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The Application of the Just-in-Time Philosophy in the Chinese Construction Industry

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Abstract: The Just-in-Time (JIT) philosophy originated from the Toyota Production System (TPS) and has been used in the manufacturing industry for many decades. It has helped to increase the productivity of the industry and has also increased the quality of its products. In recent years, numerous studies in developed countries have endeavoured to introduce JIT in the construction industry to reap similar benefits. This study focused on applying JIT to the Chinese construction industry with the goal of improving its performance and thus its competitiveness. This paper discusses the current state of the Chinese construction industry; presents the potential impediments to implementing JIT; and proposes a framework for JIT implementation in the areas of design, procurement, construction and inspection. The results of this study suggest that government and educational institutions should play a key role in spearheading the application of JIT in the construction industry in China.

Keywords: Just-in-time (JIT), Chinese construction industry, Quality, Productivity, Profitability

INTRODUCTION

The construction industry in China has been growing at a steady growth rate of 10% in recent years. The National Bureau of Statistics of China (2009) indicated that the construction sector had contributed 5.67% to the Chinese Gross Domestic Product (GDP; RMB 30,067 billion) at the end of 2008 and suggested that the construction sector will continue to play a significant role in the Chinese economy. However, the construction industry within China is still perceived as a less-developed sector and is viewed to have low productivity, low quality products, low profit margins, and poor working conditions on site. Hence, the construction industry needs to become more competitive and change its image in a positive way.

The underlying concept of the Just-in-Time (JIT) philosophy is to smooth the manufacturing process through the efficient handling of materials, such as providing the right materials in the correct quantity and quality, just in time for production (Low and Chan, 1997) to eliminate or reduce waste, thus producing the maximum value for the customer. The original concept of JIT was created by

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Taiichi Ohno, the chief developer of the Toyota Production System (TPS). The TPS provided the basis for what was to become popularly known as JIT (Liker, 2004). Initially it was applied to the manufacturing industry. This successfully helped to accomplish better product quality, preventive maintenance and employee motivation, and it also improved workers' involvement and commitment to their organisation. Additionally, JIT has helped to reduce lead time, throughput or set-up times, defects, ultimate costs, reworks, factory overheads, inventory levels and storage space, and it has also enhanced the competitive advantage of firms (Akintoye, 1995; Low and Chan, 1997; Low and Tan, 1998; Low and Mok, 1999). However, this does not mean that the application of JIT should be limited to the manufacturing companies. More recently, the practice of JIT has been expanded to include construction companies, where JIT concepts have been shown to deliver numerous benefits to the construction organisations (Lim and Low, 1992; Akintoye, 1995). The JIT philosophy therefore has the potential to help solve the problems that have plagued the Chinese construction industry and may be able to change the poor image of the construction industry for the better. The objective of this study was to examine how JIT can be implemented in the Chinese construction industry.

RESEARCH METHODOLOGY

The deductive approach was adopted in this study. The study began with a literature review of JIT and the Chinese construction industry, with the goal of proposing appropriate recommendations for the potential implementation of JIT by different stakeholders within the Chinese construction industry. The structure of this component of the study is shown in Figure 1.

REVIEW OF JIT

Background

JIT is as a set of principles, tools and techniques that allows a company to produce and deliver products in small quantities with short lead times to meet specific customer needs (for examples see Voss, 1987; Liker, 2004; Harber et al., 1990). JIT can also be referred as a management philosophy. JIT relates to the way in which a manufacturing company organises and operates its business (Low and Chan, 1997). JIT is viewed by Gyampah and Gargeya (2001) as a long-term strategy that can promote excellence and eliminate waste throughout the entire organisation.

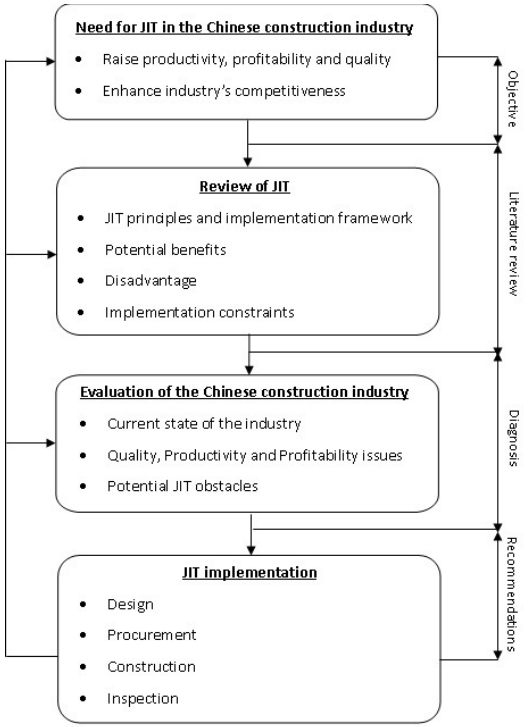

Figure 1. Structure of the Study on JIT for the Chinese Construction Industry

JIT Principles and Implementation Framework

Previous studies have reported the benefits of JIT in improving productivity in manufacturing. Researchers and practitioners from the construction industry have increasingly explored the possibility of applying knowledge gained in the manufacturing industry (and other industrial sectors) to solve the problems in the construction industry (Bresnen and Marshall, 2001; Bates et al., 1999; Bertelsen, 2002). This history can be traced back to Lim and Low's (1992) book, which collated the distinctive features and broad principles of JIT. This concept was further adopted by Low and Chan (1997) with the development of a JIT framework for application at an off-site prefabrication sector in Singapore. This framework is shown in Figure 2. The same framework was also adopted in site layout management to pursue uninterrupted construction processes, better materials and better plant management (Low and Mok, 1999).

Recently, additional studies on JIT implementation in developing countries have been conducted (Salaheldin, 2005; Gyampah and Gargeya, 2001). Oral et al. (2003) argued that the construction industry in developing countries (DCs) could also benefit from JIT in terms of substantial productivity and quality problems.

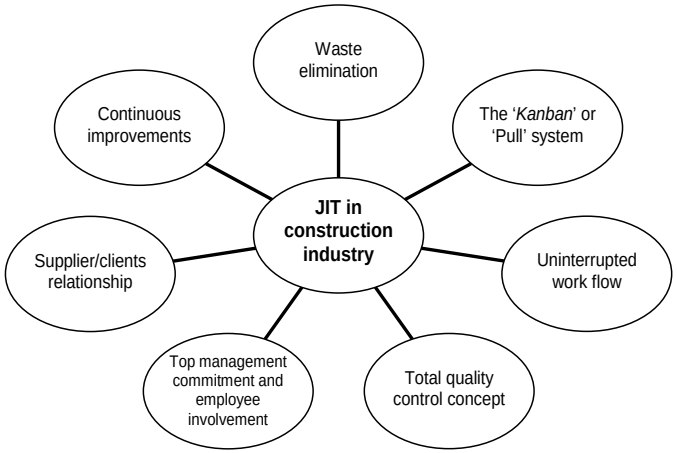

Figure 2. JIT Framework for the Prefabrication Industry
Source: Low and Chan (1997).

Potential Benefits and Disadvantages of JIT

The positive results from JIT application in the construction industry (see Akintoye, 1995; Bertelsen, 1995; Low and Chan, 1997; Low and Mok, 1999) include: (1) enhancing the competitive advantage of firms in terms of consistently and continually meeting customer requirements, (2) improving quality of construction materials and components, (3) productivity enhancement, (4) cost reduction in terms of minimising the levels of inventory, (5) improving relationships with suppliers, (6) completing work ahead of schedule, (7) improving the tidiness of construction sites and (8) eliminating site congestion and inconveniences caused to neighbourhoods. However, the benefits of JIT cannot be achieved without initial investments (Waters, 2009). For example, reducing setup time may require more sophisticated equipment, and more skilled employees will result in higher training costs (Waters, 2009; Polat and Arditi, 2005).

Barriers to JIT Implementation

Some organisations have failed to implement JIT concepts successfully due to a variety of issues. Ang (1999) broadly classified the barriers that building professionals encountered into two categories: industry related problems (e.g., building regulations, lack of certainty, inflexibility of JIT schedule) and human related problems (normally involving all the stakeholders such as the contractor, subcontractors, suppliers, and clients). Low and Tan (1998) highlighted that limited support from the government, consultants, clients, and statutory boards does not promote JIT implementation in the construction industry. Oral et al. (2003) identified six common characteristics of developing countries and their likely

impact on JIT implementation: (1) implementation costs, (2) costs of technology and maintenance, (3) labour productivity and labour costs, (4) inflation and the supply conditions, (5) the demand conditions and (6) culture.

How the Government and Educational Institutions can Facilitate JIT Application

Initiatives from the government and support from the government on new management philosophies are significant factors in aiding the transformation of the construction industry. The Egan Report (1998) noted that construction performance in the U.K. could be improved through greater standardisation of components, more off-site prefabrication and the use of "lean" construction techniques. In Singapore, the Construction Industry Development Board (1992) also recommended lean construction techniques, including their use in tertiary education construction (Low and Le, 2009). The Commonwealth of Australia (1999) advised that construction firms use the newest technologies and management processes, including JIT techniques, to ensure that the Australian construction industry remains competitive.

Table 1. Characteristics of Developing Countries and their Likely Impact on the Implication of JIT

Category	Characteristics of Developing countries	Likely impact on the JIT implementations
Implementation costs	High interests rates High costs of quality system	No tendency towards any investment; Tendency not to utilize any quality assurance system
Costs of technology and maintenance	High costs of technology High maintenance costs	Limited funds for R&D; Limited preventive maintenance
Labor productivity and labor cost	Low labor costs; High costs of training	No tendency to increase labor productivity; Limited labor training within the company
Inflation and the supply conditions	High inflation rates	Tendency towards materials, sub-products and product inventory
The demand conditions	State, the dominant clients of the construction industry Few number of domestic supplier	Regulations and politics affects the demand and the rivalry condition; No bargaining power of the producers; Tendency towards keeping materials inventories
Culture	High power distance culture; High uncertainty avoidance culture	Top management avoid participative decision making; Employees do not resist change

Source: Oral et al. (2003)

THE CHINESE CONSTRUCTION INDUSTRY

Current Status of the Chinese Construction Industry

While the increasingly improved performance in the Chinese construction industry is laudable, the domestic market still faces the construction sector in China is still lagging behind of the developed countries *in the area of legal framework and institutional mechanism, industrial structure, technology, and international market share* (see Xu et al., 2005). Thus, it is worthwhile to examine the Chinese construction industry as a whole prior to making recommendations for the implementation of JIT in the industry. It has been reported that many Chinese construction companies are suffering from low productivity (Low and Jiang, 2003; Xu et al., 2005), low quality projects in their portfolios (Yao et al., 2001; Chen, 1998; Xu et al., 2005) and low profitability (Chen, 1998; Cheah et al., 2007; Zeng et al., 2003). These problems are explained below.

Productivity

Low productivity is a constant issue in the construction industry because construction is a crafts-based industry. For this reason, productivity is largely dependent on human factors. Considering the output value of the construction employees, construction productivity in China tremendously improved from only $500 USD per person in 1980 to $20,000 USD per person by 2008 (National Bureau of Statistics of China, 2008). Xue et al. (2008) suggested that productivity in the Chinese construction industry experienced a continuous improvement from 1997 to 2001 and reached a peak during 2002–2003. Their study further revealed that there were still large gaps in the productivity levels between different regions and recommended that the Chinese government adopt effective policies and measures to improve productivity. Furthermore, the construction industry in China is less productive than other countries. Table 2 indicates that China's construction productivity in 2000 lagged behind three developed countries, including the United States, Japan and the UK, with the output per person in China being only 5% of the general level in the three developed countries (Xu et al., 2005).

Quality

Although quality management has increasingly been achieved in China, its implementation appears to be uneven in terms of ownership (Li et al., 2003). Low (1999) highlighted that the ISO 9000 can offer a systematic approach to quality management, with standard clauses and guidelines that can assist JIT implementation. The ISO

Table 2. Productivity Comparison of Construction Companies in China, the United States, Japan and the United Kingdom in 2000

Country	Number of construction enterprises	Construction output (millions of US$)	Number of employees (millions)	Average number of employees per enterprise	Average construction output per person (US$)
China	97,263	150,573	27.41	282	5,493
United States	709,590	820,345	6.573	9	124,805
Japan	600,980	653,200	6.53	11	100,030
United Kingdom	163,426	99,537	0.946	6	105,219

Source: Xu et al. (2005)

9000 certification has been gradually implemented in China since 1992. In 1992, attempts were made by the Chinese government to introduce the ISO 9000 in the hope that regulating quality behaviour would build and enforce quality consciousness amongst staff (Li et al., 2003). By June 1999, ISO 9000 certified construction firms made up 13.3% of the total certified organisations in China (Zeng et al., 2003). By utilizing the data from China's Statistic Bureau over the period 1993 to 2001, Yung and Yip (2009) discovered that construction quality in China has improved in this period and has been largely influenced by the gradual implementation of mandatory construction supervision systems, higher labour productivity, and the use of more plants and machinery per square metre of floor space. However, the criticism and complaints about poor construction quality in China have continued (Chen, 1998; Lam and Cheng, 2004), as evidenced by the large number of buildings that collapsed during the 2008 Sichuan earthquake, the Metro tunnel collapse in Hangzhou in 2008 and the toppling of a completed apartment block in Shanghai in 2009.

Profitability

Despite the rapid growth of the Chinese construction industry, many Chinese construction firms are still plagued by a low level of profitability (Cheah et al., 2007). Based on data from the National Bureau of Statistics of China (2008) and the Office for National Statistics of United Kingdom (2007), Figure 3 compares the average profitability level (profit after tax) of Chinese and British construction companies from 2000 to 2007. Figure 4 describes the difference in the profit margins generated in the manufacturing and construction industry in China.

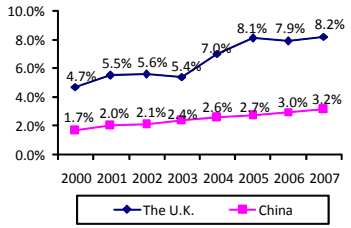

Figure 3. A Comparison of Profitability Levels of Chinese and British Construction Firms from 2000–2007
Sources: The National Bureau of Statistics of China (2008), The Office for National Statistics of the U.K. (2007)

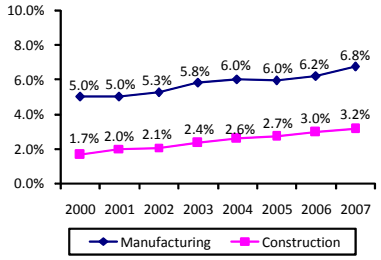

Figure 4. A Comparison of Profitability Levels of the Manufacturing and Construction Sector in China from 2000–2007
Source: National Bureau of Statistics of China (2008)

Figure 4 demonstrates that the net profit margins of the Chinese construction industry are lower than those of the Chinese manufacturing industry and the construction industry in the United Kingdom. The gaps in both Figure 3 and Figure 4 are notable. Cheah et al. (2007) highlighted that one of the possible reasons for this disparity is the lack of long-term strategies for survival and growth in the Chinese construction industry.

These disturbing trends should motivate the construction firms to undertake initiatives such as adopting the JIT concept to enhance their level of productivity, quality and profitability in China.

CONSTRAINTS OF JIT IMPLEMENTATION IN CHINA

Poor Labour Skills and Insufficient Training

It is important to note that the Chinese construction industry is a highly labour intensive sector, and most of the construction labour force is composed of peasants and unemployed workers, who can be easily recruited due to both the relatively low requirements for skills in construction and massive urban development needs in China. The official statistics from the Ministry of Construction reveal that only 10% of the 32 million farmers who have become

construction workers had basic training in their career, compared with more than 70% in developed countries (Xinhua, 2009). Xu et al. (2005) found that 97% of the construction employees had an education level below that of a university or college diploma. Ling et al. (2005) noted that the level of professional skills was so low that workers require very detailed drawings to operate machinery.

Lack of Project Management Experience

Previous studies have found that the project management skills in China are lagging behind those of developed countries. The limited management skills have prevented construction workers in China from working efficiently. Inadequate project management skills were identified by Zhao and Shen (2008) as the most significant weakness of the Chinese contractors in the international market. Approximately half of the Chinese construction enterprises have not established a comprehensive project management system (Hu, 2003).

Poor Organisation Structure

Zeng et al. (2003) found that most Chinese construction firms have three or four layers of hierarchy in the organisational structure. However, there is a vague division of work and economic relationships between these layers. Each level sets its own goals, liabilities and targets and carries on its individual tasks. This poor organisational structure results in project managers having to bear the risk of making decisions and solving problems. This also explains why the Chinese construction managers have a difficult time handling responsibilities (Flanagan and Li, 1997).

Chen and Partington (2004) compared the cultural differences between Chinese and western countries in handling construction projects and highlighted that management processes in China have been heavily influenced by the "relationship culture," which emphasises hierarchy and the need to maintain harmony, as well as valuing long-term co-operation for mutual benefits.

Unstable Construction Material Prices and Poor Material Management

China is an intensive user of raw materials. The increased demand for raw materials is due to China's high demand for infrastructure construction in the recent years. In addition, rising oil prices, raw material prices, fuel prices and transportation costs inevitably and continually have a direct impact on the building materials industry. To take advantage of the discounts on large orders, Chinese contractors will usually order large amounts of material and

make early purchase orders from suppliers. This has been identified as a normal practice in developing countries (Polat and Arditi, 2005).

Poor material management in the Chinese construction site is a serious problem, leading to the following undesirable consequences:

- Bulk materials are often stored on site, taking up valuable space in often confined sites. Stored materials are also susceptible to damage.
- Poor planning and skills in fabricating materials (e.g., cutting rebar) on site, thus causing significant waste and air pollution.
- Poor material procurement schedules and congested traffic conditions, especially in municipal cities, usually lead to frequent delays (Zou et al., 2007).

Supplier Relationships

The bargaining power of local building material suppliers in China has been gradually eroded over the last decade (Lan and Jackson, 2002). The risk for suppliers with low bargaining power is that they have to bear the extra cost of delivering materials in small quantities (Harber et al., 1990) if JIT is to be implemented. Lan and Jackson (2002) found that conventional building materials were in excess supply due to deregulation and low concentrations of production in building material manufacturing. There were more than 200,000 building material suppliers throughout China in the mid-1990s, without a monopoly by one company. In most cases, long term partnerships between a single source supplier and main contractors are rarely established. Suppliers' relationship ("guan xi") with relevant stakeholders (e.g. client or contractor) could potentially influence the favorable outcome in the selection process. Moreover, Lu and Yan (2007) found that most Chinese construction companies do not understand formal partnering approaches clearly, and cannot perceive the project-based benefits of partnering.

Limited Use of Prefabricated Components

The limited use of prefabricated components in China's construction sector appears to suggest that the overall level of workflow is not smooth and that standardisation is rather low in the entire industry. Lu (2002) identified the deterrent factors of the precast concrete industry as:

- The price mechanism of the prefabricated components in the planned economy, where price was determined by the government, largely restricted the development of enterprises and technological innovations.

- Low levels of product quality standards.
- The construction industry placed undue emphasis on saving the construction materials as a strategy in manufacturing prefabricated components in the 1970s, which resulted in poor quality products that jeopardised the construction industry reputation.

The Undeveloped Subcontracting Sector

Lan and Jackson (2002) noted that the Chinese subcontracting sector is problematic. First, there is no clear relationship between contractors and subcontractors in China. Hence, it is unclear what percentage of construction jobs is or should be undertaken by subcontractors. Second, due to the fast development of the construction sector and huge demand for construction labour, subcontracting is becoming unavoidable. Alarmingly, many contractors seek profits by illegally leasing their licenses or by subcontracting their jobs to unqualified firms (Lan and Jackson, 2002). As a result of this practice, a subway tunnel collapsed in Hang Zhou City because the construction works were illegally subcontracted out four times (Shanghai Daily, 2008).

Design with Low Constructability

China has a very well established system of design institutes (Low and Jiang, 2003), with a large number of professionals who are equipped with the necessary qualifications and skills in construction technology, economics and management (Xu et al., 2005). However, Liu and Low (2007) argued that the low level of constructability in China is due to very limited interaction between design institutes and local contractors. They suggested that appropriate repetition and standardisation in the Chinese construction industry would help to lay the path for a JIT environment.

Procurement

Currently, the most widely adopted procurement system in the Chinese construction industry is the design-bid-build approach. This approach was implemented by the Ministry of Construction (MoC). However, the MoC makes domestic design institutes and contractors responsible for only their own work and thus fails to fully foster collaboration prior to the completion of the drawings (Liu and Low, 2007). A survey by the Ministry of Housing and Urban-Rural Development (MOHURD, 2008) to investigate the use of design and build (D&B) procurement in China showed that only 18 out of 37 large construction enterprises were experienced in the D&B mode. The limited use of D&B

procurement in China has directly discouraged constructability and indirectly hindered the implementation of JIT in the Chinese construction industry.

Legislative Control

Another potential obstacle to the successful implementation of JIT is the legislative control in the construction industry (Ang, 1999). The stringent requirements of the industry demand approvals from many governmental bureaus (e.g., the Construction Bureau, Fire Bureau, Environmental Bureau) as a result of the multi-layered and fragmented nature of governance structure in the Chinese construction industry (Chan et al., 1999; Cheah and Chew, 2005). For most construction and design projects, this will potentially delay the commencement of construction. The associated inefficiency can have a knock-on effect on the planning arrangements as well as the procurement of equipment and labours. Also affected are planning agreements that made between the construction firm with other stakeholders (e.g., suppliers and subcontractors). The complex and time-consuming process to obtain building approvals in China therefore requires further enhancement.

DISCUSSION

Larger organisations with strong financial resources appear more likely to receive benefits from JIT implementation (Adrian, 1987; Waters, 2009). In addition to the financial considerations, Zhu et al. (1995) argued that the implementation of JIT would also bring tremendous organisational change. In the event that this change will extend to the entire industry, the implementation of JIT in the Chinese construction industry cannot be carried out by all construction enterprises at the same time. A reasonable approach would be to offer experimental trials among the larger, better endowed, state-owned construction enterprises (SOEs) that are likely to adopt JIT as a long-term strategy (Liker, 2004).

In the event that a decision is made to proceed with the JIT philosophy, the implementation requires careful consideration and planning (Low, 1992). Figure 5 offers a framework for the adoption of JIT principles in the areas of design, procurement, construction and inspection in China.

Design

The concept of JIT originated in the manufacturing industry by promoting standardisation (Akintoye, 1995). Building clients, however, may prefer a unique project instead of a

standard design project. The strategies to overcome this obstacle include:

- More training workshops and seminars to develop better communication skills: This will help engineers to know more about the client's real needs and expectations to avoid rework at a later stage.
- More buildable designs by incorporating buildable principles: As Liu and Low (2007) suggested, builders in Singapore have relevant knowledge and expertise in constructability, and these skillsets can be transferred to China, with appropriate modifications, to improve the effectiveness and efficiency of the Chinese construction industry, especially in the area of design work. This recommendation is parallel with one of the goals of JIT – design for optimum quality, cost and ease of construction.
- Gradually replacing the traditional procurement approaches with new and integrated approaches, such as D&B, with supporting in-house design teams.

Procurement

The procurement of suppliers and subcontractors is a vital starting point in the JIT process. Once implementation commences, the following issues are critical:

- Long term supplier relationships: Develop a localised supply chain with fewer supply sources and then establish relationships and partnerships with the best suppliers from among them. This will create trust and transparency so that the products required can be delivered at the right time and in the correct quantities. More frequent deliveries of smaller quantities of building materials with uniform quality must be guaranteed (Harber et al., 1990).
- Long term subcontractor relationships: Establish a minimum acceptable quality level for all subcontractors. No nominated subcontractors through "guan xi" should be used. Coordination and communication between subcontractors should be encouraged by the establishment of multi-functional teams.

Site scheduling, planning and construction

In terms of site scheduling, planning and construction, the following factors should be considered for JIT implementation:

- Joint efforts in site scheduling: Involving all subcontractors/suppliers during the planning and scheduling process to optimise work low. The

"Kanban" (pull) system can be introduced for ordering materials. At the construction site, access time needs to be monitored and ensured so that resources can be utilised at the right time, in the right place and with the correct quantities.

- Quality control: The Chinese government requires construction clients to enhance on-site supervision. The on-site project supervision process to ensure that total quality control is achieved is the responsibility of the supervisory company. Those companies that have not obtained the ISO 9001 quality management system certification should be advised to do so. In this context, Chinese construction firms should create a corporate culture for quality assurance.
- Training: Training of skills to eliminate waste, standardise operations and other technical principles, as well as cultivating the right attitudes among employees, is critical. Over time, promising employees should receive formal professional education and obtain qualifications to work in construction projects as multi-skilled workers as advocated by the Toyota Production System. Multi-disciplinary training will allow the workforce to be exploited to its fullest potential. This provides greater flexibility in deploying workers to improve productivity. For construction managers, the training should include their commitment to JIT implementation. Furthermore, training also needs to be provided for the suppliers and subcontractors so that they can better understand the JIT principles.
- Employee involvement: Establish a flat model, remove hierarchies and give more responsibility to individual project teams. As Akintoye (1995) highlighted, JIT requires flexibility and worker's participation in the decision making process. Moreover, encouraging the labour force to stop work once any problems are identified has worked on the Toyota shop floor (Liker, 2004). In China, most of the construction workers do not possess a high level of education. Nevertheless, the need to take responsibility and to build effective teamwork skills needs to be emphasised among the Chinese workers.

Inspection

The following factors need to be considered to reduce and eliminate inspections:

- Elimination of defects through higher working standards and improved quality control should be planned throughout a building project.
- Highlighting key shortfalls during the building process and learning from them for future projects is essential. This is an exercise of incremental and continuous improvement.

LESSONS FROM THREE COMPLETED STUDIES

Three previous JIT studies are presented in this section to highlight the benefits that can be derived from JIT implementation.

JIT in Site Layout

Neo Corporation was selected for this study because this company was among the first construction firms in Singapore to achieve ISO 9002 certification for its quality management system. In addition, the top management employees endeavoured to achieve higher productivity in their construction projects, including applying the JIT philosophy for their site operations (Low and Mok, 1999).

Low and Mok (1999) detailed how Neo Corporation incorporated the seven JIT principles in its site layout management practice. Following the introduction of the JIT philosophy, seven forms of waste were identified and largely reduced on site to achieve productivity improvement (Low and Tan, 1997).

JIT in Precast Concrete Construction

The second study was completed by Low and Choong (2001), who examined the readiness of contractors in Singapore to adopt the JIT philosophy for receiving and installing precast concrete products and their related operational services on site. Low and Choong (2001) observed that the benefits included being able to reduce storage levels on site within the context of site space constraint, shortening storage periods and keeping the acceptable buffer stock for precasters and contractors to meet specified JIT delivery needs.

JIT in the Ready Mixed Concrete (RMC) Industry in China

Low and Wu (2005) investigated the implementation status of JIT management in the ready mixed concrete (RMC) industry in Chongqing, China and observed that all RMC suppliers in Chongqing were practising JIT procurement of cement, long-term relationships with the contractors, group technology and other JIT principles. Through a comparative study in the same industry of batching plants in Singapore, Low and Wu (2005) suggested that it is feasible to apply the JIT purchasing system to procure the raw materials, which can significantly reduce the amount of buffer stock on site.

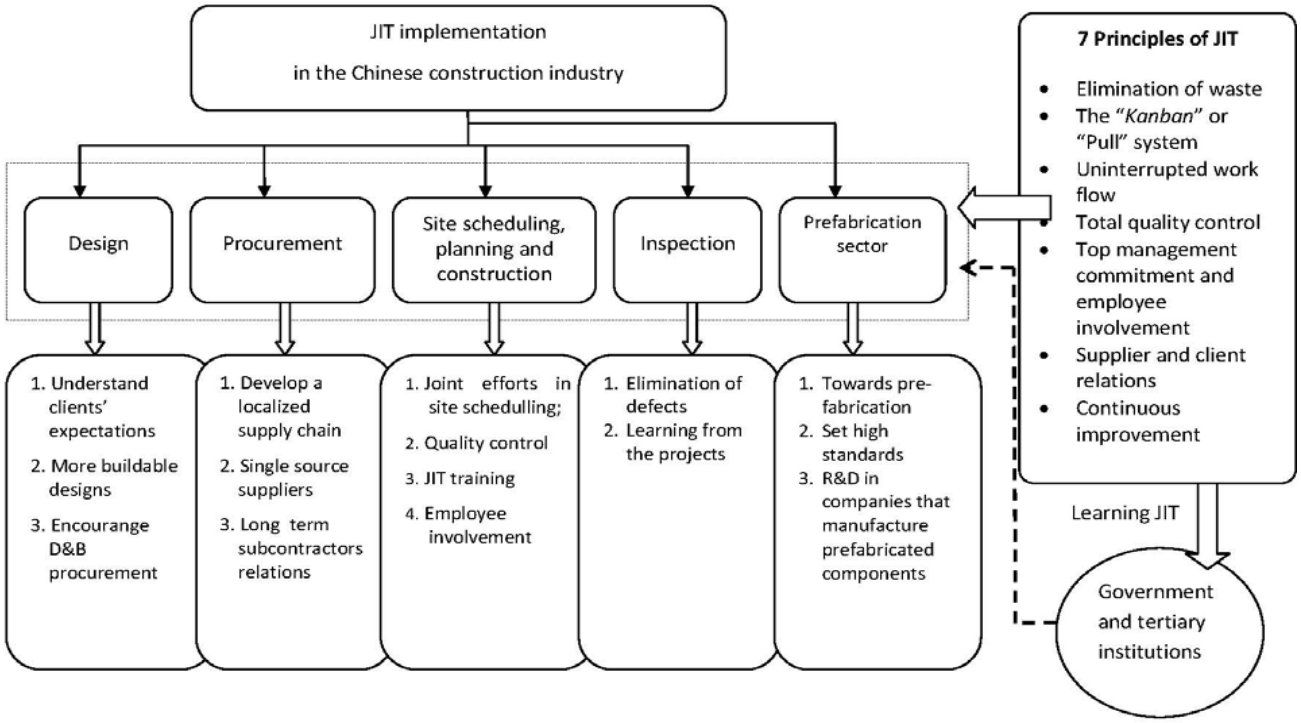

Figure 5. The Framework for JIT Implementation in the Chinese Construction Industry

In summary, these previously conducted studies demonstrate that it is worthwhile to transfer JIT principles to China. In this context, recommendations are made below for the role that the Chinese government can take in JIT implementation.

RECOMMENDATIONS FOR THE ROLE OF THE CHINESE GOVERNMENT

Based on past experiences, government support and learning from other countries are the two necessary driving forces in the initial stages of JIT implementation. Construction bureaus can lend their support to the companies that are intent and committed to implementing the JIT system. The following recommendations are for the Chinese Government to implement JIT in practice:

- Training: Conduct training programs in JIT for top management from the SOEs to raise their awareness of the benefits that may be derived from JIT and consequently reinforce their commitment. It is also necessary to educate construction-related government officials on the principles of JIT and the benefits that JIT can bring about. By doing that, the authorities are expected to have their support and impact on JIT adoption among Chinese construction firms. In addition to training for the industry, formal JIT education in the tertiary institutions is also important.
- Lend support to the prefabrication sector: Past studies have highlighted the application of JIT in the prefabrication sector. In China, this would also be a very good starting point to promote the use of prefabricated components in the construction industry. A growing prefabrication sector can deliver high quality off-site products to enhance productivity.
- Reward and recognise those companies that have experimented with JIT implementation: Training can be offered to workers in JIT to encourage the more widespread use of prefabricated components.
- Establish JIT consultancies to provide training/educational services to construction practitioners and facilitate the changes that JIT brings about to their organisations.
- Simplify the approval process for legislative controls to ensure that there is no delay in the commencement of construction works arising from insufficient submission documents. Promote the collaboration and cooperation between different bureaus to expedite the approval process.

CONCLUSIONS

Based on the review of the literature relating to JIT and an examination of the Chinese construction sector, it can be concluded that there is the potential for JIT application to address the low productivity, low profitability and low quality issues in China's construction industry. The Chinese government and the educational institutions should recognise the importance of JIT and provide appropriate training and other assistance to facilitate the widespread adoption of JIT in the Chinese construction industry.

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