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Research for protection, conservation and enhancement of cultural heritage : opportunities for European enterprises

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Research for protection, conservation and enhancement of cultural heritage : opportunities for European enterprises

La recherche pour la protection, la conservation et la mise en valeur du patrimoine culturel : opportunités pour les entreprises européennes

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It is the first time within the series of the European Commission's Conferences on the Research for the Protection of Cultural Heritage that the author's contributions are gathered under a single publication.

At the dawn of the 3rd millennium and following fifteen years of EC continuous support and funding, research of this nature has reached a critical mass in terms of scientific topics and research teams coming from all over Europe to advance Europeans' cultural heritage. At world level, Europe is now recognised as a leading player in the innovative field of sustainable cultural heritage.

Under the French Presidency, the Ministry of Culture and Communication initiated the 4th European Conference which was held in Strasbourg. This historical city, renowned as a symbol of European unity and co-operation, illustrates, on a cultural level, important aspects of our common European patrimony.

Europe must now make a firm and renewed commitment to research and technology in order to maintain its pioneering position in the field of sustainable cultural heritage. The huge number of contributions presented at the Strasbourg Conference clearly demonstrate the increasing success and growing interest in this field and prompted the European Commission and the French Ministry of Culture and Communication to publish the outcome of this event. The publication aims to document accurately these European achievements which will benefit both scientists and end-users including cultural heritage owners, conservators and SME's.

The editors wish to thank all those who contributed to these proceedings for their willingness and their valuable co-operation.

C'est la première fois dans la série des conférences de la Commission européenne sur la Recherche pour la protection du patrimoine culturel que les contributions des conférenciers sont publiées. Au seuil du 3ème millénaire et après quinze années de soutien et de financement continus, la recherche dans ce domaine a atteint une masse critique en termes de sujets scientifiques et d'équipes de recherche venant de l'Europe entière pour le plus grand bénéfice du patrimoine culturel.

Sous la Présidence française de l'Union européenne, le Ministère français de la culture et de la communication a pris l'initative de tenir la 4ème conférence de la Commission européenne à Strasbourg. Cette cité historique, symbole de l'unité et de la coopération européenne, illustre sur le plan culturel divers aspects importants de notre patrimoine européen commun.

L'Europe doit maintenant renouveler son soutien sans faille à la recherche et à la technologie afin de maintenir sa position de leader dans le domaine du développement durable du patrimoine culturel. Le nombre important des contributions présentées à la conférence de Strasbourg montre clairement le succès et l'intérêt croissants pour ce domaine et a convaincu la Commission européenne et le Ministère français de la culture et de la communication de publier les retombées de cette conférence. La publication vise à témoigner des efforts accomplis au niveau européen qui vont bénéficier à la fois aux scientifiques et aux utilisateurs finaux notamment les propriétaires du patrimoine culturel, les conservateurs et les PME.

Les éditeurs souhaitent remercier tous ceux qui ont bien voulu contribuer à la publication de cet ouvrage pour leur engagement et précieuse coopération.

Welcome adresses and introduction
Allocutions de bienvenue et introduction

Jean KLOTZ, Adjoint au Maire de Strasbourg

Messieurs les Présidents, Messieurs les Directeurs, Mesdames, Messieurs, au nom de Madame Catherine TRAUTMANN, Maire de Strasbourg, je vous souhaite la bienvenue dans notre ville à l'occasion de la quatrième conférence de la Commission européenne intitulée " La recherche pour la protection, la conservation et la mise en valeur du patrimoine culturel : opportunités pour les entreprises européennes ".

Comme le titre l'indique, le contenu de vos travaux sera essentiellement pratique dans des domaines très variés : scientifiques, techniques, économiques, socio-administratifs et touristiques. Chercheurs, chefs d'entreprises, scientifiques, représentants d'administrations et élus, vous êtes là pour un travail en commun, concret, pragmatique, et qui, je l'espère, sera fécond et fructueux.

Au-delà des effets de mode, le patrimoine constitue un enjeu majeur pour la collectivité locale. La ville de Strasbourg se propose d'optimiser les moyens importants qu'elle consacre à son patrimoine culturel bâti et de rendre plus évident à ses citoyens la politique menée en ce domaine. C'est un moyen de faire adhérer les citoyens à cette politique, de leur faire prendre conscience que le patrimoine est un bien commun, qu'ils habitent le centre ville ou les faubourgs, qu'ils soient jeunes ou vieux, qu'ils soient riches ou pauvres.

Pour cela, Madame Catherine TRAUTMANN a demandé aux services municipaux de préparer, en liaison avec les services de l'État et des autres collectivités locales, un plan patrimonial de la ville de Strasbourg. Ce plan pluriannuel prendra en compte l'important patrimoine architectural de la ville, qu'il soit public ou privé. Il portera notamment sur la conservation, la mise en sécurité, l'ouverture au public, d'éventuelles reconversions d'usage (par exemple, le patrimoine des hôpitaux universitaires de Strasbourg) ainsi que sur la mise en place des moyens financiers.

Pour terminer, je voudrais dire un mot au sujet de deux domaines patrimoniaux qui me tiennent particulièrement à cœur. Ils seront sans doute, du moins je le pense et je l'espère, présents dans vos débats. Le premier point concerne le patrimoine de demain, que nous construisons aujourd'hui. Non loin d'ici, vous avez le bâtiment que la ville de Strasbourg a construit avec d'autres partenaires pour le Parlement Européen ; il s'agit du patrimoine de demain. Avec nos amis allemands de Kehl, nous avons également pour projet un jardin des deux rives, à cheval sur le Rhin. Ce jardin, avec les constructions qu'il abritera et sa passerelle sur le Rhin, constituera un des éléments forts du patrimoine que nous transmettrons aux générations futures.

Le deuxième point concerne le patrimoine immatériel, c'est-à-dire la transmission de savoirs et de savoir-faire. Il s'applique à bien des domaines : la musique, la danse, la sculpture, la taille de pierre. Nous avons à Strasbourg depuis plusieurs siècles, avec la Fondation de l'Œuvre Notre Dame, un lieu de transmission de ces savoirs ; nous y sommes très attachés. Je terminerai là-dessus. Encore une fois : bienvenue à Strasbourg, et bon travail !

Jean KLOTZ, Deputy Mayor of Strasbourg

Ladies and gentlemen, on behalf of Madame Catherine TRAUTMANN, Mayor of Strasbourg, I would like to welcome you to our city for the 4th European Commission conference about "Research for protection, conservation and enhancement of cultural heritage : opportunities for European enterprises".

The contents of your work, as the title indicates, will mainly come from wide-ranging areas : scientific, technical, economic, socio-administrative and the tourist trade. The reason why researchers, company executives, scientists, administration representatives and elected officers are assembled here is in order to work together in a concrete and pragmatic manner so as to achieve, I hope, prolific and fruitful results.

Heritage is more than a passing trend. It represents an important stake for the local communities. The city of Strasbourg intends to render more efficient the huge means it dedicates to its heritage buildings, whilst making the policies employed, for this purpose, in this field, clearer to its citizens. This is also a way of making citizens adhere to this policy, by making them aware of the fact that whether they live in the town centre or in the suburbs, whether they be young or old, rich or poor, heritage is their common property.

To this end, Madame Catherine TRAUTMANN has asked the municipality to prepare, in collaboration with the services of the French State and other local communities, a heritage plan for the city of Strasbourg. This plan, ranging over a number of years, will take into account the considerable amount of both publicly and privately owned architectural heritage in the city. It will pay particular attention to conservation and security aspects, to opening facilities for the general public and to possible heritage reconverting that alters the usage like the university hospitals of Strasbourg, as well as implementation of financial means.

To end my speech I would like to say a few words about two heritage fields that I am especially attached to and which I hope and believe shall be included in your discussions. The first is about the heritage of tomorrow that we are building today. Not far from here you will find the building that the city of Strasbourg has built in collaboration with other partners for the European Parliament ; this is tomorrow's heritage. We are also planning, with our German friends from Kehl, a riverbank park on either side of the Rhine. This park, the buildings within it and the footbridge over the Rhine that will be constructed, will also become major elements in this heritage that we are passing down to our descendents.

The second aspect involves intangible heritage : the transfer of knowledge and know-how. This comprises many fields – music, dance, sculpture, stone masonry – and with the "Oeuvre Notre Dame " foundation in Strasbourg that we are very fond of, we have a place where such knowledge has been transferred for many centuries. I shall end there. Welcome to Strasbourg and I wish you well in your work.

Philipe RICHERT, Président du Conseil général du Bas-Rhin

Monsieur le Maire adjoint, Monsieur le Directeur général, Monsieur le Chef de la mission, Mesdames, Messieurs, c'est avec plaisir que je m'associe à Monsieur KLOTZ pour vous souhaiter la bienvenue à Strasbourg à l'occasion de cette conférence sur le thème de la préservation de notre patrimoine culturel organisée à l'initiative de la Commission Européenne. Je voudrais d'abord féliciter la Commission Européenne et vous même Monsieur le Directeur pour cette intéressante et excellente initiative.

Je me sens tout particulièrement concerné par ce sujet, d'abord à titre personnel, car comme vous tous et bien d'autres, je suis très attaché à la protection et à la mise en valeur des richesses de notre patrimoine. Je me sens concerné également de par mes fonctions de Président d'une collectivité territoriale d'environ un million d'habitants mais aussi parce que je suis, au Sénat, le Président du groupe d'étude du patrimoine architectural. Je considère que le patrimoine culturel est un domaine de tout premier plan. Au delà de considérations purement économiques, il permet d'afficher, au niveau de l'Europe, une cohésion et une identité nécessaires à son avenir commun.

Ces derniers temps, le patrimoine culturel est devenu un enjeu de société. Nos concitoyens, et par conséquent les pouvoirs publics, sont de plus en plus sensibles à la nécessité de préserver ce patrimoine commun, qu'il soit naturel ou architectural, rural ou urbain, d'intérêt mondial ou local. La notion de développement durable s'impose peu à peu.

Le patrimoine n'est-il pas pour toute civilisation un élément essentiel de transmission du passé au présent, et du présent au futur ? La notion même de patrimoine culturel a évolué. Des seuls monuments architecturaux et des ensembles historiques, nous sommes passés à des architectures vernaculaires, techniques et industrielles ou à des paysages culturels. En France, si vous me permettez de prendre cet exemple, mes concitoyens manifestent une volonté vive de sauvegarder des traces de leur passé. Certes, elles sont parfois modestes d'un point de vue esthétique, mais elles leur sont chères. A cela s'ajoute une réelle prise de conscience de l'intérêt économique de préserver ce patrimoine, notamment à travers l'activité touristique. Strasbourg, que nous pouvons citer sans avoir à rougir, est l'exemple de ce que le patrimoine culturel peut apporter en matière de tourisme.

Le rythme des classements est en France très significatif de cette évolution. Ces dernières années, nous avons classé comme jamais depuis les années soixante. L'état de dégradation particulièrement alarmante de ces nouveaux sites classés est une de leurs caractéristiques. Selon la typologie des architectes en charge des monuments historiques, 4500 monuments sur 3691 sont dans un état défectueux et 470 sont dans un état dit de péril. Certes, cette situation suscite l'intérêt des entreprises spécialisées, mais elle pose aussi un certain nombre de problèmes appelant des réponses urgentes. D'abord, le nombre de partenaires impliqués a augmenté en même temps que le nombre de sites à protéger. Désormais, le patrimoine n'est plus l'affaire exclusive de l'Etat ; le département et les communes concernées sont très fortement impliqués. Les structures porteuses d'un projet sont donc souvent des collectivités ou des associations aux moyens plus ou moins limités. À l'avenir, la recherche de techniques performantes à moindre coût sera un sujet de réflexion majeur.

Au-delà de cet aspect, et de façon plus générale, il est nécessaire de réfléchir à de nouvelles sources de financement. Le mécénat, largement pratiqué en Europe, aux États-Unis et au Japon est une piste qui mérite d'être explorée et davantage encouragée. En France, le mécénat est fortement entravé par une conception archaïque des relations entre le secteur privé et le secteur public. Les entreprises ont peu de moyens de valoriser leurs interventions à travers l'apport des fondations. Je crois qu'il est nécessaire de mettre en place une réflexion qui permette que, demain, ce mécénat puisse se développer dans notre pays sans que cela se fasse au détriment de l'intervention étatique ou publique. Une diminution de l'aide publique en matière patrimoniale serait en effet une réelle régression ; il est nécessaire que les professionnels de la préservation du patrimoine et les parlementaires demeurent extrêmement vigilants sur ce point.

Par ailleurs, l'opinion publique est de plus en plus consciente de la nécessité de préserver notre capital environnemental. Notre planète, nous le découvrons un peu plus chaque jour, est fragile, et son équilibre de plus en plus menacé. La recherche de techniques moins polluantes et plus respectueuses de l'environnement bâti ou naturel doit permettre de répondre à ce nouvel impératif, à cette nouvelle demande sociale, à cette attente de nos concitoyens. Cet aspect sera longuement évoqué à l'occasion de ce colloque et je m'en réjouis. L'éclectisme du patrimoine protégé implique la prise en compte de nouveaux problèmes tels que la dépollution des sites industriels, de plus en plus nombreux à susciter l'intérêt des populations et des collectivités. Face à de tels enjeux, une collaboration s'impose entre les professionnels, les administrations centrales, les collectivités et les élus, ainsi qu'entre les Etats européens.

Depuis un certain temps, le patrimoine n'est plus l'affaire exclusive de l'Etat. Aujourd'hui, il est nécessaire de s'interroger sur la redéfinition des modes de fonctionnement, sur le rôle des sociétés privées, des collectivités ou des instances européennes, sur l'opportunité de nouvelles règles harmonisées au niveau européen pour assurer la protection optimale de notre patrimoine commun, un échange toujours plus grand et plus efficace des connaissances et des techniques. Je prends pour exemple la nouvelle législation française en matière de fouilles archéologiques préventives. Il était nécessaire, nous le savons tous, de réformer les pratiques de notre pays, notamment sous l'injonction de l'Europe. Nous savons aussi que l'AFAN (Association pour les fouilles archéologiques nationales), qui a réalisé un travail considérable de fouilles de protection, n'est plus aujourd'hui à la hauteur des enjeux. Un texte adopté par le gouvernement et voté par l'Assemblée nationale renforce ce qui existait déjà en conférant le monopole à cette association, transformée en établissement public. Il est stipulé certes que dorénavant cet établissement pourra faire appel à d'autres partenaires, par exemple, aux collectivités territoriales qui disposent d'équipes d'archéologues compétents ou aux universités.

Le Sénat n'a pas accepté la remise en place d'un tel monopole. Pourquoi seul cet établissement public pourrait-il réaliser pour le compte de l'État ces fouilles préventives ? Chaque fois que cela est possible, nous souhaitons pouvoir faire confiance aux équipes qui disposent de moyens et de compétences ; les collectivités, par exemple. Comment imaginer que l'on puisse aujourd'hui recréer un secteur réservé alors que chacun sait par ailleurs que les universitaires, eux aussi, ont les compétences requises pour mener les fouilles préventives ?
Mais l'Assemblée nationale et le gouvernement n'ont rien voulu savoir, restant sur leur position. Il y a eu une réunion de la commission mixte paritaire entre parlementaires de l'Assemblée nationale et du Sénat. Ce fut une rencontre très agréable entre personnes qui apprécient le patrimoine. Toutefois, au bout de dix minutes, nous en avons conclu qu'il était impossible de nous entendre ; les uns s'imaginant que grâce au monopole nous parviendrions aux meilleurs résultats, les autres estimant que nous n'y parviendrions que par le dialogue et l'ouverture entre les personnes et les instances compétentes. Oui, je crois qu'il faudrait envisager de créer, à l'instar de ce qui a été réalisé récemment, une fondation européenne fédérant les initiatives des associations, des collectivités et des administrations autour d'une politique de réseau du patrimoine dans son ensemble. Il faut apprendre à franchir les frontières qui sont souvent tracées de façon artificielle, même si elles ont parfois leurs raisons d'être.

Les thèmes, vous le savez mieux que moi, sont légion et tous sont plus motivants les uns que les autres. Aussi les débats des jours à venir devraient être passionnants. Ils contribueront, j'en suis certain, à identifier, à déchiffrer de nouveaux problèmes, à renforcer davantage encore le dialogue et la collaboration entre les experts que vous êtes et dont nous attendons beaucoup.

Pour terminer, permettez-moi de vous souhaiter un agréable séjour dans notre département, et plus particulièrement à Strasbourg, ville de patrimoine qui, je l'espère, saura vous charmer avec ses multiples richesses culturelles et patrimoniales. Bon travail !

Philippe RICHERT, Chairman of Bas-Rhin District Council

Ladies and gentlemen, it is with great pleasure that I join Mr KLOTZ in welcoming you to Strasbourg. I would first of all like to congratulate you, Mr PATERMANN, for this conference about preservation of our cultural heritage, organised by the European Commission, which is an excellent and very interesting initiative.

Being personally very attached to the protection and enhancement of our wealth of heritage, like all of you and many others besides, I, myself, feel particularly concerned by this subject. My involvement also stems from my functions as chairman of a territorial community of a population of around one million and also because, I am director, in the French Senate, of an architectural heritage study group. I consider cultural heritage to be a field of the utmost importance. Besides the purely economic considerations, it enables the cohesion and identity required by our common future to be displayed on a European scale.

In the last few years, cultural heritage has become a major stake for society. Our fellow citizens and consequently, the public powers, are increasingly aware of the need to preserve this common heritage, whether it is natural or architectural, rural or urban, of worldwide or local interest. The idea of sustainable development is gradually becoming the rule.

Isn't heritage something of an essential item for all civilisations that ought to be handed down from the past to the present and from the present to the future ? The very idea of cultural heritage has evolved. We have progressed from only architectural monuments and historic groups to vernacular, technical and industrial architecture or to cultural landscapes. In France (if you would kindly permit me to use this example), my fellow citizens are showing a real will to safeguard the traces of their past. Although often only very small from an aesthetic point of view, they cherished nevertheless. The economic advantages of preserving this heritage, in particular through tourist activity are also becoming evident. I am proud to be able to give the example of Strasbourg as a place where cultural heritage is a tourist attraction.

This development in France is clearly shown by the increase in the additions to listed buildings. In the last few years we have listed more buildings than ever since the 1960s. The state of damage of these new listed sites is especially alarming and this is one of their characteristics. According to the typology set down by the architects responsible for historic monuments, 3691 of the 4500 monuments are in a state of disrepair and 470 are said to be in imminent danger. This situation is, of course, of interest to specialised companies, but it also poses quite a few problems that require an urgent response. First of all, the number of participating actors has increased in conjunction with the number of sites that require protections. Nowadays, the responsibility for heritage is no longer solely the business of the State. The department and the local communities are very involved. A project's supporting structures are therefore often found to be the local communities or organisations having more or less limited capacities. Research for less expensive, high-performance techniques will be the subject future consideration.

New sources of funding must be sought out beyond this aspect and more generally. The patronage system, widely used in Europe, in the United States and in Japan, is a method that deserves further exploration and should be encouraged. In France, the patronage system comes up against obstacles due to an archaic opinion of the relationships between public and private sector. Companies have limited means by which to demonstrate their good intentions through provision of foundations. Further reflection, I believe, is necessary to enable this patronage system to develop within our country, in the near future, without this being at the detriment of the State's or public intervention. A decrease in public funding in heritage matters would indeed be a step backwards ; it is necessary that the heritage preservation trades and the parliament remain extremely vigilant on this point.

Furthermore, public opinion is becoming more and more aware of the need to preserve our environmental capital. Every day we learn a little more about our fragile planet and its equilibrium is becoming increasingly threatened. The research for less polluting techniques that respect the natural or

built-up environment should respond to this new imperative, this new request from society, to the expectations of our fellow citizens. This point will be dealt with exhaustively during this conference and this is something that gives me great pleasure. The eclectic nature of protected heritage implies that new problems such as removal of pollution from industrial facilities that are beginning to attract the attention of the local communities and populations must be taken into account. With this at stake, collaboration is required between tradesmen, central administration, local communities and elected bodies as well as between European states themselves.

The state is therefore no longer solely responsible for heritage. Nowadays we must look into possible redefinition of operating modes, the role of private companies, local communities or European courts, at the opportunity of providing new rules, harmonised at a European level in order to ensure optimum protection of our common heritage, ever-increasing and improved exchange of knowledge and technology. For example, let us consider the new French legislation with regards to preventive archaeological excavations. We all know that our country's practices require reforms, in particular where the injunction of Europe is concerned. A considerable amount of protective excavation work has been undertaken by AFAN "Association pour les fouilles archéologiques nationales" (French national archaeology organisation), who are no longer able to meet today's requirements. A paper, adopted by the government and voted by the French national assembly further aggravates the existing situation by giving this organisation, which has been turned into a public establishment, the monopoly. Admittedly, this establishment could call upon other partners, for example, territorial communities, who may be able to provide skilled archaeology teams or upon universities.

The senate has not accepted the implementation of such a monopoly. Why should this public establishment alone be able to perform preventive excavation for the State ? Whenever possible, we would like to be able to depend upon teams such as, for example, the local communities who have the means and the skills at their disposal. Is it conceivable that a reserved sector may today be recreated whilst everyone knows that is it the universities who possess the skills required to perform preventive excavations ?

But the French national assembly and the government have not wished to listen and remain adamant. One meeting of the joint commission between the national assembly parliamentary representatives and the Senate took place. This was a very pleasant meeting of people who all appreciate heritage. After just ten minutes, however, it was decided that it would be impossible to come to an understanding. There were those who felt that thanks to the monopoly we would achieve better results, others believing that this would only be achieved through discussion and a market open to skilled organisations. Yes, I do believe that we should follow the example of the recently created European foundation that federates the initiatives of organisations, local communities and administrations around a policy of a heritage network in its entirety. We must learn to surmount the barriers that are often drawn up artificially, even if they have valid reasons for being there.

There is a whole host of fascinating subjects. The discussions of the next few days promise to be compelling. I am sure that they will contribute to identification and deciphering of new problems and to a strengthening of the discussions and collaboration between experts such as you are and we expect great things to come of it.

Finally, let me wish you a pleasant stay in our department and especially in Strasbourg which will appeal to you as a city with a wealth of heritage and culture. Enjoy your conference !

Jean-Pierre DALBERA, Chef de la Mission de la recherche et de la technologie au Ministère de la culture et de la communication

Monsieur le Président du Conseil général du Bas-Rhin, Monsieur l'adjoint au Maire de Strasbourg, Messieurs les Directeurs, Mesdames, Messieurs, chers collègues, au nom de Madame Catherine TASCA, Ministre de la culture et de la communication, je voudrais d'abord féliciter la Commission européenne d'organiser chaque année dans un pays membre de l'Union cette manifestation consacrée à la recherche en faveur du patrimoine culturel européen. Elle est devenue, il faut le dire, un rendez-vous des spécialistes du domaine ; nous nous en réjouissons tous.

Je suis évidemment particulièrement heureux que cette quatrième rencontre, co-organisée cette année avec le Ministère français de la culture et de la communication et la Maison des Sciences de l'Homme, se tienne à Strasbourg durant la période où notre pays, la France, assure la présidence de l'Union européenne.

Je voudrais remercier vivement Madame Catherine TRAUTMANN, ancienne Ministre de la culture et de la communication, aujourd'hui Présidente de la Communauté urbaine et Maire de Strasbourg, d'accueillir cette manifestation dans sa ville.

Capitale intellectuelle, artistique et économique de l'Alsace, Strasbourg est une ville dont on ne se lasse pas. La richesse de ses musées et de ses monuments, le dynamisme de sa vie culturelle comme la réputation de sa gastronomie en font un pôle européen d'excellence.

Je tiens aussi à remercier Monsieur le Président du Conseil général du Bas-Rhin d'avoir contribué à la réussite de cette manifestation scientifique. Comme Strasbourg, votre département possède un patrimoine historique d'exception. Les congressistes qui resteront jusqu'à samedi auront sans doute l'occasion de visiter Ebersmünster et de profiter du concert donné sur l'orgue de l'église abbatiale par son titulaire, Monsieur Bernard CHALTE. Vous savez sûrement que cet instrument remarquable construit au début du XVIII^{e} siècle par le grand facteur d'orgue André SILBERMANN a traversé les aléas de l'histoire et des restaurations intempestives du XIX^{ème} siècle sans être altéré. Vous l'apprécierez, j'en suis sûr, à sa juste valeur.

Mes remerciements, bien sûr, vont aussi au Directeur régional des affaires culturelles d'Alsace et à ses collaborateurs, qui ont contribué à la préparation de cette conférence. À l'initiative de la direction, plusieurs visites de chantiers de restauration vous seront proposées jusqu'à samedi comme autant de contrepoints à vos travaux.

Je n'oublierai pas non plus de mentionner un de nos partenaires de longue date : la Maison des Sciences de l'Homme et son directeur adjoint Monsieur Jean-Luc LORY, qui sera parmi nous demain, et qui a fait bénéficier le Ministère de la culture et de la communication de sa solide expérience dans la gestion d'opérations scientifiques internationales. Son aide a été particulièrement précieuse à mon adjointe Madame Astrid BRANDT-GRAU, qui a pris en charge toute la coordination française de la rencontre et que je remercie tout particulièrement et chaleureusement pour ses efforts.

La préparation de cette manifestation par les services de la Commission de Monsieur Christian PATERMANN et ceux du ministère a donné lieu à de nombreux et fructueux échanges. Je suis persuadé qu'ils se poursuivront à l'avenir pour développer plus largement encore au sein des programmes de l'Union européenne les synergies entre la science, la technologie et la culture.

Le Ministère de la culture et de la communication accorde une très grande importance aux recherches appliquées à la conservation et la restauration du patrimoine culturel. Ce domaine occupe en effet plusieurs centaines de conservateurs, d'ingénieurs et de techniciens. Près de 20 % du budget de la recherche du ministère y est consacré.

À ces moyens s'ajoutent ceux de plusieurs laboratoires du CNRS (Centre National de la Recherche Scientifique), ceux d'universités, du CEA (Commissariat à l'Énergie Atomique), du Museum national d'histoire naturelle ou de collectivités territoriales particulièrement sensibles à ces questions. Je pense, en particulier, aux départements de Loire-Atlantique, de l'Isère, des Bouches-du-Rhône, au district de Nancy, à différentes régions, notamment, la région Provence-Alpes-Côte-d'Azur ou la région Rhône-Alpes. Sur le stand du ministère de nombreux laboratoires intervenant sur le patrimoine national sont mentionnés à titre d'exemple.

Un aperçu des activités des principaux laboratoires français vous est proposé dans l'Espace forum ; ces deux jours de conférences vous permettront, évidemment, de vous faire une idée de l'état de la recherche dans le domaine de l'art, laquelle est soutenue par la Direction générale " Recherche " à la Commission européenne. Je suis tout à fait convaincu que de nouveaux sujets de recherche émergeront de vos débats, notamment la question de l'intégration du patrimoine culturel dans la ville de demain, ou encore, comme vient de l'évoquer le président RICHERT, la question des nouveaux modes de valorisation des richesses de nos pays respectifs. Ces sujets, relatifs au cadre de vie, à l'environnement urbain mais aussi au développement économique font partie, et nous nous en réjouissons, des priorités du 5ème Programme-cadre de recherche et de développement de l'Union européenne.

Mesdames et Messieurs, à l'heure de la mondialisation, le gouvernement français attend beaucoup de la recherche et de l'innovation, non seulement pour rendre les industries de nos pays compétitives et créatrices d'emploi, mais aussi pour construire un espace culturel et social européen riche de son patrimoine et de sa diversité. Les richesses culturelles et artistiques de l'Europe sont des atouts pour les pays qui la composent, pour un développement durable assurant la qualité de la vie de ses citoyens, pour l'éducation de la jeunesse et pour la connaissance de l'histoire des peuples. Ce sont aussi des atouts, on l'a dit tout à l'heure, pour un tourisme de qualité.

Ce sont les travaux des chercheurs en archéologie, en histoire, en histoire de l'art, en anthropologie, en ethnologie, qui révèlent ces richesses culturelles et les rendent accessibles à tous. Ce sont aussi les travaux des chimistes, des physiciens, des biologistes et des informaticiens - et ils sont nombreux dans la salle -, qui permettent de conserver, de faire connaître ces richesses grâce à leurs méthodes et à leurs techniques. Ce sont des entreprises privées qui appliquent à grande échelle, lors des travaux de restauration ou de conservation qu'elles effectuent, les résultats de ces recherches.

C'est pourquoi le thème de cette conférence souligne leur rôle dans la valorisation des résultats ; la bourse d'échange, organisée vendredi matin par l'association Relais Culture Europe à la demande du ministère, sera certainement l'occasion de rencontres et de transferts de technologies ; comme la table ronde finale qui débattra, demain, des responsabilités respectives du secteur public et du secteur privé.

À l'occasion des discussions sur les futures orientations du 6ème et prochain programme-cadre, la création d'un " espace européen de la recherche " fait actuellement l'objet de nombreuses réflexions dans tous les pays et à la Commission européenne. Pour atteindre en effet les objectifs stratégiques fixés en mars dernier, lors du sommet européen de Lisbonne, il est indispensable de parvenir à une plus grande cohérence entre les politiques nationales et les politiques communautaires, et à une meilleure utilisation des ressources européennes.

Un consensus se dessine sur la nécessité d'adapter et de compléter les instruments d'action de la Commission, favorable à la mise en œuvre de cet " espace européen de la recherche ". Dans cette perspective, certains pensent que le prochain programme-cadre devrait être restructuré et élargi. Des articulations entre les différents programmes de la Commission européenne devraient être mis en place lors de la définition des différents objectifs ainsi que des partenariats plus étroits entre la politique de recherche de la Commission européenne et les autres politiques communautaires. Les mesures favorisant la mobilité des chercheurs devraient être renforcées. Les sciences de l'homme et de la société, encore peu impliquées dans des actions de recherche, devraient enfin trouver la place qu'elles méritent au sein du futur programme-cadre.

Ces évolutions sont cruciales pour le développement d'une politique communautaire en faveur du patrimoine et de la culture européenne. Aujourd'hui plusieurs directions de la Commission interviennent dans des champs complémentaires. Je ne citerai que les plus connues des services du Ministère de la culture et de la communication : la Direction générale " Recherche ", avec l'action-clé " Ville de demain et patrimoine culturel ", la Direction générale " Société de l'information ", avec le programme " Applications au patrimoine culturel ", mais aussi le programme " Eumedis " de développement de la société de l'information dans l'aire méditerranéenne, la Direction générale " Éducation et culture ", avec le programme " Culture 2000 ", la Direction " Relations extérieures " avec, en particulier, les volets sur la culture et la société de l'information du programme MEDA.

Tout en se félicitant des excellents résultats obtenus par ces différents programmes, on peut légitimement s'interroger sur leur articulation. Une meilleure coordination permettrait sans doute de les enrichir, de les harmoniser et de contribuer de façon plus efficace à la construction de cet espace européen de la culture et de la recherche que nous appelons de nos vœux.

Au-delà des nécessaires restructurations, de nouvelles actions de recherche pourraient combler les manques actuels, en particulier, en faisant appel aux sciences humaines et sociales pour apporter des éclairages sur la culture européenne et une meilleure compréhension de l'histoire commune des peuples qui la composent, étudier les politiques publiques et éclairer les choix de société face à des enjeux technologiques industriels majeurs qui se développent très vite.

Enfin, il me semble qu'il faut s'interroger sur les moyens de renforcer et de pérenniser les partenariats en matière de recherche culturelle. Dans ces disciplines les institutions sont, en général, de tailles très modestes et nous le savons tous, l'accès au programme cadre leur est souvent difficile. La création d'un GEIE (Groupement Européen d'Intérêt Économique) permettrait sans doute, je le crois et mon ministère aussi, de rapides progrès dans la structuration des réseaux d'acteurs de la recherche, mais également de la société de l'information.

Telle est l'ambition affichée d'une société européenne de la connaissance, capable de concevoir et d'assurer un développement social, culturel et économique durable.

Mesdames et Messieurs, nos services et ceux du Ministère français de l'équipement ont accompli des efforts importants pour faire connaître l'action clé " Ville de demain et patrimoine culturel ", pour conseiller et soutenir les porteurs de projets, grâce à la mise en place de points de contacts nationaux. Nous continuerons en ce sens car nous croyons vraiment aux capacités structurantes des programmes européens. Mais nous voulons aller encore plus loin et construire une société européenne qui soit celle des technologies et de l'innovation mais aussi celle des cultures.

Mesdames et Messieurs, je vous remercie de votre attention et je vous souhaite de fructueux travaux.

Jean-Pierre DALBERA, Head of the research and technology mission for the French Ministry of culture and communication

Ladies, gentlemen, dear colleagues, on behalf of Madame Catherine TASCA, French Minister of culture and communication, I would first of all like to congratulate the European Commission for the annual organisation in a Union member state of this gathering dedicated to research for the benefit of European cultural heritage. It has become, I must say, an acclaimed meeting for specialists in the field and this gives us all great pleasure.

It is my particular pleasure that this fourth gathering, jointly organised this year by the French Ministry of culture and communication and the human sciences department, is being held in Strasbourg at a time when France, our country, holds the presidency of the European Union.

I would like to give a warm thank you to Madame Catherine TRAUTMANN, former French Minister of culture and communication and who is now chairperson of the urban community and Mayor of Strasbourg, for welcoming this gathering in her city.

Strasbourg is the intellectual, artistic and economic capital of the Alsace region and a city that one never tires of. With a wealth of museums and monuments, the driving force of its cultural life and its gastronomic reputation, Strasbourg is a centre of European excellence.

I would also like to thank the chairman of the regional Bas-Rhin council for having contributed to the success of this scientific gathering. The region, like Strasbourg, is endowed with an exceptional historic heritage. The congress participants who are to remain here until Saturday will no doubt have the opportunity to visit Ebersmünster and to take advantage of the concert given on the abbey priory organ by its current occupant, Monsieur Bernard CHALTE. You are no doubt aware that this remarkable instrument, built at the beginning of the XVIIIth century by the famous organ maker, André SILBERMANN, has survived throughout history and the untimely restorations of the 18th century without alteration. I am certain that you will appreciate its true value.

My thanks, of course, go out also to the French Alsace regional manager of cultural affairs and his colleagues who have contributed to this conference's preparation. According to the management's initiative, several restoration site visits will be on offer between now and Saturday to complement your work.

Neither will I forget to mention one of our long-term partners : the human science department and its vice-managing director, Monsieur Jean-Luc LORY, who will join us tomorrow and who has lent his wealth of experience to the French Ministry of culture and communication with respect to the management of international scientific operations. His help has been particularly precious to my vice chairperson, Madame Astrid BRANDT-GRAU, who has undertaken the entire co-ordination of the French part of the meeting and who I thank most particularly and most warmly for her effort.

The preparation of this gathering by the Commission service of Monsieur Christian PATERMANN and the ministry has given rise to several fruitful exchanges. I am certain that they will continue in the future to develop even wider synergies within the European Union programmes between science, technology and culture.

Applied research on conservation and restoration of cultural heritage ranks very highly for the French Ministry of culture and communication. This field does in fact involve several hundreds of conservators, engineers and technicians. Nearly 20% of the ministry's budget is dedicated to it.

In addition to this funding other means are provided by several CNRS " Centre National de la Recherche Scientifique " (French national scientific research centre) laboratories, university laboratories and the

CEA " Commissariat à l'Energie Atomique " (French atomic energy commission), the French national natural history museum or territorial communities who are especially sensitive to these points. I refer, in particular, to the Loire-Atlantique, the Isère, the Bouches-du-Rhône, the Nancy regions, and more precisely to the Provence-Alpes-Côte-d'Azur or Rhône-Alpes regions. On the ministry's stand, several laboratories participating in national heritage are given as an example.

An overview of the activities of the main French laboratories is given in the forum room ; these two days of conferences will, I understand, give you a good idea of the current state of research in the field of art, which is supported by the European Commission directorate-general for "Research". I am quite convinced that new subjects for research will emerge from your debates, in particular, the question of integrating cultural heritage into the city of tomorrow, or even, as Chairman RICHERT has just said, the question of new modes of development of riches by our respective countries. These subjects, with regards to daily lifestyles, the urban environment but also to economic development, are included in the priorities of the European union's fifth framework programme for research and development and this gives us all great pleasure.

Ladies and gentlemen, at a time of globalisation, the French government expects a large amount of research and innovation, not only to render our countries' industries more competitive and to create employment but also to build a European social and cultural place that is rich in heritage and variety. Sustainable development ensures the quality of life for its citizens, for education of young people and for the historical knowledge of its people and cultural and artistic riches are assets for European countries. They are also attractions, and we will be coming back to this point, for quality tourism.

These cultural riches are uncovered through the work of researchers in the fields of archaeology, history, fine art history, anthropology, and ethnology and are thus made available to all. The conservation of these riches and knowledge gained about them is brought about through the work of chemists, physicians, biologists and computer scientists (who are well represented in this hall) thanks to their processes and techniques. Private companies are applying the results of this research in their restoration or conservation work.

It is for this reason that the theme of this conference highlights the role they play in the development of results. The partner mediation event organised on Friday morning by the Relais Culture Europe organisation upon the Minister's request will certainly be an opportunity for getting together to discuss and exchange technology ideas, as will the final round table, which, tomorrow, will debate the respective responsibilities of the private and public sectors.

The future direction to be taken by the next and sixth framework programme is currently being discussed and the creation of a "European Research Area" is currently being considered in all the countries and at the Commission. In order to actually reach the strategic objectives set down last March during the European summit in Lisbon, the widest coherence possible between national politicians and local community politicians must be achieved and European resources must be put to better use.

A consensus is being drawn up concerning the need to adapt and finalise the Commission's action instruments, which give preference to the implementation of this "European Research Area". With this in mind, some believe that the next framework programme should be restructured and be more broad-based. Structures that link together the Commission's several programmes should be implemented during the definition of the final objectives such as strict partnerships between the Commission's research policy and other community policies. Measures that help researchers to become more mobile should be strengthened. Human and society sciences should finally be given their rightful position within the future framework programme as they have yet to play an adequate role.

These developments are crucial in order to draft a community policy that benefits European heritage and culture. Several of the Commission's directions are involved in complementary fields. I will only refer to the more well-known services of the Ministry for culture and communication : the "research" directorate-general, with the "cultural heritage and the city of tomorrow" key action, the "information society"

directorate-general, with the "cultural heritage applications" programme, but also the "Eumedis" programme for development of the information society in the Mediterranean area, the "education and culture" directorate-general with the "Culture 2000" programme, the "external relations" management with, notably, the items relating to culture and the information society in the MEDA programme.

Whilst we should congratulate ourselves on the excellent results obtained by these different programmes, we ought quite rightfully to question their structure. Better co-ordination would no doubt enable them to be enhanced, to harmonise them and to more efficiently contribute to the building of this European Culture and Research Area that we all aspire to.

As well as the required restructuring, new research actions could fill the current gaps, in particular, by calling upon human and social sciences to shed light on European culture and a better understanding of the common history of the people it comprises, studying public politics and underlining the choices of society when faced with major industrial technological stakes that are developing very quickly.

Finally, I feel that we should question the means by which to strengthen and sustain the partnerships in matters of cultural research. The institutions in these disciplines are generally very small and we all know that access to the framework programme is often difficult. The creation of an EEIG (European Economic Interest Grouping) would, my ministry and I are both convinced, enable quick progress to be made in the restructuring of the network of research actors, and also the information society.

This is the ambition of a European knowledge enterprise, able to design and meet sustainable, social, cultural and economic development demands.

Ladies and gentlemen, our services and those of the French ministry of Equipment have put a great amount of effort into enhancing the awareness of the "cultural heritage and the city of tomorrow" key action, to advise and support project proposal makers, thanks to the implementation of national contact points. We are continuing in this direction, as we truly believe in the structural capacities of the European programmes. However, we would like to go even further and build a European technology, innovation and culture society.

Ladies and gentlemen, I would like to thank you for your attention and wish you good luck in your work.

Christian PATERMANN, Directeur du programme " Environnement et développement durable " à la Direction générale " Recherche " de la Commission européenne

Chers amis, Monsieur le Président, chers collègues, après Rome, Aix-la-Chapelle et Saint-Jacques de Compostelle, nous organisons aujourd'hui, à Strasbourg, la 4ème conférence de la Commission Européenne intitulée : " La recherche pour la protection, la conservation et la mise en valeur du patrimoine culturel : opportunités pour les entreprises européennes ". Je tiens à féliciter et à remercier la présidence française de l'Union européenne et le Ministère de la culture et de la communication d'avoir pris l'initiative d'organiser cette conférence à Strasbourg.

Nous sommes heureux de l'intérêt que la France porte au renforcement d'une dimension européenne de la recherche pour la protection du patrimoine. Je remercie personnellement ceux qui ont contribué à l'organisation de cette conférence et ceux qui ont accepté de présenter leurs travaux à cette occasion. Au nom du Commissaire de la recherche, Monsieur Philippe BUSQUIN, je souhaite la bienvenue à tous les participants à la conférence, et en particulier, à ceux qui viennent des pays candidats à l'adhésion à l'Union européenne.

Le patrimoine culturel, les monuments et les objets d'art ont une importance capitale pour tous nos concitoyens, non seulement parce qu'ils sont le symbole de notre culture commune, mais aussi parce qu'ils représentent, en terme de développement économique et technologique, de création d'emplois et de qualité de vie des citoyens, un potentiel unique au monde.

Afin d'illustrer mon propos, j'aimerais vous présenter un aperçu de l'ensemble des activités de la recherche pour la protection du patrimoine culturel développées depuis 1986, grâce à notre programme au sein de l'Union européenne. Jusqu'à présent, nous avons coordonné 80 projets de recherche et financé plus de 200 instituts de recherche dans les Etats membres. Des pays comme la Norvège, la Pologne, la Suisse, la Roumanie, la République tchèque, la Slovénie, Malte, etc. y ont également été associés. Ces projets portent sur la protection du patrimoine mobilier et immobilier et couvrent l'ensemble des matériaux et toutes les formes d'œuvres d'art.

Vous savez que la Commission européenne a présenté en début d'année le projet de création d'un " Espace Européen de la Recherche ". Ce projet est devenu la référence dans les débats sur la politique de recherche en Europe. Son objectif est de renforcer la cohérence des efforts de recherche menés au niveau national et européen. Le prochain programme-cadre de recherche de l'Union européenne sera donc largement remanié dans sa conception et sa mise en œuvre. On passera d'une approche centrée sur des projets de recherches individuels à une approche plus large, mise en œuvre par l'intermédiaire d'un ensemble cohérent d'actions, dans lesquels l'intervention de l'Union européenne représentera une partie seulement d'un dispositif plus large. Il s'agit réellement de concentrer les efforts sur les thèmes d'intervention qui apportent une valeur ajoutée européenne et d'introduire des formes d'intervention de plus longue durée, à mi-chemin entre le soutien de projets et le financement institutionnel.

Dans la communication officielle de la Commission européenne au Conseil européen concernant le domaine de la recherche européenne, le chapitre intitulé " Les instruments et les modes d'interventions " proposent une série d'activités relatives à la science, à,la société et aux citoyens. À l'issue des conclusions du Conseil européen de Lisbonne de mars 2000, des actions seront menées pour renforcer l'adaptation des activités et des politiques de recherche aux besoins de la société.

Des activités RTD (Recherche et Développement Technologique) concernant le patrimoine culturel sont détaillées dans la partie de la communication consacrée au domaine de la recherche européenne. Dans la partie " dialogue science & société ", le soutien à la collaboration entre les musées et les centres de culture scientifique est l'une des initiatives les plus pertinentes pour rassembler chercheurs, industriels,

décideurs et citoyens. Cela confirme que la recherche sur la protection du patrimoine culturel est un intermédiaire idéal entre les besoins de la société et les réponses de la science et de la technologie. Ce domaine de recherche a pour spécificité de coupler la recherche fondamentale sur le comportement des matériaux exposés aux risques environnementaux et aux développements technologiques tels que le transfert de technologies et l'innovation, créant ainsi de nouveaux outils et de nouvelles méthodes de conservation des matériaux du patrimoine culturel.

La valeur ajoutée à ce domaine de recherche est le couplage de la science sociale et de la recherche urbaine pour améliorer les compétences des décideurs chargés de la planification et de la gestion des biens culturels mais aussi de souligner l'importance de l'identité culturelle de notre continent. Je crois que cela a une importance capitale pour les Etats d'Europe Centrale et d'Europe de l'Est, candidats à l'adhésion à l'Union européenne.

Dans les domaines de la recherche fondamentale et du développement technologique, l'Europe et la communauté de recherche européenne sont au premier rang mondial, grâce à l'existence d'un solide réseau d'excellence. L'aspect socio-économique et la gestion sont développés pour que chaque Etat membre puisse créer ses propres pratiques de restauration et de préservation.

La recherche pour la protection du patrimoine culturel est l'exemple d'une collaboration entre science, société et citoyens. Elle est indispensable à un développement économique, social et environnemental durable. Nous devons faire en sorte que notre patrimoine culturel puisse être bénéfique aux générations futures. C'est aussi un domaine auquel pourrait parfaitement s'appliquer le principe de précaution ; le patrimoine culturel est, lui aussi, menacé par les catastrophes naturelles comme les inondations, les tremblements de terre, les incendies de forêt et la sécheresse. Dans le document d'orientation de la Commission, l'un des fondements du sixième programme-cadre, l'application du principe de précaution et de développement durable est une des priorités absolues.

De plus, cet aspect est souvent ignoré, la société et les citoyens de l'Union européenne bénéficient directement de ce domaine de recherche, lié au tourisme, le plus actif des secteurs industriels. Le tourisme culturel est l'une des principales sources de revenu en Europe et l'un des premiers secteurs de création d'emplois. Ce secteur, vital pour notre économie, dépend en grande partie de la conservation et la protection de tous les aspects du patrimoine culturel.

Mais revenons au sujet de notre conférence : les opportunités pour les PME. Ce domaine de patrimoine culturel, qui comprend les monuments historiques, les objets d'art et toutes sortes de matériaux et de caractéristiques, est un secteur dont les retombées ne sont pas négligeables pour nous. Dans chaque nouvel Etat membre, un grand nombre de PME travaillent dans ce domaine. Nous savons aussi qu'un grand nombre d'entreprises spécialisées sont très actives dans ce domaine dans les pays candidats à l'adhésion. Un des objectifs de l'espace européen de la recherche est de renforcer les capacités d'innovation technologiques de l'Union européenne en soutenant la recherche dans les petites et moyennes entreprises. Cette conférence a pour principal objet de rassembler les acteurs capables de réaliser ces ambitieux objectifs. Dans le document d'orientation qui a été adopté le 4 octobre, le Commissaire européen pour la recherche Monsieur Philippe BUSQUIN déclare : " À Lisbonne, les chefs d'État et de gouvernements ont reconnu la priorité de la recherche dans une société européenne de la connaissance et de l'innovation. Grâce à ce document d'orientation, la Commission a fait les premiers pas en ce domaine. Les mesures que je propose devraient permettre à la recherche en Europe de mieux fonctionner à l'échelle mondiale, et en particulier avec nos partenaires d'Asie et des États-Unis. "

Cette formule s'applique parfaitement à ce domaine de recherche car aujourd'hui la Commission Européenne gère la plus grande initiative mondiale. Vous êtes la communauté scientifique et l'Asie et les États Unis seront sans doute vos futurs clients. Il y a un énorme potentiel pour de futurs travaux dans ce domaine. Je pense d'ailleurs que le sujet sera traité ultérieurement dans une autre conférence.

Notre travail vise à consolider la base scientifique et technologique européenne, capable de créer des

outils et des méthodes efficaces pour protéger, conserver et restaurer l'ensemble du patrimoine culturel : mobilier, architecture ou objets d'art. Pourquoi l'Union européenne manifeste-t-elle un si vif intérêt pour la recherche en ce domaine ? Nous savons tous que la dégradation des biens culturels est due aux effets de l'environnement. Ces risques environnementaux peuvent se présenter sous la forme de catastrophes naturelles comme les tremblements de terre, mais l'essentiel des risques auxquels est exposé le patrimoine culturel est d'origine humaine, notamment les dégradations environnementales au sein de l'espace urbain. Les biens culturels sont exposés à de nombreux facteurs de risque tels que la pollution de l'atmosphère, les vibrations liées au trafic, la biodégradation , les changements de température mais aussi aux visiteurs, à l'usage impropre de certaines technologies au sein des musées, au transport des œuvres d'art, aux graffiti, au développement urbain et enfin au tourisme de masse, qui est un facteur de risque non négligeable. Je suis heureux de constater que chacun de ces problèmes seront abordés lors de sessions qui se dérouleront dans le cadre de cette conférence.

Dans la mesure où les effets environnementaux ne s'arrêtent pas aux frontières de chaque pays, il est dans l'intérêt des États membres de l'Union européenne de conjuguer leurs efforts et leurs moyens afin d'évaluer et d'améliorer les connaissances et les stratégies communes pour protéger les biens culturels. Cela renforcera, en même temps, le consensus de l'Union européenne et la qualité de vie de ses citoyens. C'est pourquoi la Commission européenne gère et développe cette initiative RTD depuis 1986 dans ses programmes-cadres.

Je voudrais aussi souligner rapidement que la pluridisciplinarité est tout à fait indispensable au développement, présent et futur, de technologies de conservation du patrimoine culturel. Le secteur du bâtiment, les musées, les bibliothèques et les salles d'exposition associés aux autorités régionales comme le Conseil général du Bas Rhin ou la Mairie de Strasbourg peuvent à la fois être l'instigateur et le bénéficiaire de projets de recherche liés à la protection du patrimoine culturel.

Je vais conclure en vous donnant quelques pistes pour les appels à propositions qui, avec la bourse d'échanges d'après-demain, motivent votre présence ici. Il est important que vous sachiez qu'il n'y aura plus qu'un seul appel à propositions. Cet appel, ouvert depuis le 15 novembre, comporte deux échéances : le 15 février et le 15 octobre 2001. Je vous demande d'étudier attentivement l'agenda des travaux et le manuel d'évaluation, ainsi que d'autres informations que vous pourrez trouver sur CORDIS (Service communautaire d'information sur la recherche et le développement), car il y a eu pas mal de modifications. N'oubliez pas qu'au sein de l'Union européenne, la priorité est accordée à des projets de plus en plus importants. Nous attendons des projets avec de plus gros budgets ; vos contributions seront de l'ordre de 1,4 millions d'Euros. Telles sont les exigences de la Commission. Nous espérons développer synergie et valeur ajoutée européenne en privilégiant des projets plus importants. N'oubliez pas non plus de vérifier tous les autres détails communiqués, y compris ceux dont vous avez eu connaissance dans le rapport de consensus, et qui concernent les projets qui ont déjà été proposés.

Nous espérons que les participants à cette conférence seront nombreux à répondre à cet appel. Je leur souhaite chaleureusement la bienvenue. À ce propos, la bourse d'échange, organisée par le Relais Culture Europe, est apparemment un outil efficace pour aider les participants à faire de nouvelles propositions.

Je vous remercie tous encore pour votre présence, la préparation de cette conférence et vos contributions. Je souhaite que cette 4ème conférence soit un franc succès.

Christian PATERMANN, Director of the "environment and sustainable development" programme at the European Commission directorate-general for "Research"

Dear friends, colleagues, after Rome, Aachen and Santiago de Compostela, the 4th European Commission conference entitled "Research for protection, conservation and enhancement of cultural heritage : opportunities for European enterprises" is today being organised in Strasbourg. I would like to congratulate and thank the French Presidency of the European Union and the French Ministry of culture and communication for having the initiative to organise this conference in Strasbourg.

It gives us great pleasure to see the interest shown by France in the strengthening of a European dimension for research for the protection of heritage. I would like to personally thank those who have participated in the organisation of this conference and those who have agreed to present their work on this occasion. On behalf of the Commissioner for research, Mr. Philippe BUSQUIN, I would like to welcome all those participating in this conference, and in particular, those who come from European Union candidate countries.

Cultural heritage, monuments and works of art are of major importance for our fellow citizens, not only because they are the symbol of our common culture, but also because they represent, in terms of economic and technological development, job creation and quality of life of the citizens, the only potential of its kind in the world.

In order to illustrate my statement, I would like to present an overview of all the research activities for protection of cultural heritage that have been developed since 1986, thanks to our programme within the European Union. Up until now we have managed 80 research projects and funded more than 200 research institutes in the member States. Countries like Norway, Poland, Switzerland, Romania, the Czech Republic, Slovenia, Malta, etc. have also been associated with it. These projects include the protection of movable and immovable assets and extend to all materials and forms of works of art.

You know that the European Commission has presented, at the beginning of the year, the project of building a "European Research Area". This project has won acclaim for its debates on research policies in Europe. Its aim is to strengthen the consistency of research efforts made on a national and European scale. The next European Union research framework programme will therefore be widely restructured in its design and its implementation. We will go from a centralised approach to individual research projects towards a wider approach that is implemented by means of a consistent group of actions, within which the European Union's intervention will represent but one part of a wider scope. This is really about a concentration of efforts made on intervention themes which provide European added value and introduce forms of intervention that are of a more long term nature, mid-way between project support and institutional funding.

In the official text of the communication of the European Commission to the European Council about the European Research Area, under the chapter "Instruments and methods of intervention", several activities are proposed, covering areas such as Science, Society and Citizens. These activities are planned to be carried out further to the conclusions of the European Council in Lisbon of March 2000, to tailor research activities and policies more closely to the needs of society.

RTD activities concerning cultural heritage are explicitly mentioned in this chapter of the European Research Area document. The support for collaboration between museums and centres of scientific culture is considered one of the most relevant initiatives in the area of "Science and society dialogue", to bring together researchers, industry, policy makers and citizens. This acknowledges the fact that research for the protection of cultural heritage is a perfect bridge between social needs and the response of science and technology.

This Research Area has the unique and special characteristics that ensure a combination of basic research on the behaviour of materials facing environmental attacks, with technological developments such as technology transfer and innovation by producing new tools and instruments, to ensure the overall protection of those cultural heritage materials.

As an added value, social science and urban research are brought together in this Research Area so as to improve the know-how of decision-makers for planning and management of cultural goods and the importance of the cultural identity of our continent is underlined. I believe that this is of particular interest to all the newly associated States in Central and Eastern Europe who are going to join the European Union.

As far as basic research and technological development are concerned, Europe and the European research community are world leaders, due to a very well consolidated network of excellence in this area. The socio-economic and management aspects are developed so that each Member State establishes its own cultural heritage practices for conservation and preservation.

Research for the protection of cultural heritage is an example of co-operation between science, society and citizens, which is necessary for sustainable development, environmentally, economically and socially. We have to treat our cultural heritage in a way that will allow both our children and their children to enjoy it. It is also a sector that could be very appropriate for the application of the precautionary principle, as the protection of cultural heritage is also threatened by natural risks such as floods, earthquakes, forest fires and droughts. In the Commission's "Orientation paper", which is a very important basis for our 6th Framework Programme, both the precautionary principle and sustainable development hold a very important place.

Furthermore, this Research Area is of great concern for society and citizens of the European Union because it is linked to tourism, the largest industrial sector and this is frequently forgotten. Cultural tourism is one of the most important economic sources in Europe and is also a major employer. This vital sector of our economy is somewhat dependent on the conservation and protection of all aspects of cultural heritage.

Coming back to the subject of our conference, the interest of SMEs. This field of cultural heritage, comprising historical buildings, works of art and all kinds of materials and characteristics, is a very important area for us. There are many SMEs working in this field in each new Member State and we know that there are also very active specialised companies in this area in the candidate countries. One of the objectives of the European Research Area will be to strengthen the technological innovation capacities in the Union, and in particular, by supporting research for and in small and medium-sized companies. The main reason for this conference is to bring together the actors that can make possible these ambitious objectives. Our Commissioner, Mr Philippe BUSQUIN, in the Orientation paper approved on the 4th of October, said the following :
"In Lisbon the Heads of government affirmed the leading role of research in the knowledge-based society and for the competitiveness of industry in Europe. With this proposal the Commission started the process of making a reality of this Area. The measures that I am proposing should enable research in Europe to perform better on the world stage in particular with our partners in Asia and America."

This phrase is perfectly applicable to this Research Area as the European Commission now co-ordinates the biggest international initiative for which you are its scientific community and Asia and America will no doubt be its customers for tomorrow. There is an enormous potential for future work in this Area, and I think we should concentrate on this matter in a future meeting.

The objective of our work is the consolidation of a European scientific and technological basis for the establishment of measures and better practices for protecting, conserving and enhancing all aspects of cultural heritage, including both movable and immovable cultural assets and art objects.

Why has the European Union particular interest for research in this field ? We all know that environmental effects are at the origin of the damage of cultural assets. These environmental threats can arise from natural hazards like earthquakes, but the environmental effects damaging cultural heritage have

mostly a human induced origin, especially within the context of urban environmental damage. Threats to cultural assets, such as air pollution, traffic vibration, bio-deterioration, and microclimatic changes are caused by numerous factors, including visitors, the inappropriate use of technologies inside museums, the transport of works of art, the risk of graffiti, urban development, and last but not least, the risk of mass tourism. I am very pleased to say that each of these issues will be addressed during the parallel sessions of this conference.

Since all these environmental effects ignore geographical boundaries, it is in the interest of each of the Member States of the European Union to combine their efforts and resources, in evaluating and improving common knowledge and strategies for protecting cultural goods, while at the same time contributing to the cohesion of the Union and their citizens' quality of life. That's simply why the European Commission has been developing and co-ordinating this RTD initiative within the Framework Programmes since 1986.

Please allow me to stress, for a moment, the multidisciplinarity, which is so essential for the present and future development of the technology concerning cultural heritage protection. The construction sector, museums, libraries and galleries together with regional authorities such as the Conseil regional du Bas Rhin as well as local authorities such as la Mairie de Strasbourg can be both the source and the final user of research issues simultaneously related to the protection of cultural heritage.

Let me come to the end now and give you some practical hints for the new call for proposals, which is the reason for your being assembled here and for having the partner mediation event the day after tomorrow. It is important for you to know that we will only have one more call, but this call, which opened on the 15th of November, will have two deadlines, the first is on the 15th of February 2001 and the second is on the 15th of October 2001. Please look carefully at the work programme and the evaluation manual, also at all the other information we have given you on CORDIS because there are quite a few changes. Please bear in mind the current European Union trend for larger projects. We expect a minimum threshold of future projects with 1.4 million Euro contributions from your side. This illustrates the expectations of the Commission as we hope to get better synergies and a stronger European added value when the projects are larger. May I please remind you to have another look at all the other details, including those for the resubmission of projects where that is given in the consensus report ?

We are aware that there are many potential proposal makers for this call among participants of this conference and to them ; I also extend a very hearty welcome. With regards to this, the partner mediation event, organised by "Relais Culture Europe", appears to be a very appropriate instrument to help the participants in the preparation of new proposals.

I thank all of you again for gathering here, for preparing this conference and for contributing to it and I hope that this fourth conference will be a great success.

Parallel sessions
Sessions parallèles

Session A — How do we assess pollutant damage and achieve a balance between costs and benefits ?

Session A — Comment évaluer les dommages dus à la pollution et équilibrer coûts et bénéfices ?

Rapporteur : Peter BRIMBLECOMBE

Session A was about the assessment of pollution damage and balancing the costs and benefits of conservation approaches. One of the very important ideas that arose was the need to integrate and correlate environment and damage. How does environmental pollution and humidity interact and cause damage to cultural heritage ?

The next notion dealt with the idea of thresholds. This idea was more tenuous and perhaps more difficult to address. Most people felt there really were no thresholds to damage and that the first molecule from the atmosphere would actually damage the object. Others thought to identify operational thresholds. The latter would be identified as the point where the rate of damage decreased to such a small amount that natural damage, as it was called, became of equal importance.

The ideas used to evaluate thresholds resulted particularly from the acid rain arguments, where critical loads are a key method for assessing environmental damage. Such subjects as natural damage rate were presented. This can be thought of as the minimum rate of damage to heritage below which further reductions are impossible, the damage being inherent. However, such ideas were questioned by the audience. There was also concern about the existence of a linear relationship between dose and damage. The presentations enables us to contemplate this relationship, as other sorts of thresholds exist, for instance, thermodynamic thresholds, and additional issues that cause non-linearity such as in the shape of objects. Much of the work up to now has been done with very idealised surfaces. The kind of equation that was presented, giving the relationship between the acceptable rate of damage to background damage was as shown.

The first two presentations dealt with the very specific kinds of damage, that of damage to stone and mortars. These presentations looked at damage indicators and expansiveness, the idea of mortar exploding and of course increasing in size, thereby damaging the monument.

Two important minerals were mentioned. Gypsum, which when formed on the surface of a monument leads to an increase in size, and heteringite in concrete which acts in very much the same way. We were reminded that these transformations both result from sulphation, induced by the deposition of sulphur dioxide onto the surface. As sulphur dioxide is now very low in most cities, other mechanisms of damage should be investigated. However, the production of sulphates, hence the production of these minerals that are so degrading, is increased by the existence of catalysts on the surface of materials, despite low levels of sulphur dioxide. The intellectually interesting point here is that the minerals heteringite and gypsum are interesting indicators of damage.

We then heard a lot about interfacing the science with policy. The social science aspect and interfaces were very much part of the REACH project. This involved taking scientific observations of mechanisms into the policy arena. The type of interface that many of the later speakers included in their presentations was between mechanisms of damage and scientists, on one side and conservation policy, conservators and practitioners on the other side. There was general agreement that the area, interface and understanding of this interface between policy and science was still under development. The speakers were tentative about what sort of tools were available to explore and understand this interface. I now intend to list their statements and the tools seen to be available. This includes the speakers and also some of the early talks that were heard before the sessions started. The fact that sustainability could possibly be a tool for understanding this particular interface between science and policy was evoked. Economic arguments, subjects such as contingent evaluation and similar methods that are so difficult to understand for some scientists, are further tools. The concept of risk assessment follows and is being applied to conservation. Life cycle analysis, was suggested by one speaker, with the potential for understanding interface. The precautionary principle was discussed throughout the day as well as adapting such instruments as the United Nations human development indices into the cultural arena in order to explore policy developments of this kind.

Rapporteur : Peter BRIMBLECOMBE

Cette session était consacrée à l'évaluation des dégâts dûs à la pollution, ainsi qu'à la question de l'équilibre entre coûts et bénéfices des méthodes de conservation. L'une des idées les plus importantes évoquées était la nécessité de prendre en compte la relation entre l'environnement et la détérioration des œuvres. Comment la pollution et de l'humidité interagissent-elles pour engendrer des dégâts ?
Le débat a porté également sur les seuils, concept extrêmement subtil et délicat. La plupart des participants ne croyaient pas en l'existence de seuils en matière de dégradation, pour eux la première molécule venue de l'atmosphère détériore systématiquement l'objet. D'autres pensaient pouvoir distinguer les seuils à la limite des dégradations naturelles. Pour déterminer ces seuils, les pluies acides ont été prises comme exemple et le concept du taux de détérioration naturelle a été débattu. De telles idées n'ont cependant pas convaincu l'ensemble de l'assistance et l'une des préoccupations majeures est de vérifier s'il existe un rapport linéaire entre les quantités déposés et l'ampleur des détériorations. Cependant d'autres seuils, comme le seuil thermodynamique, existent ainsi que les facteurs entraînant une absence de linéarité comme la forme des objets. Une grande partie des travaux réalisés à ce jour ont pris pour modèle des surfaces trop idéales. Des équations ont été proposées, associant niveau de détérioration acceptable et dégradation.
Les deux premiers exposés présentés concernaient le domaine de la détérioration de la pierre et des mortiers et, plus précisément, les indicateurs de dégradation et le problème de l'expansion du mortier qui, en prenant du volume, endommage les monuments. Deux minéraux particulièrement importants ont été évoqués. Le gypse qui, lorsqu'il se forme à la surface d'un monument, entraîne une augmentation du volume et l'héteringite, qui produit un effet similaire sur le ciment. On a rappelé que ces transformations résultent toutes deux de la sulfatation due au dépôt du dioxyde de soufre à la surface. Il a été rappelé que le taux de dioxyde de soufre est actuellement relativement bas dans la plupart des villes et que d'autres mécanismes de dégradation doivent donc être pris en considération. Il est un fait que, bien que ce taux soit peu élevé, on trouve, à la surface de certains matériaux, des catalyseurs pouvant favoriser la production de sulfate qui accélère la production des minéraux les plus destructeurs. Il est cependant intéressant de noter que des minéraux tels que l'héteringite et le gypse, sont également des indicateurs utiles de dégradation.
L'interaction entre science et processus décisionnels représentait une part très importante du projet REACH. L'importance de l'intégration de l'observation scientifique des mécanismes de détérioration aux politiques de conservation a été soulignée, mais il a été reconnu que ce domaine est encore à l'état de développement. La plupart des participants ont énuméré les divers outils disponibles pour mieux explorer et comprendre cette relation. Le concept de développement durable pourrait ici favoriser le dialogue entre science et politique. L'évaluation contingente et d'autres méthodes apparentées ont été également citées ainsi que l'évaluation des risques, appliquée à la conservation et à l'analyse du cycle de vie. Il a été également question du principe de précaution. Il a été suggéré d'adapter des informations telles que contenues dans les indicateurs de développement des Nations Unies à la sphère culturelle comme aide à la décision.

Damage caused by SO_2 pollution on hydraulic mortars in ancient and modern monuments

Altérations des mortiers hydrauliques dans les monuments anciens et modernes dues à la pollution au dioxyde de soufre

Koenraad VAN BALEN[1], Cristina SABBIONI

Abstract

The damage caused by SO_2 on hydraulic mortars has been the focus of an EC Project "Environmental Deterioration of Ancient and Modern hydraulic Mortars" (EDAMM). A procedure has been set up to identify the type of binder used in historic hydraulic mortars. Sampling on ancient and modern monuments was performed to verify the set up methodology and to evaluate the deterioration due to environmental deposition. Since sulphation was the most important damage mechanisms found to occur, SO_2 exposure tests were performed on replicas of different hydraulic mortars. The formation of sulphur-containing species, such as gypsum, ettringite and thaumasite, has been studied in controlled conditions. The results obtained prove that the sulphation affecting hydraulic mortars is strongly influenced by the composition of the binder.

Résumé

Les dégâts causés par le SO_2 sur les mortiers hydrauliques ont constitué le thème central d'un projet européen intitulé "Détérioration Environnementale des Mortiers Hydrauliques Anciens et Modernes/Environmental Deterioration of Ancient and Modern hydraulic Mortars" (EDAMM). Une procédure a été mise en place afin d'identifier le type de liant utilisé dans les mortiers hydrauliques anciens. Des prélèvements ont été effectués sur des monuments anciens et modernes afin d'estimer la méthodologie existante et d'évaluer le rôle des dépôts extérieurs dans la détérioration. La sulfatation étant le plus destructeur des mécanismes connus, des tests d'exposition au SO_2 ont été faits sur des répliques de divers types de mortiers hydrauliques. La formation de plusieurs variétés minérales contenant du soufre tels que gypse, (éttringite ou thaumasite) a été étudiée en milieu contrôlé. Les résultats obtenus prouvent que la sulfatation affectant les mortiers hydrauliques est fortement influencée par la composition du liant.

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The Environmental damage to Ancient and Modern mortars (EDAMM) EC-project in which three European Research institutes[1] have been collaborating from Belgium, Spain and Italy aimed at contributing to a better understanding of the role of environmental pollution in the deterioration of ancient and modern hydraulic mortars (hydraulic lime, pozzolan and cement-based). New monuments, monuments built in the 19th and 20th century, were constructed with those type of hydraulic mortars. More and more of those monuments need restoration in all European countries. Similar hydraulic mortars have been widely used in restorations performed during the last and present century. The understanding of their durability is essential for the understanding of the need of further conservation treatments in the future on the built heritage.

Relevant results are presented on the research carried out on the identification of historic hydraulic mortars, on the evaluation of damage on samples taken from historic buildings and on the laboratory simulations carried out to investigate the damaging mechanism.

Ancient and modern hydraulic mortars

Since ancient times, materials of different origin have been added to the lime in order to obtain hydraulic mortars. "Hydraulic" refers in that context to two related properties :

- The capacity to harden also under water.
- The property of hardening when water is added to the dry binder.

A short historical overview :

In the 10th century BC, Phoenicians and the Israelites used hydraulic mortars to protect all hydraulic works (i.e. aqueducts, ports, tanks) ; the drinking-water reservoirs that King Solomon ordered to be built in Jerusalem were protected by hydraulic mortar obtained by mixing lime and crushed ceramics.

In antiquity the Greeks employed pozzolanic sand obtained from volcanic ash from the island of Santorini. Later the Romans developed the knowledge to fully understand the importance of pozzolan in hydraulic works and constructions exposed to atmospheric weathering. They utilized it regularly for hydraulic mortar preparation. They had discovered that the use of sand of volcanic origin (of the type present near Pozzuoli) to substitute ordinary sand in lime mortar, caused the mortar to become hydraulic.

The discovery of hydraulic lime, a special type of lime that, independent of the presence of pozzolan, has by itself the ability to harden under water, occurred only in the 16th century by an Italian architect, Andrea Palladio. Smeaton discovered the hydraulic reactions in 1756, while attempting to make a water resistant lime. From the chemical analysis of the limestone used for the production of natural hydraulic lime he decided that the presence of clay in limestone is the most important, if not the only, decisive factor for the hydraulicity. In 1812 Vicat proved that hydraulic properties were due to the burning together of limestone and clay.

The hydraulic lime represents the connecting link with the modern hydraulic binder developed in the mid-19th century : Portland cement. The use of cement spread rapidly at the end of the 19th century and in the present one has assumed its position of absolute predominance. Cement in various mixtures has therefore been used in great amounts for the construction of the buildings from the 19th and early 20th century of which many are considered nowadays “modern monuments”, the use of cement fitted well in the concept of “modernity”.

Mortar identification procedure

At the start of the project it became clear that a more precise analytical scheme had to be developed to identify the nature of the hydraulic binders in hydraulic mortars. Existing publications and most of the standards used for that purpose are based on the identification of cement, which implicitly considered relative proportions of its components and therefore falsify results from analysis on samples made from hydraulic lime or lime with pozzolana. In the conservation world a lot of attention has been given in the past to hydrated lime, or "pure" lime of which the analytical procedures have been demonstrated not to be applicable to hydraulic mortars.

The first step in the set-up procedure consists in the separation and in the study of the aggregate and the binder type. The basic operations to be performed consist, first, of a visual analysis. This operation aims in the general description of the unknown sample. A complete optical microscopy study is the following step. This is the basic technique of the set-up procedure, aiming in the identification of the aggregate and the study of the binder. Schematically, the steps in which the set-up methodology consists are illustrated in figure 1.

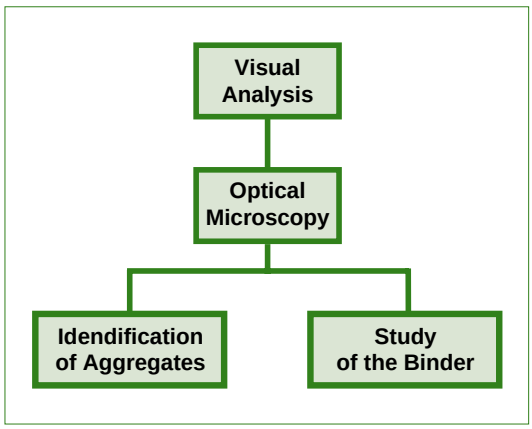

Figure 1 :
Procedure for mortar type identification.

The study of the binder is also based on a combination of the aforementioned operations. In this case, however, the optical microscopy results may be confirmed through the use of complementary techniques. In the set-up methodology, those are :

- X-ray diffraction.
- Chemical analysis involving (a) a pozzolanicity test or (b) the determination of the soluble silica within the sample.
- Thermo-gravimetric analysis (DTA/TGA).

The binder identification procedure is presented in figure 2. A first basic distinction permits the separation of lime mortars and hydraulic mortars. Indeed, if the sample is characterized by a carbonate matrix and the absence of minerals, such as pozzolan tracers (to be discussed further) or brick fragments, it can be concluded that it is a lime mortar. If this is not the case, then two cases are more likely to occur.

In the first case, the presence of a carbonate matrix as well as the presence of pozzolan tracers or brick fragments is assessed. It may be concluded, that the mortar is a pozzolan one. This conclusion should be confirmed. The most appropriate technique is considered to be X-ray diffraction analysis, which aims at highlighting the presence of pozzolan tracers. In case of doubt, as it will be further explained in detail, additional tests, named pozzolanicity tests, should be applied.

In the second case, the analysis concludes that the material either does not contain a carbonate matrix or it does not contain pozzolan tracers. If, however, belitic or

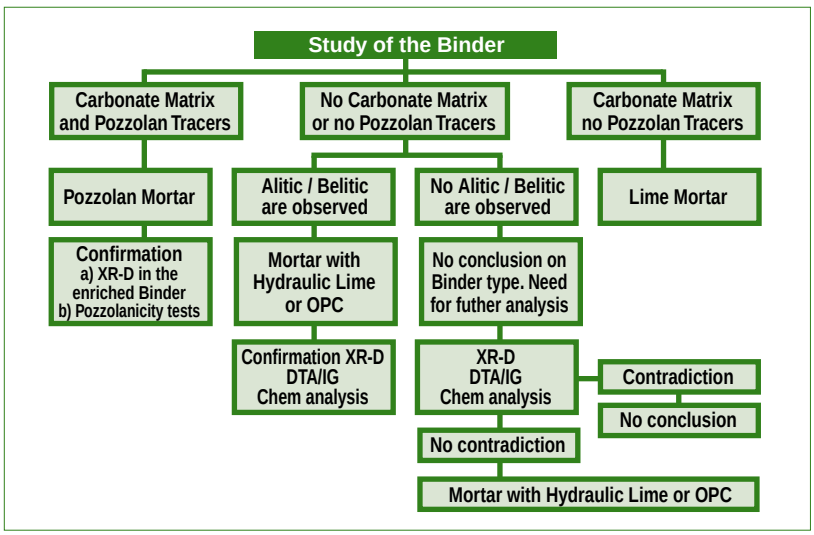

Figure 2 : *Flow-chart of the binder analysis procedure*

alitic areas are observed, then it may be concluded that the binder is hydraulic lime or Portland cement. As previously, this conclusion should be confirmed through one (or more) of the recommended techniques, such as X-ray diffraction, DTA/TGA and chemical analysis for the determination of soluble silica. Finally, if no alitic or belitic areas are detected, then no conclusions may be drawn ; further analyses are required and may be performed by the combination of the aforementioned techniques. If no contradictions between the results arise, then the conclusion is that the binder is hydraulic lime or portland cement. If, however, the results are contradictory, then no conclusion may be drawn. The application of the set-up procedure on various binder types is illustrated in the third paragraph of this chapter.
As it has already been mentioned, research has focused on the development and testing of two operational procedures. The first is part of the study of lime-pozzolan binders through pozzolanicity tests, whereas the second is related to the determination of soluble silica coming from a hydraulic reaction.

One of the most interesting findings is the identification of ß-C_2S as the major binder in hydraulic lime as is understood from literature but fails to be included in standardized procedures.

Historical buildings

Investigation of damaging mechanisms due to air pollution was executed on a number of buildings corresponding with the above mentioned types of heritage. Examples of those sites are the Cité Moderne (Brussels), the Saint Joris church (Antwerp), the Claudian aqueduct (Rome), the Minturnae aqueduct (Minturno, Latina) and the Parroquía nuestra Señora del Pilar (Spain). The following summarise the peculiarities of those sites.
A surface damage layer was found to be present in almost all the hydraulic mortars analysed, both pozzolan and cement based. All the hydraulic mortars sampled on ancient and modern monuments show that sulphation is the main damage process due to the effect of atmospheric deposition.
The presence of gypsum is otherwise attributed to the sulphation process occurring at the sample

1. Cité Moderne (Brussels)
- *Social housing*
- *1922-1925*
- *urban context (suburbs of Brussels)*
- *Samples :*

- plasters covering different types of masonry or type of concrete.

2. Saint Joris Church (Antwerp)
- *Church building*
- *Late gothic*
- *Repairs and maintenance works*
- *Urban area (Antwerp)*
- *Sample :*

- from cement (?) covering/joint at the back of the front façade ; wet and shaded environment.

3. Anio Novus Aqueduct (Rome)
- *Roman aqueduct, 38 A.D.*
- *Urban environment*
- *Sample :*

- Plastering mortar from base of the pillar.
- Supporting wall : stones, bricks and mortar.
- Condition: well preserved; black friable patina on the external surface.

4. Minsturnae Aqueduct (Minturno)
- *Roman aqueduct*
- *1st century B.C.*
- *Urban environment*
- *Sample :*

- Jointing mortar
- From pillar
- Supporting wall: stones and mortar
- *Condition : well preserved ; hard mortar with porous structure and coarse inclusions.*

5. Parroquia Nª Senora del Pilar (Spain)
- *Church*
- *Neo-gothic (1905-1907)*
- *Urban environment*
- *Sample :*

- Plaster
- From buttress
- Supporting wall : bricks
- *Condition : wall in good state; a little bit loosed.*

surface as a reaction between atmospheric sulphur compounds due to wet and dry deposition. Along with gypsum, also observed were carbonaceous particles, with their characteristic spongy morphology, which are emitted into the atmosphere by combustion processes. With their carbonaceous matrix, such particles act as catalysts in the oxidation of sulphur dioxide because of their heavy metal (Fe, V and Ni) content. They therefore enhance the sulphation process.
Furthermore, the samples presented small amounts of sulphite, a finding which confirms that sulphite is an intermediate product of the sulphation mechanism. Sulphation is in fact proved to take place due to the dry deposition of SO_2, which after hydration, oxidises into sulphate at the surface of the material. A crucial role in this process is played by the catalysts present in particles both due to atmospheric deposition (e.g. soot) and in the material itself. Thus, sulphate interacts with the carbonates and aluminosilicates found in the binding matrix of the mortars exposed to the polluted environment.
In addition, cement mortars revealed the presence of needle-like ettringite crystals, which were also observed underneath the external gypsum degradation layer. The amount of ettringite in the samples was found to be higher in the external part compared to the inner one, suggesting that its formation is due to the reaction between the gypsum originating from the mortar/pollutant (SO_2) interaction and the calcium aluminate hydrates of the binder.
In summary, air pollution on hydraulic mortars gives rise to the formation of two damage products : (1) gypsum as primary damage product, and (2) ettringite, as secondary one that is even more damaging than the first. This is because ettringite formation processes are in general highly expansive, leading to the destruction of the material.

No detailed investigation was known to have been performed on the "problem" of ettringite formation in cementitious materials used in buildings due to SO_2 pollution attack, with the ensuing formation of "environmental ettringite".

Laboratory tests

A systematic study was therefore carried out in the laboratory under controlled atmospheric conditions, with the aim of elucidating the mechanism of interaction between SO_2 and hydraulic mortars. Tests in a climatic chamber were performed on pastes, i.e. the single components of the binders, on mortars and, finally, sulphated mortars.
The paste specimens of synthetic hydrated Portland cement (HOPC) and its single components were exposed for a period of 6 and 12 months in air with 0.3 ppm SO_2 at 25 °C temperature and 95% relative humidity. Subsequently, both soluble sulphate (gypsum) and insoluble sulphate (ettringite) were measured on the exposed samples. According to the results obtained, the silicate paste had the lowest reactivity to SO_2, while calcium aluminate and cement pastes had the highest reactivity. Moreover ettringite was identified on the aluminate and cement pastes, a finding linked to their chemical composition. Calcium aluminate paste contains, in fact, the highest concentration of Al (i.e. 20%) ; when aluminates are present in the system, ettringite is formed, which captures the SO_4^{2-} ion from the solution and favours new dissolution of SO_2.
Exposure test on mortars were performed both on pozzolan and cement samples, under the same conditions as the paste samples. The cement samples show the highest reactivity to SO_2, clearly greater than the pozzolan ones. Ettringite needles were detected on the surface of the cement samples (both synthetic and ordinary Portland) at twelve months. This confirms that ettringite is derived from the reaction between sulphate forming in the chamber and the calcium carbonate and aluminate present in the samples.
The mortar tests revealed that the sulphation process is influenced by different parameters characterising the materials, such as the total porosity, which is well correlated with S compounds forming within the chamber, the chemical composition of the mortar (mainly aluminium content) and the presence of catalysts, particularly in the case of the natural pozzolan mortar. These results highlight the importance of compatibility among materials against SO_2.
Finally, tests were performed on already sulphated samples of hydraulic mortars, such as hydraulic lime, pozzolan and cement mortars. The samples had been previously sulphated at 300 ppm and then exposed at low temperature 5°C. One set of samples was exposed to SO_2 and the other without SO_2.
Thaumasite formation was observed on previously sulphated cement and hydraulic lime mortars exposed without SO_2, but was not found on the pozzolan mortar or on any of the samples exposed to SO_2 The formation of thaumasite seems to pass through the different stages : formation of ettringite, partial decomposition of ettringite, formation of solid solution ettringite-thaumasite and, finally, thaumasite formation.
The destructive effects of thaumasite has been evaluated in the laboratory and the formation of a soft pulpy mass was found to cause breakdown by expansion.

Conclusions

Briefly, the results obtained both on ancient and modern monuments and in laboratory tests show that :
1. The main effect of air pollution on hydraulic (cement and pozzolan) mortars is gypsum formation, measured also as soluble sulphate.
2. The presence of gypsum in hydraulic mortars produces two secondary damaging products ettringite and thaumasite, measured also as insoluble sulphate.
3. The formation of ettringite depends on the composition of the material (aluminium content).
4. SO_2 concentration and temperature are the atmospheric parameters controlling thaumasite formation.
In conclusion, among multipollutants, SO_2 is the main component of pollution producing damage on hydraulic mortars, which turn out to be the most sensitive building materials because of the formation of primary and secondary damage products. Although having important implications on the development of conservation strategies for monuments and historic buildings, this result is also of great relevance to the built environment as a whole.

Finally, since SO_2 concentrations in urban areas are chiefly due to local emissions, it is necessary to identify air quality threshold levels for a sustainable conservation of Cultural Heritage in European cities.

Acknowledgments

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Biography

Koenraad VAN BALEN – Engineer-architect (1979), Ph.D in engineering (1991) at the K.U.Leuven. After having worked as an architect, as a state employee at the service of monuments (Flanders) he returned to the K.U. Leuven for carrying out research on structural conservation and on historical building materials as lime mortar. He is actually professor at the department of Civil Engineering and at the Raymond LEMAIRE Center of Conservation at the K.U. Leuven. His main scientific interest is the preservation of historic structures and buildings and more particularly on ancient masonry structures. He has co-ordinated various national and European research projects. He is member of local and international monument preservation organizations and member of different scientific organizations dealing with his field of research.

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Ozone in Museums : an indoor problem

L'ozone dans les musées : un problème d'environnement intérieur

Franco DE SANTIS[1]

Abstract

The principal objective of this paper is to review the current state of knowledge and to assess the effectiveness and adequacy of the measures taken in addressing the critical needs of artworks exposed indoors. Indoor ozone levels represent a dynamic balance between the rate of ozone introduction into a building from outdoors versus ozone destruction by reaction at interior building surfaces. Higher outdoor air exchange rates increase the rate of introduction of ozone from outdoors and thereby raise indoor ozone levels. However, chemical reactions occurring indoors could be complex and could affect the distribution among indoor pollutants. In particular, having ozone and nitrogen dioxide in the same indoor settings can lead to the formation of nitric acid and other reactive secondary products at a rate markedly higher than that due to simple transport from outdoors.

Résumé

Ce document a pour but d'évaluer l'efficacité et le bien-fondé des mesures employées pour répondre aux problèmes essentiels des œuvres d'art exposées en intérieur, tout en examinant l'étendue des connaissances actuelles en la matière. Les niveaux d'ozone des lieux fermés représentent un équilibre dynamique entre le taux d'introduction d'ozone provenant de l'extérieur et la destruction de l'ozone en réaction aux surfaces intérieures du lieu. Des taux élevés d'échange d'air avec l'extérieur augmentent le taux d'introduction d'ozone et, par conséquent, le niveau intérieur. Néanmoins, les réactions chimiques se produisant à l'intérieur peuvent s'avérer complexes et avoir un effet sur la répartition des polluants. En particulier, la présence combinée d'ozone et de dioxyde d'azote en un même lieu fermé peut entraîner la formation d'acide nitrique ainsi que de diverses substances réactives secondaires à un taux nettement plus élevé que celui du simple échange d'air avec l'extérieur.

The issue

Photochemical air pollution, first identified in Los Angeles in the 1940s, is now a widespread phenomenon in many of the world's population centers (e.g. see PORG 1997; NRC 1991). The main primary pollutants in photochemical pollution are nitrogen oxide (NO) and volatile organic compounds (VOC), which are converted to secondary pollutants, such as ozone, nitrogen dioxide and other oxidation products as nitrous acid (HONO), HNO_3 and peroxyacetyl nitrate (PAN) (FINLAYSON-PITTS. & PITTS, 1986). Tropospheric ozone, the most important pollutant formed through photochemical air pollution, is a major pollutant produced by various sources, among them urban traffic through photochemical transformation of the above mentioned primary pollutants. The production of elevated levels of ozone at ground level is of particular concern since it is known to have adverse effects on human health, vegetation (e.g. crops) and materials (PORG, 1997). The relation between ozone and its two main precursors, nitrogen dioxides NOx ($NO + NO_2$) and VOC, represents one of the major scientific challenges associated with urban air pollution. It is generally known that for some conditions the process of ozone formation is controlled almost entirely by NOx and is largely independent of VOC, while for other conditions ozone production increases with increasing VOC and does not increase (or sometimes even decreases) with increasing NOx. The dependence of ozone production on the initial amounts of NOx and VOC is frequently represented by means of an ozone isopleth diagram (FINLAYSON-PITTS. & PITTS, 1986, pp. 611-618). From these diagrams it is apparent that an increase of NOx can lead to an increase of ozone up to a certain point beyond which there is a decrease again when NOx increases. This is in contrast to common sense but the reason for this behaviour is that the production of ozone is non linear and it is the result of many subsequent reactions.

Legislation and policy

The contrast between NOx sensitive and VOC sensitive regimes of air photochemical pollution illustrates the difficulties involved in developing policies to reduce ozone in polluted regions : ozone can be reduced only by reducing emissions of its precursors. Reduction of VOC will only be effective

if VOC sensitive chemistry predominates. Reduction in NOx will be effective in reducing ozone only if NOx sensitive chemistry predominates and may actually increase ozone in VOC sensitive regions. It should be noted that established air quality standards for ozone are frequently exceeded, and the formulation of control policies is therefore a major objective of environmental policy (UNECE, 1993). There are a number of questions regarding the strategy to tackle the problem of ozone. In the new Daughter Directive recently agreed at the European Council a two-level objective for ozone was established, with a target value for the year 2010 (25 exceedances of the 8 h maximum of 60 ppb per year) that takes into account considerations of practicability, feasibility and costs. To this target value, a "long term" objective value (corresponding to a situation of no exceedances) which is essentially based on consideration of the effect and impact of ozone on human health is added.

Can we reach this target value easily ? Or, we could say : how difficult will be to reach in Italy this target value (or even more) the long term objective ?

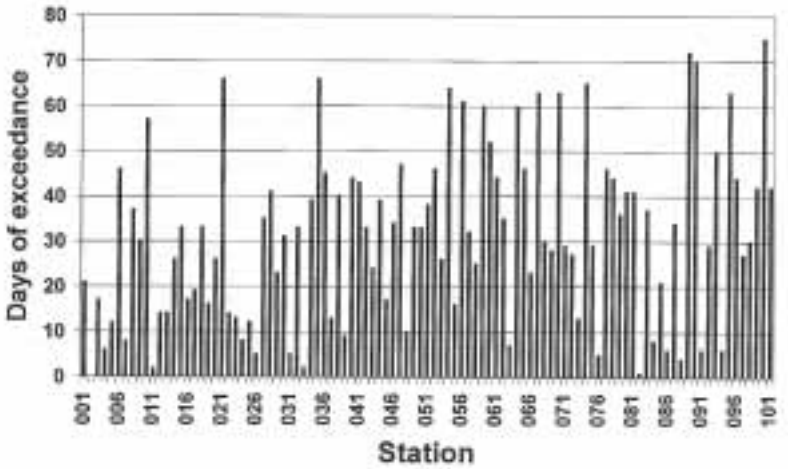

Figure 1 : *Exceedance of 60 ppb (average of 8 h) for 103 Italian Stations. Summer months of 1999.*

The situation of 103 Italian stations in the year 1999 is shown in figure 1. The figure clearly shows that, at present, many places in Italy - and similarly in other places in Europe - are in a very bad situation because they largely exceed the twenty-five exceedances allowed.

Ozone and artworks

Besides these general aspects of the tropospheric ozone issue, the question that I would address here is the following : does ozone constitute a hazard for delicate surfaces stored indoors ? Many studies carried out in the past several years suggest that it does, even at levels well below the current safety standards for humans and/or vegetation (e.g. THOMSON, 1986; SHAVER and al, 1983; CAMPBELL and al., 1974). A large number of pigments, including natural organic colorants are quite sensitive to ozone. In addition to ozone other oxidising gases are present in urban areas.

SHAVER and al. (1983) and SALMON and CASS (1993) have studied the fading of several colorants to ozone, NO_2 and HNO_3. The ozone induced fading of natural colorants typically affects chromophore yielding colourless reaction products. Pigments and dyes based upon the indigo family, the madder lakes and saffron, for example are especially susceptible to ozone damage. In contrast, the reaction with NO_2 and HNO_3 entails coloured species and a change of the colour and not a simple fading. Considering this potential for fading as well as the potential for ozone induced attack on organic materials such as cellulose, textiles and binders used in various paints, limits have been set on the indoor ozone concentrations in museums in galleries and archives. Recommended values are no higher than a few ppb with the most frequent recommendation of an average of 1 ppb (BAER and BANKS, 1985; BRIMBLECMBE, 1990)

Risk analysis and the issue of ozone threshold

It is important to stress that a perusal of the cited shows that scientific uncertainty makes precise risk analysis difficult to achieve. To make the solution of the problem even more difficult it has been shown that the impact of ozone on surfaces tends to vary according to whether or not other pollutants, such as nitrogen dioxide, are present (TIDBLAD and KUCERA, 1996), making it difficult to untangle which factor to blame. Even natural degradation factors can confuse the picture.

Although, no one doubts that high concentrations and/or deposition of ozone can damage the delicate surface of artworks a key question that we should ask is : at what point do these concentrations go from acceptable levels to dangerous levels ?

We must admit that our knowledge about the effects of ozone and other photochemical pollutants (such as nitric acid or OH radicals, see WESCHLER, 1996) on surfaces of interest for cultural heritage has grown considerably in the past two decades. However this knowledge remains fractional and limited in the key aspect of establishing a threshold level. Obviously, it would be naive in this case to make any evaluation of damage on the bases of simple concepts of technical and economic considerations. This approach is clearly inadequate if a threshold is to be set for a surface which, by definition, cannot be replaced.
Since it is not possible to identify no-effect thresholds for ozone and materials, a risk management approach to the definition of limit values should be adopted. This approach should attempt to identify the concentration at which effects on the surface as a whole is small (or of the same order) compared with the effect of such factors as natural weathering (i.e. the effects of meteorological parameters such as relative humidity, temperature when indoors and precipitation for a sensible material exposed outdoors).
An example in the field of vegetation damage can be of help to understand this approach.
Figure 2 shows a plot of macroscopic leaf injury of clover (as measured according a certain protocol) vs. ozone concentrations. The macroscopic leaf injury due to ozone concentrations ("damage" as y axis) is apparent only at ozone concentrations higher than about 35 ppb. In other words, the biological damage, or a functional relationship with ozone, is distinguishable only above a certain concentration. Obviously, the same cannot be true in the case of a surface and the threshold should be linked to "natural" weathering .

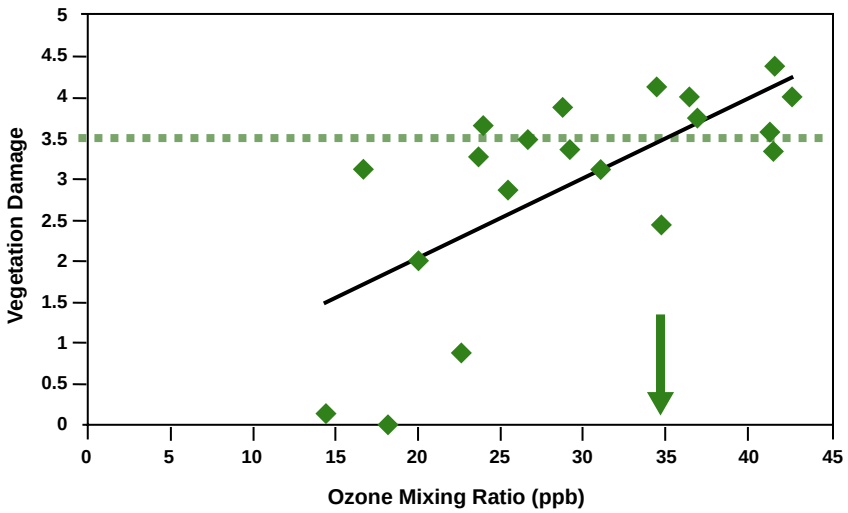

Figure 2 : *Damage of an ozone sensitive clone of clover vs. ozone concentration.*

As I already mentioned above, the European Council will adopt a new Directive on ozone. This Directive will establish procedures for harmonised monitoring of concentrations at European level, for exchange of information among member states for communication with the population and for optimising the action needed to reduce ozone pollution within the European Union. The threshold level considered for ozone in the document that was used in the preparation of the Directive (the so-called Position Paper, 1999) established for the protection of a generic surface a level of 20 ppb as yearly average. It is interesting to note that it is important to note that (on the basis of measurements done in seventy European rural stations of the EMEP network) the European marine background - that is the air advected from the Atlantic ocean - is about 30 ppb (Position Paper, 1999). This means that the masses of air that we as European have "at our disposal" - and to which we can only add a certain degree of higher pollution - contains 30 ppb of ozone. It is clear that the threshold indicated for ozone in the position paper (20 ppb) is not realistic and cannot be reached by any means at least in the foreseeable future.
Despite the fact that ozone is ubiquitous in the ambient atmosphere and indoor microenvironments where artworks can be potentially exposed, few data are available to understand the exposure to this species. This is perhaps due partly to the lack of a convenient method to measure the concentration of ozone indoors. What kind of instruments can be used indoors ? Conventional ozone measurement

methods are typically based on (a) ultraviolet absorption, (b) a chemiluminescence reaction with ethylene gas. The use of these analysers indoors is cumbersome and difficult due to problems with dimensions (size) and noise. It is easy to imagine what kind of difficulties entails to measure ozone (and other pollutants as we will see below) in a museum by using traditional analysers. Another important point is that a traditional instrumentation, due to its cost and complexity of use, can normally be deployed and used for monitoring only in one room of the museum.
It is, however, interesting to study the spatial variation of the air quality in different rooms and simpler measurement techniques for assessing air quality may offer a cost effective alternative to conventional techniques for large-scale measurements carried out for mapping the air quality distribution. This can be done by using a new type of passive samplers which has recently been developed at my Institute.
This simple, inexpensive passive sampler for ozone is shown in figure 3. The simplicity of design, ease of use, and low cost make the device particularly suitable for use in large scale surveys in Museums. In general, these passive samplers can be used as screening devices for those locations where no prior ozone monitoring has taken place and for mapping the air quality distribution on temporal and spatial scale.
The sampler consists of a circular vessel (1) with an absorption filter (4) treated with appropriate reagents to trap ozone.
Indoor and outdoor concentrations of photochemical pollutants and various trace species included nitrous and nitric acids were measured in the Uffizi Gallery, Florence by using conventional analysers and a denuder diffusion technique (ALLEGRINI and al., 1987). During the measurement period the indoor levels of ozone were typically 40% - 60% of those outdoors (see figure 3, DE SANTIS and al. 1992).
A more recent study also based on conventional analysers and denuders for measuring nitrous and nitric acids has shown that chemical reactions occurring indoors are complex and can affect the distribution among indoor pollutants (DE SANTIS et al. 1999). The application of a single-box model suggests that one might expect a substantial contribution of the reaction of NO_2 and O_3 to the HNO_3 indoor level and that isoprene, a body effluent, could generate OH radical, by reaction with ozone, at a rate comparable to penetration from outdoors.

Figure 3 : *Exploded view of the passive ozone monitor ANALYST®*

It has also been suggested (WESCHLER and al., 1992) that in indoor environments significant concentrations of nitrate radical can result from the reaction between O_3 and NO_2. The nitrate radical is able to rapidly equilibrate with N_2O_5 (formed from the reaction $NO_2 + NO_3$) and both species can further reacts with water and volatile organic compounds to produce HNO_3. It is well known that this chemistry occurs outdoors at night (Willard Richards, 1983). During daylight hours, the same reactions are relatively unimportant outdoors because the nitrate radical is photolitically unstable. However, in indoor environments, with the absence of direct sunlight, conditions may be rather similar to those that occur outdoors at night.
On the basis of the relatively high concentrations of indoor ozone, we have evaluated the possibility that indoor chemistry can generate hydroxyl radicals (WESCHLER and al., 1996) in the Uffizi Gallery. In this regard, it should be stressed that reactions among indoor pollutants can produce products that, otherwise, might not be present in an indoor environment. In fact, many of these reactions depend directly or indirectly on the presence of ozone i.e. on outdoor-to-indoor transport (considering that there are no indoor sources in the Gallery).
When indoor O_3 is 20 ppb and indoor NO_2 is 40 ppb (majority of mid-afternoon periods) the reaction sequence mentioned above which involves NO_3 radical and N_2O_5 has the potential to generate 2.2 ppb h-1 of HNO_3.

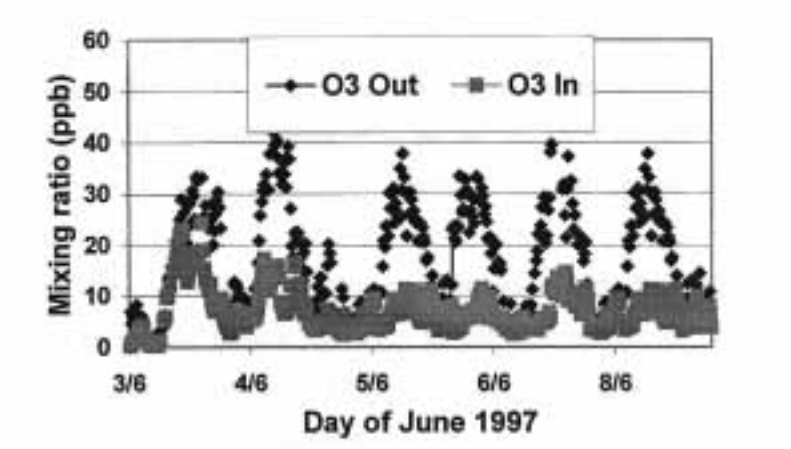

Figure 4 : *Diurnal variations in the indoor and outdoor ozone mixing ratios in the Uffizi Gallery, Florence, 3-9 June 1997.*

Assuming steady-state conditions we calculate a contribution of reaction $O_3 + NO_2$ to indoor nitric acid of about 0.5 ppb which is comparable with the concentration level measured.

Conclusions

When we look at the risks to delicate surfaces, those posed by indoor air pollution by ozone and other photochemical pollutants appear of the same importance or higher than the risks posed by other environmental problem such as temperature and relative humidity. Chemical reactions occurring indoors could be complex and could affect the distribution among indoor pollutants. Conventionally, indoor pollutants are considered either to be derived from outdoors or to be emitted directly from indoor sources. Sinks for indoor pollutants are also simply considered to be deposited onto indoor surfaces and removal with exfiltrating air. The results from various sources indicate that the conventional view is simplistic compared to the real situation. In particular, having ozone and nitrogen dioxide in the same indoor settings can lead to the formation of nitric acid and other reactive secondary products at a rate markedly higher than that due to simple transport from outdoors. Even though it may be argued that indoor concentrations for most of these compounds is fairly low, it is also true that the information on the corrosive properties for some of them is very scarce and also that even a low level of corrosion is unacceptable for the delicate surfaces of paintings housed in the gallery.

Artist's pigments are applied in the presence of binders, ranging from light gum base in the case of watercolours, to acrylic or linseed oil bases in the case of thicker preparations. Whether these binders form a protective layer over the pigment particles or alternatively absorb ozone by increasing contact should be investigated.

Indoor ozone levels represent a dynamic balance between the rate of ozone introduction into a building from outdoors versus ozone destruction by reaction at interior building surfaces. Higher outdoor air exchange rates increase the rate of introduction of ozone from outdoors and thereby raise indoor ozone levels.

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Biography

Dr. Franco De SANTIS graduated cum laude in Chemistry from the Rome University in 1971. After having worked as a research analytical chemist at the R&D of a leading chemical Company based in Milan, he joined (Sept. 1982) the Institute for Atmospheric Pollution of the National Research Council (IIA - CNR) of Italy. He has conducted research in a variety of air pollution-related areas, most notably development of diffusion based technique for sampling of reactive non criteria pollutants. He has a long experience in basic and applied research. In particular has gained many years of experience in laboratory studies on deposition of pollutants on surfaces of cultural interest, field experiments for the determination of criteria and non-criteria pollutants and modelling studies especially in the field of urban pollution. He has successfully participated in several EU Projects.

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Dose-response functions as a basis for assessment of acceptable levels

Fonctions dose-réponse comme base pour l'évaluation de seuils acceptables

Vladimir KUCERA[1]

Abstract

Air pollutants in combination with climatic parameters accelerate the corrosion and deterioration of many materials. Dose-response functions separating the effects of dry and wet deposited pollutants have been developed within the UN ECE Convention on Long-Range Transboundary Air Pollution. These functions can be used for assessment of acceptable pollution levels, for mapping of areas with elevated rates of corrosion and for cost-benefit analysis at different pollution scenarios. The ultimate goal is to apply dose-response for derivation of threshold pollution levels for materials in the multipollutant situation and to include them in the EC Air Quality Directives for protection of areas with important objects of European cultural heritage.

Résumé

Les polluants de l´air en combinaison avec des paramètres climatiques accélèrent la corrosion et la dégradation de beaucoup de matériaux. Des fonctions dose-réponse séparant les effets des polluants des dépôts secs et humides ont été développées dans le cadre de la Convention UN ECE sur la pollution atmosphérique transfrontalière à longue distance. Ces fonctions peuvent être utilisées pour la prédiction de seuils acceptables, pour la détermination de zones à corrosion élevée et pour l´analyse des coûts associés à la pollution atmosphérique. Le but final est d´appliquer les fonctions dose-réponse à la définition de limites de pollution acceptable pour les matériaux dans le cadre d´une situation multi-polluants ; ceci afin de les inclure dans les directives de la qualité de l'air de la Commission européenne pour la protection de zones comportant un grand nombre d'objets figurant au patrimoine culturel européen.

Air pollutants emitted at combustion of fossil fuels have since a long time been acknowledged as responsible for increased atmospheric corrosion of several metallic and non-metallic materials. An important task in the preservation of the European cultural heritage is the quantification of the effects of air pollutants. This knowledge is essential for the efforts to reach a balance between costs and benefits in the strategies for reduction of pollution. In this process the dose-response (DR) functions play a central role. This presentation will illustrate how the DR functions are obtained and how they can be used, based primarily on the activity of the UN ECE International co-operative programme on effects on materials (ICP Materials) within the Convention on Long-Range Transboundary Air Pollution.

Effect of pollutants in the multi-pollutant situation

The decreasing sulphur dioxide levels in most parts of Europe and the increasing car traffic causing elevated levels of nitrogen compounds, ozone and particulates has created a new multi-pollutant situation. This has been acknowledged i.a. in the activities within the UN ECE Convention on long-range transboundary air pollution (CLRTAP), where a multi-pollutant, multi-effect protocol has recently been adopted. This changed pollution situation must be taken into account in the development of an improved model for the effects of pollutants on the deterioration of important material groups.

There are many parameters that can influence the damage to materials in the atmosphere, it is an interplay between chemical, physical and biological parameters. This presentation will focus on the aspects specific to the urban situation, i.e., man-made pollutants and their interplay with natural climatic factors. It is, however, important to recognise that corrosion is a process that occurs even in the absence of pollutants and it is important to quantify to which extent urban conditions affects and accelerates the "natural" or background corrosion of materials.

Sulphur and nitrogen compounds including secondary pollutants and particulates are the most important pollutants acting as corrosive agents. Systematic laboratory exposures in the 1930's

demonstrated the corrosive effect of SO_2 on metals. This was later also proved by field exposures and SO_2 was for a long time considered to be the main corrosive pollutant.

In the last decade a synergistic corrosive effect of sulphur dioxide and nitrogen dioxide and later also of sulphur dioxide and ozone has been discovered. With decreasing levels, SO_2 is no longer regarded as the only important corrosion stimulator. Instead, its effect in combination with other gaseous pollutants such as NO_2, O_3, and their reaction products needs to be considered. A multi-pollutant situation has arisen where also two other pollutants deserve special attention, nitric acid and particles. They are both potentially harmful to materials used in objects of cultural heritage and they are both less studied than other pollutants in the field of atmospheric corrosion.

In contrast to SO_2, the effects of O_3 and N compounds are not well documented and in particular the total effects of car traffic. This is especially true for nitric acid (HNO_3), a secondary pollutant formed by the oxidation of NO_2. HNO_3 can reach appreciable concentration levels in urban areas – reports usually are in the interval 1-7 $\leq$ g/m^3 but in some cases the concentration can be above 10 $\leq$ g/m^3. HNO_3 is a strong acid with a high deposition velocity that is relatively independent of the relative humidity, which makes it relatively more harmful for dry and warm climates. Another effect of HNO_3 formation is that acidity of precipitation is significantly increased. The magnitude of its effect relative to other pollutants such as SO_2 is so far not investigated for most materials.

Particles can damage materials both by enhancing the rate of degradation and by soiling. Anthropogenic particles can be divided into primary and secondary. The primary particles which are directly emitted from combustion, have a relatively short life span and deposit near the source. Secondary particles are smaller, less than two micrometers, long-lived, and are the result of chemical reactions amongst other pollutants i.a. SO_2, NO_2, volatile organic compounds and ammonia. The effect of particles on corrosion can be either direct or indirect. Particles containing NH_4NO_3, $(NH_4)_2SO_4$ and NH_4HSO_4 play an important role in atmospheric corrosion related to their ability to increase the time of wetness due to their hygroscopic properties. In addition to the prolonging of the time of wetness, ionic particles enhance the corrosion by providing or adsorbing corrosion stimulators. Particles may in some cases also decrease the corrosion rate if they are basic by neutralising the surface water film formed on the degraded material. Inert particles can reduce the active surface of the corroding material and individual particles may initiate nucleation of corrosion products.

Quantification of effects – dose-response functions

A DR function is an equation which express the corrosion attack as a function of environmental parameters. For unsheltered positions the materials damage is usually discussed in terms of dry and wet deposition. Wet deposition includes transport by means of precipitation and dry deposition transport by any other process. One important task is to estimate the relative contribution of dry and wet deposition to the degradation of materials. Therefore, and also because it makes sense from a mechanistic point of view, DR functions have been developed where the corrosion attack, K, is described in terms of dry and wet deposition effects separated as additive terms

$$K = K_{dry}(SO_2, NO_2, O_3, Rh, T) + K_{wet}(Rain, H^+)$$

The dry deposition term is presently quantified in terms of the parameters SO_2, NO_2, O_3, relative humidity and temperature whereas the wet deposition in terms of total amount of precipitation and precipitation acidity.

UN ECE ICP materials

ICP Materials is one of several effect oriented International Co-operative Programmes (ICPs) within the United Nations Economic Commission for Europe (UN ECE). Early in the discussions on the Convention on Long-range Transboundary Air Pollution (CLRTAP) it was recognised that a good understanding of the harmful effects of air pollution was a prerequisite for reaching agreement on effective pollution control. Consequently an extensive field exposure programme was started in September 1987. It involved thirty-nine exposure sites in twelve European coun-

tries and in the United States and Canada. A task Force is organising the programme (ICP Materials) with Sweden as lead country and the Swedish Corrosion Institute serving as the main research centre. Sub-centres in the Czech Republic, Germany, Norway, United Kingdom, Sweden and Austria have been responsible for evaluation of individual groups of materials including structural metals, stone materials, paint coatings, electric contact materials, glass and polymer materials. The aim of the programme was to perform a quantitative evaluation of the effects of sulphur pollutants in combination with NOx and other pollutants as well as climatic parameters on the atmospheric corrosion of important materials. This was achieved by measuring gaseous pollutants, precipitation and climatic parameters at or nearby each test site and by evaluating the corrosion effects on the materials. ICP Materials is an on-going research activity. A finalised part, however, is the extensive 8-year field exposure programme that was started in September 1987 and the results presented here are based on this 8-year programme. For further details on this programme see ref. 1.

Dose-response functions for unsheltered materials

A list of all dose-response functions obtained within ICP Materials, including temperature functions, for exposure of unsheltered materials is given in Table 1. A detailed discussion on the individual groups of materials can be found elsewhere (2). In addition functions have been obtained for weathering steel, zinc, copper, bronze, nickel, tin and glass M1 representative of medieval stained glass windows exposed in sheltered positions (1).

Table 1 : *List of dose-response functions, including temperature function, for unsheltered materials. The corrosion attack is expressed as mass loss (ML in g m-2) for metals, surface recession (R in µm) for stone materials, ASTM D 1150-55 rankings (1 to 10 where 10 means a fresh sample and 1 a completely degraded) for paint coatings or depth of leached layer (LL in nm) for glass. The environmental parameters included are expressed as annual mean averages and are time in years (t), temperature in °C (T), relative humidity in % (Rh), SO2, NO2 and O3 concentration in µg m-3, amount of precipitation in mm (Rain) and H+ and Cl- concentration of precipitation in mg l-1.*

Material (N=number of observations, R^2 = explained variability) Dose-response function Temperature function
Weathering steel (N=148, R^2=0.68) $ML = 34[SO2]^{0.33}\exp\{0.020Rh + f_{Ws}(T)\}t^{0.33}$ $f_{Ws}(T) = 0.059(T-10)$ when $T \leq 10°C$, $-0.036(T-10)$ otherwise
Zinc (N=98, R^2=0.84) $ML = 1.4[SO_2]^{0.22}\exp\{0.018Rh + f_{Zn(}T)\}t^{0.85} + 0.029Rain[H^+]t$ $f_{Zn}(T) = 0.062(T-10)$ when $T \leq 10°C$, $-0.021(T-10)$ otherwise
Aluminium (N=106, R^2=0.74) $ML = 0.0021[SO_2]^{0.23}Rh{\cdot}\exp\{f_{Al}(T)\}t^{1.2} + 0.000023Rain[Cl^-]t$ $f_{Al}(T) = 0.031(T-10)$ when $T \leq 10°C$, $-0.061(T-10)$ otherwise
Copper (N=95, R^2=0.73) $ML = 0.0027[SO_2]^{0.32}[O_3]^{0.79}Rh{\cdot}\exp\{f_{Cu}(T)\}t^{0.78} + 0.050Rain[H^+]t^{0.89}$ $f_{Cu}(T) = 0.083(T-10)$ when $T \leq 10°C$, $-0.032(T-10)$ otherwise
Cast Bronze (N=144, R^2=0.81) $ML = 0.026[SO_2]^{0.44}Rh{\cdot}\exp\{f_{Br}(T)\}t^{0.86} + 0.029Rain[H^+]t^{0.76} + 0.00043Rain[Cl^-]t^{0.76}$ $f_{Br}(T) = 0.060(T-11)$ when $T \leq 11°C$, $-0.067(T-11)$ otherwise
Portland limestone (N=100, R^2=0.88) $R = 2.7[SO_2]^{0.48}\exp\{f_{Pl}(T)\}t^{0.96} + 0.019Rain[H^+]t^{0.96}$ $f_{Pl}(T) = -0.018T$

White Mansfield sandstone (N=101, R^2=0.86)
$R = 2.0[SO_2]^{0.52}\exp\{f_{Ms}(T)\}t^{0.91} + 0.028Rain[H+]t0.^{91}$
$f_{Ms}(T) = 0$ when $T \leq 10°C$, $-0.013(T-10)$ otherwise

Coil coated galvanised steel with alkyd melamine (N=138, R^2=0.73)
$(10\text{-}ASTM) = (0.0084[SO_2] + 0.015Rh + f_{cc}(T))t^{0.43} + 0.00082Rain \cdot t^{0.43}$
$f_{cc}(T) = 0.040(T-10)$ when $T \leq 10°C$, $- 0.064(T-10)$ otherwise

Steel panels with alkyd (N=139, R^2=0.68)
$(10\text{-}ASTM) = (0.033[SO_2] + 0.013Rh + f_{sp}(T))t^{0.41} + 0.0013Rain[H^+]t^{0.41}$
$f_{sp}(T) = 0.015(T-11)$ when $T \leq 11°C$, $- 0.15(T-11)$ otherwise

Glass M1 representative of medieval stained glass windows (N=46, R^2=0.56)
$LL = 0.013[SO_2]^{0.49}Rh^{2.8}t$

Use of dose-response functions

The ICP Materials dose-response functions are at present the best available functions to apply for mapping procedures and for calculation of costs of damage on both national and European scales. Mapping of corrosion attack and of exceedances of acceptable levels at a national scale is possible using environmental parameters obtained from national and international meteorological centres, international organisations (e.g. WHO), international research and monitoring programmes (e.g. EMEP) or national organisations or authorities responsible for environmental protection. This has already been carried out at scales varying between 50 km and 1 km squares. The mapping procedure can be an important tool for identifying areas with elevated risk of corrosion and for selection of materials to be used in a particular area. Stock-at-risk data are an essential part of any estimate of the extent of damage to materials and the associated costs, and the potential benefits of pollution abatement. In the future, effort needs to be concentrated on the collection of data on the geographical distribution and quantity (stock) of the materials at risk which applies especially for objects of cultural heritage.

Acceptable levels of pollution

Atmospheric corrosion and deterioration of materials is a cumulative, irreversible process which proceeds even in the absence of pollutants. The critical loads/level approach used for the effects of acid deposition on ecosystems has to be modified in relation to degradation of materials as even the lowest concentration of pollutants causes an increase in the deterioration rate. This leads to the well-established concept of acceptable corrosion rates and pollution levels defined in the UN ECE Convention on Long-Range Transboundary Air Pollution report "Manual on methodologies for mapping critical loads/levels" (3).

The acceptable corrosion rate is determined by technical and economic considerations based on the specific application of a material. For model calculations, however, and for the purpose of comparing different materials with respect to their pollution sensitivity, different levels of acceptance can be defined by relating the corrosion rate to corrosion rates in areas with 'background' pollution. It has proven to be useful to define a dimension less number, n

$$n = K_{acc} / K_b$$

Where Kacc is the acceptable corrosion rate and Kb is the background corrosion rate. The use of a specified acceptable corrosion rate in the dose-response function implicitly describes an acceptable (acc) multi-pollutant situation :

$$K_{acc} = K_{dry}(SO_{2,acc}, N_{O2,acc}, O_{3,acc}, Rh, T) + K_{wet}(Rain, H^+_{acc})$$

It is possible to reach an acceptable situation from an unacceptable in several ways and there is, consequently, not possible to derive threshold levels directly and uniquely. It is, however, possible

to assess different scenarios based on reasonable assumptions and to analyse the results of the assessments together with a sensitivity analysis in order to propose reasonable threshold levels for most important pollutants for special areas containing objects of cultural heritage, taking into account existing directives for threshold levels in general. For example, consider the equation for copper given previously. If an acceptable ML value is specified and it is assumed that O_3 and pH levels will be constant, then it is possible to calculate an acceptable SO_2 level as

$$[SO_2]_{acc} = [\ (ML - 0.050Rain[H^+]t^{0.89})/(0.0027[O_3]0.79Rh\cdot\exp\{f(T)\}t^{0.78})\ ]^{1/0.32}$$

In this way the synergistic effect of SO_2 and O_3 can be assessed in the multipollutant situation. The acceptable levels of SO_2 for some materials and n values using this concept are given in Table 2.

	n = 1.5	n = 2.0
Weathering Steel	5	45
Zinc	12	49
Aluminium	10	39
Copper	7	33
Bronze	5	12
Limestone	7	12

Table 2 : *Acceptable levels of SO_2 in µg/m³ calculated from UN ECE ICP Materials dose-response functions*

Present state and need for future action

The development of dose-response relations, which quantify the effects of pollutants in combination with climatic parameters on the deterioration and soiling of different materials in the multi-pollutant situation, constitutes a necessary condition for prediction of damage and for establishment of threshold levels. The results of this highly innovative research which is performed as a combined effort of the UN ECE LRTAP Convention and the research activities within EU 5FP are planed to be fed into air quality policy for the next decades. A comparison of threshold pollution levels for human health and for ecosystems in the EU Air Quality Directive, see Table 3, with the accepted pollution levels for materials shows that materials are more sensitive to air pollution than people, animals and vegetation.

	SO_2	NO_2	PM10
Urban zones - health effects			
Hourly limit value	350	200	
Daily limit value	125		50
Annual limit value		40	40
Rural areas - ecosystems			
Annual limit value	20	30	

Table 3 : *Limit values of pollutants, µg/m³, in Air Quality Directive 99/30/EC (4).*

Highlights the need to obtain well-established pollution thresholds for effects on materials and to incorporate them into the EU Directives on urban air quality. This would be an efficient tool for authorities, organisations and individuals responsible for the care of cultural heritage in the efforts to preserve objects of cultural heritage and to reduce the cost for maintenance. It could be mentioned in this connection that steps in this direction have already been taken in individual member countries as illustrated by the environmental targets for pollution levels in Sweden, Tab.4, p.50)

Conclusions

The following main conclusions can be listed.

- UN ECE dose-response functions permit the quantification and separation of the effect of dry and

Pollutant	Target concentration annual value, µg/m³	Implementation date
Gases		
NO_2	20	2010
SO_2	5	2005
O_3	50*	2020
Particulates		
PM 10 (health)	15	2020
Soot (materials)	10	2020
** March to October*		

Table 4 : *Environmental targets for pollution levels in Sweden (5).*

wet deposition of pollutants. They include primarily the SO_2 levels and rain acidity, which have the dominating pollutants in the past.

- The research is now directed to development of dose-response functions describing the multi-pollutant situation with decreasing levels of SO_2, taking into account synergistic effects with NO2 and O_3 and including the effect of particulates and HNO_3.
- The dose-response functions developed are suitable for mapping, for cost-benefit analysis and for planning of abatement strategies using the concept of acceptable levels of corrosion attack and of pollution levels.
- One of the ultimate goals is the inclusion of threshold pollution for materials for protection of important objects of cultural heritage in the EC Air Quality Directives, which would greatly strengthen the efforts to safeguard the European cultural heritage.

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Biography

Graduated in 1960 at the Chemical-Technical University in Prague, where also obtained the Ph.D. degree in Corrosion science in 1966. Spent a post-doc year at the Royal Institute of Technology in Stockholm. Since 1969 at the Swedish Corrosion Institute as scientist, as director of research and since 1999 as deputy managing director. Special research interest in the field of atmospheric corrosion and effects of acidification on technical materials and objects of cultural heritage. Chairman of UN ECE ICP Materials since 1985, responsible for several international projects, co-ordinator and participant in projects and activities within EU DG Research and DG Environment. Organiser of national and international congresses and workshops. Author of numerous scientific and technical publications and reports.

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Case study - Contribution to the REACH project : reconstruction and restoration of the Municipal House of Prague

Etude de cas - Contribution au projet REACH : reconstruction et restauration de la Maison Municipale de Prague

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Abstract

Case studies represent a specific contribution for the research team and for output users. Structure and cost of maintenance work and expected or actual economical benefits controls the restoration process and help for understanding by users or protection authorities. Six case studies for different types of monuments were elaborated within the task, case study for the Municipal House of Prague represents a case for a demanding general reconstruction with a positive economical balance.

Résumé

Les études de cas constituent une contribution particulière pour l'équipe de recherche et les utilisateurs finaux. Ce sont la structure et le coût de la maintenance ainsi que les bénéfices économiques réels ou escomptés qui contrôlent le processus de restauration et permettent aux utilisateurs et aux autorités responsables de la protection de mieux comprendre le problème. Six études de cas ont été faites sur différents types de bâtiments. L'étude concernant la Maison Municipale de Prague offre un exemple de reconstruction générale difficile et de balance économique positive.

Case studies are individual results of solutions, which represent a specific contribution for the solution team during the research and for output users afterwards. A targeted analysis related to degradation by the present and historical environment, structure and cost of maintenance work, and expected and actual economical benefits of a specific restored monument stimulates and controls the solution process. Results help for understanding and use of the proposed solution model by users of various categories (owners or operators of an object, regional administration, historical protection authorities).

Six studies were elaborated within the task. They were chosen to cover geographical, environmental and type aspects equally, as well as political and economical context.

The studies involve both important monuments - solitaires (cathedrals, the Municipal House) and groups of historically valuable residential houses, forming a part of cultural heritage in various geographical and economical conditions (Oslo, Prague, Telc). They also involve a monument, which is not a construction object - rock carvings - specific by its age, form and manner of protection and use.

The results will be documented by example of case study worked out in the Czech Republic.

The Municipal House - Monument and his history, location and present use

Prague Municipal House is a national cultural monument listed on the list of historically protected objects of the Ministry of Culture of the Czech Republic. It was built between 1905 and 1912 at the place of nowadays Square of Republic (namesti Republiky), in the vicinity of gothic tower Power tower (Prasna brana) from the funds of the Prague City Authority. This locality of Prague was of a big importance to the Czech national history.
The construction was started in autumn 1905. A unique piece of work was created during the following six years, bearing contributions of not only architects, but also several generations of Czech artists, namely painters and sculptors. So this prestigious order brought together artists as e.g. ALES, ZENISEK, PREISLER, SPILAR, MARATKA and also MUCHA, who lived abroad. The house is an example of secession architecture (architects Antonin BALSANEK, Osvald POLIVKA), but with some disunity of styles.

Figure 1 : *The Municipal House of Prague*

Basic data on the building

Total built-up area	4,214 m^2
Total built-around space	158,500 m^3

Since its opening in 1912 the Municipal House became an important cultural center of the capital city, but also a place for important political meetings.

The period of World War II, as well as the period of the communist administration, represented a great decadence for this remarkable building. In the period of fascist occupation various decorations and original wallpapers were painted over with a green and brown paint, and the movables and lights were changed. The communist regime further devastated the cultural level of the building in many aspects. There was no actual maintenance or investments into renewal.

The building survived in this manner until 1989, when the newly formed democratic state admitted responsibility for the cultural monument, tradition and importance which belongs to the Municipal House.

The Municipal House is owned by the City of Prague. A specific thing about the Municipal House is that historical protection and maintenance is carried out in demanding conditions of an open-access building, which offers besides exhibition and concert spaces also spaces for conferences, restaurants and others.

Pollution situation

Prague, especially its center, is the most polluted area in the Czech Republic. The level of atmospheric pollution by classical pollutants (SO_2, NO_x, CO, solid particles, CO_2) culminated in the Czech Republic in the mid 80's. Since then the total amount of pollutants in the atmosphere has a decreasing tendency. During 90´s the pollution of atmosphere slowly decreased. In 1997 the relatively highest pollution by sulfur dioxide - above 30 µg/m^3 - and of nitrogen oxides - about 90 µg/m^3 - were recorded in the center of Prague. Dust fallout is an important deterioration factor of the center of Prague (120 µg/m^3 of SPM).

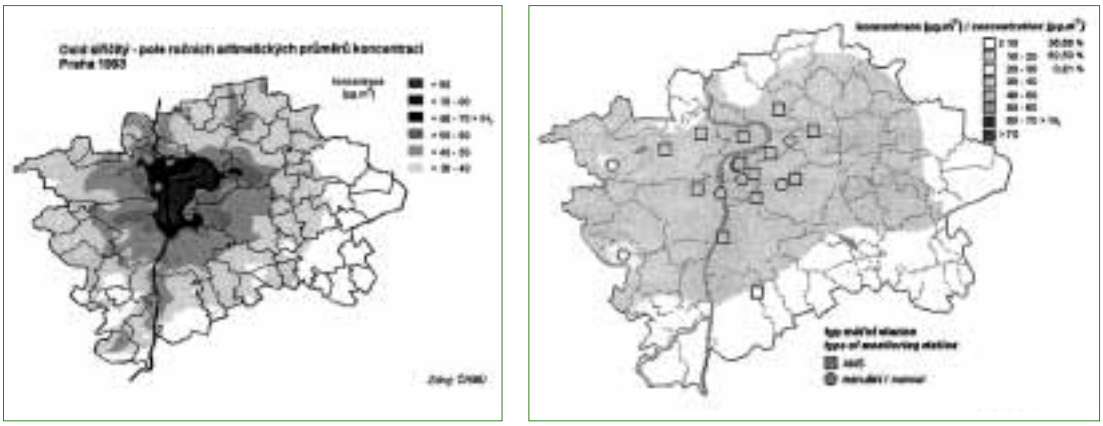

Figure 2 : *Pollution situation of SO_2 in Prague in 1993 and 1998*

Deterioration and maintenances in the past

There are no records on partial repairs in the past involving evaluation of the condition before the repair, which would allow for evaluation of the course of degradation of materials and protection systems in dependence on aggressivity of the environment.

Reconstruction of the eastern facade was carried out in 1992 - 93, however the implementation was not very successful.

The general reconstruction of the Municipal House in 1994 - 97 was the most extensive reconstruction in the Czech Republic after 1989. An option which was the best from the restoration point of view, but which was technically and financially most demanding, was selected.

The Municipal House is a building open to the public, which must meet all criteria of the present time, including fire protection, hygienic requirements and technical requirements. During work on bringing the object into its original condition, it was necessary to dismount and to restore more than 300 000 pieces of art and craft.
The study further describes namely exterior work, which is further divided into construction and restoration work.

Building Reconstruction Work

Plasters and Facades

The whole reconstructed surface of facades of 7,000 m^2 (surface without windows) may be divided into three main parts : inner yards, northern and southern facade, eastern facade.

Inner yards
Condition before reconstruction - they were in a bad technical condition, the facade was most damaged at places where gutters or other tinsmithery elements were damaged and where long-term leaks occurred.

Northern and southern facade
Condition before reconstruction - number of local defects were found on the facades, the degree of damage was considerably higher on the southern facade. There were three types of decorative materials used here:
(a) Stucco on the surface, geometrical ornamental and figurative decoration.
(b) Cufstein lime - casted mixture used for plastic decorations on facades.
(c) Czech stone - sandstone from locality Horice, statues made of sandstone placed on the molding.
As elsewhere, the facade was most damaged at places where the tinsmithery elements were damaged and where long-term leaks occurred.

Eastern facade
Condition before reconstruction - facade was reconstructed between 1992 and 1993, when it was mechanically cleaned and the system of plaster layers was repaired only locally. An uncongenial solution was chosen for flashing, when zinc sheet was used in combination with copper sheet. Connection of tinsmithery and girdling elements was also carried out in a bad manner (rivets).
A bad complete preparation of the facade before reconstruction caused that the whole eastern facade had to be rescued and reconstructed again.

Hole Fillings

The total number of 359 windows and display-windows may be divided into two groups with respect to the reconstruction :
(a) Repaired windows and display-windows - the total number of 36 oak display windows on the eastern facade.
(b) New windows and display-windows - the total number of 323 windows made of soft wood, manufactured as copies of the original windows.

Roofs
The total area of roofs is approximately 8,900 m^2. According to shape and composition, roof constructions may be divided into the following groups : roofs made of glazed tiles, roofs with titanium-zinc sheeting, flat roofs and cupola roofing.

(a) Roof made of glazed tiles.
This represents part of the roof of approx. 525m^2.
The original glazed tiles were removed including timbering, steel construction of the roof was treated with a protective coating. The glass soffit was padded warm with segments made of aluminum frames filled with polycarbonate clear filling.
(b) Roofs with titanium-zinc sheeting.
This represents roofing of the Smetana's Hall and other parts of roofs in the total area of approx. 4,900 m^2. Roofing was made of titanium-zinc sheet of 0.7 mm thickness, skylights were glassed with wire-glass into silicone cement.
(c) Flat roofs.
This represents total number of approximately 1,225 m^2 of flat roofs, where the original bituminous covering and fill were removed to the concrete slab and a new composition of hydro-insulation layer was carried out.
(d) Repair of the main cupola.
Surface of the cupola is approximately 400 m^2. The cupola was cleaned from deposits of pigeon excrements, decorated macaroons were newly equipped with elements protecting against pigeons. The original roofing made of copper sheet was restored at the place, including glassing. Variety of colors on the copper sheet caused by configuration of the cupola and decorative elements or leaks of precipitation was not modified.

Figure 1 : *The Municipal House of Prague*

Restoration reconstruction work

Stucco Work

(a) Stucco elements in relatively good condition were consolidated and hydrophobically conserved.
(b) Relieves, which needed a demanding restoration intervention, were cleaned and consolidating coating were applied. The missing parts were re-modeled.
(c) Relieves in the state of decomposition, which could not have been rescued, were reproduced

Stonecutting Work

Stonecutting work is represented by restoration of statues on the attic of the Municipal House, which are made of stone, sculpted from sandstone of the Horice type, except four cases.

Locksmithery and Girdling Work

The whole work may be divided to restoration of canopies above side entrances, railings on balconies on the northern and the southern facade, and terrace railings.

Costs in respect of the volume of construction work

The main investor of the Municipal House is a contribution organization Municipal House founded by the City of Prague. Funds for reconstruction were acquired from revenue from bonds of the City of Prague in the total sum of CZK 400 million and from a specific state grant of CZK 130 million. Other funds were provided from the budget of the City of Prague.

Other parts of work	Costs including VAT	
	million of CZK	million of EUR
Construction objects and sub-objects (costs for the actual construction work, electrical equipment, distribution of water, gas, sewage, internal telephones and computer network)	740.9	21,2
Operational sets and sub-sets (costs for environmental equipment, central heating, elevators, scenic technology and organ)	316.8	9,0
Other complex supplies (costs for repairs and restoration, new interior elements and furniture)	389.1	11,1
Other	212.2 6,0	
Total	**657.0**	**47,3**

Table 1 : *Outline of costs for supplies of construction work*

Next tables present more detailed analysis of costs for reconstruction of roofs, facades and windows.

Item description	Amount / m2	Costs incl. VAT
Roofs with tile roofing (complete roof covering)	525	
Roofs with titanium-zinc sheeting (complete roof covering)	4,900	2.1 million
Flat roofs (complete roof covering)	1,225	
Roof elements of facades (gutters, flashing, etc.)	1,800	
Cupolas and ridges (complete roof covering)	450	0,7 million
Total	**8,900**	**2.9 million**
Costs for a square meter of roofs with the total area of approx.	**8,900**	**2.9 million**

Table 2 : *Costs for reconstruction of roofs (prices in EUR)*

Item description	Costs incl. VAT
Construction part including scaffolding	0.8 million
Stucco and sculpting work	0.2 million
Locksmithery and girdling work	0.2 million
Total	**1.1 million**
Costs for a square meter of facade (without windows) with the total area of approx. 7,000 m²	**5,714**

Table 3 : *Costs for facade work (prices in EUR)*

Item description	Amount	m²	Costs incl. VAT
Repaired windows (eastern facade, left part)	18 pcs	612	0.1 million
Repaired windows (eastern facade, right part)	18 pcs	612	0.1 million
New windows (jamb, double, curly grain)	323 pcs	1,938	0.4 million
Total	**359 pcs**	**2,752**	**0.7 million**
Costs for a square meter of windows			**0,02**

Table 4 : *Costs for windows (prices in EUR)*

Item description	Costs incl. VAT
Costs for a cubic meter of the building with the total volume of built-around space of approx. 158,500 m3	**0,32**

Table 5 : *Costs for a cubic meter of the building*

Importance of the reconstruction for the operational quality of the object

The complete reconstruction of the Municipal House did not mean only preservation and restoration of an important secession building in the center of Prague. It brought the capital a new multi-purpose object for various social and cultural activities. The attendance after reconstruction doubled (approx. 1 million people visit the object each year), which made the financial returnability much easier, and the social returnability is invaluable.

The above described facts document that investments into the Municipal House represented an important possibility to exploit this historically protected building for an everyday operation. The Municipal House is a live object today, which serves to the citizens of Prague and visitors.
Benefit serves for part payment for bonds of the City of Prague.

Conclusion

Solution of the REACH project as a whole has a generalizing character. The model represents a prototype of the management software for a cost-benefit analysis and can reflect specific aspects of individual solutions only in a limited extent.

Case studies analyze specific cases with all their specific aspects. They show which inputs may be acquired in what extent and how these inputs are reflected in the solution. In this sense, the carried-out studies represent an independent part, which is important for the use of results of the solution.

Income	million of CZK	million of EUR
Long-term lease	38	1,09
Short-term lease and services	48	1,37
Retailing of souvenirs, books, art, etc.	2	0,06
Entrance-fees (sightseeing tour)	2	0,06
Entrance-fees (exhibitions)	3	0,09
Total sum	**93**	**2,66**
Costs		
Operating expenses	50	1,43
Expenses for exhibitions	8	0,23
Total sum	**58**	**1,66**
Benefit	**35**	**1,00**

Table 6 : *Analyses of economic balance of the Municipal House in 1999*

Biography

Dr. Dagmar KNOTKOVA is senior scientist in the branch of atmospheric degradation and corrosion of polymers, coatings, metals and their protective systems. She practises in testing and standardisation, monitoring of effects of environment on materials and equipment, last decade also in connection to monuments.

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Evaluating the benefits of cultural heritage preservation : an overview of international initiatives

Evaluation des bénéfices de la préservation du patrimoine culturel : le point de vue sur les initiatives internationales

May CASSAR[1]

Abstract

This paper evaluates the benefits of cultural heritage preservation by giving an overview of international initiatives in this field. It puts forward the case for scientific research as a means by which to demonstrate socio-economic benefits for Europe's citizens. Cultural heritage enhances European identity and improves quality of life. This is leading to an increase in demand for access. If use of the heritage is not managed well, however, this will result in public consuming the items it wishes to preserve for the education and enjoyment of future generations. Scientific research forms the basis for understanding the preservation needs of cultural heritage. It provides the evidence necessary to ensure that sustainable use of the heritage takes place. Uniquely, in Key Action 4, "City of Tomorrow and Cultural Heritage" of the 5th Framework Programme, socio-economic benefits from cultural heritage are seen to be derived from scientific research. Scientists are being challenged to demonstrate that their research will not only benefit the preservation of cultural heritage, but that by applying appropriate decision-making tools such as risk assessment and cost/benefits appraisals, a balance between preservation needs and use can be achieved.

Résumé

Ce document fait l'évaluation des bénéfices de la préservation du patrimoine culturel en proposant une vue générale des initiatives internationales en ce domaine. Le concept selon lequel la recherche scientifique se doit d'être un moyen pour démontrer les bénéfices aux citoyens européens y tient une place prédominante. Le patrimoine culturel renforce l'identité européenne et améliore la qualité de vie et c'est la raison pour laquelle l'ouverture au public fait l'objet d'une demande de plus en plus importante. Cependant, si cette utilisation du patrimoine n'est pas gérée correctement, il en résultera que les visiteurs "consommeront" ce qu'ils voulaient préserver pour l'éducation et l'agrément des générations futures. C'est grâce à la recherche scientifique que l'on peut connaître les impératifs de la conservation du patrimoine. C'est elle qui nous fournit les preuves indispensables pour nous assurer que nous l'utilisons de façon adéquate et durable. Dans la quatrième action clé, " Ville de Demain et Patrimoine Culturel ", du 5ème PCRD, on constate que les bénéfices socio-économiques du patrimoine culturel découlent de la recherche. Les scientifiques sont mis au défi de démontrer que leurs recherches ne bénéficieront pas uniquement à la préservation du patrimoine culturel mais, également, qu'en utilisant les outils décisionnels appropriés, tels que l'évaluation des risques et les études coûts/bénéfices, il est possible de concilier les impératifs de la conservation et de l'accès.

In recent years, there have been numerous initiatives, by organizations ranging from development banks and agencies to universities and individuals attempting to evaluate the benefits of cultural heritage preservation. While being selective, I hope that this contribution succeeds in giving a flavour of the broad interest that exists in this area.

My own view is that there should be greater public access and end-user involvement in cultural heritage decision-making ; that achieving this is fundamental to ensuring that cultural heritage remains relevant and reflects the lives of communities. However this does not mean that everything is permissible. We must reappraise how we manage cultural heritage, because its use must be commensurate with good preservation practice based on sound scientific research.

Evidence for need for evaluation of benefits of cultural heritage preservation to society

There is growing evidence that cultural heritage preservation carries benefits in many areas of life. In the area of economic development, multilateral development banks, bilateral development agencies, institutions and individuals involved in development programs have recognized the urgent need to assist developing countries in preserving their cultural resources and assets, and moreover to relate cultural values to development.

In the area of the environment, preservation and re-use of historic buildings in urban areas has not

only brought about improvements in the appearance of city centers, but also in air quality for human health and heritage preservation because of the demand for improved transport planning that has been generated. While critical levels of pollution are different for cultural heritage and human exposure, both benefit from reduction of pollution in the urban environment.

In the area of education and access to information, research on preservation is playing a vital part in unlocking the information contained in objects and interpreting them to the public. The National Curriculum in the UK uses collections as part of science teaching, drawing on preservation to predict, hypothesize and test material types and uses. Museums in urban areas are becoming focal points for access, not only to collections, but for information in general and other services. This is helping to stimulate the social and material vitality of areas around museums.

In the area of construction, it has been estimated that 50% of all building refurbishments in European cities relate in some way to heritage preservation. Refurbishment of historic city centers provides the means for social revitalization of communities and neighborhoods. Physical access to historic buildings is a key factor in improving social inclusion, an important indicator of quality of life.

In the local economy, cultural heritage has an impact on economic prosperity, such as the effect of cultural tourism on local businesses. The South-West Museums Council in England's report on 'The Economic Contribution of Museums in the South-West' (the second largest region in England) describes the huge impact that cultural heritage has on local communities : stimulating small and medium sized enterprises, developing new technologies and markets and encouraging tourism and inward investment.

The growing interest in the links between cultural heritage preservation and mainstream societal concerns such as development, environment, health, education, access to information, construction and the economy is self-evident. But how do we evaluate its benefits ?

Comparison between cultural heritage preservation and the global environment

The interest in cultural assets today is similar in some ways to actions on behalf of the environment more than three decades ago. Like the environment, there is a risk of permanent loss of diversity among the immoveable and moveable heritage. Efforts to preserve and enhance cultural assets not only reduce the risks, but they can provide important economic benefits and opportunities for greater social cohesion, reinforcing a common identity and strengthening socio-economic aspirations. The key action, 'City of Tomorrow and Cultural Heritage' emphasizes the obligation for scientific research into the cultural heritage preservation, to demonstrate the socioeconomic benefits that Europe's citizens can derive from it.

It is also the responsibility of scientists to enable us to understand better the physical impact of our increasing demand for access to cultural heritage, so that we can manage access better. Otherwise we will end up destroying the very items we wish to benefit from. Scientific research : the development of technologies, tools and methodologies to forecast, monitor and assess damage, forms the basis of our understanding of the preservation needs of cultural heritage. It provides the evidence necessary to ensure that we make sustainable use of our heritage. Uniquely, in this Key Action socioeconomic benefits from cultural heritage must flow from knowledge based on scientific research.

Scientists are being challenged to demonstrate that research will not only benefit the preservation of cultural heritage, but that by applying appropriate decision-making tools, such as risk assessment, cost/benefits appraisals and valuations, a balance between preservation and end-user needs is achieved.

EC research linking scientific research for cultural heritage to economic benefits derived from it, started in the 4th Framework Program. For example, the project, Rationalized Economic Appraisal of Cultural Heritage (REACH) (Contract No. ENV4-CT98-0708) was funded under the 4th Framework Program. It is worth reflecting on how relevant the original research objectives still are, including

bringing together the technical and economic information required by managers concerned with the care of the built cultural heritage with respect to damage from air pollution and its re-mediation ; developing an integrated cost/benefit model incorporating the relevant factors, developing a preliminary management tool based on different IT platforms to enable those in control of monuments to assess readily the economics of intervention at local and national level drawing on current best practice.

The value of these EC initiatives must be seen in the context of the interest of other international bodies concerned with evaluating the benefits of cultural heritage preservation. These benefits have often been perceived as economic in the first instance, with social benefits deriving from them.

Which other international organizations have been involved with evaluating the benefits of cultural heritage preservation?

For a long time, UNESCO has advocated greater concentration of human and financial resources for cultural development. Following this lead, others such as the World Bank, have begun to include activities in their programs aimed at preserving cultural heritage and supporting cultural programs in developing countries.

While the World Bank's primary objectives are focussed on economic and social areas : reducing poverty, promoting sustainable development and investing in people, it is now also bringing culture into the mainstream in its lending programs. It has launched several projects that include culture in a broader range of development activities by providing financial and technical support and working in partnership.

Just over a year ago in October 1999, the World Bank and the Government of Italy in cooperation, with UNESCO co-sponsored the conference, 'Culture Counts - A Conference on Financing, Resources and the Economics of Culture in Sustainable Development'. The premise was that culture is crucial to advancing sustainable development. Such activity signals that the World Bank sees an economic justification for investment in culture, while at the same time recognizing its intrinsic value and positive impact on society.

The World Bank has used different economic analysis techniques in different situations. These techniques give different levels of confidence to estimating value. For example, market-price methods and replacement costs are quite accurate, though limited in their application to cultural heritage. Other types of qualitative or subjective benefits are more difficult to measure or they are scattered over a wide area and a large number of people. These benefits can only be estimated using techniques such as contingent valuation and other 'stated preference' techniques that often rely on surveys producing large data sets. Techniques which demonstrate cost-effectiveness or which use cost/benefits appraisals to evaluate benefits and costs may be more appropriate for analyzing economic investment in preservation.

Cost/benefits or cost-effectiveness ?

In dealing with cultural heritage there are sometimes objects, buildings, monuments and sites that are so valuable that they should be conserved at all costs, because of their uniqueness or significance. In these cases, the appropriate analytical approach is of cost-effectiveness rather than cost/benefit. We must find the cheapest and most effective way of achieving our preservation goals. The use of this approach is often limited by the scarcity of conservation resources ; the only way we can improve on this situation is through sound scientific research that establishes where the limits of 'minimal intervention' might be set. Cost-effectiveness has little use when there is a broad range of choice on the degree and nature of improvements that are possible. Uniqueness can justify a minimal level of protection, but anything beyond this requires a cost/benefit analysis. Whatever the method, the main interest for the World Bank is to be able to evaluate the change in value that will result from a proposed project.

Just as with the World Bank's premise that culture is crucial to advancing sustainable development, there is also the scope in the United Nations Human Development Index (HDI) for including the

benefits of cultural heritage as a measure of human development. Currently, the Index provides a more comprehensive socioeconomic measure than GDP alone. The HDI is a composite of 3 basic components of human development : longevity, knowledge and standard of living. *Longevity* is measured by life expectancy, *knowledge* by a combination of adult literacy and mean years of schooling and *standard of living* is measured by purchasing power based on real GDP per capita adjusted for the local cost of living.

Ideally the HDI should reflect all aspects of human experience, but lack of data has imposed these limits. More indicators could be added as information becomes available, and these should include the benefits to society of cultural heritage preservation. In fact, in discussion with some national coordinators of HDI research, there is interest to explore this issue further. Though at this stage including the benefits of cultural heritage preservation among HDI assessment criteria is a longer-term rather than an immediate goal.

Like the World Bank's interest in *change in value*, the UN's Human Development Index is interested in a common measure for the socio-economic distance traveled by a country. The HDI enables people and their governments to evaluate progress over time and to determine priorities for policy intervention. Using the HDI to link preservation to improvements in quality of life could be attractive to decision-makers because it does not propose a completely different way of evaluating the benefits of cultural heritage, instead a logical development of the HDI methodology. However, the gaps that exist in our scientific knowledge need to be addressed first by research that generates a large and reliable data set.

In recent years, issues relating to the challenges facing preservation and how to link more strongly our understanding of the value and meaning of objects to the benefits demanded by society have been discussed by conservation professionals and trusts, non-governmental organizations, universities and governments.

The Dahlem Konferenzen on `Durability and Change The Science, Responsibility and Cost of Sustaining Cultural Heritage' that took place in Berlin in 1992 aimed to further understanding of all aspects of durability and change within material cultural heritage among researchers, practitioners and decision-makers. It sought to address issues relating to factors that determine the durability of objects and the modalities of preservation including decision-making, societal attitudes and politics, the synergy of deterioration factors (physical, chemical, biological) together with the dynamics of these factors (cycles, doses, events), the rate of change that is acceptable and the responsibility of past, present and future society for the preservation of cultural heritage and its cost.

At the International Council of Museums' Committee for Conservation Triennial Meeting in Lyon in September 1999, the meaning - and by extension the value - that non-scientists give objects was discussed by the 'History and Theory of Conservation' Working Group. The anthropomorphic nature of objects - the language of the living that we often use when referring to objects - is closely linked to the meaning that we invest in objects and is a measure of how closely we identify -with cultural heritage. If objects have meaning, it is logical to conclude that they also have value.

The activities of the Getty Conservation Institute's Agora Program have included an ongoing inquiry into the values and benefits of cultural heritage, exploring the economics of cultural heritage and its conservation and the organization of a leadership roundtable involving cultural heritage organizations worldwide.

As part of the economics inquiry, a meeting was held in 1998 on the relationship between 'Economics and Heritage Conservation', followed in 2002 by the publication of a research report on 'Values and Heritage Conservation'. The purpose of the meeting and the report are to enrich the value concepts held by cultural economists with those values typical for cultural heritage conservation. The meeting concluded that a key feature of heritage institutions - such as museums - is the broad range of ways in which they are valued : aesthetic, cultural, educational, political as well as economic, and that no single approach can capture the full range of these values. The means that

we choose to use to measure value reflects our background and attitude about what is important and what is not, and that interest in cultural heritage goes beyond those involved in preservation.

The concept of cultural capital was proposed as a means of encapsulating what we mean by sustainable use of cultural heritage. It focuses on the shared responsibility of end-users for preservation. If we treat cultural heritage as a capital asset, we may use it but not consume it because we hold it in trust for future generations. This is the same principle that applies to the conservation of natural resources. It does however require some hard questions to be faced on how cultural heritage is valued by society. In a world with limited conservation resources, questions on what society values enough to invest in and to preserve must be addressed.

At the same time, ICCROM organized the Forum project with similar objectives, contents and working methods as the GCI's Agora Program. The main differences between the two are that the Agora Program initially linked conservation economists with conservation professionals and conservation managers, while the Forum project brought in experience from outside the cultural heritage area. The projects are so similar that both organizations could have combined their resources to work on this project together.

It is worth noting that the International Scientific Committee on Economics of Conservation of ICOMOS, the International Council on Monuments and Sites is currently writing a new 'Charter on Conservation Economics' that will be ready in 2002. It aims to establish as clearly as possible economic terms and definitions, objectives, agreed principles and the economic tools that ICOMOS will use.

Earlier, reference was made to different economic analysis techniques available to estimate value. Research within universities to value the benefits of preservation, has largely taken place within social and economic departments such as University College London's Center for Social and Economic Research on the Global Environment, the Université Paris 9 Dauphine Département des Sciences Economiques, the Erasmus University's Erasmus Centrium voor Kunst and Cultuurwetenschappen, the Catholic University of Leuven's Department of Social and Economic Geography and the University of Zurich's Institute for Empirical Research in Economics.

These have often used 'stated preference' techniques such as contingent valuation and ranking to determine the end-user's willingness to pay for preservation. Surveys have been used to gather information scattered over a wide area and a large number of people to produce large data sets from which to estimate the benefits of cultural heritage preservation. Scientific data from measuring dose-response does not exist in sufficient quantity and quality to enable decisions to limit damage to be made. There are gaps in scientific research that measures damage functions and its impact on cultural heritage because this research is expensive and takes time to produce reliable results. Nevertheless, the dose-response data that does exist must be gathered together and used. This should enable a more equitable balance between scientific research on preservation on the one hand and social and economic research on the other, in estimating the benefits of cultural heritage preservation. This balance can only be achieved within interdisciplinary research teams that bring together scientists, economists and end-users.

The benefits of interdisciplinary are that it produces synergy : working in teams enables more to be accomplished, far more than working as individuals. It provides added value : the whole is greater than the sum of the parts. It encourages interdependence that paradoxically strengthens each individual's involvement by recognizing the different yet complementary contribution of each discipline to achieving a balance between cultural heritage preservation and use.

A practical example of how preservation of cultural heritage can be tied to the economic benefits enjoyed by citizens can be found in legislation enacted by the State Government of Minas Gerais in Brazil. All state governments of Brazil are required by Federal Legislation to distribute a percentage of taxes they earn on goods and services to the municipalities in their region. The State Government of Minas Gerais found that the way the tax was being distributed meant that those municipalities that were already richer were getting richer, while those that were poor were in effect getting poorer.

It decided to implement a more equitable distribution according to need. It passes what is in effect a 'Robin Hood' law that enables poorer municipalities to get a greater proportion of tax revenues if they can demonstrate that they are taking measures to protect and preserve their cultural heritage. These measures must include : listing or making the cultural heritage inalienable, that is, it cannot be sold ; implementing policies ; drawing up inventories and conservation plans, and carrying out technical assessments of moveable and immoveable heritage, historic centers and surroundings as appropriate.

Conclusion

A balanced approach which benefits cultural heritage preservation and the end-user can be achieved by conservation scientists using their knowledge and skills to define preservation issues, social scientists and economists have an important supporting role in defining end-user needs, conservation scientists clearly demonstrating the benefits of the research they undertake, and social scientists and economists using the results of scientific research into preservation when evaluating the benefits of cultural heritage to society.

Biography

Director of the Center for Historic Buildings, Collections and Sites at UCL providing integrated solutions on the preservation and use of the moveable and immoveable heritage through research, teaching, advice and consultancy. Formerly, Environmental Adviser to Resource : the Council for Museums, Archives and Libraries, providing policy and strategic advice including preventive conservation, environmental design and management of buildings. Project co-ordinator for the European Parliament's Scientific and Technological Options Assessment Programme (STOA) Study on the 'Technological requirements for solutions in the conservation and protection of historic monuments and archaeological remains'. Member of the External Advisory Panel for the European Commission's 5th Framework Programme Key Action, 'The City of Tomorrow and Cultural Heritage'. Author of seven books and over thirty published papers in peer-reviewed journals, other journals and conference proceedings on preventive conservation.

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Session B What is the scope for using optical technologies for cultural heritage conservation ?

Session B Quelles applications pour les technologies optiques dans le domaine de la conservation du patrimoine naturel ?

Rapporteur : Eddy DE WITTE

Session B was devoted to the use of optical technologies for cultural heritage conservation. It can be divided in three topics : the use and development of laser systems for cleaning, the use and development of laser systems for diagnostics and finally the designing of lighting systems for works of art.

The session began with a "Craft project" on an advanced working station for cleaning paintings. An automatic system to clean paintings has been designed here. The interesting conclusions of this project were that there are both advantages and disadvantages to the system. Disadvantages have been found to be surface effects, colour changes, binding medium oxidation as well as small chemical changes. The advantages, that are also limitations, are the removal of over paints and the partial removal of varnish.

This presentation was followed by a "Eureka project" on laser cleaning of large surfaces. In this case, the aim is to construct a laser cleaning system that is more financially competitive than traditional cleaning systems. In order to achieve this objective, a system has to be devised where at least ten square metres per hour can be cleaned. The project has already reached a first goal in phase one where apparatus has been built. The yield achieved for this apparatus is between 2 and 2.5 square metres per hour. The second phase, which is upgrading of the apparatus is now under construction. The co-ordinator hopes to achieve the final goal and thus reach ten square metres per hour.

A third project on laser cleaning of stone presented the design of a non-standard laser system based on thermal and chemical modelling of laser impact. Relatively few details have been given on this system. Some practical examples were shown that illustrated the use of the newly designed apparatus on art objects.

A very interesting contribution came from the European Commission "Standard, measurement and testing" programme. A portable post-holographic recording system has been designed in order to diagnose the state of conservation of icons. Another system based on acoustic oscillation has been designed for frescoes. Both qualitative and quantitative information can be obtained by this system.

Finally, a project on the lighting of works of art was presented. To my knowledge, this subject has not been so thoroughly dealt with in this kind of conference. Where this very interesting project is concerned, a museum lighting system is proposed, which monitors the light quality and light level.

As far as the discussions are concerned, it became quite clear that there is still a huge gap to fill between scientists working on the development of lasers and conservators working in a museum environment. It is quite clear that some misunderstanding as well as non-understanding still exist. On the one hand there are scientists in the laser business who are very fond of automation and on the other hand, people working in the conservation sector do not like automation. The two sides should be brought together in order to explain why automation is required and that this does not necessarily rule out the need for conservators whose presence is compulsory.

The conclusions of the discussions also included the lack of comparative testing. Those working on the development of laser techniques do indeed undertake a large amount of very thorough and interesting analysis of the systems. Unfortunately, the results are not always compared with more traditional cleaning techniques. It is my opinion that it would be a good idea to incorporate such a comparison in the research.

There also seems to be quite some confusion about the different natures of laser systems used. Those representing the laser industry should be well aware that there are quite a lot of different lasers systems available. We can no longer simply refer to 'a laser' system. The exact type of lasers under investigation must be defined. It would seem that inter-comparative studies between different lasers may prove very useful in the future.

Rapporteur : Eddy DE WITTE

Cette session était consacrée à l'utilisation des technologies optiques dans le domaine de la conservation du patrimoine culturel. Elle se divisait en trois parties : l'utilisation et le développement de systèmes laser pour le nettoyage, le diagnostic et l'éclairage des œuvres d'art.
Un projet " CRAFT " sur le nettoyage au laser des peintures a été présenté en insistant sur les avantages et inconvénients de cette méthode. Comme inconvénients ont été signalés les conséquences sur la surface picturale, les changements de couleur, l'oxydation des liants et les légères transformations chimiques. Les avantages sont liés à l'élimination des repeints et à la disparition partielle du vernis.
Le projet Eurêka " RESTOR " concernant le nettoyage au laser de grandes surfaces de monuments historiques a été ensuite présenté. Son objectif est la construction d'un système de nettoyage laser plus compétitif sur le plan financier que les méthodes traditionnelles. Pour atteindre cet objectif, ce système doit pouvoir traiter 10 m2 par heure au minimum. Dans un premier temps, un appareil pouvant traiter de 2 à 2,5 m2 par heure a déjà été élaboré. La deuxième phase touchant à l'augmentation des capacités de ce dispositif est actuellement en cours. Le coordinateur a bon espoir de parvenir au résultat escompté.
Un troisième projet sur le nettoyage de la pierre au laser proposait un système reposant sur la modélisation thermique ou chimique de l'impact du laser. Des applications sur divers objets ont été montrées. Dans le cadre du programme " Normes, Mesures et Essais " de la Commission européenne, un système d'enregistrement post-holographique portable a été conçu pour diagnostiquer le degré de conservation des icônes. Il existe un autre système, basé sur l'oscillation acoustique, permettant d'obtenir des informations aussi bien qualitatives que quantitatives.
Finalement un programme sur l'éclairage des œuvres d'art a été présenté. L'objectif de ce projet est de contrôler la qualité et l'intensité de l'éclairage d'un musée.
En ce qui concerne les débats, il est apparu que le fossé reste important entre les scientifiques travaillant au développement des systèmes laser et les conservateurs et les restaurateurs. De toute évidence, des malentendus subsistent encore. D'une part, les scientifiques spécialistes des techniques laser sont partisans de l'automatisation, et d'autre part, le milieu de la conservation y reste réticent. Deux écoles qui devraient être encouragées à se rapprocher afin de démontrer pourquoi l'automatisation est nécessaire et pourquoi elle ne va pas nécessairement enlever du travail aux restaurateurs. Il est également apparu que le nombre d'essais comparatifs est actuellement insuffisant. Les scientifiques engagés dans le développement des techniques laser ne comparent malheureusement pas toujours leurs résultats à ceux obtenus par des techniques de nettoyage traditionnelles. Il semble également qu'une grande confusion continue de régner quant à la nature des différentes techniques laser utilisées. Les spécialistes en la matière n'ignorent pas qu'il existe de nombreux systèmes différents et qu'il est, par conséquent, impossible de parler d'un système laser mais qu'il est nécessaire de définir exactement le type dont il est question. Dans les années à venir les études comparatives entre les divers systèmes laser devraient devenir primordiales.

Laser treatment of stone : its application in the conservation of statuary and monuments

Traitement des pierres par laser : applications pour la conservation des sculptures et des monuments

Renzo SALIMBENI[1], Roberto PINI, Salvatore SIANO

Abstract

Laser methodologies in stone conservation are gaining a convinced acceptance by the conservators community after decades of debated results. The intrinsic control of the laser approach allows the removal of the encrustation with a precision not affordable with the traditional techniques. With a careful choice of the operative parameters of the laser, side effects are negligible and valuable patinas are well preserved. In other words, the laser cleaning methodology may be advantageously integrated in the conservation procedures of historic monuments and particularly indicated for the statuary masterpieces.

Résumé

En ce qui concerne la pierre, le milieu des restaurateurs accepte désormais l'utilisation du laser avec une conviction croissante après des décennies de résultats discutés. La maîtrise inhérente à cette technique permet une élimination des incrustations d'une précision inaccessible aux méthodes traditionnelles. En choisissant consciencieusement les paramètres opérants du laser, les effets secondaires sont pratiquement inexistants et les précieuses patines très bien préservées.
En d'autres termes, le nettoyage au laser peut être intégré aux diverses méthodes d'entretien des monuments historiques de manière avantageuse et s'avère particulièrement indiqué pour les chefs-d'œuvre de l'art sculptural.

More than thirty years after the first proposal (1), laser techniques in conservation are experiencing in the last decade a renewed and finally mature interest, as underlined by the increasing number of case studies reported in topical conferences (2), and in scientific journals of both conservation and laser technology fields. At the European level, several research initiatives on this topic have been considered within the 4th and the 5th Research Programmes of the European Commission, and other ones should necessarily be supported in the 6th Programme too.
At national level, Italy started quite early, hosting in Venice in the late 70's the pioneering works by Asmus, and arriving in the middle 90's to a national research project on laser cleaning of artworks. The program was aimed to carry out basic studies (3) on the process of laser cleaning, as well as laboratory tests and analyses on a variety of materials and lasers systems, which involved in interdisciplinary studies physicists, chemists, lasers engineers, geologists, restorers and art historian, in order to define and optimise the laser cleaning procedure.
The importance of the laser methodologies in art conservation is today more and more recognised as a crucial contribution from physics for a better understanding of the problems and for their solution. In this work we describe our scientific approach in close cooperation with conservation institutions in Italy, demonstrating the excellence of laser techniques in the most challenging cases of stone conservation.

Our program in the field

The interest for laser application in conservation has had several starts in Italy. The beginning was a test by John ASMUS in Venice in 1970, in which the potential of the method was clearly indicated, but the not yet mature technology of the Ruby and Nd :YAG laser systems did not allow at that time extensive investigations by the official institutions. Other sporadic studies didn't produce convincing and final evaluations about the laser technique.
In middle 90's the initiative of CNR of a Special Project devoted to the Safeguard of Cultural Heritage, and a contemporaneous initiative of the Regional Network of Tuscany for High Technology in conservation, have given to us the possibility to propose an interdisciplinary approach to this issue, with the coordination of laser physicists, chemists, restorers, petrologists, archaeologists, and engineers. The team was headed by the IEQ-CNR as the proposer, and had contributions by Opificio of Pietre DURE in Florence, the Institute of Environmental Geochemistry of the University of Siena, the Department of Historical Science of the University of Pisa, the Restoration Center of Tuscany Archaeological Superintendence, the Department of Earth Science of the University of Florence, the Istituto Centrale per il Restauro in Rome. Two companies, EL.EN. Spa and Restauro Italia Srl were also involved for the development of laser products and for the use of the laser system. A RITTS Project (Regional Innovation and Technology Transfer Strategies of the EC) confirmed the interest for innovative technologies in this field, and our program is presently ongoing under a Pilot Project RIS+ Tuscany "Technologies for Cultural Heritage".
In this activity our main tasks have been :

- A critical reviewing of the laser–material interaction, with studies concerning the physical processes excited by the lasers most frequently employed in conservation treatments, the side effects under different operating regimes, the material behavior and so on.
- The selection of the optimum laser parameters for different materials (stone, metals), considering the need to minimise mechanical stresses and thermal effects in the valuable layers and in the substrate.
- The design and construction of non–standard laser systems, allowing suitable operating regime.
- To devise operating methodologies for the operator which put in their hands the entire control of the laser action, in order to perform as a "tool".
- The investigation over the performance of such non-standard laser systems in various preservation problems difficult to be solved with other methods.

• Analysis and validation of systems and methods in comparison with the capability provided by other research groups.

The stone deterioration problem

In urban environment, anthropogenic pollution makes the atmosphere much richer in sulfur dioxide (among other pollutants) than the natural environment. Thus the pattern of alteration, albeit substantially similar, is quicker and more aggressive, leading to more marked effects in an equal period of time. The urban atmosphere is also richer in particulate matter (especially residues of combustion), which gives rise to deposits, made even more evident by their blackish color.
In time, the combination of these processes produces a deterioration stratigraphy, which can be observed and interpreted by thin-section petrographic study (4). Figure 1 shows a typical example. The most external level is represented by a mixture of atmospheric particles (composed of carbon residues) and mineral granules among the most abundant in nature (clay minerals, calcite, iron oxides, quartz, etc.), to which is added varying quantities of minute reddish fragments arising from bricks. All this is bound together by essentially by gypsum and lesser quantities of chlorides and nitrates (the whole is the so-called "black crust"). Upon contact between the rock and the deposits, another aggressive phenomenon begins and is added to the initial one, consisting of solubilization of the calcite from the intergranular zones. The water, which occasionally bathes the crust, percolates easily because of the crust's abundant porosity. It becomes charged with sulphates and thus impregnates the rock through the intergranular spaces. These solutions produce sulphation phenomena that lead to a progressive and total transformation of the granular calcite into gypsum.

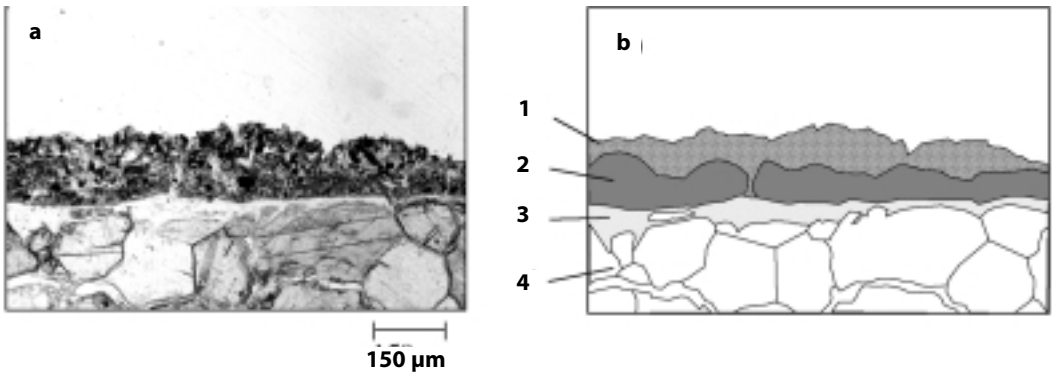

Figure 1 : a) *Stratigraphy of the deterioration horizon observed by an ultrathin section.*
b) *Descriptive scheme : 1) Black crust, 2) Sulfated Ca-oxalates film (showing craquelure), 3) Surface pseudomorphic sulfation layer i.e. reproducing the shape of the original surface, 4) Calcite crystals with intergranular decohesion.*

This last exhibits a relatively high solubility thus humidity fluctuations can easily produce solubilization-recrystallization cycles, which has devastating consequences on the stone material. It gradually tends to lose compactness because of the decohesion of the constitutive granules.
The lesser reactivity of the oxalates, as a result of their poorer solubility (with respect to calcite), renders these phenomena slower and partial, so that they partly screen the underlying material for a certain time, thus acting as protection. However, when sulphation attacks also the oxalate films, there can arise the necessity to remove them during the cleaning. It should be added that the oxalate films very often exhibit a complex stratigraphy. It is important to identify this not only for historical-cultural reasons but also to make a more suitable choice of the intervention.

The laser cleaning technique

The laser ablation process may be generally defined as the removal of a superficial layer by a pulsed laser irradiation of the material at a proper fluence (J/cm^2). The process is well known and it is employed in a variety of different fields from surgery to material processing in production. Typically the laser ablation is characterised by many very interesting features :

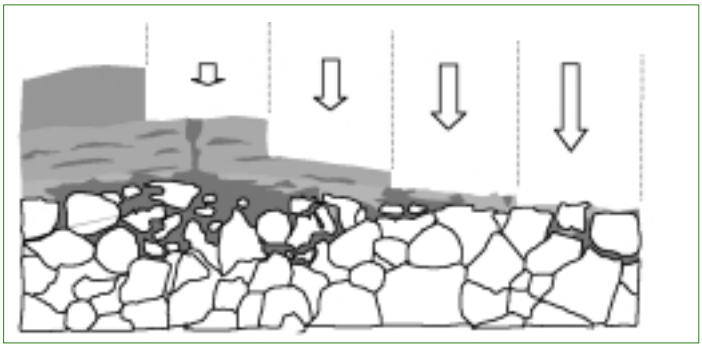

Figure 2 : *Increasing the number of pulses on the same area a deeper removal is possible, so the cleaning procedure is under control by the operator who may decide when to stop the treatment and work on another area.*

- It is a non-contact procedure.
- It may provide a selective removal of the degraded layer preserving the substrate.
- The laser beam may be directed very precisely following the most complicated morphology.

These possibilities are very important in conservation in order to achieve a cleaning methodology which may be far advanced in respect of the traditional techniques, chemical or abrasive cleaning, in terms of

- Etching depth control.
- Preservation of specific historical layers.
- No diffusion of solvent into the material.

These goals may be entirely achieved by means of a proper selection of the laser irradiation parameters.

The reference to a proper fluence is just a simplification to underline the importance of this parameter. Actually, in any laser ablation process a threshold fluence is usually determined, under such a value laser irradiation produces just a heating of the material, while for higher values the surface layer is finely removed with very neat contour. This happens because of the laser energy release into the irradiated volume through direct and indirect channels. Typical direct channel is optical absorption of laser radiation. It means that molecular species convert photons absorption in vibrational and electronic excitations, which relax in a very short time in a direct heating of the material up to the vaporisation threshold. An example of indirect channel is the plasma mediated ablation : if the laser intensity is very high (as it may be with nanosecond pulses) an electronic avalanche is likely to occur, determining a fast ionisation of the air over the irradiated area. In this case the laser radiation is absorbed by the plasma and the material is mostly heated and destructed through plasma interaction rather than by optical absorption.

It is clear that the wide span of parameters offered by the laser choice (wavelength, pulsewidth, intensity etc.) and the material properties (absorbance, reflectance, vaporisation temperature, etc.) determine very different physical processes under the same general definition of ablation.

In conclusion it should be underlined that for each laser cleaning treatment thermal or mechanical side effects have to be controlled in order to achieve the removal of the degraded layers without any injury to the inner layers and the substrate. For this task a direct energy deposition is generally preferable.

Devising laser selection criteria

In recent years, the Nd:YAG lasers have been unanimously recognised as the best compromise to provide high efficiency in the removal of stone alterations, high performance reliability and low cost maintenance with respect to other laser types. Typically, these lasers can operate in two distinct regimes of emission, characterised respectively by short pulse duration (2-10 ns, Q-switching mode) and long pulse duration (0.2-1 ms, normal mode). Our study started from tests on such standard laser systems in order to analyse and evaluate the risk of side effects related to the specific interaction processes they induce onto the stone. This investigation phase provided clear indications that an intermediate emission regime between nanosecond and hundreds of microseconds pulse duration could allow the optimisation of the laser cleaning of encrusted stones.

The indications emerging from these studies were useful to design a new Nd:YAG laser system, specially dedicated to the conservation of stone artworks, to be employed on statues and monuments. The first prototype, called "Smart Clean" was the result of a critical review of the characteristics of standard Nd:YAG laser systems, already proposed for stone cleaning, Our previous experiences in the development of laser technology permitted to design a new device emitting suitably tailored pulses of 20μs; which allowed to reduce significantly the risk of both photomechanical and heat damages, that are more likely to occur with shorter and longer laser pulses, respectively. Another unique feature of this laser is the possibility to transmit laser radiation through long optical fibres.

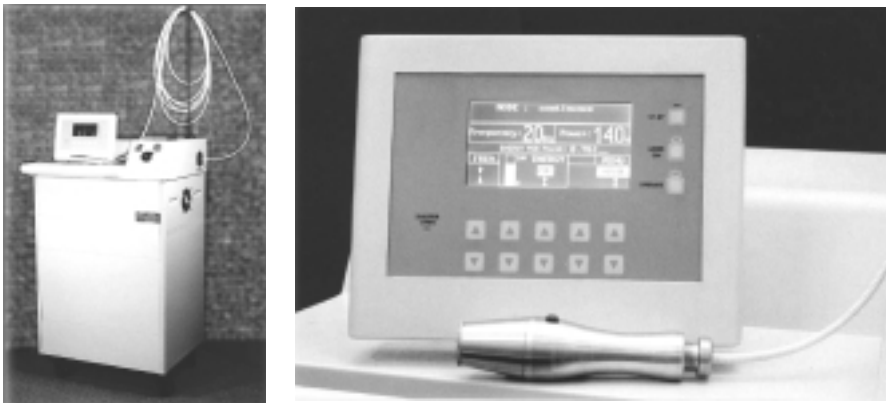

Figure 3 : *"Smart Clean" L aser with details of the display, optical cable and of the handpiece.*

This is an important advantage for the application to the façade of monuments, allowing to bring onto the scaffoldings just the fibre cable.

Devising a methodology

In order to address conveniently the methodology of application of laser techniques cleaning trials were performed on several original samples of typical problems encountered in stone restoration on monuments and historical buildings. One of these has been a tortile column piece (about 18 cm in diameter, 50 cm in length) of Carrara marble at an advanced stage of deterioration. It was removed from S. Maria Del Fiore façade because of mechanical stability problems due to its strong decohesion. The laser cleaning trials were performed by employing the experimental short free running Nd:YAG laser emitting up to 2 J/pulse, with a pulse duration of 20 μs (FWHM). The laser beam is fibre coupled and can be easily controlled by means of a small optical manipulator. This last allows a dynamic control of the spot diameter and then of the laser fluence released through the irradiated surface. We investigated the cleaning results both in water assisted and in dry conditions. In the first case, the surface was repetitively wetted during laser irradiation, in principle to ensure a constant water saturation of the irradiated volume.
The minimum laser fluence allowing a complete cleaning in water assisted conditions was of about 4.5 J/cm2, which can be then referred as the cleaning threshold. The ochreaceous colour of the laser cleaned sites appeared relatively more homogeneous and saturated with respect to the areas treated with chemical pad or micro-sandblasting.

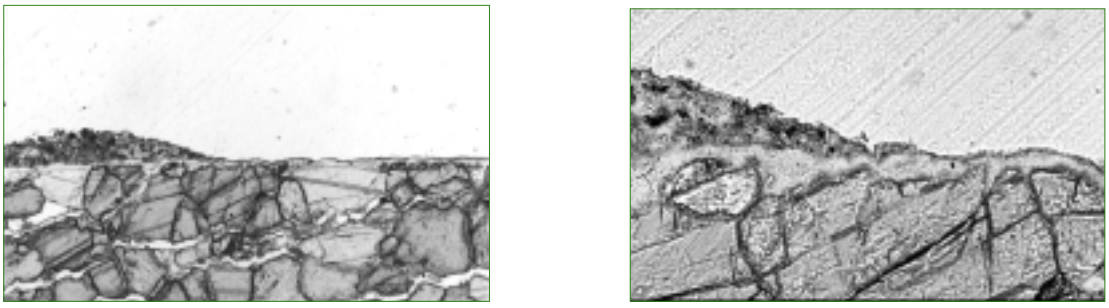

Figure 4 : *Laser cleaned site : details of a transition between treated and untreated regions.*

Laser cleaning in water assisted condition allowed to achieve the desired cleaning level in all test sites. As shown in Fig. 4, the trace of the original surface was discovered without any change of its specific area. Not complete removal of the encrustation and residual white gypsum were observed over the areas cleaned in dry condition. This effect is basically due to the inhomogeneous optical absorption within the encrustation, determined by the oxalates film color and carbon inclusions. Thus, laser irradiation removes selectively the absorption centers leaving on the surface whitish components. In water assisted conditions, their removal is aided by multiphase jet associated with water vaporization.

The previous considerations are in particular true for a laser pulse duration in the range of microseconds or more. Thus in our opinion, the encrustation must be wetted during laser cleaning, compatibly with the conservation state of the artefact.

Tests and interventions on monuments

The effectiveness of the "Smart Clean" laser system was firstly tested in the laboratory on many types of stones and metals, and after it was applied on Italian monuments, as listed in the following:
- Cappella di Piazza del Campo in Siena, for cleaning tests on marbles of the façade
- Palazzo Rucellai in Florence to perform the complete cleaning of the capitals of the first of first level (pietra forte).
- S. Maria del Fiore in Florence to test cleaning of marble, serpentine and other stone types of the façade
- Mausoleo di Teodorico, Ravenna where the laser was successfully used with a long optical fibre to complete the cleaning of the denticulate decoration at the base of the monolithic dome (Aurisina stone).
- Church of S.Giovanni in Zoccoli, in Viterbo, to remove graffiti produced by a red synthetic paint from the internal walls formed by blocks of a soft volcanic sandstone (peperino).
- Baptistery of Pistoia, for cleaning tests on marbles of the façade.

Here we describe in some details only the applications to Palazzo Rucellai in Florence and to Mausoleo di Teodorico in Ravenna.
Palazzo Rucellai, designed by Leonbattista Alberti and built in 1452-1470, has been recently subjected to a restoration program in order to clean and consolidate the façade made of the typical Florentine pietra forte sandstone. In facts, in the last decades the stone surface had been severely attacked by urban pollution, with formation of thick "black crusts" that substantially depleted the aesthetic content of the monument and endangered its future conservation.
The first cleaning phase was carried out with chemical means (ammonium carbonate), which effectively removed most of the black gypsum from the surface of the stone. This operation brought to light the underlying "age" patina, mainly composed of a calcium oxalate film (about 100μm in thickness), which appeared discontinuous and of a very dark colour. The restoration protocol considered to preserve this film for both historical and protection reasons, but required to attenuate its dark colour, being aesthetically unacceptable and disturbing the view of structures and decorations of the façade. This result could be achieved by reducing the thickness of the oxalate film, i.e. by removing the very upper layer of the film (typically of few tens of microns), which was much darker than the stone because it encapsulated carbonaceous particles. Practically, the correct solution of the problem required the choice of a very precise and controllable cleaning method to be applied mostly on decorated surfaces. In addition, cleaning operations were complicated by the presence of previous consolidation treatments with fluosilicates, which rendered almost impossible the cleaning of the oxalate film by further applications of chemical pads.
The laser cleaning solution was indicated by the experts of the Opificio delle Pietre Dure, which were in charge of the scientific supervision of the restoration.
Preliminarily, laboratory tests of laser cleaning test were performed on some stone samples, already detached from the façade. They permitted to identify the more suitable laser cleaning parameters, by correlating the laser fluences (energy per surface unit) and the irradiation times with the thickness of the Ca-oxalates film to be removed. Moreover, the laser action presented a marked colour selectivity that helped to identify a fluence range (3-6 J/cm2), where the precise removal of the dark upper layer of the Ca-oxalate film could be accomplished in a controlled and safe way. Laser irradiation was always associated with spraying of little quantities of distilled water, which made the laser removal more effective by increasing the colour contrast between the dark surface to be cleaned and the clearer underlying Ca-oxalate film, and produced at the same time a good cooling of the irradiated area.
The laser intervention in the restoration yard lasted three weeks and was aimed to treat mainly decorated parts, such as all the capitals of the columns order of the first floor and details of the massive classical cornice with a motive of plumes.
The possibility to use long optical fibres (10-50 m) to deliver laser radiation was a key point for the success of laser cleaning operations. In fact, the laser was kept at the street level for the whole

duration of the intervention, while the very light-weight fibre cable allowed the restorer to easily operate on different works-sites of the façade. In terms of productivity, laser cleaning showed similar application time in comparison with micro-sandblasting. Moreover, thanks to colour selectivity, laser removal was easily and effectively applied to some regions of the façade where the Ca-oxalate film remained in isolated dark spots, without any damage to the adjacent clearer areas of the stone surface where the film was missing.

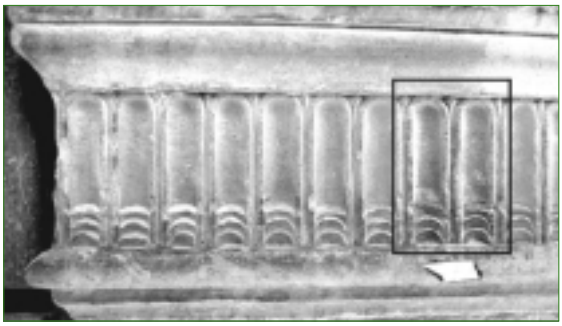

Figure 5 : *Details of a column capital. In the frame twoslots have not yet been cleaned.*

The conservation program of the Mausoleum of Teodorico (520-526 AD) concerned the treatment of the different types of superficial alteration and encrustation of the façade, such as lichens, fungi, algae, as well as black encrustation of gypsum.
After biological treatment, the removal of residual black crusts was approached by means of chemical pads (EDTA). The result was satisfactory except that for the denticulate decoration at the base of the frieze. Here, thick and tenacious black crusts, probably hardened by a previous consolidation treatment with Paraloid, could not be effectively. Micro-sandblasting was also tried, but the risk of causing damages to edges and small details of the decoration did not allow to obtain a satisfactory result.
The proposal of a laser approach was favoured by the possibility to preserve the calcium oxalate film that was found to overlay the original stone surface, as confirmed by preparatory laboratory cleaning tests, carried on Aurisina stone samples collected from the monument. These results were evaluated by pre- and post-cleaning analyses, such as stereomicroscope observations of the surfaces, polarising microscope observations of ultrathin sections and diffractometry analysis. The microstratigraphy of untreated samples showed, from top to bottom, a thick layer (300 µm) of black crust, and underneath, a level mainly composed of calcite and Ca-oxalates (100 µm in thickness), with a light grey-yellowish coloration. Finally, the carbonate substrate was well preserved, with rare traces of sulfation. Post-cleaning analysis indicated that the laser treatment provided precise and selective cleaning operations, removing the entire black crust level and preserving at the same time the Ca-oxalate film.
Before starting the operative phase on the dome of the mausoleum, it was necessary to solve the practical problem of keeping easy and safe tourist access to the monument during cleaning operations. This hindered the location of the laser in the close proximity of the sites to be cleaned. The problem was solved by using, as in the previous case, long fibre cables, which permitted to keep the laser body at the ground level, apart from the tourist walking route inside the monument.
The intervention required seven working days to be completed. Particular care was given to clean close angles and cavities of the decoration, where the black crusts were significantly thicker than on flat surfaces. The laser treatment was facilitated by the use of the flexible fibre cable, terminating in a lightweight and compact hand piece including an adjustable focusing lens. Operative laser fluences were in the range of 3-5 J/cm2 and the pulse repetition rate was set at 20 Hz. Ultrathin sections of samples collected at the end of laser operations confirmed that the laser treatment provided precise and selective removal of residual black crust, preserving at best the Ca-oxalate film.

Tests and interventions on statues

In other interventions the conservation problem was regarding very valuable pieces such as marble statues of the florentine renaissance period located outdoor in the center of Florence. This has been the case for the Prophet Abacuc by Donatello, or for the group "Quattro Santi Coronati" by Nanni di Banco. After testing in comparison the ability of the various approaches to preserve at best all the fine details of the figures, including some gilding remnants on the hairs and the dress borders, the solution selected for these masterpieces by the conservators at the Opificio of Pietre Dure was cleaning with lasers. Along the complete treatment many lasers with different operating regimes were investigated, and certainly our solution using intermediate pulse duration was confirmed to give uncritical behavior on the material, with no yellowing of the marble, and no occasional spotting of the oxalate patina as observed with short high intensity pulses. For these reasons the Restoration Laboratory at the Opificio of Pietre Dure is presently equipped with several Smart Clean laser systems, suitably preferable for valuable pieces.

Figure 6 :
The Mausoleum of Teodorico under restoration. The laser can be noted on the left at ground level. The cleaning operation on the scaffolding is carried on by means of the optical fibre handpiece.

Figure 7 :
The Prophet Abacuc by Donatello during the laser cleaning procedure.

Conclusions

Our approach to the field of laser cleaning in art conservation has been based on interdisciplinary studies closely involving laser physicists, conservators, petrologists and engineers. The critical reviewing of the laser technology and the design of laser systems operator–oriented and with well predictable effects on the materials have been crucial to dissipate all the doubts and misunderstandings about these techniques, mostly due to previous incorrect procedures and laser parameters. Now several projects at regional, national and European level have promoted a correct approach with successful results for a wide variety of conservation problems. This has determined a big change in the point of view of the conservators community, with a well recognised acceptance of laser methodologies as new very useful approaches to be used as stand alone techniques or in association with other more traditional techniques on monuments and historical buildings, whenever they are really needed. Still there are open issues which need further research to be completely addressed, such as to enhance the "productivity" of a laser cleaning technique in comparison with less expensive ones, especially for large surface treatments. But this becomes important now, because the technology is mature enough for being considered in the costs forecast of real restoration interventions, and with no doubt other laser solutions are likely to be proposed for large surface tasks, as it can be reported recently (5). In the same time Nd:YAG lasers with intermediate pulse duration appear today the best choice for conservators, and represent an almost ideal solution for the conservation of highly valuable masterpieces such as statues, and artistic details of monuments and historical buildings.

Acknowledgements

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Biography

Dr. Renzo SALIMBENI was graduated in Physics at the University of Florence in 1975. Dr. SALIMBENI joined the National Council of Research at the Laboratory of Quantum Electronics, working primarily on laser physics and technology. In 1978 he had an annual fellowship by IBM Corp. working at the IBM Research Laboratory in S.Josè, California, studying non-linear optics and laser instrumentation.
Since 1991 Dr. SALIMBENI is the Director of the Institute of Quantum Electronics in Florence. He has published more than 100 papers on the subjects of lasers and their applications, and has been responsible for a number of scientific projects related to applications of lasers in biomedics, in industrial technology and in conservation. His present interests are physical processes induced by high power laser in material processing and in cultural heritage conservation. He is the Italian delegate for the COST Action G7 on the subject of Art conservation with lasers.

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Non invasive laser measurement for diagnosing the state of conservation of frescoes and wooden icons

Mesures non destructives par laser pour le diagnostic de l'état de conservation de fresques et d'icônes

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Abstract

The project aimed to assess the state of conservation of frescoes paintings and icons by means of non-destructive laser measurement techniques and specifically Laser Doppler Vibrometry (LDV) and Optical coherent techniques with emphasis on Holographic interferometry (HI). The investigation was structured in three consequent phases starting from the definition of the diagnostic problems encountered in art conservation in which an issue of primal importance is the detection of buried defects developing as detachments and cracks within layered structures, to the definition of experimental procedures and techniques suitable for art conservation limitations and requirements to finally develop prototype systems suitable for on-field structural diagnosis of artworks.

Résumé

Ce projet a pour objectif d'évaluer le degré de conservation des fresques et des icônes par des mesures laser, en particulier par la méthode LDV (Laser Doppler Vibrometry) et diverses techniques optiques principalement basées sur l'Interférométrie Holographique (IH). Cette recherche s'est déroulée en trois phases. La première concernait la définition des problèmes de diagnostic dont l'un des plus importants est la détection des défauts couverts pouvant aboutir à des détachements ou des fissures sur les structures stratifiées ; la seconde, les différents procédés expérimentaux adaptés aux limites et nécessités de la conservation et la dernière, le développement de systèmes prototypes pour le diagnostic structurel des œuvres sur le terrain.

Objective and repeatable structural diagnostic techniques become of critical importance in art conservation of movable and immovable cultural heritage. The former are frequently transported for tour-exhibitions and the latter share an increasingly unstable and polluted environment. The assessment of structural condition and mechanical integrity of such precious cultural heritage items and sites still relies either on manual inspection practices and point-by-point estimation (microscopes-stereoscopes) or wherever applicable on heavy installation facilities (x ray). Only the thorough analysis of existing deformations can safely lead to prevention of subsequent deterioration processes blocking the otherwise progressively developed irreversible mechanical damage and aesthetic failure of the artwork.

In this context, the measuring capabilities of laser techniques are exploited to overpass the fragmented conservation practices in structural damage assessment and mechanical response definition of plaster and wooden paintings. They share common and complementary technical characteristics uniquely suited for artwork investigation. Among the most important shared ones are the non-destructive and non-contacting investigation procedures ensuring the lack for sample removal or surface preparation, and the use of safe optical irradiation for both the item and the operator. Complementarity is fulfilled by the high spatial resolution capabilities of holographic recording allowing visualisation of defect formation in one acquisition with the remote access investigation capabilities of scanning vibrometry both provided without requirement for permanent installation facilities.

Two main defect types are accused for acceleration of degradation processes both in frescoes paintings and wooden icons and are herein investigated. These are detachments developed between and cracks developed across the layers. The laser-based approach utilised for their diagnosis rely on the analysis of the investigated surface under forced excitation inducing differential displacement of the defected region in regards to the unaffected regions.

Experimental techniques

The LDV and HI measurement techniques employed provide objective and repeatable measurement on the presence of cracks and detachments in the structure recording their location, shape and size to output a full mapping for diagnoses and monitoring the state of conservation.

Scanning Laser Doppler Vibrometry : principle and methodology

Scanning Laser Doppler Vibrometry (SLDV) is a non-destructive technique based on measurement of surface vibrations of an object to infer the presence of hidden defects, in particular voids and delaminations. The standard Laser Doppler Vibrometer (LDV) is a non-contact velocity transducer working on the principle of measuring the Doppler frequency shift of a laser beam scattered from a moving target by means of an interferometer [1]. The on-board electronics converts the Doppler signal to an analog voltage proportional to the instantaneous velocity of the target. The combination of an interferometer with two moving mirrors driven by galvanometric actuators makes it possible to direct the laser beam to the desired measurement points. Such an instrument, the Scanning Laser Doppler Vibrometer [2], quickly performs a series of velocity measurements on a grid of points over the structure under test [3]. By scanning the laser beam across an object one can observe the frequency content of the velocity signal that will show significant differences in presence of a hidden defect, e.g. a void, with respect to an integral sample or to an integral area of the same defected sample, figure 1a, b. Based on all previous experiences is defined a general measurement procedure, consisting of two different stages, leading to defects identification and characterization. The first scan on the work of art is done by white noise excitation and measuring the RMS value of surface vibration by SLDV ; the result is a point-by-point map of the surface RMS velocity. This puts in evidence the detached areas very quickly, because they show as higher velocity ones. After defects localization it is possible to investigate the associated spectrum by pointing the laser, for example, at the center of the detached regions. Employing an FFT analyzer, resonance frequencies are identified and subsequent scans are executed looking surface vibrations at these same single frequencies.

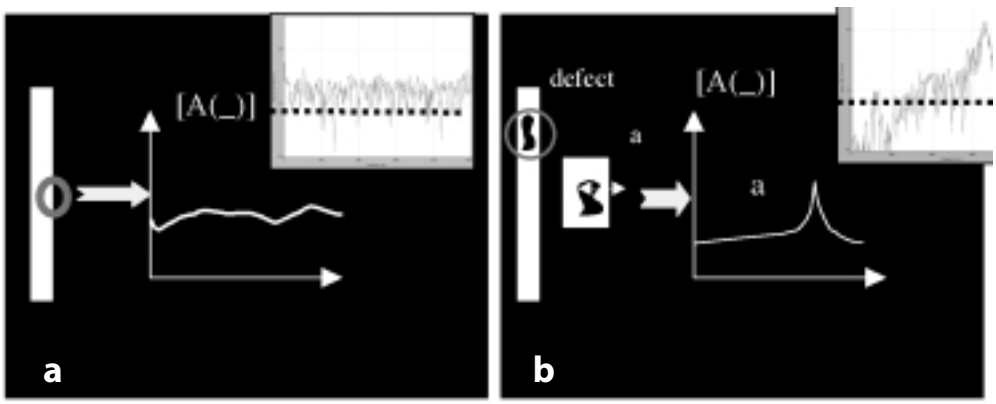


Figure 1, a b : *The velocity signal shows significant differences (a) an integral sample or to an integral area of the same defected sample with respect to (b) presence of a hidden defect, e.g. a void.*

Holographic interferometry : principle and methodology

Holographic Interferometry is a non-contact and non-invasive technique for detecting detachments and cracks underneath the surface of a variety of objects independently of shape, surface texture, composition or size. In a holographic interferometer the rough surface of the object scatters light into a variety of directions, any one of which can be used for 3D viewing, analysis and archiving. The full field view provided by lensless hologram interferometry allows for the overall qualitative and quantitative analysis of objects under test and the simultaneous defect detection, location and sizing [4]. Uniform low-spatial-frequency fringes covering the whole surface of the object are generated from small surface displacement due to an external thermal gradient intentionally induced to surface layer. These are interrupted from non-uniform local discontinuities indicating the defects while from the local fringe features is estimated the kind and size of the defect. In figure 2 are shown holographic interferograms with characteristic fringe systems prior and post laser-cleaning operation. The irregular fringe distribution prior to laser cleaning denotes presence of subsurface detachment. The regularity of fringes after the laser cleaning is characteristic of non-defect presence. Usually two beams of the same laser source provide the interferometer from which one will be scattered by the object and the other will serve as a reference wave for holographic interference. Over-

Figure 2 : *A ceramic statuette in the middle examined with holographic interferometry at left prior and at right after the laser cleaning. The circular pattern reveals a characteristic detached region due to lost of adhesion of the upper pigment layer to the solid whereas the continuity of fringes observed after the cleaning confirms successful restoration process.*

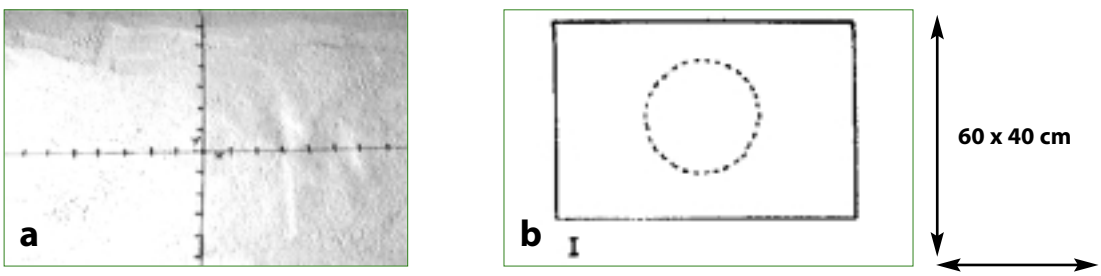
lapping the hologram of the object in an initial and an excited state produces a double exposure holographic interferogram. The introduction of a thermal gradient produces a desirable structural deformation owing to the variety of thermal expansion coefficients of multi-layered structures. A CCD camera positioned at the observation plane can deliberately be used to capture the interferogram if further image processing and quantitative interference analysis is concerned[5]. The principle is very convenient for artworks investigation since it provides from a simple and similar to photographic process investigation an overall fringe system unique to the whole artwork response to external stress while it locates areas of deviation due to defect presence. Holographic interferometry can be performed in a variant of geometry arrangements according the requirements of the investigation providing thus a flexible diagnostic tool adjustable to the various artwork relevant investigation demands[6-8].

Results

The series of experiment during the first exploratory phase of the application of the techniques were performed on simulated samples with induced defects constructed by specialised conservators and tests were further proceeded on-field with transportable prototypes. Characteristic examples are presented.

Investigation on Fresco paintings

Inspection of fresco surfaces is currently performed by an experienced restorer that knocks on the wall surface while listening to the reflected sound signal. Detached regions produce a bass instead of a shallow sound that is produced by well-attached regions. The manual practise is poorly repeatable and time consuming preventing from periodic monitoring. The rough estimation of the size and magnitude of deformation of the detached region provided is not suited for assessing the time evolution of damage and planning for preventive deterioration strategies.
Highly sensitive measurement techniques are required for early detection of structural damage to allow early restoration that prevents irreversible damage to occur. In this context the fast and accurate defect detection capabilities of the proposed techniques accelerate and ensure the restoration processes. In figure 3a-f is shown the photograph of a fresco sample and the topography map showing the induced detachment constructed by the restorer. HI successfully detected the detachment with high accuracy within seconds, results shown at figure 3c-f.



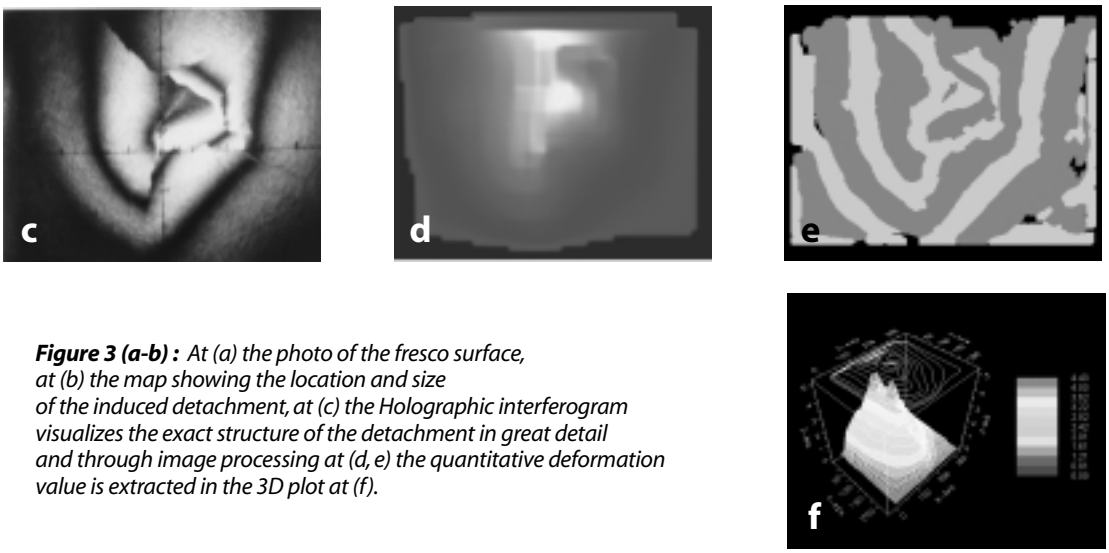


Figure 3 (a-b) : *At (a) the photo of the fresco surface, at (b) the map showing the location and size of the induced detachment, at (c) the Holographic interferogram visualizes the exact structure of the detachment in great detail and through image processing at (d, e) the quantitative deformation value is extracted in the 3D plot at (f).*

The SLDV system performed investigation on frescoes of Orvieto Cathedral to support the actions of restoration. The SLDV results compared to the restorers map traced more defects and defined with more accuracy the known ones from a distance of 2 m. A photograph of the Cathedral and the SLDV system with the acquired results are shown at figure 4a-d.

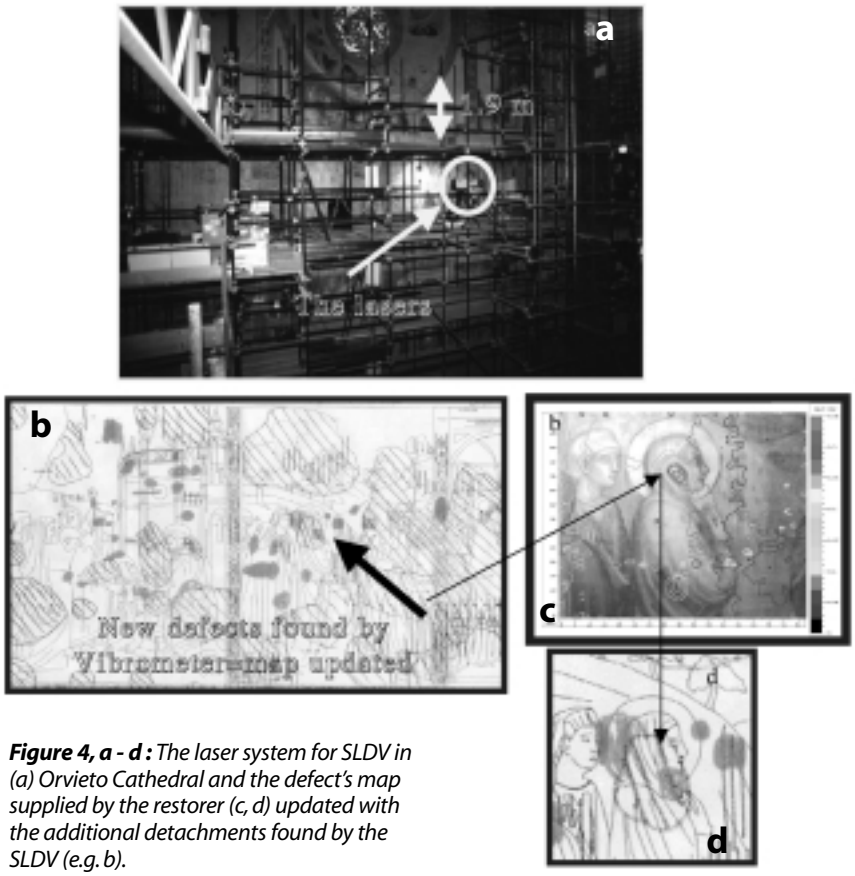


Figure 4, a - d : *The laser system for SLDV in (a) Orvieto Cathedral and the defect's map supplied by the restorer (c, d) updated with the additional detachments found by the SLDV (e.g. b).*

Investigation on paintings and Byzantine icons

Wooden paintings such as Byzantine icons, conservation and diagnosis problems are related not only to ageing but also to transportation. They are often moved from one location to another for exhibitions and the most precious ones are often subject to damage due to increase interest of

exhibiting them. The need to determine their state of conservation is related not only to conservation problems but also to certification for legal and insurance purposes. The use of x-ray radiography, infrared thermography or manual inspection show poor spatial resolution identifying only defects of extended dimensions. Identification of small defects and provision of accurate topographic maps of defect location and size can define any alterations due to transportation while aids the restoration process and the comparison of conservation state among different instances in time. Two characteristic results obtained with HI and SLDV are discussed here in regards to the application on Byzantine icons. The first is related to the ability of the techniques to assess restorers' interventions and retrieval of defected areas untraceable, in case of HI by x-ray that is still considered the ultimate tool for structural diagnosis and in case of SLDV by manual inspection of experienced restorers, provides the second.
At figure 5a is shown an El Greco painting examined with HI during the drying of consolidation process and after a year. These two results form part of an extended study that was made on this painting prior and after an exhibition tour. A surface region of loose adhesion generates a lot of detachments seen in holographic interferogram (figure 5b) as highly discontinuous local fringes the magnitude of which results to an overall extreme deformation value of the central theme of the painting (3D plot figure 5c). The successful consolidation of the same detail is seen at figure 5d as minimisation of fringe discontinuities and allows detecting the mechanical influence of the underlying crack seen in the 3D plot of figure 5e as three regions of diverse displacement direction.

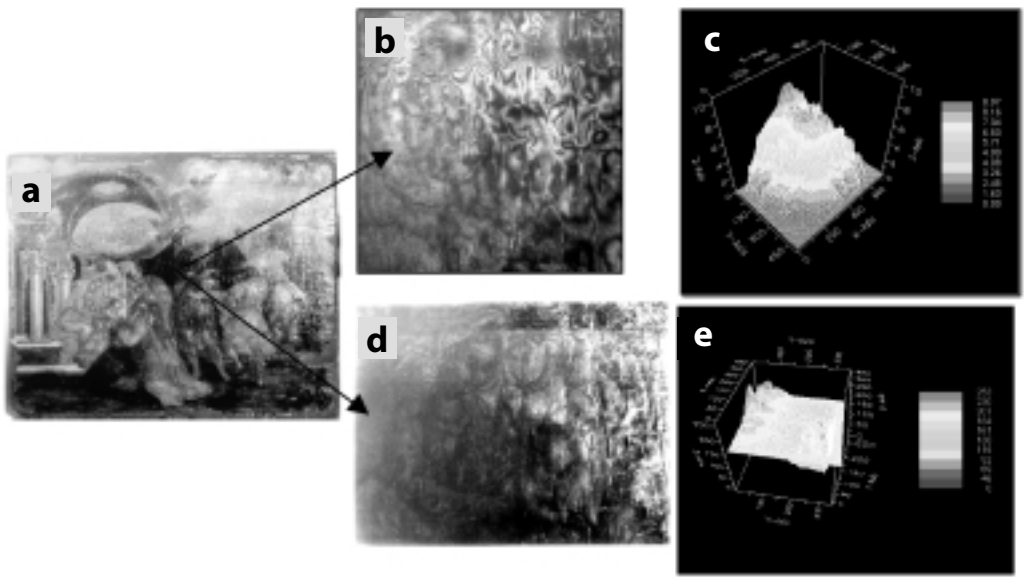


Figure 5, a - e : *The early El Greco painting at (a) was investigated with HI. In this example is shown at (b, c) the alarming influence of many small detachments of the surface layer, at (d) the consolidation of the surface layer that allowed at (e) tracing the effect of an underlying crack.*

Figure 6a-c compares two on field SLDV measurements on the same icon before and after the execution of a restoration to consolidate the damaged paint layer. Before restoration the area surrounding the Christ head was clearly vibrating more than the rest of the artwork, thus revealing a detachment of this part of the sample. After restoration there appear to be no relevant difference in the vibrational behaviour of the whole of the icon, thus confirming the good output of the intervention.

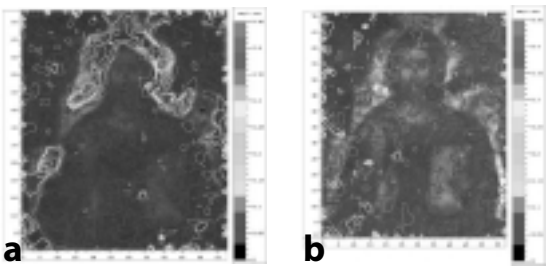


Figure 6 :
The Byzantine icon investigated by SLDV in (a) before restoration and in (b) after restoration.

It is well known in conservation laboratories that the ultimate tool to assess the conservation state of movable artworks is use of x-rays. In figure 7 can be seen a HI example of the on-field investigation of a Byzantine icon (7a) in comparison with the x-ray (7b), the x-ray shows the two visible holes, the holographic interferogram (7c) has detected an extended deformation in the region due to the influence of the two holes.

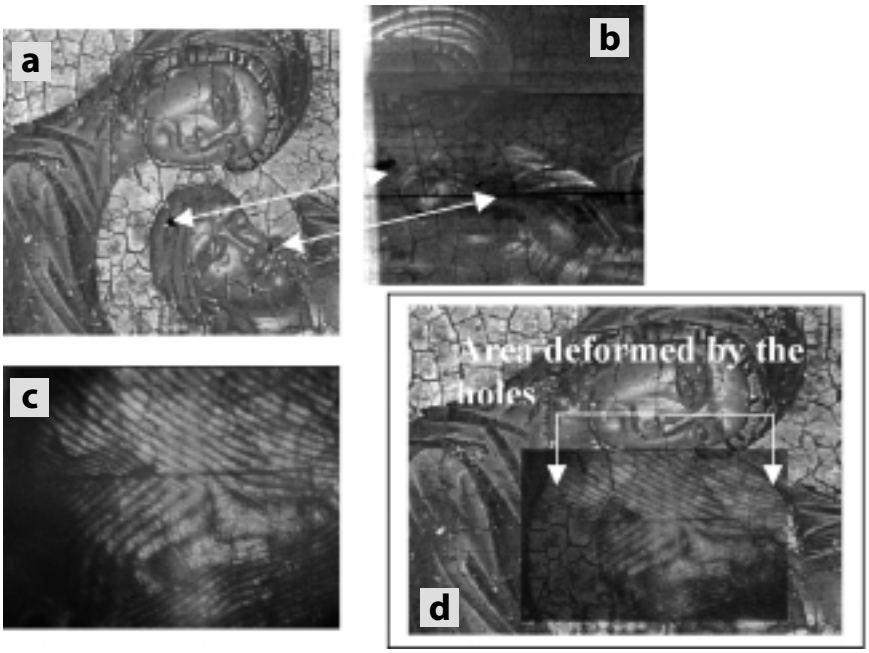


Figure 7 :
The Byzantine icon at (a) and its x-ray image at (b) with the two holes shown by arrows, at (c) the holographic investigation revealed a whole region among them degrading by their influence.

An experienced restorer can distinguish differences in the sound produced when a detachment is present. There are cases though that the extent of damage is not easily identified and the restoration process is further delayed. The old library of the Charlemagne Lyceum in Paris (figure 8a) is in a building constructed in the XVII century and important modification in the library structure made invisible the frescoes decorating the roof (figure 8b). Only recently they have been "rediscovered" and restorers exploring them using different techniques before starting a complete restoration. An SLDV investigation provided a mapping of the critical for restoration regions detailing the complex overlapping of detachments (figure 8c-e) that allowed to restorers to update their maps and to get envisaged the endangered areas for restoration.

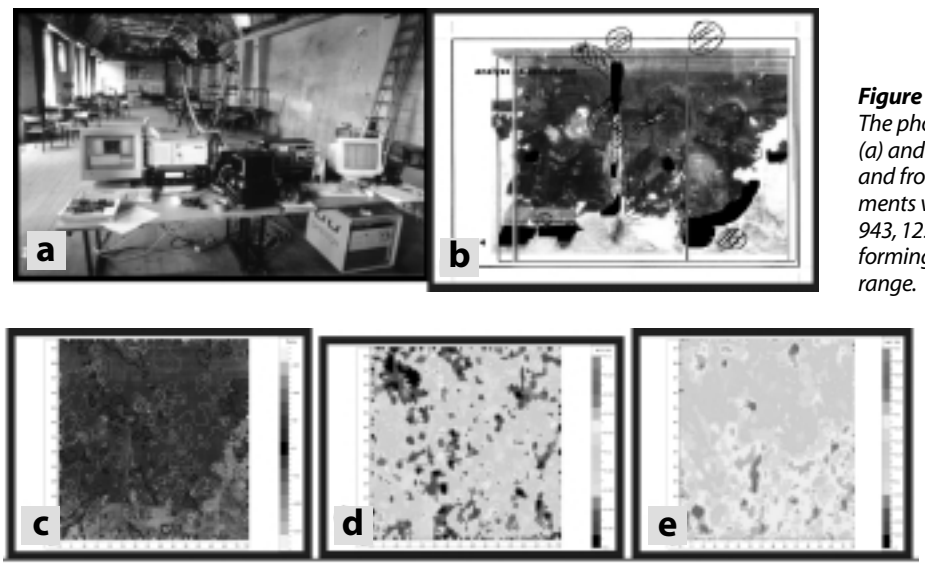


Figure 8, a - e :
The photos of the library (a) and hidden frescoes (b) and from (c-e) detachments vibrating at 830, 943, 1235 HZ respectively forming a full detection range.

Conclusions

A completely non-invasive, non-destructive laser-based diagnostic investigation based on the alternate use of Holographic Interferometry and Scanning Laser Doppler Vibrometry has been realised in conjunction with conservators and in comparison with conventional structural diagnostic documentation. Such an approach in conservation is first time realised according to our knowledge. The techniques overpass the limitations of conventional structural diagnostic practices offering objective and repeatable measurements. Holographic interferometry allowed in one acquisition (~1 sec) a highly detailed defect definition and outclasses current methods by visualisation of defect propagation that extrapolates future deterioration. The output is uniquely suited for movable artworks, which can be routinely tested by the small transportable holographic inspection system developed for the presented investigation. Scanning Laser Doppler Vibrometry incorporates the ability to reach far away artworks with a scanning beam without dependence on distance and weather. The remote access capability offered overpasses any known given practise in fresco restoration. Generally the systems have demonstrated good characteristics as diagnostic tools for artworks inspection although there still remains room for system improvements. However even at the present state, offer a series of important advantages over traditional techniques : a) no sample removal, b) remote measurements, c) fast and objective results, d) high sensitivity, e) transportability.

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Biography

Vivi TORNARI (BSc., PED, MPhil-DIC), is currently research scientist at the Foundation for Research and Technology Hellas in the Institute of Electronic Structure and Laser (FORTH/IESL) in the Laser Applications Laboratory (LAL). Nationality Hellenic, born in Athens. Optics degree 1990 (National Technological-Educational Institute of Athens). Post Educational studentship granted with EC Scholarship for a P.E.D on Applied Optics-Holography in Royal and Imperial College (RCA/ICSTM) in London at 1991. Post Graduate studentship awarded from the Joint Interdisciplinary Research Course for an MPhil/DIC degree in Optical Holographic Interferometric applications in artwork conservation, departments of Applied Optics–Holography-Conservation accordingly at ICSTM/ RCA/V&A from 1992-1995. MPhil awarded July 1996. Since 1996 employed as research staff at the FORTH/IESL in Crete operating the Holography and Holographic Interferometry unit for the ULF (EC- Ultra Violet Facility).

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Lighting works of art : problem definition

L'éclairage des œuvres d'art : définition du problème

Giancarlo CASTOLDI[1]

Abstract

Light is a fundamental aspect for artworks. Here below I'll describe the theme from a scientific point of view , at least mentioning the essential elements and from an emotional approach. There are also some case histories on projects and research made in this field, like a new product and the lighting system for Last Supper of Leonardo da Vinci in Santa Maria delle Grazie in Milano.

Résumé

En matière d'art, l'éclairage a une importance cruciale. J'aborderai ici ce thème sous son angle scientifique en ne mentionnant que les éléments essentiels ainsi que du point de vue émotionnel. Je citerai également quelques exemples de recherches et de projets tels que ceux d'un nouveau produit et du système d'éclairage de la Cène de Léonard de Vinci à Santa Maria delle Grazie à Milan.

It does not exist one type of light good for everything, but each case may be treated in an infinite number of ways, according to how we want to "show". In fact the artwork, without light, "disappears". There are many ways to make it "appear again".

Scientific Approach

As you know, visible light contains all colours, but in reality, we have to work only with parts of this spectrum (light sources).
Changing the spectrum changes also Colour Temperature and not only the results are quite different, but certainly the emotional impact is definitively different.
Analysing the spectrum is only one part of the problem. We must analyse the surface as well in at least three main aspects

1. The reflection factor, very important when you will have to decide the positioning of the luminaries (and not only !).
2. The sensitivity to photo damaging of the surface. Often is a quite complex process because the materials may be many : including those used during restoration.
3. Still analysing the surface, the third aspect we need to study, is the way colours are being given back by the surface. In fact, the surface will select a part of the spectrum and absorb it and will give back all the rest, but not 100% of the quantity received.

Some times it will give back only 20% or even less (very dark subject, or matt surfaces, etc). Moreover, as "pure colours" almost does not exist, the missing of one part of the spectrum means not only to loose the colour related to that specific part. If we take away the blue, we do not only loose the blue, but also all the blue which is used to render all the other colours.

Now that we have an idea of which **colours** will be reflected and in which **quantity** will be reflected (dark or clear subjects) we may add the information about the total sensitivity of the surface. In this case, paper and watercolours : if it is true that UV radiation is very harmful, also colours near to 380nm arte still quite damaging. It is not sufficient though to avoid UV, but the total amount of energy we use, must be reduced as much as possible. It means that we have to control not only the amount of light on the artwork's surface, but also the light we put in the surroundings : if we keep very "dark" the whole environment, a minimum amounts of light is still enough to have a good **perception**. But…what is Perception? What is Vision?

Emotional approach

A subject may change in different light conditions. It is possible to play with architecture to create some "full" and some "empties. At night, the situation is totally reversed : the empties are full and vice versa. It is possible also to play with materials. In fact glass may be transparent or not reflecting light.

The project to light David of Michelangelo at Museo dell'Accademia in Florence is a good example of different emotions you may obtain. The scientific analysis told almost zero ! Any "white" light could be OK, despite the colour rendering, as the surface is white marble. Second, marble is quite resistant to photo damaging, so I can use "whatever I want". The idea was to "put back under daylight" the David as it was originally in front of "Palazzo Vecchio" and try to give some of the infinite variations that may occur under the sunlight. You will see, summer days, winter days (cold light), sunsets, etc.
Interference filters, allow you to manipulate an existing spectrum and "tailorise it" by *cutting off* the undesired wavelengths.
There are many ways to control perception : one of the most obvious is the way you illuminate.

A subject in the middle of nowhere may appear totally alone. If I focus the space around him it appears "less important" or "less unique" than previously.But, most of all the real problem to face, is how to control luminance. Luminance is the light which we actually see. Is the light reflected by the subject.

Case histories - "Light navigator"

As we saw up to now, the control of the spectrum is a key factor. When you control all the light emitted into an environment, but what happens when you have "a window" ? I mean, of course any kind of light which may penetrate the given environment and which is not foreseen in the lighting design. This "intrusive light" will most probably change the spectral conditions of the light on the artwork and therefore the perception. The University of Florence just finished a specific research on how to control this phenomena. The research was carried out in the Laboratories of the University which are located inside the premises of Targetti Sankey in Firenze.
A system to *automatically control* and *guarantee* a given spectrum, independently from other intruding "lights".

Last Supper of Leonardo da Vinci

Last supper - sponsored by Olivetti - took more than 20 years to be restored and many people and experts were involved to help Mrs Pinin BRAMBILLA, the chief restorer, to accomplish such an extraordinary enterprise. We were called with a very short notice to solve a quite complex lighting problem.
The dimensions of the art work were pretty unusual, considering that it is placed at about two meters from the floor.

There were more than one problem to face regarding vision, the dimensions and the space where not easy to handle, as well as the colours, due to a safety problem the very low levels of radiation that the masterpiece can support. Regarding security, it was advisable to avoid any interference between the public and the artwork.

Although the time given was quite short, a good amount of it was dedicated to the technical analysis
This were the results of the analysis.
- A "working level" of 50 lux, for the standard visitors, and occasionally the possibility to increase these values during very special situations.
- The best possible uniformity on the whole surface. A controlled flux, meaning that the light had to be used ONLY on the artwork, leaving all the other surfaces possibly in darkness, so to concentrate the attention on the painting and therefore be able to see it in a minimum light condition.
- The positioning of the illuminator, should not exceed this distance.
- Ideal in terms of appreciation of both, details and the whole.

The choice of the light source was a philological choice : during the restoration, similar light sources were used, therefore colour matching and colour references were judged according to a similar flux. The colour temperature was decided on the basis of the general gamut range used by Leonardo. Another good reason to use light-efficient sources, was to minimise the emission of Infra Red (temperature) in the room. In fact, electronic gear - highly efficient - were used for the flux control.

Today's technology allows the use of dimmers with these kind of sources, without having too many variations on the rated spectrum.
Simplicity is a key for the success of a system over the time. Maintenance has to be easy and without the risk of compromising the lighting results: not during relamping nor during the cleaning.
A first photometric study showed the need of series of extremely asymmetric beams, with an independent control systems, but soon appeared that the edges of this photometry, were not sufficiently controlled and would have illuminated surfaces around the painting.
To have a total control on each lumen emitted by the source, a fully indirect flux was designed and no uncontrolled light was allowed outside of the luminaries.

Hidden light source, vertical anti glare louvers controlling the spillage of the C90° plane (which means along the luminaries) . They are internal to the fixture to avoid deposition of dust (reflective).

Results we obtained with our system.

- Maximum efficiency thanks to a double evolving first reflector.
- Totally enclosed fixture (to maintain efficiency over the time).
- Smallest possible dimension of the opening.
- Dimming control to balance the illuminance of each segment.
- An anti UV polycarbonate filtering screen to close the luminaries.

Conclusion

Light is a formidable mean of expression, which may allow us to describe the world in an infinite number of ways. A scientific approach is very important but also the emotional approach is essential for a proper understanding and full perception of an artwork.
Lighting is a discipline in constant evolution and I would like to focus the attention on a specific space, recently founded where Light and all the phenomena related to light, are studied, talked about, teached, learned., etc.
The "La Sfacciata" Lighting Academy in Firenze is a non profit organisation sponsored by the highest authorities in the field. The address of the Portal of Light is www.lightingacademy.org.
This dedicated space, is fully devoted to the promotion of the Culture of Light, that light which not only allows us to see the surfaces, but, when properly used, may give us a level of perception which goes well beyond surfaces.

Biography

Giancarlo CASTOLDI has been working for about twenty years in lighting field for Targetti Sankey S.p A. He has an international experience that allows him to work with the most important . Lighting Designer and professionals in many countries. Actually he is the director of Business Development Division of Targetti Group.

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Session C How do we reconcile the sustainable development of cities with the preservation of cultural heritage ?

Session C Comment concilier développement durable urbain et préservation du patrimoine culturel ?

Rapporteur : Talaat TANTAWY

The first two presentations were on strategies of preventive archaeology in an urban context. These presentations explained the role of the planner and of the decision-maker as well as the protection techniques employed in order to reduce risks. The legislation of the different European countries for the protection of archaeological assets was also presented.
The second two presentations dealt with the protection of historic monuments from the effects of tunnelling and settlement. A method of modelling before tunnelling and a method to introduce some corrections were presented. The monitoring of historical monuments during construction activities that produce vibration was also explained.
The last presentation showed a case study about the integration of new library buildings in the centre of historical cities.
In my opinion, the conclusion of this session is that the cultural heritage has established equilibrium with the environment. Modification of the environment has an impact on the cultural heritage. The threats to cultural heritage originate from pollution and settlement. There is also a threat from planners and decision-makers who are unaware of the potential danger they can cause to cultural heritage. This session was very interesting in that it pointed out new subjects for European Commission research in the coming years.

Rapporteur : Talaat TANTAWY

Les deux premiers exposés concernaient les stratégies d'archéologie préventive en milieu urbain et présentaient aussi bien le rôle du promoteur que celui du décisionnaire. Il a également été question des techniques de protection visant à réduire les risques encourus et des législations des différents pays européens en matière de protection des vestiges archéologiques.
Les deux exposés suivants ont traité de la protection des monuments historiques contre les effets des constructions souterraines et de l'urbanisation. Des tentatives de modélisation et d'introduction de corrections ont été présentées. Les méthodes de contrôle régulier de l'état des monuments historiques au cours des travaux ont également été évoquées.
Le dernier exposé proposait une étude de cas illustrant l'intégration de nouveaux bâtiments de bibliothèques aux centres historiques des villes. Cette session a pu mettre en évidence que le patrimoine culturel et l'environnement sont en équilibre et que la modification de ce dernier n'est pas sans conséquence pour le premier, menacé non seulement par la pollution et l'urbanisation mais également par l'inconscience des promoteurs et des décideurs face aux dangers encourus. L'intérêt de cette session a été de désigner les sujets à aborder dans le cadre des programmes de la Commission européenne au cours des prochaines années.

Planning for construction and the protection of buried archaeological remains

La programmation des travaux publics et la protection de vestiges archéologiques enfouis

Taryn NIXON[1]

Abstract

This paper is about the integration of archaeological work with construction. It will focus on the decision-making process – as distinct from the formal town-planning process, and on the issues relating to buried archaeological deposits rather than to historic structures above ground. The paper argues for an holistic approach to decisions about development, whereby the best (most sustainable) development decisions are achieved by integrating cultural considerations with the other social, economic and political influences. In this way, the resultant development decisions will strike a balance between the need to preserve the past and renew for the future. Importantly, such decisions also aim to strike a balance between the many variables that make modern urban living a success. The paper emphasises the particular importance of priorities that are established at a local level. The following text is as spoken.

Résumé

Ce document traite de la prise en compte des travaux archéologiques dans la construction et plus particulièrement du processus décisionnel, distinctement du processus officiel de planification urbaine. Consacré aux problèmes liés aux vestiges historiques souterrains plutôt qu'à ceux des édifices historiques situés en surface, il défend une approche complète des décisions relatives au développement afin d'obtenir les meilleures (les plus cohérentes dans la durée) grâce à la reconnaissance de considérations culturelles parallèlement aux influences sociales, économiques et politiques. De telles décisions mèneront à un équilibre entre la nécessité de préserver le passé et celle de le renouveler pour l'avenir ainsi qu'entre les divers facteurs favorisant le succès de la vie urbaine contemporaine. Ce document souligne également l'importance à accorder aux priorités locales.

International, national, regional and local planning

When we plan for archaeology and construction, we turn naturally to international conventions, European directives and national laws. For example, we follow the Malta Convention (1992) and apply the principles of the Venice Charter (1964) ; we implement the Environmental Assessment Directive [85/337/EEC and 99/11/EC]. And across Europe, the different member states each have their own ancient monuments laws and systems for listing and legally protecting archaeological treasures… Whether they are above ground or buried, and whether they are splendid tourist attractions or less presentable (yet information-rich) buried sites. In England, the laws include the Ancient Monuments and Archaeological Areas Act (1979), and at a national level, the principles of integrated conservation are implemented through a powerful piece of planning policy : Planning Policy Guidance 16 (1990).

But of most significance is how national laws and policies are implemented at the local level. Local plans state what is really important to a particular region, or city, or province. Local plans describe the particular and unique needs, hopes and priorities for that particular region. It is the local plan which draws on legal frameworks, but which tackles the competing influence of social, economic and political pressures and gives clear guidance. It is the local plan which can say "this is the sort of town, or region, we want to be". Importantly, it is the local plan which can consider the whole spectrum of aims together, in a whole, rounded package. This is, for me, a vitally important point : that in order to weigh up a planning proposal, we need to look at the local priorities.

In exactly the same way, decisions about archaeology – whether to preserve or to excavate (or both) – are best made at a local level. What we are trying to do is preserve a representative sample of the nationally important archaeological resource (not everything ; not just, say, displayable structure ; but a representative sample).

Striking a balance

A good planning decision will aim to strike a balance. As the new Council of Europe Code of Practice on Archaeology and the urban project (EC 2000) states : "in order to prosper, towns must continue to change and develop as they have always done in the past. This means that a balance must be struck between the desire to conserve the past and the need to renew for the future." Sustainable development requires just such a balance of aims … and archaeological preservation in the midst of living, breathing communities is, too, a balancing act.

So these are the two philosophical points underpinning my talk today :
First, that the best planning and the best decisions (in the best interest of the community), are made at a local level, and second, that striking the balance on any particular scheme, in any particular city or region at any one time, is a balance between all the many variables that make modern living a success.

To strike the right balance, therefore, must be a judgement. The following are a few examples (largely from work in central London) of how such judgements have been made, with suggestions for how the decision-making process might be improved in the future.

The role of the professional archaeological unit

The Museum of London Archaeology Service comprises over 200 professional archaeologists, with research interests covering all periods ; we also employ qualified surveyors, environmentalists, geographers, graphic illustrators, computer design experts and project managers. Like all archaeologists who work in the context of property development and construction, we wear two hats. The first represents archaeological research, and the work we do to understand our past and provide our public and our clients with a sense of their own past and their own identity. The second hat is that of the client's professional employee : we give our developer clients guidance and steer them through the planning process, helping them to meet their archaeological requirements as cost-effectively as possible and with as much benefit as possible.

So to our clients, we are both consultants, bringing archaeological expertise to a development team, and contractors, providing practical, services like survey, excavation, recording, publication, public consultation, exhibition… But sadly, archaeologists are not necessarily the most popular members of the team. Archaeology is a very young profession, and even today, with archaeology firmly built in to European, national and local law, when it comes to an individual project, our clients - property developers - will commonly fear unexpected discoveries, with the potential for delays, additional costs, or perhaps the requirement to redesign the development or re-route the road or pipeline. These are very real fears with very real costs attached, potentially affecting rental or sale income and perhaps even placing constraints on how a development site might be used in future.

So archaeology is often seen by the property world as a major, negative risk. When a client has not dealt with archaeology before, they might be tempted to wait until the last moment, and contact us after the foundations have been designed and after the overall budget has been planned … so of course archaeology then becomes a major nuisance. All the archaeologists can do then is try to minimise the impact of their work and prevent disasters ; but overall, this sort of situation sets all parties against one another ; there is no true integration of aims and objectives here.
To overcome these problems, I believe that archaeologists need to embrace four fundamental aims.
One : to provide relevant information early enough to enable our clients to integrate archaeology with their proposals, and to enable the government planning authorities to make informed decisions about how to treat the archaeology.
Two : archaeologists need to give clients as much certainty as possible. This means we must aim to identify archaeological risk, in order to eliminate it, reduce it, or manage it. We all know that archaeology is about discovery, and therefore by definition should be full of uncertainty. Our approach should quite simply be modelled on risk management practice.
Three : archaeologists need to seek acceptance as part of the development team. This is a two way process : in England, ten years or so ago, it was the archaeologist's ambition to fit in with a construction programme, to try not to have an impact. Today, our ambition has evolved to a more

sophisticated level : archaeology not only has a valid place in the development process but should also make a contribution to an overall development. This can't be achieved if archaeologists are treated only as a visiting specialist : the archaeologist has to be an integrated part of the team, working towards the common project aims.
Four : therefore, the team should work to use the archaeology to add value to development.

The following examples illustrate these four aims

One : Providing early information to enable sustainable decisions
Basic information on the presence and nature of archaeology (and the associated 'risks') is often provided to clients before they even acquire a site. Then, once the planning application process starts, more detailed archaeological information is normally prepared by archaeologists, to provide to local authority planners on the client's behalf. This is normally provided through two formally defined pieces of work : a Desk Based Assessment, and a Field Evaluation (which might involve either non-intrusive (eg geophysical survey) techniques or intrusive techniques (eg test pits, boreholes) or both). Both these stages are described in the Government policy on archaeology and planning (DoE 1990), and both stages act as formal steps in risk assessment and risk management.

At a major urban development such as 1 Poultry, in the heart of the City of London, the desk based assessment (typically) summarised the likely survival and significance of archaeological remains, and the impact of the proposed development, and the field evaluation, or trial work (in this case taking the form of deep test pits excavated within the standing basement) was targeted specifically to identify the nature, or type of deposits and their extent - in other words their location, complexity and depth. Often more difficult to apply reliably in an urban context is the range of non-intrusive evaluation techniques (eg Ground Penetrating Radar). Urban field evaluation can be particularly expensive, so it is important for archaeologists, developers and planners to realise the implications of their proposals.

As proposed at the 1996 conference in London on Preserving Archaeological Remains *in Situ* conference (Nixon 1998), it would be helpful if assessments and evaluations could be *required*, by planning authorities, to include statements (a) about the type of development, and financial indicators for the different options for treating the archaeology, and (b) about chemical, biological and physical criteria. This would help to establish criteria and threshold values for preservation *in situ*, and would help planners to think about the long-term affects on the archaeology, and make much more informed, more rounded decisions about the archaeology in its local context, against the background of the local social and economic needs and aspirations.

This information was provided, for example, for an EIA on a railway extension project in Hong Kong. Here, MoLAS not only developed a new assessment technique to predict the potential survival of deposits of different significance in areas where very little was known about archaeology, but we also considered both the desirability and the feasibility (financial and practical) of preserving archaeological and historic remains along the railway route. The economic and social pressures for the railway were so high, that substantial investment in protecting cultural remains was justified.

Two : reducing risk and providing certainty
With adequate information, developers have a far better chance of assessing risks, and of being able to prepare a substantiated strategy for submission to planning authorities. Our role as archaeologists is to provide the certainty the developer needs to prepare that strategy.

How, then, do we build certainty into archaeological projects, when archaeology itself is a process of discovery ? Put simply, in two ways : first, by predicting and managing what we will find during excavation, and second, by knowing how buried deposits really behave so we can be confident about decisions to preserve.

For example, at a site on the north bank of the Thames in London, we had a good understanding of the likely nature and extent of the buried, waterlogged, archaeological deposits, which ranged from the Roman through to the post-medieval period. Certainty was found by means of a management

plan. Literally 50% of the site was excavated, and, by redesigning the basements, 50% of the site was piled around, and built over while preserving the environmentally rich, timber revetments and multi-period timber waterfronts in a sealed deposit, preserved for posterity. In this case, we will not know, perhaps for another fifty years or more, how successful the preservation strategy has been.

Another London example is from a 1.5 hectare site also in the City of London, where a strip of archaeological deposits are being preserved in situ outside the secant piled wall around the edge of the site. Here, the engineers installed monitoring equipment to trace major hydrological and chemical changes in the burial environment. We accept, however, that we are still very uncertain about the processes of change in the burial environment. This is why a conference like this is so important – in offering the opportunity for finding new partners to embark on the research needed to be able to give developers, archaeologists and planners the reassurance they need.

Similarly, at the site of the Millennium footbridge over the River Thames, certainty was sought through a common risk management technique : 'scenario planning' (thinking through all the hazards, all the things that might go wrong, and either removing them, minimising them or at least being prepared to manage them). We needed to make sure that the enabling works by the contractors were flexible enough to let us cope with waterlogged deposits, and large timber and stone structures. At the beginning, archaeology was seen by the construction team as one of the most serious risks. However, with enough preparatory assessment and evaluation work, with careful review procedures built in to the project, and with 'scenario planning', the groundworks methodology worked ; the archaeological remains were excavated according to plan … and in fact we finished ahead of schedule.

Conversely, an example of a less successful project was the Guildhall project nearly fifteen years ago (long before the now current planning policy). Here, at the site of London's Roman amphitheatre, the decision was taken early on in the planning process to partially excavate, and then display the amphitheatre remains in the completed basement. The problem was that they had not been excavated yet ; and we didn't yet know exactly where they were, or what they looked like, how stable they were, etc. On this site, therefore, uncertainty was actually built into the project. The engineering design - even the piling configuration - could not be completed until we had exposed the Roman structures. The result was considerable expense, and, given the uncertainty surrounding the whole groundworks design, the archaeologists were, understandably, fairly unpopular. This project was an example of non-integrated decision making.

And this leads on to the aim three : the importance of truly integrating archaeology with development and having archaeologists as part of the development team.
In England in the last decade or so, archaeologists have worked hard, for example on major schemes such as the Jubilee Line Extension Project for London Underground, to integrate archaeological work into construction programmes with as little impact as possible. This concept is captured beautifully in the image of archaeological work taking place underneath an active roadway, under artificial light, with the many live electricity/water services hanging suspended from the bottom of the road deck and London's busy commuter traffic continued to clatter back and forth into and out of London.

This is a good thing. We have come a long way in the integrated approach. But we have much further to go, and integrated cultural heritage policies, like the new Council of Europe Code of Practice, addresses the issue. It says that developers and architects should "see the archaeologist as a member of the project team". Bravo ! However, it goes on to say that the archaeologist should 'be given appropriate access to the site and be properly informed of all design and programming changes'. If I could rewrite that part, I would say that even better integration – and better results for the project – will be achieved not by *informing* the archaeologist, but by i*nvolving the archaeologist in decisions* about design and programme.

And so, if we have achieved all of these three points (provided full assessment and evaluation information ; created a scheme where risk management has been embraced ; and provided as much

certainty as possible), how do we move on to aim *four*, and add value to a development through the archaeology ?

One very simple example is our work at Spitalfields Market in the London Borough of Tower Hamlets. Last year we began a 1 hectare urban excavation after very detailed planning, spread over several years. The archaeological implications of development were completely integrated into the scheme, and we carried out extensive 'scenario planning'. One important aspect to scenario planning is that it helps to spot ways of turning negative risk into positive opportunities. The local residential community held some fairly strong views on the redevelopment of their historic market site, and so one of the things that the developer did was to use the archaeology as a means of communicating with that community. MoLAS opened an Archaeology Visitor Centre and, even opening only at lunch times and on Sundays (when the market was busiest), during the twenty-nine weeks of our excavation, over 27,000 people visited. Many of the visitors came with questions like 'why are the developers destroying all this precious archaeology', and what the centre gave us the chance to do, was explain that actually they weren't, that we were actually being paid, by them, to discover the history of the site, and to create a lasting record of it. All in all, we were able to send a powerful message to the Spitalfields community that the value and the identify of the area was being discovered by the team – the team of developers and their contractors, including their archaeologists – and being shared with them. And we received an overwhelming message of appreciation in return.

So far I have presented quite a rosy picture, but we recognise that unexpected discoveries do occur *are* made. In the City of London and City-fringe since 1990, when the planning guidance that local authorities implement was introduced, I can cite only one unexpected discoveries that led to major changes in the intended construction scheme (and I would emphasise, by the way, that I consider this to be a very good track record). This was a spectacular Roman conduit surviving to over 20m in length, made of stone and tile courses, with a narrow wooden drain and silt traps along the bottom – perhaps part of the drainage system leading from London's Roman forum and basilica down to the River Thames. The point to realise is that we did everything right on this project. The assessment was detailed, and suggested that monumental remains might be found. The evaluation was therefore very extensive and comprised over twenty test pits, on a very small site. In the end, this monument was reburied and preserved voluntarily by the developers, who as a result lost part of their basement. This was a small scale city-centre residential scheme.

To conclude, I have emphasised the notion that decisions about preserving archaeology today are about striking a balance, and the view that the best way of achieving the right balance for a particular location, is to follow the issues and aspirations that are relevant locally.

I have also stressed that decisions about archaeological preservation are a judgement ; we strive to achieve certainty, but we still know very little, really, about the long-term implications of reburial, or preservation *in situ* – that is why we need to do much more research into the processes of change going on in the soil among highly variable, highly complex burial conditions. The next 'PARIS' conference ('Preserving Archaeological Remains *in situ*'), in London in September 2001, will be looking at the results of latest research in this area and, importantly, also trying to address strategies both to guide future research and to inform future planning decisions.

In the meantime, what we should aim for is, I believe :

- Fuller, more ambitious Archaeological Assessments that look beyond the archaeology at social, economic and political drivers.
- More ambitious archaeological Field Evaluations that record relevant criteria and value thresholds for preservation *in situ*.
- Integrated decision-making and good risk management and cost-benefit analyses, in an aim to find certainty.
- And, judgements which are ultimately based on providing real value to the community.

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Biography

Taryn NIXON is the Managing Director of the Museum of London Archaeology Service, in London, England - an organisation of over 220 professional archaeologists which carries out archaeological research and provides consultancy advice and practical services to the property development industry. She is actively concerned with the effective integration of archaeological endeavour with sustainable development. Taryn is a former Chair of the UK professional body the Institute of Field Archaeologists.

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Strategies for preventive archaeology in the urban contact
Stratégies dans le domaine de l'archéologie préventive en milieu urbain

Patrick MONOD[1] – Marc GAUTHIER

L'idée de concilier le développement urbain et la conservation du patrimoine archéologique est une idée neuve. Jusqu'au milieu du XX^{ème} siècle, l'histoire des villes se résume généralement à une suite de destructions et de reconstructions où chaque ville utilise, pour ses fondations successives, les ruines arasées de la cité qui la précède. C'est à la fois le malheur et le bonheur des archéologues. Car les villes sont ainsi détruites les unes après les autres, mais cet empilement de vestiges stratifiés constitue le plus fantastique livre d'histoire à la disposition des chercheurs.

Encore faut-il que des terrassements n'aient pas bouleversé ou entièrement effacé ces pages d'histoire en les arrachant au sous-sol qui les conservait. Jusqu'à l'apparition des engins mécaniques, au début du XX^{ème} siècle, les risques étaient faibles. On ne songeait guère à évacuer les décombres d'un immeuble ou d'un quartier en ruine après un pillage ou un incendie. Il aurait fallu le faire à la main. Il était plus rapide et moins coûteux d'araser les ruines et de les aplanir que de les évacuer. Encore que d'illustres exemples viennent infirmer la règle. La transformation du centre de Paris à la fin du XIX^{ème} siècle, sous l'impulsion du baron Haussmann, ne fit appel qu'à la traction animale et à la main de l'homme. Du moins la lenteur des travaux de terrassement permettait-elle aux archéologues de faire quelques observations à une époque où leur bonne volonté pouvait seule pallier l'absence de législation protectrice du patrimoine archéologique.

Tout change après la seconde guerre mondiale. La plupart des grandes villes d'Europe sont à reconstruire ; leurs centres historiques sont souvent endommagés ; une volonté de modernisation s'affirme à l'égard d'un tissu urbain parfois figé depuis le Moyen Age. Et surtout bulldozers et pelles mécaniques remplacent désormais le travail manuel.

Face à cette révolution dans les méthodes de construction en milieu urbain, les archéologues et les responsables de la politique patrimoniale vont devoir faire preuve d'imagination. C'est alors qu'ils développeront les premières stratégies susceptibles de permettre le sauvetage des gisements archéologiques ou, au moins, leur exploration rapide, sans entraver la reconstruction des villes.

De l'archéologie de sauvetage à l'archéologie préventive.

Ces stratégies vont évoluer en trois grandes phases : celle des sauvetages sous les dents des pelles mécaniques ; celle des conflits entre archéologues et bâtisseurs ; celle, enfin, de la mise en œuvre de procédures de travail rapprochant ces deux mondes qui s'ignoraient. Chaque pays d'Europe, d'une manière ou d'une autre, a connu ces trois étapes en fonction de sa propre histoire, de son organisation administrative et de sa politique patrimoniale.

Pour mesurer la révolution des mentalités, on doit se rappeler qu'à la fin des années soixante, pour s'en tenir à l'exemple français, la seule archéologie digne de ce nom, à l'exception de la préhistoire, s'exerçait hors du territoire national : en Italie, en Grèce, en Egypte, au Proche-Orient, en Asie. Les premiers archéologues qui tentèrent d'intervenir sur les chantiers de construction, en France, furent considérés comme d'aimables rêveurs. Parfois tolérés, le plus souvent refoulés par les chefs de chantiers, dépourvus de moyens d'intervention, ils durent se contenter d'observations fragmentaires recueillies à la dérobée et de quelques objets ramassés sur les tas de déblais. Mais, l'archéologie de sauvetage était en train de naître.

Rapidement, cette attitude de quémandeur fit place à des comportements plus offensifs. La législation archéologique française, promulguée le 27 septembre 1941 et validée en 1945, n'avait certes

pas prévu le développement de l'archéologie urbaine ni les moyens de contraindre les aménageurs à accepter l'intervention des archéologues sur leurs chantiers. Cependant, la loi leur permit de contourner cet obstacle. En effet, elle interdit de détruire des vestiges archéologiques et, par ailleurs, elle oblige à déclarer toute découverte fortuite. Bien évidemment, aucune de ces deux contraintes n'était habituellement respectée sur les chantiers urbains pour des raisons de coût et de délai. Raisons véritables ou prétextes selon les cas. Quelques procès et quelques condamnations exemplaires, puis l'arrêt d'un vaste chantier de construction sur le port de Marseille, mirent un terme à cette époque de destruction du patrimoine archéologique. Ajoutons que les archéologues commençaient à sortir de leur tour d'ivoire (de leur isolement) et que la presse prenait leur parti. Désormais le conflit était ouvert entre archéologues et aménageurs, conflit souvent présenté comme une nouvelle querelle des anciens et des modernes.

Cette période conflictuelle, d'une vingtaine d'années, eut un mérite : elle apprit aux adversaires à se connaître et souvent s'estimer. Les archéologues découvrirent qu'un chef de chantier, un ingénieur, un architecte ou un promoteur ne sont pas plus insensibles au patrimoine archéologique qu'un chercheur ou un historien de l'antiquité. De même, les aménageurs comprirent que les archéologues ne vivaient plus sur une autre planète et qu'ils n'étaient pas opposés au développement des villes modernes. Mais pour concilier les intérêts des bâtisseurs et ceux des archéologues, un objectif devrait être atteint : éviter l'arrêt brutal des chantiers de travaux publics dès que se produisaient des découvertes archéologiques. En quelque sorte, remplacer l'intervention chirurgicale par la médecine de prévention, le sauvetage par l'archéologie préventive

Stratégies actuelles de l'archéologie préventive en milieu urbain.

Cette prise de conscience, mûrie au cours des années quatre-vingt, a servi de fondement aux stratégies qui permettent aujourd'hui de mieux concilier les objectifs des aménageurs et ceux des archéologues, ce qui semblait impossible, il y a seulement quelques années. Cette évolution doit beaucoup aux réflexions conduites dans un cadre européen. Il faut en rappeler les grandes étapes.

En 1980, pour la première fois en France, un colloque international d'archéologie urbaine est organisé à Tours par le Ministère de la culture. Les relations archéologues-aménageurs sont au cœur des débats. Mais les aménageurs y font figure d'accusés et ont choisi d'être absents. Ce qui se comprend : dans la décennie précédente, la curie romaine d'Avignon, le forum de Poitiers, les quartiers antiques de Saint-Just à Lyon, etc. ont été détruits par les bulldozers. Aucune fouille méthodique n'a pu être réalisée sur ces sites de grand intérêt historique. Et la France n'est pas la seule à connaître une telle situation en Europe.

Quatre ans plus tard, se tient à Florence, sous l'égide du Conseil de l'Europe, un colloque intitulé " Archéologie et aménagement " ; puis en 1987, à Nice, dans le même cadre, un autre colloque international : " Archéologie et grands travaux ". Une enquête lancée auprès des 21 états membres du conseil de l'Europe a précédé cette réunion. Cette fois-ci, les aménageurs sont présents dans la salle et participent aux débats. Non pas en tant qu'adversaires, mais comme partenaires soucieux de trouver des solutions de travail en symbiose avec les archéologues. Tous s'accordent sur l'objet prioritaire de l'intervention archéologique : enrichir nos connaissances sur l'histoire des villes. Reste à trouver des méthodes de travail.

Elles vont s'élaborer dans le cadre européen, tout d'abord sous forme d'une Recommandation aux Etats membres en faveur de la protection et de la mise en valeur du patrimoine archéologique. Elle est adoptée par le Comité des ministres du Conseil de l'Europe, le 13 avril 1989. Elle est suivie, le 16 janvier 1992, par une convention internationale, dite Convention de Malte, qui prend acte des mutations qu'a connues l'archéologie dans ses méthodes et, surtout, des conséquences de l'aménagement du territoire sur la préservation du patrimoine archéologique. Cette convention affirme, en particulier, la nécessité, pour les aménageurs, de financer les fouilles préalables à leurs travaux de construction, selon un principe inspiré du droit de l'environnement qui veut que " le pollueur soit le payeur ". Elle s'applique à tous les travaux comportant des terrassements susceptibles de détruire des sites archéologiques. Simultanément, elle apporte aux constructeurs des garanties en faveur du bon achèvement de leurs projets.

L'application de cette convention permet de dépasser la période des conflits aménageurs-archéologues. Les uns et les autres trouvent avantage à travailler en bonne intelligence : les archéologues font désormais partie des acteurs du monde contemporain ; les aménageurs financent, souvent en totalité, le programme d'archéologie préventive pour ne plus dépendre de l'obtention, toujours aléatoire, de crédits publics. En contrepartie, les archéologues interviennent avant le lancement des travaux d'aménagement et libèrent les terrains au jour convenu avec les aménageurs.

Huit ans après la signature de la convention de Malte, des stratégies se mettent en place, dans la plupart des pays d'Europe. Elles obéissent à quelques grands principes que l'on peut résumer comme suit :

1/ Afin d'informer les aménageurs des contraintes liées à l'utilisation de terrains recelant des gisements archéologiques, il convient de dresser des inventaires régionaux et nationaux des gisements connus ou présumés, de les cartographier, et de rendre cette banque de données accessible. Cet accès doit être contrôlé afin que la banque de données ne facilite pas le pillage des gisements par les chercheurs de trésors.

2/ A partir de cette cartographie, les services publics peuvent fixer des prescriptions portant sur chaque gisement, en fonction de son importance scientifique. Celles-ci peuvent aller de l'obligation d'un simple contrôle préalable au moyen de quelques sondages précédant l'ouverture du chantier de construction jusqu'à une protection totale par la création de réserves archéologiques gérées par la collectivité publique.

3/ La réussite des interventions archéologiques et le bon déroulement des travaux d'aménagement supposent que les aménageurs et les autorités responsables du patrimoine archéologique programment et coordonnent leurs travaux du commencement à la fin des opérations. Autrement dit, depuis le moment où un aménageur envisage d'intervenir sur un site susceptible de receler des vestiges archéologiques jusqu'au moment où les travaux de construction sont entrepris.

4/ Même si cette stratégie a pu se développer jusqu'à présent dans un simple cadre contractuel ; il est devenu indispensable que l'archéologie préventive dispose d'un cadre juridique adapté à l'évolution du monde contemporain, La législation française de 1945 ne suffit plus. C'est pour cette raison que l'Assemblée nationale et le Sénat achèvent en ce moment l'examen d'un projet de loi relatif à l'archéologie préventive, conformément aux engagement souscrits par la France lorsqu'elle a ratifié la convention de Malte. Cette loi devrait être adoptée par le Parlement avant la fin de l'année. Elle dotera la France d'une réglementation véritablement opérationnelle pour assurer la protection de son patrimoine archéologique.

Il faut évoquer ici la nature et le rôle des opérateurs archéologiques, et s'interroger sur la possibilité de confier l'exécution des chantiers d'archéologie préventive à des entreprises privées, dans un cadre concurrentiel. Après une longue enquête conduite notamment auprès des aménageurs et des organismes professionnels du bâtiment, la France a choisi une formule dictée par la conviction que l'archéologie préventive relève pleinement d'une activité de service public. Les opérations d'archéologie préventive seront donc confiées à un établissement public de recherche à caractère administratif doté de droits exclusifs. Cette formule a paru la mieux à même de garantir la réalisation des prescriptions scientifiques qui seront édictées par l'Etat, tout en apportant aux aménageurs les garanties de délai qu'ils sont en droit d'attendre. Ajoutons enfin que cette activité scientifique a engendré, en vingt-cinq ans, la création d'environ 1300 postes d'archéologues qui se trouveront ainsi consolidés.

Pour conclure, j'exprimerai un constat et un souhait. Le constat, c'est que l'Europe est sur la voie de l'harmonisation des politiques concernant la protection du patrimoine archéologique. Cette harmonisation est essentielle pour une meilleure connaissance de notre histoire commune. Elle a beaucoup progressé depuis un quart de siècle. Et l'adoption par le Comité du patrimoine culturel du Conseil de l'Europe, le 20 mars 2000, d'un " code européen de bonne pratique " applicable à l'archéologie et au projet urbain montre qu'elle reste un souci majeur des instances européennes.

Mais ce constat optimiste ne doit pas laisser croire que tout est réglé même s'il est désormais possible de concilier les projets d'aménagement urbain et les exigences de la protection du patrimoine archéologique. Il faut savoir qu'en un demi-siècle, environ 50% des gisements archéologiques urbains ont disparu à l'occasion des restructurations opérées au centre des villes anciennes.

Ce bilan nous impose désormais de songer à une autre politique en archéologie urbaine… Chaque fois qu'une évaluation scientifique professionnelle aura démontré le caractère exceptionnel d'un gisement archéologique, on ne devra plus se contenter d'une fouille préalable à la destruction du gisement, si bonne soit-elle.

L'objectif, et c'est le souhait que je formule, doit être maintenant de conserver in situ ces gisements archéologiques d'exception pour que les génération futures, avec des méthodes de recherche plus élaborées, puissent parvenir à des connaissances aujourd'hui inaccessibles.

Si nous n'adoptions pas une telle démarche, c'est notre histoire commune que nous laisserions détruire.

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Protecting historic monuments from the effects of tunnelling and settlement : predictive modelling and grouting techniques

Protection des monuments historiques contre les effets de percement de tunnels et de tassement de terrain : modélisation prédictive et techniques d'injection

Jose Maria RODRIGUEZ ORTIZ[1] and Pedro SOLA

Abstract

The effects of tunnelling operations on buildings are briefly commented, along with the analytical or empirical methods of subsidence prediction. A short review of usual methods for protecting existing monuments is also made, including grouting, barrier piles, underpinning, bridging, etc. Special attention is paid to modern compensation grouting techniques where the ground between the tunnel and the building is previously compressed by grouting through a fan of horizontal sleeve tubes, thus provoking a slight heave matching the expected subsidence.

Résumé

Les conséquences sur les édifices du percement de tunnels ainsi que les méthodes analytiques et empiriques de prévision d'affaissement sont brièvement commentées. Les méthodes courantes de protection des monuments telles que coulis de ciment, barrières de renfort, étayage, ponts de soutien, etc., sont également rapidement passées en revue. Enfin, les techniques contemporaines de compensation par mortier liquide pour lesquelles on compresse préalablement le sol entre le tunnel et le bâtiment en injectant du ciment au travers de manchons horizontaux afin de provoquer un léger soulèvement pour contrecarrer l'écroulement redouté y font l'objet d'une attention particulière.

The estimation and prevention of subsidence

Very often underground works affect urban areas with monuments or ancient buildings. It is well known that tunnelling induces settlements in the buildings and facilities above, due to the deformation of the excavated cavity until a lining is placed. In soft or loose ground the soil extracted in excess during excavation or trained by groundwater also contributes to settlements. We call it volume loss and it can amount from below 0,5% of the tunnel volume in good ground up to more than 5% in soft or bad ground (figure 1).

The method of construction also affects the final displacements. Hand excavation or flexible supports as the New Austrian Tunnelling Method, eventually aided by compressed air, are being replaced by modern slurry shields or earth pressure balanced machines.

The shape of the settled surface closely fits a gaussian parabola. The maximum settlement and the gradient of the settlement trough are relevant to the risk of damage in the buildings and monuments (figure 2, p.96).

Ancient monuments, commonly constructed in masonry, are very sensible to differential settlements or distortions. From the shape of the settlement trough it is clear that the worst position is were the edge of the monument lays close to the inflexion point of the settlements.

When the tunnel crosses near the centreline of the monument, the risk is lower due to the symmetry of settlements.
A number of criteria have been developed in order to ascertain the risk of cracking or structural failure in buildings due to uneven settlement. As refers to monuments a ratio settlement to length of about 1/2000 is frequently used.

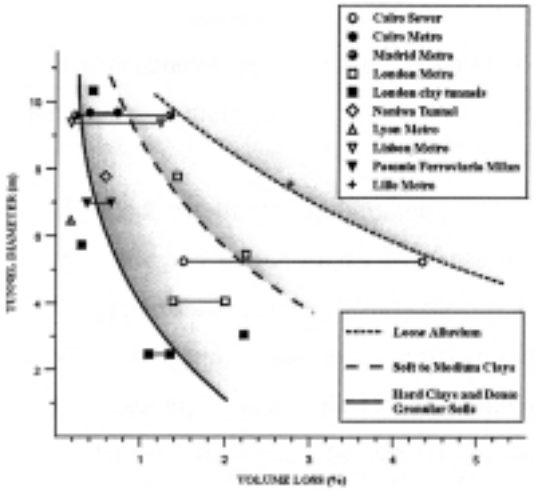

Figure 1 : *Volume lost of tunnels in different grounds*

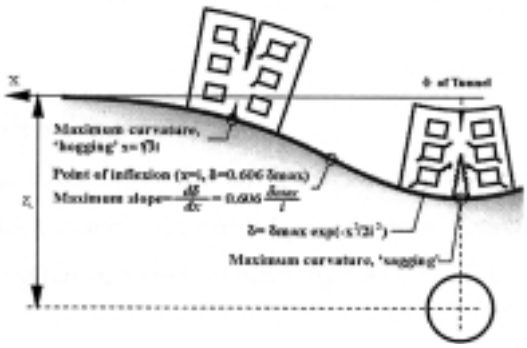

Figure 2 : *Idealized seattlement through over tunnel*

This ratio can be obtained from the gradient of the settlement trough as follows :

$$ß = \frac{0{,}242\ V_s}{\sqrt{2\pi i^2}}$$

For a normal tunnel 9 m in diameter (63,6 m2), at a depth of 1,5 D, i.e. H = 13,5 m, in medium strength clay, a volume loss of about 1% can be expected, corresponding to Vs = 0,01 x 63,6 = 0,636 m3/m. The position of the point of inflexion can be approximated by i= 0,50 H = 6,75 m. The local angular distortion results

ß = 0,00337 = 1/ 296

a value well above the critical threshold for structural damages.

The analytical procedure above has been checked in many tunnelling works and some empirical relationships have been developed for direct estimations.
Unfortunately each tunnel is different from others and it is difficult to translate measurements to other ground conditions.
The figures above justifies the adoption of preventive measures before the passage of the tunnel.
The usual procedures are:

- Underpinning of the building (rarely in monuments).
- Bridging of the tunnel by constructing a frame of piles and deck slab, very often in prestressed concrete. This is the case when the tunnel crosses below a building (figure 3).
- Establishing a barrier to the lateral spreading of the settlements by inserting a row of piles, micro-piles or jet-grouted columns.
- Ground improving by grouting or freezing (in case of water-bearing granular layers) (figure 4).
- Counteracting the settlements by previous compression through cement grouting (compensation grouting).

This last method will be discussed in greater detail in the second part of this paper.
Very interesting cases can be found in the literature. An early example is the inclined pile wall constructed for building the St. Stephan Station close to the Vienna Cathedral (HAFFEN, 1976). The wall was completed with intensive grouting above the future cavern in order to protect other buildings and near surface facilities (figure 5). Grouting was also a common procedure when driving tunnels across granular soils under the water table.

Barrier walls of piles or micropiles are a frequent solution. The example of the protection of the Shanghai observatory, constructed in 1884, is shown in figure 6 (CHEN and al. 1998). The same solution has been also extensively used in the Madrid Subway.

Drainage due to tunnelling operations is also responsible for settlements of monuments as the depressed water table, removing buoyancy, increases effective stresses and it results in consolidation of compressive silts and clays. A worse effect occurs when soil migrates towards the cavity under the high gradients created by the excavation.

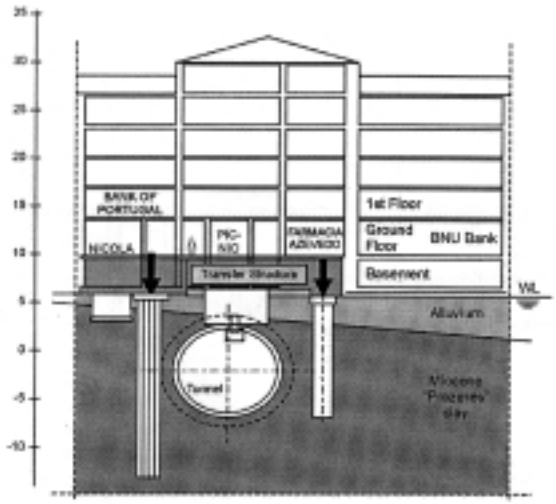

Figure 3 : *Building bridging the Lisbon Metro (Moreira &Flor, 1998)*

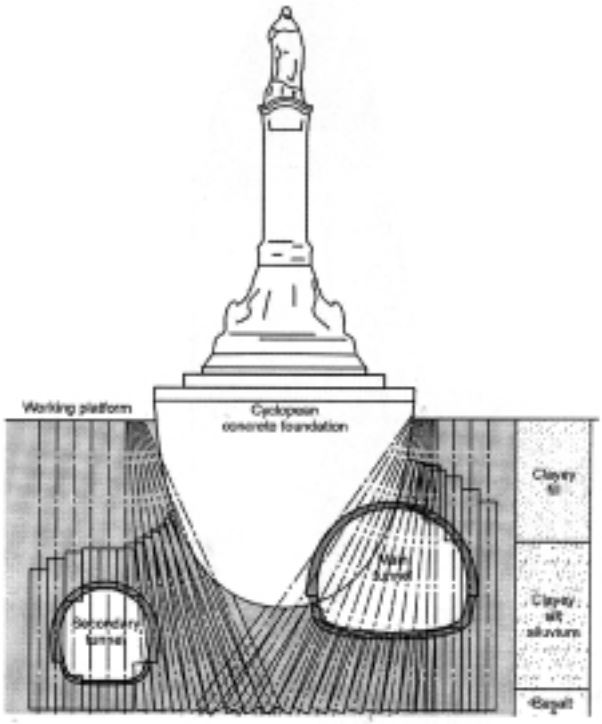

Figure 4 : *Ground strengthhening by jet-grouting below the Marquis of Bompal statue in Lisbon (courtesy Bachy)*

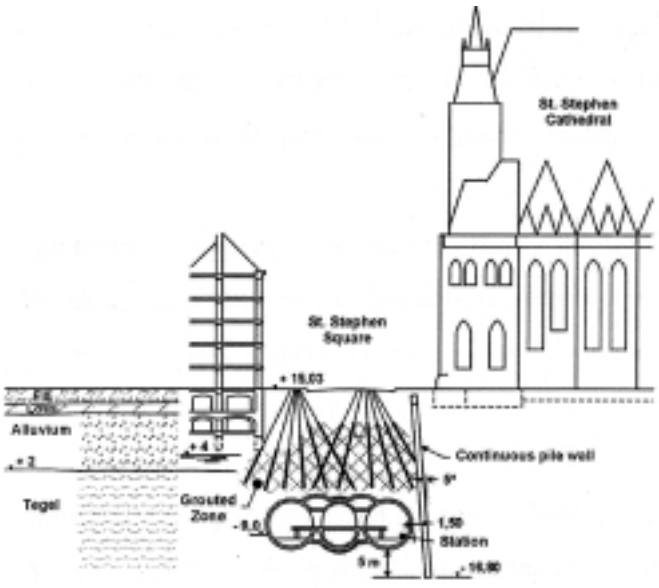

Figure 5 : *Preventive measures for the passage of Line U.1 of the Vienna underground close to St. Stephen cathedral (Haffen, 1976)*

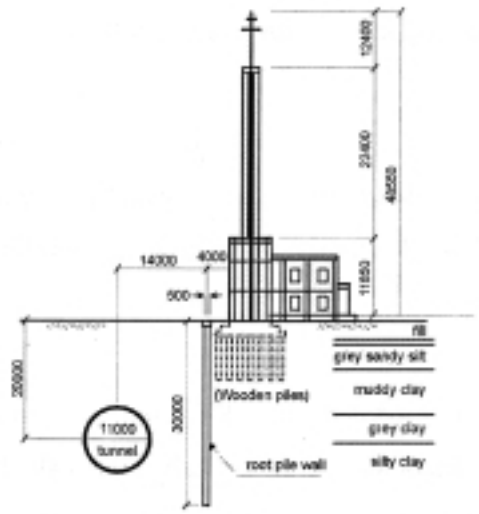

Figure 6 : *Barrier of micropiles for protecting the Shangaï observatory (Chen et al., 1998)*

As tunnelling is the most important source of problems attention should also be paid to open excavations supported by wood bracing or more frequently by pile or diaphragm walls. These walls are quite flexible and give way to significant movements in the ground outside. The solutions include more rigid walls and bracings, preventive underpinning of the nearby buildings or the improvement of the ground through grouting.

The compensation grouting procedure

The principle of this method is based on introducing a controlled volume of fine grout or mortar (cement-bentonite and some sand) at an intermediate, near-horizontal, level between the tunnel and the building (figure 7). This injection compresses the ground, consolidating the soft layers and even causes a certain surface heave which will offset or compensate the excavation induced settlement. Sometimes the ground over the tunnel can collapse, thus consolidation of the ground prior to excavation by using grouting or some other procedure would be necessary (figure 8).

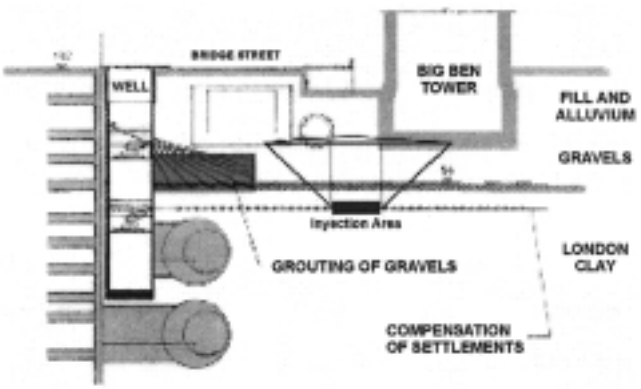

Figure 7 : *Compensation grouting under the Parliament tower (London)*

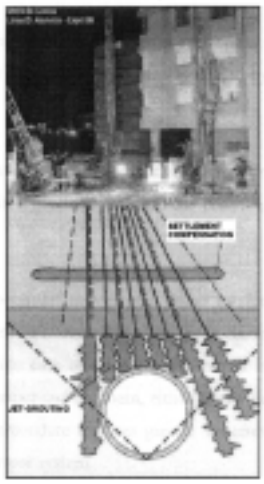

Figure 8 : *Soil treatment in the Chelsea area, Lisbon Subway*

The grouting is performed from vertical shafts through fans of horizontal sleeve-tubes (pipes with spaced holes, covered by an elastic band, which can be isolated by packers in order to control the pressure and volume injected through each hole). The grouting is repeated several times until the expected vertical movements are achieved. The system allows an uneven distribution of grouting as well as to concentrate it in the required points.

The method requires a precise monitoring through continuous levelling, frequently performed by electrolevels or automated theodolites. A complex software is necessary to control pressures and volumes at each injection point, as well as the properties of the grout and the sequence of successive grouting operations.

Compensation grouting must be started before the excavation takes place (pre-treatment phase) in order to prepare the ground and test the equipment and movement control systems. This phase ends when a small heave of 2 – 3 mm is achieved.

The volumes grouted during pre-treatment can vary between 30 and 300 l/m2 depending of the nature of the ground. The grouting pressures depend also upon the type of grout used, and increase as more grouting episodes are undertaken reaching values of 15-30 bar when using cement grouts and 40-60 bar with mortar grouts.

The grouting phase corresponding specifically to the compensation of ground movements requires information regarding the magnitude and distribution of possible movements induced by the tunnel excavation.

Numerical models derived from the theory of expansion of cavities by internal pressure allow an estimation of the relationship between the injected volumes in a given ground and the resulting uplift.

Where tunnels are concerned, and as in these cases the potential movements cause by the excavation are foreseeable, the grouting should be undertaken simultaneously as the excavation advances (concurrent of proactive procedure). However, in the case of open excavations, it is wise to wait for the movements to occur and subsequently compensate for them, either totally or partially (observational or reactive procedure). This second procedure requires greater volumes and grouting episodes as well as a more intense movement control system.

As the grout shrinks and permeates the ground, the total volume injected must be 4 to 6 times greater than the volume of settlements to be compensated for. Pressures range between 7 and 9 bars and volumes up to 50 liters/m2 have been injected.

Numerical models derived from the theory of expansion of cavities by internal pressure allow an estimation of the relationship between the injected volumes in a given ground and the resulting uplift.

It is important to locate the grouted "slab" at a level where the local pressures were "smoothed down", in order to avoid any harmful effects on the constructions above.

The method is logically quite expensive but is worth wile when the historical heritage can be affected or the damages give way to a stoppage of the works.

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Biography

J.M. RODRIGUEZ ORTIZ graduated in Civil Engineering in 1965 and obtained his Ph.D. degree in the Polytechnical University of Madrid in 1974. He worked as research engineer in the Laboratory of Geotechnics of the Ministry of Public Works until 1975. After this date he headed the Geotechnical department of several consulting firms working in Soil and Rock Mechanics, foundation engineering, etc. In 1980 he became full Professor of Soil Mechanics at the Madrid University. He is currently advisor to the Madrid Subway.
Pedro SOLA graduated from the Polytechnical University of Madrid in Civil Engineering in 1973. Since 1975 he has worked in GEOCISA, Geotecnia y Cimientos, S.A., part of the Dragados Group of companies, where he now is Development Director. He is representative of the Board of Directors of the SEMSIG and Chairman of the Technical Committee of AETESS.

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Vibration monitoring of cultural heritage adjacent to construction works

Surveillance des dommages causés au patrimoine culturel par les vibrations liées aux travaux publics

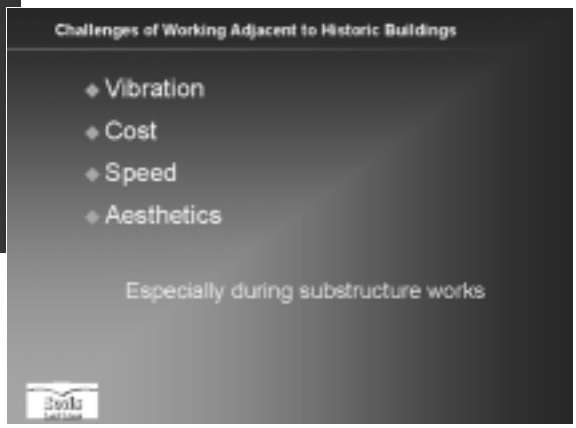
Henryk J LISZKA[1]

Abstract

The preservation of buildings of cultural heritage within the development of cities has attracted considerable research resulting in specific techniques being adopted during substructure works. The challenges of working adjacent to Historic Buildings are four-fold, Vibration being crucial with Speed, Aesthetics and Cost being secondary.
A recently developed technique which is widely applied, called zero clearance piling, is an ideal solution for such foundation works. This technique provides for excellent levels of environmental protection as the use of static load pressing allows for the virtual elimination of vibration and noise, with the set up affecting only a small area of land, thereby respecting the surrounding environment. In addition this is considered to be an extremely safe process as the piler grips previously driven piles providing stability, ensuring that accidents should never happen. Such a construction revolution has considerably simplified foundation works thus making the preservation of heritage buildings an easier and more commonly undertaken task.

Résumé

La conservation des édifices du patrimoine culturel dans un contexte de développement urbain a fait l'objet de recherches considérables qui ont abouti à l'adoption de techniques spécifiques pendant les travaux de fondations. Les difficultés à travailler à proximité de bâtiments historiques se comptent au nombre de quatre: deux d'importance cruciale, les vibrations et la rapidité; et deux d'importance moindre, l'esthétique et le coût. On applique désormais fréquemment une technique récente connue sous le nom de «zero clearance piling» et qui s'avère une solution idéale pour de tels travaux de fondations. Cette technique offre une excellente protection de l'environnement car l'utilisation de «static load pressing» permet d'éliminer pratiquement toutes les vibrations et le bruit, le dispositif ne travaillant que sur une surface réduite, respectant ainsi les alentours. En outre, la sécurité de ce procédé est considérée comme extrêmement bonne puisque le «piler» ne serre que les piliers préalablement «driven» pour la stabilité, garantissant ainsi qu'aucun accident ne devrait survenir. Une telle révolution de la construction a immensément simplifié les travaux de fondations et rendu la préservation des édifices patrimoniaux à la fois plus facile et plus fréquente.



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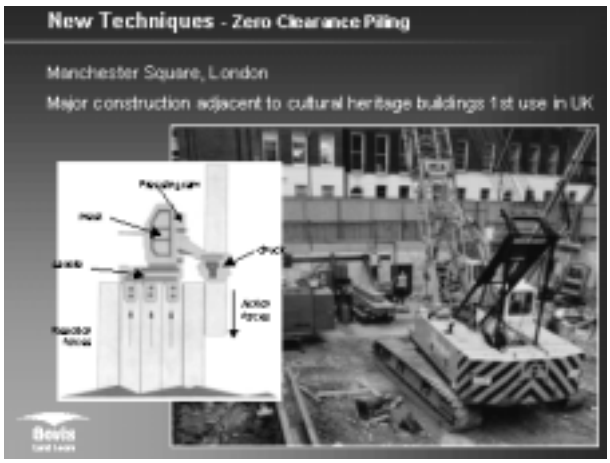

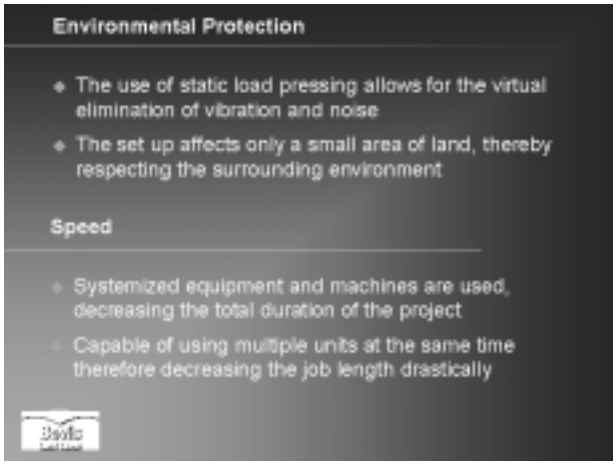

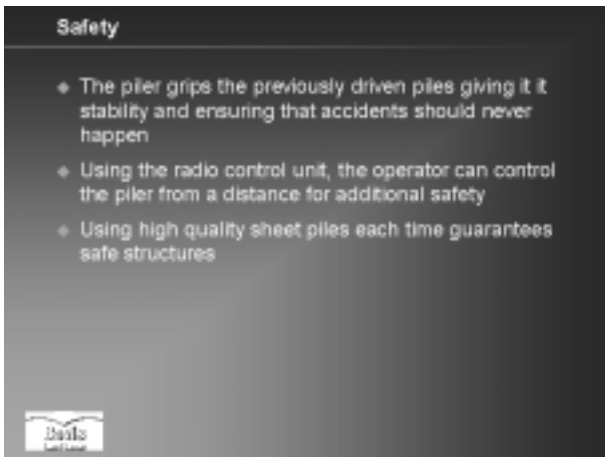

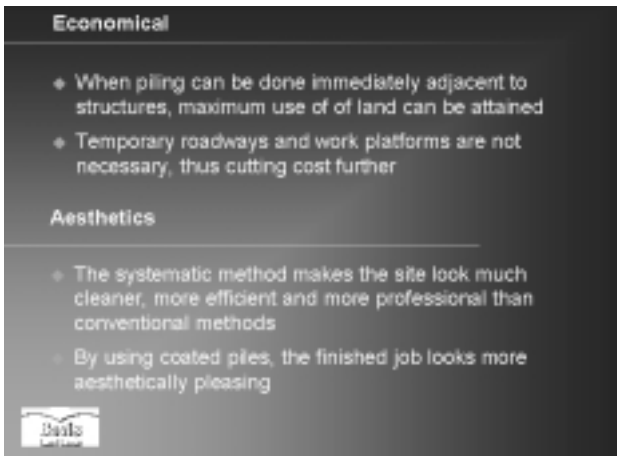

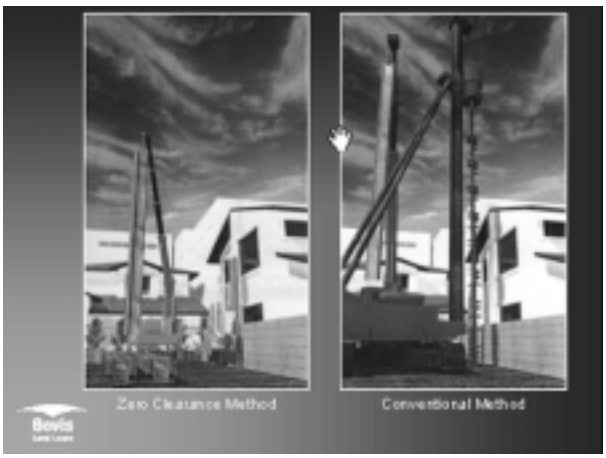

Biography

Henryk J. LISZKA specialised in the management, planning and design of projects and their associated commercial and budgetary control. Particular reference was paid to Client liaison and co-ordination of resources. As Regional Managing Director, he is now responsible for Bovis Lend Lease's activities in Eastern Europe. Having been Project Executive on four contracts in Poland, he was appointed a Bovis Director in 1993. He has a staff of 200 under his control currently managing in excess of $250 million construction value turn-over per annum.

Integration of new buildings within historic city centers : an example of the publics libraries in France

L'intégration de bâtiments neufs dans les centres historiques des villes : l'exemple des bibliothèques publiques en France

Florence PONCE[1]

Abstract

Several examples of integration of new buildings within historic city centres are provided through the regular construction of public libraries, frequently located in the town centre, in France. The French state means are rapidly presented, hereafter. Said means ensure the quality of these public buildings, the main contractor being the local communities. Three real examples of libraries constructed in the 1990s are then developed in the French cities of Evreux (Haute-Normandie), Poitiers (Poitou-Charente) and Limoges (Limousin).

Résumé

Le rythme soutenu des constructions de bibliothèques publiques en France, ainsi que leur localisation fréquente en centre ville, fournissent de nombreux exemples d'intégration de bâtiments neufs dans les centres historiques. Les moyens de l'Etat pour garantir la qualité de ces constructions publiques, dont la maîtrise d'ouvrage relève des collectivités locales, sont présentés rapidement. Trois exemples concrets sont ensuite développés dans les villes d'Evreux (Haute-Normandie), Poitiers (Poitou-Charente) et Limoges (Limousin) pour des bibliothèques construites dans les années 1990.

L'intégration de bâtiments neufs dans les centres historiques des villes est étudié ici à partir de l'expérience française de construction de bibliothèques publiques.

En effet, le nombre de bibliothèques a triplé en France ces vingt dernières années et la Direction du livre et de la lecture, au sein du Ministère de la culture et de la communication, recense chaque année environ 200 chantiers de construction ou d'extension.

Les collectivités locales - communes urbaines, départements, ou communautés de communes – qui décident ces constructions privilégient souvent une implantation en centre ville, car les bibliothèques générant des flux importants et réguliers de visiteurs (2000 entrées/jour à la médiathèque François Mitterrand à Poitiers, ville de 80 000 habitants, par exemple), elles sont considérées comme un instrument de revitalisation des quartiers centraux.

La question de la qualité de cette intégration se pose d'autant plus que la bibliothèque doit être souvent, pour les élus qui en décident la construction, une image de la modernité de leur ville, tant dans ses contenus technologiques (Cédéroms, Internet...) que dans son architecture.

La maîtrise d'ouvrage relève des collectivités locales et l'Etat tend à garantir la qualité des constructions publiques par divers moyens, dont principalement la définition d'un cadre juridique et le développement de services d'assistance et de conseil. Parmi les éléments juridiques, sans revenir sur la législation des secteurs protégés, on peut citer la loi MOP du 12 juillet 1985 qui a rendu la programmation obligatoire pour les maîtrises d'ouvrages publics. Pour l'assistance et le conseil, la Mission interministérielle pour la qualité des constructions publiques (http://www.archi.fr/MIQCP/publications/index.html) joue un rôle majeur, ainsi que la Direction de l'architecture et du patrimoine (DAPA), créée en 1998 au sein du ministère de la culture et de la communication. Dans le secteur présenté ici, il faut citer aussi le rôle des architectes-conseil de la Direction du livre et de la lecture, ainsi que celui des conseillers livre et lecture au sein des Directions régionales des affaires culturelles (DRAC).

L'intervention a présenté ensuite trois exemples, à partir de photographies que l'on peut consulter à partir de la base de données Malraux sur le site http://www.culture.gouv.fr.

• La médiathèque d'Evreux (3 700 mètres carrés, architecte : Paul CHEMETOV, ouverte au public en 1995), près de la place de l'hôtel de ville et de la cathédrale, qui a intégré un tronçon du rempart gallo-romain découvert lors du chantier (http://evreux-info.org/histoire/index.html

• La bibliothèque François MITTERAND à Poitiers (8 000 mètres carrés, architectes GIACOMAZZI et BEAUDOUIN, ouverte en 1996), dont la modernité dialogue avec la toute proche façade romane de l'église Notre-Dame-la-Grande.

• La bibliothèque francophone multimédia de Limoges (14 800 mètres carrés, architecte : Pierre RIBOULET, ouverte en 1999), où la construction a inclu une aile de l'ancien hôpital et une mosaïque gallo-romaine de 9m70 sur 6m 75, trouvée sur place, mise en scène dans un atrium spécialement aménagé pour elle, rappelant ainsi le passé du site au cœur d'un bâtiment pourtant résolument contemporain.

Biographie

Florence PONCE est chargée de mission aux affaires européennes et à l'action internationale au sein de la Direction du livre et de la lecture, Ministère de la culture et de la communication. Elle a précédemment été responsable des périodiques d'Europe centrale et orientale à la Bibliothèque de documentation internationale contemporaine (BDIC) à Nanterre.
Ancienne élève de l'Ecole nationale supérieure (Paris), docteur en géographie, elle a suivi la formation nationale au métier de conservateur à l'Ecole Nationale Supérieure des Sciences de l'Information et des Bibliothèques, à Villeurbanne.
Elle est membre de l'Association des bibliothécaires français (ABF), de l'association des Bibliothécaires en études slaves et documentalistes associés (BESEDA) et du comité permanent « Bibliothèques publiques » de la Fédération internationale des associations de bibliothécaires (FIAB/IFLA).

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Session D Conservation materials : treatment compatability, re-treatment or reversibilility ?

Session D Matériaux de conservation : compatibilité de traitements, retraitement, réversibilité ?

Rapporteur : Clifford PRICE

Despite the title of the session, re-treatment or reversibility were scarcely mentioned, and the emphasis was largely on compatability.
The papers dealt with the compatability of a wide range of materials and substrates. For example, the use of mortars, consolidants, water repellents, biocides and paint sytems on stone, brick, mortar and waterlogged wood were presented.
One such issue is, in fact, the incompatability, between treatment evaluation and the length of time that is available for it. Several speakers spoke of pressure to implement treatments without their being subjected to proper evaluation, whilst others spoke of problems that arose only after a period of ten or twenty years. Another issue is the compatability of benefits and profits
Compatability between end-users and chemicals is clearly a matter of concern. Some end-users regard chemicals as nasty, unwholesome things that have no place in cultural heritage. The question of compatability between end-users and researchers is then reached. This, of course, is the whole point of this conference. We must ensure that end-users and researchers communicate effectively with one another, in order that research results are applied in practice.

Rapporteur : Clifford PRICE

En dépit du titre de cette session, le retraitement et la réversibilité ont été très peu abordés alors que la compatibilité entre matériaux en a été le thème principal. Les exposés ont présentés la compatibilité d'un large éventail de techniques telles que l'utilisation des mortiers, des consolidants, des enduits imperméabilisants, des biocides et des revêtements appliqués à la pierre, au mortier ou au bois gorgé d'eau. L'un des aspects abordés a été celui du manque de temps pour évaluer les traitements. Plusieurs participants ont évoqué la pression exercée pour implanter des traitements alors qu'aucune évaluation n'ait été conduite auparavant, d'autres ont évoqué les problèmes ne survenant que dix ou vingt ans après l'application d'un traitement. L'objectif de rentabilité est un autre facteur pouvant entrer en conflit avec l'objectif de qualité.
L'attitude des utilisateurs finaux envers les produits chimiques est un sujet de préoccupation puisque certains considèrent les produits chimiques comme nocifs et tout à fait indésirables dans le domaine du patrimoine culturel.
L'attitude des utilisateurs finaux vis-à-vis les chercheurs était la véritable raison d'être de cette session. Il faut que les utilisateurs finaux et les chercheurs communiquent efficacement de sorte que les résultats des recherches puissent être mis en pratique.

Maintenance of pointing in historic buildings : decay and replacement

La maintenance des jointements dans les monuments historiques : dégradation et remplacement

Rob VAN HEES*, Silvia NALDINI, Loek van DER KLUGT , Luigia BINDA, Giulia BARONIO, M. PILAR DE LUXAN, Fernando DORREGO, Koenraad van BALEN, Roald HAYEN

Abstract

The choice of incompatible mortars for the repair of pointing in historic buildings is among the most important causes of damage and too early maintenance need. Central in the project was the compatibility of mortars in historic buildings. The assessment of recurrent damages in which re-pointing is involved, hypotheses on the role of the re-pointing mortar in the occurrence of damage and laboratory research on incompatible and compatible solutions form the framework of the research undertaken. The research has led to deliverables for end-users, like a damage atlas on re-pointing, an additional module for the expert system MDDS as well as the introduction of a section on background information in the same expert system. A procedure on mortar analysis and requirements for compatible re-pointing mortars were developed.

Résumé

Le choix d'un mortier incompatible avec la réparation des jointements dans les monuments historiques est une des causes les plus importantes de dégradation et entraine des interventions prématurées de maintenance. Ce projet s'est concentré sur la compatibilité des mortiers dans les interventions à destination des monuments historiques. Dans le cadre de ce projet ont été entrepris l'évaluation des dommages dans lesquels des mauvais jointements sont la cause, des hypothèses sur le rôle joué par de tels mortiers ont été formulées et des simulations en laboratoire ont été entreprises. La recherche a permis de fournir des recommandations pour les utilisateurs finaux; un atlas des dommages et un module supplémentaire pour le système expert MDDS avec des informations de base ont été fournis. Une procédure pour l'analyse des mortiers et les recommandations pour un mortier de réparation compatible avec la substance originale ont été également développées.

Introduction

Maintenance and protection of historic buildings all over Europe includes the need to repair and replace mortar joints. Replacement of historic pointing should only be done when it is absolutely necessary. Historic pointing is very valuable, as it has both a technical (protective) function and an aesthetic role and has, moreover, a documentary value. When re-pointing is needed this should be not only technically, but also historically and aesthetically compatible with the masonry.

Unsound repair or substitution of pointing can be considered among the most important causes of damage to historic brick and natural stone masonry, consequently leading to early maintenance interventions[1].

Aesthetic and historical damage is very often caused to monumental buildings, due to inconsiderate choice of re-pointing. Hence the necessity was felt to start an international co-operation project on the causes of damage to pointing and correct re-pointing procedures.

Central in the project was the study of the damage to pointing, in terms of compatibility of the materials within the historic masonry. On this basis, criteria for compatible solutions for re-pointing were laid.

Partners

The following institutes were involved in the research project :

- Politecnico of Milan.
- Institute of Construction Science "Eduardo Torroja", of the Spanish Council for Scientific Research (CSIC), Madrid.
- Catholic University of Leuven.

1. Previous research has shown the risks related to the application of surface treatments, cf. R.P.J. VAN HEES, J.A.G. KOEK, H. DE CLERCQ, E. DE WITTE, L. BINDA, G. BARONIO, Evaluation of the performance of surface treatments for the conservation of brick masonry, Proceedings 8th International Congress on Deterioration and Conservation of Stone, Berlin, 1996, pp. 1695-1716.

• Netherlands Organisation for Applied Scientific Research, TNO, Delft, as co-ordinator.

Aims of the research

The reported research project was centred on the decay and the replacement of pointing in historic buildings.
Main aim was to assess the causes of decay, and to evaluate the possibilities, the limits and the risks concerning methods and materials used in replacement and repair of decayed pointing.
Further aims were to define identification methods as well as performance and quality criteria for pointing in historic buildings (taking into account the criterion of compatibility with the historical situation).

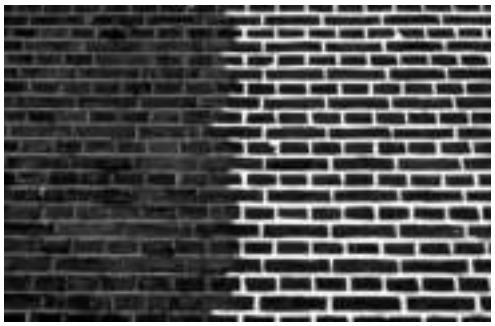

Figure 1 : *The aspect of the façade changes completely, when colour or even shape of the pointing changes.*

Definition

The following definition of pointing was proposed : 'Pointing is the (process of) filling of the outer part of the joints in stone and brick masonry where the bedding mortar has been deliberately left or raked back from the surface or where the original mortar is recessed from the surface[2]. Pointing is made after brick - or natural stone-laying, within an additional operation, and using a different mortar composition. In the case that the bedding mortar is tooled and/or given a shape directly after application the visual part of it would not be called pointing, but 'tooled bedding mortar'.
In brick masonry the pointing generally occupies less than 25 % of the surface, but it has a much greater influence on the aspect of the façade than suggested by this percentage, as figure 1 illustrates.

Methodology

The performance of mortars used for re-pointing in restoration in the participating countries was studied in the field and in laboratory. Material properties were assessed, that are essential for the compatibility of pointing mortars with the materials present in the existing historic structures.
On the basis of field and laboratory studies, criteria to assess the performance of pointing mortars were defined as well as material properties, required to obtain pointing mortars compatible with the substrate.
In order to make the results of the project accessible for end-users involved in the conservation of buildings it was decided to develop a module within the expert system MDDS (Masonry Damage Diagnostic System). This module includes advice on how to diagnose the damage to pointing and for the choice of pointing materials, that is to say for giving advice on the choice of the most suitable materials for re-pointing, under different conditions. A methodology for assessing pointing quality was developed.
Central in the project were the analysis of cases of damage, the assessment of recurrent damages related to re-pointing and the assessment of criteria determining compatibility or incompatibility of a certain solution.
The recurrent damages and the compatibility criteria deriving from case studies formed the starting point for the laboratory research that was carried out.

From damage analysis to compatible solutions - Recurrent damages : incompatibility -

The most recurrent causes of damage involving (re-)pointing have a technological/mechanical or environmental origin.
Technological/mechanical causes are : incompatibility of materials (chemical, physical and mechanical) ; too fast drying (burning) ; shrinkage ; bad, insufficient elimination of decayed old mortar and not careful preparation of the area to be re-pointed ; treatments (like water repellents) present ; use of too weak mortars, consequences of the removal of the old pointing.
Environmental causes are : salt transport and crystallisation, frost, pollutants, etc.
The damaging processes may be speeded up or made more severe if the environment becomes

2. Cf. ASHRUST J. and ASHRUST N., Brick, terracotta and earth, 'Practical Building Conservation', English Heritage Technical Handbook, Gower Technical Press, Aldershot 1988, II.

more aggressive (acid rain) or when the materials are richer in salts, due to accumulation processes. Lack of maintenance of the monumental buildings can play an important role, as well as the lack of knowledge of the persons responsible for the restoration. Sometimes old or trusted recipes are too easily followed, without sufficient knowledge of mortar technology and of damaging mechanisms, or too dense pointing mortar is used, just because it is supposed to be more durable, without carefully evaluating the characteristics of the materials involved, their state of conservation and their environment.
The choice of a re-pointing composition may influence the physical properties of masonry, like the drying behaviour, in an unfavourable way or may lead to unwanted chemical reactions.
The first step was thus the identification of the most recurrent damage types, in which the pointing mortar was involved, and the damaging mechanisms leading to them, in case studies carried out in the participating countries. The systematic methodology followed, compatible with that of MDDS, made it possible to organise and incorporate the knowledge in the system.
Cases of damage were selected for further investigation, and eventually for solution. The most relevant were considered : frost damage (leading to push out, crumbling, bulging), salt crystallisation (leading to push out, efflorescence), chemical conversion (leading to mortar swelling, bursting, cracks), creep of heavy masonry structures (leading to cracks in masonry).
Very important recurrent processes appear those related to salt and frost.

Look-alike damages

Often damage having a certain aspect could be related with more than one damaging process. This sort of damage was called 'look-alike' damage, and requested in depth study to exactly find out the mechanisms leading to it. Special attention was devoted to frost damage to bedding mortar, resulting in deformation of the whole structure and to creep in towers and heavy buildings, leading to vertical cracks similar to those resulting from the salt swelling in bedding mortar (chemical conversion). Some examples of look alike damage are given here.

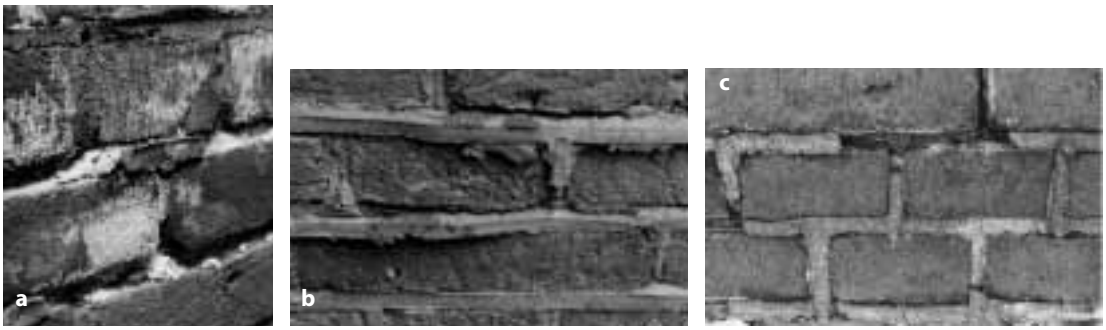

Figure 2a, b, c : *Look alike damage : push out of pointing due to different processes (salt crystallisation, swelling pointing mortar, frost action to bedding mortar).*

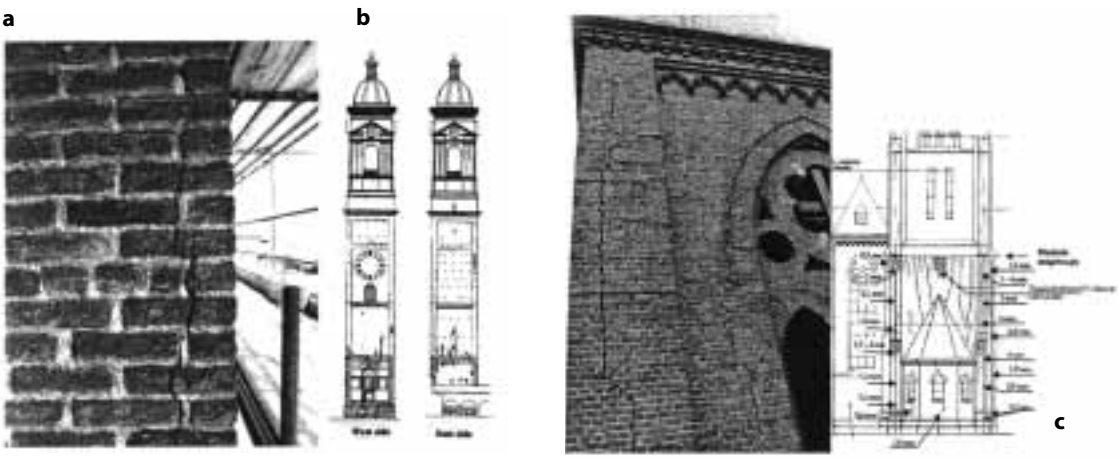

Figure 3 a, b, c : *Figure 3 a, b Look alike damage : cracks, due to different processes (creep under high statical load to the left and formation of thaumasite in the bedding mortar of the inner leaf of the masonry to the right).*

Mortar analysis and requirements for repair mortars

In order to assess the causes of damage and to arrive at a compatible repair method, mortar analysis will generally be one of the steps to be taken.
A procedure on how to analyse and characterise mortar was developed in co-operation with RILEM committee TC-COM.
In those cases where the existing masonry is damaged, the characterisation of the materials and more specifically the mortars will contribute to understanding the mechanisms responsible for the damage, in fact clarifying the lack or the limit of compatibility.
Research for the technical compatibility requirements for the repair mortar includes :

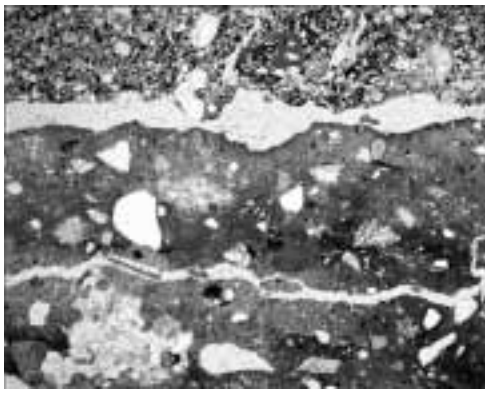

Figure 3 : *Example of a mortar analysis using thin sections : mortar composition, binder and aggregate type as well as damaging process (parallel cracks, due to frost action) can in this case be assessed.*

- Identification of damaging processes.
- Characterisation of the texture and the composition of the (existing) mortar.
- Identification of the physical properties (porosity etc.), mechanical properties, texture and structure of the mortar.
- Identification of the nature of aggregate, binder, (organic) additives and their relative proportions.

The technical compatibility can be defined using an identification methodology represented as a scheme of analytical techniques combined with the diagnosis of damage, which has to be used taking into account the limits of sampling in historic buildings. In line with the way of reasoning of the Masonry Damage Diagnostic System a goal - oriented approach is proposed to help end-users find the most suitable analytical procedure.

Laboratory research on recurrent damage - (in)compatibility

The guideline in the laboratory research was formed by to two keywords : compatibility and recurrent damage types.
The compatibility of a re-pointing mortar can be defined as follows :
It is the capacity of the mortar to interact with the ancient materials, present in a façade, without inducing (directly or indirectly) any decay to the ancient materials. Apart from that the re-pointing should be as durable as possible, however, without compromising the compatibility requirement.
Compatibility can not be considered an intrinsic material property, it is a characteristic that depends on a complex of factors (physical, chemical and mechanical), that are determined both by the ancient materials and their history or 'memory' and by their environment. Sometimes material factors may prevail and sometimes environmental factors clearly do so.
In the field of technical compatibility, physical, chemical and mechanical aspects may be distinguished.

Physical aspects (see for example figure 4)

- Moisture and salt transport properties; influence on the drying behaviour.
- Frost resistance or vulnerability.
- Dimensional changes (humidity, temperature).
- Salt crystallisation.

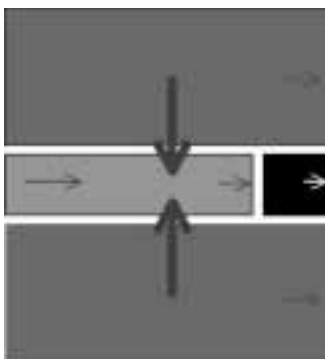

Figure 4 : *Example of a mortar analysis using thin sections : mortar composition, binder and aggregate type as well as damaging process (parallel cracks, due to frost action) can in this case be assessed.*

Chemical aspects

- Reaction of mortar components with salts (conversion into swelling salts or compounds).
- Reaction of mortar components with various compounds (dissolution of binder leading to loss of cohesion).

Mechanical aspects

- Deformability or stiffness.
- Resistance to seismic movements.
- Adherence (too good adhesion may lead to damage to masonry unit in case of push out of pointing mortar).

In the laboratory research several aspects of compatibility were studied :

- Compatibility of old and new materials. Starting with a hypothesis on the influence of the re-pointing, both solutions assumed to be compatible and solutions assumed to be incompatible were studied in order to verify the hypothesis and to gain knowledge ; mainly physical and chemical aspects have been studied.
- A better behaviour under certain external influences, i.e. better dealing with the local circumstances ; mainly mechanical aspects have been studied. For example a deep re-pointing with a strong mortar can under circumstances help to sustain a monument in a seismic area, although the drying behaviour of the masonry may be influenced negatively ; but in this case dealing with seismic circumstances would prevail in reaching the most compatible solution.

Some examples will be described more in detail hereafter.

In depth study of frost damage

In case studies of frost damage to bedding mortar, showing push out of the pointing, the study concerning the damaging mechanisms focussed on the high moisture content of the materials and the role of unsuitable pointing mortar, hindering evaporation[3]). Laboratory research was planned to study the drying behaviour of the mortars. Different mortar compositions were chosen, ranging from a tooled bedding mortar, assumed to show a good drying behaviour not hindered by any pointing layer, to a very dense cement rich mortar, with a high binder content, thought to hinder evaporation.
An innovative technique, NMR, was used to study the influence of different re-pointing compositions on the drying behaviour of the masonry (figure 5) Parallelly masonry specimens were subjected to a frost test.

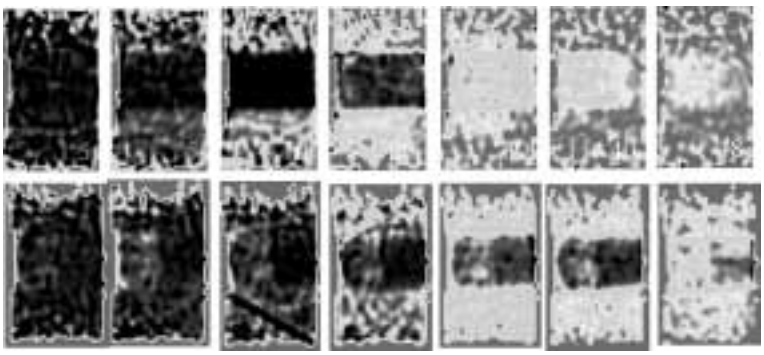

Figure 5 : *Example of a mortar analysis using thin sections : mortar composition, binder and aggregate type as well as damaging process (parallel cracks, due to frost action) can in this case be assessed.*

The re-pointing mortar proved to play an important role in the damaging process indeed. The results of the experiments showed that the composition and probably also the execution of the re-pointing (contact between bedding and pointing mortar) may influence the vulnerability of the masonry to frost. This observation is extremely important for the re-pointing of historic masonry, that is generally based on lime bedding mortars with a relatively high water retention in combination with a coarse porous brick. A decrease in the drying rate due to the choice of an incompatible re-pointing mortar may lead to frost damage to materials.

3. R.P.J. VAN HEES, L. PEL, B. LUBELLI Towards compatible repair mortars for masonry in monuments, Protection and Conservation of the Cultural Heritage of the Mediterranean Cities, 5th Int. Symp. on the Conservation of Monuments in the Mediterranean Basin, Seville, Spain, 2000.

It was shown that the original situation (with tooled bedding mortar) showed the best behaviour, however even a lime based mortar with exactly the same composition, as the bedding mortar is not necessarily the (most) compatible one. Figure 6 gives some results.

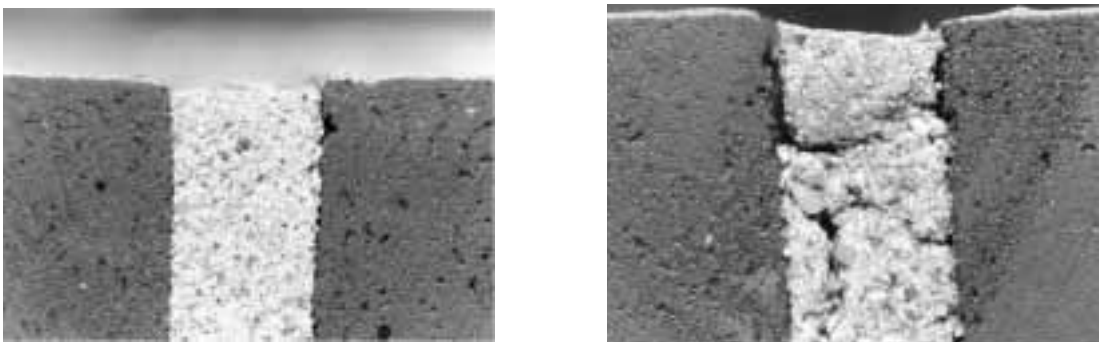

Figure 6 : *Examples of the results of the frost test, using different pointing mortars, after sixty-three cycles of freezing and thawing ; left no damage, right loss of bond and push out of the re-pointing, crumbling and start of layering of the bedding mortar.*

Mechanical compatibility

Two different aspects of mechanical compatibility have been dealt with in the research, three axial behaviour (deformability) and the effect of deep re-pointing.

Part of the compatibility issue within the context of restoration of pointing is mechanical in nature. The introduction of a new layer of mortar at the external part of the mortar joint inevitably alters the mechanical behaviour of the masonry. The new re-pointing mortar will generally not be chosen because of its compressive strength, since the mortar is introduced in a fresh state into a masonry that has already settled under the existing load. And although the re-pointing generally has only little influence on the strength of the masonry, its ability to adapt to settlements, hence the deformability of the masonry, will anyhow be influenced.
The failure of masonry is not only determined by the deformability of the mortar, but also by the effective tensile strength of the brick or natural stone units. The ultimate state of the masonry at failure can be understood by the analysis of the brick/stone-mortar interaction in the tri-axial yield surface. While at failure of the masonry the cement mortar remains a quasi-brittle material, the lime mortar turns into a viscous material, with a total deformation reaching values, which are up to fifty times higher than its uni-axial value. The issue of mechanical compatibility, upon applying new materials in historic masonry as in the case of re-pointing, should therefore not focus on maximising the strength characteristics of the new material, but it should turn to the evocation of the viscous material behaviour in tri-axial compression, instead. The restored masonry will fully employ its ability to adapt to the imposed settlements.

Deep re-pointing proved to be applicable as a reinforcement system in poorly constructed stone masonry in Umbria (Italy) which had been damaged by earthquakes. The traditional architecture, consisting of multiple leaf stone masonry, showed a typical type of damage after seismic action, whereby the separation of the two leaves took place causing partial or total collapse of the walls. Deep re-pointing was tested in laboratory and on site and an increase of strength assessed.
Deep reinforced re-pointing can also offer a solution for masonry damaged by heavy dead loads and showing cracks. The process of long-term creep behaviour can eventually lead to the collapse of the structures, like in the recent cases of the towers of Pavia and Noto in Italy. The insertion of a reinforced mortar in the bed joints of the masonry should be performed, possibly together with transversal connections by steel ties. The results of the laboratory tests showed that the technique results in a confinement for the existing crack patterns.

Knowledge transfer and deliverables

Development of MDDS and Atlas on damage to pointing

The decision on the most suitable re-pointing should be based on a thorough diagnosis of the

damage or decay, taking into account the necessary circumstances for the damage to occur. The use of MDDS, the Masonry Damage Diagnostic (expert) System will enable the user to reach a diagnosis considering the mentioned aspects. A Pointing Damage Atlas, included in the Background Information of MDDS will be of great help in the identification of the damage, and the related literature will further support the research.
A Pointing Damage Atlas was developed within the framework of the project, including types of damage due to poor craftsmanship, water penetration and environmental pollution, salt and frost. Such an overview, furnished with explanations, is meant to provide help to correctly identify and define the damage.
In the case that substitution is necessary, the re-pointing should meet some essential requirements, both from the technical as well as from the aesthetical and historical point of view. The contributions deriving from the Pointing Project and included in MDDS will help the user to plan the needed investigations to come to a compatible pointing mortar, under the given circumstances.

Decision guidelines for re-pointing

Having understood the causes of damage, a compatible re-pointing mortar should be identified. Technical and aesthetical/historical aspects should be considered before choosing the type and composition of the mortar and planning the substitution.
Guidelines on how to correctly plan a re-pointing will be described in the end report in a chapter on Historic and Aesthetical Compatibility, in a chapter on Mortar Analyses and in a more technical chapter handling with the ideal procedure to be followed : Guideline for Ideal Re-pointing. The technical requirements the re-pointing mortar should posses are pointed at in a specific contribution on Technical Requirements.

Requirements for compatible mortars

The re-pointing mortar should meet requirements concerning technical and conservative aspects and leading to compatibility with the other masonry materials.
Guidelines about mortar composition, nature of the raw materials and considerations on the way to apply (re)pointing mortar that would fit in the general and technical requirements will be given.
The mortars should not need maintenance too frequently. Nevertheless the principle defining the pointing as a sacrificial part of the masonry can often guarantee the best compatibility.

Innovative aspects of the research

Innovative techniques were applied in the study of (in)compatible re-pointing. NMR (Nuclear Magnetic Resonance) was used to study the moisture transport and the drying processes in the system bedding mortar-pointing mortar-brick.
Innovative and interesting for the study of the ultimate state of the masonry at failure (incompatibility) was further the investigation of the brick/stone-mortar interaction in the tri-axial yield surface.
The development of alternative compatible re-pointing mortars with respect to moisture and salt transport mechanisms was studied. Compatibility was checked in relation to moisture transport mechanisms and salt crystallisation.
Innovative results were the successful use of combinations of gypsum and lime and the use of in-mass water-repellent additions to pointing mortar systems.

Biography

Rob VAN HEES studied Building Physics, Eindhoven University of Technology, graduated 1976. Fifteen years experience in the field of cultural heritage and materials sciences. Co-ordinator of the product group Conservation Technology within TNO. Specialised in stone like materials, mortars, conservation treatments. Operated in EU research projects like Expert system MDDS, Surface treatments, SCOST, Pointing, in several of them as co-ordinator.

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Development of an innovative water repellent/biocide surface treatment for mortars : assessment of performance

Développement d'un traitement de surface hydrophobe/biocide innovant pour les mortiers : évaluation de la performance

C. SAIZ-JIMENEZ[1], M.T. BLANCO-VARELA, C. URZI[3], E. BOCK, I.B. BEECH, R. BALZAROTTI and A. GOMEZ-BOLEA

Abstract

The performance of a new formulation including a combination of silicone and biocide was tested for surface treatment of mortar monuments. This combination is an environmental-friendly, water-compatible formulation to avoid the problem of using aromatic or chlorinated solvents. The formulation has been found to be particularly adequate for treatment of sand, lime and pozzolana mortars.

Résumé

La performance d'une nouvelle formule constituée d'une combinaison de silicone et de biocide a été testée pour le traitement des monuments en mortier. Cette formule respecte l'environnement et est compatible avec l'eau, ce qui permet d'éviter les problèmes inhérents à l'utilisation de solvants aromatiques ou chlorés. Elle s'est avérée particulièrement adéquate pour le traitement du sable, de la chaux et de la pouzzolane.

The aim of the project "Development of an innovative water repellent/biocide surface treatment for mortars : assessment of their performance by using modern analytical tools and surface analysis", contract ENV4-CT98-0707, was to develop a new formulation based on a water emulsion of an alkyltrialkoxysilane and a biocide. This innovative formulation confers water repellency to mortars and controls growth of bacteria, fungi, algae and lichens.
The formulation was tested using different analytical methods and their performance and durability, both in laboratory (accelerated tests) and in field exposure studies was investigated. After the results obtained with the new formulations, part of which are presented in this contribution, the new products were launched to the European market under the commercial names of Hydrophase Malte and Algophase Acqua.

Experimental

Preparation of probes

The test carried out in this project were made on mortar probes made of sand and lime (L) and sand, lime and pozzolana (L+P). Once the solid constituents of the mortars were weighted and mixed, some water was added to the mixture. The mixture was homogeneized for 3 minutes and the moulds were then filled with the mixture and a mechanical tamping was applied with a shaking table. The probes were prepared as cubes of 3 cm side, prisms of 1 x 1 x 0.5 cm and of 3 x 5 x 0.5 cm. For L mortars the lime/sand ratio was 1:3, and the water/lime ratio 0.85. For L+P mortars, lime/pozzolana/sand ratio was 1:1:6 and water/lime + pozzolana ratio 0.55.
For L mortars the moulds were maintained at 21±1°C and 60 % RH for one day. Subsequently, the probes were demoulded and moved to a carbonation chamber in contact with CO_2 until complete carbonation of $Ca(OH)_2$. This process was controlled through X-ray diffraction and FTIR spectroscopy. For L+P mortars, the moulds were maintained at 50°C and 100% RH for 3 days. The probes were then demoulded and maintained at 50°C and 100% RH for 4 days. Finally they were immersed into water at 50°C for 3 more days. Afterwards, the probes were dried in an oven at 50°C for 3 hours. They were left to cool and then moved to a carbonation chamber.

Impregnation treatments

Once the mortars were carbonated, they were impregnated with two commercial silicones (Hydrophase Superfici, Phase, Italy, and Rhodorsil RC-80, Rhone-Poulenc, France) and the new formulations

developed along the project : Ph-91503 (silicone) and Ph025/d (biocide). A set of probes were also impregnated with a biocide : Algophase (Phase, Italy). In this way, 7 treatments were carried out, as shown in Table 1.

Treatment Identification	Product used	Treatment Identification	Product
T-0	Control	T-4	T-1 + Algophase
T-1	Hydrophase Superfici	T-5	T-2 + Algophase
T-2	Rhodorsil RC-80	T-6	T-3 + Ph025/d
T-3	Ph-91503	T-7	Algophase

Table 1 : *Treatments on mortars*

Properties of the mortars

Different measurement were performed on the mortars. They included :
Mortar porosity. Measurements of porosity and pore size distribution were performed with a mercury porosimeter (Autopore II 9220).
Water repellency coefficient and saturation coefficient were measured following RILEM recommendations (RILEM, 1978).
Colorimetric characterization was performed according to CIE Color Space.
In order to know the influence of the superficial treatments on mortars durability, they were subjected to accelerated ageing tests, including crystallization of salts, frost resistance, wetting-drying and ultraviolet radiation.
Salt crystallization cycles. They were carried out according to RILEM recommendations (RILEM, 1978)
Freeze-thaw cycles were carried out in agreement with standard UNE 67-034-86 (Norma UNE, 1986).
Wetting-drying cycles were carried out according to ATZENI and al. (1994).
Cycles of ultraviolet radiation. Test was carried out in an UV-B radiation chamber that was equipped with 8 ultraviolet fluorescence tubes of 300 nm wavelength. The chamber also contained a device for producing condensation. Each cycle lasted for 12 hours divided in 2 periods : 8 hours of ultraviolet radiation at 50ºC, 4 hours through condensation at 100% relative humidity and 50ºC.
Colonization of microorganisms in the laboratory was performed with different mixtures of bacteria, fungi, cyanobacteria and algae. Colonization was also studied in the exposure sites at Duisburg (Germany), Barcelona (Spain) and Messina (Italy).

Results and discussion

Porosity

Total porosity of L mortars decreased in all cases when applying the different water-repellent treatments previously described. Decreasing were between 25% for T-2 and 12% for T-6 as shown in Table 2. This was due to size reduction of biggest pores since they were partially filled with silicone. It was found that all treatments occupy pores of size 1 to 0.1 mm, while for pores sized 0.1 to 0.01 mm the treatment only filled some of them.

	T-0	T-1	T-2	T-3	T-4	T-5	T-6	T-7
Lime	25.18	20.40	18.96	19.31	20.95	19.85	22.27	21.62
Lime + Pozzolana	23.72	23.15	22.85	22.06	23.02	22.07	22.35	23.83

Table 2 : *Total porosity of mortars (volume %)*

In L+P mortars total porosity decreased slightly due to the treatments. Opposite to what happened in L mortars, addition of biocide caused more decreasing in porosity (Table 2). A decreasing of pores sized between 1 and 0.1 mm developed in all treatments, approximately in the same magnitude as in L mortars. There was an increasing of pores sized between 0.1 to 0.01 mm in all treatments. This increase was due to the filling of the pores of biggest size as a result of the treatments.

Water repellency

Efficiency of water-repellent treatments was proved by the increasing of the amount of water repelled with respect to non treated samples. In L mortars, as well as in L+P mortars percentages of repelled water were high (Table 3). This property, together with the decreasing of total porosity improved mortar resistance regarding the action of water. Treatment T-7 (biocide) provided L mortars with low water repellency ; while in L+P mortars all water was absorbed.

	T-0	T-1	T-2	T-3	T-4	T-5	T-6	T-7
Lime	-----	97.9	99.8	99.66	99.22	99.93	99.51	63.03
Lime + Pozzolana	-----	99.7	100	100	99.4	100	99.2	0.00

Table 3 : *Percentage of water repelled from mortars*

Saturation coefficient

A decreasing of the saturation coefficient of treated samples when compared with that of the non treated sample (T-0) can be observed in Table 4. In L mortars, T-1, T-2 and T-5 samples showed a very important saturation coefficient reduction. In L+P mortars the most important reduction in the saturation coefficient was shown by T-3 and T-6 samples.

	T-0	T-1	T-2	T-3	T-4	T-5	T-6	T-7
Lime	13.5	2.4	1.0	8.9	11.2	3.7	10.1	13.2
Lime + Pozzolana	13.5	10.8	12.2	2.7	11.4	11.3	3.6	12.4

Table 4 : *Mortars saturation coefficient (weight %)*

These results are in good agreement with data of total porosity. In L mortars, the decreasing of saturation coefficient was higher than in L+P mortars, and the same happened with respect to total porosity.

Colorimetric coordinates

In all cases color variations were so small that it could not be perceived by naked eye.

Durability of treated mortars against aggressive agents

The aspect of L mortar and L+P mortar samples, before and after being subjected to the different tests, is shown in figure 1.

Cycles of salts crystallization

L mortars had a remarkable deterioration after 5 test cycles, as shown in figure 1. L mortar, with 10.7 Mpa of compressive strength, was a material with poor resistance to salt crystallization. Deterioration was evidenced by the loss of the surface layer of the probes (2 mm thick), that corresponded to the zone impregnated with the silicones. This deterioration produced the lost of all improved properties, such as initial hydrophobicity or reduction of porosity and smaller saturation coefficient. By losing the protection, weathering by crystallization pressure of salts was easy and thus material destruction happens fast. All specimens were similarly destroyed, except for T-2 and T-5, (less porous samples). This was due to the low saturation coefficient.

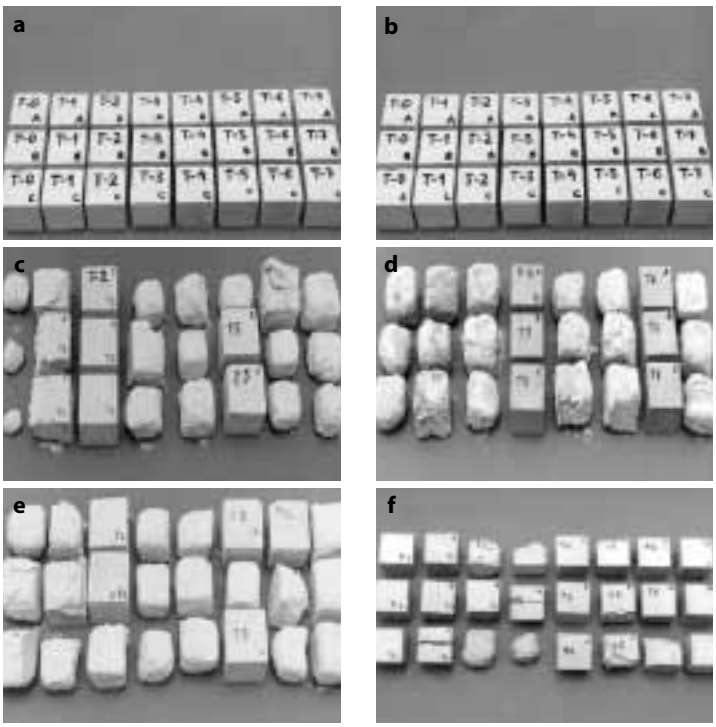

Figure 1: *Accelerated ageing tests.*
a : Lime and pozzolana mortars before testing. b : Lime mortars before testing. c : Lime mortars after 5 salt crystallization cycles.
d : Lime and pozzolana. e : Lime mortars after 15 freeze-thaw cycles.
f : Lime and pozzolana mortars after 22 freeze-thaw cycles.

L+P mortars whose compressive strength was slightly higher (13.5 Mpa) than L mortars, deteriorated in the same way, but in a lesser degree. As in the L samples, they lost their water repellence properties when lost the superficial silicone layer. The only specimens not affected by the test were T-3 and T-6, which had the lowest porosity (Table 2) and the lowest saturation coefficient values (Table 4) reason why it is harder for the solution to find an access into the mortar. This improved behavior was due to the reaction of lime with the pozzolana, which develops agglomerating products which produced a higher mechanical strength.

Frost resistance

L mortars underwent a remarkable deterioration after 15 freeze-thaw cycles. The deterioration process of probes starts with the appearance of cracks on the surface and later the surface layer containing silicone becomes detached. In such a way samples gradually lost their hydrophobic properties, and increased their porosity, which facilitated water access into the material resulting in an accelerated deterioration.
As in earlier cycles, all mortars were equally affected, except T-2 and T-5. Due to these factors, mortars T-2 and T-5 were the ones presenting lesser weight loss.
In L+P mortars, deterioration after 15 cycles was not strong enough to produce their destruction, reason why the test was continued until 22 cycles. When 22 cycles were completed, cracks and fractures were observed in samples T-1 and T-3. The remaining probes lost, in different degree, the outer silicone layer corresponding to the impregnation treatments, also showing cracks and fractures of different magnitude.
Wetting-drying cycles. L mortar samples were not affected by this test. The visual aspect, saturation coefficient, and hydrorepellency remained constant after completing the 30 cycles. Only a slight weight loss in all mortars should be mentioned. Behavior of L+P mortars was similar.

Ultraviolet radiation test

Water-repellence coefficient of mortars, before the beginning of the test and after 500, 1000, 1750 and 2000 hours of UV exposure were determined. Both L and L+P mortars showed no variation in

water-repellent properties, except for treatment T-5, in which the percentage of repelled water decreased 6.8% at 1750 hours, and 7.4% at 2000 hours, which affected their hydrorepellency.

Microbiological analyses

After 15 months of inoculation with bacteria, mortars revealed the presence of microorganisms in most probes. Only T-4 and T-5 probes showed a total absence of bacterial colonization. Fungal colonization were observed in untreated mortars and mortars treated with silicones after 21 months of inoculation. No fungal growth was observed on the mortar surfaces treated with Algophase alone (T-7) or in combination with silicones (T-4, 5 and 6). The same was found for algal colonization.

Table 5 shows the results of the inoculation of mortars with pure cultures of cyanobacteria. Inoculation with Gloeothece membranacea or Phormidium fragile resulted practically in the absence of growth in mortars treated with biocide after 12 months of incubation.

			Gloeothece membranacea			Phormidium fragile		
Mortar composition	**Treatment**	**Sample**	**Growth (months) 3**	**6**	**12**	**Growth (months) 3**	**6**	**12**
Lime	None	T-0	-	-	-	-	-	-
	Silicone	T-1	-	-	-	-	++	++
		T-2	-	-	+	-	++	++
		T-3	-	-	-	-	++	++
	Silicone + Algophase	T-4	-	-	-	-	-	-*
		T-5	-	-	-	-	-	-*
		T-6	-	-	-	-	-	-*
	Algophase	T-7	-	-	-	-	-	-
Lime + Pozzolana	None	T-0	+	+	-	-	+++	+++
	Silicone	T-1	-	+	+	-	+++	+++
		T-2	+	+	+	+++	+++	+++
		T-3	-	+	+	+++	+++	+++
	Silicone + Algophase	T-4	-	-	-	-	-	-
		T-5	-	-	-	-	-	-
		T-6	-	-	+	-	-	-
	Algophase	T-7	-	-	-	-	-	-

** fungal colonization*

Table 5 : *Colonization of mortars by cyanobacteria*

Mortar probes exposed in Duisburg, Barcelona and Messina showed different behavior. In Duisburg, a very polluted industrial city, after 18 months of exposure all samples were colonized by bacteria, fungi and algae. In Barcelona, after 24 months of exposure there was not evident colonization of photosynthetic organisms (cyanobacteria, algae and lichens) in normal conditions (45° inclination and facing to the North), although dematiaceous fungi were present. A second set of probes placed in horizontal position to facilitate humidity retention evidenced that colonization was different after 12 months, in such a way that algae were present in control mortars, but not in silicone and silicone + biocide mortars. However, fungal colonization was very abundant in control mortars (T-0 and T-7) and mortars with silicones (T-1, 2, 3), while mortars with silicones and biocide (T-4, 5, 6) showed no colonization either by fungi or algae. In Messina, after 22 months exposure it was observed that natural settlement of airborne fungal conidia and spores occurred on the surface of

mortar probes and thus fungal colonization was evident. Algae were located on the natural cavities of mortars. It was found that silicones alone were not sufficient to prevent microbial colonization, while associated to the biocide reduced this colonization.

Conclusions

1. To test the performance of the new formulations, two types of mortar probes were prepared, one based on sand and lime and another on sand, lime and pozzolana. The probes were subjected to different impregnation treatments with two commercial silicones and with the new silicone, and were also treated with the biocide. Controls were also prepared.

2. Testing of the mortar probes showed that water repellency was very good, saturation coefficients of mortars decreased in all treatments, color changes were not significantly present after impregnations, and exposure to ultraviolet radiation for 2000 hours had not variation in water-repellence properties. In accelerated ageing tests impregnation with silicones conferred more resistance to lime mortar treated with Rhodorsil RC-80, while for lime and pozzolana mortars the best results were obtained with the new formulations.

3. Mortars were a suitable substratum for the colonization of micro-organisms, even when water availability was scarce. The efficacy of the biocide was tested against pure cultures of micro-organisms and mixtures. The tests demonstrated that the biocide alone or in the new formulation had a high efficacy against a wide range of stone inhabiting micro-organisms including nitrifying bacteria, heterotrophic bacteria, fungi, cyanobacteria and algae.

4. Application of water-repellent to mortars succeeded to reduce natural weathering of mortars exposed outdoor, but the treatment alone was not sufficient to prevent microbial colonization, while the association with the biocide was more effective.

Acknowledgements

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Biography

Cesareo SAIZ-JIMENEZ is Research Professor at the Spanish Council for Scientific Research. He is Ph. D. in Biology (University of Madrid) and Ph. D. in Chemical Engineering and Materials Science (Technological University of Delft). He participated in all different Cultural Heritage EC programmes since 1987 and has been involved in the last ten years in a total of twenty-five projects, many of them as coordinator. He is member of the editorial board of Aerobiologia, International Journal of Aerobiology, International Biodeterioration and Biodegradation, and Annals of Microbiology. He published more than 200 papers in international journals, congresses and workshops.

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Optimalisation of mineral repair mortars for historic buildings (lithos arte® mortars)

Optimisation des mortiers mineraux de restauration pour les monuments historiques (lithos arte® mortars)

Filipo MOENS[1] and Eddy de WITTE

Since more than a century repair mortars are used to reconstruct lost parts of carved stones which still are structurally sound. To prepare these mortars, up to now, several binding media have been used. There are mineral binding media such as cement, putty lime, hydraulic lime, puzzolane and zinc oxide. And organic binding media such as polyester, epoxy, polyuethane and acrylics.
Most of these binding media have some disadvantages :

- Lime based mortars harden rather slow, which limits the application thickness.
- Cement based mortars are very sensitive during hardening to temperature and relative humidity, they also show important shrinkage and the water transport through the mortar is unfavourable.
- Epoxy, polyester, polyurethane and acrylic mortars are easy to apply, but their light stability don't meet conservation standards.

Zinc oxide mortars have been introduced in the second part of the 19th century and widely used in France, Belgium and sporadically in Germany and the UK. After the Second World War, this material disappeared almost completely from the market, till about ten years ago when we see a reappearance of such products mainly in Belgium. Although in general the results seem to be quite convincing, once in a while problems do occur. A few cases of unacceptable shrinkage or low frost resistance have been observed. Preliminary research proved that sometimes relatively high amounts of free chlorides could be detected. Literature research didn't provide any information on reaction kinetics but did provide a number of divers formulas. Unfortunately non of them alike.

In order to get a better understanding of the problem a craft project has been proposed to the European community. The project : Optimalization of Mineral Repair Mortars for historic Buildings has been accepted under the contract number : ENV4-Ct 98-0769.

The consortium consists of the prime proposer FTB restoration, the research provider (KIK-IRPA) and two end users Bauer-Bornemann and Merindol. FTB restoration is a company specialised in the production of restoration products. KIK-IRPA is a federal conservation laboratory in Belgium. Merindol is a restoration company, which has a tradition of using ZnO mortars. Bauer-Bornemann is also a restoration company, which never used this kind of materials before.

The main objectives of the project are :

- To evaluate the state of preservation in practice of several commercial repair mortars.
- To investigate the chemical reaction as well as the kinetics of the zinc oxide mortar.
- To determine the influence of the chemical and physical parameters of the aggregate on the properties of the final product.
- To develop a complete stone repair system, consisting of a consolidant, a repair mortar, an appropriate water repellent or paint system.
- To evaluate on a comparative base commercial repair mortar.

The project ended in December 2001. In a first stage a photographic inventory has been made of the state of conservation of repair mortars used in the past. Some problems have been observed such as :

Figure 1 : *Shrinkage*

Figure 2 : *Lack of adhesion*

Figure 3 : *The colour doesn't match (to dark or to light).*

Figure 4 : *Biological aggression (more biological layers than on original stone or less biological layers than sandstone).*

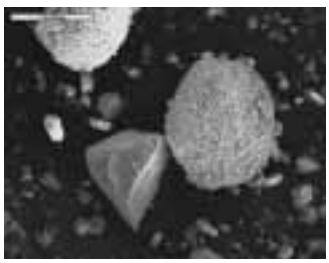
Figure 5 : *To coarse grained*

Figure 6 : *Salt efflorescence*

During the research it has been possible to elucidate the nature and the kinetics of the chemical reaction. Zinc oxide can react with zinc chloride in the presence of water to give at least nine complexes were x can range from one to nine.

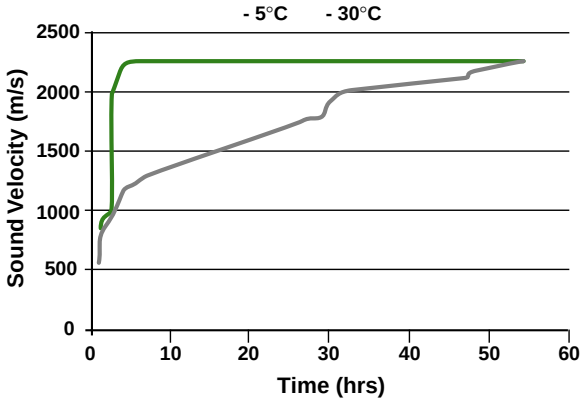
$Zn_2H_2Cl_2O_2$
$Zn_3H4Cl_2O_4$
$Zn_4H_6Cl2O_6$
$Zn_5H_{10}Cl2O_{10}$
$Zn_6H_{12}Cl_2O_{12}$
$Zn_7H_{14}Cl2O_{14}$
$Zn_8H_{16}Cl_2O_{16}$
$Zn_9H_{18}Cl2O_{18}$
$Zn_{10}H_{20}Cl_2O_{20}$

Only the tetra zinchydroxy zincchloride is suited as binding medium. This can be obtained by limiting the concentration of the different compounds between well-defined limits.



Another parameter, which proves to be very important, is the preparation of the mixture ZnO granulates. Only when the granulates are perfectly coated by ZnO (as you can see here in contradiction whit this one) optimum results are obtained.

The reaction kinetics has been studied by measuring the sound velocity in freshly prepared mortars. As we see in the graph, measurements started after fifty minutes when the mortar was removed from the mould. The reaction at that moment is still going on. The complete reaction is obtained after seventy-five minutes after which the sound velocity continues to increase due to the evaporation of the water. After about four hours, at 20°C, the mortar obtains his final properties.



Similar tests executed at 5 and 30°C prove that there is a slight influence of temperature on the reaction speed. As can be expected, evaporation of the water takes much longer at 5°C than at 30°C however, even at 5°C the final properties are obtained after two days.

Depending on the granulates used for the preparation, mortars are obtained with varying hardness and porosity. The drill force resistance of some mortars and stones are compared. The Lithos Arte ® 1 has almost the same hardness as the Savoniere and the Lithos Arte ® 2 has almost the same hardness as the St-Maximim. Just by varying the granulates, it is possible to create two mortars with different hardness.

Freeze thaw tests between minus 10°C and plus 15°C after impregnation with water under atmospheric pressure as well as under 14 mm vacuum prove that the new formulation is frost resistant.
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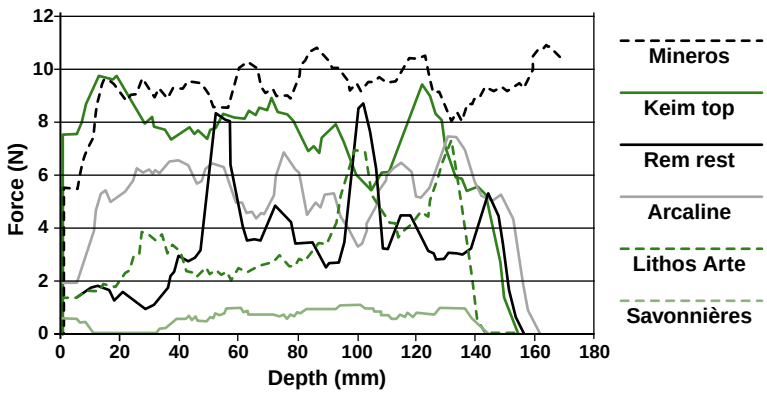
1006 hours light ageing show no colour change on the most coloured samples such as –ferruginous sandstone and brick.

One of the tasks was to develop a complete stone repair system consisting of a consolidant, a repair mortar, an appropriate water repellent or paint system. We can now say that the effectiveness of siloxane based water repellents is as good as the effectiveness on natural stone. Consolidation of a surface after partial restoration with a repair mortar is possible. A paint system based on siloxane paints has been developed (as we can see in the next slide) after 1006 hours of weathero meter ageing : colour and adhesion are still perfect.

Finally the properties of a number of commercially available mortars were compared with those of the improved ZnO formulation. Quite a number of results are already obtained such as water accessible porosity and mercury porosity, capillary water absorption, compressive strength and E-modulus. Just as an example the drill force resistance measurements of a natural stone : Savonierre and some of these mortars are shown. As you can see the Lithos Arte ® is slightly softer than the original stone but still very close in contradiction with the other mortars.

DFMS measurement



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Ancient waterlogged wood treatment by using starch impregnation and D.I.C. technology (Arkè Method)

Traitement du bois trempé ancien par imprégnation à l'amidon et par la technologie DIC (Méthode Arkè)

Rebecca IPPOLITI[1]

Abstract

The most interesting result of this project is the creation of a simple model to apply the Arkè method to restore any kind of waterlogged wood based on its degradation level. With this method it will be possible to consolidate waterlogged samples of any wood species in order to exhibit it in an exposition structure. This process consists of consolidating the waterlogged wood with a treatment that comprises impregnation coupled with innovative desiccation in a special treatment chamber.This method is economical (lower costs compared to existing methods), totally reversible, ecological (more natural appearance of the wood; use of environmentally friendly products), quick (ten times quicker than the PEG + freeze-drying method) and large pieces of wood can be treated with this method.

Résumé

Le résultat le plus intéressant de ce projet est d'avoir facilité l'application de la méthode Arké pour la restauration de toute sorte de bois détérioré par l'absorption d'eau en fonction de son niveau de dégradation. Cette méthode permet de renforcer les spécimens, quelle que soit la variété du bois, afin de pouvoir les exposer. Le procédé consiste à solidifier le bois grâce à un traitement associant l'imprégnation d'amidon et une nouvelle méthode de dessiccation s'effectuant dans une étuve spéciale. Cette technique est économique (les coûts sont inférieurs à ceux des techniques existantes), totalement réversible, écologique (le bois conserve un aspect plus naturel et les produits employés respectent l'environnement), rapide (dix fois plus que la méthode PEG et celle du séchage par le froid). Elle permet également de traiter des objets de grande superficie.

The Craft West project (Wood Exploitation by using Starch Impregnation and D.I.C. Technology, n. ENV 4 CY 98 0767), started the 1/12/1998 and ended the 30/11/2000, was funded by the European Community "Environment R&D program".The partners of the project are both SME's proposer and RTD performers ; they are :

- Contento Trade SRL (coordinator) IT
- Centro Restauri (prime proposer) IT
- NEU Sechage Industriel SA FR
- All System SRL IT
- Ecoplan SRL IT
- Terminal Bois Nord 19 FR
- Divergent FR
- Gradient FR

The project aims at the development (through the building of a pilot plant) of a recently patented process for the archaeological - wood sector (Arkè method) that can also be applied to fresh wood. This process consists of consolidating the waterlogged wood with a treatment that comprises impregnation coupled with innovative desiccation in a special treatment chamber.
The waterlogged wood problems that need to be solved to restore the wood are the following :

- The ancient wood contains a lot of water (till 90 % of the dry wood mass).
- The cellulose disappears during the long immersion.
- During the desiccation treatments the wood shrinks, cracks and its structure collapses.

The most used and successful restoration techniques at present is the Poly - Ethylene Glycol (PEG) technique, where PEG is used as impregnation agent (with different molecular masses) and in some cases is coupled to freeze drying for the desiccation.
The advantages of this method are the substitution of the water in the wood structure, the maintenance of the initial dimensions (reduced shrinkage) and the stabilization of the structure.
The disadvantages of this method are the long duration of the treatment (several years), the

expensive treatment, the bad quality of the obtained products, such as the sticky aspect of the external texture and the darker color of the treated objects, the fact that the wood has a high hygroscopicity after the treatment and the irreversibility of the treatment.

Work carried out

Contento Trade SRL together with the partners of the project developed a new restoration technique called Arkè Method, using starch impregnation and D.I.C. technology.The innovative proposal so, aims to test and optimize the Arkè method and to plan and realize a pilot plant for the waterlogged wood treatment.
The Arkè method consists in four main treatment phases :

- Evaluation of the degradation level of the wood.
- Impregnation of the wood with starch and derivatives.
- Intermediate thermal treatment.
- Final desiccation.

To these phases it's possible to add a fifth one for the improvement of the museal exposition of the treated object, so it includes the superficial treatment of the object and a structural consolidation

Evaluation of the degradation level of the wood

The determination of the wood degradation level it's fundamental for planning an appropriate restoring intervention. It's necessary to know two characteristics of the wood : identification of the wood species and determination of the Maximum Water Content (MWC). This last property indicates the degradation of the wood, expressed as percentage ratio between water and wood under complete saturation conditions. In the fresh wood this ratio shifts from 60 to 100% while in the waterlogged wood this ratio shifts between 120% to 800% but can exceed the 1.000 %.

Impregnation of the wood with starch and derivatives

The impregnation takes place at room temperature and with a slow agitation of the impregnating agent and can be done inside the treatment chamber.
Together with the starch, also anti - fungi and anti- bacteria agents can be put in the wood. The innovation of Arkè impregnating process is schematized in the following table :

	Arkè method	Other methods
Function of the impregnating walls with molecules	Reinforcement of the cellular chemically similar to cellulose of the wood, without saturating the structure of the wood.	Saturation of the wood structure
Reversibility of the impregnation process	Nearly total reversibility (% of recovered impregnating agent by simple water washing.	Good reversibility (<90%) for the methods based on sugar, the methods based on sugar, very scarce reversibility for all the others methods.

As it's possible to notice, our impregnation is nearly totally reversible and the wood cells are reinforced with molecules similar to the natural cellulose, for this reason the wood is not totally saturated and so also its weight is much lighter than the one obtain with traditional methods.

Intermediate thermal treatment

It's a steam treatment (max 140°C) short lasting (max 30 min.), similar to the treatment used for the fresh wood. It's done inside the same impregnation treatment chamber. The obtained results are schematized in the following table.

	Arkè method	Other methods
Function of the intermediate thermal treatment	Polymerisation of the granular starch used as impregnating agent Relaxation of the fibers for the minimisation of the shrinkage in the desiccation phase. Complete de-bacterisation of the treated object.	Not used

The result of this third passage is that the shrinkage of the wood is really minimum and moreover the wood is debacterized and so the bacteria and fungi have more difficulties in attacking it.
Finally the starch, coming inside the wood, becomes polymerizes and fills all the holes, such avoiding the possibility of structural collapses.

Final desiccation of the treated woodArkè method uses a special de-hydration at successive decompression (DDS) to obtain a desiccation of the treated wood. This rapid method is based on the Instantaneous Controlled Decompression (DIC).

The wood is maintained under vacuum (30-800 mbar) at room temperature and, with intermittent pressure changes, the water inside the structure auto-evaporates.
Another version of the DDS treatment works with higher vacuum level and temperatures < 0°C .
Both these treatments can be applied inside the treatment chamber used in the first two phases. The innovations of the desiccation Arkè process compared to the traditional methods are the following :

	Arkè method	Other methods
Function of the desiccation treatment	De -humidify the treated sample at room T (or at low T) contrasting the collapse of the structure with intermittent and cyclic decompressions..	De-humidify the treated sample trying to limit the shrinkage of the structure.
Rapidity of the desiccation treatment	DDS treatment is the most rapid compared to the ones existing on the market, adapt to impregnated and not impregnated woods.	The freeze- drying treatment is the slowest compared to the ones existing on the market.
Costs of the desiccation treatment	DDS treatment needs energy consumption inferior to freeze drying and desiccation under vacuum treatments.	The freeze- drying treatment needs the highest power consumption compared to any other treatment.

Our method is really competitive from the economic point of view (lower costs compared to the existing methods) ; the time needed for it's the waterlogged wood restoration is very rapid (ten times quicker than the PEG + freeze drying technique) and moreover the treated woods look like fresh one because they don't collapse and their color is similar to the fresh wood one.

The results obtained with the Arkè method on woods with different initial maximum water content are the following :

MWC before the treatment	Wood species tested	Anti shrinkage effect	Colour alteration	Mechanical stability	Texture	Durability
< 200	Abies, Pine Quercus	> 90%	No alteration	No fissuration Self sustaining	Wood texture	> 2 year lab conditions
>200 <300	Abies, Pine Quercus	> 90%	No alteration	No fissuration Self sustaining	Wood texture	2 year lab conditions
>300 <500	Abies, Pine Quercus	> 85%	No alteration	No fissuration Self sustaining	Wood texture	> 2 year lab conditions
> 500	Ficus	To be treated with low temperature DDS Data not available at the moment				
Optimal values	All	>85% (corresponding to those fresh)	No alteration	No fissuration Self sustaining	Wood texture	Higher as possible

It's possible to notice that, with the tested wood species, the treated wood has is a more natural appearance (and more the products used to impregnate it are environmentally friendly), it has a very small shrinkage effect and no fissuration processes.

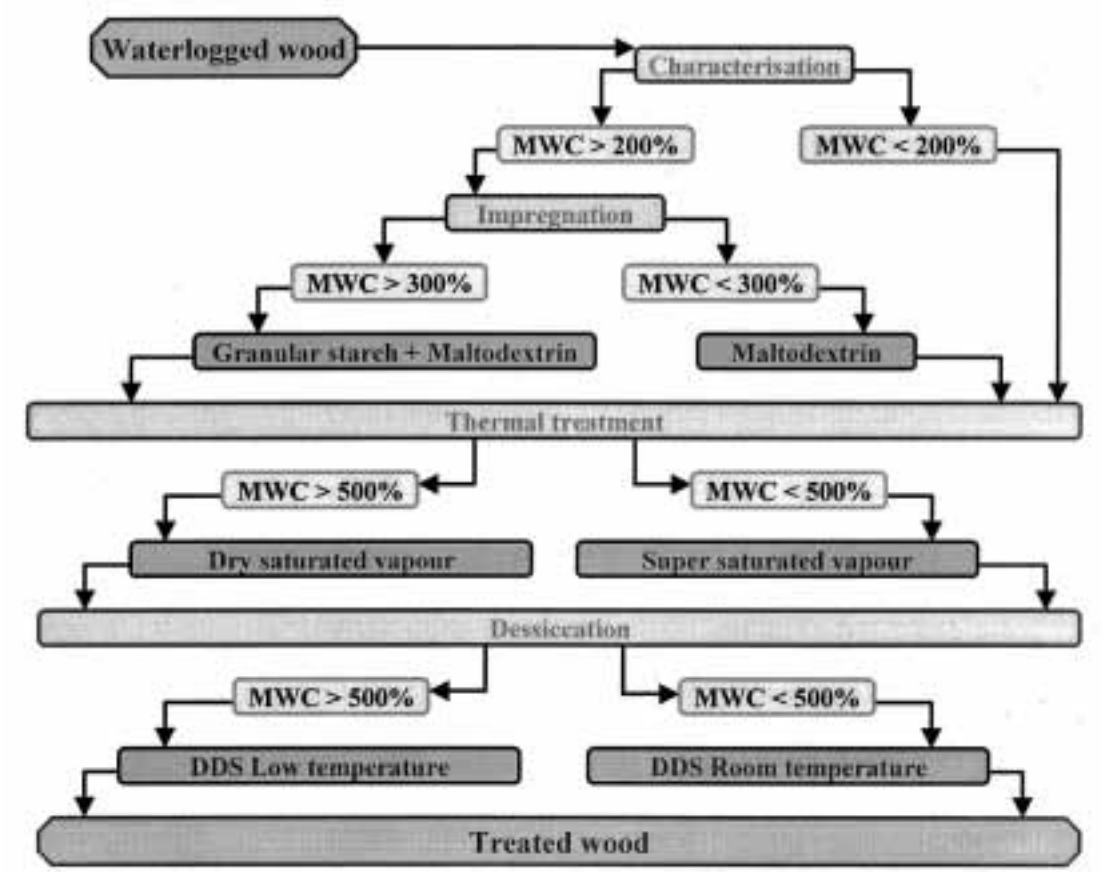
The results obtained with our innovative method can be observed in the following photos.

Before Arkè treatment

After Arkè treatment

Conclusion

The most interesting result of this project is the creation of a simple model to apply the Arkè method to restore any kind of waterlogged wood based on its degradation level. With this method will be possible to consolidate waterlogged samples of any wood specie in order to exhibit it in a exposition structure.
The model is presented in the following diagram.



For more information please consult the following site : www.contentotrade/mest or write to: west@contentotrade.com

Biography

Rebecca IPPOLITI is a researcher involved in the project. Expert in Natural Sciences, she works in the field of the waterlogged wood characterization and in the development of the wood consolidation system.

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Session E Microclimate within museums, churches, libraries and archives : for better or for worse ?

Session E Microclimats dans les musées, églises, bibliothèques et archives : pour le meilleur ou pour le pire ?

Rapporteur : Jonathan ASHLEY-SMITH

The essence of this session was that within any enclosure, be it a building, a room, a showcase or a plastic bag, there will be environmental factors that are going to be different to those outside the enclosure. There will be an interaction between the microclimate and the object. This is perhaps to be discouraged or even encouraged. The study will consist of measuring the environmental factors outside and inside the enclosure and arriving at a transport mechanism which explains the difference between the two.

Something must then be known about the nature of the object and its complexity. Good examples of understanding the complexity of metal, painting; leather, stucco and stone have been given.

The study of change follows. This could involve a change in colour, or there could be changes in chemical composition which may need very expensive equipment to determine. Good examples of measurement and assessment for a single parameter were then given. For instance, the development of diffusion tubes for measuring parts per trillion of hydrogen sulphide and carbonyl sulphide. There were also multiple criteria measurements or assessments, using a range of pigments in a binder to simultaneously measure the effects of a wide variety of environmental parameters. There was good understanding of the object and also the object-and-environment as a system to be studied.

During the discussion time it became obvious that all of these were complex systems and that objects themselves are complex. Research should be orientated towards studying that complexity rather than dealing with a reductionist view.

The research did lead to good, end products in the form of control mechanisms such as new absorbants for pollutants.

There was discussion of passive and active intervention to alter relative humidity. Some methods were cheap, some very expensive and not always working properly. We also had very good examples of technology transfer. Research should be moved away from pure reductionist science and redirected towards something a little more involved with people.

Rapporteur : Jonathan ASHLEY-SMITH

Cette session était consacrée à l'impact de l'environnement sur les objets conservés à l'intérieur d'un bâtiment, d'une salle d'exposition, d'une vitrine ou d'un conditionnement clos, ainsi qu'à la prise en compte du microclimat autour de l'objet. Selon le cas on souhaite favoriser ou défavoriser l'établissement d'un tel microclimat. L'étude va alors se focaliser sur la mesure à l'interface et sur les mécanismes de transport des fluides.

Pour cela il est nécessaire de bien connaître la nature et la complexité de l'objet. De bons exemples ont été donnés pour les matériaux tels que le métal, la peinture, le cuir, le stuc et la pierre.

Il est ensuite nécessaire d'observer les transformations. Celles-ci peuvent se produire sous forme de changements de couleur ou de modifications de la composition chimique dont la détection exige souvent un équipement coûteux. De bons exemples de mesures ont été présentés, tels que l'élaboration de tubes lumineux permettant de mesurer le sulfure d'hydrogène ou de carbonyle au trillionième près. Des méthodes à multiples critères consistant à mélanger de nombreux pigments différents à un liant afin d'étudier l'impact simultané des facteurs environnementaux ont été présentées. L'objet en lui-même ainsi que la relation objet-environnement ont été pris en compte. Des exemples de modélisation ont été donnés tout en insistant sur la complexité des objets.

Grâce à la recherche, il existe aujourd'hui de nouveaux moyens pour adsorber les polluants et contrôler de façon active ou passive l'humidité relative. Certaines méthodes sont économiques, d'autres très coûteuses et pas toujours efficaces. De bons exemples de transfert de technologie ont été présentés, mais l'impact des visiteurs ou des usagers n'est pas toujours suffisamment pris en compte. Il est impératif que la recherche abandonne une vision trop simpliste et réductrice.

Church heating : a challenge looking for solutions

Chauffage d'église : un défi à la recherche de solutions

Dario CAMUFFO[1], Giovanni STURARO

Churches and other historical buildings contain an immense number of works of art : paintings on canvas or tablets, frescoes, statues, decorations, ancient books, organs, tapestries and so on. Many historical artefacts that have been preserved per centuries in the same environment have adapted to the natural microclimate with structural irreversible modifications, loosing with time their original elasticity and reversibility. Now, any departure from the original conditions is dangerous and any cycle has in the long run a cumulative effect that, soon or later, becomes visible. The present church heating, mainly operated sporadically, and the massive presence of cultural tourism constitute a tremendous challenge for conservation of this extremely important cultural heritage.

This patrimony is often preserved in inappropriate conditions. In fact it is not easy to create and manage a microclimate which meets the requirements of both artwork conservation and people comfort in historic churches. The heating system planning is generally based on the following factors : (i) cost ; (ii) level of human comfort ; (iii) an incomplete knowledge of the interaction between the outdoor climate and the indoor microclimate determined by the historical building and its internal sources of heat, and (iv) a great confidence in a powerful heating system that may seem to overcome every drawback due to the lack of knowledge of the key factors.

Although these issues have been tackled with particular case studies, the knowledge of the response of the building interior to the external (and internal) forcing is still incomplete and needs further research. Some forcing factors (e.g. the regional climate and the heat and moisture released inside by people or by damp overcoats) can be easily measured. However, the exchanges through openings and fissures are more difficult to measure. As a result, it is very difficult to evaluate the amount of vapour that is absorbed by mortars, furnishings and decorations. Indoor sources and sinks of heat and moisture are continually variable and induce exchanges with the fabrics and air movements. The consequences are increased deposition rates of smoke and pollutants, and physical, chemical and biological mechanisms, which damage objects and the fabrics.

Parishes and building service engineers who install heating systems in churches not always are expert in conservation science, so that economy and human comfort are the key factors in choosing the heating system. Heating is mainly planned for the well-being of people and not for conservation, without understanding of ancient artistic techniques and restoration technologies. Unfortunately, works of art can not protest as people do and, consequently, the signs of degradation show up only slowly and irreversibly after some time.

In order to realise an immediate economy (i.e. without considering the costs concerning artworks deterioration and restoration), churches are often heated with methods that cause rapid warming or release excess moisture and are therefore dangerous for conservation. Always for economic reasons heating is often planned for the limited period in which people are present. The majority of churches are warmed only weekly, in view of the sunday liturgy, with inappropriate systems. This common practice causes abrupt changes in the air temperature and relative humidity. These environmental cycles generate stress, fatigue and damage to the works of art preserved inside, and in some cases the consequences are dramatic.

What is known about deterioration mechanisms

Despite an extensive literature, deterioration mechanisms are not fully known. Often the dynamic regime established with weekly heating cycles associated with release of moisture from people can generate conflicting situations : the sharp warming of the air causes a drop in the relative humidity, and artworks with short-time temperature inertia (e.g. paintings on canvas) are dehydrated and contract. On the other hand, the walls for their slow response remain cold, below the dew point, and part of the moisture emitted by people condenses on frescoes, decorations and mortars, with negative consequences.

Unfortunately, wood, ivory and parchment are extremely sensitive to temperature and especially humidity changes (MECKLENBURG, and al., 1994, 1995 ; MECKLENBURG and TUMOSA, 1999). The reason of the rapid decay of works of art, which occurs nowadays in churches, is that all materials expand or contract because of heat and humidity excursions. If a thermo-hygrometric variation occurs very slowly (e.g. seasonal changes), the expansions or contractions take place equally throughout the entire volume of the object with a limited damage, except in the case of structures made of wood with a rigid combination of planks having grains differently oriented, as in frames, furniture, music instruments, which generate differential expansions and stress, often with formation of cracks. This mechanism is even more dramatic in the case of a rapid change of temperature or humidity, since steep gradients are formed from the outer surface of an object. The surface layer, which is most affected, is deformed differently from the innermost levels, giving rise to great inner tensions, that then turn into superficial micro- or macro-cracks, or the outer layer detaches from the underlying ones.
Although the air becomes too dry in terms of relative humidity due to the air overheating, the increased moisture content of the air generated by people respiration and transpiration rises the dew point above the wall and ceiling temperature, causing condensation on the plaster. As a consequence of the surface condensation, mortars and stones in walls undergo dissolution-re-crystallisation cycles, which lead to a rapid decay of the building material (ARNOLD and ZEHNDER, 1991 ; ARNOLD and al., 1991). Temperature variations of the buildings originate also freezing-thawing cycles. Also biological life is favoured by the moisture absorbed into walls, with growth of mould or algae (SANCHEZ MORAL and al., 1999).
Another undesired effect connected with the air motions generated by the air-walls temperature differences and the wall condensation, is the increased soiling rate of all the surfaces, where the smoke particles of candles and incense deposit and stick, blackening objects, paintings and decorations (HUYNH et al., 1991 ; ARANDT, 1993).
These deterioration mechanisms happen very often as a number of case studies in the literature demonstrate (ARENDT, 1993 ; BATTERMAN, and BURGE, 1995 ; BREIDEN and SCHMIDT, 1995 ; CAMUFFO and BERNARDI, 1995 ; CAMUFFO et al. 1999 a, b ; DULOSY, 1981; FITZNER, 1986 ; KAMPF and CLASEN, 1995 ; KOZLOWSKI, 2000 ; KOZLOWSKI and al. , 2000 ; KROLKIEWICZ, 1989 ; SCHELLEN, and al., 1994 ; SCHELLEN and DE WIT, 1999 ; SCHELLEN, 2000 ; STANGIER and al., 1995 ; TASSOU and al., 2000), and the most common problems are reported in the next section.

The most common problems concerning church heating

Condensation due to the presence of people

Whatever is the heating system, people breathing and transpiring emit water vapour at a rate 0.05 kg/h (i.e. 0.03 kg/h respiratory and 0.02 transpiratory) per person. The increase in moisture content in the air leads to an increase in the dew point (DP) temperature. When the DP rises above the wall temperature (which remains substantially constant or varies very slowly for the great thermal inertia of the building structure), immediately condensation occurs on walls (figure 1c), whatever is the relative humidity in the air (CAMUFFO, 1998). Frescoes, decorations, plaster and bricks are immediately soaked, giving rise to wetting/drying cycles followed by leaching and migration of the soluble salts, formation of efflorescences, scaling and other effects generated by the dissolution/re-crystallisation cycles.

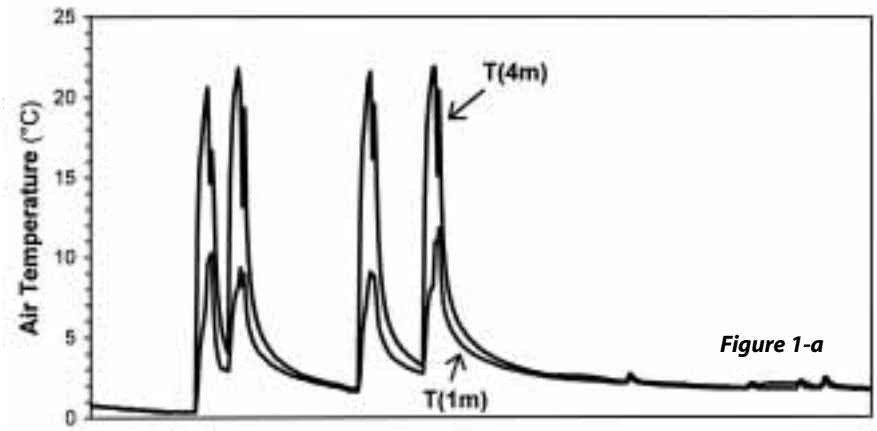

Figure 1-a

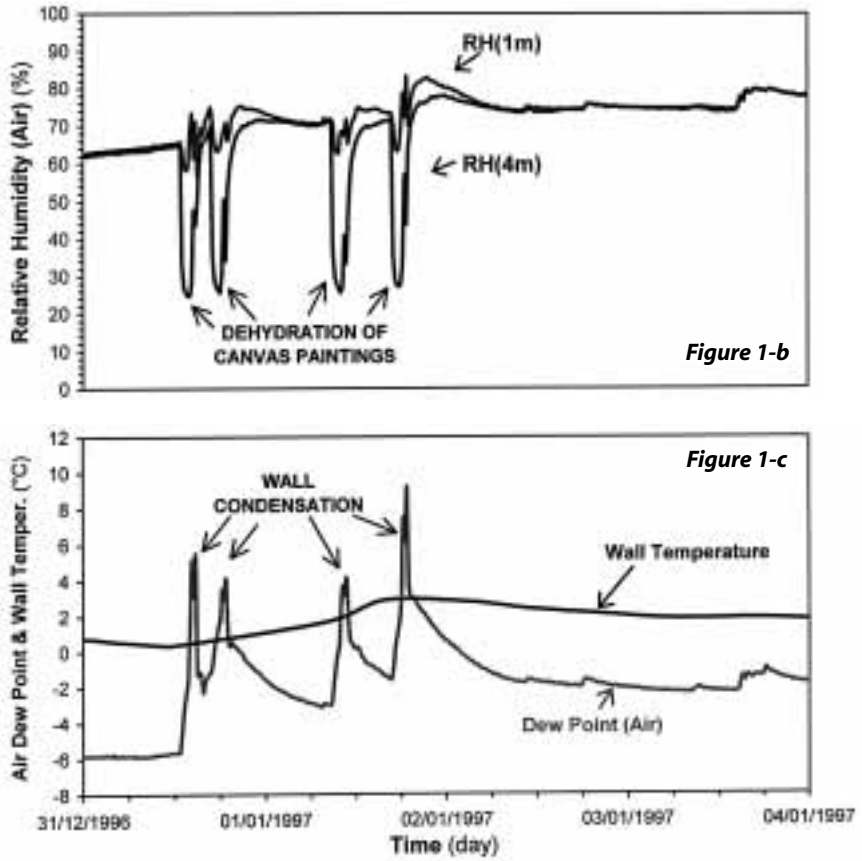

Figure 1 - a, b, c : *Microclimatic changes induced by a hot air heating system (used intermittently only during main church services) and by the presence of people. The plots show the change in air temperature (upper graph) and relative humidity (middle graph) at two levels (1 and 4 m) and the corresponding change in dew point and wall temperature (lower graph).*

Hot air warming

Violent airflows of hot air are ejected from a number of grids into the church, only during services (figure 2). The airflow partially mixes with the indoor atmosphere, generating a wide spectrum of air temperatures. Hot air forced by its buoyancy reaches the ceiling and forms a hot layer there. The dense, cold air originally present in the room accumulates near the floor. Finally, air parcels having intermediate densities find their level of equilibrium, resulting in a strong atmospheric layering (CAMUFFO and al., 1999 a). The violent flow of hot air causes the rapid heating and drying of all the objects, in particular the wood statues, the canvas paintings and the ancient books which immediately shrink and break (figure 1a, b) .In addition the flow generates great atmospheric mixing in the environment with the result of an increased deposition rate of the candle smoke, which sticks to the cold walls with paintings and frescoes (ARENDT, 1993). As warm air stratifies over the colder one, the effect is an overheating of the upper part before a welfare temperature in the lower part of the church is reached. In addition, the hot air, coming in contact with the cold walls, immediately becomes colder and denser, and sinks, flowing along the walls, increasing the aerodynamic deposition of pollutants and soiling the surfaces. The hot air warming is one of the worst heating methods.

A mitigating intervention would be to mix the air vertically with fans, in order to destroy the thermal layering (figure 3). The air mixing reduces the dramatic temperature rise aloft and the associated humidity change, but increases the deposition rate of particles on the surfaces beside reducing people comfort. In order to avoid an excessive room turbulence, the fan can be inserted into a vertical tube, with the lower opening near the floor and the upper near the ceiling. This mounting will generate turbulence only near the two ends of the tube, i.e. in the zones of convergence and divergence of the forced flow.

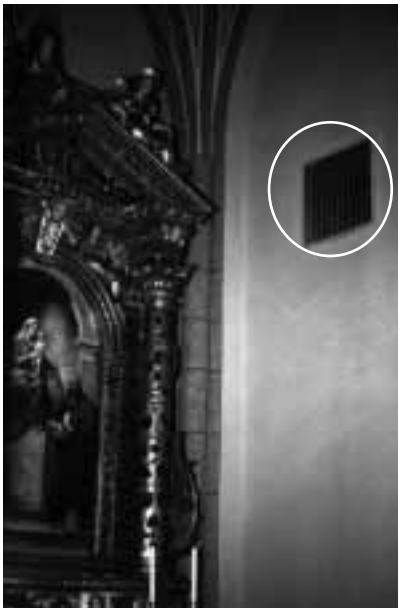

Figure 2 : *Outlet grid of a hot air heating system. A violent airflow of hot air is ejected in proximity of wooden altar and canvas painting.*

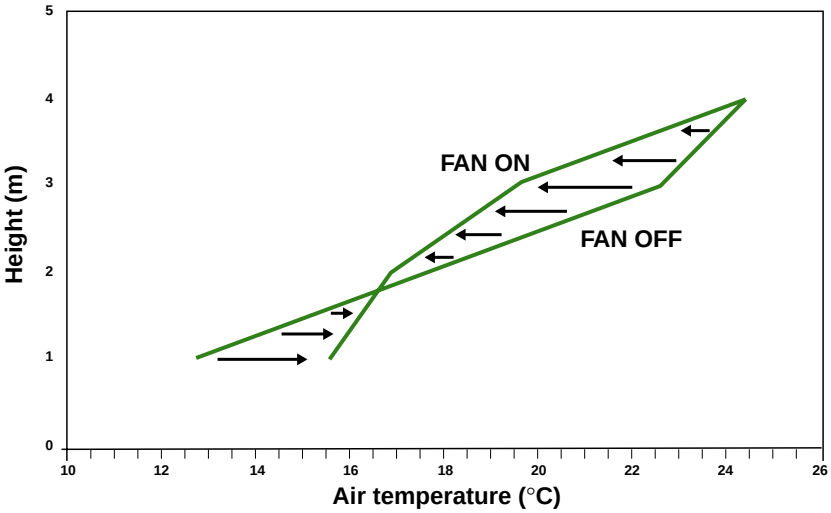

Figure 3 : *Hot air heating system : vertical temperature profile (blue line) and mitigation operating a gentle vertical mixing with fans (red line).*

Direct gas burning and catalytic (mantle) stoves

This system is based on flame combustion controlling liquid gas in a catalysed metallic grid environment (figure 4). In addition to the above effects of hot air, the most negative consequence of the combustion of the liquid gas (mainly propane) with atmospheric oxygen, i.e.

CH_3-CH_2-CH_3 + 5O_2 -> 3CO_2 + 4 H_2O

Is the generation of too much water vapour, which will mainly condense on the cold walls. Gas fired heating systems release approximately 0.11 kg of water vapour per kW of energy input (TASSOU and al., 2000). The vapour released in air attenuates the drop in relative humidity, but when the water vapour molecules come in contact with the cold walls, paintings, statues and decorative paraments, the excess vapour condenses immediately on the cold objects, damaging in a short time every work of art. In fact, the new vapour emitted in air rises the dew point DP, which in short times exceeds the temperature level of walls and objects. Only a small fraction of the condensed water is on the cold windows, where rivulets of water are formed, but the main part of water is absorbed by the porous surfaces of walls and decorations, condensing into the micropores, weakening stuccoes, swelling and shrinking wood, fading tissues, favouring microbial decay and so on.

Figure 4 : *Direct gas burning (catalytic or mantle stoves) releases dangerous moisture that may condense on cold walls.*

Hot floor (radiant) heating

Hot floor heating is reasonably comfortable and reasonably safe (BOWMAN, 1987) only if is kept continually operating, day and night, without interruptions for the whole cold season. The problem is that a continuous use is expensive, so that a parish may prefer a short use for the occasion of the liturgical celebrations. Systems based on floor heating need several hours to warm the surface layer and to reach the highest efficiency, so that they must be put in operation one or two days before their use, implying dangerous environmental cycles and increased expenses. In practice, in order to abate costs and to shorten heating times, these systems are often integrated with other faster systems, e.g. with inflows of hot air, which have the negative consequence of increasing the amplitude of environmental changes.

If costs were neglected, and the floor heating system were continually kept in operation for the whole season, in theory the whole room, walls and ceiling would reach equilibrium and the problem would be easily solved, at least for the well-being of people, but such a practice is not completely safe for conservation. In practice, field surveys have shown that floor heating is sometimes unable to reach a comfort level, so that dangerous integrative systems are often used. In addition, the air movements, which are established indoors, and the cold walls, windows and ceilings increase the deposition rate of smoke, soot and dust. Convective motions continually mix the air, heated from below, leading to an increased deposition rate of suspended particles and surface blackening. Some problems arise also from the point of view of human well-being. The benefit of a radiant floor is equivalent to the effect of having a room temperature 2 or 3°C higher, and churches with radiant floor heating in cold climates have a room temperature between 5 and 10°C that is in any case too low for human welfare. In addition, radiant floors are convenient in big rooms, free from obstacles, where a person can be reached by infrared radiation emitted from a very large surface. In the case of a church, with the floor covered with pews, the near totality of the IR radiation is intercepted by pews, without any benefit to people. For this reason the addition of radiant panels on the walls is welcome, but the hot panels generate convective motions and blackening of frescoes and paintings on walls. Finally, also the hot floor generates convective motions, so that people are affected by unpleasant flows of cold air sinking from the ceiling.

An interesting example is given in figure 5, for a case study of a church with floor heating included into a wooden base below the pews. The case study shows the first two days (16 and 17/01/1997) with the system supplying hot water in heating pipes at 30°C ; the next two days (18 and 19/01/1997) at 60°C and then again (20/01/1997) at 30°C. The raise in hot water temperature corresponded to a raise in the wooden base temperature from 15 to 23°C and an extremely modest heating in the air in the seating area. Considering that also IR was intercepted by pews, the increase in power supply has been only followed by an increase in cost, not in comfort.

Pew heating

Pew heating constitutes a localised, soft heating which gives benefit to people sitting, with their feet on a mild surface. However, this system alone provides little comfort, so that is generally integrated with other systems, e.g. hot air heating or catalytic stoves, with the problems discussed

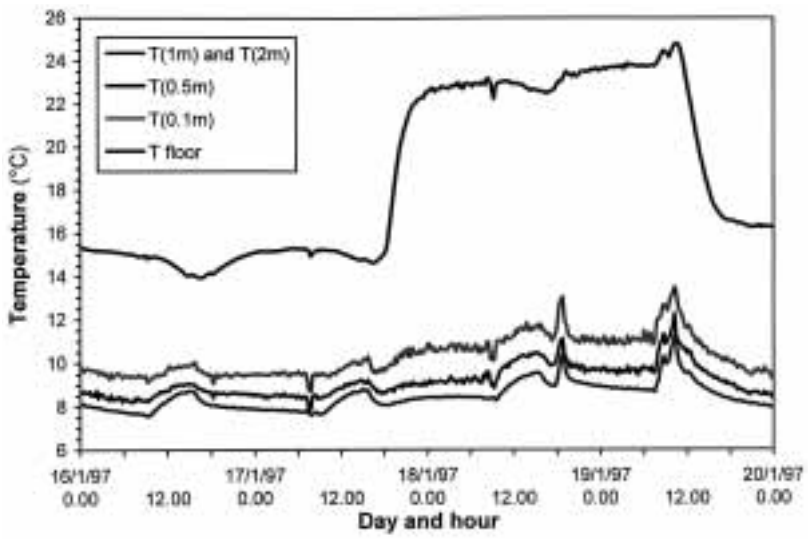

Figure 5 :
Radiant floor heating. Wooden floor temperature (black line) and air temperature at 0.1, 0.5, 1 and 2 m above the floor.

above. In some cases the pew heating is realised with hot water pipes, which have several limitations and are dangerous to historic wood pew. In a better solution, pew heating is made with resistive foils heated with electric power at mild temperature (figure 6). This system is friendly to conservation as it has a minor environmental impact. However, the cost is prohibitive in countries where electric power is expensive. Costs may be reduced by using an electric power generator during liturgical services.
In the case of church heating made with this system only, the problem remains of water vapour released by people. In fact, the indoor air and surface temperatures remain low, and the release of moisture causes a rise in specific and relative humidity, and not only walls and ceiling are damped, but also furniture, wood objects and paintings on canvas.

Figure 6 : *Electric pew heating. Thermo-electric heating foils can be inserted into pews themselves to avoid visual impact (by courtesy of HTS EGGER & GRUTSCH KG, Austria http://www.thermotex.at)..*

Assessing the level of human comfort

A physiological study is useful to establish the thermal conditions in the church that produce reasonable thermal comfort level for the majority of the people (RISSANEN and al., 1994, 1996 ; RISSANEN and RINTAMAKI, 1997). In spot heated churches the situation is rather uncomfortable for several reasons, i.e : cold surfaces, hot and dry air, uneven distribution of the air temperature with cold feet and hot face, chilly flows of air that has cooled at the contact with the cold ceiling or walls and many other unpleasant effects. Low activity during services may also result in the cooling of the body. Satisfactory levels of comfort can be reached with permanent heating but they are very expensive, not allowable for the finances of parishes and not justified for a few hour service every week.
The realistic goal for a church is that human thermal state could be maintained slightly lower than comfortable or neutral (FANGER, 1979 ; MCINTYRE, 1980) for most of the people in the church. Vigilance (to listen, pay attention and pray) is known to be higher when person feels slightly cool (ENANDER, 1987). The other important goal is to obtain thermal comfort for the whole body by preventing sensation of discomfort and draught. The age of the churchgoers should be taken into account because thermo-regulatory responses of the elderly people and children are slightly different from the other age groups (YOUNG and LEE, 1997). Clothing and local traditions are also important and should be carefully considered.

Assessing the visual impact

The problem for the visual impact is complex, especially because it is of subjective nature. Whatever intervention is made, always some change or implantation of new elements, permanent or removable and temporary, is involved. This always requires a very delicate, harmonic equilibrium between leaving untouched the historic buildings and the non-invasive insertion of technology. A decision whether a new inclusion, and its visual impact, is acceptable or not, should this be a simple nail or a complex heating system, must be decided by conservators-restorers, historians of art and the official authorities responsible for a given cultural property. Only a fruitful interaction between all of the involved skills will lead to the best solution.

No heating

Although warm climates are blessed because the installation of a heating system can be avoided, the use of historical buildings still poses challenges for conservation. In fact, the lighting system might become a primary source of heat to manage, together with the presence of people. Excess moisture undergoes condensation on wall in much the same way as described above. Relative humidity changes in unpredictable ways depending on the church volume, the sources of 'indirect' heat and the release of moisture. Even with a large church volume, during certain services (e.g. during Christmas liturgy) the mass gathering might cause a 3-4°C heating in an hour, while relative humidity variations remain around 5-10% buffered by the release of moisture through transpiration (CAMUFFO and al., 1999 b).
Apart from internal forcing, historic buildings with thick walls lessen the impact of the external temperature and humidity variations. In the case of one of the largest Basilicas of the Catholic Church (S. Maria Maggiore in Rome) an attenuation of 70-90% of the daily external temperature curve was observed indoor (figure 7).

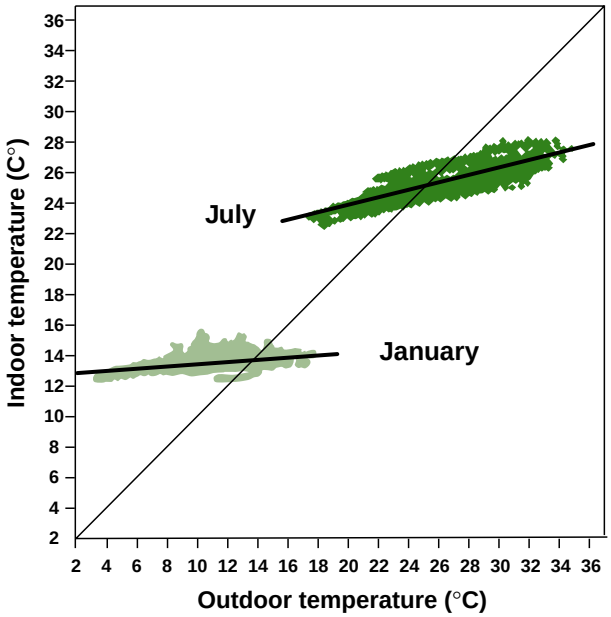

Figure 7 : *Indoor vs. outdoor temperature for data measured every fifteen minutes at the Basilica of S. Maria Maggiore, Rome. In January the indoor temperature ranges 12-16°C, i.e. much less than outdoor (3-18°C). In July the external temperature cycle is less attenuated : the indoor range is 22-28°C, outdoor 17-35°C.*

On the other hand a negative factor is linked with historical buildings left totally unheated during the cold season : the springtime condensation. This is typical when warm and humid air, blown by wind, meets the cold walls having temperature below the dew point (figure 8) (CAMUFFO, 1998).

Figure 8 : *Springtime condensation on cold walls at Castel del Monte (Southern Italy). When the warm and humid Sirocco wind blows at the end of the cold season, walls cover with water droplets, here evidenced by the use of flash light. For surfaces perpendicular to the flash light, the light crosses the droplets, which then appear invisible (on the right). For nearly parallel surfaces, light undergoes multiple reflections inside droplets, which then appear brilliant white (on the left).*

Conclusion : is a friendly heating possible?

In a church, heated only one day per week for liturgical celebrations, the problem of combining cost for heating, comfort and conservation is still without solution. The environment is generally uncomfortable for churchgoers and very often the air results too dry for paintings on canvas and tapestry and at the same time reaches condensation on cold surfaces like frescoes, statues, stucco decorations on walls, ceiling and stained glasses. The apparently counteracting behaviour of moisture (at the same time too dry - too moist) derives from the very different thermal inertia (or temperature) of these artefacts. In addition, in the long run the cycles in temperature and humidity causes further damage to artworks.

The ideal solution would be to keep the building always at the same temperature and the same humidity level. In practice, the changes in indoor microclimate can be avoided only in one of the following ways.

(1) Prohibiting the use of the building (a non-sense).

(2) Keeping always the heating system operating and removing or compensating the excess moisture during the liturgical offices or in the occasion of concerts (extremely expensive and never made).

(3) Leaving the church in the 'natural' condition found before the entrance of churchgoers, and making thermally comfortable only the seating area, removing or compensating the excess of heat and moisture generated by the presence of visitors (not yet invented).

However, the last possibility presents some clear advantages.

It provides heat only concentrated in the seating area where people stay, without dispersing it in the environment with the consequence of making the air too dry (in terms of relative humidity) and de-hydrating painting on canvas.

It reduces the excess moisture released by people that soon or later will reach the cold surfaces generating condensation there, as always occurs when people are concentrated in rooms normally unheated, or heated only at times.

Keeping the warm air contained mostly in the manned area hinders formation of unpleasant and unhealthy flows of chilly air reaching people after having cooled on the ceiling or the walls of the church.

Heating only a small portion of the indoor air, i.e. the manned area, far from the massive walls and the ceiling of the church which absorb a huge amount of heat, the new heating system will require only a very small consumption of energy, with the clear advantages of economy and being friendly to the environment.

In the controlled area it is possible to provide a fully satisfactory thermal comfort to churchgoers, especially considering the dressing style conditioned by the external temperature.

In conclusion, such a novel heating will have the clear advantage of providing an efficient conservation strategy for indoor cultural assets based on preservation measures and constitutes a useful new, high quality tool for the sustainable management of cultural heritage. However, it would require further research to keep heat and moisture confined in a limited area. Further research is also due to minimise the risk associated with leakage of hot and moist air that ultimately will reach artworks on walls and ceiling. This is equivalent to study a system to control the dispersion of heat and moisture and their impact on different materials. In reality, this is a difficult, but not an impossible task.

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Environmental research for art conservation: a new risk assessment tool

Recherche environnementale pour la conservation des œuvres d'art : un nouvel outil pour l'évaluation des risques

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Abstract

The development and testing of paint-based dosimeters, as a risk assessment tool for indoor environments in museums and galleries, was performed within the ERA project (Environmental Research for Art Conservation, EU Contract No. EV5V-CT94-0548). The design (choice of pigments and binding medium), preparation of the paint and the dosimeters in the form of small "mock" paintings has been described elsewhere (van den Brink et al., 2000). Their exposure in selected galleries in (Northern and Southern) Europe was supervised by curators/conservation scientists who also provided information on the indoor environmental conditions. Three scientific laboratories analysed the paint strips, prior to and after their exposure at the sites, and also after artificial ageing. Quantification of the physicochemical changes in the paint enabled calibration of the response of the paint dosimeters to enhanced light levels. Ranking of the sites in terms of measured dosimeter damage, together with an additional survey conducted at the Rijksmuseum, using shorter exposure times for the dosimeters, is described in this paper. Future work will extend calibration with respect to pollutant gases, and apply a piezoelectric quartz crystal array system to damage assessment (MIMIC Microclimate Indoor Monitoring in Cultural Heritage Preservation, EU project Contract No. EVKV-CT-2000-00040).

Résumé

L'élaboration et les tests du dosimètre de peinture en tant qu'outil d'évaluation pour l'environnement intérieur des musées et galeries se sont déroulés dans le cadre de l'ERA (Environmental Research for Art Conservation), projet de l'UE, Contrat No ; EV5V - CT94 – 0548. La conception (le choix des pigments et du médium), la préparation de la peinture (BACCI et al, 2000) et les dosimètres sous forme de "faux" tableaux ont déjà été décrits ailleurs (VAN DEN BRINK et al, 2000). Leur exposition dans les galeries européennes sélectionnées a été supervisée par des scientifiques administrateurs ou conservateurs qui ont également fourni les informations relatives aux conditions d'environnement (ODLYHA et al, 2000). Trois laboratoires ont analysé les bandes de peinture avant et après leur exposition sur les sites ainsi qu'après vieillissement artificiel. La quantification des modifications physico-chimiques de la peinture a permis de mesurer la réaction des dosimètres à des niveaux de lumière élevés. Ce document comporte également un classement des sites en terme de mesure des dommages causés aux dosimètres, parallèlement à une enquête supplémentaire menée au Rijksmuseum avec des temps d'exposition plus courts. Les travaux à venir étendront les mesures aux gaz polluants et utiliseront un système d'exposition à quartz piézo-électrique pour l'évaluation des dégâts (MIMIC Microclimate Indoor Monitoring in Cultural Heritage Preservation, EU project Contract No ; EVKV-CT - 2000 - 00040).

Rationale

The indoor environment of museums and galleries is subject to fluctuations in a number of variables such as relative humidity, temperature, light intensity and levels of pollutants such as nitrogen oxides. Previous studies of the indoor conditions in museums and galleries have involved monitoring of a number of these factors. However, it is important not just to measure these variables, but to investigate the actual damage that is caused by each of these factors, and more appropriately, the damage resulting from their synergistic action which may well differ from that caused by the individual factors. A further disadvantage is that unexpected factors can easily be overlooked. For example, during a routine conservation survey of the collection at the Herbert F. Johnson museum of Cornell University an oily layer was discovered on many objects and display cases (VOLENT & BAER, 1985). Mass spectrometric analysis of the material revealed that this layer was due to diethylaminoethanol (DEAE), which had been introduced into the museum environment by an open steam humidification system in which it was used as a corrosion inhibitor.

The most effective way of assessing the overall damage occurring to artworks in a given environment would be to measure changes with time in the objects themselves. With non-invasive techniques this is possible and colour changes have been measured as in the case of the Predella

della Trinita (Luca Signorelli) in Leonardo's room in the Uffizi Gallery. The same areas of the painting were tested over a period of sixty-six months and revealed colour changes (BACCI and al., 1996). Damage in terms of structural changes has also been assessed. Laboratory studies on canvas supported paintings have shown that they respond to environmental fluctuations and the tension in the supporting canvas changes so that paintings move or "breathe" when the environmental conditions change. Measurements on modern primed canvas demonstrate the changes in stiffness which occur with fluctuations in relative humidity, and these changes can eventually lead to damage by cracking of the paint layer and eventually paint loss (ODLYHA,1998). Therefore individual paintings are themselves dosimeters of damage which include, however, the effects of previous storage conditions and conservation treatment.

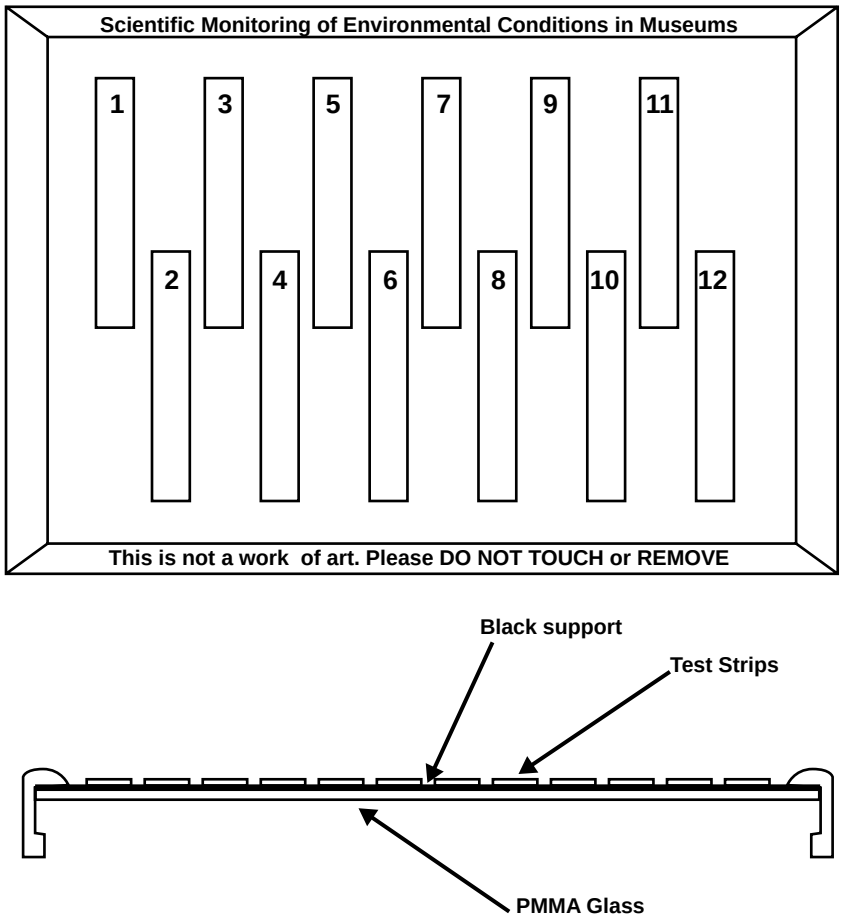
The ERA project

In the ERA project, the idea was conceived to construct test or mock paintings (paint-based dosimeters). Previously glass dosimeters have been developed which degrade as a function of the total experienced acidity of the environment during their exposure (LEISSNER & FUCHS, 1993 ; PILZ & LEISSNER, 1993) The paint-based dosimeters would then monitor the amount of damage incurred directly from the quality of the museum environment (i.e. integrate the effect of fluctuations and unexpected risks). Damage or environmental stress at the exposed sites would be equated with the physico-chemical changes in the paint. At the same time the study would provide information on the degradation mechanisms of the paint used which would be of future service to conservators and conservation scientists. It was decided to use egg tempera paint based on an historical Italian recipe. A more detailed account of the choice of this binding medium is given elsewhere (VAN DEN BRINK and al., 2000). Pigments were also selected primarily on the basis of traditional painting practice, and also in terms of their suitability for paint dosimetry i.e. that the selected pigment/binding medium mixture should be potentially sensitive to deterioration by light, humidity and corrosive gases (BACCI and al., 2000).

The prepared paint, after a period of curing, was then exposed using a twin track approach involving either artificial ageing or site exposure. Artificial ageing included light and thermal ageing, and exposure for a given time to a known level of pollutants. The artificial light ageing was performed using controlled conditions of light (18,000 lux) at known values of relative humidity and temperature for periods from 4 to 64 days. Thermal ageing was performed at 60°C for selected periods 7-21 days. Exposure to pollutants was for 4 days and the overall concentrations of SO2 and NOx in the chamber averaged 10.2 ppm and 16.7 ppm respectively during exposure. VAN DEN BRINK and al.(VAN DEN BRINK and al., 2000) have given a detailed description of the ageing conditions. This first set of differently artificially aged samples served as a calibrant for the site-exposed samples. The analytical data collected from these samples was used as a basis for interpretation of the data from the site exposed-samples.

An identical set of unexposed paint samples was displayed in museums and historical sites for a period of nine months (December 1996 - September 1997). Test paintings were prepared in a way that would not interfere with display in the gallery environment. Stephen Hackney (Tate Britain, London) advised from the point of view of a museum curator. The final design of the test system consisted of unexposed paint strips mounted with double-sided adhesive tape onto a black background. Figure 1a, p. 139, is a drawing of the front side of the system, which reveals the twelve 9x65 mm strips of the different paint systems. Figure 1b is a cross-section, which shows the test strips, the black background, and a backing of a polymethylmethacrylate support plate. The composite was contained in an aluminum frame (19cm in width x 14cm in height).

Figure 2, p. 139, depicts the installation of the dosimeter at the Clore Gallery (Tate Britain) by the conservator & conservation scientist in the proximity of the painting "Two Women with a Letter" (19th century British artist J. M. W. Turner c.1830, N05501, oil on canvas). Three of the other selected sites represented heavily visited places, both in semi-rural and urban settings, El Alcázar, Segovia, Rijksmuseum (Nightwatch room) and the Uffizi Gallery. With regard to the Uffizi Gallery, the choice of Leonardo's room was particularly suitable since additional environmental data have been collected for this room in previous years, within the framework of a CNR-project, the 'Progetto Uffizi'



1. *egg*
2. *unpigmented*
3. *lead white*
4. *lead chromate*
5. *curcumin*
6. *sienna*
7. *cinnabar*
8. *alizarin*
9. *azurite*
10. *smalt*
11. *mastic*
12. *Naples yellow*

Figure 1

(CAPELLINI, 1993). Colorimetric measurements have also been performed as mentioned above (BACCI and al., 1996). The selected sites also included one which was less heavily visited and in a semi-rural location, SANDHAM Memorial Chapel (National Trust, England), and one which had no visitors at all, the store of the Rijksmuseum which also has low light levels. Details of indoor environmental conditions at the sites are given elsewhere (ODLYHA and al., 2000 a; COHEN and al., 2000).

Figure 2 : *Installation of the paint dosimeter in the Clore Gallery.*

Results

The effect of artificial ageing in the exposed paint samples was measured using advanced analytical techniques. These included : (1) colorimetric analysis and reflectance spectroscopy which quantified colour change and measured changes due to pigment/medium interactions (BACCI and al., 2000) (2) direct temperature resolved mass spectrometry which gave detailed information of chemical changes occurring at the molecular level (VAN DEN BRINK and al., 2000) (3) Fourier transform infrared spectroscopy (FTIR) which also measured chemical changes at the molecular level; the information was not as detailed as that obtained from mass spectrometry, but could be used as a preliminary stage in assessing the condition of paint-based dosimeters (COHEN and al., 2000) (4) thermoanalytical techniques (differential scanning calorimetry, thermogravimetry, thermomechanical analysis) provided information on the quality of the paint (medium, lean or rich, in terms of the pigment binder ratio), measured changes

in the thermal stability of the paint on ageing, and in the viscoelastic properties and the glass transition temperature (Tg) of the paint (ODLYHA and al., 2000 a). The latter is a valuable marker for the condition of the paint and its potential to resist environmental degradation. A low Tg encourages sorption of materials from the environment and a high Tg encourages embrittlement of paint and microcracking.

Mass spectrometric measurements revealed that oxidation and hydrolysis of the lipid components of the egg-based paint binding medium occurred on artificial ageing (VAN DEN BRINK and al. 2000 and 2001). In FTIR this was seen as an extensive broadening of the lipidic carbonyl peak (in the region of 1740cm-1), and was used for quantification of the chemical change. It was found that on artificial ageing, particularly involving exposure to pollutants, in addition to the broadening of the carbonyl peak, peaks appeared in the exposed sample at wavenumber positions which corresponded to the likely presence of nitrates/nitrites (COHEN and al., 2000). Xray surface chemical analysis (XPS) indicated the presence of these compounds in pollutant exposed azurite tempera samples (ODLYHA and al., 2000 b).

Thermoanalytical measurements of the artificially aged samples revealed changes in the thermal stability of the samples. A good correlation was obtained between ageing time and degree of chemical change for artificially light lead white tempera ; the thermal stability index, as measured by differential scanning calorimetry, was plotted against the number of days of artificial ageing (COHEN and al., 2000). Reflectance spectra of lead white tempera furthermore revealed that light affects lead white tempera in a different way to temperature or NOx/SO2 (BACCI and al. 2000). The light aged sample reflects more light than the control, whereas the contrary happens for the NOx /SO2 and thermally aged samples, which showed that a discoloration occurred to yellow. In the case of NOx/SO2 exposed samples, this could due to the formation of nitrates/nitrites.

Analysis of the site exposed dosimeters provided a means for ranking the sites in terms of the measured damage. Paint strips, particularly the inorganic pigmented temperas, from the Clore Gallery-exposed dosimeter showed a very low degree of chemical change, as expected for a site of Museum Class 1 environmental control (THOMPSON, 1986) (BRADLEY, 1996). This was not the case for some of the other pigmented strips of the dosimeter, as shown by reflectance spectroscopy. In particular, the alizarin paint strip (sensitive to acidic environments) showed high values of change, on a par with uncontrolled environments as determined by reflectance spectroscopy (BACCI and al., 2000). An unexpected potential hazard was thus identified in the Clore Gallery in the region of the exposed dosimeter.

The three sites where physico-chemical changes in the dosimeters were high were as follows : El Alcázar (Cord room) a historic castle in Segovia, Spain, Sandham Memorial Chapel (Hampshire, England) and the Uffizi Gallery (Leonardo's room). Thermoanalytical data, in particular of the smalt tempera in the exposed dosimeters at El Alcázar , revealed a high level of change (ODLYHA and al., 2000 a). In Figure 3, p.141, the thermal stability index, as calculated from differential scanning calorimetry, has been plotted against the extent of light ageing for smalt tempera (left hand side of bar graph). A systematic progression of degree of chemical change with length of ageing occurs. Ranking of sites is also shown El Alcázar (ALC), Sandham Memorial Chapel (SAC) and Uffizi Gallery (UFF) display the highest level of change. The site labelled FOM refers to the control sample kept in the FOM Institute, and this showed negligible change for the duration of the project.

In the case of the first two, uncontrolled indoor conditions may contribute to the damage, and in El Alcázar light levels were also of concern. In the case of the Uffizi Gallery (Leonardo's room) where some environmental control is used, other factors may be considered. Levels of pollutants in the Uffizi gallery have been measured (DE SANTIS and al, 1993) and these are significantly higher than those registered for other galleries, in particular the Clore Gallery where levels of pollutant gases have been recorded as less than 2ppb.

Surface morphologies of the site-exposed dosimeters were also recorded using scanning electron microscopy, and these are shown in figure 4 for the dosimeter exposed at Sandham Memorial Chapel. Figure 4, p.141, displays the surfaces (x1000) of the control sample of lead chromate tempera

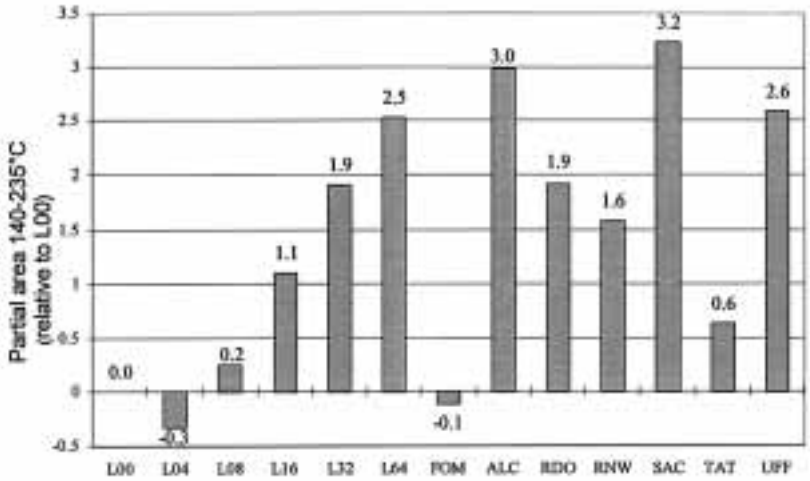


Figure 3 : *Degree of chemical change, the thermal stability index as calculated from differential scanning calorimetry, versus the extent of light ageing for smalt tempera (4-64 days). Ranking of sites is also shown (ALC = El Alcázar, RDO = Rijksmuseum (store), RNW = Rijksmuseum (Nightwatch), SAC = Sandham Chapel, TAT = Clore Gallery, UFF= Uffizi Gallery). ALC, SAC and UFF display the highest level of change. Site labelled FOM refers to the control sample kept in the FOM Institute.*

and the site exposed sample respectively and the damage incurred to the paint. In the latter the medium has been worn away and the pigment particles are more vulnerable. X-ray surface analytical measurements (XPS) of azurite tempera samples have shown that surfaces become more oxidized with accompanying changes in the oxidation state of the metallic (Cu) ion (ODLYHA and al., 2000b).

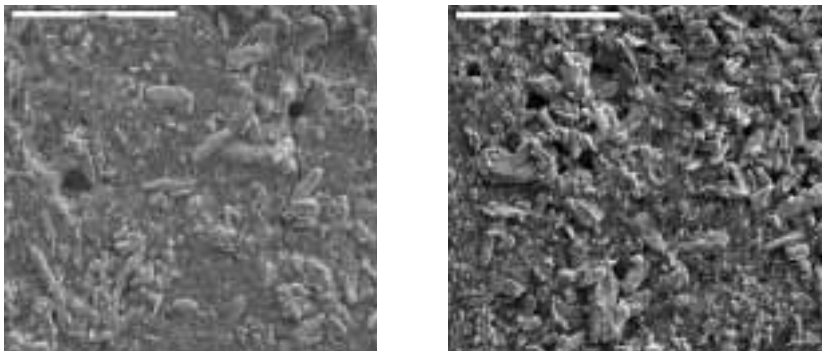


Figure 4 : *SEM micrographs (x1000) of lead chromate tempera control (L00) and SAC (Sandham Memorial Chapel). Surface weathering effects can be seen in the lead chromate tempera samples, when comparing the control and SAC dosimeter (figures 4a & 4b), with SAC being an uncontrolled environment.*

The Rijksmuseum Nightwatch room and the Rijksmuseum store (Depot "Oost") were among the other selected sites. The latter was selected also as a site where light levels were very low (2-12 lux) and as mentioned previously there were no visitors. The exposed dosimeter at this site showed least change by colorimetric analysis and by reflectance spectroscopy of the paint temperas. This was as expected if light was considered to be the main agent causing color change and alterations in pigment medium interactions. The change in chemical composition, however, as measured by mass spectrometry, and in thermal stability as measured by DSC, was higher than expected. A possible explanation for this is that light in this case is not the main agent of change, and that in the dark the action of an oxidizing agent contributes to additional chemical changes. The Nightwatch room of the Rijksmuseum also showed a higher degree of chemical change than expected. On the basis of these findings it was suggested by the staff of the Rijksmuseum that the climate in the rooms in the museum in the older part of the building (where the Nightwatch room and the store are located) should be tested along with the newer part of the building.

Rijksmuseum Study

Therefore, another survey was performed which included nine different sites within the Rijksmuseum (VAN DEN BRINK, 2002). In the new survey the dosimetric mock paintings were exposed for only three months (ninety-seven days). Since the effects of nine months' exposure were already severe, shorter exposure of the mock paintings was thought to be advantageous and it was thought that it would lead to enhancement of the differences in degree of chemical change among the sites.

In the Nightwatch room 2 dosimeters were exposed simultaneously, one of which was shielded from the light. This is in the older part of the museum. It relies on central air conditioning and it has UV- filtered light. Other sites included the newer South wing with improved relative humidity and temperature control and moderate museum lighting.

Mass spectrometry results showed the following : there were significant differences between the older and newer South wing, the shorter exposure times (three months) for the unpigmented temperas gave good discrimination between the sites, and that a very small degree of chemical change occurred in the light shielded dosimeter. This indicates that either the activation by light plays a decisive role in the ageing processes or that the design of the box for light shielding hampers the free flow of air and hence understates the influence of the air quality on the chemical composition of the test system. Additional experiments, which are very valuable for the understanding of the ageing processes, are required to resolve this matter.

Discussion

In the ranking of the sites, data from the site-exposed samples were compared with data from the artificially aged samples. It was found that changes induced by site exposure were not entirely comparable with those on artificial ageing, in particular the inorganic pigmented temperas, where they were much greater. For example the glass transition temperature (Tg) of a sixteen days light aged sample (lead chromate tempera, the only non-traditional pigment in the study) did not shift to the higher temperatures recorded for the Tg of the lead chromate strip from the Uffizi Gallery exposed dosimeter. The higher Tg value in the case of the Uffizi exposed paint strip implies that a greater degree of paint embrittlement had occurred In terms of estimated damage even the so-called "best" sites showed damage equivalent to eight days light ageing. From the reciprocity principle this is equivalent to 3.5 Mlux hrs and greatly exceeds the annual museum dose of 650 klux hrs. Observations imply that with site exposure the synergistic action of the environmental factors (e.g. light, relative humidity, temperature, pollutants) is contributing to the damage, and that the damage differs from that where only factor in artificial ageing (e.g. light) has been used.

Therefore there are clear advantages in using paint-based dosimeters. Damage caused by the synergistic action of environmental variables at the sites can be assessed, and differentiation between sites, in accordance, with known environmental conditions can be obtained. Unexpected risks can also be identified (e.g. Clore Gallery). A new understanding of the chemistry of ageing of paint tempera and the differential effect of pigments has been obtained which will be of benefit to technical studies on paintings and their preservation. A database of chemical information of artificially aged and naturally aged tempera paint has been established and will be made accessible to conservation scientists and conservators. It must be remarked that paint-based dosimeters which are similar to the ones used in the ERA project have been used for an effective study in the framework of the European research project "Advanced workstation for controlled laser cleaning of artworks" (ENV4-CT98-0787).

Future work

Further developments in the framework of a new project (MIMIC Microclimate Monitoring in Cultural Heritage Preservation, Contract No. EVKV-CT-2000-00040) have involved preparation of dosimeters with modifications to medium preparation (e.g. use of egg yolk only as the medium). On the basis of existing knowledge, differently pigmented strips have been selected to characterize in more detail the specific risks e.g. greater sensitivity to NOx, to light, or to relative humidity. Shorter exposure times, as shown by the additional survey conducted at the Rijksmuseum, will also be used. The egg tempera will also be applied to piezoelectric quartz crystals (PQCs). Within the ERA project (EV5V-CT94-0548) coated PQC dosimeters were used for continuous monitoring of relative humidity across a selected painting in Sandham Memorial Chapel for twelve months (ODLYHA, 2000c). The useful property of PQCs is that they allow a binding event e.g. coating to the gold substrate to be converted into a measurable signal, for example resonance frequency changes (BIZET and al., 1999). The measured frequency shift can then be related to physico-chemical changes in the coating and a measure of environmental stress. It offers many applications and an increasing number of publications provide evidence of this (JANATA and al., 1998, MC CALLUM,1989). The MIMIC project will use systems

developed by QuartzTech technology which are based on optimization of sorption sensor arrays. The instrumentation is currently used for detecting and deconvoluting mixtures of industrial vapors (Lau et al., 1998). The MIMIC project will adapt it to monitor damage through the knowledge obtained of the behavior of the egg tempera paint in the ERA project.

The problems addressed in the ERA project and in the current MIMIC project are that of damage assessment, as given by the physicochemical changes in the paint-based dosimeters, and estimation of threshold levels of damage, i.e. estimating conditions under which damage is initiated. The ERA project demonstrated that damage could be quantified and that some differentiation between damage at the sites could be obtained. In the MIMIC project environmental conditions at the selected sites are being monitored continuously in terms of relative humidity, temperature, light intensity, and indoor pollutant levels (NO_x, SO_2 and ozone). The data will be considered in the light of the resulting damage as obtained from the paint-based dosimeters. Artificial ageing experiments involving pollutants will be performed to obtain an understanding of the mechanism of degradation of paint tempera. This will also assist in characterizing threshold levels of damage. The overall objective of the MIMIC project is to provide portable damage dosimeters based on PQC technology for continuous recording of damage, as measured by shifts in quartz crystal oscillation frequency through changes in the characteristics of the coatings.

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Biography

Marianne ODLYHA is Ph.D in Chemistry from Birkbeck College, University of London. Since 1988 Manager of University of London Thermal Methods Laboratory and special lecturer in M.Sc Analytical Chemistry and undergraduate chemistry (3rd and final year options in polymer chemistry and biophysical methods). Specialised in the application of thermoanalytical techniques to cultural materials. UK Research Council grant "Application of Dynamic Mechanical and Dielectric Analysis for Monitoring Effects of Moisture based Conservation Treatment". Developed a non-invasive method for monitoring moisture loss/uptake in materials using microwave dielectric spectroscopy (Patents : GB 2293017, USA 5,744,971). Coordinator of two EU projects : ERA (Environmental Research for Art Conservation, Contract No. EV5V-CT94-0548), MIMIC (Microclimate Indoor Monitoring in Cultural Heritage Preservation, Contract No. EVKV-CT-2000-00040) and participated in "Microanalysis of Parchments" (SMT4-CT96-2106). Lecturer at Advanced Study Course "Methods in the Analysis of the Deterioration of Collagen based Historical materials in relation to Conservation and Storage" July 1999, School of Conservation, Copenhagen.

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Deterioration and conservation of vegetable tanned leather in ancients books

Dégradation et conservation de cuirs au tannage végétal des livres anciens

René LARSEN[1], Claire CHAHINE

Abstract

Two European research programmes allowed the development of analytical methods to determine the state of deterioration of vegetable tanned leather. The projects clarified that the chemical deterioration is due to both acid hydrolysis and oxidation. These two phenomena are independent, but take place through interactive reaction mechanisms with predominance of one or the other according to the environmental conditions. The study brought into focus the negative part that the vegetable tannins play in favouring the adsorption of suphur dioxide from polluted atmospheres. A method of artificial ageing has been standardized, associating heat and pollutants. The effectiveness of conservation treatments such as neutralisation of acidity, surface protection, retannage, lubrication have been studied comparatively. None of these treatments is completely satisfactory, however the study brought a better understanding of their effect on the material. Recommendations on storage, conservation and choice of new leather for restoration have been drawn from these research programmes.

Résumé

Deux programmes de recherche européens ont permis le développement de méthodes analytiques pour déterminer le degré de dégradation du cuir tanné. Ces projets ont révélé que la détérioration chimique provient de l'hydrolyse et de l'oxydation. Ces deux phénomènes sont indépendants mais surviennent à cause de mécanismes de réaction interactifs avec prédominance de l'un ou de l'autre selon l'environnement. Cette étude a mis en lumière les effets négatifs des tannins végétaux qui favorisent l'absorption d'anhydrique sulfureux provenant d'atmosphères polluées. Une méthode de vieillissement artificiel associant chaleur et polluants a été standardisée. L'efficacité de traitements de conservation tels que neutralisation de l'acidité, protection des surfaces, re-tannage et lubrification a fait l'objet d'études comparatives. Aucun de ces traitements ne s'est avéré totalement satisfaisant mais les recherches ont cependant permis de mieux comprendre les effets spécifiques de chaque traitement sur la matière. Les programmes ont abouti à diverses recommandations concernant le stockage et la conservation ou le choix du cuir neuf pour la restauration.

The deterioration of millions of bookbindings and other vegetable tanned leather objects in archives, libraries and museums constitute a continuously increasing large scale conservation problem. Moreover books bound in vegetable tanned leathers a few decades ago have deteriorated to such an extent that they require repair or rebinding. New leathers used for restoration and new bindings are not of real long term quality.

This research and development work on deterioration and conservation of vegetable tanned leather has been performed within the frame of two projects based on the complementary expertise, knowledge and equipment of the major participants and several other European institutions. These projects resulted in the elaboration of a complete analysis program which allowed a better understanding of the deterioration mechanisms of leather, the development of an ageing process and resulted in recommendations for appropriate storage conditions, conservation and choice of new leather for restoration.

STEP Leather Project 1991-1994.

Evaluation of the correlation between natural and artificial ageing of vegetable tanned leather and determination of parameters of an artificial ageing method

The following partners were involved.

- School of Conservation, RDAFA – DK
- Centre de Recherches sur la Conservation des Documents Graphiques – F
- Central Research Laboratory for Objects of Art and Science – NL
- The Leather Conservation Centre – UK
- Department of Library Research, RL - N

Environment leather project 1995 –1996.
Deterioration and Conservation of vegetable tanned leather
The following partners were involved.

- School of Conservation, RDAFA – DK
- Centre de Recherches sur la Conservation des Documents Graphiques – F
- Royal Institute for Cultural Heritage – B
- School of Environmental Sciences, UEA – UK
- The National Trust - UK

The methodology of the research work developed in the projects has been based on comparative analysis of naturally deteriorated leathers and artificially aged leathers and hides. The analytical program included both studies of the material itself, such as mechanical properties, hydrothermal analysis, pH measurements, and analysis of its constituents : collagen and amino acids, tannins, fats, water, anions (sulphates, nitrates).

During the projects different kinds of vegetable tanned leathers have been analysed.
- Fragments of historical leathers dating from 16th to 20th centuries of different place of origin and having suffered different conservation conditions.
- Long term storage leathers.

These leathers were part of a major investigation started in the 1930's in the United Kingdom to determine the cause of leather deterioration. Pairs of leather bookbinding's were deposited in two different locations, the British Library in London and the National Library of Wales, which represented two different environments. The London site is heavily polluted, Aberystwyth in Wales is a rural/coastal site with an unpolluted atmosphere. This well documented long term storage constituted an invaluable source of information on the deterioration and durability of vegetable tanned leathers.

Medium term storage leathers.

New leathers have been treated and/or exposed in different sites in France and Denmark for over 10 years

Artificially aged leathers.

New leathers have been aged with heat, light and pollutants such as SO_2 and NO_2.

The projects clarified that the chemical deterioration of leather is due to acid hydrolysis and oxidation. Acid hydrolysis is promoted by air pollution and oxidation is promoted by heat, light, and other radiations. These two phenomena are independent, but take place through interactive reaction mechanisms. In theory one mechanism may take place alone. However, in real life both are involved in the breakdown of leather. Studies of the naturally and artificially aged leathers showed that the acid hydrolysis is the more aggressive, leading to a faster deterioration. This type of breakdown seems to be dominant for leathers stored in polluted areas, where the acidity suppresses the oxidative deterioration and may change the deterioration pattern. This was illustrated by the behaviour of the long term exposure of the British leathers as shown in the table below giving the average values obtained in the two sites of storage.

	British Library leathers		National Library of Wales	
	Hydrolysable	Condensed	Hydrolysable	Condensed
Sulphates %	2,8	4,8	0,6	0,6
B/A*	0,64	0,62	0,60	0,59
Shrinkage température °C	70	52	83	75

B/A = content of Basic amino acids / content of Acid amino acids.*

***Table 1 :** Analysis of the British leathers after sixty years of exposure*

The sulphate values reflect the uptake of SO_2 by leather from the atmosphere. The B/A ratio indicates the degree of oxidation of collagen : for a new, undeteriorated leather, it is close to 0,70 and it decreases with oxidation of the protein. The shrinkage temperature which also decreases with deterioration is a good indication of the state of conservation.

Moreover, it was established that the rate of chemical deterioration of leather depends on the tannin type and the storage conditions. Vegetable tannins impart to leather a high sensitivity to pollution, and particularly to SO_2 which is readily adsorbed from the polluted atmospheres. Among the two types of vegetable tannins, hydrolysable and condensed types, the later has the most marked characteristic of promoting adsorption of SO_2, giving the highest vulnerability to leather.
Sensitivity to deterioration in a polluted environment can be ranked as follows.

untanned and mineral<vegetable tanned (hydrolysable type)<vegetable tanned (condensed type)

Figures 1 and 2 showing the behaviour of leathers tanned with quebracho (condensed type) and sumac (hydrolysable type) under the two different storage sites illustrate the highest deterioration in a polluted environment, and the highest vulnerability given to leather by a condensed tannin.

Figure 1 :
Bookbindings made of leather tanned with quebracho and stored during sixty years in the National Library of Wales in Aberystwith (left) and in the British Library in London (right)

Figure 2 :
Bookbindings made of leather tanned with sumac and stored during sixty years in the National Library of Wales in Aberystwyth (left) and in the British Library in London (right)

The nitrogen dioxide and sulphur dioxide concentrations were measured in and around the British Library and the National Library of Wales. In general it was found that the concentrations of the two pollutants decreased from outside to the interior of the building where the measurements were taken. However the concentrations of gases may approach that of outside in open spaces or rooms frequently used by people. A ratio indoor/outdoor of 0,05 has been calculated for SO_2, indicating the easy deposit of this gas on the surfaces it comes in contact with. It has been estimated that the materials inside the two libraries have been exposed to a total dose of 245 ppb/year of SO_2 in London and 12 ppb/year in Wales during their sixty years of storage.

Artificial ageing is an absolute necessity for testing the effect of conservation treatments and the durability of new leathers. To imitate the very complex natural ageing of leathers, one single standard method is not enough, because both oxidation and acid hydrolysis are needed. During the project, a process involving cycles of heat (for oxidation) and exposure to sulphur dioxide and nitrogen dioxide in a pollution chamber (for hydrolysis) was developed and standardised. The conditions settled for one cycle were one day at 120°C then six days exposure to 25 ppm SO_2 and 10 ppm NO_2 at 40°C and 35% RH, the cycles being repeated four to eight times. In general, this standard method should be regarded as a quick mean to simulate the deterioration like that generally observed over more than thousand years in historical leathers. However it could be modified according to the characteristics of the environment to simulate. A high level of pollution combined with low heat would be close to heavy polluted atmospheres, whereas a low level of pollution and higher heat would more imitate a less polluted atmosphere.
Attention must be drawn to the fact that this standard method is especially fitted to vegetable tanned leather which has been the subject of study of these programmes. Other types of tanning would require their own artificial ageing method.

Thanks to the very fine methods of analysis which were developed by the partners working in close collaboration and the method of artificial ageing made available, it was possible to evaluate the effect on the long term of different materials and treatments designed for conservation. The following were tested : buffers for neutralisation of excessive acidity, natural or synthetic polymers for consolidation and protection of surface, aluminium alkoxides for retannage and lubricants for softening. These compounds were applied on new and old leathers which were subsequently artificially aged. Naturally aged leathers containing some of these chemicals applied in the past were also examined.

Comparing the behaviour of the treated leathers versus the untreated, the following observations have been drawn.
The neutralisation of the acidity with different alkaline salts results in less hydrolysis and consequently less oxidation. The content of sulphates of the treated leathers is generally high, indicating higher adsorption of SO_2, but still the pH are high. The physical resistance is better maintained. The problem is the formation of spews which can appear with time.
The consolidants experimented (GLAIR, KLUCED G, PARALOID B72) did not produce any protection against deterioration.
Retannage of vegetable tanned leather with aluminium salts is a process used for several years in the industry to obtain leathers with certain characteristics. Neutralisation and retannage were expected from aluminium alkoxides treatment. But these compounds gave no evident protection, presenting even the risk of causing physical damage under application. Still one of them (aluminium diisopropoxide) could be recommended in the case of strongly deteriorated leathers to prevent complete acid destruction by moisture contact when moisture based treatments have to be applied.
Lubrication of leather may be needed to maintain flexibility, which is a particularly important characteristic in the case of bookbinding. Dressings, especially when they contain wax, give some protection to leather which adsorbs less sulphates as shown in the graph below and help to maintain physical resistance. Nevertheless, the use of these compounds is controversial, because they can have detrimental physical side effects when too heavily applied. Still in one case of regular application in very small quantity, the protection was very effective after 10 years of exposure in a polluted site.

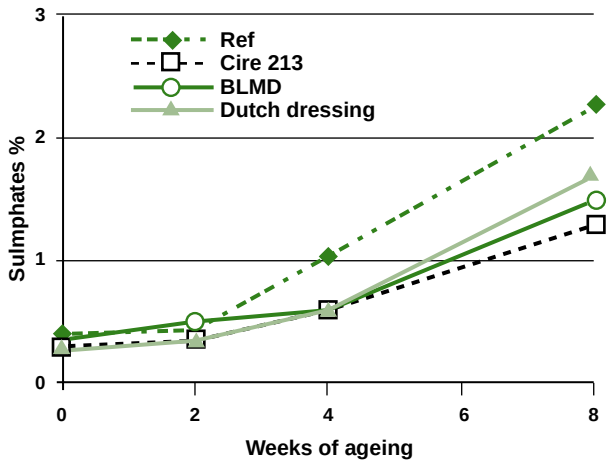

Figure 3 : *Evolution of the sulphate content of leathers treated with different lubricants and artificially aged during eight weeks*

It appears from these trials that, although some interesting results can be obtained in certain cases, there is no completely satisfactory method to conserve deteriorated objects made of vegetable tanned leather. Moreover the methods are most effective in preventing acid hydrolysis, and although less aggressive, oxidation seems to be the most difficult deterioration to counteract. A possible way will be to develop chemical means of blocking or protecting the areas of the collagen and tannins sensitive to oxidation.
In terms of preservation, the concern is very acute for bookbindings which are stored most of the time in city centers where pollution is generally heavy. Moreover they are objects of use and must give effective mechanical protection to the book. Preservation against damage is then very

important. The best way of preserving and prolonging the life of a vegetable tanned leather is storage in a stable unpolluted environment, where the indoor concentration of SO2 is maintained below 0.06 ppb, threshold deduced from the studies on air pollution in the two British sites and the sulphate content of the bookbindings they housed. The room temperature should be of 18-20°C and the relative humidity between 50-55 % (as constant as possible). Leathers with a shrinkage temperature close to 30°C should be stored in the cold at low and stable RH. Leathers gelatinising at room temperature by normal or high RH should be stored in a freezer. There should also be a low level of UV radiations maintained in the storage rooms.

These projects were addressed to end-users, i.e. curators responsible for collections, conservators-restorers performing practical conservation and restoration of leather, but also producers of leather. Scientists performing analysis and research on leather, collagen and other protein materials should also be interested in the conclusions of these two projects. A full set of specialised analysis as well as quick and simple routine tests were developed, for the assessment of the deterioration rate of historical leathers, and for testing quality and durability of commercial leathers for use in conservation. In addition to the recommendations on storage and conservation, recommendations for the choice of new leathers have been made.

The project results have formed the basis for the development of more effective conservation methods, conservation planning and production of durable leathers to help cost saving to the society, prolong the life and improve access of the public to the cultural heritage leather objects.

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Biography

René LARSEN works at the School of Conservation in Copenhagen where he has been since 1986 in charge of the research and teaching within the areas of deterioration, conservation and restoration of books, manuscripts and objects of parchment, leather and other hide collagen based materials as well as protein chemistry. He has published more than forty scientific papers on research within cultural heritage leathers and parchments and has been the co-ordinator of three successful European research projects, the two projects presented here on leather, as well as one on Micro analysis of Parchment (1996-1999). In 1999 he organised an Advanced Study Course within the framework of the European Commission "Methods in the analysis of the deterioration of collagen based historical materials in relation to conservation and storage". He is presently Rector of the School of Conservation
Claire CHAHINE works in CRCDG in Paris where she is responsible of the leather and parchment department. Her research areas are development of analytical methods for the assessment of the deterioration of leather and parchment, and development of conservation treatments for these materials such as disinfection, cleaning, lubrication, consolidation, drying (flooded bookbindings and waterlogged archeological leather), as well as artificial aging for modeling the behavior of these materials. She teaches in different French institutes devoted to education of curators and conservators. She participated in the three mentioned European projects and course. She is the coordinator of the ICOM-CC leather group and she acts as an expert for different museums and institutes. She is the assistant director of CRCDG.

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Baroque artificial marble inside monuments : environmental impacts, degradation and protection

Faux marbre baroque à l'intérieur des monuments : impacts de l'environnement, dégradation et protection

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Abstract

The primary objective of the EC research project ENVIART presented here was to obtain detailed information on structure, properties and deterioration mechanism of baroque artificial marble, or stucco marble. Modern scientific methods were used to understand the general mechanisms of decay and to find answers regarding optimum maintenance and conservation measures.

The research program consisted of two main components. One was a detailed, in situ investigation of stucco marble decorations at the Dukes Chapel in Krzeszów, Poland. The other involved laboratory investigations of the stucco samples, collected in Krzeszów and from selected buildings in Austria. Carefully crafted replicas, the use of which is planned for restoration measures, were also investigated. The results obtained were used to develop criteria for proper maintenance and conservation of stucco marble.

Résumé

Le premier objectif du projet de recherche européen ENVIART, présenté ici, était d'obtenir des informations détaillées sur la structure, les propriétés et les mécanismes de détérioration du marbre artificiel baroque (ou stuc). Des méthodes scientifiques modernes ont été utilisées pour comprendre le fonctionnement général de sa dégradation et trouver des réponses optimales en matière de maintenance et de mesures de conservation. Ce programme de recherche était constitué de deux éléments principaux. Le premier consistait en une étude détaillée des décorations en stuc de la Chapelle des Ducs à Krzeszow, en Pologne, et le second, en des recherches en laboratoire sur des échantillons de stuc provenant soit de ce même site, soit d'une sélection de bâtiments autrichiens. Des répliques méticuleuses, utilisées pour la restauration, ont également été étudiées. Les résultats obtenus ont servi à déterminer un certain nombre de critères pour améliorer les techniques de maintenance et de conservation du stuc.

Stucco marble occupies an important place in the history of art and architecture of Central and Southern Europe. Various techniques, using mixtures of gypsum, pigments, water and glue, were introduced first to imitate the natural marble for the decoration of building interiors, then even to surpass richness and decorativeness of natural stones with man-made material. The technique of decorating palace and church interiors with stucco marble, was perfected to its highest artistic level around 1700. At the end of the eighteenth century the use of the material was discontinued and the original baroque technology was practically forgotten.

The stucco marble was made by mixing gypsum and water with animal glue. The glue played an essential role in retarding the setting of gypsum and producing the material which was very hard and easy to polish. Pigments were added to the fresh stucco paste to obtain a uniform coloring. To obtain marble like patterns, small balls of the paste in different colors were skillfully connected, kneaded and cut into slices a few millimeters thick. The layers while damp were placed on the surfaces to be decorated, usually plastered brickwork or stone. The pores and holes in the laid stucco were then filled and its surface smoothed, ground and polished with the use of the grinding stones. To give more gloss to the surface, oil and wax coatings were often added.

It is well known that mineral building materials, wherever exposed to impacts from the atmosphere or from the architectural structure of which they form part, suffer alteration to various extents. Generally, physical and chemical factors, which, depending on their origin, can be external or internal, interact in complicated ways. If the material is susceptible to chemical attack, the corrosion opens way to further physical damages ; when, in turn, physical processes in terms of mass and/or energy flow are likely to affect the material in depth, this will in many cases facilitate access of corrosive substances.

In this context, stucco marble must be considered as a specially sensitive material. First, it is most frequently composed of gypsum, a water-soluble mineral. Any attack of water or aqueous solutions would to some degree result in its dissolution. Secondly, crystals are arranged in a way that a notable amount of microporosity is likely to predominate the material's pore system. Micropores yield the space where a number of physical processes such as capillary condensation and related hygral swelling take place. Further, due to the technique of its application, stucco marble exhibits a gradient in its physical properties, showing a very compact surface layer differing from much more porous structure of the bulk.

Stucco marble, being to high extent susceptible to chemical and physical attack, is further designed to show a highly glossy and decorative surface. It is obvious that in the course of long-term exposure to corrosive agents the shine of the surfaces can easily get lost. With the absence of the gloss the material looses one of its major aesthetic values.

It is thus not surprising that the stucco marble decorations of many church and palace interiors have undergone a manifold degradation. On thin stucco marble layers cracks and losses appear as a result of the layer deformation and detachment from the ground. The glossy polished surface can become soiled, dark, eroded and rough, and the original material deformed and porous. The deterioration is often not limited to the stucco layer itself ; sometime the stucco undergoes total destruction and the disintegration of the ground is observed.

Information available in literature is limited mostly to practical advice as how to repair and reconstruct the damaged areas. Detailed information concerning structure, physical and chemical properties and deterioration mechanism of the baroque stucco marble has been lacking so far. Willingness to investigate this historic material, to improve methods of its conservation, to raise the sensibility of the professionals involved in the care and preservation of the concerned objects has led to initiation of an interdisciplinary and international project "Baroque Artificial Marble: Environmental Impacts, Degradation and Protection- ENVIART". The project was financed by the European Commission within one of the topics of the Environment and Climate Program concerned with protecting and rehabilitating the European cultural heritage. Scientists and restorers from Germany, Austria, Belgium, and Poland worked together, each group contributing specific investigations and practical tests aiming at understanding adequately the "stucco marble" system.

The primary objective of the project was to obtain detailed information on structure, properties and deterioration mechanism of the baroque stucco marble. Modern scientific methods were used to understand the general mechanisms of decay and to give answers as to optimum maintenance and conservation measures.

The investigations consisted of two important components. One was a detailed, in situ investigation of stucco marble decorations at the Dukes Chapel, being part of the famous Cistercian abbey in Krzeszów located in lower Silesia/Poland, foreseen for UNESCO world heritage list.

The church is a masterpiece of European baroque architecture with rich stucco marble decoration of the interior and displays various kinds of stucco damages. In order to broaden the knowledge further stucco marble samples from objects in Austria of the same period were investigated. The second part of the project involved laboratory investigations of the collected samples and replicas made in workshop the use of which is planned for restoration measures.

After two years of research work the participants of ENVIART-project gathered valuable knowledge on preparation technique, degradation mechanisms and solutions to the stucco marble damage problems. A profound insight into the properties of the material has been gained. The international and interdisciplinary collaboration developed in an animated and effective way. The contributions of the research groups involved in the project focused on principal points of the study complementing one another (see WITTENBURG 1999).

Stimulated by the ENVIART-project, the owner of the

Figure 1 : *Stucco marble decorations at Dukes Chapel, Cistercian abbey in Krzeszów, Poland.*

Dukes Chapel, the diocese of Legnica, succeeded in getting funds for its comprehensive restoration. The outcome of the research found thus a practical implementation and contribute to the preservation for future generations of this wonderful site and will hopefully be of benefit to the preservation and restoration of many other objects where this delightful decorative technique was used.

Stucco marble : structure and degradation

The Dukes Chapel was an ideal object for studying stucco marble decorations and the problems of their preservation. The monument contains decorations of authenticity and value which display manifold deterioration phenomena. As the deterioration observed can be regarded as typical of the material, the findings are of benefit for stucco marble restoration in general.
A search through the scientific literature and archival sources covered all technical and aesthetic aspects of the stucco techniques, such as *scagliola, stucco marble, stucco lustro, artificial marble*, and *marmorino*. Their definitions in the literature are sometimes ambiguous. According to several authors, the technique used at Dukes Chapel in Krzeszów is best described by the term "*stucco marble*".
The investigations of the structure and the pore-space revealed that stucco marble, though it looks dense and compact due to its smooth and polished surface, possesses in fact a high total porosity of 30-35% by volume. Between 55% and 70% of this volume is accessible to liquid water and, at a slight over-pressure, nearly the whole pore space is filled with water.
Three different types of pores can be distinguished. The first category consists of macro pores of sizes ranging between 10 microns and 1-2 mm, of round or elliptical shape due to enclosed air bubbles. In general these pores are part of a interconnected pore space. Formation of gypsum crystals, frequently observed within the macro pores, seems to be part of the hardening process. The second type of pores includes intergranular pores of irregular shape within the range of several microns down to several tenths of microns. They are interconnected to a high extent and make up the prevailing part of the total pore space. Intragranular pores of sizes below 1 micron formed within the gypsum crystals belong to the third pore category observed (GAGGL and *al*. 1997).
A surprisingly limited number of pigments were used to obtain stucco marble in rich variety of color shades. In most cases the pigmentation did not cause any detectable alteration of the fabric. Only for dark red coloration more than 10% by mass of iron oxide had to be added, which resulted in a comparably dense structure.
The presence of synthetic ultramarine, a blue pigment used in the Dukes Chapel, turned out to be a key feature for distinguishing the original baroque stucco marble from nineteenth century replacements. This is due to the fact that manufacturing of ultramarine was developed only in the first half of the last century. In baroque times the use of natural ultramarine was very limited due to its high costs.
The thickness of stucco marble layers in the Dukes Chapel varies between 4 and 7 mm as it was determined by drilling resistance measurement. The recording and processing of the data were improved during the run of the project and the method allows now for a reliable evaluation of hardness profiles. The colored stucco layer is followed by one, sometimes two intermediate layers which fix the stucco marble to the support material. By ultrasonic measurements areas with stucco layers detached from the material underneath could be identified.

To analyze the organic binder added to the gypsum mass during the preparation, a method based on NaOH-extraction and the subsequent analysis of the amino acids was developed. The proteinaceous compound in the stucco marble was found to consist of nearly pure collagen in a mass concentration of 0,41±0,17 %. (WOUTERS and *al*. 2000 a) This indicates that the glue used for the preparation of the stucco mass was gained from collagen - containing materials like fish, animal bones or skins. On the other hand, non collagen protein was found in the intermediate layers used to fix the stucco to the support as well as in the white stucco marble. This points to a different preparation technique of these layers. The same differences were also found in stucco samples from Austria in which the white underlying layer always exhibited lesser protein content and specially lesser collagen-specific content when compared to the respective colored decorative layer.
Ageing of the organic binder present in the stucco marble results in a shift of the extractability ratio in water and NaOH. By artificial ageing of replica samples in laboratory, this solubility ratio as well as the B'/A value, which is ratio of basic to acidic amino acids originating from the protein, decreases, finally reaching values comparable to those of the 250 year old samples from the Dukes Chapel (WOUTERS and *al*. 2000 b).

Historic stucco in Krzeszów were generally given a polish based on linseed oil with possibly a small admixture of rape seed oil. The abundant organic coatings were identified on the highly glossy stucco marbles of the columns, least material was found on the stucco imitation of the white marbles of the statues, though they posses a high degree of gloss as well.
The deterioration of stucco marble is mainly due to attack by water. Water penetration from the support material is an important cause of deterioration. Just a few soaking/drying cycles are sufficient for extensive decay.
By way of contrast, condensation of water on the stucco marble surface, rendered hydrophobic by polishing and coating, brings about much slower degradation. From that point of view, a final treatment with an organic coating such as linseed oil can be recommended as a protective measure, specially that the tests had not revealed any severe reduction of water vapor permeability for the coated material. The degraded stucco marble suffers usually from formation of cracks and disintegration of the surface. On a microscopic scale, weathering results in recrystallization of the fabric due to the formation of well-developed thin-tabular gypsum which encloses pores of predominantly small size, and dissolution processes, which enlarge the size of pores. The overall effect is development of two maxima in the pore size distribution curve.
Analyses of several samples for the salt content showed that damages due to salt crystallization at Dukes Chapel are nearly exclusively connected to the presence of magnesium sulfate as hexahydrite and epsomite. Laboratory experiments produced evidence that the $MgSO_4$-formation is linked to the washout of dolomite from the mortar of the masonry and its subsequent reaction with the gypsum plasters. The mechanism of decay is powered by cyclic dissolution - crystallization of the magnesium containing phases going into solution when the relative humidity of the surrounding air reaches values above 90% or when moisture condenses on the walls, and crystallizing when the walls dry out. Measurements of the sorption isotherms proved that uptake of water by the degraded stucco is driven by the salt content of the material. Furthermore, dissolution and recrystallization of gypsum on the surface, leading to the formation of a whitish bloom, is very frequent.
Hygral dilation was found to be another important factor causing degradation whenever the stucco marble layer is in contact with liquid water. Cyclic swelling and shrinkage result in curvature and cracking. Shrinkage cracks within the intermediate layers were observed also within apparently undamaged samples, which indicates that this layer is one of the weak points of the layered stucco marble structure. To prevent development of cracks in the stucco marble layer during the very first stages of the deterioration, the intermediate layer should be of a low mechanical strength. To produce an intermediate layer of such property, formulations with a high water and a low glue content are recommended (WITTENBURG and *al*. 1997).
It has also been revealed that the addition of alum, which is mentioned in some formulations as enhancing the hardness of the stucco, causes a significant increase in the total porosity and yields a highly porous fabric made of tabular gypsum. In contrast, no detectable changes in hardness were found in the drilling resistance measurements. No fabric of the described type was detected within unweathered original stucco marble. Therefore, it can be concluded that the investigated decorations were made without the addition of alum.
Varying the glue content has a significant impact on the material properties. It has been proved that not so much the glue content in the water-glue solution used for preparation but the absolute amount of glue in the final stucco marble mass is the decisive factor. Excess glue will result in curvature already during the setting and in very pronounced inhomogeneity of the fabric. Furthermore, a significant increase in hygral dilatation is observed. Glue content which are too low lead to a less compact fabric and a powdery surface.
The measurement of the climatic conditions in the Dukes Chapel made clear that the most important feature of the interior's microclimate is a considerable thermal inertia of the building. It causes an intense condensation of moisture during the spring and summer period when masses of warm outdoor air flowing into the chapel cool down on contact with the walls still cold after winter. Outdoor air can easily enter the chapel through leaking windows and by frequent opening and closing of the door in the northern wall through which visitors enter the chapel (KOZLOWSKI and *al*. 2000).
The uptake of water from the atmosphere inside the chapel was also proved by the measurement of the moisture content at different depth in the walls. After the spring period a high water content was found in the first centimeter of the stucco and it decreased in the interior of the walls.
At the base of the walls, specially in the northern aisle of the chapel, an enhanced level of humidity

was found. It can be accounted for by the capillary rise of moisture from the foundation walls supplied with water from the damaged draining system.
For documentation of the research work a three-dimensional model of the Dukes Chapel was set up and put on Internet. The model was used as a "gate" to the database containing the results of investigations of the samples collected in the chapel. Next to numerical data and descriptions, one can view photographs, micrographs, plots, and diagrams explaining the specific investigations and methods used. The 3-D-model allows a virtual "walk" through the chapel and an access to information available for a chosen area. It has facilitated the collaboration of the research teams, it has been used to prepare in a novel way the conservation documentation and provided an excellent mean of presenting results to a broader public interested in the topic. The homepage of the project is accessible at the following address : http://www.chemie.uni-hamburg.de/projects/enviart.html.
The 3-D-model contains a full inventory of the deterioration phenomena in the object such as soiling, surface cracks, missing fragments as well as information on the material structure of the chapel's interior which will be very useful during the planned restoration of the Dukes Chapel.
Though not all questions arising during the work on stucco marble could be answered during the duration of ENVIART-project, a large number of results from different disciplines have been accumulated and best possible insight into the material properties has been gained within the available resources. It was a challenging time for learning new methods in the frame of an international collaboration at an historic building which was only marginally known before.

Stucco marble : protection and conservation

The threats to the preservation of the unique stucco marble decorations of the Dukes Chapel, identified during the present investigations, require the development and implementation of strategies for protection and conservation of the site.
The key element of any preventive strategy should be improvement in the stability of the microclimate, in order to restrict the damaging condensation of moisture on the chapel's walls. This goal can be achieved by reducing the air exchange between the chapel and the exterior, specially during the critical spring - summer period, by effective draught - proofing of doors and windows. Ingress of outside air into the interior can be also reduced if the visitors enter through the pair of doors linking the chapel with the church rather than through the exterior door. Air flowing from the large space of the church interior is to a marked extent cooled and dehumidified.
The above strategy has been accepted by the owner of the object and the conservation professionals responsible for beginning restoration of the chapel. It has a big advantage of simplicity and introduces almost no change into the object. It should be born in mind that the chapel has never had any electrical or heating installation. Introducing one would mean a considerable change in the character of the building which the owner and restorers would like to avoid.
There are two further possible methods of reducing relative humidity in the chapel, by heating or by drying the air. Heating which is controlled to maintain the humidity within a specified range is often referred to as 'conservation heating'. In the chapel the favorable conditions are maintained naturally during most of the year so the possible heating system could operate only during the crucial winter - spring period. Infrared radiators could be used to heat gently the walls. The accumulated heat would protect the interior against leakages of the external air and possible condensation of moisture.
Drying air in the draught - sealed space of the chapel with the use of a commercial dehumidifier is another possibility. The dehumidifier steered by a humidistat could operate only during the critical spring period.
As to the conservation of the stucco marble decorations, magnesium sulfate from the damaged fragments should be removed as completely as possible. In places where the destruction is irreversible, the damaged fragments and salt laden grounding should be removed completely. Where the state of preservation of the decoration allows for their conservation, wet poultices should be applied and protected from drying with a polyethylene foil. This method was tried out to remove magnesium sulfate from the corroded and damaged dolomitic elements. The large volume of water in the poultices allowed for a diffusion of large amounts of salts from the stone. Experiences showed that the first poultice could take up until 90% of the salt present in the stone.
The restoration program calls for the repair and improvement of the existing drainage and pipework system collecting the rainwater, in order to reduce the amount of water rising into the foundations walls. Severe damages in both upper and lower parts of the chapel will make necessary a partly reconstruction of the lost stucco layers. The replacement material should be formulated with a possibly low

glue content to restrict the damaging hygral dilatation which otherwise could occur again in the future. In order to keep replacements, wherever they are necessary, as close as possible to the authentic baroque technique, the pigments identified should be used for the coloration of the stucco masses. Only the use of copper pigments should, however, be avoided as it turns out that copper-bearing phases enhance the degradation of the proteinaceous binding material.
It can be derived from the study of replicas that a glue content of about 1.5 weight percent in the final mass make a well-workable stucco marble which after hardening yields fabric comparable to that of the original material. This can be achieved using a water-glue solution containing 5% of glue during the preparation. When large amounts of pigments, such as iron oxide reds, have to be added, the concentration of the glue solution has to be adjusted appropriately.
Penetration of water from any sources should be generally avoided, in particular in the period after the stucco application because of the enhanced solubility of the glue component. This sensitivity of the material to water diminishes after setting.
Addition of alum results in a change of the internal structure without giving any visible advantages. When application of organic coatings to produce glossy surfaces is foreseen, the use of linseed oil could be considered.
The intermediate layer used to attach the stucco layer to the support material has to be applied with great care. A mortar or limewash of great flexibility should be used because this layer has to cushion the differences in dilation of the stucco layer and the material underneath.
Last but not least the proper restoration of this beautiful stucco marble interior requires skilful craftsmen capable of reproducing colors and patterns aesthetically as close as possible to the baroque original.

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Biography

Christian WITTENBURG studied inorganic and analytical chemistry and received his doctorate for the work on dry deposition of gaseous and particulate matter on building stones at the University of Hamburg. His main interests are the degradation of materials under the impact of the environment. Since 1989, he worked within different national and international research projects on this topic and was coordinator of ENVIART project.
Roman KOZLOWSKI graduated in chemistry at Jagiellonian University of Cracow, Poland, received his doctorate there in 1974 and in the same year joined the Institute of Catalysis and Surface Chemistry of the Polish Academy of Sciences in Cracow. Since 1986 he has worked on a wide range of conservation research projects. His current interests include monitoring the microclimatic conditions in historic buildings and the interaction of water vapour with historic materials.

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An expert chemical model for determining the environmental conditions needed to prevent salt damage in historic porous materials

Un modèle chimique expert pour déterminer les conditions environnementales afin de prévenir des dégradations par le sel dans les matériaux historiques poreux

Clifford PRICE[1]

Abstract

Salt damage in porous materials may be prevented by appropriate control of the local environment (temperature and relative humidity). If only one salt is present, prediction of the necessary conditions is straightforward. However, the situation is much more complicated if several salts are present. This paper describes a system that is capable of predicting the environmental conditions that are necessary to prevent damage from salt mixtures, given the ionic composition of the salts in question.

Résumé

Les dégâts entraînés par le sel peuvent être évités grâce à un contrôle approprié de l'environnement local (température et humidité). S'il est facile de déterminer les conditions nécessaires en présence d'une seule variété de sel, la situation se complique néanmoins nettement lorsqu'il y en a plusieurs. Ce document décrit un système permettant d'établir ces conditions à partir de la composition ionique des types de sel représentés afin de prévenir la dégradation.

Porous materials, such as stone, brick, plaster and ceramics, can be severely damaged by the growth of salt crystals within their pores. The growing crystals are capable of exerting such high stresses on the pore walls that the material crumbles and disintegrates. Examples of salt damage are common throughout the world. In some cases, damage can be so severe as to cause structural collapse of a monument or complete loss of an artefact (GOUDIE and VILES, 1997).
Crystal growth can occur through evaporation or cooling of a saturated salt solution, through the hydration of certain solid minerals, or as a result of chemical reaction. Crystallisation and hydration are initiated by changes in the environmental conditions affecting the monument or artefact : crystallisation damage, for example, can occur through the drying of a wet, salt-contaminated material. However, damage is not limited to the outdoor environment. It can also occur indoors, as a result of fluctuations in the ambient relative humidity. Severe damage to objects has been reported, even when the objects have been kept in the supposed safety of a museum store or display (HANNA, 1984).
All soluble salts exhibit a critical relative humidity at any given temperature, above which they absorb moisture from the air, and below which they crystallise. It is thus relatively easy to prevent damage in an object that is contaminated with a single salt: all that is necessary is to maintain the ambient relative humidity permanently above, or permanently below, the critical level for that particular salt. Under such conditions, the salt remains either permanently in, or permanently out of, solution, and no crystallisation occurs. Transitions across the critical humidity must be avoided, for it is these that result in damage (figure 1). Similar arguments apply to hydration damage.

Unfortunately, objects and monuments are rarely contaminated with a single salt, but contain a mixture of salts – typically chlorides, nitrates and sulphates of sodium, potassium, magnesium and calcium. This situation is much more difficult to deal with. The various anions and cations can combine in many different ways to give a range of possible solid crystals, and there are no longer single critical values at which crystallisation and hydration take place. Instead, crystal growth occurs over a range of relative humidities (figure 2).

Purpose of project

The purpose of the EC project described in this paper was to find a way of predicting the solid crystals that would exist under specified environmental conditions, given the ionic composition of

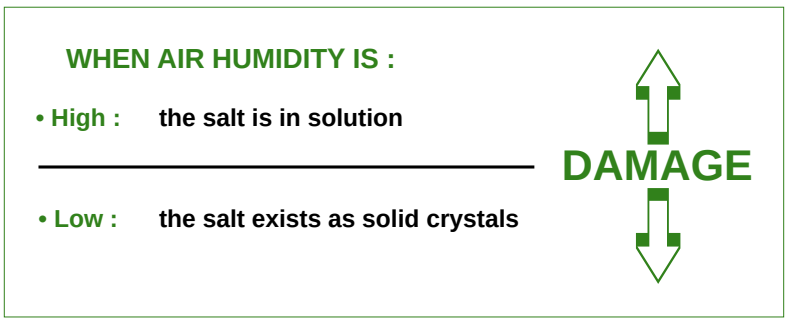

Figure 1 : *Damage occurs if the ambient relative humidity repeatedly crosses the salt's critical relative humidity.*

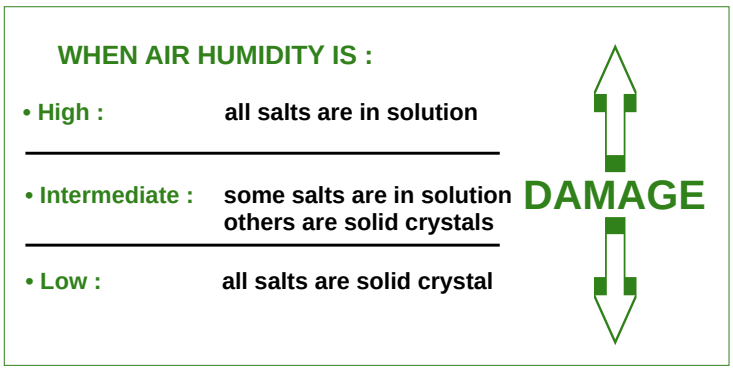

Figure 2 : *If a mixture of salts is present, damage occurs across a wide range of relative humidities.*

the salts that were present in the object or monument under investigation. More particularly, it was necessary to predict the relative volume of those salts, in order to determine the ranges of ambient relative humidity over which damage would occur.
In order to predict the behaviour of salt mixtures, it was necessary to model the interactions of all the anions and cations. This was done using a thermodynamic approach that was originally proposed by PITZER (1973). Some of the necessary data were already available in the literature ; other measurements (for example, of solubilities and vapour pressures) had to be made by the project partners. This was a major undertaking, described fully in the final project report (Price, 2000).

The ECOS program

Once the thermodynamic modelling was complete, it was necessary to develop a computer program that would make the model accessible to conservators and conservation scientists. The program (known as ECOS : Environmental Control of Salts) enables the user to input the ionic composition of the salt mixture in question, whereupon a range of outputs is available. For many situations, the most useful is a graph showing the volume of all the minerals that are present across a given range of relative humidities. The user is thus able to select a 'safe' range across which there is little volume change, and thus little risk of damage. Alternatively, one can select a particular humidity, and then plot changes in mineral composition against temperature. Other facilities include the ability to adjust for any imbalance in the ionic charges ; to identify individual minerals on the graph ; to obtain relevant thermodynamic data ; and to list relevant literature. A typical output is shown in figure 3 (the output is in colour, with lines of different colours identifying the different minerals).

Limitations

The user should be aware of a number of limitations of the program, which are discussed at length in the final report (PRICE, 2000).

- The program deals only with equilibrium conditions. It does not consider the rate at which phase transitions take place.
- The program cannot readily address the problem associated with fractionation : the fact that the first salts to crystallise out may be cut off from the remaining solution as it recedes, and are thus no longer in equilibrium with it.

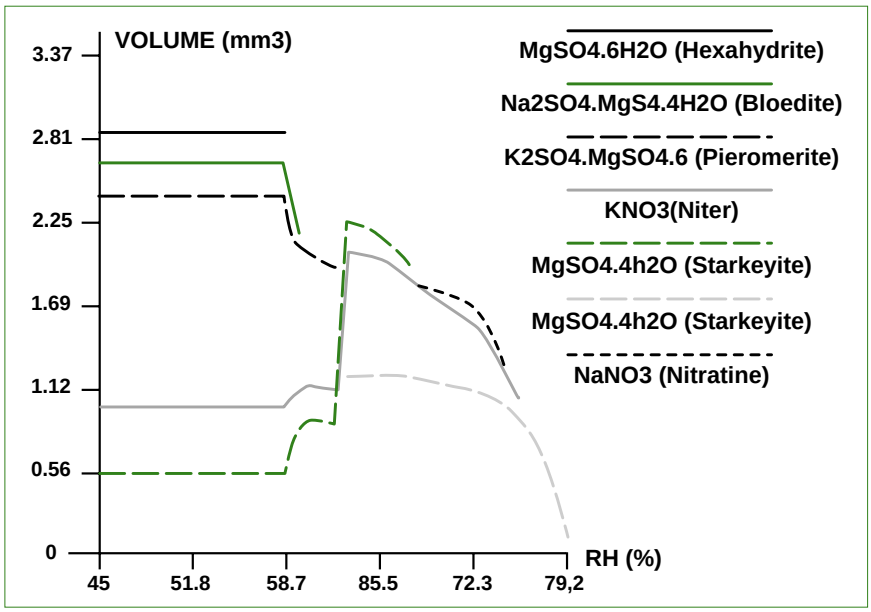

Figure 3 : *Typical ECOS output, showing the cumulative volume of salts existing in the solid state under equilibrium conditions.*

¸ The program is concerned only with situations in which the salts are affected by moisture from the air ; it cannot deal directly with situations involving rising damp, for example.
¸ It may be difficult to obtain samples that are representative of all the salts present in an object or monument.

End users

It is expected that the program's end-users will include conservators, curators, conservation scientists, conservation architects, SMEs (small and medium-sized enterprises) working in the field of cultural heritage, and researchers in other fields. Copies of the program are available to bona fide users from the author (c.price@ucl.ac.uk).

The partners

The research described in this paper was carried out by three partners :
• Institute of Archaeology, University College London (Clifford PRICE, Shaiba MAHMOUD, Julie EKLUND and Alison SAWDY).
• School of Environmental Sciences, University of East Anglia (Simon CLEGG, Peter BRIMBLECOMBE and Nick REEVES).
• Institut für Anorganische und Angewandte Chemie, University of Hamburg (Michael STEIGER, Roland BEYER, Joachim DORN and Anke ZEUNERT).

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Biography

Clifford PRICE gained a PhD in chemistry at St Catharine's College, Cambridge. In 1972 he joined the Building Research Establishment, where he became Head of the Stone Conservation Section. In 1983 he was appointed Head of the Ancient Monuments Laboratory, English Heritage, and in 1990 he moved to the Institute of Archaeology, University College London, where he is Professor of Archaeological Conservation.

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Session F How do we balance tourism with sustainable exploitation and management of cultural heritage ?

Session F Comment concilier le tourisme avec l'exploitation et la gestion durable du patrimoine culturel ?

Rapporteur : May CASSAR

Of all the issues that were discussed in this session, I found the complex and interdisciplinary nature of this area most impressive. Some of the issues related to problem definition. Others were orientated towards providing model solutions based on how the speakers had tackled some of the problems. All related to the balance between preservation and access, which I think has been at the heart of this session. Many interesting examples of the use of different methodologies, tools and technologies were given, some of which were site specific and others having more generic applications. The partnerships that have been forged were discussed, either with organisations such as local authorities or with individuals. The context within which cultural tourism was described in this session was indeed very varied. It covered historic towns, buildings, complexes, individual buildings such as historic properties and churches as well as archaeological sites.

The end-users were uppermost in people's minds. At various times these were described as local communities that live and must survive around cultural heritage and the impact on their lives of having to live with fluctuating numbers of tourists around them. The question was raised as to whether tourists visit for the individual monument or the single key attraction or are they attracted to the area by the historic landscape ? The map of cultural tourism and the profile of the cultural tourist was also touched upon. Who are the tourists and where do they come from ? Are we looking mainly at domestic tourists ? Or are we dealing mainly with tourists from overseas ? What is their age profile ? It is my opinion that one of the things missing from this session is that Europe is becoming increasingly multicultural and multi-ethnic and how should these developments be reflected when discussing cultural heritage with regards to European identity.

The developing roles of different "stewards" of cultural heritage was also described. The shared responsibility for preservation and use was highlighted by all the speakers. We have heard examples of the complex and three-dimensional nature of research. Politicians and administrators may have seen themselves as protectors of cultural heritage, but they were also publicly accountable for the expenditure of money. They were therefore responsible for ensuring that there was a balance between costs and benefits. Examples of conservators and scientists as communicators demonstrating the nature of their work to the public were given as well as the fascination that having access to conservation generates among the public. There were also presentations that dealt with the vital role of volunteers. The need of training for volunteers was highlighted repeatedly by the speakers. The role of the public in preservation and how they can participate by their support of cultural heritage through their visits was also highlighted.

The interest among the session participants on how to integrate cultural heritage within the changing urban landscapes was also raised because the situation is far from being static. The issue of the impact on infrastructure, particularly the transport of tourists to and from sites at different times of the year, the peaks and the troughs that might be experienced and their impact on local communities was also raised.

The shopping list which emerged after the question as to whether there is a future need for research in this area reaffirmed the need for scientific research to produce evidence that underpins access strategies to cultural heritage. There was also a considerable requirement identified for socio-economic research into cultural heritage.

Rapporteur : May CASSAR

C'est la nature complexe et pluridisciplinaire de cette session qui surprend avant tout. Certains exposés étaient orientés vers l'identification des problèmes alors que d'autres visaient à offrir des solutions modèles basées sur l'expérience des intervenants. Tous traitaient de l'équilibre entre conservation et accès au public, thème qui a été, d'ailleurs, au centre du débat tout au long de cette session. Différentes méthodes, outils ou techniques ont été présentés, soit pour des sites spécifiques, soit pour des applications plus générales. Les partenariats avec les autorités locales et les particuliers ont été présentés.

Lors de cette session, le tourisme culturel a été abordé sous ses aspects les plus variés. On y a évoqué les villes touristiques, les édifices et les sites archéologiques. Les participants ont particulièrement insisté sur les utilisateurs finaux –qui à maintes reprises, ont été définis comme les communautés locales vivant aux alentours des sites patrimoniaux - et sur les effets des fluctuations touristiques sur l'existence de ces dernières. Les motivations des visites touristiques - visite d'un monument précis ou d'un paysage historique ont été analysées: La carte du tourisme culturel et le profil du touriste culturel ont été évoqués. Qui sont ces touristes ? D'où viennent-ils ? S'agit-il principalement de touristes locaux ? S'agit-il principalement de touristes internationaux ? Quelle est leur moyenne d'âge ? On peut cependant regretter l'absence de réflexion sur la manière d'intégrer le caractère multi-ethnique et multi-culturel de l'Europe aux discours concernant le patrimoine censé la représenter. Après quelques explications sur le rôle de plus en plus important des médiateurs du patrimoine culturel, les participants ont insisté sur l'importance du partage des responsabilités aussi bien en matière de conservation que d'usage. Quelques exemples de la nature complexe de la recherche ont été donnés. Les politiciens et les administrateurs se sont présentés comme des protecteurs du patrimoine culturel mais également comme les garants des dépenses publics, responsables du bon équilibre entre coûts et bénéfices. Enfin, des conservateurs et des scientifiques ont expliqué la nature de leur travail et évoqué le vif intérêt du public pour la conservation.

Le rôle des bénévoles dans la protection et l'administration du patrimoine a été discuté. Les intervenants présents ont principalement rappelé l'importance de leur formation. Le rôle du public et sa contribution à la conservation sous la forme de visites ont été également évoqués.

Les participants ont montré un vif intérêt pour les différentes manières d'intégrer le patrimoine à un milieu urbain en perpétuel changement. Les conséquences du tourisme culturel sur les infrastructures et les communautés locales, plus particulièrement en ce qui concerne l'accès aux sites et les fluctuations saisonnières ont été débattues.

A la question de la nécessité du maintien de ce thème aux sein des programmes de recherche, l'ensemble des participants ont répondu par l'affirmative. Il y a un fort potentiel de recherche, notamment dans le domaine de la socio-économie pour étayer les stratégies d'accès aux sites patrimoniaux.

Management of visitors in world heritage sites

Gestion des visiteurs dans les sites du patrimoine mondial

Milos DRDACKY[1] , and Maria GALOVA

Abstract

Paper analyses in relation of mass tourism to cultural heritage stability based on knowledge taken from Central European experience. It presents a sample of the situation in one of the World Heritage Cities - Telc. There are studied impacts and risks generated by a high attendance of visitors to cultural monuments as well as risks to visitors and their mitigation possibilities. The contribution also deals with the role of cultural tourism in social and economic stability of cultural heritage sites and the needs of tourism concerning development planning. Conclusion contains some recommendations for the creation of a tourism management policy.

In the paper are utilised results of research supported by grants of the Czech Grant Agency No. 103/98/S051 and the Institutional Research Plan AV0Z2071913.).

Résumé

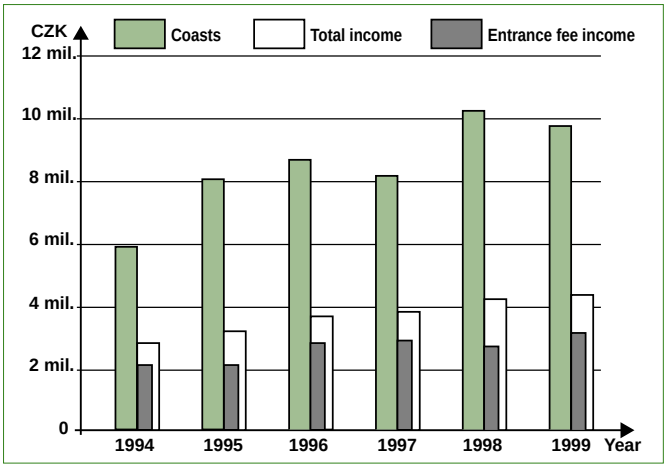
Ce document analyse le rapport entre le tourisme de masse et la durabilité du patrimoine culturel en se fondant sur des connaissances acquises en Europe centrale. Prenant pour exemple la situation de l'une des villes concernées, on y étudie les conséquences et les risques que peut entraîner une fréquentation importante pour les monuments comme pour les

visiteurs mais également les moyens de les limiter. Le rôle du tourisme culturel dans la durabilité économique et sociale des sites ainsi que ses besoins en matière de programmes de développement y sont également abordés. Enfin, la conclusion propose un certain nombre de recommandations pour la création d'une politique de gestion du tourisme.
Des résultats de recherches effectuées avec le soutien de la Czech Grant Agency No.103/98/S051 et du Institutional Research Plan AV0z2071913 ont été utilisés pour cette étude.

At the threshold of this century tourism reached immense proportions and became a mass means of recreation. Tourism for recreation and entertainment greatly outnumbers so called cultural tourism whose focus is historical and cultural heritage monuments. Nevertheless, it is expected that the latter type of tourism will develop very quickly and might almost reach the volume of recreational travel. Central and Eastern Europe are not typically disposed towards the ideal conditions of recreational tourism. Of course, a great amount of well preserved cultural monuments and the density of historical cities attracts many cultural tourists. In fact, we do not observe any heavy increase of cultural tourism in the country recently and the number of visitors did not overcome historical data.

Situation in small Czech cultural heritage sites

It is very difficult to forecast development of tourism in Central European countries because there is little experience with such a situation. From the recent data it follows that increase in number of tourists will be rather dependent on Czech citizens than on foreigners, on accompanying cultural or recreational opportunities and, naturally, on economic situation in the country. National income from tourism represents also in the Czech Republic a very substantial percentage in the NGP. Nevertheless the benefits directly associated with individual cultural monuments are not sufficient to balance maintenance and operational costs. The ratio of income generated by the Telc Castle, (mostly from the entrance and rental fees), to the maintenance and operational costs is shown in the figure. The State subventions increase faster than local direct income in which, moreover, the important part yields from use of the Castle for historic movies production, which occasionally limits its availability for visitors.



Impact and risks of a high attendance on cultural heritage objects and small cities

It is practical to distinguish four groups of impacts and risks generated by visitors. *The environmental aspects* include namely *moisture and temperature changes, increase of dust deposits and radiation (light)*. They may cause mechanical damages due to constraint volumetric changes, create environment suitable for biological or electrochemical deterioration and together with dust deposits may intensify staining. Light attacks mainly stability of colours. Movement of visitors is accompanied with *an increased mechanical wear* of historic structures, which decreases their life cycles. Many historic objects have to suffer from everyday increase of loading and sometimes even overloading. Fortunately, those structures are mostly sufficiently robust and sustain the above described situations without critical damages. Unfortunately, *intentional damage* cannot be omitted. Also cultural heritage objects are targets of vandalism and terrorist actions. The former is represented namely by graffiti movement as well as by "souvenirism", i.e. a desire to transport a particle or even a part of a cultural heritage object home. Considerable damages are caused also by *ignorance and negligence* of tourists, especially by groups of youth. Typical problems of soiling include rests of foodstuffs, cigarettes and chewing gums.
According to the above-mentioned types of impact relevant reduction measures may be applied.

First of all, the *number of daily visitors* must be *limited*. In the Tel_ Castle, e.g. the maximum daily capacity of about 1200 visitors has been determined. Only guided visits are offered and, according to the local conditions, there are forty-fifty visitors in one group on the trail A and only twenty-five for the circuit B, where the interior is more fragile. The regulation is ensured by means of time entrance tickets. Guided visits are the best tool for *control of movement and behaviour of visitors* in the cultural heritage environment. They enable an easy supervision, regulation of velocity of movement as well as warning of visitors. Risks from mechanical wear as well as from intentional damages can be reduced by *prevention of historic fabric from close contact with harmful environment or visitors*. Sensitive materials must be appropriately permanently or temporarily covered, light should be reduced and its intensity kept under recommended levels (50 lux). Soiling can be effectively reduced by limitations in visits during climatically unsuitable periods, (rainy spring and autumn months), as well as by *education of visitors*.
The high attendance of cultural heritage sites may generate two groups of problems in connection with action toward the visitors. The first is associated with *quality of presentation and interpretation* of cultural heritage issues. However, the visitors of cultural heritage objects meet a real danger of *injuries* mostly due to *falls on stairs or floor level changes* especially in dark rooms. Fortunately, the percentage of those cases is rather low reaching a fraction of per mile. Another category of risks yields from *inappropriate equipment* of historic objects, e.g. missing handrails and elevators. Insufficient are very often also facilities – technical as well as exposition - for handicapped visitors. Some visitors may be victims of an *overestimation of their own capability*, which is a more frequent case at natural or archaeological sites, but also in high towers where are recorded heart attacks after climbing the steps.
The above mention impact and risks can be improved or reduce by means of *passive (technical) measures* through installation of railing, elevators, providing caution paints, (if possible), and warning tables. Here it seems again very useful to utilise *active measures*, namely voice explanations and warning by guides who are properly trained and educated.
There are other risks from tourism to small sites and their citizens, as e.g. a danger of breaking historic continuity, context and memory. Tourism is thus negatively marking the *stability* of conditions necessary for the protection of natural life and tradition in the historical core of the town which can be easily converted into a place and an object of *tourist consumption*. An artificial renaissance of historical operation including historical requisites takes place following this, leading to the creation of a distorted model of life in the historical core. This illusion can be so good as to delude a tourist from noticing the deception, especially when coming from a different cultural region. A citizen of the town on the other hand knows the truth and the historical centre is dead for him. This situation vulgarises citizens' approach to monuments and brings a number of other problems particularly out of season when historical parts of town are continuously empty.
Tourism has a very strong i*mpact on infrastructure* in historic sites. It demands a special infrastructure which in other areas of a small town's life is not useable. Such an infrastructure stays idle for a majority of the year in cases of seasonal tourism and requires costly maintenance. In question is mainly the capacity for *room and board*. A bigger problem we encounter is *parking* and perhaps the worst consequence of tourism for the infrastructure is the remarkable change in the composition of the *business net* in the historical core. Tourist shops gradually drive out of the centre an assortment of goods necessary for the inhabitants and inhibit the year round liveliness of the business spaces.
Cultural heritage issues and their utilisation for tourism have, of course, many positive consequences, too. They increase the *attractiveness* of the place, improve conditions for *cultural life* and enrich that life by many activities and events. *Socio-economic impact* can be reasonably influenced by means of proper development planning and management of tourism, which is based on integration of cultural heritage into the life of society.

Tourism and development of cultural heritage sites

It is possible to manage and lead a historical town to permanent liveability only with a complete knowledge *of the town's interior development potential for tourism* and with a well *prepared strategy*. In regard to this notion it is necessary to support such activities which satisfy *the needs of tourists* while demanding the *participation of inhabitants*. For example : in Telc we support a creation of so-called "distributed hotel", which means small accommodation possibilities in historical houses on the square. This is an effective use of free spaces serviced by owners who live in these houses. This arrangement is convenient for the city also from the perspective of income due to the tax system

in place. Private capacities are completed by a few small hotels (around twenty-five beds) with dining possibilities. This helps to preserve life in the town core and as well offers to tourists an attractive service which enables a high concentration without disturbing the existing scale and rhythm of the towns life.

Tourism management policy recommendation

In conclusion several points should be stressed, which would help to sustainability of tourism in cultural heritage places.

Targeted and interdisciplinary research. Tourism brings in problems which concern many spheres of cultural heritage site preservation. Many consequences are still not well known, some experienced only in a narrow field. This is why we consider it to be necessary to carry out special inquiries and focused research in order to be able to define these problems complexly and find an appropriate solution optimal for a wide range of social, economic, technical, cultural and political viewpoints. In many cases the problems of tourism are still being dealt with monothematically and by amateurs.

Tourism strategy on all territorial levels. Strategy of tourist management ought to be prepared not only on the level of towns, regions and nations, but as well on the international level. Travel and tourism has become a profitable industry and travel agencies operate in a space with no borders and often with out consideration for local culture.

Scaling and dispersion on all levels. The general policy, which should be kept in cultural heritage regions, is to prevent the creation of mass tourism centres, villages or enormous hotels. The activities are aimed at being scaled according to the sustainable capacity of the places of interest. In the Czech Republic, there is an effort to disperse cultural tourists onto a larger area and offer them also places to visit other than monuments.

Reflection of tourism needs in urban planning. As it has been already mentioned all planning documents have to contain measures reflecting needs of sustainable tourism in territories with important cultural heritage characteristics.

Training of professionals. Another necessity for a successful tourist management are educated experts. Starting from the year 1997 the city of Telc has a specialised college aimed at travel and tourism. It is not enough to organise conferences and publish declarations; it is necessary to prepare tools for application of appropriate tourist management in practice.

Quality instead of quantity in cultural heritage tourism. Social and economy impact as well as sustainability of cultural heritage tourism might be substantially improved by seeking for quality measures rather than by a continuous increase of number of visitors of cultural heritage sites. There is further necessary to find a balance between modern information technology possibilities and simple human personal experience in learning and enjoying cultural heritage.

Biography

Milos DRDACKY has been working as researcher and Director of the ITAM-ARCCHIP Centre of Excellence (Advanced Research Centre for Cultural Heritage Interdisciplinary Projects) of the Czech Academy of Sciences. Lecturer at several Czech Technical Universities, past Head of the Telc Town Architect Office and consulting expert to Telc Mayor and Senator of the Parliament. He has been engaged in several research projects granted by the Czech Grant Agency, Czech Ministries, Council of Europe or EC oriented to problems of historic cities as well as historic materials and structures.

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Strategies for visitor management at National Trust properties

Stratégies pour la gestion des visiteurs dans les propriétés du National Trust

Helen LLOYD[1]

Abstract

The National Trust is responsible for both conservation and access to its historic buildings and their settings. Visitor pressure now threatens to destroy the spirit of each place, risks damage to collections, and may overload vulnerable building structures. Curators, conservators and house staff work together to develop cleaning regimes and protective measures based on museum conservation standards and historic housekeeping methods. These measures enable collections to withstand the risks associated with public access yet respect the 'spirit of place'. Strategies for visitor management are flexible and adapted to suit each collection. The sustainable capacity of each property is defined, and wear-and-tear, light damage and soiling are minimised. Opening arrangements are modified to provide access at times when it is most popular, and traditional housekeeping techniques and conservation science are explained to visitors.

Résumé

Le National Trust est responsable de la conservation et de l'accès public aux bâtiments historiques et leurs environs. Aujourd'hui le nombre de visiteurs commence à menacer l'état de conservation, comporte des risques pour les oeuvres d'art, et peut mettre en danger la stabilité des bâtiments vulnérables. Les conservateurs, restaurateurs, et le personnel sur place travaillent ensemble pour développer des méthodes de nettoyage et des mesures protectrices, fondées sur des standards muséologiques et des méthodes d'entretien éprouvées. Ces mesures préservent les collections des risques associés à l'accès public, et respectent toujours l'»âme » du lieu. Les stratégies de gestion des visiteurs sont flexibles et adaptées aux besoins de chaque endroit. La capacité de chaque propriété de résister à l'accès est définie et les dégradations, les effets nuisibles de la lumière, et la salissure sont réduits au minimum. Les horaires d'ouverture sont déterminés pour permettre un accès aisé au public et les méthodes d'entretien traditionnelles et de conservation scientifique sont expliquées aux visiteurs.

The National Trust for England, Wales and Northern Ireland is a charity founded in 1895. Its mission is to preserve places of historic interest or natural beauty, for the benefit of the nation. The Trust is independent of the state and derives its income from the subscriptions of its 2.5 million members, from legacies, admission fees, donations, grants, sponsorship, endowments and property rents. Even so, resources are tight, and four out of five historic houses run at a loss.

The aims of its founders were primarily to acquire and protect areas of countryside under threat from industrialisation and uncontrolled development. However since World War II the Trust has also acquired 200 historic houses and estates, many of which were threatened by the crippling inheritance taxes imposed on their owners.

With those houses came a wide range of rare and fragile artefacts, from great works of art to humble items of domestic paraphernalia. The long association with one house and many generations of one family enhances the aesthetic and historical significance of each collection. Collectively the Trust is one of the greatest repositories of decorative arts in the world, and this imposes on it enormous responsibilities of care and conservation.

The Trust's purposes embrace both conservation and access, but this poses particular challenges in the context of historic buildings and their settings. The Chairman of the Trust said in 1967, 'Our primary responsibility is the preservation of places of historic interest or natural beauty. It is also our duty to give public access to these places, but we are not designed as a money-making concern which wishes, at the expense of preservation, to have the maximum number of visitors to our properties. We are not part of the tourist industry. In a way, this makes our job, which is essentially conservation, all the more difficult.'

Visiting country houses has been fashionable since the 17th and 18th centuries but today it is so popular that in 1999 National Trust houses received 12 million visitors. The rapid rise in visitor numbers particularly over the past 20 years has increased the conflict between the Trust's twin aims of access and conservation. Visitor pressure at some properties now threatens to destroy the spirit of the place, risks damage to collections, and may overload vulnerable building structures. This paper discusses how we manage visitor access at historic houses regularly open to the public in order to conserve these fragile places for the benefit of future generations, while providing access for visitors today.

Presentation of historic houses

The Trust's policy is to display its houses to visitors as though they were still privately occupied homes. The introduction of museum standards and preventive conservation measures, and the rearrangement of furnishings to permit visitor access, must safeguard the 'spirit of the place', its particular historic and idiosyncratic characteristics.

Traditional housekeeping

In earlier times households understood the potential threats to their valuable possessions caused by light, damp, dust, pests and wear. They developed practical and inconspicuous methods of controlling these agents of deterioration. For instance, even while families were using the rooms, decorative case covers and dust covers made of leather, linen or cotton were traditionally used to protect valuable possessions. Chairs, tables, beds, carpets, curtains, tapestries, watercolours and globes were all provided with these covers, which were only removed for grand occasions on a few days a year (figure 1).

Figure 1 : *Slide of two chairs in Carved Room at Petworth, one with traditional checked cover, other with Aesops' Fables tapestry upholstery. Case covers were traditionally used to protect upholstery from wear, light and dust.*

When we have used modern technology to research conditions in our buildings and evaluate preventive conservation measures, we have found that traditional housekeeping methods were designed to deliver similar benefits, in ways that are more often in keeping with the 'spirit of the place' than modern museum practices (for example, placing all vulnerable objects in display cases).

Visitor impact

Today, rooms designed and furnished for only occasional use are opened continuously for seven months from April to October, so in one year their contents are exposed to more physical wear, light, dust and handling than in decades of family use. There have been many instances of damage caused by visitors accidentally abrading fragile surfaces, or deliberately touching tactile materials such as textiles and wallpaper. The passage of feet has caused erosion of carpets and hard floor surfaces, overloading of weak structures such as cantilever staircases, and vibration of floors affecting plaster ceilings below.

Visitor management

Our strategies for visitor management are designed to reduce the impact of overcrowding at peak periods of visiting during the summer months and on public holidays, as well as to reduce the cumulative and more insidious damage caused by visitor access over many years. Our objective is to define the sustainable capacity of each property, to minimise the wear-and-tear and light damage, and to improve viewing conditions so that people can enjoy their visits more.

Light levels

The sensitivity of historic collections to light is a major factor in determining levels of visitor access. In museums, exhibits are often grouped in glass cases according to material type. Museum guidelines on light exposure recommend that light-sensitive organic materials should be exhibited at 50 lux. Total hours of exposure to light are controlled by the use of artificial lighting and by rotating exhibits so that they are on display perhaps only one year in every five.

In historic houses, interiors are presented as furnished homes, with mixed materials displayed in a common environment. Rotation of collections is rarely possible because this destroys the historic integrity of the presentation. Illumination is almost entirely by daylight through side windows, and controlled using traditional methods such as sun blinds and sun curtains. Light on sensitive organic materials cannot be reduced to 50 lux without leaving some parts of rooms in near darkness.

Access allocation

Since light damage is cumulative, we can control the rate of exposure by restricting the length of time a property is open, as well as by reducing light levels. In museums where light is controlled at 50 lux for 3000 hours per year, this gives a total annual light exposure of 150,000 lux hours. In historic houses, if light is controlled to 150 lux then the same annual exposure can be achieved by restricting opening to 1000 hours. This provides reasonable viewing conditions throughout each room. We call this period of opening the access allocation, and the figure of 1000 hours is adjusted to suit the sensitivity of individual collections.

During open hours light meters are used to determine acceptable light levels for public access, and blinds are lowered to achieve those levels (figure 2). UV-absorbent filters are applied to windows. Blue wool dosimeters and data loggers are used to monitor cumulative light exposure. Whenever houses are not open, blinds are drawn and shutters closed to exclude light completely.

Figure 2 : *Slide showing member of house staff at Kingston Lacy using light meter while adjusting the height of the window blind. Using a light meter when setting traditional glazed 'Holland' blinds*
© National Trust Photo Library/Ian Shaw

Determining the need to control access

In addition to controlling light damage, we need to control visitor wear-and-tear caused by people deliberately touching or accidentally brushing against vulnerable surfaces such as textiles and wallpaper, or abrading floors and carpets. Some damage can be prevented by the use of ropes and pro-

tective covers, or by altering visitor routes. However too many preventive measures interfere with visitors' ability to appreciate historic interiors, so it may be necessary to impose restrictions on access.

Wear-and-tear is determined by two factors, the total number of visitors in one season, and the number standing in (or passing through) a room or space at one time. We control this damage by defining the sustainable capacity of each room. This is the number of visitors that each space can continuously accommodate without jeopardising the conservation or security of the collection, without obstructing other people's views, and without overloading the structure or creating vibrations in the building that may damage fragile structural elements, such as plaster ceilings or cantilever staircases.

Surveys are carried out to assess the capacity of each room, the total capacity of the building, and the rate of entry at the front door that prevents continuous overcrowding throughout the rooms. Vibration levels and the displacement of structural beams can be measured to ensure that the building is not overloaded. These assessments allow each property to determine the maximum number of visitors that can be accommodated at one time, and the total number of visitors that can be accepted each day.

Methods of controlling access

This research has resulted in the introduction at some properties of timed tickets, to control the entry flow rate at the front door, and to ensure that overcrowding does not occur further along the visitor route. At very popular properties, these tickets are only available by booking in advance. At other properties, it is better to count in a number of visitors at the beginning of the day, and not to allow more in until others come out. This system can be managed formally by an electronic counting device or informally by the steward standing at the front door. Good communication skills are needed to explain the conservation reasons for the delay. Volunteer room stewards have an important role in monitoring and controlling visitor flow from one room to the next, and ensuring that the sustainable capacity of each room is not exceeded.

Continuous records are kept of the number of people visiting the house each hour. These figures help managers to design visitor facilities such as car parks, lavatories, restaurants etc to meet but not exceed the sustainable capacity of the house. The figures indicate which hours of the day are most popular, so that opening arrangements can be adjusted to suit the majority of visitors. The figures also inform marketing and promotional strategies to attract more visitors only on days when the house is unlikely to be full.

Other restrictions apply at properties with particularly vulnerable contents, fragile decorative surfaces, or narrow visitor routes, and these are advertised to visitors in the Members' Handbook and in leaflets describing the Trust's conservation policies.

Cleaning and protective measures

Opening houses to visitors leads inevitably to soiling of collections. We control this by high standards of maintenance and care at our properties. Eighteen Regional Conservators are responsible for training property staff in preventive conservation and housekeeping practices that are described in the Manual of Housekeeping, and demonstrated in the Keeping House video.

Recent research by the University of East Anglia indicates that fibres from visitors' clothing are the principle source of soiling on objects displayed between knee and eye level. Even though these fibres account for only 3% of the total dust, they are larger and more visible than fine particles. The density of dust increases with the number of visitors, but decreases by half with every metre distance between the visitors and the collections. These findings emphasise the benefit of using rope barriers to minimise the dust falling on fragile surfaces, as well as to prevent touching, and to improve viewing conditions by routing visitors through densely furnished and crowded rooms (figure 3).

Figure 3 : *Slide of inlaid chairs at Charlecote Park with rope in front. Rope barriers protect against touching, prevent dust, and improve viewing conditions. Credit The National Trust/Katy Lithgow*

Figure 4 : *Slide showing Sharp Heeled Shoe Notice Sharp-heeled shoes damage floors and carpets. Plastic overshoes are provided for rugged or dirty footwear. Credit National Trust/Sheila Stainton*

Figure 5 : *Slide of drugget, at Kingston Lacy, rolled back to show Rugstop, carpet, underfelt. Druggets and underfelt protect carpets from wear. © National Trust Photo Library/Ian Shaw*

Visitors bring dust into the house on their shoes, and this is effectively removed by providing traditional doormats at entrances. Shoes with sharp heels that cover an area smaller than 1cm square damage floors and carpets are not permitted. Visitors arriving in unsuitable or dirty footwear are asked to remove their shoes and wear the plastic slippers provided (figure 4). Many floors have been scratched by pieces of grit and gravel trapped in the ridged soles of fashionable leisure footwear. We provide traditional boot-scrapers and brushes for visitors to clean their shoes. Carpets and other floor surfaces are further protected from grit and dust from visitors' shoes by covering them with druggets. Traditionally these were linen damask floor coverings, but as a result of research, we now use wool carpet or felt to reduce the impact of shoes on historic carpets (figure 5).

To minimise the risk of accidental damage in small and densely furnished spaces, visitors are asked to leave at the entrance any bulky bags, rucksacks and camera cases. For security reasons, photography is not allowed. At many properties we cannot admit small children in prams, pushchairs or baby back carriers. Manual wheelchairs are admitted to the ground floor of larger properties, and new research will define where it is safe to admit powered wheelchairs. In houses with many

uneven floor surfaces, narrow passages and steps, these restrictions are necessary to prevent accidents to children and disabled visitors and inconvenience to other visitors, as well as to minimise damage to historic collections.

During the closed season in winter the collections are protected with dust covers. A thorough spring-cleaning programme ensures that every surface of the building, and every item in the collection, receives careful inspection and cleaning. The heating systems are designed to deliver constant humidity levels, but the resulting temperatures are too low for the comfort of visitors.

During the open season, daily vacuuming to remove dust and grit reduces abrasion and soiling on robust or renewable surfaces, such as polished wood and modern carpets or druggets. It also helps to reduce the amount of fine dust on fragile surfaces. Fragile historic materials such as textiles and gilded wood and metal should only be cleaned infrequently, as repetitive cleaning cumulatively wears away their surfaces.

Service time

On average it takes one hour to clean a room and prepare it for opening. With only a small team of part-time staff, most houses need 3-4 hours to complete the cleaning each day before visitors arrive. The hours of light used for cleaning are recorded daily to determine an annual figure for what we call service time, on average 400 hours of light exposure per room. This figure is then deducted from the access allocation, to determine how many hours remain available for public opening, or for specialist visits and events at other times.

Opening hours

At the most important and fragile properties such as Hardwick Hall and Knole, where for reasons of light sensitivity the access allocation must never exceed 1000 hours, the deduction of 400 hours for service time leaves 600 hours for public access. As a general rule, sensitive houses are open to visitors for 4 hours per day, 5 days per week, for 30 weeks per year, from April to October.

Other houses that are less vulnerable to damage may set their access allocation around 1100, 1200, 1300 or 1400 hours per year. Where they have sufficient trained staff, it may be possible to complete the cleaning using only 300 hours of service time, thus releasing more time for visitor access.

Property staff are responsible for monitoring light exposure and open hours, and each year the opening arrangements are discussed with conservators and adjusted to achieve our goal of sustainable access. The greatest variable is in the time allowed for education visits, events and guided tours. Property staff need to make careful choices between hours allocated to these activities and hours for general visitor access.

Managing visitor access for conservation

Our policies for visitor management are flexible and can be adapted to suit each collection, according to its fragility and sensitivity to light. There may be options for isolating or reducing access to particularly vulnerable parts, so that access to a whole property is not restricted by the need to protect only one or two fragile elements. We are developing an increasingly sophisticated approach, and modifying opening arrangements to provide more access at times when it is most popular. In other words we are opening for longer hours at weekends and during the summer holidays, but reducing open hours on week days and during the autumn months when there is less demand.

As part of the wider approach to sustainable tourism and development the Trust takes a holistic approach to preserving its properties. We are consulting the interests of the local community, and providing free entry days for the disadvantaged. We are working hard to meet the challenges of the Disability Discrimination Act, and to provide access for all. We regularly review our strategies for sign posting and marketing. To prevent traffic pollution and to minimise car-parking facilities, we are encouraging visitors to use green transport. All new buildings and processes are designed to be environmentally friendly.

The Trust has carried out market research to assess visitors' views on access arrangements, such as hours of opening, control of queues and crowds, facilities for children and for disabled visitors, as well as restrictions on access due to the Trust's conservation policies. The research shows clearly that overcrowding reduces not only the pleasure of a visit and the time that a visitor spends on the property, but also the money they spend in the restaurant and shop. Most visitors are happy to accept that restrictions on access are for the benefit of the long-term preservation of the properties, and also to improve the quality of their visit.

Conservation and interpretation

Many visitors are fascinated by methods of traditional housekeeping and modern conservation science, especially those that they can apply to the care and preservation of their own possession. Demonstrating these methods of care to visitors is also a valuable tool for interpreting the social history of our properties, deepening their interest and broadening their appeal to a wider audience. These methods of care and protection are being continuously refined through further historic and scientific research.

Conclusion

Curators, conservators and house staff work together to develop cleaning regimes and protective measures that enable collections to withstand the risks associated with public access. Protective measures are designed to reflect traditional housekeeping practices, or to be unobtrusive. Visitor access is controlled by measuring rates of light exposure to determine annual hours of access, and by calculating the number of visitors that can be accommodated at one time, and over time.

The future for historic houses depends on achieving a sustainable balance between access and conservation. Preservation remains the Trust's first task, and will always take precedence over public access. This principle was established by John Bailey, Chairman of the Trust from 1923 to 1931, when he said: 'Preservation may always permit access, while without preservation access becomes forever impossible.'

Biography

Helen LLOYD received a diploma in conservation of ceramics at West Dean College in 1981, after eight years in business administration. She joined the National Trust in 1981, and succeeded Sheila Stainton as The Housekeeper in 1989. She is responsible for co-ordinating the work and professional development of 18 regional conservators, and providing training in preventive conservation and housekeeping for all staff who work in historic houses. She is also Adviser for Conservation of Ceramics and Glass.

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Strategies for managing religious tourism in the Holy Year

Stratégies pour la gestion des touristes-pèlerins pendant l'Année Sainte

Cristina CARLO-STELLA[1]

Abstract

The article focuses on the initiatives taken by the Catholic Church in regards to the management of tourism in the context of the impact of this phenomenon on her religious cultural heritage, and gives a general overview of the organizational structure adopted in Rome and the Vatican for the management of the Great Jubilee Year of Christianity. Essential to the analysis of this phenomenon are the principles guiding the actual nature and aims of the cultural heritage of the Church from which it assumes a particular meaning and dimension within the evangelizing and pastoral action carried out by the ecclesial community. As a principal investigator and host of cultural tourism, the Church has made and continues to make an enormous contribution to the development of standards and innovative procedures. As today's society is swept by the phenomenon of globalization, tourism aimed at cultural heritage, and religious cultural heritage has been a focus of particular concern by various international organizations. A synergism between the guidelines issued by these organizations in recent years and those issued by the Church, have pointed to the essential importance of developing and applying an ethical policy for tourism whereby conservation and preservation measures, a contextual approach, a humanistic dimension have to be considered focal points to be safeguarded and enhanced.

Résumé

Cet article est principalement consacré aux initiatives prises par l'Eglise catholique pour gérer les effets du tourisme sur son patrimoine culturel et religieux. Il offre une vue d'ensemble de la structure organisationnelle adoptée par Rome et le Vatican pour le Grand Jubilé du Christianisme. Le patrimoine culturel étant porteur d'une signification particulière dans l'action évangélisatrice et pastorale du monde ecclésiastique, les principes déterminant la nature et les objectifs de son administration interviennent de façon capitale dans cette analyse. En tant que principal instigateur et hôte du tourisme culturel, l'Eglise continue de contribuer très largement au développement de sa qualité générale comme à celui de multiples procédures innovatrices. La mondialisation tenant, aujourd'hui, une place de plus en plus importante dans la société, le tourisme culturel et religieux compte désormais parmi les préoccupations premières de plusieurs organisations internationales. La similitude entre les grandes lignes du discours actuel de ces dernières et celles de l'Eglise fait clairement apparaître la nécessité de la mise en place et de l'application d'une politique d'éthique préservant et encourageant les mesures de conservation ainsi qu'une approche contextuelle et humaniste du problème.

As a short introduction to the specific topic I will address concerning religious tourism, I would like to delineate briefly a general background of fundamental principles upheld by the Church in regards to the nature and function of religious cultural heritage and human creativity.
Indeed, one could rightly ask himself why has the Church chosen for centuries to support, encourage, utilize artistic creativity and cultural patrimony ? If we begin with the assertion that the artistic creative process develops as a result of the intimate dialogue between nature that surrounds us (that is the extrinsic dimension of the cosmos) and the intellective-creative forces that characterize the human being and make him "in the likeness of the Absolute Creator", art becomes the umbilical cord that unites every man to the tangible and to the Spirit, to creation and its Creator. The work of art, as J. MARITAIN has said, is "a genuine revelation both of things as well as of the Being"(1). Since every individual has been endowed this creative potential, art represents a universal as well as an all-encompassing means of communication as it involves rational knowledge, intellectual wisdom, and sensible perception. This is how art represents an efficient instrument of communication particularly within a community environment that gathers people in order to lead them to transcend and contemplate that which is beyond, that which awaits them as the supreme goal of their existence : absolute beauty, perfect harmony, the light of Truth and Eternal Life.
The Church from the very beginning of her existence became immediately aware of this potential and exploited it specifically at the service of a community environment to serve three functions – worship, catechesis, charity. The latter areas of evangelizing activity also represent the principal

components of that "inculturation" phenomenon that has meant the translation of the Gospel message within the various cultural realities that surrounds the human person. Naturally this has made the Church one of the principal and most faithful patrons of the arts and at the same time has rendered her own cultural patrimony immense in size and diversified in type.

Already by the 2nd century the Church had institutionalized roles and specific offices for the care and protection of her cultural heritage, marking the beginning of a long and constant tradition down the centuries whose impact has been tremendous also for the safeguard and promotion of culture in general in the various nations as well as the development of civil legislations. Indeed, our European cultural identity and entire Western culture, can not be fully understood or appreciated without considering the enormous contribution made by the Church through her immense cultural patrimony – which in many countries represents more than half of the patrimony nationwide.

The institution by Pope John Paul II back in 1988 of a Pontifical Commission for the Cultural Heritage of the Church can be considered a natural outcome of this millennia-long tradition. The Decastery has the responsibility of supporting and encouraging efforts carried out by the Particular Churches around the world for the protection – conservation – enhancement of her cultural heritage. Thus, as the "Ministry for Cultural Heritage" of the Holy See, this Decastery is called to work with, "agere cum", the individual dioceses around the world and their Bishops, in order that the cultural heritage of the Church may continue to serve as a major vehicle of their pastoral and evangelizing mission.

Today the challenges that accompany this essential pastoral action of the Church are indeed great as the phenomenon of globalization, with its fast moving pace and intense mobility of people on short-term and long-term bases, has rendered our societies boundless and of multi ethnical, cultural, religious fabrics with direct consequences on the sustainable survival and development of our cultural and natural heritage.

This is why the issue of tourism -and particularly mass tourism and cultural tourism – in the specific context of its effects on religious cultural heritage represents an area of concern for our Pontifical Commission. While one could argue, in fact, that the development of cultural heritage per se has in someway directly depended upon human mobility, the same factor can be considered particularly incisive for the development of the cultural heritage of the Church due to her fundamental evangelizing mission. In this respect, she assumes a double role as **promoter** (instigator) of human mobility through her fundamental *evangelizing* mission and at the same time principle **host** of human mobility as dictated by one of the essential works of charity recommended by Our Lord Jesus "I was a stranger and you welcomed me…".

Welcoming as a civilized, useful and necessary act is, in the Christian consciousness, a fundamental requisite associated to the pastoral mission of bringing the Good News "*ad gentes*". Since the subject of the welcoming action is the human person, a to urism rooted in this spirit must tinge itself with an essential *human* dimension. This human dimension must represent in fact its underlining intrinsic value and principal focal point as part of its "cultural component." In this sense, tourism operators can become builders of humanity, since, as John Paul II has said, "tourism can become a form of self-education and enrichment of the entire human person". According to this specific perspective, tourism is considered by the Church a "cultural good" since the inter-personal relationship, a communication based on and directed towards *dialogue,* are seen as the fundamental premises and the necessary components for the inculturation of the Word of God – the basic function of the cultural heritage of the Church.

Such a natural symbiosis between the cultural heritage of the Church and tourism is particularly evident in the *pilgrimage phenomenon* that has not only directly marked the development of specific ecclesial architectural forms in the West (as the pilgrimage church) but has also led the Church to become an excellent manager of tourism through practical initiatives that have become exemplary down the centuries, as recorded by the famous Callistine Codex (2) (a medieval "Touring Club Guide that contained detailed descriptions of religious sites along the itinerary, local traditions, encouraged a uniform system of road signals indicating inns, hostels and accommodations). The enormous success and popularity of this specific form of human mobility (the pilgrimage) to the present day testify to the need for a contextual approach towards religious cultural heritage in general that can take into account its fundamental and authentic spiritual significance and religious function.

But before I elaborate this particular point in regards to management strategies, it is useful to recall that developments sponsored by international Organizations in the last decade have greatly

contribute to make the dawn of this New Millennium a true kairos to deal with cultural tourism in more depth. Fundamental principles outlined by studies like the Luptowitz Report of 1977 (3) or Recommendation 1133 of 1990 (4) aimed at defining a concerted European policy to promote quality tourism, and more recently the attention raised by the Helsinki Ministerial Conference of 1996 towards cultural tourism as an area of priority action for the conservation and enhancement of our cultural patrimony has highlighted a principal focal point : the need for an ethical approach regarding the potential and development of cultural tourism according to qualitative standards.
Just this year as a follow-up to the Helsinki Conference, we have witnessed three major initiatives : a draft Recommendation issued by the Council of Europe on tourism to promote cultural heritage as a factor for sustainable development (5); an International Colloquium on "Tourism and monument conservation" held just a few weeks ago in Lucern ; and a specific Charter on "The Ethics of Cultural Tourism" issued just a month ago by the European University Center in Ravello.
In addition, major contributions to this field by international Organizations like ICOMOS, OMT, UNESCO, the Getty Conservation Institute, BITS and particularly OVPM have served to further delineate specific priority concerns. I will briefly list some of these in order to offer a comparison with the guidelines issued by the Church in recent years that I will refer to later :

- The need to devise an access policy based on the assessment of conservation conditions and in respect of the authenticity as well as the specific function of the sites.
- The development of tourist strategies, management plans for sustainability based on the cooperation and shared responsibility of all categories involved.
- An adequate preparation of visitors through quality information and proper training of operators.
- A deeper awareness raising of the local population towards their heritage as an encouragement to develop an attitude of welcoming hospitality.
- Increase collaboration on the part of the tourism industry for the protection, salvage, and responsible management of cultural heritage.
- Proper documentation and inventory of the cultural resources made available to the cultural tourism industry.
- The development of measures to improve the living standards of residents in respect of their cultural identity and traditions.
- To encourage the potential of tourism as a major protagonist for the recovery of urban historical centers.
- To turn mass tourism into a personalized quality activity.
- Promote a deeper knowledge of places and things visited by presenting their authentic identities and intrinsic qualities as well as cultural environments less known to the normal tourism itinerary.
- To include issues and problems of conservation and restoration in the training programs offered to guides.

These fertile developments sponsored by various international organizations find adequate resonance in the action conducted recently by the Catholic Church. Quite a number of Particular Churches in Europe have dedicated their attention in the last decade to study this subject through Seminars, Conferences, and specific Documents. This is understandable since, as I stated earlier, globalization is bringing about new problems of management of tourist flow which, in Italy alone, numbers circa 30 million a year around an estimated 85,000 religious sites managed by the Church. For example, the Episcopal Conference of Italy dedicated two Colloquia back in 1995 (at Cervia Marittima) (6) and 1996 (in Rome) (7) focused on this problem area since already then an explosive development was foreseen during this Jubilee year.
The following concerns were valued of particular importance during these meetings :

- The need to involve the local clergy and the local Church community.
- The usefulness of maintaining an effective strategy of access in respect of all the normal liturgical and religious functions of the buildings visited.
- The fundamental importance of providing the necessary formation and preparation for both visitors and especially guides who should be trained properly to deal with religious cultural heritage by presenting the Church site, its art historical value, in the context of its sacred character and liturgical-religious function and by underlining its essential significance as a product of a community of believers.

• The need to establish good working relations with tour operators – and especially those working regularly with foreigners of different religious backgrounds - in order to promote a contextual approach to the buildings which sometimes should represent a strict priority even if it means altering the tour operator's normal time allotment.
• And finally the necessity to involve young people and groups of volunteers, a special challenge in a consumer society principally motivated by profit-making opportunities.

Specific initiatives were presented by some of those Archdioceses that manage a particularly huge tourist flow, as in the case of Florence where 18,000 tourists are recorded a day for a total of circa two-three million a year (just around its major Church sites). Here a specific Diocesan Office has been established for the Catechesis through Art which holds a series of conferences on different thematic issues around a Church monument. In addition, a volunteer association of university students called "*Ars et Fides*" has also been instituted in order to offer a personalized visit to the tourist that, if desired, can also include a contemplative approach. Due to the limited resources available to Church authorities or foreseen by the legislative agreements with state and national authorities, quite a number of Dioceses have reported particularly efficient and useful the collaboration with specific "Consortia" which take care of the actual management of the sites. They help to assure orderly access of the public as well as environmental conservation, and the hospitality and preparation of the visitors. Members of the Consortia receive proper training by professionals of the State Ministerial offices and by members of the diocesan committees active in the area of cultural heritage and tourism. Other initiatives involve directly the school population (as in the Archdiocese of Naples), or specialized groups specifically instituted to manage particular sites (as the "Friends of the Museum" in the Diocese of Lucca).
Besides these and similar initiatives sponsored by the Episcopal Conferences in the various nations which, as I have been able to observe through my work travels, have multiplied in the past three years, the Pontifical Commission for the Cultural Heritage of the Church has conducted a survey in 1997 – that is, one year after the European Ministerial Conference held in Helsinki – in order to gather comments and suggestions also on this issue from the various Conferences of Bishops in each European nation. They were asked to evaluate cultural tourism and its effects on the conservation and enhancement of their local religious cultural heritage.
The results emerged from the survey have shown that in many instances the desired objectives of cultural tourism have been obtained through the *collaboration* of different Episcopal Commissions (Liturgy, Tourism and Cultural Heritage) leading to the publication of numerous documents which were distributed on a diocesan level. In many instances it was reported that cultural tourism has, in fact, been instrumental in encouraging a more intense effort to apply an efficient restoration and conservation policy. In quite a number of Churches a permanent exhibit has been installed showing the restoration and maintenance projects sponsored in recent years or in progress (as for example in S. Maria Maggiore in Rome) as an awareness-raising activity for visitors. On the other hand, it has also had the negative effect of increasing illicit trafficking of artworks and Church movables by inserting sites and devotional spaces that have not been inventoried and are closed to the public within tourist itineraries. The majority of the Episcopal Conferences have valued the role of volunteer groups as an essential and fundamental resource for the correct management of cultural tourism and the sustainable development of their cultural heritage. Similarly, they viewed satisfactory and at times even exemplary their relations with civil national and local authorities. Finally, a strong need to intensify the *pastoral* dimension and potential of the cultural heritage of the Church in relations to the tourism phenomenon was felt almost unanimously. This has been done in many cases by reviving and encouraging parishes to conduct devotional pilgrimages to the sites which include sessions of meditation and art-historical instruction.
This finally leads me to the management strategy or strategies adopted on occasion of the Great Jubilee Year. An event which has meant also a great revival of the Pilgrimage as a fundamental phenomenon of human mobility around religious sites, a characteristic form encouraged by most religious denominations at different time and space frames. The Great Jubilee of the Year 2000, celebrating 2000 years of Christianity at the dawn of a New Millennium, has opened with the meaningful example of His Holiness Pope John Paul II conducting a special pilgrimage to the sites of the Holy Land. In a specific Pastoral Letter issued in 1999, he has exhorted all the faithful to conduct their pilgrimage as a time of spiritual renewal but also as a time to participate in the building of a society of brotherhood, mutual understanding and peace.

It is the wish of the Holy Father that the Great Jubilee be celebrated by each Particular Church in every nation of the world first of all *locally* and then by perhaps foreseeing a special pilgrimage to one of the holy sites of Christianity. Naturally Rome and the Vatican where the foundations of Christianity was officially established and where the Holy Father resides, is on top of that list. Long term planning has involved the entire urban community. Special efforts of awareness raising by both local civil and Church authorities have been conducted in this sense to prepare residents for this great event. The Diocesan Synod of Rome invited all the local faithful to offer domestic hospitality to the pilgrims ; archeological and monumental structures were subject to special assessment and conservation measures ; new alternative itineraries were planned and enlarged didactic spaces developed as, for example, at three major Christian catacombs (S. Sebastiano – where the old itinerary of St. Philip Neri has been opened for this occasion ; and at the catacombs of Priscilla and Domitilla).

Unlike previous Jubilee events, this year's celebration is made up of a series of Jubilee days or weekends dedicated to *specific categories of faithful*. In addition, one great World event was also planned in connection to the Jubilee : the World Youth Day which saw a gathering of 2 million young people and an army of 27,000 volunteers at work. The Jubilee celebration has represented also a great tourist attraction promoted by tour operators who have de-contextual the event as an occasion to experience a special type of religious folklore, with the result of a more diversified ethnic and cultural public from all continents.

Such an extraordinary event, because of the sheer numbers of pilgrims expected but also due to the extended time frame, required very careful planning and an effective systematic management strategy. A Central Coordinating Office for the Jubilee was established and various Committees instituted to plan and manage the various Jubilee days of the different categories, including an Artistic-Cultural Committee headed by the President of the Pontifical Commission for the Cultural Heritage of the Church – Archbishop Francesco Marchisano.

Nevertheless, a stable pool of resources had to be devised to assure the daily organization and management of the events and the pilgrim flow, while keeping the costs involved limited to an affordable level. No national, state or municipal authority could have assured assistance alone for such a long period. Neither could the Church afford to employ such a great number of human resources needed.

The only alternative possible was to find and recruit an army of good-will individuals who could afford to volunteer their services in order to assist the organization of this event. It has turned out to be the greatest experience of volunteer activity up to our present age. The recruitment procedures were conducted through a number of screenings of possible candidates by the Episcopal Conferences and the dioceses in the nations of the world, as well as from major volunteer associations recognized and active in Church communities, and from religious movements. Candidates could indicate on their application form their experience and any particular function they wished to conduct during their service. After the selection had been finalized the candidates were given training on a local diocesan level through specialized courses taught by tutors who were previously trained in Rome in 1999.

The resources are replenished on a rotational regular basis (period of an average of 10 days shifts that involves a total of 70,000 to 75,000 volunteers from more than 60 different nations). Once the volunteers arrive in Rome, they are given *in situ* training of two hours each day that includes some theological-pastoral concerns, practical guidelines, some art historical background. Many are housed by Roman families and citizens who, following the request of the Diocese of Rome, have wanted to spontaneously contribute their solidarity to the Jubilee event. This was particularly the case for the World Youth Day that, despite the huge attendance, ran very smoothly because the enthusiasm of these young people was able to contaminate and motivate local citizens.

The functions vary from a simple activity of guarding the entrances and welcoming the visitors, helping the flow of masses, supervising special events (concerts, exhibits, etc.), looking after the protection of the environment, but also more simple and remedial jobs. The essential concern is that they learn to carry out these functions with the total dedication that characterizes volunteer work : first, and above all, to be able to express at all times a *welcoming* attitude which must be at the basis of the Jubilee event, *and to be able to recognize the individual needs of the different categories of pilgrims and visitors*. Certainly it is not easy to discern, cope with and supply the needs of a modern pilgrim – particularly those coming from nations who are experiencing a transitional period.

Nevertheless the contextual approach that introduces the modern-day pilgrim to the authentic spiritual characteristics of the event and the *profound religious significance* of the sites, has produced positive results and has represented *a contaminating factor*, as municipal and local civil authorities have followed this same approach around the urban sites. But the contribution of the Jubilee volunteers goes even beyond these confines and extends to provide a precious resource for those charitable and social activities conducted normally throughout the city. This exemplary level of *motivation and collaboration with local institutions and authorities*, we believe, will open up a new Millennium chapter of human history with renewed hope of how cultural tourism and religious cultural tourism can contribute in the revival of a new era of humanity and individual fulfillment based on inter-cultural dialogue through the material and immaterial cultural heritage that characterizes our European identity… because, as John Paul II has said, "a world without art risks becoming a world shut from love, and mute of its most beautiful voice."

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Biography

Cristina CARLO-STELLA is presently the Office Manager of the Pontifical Commission for the Cultural Heritage of the Church in charge of the Department supervising the English speaking Section as well as contacts with International Organizations. She has served for almost a decade on the Cultural Heritage Committee of the Council of Europe as official delegate of the Holy See and has been nominated member of the Holy See delegation at the Conferences of European Ministers responsible for Cultural Heritage held in Helsinki in 1996 and in Portoroz (Slovenia) in 2001. She holds a Master of Arts in Art History from the University of Massachusetts and a Laurea in Lettere from the University "La Sapienza" of Rome with specialization in archeology (etruscology).

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Tourism management of archaeological sites within an urban context : a balanced compromise between preventive conservation and cultural use

Gestion du tourisme dans les sites archéologiques dans un contexte urbain : un compromis équilibré entre conservation préventive et usage culturel

Roberto NARDI[1]

Abstract

The real emergency today and even more tomorrow, will not be in those sites in the urban environment, known, visited and sometimes also maintained, but in the tens of thousands of sites where decay and destruction are everyday events because they have been abandoned, or because they are poorly managed. Sites that yesterday enjoyed "a certain oblivion", but today are entering more and more into the big circuit of so called "cultural tourism". Everyday cultural property suffers irreversible damage due to the lack of even minimal protective measures. The consequence of this, if we want to turn the above statement into a constructive key, is that we should orient our future efforts towards three objectives :
- Stop active causes of decay due to inappropriate behaviour.
- Stabilise the state of conservation of cultural properties bringing it back over the limit of sustainability.
- Enhance the conditions of use for the "cultural client".

This article presents three initiatives carried out by the Centro di Conservazione Archeologica of Rome in the field of training, maintenance and raising awareness. The first initiative is related to a training programme for site directors, that CCA organised for UNESCO financed by the Italian Ministry of Foreign Affairs. The second initiative is related to the study and application of techniques of maintenance of archaeological structures in sites open to the public. The third and last initiative concerns the raising awareness to themes of fragility of the cultural heritage and its safeguarding. An exhibition entitled "S.O.S. Save Our Sites " made up of 26 panels, divided into three sections, in English and Arabic organised by CCA for the Amman Office of UNESCO is presented.

Résumé

La véritable urgence aujourd'hui, et plus encore demain, ne concerne pas les sites urbains connus, visités et entretenus mais plutôt les dizaines de milliers dont l'usure et la dégradation sont le lot quotidien parce qu'abandonnés et privés de soins suffisants, des sites qui, hier encore, baignaient dans un « certain oubli » mais reviennent peu à peu dans le circuit du soi-disant « tourisme culturel ». Chaque jour, des propriétés subissent des détériorations irréversibles par simple manque de mesures de protection, aussi basiques soient-elles. Il en résulte que, pour réagir de façon constructive à ce constat, il nous faudrait orienter nos efforts vers les trois objectifs suivants :

- Mettre fin aux dégradations dues à de mauvais comportements
- Stabiliser l'état de conservation des sites culturels et les ramener au-dessus du seuil de durabilité
- Améliorer les conditions d'utilisation pour les « touristes culturels »

Cet article présente trois initiatives prises par le Centre de Conservation Archéologique de Rome dans les domaines de la formation, de la maintenance et de l'information. La première consiste en un programme de formation destiné aux directeurs de sites, organisé par le CCA pour l'UNESCO et financé par le Ministère italien des Affaires étrangères. La seconde est consacrée à l'étude et à l'application de techniques de maintenance des structures archéologiques de sites ouverts au public. Enfin, la troisième a pour but d'attirer l'attention sur les thèmes de la fragilité du patrimoine culturel et de sa sauvegarde. Une exposition intitulée « S.O.S. Save Our Sites/Sauvez Nos Sites » constituée de 26 panels et divisée en trois sections a été présentée en langues anglaise et arabe par le CCA pour le Amman Office de l'UNESCO.

Some months ago, when we started to think of this topic, I accepted with enthusiasm the idea of presenting some experiences organised by the Centro di Conservazione Archeologica of Rome in the field of conservation of archaeological sites in the urban environment. I was thinking of the Roman Forum and the Crypta Balbi in Rome, of Ostia Antica, of Jerusalem and so on as examples. All of them being sites characterised by a great number of visitors and by the existence of public structures for management.

Then, during the preparation of the paper, I found myself asking if the real emergency in terms of use and protection of cultural heritage is represented by this category of sites, or if a better example could be found elsewhere.
That's how I convinced myself that the real emergency today and even more tomorrow, will not be in those sites in the urban environment, known, visited and sometimes also maintained, but in the tens of thousands of sites where decay and destruction are everyday events because they have been abandoned, or because they are poorly managed.
Sites that yesterday enjoyed a "a certain oblivion", but today are entering more and more into the big circuit of so called "cultural tourism".

Everyday cultural property suffers irreversible damage due to the lack of even minimal protection measures

The consequence of this, if we want to turn the above statement into a constructive key, and if we want to act in a logical and effective way, is that we should orient our future efforts towards three objectives :

- Stop active causes of decay due to inappropriate behaviour.
- Stabilise the state of conservation of cultural properties bringing it back over the limit of sustainability.
- Enhance the conditions of use for the "cultural client".
- therefore thought it would be useful to present three initiatives carried out by the Centro di Conservazione Archeologica of Rome in the field of training, maintenance and raising awareness.

The first initiative that I am going to present is relative to a training programme for site directors, that we organised for UNESCO financed by the Italian Foreign Ministry, Co-operation and Development Department.
"Training programme on Conservation and management of Archaeological sites for staff of Syrian and Jordan departments of Antiquities"
The programme was designed for ten civil servants of the Department of Antiquities of Syria and Jordan ; directors of some of the most important sites in the region (Petra, Jerash, Amman, Palmyra, Damascus, etc.). Among the various activities carried out, the group, in collaboration with various European specialists, analysed two archaeological sites with the idea of creating a plan for the protection, conservation and development of the sites.

The two sites, Palmyra in Syria and Umm Qais in Jordan, were selected from many, because they were believed to have common conditions with most Mediterranean sites.
Each site was studied and analysed in situ for three weeks. Six weeks of work followed in our Centre in Italy. During these last six weeks the difficulties individualised in situ were analysed and put in order to form a list of problems on which a strategy could be formulated when a management plan was outlined.

First a mission statement was defined :
To let the public to appreciate the site in its landscape and conserve both for future generations.
Second, the conditions for a proper implementation of the mission statement were established:

- In their complete historical, cultural and natural values.
- At minimum risk to structures and natural features.
- Into a network of sites in the region.
- With cultural, social and economical advantages for the local community.

Third a strategy for designing an action plan was outlined. The resulting strategy was made up of fourteen areas of action.
These are : interpretation, documentation, legislation, social relation-ship (local communities), excavation policy, human resources, conservation, information (museum, raising awareness), infrastructures, circulation-trails, added services, general maintenance
visitors relation-ships.
Research with an international outlook followed this analysis to individualise any solutions adopted elsewhere in similar cases that could represent a valid answer to our problems – an answer that could be used in the programme.

I will not show any of these solutions now because I don't believe that these are of interest here today. What is of interest here is the methodology.
This allowed us to separate the general and broad problem of site management into fourteen parallel plans of action corresponding to the same number of lines of research finalised in defining the level of actual knowledge and to verify the practical value of applicability on site.
In fact, even if in certain cases it was easy to find the answers to problems, the reality is that in the majority of the fields lacunas and lack of knowledge were encountered, thus to suggest specific research development.

The second initiative that I would like to present is related to the study and application of techniques of maintenance of archaeological structures in sites open to the public.
This programme, began by CCA fifteen years ago, is based on the principle of :
- Recovery of original techniques
- Use of local material
- Use of the local workforce

This programme runs on two parallel lines of practical execution :
- The conservation interventions
- Direct on site training

Such choices, applied to mosaics, mural paintings, stone structures in various countries in the Mediterranean area (Italy, Tunisia, Turkey, Israel, and we are ready with programmes for Greece, Albania, Syria, Jordan and Yemen) were planned based on extremely simple principles : compatibility and sustainability.
Compatibility : because techniques and materials used re-propose history and chemical-physical compositions of the originals.
Sustainability : because the availability of local people and materials make the operation economically convenient and socially beneficial.

Some of these programmes have been active and independent for years demonstrating in the field their value and their efficiency such as the Capitolini Museums and Ostia Antica in Italy and Masada, Zippori and Mamshit in Israel.
Others have been temporarily suspended owing to lack of funds or interest. The reason for this is a contradictory mechanism where economic interest and therefore investments in research decrease in areas where the resources needed are extremely modest.
And so, in this strange world of great investors and great projects, what should be the strong point : its great economic advantage, becomes its weakness.
For this reason my second point ends by urging you all to sustain the research in maintenance programmes.

The third and last point in this presentation concerns the raising awareness to themes of fragility of the cultural heritage and its safeguarding.
This is a theme that we timidly raised half way through the 80s when we opened our conservation sites to the public with the sensation that the public was in some way the final beneficiary of our work. Then slowly but surely we became convinced of the soundness of this choice or rather the necessity to continue in this direction of awareness using also more tools for communication such as the realisation of a travelling exhibition.

Briefly reassuming the process that pushed us to invest so much energy in the field of awareness I would start with certain questions. Who is the final beneficiary of our actions? The answer is the public, and public is the cultural heritage and all the resources that we invest in the profession. What is our professional aim? Our aim is to preserve the cultural heritage and at the same time facilitate the transmission of its historical message. Furthermore as conservators we are in a privileged position because we work in the "front line" in direct contact with monuments and visitors.

The public is the main user of the cultural, our aims are :
- To preserve *cultural heritage*.

- To facilitate the transmission of its *historical message*.
- Conservators are in a privileged position because their actions are implemented in direct contact with the public (the "front line"). We have to use this position of privilege to catch the attention of the public to communicate :
- The importance of the *historical message* that *cultural heritage* can transmit.
- The fragility of *cultural heritage*.
- The efforts required to preserve *cultural heritage*.

Our action must be directed to :

- People that are already interested in Cultural Heritage and therefore are *visitors*.
- And at the same time we have to involve all those that at the moment are not interested.
- Acting together with the *media*.
- Investing in initiatives for *children,* to educate them to be the *visitors* of the *future*.

This way our work will have :

Short term results (acting directly on Cultural Heritage)

- To preserve and to manage Cultural Heritage

Long term results (acting indirectly on the Public)

- To facilitate the transmission and the understanding of the Historical Message
- To limit potential aggression and to prevent damage
- To stimulate participation and to create opinion
- To educate future generations

In the category of long term results the last initiative I would like to present is an exhibition entitled "S.O.S. Save Our Sites "organised by CCA for the Amman Office of UNESCO. The exhibition, made up of twenty-six panels, divided into three sections, in English and Arabic, presents, with photos, drawings and text :

- The general meaning of cultural heritage with reference to Mediterranean sites.
- The main factors of deterioration.
- The sustainable solutions to protect and transmit our archaeological heritage to the future.

The exhibition was presented to the museum and university public of Syria and Jordan.

I would like to conclude this presentation taking up my initial theme : the apparent conflict between cultural use and the safeguarding of the cultural heritage, the juxtaposition between protection and use ; "cultural tourism " against " conservation of the Heritage". This is a phenomenon that found administrators and monuments unprepared. The former engaged in "defensive " management of the cultural heritage ; the latter often reduced to ruins on its last legs. In this situation, the great development of tourism and the demands for greater availability of monuments and sites "for use" has had a detonating effect. The consequences are : administrations in crisis and monuments in decay. This explains why "cultural tourism " is today often received as an ominous event.

The truth is another. The increasing interest from more and more people represents the result of the efforts of administrators and operators. It represents the acceptance of the meaning of cultural heritage, and it is itself the justification for so many administrations at work. If we accept the statement that something is changing in this field, we first have to overturn the attitude of administrators and operators toward the public. We all work for the public, not against the public. Our aim is to facilitate the passage of information from the cultural heritage to the public. Our objective is to guarantee the protection of the cultural heritage and the comfort of the public. The bad habit of passively enduring the public must leave a place for constructive attitudes based on an active management of the phenomenon. The public must be guided, not repressed ; the damage must be prevented, not cured.

The phenomenon of the cultural tourism must become the impulse for a new attitude for managing cultural heritage : an attitude focused on the transmission to the public of the historical contents of cultural heritage and its preventive conservation.

Figure 1-3 : *Training course in Syria and Jordan on Conservation and Management of Archaeological Sites.*

Figure 4 : *Training course in Tunisia on Conservation, Documentation and Maintenance of Archaeological Sites.*

Figure 5-6 : *Implementation of maintenance programmes on archaeological monuments in urban environment : the Arch of Septimus Severus in the Roman Forum..*

Figure 7 : *Yemen Maintenance of monuments by using traditional materials and techniques.*

Figure 8 : *Ostia Antica Maintenance of monuments by using traditional materials and techniques.*

Figure 9 : *Ostia Antica The public is the main user of the Cutural heritage.*

Figure 10 : *Rome Musei Capitolini A conservation work-site opened to the public to raise public awareness.*

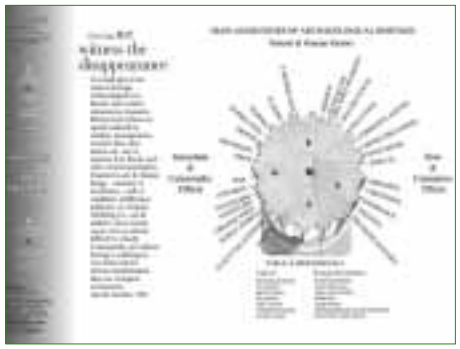

Figure 11-16:
S.O.S. Save our Sites An exhibition of Preventive Conservation on Archaeological Sites.

Biography

Roberto NARDI graduated in archaeology at the University of Rome and he took his certificate in conservation at the Istituto Centrale del Restauro in Rome.
In 1982 he founded the Centro di Conservazione Archeologica (CCA), a private company acting under public commitment in the field of conservation of archaeological sites and monuments and since that moment he leaded several conservation and training programs in Italy and abroad.
His projects have been characterised by a great attention given to the improvement of professional methodology such as documentation and application to conservation of historical techniques on the arch of Septimus Severus and the Temple of Vespasian in the Roman Forum; in situ conservation, preventive conservation and maintenance at the Crypta Balbi in Rome, Ostia Antica and Zeugma in Turkey.
Since the middle 80's a special effort has been given to raising awareness on the themes of fragility and safeguard of cultural heritage by opening CCA's conservation work-sites to the public, such as the Capitoline museum and Masada in Israel.
During the past fifteen years, training in conservation has been the activity that brought him visiting many different countries, with special reference to South America, Middle East and countries of the Mediterranean area.
At the moment he is working at a new centre that CCA opened in a convent north of Rome especially restored and equipped for training in general and preventive conservation.

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To guarantee European cultural heritage preservation through sharing between the public and private sector

S. PEREZ-VITORIA - The theme of this round table for which I am to lead the discussion, is "To guarantee European cultural heritage preservation through sharing between the public and private sector". High costs are involved in the preservation of cultural heritage. The question of shared responsibility between the private and public sectors should therefore be examined. Each European country has its own practices and experience with regards to heritage preservation, management and enhancement with different methods of distribution between the private and public sectors.
During this round table we intend to discuss the various experiences they have had. We shall attempt to define what the objectives should be in order to improve the preservation of European cultural heritage.
First of all I would like to introduce the round table participants : Mrs Cristina GUTIERREZ-CORTINES, European Deputy for Spain and university Professor of History of Art, Mrs Helen LLOYD, conservator representing the National Trust of Great Britain, Mrs Cristina CARLO-STELLA, Head of the pontifical Commission office for Church cultural heritage and Delegate of the Holy Seat on the European Council Cultural Heritage Committee, Mr Raphaël CRESPEL, lawyer and project leader for the French Ministry of culture and communication vice-directorate for legal affairs, Mr Pierre MAURIN, restorer representing the European Association of Craft, Small and Medium-sized Enterprises (UEAPME), and Mr Jacques GRATICOS, president of the group of elected bodies in the city of Strasbourg.

May I suggest that this debate be centred around the following three questions.
- In your opinion, is the relationship between the public and private sectors well balanced where cultural heritage preservation is concerned ?
- Is cultural heritage better protected by the public or private sector ?
- How may the relationships between public and private sectors, if any, be improved upon ?

I will hereby open the debate with the first question. Do you consider the relationship between the public and private sectors, where cultural heritage preservation is concerned, to be well balanced ?

H. LLOYD - From the United Kingdom point of view and also from the point of view of the private sector, I think that the relationship is well balanced. The two sectors work together pro-actively. Our properties are particularly concerned as they are in private ownership and national and local authorities resolve the issues affecting them. They must also deal with some of the wider issues that affect the cultural heritage throughout Europe such as access and traffic congestion. In the United Kingdom, English Heritage provides the legal framework as well as the grants that may be applied for in order to maintain our properties.
On our part, the National Trust is responsible for achieving high standards so that the conservation work meets the legal requirements. I think there is another relationship, that is to say, the management of archaeological sites where the private sector, the developer of a site, pays for the archaeological work. Funds are not transferred from the public sector to the private but from the private to the public. We are working together and this ensures that we are meeting common standards.

R. CRESPEL - In comparison to the situation in other European Community countries, France is quite unique whereby the protection of heritage is mainly undertaken by the public sector. That is to say, the State, its public establishments and territorial communities are all responsible.
Private sector participation obviously exists. These are mainly private owners but also companies and foundations such as the Fondation du Patrimoine (heritage foundation), as well as non-profit

organizations who are very active. The question, as far as we are concerned, ought to be how to ensure that the State plays its part in vouching for heritage preservation ? The regal responsibilities of the State, such as rules and regulations, control, policing and sanctions, may not be delegated to a third party. Where preservation is concerned, however, these duties could be shared out. In this sharing dynamic, sub-contracting should be strengthened.

C. CARLO-STELLA - It is my duty to speak on behalf of the office of the Holy Seat. The pontifical commission for the cultural heritage of the church was founded in 1988. Our vision is not only European, it is worldwide. We are in contact with the Episcopal conferences of Catholic bishops in each nation of the world and we have been able to see various situations.
France has a very specific situation between the public and the private sectors in terms of Church property. Other countries have a different situation. From the point of view of the Church, and the Holy Seat, we believe that the balance will be efficient if there is a good and effective partnership between the public sector and Church authorities.
In my opinion we share almost exactly the same commitments, goals, and finality towards cultural heritage. Where the Church is concerned, religious patrimony has both a very strong community and social function. This must therefore be at the basis of the nature of the authenticity of religious cultural patrimony.
It is my belief that developments have taken place. In the past ten years, both here in Europe but also elsewhere in the world, initiatives are really becoming increasingly effective as a result of partnership between Church authorities and public authorities. This is really the model that we intend to promote for the future. Part of the theme of this conference deals with cities of the futures and I think more partnerships and more collaboration is the key concept for this balance that will lead to some efficient results.

J. GRATICOS - I would first like to stress the difficulty we all have in meeting the requirements of our fellow citizens. They are very sensitive to heritage preservation and expect us to take all the measures that are within our power in order to preserve this heritage. Unfortunately, it is not always easy to proceed at their desired rate.
How are the public and private sectors to be brought together ? The private sector is prepared to invest provided that it is able to reap a certain amount of benefits and rewards itself.
Please allow me to give you some examples. The first is the Cour du Corbeau in Strasbourg. We endeavoured to seek the interest of a hotel group. They agreed to set up in the Cour du Corbeau, an architectural object of very high value, in order to build a prestigious hotel. This hotel group quickly realized, however, that they would not be able to set up there. Prices in Strasbourg are not sufficient for the planned restoration work to be performed. The hotel group's withdrawal triggered public disapproval.
Another example is that of the Ciné bal, located in Strasbourg in the place Kleber. We suggested that this building be let after restoration work, to private companies, but the draconian limitations of historic monuments where matters of preservation are concerned has led us to abandon this project.

S. PEREZ-VITORIA - Following this statement, may I suggest that we now look at the managerial differences between the public and private sectors ?

R. CRESPEL - Management of historic monuments in France is mainly founded upon the law dated 1913. Despite this law being subject to quite a number of limitations it is probably thanks to its application that French heritage is among the best maintained.

C. GUTIERREZ-CORTINES - May I first thank the European Commission for having invited me here. It is one of the first times that the European parliament and the European Commission have worked together in this field. Coming back to our subject, I believe, first of all, that we should define that which falls under the responsibility of the public sector and that which comes under the jurisdiction of the private sector.
The State owns many historic monuments. They have the necessary skills available to them in order to preserve and take responsibility for their enhancement. Management of this heritage is very important. I believe that the State may play a large part. There are many private foundations in Europe, but few pay any attention to the preservation of cultural heritage.

P. MAURIN - I personally do not really think that there is a boundary between the public and private sectors. In France, in any case, we have more of a boundary between listed and classed monuments that are themselves preserved according to good practice and the rest of the heritage which is not listed. Preservation of the latter type of heritage is often inconsistent, as it is only connected to one local elected body or group of citizens. Furthermore, companies who participate in restoration of this type of heritage do not always possess the necessary skills.

C. CARLO-STELLA - I would just like to stress the point of view of the church in terms of its cultural patrimony. It has never been considered a burden. In its history, from the early Christian times, the cultural patrimony of the church has always been considered instrumental in bringing the gospel message to the community of faithful. In other words, the cultural patrimony, from the point of view of the church has this specific notion. Therefore from the first century onwards there have been very specific initiatives taken to protect and preserve its patrimony.
Funding, however, constitutes an entirely different problem. Of course, every Episcopal conference has its particular financial means at its disposal and this is where we feel that the support of public authorities is essential. However, we cannot say that we do not have the know-how or the restoration ability or capacity to preserve the patrimony. Yes, there is partnership and collaboration between state restoration laboratories and the church authorities to implement conservation policy. On the other hand, there are quite a number of initiatives that are sponsored by Church authorities. Their aim is to promote this know-how within the Church environment.
In terms of fundraising some help is needed because, in most countries, religious patrimony is at least 60% or 70% of patrimony nationwide.

S. PEREZ-VITORIA - Thank you very much, I would now like to ask Mrs LLOYD, in the field of research, how is collaboration achieved between the public and private sectors ?

H. LLOYD - We can only really achieve research through partnerships with other organizations. These could be universities or English Heritage. Partnerships with the people who have the technical and scientific expertise and the equipment to carry out research are needed as well as partnerships with the people who have money to invest in the research that we require. The National Trust can commission research that will benefit a large number of properties. One of the difficulties perhaps for the rest of the private sector in England and Wales, Northern Ireland and to some extent, Scotland as well, is that there are a number of very much smaller organisations responsible for the cultural heritage. They do not have access to the resources or expertise amongst their own staff required in order to obtain this information. The National Trust should do more to try to bring people together and make information available to a wider number of end users.

S. PEREZ-VITORIA - I think that everyone at this table agrees on the necessity for partnerships. How are the relationships between private and public sectors to be improved upon ? Is it necessary to implement new legislative or organisational tools ?

R. CRESPEL - France has quite an organic view of the public culture service. Partnerships are unavoidably made on the basis of shared willingness and there must be some attractions that will to encourage the private sector to participate in the field of heritage preservation.

C. GUTIERREZ-CORTINES - The question of franchising must also be addressed with regards to Europe, but also with regards to the State. Private owners, churches, for example, perfectly preserve their heritage. In the same manner, owners of historic residencies are required to enhance their property by opening them up to tourists. Whole villages, however, must not be transformed into museums, forcing out the inhabitants, as unfortunately happens in some places. Similarly, the question of reusing historic monuments for other means must be addressed. There is a risk here that short-term profits lead cultural heritage astray.

J. GRATICOS - I think progress will mostly be generated from a good understanding of the interest. Our citizens' interest in seeing public contributions decreased thanks to private sector participation. The interest from companies themselves where their image is concerned. I mean the repercussions,

for instance, of the contemporary music festival, Musica pour Gaz in Strasbourg in particular.
I have also observed how we are very often confronted with citizens who question us about the use of the council budget and who find that too much money is dedicated to heritage conservation. Perhaps a more subtle, more intelligent method must be found, one that is wiser in terms of presentation of these budgets, in order to help our citizens to understand that preservation of heritage represents an investment for future generations. Our fellow citizens must not be given the impression that companies are seizing public heritage.

S. PEREZ-VITORIA - Mrs LLOYD, your experience has been completely different experience in that the English population actively contributes to your foundation and shows a real interest in the enhancement of their heritage.

H. LLOYD - In our experience, the more we can involve the local community and the visitors in what we are trying to achieve, the more they understand our motives and are prepared to contribute to the effort. This may be in terms of financial resources, by means of both gifts and donations and occasionally by legacy, but also by the time they give to our organisation. The National Trust as an organisation has 38 000 volunteers from local communities across the country and they contribute with their time to achieve our conservation aims. Professional people who are interested in cultural heritage, but perhaps have retired or are only working part-time, are prepared to help the Trust's professionals with their work and to supplement our small workforce. We also have volunteers who simply give up their time to stand in the rooms of our houses that are open to the public. They ensure that visitors understand that they should not touch or steal the collections. They can also help to interpret the collections for the visitors and to help them to enjoy their visit to a particular property. Many opportunities for involving local communities in sharing our common goals of preserving the cultural heritage exist besides just financial donations.

C. CARLO-STELLA - I would like to make a final point concerning the last statement. Volunteer groups are very important for the preservation of a church site. We have gained a lot of experience from the Jubilee celebration in Rome and elsewhere where volunteer groups have been absolutely essential. The idea of getting motivated groups involved is extremely important as a preventive measure and is a very large resource, besides.
Promoting quality formation and training is also important. Please allow me to point out a couple of the pontifical commission's initiatives. We are very much aware that the problem of preservation dispersal and promoting of church sites depends on the knowledge of the community of faithful but also on the awareness of the clergy and the religious communities.
For example, a circular letter was addressed to all the catholic bishops around the world. The object of the letter was the importance of proper professional training and information in the seminaries. A similar letter was written to the major religious congregations around the world. Members of religious communities who have a vocation towards creativity and the cultural patrimony should have the chance to develop these talents. Furthermore we are focusing closely on training and awareness of inventory and cataloguing of both church immovables and movables. Just a few months ago, the pontifical commission issued a circular document to all the bishops around the world about the need for proper professional inventory and cataloguing procedures. I have to remind you that in the Canon law code, there are specific canons that make all the bishops responsible, in a legal sense, for the inventory and cataloguing of the church goods in each diocese.

P. MAURIN - Prior to training, there must be diffusion of the information. Communication of the information is more general and could involve the general public. Nowadays we see that our fellow citizens are increasingly interested in heritage thanks to public heritage days. They are more interested, however, in heritage in terms of image rather than in material or technological know-how terms.
Training is obviously essential. It must be performed at our level as well. We are therefore organizing awareness campaigns involving training actions.

S. PEREZ-VITORIA - Since we are gathered here within the scope of a European conference, I think that a large number of participants have suggestions to make as a follow-up to this discussion.

H. LLOYD - I would like to emphasise that it is important is to enhance the partnership between the public and the private sector. We should try to develop common or complementary goals. There should be plenty of opportunity to discuss our mutual interests and ways in which to address the difficulties that we face in maintaining our cultural heritage whilst always respecting the individual circumstances of the different organisations that are involved and the different sizes and resources of those organisations. In every individual instance, I believe that an effort is being made to develop the art of what may be achieved.
Smaller organisations benefit enormously from specialist help they obtain from the larger or national organizations and which they cannot afford themselves. While at the same time, the larger and particularly the public organisations need to be aware of the needs and the difficulties of the small organisations and participate in trying to find solutions for their problems.
The legislation that seeks to remove the discrimination against disabled people, measures that are taken to try and ensure that our buildings are safe for public access, and which endeavour to ensure that wildlife species occupying our historic buildings are protected are perhaps not particularly designed to be directly applied to cultural heritage. The design of some of these laws can occasionally be very heavyweight for small organisations to respond to. They can be difficult to implement in the context of the cultural heritage where the history, the aesthetics and the presentation of the property must be preserved. There is also room, in my opinion, for continuing discussion between all the people who make these laws to ensure that it is possible in a practical and very simple way to implement them at the properties. This should not be in conflict with our aims to conserve the cultural heritage.
It would be marvellous if, with the help of the European Union, we could have resources to facilitate these discussions between the public and private sector to define the needs of the cultural heritage. Management tools need to be developed for better communication between all the parties who are involved in decision-making that affects cultural heritage. These forums must be multidisciplinary so that the outcome achieves some balance and harmony between all the parties and all their objectives, which may potentially be conflicting if this discussion has not taken place at an early enough stage.
There is also much more work to be done in disseminating the results of our scientific research and our understanding of the decay mechanisms that affect the cultural heritage. We must raise everyone's awareness of these matters and include the outcome of that research in the training of the professionals who are involved in the care of the cultural heritage as well as the craftspeople and the conservators who actually carry out the work. This should include education and awareness raising for the local communities as well. They support the buildings within their local geographical area. I therefore believe that anything that could be done to facilitate this communication in all ways would be very beneficial.
Finally, is a potential financial resource available to us through the tourism industry ? The tourism industry is able to make profits out of using the cultural heritage as an attraction for the people that it is either providing transport or accommodation for. At the moment there is very little contribution from the tourism industry to the maintenance of those sites that their clients are paying to see.
Perhaps some greater, stronger links with the tourism industry may be developed. It may be possible to make them aware of the difficulties that we face in maintaining our cultural heritage and the part that they need to play in contributing to safeguarding the cultural heritage. They would, otherwise, have no heritage attractions to take their clients to in the future.

S. PEREZ-VITORIA - We must now draw this interesting discussion to a close. I would like to thank you and hope that we shall have the opportunity to continue the considerations of these themes during future conferences. I would like to thank you all, particularly the participants of this round table, for having joined in.

Vers un partage entre le secteur public et le secteur privé pour garantir la préservation du patrimoine culturel européen

S. PEREZ-VITORIA - Je suis chargée d'animer cette table ronde intitulée : Vers un partage entre le secteur public et le secteur privé pour garantir la préservation du patrimoine culturel européen. Le coût inhérent à la préservation du patrimoine culturel est très important, c'est pourquoi s'interroger sur une prise en charge partagée entre le secteur public et le secteur privé paraît légitime. Chaque pays européen a des pratiques et des expériences particulières en matière de préservation, de gestion et de valorisation du patrimoine ainsi que des équilibres différents entre le secteur public et privé. Au cours de cette table ronde, nous débattrons de ces différentes expériences et tenterons de voir vers quoi nous pourrions tendre pour améliorer la préservation du patrimoine culturel européen.

Je vais d'abord présenter les participants à la table ronde : Mme Cristina GUTIERREZ-CORTINES, députée européenne espagnole et professeur d'université en histoire de l'art ; Mme Helen LLOYD, conservatrice, représentant le National Trust de Grande Bretagne (ONG chargée de la conservation des sites remarquables) ; Mme Cristina CARLO-STELLA, chef du bureau à la Commission pontificale de biens culturels de l'Église et déléguée du Saint Siège au Comité du patrimoine culturel du Conseil de l'Europe ; Mr Raphaël CRESPEL, juriste et chargé de mission à la sous-direction des affaires juridiques du Ministère français de la culture et de la communication ; Mr Pierre MAURIN, artisan - restaurateur représentant l'UEAPME (Union européenne des artisans et des petites et moyennes entreprises) ; et Mr Jacques GRATICOS, président du groupe des élus de la ville de Strasbourg.

Je propose de structurer le débat autour des trois questions suivantes :
- Les rapports entre secteur public et privé en matière de préservation du patrimoine culturel vous paraissent-ils bien équilibrés ?
- Le patrimoine culturel est-il mieux protégé par le secteur public ou par le secteur privé ?
- Comment améliorer, s'il y a lieu, les rapports entre le secteur public et le secteur privé ?

J'ouvre donc le débat par la première question. Pensez-vous qu'en matière de protection du patrimoine culturel, les rapports entre secteur public et secteur privé soient bien équilibrés ?

H. LLOYD - Concernant le Royaume-Uni, je pense que les rapports entre le secteur privé et le secteur public sont bien équilibrés ; les deux parties prenant au préalable des mesures pour travailler en commun avec les collectivités nationales et locales, pour résoudre les questions concernant le patrimoine – en particulier le nôtre, qui est privé – mais aussi pour traiter de problèmes plus larges, comme celui de l'engorgement du trafic qui affecte le patrimoine culturel en Europe. En ce qui nous concerne, nous sommes dotés du English heritage (Patrimoine anglais) qui définit aussi bien le cadre légal que les bourses auxquelles nous avons droit pour la restauration de nos biens. Le National Trust est chargé, quant à lui, de réaliser des travaux de rénovation de haut niveau, respectant la législation en vigueur. Pour la gestion des sites archéologiques, on a affaire à un autre type de rapport : c'est le secteur privé, le promoteur immobilier du site, qui finance les travaux archéologiques. Les fonds ne transitent pas du secteur public vers le secteur privé, mais du privé vers le public. Nous travaillons ensemble, ce qui garantit le respect des normes communes.

R. CRESPEL - La situation de la France par rapport aux autres pays de la Communauté européenne est assez particulière dans la mesure où la protection du patrimoine est majoritairement prise en charge par le secteur public, c'est à dire l'État, ses établissements publics et les collectivités territoriales. Bien entendu, les intervenants privés existent. Ce sont, au premier chef, les propriétaires privés mais aussi les sociétés commerciales, les fondations, comme la Fondation du patrimoine, ainsi que les associations, qui sont très actives. Pour nous, la question qui se pose est la suivante : comment

s'assurer que l'État joue son rôle de garant de la préservation du patrimoine ? Tout ce qui relève des fonctions régaliennes, c'est à dire la réglementation, le contrôle, la police, la sanction, ne peut être délégué. En revanche, il peut y avoir un partage pour ce qui est du domaine de la prescription et de la préservation. Dans cette dynamique de partage, la contractualisation doit être renforcée.

C. CARLO-STELLA - J'interviens ici au nom du bureau du Saint-Siège, que je représente, et de la Commission pontificale pour le patrimoine culturel de l'Église, fondée en 1988. Notre perspective n'est pas seulement européenne, mais mondiale. Nous sommes en contact avec les corps épiscopaux du monde entier et nous avons pu observer diverses situations. En France, les rapports entre le secteur public et le secteur privé concernant les biens de l'Église est très particulier, la situation des autres pays est différente. L'Église et le Saint-Siège pensent qu'un équilibre efficace ne pourra être assuré que s'il existe un véritable partenariat entre le secteur public et les autorités religieuses. Je pense que nous devrions tous être soumis à peu près aux mêmes règles, poursuivre les mêmes buts, la même finalité pour le patrimoine culturel. L'Église a une très solide communauté et un patrimoine religieux doté d'une fonction sociale ; c'est ce qui fonde l'authenticité du patrimoine culturel religieux.
Je pense qu'il y a eu des progrès en ce domaine. Ces dix dernières années, nous avons pu observer, en Europe et dans le reste du monde, que les initiatives de partenariat entre les autorités de l'Église et les pouvoirs publics sont vraiment de plus en plus efficaces. C'est ce modèle que nous voulons promouvoir pour le futur. Je parle des villes du futur qui font partie intégrante du thème de cette conférence ; je pense que le renforcement du partenariat et de la collaboration est le concept clé pour obtenir un équilibre et des résultats efficaces.

J. GRATICOS - Je souhaite d'abord insister sur la difficulté que nous avons à répondre aux attentes de nos concitoyens. Ils sont très sensibles à la préservation du patrimoine ; ils attendent que nous mettions en œuvre tout ce qui est en notre pouvoir pour le préserver. Malheureusement nous n'avons pas toujours la possibilité d'aller aussi vite qu'ils le souhaiteraient. Comment faire pour associer le secteur public et le secteur privé ? Le secteur privé est prêt à s'investir à condition d'en retirer les fruits et les bienfaits. J'en donnerai quelques exemples. Le premier concerne la Cour du Corbeau à Strasbourg. Nous avions sollicité un groupe hôtelier qui avait accepté de s'installer dans la Cour du Corbeau (un élément architectural de très grande valeur) pour y créer un hôtel prestigieux. Cependant, très rapidement, ce groupe hôtelier s'est aperçu qu'il ne s'y retrouverait pas ; les prix pratiqués à Strasbourg n'autorisaient pas en effet de faire les travaux de restauration prévus. Le désengagement du groupe hôtelier a provoqué le mécontentement de notre population. Un autre exemple, celui du Ciné bal, situé place Kleber à Strasbourg. Nous nous proposions, après restauration, de louer cet espace aux entreprises privées, mais les prescriptions draconiennes des Monuments historiques en matière de préservation nous ont fait renoncer à ce projet.

S. PEREZ-VITORIA - Suite à cette intervention je propose qu'on s'interroge maintenant sur les différences de gestion entre le secteur public et le secteur privé.

R. CRESPEL - La gestion des monuments historiques en France est régie essentiellement par la loi de 1913. Il s'agit d'un texte de loi assez contraignant, mais c'est probablement grâce à l'application de ce texte que le patrimoine français est l'un des mieux entretenu.

C. GUTIERREZ-CORTINES - Je remercie tout d'abord la Commission européenne de m'avoir invitée. C'est une des premières fois que le Parlement européen et la Commission européenne collaborent dans ce domaine. Pour revenir à notre sujet, je crois que l'on doit d'abord définir ce qui est du ressort du public et ce qui est du ressort du privé. Un grand nombre de monuments historiques appartient à l'État ; il dispose des compétences nécessaires pour leur préservation et il a la responsabilité de leur mise en valeur. La gestion de ce patrimoine est très importante. Je crois que l'État a un rôle majeur à jouer car si l'Europe compte beaucoup de fondations privées, peu s'intéressent à la préservation du patrimoine culturel.

P. MAURIN - Je ne pense pas que la frontière se situe entre le secteur public et le secteur privé. En ce qui concerne la France, la frontière se situe plutôt entre les monuments classés et inscrits, pré-

servés selon les règles de l'art, et l'autre patrimoine, non répertorié. La préservation de ce type de patrimoine est assez aléatoire ; elle est souvent liée au seul intérêt d'un élu local ou d'un groupe de citoyens. Par ailleurs, les entreprises qui interviennent pour la restauration de ce type de patrimoine ne sont pas toujours compétentes.

C. CARLO-STELLA - Je voudrais insister sur l'attitude de l'Église envers son patrimoine culturel. Elle ne l'a jamais considéré comme un fardeau. Depuis les premiers chrétiens et tout au long de son histoire, l'Église a toujours considéré le patrimoine culturel comme un moyen de transmission du message divin à la communauté des croyants. Autrement dit, le patrimoine culturel a pour l'Église un sens bien particulier. Dès le premier siècle, l'Église a pris des mesures spécifiques pour protéger et préserver son patrimoine. Maintenant, du point de vue financier, c'est un autre problème. Chaque corps épiscopal dispose, bien entendu, de fonds propres, mais nous pensons que le soutien du secteur public y est essentiel. Nous ne pouvons pas dire que nous ne possédons ni le savoir-faire en matière de restauration ni la capacité de préserver le patrimoine. Il existe en effet un partenariat et une collaboration entre les laboratoires publics de restauration et les autorités de l'Église pour mettre en place une politique de conservation. Et inversement, il existe un certain nombre d'initiatives financées par les autorités de l'Église afin qu'elle puisse, elle aussi, posséder ce savoir-faire. Concernant les collectes de fonds, nous avons besoin d'aide. Pourquoi ? Dans la plupart des pays, le patrimoine religieux représente 60 à 70% du patrimoine national.

S. PEREZ-VITORIA - Merci beaucoup. J'aimerais demander à Mme Helen LLOYD, comment se passe la collaboration en matière de recherche entre le secteur public et le secteur privé ?

H. LLOYD - On ne peut réellement mener de recherches qu'en partenariat avec d'autres structures, que se soit les universités ou le English Heritage. Nous avons besoin de partenariats avec ceux qui possèdent les compétences scientifiques et techniques, mais aussi avec ceux qui peuvent investir dans les recherches que nous voulons mettre en œuvre. Le National Trust peut commanditer des recherches qui bénéficieront à un grand nombre de sites. En revanche, la plupart des petites structures responsables du patrimoine culturel n'ont ni les ressources ni le personnel compétent pour bénéficier de ces informations ; c'est sans doute l'une des difficultés d'une partie du secteur privé en Angleterre, au Pays de Galles, en Irlande du Nord – et dans une certaine mesure, en Écosse. Le National Trust doit renforcer ses efforts pour tenter de rassembler les différents acteurs et pour diffuser les informations à un maximum d'utilisateurs finaux.

S. PEREZ-VITORIA - Je crois qu'il y a un consensus autour de cette table sur la nécessité de partenariat. Comment peut-on améliorer les rapports entre secteur public et privé ? Est-il nécessaire de mettre en place de nouveaux outils législatifs ou organisationnels ?

R. CRESPEL - La France a une conception assez organique du service public culturel. Le partenariat se fait inévitablement sur la base d'une volonté partagée ; il faut qu'il y ait un caractère attractif pour inciter le secteur privé à intervenir dans le domaine de la préservation du patrimoine.

C. GUTIERREZ-CORTINES - Il faut également se poser la question de la subsidiarité par rapport à l'Europe mais aussi par rapport à l'État. Des propriétaires privés, les églises par exemple, ont parfaitement bien préservé leur patrimoine. De même, des propriétaires de demeures historiques sont parvenus à valoriser leurs biens en les ouvrant au tourisme. Il faut cependant se garder de transformer des villages entiers en musée et d'en chasser leurs habitants comme cela se fait malheureusement dans certains endroits. À l'inverse, se pose aussi la question de la réutilisation des monuments historiques à d'autres fins. Il y a ici le danger de dévoyer le patrimoine culturel à des fins de rentabilité à court terme.

J. GRATECOS - Je pense que c'est surtout un intérêt bien compris qui permettra de faire avancer les choses. Intérêt pour nos concitoyens de voir diminuer les contributions publiques grâce à l'intervention du secteur privé ; et intérêt pour les entreprises elles-mêmes en matière d'image. Je pense en particulier aux retombés du festival de musique contemporaine de Strasbourg, Musica pour gaz. Je constate également que très souvent, nous sommes confrontés à des concitoyens qui nous inter-

rogent sur l'utilisation du budget municipal, trouvant que trop d'argent est consacré à la conservation du patrimoine. Il faudrait peut-être trouver un moyen plus fin, plus intelligent, plus judicieux de présentation de ces budgets pour faire comprendre à nos concitoyens que la préservation du patrimoine représente un investissement pour les générations futures. Il ne faudrait pas non plus laisser l'impression aux concitoyens que les entreprises s'emparent du patrimoine public.

S. PEREZ-VITORIA - Mme Helen LLOYD, l'expérience que vous avez est tout à fait différente, puisqu'au contraire, les Anglais participent activement à votre fondation et manifestent un intérêt réel pour la valorisation de leur patrimoine.

H. LLOYD - Notre expérience montre que lorsque la communauté locale et le public sont impliqués dans ce que nous essayons d'entreprendre, ils comprennent mieux nos motivations et sont davantage prêts à contribuer aux efforts. Cela se traduit en terme de soutien financier, par des cadeaux, des dons et parfois même des donations, mais aussi en terme de temps consacré à notre organisation. Le National Trust est une organisation qui rassemble près de 38000 bénévoles des communautés locales à travers le pays. Grâce au temps qu'ils consacrent, ils contribuent à atteindre nos objectifs de préservation. Certains professionnels intéressés par le patrimoine culturel, parfois à la retraite ou ne travaillant qu'à mi-temps, sont prêts à aider les professionnels du National Trust ; leurs contributions complètent notre petite force de travail. Nous avons aussi des bénévoles qui, plus modestement, consacrent leur temps à des permanences dans les lieux ouverts au public, afin de garantir que le public ne volent ni ne touchent aux collections. Ceux-ci peuvent également aider le public à mieux comprendre les œuvres, à apprécier la singularité du site. Les occasions d'impliquer les communautés locales à partager nos buts communs de préservation du patrimoine culturel sont nombreuses et elles peuvent se manifester autrement que par une contribution financière.

C. CARLO-STELLA - Juste un commentaire sur ce qui vient d'être dit. L'action des bénévoles est très importante pour la préservation des sites religieux. Lors de la célébration du Jubilée, à Rome et ailleurs, l'action des bénévoles a été essentielle. Le fait d'impliquer des groupes motivés est extrêmement important comme mesure préventive, c'est aussi une très grande ressource. En revanche, il est également important de promouvoir des formations et des stages de qualité. Je voudrais juste présenter deux des initiatives proposées par la Commission pontificale. Nous sommes très conscients du fait que le problème de la préservation et de la promotion des sites religieux dépend à la fois de la connaissance de la communauté et des croyants mais aussi de la connaissance et la sensibilisation du clergé des communautés religieuses. Nous avons, par exemple, rédigé une circulaire destinée aux évêques catholiques du monde entier dans laquelle nous soulignons l'importance d'une véritable information et d'une véritable formation dans les séminaires. Nous avons également envoyé aux principales assemblées religieuses du monde entier un autre courrier qui dit exactement la même chose. Il est destiné aux membres de la communauté religieuse qui s'intéresse à la création et au patrimoine culturel et qui devraient pouvoir développer leurs compétences. Nous insistons également beaucoup sur l'apprentissage, la sensibilisation à l'inventaire et au catalogage des biens mobiliers et immobiliers de l'Église. Il y a quelques mois à peine, la commission pontificale a rédigé une nouvelle fois à l'attention des évêques du monde entier une circulaire sur les besoins d'inventaire, de véritables procédures professionnelles d'inventaire et de catalogage. Je vous rappelle que dans le code de loi (droit) canon, des canons spécifiques attribuent aux évêques la responsabilité légale de l'inventaire et du catalogage de leurs biens, des biens de l'Église dans chaque diocèse.

P. MAURIN - Avant la formation, il y a l'information. L'information est plus générale et elle pourrait se faire auprès du grand public. Grâce aux journées du patrimoine, nous constatons que nos concitoyens s'intéressent de plus en plus au patrimoine. Mais ils s'y intéressent davantage en terme d'image qu'en terme de matériaux et de savoir-faire technologiques. Bien entendu, le travail de formation est indispensable et il doit également se faire à notre propre niveau ; nous organisons aussi des campagnes de sensibilisation et des actions de formation.

S. PEREZ-VITORIA - Puisque nous sommes ici dans le cadre d'une conférence européenne, je pense qu'un certain nombre de participants ont des propositions à faire pour poursuivre ce débat.

H. LLOYD - J'aimerais souligner le fait qu'il est important d'améliorer le partenariat entre le secteur public et le secteur privé. Nous devrions essayer de développer des objectifs communs ou complémentaires. Il devrait y avoir de nombreuses possibilités de débattre ensemble de nos intérêts mutuels et des moyens de surmonter les difficultés auxquelles nous sommes confrontés dans la préservation de notre patrimoine culturel ; et ce, en respectant les particularités individuelles des différentes organisations impliquées et en tenant compte de la taille et des ressources de chacun de ces organismes. En tout cas, je crois que nous essayons de développer l'art d'atteindre le possible ; nous essayons de faire en sorte que les petites structures puissent bénéficier de l'aide des spécialistes de structures plus importantes, voire d'organismes nationaux. Les grosses structures, et en particulier celles du secteur public doivent tenir compte des besoins et des difficultés des petites structures. Elles doivent contribuer à résoudre leurs problèmes, notamment concernant la législation qui ne s'applique pas exclusivement au patrimoine culturel ; il existe des lois qui tentent d'endiguer la discrimination envers les handicapés, d'autres mesures qui sont prises pour garantir la sécurité du public dans nos locaux ou protéger les espèces sauvages qui peuplent nos monuments historiques. Pour de petites structures, certaines de ces lois peuvent parfois être très pesantes et compliquées à respecter ; elles sont également difficilement applicables dans le domaine du patrimoine culturel où l'on tente de préserver l'histoire, l'esthétique et l'aspect des biens. Je pense pourtant qu'il existe encore un espace de dialogue entre les décideurs pour garantir une plus grande souplesse dans l'application de ces lois ; elles ne doivent pas être un obstacle à notre objectif de conservation du patrimoine culturel.
L'idéal serait, je pense, de pouvoir obtenir, d'une manière ou d'une autre, des fonds de l'Union européenne pour faciliter le dialogue entre le secteur privé et le secteur public, pour définir les besoins du patrimoine culturel. Nous avons besoin de développer des outils de management pour améliorer la communication entre les parties impliquées dans les prises de décision concernant le patrimoine culturel ; il faut aussi que ces espaces de discussion soient pluridisciplinaires afin d'obtenir, de façon certaine, des résultats permettant l'équilibre et l'harmonie entre toutes les parties et leurs objectifs, qui, nous le savons, entreront en conflit s'il n'y a pas eu de dialogue au préalable.
Il y a encore beaucoup à faire en matière de diffusion des résultats de nos recherches scientifiques et de nos connaissances des mécanismes d'altération qui affectent notre patrimoine culturel ; beaucoup à faire également pour sensibiliser chacun à ces problèmes, et pour intégrer les résultats de ces recherches dans la formation des professionnels chargés de veiller au patrimoine culturel et dans la formation des artisans et des conservateurs en charge des travaux. Ceci devrait intégrer la formation et la sensibilisation des communautés locales qui, dans leur zone géographique, soutiennent les monuments historiques. Tout ce qui peut être fait pour faciliter la communication sous toutes ces formes sera bénéfique.
J'ai encore une chose à ajouter : je me demande si l'industrie du tourisme est réellement une source potentielle de revenus pour nous. Si l'industrie du tourisme tire profit du patrimoine culturel en utilisant ses attraits (en offrant, par exemple, des services de transport ou d'hébergement), il n'existe, selon moi, qu'une très faible contribution du tourisme à la préservation des sites que la clientèle paye pour visiter. Nous pourrions sans doute tisser davantage de liens solides avec l'industrie du tourisme, lui faire prendre conscience des difficultés que nous rencontrons dans la préservation de notre patrimoine culturel et le rôle qu'elle a à jouer pour garantir la sécurité des sites culturels, sans quoi, elle ne pourra plus en bénéficier à l'avenir pour attirer sa clientèle.

S. PEREZ-VITORIA - Je vous remercie beaucoup. Nous sommes malheureusement obligés de clore cet intéressant débat. J'espère que nous aurons l'occasion de continuer à réfléchir sur ces thèmes lors des prochaines conférences. Je remercie les participants de cette table ronde pour leurs interventions. Merci beaucoup à tous.

Conference closing speech
Discours de clôture de la conférence

Michel DUFFOUR, Secrétaire d'Etat au patrimoine et à la décentralisation

Mesdames, Messieurs, je suis particulièrement heureux d'être parmi vous pour la clôture de cette 4ème conférence de la Commission Européenne consacrée à la recherche pour la protection, la conservation et la valorisation du patrimoine culturel européen.

Permettez-moi de m'approprier pleinement la démarche qui vous anime. Pendant deux jours, elle a donné lieu à des présentations de projets innovants et à des débats fructueux entre chercheurs, industriels et décideurs. Je suis certain que de nouveaux projets communs verront le jour, ici même, grâce à la bourse d'échange qui aura lieu demain.

Professionnels impliqués dans la protection, la conservation et la valorisation du patrimoine, vous avez su confronter vos approches respectives au cours de six sessions thématiques.

Vous avez révélé les risques environnementaux auxquels notre patrimoine culturel est exposé et présenté les nouvelles méthodes et les nouveaux procédés de conservation. Vous avez également débattu de l'insertion du patrimoine culturel dans l'environnement urbain et de sa valorisation tout en explorant les nouveaux modes de gestion des monuments et des sites touristiques qui conditionnent en grande partie la conservation à long terme de notre patrimoine.

Le ton, et les pistes proposées par les organisateurs de cette conférence montrent bien que nous assistons à de profondes mutations dans ce domaine. La conservation du patrimoine trouve sa justification et sa finalité dans les actions qui permettent son accessibilité et sa mise en valeur.

C'est pourquoi la transmission des connaissances a une importance majeure. L'action des scientifiques et des ingénieurs doit être relayée par celle des conservateurs et des restaurateurs du patrimoine. Les considérations culturelles, sociales et économiques deviennent de plus en plus importantes et doivent être harmonisées.

Cela implique de prendre toute la mesure des évolutions en cours. Ainsi, nous sommes passés progressivement de la protection de monuments exceptionnels à celle d'éléments quotidiens de notre environnement, de la protection de bâtiments isolés à celle d'ensembles urbains et de paysages façonnés par l'homme, de la protection du patrimoine traditionnel à celui du 20ème siècle.

La requalification et la reconversion des bâtiments et des friches industrielles se multiplient. L'intégration dans le paysage urbain de vestiges archéologiques que nous pouvons qualifier d'« archives du sol » a été repensée.

De même, le tourisme culturel est devenu un phénomène de société avec un impact économique considérable. Ces mutations révèlent à quel point le patrimoine culturel contribue à refaçonner l'identité de chaque pays. Élément essentiel des politiques de coopération et de construction européenne, il favorise la prise de conscience d'une mémoire collective spécifique à l'Europe. Sa protection, sa conservation et sa mise en valeur n'impliquent plus seulement les administrations qui traditionnellement en sont chargées, mais l'ensemble des intervenants économiques et sociaux relayant l'action des pouvoirs publics.

La notion de patrimoine européen ne doit d'ailleurs souffrir d'aucune ambiguïté. Il ne peut s'agir en effet de s'accorder sur un plus petit commun dénominateur, ou encore moins, d'imposer un fonds patrimonial unique et homogène. Ce serait commettre un total contresens et gâcher une opportunité : l'Europe est riche de la diversité des patrimoines nationaux qu'elle recèle. Dans ce domaine comme dans tous les autres, c'est en cultivant ses différences qu'elle renforcera son unité.

Face à cet enjeu, une politique de recherche au niveau européen est primordiale. On attend qu'elle apporte des réponses aux interrogations des citoyens et des décideurs. Ainsi, trois grands enjeux peuvent être identifiés. Il s'agit des articulations « patrimoine et territoire », « patrimoine et lien social », « patrimoine et développement économique ».

Permettez-moi de proposer quelques pistes de réflexion à partir du premier thème : « patrimoine et territoire ».

Dans une société de plus en plus soumise à l'économie mondialisée, où l'individu risque de perdre ses repères, l'attachement au patrimoine correspond au besoin d'enracinement. Ceci va de pair avec le souci de proximité et de développement local. Ce besoin se traduit par l'évolution des habitudes et des modes de vie. Un environnement harmonieux, intégrant des références au passé, contribue grandement à améliorer la qualité de vie à laquelle chacun aspire.

L'intégration du patrimoine dans la ville en devenir, et au-delà, dans un paysage urbain sans cesse renouvelé, est un formidable défi pour le 19ème siècle. C'est en considérant notre héritage que nous portons notre regard sur l'avenir. Le Ministère de la culture et de la communication a engagé, en France, un certain nombre d'actions en étroite coopération avec les collectivités territoriales, qu'il s'agisse de la sauvegarde du patrimoine architectural ou des secteurs protégés, du réseau « villes et pays d'art et d'histoire », ou bien encore, des « conventions de ville pour l'architecture et le patrimoine ». L'implication de nombreuses associations de citoyens a été encouragée pour favoriser l'appropriation des projets d'aménagement et de réhabilitation par les habitants eux-mêmes.

À ce titre, le forum sur l'architecture et le patrimoine qui s'est tenu en juillet dernier à Paris, dans le cadre de la Présidence française, a permis de souligner le droit du citoyen à un environnement de qualité et la nécessité d'impliquer les habitants dans les politiques de développement durable de l'environnement urbain et bâti, et donc du patrimoine.

Les recherches doivent s'articuler avec les politiques environnementales et les directives européennes sur la qualité de l'air, la diminution des nuisances sonores, la réhabilitation des bâtiments anciens et des friches industrielles. Elles doivent également prendre en compte l'intégration du patrimoine culturel, y compris celle des vestiges archéologiques, dans un environnement urbain et para-urbain en constant renouvellement.

Quant au second thème « patrimoine et lien social », je voudrais insister sur le renforcement de la cohésion sociale à travers le partage de la prise en charge du patrimoine culturel par les autorités publiques, les organisations privées et les citoyens. La protection et la mise en valeur du patrimoine favorisent l'insertion sociale et aident à prendre conscience de la nécessité de développer le sens de la citoyenneté.

De même, la concertation entre le secteur public et le secteur privé doit être repensée et développée en impliquant les citoyens. En France, la mise en œuvre de la loi « Solidarité et Renouvellement Urbain » donnera lieu à un plan d'actions commun entre le Ministère de la culture et de la communication et le Ministère de l'équipement. Cette réforme devrait voir le jour à la fin de l'année. Des contrats de villes et d'agglomérations seront signés. D'autres projets se concrétiseront grâce aux fonds structurels européens.

Au cœur du chantier, les nouvelles technologies de l'information et de la communication ont un rôle de premier plan. À présent, l'interconnexion entre Internet et les systèmes d'information géographique en ligne, reliés à des bases de données et permettant des approches multiples, constitue un chantier majeur. Les notions d'accessibilité à l'information, du niveau réservé aux professionnels à celui ouvert au grand public, doivent être débattues. Ces nouvelles méthodes vont faciliter l'acquisition de connaissances pour tous. Elles permettront une utilisation autonome et la mise en place de stratégies de conservation au niveau approprié.
Quant à l'articulation « patrimoine et développement économique », il m'inspire les réflexions suivantes :

d'après les statistiques, la réhabilitation du patrimoine bâti représente environ 50 % du marché de l'industrie du bâtiment en Europe. Les retombées économiques directes pour ce secteur et indirectes pour celui du tourisme et du temps libre contribuent à la création de nouveaux emplois et à l'émergence de nouveaux métiers. C'est pourquoi, en France, le Ministère de la culture et de la communication et le Secrétariat d'Etat au tourisme viennent de signer une convention en faveur d'une politique commune de tourisme culturel. La valorisation du patrimoine participe à la fois de l'offre culturelle et de l'efficacité économique.

Le succès de la campagne « l'Europe, un patrimoine commun », initiée par le Conseil de l'Europe témoigne, pour sa part, de l'intérêt que la population européenne porte à son patrimoine. Les recherches sur ce thème doivent donc privilégier l'émergence de nouveaux produits, procédés et services dans le domaine du patrimoine. Elles doivent mettre l'accent sur son accessibilité réelle ou virtuelle. Le développement de nouveaux outils informatiques permettra ainsi d'explorer virtuellement monuments, sites et musées. Ils rendront accessibles aux chercheurs les réserves des musées, les fonds des bibliothèques et des archives. La recherche doit produire de nouvelles connaissances et stimuler l'innovation. Comment construire en Europe cet espace de la connaissance et de l'innovation ?

La récente communication du commissaire européen pour la recherche Philippe BUSQUIN, « Vers un espace européen de la recherche », nous a rappelé la nécessité d'une meilleure articulation des politiques, des objectifs et des moyens, afin de garantir l'efficacité de l'investissement public.

Toutes les réflexions communautaires actuelles sur l'espace européen de la recherche et de l'innovation portent un regard nouveau sur les politiques menées et les défis à relever. Les programmes-cadres de recherche et de développement se sont révélés être de précieux instruments pour stimuler la recherche au niveau européen, mais ils rencontrent aujourd'hui leurs limites.

Pour compléter les dispositifs existants, il est souvent suggéré de mettre en place des « coordinations ouvertes et non contraignantes ». Sur la base d'expériences réussies au plan national ou local, l'objectif est d'identifier les priorités communes aux Etats membres, de comparer les solutions mises en œuvre et de rendre compte de la variété des approches.

Un espace européen de la recherche s'esquisse donc. Il prend appui sur l'évolution des comportements dans les Etats membres. Ce nouveau défi place la dimension européenne au cœur des politiques nationales. Le domaine de la recherche sur la protection du patrimoine culturel ne constitue pas une exception. Cependant, il ne faut pas ignorer que les acteurs intervenants dans ce domaine ne sont pas toujours armés pour faire face aux logiques d'importants consortiums de recherche industrielle. Qui plus est, le patrimoine culturel ne se laisse pas réduire à de simples logiques de marché. C'est ce qui motive tout l'intérêt de ce colloque.

L'acuité, voire la vivacité des débats, amènent nécessairement à s'interroger sur la manière de poursuivre les discussions, de permettre les échanges. Ne pourrait-on pas réfléchir à une organisation souple mais durable ? Un réseau d'expertises et de discussions, un lieu de convergence des recherches, des expériences et des problématiques, bref, une façon d'agence qui serait un lieu de partage.

Non pas un outil à produire de la norme, mais un cercle, articulé sur les initiatives et les expériences nationales. La mission serait de savoir, de faire savoir et de contribuer aussi bien à éclairer l'Union européenne qu'à établir le socle d'un meilleur échange au plan européen, au bénéfice des Etats, des régions, des collectivités territoriales.

En tout cas, un tel colloque illustre à l'envi que la préservation scientifique et raisonnée du patrimoine s'inscrit à part entière dans cette double dimension si singulière de la culture : valeur unique, diverse pourtant dans ses débats, ses enjeux et ses expressions.

Bravo pour votre colloque et merci pour votre attention.

Conference closing speech
Discours de clôture de la conférence

Michel DUFFOUR, French State Secretary for Heritage and Decentralisation

Ladies and gentlemen, it is my great pleasure to be among you for the closing of the 4th European Commission conference dedicated to the research for protection, conservation and enhancement of European cultural heritage.

Please allow me to join the debate on this subject that unites us all here. For two days, it has given rise to innovative projects and presentations and also to fruitful discussions between researchers, representatives from industry and decision-makers. I am convinced that new, common projects will emerge, right here, thanks to the brokerage event that is organised for tomorrow.

As professional bodies participating in the protection, conservation and enhancement of heritage, you have presented your respective approaches during the six thematic sessions.

You have revealed the environmental risks to which cultural heritage is exposed and have presented new conservation methods and processes. You have also discussed the integration of cultural heritage within the urban environment and its enhancement whilst exploring the new managerial procedures for tourist sites and monuments, which the long-term conservation of our heritage largely depends on.

The tone of this conference and the ideas put forward by the organisers show that we are witnessing deep-seated changes in this field. Heritage conservation is being substantiated and finding its purpose through the actions that enable it to be accessed and enhanced.

That is why the transfer of knowledge is of utmost importance. Heritage conservators and restorers should continue actions of scientists and engineers. The cultural, social and economic considerations are becoming increasingly important and should be harmonised.

This implies taking all necessary steps for the current developments. We have thus gradually gone from the protection of exceptional monuments to that of every-day items in our environment, from the protection of isolated buildings to that of whole urban groups and landscapes that are fine-worked by man, from the traditional protection of heritage to that of the 20th century.

The requalification and the reconverting of buildings and derelict industrial property is growing. The integration into the urban landscape of archaeological relics that we could call "the ground's archives" has been reconsidered.

In the same manner, cultural tourism has become a phenomenon of the society that possesses quite a considerable economic impact. These changes reveal to what extent cultural heritage contributes to reworking each country's identity. It is an essential part of these European co-operation policies and constructions, and aids awareness making of a collective souvenir that is unique to Europe. Its protection, conservation and enhancement does not only involve the administrations who are traditionally responsible for it, but all the intervening financial and social parties who continue the actions of the public powers.

Neither should the idea of European heritage be ambiguous. It is not a matter of agreeing on one smaller common denominator, or even applying one unique and homogenous method of heritage funding. This would be going against the matter in hand and losing an opportunity. Europe holds a wealth of different national heritages. Within this field, as in all others, it is when cultivating differences that these are united.

With such matters at stake, a European level research policy is essential. It is expected to respond to the questions put forward by citizens and decision-makers. The main stakes may therefore be identified. These are the "heritage and territory", "heritage and social relationships" and "heritage and economic development" structures.

Would you now please allow me to suggest some points upon which we may be able to reflect from the first theme : "heritage and territory".

In a society that is increasingly subjected to a global economy, where individuals run the risk of losing their bearings, the attachment to heritage corresponds to a need for origins. This need runs alongside local concerns and developments and is illustrated by habits and ways of life. A harmonious environment that integrates references to the past is a major contribution to the quality of life that we all aspire to.

The integration of heritage in the city, and beyond into the urban landscape that is continually evolving, is quite a challenge for the 21st century. When contemplating our heritage we are looking into the future. In France, the Ministry of culture and communication has undertaken several actions in strict collaboration with the territorial communities, whether it be a matter of safeguarding architectural heritage or protected sectors, the network of "cities and countries of art and history", or even "city conventions for architecture and heritage". The involvement of many citizen organisations has been encouraged in order to aid the delegation of planning and rehabilitation projects by the inhabitants themselves.

It is in this context that the forum on architecture and heritage which took place last July in Paris within the scope of the French Presidency highlighted the citizen's right to a quality environment and the need to include this in sustainable development policies for the urban and built environment and therefore, heritage.

Research should be based upon environmental policies and European directives concerning air quality, reduction of noise pollution, rehabilitation of old buildings and derelict industrial property. It should also take into account the integration of cultural heritage, including that of archaeological ruins, into an ever-evolving urban and para-urban environment.

With regards to the second theme, "heritage and social relationships", I would like to stress the strengthening of social cohesion through sharing of cultural heritage responsibilities between public authorities, private organisations and citizens. The protection and enhancement of heritage aids social reintegration and increase the awareness of a sense of citizenship.

In the same manner, citizens should be involved in the consideration and development of the agreement between the public and private sectors. The introduction in France of the law for "urban renewal and solidarity" will lead to a common action plan between the Ministry of culture and communication and the Ministry of equipment. This reform should begin at the end of the year. Agreements with towns and built-up areas will be executed. Other projects will be formalised thanks to structural European funding.

At the heart of this construction site, new information and communication technology are at the forefront. At the moment, the interlining of Internet and online geographic information systems, connected to a database and enabling multiple approaches, is a major construction site. The notion of access to information, from the level reserved for professional bodies to that open to the general public, should be discussed. These new methods will help everyone to gain knowledge. They will enable an autonomous use and the implementation of conservation strategies at a relevant level.

With regards to the "heritage and economic development" structure, the following thoughts spring to mind : according to statistics, the rehabilitation of built heritage represents around 50% of the European construction market. The direct economic repercussions for this sector and indirect for the tourism and leisure sector, contribute to new job creation and to the appearance of new trades. It is for this purpose that the French Ministry of culture and communication and the Secretary of State for tourism have just signed a convention in favour of a common policy with regards to cultural tourism. The enhancement of heritage is included in both the cultural attraction and economic efficiency.

The success of the "Europe, a common heritage" campaign, initiated by the European Council, illustrates, from its point of view, the interest that the European population shows for its heritage. The creation of

new products, processes and services in the field of heritage should benefit from research on this theme. It should underline true or virtual accessibility. The development of new computer tools has therefore enabled monuments, sites and museums to be visited virtually. They give researchers access to archives and reserves from museums and libraries. Research should produce new knowledge and instigate innovation. How is the European Knowledge and Innovation Area to be built ?

The recent paper issued by Philippe BUSQUIN, European Commissioner for research, entitled "For a European Research Area", reminded us of the need for a better structure of policies, aims and means in order to guarantee the efficiency of public investment.

These current community considerations about the European Research and Innovation Area take a new look at policies that are in use and the challenges to be met. The research and development framework programmes have shown themselves to be precious instruments in stimulating research at a European level, but they are now reaching their limits.

In order to add to existing devices, it has often been suggested that "open and uninhibiting synergy" be implemented. On the basis of local or national successful experiments, the aim is to identify priorities that are common to the member States, to compare the solutions implemented and to take stock of the diverse approaches.

A European Research Area is therefore being drawn up. It depends on the behavioural development of the member States. The heart of national politics is thus given a European dimension as a result of this new challenge. The field of cultural heritage research is no exception to this rule. It is important to remember that the actors participating in this field are not, however, always equipped to face the logic of large industrial research consortiums. Furthermore, cultural heritage may not be simply treated with market logic. That is what this conference is all about.

The discussions are keen and lively and the question as to the manner in which dialogue ought to be pursued in order to enable exchanges must ultimately be arrived at. Perhaps we could reflect upon a flexible yet sustainable organisation, a network of expertise and dialogue, a place where research, experiments and problems converge, in short, an "agency method" that would be a place for sharing ?

Instead of a tool for producing standards, a circle should be structured around national initiatives and experiments. The task would be to make known and contribute as much to highlighting the European union, as to establishing the foundations of better exchanges on a European scale, to the advantage of the states, regions and territorial communities.

Such a conference makes it obvious that scientific and reasonable preservation of heritage is entirely contained within this exclusive dimension of culture : though unique in value, it is varied in its discussions, its stakes and its expressions.

Well done for your conference and thank you for your attention.

Christian PATERMANN, Directeur du programme « Environnement et développement durable » à la Direction générale « Recherche » de la Commission européenne

Un grand merci à vous Monsieur le Ministre et Madame la Député, notre conférence sur la recherche pour la protection, la conservation et la mise en valeur du patrimoine culturel touche à sa fin, mais les opportunités pour les entreprises européennes restent entières. Demain nous aurons notre bourse d'échange. J'espère que beaucoup d'entre vous y participeront afin de préparer des projets pour le prochain appel à propositions.

Messieurs, Mesdames, Monsieur le Ministre, Madame la Député, nous avons assisté à une conférence particulièrement intéressante. Un programme d'accompagnement vous est proposé à partir de ce soir avec un concert d'orgue dans la cathédrale. Nous n'avons jamais eu une participation aussi importante et variée. D'après nos premières statistiques, 15% des participants sont des utilisateurs finaux venant de musées, de galeries et de municipalités, 30% viennent du secteur de l'industrie, c'est un record, 50% sont des chercheurs, membres de laboratoires de recherche et d'universités, les 5 % restant viennent d'organisations gouvernementales. Nous nous félicitons également du fort pourcentage de conférenciers venant des pays candidats à l'adhésion à l'Union européenne.

Je pense que nous sommes déjà en train de pratiquer le processus d'élargissement qui a commencé en Europe. Vous tous savez que les pays candidats sont déjà associés au cinquième programme-cadre. C'est pourquoi je souhaite vivement que la 5ème conférence de la Commission européenne consacrée à la recherche sur la protection du patrimoine culturel se déroule dans un des pays de l'Europe centrale et de l'est, au premier semestre de l'année 2002.

Messieurs, Mesdames, je vous remercie pour votre participation, vos interventions et votre enthousiasme. Je remercie beaucoup mon équipe ainsi que le Ministère français de la culture et de la communication, la ville de Strasbourg et le Conseil général. Merci à tous ceux qui ont contribué à faire un succès de cette conférence. Je remercie aussi vivement les traducteurs pour leur travail de très grande qualité. Merci à vous tous.

Conference closing speech
Discours de clôture de la conférence

Christian PATERMANN, Director of the « Environment and sustainable development » programme at the European Commission, Directorate-General for « Research »

I would like to thank the Minister and directors. Our conference on research for protection, conservation and enhancement of cultural heritage is now drawing to a close, but the opportunities for European enterprises remain considerable. Tomorrow will be the brokerage event. I hope that many of you will join in so as to prepare projects for the next call for proposals.

Ladies and gentlemen, we have participated in a particularly interesting conference. An accompanying programme of events is on offer with an organ concert this evening in the cathedral. We have never received such wide and diverse participation. According to our first statistics, 15% of the participants are final users who come from museums, galleries and town councils, 30%, a record number, come from the industrial sector, 50% are researchers, research laboratory and university members and the remaining 5% come from government organisations. We would also like to congratulate the high percentage of conference participants who come from candidate countries for the European Union.

I believe that we are already undertaking the broadening process that is taking place in Europe. You all know that the candidate countries are already associated with the 5th framework programme, that is why I truly hope that the 5th European Commission conference dedicated to research for protection of cultural heritage will take place in one of the Central or Eastern European countries in the first six months of the year 2002.

Ladies and gentlemen, thank you for your participation, your presentations and your enthusiasm. I would also like to thank my team as well as the French Ministry of culture and communication, the city of Strasbourg and the district Council. Thank you to all those whose involvement has made a success of this conference. My warm thanks also to the translators for their work, which is of a very high standard. Thank you all.

Poster session
Session de posters

Rapporteur : Peter BRIMBLECOMBE

There were four posters on these very complex ensembles which are urban landscapes, cities and archaeological sites. There were a lot of posters on stone, but this represents a transition when compared with the situation a decade ago, where a lot more would have been seen in this area. Studies on organic materials related to an indoor context were presented. Wood was by far the most dominant over all other areas. There were quite a few posters on metals and the interesting thing is the dominance of lead as a metal. There were also posters on wall paintings, on paintings on wood, on Egyptian paintings, but also on techniques dealing with stresses on canvas.

It is interesting to notice that there were only a few posters presenting damaging environmental factors. One poster displayed light, another showed particles, and another dealt with SO_2. Three posters dealt with various modes of insect damage or bacteriological damage. In my opinion, there is a transition taking place here. I suspect, again, that a number of years ago much more work on the environmental factors in the posters would have been seen.

A somewhat larger group of posters dealt with various methods of studying cultural heritage. There were four posters dealing with sociological analysis, ideas about management, risk assessment approaches. Once again this is an area where there has been an increase of interest in recent years although it was pointed out that only four posters seems a small number.

There were just a few posters looking at traditional techniques of use of wood, lime washing and other such subjects. The dominant interest seems to lie in the field of laser techniques using lasers for a range of conservation methodologies. Very impressive sets of models from fluid dynamic models to engineering models in assessing cultural heritage were also available.

When contemplating this dominance of studying particular heritage, it was obvious that this might well result from a need to understand the mechanisms and the way in which these particular materials, objects and items of heritage are damaged.

It is interesting to wonder now about future study of external environmental factors, particularly those we legislate against, such as air pollutants. I suspect we are going to see an increase in these types of studies.

What was noticeably absent from the posters was an integration of end-users within their content. Now it could be, of course, that most of the posters were designed to encourage scientists to join up with other collaborators. The was perhaps expected that the poster audience would consist of conservation scientists. Alternatively it could be that the ideas of linking with end users, very much embodied in the fifth Framework of the European Commission, are in projects that have yet to mature.

Rapporteur : Peter BRIMBLECOMBE

Quatre posters étaient consacrés aux paysages urbains, aux villes et aux sites archéologiques. D'autres posters traitaient du secteur de la pierre, mais ils étaient moins nombreux que ce qu'ils auraient pu être les années précédentes. Parmi les études sur les matières organiques, c'est le bois qui était le plus représenté. Il y a eu quelques posters traitant du métal où l'on a pu remarquer la prédominance des études concernant le plomb. Il y avait enfin quelques posters traitant des peintures murales et des peintures de chevalet, de l'art égyptien mais également des contraintes mécaniques exercées sur les peintures sur toile.

Il est intéressant de noter que peu de posters étaient consacrés aux agents de dégradation liés à l'environnement. Quelques posters traitaient des effets de la lumière, des particules et du dioxyde de soufre. Trois posters exposaient les dégâts causés par les insectes et les bactéries. Cela traduit-il une transition ? Il y a encore seulement quelques années, les agents de dégradation liés à l'environnement auraient tenu une place beaucoup plus importante. Des recherches dans le domaine de l'environnement pour lequel des réglementations sont émises, sont censées se développer encore à l'avenir.

Un certain nombre de posters étaient consacrés aux différentes méthodes pour l'étude du patrimoine culturel. Quatre posters étaient consacrés à une analyse sociologique, à la gestion et à l'évaluation des risques, des domaines qui ont connu un gain d'intérêt ces dernières années.

Peu de posters traitaient des techniques traditionnelles d'utilisation du bois, de la chaux, etc. En revanche, le secteur des techniques laser appliquées à la conservation, semblait prédominer dans les présentations.

Plusieurs exemples de modélisation ont été donnés, allant des fluides dynamiques aux outils d'évaluation empruntés au domaine de l'ingénierie. Il apparaissait de façon particulièrement évidente le besoin de comprendre les mécanismes de détérioration des matériaux.

On peut constater que les posters ne tenaient pas assez compte des besoins des utilisateurs finaux. L'objectif des exposants étaient probablement d'attirer l'attention de leurs pairs scientifiques davantage que celle des utilisateurs de leur recherche. Le désir exprimé par le Commission européenne d'impliquer davantage les utilisateurs finaux de la recherche doit encore se concrétiser.

Development and implementation of energy efficient passive pollution control for museums, galleries and archives

Nigel BLADES, Tadj ORESZCZYN, May CASSAR

A recently completed UK research project ('Energy Efficient Pollution Control in Museums and Galleries') demonstrated the possibilities for passive control of externally generated pollutants in heritage buildings. By measuring the concentrations of nitrogen dioxide, sulphur dioxide, hydrogen sulphide and ozone inside and outside a range of museum buildings, it was shown that the naturally-occurring process of surface deposition, either to existing surfaces, or to purposely-introduced absorbing materials could reduce reactive pollutant concentrations. Reductions of more than 90%, were possible if the ventilation rate of the room or gallery was below 0.5 air changes per hour. Based on the work of this project a document to help museums in dealing with pollution issues, 'Guidelines on Pollution Control in Museum Buildings' has been published. Current research titled 'Innovative Modelling of Museum Pollution and Conservation Thresholds' IMPACT (funded under the EC 5th Framework RTD Programme) seeks to build on these results by developing a web-based tool, to model the behaviour of pollutants inside buildings, predict indoor/outdoor ratios, and the effects of different pollution control strategies.

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Evaluation of urban archaeological deposit for a better protection of the inheritance

Brigitte BOISSAVIT-CAMUS

Urban archaeological deposit should be regarded both as a scientific object and a rich inheritance. Through evaluation of both archaeological deposit and ancient buildings, one can improve archaeological knowledge as well as promote a better managment of archaeological work. This also requieres a precise evaluation of the various kinds of threat and the mapping of archaeological potential according to areas within the town. The " Centre national d'archéologie urbaine " (Ministère de la culture et de la communication, Tours, France) has initiated this process through individual studies : so far, 19 volumes have been published.

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Analysis of glazes with micro-beams of charged particles : examples from the study of some della robbia terracotta sculptures

A. BOUQUILLON, J-R. GABORIT, M. BORMAND, G.LANTERNA J.SALOMON, A. ZUCCHIATTI

The Italian Renaissance terracotta sculptures of the della Robbia's bottega are characterised by the use of bright, opacified coloured glazes. Structures and textures of a glaze, as well as the occurrence of minor and trace elements depend on the preparation and on the source of raw materials and should help characterise and differentiate renaissance artefacts from modern imitations. Analysis obtained by μ-PIXE on microsamples or directly on the artefacts and by Scanning electron microscopy on microsamples are compared and results on some problematic sculptures from the Louvre museum are presented.

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Estimating the total economic value (tev) of cultural heritage conservation

Julie Elaine BROWN

The aim of this three year project is to provide a thorough understanding of the total economic value (TEV) placed by society on cultural heritage conservation. Following a review of existing methodologies, the TEV approach will be demonstrated using a combination of survey based economic valuation techniques, namely Contingent Valuation and Choice Ranking. The main determinants of the quality of a visit to three UK National Trust (NT) properties will be investigated in an attempt to uncover the TEV of individual cultural attributes. In addition, specific issues such as access vs conservation and conservation over time, will be addressed. The project will also attempt to demonstrate 'benefits transfer' of cultural values across populations. The survey instrument has been developed after a rigorous pre-testing and piloting phase. Face-to-face surveys of 400 visitors and members will be conducted at each of the three National Trust properties during Summer/Autumn 2001. This research has important policy implications for the sustainable management of cultural resources both in the UK and abroad.

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Micro-pixe analysis of an ancient egyptian papyrus : identification of pigments used for the "book of the dead"

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This paper reports a study of colours and inks of an ancient Egyptian papyrus using an external proton microprobe in PIXE mode. Representing the Book of the Dead, this papyrus is dated from the 19th dynasty, New Kingdom (c.1295-1186 B.C.). Elemental maps were obtained by moving the papyrus under a fixed focused external beam using a motorised support. The maps were compared to photographic pictures taken in visible light. Inks used in the hieroglyph text appeared to be based on carbon (black) and iron oxide (red). Coloured drawings illustrating the text showed a wider palette : hematite, ochre, orpiment, Egyptian blue, verdigris. Most intriguing was the observation in several parts of the drawing of a whitish pigment containing strontium. Deposits of strontium-rich minerals (e.g. strontianite, celestite) have been identified in Egypt. The exact nature and the archaeological implications of this pigment have still to be determined. Finally, fine powder and coarse grains of arsenic oxide were observed, probably remaining from an early preservation treatment against insect attacks after excavation.

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Contractors… join your European colleagues

C. CHARBONNEAU

The European Association of Firms specialising in Restoration of the Architectural Heritage (A.E.E.R.P.A.), created in 1992, federates approximately one hundred firms from 15 different countries, all specialising in the various areas of restoration.

Its main objectives are :

- To seek, investigate, define and promote at European level all means of contributing to the development and progress of skills involved in the restoration of the architectural heritage, historic buildings, monuments and sites.
- To organise meetings between the various countries to analyse the employment, funding, markets, methods of contracting and training in each country.
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P-wave velocities for organizing the surface protection of stones

Basile CHRISTARAS

The P-wave velocities can be used for the estimation of the depth (D) of weathered or artificially consolidated layers as well as the depth of cracks at the surface of stones. This technique can be applied in the protection of both geological and cultural heritage. The depth of weathering at a stone surface can be evaluated using the indirect ultrasonic velocity technique. In this case the transmitter is placed on a suitable point of the surface and the receiver is placed on the same surface at successive positions along a specific line. The transit time is plotted in relation to the distance between the centres of the transducers. A change of slope in the plot could indicate that the pulse velocity near the surface is much lower than it is deeper down in the rock. This layer of inferior quality could arise as a result of weathering. The above mentioned technique could not only be performed for investigating the damage depth at the surface of stones but also for evaluating the effectiveness of this method for estimating the consolidation depth at the stones, after treatment. The above mentioned technique could not only be performed for investigating the damage depth at the surface of stones but also for evaluating the effectiveness of this method for estimating the consolidation depth at the stones, after treatment. For this purpose, the above mentioned methodology was performed on the walls of the Medieval City of Rhode Island (Greece) as well as in Delos island providing data for the effectiveness of the consolidation treatment on the walls.

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Wood exploitation by starch impregnation and DIC technology

Maria Pia CONTENTO

The project aims at the development (through the building of a pilot plant) of a recently patented process for the archaeological wood sector (Arkè method) that can also be applied to the fresh wood. This process consists in the consolidation of the waterlogged wood and in reinforcing the fresh one, by using a treatment that comprises impregnation coupled with an innovative desiccation with the DIC plant (Instantaneous Controlled Depression).

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Ultra-thin and ultra-light fire-barrier made of fire-proof poly sialate fibre reinforced sheets (cfrp)

Joseph DAVIDOVITS

Use of Carbon Fibre Reinforced Polymers (CFRP) for repair and rehabilitation has been steadily increasing over the past 10 years. The primary concerns are their resistance to high temperature such as exposure to fire and formation of an impervious layer preventing vapour pressure release from stone and concrete masonry. If vapour pressure release is prevented, the interface between the stone or brick or concrete structure and the composite layer seems to weaken and delamination occurs. A new inorganic alumino-silicate (ceramic-glass matrix) Geopolymer-Carbon-fibre sheet has been successfully tested for aviation application, providing excellent fire-resistant properties. Tests carried out on concrete beams indicate that Geopolymer-Carbon Composite provides excellent adhesion both to concrete surface and in the interlaminar planes of fabrics. In addition this geopolymeric matrix is pervious to vapour and is compatible with concrete, bricks and stones and can be formulated to provide vapour pressure release from these substrates.

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Preventive treatment of the atmosphere of cultural heritage premises by essential oil volatiles Evaluation of the antifungal activity of citronella essential oil

V.G. de BILLERBECK, C. ROQUES, J-L. FONVIEILLE

The preventive struggle against the infestation of museums, libraries and archives by micro-organisms may be improved by the use of natural plant extracts, such as essential oils. This study belongs to a scientific research program, led by the "Disinfection group of museums and archives" of the French Ministry of Culture. The work presented deals with the antifungal activity of Cymbopogon nardus (L.) W. Watson essential oil ("Ceylon Citronella") on a cellulolytic mould : Aspergillus niger. The volatile phase of the essential oil (encapsulated or not) presents a fungistatic activity in a model bioreactor. This activity is strongest on mycelium stage than on spores. The second phenomenon observed is the inhibition of the mycelium sporulation, after the subculture of the treated inoculum (spores or mycelium). Thus, these findings indicate the possibility of employing essential oils in a preventive way, as atmospheric preservative agents, to limit the development and the dissemination of cellulolytic moulds in archives and museums.

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Conservation of lead seals at the national archives of France

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Museum objects containing metallic parts (copper, silver or lead) frequently undergo severe alteration due to attack by reactive gaseous components of their storage environment. As an example, historical lead seals kept in the National Archives of France exhibit marked corrosion features linked to the emanation of volatile organic acids from the oak shelves and drawers where they are kept. A policy of preventive conservation requires a better control of the atmosphere prevailing in the museum showcases and reserves. This task can be done quite simply by means of corrosion monitors made of the same metal as the museum object and placed under the same conditions for increasing time-spans. An accurate and versatile method to study the corrosion kinetics relies on thin metallic layers (a few hundred nm thick) upon a silicon substrate. This type of monitors is well fitted to the use of conventional RBS for measuring the thickness and composition of the superficial altered layer. In addition, RBS can be used to calibrate commercial corrosion monitors based on resistivity measurements.

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The SUIT project

Albert DUPAGNE

The SUIT project aims at establishing a flexible and consistent Environmental Assessment methodology to assist with the active conservation of historical areas. This methodology will be designed to help municipalities and local authorities in assessing the suitability of new urban developments which will promote sustainable exploitation of urban and architectural cultural heritage. The methodology will also help to match existing historical areas with current socio-economic requirements, through an active integration of this heritage within new development projects.
The outcomes of the research will mainly be targeted at municipalities and town councils, which normally lack the expertise to handle complex research prototypes and state-of-the-art techniques. It has thus been considered that the main operational outcome of the project should consist of the camera-ready version of a Guideline about the Environmental Assessment of the effects of certain plans, programmes or projects upon the heritage.

Contractors
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EIA Unit - University of Wales (UK), MRW-DGATLP (BE)
LDB - University of Dortmund (DE)
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Colour measurement using a gonio-spectrophotometer in the visible range

Guillaume DUPUIS, Lionel SIMONOT, Mady ELIAS, Michel MENU

The C2RMF has developed a gonio-spectrophotometer with optical fibers which analyses the back-scattered light in the visible range. The device is transportable, the measurements are non-destructive and without any contact with the work of art.
Three kinds of applications have been expanded.

- The pigment identification of a pictorial layer : the unknown reflectance spectrum is compared to those of a dry elementary pigment spectra database.
- The geometrical surface state characterisation: the reflected intensity is measured as a function of the back-scattering angle, then the surface roughness is deduced.
- The colorimetric analysis : the trichromatic co-ordinates L*a*b* are calculated from the reflectance spectrum. They allow a fast check of the colour evolution of works of art.

These measurements are of great interest when studying works of art to characterise their materials, to understand the artist's know-how, or to optimise their conservation in a museum.

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City cafe - comparative assessment of forward looking scenarios and visions for the european historical city of tomorrow

M. Antonietta ESPOSITO

The aim of the project is to check and show the effectiveness of a SET (Suitable Exploitation Tool-kit) based on the scientific results of the HISTOCITY TMR Euro-conferences series by establishing a NETWORK to demonstrate cases study made by medium size European historical cities. It would show an innovative decision support tool-kit to approach scenario definition, analysis and suitability assessment of projects for urban renewal and economic exploitation in the European Historical Cities. A good example of the potential application field of such tool-kit is the urban renewal and transport policies offer confronted with suitable and culture conscious tourism management demand in historical cities. The Suitable Exploitation Tool-kit supplies an effective decision support system to design innovative strategies both for conservation and renewal as well and to develop such projects within urban stakeholders involved in the historical cities complex realty. The new Project Proposal would meet several Key Action points in particular the suitable city planning and rational resource management : 4.1.1.Improving urban government and decision making. The Project could make possible to integrate different multi-dimentional analysis in scenario definition, including cultural variables as well as the economic and the environmental ones basically in a spatial decision support system, showing offers and demand and simulating the different possible scenarios assessing in advance their "suitability score" facing stated objectives. The results of the initiative will be diffused by the CITY-CAFE network, also in connection with Associations of Cities and of operators in the field.

Partners
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Stone decay and polychromy characterisation of jacopo da carrara funeral monuments in eremitani church in padua

Vasco FASSINA, Annamaria SPIAZZI, Monica FAVARO, Francesca CRIVELLARI, Andrea NACCARI

The sarcophagus dedicated to Jacopo da Carrara was built in the middle of XIV century by using a soft limestone from Berici Hills and was completely painted.
Before the restoration a complete survey on stone materials and on the causes of deterioration was undertaken on different areas according to the decay pattern macroscopically visible.
Analyses performed on the painted layers showed that different techniques have been employed.
Main soluble salt present are sulphates which have caused a differential decay depending on localised position. Gypsum efflorescences are present in the intrados, which is an area closely connected to the wall masonry. The present sulphation process is due to sulphur bearing compounds which reacting with limestone form gypsum. Soluble salts migrating towards the superficial strata have crystallised thus causing the detachment of the superficial pigment layer.

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Stone monuments in South Tyrolia - approach to a regional conservation concept

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A study concerned with building materials of monuments in South Tyrolia/Italy has been conducted in the frame of an Italian-Austrian EU-Interreg-II program. The aim of the project was twofold : documentation of the material inventory of churches and investigation of the properties and weathering behaviour of the materials. In the first part of the study a mapping of the regional distribution of the building materials was done. The results show a close correlation to the local geology except for specific architectural stone elements made of farther transported material. The second part of the study concerned the determination of basic petrographical, chemical and physical parameters, such as mineralogical components, sedimentary fabrics, salt content, pore and hygric properties for the main materials. The data provide the relevant material information for decision making in restoration work.

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Reconstruction of two traditional rural buildings

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The Working Group developed the project and managed the reconstruction of two rural buildings that belong to the traditional building heritage of the Trentino Region (Italy). They are the first buildings in a new open air museum, part of the "Ethnographic Path Rio Caino" in the munici-

pality estate of Cimego, where the meaningful traditional rural buildings of the region will be preserved.
The Aims are to promote the knowledge of the traditional building heritage, to maintain the original shape of examples of the traditional buildings, to preserve the building techniques, to train young carpenters and masons, to improve the offer the cultural tourism.
Main Phases of the Work and Results :

- The Geometrical Survey and the Technical-Structural Analysis of the components summarized into synthetic charts.
- The Reconstruction Plan.
- The Reconstruction made by skilled workers, where traditional working techniques and tools have been used. The reconstruction of the buildings began in March 2000 and ended in July 2000.

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Applications of vibrational microspectroscopy to art and archaeometry

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Identification of materials used by historic and prehistoric artists and artisans is of great interest to better understand the development and transfer of technology of earlier times. Samples of finished products from earlier civilizations are normaly quite rare, however, and thus are of great value. Chemical analyses of such products is therefore limited to non-destructive analyses of the product as it exists, or to methods sufficiently sensitive that the amount of sample required is extremely small, in some cases so small that the samples removed from the product results in changes which are undetectable to the unaided human eye. The techniques of microspectroscopy are well-suited to such problems and are thus useful contributors to historic knowledge. Small areas of relatively large samples can be fairly readily studied by Raman microspectroscopy, and pigments used in various early manuscripts and fragments of archaeological materials were successfully investigated.
The details of lichen encrustation of Renaissance frescoes has ben the subject of a continuing study. The primary deposit is composed of calcium oxalate monohydrate and dihydrate, but smaller amounts of other oxalates and certain organic compounds formed by the lichen have also been identified. The encrustation is very heterogeneous, occurring on certain pigments and not others, in certain forms at one spot and another form at another spot, etc. Chemical information obtained from the interface of the lichen and substrate can be important in determinig the mechanism of biodeterioration. This information, in turn, can be important in remediation processes.
Identification of certain pigments by in situ Raman microspectroscopic analysis of various medieval and more modern manuscripts have been reported.
Most paintings consist of several layers and the layer structure and composition can be as characteristic of the artist and/or the true period as is the painting style used. Although pigments can sometimes be identified by optical microscopy, organic binders cannot. Infrared microspectroscopy of the layers is often useful for characterizing these materials. The method has been applied to paintings from the 9th century.
Until relatively recently, organic have been ignored by archaeological chemists because only small quantities survive in the archaeological context. These fragmentary and fragile organic remains have become more amenable to study by the advent of new, sensitive methods of analysis, especially microspectroscopy. The study of historic and prehistoric textiles has been particularly aided by both infrared and visible microspectroscopy is not very useful, although recent results with FT-Raman microspectroscopy offer promise with such samples.

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A preliminary study of the chemical composition of the wall paintings of p-26 debyel barkal pyramid (Karima, Sudan)

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The staff of conservation-restoration department of the University of Barcelona includes specialist in easel and wall painting, archaeological materials, paper supported artworks, building façades restoration as well as analytical chemistry.
Our activities are mainly focused in two lines : the restoration of singular artworks and the development of research projects orientated to the study of treatments reversibility and the physical and chemical characterisation of artworks, including the development of applied technology.
Debyel Barkal is an archaeological site located near of the city of Karima, 400 km Northwest of Garter, Sudan. The pyramid P-26 was excavated in two campaigns in 1995-6 by the team of the Jordi Clos Foundation. This pyramid belongs to the black pharaoh culture and it is dated in the Napatiense period (650-310 a.c.).
From this period, there are several pyramids with decoration in the external chapels but P-26 is one among the six that also has decoration in the funerary chambers. The composition of the wall painting was not determined at any case.
In this study, we present the preliminary results corresponding to chemical composition of the mortar and the pigments (black, blue, red and yellow) used in P-26. The compounds found are quite similar to those employed in the contemporary Egyptian monuments.

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Save art

Ercole GIALDI

The presently used pesticides, to control parasites in museums, archives and libraries, are risky to people's health, pollute the environment and cause alterations to collections' materials.
The state of the art technology to control insect pest of Cultural Heritage was developed through the EU project SAVE ART whose outcome is VELOXY® (VEry Low OXYgen); it is the safe alternative to chemicals that kill parasites by poisoning them. By VELOXY® the collections are free from parasites just exposing them to atmospheric air to which oxygen has been extracted ; the laboratory and large scale tests have shown that with the new method any specie of parasite at any stage of its life is killed in few weeks.
The novel strategy respects the human health ; the environment and the integrity of Cultural Heritage.

Contractors
C.S.L. (UK) ; MASTER Srl (IT) ; C.S.I.C. (ES) ; I.C.P.L.(IT) ; N.R.M. (SE)

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Architectural photogrammetry for documentation and 3-d modeling of cultural heritage

P. GRUSSENMEYER, M. NOUR ELDIN, O. AL KHALIL, S. GUILLEMIN

Photogrammetric techniques are interesting for documentation, restoration, visualization of historical sites and monuments. Terrestrial or aerial photographs (glass plates from archives, films or digital images) are detailed representations and archives of world cultural heritage. Photogrammetric 3-D modeling methods are based on stereoscopy or multi-image techniques from

any kind of metric or amateur image. The improvement of methods for surveying historical monuments and sites is an important contribution to recording and perceptual monitoring of cultural heritage as a support to architectural, archaeological and other art-historical research. The poster is intended to give an overview of recent photogrammetry based projects realized by members of our group in the domain of architecture and archeology in France, Greece, Romania, and Cairo-Egypt.

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"System for maintenance management of historic (wooden) buildings" (acronym : mmwood)

Svein HAAGENRUD

Methods and tools for obtaining a systematic maintenance strategy on the European level are major objectives and focus of the EU Action Plans and FW programs in the Cultural heritage field. The MMWood CRAFT project addresses these needs. It builds on its predecessor, the ENV4-CT95-0110 Wood-Assess project, and has completed all its tasks and achieved all its objectives. The MMS application (b-version) is a generic software tool to aid the documentation, inspection and maintenance management of cultural buildings. The technology is open and object oriented and can be extended to any kind of objects. MMS enables the documentation of the building and collection of information regarding its state and condition. It enables the user to integrate and link documents, drawings, and pictures to the building or to any specific part/location/observation of the building, and to link the buildings to maps in a Geographical Information System (GIS), which is shown by the reports for the chosen objects in Germany, Sweden, Italy, and Norway.

Participants
German Centre for Crafts and the Preservation of Historic Monuments, Fulda, Germany ; Restaurator AB, Stockholm, Sweden ; Mycoteam AS, Oslo, Norway ; Norwegian Building Research Institute, Oslo, Norway ; Interconsult AS, Oslo, Norway ; Centre for Built Environment, Gävle, Sweden ; Environmental Centre, Fulda, Germany ; Univerity of Trento-Laboratory of Building Design, Trento, Italy.

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Protecting and developing the dutch archaeological landscape

H. KARS, J.H.F. BLOEMERS, W.J.H. WILLEMS and M.-H. WIJNENSEN

The Dutch rural and urban landscape is, as many other densely occupied areas in Europe, in a state of continual transformation. The vulnerability of the invisibile archaeological resources present in the subsurface of this modern landscape requires tremendous research efforts which will lead to the sustainable development of the archaeological-historical landscape. Project strategies are focusing on establishing a link between scientific knowledge, archaeological resource management and planning policies in the Netherlands. The project starts in 2001, the budget (3.000.000 Euro + plus matching) is provided by four governmental departments and the Netherlands Organization for Scientific Research. This national program favours international cooperation in order to create an international network in the interdisciplinary fields of archaeological resource management, planning and urban/landscape design.

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Bone as an indicator in the deterioration of the european archaeological property

H. KARS, A. NORD, M. COLLINS, P. ARTHUR, N. EARL

All over Europe there is discussion concerning the degradation of the archaeological record in the soil with subsequent loss of information. This discussion has to lead to a uniform approach to preserve, where possible, our archaeological heritage in situ, because the heritage is neither regenerable nor replaceable. The loss is apparent for the features, like post-holes, ditches and waste dumps, but is also true for the archeomaterials, such as ceramics, glass, metals and organic materials, including bone. The objectives of the project are : i) an establishment of techniques for the assessment of small changes in the deterioration state of bone, and ii) the prediction of the long-term preservation of bone in different soil environments in Europe, this in light of the verification of current concepts of archaeological heritage management. The international and multidisciplinary partnership will achieve answers to the following questions : i) how do environmental impacts influence the chemico-physical and microbial stability of archaeological bone, and ii) Can an understanding of the degradation mechanisms of bone be used to predict the preservation potential of a given soil type ?

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Some relationships between wooden art works and forests from medieval periods : primitive paintings and the vosges area

Catherine LAVIER

Dendrochronological approaches have been experimented with conifers from the Vosges forests. This region has been mainly exploited for its mineral deposits during the XIV-XVIIth c. The use of firs (Abies alba) for the propping up of tunnels roofs, for haulage tracks and washing stations has enabled us to study hundred of samples. Our method is based on the comparison of their tree-rings widths.
Firstly, we were able to connect wood purchases, discovered in financial accounts, with the cutting dates, given by dendrochronology. Secondly, these investigations are of particular interest to the archaeologist and the historian but also lead to the domain of works of art. By establishing chronologies, we defined specific biogeographic groups suitable to set up geographic replacements for a large part of very famous collection of Primitives paintings (Colmar - Alsace) from "German Schools" (XV-XVIth c.). The wood used for the panels allowed us to trace an origin mainly back to the Vosges area from others to southern Germany.

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Timbers and forest origin in burgundy at the end of the middle ages

Christine LOCATELLI

Towards the end of the Middle Ages, the duchy of Burgundy was an important European political entity. Numerous buildings (churches, abbeys, hospitals, chateaux, houses, cellars and barns) constructed during this period are still standing. Dendrochronology reveals, even today, in these structures, the presence of wood dating from that period. In archives can be found precise infor-

mation for certain of these buildings concerning the artisans and the supply of the materials used to construct, maintain, or reconstruct. By integrating historical sources with the dendrochronological data from timbers, little by little, we are identifying the forests that supplied building wood to different sectors of Burgundy. Comparison of growth patterns of timbers from well documented buildings with wood from structures for which the sources are less well known permits us to gradually extend our understanding of forest management at the end of the Middle Ages.

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Biodeterioration and cultural heritage : aerobiological measurements

Paolo MANDRIOLI, Paola DE NUNTIIS, Raffaella MAGNANI

Biological particles of different dimension, shape, and source (bacteria, yeats, pollen, fungal spore) are present in the atmosphere. The instruments used in this type of sampling are show in this work. The aerobiological sampling aimed at the conservation of Cultural Heritage is important for the recovery and restoration of the already damaged material. It is also useful in order to : evaluate the environment at risk in relation to the circulation of air and particle adsorption ; check the risk of a biological attack on the vulnerable materials when thermohygrometric value become critical ; check the influence of human presence to evaluate the increased microbic concentration on the exposed materials ; evaluate the glass cases suitability through a quantitative and qualitative comparison between the outdoor and indoor atmpspheric bioaerosol ; check the efficiency of air filtration system and carry out proper maintenance, check the efficiency of disinfection, conducting appropriate sampling and monitoring before and after the treatment.

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In situ RBS study of the kinetics of galena thermal oxidation by means of the external micro-beam

P. MARTINETTO, J.C. DRAN , B. MOIGNARD , J. SALOMON, P. WALTER

Galena (lead sulphide PbS) is a component of the eye shadows (kohl) used since ancient Egypt. Numerous traditional recipes in North Africa still deal with the processing of this mineral before applying it around the eyes. In particular, the Tunisian tradition stresses the usefulness of a heat treatment of the mineral lump wrapped in a piece of textile: « have the piece of kohl dried directly on live charcoal, after having wrapped it in a dark blue rag saturated with olive oil ». Experiments performed on cleaved cm-sized crystals of galena (PbS) show that heating in air during a few hours at temperatures varying from 400 to 600°C induces iridescence. This feature seems to be sought in North Africa to produce coloured eye make-up. We have built a furnace with small dimensions to study in situ the oxidation of a mm-sized galena crystal. Experiments can be performed up to 600°C and the thickness of the oxidised layer is measured every two minutes by means of the lead signal in the RBS spectrum, using a 3MeV 4He2+ external focused beam (about 100µm). We infer the diffusion mechanism from the growth of a phase, which is more or less stable when increasing the temperature. This probing beam allows one to characterise layers of thickness extending from about 100 nm to 2000 nm. The archaeological interest of this work is to show a likely thermal treatment of material in Antiquity for aesthetic purpose and to precise the understanding of ancient metallurgical processes.

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High-resolution computerised x-ray tomography

Patric JACOB, Florias MEES

Computerised X-ray tomography (CT) is a non-destructive technique for visualisation of the internal structure of objects. Microfocus X-ray tomography (mCT) systems are currently capable of producing cross-sections with a resolution of about 10 µm. At the University of Ghent, mCT scanning has been intensively used for the evaluation of the corrosion state of glass fragments from archaeological sites, as a contribution to an EC-funded project. Other potential applications in the field of cultural heritage that have been tested with the available system include studies of porosity, salt distribution and resin penetration.

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Development of new corrosion inhibitors for metallic archeological artefacts protection

C. RAPIN, E. ROCCA, F. MIRAMBET, J. STEINMETZ

One of the objectives of research in conservation is to develop new processes which can contribute to a decrease of the corrosion rate of metallic artefacts. It has been shown that the application of corrosion inhibitors can reduce metallic corrosion by interfering with the electrochemical mechanisms of corrosion reactions. In this work, we have studied the inhibitor properties of sodium monocarboxylates of general formula $CH_3(CH_2)_n$-2COONa noted NaC_n with n=7 and n=10. The efficiency of these compounds to inhibit corrosion of bronze and lead has been evaluated both by electrochemical measurements and accelerated laboratory testing in climatic chamber. In the case of lead sample, best results are obtained for a NaC10 inhibitor concentration of 2.5Œ10^{-2} mol/l. For bronze sample the highest values of polarisation resistance were recorded for NaC7 inhibitor concentration of 2.5Œ10^{-2} mol/l.

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Damage assessment of historic tapestries on display

M. ODLYHA , D. HOWELL, J. WOUTERS, C. HERRERO

The aim of the poster was to promote collaboration between conservators-restorers and scientists with previous experience in textile research and historic tapestry characterisation. This revealed that some data already existed in the following areas : novel thermomechanical testing on fabrics and fibres, gel chromatographic techniques for monitoring molecular weight changes in silk, and biological source detection in tapestries of Flemish production from the 15th to the 17th centuries. The positive outcome of the poster is the three year project "Monitoring of Damage in His-

toric Tapestries (MODHT) Proposal No. EVK420001-00020 which now includes a wider consortium (C.Carr, University of Manchester, Institute of Science & Technology) A. Quye National Museums of Scotland, and A. Hulme, University of Edinburgh). Its main aim is to provide a physico-chemical study for damage assessment of model tapestries, prepared according to traditional techniques, and historic tapestries, an integrated research programme which includes microscopic investigation of fibre morphology, monitoring of colour change, research into wet cleaning, and improving tapestry conservation techniques. Testing will be performed on model and historic tapestries from collections at Hampton Court Palace, the Palacio Real in Madrid, and Musea in Brussels.

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Remote monitoring of buildings by fluorescence lidar

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The project is a voluntary cooperation for developing and testing a methodology, based on the Laser Induced Fluorescence (LIF), for the remote monitoring of building surface characteristics and their presentation as thematic images easy to read by the final users. Laboratory and field experiments have demonstrated the feasibility of a remote LIF detection and characterization of biodeteriogen colonization, efficiency of biocidal treatments, surface treatments, and stones. The field experiment have been successfully carried out on the Parma Cathedral and Baptistery, the Lund and Pisa Cathedrals. Parts of the project have been supported by the EU program "Access to Large Scale Facilities", the CNR project "Cultural Heritage", other national projects, or the scientist Institutions.

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Water repellent treatments test methods and performance criteria

André PIEN

The aim of this research is to define standardized test methods for the measurement of relevant parameters and performance criteria for hydrophobic agents. Such recognized test methods are necessary to obtain objective technical information for the comparison of the large number of hydrophobic agents marketed in Europe. A literature survey and a comparison of existing test methods was followed by the definition and identification of hydrophobic agents, the selection and the characterisation of the test substrates, the definition of the application procedure and eventually the testing of representative hydrophobic agents on selected substrates. Examination of the outcome of the experiments will result in the definition of a test procedure and perfor-

mance criteria. Methods for the evaluation of the durability of hydrophobic treatments are not included in this project.

Partners
BBRI (Belgium), BBA (United Kingdom), TNO (the Netherlands), KIK-IRPA (Belgium), IET/cc (Spain), BAM (Germany).

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Dendrochronological and technological study of french medieval furniture

Didier POUSSET

Medieval furniture preserved in French museums or in private hands has up to now rarely been scientifically studied. Dendrochronological and tracaeological investigations were recently undertaken on French and Flemish furniture collections dating from the 14th to the 15thcenturies.
These studies furnish new information on the wood used at that time, its biogeographical origins and on the building practices then in use. The different phases of wood working, from felling and cutting to actual furniture making are restituted. The technology used testify the ingenuity and know-how of the artisans at the end of the Middle Ages. The oak wood used was carefully selected for its anatomic properties. Dendrochronological analyses suggest the wood was imported from the Baltic area where the climate favoured the growth of high quality wood.

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Long-term studies on polymer-based impregnation agents on natural stones

M. RAUPACH

Polymer-based impregnation agents have been developed with the aim of reducing the deterioration of natural stone buildings and monuments. Prior to using these products on historic buildings, various tests on effectiveness and durability had to be carried out. The problem of accelerated ageing methods is that they can induce material damage which is not comparable to processes occurring in nature, but long-term outdoor exposure is time-consuming and costly. At the Institute for Building Materials Research an experimental apparatus called "VENUS" (German anagram denoting 'test plant for the development of realistic environmental simulation concepts') is used for accelerated, reproducible, complex weathering. To estimate the quality of natural simulation and the rate of acceleration in the VENUS concept, additional outdoor weathering has been carried out. The characteristic material parameters have been determined on the stone specimens exposed to outside weathering for a period of approximately ten years and on the specimens subjected to weathering in the VENUS plant.

This project was sponsord by the Federal Ministry of Research and Technology

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A light dosimeter for monitoring cultural heritage : development, testing and transfer to market

Hannelore ROEMICH

The aim of this project (EVK4-2000-00016) is to develop and test light dosimeters for application in museums. The new dosimeter will consist of sensitive dyes embedded in a polymer matrix and will be applied on a substrate (glass or paper). Laboratory and field studies will include investigations of the colour change of dosimeters to determine threshold values for light induced effects, saturation effects, reciprocity failure, time dependence, intermittence effects, spectral sensitivity and synergetic effects with temperature, humidity and pollutants. The field application of dosimeters will be carried out on different sites where the lighting conditions are monitored with commercially available instruments.
Light dosimeters will provide a new tool for conservators and curators for quantifying the effect of light in museums before damage on sensitive objects occurs.

Partners
Centre de Recherches sur la Conservation des Documents Graphiques (CRCDG, F), Instituto di Ricerca sulle Onde Elletromagnetiche (IROE, I), Viktoria & Albert Museum (V&A, UK), State Institute for the Care of Historical Monuments (SUPP, CZ), Particle Technology (UK), Dr. Dieter Kockott UV-Technik (D).

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Chances for churches - extended use and conversion of churches in Europe - research and transfer of best practices

Tim ROESSLE

Objectives : to preserve historic fabric of church buildings ; to enhance attractiveness of city neighbourhoods ; to improve public's access to cultural heritage, to compile and disseminate best-practice models, to improve planning & operational skills and tools.
Approach : methodologically flexible, inter-disciplinary, quantitative and qualitative research of successful and failed church use extension projects ; identification and systemization of success factors ; networking and dialogue of institutions.
Results : The results are a handbook, interactive CD-ROM and web-page, a brochure with 10 best-practice examples, and action recommendations for relevant stakeholders

Partners
De Montfort University, Leicester, UK, COTAC, London, UK, RICS Foundation, London, UK, Monumentenwacht, Amersfoort, NL, C.A.M., Mertola, Portugal, RAADVAD, Lyngby, Denmark.

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Sustainable heritage : historic towns working together

Brian SMITH

The Proposal builds on the recently formed European Association of Historic Towns and Regions –and provides a unique opportunity to develop a research programme into the sustainable management of historic towns across Europe.
It offers a practical basis - through the creation of a thematic network involving European historic towns and universities - for the delivery of relevant in-depth research into sustainable heritage and effective dissemination of good practice.
Progress so far includes twelve National Associations and approximately 450 historic towns in the network, plus the creation of a major web portal - www.historic-towns.org

Work is currently progressing on developing work packages in collaboration with the research network - 'Histocity 'under the project title 'City Café'. This will be submitted in October 2001. Historic towns interested in participating should contact : the co-ordinator.

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An integrated approach for enhancement of eastern cultural heritage

Ramiro A. SOFRONIE, Gabriela POPA, Alfonso NAPPI, Nikos NIKOLAOU

The oldest monumental buildings preserved in the Carpatho-Danubian-Pontic space are churches. In the frame of INCO Copernicus Project IC15-CT96-0208 the Eastern Churches of three-lobed plane were multidisciplinary investigated. Their structural concept, seismic behaviour and environment were analysed with the most advanced existing tools. Field investigations and laboratory tests completed the integrated approach obtained. It is useful for both preservation of the existing cultural heritage and enhancing it by computer-aided management.

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Lips analysis of the alloys used by lorenzo ghiberti in Florence

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In the present study, some bronze specimens coming from Ghiberti's east door of the Baptistery of Florence (Paradise's Gates) and from Ghiberti's statue of St.Thomas in Or San Michele, have been analyzed by means of LIPS and other techniques in order to point out the differences in the composition of the alloys. In particular, the comparison between the SEM and LIPS results coming from the present study confirms once more the latter's validity for bulk analyses of bronze artifacts and highlight the complementarity of the two used techniques : with the LIPS procedure, in fact, it is possible to obtain compositional information with no sampling, on the other hand, the SEM analysis, allowing to obtain the image and the map distribution of the different elements, enables the metallographic investigation which can evidence the working procedures used by the artist.
Moreover, the possible use of LIPS for depth-profile analysis may increase the efficiency of the complementary use of the two techniques in order to obtain more complete information also about the composition of the patinas.

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The development of archival bookbinding leather brite euram craft programme

Roy THOMSON

An examination was made of the subjective methods used to assess leathers. Objective tests were developed which correlated with these. The artificial ageing method developed during the STEP leather poject was found wanting and an alternative regime tested. Samples of commercially available leathers were obtained and examined for their chemical, physical, organoleptic and ageing characteristics. Experimental leathers were produced and tested for the same properties. As a result, by the end of the project, archival quality leathers were being produced and sold commercially to bookbinders worldwide.

Partners
Brotini, Italy ; Harmatan, UK ; Hewit, UK ;
Kripper, Germany; Moldovanidis, Greece.
Bookbinders : Codina, Italy; Ganiaris, Greece.
Conservators: British Library, UK ; Deutsche Ledermuseen, Germany.
Research Organisiations : CGS, Italy ; El Ke De, Greece ;
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Assessment of damage risk in heated churches with cfd

Alexandra TROI

The objectives of the work are :

- Firstly to determine the probably damaged zones and the respective damage-risk in heated churches (soiling, humidity degradation, biodeterioration, salt damage, deformation due to changes and gradients in relative humidity).
- Secondly to analyse how the characteristics of both heating system and church building influence the size and distribution of the damaged zones.
- And finally to visualise the results.

These objects are achieved by simulation of the microclimate with the CFD-code “Fluent 5” and further analysis of the three-dimensional results of the simulation with graphical and statistical instruments.

Partners
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A novel non-destructive method for the determination of water vapour and pollutant fluxes to surfaces

Christian WITTENBURG, Michael STEIGER, Andreas BEHLEN

A novel technique for the detection of pollutant and water vapour fluxes to surfaces was developed in order to characterize the behaviour of materials in contact with the surrounding atmosphere and to evaluate the efficiency of conservation treatments.
The uptake rates of can be detected in situ by fixing a chamber at the surface of the material under investigation. In contradiction to former approaches the experiments are carried out at ambient pollutant concentrations, ensuring a realistic and comparable detection of the resulting flux and the deposition velocity.

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A review of health hazards linked to the use of lasers as cleaning tools for stone building components and artefacts

Véronique VERGES-BELMIN, Gunter WIEDEMANN, Lothar WEBER, Martin COOPER, Derrick CRUMP, Raphaël GOUERNE

One of the most recent applications of lasers lies in the field of artworks conservation. Stone cleaning, using Nd-YAG Q-switched lasers (= 1.06µm), has developed significantly within the last years. The improving technology allows increasingly powerful lasers to appear on the market, and as a consequence, higher cleaning rates can be obtained at lower costs. The tendency is to extend the field of application from the cleaning of individual artworks to the cleaning of entire building façades, so that more and more people will be exposed to the laser risks.
The hazards linked to the use of a laser tool fall into four main categories : (i) : Radiation hazards, either from the direct beam, specular or diffuse reflections (IR : 1,06 µm), and connex radiations (UV, visible); (ii) : Electric and fire hazards ; (iii) : Particles and Volatile Organic Compounds (VOC) hazards ; potential hazards must be assessed through bio-medical tests (looking for mutagenic, cytotoxic and genotoxic effects) and specific research of potentially dangerous species in the laser plume ; (vi) : Noise hazards due to extraction equipment and laser beam interaction with the surface being cleaned.
This project, was submitted in february 2000 to the program « Quality of life and management of living ressources ». It was rejected, mainly because it was considered that the exposed population was too small.

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Charisma : cultural heritage, access and risk management

D. BALL, J. WATT

This poster set out an exciting area of potential research in the area of sustainable conservation of heritage, in order to start a dialogue with potential partners. It suggested that harm may be caused to our heritage by other social policy measures, which of themselves may be highly desirable (such as visitor safety or access for people with disabilities). It suggested that existing techniques of environmental impact analysis, risk assessment and risk management can readily be adapted to the field of heritage protection. Three main objectives were discussed which were firstly to identify conflicts resulting from social policies, secondly to develop a holistic risk management tool and thirdly to provide practical information and guidelines to site owners, managers and policy makers. Essentially, our proposal was designed to find a means of achieving a suitable methodology for decision making by heritage managers. We expect such

a project to produce a blueprint for a methodology which would find wide application by heritage site managers throughout Europe. It would focus attention on the need to be aware of the special needs and compromises that are necessary if heritage is to be properly accessed and protected.

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Cleaning and analysis of painted artworks using lasers

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The activities of the team are aimed at : a) investigation of the conditions in which laser cleaning can be safely applied on paintings and polychromes (sometimes gilded) ; b) evaluation of the chemical and physical effects induced by laser irradiation on painting materials ; c) investigation of optical laser–based and vibrational techniques and mass spectrometric techniques for the analysis of those materials. The main achievements include : 1) investigation and identification of effects of UV light and the removal of varnish overlayers from tempera paint systems (EU Research Project "Advanced workstation for controlled laser cleaning of artworks") ; 2) study of the applicability and complementarity of spectroscopic techniques, Fourier Transform Raman (FTR), Fourier Transform Infrared (FTIR), Laser Induced Breakdown Spectroscopy (LIBS), Laser Induced Fluorescence (LIF) and time of flight mass spectrometry (TOF MS) to characterize the pigment and binding media composition of painted artworks from different Spanish artistic periods.

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Iron gall ink corrosion

Louis DAMEN

Thousands of drawings and documents in iron gall ink are in grave danger of being lost within the next 150 years if the ink's corrosive action is not stopped. Though recent research has revealed a lot about the causes and basic mechanisms of this corrosion, more research is necessary due to the complexity of the ensuing degradation processes. So far there is no single solution or applicable method of treatment. The best method to date seems to be the treatment with fytate, developed by The Dutch Institute for Cultural Heritage Amsterdam, but little is known about its side, or long-term, effects. In the meantime, the best possible preventive conservation methods need to be adopted with research into this field being carried out by TNO Industrial Technology, Delft. Therefore there is an urgent need for international co-operation in further research including fund-raising for such reseach which has passed beyond the means of conservation and museum studios.

Partners
Dutch State Archives, Art Innovation, Weiss Enet, Archimascon/Bookkeeper, Shell Research & Technology Centre, Ministry of Economic affairs.

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Applications of vibrational microspectroscopy to art and archaeometry

M.J. Freiría GANDARA

Identification of materials used by historic and prehistoric artists and artisans is of great interest to better understand the development and transfer of technology of earlier times. The techniques of microspectroscopy are well-suited to such problems. Small areas of relatively large samples can be fairly readily studied by Raman microspectroscopy, and pigmets used in various early manuscripts and fragments of archaeological materials were successfully investigated. The details of lichen encrustation of Renaissance frescoes has been the subject of a continuing study. Chemical information obtained from the interface of the lichen and substrate can be important in determining the mechanism of biodeterioration and in remediation processes. Until relatively recently, organic materials have been ignored by archaeological chemists because only small quantities survive in the archaeological context. These organic remains have become more amenable to study by the advent of new, sensitive methods of analysis, especially microspectroscopy.

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Acropole : a center for conservation of historic and artistic works in Poitou-Charentes

Raphaëlle MUSSOT

Acropôle conservation center receives private conservators working in historic artifacts conservation. The center proposes for moderate rent six safe and pre-equipped workshops (alarm, climat control system...) to conservators of different specialities. Acropôle is established since 1999 in Saint-Savin-sur-Gartempe (famous for her Abbey and the ensemble of mural painting inscribed on the World Heritage List) by the district Montmorillonnais with the support of the Vienne departement, french governement and European Union. Beyond the reception of professionals, the aim of which is to enlighten the public to the preservation of cultural property by occasional exhibitions, demonstrations, seminars or informal conversations. A last mission consist in promote communication and collaboration of the various actors of cultural heritage (conservators, curators, archaeologists, art historians, artists, student of museology, guides...). Today two conservators (specialised into paper, metals, and archaeological/ethnographical artefacts) are established.

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Please touch !

J. TATE

In the "Touchy-Feely Display" samples of typical material in museum objects were displayed and visitors invited to touch or feel each one. The number of times each sample was touched was monitored and the cumulative total number was displayed at each sample. Half of each sample was protected from touching so that by comparison a simple visual indication of the damage rate built up. The results illustrate damage to copper ; paper ; silk ; plaster ; marble ; and wood by visitor handling. Having demonstrated the problem we wish to understand the nature and criteria which control the rate of soiling and suggested that which might be part of an EU collaborative study.

- The influence of gallery environment parameters, for example temperature, relative humidity, gaseous pollutants, dust and particulates.
- Analytical determination of the composition of soiling.
- Development of a standard soiling monitor which can provide quantitative results.
- Deployment of a standard monitor in different environmental and geographical locations to inform the above.

• Relate soiling to subsequent cleaning and its conservation methods including the effects of preventive lacquers and barrier films.

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Histride : an integrated software environment for dynamic structural identification

G. GIUSEPPETTI

HISTRIDE (High Performance Structural Identification Environment) has been developed by five European partners within the EC ESPRIT HPCN Project n.28249. Theoretical models of civil engineering structures (such as bridges, dams, towers, domes, historical monuments etc.) are essential for assessment and rehabilitation. For elder structures these models often do not exist and where they do exist they are often inaccurate. Given the shortcomings in surveys as a basis for structural models, it is clear that better non-destructive methods are needed for creating reliable models that accurately reflect the shape and condition of existing structures. This process of adapting theoretical, approximate models to fit with observed behaviour is called structural identification. HISTRIDE greatly extends and simplifies a non-destructive identification approach based on dynamic structural response. The physical parameters of the Finite Element model of a structure are modified iteratively to reduce the error between experimental modal features and computed ones.

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Raman laser optical fiber strategy for non destructive pigment analysis

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The laser spectroscopy Group (GEL) of the UPC works on the performances the photonic technologies can offer to the non-destructive analysis of artworks. Two different lasers (green and red) and the optical fiber technology are employed for a complete Raman analysis of the artistic materials. Various aspects are investigated in order to optimise all the optical components involved, such as the double notch filter, the inteferential filter, dichroic mirrors and the maximum length of the fiber. As an example of an application in art, we are now investigating the important problem of the lead yellow pigments in reference to the italian XVII century. At the moment, we have the first experimental observation with Raman spectroscopy of a non-standard yellow pigment which deals with a triple oxide of lead, tin and antimony. This result has been confirmed with both red and green lasers in some italian paintings (Langetti, Giordano and Poussin).

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Rationalised economic appraisal of cultural heritage (reach)

R. HAMILTON

The REACH project uses a cost/benefit approach to valuing measures to protect our heritage, specifically from air pollution. It was established to bring together existing techniques into a new synthesis, which will demonstrate what can be achieved and assess the implications for sustainable protection of heritage. The programme has three main objectives, firstly to develop a

method to integrate the different aspects of cost/benefit analysis that can be applied to cultural heritage. Secondly to develop a working prototype management tool with a modular design that can be used to evaluate cost/benefit scenarios at different scales and thirdly to validate this software by use of practical case studies. The poster presented the development to date of the management tool.
The major components that have been developed are designed to show how to undertake.

- Calculation of direct cost of air pollution to materials via dose/response
- Calculation of direct cost by inventory
- Calculation of Indirect Benefits/Costs
- Willingness-to-pay
- Spin-offs
- Calculation of Direct Income
- Scenario manager, Report generator, Online Illustration

Partners
BRE (UK), NILU (NO), SCI (SE), IST (PT), IOES (NO), Norgit (NO), Ecotec (UK), SVOUM (CZ).

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Conservation of damaged lead seals attached to their original parchment

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Lead objects exposed to corrosive organic vapours (evolved from oak cabinets) are heavily damaged. It's due to the formation of a superficial layer of highly fragile and active basic lead carbonate (hydrocerusite). Consequently inscriptions and decorations contained in this layer may be lost due to handling and abrasion. An effective stabilisation procedure (consolidative reduction) has been developed based on cathodic polarisation to consolidate the surface by reduction of basic lead carbonate to lead. An adapted procedure had to be defined when lead is associated with textile such for lead seals still attached to the parchment. Three aspects have been considered in this research : assessment of the risks of damage of the silk (or hemp) cords during the lead treatment, determination of a protection for the cords and the parchment and realisation of a support for the handling of the protected document during the treatment.

This research has been funded by the Mission de la Recherche et de la Technologie du Ministère de la culture et de la communication

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Realisation of a drilling prototype to clean the core of cannons recovered from shipwrecks

C. DEGRIGNY, G. BARON

Electrolytic stabilisation of marine iron artefacts such as cannons and anchors is quite effective on the outside of the materials. In order to stabilise the material as a whole in the case of artillery artefacts, including the core that is often blocked with concretions and leftover ammunition, a drilling system prototype was developed in collaboration with the IUT of Nantes. The goal was to create a support that could be used with any type of cannon, allowing the piece to rotate and

ensuring that the axis or the core remains perfectly horizontal. The IUT created a system of two supports (one fixed and the other adjustable) with rollers. The drilling device is a core drilling machine. The drilling diameters is approximately 6 cm. After this operation, the entire core can undergo electrolytic treatment, so that the residual concretions and any remaining ammunition can be gently released.

This research has been funded by ANVAR and la Région Pays de La Loire

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PCR « fers chlorures »

C. DEGRIGNY, F. MIRAMBET, F. BERTIN, F. DUSSERE

This research is conducted by four conservation laboratories involved in the treatment of archaeological iron artefacts. The objective is to study the effectiveness of stabilisation processes among which the alkaline sulphite process, the cathodic polarisation and the Hydrogen Plasma. The accent is placed on the comparison between the mechansims of transformation of corrosion layers covering the surface of iron artefacts during the different stabilisation processes (extraction of chlorides). These transformations are then studied on archaeological artefacts. Finally a post-treatment diagnosis methodology has been precisely defined.
A large amount of artificial coupons have been used for the first step to test the reproducibility of the results between the four laboratories involved. The understanding ot fhe transformation of corrosion layers is based on the monitoring of the stabilisation processes and the analysis of the corrosion layers before and after treatment. The stabilisation processes of immersion techniques are monitored through the measuring of electrochemical parameters and the extraction of chlorides. For plasma technique, some specific equipment is required.

This research has been funded by the Mission de la Recherche et de la Technologie du Ministère de la culture et de la communication

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Microclimatic damage to wall paintings on wood

Roman KOZLOWSKI

During a year long monitoring in the fifteenth century wooden church of Debno, Poland, the expansion and contraction of wood with fluctuations of the relative humidity were recorded with precision displacement transducers attached across wooden beams. The method proved remarkably sensitive and accurate. Furthermore temperature/relative humidity sensors were placed close to the wood surface inside airtight plastic chamber gently pressed to the wall. The method allowed for an indirect monitoring of the moisture content in the wood. The results correlated well with the dimensional change. The methodology allows for an assessment of environment-induced stresses in the real display conditions. The field offers a particular opportunity for East – West co-operation since painted historic wooden churches constitute a massive endangered heritage of Central and Eastern Europe.

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Carbon content and origin of damage layers in European Monuments (CARAMEL)

Hélène CACHIER, Cristina SABBIONI, Cesareo SAIZ-JIMENEZ, Peter BRIMBLECOMBE

The CARAMEL project is focused on the role of black patinas in stone decay layers and on the relationship between elemental carbon particle atmospheric contents and monument blackening rates. This relationship is likely to vary geographically and to be different in the future city environment. The modeling of particle transfer has to account for the variability of sources and meteorological conditions and the diversity of stone substrates.

CARAMEL will offer appropriate and robust arguments to help deciders for improving urban atmospheric environment throughout Europe especially for the organization of individual and public traffic in the context of ongoing environmental changes.

The main impact of results is expected as suggestions for regulation and implementation of atmospheric soot-based thresholds in the light of European policies on air quality and sustainable protection of Cultural Heritage. An indirect spin-off effect may also reside in the area of population health as both cumulative and peak effects of elemental carbon particles are still under debate.

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Summary
Résumé

Résumé

La 4ème Conférence de la Commission Européenne sur « La Recherche pour la protection, la conservation et la mise en valeur du patrimoine culturel » qui a eu lieu à Strasbourg du 22 au 24 novembre 2000 dans le cadre de l'Action-Clé « La Ville de Demain et le Patrimoine Culturel » du 5ème programme-cadre (1999-2002) de recherche et de développement de l'Union Européenne a été organisée sous la Présidence française de L'UE en étroite collaboration entre la CE et le Ministère française de la Culture et Communication avec le soutien des autorités locales. Cette conférence, qui a connu un très large succès, a eu pour but de promouvoir les coopérations en matière de recherche dans ce domaine et les transferts de technologie vers les entreprises européennes, notamment les PME, pour le développement de méthodes et technologies pour le patrimoine culturel, et aussi de sensibiliser et mobiliser les administrations locales et nationales ainsi que les organisations publiques et privées en charge de la gestion et de l'exploitation durable du patrimoine culturel. Plus de trente contributions scientifiques ont été présentées réparties en six sessions portant sur l'évolution des dommages et l'analyse coût-bénéfice de la préservation, la relation entre développement durable des villes et l'intégration du patrimoine culturel, les technologies optiques et les matériaux de conservation, les conditions microclimatiques, et les façons de concilier le tourisme avec l'exploitation et la gestion du patrimoine culturel. Ces Actes de la Conférence doivent permettre de conserver en mémoire les principaux apports scientifiques de cette manifestation qui seront utiles à tous ceux qui y ont assisté – plus de 300 participants et experts de 15 pays différents, avec près de 80 PME – et plus généralement a tous ceux qui contribuent ou s'intéressent dans un cadre européen élargi aux applications les plus récentes de ces recherches.

Summary

The 4th EC Conference on "Research for protection, conservation and enhancement of cultural heritage, opportunities for European enterprises" was held in Strasbourg on 22-24/11/2000. The conference was organised under the 5th Framework Programme, Key Action 'City of Tomorrow and Cultural Heritage' (1999-2002). It was organised by the French Presidency of the EU in close collaboration with the EC and the French Ministry of Culture and Communication, with the support of the local authorities. This conference was a great success. It had several aims: firstly, to promote co-operation in the field of research and the transfer of technology between European industries particularly the SMEs for the development of methods and technologies for Cultural Heritage, and secondly, to make aware and mobilise local and national administrations and also private and public organisations in charge of management and sustainable exploitation of cultural heritage. More than 30 scientific contributions were presented in six sessions dealing with many issues. These issues included the evolution of damage and cost benefit analysis of preservation, the relationship between sustainable urban development and the integration of cultural heritage, optical technologies and conservation materials, microclimatic conditions and the ways to reconcile tourism with the exploitation and management of cultural heritage. The Report of the Conference outlines the principle findings of this event, which will be useful both to those who took part – more than 300 participants and experts from 15 different countries, with almost 80 SMEs – and, more generally, to all those who are interested in the most recent applications of this research in an enlarged European framework.

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