

Joint Research – A Need for Construction Innovation

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1. ABSTRACT

Increased demands on the built environment require continued and enhanced research and development activities. Due to the fragmented nature of the construction industry and immense costs for developing innovative methods and products, using the capability of different partners within collaborative projects offers a cost-effective solution to this challenge. The European Network of Building Research Institutes (ENBRI) offers excellent knowledge and experience within such collaborations. Furthermore, the institutes provide a unique set of test facilities as well as site experience all over Europe. Over the years the institutes have demonstrated exceptional capabilities, creating new technologies and innovations for the construction industry including 'spin-in' of research from other industries. Furthermore, the research has created 'spin-out' to other industries. The article explains the structure and working of ENBRI, based on selected examples emphasizing the benefit of collaborative research.

2. INTRODUCTION

Traditional building technology can be considered to be well developed. Nevertheless, society and industry continues to demand improved competitiveness, customer and user satisfaction, sustainability, quality and safety of the built environment. This requires a continued and increased focus on research and development. More and more joint research is required to bridge basic research and applied research for achieving useful projects and useable results. The special experience and competence of individual research centres needs to be combined to create multidisciplinary and user-oriented research and innovation. The European programmes focus just on these synergetic effects. The ENBRI network offers an excellent basis for such collaborations.

3. WHAT IS ENBRI AND HOW DOES IT WORK?

In 1988 the principal building research institutes of 7 European countries established the European Network of Building Research Institutes ENBRI. It was the time of implementation of the Single European Market and of the Construction Products Directive (CPD). According to the Memorandum of Understanding, the network should enable its member institutes to contribute more effectively to these objectives. This should be done by advising the European Commission on technical aspects of buildings and their constituent materials, components and systems, advising the construction industry including suppliers and to the representative bodies of the industry, advising owners and users of buildings and customers of building products and last, and by no means least, by undertaking research and technical studies to support such advice. In consequence, ENBRI and its member institutes were able to identify the needs for research and development and to submit important information to the European Commission with regard to research framework programmes.

For operational efficiency each country is represented in ENBRI by only one principal building research institute. Most members have been or still are national institutes. The membership was initially restricted to the European Community but has subsequently been extended to Associated and Candidate States. The network currently comprises institutes from 21 European countries (Fig. 1).



Figure 1: Member institutes of ENBRI (<http://www.enbri.org>)

There is an intensive exchange of information between the institutes. The Board of Directors meets twice a year for comprehensive full-day discussion on European research and development matters. By visiting laboratories and, occasionally, construction sites information on practical aspects of construction research is achieved. Working groups prepare and support the work of the Board. A particularly important Working Group is the Research and Technical Development Working Group which meets also twice a year and provides the Board with vital support on day-to-day EU research and development matters. The network is led by the President and Vice-President who are elected from the Board of Directors for a period of two years. The management is undertaken by the Executive Secretary and his secretariat. ENBRI is a member of ECCREDI, the European Council for Construction Research, Development and Innovation (<http://www.eccredi.org>).

Each institute is closely linked with national stakeholders in the construction area – from user and clients, consultants, contractors, material suppliers to researchers and policy makers. The institutes have outstanding user-oriented and multidisciplinary research competencies as well as excellent experience in management of large research projects and programmes with a wide group of stakeholders.

ENBRI is also able to compile and disseminate valuable information and knowledge. The ENBRI website is an effective tool for this purpose (<http://www.enbri.org>). It includes the digital version of the regular ENBRI newsletter “Construction Technology in Europe”. The website is linked with those of each member institute. A particular benefit for cooperation is a list of middle-management contact

points in its private area that enables the researchers to find quickly the competent partners. Information on very special facilities is also available.

4. COMPETENCE AND FACILITIES

Research and technical development as well as the implementation of innovative products and systems on the market demands more and more specialized knowledge and experience and expensive test facilities. To minimize the costs and make the best progress, it is logical to make use of the capability which is offered by different institutes in Europe. Within the ENBRI network a wide range of competence and outstanding equipment is available.

ENBRI represents about 3,000 researchers in various disciplines as well as a large number of skilled engineers and laboratory technicians. These researchers are involved in applied research projects as well as in application, on-site monitoring and other associated activities. Active participation in national and European standardization and legacy committees provides information on relevant technological progress and future needs. Similarly, ENBRI researchers are able to influence the regulations based on their experience from research and testing.

ENBRI's general fields of activities include amongst others:

- Building materials
- Structures
- Roofs and facades, coatings
- Housing
- Service life of buildings
- Corrosion and corrosion protection
- Fire resistance
- Thermal insulation, energy saving
- Acoustics, mitigation of vibration
- Climatic impact, marine environment
- Geo-engineering, earthquake resistance
- Extreme loading, dynamic loads
- Health and indoor environment
- Housing and social development
- Installations
- Building services
- Construction process
- Monitoring and non-destructive testing
- ICT
- Modelling in all mentioned fields
- Consultancy for government, authorities, industry and private customers

Within the past ten or fifteen years, there has been a change of paradigm for most of the ENBRI institutes. While routine testing and investigations are increasingly shared with numerous small institutes, technological and socio-economic development as well as international competition in the construction area required institutions with outstanding capability with regard to competence and unique facilities. ENBRI institutes took up this challenge. Some examples are outlined here.

Building materials:

Due to regional tradition, some institutes are well experienced in wood materials. Special competence in timber structures has been developed with regard to loading on wide-span girders, e.g., or fire impact. The resistance against dry rot or insects can be investigated, and one institute even provides colonies of termites for such tests. Others create on a nano-scale innovative building materials using

wood as raw material or by silicification of timber. The microbiological impact and pollution effect on organic and inorganic building materials focuses attention on surface properties. There is an increasing competence concerning innovative functional building materials and particularly photo-catalytic coverings.

Climatic impact:

The climatic impact on buildings and structures is one of the most important factors of a building's life-time. Each institute has climatic chambers for special purposes. Additionally some unique facilities are available. The "Jules Verne climatic wind tunnel", e.g., can recreate any weather conditions on more than 5,000 square metres (Fig. 2). Full-scale studies are possible in snow, sleet or dry heat-waves, in sandstorm, fog or cyclone. The wind-loads on structures and its effects on stability and dynamic behaviour can be measured in combination with other climatic parameters. For linking laboratory studies with the practice, the institutes have numerous exposure sites at their disposal, from the Mediterranean to the Polar region and in marine as well as in continental climatic conditions. In this context, the special competence in structural engineering in extreme conditions, particularly cold climate, should be noted.

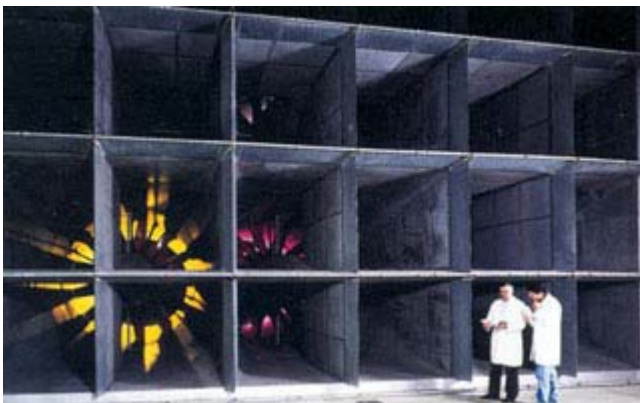


Figure 2. Jules Verne Climatic Wind Tunnel at CSTB

Structures:

The complexity of static and dynamic loads on and the response of structures can be determined only by large scale tests. Fig. 3 shows a device for measuring the behaviour of cable-stayed bridges giving information on structural and material-related demands with regard to stability, vibration and damping measures. The residual lifetime of old steel bridges can be determined by testing original girders implementing those dynamic loads at different points which have been identified on site (Fig. 4). While the mitigation of vibration is a basic task for building research, several institutes deal with earthquake impact. The special experience combines both data bases as well as specialist test facilities for either components or down-scaled buildings, enabling reliable seismic risk assessments to be made. This knowledge is indispensable for construction in many regions all over the world.



Figure 3. Laboratory test field "Adaptive cable-stayed bridge" at EMPA



Figure 4. Universal test machine for static and dynamic loading of bridge girders at BAM

Health and Indoor environment:

With regard to occupants' health and comfort, the indoor environment has become an important issue. In special climate chambers equipped with absolute clean boxes, the emission from building materials, floor materials or furniture can be exactly measured. Concerning the wellbeing of users and the acceptance of materials, the smell of these emissions can even be determined by a sensory assessment (Fig. 5). A special daylight laboratory can be used for full-scale studies of the quality and utilisation of daylight and lighting in buildings with regard to structural design, window components and lighting systems. These studies utilize a combination of techniques and perception methods and assessment.



Figure 5. Test panel in the Air Quality Laboratory at DBUR

Construction process

Over the last couple years there has been an increased focus on how the quality and the productivity of the construction sector can be improved through a development of the construction process. One of the focus areas has been to develop methods and tools for improving the decision making in construction both in new buildings and in renovation. Digital model can automatically transform 2D sketches from the early phases to simple 3D visualisation models (Fig. 6). Other tools can give an early price estimate in relation to the chosen value based on the simple 3D visualisation. Generally, this provides a better optimisation of the value against price and time in the early phases and improves the communication with the user, leading to improved user satisfaction. The digital communication tools combine IT and knowledge on design, building technology, process and user.



Figure 6: Digital communication tools for decision making in construction.

Dissemination & Information:

Obviously, the ENBRI institutes have to play an important role in transferring information to all those involved in the act of construction. This is being done in association with others in many respects:

- Through demonstration projects which can be visited by stakeholders and the public at large, a typical example is the recycled house being built in Limelette, Belgium which can be visited on demand or virtually at www.recyhouse.be. Recyhouse is a building incorporating a very large amount of new construction materials produced with residues of all sorts. The objective is to demonstrate that it is indeed possible to construct a building almost entirely with the means of recycled materials.
- Another example also from Belgium is the exposition Centre CEDUB0 (www.cedubo.be) where latest technologies related to sustainable construction are demonstrated. Another similar initiative is INHAM (www.inham.be) where the focus is on building for disabled persons and elderly.
- The latest state of the art electronic dissemination techniques are demonstrated and used in real life at <http://www.brebookshop.com/> which brings you over the internet easy one-stop access to the information providers in the built environment sector.

Spin-outs and Spin-ins:

A typical example of spin-out is the CabinAir project where 3 ENBRI partners collaborated with the aircraft industry to study the problem of indoor air quality in airplanes using their extensive knowledge developed in building ventilation projects (http://enbri.cstb.fr/docs/issues/issue13_.pdf).

Different Spin-in projects can be highlighted where ENBRI institutes have been active in introducing in the construction industry technologies emerging in other sectors, to mention a few:

- The Micro-computer tomography introduces medical imaging techniques to construction materials. Combined with the micro-XRF, a very novel tool providing quick mapping of elemental distribution, these methods deliver essential aspects for understanding of degradation phenomena. (http://enbri.cstb.fr/docs/issues/issue32_.pdf)
- The virtual reality sound in three dimensions to associate sound and visual representations in a realistic virtual rendering system based on special models where media technology is being exploited to its full capacity in design situations (http://enbri.cstb.fr/docs/issues/issue12_.pdf)

- The use of CFD (Computational Fluid Dynamics) in fire safety engineering to solve smoke movement problems in building design where modeling technologies developed for space- and aircraft applications are being used in construction related applications (http://enbri.cstb.fr/docs/issues/issue9_.pdf)

This selection of examples demonstrates the variety of very special and complex facilities and capabilities within ENBRI. Each institute has developed its own significant profile, but it can be stated that under the umbrella of ENBRI the whole building and construction sector can be covered.

5. THE BENEFIT OF COLLABORATION WITH AND WITHIN ENBRI

The stability of buildings and structures in case of fire is one of the essential requirements with regard to health and life of the users. For steel skeleton structures, the assessment is based on simple tests on the fire resistance of steel columns under compressive load. This does not represent the reality where multiple interactions of the whole structure occur. So the capacity of one institute was used to measure the stress and displacement in parts of an eight-storey full-scaled steel framed structure during fire impact at certain points. This data base could be used to perform tests in another institute with a special large-scale column test oven. The loading and bending moment during fire could be steered according to the potential behaviour of the whole structure and its interactions (Fig. 7). A further institute specialised in numerical calculation methods, their “Sub-structure technique” could be developed as a novel tool for this application, supporting the progressive “Performance Based Design”. The combination of different and unique facilities and expertise lead to an innovative approach for safer and better use of structures.

This is only one example of the benefit of collaboration. It is evident that for economic reasons the utilisation of the different facilities and skills at different locations for solving this complex problem is the only reasonable way forward. Further examples could be mentioned. The large number of EU funded projects with participation of more than one ENBRI institute demonstrates this benefit and capability.

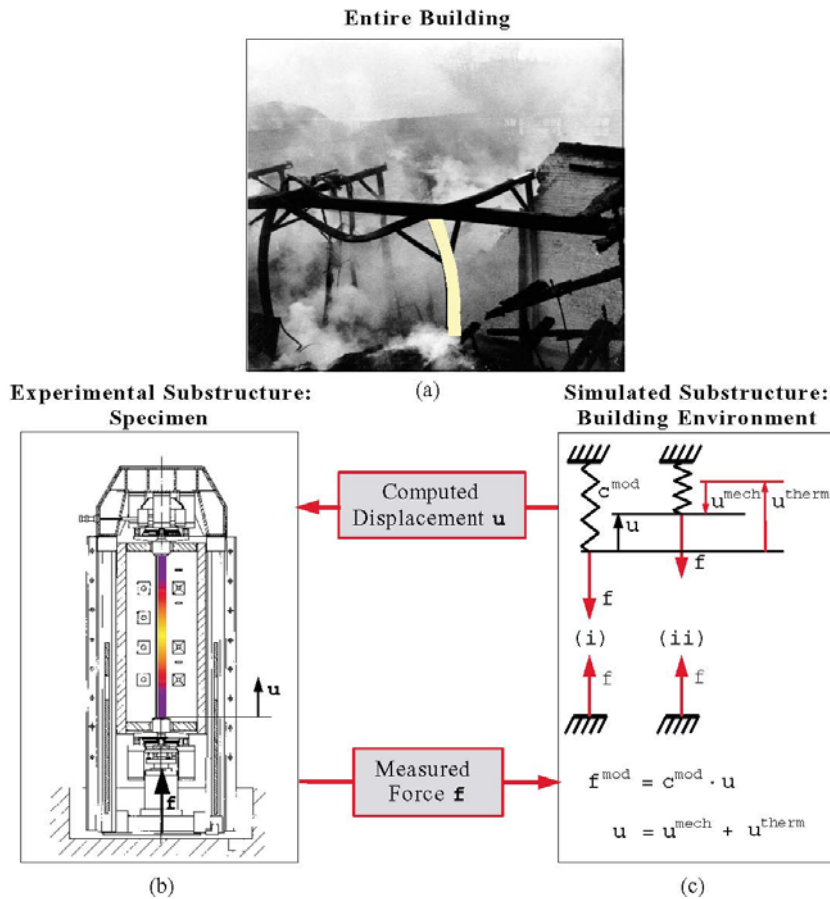


Figure 7- . Basic idea of the Substructuring Method – (a) real case (large-scale test), (b) special furnace test under controlled loading and displacement, (c) modelling

6. CONCLUSION

Innovation in buildings, housing and construction technology demands a capability in research and technical development which is able to solve complex and multidisciplinary problems. The principal building research institutes in Europe, represented by the institutional network ENBRI, offer comprehensive experience in a wide range of disciplines, with in-depth knowledge in specialist fields at different locations, which can be combined for solving particular problems with high scientific input and the use of often unique test facilities. The ENBRI institutes are involved in numerous EU projects, as well as those of national research programmes. The institutes have excellent experience in management of large research projects, networks and programmes both on European, national and regional level with involvement of a wide group of stakeholders. For instance, ENBRI is one of the initiators of the Thematic Network E-CORE, the European Construction Research Network (<http://www.e-core.org>). It is managed by ECCREDI and ENBRI members are actively participating in this network.

Furthermore, the institutes are well established within the scientific community. They are partners of industry, authorities, users and standardisation bodies. The use of this huge potential by the construction industry and policy bodies to create construction innovation is an absolute need.