

(Industrial) Research on Building Production: results and future developments (1)

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Abstract

In accordance with the most recent management mandate, ISTeA (Italian Society of Science, Technology and engineering of Architecture) has devoted its efforts to outlining those topics which are of fundamental importance for the activity of its stakeholders, in line with the road maps of national and Community funding programmes and with the strategic objectives of (Industrial) Research which range from the energy-environmental performance of buildings and districts to automation in construction within the context of Smart Cities and Social Innovation. These research programmes need to be planned and negotiated with industrial stakeholders and carried out in partnership with them.

This explains why the 2011 ISTeA Conference produced a number of position papers, the 2012 Conference traced the state of the art in the topics identified and the 2013 Conference deals with the non-instrumental relationship between Building Production and ICT.

Keywords: Research Policies, Construction Industry, Knowledge Management, Energy Efficiency, Automation in Construction

Introduction

In September 2011, ISTeA organized a conference in Ancona with the aim of taking stock of the wealth of knowledge acquired in the Building Production sector. This experience led to the release of the position papers, made public during the Milan 2012 Conference, representing fragments of the Group's research activity.

The Society pressed forward along the path it had started out on, gathering contributions from scholars from different backgrounds on the topics which look likely to dominate in the near future (2), and presenting them at the 2012 Milan Conference during the technical report presentation sessions on 18th October and at the plenary session on the 19th October held at Made Expo 2012.

With a view to reorganizing national and Community policies on industrial research, the following key issues for our sector were identified: (Alaimo et al., 2012):

1 - Dal progetto al prodotto di qualità per l'industria delle costruzioni (Imperadori, Dell'Osso, Esposito, Masera, Pierucci and Ruta, 2012)

2 - La gestione del ciclo di vita nelle costruzioni (Daniotti and Nicolella, 2012)

3 - L'automation in construction (Naticchia, Novembri and Carbonari, 2012)

4 - Le attività sperimentali e il knowledge reuse (Morra and Alaimo, 2012)

From project to quality product for the construction industry

The principal objective of this field is to improve the quality and sustainability of constructions (3), where innovation focuses on energy efficiency, the sustainability of materials and products, highly efficient alternative technologies and the safety of construction sites and buildings.

Two strategies can be identified within this field:

- the use of technologies which employ easily renewable resources aimed at flexible and reversible assembly (Design for Disassembly);
- the construction of very low energy consumption buildings.

These strategies normally employ the LCA (Life Cycle Assessment) method to assess environmental sustainability and are valuably supported by Building Automation systems.

The innovations identified relate to technologies, processes, materials, components and their integration, design or assessment tools and techniques, construction or disassembly techniques and advanced management systems (smart-operation).

The following main research topics were identified in relation to these innovations:

- Sustainable, low-energy buildings;
- Technological systems to monitor the performances of the building envelope;
- Buildings with high flexibility and reversibility (for example, Sustainable Smart Eco-Buildings);
- The building process and integrated information management (for example, the InnovANCE Project);
- Collaborative management systems for design processes;
- Management of construction processes (Lean Construction).

Maintaining quality standards throughout the transition from process to product also requires fruitful discussion and a perspective of Collaborative Design amongst the design teams, an approach which has seen research lavishing considerable efforts to identify and formalize Design and Construction Models.

Knowledge Management (KM), of which Information Technology is a part, has a very important role to play in Building Design Management. With this in mind, the approaches involve:

- IFC for the exchange of interoperable and smart models/objects;
- BIM (Building Information Modelling), as an application tools interface;
- Lean Process to espouse Knowledge Management with the organisational and process aspects.

Two main strategies were identified in the Construction Management stage:

- research aimed at integrating ICT and Construction;
- research which focuses more on Automation in Construction and is aimed at introducing Robotics into working activities, particularly through the use of Sensoristics and Distributed Intelligence.

We shall examine this research more closely later on.

Life Cycle Management in construction projects

This area of research can be split into two key strands:

- the development of Predictive Models of Behaviour (Durability and Service Life Prediction);
- the development of Management Models for buildings and their component parts.

One of the most important aspects in this field is the durability requirement, knowledge of which facilitates balanced planning of the resources to use in the different stages of the building process, ultimately contributing to the sustainability of the construction activity.

On the basis of the work carried out in recent years, Italy is coordinating the CIB Working Group, Methods for Predicting Service Life, and has overseen a publication on methods for assessing service life edited by the CIB.

At an international level, ISO 15686 standards deal with methods for assessing service life, and the use of these methods for planning maintenance and for assessing economic and environmental sustainability.

The seventh requirement of Regulation UE 305/2011, repealing Directive 106/89/CEE, concerns the sustainable use of natural resources, and foresees the durability of construction works (...).

At a national level, the UNI 11156: 1-2-3 standard - Assessment of durability of building components - was published in Italy in 2006.

Italian Ministerial Decree of 14 January 2008 (Technical Rules for Construction) reaffirms the principle of service life in the design of different types of constructions.

The main areas of research on the subject, on both a national and international level, are concerned with:

- The implementation of databases in which to store information on the service life of building components.
- Methods for the prediction and experimental assessment of the service life and reliability of building components.
- Tools and methods for assessing and implementing maintainability.
- LCA sustainability and assessment
- Management models (Calls to tender, Regulatory, Performance Specifications, Contracts).

The principal stakeholders concerned are real estate owners and managers, public bodies, producers of components and materials, trade associations, professionals and building companies.

Within these fields, researchers can contribute to the sector by means of both pre-regulatory and regulatory activities (CIB, ISO, UNI,...) and by setting up databases containing information on the service life of building components, in collaboration and in synergy with stakeholders. What is more, they can provide support for the research being carried out by producers and building contractors, as well as consultancy services.

Automation in Construction

The development of Information Technology has opened up new horizons in the construction industry, both in terms of procedures and the technologies to be adopted. In this respect, ISTeA is strongly committed to its work in the following two sectors:

- innovation in building sites, where the construction process is increasingly being supported by advanced technologies for monitoring purposes, technologies for interaction between human resources and construction elements and for communication between different production sites, robots;
- new building concepts, in which the building itself becomes a structure that is capable of relating to its occupants and to the context and of accommodating automated management logics.

The main research topics include: Health and Safety in Construction, Computer Aided Design and Engineering, Facilities Management, Management Information Systems, Building Management Systems, Robotics and Machinery, areas in which scientific activity can be characterized by the production of patents and also by innovations with a high degree of technological transferability.

Within this framework, and in a situation where professionals in the field are increasingly focused on providing integrated engineering services throughout the entire value chain, there are many sectors which would welcome innovations in terms of Automation in Construction (4).

The field of "on site" automation encompasses the creation of advanced systems designed to perform facilitated construction or management techniques, as well as the development of autonomous robotic heavy equipment or equipment to support human activity.

In this field of research:

- an initial approach focuses on integrating ICT in the construction process;
- a second approach concentrates more on Automation, particularly the introduction of Robotics.

There is a great deal of research being carried out into integrating widespread artificial intelligence and a pervading interactivity in the construction sector, starting with the systematic application of sensoristics to products, equipment and skills in order to achieve computational integration in real time. This innovative approach aims at achieving an interaction with materials, components and assemblies directly on-site, in order to obtain contextualized data that can be "superimposed" on the direct perception. As one can imagine, the vertically applied research also involves efforts geared towards (IFC and BIM) interoperability.

The development of ICT opens the way to the creation of smart products and systems capable of interacting with the context and physically connecting (5) the real world with the world of computing, making it possible to reach a new concept in building structures. This field of research also has a wide range of applications:

- from the setting up of automated building management systems

- to the integration of smart components with variable automated performances, in response to external forces.

Buildings themselves can become proactive and respond preventively to the needs of their users. Smart buildings will be network linked (to exchange information, energy) with the urban context (smart city), at neighbourhood or district (smart district) level.

Experimental activities and Knowledge Reuse

In ISTeA, experimental activities, which are a manifestation of immaterial investments and funding in innovation research, represent a very important field offering an abundance of experiences, one which encompasses all the research topics mentioned previously. However, given that the knowledge obtained appears to be somewhat scattered, it was decided to combine the topic of experimental activities with that of knowledge reuse.

A sizeable proportion of the activities carried out at the different research centres and presented at ISTeA's annual meetings since 2005 relate to the building envelope, which in recent years has been the protagonist of a rapid evolution, due to the fact that it is the place where energy exchanges take place between the building's interior and exterior spaces.

The following is a list of some of the experimental research being carried out.

- Technological innovation for sustainability and energy efficiency
- Safe Construction Management (Construction Management, Integrated ICT)
- Innovation for technological transfer
- Innovative assemblies of real life construction techniques
- Quality Control, Durability, Process Innovation
- Product Innovation (natural materials for new uses)
- Automation in Construction

Conclusions

It is a universally acknowledged fact that the building industry needs to rethink a development model of its own which is compatible with the demand for sustainability, competitiveness and productivity (CNEL 2011), increasing the use of organizational and production techniques, investing in research and in human capital (Draghi, 2010). These demands are particularly important for researchers.

It may therefore be useful to reflect on the role of knowledge and, especially, the importance of knowledge reuse, aimed at enhancing the value of innovation.

Our Sector needs to respond to the demand for development and the need to relaunch itself through a clear, non-rhetorical vertically integrated approach (Federcostruzioni, 2011) in which effective and efficient interdisciplinary research carried out by establishing networks and by identifying shared projects and which produces rapid and generally available results in terms of new knowledge, will play a paradigmatic role.

It is clear that these aspirations will require the overcoming of the separation between research which is carried out inside Universities and which is aimed predominantly at

communicating innovation, and research carried out by the construction industry, which is more resolutely aimed at applied innovation.

One example of this type of approach is the international Reference Service Life (RSL) Database (Daniotti and Lupica Spagnolo, 2009) which gathers, selects and formats data on Reference Service Life (RSL) useful for assessing the Estimated Service Life (ESL) of buildings components.

The database constitutes the final "product" of a vertically integrated approach between local, national and international networks aimed at the reuse and dissemination of specialist technological knowledge directed at everyone involved in the Building Process. The database constitutes a standardised method (ISO 15686-8) for organizing knowledge, according to the principles of Knowledge Management, with the help of ICT.

Knowledge Reuse can therefore play its part as an "Inspiration towards Innovation" and, together with the enhancement of the value of online multidisciplinary work and greater access to information, can contribute to the required increase in productivity and competitiveness.

A recently circulated idea within ISTeA involves setting up research and experimentation network structures between the different centres, groups and researchers within the macro-areas, all having different objectives. This would require the establishment of coordination units and would allow the benefits of knowledge reuse as well as the communication of results to be enjoyed fully within the network structure.

The potential benefits that could be obtained include:

- the limiting of fragmentation and individualism in research;
- the rationalization of resources, including human resources, and an increase in productivity and competitiveness;
- the possibility of offering a broader service and, together, the strengthening of relations between Research and Production;
- focused temporary mobility of young researchers;
- facilitation of applied research development processes and transfer of technology.

NOTES

- 1) From the report presented by G. Alaimo to the ArTec – ISTeA – SITdA Joint Assembly on 21 June 2013 in Turin.
- 2) Ministerial calls for tender, Community calls for tender for the Seventh Framework Programme, Horizon 2020.
- 3) In line with: "Europe 2020" Strategy, European Directive 31/2010/CEE, National Energy Efficiency Action Plan (PAEE) 2011, Technology Platform, ANCE (Italian Association of Private Construction Contractors) and Federcostruzioni.
- 4) The international scientific community which is active in these areas, is represented by IAARC (*International Association for Automation and Robotics in Construction*) and CIB (*International Council for Research and Innovation in Building and Construction*), organizations which entered into a collaboration agreement in 2009.

5) Interconnecting structure which in ICT jargon is referred to as "The Internet of Things".