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Best practice of prefabrication implementation in the Hong Kong public and private sectors

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ABSTRACT

Prefabrication has been developed since the 1970s. The technologies have been further developed and improved for the past thirty years. The successful implementation of quality control and construction efficiency has been addressed with support from the public sector. The technologies however did not receive attention from the private sector since prefabrication requires dimensional coordination and standardization in the designs. This situation has changed from 2002 as the Hong Kong government promotes incentives schemes, i.e. gross floor area concessions for private developers to encourage them to adopt prefabrication techniques. This paper discusses and evaluates the best practice of prefabrication implementation in the Hong Kong public and private sectors using two leading case studies. Their adoption of prefabrication, construction methods and cost effectiveness are investigated. Discussions on effective implementation for the sectors have also been explored. The findings provide ameliorated understanding on the best practice of the implementation of prefabrication and provide courage for further improvement and implementation for the industry.

1. Introduction

In accordance with new production philosophies, waste is an inefficient result in use of equipment, materials, labour, or capital in larger quantities than those considered as necessary in the production of buildings (Koskela, 1992). Waste should be defined as any losses produced by activities generating direct or indirect costs but that do not add any value to products from the point of view of clients (Formoso et al., 1999).

With the increasing demands in implementing major infrastructure projects, together with many commercial buildings and housing redevelopment programmes, a large amount of construction waste is being produced (Yuan, 2013). Normative literatures have proposed various waste management approaches. Petts (1995) promoted proactive community involvement in implementing waste management, and suggested consensus building among the public in order to control waste generation and mitigate the impacts of waste impacts on the environment (Petts, 1995). Coffey (1999) pointed out that considerable waste reduction can be achieved if waste management is implemented as part of project management functions. He espoused that whilst the choice of the optimum waste handling methods should be determined by considering the cost implications, any practices, which will induce waste reduction, must be encouraged.

The provision for training and education among staff and involving employees' participation as more effective approaches in implementing waste management (Lingard et al., 2000). However, employees' participation could only be effective with genuine support from management (Lingard et al., 2000). A previous survey reported that waste management has been receiving less attention from business senior management in comparing with construction cost and time (Shen and Tam, 2002; Zeng et al., 2004). The cost for implementing waste management is often given more concern than the possible benefits that the organization can gain from the implementation.

In recent years, construction waste reuse and recycle have been promoted in order to reduce wastes and protect the environment, but the effectiveness of their application has been limited because the conditions for applying these approaches were not provided (Chun et al., 1997). These conditions include proper site location and equipment for waste sorting, good experience in waste recycling operations, trained supervisors and employees, knowledge of

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secondary materials markets and knowledge of environmental and safety regulations.

With the growing awareness on sustainability, an official undertaking "Study on Sustainable Development for the 21std Century (SUSDEV 21)" organized by Planning and Lands Bureau, Hong Kong Special Administrative Region was carried out from 1997 to 2000. It aimed to increase the public awareness of concept on sustainable development and improve the impacts of governmental policies on society, economy and environment.

The Construction Industry Review Committee (CIRC) of Hong Kong was then appointed by the Chief Executive in 2001 to: (i) examine the current state of the construction industry in respect to quality, quantity, environmental friendliness, manpower, safety and supervision; (ii) identify specific actions and good practices to improve the efficiency and cost-effectiveness of local construction in terms of quality, customer satisfaction, timeliness in delivery and value for money and (iii) advise on an order of priority for implementation. CIRC pointed out that the existing problems in current construction industry particular in heavy relying on labour and lots of wet-trade works retarded continuous improvement on excess site supervision on quality assurance, environmental pollution on dust and noise nuisance from in-situ concreting and formwork fixing process, and unrecoverable wastage costs. Meanwhile, CIRC proposed that the use of prefabrication in terms of standardization and modular on building industry can solve the aforesaid problems. Repetitive and standard modular production in a facilitated working environment must ensure the products achieving quality standard (Jaillon and Poon, 2008). Mass production can also ensure cost-effectiveness. It should also be highlighted that the implementation of prefabrication requires proper urban development policies with the facing current urban challenges for transitioning as a sustainable urban metabolism city (Zhang et al., 2011). Besides the case in Hong Kong, there is an increasing need for prefabricated housing to address the urgent demand for housing in cities of developing countries such as China. Substantial benefit and possible hindrance to prefabrication on affordable housing construction in China have also been identified in the study of Zhang and Skitmore (2012) and Zhang et al. (2014).

Low-waste construction technologies have been advocated for many years around the world including: (i) design for thinner internal walls and floor slabs (Balow, 1999; Poon et al., 2003); (ii) waste sorting technologies (Poon et al., 2001; Kang et al., 2006; Wang et al., 2010; Yuan et al., 2013); (iii) design for reducing foundation sizes (Austin et al., 1999; Chen et al., 2002; Tam et al., 2006a); (iv) design for reusing excavated spoils as backfill materials to balance cut and fill (Tam et al., 2007a); (v) modular building designs and prefabricated components (Ting, 1997; Poon et al., 2003; Tam et al., 2006b, 2007b); (vi) reuse technologies for construction waste (Catalli and Goode, 1997; Begum et al., 2006; Tam and Tam, 2006; Chen et al., 2010); (vii) design for recycled materials (Chau et al., 2007; Esin and Cosgun, 2007; Hao et al., 2008); (viii) deconstruction or sequential demolition technologies (Guy and McLendon, 2001; Colajanni et al., 2005; Dantata et al., 2005); (ix) use of large-panel formwork (Poon, 1997; Poon et al., 2004a) and (x) design for hanging cradles (Poon et al., 2003; Roper, 2006; Zhang et al., 2012). Prefabrication has brought a substantial change to the development of construction industry and has been adopted in building projects for centuries. In addition, there was a great demand for housing due to World War II of server trauma. To address the housing shortage, both Asian and European countries made use of prefabrication techniques in speeding up housing production. For example, mass production of housing using prefabrication was found in Japan since 1965 (Barlow et al., 2003). United Kingdom's construction of prefabricated houses was also widely adopted after World War II. In the 1960s and 1970s, the UK built lots of prefabricated buildings, mainly reinforced concrete structures (Nicholas, 2002). Despite long-standing knowledge regarding the productivity benefit, the uptake of prefabrication has been relatively slow in the European countries (Johnsson and Meiling, 2009). Many of the systems have also suffered from water penetration as the joining materials aged. Poor thermal performance has also been a feature of prefabricated buildings. Prefabricated buildings were always labelled as poor quality products with the associated social stigma. To allow the successful application of prefabrication, past mistakes need to be recognized and addressed.

Through a 30-year continuous improvement by the Hong Kong government in conducting research and development on prefabricated housing production, qualitative construction and sustainable development are further achieved in the public sector. Research and development has resulted in principles of cost effectiveness, and quality through innovation and sustainability (Fung, 2007). Table 1 provides a brief summary for comparing conventional in-situ and prefabricated construction. Among the low-waste construction technologies, Buildings Department first identified prefabrication as one of the effective lean construction techniques which has proved a merit on increase in productivity and competitiveness, quality assurance, cost effectiveness and low accident rate (Tam et al., 2005; Shen et al., 2009; Tan et al., 2011). Since the early 1980s, all public housing projects were stipulated to use precast concrete elements and steel formwork (Yau and Wong, 1997). Prefabrication technologies have been practiced in numerous public residential housing projects in Hong Kong.

The private sector has traditionally implemented limited prefabrications in the past decades. It is easy to understand since cost and time are the major factors controlling construction methods

Table 1
Comparison between conventional in-situ and prefabricated construction (Wilson et al., 1998; Tam et al., 2007b).

	Conventional in-situ	Prefabricated construction
Construction cost	Low initial construction cost	Cost saving due to repetitive and standard modular production
Quality control	Low (Difficult to control the quality as the site condition always varies)	High (better quality achieved at the factory production, but the Poor jointing of prefabricated walls with other prefabricated or in-situ elements may cause water seepage problems)
Crew sizes on site	Labour Intensive (involve the use of timber formworks, in-situ concreting, wet trades and bamboo scaffolding)	Low (most of the construction elements are prefabricated in the factory/precast yard)
Construction Time	Longer	Shorter (as few construction activities are on site, the productive time improved by approx. 12%[1])
Design Flexibility	Relative flexible to the design changes	Inflexible to the design changes (for the dimensional coordination and standardization, design need to be frozen at the early stage)
Construction waste on site	High	Low (up to 84.7% per cent can be saved on wastage reduction)
Site Safety	Difficult to manage (as it involve many work trades)	Easy to manage (site tidiness is obviously improved as less work trades is on site, resulting in reduction in site accidents)