

Accelerating the Green Agenda through Innovative Building Technologies

Keywords: Innovation, performance, sustainability

Background and Context

This chapter flows out of study (CSIR 2013b) prepared for the Presidential Infrastructure Coordinating Commission (PICC) in May 2013 which prepared a value proposition for the use of Innovative Building Technology (IBT) for the construction of clinics, schools, and student residences.

Aim and Objective

The **aim** of the study was to encourage innovation in the building industry as a means of accelerating green building. Green building rating systems include, as part of their objectives, demonstrating leadership to the building industry with regard to improving the environmental performance of buildings. The Green Star rating system is advocated on the following premise (GBCSA 2015):

- Establish a common language and standard of measurement for green buildings;
- Promote integrated, whole-building design;
- Raise awareness of green building benefits;
- Recognise and reward environmental leadership; and
- Reduce the environmental impact of development.

While rating systems have achieved various degrees of success with regard to the above, international industry reports (see below) hold the view that systemic challenges within the industry continue to impede an industry-wide transition to true sustainability. Similarly, the lack of innovation in the building industry is seen as one of the systemic challenges impeding transformation – a factor recognised by rating tools through the encouragement of green innovation.

The **main objective** of the study was to analyse, compare and validate the efficacy of IBT (time, cost and performance) in accelerating green and sustainable building in South Africa.

The secondary objectives were to:

- Quantify the benefits accruing to a project from IBT (time, cost, performance)
- Quantify the benefits accruing to the country from IBT (local beneficiation, economic growth, job creation, skills development)
- Support the development of a viable IBT industry in South Africa
- Reduce the quantity and mass of materials used in the building process
- Develop and utilise construction materials with low embodied water
- Develop and utilise construction materials with a low maintenance requirement
- Strengthen the local content of IBT
- Develop and utilise construction materials with low toxicity

Rationale

The construction industry in South Africa, particularly the building sub-sector, has a critical role to play in delivering social infrastructure facilities. However, the delivery process associated with conventional building technologies, i.e., brick and mortar, is slow due, in large part, to the

technology requirements (diverse and plentiful building systems, products and components assembled on site and the curing periods associated with 'wet' works).

Some IBT's on the other hand, adopt a more industrial approach to building and construction, i.e., more of the building systems, products and components are manufactured in a factory, and assembled on site. This method improves performance because quality control can be properly exercised under factory conditions, and the amount of time required on the construction site is reduced.

Construction reform

There has been numerous construction industry initiatives globally aimed at improving construction performance. From a review of these global initiatives as well as the South African Construction Industry Status Report, 10 systemic issues affecting construction industry performance in South Africa are identified (CSIR 2006). These are:

- i) Poorly integrated delivery system
- ii) Low performance expectations
- iii) Poor knowledge base
- iv) Inadequate construction inspections
- v) Inadequate construction warranties and services certification
- vi) Complicated procurement environment
- vii) Social, environmental and economic challenges
- viii) Inadequate quality-based regulatory environment
- ix) Poor business acumen, management and innovation
- x) Inadequate research and development

Research method

For the investigative research a mixed-method approach is adopted where both quantitative and qualitative analysis is used to arrive at a conclusion. The primary research question set is: how, and in what way, can the use of IBT assist building infrastructure delivery in a manner that delivers improved performance and sustainable human settlements? Five secondary questions are posed for discussion, namely:

- i) What is innovative building technology
- ii) Why is innovative building technology used
- iii) Where is innovative building technology used
- iv) How do innovative building technologies perform
- v) What is the value proposition promised by innovative building technologies

Research plan

The research plan used for the study is shown below.

Data collection

The following sources were used.

CSIR Parliamentary Grant Funded Research – the advancement of construction has been a focus of the CSIR Building Science and Technology competence area under the banner of the Advanced Construction Technology Platform (ACTP) for over a decade and numerous research reports prepared on the subject.

Literature Review – a desktop study was undertaken to obtain data pertaining to the main objective of this study.

Interviews – interviews were held with construction industry specialists both in South Africa and abroad.

Conference Papers – the CIB World Congress 2013 was attended in Brisbane Australia to obtain first-hand knowledge of the status of alternative building methods and technologies as well as to hold interviews with leading international academics and researchers in construction. This academic conference is held every three years and concludes a three year research cycle.

Case studies – use was made of three case studies to gain actual data based on South African projects where IBT were utilised.

Data collation – data collected from the research sources was collated using the primary and secondary research questions.

Synthesis – the data was synthesised to answer the sub-questions.

Conclusion – the synthesised data was used to derive a conclusion.

Limitations

The following limitations apply to this study:

- The availability of data on the use of IBT in South Africa is limited: Statistics South Africa does not capture construction data based on technology types.
- Only a few IBT trade associations exist, thereby impeding access to data about technology uptake in the building sector.
- Time restrictions applied to the research study, thus limiting the depth to which the study could delve. More time would be required for a thorough analysis to be done.
- Much of the data included in this report was provided by contractors and although their bona fides is not contested, the data has not been validated by the CSIR.

Delimitations

The following delimitations apply to this study.

- The study was located within the context of IBT, an international initiative to shift construction away from on-site bespoke construction to off-site manufactured construction.
- A Life Cycle Analysis had not been done to determine the environmental performance of IBT.
- No economic impact assessment had been undertaken.

What are Innovative Building Technologies?

Innovative Building Technologies (IBT) in the context of the study was the use of materials other than brick and mortar, and the use of construction methods other than on site mixing and erection. Within the building regulatory environment IBT refers to the use of materials and technologies not covered by the SANS 10400 building standards in the National Building Regulations and Building Standards Act 103 of 1977 (NBR Act), and where building permission is granted for such systems, materials and technologies based on either a rational design or an Agrément Certificate.

IBT can generally be described by its materials, i.e., either light (steel frames) or heavy (concrete panels), and methods, i.e., either on site (mixing and erection of raw materials on the construction site) or offsite (factory-based fabrication).

Globally IBT's form part of a larger initiative aimed at industrialising construction, i.e., the building process is more closely aligned with a manufacturing process where more of the components are manufactured and assembled on the factory floor and delivered to the construction site in modules of various sizes. This form of construction is known variously as Offsite Manufacturing (OSM), Modular Construction, Modern Methods of Construction, and Prefabrication.

In the context of this chapter IBT is defined as using alternative building materials, usually lightweight materials such as light steel frame sections, and offsite building technologies, where more of the components are manufactured on a factory floor.

Why are Innovative Building Technologies used?

The use of IBT is predicated on the desire to reduce the time (reductions of up to 35%) and cost (savings of up to 41%) of construction, to improve the quality of construction, and to improve the performance and the sustainability of construction products (CSIR 2013). The need to create a stimulating and rewarding working environment in order to attract young people to the sector is also a primary driver of IBT.

The case study (CSIR 2013a) found sufficient evidence to support IBT claims of cost benefits (reductions of up to 41%) and time benefits (up to 35%) as well as health, quality and sustainability improvements through international and local case study and questionnaires.

Buildings, both the construction and operation thereof, are a significant consumer of scarce resources. It is typically referred to as the '40% industry' – 40% of energy consumption, water consumption and raw material consumption can be ascribed to the global construction industry.

The increasing demand for a step-change in the performance of buildings is something that traditional construction method struggles to deliver. To ensure high levels of performance requires a high degree of accuracy in the construction process. This is expensive to achieve through traditional construction methods and the inevitable reworking and additional use of materials and investment in additional levels of supervision. This approach is costing money and eventually all such additional costs will accrue to the client. Adopting an approach to construction based on the assembly of components manufactured in factories to a high level of accuracy offers a realistic and much more certain approach to achieve the required levels of performance. The uncertainty and inconsistency of traditional methods does not offer a similar opportunity (Buildoffsite 2012).

Traditional construction methods give rise to significant waste of material whether as a result of the common practice of over-ordering, 'shrinkage', reworking to remedy defects of poor quality, or damage on site. No matter what the cause the client ends up paying for every scrap of material that is wasted and paying again for landfill. Aside from the financial cost this practice has a significant impact on the environment. There is no sign that the traditional construction industry has been able to effect any significant improvement in practice and frankly as the cost is simply passed on to the client and end user there is no incentive for change. The manufacturing and assembly of offsite construction solutions give rise to very little waste to landfill. Manufacturing waste is modest, readily measurable and in almost all cases collected for reuse and recycling (Buildoffsite 2012).

To achieve high performance green buildings will require the adoption of advanced and innovative technologies which conventional building techniques have struggled to achieve over the past 30 years. To achieve sustainable building and construction activities requires the development of the third generation of construction materials and methods, essentially those emerging as part of IBT.

It would be a mistake to see the shift towards IBT solely as a response to more rapid social infrastructure delivery: on the contrary, a shift toward IBT can be the catalyst for construction sector reform.

Numerous initiatives have been undertaken by various countries to enhance the capability of their construction industry particularly since the end of World War II. Stakeholders of the construction industry have responded to global challenges and domestic pressures exerted on the industry through research resulting in a series of major studies undertaken over the past 50 years.

Studies within the international arena include several by international agencies such as the United Nations, the World Bank, the International Bank for Reconstruction and Development, and the International Labour Office. Governments, clients and contractor organisations have also invested heavily in initiatives aimed at reforming the construction sector, with a specific emphasis on industry performance improvements and on increasing the sector's ability to innovate. The U.K. industry in particular undertook a spate of investigations such as the Simon (1944), Banwell (1964), Wells (1986), Latham (1994), Levene (1995), and Egan (1999) reports. These stimulated widespread international interest and spurred a spate of similar initiatives, including countries such as Ireland, Sweden, Finland, Australia, Singapore and more recently, Netherlands.

In the main the objective has been to elevate the construction industry into a vibrant, reputable and professional sector. Some have opted for best practice-type improvements to enhance delivery quality while others are actively pursuing new technologies. In reviewing the industry visions and strategies of these studies, the following issues appeared most consistently (CSIR 2006):

- i) **Technology as an agent of change** – many of the visions recognise the need for the industry to become more innovative and to a greater or lesser extent look to technology as the vehicle. Huge variations exist in terms of which technologies should be pursued, although the drive toward the greater use of off-site assembly processes appears consistently, especially in the Asian region.
- ii) **Strategies and structures for achieving change** – this includes the respective roles of official and industry bodies, strategy preparation and communication, and how individual stakeholders can participate in the change process.
- iii) **Procurement as a driver of behaviour** – this examines the degree to which procuring bodies can shape industry performance through their ongoing purchasing power, including new contractual and financing systems, the balance between imposed and negotiated requirements, and the entire supply chain delivery process.
- iv) **Monitoring and evaluating change** – every strategy has a monitoring system attached to determine the extent to which the objectives are being met, and usually includes benchmarking and indicators in its application.
- v) **Regulatory environment** – the introduction of statutory controls is a common approach to driving behaviour, although some markets are less amenable to government intervention than others.
- vi) **Human capital** – without fail, all visions recognise the dire need to greatly advance the depth of human capital within the construction industry, and advocate a number of strategies aimed at attracting skills, encouraging change, training for change, and creating a safe and healthy workplace conducive to innovation and improved productivity.

Where are Innovative Building Technologies used?

The uptake of IBT as defined for this study is generally higher in countries that have a tradition of light weight construction whereas the uptake is low in countries that have a tradition of brick and mortar construction. However the market penetration of IBT is increasing in the latter markets in

response to the pressures emanating from raw materials scarcity, the demand for higher performing buildings, the need to reduce associated construction risks, and the need to reduce construction costs.

In the BRICS countries interest in IBT is growing in response to developmental challenges with both China and Brazil showing an increased appetite to move in this direction. Certainly the use of prefabrication is fairly common in the BRICS countries especially with regard to precast concrete panels. There is evidence that light steel frame construction and structurally insulated panels are used in Brazil, Russia, India and China. However, the interest is now extending to innovative and advanced construction materials in the search for high performance, green buildings. In this regard Brazil is a member of the World Federation of Technical Assessment Organisations (WFTAO), an organisation which supports the technical assessment of non-standard systems and of which Agrément South Africa is a member as well.

How do Innovative Building Technologies perform?

Agrément South Africa certifies non-standard building products and system as fit-for-purpose by assessing the product and/or system against performance criteria. These criteria ensure that the system meets the performance requirements of the NBR Act.

For purposes of the study (CSIR 2013b) each certified system was scrutinised to determine whether the system was certified for the targeted use, i.e., clinics, schools, and student residences. In addition, only those systems with maximal local content were selected. The selected systems were then scored against key performance indicators derived from the Agrément Certificates and compared to a Standard Brick House (SBH), the benchmark used by Agrément as it meets the requirements of the NBR Act.

The result showed that the SBH scores an aggregate of 3.6. This places the SBH 32nd out of a total of 40 building systems according to the performance criteria as set out. From this data it may be said that most of the systems outperform the standard brick house.

To assist in the selection process the CSIR has developed an assessment tool – the IBT Rating Tool – to rate systems on optimal performance with regards to building performance, logistics, and climatic conditions.

What is the value proposition?

From the data it is evident that IBT demonstrate significant value-add to construction products. Sufficient evidence exists to confirm that IBT reduce construction cost by about 41% on average in South Africa depending on type and location; reduces construction time (by up to 50% in South Africa) depending on type and location; out-performs the standard brick house (SBH ranks 32nd out of the 40 systems); reduces the construction costs¹ of schools by up to R2,749/sq.m. (from R7,581 to R4,832); reduces the per student bed cost² in student residences by up to R44,146 offering a potential R8,8bn saving on the 200,000 bed backlog; and can act as an agent of construction industry reform by supporting the industrialisation strategy, local raw material beneficiation; the creation of decent jobs; and the green economy.

As stated earlier, it would be a missed opportunity to simply procure IBT to expedite construction delivery – the significance of IBT is located in the technology step-change and the ability to deliver construction products on time, to quality, to budget, with enhanced building performance.

¹ At 2013 prices

² Ditto

Using the ten systemic issues undermining construction industry performance identified in the Foresight Report (CSIR 2006), IBT's are able to overcome each of the systemic issues identified in the Status Report, namely;

- Simplifying the delivery system
- Establishing performance expectations
- Strengthening the knowledge base
- Adding to construction inspections
- Enhancing construction warranties and services certification
- Establishing defined procurement protocols
- Enhancing economic, social and environmental performance
- Strengthening business acumen, management and innovation
- Supporting research and development

Conclusion

Buildings and infrastructure contribute in large measure to the quality of people's living-, working- and leisure environment. But they also provide the infrastructure for mobility, industrial and commercial activities. It is clear in this way that a lack of innovation in the construction sector directly influences the costs and competitiveness of other industrial or economic activities within South Africa. For those reasons, innovation in the construction sector should be a major concern of South African institutions.

More than ever any focus on the construction industry must bring about a new total construction capability founded on customer orientation (addressing of unique processes), environmental design-based consciousness (ecological judgement), and a technology-driven (knowledge and expertise) delivery chain, including the built environment professions, material manufacturers and contractors. This will result in a re-conceptualisation of construction delivery best practice away from determining what processes are required from a construction perspective to what processes are required for the optimal formation of immovable assets. Inherent in this refocus is the building of construction competence and product knowledge on the basis of post-completion evaluation, assessment and re-application to achieve immovable asset fitness-for-purpose.

The study showed that IBT's offers an opportunity for a technology transfer paradigm shift that will transform traditional construction methods into a manufactured production process that will benefit society through improved property performance, which will directly impact national concerns about the environment, the state of social infrastructure and the improvement of the quality of life of communities. The study shows that IBT's outperform conventional building technologies against a basket of indicators, and without a loss of quality. In addition, the study shows that both cost and time is reduced, and that working conditions are greatly improved, creating decent jobs and making the construction sector more inviting for young entrants.

References

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