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Integrating waste management into the design of construction products

CSTB's scientists have developed an overall approach to waste management, from the design of products to the demolition of structures. It is based on their environmental quality evaluation tools developed with the assistance of ADEME.

What can be done with the 31 million metric tons of wastes generated every year by building sites, and when the demolition of 15,000 low-rent housing units is planned for the year 2003 (compared with 4,000 in 1999)? The risks and rewards of sustainable development and the toughening of European legislation will progressively cause manufacturers to recycle as much waste as possible and to limit the amount that is dumped.

For this purpose CSTB has developed an overall approach to waste management ranging from the design of construction products to demolition operations. It has two objectives:

- to limit at source the amount of wastes generated by sites by studying the environmental characteristics of construction products as soon as they are designed
- to improve the management of such wastes by anticipating their production and collection, and by determining relevant recycling applications during construction, improvement and demolition operations.

The approach depends on tools developed by CSTB for the acquisition and organisation of data, aimed at assisting decision-making during the various phases of a building's lifetime.

Product design

Designed to evaluate the overall environmental performance of construction products, the EQuity 2 software is a life-cycle analysis tool. In particular it makes it possible to evaluate ways to reduce the amount of wastes generated by a product depending on the execution process, the type of maintenance or the type of building demolition involved.

Endorsement of products

Developed on the basis of data provided by Equity, INIES files (INformations sur l'Impact Environnemental et Sanitaire) give opinion-shapers, general contractors and contracting authorities (clients) a synoptic overview of the environmental and health effects of a product or family of products. They also provide information about the manufacture, installation, useful lifetime and final disposal of products.

'Monomur' incorporating recycled paper

Organisation of demolition sites

Taking into account the flows generated at every stage in a product's lifetime, particularly during its installation and useful lifetime, the GRADE (Grille d'Aide à la Décision pour l'Environnement) software program, which is currently under development, will be very helpful when organising improvement and deconstruction sites. It makes it possible to predict:

- procedures and materials that will be required to manage wastes, including both collection and sorting (e.g. skip for plastic wastes)
- hygiene and safety measures to apply on the site
- ways to limit pollutant emissions (dust, fibres, etc)
- nuisances (noise, smells).

Sorting wastes on a building site

in brief

JRC reorganisation
The Joint Research Centre (JRC) is reorganising to match new policy priorities and resources. The move aims to reduce costs and allow increased focus on two key policy areas of the environment and health and safety. The reorganisation will also include a cut of 200 posts.

Of interest to the construction industry is the establishment of an Institute for Environment and Sustainability (IES). The IES will focus on investigating air, water and soil contaminants and their effect on the environment and individuals and promoting a sustainable energy supply.

For more information, see: www.jrc.org

FP6 Progress
The timescale for implementation of FP6 suggests first calls emerging at the end of 2002/beginning of 2003. An outline timescale is:

July/Sept 2001	First reading by the European Parliament
Oct/Dec 2001	Common position of the Research Council
Mid 2002	Council and Parliament adopt final text, including budget
End 2002	Council to decide on 'specific instruments'
Beg. 2003	Launch of calls for proposals

"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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Wastes: rallying the construction industry

By chairing the 'wastes and construction' group, initially a French mirror group for European activities in the field of wastes and the construction industry, CSTB is facilitating relations between the various players involved including:

- manufacturers of construction products
- builders
- contracting authorities (clients)
- general contractors
- recyclers
- waste managers
- Ministries of the Environment the French Ministry for Facilities and Housing
- certification bodies.

A platform for recycled materials

At its site in Grenoble, CSTB is setting up a 'Recycled Materials for construction' platform that will use CSTB's evaluation tools.

Manufacturers will thus gain access to the regional (Rhône-Alpes) skills network dealing with 'management and use of wastes in construction' and will become eligible for diagnoses and feasibility studies for recycling activities.

The platform will develop its activities in synergy with platforms in Lyons (environmental evaluation of wastes, soils and materials) and in the Savoy region (environment-friendly design and waste recycling).

The software can also be used to organise deconstruction, providing for the transport of wastes according to their end-use or tonnage, for example.

Identification of recycling outlets

To help manufacturers to identify a waste-recycling activity, CSTB has designed a 'Recycling Diagnosis'. This makes it possible to estimate not only the technical, economic and environmental feasibility of any new process that uses 'secondary' raw materials, but also the performance of the resulting product.

The diagnosis is complemented by a charter of good practices for the incorporation of secondary raw materials into construction products. The charter, which will be published soon, defines rules for carrying out feasibility studies of activities selected to recycle wastes. It gives players advice about which approach to follow to ensure the relevance of the recycling activities and the social acceptability of the project.

With this battery of tools, CSTB is helping every player in the building industry to manage the environment in a sustainable way and is supporting them in their approach to quality.

Profile of a window made of recycled PVC

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Regulating energy performance in buildings

Under the Kyoto protocol, the European Union has committed itself to reduce the emissions of greenhouse gases (GHG) by 8% in the period 2008 to 2012 compared to the level in 1990. The emissions of carbon dioxide (CO_2), the most important greenhouse gas, are mostly linked to the combustion of fossil fuels and, therefore, increases in energy efficiency are expected to contribute considerably to the achievement of GHG emission reduction goals. In particular, energy use in buildings accounts for more than 40% of energy use in the EU.

In recent years considerable effort has been used at both national and European level to improve the energy efficiency of buildings. In particular, building codes have been tightened in most countries several times within the last three decades.

Many European countries have a building regulation element based on energy performance requirements. It may deal with aspects such as:

- transmission losses of the envelope
- ventilation losses
- performance of heating and cooling appliances and hot water supply
- lighting
- ventilation systems
- solar gains.

It may also deal with comfort aspects such as:

- thermal comfort
- indoor air quality
- visual comfort.

An energy performance evaluation assesses the total energy use of the building in one overall calculation procedure.

Nowadays, many EU Member States consider energy performance standardisation and legislation to be an attractive tool for increasing the energy efficiency of new and/or existing buildings. Several countries have an Energy Performance Regulation (EPR) in force (the Netherlands, France, Spain, Sweden, etc) and/or are preparing a new regulation (Belgium, Denmark, Germany, Greece, etc).

The background and the political reasons to implement such new approaches may be different from country to country. These different philosophies may affect the technical approach and the calculation procedures adopted.

In principle, the European Construction Product Directive (CPD) (1989) aims to create a European platform for the performance assessment of building components and systems in an open market. The standardisation activities in the framework of CEN and CENELEC are a crucial part of the practical implementation. All member states have to implement these standards at national level and withdraw any conflicting national standards.

Despite these European harmonisation efforts, when it comes to building codes, and energy performance legislation in particular, there are still major differences remaining between the various approaches, either existing ones or under development.

This situation represents some important disadvantages.

- There is a lot of redundant activity because most Member States develop their EP methods on their own with little collaboration with other Member States.
- There are probably major differences in the approaches and in the overall quality of the procedures. It must be possible to substantially improve the quality of most procedures.
- It probably creates (intentionally or unintentionally) new barriers.
- It represents a major barrier for innovation because industry is confronted with a whole range of different concepts.

Moreover, a new proposal for a European Directive on the energy performance of buildings is under preparation. It will impose on the Member States a need to apply minimum standards on the energy performance of new and renovated buildings based on a common methodology for calculating the integrated energy performance of buildings.

A major aim of the European SAVE project ENPER-TEBUC is to bring most of the national key actors in the field of energy performance calculation and regulation (both from scientific and political point of view) together to set up a platform for information exchange and to develop proposals for a European model building code. The project is the result of the clustering of two project proposals: ENPER (European collaboration in relation to ENergy PErformance Regulation for buildings and model code development) and TEBUC (Towards a European BUilding Code). In total, there are 21 research organisations from 15 European countries involved in this project.

The ENBRI members are well represented in this project. BBRI is project co-ordinator with BRE, CSTB, NBI, SBI, TNO and VTT playing key roles in the project.

A series of workshops is planned, of which the first one was held in Brussels on 18 June 2001. The workshop provided an overview of the present situation in European countries with respect to energy performance schemes and an understanding of the various approaches. In addition the impact of the new directive was explored. A second workshop will be held in Paris on 12 November 2001, dealing with innovative technologies and how these are evaluated in an energy performance scheme.

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Smoke control inside enclosed car parks – CFD study of jet fans

Motivation

The smoke behaviour inside enclosed car parks has been a concern for regulators. During fires the low floor height, typical of this kind of construction, makes it impossible to create a clear space below the smoke layer to provide a safe escape route for people. Furthermore, the large undivided floor area makes possible the mixture between smoke and fresh air, increasing the amount of smoke and cooling it. Currently, the solution found by regulators relies on the subdivision of the space in order to avoid the spread of the smoke and in the use of mechanical or natural ventilation.

Recently, jet fans suspended below the ceiling have been used in enclosed car parks to force the smoke flow to smoke outlets. This solution has been applied for years for pollution and smoke control inside road tunnels with good results, and it is expected that its use could avoid the subdivision of the parking space and the duct network. However, due to the general shape of car parking, the flow can be very complex and the location, direction and speed of jet fans must be carefully determined. Computational Fluid Dynamics (CFD) seems to be a helpful tool in order to predict accurately the expected flow patterns.

LNEC have developed and validated a CFD program to carry out simulations for smoke dispersion in enclosed spaces and is now performing specific studies on the underground car park of the Forum Algarve shopping centre near Faro in the Algarve region of Portugal. The car park, an open space of 58,450 m^2, has 2,070 parking spaces on one level. In this car park 186 jet fans were installed. Eleven smoke control areas were defined in the car park and the direction the jet fans operate depended on the location of the smoke source.

Smoke testing in an underground car park

Methodology

The work programme was established using the following steps.

1. Use of LNEC CFD code for natural ventilation fire scenarios.
2. Validation of CFD code for isothermal flow generated by jet fans.
3. Selection of typical smoke control zones to carry out simulations (three zones were selected: a corner, an intermediate zone with an obstruction in the flow and a zone with an opening in the ceiling).
4. Development of CFD predictions for isothermal flow as generated by jet fans for the selected smoke control zones.
5. Comparison of CFD predictions for isothermal flow with measurements carried out at the car park (the use of a fire source for validation purposes could cause undesirable damage to the working site, therefore only isothermal measurements could be carried out).
6. Development of CFD predictions with a fire source of 4 MW (corresponding to a small van fire) for the flow generated by jet fans at the selected smoke control zones.

Conclusions

Although presenting some local quantitative discrepancies, the numerical model results describe the general flow patterns and with fair accuracy the isothermal flow velocities. The model is expected to reasonably reproduce the temperatures of the field. Jet fans impose a general pattern of the flow that is only locally disturbed by the fire source. This general flow is able to restrict the smoke downstream and keep areas upstream clean. The smoke is diluted by the forced flow and the general temperature of the smoke zone is less than 80°C (except close to the fire source), that may reduce the possibility of fire spread. Furthermore, the predictions show that a thermal stratification still persists in a large part of the calculation domain downstream.

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Maintenance of pointing in historic buildings: decay and replacement

The project, in the field of protection of the cultural heritage, was carried out in the EUs 4th Framework Programme. Two universities were involved: the Politecnico of Milan and the Catholic University of Leuven; and two ENBRI institutes: CSIC/IET and TNO Building and Construction Research. TNO acted as co-ordinator.

The theme of the research project was the decay and replacement of pointing in historic buildings. The main aim was to assess:

- the causes of decay
- the possibilities, limits and risks concerning methods and materials used in replacement and repair of decayed pointing.

Research on the interaction between new mortars and original materials, in order to find a clue to material compatibility, was considered one of the most important guidelines in the project.

Work content

The research started with a desk study on the history of pointing, the materials and techniques used, the role or function of pointing and the differences in the countries involved.

Field studies were carried out in order to:

- define the type of damage originated by or related to pointing, and to characterise the material used for pointing (both ancient and modern mortars and ancient/traditional protective treatments)
- assess the causes of failure; study the compatibility of materials in masonry and the interaction of materials and environment (apart from pollution attack, mainly factors like salts, moisture, frost, etc) – see figs 1 and 2
- assess limits and risks of techniques used to remove old pointing and to re-point.

The laboratory research concentrated on the most recurrent damages and damaging processes met in the field in the four countries involved. The influence of the choice of a mortar composition on durability, and risk of damage to the existing older materials, was assessed.

Figure 1 Push out of pointing, provoked by salt crystallisation

Differences could be shown between compatible and incompatible mortars. As moisture (and salt) transport is a factor of extreme importance in decay processes, much attention was paid to transport phenomena. Nuclear Magnetic Resonance (NMR) apparatus, specially adapted to study moisture transport in building materials, was used to assess the influence of different pointing mortar compositions on the drying behaviour of masonry.

On the basis of field and laboratory studies, criteria were defined in order to assess the performance of pointing mortars as well as material properties, to ensure compatibility between mortar and substrate.

Results

The research resulted in:

- the development of methodology and techniques for the characterisation of ancient mortars
- the further development and application of advanced techniques, such as NMR
- the definition of requirements for compatible re-pointing mortars
- several decision tools for end-users, such as guidelines, an expert system for diagnosis and advice (MDDS) that will be available on the internet, and a damage atlas (see fig. 3).

Figure 2 Push out of pointing, provoked by frost action. The choice of the pointing mortar composition may determine the extent of the damage

Several national and international workshops were organised within the framework of the project to transfer the knowledge gained to end-users, i.e. maintenance organisations, restoration architects, building restorers and universities.

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Figure 3 MDDS, Masonry Damage Diagnostic System – on line

Self-compacting concrete

Self-compacting concrete can bring many benefits to the concrete construction industry, but in many countries it is not yet widely used. BRE's Chris Goodier explains the value of this technique and describes a new UK project to promote its use.

Self-compacting concrete (SCC) technology produces a very fluid concrete able to flow into and fill – without being compacted – spaces of almost any size or shape.

This can bring many benefits, particularly when casting conditions are difficult such as with complicated formwork or congested reinforcement. It also means that more slender building elements, and those of more complicated and architecturally interesting shapes, can be made to a high quality out of concrete.

Strength, stability and finish

SCC achieves this fluidity without loss of strength or any associated changes in durability. It also suffers no loss of stability; ie the concrete remains homogenous throughout, with the aggregates staying evenly in suspension rather than segregation occurring as might be expected in such fluid material. The resulting concrete has a high-quality finish without the surface blowholes and honeycombing sometimes associated with traditional vibrated concrete.

These properties are achieved through the use of increased quantities of cements and fine fillers, such as limestone powder, and the latest generation of concrete admixtures, to control the flow characteristics and stability of the concrete.

Self compacting

As its name indicates, a key feature of this technology is the concrete's ability to self compact. Normal concrete must be compacted to remove entrapped air within the concrete; this also helps to move the concrete around within the formwork. Compaction is normally done by inserting vibrating pokers into the concrete while it is being poured, a process that is unnecessary with self-compacting concrete. As well as removing a significant source of noise pollution from in and around the construction site, this avoids the health and safety issues that can accompany the extended use of compacting equipment, such as vibration white finger.

The fact that SCC does not need compacting – and the ease of its use – can potentially bring higher productivity and lower costs on site. However, these savings are currently offset by the higher material costs of SCC compared with traditional concrete.

To summarise, the main benefits of SCC include:

- reduced noise pollution from the construction site
- improved health and safety on sites
- a higher quality and range of finished product
- the potential for higher productivity and lower costs
- opportunities for more elaborate and exciting structures.

Photograph courtesy RMC Readymix

Showing a chimney constructed from self-compacting concrete

The need for research

The SCC technique is becoming increasingly used in Japan where it was originally developed. Some European countries, particularly in Scandinavia, are also adopting SCC in all forms of concrete construction, but in others, including the UK, uptake of SCC is slow – it is often perceived as a high-cost, high-strength, high-tech product for specialist applications only.

In view of this the Construction Industry Directorate of the UK Government's Department of Trade and Industry, is funding a BRE project to demonstrate that self-compacting concrete is suitable for wider use, and to promote the economic, social and environmental advantages it offers over traditional cast in-situ concrete construction.

This will be done over a three-and-a-half-year period, primarily through four key activities:

- reviewing current practice and new research and developments
- consulting with UK industry on its perceptions of SCC, particularly the barriers to and problems with its use
- researching the production of SCC mixes suited to the UK industry, plus information on their costs and long-term performance
- disseminating information through events demonstrating SCC and its advantages to industry, and through the publication of case studies and simple guidance material.

A User Group has been established to advise the project team on key issues, to provide contact points with industry, and to review the reports and plans for dissemination activities. The Group includes designers, contractors, producers and material suppliers.

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