

Implementation of new European standards for natural stones: the challenges in application



Laboratory work in the I-STONE project has revealed a number of areas in current stone standards which may need reconsideration as these standards are revised.

Implementing the new European standards

When trying to write national guidelines and/or application documents covering the new standards one has to assess the relationship between the laboratory test and the performance of the product in the construction. This is in many cases not possible since the new standards only cover material properties. The product properties included are mostly of dimensional character. A few examples of application problems in some standards are given below.

EN 1343: Kerbs of natural stones for external paving – Requirements and test methods

The required flexural strength of a kerb in the highest strength class, using a normal thickness (300mm) and width (120mm) and length (900mm) is 5.0 MPa. In Sweden, where granites are mostly used for this application, this is about one third of the mean of all Swedish granites. A granite with such a low flexural strength is most likely full of micro-cracks or severely aged.

The equation is, in principle, correct but table B1 has to be changed. In addition, observed damage (Figure 1) does not correlate to any property defined in the standard. A new test method may therefore need to be considered, maybe



Figure 1: Kerbstone damaged shortly after installation, most likely due to poor resistance to mechanical impact. A property not included in the product standard.

rupture energy? In the I-STONE project, one task is to focus on the relationships between material properties and product properties, e.g. in order to develop more object related tests. Laboratory test specimens with dimension in accordance with the standards have therefore been compared to full scale testing of kerbs (Figure 2). The results clearly indicate that a revision of the equation in Annex B also needs to be considered.

EN 12371: Determination of frost resistance

Frost damage is a complex phenomenon, and in many cases is accompanied by the influence of other mechanisms. In the Nordic countries and others, de-icing salts are commonly used on the roads,

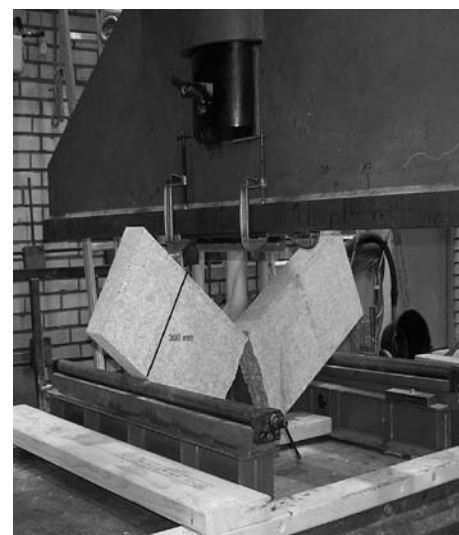


Figure 2: Full scale testing of kerbs to validate the equation in EN 1343 Annex B

In brief

The ERABUILD initiative

Readers of Construction Technology in Europe may be interested in the activities of ERABUILD. This EU funded activity ensures strategic cooperation between national (usually Government-funded) programmes promoting sustainable construction and operation of buildings.

ERABUILD has the long-term objective of supporting the creation of the European Research Area in research on sustainable development in the construction and operation of buildings.

A medium-term goal in this objective is establishing a trans-national R&D programme in the area whilst in the short-term the group aims to develop a learning network of government organisations active in the field of funding construction-related research.

You can find out more about ERABUILD at www.erabuild.net

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Progress towards FP7

At the end of September the Council adopted its common position on FP7. This was forwarded to the European Parliament for a second reading in late November.

Plans are in place to launch FP6 in late 2006 with the first calls in early 2007.

You can find out more about FP7 and progress towards its implementation at <http://cordis.europa.eu/fp7/home.html>

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streets etc. The influence of marine salts is quite common in many countries. In combination with freeze-thaw cycling this proves to be a very severe exposure condition, much harsher than winters with permanent temperatures below -20 or 30°C. The present European standard does not take this into consideration. In addition, there is a mismatch between the number of freeze-thaw cycles in different product standards without any relevant explanation.

EN 14157: Determination of the abrasion resistance

Testing of abrasion by use of the Wide Wheel Method (the reference method) has proven to give very poor correlation with the previously used national standards for the same purpose. Even the examples given in the standard clearly show that totally different correlation equations give the same rather poor correlation coefficients. However, much worse is the fact that the method fails to discriminate between several different qualities. This has a direct influence on the service-life of the product and the price a producer can charge for the product.

The Wide Wheel Method is scientifically unsound due to the simple fact that the testing conditions change during the actual test. The pulling force of the counterweight, about 14kg, initially works on the line of contact between the wheel and the stone specimens. During the test, the line gradually changes into a wider groove and the pulling force of the counterweight gradually decreases. This is in contrast to the weight applied on top of the specimens in the Böhme and Amsler methods. There the weight remains the same throughout the entire test.

EN 14231: Determination of the slip resistance by means of the pendulum tester

Slip resistance is a very important property since a slippery surface may easily cause severe human damage, which may be the case when a non-suitable stone or surface finishing has been chosen. The present test method has a poor reproducibility since the test result is very operator dependent. The same pendulum is used for aggregate testing. However, for those tests, the result is corrected for the value of a reference aggregate tested in parallel.

Sample conditioning

Drying in 70°C is the standard procedure for conditioning of test specimens in most standards. This is too high a temperature for many carbonate rocks. The TEAM project www.sp.se/building/team has clearly shown that degradation of several carbonate rocks (limestone and marble) starts at 40°C. TEAM has therefore recommended drying in 40°C in one week instead of 70°C in order to achieve relevant test results, especially when testing strength and mechanical parameters.

The above mentioned errors have to be corrected and with the first five-year standard review now due it is timely to consider the development of suitable revisions.

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Polymer cement mortar – composition and performance



Aiming at investigating the action of polymers on a cement matrix, polymer cement mortars (PCM) have been formulated, based on four polymeric families with growing application to the repair of reinforced concrete structures. The work mentioned in this article aims to extend the knowledge known about the main factors and the remarkable features of polymers and their effect on the performance of hydraulic cement mortar by showing the differentiated behaviour of each polymeric family.

PCM are traditional mortars with a new component – the polymer – which is usually added to the mixing water just as other chemical admixture, but at a dosage of 10% to 60% by weight of cement. Polymer admixtures that are being used with cements are dispersed polymer liquids (latex), re-dispersible polymer powders, water-soluble polymers and liquid resins. Since the 1940s, synthetic PCM and polymer-modified concrete (PCC) have been used in various applications, such as floorings, paving and adhesives.

At international level, significant work about the PCM characteristics has already been done by several authors, such as Dhir, Rixom, Mailvaganam and Lovell from the UK, El-Aasser from the USA, and Ohama from Japan. However, the state of art in some subjects remain insufficiently supported, such as: polymer action on the compressive strength of PCM, factors involved in the increase of tensile and flexural strength of PCM, the reasons for the reduced water absorption/permeability and oxygen permeability of PCM and predicting the weatherability of PCM.

An extensive research programme has been developed to investigate matters related to PCM applications to the repair of reinforcement concrete structures. Four polymeric families were used to modify the properties of hydraulic cement mortar – Styrene-Butadiene (SB), Vinyl (VAc), Acrylic (AS) and Epoxy (EP). Eight different polymer admixtures available on the Portuguese market were tested. The experimental work was to assess the influence of polymeric admixtures

on the unhardened properties of cement mortar. The experimental results revealed the simultaneous action of polymer admixtures as superplasticisers, air entrainers and setting retarders (Figure 1).

Both the PCM mechanical and deformability properties determination (Figure 2) and the porosity and penetrability were evaluated, as well as the main durability related properties (carbonation, resistivity and chloride penetration).

The characterisation of microstructure building in PCM (film formation, cement hydration) was carried out by scanning microscope observation (Figure 3) and radius X spectrograph.

In order to evaluate the influence of the compaction procedure, a comparison was established between vertical ('in-situ' simulating) and horizontal (laboratory simulating) applications of mortar. The analysis of experimental data was performed by mechanical and permeation properties of PCM.

Some artificial accelerated methods such as UV radiation and water exposure cycles and thermal tests were used to predict the PCM lifetime.

Due to the good performance of PCM with SB as a barrier against carbonation it was decided to study the carbonation resistance of PCM with SB at a natural ambient (XC3) and to assess it as a repair material for concrete structures.

The results revealed that inside each polymeric family remains a differentiated behaviour, more notorious on shrinkage. The negative action of polymer on PCM compressive strength and elasticity modulus was observed. The permeability changed with porosity according to $(At + Var)/C$. Internal curing by polymer action rendered PCM less sensitive to the lack of curing, reducing the paste micro-cracking. The size and shape of $Ca(OH)_2$ crystals in the matrix, as well as the transition zone between the binder matrix and the aggregates, are changed by the presence of the polymer particles and film.

This work opens the door to a new research programme within the scope of adhesion bond agents, chloride penetration in PCM, polymer action on capillary tension changes and dissemination of film formation on the porosity of PCM.

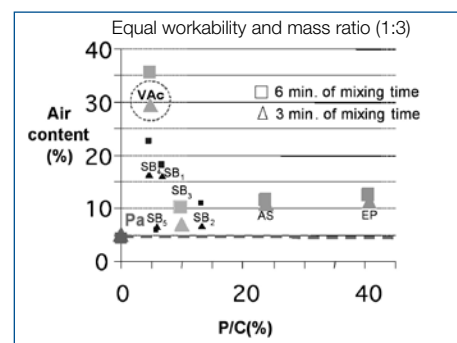


Figure 1: Air Content versus P/C Ratio of PCM and Reference Mortar (Pa). Rise of air content with mixing time

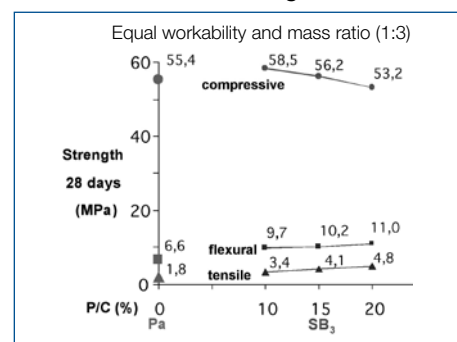


Figure 2 : Mechanical Strength versus P/C Ratio at 28 days of PCM of SB3 and Reference Mortar (Pa)

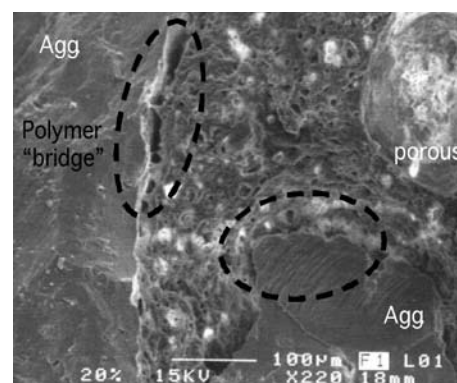


Figure 3: Polymer 'bridge' at the transition zone between the aggregate and the polymer cement binder of PCM with SB3, P/C=20%

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Numerous dangers still lurk in the indoor climate



Although it has been known for many years that poor indoor climate can cause illness, numerous dangers continue to be present in the indoor climate. Poor indoor

climate increases the risk of contracting cancer, cardiovascular diseases, infectious diseases and allergic reactions as well as a number of symptoms including headaches and irritation of the eyes and the respiratory tract. Moreover, a poor indoor climate is a nuisance and diminishes our comfort and overall wellbeing. This can be measured in the form of reduced productivity in offices and reduced learning capacity in schools.

This is substantiated by a new extensive review of status and perspectives relating to the indoor climate. The review was prepared for the Danish Environmental Protection Agency by a multidisciplinary research group coordinated by senior researcher Lars Gunnarsen, SBI.

Recently we have realised that the particles surrounding us, whether we are indoors or outdoors can pose a serious problem. Previous investigations show that particles originating from outdoor pollution sources cause 3,400 additional deaths annually in Denmark. In addition, there is an unknown number of deaths resulting from particles from indoor pollution sources. Both types of particles are present in the indoor climate. Danes spend 80-90% of their time indoors, so the number of additional deaths would presumably be much lower if the indoor particle pollution could be limited.

Particles are only one of many dangers that we are exposed to in the indoor climate. The researchers' review of the current knowledge about the importance of the indoor climate for the health and comfort of the Danish population points to a number of areas that we – and private sector, enterprises and authorities – should treat more seriously.

Everybody can do something

Primarily each one of us could limit the indoor pollution not only from tobacco smoking, but also from items like candles and wood-burning stoves. We should air our rooms more often to



'I believe we have to a great extent overlooked the risks connected with the indoor climate in dwellings' says senior researcher Lars Gunnarsen, seen here in a dwelling with heavy mould growth on the exterior wall of the living room. (Photo: Jørgen True)

prevent high relative humidity resulting, for example, from drying clothes.

The construction sector could take greater care of construction materials. These materials should not be left to get moist or wet on building sites. This can result in mould growth in the finished construction. Also it could limit the indoor use of materials containing substances that affect your health adversely, substances such as phthalates, formaldehyde and fungicides.

Building owners should provide careful maintenance to, prevent water damage that can cause problems for the indoor climate and ensure that ventilation systems work as intended.

Finally, the authorities could do something, for example in relation to the radioactive gas radon that leaks from the ground, into a building through cracks in the floor. Every year about 250 people die from lung cancer as a result of inhaling this gas. Researchers recommend that new buildings be checked for air tightness against the ground as stipulated in the Danish Building Regulations. What may be required is that the authorities initiate the development of recommended building solutions that can ensure air tightness.

Unfortunately, the review shows that particle pollution is far from being the only area where we know too little about

the indoor climate. In general there is a tremendous need for knowledge about the exposures we are subjected to in the indoor climate of our dwellings.

'I believe that we have to a great extent overlooked the risks connected with the indoor climate in dwellings. It seems a paradox that we spend more than half of our life there and that we know very little about how the indoor climate of the dwellings affects us. This is in contrast to work places and institutions, which are much better understood says senior researcher Lars Gunnarsen.

The report 'Status and perspectives relating to the indoor climate', financed by the Danish Environment Protection Agency, forms part of the follow-up on the Government's strategy relating to health and environment. The Government has selected the indoor climate to be an area of intensified research efforts.

For more information about status and perspectives relating to the indoor climate, please visit www.sbi.dk/lindeklima/generelt/status-og-perspektiver-paindeklimaomradet

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Atmospheres at the Musée des Arts Premiers



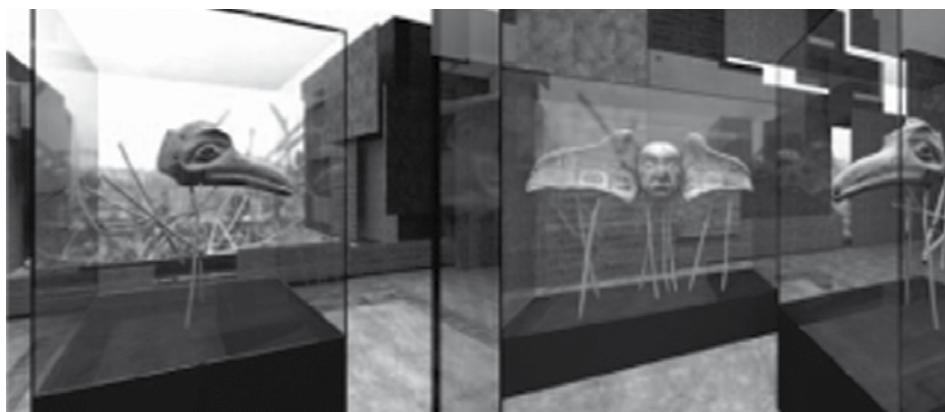
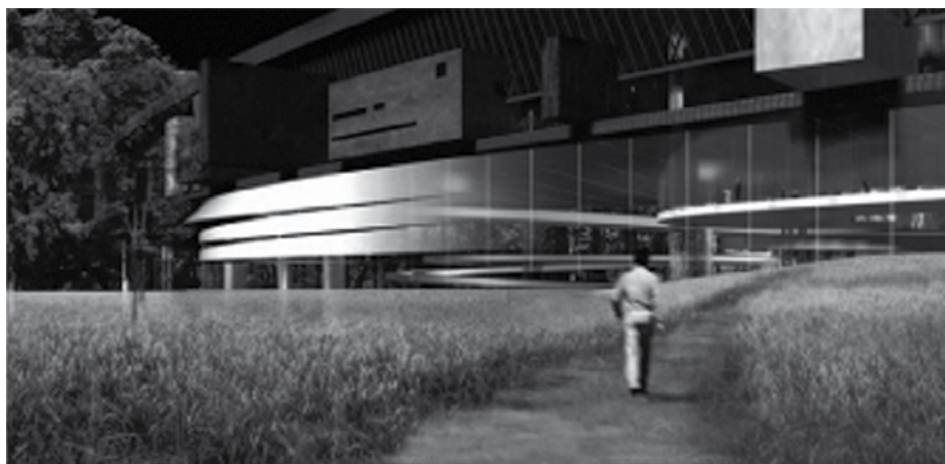
The Musée du quai Branly in Paris, which exhibits, studies and conserves the art and civilizations of Africa, Asia, the Pacific and the Americas, will group exhibits from the Porte Dorée museum and the ethnology laboratory of the Musée de l'Homme (Museum of Mankind). It will cover an area of 39,000 m² and will exhibit 300,000 objects, some of which have never been shown to the public before.

At the request of the Jean Nouvel architecture agency and the associated design and engineering offices ARCORA and INGEROP, the Musée du quai Branly

public corporation has asked CSTB to carry out a range of studies relating to the much-awaited Musée des Arts Premiers.

Designed by architect Jean Nouvel, the museum takes the form of a gallery on stilts covered with wood and hidden by dense vegetation. Also a conference centre, the museum is equipped with a media library and an auditorium. The building is located at the centre of a garden covering 1.8 hectares; it is protected from the traffic outside by a glass wall 200 metres long.

CSTB's lighting experts and aerodynamicists were consulted on two points: atmospheres and comfort (visual atmospheres, indoor lighting, climatic ambience of outdoor areas), and the sizing of the structure.



Winner of a European call for bids, CSTB has carried out project management tasks relating to the lighting of the museum: protection of the exhibits, visual ergonomics, management of the filtering of natural light.

Visual comfort first

CSTB was asked to study the natural indoor lighting and to optimise the lighting of the museum from several angles:

- protection of exhibits,
- visual ergonomics (reflections, and backlighting effects),
- management of the filtering of natural light to ensure visual comfort without distorting the view of landscape.

To do this, the team studied the availability of daylight within the museum before carrying out a virtual prototyping of visual atmospheres using the Phanie photosimulation software. Various design scenarios were envisaged, simultaneously varying the filtering of the bay-windows and the power of artificial light sources on statues modelled in three dimensions.

On a monitor calibrated to show the correct colour and luminance, the contractor and the contracting authority (client) were able to reliably display the project's appearance and true performance according to the real nature of the materials and light sources used.

These images synthesized by calculating the propagation of light, enabled all those involved in the project to work on a common medium and to decide which systems to install.

Outdoor climatic ambience and wind resistance

Carried out over a period of a few months, the studies involved three successive and complementary approaches, in particular for the study of climatic ambiances in the project's outdoor areas (garden and roof terrace, which will house a panoramic restaurant):

- a climatic environmental impact study qualifying the project's aerodynamic effects on neighbouring streets,
- exploration of wind-related atmospheres in the project's outdoor areas, with a diagnosis of sensitive points and an evaluation and quantification of the nuisances involved.
- work in consultation with the contractor and the contracting authority (client) in order to provide appropriate aerodynamic processing of uncomfortable areas.



Tests in wind-tunnels

Local and global stresses on front walls, screens and roofing components (including the dome) were also studied, while the dynamic behaviour of the acoustic screens and dome were also analysed.

For these two approaches, wind speeds and pressures had to be measured in order to quantify the phenomena involved. To do this, a physical simulation was carried out by placing a 1/200 scale model of the project.

Including its immediate environment within a radius of 300m, in an atmospheric wind tunnel (also currently called 'boundary layer wind tunnel') reproducing natural winds in an urban environment on a small scale.

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