European Network of Building Research Institutes
http://www.enbri.org

Future Needs for European Construction RTD

0. Summary

The European Network of Building Research Institutes (ENBRI) links the leading, non-academic centres for building and construction research in Europe. Its 21 members employ in total over 3000 professional research staff. The knowledge base of ENBRI and its members covers all significant aspects of building and construction, including not only the performance of materials, systems, buildings and other structures but also the associated design, management and communication processes. Through their strong links with both industry and government bodies, ENBRI members play crucial roles in creating and disseminating new knowledge and assisting innovation across construction which is the single largest industrial sector in Europe.

Construction faces major challenges, including consequences of climate change, energy shortage, demographic change, mobility problems, need to upgrade a large proportion of Europe's building stock and urban areas, rising consumer expectations and demand for comfort, global competition and low profit margin within the sector etc. All this will require new technologies and processes which can bring about radical improvements.

The range and depth of understanding of technical, environmental and social issues in construction within ENBRI members, coupled with their leading position as national centres of excellence, enables them to play a distinctive role in addressing these issues, working with both industry and government. Their contribution will come through research, demonstration projects, information programmes, education and training etc. ENBRI will also be playing a full part in supporting the European Construction Technology Platform and the associated national platforms.

This paper discusses the issues facing construction, sets out how the expertise and capabilities of ENBRI members is relevant to them, and summarises how ENBRI and its members will contribute to the achievement of ENBRI's vision for the construction sector:

A sustainable and knowledge-based European construction sector, which is competitive, innovative, market driven and meets user and societal needs by providing the best living and working conditions for all people.

The main action lines identified to reach this vision are respectively concerned with:

- Raising environmental standards.
- Fulfilling user and stakeholder requirements and aspirations.
- Changing construction processes and relationships.
- Updating and improving the built environment.
- Exploiting new materials and technologies.
- Promoting education and training, knowledge transfer, quality employment and innovation.

1. Introduction

The European Network of Building Research Institutes (ENBRI) was founded in 1988 to bring together principal building and construction research institutes in Europe. Currently, the network has 21 members, each being the sole representative of their country in ENBRI.

Members of ENBRI undertake a wide range of research and innovation actions relevant to construction and the built environment, and manage unique research facilities. In addition, each plays a very significant role in their country in communicating research findings to all actors within the construction sector through publications, seminars and other means. Moreover, ENBRI members are closely linked to public authorities, advising upon and assisting the

development of regulations, standards and codes of practice at regional, national, European and global levels. They therefore occupy a distinctive position, as intermediaries and brokers between research, industry and the public, in the promotion of innovation in building and construction. Each ENBRI member is closely linked with all national stakeholders of the construction sector and has its own distinctive profile of user-oriented and multi-disciplinary research competencies. Overall, the ENBRI network provides a full coverage of topics for the construction and built environment and guarantees a steady up-dating of international knowledge and experience for the construction sector. Further information about ENBRI members' competences is given in the *Annex* to this paper.

The aims of ENBRI are:

- To promote co-operation among its members, and with the European Commission and stakeholders of the European construction sector, in order that ENBRI members may contribute effectively to the improvement of competitiveness, sustainability, quality and safety of the built environment.
- To promote the benefits of investment in research and development in construction and the built environment at regional, national and European levels.
- To advise policy makers and wider public on issues related to research and innovation in the built environment.

Key elements in supporting these aims are research, innovation and knowledge transfer activities for development of the built environment.

Based upon the knowledge and experience of ENBRI members, this paper seeks to:

- Summarise the principal challenges facing the construction sector.
- Show how the capabilities of ENBRI members can create added value in addressing these challenges.
- Affirm the commitment of ENBRI to working with others to advance European strategies for construction RTD and supply all stakeholders with results aimed at the creation of a higher quality built environment in Europe.

2. Challenges for Construction

'Construction', is generally interpreted to embrace all the activities that contribute to the creation, maintenance and operation of the built environment. It thus includes not only the design and construction of housing, other buildings and infrastructure works, but also their operation, repair, refurbishment and ultimate demolition and recycling, and the extraction and supply of construction materials and products. Construction thus defined is a major economic sector, with a turnover of 1000 billion Euros. It accounts for well over 10% of European GDP and employs some 12 million people.

But the indirect impacts of the construction sector go much wider. The quality and usability of the built environment influences the behaviour and performance of individuals, organisations and society in general. A commonly quoted figure is that the cost of activities taking place within a commercial development over its lifetime may be up to 200 times that of the initial cost of construction and so a small improvement in productivity achieved through better design can be repaid many times. As another example, it is well known that the design of urban areas can promote or discourage crime and anti-social behaviour. Overall, through these indirect effects, the built environment exerts a leverage on economic and social development which far exceeds its direct economic contribution.

In addition, construction is central to the achievement of sustainable development. The sector accounts for some 40% of resource consumption (raw materials and water) and for 50% of solid, liquid and gaseous emissions. Environmental issues faced by the sector include: reducing emissions of greenhouse gases through enhancing energy efficiency, restoring sites affected by industrial pollution, conserving natural resources such as raw materials, greenfield land and water supplies, and creating ecosystems in balance with urban requirements. In particular, construction has a crucial role to play in reducing overall use of energy and creating the means of harnessing ambient energy sources.

The effective creation, management and improvement of the built environment require the synthesis of a wide range of social, environmental and economic issues, reflecting both immediate and long-term problems and opportunities. Addressing these issues is central to achieving economic development and sustainable growth as well as for enhancing the quality of life for all Europe's citizens. Some of the principal challenges to be addressed by construction are set out below.

The first is the need to create a built environment suited to the needs and aspirations of people in the 21st century. On average across Europe, at least 80% of each person's life is spent inside buildings and so it is essential that buildings provide an environment where

people can comfortably live, be protected and carry out business and leisure activities. An indoor environment that is healthy, comfortable, accessible, controllable, usable and safe has enormous economic and social benefits through its impact on productivity, health costs and quality of life. Furthermore Europe's built environment faces a demographic challenge. By 2020, around one third of the European population will be aged over 60. The built environment will need to accommodate to this change by embracing a 'design for all' approach – a paradigm shift in design and operation to ensure that the built environment serves all Europe's citizens.

And expectations are rising. There is heightened awareness of natural and man-made hazards such as flooding (likely to be exacerbated by climate change), earthquakes, storms, fire explosive and other terrorist impacts. Our society is becoming more mobile, placing higher demands on current transport infrastructure and greater stresses on structures and equipment. But at the same time we wish to preserve the character of Europe's historic towns and countryside, and so modern requirements have to be reconciled, though new technologies and design approaches, with traditional values and our cultural heritage.

Change is also taking place at the urban level. Today, 80% of Europe's population lives in cities. However, people increasingly prefer to live on the periphery of urban areas owing to pollution and the generally poor state of housing in the inner city. This phenomenon of 'urban sprawl' requires innovative solutions, with the development of mixed communities that reduce the need for daily travel and new means of renewing and revitalising the buildings and infrastructure of older city areas. Also, if the EU is to live up to the Kyoto Protocol and to reduce substantially its greenhouse gas emissions an enormous challenge is ahead in implementing energy efficiency measures in the current building stock as it is obvious that in view of the low replacement rate concentrating only on new buildings will not be sufficient.

In addition to these social and economic issues, and those posed by environmental demands, the construction sector faces internal challenges. It forms the largest industrial sector in the EU, representing one quarter of the total industrial output. However, the sector faces increasing global competition, tends to have low profit margins, is dominated by small firms and has a bad image and safety record. Typically, in each Member State, more than 90% of construction employment is accounted for by very small firms with fewer than 10 people. These features of the industry present barriers to the communication and assimilation of new developments and inhibit investment in the production of new knowledge. New structures, processes and relationships are required to create business environments that promote innovation, so that the industry meets the needs of clients, users and society more effectively and makes a full contribution to sustainable development in Europe.

3. The ENBRI Vision for the future construction sector

Reflecting the position of its member institutes in seeking to bridge and balance public and supply sector interests in construction, the vision of ENBRI is to contribute to the development of

> *A sustainable and knowledge-based European construction sector, which is competitive, innovative, market driven and meets user and societal needs by providing the best living and working conditions for all people.*

ENBRI members will facilitate and promote the achievement of this vision through conducting research, assisting innovation, providing training and through the objective advice that they provide to official bodies and industry. The capabilities and expertise that ENBRI can bring, to bear on some of the major change themes that have been identified, are considered in the next section.

4. Addressing the Challenges – Transforming Construction

4.1. Raising environmental standards

Europe is committed to the implementation of sustainable development and the performance of the built environment is central to this aim. The construction sector has a key role to play in preserving the natural environment and our cultural heritage, restoring polluted areas, and conserving natural resources such as water, energy and raw materials. Furthermore, the sustainability and quality of urban life, subject as it is to environmental pressures (noise, air quality, etc) from transport and industry, demands particular attention.

Perhaps the most important challenge is to reduce Europe's contribution to climate change, and at the same time its dependence on imported energy, whilst continuing to improve the quality of life of all European citizens. Since the built environment accounts for over 40% of European energy consumption, there is an immediate requirement for enhanced energy efficiency in both new and existing buildings, to be achieved through:

- Giving the development and implementation of energy-related technologies in existing buildings as high a priority as raising the performance of new buildings
- Developing technological and operational means of achieving very high efficiency of energy use, appropriate for mid- and long-term deployment, and business models to enable Europe to promote these competitively on the world market. This requires new materials, sophisticated technologies, networks and sensors at all scales for automation, plug and play components etc.
- Introducing new concepts for cost-effective energy-positive buildings which would transform the built environment into a principal supplier of energy instead of a consumer. This requires both technological and institutional developments, so that renewable energy supplies from buildings and other sources may be effectively utilised in local markets for heat and electricity.

Buildings also account for a substantial proportion of water usage. Rising living standards and possible shifts in weather patterns through climate change will increase pressure on water supplies and create demands for more effective use and re-use of water. Similarly, construction will need to reduce its call on raw materials, where it is the largest single user and the largest producer of waste. This will require better integration of suppliers with construction processes, to reduce wastage, as well as to promote the recycling and reuse of materials and components taken from existing buildings and structures. Flexibility of design, so that buildings do not become obsolete before the end of their useful lives, will also promote sustainability.

ENBRI members' efforts in technological and societal R&D will help the construction sector to identify innovative practices, technologies and ways of working which focus on the end-user and help to create a sustainable construction industry. ENBRI and its members bring to these issues:

- A deep understanding of individual technologies for energy and water use, and materials performance, integrated into an understanding of whole-building performance. Hence the ability to create and validate Life Cycle models of performance, taking full account of environmental impacts.
- Long experience in the development and authoritative assessment not only of technologies but also pan-European design and operational tools and systems.
- Understanding of user perceptions and behaviours, relevant to motivating users to more efficient use of energy and water.
- The ability to contribute both to regulations (which 'push' higher environmental standards) and advanced technologies and designs (the 'pull' factor) and experience in the management and exploitation of promotional tools such as demonstration projects and education and training programmes.

4.2. Fulfilling user and stakeholder requirements and aspirations

Enhanced global competitiveness will need to be based on better understanding of user, client and societal stakeholder requirements and more effective means of interpreting and fulfilling these, resulting in higher levels of customer satisfaction. At present, the concepts and tools available for expressing these different requirements are inadequate, with the result that construction has tended to be supply-driven and focussed on price rather than performance. There is a particular challenge for clients, who are the link between the end-user and the construction team. They have to identify the performance they need from their built environment asset in many dimensions: visual impact, functionality, internal environmental quality, safety, security, flexibility, operating costs, expected lifetime etc, all of which need then to be related to time and price and ultimately to a 'value' judgement. And this will then be influenced by the requirements of users and society, through regulatory and land-use controls, and through the influence of community groups, employees' representatives, etc.

That 'value' assessment, which is vital if construction is to become a value-based industry, requires the development of new knowledge and new tools: knowledge of the impact of buildings and other aspects of the built environment on user activities and behaviour and tools based on new technologies for supporting the communications and interactions required with many interests. Clients need the ability to state their requirements in terms of performance, and the impacts expected on their business or public service functions. Designers need to be able to interpret these and show how their designs are optimised to meet the value dimensions of stakeholders. Both require new visualisation, virtual reality and communication tools, based on advanced ICT systems, to support their interactions. The development of such tools will be driven by a fundamental re-thinking of the way users and clients are engaged in the whole construction process, which will be dynamic as needs and opportunities evolve.

Finally, following occupation, clients will need tools to evaluate the performance of the final output so that this can be optimised, and the experience incorporated in future designs.

ENBRI members' efforts in construction research and innovation help the construction sector to change from a supply driven and price-focused industry into a demand driven and value-focused one. The ENBRI contribution to the development of such knowledge and tools will be based on:

- An in-depth understanding of building performance, coupled with the ability to investigate and model building-user interactions.
- Detailed knowledge on construction process, and expertise in stakeholder dialogue and decision-making.
- Experience in the development of ICT-based design aids and visualisation systems.
- Specialist research capabilities relevant to the provision of healthy and productive internal environments - access, lighting, air quality, acoustic performance etc – and reducing undesirable impacts of construction activities - noise, dust, etc.

4.3. Changing construction processes and relationships

The construction sector is highly fragmented, with separate organisations taking responsibility for different phases of construction - design, site works and operation – and many suppliers, subcontractors and specialists involved in both design and on site. This provides much scope for confusion of responsibilities and ambiguity in communications, which prejudices ultimate customer satisfaction. This fragmentation, the temporary nature of the relationships formed on individual projects, and the prevalence of very small firms in the sector, all serve to inhibit the sector's learning processes, both the ability to carry forward experience from one project to another between projects and the collective learning necessary to achieve process and product innovations. Different industry structures are required, with longer-term relationships and greater integration of project teams.

Another aspect of change stems from the current nature of site activities. The quality of employment available in construction tends to compare unfavourably with that of other sectors. Accident rates are too high, and site conditions often poor. A principal cause is the price-based competition in the industry, which inhibits investment in training and welfare. In addition, there is some evidence that construction productivity has not risen in line with that of other sectors, which further reduces the potential for investment. Change is required in site activities, if construction is to raise productivity and compete for workers (both male and female) in a labour market where demographic change is reducing the supply of young male workers who traditionally have formed the core of the construction workforce.

Rationalisation of construction processes, with off-site assembly of large, fully-fitted components and mechanisation of site activities aided by new automation and guidance technologies will be a route to more efficient construction process. But there will be institutional and perceptual barriers to overcome. Previous experience of industrialised construction, notably in the 1960s, was poor but current flexible manufacturing systems and associated quality systems are able to provide a final product tailored to the needs of individual clients, and with the right quality.

These new approaches, requiring the integration of many different inputs, will reinforce the move to new contractual and organisational structures which provide for clear overall responsibility and embrace long-term alliances within the supply chain and between suppliers and clients. These will be supported by ICT systems founded on interoperability standards. In parallel, better identification and management of risks, and revised regulatory frameworks, will reduce the barriers to innovation and create incentives for take-up of new technology.

ENBRI members are committed to help create the fundamental changes in construction process and industry structure through applicable and user-focused innovation. ENBRI institutes will therefore prepare research and innovation programs and demonstration projects as well as knowledge transfer programs for spreading of research outputs, results of innovation processes and best practices to firms, education and training organisations and regulators.

ENBRI members, with their close links to client, industry and regulatory interests, are uniquely placed to promote these changes, by providing objective evidence on the benefits of change and assurance of the effectiveness of new ways of working. By a combination of traditional construction expertise with a wide range of social science and management expertise, ENBRI members can:

- Develop and monitor the use of performance indicators (productivity, safety, environmental).
- Investigate new forms of relationship and publish objective guidance on their outcomes and the factors that lead to success.
- Monitor and promote the outputs of demonstration projects.
- Develop and promote ICT systems appropriate for more integrated project teams (including teams drawn from different countries in Europe) and contribute to the generation of international standards for interoperability.

- Develop and assess technologies for mechanising the construction site and for enhancing safety.
- Create common standards for off-site construction (e.g. for connection of services) and undertake quality assessment of proprietary systems to give confidence in their use.

4.4. Updating and improving the built environment

With societal and demographic changes, there are new demands on the built environment. Changing age distributions and lifestyles, greater disposable income, changing family and social structures, new technologies and greater awareness of health and safety issues all pose challenges. New requirements can be accommodated relatively easily in new buildings and townships. However, more than 50% of Europe's built environment was constructed between 1945 and the 1970s. It is impractical, and unsustainable, to demolish and replace this large stock, representing the investment of billions of Euros. Therefore there is a need to modify and refurbish existing buildings and structures, taking into account inherent limits to performance and the uses expected during the remaining lifetime.

In turn, this gives rise to a great need for diagnostic tools and modelling processes that can provide an assessment of the condition of a building or other structure, and lead to an accurate evaluation of the cost of conversion or restoration which can be set against its likely performance and utility. These tools require not only detailed knowledge of the life-time performance of materials and components, but also of the effect of new services (e.g. heating systems) on these, the regulatory (e.g. fire) requirements that will need to be satisfied, and how the eventual environment provided will satisfy the needs of users. In addition, issues such as the complexity of refurbishment works, the availability of requisite skills (particularly for cultural heritage buildings) and the disruption to users and to be adjoining locality will have to be considered.

The multi-disciplinary capabilities of ENBRI members enable them to be a focus for the development of such tools and evaluation systems. They are able to bring together knowledge from a wide range of disciplines to be able to predict the impact of interventions in existing buildings, which will require older elements to operate successfully with new materials and service systems. The ENBRI contribution will be based upon:

- Detailed understanding, based on long experience, of behaviour of materials and structures and the ability to investigate and predict long-term performance, with integration of technical, environmental and usability considerations in assessment tools.
- Knowledge of safety and other regulatory requirements and of natural and man-made hazards/threats, with the ability to contribute to regulations and codes that hold a balance between ensuring protection for building users and making re-use of buildings uneconomic.
- The ability to develop and assess technologies for improving energy and, more generally, environmental performance.
- Specialist expertise relevant to cultural heritage – eg in fire safety and the use of traditional materials.

4.5. Exploiting new materials and technologies

The need for more durable, higher performing and sustainable forms of construction will drive innovations in building materials and construction technologies. Traditional materials will continue to be used, but in new forms and in combination with other materials that will enhance their performance. Construction has imported many technologies from other sectors, and the developments now taking place in nanotechnology and biotechnology will ultimately lead to higher performance building materials. Examples include renewable natural fibres, organic additives for inorganic materials and surfaces with greater resistance to adverse environments. Other developments will lead to materials with the ability to capture ambient energy or to have controllable thermal characteristics. The re-discovery of wood as a basic, sustainable construction material which 'locks

up' carbon dioxide needs to be complemented by innovative ways of enhancing its resistance to degradation and could benefit from developments in biotechnology related to gene transformations.

Intelligent materials and systems will combine structural or aesthetic properties with ICT capabilities. Thermal, wind and impact stresses will result in compensating responses and data transmission to a management centre. 'Embedded intelligence' in components will facilitate automated assembly and life-time monitoring of performance. New sensors and communications systems will lead to new services.

Through their leading position in many material and technology fields, ENBRI members will participate and facilitate such developments. They have:

- Global links to technology sources through which they can maintain Technology Watch programmes, identifying technologies in other sectors that could be employed in construction.
- An in-depth understanding of the response of materials and systems to environmental stresses and user demands, leading to an ability to assess and adapt new technologies.
- Close links both with potential users of technology in the construction sector, enabling them to act as technology brokers.

4.6. Promoting education and training, knowledge transfer, quality employment and innovation

The construction sector is huge and diverse, embracing industrial mass production of building materials and products, site assembly processes, maintenance, the creativity of engineering and architectural design and the social development of urban communities. Achieving innovation requires consensus across many interests. The development of a knowledge-based industry requires new developments to be communicated to a multitude of firms and individuals, but also requires those firms to have the ability to assimilate and apply the knowledge that they receive.

Education, training, specialisation and coordination therefore have a central role to play in the transformation of the industry. New means of communication, and of providing construction workers with 'just-in-time' information, will be required.

Understanding of cultures and attitudes, of modes of learning, and of incentives and rewards, will be a foundation for promoting higher safety practices, changed relationships and more satisfying working arrangements. Without such changes, the sector will not succeed in attracting the skills required for global competitiveness.

At the same time, though the industry will need to address its image through promoting its central role in sustainable development and the preservation of the natural environment. It must present itself as a sustainable business sector that serves society creates value for its clients, staff and shareholders, respects its people and adds to quality of life. It will need to involve all stakeholders in this process. This requires new ways of co-operation and alliances between businesses in the supply chain. Also, co-operation between public and enterprises is necessary in order to create a longer-term, future-oriented view on developing the built environment. Public-private partnerships should be promoted more intensively both with regional and local governments.

ENBRI members support these routes to change in many ways:

- By having extensive communications and knowledge transfer programmes which reach out to all parts of the industry.
- By managing and promoting demonstration projects for new technologies and applications as well as new-ways of co-operation.
- By contributing to educational courses and training programmes, using the capabilities of new ICT technologies.
- By demonstrating that research and innovation have a role in the development of a modern, knowledge-based construction sector and providing attractive entry points to the sector for high calibre specialists.

5. The roles of ENBRI and its members in advancing the Vision

The vision for construction and the built environment set out in this paper is consistent with that now adopted by the European Construction Technology Platform. ENBRI and its members look forward to working with their partners in the Platform to give effect to that vision and its Strategic Research Agenda with a particular focus on both society and industry needs. In addition, as a founding member of the European Council for Construction Research Development and Innovation (ECCREDI), ENBRI will be working with the industry representative bodies from the Council and other parties to promote policies and initiatives at the European level that will promote the vision.

Many policies and programmes that influence construction, however, are the responsibility of Member States. The individual members of ENBRI will therefore be active in promoting the vision in their own countries. As independent focal points for construction research and innovation, they are particularly well placed to do so. Innovation in

buildings, as in construction generally, demands a multi-disciplinary approach to issues which ENBRI member institutes are uniquely able to provide. The insights gained through their research and development can then be shared with firms and representative bodies at national level, and can inform the policies and strategies of national governments.

A key forum for influence will be the National Platforms now created in many Member States to interface with the European Platform in order to promote coherence between national and European strategies for construction research and innovation. ENBRI members will be active in those National Platforms.

Collectively, the members of ENBRI represent Europe's principal resource for developing and promoting the technologies and processes needed for the creation of a sustainable European built environment and a competitive, knowledge-based construction sector. With more than 3000 researchers in a wide range of disciplines in the natural and social sciences and engineering, supported by experts in promotion and communications, they are a resource for all parts of construction but particularly they are able to promote and broker change through their position as independent institutes enjoying close relationships and the confidence of both industry bodies and public authorities. The ENBRI network guarantees a steady updating of international experience and enables the synergetic use of research and development capabilities as well as research focused on the applicability of results. This resource will be deployed at both European and national levels for common benefit of industry, authorities and society.

6. Concluding Comments

The performance of the built environment, and of the industry that creates and maintains it, is central to achieve a sustainable and competitive Europe. The industry is, moreover, the largest industrial sector by output and employment and the largest consumer of raw materials. It is essential that it should match the performance of other sectors. This paper has set out a vision for that industry, highlighted some principal themes in its future evolution and shown how the multi-disciplinary and internationally linked expertise of ENBRI members, and their positions as independent national focal points for the development and assessment of construction methods, products and processes, can contribute to the achievement of that vision.

ENBRI and its members are committed to achieving a sustainable and knowledge-based European construction sector. The creation of the European Construction Technology Platform, and the accompanying National Platforms, provides an opportunity for the development and implementation of strategic research agendas that will address that aim and ENBRI members will deliver input to these Platforms at both European and national levels. ENBRI looks forward to working with all stakeholders in the built environment in obtaining this long-term but vital vision and key challenges for the built environment. ENBRI, both as a network and through its individual members, has a distinct and substantial role to play in the creation of the future European construction sector.

ANNEX

ENBRI Competences and Capabilities

Research, technical development and the application of innovative products and systems in the market demands increasingly specialised knowledge and experience and expensive test facilities. To minimize the costs and make the best progress, it is logical to make use of the capabilities which is offered by different ENBRI members. Within the ENBRI network a wide range of highly specialised scientific competence and outstanding equipment are available.
Together ENBRI members have over 3,000 researchers/scientists in various disciplines as well as a large number of skilled engineers and laboratory technicians. These researchers are involved in research projects as well as in application, on-site monitoring and other associated activities. The institutes also deal with testing and certification. Active participation in national and European standardisation 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 members contribute to the harmonisation of European

ENBRI's general fields of activities include:

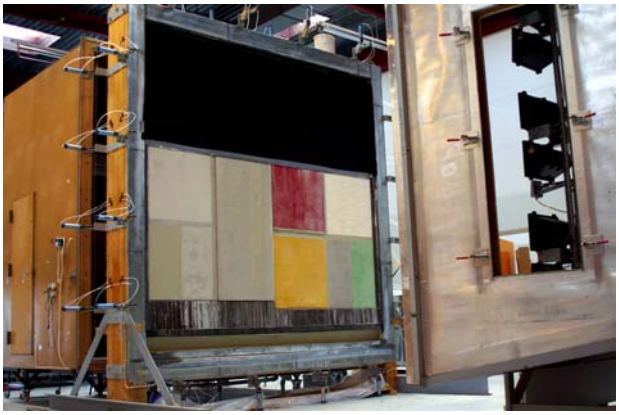
– **Construction – materials and structures** – materials science; whole life performance and life cycle of construction materials and buildings; geo-engineering and earthquake; resistant structures; heritage buildings, stone and masonry, risk assessment of structures, etc.
– **Construction – process –** process management, modern methods of construction, building services, housing and social development, business development, building economics.
– **Environment** – climate change and environmental sustainability, environmental engineering and performance; heating, ventilation, cooling, acoustics, daylight and lightning; occupants' comfort, productivity, safety and health.

– **Energy efficiency** – materials, techniques and technologies for the effective management of energy and the integration of new and renewable energy systems in buildings.
– **Fire safety engineering and risk management** – fire initiation, growth and explosion, fire containment, fire threat to people and the environment.
– **Codes and standards** – European design codes and product and test standards, national building codes, technical approvals of innovative products.
– **People** – quality of life, safety, skills development and training.
– **IT and knowledge management** – construction IT; intelligent buildings, building management systems.

Each member has developed its own significant profile, but under the umbrella of ENBRI the whole building and construction sector can be covered.
Innovation in buildings, housing and construction technology demands a capability in research and technical development, which is able to solve complex and multidisciplinary problems. ENBRI institutes 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 outstanding, often unique test facilities. Furthermore, ENBRI members have a broad experience on user requirement and working relations with industry partners, which results in research and innovation that is both useful and useable by the industry. The members

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.
ENBRI's Capabilities covers:

- Research and development
- Practical innovation applications
- Management of large research projects and programmes
- Investigation, testing, certification, assessment and evaluation
- Knowledge transfer, education, training
- Advice on the built environment and investment in related reseach and developement
- A multi-disciplinary European research network on the built environment.



Actions cover the full range of initiatives going from support to the single inventor seeking to obtain a patent and reaching to collective actions in standards and good practice documents, passing amongst others also over problem solving, technical advise, innovation stimulation, pre-normative research, pre-competitive research on cutting edge technologies, demonstration actions and teaching.

ENBRI members are fully integrated in the private and public networks and recognise partnerships between members and specific parts of the industry. The ENBRI members are well established within the scientific community. Each of them and all together are competent partners of the construction industry, owners and end-users, authorities and government, standardisation bodies and research institutions. It must be emphasized that ENBRI members are independent and neutral.

List of members

1. BAM – Bundesanstalt für Materialforschung und –prüfung, www.bam.de
2. BRE – Building Research Establishment, www.bre.co.uk
3. BYGGFORSK – Norwegian Building Research Institute, www.byggforsk.no
4. IETcc-CSIC – Instituto de Ciencias de la Construccion Eduardo Torroja, www.ietcc.csic.es
5. CSTB – Centre Scientifique et Technique du Bâtiment, www.ctsb.fr
6. WTCB/CSTC – Centre Scientifique et Technique de la Construction, www.cstc.be
7. EMI – Non-profit Company for Quality Control and Innovation in Building, www.emi.hu
8. EMPA – Swiss Federal Laboratories for Materials Testing Research, www.empa.ch
9. Enterprise Ireland, www.enterprise-ireland.com
10. IBRI – Icelandic Building Research Institute, www.rabygg.is
11. INCERC – Institutul National de Cercetare in Constructii – National Institute for Building Research, www.incerc.ro
12. ITC – Istituto per le Tecnologie della Costruzione – Construction Technologies Institute, www.itc.cnr.it
13. ITB – Instytut Techniki Budowlanej – The Building Research Institute, www.itb.pl
14. LNEC – Laboratório Nacional de Engenharia Civil, www.lnec.pt
15. SP – Swedish National Testing and Research Institute, www.sp.se
16. SBi – Danish Building Research Institute, www.sbi.dk
17. TNO – Building and Construction Research, www.bouw.tno.nl
18. TSUS – Technický a Skúsobný Ústav Stavebný – Building Testing and Research Institute, www.tsus.sk
19. TZUS – Technical and Test Institute for Constructions Prague, www.tzus.cz
20. VTT – Building and Transport, www.vtt.fi/rte
21. ZAG – Zavod za Gradbenistvo Slovenije – Slovenian National Building and Civil Engineering Institute, www.zag.si