Material and equipment procurement delays in highway projects in Nepal

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Abstract

Delay in the delivery of materials and equipment to construction sites is often thought of as a contributory cause of cost overruns in construction projects in developing countries. A cursory examination of the environment in which projects are executed in developing countries appears to support this thinking. However, there does not seem to have been much research work conducted that investigates whether this is actually the case and also assesses the causes of these delays and magnitude of their impacts on project costs. This research was aimed at firstly ascertaining the occurrence of material and equipment procurement delays in highway projects in Nepal. An assessment of the causes of the delays and the magnitude of their impact on project costs was also made. The survey method was used in conducting this research involving 22 highway projects. The main causes of material and equipment procurement delay were found to be (in rank order) organizational weaknesses, suppliers’ defaults, governmental regulations and transportation delays. However, the actual impact of these delays on project costs was found to be on average, only about 0.5% of the total budgeted cost of the projects. Among materials, delays in the supply of aggregates were found to occur most frequently while delays associated with pavers occurred most frequently among equipment.

1. Introduction

The primary goal of any construction project is the transformation of the expressed desire of the owner into tangible artefacts that satisfies that desire. For such transformations to be cost-effective, human and material resources have to be garnered and managed with the highest degrees of efficiency achievable. Since any artefact or structure is much more than the sum of the materials that comprise the structure, it stands to reason, that at the very least, a prerequisite for cost-effective construction is the availability of materials at the time and location that these materials are required on site. Not any less important are the equipment and manpower required to place these materials in the exact location and sequence that have been prescribed either in the contract documents or dictated by acceptable standard practices in the industry. The term procurement encompasses a wide range of activities that includes purchasing of equipment, materials, labour and services required for construction and implementation of a project [1]. However, this paper uses the term in the limited context of materials and equipment.

2. Motivation for research

The importance of material procurement mainly stems from the fact that the cost of materials constitutes a significant part of project costs [2]. The general notion that is prevalent both in academia and industry is that shortage of materials and equipment required for construction is a grounded reality in construction projects in developing countries. Ofori [3] notes that such
shortages are significant and adversely affect these projects. In fact, even a cursory examination of the environments in which construction projects are executed in developing countries will reinforce Ofori’s observation. Although there have been a number of research efforts that have dwelt on the broad area of construction in developing countries [4–14], to the best of the authors’ knowledge there has not been any prior work done in the area of materials and equipment procurement delays in construction projects. While a comprehensive research effort to ascertain the existence or otherwise of material and equipment shortages on a global scale would be prohibitively expensive and take an inordinate amount of time, Ofori’s work does stimulate interest in a more feasible investigation within the narrow confines of particular sectors of the construction industry in a developing country. The motivation for the investigation stems not only from the fact that many developing countries are now undertaking massive infrastructure development projects [15] but perhaps more importantly the effects of poor performance in these projects can prove to be extremely detrimental to the often fragile economies of these countries

3. Research objectives

To help precisely define the scope and objectives of the research, the authors decided to substitute the phrase “procurement delays” for “shortages” as it was felt that the shortages could in the extreme case be interpreted to mean a shortfall leading to cessation of work on the project. The primary objectives of this research were to: (a) ascertain the occurrence of material and equipment procurement delays in highway projects in Nepal and (b) determine the causes of the delays. The secondary objective was to estimate the impact of the delays on project costs.

4. Research methodology

The survey method was used in this research as it was found to be well suited to the task of collecting the information required. Both qualitative and quantitative information was utilised in the research. Whilst qualitative information was required to establish the incidence of procurement delays and establish the causes of the delays, quantitative information was required to estimate the impact of the delays on project costs. In all, 22 highway projects were surveyed as part of this research.

Primary data was collected with a view to gaining an understanding of the policies and procedures used for materials and equipment procurement. It also helped us obtain general perceptions of the problems in the area of materials and equipment procurement prevalent among the personnel working on the projects and more specifically gain insights into the nature of the manifestations of the causes of procurement delays. The instruments used for collecting primary data were semi-structured interviews. The questions used for the semi-structured interviews are listed in the Appendix.

The paucity of secondary data sources was a major obstacle that would have been difficult to overcome were it not for the fact that one of the authors had intimate knowledge of the workings of the Nepalese construction industry in general and highway projects in particular. As is the case in many developing countries of the world, most field-related operations in the construction industry are carried out without the help of any form of records of these transactions. This fact probably explains in part, the lack of documented research work in the area. The secondary data obtained was painstakingly collected taking advantage of personal contacts and were predominantly from records in the purchasing departments of firms, site offices and on-site stores. This was supplemented by directed questions addressed to these individuals and the answers elicited were used to fill the gaps in the information required for the research. To answer questions the interviewees often had to refer to their record of events and jottings in personal diaries. The secondary data obtained were the planned order date, actual order date, planned delivery date and actual delivery date for the following items that were most commonly used in highway projects in Nepal:

1. Aggregates
2. Cement
3. Bitumen
4. Gravel
5. Earthwork equipment
6. Asphalt mixer
7. Galvanized Iron (G.I.) wire
8. Steel Reinforcement
9. Compaction equipment

In addition, information on acceleration costs, liquidated damages, labour and equipment usage, sanctioned overtime and overtime rates were obtained. Hiring rates for equipment was obtained from the Department of Roads, Ministry of Works and Transport, His Majesty’s Government as amended in January 1998. Costs of liquidated damages were obtained from contract documents of respective projects.

5. Data analysis

The symbols used in this section have the following meanings:
The planned and actual dates of order and delivery were used to obtain an idea of the overall efficiency of procurement operations on the project. In particular the difference between planned date of delivery and actual date of delivery was defined as the procurement delay. If the procurement delay computed is positive, that is, the actual date of delivery is later than the planned date of delivery, it causes all activities dependent on that particular item to be delayed. On the other hand, if the procurement delay is negative, it results in inventory costs. It should be noted that this research focused exclusively on positive procurement delay. In instances where acceleration was ordered, the acceleration cost for any activity \( k \) was calculated using Eq. (1a). The total acceleration cost was calculated using Eq. (1b).

\[
C_a = CD_k \times \left( \sum_i L_i R_i + \sum_j E_j R_j \right) \tag{1a}
\]

\[
C_{tot} = \sum_k (C_a)_k \tag{1b}
\]

In cases where the material and/or equipment resources that were to be supplied to site was delayed, the manpower and equipment already deployed had to remain idle. This induced additional costs to be incurred. In rare instances, part of the deployed manpower was temporarily diverted to other activities. However, accurate details of such redeployment were not available. Since the aim in this research was to obtain an order of magnitude estimate of the cost impact and bearing in mind the fact that such redeployment does not normally result in the realization of the gang's full productive potential in the new activity, it was felt that an assumption of 100% idle time could be made. However, this assumption would necessarily result in the estimate of the costs being an upper bound of the actual costs of acceleration. Idle cost incurred for any activity \( m \) was calculated using Eq. (2a). The total idle cost was calculated using Eq. (2b).

\[
IC = IT_m \times \left( \sum_d L_d R_d + \sum_d E_d R_d \right) \tag{2a}
\]

\[
IC_{tot} = \sum_m (IC)_m \tag{2b}
\]

Liquidated damages were calculated using Eq. (3):

\[
LD = DD \times LDR \tag{3}
\]

In calculating the total cost impact due to procurement delay the following variations of the use of acceleration in the projects studied were considered:

1. No acceleration was carried out
2. Acceleration was carried out
3. Acceleration was carried out and liquidated damages were not incurred
4. Acceleration was carried out but liquidated damages were incurred
5. Partial acceleration—acceleration was carried out for a period that was less than the number of delay days.

The total cost impacts for the projects were calculated using Eq. (4):

\[
C_t = C_{tot} + IC_{tot} + LD \tag{4}
\]

6. Research results

6.1. Occurrence of delays

It was observed that 17 of the 22 (almost 78%) of the projects studied were adversely affected by delays in procurement of aggregates. Thus delays related to procurement of aggregate occurred in most number of projects followed by cement, bitumen, gravel, G.I. wire and steel reinforcement. Compaction equipment affected
only one of the 22 projects studied. Table 1 summarizes the results of the delays experienced on projects due to various materials and equipment considered in the study. Delays due to aggregates occurred most frequently among materials while delays due to paving equipment occurred most frequently among equipment. These findings are summarized in Tables 2 and 3.

6.2. Causes of procurement delay

The following major causes of procurement delay (in rank order in terms of the instances of occurrence) were identified in the study:

1. Organizational weakness
2. Supplier default
3. Governmental regulations
4. Transportation delays

Table 4 summarizes these findings.

Organizational weakness was observed to be the most significant cause of procurement delay. The study revealed that in most projects that experienced procurement delays, high turnover of staff in the firms employed in the projects was observed resulting in the loss of continuity and consequent breakdowns in the command structure and communications. Contractors also tended to stick to a “play safe” policy in a chronically uncertain environment by keeping the minimum number of permanent employees on their payrolls. Another factor was that contractors tended to adopt a myopic policy with regard to hiring of qualified staff. Less qualified staff were hired ostensibly to cut costs. Furthermore, with a view to “getting the most” out of the qualified staff, the firms generally made them responsible for far too many projects running concurrently, thus drastically reducing their effectiveness. An absence of systematic record-keeping pertaining to the execution of the projects, lack of preplanning and a superficial understanding of contract clauses and documents were the other factors that contributed to procurement delays.

The factors contributing to suppliers’ default were identified as monopoly control of the market by some suppliers, work stoppages in factories manufacturing materials, fluctuating demands forcing suppliers to wait for accumulation of orders and difficulties in importing required raw materials from other countries. Governmental regulations causing procurement delays manifested themselves in the form of delays in sanctioning the release of foreign currency required for importing materials and equipment, delays in customs clearance, bureaucratic procedures and red tape.

Transportation delays were found to be mainly caused by landslides and heavy rainfall. Intense cold also hindered movement of materials especially if they were being transported by animals and human porters. On rainy days transportation of materials like cement by animals and porters had to be stopped to ensure that the material remained dry and fit for use.

6.3. Estimate of cost impact of procurement delays

The total cost impact of procurement delays in materials and equipment in the 22 projects considered in this study was found to be 4.4 million Nepal Rupees (approx. 64,000 US Dollars) and is about 0.48% of the total budgeted cost of the projects. The detailed breakdown of the total cost impact of the material and equipment considered in the study is shown in Table 5. It can be observed from the table that aggregates have

Table 1

<table>
<thead>
<tr>
<th>Material/equipment</th>
<th>Projects that experienced procurement delay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of projects</td>
</tr>
<tr>
<td>Aggregates</td>
<td>17</td>
</tr>
<tr>
<td>Gravel</td>
<td>7</td>
</tr>
<tr>
<td>Cement</td>
<td>14</td>
</tr>
<tr>
<td>Bitumen</td>
<td>13</td>
</tr>
<tr>
<td>GI Wire</td>
<td>7</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>3</td>
</tr>
<tr>
<td>Earthwork equipment</td>
<td>1</td>
</tr>
<tr>
<td>Pavement equipment</td>
<td>2</td>
</tr>
<tr>
<td>Compaction equipment</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2

<table>
<thead>
<tr>
<th>Material</th>
<th>Rank according to impact</th>
<th>Rank according to frequency of occurrence of delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregates</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Gravel</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Bitumen</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Cement</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>GI wire</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Reinforcement</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
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Table 3

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Rank according to impact</th>
<th>Rank according to frequency of occurrence of delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement equipment</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Earthwork equipment</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Compaction equipment</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>
the highest cost impact. On further investigation it was found that this occurs because of the following:

1. Non-availability of crushers at quarries
2. Delays in obtaining government permits to begin quarrying from nearby quarry sites and river beds
3. Lack of the required type of aggregates that match specifications
4. Aggregates are the most common component of roads and hence delay in aggregate supply more often than not cause delay in other activities necessitating acceleration.

7. Conclusions

The study came up with some interesting results. It confirmed the existence of material and equipment procurement delays in road projects in Nepal. The total cost impact was insignificant, averaging about 0.48% of the total budgeted costs of the projects studied. However, care should be exercised in extrapolating or generalizing these results to other countries or projects. Under similar project environments with the same factors influencing procurement, impact costs could be far higher for a more complicated project like an industrial project or even a commercial building project. Road projects are far less complicated than most other types of projects with relatively fewer materials involved. Industrial projects, on the other hand, are characterised by a large number of complicated mechanical, electrical, instrumentation and piping activities with complex inter-dependencies requiring a relatively higher number of different types of materials. This would not only mean that a larger number of activities could be directly affected but also that the combinatorial effect of a far greater number of downstream activities being affected by upstream ones could also occur. Thus delays in the delivery of materials to site resulting in their non-availability for scheduled operations will have a more pronounced impact percentage-wise on overall costs. Furthermore, labour costs for activities on industrial projects are likely to be higher as the ratio of skilled labourers to unskilled labourers is relatively high. The same is true of commercial building projects, which are again characterized by large numbers of different types of materials, complex inter-dependencies and relatively high skilled-to-unskilled labour ratio.

Organizational weaknesses and suppliers’ defaults were found to be the most significant causes of procurement delay followed by government regulations and transport delay. This finding is significant because it provides an insight into the source of problems in material and equipment procurement. Furthermore, the facet of the materials and equipment procurement issue in Nepal and possibly other developing countries that provides room for optimism is that the underlying causes are not immutable characteristics of the physical environment or geography of the region but rather manifestations of the consequences of poor management at various levels in the construction supply chain.

It is our hope that this research and other similar research to be conducted in the future will pave the way for developing countries to streamline their materials and equipment procurement systems to help them compete successfully in an increasingly complex and global construction market place of this millennium.

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Appendix

List of questions for conducting semi-structured interview

1. Do you see material and equipment procurement delays as a major problem in highway projects in this country?
2. Does your company have policies and procedures in place for materials and equipment procurement?
3. Are these policies and procedures being used on this project?
4. Organisational weakness, supplier default, governmental regulations and transportation delays were identified as the major causes of procurement delay in highway projects in this study. Could you please explain how (i.e. in what form) these causes manifest themselves?
5. Are there any other aspects of the materials and equipment procurement operations in your company that you would like to share with us that would shed light on the problem of procurement delay in highway projects in this country?

References