COMPLEXITY IN REFURBISHMENT OF SERVICES SYSTEM FOR HISTORICAL BUILDINGS IN MALAYSIA

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***Abstract*—Building refurbishment is an important sector in the Malaysian construction industry. High demand for refurbishment projects mainly contributed by increase the number of building renovation, extension and extensive repair works. However, refurbishment projects are difficult to manage compared to new-built projects. This due to uncertainty factors, which are inherent in the projects. The uncertainty of refurbishment project is reflected in the difficulty of getting design information during the design process. As a result, most of refurbishment project end up with high cost and time variances. Therefore, the main objectives of this paper are to present the factors that contribute to the uncertainty in refurbishment of services system for historical building and show how they affect the overall performance of refurbishment projects. Triangulation technique is used for research methodology, which consists of review of literature, semi-structured interviews with 15 architects and postal questionnaire survey that involved 234 respondents. From 234 questionnaires sent out, 82 questionnaires found to be suitable to form a database for analysis. Descriptive and inferential statistics are used in data analysis. The result concludes that refurbishment of services system for historical buildings is complex and difficult in which variables availability of design information, ease of access to building and client's needs were affect performance of the projects.**

***Keywords*-Refurbishment, Building Services, Historical Building, Malaysia**

I. INTRODUCTION

Refurbishment sector has grown rapidly and has become an important economic driver in some developed countries such as in the United Kingdom and United States [1]. For instance, in the UK, almost 50 percent of total construction output was contributed by this sector [3]. This trend has spread over to Malaysia. The CIDB [5] reported that in year 2006 refurbishment constituted 16 percent of total Malaysian construction output. However, many refurbishment projects carried out are unreported, especially those undertaken by house owners who have carried out illegal renovation works. Therefore, if this figure is taken into account, the actual value of refurbishment works in Malaysia should be higher.

The content of services work in refurbishment projects is a major factor that contributes to uncertainty of refurbishment projects. Hidden items such as piping and electrical cables induce designers to make assumptions on the services routing in their design. As a result, changes of design frequently happen during the construction stage, due to inaccurate routing design [15].

CIRIA [7] pointed out that when a building is occupied during the design process, the time taken to produce a design is longer because of difficulty to investigate the site. The designers need to inspect the building thoroughly in order to obtain accurate design information, but occupants may be uncooperative because the disturbance affects their routine activities. This could delay the information gathering process. In addition, an occupied building requires that the building operates concurrently with the refurbishment works. Thus, temporary services such as HVAC need to be designed by a certified engineer to cater for building's operation.

Therefore, the rationale for conducting this study is to improve the management of refurbishment works especially on the identifying factors that contribute to uncertainty. The study will be extended to investigate on relationship between uncertainty factors towards project performance.

II. THE MEASUREMENT OF UNCERTAINTY IN REFURBISHMENT PROJECTS

The fragmentation of the refurbishment project is compounded by complexity and uncertainty

nature of works. Uncertainty means that there is a difference between the amounts of information available to perform a task [10].

According to Young et al. [28], managing refurbishment projects means managing an uncertain project condition in which the situation could be changed drastically. Data used to guide the refurbishment works are limited and in some cases are not available, especially during the initial stage of project. Therefore, uncertainty in refurbishment projects needs to be addressed explicitly, since it involves many independent decisions.

Literature measuring uncertainty and complexity in refurbishment projects is lacking. Some authors have measured uncertainty during the construction period, such as Naoum [17] who measured the effect of uncertainty by looking into the aspect by which an integrative mechanism is used in project organizations. The study measured uncertainty by asking respondents' opinions on the degree of uncertainty in their organization using a three-point scale: simple, medium, or complex. However, the measurement is too vague to make much contribution to the improvement of refurbishment projects. The variables that contribute to uncertainty need to be highlighted explicitly because different solutions are required for different problems.

Faniran et al. [9] used both subjective and objective approaches in measuring uncertainty of construction projects. Some of the situational variables measured objectively were the number of subcontractors and the number of construction trades involved in the construction projects, whereas the variable measured subjectively were the percentage of completion of design before work started on site, past construction experience, weather predictability, availability of labour and availability of materials in the vicinity of the construction projects.

Winch [27] argued that project complexity and project uncertainty were strongly associated. By measuring one, it would represent both. This shows some similarity to the situational variables measured by Santana [23] and also measured by Faniran [9]. Some of the approaches used by construction management authors such as Santana [23] were too broad to claim that a refurbishment project is uncertain and complex. The situational variables need to be thoroughly discussed before a conclusion could be derived. Therefore, the approach used in measurement of uncertainty in the present study follows Rahmat's [19] approach.

Rahmat [19] measured uncertainty in refurbishment planning by identified thirteen dominant project characteristics. Variables termed as "situational variables" covered uncertainty and complexity in the refurbishment planning process. The variables were measured on a five-point scale from very low (1) to very high (5). Hashim [11] who studied safety in refurbishment projects duplicated the approach. Nine situational variables were identified in the study but none of them was similar to Rahmat's [19] study. This was mainly because issues in each study were different and not interrelated. However, it could be expected that some of the situational variables in Rahmat [19] would appear in the present study due to some similarity in problems faced in the refurbishment of services systems. Therefore, the uncertainty variable in the refurbishment design process would be measured using the method discussed above. The variable is categorized as 'Project Variables'.

III. PROJECT VARIABLES IN REFURBISHMENT PROJECTS

Rayers and Mansfield [20]; and Rahmat [19] suggest that uncertainty factors in construction need to be mitigated. There is consensus that significant problems in refurbishment projects are due to the existence of uncertainty in managing the projects. A study of the literature has identified six (6) dominant project variables that are associated with refurbishment of services systems. The variables are:

a. Availability of Design Information
b. Percentage of Services Design
c. Occupancy in Refurbished Building
d. Ease of Access to the Building
e. Fulfilling Statutory Requirements
f. Client's Needs

A. Availability of Design Information

Limited information about services contributes to uncertainty in design. The state of existing services is not easy to ascertain. In today's design of commercial building, requirements regarding services are very stringent because automation and information communication technology (ICT) have became so advanced. This requirement often necessitates complete refurbishment of the existing building. The installation of features such as new workstations and infinite access floors related to ICT stations could be a major cost item as well as presenting problems in incorporating them into old services. McKim et al. [15] discovered that uncertainty in services information was exacerbated by unforeseen site condition. Information about building services is normally very limited and is one of the major elements of unforeseen building condition. This is mainly due to the fact that the majority of services parts such as electrical wiring and piping are embedded in walls or ceilings. In addition, the insufficiency or unavailability of service information often forces the designers to make their decisions based on rules of thumb and

personal preferences [25]. This could lead to error such as wrong calculations that result in major design failure. Error in design could affect the work on site by delaying the progress.

B. The Percentage of Services Work to Contract Value

The percentage of services work to contract value also contributes to the uncertainty of refurbishment projects. The higher the proportion of services works, the greater the problem of accuracy of services design expected in refurbishment projects. Stone [26] pointed out that increase in services work had lead to problems during construction stage. Harris [12] mentioned that the difficulties in refurbishment works depend on interrelatedness among the building systems. If building services were installed concealed in the wall or other building finishes, the services information obtained is more uncertain. In this situation, it involves other related designers such as structural engineers and architects to get involved in confirming the accuracy of the information. The lack of involvement of other designers could contribute to unforeseen site conditions during the construction stage. McKim et al. [15] mentioned that concealed elements for services such as piping, ductwork and electrical wiring coupled with inaccurate as-built drawings are major factors contributing to the unforeseen site conditions. The late discovery of services information during the construction stage leads to changes in design. Refurbishment works normally involved more design changes in building services than what are anticipated.

C. Occupancy in a Refurbished Building

Daoud [8] pointed out that concurrent operation by the building's users would interrupt the overall flow of refurbishment projects. The sequence of work is difficult to determine when ownership of building needs to be shared between the occupants and the project team. This creates difficulties especially during design development, because the contractors need to decide jointing of the new installation parts especially for services items. Each services system normally forms an integrated network, which runs to the various parts of a building. The installation of services parts could become highly complicated for refurbishment works when only a certain part is available at a particular time, which would affect other parts. Quah [18] said that refurbishment work in an occupied building should not interfere with the normal usage of the buildings. However, no matter how much effort is made to reduce the inconvenience, the occupants have to bear some amount of disturbance and restriction in normal activities around the building. This approach would lengthen the total refurbishment period and overhead cost. CIRIA [7] pointed out that occupancy during the construction stage of refurbishment projects could increase overall cost and lengthen the time for the projects.

D. Ease of Access for Existing Buildings

The uncertainty of available access to the work area can result in refurbishment works being more difficult compared with new-build projects. The Chartered Institute of Building [4] pointed out that the difficulty of access to refurbishment projects sites could increase the level of uncertainty in refurbishment projects. Since the site of refurbishment projects is located inside an existing building, the designers have to consider during the design development the available access such as doors, window, stairs and lifts to transfer tools, equipment, material and other design features to the actual refurbishment site. Refurbishment projects that involve high-rise building might face problems since the available access to the higher floors is only by means of stairs or lifts. Mitropoulos and Howell [16] mentioned that the level of uncertainty associated with access to buildings need more time and cost. This is because more time is needed to spend for coordination and to obtain information for the material used, such as size and weight in producing and handling on site. In some cases, more coordination with the structural engineer is required when the project involves lifting of heavy equipment and demolition of building structure for ease of access.

E. Fulfilling Statutory Requirements

Design in construction projects needs approval from the appropriate authorities before it could be implemented. Holm [13] pointed out that construction is one of the sector affected by the complexities of legislation requirements. In refurbishment projects, there is also a need to comply with statutory requirements [14]. Certain types of refurbishment projects, which involve change of use, alteration of facade and historical building are subject more broadly to statutory requirements [7]. In addition, the requirements for refurbishment of listed building are more stringent and need to be handled with sensitivity by the designers. Fire, thermal and acoustic requirements also usually affect the refurbishment schemes. Moreover, time taken by authorities especially for the issuance of design approval is uncertain and difficult to predict. Mitropoulos and Howell [16] also found that the main reason for to delay in refurbishment projects was the process of getting approval from the local authority.

F. Client's Needs

Client's needs is related with design brief. Briefing is a process running throughout the construction projects by which means the client's

requirements are progressively captured and translated into reality [2]. Inability of the client to provide an adequate brief and input always contributes to additional work and design variations [24]. Poor briefing and breakdown of communication always happens when the client always changed their needs. Cox et al. [16] noted that clients contributed to reworking of the design because they initiated design changes. The client was found to be the main contributor of design changes, besides other reasons such as new information discovery on site, error in design and changes in statutory regulations. This happened due to changes in client's preferences throughout the project period. Some clients are still uncertain about their needs during the initial stage of the design process. In this situation, it is likely that the design requirements would be changed throughout the project period.

IV. RESEARCH METHODOLOGY

This study was designed with a triangulation technique, which combined the quantitative and qualitative approaches [11, 1]. Semi-structured interview were used for qualitative part whereas for quantitative, questionnaires surveys have been used for data collection method. The respondents in this study were contractors who have experienced in refurbishment of services works. A set of questionnaire sent to the final list of 234 respondents. After filtration made from 92 replied questionnaires, 82 questionnaires found to be useful to form a database for analysis. The replied questionnaires represent 82 different refurbishment projects, which a minimum contract value of RM500,000.00 (USD150,000.00). Profile of the respondents is shown in Table 1. The profile shows almost two-third of the respondents was project managers. The result also indicates that nearly 95 percent of them had more that 15 years of experience in refurbishment of services system for historical buildings.

Table 1: Profile of the respondents

Position	Percentage, n=82
Project Manager	69
Construction Manager	15
Project Executive	10
Others	6
Total	100

For qualitative part, the data were analysed together with the discussion in ranking analysis to complement the answers. This is in order to make a discussion more realistic. In the discussion, the researcher highlighted the number of occurrence of the subjects issued during the interviews. This approach of analysis has been used by Rahmat [19]. For data analysis, associative test was used to check significant relationships between project variables and performance variables.

V. RESULT AND DISCUSSION

In the questionnaire survey, the respondents were asked to rate degree of uncertainty of project variables using five points of the likert scale ranging from least important to very important. The questionnaire consisted of a total of 12 questions, which covered all the identified variables in the present study. This was considered sufficient to provide the required information. It was presented in two pages, doubled-sided on 80 grams pink coloured paper. The questionnaire was set out clearly with appropriate margin, a suitable size of font and spacing where necessary. Ali [1] stressed the importance of questionnaire design as factor that could influence the response rate of a survey. Respondents were asked to answer the questionnaire based on a refurbishment project that has been chosen. Examples of questions asked are shown below.

1-Please indicate the degree of certainty of the following variables in the refurbishment project.

- *Ease of access to building*

Least important OOOOO Very important

- *Percentage of Services Design*

Least important OOOOO Very important

2- What is the ratio of actual design time to target design time in the refurbishment project.
e.g. if the actual time spends for design was 10 weeks and target design time was 8 weeks, divide 10 by 8, so the ratio is 1.25
[ ] 0 to 0.8 [ ] 0.81 to 0.9 [ ] 0.91 to 1.00
[ ] 1.01 to 1.1 [ ] 1.11 to 1.20 [ ] more than 1.2

Table 2 shows the result of ranking of priority based on mean readings for the project variables in refurbishment of services system.

Table 2: Analysis of Results Based on Means for the Project Variables

Project Variables	Mean, (n= 82)	Rank
Availability of Design Information	0.85	1
Client's Needs	0.81	2
Ease of Access to Building	0.78	3
Fulfilling Statutory Requirements	0.73	4
Percentage of Services Design	0.70	5
Occupancy in Building	0.68	6

The result indicates that availability of design information was considered the most important

variable with regards to the uncertainty of refurbishment of services system. In contrast, occupancy in building was rated the least important among all the project variables. The results support finding from McKim et al. [15] and Ali [1] who mentioned the importance of services information in the early stage of refurbishment projects.

The client's needs ranked second in the analysis; thus, it could be considered important as factor that contributes to uncertainty in managing refurbishment of services system. This finding reconfirmed the statement by Cox et al. [6] who said that briefing is one of the factors that contributes to uncertainty in construction projects. Poor briefing by the client needs to be avoided since to it is a major factor interfering in the production of complete design and information for refurbishment projects. In the semi-structured interview, ten project managers highlighted the issue of client's needs always change, due to the late requests from clients. It could happen if the client's representative for the refurbishment projects had limited authority in deciding certain aspects. The completed brief could later be amended by other parties in the client's organization.

It is interesting to note that variable access to building ranked third. In the semi-structured interview, five project managers in Kuala Lumpur revealed that for refurbishment projects that did not involved huge mechanical plant, normally they would not be a problem in terms of accessibility to the site. Basic construction materials such as cement, sand and other small services parts could be accessible through standard building openings such as windows and doors. No special openings were required to bring in all the construction materials or equipments to the refurbishment sites. In the case that involved large equipment, sometimes contractors had to consider special openings so that the equipment could be transferred to the required area. The refurbishment projects included in this study were not involved in the installation of large plant. This is why the project managers did not report any problem concerning access. Moreover, the interviews also indicated that if the size of design material and services equipment was know, access to the refurbishment site could be improved. The availability of access affected by the installation of larger mechanical plant such as a boiler, chiller or cooling tower for an office building needed special attention from the contractors and designers during the initial stage of refurbishment projects.

To further investigate any significant relationship between project variables and project performance, associative test using Spearman rank correlation coefficient has been used. Two performance variables involved in the test. They are cost and time variances. The results of the associative test are shown in Table 3.

Table 3: Correlation Matrix between Project Variables and Performance Variables

Project Variables	Cost variance	Time variance
Availability of Design Information	-.378*	-.317**
Client's Needs	-.167	-.319**
Ease of Access to Building	-.308*	-.164
Fulfilling Statutory Requirements	-.148	-.075
Percentage of Services Design	-.130	-.164
Occupancy in Building	-.053	-.075

Notes: * Correlation at 5% significance level
** Correlation at 1% significance level

Table 3 shows that generally more negative correlations were detected in the test. However, only 4 significant correlations were found. They are:

- Availability of design information correlated with cost variance
- Availability of design information correlated with time variance
- Client's needs with time variance
- Ease of access to building with cost variance.

This indicates that project variables influence the design performance of refurbishment projects. The correlation result also supported the ranking analysis result, which shows variable 'availability of design information' and 'client's needs in the highest rank.

VI. CONCLUSION

Literature review identified six dominant variables that contribute to uncertainty in refurbishment of services system for historical buildings. Of those variables, three found to be significantly correlated with project performance variables. This indicates that performance of refurbishment of services system for historical buildings suffered from uncertainty nature of the projects. The significant variables are 'availability of design information', 'client's needs' and 'ease of access to building'.

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