CONFERENCE PROCEEDINGS

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PLACES AND TECHNOLOGIES 2018

THE 5TH INTERNATIONAL ACADEMIC CONFERENCE ON PLACES AND TECHNOLOGIES

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TABLE OF CONTENTS

TABLE OF CONTENTS

CITIZEN EMPOWERMENT, PUBLIC PARTICIPATION AND DEMOCRATIC CITIES

ARCHITECTURAL DESIGN AND ENERGY PERFORMANCE OF BUILDINGS

ARCHITECTURAL DESIGN AND NEW TECHNOLOGIES

HERITAGE, TOURISM AND DANUBE CORRIDOR

SPATIAL AND RURAL DEVELOPMENT

APPLICATION OF BIM TECHNOLOGY IN THE PROCESSES OF DOCUMENTING HERITAGE BUILDINGS

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ABSTRACT

Building Information Modelling (BIM) is present for more than two decades in domain of new build construction, and is already gaining certain levels of maturity. In the centre of this technology stands a 3D model, consisting of intelligent objects, as an infrastructure for all non-geometric information. Theoretically the model is accessible to all participants of the processes of building conception, design, construction and use, until the end of its life cycle. In domain of built heritage, however, BIM is still a new technology that needs to be tested and examined on various examples, from different points of view. In this study we are focused on selected cases from international practice, in which BIM has been applied in heritage domain with aim to examine the technology, its usefulness and various purposes of its application. The three analysed cases (Harmondsworth Barn, Manchester Town House Restoration and Sydney Opera House) are selected by diversity, searching for different building sizes, significance, chronologic appearance and functionality, as well as by BIM application purposes. All of the selected cases of BIM application are part of wider research projects financed by either government agencies, ministries or city councils. Methodologically this study is based on the analysis and comparison of the contents of detailed research reports accompanying each of the considered cases. After giving a general introduction of BIM technology, in this paper we are highlighting some specificities of BIM application for the heritage buildings and places. The paper proceeds with brief analyses of each of the three cases, than a comparison of initial data and the main findings. After that, a discussion of possible generalization of the main findings is given. The paper concludes with a set of general directions for the possible BIM technology application in domain of built heritage.

Keywords: BIM, Building Information Modelling, heritage, documenting

Introduction

Building Information Modelling (BIM) is considered as one of the most radical steps forward in design technology since introduction of ICTs in design process. In the core of BIM technology stands a 3D model of a building, consisting of intelligent objects representing real building components, their main features and interrelations. The 3D model is a geometric representation of an object that serves as infrastructure for linking all other relevant, non-geometric information. Theoretically, such model is used during an entire life-cycle of an object, from its early conception, design, documentation, construction, operation, until its demolition. It should be accessible to all participants in the conception/design/construction/operation process, who use the information from other participants and contribute information from their specific disciplines. Working in a BIM environment means dealing with 3D models and using a variety of interoper-

1 Corresponding author

able software, equally able to read information from each other. The interoperability is therefore one of the most important requirements from contemporary software.

Discussing BIM application, nowadays it is possible to distinguish four levels, known as levels of BIM maturity. BIM Level 0 is based on simple 2D CAD drawings that are not interlinked with each other on the way that a change done on one element has automatically been executed on the same element in all documentation. The documents on this level are exchanged among participants in the design process as paperwork or as electronic CAD drawings, while a 3D model does not exist. BIM Level 1 is partly based on 2D documents, while some disciplines might produce 3D models. The models are not exchanged among disciplines. BIM Level 2 presumes using of 3D models by all involved disciplines and a possibility among the disciplines to exchange the models instead of 2D documents. BIM Level 3 is characterized by a common, centralized model to which all disciplines contribute.

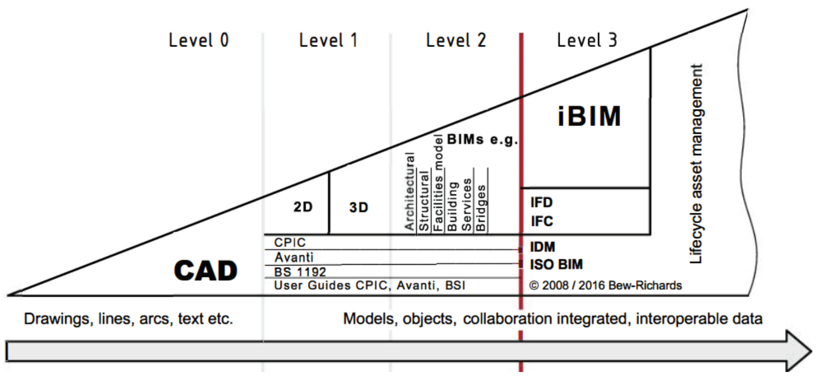


Figure 1 BIM maturity levels according to Bew and Richards (PAS 1192-2:2013, pp. Vii)

Application of BIM technology in domain of built heritage, called HBIM, is a logical advancement, after establishing the technology in the new-built sector.

Analysis of selected cases of BIM application in documenting heritage buildings

In the process of selecting examples for this study, the first principle was to look for differences, i.e. to analyse the cases that treat objects differing in size, function and importance. The second requirement was to select the cases well presented by both professional media coverages and independent scientific reports. That way the following three cases are chosen for analysis:

- Harmondsworth Barn documenting
- Manchester Town House restoration
- Sydney Opera House documenting

Two of the selected examples come from UK and it is not by chance, because UK represents one of the most advanced BIM markets.

Harmondsworth Barn documenting

Harmondsworth Barn is one of the largest timber framed buildings in England and an outstanding example of medieval carpentry. It was erected around 1426 in the village of Harmondsworth, today in the proximity of the Heathrow airport. It is categorized Grade 1 heritage object by English Heritage. The building is 58m long and 11.3m wide, with a footprint of 661m^2, consisting of 12 bays (HarmondsworthGreath Barn, Wikipedia, 2017).

After purchasing the barn in 2012 by English Heritage, an initial 3D model based on an accurate 3D scan of this building, was made in 2014 by CyArk (www.cyark.org), an institution dedicated to creation of a 3D library of world heritage objects. This model was the so called mass-model and not entirely appropriate for integration of wider information (Brookes, 2017).

In 2016 a company called Ramboll has been commissioned to perform a range of research activities, through collecting existing information and acquiring new ones, systematizing available datasets, testing available software and creating new one, extensive modelling, comparing different 3D scanning technologies, etc. 12 software have been applied and tested, one of which produced in-house, and 8 models have been produced. Majority of the information produced has been integrated and put in cloud, so that it could be accessed using Web browser by various participants in the process of managing and maintaining the barn (Ibid., pp. 5).

One of important characteristics of the reported research on documenting the Harmondsworth Barn is examining four different levels of detail (LOD) in modelling the timber framed structure. The LOD1 to LOD4 examples have been illustrated and systematized in tables (Figure 2).

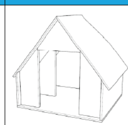
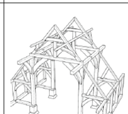
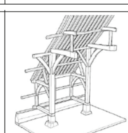
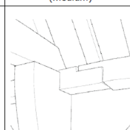
LoD	Description	Visual example (model tolerance)	Survey Class (listing grade)	Potential Uses
1	A simplified representation of the overall size and arrangement Includes walls and floors/ceilings No doors or windows Modelled as single or multiple objects Information/data potentially tagged to locations and/or simple objects	 (Simplistic)	L1 L2 L3 (any)	Simplest way of providing spatial context to building/site Linking Asset management data using information tagged to locations
2	Primary features are represented in a simplified form Window and door openings Most objects modelled as correct category wherever possible Most objects modelled as individual forms of approx. correct size, shape and location Information/[illegible] attached to each part		L1 L2 L3 M1 M3 (any)	Site orientation and single coordinate system for positioning Geometry complete enough to plan conservation projects Asset management data added to representative individual [illegible]
3	Most building features are represented using illustrative family types or modelled-in-place elements of correct type where possible Windows and doors as families/components in the style of the actual objects	 (medium)	L2 L3 M1 M3 (II*,I)	Site orientation and single coordinate system for positioning Geometry complete enough to plan in detail conservation projects Asset management data added to representative individual objects Accurate Visualisation Clash detection
4	As many features as possible represented as realistically as possible Potentially using custom built families Walls potentially showing inclined and/or bowed profile Beams and columns showing actual shape (i.e. loaded shape) Connection details to be included	 (high)	M2 M3 M5 (I)	As LoD 3 but geometry modelling detailed enough to fabricate, fit and manufacture repairs/restoration of parts Geometry models good enough for 3D printing technology

Figure 2Harmondsworth Barn – a table illustrating four levels of detail (LOD) examined while modelling the building (source Brookes, 2017, pp. 23)

An important effort has been done in producing a LOD2 BIM model of two bays, consisting of (idealised) simplified intelligent objects. Each of the objects has been described by a considerable amount of well structured, non-geometric information (Figure 3). The methodology of lowering the level of detail (LOD) and increasing level of information (LOI) might be appropriate having in mind that in the case of heritage objects there are other methods of documenting, like photographing, video recording etc. that could be linked with the simplified elements of a model.

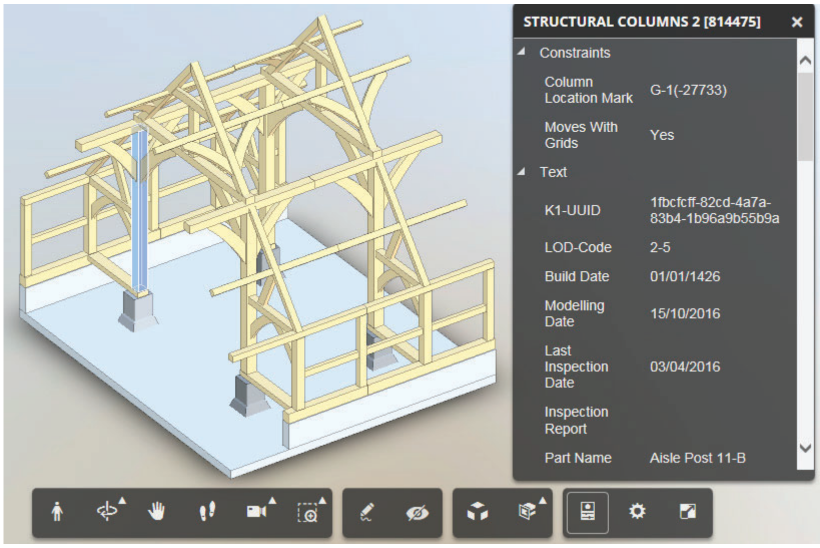


Figure 3Harmondsworth Barn – the LOD 2 model of two bays with the additional information retrieved for a highlighted column, available at http://a360.co/2fiBdqj.

One of the most interesting results of documenting the Harmondsworth Barn is the conclusion that a mesh modelling according to a cloud of billions of points obtained from a 3D scan, might be too demanding in terms of modelling time and efforts. It is therefore proposed a technique of a so called hybrid modelling in which selected intelligent objects have been added into a point-cloud representation of a complex structure (Figure 4). This technique is to be further examined and developed.

Figure 4 , Harmondsworth Barn – the hybrid model combining a scanned cloud of points with modelled intelligent objects, available at http://bim4h.org/hybrid-panos/1.html

Manchester Town House Complex restoration

The Manchester Central Library, a part of the Town House complex (Figure 5) is a grade II listed buildings of UK national significance, designed in 1930s by Emanuel Vincent Harris (Manchester Central Library, Wikipedia, 2018).It has been restored from 2010 to 2014 with a budget of £100m. In 2009 Ryder Architecture won the contract to redesign the Central library, and the City Council made commitment to use BIM in all its projects.

Figure 5 Manchester Central Library and the Town Hall extension (source of illustration Wikipedia https://en.wikipedia.org/wiki/Manchester_Central_Library)

As reported by the Ryder Architects (Mallett, 2015), one of main benefits of BIM application in this project, apart from conducting a coordinated design process involving all participants similarly as in new-built projects, was a possibility to simulate proposed building solutions through an integral model (Figure 6) and communicate the proposed solutions to English Heritage professionals being responsible for final approvals.

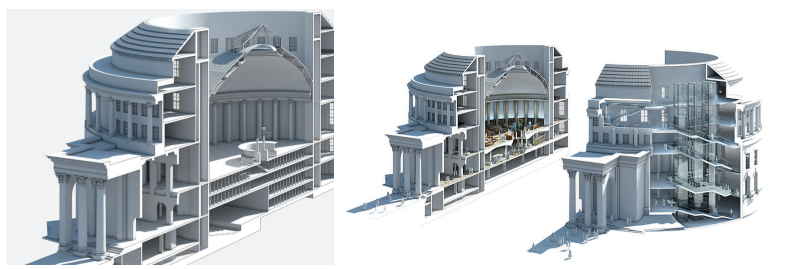


Figure 6 Manchester Central Library – using the BIM model to examine proposed restoration solutions (source of illustration e-architect https://www.e-architect.co.uk/images/jpgs/manchester/manchester_library_proposal_r120511.jpg)

Sydney Opera House documenting

Sydney Opera House is one of the best known 20 century landmark objects in the world. It is designed by Danish architect JørnUtzon and opened in 1973.

The research related to BIM applicationhas been done from 2005 to 2007 within the Sydney Opera House FM Exemplar Project funded by CRC (Cooperative Research Centre) for Construction Innovation and the Australian Government Facilities Management Action Agenda. One of the main reasons for this activity was the fact that the Sydney Opera House documentation was digitized from paperwork but is not consistent, nor accurate. No integral digital model of the building existed.

Figure 7 Sydney Opera House – An examination of interoperability between BIM and FM applications (source of illustration Mitchell and Schevers. 2006, pp. ix)

The focus of this research was on examining interoperability using the IFC (Industry Foundation Classes) standard for exchange of models among different software platforms.Experimentally, a partial structural model done by ARUP in the Bentley's Microstation has been exchanged with ArchiCADand then with several FM software (Figure 7).A perspective for creation of an integral main model from the partial multidisciplinary models was foreseen as realistic and a set of internal standards has been developed in this regard.

An important result from the Sydney Opera House research is the recommendation for a wider FM industry to adopt the IFC standard for exchanging information with BIM systems.

Conclusions

The application of BIM technology has been one of the important requirements for construction of public buildings in many countries. Since the heritage buildings mostly belong to the public sector, or are of a wider public interest, it is expectable that the similar requirement for BIM application will soon be set for the heritage domain.

Unlike the new-built sector in which the application of BIM has been forced by a requirement to reduce the construction costs, in the case of HBIM the main reason of application could be a need to re-integrate information fragmented among various stakeholders (like in the case of Harmondsworth Barn) or obtaining up-to-date documentation (like in the case of Sydney Opera House) prepared for a more efficient management of facilities, or upcoming reconstructions (like in the case of Manchester Town Hall).

In terms of technical requirements HBIM slightly differs from BIM applied in a new-built sector, requiring more specific modelling, stronger hardware resources and integration of additional technologies like laser scanning. It also introduces some new modelling techniques like the hybrid modelling, in which a super-accurate model based on a cloud of points obtained from a 3D laser scanner has been combined with newly modelled, intelligent, information reach components.

It might be a good practice for related authorities to do the efforts towards allocating certain funds for experimental application of HBIM in documenting carefully selected, characteristic heritage objects, involving industry, academia and national heritage preservation bodies. Precious experiences obtained from such experimental application, might contribute to creation of localized instruction manuals and standards in documenting national heritage buildings.

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