



OpenAIR@RGU

The Open Access Institutional Repository at Robert Gordon University

<http://openair.rgu.ac.uk>

This is an author produced version of a paper published in

Architectural Technology, Towards Innovative Professional Practice :
Conference Proceedings of the 5th International Congress of Architectural
Technology, Aberdeen 2014 (ICAT2014) (ISBN 9781907349096)

This version may not include final proof corrections and does not include
published layout or pagination.

Citation Details

Citation for the version of the work held in 'OpenAIR@RGU':

MELLON, S. and KOUIDER, T., 2014. SMEs and BIM in preparation
for 2016: a case study. Available from *OpenAIR@RGU*. [online].
Available from: <http://openair.rgu.ac.uk>

Citation for the publisher's version:

MELLON, S. and KOUIDER, T., 2014. SMEs and BIM in preparation
for 2016: a case study. In: T. KOUIDER, ed. *Architectural
Technology, Towards Innovative Professional Practice :
Conference Proceedings of the 5th International Congress of
Architectural Technology, Aberdeen 2014 (ICAT2014)* 7 November
2014. Aberdeen: Robert Gordon University. Pp. 226-241.

Copyright

Items in 'OpenAIR@RGU', Robert Gordon University Open Access Institutional Repository,
are protected by copyright and intellectual property law. If you believe that any material
held in 'OpenAIR@RGU' infringes copyright, please contact openair-help@rgu.ac.uk with
details. The item will be removed from the repository while the claim is investigated.

SMES AND BIM IN PREPARATION FOR 2016

A Case Study

MELLON S., KOUIDER T.

Design Manager at Team Xero & MSC Student @ RGU

s.mellon@rgu.ac.uk

S. Lecturer and UG Program Leader, Robert Gordon University

t.kouider@rgu.ac.uk

Abstract: The UK Government has mandated the use of Level 2 Building Information Modelling (BIM) on all publicly funded projects above £5 million by 2016. As a major construction client, the government would hope to see the widespread adoption of BIM throughout the industry as the requirements disseminate through the supply chain. The drive towards this target has been accompanied by much publicised advances in the information technology associated with BIM but while many larger firms in the construction industry are well advanced in their plans to implement the government plans, a large proportion of SMEs are not so well prepared for the deadline. The National Federation of Builders (2012) found that 81% of SMEs have either no familiarity or a vague familiarity with the levels of BIM. Findings such as this have led to fears of an emerging two tier industry.

This study aims to determine the extent of readiness of SMEs to meet the requirements using a live case study, and examines the barriers that such firms working in this environment may encounter. The case study emphasises the benefits of the adoption of a collaborative mindset, underpinned by IT tools, which is the concept behind the government definition of BIM. However, research has shown that significant barriers still exist among SMEs to the adoption of BIM and this has been borne out by findings in this case study, though potential solutions to some of the issues are suggested.

1 Background

The live case study which forms the basis for this report is a project incorporating the detail design and construction of eight townhouses and six apartments (Block D) contained within a larger retail development in Shirley, near Solihull in the West Midlands of England.

The development has courted controversy from the outset, with challenges to the ownership of the land, over-running building works and other factors. The main contractor for the retail areas is a large company with a large housebuilder constructing most of the residential plots. However, due to the fact that Block D plots were immediately adjacent to the rear wall of the superstore within the retail development, the main contractors were to construct these residences which *“...were incorporated and designed to screen the back of the foodstore to provide a high quality elevation facing the park”* (the adjoining Shirley Park) (Solihull Planning Committee, 2014 p3).

Consequently, completion of Block D was an integral part of the planning conditions for retail activities to begin. However, due to the impending opening date, it was decided that the construction of these townhouses would be awarded to an alternative contractor. Construction of the shell of the apartments is still to be undertaken by the main contractor but the alternative contractor will also be tasked with fitting out this building. Permission was sought to vary the planning conditions and allow the retail element to begin trading before completion of the townhouses. The fact that a variation of the conditions of planning permission was sought at a very late stage and that, at the time of writing, construction of Block D has only just begun with days until trading commences is perhaps illustrative of the lack of priority given to this zone.



Figure 1. Bloc D in construction

1.1 THE CLIENT

The client in this case is a Joint Venture between two large property investment and development concerns. Block D can be seen as being somewhat of a ‘means to an end’ for the client. As cited above, they screen the rear of Asda superstore which, coupled with promised regeneration works in the park, and relocation of the existing Baptist Church and British Legion, would have made granting planning permission a more attractive proposition to the council. This is further highlighted in the planning appeal decision:

‘...it would transform the juxtaposition between Shirley Park and the ‘town centre’ replacing the muddle of back elevations and dreary access ways with a carefully delineated frontage...’ (The Planning Inspectorate, 2011, p14).

The Employer Requirements Document itself contains few specific requirements for this site and is very much a ‘standard issue’ document. Other than adhering to planning permissions obtained, the design team were at liberty to amend the concept design as they saw fit.

1.2 THE CONTRACTOR

The alternative contractor appointed for the construction of Block D is Team Xero, a young, relatively small construction company who support ‘...*a whole-building approach that encourages early collaboration between stakeholders...*’ (www.teamxero.net, 2014). Their commitment to a collaborative way of working is evidenced by the use of a ‘Cloud’ drive to which appropriate sub-contractors are given access and appropriate editing permissions. The company has also recently commenced the use of a cloud based information management tool, again, to which concerned parties are given access.

1.3 FACTORS AFFECTING DESIGN

The process of design management, according to Dale Sinclair, ‘...*is the discipline of planning, organising and managing the design process to bring about the successful completion of specific project goals and objectives.*’ (Sinclair, D., 2011, p 4) In order to accomplish a successful project, the design manager must identify and investigate the factors which may affect the design. Once these factors are identified the process of planning, organising and managing can begin, taking these considerations into account.

1.3.1 Provision of Screening to Retail Areas

As referred to above, Block D will have the effect of screening the rear of Asda from the park and as such, will benefit the community who use the park and the shopping centre by the provision of a more attractive (and completed) built environment ensuring ‘...*a high quality public realm that benefits from natural surveillance and a perimeter block development...*’ (Solihull Planning Committee, 2014, p.2).

Due to the delayed construction of Block D, the community; both park users and potential users of Parkgate will not, initially, benefit from this desire of the Planning Committee. It is advantageous therefore, that construction is completed as swiftly as possible and Team Xero, taking this into account as well as the site constraints to be discussed later, have modified the concept designs to take advantage of modern methods of construction, in order to accomplish this.

1.3.2 Improved Liveability

Upon reviewing the concept design, it was felt that better use could be made of the spaces within the townhouses. The layout of the interior was improved to increase the appeal of these properties, and thereby, increasing their saleability.

Due to the fact that the houses were elevated “...to give a defensible space for the residents and definition to the edge of the park” (Parkgate, Shirley, Design and Accessibility Statement, (vol 1), p23), an underfloor area was created. The concept design stipulated that this area could not be a void as through ventilation would not be possible due to the lack of space between the Asda service yard wall and the rear of the property. It was envisaged that this area would be filled with concrete. This solution would have been a feasible one had the properties been constructed as planned, in tandem with Asda. However, the timing of construction in the event meant that the delivery of concrete which would take long periods of time, would be extremely problematic due to site constraints.

In the early stages of the construction of the foodstore, the original contractor had undertaken the laying of the foundations for the townhouses. At this stage, block built apartments were planned on the site of Block D. It was decided later to construct townhouses instead, mainly due to parking issues. However, the foundations were already laid and are in effect too large and over engineered for the townhouses, especially now these are to be timber framed and therefore much lighter than the originally intended block built structure.

Team Xero, in conjunction with the architects realised that as the foundations were larger than required for the planned properties, it was possible to move the houses forward thus creating enough space at the rear to allow through ventilation to the underfloor area. Design and manufacture of a beam and block floor has now been commissioned which has allowed for the creation of a storage area beneath the houses and a place for wheelie bins which had not been considered before. These simple additions should increase the appeal of the properties to families who often have greater requirements for storage space than the concept design provided for.

A further improvement made is the installation of a whole house ventilation system. Rather than the more conventional method of ventilation which would require a vent in the wall next to the terrace, each room has a duct which feeds into a central duct and takes polluted air out through the roof. This method maintains interior air quality and improves the appearance of the houses by dispensing with unsightly vents in prominent places.

1.3.3 Economic Factors

The method of procurement agreed upon for the construction of block D was Design- Build. A sum was agreed with Team Xero for the detail design and construction of the properties. The design team have moved towards more modern methods for this project as it is believed that these can enable value for money as well as a better service for the client, as compared to more traditional approaches indicated by the concept design. Thus, these perceived

improvements to the design, will benefit both parties; the client should receive a more saleable property and the contractor will realise a good profit margin.

It is important to note that while the design-build method of procurement involves a certain amount of leeway with the detail design, the design builders enthusiasm to improve on concept design, must be tempered by the fact that they must finance the construction. This is especially the case for SMEs who can often have cash flow issues. It is imperative that there is strong administrative support here to ensure that agreed stage payments are processed on time in order to provide funds to pay suppliers on time.

1.3.4 Modifications to Design

As referred to above, the townhouse element of Block D was initially designed as a traditionally constructed apartment block. In reviewing the plans, many areas of the properties were found to be over engineered. This was due to the fact that the concept design had introduced little in the way of structural change when the decision was made to substitute the apartments for townhouses. The foundations have already been mentioned, but as these were laid prior to site access being granted, this was a factor that had to be accepted and indeed have proven to have some benefits. However, the wall and floor thickness, designed with apartments in mind, were thicker than is required in a single residence. These were re-engineered to make them thinner, thereby reducing material content and cost.

As Block D is low priority for the client, they have, to date, not been greatly involved in the detail design, and do not appear to be inclined to. Further, they did not negotiate to any great extent on the price of construction. Team Xero were in the fortunate position of not having any real competition for this contract which would have forced prices down. This is enabling Team Xero to aim to provide properties which are above expectation for the client, at a reasonable cost to them, and thereby build their reputation.

According to Levy; ‘*One of the first assurances [for the client] will rest with the desire of the design-build team to maintain their reputation as a quality design- builder; or for a first time design- build team, a need to establish a reputation for quality work.*’ (Levy, S.M., 2006, p 31)

While this particular client does not seem concerned about the design, it is still the case that it is vital that Team Xero establish a good reputation. Also, while the contractor is a relatively new company, the architect’s firm employed to undertake the design work, is an established local business who would also want to ensure that their reputation is not compromised in any way.



Figure 1. Plan layout of the new townhouses design

1.3.6 Site Constraints

Had construction of Block D taken place as originally intended, this would have had the added benefit of facilitating coordination during construction on what is a very restricted site. Delivery access to Block D is via the Asda service yard. Deliveries are by arrangement with the store manager and must be coordinated so as not to interfere with Asda deliveries, which have priority. During the initial few weeks of construction, and at the time of writing, the store is undergoing its initial merchandising period and deliveries to the store are frequent. The frequency should reduce somewhat once the store is trading, easing the pressure a little on deliveries to the Block D site. This restriction has impacted detail design of Block D as any site deliveries have to be made punctually and swiftly.

The decision to construct with timber frame rather than the originally intended block built structures was at least in part taken to ease the pressure of deliveries to site. The components can be manufactured off site in relatively large parts and delivered to site when convenient and on a just in time basis. The timber frame manufacturer's team can then erect the frame in a relatively short period. While easing pressure on deliveries, this decision will also ease the additional difficulty of site storage which is comparatively scarce. The other factor affecting the design modification to the timber frame was again due to site space constraints which allowed no space for scaffolding to be erected at the rear of the properties thereby making blockwork built structures impossible.

Rain screen cladding is also to be installed on this project and again will be delivered to site relatively quickly, saving on site storage space and installed quickly by the manufacturer's team.

The contractors also elected to install a beam and block floor which brings the benefits referred to above but also has the advantage of being pre-fabricated off site, again, thereby reducing pressure on site to accommodate deliveries.



Figure 2. Site access plan showing site access constraints with the food store located at the top and the park at the bottom.

1.3.6 off Site Manufacture

Offsite manufacture of building components is becoming more commonplace and it has many benefits. A major benefit is the reduced risk in terms of Health and Safety to site employees; a major driver for the UK Government in recent years has been to reduce construction site accidents. To realise the full benefits of off-site manufacture: *“The integration of prefabricated should become an inherent part of the overall design...disproportionate costs and subsequent waste can arise... from a failure to fully understand the implications of the design.”* (Stirling, C., 2003, p1)

The potential for cost reduction is greatest during the concept design phase (Stirling, C., 2003). While, in many areas, the decision to opt for prefabricated components was necessary due to the site constraints, Team

Xero have incorporated these in the detail design. However, this is due to the rework of the concept design plans; so did introduce a significant amount of waste into the process. That said, this was perhaps unavoidable due to the change in circumstances of the project and the inclusion of prefabricated elements has provided solutions to the new site restrictions faced since the concept design was completed.

2. Rationale

The rationale behind this paper is to study the extent to which SMEs are equipped to meet the Government's requirement of use of BIM on all publicly funded construction projects costing more than £5 million by 2016. There is some concern in the industry that SMEs are not keeping pace with the progress required to meet this deadline leading to further concerns about the potential emergence of a 'two-tier' industry. In order to illustrate the issues associated with this, a live case study is used.

The objectives of this paper are to examine, through a live case study, some of the design management issues which may arise for an SME within a BIM context and also to examine some of the IT design and communication tools used in this process. A further aim is to examine some of the barriers to adoption of BIM which SMEs face.

A small survey was undertaken taking the form of a short questionnaire which was issued to some of the stakeholders. This requested information about the respondent's company, followed by a section on the IT tools used on the Block D project and thereafter some questions on their awareness and use of BIM. Responses were received from the contractor, the architect and the quality assurance consultant. All of the respondents work for SMEs and all are at differing stages as concerns the adoption of BIM.

3 Design Management Process

3.1 3D DESIGN

One of the main requirements for level 2 BIM is the use of 3D design tools. The detail design for Block D is being undertaken in 3D. This has facilitated the review of plans and the development of solutions to the site constraints on this site. While in this case it has been beneficial, it should also be stressed that this is essentially a wasteful process as effort expended during the concept design was essentially lost once the project was handed over to Team Xero. According to Koskela, Huovila and Leinonen, "*...unnecessary rework is one of the most important waste types in construction design...*"

(2002, p7) This is also the case for the detail design as drawings are passed to the contractors in 2D form.

3.2 COMMUNICATION

Effective communication is an essential requirement of BIM and some issues encountered in this case study are illustrative of the extent to which design has been facilitated or hindered through communication.

As stated elsewhere, the client did not provide a detailed brief. This was partly due to the late change of contractor and perhaps an assumption that the concept design would be more closely followed. However, it was felt by the contractor that substantial benefits could be realised with certain changes from the concept design. Some of these were borne out of necessity due to site constraints such as the decision to construct timber frame properties. Others came from a desire to provide more liveable properties and thus more saleable ones. While communication with the client has been minimal, good communication channels with the Project Manager have been developed which has facilitated the design process.

Communication within the design team is strong. The architect has quickly bought into Smartsheet (discussed below) and is using it fully. Other team members are gradually being brought on board but seem receptive to the concept. This way of working will improve communications amongst all users and provides project data in a convenient, easy to access place, making reworking less likely and thereby freeing up the team to be more productive.

Good relationships with the foodstore management team are crucial if construction is to run smoothly. As discussed earlier, the detail design has been amended to take into account potential difficulties with deliveries.

One potential difficulty which has arisen is with the site manager appointed by the contractor. While maintaining excellent standards on site, he is not IT literate and is unwilling to communicate by email and to use other communication tools utilised by the rest of the team. For this reason, drawings are delivered in hard copy but potentially this could cause difficulties where a plan is amended and he continues to use an outdated version. Avoidance of this problem is one of the major benefits of BIM.

4 Design and Communication Tools

4.1 SMARTSHEET

Team Xero has recently implemented the use of Smartsheet as a cloud based project and information management tool which delivers: *'...all notes, discussions, files and information in one centralized location that's*

accessible across browsers, devices and operating systems. ..Real time collaboration that streamlines communication, empowers teams, and drives efficiencies.” (Smartsheet.com, 2014)

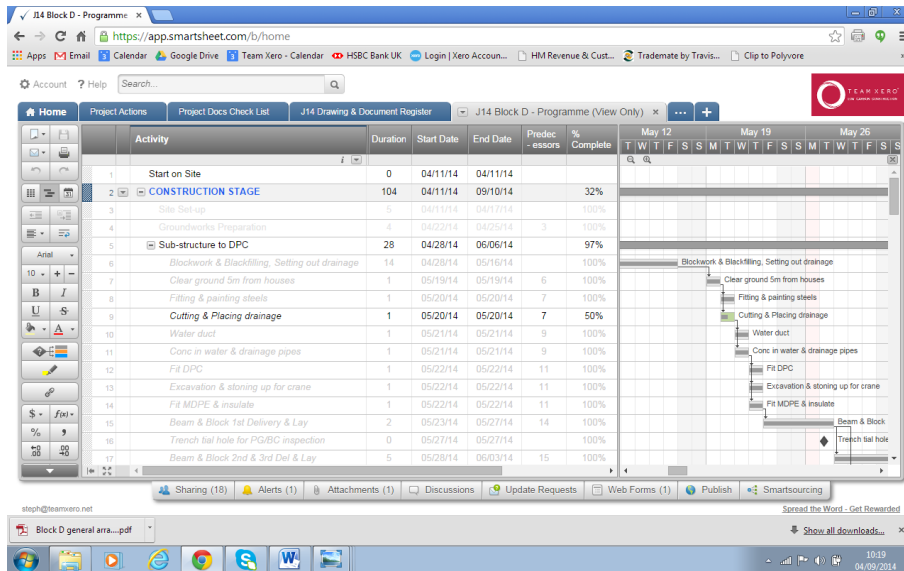


Figure 3. The screenshot above shows part of the Programme sheet which features a Gantt chart for design and project management.

Team members are invited to access the Smartsheet, and are given appropriate permissions. Not all of the capabilities of this tool are being employed yet but currently, users can set alerts for changes, participate in discussions and attach files and drawings. Update requests can also be sent to other users.

The Smartsheet app also facilitates the viewing of drawings and documentation on site or at meetings. The Block D site is equipped with laptops with an internet connection but is soon to be equipped with tablets also which will allow use of the app while away from the site office.

The commitment of the constructor to collaborative working methods is further evidenced by the organisation of a briefing session on Smartsheet, to which all users, including the client and their representatives have been invited.

Two of the principal tabs in use are the Drawing and Document Register to which is appended the most recent version of each drawing with a calendar indicating when each version was updated; and the Programme tab which displays a Gantt chart for the project. This tab is ‘view only’ demonstrating the flexibility of the permissions function as a user can be assigned editor status but this can be overridden for a particular tab.

PAS1192-3:2013 is the British Standard relating to the requirements for achieving BIM Level 2. It requires the production of information “...using standardized processes and agreed standards and methods, to ensure the same form and quality, enabling information to be used and reused without change or interpretation.” The use of Smartsheet, while perhaps not fully meeting these requirements, is an important step towards this goal. If all parties could be persuaded to use this platform, the objectives of PAS1192-2 would be closer to being met.

	Title	Scale	Ref	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
7	Townhouses - GA's																		
8	Site Set-up Plan		2254/SK01					B											
9	General Arrangement Plans	1:100	2254/01	A	B			E											
10	General Arrangement Elevations	1:100	2254/02	/	B														
11	Areas		2254/03																
12	ASDA Service Yard, Marshalling Area 3D	NTS	2254/04					/											
13	Rear Wall Elevations	1:50	2254/05					/											
14	Setting out	1:100	2254/06				A	B				D	E	F	G				
15	Model Plans	1:100	2254/07																
16	General Arrangement Roof Plan	1:100	2254/08																
17	General Arrangement Elevations 1	1:50	2254/09																
18	General Arrangement Elevations 2	1:50	2254/10																
19	GF Setting out Part 1	1:50	2254/11																
20	GF Setting out part 2	1:50	2254/12																
21	Drainage Layout		2254/14																
22			2254/15																
23	Window & External Door Schedule	doc	2254/16																
24	Munster Window Schedule	doc	2254/17																
25	Details Sheet 1		2254/18																

Figure 4. Screenshot of a Smartsheet segment from the Drawing and Document Register. An attachment is indicated on the left and the drawing version attached is indicated on the right by a letter and the date it was amended. This should ensure that only the most recent version is available.

4.2 3D DESIGN

While 3D design is an integral part of BIM, it has not been fully utilised on this project as referred to earlier which has to some extent, led to a wasteful design process. Nevertheless, its use has contributed to the solution to detail design on what is a very constrained site.

4.3 BUILDING INFORMATION MODELLING

One of the aims of BIM is to drive out the large amounts of waste that the construction industry is notorious for. The Block D project has been guilty of wasteful practices in part due to the change in contractor but also because the detail design drawings are taken (in 2D) from a 3D design platform, thus increasing workload but also rendering some of the advantages of the 3D design negligible. This is a very common situation and will require interoperable BIM software within design teams to solve.

The UK Government has defined BIM as ‘...*a collaborative way of working, underpinned by the digital technologies which unlock more efficient methods of designing, creating and maintaining our assets...*’ (HM Government, 2012, p3)

The contractor has thus far, demonstrated a commitment to a collaborative way of working but does not possess the appropriate software and trained personnel to declare themselves BIM compliant. Given the Government’s 2016 deadline, it is clear that an investment in this is crucial in the near future in order to continue to grow the business. Given the collaborative methods of working, Team Xero has demonstrated that they possess the mindset to operate BIM successfully but this is a large financial commitment for an SME to consider. A possible solution to this difficulty would be to form a partnership with likeminded firms in the supply chain. For example, Team Xero partnering with MRT Architects, structural engineers, mechanical and electrical engineers, and other design subcontractors. The costs of appropriate software and training could then be shared. Obviously, this could give rise to some legal and contractual issues, but if these are overcome, this could be a way of delivering the digital technologies to underpin the collaborative way of working sought by the Government. The focus on such collaborative partnerships could be the secret not only to achieving BIM but also to developing a new business model as summarised by Ken Sanders: ‘...*The critical path isn’t BIM, but rather process innovation squarely focused on people, partnerships, shared expertise, and timely decision making*’ (Sanders 2004).

5. Summary of Findings

Some of the main points arising from the survey are that all participating parties have found Smartsheet to be a powerful communication and management tool. The Quality Assurance consultant on this project commented that it ‘*gives confidence that the information you are viewing is the most up to date*’.

As concerns BIM, the architect, whose firm has invested in BIM compliant software, commented that while they have the capability, they do not generally use it to its full extent as much of their work is domestic and ‘... *there are very few other consultants using it.*’. He further commented though, that should they gain any government work, they will be ‘...*well placed to develop into collaborative working*’. The Quality Assurance consultant believes that there is ‘...*no doubt that the industry will save in the long run and produce better value projects*’.

6. Conclusions

Kouider and Paterson (2013) assert that 90% of the UK construction industry is made up of firms with ten or less employees. Three issues with the 2016 deadline are identified:

- The timescale is short
- BIM Software is constantly developing and the ICT requirements will impact on firms trying to implement BIM, this is especially true of SMEs
- ‘...*the human, financial and expertise resources needed to effect change may put a considerable strain on the industry...*’ (Kouider, T. and Paterson, G.J., 2013, p125)

The aim of this study has been to assess the readiness of the industry, in terms of SMEs, to adopt BIM by 2016. While ‘mindset’ is often cited as being a significant barrier to adoption, this does not appear to be the case here. Almost all parties involved have embraced the collaborative environment enabled by Smartsheet. However, it would seem that even those who are fully ‘BIM enabled’ have not recognised that the collaboration applied on this project is the kind of mindset that would be required on a full scale BIM project.

The responses to the survey suggest cost is a major barrier in the adoption of BIM. Not only in terms of the initial investment but also the perceived added cost to a project. The contractor commented that ‘...*at our project size the fees for the professional team are often highly competitive leaving little scope for ‘extras’ to be offered*’. It is hoped that at some point in the future, as occurred with CAD, that BIM will become more of a standard offering but in order for this to happen its use needs to become far more widespread and will require a change in perception from it being seen as an ‘extra’.

As suggested by Kouider and Paterson, the financial cost may well put considerable strain on the industry. This study has shown that perhaps the adoption of a collaborative mindset contributes towards some of the aims of BIM. Further, in consideration of the expertise required for the adoption of

BIM, collaboration between firms may well contribute to acquiring a ‘pool’ of expertise and would help in sharing the cost of adoption. An example in this project would be the information session held on Smartsheet which was open to all potential users.

SMEs in general will require substantial support in order to become BIM compliant, but in utilising the collaborative mindset, potential solutions do exist which may reduce the impact of the issues identified by Kouider and Paterson.

References

- [BRITISH STANDARDS INSTITUTION, 2013. *PAS1192-3:2013. Specification for Information Management for the Capital/Delivery Phase of Construction Projects Using Building Information Modelling. London: British Standards Limited.*](#)
- HM GOVERNMENT, 2012. *Building Information Modelling*. [online]. London: HM Government. Available from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/34710/12-1327-building-information-modelling.pdf [Accessed 4th May 2014].
- KOSKELA, L., HUOVILA, P. and LEINONEN, J., 2002. Design Management in Building Construction: From Theory to Practice. *Journal of Construction Research*, 3(1), pp 1-16.
- KOUIDER, T and PATERSON, G.J., 2013. Architectural Technology and the BIM Acronym. In: KOUIDER, T., ed. *Architectural Technology: The Defining Features. Proceedings of the 4th International Congress of Architectural Technology*. 2013. Sheffield: ICAT. pp 122-141.
- [LEVY, S.M., 2006. *Design- Build Project Delivery*. New York: McGraw- Hill.](#)
- [NATIONAL FEDERATION OF BUILDERS, 2012. *BIM: Ready or Not?* Crawley, West Sussex: National Federation of Builders.](#)
- PARKGATE, SHIRLEY, DESIGN AND ACCESSIBILITY STATEMENT (Volume 1). [online]. Available from: http://www2.solihull.gov.uk/PlanAppDocs/2010/1260/1260_design_and_access_statement_volume_1.pdf [Accessed 3rd May 2014].
- PART M, THE BUILDING REGULATIONS, 2010. [online]. Available from: http://www.planningportal.gov.uk/uploads/br/BR_PDF_AD_M_2013.pdf [Accessed 3rd May 2014]
- SANDERS, K., 2004. Why Building Information Modelling isn’t Working Yet? *Architecture Record*, September 2004.
- SINCLAIR, D., 2011. *Leading the Team: An Architect’s Guide to Design Management*. London: RIBA Publishing.
- SMARTSHEET.COM, 2014. *Product Tour, Collaboration*. [online]. Smartsheet.com. Available from: <http://www.smartsheet.com/product-tour/collaboration> [Accessed 4th May 2014].
- SOLIHULL METROPOLITAN BOROUGH COUNCIL PLANNING COMMITTEE, 2014. *Revisions to Parkgate Phasing Condition (Planning Application 2010/1260)*. (Head of Development Management). [online] Solihull Metropolitan Borough Council. Available from: <http://eservices.solihull.gov.uk/mgInternet/documents/s3616/Revisions%20to%20parkgat>

[e%20Phasing%20Condition%20Planning%20Application%2020101260.pdf](#) [Accessed 30th April 2014]

STIRLING, C., 2003. *Off- site Construction: An Introduction*. Watford: Building Research Establishment.

TEAM XERO, 2014. *Home*. [online]. Wellesbourne, Team Xero Ltd. Available from: <http://teamxero.net/> [Accessed 30th April 2014].

THE PLANNING INSPECTORATE, 2011. *Appeal Decision: Appeal Ref: APP/Q4625/A/10/2143309*. (D.R. Cullingford). The Planning Inspectorate