Abstract — Nowadays projects are more complicated involving huge contract values, participants from multi-discipline, more specialized works, tighter schedule, stringent quality standards, etc. Ultimately, cost and time are the two key parameters that plays significant role in a project success. The study focuses on multiple Design and Build (D&B) project which has complicated risk and is governed by fixed contract sum (Lump sum). As such, there is no such specific study to address this problem faced in Malaysia construction industry. Qualitative research was applied at three stages of projects for time delay and two aspects for cost overrun. This paper presents one aspect each for time delay and cost overrun. This benefits the industry in managing projects proactively with appropriate risk response plan to the respective region.

Keywords — Cost overrun, D&B projects, qualitative risk analysis, time delay.

I. INTRODUCTION

The construction industry plays an important role in achieving fully developed nation status [1]. Completing projects on time are an indicator of efficient construction industry [2]. In fact, a project is considered ‘successful’ if it is completed on time, within budget and to the specified quality [3]. Normally, when the projects are delayed, they are either extended or accelerated and therefore, incur additional cost [4]. To the dislike of owners, contractors and consultants many projects experience extensive delays and thereby exceed initial time and cost estimates [5]. The construction process is subject to many variables and unpredictable factors [6]. Delivering a project on time does not occur by hoping that the required completion date will be met [7]. To plan and manage a successful project, the three parameters of time, cost and quality should be considered. The clients in the construction industry are primarily concerned with quality, time and cost. But majority of construction projects are procured on the basis of the constraints time and cost [8]. Cost escalation and time overruns are typically associated with poor management practices [9].

Any delay in delivery is not going to facilitate the full purpose of the projects’ implementation under development plan [10]. Among all procurement methods the Design and Build (D&B) projects is significant in implementing development projects in Malaysia and other countries [11].

Only specialised development projects are procured in D&B mode in which the D&B contractor has the combined responsibility of both design and construct component defined in the form of contract. D&B projects has fixed contract sum and contract period. Variation orders are not considered for contract procured in this method. These new procurement schemes require us to be more careful about risks, because they increase the complexity of projects [12]. Majority of D&B projects encounter events and/or changes that affect the original plan of executing a project [13]. A multi-project setting is one in which several projects are being performed at the same time in parallel with differed start and completion dates. This multi-setting has the benefit of sharing the human resources and equipments from a common resource pool and further enabling to use and share certain expertise in an efficient manner with less idle time. Time and cost related case study, discussion of analysis and the conclusions are reported in the following sections.

II. MULTIPLE D&B PROJECTS CASE STUDY

The development projects procured by D&B Method consisted of Five contract packages comprising 45 bridges located in 12 districts in the state having 76,115 Sq. Km coverage area (Wikipedia, 2007) and two ongoing contract packages comprising of 12 bridges in three districts. The bridges were constructed in almost all the districts of Sabah (Fig.1) namely: (1) Tawau, (2) Kunak, (3) Lahad Datu, (4) Ranau, (5) Kudat, (6) Kota Belud, (7) Sandakan, (8) Pitas, (9) Kota Marudu, (10) Keningau, (11) Kota Kinabalu, (12) Papar, (13) Tambunan, (14) Weston and (15) Beaufort.
The distance between the districts was analyzed (Fig. 2). The logistic plan was complex due to the distances between districts, ranging from minimum 40 Km to maximum 682 Km with 65 combination routes in-between districts.

III. RESEARCH METHODOLOGY

The case study is the widely practiced approach by all researchers for qualitative research involving non statistical procedures. Qualitative research is, broadly defined as "any kind of research that produces findings not arrived at by means of statistical procedures or other means of quantification" [14]. Qualitative analysis involves analysis of data such as words (e.g., from interviews), pictures (e.g., video), or objects (e.g., an artefact).

Case study research is highly relevant to an industry that is project driven. However, application of case study approach within the construction management research community is seemingly at a relatively low level [15]. A case study is an exploratory research technique that investigates one or a few situations that are similar to the research problem. It consists of detailed investigations, often with data collected over a period either on completed projects or ongoing projects, within the context.

In this research, case study was conducted during execution stage to find the delaying activities and activities at pre-design stage through element optimisation that burst the budget ceiling in multiple D&B Projects.

IV. IDENTIFY CAUSES OF TIME DELAY THROUGH PROJECT CASE STUDY

The projects in the case study are studied to identify the time delay factors for verification with the delay factors identified in quantitative analysis. The research work presented identifies the causes of delay in projects experienced in practical field. This research study was divided into three sections namely: Management at pre-design stage, Management during construction phase and Interview experts for the reasons of delays as shown in figure 3. Management at pre-design stage using optimization techniques is described in the following sections.

V. MANAGEMENT AT PRE-DESIGN STAGE

The lack of knowledge of design professionals to consider how a builder will implement the design can result in scheduling problems, delays, and complicated disputes during the construction process. Hence the design stage plays a very important role to minimise the problem at initial stage of the project. This proactive approach at early stages of design phases will eliminate the complex problem and helps to complete the project on time. A D&B contractor has the full
authority to design and propose options that suit client / owner’s need. To utilise this opportunity in D&B contracts the right step has to be followed at right time.

The construction process and success in management of multiple bridge projects directly relies on the selection and optimization of their elements / components at pre design stage. A systematic optimization process requires to be adopted during the conceptual design stage to overcome the resource constraints during the construction phase. The knowledge of construction experience is also utilized during the element optimization process as presented in the following sections that covers both completed and ongoing projects.

VI. ELEMENT OPTIMISATION TECHNIQUE

Bridge structures are designed with high quality and safety standards with stringent execution works and inspections. Construction problems encountered during execution are complex and costly. Many construction problems can be avoided with proper attention and consideration of the construction process during the design phase [16]. Factors of simplicity, flexibility, sequencing, substitutions and labour skill / availability should be the part of design. The appropriate use of standardization can have several benefits [16]. These include increased productivity and quality from the realization of repetitive field operations, reduction in design time, savings from volume discounts in purchasing, and simplified materials management. This method of standardizing bridge elements may be suitable for selective projects of same nature but are less significant and more complex in the construction of multiple bridge projects situated at different geographical conditions.

Bridge element ratio is the percentage contribution of each element / component to form a bridge. Each element may have different percentage based on their weightage / implication in constructing that bridge. The weightages were computed using a common and consistent factor. In this case study the value parameter is used to calculate the element weightage (Equation 1) which is common and consistent for all the bridges in the multiple settings.

The element ratio comparison and analysis is made using the following steps.

• Review all the five projects and compile the summary.
• Prepare the element ratio table and Pie chart for each bridge of all the projects and analyse the ratio of their impact on the individual bridges.
• Compress and derive a single and common average ratio table and pie chart showing the overall impact of each element for the entire multiple projects.
• Identify the critical and crucial elements that need attention.
• Discussion on the element of major contributions i.e. analyse the element with maximum element ratio. The analysis was carried out in three steps as mentioned below:

Step 1 - Graphical representation of element ratio in each bridge to reveal the individual contribution of the elements in each project.

Step 2 – Determine the average presence of elements in each project.

Step 3 – Overall average ratio of the elements in a multi-project setup.

The element optimisation analysis is carried out for the 5 completed projects from sub package 1 to sub package 5. Following it, the current ongoing projects namely sub package 6 & sub package 8 are analysed.

Element Weightage (%) = \[
\frac{Value\ of\ the\ component}{Total\ value\ of\ the\ bridge} \times 100
\]

VII. DISCUSSION OF RESULTS

The multiple projects procured under D&B method with total 57 bridges in 7 different projects located in 15 districts, are analyzed qualitatively. The distance chart is prepared for the purpose of logistics planning showing the minimum distance between sites ranging from minimum 40 Km to 682 Km. The completed projects had a life cycle from July 2003 to June 2007, but due to EOT of 6 months for sub package 4 and 5 the projects were delayed until December 2007. Sub package 6 and Sub package 8 has construction period from March 2009 to February 2011 but Sub package 6 projects were delayed for 1 year with 2 EOTs and were scheduled to complete in December 2011.

The cost overruns factors that affected the projects namely the EOTs and Price fluctuation of raw materials like Diesel and Steel reinforcement were calculated. Thus the factor ‘fluctuation of material price’ has lead to a large cost overrun to contractor.

A. Time delay - results

The research study was conducted in three sections which are: Management at pre-design stage, Management during construction phase and Interview experts. This section presents only the results analysis at pre-design stage.

B. Management at predesign stage – Optimisation technique

The elements having high ratios (or high presence) are high impact causers. From the completed multiple project the overall influence of the elements “Piling” and “Beams” in bridge completion are critical. Even though the quantum of these elements are less compared to other elements of the bridges, the ratio of their influence in the construction is more due to their level of special technology, specialist availability, method of construction, risk involved and limited usage / availability of resources for production. The individual component ratios are combined and overall average ratio is determined. This helps to identify the weightage of the critical components in percentage as Piling and beams have the maximum presence of 25.87% and 38.46% respectively. For those two items, presence is more with less volume of work because of its speciality and use of uncommon materials.

Overall average ratio of elements in Multi-project setup:
The Table I and Figure 4 show the overall influence of these elements in the completed multiple projects. It is observed that the critical elements that need more attention are “the foundation (piling) works” and “Superstructure Beam works”.

<table>
<thead>
<tr>
<th>Description</th>
<th>SP 1</th>
<th>SP 2</th>
<th>SP 3</th>
<th>SP 4</th>
<th>SP 5</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foundation (Piling)</td>
<td>22.64%</td>
<td>29.41%</td>
<td>22.44%</td>
<td>33.82%</td>
<td>21.05%</td>
<td>25.87%</td>
</tr>
<tr>
<td>Abutment and Wing</td>
<td>16.33%</td>
<td>12.68%</td>
<td>12.13%</td>
<td>16.24%</td>
<td>8.67%</td>
<td>13.21%</td>
</tr>
<tr>
<td>Wall Piers, Crossheads and</td>
<td>1.57%</td>
<td>8.79%</td>
<td>13.56%</td>
<td>1.42%</td>
<td>1.78%</td>
<td>5.43%</td>
</tr>
<tr>
<td>Pilecaps</td>
<td>39.88%</td>
<td>32.50%</td>
<td>31.73%</td>
<td>31.36%</td>
<td>56.84%</td>
<td>38.46%</td>
</tr>
<tr>
<td>Prestressed Beam &amp; Prestressed</td>
<td>12.11%</td>
<td>1.63%</td>
<td>2.64%</td>
<td>12.15%</td>
<td>2.16%</td>
<td>2.32%</td>
</tr>
<tr>
<td>Ancillary</td>
<td>4.70%</td>
<td>11.88%</td>
<td>13.84%</td>
<td>2.27%</td>
<td>7.77%</td>
<td>11.91%</td>
</tr>
<tr>
<td>Bridge Deck and Run-On-Slab</td>
<td>2.77%</td>
<td>3.11%</td>
<td>3.66%</td>
<td>2.73%</td>
<td>1.72%</td>
<td>2.80%</td>
</tr>
<tr>
<td>Diaphragms</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

Hence extra care was given while deciding the design for these critical elements. The repeated occurrence of the same element will create heavy dependence in scheduling and result in complexity. Therefore few design optimizations were adopted to reduce the complexity and to ease implementation in the field. The techniques adopted in element optimization for the multiple bridge construction were successful and resulted in the projects being executed in time and within budget.

In sub package 6, the percentage of steel structure is more and so their impact on delay is also more. The project was delayed due to Land Acquisition and started after 6 months. The work was accelerated for all the components of the work, but the progress of steel component work couldn’t be on fast track due to their high ratio, representing the complexity of the activity. So the delay cannot be mitigated. Hence the project was under second EOT for another 6 months. The critical components namely ‘Piling works’ is around 15% and ‘steel arch and erection’ is more than 60%. Therefore, the high ratio elements need to be handled carefully with pre planning due to the specialised and complex nature of the work.

Sub package 8 was reported to be on time for completion with no time delay but facing cost overrun problems due to price fluctuation of raw materials. The element ratio result shows an almost even distribution for all the bridge components of around 10% to 18% but piling is high at 29%. This could be one of the reasons for completing the project on time.

In spite of recognising the steel girder manufacturing as an important component having high impact to the project time frame, there are no records maintained to monitor the works at steel fabrication yard. It is found that some of the bridges are waiting for the beam launching after completing the sub structures like abutment and pier. They are delayed due to the late delivery of steel girder components from the fabrication yard (off site).

C. Cost overrun - results

The price fluctuation of diesel has shown a cost increase with the lowest level of 6% to a maximum level of 67% from the basic price. This cost overrun amount is almost equivalent to 30% of the purchase price of diesel. Price fluctuation of steel rebar has shown a cost increase with the lowest level of 7% to a maximum level of 27% from the basic price. The overall additional cost incurred by the contractor are due to price fluctuation of raw material and fuel.

D. Time delay and Cost overrun - discussions

Firstly, under Management at pre-design stage, element optimisation technique was applied to the completed project. The critical components in percentage were Piling and beams which have the maximum presence of 25.87% and 38.46% respectively. The ongoing projects Sub package 6 shows that the critical components are ‘Piling works’ whose presence is around 15% and ‘steel arch and erection’ whose presence is more than 60%. Whereas for sub package 8, the element ratio result shows an almost even distribution for all bridge components of around 10% to 18% but piling is high at 29%. This could be one of the reasons for completing the project on time. Through this research study it is suggested to adopt few design optimizations and reduce the complexity and to ease implementation in the field.

Cost overrun due to the ‘price fluctuation of raw material’ factor is calculated and it shows that the cost increase for diesel fuel varied at lowest level of 6% to a maximum level of 67% from the basic price. Price fluctuation of steel rebar has shown a cost increase ranging at the lowest level of 7% to a maximum level of 67% from the basic price.

VIII. CONCLUSIONS

1. The case study of completed projects sub packages 1 to 5
showed that two projects sub package 4 & 5 faced EOT for six months due to external factors. For the ongoing projects, the Sub package 6 was delayed for one year due to external factor and sub package 8 was completed on time.

2. The cost overruns to the ongoing projects are due to the EOTs and price fluctuation of raw materials. Combining the diesel and steel rebar cost increases, the cost overrun was calculated.

3. Element optimisation technique was applied to completed projects and it identified the critical components in percentage as Piling and beams. They have the maximum presence of 25.87% and 38.46% respectively. The management at predesign stage suggests few design optimisations that will reduce the complexity and ease implementation at field.

4. Cost overrun due to the ‘price fluctuation of raw material’ factor is calculated and it proves that cost increase for diesel fuel ranged from the lowest level of 6% to a maximum level of 67% from the basic price. Thus the Contractor incurred additional cost for fuel.

5. Price fluctuation of steel rebar has shown a cost increase ranged from the lowest level of 7% to a maximum level of 67% from the basic price. Thus the Contractor incurred additional cost for steel rebar.

REFERENCES


