Uncertainties in Building Refurbishment Projects; an Exploratory Factor Analysis (EFA) Approach

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Abstract— Building refurbishments involve improvement, repair, retrofit, renovation, and upgrading of existing buildings. It is an important sector of the construction industry. Building refurbishment projects are more uncertain than new-build projects. This paper adopted the quantitative approach and Exploratory Factor Analysis (EFA) to grouping uncertainty in building refurbishment projects in Malaysia. The questionnaire sent to managers and professionals from construction and architectural firms in Malaysia. One-hundred-eighty-eight (188) refurbishment projects formed a database for this paper. This paper divided uncertainties to three (3) groups. The group items named as Documentation Factor, Site Factor, and Human Factor.

Keywords— Building Refurbishment Project, Uncertainty, Exploratory Factor Analysis (EFA), Existing Building, Documentation Factor, Site Factor, Human Factor

1 Introduction

Building refurbishment is defined as works that involve renovation, upgrading, retrofit, improvement, and repair of existing and occupied buildings [1], [2]. In recent years, there has been an increasing interest in building refurbishment works due to the change in economic conditions and the emphasis on sustainable development [3]. The benefit of refurbishing existing buildings has recently been brought into focus the concern on environmental impacts of buildings [4]. Investment for new construction projects would likely to decrease but the need for building refurbishment works would likely to increase. This is because of the demand for building refurbishment projects comes from various sources such as obsolescence and deterioration. Buildings owners still need to refurbish their property, despite the economic slowdown [5]. In Malaysia, building refurbishment is fast becoming an important sector in the construction industry. The key factors that contribute to the growth of building refurbishment works in Malaysia are; economic recession, building deterioration, obsolescence and growing demand for green buildings [6]. Besides, the demand for building refurbishment works are likely to increase in the next decade due to the regeneration of inner cities and town, and growing concern about building on greenfield sites. Hence, building refurbishment of existing buildings plays a significant role in achieving a sustainable environment in the urban area [7].

In Malaysia, the building refurbishment sector contributed to 17 percent in 2005 and increased to 24 percent in 2014 [8]. This shows the increasing importance of building refurbishment sector in Malaysia.

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Figure 1.1 shows the two principal components of all the construction works output in Malaysia been growing. From the Figure 1.1, it is apparent that building refurbishment works have been growing from 2011 to 2014. However, the output dropped in 2013 due to the economic downturn of the construction industry.

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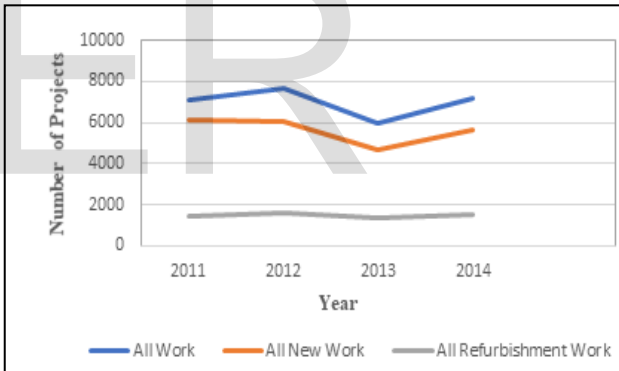

Fig. 1. Output in Malaysian Construction Source: (CIDB, 2016)

It should be highlighted that many building refurbishment projects have not been reported during these years, especially those small works carried out by residential building owners. Therefore, the value of building refurbishment projects could be higher. Due to the increasing importance of refurbishment sector regarding value and sustainability of the construction industry, more research needs to be done to resolve some of the pertinent issues of building refurbishment projects. The main issue is the high degree of uncertainty of building refurbishment projects [9], [10], [11, p. 18].

Galbraith, 1977 [12] defined the uncertainty, as a gap between the information available and information required for the decision-making. Developing a framework for managing the uncertainty would help to improve the performance of the construction industry and the country. Despite the growing

importance of refurbishment sector, research in refurbishment is still lacking. This should not be the case because refurbishment projects are known to be more uncertain than new build projects and need to be managed differently [10], [13], [14], [15]. Even though there is numerous research on the uncertainty of construction projects, but most of them are focussed on new projects [16], [17], [18], [19], [20]. Due to the lack of research and publications in building refurbishment projects, improving the skill of managers and practitioners and gaining knowledge in building refurbishment is consequently tricky, unless they have the chance to be involved in building refurbishment projects. This paper aims to categories the factors that contribute to the uncertainty in building refurbishment projects.

2 Literature Review

The main reason for refurbishment project's uncertainty is that every project is a prototype because a model cannot be built to see if it works as anticipated. It is difficult to decide how best to build it, to determine whether it can be built economically, and to resolve problems before construction. The procedural uncertainty comes from the inability of the organizations to interpret and recognize the relevant information, even when available. Uncertainties can also happen due to changes, which is unavoidable in construction and building refurbishment projects [21]. Uncertainties also arise when the details and information of project/site are unpredictable, complex, unclear, inconsistent or unavailable [22]. Literature review reveals several factors used for the measuring uncertainty in construction and refurbishment projects. The most frequently measured factors that contribute to the uncertainty of building refurbishment projects are shown in Table 1. The next part presents and discusses methodology adopted for this paper.

TABLE 1
THE FACTORS THAT CONTRIBUTE TO THE UNCERTAINTY IN BUILDING REFURBISHMENT PROJECTS

NO	Factors That Contribute to Uncertainty	Authors
1	Lack of Archive Document of the Existing Building.	[16], [26], [27], [28], [29],
2	Incomplete Services Information of the Existing Building	[16], [30], [26], [31],
3	Unavailability of Non-Destructive Testing Results	[26], [27], [32], [33], [10]
4	Unavailability of Building Inspection Results	[34], [35], [36], [37]
5	Unavailability of Building Site Survey Results	[16][6], [38], [39], [40]
6	Lack of The Design Information During the Design Stage	[6], [41], [11],[38], [42],
7	Lack of The Design Information During the Constructing Stage	[43], [11], [28], [44], [45],
8	Difficulty of The Access to The Site	[46], [47], [34], [48], [10],
9	Inadequate the Space Needed for Working on the Site	[49], [46], [47], [48], [50],
10	Inadequate the Space Needed for Storage Material	[47], [46], [34], [48], [50],
11	Unforeseen Site Conditions	[16], [51], [52], [53], [45]
12	Unclear the Scope of Work	[32], [39], [11], [40], [1],
13	Unclear the Contractual Obligations	[54], [55], [11], [56], [57]
14	Difficulty to Matching New Materials with The Existing Materials	[58], [11], [59] [60] [33]
15	Difficulty to Obtaining the Construction Materials	[61], [43], [58], [6], [11],
16	Lack of Client's Skill and Knowledge in The Building refurbishment project	[62], [63], [11], [64], [65]
17	Uncertain the Client's Needs	[66], [67], [68], [36]
18	Design the Changes Made by The Client	[16], [21], [11], [42]

3 Methodologies

This research designed with the quantitative approach, which implements a Web-based questionnaire survey for data collection method. Questionnaires were short and simple and did not take much time for respondents to answer to get a high response rate. The respondents in this research were designers and architects who were directly involved in refurbishment projects with a contract value of RM500,000. A set of questionnaires sent to 1050 construction firms and 733 architectural firms. 188 questionnaires were completed and returned.

The Exploratory Factor Analysis (EFA) was conducted to validate and refine the data collected. The Statistical Package for Social Science (SPSS) was used in both descriptive and inferential statistics. Factor Analysis (EFA) is a statistical technique employed to classify a relatively small number of factors that can be used to represent the relationship among sets of many interrelated variables [23]. Moreover, FA takes a broad set of variables and looks for a way the data may be 'reduced' or summarised using a smaller set of factors or components. It is indicated in SPSS as a 'data reduction' technique. One of the main approaches to factor analysis is Exploratory Factor Analysis (EFA) [24]. EFA typically used to regroup variables into a limited set of clusters based on shared variance. Hence, EFA helps to isolate constructs and concepts [25].

4 Findings and Discussion

In this paper to verify that data set is suitable for Exploratory Factor Analysis (EFA), Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) and Bartlett's Test of Sphericity (BTS) were employed. The value of KMO is >0.6, and the significant value of BTS is <0.05 [24]. Table 2 shows that the amount of KMO was more significant than 0.6 that is an acceptable KMO value. Thus, Bartlett's Test of Sphericity (BTS) is significant, so the data meets this assumption, and the values are appropriate for EFA.

Table 3 shows the EFA analysis for Uncertainty in Building Refurbishment Projects by using the Principal Components (CP) extraction method, and Varimax Rotation method. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy indicated that the strength of the relationships among variables was high (KMO =0.899). Thus, it was acceptable to proceed with the analysis, where the acceptable value of KMO is >0.6 [24]. Bartlett's Test of Sphericity (BTS) for the uncertainty items in building refurbishment projects was significance where the significant value of BTS is <0.05 (X2 (153) = 2490.606, P<.001).

TABLE 2
INITIAL ASSUMPTIONS OF EFA

	KMO	BTS		
		Approx. Chi-Square	Df	Sig
UNC	0.899	2490.606	153	0.000

Note: KMO = Kaiser-Meyer-Olkin; BTS = Bartlett's Test of Sphericity; UNC= Uncertainty in Refurbishment Projects

Therefore, it can be concluded that the values are appropriate for Exploratory Factor Analysis (EFA). Moreover, Table 3 shows that three variables should be extracted from building refurbishment projects uncertainty since three Eigenvalues were exceeded (Eigenvalue = 9.105, 1.160, and 1.207). These extracted variables are predicted having a 66.18% of the Variance Explained to explain the Building Refurbishment Projects Uncertainty variables. The group items were name as Documentation Factor (Cronbach's alpha = 0.901), Site Factors (Cronbach's alpha = 0.858), and Human Factors (Cronbach's alpha = 0.881). It shows that all grouped items having good reliability values since all Cronbach's alpha values were above 0.80 where the acceptable value is >0.70 [24].

Based on Exploratory Factor Analysis (EFA), it could be concluded three main factors contribute to the uncertainty of refurbishment projects (i.e. informational factors, site factor and human factor). Informational factors include lack of archive document and incomplete services information of the existing building, unavailability of non-destructive testing, building inspection results, and building site survey results, lack of design information during the design and the constructing stage. Site factors involve difficulty of access to the site, inadequate space needed for working and storage material at the site, unforeseen site condition, and unclear scope of work. Furthermore, human factors include design changes made by the client, lack of the client's skill and knowledge, uncertain client's needs, unclear contractual obligations were clear, difficulty to match new materials with the existing materials and obtaining construction materials.

TABLE 3
SUMMARY RESULTS OF EFA ANALYSIS FOR BUILDING REFURBISHMENT UNCERTAINTIES

	Factors and Items Included	Factor Loading	Communalities
Documentation Factor (DF)	Inspection Results	.789	.745
	Site Survey Results	.789	.776
	Services Information	.760	.597
	Archive Document	.721	.717
	Design Information During the Design Stage	.687	.753
	Design Information During the Constructing Stage	.641	.710
	NDT Results	.555	.563
	Eigenvalue = 9.105, % Variance Explained = 24.98%, Cronbach's alpha = .901		
Site Factors(SF)	Space for Material	.798	.674
	The Unforeseen Site Conditions	.774	.717
	Space for Work	.721	.653
	The Access to The Site	.635	.660
	Eigenvalue = 1.160, % Variance Explained = 22.24%, Cronbach's alpha = .858		
Human Factors (HF)	The Design Changes Made by The Client	.814	.793
	The Obtaining Materials	.762	.669
	Client's Needs	.640	.710
	Scope of Work	.590	.597
	The Client's Skill and Knowledge	.559	.753
	Contractual Obligations	.556	.611
	The Matching Materials	.552	.711
	Eigenvalue = 1.207, % Variance Explained = 18.95%, Cronbach's alpha = .881		

5 CONCLUSIONS

The review presented in this paper showed that refurbishment projects are tending to be complicated and uncertain. The finding of this paper shows the uncertainty factors that contribute to the uncertainty can be in 3 categorized groups. The groups are namely informational factor, site factor and human factor. The findings presented in this paper would help the refurbishment managers to reduce or identify factors that contribute to uncertainties in building refurbishment projects. Thereupon, the performance of project could be increased by reducing Uncertainty.

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