Plaster, culture heritage and building applications
Properties and behaviour characterisation using invasive and non invasive techniques

Jeudi 27 octobre 2016
à partir de 13h30
Amphithéâtre de la MIR, site de Neuville

Dans le cadre du lancement des activités de la Maison Internationale de la Recherche de l'Institut d'Etudes Avancées - UCP,
le L2MGC a la plaisir de vous inviter à une demi journée de conférences dédié au plâtre ; Matériau du patrimoine, patrimoine culturel et bâti. Il reste encore aujourd'hui omniprésent en matière de développement d'œuvres et leurs réhabilitations, dans le domaine de l'habitat pour le second œuvre et les ornements, mais également en matière de protection incendie ou d'innovation.
Ce liant hydraulique millénaire fabriqué à partir du gypse est recyclable, est faiblement impactant pour l'environnement et les ressources sur notre territoire restent encore aujourd'hui importantes pour des solutions à faible coût.
Au travers de cinq présentations, nous abordons le plâtre dans le contexte patrimonial, puis dans un contexte formulation pour l'habitat et son confort thermique. A la suite, deux présentations sont dédiées à des techniques de caractérisation non invasives (holographie laser et acoustique terahertz) adaptables au cas de systèmes sollicités (mécaniquent, thermiquement, …) et endommagés. Le potentiel de telles méthodes augure, notamment, de nouvelles interprétations des systèmes de protection passive incendie à base de plâtre dont une base de données est déjà acquise par techniques invasives.

Agenda

13h30 : Accueil des participants

13h45 – 13h50 : Introduction

13h50 – 14h30 : External gypsum renders of Île-de-France: synergy between the architect and the engineer
Tiffanie LE DANTEC, Jean DUCASSE-LAPEYRUSSE, Véronique VERGES-BELMIN

14h30 – 15h10 : New composite building material incorporating phase change material with solid-solid transition
Thibault HARLE, Ronan HEBERT, Tran Minh Giao NGUYEN, Béatrice LEDESERT, Yannick MELINGE

15h10 – 15h50 : Direct quantitative structural diagnostics based on the use of holographic interference digital visualisation and measuring portable system: exemplary applications on cultural heritage research and conservation studies
Vivi TORNARI, Eirini BERNIKOLA, Kostas HATZIGIANNAKIS, Michalis ANDRIANAKIS

15h50 – 16h10 : Pause café

16h10 – 16h50 : Terahertz Time Domain Imaging Spectroscopy on Cultural Heritage : case study on plaster
David GIOVANNACCI, Hoi Ching CHEUNG, Didier BRISSAUD

16h50 – 17h30 : THCM gypsum board behavior thermally loaded on one side under standard fire condition
Yannick MELINGE, Amandine ROJO, Javad ESLAMI, Ronan HEBERT, Béatrice LEDESERT

17h30 : Clôture

External Gypsum renders of Île-de-France: synergy between the architect and the engineer

Tiffanie LE DANTEC, Jean DUCASSE-LAPEYRUSSE, Véronique VERGES-BELMIN

In 1667, The French king Louis XIV made the use of gypsum plaster compulsory in Paris in order to avoid the total destruction of the buildings in case of a fire similar to the one that occurred in London in 1666. In the XVIIth and XVIIIth centuries, Paris became a white city where all the popular houses and 75% of the *hôtels particuliers* were covered with gypsum renders. Following Paris' example, the use of this material spread throughout the region (called Île-de-France).

The plaster façades of Paris are witnesses of this white past, which define the identity of the Paris region.

Gypsum renders made before 1850 have the reputation of being durable, as a number of plaster façades have resisted deterioration in the external environment for more than two centuries. Despite its remarkable performance and importance in the city's cultural heritage, the old plaster of Paris is poorly known in its composition and application process. Understanding this material may bring an answer to the contemporary issues of sustainability, conservation, and compatibility of modern materials with old structures.

The research program has two aims. The first is to establish the composition and the durability factors of gypsum renders and to find a way to replicate or restore them. The second is to achieve a better understanding of the history of these renders and of the design of the Parisian facades.

This project associates historical research with architectural and scientific analyses. A fundamental part of the program is the complementarity between the architect and the engineer's research.

The research program concerning external gypsum renders in Île-de-France is composed of two projects:

An architectural PhD thesis conducted by the Conservation Architect Tiffanie Le Dantec at the University of Versailles Saint-Quentin and funded by the foundation LabEx PATRIMA with the material support of the Laboratoire de Recherche des Monuments Historiques (LRMH).

A three years research program conducted by the research engineer Jean Ducasse-Lapeyrusse and initiated by the LRMH and the Cercle des Partenaires du Patrimoine (CPP).

The presentation will focus on the synergy between the architect and the engineer needed for this interdisciplinary project.

New composite building material incorporating phase change material with solid-solid transition

Thibault HARLE, Ronan HEBERT, Tran Minh Giao NGUYEN, Béatrice LEDESERT, Yannick MELINGE

Phase change material (PCM)

PCM with solid-solid transitions perform transitions between an amorphous state and a crystallized state. They remains solid in a given temperature range in order to avoid micro or macro encapsulation. In this work we produce a new solid-solid PCM that remains solid in the buildings temperature range. This PCM is safe for human health and environment. The PCM produced have a latent heat of fusion between 80J/g and 120J/g. The granularity of the PCM is controlled before incorporation. A patent is deposited.

Characterization of the composite

Thermal behaviour is then characterized by differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). We investigate the ability of PCM to perform its phase transition. The composite is instrumented with K type thermocouple for thermal cycling in stove with humidity control. The emissions of the composite in the building inside air are analysed by infrared from ambient temperature to degradation temperature. Thermal cycling test are performed on the composite to evaluate the durability of the thermal properties of the PCM.

The mechanical resistance of the composite is determined by mechanical tests: compression and flexural. The interaction between PCM and gypsum crystals is observed by scanning electron microscope.

Results

The incorporation of the PCM into a hydraulic binder does not change the abilities of PCM to perform its transitions. The thermal monitoring of the composite shows a decrease of temperature peaks and a time lag of temperature increasing and temperature decreasing. For temperature ranged from 350 to 450°C, TDA/TGA analysis highlight an endothermic chemical reaction combined with mass transfer. Such a behavior represents a good interest In fire applications. The PCM could delay heat increase in the buildings during its degradation.

The composite shows better mechanical properties than commercial products. The incorporation of PCM seems to decrease the mechanical behaviour of the composite but ways of improvements are under way.

Direct quantitative structural diagnostics based on the use of holographic interference digital visualisation and measuring portable system: exemplary applications on cultural heritage research and conservation studies

Vivi TORNARI, Eirini BERNIKOLA, Kostas HATZIGIANNAKIS, Michalis ANDRIANAKIS

The technique of holographic interferometry is a coherent laser based method to implement the optical interference phenomenon in its highest spatial information content. In the optical acquisition form of data retrieval, each recorded image or hologram can reach up to 5000 lines/mm and depending on the laser power. The 3D field of view can be as high as dozens of meters. There is no theoretical limitation in highest spatial frequency or beam divergence other than the diffraction limit. However, there is the drawback of high demand for structural stability due to vibration sensitive phase recording of interference. The digital acquisition form of data retrieval allows from few tenths to few hundreds of lines/mm spatial frequency acquisition offering a much lower counterpart than that of optical recording. Despite this decrease in the technical parameters of the recording system it is the digital recording and the use of speckle interference field that allows the technique to work out of laboratory conditions.

Hence we have designed and developed a system aiming to be transportable for on-field measurements. The system make use of off-axis optical geometry implementing reference beam and lens generated speckle fields back scattered from the target and we termed it Digital Holographic Speckle Pattern Interferometry. Important properties are the full field non destructive quantitative measurements in visible imaging of the spectrum.

It is a user friendly portable pc driven optoelectronic device with dedicated software development to artwork recording and analysis. Has been used for on-field and in laboratory research on materials, artworks and monuments, and can be implemented to document indoor or outdoor impact responses by monitoring real time data. The method applies to complex and inhomogeneous artworks and materials independently of construction geometry requiring though highly trained operator and post processing experience. Analysis of post processed data depends on *apriori* knowledge of experts according to the target.

The method and system will be presented with previous examples from artworks and monuments as well as since has been used in the L2MGC of the UCP most exemplary results will be shown. In this respect, the system has been coupled with other techniques as IRT and combinational data and results already validated in order to better understand the THCM behavior of plaster board thermally loaded.

Terahertz Time Domain Imaging Spectroscopy on Cultural Heritage : case study on plaster

David GIOVANNACCI, Hoi Ching CHEUNG, Didier BRISSAUD

Non-destructive and non-contact analysis technique is of great importance in cultural heritage applications. Scientific research on cultural heritage can provide information for conservation and archaeometry, in terms of structure, composition, dating and production process. There are many existing spectroscopic techniques applied for different types of artwork in order to identify the material compositions and get images for the under layers. The most commonly used are X-ray, Ultraviolet (UV) Infrared (IR) and laser spectroscopy. By comparison with the mentioned techniques, Terahertz (THz) spectroscopy is an innovative, non-invasive and non-contact option. It has good penetration depth through different materials, low scattering and broad spectral bandwidth. THz spectroscopy first entered the field of cultural heritage application in 1998 and it had been already widely applied to various artwork analysis like pigment analysis, painting and wall painting analysis.

As terahertz time-domain imaging spectroscopy (THz-TDI) is a comparatively new technology, scientists have various questions and difficulties on the development of this technique. For examples, some materials are transparent in this electromagnetic (EM) wave region while some materials give specific absorption spectra waveform, so a database will be needed for identification; the reflected signals from different layers of the sample are very complex and extracting information from them is difficult. So advanced data treatment with different program or software will be needed, etc. On the other hand, there are also different problematic for each type of artworks in cultural heritage. Generally, the problems include material identification, dating, place of origin and production or restoration process. Applying THz-TDI system to artwork can have significant result and provide information that other techniques cannot or in a safer condition.

In this work, terahertz time-domain imaging spectroscopy (THz-TDI) applications on cultural heritage materials were investigated. A focus is made on plaster materials and the capacity of the system to image the internal structure of such a material.

THCM gypsum board behavior thermally loaded on one side under standard fire condition

Yannick MELINGE, Amandine ROJO, Javad ESLAMI, Ronan HEBERT, Béatrice LEDESERT

The identification of the behaviour of passive fire protection in building application is the main objective of the present study. During fire in a building, two main periods can be highlighted:

- The first period appears at the beginning of the event and the material reaction to fire takes a large place of the fire development. The fire is started and the flames are under development. Energetic equilibrium can't be reached during this period,
- The second one occurs when the fire is fully developed. Then, the material resistance to fire is very important to enlarge the efficiency of the thermal barrier. Due to the evolution of the structures properties, during this period, the energetic equilibrium can't be also reached. Because the state of the fire is fully developed, the external energetic contribution can be neglected.

Our proper research activities concern the second period of the fire effect. The structures protection are often realised with the use of passive protection. To prevent some large damages, the material (or formulation) selection is crucial to delay the structures temperature increasing and give an extension duration for people evacuation and to ensure the data protection and equipments. Among the passive existing solutions, the latent heat insulator based on gypsum content take an important place. These hydrated mineral compounds retain 20 % of the total mass of water and these materials present a very low cost. Such materials under temperature evolution, like standard temperature evolution, evolve with combined actions: thermal, mechanical, chemical and hydrodynamical. Such combined actions need to introduce different scale point of view to highlight the effect of each of them to ensure a good prediction of the behaviour of the building materials under fire conditions.

External Gypsum renders of Île-de-France: synergy between the architect and the engineer

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New composite building material incorporating phase change material with solid-solid transition

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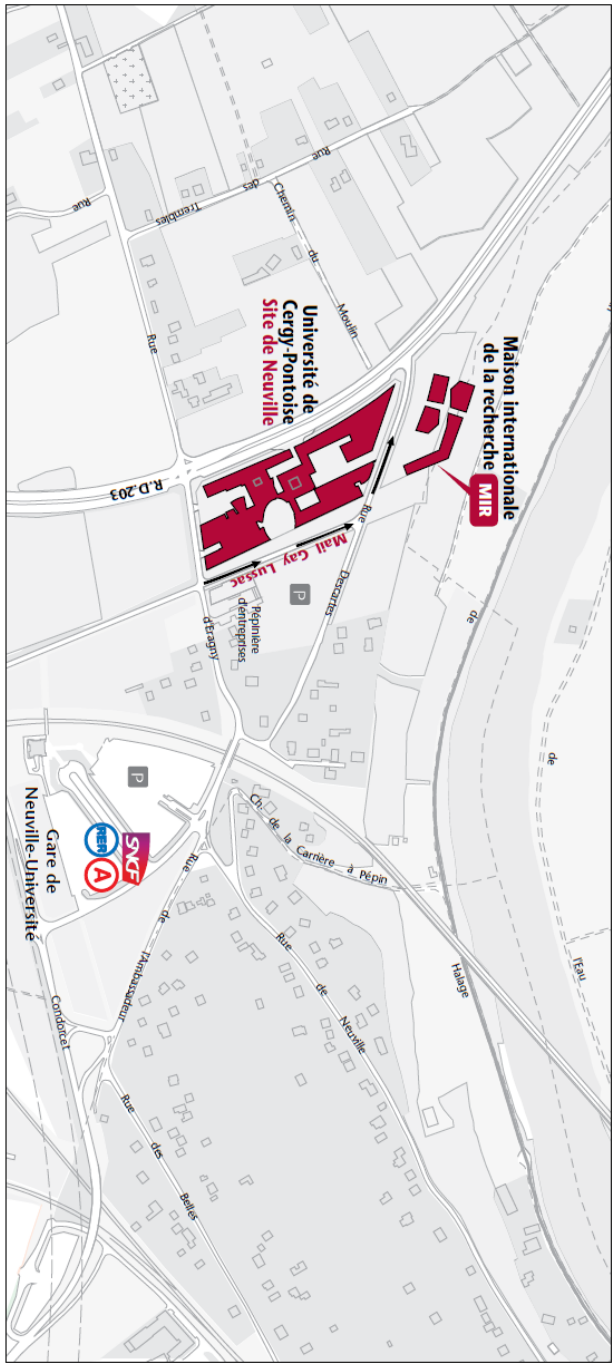

La conférence est libre d'accès dans la limite des places disponibles.
Merci de confirmer votre présence à l'adresse suivante :
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Les conférences se tiendront dans l'amphithéâtre de la MIR située rue Descartes (dans le prolongement du mail Gay Lussac).