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***Research paper***



# Risk Management – Decision Making Using Analytical Hierarchy Process

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**Abstract**

A risk assessment practice determines the risk both quantitatively and qualitatively, such that risks are analysed and assessed thoroughly. Several methods are available to mitigate the failures in a construction project. This project focuses on identifying risks and mitigating them to reduce failures. On a questionnaire basis, a survey from various employees working on different projects is conducted by considering seven major factors of risks and the normalised score of each factor is ranked. Based on the normalized score values, least three risk factors were identified and Analytical Hierarchy Process(AHP) is applied by manual calculations. AHP is based on human judgements and objective evaluation, which examines the consistency of the evaluation by Eigen values. Validation of the identified factors is also done through MAT Lab and is compared with the manual method. Consistency and hierarchy of the identified factors has been found out, thereby mitigating the failures and increasing the efficiency of the projects.

***Keywords:*** *Risk Management, Analytical Hierarchy Process, Risk Factor, Eigen value.*

## 1. Introduction

Construction industry is one of the rapidly growing sectors of the Indian economy. Construction process is characterized by a number of uncertainties like competition in the market, weather conditions, legal changes, availability of resources, technological changes, customer demand and financial problems. Therefore, projects fail to achieve in their time limits, economy and quality goals. Risk management consists of identification and handling of risks by qualitative and quantitative assessments. This boosts up confidence level in achieving objectives and facilitates the calculation and management of contingencies. By identifying these risks before their occurrence, they can be controlled and managed by preventive measures.AHP proves to be the best method for complex decision making, by assisting in identifying and analysing data obtained. AHP focuses on subjective and objective evaluation measures. This provides a suitable mechanism the consistency check, thereby promoting unbiased decision making.

Pejman Rezakhani Kyungpook [14] categorizes the essential risk factors in a construction project. For efficient risk management in a project, existing approaches may be summed up to a four step process namely - identifying the risk, assessing the risk, responding to the risk and monitoring the risk. Kinnaresh Patel [2] discusses a study on assessing and managing risk in India. It identifies a method to identify and manage risk. The objective of this study is to advance to a method of mitigating risks to reduce the risks in the future. These risks commonly prevent the completion of construction project objectives in India.

Andi [5] discusses about the ways to correct defective designs. Firstly, a responsive measure that acts as an inspective mechanism is proposed which gives systematic instructions to identify primary causes of past defect occurrences. Yet another measure is to operate earlier than defective design development. This regularly assesses all the influencing factors and also indicates the ones that require correction. Generino P. Siddayao [10] explains about AHP in spatial modelling for floodplain risk assessment. In this study, AHP and GIS methods analyse flood risk in Enrile at Northern Philippines and were validated consistent by standard consistency index. Prasanta Kumar Dey [12] discusses about risk management of a project using AHP and decision tree. Due to lack of technology, involvement of several stakeholders and capital in big projects of construction, there arises an uncertainty in quality, cost and duration. In this paper, project management efficiency of using AHP and DTA is demonstrated through a case study of a petroleum pipeline project. This research finally recommends a project management model by applying risk management principles.

The scope of this project study is to identify factors that affect the construction process. This can be done by conducting a survey that involves the opinion of working professionals. To this, AHP is applied by manual methods and software calculations. Thus, this increases the efficiency of the construction project.

## 2. Experimental Methodology

### 2.1 Literature Review

For this project AHP model is been used. So, base papers related to AHP model are collected and it was been analysed. This

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analysis was done in order to get a clear idea for how to proceed with the project further to achieve the successful completion of the project.

### 2.2 Questionnaire Preparation

A questionnaire is prepared by highlighting the 7 key risk factors which are faced during construction by engineers, contractors, project managers and field supervisors. The 7 key risk factors are Customer demand, Availability of resources, Technological changes, Competition in the market, Legal changes, Weather conditions and Financial problems.

### 2.3 Surveying the Questionnaire

The questionnaire is distributed among contractors, engineers, field supervisors, project managers. They were asked to fill in the questionnaire based on their own experience.

### 2.4 Computation of the Data

The collected data is categorised based on their designations. Then the values are converted into a matrix form by taking the average of the data collected. Next step is the calculation of normalized score. Based on the normalised score values, least 3 risk factors were identified for further calculation, i.e., application of AHP.

### 2.5 Validation of Data by Manual Calculation

AHP is applied by doing manual calculation only for the identified 3 risk factors because they are considered to be the most critical during construction.

### 2.6 Validation of Data by using MAT Lab Software

For the same 3 risk factors, values are obtained by entering the values in the MAT lab. After obtaining the result, comparison is done between the values obtained from manual calculations and software calculations. Finally consistency check is done.

## 3. Results & Discussions

### 3.1 Computation of Values

The obtained data is transformed into a matrix by taking the average of the collected data. A 7x7 matrix is formed as shown below and is named 'a'.

$$a = \begin{pmatrix} 7.12 & 6.96 & 7.08 & 6.60 & 7.32 & 7.04 & 7.24 \\ 6.73 & 6.66 & 5.86 & 6.06 & 6.06 & 6.00 & 6.13 \\ 6.40 & 5.93 & 5.60 & 6.20 & 6.00 & 6.40 & 5.74 \\ 5.93 & 5.91 & 5.92 & 6.20 & 5.80 & 5.90 & 5.60 \\ 5.20 & 5.30 & 4.50 & 4.80 & 4.50 & 4.90 & 4.80 \\ 5.50 & 5.30 & 4.50 & 4.90 & 4.70 & 5.20 & 4.70 \\ 5.00 & 4.90 & 4.40 & 4.80 & 4.50 & 4.90 & 4.90 \end{pmatrix}$$

Each row denotes employer and each column denotes the risk factors as follows: 1st column – customer demand, 2nd column – availability of resources, 3rd column – technological resources, 4th column – competition in the market, 5th column – legal changes, 6th column – weather conditions and 7th column – financial problems.
From 'a' matrix, range value is set between 0 – 10, thereby forming a new matrix.

$$b = \begin{pmatrix} 3 & 6 & 4 & 7 & 1 & 5 & 2 \\ 1 & 2 & 6 & 5 & 5 & 4 & 3 \\ 1 & 4 & 6 & 2 & 3 & 1 & 5 \\ 2 & 4 & 3 & 1 & 6 & 5 & 7 \\ 2 & 1 & 5 & 4 & 5 & 3 & 4 \\ 1 & 2 & 6 & 4 & 5 & 3 & 5 \\ 1 & 2 & 5 & 3 & 4 & 2 & 2 \end{pmatrix}$$

The sum of each column is 11, 21, 35, 26, 29, 23, and 28. And the total sum is 173.
From 'b' matrix, normalized score values for each column are found using Eq. (1)

$$\left[1 - \frac{Sum}{Total\ Sum}\right] * 0.5 (1)$$

The Normalized score for 1st, 2nd, 3rd, 4th,5th,6th and 7th columns are 0.4682, 0.4393, 0.3988, 0.4280, 0.4161, 0.4335 and 0.4191 respectively.
Based on the normalized score values for different risk factors, ranking is done as depicted in Table 1.

**Table 1:** Ranking Risk Factors

| RISK FACTORS | NORMALIZED SCORE VALUES IN % | RANK |
|---|---|---|
| Customer demand | 46.82 | 7 |
| Availability of resources | 43.93 | 6 |
| Technological changes | 39.88 | 1 |
| Competition in the market | 42.80 | 4 |
| Legal changes | 41.61 | 2 |
| Weather conditions | 43.35 | 5 |
| Financial problems | 41.91 | 3 |

Based on the ranking least 3 factors were selected and were found to be Technological changes, Legal changes, Financial problem.

### 3.2 Application of AHP by Manual Calculation

For the three factors, a comparison matrix is formed as shown below.

| | A | B | C |
|---|---|---|---|
| A | 1 | 5 | 7 |
| B | 0.2 | 1 | 3 |
| C | 0.14 | 0.33 | 1 |

This matrix is transposed and the sum of each column is calculated as 1.34, 6.33and 11 respectively.
Each element in the transposed matrix is divided by its sum and the following matrix is obtained.

| | A | B | C |
|---|---|---|---|
| A | 0.746 | 0.789 | 0.636 |
| B | 0.149 | 0.157 | 0.272 |
| C | 0.104 | 0.052 | 0.090 |

The sum of each column is 1.
The normalized principle eigen vector is found by taking an average of the rows and is obtained as 0.723, 0.192 and 0.082 for the 1st, 2nd and 3rd row respectively.

The Principle Eigen Value is found by summation of products between each element of Eigen vector and the sum of columns of the transpose matrix.

$$\lambda_{max} = 1.34\ (0.723) + 6.33\ (0.192) + 11\ (0.082)$$
$$= 3.086$$

Consistency check is done for the above found $\lambda_{max}$ value as shown in Eq.(2) and is found to be 0.043.

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (2)$$

Where n is the number of factors.
Then, consistency ratio is found by Eq. (3) that gives the value of 0.0741

$$CR = \frac{CI}{RI} \quad (3)$$

Where, CI represents the consistency index, RI the random consistency index (0.58, which is obtained from random consistency index table proposed by Saaty [13]). Since the CR value is smaller than 10%, the inconsistency is acceptable.

### 3.3 Application of AHP by Using MAT Lab Software

Numerical computation of the eigen vectors and values is done by MATLab software.$\lambda^*_{max}$was found to be 3.0537. The principle eigen vector corresponding to the highest eigen value is calculated as 0.9630, 0.2479 and 0.1055 for the 1st, 2nd and 3rd row respectively. The normalised principle eigen vector is obtained by dividing each value by the sum (1.3164) and is found to be 0.731, 0.188 and 0.080 for the 1st, 2nd and 3rd row respectively.
Consistency check is done for the $\lambda_{max}$ value as per Eq.(2) and is found to be 0.026. Consistency ratio is found by Eq. (3) that gives the value of 0.0448. . Since the CR value is smaller than 10%, the inconsistency is acceptable.

## 4. Conclusion

This study indicates that Analytic Hierarchy Process tool is used in finding the consistency and hierarchy of the identified risk factors. By this, preferences and alternatives can be accordingly given to mitigate the failures and increase the efficiency of projects. As stated, AHP tool is applied for the identified risk factors which were gathered from the experienced people working in mega projects. Based on the hierarchy of various factors, 3 important factors have been determined. Those factors are Technological changes, Legal changes and Financial problems. The above found results are been cross checked by finding the consistency ratio value through AHP method (manual and software calculated) for the identified factors. Consistency ratio obtained from manual calculation is 7.41% and by using MAT Lab software is 4.48%. By using both the methods, the CR value is smaller than 10%. Hence, the inconsistency is acceptable. Therefore, more importance has to be given for those 3 factors to mitigate the construction delays during construction of the project. AHP can be widely used in decision making situations such as choice and priority, resource allotment, quality management and dispute resolution.

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