PERGAMON

Building and Environment 37 (2002) 983–991

BUILDING AND ENVIRONMENT

www.elsevier.com/locate/buildenv

Evaluation of construction methods and performance for high rise public housing construction in Hong Kong

C.M. Tam *, Z.M. Deng, S.X. Zeng

Department of Building and Construction, City University of Hong Kong, 83 Tat Chee Avenue, Kowloon, Hong Kong

Received 6 April 1999; received in revised form 6 September 2001; accepted 11 September 2001

Abstract

Time, cost and resource usage are some of the most important production performance issues in the construction industry. This paper investigates the impact of using different construction methods or techniques on production performance in the context of high-rise public housing construction in Hong Kong. Three different construction schemes with the same standard "Harmony" design were investigated. These schemes differ in the floor slab construction methods and the material handling plant input. Cycle duration, labour resource usage and costs in three schemes are analysed and examined. The findings have revealed that Scheme 2 with a six-day floor cycle duration is the most economical option on the basis of manpower and cost. However, Scheme 3 with four-day floor cycle duration is the preferred option because the speed of construction is of paramount importance in Hong Kong.

Keywords: Construction methods; Production performance; Time and cost; Public housing construction; Hong Kong

1. Introduction

Many questions or myth have been raised to the reportedly remarkable speeds of construction achieved in Hong Kong [1]. For example:

1. Is the speed of construction really remarkable in Hong Kong?
2. Is it at the expense of higher costs? Is the labour more productive? Is the technology superior?
3. Have we reached a point of diminishing returns in terms of time compression? (Alternatively, is it possible to build even faster without compromising quality and safety, or significantly enhancing costs; in other words, achieving continuous improvement?)

Some similar or related issues were raised elsewhere, such as in the UK, Singapore, Kuwait and Israel [2–7].

This paper aims to investigate the impact of using different construction methods and techniques on the production performance including resources requirements, speed of construction and construction costs of high-rise public housing construction in Hong Kong.

* Corresponding author. Tel.: +00-852-2788-7620; fax: +00-852-2788-7612.

E-mail address: bctam@cityu.edu.hk (C.M. Tam).

2. Review of previous work

The issues of shortening construction time, reducing cost and improving production performance have engaged both practitioners and researchers for a long time. The studies include motivation and productivity investigations as well as the analysis of planning and scheduling techniques [8,9]. Extensive comparative evaluation of international productivity has been conducted [10–12]. Some investigated the effects of managerial actions on the objectives of reducing time, cost and improving quality [13]. Technological improvements have been identified as the most likely approach to address the above issues [14,15]. The term "technological improvements", as defined by Rosenfeld et al. [14], refers to using different materials, tools, and/or equipment and to adopting new construction methods. Being one of the greatest technological improvements in construction, prefabrication and industrialisation have long been recognised as the major way to achieve a quantum leap in productivity improvement in the building industry. Prefabrication and industrialisation have been used successfully in limited regions such as Finland and Israel [16] as well as in wider regions such as rebuilding of Europe after the destruction of the Second World War or "Operation Breakthrough" in the United States [17] in early 1960s. Prefabrication and industrialisation have also been used widely in the public housing

0360-1323/02/$ - see front matter
PII: S0360-1323(01)00081-6

construction in Hong Kong and Singapore since early 1980s. The methods are considered having the potential to considerably reduce the labour requirement on site, total construction costs and the project completion time [18]. Other innovative construction methods, such as modular boxes, prestressed panels and polystyrene blocks, have been developed and implemented due to the unique Israeli situation of the urgent need for mass housing during the recent years [16].

Some relevant research on the above issues in Hong Kong has also been reported. Ganesan [19] discussed a wide range of construction productivity issues in Hong Kong. Chau and Walker [20] analysed the total factor productivity of the Hong Kong building industry. The productivity results of concrete pours observed on building sites in Hong Kong between 1991 and 1993 have been reported by Anson and Wang [21], which represent the yardsticks of the concrete placing performance during that period of time. More recently, Chan and Kumaraswamy [22] investigated a range of factors affecting construction project duration in Hong Kong and explored some microfactors such as plant utilisation levels and site labour requirements. The optimum project duration and cost curve applied to "Harmony" type public housing projects in Hong Kong were investigated by Khosrowshahi in 1997 [23]. Specific indicators for productivity and/or speed, such as concrete placing productivity, time-cost performance and built-up area per week, have been compared across the UK, West Germany, Beijing and Hong Kong [22,24]. An interesting conclusion from those comparisons is that public housing projects in Hong Kong appear to perform much better than other countries. However, there is no research, to our knowledge, that tries to gauge the productivity and/or speed with the construction methods/techniques and to analyse their impact on time, cost and resource requirements.

3. Research methodology

In Hong Kong, there is a very high demand for public housing. Lately, the government has announced the housing construction target of 85,000 units per year, of which 50,000 units fall into the category of public housing. It demands for speedy construction which has priority over the construction cost, though cost is receiving increasing attention for the accountability of the government. Meanwhile, like most developed cities, the construction industry in Hong Kong cannot attract sufficient young people to join and thus has a severe shortage of skilled workers, which adds difficulties to achieve the construction target. This paper concentrates on studying the impact of using different construction methods or techniques on production performance of public housing construction in Hong Kong. The research objective is to investigate the relationship between construction methods, cycle duration, labour requirements and costs for labour and plant. The work is intended to be a pilot study to develop a system of sustained and systematic improvements for public housing construction in Hong Kong.

In this research, the subject of the study was the structural frame construction of public housing, which has a great influence upon the total duration of the project [25]. The criteria for evaluating different construction schemes are (1) the duration of concrete-frame construction of the upper typical floor, (2) the labour input, especially the skilled labour trades, and (3) the costs for direct labour and plant. Quality, although is paramount concern in the public housing construction and deeply related to time, cost and construction methods, will be dealt with in another paper [26].

Literature review reveals two commonly used research methodologies to evaluate production performance. Chan and Kumaraswary [22] used the work study technique to analyse plant utilisation levels and site labour productivity in Hong Kong. Proverbs et al. [2] used a model project complemented with a structured questionnaire to compare and evaluate the production performance in in situ concrete construction in several European countries. The work study technique including activity sampling and continuous time study is adopted in the research [27]. The direct information collected from the site will give more confidence on the accuracy of the data. The large number of "Harmony" projects in Hong Kong makes our method possible and reliable.

In order to investigate the construction sequence and to collect data of such housing projects, three large construction firms, which have occupied about 36% public housing construction market from 1994–1998, were approached and permissions to study their sites were granted. The data were collected from 20 sites between March 1997 and March 1998. During this period of time, Schemes 2 and 3 which will be detailed later in the paper, were being used by different contractors. We also found that one contractor was using concrete pumps for concrete placing in one of his projects. This kind of material handling method is not covered in this paper since this method is not commonly used. Site data for Scheme 1 was obtained from authors' earlier research [25]. The time consumed by each operation was collected by site observation, supplemented by interviews with site management. It was found from site data collection that the production rates for the operations with same technology and resources were very close in the three different schemes studied. The production rates were also found to vary from lower floors to higher floors, which may be resulted from the learning effect, though site data show that the variations are minimal. In order to average out the productivity data, information from middle levels (Floors 12–15) of site activities, which is least affected by learning effects, were used. Cost data were obtained from a single contractor only as it is difficult to compare the costing data of different contractors. The cost data of Scheme 1 projects were extracted from project reports and adjusted to 1998 values so that the timeframes of the projects under investigation are consistent.