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Risk Assessment and Analysis of Construction Sites in Kerala

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ABSTRACT

A construction project is started, coordinated, and completed from beginning to end while staying on schedule, within budget, and up to the required quality standards. This study aims to examine the need for risk assessment at construction sites in Kerala, India, and to demonstrate the usefulness of various methods, including the Relative Importance Index (RII) Test, the Importance Index (IMPI) Test, and the Fuzzy Dematel in analysing survey data. The survey was conducted through questionnaires administered to workers, supervisors, and managers at selected construction sites in the state. The results indicate the crucial need for risk assessment to minimise cost, time, and other risk factors. The RII Test and IMPI Test were used to rank the factors according to their influence, while the Fuzzy Dematel method was used for a more detailed analysis. The study highlights the importance of risk assessment at construction sites and provides a framework for conducting such assessments. It can serve as a useful reference for construction companies and policymakers in developing effective risk management strategies in the construction industry. Despite the high risk involved in construction projects, there is a lack of studies on risk assessment, making this study a valuable contribution to the field.

Keywords – Risk Assessment, Survey, Relative important index (RII), Importance index (IMPI), Fuzzy Dematel method.

1. INTRODUCTION

The construction industry is an essential part of any developing economy, creating jobs and infrastructure for society. However, it also poses a significant risk to workers and the public. Construction sites in Kerala, India, are no exception, as workers are continuously exposed to various risks that can result in severe accidents or even fatalities. According to several reports, the construction industry has the highest accident rates compared to any other sector in many parts of the world.

To address these concerns, this conference paper presents a comprehensive risk assessment of construction sites in Kerala using several analytical methods, including the Relative Important Index (RII), the Important Index Test (IMPS), and the Fuzzy Dematel method. These methods were carried out by preparing surveys based on a set of questions that were developed by following several steps, such as referring to various articles, discussion with experts, reliability and validity checks, and pilot testing.

The study aimed to identify and rank the factors that affect project time and cost and assess the risks associated with multi-storey residential building construction. The research also analyzed the affect and cause factors of these risks. The paper includes a literature review, questionnaire preparation, data collection, and analysis, culminating in a comprehensive risk assessment using the Fuzzy DEMATEL method.

Overall, this study highlights the importance of risk assessment in the construction industry, particularly in high-risk regions like Kerala. The findings of this study can help construction managers and workers better understand the risks involved in their projects and take necessary steps to mitigate those risks. Additionally, the paper demonstrates the effectiveness of using multiple analytical methods to identify and rank risk factors, providing a more comprehensive understanding of the risks involved.

2. OBJECTIVES

- To determine the important elements influencing the behaviour of various Mega projects.
- To evaluate the major elements influencing the delay.
- To analyze and rank the aspects that impact a construction's time and cost.
- Compare the results derived from the analysis using these various techniques.

- Find out the cause and affect elements by performing a risk assessment on the multi-story residential structure.

3. RESEARCH METHODOLOGY

This study aimed to identify the most influential factors affecting project management in construction firms in various regions of Kerala, India. To achieve this, data was collected through an explorative questionnaire administered to respondents involved in the daily activities of construction firms. The questionnaire was designed to allow respondents to rank their answers based on their opinions, and the collected data was analyzed using the Relative Importance Index (RII) method, the Important Index (IMPI), and the Fuzzy Dematel method.

The analysis of the collected data involved assigning ranks to the causes contributing to major delays in construction using the Likert scale, ranging from less important to very important. The RII method was used to determine the relative importance of each factor, and the results were used to identify the most influential factors affecting project management in construction firms in the region. The Fuzzy Dematel Method was used to identify the most important factors based on the expert opinions collected.

4. DATA COLLECTION

To conduct the study, civil engineering and building construction firms in Kerala, including architects, contractors, and developers, were the target population. The total number of surveys conducted and their details were collected through the internet to determine the sample size of the study. One hundred questionnaires were distributed, and 60 questionnaires were received, which were analyzed to calculate the Relative Importance Index and Important index of each clause. The respondents included a diverse group of professionals, such as owners, contractors, builders, architects, and consultants. Furthermore, the Fuzzy Dematel survey was conducted with the participation of five experts from the field.

5. DATA ANALYSING METHODS

5.1 Relative Importance Index (RII)

The Relative Importance Index (RII) technique is a method used to assess the relative importance of different factors in a particular field or domain. It is a popular method used in research studies and decision-making processes, particularly in the fields of social sciences and business. The RII technique involves the use of a questionnaire that asks respondents to rate the importance of different factors on a Likert scale. The scale typically ranges from 1 to 5, with 1 representing "not important" and the highest number representing "very important" [1]. The scores are then weighted and averaged to provide an overall score for each factor. The equation for finding RII is:

$$RII = \Sigma W / (A*N) \quad (1)$$

In (1), W denotes the respondents' weightings (ranging from 1 to 5) for each element, A denotes the maximum weight (in this case, 5), and N is the total number of respondents. More significant the cause of delays was, the higher the RII rating.

5.2 Importance Index (IMPI)

In this method, determine the relative significance of several aspects in a given domain. It is frequently utilised in research projects and is a helpful tool for decision-making processes. With this method, two questions were posed for each cause or factor: How frequently does this cause occur? And how serious is this reason for the project's delay?

A five-point scale was used to rate severity and frequency of occurrence. There are four categories for frequency of occurrence: always, often, occasionally, and infrequently (on a 5-to-1 point scale). Similar classifications were used for severity levels: intense, great, moderate, and small (on a 5-to-1 point scale) [1].

Based on both the frequency (3) and severity indices (4), the importance index of each cause is determined as follows:

$$\text{Importance Index (IMPI) (\%)} = [\text{F.I.} * \text{S.I.}]/100 \quad (2)$$

5.2.1 Frequency Index:

Based on the participants' reported frequency of occurrence, a formula is employed to rank the causes of delay:

$$\text{Frequency Index (F.I.) (\%)} = \Sigma a\,(n/N)*100/5 \quad (3)$$

In (2), n is the frequency of the responses, a is the constant representing the weighting given to each response, and N is the total number of responses.

5.2.2 Severity index:

According to the severity assigned by the participants, a formula is employed to order the causes of delays:

$$\text{Severity Index (S.I.) (\%)} = \Sigma a\,(n/N)*100/5 \quad (4)$$

In (4), a represents the constant indicating the weighting applied to each response N is the total number of responses, and n is the frequency of the responses.

5.3 Fuzzy Dematel

The study described here uses the Fuzzy Dematel method to evaluate the causal relationships between accidents and construction processes. This method is particularly useful for dealing with the imprecise and subjective nature of human judgements. Instead of using real numbers, interval sets are used in fuzzy set theory to represent the different linguistic terms used to describe the factors being evaluated. These linguistic terms are then converted into fuzzy numbers for analysis.

The Fuzzy Dematel method provides a way to analyze and rank the criteria related to the types of relationships and the impact of a severe degree on each criterion. This allows for a more thorough understanding of the relationships between different factors and can help identify key areas for improvement. By using this method, the study is able to provide a more accurate and nuanced assessment of the causal relationships between accidents and construction processes [2].

The basic steps for the Fuzzy Dematel method are:

1. During this step, the relevant elements pertaining to the problem and the degree of influence between these elements are identified and defined. The influential factors that contribute to the complexity of the system are established by collecting data from literature reviews, brainstorming sessions, or by consulting with subject matter experts.

2. Once the relevant elements and their degree of influence have been identified, a direct relation matrix is constructed. This matrix provides a visual representation of the relationships between different elements within the system. After defining the importance of the measurement scales, a questionnaire survey method is conducted. This survey helps to gather data and feedback from experts or stakeholders in the field, which can then be used to further refine and validate the direct relation matrix.

$$\begin{bmatrix} 0 & x_{12} & \dots & x_{1n} \\ x_{21} & 0 & \dots & x_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ x_{n1} & x_{n2} & \dots & 0 \end{bmatrix} \quad (5)$$

3. Equation (6) is used to build a normalized direct relation matrix based on the direct relation matrix previously constructed. This normalized matrix takes into account the strength of the relationships between different elements and standardizes these values to ensure that they fall within a specific range. This process helps to eliminate any potential biases or inconsistencies in the data and allows for a more accurate analysis and interpretation of the results.

$$\lambda = \frac{1}{\max\limits_{1\le i\le n}\left(\sum_{j=1}^{n} x_{ij}\right)}, i, j = 1,2,\dots,n \qquad N = \lambda X \quad (6)$$

4. The total relation matrix (T) is calculated by the equation (7):

$$T = \lim_{k\to\infty}(N + N^2 + \cdots + N^k) = N(1-N)^{-1} \quad (7)$$

5. In this stage, the total relation matrix's values for each column and each row are added together. R_j displays the sum of the *j*th column, while Di displays the sum of the *i*th row. D_i and R_j provide as examples of the direct and indirect effects between various components respectively.

$$D_i = \sum_{j=1}^{n} t_{ij} (i = 1,2,\dots,n) \quad (8)$$

$$R_i = \sum_{i=1}^{n} t_{ij} (j = 1,2,\dots,n) \quad (9)$$

6. In this stage, a cause-and-affect diagram is created to analyze the data obtained from the previous steps. The horizontal axis of the diagram is constructed by summing the values of D_i and R_j, which represent the prominence and importance of each criterion. The vertical axis is constructed by subtracting the value of R_j from D_i, which represents the relation between different criteria and the extent of their influence on each other.

The resulting diagram allows for a visual representation of the relationship between different criteria and their impact on the system. If the value of (D-R) is negative, the criterion is considered part of the affect group, meaning it is influenced by other criteria in the system. Conversely, if the value of (D-R) is positive, it indicates that the criterion has a significant impact and should be prioritized for improvement. This analysis helps to identify key areas of concern and prioritize actions for improving the overall performance of the system.

To evaluate and analyse the causative relationships of accidents in the building processes, fuzzy dematel methodology is utilised. In fuzzy set theory, interval sets are utilised as opposed to actual numbers. Fuzzy numbers are created from linguistic phrases. The suggested approach is advantageous for revealing links between variables and rating criteria based on the nature of linkages and the effect of severity on each criterion.

5. RESULTS AND DISCUSSIONS

5.3 RII Method

Using the Relative Importance Index (RII) technique, the top 15 risks or causes of delays in the Kerala construction industry were identified and ranked according to their RII values. Based on the data collected and analysed, the rankings for the 15 important risk factors of civil construction management developed by RII were:

Table 1: Ranking of risk factors by RII method

Rank	Causes Or Factors	Points
1	Safety Management	0.812
2	Labours Poor Education And Inadequate Safety Training	0.764
3	Poor Site Management	0.758
4	Workers' Health Or Fatigue	0.734
5	Site Conditions	0.72
6	Lack Of Proper Communication	0.718
7	Workers' Capabilities	0.714
8	Workers' Actions And Behaviour	0.712
9	Unsuitability Of Equipment	0.706
10	Construction Methods	0.704
11	Work Scheduling	0.702
12	Lack Of Time	0.686
13	Overtime Work For Workers	0.654
14	Unsuitability Of Materials	0.642
15	Noise Hazards	0.542

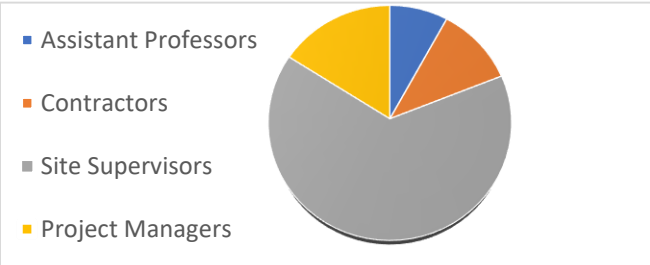


Figure 1: Participants in the survey

5.3 IMPI Method

The IMPI technique was used to identify and rank the top 15 risks or causes of delays in the construction industry in Kerala based on their IMPI values. The data collected and analyzed helped to develop a ranking of the most important risk factors in civil construction management.

Table 2: Ranking of risk factors by RII method

Frequency Index		
Sl No.	**Causes Or Factors**	**Points**
1	Site Conditions	58.75
2	Work Scheduling	66.25
3	Safety Management	70
4	Construction Methods	61.25
5	Labours poor education and inadequate safety training	67.5
6	Lack of Time	60
7	Poor Site Management	65
8	Unsuitability of Materials	45
9	Unsuitability of Equipment	46.25
10	Workers' Actions and Behaviour	60
11	Overtime Work for Workers	52.5
12	Workers' Capabilities	57.5
13	Lack of Proper Communication	65
14	Workers' Health or Fatigue	55
15	Noise Hazards	48.75

Table 3: Ranking of risk factors by RII method

Severity Index		
Sl No.	**Causes Or Factors**	**Points**
1	Site Conditions	67.5
2	Work Scheduling	68.75
3	Safety Management	77.5
4	Construction Methods	60
5	Labours poor education and inadequate safety training	66.25
6	Lack of Time	68.75
7	Poor Site Management	76.25
8	Unsuitability of Materials	53.75

9	Unsuitability of Equipment	56.25
10	Workers' Actions and Behaviour	71.25
11	Overtime Work for Workers	61.25
12	Workers' Capabilities	58.75
13	Lack of Proper Communication	67.5
14	Workers' Health or Fatigue	57.5
15	Noise Hazards	53.75

Table 4: Ranking of risk factors by RII method

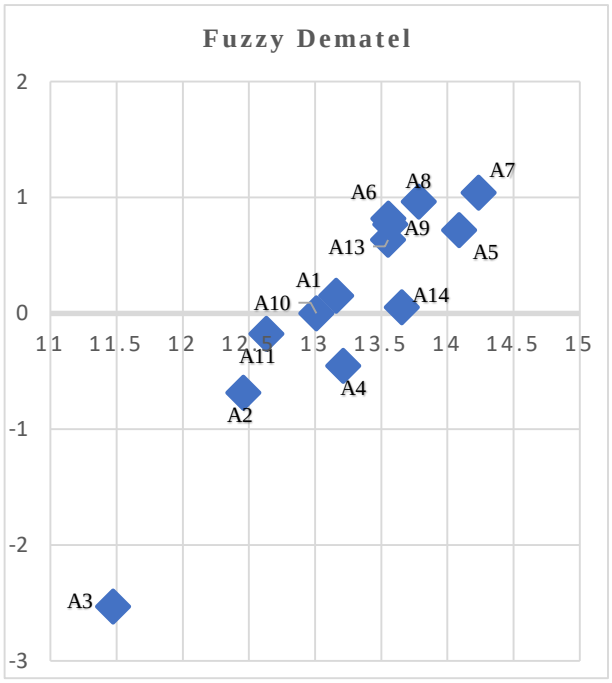
Important Index Method		
Sl No.	**Causes Or Factors**	**Points**
1	Safety Management	54.25
2	Poor Site Management	49.56
3	Work Scheduling	45.55
4	Labours poor education and inadequate safety training	44.72
5	Lack of Proper Communication	43.88
6	Workers' Actions and Behaviour	42.75
7	Lack of Time	41.25
8	Site Conditions	39.66
9	Construction Methods	36.75
10	Workers' Capabilities	33.78
11	Overtime Work for Workers	32.16
12	Workers' Health or Fatigue	31.63
13	Noise Hazards	26.20
14	Unsuitability of Equipment	26.02
15	Unsuitability of Materials	24.19

5.3 Fuzzy Dematel Method

Five specialists in the field of civil engineering are contacted in order to conduct a thorough survey for the analysis utilising the Fuzzy Dematel. The stages of this survey grow significantly as the number of factors rises since each element needs to be compared separately.

Table 5: Ranking of risk factors by RII method

Labels	Causes Or Factors
A1	Site Conditions
A2	Work Scheduling
A3	Safety Management



A4	Construction Methods
A5	Labours poor education and inadequate safety training
A6	Lack of Time
A7	Poor Site Management
A8	Unsuitability of Materials
A9	Unsuitability of Equipment
A10	Workers' Actions and Behaviour
A11	Overtime Work for Workers
A12	Workers' Capabilities
A13	Lack of Proper Communication
A14	Workers' Health or Fatigue
A15	Noise Hazards

Figure 2: Participants in the survey

Fig. 2 shows the output of the analysis that we get from the Fuzzy Dematel method. Apart from the other two methods, the Fuzzy Dematel method shows which factor is the main cause factor among all of them and also which factors are the affecting factors. In Fig. 2, the factors that are labelled above the x axis are the cause factors, and the factors that are below the x axis are the affecting factors. The factors corresponding to the labels are mentioned in Table 5.

5. CONCLUSION

In the case of construction management, cost and time are two big factors. In order to reduce the time and cost of the construction, we have to find the factors that are affecting them. The main thing is that in different sites and in different management systems, the factors affecting them will differ.

In this paper, we analyse these factors, which affect construction management, using the most popular analytical tools: RII, IMPI, and fuzzy dematel. RII is a commonly used analytical tool because it is easy to use and the steps are simple. The result from the RII method shown in Table 1 indicates that safety management has the highest RII values, which means it is in Rank 1.

In the IMPI method, the frequency index and severity index are calculated. Even though the result of the IMPI is similar to the ranking of the RII, here the frequency of occurrence of the cause factors and their severity are taken into consideration. Table 4 shows the IMPI ranking. The fuzzy dematel is not a tool for ranking but a decision making tool to categorise the factors into cause and affect by cause. The main advantage of this study is that it helps managers or supervisors understand which factors they have to work on first. Because some factors are the main cause and some are affected by those factors, working on or solving the main cause factors automatically solves the affecting factors. So by looking at the ranking table of RII and IMPI, this is not possible. Fuzzy dematel helps the decision-makers in construction management take quick decisions. Some of the findings and conclusions are:

- The RII method is the most popular and easiest method for analysis among these three.
- The ranking result that we get through the RII method is only based on a single factor, whereas in the IMPI method, two factors are separately considered: frequency and severity. Even though the length of the survey increases as the study is carried out on two parameters, it shows more accurate results.
- As per the ranking tables (Table 1 and Table 4), we can see that in Kerala, one of the main factors is safety management. As we all know, safety management is critically important on construction sites, as construction work is inherently hazardous and can be dangerous if not managed properly.
- But the remaining factors have slightly different rankings, i.e., when frequency and severity are taken into consideration, factors like work scheduling and site conditions are more important.
- Fuzzy dematel analysis shows some interesting results, i.e., in this analysis, safety management has the highest value, but from Fig. 2, we can see that it lies in the affect plot area. Which means it is not the main factor on which we want to focus first. As per this analysis, poor site condition, unsuitability of materials, unsuitability of equipment, etc. are some of the priorities.
- With the advantage of a fuzzy dematel study, we can see that as these priority cause factors are improved, the safety management will also improve.

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