ENBRI

Construction Technology in Europe

Spring 96 Issue 3

Regular digest of news from the members of the European Network of Building Research Institutes (ENBRI)

Indoor air quality in office buildings

SIXTEEN European research institutes in 11 countries, participated in the development of a common agreed Europe-wide method to investigate indoor air quality in office buildings. The budget of this European Audit project to optimize indoor air quality and energy consumption in office buildings, coordinated by TNO Building and Construction Research, was 1.6 million ECU.

This JOULE project started at the end of 1992, in which current methods as well as a trained panel were used to investigate office buildings all over Europe. The main aim of this EC-Audit was to develop assessment procedures and guidance on ventilation and source control, which help to optimize energy use in buildings while assuring indoor air quality. A common agreed European questionnaire and walk-through survey checklist were among others developed.

The participating institutes originated from The Netherlands (TNO Building and Construction Research had the coordination), Denmark, France, Belgium, United Kingdom, Greece, Switzerland, Finland, Norway, Portugal, Germany.

In the frame work of this project, in nine European countries a total of 56 buildings were selected. Measurements were performed at five selected locations in each building. The buildings were studied while normally occupied and ventilated to identify the pollution sources in the spaces and to quantify the total pollution load caused by the occupants and their activities and the ventilation systems.

The investigation in the spaces included physical and chemical measurements, assessment of the perceived air quality by a trained sensory panel and measurement of the outdoor air supply to the spaces.

A questionnaire for evaluating retrospective and immediate symptoms and perceptions was given to the occupants of the buildings. The building characteristics were described by use of a check-list. The annual energy consumption of the buildings and the weather conditions were registered.

The energy consumption varied substantially from building to building, with as much as a factor seven between the least energy-consuming building to the most energy-consuming building. The indoor air quality measured as perceived air quality, TVOC concentration and occupants' responses also varied significantly from building to building. No contradiction between energy consumption and IAQ was found, in fact some of the audited buildings showed both good indoor air quality and low energy consumption which demonstrates a significant potential for improved indoor air quality without consuming more energy.

The audited European office buildings in general showed rather poor indoor air quality, as perceived by the sensory panels, with some dissatisfaction among the occupants in spite of the high ventilation rates. One reason was that there were many substantial sources of indoor air pollution in the buildings.

This study quantifies that the occupants are a less dominant pollution source and that sources of pollution in the audited European office buildings comprised mostly building materials and components in the ventilation systems.

Source control is the first priority instead of dilution of pollutants by ventilation or by cleaning the air.

Source control must be applied to the materials, the systems and activities (e.g. smoking).

Outside some of the audited European buildings the perceived air quality was found to be poor. In some cases even poorer than the perceived air quality indoors. In such cases increased ventilation with outdoor air would not help to improve the indoor air quality.

Development for improved methods to clean outdoor air is recommended.

The control of the office environment was generally rated low by the occupants in the audited buildings, especially the control of the office ventilation. Adverse perceptions and building related symptoms are expected to be improved by individual control.

The sensory and chemical measurements and the inspection showed that the ventilation system is often a significant pollution source in itself. The system (especially the filters) should be properly maintained and cleaned.

One of the identified pollution sources in the European buildings was cleaning agents, so selection of proper materials for cleaning should also be considered.

The present procedure with a one-day building audit was successfully carried out in all buildings. In future building audits the method could be used and compared with the results from the present Europe-wide survey.

in brief

Construction projects in Brite-Euram III programme

It was reported in the last ENBRI Newsletter that the number of construction related proposals in the Brite-Euram III programme had risen from previous levels. Following the evaluation and selection process a total of 209 proposals were approved, of these 9 are construction related projects. This represents about 5% of the total projects approved. About 8% of the proposals were from the construction sector. Commission comments concerning construction sector proposals in general included:

- not enough "new players", particularly SMEs
- not enough new ideas
- many consortia "not balanced"

ENBRI EC Research Liaison Group

ENBRI has set up a group to liaise between member institutes on issues relating to the EC's Framework programmes. It is planned that network members will be able to exchange information on opportunities to secure funding to ensure that these opportunities are implemented efficiently, securing maximum benefit to both ENBRI members and the European construction industry in general.

Proposal for an EC Task Force: Building Tomorrow

The European Council for Construction Research, Development & Innovation (ECCREDI, of which ENBRI is a member) has formally made a proposal to the relevant European Commissioners (Mr Bangemann, Mme Cresson and Mr Kinnock) that a Task Force be set up to review the construction industry's needs for R&D. Called "Building Tomorrow", the proposed Task Force would identify priorities for research activities in close co-operation with industry and research bodies from all Member States. The Commissioners welcomed the proposal, however, no decision has yet been reached regarding its implementation.

Predicting strength of nailed tim

According to modern seismic design codes, it is generally accepted to take advantage of the ductility and energy dissipation capability of timber structures with mechanical fasteners, if a suitable behaviour of their structural joints under alternating load cycles is proved by testing. However, the experimental characterisation of joints is generally time consuming and expensive.

The behaviour of these dissipating mechanisms, which conditions the overall ductility, is particularly important in the seismic design of buildings, as it allows a much more economic design than if every member of the structure had to be kept in its elastic range.

The establishment of numerical models to predict the behaviour of structural joints subjected to monotonic loading has been successfully done for many years, based on the properties of the materials involved in the joint, namely the embedding strength of timber.

Nevertheless, in what concerns their dynamic behaviour and the assessment of ductility, most numerical modelling developed so far correspond to empirical models fitted to joint test results, which are of difficult generalisation.

A research programme (developed mainly during 1989-93, in collaboration with Brighton University) aimed to extend to the case of timber joints subjected to alternating load cycles the general approach of using embedment test data to develop numerical models able to predict the joints strength and their energy dissipation capability.

The experimental programme involved monotonic and cyclic (tension-compression) embedment tests on wood and plywood, using loading parallel and

Hipervib: *International competition on vibratory driven piles installation, especially on drivability and environment hindrances*

BELGIAN BUILDING RESEARCH INSTITUTE
WTCB - BBRI - CSTC

The technique of settling foundation elements (piles or sheet piles) using vibrating drivers has largely emerged over the last two decades to the detriment of the hammer, but many problems have arisen due to the total lack of reliable methods predicting the vibration drivability and the hindrances generated by this technique to the environment. Because of this contractors have worked according to the principle of tests and errors, but the cost of these errors was often very high.

The manufacturers of engines have also progressively improved their equipment and developed some empirical prediction methods.

This research work, developed within the framework of a collaboration between France, Belgium and United Kingdom, had a double aim. Firstly, developing a new generation of vibrators allowing the permanent adaptation of their performances according to the geotechnical conditions variable in depth and in site as well as a reduction of the environment hindrances. And secondly, developing a mathematical model allowing a good prediction of the settling aptitude, of the level of vibrations and noise transmitted to the neighbourhood.

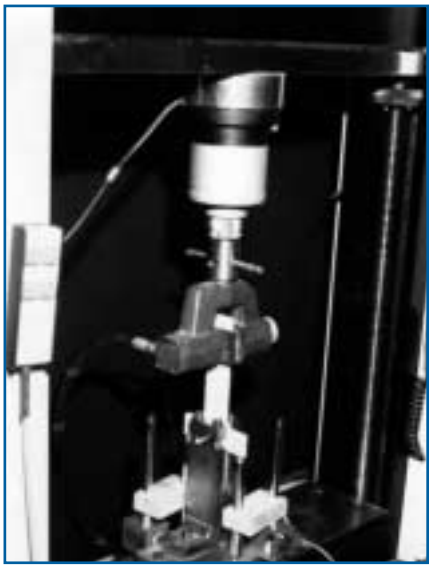
Equipment similar to those developed during this research are beginning to be used all around the world and could soon become the standard equipment used on sensitive sites especially in town.

The use of prediction models is not yet widely spread but a research campaign set up by the whole group of European manufacturers of metallic sheet piles will work for it.

It always takes longer to convince people that they should first carry out design studies than that they should use new machines or techniques.

Contact: Christian Legrand, CSTC / WTC

r joints under loading



perpendicular to grain, two moisture content levels (12 and 18%), untreated and CCA preservative treated wood covering a wide range of wood density. The main objectives of these tests were:

- to assess the influence of these parameters in test results (embedment strength and the related dissipated energy);
- to collect data suitable for the establishment of constitutive laws for the modelling of structural timber joints under alternating cyclic loading.

Cyclic tests on a number of nailed timber joints were also conducted to verify the predictive ability of this approach.

It was concluded that timber treatment has a negligible effect on test results and that moisture content highly influences strength but not the energy dissipated; three-parameter exponential functions were fitted to load-embedment envelope curves, and hysteretic loop diagrams were approximated by linear and polynomial expressions, subsequently used to feed the joint numerical model, together with relevant nail properties.

The same approach should be suitable for other joints with dowel type fasteners and different loading.

Results showed that embedment properties of wood (strength and dissipated energy) can be predicted on the basis of wood density and on the loading pattern applied, and that these can be used to predict the strength and the ductility (energy dissipation) of structural timber joints made with mechanical fasteners subjected to alternating load cycles.

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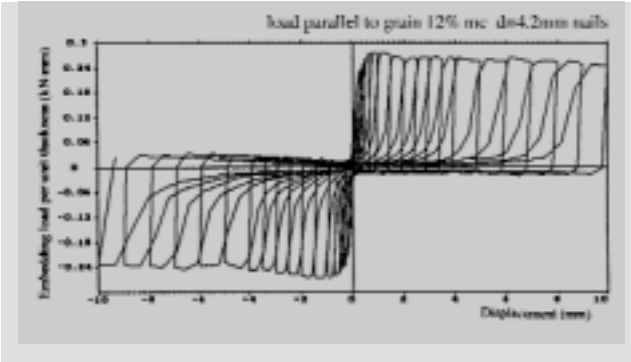

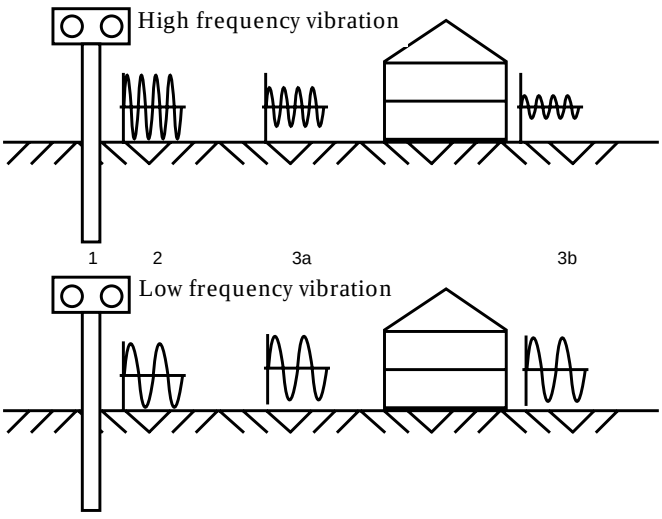

Key:

1 The foundation element is being driven into the soil by means of a vibrator

2 A significant part of the vibration energy is transmitted to the environment

3 During the propagation, the damping (amortization) of high frequency vibration is relatively high compared with the low frequency and the influence on buildings is really low (3b)

Air quality stud

SBI

The **air quality laboratory** provides unique opportunities for studying conditions influencing the air quality in buildings

- how the environment (temperature, air humidity, the concentrations of air pollutants), the age of the materials and operational conditions (cleaning and maintenance) influence the emission from building materials;
- how the adsorption and desorption processes affect the air quality.

The laboratory offers the possibility for simultaneous sensory assessments performed by persons and chemical measurements of material emissions in small test chambers. *(pictured above)*

The air quality laboratory can be used for simultaneous testing of up to 24 different materials in small test chambers or for full-scale experiments in two individual chambers.

The laboratory is also used to investigate how microbial growth on building

The constructio

VTT BUILDING TECHNOLOGY

VTT Building Technology has conducted a study on the construction markets of the Baltic Sea Area. In addition to an English-language report, Finnish-language reports on various countries' sources of information on the construction branch and national and international financial support have been compiled.

Separate surveys of the construction markets of Germany, Poland, the Baltic states and St. Petersburg have also been made. The researched area included Germany (old and new states), Poland, Latvia, Lithuania, Estonia, St. Petersburg, Finland, Sweden, Norway and Denmark.

In 1994, the value of the construction market of the Baltic Sea Area was about USD 400 billion, i.e. about half of that of the EU market. Germany dominates the market with an 80% share. The market of the new German states is significant – equal to the combined Nordic market.

A total of about 670,000 new dwellings were produced in the Baltic Sea Area in

s in the lab and real buildngs

materials is influenced by building, humidity and material technical conditions.

Calibrating, testing and further development of air change measurement techniques is also carried out in the air quality laboratory.

Contact: Henrik N. Knudsen.

PFT equipment for air change measurements

The PFT technique (**P**er**F**luorocarbon **T**racer) is used to measure ventilation conditions in buildings in use.The technique is a multiple tracer gas method based on passive sampling. It makes it possible to perform large-scale field investigations in a simple and economically feasible way.

The technique provides an opportunity for measuring in different zones of a building because several different types of tracer gasses can be used simultaneously.

The PFT technique makes it possible to determine the total outdoor air supply to the building and the outdoor air supply to each individual zone and the internal air exchange between the zones.

The PFT technique involves using equipment consisting of tracer gas sources and adsorption tubes for use in the field and stationary equipment for analysis in the laboratory.

Contact: Niels Christian Bergsøe.

narket of the Baltic Sea area

1994. The old German states and Finland built the most dwellings in relation to population: nearly 6 units per thousand people. The corresponding ratio varied from 1.5 to 3 in Poland, the Baltic states, St. Petersburg and the new German states. Denmark and Sweden produced the least dwellings of the Nordic countries.

The construction markets of St. Petersburg and the Baltic states are still small measured in Western currencies. The markets are much larger measured, for instance, in terms of completed housing units. St. Petersburg produces the same number of new housing units as Sweden and Norway.

The Baltic Sea Area construction market grew by about 5% in 1994 and 3–4% is predicted for 1995. Construction has increased in the Area countries with the exception of St. Petersburg and Lithuania. The new German states have seen the strongest growth.

The focus of construction in the Baltic Sea Area has been on new building construction. In 1993, the sector's share in the Area was about 55%, while it was 47% in the EU. New building construction has, however, decreased in many countries and renovation and modernization has increased. In 1994, the share of renovation and modernization will exceed that of new building construction.

The large differences in economic development between the Baltic Sea Area countries are also shown by the per capita spending on construction. Germany and the Nordic countries spend about USD 3,000 per citizen annually on construction. The corresponding figure for Poland is about USD 350 and for the Baltic states and St. Petersburg about USD 100.

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Machine strength grading of timber

According to Eurocode 5 – the European timber design code – timber for structural use shall be strength graded. The grading can be made either by visual inspection or with a grading machine. The main advantage with machine strength grading is a more correct evaluation giving a better yield, especially in the higher strength classes.

A strength grading machine uses one or more non-destructive measuring devices to determine timber properties which correlated to the strength. These properties can be timber stiffness, density, slope of grain, size and location of knots etc.

The traditional technique is to bend the timber and measure the bending stiffness. The progress on the computer side has now opened up other possibilities such as image analysis for defect detection, which was not possible a few years ago.

SP is working on a number of different projects aiming at improved machine strength grading of timber. The research is carried out in collaboration with institutes in the Nordic countries, Great Britain, France and others. The following is a selection of activities that have been carried out:

- Questionnaire study of the industry needs. The most important requirements for strength grading machines are trouble-free operation, correct grading, and the possibility of internal machine control.
- Procedures and equipment for calibration. Due to the European harmonisation, it is important that all machines are controlled and calibrated in the same way. The development of procedures and equipment for such calibration is therefore of great importance.
- Machine settings for different strength classes. In the European standard EN 338, nine strength classes are specified for softwood sawn timber. Machine settings must be established for the strength classes concerned. Furthermore, different machine settings must be used depending on factors such as timber dimensions and moisture content.
- Improvement of existing bending machines. There is a major problem concerning vibrations in the existing bending machines, which leads to a down-grading of the timber. This problem can be solved either by software filtering or by mechanical damping.
- Development of new machines using different measuring techniques. There are many different non-destructive techniques that can be used. Timber density can be measured with X-rays, gamma-rays or micro-waves. Timber stiffness can be determined by measuring the resonant frequency, or the speed of a pulse travelling through the timber. Defects such as knots can be detected and measured by different camera techniques, as well as by radiation methods.
- Approval of new machines. Before a new machine can be introduced to the market it must be approved. The machine is throughly inspected and tested before an approval is issued.

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BREEAM: Environmental performance assessment for buildings

Environmental performance is of major importance to any organisation wishing to thrive in a competitive marketplace. Businesses throughout the UK are recognising this as a key corporate objective with substantial business benefits. They are also now recognising the role of buildings as an important and effective means of achieving rapid and visible improvement.

BREEAM (the Building Research Establishment Environmental Assessment Method) is a world leading independent and authoritative method for assessing the environmental performance of both new and existing buildings. Developed by the Government's Building Research Establishment (BRE) with the private sector, it presents an opportunity to measure and visibly demonstrate a building's environmental quality and provides a powerful marketing and auditing tool for developers, designers, landlords, occupants and managers.

BREEAM draws on the latest scientific knowledge of the wide-ranging effects of buildings on the environment and can help demonstrate environmental achievement. It provides visible recognition of improved environmental performance and communicates the commitment made to customers, staff, shareholders or legislators alike.

World class research on the extremely diverse range of environmental issues underpins the BREEAM methodology. There are currently five BREEAM schemes in operation, covering new offices, existing offices, industrial units, superstores and new homes (known as The Environmental Standard Award). Each scheme has been developed and designed by BRE with the help of a wide range of organisations in the construction, property and environmental sectors, together with the support of Government.

Assessments for each scheme are carried out by independent assessors that are licensed and strictly quality controlled by BRE, and when a assessment is completed, a certificate is provided as visible recognition of the achieved environmental performance of the building.

BREEAM provides a complement to regulation and awareness programmes by establishing a market mechanism which achieves competitive advantage for assessed buildings of higher environmental quality. It thus provides a prestigious market place reward for developers and operators seeking to achieve best environmental practice.

As well as providing advice to governments, BRE also provides services in a number of related specialisms including indoor air quality, sick building syndrome, and building on contaminated land.

BRE is also noted for its wide range of testing, demonstration and laboratory facilities at Watford, including a major air conditioning evaluation facility (where research is carried out into the efficiency of air conditioning systems), lighting and acoustic laboratories and a matched pair of houses used for research into energy use for the domestic sector.

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Overcoming damp in buildings

Researchers at CSTB have developed software to predict water and heat transfers in buildings throughout their lifetime so that structural components can be designed accordingly.

Each year, the outside walls of a house are exposed not only to some 60 tonnes of rain but also to the water vapour produced by the inhabitants and their activities i.e. 8 to 20 kg per day for a family of four.

Hygroscopic materials used in construction are also the seat of moisture exchanges. First, the concrete must dry, after which the framework of the building exchanges 200 to 300 kg of water with the ambient air between summer and winter.

Furniture, paper and clothing absorb and release about 150 kg of water between winter and summer. A total of nearly 500 kg of water are thus transported over à one-year period.

These impressive quantities of water are mainly evacuated by air renewal. The inside air, which is continually laden with water vapour, always has a higher moisture content than the outside air. This phenomenon is accentuated in winter when the very cold outside air can only contain a small amount of vapour.

Day after day, the resulting imbalance causes water to accumulate in the building, resulting in mildew, dust mites and damage to the actual structure, particularly cracking.

In order to evaluate this phenomenon more accurately and incorporate it into the design of buildings, researchers at the CSTB have developped a series of software programmes to simulate the behaviour of the building's structural components under the action of heat and moisture in the course of time.

It is thus possible to completely define the reactions of a façade component when subjected to climatic stresses, for example i.e. in terms of temperature, relative humidity, partial water vapour pressure, moisture content, etc.

These models were also used by CSTB researchers to develop an anti-condensation system for the façade of the National Library of France. Today, the software is used to design efficient outside insulation systems particularly by the reduction of thermal bridges.

On a microscopic level, the behaviour of materials requires a detailed analysis of the phenomena involved. This basic research is more especially conducted by the CSTB's Materials Department in Grenoble.

The measuring and forecasting methods developed by the CSTB's various teams in the field of hygrothermal transfers therefore cover every aspect of the question, from a microscopic scale to a complete building including its occupants.

The analytical means currently available are the result of large-scale investments in scientific and technological research. All the physical phenomena involved and the combined transfers of heat and water in liquid and vapour form, have now been represented by more complete models than any available before.

The new models required the implementation of an adequate definition procedure. Simulation software also had to be developed so that the models could be used. The migration of water in liquid and vapour form in building components can now be described with sufficient precision. With conventional models, such as "Glaser", it was only possible to estimate the risk of the liquid phase appearing - studying the real development of moisture in hygroscopic materials was impossible.

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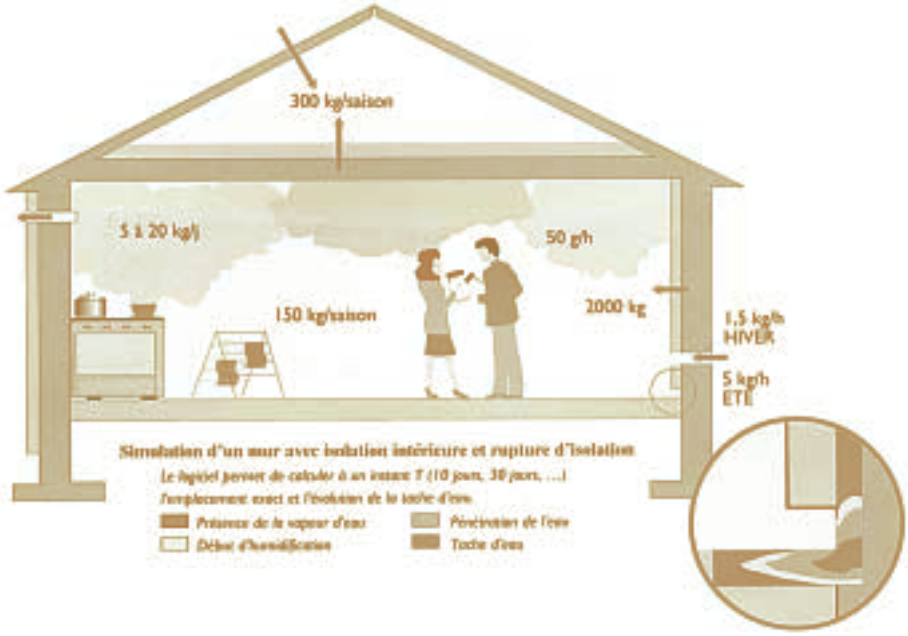

Published on behalf of the European Network of Building Research Institutes (ENBRI) by BRE.
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