International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 08 | Aug 2020 www.irjet.net p-ISSN: 2395-0072

ANALYSING AND MANAGING BRIDGE CONSTRUCTION PROJECTS IN INDIA

Madhumitha T S[1], Shankar C[2]

[1]PG Student, Coimbatore Institute of Technology, Coimbatore
[2]Assistant Professor, Coimbatore Institute of Technology, Coimbatore

---

Abstract - *Risk is inherent in all construction projects. Risk is one of the uncertain events that occurs in construction project which will impact the project objectives like cost, time and quality. To enhance the project objectives, risk in the construction project has to be minimized. Risk in the construction projects cannot be eliminated completely but it can be minimized. Poor performance of the project is because of lack of proper risk management process. This paper discusses about the risk that occurs in bridge construction projects in India. The major factors that causes risk in bridge construction in India was found out and were divided into seven major attributes and twenty-seven sub attributes. A questionnaire survey was conducted with the project managers, contractors, engineers, supervisors and also through direct survey. Before the questionnaire survey, a pilot survey was conducted. The answers from the experts were analyzed to find the risk and their contribution in bridge construction projects. The results obtained from the analysis helps the engineers and project managers to minimize the risk during pre-construction, construction and post construction stage of bridge projects. Through this, the cost overruns can be reduced and the quality of construction can be improved.*

Key Words: **Risk, cost, time, quality, bridge, survey.**

1. INTRODUCTION

Risk management is the process which identifies and manages the risk which occurs during the project implementation. Risk are measured by the probability of occurrence and impact in the project. Compared to other construction projects, bridge construction has more uncertain factors during execution. Bridge construction has high risk because it requires high capital and lots of resources, intricate site condition and size of the project. The scope of the project is to improve the project performance by effective risk management of time, cost and quality. If risk management is not considered, the project cannot be delivered on time, budget and with the desired quality. Risk has both positive and negative impact in the success of the project. The potential risks were found through literature survey, expert opinion and field observation. Survey is conducted to determine the risk which has highest contribution during pre-construction, construction and post construction stage and then the data is analyzed using SPSS software. The probability of occurrence and the relationships between each of the risks has been found. The last step involves providing risk mitigation measures in order to reduce time, cost over runs and improve quality of construction.

2. LITERATURE SURVEY

- Rafiq M. Choudhry, Mohammad A. Aslam, Jimmie W. Hinzeand Faisal M. Arain, ASCE 2014 has divided the risks into seven categories like financial, contractual, design, health and safety, management, external and construction risk. They also divided this major seven categories into thirty-six sub category. This paper says that the financial risk is the highest ranked risk and the affecting factor is unavailability of funds. The top 5 highest ranked risk sub factors were unavailability of funds, financial failure of contractor, poor site management and supervision, inadequate investigation and inadequate project planning. The relative importance index categorized seven risk categories in descending order like financial risks, external risks, design risks, management risks, construction risks, contractual risks, and health and safety risks
- Hosein Naderpour, Ali Kheyroddin, and Seyedmehdi Mortazavi (ASCE 2019) has divided the risks into nine main categories. The nine main categories are financial, safety, contractual, management, external, design, construction, environmental and post exploitation. The risks were identified through interviews, questionnaires and through site visits. This paper says that the financial risk is the one most crucial risk factor which influenced the projects negatively. The order of risk in descending order is financial, safety, external, contractual, management, design, environmental, construction and post exploitation
- Chau Ngoc Dang, Long Le-Hoai, Soo-Yong Kim, Chau Van Nguyen, Young-Dai Lee and Sun-Ho Lee (Emerald insight 2017) has conducted a questionnaire survey with 48 experienced practitioners and collected data from road and

bridge construction projects in Vietnam. Based on likelihood and impact, the probability of occurrence of each risk is found. Fifty-one risk factors were identified and found that the relationship between the owner and government is the major risk factor. The suitable measure has been taken to reduce the risk and improve the project performance.

- Albert P.C. CHAN, Robert OSEI-KYEI, Yi HU, Yun LE (Front. Eng. Manag. 2018) has divided the risk into thirty-two major risk factors. A questionnaire survey has been conducted based on five-point Likert scale and found that the operational risk is the major risk factor. The risk were also divided into four critical risk groupings like construction and land risk, commercial risks, operational risks and political risks.
- Hery Suliantoro, Nurul Fitriani and Bagus Hario Setiadji has divided the risk into six major categories and thirty-six sub categories. The major categories include materials and equipment, design, human resources, finance, management, nature and environmental conditions. Bad weather risk is the highest risk and cause temporary work stoppages. The risk mitigation taken is to evaluate the risk and rearrange the work schedule by considering the weather forecast report.

3. METHODOLOGY

The risk analysis process is as follows

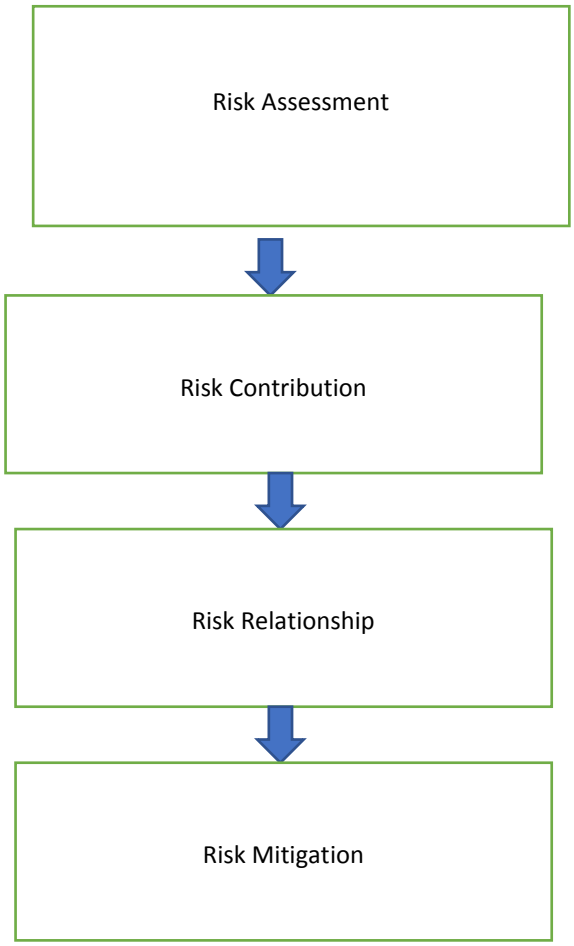

Fig 1: Risk analysis methodology

4. RISK IDENTIFICATION

The major risks that occur in bridge construction is found out from experts and through literature survey. From literature, the risks which occur in India and other countries are found out and with the help of experts, the predominant risks are taken for assessment. The risks identified are divided in 7 main attributes and 27 sub attributes. The identified risks are as follows

1.Financial risk
(i) Unavailability of funds
(ii) Inflation
(iii) Escalation of material prices
(iv)Financial failure of contractor
2.Design risk
(i)Design changes and inadequate scope
(ii)Inadequate site investigation
(iii) Defective design
(iv)Delay in examining and approving of design alteration
3.Contractual risk
(i) Change in project scope and change orders
(ii)Dispute and claims
(iii)Unrealistic cost estimates and schedule
(iv)Contractual deviation
4.Environment Health and Safety
(i)Accidents
(ii)Poor safety facilities
(iii)Pollution
(iv)Infecting soil or water sources of project site
5.Management risk
(i)Inadequate project planning
(ii)Strikes and theft
(iii)Incompetent sub-contractor
(iv)Inadequate project organisation structure
6.Construction risk
(i)Construction delays
(ii)Defective work and quality issues
(iii)Low labour productivity
7.Political risk
(i)Changes in law
(ii) Requirements of permits and approval
(iii)Loss due to political changes
(iv)Public or political opposition

5. DATA COLLECTION

A questionnaire survey has been conducted and the responses were obtained from the experts and also from the engineers who worked in bridge construction projects. Pilot survey has been conducted prior to the questionnaire survey to ensure that the questions were correct. Around 75 responses were obtained. The cause of each of the sub attribute and the major risk factor has been found out from the survey. Also, direct survey has been done to know the risks occur in bridge construction projects. The questionnaire survey is based on five-point Likert scale from one to five. The scale one represents strongly disagree, two is disagree, three is neutral, four is agree and five is strongly agree.

6. RISK ASSESSMENT

Risk assessment is done by means of the software SPSS. Through this, the probability of occurrence of each type of risk is found and also the relationship between each type of risk is found. The risk which has major impact on bridge construction and contribution of each risk type is found out.

7. RESULT FROM THE ANALYSIS

7.1 Factor Analysis

To ensure the adequacy of the sample, the factor analysis has been done. Kaiser Mayer Olkin (KMO) and Bartlett's sphericity test has been done. The acceptable values need to be greater than 0.5 (George and Mallery 2006, p. 22). The value obtained is about 0.724 which is adequate to carry out the factor analysis. The chi square value obtained from the Bartlett's test of sphericity was large. The chi square value is 1090.8580 with the small significance level of $P<0.001$. Bartlett's test determines if the relationship between the variable's matrixes is an identity matrix.

7.2 Internal Consistency Analysis

Cronbach's internal consistency analysis is done to check whether sufficient number of items are present to capture the concept adequately. The alpha value of 0.7 is found to be sufficient (Nunnally 1978, p. 18). The obtained Cronbach's alpha value for the twenty-seven variables is $\alpha=0.9$ which is excellent.

7.3 Relative Importance Index

The relative importance of each risk factor was calculated using the following equation (Shash1993)

$$RII = \sum (aX) \times (100/5)$$

Where a = the constant (weightage given to each response, ranging from 1 (strongly disagree) to 5 (strongly agree)); X = n/N, n is the frequency of the responses; and N is the total number of responses obtained. The relative importance index of the main attributes are Financial risk (RII=79.07), Design risk (RII=76.20), Contractual risk (RII-75.13), Environmental Health and Safety (RII=70.47), Management risk (RII=75.20), Construction risk (RII=61.13), Political risk (RII=77.27). The main attributes were ranked in descending order in the below table

Main Attributes	RII
Financial risk	79.07
Political risk	77.27
Design risk	76.20
Management risk	75.20
Contractual risk	75.13
Environment Health and Safety	70.47
Construction risk	61.13

Table 1: Relative Importance Index

From the table, it is clear that the financial risk is the predominant risk which is occurring in bridge construction projects in India.

7.4 Pearson's product-moment correlation

This gives the relationship between the variables. The values will be between -1 and +1. The sign says whether the relationship is negative or positive. If the value is positive, the relationship will be like if one variable value increases

then the value of another variable also increases. If the value is negative, it says that if the value of one variable decreases, the value of another variable also decreases.

Risk	Financial	Design	Contractual	Environment Health and Safety	Management	Construction	Political
Financial	1	-	-	-	-	-	-
Design	0.622**	1	-	-	-	-	-
Contractual	0.269*	0.677**	1	-	-	-	-
Environment Health and Safety	0.327**	0.365**	0.489**	1	-	-	-
Management	0.438**	0.492**	0.395**	0.562	1	-	-
Construction	0.375**	0.566**	0.371**	0.232**	0.589**	1	-
Political	0.323**	0.508**	0.416**	0.432**	0.450**	0.515**	1

**Correlation at significant level of 0.01
*Correlation at significant level of 0.05

Table 2: Pearson's product moment correlation

The correlation coefficient value is large for Design and Contractual risk (0.677) at the significant level of 0.01. Next to that Design and Financial risk has coefficient value of about 0.622 with the significant value of about 0.01. This says that the design risk and financial risk are positively correlated and also Design and contractual risk were also positively correlated. Which says that the cost of project depends on the design. Also based on the contract, the design changes will occur. Next to that construction risk and management risk has the correlation coefficient value of about 0.589 at level of significance 0.01. This says that the construction risk increases if there is poor management. So, a proper construction management process has to be carried out.

8. RISK CONTRIBUTION

The contribution of each (sub attributes) type of risk is found. Also, the causes of each type of risk is mentioned in the below table.

Risk factors	Probability	Rank	Cause of the risk
Construction delays	0.8400	1	Financial problems
Incompetent sub-contractor	0.8213	2	Poor performance
Defective work and quality issues	0.8187	3	Lack of training
Financial failure of contractor	0.8023	4	Delay in collecting debt from client
Requirements of permits and approvals	0.8000	5	Bribery/corruption
Unavailability of funds	0.7974	6	Late payment from government/client/agency

Delay in examining and approving of design alteration	0.7973	7	Change of government
Loss due to political changes	0.7894	8	Financial loss by giving bribery
Design changes and inadequate scope	0.7893	9	Inadequate planning
Low labour productivity	0.7867	10	Unskilled labour
Escalation of material prices	0.7814	11	Tariff increase
Unrealistic cost estimates and schedule	0.7813	12	Improper planning of unplanned cost
Inflation	0.7787	13	Unavailability of labour
Inadequate project organisation structure	0.7786	14	Poor communication
Public or political opposition	0.7760	15	Amount of acquisition is less and health problems
Inadequate project planning	0.7680	16	Lack of expertise/training
Change in project scope and change orders	0.7627	17	Problem in site
Contractual deviation	0.7547	18	Error in omission of Bill of Quantities
Inadequate site investigation	0.7440	19	Lack of client/contractor awareness
Infecting soil or water source of project site	0.7360	20	Dumping of waste and debris
Pollution	0.7307	21	Dust during work/demolition dust
Changes in law	0.7253	22	Change in design
Defective design	0.7174	23	Communication gap between client/contractor/architect
Poor safety facilities	0.7173	24	Company not insisting safety
Disputes and claims	0.7067	25	Ambiguous contract terms and document
Strikes and theft	0.6400	26	Unprotected job site
Accidents	0.6347	27	Lack of safety precaution

Table 3: Risk ranking table

9. RISK MITIGATION

In order to reduce the risk during construction or pre construction, the factors that causes the risk should be minimised. Because, the risks cannot be eliminated completely only the degree of effect which is caused by the risk is alone reduced. The project should be very well planned such that the factors which cause risk are reduced.

10. BAYESIAN SEM ANALYSIS

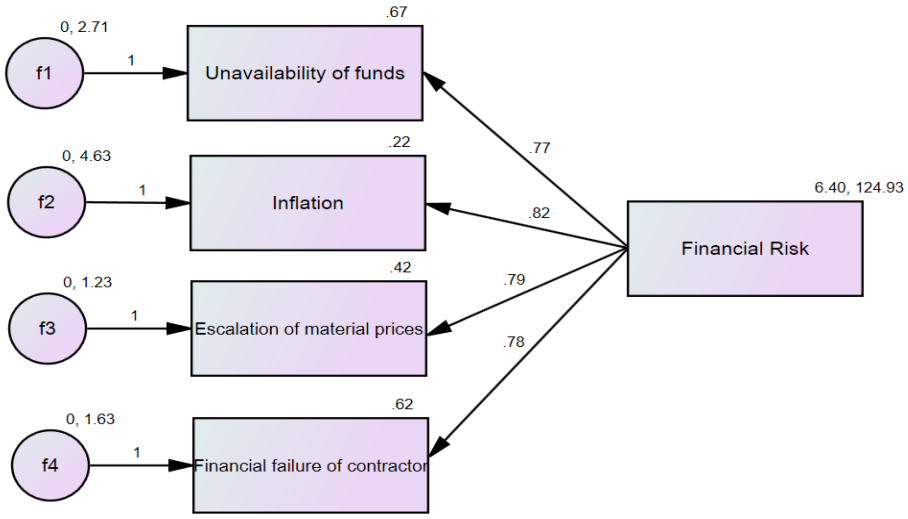

Fig 2: Financial risk

The financial risk has four major risks which includes unavailability of funds, inflation, escalation of material prices and financial failure of contractor. The unobserved variables which cause risk in finance are named as f1, f2, f3 and f4. These unobserved variables are the factors which cause risk in bridge construction. From the analysis, it is clear that inflation is the one which has the highest probability of occurrence. The unavailability of funds is the one which has the lowest probability of occurrence. Which means this risk can be eliminated to the maximum. The other two has the moderate probability of risk. The probability of risk caused by the external factors is also known from the analysis.

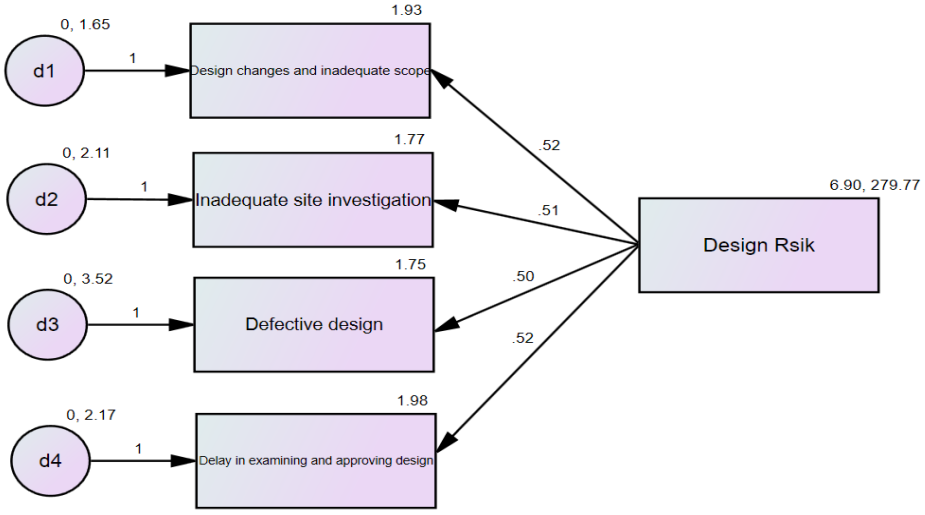

Fig 3: Design risk

The design risk for the bridge construction projects includes design changes and inadequate scope, inadequate site investigation, defective design and delay in examining and approving of the design alteration. Among these four, the inadequate site investigation has the most probability of occurrence, if this is not studied properly, the bridge construction will become a major disaster. The one which has the lowest probability of occurrence is the defective design. This is because, the design will be analyzed clearly before the construction by the experts. The unobserved factors which cause risk are mentioned as d1, d2,

d3 and d4. Due to the observed and unobserved factors, the risk which has the highest probability is the design changes and inadequate scope.

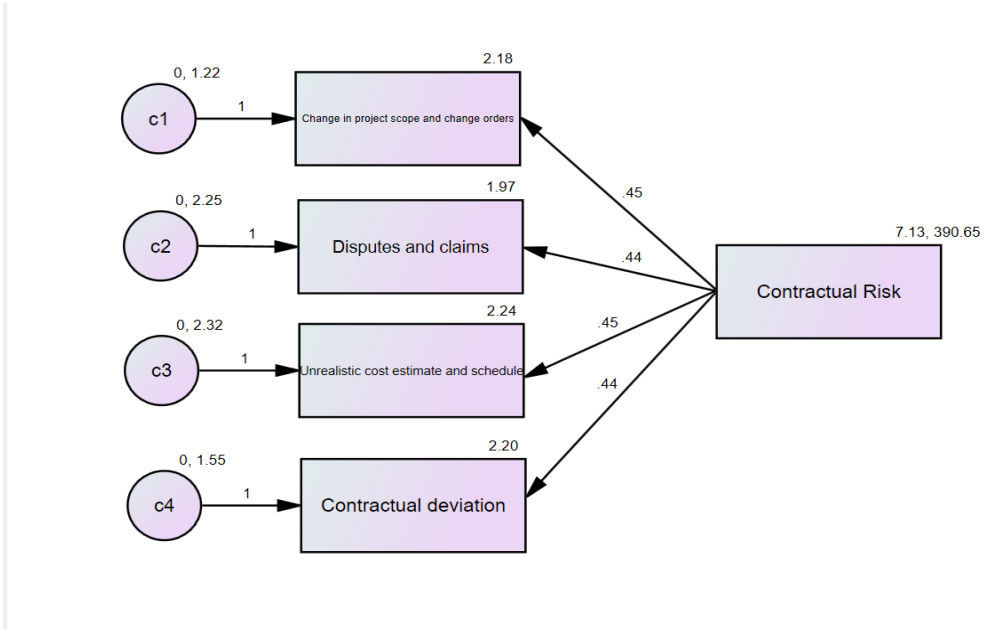

Fig 4: Contractual risk

The contractual risk includes four predominant risks like change in project scope and change orders, disputes and claims, unrealistic cost estimates and schedule and contractual deviation. The unobserved factors which cause the contractual risk are mentioned as c1, c2, c3 and c4. The risk which has the most probability is the change in project scope and change orders and unrealistic cost estimates and schedule. But by comparing both the observed and unobserved factors which cause risk, unrealistic cost estimates and schedule is the one which cause the maximum risk.

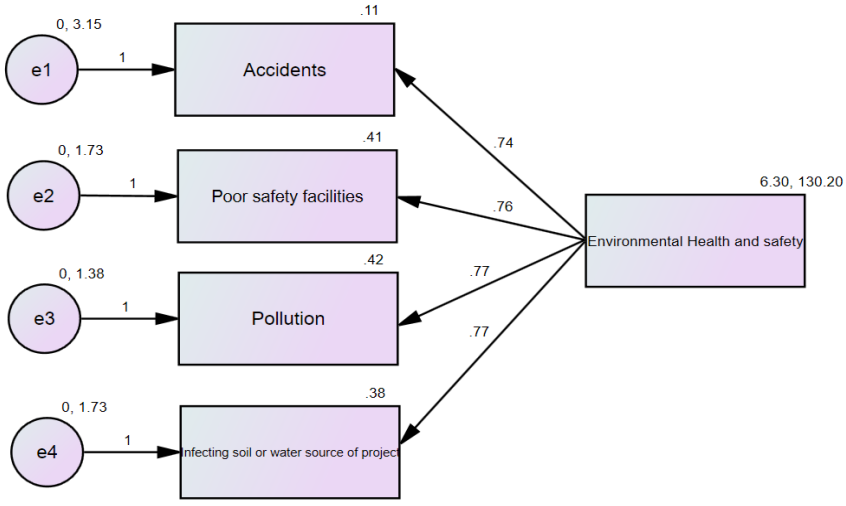

Fig 5: Environmental Health and Safety risk

The factors which cause risk in environmental health and safety are accidents, poor safety facilities, pollution and infecting soil or water resources of project site. The unobserved variables are denoted as e1, e2, e3 and e4. The main factor which cause risk is pollution and infecting soil or water resources of project site. The contribution of unobserved variable for the environmental risk confirms that pollution is the risk factor. Pollution should be controlled or it will cause various disease.

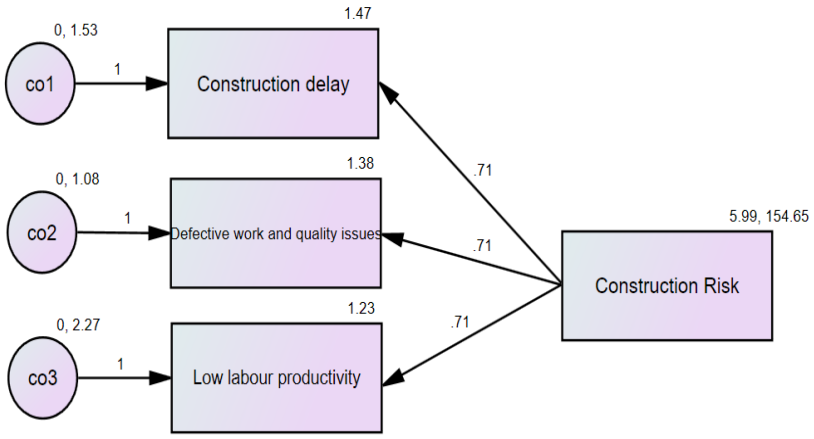

Fig 6: Construction risk

Construction risk is mainly caused by construction delay, defective work and quality issues and low labor productivity. All three contribute same amount of risk but due to the effect of the other unobserved variables, construction delay is the one which will cause risk. The delay may be due to bad weather conditions, increase in price of the materials or the opposition of the public.

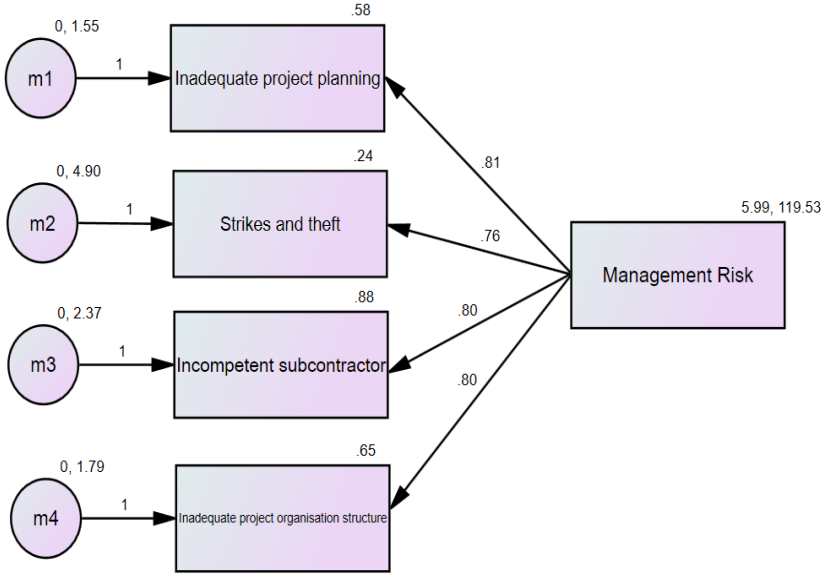

Fig 7: Management risk

Management risk is caused by inadequate project planning, strikes and theft, incompetent sub - contractor and inadequate project organization structure. The incompetent subcontractor is the one which has the highest probability of occurrence. The unobserved variables are taken as m1, m2, m3 and m4.

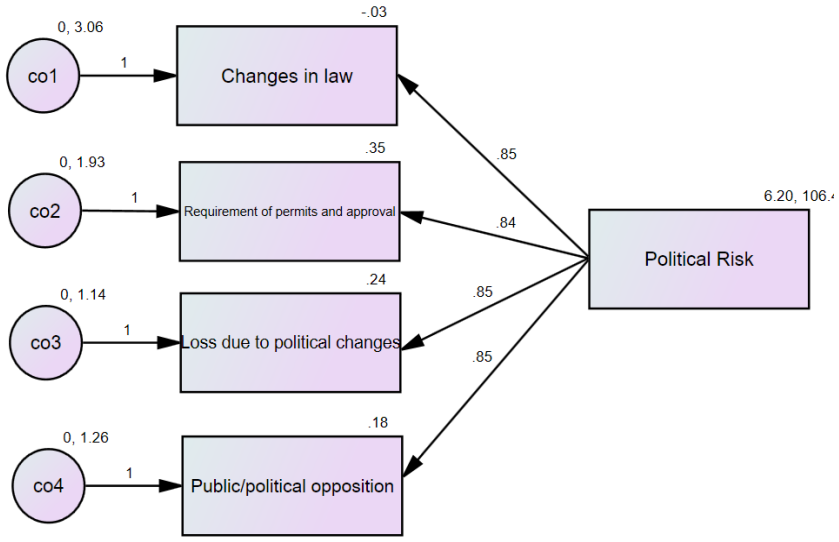

Fig 8: Political risk

Political risk is caused by changes in law, requirements of permits and approval, loss due to political changes and public or political opposition. From the analysis, it is clear that requirements of permits and approval is the one which causes risk. These permits cannot be easily obtained due to the reasons like bribery, change of the officers and opposition of the political parties.

11. RESULTS AND DISCUSSIONS

The risks were divides into seven main attributes and twenty-seven sub attributes. Based on the probability and ranking approach, it is clearly understood that the financial risk is the major attribute which will cause risk in the bridge construction project. In order to reduce this, the factors which cause risk must be taken into consideration during construction and pre construction stage. This paper helps the engineers, contractors, project managers and architects to take minimize the risk. The prioritization that should be given to bridge construction projects in descending order is financial risk, political risk, design risk, management risk, contractual risk, environment health and safety and construction risk. Thus, by taking in consideration all the risk factors, the time and cost can be reduced and the quality of construction can be improved.

REFERENCES

[1] Hery Suliantoro, Nurul Fitriani and Bagus Hario Setiadji, Risk analysis and strategic planning on bridge construction works at the toll road procurement projects in Central Java Province, SHS Web of Conferences 49, 02020 (2018)
[2] Beliz Ozorhona, Sevilay Demirkesena, Managing Risks in Public-Private Partnership Projects: The Case of Izmit Bay Suspension Bridge, Eighth International Conference on Construction in the 21st Century (CITC-VIII) "Changing the Field: Recent Developments for Future Engineering and Construction" May 27-30, 2015, Thessaloniki, Greece
[3] Albert P.C. CHAN, Robert OSEI-KYEI, Yi HU, Yun LE, A fuzzy model for assessing the risk exposure of procuring infrastructure mega-projects through public-private partnership: The case of Hong Kong-Zhuhai-Macao Bridge, Front. Eng. Manag. 2018, 5(1): 64–77
[4] Hosein Naderpour, Ali Kheyroddin and Seyedmehdi Mortazavi, Risk Assessment in Bridge Construction Projects in Iran Using Monte Carlo Simulation Technique, 2019 American Society of Civil Engineers.
[5] Rafiq M. Choudhry, Mohammad A. Aslam, Jimmie W. Hinzeand Faisal M. Arain, Cost and Schedule Risk Analysis of Bridge Construction in Pakistan: Establishing Risk Guidelines, 2014 American Society of Civil Engineers
[6] Chau Ngoc Dang Long Le-Hoai Soo-Yong Kim Chau Van Nguyen Young-Dai Lee Sun-Ho Lee, (2017)," Identification of risk patterns in Vietnamese road and bridge construction Contractor's perspective ", Built Environment Project and Asset Management, Vol. 7 Iss 1 pp. 59 - 72