The Effect of Structural Content
On The Performance of Refurbishment Projects

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Refurbishment projects contribute to increase the number of building physical improvements, extensions and extensive repair works. However, refurbishment projects are more difficult to manage compared to new-built projects. This is due to the uncertainty factors inherent in projects. The uncertainty of refurbishment project is reflected in the difficulty of obtaining structural design information during the design process. As a result, most of the refurbishment projects end up with poor project performance. Therefore, the main objectives of this paper are to present how the structural content in a refurbishment project could affect the overall performance of refurbishment projects. This paper employed the triangulation technique with a combination of quantitative and qualitative approaches. The study started with literature review followed by semi-structured interviews with 21 professional structural engineers and a final questionnaire survey. The final questionnaires were distributed to 100 refurbishment projects. This study concludes that the performance of refurbishment projects suffered from the uncertainty where the structural content affected the project performance.

Introduction

"Refurbishment is defined as a work on existing building that comprises rehabilitation, modernisation, renovations, improvements, adaptation, additions, repairs, renewal and retrofitting; carried out on existing buildings but excludes routine maintenance and cleaning work (Young et al., 1996). The refurbishment sector has grown rapidly and has become an important economic driver in some developed countries such as United Kingdom, Europe and the United States. However, there is no comprehensive and accurate data on the value of refurbishment work in Malaysia. The data compiled by the Malaysian Construction Industry Development Board (CIDB) shows that repair and maintenance, which is normally used by practitioners as a guide on the value of refurbishment work, accounted for 2 percent of total construction output in the year 2002. It rose to approximately 20 percent of total construction output in year 2010. The data however, does not include illegal renovation works carried out by house owners or by unregistered contractors. Therefore, the actual value of refurbishment works is probably larger.

Refurbishment works is further compounded by the project uncertainty factor. Researchers such as Hashim (2004) have provided evidence of the uncertainty of refurbishment projects. The problem mainly derives from the lack of information available to perform a task, especially during the initial stage of the design process (Stacey et al., 2000). Many construction management writers agree that uncertainty in refurbishment projects makes them more difficult to manage (Ali, 2008).

Refurbishment projects became even more uncertain when they involve structural modifications, which are sensitive, dangerous and difficult in operations. Extra precautions need to be taken into account when dealing with structural modifications (Daoud, 1997). Temporary supports, which are normally needed for demolition and alteration of building structure, are more widely used in this type of refurbishment work compared with new-build projects (Friedman and Oppenheimer, 1998). Moreover, according to Egbu (1997), a refurbishment project is normally dangerous when it involves demolition work. In this case, the designers are required to have extra knowledge of the building structure in order to produce a
design for temporary supports such as scaffolding and shoring. It is the responsibility of the designers to ensure that the temporary supports used can withstand the necessary loads and that the site conditions are safe to deliver what they have designed during the commencement of alteration works. Hence, the temporary support needs to be designed by a certified engineer.

As the refurbishment sector grows in importance, the difficulty of managing performance provides an impetus for this study.

The Structural Work in Refurbishment Work

Ali (2008) pointed out the important of structural item in refurbishment projects. His study revealed that almost two-thirds of the buildings renovated for the same class usage required changes to the structural system and almost 90 percent of the buildings renovated for new class usage required structural alterations. The statement shows that the majority of the refurbished building involved structure alterations as part of their scope of work.

In line with this argument, Friedman and Oppenheimer (1998) highlighted that in refurbishment projects, the difficulty of particular structural change can greatly influence the architectural design part. He added that the amount of design work required in refurbishment projects influenced by the scope of alteration of an existing building and the state of existing building structural elements. The design work could be more difficult if the scope of work involves demolition and stabilising the existing structure. In the unique project like that, it usually involves procedures and many steps of investigation such as probing, testing and shoring that resultant to the destruction of architectural finishes. The important sources of information concerning to the structural for refurbishment design were establishing history of the building, its structural system and cause of any known damage. In absence of this information, it is almost certain to cause the final design document be incomplete, the cause of delays and extra cost to the refurbishment projects. Ali (2008) maintained the importance of having site investigation with the use of probing and testing techniques to reveal the required information concerning the structure of a building due to the uncertainty of structural information.

In addition, Friedman and Oppenheimer emphasised that during the handling of this situation, the engineer needs to be familiar with the load travels in an existing building and guide the designer architect who needs to be familiar with the concept of building structure and to participate in structural discussions. The coordination is important to avoid any important missing information that could cause harm to the building. Daoud (1997) maintained that the role played by the designer is important as it has serious impact to the building systems. He added that the design and installation of additional supports is sensitive and difficult, and it needs to be approached cautiously by the designer.

The nature of refurbishment project requires a lot of information prior to planning and coordination in contrast with new-build projects. The constraint imposed by the existing structures invariably gives rise to all sorts of problems with regards to installation work. Ali (2008) highlighted that refurbishment work often involved alteration of the existing building structure that needs shoring and temporary supports. It could be argued that the respective project manager and design team need to work closely to ensure a safer engineering design is executed. Nonetheless, the involvement of the client is important to ensure the responsibilities are clearly defined and accepted during the early stage of the project.

Similarly, Clancy (1995) maintained that refurbishment and repair projects are found to be more complicated compared to new-build projects. This is due to the need to consider more unknowns and the need for more predictions to be done for this type of projects. Clancy (1995) argued that the structural appraisal exercise require close coordination where the engineer should liaise frequently and constantly with the other design team members.

The review of literature shows the important of structural aspects in refurbishment projects. It is argued that the greater content of structural work could affect the refurbishment project performance.

Research Methodology

This study was designed with a triangulation technique, which combined quantitative and qualitative approaches. Semi-structured interviews were used for the qualitative part while for the quantitative part, questionnaires surveys were used for data collection. The respondents in this study were structural engineers who have experience in refurbishment of building structures. A set of questionnaire was sent to the final list of 100 respondents. After filtration was made from 92 replied questionnaires, 81 questionnaires were found to be useful to form a database for analysis. The replied questionnaires represent 81 different refurbishment projects with a minimum contract value of RM500,000.00 (USD150,000.00). As for the qualitative part, the data was analysed together with the discussion in descriptive analysis to complement the answers. This is to make the discussion more realistic.

...it is necessary for designers or surveyors to use special techniques such as destructive and non-destructive testing to obtain more accurate design information.
Table 1: Percentage of Structural Work

<table>
<thead>
<tr>
<th>% of Structural Work to Contract Value</th>
<th>Percentage (N=81)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0% - 10%</td>
<td>28.6</td>
</tr>
<tr>
<td>11% -20%</td>
<td>37.1</td>
</tr>
<tr>
<td>21% - 30%</td>
<td>11.4</td>
</tr>
<tr>
<td>31% -40%</td>
<td>10.0</td>
</tr>
<tr>
<td>More than 40%</td>
<td>12.9</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 2: The Percentage of Structural Work to Contract Value

<table>
<thead>
<tr>
<th>% of Structural Work</th>
<th>Percentage (N=62)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 10%</td>
<td>40.3</td>
</tr>
<tr>
<td>11% - 15%</td>
<td>21.3</td>
</tr>
<tr>
<td>16% - 20%</td>
<td>17.7</td>
</tr>
<tr>
<td>21% - 30%</td>
<td>4.8</td>
</tr>
<tr>
<td>More than 30%</td>
<td>16.1</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Source: Rahmat (1997)

Table 3: The Correlation Matrix between Structural Content and Design Performance

<table>
<thead>
<tr>
<th>Project variables</th>
<th>Completeness of design before work started</th>
<th>Changes of design during the construction stage</th>
<th>provisional sum to contract value</th>
<th>Time variance</th>
<th>Cost variance</th>
<th>Compatible with existing site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural content</td>
<td>-.049</td>
<td>-.117</td>
<td>-.319**</td>
<td>-.148</td>
<td>-.067</td>
<td>-.069</td>
</tr>
</tbody>
</table>

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

Result and Discussion

Table 1 shows the percentage of structural works in refurbishment projects. The results indicate that about 35 percent of the refurbishment projects have structural work where the content is more than 20 percent of the contract value.

The content of structural work is lower, indicating it is less important in refurbishment projects. Rahmat’s (1997) result in Table 2 indicates that the percentage of structural work for refurbishment projects are lower in the UK; that is only about 20 percent of refurbishment projects involve a structural content of more than 20 percent.

Again, the percentage is higher for refurbishment projects in the Malaysian study. A comparison of results indicates that refurbishment projects in Malaysia are more uncertain, concerning the content of structural works. A higher content of structural works signify greater complexity and uncertainty in refurbishment projects. It could be even more difficult if the scope of work involves demolition and stabilising of the existing structure, which requires extensive works in design and construction to be carried out. There could be much unknown information associated with structural elements. The result implies that designers need to use design information that is as accurate as possible when dealing with structural alteration, and one of the ways is by conducting appropriate testing of the structural elements. This supports the view of Friedman and Oppenheimer (1998) who suggested the use of testing when dealing with structural parts of a building. Besides testing, shoring and demolition works, structural work also involves a large quantity of dust and debris that cause problems for the designers to carry out investigation on the buildings. The occupants could also find it difficult to stay in the building during a period of the design process. Three principal structural engineers in Kuala Lumpur and Johor Bahru mentioned during the semi-structured interviews that due to occupancy problems, some of the owners did not allow the designers to carry out massive testing during the schematic design stage. As a result, many assumptions had to be made by the designers to cover the risk of lack of access to the refurbishment site to obtain information. However, the interview revealed that in many cases where the content of structural works in the refurbishment projects was higher, the likelihood of people staying in the building during the schematic design and construction stage is very slim.

Table 3 shows results for associative test between structural content in
refurbishment works with project performance. A significant correlation between the structural content and the provisional sum to the contract value was detected. Structural works involve complex activities such as temporary supports, wall hacking and demolition work. This requires extra design work. Uncertainty about structural parts includes aspects of structural integrity such as steel bar size and concrete strength.

It is difficult to ensure the structural integrity of an existing building when the higher structural content is involved. The amount of material and scope of work involved in the alteration of a building’s structure is difficult to estimate. Therefore, the provisional sum can be used to substantiate the uncertainty of structural works. The result supports statements by Daoud (1997) who said that structural content affects the design performance in refurbishment projects.

The result implies that it is necessary for designers or surveyors to use special techniques such as destructive and non-destructive testing to obtain more accurate design information. The uncertainty in information such as concrete strength could be revealed by applying a crushing test and the size and routing of steel bars could be confirmed by using an appropriate tool, i.e. a concrete hammer test meter. This would help the designers to make accurate decisions pertaining to this issue. Second, it is important to involve the C&S engineer during design process when the structural content in refurbishment projects is high. Structural alteration in refurbishment projects is complex and dangerous work. The C&S engineer is more knowledgeable about building structure and is able to decide the appropriate testing that needs to be used in order to obtain accurate design information.

**Conclusion**

In conclusion, almost one fourth of the refurbishment projects, the content of structural work were more than 30 percent. Structural scope in refurbishment project is a complex task, which involved temporary supports and destructive testing to obtain accurate design information. However, not many designers carry out detail investigation during the schematic design stage because occupancy and limited designs period. The associative test indicated significance correlation between structural content on amount of provisional sum to contract value. This indicated that performance of refurbishment suffered from greater content of structural scope of work.

**Reference**


