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Progress in European research project on the recycling of building rubble

BAM

THE technical objective of this Brite-Euram project is the reuse of processed demolition rubble for the production of cement as well as for manufacturing concrete, both of a high quality.

The speciality of the project is the exclusive use of material from processing plants. This is to demonstrate the technical feasibility in cement factories and concrete mixing plants and to avoid simply academic studies.

More than 60 tonnes of processed material were taken from 13 places in Germany and the UK for the tests on concrete. Additionally 20,000 tonnes were taken from Spain for the intended investigations on cement manufacturing. It can be anticipated that these samples are representative of the processed rubble from concrete structures in Europe.

Though two of the selected materials contain considerable amounts of ceramic and sand lime bricks and another one contains a remarkable proportion of asphalt, the project focuses on concrete rubble which usually is more or less free of other materials.

In the course of selection the state of the art of the actual processing technique was assessed by visual inspection and by additional questionnaires to more than 50 plants.

The cost of well processed concrete rubble ranges from 3 to 4 ECU in Spain, 3.4 to 6.2 ECU in UK and 2.5 to 7.5 ECU in North West and Central Germany and even up to 11 ECU in the Berlin region. The cost depends on the local market of natural aggregates and the economic conditions.

The previous results prove, in principle, the feasibility of both methods of reuses. The partial replacement of natural raw materials for the cement production appears possible without impairing the cement quality and increasing the pollution.

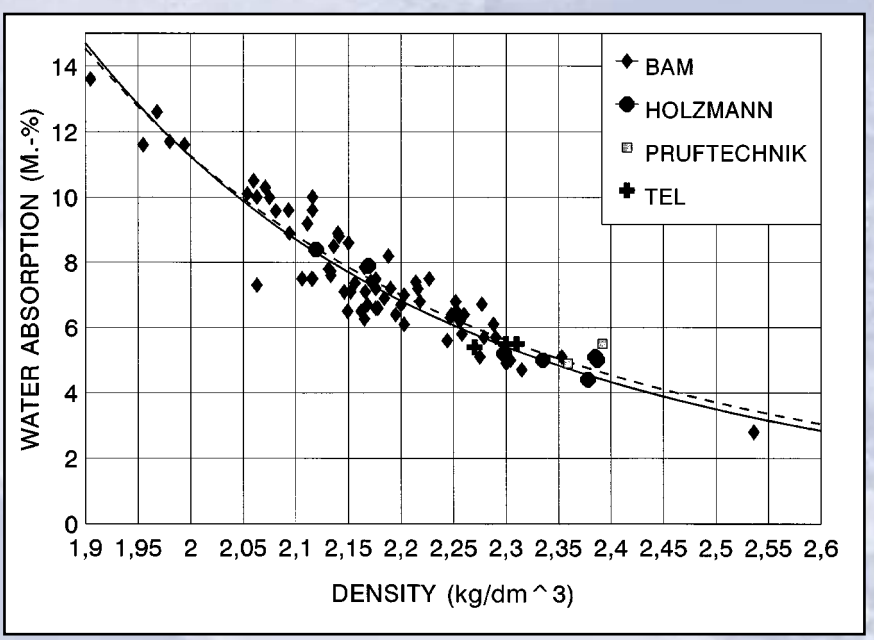
The partial as well as total replacement of gravel in concrete mixes also gives graded concrete so far as the test results are available. The study of the long-term behaviour, i.e. creep and shrinkage, strength development and durability aspects, is still going on.

With regard to the characteristics of recycling aggregates, the short-term and total water absorption of the particles are the most important ones. An excellent correlation of die water absorption and density was found, being valid for all materials used by the four partners in the project with concrete as the main constituent *(see figure)*.

The strength as well as elastic parameters seem to depend not only on the water / cement ratio, based on total or effective water proportion, but also on further properties of the particles. These are, for example, the particle shape and density.

The very different approaches the partners are using for the concrete mix design and mixing procedure cover the conditions that might occur in practice. They range from optimisation of composition to the “worst case”. Nevertheless, the results suggest very good properties of the hardened concrete when compared with conventional concrete. The partners are confident that they will successfully complete the project in the provided period and enhance the graded reuse of building rubble.

For further information please contact
Dr.-In. Matthias Maultzsch.
Tel +49 30 81 04 17 10,
fax +49 30 81 04 17 07.



The Technologies of Recycling edition

in brief

Framework Five Progress

The European Parliament, Council and Commission now have agreed positions on the structure of the Fifth Framework Programme (FP5). All have agreed on FP5 comprising four Thematic Programmes although there are some differences in the Key Actions within these Thematic Programmes. However, these differences are relatively minor. The major difference between the positions is in relation to the budget. The Council have proposed a budget of 14 BECU whilst the Parliament propose one of 16.7 BECU. It is expected that this difference will mean that an agreement between Parliament and council will not be reached by September 1998. This would trigger the conciliation process between the Parliament and Council. This process, which has a set timetable, will be jointly chaired by Austria (in their role of Presidency of the Union) and the European Parliament. It is likely that the Key Action of most interest to the construction industry - The City of Tomorrow and Cultural Heritage - will be in the Energy and Environment Key Action.
At a recent conference a representative from the Commission expressed the view that calls for proposals from FPV should start in "early 1999".

Environmentally Friendly Construction Technologies

The EC-funded Targeted Research Action (TRA) "Environmentally Friendly Construction Technologies" is now a well-established activity in the field of EC-funded construction-related research. In its first year of activity the TRA has held a major workshop and several topic-specific workshops, established a website and produced and distributed four issues of its newsletter. For further information on the TRA visit their website on http://www.tra-efct.com

Executive Secretariat ENBRI
c/o WTCB-CSTC
rue de la Violette, 21-23
B-1000 BRUSSELS, Belgium

Tel: +32 2 716 42 11
Fax: +32 2 725 32 12

Netherlands seeks more opportunities for high quality reuse of concrete and masonry

UNDER the auspices of a research Committee of The Centre for Civil Engineering Research and Codes (CUR) in The Netherlands, TNO Bouw and Delft University of Technology (Faculty of Civil Engineering) are engaged in a research project that aims at increasing the opportunity for reuse of concrete and masonry rubble as coarse aggregate in structural concrete.

A leading position for the Netherlands
Generally it can be seen that the importance of reuse of concrete and masonry rubble was first recognised in densely populated countries where there is only limited land space for dumping demolition debris. So, in the Netherlands in the early eighties an extensive research project in which the consequences of replacing traditional aggregates (gravel and sand) in concrete by recycled concrete and masonry was performed. The first recommendations giving the requirements with respect to the aggregate properties date from 1984.

Since the early nineties it is allowed in the Netherlands to replace 20% (by volume) of the coarse aggregate in concrete by concrete and masonry aggregate with the restriction that the total amount of masonry aggregate is not more than 10% of the total coarse aggregate volume. For these percentages of replacement of coarse aggregate there are no additional rules compared to concrete with 100% traditional aggregates like river gravel.

To higher replacement percentages
In current building practice there is a desire to replace more of the traditional coarse aggregates in concrete by 'menggranulaat', which is a mix of concrete and masonry aggregate. By definition the percentage of concrete aggregate with a volume weight of at least 2100 kg/m^3 in 'menggranulaat' should be higher than 50%. Based on existing knowledge, in 1997 a CUR-recommendation was issued that gives additional rules for the application of 100% 'menggranulaat' in concrete walls in lower safety classes. The recommendation applies to concrete strength classes up to B35 and to the milder environmental classes 1 and 2. With respect to various design rules the same approach is followed as for lightweight concrete. So for example Young's modulus, a multiplication factor based on the oven-dry volume weight of the concrete, has to be used.

New research project
In order to be able to widen the scope of the CUR-recommendation for more applications it was decided first to perform a research project in which the behaviour of concrete with 'menggranulaat' is further investigated. Besides verification of basic material properties and a number of phenomena like shear capacity, bond behaviour and behaviour under concentrated loads, there is special interest in the time dependent behaviour: shrinkage and creep. The limited amount of experimental results available so far points to the fact that compared to lightweight concrete time dependent deformations are significantly larger. Besides shrinkage and creep tests on small specimens the deformation behaviour of horizontal load carrying elements will also be investigated by comparing similar elements made from river gravel concrete and concrete with 'menggranulaat'. For the concrete strength class B25 as well as B45 will be used.

For further information contact: Dr Dick Hordijk at TNO Bouw. Tel. +31 (0) 15 284 2145, fax. +31 (0) 15 284 3976, email: D.Hordijk@bouw.tno.nl

Characterisation of recycled aggregates and p

THE research examines the use of aggregates, derived from crushing and treatment of construction and demolition rubble, in new concrete products.

The first phase of the study concerns the characterisation of aggregates: grading curve, mass per unit volume and presence of polluting substances have all been evaluated. In addition some characteristics influencing the aggregates' behaviour have been analysed:

- water absorption (greater than natural aggregates due to grains microporosity) which modifies concrete's water/cement ratio and therefore its workability
- production of fine fractions during the mixing phase; these modify the grading curve and must therefore be known and controlled.

In the second phase, the characterised aggregates are used to prepare different concrete mixtures whose properties are then analysed with fresh concrete (required water amounts, workability) and hardened concrete (tensile strength, modulus of elasticity, shrinkage).

To date, the performance of the following mixtures have been examined and compared

EC training contract awarded to BRE Cardington

RECOGNISING BRE Cardington as the world's premier facility for whole building studies on multi-storey steel, concrete and timber structures, the EC recently awarded the facility with a contract for the training of European researchers.

TMR, the Training and Mobility of Researchers programme run by the Science, Research & Development Directorate of the EC, finances the participation of young researchers in unique and innovative research projects across the European community. Its aim is to assist in the development of a future generation of leading European scientists.

With three full scale buildings in concrete, steel and timber, BRE Cardington, a former airship hangar located 70km north of London, is the largest enclosed experimental facility in the world. Under the TMR programme it offers an exciting opportunity for young European researchers to be involved in its ground-breaking whole building projects.

- Constructed in 1993, the steel framed building is similar to a typical London headquarters office block, eight storeys in height. It has been subjected to extensive construction process and performance projects at domestic and European level. Further work will explore the potential for repairing the fire damaged steelwork
- TF2000 is a six-storey timber framed building, the largest of its kind in Europe. It is being tested to ensure the provision of a sound basis for design and construction of medium rise timber frame buildings. Its aims to demonstrate the benefits of timber frame construction against proven benchmarks.
- A seven storey in-situ concrete frame building is soon to be completed. Part of the European Concrete Building Project (ECBP), the building is the first of four (in-situ, precast, hybrid and innovative) to be constructed at the facility. Research will initially focus on the construction process aiming to reduce costs, increase the speed of construction and improve quality.The ECBP is currently the biggest, most ambitious concrete research programme in the world.

Dr David Moore, Head of the Centre for Whole Structure Behaviour, who will manage the contract says: "BRE Cardington has never had a more exciting time with three major whole building projects under way in concrete, steel and timber. The TMR project will run for two years and offers a real opportunity for young researchers to be involved at the cutting edge of industry advancements."

If you would like to be involved in the TMR programme or would like further information, please contact Dr David Moore, BRE, Garston, Watford, WD2 7JR, UK Tel +44 1923 664578, fax +44 1923 664096, email mooredb@bre.co.uk

erformance verification of derived concrete products

with different groups of tests:

- mixtures containing 100% recycled aggregates
- mixtures containing recycled aggregates only for the coarse fraction (59%) and natural aggregates for the fine fraction (41%)

Mixtures	*Average breaking resistance(kg/cm²)*		*Average density (kg/m³)*	
	After 7 days	After 21 days	After 7 days	After 21 days
100% recycled	219.50	285.86	2148.52	2170.67
59% recycled coarse fraction	265.02	324.78	2217.48	2188.15
100% natural	293.92	377.10	2274.07	2256.59

- mixtures made with the same grading curves as previous mixtures, but using 100% natural aggregates.

The first results are shown in the accompanying table.

As regards recycled aggregates to be used in the preparation of prefabricated concrete blocks, the third phase of the research involves the performance of further tests for the characterisation of the aggregates in order to evaluate some more specific requirements that are extremely important to include them in the manufacturing process.

A study is being planned in co-operation with manufacturers to produce different types of mixtures in order to optimise the use of recycled aggregates with reference to their characteristics.

The final phase envisages the execution of some performance verifications on blocks in order to compare the products prepared with natural aggregates with those prepared with a variable percentage of recycled aggregates.

For any further information about the project, please contact Mrs. Luisa Morfini c/o ICITE-CNR, via Lombardia, 49 – 20098 San Giuliano Milanese (MI) –ITALY. Tel:+39 2 9806450, email:icitecner@enter.it

Belgium looks towards larger and better performing recycling plants

RUBBLE represents more than 80% of total C&D waste. Regional targets in Flanders, Brussels and Wallonia aims at a minimum recycling rate of 70%. In respect of the pareto principle *much attention is spent on recycling of rubble as secondary aggregates. CSTC/WTCB recently completed a survey of the recycling sector for the Flemish Waste Agency (OVAM).*

Some 60% of C&D waste is at present recycled in crushing plants, the rest being used in low grade applications such as embankment. Due to the high environmental tax policy (9 ECU/Tonne) the dumping of rubble is less than 5%.

From a total of 80 fixed installations, 45 plants have a capacity larger than 100 000 ton/year. This represent 80% of the recycling capacity in Flanders. A production of 100 000 tonnes a year is also considered as the break-even point for a commercial recycling plant.

More and more recycling plants choose horizontal and vertical integration and invest in C&D waste sorting capacity and concrete mixing installations. The latter enlarges the marketable products to cement stabilised sand and lean concrete.

Public and private works use concrete aggregates (50-70%) and mix material (5-15%) in unbound base-course and sub-base material. Cement stabilised sand and lean concrete with recycled aggregates also find a broad application. The use of recycled concrete is limited to some private works and demonstration projects (approximately 100 000 tonne/year).

Technical quality assurance and environmental requirements for secondary aggregates (leaching, composition, impurities) will very shortly become obligatory in a new Flemish regulation. Currently only 17 firms have a COPRO quality label. So the recycling sector faces a new challenge that will lead to fewer but larger and highly professional recycling plants.

The survey highlighted the location and capacity of the recycling plants linked to the origin of C&D waste. The calculations of capacities, quantities and operation range were presented in several map projections. In general recycling capacity is satisfactory and no government participation is required. Shortage of capacity is limited to one zone, over-capacity influencing the economic viability in a negative way is observed in two areas.

For further information please contact Johan Van Dessel, CSTC/WTCB, tel: +32 2 655 77 11, fax: + 32 2 653 07 29, email: johan.van.dessel@bbri.be

Environmental data for selected building elements

THE Danish Building Research Institute has just published a new publication titled 'Environmental Data for Selected Building Elements' presenting the results of the research projects 'Database for inventory and assessment of energy-related impacts from buildings' and 'Development of a method for environmental assessment of building materials and components'. Moreover, the Danish projects 'Environmental management in project design' and 'Energy and environmental analyses of buildings' contributed data for the project.

All the projects contributed to the determining of methods and parameters for collection and calculation of environmental data and provided data for materials produced in other countries.

In connection with the above mentioned projects SBI has prepared a database and inventory tool which can be used for storing environmental data and for calculation of input/output, data i.a. for building elements. The tool is available free of charge on SBI's web-server (http://www.sbi.dk), but it is necessary to have the program Microsoft Access (version 2.0 or a later version) in order to be able to use the tool.

The data on products presented in the report include energy-related environmental data for most essential building products. All data were checked critically and verified in connection with this project. On the basis of these data, it is possible to establish the important part of the environmental load from a given building element or a building.

To show the application of the collected data, calculations were made for a number of selected building elements by means of the database tool. Moreover, a normalisation and comparison were made of the environmental effects of the building elements.

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ENBRI Members

France - CSTB
+33 1 40 50 28 28
+33 1 45 25 61 51
www.cstb.fr

UK - BRE
+44 1923 664000
+44 1923 664010
www.bre.co.uk

Ireland - FORBAIRT
+353 1 837 0101
+353 1 836 8139
www.forbairt.ie/

Belgium - CSTC / WTCB
+32 2 716 4211
+32 2 725 3212
www.bbri.be

Netherlands - TNO-Bouw
+31 15 284 2000
+31 15 284 3990
www.tno.nl/instit/bouw

Spain - I.E.T.c.c.-CSIC
+34 91 302 0440
+34 91 302 0700
www.csic.es/

Portugal - LNEC
+351 1 848 2131
+351 1 849 7660
www.lnec.pt/LNEC/portug

Italy - ICITE
+39 2 98061
+39 2 98 28 00 88

Germany - BAM
+49 30 81 04 17 00
+49 30 81 04 17 07
trappist.kb.bam-berlin.de/bam.html

Denmark - SBI
+45 45 86 55 33
+45 45 86 75 35
www.sbi.dk/sbihome.htm

Finland - VTT
+358 9 4561
+358 9 456 7031
www.vtt.fi/rte/bldtech.html

Norway - NBI
+47 2 296 5500
+47 2 269 9438
www.byggforsk.no/english.htm

Iceland - IBRI
+354 5 67 6000
+354 5 67 8811
www.randburg.com/is/icebuild.html

Sweden – SP
+46 33 16 51 01
+46 33 16 50 10
www.sp.se

Construction materials – defeating bacteria

TOGETHER with Paris XII University and the Institut National de Recherches Agronomiques (French Agronomic Research Institute), CSTB researchers have just developed an original methodology for simulating the contamination of materials by air-borne micro-organisms and defining vulnerability criteria. A first in France.

Fungus, bacteria and viruses .are omnipresent both indoors and outdoors. Carpets, ceiling tiles, wall coverings, insulating materials and ventilation system parts are their favourite haunts. All they need is an ideal breeding ground (heat, damp, inadequate maintenance) to move in and begin attacking the surrounding materials.

The resulting damage can even include the destruction of external finishings which peel off through lack of adhesion.

Micro-organisms also have the annoying habit of being air-borne, which means that they can easily work their way indoors, causing endless health problems in the occupants such as colds, allergies and, in some extreme cases, Legionnaires' Disease (a serious infection similar to pneumonia). They are also responsible for nosocomial infections which are a threat to public health in hospitals.

In the absence of suitable measuring instruments and adequate field data, it has been difficult up until now to evaluate the behaviour of materials in the face of microbial contamination and identify factors which will enable proliferation to be controlled.

That is why CSTB researchers, backed up by the relevant Paris XII University laboratories (Aerosol Physics and Microbiology Applied to the Environment), have just developed an experimental methodology to study the behaviour of materials in relation to biocontamination.

This experimental tool is a first in France. It is used to re-create, under fairly realistic conditions, the biocontamination of materials using an air-borne purpose-designed bacterial aerosol. The contamination of materials by air can thus be simulated and the development of microbial populations on the surface of materials observed in various environmental conditions.

It is easy to understand the advantage to be gained by developing this tool, particularly in the case of materials used in the food processing and hospital sectors.

Research is also being conducted with the French Institute of Agronomic Research (INRA) in Massy, in its hygiene engineering and food processing laboratory, to gain a better understanding of the phenomena which determine the fixing of micro-organisms on surfaces.

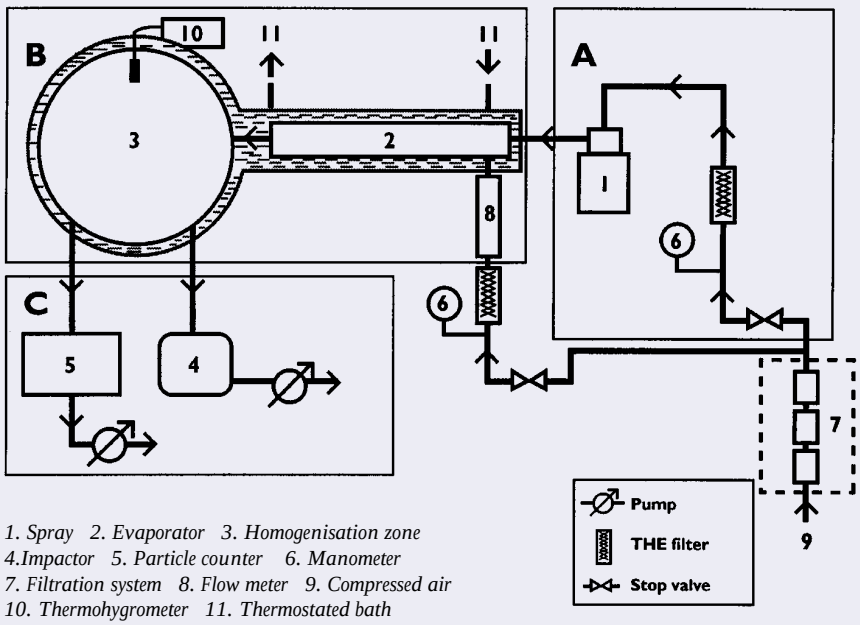
Scan of a fungus culture from an indoor environment

The aim is to define the effects and role of environmental factors on microbial multiplication, dissemination and survival of germs, in order to better prevent and control the pollution of indoor air and surfaces, particularly through the choice of appropriate materials

Criteria for classifying materials with relevant hygienic properties are not only of interest to the medical profession, and more especially the technical managers of hospitals, but also to architects and apartment building administrators; these criteria will help them choose adapted surfaces and materials.

For further information, contact Dominique Derangère, CSTB Marne-la-Vallée, tel.: 33 01 64 68 82 71, fax: 33 01 64 68 84 73,email derangere@cstb.fr

Biobat: operating diagram



1. Spray 2. Evaporator 3. Homogenisation zone
4.Impactor 5. Particle counter 6. Manometer
7. Filtration system 8. Flow meter 9. Compressed air
10. Thermohygrometer 11. Thermostated bath

The aerosol is produced in part A whose pressure is controlled by a pressure gauge. It is then sprayed into a homogenisation chamber (B) with controlled temperature and humidity. The bacterial and particle concentrations thus produced are evaluated at the end of the production chain (C). The bacteria are sprayed onto the material to be tested using an impactor (4).

The laboratory operates in dynamic mode, with the incoming and outgoing flow rates balanced out so as not to create negative pressure. For reasons of security, the assembly is made airtight and placed under a laminar hood.

Recycling of wood – *A Nordic Wood project*

IN A GREEN community the raw materials extracted from nature are reused, recycled and disposed of in such a way that harm to the environment is minimised.

It is no longer possible to consume our resources and indiscriminately dump demolition waste in a landfill. In comparison to other materials wood is regarded as having several advantages from the environmental point of view, primarily due to the fact that it is a renewable resource.

Wood waste has traditionally been used for burning and energy-recycling in the Nordic countries. Smaller amounts of wood and wood components have always been reused. With time, as green ideas gain ground, it is the recycling of materials which will be brought to the forefront.

This project resulted in a check list for a coarse assortment of wood waste from the building industry, with respect to the possibility of reusing, or material - and energy-recycling the wood waste.

One pre-requisite was that this check list should be easy to use and that it should be possible to use during the planning of the demolition and on the demolition site.

The report (*SP report 1998:15* is available from SP)also discusses the strength grading aspects of construction timber, and tested material indicates that it should be possible to use existing grading rules for newly felled logs and apply them to grade recycled timber.

It seems that old timber has a lower stiffness but a strength equally high to new timber. However, the timber in this project showed larger and more frequently occurring knots than in newly felled logs, which, in general, lead to a lower grade. The strength in old timber did not seem to be affected by large cracks or fissures, or by deep nail holes.

When it comes to historical or aesthetical aspects, conflict of interests can arise especially concerning assembled designs, such as roof trusses, as they must be redesigned according to the present design code.

For further information, contact Charlotta Holmqvist, SP Swedish National Testing and Research Institute, Tel +46 33 16 51 32, fax +46 33 13 45 16.

Environmental Data for Selected Building Elements

Continued from page 4

The report first describes the basis for environmental assessment based on the systematics of life-cycle assessments (LCA), including conditions regarding purpose, parameters, data quality, inventory and assessment.

Secondly, the environmental database that was used for storing environmental data and for the inventory of the total environmental impacts from the examined building elements is described. Furthermore, the building elements and products are listed for which environmental data were collected, and energy sources and means of transportation for which standard data were used.

Finally, the environmental loads of the selected building elements are shown as input/output data and as environmental effects and normalised environmental profiles. Comparisons between the environmental profiles of building elements, and an outline of future tasks are presented.

The data presented were checked in relation to different sources. It was not possible to indicate the uncertainty for each individual data and thereby carry out uncertainty calculations of building elements. As the database is designed to handle uncertainties, future data collection will aim to obtain data about uncertainty (in minimum, probable and maximum values) for each individual datum.

The database is designed so that data for a given process can only be found in one place in the database. This facilitates up-dating of data. The database has no limits with regard to the level of detail or the expansion of the number of environmental parameters associated with each individual process. Moreover, the database can add environmental data on a material, building-element and building level. The database is therefore a flexible tool for storing, up-dating and adding environmental data for buildings. It should be noted that it is possible to add comments and descriptions of production processes, data sources and data quality to the database. Thereby a thorough verification of the data is achieved.

The database contains data for many building materials, but data is lacking for paints, enamels, joint fillers/sealants, and some plastic materials. It will therefore be the aim in a subsequent EFP project to expand the database with data for these groups of materials. Furthermore, a significant increase of the contents of the building elements will take place.

In the future, work will progress on the facilities of the database tool for comparison between building elements made from different materials, e.g. regarding clarification of what building materials in a building element contributes most to a given environmental effect.

Further information can be obtained from: Project coordinator, senior researcher Jorn Dinesen,Danish Building Research Institute (SBI). Tel (+45) 45 86 55 33, fax (+45) 45 86 57 34, email sbi@sbi.dk Website http:www.sbi.dk

Published on behalf of the European Network of Building Research Institutes (ENBRI) by BRE, Garston, Watford, Herts, WD2 7JR
Telephone: +44 (0)1923 664312 Fax: +44 (0)1923 664101