Analysis of Risk Assessment in Highway Projects Using Importance Index

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Abstract: Road construction delay is considered to be repetitive problems in the construction industry causing various negative effects on project success in terms of time, money, and quality. Therefore it is essential to identify and analyze the causes of highway construction delay. The main purpose of this study is to identify the causes of delay affecting highway construction projects. 40 delay causes were identified using a literature review and were categorized into 13 groups. Data were collected through a questionnaire survey. Questionnaires were distributed to 425 respondents out of which 388 were received. Values of Frequency and severity of occurrence of delay causes are calculated for getting values of importance index. Risk factors are ranked using the importance index. Results indicate that the top five harmful delay factors are change in design, Delayed payment, Inaccurate details in drawings, Financial difficulties, and Poor project management, and least five harmful delay factors are Physical obstruction during construction, Road blockage, and traffic at the construction site, Labor dispute, Sudden change in government law and skilled labor. The findings can help the Project team to decrease highway construction delays.

1. Introduction
Completion of road projects on time is very important because delay in its completion can lead to disputes, loss of money, claims, and a negative impact on the company’s reputation. Risk can cause cost overrun and schedule delays in many projects. For making risk management more efficient, each member of the construction project must understand risk responsibilities and risk management capabilities [24]. A highway construction project involves various activities and each activity involves hazardous risks due to the association of various people like the design team, contractors, Engineers, supervisors, and other workers [23]. Delay affects each party involved in the construction project differently. Delay can make a negative effect on the client, consultant, and contractor in terms of growth, mistrust, and cash flow problems. To overcome road construction delays in developing countries suggestions were made for stakeholders management and fundamental and large-scale reforms in the procurement system [1].
Mahamid et al. [16] recommend that government should give attention to conduct a training program to improve the managerial skills of various construction parties. Risk assessment is done to have control over project-related threats [23]. Various risk factors affect road construction activities separately and it becomes very important to determine the activities which are vulnerable to various risk factors so that risk can be minimized to a certain level.

Various studies were conducted to identify the causes of delays in highway construction projects. Mahamid et al. [16] conducted a study to investigate the time performance of road construction projects to determine delay causes and their severity according to contractor and consultant. In his study, 52 causes of delay were identified and combined into 8 groups. Aziz et al. [1] proposed a model for predicting actual road project durations and indicate that findings can helpful for the project manager to mitigate delay in the road construction project. A list of 293 delay causes from the literature review was identified and a questionnaire was distributed among various professionals to rank the importance of delay causes. Mahamid et al. [16] recommend that government should give attention to conduct a training program to improve the managerial skills of various construction parties. Risk assessment is done to have control over project-related threats [23]. Rachid et al. [19] collects data through a questionnaire survey and conducted direct interviews with experts to identify the causes of delay. Results showed that owner related problems are the source of delay in construction projects.

Alsuliman [7] categorized the delay factors according to the different stages of the construction project. The study developed a formula to calculate the effect of delay caused on the project site and provide appropriate solutions to reduce any delays. Prasad et al. [18] identified root causes of delay in a different project. 60 delay factors are identified and an importance index was used to rank delay factors. Delay in settlement of claims and late payment from contractor identified as major delay factors. Edison and Singla [9] developed a scale that measures the factors affecting delay in construction projects. 45 delay factors were identified and subjected to Exploratory and confirmatory factor analysis. Six factors were identified by the study which creates a delay in construction projects. Kog [15] identified eight of the top delay factor attributed to the contractor. Delay factors according to each party are identified as a result of the research. Various risk factors affect road construction activities separately and it becomes very important to determine the activities which are vulnerable to various risk factors so that risk can be minimized to a certain level.

2. Objectives of the study
The main objectives of this study are:
- To determine the causes of delay in Highway construction projects.
- To rank risk factors based on the frequency and severity of delay causes.

3. Methodology
Various important risk factors were listed out from literature review and expert opinions. Based upon risk factors a questionnaire was made and distributed among various professionals who had good experience in the construction industry. Target respondents were Site Engineers, Project Manager, Site Manager, and Site Supervisor. Data was collected from 425 respondents and respective data was selected. The data analysis is done using frequency and severity index, and based on frequency and severity values Importance index was calculated. Ranking of risk factors was done using the importance index. Five-point Likert scale ranging from no happen to always for frequency and for severity very low to very high was adopted.

3.1 Data Analysis
Delay causes in road construction projects are ranked by frequency and severity index (shown in Table 1). The formulas which are used to calculate their frequency and severity values are given in equation (1) and equation (2).
Frequency index

\[
\text{Frequency Index\%} = \sum a \left( \frac{n}{N} \right) \times 100
\]  

Severity index

\[
\text{Severity Index\%} = \sum a \left( \frac{n}{N} \right) \times 100
\]

Where \(a\) = Weighting given to each response, ranges from 1 to 5. 
\(n\) = Frequency of the responses. 
\(N\) = Total number of responses.

Importance index

\[
\text{Importance Index\%} = \text{F.I} \times \text{S.I}
\]

Where F.I represents frequency index and S.I represents severity index.

Table 1 Ranking of Risk Factors.

| Risk Category   | Risk Factors                          | F.I   | S.I   | Importance Index | Rank |
|-----------------|---------------------------------------|-------|-------|------------------|------|
| Design Group    | Design errors                         | 0.7212| 0.7373| 0.531            | 6    |
|                 | Inaccurate details in drawings         | 0.68627| 0.8824| 0.605            | 1    |
|                 | Change in design                       | 0.6656| 0.8569| 0.570            | 4    |
| Contract Group  | Not following contract conditions      | 0.54313| 0.652 | 0.354            | 19   |
|                 | Impractical contract duration          | 0.4921| 0.6971| 0.343            | 21   |
|                 | Inaccurate contract documents          | 0.5441| 0.6892| 0.375            | 16   |
| Financing Group | Financial difficulties                 | 0.6794| 0.7941| 0.539            | 5    |
|                 | Delayed payment                        | 0.7098| 0.8284| 0.588            | 3    |
|                 | Increase in material cost              | 0.4245| 0.6471| 0.274            | 34   |
| Consultant Group| Delayed design documents               | 0.4421| 0.6843| 0.302            | 31   |
|                 | Inadequate consultant experience       | 0.5352| 0.6314| 0.337            | 22   |
| Contractor Group| Less contractor experience             | 0.4970| 0.8461| 0.420            | 13   |
|                 | Management difficulties by contractor  | 0.5666| 0.8265| 0.468            | 11   |
|                 | Rework due to wrong work               | 0.551 | 0.8333| 0.459            | 12   |
| Equipment Group | Insufficient machinery/equipment       | 0.4735| 0.7961| 0.376            | 15   |
|                 | Failure of equipment                   | 0.4254| 0.8069| 0.344            | 20   |
|                 | Unskilled operator for Machinery       | 0.4598| 0.6627| 0.304            | 28   |
| Material Group  | Delay in transportation construction materials | 0.6235| 0.8275| 0.515            | 8    |
|                 | Reworks because of poor materials      | 0.6598| 0.7137| 0.470            | 10   |
|                 | Poor construction materials            | 0.4666| 0.6804| 0.317            | 25   |
| Site Group      | Inaccuracy in soil investigation        | 0.4490| 0.6647| 0.298            | 33   |
|                 | Unpredicted underground condition       | 0.5088| 0.649 | 0.330            | 24   |
|                 | Sudden rise in underground water       | 0.4980| 0.6637| 0.335            | 23   |


| Scheduling and Controlling group | Wrong project cost estimate | 0.5823 | 0.6304 | 0.367 | 17 |
|----------------------------------|-------------------------------|--------|--------|-------|----|
|                                  | Poor project management       | 0.727  | 0.8167 | 0.594 | 2  |
|                                  | Poor contractor staff management | 0.4235 | 0.7167 | 0.303 | 30 |
| Owner Group                      | Problem of occupant land expropriation | 0.699  | 0.7461 | 0.521 | 7  |
|                                  | Delayed design documents      | 0.4872 | 0.6137 | 0.299 | 32 |
|                                  | Delay in payment of finished works | 0.5549 | 0.8603 | 0.477 | 9  |
| Labor Group                      | Skilled labor                 | 0.4431 | 0.5873 | 0.260 | 37 |
|                                  | Deficient laborers            | 0.4320 | 0.7186 | 0.310 | 26 |
|                                  | Less laborers productivity    | 0.5411 | 0.701  | 0.379 | 14 |
|                                  | Labor disputes                | 0.3813 | 0.7    | 0.266 | 36 |
| External Group                   | Physical obstructions during construction | 0.4352 | 0.5147 | 0.224 | 39 |
|                                  | Rain effect on road activities | 0.4382 | 0.8255 | 0.361 | 18 |
|                                  | Road blockage and traffic at site | 0.5166 | 0.5029 | 0.259 | 38 |
|                                  | Sudden Changes in government laws | 0.4    | 0.5304 | 0.212 | 40 |
| Rule and Regulation group        | Getting permissions from government | 0.4333 | 0.7039 | 0.305 | 27 |
|                                  | Difference between design specification and codes | 0.4794 | 0.5608 | 0.268 | 35 |
|                                  | Material misuse               | 0.4764 | 0.6382 | 0.304 | 29 |

4. Results and Discussions

The frequency and severity of risk factors were calculated based on the obtained responses from the questionnaire survey. For frequency rank for risks are based on the frequency of occurrence of the risk and for severity how much harm they can cause to project.

According to the survey, the top five risk factors which can cause a delay in road construction are Change in design, Delayed payment, Inaccurate details in drawings, Financial difficulties, and Poor project management - bar analysis shown in Figure 1 and least five harmful factors are Physical obstruction during construction, Road blockage and traffic at the construction site, Labor dispute, Sudden change in government law and skilled labor- Bar analysis shown in Figure 2.

![Figure 1. Top 5 harmful risk factors in Highway construction](image-url)
Figure 2 Least 5 harmful risk factors in Highway construction

Risk assessment is a very important task to avoid delays in Highway construction projects. The risk assessment will give an idea about the consequences that could occur during highway construction. Moreover, the project team gets to know about risk factors that require major attention and can be neglected by making new strategies and decision making. This study provides knowledge about risk factors contributes to delay in highway projects and how crucial it is to complete Highway projects on time. By performing risk assessment before starting construction projects will help the project team to achieve quality, less time, and less construction cost in terms of project success. Change in design, Delayed payment, Inaccurate details in drawings, Financial difficulties, and Poor project management are the top five factors contributing to delay in highway projects. Preventive measures can be made for these factors to avoid delays in construction projects.

5. Conclusion
The objective of the study was to identify the factors affecting highway construction projects. A detailed literature review was conducted to identify the factor affecting highway construction activities. 40 delay factors were identified and subjected to a questionnaire survey. Each delay factor is categorized according to the responsible group. A questionnaire was distributed to various professionals who had a good experience in the construction industry. 388 questionnaire responses out of 425 were received. Values of frequency and severity were calculated for each delay causes. The importance index was calculated to rank 40 delay causes. Based on the importance index values top-five and least five factors affecting delay to highway construction activity were identified. These identified factors can help the project team to reduce the incidence of delays.

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