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Issue 18

Diagnosis and management of the environmental parameters in museums

The importance and size of the European historical, artistic and architectural heritage is well known. Even so, adequate indoor environment control and management systems often do not correspond to the amount and quality of such works.

Several national and international working groups working in the field of conservation underline the importance of the protection and maintenance of cultural heritage. Among these actions the Italian Ministry for University and Scientific Research has started a project to study and define techniques and equipment for the control and management of the indoor environment in museums.

Within this project ICITE-CNR has studied and developed a prototype of an integrated system for the monitoring, control and diagnosis of the indoor environment, specifically conceived to be used in buildings containing historical and architectural works. The system is simple to manage, flexible to use and adaptable to buildings with different construction and building services plant. It is able to assess the indoor environment; acting in real time to modify the values deemed to be dangerous for the protected objects and for the users' comfort.

The software consists of different components able to manage the database of the acquired data and to visualise from a synoptic to set standard control logics to control the HVAC plants. A mathematical model allows the simulation of the trends of the microclimatic parameters in the building as a useful tool for the diagnosis and the definition of adequate intervention strategies.

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The Diocesan Museum of Sulmona (L'Aquila)

in brief

E-CORE starts work

This autumn has seen the launch of E-CORE, the European COnstruction REsearch Network. The network is managed by ECCREDI (the European Council for Construction Research, Development and Innovation). E-CORE has four basic objectives:

- develop an EU construction RTD project database and web portal
- maintain a construction technology watch
- help develop a European RTD construction research strategy
- manage EU construction RTD information dissemination.

One of the first public E-CORE activities was the organisation of a workshop in Brussels in December 2001 to explore options in the development of an EU RTD project database.

Further information on E-CORE can be found at http://www.e-core.org.

FP6 gets closer

In November of 2001 the European Parliament suggested over 300 amendments to the Commission's initial FP6 proposal. Subsequently the Commission accepted nearly 250 of the amendments. The FP6 budget is expected to be about 17% greater than FP5. Further progress in the co-decision process was made at the Research Council meeting in December 2001. FP6 continues to be on-track for first calls to be made at the beginning of 2003. For further information on FP6 progress please see:

http://www.cordis.lu/rtd2002/home.html

"ENBRI brings together the principal Building Research Institutes of the European Union (EU) and of the wider European Economic Space (EES), for the benefit of the world of construction."

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City of the Sun: home of a new PV concept

The 'City of the Sun' is a Dutch VINEX location in Heerhugowaard, Alkmaar and Langedijk. The new district in what is called a HAL region partly owes its name to the solar panels that will be installed on the roofs of thousands of residential buildings. Together, these solar panels are expected to yield a capacity of five megawatts of photovoltaic (PV) solar energy, representing a sustainable source of energy that directly converts solar energy to electricity.

For this project, a new PC roof concept for large-scale application on sloping roofs was developed. VOS Projectontwikkeling B.V. (VPO) is responsible for a large part of the project and operates according to the principle that construction contract costs must be reduced as much as possible. The PV facilities must be realisable for less than 4.5 EUR per watt peak (1 kWp represents approximately 9 square metres of PV panel, yielding around 750 kWh per year). A second important prerequisite for the project is that the facilities on the roofs do not involve structural uncertainties. To meet these requirements VPO set up a team of experts, for which TNO Building and Construction Research supplied some of the staff. In addition to TNO Building and Construction Research, the partners involved in the project are VUREN HAWA, Axys Innovations B.V., Phoenix Benelux, ISOVER, Witteveen Daktechniek Noord, Alcoa Europe B.V., Solarned, BP Solar and several other companies.

Built-in humidity

TNO Building and Construction Research was involved at an early stage in the development of the new roof concept. With the aid of the team members, TNO developed a new universal mounting system for the solar panels. TNO also handled the structural testing of the roof element. For these tests, TNO Building and Construction Research specifically examined the possible appearance of internal condensation within the roof element.
A virtually vapour-proof roofing material was used for the solar roof and internal condensation would represent an important risk of damage. Previous research had demonstrated that built-in humidity would be one of the main risks. This problem may occur when hygroscopic materials are applied, for instance woods that may absorb humidity during transport, storage and on-site assembly. The parties involved in the construction project are responsible for preventing such risks.

Successful concept

A trial roof was assembled which was mounted on top of TNO's solar house to provide certainty with respect to the structural quality of the roof concept before it was actually implemented. TNO also tested the application of plastic (EPDM) roofing materials and the mounting system for the solar panels on this trial roof. The organisation's experts then monitored the humidity behaviour of the roof element throughout the winter.

While the study has not yet been concluded, it has become clear that VPO, TNO Building and Construction Research and the other partners have developed a successful roof concept that represents a major innovation for the Dutch market.

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The trial roof, mounted on top of TNO's solar house

Investigations of some material pro analysis of LECA masonry

BYGGFORSK
Norwegian Building Research Institute

Masonry made from Light Expanded Clay Aggregate (LECA) concrete blocks is the topic of a Doctoral Thesis at the Norwegian University of Science and Technology. Such masonry is by far the most popular manufactured masonry in Norway. The study is being carried out in close collaboration with Norwegian Building Research Institute.

The main objective of the study is to expand the knowledge about the material properties of LECA masonry in order to enable more accurate structural analysis and design of such masonry. The thesis comprises largely of experimental studies on the material behaviour of LECA masonry. Due to the relatively limited knowledge on the material properties of LECA masonry compared to that of concrete, a wide range of properties of LECA masonry is being studied.

Because restrained shrinkage cracking is a major cause of damage to LECA masonry, mapping the behaviour of masonry with obstructed shrinkage has been selected as an example. To be able to determine the deformation process of restrained LECA masonry, the following actions are being studied:

- compressive stress
- tensile stress
- shear stress
- shrinkage
- creep
- change of temperature
- restrained shrinkage.

An important part of the experimental work has been carried out at Technische Universiteit Eindhoven, in the Netherlands. The supervisor during the period in the Netherlands has been Rob van der Pluijm at TNO Building and Construction Research.

By determining a relatively wide range of important material properties, the study has been largely instrumental in expanding the knowledge about the material behaviour of LECA masonry. While the composition and the properties of the raw materials of the LECA blocks are documented, the study will form an important basis for further structural analysis of performance and further product development of such masonry.

Even though a restrain shrinkage example was taken as a basis for the identification of interesting material properties, the experimentally obtained properties are relevant also for application of other structural problems. The validity of the properties is, however, limited to the LECA block quality '3/770' only.

In order to pave the way for finite element analysis and design of LECA masonry structures, experimental determination of relevant material/model parameters was carried out. A micro-model can be restricted in such a way to account for the quasi-brittle material behaviour of the LECA and the average in-situ properties of the applied mortar. By applying generic material models in DIANA (DIsplacement ANAlyzer), the current tests of LECA masonry subjected to uniaxial

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BELGIAN BUILDING RESEARCH INSTITUTE
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-GEOTECHNET-

European Geotechnical Thematic Network

A European Geotechnical Network called Geotechnet started operating on 1st December, 2001.

The general objectives of Geotechnet are to:

- establish and develop European networking
- optimise research efforts
- determine future challenges for Research and Technology Development (RTD) in the field of geotechnical engineering for the benefit of all in the European community.

Geotechnet aims to determine priorities that are described in special work packages in order to contribute to economic, environmental and social needs related to the major evolutions that geotechnical engineering is going through in Europe. These priorities include:

- the implementation of Eurocode 7 that is planned in 2002-2003 with a transition period of five years
- the introduction of innovative design methods
- a growing need for innovative construction on land of poor quality
- complex underground structures in urban areas
- the EU Water Directive due to be implemented in 2007
- an increased concern about the socio-economic impact of natural disasters, like earthquakes, landslides and floods.

As a result of these evolutions there are many ongoing European, national and regional RTD projects and Geotechnet has established a strong and well-balanced consortium of over 40 partners from 17 European countries. The consortium represents all relevant parties involved in geotechnical engineering practice including research organisations, universities, consultants, contractors, manufacturers of geotechnical equipment and end-users (national regional authorities or companies responsible for infrastructure works). This network will create a European platform for the dissemination of RTD results and technology transfer, streamline RTD activities and give impetus for co-operation within Europe. Special attention will be given to extending the Geotechnet network with the addition of a large number of corresponding members.

Main objectives of Geotechnet

- To disseminate know-how and results of European and National RTD projects, address geotechnical engineering issues in order to optimise research efforts and the fostering of co-operation, and to contribute to safe, cost-effective and environmental friendly construction. An on-line database will be developed to support these objectives. This database will be a full web portal, with a search engine and links not only to all partners, but also to European Members State platforms, to Geotechnet corresponding members and to centres of competence in the geotechnical RTD domain.
- To motivate and accelerate the implementation of Eurocode 7 and to establish recommendations for the convergence of the different NADs – National Application Documents.
- To stimulate and accelerate the use of innovative, cost-effective design methods.

operties for structural

tension and compression/shear gave satisfactory results.

Although the average stiffness and strength of mortar is usually somewhat higher than for the LECA blocks, a macro-model based on the LECA block properties should, in general, give sufficiently accurate results in global analysis of real structures. It must, however, be emphasised that the open perpend joint of LECA masonry makes the compound behaviour highly anisotropic. This anomaly represents discontinuity planes, which may be accounted for by interface elements representing predefined discrete cracks.

By adopting the experimental results of this study in generic material models available in general FEM-packages like DIANA, the models should generally permit analysis of structures with random geometry, boundary conditions and loading. Such analyses will cover the complete deformation process, from elastic behaviour via cracking to global failure. The full-scale testing of restrained shrinkage carried out in this study should serve as a suitable verification case for global analysis of LECA masonry.

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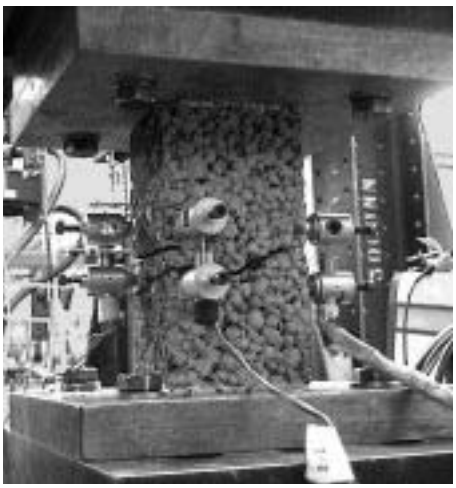
Deformation controlled tensile test of LECA block



Key innovative methods that will be considered are Finite Element Methods (FEM) and Observational Methods (OM). Geotechnet wishes to promote these methods and to demonstrate the proper use of them, via design exercises and a subsequent report on proper FEM use and applications of OM.

- To develop recommendations for improved health and safety conditions for workers and third parties during geotechnical construction.
- To evaluate the environmental impact of relevant geotechnical working methods with specific reference to the European Water Directives and to raise awareness of all parties involved of the implications of these future Water Directives. This will be achieved with the production of a practice document.
- To review data from natural disasters (e.g. earthquakes, landslides or flood) that can result in geotechnical engineering problems in order to determine the socio-economic impact and identify omissions in ongoing RTD. Recommendations of priorities for future RTD shall be established.

ENBRI members that are involved in the Geotechnet partnership are the Belgian Building Research Institute (BBRI), the UK's Building Research Establishment (BRE), Portugal's National Laboratory of Civil Engineering (LNEC) and Finland's VTT-Technical Research Centre.

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Smart structures – integrated monitoring systems for durability assessment of concrete structures

Since 1998 BAM has been involved in a BRITE/EURAM project dealing with the development of an integrated bridge monitoring system using new and inexpensive probes for monitoring existing structures. As a result, inspection and maintenance costs and traffic delays can be reduced. The most important deterioration mechanisms will be dealt with and the deterioration rates will be predicted by monitoring key materials parameters.

The major part of European infrastructure has reached an age where the capital costs have decreased, but the inspection and maintenance costs have grown to such an extent that they constitute a major part of the current costs of the infrastructure. The objective of this project is to produce an integrated monitoring system so that inspection and maintenance costs and traffic delays can be reduced.

The development of an integrated, modular monitoring system for new and existing concrete structures will be combined with enhanced deterioration models. A number of new inexpensive probes for monitoring existing structures will be developed to extend the functionality of currently available probes. Extensive laboratory tests of sensor performance and improvement were carried out at BAM before the complete monitoring system is applied to a real structure: the 'Skovdiget' bridge north-west of Copenhagen.

The monitoring will cover the parameters that influence or represent the most relevant deterioration mechanisms:

- chloride-induced corrosion
- carbonation of concrete
- freeze-thaw damage
- alkali-aggregate reaction
- mechanical damage.

The progress of these mechanisms can be predicted by monitoring key material parameters (temperature, moisture, pH and corrosion rate/initiation), either on the surface or as a profile through the concrete of the structure and the mechanical parameters (strain, deflection and vibration).

The final results will be:

- a manual for site-tailoring of monitoring system
- a prototype of an integrated model for damage development
- a prototype of new probes for:
  - moisture and temperature profiles
  - corrosion risk (corrosion current or time to initiation)
  - pH level
  - chloride concentrations
  - strain and deflection (based on optical fibers)
  - vibration and acoustics (based on optical fibers)
- local data collecting units combined with a long-distance data-transfer system.

It is estimated that the use of this system could generate reductions in the order of 15% of the current operating costs. In addition, the design of new construction projects will benefit from the improved prediction models, yielding an additional saving of around 10% in life-cycle costs.

The project is carried out by a consortium of eight European partners:

- G. M. Idorn Consult in RAMBØLL (Coordinator) – DK
- Force Institute – DK
- Bundesanstalt für Materialforschung und -prüfung (BAM) – D
- Autostrade Concessioni e Construzioni Autostrade S.p.A. – I
- OSMOS DEHACOM SA – F
- Danish Road Institute – DK
- S+R Sensortec GmbH – D
- Deutsches Zentrum für Luft- und Raumfahrt e.V. – D.

The consortium represents major consultant companies, scientific institutes, national road authorities, owners of toll-roads and specialists in sensor and monitoring technology.

The project was awarded a top-rating (A1) in the evaluation, placing it among the best 20 project proposals out of more than 600 proposals for European R&D funding. The project has a budget of 3 million EUR and represents a total of 250 man-months of work over 3.5 years.

Final results will be published at the beginning of 2002 and further details can be seen at http://smart.ramboll.dk/smart_eu/

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Monitored 'Skovdiget' bridge north-west of Copenhagen

Evaluation of roof insulation solutions

LNEC plays a decisive role in Portugal in the evaluation of both traditional and innovative thermal insulation solutions. Studies carried out either by LNEC's initiative or by manufacturers' request:

- increase LNEC's expertise knowledge
- offer manufacturers technical support at an early stage
- help designers and users in the choice of relatively unknown solutions.

In recent years an increasing diversity of roof thermal insulation solutions, aiming to reduce both winter heat losses and summer heat gains, is being offered by industry.

Two recent examples of such solutions and related research studies carried out by LNEC are:

- inverted roof insulation based on a special kind of expanded polystyrene boards (EPS) claiming to have very low water absorption characteristics
- a wide range of reflective insulation products based either in aluminium or metallised polyester foils facing polyethylene film, Kraft paper or flexible extruded polyethylene.

EPS boards in inverted roofs

These new EPS boards can be moulded in their final shape or obtained by cutting large-size blocks.

The study focused on the critical aspects of water absorption by immersion and diffusion/condensation, which can dramatically decrease the thermal resistance of EPS boards.

Laboratory long-term water absorption tests by immersion (EN 12087) and by diffusion (EN 12088) have been carried out on both types of EPS boards with densities ranging from 22 kg/m^3 to 31 kg/m^3. On both tests moulded boards showed much lower water absorption; corresponding best values were in fact quite similar to those usually obtained on XPS boards.

Field tests have also been carried out on an experimental inverted roof built in a LNEC's building (Fig.1).

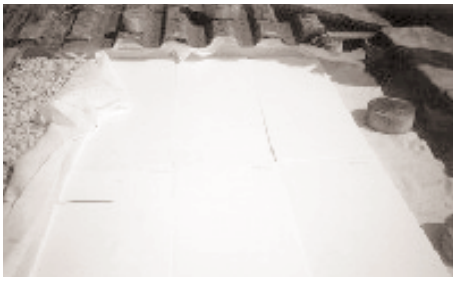

Figure 1 Experimental inverted roof with EPS boards

After two years of exposure, the moisture content of specimens removed from EPS boards has been measured at the end of two winters and one summer season. Moisture content, although somehow greater than those measured on XPS samples, was still relatively low (1% to 2% w/w).

Field monitoring of this experimental site will continue and a new field application is planned in the rainier northern part of the country.

Reflective insulation in pitched roofs

Reflective insulation bases its performance in the high reflectance and low emittance of bright metal or metallised surfaces.

Due to the high solar irradiation characteristic of most of the Portuguese territory, one can expect that the use of reflective insulation will be advantageous, at least during the sunny hot season.

In order to evaluate the real performance of such solutions a field research study has been carried out at LNEC. Two similar full-size test cells located in LNEC's Lisbon campus have been used. In the pitched roof of the attic of one of the cells different types of reflective insulation products have been sequentially applied (Fig 2). The attic of the other test cell was left uninsulated during the whole summer.

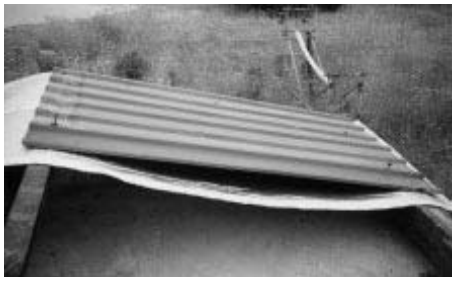

Figure 2 Experimental pitched roof with reflective insulation

Temperatures and heat fluxes were measured at various points and a comparative analysis of the thermal performance of both attics was performed.

Initial evaluations suggest that although daily thermal amplitudes were considerably lower in the insulated attic, average temperatures were quite similar in both test cells. During a winter season both test cells were electrically heated at the same temperature level. The insulated cell showed a slightly lower power consumption.

Further research is required in order to adequately assess and quantify the performance of reflective insulation.

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