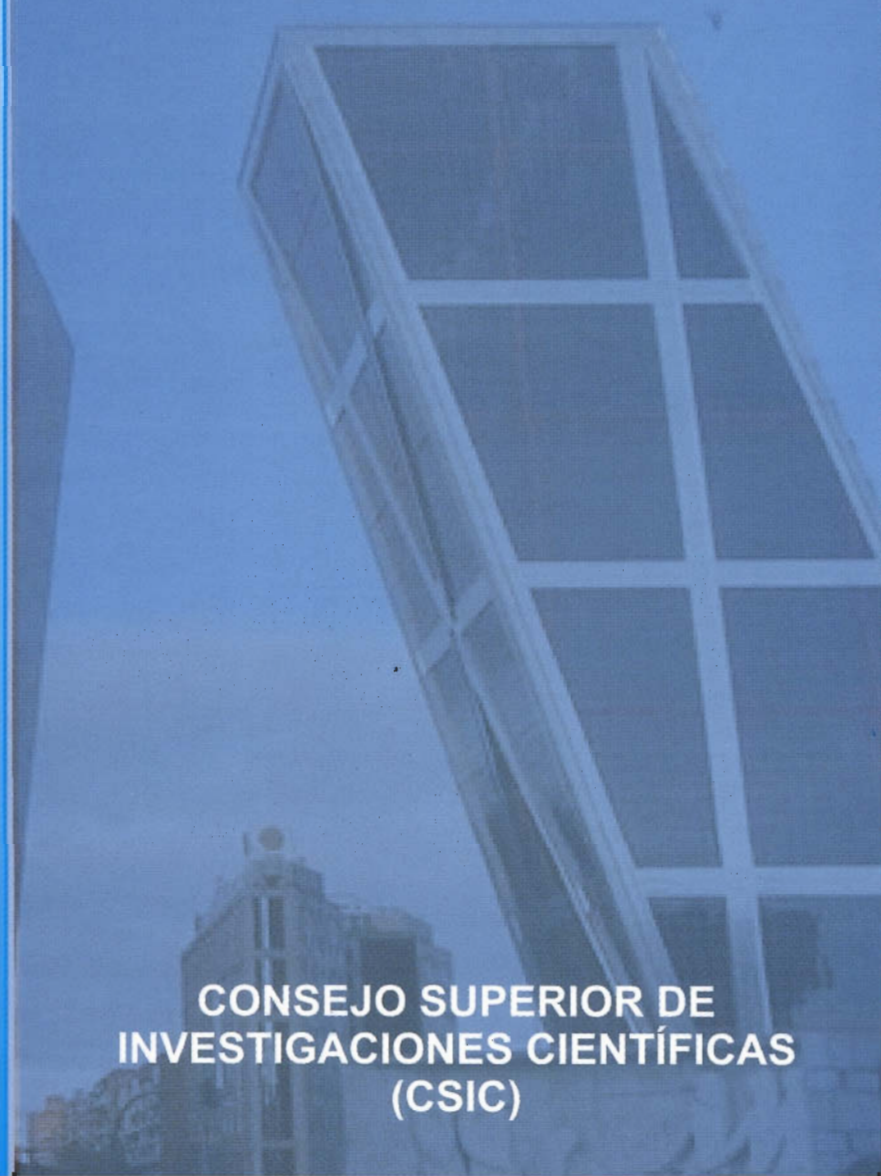
2006 HWC Madrid

21-24 JUNE 2006

Heritage, Weathering & Conservation

Book of Abstracts



CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS (CSIC)

CSIC

MINISTERIO DE EDUCACIÓN Y CIENCIA

Heritage, Weathering and Conservation 2006

BOOK OF ABSTRACTS

8th Thematic Network on Cultural and Historic Heritage Scientific Meeting
&
Stone, Weathering and Atmospheric Pollution Network Scientific Meeting

2006

Catálogo general de publicaciones oficiales
http://publicaciones.administracion.es

MINISTERIO
DE EDUCACIÓN
Y CIENCIA

CONSEJO SUPERIOR
DE INVESTIGACIONES
CIENTÍFICAS

UNIVERSIDAD
COMPLUTENSE
DE MADRID

NIPO: 653-06-018
ISBN: 84-00-08421-7
Depósito legal: M.25.055-2006

Impreso en España – *Printed in Spain*
Impreso en Taravilla
Mesón de Paños, 6 – 28013 Madrid

Heritage, Weathering and Conservation 2006

International Conference
Madrid, 21 – 24 June 2006

BOOK OF ABSTRACTS

Edited by

Rafael Fort, Mónica Álvarez de Buergo, Miguel Gómez-Heras, Carmen Vázquez-Calvo, César Chenel, M. José Varas, Elena Pérez-Monserrat

CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS
MADRID, 2006

ORGANIZATION:

Instituto de Geología Económica (CSIC-UCM)

ORGANIZING COMMITTEE

Rafael Fort (Chair)
Mónica Álvarez de Buergo (Co-Chair)
Miguel Gómez-Heras (Co-Chair)
Carmen Vázquez-Calvo (Secretary)
César Chenel
M. José Varas
Elena Pérez-Monserrat

CONTRIBUTORS:

SCIENTIFIC COMMITTEE

L. Aires-Barros
Inst. Superior Tecnico Lisboa (Portugal)

D. Anglos
FORTH-IESL (Greece)

D. Camuffo
CNR-ISAC (Italy)

M. Castillejo
CSIC-IQFR (Spain)

F. Criado
CSIC-IEGPS (Spain)

E. Doehne
Getty Conservation Institute (USA)

R. Esbert
Oviedo University (Spain)

B. Fitzner
RWTH-Aachen University (Germany)

E. Galán
Seville University (Spain)

M.A. García del Cura
CSIC-IGE (Spain)

H. Guillaud
CRATerre - EAG (France)

R. Koestler
Smithsonian Center for Materials (USA)

F. Mingarro
Complutense University of Madrid (Spain)

D. Mottershead
Portsmouth University (UK)

C. Price
University College London (UK)

R. Prikryl
Charles University (Czech Republic)

C. Sabbioni
CNR-ISAC (Italy)

C. Sáiz-Jiménez
CSIC-IRNAS (Spain)

E. Sebastián
Granada University (Spain)

A. Sgamellotti
CNR-ISTM (Italy)

S. Siegesmund
Göttingen University (Germany)

B.J. Smith
Queens University of Belfast (UK)

A. Török
Budapest Univ. Techn. & Economics (Hungary)

R. Van Grieken
Antwerp University (Belgium)

H.A.Viles
Oxford University (UK)

K. Zehnder
Federal Inst. of Techn. Zurich (Switzerland)

TABLE OF CONTENTS

Non-invasive imaging of ancient foundations status in Venice using the Electrical Resistivity Tomography technique

N. Abu-Zeid[1], G. Cocco[2], G. Santarato[1]

[1] Dipartimento di Scienze della Terra, Via Saragat 1, Blocco B, I-44100 Ferrara, Italy
[2] Project and consultant Engineer on behalf of Insula S.p.A., Venice (Italy). Via Marignana 69, Mogliano Veneto (Treviso), Italy

ABSTRACT

Electrical Resistivity Tomography (ERT) is a geophysical method of investigation that has proved to be an outstanding non invasive technique to evaluate the relative degradation state of historical buildings, both under normal dry conditions (e. g.: Cardarelli et al., The Leading Edge, 21, 467-470, 2002) as well as in a much more difficult environment, where materials are saturated with salt water, as is the case of Venice foundations (Abu-Zeid et al., in press on NDT and E Int.).

The reason of its success stems from the fact that highly saline environment doesn't affect neither resolution nor depth of investigation. Modern equipments allow for data to be acquired also under water with a multi-electrode array, which renders the method more attractive. In addition, the availability of powerful inversion software allows to estimate the resistivity model in two (2D) and three (3D) dimensions.

Using a multi-electrode equipment, a 16 m long portion of a canal's wall located at the "Lido" district (Venice, Italy) was investigated. The canal's protection wall consists of two adjacent bricks of about 25 cm total thickness aimed to protect the walls against damage caused by wave action generated by the transport vessels. In this case, the main danger is linked to the formation of voids behind the wall itself, which cannot be seen by the naked eye, nor by other indirect investigation tools such as the GPR technique due to the high energy attenuation due to the presence of salt water. Preliminary results about the foundation conditions were gained by visual inspection. These highlighted that the cement between the bricks was, in some cases, partially or completely absent hence permitting the complete extraction of the brick out of the wall. A closer inspection showed the presence of less compacted materials behind the bricks, which insinuated worries about the resistance of these materials. Based on these preliminary considerations, the consultant asked for the execution of the ERT survey in order to investigate the wall conditions also for the portion under water. The survey was conducted during the maximum tide level. The survey consisted in the execution of 16 vertical profiles each of 3 m long; the electrode spacing was 30 cm. The collected apparent resistivity data were inverted to obtain the best estimated distribution of the resistivity within the wall. The results suggested the presence of highly degraded zones within the first 30 cm of the wall in accordance with the preliminary visual inspection results. The test proved its efficiency in detecting highly degraded zones although immersed in salt water.

Corresponding author: g.santarato@unife.it

Performance of some commercial consolidating agents on porous limestones from Egypt

"Tura and Mokattam quarry"

H. Ahmed[1], Á. Török[2], J. Lőcsei[3]

[1] Helwan University - Academy of Applied Arts, Dept. of Sculpture and Monument Conservation, Orman Giza, Egypt
[2] Budapest University of Technology and Economics, H-1111 Budapest, Stoczek u. 2., Hungary
[3] H-2013 Pomáz, Széchenyi u. 21, Hungary

ABSTRACT

Two types of fresh Egyptian limestones from Mokattam and Tura quarry were used to test the consolidating performace of four different agents on porous limestones. All of these stones were intensively used in the monuments of Ancient Egypt (Sakkara Plateau, Old Cairo City). The fresh quarry samples were consolidated in laboratory conditions by silica-acid-aester, aliphatic-uretan-resin, acrylate resin and Paraloid-72. Before the consolidation and after the treatment the petrophysical parameters of more than 120 cubic samples (5 cm); such as bulk density, ultrasonic sound velocity, real and apparent porosity, Duroscope rebound values were recorded, water absorption by capilary and total immersion for treated and non-treated limestone samples were also compared. Mineralogical composition of non-treated limestone samples were detected by using XRD. The analyses have shown that quarry stones contain salts.

Test results have shown that the Tura limestone can adsorb from 2.90 to 5.60 % of stone consolidant and Mokatam limestone from 5.14 to 9.11%, depending on the Viscosity of the consolidant materials.

The absorption curves of different consolidants for different stone types reflect the differences in pore size distribution and viscosity of conserving agents as well as primary salt content of samples. Duroscope tests have shown that after the first cycle of consolidation there is insignificant change in surface strength of treated specimens compared to the non-treated cubes and is vary from one consolidant to the second.

Corresponding author: torokakos@mail.bme.hu

Natural re-colonization of restored mural paintings

E. Akatova, L. Laiz, J.M. Gonzalez, C. Saiz-Jimenez

Instituto de Recursos Naturales y Agrobiología, CSIC, Sevilla, Spain

ABSTRACT

The Necrópolis of Carmona (Sevilla, Spain) shows colonization by microbial communities of some of its tombs. Among the microorganisms provoking this biodeterioration, many violaceous spots were found in the Circular Mausoleum. From these spots, a *Streptomyces* sp. was isolated and produced a violet pigment in the culture media. The purpose of this study is to analyze the microbial community associated to the pigment-producing *Streptomyces* and to assess their expansion in the tomb.

Both molecular and culturing techniques were used in order to approach the detection of biodiversity with the functionality of the microorganisms found in these colonies. Molecular methods were based on the detection of microorganisms from DNA and RNA, extracted directly from minute samples collected at the cave and did not require the culture of these microorganisms. Culturing methods required the growth of these microorganisms on previously determined culture media. Media used in this study were appropriated for the growth of aerobic heterotrophs.

Results showed the presence of a large diversity of microorganisms detected from both molecular and culturing methods, and a large proportion of them presented homology to so far uncultured microorganisms. A number of microorganisms were present in these samples, and a fraction of them were metabolically actives suggesting their direct participation in the growth and expansion of the microbial community. Cultures allowed a detailed characterization of the function and capabilities of these microorganisms.

Corresponding author: katren80@yandex.ru

Control of biofilm growth through photodynamic treatments combined with chemical inhibitors: in vitro evaluation methods

H.L. Alakomi[1], A.A. Gorbushina[2], W.E. Krumbein[2], C. McCullagh[1], P. Robertson[3], M. Saarela[1], K. Rodenacker[4]

[1] VTT, Espoo, Finland
[2] ICBM, CvO University Oldenburg, Germany
[3] RGU, Aberdeen, UK
[4]GSF-IBB, Neuherberg, Germany

ABSTRACT

Scientific approaches to the safeguarding of stone monuments have evolved over the years to reach a high level of sophistication. Deeper comprehension of natural biodeterioration processes on stone surfaces has brought about a concept of complex microbial communities, perfectly adapted to rock surfaces growth conditions, and referred to as "subaerial biofilms". The practical implications of biofilm formation are that control strategies must be devised both for testing the susceptibility of the organisms within the biofilm and treating the established biofilm to alter its structure. Effective treatment strategies will incorporate chemical and physical agents that have been demonstrated to penetrate and kill biofilm organisms or treatments that target specific and important components of the biofilm matrix. A better understanding of the in situ biofilm response to selected treatments requires more study and more sophisticated use of biocidal systems.

Also the analysis and the treatment of these detrimental biofilms have made significant progress. A conventional use of single pure cultures as test objects for inhibition tests provides only preliminary information for a treatment. Reactions of controlling agents on harmful subaerial biofilms cannot be faithfully reproduced by single culture test. Cells associated with mineral surfaces and/or growing in biofilms are known to possess significantly different biological properties and are frequently refractory to conventional treatment. For a model biofilm a number of characteristic target species were selected, and their in vitro reactions to the substances in question have been studied.

Another line of evolution of techniques and application proposals is the combined use of biocidal chemicals together with physical activation techniques. The main goal of the study was a clarification of a general reaction of an entire subaerial biofilm system to the treatment suggested. A new testing technique for the integral assessment of a model biofilm formed *in vitro* has been elaborated and tested. A combination of scanning microscopy with image analysis was applied along with traditional cultivation methods and fluorescent activity stains. Such polyphasic approach allows a broad evaluation of the biofilm status and development. Biofilm growth and viability after various treatments is judged by this approach in a quantitative way using chemical, optical and image analysis techniques. An evaluation of the potential success of the newly developed application techniques is given.
This project is funded by the European Community Contract No. EVK4-CT-2002-00098.

Corresponding author: a.gorbushina@uni-oldenburg.de

Physical-mechanical characterization of hydraulic and non-hydraulic lime based mortars for a French porous limestone

M. Al-Mukhtar, K. Beck

Centre de Recherche sur la Matière Divisée, Ecole Polytechnique de l'Université d'Orléans, CNRS-CRMD, 1B rue de la Férollerie 45071 Orléans Cedex 2, France.

ABSTRACT

Sedimentary rocks such as limestone have been commonly used in the construction of several historically important monuments and structures for many centuries in various parts of the world. These structures have an important role towards educating the present and future generations about our human culture, heritage and civilization. However, due to the action of water and the influence of environment, these structures gradually deteriorate over a period of time. Several millions of dollars are annually spent for the maintenance and repairs of these valuable structures in various parts of the world.

There are various construction methods that have been developed based on experience to repair these structures. Investigations indicate clearly that development of suitable repair mortars requires obtaining quantitative technical data about the mechanical, physical and chemical properties of the mortars in addition to a rigorous evaluation process of their performance under real environmental conditions. The analysis of numerous cases of degradation of the heritage architectural monuments in Val de Loire (France) show that the damages often find their origin in the association of mortar – local limestone tuffeau.

This paper examines the mechanical and hydraulic behaviour of the association lime-mortar. Quick and hydraulic lime are used to compose mortars with the aggregates obtained from fragments and\or from powder of the stone tuffeau. Mortars so conceived will have to present similar physico-chemical and hydro-mechanical properties and compatible with those of the tuffeau. This study is interested in the establishment of reliable criteria to estimate the degree of compatibility stone-mortar.

Mechanical performance (compression, tensile and flexion strength) and hydraulic properties (capillary, permeability and water adsorption and desorption) are evaluated for mortar samples composed with different percentages of lime and water. Moreover, mechanical and hydraulic behaviour of sandwich samples (mortar between two pieces of cylindrical samples of stone) are also studied. Adhesion forces of mortar in the sandwich samples are also measured. Finally, in order to study the durability of the stone mortar with the environmental conditions changes, preliminary tests concerning the long term behavior of different samples are also carried out and some of these results will be presented in the conference.

Corresponding author: muzahim@cnrs-orleans.fr

Atmospheric particles in an urban background: damage to building stone

F.J. Alonso[1], F. Díaz-Pache[1,2], C. M. Grossi[1,3] & R.M. Esbert[1]

[1] Dep.de Geología (Petrología y Geoquímica). Universidad de Oviedo. Oviedo (Spain)
[2] Fundación Laboral de la Construcción del Principado de Asturias. Oviedo (Spain)
[3] School of Environmental Sciences, University of East Anglia, NR4 7TJ, UK

ABSTRACT

Different experimental methods were used to collect and analyze atmospheric particles at an urban background site: the Cloister of the Cathedral of Oviedo (Spain). Particles were collected during seven months using a cascade impactor sampler, carbon layers and stone surfaces. SEM-EDX through X-ray mapping and Featurescan –a program for automated particle characterization– were utilized for the morpho-chemical analysis of approximately 6.500 particles, ranging 0.05 – 1000µm. Particles were classified using an exhaustive statistical analysis, which included factor, cluster and discriminant techniques. This classification allowed us to establish main sources of particles and pollution. Fine particles present high sulphur contents and probably come from condensation of atmospheric sulfur dioxide generated by combustion processes. Dust or erosion particles, richer in calcium and silicon, tend to concentrate in coarser fractions. Stone surfaces develop a uniform gypsum coating after only few months of exposure. Results also evidenced a relationship between the type of particles and stone decay, which can be useful when suggesting recommendations for appropriate conservation interventions.

Corresponding author: jalonso@geol.uniovi.es

The effect of fire on an earthen building

M. Alvarez de Buergo[1], A. Török[2], M. Gómez-Heras[1], M. Hajpál[2], R. Fort[1], M.J. Varas[3]

[1] Instituto de Geología Económica (CSIC-UCM), Madrid, Spain (RTPHC-CSIC)
[2] Technical University of Budapest, Hungary
[3] Facultad de CC. Geológicas (UCM), Madrid, Spain

ABSTRACT

The aim of this study is to characterize the changes undergone by an earthen construction as the result of a fire. The study has been focused on an earthen rural building located in the outskirts of Becilla de Valderaduey, Valladolid (Spain). This building was selected due to the fact that it was affected by a fire event and because both earthen building materials –rammed earth and adobe- were used for its construction. This research has been developed within the framework of both *Action COST C17: Built Heritage: Fire Loss to Historic Buildings* and a Hungarian-Spanish Cooperation (*HH2004-0036, Behaviour of earth-based building materials and stones in fire*). The building presents only remains of three of the four walls; the Eastern wall completely collapsed. The Southern wall (the best preserved) and the Western one were built with rammed-earth; the Northern wall was built with adobe. The ruined construction had a rectangle ground plan; from the remains left, we can inferred it was 7 m wide, longer than 11 m (partially collapsed) and, at least 3,5 m high.

The reddened section of the adobe wall (Northern wall) is 17 cm thick from the surface; and comprises, from the exterior to the interior: a red layer of 4 cm thick, followed by a discontinuous blackish layer of around 6 cm thick, a deeper reddish layer and, finally, the unfired adobe. The reddened section appears in the first meter of height of the wall. The deeper in the wall the thinner the reddened layers (wedge-shaped). In the Southern wall, built of rammed-earth, the reddish layer takes up 10 cm deep favouring a spalling process and its detachment through the fired-unfired interface, and no blackish layer is observed. The reddening process affects up to 2 m high. A difference in colour is observed in the superimposed layers of the rammed-earth wall.

The results of the analyses on sixteen samples, including fired and unfired adobe and rammed-earth, are presented. The effect of the fire on these materials was assessed by comparative analyses between fired and unfired areas. Theses analyses included: X ray diffraction (XRD), mercury intrusion porosimeter (MIP), thin sections under polarizing microscope, and observations under Scanning Electron Microscopy (SEM) together with EDX analyses.

Corresponding author: alvarezm@geo.ucm.es

Sandstone weathering rates at Angkor temples (Cambodia)

M.F. André

Laboratory of Physical Geography – GEOLAB – UMR 6042-CNRS
University of Clermont-Ferrand, France

ABSTRACT

Angkor was listed by UNESCO among the World Heritage Sites in 1992. It includes over 100 structures spread over 200 km^2, that have been mostly cleared of mines and are currently managed by APSARA (Autorité pour la Protection du Site et l'Aménagement de la Région d'Angkor). The Angkor temples (9^{th}-13^{th} centuries) offer reliable reference surfaces, with accurate chronological control, based on epigraphic and stylistic studies carried out by the EFEO (Ecole Française d'Extrême-Orient) since 1907 (e.g. Coedès 1937-66, Stern 1965). Sandstone flaking is the main expression of the historical stone decay the evaluation of which has been undertaken in fifteen temples. These preliminary surveys provide two distinct weathering rates : 1. a general back weathering of bas-reliefs and temple-mountain tiers at 1.8-7.7 mm ka^{-1}; 2. a localized accelerated weathering of pillars, door frames and elephant statues due to capillary migration at 7.7-46.3 mm ka^{-1}. Further investigations are in progress to refine these tentative evaluations and to search for causative processes through 3D-mapping of weathering forms and associated phenomena (salt efflorescences, biofilms, …) at some selected sites.

Corresponding author: m-francoise.andre@univ-bpclermont.fr

Influence of capillary properties and evaporation on salt weathering of sedimentary rocks

M. Angeli[1], J. P. Bigas[2], B. Menendez[1], R. Hébert[1], C. David[1]

[1] Department of Earth Sciences and Environment – University of Cergy-Pontoise
5 Mail Gay-Lussac, Neuville-sur-Oise, 95031 Cergy-Pontoise, France
[2] Department of Civil Engineering – University of Cergy-Pontoise
5 Mail Gay-Lussac, Neuville-sur-Oise, 95031 Cergy-Pontoise, France

ABSTRACT

Salts are one of the main destructive agents governing the decay of natural building stones. They have multiple origins: the atmosphere (halite from seashore, S or CO_3^{2-} from urban pollution), external agents (de-icing salts), the stone rearranging (cement mortars)… If salts are present, they propagate into the stone through the porous network, carried by the water.

We studied the relationships between the pore network properties and salt transport in different sedimentary rocks. Several capillary and salt tests have been performed in order to evaluate the importance of the capillary properties in salt decay. The studied rocks are three Lutetian limestones composed of more than 90% of calcite: the "liais" with 13% porosity is heterogenous and very competent; the "roche fine" is homogenous, very porous (36%) and very fragile; the "roche franche" with 20% porosity has intermediate properties. We use also two types of Fontainebleau sandstones composed of more than 95% of quartz: the "grès dur" which is the most competent with merely 6% porosity; the "grès tendre" which is much less competent and has a porosity up to 13%.

In the first experiment, we use mirabilite saturated water for capillary imbibition; in the second experiment we use clean water and a thenardite saturated sample; in the third one, the sample is saturated with thenardite and the solution with mirabilite. We work on 7x7x7 cm^3 samples, but we also studied the size effect on other sample sizes (e. g. 25x3x2 cm^3 bars).

We observe desquamation in the subefflorescence zone for the "roche fine". This desquamation occurs for tensile strength around 2 MPa and below. For the "liais" and the "roche franche", the efflorescence zone is closely related to the heterogeneities of the samples. For instance, in a macrofossil-rich limestone ("roche franche"), the boundaries of the efflorescence zone follow some of the shells who act like a permeability barrier. We also notice in the experiment with the 25x3x2 cm^3 sample a remarkable illustration of the relationship between capillary imbibition and evaporation.

In order to be as close as possible to stone conditions in buildings and monuments (i.e. taking into account the fact that evaporation is not allowed in every direction) we performed the same experiments with only one side open to evaporation, and the others isolated by an aluminium film.

Corresponding author: matthieu.angeli@geol.u-cergy.fr

Main constraints in numerical modeling of weathering phenomena – preliminary studies

M. Angeli[1], B. Menendez[1], J.P. Bigas[2], C. David[1], R. Hébert[1]

[1] Department of Earth Sciences and Environment – University of Cergy-Pontoise
5 Mail Gay-Lussac, Neuville-sur-Oise, 95031 Cergy-Pontoise, France
[2] Department of Civil Engineering – University of Cergy-Pontoise
5 Mail Gay-Lussac, Neuville-sur-Oise, 95031 Cergy-Pontoise, France

ABSTRACT

Stone weathering is a very complex mechanism, involving physical, chemical, biological and geological processes. For the moment it is very hard to predict the decay of a stone, even if we know many intrinsic properties of this stone and the environment in which it evolves.

There are mainly two ways of modelling natural phenomena: one using statistical methods and the other one based on physics equations. In order to make the most reliable model, we chose to start on a model based on the mineral properties, at the grain scale. We then chose to focus on salt weathering, since a lot of thermochemical data is available for estimating the stresses induced by salt crystallization.

First we have performed accelerated salt weathering experiments with different sedimentary rocks (Lutetian limestones, sandstones). Most of the time, we followed the European Standards and made a continuous monitoring of weight and aspect, and sometimes also colour, P-wave and S-wave velocities. These experiments provided us with data to constrain our phenomena.

We thus measured some intrinsic stone parameters like the traction strength via Brazilian tests, the capillary properties, the pore size distribution through mercury injection tests, and we obtained SEM micrographs of the induced damage at the grain scale. We check the reliability of different existing estimators and use our results to focus on what we think are the most important parameters in salt weathering (porous network, tensile strength and salt chemical potential) with the aim of including them in a simple model for stone decay prediction.

Corresponding author: matthieu.angeli@geol.u-cergy.fr

Microclimatic factors affecting composition and distribution of of photrophic communities in monuments

X. Ariño[1], A. Gomez Bolea[2], C. Saiz-Jimenez[3]

[1] BMA S.L
[2] Universitat de Barcelona, Unitat de Botànica
[3] Instituto de Recursos Naturales y Agrobiología de Sevilla (CSIC), Spain
(RTPHC-CSIC)

ABSTRACT

Buildings, monuments and archaeological sites are usually associated with rapid biological colonization, especially by pioneer microorganisms of bacteria, actinomycetes, cyanobacteria, algae, fungi and lichens, a natural process creating a living mosaic of colours and textures.

As far as microbial organisms is concerned, it has been suggested that while both the composition and the structure of the substratum are important in determining the nature and composition of communities, it is the microclimatic factors which determine the abundance and distribution of these organisms. Both colonization and distribution of taxa are directly related to the environmental conditions and some communities replace others depending on the orientation. Of these, moisture availability is the major constraint affecting microbial diversity.

Cyanobacteria, algae and lichens, among photosynthesis-based organisms, are the pioneers that inhabit dry walls receiving abundant sunlight. In addition, there is a certain variability in the ratio of the number of taxa of cyanobacteria vs algae depending on the availability of water.

The presence of such communities, and their total biomass, is a consequence of a number of factors affecting the monument at the long-term. For this reason, the close relationship between these communities and microclimatic factors suggests that it may be possible to use them for biomonitoring, as a tool for assessing climatic global change. On the other hand, small changes on microclimate may represent a significant disturbance on the natural balance between organisms and the subsequent modification of biodeterioration processes, including those from an aesthetic point of view.

Corresponding author: dtec@bmasl.com

Scientific/documentary study of stone materials in the Palace of the Congress of Deputies in Madrid

M.I. Báez[1], J.L. Baldonedo[2], F.D. Sanz[3], P. Garcés[3]

[1] Departamento de Pintura-Restauración. Facultad de Bellas Artes.
Universidad Complutense de Madrid. Spain
[2] Centro de Miscroscopía y Citometría. Universidad Complutense de Madrid. Spain
[3] Departamento de Construcción y Tecnología Arquitectónicas. Escuela Técnica Superior de Arquitectura. Universidad Politécnica de Madrid. Spain

ABSTRACT

The Palace of the Congress of Deputies is one of the most emblematic examples of late classicist architecture in Madrid. In addition to being highly representative, it is remarkable for the wealth of decorative elements which were added to the interiors, especially in view of the material and cultural poverty of the period.

Within the line of research that the authors have been pursuing with the object of completing a documentary and technical study of a major part of the Palace's mural decorations, the aim of the present work was to identify and characterize various eminently architectural stone materials (granite and limestone). Specifically, the study has focused on the stone of the facade and the various different elements in the exterior, completing the study is an analysis of the marble of the fireplaces in the Conference Hall. The work follows two parallel lines:

- On the one hand, the archived documentary information has been used to determine the various materials employed and their distribution in the building, and most importantly, it has been possible to identify approximately where they were quarried.
- At the same time, microsamples taken directly from the building have been used to conduct characterization assays: x-ray diffraction (x-ray spectrometry), and morphological study and microanalysis by x-ray energy dispersion (EDX) using scanning electron microscopy (SEM).

The data presented here are the result of a documentary and technical study of the samples, from which it has been possible to arrive at a proper characterization of the materials. On the basis of these data, we are proceeding in a second stage to make a comparative study of samples taken from the quarries cited in the historical documentation.

Corresponding author: mibaez@art.ucm.es

Characterization of marble stuccos in Writing Rooms in the Palace of the Congress of Deputies in Madrid, Spain

M.I. Báez[1], A. Rodríguez[2], J.L. Baldonedo[2], M.J. García Molina[1]

[1] Dpt. de Pintura-Restauración. Facultad de Bellas Artes. Universidad Complutense de Madrid, Spain
[2] Centro de Miscoscopía y Citometría. Universidad Complutense de Madrid, Spain

ABSTRACT

Marble stucco is an important variety of mural decorative technique which attained great splendour starting in the 17th-18th centuries thanks to the growth of French sumptuary architecture and the taste for noble materials. With work of this kind it is possible to imitate rich marbled surfaces using cheap and plentiful materials (gypsum and lime).

There are numerous examples of marble stucco in Spain, and one of the finest can be found in the Palace of the Congress of Deputies in Madrid. The principal chambers of the original edifice were designed with a wealth of mural decorations, from frescoes to gilt complexes in relief; but one of the elements that best characterizes this varied decorative work is undoubtedly the fine imitation-marble stucco-work that covers much of the walls of the Palace's most important spaces: the Lobby, the Conference Hall with its four adjoining Writing-Rooms and the Session Hall.

The authors are part of a cross-disciplinary team of researchers in the sphere of Conservation of Cultural Assets which is currently working on the Scientific Research and Technological Development (R&D) Project presented here. The objective is to complete a documentary and technical study of the marble stucco work in the Palace of the Congress of Deputies as an artistic assemblage. It is proposed to present the methodology followed in characterizing the materials used, and the first results to emerge. The study is based on numerous microsamples taken from the stuccos. The salient aspects of the study are:

- Morphological study of individual particles by light microscopy (LM), scanning electron microscopy (SEM) and transmission electron microscopy (TEM).
- X-ray energy dispersion (EDX) microanalysis with SEM and TEM. Electron diffraction (ED) with TEM.
- X-ray diffraction (XRD) by X-ray spectrometry.

At the time of presenting the results, we have completed our analysis of the four Writing-Rooms in the palace, which are the work of Italian stuccoist Francisco Poncini. With these data we have been able to complete the characterization as regards the nature and preparation of the materials, especially the pigments used by the artist.

Corresponding author: mibaez@art.ucm.es

Characterization of the metallic threads in some medieval court gartments and ecclesiastical vestments by using SEM-EDS

I.Z. Balta[1], M. Donten[2], I. Cretu[3]

[1] National Research Laboratory for Conservation and Restoration of Mobile Cultural Heritage, Bucharest, Romania
[2] Faculty of Chemistry, Warsaw University, Poland
[3] National Art Museum of Romania, Bucharest, Romania

ABSTRACT

Metallic threads prelevated from some medieval court garments and ecclesiastical vestments, dating from 15th and 16th century – brocades and embroideries from the Medieval Art Gallery collections within the National Art Museum of Romania, former preserved in the Wallachian and Moldavian monasteries, were studied by SEM-EDS and optical microscopy.

The information obtained regarding their physical and chemical nature, structural features of the metal wrapping the textile core fibers, metal composition, surface homogeneity and width of the wrapping metal, they were used to determine the technique of production and to clarify and complete the existing information concerning their provenance. Some difficulties were encountered during the SEM-EDS analysis, resulting from the metal corrosion and from the metal thread unhomogeneity in the manufacturing process or because of textile handling.

Conclusions were drawn by comparing the resulted data on their nature with the existing data on the composition and structure of metallic threads, from similar categories of textiles provenating from Western Europe and Near Orient.

Corresponding author: ileana_balta@yahoo.co.uk

Laser cleaning of archaeological metal objects

J. Barrio[1], M. Arroyo[1], J. Chamón[1], A.I. Pardo[1], A. Criado[2]

[1]Dpt. of Prehistoric and Archaeology. Universidad Autónoma de Madrid (UAM). Campus of Cantoblanco, 28049 Madrid, Spain.
[2]Universidad Complutense de Madrid, Facultad de Ciencias Químicas, Dpto. de Ciencia de los Materiales, Madrid, Spain

ABSTRACT

Laser cleaning techniques is one of the procedures which are being proven to be the best chance of cleaning metal archaeological artifacts. Beside traditional mechanical cleaning techniques, laser cleaning gives some interesting advantages that we have appreciated in our work.

Our main objective is the application of the most suitable cleaning techniques and the most effective treatments of restoration/conservation in order to recover those metal artefacts; specially, innovation techniques which are now in at the forefront of the Archaeological Metallic Heritage intervention methods.

Archaeological metal research is a field in which enough experience has not been yet acquired in order to get contrasted results. However, the recovering of the original surface of the artefacts, now turned into a patina, demands the application of methods which allow a more effective conservation. At this point, laser is expected to become one of the best techniques in the conservation/restoration field.

Experiments have been performed in our Laboratory with iron, bronze and gilded copper pieces, all corresponding to different chronologies: Roman, Prerroman and Islamic. All of these pieces show a severe general corrosion of its surface, with deposition of oxides, hydroxides and chlorides of different compositions in a layer which hides the original surface of these pieces. In all cases, before carrying out the intervention, a characterization of the corrosion layers has been performed, using various techniques: radiology test, X-Rays diffraction, scanning electronic microscope (SEM), X-ray energy dispersed spectrometry (EDS), electron microprobe. These tests have allowed us to identify the corrosion products that should be eliminated.

Our Laboratory laser facility consists in a solid-state optics of Nd:YAG (Yttrium Aluminium Garnet crystal, dopped with Neodymium) equipment. It has a wave lenght of 1064 nm and operates in Short Free Running Mode. Pulse duration ranges between 60 and 120 microseconds and the energy per pulse goes from 50 to 1000 mJ.

Results of laser cleaning of archaeologic metal surfaces have been successful, obtaining a high detail recovering of the original surface of these pieces. Therefore, at the expense of more experience in this field, this technique appears to be a technological resource of great possibilities for the restoration of metallic heritage.

Corresponding author: jchamon@quim.ucm.es

Ultrasonic sound test on stone: comparison of indirect and direct methods under various test conditions

R. Bellopede, L. Manfredotti

Politecnico di Torino, C.so Duca degli Abruzzi, 24, 10129, Torino, Italy

ABSTRACT

Non-Destructive Tests (NDT) represent a useful tool to investigate the state of conservation of monumental and cultural heritage. Among all the available NDT, the ultrasonic technique is one of the cheapest, portable, easy and practical to use. Besides, the use of this technique on the stone, predominant element of cultural heritage, has been spread in the recent years and some international papers deal with its application [Christaras, B. 2003, in Proceeding of Industrial Minerals and Building Stones (ed. Yüzer, E. Ergin, H. & Tuğrul, A.) (Istanbul, Turkey)], [Weiss, T. Rasolofosaon, P.N.J. & Siegesmund, S. 2002, in Natural Stone, Weathering Phenomena, Conservation Strategies and Cases Studies (ed. Siesgesmund, S. Weiss, T. & Vollbrecht, A.) (London, UK)].

However, in the field of the study of the weathering and conservations of the natural stones, the definition of the characteristics of the ultrasonic technique and of its limits, in relation of the kind of stone detected, could be a reference for all the workers of the sector.

A series of ultrasonic tests by means of transmission technique (both with direct and indirect method) on different rock categories (marbles, limestones and sandstones) have been executed both *in situ* and in laboratory. To investigate the limits of the ultrasonic method and to define the best applicable methodology many tests with different conditions have been performed.

The research has led to: define the accuracy of the measurements for each kind of stone analysed, make a comparison between the direct and indirect method, evaluate the influence of the pressure applied during the measure, study of the attenuation, correlate the results obtained with different frequencies of measure. The laboratory tests have been performed both on specimens artificially decayed and on specimens naturally decayed until a time of three years.

After the definition of the advisable parameters to perform the ultrasonic tests on the rock analysed a correlation between the results of ultrasonic test and the results of destructive test have been executed.

Specimens are chosen and part of tests performed within the European Project McDUR-Acoutherm (“Effects of the Weathering on Stone Materials: Assessment of their Mechanical Durability”- Contract no. G6RD-CT-2000-00266 – GRD3-CT2001-60001) dealing with the evaluation of weathering degree of stone performed with Non Destructive Tests.

Corresponding author: rossana.bellopede@polito.it

The influence of the humidity on the decay of marble

R. Bellopede[1], C. de Regibus[1], N.M. Luodes[2], P. Marini[1]

[1] Politecnico di Torino, C.so Duca degli Abruzzi, 24, 10129, Torino, Italy
[2] Stone Pole Oy, Kuhnustantie 10, 83900 Juuka, Finland

ABSTRACT

From site inspections and from analysis of the different climate between Italy and Finland has been noticed that a factor that can influence the deterioration of marbles used on building thin claddings could have been the humidity. The effect of the humidity has been studied and pointed out throw two different laboratory tests in which three kinds of marble have been selected depending both on their availability on building sites both on their structure and composition.

During one test the two Italian calcitic marbles and one Greek dolomitic marble have been subjected to weathering action combining changes of humidity and temperature.

The marbles have been subjected to thermal cycles between -10°C and +70°C, range of temperature that include damages from frost, heat and that can represent extreme weathering conditions, mainly reachable in the Nordic countries.

In order to evaluate the effect of the humidity, one thermal test has been performed maintaining the humidity at 20% and the other at 90%. In each test the specimens have been divided in three groups and have been subjected to 20, 40 and 60 cycles. At the end has been analysed the effect of the weathering on the physical and mechanical properties of the marble using both non-destructive and destructive methods. The difference of water absorption performed before and after the thermal test shows that there has been a surface decohesion while the evaluation of flexural strength on fresh and deteriorated material shows the weakening of the mechanical characteristics due to the thermal cycles and even more due to the humidity.

A second test has been performed to investigate another effect of the humidity on marbles: the thermal expansion. This test has been executed within the European Project TEAM ("Testing and Assessment of Marble and Limestone" Contract no. GRD1-1999-10735) and focused on the analysis of thermal expansion of marbles subjected to thermal cycles in wet conditions. The selected marbles have been immersed in water and subjected to several heating cycles from 20°C to 80°C. Their dilatation has been recorded during the test and from the results obtained is visible that the marbles reacted in a different way depending on their structure and on their composition.

The marbles subjected to the tests showed coherence in the results obtained and the effect of the humidity is readable on all of them even if with different entities.

Corresponding author: nike.luodes@kivikeskus.com

The decolouration of brecciated black marbles used in heritage monuments in Alicante

D. Benavente[1,2] , A. Bernabéu[1,2], R. Fort[1,3], J. Martínez Martínez[1,3], M.A. García del Cura [1,3]

[1] Laboratorio de Petrología Aplicada. Unidad Asociada CSIC-UA. Spain (RTPHC-CSIC)
[2] Dpto. Ciencias de la Tierra y del Medio Ambiente. Universidad de Alicante. Spain
[3] Instituto de Geología Económica. CSIC-UCM. Spain (RTPHC-CSIC)

ABSTRACT

The influence of the weathering of physical surface properties on the colour variation of a black brecciated marble is studied. An experimental laboratory test is used for simulating the weathering process and is compared to outdoor stones of monuments.

In this study, one geological marble, formed by contact metamorphism, was chosen because of its colour and petrographic characteristics: the *Jabalina Stone* or *Black Stone of Callosa* (a Triassic black calcodolomitic marble). Jabalina Stone is a fine-granoblastic heteroblastic calcitic marble with dolomite and has xenoblastic and hypidioblastic textures. The main structural features are pre- and posttectonic calcite veins, which mainly exhibit a white colour and often define a brecciated structure. Dolomite seldomly has premetamorphic textures (dolomicrite), in which the calcite has a micro and/or mesocrystalline texture. Ferroan dolomite and ankerite are associated to veins and stylolites. The *Jabalina Stone* presents low chroma and lightness and is widely used in heritage monuments in the Alicante province. In particular, three historical monuments from Orihuela, dating from the 15th, 16th and 17th centuries in Orihuela have been studied: the School of Santo Domingo, the Salvador Cathedral and Nuestra Señora de Monserrate Church.

A detailed study of the evolution of colour, gloss and roughness is realised. Moreover, in order to study the stone surface, scanning electronic microscopy (SEM) and X-ray photoelectron spectroscopy (XPS) are used. The total colour changes, mainly the lightness, and surface roughness are particularly affected during the weathering process. Moreover, results from both SEM and XPS show that the changes in the oxidation state of chromogen minerals cannot be clearly determined. This fact explains that decolouration is due mainly to changes in surface roughness rather than chemical reactions that may alter the oxidation state of the chromophore in the chromogen of the stone.

This research is based on Project MAT2003-01823 .

Corresponding author: david.benavente@ua.es

Cementation of porous building stone by an accelerated carbonation process

A. Bernabéu[1,2], M.A. García del Cura[2,3], C. Hills[4], P. Carey[4]

[1] Laboratorio de Petrología Aplicada. Unidad Asociada CSIC-UA. Alicante, Spain (RTPHC-CSIC)
[2] Departamento de Ciencias de la Tierra y del Medio Ambiente. Universidad de Alicante, Spain
[3] Instituto de Geología Económica. CSIC-UCM. Madrid, Spain (RTPHC-CSIC)
[4] Department of Earth and Environmental Sciences. Centre for Contaminated Land Remediation. University of Greenwich. Chatham Maritime. Kent. United Kingdom.

ABSTRACT

In order to prevent the decay of porous stones commonly used both in ancient buildings or monuments and actual constructions, the application of consolidating products is extended. The main aim of these products is to strengthen the weathered stones and to improve their durability.

Nowadays alternative approaches have been investigated based in the cementation of porous materials by products with similar nature than minerals which compound the stone consider. These are mainly based in methods, with which it is possible to induce the new formation of mineral phases, like calcite. This will overcome the negative effects observed for the organic products, related both to their chemical structure and to the use of solvents.

Natural carbonation of aqueous solutions of calcium hydroxide (its saturated solution is often called limewater) have been used for many centuries to protect and consolidate limestone. Calcium hydroxide itself does not appear to consolidate stone, but when in solution or a wet state it reacts with atmospheric carbon dioxide by a carbonation process, insoluble calcium carbonate is formed.

In this work cementation of a porous building stone, (a biocalcarenite named Bateig stone), was carried out by the carbonation from solutions inside the porous system. The solutions employed to generate the corresponding carbonate were: $Ca(OH)_2$; $Ba(OH)_2$ and MgO. The aim of this carbonation is the improvement of quality of the porous material. In this work two different relative humidities were used.

The physicochemical process involved in the carbonation can be summarized as follow:

1) Diffusion of CO_2 in the gaseous phase and its dissolution in the "pore water". (The pore water is in each case the different solutions employed)

2) The reaction of the CO_2 with the solution in pore system.

The evaluation of carbonation effect in the samples have been carried out by the study of the variation of the porous system: (% porosity, pore size distribution) and the Identification of the carbonated phased formed inside the porous system by SEM.

Corresponding author: Ana.Bernabeu@ua.es

Cycles of dry and wet depositions: effects on G85 bronze exposed to rain/particulate solutions

E. Bernardi[1], C. Chiavari[2], C. Martini[2], D. Prandstraller[2], L. Morselli[1]

[1] Dep. of Industrial Chemistry and Materials, University of Bologna - Via Risorgimento 4, 40136 Bologna (Italy)
[2] Institute of Metallurgy, University of Bologna - Via Risorgimento 4, 40136- Bologna (Italy)

ABSTRACT

With the aim of investigating cause-effect correlation between atmospheric depositions and corrosion of outdoor metals and of evaluating the decay evolution, a multidisciplinary work, inclusive of numerous monitoring techniques, has been set up. In this research project, the test materials are G85 bronzes, that are typical alloys used for artistic casting.

In the first phase of the project, a condition of stagnation was simulated through the wet-dry technique. In particular, a comparative study was performed by following the corrosion behaviour of bronze specimens exposed either to natural rain or to an artificial solution very similar in terms of concentration to the main inorganic pollutants [Morselli, L., et al. *App. Phys. A-Mater* 79 (2004) 363-367]. To deeply understand these mechanisms, a new phase of the project has started, in order to simulate a more realistic cycle of dry deposition followed by rain. To this end, an appropriate dropping device has been designed.

In this study, real atmospheric particulate, collected in the urban area of Bologna, has been characterized and spread on the specimens. Then, the real rain, collected in the same area, has been dripped on the bronze for a week. The leaching rain has been collected and the amount of metal ions transferred to the solution analysed. The same experiment have been performed with the synthetic rain and the results compared.

The microstructure of the bronze and the morphology of corrosion products have been studied by SEM with EDS microprobe; the phase composition of the patina has been analysed by X-Ray Diffraction (XRD). In particular, the evolution of the patina composition has been followed during the tests by ESEM (Environmental Scanning Electron Microscope) integrated with μ-Raman probe.

Preliminary results are reported.

These comparative procedures allow the formulation of interpretative models of the bronze corrosion phenomena. The correlation between data collected in real conditions and laboratory experiments consents to evaluate the reliability of the proposed models, then their effectiveness for diagnostic and conservative purposes.

Corresponding author: bernardi@ms.fci.unibo.it

Reliability of surface analyses on ancient historical glasses

R. Bertoncello, B. dal Bianco

Dipartimento di Scienze Chimiche, Università degli Studi di Padova. via Marzolo 1, 35131 Padova, Italy
Consorzio Interuniversitario Nazionale per la Scienza e Tecnologia dei Materiali (INSTM) via Varchi 59, 50132 Firenze, Italy

ABSTRACT

The study intends to present evidences of alterations induced on ancient glass analyses by surface techniques. The analyses, partly conduced on historical samples, and partly verified on new glasses used to simulate the degradation effects, employ the main surface techniques, such as XPS (X-Ray Photoelectron Spectroscopy), SIMS (Secondary Ion Mass Spectrometry) and RBS (Rutherford Backscattering Spectrometry).

The first alteration that can be observed at first glance when glass or ceramics have been subjected to a X-Ray beam (typically XPS, X-ray fluorescence and XRD) is the formation of a coloured spot in the analyzed area of the sample. This phenomenon is known in literature and it is related to the formation of electron traps in the sample. Heating the sample for some minutes will usually eliminate the coloured spot so that the treatment is considered to be non destructive for the sample, due to the fact that the melting temperature of the glass is higher. Even RBS analyses through the Helium ion MeV bombardment can produce a coloured spot, in this case however the phenomenon is thermally irreversible.

A second problem typical of the surface analyses is the reliability to estimate the chemical composition of a sample through a depth profile. XPS and SIMS usually adopt a method that involves subsequent ion-sputtering phases on the surface of the sample, that are low invasive on the sample itself (the sputtered area is generally lower than 2x2 mm^2) but are essential for the surface analysis. During sputtering, some ions can be preferentially sputtered or induced to migrate inside the sample so that they are not more visible at the surface in their correct position and amount.

The last question deals with the idea that a thin slice of sample keeps the complete information on its structure and composition. Some drastic treatments, like preparing slices using a water cooled saw, induce a general leaching of the glass surface that looses its high mobile ions (typically alkaline ions) due to the combined effects of water and high local temperature action.

Corresponding author: barbara.dalbianco@unipd.it

Architectural surfaces in cultural heritage - conservation and restoration of plastered façades. The "Liebfrauenkirche" in Kitzbühel, Tyrol, Austria

T. Bidner[1], M. Pescoller[2], A. Diekamp[3], W. Hauser[4]

[1] TB/B Private Consultant – Restoration and Preservation of Historic Buildings, Tulfes – Innsbruck, Austria
[2] Pescoller Werkstätten Gmbh, Bruneck, Italy
[3] Institute of Mineralogy and Petrography, University of Innsbruck, Austria
[4] Austrain Federal Office for the Care of Monuments, Innsbruck, Austria

ABSTRACT

Architectural surfaces, as a monuments skin, are meeting the emotional value inherent to the first confrontation of man with a historic building. The recognition and acceptance of architectural surfaces as an important dimension of cultural heritage is a fairly recent development within the preservation of historic buildings. For many years original plaster, render and their colour schemes have been "renewed" by contemporary "ideal technical solutions". Conservation / Restoration of original architectural surfaces is today vital to meet the concept of authenticity [Jokilehto, J. (1997) In Architectural Surfaces–Conservation and Restoration of Plastered Facades; pp.44–54, Bundesdenkmalamt Österreich, Arbeitshefte zur Baudenkmalpflege, Kartause Mauerbach]. Due to its built tradition, the use of plaster and render is most common in the alpine region since Late Romanesqu/Early Gothic times. From the need to find sound, sensitive techniques for the conservation / restoration of these historic surfaces, intensive research has been inspired at the University of Innsbruck since some years now, to characterise and understand, in a technical sense, the different types of historic plaster, mortar and render in the alpine region [Diekamp, A., et al (1995) In 4th Eurolime-meeting at Ballenberg, August 4 – 6th 2005; Eurocare-project EU 791 "EUROLIME"; Diekamp, et al (2006) in: Heritage, Weathering and Conservation – Promoting Networks on Heritage Sciences; Instituto de Geologia Económica, Madrid, 21-24 June 2006]. The "Liebfrauenkirche" in Kitzbühel, Tyrol, Austria, is the best example at the moment for modern conservation of architectural surfaces, respecting the original materials in its individuality, and even state of decay, in Tyrol. Detailed investigation by an interdisciplinary team of experts revealed the different historic surfaces still preserved, in their historic-aesthetic value, their material properties and decay, and gave way to an individual conservation / restoration concept. We present the methods and results of these investigations, focusing on Mineralogy, Physics and Chemistry of the original materials and conservation methods.

Corresponding author: thomas.bidner@tb-bidner.com

Failures of architectural heritage due to wind effects

J. Bláha, M. Drdácký, S. Pospíšil

Institute of Theoretical and Applied Mechanics, Academy of Sciences of Czech Republic,
Prague 9, Prosecká 76, 19100, Czech Republic

ABSTRACT

The article presents recent research results in the field of wind effects on the structures with high historical value like churches, castles and watchtowers with many structural details of non-uniform shape. There is naturally a large complication in general description of wind effects on such structures.

The negative effects of the wind load may result not only in the destruction but also into an accelerated weathering exposure and therefore to the damage of the structure. A database of damages caused by strong or moderate winds will be presented. On the basis of a historical survey, the structures and structural elements are classified according to their susceptibility to wind effects.

A detailed research is focused on the field analyses as well as experimental and numerical investigations of the two basic groups of historical towers that despite their different shapes have generally some similar patterns.

An experiment is performed on two scaled models of selected church towers in the Boundary Layer Wind Tunnel. The pressure and wind velocity measurement serves primarily as the prototype for the subsequent numerical models, which can be used for parametrical studies.

Case studies showing combined wind and weathering effects and failures on tall historic towers in the Czech Republic are presented.

The contribution is accompanied with a review of typical timber roof framework on towers and with a short evaluation of the typology development on the behaviour of different structural forms.

The paper presents selected results of the EC FP6 project NOAH'S ARK.

Corresponding author: roofs@roofs.cz

Soiling and blackening in archaeological sites and monuments of Iranian cultural heritage

A. Bonazza[1], C. Sabbioni[1], N. Ghedini[1], B. Hermosin[2], C. Saiz-Jimenez[2]

[1] Institute of Atmospheric Sciences and Climate, CNR-ISAC, 40129 Bologna, Italy
[2] Instituto de Recursos Naturales y Agrobiologia, 41012 Sevilla, Spain

ABSTRACT

The present paper focuses on the results obtained from the investigation on the soiling affecting surface monuments and reliefs of important Iranian archaeological sites. For this purpose, samples of surface deposit and damage layers were collected on immovable cultural relics located in the provinces of Khuzestan and Fars, in Southern Iran. Different analytical techniques were applied with the aim of characterising the mineralogical composition of the damage layers, investigating the embedded atmospheric particles, measuring the soluble salt concentration, identifying and quantifying the carbon components present.

The results obtained will be presented, paying particular attention to the carbon fractions not linked to the carbonate substrate, but originated by biological agents and anthropogenic activities. The quantitave data of non carbonate carbon, comprising both elemental and organic fractions, obtained through the application of the methodology set up during the CARAMEL EC Project, as well as the organic composition of the soiling deposits (investigated by thermally assisted hydrolysis and methylation and gas chromatography-mass spectrometry) will be illustrated and discussed.

Corresponding author: A.Bonazza@isac.cnr.it

Conservation treatments on altered glass. A case study: the glass mosaic of the Porta della Mandorla in Florence

S. Bracci[1], E. Cantisani[1], A. Giusti[2], G. Raddi[2]

[1] Istituto per la Conservazione e la Valorizzazione dei Beni Culturali, ICVBC-CNR
Via Madonna del Piano, 50019 Sesto Fiorentino, Florence, Italy
[2] Opificio delle Pietre Dure, Via degli Alfani, 78 – 50121 Florence, Italy

ABSTRACT

The *Porta della Mandorla*, located on the north side of the cathedral of *Santa Maria del Fiore* in Florence (Italy), is the most beautiful and monumental of the four side doors of the Florentine cathedral. Work on the complex marble structure was begun at the end of the XIV century and completed in 1422. In the lunette over the *Porta* a vitreous mosaic depicting the "Annunciation" is posed in the 1490, made by Domenico and Davide Ghirlandaio.

In this paper the diagnostic analyses performed on the vitreous tessera of mosaic and the studies about the restoration work are presented.

The restoration of this vitreous mosaic is included in a general restoration project that will interest the whole structure of the *Porta della Mandorla* and that will be completed in 2006.

The mosaic's *tesserae* present a good state of conservation, except for the development of powdery, whitish materials of different consistencies on some of the black and green *tesserae* irregularly distributed throughout the mosaic. We have analyzed 24 samples of whitish powdery materials of different consistency and 14 samples of vitreous tesserae having different state of conservation, colour and aspect.

The restoration works have been accompanied with an extensive study, performed in the laboratory and *in situ*, on some products proposed for the conservation of the altered tiles.

The products, belonging different chemical categories, have been studied both in laboratory and *in situ*. For this latter aspect the products under study have been applied on different altered areas of the mosaic and the evolution in time has been followed by visual observations and colorimetric measures. In the laboratory the behaviour of the same products applied on testing glass, either before or after artificial ageing (thermal and Xenon tests), has been evaluated in order to investigate the possible drawbacks of the tested materials.

Corresponding autor: s.bracci@icvbc.cnr.it

Climate change critical to cultural heritage

P. Brimblecombe[1], C.M . Grossi[1], I. Harris[2]

[1] School of Environmental Sciences; University of East Anglia, Norwich, NR4 7TJ, UK
[2] Climate Research Unit, School of Environmental Sciences; University of East Anglia, Norwich, NR4 7TJ, UK

ABSTRACT

Although modellers have established the type of climate expected in Europe over the coming century, they have not been concerned with the combination of meteorological variables most important to building damage. We have identified the climatic parameters most likely to be critical for architectural surfaces and structures. They have been loosely grouped as:

Temperature derived parameters - range, freeze thaw, thermal shock

Water derived parameters - precipitation, humidity cycles, time of wetness

Wind derived parameters - wind, wind driven rain, wind driven sand, salt.

We also looked at pollution derived parameters such as SO_2, NO_2, elemental carbon and pH, but neglect these in this analysis which focuses on a European situation with much reduced air pollution. As expected a future Europe will experience less frost damage to porous stone, although higher temperatures can enhance fungal growth on wood. Drier summers seem likely to increase structural problems from desiccated soils and salt weathering of porous stone. Our work illustrates the areas of the continent that are most likely to need different heritage management strategies in the future.

Corresponding author: p.brimblecombe@uea.ac.uk

Evaluation of three consolidants in Miocene sandstones from the Ebro basin

O. Buj, J. Gisbert

Departamento de Ciencias de la Tierra, Universidad de Zaragoza, Spain.

ABSTRACT

The aim of this research was to examine the effects of three consolidants on Aragon sandstone used for building purposes.

The stones studied are three Miocene sandstones of the Ebro basin; Ayerbe sandstone, Uncastillo sandstone and Alcañiz sandstone. All these stones have a porosity ranging from 10 to 15% and therefore have a high absorption coefficient.

Conservation products tested were Paraloid B-72 (metacrylate and etilmetacrylate copolymer), Bersil (lithium silicate) and Betolin (potassium silicate). The products were tested on 5-cubic-centimetre samples of the stones using two techniques for each: total immersion at atmospheric pressure and brushing.

The characterization of the porous system was carried out by petrographical and electronic microscopy and evaluated by image analysis systems. The measurement of the porosity and the physical properties was carried out on the samples both before and after the treatment with the consolidants. The properties measured were water absorption, capillary water absorption, Shore- D surface hardness, bulk density, colour, real density and porosity accessible to water.

In addition, we did tests to characterize the behaviour of these stones in contact with water on treated and untreated samples. For this purpose we have elaborated the graph continuous absorption / time and the graph continuous desorption / time. For which, we have taken continuous measurements by a computer. These graphs show the changes caused in the porous system when consolidants treatment was applied.

In order to determine the durability of these stones we have used the salt crystallization weathering test. For this test, sodium sulphate was employed as by Rilem 1980 V. Ib.

These three sandstones have different behaviours which also depend on the type of consolidant treatment applied. The consolidant action of a product depends on the geometrical configuration and mineral composition of the stone studied, thus the test results allow us to ascertain the potential of these stones for use in construction.

Corresponding author: oscarbuj@unizar.es

The integrated archaeometric and archaeological approach in the study of Late Roman 1 amphora types produced at Elaiussa Sebaste, Ayash (Turkey)

F. Burragato[1], M. di Nezza[1],A. F. Ferrazzoli[2], M. Ricci[2]

[1] Dipartimento di Scienze della Terra, Università di Roma "La Sapienza", Italy
[2] Dipartimento di Scienze Storiche, Archeologiche ed Antropologiche dell'Antichità , Università di Roma "La Sapienza", P.le A. Moro 5, 00185 Roma, Italy

ABSTRACT

The ancient city of Elaiussa Sebaste (Ayash, Turkey) is located on the south-eastern coast of Asia Minor (the old district of Cilicia Tracheia). The pottery circulation in this area, as well as the local productions, is quite unknown. A preliminary study on the various ceramics coming from the excavations at Elaiussa Sebaste, provides an interesting view on the Late-Roman and Byzantine ceramics trade in the Eastern Mediterranean.

On the basis of sixth and seventh century archaeological contexts, it can say that Elaiussa was a Late Roman 1 (LR1) amphorae and coarse wares production centre. On the basis of archaeological classification which describes different classes of using and their possible provenance, with the following mineralogical and petrography studies, it is possible to confirm partly archaeological data. The study of thin section of ceramic sample shows hiatal and serial distribution of grain sizes. It is evident that the large fragments in hiatal distribution pattern were not present in the clay from the beginning, but were added to it during the processing phase. The chemical composition of pottery can be used to distinguish products of different origin. The chemical composition of the sherds is determined using wavelength-dispersive X-ray fluorescence spectrometry. Depending on the available amount of powdered sample, all major chemical elements and some minor elements (Zn, Cu, Ni, Co, Ce, Ba, La, Cr, V, Th, Pb, Ga, Rb, Sr, Y, Zr, Nb) were analysed thus yielding sufficient information to distinguish groups. The XRF data seem to identify that most LR1 samples used similar or even the same source(s) of clay (homogeneity of XRF data), but are nevertheless probably separate fabrics. This section studies were applied to control the resulting chemical grouping and to find traces of the geological background of the manufacturing area. The variation in potassium and sodium contents is larger than it would be expected if any of this pottery were made from one clay. From the typically high Mg, Cr and Ni contents and from typical inclusions of serpentine and pyroxenes which can be seen in microscopical study of the paste, clay used has a probable origin from ophiolithic rocks. It will be compared to the ophiolithic rocks, a possible provenance of the raw materials from ophiolitic belt which goes from the Taurus to the Mediterranean coast near Antiochus, with the inclusions of pyroxene and serpentine as typical inclusions in LR1. The high calcium contents show larger variation between 27,67 and 19,06 % of CaO; using calcareous clays was common in the pottery tradition of the Mediterranean and the Near East except for some cooking pot wares.

Corresponding author: mariahdn@tin.it

Digital image mapping as an analysis and evaluation tool in heritage conservation and restoration processes

R. Bustamante[1], D. Sanz[1], N. Prendes[2], I. Salto-Weis[1]

[1] Universidad Politécnica de Madrid. Madrid, Spain
[2] CEDEX-Ministerio de Fomento. Madrid, Spain

ABSTRACT

An integrated Digital Image Analysis, Laboratory Test, and Geographic Information System (GIS) method is presented. The purpose of method is to know the weathering causes and the decay process evolution.

The methodology set three different work steps:

In the first step we get the precise building cartography, by means of photogrametry, traditional photography, thermograph data, acoustics test…That is the level 0 of the GIS.

In the second step the materials properties are tested, the alteration forms are mapped, and all of these are related in a data base with the images, recording the relationship in different levels.

The third step is the analytical one. It is possible to study the decay effect-cause crossing the information levels; a state of the art map is generated with at least three information sources.

A comprehensive knowledge from the building and its weathering process is obtained.

Corresponding author: rbustamante@aq.upm.es

Study of natural cements from the French Rhône-Alpes Region

E. Cailleux[1], E. Marie-Victoire[2], D. Sommain[3]

[1] Cercle des Partenaires du Patrimoine, France
[2] Laboratoire de Recherche des Monuments Historiques, France
[3]Centre Technique Louis Vicat, L'Isle d'Abeau, France

ABSTRACT

Natural cements are generally considered as the first cements used as binders in concrete, preceding the development of artificial Portland cements and reinforced concrete. In the French Rhône-Alpes region, due to surface ochre colour, these cements were massively used in building construction in the 19th century as an alternative of stone.

At this period, the casting properties of this new material were particularly used to produce numerous sculptures and decorations. Today, because of a lack of appropriate repair materials, the restoration of these buildings consist mainly in the use of grey Portland mortar and the painting of the concrete surface which is particularly problematic for the conservation of the original appearance.

This study corresponds to a global experimental characterisation of these natural cements and their alteration mechanisms. The aim was to develop compatible repair materials to preserve the culture heritage of this region. In a first step, buildings using natural cements were inventoried and their alterations were listed. In a second step, samples were taken from representative buildings.

Microstructures and compositions of the ancient cements were characterised and alteration mechanisms were identified. Finally, in a third step, the main physical and mechanical properties of the old cements were evaluated, a numerical thermo-mechanical model of the repair system was developed and a parametric study was performed. Results of these analyses allowed drawing several conclusions concerning the composition and the main properties of the repair materials, which could assure a chemical and dimensional compatibility with the old support.

Corresponding author: emmanuel.cailleux@culture.gouv.fr

The Saint-John Sepulchre at Brindisi (South Italy): identification and provenance of marbles

A. Calia[1], M.T. Giannotta[1], G. Quarta[1], A. Cimino[2]

[1]CNR - Istituto per i Beni Archeologici e Monumentali (IBAM), Prov.le Lecce-Monteroni, - 73100 Lecce, Italy
[2]Master SIDART – ISUFI – Università degli Studi di Lecce, Italy

ABSTRACT

The church of Saint-John Sepulchre in *Brindisi* is a building on the central circular plan. The church shows different building stages: the first is datable to 8th century (west portal), while the latest to 12th century (portal with portico). It was assigned to the Order of Holy Sepulchre.

Apulian Romanesque architecture is marked by a large-scale use of architectural marble elements (capitals, column shafts, cornices) taken from ancient monuments. The study of re-used architectonic pieces (*spolia*) is strictly connected to that of the identification of the places and monuments of origin, which are not limited to the local Roman sites, but include also other Mediterranean sites.

The columns, capitals and other architectural elements of Saint-John Sepulchre church are *spolia* marbles. In particular, there are a large variety of white marble capitals and coloured marble columns, which show their provenance from Roman, ancient Christian and Byzantine monuments.

The present work offers the results of a multidisciplinary study conducted on *spolia* marbles. With the aim of improving our knowledge of the source of such materials and the areas they were taken from, we conducted a typological study of the architectural elements coupled with the mineralogical-petrographic features of the constituent marbles (by means of X-Ray diffraction analyses and observation of thin sections with an optic microscope) in combination with stable isotope analyses.

Corresponding author: g.quarta@ibam.cnr.it

Surface finishes on historic buildings in the Salento Peninsula (Apulia, South Italy): early data

A. Calia[1], G. E. de Benedetto[2], M. Lettieri[1], M. Masieri[1], G. Quarta[1]

[1] C.N.R. – I.B.A.M. (Istituto per i Beni Archeologici e Monumentali)
C/o Campus Universitario, Prov.le Lecce – Monteroni, 73100 Lecce, Italy
[2] Dipartimento dei Beni delle Arti e della Storia, viale San Nicola, 73100 Lecce, Italy

ABSTRACT

Many façades of historic buildings (churches and palazzos) in Lecce and the Salento bear scialbi (lime washes), patinas, painted layers, etc of varying extent. While there are various anecdotal sources referring to standard practices for applying finishes to surfaces by using natural products, there is little or nothing in the way of documentation. Furthermore the colouring that the stone naturally takes on with the passing of time is hard to distinguish from the colouring deriving from intentionally applied treatments for the surface finishes.

IBAM has begun a study of the façades of historic buildings in the Salento, aimed at the characterization of stone surfaces, in order to identify the nature of the patinas, characterize the different types of finish, and discover what, if any, treatments have been carried out in the past and their function. This paper looks at two case studies: the church of Saints Nicolò and Cataldo (12th century) and the church of S. Teresa (17th century). We are dealing here with buildings made of *pietra leccese* (a fine bio-calcarenite), on whose surfaces the presence of brown-ochre finishes of varying chromatic tonalities has been observed. The paper sets out the preliminary results of the study concerning their characterization, conducted by means of: mineralogical-petrographic and stratigraphic observations using optical microscopy with reflected and transmitted light, FT-IR and micro- FT-IR analyses, EDS microanalyses, DRX analyses, and GC-MS analyses.

Corresponding author: a.calia@ibam.cnr.it

Modelling the penetration of SO_2 within the pores of calcareous stones and the concentration of gypsum in the near surface layer

D. Camuffo[1], M. del Monte[2],
R..A. Lefèvre[3], P. Ausset[3], E. Pagan[1]

[1] Consiglio Nazionale delle Ricerche, Institute of Atmospheric Science and Climate, Corso Stati Uniti 4, 35127 Padova, Italy
[2] Dipartimento di Scienze della Terra e Geologico-Ambientali, Universià degli Studi di Bologna, Via Zamboni 67, 40127 Bologna, Italy
[3] Laboratoire Interuniversitaire des Systèmes Atmosphériques, Université Paris XII, 94010 Créteil, France

ABSTRACT

A theoretical analysis of the physical mechanisms which govern the penetration of airborne pollutants into the porosity of carbonatic stones has been made for a number of different cases, i.e. small pores and large pores, very low and very high SO_2 concentration. All the cases lead to conclude that the number of SO_2 molecules that can react with the stone decreases exponentially with increasing depth. The same law of exponential attenuation with depth holds for both the SO_2 penetration within the pores and the percentage of gypsum formed in the pores as a product of the rock sulphation in the presence of water. Field observation of marble samples from monuments kept outside but shielded from rainfall has confirmed this finding, and the same did laboratory tests performed in simulation chamber under controlled conditions on limestone, carbonate sandstone and tuffeau. It has been possible to establish experimentally a penetration depth δ after which the gypsum concentration is halved. The value δ has been found to range between 0.1 and 0.2 mm. The small thickness of the sulphated layer found in both recent and archaeological stone artworks means that monuments exposed to air pollution, but sheltered from rainfall, may survive in relatively good conditions for many centuries.

Corresponding author: d.camuffo@isac.cnr.it

Definition of protection areas in a prehistoric art cave (Tito Bustillo cave, N Spain)

J.C. Cañaveras[1,2], S. Cuezva[3], E. Sanz-Rubio[3], S. Sánchez-Moral[3]

[1]Departamento de Ciencias de la Tierra y del Medio Ambiente, Universidad de Alicante, Ap. Correos 99, E-03080 Alicante, Spain.
[2]Laboratorio de Petrología Aplicada. Unidad Asociada CSIC-UA. Spain (RTPHC-CSIC)
[3]Museo Nacional de Ciencias Naturales, CSIC, José Gutiérrez Abascal 2, 28006 Madrid, Spain, (RTPHC-CSIC)

ABSTRACT

Karstic terrains house geological, biological and/or historical elements (e..: paleolithic paintings and engravings), which must be considered cultural heritage and it is therefore necessary to make their availability to the public compatible with their suitable conservation. In this way, the conservation and protection of karstic caves necessitate the appropriate management tools. Based on a detailed knowledge of karstic parameters, the definition and delimitation of protection areas is one of the main tools in cave management that can help to the combination of the tourism and the cultural heritage, as well as to the conservation of the rock-art.

Tito Bustillo Cave (Asturias, N Spain) is one of the most important sanctuaries of the Palaeolithic art of the Iberian Peninsula and Western Europe. Since its discovery, several conditioning works have been carried out for its adaptation for the mass tourism. This cave belongs to a relict polygenic karst system (Ardines karst) initially developed during the Lower Pliocene on a carboniferous calcareous relief (Ardines Massif). Tito Bustillo cave acts as the main discharge area for the San Miguel drainage basin; the San Miguel River sink into the Ardines karst (Gorgocera ponor) and intermittently flow (approximately 600m) through Tito Bustillo Cave´s passages, towards its mouth in the Sella inlet.

For the delimitation of protection areas and the definition of specific protection measures a complete background of the geological, petrological and hydrogeological characteristics of the study area must be necessarily achieved. In addition, it is essential to carry out the identification and delimitation of natural and/or artificial (anthropic) weathering processes and products that cause deterioration on the main cave values (e.g.: rock-art paintings). Three levels of protection areas, ranging from highest to lowest protection levels, have been delimited in Tito Bustillo cave and surroundings: Immediate cave protection area; karstic groundwater flow area (subsurface drainage area), and total catchment area.

Corresponding author: jc.canaveras@ua.es

Experimental weathering of carbonate rocks promoted by simple and combinations of salts

C. Cardell-Fernández

Department of Mineralogy and Petrology, University of Granada
Fuentenueva s/n, 18002-Granada. Spain.

ABSTRACT

Knowledge of the properties of salts content in porous materials is an issue of major interest in conservation. Accelerated experiments of weathering by salt crystallisation in porous media often are used to evaluate the alteration behaviour of materials with and without treatments. However, these kinds of tests give little or no information regarding the mechanisms involved in crystal growth. Moreover, there is a lack of experimental data on crystallisation properties of salt mixtures. In order to increase understanding concerning the processes involved in material-salt reciprocal action, a salt crystallisation experiment based on the "wick effect" (Gauri, 1986) has been designed in which the nature and concentration of different salt solutions and temperature and relative humidity were controlled.

The experiment consists of ascending migration of salt solutions (60cc) in a probe (79.35cc) made of calcarenite –carbonate rock– placed in a recipient sealed with wax to force evaporation only through the probe. Fifty-two salt solutions of different nature and concentrations were tested, including simple and combinations of the follow salts: NaCl, KCl, $MgCl_2$, $NaNO_3$, KNO_3, $Na_2SO_4 \cdot 10H_2O$, K_2SO_4, $MgSO_4 \cdot 7H_2O$, $Mg(NO_3)_2 \cdot 6H_2O$ and $CaSO_4 \cdot 2H_2O$. The objectives achieved with the mentioned experiment have been:

- identification of the types of "fluid transport" operating on the crystal growth mechanisms;
- determination of the influence of cations, anions and diverse combinations and concentrations thereof in the salt morphologies and their location in the calcarenite probe;
- determination of the weathering effects induced by each salt solution on the calcarenites;
- evaluation of the relation between substrate humidity and crystal habits; and
- identification of the influences of both (a) salt solution supersaturation and (b) evaporation rate on the crystallised salt, the site of precipitation on the probe, and the effect of either cementing or disrupting the salts in the calcarenitas.

Corresponding author: cardell@ugr.es

Characterization of historical and model lead glasses by LIBS

N. Carmona[1], M. Oujja[2], S. Gaspard[2], M. García-Heras[1,3], M.A. Villegas[1], M. Castillejo[2]

[1] Centro Nacional de Investigaciones Metalúrgicas, CENIM-CSIC. Gregorio del Amo 8, 28040 Madrid, Spain
[2] Instituto de Química Física Rocasolano, CSIC. Serrano 121, 28006 Madrid, Spain
[3] Instituto de Historia, CSIC. Serrano 13, 28001 Madrid, Spain

ABSTRACT

Glass is a material used since ancient times. Its chemical composition has been barely modified through the centuries, even though there is a relation between composition and expected properties. The introduction of lead oxide in glass composition began in 17th century AD. By using high proportions of lead oxide instead of potash, a high brightness glass was produced, thereby enlarging the forming process in plastic-state and reducing the hardness. In this way, decoration and engraving of glass for valuable and high artistic outstanding objects is facilitated. Currently, there is a high amount of precious lead crystal glass pieces in museums and private collections. The knowledge of the estimated lead oxide content is important in order to allocate the provenance, origin and period of manufacture.

This work is focused on the evaluation by Laser-induced breakdown spectroscopy (LIBS) of the lead oxide content in different types of lead crystal glasses (sonorous glass, which contains ~ 10 wt. % PbO; lead crystal glass, with at least 24 wt. % PbO; and sparkling lead crystal glass, with at least 30 wt. % PbO). Characterization of the corrosion degree of these types of glasses has been also carried out. Results obtained by LIBS have been compared with those obtained by conventional techniques used for glass characterization (XRF analysis for the bulk and SEM/EDX for the weathered surfaces).

The LIBS system used consists of a Nd:YAG laser operating at the four harmonic wavelength (266 nm) and a 0.30 m spectrograph coupled to a time gate ICCD camera. Seven different historic-original and model glasses with different PbO content were selected and immersed into three different pH solutions for 200 hours.

Among the obtained results, successive LIBS spectra taken on the same position of the corroded glass samples indicated the change in composition in the transition from the corrosion layer to the bulk. Calibration curves for specific Pb spectral lines (405.78 nm) showed a linear relation between the absolute intensity and the Pb content in the glass. The results prove that LIBS is a valuable technique for the classification of different glass types by their content of lead oxide. Glass classification will be useful for studies about the provenance and dating of original historic glass objects. The corrosion process could be also characterized by LIBS. Both the altered layer depth and the elemental composition can be determined by means of this low invasive analytical method, where damage only occurs on a micrometric spot of the glass surface.

Corresponding author: ncarmona@cenim.csic.es

The pottery of a peasant community of Las Médulas (León, Spain): archaeometric study of the Orellán site, 1st – 2nd centuries AD

N. Carmona[1], M. García-Heras[1,2], M.A. Villegas[1], M.D. Fernández-Posse[3], J. Sánchez-Palencia[2]

[1] Centro Nacional de Investigaciones Metalúrgicas, CSIC. Avda. Gregorio del Amo, 8. 28040 Madrid, Spain. (RTPHC-CSIC)
[2] Instituto de Historia, CSIC. Duque de Medinaceli, 6. 28014. Madrid, Spain. (RTPHC-CSIC)
[3] Instituto de Patrimonio Histórico Español. El Greco, s/n. 28040 Madrid, Spain.

ABSTRACT

The archaeological zone of Las Médulas (León, Spain), which is included in the Humanity Heritage List, had an intense exploitation in Roman times to obtain gold. This mining activity meant the emergence of a new settlement pattern and the imposition of the Roman provincial system over the inhabitants. The metallurgical site of Orellán was occupied throughout the first and second centuries A.D. by an indigenous population, which exploited iron minerals and produced several types of tools to serve the Roman interests in the area.

The main goals of this study were to determine the production technology of some domestic pottery types of the site, such as common wares, grey ware jars or wares made following an indigenous tradition; as well as to provide some insights into their probable provenance. Both pottery and raw material samples were characterised through optical microscopy (OM), petrographic thin-section, X-ray diffraction (XRD), X-ray fluorescence (XRF) and scanning electron microscopy (SEM).

The resulting data revealed that all the wares were manufactured from iron rich non-calcareous illitic clays and fired between 700 and 800/850°C. The samples can be classified into two separate groups, as a function of the size and amount of inclusions in the clay sediment. The inclusions are composed of quartz, potassic feldspar, mica (muscovite and biotite), plagioclase, quartzite, and low percentages of slate and sandstones. They are compatible both with the raw materials and the general geological features of the site landscape. These results suggest that most of the wares were locally produced rather than having been imported into the region from other areas. The results are in agreement with the settlement historical context of the Las Médulas zone, in which the inhabitants are considered as manpower in the service of the Roman interests. Imported ceramics were reduced to the finest manufactures, such as *terra sigillata*, which is low represented; while everyday pottery were locally produced, not necessarily in the own site. The research thus ratifies the rural and tributary nature of these peasant communities, which had a very restricted access to the trade circuits of the Roman Empire.

Corresponding author: mgheras@cenim.csic.es

Valuation of the efficiency of an antigraffiti product applied on "Blanco Paloma" limestone

P.M. Carmona-Quiroga[1], S. Martínez-Ramírez[1], M.T. Blanco-Varela[1], R. Fort[2]

[1]Instituto de Ciencias de la Construcción Eduardo Torroja (CSIC), Madrid, Spain (RTPHC-CSIC)
[2]Instituto de Geología Económica (CSIC-UCM), Madrid, Spain. (RTPHC-CSIC)

ABSTRACT

To the traditional decay agents of the materials of construction, water as rainwater or humidity, pollutant substances (SO_2, CO_2, NO_x) that this one transport in dissolution, biological agents like bacteria, fungi, lichen, plants, animals ... it is necessary to join the vandalic actions and among these ones, the most widespread are *graffiti*, which causes irreversible damages on the surface of the materials of construction. In order to reduce this bad practice, *antigraffiti* products have been developed to protect the surfaces of the materials by hindering the entrance of paints within the porous matrix and by making easy another cleaning procedures (chemical products, water underpressure ...). The majority of the protective treatments, with the exception of the fluorinated polymers, are characterized by their short durability due to the ultraviolet radiation.

In this research was studied the efficiency of a permanent *antigraffiti* product, a fluorinated siloxane, applied on an oolitic limestone, "Blanco Paloma", selected by both its monomineral composition (calcite) and its monochromatism that simplify the study of the effects of the superficial treatment, and by its high porosity (13 %) that determines the depth of penetration of the treatment and in last instance its his protective capacity. The modifications of the petrophysics properties induced by the protective treatment have been evaluated: the water repellency through the determinations of the pipe method and the measurements of contact dynamic angle, which reveal a decrease in the quantity of water absorbed by the treated material but not a long-lasting water-repellent efficiency, the permeability to the water vapour, which is reduced in only 16 %, the chromatic variations which are slightly significant and the scratching resistance of the surfaces, which is increased after the application of the treatment due to its elasticity.

The protected samples sprayed with three synthetic paints, were cleaned by a combined procedure of peeling, chemical cleaner, warm water and brushed. After that, the chromatic parameters and the water-repellency of the surfaces were again analysed, in order to evaluate in the strict sense of the word, the efficiency of the treatment as an *antigraffiti*. According to the latter aspect, it has been concluded that the treatment helps to clean the surfaces but doesn't avoid from the presence of remained paint in the smallest pores of the material.

Corresponding author: paulacq@ietcc.csic.es

Re-use hypothesis for the valorization of the castle of Maddaloni and its towers

A. Catalano, M. Cristiano

Università degli studi del Molise, Facoltà di Ingegneria, Termoli, Molise (ITALY).

ABSTRACT

The castle, fulcrum of the ancient fortified citadel of Maddaloni, in the province of Caserta, rises in a strategic position, on the top of a hill at the crossing of two important communication pathways, the Appia and the Sannitica. The fortified complex, encircled by walls, rose in the longobard age on structures of roman origin, as a defensive "roccaforte" (stronghold). It is made up by three different buildings, arranged on two contiguous hilltops: the castle is in the central position, the tower of the Artus next to it, was built in Angioina age; while the high tower, called "Castelluccio", is situated in a elevated and isolated position,. As every building that assumes political and symbolic values, also the Castle of Maddaloni bears the signs of the various dominations that, in the course of the centuries, have held the manor from it's moments of splendour to it's periods of forfeiture. During the Borbonic age the ancient fortified complex was transformed in a rich noble dwelling, with a magnificent garden around it. The beginning of the ruin of the castle begins, when the Garibaldini invade Maddaloni, carrying away, with the last signs of the Borbonic dynasty, also the spirit of the fortified citadel. and it culminates with despoliation that occurred during the last world-wide conflict. Even if today this ancient fortress is the dwelling only of climbing plants it still represents for the inhabitants of the place a tangible sign of their history, rich in traditions and culture and many are the plans in order to bring back it to new life. The study illustrates a plan, in consideration of the precarious conservation conditions, of a partial restoration of the functionalities of the construction. The destination thought for the castle is as conferences centre with library, newspaper collection and theatre laboratory, where the development of mass events is possible, with the renovation of the gardens, the restoration of the ruins and consolidation of the towers.

Corresponding author: agocatal@unimol.it

Nanotechnologies for the conservation of waterlogged wood: the Vasa case studies

D. Chelazzi, R. Giorgi, P. Baglioni

Department of Chemistry and CSGI, University of Florence, via della Lastruccia 3 - Sesto Fiorentino, 50019 Florence, Italy

ABSTRACT

Conservation of waterlogged wood is a hard challenge in cultural heritage conservation. Particular attention has been focused on shipwrecks, as complex matrixes showing different degradation phenomena.

Samples, from the Swedish warship Vasa, have been investigated in order to formulate innovative methods for its preservation. One of the main causes of the Vasa wood degradation is acidity; the huge amount of sulfur, produced by metabolic action of bacteria in the seabed, is consistently converted to sulfuric acid and it is now a strong threat for the conservation of wood.

Application of nanoparticles of earth-alkaline hydroxides neutralizes the acidity of wood and provides an alkaline reservoir inside, conferring a long-term protection to cellulose as evidenced by hydro-thermal aging of the treated samples.

Oak and pine samples from the Vasa wreck were characterized and treated with alkaline magnesium and calcium nanoparticle dispersions in non-aqueous solvents. De-acidification effects were monitored by pH changes and thermal analysis.

Maximum pyrolysis temperatures of cellulose were specially analyzed in order to evaluate the degradation *status* of wood. The correlation between the temperature shifts of degraded wood respect to the unaged one and the corresponding polymerization degree of cellulose were also investigated.

New formulations based on the usage of cellulose-based gels for the filling and consolidation of waterlogged wood were also studied and tested.

The results obtained opened a new perspective in wood conservation.

Corresponding author: giorgi@csgi.unifi.it

Where it was, how it was

D.G. Chizzoniti, G. Canella, E. Bordogna, P. Bonaretti, L. Monica

Plytechnic of Milan, Department of Architectural Design
Via Durando 10, 20158 Milan, Italy

ABSTRACT

The material presented here is essentially an update of the project (Project team: G. Canella, leader, with E. Bordogna, P. Bonaretti, L. Monica) already presented at the Alcalá de Henares conference [Canella, G., et al., 2001, in *Proceedings of the 3rd International Congress on Science and Technology for the Safeguarding of Cultural Heritage in the Mediterranean Basin*, (Madrid, UAH-CNR). pp. 695-702]. Specifically, we will discuss the refinement of certain investigative techniques in the reconstruction of Milan's Teatro della Canobbiana on Via Larga – sister theater of the more famous La Scala, both built by Giuseppe Piermarini between 1776 and 1778 – following the numerous interventions which, from the late 19th through the first half of the 20th century have seen the avant-corps, the hall and stage repeatedly reworked. The aim here was, first and foremost, to complete the historical and architectural documentation of the theater by scouring the archives of the cities of Milan and Vienna, since the surviving descriptive documentation of La Canobbiana turns out to be only partial at best. A philological reconstruction was thus the chosen approach, based on the principle of comparison with the far more abundant and exhaustive documentation left by Piermarini for his Teatro della Scala. Graphic re-elaborations and computer simulations helped reveal the original structure of the theater, the character and outfitting of the lobby, and the form of the hall, of particular interest insofar as the invention of the horseshoe-shaped hall '*all'italiana*' would condition the evolution of Baroque and Romantic lyric opera and melodrama.

Historical documentation. A database was created which organizes all the archival documents according to a hierarchy of specificity, with two main search criteria: critical/descriptive documents, and architectural/technical documents. This allows a helpful degree of cross-referencing, with the option of inserting new data as the work progresses.

Proposed reconstruction. The documentation obtained, combined with highly credible computerized projections of the theater's structure, have led to these models for the restoration of the Teatro della Canobbiana to its original state. The models were then compared to Piermarini's ideas for La Scala. Through relationships of proportion and analogy (La Canobbiana was slightly smaller than La Scala) it has been possible to recreate the original aspect of the theater, including the conformation of the hall (disposition, number and order of boxes), the stage (geometry of the tower, and proscenium) and the avant-corps.

Corresponding author: domenico.chizzoniti@polimi.it

A microclimatic study for the design of new shelters for the archaeological site of Castellammare di Stabia – Naples

M. Citterio[1], E. Giani[2]

[1] ENEA CASACCIA - SIST Via Anguillarese, 301 – 00060 Santa María di Galeria (Roma, Italy)
[2] Istituto Centrale per il Restauro Via San Francesco di Paola, 9 00184 (Roma, Italy)

ABSTRACT

The archaeological site of Castellammare di Stabia is a large area facing the Gulf of Naples, with many roman buildings constituting the Villa di Arianna. The area is also characterised by a large number and typologies of shelters built in different years, with different materials and technologies also depending on the morphologic features of the ground. Many of them have been built as temporary protections, some others have been realised *ad hoc* as definitive shelters.

The microclimatic monitoring campaign, lasted one year, had the aim to support the design of new and more efficient shelters to protect the roman mural paintings of the roman Villa di Arianna. The microclimate of some rooms of the buildings has been controlled by recording air temperature, frescos surface temperature, shelters surface temperature, relative humidity, wind speed. Internal and external microclimatic conditions have been compared and the influence of the external climate on the internal one has been highlighted. By the microclimatic monitoring of different areas covered with different type of shelters has been possible to compare the state of conservation of the mural paintings related with the different typology of shelters.

At the end of the microclimatic study data have been used for designed the new shelters. In particular a simulation programme based on the external climatic conditions, on the geometric features of the walls and on the constructive elements and materials, has allowed to foresee the new internal microclimatic conditions after the installation of the new shelter. Finally the new built shelters are described.

Corresponding author: eligiani@tiscali.it

Diagnostic studies aimed to conservation works in S. Fedele church (Milan)

C. Colombo, C. Conti, M. Realini, A. Sansonetti

ICVBC-CNR Istituto per la Conservazione e la Valorizzazione dei Beni Culturali, Sezione di Milano "Gino Bozza",
Pza Leonardo da Vinci 32 – 20133, Milan, Italy

ABSTRACT

S. Fedele Church, built by Pellegrino Tibaldi in the late sixteenth century, is one of the most famous examples of the Counter-Reformation religious architecture; it represented the new Jesuits's Church dedicated to S.Fedele, and it was erected close to a pre-existent church. The facade, completed in 1835, and the hip have been finished with Pietra d'Angera slabs; since the quarries of Pietra d'Angera are located along the eastern shore of Lake Maggiore, close to Angera town, this dolomitic stone has been widely used in the Lombard historical architectures, from Roman period to the Renaissance, and especially in the XVII and XVIII centuries.

A peculiarity of this stone is the poor durability which is the cause of the advanced decay observed nowadays in the facades. Furthermore, during the Second World War, Milan was bombed; even if the Church was not directly hit, it was seriously damaged. These are the reasons because a lot of conservation works have been made since the end of the eighteenth century.

In this paper the analysis of the stone conservation state, the characterization of the finishing layers and of the products used during previous conservation works will be presented; the surfaces conservation methods, which has been consequently planned, will be presented and discussed in a linked paper in this same congress.

The study of the state of conservation and of finishing layers have been carried out by X-ray diffractometry, ion chromatography, optical microscopy by reflected light and polarized light, scanning electron microscopy with energy dispersive spectrometry and FT-IR spectrophotometry with diamond cell.

The worrying state of conservation of stone is characterized by a high amount of sulphates. The products applied during the last conservation works, carried out during the 80's, played a part in the decay of the facades. The analyses of the remains of these products showed the presence of acrylic resins mixed with titanium dioxide and silicatic sand. Acrylic resins have been used as a binder and as a protective agent; titanium dioxide has been probably used as filler and sand has been used to give a texture to the finishing layer obtained. Moreover the use of epoxy resin to mould integrations has been individuated and its presence constituted a great problem in their removing.

Corresponding author: chiara.colombo@polimi.it

Characterization of mortars used in construction and rehabilitation of Aeminium Criptoportico

J. Coroado[1], A. Velosa[2], R. Silva[3], P. Redol [3], A. Alarcão[3]

[1] Departamento de Arte, Conservação e Restauro, Instituto Politécnico de Tomar, 2300 -313 Tomar, Portugal
[2] Departamento de Engenharia Civil , Universidade de Aveiro, 3810 -193 Aveiro, Portugal
[3] Museu Nacional Machado de Castro, Instituto Português de Museus, 3000 -193 Coimbra, Portugal

ABSTRACT

The urban nucleus from where Coimbra (Portugal) grew up was an important roman "civitas" named Aeminium. The last important structure that we can recognize as a roman construction is the "*Criptopórtico*", composed with arches and corridors that sustain a platform over which a palace was built and where, today, is the Machado de Castro Museum.

This structure, made of dolomitic limestone, bricks (used mainly in arches) and lime mortars, has been reconstructed and rehabilitated since it was built during the 1st century AD, and at least three important interventions were reported: during the XII century, XVI and XVII century and the last during the XX century,; furthermore there isn't a systematic characterization either of original materials or those used in the several interventions.

The aim of our study was to characterize the compositions of several mortars with a known context to be used as references to compare with others without any context and with some binders' and aggregates' raw materials. This has allowed us both to assess several phases of intervention in the monument and also to study the provenance of mortar components.

The study of mortar's mineralogy was performed by X-ray Diffraction; their thermal behaviour was obtained by Thermogravimetric Analysis (Tg) and Differential Scanning Calorimetry (DSC). Optical Polarized Microscopy (OPM) was applied after the execution of thin sections to study the texture as was the Scanning Electron Microscopy (SEM). The aggregate particle size distribution (dry sieved for fraction > 63 μm and x-ray reflection by Sedigraph for < 63 μm fraction) and the binder/aggregate relation were obtained after wet dissolution of the carbonated phase in acetic acid.

Corresponding author: jcoroado@ipt.pt

Characterisation of Roman fibulae from a Parisian excavation site using electrochemical techniques

V. Costa[1], K. Leyssens[2], N. Richard[3]

[1] IRRAP, France
[2] Ghent University, Belgium
[3]DHAA, France

ABSTRACT

Among the numerous metallic artefacts excavated in 2001 at the Sorbonne Square (Paris) there are several Roman fibulae, consisting mostly of cuprous alloys, currently recovered with greenish corrosion products. During the restoration campaign, a careful examination of the objects put in evidence the presence of a second type of compound, different from the usual by its powder texture and grey colour. Moreover, this product occurs only inside the decorative grooves, in a very localised and symmetrical form. Such remarks seem to indicate that it was the matter of using incrustation of a contrasting metal to enhance details, a technique not yet described in the literature for this kind of artefacts.

In order to answer this question, an electrochemical technique was employed to characterise the material. This technique is especially adequate in such cases, because it needs extremely few materials (some ug) and can be considered non-destructive. Moreover, it is an excellent tool for local analysis, because samples can be directly taken by gently abrading with a graphite electrode at very specific places on the object. Finally, the electrochemical reduction of the compound allows its identification in a structural level, instead simple elemental analysis given by other methods. In the present work, linear sweep voltammetry (LSW) was performed in oxalic acid solution using a three-electrode arrangement.

Results confirm the presence of a different material in the regions presenting the grey corrosion product, corresponding to silver corrosion products. This relevant fact has to be considered when restoring such objects, to prevent any inadvertent material removal. Furthermore, it has to be taken into account when examining similar artefacts, in order to recognise similarities particular to a given workshop or region.

Corresponding author: virginiaco@aol.com

Impact of environmental conditions on metallic artefacts from the treasure rooms of Reims Cathedral

V. Costa[1], A. Texier[2], D. de Reyer[2]

[1] IRRAP - France
[2] LRMH - France

ABSTRACT

The ancient palast of the archbishop of Reims in the 5th century, later rebuilt and used for the banquet of the sacring, was finally transformed to receive, among others, the royal treasure and tapestry. Prestigious objects, such as the talisman of Charlemagne (9th century), the chalice of the sacring (12th century), the….. are currently exhibited in 3 rooms conceived more than 30 years ago according aesthetical and historical lines, but disregarding the potential harmful effect from emanation of the employed materials (oak, wool, etc) on the artefacts.

To evaluate environmental conditions regarding the conservation of the treasure objects, a 5-year study was performed, in which metallic – silvered brass - coupons have been exposed in different places among the rooms. By reacting with airborne pollutants, the coupons act as sensors, and periodical analysis of compounds formed on their surface, together with other climatic parameters (T, RH), give a good indication of the appropriateness of the environment.

Surface changes and oxidation degree of the coupons have been evaluated by an electrochemical technique, the linear sweep voltammetry (LSV). It allows the identification and quantification of compounds by reducing them under adequate conditions. In the present case a conventional three-electrodes arrangement in oxalic acid as electrolyte was used. The resulting curves present current peaks for all reduction reactions, each of them could be assigned to a specific compound, allowing its identification. Moreover, since the areas under the peaks correspond to the charge involved in the reaction, their integration can be correlated to the total mass of product, using the Faraday law.

In this way, for each investigated location, the nature of corrosion products could be defined and, in some cases, attributed to a probable emanation coming from showcase materials. Tarnishing rates could as well be evaluated, and their extrapolation over longer periods, considering the cleaning frequency, allows to estimate the long term effect of the environment on the objects conserved in the treasure rooms.

Corresponding author: virginiaco@aol.com

The stone elements of "Via Krupp" in Capri, survey and conservation hypothesis

M. Cristiano

Dipartimento di Ingegneria Edile,
Università di Napoli Federico II,Piazzale Tecchio 80, 80125, Napoli, Italia

ABSTRACT

This paper presents the results of an extensive survey that analyzed the stone elements, of the "Via Krupp" in Capri, and the conservation hypothesis proposed.

The "Via Krupp" was built in 1902 and donated to the municipality by the renowned magnate Friedrich Alfried Krupp and is one of the most characteristic landmarks of the famous island, winding up from Marina Piccola to the Gardens of Augustus.

Built with local stone, on the design of the engineer E. Mayer, it is now closed of because of the deterioration of the materials and the instability of the vertical cliff into which the road was built.

The aim of the survey was to determine the causes and extent of the damage and propose the correct conservation procedures.

Corresponding author: mcristia@unina.it

Reevaluating the cultural value of Segovia's Romanesque churches through biodiagnosis

A. de los Ríos[1], V. Galván[2], C. Ascaso[1]

[1] Instituto de Recursos Naturales, CSIC, Serrano 115 dpdo. Madrid-28006. Spain (RTPHC-CSIC)
[2] Universidad SEK, Convento de Santa Cruz la Real. Segovia-40003, Spain

ABSTRACT

Segovia, city declared Patrimony of the Humanity by UNESCO, includes in its urban structure different monuments which are known in all the word, such as "Acueducto Romano", "El Alcazar" or the Cathedral. Segovia Romanesque churches go more unnoticed but they have also an important historic and artistic value. The conservation and revaluation of this Heritage is essential. We intend to put these romanesque churchs into value by means of the difussion of biodeterioration diagnose of some outstanding examples of them. The following Romanesque churches from Segovia: La Vera Cruz, San Lorenzo, San Justo, San Millán, San Martín y San Miguel is being analyzed.

For this study, several microscopy and microanalytical approaches need to be combined, including scanning electron microscopy with back scattered electron imaging (SEM-BSE), low temperature scanning electron microscopy (LTSEM) and the spectroscopy by dispersive energy of X-ray microanalytical tecnique. The use of these techniques is a reliable method of approaching the biodeterioration of monument rock. This approach allows the *in situ* analysis (biological components do not need to be separated from the lithic material which arrives at the laboratory) of the different elements that comprise the altered substrate zone, the processes occurring in it, and the effects of measures aimed at impeding further biodeterioration.

The diffusion of the obtained results will contribute to the divulgation of these churches in Spain and abroad and constitutes a new alliance between Science and Cultural Heritage.

Corresponding author: arios@ccma.csic.es

Restoration of the façades at the Moorish Pavilion

B. C. G. de Lourenço

Departament of Historical Heritage / Casa de Oswaldo Cruz - Fundação Oswaldo Cruz.
Avenida Brasil 4365. Castelo. Sala 13. Manguinhos.
Rio de Janeiro - RJ. CEP 21045-900, Brazil

ABSTRACT

This research aims to make public the investigations done during almost ten years about the original protective coat of the ornamentals façades of mortars, constituted of cement, sand and lime, at the Moorish Pavilion in Oswaldo Cruz Foundation. The doubts about the use of commercial paints on those façades have shown to the need of realizing a variety of tests in order to compare different contemporary products. The obtained results were compared with the original protective coat of limestone on that paint remaining, regarding color, texture and shine. Laboratorial tests made for these finallities have contributed to the definition of more appropriate products. This study also lines some similarities and possible questions on related to performance and durability of those paint layers under of all weather conditions.

Corresponding author: bettina@coc.fiocruz.br

EIS investigation of resin and wax degradation on different atmospheres of the Museum of Ethnology and Archaeology of the University of Sao Paulo

H.G. de Melo[1], A.C. Neiva[1], R.P. Bendezú-Hernández[1], A.F.C. Ribeiro[1], S.C. Lima[2]

[1] Departamento de Engenharia Química, Escola Politécnica, Universidade de São Paulo
Av. Prof. Luciano Gualberto, Trav. 3, n. 380, CEP 05508-900
São Paulo-SP, Brazil
[2] Laboratório de Conservação e Restauro, Museu de Arqueologia e Etnologia, Universidade de São Paulo, São Paulo, Brazil

ABSTRACT

Varnishes and waxes are frequently used in museums to protect metallic artefacts against weathering and corrosion. However, their performance is dependent on the environment they are exposed to, as well as on their composition. In this work we have used electrochemical impedance spectroscopy (EIS) to evaluate the protection afforded by two kinds of resins and one microcrystalline wax normally used by conservators to protect metallic objects. The coatings were applied on silver samples, and the coated samples exposed to two different environments of the Museum of Ethnology and Archaeology of the University of Sao Paulo, namely the exhibition room and the technical reserve. For corrosion protection tests, the samples were periodically removed from their exposure site and submitted to the electrochemical experiments in deionised (di) water. After each essay, they were re-exposed to their original environment. In both environments, even after only one week of exposure, all the coatings showed some degradation, detectable by visual observation. EIS results have shown that the contact of the samples with the test electrolyte (di water), even during the short time of the electrochemical test, greatly accelerates the degradation process, indicating a high susceptibility of all the tested materials to humidity. Even for only five weeks of exposure, the impedance diagrams have clearly evidenced different behaviour between the three coatings in the same exposure site, and, in addition, they also reflected the effect of the different exposure sites on the performance of each coating. For longer periods, rankings can be established for the different tested coatings according to their intrinsic corrosion resistance and their stability after water exposure, for each of the two different exposure sites which were studied.

Corresponding author: hgdemelo@usp.br

EIS characterization of artificial patinas applied on copper and bronze samples

H.G. de Melo, A. C. Neiva, R. P. Bendezú-Hernández, C.F. Salgueiredo

Departamento de Engenharia Química, Escola Politécnica, Universidade de São Paulo
Av. Prof. Luciano Gualberto, Trav. 3, n. 380, CEP 05508-900
São Paulo-SP, Brazil

ABSTRACT

Artificial patina layers are often used to give final appearance and also to restore damaged old copper and bronze surfaces. The main inconvenient with these treatments is that they often require surface heating or total immersion of the objects in the patinas solution. In this work we have used electrochemical impedance spectroscopy (EIS) to compare the stability (corrosion behaviour as a function of preparation period) and the corrosion protection afforded to copper and bronze by three different patinas: one produced by the immersion of the samples in a solution of sulphates at 50^{o}C, the other two produced by dabbing the samples surface with nitrate solutions at room temperature. The tests were performed in a conventional three-electrode cell with 0.1 M NaCl solution. After the first essay, the samples were taken out of the cell and exposed either to the open laboratory environment, where humidity and pollutants are present, or stored in a desiccator, in order to evaluate the effects of formation conditions in the patinas' stability. After that, they were periodically essayed. The essays were made in the corrosion potential, after stabilization for at least 30 minutes, and the frequency scan was from 1000 to 0,005Hz. Before and after the electrochemical tests, the samples were observed by scanning electronic microscopy. In each environment, a clear relationship was observed between the structure of the patina layers, the formation of corrosion products and the electrochemical behaviour.

Corresponding author: hgdemelo@usp.br

Causes of salt decay and repair of plasters and renders of five historic buildings in Portugal

T. Diaz Gonçalves, J. Delgado Rodrigues, M. Marinho Abreu,
A.M. Esteves, A. Santos Silva

Laboratório Nacional de Engenharia Civil (LNEC), Lisbon, Portugal

ABSTRACT

An overview of salt decay problems in plasters and renders, is given on the basis of five Portuguese historic buildings: i) Sta. Clara-a-Nova Monastery, Coimbra; ii) Salvas Chapel, Sines; iii) Alhos-Vedros tide-mill; iv) House of Despacho of the Misericórdia Church of Pereira; v) St. Sebastian Church, Almada.

As most of the Portuguese ancient buildings, these five buildings are based on thick rendered/plastered ordinary masonry walls, composed of weak lime-bedding-mortars and irregular stones (brick, in one case) of variable size and variable nature.

Diagnosis of the several cases was based on site-inspections and on a systematic sampling/testing procedure, which will be presented and discussed. This procedure is largely based on moisture / hygroscopic moisture profiles, allowing to identify the sources of moisture and to evaluate their importance, as well as to select adequate points for chemical analysis. Ion chromatography and XRD analysis were performed on selected samples.

The variability of situations that may occur in historic buildings will be shown, either in what concerns the decay (type of salts and origins of moisture) and the repair (main damaging factors, main repair measures and most adequate working principle for the new plasters/renders). Some systematic causes of decay are identified and discussed.

Corresponding author: teresag@lnec.pt

Intervention in the sector of Porta de Vila in the city walls of Lagos, (Algarve, Portugal): historical, technical and constructive aspects

M. Díaz-Guardamino[1], E. Morán[1] y T. Valente[2]

[1] Archaeologists, Gabinete do Centro Histórico, Cámara Municipal de Lagos, Portugal
[2] Architect, Monumentos Nacionais, Portugal

ABSTRACT

The construction of the Modern city wall with bulwarks (16 - 17th centuries) altered and enlarged the mediaeval fortification. Due to *poliorcetica* criteria, in order to build the bulwark of Santa Maria, the mediaeval outline in the sector of *Porta da Vila* was modified. Some difficulties that arouse on carrying out the project are evident through the different techniques used in the wall construction, as well as through the incapacity to build some of the projected elements. Conservation works of the city wall are currently being carried out. These comprise filling up construction gaps as well as the construction of the top of the city wall with mud wall (*tapial*).

Corresponding author: centro.historico@cm-lagos.pt

Gothic dolomitic mortars with slag fragments from the Liebfrauenkirche and the St. Andreas Kirche in Kitzbühel, Tyrol, Austria

A. Diekamp[1], T. Bidner[2], J. Konzett[1], P. W. Mirwald[1]

[1] Institute of Mineralogy and Petrography, University of Innsbruck, Innrain 52, 6020 Innsbruck, Austria
[2] TB/B Private Consultant – Restoration and Preservation of Historic Buildings, Tulfes, Austria

ABSTRACT

Within the framework of an EU-Interreg project, the composition and preservation state of Romanesque and Gothic plasters and mortars from several buildings in Northern Tyrol (Austria) and Southern Tyrol (Italy) were studied to obtain information on the remarkable durability of these materials compared to modern lime plasters and mortars. The approach in this study is exemplified using the inventory of Gothic plasters from the Churches "Liebfrauenkirche" and "St. Andreas" from the "Churchhill" in Kitzbühel, Northern Tyrol.

Aside from documenting the general state of preservation (detailed mapping of building materials and their preservation state), the local environmental conditions were analysed and samples were selected for laboratory work. The materials were analysed with respect to composition, fabric, load of salts and decay features by wet chemical analysis, optical microscopy, X-ray diffraction, electron microprobe, differential thermal analysis, BET, Hg-porosimetry and salt eluation.

Considering the extreme climatic conditions in this alpine region, the Gothic plasters from these two churches in Kitzbühel are in an amazingly pristine state of preservation.

Unusual features of the mortars investigated are (1) the usage of dolomitic lime and (2) the addition of slag fragments that were presumably supplied by the smelting of copper ores mined from the Kitzbühel district. The setting of the mortar involving dolomite material results amongst other phases in the formation of hydromagnesite [$Mg_5(CO_3)_4(OH)_2 \cdot 4H_2O$]. The slag fragments are characterised by the presence of coexisting monticellite [$CaMgSiO_4$], merwinite [$Ca_3MgSi_2O_8$] and Mg-Silicate ground mass phase. These slag fragments show reaction rims with the dolomitic lime-based binder, thus acting as a hydraulic component. This is assumed to be responsible for the high strength and the outstanding durability of these plasters.

The addition of slag material to mortars with obviously hydraulic effects is a feature unique to the Tyrolian region, where otherwise only lime mortars, dolomitic lime mortars or lime mortars with natural hydraulic components were used. The addition of hydraulic components to lime mortars is similar to techniques already applied in the Roman Empire (adding pozzolanic materials like volcanic ashes or crushed bricks) but apparently lost before the Middle Ages.

Corresponding author: anja.diekamp@uibk.ac.at

Impact of tourism on historic materials, structures and environment

T. Drdácký[1], M. Drdácký[2]

[1] Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences, the Centre of Excellence ARCCHIP, Dept. of Historic Settlements and Environment. PhD. Student at Dept. of Urban Planning, School of Architecture, CTU Prague
[2] Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences, the Centre of Excellence ARCCHIP

ABSTRACT

The paper presents selected research results from the EC 6FP PICTURE Project dealing with the Pro-active management of the Impact of Cultural Tourism upon Urban Resources and Economies.

Existing knowledge about the impact of tourism upon built heritage was gathered. It is based on a scientific literature review and previous work, done by ITAM-ARCCHIP, with a focus on impacts and risks generated by large visitor numbers at sites and built objects of cultural heritage interest. This overview is accompanied by research work based on case studies, namely the World Heritage City of Telč (Czech Republic), where these measures have been monitored in detail.

As far as architectural objects is concerned, special attention is focused on environmental aspects, (mainly moisture and temperature changes, dust deposits, air pollution and radiation problems), mechanical deterioration (wear, dynamic loading etc.), intentional damage as well as ignorance and negligence of tourists.

In the context of small historic cities, the impact of tourism affects both intangible and tangible cultural heritage, and it has an effect at different levels and scales, and changes dynamically in relation to tourism development. The impact of mass tourism on individual objects/buildings can be followed relatively easily through monitoring their state and changes. Therefore the authors approach the issue by studying impacts and risks related to buildings and those apparent in the urban environment, in the latter taking into account also the landscape and natural heritage context.

There are very few studies providing reliable data concerning impacts and risks generated by a large number of visitors and which are clearly linked to tourism. Long-term direct measurements and studies describing deterioration development and surface or structural damages and changes are rare or even lacking. Innovative methods to assess more specifically the effects of cultural tourism are based on an identification and organisation of built "resources" in urban areas and monitoring the evolution of built heritage diversity over time using landscape metrics. Based on case studies and other sources, examples of impacts are presented. This is so that a catalogue of the impacts can be created, in order to better illustrate the effects of tourism in historic places.

Corresponding author: drdackyt@itam.cas.cz

Non-invasive survey of detachment of historic rendering

M. Drdácký, J. Lesák

Institute of Theoretical and Applied Mechanics of the Academy of Sciences of the Czech Republic, ARCCHIP Centre of Excellence

ABSTRACT

Separation of surface layers from a compact structural body is a quite frequent defect of historic structures which can be a result of different processes. It is typically caused i) by action of vapour pressure under impermeable or hardly permeable surface layers, ii) by mechanical pressure of corrosion products or salts developed on an interface between two materials or a moisture interface, separating surface layers from substrate or iii) due to repeated shear stresses generated by uneven temperature or moisture changes with a high gradient. Those defects endanger especially plaster layers and may cause significant loss of wall paintings.

The paper presents three methods recently analysed and developed in ITAM for non invasive survey of delamination defects. The most used method in restoration practice is based on percussion and recording places of different acoustic response.

An automated approach to acoustic tracing has been developed during the EC FP5 ONSITEFORMASONRY project and some results are presented in the paper. The method takes advantage of analysis of the acoustic signal generated by knocking the surface in densely located points, which is registered together with their geometrical coordinates by means of a video camera. The acoustic signals and coordinates are analysed using specially developed software tools.

Analysis of warming and cooling processes in non-metallic bodies after or during their internal or external heating is quite well elaborated theoretically. In civil engineering, there has been applied rather passive thermography, nevertheless, the active variant is suitable for detection of defects (voids) inside materials of low conductivity. Therefore, the thermal radiation measurement was used as an alternative experimental technique for indication of plaster detachment. Here the detection of loosed parts is based on an idea to measure their differential cooling or heating compared to the heavy and integral parts with higher thermal inertia and different conductivity. The paper presents comparative data to the previous method, acquired on a masonry trial wall covered with different rendering and coats with artificial defects.

The last presented method utilizes the fact that the detached plaster has considerably lower bending stiffness than the wall as well as the layer firmly attached to the bearing brick wall. Therefore, during excitation, the attached plaster follows the velocities and frequencies of vibrations of the wall on the contrary to the detached parts which vibrate with different frequencies and velocities. This response can be measured optically and the best results are provided by laser Doppler interferometry.

Corresponding author: drdacky@itam.cas.cz

Analysis and restoration of an exterior plaster floor of the 19th century

M. Drdácký, Z. Slížková, A. Zeman

Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences
Prosecká 76, 190 00 Prague 9, Czech Republic

ABSTRACT

The article describes a case study aimed at analysis of an ancient exterior plaster floor and development of a repair mortar of similar characteristics.

In the introduction, there are summarized examples of recent research studying possible improvements of lime mortars in order to increase their strength and durability performance. The attention has been paid mainly to fibrous additives and to pozzolan or latently hydraulic admixtures.

In the referred case study the goal was to replace heavily damaged plaster floor on a medieval castle wall by a new and similarly durable material. The ancient plaster floor was cast in situ during a massive restoration works at the end 19th century and it exhibits surprisingly high durability and strength. Therefore, the first part of the paper describes a series of tests which were carried out in order to attain a better knowledge about the material. They involve non standard mechanical tests concerning compression and tension strength, modulus of elasticity or deformability, abrasion resistance, moisture sorption, aggregate characteristics, porosity, etc. The physical tests were completed with petrography and chemical analyses, namely XRD and special tests looking for organic compounds in the ancient plaster. For some measurements, new approaches had to be applied because the samples taken from the original building did not allow for making standard specimens. For example, the mechanical tests took advantage of a prolongation technique using wooden prostheses and the deformations were analysed by means of optical record and semi-automatic digital evaluation. For the sake of comparison strain gage measurements were carried out as well as overall deformation measurements by LVDTs. All non-standard methods are explained in the paper in detail.

The second phase of work is presented in the second part of the contribution. It consists in design and verification of required characteristics of new mixtures intended for restoration works. This part is based on the former analyses and research as well as on new "experimental archaeology" attempts focused mainly on technological aspects proper mixture composition, its casting, curing and compacting. Some procedures described in ancient literature have been tested. The new material was subjected to weathering tests in a climatic chamber. The real performance of the in situ applied material has been and will be followed up.

Corresponding author: slizkova@itam.cas.cz

Maastricht limestone: a regionally significant building stone in Belgium and the Netherlands. Extremely weak, yet time-resistant

C.W. Dubelaar[1], M. Dusar[2], R. Dreesen[3], W.M. Felder[4] & T.G. Nijland[1]

[1] TNO Building & Geosciences, Utrecht/Delft, The Netherlands
[2] Geological Survey of Belgium, Rue Jenner 13, B-1000, Brussels, Belgium
[3] VITO Flemish Institute for Technological Research, Boeretang 200, B-2400 Mol, Belgium
[4] Oude Trichterweg 26, 6294 AL Vijlen, The Netherlands

ABSTRACT

Upper Cretaceous limestones in the Belgian province of Limburg and in southern Limburg (the Netherlands) have long attracted the attention of local inhabitants. During Roman times the Maastricht limestone was already used for building purposes and probably also as a fertiliser. Maastricht limestone became the predominant building stone for gothic and renaissance-style buildings, which were often constructed solely with this stone. Later on, and up to the early 20th century, the Maastricht limestone became subordinated to the more compact and harder Carboniferous limestones. As a result, the Maastricht limestone characterizes a distinct architectural province neatly coinciding with both geographical provinces of Limburg, on both sides of the Meuse river.

The Maastricht limestone is outcropping in a restricted belt of about 40 kilometers wide, between the towns of Tongeren, Maastricht and Heerlen. Several stone qualities are recognized, based on regional facies types that are mined from different stratigraphical horizons. Among the soft building stones, the Zichen, Sibbe and Kanne block types can be distinguished, based on their fossil content and diagenetic fingerprint. More tight varieties are restricted in distribution and/or rarely used. All carbonate facies types comprise predominantly bioclasts of sand-size, exhibiting a calcarenitic (grainstone) fabric. They consist of very pure limestone (between 94 - 98 % $CaCO_3$) with slight differences in colour, mineralogy, cement, porosity (up to 40 - 50 vol.%) and type of fossil fragments. The grains are loosely packed; cementation is mostly related to syntaxial cements overgrowing echinoderm particles. Evidence of pressure-solution or compaction is hardly observed. Notwithstanding the low compressive strength (5 - 30 MPa or even less), the durability of the soft Maastricht limestone is remarkably high. A thin protective layer of calcite, the ‘calcin’ deposited on the surface of the stone, protects the stone from fast abrasion and further dissolution of the carbonate. Cracks seldomly appear and the most common feature during weathering is loss of grains as a result of poor lithification. Due to the high porosity and connecting intergranular pore spaces the Maastricht limestone is not or weakly sensitive to frost action. Dissolution of aragonite and precipitation of calcite as a pore cement gave rise to durable stones such as the currently quarried Sibbe facies, supplying high quality stones for sustained use.

Corresponding author: wim.dubelaar@tno.nl

Urban soiling on calcarenite of El Salvador church, Sevilla, Spain

A. Durán-Benito[1], J. García-Talegón[2,3], M. González-Sánchez[2,4], M.C. Jiménez de Haro[1], A.C. Iñigo[2,4], A. Justo[1], E. Molina[2,3]

[1] Instituto de Ciencia de los Materiales de Sevilla, Avda. Américo Vespucio, s/n, 41092 Sevilla, Spain. (RTPHC-CSIC)

[2] Unidad Asociada IRNA-CSIC Salamanca/Univ. Salamanca, Salamanca, Spain. (RTPHC-CSIC)

[3] Departamento de Geología, Universidad de Salamanca, 37008-Salamanca, Spain.

[4] Instituto de Recursos Naturales y Agrobiología, CSIC, c/ Cordel de Merinas 40-52, 37008 Salamanca, Spain.

ABSTRACT

Conservation of our Historic Cultural Heritage built in stone requires studies on the material itself and on the environment where the monument is located, and even on the microclimate affecting a particular stone in the building.

In this paper, building stones with black crusts from the church of El Salvador in Sevilla, Spain, have been studied**.** The samples have been taken from the flying buttresses and external walls of the building. The construction of the actual baroque building took place among the years 1674 and 1712, the last period of the works being directed by the architect Leonardo de Figueroa. The Church is suffering in these moments an integral process of restoration of the whole building.

The stony substrates and the black crusts have been studied by X-ray diffraction, optical microscopy, scanning electron microscopy with chemical analysis by X-ray dispersive energy, infrared spectroscopy with microscope, and x-ray fluorescence.

The obtained results demonstrate that the stone substrate is a biocalcarenite of the Upper Miocene-Pliocene. Their major components are quartz and calcite, with presence of fossil remains: corals, algae, bryozoa, etc.

On the other hand, the black crusts that cover the studied samples present a high content in gypsum, so much for diffraction of rays X like for infrared spectroscopy. Besides the gypsum, the study by scanning electron microscopy shows the presence of spheres coming from contamination (carbonaceous particles and of iron oxides), grains of pollen, hyphae of fungus, pyrite cubes, etc. These crusts have been subjected to extraction with organic solvents, showing the infrared spectra of the extracted material a high proportion of organic compounds.

Ackowledgments: Authors thank finantial support from Ministerio de Educación y Ciencia (projects MAT2004-04498 and CGL2004-07066-CO2-02/BTE), and Junta de Castilla y León (CSI08/03).

Corresponding author: adrian@icmse.csic.es

Study of copper alloys alteration by direct human action

A. Durán-Benito[1], A. Justo[1], M.C. Jiménez de Haro[1], J.L. Pérez-Rodríguez[1], J.M. Martínez-Blanes[1], B. Sigüenza[1], J.C. Pérez-Ferrer[2]

[1]Instituto de Ciencia de Materiales de Sevilla, CSIC. Avda. Américo Vespucio, s/n, 41092 Sevilla, Spain. (RTPHC-CSIC)
[2] Tratamientos de Conservación y Restauración, S.L., Spain

ABSTRACT

The "Puerta del Perdón" gateway in the Mosque Cathedral of Córdoba is dated in 1377, being related with the Almohade doors of the Cathedral of Seville. The door was rebuilt in 1739. It is built with pine wood, lined with brass plates that form geometric Mudejar drawings.

At the beginning of the ninety decade of the last century, the door suffered a process of cleaning by a non specialized company. Starting from then a very quick process of deterioration of all the metallic components began. The wings present a strong deterioration that is manifested in two forms. In first place the iron nails that hold the brass pieces to the wooden settings are in an advanced state of oxidation. In second place, the brass presents an accused degree of corrosion.

The samples have been analyzed by optical microscopy, X-ray diffraction (XRD), scanning electron microscopy (SEM) equipped with X-ray energy dispersive analysis and infrared spectroscopy.

From the analytical study, a high proportion of atacamite (basic copper chloride) is detected in all the altered samples, being observed on the surfaces of the brass plates the presence of gypsum, spherules of iron chlorides, and other products of contamination.

This rapid deterioration can be due to the aggressive products that were used to "try to clean" the brass, perhaps due to the own nature of the product or more probably by an insufficient rinsing with distilled water after the treatment.

Acknowledgments: Authors thank financial support from Consejería de Cultura, Junta de Andalucía.

Corresponding author: jjusto@icmse.csic.es

Simulated ageing of lime mortars - a mechanical property, structural and compositional study

A. El-Turki, R. J. Ball, G. C. Allen

University of Bristol, Interface Analysis Centre, Bristol, BS2 8BS, UK

ABSTRACT

Lime mortars have been used throughout history in a range of historic buildings and monuments. It is widely accepted that these mortars develop their strength by a combination of hydration and carbonation reactions. Studies have shown that environmental parameters such as temperature, humidity and carbon dioxide concentration play a key role in influencing reaction rates and structural development.

This paper presents results from the study of hydraulic limes including NHL2, NHL3.5, NHL5 and calcium lime/ordinary Portland cement mortars. Compressive testing provided information on strength development while environmental scanning electron microscopy (ESEM), focused ion beam (FIB) and Raman spectroscopy have evaluated the structure and composition. Samples have undergone a series of tests including stress cycling, wetting and drying cycles, creep and exposure to controlled environments. Results demonstrate that certain weathering conditions may enhance the strength development of these mortars by the influence of nucleation and growth mechanisms. Conclusions are drawn as to the most appropriate mortars for use in certain applications.

Corresponding author: A.El-Turki@bristol.ac.uk

Geopolymerization as a novel method to consolidate earthen architecture: preliminary results

K. Elert, C. Rodriguez-Navarro, E. Sebastian

Dpto. Mineralogía y Petrologia, Universidad de Granada. Fuentenueva s/n, 18002 Granada, Spain

ABSTRACT

Man has use clay-rich materials, such as earth, as a primary building material since prehistory. However, clay-water interactions result in swelling and significant microstructural damage that over time lead to crumbling and lost of earthen structures. Such processes endanger the survival of invaluable archaeological sites such as Chan Chan in Peru or the Alhambra in Granada, Spain. Historically, natural and artificial additives such as dung, animal blood, or slaked lime were added to earth in order to increase its water resistance and mechanical strength. More recently, polyvinyl alcohol, portland cement, ethyl silicates, epoxy and acrylic resins have been applied to consolidate or protect earthen structures, however with limited success. Here, in an effort to design a new procedure for stabilisation and consolidation of earthen structures, geopolymer-like reactions of clay-rich earth used in southern Spain earthen architecture (i.e., the Alhambra fortress) were studied. Geopolymerization is defined as the reaction underwent by reactive aluminium-silicates (clay minerals) in a highly alkaline medium, resulting in the precipitation of (very stable) zeolite-like, poorly-crystalline (or amorphous) aluminium-silicate phases, with strong cementing properties. Alhambra Formation clays were treated with Ca(OH)2, NaOH and KOH solutions. The most sensitive smectite fraction was rapidly destroyed after alkaline treatment. Further modifications occurred upon NaOH and KOH treatments, resulting in precipitation of sodium or potassium silicate hydrate gel-like cements, respectively. These preliminary results point to geopolymerization as a new means to efficiently consolidate earthen architecture, as well as other clay-rich building and ornamental materials.

Corresponding author: carlosrn@ugr.es

The restoration of modern architecture: diagnostic and pre-project activities. **(abstract withdrawn)**

F. Fernandez, V. Ruggirello

Faculty of Architecture, University of Palermo, Italy

ABSTRACT

The problems linked to the conservation of mosaic surfaces and armed concrete elements in a building of the 60's, renewed for its peculiar and valuable architectonic configuration, in this case is faced with an approach deriving from the field of monumental restoration: before any intervention a series of preliminary surveying as well as evaluations have been carried out, conveying to a project strictly related to the decay causes and forms. Although techniques and materials deriving from the restoration field have been used, one important outcome was the costs economy which was restricted by the preliminary diagnostic activities.

With this example we would like to underline the importance of a correct preliminary anamnesis carried out before the project itself, including all the evaluations and diagnostic activities, even when is taken under consideration the case of the recovery-restoration of modern architectures made by reinforced concrete.

The deep survey of the conservation *status* of the mosaic surfaces has allowed us to identify punctually the causes of the detachments and fractures of the *tesserae*.

Some interventions have been experimented in order to approach and solve the problems which came out and the comparison of the obtained results took us to the final choice of the methods to include into the final plan.

Corresponding author: federicafernandez@libero.it

Metallographic studies of copper based scraps from the Late Bronze Age Santa Luzia archaeological site (Viseu, Portugal)

E. Figueiredo[1], M.F. Araújo[1], R. Silva[2], F.M. Braz Fernandes[2], J.C. Senna-Martinez[3], J.L. Inês Vaz[4]

[1] Instituto Tecnológico e Nuclear, Departamento de Química, Estrada Nacional 10, 2686-953 Sacavém, Portugal
[2] CENIMAT / Departamento de Ciência dos Materiais, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal
[3]Instituto de Arqueologia, Faculdade de Letras, Universidade de Lisboa, Lisboa, Portugal
[4]Universidade Católica, Viseu, Portugal

ABSTRACT

Once metal was recognized as a new material in prehistorical times metal artefacts began to be made and the metallurgical skills started to develop. Metallurgical scraps found in archaeological sites normally evidence metallurgical production of artefacts *in situ*.

Studies of metal scraps can reveal different stages of thermo-mechanical treatments that the artefacts were subjected to in order to obtain a chosen shape and hardness.

While for metal artefacts sample taking can be problematic, sample taking in metallurgical scraps can be easier since scraps have normally no artistic/esthetical value.

Additionally, corrosion phenomena can be evaluated in scraps that have not been subjected to any conservation treatment.

This paper deals with metallographic (optical and electron microscopy), EDS-SEM, XRD and EDXRF studies that have been undertaken in prehistoric copper based metallurgical scraps from central Portugal.

[1] corresponding author: elin@itn.pt

Weathering and conservation of rhyolite tuff from the area of Eger, Hungary

L. Z. Forgó, Á. Török

Budapest University of Technology and Economics, H-1111 Budapest, Stoczek u. 2, Hungary

ABSTRACT

Rhyolite tuff is an extrusive acid piroclastic rock. The light, whitish grey, sometimes yellowish stone is an important building and ornamental stone in Hungary. It was used among others as building stone of the castle of Eger. The tuff was not only a construction material but it was also used as foundation rock and host rock of large network of cellars with several stability problems in the area of Eger.

Weathered monumental tuffs from the castle were compared with fresh quarry stones. On-the-spot investigations showed the heterogeneous texture of the rhyolite tuff: five lithotypes were distinguished on a historic wall from the 16th century. The typical textural feature of the groundmass is the flow-bonding porous glassy structures and aligned phenocrysts like quarz, feldspars and biotite. The most common lithoclast is pumice. As main weathering features crumbling, sanding, scaling, flaking and crusts were visible.

Petrographical tests (XRD, microscopy) showed the various texture and mineral phases of the material. The high glass content of the tuff is chemically instable and a clay mineral, montmorillonite can be found, which is a decay source due to its swelling. As a result of weathering, gypsum and calcite were detected, while weathering-prone feldspar albite disappeared. Rhyolite tuffs have high effective porosity (up to 45 V%). Mercury porosimetry and image analysis of microscopy give the pore size distribution. The rainwater and the dissolved contaminants or also the conserving agents can relatively easily infiltrate into the larger pores and more difficultly, if it can penetrate into it at all, into smaller pores. Consequently, the stone type with smaller porosity must be more resistant to weathering.

The status of rhyolite tuff monuments and the stability of cellars considerably depend on the water-content. Petrophysical tests have shown that indirect tensile strength of water-saturated tuffs can be one fourth of the air-dry ones. Hydrophobisation makes the stone more resistant to weathering rhyolite tuff due to the reduction of water content in the stone. In the case of strengthening a silica acid ester supply the losed binder or changed mineral phases in the weathered stone areas. Conservation of rhyolite tuffs is very complex. Drill resistance, strenght tests, frost resistance tests, porosity studies, thermal expansion, XRD and microscopy can provide information about the effects of the applied agents in laboratory conditions. Conservation methods can be offered not generally, but in function of mineral content and pore size distribution.

Corresponding author: forgo.lea@gmail.com

The Royal Hotel of the Poor. A giant that awakens

V. Gambardella

Dipartimento di Ingegneria Edile, Università di Napoli Federico II,
Piazzale Tecchio 80, 80125, Napoli, Italia

ABSTRACT

"That zeal, that feeds our Royal spirit for the greater happiness of the State, does not allow us anymore to watch with indifferent eye all those disorders, that derive from so much poor people, that overflow this populous city [...] Therefore [...] has deliberated to build in this capital a general Hotel for the Poor of every sex, and age, and therein to introduce it's own, and necessary arts, so that this work is pleasing in the eyes of God, and a benefit to this City, and Reign."...

These are the "Royal Dispositions" with which Carlo di Borbone, King of the two Sicilies, orders in 1751 the realization, by the arch. Ferdinando Fuga, of the greatest architectonic work of the Reign, destined to receive and to make productive the huge mass that crowded the city streets, accommodating them forcedly, with a strict division for sex and age and constituting therefore a deep ambiguity of functions, between prison and charity, marginalization and moral redemption.

For Naples it is today a sleeping giant with all its dreams and its records: 250 years of life, 130 thousand square meter surface, 830 thousand cubic meter volume, 9 kilometers of corridors, 440 rooms, 8 thousand hosts. Thought unfit for use as a result of the earthquake of the ' 80, it is will of the city's administration to give back the Palace to the city, as a place of acceptance, instruction and formation, in coherence with the original destination of the building, through a conservative recovery able to resolve the intrinsic embitterment of the building from the seismic point of view, without disturbing the architectonic structures, in light of the new technologies in this field.

Corresponding author: vgambard@unina.it

Microenvironments in the inner and outer parts of the Zamora Cathedral

J. García-Talegón[1,2], M. González-Sánchez[2,3], S. Vicente-Tavera[2,4], A.C. Iñigo[2,3], V. Rives[5]

[1] Departamento de Geología, Universidad de Salamanca, Spain
[2] Unidad Asociada IRNA-CSIC Salamanca/Universidad de Salamanca , Spain (RTPHC-CSIC)
[3] Instituto de Recursos Naturales y Agrobiología de Salamanca, CSIC, Spain (RTPHC-CSIC)
[4] Departamento de Estadística, Universidad de Salamanca, Spain
[5]Departamento de Química Inorganica Universidad de Salamanca, Spain

ABSTRACT

Zamora is a city located on the Central Meseta of Spain whose climate follows a continental trend with strong daily fluctuations in temperature, that produce stresses in exposed materials owing to processes of dilation/contraction (thermoclasty and freezing-thawing), specially in heterogeneous materials such as Zamora stones. These stresses or decay processes lead to microfissures, plates, flakes and surface arenization. The different degrees and types of decay observed in exposed and protected materials in the Zamora Cathedral microenvironments are largely due to the above phenomena.

In the present work, the data of relative humidity and temperature from five sensors in the inner and outer parts of the Zamora Cathedral are analyzed to characterize different microenvironments in it, as well as to determine the effect of the installation of the heating from year 1999 and the closing of the cloister from year 2000.

The five sensors are located in: i) the outwards and higher part of the building (Dome), ii) the Cloister, iii) upper part of central nave (North balustrade), iv) upper part of central nave (South balustrade), iv) lower part of central nave (column). When comparing the data from external sensor of the Catedral (Dome), with respect to the data of internal sensors of the building, the fluctuations in relative humidity and temperature were found to be very low. In addition, the variations in temperature and relative humidity between the inner and the outer of the monument, increased when the installation of the heating and the closing of Cloister. These rehabilitation works of the monument have produced a smoothing in the fluctuations of the temperature and relative humidity throughout the year.

Acknowledgments: Authors thank financial support from Ministerio de Educación y Ciencia (project CGL2004-07066-CO2-02/BTE), Junta de Castilla y León (project CSI08/03). Thanks to Angel Casaseca (Architect of Plan Director of Zamora Cathedral)

Corresponding author: talegon@usal.es

Pulsed laser deposition of polymers doped with fluorescent probes. Application to environmental sensing of cultural heritage

S. Gaspard[1], E. Rebollar[1], M. Oujja[1], M. Castillejo[1]
T. Corrales[2], M. M. Villavieja[2], P. Bosch[2]
S. Georgiou[3]

[1] Institute of Physical Chemistry Rocasolano, CSIC, Serrano 119, 28006 Madrid, Spain (RTPHC-CSIC)
[2] Institute of Polymer Science and Technology, CSIC, Juan de la Cierva 3, 28006 Madrid, Spain (RTPHC-CSIC)
[3] Foundation for Research and Technology-Hellas, Institute of Electronic Structure and Laser, P.O. Box 1527, 71110 Heraklio, Crete, Greece

ABSTRACT

Fabrication of thin films of polymeric materials and biomaterials in the new domain of nanoprocessed and nanostructured deposits provides innovative solutions for the pharmaceutical industry, bioengineering and development of sensors. In this work pulsed laser deposition (PLD) has been used to obtain films of polymers doped with fluorescent probes that could be used as sensors of the presence in their environment of contaminating agents (volatile organics or acids). Sensors based in thin polymeric films offer a series of advantages in comparison with other alternatives as the diffusion time of the contaminant is shortened increasing the capacity for real time monitoring. Moreover, the possibility of growing nanostructures by PLD increases the surface of interaction and consequently reduces the detection threshold.

As starting material we have used polymeric matrices of poly(methyl methacrylate) (PMMA) and polystyrene (PS) doped with amino aromatic compounds and some functional dendrimers synthesised from the single probes. These dopants have been shown to be sensitive both in solution and inserted in polymeric films to changes in pH, viscosity and polarity, increasing their fluorescence emission and/or modifying the position of their emission band. PLD is performed at room temperature irradiating disc-shaped targets (5 mm thickness, 25 mm diameter) with two different laser sources: an excimer KrF laser (248 nm, 20 ns pulse) and a Ti:Sa laser (800 nm, 120 fs pulse). Analysis and characterisation of the obtained deposits on quartz substrates is carried out via laser-induced fluorescence and optical, fluorescence, Raman and environmental scanning electron microscopies. Properties of the deposits including thickness and composition are strongly dependent on the laser source used for target irradiation and on the light absorption characteristics of the targets. The analyses reveal the transfer to the substrate of both the polymer and the probe.

Corresponding author: sgaspard@iqfr.csic.es

Integrated analysis and interpretation of architecture changes and vulnerabilities by combined use of historical sources and infrared thermography: the study case of San Francesco convent near Montella (AV), Southern Italy. **(abstract withdrawn)**

E.Geraldi, G. Colesanti, C. Dolce

CNR IBAM, Via Federico II, Castello di Lagopesole, 85020 Lagopesole (PZ), Italy

ABSTRACT

In order to reconstruct architectural changes during the centuries often we are forced to trust merely on the evidences of archives sources as "platee", notarial deeds and similar which could sometimes supply the description of the building or of a specifically build phase or again, the drawing of the plan. The problem is the interpretation of planimetry or documents description and the translation in a hypothetical vertical section of the building. The historical building structure, shape and masonry, as it appear at the present are often the final result of a stratification of different phases deeply connected with artistic and technological culture of the age in which it is designed and realized. Stylistic features, building techniques and functional aspects change in time leaving often a written trace in archives sources such as on the building envelope stone masonry texture sometimes hidden by plasters. In such situation the ND investigation by infrared thermography can be useful to verify the wall morphology and to detect the presence of local defect and/or other material inclusions which belongs to the different building phases.

Starting to these preliminary remarks, this paper deals on the emblematic study case of San Francesco convent near Montella (AV) because of complex vicissitudes experienced in last centuries which has been reason of radical transformation of the buildings and church. Historical and archival research has been carried out by the study of published and unpublished documentation of the 17th and 18th centuries which permits to give an interesting chronology of all the interventions and planimetric transformations of the buildings. This data has been correlated with the results of the infrared thermography survey on plaster covered fronts of the buildings, leading to a map of the hidden masonry texture. Masonry analysis on infrared images structured in GIS architecture showed the different building phases pointing out the correlation with the structural vulnerabilities.

The integrated and multidisciplinary researches carried out on historical and archival data and the use of building analysis techniques based on infrared thermography and GIS show the enormous potential of the use of this interdisciplinary approach.

Corresponding author: e.geraldi@ibam.cnr.it

Natural vs built environment: integrated methodological approach for reconstruction of connections between urban transformations and natural environment of the ancient Tursi Rabatana citadel, southern Italy. (abstract withdrawn)

E. Geraldi[1], M. Lazzari[1], M. Lapenna[2], A. Loperte[2]

[1] CNR IBAM, Via Federico II, Castello di Lagopesole, 85020 Lagopesole (PZ), Italy
[2] CNR IMAA, C.da S. Loja, 85050 Tito Scalo (PZ), Italy

ABSTRACT

Tursi and its medieval citadel called "*Rabatana*", located to the top of a sandy-clayey hill, is one of the most representative sites of the cultural heritage of Basilicata region, southern Italy. In spite of this, the historical origin of this small citadel characterized by an Arabian toponym is still now not well defined. Historically the first phase of life of Rabatana's citadel is deeply connected with caves excavation along the steep slopes of the hill, used as shelter for men and animals as well as part of a hydraulic system to collect water in cisterns. The interaction during the last centuries between anthropic activity (caves excavation, birth and growing of a built-up area and following recent desertion of the settlement) and the characters of this natural environment have been the reason of a progressive increasing of the hazard and vulnerability levels of this site. In order to reconstruct the complex interactions of the last ten centuries between the natural and the built environment of Tursi-Rabatana site an integrated methodological approach has been carried out. Urban form, individuation of the settlement's location as well as all that belongs to the anthropic activity is the expression of the military, religious, artistic and technological culture of the age in which it is designed and realized. Stylistic features, building and hydraulic techniques and functional aspects change in time often modifying the link that each settlement has with the environment to which it belongs.

Integrated analysis between historical documents, (urban structure and its evolution, building and hydraulic techniques) territorial data and a geophysical survey has been carried out in order to understand the meaning of the labyrinth of interconnected and overlapped ancient buildings to hypogeal structure, such as cisterns, crypts and caves, with respect to the urban origin and development, as well as the present risk level of the settlement. The geophysical investigation, combining the Electrical Resistivity Tomography (ERT) method with the Ground Penetrating Radar (GPR), permitted to map shallow cavities and tunnels in the subsurface giving a contribute to better reconstruct the hypogeal environment excavated in the shallow sandy layers. The work also evidenced as the ancient hydraulic systems, now almost completely forgotten, used to collect and store water inside the urban area, as well as the morphoevolutive processes linked to the lithology of the substratum and rainfalls have been determinant for increasing the risk level.

Corresponding author: e.geraldi@ibam.cnr.it

Spectroscopic analysis using a hybrid LIBS-RAMAN system

A. Giakoumaki[1], I. Osticioli[2] & D. Anglos[1]

[1] Institute of Electronic Structure and Laser, Foundation for Research and Technology-Hellas (IESL-FORTH), P.O. Box 1527, GR-711 10 Heraklion, Crete, Greece
[2] University of Florence, LENS, Via della Lastruccia n. 3, Polo Scientifico Universitario, I-50019-Sesto Fiorentino (Fi) Italy

ABSTRACT

In the present study, a novel laboratory system, combining two spectroscopic techniques, laser induced breakdown spectroscopy (LIBS) and Raman spectroscopy, for the analysis of materials in objects of cultural heritage, was developed. While both Raman microscopy and LIBS have been used extensively as diagnostic tools in art and archaeology their combined use is limited, as it generally requires different instruments. The goal of this research is to demonstrate the applicability of a hybrid LIBS-Raman unit as an analytical tool for the investigation of samples and objects related to cultural heritage.

The system proposed utilizes a nanosecond pulsed Nd:YAG laser (532 nm) for both LIBS and Raman analysis. In the Raman mode a low intensity beam probes the sample surface and the scattering signal is collected into a grating spectrograph coupled to an intensified CCD detector, which records the Raman spectrum. In the LIBS mode a single high intensity pulse from the laser irradiates the sample surface and the time- and spectrally-resolved emission from the resulting laser ablation plume yields the LIBS spectrum. The advantage of the hybrid system implemented is that it employs a single laser source, common optics and the same spectrograph-detector system detection enabling the convenient application of both analytical techniques in a practically simultaneous way.

The performance of the hybrid LIBS-Raman unit was tested with the analysis of selected pigment and mineral samples. Thus, the present system can be proved useful providing simultaneous atomic and molecular information in a rapid and convenient way. The limitations of the hybrid unit are also discussed and should be considered.

Corresponding author: annie@iesl.forth.gr

The use of an environmental data sheet: the case of Musei Civici of Pesaro (Italy)

E. Giani[1], A. Giovagnoli[1], M.P. Nugari[1], E. Ruschioni[2], L. Gordini[1]

[1] Istituto Centrale per il Restauro, Piazza San Francesco di Paola, 9 – 00184 Rome, Italy
[2] Centro di Fotoriproduzione, Legatoria, Restauro degli Archivi di Stato, Via C. B. Vaccolini, 14 - 00153 Rome, Italy

ABSTRACT

The *ICR Data Sheet* is a useful instrument to reach a global view of the conditions of exhibition and storage areas of museum. In the data sheet several parts have to gather synthetically all the information about the environment conditions in order to evaluate if they are suitable for the conservation, also in relation with the typology of the materials of the collections.

Three different thematic units constitute the data sheet: building, museum, out-door environment. In particular the part "museum" divides into three basic groups of information: the presentation of the museum, the description of the specific rooms under enquiry, the measures of environmental parameters (air quality, physical parameters, biological agents of deterioration).

This study regards the application of the *ICR Data Sheet* in Musei Civici in Pesaro: the research has been focused on Pinacoteca because there are in exhibition the most esteemed wooden works, as the Giovanni Bellini's Pala Pesaro.

The work has started during the autumn 2003 and it will go on until the summer 2004. The aim of the research is to give useful information about forwards planning for the new mounting project of the Museums. All collected data offer an useful help to fill in the facility reports give with the loan form.

The *ICR Data Sheet* has pointed out the risk connected with the management of the environment. For instance the influence of heating system and the cleaning of the exhibition halls on the state of conservation of the organic support.

Corresponding author: alama@libero.it

Greek painted chamber tomb in Taranto (South Italy): characterization of plasters and pigments

M.T. Giannotta, G. Quarta

CNR - IBAM (Institute of Archaeological Heritage Monumental and Site)
Campus Universitario, via Monteroni 73100 Lecce (Italy)

ABSTRACT

At the end of the nineteenth century frenetic building development in the ancient nucleus of Taranto to the East of the old town led to the destruction of many monuments and archaeological remains to the Greek and Roman periods. The monuments that were saved constitute an exception, and include some chamber tombs of the Greek period which have been maintained because of their extraordinary features and state of conservation.

Among these are some hypogeum funeral chambers with plastered and painted walls, which are recently restored.

We present here the results of a archaeological study and the analytical data for the "Gemina" chamber tomb dated to the last quarter of the fourth century B.C.

The aim of the present work is to analyse the constituent materials and the techniques used in execution, as well as the conservation of the plasters and the paintings in the tombs.

The samples taken were subjected to chemical analyses using ESEM observations with EDS microanalyses and FT-IR, and mineralogical-petrographical analyses by XRD an by observations on thin sections.

The results obtained indicate that the walls of the tomb were constructed using blocks of medium-to-fine grained calcarenite. On the surface was applied a layer of plaster composed of a carbonate hydrate lime binder and en aggregate made up of crystals and fragments of sparry calcite. The pigments used in the paintings are lime-wash, red and yellow ochres, and egyptian blue.

The present work contributes to the analysis of Greek funerary painting, under stood as the study of materials and painting techniques, and the results obtained may be compared with those of research conducted on other ancient paintings monuments, Greek and Indigenous, in pre-Roman Italy.

Corresponding author: mt.giannotta@ibam.cnr.it

Stone materials from Tudela cathedral (Navarra, Spain). Characterization of stone and evaluation of deterioration processes

J. Gisbert, P. Navarro, O. Buj, B. Franco, N. Mateos, B. Bauluz

Departamento de Ciencias de la Tierra, Universidad de Zaragoza, Spain.

ABSTRACT

This paper shows the study of the stones and their decay forms, in order to establish the causes and mechanism of decay. Tudela Cathedral is built of upper Miocene limestone (80%) and Miocene sandstone (20%). This sandstone was introduced mainly in the XX century during a number of different restorations.

The stones were studied by petrographic microscopy. Campanil limestone is classified as bioclastic wackestones-packstones, with a terrigenous content ranging from 2% to 6% and organic matter from 1,5% to 2,5%. Sandstone from the Ebro basin is classified as litharenita, made up of litihic fragments 38%, calcite cement 28%, quart 20%, dolomite 3%, feldspars 2%, matrix 9% and porosity 14%.

The main type of decay that affects this limestone is both very aggressive and very fast. This type of deterioration seemed to be mechanical, given that there were fractures with conchoidal surfaces and sharp edges.

The morphological study of the stone indicated that there was an expansive process. Dilation by water absorption tests were carried out and the increase in length after testing was $2{,}5^{0}/_{00}$; this increase in length did not justify the deterioration which was present. However, laboratory studies have suggested that during extreme drying (with a magnesium sulphate solution 5%), the samples increase their volume causing stresses with fracture and loosen the surrounding material. These increases in length are about ten times greater during the extreme drying than during water absorption. In addition, there is a good correlation between increases in length and the amount of organic matter present.

Portland cement and sandstone have played an important role in the stone decay, as they have been the origin of magnesium salts. Both of them have been used from 1900 until 1980 in several rehabilitation operations. The different lithological types present variations in the pore size distribution and in its effective porosity. Laboratory tests carried out on samples suggested that there is a magnesium salt migration from macroporous sandstone to microporous limestone. This process has been reproduced in laboratory.

The result of petrographical and physical tests carried out suggested that expansion by drying (EPS) is due to the action of salts magnesium, organic matter and extreme drying.

Corresponding author: gisbert@unizar.es

Influence of simulated heating regimes on the crystallisation morphologies of sodium chloride (NaCl)

M. Gómez-Heras, R. Fort

Instituto de Geología Económica (CSIC-UCM)
C/ José Antonio Novais 2, 28040 Madrid, Spain
(RTPHC-CSIC)

ABSTRACT

The crystallization of soluble salts within the pores of the stone is widely recognised as a major mechanism causing the deterioration of monuments and architectural heritage and the temperature is one of the main controls on the crystallisation dynamics.

The temperature controls the free energy (ΔG) of the saline solutions, and therefore the salt precipitation. Temperature also controls the pressure of crystallisation salts. In addition thermal expansion of salts is much greater than the thermal expansion of host rocks, such as granites or limestone. Therefore the distribution of temperatures within the material is of great importance for considering the mechanisms of stone decay by salt crystallisation.

As most (if not all) laboratory experiments on decay generated by salts are carried out with convective heating regimes, the aim of this work is to assess the morphologic differences and changes in distribution of salts within a porous stone tested with different heating regimes (convection and radiation).

Results show that heating regime noticeably controls the salt distribution within a porous stone. In the case of sodium chloride, radiation heating favours the generation of subefflorescences, while convection heating promotes the formation of efflorescences. This has a clear implication both on the stone decay in natural environments and on the methodologies for testing salt decay, as subefflorescences are more destructive than efflorescences.

In natural environments this means that in a building, stones in insolated areas will be more susceptible to present spallings related with sodium chloride crystallisation than other areas with insolation, in which the efflorescence of sodium chloride will generate more aesthetical damage and less mechanical breakdown of the rock.

Regarding laboratory experimentation, the use of convective heating will underestimate the potential damage that sodium chloride may generate, and counsels the use of radiation heating test methods for the laboratory study of salt crystallisation.

Corresponding author: mgh@geo.ucm.es

Evolution of porosity in Hungarian building stones after simulated burning

M. Gómez-Heras[1], M. Hajpál[2], , M. Alvarez de Buergo[1], A. Török[2], R. Fort[1], M.J. Varas[3]

[1] Instituto de Geología Económica (CSIC-UCM), Madrid, Spain
[2] Technical University of Budapest, Hungary
[3] Facultad de CC. Geológicas (UCM), Madrid, Spain

ABSTRACT

The porosity and the distribution of the porous system of stone are one of the most important properties to be taken into account in the studies on stone decay. Pore distribution conditions the absorption and circulation of water within the stone and the water dynamic has an outstanding influence in relevant stone decay agents such as, for example, salt crystallisation or biodeterioration. These changes have to be taken into account in addition to the damage generated by the fire itself

Fire may generate both chemical and physical changes in building stones. The main effect of fire in tough stones is the modification of porous system due to the generation of fissures due to the thermal stresses generated by the sudden temperature variations all through the fire episode. New fissures are developed because of the thermal expansion of individual minerals and the mismatches between the thermal expansion of adjacent minerals. This is coupled with the growth of pre-existing microcracks. The absence of matrix, which in friable materials muffles the effects of thermal expansion mismatch, and the low porosity, which conditions a greater packing of the minerals, favour the generation and propagation of fissures.

The aim of this work has been to characterize and assess the changes generated in the porous system during laboratory simulated burning of four tough stone types commonly found as building materials in Central Europe. These stone types include a rhyolitic tuff and three types of limestones with varied initial characteristics of overall porosity and porous system distribution.

Laboratory simulated burning has been carried out with oven-based techniques on several core-samples of fresh quarry materials. Porous system characterisation was carried out by means of Mercury Intrusion Porosity (MIP).

Corresponding author: mgh@geo.ucm.es

Current advances in the molecular characterization of microbial communities on cultural heritage

J.M. Gonzalez, C. Saiz-Jimenez

Instituto de Recursos Naturales y Agrobiología, CSIC, Sevilla, Spain
(RTPHC-CSIC)

ABSTRACT

Biological colonization of cultural heritage requires urgent attention. Our objective is to understand which communities develop on art work to be in a favourable position to approach its conservation. Microorganisms are present nearly everywhere and due to their versatility they are able to colonize almost any habitat on Earth, including our cultural heritage. In this study, we will analyze the current possibilities for the detection and characterization of these microbial communities. Both molecular and culturing techniques are needed to determine the identity of microorganisms and the assessment of their functional role in the environment.

Novel molecular techniques are being developed in order to detect the components of these microbial communities using smaller samples, increasing our accuracy, and performing faster and cheaper analyses than previously done. Results have showed a high proportion of unknown microorganisms are actually developing on cultural heritage. Since we do not know their metabolic capabilities, we are unable to deduce their potential effect on works of art. Culturing techniques might provide highly significant insights into the role of these unknown microorganisms. Although most microbes are difficult to culture, several new species retrieved from cultural heritage are described every year. The requirements of knowing which microorganisms are present and metabolically active, and the metabolic capabilities and physiology of these microbial community components must be met. Potential negative effects might be provoked if actions are taken against biodeterioration without a significant comprehension of the biodiversity and metabolism of the microbial communities.

Corresponding author: jmgrau@irnase.csic.es

BIODAM - Novel polyphasic approaches to biofilm control using molecular techniques

A.A. Gorbushina[1], W.E. Krumbein[2], J. Marquardt[1]

[1] Geomicrobiology, ICBM, Carl von Ossietzky Universitaet Oldenburg, Oldenburg, Germany
[2] BIOGEMA Consulting, Lindenweg 16a, D-26188 Edewecht, Germany

ABSTRACT

Building materials such as stone, bricks and concrete or clay based materials often contain organic compounds or receive organic particulates from the surrounding atmosphere. They are thus very susceptible to the growth of sub-aerial biofilms attacking the substrate they settle on. Chemical and physical biodeteriorative forces may be involved. Depending on the environmental conditions and water retention the surface biofilm may transform into networks going deeper into the material (biodictyon). Biocide treatments of monuments create health and environmental hazards. Thus research and development of new applications and treatments must concentrate on a minimal use of the least dangerous biocide substances. The latter must be as firmly as possible integrated into the materials. Otherwise very serious hazards may evolve. A polyphasic treatment by biocides, permeabilisers, and physical (light) induction of the activity of both compound groups have been developed by an R&D team supported by the cultural heritage program of the EU under the project name BIODAM. A brief survey is given of potential techniques as well as on the damage factors, responsibility and cost of repairing biofilm damage related to buildings with stone surfaces. The special part of fungal biofilms and networks within the problem is described and molecular techniques to identify fungi and the elimination of fungal compounds is a special focus of this contribution. An outlook is given on climatic situations under which biocide treatments are useful or should be avoided because due to climatic conditions the treatments would not be effective.

This work was supported by EU project grant EVK4-CT2002-00098.

Corresponding author: a.gorbushina@uni-oldenburg.de

Investigations in Islamic tapia wall construction in the south of Spain

A. Graciani-García, Á. Barrios-Padura[2], M.Á. Tabales Rodríguez, J. Barrios Sevilla

Universidad de Sevilla, Spain

ABSTRACT

There is a lot of information about Islamic tapia wall construction in the south of Spain, but the studies done are disconnected, hidden and in many cases whenever you get to them, the investigations are lacking of enough results to approach a refurbishment project.

We are an interdisciplinary group of researches of the Investigation Project I+D (2004-2007) BIA 2004-01092, titled: Proposals of maintenance, evaluation and restoration for rehabilitation of buildings and urban infrastructures with historical tapia walls in the Province of Seville (Spain). Architects, Archaeologists, and Chemists, working together to gather results of the investigations developed in the past, and analysing new building and archaeologist sites to make up a data base to offer to the restorers, public authorities, and whoever is involved in restoration processes, that consider construction types, characterisation of the materials, common injuries, and restoration techniques.

We will expose the results of our investigations in Islamic tapia wall construction, expecting that any other researcher who can be working in the same themes could join us and enrich our work, being conscience of the need of connection between any place in the world that has in its cultural heritage any traces of Islamic architecture.

Corresponding author: agracianig@us.es

Products of historical concrete degradation: qualitative and quantitative study

M. Gregerová[1], P. Pospísil[2]

[1] Masaryk University in Brno, Faculty of Science, Institute of Geological Sciences, Kotlarska 2, 611 37 Brno, Czech Republic
[2] Brno University of Technology, Faculty of Civil Engineering, Department of Geotechnics, Veveri 95, 602 00 Brno, Czech Republic

ABSTRACT

Methods and results of study of selected concrete samples from historical structures are presented and discussed in the paper.

The emphasis is put on the right choice of proper field methods of investigation, especially on methods of representative sampling of structure together with collection of relevant data about outer and inner environment affecting formation of degradation products (neogenic minerals).

They are discussed in detail recommended methods of sample preparation for laboratory study in comparison with own opinions with sample preparation.

Both methods of field and laboratory methods have been repeatedly applied and verified in the process of special investigation before remediation of the structure, also from the point of view of ratio of amount of relevant results usable for remediation and expended financial resources.

The result of study is description of alteration of original composition of building material and detail classification of degradation products both from qualitative and quantitative points of views. An integral part of complex assessment is analysis of formation and progress of degradation processes of building materials, caused by interaction of individual material components and in the relation to outer environment.

The research was supported by project MSM 0021622418 Ministry of Education of the Czech Republic.

Corresponding author: mirka@sci.muni.cz

Technological features of glazed Protomajolica wares from Benevento (Italy)

C. Grifa[1], V. Morra[1], A. Langella[2], G. Cultrone[3], E. Sebastian[3]

[1] Dipartimento di Scienze della Terra, Università Federico II, Via Mezzocannone, 80134, Napoli, Italy
[2] Dipartimento di Studi Geologici e Ambientali, Università del Sannio, Via Port'Arsa, 11 82100, Benevento, Italy
[3] Departamento de Mineralogía y Petrología, Universidad de Granada, Fuentenueva,s/n 18002, Granada, Spain

ABSTRACT

The production of glazed ceramics in Italy started in 12th century, following the Islamic technique. *Protomajolica* samples, proceeding from two high-medieval archaeological sites in Benevento, were analyzed from mineralogical and petrographical points of view to individualize and characterize local production of glazed coarse wares. Samples are composed by jugs and amphorae, with glazed slip inner and outsider walls, and bowl and dish with thin glazed surface only on the internal wall. Fragments show decorations (animal and vegetal fantasies) and the colour's paste range from creamy to orange.

In the same archaeological levels, ceramic fragments dark grey coloured and affected by over burning of the paste (probably, kiln refuses) were collected. Optical microscopy analyses evidence a very fine paste (0.1-0.3 mm), with rounded grains of quartz, feldspars and muscovite lamellae, dispersed in a low birefringence matrix. Sporadically, larger crystal and/or volcanic fragments (sanidine, clinopiroxene and pumice) are observed. X-ray diffraction points out the large amount of quartz and feldspars in all samples. Some fragments are distinguished for the presence of calcite and gehlenite at the same time, probably due to a partial decomposition of carbonates. In addition, the presence of illite suggests a firing temperature of ~ 800°C.

Other samples (kiln refuses included) show diopside and gehlenite which indicate a higher firing temperature (~950°C). Scanning electron microscopy (SEM) confirms diffractometric data: the samples fired at ~ 800°C (calcite and gehlenite-bearing) evidence a partial vitrification, while the samples fired at higher temperature (diopside-bearing) show a total vitrification of the matrix. X-ray fluorescence detects high values of calcium oxide (approximately 13%) indicating a calcareous character of raw materials. The large similarity in chemical composition comparing ceramics and kiln refuse can indicate a local production of *Protomajolica* wares.

The analysis of glazed covers by SEM shows neither radial fractures nor bubbles. It has been observed a great adherence of glass to ceramic paste. It has been distinguished a Pb-rich glass layer in contact with the paste (used as catalyst), and an upper silica glass layer with cassiterite crystals.

Corresponding author: celgrifa@unina.it

Sulfate and carbon compounds in black crusts from the Cathedral of Milan and Tower of London

C.M. Grossi[1], P. Brimblecombe[1], A. Bonazza[2], C. Sabbioni[2], J. Zamagni[2]

[1] School of Environmental Sciences; University of East Anglia, Norwich, NR4 7TJ, UK
[2] Institute of Atmospheric Sciences and Climate, CNR-ISAC, 40129 Bologna, Italy

ABSTRACT

This paper interprets the processes within black layers of historical buildings in terms of atmospheric deposition, transfer from the underlying original stone, chemical transformation within the crust and finally dissolution, migration and loss of soluble compounds. Our conceptual model focuses on the relation between carbon compounds and inorganic salts such as sulfates or chlorides. This allows us to understand the different rates of mobilization and accumulation of materials on stone surfaces. Sparingly soluble compounds such as oxalate and sulfate have a long residence time in the crust and undergo subsequent transformations slowly, so are likely to be conserved. Conversely more soluble ions, such as chloride and formate are removed from the layers relatively quickly by rainfall. Organic compounds are the result of biological transformations of carbon so may be continually produced within the crust. Some of these (e.g. acetic acid) although soluble are maintained at reasonable concentrations by biological activity and some inorganic anions such as nitrate may also be part of biological processes. Sulfite, although easily oxidized in the crust can be maintained by a steady deposition of sulphur dioxide from the atmosphere. Our study of crusts from the Tower of London and the Cathedral of Milan establishes transformation rates and fluxes in modern crusts that are richer in organic materials than typical of the crusts derived from coal smoke that characterised buildings a hundred years ago.

Corresponding author: c.grossi-sampedro@uea.ac.uk

The succession of biofilms on building stone and its possible impact on biogenic weathering

M. Hoppert[1], S. König[1,2]

[1] Universität Göttingen, Institut für Mikrobiologie und Genetik, Grisebachstr. 8, Germany
[2] present address: Universität Göttingen, Albrecht-von-Haller-Institut für Pflanzenwissenschaften, Justus-von-Liebig-Weg 11, Germany

ABSTRACT

All surfaces of building stone are exposed to the environment and may be colonized by organisms. The organisms are often organized as microbial biofilms that cover the surface of the material and/or penetrate the substratum. It appears to be logical to consider that organisms, especially when they penetrate the substratum, destroy the surface. This has been - in fact - frequently observed on the micro- and macroscale. Our investigations show that the extent of biogenic weathering depends on the state of biofilm development [Hoppert, M. et al. Environ. Geol. 46, 421-428, 2004]. During initial stages of biofilm development, organisms grow rapidly and achieve fast colonization of the surface. This strategy also allows for a high loss rate of the organisms either by biogenic or abiogenic weathering. Rapid growth rates quickly compensate for these losses.

In an advanced state of biofilm development, the pioneer colonizers are replaced by colonizers with different life strategies: they exhibit slower growth rates and longer generation cycles, but are generally better adapted to their environment than the primary colonizers. This leads to a step-by-step displacement of the pioneers. This stage of colonization does only take place, if weathering (biogenic as well as non-biogenic) is low. Thus, the secondary colonizers have developed mechanisms for a more "sustainable" colonization of their substratum. In order to achieve this, the organisms will treat their substratum in a way that loss of material is limited – otherwise, the organisms themselves may get lost together with the material and would not achieve successful colonization [Kemmling, A. et al. Environ. Geol. 46, 429-435, 2004]. It appears that some organisms (e.g. certain lichen species) may even protect their substratum from (non-biogenic) weathering. These features will be elucidated and discussed in view of management of biofilm growth on building material.

Corresponding author: mhopper@gwdg.de

Low pressure abrasive cleaning on historic building materials

M. Iglesias[1,2], B.Gea[1], J.L. Prada[2], N.Guasch[2]

[1] Materias Primas Abrasivas - MPA, S.L., Spain
[2] CETEC-patrimoni (Universitat Autònoma de Barcelona – Institut Químic de Sarrià), Spain

ABSTRACT

In this paper, we explain a series of tests with low pressure abrasive cleaning on different materials of historic buildings, mainly stone, with different historical layers to eliminate (dirt and restoration polychromies) and to conserve (patina and ancient polichromy).

In order to decide on the type of tests, and the subsequent execution, we make first, an evaluation of the material conservation and the layers to be eliminated. Once this information is obtained, the type of cleaning process to apply is evaluated. The advantage or disadvantage of each technique (water cleaning, chemical or mechanical cleaning) regarding the material conservation and the development of the restoration works, are shown.

After these considerations, mechanical cleaning was chosen for the cases studied with a specific abrasive. Various test were carried out using different parameters of blasting technique (pressure, angle, distance, etc.) in order to determine the more appropriate.

To evaluate the effectiveness of the mechanical cleaning test, in this first phase, various visual analyses with binocular magnifying glass and optic microscopy were carried out. This previous information allows us to decide if the test results are suitable, because surface abrasion is normally the first damage. Another technique used to evaluate the tests was SEM, to observe morphologic and textural changes, and possible alteration on the superficial composition (polychromies).

The results obtained in these tests have been used in specific restoration works: the Romanesque Façade of Sant Martí de Puig-Reig (El Berguedà-Catalonia) and the Romanesque Cloister of Sant Pau del Camp (Barcelona).

Corresponding author: miglesias@mpa.es

Novel species of the genus Phyllobacterium in the biofilms covering the walls of Roman Catacombs

V. Jurado[1], J.M., Gonzalez[1], L. Laiz[1], M.C. Portillo[1], M. Hernandez Marine[2], C. Saiz-Jimenez[1]

[1]Instituto de Recursos Naturales y Agrobiología, CSIC, Sevilla, Spain
(RTPHC-CSIC)
[2]Facultad de Farmacia, Universidad de Barcelona, Spain

ABSTRACT

Molecular surveys of microbial communities in Roman catacombs of Saint Callixtus (Rome, Italy) have revealed the presence of *Phyllobacterium* 16S rRNA gene sequences. In these environment, *Phyllobacterium* appears to be linked to the development of cyanobacterial colonization of catacomb walls. This finding represents a novel niche for members of this genus since previously described *Phyllobacterium* has always been associated to plant nodules or the rhizosphera.

To complement molecular surveys, attempts to culture strains of the genus *Phyllobacterium* resulted in the isolation of two strains, CSC19 and CSC32. These two strains were characterized following a polyphasic approach. The 16S rRNA gene sequence allow to classify these strains within the genus *Phyllobacterium*. Previously described species of this genus *P. myrsinacearum* and *P. trifolii* show significant differences with the two isolated strains. Further genotypic and phenotypic tests suggested the proposal of a new species *Phyllobacterium catacumbae*, so far constituted by the two isolates obtained during this study.

Our results showed that members of *Phyllobacterium* are common components of the microbial communities in catacombs and they might have interest as potential biodeteriorating agents in these environments.

Corresponding author: vjurado@irnase.csic.es

Experimental and numerical evaluation of a new method for joining together fragmented structural members

S. K. Kourkoulis[1], M. Mentzini[2], E. Ganniari-Papageorgiou[1]

[1] Department of Mechanics, National Technical University of Athens, 157 73 Zografou, Athens
[2] Committee for the Conservation of the Acropolis Monuments, Acropolis, Athens

ABSTRACT

The present study assesses a recently introduced approach for the calculation of the reinforcement required for the restoration of fractured architraves using titanium bars. The method focuses on the restoration of fragmented structural members on the basis of the maximum expected loading [Ioannidou, M. and Paschalides, V. 2002, in Proceedings of the 5th International Meeting for the Restoration of the Acropolis Monuments, 291-300 (ed. Malouhou-Tufano, F.) (Committee for the Conservation of the Acropolis Monuments, Athens)], as opposed to the restoration on the basis of the initial strength. The evaluation of the method is carried out both experimentally and numerically.

For the experimental assessment of the method an identical copy (model) of the worse damaged architrave of the north colonnade of the Parthenon Temple on the Acropolis of Athens was constructed under a 1:2 scale. The model was prepared very carefully taking into account all the material and geometrical characteristics of the authentic architrave. The material used for the construction was Dionysos marble, since it is the material used almost exclusively for the restoration of the Acropolis monuments. This marble is composed by 98% of calcite, and contains amounts of muscovite, sericite, quartz and chlorite. It is an orthotropic material with three distinct anisotropy directions (one parallel to the layers, a second one along the width of the web and a third one along the thickness of the web). A long series of experiments indicated that the mechanical properties along the first two of these directions are similar to each other and the material can be considered as transversely isotropic. Also, it should be stressed that the size effect is very strong for this material [Vardoulakis I., Kourkoulis S., Exadaktylos G. & Rosakis A. 2002, in Proceedings of the Interdisciplinary Workshop: The building stone in monuments, 187-210 (eds. Varti-Mataranga M. and Katsikis Y.) (IGME Publishing, Athens)] and the relative dependence of the strength on the specimen size was carefully considered during the present analysis.

The model was subjected to eight-point bending, in an effort to simulate a uniform load distribution. During the loading procedure the strains, the deflections and the opening of the cracks were recorded with the aid of a system of strain gauges, dial gauges and COD-clips, respectively. The analysis of the experimental data proved that the initially multi-fractured architrave undertook loads, behaving as an intact structural member for load levels exceeding the maximum expected load about 100%. The experiment was then modeled numerically by the finite element method in an effort to enlighten various phenomena observed during the loading procedure. The most striking conclusion of the numerical analysis was that major attention should be paid to the accurate determination of the actual span of the architrave. Indeed during the loading process the contact surface between the architrave and the respective capitals changes gradually causing a serious change of the maximum bending moment estimated and therefore of the amount of reinforcing bars required for the restoration.

Johannes Aquila and the technique of Gothic mural painting (14th century)

A. Kriznar[1], A. Ruiz-Conde[2] , P.J. Sánchez-Soto[2]

[1] Department of History of Art, Faculty of Philosophy, University of Ljubljana, Slovenia
[2] Institute of Materials Science of Sevilla (CSIC-University of Sevilla), c/Américo Vespucio 49, Isla de la Cartuja, 41092 Sevilla, Spain (RTPHC-CSIC)

ABSTRACT

The authors are involved in an interdisciplinary approach to investigate the technique of mural painting in Slovenia. Two years ago, a project dedicated to this interesting subject of Cultural Heritage in Europe was started involucrating art historicists, restorers and materials scientists. This paper presents a part of the results and it is dedicated to one of the most important gothic painters in Slovenia, Johannes Aquila, the first artist known by name. The investigation has been carried out as a collaboration between the Department of Art History and the Faculty of Philosophy, University of Ljubljana (Slovenia) and the Institute of Materials Science in Sevilla (Spain).

The conservated works of Johannes Aquila, artist who came from Radkesburg in today's Austria, are dated into the last quarter of XIV century. At first he worked alone, later he organized a large workshop which carried out the orders. From the two huge fresco cycles painted by Aquila on Slovene northeast territory (Prekmurje) in the churches of Turnisce (1380/81-83, presbitery, and 1389, nave) and Martjanci (1392), selected tiny samples of mortars and pigments were taken. These samples were studied by different laboratory procedures and instrumental techniques: elaboration of cross-sections, optical microscopy (OM), scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS), Fourier Transform Infrared Spectroscopy (FTIR) and X-ray Diffraction (XRD). Our goals in this research were: a) to see what was the technique of mural paintings used by the master: *a fresco*, *a secco* or *lime technique*; b) the composition of the mortar; c) what kind of pigments were used; d) the manner of masters' painting: did he use predrawings, underpaintings, incissions, how was his colour modelation, and e) the weathering and conservation state of the main mural paintings. The results showed us, among other interesting things, the specific design and construction of mortars made by lime, sand and organic fibres, and the painters' pallet, consisted of mainly natural inorganic pigments. In some rare cases, we have found the presence of lead pigments. We compared all these aspects of the technique of Aquila with his disciples, observing the graduate loss of quality. All these features are important in the caracterization of the state of conservation of Johannes Aquila's mural paintings.

Acknowledgments: Project MAT2002-02549, financied in part with FEDER, and bilateral cooperation.

Corresponding author: aruiz@cica.es

Microbial assessment of biological colonization on roofing tiles

L. Laiz[1], J.M. Gonzalez[1], M.C. Portillo[1], M.F. Gazulla[2], E. Sanchez[2], C. Saiz-Jimenez[1]

[1] Instituto de Recursos Naturales y Agrobiología, CSIC, Sevilla, Spain
[2] Instituto de Tecnología Cerámica, Castellón, Spain

ABSTRACT

Biological colonization of roofing tiles affects not only the aesthetic aspect of the roof but also its functionality. Herein, we analyzed the composition of natural microbial communities developed on roofing tiles aiming to be able to reproduce the colonization process as a method to evaluate the bioreceptivity of roofing tile materials.

In this study, both molecular and culturing techniques have been carried out. Cultures were developed in order to reproduce the capabilities of different types of microorganisms to develop on roofing tiles in laboratory experiments. Bacteria, fungi, microalgae, and cyanobacteria were cultured and classified taxonomically by DNA-based molecular analysis using the small subunit of the ribosomal RNA gene (16S and 18S for prokaryotes and eukaryotes, respectively).

Microbial community fingerprints were obtained from naturally colonized roofing tiles and both phototrophic and heterotrophic cultures were prepared. Several strains of *Streptomyces* sp., a fungus (*Fusarium* sp.), and mixed cultures of phototrophic microbial communities were isolated and assayed for their capability to colonize roofing tiles. Complex microbial communities naturally develop on roofing tiles constituting the first stage in the colonization of these covering materials by on macroscopic organisms. Representative microorganisms constituting these microbial communities were cultured and evaluated by their ability to develop on these roofing materials. Our results demonstrate that roofing tiles are highly bioreceptive to microbial colonization and the process can be reproduced under laboratory conditions.

Corresponding author: leo@irnase.csic.es

Methodology of study of the bioleaching of a cement matrix

H. Lajili[1,2], J.-R. Degorce-Dumas[1], C. Grambin-Lapeyre[2],
J. Roussy[1], P. Devillers[1], J.-P. Bournazel[1]

[1] Ecole des Mines d'Alès, Laboratoires LGEI et CMGD, France
[2] Ecole des Mines de Paris, Centre de Géologie de l'Ingénieur, France

ABSTRACT

The phenomenon of concrete biodegradation was firstly studied and characterised by Parker (1945). The most frequent micro-organisms reported in literature to be implicated in the degradation of buildings materials, especially composites, are bacteria. Recent studies indicate that fungi can be responsible of the alteration of cement matrix (indirectly via organic acids secretion).

The alteration of cement pastes by biolixiviation is due to dissolution of portlandite and decalcification of the hydrates, specially C-S-H gel and hydrated aluminates. Thus, it is a very important phenomenon for concrete structures subjected to aggressive water, in particular for agricultural structures and sewer systems. The biolixiviation involves physicochemical and mechanical deterioration of the cement paste.

The poster presents the methodology of study of the biolixiviation of a cement matrix by the fungus *Aspergillus niger* and experimental results for 3 months of degradation for an ordinary Portland cement paste. This methodology includes the development of protocols for biolixiviation and controls to perform a rigorous interpretation of the phenomena observed during the biolixiviation test.

Corresponding author: habib.lajili@ema.fr

VHR satellite images for the knowledge and the valorization of cultural landscapes: the medieval deserted villages in Basilicata (Southern Italy)

R. Lasaponara[1], A. Lanorte[1], N. Masini[2], M.R. Potenza[2]

[1] Istituto di Metodologie per l'Analisi Ambientale, IMAA-CNR, C.da S.Loja - 85010 Tito Sc. (PZ), Italy.
[2] Istituto Beni Archeologici e Monumentali, IBAM-CNR, Sezione di Potenza, Via Federico II, 85020 Lagopesole (PZ), Italy.

ABSTRACT

In the last century panchromatic aerial images have been the only tools employed in the aerial archaeology. The use of satellite remote sensing data has been generally restricted due to the limited spatial resolution of conventional imagery, such as TM (30 m) or Spot (10 m). The recent availability of Very High Resolution (VHR) satellite images, such as IKONOS (1999) and Quickbird (2001), can provide new perspectives in the field of archaeological remote sensing.

This paper deals with the potentialities of QuickBird data to detect the typical marks (shadow, soil and crop marks) expected in the presence of archaeological buried remains.

Test sites are relative to some medieval abandoned villages located in the Basilicata Region (Southern Italy). They were founded in the early Middle Ages and disappeared during the Middle Ages as was common throughout Europe during that age, thus, the phenomenon of deserted villages has become a very popular and relevant historical and archaeological topic.

The investigated test sites present different features from the geological, pedological and land-use point of view, thus allowing a detailed analysis of the spectral responses observed for the different features. The application shows the feasibility of QuickBird data not only for the detection but also for the spatial characterization of buried structures. Such results provided valuable information for planning archaeological excavations and for increasing the cultural value of the site.

Corresponding author: lasaponara@imaa.cnr.it

Non-destructive wood mechanical properties evaluation under continuous vibration: application to conservation of musical instruments

S. Le Conte[1], S. Vaiedelich[1], M. François[2]

[1] Laboratoire de Recherche et de Restauration du Musée de la Musique, 75019 Paris
[2] Laboratoire de Mécanique et Technologie de Cachan, 94235 Cachan Cedex

ABSTRACT

Museums keep in their collections musical instruments maintained in playable conditions. Some of them belong to the strings instrument family. A main conservation difficulty comes from the unpredictable behaviour of these instruments on a long period, considering that they are mainly made of wood and subject to considerable stresses due to string tension. The aim of this study is to measure the viscoelasticity properties of wood under a strain field, in varying vibration and thermo-hygrometric conditions, knowing that viscoelasticity seems to be deeply involved in the quality of sound and structure stability.

In a first time, the laboratory experimentation consisted in measuring the frequency dependence of the viscoelasticity through a quasi-static method. Being a direct measure, this approach presents the advantage of emitting no hypothesis on the wood characteristics. The principle is the following: when a piezoelectric emitter imposes a strain on the wood sample, a second piezoelectric receiver measures a dephasing, due to wood viscoelasticity.

We study these properties, in the first hand, on a panel of different wood species samples, and in the second hand, on a panel of single wood specie but from different ages.

Furthermore, we should present results of the experiments made under thermo-hygrometric and vibration varying conditions. These measurements, especially when made under vibrations, will allow us to build a database that should represent an important tool in the anticipation of rupture of ancient musical instruments kept in playable conditions.

Corresponding author: sleconte@cite-musique.fr

The stock of material at risk of air pollution deterioration in the Centre of Paris inscribed on the UNESCO list of World Cultural Heritage

R.A. Lefèvre[1], A. Ionescu[2]

[1] Laboratoire Interuniversitaire des Systèmes Atmosphériques, Université Paris XII, 94010 Créteil, France
[2] Centre d'Etudes et de Recherche en Thermique, Environnement et Systèmes, Université Paris XII, 94010 Créteil, France

ABSTRACT

Within the framework of EC-CULTSTRAT Programme, «Assessment of Air Pollution Effects on CULTural Heritage – Management STRATegies», an evaluation of the total surface of stone, rendering, mortar, glass, brick and metal involved in the façades of the buildings situated on the banks of River Seine in Paris, between Sully Bridge and Iéna Bridge, which are inscribed on the UNESCO List of World Cultural Heritage was performed. The risk for stone (Parisian Lutetian limestone) of buildings, bridges and statues, and for modern glass (Si-Ca-Na) of windows due to atmospheric pollution was evaluated and mapped utilizing Dose-Response Functions and maps of distribution of pollutants. The doses received by the materials are SO_2, NO_x and $PM_{2.5-10}$ concentrations and the responses of the materials are sulphation and nitration of stone, and soiling of stone and glass. The cost of sustained maintenance and restoration was evaluated for the stock at risk.

Corresponding author: lefevre@lisa.univ-paris12.fr

Integration of NDT techniques for the restoration of a rose-window: case study

D. Liberatore[1], N. Masini[2] A. Calia[3], F.T. Gizzi[2], L. Nuzzo[4], E. Rizzo[5], G. Spera[1]

[1] Università della Basilicata, Dipartimento di Strutture, Geotecnica, Geologia applicata all'Ingegneria, Viale dell'Ateneo, 85100 Potenza, Italy
[2] Istituto Beni Archeologici e Monumentali, IBAM-CNR, Sezione di Potenza, Via Federico II, 85020 Lagopesole (PZ), Italy
[3] Istituto Beni Archeologici e Monumentali, IBAM-CNR, Sezione di Lecce, Prov.le Lecce-Monteroni, - 73100 Lecce, Italy
[4] Dipartimento di Scienza dei Materiali, Università di Lecce, Via per Arnesano, 73100 Lecce, Italy
[5] Istituto di Metodologie per l'Analisi Ambientale, IMAA-CNR, C.da S.Loja – 85010 Tito Scalo. (PZ), Italy

ABSTRACT

The rose window of Troia Cathedral is one of the most precious Romanesque artefacts in Southern Italy. Its preservation could be compromised by cracks and failures underwent as a consequence of past seismic events.

Careful diagnosis of its state of decay and accurate knowledge of materials and building techniques were indispensable for effective rehabilitation works.

In particular diagnostic tests were aimed to:

1) The knowledge of mechanisms and causes of structural failures.
2) The internal survey of building elements to help restoration intervention which may require total or partial dismantling of the rose window.

To this end more Non-Destructive Testing (NDT) methods (such as Surface Penetrating Radar (SPR), Infrared termography (IRT), sonic and ultrasonic tests) laboratory analyses for the mineralogical and petrographic characterization of materials, photogrammetric and laser scanner survey of cracks and strains, were employed.

The integration of diagnostic methods allowed to optimize information acquired as well as to solve logistic problems which limited the use of some NDT techniques, due to the geometrical complexity and small dimensions of some components of the rose-window.

The results obtained provided information on the causes of failures and suggested techniques and procedures to use in the restoration intervention.

Corresponding author: n.masini@ibam.cnr.it

Weathering rates of bronze outdoor sculpture

R.A. Livingston

Office of Infrastructure R&D, Federal Highway Administration, USA

ABSTRACT

Over the long term, the loss of patina from copper and bronze outdoor sculpture is dominated by the dissolution rate of its constituent minerals, rather than the oxidation rate of the metal. Thus it is appropriate to treat the problem as a mineral weathering process. The development of a modified Pourbaix diagram reveals that the stable copper mineral phase should be the basic copper sulfate, brochantite. This can dissolve incongruently or by neutralization of acid rain.

Runoff studies of bronze sculpture at Gettysburg National Park, indicates that copper dissolution rate is not correlated with incident rain pH. This implies that the loss rate is controlled by incongruent dissolution and possibly by ammonium sulfate particulate deposition, but not by acid rain. The estimated section loss at Gettysburg is 2.6 ± 1.6 microns per year. This is in good agreement with the 100-year average rate of 1 micron measured on the Statue of Liberty. Another implication is that the application of artificial patinas for conservation of bronze outdoor sculpture will be ineffective over the long run.

Corresponding author: dick.livingston@fhwaa.dot.gov

Assessment of performances of a « facing » process

S. Logel, C. Thomachot

Laboratoire d'Etude de Matériaux (LEM), 20 route du Kochersberg, 67700 Saverne, France

ABSTRACT

Within the framework of the restoration of the Panthéon (Paris), problems were found in the ceilings where blocks were cracked and dissociated from the structure, threatening to fall. Before the restoration stage, the first stage of intervention was a preventive conservation for the security of the site. A "facing" process was chosen. It consisted of webs holding in position the blocks. Only the edge of the web was stuck.

The aim of the study was to assess the effectiveness of the process and its reversibility. Three kinds of limestone were tested: the Saint Maximin limestone commonly used for the building of Parisian monuments, the Saint Nicolas limestone and the Pierre de Bercy limestone which are similar stones to those used for the Panthéon. These rocks have mixed transfer properties. Three kinds of web were also tested: Sin galette, fine gauze and rigid gauze. And also two types of glue: Epoxy and Paraloid.

To determine the maximum load per surface unit and the surface of edge to paste, mechanical tests (tensile and shearing strengths) were performed by means of a compression machine and a frame holding two samples ($5 \times 5 \times 30$ cm^3) linked to each other with a pasted web. Then reversibility and ageing tests were carried out. Results showed no influence of the properties of the support and the type of glue on the resistance of the system. Only the type of web was decisive. The Sin galette web was more resistant than the rigid gauze, itself more resistant than the fine gauze. From these results, a relation could be established between the minimum of surface of the web to paste and the different parameters. Cleaning tests using acetone showed that the "facing" was reversible on the less porous limestone. Thus, the "facing" process, that allows maintaining dissociated blocks of several kilograms, is a possible solution to a preventive and reversible conservation.

Corresponding author: slogel@lemlabo.com

The use of protective glazing to prevent dust deposition on stained-glass windows

T. Lombardo[1], A. Chabas[1], R. Lefèvre[1], P. Ausset[1], H. Cachier[2], O. Favez[1,2], K. Oikonomou[2], A. Ionescu[3]

[1] Laboratoire Interuniversitaire des Systèmes Atmosphériques, Université Paris XII, Créteil, France
[2] Laboratoire des Sciences du Climat et de l'Environnement, CEA-CNRS, Gif sur Yvette, France
[3]Centre d'Etudes et de Recherche en Thermique, Environnement et Systèmes, Université Paris XII, France

ABSTRACT

Due to the deposition of particulate matter stained glass windows undergo soiling, that is to say an optical impairment of their transparency. In the framework of the EC Project VIDRIO, the efficiency of protective double glazing in the abatement of soiling was studied using *modern glass soiling sensors*.

Several samples of a silica-soda-lime glass (float glass) have been exposed in the Cologne Cathedral (Germany) and in the Saint Urbain Basilica in Troyes (France) in different locations: in the inter-space between the protective glazing and the stained glass window and inside the building nearby the stained glass window. The deposit occurred on the glass soiling sensors were analysed chemically and optically (haze measurement).

The *mass* of the main constituents of the deposit, namely insoluble, carbon-rich and soluble particles deposited on the soiling sensor after 1-year exposure was determined. In the case of Cologne Cathedral, the mass of the total deposited particles on sensor exposed in the inter-space is lower than on those exposed indoor. This is verified for each constituent of the deposit. In the case of Troyes, the total mass of the deposit occurred in the inter-space is higher than inside. In detail, the mass of carbon-rich and soluble particles decreases on inter-space exposed soiling sensor as compared to those exposed indoor. On the contrary, insoluble particles mass is higher on the inter-space sensors. These insoluble particles consist mainly in calcite grains and metallic debris which very likely come from the degradation of the cementing and of the iron bars used to fix the stained glass window.

The *haze* measured on sensors exposed 4, 6, 8 and 12 months indicates in both churches a lower value in the inter-space by comparison to those located indoor. The much more pronounced decreasing of haze in Troyes might be due to the fact that the ventilation there is very low efficient and that the input of particle coming from the Basilica is very low. On the contrary, in Cologne where the ventilation is very efficient, the possibility that particle are transported by the air streams coming from the basilica toward the inter-space are much more higher, and therefore the deposition is higher.

Finally the protective double glazing appears to be efficient in the abatement of dust deposition on stained glass windows.

Corresponding author: lombardo@lisa.univ-paris12.fr

Kinetics of sodium sulfate efflorescence as observed by humidity cycling with ESEM

P. Lopez-Arce, E. Doehne

The Getty Conservation Institute, 1200 Getty Center Drive, Los Angeles, Ca, 90049, USA

ABSTRACT

The behavior and development of thenardite (anhydrous sodium sulfate) from mirabilite (sodium sulfate decahydrate) under the Environmental Scanning Electron Microscope (ESEM) during humidity clycling (50%-100%) was observed. After 7 cycles a microcrystalline porous structure of thenardite was formed with an increased surface area and volume compared to mirabilite. At this point expansion and contraction take place with raising and lowering the relative humidity (RH). Hydration and dehydration reactions of sodium sulfate were determined by weight changes, after storage of this salt in RH control chambers. The critical RH value of 75% was found to be the inflection point for the expansion/contraction and hydration/dehydration reactions (observed under the ESEM and in the RH chambers, respectively). The rates of these reactions become more rapid above and below 75% RH as the humidity was increased or decreased. After 20 cycles expansion and contraction and the associated change in volume no longer ocurred. On continuing RH cycling the microcrystalline structure moved suggesting attraction and repulsion between similar structures with the increase and decrease of RH, respectively. The rapid physical movements observed under the ESEM suggest that they may play an important role in the damage process due to humidity changes.

Corresponding author: edoehne@getty.edu

The Restoration of a stone bridge in semiarid environment: Puente Viejo of Elche (SE Spain)

M. Louis[1,2], M.A. García del Cura[2,3], A. Bernabéu[2,4],
A. La Iglesia[2,3], Y. Spairani[1], J.A. Huesca[1], R. Prado[1]

[1] Departamento de Construcciones Arquitectónicas. Universidad de Alicante. Spain.
[2] Laboratorio de Petrología Aplicada. Unidad Asociada CSIC-UA. Alicante, Spain. (RTPHC-CSIC)
[3] Instituto de Geología Económica. CSIC-UCM. Facultad de Geología, Madrid, Spain (RTPHC-CSIC)
[4] Dpto. Ciencias de la Tierra y del Medio Ambiente. Universidad de Alicante. Spain

ABSTRACT

Puente Viejo or Puente de Santa Teresa of Elche was constructed in a late gothic style beginning in 1705 and finishing in 1756. In 1751, it was seriously damaged by a big flood so it was redesigned with two spans (two masonry pointed archs and central pilaster) and cutwater. The basis and the pavement were restored in 1820 after another big flood.

The bridge is mainly built using biocalcarenites, prevailing the local stone named Piedra de Ferriol, in the basis some ashlars are conglomerates. In 2004, the masonry revealed some broken pieces and some others with different weathering forms: alveolization, flaking and differential erosion in conglomerated materials. Some ashlars placed with the sedimentary layers in up-right position show a highest severe damage.

The south face is the ore to present more severe damage, flaking clearly appears in the inside of the vaults where efflorescence chemical composition is sodium sulphate essentially. In the south wall, these salts present a complex composition: sulphates, chlorides and nitrates of sodium, calcium potassium and magnesium, containing mainly sulphate and sodium ions and scarcely calcium and nitrate ions.

In the past, in the basis of the bridge cement concrete plaster were realized. This solution is inadequate to this kind of construction due to saline effect and to retraction during hardening and the excessive strength, so this plaster could be responsible for the severe damage of some ashlars.

Intervention of 2005: after several probes and analysis, superficial salts have been partially removed by aluminium silicate powder micro projection abrasion and later application of FK-12 (salt and micro organisms removal from Fakolith Co.) and Tecosel (inhibiter from Edylteco Co.) where slight damages were found. The last preventive measure has been the consolidation of ashlars with granular disaggregation and hydrofuged of the whole bridge with FK-34 and FK-37 from the company above.

Corresponding author: angegcura@ua.es

Biological coloration of calcareous stone surfaces in Portuguese ecclesiastic monuments

P.M.L. Lourenço[1], M. L. Tavares[1], F. de Llera Blanes[1], P. Pereira[2]

[1]IN SITU – Conservação de Bens Culturais, Lisboa, Portugal
[2]Laboratório de Microbiologia Industrial, Instituto Nacional de Engenharia, Tecnologia e Inovação, Lisboa, Portugal

ABSTRACT

The present communication refers to a pink patina that can be observed on calcareous surfaces of several monuments in Portugal. It can be seen on walls not exposed to direct sunlight, e.g. cloisters, but it is neither noted on the facades exposed to strong sunlight nor on surfaces normally kept in complete obscurity. The moderate photophilic behaviour seems to be compatible with a biological origin.

Besides direct observation, a number of other procedures were carried out in an attempt to characterize the phenomenon. The target surfaces were either scraped with a sterile scalpel or sampled with contact agar plates for bacteria, fungi or algae. The powder obtained was observed under light microscopy and used either as inoculum for solid bacteria, fungi or algae cultures media or for directs DNA extraction. The extracted DNA was destined to 16s rDNA PCR amplification.

The obtained data is consistent with the possibility that the observed coloration is caused by cyanobacteria-like organisms.

The present work is part of the projects "*Recuperation and improvement of Lorvão Monastery– Diagnosis of Conservation Status of Stone Elements and Revetments of the Monument, and Proposal of Intervention*" and "*Conservation, Restoration and Improvement of Santa Cruz Monastery of Coimbra - Diagnosis of Conservation Status of Stone Elements and Revetments of the Monastic Set and Proposal of Intervention"* that *INSITU - Conservation of Cultural Goods* is conducting for *IPPAR – Portuguese Institute of the Architectural Heritage* - Coimbra.

Corresponding author: insitu@insitu

Conservation condition of the Wall of Talamanca de Jarama, Madrid, Spain

J. Luque, M.J. Varas, E.M. Pérez-Monserrat, R. Fort

Instituto de Geología Económica (CSIC – UCM), Madrid, Spain
RTPCH - CSIC

ABSTRACT

This study consisted of the analysis of the building materials of the Wall of Talamanca de Jarama, 40 km Northern from Madrid city. The structure is inscribed as a Cultural Interest Property of the region of Madrid. Its original role was as a defensive system around the village against enemies, with references to the beginning of its construction dating back to the 10^{th} – 11^{th} centuries. The Wall is partially ruined, completely lacking some sections. The building materials used for the construction of the Wall are bricks, mortar (both joint and rendering mortars), stone and rammed-earth. The brick, due to its abundance and variability has been deeply studied.

A detailed mapping of the different building materials was carried out. The petrography of the materials was performed by means of polarizing-light microscopy. Mineralogy was determined by X-Ray Diffraction. In the specific case of rammed-earth materials, granulometry analysis was carried out. Among the petrophysical properties, the following were determined: colour (spectrophotometer), anisotropy (ultrasounds velocity), hardness (Schmidt hammer), porosity and densities (saturation test), and micro and macroporosity (Hg intrusion porosimeter).

Regarding bricks, results show five tipologies which could probably account for different historical periods. Firing temperatures have resulted on the best quality index for bricks.

The main decay forms that have been observed in the Wall are grain-disintegration, efflorescences, man-induced scratching, biodeterioration and dampness. Main decay causes are related to the water entry. Original bricks resulted better preserved than the more modern ones used for the substitution of the formers.

The main aim of this study is to get a deep knowledge of the building materials constituting the Wall, in order to carry out the appropriate restoration project in a future, thus, avoiding a further deterioration of the Monument.

This study has been financed by Agreement between CSIC (Spanish Council for Scientific Research) and the Government of the Autonomous Region of Madrid (Research General Department, Regional Cultural Ministry), 2005.

Corresponding author: john_lm154@yahoo.es

Comparison of Shelters' performance at Joya de Cerén, El Salvador

S. Maekawa

The Getty Conservation Institute, LA, USA

ABSTRACT

Environmental monitoring was conducted at the archaeological site of Joya de Cerén, El Salvador, to identify deterioration mechanisms affecting historic adobe structures at the site by analyzing the site climate, climates under four shelters, and responses of the adobe under the shelters. Environments under shelters for Group A and Structure 3, which are more open to the outside than other two, closely tracked the changes outside. A combination of wind conditions and the shelters' openings (visitor viewing areas) caused large environmental variations in these shelters by allowing major infiltration of dry afternoon air.

However, shelters for Group B and Structure 4, whose excavation pits are deeper and side protections are better provided than the other two, limited the temperature rise and maintained higher relative humidity environments for the adobe structures, especially during the dry season. These shelters have larger soil and Tephra surfaces that conditioned the sheltered environments and buffered changes of the outside environment. The combination of a deep excavation pit and a roof structure extending to the ground can produce a protective environment that maintains low temperatures and high relative humidity by limiting the infiltration of outside air. The ability of these shelters to reduce both annual and diurnal climatic variations was quantified for comparison.

There were significant variations of moisture content in adobe structures among different locations within a shelter, as well as locations within each individual adobe structure. Variations within a shelter were affected by the infiltration of outside air that tends to dry the adobe. Variations within an adobe structure were influenced by its distance from the ground floor of the excavated pit, indicating the capillary rise of groundwater. The moisture contents changed as the outside climate changed, and the wetter areas increased during the wet season. This may be due to increased moisture content of the air, reduced rates of the evaporative-transpiration at adobe surfaces, increased water content in ground soil which is in contact with the adobe structures, or a combination of these situations.

Corresponding author: smaekawa@getty.edu

Comparison of in-situ mechanical tests on masonry mortars: sphere impact and controlled penetration test

A.C. Magalhães, M. R. Veiga

Laboratorio Nacional de Engenharia Civil (Portugal)

ABSTRACT

Two different light destructive "in situ" techniques to determine the mechanical characteristics of masonry mortars are compared and cross calibrated. Both techniques are potential tools for *in situ* evaluation of mortars' properties, namely to characterise the state of conservation of ancient buildings' renderings and to evaluate compatibility of substitution renderings in old buildings: *sphere shock* gives information about the render deformability and *controlled penetration test* gives information about the resistance of the internal coats of renders.

The two techniques are compared using obtained results in a set of case studies; the values obtained are also compared with previous results for experimental well known render applications to establish a correlation between them and the state of conservation of old renders.

In this paper, the techniques are described and the case studies are referred. The main results of the previous "in situ" work are presented. A comparative analysis of the results and a correlation with the degradation level is performed in order to calibrate these techniques for the evaluation of the state of conservation of old renders.

Corresponding author: anacristian@lnec.pt

The "contact sponge": study of the applicability of a new and simple methodology

M. Manfredotti, P. Marini

Politecnico di Torino, DITAG, C.so Duca degli Abruzzi 24, 10129 Torino, Italia

ABSTRACT

The "contact sponge" is a new diagnostic tool developed by CNR-ICVBC (Firenze, Italy) to evaluate the effectiveness of protective water repellent product applied to monuments and historical buildings (Tiano, P. & Pardini, C. 2004. Arkos, 5, 30-36). This tool measures the amount of water absorbed by the surface of the stone: it is simple to be used in external applications, while similar methodologies, found on the application of the Kartsen tube or "pipette", have shown technical difficulties which hinder the practical use.

The apparatus consists of a sponge (brand Spontex, type Calypso) made by natural fiber, cut with socket punch 55 mm diameter and seated in a plastic contact plate (1034 Contact Plate Rodac, brand Falcon). This kind of sponge has been selected between those present on the market for its characteristics: good capacity to retain water, compactness and adaptability to surface.

The aim of this work is to show the applicability of this method to study the weathering of the stone: moreover, the achieved results, supported by several laboratory and *in situ* tests, show that the variation of the amount of water absorbed by the stone surface and measured with the "contact sponge" can be related to the increase of weathering degree.

Data collected from laboratory tests point out the repeatability of the measurements made with the "contact sponge" method, even if some preliminary remarks should be considered: in fact, different measurements should be compared only if the load applied on the sponge, the water content of the sponge and the time of contact between the sponge and the surface are the same.

This tool was also used to test different set of specimens submitted to several laboratory cycles of accelerated artificial ageing treatments (freeze-thaw, thermal shock) in order to simulate natural ageing conditions. Collected data show that the measured increase of the amount of water absorbed by the stone surface is related with the increase of weathering degree.

Several *in situ* tests were made on different architectural elements made of a Piedmontese marble, largely used for historical buildings, which surface was characterized by different weathering degree and different treatments applied. Data collected give information about the condition of the stone and the effectiveness of the treatments applied. This methodology is particularly useful *in situ* because it is a portable instrument, easy to be used on different surfaces with a 60x60 mm flat zone.

Natural stones used in Royal House of Piedmont (Italy)

P. Marini[1], C. Mossetti[2]

[1] Politecnico di Torino, DITAG, C.so Duca degli Abruzzi 24, Torino (Italy)
[2] Soprintendenza per il Patrimonio Storico Artistico e Etnoantropologico del Piemonte, Torino (Italy)

ABSTRACT

In the beginning of the 17th century, in Piedmont, the "Maisons de plaisance" built in the boundaries of the capital town, Torino, on the river or on the hill, represented the importance and the role of the owner and became then basic elements in the development of the town. "Villa della Regina", built on the hill by one of the duke's of Savoia sons, Principe Cardinal Maurizio, at the beginning of 17th century, is the last example of a "Vigna" residence with Italian gardens, palace, woods and vineyard. The design of gardens and park, and the palace were enlarged for his wife at the middle of 17th century and for the Queen Anna d'Orleans, at the end of the century. Architectural and decoration changes were undertaken during 18th century on Filippo Juvarra ideas carried out by Baroni di Tavigliano. The royal Villa was again enlarged for the Court conveniences (18th-19th centuries). On 1864 the King gave the property as a gift to the Istituto Figlie dei Militari, a girl college. Changes during 19th and early 20th century, reparations of the Second World War damages and finally the end of the activity of the college led to serious conservation problems for buildings and gardens.

Few documents have been found, but the General Conservation Project undertaken by the Soprintendenza per il Patrimonio Storico Artistico of Torino, institution of the Italian Ministero per i Beni e le Attività Culturali, that has in charge the property since 1994, made possible to restore Villa della Regina, to study and understand its history.

The complexity of the "Villa della Regina" life implies the presence of a big variety of stone materials, from the original ancient Piedmontese marbles (17th-19th centuries) to the stones used during 19th-20th century works. Moreover, the reuse of stones makes difficult to date with accuracy the most important building interventions in the Villa. The 17th century stone used comes from two different Piedmontese geographic areas: the Susa Valley and the Saluzzo area. In the next century a stone coming from Frabosa quarries, the exploiting basin supplying the marbles for the SS. Sindone Chapel, was introduced. In further interventions many other kind of stones were placed.

In this paper the authors mean to give a description of all the stone material used in the Villa, the historical reconstruction of the building phases, together with the evaluation on the results of the conservative interventions.

Corresponding author: paola.marini@polito.it

Mortar analysis of samples from the Royal Botanic Gardens, Sydney

T. Markopoulos[1], D. Dragovich[2], V. Perdikatsis[1], E. Repouskou[1]

[1] Technical University of Crete, Dept. Mineral Resources Engineering 73100 – Chania, Greece
[2] School of Geosciences, Sydney University, Australia

ABSTRACT

Mortar samples from the seawall of the Royal Botanic Gardens, Sydney, have been investigated by binocular microscopy, polarised light microscopy from thin and polished sections, X-ray diffraction analysis, scanning electron microscopy joined with EDS analysis and granulometric analysis.

The aim of this research is the identification of the different phases present in the mortars, and their compatibility with the building stones of the seawall, in order to select appropriate materials for restoration purposes.

The aggregates of the mortars which include cataclastic quartz and volcanic rocks, mainly basalts and dacites, range in size between 0,5 - 2mm. The ratio "aggregate: binder" is 2,4 : 1. The binder consists mainly of calcite, vaterite, aragonite and minor amounts of kaolinite, halloysite and gypsum as a secondary formation.

Kaolinite is the binder mineral of the Sydney sandstone and halloysite is an alteration product of the volcanic fragments. Calcite derived mainly from carbonated lime. Aragonite and micron sized spheres of aterite indicate that lime was made of sea shells, while gypsum probably formed due to atmospheric pollution.

Corresponding author: markopou@mred.tuc.gr

Study of old and rehabilitation mortars by common analytical techniques

S.F. Marques[1], V.M. Ferreira[1] , J.A. Labrincha[2], L. M. Silva [3]

[1] Departamento de Engenharia Civil / CICECO, Universidade de Aveiro, 3810 –193 Aveiro, Portugal
[2] Departamento de Engenharia Cerâmica e Vidro / CICECO, Universidade de Aveiro, 3810 –193 Aveiro, Portugal
[3]St Gobain Weber-Cimenfix, Aveiro, Portugal

ABSTRACT

The need of compatibility between the old materials and the rehabilitation ones must always be taken into account, among other issues, in any correct building's rehabilitation process. A proper characterisation of old materials becomes thus an essential step, and therefore, must be comparatively performed at various levels. But this is usually a complicated procedure due to several parameters involved if one thinks about the differences that might occur in terms of binder and aggregates nature and ratios, present additives and admixtures and so on.

Many characterisation techniques can give important information that permits to identify the mortar, comprising physical, chemical and mechanical strength determinations. Techniques like X-ray diffraction, differential thermal analysis, thermogravimetric analysis, can give considerable information on the mortar's type and chemical composition. Mechanical properties and porosity determinations, among others, can verify the compatibility between the old and rehabilitation mortars. This research process can become faster and easier if a well-known characterisation methodology is followed. When compatibility between old and new mortars can not be totally achieved weaker mortars must be used in order to not compromise the support structure, having a sacrifice function in case of deterioration.

This work remarks the important aspects to take in consideration during the characterisation of old mortars, applying first these techniques in well known chemical composition and laboratory prepared mortars. Then, the same methodology will be used on the characterisation of specifically chosen old mortars and, for each case, an attempt will be made to point out the more adequate rehabilitation mortars.

Corresponding author: victorf@civil.ua.pt

Comparative study of building materials in the Patio de las Doncellas in Seville´s Reales Alcázares (Spain)

J.J. Martín del Río, F. J. Alejandre, G. Márquez, F.J. Blasco

Dpt. de Construcciones Arquitectónicas II. Universidad de Sevilla, 41011 Sevilla, Spain

ABSTRACT

Seville's Reales Alcázares the ancient city's Royal Palace and Fortress - is considered to be Europe's oldest building of its kind. One of the most important parts of this monument is the well-known "Patio de las Doncellas", located inside the living quarters of King Peter the First, dating back to the 14th century period known as the mudéjar stage. The study carried out in this singular place has consisted of characterizing six distinctive samples: two lime concrete-based foundations, two mortars and two facing bricks.

The different techniques used for this research work were as follows: optical microscopy (OM) was used in order to observe surface texture (e.g. lime nodules, carbon particles, vegetal fibers, etc.); mineralogical composition of the samples were established by X-ray diffraction (XRD) using the powder and oriented-aggregate methods. Besides, carbonate chemical analyses were done through Bernard's calcimeter - NLT-116/72 - with the aim of approximating the original amounts of lime in the four conglomerates, as well as several analyses of their sulphate contents - according to UNE-EN 1744-1-1999 - to identify the presence of gypsum in the above mentioned conglomerates. Lastly, the corresponding porosity and compressive strength measures were taken.

The experimental results enable us to come out with the following conclusions: one of the two analyzed concrete-based foundations can be characterized as having higher compressive strength and less porosity than the other one. In regards two mortars, both of them have high compressive strength due to the rich content of lime or the presence of tobermorites, respectively. These last ones were likely obtained by means of reaction between lime from the mortars and brick dust added intentionally, as the corresponding ceramic phases have been detected. It must be stated that both facing bricks also have very different values of resistance and baking temperature. Finally, several salts - sodium, potassium and magnesium sulphates, as well as sodium and calcium carbonates or nitrates - were only clearly identified in two mortars and/or both facing bricks, thus these salts - except nitrates - most likely not coming from the ground.

Corresponding author: jjdelrio@us.es

Weathering of speleothems by microbial activity. An example from Castañar de Ibor Cave, Cáceres (Spain). **(abstract withdrawn)**

A. Martín-Pérez[1], A.M. Alonso-Zarza, I. Gil-Peña[2], E. Martinez-Flores[3], P. Muñoz-Barco[3]

[1] Dpt. Petrología y Geoquímica. Fac. CC. Geológicas. Univ. Complutense. 28040 Madrid, Spain
[2] IGME. Área de Estudios Geológicos. C/Rios Rosas 23. 28003 Madrid, Spain
[3] Gral. de Medio Ambiente. Consej.de Agric. y M.A. Junta de Extremadura. Avda. Portugal, s/n. Mérida, Spain

ABSTRACT

The Castañar de Ibor Cave (Cáceres), has been declared Natural Monument due to its situation within an area with few karstic features and the beauty of its speleothems. This cave formed in the Precambrian dolostone beds of the Ibor Group, in the southeast sector of the Central Iberian Zone. The speleothems include stalactites, stalagmites, curtains, flowstones, helictites, gours, frostwork and moonmilk deposits. They are calcitic and aragonitic.

The most important processes now operating in the cave are: calcite and aragonite precipitation, aragonite-calcite inversion, speleothem dissolution, dolomitization, biomineralization and bio-dissolution. The processes that mostly contribute to the alteration of the initial speleothems are mainly controlled by organic activity, such as moonmilk formation.

Moonmilk deposits form crusts in the soil of the cave and grow over other speleothems. Moonmilk gives the speleothems a white, powdery appearance and aragonite crystals lose their brightness and are even replaced by moonmilk. The moonmilk deposits include spheroidal dolomite and huntite that form in relation to microbial films that develop on the aragonite crystals or other speleothems and corrode all of them.

The Castañar de Ibor cave can be considered as a “natural laboratory” where we can observe processes taking place at present. Their identification and knowledge will help us to find the better way to preserve the cave resources and to understand meteoric diagenesis.

Corresponding author: andreamar@ucm.universia.es

Study by SEM/EDX and FT-IR spectroscopy of resin bound mortars based on hydraulic and synthetic binders combined with "Tosca de Rocafort" and Bateig stones

X. Mas i Barberà, M.T. Doménech-Carbó, J.L. Roig-Salom

Dpt. Conservation and Restoration of Cultural Heritage, Polytechnic University of Valencia, Camino de Vera 14, 46022 Valencia, Spain

ABSTRACT

This work has pretended to develop a systematic methodology for the Conservation and Restoration of Artistic and Monumental Heritage (sculptures and ornamental pieces) made with "Tosca de Rocafort" stone (generically Godella Stone) and "Bateig" stone (commonly Novelda Stone).

These lithic materials, which appear in the Valencian Community specially in very important monuments of Valencia City (Rasher, Cathedral, Serranos Towers, etc), are suffering a considerable physic, chemical and biologic deterioration [Roig-Salom, J.L., 1995, Tesis Doctoral. Univ. Politécnica de Valencia].

Although the use of stone resin bound mortars is very extended all over Europe, there are not scientific studies aimed at the optimization of different formulations and nothing respect to these two types of stony materials is mentioned.

The intervention is based on the use of resin bound mortars made of hydraulic and polymeric binders with fillers of "Tosca de Rocafort" and "Bateig" Stones. The filler materials form the major component of the mortar and the distribution of their particle size influences the properties and characteristics of the resin bound mortar. The purpose we made is to use the artificial materials as an alternative to natural stone. We intend to find solutions for the replacement of missing parts or the replica of the whole piece altered [Roig-Salom, J.L. et al. *Anal. and Bioanal. Chem.* 8-375, 1175-1181, 2003].

For this investigation we have carried out different accelerating tests such as thermal ageing, UV light ageing, ageing in SO_2 pollutant chamber, freezing ageing cycles, salt crystallisation tests, natural ageing and biological attack on a series of test-specimens prepared with polyester resin, acrylic resin and lime as binders of the mortars. Measurements of porosity, water absorption, compression and flexion strength have been made. Morphological examination, measurement of chemical composition and chromatic coordinates before and after ageing treatments were also performed. The overall of experiments have led to establish the higher stability and resistance properties of these types of resin bound mortars by comparison to those made of the natural stone.

Aknowledgements: Financial support is gratefully acknowledged from the MEC project CTQ2004-06754-C03-01, which is also supported with FEDER founds.

Corresponding author: tdomenec@crbc.upv.es

Catalogue of building techniques of vernacular architecture: case study in Southern Italy

N. Masini

Istituto per i Beni Archeologici e Monumentali, IBAM-CNR, Sezione di Potenza, Via Federico II, 85020 Lagopesole (PZ), Italy

ABSTRACT

Vernacular architecture is the expression of a building culture based on the use of simple techniques, sober style, poor and local materials. Its value is historical, environmental and sometimes artistic, when shapes and ornamental elements feel the effects of artistic styles. Nevertheless, the preservation of vernacular architecture is difficult due to scarce awareness of cultural values and building techniques. Therefore, it is necessary to analyse, classify and catalogue building techniques and materials in order to obtain information necessary for correct restoration procedures.

This paper is a tribute for the development of a study methodology of vernacular architecture aimed at its preservation. To this end, a significant study case located in Basilicata (Southern Italy) has been selected. It is Rabatana, the old part of Tursi town that actually is almost completely abandoned and affected by heavy problems of decay and geological instability. It is characterized by a picturesque integration between architecture and environment. Just the preservation of its aspect is the main aim of any restoration works.

To this end, masonries, plasters, portals, door and window frames, cymas, tile covering etc. have been classified, analysed from the material, technical and decay point of view. The information obtained is contained in a catalogue of building components useful to carry out a restoration handbook of the preservation of vernacular architecture of Rabatana.

Corresponding author: n.masini@ibam.cnr.it

Monitoring salt systems in monument stones: comparing two electrochemical methods

A. Maurício, C. Figueiredo, L. Aires-Barros

Laboratório de Mineralogia e Petrologia, Instituto Superior Técnico, Av. Rovisco Pais 1, 1049-001 Lisboa, Portugal

ABSTRACT

An electrochemical procedure based on ion-selective electrodes has been developed to track out some chemical species associated with the weathering of the *Lioz* limestone, which is the building or revetment material in most Lisbon monuments. The results herein refer to indoor studies in simulated salt-laden atmospheres, which are known to cause deleterious effects on calcareous materials in both aesthetic and mechanical terms. Sensing devices were assembled into *Lioz* limestone samples and their potential output was followed in real-time mode, while the test surfaces were going through changes in a microclimatic chamber.

Response dynamics are discussed in terms of time-lag features and in-depth profiles for exogenous factors of stone decay in marine environments.

Based on ionic conductivity measurements of different samples of a geologic material "Pedra de Ançã" (it is a whitish Jurassic limestone with total porosity varying from 5 to 24% and air permeability varying from 18 to 460mD according the rock stratification) contaminated with NaCl and KCl pure aqueous solutions of different concentrations and at different temperatures, it was possible to assess the onset and the evolution of the crystallisation process inside the stone interactively and in a non-destructive way. Furthermore, it was possible to monitor the quantity of pure hygroscopic soluble salts inside the stone by electrical potentiometric method within a range of values, whose limits will be specified in the near future.

The two methods will be compared and examined inasmuch as they are prone to miniature probing and so to an almost negligible impact on any structure under surveillance. In principle the new techniques seem as interesting as non-destructive monitoring tools but it will be shown why the ionic conductivity method is potentially more promising.

Corresponding author: pcd2045@ist.utl.pt

Calcium loading of building sandstones by lime rendering: implications for decay

S. McCabe, B. J. Smith, P. A. Warke

School of Geography, Queen's University Belfast

ABSTRACT

Sandstones are commonly used as building stones throughout Britain and Europe. They are often deployed in culturally significant buildings, whereby value (cultural, historical, informational, economic) is imputed to the stone. The decay of value-laden sandstone buildings and monuments is a widespread problem. This decay is commonly associated with the action of salts, especially calcium sulphate (gypsum) in urban areas. Gypsum forms readily on calcareous stone by the reaction of inherent calcium with atmospheric sulphur. In non-calcareous stones some other source of external calcium is needed for the reaction to take place and gypsum to form. A potential external source of calcium has been identified by previous research, whereby stones undergo a one-off loading with calcium during construction by mortar.

This paper seeks to explore this phenomenon further by testing for calcium loading not simply from lime mortar, but from a lime render. Experimental walls were constructed from Dunhouse Sandstone and Peakmoor Sandstone, and were completely covered in a lime render. After three weeks, blocks were analysed for calcium content, and results showed that calcium had penetrated into blocks to a significant depth, further than the previous mortar studies had suggested, due to differences in the methods of application of the render and mortar, and length of drying time. Implications of calcium loading for the decay of sandstone monuments are discussed and the potential for the enhancement of the salt-fuelled surface retreat of blocks by calcium loading is explored experimentally.

Corresponding author: stephen.mccabe@qub.ac.uk

The application of geostatistical techniques in weathering studies of natural building stone

J. McKinley[1], P.A. Warke[1], B.J. Smith[1], J. M. Curran[2]

[1]School of Geography, Queen's University Belfast, Belfast BT7 1NN, UK
[2]Stone Conservation Services, 4b Cromac Quay, Belfast BT7 2JD, UK

ABSTRACT

Knowledge of how fluids and associated salts move through rocks is important in the investigation of natural stone weathering. Characterising the rock properties of porosity, the fractional space between solid particles, and permeability, a measure of how easily fluids move through rocks, can provide a greater understanding of fluid flow processes in a porous medium such as natural stone. A major complicating factor is the spatial variability of permeability and porosity within rocks and the implications of this for moisture movement and the nature and rate of weathering-related breakdown. Since the detail required to adequately characterize the spatial variability of physical rock properties such as porosity and permeability far surpasses the detail of most sampling schemes, some degree of interpolation, simulation and interpretation becomes necessary.

In this study geostatistical techniques including spatial prediction and spatial simulation have been used in combination with geological interpretation to investigate the spatial characteristics of different types of rock which are commonly used as building stones. Blocks of Dumfries sandstone, Portland limestone and Leinster granite were put aside from a set of blocks involved in salt weathering experiments. Non-destructive permeability measurements, using an unsteady-state Portable Probe Permeameter, were made on three adjacent faces of the cubic blocks following a regular square grid scheme with a 1cm sample spacing. The findings from the study indicate that the spatial distribution and variability of permeability is more important in predicting the overall durability and weathering properties of natural building stone than mean permeabilities. The innovative use of geostatistical analysis can be an important tool in weathering studies and may be used to provide a potentially important index of spatial variability in permeability for different types of natural building stone.

Corresponding author: j.mckinley@qub.ac.uk

Microbial biofilms inside historic stone

C.J. McNamara, K. Bearce, T.D. Perry IV, R. Mitchell

Laboratory of Microbial Ecology, Division of Engineering and Applied Sciences,
Harvard University, Cambridge, MA 02138, UK

ABSTRACT

Microoorganisms are able to colonize the interior of porous stone. However, little is known about these endolithic (interior) microorganisms and their role in the biodeterioration of historic stone. The purpose of this study was to compare epilithic (surface) and endolithic bacterial communities from historic limestone. We collected stone cores from the Acropolis at the Maya site Ek' Balam (Yucatan, Mexico) to compare the composition of epilithic and endolithic bacterial communities.

Endolithic bacteria were stained with the fluorescent DNA stain DAPI and enumerated using epifluorescence microscopy. DNA was extracted from stone samples. Bacterial 16S rDNA was amplified using PCR, a clone library was constructed, and sequences from epilithic and endolithic clones were compared. A large bacterial community was found inside the stone (2.9×10^6 bacteria/gr). Analysis of clone sequences indicated that different bacterial communities were present in the epilithic and endolithic habitats. Bacteria were cultured from endolithic samples and we used a calcium binding fluorochrome to determine their potential to cause biodeterioration of limestone in a laboratory experiment.

Endolithic bacteria increased the rate of calcium release from the stone, indicating accelerated dissolution which probably occurred due to the production of organic acids. Endoliths have the potential to accelerate deterioration of limestone *in situ*. The presence of an endolithic bacterial community that is different from the epilithic community has important implications for the conservation of stone cultural heritage materials as well as for the weathering of minerals in natural environments.

Corresponding author: mcnamara@deas.harvard.edu

Preserving cultural heritage, the local agenda on the global stage. The impacts of international tourism

E. Meehan

Department of Sociology and Social Policy, Queens University Belfast, UK

ABSTRACT

The impact of international tourism upon cultural identity has acquired a prominent position of enquiry in the sociological field. Previous research has focused on the tourist perspective, though more recently research in this field has sought to examine the impacts upon the receiving society in the aftermath of tourism and tourism planning. The following attempts to investigate the socio-cultural impacts of the tourism industry, which is set on the international scale. It seeks to look at the impact upon identity, community, and culture on the local level in response to the construction of place for tourist purposes.

The globalisation effect of international tourism transports the local to the global arena, which 'links the local to regional, national and supra-national spheres', [Quinn, 2003: Cronin M, and O'Connor B, (eds.), 2003. *Irish Tourism:* Image, *Culture and Identity*. Great Britain: Cromwell Press]. Appreciably the complex power relations involved in this process render the task of preserving place and identity problematic on the local level. International tourism that is promoted from an economic agenda at the global/macro level Lanfant suggests leads to the '*internationalization of cultures'* as globalisation processes controls the production of culture for economic purposes. This places significant challenge upon regions to preserve their own uniqueness. As Lanfant et al. [Lanfant, M-F, J B Allcock & E M Bruner (eds.), 1995. *International Tourism: Identity and Change*, London: Sage] notes 'Challenge to identity is an experience of alterity'.

Simultaneously the economic context of international tourism places communities under significant pressure to commodify place and identity, to deliver unique niche products and *invent localities* that may compete on the international scale for a share of the tourist market. Casey [Cronin & O'Connor, 2003, *Irish Tourism: Image, Culture and Identity*. Great Britain: Cromwell Press] warns that the extensive commodification of landscape into symbolic form for economic purposes may in fact result in the 'divorce' from its social and historical contexts. She notes how the maintenance of the tourist gaze in the current tourism context will necessitate the construction and elevation of place to 'exotic destination' Preserving identity that emerges from the global agenda thus takes on a 'prescriptive' role as 'the object of the tourist gaze is constantly being redefined' (Cronin & O'Connor, 2003).

This research questions what is exactly is being preserved of cultural heritage that is demanded on the international scale?

Corresponding author: emeehan04@yahoo.co.uk

Analysis of parchment book-binding by infrared thermography

F. Mercuri, F. Scudieri, S. Paoloni, M. Marinelli

Università di Roma "Tor Vergata" e INFM - Roma (Italy)
Dip. di Ing. Meccanica e Laboratorio Me.Te.R. della Facoltà di Lettere e Filosofia

ABSTRACT

It has been recently shown that many aspects of the ancient book-bindings can be fruitful studied by mean of the infrared thermography (IRT), a non destructive method to investigate the subsurface structure of the artefact [Colombo G. et al., *Restaurator* 26, 92-104, 2005].

In this work, IRT has been applied to the detection of subsurface damage, to the characterization of the binding assembly technique and to the analysis of the physical properties of the component materials providing information on their preservation state. In particular the thermal transport properties of the parchment, one of the most common components of the ancient book-binding, has been studied. The thermal diffusivity analysis reveals an anisotropy of the heat diffusion process in the parchment being the *in-plane* thermal diffusivity value $D_{\perp}$ different from the one, $D_{\parallel}$, which characterize the heat diffusion *across* the leaf. Measurements performed on parchment leaves showing different preservation states, suggest that aging affects $D_{\perp}$ while leaving substantially unchanged $D_{\parallel}$. A possible explanation for that results is provided by electron microscopy observations which have shown that concentration of defects in the layered structure of the parchment also depends on aging. The thermal transport properties can therefore provide information related to preservation state of the analysed parchment. Two different configurations of the IR thermographic set-up were used to perform the above measurements. A pulsed method has been used to investigate the heat diffusion across the sheet while a lock-in method was used to study the in-plane diffusion. In both the cases a small (less than 1°C) thermal perturbation was generated at the artefact surface by light absorption [Scudieri F., et al., *J. Therm. Anal. Calorim.* 66, 307-314, 2001]

Corresponding author: mercuri@uniroma2.it

The treatment of weathered Globigerina Limestone: the surface conversion of calcium carbonate to calcium oxalate

T. Mifsud, J. Cassar

Institute of Masonry and Construction Research, University of Malta, Malta

ABSTRACT

The behaviour of oxalate films and the surface protection that they provide has in recent years started to be explored, especially in Italy at the Opificio delle Pietre Dure in Florence by Matteini et al. where research began in 1985. Studies were carried out on naturally occurring films and these were found to be more resistant to acid attack than calcium carbonate, but they were also found to be non-porous. In spite of the fact that it had taken centuries to form these films, it was believed that they could actually be induced to form on the stone through treatment while still retaining the porous properties of the stone. Matteini, Moles and Giovannoni published these findings in 1994. Others subsequently took up this research.

Studies have also commenced on the local Globigerina Limestone and its surface conversion to calcium oxalate with the research of Yoko Taniguchi et al. and Paola Croveri. Taniguchi et al. researched on calcium oxalate as a surface protective treatment for quarry franka samples and deteriorated soll samples and Croveri worked on the consolidating effects of calcium oxalate on quarry franka samples and quarry soll samples. The next stage of research points towards investigating this treatment on deteriorated franka samples. In practical terms, this treatment could be used in the field of conservation as consolidate or protective treatment on historic buildings in Malta, a large number of which are composed of deteriorated franka.

The aim of this research is to investigate the performance of an induced surface conversion of powdering/weathered Globigerina Limestone from calcium carbonate to calcium oxalate, and the prospects of it being used as a conservation treatment with possible consolidating and protective properties.

Corresponding author: tabitha@ap.com.mt

Mapping and characterization of a green biofilm inside of Vilar de Frades Church (Portugal)

A. Miller, M. F. Macedo

Departamento de Conservação e Restauro, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal.

ABSTRACT

Vilar de Frades church is integrated in the Vilar de Frades Monastery, located in the North part of Portugal (city of Barcelos). The monastery was founded in 566 by the bishop S. Martinho de Dume. It suffered several architectural modifications and restoration works, the most relevant in the XVI century, modified substantially the look of the old Romanesque monastery.

The interior of the church, in granite, has one nave and six bays, holding ten chapels with vaults of crossed ribbings. Nowadays, the chapels present a severe biological colonization characterised by an intense green biofilm. This biofilm appear to be increasing in size and becoming apparent in other locations inside the church where a biocide was applied in a recent intervention of conservation and restoration.

Prior to cleaning and treatment of the entire church, a complete study of the green biofilm was necessary. An accurate survey was planned in order to map biological colonization, identify main biodeterioration agents and determine the environmental conditions. Laboratory analyses were accomplished with optical microscopy and spectrofluorometry.

This study presents the results of this campaign. Details on conservation or preservation works that need to be implemented are also presented.

Corresponding author: mfmd@fct.unl.pt

The DRMS drilling technique with pilot holes

J. Mimoso, D. Costa

Laboratório Nacional de Engenharia Civil, Lisbon, Portugal

ABSTRACT

The Drilling Resistance Measuring System (DRMS) is basically a power drill with constant feed and a force transducer that measures the thrust as a function of the drilling depth. The drilling test has been used to characterize stone hardness in depth and to evaluate stone treatments (in situ and in the laboratory).

The DRMS is used with drill bits that have two main cutting edges. These cutting edges do not meet at a point and so a partially non-cutting edge (called chisel edge) exists between the two cutters. When a hole is drilled the chisel edge immediately engages the stone causing the measured thrust to grow rapidly, not because of the actual stone resistance but because the middle part of the chisel edge does not cut but rather indents the stone.

In a communication presented in 2005 we proposed a new technique to do away with the so-called "chisel edge effect" based on pilot holes, associated or not with the blowing of air applied during drilling (to avoid the eventual resistance increase caused by the packing of stone dust during drilling).

According to the proposed method a measuring run is made, not by drilling a direct 5 mm hole in the stone, but rather by drilling a 5 mm hole over a previously drilled 3 mm pilot-hole. The drilling of the pilot-hole is not a measuring run, but merely serves to remove the material that would otherwise be indented by the chisel edge. The thrust needed for drilling is therefore sharply reduced, the results are more clearly related with the stone resistance to cutting, the abrasion of the drill bit tip is lowered, and the DRMS system may thus be used to test harder zones or materials that are presently out of its measuring range.

In this paper we compare, for several stones, the results obtained by the classical single-hole method with the results obtained through the hole-over-hole technique that we proposed. We therefore discuss the consequences of drilling with pilot holes on the characterization of the first few millimetres depth of the stone surface that are capital for the study of consolidation treatments.

Corresponding author: drcosta@lnec.pt

Diagnostic techniques to assess mechanical characteristics of historical timber

J. Minster[1], M. Drdácký[1], I. Jirovský[1], M. Kloiber[1], M. Micka[1], Z. Slížková[1], P. Václavík[2]

[1]Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences, Prague, Czech Republic
[2]Czech Technical University in Prague, Faculty of Mechanical Engineering, Division of Precision Mechanics and Optics, Czech Republic

ABSTRACT

The paper discusses some important problems of a complex survey of historical timber structures. It starts with examples of specific features of surface survey of historical timber structures, mainly technological traces from historical carpentry tools and from historical surface treatment.

It further introduces recent results concerning estimation of actual mechanical characteristics of historical built-in wood by means of small sample testing. This medium destructive method uses core drilling for compression tests and an extraction of small tension coupons for tension tests. The achieved results are compared to standard test results and correlated to other physical characteristics (density, annual rings). Comparative tests on deteriorated timber take advantage of impact methods (Pilodyn) and ultrasonic.

Detailed studies have been carried out on cores of about 5 mm diameter which are tested in a special fixture enabling loading the core cylinder on two opposite parallel lines as in the case of splitting tests. Here the displacement field on the core ends were measured by means of moiré-interferometry technique and compared to a numerical model based on the FEM approach.

In the concluding part, some non-destructive testing methods for architectural as well as structural health survey are presented by means of examples referring to case studies from important Czech historical buildings, mostly the National monuments. The application involved the above mentioned approaches as well as other methods, namely X-ray, resistance drilling and thermography.

Corresponding author: minster@itam.cas.cz

Oil-Paintings of Bartolomé Esteban Murillo (1618-1682) using an unusual support: polished obsidian

R. Moreno, A. Ruiz-Conde, P.J. Sánchez-Soto

Institute of Materials Science of Sevilla (CSIC-University of Sevilla), c/Américo Vespucio 49, Isla de la Cartuja, 41092 Sevilla, Spain. (RTPHC-CSIC)

ABSTRACT

In 1999 the Louvre Museum started the opening of new exhibition halls. With this purpose, a restauration of several artworks was carried out to place them in these new museum dependences. It originated several important discoveries. One of them was the finding of two oil-paintings, documented of Bartolomé Esteban Murillo (1618-1682), using an unusual support. This support was considered firstly as a black stone (1685); later as jaspe, basalt and even black marble. After non-destructive chemical analysis (1999) using proton induced X-ray emission (PIXE), it was concluded that the supports are made in a vitreous material, obsidiane, of volcanic rock origin. There is not any antecedent in other world Museums. We speculate that this particular material possibly was carried out from South America because Sevilla, in Murillo's time, was the main port of commercial exchange with the New World. Rock obsidiane materials were used in several civilizations to perform distinct objects, as masks, mirrors (Incas' mirror), knives, etc. Murillo used two plates of this material for his painting artworks "Cristo en el Huerto de los Olivos" (0.357 x 0.263 x 0.25 m) and "Cristo atado a la columna" (0.337 x 0.307 x 0.23 m). These two oil-paintings were acquired by Louis The XVI from the collection of Count of Vandreil (November 24th, 1784, price 2001 pounds). They were exposed in the Louvre Palace (Pavillon Neuf) from 1785. A research was conducted for a diagnostic of conservation state of these oil-paintings.

After several analysis using photography methods (visible and IR), optical microscopy (OM), image treatments and a set of software tools, it was understood the method of Murillo's work in these two oil-paintings. The author used the unusual support of polished obsidiane as a natural beauty crystal without any preparation procedure, because the black colour is preserved around the figures. However, the results suggested the application of different types of aglutinants, even with oil, to paint the figures at the top. The study by OM revealed microcracks in plates on several painted zones and colours, in particular blue pigments (lapislazuli). Alteration products have been also found. Lead and tin yellow, black pigments, ochres, lead and copper pigments, azurite, and zinc yellow (this pigment in works of old restaurations) have been identified. It is remarkable the finding of these two oil-paintings as single works in the Cultural Heritage.

Acknowledgments: The financial support of Research Group TEP204 (Junta de Andalucía) and Project MAT2002-02549, financied in part with FEDER, are acknowledged.

Corresponding author: aruiz@cica.es

Inheritance in form and process of rock surface evolution: evidence from shore platforms

D. Mottershead, R. Inkpen

Department of Geography, University of Portsmouth. United Kingdom

ABSTRACT

Weathering forms tend to persist for long periods of time, but their relationship to rates of weathering is relatively little studied. A preliminary analysis of this relationship is made using data from two studies of the erosion of wave-cut platforms, one in Prawle, Devon, United Kingdom, the other in Kaikoura, South Island New Zealand. The influence of initial erosion rates on subsequent erosion at a point is assessed. There appears to be a rapid decline in the influence of initial erosion rates on subsequent measured erosion rates. This relationship holds for both platforms in both locations. The weathering forms within which erosion takes place, however, do not alter substantially. Using topographic indices the relationships between erosion rates over time and topographic change over the same time periods are explored. From this analysis some suggestions are made to reconcile the trend in erosion rates and the persistence of topography.

Corresponding author: robert.inkpen@port.ac.uk

The long term effects of a water repellent treatment on a volcanic tuff

U. Müller[1], F. Weise[1], S. Grell[2]

[1] Federal Institute for Materials Research and Testing (BAM), Germany
[2] Freelance Architectural Conservator

ABSTRACT

The treatment of stone surfaces with chemical consolidants or water repellent systems is often a useful way in order to improve the condition of a building stone or protect it from environmental influences. In the literature there are many articles concerned with the topic of how to treat stone but unfortunately only few papers deal with the long term performance and effects of those treatments on actual buildings.

In 2005 we had the opportunity to investigate the condition of the 'Charlottenburg Gate' in Berlin in the course of a conservation measure. The building itself, erected in 1908-09, consists of a volcanic tuff variety from the Eifel region in Western Germany. The stone surfaces were treated with a water repellent in 1986 which consisted of an alcylated silicon resin. Several years after the treatment, surface parallel exfoliation of large areas of the tuff occurred more and more frequently at the building. The present condition shows a considerable loss of original surface in particular in areas of high moisture exposure. One of our task was to find out if the exfoliation of tuff was in a causal connection with the treatment in 1986.

A wet sponge test performed on site proved that part of the water repellency of the treated tuff surface was still existing at many places. Subject our actual investigation were drill core samples, which were removed from a vertical axis (resp. different exposure conditions) of the building. The core specimens were subjected to physical and mechanical tests and analysis of the micro texture by light and electron microscopy. The latter one was applied on polished thin sections which were prepared from a 5 cm profile of the drill core samples. In most of the samples the present penetration depth of the water repellent could be detected and it did not exceed more than 10 mm. The tuff material itself showed a considerable porosity and hygric dilation. The micro texture revealed the enrichment of gypsum in the surface region of the samples. But large scale elemental mapping showed that gypsum was mostly enriched not directly on or beneath the surface but in a depth of 5 to 10 mm. This results coincided well with the penetration depth of the water repellent agent.

All the results of the study pointed towards the major influence of the water repellent treatment in conjunction with water ingress from areas were water repellent was not present or degenerated on the stone surface. The presence of both factors caused stress by different hygric dilation and gypsum crystallization on the interface between treated and untreated stone and were therefore identified as major decay mechanisms for the volcanic tuff from the Charlottenburg Gate in Berlin.

Corresponding author: urs.mueller@bam.de

Fire safety requirements and burning behaviour of textiles in renewed historical buildings

J. Muskalska, M. Ornat, K. Robaczyńska

Institute of Textile Materials Engineering, Gdanska 118, 90 -520 Łódź, Poland

ABSTRACT

The textiles of interior furnishings in historical buildings as well as the interiors of the adjacent rooms of functional character such as hotels, restaurants together with administration and office rooms should meet not only the aesthetical and usable requirements, but also the requirements connected with the fire safety of these objects in which they are applied. The fire hazard of the historical buildings equipped with the traditional flammable textiles can be limited on condition that these textiles are replaced by the new flame retardant textiles while renovating historical buildings.

In our paper there have been discussed the requirements concerning the fire safety imposed on the textiles applied in the interior furnishings of building objects, including historical ones. The findings of flammability and flame spreading tests of the selected textiles have been presented. The tests have confirmed the suitability of the textiles for the application as the elements of interior furnishings.

Corresponding author: palnosc@iimw.lodz.pl

Lime-based repair mortars - influence by surface working methods on behaviour and durability of mortar

M. Myrin[1], K. Balksten[2]

[1] Göteborg University/ Stenkonservatorn Skanska, Sweden
[2] Chalmers University of Technology, Göteborg, Sweden

ABSTRACT

Repair mortars are, in conservation and restoration of stone monuments, essential for sealing cracks and also for reconstruction work. Traditional repair mortars are usually based on lime. The mortar always has to be well adapted to the authentic characteristics of the original stone, e.g. structure, texture and porosity.

The main purpose of this study is to follow how different surface working methods used on lime-based repair mortars influences the mortar's behaviour, durability and appearance.

The findings of the study are based on:

- Observations made during restoration work
- Observations from field stations
- Microscopic analyses of thin sections
- Parallel studies on lime plaster (these show compatible results)

The results show a clear difference in durability, appearance and behaviour of the lime mortar depending on the stage of the drying process at which the mortar is worked on. There are three main stages in the drying process, with three possible consistencies of the mortar:

1. Freshly applied, when still wet and soft
2. When damp, at the moment when it mortar stiffens up
3. Soon after drying, when a white surface film has appeared

For achieving a durable material it is important to avoid the development of a surface lime film. This can be achieved by working the mortar at the correct stage of drying, e.g. at the moment when the mortar stiffens up.

The study implies that only by working the mortar at the damp stage the mortar will be durable and have a structure, texture and porosity that is compatible with the surrounding stone material, which is a basic conservation requirement. At the other two stages, freshly applied mortar and dry mortar, inferior results are achieved.

Corresponding author: malin.myrin@skanska.se

A case study on the evaluation of consolidation treatments of Gotland Sandstone by use of ultrasound pulse velocity measurements

M. Myrin[1], K. Malaga[2]

[1] Stenkonservatorn Skanska/ Department of Environmental Sciences, Göteborg University, Storängskroken 2, SE-115 42 Stockholm, Sweden
[2] SP Swedish National Testing and Research Institute, Box 857, SE-501 15 Borås, Sweden

ABSTRACT

The main purpose of this study is to analyse changes in physical properties of sandstone after consolidation treatment and to study the durability of the treatment. For this purpose measurements were made before and after treatment by means of a portable instrument for ultra pulse velocity (UPV). The measurements have been repeated regularly in order to monitor the stone objects after conservation and thereby estimate the durability of the consolidation treatment.

For this study two stone objects from the 17th century were measured, both chiselled of the very weathering-prone Gotland sandstone. The results of in-situ measurements were compared to measurements carried out in laboratory environment freshly quarried and deteriorated sandstone as well as on stone repair mortars.

The study implies that the portable instrument for UPV measurements is useful in practical conservation work for analysing changes of physical properties due to consolidation treatment and, in combination with visual inspection, for monitoring the stone's state of conservation after treatment. Small adjustments to improve the equipment's suitability for measuring sculptured stone in-situ would allow more applicable measurements and more effective work.

Corresponding author: malin.myrin@skanska.se

Considering spurious peaks in the EDXRF analysis of metallic pre-Columbian pieces of the Museum of Ethnology and Archaeology of the University of Sao Paulo

A. C. Neiva[1], J. N. Dron[1], S. C. Lima[2]

[1] Departamento de Engenharia Química, Escola Politécnica, Universidade de São Paulo
Av. Prof. Luciano Gualberto, Trav. 3, n. 380, CEP 05508-900
São Paulo-SP, Brazil
[2] Laboratório de Conservação e Restauro, Museu de Arqueologia e Etnologia, Universidade de São Paulo, São Paulo, Brazil

ABSTRACT

A semiportable energy-dispersive x-ray fluorescence spectrometer was assembled with the aim of analysing alloys and corrosion products of artistic, ethnological and archaeological pieces. The spectrometer consists basically of an x-ray tube with W anode, with maximum output of 60kV and 2mA, and a Si-drift x-ray detector with Peltier cooling, which allows the system to be used anywhere, with no need of liquid nitrogen. It was used for the analysis of the alloys and occasional corrosion products of several metallic pre-Colombian pieces of the Museum of Ethnology and Archaeology of the University of Sao Paulo. Special care was taken to account for the contribution of spurious radiation from both the Pb primary collimator and the Zr detector collimator. The main components of most alloys were Au, Ag and Cu, but Pb, Ca, Fe and other elements were also identified. The characterization of the alloys and corrosion products is important for the subsequent conservation of the collection.

Corresponding author: acneiva@usp.br

Analysis of proteins found in wall paintings using laser induced fluorescence spectroscopy

A. Nevin[1,2], D. Anglos[2], S. Cather[1], C. Fotakis[2]

[1] Conservation of Paintings Department, Courtauld Institute of Art, Somerset House, Strand, London, WC2R 0RN, UK
[2] Institute of Electronic Structure and Laser (I.E.S.L.), Foundation for Research and Technology Hellas (FO.R.T.H.), P.O. Box 1527, Heraklion, 71110, Greece

ABSTRACT

The analysis of proteins found in wall paintings poses a particular challenge; not only are proteins often found in small concentrations, but sampling is generally necessary for their analysis. However, the use of Laser Induced Fluorescence (LIF) provides a non-invasive means of analysis which is particularly advantageous for applications in the conservation of art. In wall paintings, proteins can be found in the render, as binding medium for the ground, as a binding medium for pigments, as a preparation layer for gilding and relief and as a varnish. In addition, proteins have often been employed in the conservation of wall paintings, as a retouching medium, and more often as a consolidant, both for stabilisation of detachment and flaking. Proteins found in wall paintings come from a variety of sources including milk, eggs and animal tissues and bone, and contain casein/lactablumin, albumins/lysozyme and collagens respectively.

Intrinsic fluorescence of protein-based media is based on their amino acid composition as well as the presence of cross-linkages between acids and degradation products; differences in composition account for the fluorescence spectra of various media. The dependence of fluorescence on the basis of laser excitation wavelength can be diagnostic, as is shown for ultraviolet sources at 248 (KrF Excimer), 337 (N_2) and 355 (Nd:YAG). Further, lifetime of fluorescence emission has been explored, and is particularly advantageous for the analysis of proteins in the presence of fluorescent pigments and inorganic materials like calcium carbonate, commonly found in western wall paintings.

Results of LIF analysis are presented from a variety of samples. Model samples include films of binding media, both with and without inorganic materials and pigments (including malachite, indigo and clay earthen pigments). Further, previously characterised European and non-European wall painting fragments with a variety of supports (including earthen paintings) have also been analysed. Finally, the use of protein-based conservation treatments and their analysis by fluorescence is presented. The technique of LIF provides particular advantages for sample analysis; however, considerations of its limitations, especially in the context of alternative techniques commonly used for the analysis of paintings (including GC-MS and FTIR) are discussed.

Corresponding author: austin@forth.iesl.forth

Building stones from a muddy delta: native natural stones from the Netherlands

T.G. Nijland[1], C.W. Dubelaar[1], H.J. Tolboom[2], R.P.J. van Hees[1,3]

[1] TNO Building & Geoscience, Delft / Utrecht, The Netherlands
[2] Netherlands Department for Conservation, Zeist, The Netherlands
[3] Faculty of Architecture, Delft University of Technology, Delft, The Netherlands

ABSTRACT

Most of the country being a Quaternary delta, local supplies of natural stone suitable for building purposes are rare in the Netherlands. Since Roman times, natural stone has been imported, starting with Drachenfels trachyte and Römer tuff from the Siebengebirge and Eifel in Germany, respectively, followed, amongst others, by sandstones from Germany (Bentheim, Obernkirchen, Buntsandstein) and calcarenites and siliceous limestones from Belgium (Gobertange, Lede). Nevertheless, the Netherlands has several native natural stones that were used for monuments in the past, whereas one, the Sibbe stone from the Maastrichtian, is still, on a small scale, used for new buildings. Local Quaternary bog iron ores have been used in early medieval times (until c. 1200) in both the IJssel valley and the province of Limburg. The same holds for northern erratics, deposited in boulder clay during the Saalian ice age in the northern part of the Netherlands, and gravel deposits from the river Meuse. Miocene lithified siliceous sands, the Nivelstein sandstone, outcrop in just off the Dutch border in Germany near the bordertown of Kerkrade, Limburg. They were used already by the Romans as altar stones, and were applied in 11th – 12th century buildings in the south of the Netherlands, to be used again in the early 20th century in the same region. The Maastrichtian deposits in the southern part of Limburg province provide the major supply of Dutch natural stone. A chalky limestone, known as 'mergel', was used since Roman times, mainly in its province of origin, but in the 16th century also as far north as Utrecht, in the centre of the Netherlands. Maastrichtian cherts have been used very locally. Maastrichtian Kunrade limestone was also used locally and, to limited extent, outside the province of Limburg, for example in Amsterdam. Finally, Upper Carboniferous sandstones from the Geulle valley were used locally, mainly for farm houses. In this contribution, basic rock properties and weathering patterns will be discussed, together with replacement stones and conservation strategies.

Corresponding author: timo.nijland@tno.nl

Retables' constructive systems - N.S. Necessidades and N.S. Lapa churches. (abstract withdrawn)

M. A. Nunes, A. Valle, S.C.B. Nappi

Federal University of Santa Catarina, ECV-CTC-Campus Universitario Trindade, 88040900, Florianopolis, Brazil

ABSTRACT

In order to preserve cultural goods, it is essential a systematic study of historical, stylistic, constructive and social aspects for understanding and perpetuation for the future ages. The work here presented has an objective to present some achieved results from the study of altar constructive systems, considering the ornamental structure in wood carving behind the posterior part of the altars. The selected high altars pertain to two churches located the city of Florianopolis, in Santa Catarina state, Brazil, that are Ours Lady of the Necessities´ Church, constructed around 1750 age and located in Saint Antonio of Lisbon, and Ours Lady of the Lapa, sacred in 1806, in Ribeirão da Ilha region. The both temples are under protection of municipal and state laws. The applied methods approach are bibliography, documentary, picture surveys and characterizations of altar's material, connection pieces, causes and processes of decay. The methods adopted for inspecting the conservation state are percussion, perforation and ultrasound speed as complement. At the same time, samples are collected in order to identify the botanical species identification of wood and the elements of chromatic layer. Until the present moment, it is done the stylistic, pictorial and historical surveys and the diagnosis of the conservation state and wood identification used in the high altar of the Ours Lady of the Necessities´ Church. The planning of a digital data base is included in this research in order to be help tool for plans of conservation and restoration of heritage patrimony managed by cultural preservation institutes.

Corresponding author: angeladovalle@ecv.ufsc.br

The effects of fire and heat on natural building stones: first results from the Gröden Sandstone

U. Obojes[1], A. Saxer[2], P. Tropper[1], P.W. Mirwald[1]

[1] Faculty of Geo- and Atmospheric Sciences, Institute of Mineralogy and Petrography, University of Innsbruck, Innrain 52, 6020 Innsbruck, Austria
[2] Faculty of Civil Engineering, University of Innsbruck, Technikerstrasse 13, 6020 Innsbruck, Austria

ABSTRACT

Damages on historic building materials as consequence of atmospheric influences such as rain, air pollution, freeze-thaw cycles etc. have been intensively investigated over the last 20 years. In contrast, research on the damage effect of fire on natural building materials has received much less attention.

In order to investigate the influence of fires on natural building stones, the aim of this study is to identify the changes in the petrophysical, mineralogical- and material-specific parameters of selected building stones experimentaly heated up to 1000°C.

Up to three samples of representative building stones, which were commonly used in the area of South- and North-Tyrol during the Middle Ages, such as magmatic rocks (Brixner granite, Bozner quartz-porphyr), metamorphic rocks (paragneisses, mica schists, Laas marble) and sedimentary rocks (Gröden sandstone, Hagau "marble" and interglacial breccia from Hötting) have been selected. Simulated firing takes place in a 1-atmosphere furnace for six hours at temperatures of 200°C, 400°C, 700°C and 1000°C.

After firing, the samples are investigated by polarizing microscopy, X-Ray diffraction, scanning electron microscopy (SEM), differential thermal analysis (DTA), mercury intrusion porosimetry, BET analyses, electron microprobe analyser, ultrasonic measurements, compression- and strength tests. Preliminary data of the current investigation show, that in silicate-rich rocks (e.g. Grödner sandstone), intragranular fracturing is the predominantly visible phenomenon. Porosity increases due to micro-cracking especially within grains and at grain boundaries. Carbonate rocks show a structural collapse at 700°C and at 1000°C, CaO remains, due to extensive calcination. Subsequently, the CaO produced is transformed into portlandite due to absorption of water from the air.

The results of this study will help to identify historical fire damages, particularly if later restoration campaigns have eliminated the visible effects.

Corresponding author: Ulrich.Obojes@uibk.ac.at

Application of weathering susceptibility index to salt damage on a brick monument

C. T. Oguchi[1], Y. Matsukura[2], H. Shimada[3], N. Kuchitsu[4]

[1] Geosphere Research Institute, Saitama University, Saitama 338-8570, Japan
[2] Institute of Geoscience, University of Tsukuba, Ibaraki 305-8572, Japan
[3] Graduate School of Geoscience, University of Tsukuba, Ibaraki 305-8572, Japan
[4] Tokyo National Research Institute of Cultural Properties, Tokyo 110-8713, Japan

ABSTRACT

Salt weathering tends to cause stone monument damages. Various kinds of salts and their influence on landforms or stone structures have been reported, however, mechanisms of spatial distribution of salt efflorescence and the relationship between salt weathering and rock properties have not been clarified. To make clear this, field observations on brick kiln and laboratory experiments were performed.

The kiln building, named Shimoren kiln, a national important cultural property, in central Japan, was originally built in 1889 for manufacturing bricks. It has been out of use and subjected to salt efflorescence since 1971. The brick walls of the second floor are more severely weathered due to salts than those of the first (ground) floor. The observations were made on February 1999 and salts were sampled from brick walls at intervals of every 3-5 layers (30-50 cm). The samples were powdered and identified using XRD. Gypsum was found at the bottom of the first floor wall. Thenardite was dominant on the first floor wall. Hexahydrite was dominant on the second floor wall. The small amount of halite was also found at the top of the second floor wall. Spatial variations in types of salts result from their own efflorescence-deliquescence characteristics caused by the temperature dependence of the solubilities and equilibrium relative humidities. This also affects spatial variations of the rate of brick decay of the kiln.

To make clear the mechanisms of salt weathering on bricks, two kinds of laboratory experiments were carried out using two types of bricks having differential physical properties. Four kinds of saturated salt solution such as $MgSO_4$, Na_2SO_4, $CaSO_4$ and NaCl were used. In A-Test pillar samples with a volume of 5 cm x 5 cm x 15 cm were used. They were stood on saturated solution and dried under the condition at 50 degree Celsius and low relative humidity. In B-test, cubic samples with a volume of 5 cm x 5 cm x 5 cm were used. They were submerged in saturated solution for one day, dried under the condition at 50 degree Celsius for two days. Damaged form due to salt weathering was observed and weight loss due to salt fretting was measured. Results obtained from the both A- and B-tests show that starting cycle of weathering has a high correlation to WSI (weathering susceptibility index) value which is constructed by the parameters such as crystallization pressure, pore size distribution, porosity and tensile strength.

Corresponding author: ogchiaki@post.saitama-u.ac.jp

The Horus Temple at Edfu (Egypt): the local economic and social benefits of conservation

J. Ordóñez-García[1], C. Cardell-Fernández[2], A, Jiménez-Serrano[3]

[1] Dept. of Civil Engineering, University of Granada, Severo Ochoa s/n, 18071-Granada, Spain
[2] Dept. Mineralogy and Petrology, University of Granada, 18002-Granada, Spain
[3] Dept. of Ancient History, University of Jaén, Paraje Las Lagunillas s/n, 23071-Jaén, Spain

ABSTRACT

The concept of cultural heritage conservation needs to be part of a global policy. Until know the main target of preserving this legacy has been monuments understood as ancient constructions. Nevertheless the current reality demands consideration of environmental context including social factors.

Edfu is a medium sized town situated two km from the west bank of the Nile, between Luxor and Aswan, in Upper Egypt. The economy of the local population is based mainly in agriculture and tourism. The unique tourism attraction of the town is the Temple of God Horus. The temple was built during the Greco-Roman period (3rd century BC - 1st century AD) and is considered a paradigm for Egyptologists due to its singular relief and inscriptions, the quintessential pillars of Egyptian mythology. Although it has been included in the list of World Cultural Heritage of UNESCO since 1979, at present is in serious danger of deterioration and no progress toward its preservation has been reported recently. Conservation works have been limited to sporadic actions addressed to solve concrete problems.

Visual inspection of the Temple reveals humidity problems and salt efflorescence crystallisation in its base, which cause granular desaggregation of the stone construction - a sandstone from the nearby quarry at Gebel es-Silsila - and the irremediable loss of wall decorations. Moreover, the preservation state of the Temple has changed dramatically since the Aswan Dam was built in the 1960s, which has raised the water table in the surround area. It appears that the stability of the building is in danger due to water circulation in its foundation.

For these reasons, urgent actions for conservation must be taken in order to save this unique monument from abandonment and destruction. In addition this real threat might destroy one of the two current pillars of the local economy. In this context our Research Group is collaborating with the Supreme Council of Antiquities of Egypt in planning the diagnosis of material construction and state of conservation, the decay mechanisms operating in the Temple, as well as programming the strategies for future interventions (e.g. geotechnical aspects for protection). The conservation of the Temple will benefit cultural, economic and social aspects of local population which necessarily must be involved in the project. With this paper we want to encourage international cooperation, from both the research community and the relevant institutions, to support this scientific initiative. More scientific, technical and financial support is required to preserve this unique monument for future generations.

[1] Corresponding author: ajiserra@ujaen.es

Role of water reducing agents in mortar behaviour

H. Paiva[1], J.A. Labrincha[2], V.M. Ferreira[1]

[1] Departamento de Engenharia Civil / CICECO, Universidade de Aveiro, 3810 –193 Aveiro, Portugal
[2] Departamento de Engenharia Cerâmica e Vidro / CICECO, Universidade de Aveiro, 3810 –193 Aveiro, Portugal

ABSTRACT

The addition of a water reducing admixture like a plasticizer or an air-entraining agent in a cement-based material modifies their flow properties, apart from an obvious reduction of the kneading water. This work present a study on the effects of these admixtures on the rheological properties of a render mortar and its water permeability, which is commonly recognized as important issues either for application but also for hardened mortar final characteristics since they are very dependent on the fresh state behaviour. The studied mortar is a single-coat render mainly based in Portland cement as the binder and in siliceous sand as the aggregate material.

Because cement based suspensions usually behave like a Bingham fluid, its flow properties can be defined by two parameters, the yield stress and the plastic viscosity. In order to discriminate between these two components, rheological behaviour was studied with a specific rheometer for mortars that allows measuring the typical large particle size suspensions, which is impossible to perform with the classical rheometers. This approach allow to observe not only the variation of yield stress and plastic viscosity parameters with the admixtures content but also to study the induced rheological behaviour variation with time, particularly, the study of structure breakdown and reconstruction phenomena that happens in cement-based mortars. Correlation with the traditional workability evaluation technique (slump) will be made and taken into consideration in the results discussion.

Finally, liquid water and water vapour permeability of mortars are important issues especially in rehabilitation and can be affected by the introduction of this kind of admixtures. Samples will be made to evaluate this particular influence.

Corresponding author: victorf@civil.ua.pt

Preliminary studies on the development of lime based mortars for adobe masonry

H. Paiva[1], E. Marques[2], A. Velosa[1], J. Coroado[3], J.A. Labrincha[2], V.M. Ferreira[1]

[1] Departamento de Engenharia Civil / CICECO, Universidade de Aveiro, 3810 -193 Aveiro, Portugal
[2] Departamento de Engenharia Cerâmica e Vidro / CICECO, Universidade de Aveiro, 3810 -193 Aveiro, Portugal
[3] Departamento de Arte, Conservação e Restauro, Instituto Politécnico de Tomar, 2300 -313 Tomar, Portugal

ABSTRACT

The typical built heritage is vast and distinctive, not only in the architectural context, but also where traditional structural supports and render-types are considered. This is especially evident in ancient buildings, traditionally-built, that reflect different ages and living styles. In some regions, the most common structures are those using stone masonry or adobe, with or without glazed tiles, and renders based on lime mortars. Hence, it is important to characterize the materials in these systems and, to do so, to study original support and render materials in order to develop designed products compatible with the original materials.

This work aims to make the preliminary studies on the development of mortars for adobe masonry buildings. First, this support material is characterized in terms of mineralogical and chemical composition using X-ray diffraction and complementary techniques. Differential and gravimetric thermal analyses are also used to gain some insight in to the adobe constituents.

Mortars were formulated with different binders (aerial, putty and hydraulic lime) but with the same selected siliceous type aggregate. A ceramic brick powder additive was also used in one of the aerial lime based mortar formulation in order to approach the nature of the composition to the adobe for compatibility reasons.

Final product characteristics like the mechanical properties (dynamic elastic modulus, flexural and compression strength) but also capillarity, liquid water and water vapour permeability of mortars were also measured. It is expected to make a preliminary evaluation of the compatibility of these mortars properties with the adobe masonry characteristics, in order to get valuable information on the paths to follow in the research of this kind of rehabilitation mortars for built heritage.

Corresponding author: victorf@civil.ua.pt

Characterization of bacterial community in indoor environment

F. Palla[1], S. Marineo[2], L. Anello[3], G. Lombardo[1]

[1] Department of Plant Sciences – University of Palermo, Italy
[2] D.B.C.S.- University of Palermo, Italy
[3] I.B.I.M. – CNR, Palermo, Italy

ABSTRACT

We report the presence and characterization of bacterial colonies in indoor environments by molecular microbiology techniques. The bacterial DNA was used as template in PCR experiments in order to amplify both specific 16S rRNA locus and the 16S-23S **i**ntergenic **t**ranscribed **s**pacer (ITS). The sequence of amplified fragments were determined and analysed to elicit the prevalent bacterial species in the microbial community. Comparison between fragments sequences and bacterial genomic DNA deposited in Genebank allowed us to create phylogenetic dendrograms.

In this work we also focalised our attention on characterization of bacterial population present in library bioaerosol and onto books housed, focusing on species involved in degradation of cellulose.

Moreover, SEM observation, cellulase activity assay analyses were consistent with molecular results.

Corresponding author: fpalla@unipa.it

The last period of "Buen Retiro" porcelain factory

C. Pascual, P. Recio, S. de Aza, F. J. Valle, E. Criado, A. H. de Aza, R. Martínez

Inst. de Cerámica y Vidrio, CSIC. Campus de Canto Blanco, c/Kelsen s/n, 28049 Madrid, Spain (RTPHC-CSIC)

ABSTRACT

The introduction of the Chinese porcelain (hard porcelain) in Europe, during the XVIII century, supposed a scientific, technological and cultural revolution. The Kingdom of Spain was not indifferent to this process and it became involved in the foundation, by Carlos III, of the Royal Factory of the Buen Retiro in Madrid. The production, which extended from 1759 to 1808, was marked by a series of circumstances that diversified its production with the intent of obtaining hard porcelain using Spanish raw materials. In the last period, 1803-1808, Bartolome Sureda redirected porcelain production under new technological and economical prospects. The abrupt end of the factory, as consequence of the Independence War against Napoleon, caused, among other disasters, the loss of most of the documentation that shrouded its history in a dense nebula.

In this work, the results of the physical-chemical, mineralogical and microstructural studies, carried out on both tableware and flooring porcelain fragments from an archaeological excavation in the Retiro Park and from the "Casa del Labrador" (Aranjuez), are presented. The study has shown, for the first time, that both materials were made with the same porcelain paste, developed by Sureda and constituted of protoensteatite (14 to 20 wt%), α-quartz (8 to 15 wt%), α-cristobalite (6 to 21 wt%) and a glassy phase (55 to 58 wt%). The so-called Vallecas Sepiolite from Madrid was used as raw material in their manufacture and the firing temperature ranged between 1300 and 1350ºC. Equally novel was the use of a glaze of feldspatic nature, similar to the one used in the hard porcelains.

The over-glaze decoration of the floor tiles was made of a PbO frit and three basic pigments: Cassius purple, Naples yellow and Manganese-Iron black. The forty seven colours that have been observed in the shards were obtained by mixing the three based pigments or by adding small amounts of sulphur or transition elements such as Cu, Co and Ni.

Porcelain manufactured by Sureda, was really novel so much for its chemical composition as for its mineralogical composition, with a wide firing range and without any PbO addition, typical of all contemporary Europeans soft porcelains containing MgO, We can therefore affirm that Sureda obtained a composition of hard porcelain, unique in its class, which can really be called: *Madrid' Porcelain.*

Corresponding author: aza@icv.csic.es

Materials and techniques used in the works of art from Paulistas Church Lisbon (Portugal)

A. Pereira[1], A. Miller[1], E. Figueiredo[2], S. Trindade[3]

[1] Departamento de Conservação e Restauro, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, 2829-516 Caparica, Portugal
[2] Instituto Tecnológico e Nuclear, Química, Estrada Nacional 10, 2686-953 Sacavém, Portugal
[3] K4 – Conservação e Restauro, Lda, Av. 24 Julho 4B – Porta 12, 1250-480 Lisboa, Portugal

ABSTRACT

The works of art belonging to the church "Igreja dos Paulistas" in Lisbon are recently being subjected to conservation and restoration interventions.

A detailed study of the materials and techniques used on the religious/artistic decoration of the Portuguese church was carried out. This involved analyzing canvas paintings from the XVIII century, a mural painting and golden carved wood.

The canvas paintings analyzed demonstrated some simplicity in the materials and techniques used by the Portuguese artist André Gonçalves (1685-1762).

The mural painting analyzed documented several repainting made over the years, mainly after the Lisbon earthquake in 1755.

The carved wood analyzed showed not only the use of gold leave, but also of silver leaf in some areas of the motifs.

The study was performed by cross-section optical microscopy analysis, by FT-IR micro-spectroscopy and EDXRF micro-spectrometry.

Corresponding author: anaisabel.pereira@gmail.com

Geomonumental Routes: a useful tool for the popularization of architectural heritage

E.M. Pérez-Monserrat[1], M.J. Varas[2], M. Gómez-Heras[1], M. Alvarez de Buergo[1], R. Fort[1]

[1] Instituto de Geología Económica (CSIC – UCM), Madrid, Spain (RTPHC-CSIC)
[2] Facultad de Ciencias Geológicas, Universidad Complutense de Madrid

ABSTRACT

The concept of Cultural Heritage covers a wide range of different interrelated aspects, which are also synergistically entangled with the peoples, as it takes part of them and configures their idiosyncrasy. The Cultural Heritage is a very relevant gathering point between the peoples that have shaped it throughout all history, and therefore its preservation is essential.

The European Council undertook from 1987 the Programme of Cultural Routes framed within this philosophy, with the desire of increasing the value of the European Cultural Heritage. For this purpose, The European Institute for the Cultural Routes was created in 1998 and nowadays there are numerous routes that analyse the European Cultural Heritage from several different points of view.

The Geomonumental Routes entail the popularisation of the Monumental and Architectural Heritage from both a social and scientific perspective. This allows the interaction of subjects such as History, Geology, Chemistry, Architecture and Sociology. The prefix 'Geo' is used to highlight the depth of the link between Geology and Monuments, as any human urban settlement is conditioned by the geology of its placement and the main resources for building are extracted from the earth. The role of the stone within the built legacy of peoples is pre-eminent, which confers to it a major value by itself within Heritage. In this way, a better knowledge of stone as a building material account for a different way of understanding, conserving and appreciating the Built Heritage.

The study of the stones used in the Architectural Heritage also provides valuable information on the historical quarries, mining industry, ways of transportation, building techniques and preservation methods of each historical period. This represents an essential documentation in what is referred to the Industrial Heritage. A Geomonumental Route must, therefore, show the kind of materials consumed, their provenance, their decay and state of conservation and the possible restoration episodes underwent in the past, besides the artistic and historical aspects of the monuments involved in the route.

In the Built Heritage of the Autonomous Region of Madrid, several stone types confined to this specific region can be found in addition to other geological materials, as those which take part of earthen architecture. The information on the factors that have conditioned the evolution of the use of different materials during the history can be shared with the public through Geomonumental Routes. These routes must include not only the highlights of the Heritage of the region, but also other less-known Heritage pieces in small villages dispersed throughout the region and not included in the usual tourist routes.

Corresponding author: empmon@geo.ucm.es

Accelerated ageing by salt crystallisation: assessment of a suitable laboratory methodology

T. Poli[1], M. Positano[2], L. Toniolo[1]

[1] CNR–ICVBC Sezione di Milano "Gino Bozza", P.za L. da Vinci 32 - 20133 Milan, Italy
[2] ISRIM s.c.a r.l., Loc. Pentima Bassa, 21 – 05100 Terni, Italy

ABSTRACT

A wide experimental project aimed to define guidelines for the evaluation, in lab and in situ, of superficial consolidating commercial products and treatments, have been carried out in the last two years. The general purposes and objectives of the project [Bordignon, F. et al. 2004, in II Congresso Nazionale IGIIC, Genova 84-92 (AltriLIBRI, il Prato, Padova)] are to highlight the main advantages and drawbacks of the different test procedures. Among the other considered artificial ageing methodologies, an induced salt crystallization procedure has been developed and optimized.

The crystallization of salts and transition of these last through different hydration states are one of the main causes of natural stone degradation. The crystals growth, as well assessed, in the bulk of the stones induce mechanical stresses able to seriously damage or even break the hardest stones.

In the first phase, the methodology has been set up on a high porosity stone (Noto calcarenite) in order to exploit the enhanced effect of this kind of ageing; actually, a high amount of saline solution can penetrate in this stone and its mechanical resistance is quite low.

In this work, the results of the complete experiments on four lithotypes (Noto calcarenite, Serena sandstone, Candoglia marble and S. Terenziano limestone) having different chemical and physical characteristics, treated with six widely employed commercial products have been reported. The results have been elaborated with the aim of testing the effectiveness of the methodology and not, as usual, the efficacy of products. The paper will include a critical review on the tested methodology on the basis of the obtained data.

Corresponding author: tommaso.poli@polimi.it

Studies of the efficiency of the biocide "Biotin N" incorporated in artificial stone composed of ground natural stone and a commercial acrylic resin concerning the growth of algae

R. Portero de la Torre[1], F.C. Bolívar-Galiano[1], X. Mas i Barberà[2], M.T. Doménech-Carbó[2], J. Petermann[3], B. Uceda[1]

[1] Dpt. Pintura. Fac. Bellas Artes. Univ. Granada. Avda. Andalucía s/n 18071 Granada, Spain.
[2] Dpt. Conservació i Restauració. Fac. Bellas Artes. Univ. Politècnica València, Spain
[3] Fachhochschule für Technik und Gestaltung Mannheim, Germany

ABSTRACT

The efficiency of the biocide Biotin N incorporated into artificial stone, consisting of a natural stone and an acrylic resin, and their composition was tested regarding the growth of algae. The biocide Biotin N was tested at concentrations of 0.5% and 2%.

The mineral part was mixed with the resin in 2 different proportions which were 1:1 and 1.5:1. The used natural stones were either "Bateig" or "Tosca de Rocafort" which play an important role in the patrimony of Valencia. The stone was ground using different sieve sizes of 0.80 mm and 0.42 mm for "Tosca de Rocafort", and of 0.42 mm and 0.25 for "Bateig".

The samples of the different compositions were inoculated in the laboratory using an algae community that contained the most important types of algae: diatoms, cyanobacteria, green algae [Bolivar-Galiano, F.C. & Sánchez-Castillo, P.M. PH. *Boletín del Instituto Andaluz de Patrimonio Histórico*, 24: 54-63. 1998]. The samples were divided into different recipients according to non biocide and biocide containing.

The algae growth was monitored and examines after 1 week, after 4 weeks and after 7 weeks. The amount of growth was judged by giving indexes for the amount of growth on the surface area of the samples. Further the present species on the samples were examined using a ZEISS microscope [Sánchez-Castillo, P.M. & Bolívar-Galiano, F.C. *Limnetica*, 13, 1: 31-46. 1997].

This experiment is the second part of a recent study of the efficiency of the biocide "New Des" incorporated in these artificial stones [Petermann, J. *et al.* 13th Internatinal Biodeterioration and Biodegradation Simposium. 2005. Madrid].

Aknowledgements: Financial support is gratefully acknowledged from "I+D Generalitat Valenciana" project GV04B-441.

Corresponding author: fbolivar@ugr.es

Diversity of sulfate-reducing bacteria as an example of the presence of anaerobic microbial communities in Altamira Cave (Spain)

M.C. Portillo, J.M. Gonzalez, C. Saiz-Jimenez

Instituto de Recursos Naturales y Agrobiología, CSIC, Sevilla, Spain
(RTPHC-CSIC)

ABSTRACT

Altamira Cave (Cantabria, Spain) contains paleolithic paintings dated back to 15,000 years. The conservation of these paintings is a primary objective. Recent studies have show the existence of unknown microbial communities in this cave. Our latest studies have shown the presence of anaerobic communities detected on superficial biofilms developing on cave walls. Herein, we analyzed the diversity of a strick anaerobic microbial group, the sulfate-reducing bacteria, from Altamira Cave.

Sulfate-reducing bacteria (SRB) show a typical metabolism since they reduce sulfates producing sulfides. A consequence of this physiology is the alkalinization of their environment and a general darkening of the site due to the reaction of sulfides with metallic ions. Thus, SRB are of great interest for the conservation of rock art.

In Altamira Cave, we have detected the presence of SRB using molecular techniques based on both DNA and RNA analysis. Most of the SRB found belong to known genera such as *Desulfovibrio* and *Desulfomicrobium* althougth others represent putative novel genera. These microorganisms were detected using SRB-specific primer pairs targeting the SRB population. As well, RNA-based detection shown that these SRB are not just present in the cave but also are showing active metabolism which implies they actively participate in the development of microbial colonization in the cave. These findings expand the biodiversity list of microorganisms in Altamira Cave.

Corresponding author: mcpg@irnase.csic.es

Surface degradation of complex architectural form due to atmospheric pollution

S. Pospíšil[1], M. Drdácký[1], Z. Slížková[1], D. Knotková[1], P. Delpech[2]

[1]Institute of Theoretical and Applied Mechanics, Academy of Sciences of Czech Republic, Prague 9, Prosecká 76, 19100, Czech Republic
[2]Centre Scientifique et Technique du Batiment, Nantes, France

ABSTRACT

Many old structures in the Czech Republic are of high historical value. Despite of this, they have not been treated adequately and are often in the need of urgent repair interventions. Such interventions, however, have to be based on a proper conservation or restoration measures. Often a highly specialised research is needed to support the practice. Typically, when a new material is used in restoration, its compatibility with the historic fabric has to be ensured in order to minimise the negative effects caused by its addition. These negative effects usually results into an accelerated weathering (by moisture, gaseous pollutants, salts and wind exposure) of valuable historic architectural details, stone and brick masonry, plasters etc.

The disagreeable appearance in many larger towns of soiled buildings is caused by deposition of particulate matter arising from atmospheric pollution. The deposition of particles is characterised by the deposition velocity, similar to gas deposition. Particles deposit due to sedimentation, impaction, and diffusion depending on the size of the particles. So far, all soiling dose-response functions include the concentration of particles in $\mu g/m^3$ as an explanatory variable measure either as total suspended particles (TSP) or particulate elemental carbon (PEC). The available dose-response functions are based on two types of models, the exponential model and the square root model.

An experimental object modelling the Prague National Museum has been built and tested. The building, which is situated to the central part of capital, is relatively highly exposed to the environmental deterioration due to combination of wind, rain, dust and gaseous traffic. The museum is subjected in the long run to the measurements of the dust exposure using special sensors (samplers). Though very valuable, this experimental activity needs long period for both quantification and evaluation of data, so that our proposal is focused on the speed-up of the whole procedure by means of utilisation of the Jules Verne Wind Climatic Wind Tunnel. Two small scale models of this historic building served as the testing specimens in order to compare the results to those acquired on real prototype investigated within EC supported projects (CULTSTRAT, MULTI-ASSESS). There has been studied namely the particle deposit intensities in relation to wind speed. Adhesive samplers have done the inert dust exposure measurement. In the paper, the comparison with deposition on the real building will be presented.

Corresponding author: pospisil@itam.cas.cz

A comprehensive study on the discoloration associated with laser cleaning of stonework

P. Pouli[1], G. Totou[1], C. Fotakis[1], S. Gaspard[2], M. Oujja[2], M. Castillejo[2], C. Domingo[3]

[1] Institute of Electronic Structure and Lasers (IESL), Foundation for Research and Technology-Hellas (FORTH), PoBox 1527, Heraklion, Crete, 71110, Greece
[2] Instituto de Química Física Rocasolano, CSIC, Serrano 119, 28006 Madrid, Spain
[3] Instituto de Estructura de la Materia, CSIC, Serrano 121, 28006 Madrid, Spain

ABSTRACT

This study aims to investigate the coloration effects associated with infrared laser cleaning of pollution encrustations from stonework and establish laser cleaning methodologies to avoid or rectify such effects.

The laser-assisted removal of pollution encrustation from stonework (at 1064 nm) has been often related with unpleasant "*yellowing*". The understanding of this effect is considered vital not only for the investigation of the laser cleaning methodologies in stonework conservation but also for the study of all the parameters that may influence the laser-matter interaction during the cleaning process. The most prevailing physical and chemical processes introduced to explain such undesirable effects are: (a) Various pre-existing patinas, (b) migration of the yellowish fraction present in the pollution crust due to polar organic compounds resulting into "staining" of the original surface and (c) differential scattering of light on the voids formed due to the selective vaporisation of the dark pollution particles embedded in the crust's matrix. To avoid or rectify such effects many laser cleaning methodologies have been proposed based mainly on the combination of the cleaning beam at 1064 nm with an ultraviolet beam, either in spatial and temporal overlapping and in variable energy density ratios (*wavelength blending approach*), or in sequential irradiation conditions (*sequential approach*).

This work aims to comparatively study two different types of encrustations and substrates (homogeneous thin encrustation on Pentelic marble and thick dendritic crust on Hontoria limestone) on the basis of their composition and origin and investigate the conditions that may induce yellowing when laser cleaned with infrared wavelengths. The analytical methods employed to characterize the crusts and the effects of laser irradiation include colorimetric and optical microscopic observations of surface and cross sections, Confocal Micro Raman Spectroscopy, FTIR and Scanning Electron Microscopy coupled with Energy Dispersive X-Ray Spectrometry (SEM/EDAX). The results obtained have provided a comprehensive approach for understanding the reasons responsible for the discoloration effect, while allowing the establishment of well-defined laser cleaning methodologies that ensure optimum results without any color or structural alterations of the original stonework surface.

Corresponding authors: ppouli@iesl.forth.gr

The Romanesque façade of Sant Martí de Puig-Reig (Barcelona): chromatic layers and conservation treatments on stone

J.L. Prada, N. Guasch, M. Iglesias , M.Badia

CETEC-patrimoni (Universitat Autònoma de Barcelona – Institut Químic de Sarrià), Spain

ABSTRACT

The purpose of this document is to present a study of materials diagnosis within the project of conservation and restoration of the façade and portico of the church of Sant Martí de Puig-Reig. This work was an attempt to contribute to the advice required in the intervention and to determine the most appropriate treatments for the building's conservation.

This investigation has been carried out in constant collaboration with the restoration team. After taking data in situ and that contributed by the restoration team, it has been possible to obtain a complete diagnosis on the mechanisms and agents of alteration, and the building's historical evolution.

After first sampling the stone of the ashlars, of the mortar joints, of the biological deterioration and of the polychromies we proceeded to study them using different analytical techniques. Also some materials were selected to elaborate test tubes with fragments of stone to be treated with consolidating and hydrofuging substances. Tests were made to determine the most suitable products for the lithology in the construction.

Meanwhile some samples of polychromy remaining in the portico were selected for their characterization and to establish the chronological sequence obtaining a historical-chromatic model of the portico.

Throughout the intervention a follow-up was made with advisory technical visits, mainly in the cleaning of the portico and its polychromies, thus providing a solution to the needs of the restoration.

Corresponding author: jlprada@ctv.es

Brick degradation. Salts exudation cartography

N. Prendes[1], E. Menéndez[2]

[1] CEDEX-Ministerio de Fomento, Madrid, Spain
[2] Instituto de Ciencias de la Construcción "Eduardo Torroja" (CSIC), Madrid, Spain

ABSTRACT

Development and distribution of salts exudation has been study during five years (quantifying the average of exudation products in each registration period). These salts have been formed on brick wall in an actual edification. During this period the extension of the mark has been cartographies, and also the products concentration.

The sequence of images has been reference and correct using digital processes techniques, came from easy identifying points on the images (marked bricks). This process has permit detect the nucleation areas of exudation, and also the areas more susceptible to loss some materials due the degradation. This following has permitted establish the half time (number of cycles) to observe an important material desegregation.

The discrimination of exudation areas has been doing by definition of cut level in the histogram of grey levels that are defining by salts (that corresponding to high values in the histogram). This method permit to obtain binary images in each sequence, that using binary morphological algorisms (erosion, dilatation, phases packed, sieve, etc), permits take out quantitative facts. These quantitative facts have been compared with humidity fronts came from images, and permit to follow up the degradation processes at the brick wall.

On the other hand, some similar bricks than the using in the construction have been characterized petro-physically (humidity-dry cycles, absorption, capillarity, etc.). The exudation products has characterized by SEM-EDX, in order to establish causes, processes and typology of neoformed and exuded salts. These salts formed in the laboratory tests have been compared with those one formed over the brick wall.

The initial and final porosity have been compared by SEM using polish surfaces and digital analysis and processing images techniques. These samples have been compared before and after the petro-physical tests in order to compare the gaps and the porosity net after the exudation process.

Corresponding author: emm@ietcc.csic.es

Applications of laser vibrometry analysis to damage detection in masonry structures

F. Prieto[1], M. Martin[2], M. Viola[3]

[1] Dept. Civil Engineering. University of Minho. Campus de Azurem, 4800-058 Guimaraes (Portugal)
[2] INTROMAC (Instituto Tecnológico de Rocas Ornamentales y Materiales de Construcción), Spain
[3] Arquitecto del plan director de la Catedral de Coria, Spain

ABSTRACT

This contribution studies the applications of a non-contact experimental technique for the evaluation of damage in masonry construction. The presented method allows to correlate small defect to local dynamic stiffness and structural integrity.

Based on the vibration analysis by scanning laser Doppler vibrometer, the new methodology constitutes a powerful tool for diagnostic not only in laboratory, but also in operative conditions.

In fact, the measurement capabilities of vibrometers, such as sensitivity, accuracy and reduced intrusivity have shown to be extremely adequate for the case of old masonry buildings where perforation techniques are not always desirable.

Corresponding author: fprieto@civil.uminho.pt

"New natural stone" for the reconstruction of Charles Bridge in Prague

R. Přikryl

Institute of Geochemistry, Mineralogy and Mineral Resources, Faculty of Science, Charles University in Prague, Albertov 6, 128 43 Prague 2, Czech Republic

ABSTRACT

The construction of the oldest preserved Prague's stone bridge, now called Charles Bridge (since 1870), was started under the auspices of the Czech King and Roman Emperor Charles IV in 1357. Collapse of antecedent stone bridge, called Judita's (served from 1174, construction started 1167) that had been destroyed by terrible floods on Vltava river in 1342 entailed the main impulse for construction of a new bridge. Newly built bridge represented, for a long time (till 1839), the only connection of Malá Strana (Lesser Quarter) beneath the Prague Castle and in 14th century newly built quarter (Staré Město – Old Town) of expanding capital of the Bohemian Kingdom. The construction under direction of Master Oto and of stoneworks of Petr Parléř (after death of Master Oto in 1375) lasted till 1402. The bridge, now a UNESCO listed monument, is 516 m long and 9.5 m wide.

During both construction and later repairs, natural stone from several localities in the Bohemia, represent main building material imprinting characteristic appearance to this national monument. Some of the employed rock types range are either medieval originals or represent similar material used during later repairs, the others are just substitute for non-available original stone. Many of the stone blocks in the facing masonry of the Bridge exhibit certain degree of weathering, mainly due to the absent systematic maintenance and replacement of weathered ashlars.

During last 10 years, plans for Charles Bridge major reconstruction were thoroughly discussed. Surprisingly, serious discussion focused on the natural stone sources for this reconstruction is still missing. In previous reconstruction plans, non-authentic material has been proposed for repair based on the fact that original stone is not further available. The systematic persuasion of the responsible persons during past 2 years meant a turning point and preliminary geological prospecting has been started on the potential sites suitable for the exploitation of the original stone. In fact, the original stone of the Charles Bridge – Carboniferous arkoses – quarried since early medieval times till 1960s is not available at present but at least two areas are promising for further exploration and possibly also to the exploitation.

Corresponding author: prikryl@natur.cuni.cz

Czech limestone in Baroque Architecture: resources and deterioration

R. Přikryl[1], J. Přikrylová[2]

[1] Institute of Geochemistry, Mineralogy and Mineral Resources, Faculty of Science, Charles University in Prague, Albertov 6, 128 43 Prague 2, Czech Republic
[2] Academy of Fine Arts in Prague, U akademie 4, 170 22 Prague 7, Czech Republic

ABSTRACT

Baroque sacral architecture in the Czech Republic is characterized by the widespread indoor use of polishable limestones. These stone were extracted in two major areas: Barrandian geological unit (SW of Prague) and different geological units in Moravia (east part of the Czech Republic).

Barrandian basin comprises non-metamorphosed or low grade metamorphosed Proterozoic and Lower Palaeozoic (Cambrian to Devonian) rocks. Decorative polishable limestone comes from two upper units – Silurian (mainly compact black limestones) and Devonian (reddish, pinkish, greyish limestones). Reddish limestones were highly valued and have been used for the most representative tasks.

This study gives major overview of stone types and their properties from the above mentioned units. In the second part, the study focuses on the indoor weathering of these limestones. The example is given from the Church Virgin Mary Victorius where famous Infant Jesus of Prague is displayed. The history of the sculpture, representing a copy of a venerated wooden sculpture, starts in Spain. It probably comes from a convent between Cordoba and Seville. Doña Isabela Manrique de Lara y Mendoza gave the sculpture as a wedding gift to her daughter Maria Manrique de Lara who married a prominent Czech Nobleman Vojtěch of Pernštejn. She passed sculpture to her daughter Polyxena who married another Czech Nobleman Vilém of Rožumberk. After divorcing, she took the sculpture with her to her second marriage with Zdeněk Vojtěch of Lobkowicz and after his death she donated the statue of the Infant Jesus to the monastery of the Teresian Carmelites near the church of Virgin Mary Victorious in Prague Little Quarter. There it was placed first in the chapel. Later, in 1776 monumental stone altar has been erected. The altar was carved from Barrandian limestones (Silurian and Devonian) displaying variable colours.

In 2001, the altar was restored as the stones have shown serious weathering marked by salt efflorescences along clay rich layers. During the pre-restoration it has been revealed that the altar was not built from large blocks of the stone but just from small pieces (about 0.1-0.2 m^3) so masterfully interconnected that it is not impossible to recognise the joints from the distant view. The efflorescences were dominated by gypsum which narrow isotopic pattern ($\delta^{34}S$ = 1.06-1.6 ‰) corresponds to the common isotopic composition of gaseous SO_2 in Prague.

Corresponding author: prikryl@natur.cuni.cz

Porosity and permeability of sandstones

R. Přikryl[1], Z. Weishauptová[2]

[1] Institute of Geochemistry, Mineralogy and Mineral Resources, Faculty of Science, Charles University in Prague, Albertov 6, 128 43 Prague 2, Czech Republic
[2] Institute of Rock Structure and Mechanics, Academy of Sciences of the Czech Republic, Prague, Czech Republic

ABSTRACT

Porosity makes part of the rock fabric (term conventionally attributed just to the solid phase of the rock, i.e. to the minerals) and significantly affects many physical properties. Porosity is also one of the dominant factors governing susceptibility of the rock to the weathering. As the porosity makes part of the rock fabric, it is also influenced by the genetic processes of the rock itself (primary porosity), rock modification in the rock mass after deposition (secondary porosity), and by the alteration of the rock when taken from its original formation environment and subsequent exposition to the atmosphere (weathering porosity).

Detection of pores and interpretation of real porous structure in the rocks is the most difficult tasks of rock fabric studies. Structure of porous network in the rocks is conventionally performed using both direct (microscopic) and indirect methods. Results obtained from indirect methods are mainly influenced by the model selected for the interpretation of results.

In this study, the porous structure of common Czech sandstone has been studied by set of indirect methods. These include high pressure mercury intrusion porosimetry, water and gas permeability, water uptake by capillary action method, and determination of total and open porosity. The interpretation of results was facilitated by the use of optical microscopy of stained rock samples. This study shows that none of the methods can be used as a universal one. However, the precision of the interpretation of results obtained by individual methods can be significantly increased when using data from complementary methods.

Corresponding author: prikryl@natur.cuni.cz

Characterization and influence of the ancient mortars on the decay of medieval castle of Barisciano, L'Aquila (Italy).

R. Quaresima, H.Corpora, R.Volpe

Department of Chemistry, Chemical Engineering and Materials**,** I-67040 Monteluco di Roio (L'Aquila, Italy)

ABSTRACT

The fortified architecture in the Abruzzo region has a great historical and cultural relevance; In fact more than 700 castles, towers and fortified buildings are distributed throughout the country. Such a density of constructions yields economical and methodological difficulties of conservation and use. In this paper the case of a 12th-13th century castle (Barisciano - L'Aquila) is discussed.

This enclosure castle is located at a height of about 1706 meters in the Apennine belt. It presents serious problems of decay concerning the tower structures as well as the masonry of the walls. A methodology is proposed to identify the different stages of the decay. It analyses, by means of visual checks, eight levels of structural breakdown. Several levels of the decay were observed and classified; they range from the presence of vegetation to the collapse of the walls.

To understand the causes of decay of the masonry, the recorded different levels of breakdown were correlated with the characteristics of the mortars. According to the Italian standards UNI the mortars were sampled and characterised. The chemical and physical characterisation was performed by means of XRD, AAS, XRF, MIP. The main mineralogical and petrographical features were observed by light microscopy and SEM-EDS. The durability of the mortars was assessed by means of crystallisation test according to the standard UNI EN 12370. The mortars were realised with lime and local carbonatic aggregates; in same case was also added brick dust (*cocciopesto*). The latter show a durability greater than all of the other mortars. The distribution of the aggregate is generally shifted to the greatest sizes. This feature is responsible of the low workability of the mortars as well as of the poor adhesion within the ashlars. Considering the mountain placement of the castle a further factor of decay is due to freeze-thawing action. In fact several mortars showed the typical fractures due to this phenomenon (funnel shape pores). The content of soluble salts is low (4,6% to 8,4%), therefore the decay due to the salt crystallization seems to be not relevant.

In conclusion, the masonry was well constructed and the decay must be correlated with the technical characteristics of the mortars, in particular to the aggregate distribution and to the porous system, that result not adequate to the environment of the castle.

Corresponding author: raimondo@ing.univaq.it

Laser removal of organic coatings: fundamental studies and applications to cultural heritage

E. Rebollar[1], M. Oujja[1], S. Gaspard[1], M. Castillejo[1]
G. Bounos[2], S. Georgiou[2]

[1] Instituto de Química Física Rocasolano, CSIC, Serrano 119, 28006 Madrid, Spain (RTPHC-CSIC)
[2] Foundation for Research and Technology-Hellas, Institute of Electronic Structure and Laser, P.O. Box 1527, 71110 Heraklio, Crete, Greece

ABSTRACT

Because of the increasing importance of UV ablation for the analysis and processing of molecular substrates (e.g. in microelectronics, medicine, art conservation, etc), substantial effort has been directed towards the elucidation of the processes underlying it. In this framework, a wide range of studies have been reported on the dependence of the phenomenon on laser irradiation and material parameters. Particular emphasis has been placed on the importance of wavelength, since the use of short wavelengths has been considered to promote a photochemical mechanism at the expense of a photothermal one, with a consequent improvement of the morphology of the processed area. Surprisingly, very little work has been reported on the influence of the polymer molecular weight (M_W) on the ablation process, despite the fact that this parameter determines many of the polymer physical characteristics. The understanding of the influence of M_W on laser ablation of polymeric substrates is of crucial interest in the design of adequate strategies for laser removal of degraded varnishes on paintings. In fact, the MW of the polymer fractions of varnishes varies a lot according to their exposure to environmental factors (e.g light, humidity, etc) and as a function of the depth from the surface as a result of ageing. In all, both for mechanistic purposes and for applications, it is important to characterize the influence of polymer M_W on the laser ablation process.

In this work we report on pulsed UV laser ablation studies of films of model and real varnishes using a range of experimental techniques. These include optical spectroscopic studies of the ablation plume, real-time monitoring of the film transmission during ablation and optical microscopic examination of the irradiated area. Results obtained show that at weakly absorbed wavelengths, the extent of morphological changes in the remaining substrate and the time scale of the observed transmission transients are dependent on M_W. The observed sensitive dependence of processes on M_W is of direct importance for the optimisation of laser processing schemes in laser restoration.

Corresponding author: marta.castillejo@iqfr.csic.es

The restoration of a Codex on Arab Paper (1293-94)

M. L. Riccardi, C. Casetti

Instituto Centrale Patologia del Libro, Via Milano 76 – 00184 Roma, Italy

ABSTRACT

Our intervention on the notary's manuscript, dated 1293-1294 and written on Arab paper, tried to combine two different exigencies, normally very hard to harmonize. On one side, the consultation of the manuscript and on the other side, the conservation of each material and peculiarity of the codex.

The physical and mechanical paper degradation, happened in an undefined period, has transformed the book in a rare, quite unique exemplar. The paper fibres tangle was so full of charming, to suggest the idea to leave the book as a perfect witness of the origin of paper from rags. However, this solution was unfeasible because of the level of paper degradation –in the inferior part of the sheets -, we were deprived of the chance to read the last three or four text lines, rolled up on themselves. It was also impossible to handle the book without loosing fragments of paper: the linen fibres were dramatically weakened and vulnerables. It was necessary to allow to read the manuscript again and to give a new stability and durability to the writing material.

In our report, we'll explain in detail both the terms of the research carried out, preliminarly to all the treatments, and the achieved consolidation. Our purpose was to realize a work of "pure" conservation, preserving the tranformation undergone by the book and keeping its specificities. We aimed to avoid artificial recomposition of a normality condition lost by now, on the ground the recomposition wouldn't add anything to the understanding and to the image of the book.

Furthermore, we will explain a new use of the original parchment cover. In fact, it was deprived of its original function of operating cover, but kept to safeguard the original aesthetic aspect of the codex.

Corresponding author: ccasettibrach@beniculturali.it

Deterioration forms present in the covering materials of the Monastery of Lorvão, Portugal – Characterization and Causes

M. Rodrigues[1], M.L. Tavares[1], M.J. Basto[2], F. de Llera Blanes[1]

[1] IN SITU – Conservação de Bens Culturais, Sâo Joâo do Estoril, Portugal
[2] LAMIST– Laboratório de Mineralogia e Petrologia do Instituto Superior Técnico, Lisbon, Portugal

ABSTRACT

The study of conservation state, the causes off damage and identification off the different deterioration forms in Monuments, before restoration works is fundamental to establish a program based on scientific criterions.

The Monastery of Lorvão is located in the central part of Portugal near Coimbra. The Monastery foundation date is uncertain, but his certain that in the end of the 9th century this monastery was already founded. In the end of the 16th century and until the end of the 18th century suffered several reconstruction works. This monument is built in a white limestone "calcário de Ançã".

This paper presents the studies preformed at Monastery of Lorvão, describes the degradation forms observed in several spaces of this monastery like the cloister and the tour, and there causes. There are also present the analysis preformed to identified the salt efflorescences present. This work integrates the project "*Recuperação e valorização do Mosteiro de Lorvão – Diagnóstico do Estado de Conservação dos Elementos Pétreos e revestimentos do Monumento, e Proposta de Intervenção"* that IN SITU is developing for IPPAR – Instituto Português do Património Arquitectónico off Coimbra.

Corresponding author: maddias@clix.pt

Methodology Study for the determination of the pathologies in the constituent materials of the Milagros Aqueduct (Mérida)

M. I. Mota López[1], J.M. Ávila Macías[1], I. Rodríguez Maribona[2]

[1]INTROMAC (Instituto Tecnológico de Rocas Ornamentales y Materiales de Construcción)
Campus Univesitario s/n, adpo 135. 10071 Cáceres (Spain)
[2] Fundación Labein. Edificio 7000. C/ Geldo. 48160. Derio. Bilbao. Vizcaya (Spain)

ABSTRACT

The conservation of this prime example of national and historical heritage requires a methodology that should be based firmly on modern scientific analysis. In recent years the investigative research has moved away from informality and irregularity, and evolved towards the standardisation of multidisciplinary techniques. Therefore any intervention on a historical object should continue to respect developments in scientific methodology and in doing so preserve the physical integrity of the object together with its cultural and historical significance. The project has been divided up into five parts. INTROMAC and FUNDACIÓN LABEIN, have developed phase three: "The material and structural investigation of the 'Acueducto de los Milagros', relating to weathering and appropriate treatments".

Building materials from the Acueducto de los Milagros, in Mérida, have been classified according to deterioration, i.e. the characterisation of mineralogical, petrographical, petrophysical and petrochemical properties of the monument materials. In the Aqueduct de los Milagros there are three groups of materials: (i) Granitic rock of ashlar masonry, (ii) mortars and Roman concrete paste and (iii) ceramic bricks.

The stony materials are granite in origin. The ashlars and ceramic brick joint mortars are both lime mortars with siliceous aggregates, (both with a ratio of 1:3). The Roman concrete is a lime mortar with diorite aggregates, with a ratio of 1: 1. There are two types of bricks; the original Roman bricks of the aqueduct and substitution bricks from latter times.

Corresponding author: mmota@intromac.com

Recovery of phototrophic biofilms after biocide treatment in the tourist cave "Salnitre de Collbato" (Barcelona, Spain)

M. Roldán[1], M. J. García[2], A. Navarro[3], M. Hernandez Marine[1]

[1] Botànica, Fac.Farmàcia. UB. Av. Joan XXIII, 08028 Barcelona, Spain
[2] Gamarra & García, S. L. St. Cugat del Vallés, Barcelona, Spain
[3] Lab. Materials EUPB. UPC. Av. Dr. Marañón 44, 08028 Barcelona, Spain

ABSTRACT

Artificial illumination can damage hypogean monuments due to green sickness ("maladie verte"), the result of uncontrolled growth of phototrophic biofilms. Characterizations of such green sickness, as well as studies concerning the efficacy of remedial methods, are required in order to avoid biodeterioration and aesthetic defects.

Biofilms from Salnitre de Collbato (Barcelona, Spain) were primarily composed of chroococcal and filamentous cyanobacteria.

Biofilms covering stalactites and other surfaces were removed before applying biocidal agents (quaternary ammonium compounds) to allow better penetration. The recolonization of the treated surfaces was evaluated using several microscopy techniques that allow examination of epiphytic communities. These techniques comprised scanning electron microscopy with energy dispersive spectroscopy, and confocal scanning laser microscopy coupled to a spectrofluorimeter. The effects of cleaning and biocides were thus compared under the real cave conditions for light, temperature and humidity.

The recolonization of the substrata was highly dependent on the mineralogy of the stone as well as environmental conditions, especially dripping water and light. Significant differences in the responses of the organisms studied to the biocides were found after one year. The widespread Scytonema julianum was affected by all of the biocides used while Nostoc spp. and moss protonemata were the most resistant to treatments. These results point to the importance of evaluating biodeterioration processes and treatment efficacy before the application of remedial methods.

Corresponding author: marionahernandez@ub.edu

Fungal biodeterioration of sandarac varnish

J. Romero-Noguera[1], I. Martín-Sánchez[2], F. Poyatos-Jiménez[1], F.C. Bolívar-Galiano[1], M.A. Fernández-Vivas[2]

[1] Dpt. Pintura. Fac. Bellas Artes Universidad de Granada. Avda. Andalucía s/n, 18071 Granada, Spain.
[2] Dpt. Microbiología. Fac. Ciencias. Universidad de Granada. Avda. Fuentenueva, 18071 Granada, Spain

ABSTRACT

Natural terpenic varnishes have been widely used in art works, such as paintings and sculpture, traditionally fulfilling an important aesthetic and protective function. Many of these materials are biodegradable, and process of deterioration causes important changes in its mechanic, optical and chemical properties, seriously affecting the conservation and visual appearance of artworks.

This paper seeks to illustrate the development of fungal colonization of sandarac varnish, widely used in traditional art, and the chemical changes brought about by microbiological growth.

For this, test samples were prepared, consisting of standard laboratory glass slides covered with a varnish layer. Samples were inoculated with microorganism solution and incubated for 30 days. The species studied were recognized deterioration agents: the fungi *Aspergillus, Aureobasidium*, *Penicillium, Rhizopus, Mucor, Fusarium*, and *Trichoderma.*

Non-inoculated varnishes samples were also prepared.

After 35 days, the cultures were analysed by gas chromatography, and mass spectrometry. Major chemical changes in terpenic materials were detected. Also, images from the fungi development were taken by scanning electron microscope (SEM), revealing fungal germination on a hostile medium like sandarac varnish.

Corresponding author: juliorn@ugr.es

Fabric dependence of length change behaviour induced by ice crystallisation in the pore space of natural building stones

J. Ruedrich, S. Siegesmund

Geoscience Centre University of Göttingen, Goldschmidtstrasse 3, 37077 Göttingen, Germany

ABSTRACT

It is known that ice crystallisation in the pore space of natural building stones often results in a material deterioration. This disintegration can be traced back to physically induced stresses within the rock. The increasing scientific research in the last centuries has shown that there exist a lot of parameters which may influence the weathering by frost action. However, the driving forces and the stress concentration within the rock fabric are still in discussion.

To get more information about the mechanisms and the control of the rock fabric concerning frost weathering detailed analysis were performed. These include investigations of the rock fabric, the pore space properties (total porosity, pore radii distribution) as well as the water transport and restore properties (capillary water absorption, saturation degree). The data were compared with the results of length changes of water saturated samples during ice crystallisation. Cooling cycles from 20 °C to -20 °C and back to the initial temperature have been applied in a special modified dilatometer. Varying cooling rates between 0.8 °C/min and 0.05 °/min were tested. The investigations have been carried out on different types of sandstones, limestones and tuffs, which represent a wide range of rock fabrics and pore space properties.

In general, different types of length change behaviour induced by frost action can be observed. These types correlate with the fabric and pore space properties respectively. The first type is observable for rocks with a pore radii maximum of capillary pores and a very low content of micro pores and is characterised by a pronounced expansion below 0 °C. Typical rocks which have this pore radii distribution are well sorted sandstones. The second type shows after a slight expansion under 0 °C a strong contraction. This form is observable for clay rich sandstones and limestones. The third type exhibits a strong contraction under 0 °C followed by an expansion and occurs at samples which have a pore radii maximum of micro pores and only a slight portion of capillary pores. This pore radii distribution can be found in tuffs. A critical control on the dilatation is also regarded for the cooling rate, i.e. if the cooling is slow the influence of ice crystallisation on the length change is less pronounced.

The investigations show, that length change measurements are a very useful tool and can help to get a better understanding about weathering processes.

Corresponding author: joerg.ruedrich@geo.uni-goettingen.de

Limestone masonry performances in correlation to face components, bed mortars, and climatic decay

R. Ruggeri

Institute for Technologies Applied to Cultural Heritage
National Research Council (ITABC-CNR) – I – Via Salaria km.29, 3 Cas. Post. 10; 00016
Monterotondo Stazione, Roma, Italy

ABSTRACT

The present report concerns the experimental research results on different masonry proofs by limestone and four bed-mortars composed, and by three different plasters covered on the face to meteoclimatic factors exposed.

The constituent elements of four bed-mortars employed in the experimental masonry proofs represent most diffused types of bed-mortars that may be considered more diffused mortars in the restoration works adopted. As a matter of fact they belong to sequent family mortar types named: “aerial”; “hydraulic”; “pozzuolanic”; “cementitious”.

Based on the processed data we have carved out different water content variation tendencies. Referring to this consideration, the best performances concern “hydraulic” and “cement” bed mortar walls independently from adopted plasters.

The processed data allowed determining the water content distribution in the internal walls during the climatic factors variation.

Considering that the tensile and compressive strength on these masonry walls, is derived mainly from strength capacity of mortars, we can retain water content variation in the internal walls determine different strength that make easier or have construction disruption.

In fact being the mortar strength conditioned from water content, we can have masonry walls more or less strength, depending on the exposure to (micro) climatic factors.

Consequently we can presume that, in fixed condition of exposure, in a determined area, particularly in the ancient historical centres, (where the micro climatic factors change frequently on the same wall of the same building), one mortar employed rather than others in restoration work can increase or reduce the vulnerability of walls.

Corresponding author: roberto.ruggeri@itabc.cnr.it

The use of additives (phosphonates) as inhibitors for the crystallization of magnesium sulfate

E. Ruiz-Agudo, C. Rodriguez-Navarro, E. Sebastian

Dpto. Mineralogía y Petrología, Universidad de Granada.
Fuentenueva s/n, 18002 Granada, Spain

ABSTRACT

Salt weathering is one of the most important deterioration factors affecting ornamental porous materials. Salt weathering of unique stone monuments and sculptures has been observed all over the world. Salts are usually originated in the ground or in the mortar, but might also belong to the stone itself or come from atmospheric sources (i.e., air pollution). Under favourable conditions, these salts crystallise as efflorescence at the stone's surface, or as subfflorescence if below it. This latter case is extremely damaging because crystallisation pressure sufficient to exceed the elastic limit of the material can be generated inside the pores, causing its breakage. To preserve historic architecture from salt weathering it is necessary first to evaluate the damage and the salts present in the building materials, and then to design and apply adequate conservation treatments. In fact, the development and application of new, effective methods to mitigate or prevent the deleterious effects of soluble salts in the built heritage is an important need, since most of the existing conservation methods have been only partially successful. Recently, the use of additives that modify the salt crystallisation process has been proposed as a new means to halt and/or mitigate salt weathering. Nucleation, agglomeration, crystal growth and shape can be influenced by the presence of impurities such as the so-called crystallisation inhibitors. Crystallisation inhibitors with extended technological and industrial uses include phosphonates and polyphosphates, carboxylic acid derivatives, polyelectrolytes and ferrocyanides. While much research has been done on the effects of such additives on the crystallisation of sparingly soluble salts (e.g., $BaSO_4$), little is known regarding their effects on soluble salts crystallisation. Sulphates, e.g. magnesium sulphate, are among the most common and damaging soluble salts found in historic buildings. Epsomite ($MgSO_4.7H_2O$) and hexahydrite ($MgSO_4.6H_2O$) crystallisation frequently damage wall paintings, stone, brick and masonry. In this work we evaluate the effects of various additives (phosphonates and polycarboxylic acids) on the crystallisation of magnesium sulphate as a first step to disclose if they can be effective to control salt weathering affecting porous ornamental stone.

Corresponding author: encaruiz@ugr.es

Weathering and conservation of mural paintings in the church "Nuestra Señora de las Nieves" (La Rinconada, Sevilla, Spain)

A. Ruiz-Conde[1], M. Arjonilla[2], G. Durán[1], J. C. Rivero[1], P.J. Sánchez-Soto[1]

[1] Institute of Materials Science of Sevilla (CSIC-University of Sevilla), c/Américo Vespucio 49, Isla de la Cartuja, 41092 Sevilla, Spain. (RTPHC-CSIC)
[2] Department of Painting, Faculty of Fine Arts, University of Sevilla, Spain

ABSTRACT

A few months ago, the parish of the church "Nuestra Señora de Las Nieves" in La Rinconada (NW Sevilla, Spain) found several mural paintings after removing of wood altarpieces and cleaning of the wall. The altarpieces were deteriorated by rising humidity and wood borer. According to the Spanish History, when Sevilla was re-conquest, La Rinconada was recognized as the place where the war camp and blood hospital of King Ferdinand The Third were settled. The mural paintings appeared in a large wall hidden by layers of lime, into a cavity 3.10 x 2.20 m and at 1.5 m height from the floor. We are involved in a research project to carry out a diagnostic of conservation state and weathering of these mural paintings, which has been not studied until now, and then a proposal of restoration and conservation.

The author or authors of these mural paintings are still unknown, showing a scene of Crucifixion (attributed to XVII Century), and paintings of Saints. Other underpaintings have been attributed to unknown author or authors, possibly of Gothic period (XV Century) according to the style. The preparation of the brick wall was based in mortar of lime and sand, with addition of organic fibres. The humidity and several lime layers have affected the wall, with degradation, large material losses and alteration of pigments and supports, holes of different sizes, dirty zones, accumulation of powder and salts, which produced alterations and loss of chromatism in the pigments. In particular, the addition of gypsum for repairs has also affected negatively all these mural paintings. Samples of the wall paintings were taken and studied by different laboratory procedures and instrumental techniques: digital photography (visible and IR), elaboration of cross-sections, optical microscopy (OM), scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS). Fourier Transform IR Spectroscopy (FTIR) and X-ray Diffraction (XRD) were applied in some cases. The results have allowed to characterize mortars and pigments and alteration products. It has been found that the temper technique was used inside and oil-painting outside. According to the results, it is proposed a cleaning and conservation treatment on this work of Spanish Cultural Heritage.

Acknowledgments: The financial support of Project MAT2002-02549, financied in part with FEDER, and Research Group TEP204 (Junta Andalucía) are acknowledged

Corresponding author: aruiz@cica.es

Global climate change impact on built heritage and cultural landscapes

C. Sabbioni[1], M. Cassar[2], P. Brimblecombe[3], J. Tidblad[4], R. Kozlowski[5], M. Drdácký[6]
C. Saiz-Jimenez[7], T. Grøntoft[8], I. Wainwright[9], X. Ariño[10]

[1] Institute of Atmospheric Sciences and Climate, National Research Council, Bologna, Italy
[2] Centre for Sustainable Heritage, University College of London, UK
[3] School of Environmental Sciences, University of East Anglia, UK
[4] Swedish Corrosion Institute, Sweden
[5] Institute of Catalysis and Surface Chemistry, Polish Academy of Sciences, Poland
[6] Institute of Theoretical and Applied Mechanics, Czech Academy of Sciences, Czech Republic
[7] Instituto de Recursos Naturales y Agrobiologia, Consejo Superior de Investigaciones Cientificas, Sevilla, Spain
[8] Norwegian Institute for Air Research, Norway
[9] Ecclesiastical Insurance Group, UK
[10] Biologia Medio Ambiente Ltd., Barcelona, Spain

ABSTRACT

Although climate change over the next hundred years is likely have a range of direct and indirect effects on the natural environment, almost no studies as yet exist on the impact on cultural heritage.

The NOAH'S ARK Project is focused on the effects of climate change on Europe's built cultural heritage and landscapes over the next century. The current outputs allow the advancement of some scenarios, which underline how some processes of building decay will be accelerated or worsened by climate change, while others will be delayed. The linking of global changes to the response of the archaeological and historic built heritage, in terms of materials and structures, remains a challenge.

The pioneering EC project NOAH'S ARK will allow the prediction of the impact of climate change on cultural heritage on a European scale, with the aim of proposing adaptation and mitigation strategies to assist conservation management and support policy and decision makers.

Corresponding author: c.sabbioni@isac.cnr.it

Origin of gypsum crusts in monuments built with granitic material in A Coruña, NW Spain.

J. Sanjurjo[1], J. R. Vidal Romaní[1], C. A. S. Alves[2].

[1] University Institute of Geology. University of A Coruña. Spain.
[2] Earth Sciences Departament. University of Minho, Braga. Portugal.

ABSTRACT

During the last years, many studies on gypsum crusts in monuments have showed that its development is due to the sulphation of Ca-rich materials. This has been proved in monuments built with limestone in zones of polluted urban atmosphere (with high levels of SO2). However, in monuments built with granitic rocks the results were very different and the origin of the crusts were attributed to the Ca sulphation of the feldspars, the dissolution and sulphation of lime mortars or coatings, and even the activity of microorganisms. Only in a very few cases, reference was made to the existence of previous gypsum plasters as origin of said crusts.

The study of some crusts in several churches of the City of A Coruña (NW, Spain) showed that in most cases the crusts are formed by the deterioration of gypsum plasters applied, after the construction of the church, on the ashlars as protection layers. In fact, though there is little historical data, there were found remains of plasters practically intact in some churches of this locality.

The study of the distribution of the crusts, the analysis by DRX and SEM of their surfaces and of the cross sections with secondary electrons and backscattered electrons, EDS and map of X-rays enabled to observe the irregular composition and structure of these crusts. Only their superficial zones are blackened by deposition of particles originated by pollution of high traffic flow in those zones in which it is high (cenospheres, ash-fly, Pb-rich aggregates, etc.). Also, the different porosity of the external (porous) and internal (compact) layers of the crusts indicates that degradation by partial dissolution of the plasters in the superficial zone was produced. This origin also explains the great thickness of some of the studied crusts (up to several centimetres).

[1] Corresponding author: xexurxo@udc.es

Stone portals in Naples ancient centre. Degradation and maintenance. **(abstract withdrawn)**

C. Sansone

Università degli Studi di Napoli Federico II
Dipartimento di Ingegneria Edile
Piazzale Tecchio 80, 80125, Napoli, Italia

ABSTRACT

The report is a synthesis of a part of the research carried out by the author for her PhD dissertation. Naples Ancient Centre represents the town original settlement that is characterized by the presence of a large number of ancient buildings, whose peculiarities are the decorative elements realized with good quality stones, which define the architectural style.

The use of stones, of good quality nature, is a peculiarity of the historical building industry of Italian cities. The decorative elements, extracted from blocks of natural stones, have always held an important role in the manufacturing of the fronts, both for the natural properties of the material and for the aesthetic value springing from it. The range of usage for stony materials is wide, mainly in the structural construction area, even if the most meaningful exploitation of the stones is to be found in the production of functional and decorative elements

The maintenance of those elements aims at improving the performances and at guaranteeing the preservation and the exploitation of the building industry heritage. Our research focuses on the stone portals and points out, thanks to laboratory tests, the characteristics of the used stones and the most opportune intervention criteria for the improvement of structural and aesthetic performances.

Corresponding author: csansone@unina.it

Evaluation of protective and consolidant treatments on Angera Stone in S.Fedele Church (Milan)

A. Sansonetti, T. Poli, M. Realini, D. Gulotta

ICVBC-CNR Istituto per la Conservazione e la Valorizzazione dei Beni Culturali, Sezione di Milano "Gino Bozza", Pza Leonardo da Vinci 32 – 20133, Milan, Italy

ABSTRACT

S. Fedele Church is the issue of a paper, strictly correlated to the present, concerning the decay of the surfaces stone material, the Angera Stone, a poor durability dolostone. In this paper the diagnostic survey, aimed to evaluate performances of consolidant and protective treatments, is presented; the matter deals especially with evaluation of efficacy and harmfulness of products. Scientific debate about methodologies, which could be applied in this kind of task, is going on since many years. Nowadays, as concern protective products, Italian standard UNI 10921 published in 2001, sets the testing procedure, which should be carried out to evaluate a protective treatment in laboratory on stone specimen coming from quarry. Anyway data obtained in this way represent only a simulation of the product performance on a real case, where stones are decayed and outdoor environment interacts with the stone/product system. Because of these reasons, in the case of the important church of S.Fedele in Milan, a pilot conservation site has been planned, and consolidant and protective treatments have been evaluated in situ, by efficacy and harmfulness point of view. A flat vertical area on the façade has been chosen and divided in four portions, accordingly with the conservation team, which was working there. Angera dolostone has been cleaned, and successively treated with four different products:

- Rhodia RC 80 (a blend of ethyl silicate and polimethylsiloxane) and VP5035 Degussa (a modified ethyl silicate) as consolidant treatments;
- Silirain 50 (an organic polisiloxane) and Wacker 290 (an oligomeric siloxane) as protective treatments.

Products have been chosen on the basis of a preventive bibliographic research, aimed to survey conservation case studies on the same Angera dolostone.

In order to evaluate products performances, the following diagnostic methods have been used

- Careful observation of the surface with the aid of a Photographic camera;
- Colour Measure of the surface by means of a colorimeter using CIE L*a*b* 1931 system;
- Water absorption by capillarity with the aid of a Karsten pipe.

The whole of the diagnostic systems has been applied both before and after the product application, so that to achieve the difference induced by the application of the products.

Corresponding author: tommaso.poli@polimi.it

Characterization of Roman mortars from the historical city of Mertola (Portugal)

A. Santos Silva[1], J.M. Ricardo[1], P. Adriano[1,2], M. Salta[1],
J. Mirão[3], A.E. Candeias[2], S. Macias[4]

[1] Departamento de Materiais, Laboratório Nacional de Engenharia Civil, Lisbon, Portugal
[2] Centro de Química de Évora, Universidade de Évora, Portugal
[3] Centro de Geofísica de Évora, Universidade de Évora, Portugal
[4]Campo Arqueológico de Mértola, Mértola, Portugal

ABSTRACT

Mertola is an historical city standing high on the rocky schist margins of Guadiana River, the natural frontier between the South of Portugal and Spain. The immense legacy from different periods including Roman, Islamic and Christian makes it unique among Portuguese cultural heritage and has been the subject of intense archaeological research. The monuments materials study and identification and their characterisation and mapping of degradation forms are of utmost importance to guarantee their conservation and can give valuable information about their history and past interventions.

In this communication, we report the study of ancient mortars from two important roman monuments dating from IV-VA.C. Centuries, the river tower (the remains of a fortified roman harbour) and the Cryptoportic (a semi-underground roman gallery which supported the roman forum). This study is part of a joint collaboration between the Laboratório Nacional de Engenharia Civil, the University of Évora and the Instituto Português do Património Arquitectónico aiming the development of integrated conservation methodologies (Project CATHEDRAL - POCI/HEC/57915/2004).

X-ray diffraction (XRD), optical microscopy and scanning electron microscopy coupled with Energy Dispersive X-ray spectrometry (SEM-EDX) were used for the characterisation of the mortar's mineralogical and petrographic composition enabling the identification of the binder and aggregates used as well as for the additives and decay products. Special effort was put on the use of petrographic microscope to identify the minerals (from aggregates), describe the textures and to detect the presence and intensity of pozzolanic reactions induced by added crushed bricks. Differential thermogravimetric analysis (DTA) was used to identify various component materials and observe reactions associated with controlled heating of the mortars. Chemical analysis of the mortars was used for the determination of the aggregates particle size distribution and in combination with DTA for the determination of the binder to aggregate ratio.

Corresponding author: ssilva@lnec.pt

Texture and residual strain in Carrara marbles measured by TOF neutron diffraction

Ch. Scheffzük [1,3], S. Siegesmund[2], A. Hoffmann[2] & D.I. Nikolayev[3]

[1] GeoForschungsZentrum Potsdam, Section 5.3, Telegrafenberg, 14473 Potsdam, Germany
[2] GZG - Strukturgeologie und Geodynamik, Universität Göttingen, Goldschmidtstr. 3, 37077 Göttingen, Germany
[3] Joint Institute for Nuclear Research, Frank Laboratory of Neutron Physics, 141980 Dubna, Russia

ABSTRACT

The deterioration of the natural marble is influenced by different factors such as anisotropy of thermal expansion coefficients, crystallographic preferred orientation, called texture, grain size etc. The objective of the present work is to study internal stresses on this material by neutron time-of-flight (TOF) diffraction. The method is very suitable, because of the high penetration depth of neutrons in material. Neutron diffraction allows to investigate bulk materials and to get information of the sample's volume about strain, strain distribution and texture. The neutron TOF strain/stress diffractometer EPSILON-MDS and the texture diffractometer SKAT at the pulsed neutron source IBR-2 in Dubna were used. By peak profile analysis of the Bragg diffraction peaks strain parameters were estimated.

Carrara marble samples were measured using a strain scan through the sample and strain pole figures of the bulk sample has been determined. The investigation aims on a better understanding of the influence on marble behaviour by residual intracrystalline strain of the monomineralic calcite marble.

Strong compressional residual strain values up to -1.3×10^{-3} measured with residual strain pole figures on virgin bulk samples have been found. Obviously, the magnitude of residual strain depends on the sample size. Features of the observed texture pole figures and internal strain pole figures are related to each other by their sample orientations. Texture and residual strain measurements were combined with investigations of thermal expansions under dry and wet conditions.

To measure the thermal expansion of the sample material, cylindrical specimens (Ø 15 mm / 50 mm) were analysed, which were prepared in different directions to the main stress direction and in different directions to macroscopic elements. The directional dependence of the thermal dilatation is given as a function of temperature that varies within an interval of 20-90-20 °C during the heating-cooling cycle. The overall observation is that all test specimens demonstrate a residual strain after the temperature cycles, which is highest when testing was conducted under wet conditions.

Corresponding author: scheff@gfz-potsdam.de

Influence of admixtures in the properties of hydraulic lime based mortars

M.P. Seabra[1], J.A. Labrincha[2], V.M. Ferreira[1]

[1] Departamento de Engenharia Civil / CICECO, Universidade de Aveiro, 3810 –193 Aveiro, Portugal
[2] Departamento de Engenharia Cerâmica e Vidro / CICECO, Universidade de Aveiro, 3810 –193 Aveiro, Portugal

ABSTRACT

The fresh and hardened state characteristics of mortars can be affected by several parameters, namely, binder/aggregate ratio, kneading water content, type and amount of admixtures. The influence of most common admixtures on the rheological behaviour of cement based mortars have been a subject of more research than their effect on the behaviour of aerial or hydraulic lime based mortars. This is particularly important since lime based mortars are relevant for conservation and rehabilitation purposes. In this work, the influence of an air-entraining, a water-retaining and a plasticizer agents on the fresh but also on the hardened state products characteristics are studied.

Specifically, the rheological properties of fresh hydraulic lime-based mortars with variable amounts of air-entraining, water-retaining and plasticizer admixtures are investigated. The mortar rheological parameters, relative yield stress (g) and relative plastic viscosity (h), are investigated using a specific rheometer for mortars. Rheological data correlation with traditional consistency measurements (slump) is also performed. The rheological behaviour of fresh mortars is a key characteristic since it may determine the material workability as well as the hardened product final characteristics. Hence, the effect of those admixtures on the hydraulic lime based mortars flexural and compression mechanical strength is also reported. A correlated overview on both fresh and hardened product behaviour is attempted.

Due to its importance for the development and application of rehabilitation or new mortars, capillarity, liquid water and water vapour permeability of mortars of the materials under investigation are also measured. Once more, it is expected to evaluate the particular influence of used admixtures on these characteristics and to relate it with the established correlation between the rheology and the final properties of developed mortars.

Corresponding author: victorf@civil.ua.pt

Stone decay. A multidisciplinary case study: the columns of the Honour Court of the Ducal Palace in Urbania (Italy)

P. Semprini[1], J. Arduini[1], L. Baratin[2], U. Giostra[3], M. Maione[1], F. Mangani[1]

[1] Institute of Chemical Sciences. Urbino University. Italy
[2] Institute of Ecology and Environmental Biology. Urbino University. Italy
[3] Institute of Physics. Urbino University. Italy

ABSTRACT

The aim of this work is to suggest a multidisciplinary approach to the complexity characterizing stone decay processes. The Ducal Palace of Urbania was built in the XV century. The study focuses on the 22 columns of the Honour Court of the Palace. The building material is a local limestone. Looking at the columns some decay features are evident. The damage is not homogeneous because some columns present a higher damage degree than others. Such a distinctive decay let suppose that some conditions characterizing the environment of the Court can cause a differential damage. In order to establish the conservation state of the columns several investigations were carried out in the past years. An assessment of chemical and physical decay processes which were taking place needed further analysis. The present work has pursued the aim to enlighten such complex phenomena through a multidisciplinary approach. Several skills were needed to reach this goal. An architectonical map of the Honour Court allowed to understand how the decay has affected the columns. The map shows which kind and extension of decay has interested all the columns. There had been no measurements of soluble salts in the previous studies, so some chemical investigations were carried out to estimate them. Both salt growth inside stone micropores and freeze-thaw cycles are likely to be responsible for the alveolate shape weathering. Three columns were selected and three samples were taken on each column. They were analysed by ion chromatography, providing both nature and concentration of the ions inside the stone. At the same time two fields of microclimatic monitoring were carried out to evaluate several parameters. Mean and frequency values of temperature, RH, wind speed and direction were measured to define the environmental features inside the Court. A complex state resulted. Solar radiation produces daily cyclical variations of the temperature and temperature ranges may induce RH variation, condensation-evaporation, freeze-thaw and salt growth cycles causing stress to the material. Data from wind speed and direction let suppose that a systematic circulation of air's flows inside the Court speeds up the decay only on those columns standing in particular sites with respect to the flows. Investigations about temperature and RH pointed out that water vapour is much more present in the portico than in the open central court. New studies using a computational fluid dynamic code have been carried out to support the results of the microclimatic monitoring. A model will be able to simulate air movement and predict temperature and humidity distribution in the Honour Court.

Corresponding author: paola.semprini@uniurb.it

Rapid, catastrophic decay of building limestones: thoughts on causes, effects and consequences

B.J. Smith[1], H.A. Viles[2]

[1] School of Geography, Queen's University Belfast, Belfast, UK
[2] School of Geography and Environment, University of Oxford, Oxford, UK

ABSTRACT

Stone is widely recognised as an adaptable and sustainable construction material, with a low carbon signature, and as a repository of much of the world's tangible cultural heritage. With this recognition has come an understanding that stone has a finite life, that can be drastically curtailed when it is placed in the often-aggressive environments experienced in urban settings. Because of this it is essential that the choice of new and replacement stone and the conservation of decaying stone is underpinned by a detailed knowledge of how different stone types decay in specific environments and what factors trigger decay and control its rate once it is initiated. Unfortunately, in terms of predicting behaviour, there are many common building stones that do not decay gradually, but instead experience seemingly unpredictable, episodic and sometimes catastrophic breakdown. Typically, limestones prone to catastrophic decay are granular or, especially, oolitic and are initially prone to both chemical attack and salt-induced decay as well as severe and/or prolonged freezing. The balance of these processes inevitably changes as decay continues and the retreat of individual limestone blocks progressively shelters them from direct rainfall, but leaves them subject to wetting from dew and frost. Such limestones have been widely used as a building material in England, for example, in many large cathedrals (e.g. Wells and Lincoln) and in historic buildings in cities such as Bath and Oxford. Common perception identifies dissolution by rainwater acidified with CO_2 as the major process responsible for damage to these stones. However, within polluted environments sulphation can also occur. Sulphation produces gypsum, which although relatively soluble, can build up to form crusts in areas sheltered from runoff. If crusts are breached, underlying stone may be rapidly lost. Although, in areas of rapid particulate deposition there is some evidence of multiple episodes of scaling and surface stabilisation associated with the rapid re-development of gypsum crusts. Similar effects can be observed with biofilms and other rock-dwelling organisms that may have bioprotective role but can in certain circumstances encourage decay. Where rapid retreat does occur, it is frequently associated with salts from multiple sources that produce flaking, disintegration and alveolar forms. Indeed, a possible explanation for rapid decay is that once weathering initiates a hollow, accumulated salts are less likely to be washed away and reduced moisture availability might enhance salt concentration near the stone surface. However, this does not explain why, with reduced wash-in and near-surface concentration, any salts present are not rapidly lost together with the debris. Neither does such a micro-environmental model explain why only certain stones on an otherwise uniform façade experience rapid, catastrophic retreat. This paper therefore sets out to explore these apparent contradictions through an examination of the possible causes of catastrophic decay. It also suggests preliminary models of catastrophic behaviour that may ultimately assist in the choice of new and replacement stone that is fit for purpose.

Corresponding author: b.smith@qub.ac.uk

Weathering of archaeological masonry: from the evaluation to the restoration. **(abstract withdrawn)**

A. Sposito, F. Fernandez

Faculty of Architecture, University of Palermo, Italy

ABSTRACT

The research start from the assumption that, in the field of conservation, archaeological masonry represents a case apart; in fact, these structures are even more susceptible to the deterioration, since they are often no longer protected by plaster, and their upper part are fully exposed to the weathering. These factors, in addition to insufficient maintenance, lead to deterioration in the mechanical features of the materials and, as a consequence, a reduction in the load-bearing capacity of the structures.

The prolonged state of interment creates particular conditions of containment of the masonry; when structures are brought to light, they have to find for themselves a new static equilibrium; also considering the decay that has affected the constituent materials (the washing away of mortar, the breaking-up of plaster and stone materials, etc.).

Moreover, archaeological stonework was originally part of architectural systems made up of horizontal elements too, functional to the connections and the resistance of masonry walls. Therefore, in the absence of horizontal elements, the vertical structures would inevitably be more exposed to mechanism of static disease.

In this research we present the restoration of the *analemmata* in the theatre of Morgantina, a greek-ellenistic Sicilian archaeological site, in which we developed a deep evaluation of all the problems connected to the stone materials weathering and the static disease, to restore all the emerged structures of the theatre.

Corresponding author: federicafernandez@libero.it

Salt accumulation in historic and repair mortars

M. Stefanidou, I. Papayianni

Laboratory of Building Materials, Dept. of Civil Engineering, AUTH, Greece

ABSTRACT

Salt crystallization phenomena are often met in the structure of porous materials such as mortars through which salts solutions easily penetrate into the masonry. Old mortars are based on lime and it is well known that these materials are characterized by low strength capacity and high porosity. Into the pore system that comprises of pores and elongated cracks, is possible to find secondary minerals as salts. The distribution of the pores, their geometric characteristics and their shape can play a decisive role for the pathology symptoms that occur in these materials. Keeping in mind the longevity of the ancient mortars' service life, a fine balance between the salt content and the durability the mortars should be searched.

By using microscopic analysis techniques the location, the crystal shape and size and the composition of the salt crystals as well as the relation of the salt crystals to the crystal lattice of the binder can be defined.

In the paper an effort is made to find relationships among microscopic characteristics of salts in connection with the structure of old mortars.

Corresponding author: stefan@civil.auth.gr

Crystal growth in porous materials: influence of supersaturation and crystal size

M. Steiger

University of Hamburg, Institute of Inorganic and Applied Chemistry,
Martin-Luther-King-Platz 6, 20146, Hamburg, Germany

ABSTRACT

The pressure exerted by crystals growing in confined spaces of porous substrates is a major cause of damage in ancient and modern building materials. A review of the existing literature on the calculation of growth pressures reveals that a number of different equations are in use. In many of the existing treatments the crystallization pressure is given in terms of the degree of supersaturation S:

$$\Delta p = \frac{RT}{V_m} \ln S \tag{1}$$

Where Δp is the crystallization pressure, R is the gas constant, T is the absolute temperature and V_m is the molar volume of the solid phase. Different authors use different expressions for the supersaturation S and there appears to be no agreement among different authors even in the more recent literature.

In contrast to the equations, which are relating the crystallization pressure to the degree of supersaturation of the solution, another approach is based on the properties of curved interfaces between the crystal and the solution. Assuming spherical geometry the following equation for the crystallization pressure was derived:

$$\Delta p = 2\gamma_{cl}\left(\frac{1}{r_1} - \frac{1}{r_2}\right) \tag{2}$$

Where $r_2 > r_1$ are the radii of two crystals in adjacent pores of different size and γ_{cl} is the crystal–solution interfacial free energy. Both approaches, Eq. (1) and Eq. (2), were extensively used to calculate crystallization pressures and were often seen as representing two distinctly different types of damage mechanisms. Applications of Eq. (1) were subject to severe criticism due to unrealistic high supersaturations. Subsequently, many authors preferred the use of Eq. (2) by equating the radii of the spherical crystal in Eq. (2) with the radii of spherical pores. Most likely this approach was preferred because it is apparently more realistic to calculate crystallization pressures on the basis of a measurable quantity such as the pore size distribution, rather than estimating the degree of supersaturation in a pore solution.

This paper provides a critical discussion of the various approaches and a thermodynamically consistent equation for the calculation of crystallization pressure. In particular, it is shown that both approaches are entirely equivalent and do not represent two different damage mechanisms.

Corresponding author: michael.steiger@chemie.uni-hamburg.de

Traditional and modern lime-based plaster and coatings - do additives enhance biodeterioration?

K. Sterflinger

University of Biological Resources and Applied Life Sciences, ACBR, Vienna, Austria

ABSTRACT

Mortars, coatings, plaster, limewater, sheltercoats and limewash based on lime and hydraulic lime have been used for building purposes for thousands of years. Protein rich additives as tallow, casein, blood, egg yolk and others were used to make the fresh products easier to handle but also to make the carbonated lime-product more durable.

In Mauerbach near Vienna (Austria), on a medieval plaster of the Kartause we found evidence that *Bacillus cereus* – a bacterium that is biotechnologically used for the consolidation of limestone – is naturally established in the medieval plaster in high amounts. This suggests that bacterial calcification, that is known to be enhanced by a protein rich growth medium, can be the reason why medieval plasters and mortars that were improved with protein rich additives are still preserved, well while others with similar composition of lime putty and similar exposition are nearly lost.

Also modern lime products offered by the industry contain large amounts of additives including so called “organic binders”, tylose, methyl cellulose, hydroxy ethyl cellulose, silicone, acrylates and “superabsorbers”; however, with a different effect. In most cases the amount and exact composition of the additives remains clandestine for the user being a well guarded secret of the industry. In restoration and conservation, however, these additives might have important influence on the durability of the conservation treatment. In this study we present evidence that industrial lime-based consolidants and coatings containing organic and synthetic additives are far more easily inhabited and degraded by micro-organisms than pure lime.

As a result surfaces treated with those materials will undergo biogenic patination and biogenic decay more easily than unmodified or pure mineralic lime-products.

Corresponding author: Katja.Sterflinger@boku.ac.at

Biodeterioration of buildings and works of art - practical implications on restoration practice

K. Sterflinger, H. Sert

University of Natural Resources and Applied Life Sciences, ACBR, Vienna, Austria

ABSTRACT

The potential of micro-organisms to alter and destroy monuments and works of art was shown in many studies in the last years. Biogenic crust formation and patination, the excretion of organic acids, the mechanical penetration of materials and the degradation of organic materials have the same importance for the alteration and weathering of cultural heritage as mere physical and chemical processes. However, this knowledge is often only communicated on a theoretical level not being transferred into the daily practice of restorers and museum personnel.

For this reason, it is the aim of this study to show that biogenic weathering has important implications on the daily practice and routine of restoration and that microbiological investigations can support restorers to develop appropriate conservation and restoration concepts. In this study it is demonstrated that (a) appropriate storage of artwork in museums and their depots (b) the adaptation of the environment of outdoor monuments (e.g. plantings and sheltering hoods), (c) the choice of appropriate materials for conservation treatments as e.g. the use of sheltercoats, consolidants, putties and paints and (d) the thorough cleaning including the careful application of biocidal substances can considerably decrease the development of a detrimental micro-flora on and in materials. Several case studies carried out on stone monuments in outdoor exposition as well as in museums and depots are shown for clarification.

Corresponding author: Katja.Sterflinger@boku.ac.at

Microbial diversity on paintings and engravings in Doña Trinidad Cave (Ardales, Spain)

F. Stomeo, L. Laiz, J.M. Gonzalez, C. Saiz-Jimenez

Instituto de Recursos Naturales y Agrobiología, CSIC, Sevilla, Spain
(RTPHC-CSIC)

ABSTRACT

The Cave of Doña Trinidad (Ardales, Malaga, Spain) contains numerous paintings and engravings dated back to 20,000 years. In this study, we study the microorganisms thriving on these paintings and engravings using molecular and culturing approaches.

Molecular methods were based on the detection of microorganisms from DNA and RNA extracted directly from minute samples collected at the cave and did not require the culture of these microorganisms. Culturing methods required the growth of these microorganisms on previously determined culture media. Media used in this study were appropriated for the growth of aerobic and anaerobic heterotrophs.

Results showed the presence of a large diversity of microorganisms detected from both molecular and culturing methods and a large proportion of them was presenting highest homology to so far uncultured microorganisms. Cultures allowed a detailed characterization of the function and capabilities of these microorganisms. The diversity found in this cave will be discussed focusing on the potential function of these microorganisms in the studied environment.

Corresponding author: keka@irnase.csic.es

Conservation of old renderings - the consolidation technique through traditional and sustainable materials: the lime water (a study methodology)

M.L. Tavares, M.R. Veiga

Laboratório Nacional de Engenharia Civil (LNEC), Lisbon, Portugal

ABSTRACT

The study of external renderings in the scope of the conservation and restore has acquired in the last years great methodological, scientific and technical advances. These renderings are important elements of the built structure, therefore besides possessing a protection function, they possess often a decorative function of great relevance for the image of the monument. The maintenance of these renderings implies the conservation of traditional constructive techniques and the use of compatible materials, as similar to the originals as possible.

In the present paper, a study carried on at LNEC – Laboratório Nacional de Engenharia Civil, Lisbon, Portugal, on restore techniques for old historical renderings. In this research the aim is also to study the economic and technical viability of the use of traditional and sustainable techniques.

In this paper a compilation of the main anomalies found out in old renderings is carried out and a description of some repair works carried through with resource to the ancestral lime water technique for consolidation.

LNEC's aim with this study is to deepen the knowledge in this area, and to diffuse it among national and international technicians, as a way to contribute for an improvement of conservation interventions on old walls renderings, through the use of traditional and sustainable materials and techniques.

Corresponding author: marthal@lnec.pt

Dilation of bricks submitted to frost action: field data and laboratory experiments

C. Thomachot[1], N. Matsuoka[1], N. Kuchitsu[2], M. Morii[2]

[1] Institute of Geosciences, University of Tsukuba, Ibaraki 305-8571, Japan
[2] National Research Institute for Cultural Properties, 13-43 Ueno Park, Taito-ku, Tokyo, 110-8713, Japan

ABSTRACT

Cracking of material submitted to frost action occurs when stresses due to freezing override the medium rupture resistance. Dilation is a direct method that measures at the same time, water, vapour and ice movements. This method is thus appropriated to assess frost action on materials and to understand its mechanism. To study dilation of bricks submitted to frost action, an experimental study was carried out in the field and the laboratory.

Field monitoring was carried out on the historical site of Usui pass (Gumma prefecture, 100km NW Tokyo, Japan) is an 11.2 km long railway made of tunnels and bridges built in bricks in 1893. The north facing walls of the tunnels show weathering that can be attributed to frost action. Dilation measurements were carried out on eroded and intact bricks. Temperature data loggers were placed in walls of one of the tunnels to assess changes in climatic conditions at the surface and in depth of the bricks. Field monitoring showed that large heave corresponded to frost penetration to 5-10 cm during continuous freezing and that most of the detachments occurred during thaw penetration following the intensive frost heave and/or periods of repetition of diurnal freezing.

Bricks taken from the site were submitted to unidirectional freezing at capillary and vacuum saturation in the laboratory. Two kinds of freezing regimes were chosen from air temperature data corresponding to the heave periods in the tunnel): continuous freezing and diurnal freeze-thaw cycles. The dilation and the temperature of the samples at different height were measured during freezing. Results showed that frost damage of bricks was favoured by continuous water supply and repetition of freeze-thaw cycles.

Corresponding author: thomachotceline@hotmail.com

Use of portable X-ray fluorescence for monitoring elemental concentrations in surface units on roadside stone at Worcester College, Oxford

M. Thornbush, H. Viles

School of Geography, Centre for the Environment, University of Oxford
South Parks Road, Oxford, OX1 3QY, England

ABSTRACT

Non-destructive, in situ approaches are necessary when working with cultural buildings and structures that are heritage artworks. As an example of this approach within heritage conservation, portable X-ray fluorescence (PXRF) was used to identify and assess the accumulation of metallic pollutants within surface crusts on recently replaced stone blocks exposed since 1999 at the boundary wall of Worcester College, Oxford. The advantages of using this portable instrument are obvious as it allows for on-site data collection and reduces the likelihood of sample contamination. Lead and zinc were specifically traced because of their link with traffic pollution. Along this roadside wall, concentrations of these two elements were found in an earlier study to be high and focused near ground level. Metallic particulates are known to catalyse chemical reactions in the formation of black crusts, which are evident on the surface of older blocks of stone at the boundary wall and beginning to form on the replacement blocks. Both the pollution and climatic regimes have been monitored in central Oxford, and provide a context for the results.

Corresponding author: mthornb@ouce.ox.ac.uk

Validation of a new portable integrated system for “in situ" evaluation of stone mechanical properties

P. Tiano[148], S. Rescic[1], G. Exadaktylos[2], E. Papamichos[3] E. Valentini[4]

[1] CNR-ICVBC, Italy
[2] TUC, Greece
[3] SINTEF, Norway
[4] SINT Technology, Italy

ABSTRACT

The European Cultural Heritage deals with a great variety of structures of high intrinsic value. Among these are the stones, the key elements of our monuments. In contemporary urban environment, deterioration of stones occurs at an alarming rate. Damage diagnosis of stones is the first stage in the planning of the remedial steps to which the success of the restoration will be entrusted. Up-to-now there is not available in the market a valid "stone friendly" procedure for the in situ assessment of building stone damage, effectiveness and durability of stone consolidation treatments and the choice of compatible stone for repair in the quarries. A new portable diagnostic system has been developed for in situ evaluation of the following rock parameters: (a) elastic stiffness, (b) uniaxial compressive strength, and (c) rock toughness. It is composed by two instruments the first measuring the drilling resistance (DRMS cordless) and the second the indentation parameters (Portable Indenter).
With the first device we can perform simple but precise drilling resistance measurements, giving accurate prediction of rock toughness. This is based on a load cell, electronically controlled, that measures the force (in Newton) along the drilling profile sections having the rotary velocity and the penetration rate constants. The second one is used primarily for the direct determination of the elastic modulus of the stone, and secondarily for its deformability and uniaxial compressive strength, by using the force-displacement diagram during a loading-unloading loop.
In this paper the development, calibration and validation, both in laboratory tests and on site applications, of the integrated portable tool for in situ assessment of the mechanical properties and damage of Canaloni marble (Carrara) is reported. The results achieved indicate:

- All the measurements performed are reproducible and produce meaningful quantitative figures for the basic standard mechanical properties of marbles.
- The measurements can be performed quickly in situ with a high time/cost effective testing scheme with respect to standard tests.

[148] Corresponding author: p.tiano@icvbc.cnr.it

The façade of Milan cathedral: a case of diagnosis for the intervention

L. Toniolo[1], F. Casadio[2], C. M. Zerbi[1]

[1] CNR ICVBC Section of Milan, Politecnico of Milan, P.za L. da Vinci 32, 20133 Milan (Italy)
[2] The Art Institute of Chicago. 111 South Michigan Avenue, Chicago, Illinois (USA)

ABSTRACT

A new intervention on the façade of Milan cathedral started in 2002 and is still in progress. The wide extension of this marble façade, the complexity of its sculpted decorated surfaces, the outdoor exposition to a very polluted atmosphere, established (caused) a quite serious situation of decay of the material. The state of conservation of all the stone elements was deeply investigated in a diagnosis project that included the study of the phenomena and the analysis of their causes and mechanisms.

The façade is only two hundred years old and is entirely covered with Candoglia marble; in the last two centuries several interventions were operated, the most important of which were the restorations in 1935-36 and in 1970-72. The different phases of the diagnosis project are as follows:

- mapping of degradation and alteration phenomena;
- sampling and laboratory analysis;
- in lab and in situ study of cleaning procedures;
- in situ testing of sealing mortars;
- in lab and in situ study of the protection methodologies.

Visual observations of the degraded surfaces allowed the detection of several pattern of decay: powdered deposits; black crusts and compact deposits; erosion and differential degradation; fissuring; stains; films and patinas; residues of previous treatments and varnishes; biological patinas. About 150 samples have been collected for laboratory studies, considering that the decay was highly differentiated according to the height (about 60 m). A particular care has been put in sampling from different locations and expositions: plain surfaces, sculptures, friezes, decorated pilasters. The samples have been analysed in lab with the aid of traditional analytical tools: optical microscopy, FTIR micro-spectroscopy, scanning electron microscopy. A particular attention has been paid to the elements treated or substituted during the 1970-72 restoration campaign. Some of the most interesting results will be exposed and discussed in this paper.

Corresponding author: lucia.toniolo@polimi.it

Hungarian travertine: weathering forms and durability

Á. Török

Budapest University of Technology and Economics, H-1111 Budapest, Stoczek u. 2., Hungary

ABSTRACT

Travertine is one of the most important carbonate rock, that has been used as dimension stone from the Roman times. It is also a popular stone in Hungary where Romans constructed aqueducts, fortresses, amphitheatre and masonry structures by using the local travertine. Another period of intense use of travertine began in the late 19th century when several public buildings and monuments were partly or entirely constructed form the travertine.

To understand the decay mechanism of travertine and to test the durability façades of monuments and stone walls were studied during the field campaign. On site test results (Schmidt hammer, Duroscope rebound values) were compared to laboratory testing of quarry stones.

A wide-range of fabric types were identified including i) homogeneous cemented travertine, ii) marly travertine, iii) phytoclastic travertine, iv) oncoidal travertine and v) laminated travertine.

The laboratory analyses have shown that the average bulk density of travertine is 2240-2500 kg/m^3. The apparent porosity displays great variety depending on the texture and it ranges between 2-11%. The compressive strength varies between 35-120 MPa, while the indirect tensile strength is in the order of 2-9 MPa.

Travertine ashlars display various forms of surface alteration and deposition. Black crusts are the most frequent forms of soiling. Two morphological forms are the framboidal and laminar black crusts. Discolouration by leaching, surface dissolution pitting and flaking is less frequent.

Gypsum and calcite are the primary minerals of the weathering crusts. The maximum gypsum content of 76 % was detected in dusty framboidal black crusts. Microscopic analyses have shown that black crusts are composed of needle-shaped gypsum crystals. Opaque components, small angular quartz grains, mica flakes are wind driven particles that have been also identified. The crust surface is characterised by idiomorphic rosette-like gypsum crystals under SEM.

Schmidt hammer rebound values indicate the weathering stage of the travertine. The average rebound values of 46 of the quarry stone decreases to 30 when laminar black crust and to 28 when dissolved travertine surface is measured.

Analyses of travertine façades and quarry stones have demonstrated that the combination of mineralogical and physical tests provide useful data set to assess the durability of dimension stones.

Corresponding author: torokakos@mail.bme.hu

Weathering experiments on three Alpine marbles – comparison on exposure studies and laboratory experiments

M. Unterwurzacher[1], T. Bidner[2], P.W. Mirwald[1]

[1] Institute of Mineralogy and Petrography, University of Innsbruck, Austria
[2] TBB, Private Consultant, preservation of built heritage.Tulfes, Austria

ABSTRACT

We are studying the weathering behaviour of three different marbles by short time field exposure and weathering chamber experiments under realistic gas immission conditions. The following materials are used: Laas marble (a worldwide shipped white marble from South Tyrol), Hagau marble (a regionally intensively quarried Jurassic limestone from Northern Tyrol) and Wattenberg marble (a locally used, low metamorphic, fine grained grey dolomitic marble from Northern Tyrol).

Rock slaps of 5x5x1 cm size have been exposed on Mank's carrousels under dry and wet conditions up to one year. As exposure site served the roof of the University building in Innsbruck. Monthly each stone type has been sampled for analysis in the laboratory. The same materials have been exposed in a weathering chamber at realistic average values of SO_2, NO_2 (0.150 to 0.200 ppm), and O_3 (0.100 ppm), corresponding to the maximum mean half hour value for urban areas in Austria. This kind of approach contrasts previous studies where much higher concentrations of SO_2 and NOx have been employed. As samples served cubes of about 15 cm^2 surface being exposed in the chamber for 1 to 4 weeks at 30°C temperature. Three campaigns have been conducted at three different relative humidities (rh.) (30%, 70% and 98%). After each run the mineral assemblage on the sample surface was determined by XRD. In a second step, the deposition of sulphate and nitrate on the receptor surface has been correlated with the amount of ions as determined by chromatography of water elutes.

Preliminary results of the ion chromatography indicate that these realistic concentrations of pollution gases applied at 70 % rh. lead to the formation of Ca-sulphate and Ca-nitrate after one week already. The amount of products increases linearly with the run-duration of four weeks. The relation of Ca-sulphate to Ca-nitrate shows a very significant ratio of 10:1. The difference between the different stone materials is small, however. At 30% rh the production of sulphate and nitrate is much smaller, but nevertheless both compounds are detectable after a one week run. However, the products' ratio is close to 1:1. Obviously, the relevant mechanisms for the deposition of the damaging compounds and the implied reactions depend on the receptor surfaces and on the relative humidity. The experiments at 98% rh. posed considerable problems in data reproducibility. This seems mainly to be related to an almost exponential increase of the sorption behaviour due to a built up waterfilm.

The XRD measurements revealed gypsum formation on the Laas marble already after two weeks of chamber exposure at 70 % rh. The other stone types showed formation of gypsum after four weeks of exposure. At 30 % rh. no formation of new mineral phases was detectable. The analysis of the field exposure experiments and the data correlation between the two kind of experimental weathering approaches are in progress.

Corresponding author: michael.unterwurzacher@uibk.ac.at

Public perception and optical characterization of degraded historic stone and mortar surfaces

J. Valach, J. Bryscejn , M. Drdácký, Z. Slížková, D. Vavřík

The Institute of Theoretical and Applied Mechanics of the Czech Academy of Sciences, Prague, Czech Republic

ABSTRACT

Local authorities, owners and conservators face in the field of management of cultural heritage objects problem of maintaining the state of the objects' surface in proper physically and chemically functional conditions while assuring aesthetically appealing look of the objects at the same time. As a 'brand new' appearance of historical monuments of cultural heritage, is not positively accepted neither by public nor by professionals, some kind of 'patina' has to be preserved on restored surface.

The presented paper approaches this issue of quality of surface from the point of view of a possible replacing of empirical quantification rules build upon comparison between learned judgment of experts by quantitative data acquired from studied surface using several optical non-destructive methods, which is in the contribution explained in detail.

As the encrustation, soiling or biofilm build-up on surface, originally virgin state is getting covered by a layer of different optical properties. In this process, a state can be identified, at which a patina becomes an unwanted obscuring layer to be removed. In order to pinpoint the change, quantitative properties like surface albedo, prevailing color, optical roughness, etc. were measured using specialized optical devices and techniques developed earlier on established representative area of the surface and compared to questionnaires filled up by conservationist experts or public asked about their assessment of the surface in question qualities. The resulting 'ranges of acceptance' give a reproducible quantitative measure of surface quality which could be used for monitoring, assurance of surface cleaning consistency, etc. performed even by non-experts employing relatively simple experimental tools.

The method is applied and demonstrated on stone and mortar surfaces of selected cultural heritage monuments in the Czech Republic. The method can be also applied for quality control and checking of façade cleaning processes where a "standard" can be set by an expert and the real surface quality is compared to this standard.

Corresponding author: valach@itam.cas.cz

Depth of penetration of humid air into stone and subsequent mobilization of deliquescent salts by humidity cycling: NMR analysis of NaCl in limestone

G.H.A. van der Heijden[1], E. Doehne[2], L. Pell[1]

[1] Eindhoven University of Technology, Department of Physics, P.O. Box 513, 5600 MB, Eindhoven, The Netherlands
[2] The Getty Conservation Institute, 1200 Getty Center Drive, Los Angeles, Ca, 90049, USA

ABSTRACT

Quantitative NMR was used to determine how rapidly humid air penetrates into porous stone and mobilizes a deliquescent salt (NaCl).

A cylindrical Monks Park limestone sample 40 mm long, and a diameter of 20 mm was saturated with a 2 M NaCl solution and then freeze dried in order to obtain an initially homogeneous salt distribution inside the stone. The sample was coated with Teflon tape to prevent drying from the sides and bottom. At a controlled temperature of 20 C, the sample was subjected to *in situ* RH cycles from 0 % to 90 %. First 90 % RH for 24 hours, then drying for 18 hours, and again 90 % RH for another 44 hours, while NMR measurments were carried out on a continuous basis.

Calibrated sodium and hydrogen NMR measurements allow the presentation of quantitative profiles of moisture and salt concentration over time during each sequence. The results show penetration of humid air to a depth of 1.5 cm in 24 hours, with subsequent cycles reaching a depth of 2.5 cm in 90 hours. The moisture front is a diffusion process, and, as expected, the moving front appears to scale with the $\sqrt{t}$.

The results of the NMR experiments show that humid air penetrates rapidly and that NaCl present at a depth of 2.5 cm can be readily mobilized. Such data have important implications for the desalination of objects and masonry structures, suggesting that salts need to be removed to at least this depth to slow the return of salts to the stone surface. This work also suggest that environmental events such as rapid intrusion of moist air and rapid drying due to heating (for example for Sunday services in churches), may result in a greater degree of deliquescence and salt movement with depth than has generally been appreciated. Work in progress suggests that fluctuations in air humidity alone can move salts at depth to the surface over time.

Corresponding author: edoehne@getty.edu

Earthquake-resistant structural design guide: Retrofit conservation of Doctrinal Chapels of the Oyon region (Peru) based on performance criteria

J. Vargas-Neumann[1], M. Beas[2], P. Navarro-Grau[2], J. Velásques[1]

[1] Catholic University Perú
[2] Patrimonio Perú

ABSTRACT

In the province of Oyón, department of Lima; between 2500 and 4100 meters above sea level, exist around 40 similar Doctrinal Chapels built in the XVII century. The buildings were built by the Catholic Church in order to extirpate persistent pagan idolatries, throughout 100 years of Spanish presence in Peru.

The architectural expression of these Chapels is has a unique tipology and artistic value in their colorful altarpieces and frescos. It corresponds to a mestizo-vernacular version of the late Renaissance of the XVI th century in the Central Andes.

The tipology is of chapels open towards an ample atrium; chapels "posas", a single nave with presbitery and choir, side and front portadas, walls with buttress, wood roofs of "par y nudillo" covered originally with "icchu" straw, and separated from the main building, a bell tower in the atrium. These buildings were mostly built on top of pre-inca sacred temples

In 1999, Patrimonio Peru (PP) prepared the initial inventory and cataloguing, thanks to the support of the Getty Grant Program, and later presented this group of chapels for the 2002 World Monument Fund list of "100 endangered sites".

In 2004, PP prepared the conservation project for one of the most valuable chapels of Oyón , San Cristóbal de Rapaz. The structural proposal was prepared using the guides developed by Getty Seismic Adobe Project (GSAP) of seismically resistant structural design based on criteria of Performance instead of the traditional ones of Strenght.

From this experience, the present work defines characteristics of a structural tipology that represents this group of chapels, and develops recommendations for sismic resistant reinforcement and intervention on historic buildings, taking as example 10 representative cases.

Corresponding author: jhvargas@pucp.edu.pe

Patinas in the architectural heritage of Lerma, Burgos (Spain)

C. Vazquez-Calvo, M. Alvarez de Buergo, R. Fort

Instituto de Geología Económica (CSIC-UCM), Facultad de Ciencias Geológicas, Universidad Complutense de Madrid, C/ José Antonio Nováis 2, 28040 Madrid, Spain
(RTPHC-CSIC)

ABSTRACT

The Villa of Lerma is placed in the South of the province of Burgos (Spain). During the 16th and 17th century played a very important role in the history of Spain due to the fact that was the place chosen to be the residence of the duke of Lerma, Don Francisco Gómez de Sandoval y Rojas, court favorite of the king Philipe III of Spain.

The presence of patinas have been reported in several of the main buildings of this Villa, like the Monastery of San Blas, the Collegiate Church of San Pedro and San Pablo, the Arch-Prison and the Palace of the Duke.

All these buildings were built during the life of the Duke of Lerma with the exception of the Arch-Prison that was built in the 11th century; originally it was one of the doors of the Wall used to protect the Villa.

The characterization of the patina of some of these buildings has been carried out. Samples were taken from façades of the Monastery of San Blas, the Collegiate Church of San Pedro and San Pablo and the Arch-Prison.

The patina samples were characterized by means of Optical Microscopy and Scanning Electron Microscopy. Their mineralogical composition has been determined through X-Ray Diffraction analysis. The colour parameters have been also measured by a spectrophotometer.

Results show that an orange patina covers the limestone with which these constructions were built. This patina is mainly composed by calcium oxalates and calcium phosphates (hidroxylapatite) plus calcite and quartz.

The patina is very homogeneous and in most of the samples, it is constituted by two layers.

Despite of its homogeneity and hardness there is little patina left due to the decay these buildings have undergone, due to capillary rising of salt-enriched solutions that have produced the detachment of the limestone and also due to human factors as the vandalism.

This study has been financed by project BIA2003-0473 (Spanish Ministry of Education and Science), by a “Ramon y Cajal” contract (MAdB) (Ministry of Education and Science). CVC thanks the CSIC (Spanish Council for Scientific Research) Thematic Network for Historical and Cultural Heritage, for a scholarship co-funded by the European Social Found.

Corresponding author: carmenvazquez@geo.ucm.es

Managerial aspects of a project of re-utilization: the Scuola Grande della Misericordia, Venice (Italy). (abstract withdrawn)

M. Vecco

ICARE – International Center for Art Economics
University Ca' Foscari of Venice
Dorsoduro 3488/U, 30123 Venice - Italy

ABSTRACT

The aim of this paper is to present an economic-business analysis of the intervention of re-use and re-utilization of a historic architectonic structure.

We would therefore like to present the reading of intervention projects that were filtered by means of economic-business analysis models, trying to make them efficient as regards the interpretation of situations, events and plans, guided not only by the logic of the market but also by aims such as the promotion and diffusion of culture.

In particular, the study will concentrate on the Scuola Grande della Misericordia in Venice which was has recently undergone a complex intervention of restoration and conservation thanks to funding through the special law for the preservation of Venice.

Corresponding author: mvecco@unive.it

Characterization of stone and mortar decay - Casa Major Pessoa, Aveiro

A. Velosa[1], J.Coroado[2], F. Rocha[3]

[1] University of Aveiro, Department of Civil Engineering, Portugal
[2] Polytechnic of Tomar, Department of Art, Conservation and Restoration, Portugal
[3] University of Aveiro, Department of Geosciences, Portugal

ABSTRACT

The city of Aveiro, situated in the north of Portugal, near the seaside, has a significant presence of Art Noveau buildings. Amidst these, the most remarkable is Casa Major Pessoa, a house built in 1908, situated in the city centre and bearing an expressive façade with a profusion of Art Noveau elements. This house is particularly known for its glazed ceramic tiles with drawings and chromatics that express the artistic movement of the time. Moreover, the stone belonging to the façade is carved with rounded edges and floral elements. Documents related to the house suggest that it possessed a thorough colouring, with the use of blue over renders and a bronze pigmentation of the stone.

The present state of the house is of severe degradation, promoted by a few years of total enclosure and lack of maintenance. The limestone belonging to the main porch (by the road and canal) is enduring an accelerated degradation process, where the stone shows evidence of plaques, scales and powdering decay. Black crusts are also present in some stone elements of the exterior façade. The opposite façade, giving way to a small garden, is not in direct contact with air pollution; however, both calcareous and granitic stone used in architectural elements show signs of degradation. Limestone columns are deeply eroded and granite shows signs of scaling.

A study was carried out prior to intervention in order to evaluate the causes of the degradation process of the stone. For this purpose, samples were extracted from various locations and were analysed using XRD and AAS in order to evaluate salt formation. Thin sections of the degraded stone were executed and visualized under the optical microscope and samples were subject to SEM/EDS.

A characterization of mortars and pigments was also undertaken. Mortar residue after acid attack was sieved in order to establish particle size distribution and XRD was performed in order to determine the mineralogy of the mortars.

Studies related to the pigments that were used in the building posed further problems due to the lack of actual evidence. However, small samples were removed and XRD and RAMAN techniques were used to enable their characterization.

This paper includes presentation of results from the studies that were undertaken and their discussion related to the degradation process that is taking place.

Corresponding author: avelosa@civil.ua.pt

Historical, technological and architectural aspects in building recovery of a "Villa Liberty" in Palermo, Italy

R. M. Vitrano

D.P.C.E. Department of Project and Building Construction
Faculty of Architecture - University of Palermo - Italy

ABSTRACT

The paper describes the variables of interaction between architecture-materials-techniques and the problems inherent in building recovery and the protection of the existing Heritage. It analyzes experiences as a sample of various geographic scenarios comparing them; it centers the study on Palermo, a city that has absorbed multiple influences, stratifying them in many levels.

Palermo is unique under the cultural and social profile, in the assimilation and integration of traditions and constructive techniques of various people, still today it offers a distinctive “document panorama”. Its fascination is in this "inheritance of prints" - of history and technology etched in the stones of which it is made.

The study wants to be a deepening of the historical and architectonic perspective, starting from the analysis of the issues expressed by the city’s scenography, uneasiness also transpires, a serious decay that in many cases consumes it and that needs expert hands for the procedure to counteract it.

In giving attention to the multiple questions, on the protection and maintenance of the wide inheritance entrusted to us, we intend to begin with to interpret the relationship between technique and history considering the perceptive peculiarities and the readability in the different ages; and then to articulate on the possible valorization and "regeneration" of the built elements, respecting the preexistence, and the processes of evolution of the requirements of the present.

Corresponding author: r.vitrano@architettura.unipa.it

The "technological parameters" of heritage conservation: factors of decay-instruments of building recovery and prevention measures

R. M. Vitrano

D.P.C.E. Department of Project and Building Construction
Faculty of Architecture - University of Palermo - Italy

ABSTRACT

We have been trying for a long time to sow the lost identify in social and material becoming. We get annoyed about the unevenness and desecrations in the fabric of our cities. We complain about the absurdity of some architectonic transformations and so we point to where we haven't been able to heal wounds. We accuse the decay and the promiscuity in our historical centers, as well as the disorder of our suburbs and on the one hand we are always in the search for the right equilibrium, on the other hand we go beyond every limit of spatial and material impudence.

This is the age of the "global knowledge", of the "local inadequacies", of the specialist enterprises and of the managerial difficulties to limit the risk both material (structural decay/ physical obsolescence / security needs / static disease) and cultural and environmental (function degradations – inattentive environmental conditions) of the discontinuity between the past and the present and to realize the right living conditions and protection of heritage conservation, it is necessary to create new perspectives "to continue to make history consciousness".

The new instruments of the recovery and maintenance of the extant as well as the new strategies of equilibrium and protection for the future city development have to be searched in the complexity-changeability and variabilities which are the categories of the present.

The paper describes the methods for "protection" of the existing patrimony; it analyzes experiences as a samples of various geographic scenarios (case of study of Sicilian sites) comparing them.

To conserve the inheritance of the historical architecture means also to revitalize it, to make it part of our time.

Corresponding author: r.vitrano@architettura.unipa.it

Microwave treatment for woodworm disinfection in large-format works of art

V. Vivancos-Ramón[1], E. Pérez-Marín[1], L. Nuño-Fernández[2], J.V. Balbastre-Tejedor[2], A.T. Zona-Ortiz[2]

[1] Dpt. Conservación y Restauración de Bienes Culturales, Univ. Politécnica de Valencia, Spain
[2] Dpt. Comunicaciones, Univ. Politécnica de Valencia, Spain

ABSTRACT

The diagnosis and control of the natural agents of deterioration of the heritage are one of the greater preoccupations in the scope of the conservation. Specially, the pest control is been present from the antiquity, applying a great variety of products non entirely effective, whose purpose has been the control and elimination of the plagues. The use of the microwaves for the decontamination of wood pieces supposes an alternative to the toxic treatments and other physical treatments not absolutely effective for great formats, like inert atmospheres.

This work presents the results of a study adressed to the decontamination of works of art with ligneous support, specially focused in treatments "in situ" of great format works, like the altarpieces or the coffered ceilings. For it, we have worked with an free antenna of 1 kW of power (developed by the company Dry Parasite S.A.), that allows to work on one of the faces of the piece to treat, controlling the temperature that reaches each one of the parts of the wood, since the intensity of the wave diminishes as is penetrating in the object.

The investigation has been focused in two areas: to know the behaviour of the different constituent materials from art works, that is, its conductivity; and to evaluate the effectiveness of the treatment on woodworms, with the purpose of designing a methodology of treatment adapted for the decontamination of great format works.

With reference to the behaviour of the wood, the temperature, the loss of weight and the movements of the support have been controlled. The behaviour of the wood and its heating by the microwaves are directly related to the humidity content of the treated piece, being less important the species or its density. It has been verified that does not take place significant dimensional variations with treatments of 1 kW to 20 seconds.

On the other hand, studies have been made on wood pieces with intermediate layers (gesso, linen). The results show that these intermediate layers are heated up less than the wood, as a result of their smaller hygroscopicity and their smaller interaction with the microwaves. In addition, they do not act like screen to the propagation of the microwaves, reason why it would be possible to be radiated from the obverse of a table.

In reference to the effectiveness of the treatment, the sensitivity of the larvae and eggs of hylotrupes bajulus to the irradiation with microwaves has been verified. The tests done show the effectiveness of the treatment, independently as large as the larvae (on larvae between 50 and 200 mg. of weight). The treatments to 20 seconds with 1 kW of power are 100% cash in the points near the centre of the irradiation, with an immediate mortality in all of them. It has been verified the immediate effectiveness of the treatment, as well as the effectiveness in the mid term, being observed nutritional disorders and problems in the growth of the larvae, which pass away after long periods without feeding itself (more than eight weeks).

Corresponding author: vvivanco@crbc.upv.es

Identification of the provenance of natural stone used as roofing material in Scotland

J.A. Walsh

Historic Masonry Group, University of Paisley, Scotland, UK

ABSTRACT

Natural stone is the roofing material found on most historic buildings and in the conservations areas in Scotland. Many of these roofs are over a hundred years old and require constant supply of stone for their repair and maintenance. The first step in selecting suitable replacements is the identification of the original stone. Slate, the principal stone type used, comes from four distinctive Scottish sources; Ballachulish, Easdale, Highland Boundary, and Macduff as well as from England and Wales. Other types of stone such as Keith schist and Caithness flagstone were also used.

Samples were collected from several quarries in each of the source areas and analysed, thereby providing a database with which to compare unknown samples. A combination of methods was used in identification, from macroscopic properties such as colour, thickness, splitting properties to microscopic thin sections, XRD and XRF analyses. It was found that the bulk composition was of limited use in identifying the provenance, as the mineralogy of most slates, regardless of source, is made up of quartz, chlorite and white mica. The relative proportions vary even from the same source and with the degree of weathering. Instead accessory minerals, such as the type of carbonate, iron ore mineral and feldspar, were used to characterise the material. The presence of other accessory minerals further refined identification, e.g. paragonite in Bute slate, one of the Highland Boundary quarries, and biotite in Tarrymouth schist, one of the Keith quarries.

Another important technique was the use of trace elements. The results of over a hundred analyses were evaluated to find ways of distinguishing between some of the categories of slate, not possible based on mineralogy alone. Although some tentative identifications were made using this method, more work needs to be done to determine the natural variation within the source areas and the effects of weathering, to realise the potential of this method.

Corresponding author: joan.walsh@paisley.ac.uk

Assessment of stone durability: impact of test conditions

P.A. Warke, B.J. Smith, J. McKinley

School of Geography, Queen's University Belfast, Belfast BT7 1NN, UK

ABSTRACT

Durability characteristics of Dumfries sandstone, Leinster granite and Portland limestone are compared using the industry standard Na_2SO_4 salt crystallization test and a modified laboratory weathering simulation test combining salt weathering and freeze/thaw cycles. On a building, stone weathering can be spatially variable with considerable within block, between blocks and façade-wide differences. Prediction of stone response to weathering relies, for the most part, on standardised durability tests that confer a fixed assessment of expected durability and which, inform choice of stone for use on particular parts of a building. Unfortunately, standard tests only register the two end extremes in the progression from 'fresh' to 'failed' stone with blocks inserted as fresh samples and revisited on disintegration. In addition, such tests tend to assess durability through exposure to a single weathering process which is an unrealistic representation of the weathering system where rarely do processes operate in isolation and where complex interactions and synergistic relationships can enhance overall weathering effectiveness. Whilst recognising the need for assessing potential weathering response, it is clear that standard durability tests are not capable of identifying the subtleties of weathering related stone decay and consequently may not accurately predict stone response to weathering under complex 'real-world' conditions.

The standardised Na_2SO_4 salt crystallisation test and the modified durability test were used to rank durability of the three stone types. Discrepancy between rankings arose in the lower orders with Portland limestone and especially Dumfries sandstone responding differently to the two sets of experimental conditions. Data indicate that the range of permeability values for each stone type provided a reasonably accurate means of predicting stone durability under modified test conditions. It is suggested that the modified durability test provides a more accurate reflection of weathering behaviour because of the use of more than one weathering process, more realistic temperature parameters and a relatively dilute Na_2SO_4 solution which together enable each stone type to resolve resultant weathering stresses in ways that more accurately reflect response under 'real-world' conditions. Data reported are significant because of their contribution to better understanding of stone response to complex weathering conditions where high frequency, low magnitude weathering events combine with less frequent but higher magnitude weathering episodes. While standard durability tests provide a basic overview of response to comparatively extreme experimental conditions, they do not provide sufficient information regarding the nature of stone breakdown. In addition, because of the extreme conditions used, the reliability of resultant data may be in question especially where durability status is not clearly defined.

Corresponding author: p.warke@qub.ac.uk

Salt-weathering, conservation techniques and strategies to protect the rock cut façades in Petra/Jordan

W. Wedekind[1], J. Ruedrich[2]

[1] Wandwerk Restoration, Torstraße 107, 10119 Berlin, Germany
[2] Geoscience Centre University Goettingen, Goldschmidtstrasse 3, 37077 Goettingen, Germany

ABSTRACT

The ancient rock city of Petra (Jordan) displays with its unusual sandstone architecture an abundance of evidence of the Nabatean culture. The ancient city has gained special recognition for its hundreds of rock facades carved out on the sandstone rock found there. Today, the existence of the unique rock architecture of these monuments is in danger due to decomposition, poor maintenance and lack of conservation. Within three years of on-site work and field research in collaboration with the CARCIP (Conservation and Restoration Center in Petra), findings about the geology and geomorphology of the cambric sandstone could be gathered, acute safety repairs and restoration of stone facades new techniques for conservation could be developed and employed.

The rocks of Petra are characterized by alveolar (honeycomb) and tafoni weathering. Today more than 50% of the surfaces of the monuments are damaged by these phenomena. Nearly 12% are totally destroyed by tafoni-weathering. The main reason for this intensive backweathering is the high contamination with rock salt (halite, NaCl), which is a part of the mineral composition of the stone itself. In order to get more information about the weathering processes additional laboratory experiments on three macroscopically different sandstone types have been carried out (measurements of the pore radii distribution, the hydro and thermal dilatation as well as salt weathering tests). Especially the bimodal pore radii distribution and a partly pronounced hydro swelling of the investigated sandstone samples are probably responsible for their high sensitivity within the salt weathering tests.

The on site research underlines the interrelationship between active tafoni growing by salt-concentration, micro-climatic changes and the flow of the rainwater, as well as the dependence on the fabric and petrophysical properties of the stone.

Based on the experiences and the results of research, a new sprinkling method for desalinating natural stone was developed and first applied at Petra on monument no. 826 between 2002 and 2003. It consists of a number of fine spraying nozzles, which are sprinkling water on the contaminated areas while the conductivity of the flowing water is continuously measured to check the progress. The cyclic procedure allows a significant removal of the salt up to 90%, dependent on the initial concentration. By desalinating monument no. 826 several hundred grams of halite could be extracted and by looking at its distribution conclusions about the local geomorphology could be drawn. As a consequence of the research, an action plan for conservation of further monuments in Petra was developed.

Corresponding author: wedekind@wandwerk.de

Micro x-ray computer tomography (µ-CT) for the low invasive analysis of stone

F. Weise, U. Müller, J. Goebbels

Federal Institute for Materials Research and Testing (BAM), Germany

ABSTRACT

Micro computer tomography (µ-CT) is becoming increasingly important in material science. The advantages are obvious: the technique is a non-invasive method and allows the investigation of the micro structure of a given material without causing damage to the analyzed sample. This opens completely new possibilities in how to describe the condition of a material during a dynamic process. Traditional imaging techniques for the micros structure, such as light or electron microscopy, require the destruction of a sample specimen after a dynamic experiment, such as salt crystallization or freeze/thaw test, has been finished. Therefore for a specific specimen only the final condition can be defined by these techniques. However, µ-CT is able to image the micro structure of a specific sample before, during and after a dynamic experiment without harming the specimen itself. It is therefore possible to follow the change in material condition in incremental time periods during a dynamic process.

With the cone beam tomography a sample is rotated in the incident beam and with an area detector a multitude of projections of the sample cross sections can be registered simultaneously. Each of the image pixel in the three dimensional image matrix, reconstructed from all projections, represents a volume element (voxel). CT gives a measure of observed X-ray averaged over one voxel. In the tomographic images the different absorption values are then represented in form of 256 gray scale values. The final result of the measurement and the following computation is a 3-D image of the absorption values in the material. The absorption values are material parameters, i.e. different values are synonym with different materials.

In our study we applied µ-CT on a volcanic tuff from a historical building, the Charlottenburg Gate, in Berlin. The tuff surface was treated by a water repellent in 1986. Our interest was to demonstrate how the water transport was influenced by the treatment. For this we were able to visualize the distribution of water in a sample specimen in different time periods during wetting and drying. It is shown, that the treated layer of the tuff surface still influences the water transport even after 19 years of exposure. The results helped significantly to understand processes of decay which appear on the exposed stone faces of the building.

Corresponding author: frank.weise@bam.de

Biochemical deterioration mechanisms of cementeous matrix by fungi: preliminary results

V. Wiktor[1], R. Guyonnet[1] , P. Grosseau[1], E. Garcia-Diaz[2], A.M. Danna[1], B. Guilhot[1]

[1] Ecole Nationale Supérieure des Mines de SAINT-ETIENNE, 158 cours Fauriel, 42023 Saint-Etienne Cedex 02, France
[2] Ecole des Mines de DOUAI, 941 rue Charles Bourseul, BP 838, 59508 Douai Cedex, France

ABSTRACT

Micro organisms – bacteria and cyanobacteria, fungi, algae, and lichens - are able to grow on building materials: concrete, wall plastering, stone…. They are liable to degrade material properties: from an alteration of aesthetic aspect to a reduction of its service life. Biodeterioration mechanisms are complex and not yet absolutely understood. Usually, the biodeterioration is caused by various processes: physical (e.g.: hyphae penetration inside the matrix) and chemical deterioration (e.g.: acid production). The biodeterioration is enhanced by environmental factors such as freeze/thaw cycles. Hence, to control and to act efficiently against deterioration by micro organisms, it is necessary to have a better understanding of those mechanisms.

The present study aims to develop an accelerated laboratory test which allows describing chemical deterioration mechanism of cementeous matrix by fungi. Usually, microbial colonization of building materials starts with algae and cyanobacteria development, responsible of aesthetic deterioration, mainly. In a second time, fungi and bacteria growth causes chemical and physical deterioration in addition to aesthetic aspect. Thus fungi allow us to study the different aspect of biodeterioration: aesthetic, chemical, and physical. Two fungal strains were chosen for the study: (i) Alternaria alternata, responsible of physical deterioration instead, and (ii) Aspergillus niger, an acidogenic fungi which is representative of chemical deterioration instead. Relating to the matrix, we first focus on a model system: a pure cement paste which will permit to study systems more heterogeneous such as concrete further. Before to start biodeterioration test over a long period, it is necessary to determine parameters which accelerate fungal development on cement (way of inoculation, quantity inoculated…). Influence of conservation mode of cement samples is also studied: carbonatation (to reduce matrix pH) is performed on some samples.

In order to study minerals alterations during biodeterioration test, DRX, IRTF, and ATG-TD analyses are performed. Biomass quantification is realised with ergosterol and proteins assays. These analyses would allow us to compare and quantify two way of deterioration: physical and chemical.

An extension to this work is to study biodeterioration impact on material microstructure and local mechanical properties.

Corresponding author: wiktor@emse.fr

Salt distribution within experimentally weathered sandstone: some preliminary observations. **(abstract withdrawn)**

J. S. Wright

Institute of Environment and Sustainability Research, Staffordshire University, Stoke-on-Trent, Staffs, ST4 2DE, UK

ABSTRACT

It is now widely recognised that salt weathering plays an important role in the deterioration of masonry materials within the built environment. Thus, in order to devise appropriate management strategies it is crucial that we understand the salt weathering system as fully as possible. Although there is a long history of the use of salt crystallisation tests and laboratory simulations to determine building stone durability and assess the efficacy of salt weathering, there are limitations associated with this approach to the investigation of the salt weathering system, including: (1) the somewhat crude and ad hoc nature of many experimental procedures, e.g. the repeated immersion of samples in, or their daily spraying with, saturated salt solutions; (2) a lack of consistency between different experimental studies, limiting comparability of results; and (3) very few experimental weathering studies have investigated the distribution of salts within the stone system after testing; weight loss, degree of splitting, particle size change and visual appraisal of surface disaggregation have most commonly been used to assess change. However, the way in which the salt is delivered to the stone is an important factor in determining the distribution of salts within the stone system. The resulting distribution of salt will in turn influence the decay pathway experienced by the stone system and the morphology of the subsequent stone decay features. Thus, the aim of this paper is to investigate the effects of different salt application regimes on the distribution of salt within samples of Hollington sandstone. Four different kinds of salt application regimes were used:

1. The BRE Salt Crystallisation test procedure
2. Daily salt spray test
3. Single immersion in salt solution
4. Single immersion in salt solution followed by daily spray with deionised water.

At the end of 15 treatment cycles one sample from each regime was split into three depth zones and nine powder samples were obtained from each of these zones. Conductivity measurements were carried out on water soluble extracts from each of these powder samples. This paper presents the results of these conductivity measurements and discusses the implications for our understanding of the development of salt induced failure pathways and decay features within sandstone.

Corresponding author: j.s.wright@staffs.ac.uk

Granite soiling in Aberdeen, UK: pollutants, stone characteristics and mortars

M E. Young

Scott Sutherland School, Robert Gordon University, Aberdeen AB10 7QB, UK

ABSTRACT

Granite is a common building stone in Aberdeen (UK) having been used as a building material since medieval times. The granite used in significant medieval buildings was either gathered as loose boulders from surrounding fields or locally quarried from surface deposits and carried the short distance to where it was used. Consequently, much of this material is relatively highly weathered and permeable.

From the mid 19th century, improvements in machinery and tools resulted in great expansion of the granite industry. Quarrying of fresh granite produced a variety of stone types from deep, unweathered sources. Many of the granite buildings in Aberdeen city centre are about 100-150 years old. While granite is a robust building material, examination of building facades reveals significant, though largely superficial, decay on many granite facades.

Different granite types respond in various ways to agents of weathering, some typically displaying granulation around joints, others suffering general surface loss by flaking. This behaviour appears to be linked to the petrological nature of the granites. There is a clear link between air pollution, related to traffic volume, and the rate of granite soiling and decay. Pointing and other mortars also affect the soiling and decay of granite. These mortars may constitute a significant proportion of the exposed surface of a wall and provide a source of soluble calcium which contributes to formation of damaging gypsum crusts on sheltered stone surfaces.

Corresponding author: m.young@rgu.ac.uk

Author Index

N