Editorial

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Traditionally, and for as long as one can remember, the construction industry had been using symbols on paper (drawings and specifications) to communicate the design intent for client approval, bidding, procurement, fabrication, construction and installation. Such an approach can be rendered abstract when the project environment has no native intelligence and, as a result, human interpretations (reading) and manipulation (quantities take-offs) are required to provide meaning and value to such symbols. In moving towards a common platform to avoid some of these pitfalls, building information modelling (BIM) is therefore 'one of the most visible aspects of a deep and fundamental change that is rapidly transforming the global construction industry' (McGraw Hill Construction, 2010: p. 1).

For the construction industry to reap the rewards of higher productivity, accuracy, quality and worker safety, just like in other industries (such as manufacturing and commerce), a new approach that can describe and display the information required for the design, construction and operation of constructed facilities has to be used to bring together the different threads of information used in construction into a single operating environment thus reducing, and often eliminating, the need for the many different types of paper document currently in use (Begley *et al.*, 2005).

There is now a growing worldwide adoption of BIM following recognition of its powerful data-based modelling, visualisation, analysis and simulation capabilities. This heralds the start of a transition to an integrated digital information infrastructure that will ultimately revolutionise almost all aspects of tasks and activities in the construction industry (Smith and Tardif, 2009). The current debates on issues of adopting BIM to deliver projects include

- (a) avoiding mistakes from the computer-aided design era
- (b) developing new 'systems' approach
- (c) aligning business goals with BIM technology

- (d) the real value of BIM
- (e) managing culture change
- (f) how it really works
- (g) what is in the model
- (h) developing data exchange capabilities
- (i) assessing team capabilities and managing expectations
- (j) measuring progress and return on investments (Smith and Tardif, 2009).

Past studies (Aranda-Mena *et al.*, 2009; Eastman *et al.*, 2011; Fussel *et al.*, 2009; Gujarathi and Ma, 2011; McGraw Hill Construction, 2010; Owen *et al.*, 2013; Popov *et al.*, 2010; Succar *et al.*, 2012; Smith and Tardif, 2009) have suggested that the adoption of BIM will make a great impact on the way a construction project is managed. It will also bring about more accurate and safe construction with a more sophisticated design and data-mining process to allow all stakeholders of a construction project to input critical information into the BIM software before the start of actual construction on site. As the adoption of BIM in the construction industry is mandated in some countries, its potential benefits should be maximised in the very near future. Its utility in facilitating the unbundling and analysis of the factors that influence project performance in order to address some of the endemic problems of the construction industry, which hinder its progress towards excellence, is a significant contribution from BIM adoption.

In the call for papers for this themed issue on BIM, we articulated that BIM offers the opportunity to examine alternative design proposals, to create the link between design and construction and to eliminate errors and subsequent changes. In countries such as Singapore and the UK, fully collaborative three-dimensional (3D) BIM has now been mandated, with all project and asset information, documentation and data being managed electronically. At present there are also several companies in the construction industry with the capability to work in a fully collaborative 3D environment. However, in order to reap the full benefits of adopting BIM

across infrastructure and building projects, it is essential that the challenges and best practice in this area are shared. It is also clear that much work still needs to be done to appreciate the full benefits of this new technology. We have also highlighted that BIM will remain a topical area for discussion and debate over the next few years and it is, therefore, timely for us to share our experience and knowledge with the worldwide building and civil engineering community on current and future issues in this area. This themed issue offers contributors the opportunity to share best practice, present leading-edge thinking, challenge current practice, offer case studies or identify new research directions and approaches to enhance the adoption of BIM in design, construction, operation and maintenance of infrastructure assets and facilities.

This themed issue contains two briefing articles and five papers. The first briefing (Bew 2014) puts into focus the importance of the document PAS1192:3:2014 (HMG 2014) – the specification for information management for the operational phase of assets using BIM – as part of the programme to deliver level 2 BIM in the UK. PAS1192:3:2014 supports the level 2 BIM initiative, which is set to become policy in 2016. The briefing article provides an account of the ongoing work and significant achievements of the Institution of Civil Engineers (ICE) BIM action group in this direction.

The second briefing article, by Joyce and Houghton (2014), presents a legal note produced by ICE's advisory panel on legal affairs. It extends the outline of, and introduction to, legal issues and considerations that practitioners may encounter with common topics in construction – in this case, relating specifically to BIM. The briefing discusses the applications of BIM, the considerations for different parties and issues such as industry protocols, intellectual property, standard forms of contract as well as BIM and the Construction (Design and Management) Regulations 2007 (HMG, 2007). It is an important reference for practitioners to understand their legal positions with respect to BIM adoption in the course of their work.

The first paper, by Olatunji (2014), discusses the all-encompassing question of 'what is this change really about and who does it affect?' The paper explains the relationship between BIM-triggered change and existing change management theories. It also discusses the various types of change such as behavioural change, process change, role change, skill change, tool change, product change, project change scenarios, BIM-triggered change and change to legal frameworks. Additionally, and as an extension to the second briefing article, this paper deliberates on some of the legal implications arising from the different scenarios of BIM changes before concluding with some interesting potential areas for further research.

The second paper in this issue, by Teall (2014), evaluates the current situation and ongoing developments relating to the use of BIM tools and processes in major projects undertaken by the Highways Agency in the UK. The paper explains the benefits of BIM within the sector along with the current restrictions to its use. The current challenges in the link between major project BIM tools and highways asset management and areas to improve the whole-life management of highways assets are identified. The paper provides important lessons for highway agencies in other countries.

Also on the highways sector, the third paper (Burt and Purver 2014) reviews the opportunities and barriers to BIM adoption in private, small residential projects. The authors believe that the ambitious target in the UK (namely the mandatory BIM of maturity level 2 for all government contracts from 2016) is pushing the UK construction sector to the forefront of a new approach to working, thus potentially bringing about changes to design team organisation, procurement, contracts, programming, deliverables and professional indemnity insurance. The authors evaluate the significant productivity gains for non-government contracts where there is as yet no legislation to enforce the BIM protocol. The paper is a useful resource for stakeholders who are primarily involved with smaller projects and who wish to learn more about how BIM can gainfully be employed in this context.

In the fourth paper, Smith (2014) presents an account of an earlier journey taken by Crossrail in 2007, establishing its technical information foundation and how the project aligned with the subsequent emerging requirements as set out in the UK *Government Construction Strategy* (GCS) paper which requires all major UK government construction projects to adopt BIM by 2016 (UK Cabinet Office, 2011). The paper provides an interesting overview of the adaption and refinement undertaken by Crossrail in its approach to meeting the requirements spelled out in the GCS paper. The paper highlights valuable lessons for the industry especially for stakeholders who are preparing for BIM adoption.

The final paper, by Vernikos *et al.* (2014), presents findings from research on the need to integrate BIM and off-site construction to allow for a leaner design with a greater integration of life-time project data through the use of more novel technical solutions. The authors' findings indicate the importance of configuration and interface management, information data flow, project management delivery, as well as procurement and contracts. The paper highlights the benefits of using off-site construction within a BIM environment, the challenges faced and recommendations for implementation in order to reap the emergent benefits.

It is clear from the two briefing articles and five papers that BIM adoption is gaining much momentum in the industry,

especially with respect to a situation where BIM adoption has been declared to be mandatory in specific circumstances. This issue highlights the myriad concerns and issues relating to BIM familiarisation and implementation, with BIM being viewed as at an infancy stage where adoption by some industry stakeholders is concerned. There is still much to be learned, including work-in-progress by the ICE BIM action group to support members in their BIM endeavour. While BIM has been presented in this issue across different project types (from major highway and rail projects to off-site civil engineering to small-scale residential projects), focusing on the technical aspects of BIM, there is also a call for stakeholders to be aware of the corresponding procurement, contractual and legal issues associated with BIM implementation. Collectively, these briefing articles and papers provide an interesting overview and synthesis for BIM implementation in the construction industry with valuable lessons for other countries going down this route presently or in the near future.

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