AN ANALYSIS ON FACTORS AFFECTING SCHEDULE PERFORMANCE OF PUBLIC HOUSING PROJECTS: CASE OF SINGAPORE

Bon-Gang Hwang[1], Xianbo Zhao[2] and Si Yi Ng[3]

[1] Assistant Professor, Department of Building, National University of Singapore, Singapore
[2] Ph.D Candidate, Department of Building, National University of Singapore, Singapore
[3] Operations Executive, Retails Operations Department, Far East Organization, Singapore
Correspond to bdghbg@nus.edu.sg

ABSTRACT: With the increasing demand for public housing, the Singapore government decided to reduce the waiting time of future public housing owners, which requires these projects to be completed on time. As a result, this study aims to identify the frequent and impactful factors affecting schedule performance of public housing projects in Singapore. The survey conducted with 36 industry experts revealed that "site management", "coordination among various parties", "design changes by owner during construction", "availability of laborers on site", "availability of material", and "availability of staff to manage projects" were the six factors that should be emphasized to assure the schedule performance of public housing projects. In addition, there was statistically significant agreement between public housing projects and other building projects on both the frequency and impact ranks of the factors. The findings from this study will help practitioners involving public housing projects to take measures to assure the achievement of project schedule objectives.

Keywords: Public housing; Building; Schedule; Singapore

1. INTRODUCTION

Singapore's construction demand, measured by total value of construction contracts awarded, increased by 16% year-on-year from S$27.6 billion (1S$≈0.78US$) in 2010 to S$32 billion in 2011 [1]. The great increase was backed by strong public sector construction demand of S$15.2 billion, of which the demand for public housing projects was approximately S$6 billion, representing 18.75% of the total construction demand [1]. Hence, public housing construction has become an important element of the Singapore construction industry.

Public housing in Singapore is managed by the Housing and Development Board (HDB), which was established in 1960 in order to develop public housing and to improve the quality of living environment for its residents. Thus, the public housing projects in Singapore are generally called HDB projects. To better meet the public demands, the HDB tried to reduce the waiting time of future public housing owners, which needs the completion on time of the HDB projects. Factors related to project schedule has been recognized as critical to project success [2] and thus it is necessary to identify the factors that are likely to affect public housing project schedule.

Although factors affecting schedule performance of construction projects were identified in various literatures, few studies have been conducted to investigate critical factors for building projects in Singapore, not to mention public housing projects. Hence, this study aims to fill this knowledge gap by identifying the most frequent and impactful factors affecting schedule performance of public housing projects in Singapore. The findings from this study will provide a better understanding of the critical factors and help practitioners involving public housing projects to take measures to assure the achievement of project schedule objectives.

2. BACKGROUND

2.1 Public Housing in Singapore

Public housing in Singapore is not generally viewed as a sign of poverty or lower living standards as compared to that in other countries. The housing sector in Singapore is dominated by HDB projects. Over 80% of Singaporeans live in HDB flats, and about 90% of them own their HDB flats [3]. HDB flats are located in housing estates, which are self-contained satellite towns with schools, supermarkets, clinics, hawker centers, as well as sports and recreational facilities. HDB flats are built to provide affordable housing for the masses, and their purchase can be financially-aided by the Central Provident Fund.

The HDB plans and develops dynamic towns to provide adequate homes and a cohesive community for people to live in. With the increasing number of HDB flats to be built in coming years, there is an urgent need to strictly monitor the project schedule to ensure that housing can be delivered to new owners on time. The Singapore government has set a target to reduce the waiting time of future owners from the current three years

to two and a half years by streamlining the internal process of HDB to award tenders of projects earlier. However, delay of the HDB projects would hinder the achievement of this target. Delay happened in most construction projects [4] and it is better to identify causes of delay at the early stage of a project. As a result, it is meaningful to identify the critical factors affecting schedule performance of HDB projects.

2.2 Factors Affecting Project Schedule Performance

A variety of previous studies analyzed factors affecting construction project schedule performance. Most of them focused on identification of major causes of delays in various construction projects. However, few studies have been conducted to investigate factors affecting the schedule performance of building projects in Singapore. This study identifies 18 factors that can affect the schedule performance of public housing projects in Singapore using.

F01: Site management

Site management is related to material distribution, commitment of site employees, project monitoring, and communication between parties [5], and thus affects project schedule performance. Poor site management was found to be the most important cause of construction delay in Vietnam [6] and Hong Kong [7].

F02: Financing by contractors

Financial stability and financial status was identified among the top ten criteria for contractor prequalification and bid evaluation [8]. The owners and consultants considered financing by contractor during construction as the top cause of delay in Egyptian building projects [9]. Contractors' financial difficulties were also the most important cause of construction delay in Nigeria [10].

F03: Coordination among parties

Cooperation and coordination among different parties involved in a project facilitates its completion on time. In contrast, conflicts are detrimental to the smooth progress of work and thus cause time overruns [11]. Coordination among parties was found to be among the top ten causes of delay in construction projects in Lebanon [12], Malaysia [13] and Egypt [9].

F04: Preparation of schedule plans and updates

Poor planning and scheduling was found to be relevant to shortage of technical professionals in contractors, insufficient coordination among parties, as well as ineffective quality control by contractors [4]. Also, this factor was perceived as an important source of construction delay in Thailand [14].

F05: Experience of contractors

Experience of contractors, as a main criteria for prequalification, affects both technical and management capacities of contractors. In Hong Kong, the owners and consultants ranked inexperienced contractors among the top three causes of construction delay [15]. Similarly, inadequate contractor experience was the third most important cause of construction project delay in Malaysia [16].

F06: Construction methods

Appropriate construction methods ensure the achievement of project schedule objectives. The selection of construction methods is largely dependent on the experience of contractors. Improper construction methods implemented by contractors can cause construction delay [17, 18].

F07: Experience of consultants

In addition to the experience of contractors, the experience of consultants significantly affects project schedule performance. Inadequate experience of consultants would result in late issuance of construction drawing, delay in work approval, poor communication and change orders.

F08: Foundation conditions

Information relating to foundation conditions is typically provided by consultants. In Australia, water table and geotechnical problems significantly affected inherent site conditions and thus resulted in construction time overruns [19]. Also, in Egypt, unexpected foundation conditions encountered on site was among the top ten important causes of delay in housing projects [9].

F09: Speed of decision making of owners

Speed of decision making of owners significantly affects the activities related to the decisions. Slowness of decision making, especially those related to the activities in the critical path, results in construction time overruns. In many instances, contractors waste resources waiting for owners to decide on specialty contractors, decorative materials and suppliers, and provision of adequate information on the changes required [14].

F10: Financing by owners during construction

Financing by owners during construction ensures the progress payment of completed work. Financial difficulties of owners can result in delay of payment by owners and even shutdowns. This factor was found to be the major delay cause in Ghana [20] and Vietnam [6].

F11: Design changes by owners during construction

Owners, especially private owners, tend to change designs according to the changing economic climate, to meet customer needs, or for marketing reasons. Design changes impacts the plans of contractors and may even require extensive redesign [14]. Design changes by owners were among the top three important causes of construction delay in Lebanon [12], Jordan [4] and Egypt [9].

F12: Experience of owners

The experience of owners affects the quality and speed of their decision making, and thus affects project schedule performance. Owner's lack of experience was the third most important cause of delay in private residential projects in Kuwait [18].

F13: Project duration set by owners

Owners should set project duration after proper consideration of all relevant factors of a project. The unrealistic contract duration imposed by owners was identified as a main cause of delay in Hong Kong civil engineering projects [15].

F14: Availability of laborers on site

Sufficient laborers on site ensure the smooth progress of work. In contrast, shortage of laborers on site results in construction delay. Shortage of laborers was the top cause of construction delay in Saudi Arabia [21], and among the

major delay causes in Thailand [14], the United Arab Emirates [22] and Jordan [4].

F15: Availability of staff to manage projects

Contractors, owners and consultants all need sufficient qualified staff to manage the projects that they are engaged in. Lack of staff tends to cause a great burden on the staff at work. In turn, this increases responsibilities, disrupts concentration, causes poor quality of work [5], lowers construction management effectiveness [23, 24], and thereby results in construction delay.

F16: Availability of equipment

Equipment is an important resource that is necessary to construction, and inadequate equipment can cause low work efficiency or even suspend construction activities. Shortage in equipment was found to be the fifth most critical delay cause in road construction projects in the West Bank [25].

F17: Availability of material

Similar with lack of equipment, shortage of construction material can also lead to construction delay. Previous studies indicated that lack of materials in markets, shortage of construction materials at site, and delay of material delivery to site were the most important reasons for construction delay in the Gaza Strip [5].

F18: Availability of site

Due to the space limitation on site, the movement of material, equipment and laborers may incur idle time and construction delay. It was found that confined site caused delay in 41.7% of the construction projects in Thailand [14].

3. METHODOLOGY AND DATA PRESENTATION

The comprehensive literature review served as a foundation of this study and supported the development of a survey questionnaire. A pilot study was conducted with four practitioners and identified the 18 potential critical factors before the finalization of the questionnaire. The questionnaire consisted of two main sections. The first section was meant to profile the respondents and their companies. In the second section, the respondents were requested to assess the frequency and impact of the 18 factors affecting schedule performance of both HDB projects and other types of building projects, which include condominiums, schools, office buildings, shopping malls, hotels, and factories. A five-point Likert scale (1= never; 2= rare; 3= sometimes; 4= often; 5= always) was employed to rate the frequency of each factor, while another scale (1= little; 2= low; 3= mid; 4= high; 5= very high) was used to evaluate the respondents' perceptions on the impact of each factor.

The sampling framework used for this study consisted of contractors registered under the Building and Construction Authority (BCA) as well as the consultants and private owners listed in Real Estate Developers' Association of Singapore. 115 survey questionnaires were distributed to the randomly selected contractors, consultants and private owners from May to August 2011, and 36 completed questionnaires were collected from 36 different companies. The response rate of 31.3%, was considered high compared with the norm of 20-30% with most postal questionnaire surveys of the construction industry [26]. In addition, although the sample size was not large, statistical analysis could still be performed because the central limit theorem holds true with a sample size larger than 30 [27, 28].

As shown in Table 1, these companies consisted of 24 contractors (66.7%), four consultant firms (11.1%) and eight private owners (22.2%). The survey required each participating company to complete the questionnaire by assigning a representative with sufficient knowledge and experience in building project management. 91.7% of the respondents had more than 10 years of experience in the construction industry, which ensured the quality of the responses. It merits attention that not all the respondents were involved in HDB projects but they could still provide opinions based on their knowledge and experience in project management in other types of building projects.

Table 1. Profiles of Companies and Respondents

Characteristics			N	%
Company	Type	Contractors	24	66.7%
		Consultants	4	11.1%
		Private owners	8	22.2%
Respondent	Job title	Senior management	8	22.2%
		Project management	17	47.2%
		Project engineer	10	27.8%
		Others	1	2.8%
	Years of experience	5-10	3	8.3%
		11-15	5	13.9%
		16-20	16	44.4%
		>21	12	33.3%

4. DATA ANALYSIS AND DISCUSSIONS

4.1 Frequency and Impact Indices

The frequency and impact of the factors affecting schedule performance of HDB projects were analyzed using two indicators: the frequency index (FI) and the impact index (II).

The FI of each factor was derived from the following equation:

$$FI = \frac{5f_5 + 4f_4 + 3f_3 + 2f_2 + f_1}{5N} \quad (1)$$

where N is the total number of the respondents; f5 is the number of the respondents answering "always"; f4 is the number of the respondents answering "often"; f3 is the number of the respondents answering "sometimes"; f2 is the number of the respondents answering "rare"; f1 is the number of the respondents answering "never". The FI value ranges from 0 to 1 (0 not inclusive) and the higher

FI value indicates the factor is more likely to occur and affect project schedule.

Similarly, the II of each factor was computed using the following equation:

$$II = \frac{5i_5 + 4i_4 + 3i_3 + 2i_2 + i_1}{5N} \quad (2)$$

where N is the total number of respondents; i5, i4, i3, i2, i1 is the number of the respondents who answers "very high", "high"; "mid", "low", and "very low", respectively.

The II value also ranges from 0 to 1 (0 not inclusive) and the higher II value indicates the factor has higher-level impact on project schedule performance.

Using (1) and (2), FIs and IIs of the 18 factors in HDB projects and other types of building projects were computed and ranked, as indicated in Table 2.

Table 2. Frequency and Impact Indices of Factors Affecting Building Project Schedule

No.	Factor	HDB projects				Other building projects			
		FI	Rank	II	Rank	FI	Rank	II	Rank
F01	Site management	0.878	**3**	0.939	**1**	0.817	7	0.922	**1**
F02	Financing by contractor during construction	0.722	14	0.800	6	0.717	15	0.778	9
F03	Coordination among various parties	0.894	**2**	0.911	**2**	0.883	**2**	0.917	**2**
F04	Preparation of schedule plans and updates	0.817	7	0.794	8	0.861	**3**	0.756	10
F05	Experience of contractor	0.772	11	0.728	13	0.728	13	0.733	11
F06	Construction methods	0.806	9	0.683	14	0.789	9	0.717	12
F07	Experience of consultant	0.722	14	0.633	15	0.722	14	0.639	15
F08	Foundation conditions	0.767	12	0.617	17	0.744	12	0.589	17
F09	Speed of decision making of owners	0.744	13	0.761	10	0.783	10	0.872	**5**
F10	Financing by owner during construction	0.706	16	0.739	12	0.706	16	0.844	7
F11	Design changes by owners during construction	0.911	**1**	0.756	11	0.906	**1**	0.683	13
F12	Experience of owners	0.700	17	0.567	18	0.683	17	0.583	18
F13	Project duration set by owners	0.817	7	0.772	9	0.839	4	0.656	14
F14	Availability of laborers on site	0.878	**3**	0.911	**2**	0.817	7	0.917	**2**
F15	Availability of staff to manage project	0.806	9	0.872	**4**	0.833	**5**	0.922	**1**
F16	Availability of equipment	0.822	6	0.800	6	0.778	11	0.789	8
F17	Availability of material	0.839	**5**	0.844	**5**	0.822	6	0.867	6
F18	Availability of site	0.556	18	0.628	16	0.567	18	0.628	16

4.2 FI Ranks of Factors Affecting HDB Project Schedule Performance

Table 2 shows that top five frequent factors affecting HDB project schedule performance are "design changes by owner during construction", "coordination among various parties", "site management", "availability of laborers on site", and "availability of material".

"Design changes by owners during construction" was identified as the most frequent factor in HDB projects (FI=0.911), showing that in nearly all HDB projects, drawings and designs are often changed by owners. This factor was also ranked first in other building projects (FI=0.906), which indicated that design changes frequently occurs in almost all the building projects in Singapore.

Following on, "coordination among parties" was seen as the second most frequent factor affecting schedule performance of HDB projects (FI=0.894) and other building projects (FI=0.883). In Singapore, construction projects tend to involve contractors and subcontractors from various countries with different cultures. Thus, it is not surprising that problems relating to coordination among project players occur frequently in all kinds of building projects. Given the high frequency of this factor, coordination and communication among the parties should be emphasized to assure the efficiency of project execution.

"Site management" occupied the third position in HDB projects (FI=0.878), which implied that poor site management frequently occurs in HDB projects. This may be due to the inadequate manpower, resources and machineries on site. Site management problems would occur more frequently as the size and complexity of HDB projects have increased.

"Availability of laborers on site" was also ranked the third in HDB projects (FI=0.878), which indicated that HDB project construction was frequently faced with inadequate laborers. The availability of workers has been a major concern of the industry practitioners because most of the laborers working on construction site in Singapore are foreigners from China, Malaysia, India, Bangladesh, etc. The recent increase in levy fees for

Singapore work permit holders worsened the availability of manpower on site in Singapore.

"Availability of material" was perceived as the fifth most frequent factor in HDB projects (FI=0.839), indicating that material availability occurred frequently in HDB projects. Lack of material in the market or delay of deliver to the site may result in material unavailability on site [5]. In Singapore, the construction material supply greatly depends on imports, and thus change in export policy in another countries would more or less affect the material availability in Singapore.

In terms of FI values, "availability of site" (FI=0.556), "experience of owners" (FI=0.700), and "financing by owner during construction" (FI=0.706) were perceived as the least frequent factors affecting HDB project schedule. However, the FI values over 5.000 implied that these three factors still often occur in HDB projects.

To measure the degree of agreement associated with the FI ranks of the factors affecting schedule of HDB projects and other building projects, the Spearman rank correlation coefficient was calculated and statistically tested. The Spearman rank correlation is a method of computing a correlation between the ranks of scores between two groups. The correlation is calculated on the ranks of scores, not the scores themselves. As a result, without the consideration of normality or equal variance of data, this statistical method can be used focusing on difference in rank orders of data rather than difference in means [29]. The Spearman rank correlation coefficient equals 1 for a perfect positive correlation and −1 for a perfect negative correlation. When the correlation is not perfect, the coefficient lies between −1 and 1. A significance level of 0.05 (one-tailed) was applied for this analysis.

The Spearman rank correlation of the FI ranks of the 18 factors between HDB projects and other building projects was 0.940 (p-value=0.033<0.05). Hence, the null hypothesis that there was not a significant correlation between the FI ranks in HDB projects and other building projects had to be rejected, and this result implied that there was strong and statistically significant agreement between HDB projects and other building projects on the FI rank orders of the factors affecting schedule performance

4.3 II Rank of Factors Affecting HDB Project Schedule Performance

As Table II shows, the top five impactful factors affecting HDB project schedule performance are "site management", "coordination among various parties", "availability of laborers on site", "availability of staff to manage project", and "availability of material".

"Site management" was perceived as the most impactful factor in HDB projects (II=0.939) and other building projects (II=0.922). This implied that once there were site management problems, the schedule of all kinds of building projects in Singapore would be delayed severely, because poor site management would lead to incorrect distribution of works, no commitment of site employees, as well as poor monitoring of project [5].

"Coordination among various parties" occupied the second position in HDB projects (II=0.911) and other building projects (II=0.917), indicating that this factor exerted great impact on the schedule of all kinds of building projects in Singapore. Difficulties in the coordination among various parties would cause reworks due to construction errors and low working efficiency.

"Availability of laborers on site" was also ranked the second in HDB projects (II=0.911) and other building projects (II=0.917), which indicated that lack of laborers was a common problem seriously impacting the schedule of all building projects in Singapore because this problem may result in difficulties in distributing manpower to some work and low efficiency in construction. Similar scenarios were also found in the Middle East [4, 21, 22], where the practitioners regarded shortage of manpower as a main cause of construction delay.

Once occurring, "availability of staff to manage project" was seen as the fourth most impactful factor for HDB project schedule (II=0.872), and as the top impactful factor in other building projects (II=0.922). Thus, it was perceived that this factor was more impactful to the schedule of other building projects than to that of HDB projects. In addition, the high II rank of this factor indicated the importance of the experience and knowledge of the management staff. Furthermore, this factor is related to "site management" and "coordination among various parties". Lack of competent management staff would result in poor site management and poor coordination among parties, and thus causes project delays.

"Availability of material" was perceived as the fifth most impactful factor in HDB projects (II=0.844). Although this factor was ranked the sixth in other building projects, the II value (II=0.867) in this group was higher than that in HDB projects. Hence, this factor still greatly impact schedule of all kinds of building projects in Singapore. Adequate material supply is the precondition of nearly all the construction activities, and shortage of material would lead to project shutdown and delay [14]. In 2007, Indonesia's decision to ban exports of sand to Singapore caused skyrocketing prices of sand, concrete and granite [30], and some contractors postponed the purchase activities until the prices decreased, which caused significant project delays. Hence, it is not surprising that the respondents recognized "availability of material" as an impactful factor for HDB project schedule.

In terms of II values, "experience of owners" (II=0.567), "foundation conditions" (II=0.617), and "availability of site" (II=0.628) were perceived as the least impactful factors affecting HDB project schedule. However, the II values more than 0.500 indicated that these factors were also impactful to HDB project schedule and should not be ignored.

In addition, it should be noted that "design changes by owners during construction" had a relatively low II value (II=0.756) with a rank of 11 in HDB projects, despite its top FI rank. It can be inferred that owners' design changes occurs so frequently that HDB project players become very experienced and skilled in dealing with this factor to assure the project schedule performance.

The Spearman rank correlation coefficient of the II ranks of the 18 factors between HDB projects and other building projects was 0.986 (p-value=0.009<0.05). Hence, the null hypothesis that there was not significant correlation between the II ranks in HDB projects and other building projects had to be rejected, and this result implied that there was a strong and statistically significant agreement between HDB projects and other building projects on the II ranks of the factors that affect schedule performance.

5. CONCLUSION AND RECOMMENDATION

This study identified the critical factors affecting schedule of public housing projects in Singapore (i.e. HDB projects) and examined the agreement on the frequency and impact ranks of the factors affecting schedule performance between HDB projects and other building projects.

The data analysis results indicated that "design changes by owner during construction", "coordination among various parties", "site management", "availability of laborers on site", and "availability of material" were the five most frequent factors, and that "site management", "coordination among various parties", "availability of laborers on site", "availability of staff to manage project", and "availability of material" were the top five impactful factors. Hence, these six factors should be emphasized to ensure the achievement of HDB projects schedule objectives.

In addition, the results of the Spearman rank correlation implied that there was statistically significant agreement between HDB and other types of building projects on the frequency and impact ranks of the factors affecting schedule performance.

Despite the achievement of the objectives, there are some limitations to the conclusions that may be drawn from the results. First, 66.7% of the respondents were from contractors. Thus, the survey results might more closely represent contractors' perspectives while public housing projects also involve owners and consultants. In addition, as the sample size in this study was small, cautions should be warranted when the analysis results are interpreted and generalized. Lastly, the findings from this study were well interpreted in the context of Singapore since public housing schemes may vary in other countries.

Nonetheless, this study will contribute to filling the knowledge gap in identification of the critical factors affecting schedule performance of the public housing projects in Singapore, and provides valuable information for participants of public housing projects to assure the achievement of project schedule objectives. Further research can be focused on the factors affecting the schedule of public housing projects in other countries, where an increasing number of public housing projects are under construction, such as Mainland China and Vietnam.

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