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Critical review of the research on the management of prefabricated construction

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ABSTRACT

As a sustainable construction method, prefabricated construction is increasingly being adopted worldwide to enhance productivity and to alleviate the adverse environmental and social effects as a result of conventional construction activities. In addressing management issues of prefabricated construction, an impressive number of studies have been published by internationally renowned journals related to construction management over the past decades. However, it seems that a systematic summary on the research development in the management of prefabricated construction (MPC) discipline is lacking. Therefore, this paper examines the latest research trend in this discipline by analyzing published construction management research in 10 leading journals during the period from 2000 to 2013 (as of end of June) in terms of the annual number of MPC papers, contributions of institutions, adopted data collection and processing methods, and research interest. The analysis reveals that prefabrication is becoming increasingly important to the entire construction industry. Researchers from developed countries, including the US, the UK, Hong Kong, Sweden, and Australia, have made significant contributions to the development of the prefabrication domain, while those from developing countries, including China, Turkey, and Israel where construction remains as their main economic activity, have shown increasing interest in promoting prefabrication-related research. Major research topics in MPC include "industry prospect", "development and application", "performance evaluation", "environment for technology application", and "design, production, transportation and assembly strategies". Moreover, some innovative technologies, such as Global Position System (GPS), and Radio Frequency Identification (RFID), have been effectively applied in this field and are considered as strong vehicles in improving the performance of future prefabricated construction practices. This study is of value in helping scholars gain an in-depth understanding of the state-of-the-art of MPC research and allows them to continue from the findings of previous studies.

Introduction

The increasing recognition of the importance of prefabrication technology for productivity improvement and environmental conservation has resulted in an impressive number of studies on management of prefabricated construction (MPC) in academic journals worldwide. Based on the literature review, the academic interests toward this domain are increasing, but the content analysis of existing literature appears insufficient, preventing researchers from capturing an overall picture of the research evolution of the field. A systematic classification and integration of previous publications on prefabricated construction can significantly contribute to a comprehensive understanding on the topic and inspired the examination of MPC by subsequent researchers (Tang, Shen, & Cheng, 2010; Yang, Shen, & Ho, 2009).

The research community, particularly new researchers, widely regards literature review as a key methodology in examining the development of research on a specific discipline. For example, Xue, Shen, and Ren (2010) carried out a content analysis of publications in selected journals collaborating with construction projects and found the lack of systematic theoretical framework in measuring the performance of these collaborations. Ortiz, Castells, and Sonnemann (2009) examined sustainability development in the construction industry by compiling and studying the key

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milestones in life cycle assessment and stated that further research should focus on the development of sustainability indicators in design, construction, operations, and dismantling to target global environmental and energy concerns. Hong, Chan, Chan, and Yeung (2011) conducted a critical analysis on the collaborative research trend in construction journals and suggested the expansion of the analysis to cover the entire construction supply chain as a key research interest. Tsai and Lydia Wen (2005) and Flanagan, Lu, Shen, and Jewell (2007) stated that these systematic research reviews do not only assist researchers in gaining in-depth insights on the-advancement of a chosen research field, averting the duplication of research efforts, but also help them explore new and valuable research topics for further research.

Despite the significance of a research review, no such work has been undertaken in the field of MPC. Therefore, this paper conducts a series of content analysis of academic articles published from 2000 to 2013 (as of end of June), including examination on the current status and prediction on future research trends. The objectives of this study are: (1) to determine the coverage of MPC-related academic articles published in 10 top-tier journals; (2) to identify which countries and institutions were the primary contributors to MPC research; (3) to examine the primary methods for data collection and processing employed in MPC research; and (4) to analyze the evolution of research theme evolve and explore the future research direction of this topic.

Background of MPC

Prefabrication is a manufacturing process that takes place in a specialized facility where various materials are joined together to form a component of the final installation procedure (Sparksman, Groak, Gibb, & Neale, 1999). In the construction field, prefabrication is regarded as the first level of industrialization, which is followed by mechanization, automation, robotics, and reproduction (Richard, 2005). Previous studies had used various terms and acronyms that are associated with prefabricated construction, including off-site prefabrication, precast concrete building (Kale & Arditi, 2006), off-site construction (Pan, Gibb, & Dainty, 2008), industrialized building (Jonsson & Rudberg, 2013; Meiling, Sandberg, & Johnsson, 2013), and modern methods of construction (Goodier & Gibb, 2007), to name a few. Prefabricated construction can generally be categorized into the following four levels based on the degree of prefabrication implemented on the product: (1) component manufacturing and sub-assembly that are always done in a factory and not considered for on-site production, (2) non-volumetric pre-assembly that refers to pre-assembled units not enclosing usable space such as timber roof trusses, (3) volumetric pre-assembly that refers to pre-assembled units enclosing usable space and usually being manufactured inside factories but do not form a part of the building's structure such as the toilet and bathroom, and (4) whole buildings that refer to pre-assembled volumetric units forming the actual structure and fabric of the building such as motel rooms (Gibb, 1999; Goodier & Gibb, 2007). Prefabricated construction, as a modern construction technology replacing conventional cast-in-situ concrete construction, has attracted immense attention from many countries over the past two decades. This widespread interest can be largely explained by the inherent superiority of the technology, including, but not limited to, construction waste reduction (Baldwin, Poon, Shen, Austin, & Wong, 2009; Tam, Tam, Chan, & Ng, 2006; Tam, Tam, Zeng, & Ng, 2007), improved quality control (Jaillon & Poon, 2008), noise and dust reduction (Pons & Wadel, 2011), higher standards for health and safety (Lopez-Mesa, Pitarch, Tomas, & Gallego, 2009; Pons & Wadel, 2011), time and cost savings (Chiang, Hon-Wan Chan, & Ka-Leung Lok, 2006; Gibb & Isack, 2003), reduced labor demand (Nadim & Goulding, 2010), and low resource depletion (Aye, Ngo, Crawford, Gammampila, & Mendis, 2012; Won, Na, Kim, & Kim, 2013).

Despite the inherent superiority of prefabrication, the implementation of MPC has produced many problems, from the precast design and component production to product stockyard layout, transportation, and assembly. Jaillon and Poon (2010) revealed that only a few studies had been conducted on the design concept to promote the reuse of prefabricated buildings at the end of their life cycle. Marasini, Dawood, and Hobbs (2001) stated that due to insufficient stockyard space management by stockyard managers and ineffective technologies in selecting suitable locations for product stocks and in tracing them for dispatch, prefabricated elements are often exposed on the yard. Li et al. (2011) indicated that safety should be emphasized during the assembly of prefabricated elements because many of these elements are bulky and heavy and can potentially harm the assembly. The defects and obstacles in applying the prefabricated construction method have also been sufficiently addressed in previous research. Vertical transportation has been identified as an issue because the prefabricated modules are generally heavy and bulky. Tam (2003) interpreted in his study that the concreting of floors will likely extend from four days to six days if the prefabricated elements are used because the vertical transportation of prefabricated components from one floor to another is more time-consuming than that in conventional construction. Labor retraining is also identified as another issue because the in-situ and cast concrete construction are by nature different from prefabrication, which requires machine-oriented skills both on-site and in the manufacturing process (Chiang et al., 2006). Other studies identified the relatively high construction cost of precast technologies as a main hindrance to the promotion of prefabricated construction (Blismas & Wakefield, 2007; Pan, Gibb, & Sellars, 2008; Pan & Sidwell, 2011).

Problems have emerged from prefabrication application, necessitating a systematical review analysis of existing literature within the research scope. This review can largely help researchers by providing details on the current problem and by identifying future research directions for this discipline.

Research methodology

Selecting target academic journals

The review methods of previous research (Ke, Wang, Chan, & Cheung, 2009; Tang et al., 2010; Xue et al., 2010) offer valuable guidance in the selection of target academic journals in the MPC research domain. Ke et al. (2009) stated that a research team might contribute their research achievements to a renowned journal from their specific field or that which has a similar research topic. Accordingly, the authors of this study used the Scopus search engine to identify the journals that have published the most research on MPC from 2000 to 2013. The most-searched keywords in this search engine included prefabrication, prefabricated construction/building, precast concrete, off-site construction, modular construction/building and industrialized building/housing. Articles containing these terms in the title/abstract/keywords were considered for review in this research. The search is further narrowed based on the subject fields of engineering, decision sciences, social sciences, management, and environment, and based on the document type of the article or review. However, a certain number of unwanted articles still show in the search results despite the rigorous search criteria. The authors of this research subsequently scanned each article from the search results to filter and retrieve MPC-related papers.