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# **The Widening Knowledge Gap in the Built Environment of Developed and Developing Nations: Lean and Offsite Construction in Nigeria and the UK**

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## **Abstract**

This paper assessed the knowledge divide between the UK and Nigeria construction industries in the area of lean and offsite construction. This study utilized literature review as a method of determining the extent to which lean and offsite construction has been identified as new knowledge areas in the built environment in Nigeria and the UK by using a benchmark of 15 literature materials from journals, books, published thesis and conference proceedings for each construction concept. The findings suggest that there are few published literary materials related to lean construction in Nigeria and there were no published materials related to Nigeria in the areas of offsite construction. The literature search for lean and offsite construction in the UK revealed that there were many materials about these topics. These literary materials have been in existence for several years in the UK. This exposes the knowledge gap which has been widening over the years between Nigeria and the UK.

**Keywords:** Lean construction, offsite construction, the UK, Nigeria, construction

# 1 Introduction

Innovation and research in the built environment have been tools for improving the economies of the world (Fairclough, 2002; Hodge, 2007). The construction industry is a key sector in national economic. Several concepts and theories have been developed over the years by academics in the UK, United States of America, Australia and other developed countries. Some of these include building information modelling (BIM) (Takim, Harris, & Nawawi, 2013; Volk, Stengel, & Schultmann, 2014); lean construction (Aziz & Hafez, 2013; Issa, 2013; Marhani, Jaapar, & Bari, 2012); offsite construction (Vokes & Brennan, 2013); value engineering (Kanapeckiene, Kaklauskas, Zavadskas, & Raslanas, 2011); supply chain and inventory management in the built environment (Marra, Ho, & Edwards, 2012; Martínez-Jurado & Moyano-Fuentes, 2013); benchmarking and key performance indicators (Alwaer & Clements-Croome, 2010). These new concepts which have been developed over the years by academics have shaped many construction industries.

The purpose of knowledge is found in its application; even though these concepts in the built environment might not be new to some countries and academics, there have been very few write ups about these theories in many developing countries of the world. Most economies in Africa are beginning to emerge and they are having one of the highest GDP growth rates in the world (fDB, OECD, UNDP, & UNECA, 2013; NBS, 2012). However, if these African countries have to bridge their infrastructure divide, modern methods of construction have to be employed.

This paper compares the literary gap, when it comes to the availability of these new built environment concepts in the construction industries of Nigeria and Great Britain. Nigeria and the United Kingdom stand as key economies in the developing and the developed world respectively. Therefore, there is a need to investigate the level of knowledge shared between these two nations in the built environment. For the purpose of this paper only two of these new construction concepts will be considered. These are *lean construction and offsite construction*. These concepts are associated with modern methods of construction, however the construction industries of Nigeria and the UK have to be reviewed to understand the educational and knowledge creation capabilities.

## **2 A comparative overview of the UK and Nigerian construction industries**

Nigeria, former British colony has been independent since 1960 (Dantata, 2008). The prominence of construction organizations began in the 1940s with several construction projects (Isa, Jimoh, & Achuen, 2013). This had a catalytic effect on the embryo economy at that time. At the moment the economy of Nigeria is one of the largest in Africa (Dantata, 2008). The construction industry in Nigeria has played a significant role over the decades, valued at about \$3.15 billion, the industry continues to grow and this is based on the construction knowledge acquired from the British in the 1940s and 1960 (Isa et al., 2013). However this growth has not been reflected in the level and quality of construction delivery which has been marred by construction delays (Odeh & Battaineh, 2002) and lack of automation (Equere & Tang, 2010). The construction professions in the UK such as Architecture, Quantity Surveying, Estate Management, Building technology, land surveying, Civil engineering, were brought into Nigeria and taught as courses in early 1940s and 1970s (Isa et al., 2013). The building technology which has been taught and applied during this period is what is still in place now, although the use of ICT has become very common in Nigeria construction in recent times (Equere & Tang, 2010). There has been a low level of innovation, research and development in the Nigerian construction related institutions compared to the UK.

The UK construction industry has been investing and encouraging construction innovation and research, with many tertiary institutions which are well funded to investigate the areas of sustainability and improved housing provision. The UK construction knowledge base is vast and well structured. Great Britain has been utilizing information technology for compounding the construction industry's Knowledge and information in form of databases which are available online (Fairclough, 2002). Research and development which is supported by the Department of Trade and Industry (DTI) has gone beyond construction for profit but for sustainability, waste reduction and it is more people oriented (Hodge, 2007). The measures put in place over the years have led to the development of knowledge areas in lean construction and offsite construction. These areas have only now been the major topic of many developed construction industry because of their inherent benefits.

The awareness of any form of theory or knowledge is evident in the readily available literature or academic community related to it. The academic community in Nigeria may not have been very familiar with some of these supposedly new concepts; however there is a need to investigate and ascertain if there is a knowledge gap in these areas.

### 3 Lean construction

Lean construction rests on the production techniques of lean production. Lean production began in Toyota car manufacturing in the 1950s and it was developed by Ohno, a Japanese Engineer (Alarcón, 1997; Green, 1999). This system of production adopted the principle of eliminating waste before and during production. This terminology was created by the research team at Toyota (Green, 1999). Waste is viewed as anything synonymous to shortfall in expected performance. Therefore, the concept of lean production engulfed all activities from design to production. This innovation in production management brought about massive success in Toyota.

Lean construction is evidence that successful principles in manufacturing can be applied in the construction industry. The cost, duration and quality of construction project delivery improved greatly as a result of lean construction (Sacks, Koskela, Dave, & Owen, 2010; Tezel & Nielsen, 2013). However, some drawbacks in this new construction technique have been identified in employee's response to change. Notwithstanding, the opinion of some academics such as Green (1997) has not deterred the application of lean construction in many construction companies around the world. Under lean construction, most projects have an outlined objective which has already been established at the design stage, this makes design concurrent with production (Alarcón, 1997; Green, 1999). The control of construction activities throughout the entire process is also very unique; control in lean construction is viewed as monitoring individual activity against the established duration and time. This may be very common in most traditional approaches but lean construction utilized monitoring as a basic objective in production.

Waste reduction during production is the significant force of lean construction. Therefore, these methodologies revolve around waste reduction. Apart from this methodology, the basic instruments of lean construction as identified by Koskela (1997) includes multifunctional task groups; kaizen; just in time deliverables; co-marksanship; customer orientation and information, communication and process structure.

Lean construction has been applied in the UK, USA, Japan and some developing countries (Sacks et al., 2010; Sadreddini, 2012) , other developing nations such as Nigeria is yet to include lean construction as a new construction method (Adamu, Howell, & Abdulhamid, 2012). The benefits lean construction has needs to be tapped for the greater good of the built environment.

## 4 Offsite construction

The term offsite construction refers to a construction where part or the entire building component is manufactured in a controlled environment such as a factory (Arif & Egbu, 2010). Offsite construction is regarded as an integral part of modern methods of construction. Modern method of construction (MMC) is different from the traditional method because it does not make use of the usual building materials which involves bricks or blocks. This form of construction became common in the UK after the Second World War but there have been some evidence of manufactured construction before this time (Vokes & Brennan, 2013).

This form of construction is divided into four types which is components manufactured and sub-assembly, volumetric pre-assembly, non-volumetric pre-assembly and modular buildings (Arif & Egbu, 2010). Components manufactured are the usual elements of a building such as doors, bricks, tiles and windows. These components are manufactured in the factory and are found in manufacturers catalogues. Non-volumetric pre-assembly are individual units of building elements which are mainly wall claddings, wall panels or bridge units (Vokes & Brennan, 2013). This type of building construction is considered to be a modern method of construction, skeletal frames of building units or building services (Farrell, 2010). Volumetric pre-assembly is in the form of plants rooms, cold rooms or any form of specified units of a building which is attached to the services. Volumetric pre-assembly is produced in the factory where there specification of the required element is manufactured and transported to be included in the space (Blismas & Ron, 2007; Chiang, Hon-Wan Chan, & Ka-Leung Lok, 2006). The final stage of offsite construction is modular building; this type of offsite construction ensures that the entire building is manufactured in a controlled environment, the final product is transported to the site for fixing on a foundation (Brioscu, 1975; Brioscu & McEvatt, 1973). Modular buildings are becoming common in the construction of homes, prisons, health centres, office complexes and shopping malls. This process has a lot of benefits ranging from reduced cost, time, improved quality of buildings, productivity and management of labour (Gibb & Isack, 2003). However, some of the demerits of this form of building erection in the UK have been identified to have its toll on the employees who need to be trained to acquire new skills in construction. Change is inevitable but most contractors in the UK still prefer the traditional methods of construction.

Recent studies of offsite construction in the UK indicates that it has grown to about £6 billion in 2006 (Gibb, 2007) from about £2.2 billion in 2005 (Goodier & Gibb, 2007), this figure is increasing because of the general acceptance of this method of construction. This figure has made significant contribution to the growth of Great Britain's construction industry over the decade. The

construction industry in Nigeria may not have been extensively adopted modular buildings, but other categories of offsite construction such as non-volumetric pre-assembly and manufactured building components have been used over the years, however there are no significant data or literature supporting these.

## 5 Research methodology

Several online databases were reviewed to extract relevant literature in the areas of lean construction and offsite construction. These databases are of the academic and general online sources such as Emerald journals, Google scholar and search, Science direct and Education abstracts (EBSCO) were the main sources of literature. The category of literature used for this investigation includes books, thesis, conferences papers, and academic journal articles. Although other literatures exist in company websites and trade magazines and government reports, the quality of these write ups did not match up to the peer-review materials and academic journal articles. The scope of data search was limited to literature in the built environment academia of UK and Nigeria or any related write ups from other countries which mention Nigeria or the UK. Fifteen key journals, articles, thesis or books search was attempted for each category.

*Table 1.0 Keywords and key phrases used in the literature search*

<i>THEME</i>	<i>KEYWORDS/PHRASES</i>
<i>Lean construction</i>	<i>“Lean construction”; “lean construction in the UK”; “lean construction in Nigeria”; “lean”; “lean and UK”; “lean construction and UK”; “lean construction and Nigeria”.</i>
<i>Offsite construction</i>	<i>“Offsite construction”; “offsite construction in the UK”, “offsite construction in Nigeria”; “manufacture construction in the UK”; “manufactured construction in Nigeria”; “Industrialized building system”; “modular buildings in the UK”; “modular building in Nigeria”; “prefabricated building in the UK”; “prefabrication of building in Nigeria”; “Prefabrication of buildings”; “constructing offsite”.</i>

## 6 Result and discussion

The literature search revealed that the keywords used for lean construction in the UK produced fourteen journal articles and one book. This met the benchmark of fifteen literature search for this category. There were only four materials found for the keyword related to lean construction in Nigeria. The materials found for lean construction in Nigeria were three journals and one

conference proceeding. The benchmark of fifteen literary material related to lean construction was not met.

Offsite construction in the UK met the benchmark of fifteen literatures which were found mainly through google search and scholar. This included five books, one thesis, one conference proceeding and eight journal papers. There was no literature found for offsite construction in Nigeria after using the entire keywords. Also the literature search revealed that lean construction which began in early 1990s has not been adopted in Nigeria. The year of the write ups in this study range from 1990 to 2012. Although there has been literary materials written by Koskela in 1992, this knowledge has been disseminated to many nations of the world like Nigeria where there were less than five materials found. Offsite construction began sometime in the 19<sup>th</sup> century according to the search but majority of academic write ups for offsite construction began in the 1970s (Brioscu & McEvatt, 1973). These materials have been existing when Nigeria began its massive urbanization programs (Mabogunje, 1965). This implies that many Nigerian authors or academics in the built environment neglected or have not attached much importance to the emergence of new methods of construction during this period. In this analysis majority of the literature found for offsite construction in the UK revealed the benefits and growth offsite construction has contributed their construction industry within the last forty years. At the moment, there appears to be no write up about offsite construction in Nigeria. It appears that offsite construction in Nigeria has not been well documented or included in the Nigerian training curriculum. Although some multinational construction companies in Nigeria may have adopted volumetric and non- volumetric pre-assembly for complex construction works, the use of this method of construction remains alien to most academics in Nigeria.

From the results lean and offsite construction in Nigeria may appear to be almost 22 years behind the UK. This implies that the construction industry growth in Nigeria has been facing some hidden setbacks when it comes to adopting new methods of construction. Lean and offsite construction has been a major catalyst in the growth of major developed construction industries especially in the UK. These innovations in construction industry have been used to improve construction delivery and performance. The available literature in this study for lean and offsite construction has proved that there is available knowledge in the UK if this method of construction has to be applied.



Table 2.0 Category of literature sources from the UK and Nigeria about lean and offsite construction

Construction concept	References	Sources of literature	Category of literature	UK Author/ Related to the UK construction industry	Nigerian Author/ Related to the Nigerian construction industry
Lean construction	<a href="#">Sacks, Koskela, Dave, and Owen (2010)</a>	EBSCO	Journal article	YES	NO
	<a href="#">Genaidy, and Minkarah (2006)</a>	EBSCO	Journal article	YES	NO
	<a href="#">Becker, Shane, and Jalselskis (2012)</a>	EBSCO	Journal article	YES	NO
	<a href="#">Yu, Tweed, Al-Hussein, and Nasser (2009)</a>	EBSCO	Journal article	YES	NO
	<a href="#">El. Reifi and Emmitt (2013)</a>	EBSCO	Journal article	YES	NO
	<a href="#">Nahmens and Ikuma (2012)</a>	EBSCO	Journal article	YES	NO
	<a href="#">Chen, Goodlad, Sprague, and Housley (2012)</a>	EBSCO	Journal article	YES	NO
	<a href="#">Nahmens and Ikuma (2012)</a>	EBSCO	Journal article	YES	NO
	<a href="#">Sadreddini (2012)</a>	EBSCO	Journal article	YES	NO
	<a href="#">Pasquire and Salvatierra-Garrido (2011)</a>	EBSCO	Journal article	YES	NO
	<a href="#">Adamu and Abdul Hamid (2012)</a>	Google scholar	Journal article	NO	YES
	<a href="#">Oyewobi and Ogunsemi (2010)</a>	Google scholar	Journal article	YES	YES
	<a href="#">Abdullah, Bilau, Enebuma, Ajagbe, and Ali (2011)</a>	Google scholar	Conference proceedings	YES	YES
	<a href="#">Adamu, Howell, and Abdulhamid (2012)</a>	Google search	Journal article	NO	YES
	<a href="#">Green (1999)</a>	Google scholar	Journal article	YES	NO
	<a href="#">Picchi and Granja (2004)</a>	Google scholar	Journal article	YES	NO
	<a href="#">Alarcón (1997)</a>	Google scholar	Book	YES	NO
	<a href="#">Thomas, Horman, Minchin Jr, and Chen (2005)</a>	Google scholar	Journal article	YES	NO
	<a href="#">Miller, Packham, and Thomas (2002)</a>	Google scholar	Journal article	YES	NO
	Offsite construction	<a href="#">Pan, Gibb, and Dainty (2007)</a>	Emeral Journals	Journal article	YES
<a href="#">Arif, Bendi, Sawhney, and Iyer (2012)</a>		Google search	Conference proceedings	YES	NO
<a href="#">Azam, Ahamad, and Wan Hussin (2012)</a>		Google search	Journal article	YES	NO
<a href="#">Blismas and Ron (2007)</a>		Google search		YES	NO
<a href="#">Chiang, Hon-Wan Chan, and Ka-Leung Lok (2006)</a>		Science direct	Journal article	YES	NO
<a href="#">Farrell (2010)</a>		Google search	Thesis	YES	NO
<a href="#">Gibb (1998)</a>		Google search	Book section	YES	
<a href="#">Arif and Egbu (2010)</a>		Emerald Journals	Journal article	YES	NO
<a href="#">Pan and Sidwell (2011)</a>		Google search	Journal article	YES	NO
<a href="#">Atkinson, Gray, and Lucas (2001)</a>		Google search	Book	YES	NO
<a href="#">Brioscu (1975)</a>		Google scholar	Book	YES	NO
<a href="#">Brioscu and McEvatt (1973)</a>		Google search	Book	YES	NO
<a href="#">Lawson, Grubb, and Prewer (1999)</a>		Google search	Book	YES	NO
<a href="#">Winch (2003)</a>		Google search	Journal article	YES	NO
<a href="#">Kempton (2010)</a>		Google search	Journal article	YES	NO

The Nigerian construction industry requires a lot of innovations, designs to bridge the knowledge divide. The construction industry in Nigeria is less automated compared to the UK; therefore there will be challenges in adopting new techniques such as lean and offsite construction. Apart from this, offsite construction depends on manufacturing; Nigerian manufacturing sector is has a lot of setbacks limiting its growth. Also, most academics have concentrated their efforts in contributing more knowledge to the only available areas without exploring and adopting new possibilities. This has grossly added to the widening gap in terms of knowledge available in between Nigeria and the UK when it comes to lean and offsite construction.

## **7 Conclusion and recommendations**

Knowledge or information precedes application. Therefore the quantum of academic literatures on a subject will definitely affect the level of knowledge and understanding of the subject. Modern methods of construction such as lean and offsite construction have been applied to improve construction cost, duration, quality and performance in the UK for several years now. However, there has been little knowledge about these construction techniques in a developing nation such as Nigeria. The construction industry in Nigeria has been applying the traditional method of construction and the associated problems with this approach persist. Cost and time over runs are consistent with the traditional method of construction and many academics in Nigeria built environment have noted this (Aibinu & Jagboro, 2002; Dada & Jagboro, 2007). Also, solutions proffered by these academics in improving cost and time overruns have not identified lean and offsite construction as one of the possible means of managing these challenges.

The knowledge gap in the built environment between the developed and developing nations typified by Nigeria and the UK in this analysis is widening considering the number of years when literature relating to lean and offsite construction has been produced. Apart from this new knowledge is added yearly to the UK construction industry because of the extent of innovation and research. If this knowledge gap has to be bridged, there has to be more research, analysis, write ups, training, workshops and conferences about modern methods of construction related to lean and offsite construction in Nigeria and other developing nations.

## **8 Recommendations for further research**

This paper has only examined the knowledge divide by using literature search from online sources. There is need for extensive studies using quantitative methods which will involve surveys, rigorous scientific analysis and also qualitative method which has to involve interviews. This will

adequately determine the extent in which knowledge in the built environment is spreading to less developed nations.

## References

Adamu, S., Howell, G. A., & Abdulhamid, R. (2012). Adapting lean construction technique in Nigerian construction industry. *International Journal of Scientific & Engineering Research*, 3(12), 1-11.

Aibinu, A. A., & Jagboro, G. O. (2002). The effects of construction delays on project delivery in Nigerian construction industry. *International Journal of Project Management*, 20(2002), 593-599.

Alarcón, L. (1997). *Lean construction*: CRC Press.

Alwaer, H., & Clements-Croome, D. J. (2010). Key performance indicators (KPIs) and priority setting in using the multi-attribute approach for assessing sustainable intelligent buildings. *Building and Environment*, 45(4), 799-807. doi: 10.1016/j.buildenv.2009.08.019

Arif, M., & Egbu, C. (2010). Making a case for offsite construction in China. *Engineering, Construction and Architectural Management*, 17(6), 536-548. doi: 10.1108/09699981011090170

Aziz, R. F., & Hafez, S. M. (2013). Applying lean thinking in construction and performance improvement. *Alexandria Engineering Journal*, 52(4), 679-695. doi: 10.1016/j.aej.2013.04.008

Blismas, N., & Ron, W. (2007). Drivers , constrictors and future of off-site construction in Australia. In C. I. S. E. 2008 (Ed.).

Brioscu, A. n. (1975). *Modular components*. Dublin: Foras Forbartha.

Brioscu, A. n., & McEvatt, W. (1973). *Key modular components*. Dublin (St Martin's House, Waterloo Rd, Dublin 4): An Foras Forbartha (National Institute for Physical Planning and Construction Research).

Chiang, Y.-H., Hon-Wan Chan, E., & Ka-Leung Lok, L. (2006). Prefabrication and barriers to entry—a case study of public housing and institutional buildings in Hong Kong. *Habitat International*, 30(3), 482-499. doi: 10.1016/j.habitatint.2004.12.004

Dada, J. O., & Jagboro, G. O. (2007). An evaluation of the impact of risk on project cost overrun in the Nigerian construction industry. *Journal of Financial Management of Property and Construction*, 12(1), 37-44.

Dantata, S. (2008). *General Overview of the Nigerian Construction Industry*. (Masters of civil and environmental engineering), Massachusetts Institute of Technology, Massachusetts

Equere, E., & Tang, C. M. (2010). *Dearth of Automation: The Consequences in Nigeria Construction Industry*. Kent School of Architecture, School of Construction Management and Engineering. University of Kent, University of Reading.

Fairclough, J. (2002). *Rethinking construction innovation and research*. UK: DTLR.

Farrell, A. (2010). *Prefabrication and preassembly*. (Bachelor of science), Dublin school of Architecture, Dublin.

fDB, OECD, UNDP, & UNECA. (2013). Nigeria 2012. In A. e. o. 2012 (Ed.).

Gibb. (2007). *Offsite construction industry survey-2006*. London: Build Offsite.

Gibb, & Isack, F. (2003). Re-engineering through pre-assembly: client expectations and drivers. *Building research and information*, 31(2), 146-160.

Goodier, C., & Gibb, A. (2007). The value of the UK offsite construction market *Build offsite*: dti.

Green, S. (1999). The missing arguments of lean construction. *Construction Management & Economics*, 17(2), 133-137.

Hodge, M. (2007). Construction research program- Project show case. UK: DTI.

Isa, R. B., Jimoh, R. A., & Achuen, E. (2013). An overview of the contribution of construction sector to sustainable development in Nigeria. *Net Journal of Business Management*, 1(1), 1-6.

Issa, U. H. (2013). Implementation of lean construction techniques for minimizing the risks effect on project construction time. *Alexandria Engineering Journal*, 52(4), 697-704. doi: 10.1016/j.aej.2013.07.003

Kanapeckiene, L., Kaklauskas, A., Zavadskas, E. K., & Raslanas, S. (2011). Method and system for Multi-Attribute Market Value Assessment in analysis of construction and retrofit projects. *Expert Systems with Applications*. doi: 10.1016/j.eswa.2011.04.232

Koskela, L. (1997). Lean production in construction. *Lean Construction*, 1-9.

Mabogunje, A. L. (1965). Urbanization in Nigeria: a constraint on economic development. *Economic Development and Cultural Change*, 13, 413-438.

Marhani, M. A., Jaapar, A., & Bari, N. A. A. (2012). Lean Construction: Towards Enhancing Sustainable Construction in Malaysia. *Procedia - Social and Behavioral Sciences*, 68, 87-98. doi: 10.1016/j.sbspro.2012.12.209

Marra, M., Ho, W., & Edwards, J. S. (2012). Supply chain knowledge management: A literature review. *Expert Systems with Applications*, 39(5), 6103-6110. doi: 10.1016/j.eswa.2011.11.035

Martínez-Jurado, P. J., & Moyano-Fuentes, J. (2013). Lean Management, Supply Chain Management and Sustainability: A Literature Review. *Journal of Cleaner Production*. doi: 10.1016/j.jclepro.2013.09.042

NBS. (2012). *2012 and estimates for Q1, 2013 Gross Domestic Product for Nigeria*. Abuja, Nigeria: National Bureau of Statistics.

Odeh, A. M., & Battaineh, H. T. (2002). Causes of construction delays: traditional contracts. *International Journal of Project Management*, 20(2002), 67-73.

Sacks, R., Koskela, L., Dave, B. A., & Owen, R. (2010). Interaction of Lean and Building Information Modeling in Construction. *Journal of Construction Engineering & Management*, 136(9), 968-980. doi: 10.1061/(ASCE)CO.1943-7862.0000203

Sadreddini, A. (2012). Time for the UK construction industry to become Lean. *Proceedings of the Institution of Civil Engineers. Civil Engineering*, 165(5), 28-33. doi: 10.1680/cien.11.00009

Takim, R., Harris, M., & Nawawi, A. H. (2013). Building Information Modeling (BIM): A New Paradigm for Quality of Life Within Architectural, Engineering and Construction (AEC) Industry. *Procedia - Social and Behavioral Sciences*, 101, 23-32. doi: 10.1016/j.sbspro.2013.07.175

Tezel, A., & Nielsen, Y. (2013). Lean Construction Conformance among Construction Contractors in Turkey. *Journal of Management in Engineering*, 29(3), 236-250. doi: 10.1061/(ASCE)ME.1943-5479.0000145

Vokes, C., & Brennan, J. (2013). Technology and skills in the construction industry. In U. C. f. E. a. Skills (Ed.). UK.

Volk, R., Stengel, J., & Schultmann, F. (2014). Building Information Modeling (BIM) for existing buildings — Literature review and future needs. *Automation in Construction*, 38, 109-127. doi: 10.1016/j.autcon.2013.10.023