A Thesis on

"STUDY ON RISK AND UNCERTAINTY IN BRIDGE CONSTRUCTION"

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CONSTRUCTION TECHNOLOGY AND MANAGEMENT

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DECLARATION

I declare that the research thesis entitled **"STUDY OF RISK AND UNCERTAINTY IN BRIDGE CONSTRUCTION"** is the bonafide research work carried out by me, under the guidance of **Mr Rajiv Banerjee AssociateProfessor, Department of Civil Engineering, Integral University, and Lucknow**.Further I declare that this has not previously formed the basis of award of any degree, diploma, associate-ship or other similar degrees or diplomas, and has not been submitted anywhere else.

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CERTIFICATE

Certified that the thesis entitled **"STUDY OF RISK AND UNCERTAINTY IN BRIDGE CONSTRUCTION"** *is being submitted by* **ASHISH KUMAR VISHWAKARMA (1800103581)** *in partial fulfilment of the requirement for the award of degree of Master of Technology (CTM) of Integral University, Lucknow, is a record of candidate's own work carried out by him/her under my supervision and guidance.*

The results presented in this thesis have not been submitted to any other university or institute for the award of any other degree or diploma.

Mr. Rajiv Banerjee

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It give me great pleasure to present my deep sense of gratitude to my guide **Mr. Rajiv Banerjee, Associate Professor, Department of Civil Engineering**. For his valuable support and increasing mentality throughout the project. I am highly obliged to him for providing this opportunity to carry out the ideas and work during my project period and helping me to gain the successful completion of my project.

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ABSTRACT

Construction of bridge projects were initiated in complex and dynamic problems resulting incircumstances of high uncertainty and risk, which were compounded by demanding many constrainsThe occurrence of risk accidents in the phase of bridge construction will lead to great losses to the proprietor and construction enterprises, if the construction risk of the bridge has not paid more attention. The worst catastrophic may occur during bridge construction is collapse of permanent or temporary construction. If risk management is not considered in bridge construction projects, there is chance for unwanted problems and uncertainties, by these risks objective cannot be achieved on time, within budget, or with suitable quality results. Thequestionnaire prepared for the survey was formulated by seeing the relevant literatures in the area of construction management. This thesis seeks to identify the risks factors that affect the performance of bridge projects as a whole and analyse by using appropriate tools and technique and to develop a risk management. The risk factors are sub categorize , surveyed and analyzed In methodology. The responses were analysed using the software of SPSS. Statistical analysis of responses on the factors was segregated into distinct sets of critical factor. This study aims to identify factors that affected bridge construction project and incorporating critical factors to improve therisk analysis. The analysis results were expected to help project professionals to focus on a few factors and get the optimum results rather than giving attention to all the factors and not getting the proportionate results.

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION OF RISK IN BRIDGES

Bridges are main and important transportation structures. A bridge is a structure providing passage over an obstacle without closing the way beneath like water, valley, roads and other obstacles. The occurrence of risk accidents in the phase of bridge construction will lead to great losses to the proprietor and construction enterprises, if the construction risk of the bridge as not paid more attention. The worst catastrophic may occur during bridge construction is collapse of permanent or temporary construction.If risk management isnot considered in bridge construction projects, there is chance for unwanted problemsand uncertainties,by these risks objective cannot be achieved ontime, within budget, or with suitable quality results. Risk management in bridgeconstruction projects are considered to have more inherent risks because of theinvolvement of multiple contracting parties, such as owners(government), designers, contractors,subcontractors,suppliers and most important public who will use it.

1.2 RISK & UNCERTAINTY

Risk can be defined as the **Variability Of Return.**According to Crandall and Al-bahar, risk is the exposure to the chance of occurrence of uncertainty.Uncertainty here represents the probability that an event will occur.

1.3 BRIDGE COMPLEXITY

Bridge construction is a complex and systematic work and there are varieties of risks all the time during the whole phase of bridge constructionfrom preparation to construction completion.Bridge is highly sensitive structure when it is consider for economypeople's life and usage etc.The risk accidents will have adverse effect on the bridge construction and it may interrupt the life of people. Therefore, the risk management of bridges in construction phase has great significance to prevent the occurrence of construction accidents ofbridges.

Risk Management is defined as a systematic planning process to identify, analyse, respond and monitor project risks. This process involves processes, tools, and techniques that will help the project manager to maximise the likelihood and produce positive events and minimise the likelihood and consequences of adverse events as indicated and appropriate in the context of risk to the overall project objectives of cost, time, scope and quality. Risk management makes a major contribution to the successful completion ofthe construction projects on schedule, within budget and with minimised losses. Dueto new challenges in the construction industry, increasing costs and greater timepressure, the probability of loss increases rapidly and led to a rising demand forcomprehensive risk management.

Bridges are principal and vital transportation structures. If risk management is not considered in bridge construction projects, objectives cannot be achieved on time, within budget, or with suitable quality results. Risk management in bridge construction projects are considered to have more inherent risks because of the involvement of multiple contracting parties, such as owners, designers, contractors, subcontractors, and suppliers. These factors are also involved in temporary project teams consist from different companies, countries, and cultures; moreover, the size and complexity of these projects add to uncertainties and risks.

1.4 BRIDGE CONSTRUCTION

A bridge is a structure built to span physical obstacles without closing the way underneath such as a body ofwater, valley, or road, for the purpose of providing passage over the obstacle. There are many different designs that each serve a particular purpose and apply to different situations. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it. Bridge construction is a complex and systematic work and there are varieties of risks all the time during the whole phase of bridge construction from construction preparation to construction completion. During the construction phase of a bridge, plenty of work is high above the ground; as a result, the construction of bridges hashigher risk compared with the other engineering construction. The occurrence of risk accidents in the phase of bridgeconstruction will lead to great losses to the proprietor and construction enterprises, if the construction risk of the bridge as not paid more attention. The risk accidents will have adverse effect on the regular bridge construction and it mayinterrupt the bridge construction. For the large bridge, the investment of which is so huge, the technology is verycomplex and the construction period is too long. When the accident of the large bridge in construction phase occurs,the property damage and personal injury is more serious than the ordinary bridge. Therefore, the risk management oflarge bridges in construction phase has great significance to prevent the occurrence of construction accidents of largebridges.

In recent years it can be observed that the amount of losses in bridge construction projects has increased as well. Design and material failures, miscalculation and workmanship problems as well as negligence have often been identified as the cause of such losses (Heller *et al.*, 2002). The worst catastrophic may occur during bridge construction is collapse of permanent or temporary construction. The critical factors governing a catastrophic event are (Wannick*et al.*,2008):

- Construction of large span length, high bridges
- Geological soil conditions
- Natural exposures
- Sensitivity to weather conditions
- Complicate lifting procedures (e.g., very large and heavy bridge sections to be lifted and fixed into position)
- Traffic during construction
- Design and construction errors
- False work failure
- Overturning of cranes, launch gantries etc.

Construction projects (including bridge projects) have a variety of risks due to different factors such as weather changes, cultural differences of people involved, political instability, possibility of governmental policies changes, and financial and economical problems. The number and importance of such risks depend on the size and complexity of the project. These risks lead to costs and time overrun in construction projects (Zavadkas, et al., 2010). Therefore, the potential risks that can influence the project results should be considered. Systematic procedures for Risk Assessment and Management of constructionprojects are increasingly critical to minimize construction projects risks. And eventhough Risk Assessment is still difficult for practicing engineers to use due to therequirement of data on too many input variables, the availability of existing largequantities of data and project-specific information makes it possible to simplify theRisk Assessment procedure. (Choi & Mahadevan, 2008)

1.5 PRINCIPLES OF MANAGEMENT OF RISK AND UNCERTAINTY

There is no clear cut, definition of risk and uncertainty. Many scholars look at it from different perspectives. However, it is generally agreed that, in risk and uncertainty, the outcome or activities are likely to depart from expectations. It is considered that, the effect of the deviation from expectation could be Value-Neutral, Value-Negative or Value-Positive. In construction Industry project management, these values are in the form of Time, Quality and Economy of the project. Therefore, in construction project management, it is the effect of risks and uncertainties on project time, quality and economy that is the subject of management and management development. In dealing with risks and uncertainties management as challenges facing construction industry in developing countries in project management, the focus should be on.

- Identification of the various risks and uncertainties that the project faces.
- Categorisation and Quantification of risks and uncertainties that the project faces.
- Risk and uncertainty sensitivity analysis for the project.
- Project risks and uncertainties allocation and distributions to those with better capacity and mechanism to handle each categorisation. This may include the traditional allocation to God/gods through prayers or by ignoring the risks and uncertainties. Sometimes, some people handle it in superstitious manners either through fortune-tellers or witchdoctors or traditions for example sacrifices of some kind for certain type of projects. Risks and uncertainties allocation and distribution should be done through terms and conditions of contracts.
- Project risks and uncertainties response and mitigation by the responsible people or parties to whom they were allocated and distributed. So that when the threats occur partially or wholly, the project implementation is protected from their consequences or compensated for the consequences.

1.6 RISK ANALYSIS

Tools that can automate often support the application of a risk analysis technique. The main role of the tools is to allow for searching, gathering and managing the necessary data for the various project phases. Various techniques use different types of data and information collected from a wide range of sources using different tools, such as statistics, inspections, surveys, documentations and expert judgments. Project risk analysetechniques can be classified into two main categories, namely qualitative and quantitative techniques.

1.7 QUALITATIVE ANALYSIS

Qualitative risk analysis techniques do not operate on numerical data, present result in the form of descriptions,recommendations and ordinal scores, where risk assessments are connected with qualitative description anddetermination of qualitative scales for the probability and impact of the consequences of risk.

The main qualitative analysis techniques are:

- Brainstorming
- Delphi method
- Cause and affect diagram
- Checklist
- Event Tree Analysis (ETA)
- Risk Breakdown Structure (RBS)

Qualitative risk analysis techniques can be lists of risks, risk rankings, or risk maps. These techniques prioritize risks for subsequent further analysis or action by assessed and combined their probability of occurrence and impact. The risk were evaluated in

more conceptual terms, such as high, medium or low, depending upon the collected opinions and risk tolerance boundaries in the organization

1.8 QUANTITATIVE ANALYSIS

A quantitative analysis technique, the estimation of risk exposure related to the application of numerical measures. The impact of consequences defined as a monetary value and the likelihood by the frequency of risk occurrence based on past series of available data. In brief, quantitative techniques numerically analyse the effect of identified risks on the project objectives.

The main quantitative analysis techniques are:

- Decision Tree Analysis
- Expected Monetary Value (EMV)
- Expert judgement
- Fault Tree Analysis (FTA)
- Fuzzy logic
- Probability distribution

Risk Management is the

- a systematic planning process to identify,
- risk mapping
- risk classification
- risk summary making
- risk analysis
- evaluation process
- respond management process(strategies)

- monitor project risks

This study is all about identify the risks factors that affect the performance of bridge projects as a whole and analyse by using appropriate tools and technique and to develop a risk management system.

There are various risk factor in construction industrylike

- Financial risk
- Marketing risk
- Design risk
- Technical risk
- Environmental risk
- Political risk
- Construction risk

RISK ANALYSIS & EVALUTION PROCESS

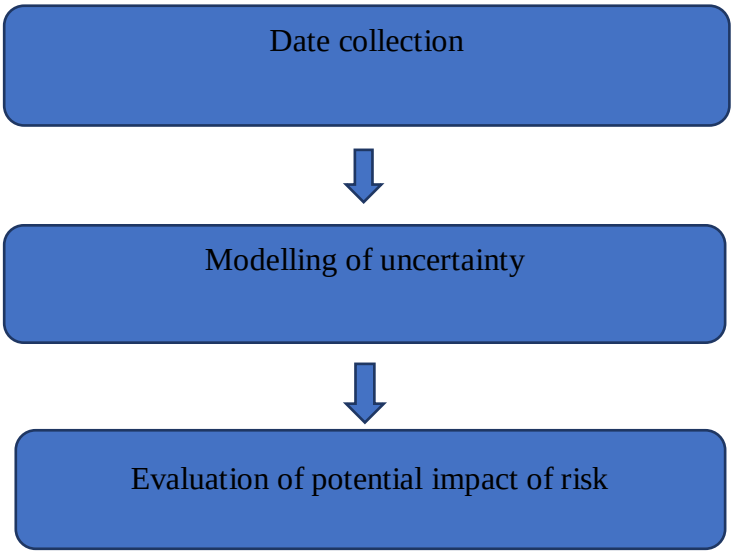


fig 1.risk analysis & evalution process

RISK TREATMENT STRATEGIES

Risk avoidance
Loss reduction & risk prevention
Risk retention and assumption
Risk transfer
Insurance

fig 2.risk treatment strategies

1.9 OBJECTIVE

- To identify potential problems before they occur so that the risk impact can be handle or made under control for minimizing losses in bridge projects.
- To identify the approaches that will help to effectively involve risk management system in bridge projects.

Project delay and cost overrun are recognized as the most common problems faced by contractors, including for Bridge Construction project. Based on thoseconditions, the objectives of this study are to identify the most probable potentialrisks and the impact level of the risk can affect to the objectives the BridgeConstruction project, in order to minimize the risks of Costs and/or Time overruns.

1.10 SCOPE

The scope of this research consists of the following matters-
The concept of risk is multi-dimensional,
so the scopes can be

- Identifying the limitation of risk management process in bridge construction may help in future planning.
- Develop a framework for the Risk Management system and use it.
- The scope of the study will give a better view on risk management in bridge construction.

CHAPTER TWO

LITERATURE REVIEW

1.) TATIANA BELASH, OLEG SAKHAROV (2004) explores the risk assessment for bridges in two ways first way is based on statistical data of previous earthquakes and the second way is based on theoretical investigation of bridges behaviour under earthquake loads, for each type of bridge the correlation between the piers displacements and their damages was estimated.

2.) SHOU QING WANG, MOHAMMED FADHIL DULAIMIAND MUHAMMAD YOUSUF AGURIA-(2004) It is important to manage the risk associated with construction projects, in particular in developing countries. A survey was conducted and twenty eight critical risk were identified, categorized into country, market and project. It is suggested that when mitigation a specific risk, the measures with higher effectiveness should be given higher priority. A qualitative risk mitigation frame work should be proposed providing detailed risk management strategies and procedures.

3.) JUNYING LIU, BINGGUANG LI &BINSHAN LIN-(2007) This research paper is based on the study done by surveys which target people who have direct or relevant experience of risk management and construction in china. Cultural consideration prevent proper implementation of risk management in china's construction, the perception and attitude of contractors plays an important role in developing risk management.

4.) TAEJUN CHOA, TAE SOO KIMB (2008) This study is on Probabilistic risk assessment for the construction phases of a bridge construction based on finite element analysis. share the information throughout the construction life cycle with the support of 3D, design and building information, a "virtual construction"research project started In

Korea. The main objectives of the study are to evaluate the risks in a suspension bridge by considering an ultimate limit state for the fracture of main cable wires and to evaluate the risks for a limit state for the erection control duringconstruction stages.The quantitative results have been compared with the conventional safety indices and allowable error for the control of deformations during construction.

5.) DARIUSZSRORUPKA-(2008) This paper is based on the study of identification and quantification of construction risks based on the Polish market .The risk analysis consists of verbal and quantitative description. Risk indicators are dependent on the type of project and its environment, several indicators could repeat in construction project, therefore fully mitigation of risk cannot be achieved.

6.) Feng Guo , Yan Chang-Richards , Suzanne Wilkinson , Ti Cun Li-(2010) This research paper is based on the case study of Yi-wan Railway Construction Project in China and the Northern Gateway Toll Road (NGTR) Project in New Zealand, the study is based on the how different project governance structures affect the management of risks. A structured mechanism is used to identify and address risks as they occur, A centralized single-agent model and an alliance model were applied in the two projects, respectively comparison shows that project governance provides a structured mechanism to identify and address risks as they occur. Both cases had included flexibility in their contractual arrangements toleverage risks among project participants.

7.) KANSALAND MANOJ (2012) studied the different methodology of risk identification techniques in the construction industry. The construction industry was specialised into industrial construction, infrastructure and heavy construction. The research carried out through questionnaires survey within the construction industry. Risk significant index method, they had analysed the collected data. A three-point rating scale was chosen to differentiate the risks.

Finally, it was identified the current used methods for risk assessments were Brainstorming, checklist, flowchart, Delphi method, Risk significant index method.

8.) RAKHMA DESTRIAN ADI MAHARDIKA (2012) Risk management in bridge construction projects are considered to have more inherent risks because of the involvement of multiple contracting parties, such as owners, designers, contractors, subcontractors, and suppliers. Project delay and cost overrun are recognized as the most common problems faced by contractors, including for Bridge Construction project. To minimise these problems, identification of the most probable potential risks and the impact level of the risk can affect to the objectives the Bridge Construction project become important. The result of this research will provide preliminary data to simplify the Risk Management procedure. Research data obtained from 5 Overhead Bridge construction project reports in Java Island – Indonesia, that have been completed within year 2006-2011.

9.) SAMAN AMINBAKHSH, MURT GUNDUZ, RIFATSONMEZ (2012) A safety risk assessment framework is presented based on the theory of cost of safety (COS) model and the analytical hierarchy process (AHP). The framework provides a decision tool for the decision makers to determine the adequate accident prevention investment while considering the funding limits. In the framework, the AHP served as a tool for checking and reducing the inconsistencies of safety risk assigned by the expert. The framework decomposed the decision problem into a hierarchy of more easily comprehended sub-problems that enhanced assignments of weights to the criteria and sub-criterions.

10.) Patrick X.W. Zou, Shouqing Wang and Dongping Fang-(2012) This paper isbased on extensive theoretical research and literature reviews, coupled with case study methodologies. To develop a life cycle risk management framework for public private partnership (PPP) infrastructure projects that lead to the realization of value for

money and balance of interests between different partners including the public and end users.

11.) AR.AKSHATA YASHWANT BEHERE (2012) Risk Management includes identifying, analyzing and responding to risk factors throughout the life of a project. An organization may use risk assumption, risk avoidance, risk retention, risk transfer, or any other strategy (or combination of strategies) in proper management of future. The acceptance or non-acceptance of a risk is usually dependent on the tolerance level for the team handling the risk. this research has been made to promote a proper use of Risk management in a given project. Aim is to study and analyse the risk factors in infrastructural projects by using relative importance index. Also the objective is to understand concept of Risk Management and its process in the Project, understand various techniques which are used for solving the risk problems, to study and compare the outcomes with similar completed projects, carry out Questionnaire survey at different sites in Pune Region and also to understand RII method for Risk Management in the construction project.

12.) HARIHARASUBRAMANYAN,PRIYADARSHH.SAWANT,VANDANA BHATT(2012) according to them risk is part of construction project .the focus of the paper is to identify the risk factors which influence the smooth running of a project, the questionnaire was prepared and filled by contractors, owners, project management experts and a total of 93 risk factors were listed in the research. fuzzy analytical hierarchy process (AHP).the risk response strategy suggested in this paper will be useful in mitigating the adverse effects of risk .

13.) KINNARESH PATEL (2013) discussed the risks which were identified in two ways for better decision making. Using the work break down structure the level of risk was determined. Through questionnaires survey they collected necessarydata. With the help of the brainstorming session questionnaire was prepared. Primavera software was

used to analyse the risk. They investigated that financial risks and construction risk were most influenced risk in Indian construction.

14.) FENG GUO , YAN CHANG-RICHARDS , SUZANNE WILKINSON , TI CUN LI-(2013)

This research paper is based on the case study of Yi-wan Railway Construction Project in China and the Northern Gateway Toll Road (NGTR) Project in New Zealand, the study is based on the how different project governance structures affect the management of risks. A structured mechanism is used to identify and address risks as they occur, A centralized single-agent model and an alliance model were applied in the two projects, respectively comparison shows that project governance provides a structured mechanism to identify and address risks as they occur. Both cases had included flexibility in their contractual arrangements toleverage risks among project participants.

15.) ATHONY D. SONGER-(2014) As per recent trends alternative procurement methods such as design-build, construction management and privatization increased the use of evolving methods which produces higher level of uncertainty with respect to long term performanceRisk Analysis tools provide improved information for pre-project decision making and performance outcome.

16.) K.JAYASUDHA DR.B.VIDIVELLI AND E.R. GOKUL SURJITH (2014) This research describes risk assessment and management in construction projects and their methodology is to study depend largely on the survey questionnaire from contractors and project manager by email or personnel meeting. The research seek out the risk factors that affect the performance of bridge project and analyse by using appropriate tools and technique like bar charts were subjected to the software of SPSS, time and finance management factors analysis of t-test and ANOVA were calculated and tabulated to develop a risk management framework.

17.) SHEN JIAN-FEI-(2014) Engineering projects are large-scale, technically complex, object-oriented, long-period, risky and susceptible to construction time and fund which lead projects to be quite possibly influenced by natural and social environment and other factors. In this paper a case study is done on residential construction project and the data was collected and after that it was utilized the expert investigation method and fault tree analysis method is used for mitigation of risk.

18.) DZIADOAZ REJMENT (2015) studied the three different methods of the risk analysis as well as stress their disadvantages, advantages and primary areas of application. These methods differ in their methodology from each other.
Analyse was done using statistical method, which determines the type of used data hence it affects the quality of the results. The result of the paper was to use the method for identification and preliminary assessment of risk by the matrix of risk and develop risk assessment model in construction projects it should be emphasized on the compilation available.

19.) NASER AND KODUR (2015) discussed the important factor that was used to quantify fire risk in present and new bridges and provide guidelines for designers to tackle the fire hazard in bridges. The degree of vulnerability ofstructural and sub structural component to fire mainly depend on fire resistance of various structural members of bridge.

20.) NEERAJ AND BALASUBRAMAN (2015) studied the key factors of risk in construction industry through mock reviews. many factors influenced risks in construction were analysed through pilot study, which include experts of academicians, government sectors and construction industry were interviewed, and interviewed experts obtained twenty two evaluation criteria as the key factor. This approach provides a more effective, accurate and organised decision support tool.

21.) NAN LI, DONGPING FANG AND YU SUN-(2015) This paper is based on the approach that interprets the subjective risk assessments by experts with a statistical method motivated by a cognitive psychology theory. By considering attributes of risks as random variables, experts as information processing systems, and expert opinion solicitation as a sampling process on the variables, the approach is designed to estimate the probability distributions of the attributes of perceived risks and analyze their criticality.

22.) TANER YILMAZ (2015) explored the risk assessment of highway bridge under multi-hazard effect of flood-induced scour and earthquake. The main aim is to improve a comprehensive knowledge-base on risk and reliability analyses of highway bridge subjected to uncertainty(multi-hazard) by developing risk assessment framework. The entire methodology is applied to real-life bridge to access multi-hazard performance of bridge ,the same framework is utilized to perform uncertainty analysis, the last phase of analyses of genric bridge considering four combinations of seismic and flood hazards based on their hazard levels.

23.) PATRICK X.W. ZOU, SHOUQING WANG AND DONGPING FANG-(2016) This paper is based on extensive theoretical research and literature reviews, coupled with case study methodologies. To develop a life cycle risk management framework for public private partnership (PPP) infrastructure projects that lead to the realization of value for money and balance of interests between different partners including the public and end users.

24.) R.SHAKTI GANESH (2017) This research is to providerisk assessment tool for the construction projects by usingFailure mode cause and Effective Analysis (FMEA).Aliteraturestudy were done to mitigate various potential riskfactors affecting construction productivity ateach stages ofconstruction progress. The main objective of this research is to investigate

the factors contributing to risks in construction projects andalso to explore the potential risk factors causing severity byusing failure mode and effective analysisConstruction Risks are more probable in theconstruction phase and post construction phase withoutproper planning in the pre-construction and also in designstages of the project. The study was used to identify thepotential risk factors that contribute to major risks or loss ofresources involved in construction projects

25.) B.VIDIVELLI, E.VIDHYASAGAR AND K.JAYASUDHA (2017) studied the prime 7 categories under which 50 questions on risk factors by the survey questionnaire with the alike societies of the bridge construction area which are contractor,engineers, designers etc. The comeback were evaluated using the software of SPSS which analyses the complex statistical data on the factors segregated into distinct set of critical factor. Various demographic experiment are done in this study.This study aims to identify the factor of bridge construction project and incorporating critical factors to improve risk analysis.

26.) ARDIYANTO NUGROHO AND YUSUF LATIEF (2018) this research is to develop a work breakdown structure on risk for cost control of steel bridge construction projects. Work breakdown standardization is very important as it affects the cost control .WBS is steel structure bridge based on regulation of the general specification of Toll road 2017 from toll road regulatory agency (BPJT) for controlling project cost. After analysis there are 15 dominant risk variables for the RBS input and there steel girder erection as the dominant sub work section resulting from pareto analysis for the WBS input of RBS*WBS matrix.

27.) HERY SULIANTORO, NURUL FITRIANI AND BAGUS HARIO SETIADJI (2018)- this research explained that the risk is the condition to uncertainty, whose effect can be managed and minimize by using risk management process This research was implemented on bridge construction work on toll road project in Pejagan-Pemalang, Pemalang-Batang and Salatiga-Kertasura. This research is to analyze the risk of bridge

development project in toll road project usingRisk Breakdown Structure (RBS) method and then the result as database indiscussing risk response strategy. There are 36 risks that affect the bridge construction procurement project. Obtained 1 (one) high category risk that is bad weather risk, this result is based on a particular toll road bridge.

28.) MR. RANJITH (2018)- this research studied the impact of risk management in construction project. This methodology was depended on the research design, approach and data. The survey was conducted in two part, first part ask the procedure followed in the organization to manage risk, second part survey attempts to specify if the project they experienced achieved the success criteria,successful implementation of risk management system to meet the scope of work.

29.) MADHAV PRASAD KORIRALA (2018) – this research is on risk factors in construction infrastructures projects & safety engineering practiced in Nepal, developing countries like Nepal where safety in comparatively lower then prosperous and accidents are not analyse in the form of risk factor, there basis methodology is ground survey by engineers. This research is for proper implementation of proper safety acts for construction industry.

RESEARCH PAPER STUDIES OUTCOME

1. Risk significant index method, they had analysed the collected data. A three-point rating scale was chosen to differentiate the risks.
2. A qualitative risk mitigation frame work should be proposed providing detailed risk management strategies and procedures.
3. Risk indicators are dependent on the type of project and its environment, several indicators could repeat in construction project, therefore fully mitigation of risk cannot be achieved.
4. Risk Management includes identifying, analyzing and responding to risk factors throughout the life of a project.
5. A safety risk assessment framework is presented based on the theory of cost of safety (COS) model and the analytical hierarchy process (AHP). The framework provides a decision tool for the decision makers to determine the adequate accident prevention investment while considering the funding limits
6. Aim is to study and analyse the risk factors in infrastructural projects by using relative importance index.
7. The research seek out the risk factors that affect the performance of bridge project and analyse by using appropriate tools and technique like bar charts were subjected to the software of SPSS, time and finance management factors analysis of t-test and ANOVA were calculated and tabulated to develop a risk management framework.

CHAPTER THREE

METHODOLOGY

This research focused on the intrinsic area of risk analysis, was carried out in a systematic manner. The literature review included academic journals, books and other published materials. The research methodology of the study included the process to classify the awareness on implementation of risk analysis in bridge construction projects. To provide a foundation a several structured questionnaire was developed, which wasfollowed throughout the project.

3.1 QUESTIONNAIRE PREPARATION

Based on the extensive literature reviews and expert's advice, the questionnaire consist of twenty eight risks fewer than five risk factors. Responses on the extent of effect of those attributes on bridge construction were sought on a four-point ordinal scale: "1" referred to "Ignore ," "2" to "Low," "3" to "Moderately," "4" to"High" and "5" . The extent of their contribution has, however, been observed to vary for a given level of project performance. The analysis result expected to help project professionals to focus on a few factors and get the optimum results rather than giving attention to all the factors and not getting the proportionate results. The questionnaire was prepared which included 5 types of risk factors. Though there were many types of risks which affected the bridge construction projects, those 5 risk factors were considered the most easy to collect all the sub risk factors. The questionnaire aimed to explore seventy risk factors related to bridge construction projects, which is time consuming and may retard respondents from participation. Secondly, the questionnaire content is broad and may not be within the knowledge context of some industries practitioners. The large sample may weaken the effectiveness of the questionnaire survey. The risk factors were further integrated in 50

sub risk factors, these sub factors were included in respective risk factor category based on the type of risk associated with the bridge construction project. The risk factors are as follows:

- Financial Risk
- Insurance Risk
- Contractual Risk
- Management Risk
- Design Risk
- External Risk
- Time Management Risk

The research study basically focus on all aspects and intrinsic area of risk analysis and its management which will be carried out in a discipline and systematic manner. This section describes the methods and procedures used in this study. Systematic research is illustrated by the flow chart that explains each step to be passed from this research.
The research methodology of the study included the process to classify the awareness on implementation of risk analysis in bridge construction projects. To provide a foundation a several structured questionnaire was developed, which was followed throughout the project.

BASIC STEPS OF THE STUDY AND DATA COLLECTING SYSTEM EXPLAINED IN THIS SECTION:

fig.3 basic steps of the study and data collecting system explained in this section:

1) **MOCK QUERY PREPARATION**-preparing question for the related people Like-
   what is the cause of occurrence of risk?
   Ranking of risk?
   Losses due to risk?

2) **Conducting Survey**-on site survey and off-site survey to get the information
3) **Classification Of Factors Of Risk**- financial risk, management risk, insurance risk, design risk, contractual risk, climatic risk , external risk
4) **Quantitative Analysis**- management tools like cause and affect diagram, checklist, risk breakdown structure, brainstorming, Delphi method, event tree analysis.
5) **Qualitative Analysis**- management tools likes decision tree analysis, expert judgement,expected monetary value, probability distribution, fuzzy logic.
6) **RANKING OF RISK**- levelling of rank by first to last.
7) **GRAPHICAL STUDY**- representation of risk by graphs

3.2 QUESTIONNAIRE SURVEY

PART(A)

1) OFFICAL ADDRESS OF FIRM-
2) AFFILIATON-
3) WORK PLACE LOCATION-
4) WORK TYPE-
5) WORK EXPERIENCE-
6) NUMBER NAME OF FIRM-
7) OF PROJECT EXECUTED IN LAST 10 YEARS-

Q-1: What is your Designation?

1) Construction Manager
2) Managing Director
3) Resident Engineer
4) Manager
5) Technical supervisor
6) Project Chairman
7) Other……

Q-2: Would you mention age group (in yrs)

1) Less than 35
2) 35-45
3) 45 or above

Q-3: Would you mention your years of experience in construction industry/business?

1) Less than 5
2) 5 to 10
3) 10 or above

Q-4: May I know your education status?

1) Less than diploma certificate level
2) Diploma certificate level
3) Bachelor level
4) Master level
5) Ph. D level

Q-5: How does it take to complete a typical project?

1. 1 yrs
2. 1-2 yrs
3. 2-3 yrs
4. 3-4 yrs

PART (B)

3.3 QUESTIONS RELATED TO RISK MANAGEMENT PROCESS

1. Do you give importance to the risk management in your organization?

   [ ] YES [ ] NO

   If yes ,please state how do you implement risk management and to what extent.

   Note

   -
   -

2. What are positive things of adopting a risk management system in your projects ?

   Note

   -
   -

3. What are types of risk associated with the bridge projects? grade them in the sequence of impact?

   [ ] design risk [ ] financial risk [ ] environmental risk

   [ ] contractual risk [ ] operational risk

   [ ] land acquisition [ ] accidental risk

4. How do achieve a effective risk management system in your system?

   Note

   -
   -

5. What are the issues in stablishing a risk management system?

   Note

3.4QUESTIONNAIRE FORMAT

Q 7- Consider a typical project you manage with the attributes you described .

1: Ignore

2: Low

3: Moderately

4: Higher

N = Total Number Of Respondents.

CATEGORY	**RISK DESCRIPTION**	**NUMBEROF RESPONDENTS SCORING**				**TOTAL**
		4	**3**	**2**	**1**	
Financial risk	Delay from clients	2	12	9	6	29
	Failure to meet revenue targets	4	13	9	3	29
	Estimated finance than expected	8	4	6	11	29
	Unpredictable variation in raw material price	12	7	6	4	29
	Liquidity of company	5	9	12	3	29
	Inflation	4	11	10	4	29
Technical Risk	Incomplete project design	11	7	6	5	29
	Improper specification	5	14	6	4	29
	Late changes of design from client side	2	10	13	4	29

	Complexity of project design	4	6	13	6	29
	Change in seismic criteria	6	8	9	6	29
	Design error delivered by the owner.	6	6	10	7	29
	Delays and mistakes in producing design documents	4	10	10	5	29
Construction risk	Disputes on project site	5	4	3	17	29
	Change in sequences of construction activity.	9	5	8	7	29
	Work permissions	4	5	8	12	29
	Worker and site safety	16	8	3	2	29
	Performance delay	16	8	3	2	29
Political risk	Pressure from any political party	5	8	11	5	29
	Union issue	3	10	7	9	29
	Chance of sub-contractor walkout	3	12	10	4	29
	Revision of price	6	10	9	4	29
	Unexpected regulatory controls or licensing requirements	8	10	5	6	29
	Change in government	4	6	10	9	29
Legal risk	Failure to achieve satisfactory contractual	3	7	13	6	29

	arrangement					
	Loss of intellectual property rights	5	9	7	8	29
	Environmental board issue	4	8	8	9	29
	Unforeseen inclusion of contingent liabilities	4	6	16	3	29

Table 1 questionnaire and response value

CHAPTER FOUR

DATA ANALYSIS

Once the data has been collected successfully then it will be analysis works. These data are to represent on Excel sheet software and was used to calculate and analyze statistical data which was collected in the questionnaire so as to carry out the data analysis in this research.

4.1 SPSS-[Statistical package for social sciences]- SPSS is a widely used program for statistical analysis in social science. It is also used by market researchers, health researchers, survey companies, government, education researchers, marketing organizations, data miners, and others. The original SPSS manual (Nie Bent & Hull, 1970) has been described as one of "sociology's most influential books" for allowing ordinary researchers to do their own statistical analysis. In addition to statistical analysis, data management (case selection, file reshaping, creating derived data) and data documentation are features of the base software.

4.2 RII INDEX METHOD-

Data of all these tables were analyzed by a RII Index was calculated for each type of claims as follows;

RII Index = $\sum$ W / (A X N)

Where, W = weight given to each factor by the respondents, ranges from 1 to 4,

A = highest weight (i.e. 4 in this case) and

Category	Risk description	Number of respondents scoring				Total (N)	Weighting (∑ W)	RII Value =∑ W/ A*N	Rank
		4	3	2	1				
Financial Risk	Delay from clients	2	12	9	6	29	68	0.58	12*
	Failure to meet revenue targets	4	13	9	3	29	76	0.65	5
	Estimated finance than expected	8	4	6	11	29	67	0.57	13
	Unpredictable variation in raw material price	12	7	6	4	29	85	0.73	2
	Liquidity of company	5	9	12	3	29	74	0.63	6*
	Inflation	4	11	10	4	29	73	0.62	7
TechnicalRisk	Incomplete project design	11	7	6	5	29	82	0.70	3
	Improper specification	5	14	6	4	29	78	0.67	4
	Late changes of design from client side	2	10	13	4	29	68	0.58	12
	Complexity of project design	4	6	13	6	29	66	0.56	14
	Change in seismic criteria	6	8	9	6	29	72	0.62	8
	Design error delivered by the owner.	6	6	10	7	29	69	0.59	11
	Delays and mistakes in producing design documents	4	10	10	5	29	71	0.61	9
Construction risk	Disputes on project site	3	11	9	7	29	70	0.60	10
	Change in sequences of construction activity.	5	4	3	17	29	55	0.47	18

	Work permissions	9	5	8	7	29	74	0.63	6
	Worker and site safety	4	5	8	12	29	59	0.50	17
	Performance delay	16	8	3	2	29	96	0.82	1
Political risk	Pressure from any political party	5	8	11	5	29	71	0.56	8*
	Union issue	3	10	7	9	29	65	0.62	15
	Chance of sub-contractor walkout	3	12	10	4	29	72	0.65	7*
	Revision of price	6	10	9	4	29	76	0.65	5*
	Unexpected regulatory controls or licensingrequirements	8	10	5	6	29	78	0.67	4*
	Change in government	4	6	10	9	29	63	0.54	16
Legal risk	Failure to achieve satisfactory contractual arrangement	3	7	13	6	29	65	0.56	15*
	Loss of intellectualproperty rights	5	4	7	13	29	59	0.50	17*
	Environmental board issue	4	2	8	15	29	53	0.45	19
	Unforeseen inclusion of contingent liabilities	4	6	16	3	29	69	0.59	11*

Table 2questionnaire, response value and RII calculation

4.3RANKING TABLE OF RISK FACTORS

The rank table by RII values is below-

RISK DESCRIPTION	Rank
Performance delay	1
Unpredictable variation in raw material price	2
Incomplete project design	3
Improper specification	4
Unexpected regulatory controls or licensing requirements	4*
Failure to meet revenue targets	5
Revision of price	5*
Work permissions	6
Liquidity of company	6*
Inflation	7
Chance of sub-contractor walkout	7*
Change in seismic criteria	8
Pressure from any political party	8*
Delays and mistakes in producing design documents	9
Disputes on project site	10
Design error delivered by the owner.	11
Unforeseen inclusion of contingent liabilities	11*
Late changes of design from client side	12
Delay from clients	12*
Estimated finance than expected	13
Complexity of project design	14
Union issue	15
Failure to achieve satisfactory contractual arrangement	15*
Change in government	16
Worker and site safety	17
Loss of intellectual property rights	17*
Change in sequences of construction activity	18
Environmental board issue	19

Table 3ranking of factors

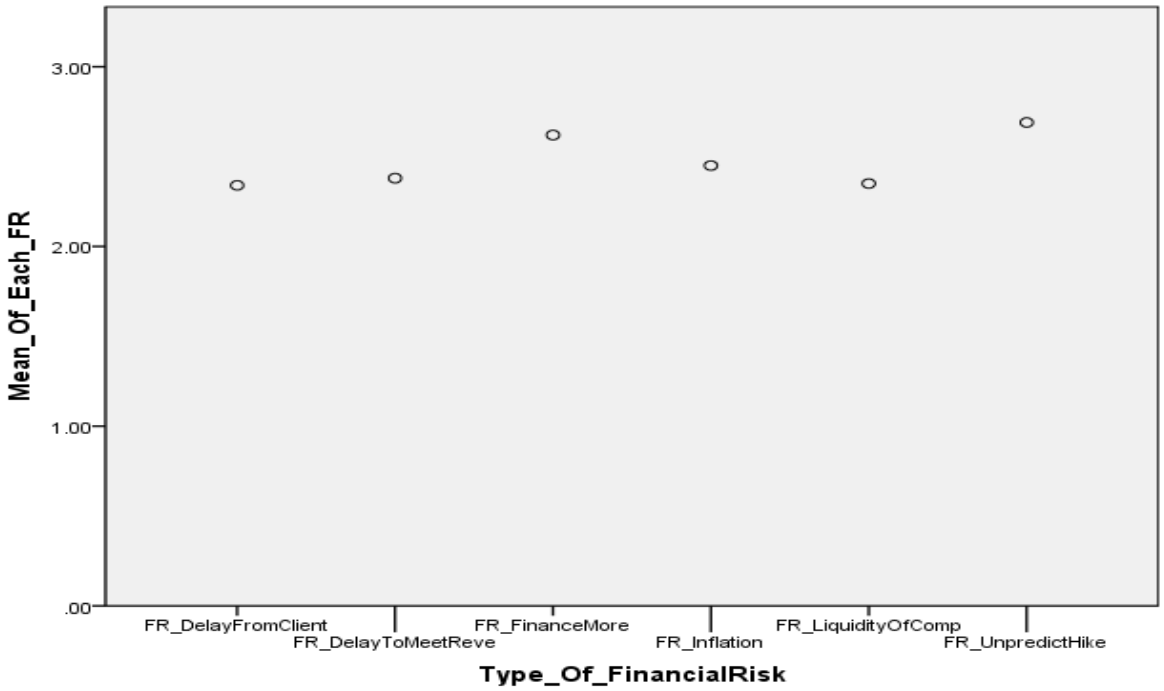
CASE PROCESSING SUMMARY

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
FinancialRisk_DelayFromClient	29	100.0%	0	.0%	29	100.0%
FinancialRisk_DelayToMeetRevenueTarget	29	100.0%	0	.0%	29	100.0%
FinancialRisk_FinanceMoreThanExpected	29	100.0%	0	.0%	29	100.0%
FinancialRisk_UnpredictableHikeInRawMaterialPrice	29	100.0%	0	.0%	29	100.0%
FinancialRisk_Inflation	29	100.0%	0	.0%	29	100.0%
FinancialRisk_LiquidityOfCompany	29	100.0%	0	.0%	29	100.0%

Table 4case processing summaryof financial risk

REPORT

	Financial Risk_DelayFromClient	FinancialRisk_DelayToMeetRevenueTarget	FinancialRisk_FinanceMoreThanExpected	FinancialRisk_UnpredictableHikeInRawMaterialPrice	FinancialRisk_Inflation	FinancialRisk_LiquidityOfCompany
N	29	29	29	29	29	29
Mean	2.34	2.38	2.62	2.69	2.34	2.45
Std. Deviation	.769	.862	.775	.850	.769	.910
Kurtosis	-.441	-.408	-.111	-.124	-.441	-.709
Skewness	-.195	.222	-.187	-.458	-.195	-.141



Graph 1 Financial Risk

CASE PROCESSING SUMMARY

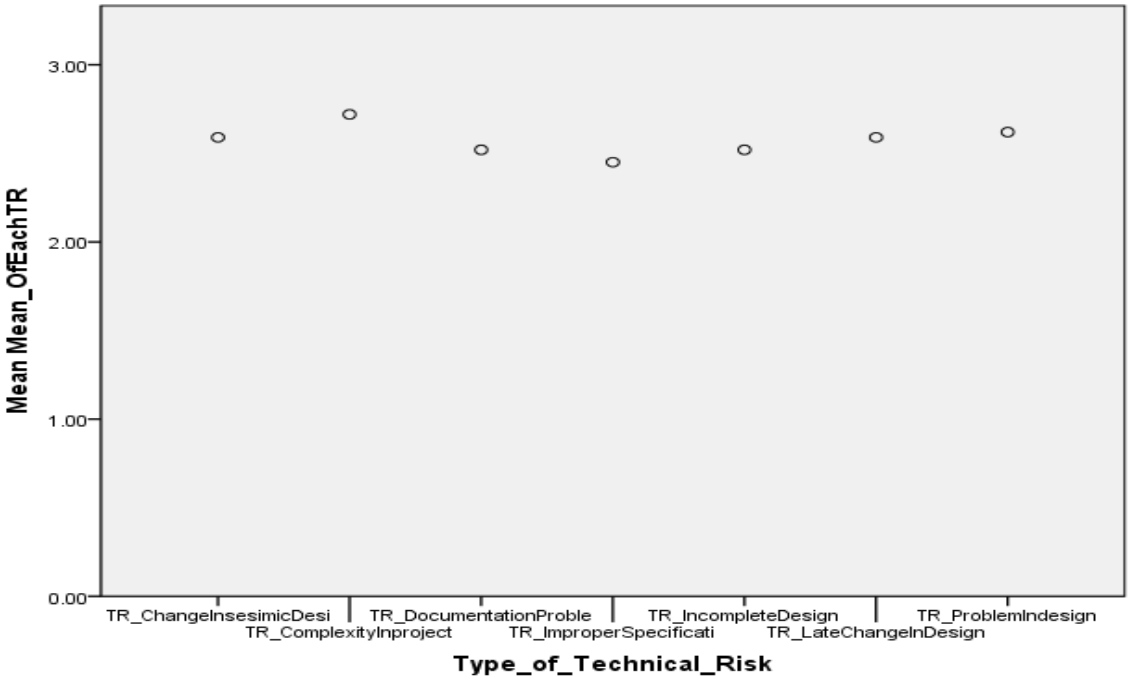
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
TechnicalRisk_IncompleteProjectDesign	29	100.0%	0	.0%	29	100.0%
TechnicalRisk_ImproperSpecification	29	100.0%	0	.0%	29	100.0%
TechnicalRisk,LateChangeInDesign	29	100.0%	0	.0%	29	100.0%
TechnicalRisk_ComplexityInProject	29	100.0%	0	.0%	29	100.0%
TechnicalRisk_ChangeInSesimicCreteria	29	100.0%	0	.0%	29	100.0%
TechnicalRisk_DesignErrorByOwner	29	100.0%	0	.0%	29	100.0%
TechnicalRisk_ProblemInDEsignDocument	29	100.0%	0	.0%	29	100.0%

Table 6case processing summary of technical risk

REPORT

	TechnicalRisk_IncompleteProjectDesign	TechnicalRisk_ImproperSpecification	TechnicalRisk_LateChangeInDesign	TechnicalRisk_ComplexityInProject	TechnicalRisk_ChangeInSesimicCretieria	TechnicalRisk_DesignErrorByOwner	TechnicalRiskProblemInDesignDocument
N	29	29	29	29	29	29	29
Mean	2.52	2.45	2.59	2.72	2.59	2.62	2.52
Std.Deviation	.829	.910	.780	.960	1.086	1.083	.911
Kurtosis	-.366	-.629	-.202	-.588	-1.219	-1.166	-.662
Skewness	-.059	.164	-.065	-.436	-.148	-.244	-.055

Table 7 report of spss technical risk



Graph 2 technical risk

Table 8 case processing summary of construction risk

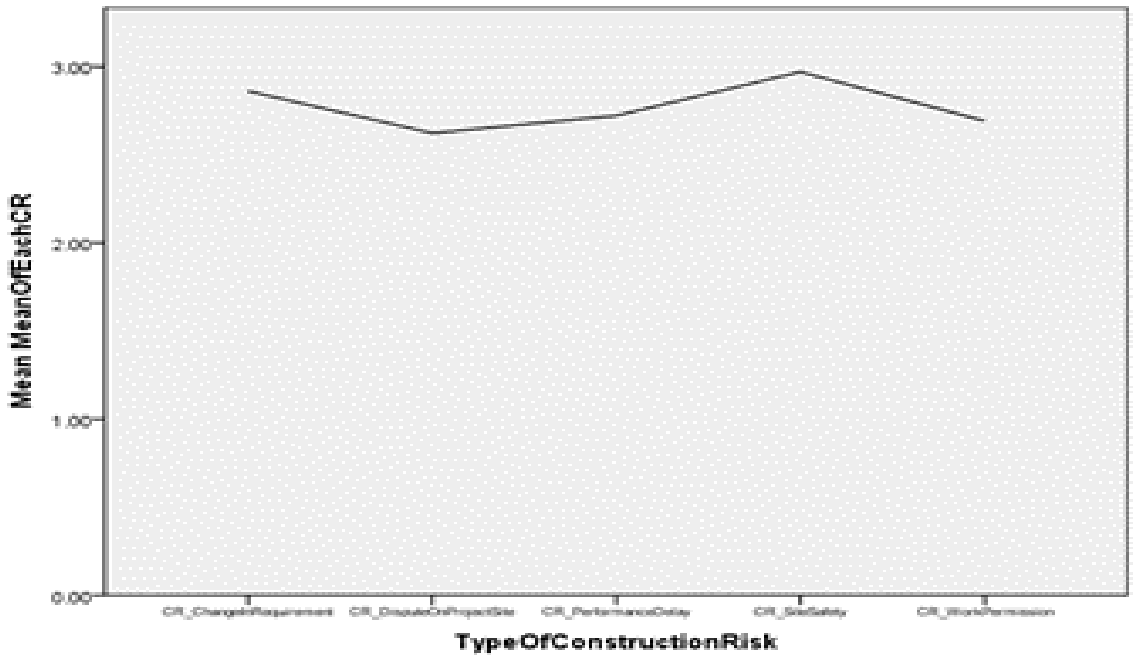
CASE PROCESSING SUMMARY

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
ConstructionRisk_DisputeOnProjectSite	29	100.0%	0	.0%	29	100.0%
ConstructionRisk_ChangeInRequirement	29	100.0%	0	.0%	29	100.0%
ConstructionRisk_WorkPermission	29	100.0%	0	.0%	29	100.0%
ConstructionRisk_SiteSafety	29	100.0%	0	.0%	29	100.0%
ConstructionRisk_PerformanceDelay	29	100.0%	0	.0%	29	100.0%

REPORT

	ConstructionRisk_DisputeOnProjectSite	ConstructionRisk_ChangeInRequirement	ConstructionRisk_WorkPermission	ConstructionRisk_SiteSafety	ConstructionRisk_PerformanceDelay
N	29	29	29	29	29
Mean	2.62	2.86	2.69	2.97	2.72
Std. Deviation	.942	.789	.930	1.085	.922
Kurtosis	-.860	-.329	-.459	-.867	-.612
Skewness	.038	-.211	-.458	-.648	-.279

Table 9report ofspssconstruction risk



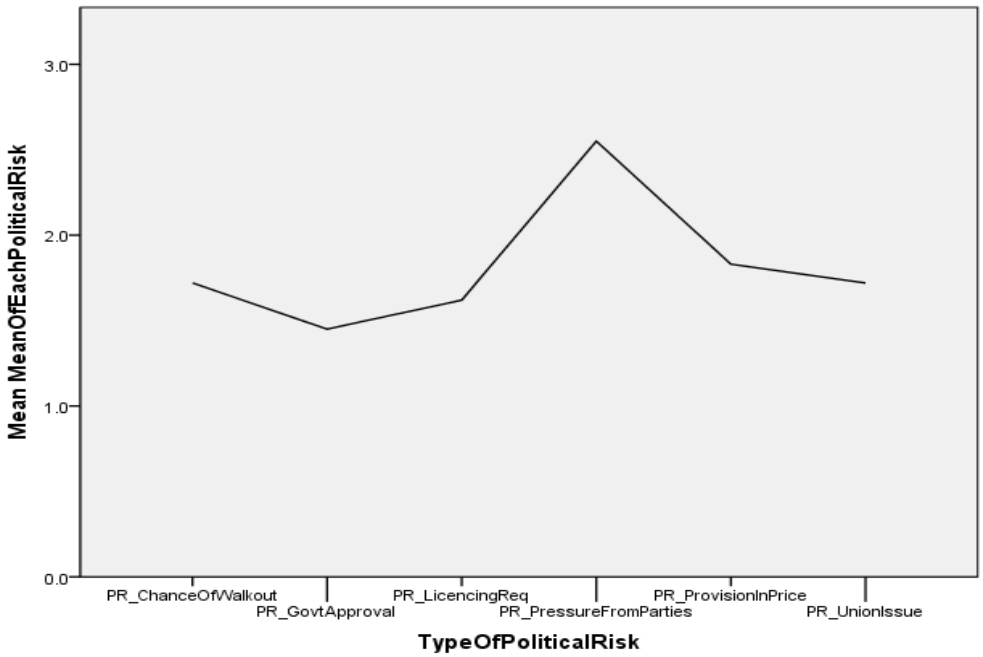
Graph 3 construction risk

Table 10 case processing summary of political risk

REPORT

	PoliticalRisk_PressureFromParties	PoliticalRisk_ChanceOfContractorWalkout	PoliticalRisk_UnionIssue	PoliticalRisk_ProvisionInPrice	PoliticalRisk_LicencingRequirement	PoliticalRisk_ChangeInGovt
N	29	29	29	29	29	29
Mean	2.55	1.72	1.72	1.83	1.62	1.45
Std. Deviation	.985	.841	.751	.848	.820	.736
Kurtosis	-.898	-1.339	-1.001	-1.535	-.965	.337
Skewness	-.154	.580	.514	.350	.835	1.345

Table 11report ofspsspolitical risk



Graph 4 Political risk

CASE PROCESSING SUMMARY

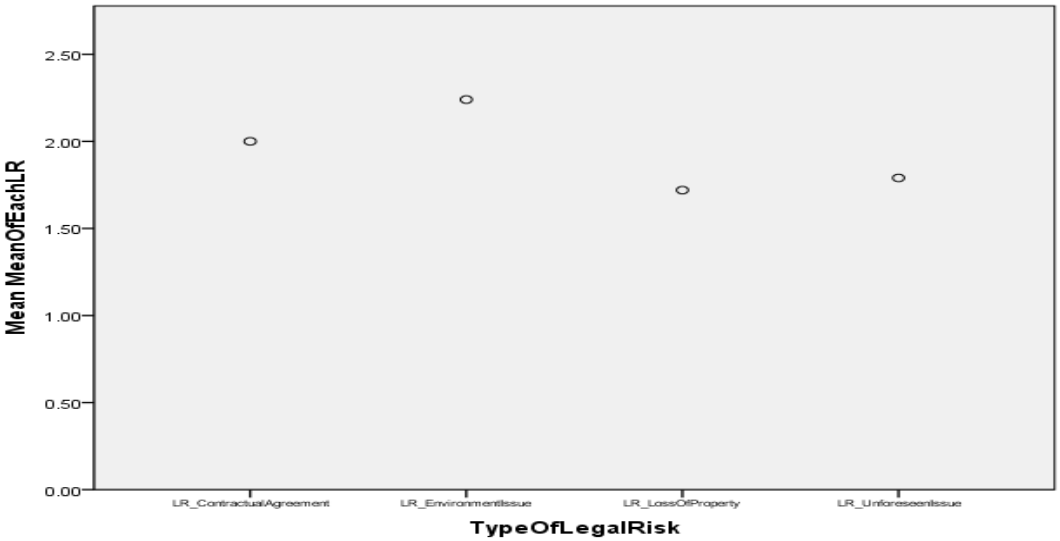
	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
LegalRisk_ContractualAgrreement	29	100.0%	0	.0%	29	100.0%
LegalRisk_LossOfIntelluctualProperty	29	100.0%	0	.0%	29	100.0%
LegalRisk_EnvironmentIssue	29	100.0%	0	.0%	29	100.0%
LegalRisk_UnforeseenIssue	29	100.0%	0	.0%	29	100.0%

Table 12case processing summary of legal risk

REPORT

	LegalRisk_ContractualAgrreement	LegalRisk_LossOfIntelluctualProperty	LegalRisk_EnvironmentIssue	LegalRisk_UnforeseenIssue
N	29	29	29	29
Mean	2.00	1.72	2.24	1.79
Std. Deviation	1.035	.922	1.023	.902
Kurtosis	-1.268	-1.601	-1.444	-1.673
Skewness	.415	.602	-.094	.439

Table 13report ofspsslegal risk



Graph 5 legal risk

RANK

Created Variables[b]

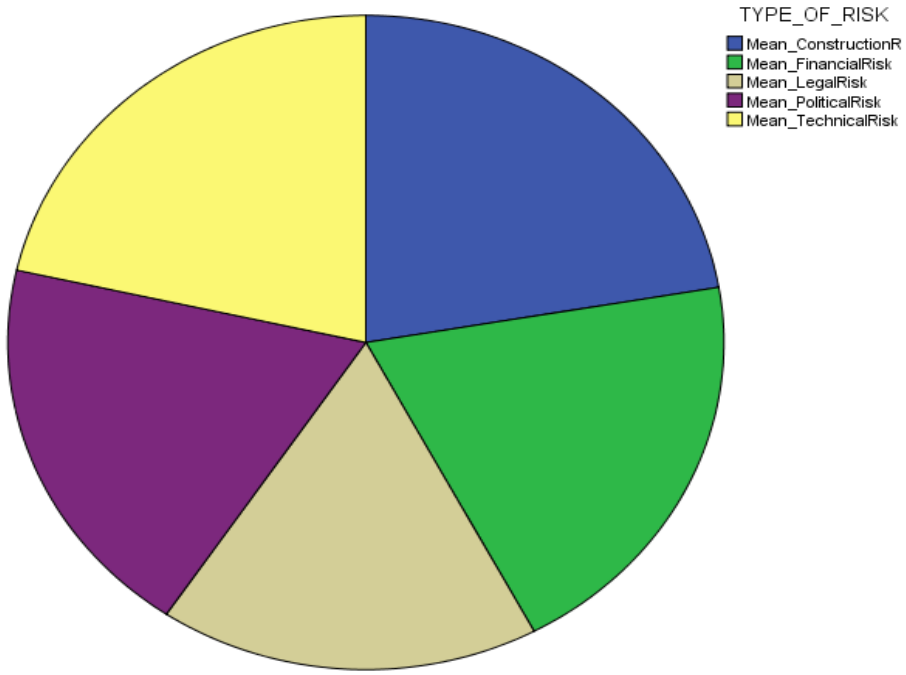
Source Variable	Function	New Variable	Label
MEAN_OF_EACH_RISK[a]	Rank	RAN001	Rank of MEAN_OF_EACH_RISK

a. Ranks are in descending order.

b. Mean rank of tied values is used for ties.

Table 14report of rank by spss

DEMOGRAPHIC REPRESENTATION



CHAPTER FIVE

CONCLUSION & RECOMMENDATION

This concluding chapter providing insights into the major findings of the research. It further provides recommendation in risk management in bridge construction.

5.1 CONCLUSION

This research can conclude a better risk management frame work for construction of bridges and can give a system to tackle the risk by its factor of impact .

This study will help for further research. The following conclusions were drawn from the data analysis:The demographical analysis of the respondents, based on the age the respondents were of all age groups .The overall ranking of risk factors for the five categories were analysed, the RII Value ranging from 0.82 to0.45 as considered as the most critical factors in the bridge projects. the top ten ranking of risk factors were asfollows: Delay during construction process, Lack of coordination, Safety equipment for workers, manymodifications on design are made during execution, Unavailability of land and right of way that restricts

access to the site, Casting and curing time is more, Inexperience when pricing tenders, Unrealistic costestimate and schedules, the owner lags behind in paying the contractors and Low level of capability ofcontractor.

5.2 RECOMMENDATION

Contracting documents to be legally registered

• Contracting duration must be specified with adjustment in case of natural calamity

- Payment mode to be specified based on progress or duration
- Specification or Dimension changes to be recorded in register
- Disputes and Errors to be solved with record proofs
- Meeting conducting periodically
- Insurance on Equipment, Machineries and Manpower to be pre-determined
- Political and Local issues to be solved by whom must be pre-determined
- Re-work must be denoted under whose scope based on fault.
- Client to be pay the payment as per modes to the contractor
- Client payment should be through BANK transaction
- Client may monitor the contractor's payment to workers
- Workers' wages also to be paid through BANK transaction
- Workers' wages to be paid in weekly or monthly payment
- Delaying payment to Workers will affect the progress
- Do not delay or reduce the wages based on Financial difficulties of contractor
- Incentives or Bonus from profit will enthusiast the workers
- Increment based on experience or efficiency will lead the workers to retain
- Client's Slow payment for completed works will affect contractor pay to labour
- Skilled staff to be deployed for tendering
- Technical skilled person to be execute the work
- Highly technically experienced person to be administrate the project
- Sufficient technical information’s to be provided in the drawings and documents
- Necessary technical trainings to be provide to the workers
- High tech technology equipment and machineries to be used to get fast and accuracy.

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APPENDIX

NAME & OFFICAL ADDRESS OF FIRM-

33 responses

PGD Construction Ltd

Rml

Amrapali Sapphire Sector 45 Flat: O-

PNC Infratech limited, near bhagwan talkies, district

NA

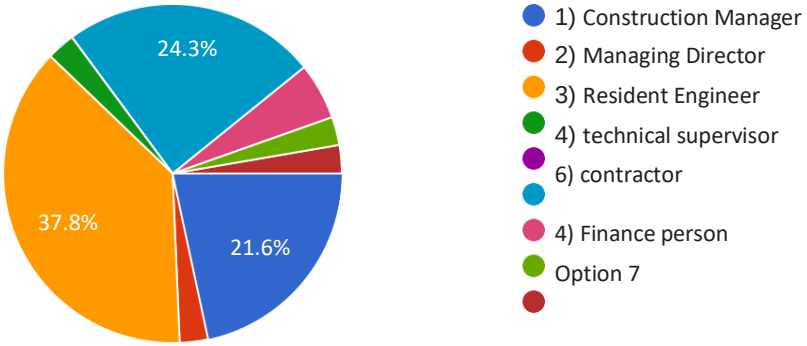
Xyz

Miral Infrastructure

Ambeybuildinfra ltd

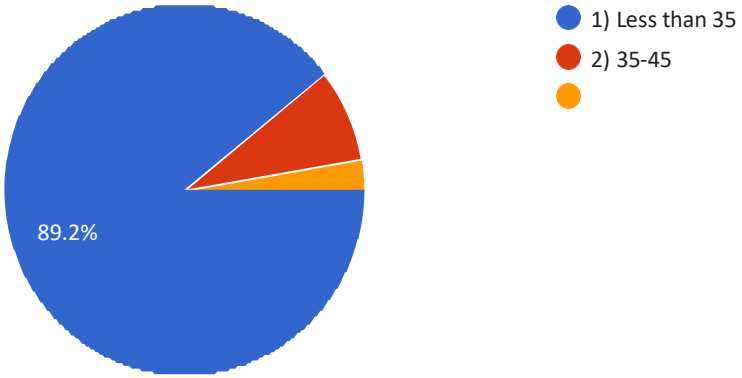
Nilson, Afcons Infrastructure

Q-1: What is your Designation?



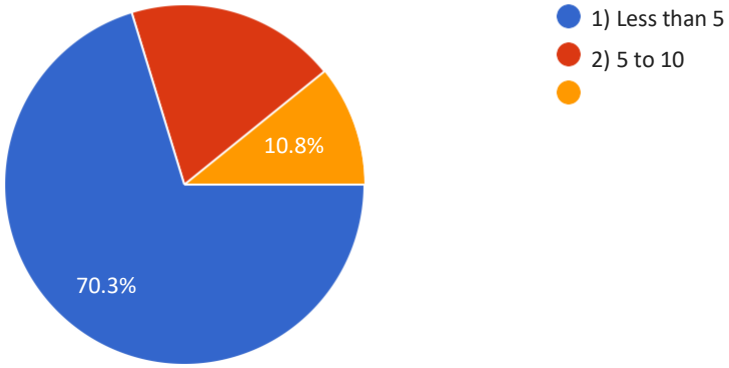
Q-2: which age group do you belong to?

37 responses

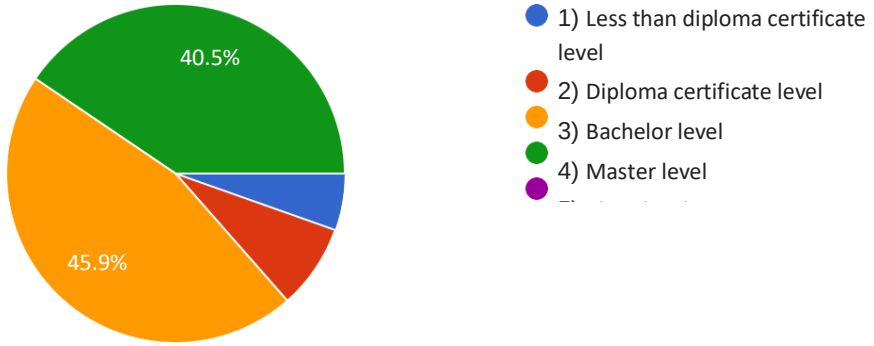


experience in constructionindustry/business?

37 responses

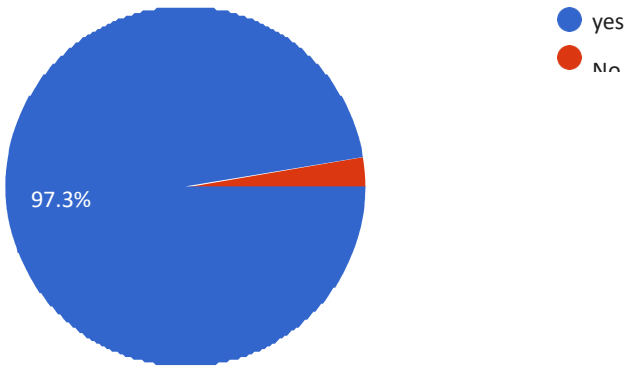


Q-4: May I know your education status?

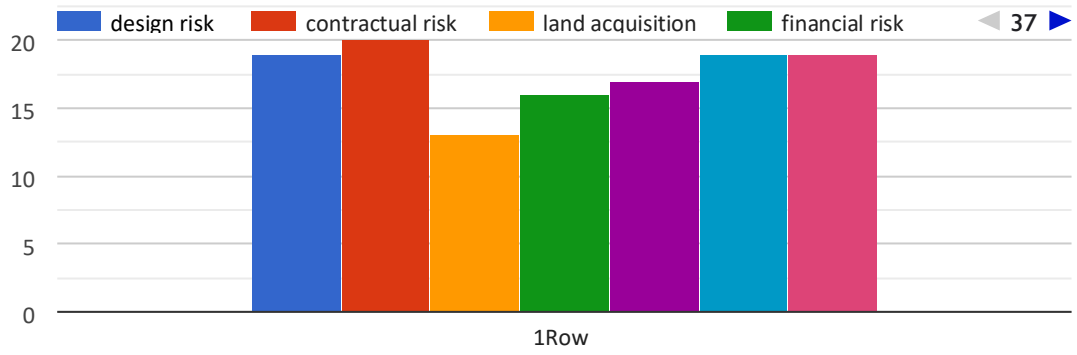


5. Do you give importance to the risk management in your organization?

37 responses

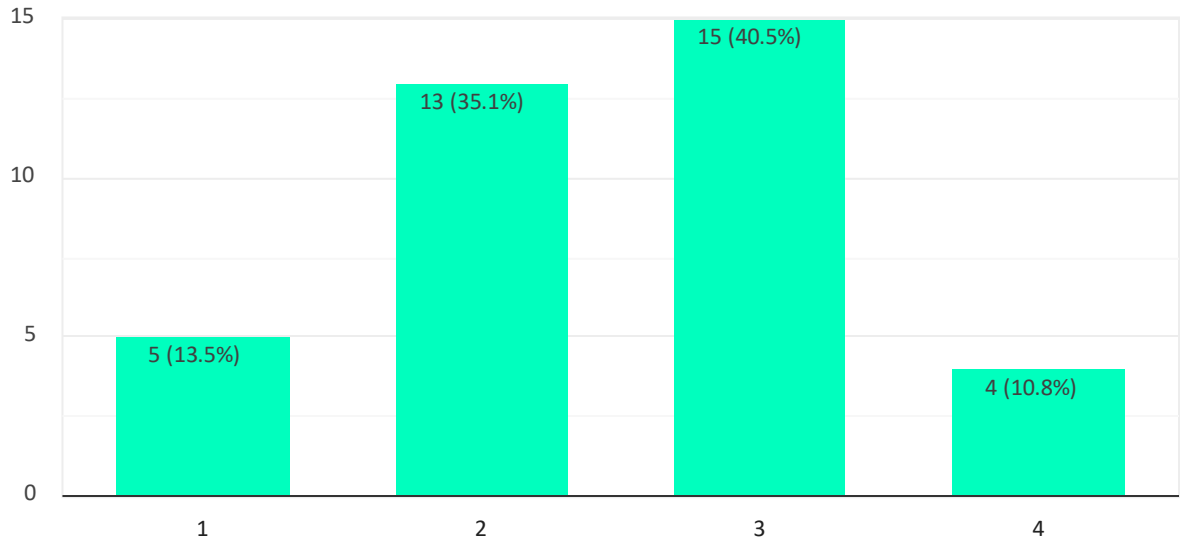


6.Whattypesofriskareassociatedwiththebridgeprojects?markthe



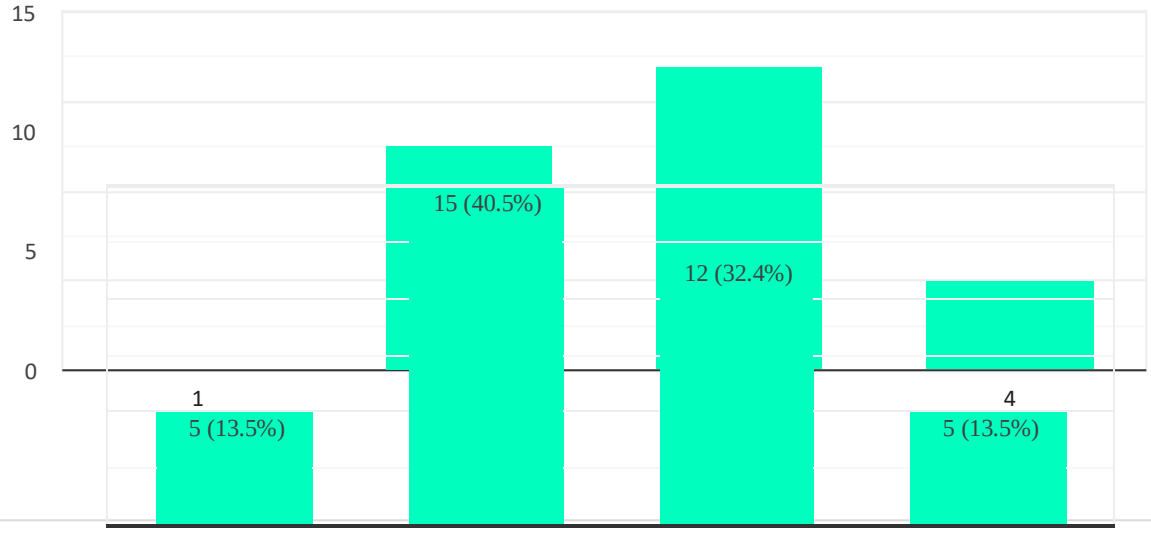
7(a)- Financial risk (Delay from clients)

37 responses



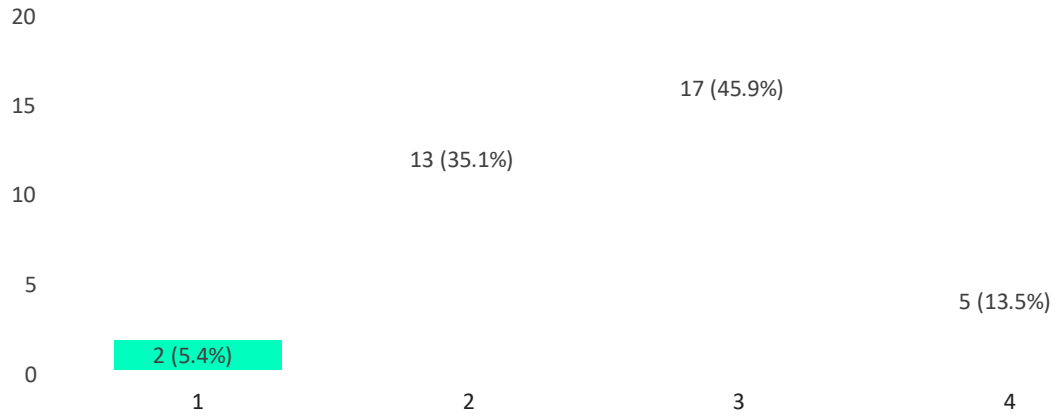
7(b)-Financial risk (Failure to meet revenue targets)

37 responses

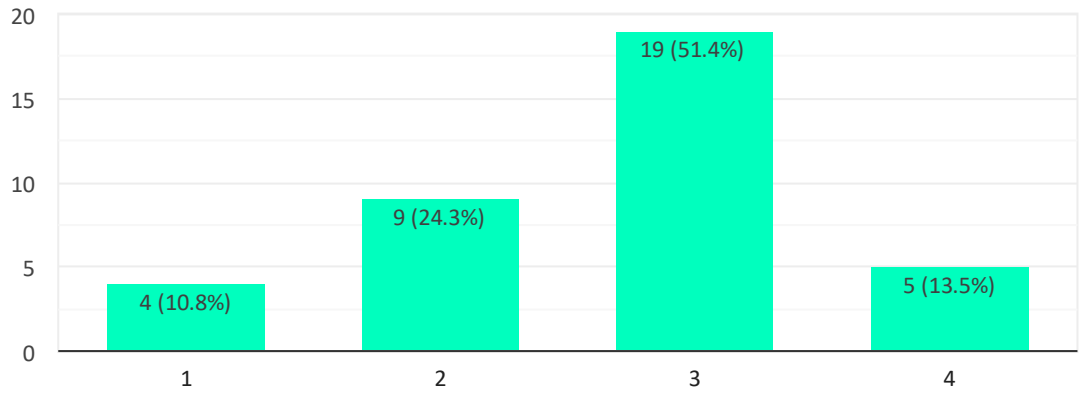


7(c)- Financial risk (Estimated finance than expected)

37 responses

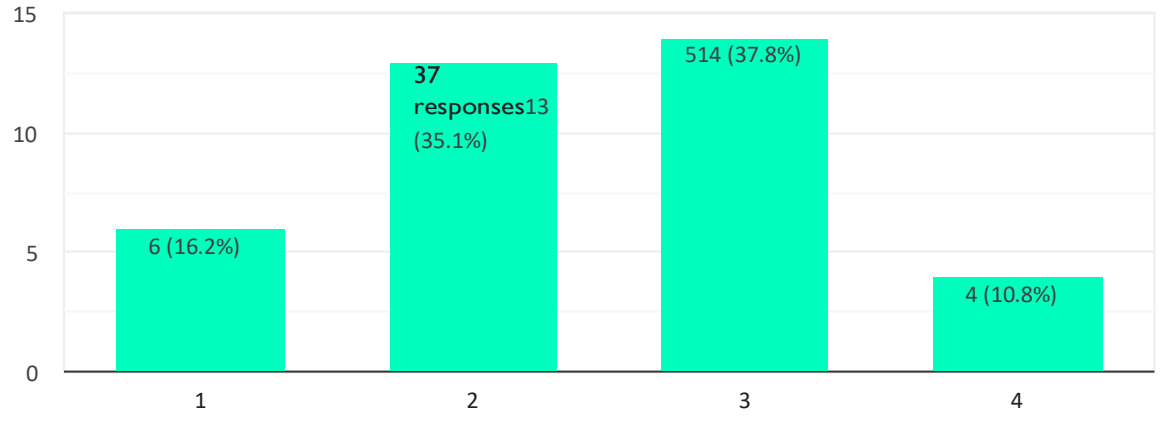


7(d)- Financial risk (Unpredictable variation in raw material prices)



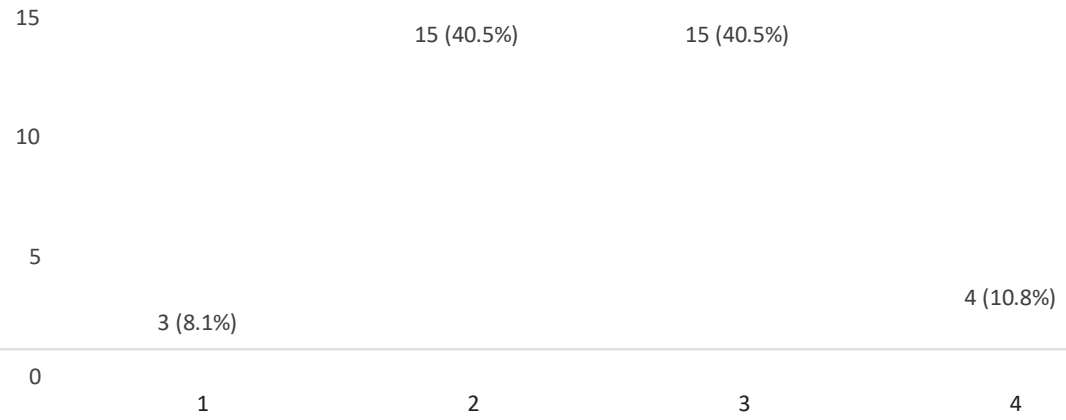
7(e)- Financial risk (Liquidity ofcompany)

37 responses

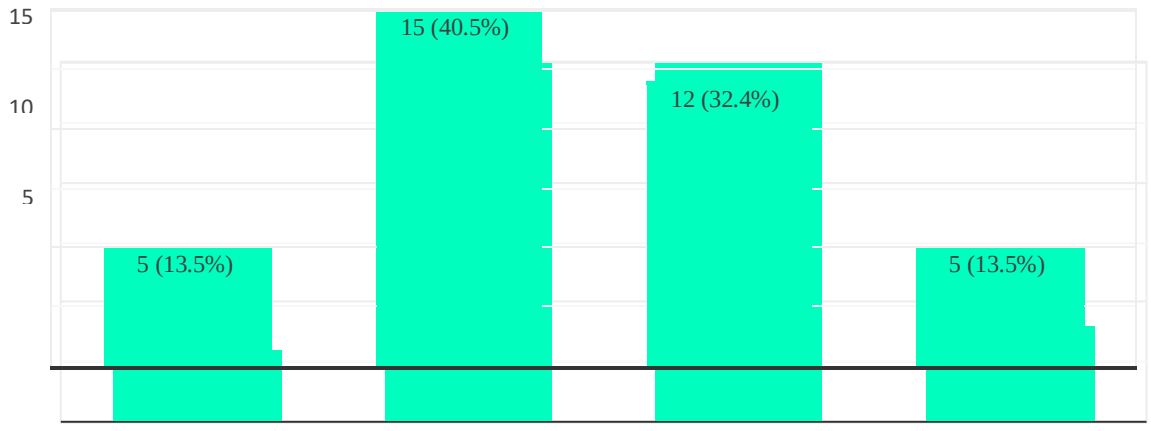


8(a)-Technical Risk (Incomplete projectdesign)

37 responses

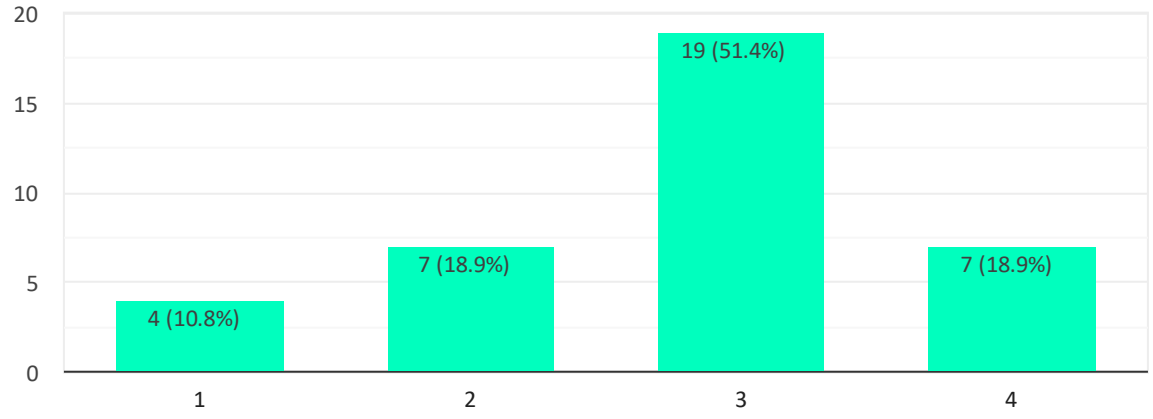


8(b)- Technical Risk(Improper specification)



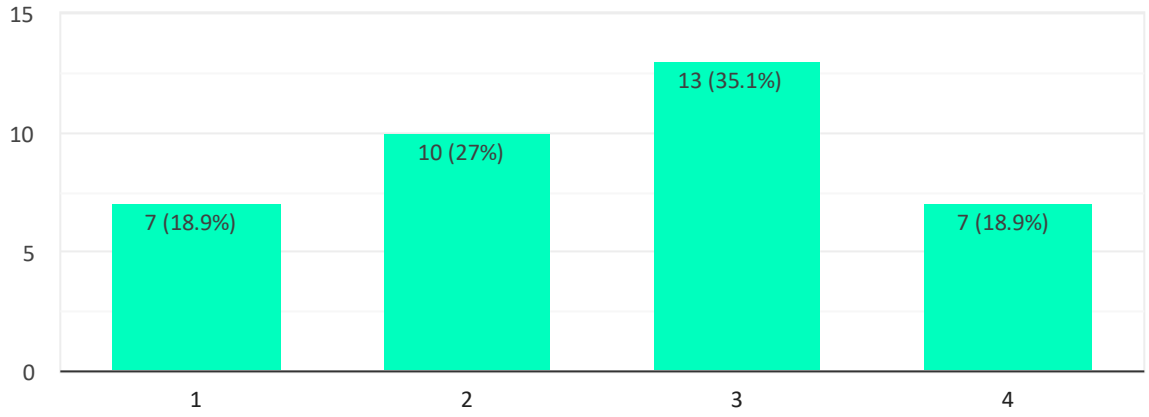
8(d)-Technical Risk(Complexity of project design)

37 responses



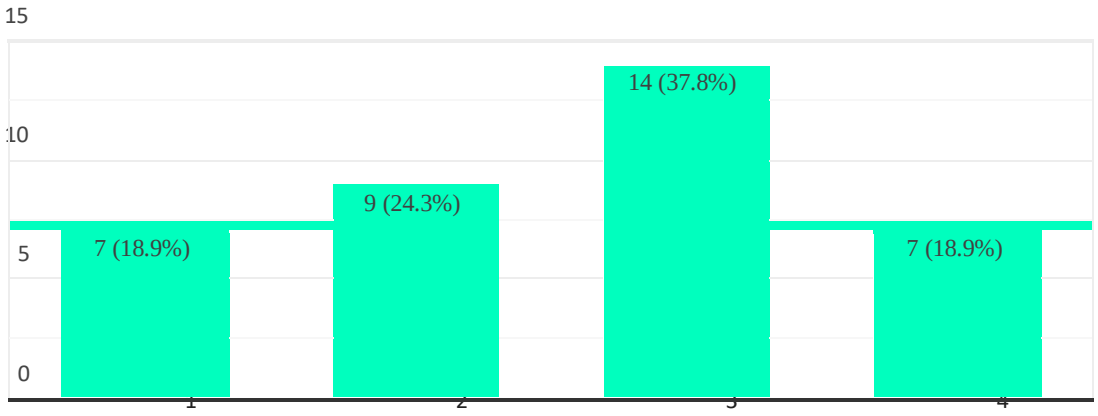
8(e)- Technical Risk(Change in seismic criteria)

37 responses



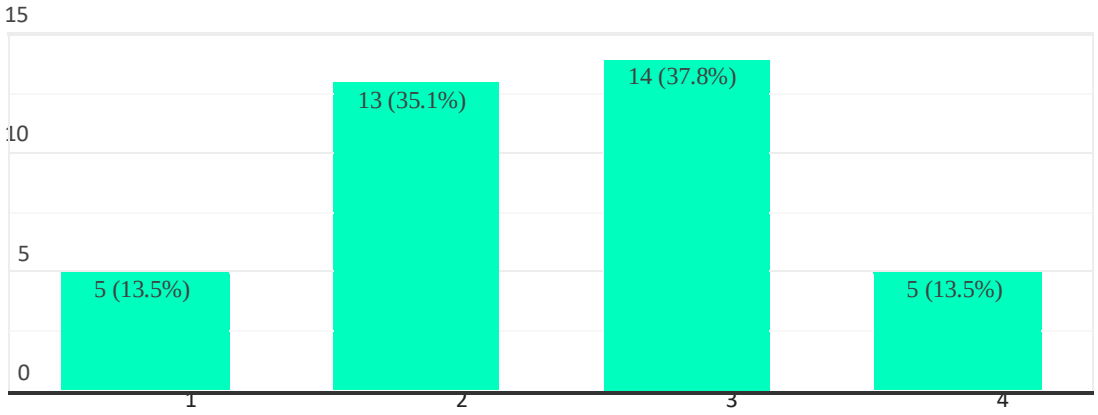
8(f)-Technical Risk(Design error delivered by theowner)

37 responses



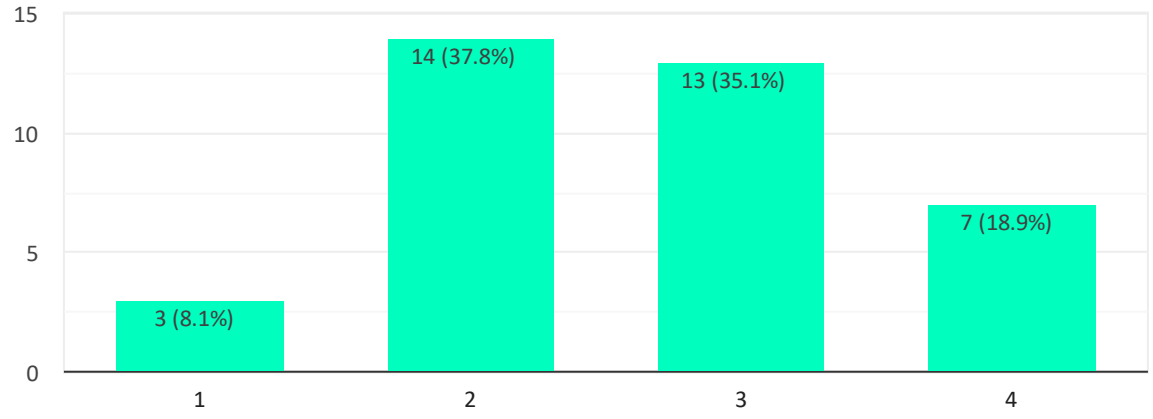
8(g)-TechnicalRisk(Delaysandmistakesinproducingdesigndocuments)

37 responses



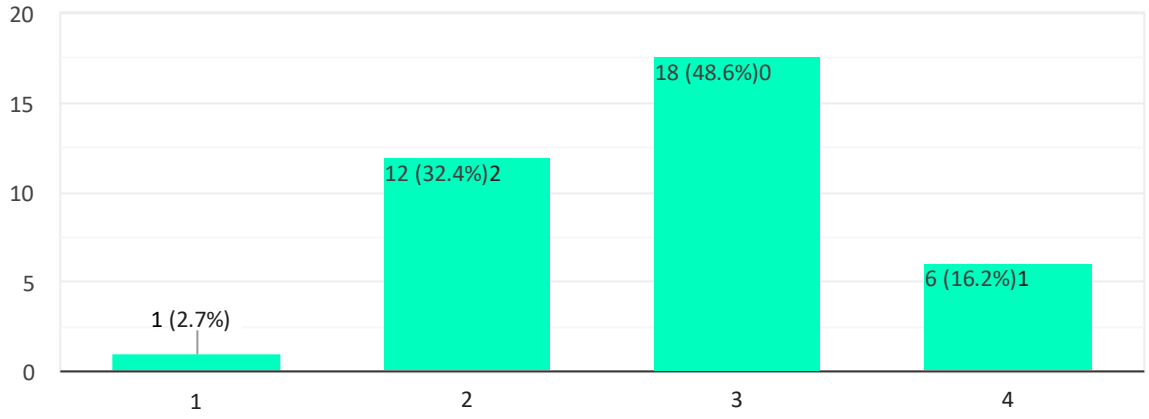
9(a)-Construction risk(Disputes on project site)

37 responses



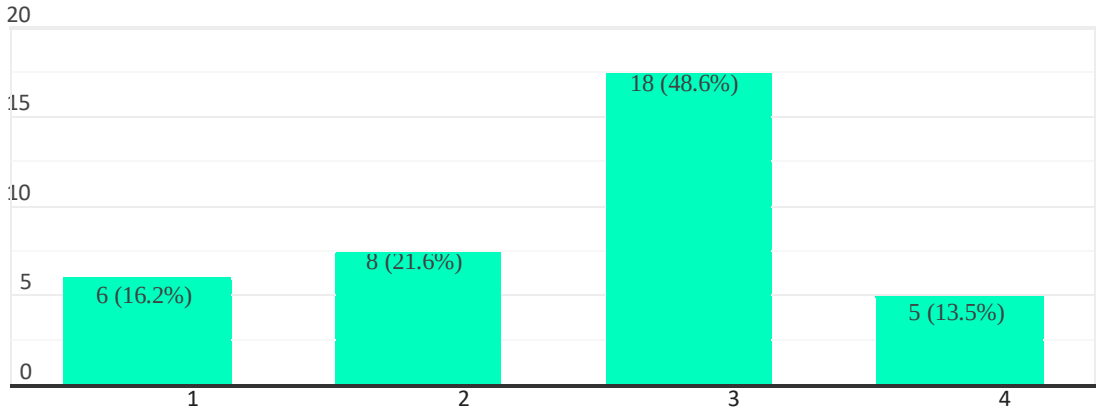
9(b)-Constructionrisk(Changeinsequencesofconstructionactivity)

37 responses

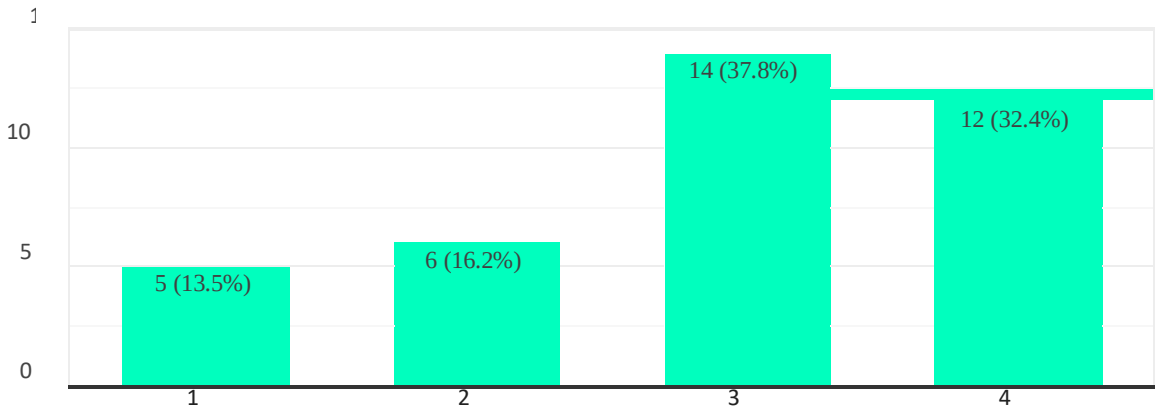


9(c)-Construction risk(Work permissions)

37 responses

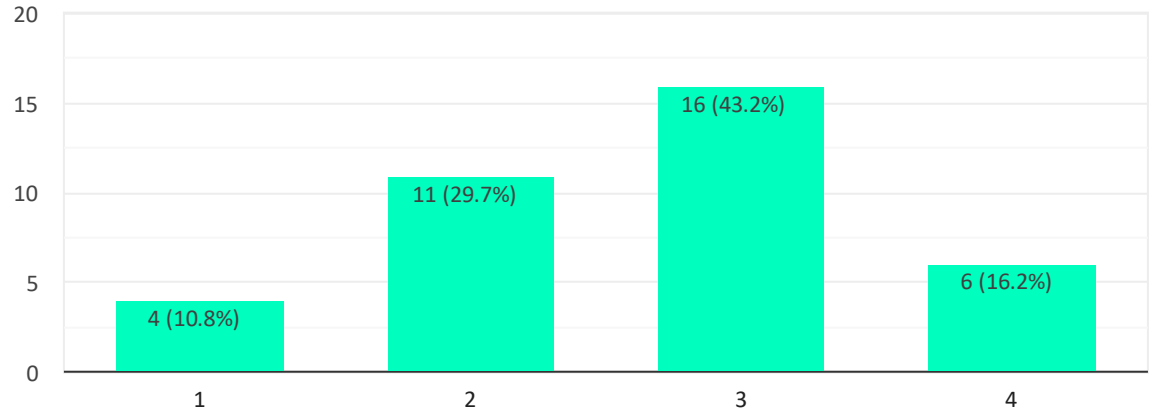


9(d)-Construction risk(Worker and site safety)

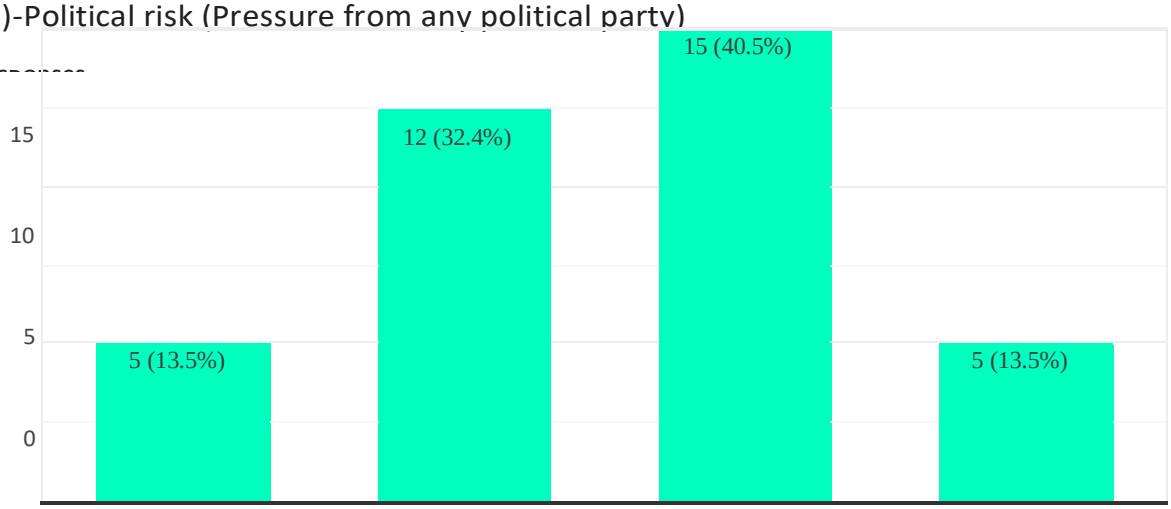


9(e)-Construction risk(Performance delay)

37 responses

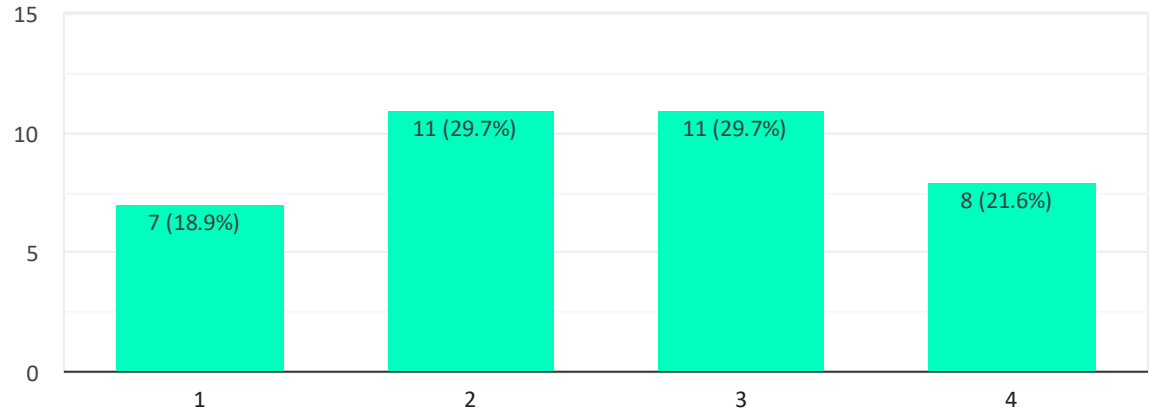


10(a)-Political risk (Pressure from any political party)



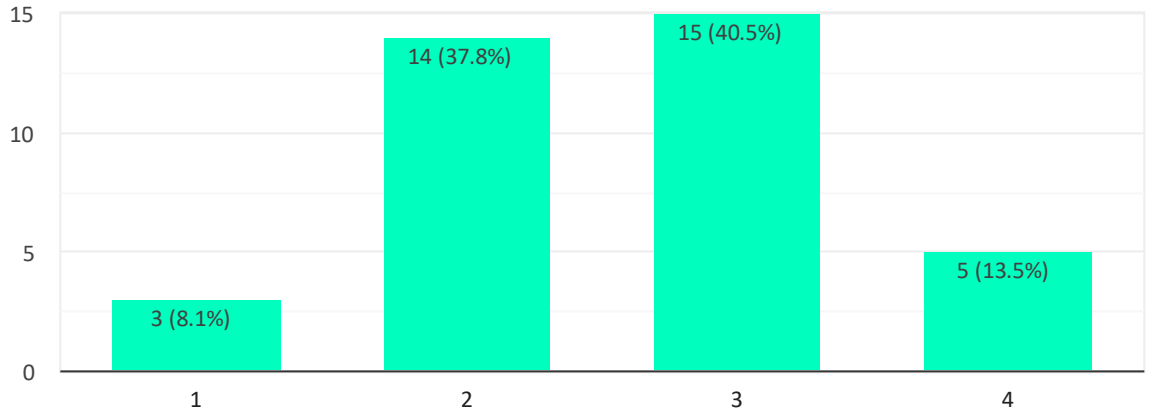
10(b)-Political risk (Union issue)

37 responses

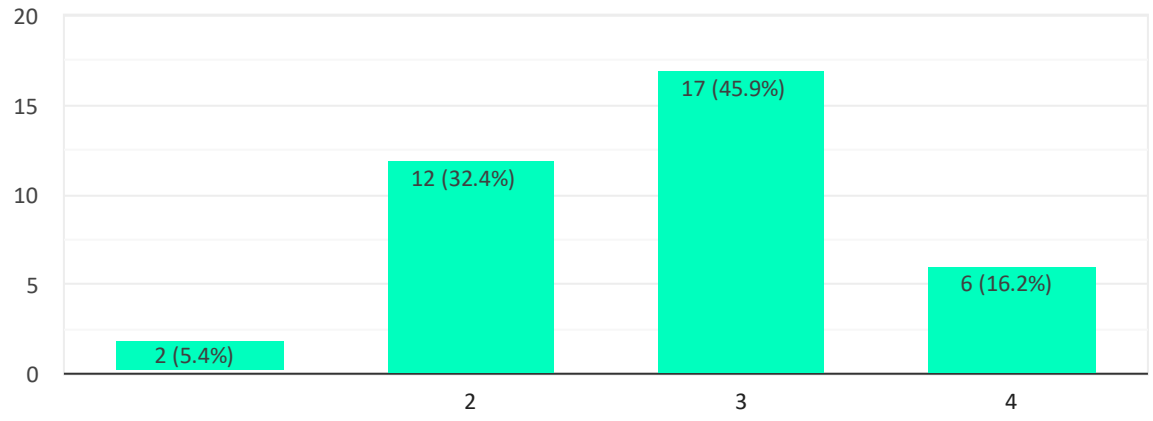


10(c)-Politicalrisk(Chanceofsub-contractorwalkout)

37 responses

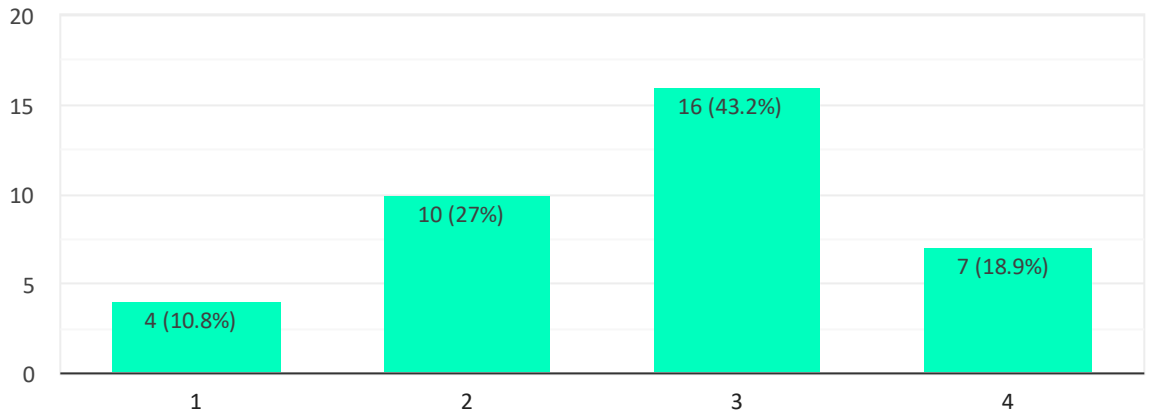


10(d)-Political risk (Revision of price)



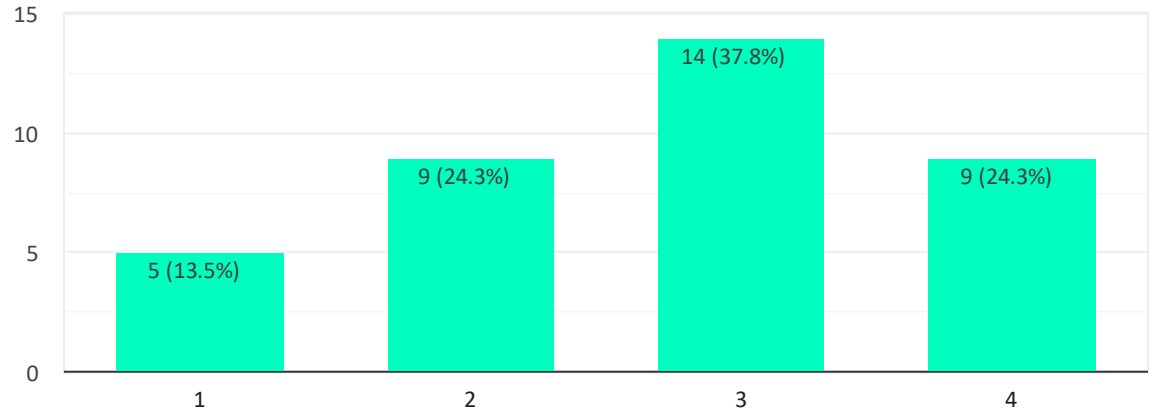
10(e)- Political risk (Unexpected regulatory controls or licensing requirements)

37 responses



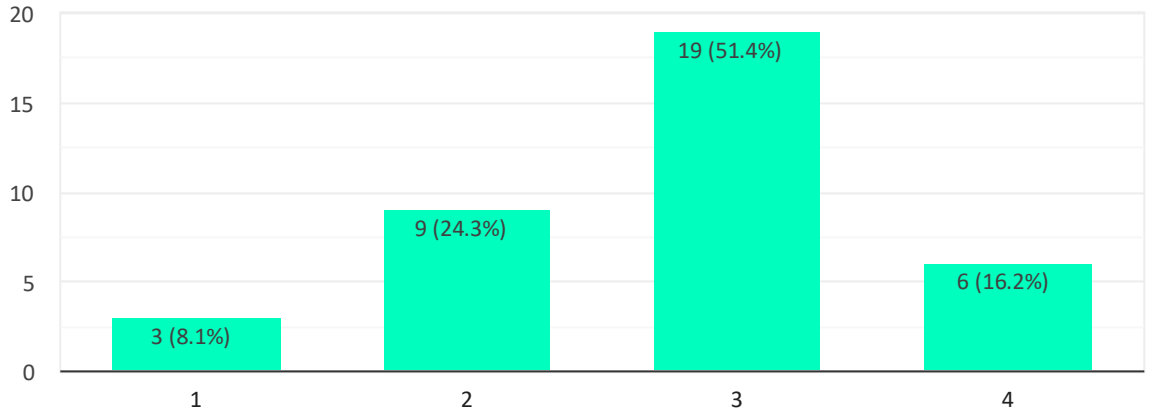
10(f)-Political risk (Change ingovernment)

37 responses



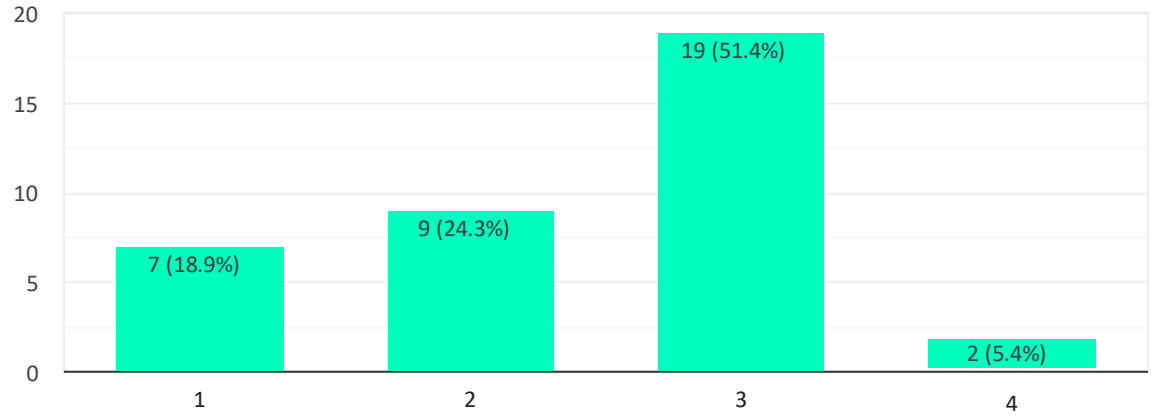
11(a)-Legal risk (Failure to achieve satisfactory contractual arrangement)

37 responses

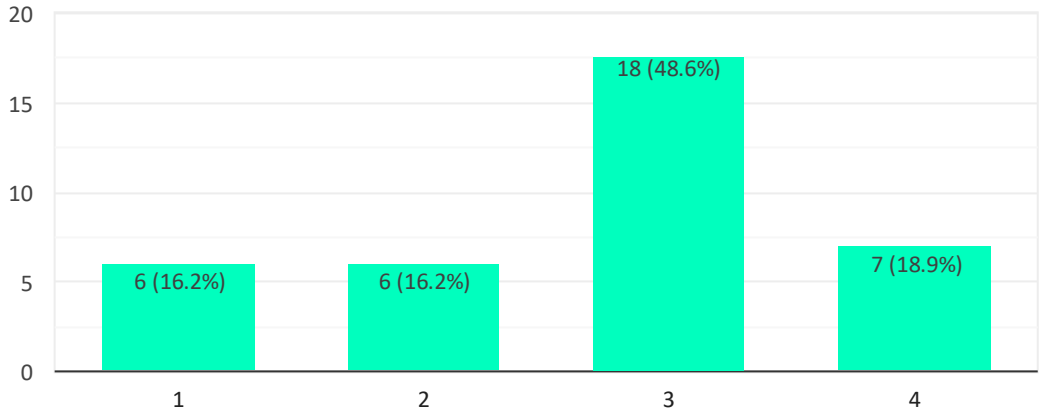


11(b)-Legal risk (Loss of intellectual property rights)

37 responses



11(c)-Legal risk (Environmental board issue)



11(d)-Legal risk (Unforeseen inclusion of contingent liabilities)

37 responses