A

Dissertation Report on

Risk Analysis and Mitigation for Survey and Design Stages of Highway Projects

Submitted

in partial fulfilment of the requirements for the degree of

Master of Technology

in

Civil-Construction Management

by

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Sponsored by

Innovision Studios, Navi Mumbai

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Rajarambapu Institute of Technology, Rajaramnagar

(An Autonomous Institute, Affiliated to Shivaji University, Kolhapur)

2018-2019

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CERTIFICATE

This is to certify that, **Mr. Ketan Kailas Kamble (Roll No- 1727006)** has successfully completed the dissertation work and submitted dissertation report on "Risk Analysis and Mitigation for Survey and Design Stages of Highway Projects" for the partial fulfilment of the requirement for the degree of Master of Technology in Construction Management from the Department of Civil Engineering , as per the rules and regulations of Rajarambapu institute of Technology, Dist. Sangli.

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Project Completion Certificate

This is to certify that, Mr.Ketan Kailas Kamble M-Tech (Civil Construction Management) final year student of Rajarambapu Institute of Technology, Islampur had done project work in Innovision Studios., Navi Mumbai on "Risk Analysis Mitigation for Survey and Designing Stages of Highway Projects" under the guidance of Mr.Vijay Raghojiwar(General Manager Projects, Dhruv Consultancy Services Ltd., Navi Mumbai) from August 2018 to April 2019. The project has been completed to our satisfaction.

We wish him all the best in his future endeavours.

Yours Faithfully,

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DECLARATION

I declare that this report reflects my thoughts about the subject in my own words. I have sufficiently cited and referenced the original sources, referred or considered in this work. I have not misrepresented or fabricated or falsified any idea/data/fact/source in this my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute.

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ACKNOWLEDGEMENTS

I would like to express a deep sense of gratitude towards my guide Mr.Vijay Raghujivar (Senior Contract Specialist) Dhruv Consultancy Ltd. And Belapur, Navi Mumbai and Prof. D. S. Patil (Department of Civil Engineering, RIT Islampur) for providing this opportunity, valuable guidance and inspiration throughout the project work.

I would like to thank all my seniors at Dhruv Consultancy Ltd. Belapur, Navi Mumbai and Innovision Studios, Belapur, Navi Mumbai for their co-operation and help in clarifying my doubts during my project work.

I am thankful to Civil engineering department and my parent institute RIT, Islampur for providing support. I am grateful towards all teaching and non-teaching staff of my college.

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ABSTRACT

Highway Projects are having various phases Planning, Scheduling, Preliminary Surveys & Designing, Execution. Highway surveys are very important phase before designing. Highway Project Development has many risks as they are having a major impact on issues related to cost, time and quantity of project delivery. Consequences of uncertainty and its exposure in project is risk. Risk analysis in the construction industry on each phase is limited to research, practical use and very rare in the industry. But it is observed that risk assessment in projects helps to enhance the quality of work. Risk mitigation is a risk response strategy whereby the project team acts to reduce the probability of occurrence and impact of risk. Mitigation plan can be carried out effectively by investigating and identifying the sources of risk associated with different activities of the project. There is less work done for mitigation of risk involved in highway design activities or highway construction design surveys. Therefore this projects aims to conduct risk analysis & mitigation research for survey and design stages of highway construction projects. The risk identified for the construction projects are the similar to risk in all types of worldwide projects, hence in proposed work it is decided to identify the risk in the highway projects for survey and design phase. Risks were identified from the ongoing projects for survey work like topography, geotechnical investigation and, design of highway projects. Also, some previous research papers were studied to identify probable risks can occur in survey and design work. After the risk is identified, the suitable assessment was done for the identified risk based on data collected on ongoing case studies. After the assessment of risk, the risk were classified for risk response plan and suitable risk mitigation techniques will be proposed and same was implemented on one of the ongoing projects. It was observed that the considerable saving can be observed in term of cost and time after implementation of mitigation plan.

Keywords: Risk Analysis ,Risk Mitigation, Risk Assessment, Risk Response

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Chapter 1

INTRODUCTION AND RELEVANCE

1.1 General

Highway Project Development has many risks as they are having major impact on issue related to cost, time and quality of project delivery [1]. Highway Projects are having various phases Planning, Scheduling, Preliminary Surveys and Designing, Execution. Consequences of uncertainty and its exposure in project is risk [2]. Risk management in construction industry on each phase is limited to research, practical use and assessment of the risk is very rare in industry. But risk assessment in projects helps to enhance quality of work. The main barrier to effective Management is the lack of the availability of joint risk management system [3]. Management can be carried out effectively by investigating and identifying the sources of risk associated with different activities of the project.

Financial risk was major factor in affecting the cost and schedule of project. Risk forecasting really helps in decision making and identification of area of concern for project stakeholder. So project manager should conduct risk analysis to identify potential threats at the early stage of bridge construction[4]. Risk analysis is required to manage cost and schedule risk involved in surveys which eventually helps to achieve given work within stipulated time and budget.

Highway pre surveys are very important phase of execution. Design of highway is totally dependent on these surveys. These surveys are having major four types: Topographic Survey, Inventory Survey, Geotechnical Survey and Topographic survey helps to design the plan and profile of proposed road. Financial risk and field risk like low labor productivities majorly affect the progress of survey. Geotechnical investigation is also key survey for designing of major bridges, culverts and plan and profile of the road. Every factor affecting progress of survey leads to schedule and cost overrun. Mitigation plan to minimize the cost overrun and schedule delay should be prepared before design work. Risk identification and analysis is key points while preparing mitigation plan.

Chapter 2

LITERATURE REVIEW

2.1 General

In this chapter, the studies and practices adopted by many researchers are reviewed. Also, research gaps in these studies are summarized, which are led to decide methodology of the dissertation work. The researches carried on this topic are shown in form of literature survey are as follows:

Abhinaya, K., (2017), "Risk management in highway construction using Risk Priority Matrix and SPSS Software." B

In this paper forty-eight risks are identified through detailed literature review. Detail questionnaire is developed. Risk analysis is done by Risk Priority matrix (RPM) in excel and by using of Statistical Packages for Social Sciences (SPSS). Improper project group causes risk in highway project and it is having high impact on construction.

Vidivelli, B., (2017), "Risk Analysis in Bridge Construction Projects."

This thesis seeks to identify the risk factors that affect the performance of bridge projects as a whole and analyse by using appropriate tools and techniques and to develop a risk management. Qualitative analysis is done by questionnaire preparation, demographic analysis, T test and one way Anova (Analysis of variance).These paper helps project professional to focus on a few risk factors and get the optimum result.

Choudhry, R.M., (2014), "Cost and schedule risk analysis of bridge construction in Pakistan: Establishing Risk Guidelines."

They have used Monte Carlo simulation results on primavera pert master V8 to quantify impact of risk on a project schedule and cost. Comparison between primavera results and actual Time and cost completion data had been done; along with Qualitative risk analysis by questionnaire was done. They found that financial risk were major factor in affecting the cost and schedule of the project. Risk forecasting really helps in decision making and identification of area of concern for project stakeholders.

Choudhry, R.M., (2013), "Identification of risk management system in construction industry in Pakistan."

This is empirical survey based study of risk management. In this paper questionnaire survey and interviews of key participants in construction industry had taken. Statistical techniques like sample population mean and ranking and sperman rank correlation are used. Financial and economic factors are most important risk faced by the construction industry, followed by quality. Risk management standard for risk analysis techniques, Risk Response Techniques, Risk Monitoring Techniques and Maturity Level of System are required to be developed.

Li, Q. and Zhang, P., (2013), "Risk identification for the Construction phases of the large bridge based on WBS-RBS."

In this paper introduced new method of risk identification with modular analysis based on WBS-RBS (Work Breakdown structure-Risk Breakdown structure). For that establishing WBS-RBS, the BCICS (Bridge Construction Information Classification System of (ISO)) used. NGT (Nominal Group Technique) is used for judgement of matrix element of the RBM (Risk Breakdown Matrix) to identify the risk information of large bridges in construction phase. This study helps for the modularized computer storage of the risk information of large bridges in construction phase.

2.2 Closure

Different research on risk analysis were studied. The conclusion was derived that previous researches have not yet explored the risk in the field of design and survey stages of project. Detail risk analysis for every stage of survey has to be done to reduce cost and schedule overrun of the project.

Chapter 3

RESEARCH METHODLOGY

3.1 General

From the literature in chapter no 2 research gap has been identified which is used to derive objective and problem statement of project.

3.2 Research gap analysis

Researches above show that various methods and tools are available for risk analysis and mitigation on heavy bridge construction project. There is less work done for mitigation of risk involved in highway design activities or highway construction design surveys. Therefore this projects aims to conduct risk analysis and mitigation research for survey and design stages of highway construction projects.

3.3 Problem statement

To analyse the various risk involved in survey and design stages of highway development projects and develop risk mitigation techniques and strategies for same.

3.4 Objectives

1) To identify and analysis the risks for survey and design stages of highway development projects.
2) To analysis the risks with respect to prepared schedule and cost of highway development projects.
3) To do comparative risk analysis of projects.

4) To develop Risk Mitigation Techniques and Strategies for Survey and Design stages of new highway development project.

3.5 Methodology

All objectives will be achieved by following Methodology as shown in Figure no. 3.1

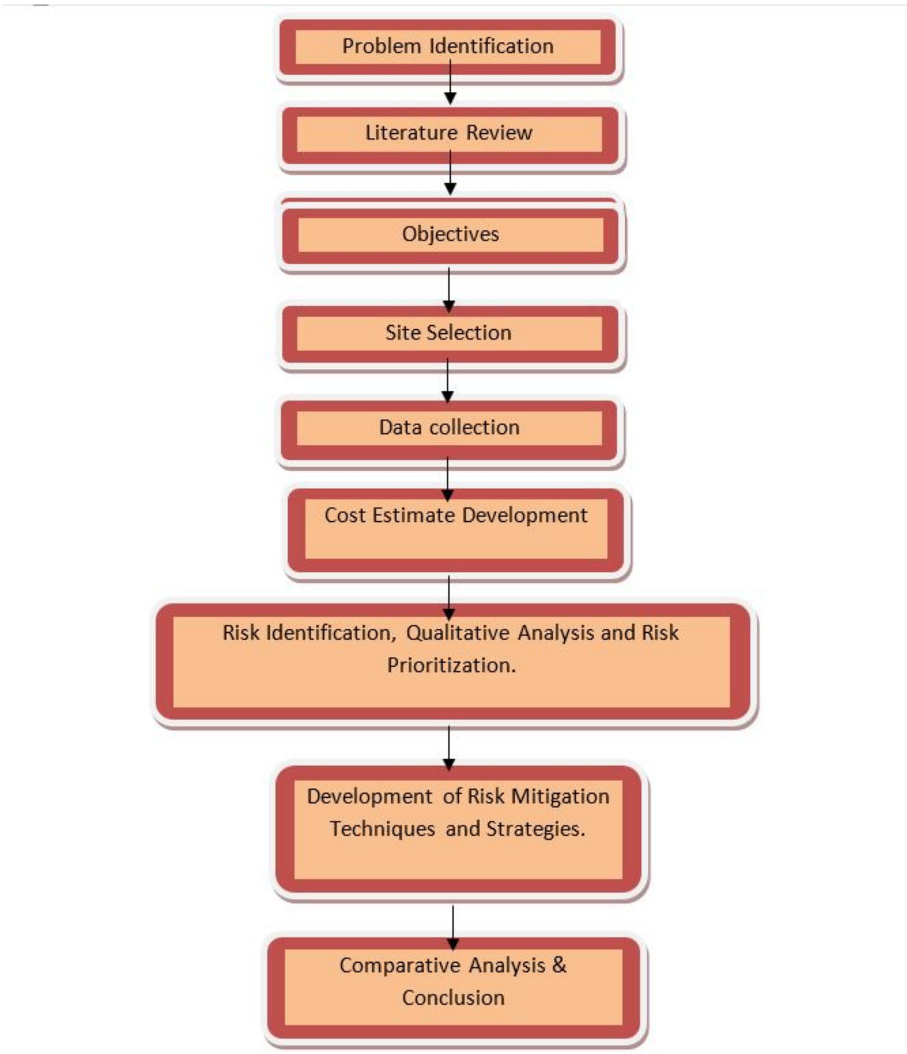

Figure 3.1: Methodology Adopted In Project Work

3.6 Closure

There is no detail research work has been done for survey & design stages of highway projects. Therefore to achieve the objectives, qualitative analysis of risk on live case studies has been adopted to get suitable mitigation techniques.

Chapter 4

RESEARCH DESIGN

4.1 General

For highway design we need to design the horizontal and vertical alignment of roads. Before highway design, engineering surveys like map study, reconnaissance the survey, preliminary survey and detail survey are the stages of survey. Topography survey and Geotechnical surveys are the main surveys to be performed.

4.2 Topographic survey for geomatrical design

A topographic survey is an Engineering survey to understand and analyse the ground features along the proposed alignment. By applying mathematical principles to the Survey data, existing or future horizontal and vertical position will be determined. The main objective of topographic survey for a road is to create a digital terrain model (DTM) by acquiring terrain data. Survey activities include road alignment, fixing centre line of road, providing permanent grid lines and benchmarks as per the applicable standards.

The topographic survey helps the engineers to:

- Prepare alignment drawings.
- Prepare cross-sectional profiles.
- Identify existing structures in the proposed road alignment
- Finalize requirement of bridges, culverts, diversions etc.
- Plan land acquisition requirements.
- Establish control of locations.
- Establish elevation difference between fixed points

• Identify the presence of underground utilities like pipelines, electrical cables etc.

4.2.1 Procedure for topographic survey

• Collect Great Trigonometrically Survey (GTS) Bench Mark data along the road sections.

• All reference pillars shall be of M20 grade of size 20 cm x 20 cm x 45 cm height. Fix a 10 mm diameter steel bar inside the concrete pillar. Fix the pillars on a firm ground embedded in M15 grade PCC up to a depth of 30 cm and 5 cm wide all around. Paint the rest 15 cm of pillar above the ground with yellow colour paint.

• All control point pillars namely horizontal control points and the benchmarks shall be of an M20 grade of size 20 cm x 20 cm x 60 cm height. Fix a 10 mm diameter steel bar inside the concrete pillar. Fix the pillars on a firm ground embedded in M15 grade PCC up to a depth of 45 cm and 5 cm wide all around. Paint the rest 15 cm of pillar above the ground with yellow colour paint.

• Fix horizontal control points using DGPS instrument at every 5 km.

• Establish Bench Mark (BM) stations at every 250 meters interval. Use double run levelling method with digital auto levels.

• Fix all cardinal points like horizontal intersection points (HIP), centre points and transit points etc. with a pair of reference pillars fixed on either side of the centre line at safe places within the ROW.

• Take spot levels at every 25 m interval for cross-sectional Topographic survey.

• Establish reference centre line and mark the same by nails on the ground. Mark by paint for the existing road surface. Take the spot levels at every 25 m interval along the centre line for longitudinal Topographic survey

• Other physical features. Capture details of all existing structures like

• Major bridges, minor bridges, culverts

• Utilities present underground or overhead – electrical lines, gas pipelines, OFC etc.

• Presence of water bodies

• Religious structures

• Any other structure of significance.

4.3 Geotechnical investigation for geomatrical design

Geological surveys and investigations were conducted to obtain information on the subsurface geological condition required for the preliminary design of the proposed bridges and roads on the F/S roads. The survey is comprised of: i) Geotechnical investigation for bridges ii) Road alignment soil survey iii) Road construction material investigation. The objectives of geological surveys were: i) To obtain necessary geological data for bridge design ii) To obtain data on subgrade strength of study routes for pavement design iii) To obtain information for weak foundation countermeasure planning iv) To obtain latest information/data on possible borrow pits and quarries as well as physical properties of the materials.

4.4 Closure

This chapter provides the detail stages for which the risk can be identified and analysed. Also it gives the brief information of procedure for topographical and geotechnical survey required for design work.

Chapter 5

DATA COLLECTION AND ANALYSIS

5.1 General

Highway designing is totally based on site surveys .Topography and Geotechnical surveys are having major role in designing the highway .Alignment and pavement can be set based on topography survey. While geotechnical Survey is required to decide the foundation level of structures. For precise designing, the accuracy of survey is needed. For accuracy we should track the various risk or issues related to the survey and try to minimize the mistakes.
For tracking the risk associated with surveys, we prepared the risk register as suggested by PMBOK .Survey of five designing projects as case studies are tracked for risk and cost overrun are calculated.

5.2 List of case study projects for tracking

• [AU100B] Up gradation/Widening of Hasta-Pishore-Bharadi-Sillod (SH 51, Length50.00Kms) to Two Lanes/Four Lanes] in state of Maharashtra under MRIP on Hybrid Annuity.
• [AU102] Up gradation/Widening of jalna-londyachiwadi-Gadesawargaon-Ghanasavangiroad (Including jalna bypass) km 450/00 to 493/00 (SH-26, Length 45.87 Km) to two Lanes/four Lanes] in the state of Maharashtra under MRIP on Hybrid Annuity.
• [AU 116] Construction of two laning with paved shoulders for package HAM: Hybrid Annuity Model AU 116 Dist. Hingoli in the state of Maharashtra, [Kalamnuri

– Sadegaon-Bolda-Kurunda-Vasmat to Dist. Border (Alegaon) Road Km. 0/00 to 61/775 (SH - 256).

• HAM [AU 115] Construction of two laning road with paved shoulders in the State of Maharashtra under (Dist. Border (Patonda) Sirsam Basainba (Km. 14/09 2 to Km, 44/326)And Hingoli Aundha Nagnath Wagewadi Nageshwarwadi Hatta to NH-61 road Km.44/236 to 97/225 (SH-249).

• [AU109] Hybrid annuity construction of two laninig road with paved shoulders DistrictBoarders to Chuncha Manatha Sawarga on Barad Mudkhed Gadga Khandgaon MukhedSawargaon (Bk) Jamb road (Part Mudkhed to Gadga Km 48/700 to 97/951) in Nanded Dist.

5.3 Case study for implementation of mitigation plan

NSK 70B: Construction of 2-lanning with paved shoulders Road on MSH 8 to Ghoghargaon to kombhali walwad karjat MDR-66 Km 0/0 to 29/800 (Design Chainage 0+000 to 30+030) District Ahmednagar in the State of Maharashtra under MRIP on Hybrid Annuity Mode.

5.4 Risk identification in survey and design stages

Identify risk is an iterative process because new risk can occur at any time through the project span. As per PMBOK, identification can be done by risk categories or by preparing Risk breakdown structure. Risk register is document in which the result of risk analysis and risk response planning are recorded .The various risk are identified from previous researches. Then the risk register is prepared for ongoing five project, collectively based on occurrence, following risk are identified.

5.5 Information gathering techniques

Checklist Analysis: Risk identification checklists are developed based on historical information and knowledge that has been accumulated from previous similar projects and from other sources of information. The lowest level of the RBS can also be used as a risk checklist. While a checklist may be quick and simple, it is impossible to build an exhaustive one, and care should be taken to ensure the checklist is not used to avoid the effort of proper risk identification. The team should also explore items that do not appear on the checklist. Additionally, the checklist should be pruned from time to time to remove or archive related items. The checklist should be reviewed during project closure to incorporate new lessons learned and improve it for use on future projects. In this project the root because analysis technique was used. Topography Risk and Geotechnical Risk has been given in Table no. 5.1 and 5.2 respectively.

Table 5.1: Classification of Risk for Topographical Survey

Survey	Risk	Description
Topo	Contractual Risk	CO1) Change in project Scope & change orders.
	Contractual Risk	CO3) Unrealistic cost Estimates & Schedule
	Contractual Risk	CO2)Dispute & Claims
	Contractual Risk	CO4) Contractors profit
	Design Risk	D5) Design changes
	Design Risk	D15) IRC norms :culvert cushioning issue
	Design Risk	D13) IRC norms :curve radius
	Design Risk	D6) Incomplete design
	Design Risk	D8) Incorrect data
	Design Risk	D16) IRC norms :MNB Hydraulics
	Design Risk	D5) Incorrect data
	Design Risk	D11) IRC norms :Design speed
	Design Risk	D14) IRC norms :Gradient
	Design Risk	D17) IRC norms :TCS
	Design Risk	D7) Inadequate site Investigation
	Design Risk	D12) IRC norms :ISSD, SSD issue
	Design Risk	D16) IRC norms :Minimum Embankment Issue
	Design Risk	D9) TM & UTM issue
	Design Risk	D10) Inadequate Site Data
	External Risk	EX.1) Delay in approval from regulatory bodies
	External Risk	EX.3) Third party delay
	External Risk	EX.4) Unavailability of land and right of way
	External Risk	EX.5) Ghats Portion
	External Risk	EX.2) Political instability
	Field Risk Benchmark	FR.A.B.3) Work interruption & lack of space
	Field Risk Benchmark	FR.A.B.1) Setting and wrong manhandling of TS.
	Field Risk DGPS	FR.A.D.3) Unexpected whether
	Field Risk DGPS	FR.A.D.5) Work interruption & Lack of space

Survey	Risk	Description
	Field Risk DGPS	FR.A.D.4) Colour Marking
	Field Risk DGPS	FR.A.D.1) Setting and Wrong Manhandling of GPS
	Field Risk DGPS	FR.A.D.2) Faulty Instrument and battery
	Field Risk Site	FR.SI.1) Total Scope and Row Investigation
	Field Risk Site	FR.SI.2) Site condition and resources availability
	Field Risk Site	FR.A.B.2) Faulty Instrument.
	Field Risk Site	FR.TR.2) Faulty Instrument.
	Field Risk Topo	FR.TO.2) Unexpected whether
	Field Risk Topo	FR.TO.4) Absence of Benchmark
	Field Risk Topo	FR.TO.3) Work interruption, delay & lack of space
	Field Risk Topo	FR.TO.1) Setting and wrong manhandling of total station
	Field Risk Traversing	FR.TR.3) Unexpected weather
	Field Risk Traversing	FR.TR.1) Setting and wrong manhandling of total station
	Field Risk Traversing	FR.TR.4) Work interruption& lack of space
	Financial Risk	F2) Financial failure of contractor
	Financial Risk	F1) Unavailability of fund
	Management Risk	MN.3) Lack of coordination
	Management Risk	MN.1) Inadequate project planning
	Management Risk	MN.2) Insufficient Expertise
	Management Risk	MN.4) Strike and theft incomplete subcontractor

Table 5.2: Classification of Risk for Geotechnical Survey

SURVEY	RISK	SUBRISK
Geotechnical investigation	Contractual risk	CO1) Change in Project Scope & Change orders. CO1a) Change in no of boreholes CO 1b) Exclusion of road patch/addition CO2) Dispute & claims CO2a) Row unavailable CO2b) Land acquisition CO3) Unrealistic Cost Estimates & Schedule CO3a) Hard strata CO3b) Land availability for rig CO3c) Resource unavailability like water, Electricity. CO4) Contractors Profit CO 4 a) Reluctant to work in patches for sampling.
		CO4 b) Bore hole Manipulation
	Design Risk	D1) Design changes/Report D1 a) Change in Span , hydraulics D1 b) Change in Surveys D2 b) Wrong levels Taken D2) Incomplete design/Report D2a) Wrong RQD Value D3) Inadequate site investigation(wrong identification of locations D4) COS D5) Approval Process D5 a) Delay in approval of IE , CE D6) Row issue D6 a) Unavailability of Land D6 a) Ghats section D8) CBR value :soak and unsoak sample testing
	Field Risk	S1) Defective work and Quality issue S1 a) Wrong drilling Technics S1 b) Wrong sampling Trial Pit S2) Insufficient Technology S3) Low labour Productivity S5) Excessive Inspection & Audits S6) Work interruption & lack of space. S7) Water availability S8)Transportation of Samples S9) Transportation of Machine S10) Labour Unavailability S11) Water Surface S12) Trial Pit Excavation : Utility lines S13) Machine Breakage

SURVEY	RISK	SUBRISK
	Financial Risk	F1) Unavailability of Fund
	External Risk	EX.1) Delay in Approval from Regulatory bodies EX.2) Political Instability EX.3) Third party Delay EX.4) Unavailability of land and Right of Way EX.5) Ghats Portion
	Management Risk	MN.1) Inadequate Project planning MN.2) Insufficient Expertise MN.3) Lack of Coordination MN.4) Strike and theft incomplete Sub Contractor.

5.6 Closure

In this chapter risk breakdown structures are prepared for topographic survey and geotechnical survey. Each risk is further divided into thr subrisk which are collected from five case studies and literature refered.

Chapter 6

RISK ANALYSIS IN HIGHWAY SURVEY AND DESIGN ACTIVITIES

6.1 General

Risk assessment has two aspects. The first determines the likelihood of a risk occurring (risk frequency). The second judges the impact of the risk should it occur (consequence severity). Risk effects are usually apparent in direct project outcomes by increasing costs or schedules. Risk Analysis is usually done by qulitative analysis and quantitative anlysis.

6.2 Risk analysis

Based on available data we can use suitable analysis method .It can be qaulitative or quantitative analysis .

A) Qualitative Risk Analysis

It is action by assessing and combining their probability of occurrence and impact. We use Risk categorization as tool to prioritize the risk. Risk can be categorized by various phases or sources of risk i.e. RBS [5]. Risk register is updated with the occurrences. Topographic survey and Geotechnical survey which are further divided into subrisk that are given in the Table no. 6.1 and 6.2 for which subsequent reasons were identified from numerous case studies and occurrence of those reason were noted down in risk register during ongoing project life cycle.

Perform Qualitative Risk Analysis assesses the priority of identified risks using their relative probability or likelihood of occurrence, the corresponding impact on project objectives if the risks occur, as well as other factors such as the time frame for response and the organization's risk tolerance associated with the project constraints of cost, schedule, scope, and quality. Such assessments reflect the risk attitude of the project team and other stakeholders. Effective assessment therefore requires explicit identification and management of the risk approaches of key participants in the Perform Qualitative Risk Analysis process. Where these risk approaches introduce bias into the assessment of identified risks, attention should be paid to identifying bias and correcting for it.

Table 6.1: Risk Assessment Chart for Topography Survey and Design Activities

Topo Risk	Description	Occurrences
Field Risk Traversing	FR.TR.3) Unexpected weather	33
Design Risk	D5) Design changes	31
Management Risk	MN.3) Lack of coordination	29
Management Risk	MN.1) Inadequate project planning	27
Design Risk	D15) IRC norms :culvert cushioning issue	25
Contractual Risk	CO1) Change in project scope & change orders.	23
Design Risk	D13) IRC norms :curve radius	22
Design Risk	D6) Incomplete design	21
Design Risk	D8) Incorrect data	21
Field Risk Topo	FR.TO.2) Unexpected whether	20
Contractual Risk	CO3)Unrealistic cost estimates & schedule	19
Design Risk	D16) IRC norms : Mnb hydraulics	19
Design Risk	D5)Incorrect data	19
Design Risk	D11) IRC norms :Design speed	18
Design Risk	D14) IRC norms :gradient	18
Field Risk Benchmark	FR.A.B.3) Work interruption& lack of space	18
Management Risk	MN.2) Insufficient expertise	17
Financial Risk	F2) Financial failure of contractor	16
Design Risk	D17) IRC norms :TCS	16
Field Risk Benchmark	FR.A.B.1) Setting and wrong manhandling of auto level	16
Field Risk Topo	FR.TO.4) Absence of Benchmark	16
Field Risk Traversing	FR.TR.1) Setting and wrong manhandling of total station	15
Design Risk	D7) Inadequate site investigation	14
Field Risk Traversing	FR.TR.4) Work interruption& lack of space	14
Field Risk Topo	FR.TO.3) Work interruption, delay& lack of space	14
Financial Risk	F1) Unavailability of fund	13
Design Risk	D12) IRC norms :ISSD,SSD issue	13

Topo Risk	**Description**	**Occurrences**
Field Risk DGPS	FR.A.D.3) Unexpected whether	13
External Risk	EX.1) Delay in approval from regulatory bodies	13
External Risk	EX.3) Third party delay	13
External Risk	EX.4) Unavailability of land and right of way	13
Field Risk Site	FR.SI.1) Total scope and Row investigation	11
Management Risk	MN.4) Strike and theft incomplete subcontractor	11
Field Risk Topo	FR.TO.1) Setting and wrong manhandling of total station	10
Contractual Risk	CO2)Dispute & claims	9
Contractual Risk	CO4)Contractors profit	9
Design Risk	D16) IRC norms :minimum embankment issue	9
Design Risk	D9) TM & UTM issue	5
Design Risk	D10) inadequate site data	5
Field Risk DGPS	FR.A.D.5) Work interruption& lack of space	4
Field Risk Site	FR.SI.2) Site condition and resources availability	3
Field Risk Site	FR.A.B.2) Faulty Instrument.	3
Field Risk Site	FR.TR.2) Faulty Instrument.	3
Field Risk DGPS	FR.A.D.4) colour marking	2
External Risk	EX.5) Ghats portion	2
Field Risk DGPS	FR.A.D.1) Setting and wrong manhandling of GPS	0
Field Risk DGPS	FR.A.D.2) Faulty Instrument and battery	0
External Risk	EX.2) Political instability	0

Table 6.2: Risk Assessment Chart for Geotechnical Survey and Design Activities

Geotech Risk	**Description**	**Occurances**
Contractual risk	CO1) Change in project scope & change orders.	5
Design Risk	D2) Incomplete design/Report	5
Management Risk	MN.2) Insuffifient experties	5
Contractual risk	CO 4 a) Reluctunt to work in patches for sampling	3
Contractual risk	co1a) change in no of boreholes	3
Contractual risk	CO4 b) Bore hole manupulation	3
Design Risk	D1 b) Change in survys	3
Design Risk	D1) Design changes/Report	3
External Risk	(EX.3) Third party delay	3
Field Risk	S8)Transportation of samples	3
Contractual risk	co1b) Exclusion of road patch/addition	2
Contractual risk	CO3 a) Hard strata	2
Contractual risk	CO3 c) Resource unavailibilty like water , electricity	2
Contractual risk	CO3) Unrealistic cost estimates & schedule	2
Design Risk	D1 a) Change in Span , hydraulics	2
Design Risk	D3) Inadequate site investigation (wrong identification of locations	2
Design Risk	D5 a) Delay in approval of IE , CE	2
Design Risk	D5) Approval process	2
Design Risk	D6 a) Ghat section	2
Design Risk	D6 a) Unvailibilty of land	2
Design Risk	D6) Row issue	2
Design Risk	D8) cbr value :soak and unsoak sample testing	2
External Risk	EX.1) Delay in approval from regulatory bodies	2
External Risk	EX.4) Unvailibilty of land and right of way	2
External Risk	EX.5) Ghat portion, forest portion	2

Geotech Risk	**Description**	**Occurances**
Financial Risk	F2) Financial failure of contractor	2
Management Risk	MN.1) Inadquate project planning	2
Management Risk	MN.3) Lack of cordination	2
Field Risk	S1 a) Wrong drilling technics	2
Field Risk	S10) Labour unvailibility	2
Field Risk	S2) Insufficient technology	2
Field Risk	S3) Low labour productivity	2
Field Risk	S6) work interreption & lack of space	2
Field Risk	S7) water unavailibility	2
Field Risk	S9) Transportatio of machine	2
Contractual risk	CO2a) Row unavailable	1
Contractual risk	CO2b) Land acquisition	1
Contractual risk	CO3 b) Land availibilty for rig	1
Design Risk	D2 a) Wrong RQD value	1
Design Risk	D4) cos	1
Management Risk	MN.4) Strike and thelft incomplete subcontractor	1
Field Risk	S1 b) Wrong sampling trial pit	1
Field Risk	S1) Defective work and quality issue	1
Field Risk	S11) water surface	1
Field Risk	S12) Trial pit excavation : utility lines	1
Field Risk	S13) Machine breckage	1
Field Risk	S4) unexpected whether	1
Field Risk	S5) Excessive inspection & audits	1
Contractual risk	CO2) Dispute & claims	0
Contractual risk	CO4) Contractors profit	0
Design Risk	D2 b) Wrong levels taken	0
External Risk	EX.2) Political instability	0
Financial Risk	F1) Unavailibilty of fund	0

Risk are prioritized above based on occurrences for all five projects together. Risk Register were prepared for to track the occurrences .

B) Quantitative Risk Analysis

Quantitative risk analysis is the process of analysing numerical effects of risk on overall project. In this process we have analysed the effects of risk identified in survey and design stages of given 5 highways projects in term of cost [6]. For Topographic survey we have calculated estimated cost and actual cost. For estimated cost we have considered total daily expenses for each stages of topography and geotechnical survey. For actual cost we have tracked the daily cash-flow of work. Topography and Geotechnical cost tracking has been done in Table no. 6.8 and 6.14

1) Topography cost Tracking

Topography activities can be compared in terms of estimated day and actual days, also the estimated cost and cost were compared. The cost overrun was prepared in summary sheet shown in Table no. 6.8

Cost overrun for AU100B topography is Rs.75967 and lag of 4 days is shown in Table no. 6.3.

Cost overrun for AU102 topography is Rs.103250 and lag of 20 days is shown in Table no. 6.4.

Cost overrun for AU109 topography is Rs.116200 and lag of 22 days is shown in Table no. 6.5.

Cost overrun for AU115 & AU116 of topography are Rs.50900 & 99017 and lag of 9 days are shown in Table no. 6.6 & 6.7 respectively.

Table 6.3: AU100B Tracking for Topography Survey

AU100B					
Activities	**Total Km**	**Estimated days**	**Actual days**	**Estimated cost**	**Actual cost**
WO	50				
GPS	50	10	12	44000	52800
TBM fix	50	8	8	44166	42400
Traversing	50	10	13	44000	57200
TBM shift	50	10	12	44000	52800
Topo	50	50	58	220000	255200
Inventory	50	8	11	36667	48400
Total		96	100	432833	508800

Table 6.4: AU102 Tracking for Topography Survey

AU102					
Activities	**Total Km**	**Estimated days**	**Actual days**	**Estimated cost**	**Actual cost**
WO	45				
GPS	45	9	15	45000	75000
TBM fix	45	8	10	47250	63000
Traversing	45	9	12	45000	60000
TBM shift	45	9	11	45000	55000
Topo	45	45	49	225000	245000
inventory	45	8	10	37500	50000
Total		88	99	444750	**548000**

Table 6.5: AU109 Tracking for Topography Survey

AU109					
Activities	**Total Km**	**Estimated days**	**Actual days**	**Estimated cost**	**Actual cost**
WO	48				
GPS	48	10	10	48000	50000
TBM fix	48	8	12	50400	75600
Traversing	48	10	15	48000	75000
TBM shift	48	10	13	48000	65000
Topo	48	48	56	240000	280000
inventory	48	8	9	40000	236700
Total		93	115	474400	**590600**

Table 6.6: AU115 Cost Tracking for Topography Survey

AU115					
Activities	**Total Km**	**Estimated days**	**Actual days**	**Estimated cost**	**Actual cost**
WO	66				
GPS	66	13	13	66000	65000
TBM fix	66	11	14	69300	88200
Traversing	66	13	15	66000	75000
TBM shift	66	13	15	66000	75000
Topo	66	66	70	330000	350000
inventory	66	11	10	55000	50000
Total		128	137	652300	**703200**

Table 6.7: AU116 Cost Tracking for Topography Survey

AU116					
Activities	**Total Km**	**Estimate days**	**Actual days**	**Estimated cost**	**Actual cost**
WO	61				
GPS	61	12	12	61000	60000
TBM fix	61	10	13	64050	81900
Traversing	61	12	16	61000	80000
TBM shift	61	12	15	61000	75000
Topo	61	61	68	305000	340000
inventory	61	10	13	50833	65000
Total		118	137	602883.33	**701900**

Table 6.8: Total Cost for Topo Survey Activities

	Topo Survey		
Project	**Estimated cost**	**Actual cost**	**Cost Overrun**
AU100B	**432833**	**508800**	**75967**
AU102	**444750**	**548000**	**63250**
AU109	**474400**	**590600**	**116200**
AU115	**652300**	**703200**	**50900**
AU116	**602883**	**701900**	**99017**

2) Geotechnical cost Tracking

Geotechnical activities can be compared in terms of estimated day and actual days, also the estimated cost and cost were compared. The actual cost was prepared in summary sheet shown in Table no. 6.14

Actual cost for AU100B geotechnical is Rs.475106 is shown in Table no. 6.9.

Actual cost for AU102 geotechnical is Rs.827399 is shown in Table no. 6.10.

Actual cost for AU109 geotechnical is Rs.989047 is shown in Table no. 6.11.

Actual cost for AU115 geotechnical is Rs.728755 is shown in Table no. 6.12.

Actual cost for AU116 geotechnical is Rs.915565 is shown in Table no. 6.13.

Table 6.9: AU 100B Cost Tracking for Geotechnical Survey

AU 100B	**Unit cost**	**No**	**Bridge Boreholes**				
Boreholes			**1**	**2**	**3**	**4**	**5**
Estimated Depth			10	10	10	10	10
Estimated Drilling in Soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in Rock	2100	1	10500	10500	10500	10500	10500
Test	4800	16					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	25					
Actual depth in soil			1.5	1	1.5	9.5	1
Actual depth in Rock			8.55	9.1	12.53	5.54	9.1
Actual Drilling soft soil			1650	1100	1650	10450	1100
Actual Drilling Hard Soil			17955	19110	26313	11634	19110
Total Estimated cost			**226800**				
Total actual cost			**256872**				
Cost Overrun			**30072**				

AU 100B	Unit cost	No	Bridge Boreholes				
Boreholes			**6**	**7**	**8**	**9**	**10**
Estimated Depth			10	10	10	10	10
Estimated Drilling in Soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in Rock	2100	1	10500	10500	10500	10500	10500
Test	4800	16					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	25					
Actual depth in soil			7	1	3	1.5	1.5
Actual depth in Rock			5.14	9.1	7.02	8.5	8.58
Actual Drilling soft soil			7700	1100	3300	1650	1650
Actual Drilling Hard Soil			10794	19110	14742	17850	18018
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 100B	Unit cost	No	Bridge Boreholes						
Boreholes			**4a**	**4b**	**5a**	**5b**	**5c**	**9a**	
Estimated Depth			10	10	10	10	10	10	**Total Amount**
Estimated Drilling in Soft	1100	1	5500	5500	5500	5500	5500	5500	**27500**
Estimated Drilling in Rock	2100	1	10500	10500	10500	10500	10500	10500	**52500**
Test	4800	16							
Mobilization	50000	1							
Reports	20000	1							
Trail pit	1500	25							
Actual depth in soil			9.5	9	1	1	1	1.5	
Actual depth in Rock			5.55	5.02	9.05	9.03	9	8.55	
Actual Drilling soft soil			10450	9900	1100	1100	1100	1650	**15950**
Actual Drilling Hard Soil			11655	10542	19005	18963	18900	17955	**94122**
Total Estimated cost									
Total actual cost									
Cost Overrun									

Table 6.10: AU 102 Cost Tracking for Geotechnical Survey

AU 102	**Unit Cost**	**No**	**Bridge Boreholes**				
Boreholes			**1**	**2**	**3**	**4**	**5**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	32					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	31					
Actual depth in soil			5	1.5	4	1	3.5
Actual depth in rock			5.05	8.57	6.05	9.08	6.58
Actual Drilling soft soil			5500	1650	4400	1100	3850
Actual Drilling Hard soil			10605	17997	12705	19068	13818
Total Estimated cost			**735600**				
Total actual cost			**827399**				
Cost Overrun			**91799**				

AU 102	Unit Cost	No	Bridge Boreholes				
Boreholes			**6**	**7**	**8**	**9**	**10**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	32					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	31					
Actual depth in soil			2	1	1.5	2	1.5
Actual depth in rock			8.1	9.05	7.02	8.1	9.3
Actual Drilling soft soil			2200	1100	1650	2200	1650
Actual Drilling Hard soil			17010	19005	14742	17010	19530
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 102	**Unit Cost**	**No**	**Bridge Boreholes**				
Boreholes			**11**	**12**	**13**	**14**	**15**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	32					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	31					
Actual depth in soil			9.5	9	1	1.5	1
Actual depth in rock			5.55	5.02	9.05	8.52	9
Actual Drilling soft soil			10450	9900	1100	1650	1100
Actual Drilling Hard soil			11655	10542	19005	17892	18900
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 102	**Unit Cost**	**No**	**Bridge Boreholes**				
Boreholes			**16**	**17**	**18**	**19**	**20**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	32					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	31					
Actual depth in soil			2.5	2	2	1.5	2
Actual depth in rock			7.56	8.5	8.05	8.5	8.1
Actual Drilling soft soil			2750	2200	2200	1650	2200
Actual Drilling Hard soil			15876	17850	16905	17850	17010
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 102	Unit Cost	No	Bridge Boreholes				
Boreholes			**21**	**22**	**23**	**24**	**25**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	32					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	31					
Actual depth in soil			7	1	1	1	1
Actual depth in rock			5.06	9.02	9.03	9.07	9.08
Actual Drilling soft soil			7700	1100	1100	1100	1100
Actual Drilling Hard soil			10626	18942	18963	19047	19068
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 102	**Unit Cost**	**No**	**Bridge Boreholes**				
Boreholes			**16a**	**20a**	**21a**	**22a**	**23a**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	32					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	31					
Actual depth in soil			1.5	6	7.5	2	2.5
Actual depth in rock			8.56	6.06	5.3	4.06	7.55
Actual Drilling soft soil			1650	6600	8250	2200	2750
Actual Drilling Hard soil			17976	12726	11130	8526	15855
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 102	Unit Cost	No	Bridge Boreholes		
Boreholes			**24a**	**25a**	**Total Amount**
Estimated Depth			10	10	
Estimated Drilling in soft	1100	1	5500	5500	**176000**
Estimated Drilling in rock	2100	1	10500	10500	**336000**
Test	4800	32			
Mobilization	50000	1			
Reports	20000	1			
Trail pit	1500	31			
Actual depth in soil			1	1	
Actual depth in rock			7.1	7.05	
Actual Drilling soft soil			1100	1100	**96250**
Actual Drilling Hard soil			14910	14805	**507549**
Total Estimated cost					
Total actual cost					
Cost Overrun					

Table 6.11: AU 109 Cost Tracking for Geotechnical Survey

AU 109	**Unit cost**	**No**	**Bridge Boreholes**				
Boreholes			**1**	**2**	**3**	**4**	**5**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	40					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	26					
Actual depth in soil			6	6	4	7	3.5
Actual depth in rock			5.05	4.03	6.05	4.02	6.58
Actual Drilling soft soil			6600	6600	4400	7700	3850
Actual Drilling Hard soil			10605	8463	12705	8442	13818
Total Estimated cost			**902000**				
Total actual cost			**991192**				
Cost Overrun			**89192**				

AU 109	**Unit cost**	**No**	**Bridge Boreholes**				
Boreholes			**6**	**7**	**8**	**9**	**10**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	40					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	26					
Actual depth in soil			5.5	7	4.8	6	8
Actual depth in rock			4.53	4.09	5.23	5.05	4.04
Actual Drilling soft soil			6050	7700	5280	6600	8800
Actual Drilling Hard soil			9513	8589	10983	10605	8484
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 109	**Unit cost**	**No**	**Bridge Boreholes**				
Boreholes			**11**	**12**	**13**	**14**	**15**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	40					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	26					
Actual depth in soil			7	0.6	1.95	0	0
Actual depth in rock			6.07	7.52	8.05	10.1	10.05
Actual Drilling soft soil			7700	660	2145	0	0
Actual Drilling Hard soil			12747	15792	16905	21210	21105
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 109	Unit cost	No	Bridge Boreholes				
Boreholes			**16**	**17**	**18**	**19**	**20**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	40					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	26					
Actual depth in soil			0	0	0	0	0
Actual depth in rock			10.07	10.04	8.09	8.05	8.08
Actual Drilling soft soil			0	0	0	0	0
Actual Drilling Hard soil			21147	21084	16989	16905	16968
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 109	Unit cost	No	Bridge Boreholes				
Boreholes			**21**	**22**	**23**	**24**	**25**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	40					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	26					
Actual depth in soil			0.5	1	3	2	2
Actual depth in rock			8	8.05	7.05	8.05	8.01
Actual Drilling soft soil			550	1100	3300	2200	2200
Actual Drilling Hard soil			16800	16905	14805	16905	16821
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 109	**Unit cost**	**No**	**Bridge Boreholes**				
Boreholes			**26**	**27**	**28**	**29**	**30**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	40					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	26					
Actual depth in soil			2	12.5	3.5	2.5	1.5
Actual depth in rock			11	2.57	6.54	7.54	8.54
Actual Drilling soft soil			2200	13750	3850	2750	1650
Actual Drilling Hard soil			23100	5397	13734	15834	17934
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 109	**Unit cost**	**No**	**Bridge Boreholes**				
Boreholes			**31**	**32**	**33**	**34**	**35**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	40					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	26					
Actual depth in soil			1.05	1.5	3	5.5	2.75
Actual depth in rock			8.59	8.56	7.02	4.53	7.26
Actual Drilling soft soil			1155	1650	3300	6050	3025
Actual Drilling Hard soil			18039	17976	14742	9513	15246
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 109	**Unit cost**	**No**	**Bridge Boreholes**				
Boreholes			**36**	**37**	**38**	**39**	**40**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	40					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	26					
Actual depth in soil			3.5	3	3	2.5	4
Actual depth in rock			6.55	7.03	7.04	7.56	6.09
Actual Drilling soft soil			3850	3300	3300	2750	4400
Actual Drilling Hard soil			13755	14763	14784	15876	12789
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 109	**Unit cost**	**No**	**Bridge Boreholes**	
Boreholes				**Total Amount**
Estimated Depth				
Estimated Drilling in soft	1100	1		**220000**
Estimated Drilling in rock	2100	1		**420000**
Test	4800	40		
Mobilization	50000	1		
Reports	20000	1		
Trail pit	1500	26		
Actual depth in soil				
Actual depth in rock				
Actual Drilling soft soil				**140415**
Actual Drilling Hard soil				**588777**
Total Estimated cost				
Total actual cost				
Cost Overrun				

Table 6.12: AU 115 Cost Tracking for Geotechnical Survey

AU 115	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**1**	**2**	**3**	**4**	**5**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	29					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	32					
Actual depth in soil			6	6	4	7	3.5
Actual depth in rock			5.05	4.03	6.05	4.02	6.58
Actual Drilling soft soil			6600	6600	4400	7700	3850
Actual Drilling Hard soil			10605	8463	12705	8442	13818
Total Estimated cost			**673200**				
Total actual cost			**728755**				
Cost Over-run			**55555**				

AU 115	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**6**	**7**	**8**	**9**	**10**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	29					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	32					
Actual depth in soil			5.5	4.5	3	4.5	5
Actual depth in rock			4.53	5	6	5	4
Actual Drilling soft soil			6050	4950	3300	4950	5500
Actual Drilling Hard soil			9513	10500	12600	10500	8400
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 115	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**11**	**12**	**13**	**14**	**15**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	29					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	32					
Actual depth in soil			4.5	4.5	1.5	0	0
Actual depth in rock			6	6	7.5	10.1	10.05
Actual Drilling soft soil			4950	4950	1650	0	0
Actual Drilling Hard soil			12600	12600	15750	21210	21105
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 115	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**16**	**17**	**18**	**19**	**20**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	29					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	32					
Actual depth in soil			0	0	0	0	0
Actual depth in rock			10.07	10.04	8.09	8.05	8.08
Actual Drilling soft soil			0	0	0	0	0
Actual Drilling Hard soil			21147	21084	16989	16905	16968
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 115	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**21**	**22**	**23**	**24**	**25**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	29					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	32					
Actual depth in soil			0.5	1	3	2	2
Actual depth in rock			8	8.05	7.05	8.05	8.01
Actual Drilling soft soil			550	1100	3300	2200	2200
Actual Drilling Hard soil			16800	16905	14805	16905	16821
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 115	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**26**	**27**	**28**	**29**	**Total Amount**
Estimated Depth			10	10	10	10	
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	159500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	304500
Test	4800	29					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	32					
Actual depth in soil			2	12.5	3.5	2.5	
Actual depth in rock			11	2.57	6.54	7.54	
Actual Drilling soft soil			2200	13750	3850	2750	97350
Actual Drilling Hard soil			23100	5397	13734	15834	422205
Total Estimated cost							
Total actual cost							
Cost Overrun							

Table 6.13: AU 116 Cost Tracking for Geotechnical Survey

AU 116	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**1**	**2**	**3**	**4**	**5**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	36					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	25					
Actual depth in soil			6	6	4	7	5
Actual depth in rock			5.05	4.03	6.05	4.02	7
Actual Drilling soft soil			6600	6600	4400	7700	5500
Actual Drilling Hard soil			10605	8463	12705	8442	14700
Total Estimated cost			**818800**				
Total actual cost			**915565**				
Cost Overrun			**96765**				

AU 116	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**6**	**7**	**8**	**9**	**10**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	36					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	25					
Actual depth in soil			4.55	15	14.5	14	5
Actual depth in rock			7.45	4	4.5	5.5	4
Actual Drilling soft soil			5005	16500	15950	15400	5500
Actual Drilling Hard soil			15645	8400	9450	11550	8400
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 116	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**11**	**12**	**13**	**14**	**15**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	36					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	25					
Actual depth in soil			4.5	4.9	3.9	4.5	4.5
Actual depth in rock			6	3.1	4.1	7.5	7.5
Actual Drilling soft soil			4950	5390	4290	4950	4950
Actual Drilling Hard soil			12600	6510	8610	15750	15750
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 116	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**16**	**17**	**18**	**19**	**20**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	36					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	25					
Actual depth in soil			4.5	5	6	6.5	6
Actual depth in rock			7.5	7	6	5.5	6
Actual Drilling soft soil			4950	5500	6600	7150	6600
Actual Drilling Hard soil			15750	14700	12600	11550	12600
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 116	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**21**	**22**	**23**	**24**	**25**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	36					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	25					
Actual depth in soil			6	6	7.5	9	7.5
Actual depth in rock			6	5	4.5	7.5	4.5
Actual Drilling soft soil			6600	6600	8250	9900	8250
Actual Drilling Hard soil			12600	10500	9450	15750	9450
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 116	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**26**	**27**	**28**	**29**	**30**
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	36					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	25					
Actual depth in soil			6.2	7.5	6	3	4.5
Actual depth in rock			6.8	9	3	7	5.5
Actual Drilling soft soil			6820	8250	6600	3300	4950
Actual Drilling Hard soil			14280	18900	6300	14700	11550
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 116	**Unit Cost**	**No**	**Bridge boreholes**				
Boreholes			**31**	32	33	34	35
Estimated Depth			10	10	10	10	10
Estimated Drilling in soft	1100	1	5500	5500	5500	5500	5500
Estimated Drilling in rock	2100	1	10500	10500	10500	10500	10500
Test	4800	36					
Mobilization	50000	1					
Reports	20000	1					
Trail pit	1500	25					
Actual depth in soil			3	4.5	3	3	6
Actual depth in rock			7	7.5	6	6	4
Actual Drilling soft soil			3300	4950	3300	3300	6600
Actual Drilling Hard soil			14700	15750	12600	12600	8400
Total Estimated cost							
Total actual cost							
Cost Overrun							

AU 116	**Unit Cost**	**No**	**Bridge boreholes**	
Boreholes			36	Total amount
Estimated Depth			10	
Estimated Drilling in soft	1100	1	5500	198000
Estimated Drilling in rock	2100	1	10500	378000
Test	4800	36		
Mobilization	50000	1		
Reports	20000	1		
Trail pit	1500	25		
Actual depth in soil			6	
Actual depth in rock			4	
Actual Drilling soft soil			6600	242055
Actual Drilling Hard soil			8400	430710
Total Estimated cost				
Total actual cost				
Cost Overrun				

Table 6.14: Total Cost for Geotechnical Survey Activities

	Geotechnical Survey	
Project	**Estimated cost**	**Actual cost**
AU100B	**402800**	**475106**
AU102	**735600**	**827399**
AU109	**902000**	**989047**
AU115	**673200**	**728755**
AU116	**818800**	**915565**

6.3 Closure

Above chapter concludes the cost overrun for topographic survey and geotechnical survey for five case studies. From above analysis, the traversisng and TBM shifting stages are majorly affecting by the risk in topography survey. In geotechnical survey the water availibilty and soil strata i.e. site investigation is majorly affecting the progress of work.

Chapter 7

PLAN RISK RESPONSE AND MITIGATION

7.1 General

After the identification and analysis remedy to reduce the the impact should be done which is called risk resopnse .While risk mitigation is steps to reduce the negative effects of risks.

7.2 Risk mitigation and Response statergy

A)Risk Response: The various strategies to be prepared .Strategies to be used to deal with Negative Risk are as follows:
1) Avoid
2) Transfer
3) Mitigate
4) Accept

1. Avoid (AD): Risk avoidance is a risk response strategy whereby the project team acts to eliminate the threat or protect the project from its impact. It usually involves changing the project management plan to eliminate the threat entirely. Examples of this include extending the schedule, changing the strategy, or reducing scope. The most radical avoidance strategy is to shut down the project entirely. Some risks that arise early in the project can be avoided by clarifying requirements, obtaining information, improving communication, or acquiring expertise.

2. Transfer (T): Risk transference is a risk response strategy whereby the project team shifts the impact of a threat to a third party, together with ownership of the response. Transferring the risk simply gives another party responsibility for its management—it does not eliminate it. Transferring does not mean disowning the risk by transferring it to a later project or another person without his or her knowledge or agreement. Risk transference nearly always involves payment of a risk premium to the party taking on the risk. Transferring liability for risk is most effective in dealing with financial risk exposure. Transference tools can be quite diverse and include, but are not limited to, the use of insurance, performance bonds, warranties, guarantees, etc.

3. Mitigate (M): Risk mitigation is a risk response strategy whereby the project team acts to reduce the probability of occurrence or impact of a risk. It implies a reduction in the probability and/or impact of an adverse risk to be within acceptable threshold limits. Taking early action to reduce the probability and/or impact of a risk occurring on the project is often more effective than trying to repair the damage after the risk has occurred. Adopting less complex processes, conducting more tests, or choosing a more stable supplier are examples of mitigation actions. Mitigation may require prototype development to reduce the risk of scaling up from a bench-scale model of a process or product. Where it is not possible to reduce probability, a mitigation response might address the risk impact by targeting linkages that determine the severity.

4. Accept (AC): Risk acceptance is a risk response strategy whereby the project team decides to acknowledge the risk and not take any action unless the risk occurs. This strategy is adopted where it is not possible or cost-effective to address a specific risk in any other way. This strategy indicates that the project team has decided not to change the project management plan to deal with a risk, or is unable to identify any other suitable response strategy. This strategy can be either passive or active. Passive acceptance requires no action except to document the strategy, leaving the project team to deal with the risks as they occur, and to periodically review the threat to ensure that it does not change significantly. The most common active acceptance strategy is to establish a contingency reserve, including amounts of time, money, or resources to handle the risks.

Risk were identified and strategies were proposed for Topography Survey and Geotechnical Survey and given in Table no. 7.1

Table 7.1: Risk Response Strategies

Risk	**Description**	**Type of strategy**
Contractual Risk	CO1) Change in project scope & change orders.	AD
Contractual Risk	CO3)Unrealistic cost estimates & schedule	M
Contractual Risk	CO2)Dispute & claims	T
Contractual Risk	CO4)Contractors profit	AC
Design Risk	D5)Design changes	M
Design Risk	D15) IRC norms :culvert cushioning issue	M
Design Risk	D13) IRC norms :curve radius	AD
Design Risk	D6) Incomplete design	AD
Design Risk	D8) Incorrect data	M
Design Risk	D16) IRC norms :mnb hydraulics	M
Design Risk	D5)Incorrect data	
Design Risk	D11) IRC norms :Design speed	AD
Design Risk	D14) IRC norms :gradient	AD
Design Risk	D17) IRC norms :TCS	AD
Design Risk	D7) Inadequate site investigation	M
Design Risk	D12) IRC norms :ISSD,SSD issue	AD
Design Risk	D16) IRC norms :minimum embankment issue	AD
Design Risk	D9) TM & UTM issue	AD
Design Risk	D10) inadequate site data	M
External Risk	EX.1) Delay in approval from regulatory bodies	AC
External Risk	EX.3) Third party delay	T
External Risk	EX.4) Unavailability of land and right of way	T
External Risk	EX.5) Ghats portion	AC
External Risk	EX.2) Political instability	T
Field Risk Benchmark	FR.A.B.3) Work interruption& lack of space	T
Field Risk Benchmark	FR.A.B.1) Setting and wrong manhandling of auto level	AC
Field Risk DGPS	FR.A.D.3) Unexpected whether	AC
Field Risk DGPS	FR.A.D.5) Work interruption& lack of space	T
Field Risk DGPS	FR.A.D.4) colour marking	M
Field Risk DGPS	FR.A.D.1) Setting and wrong manhandling of GPS	AC
Field Risk DGPS	FR.A.D.2) Faulty Instrument and battery	AD
Field Risk Site Field Risk Site	FR.SI.1) Total scope and Row investigation FR.SI.2) Site condition and resources availability	M AC
Field Risk Site	FR.A.B.2) Faulty Instrument.	AD
Field Risk Site	FR.TR.2) Faulty Instrument.	AD
Field Risk Topo	FR.TO.2) Unexpected whether	AC
Field Risk Topo	FR.TO.4) Absence of Benchmark	T

Risk	Description	Type of strategy
Field Risk Topo	FR.TO.3) Work interruption, delay & lack of space	T
Field Risk Topo	FR.TO.1) Setting and wrong manhandling of total station	AC
Field Risk Traversing	FR.TR.3) Unexpected weather	AC
Field Risk Traversing	FR.TR.1) Setting and wrong manhandling of total station	AC
Field Risk Traversing	FR.TR.4) Work interruption& lack of space	T
Financial Risk	F2) Financial failure of contractor	M
Financial Risk	F1) Unavailability of fund	M
Management Risk	MN.3) Lack of coordination	M
Management Risk	MN.1) Inadequate project planning	M
Management Risk	MN.2) Insufficient expertise	M
Management Risk	MN.4) Strike and theft incomplete subcontractor	M

B) Risk mitigation plan

Risk Response and mitigation consist of Schedule management plan, cost management plan and quality management plan. Changes in schedule are done as per requirement. Resource levelling can be used as response to delay. Cost management plan is can be revised .Budget strategy to be prepared to mitigate any fund shortage. Quality assurance, quality control is done. Contractual changes can be done to mitigate future issues. Project organization structure and work break down structure can be set according to expertise required at the site [7]. Wrong manhandling can reduce by training and supervision.

7.3 Closure

Above chapter presents the response strategies assigned to various risk identified in the project. Based on response strategy, we can proposed the mitigation techniques for risk encountered.

Chapter 8

CASE STUDY: NSK 70B

8.1 General

The case study of NSK 70B was considered for analysing the impact of risk mitigation plan that were prepared. The Probable risks that were identified on the numerous case studies were given solution based on risk response strategies that were proposed. Based on historical data present, we adopted the strategies and planed the activity accordingly. Mitigation Techniques are given below Table no. 8.1

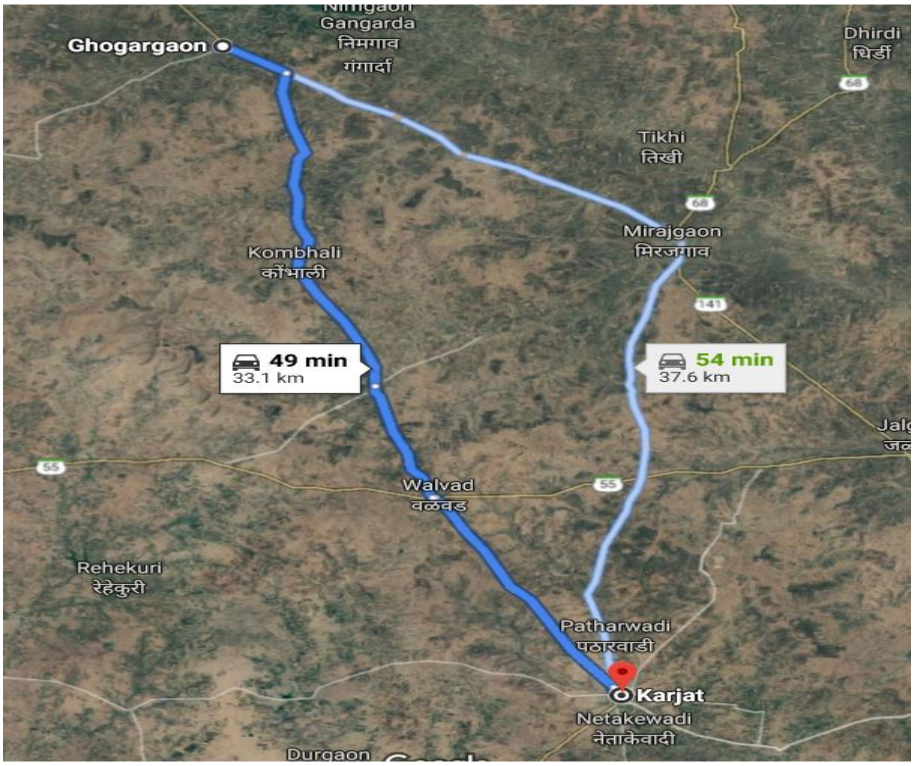

Figure 8.1: Site map of NSK 70B: Ghogargaon to Karjat, Ahmednagar

Table 8.1: Mitigation Techniques

Risk	**Description**	**Strategy**	**Mitigation**
Field Risk Travers-ing	FR.TR.3) Unexpected weather	AC	The Expertise who can plan and execute survey in meantime and special provision should be kept for delay.
Design Risk	D5)Design changes	M	Joint site visit with contractor on site should be conducted
Management Risk	MN.3) Lack of coordination	M	Proper coordination between designer and authority like independent engineer should be established , design coordinator should be appointed
Management Risk	MN.1) Inadequate project planning	M	Detail schedule should be proposed with baseline for tracking
Design Risk	D15) IRC norms :culvert cushioning issue	M	Verifying invert level at the time of designing plan and profile
Contractual Risk	CO1) Change in project scope & change orders.	AD	Cos should be approved from authority and should be conveyed to design team
Design Risk	D13) IRC norms :curve radius	AD	IRC should be follows before design time
Design Risk	D6) Incomplete design	AD	Required reports and calculation report check list to be submitted to designer before designing , every documents related to design should be checked
Design Risk	D8) Incorrect data	M	Coordination between site and design team should be established , Proper date wise data storage should be kept
Field Risk Topo	FR.TO.2) Unexpected whether	AC	The expertise who can plan and execute survey in meantime and special provision should be kept for delay.
Contractual Risk	CO3)Unrealistic cost estimates & schedule	M	Initial site survey and reconnaissance survey should be performed.
Design Risk	D16) IRC norms :Mnb hydraulics	M	Expert should be appointed with survey team, proper stream data should be collected as per designer's requirement.
Design Risk	D5)Incorrect data		schedule copy and scope should be provided to surveyor and monitoring them in stretches
Design Risk	D11) IRC norms :Design speed	AD	IRC should be followed before design time
Design Risk	D14) IRC norms :gradient	AD	IRC should be followed before design time

Risk	Description	Strategy	Mitigation
Field Risk Bench-mark	FR.A.B.3) Work interruption & lack of space	T	Meeting should be conducted and proper scheduling and planning should be followed
Management Risk	MN.2) Insufficient expertise	M	Expertise should be appointed as per requirement of site
Financial Risk	F2) Financial failure of contractor	M	Suitable cash flow diagrams should be prepared before starting of work
Design Risk	D17) IRC norms :TCS	AD	IRC should be followed before design time
Field Risk Bench-mark	FR.A.B.1) Setting and wrong manhandling of auto level	AC	Expert should be appointed with survey team for supervising site
Field Risk Topo	FR.TO.4) Absence of Benchmark	T	Checking and maintenance of pillar should be done after certain interval
Field Risk Travers-ing	FR.TR.1) Setting and wrong manhandling of total station	AC	Expert should be appointed with survey team for supervising site
Design Risk	D7) Inadequate site investigation	M	Schedules and scope should be verified before start of work
Field Risk Travers-ing	FR.TR.4) Work interruption & lack of space	T	Meeting should be conducted and proper scheduling and planning should be followed
Field Risk Topo	FR.TO.3) Work interruption, delay & lack of space	T	Meeting should be conducted and proper scheduling and planning should be followed
Field Risk Topo	FR.TO.1) Setting and wrong manhandling of total station	AC	Expert should be appointed with survey team for supervising site
Contractual Risk	CO2)Dispute & claims	T	Approval should be taken prior to commence the work, meeting should be arranged.
Contractual Risk	CO4)Contractors profit	AC	Meeting should be conducted and proper scheduling and planning should be followed

Risk	Description	Strategy	Mitigation
Design Risk	D16) IRC norms :minimum embankment issue	AD	IRC should be followed before design time
Design Risk	D9) TM & UTM issue	AD	Strategy should be decide before the work and
Design Risk	D10) inadequate site data	M	Schedule and scope should be followed
Field Risk DGPS	FR.A.D.5) Work interruption & lack of space	T	Meeting should be conducted and proper scheduling and planning should be followed
Field Risk Site	FR.SI.2) Site condition and resources availability	AC	Reconnaissance survey should be conducted on site
Field Risk Site	FR.A.B.2) Faulty Instrument.	AD	Calibration and checking should be done before work
Field Risk Site	FR.TR.2) Faulty Instrument.	AD	Calibration and checking should be done before work
Field Risk DGPS	FR.A.D.4) colour marking	M	Maintenance should be done in regular interval
External Risk	EX.5) Ghat portion	AC	Reconnaissance survey should be conducted on site before work
Field Risk DGPS	FR.A.D.1) Setting and wrong manhandling of GPS	AC	Expert should be appointed with survey team for supervising site
Field Risk DGPS	FR.A.D.2) Faulty Instrument and battery	AD	Calibration and checking should be done before work
External Risk	EX.2) Political instability	T	Contractor should appoint special team for it

The cost was tracked during the project life cycle of the case study. The considerable less overrun observed in case of NSK 70B for different activities of survey. Cost overrun is Rs. 25000. Topography cost tracking has been done in table no 8.2.

Table 8.2: Cost Tracking for Topography Survey

NSK 70B					
Activities	**Total Km**	**Estimated**	**Actual days**	**Estimated cost**	**Actual cost**
WO	65				
GPS	65	6	6	30000	30000
TBM fix	65	5	5	31500	31500
Traversing	65	6	8	30000	40000
TBM shift	65	6	6	30000	30000
Topography	65	30	33	150000	165000
Inventory	65	5	5	25000	25000
Total		58	63	**296500**	**321500**

The cost has been tracked for geotechnical survey activities. The cost overrun can be seen but amount of overrun is less as compared to other case studies studied which is summarized. Cost overrun is Rs.13950. Geotechnical survey cost tracking has been done in Table no. 8.3

Table 8.3: Cost Tracking for Geotechnical Survey

NSK 70B	**Unit Cost**	**No**	**Bridge Boreholes**				
Boreholes			**1**	**2**	**3**	**4**	**5**
Estimated Depth			10	10	10	10	10
Estimated Drilling in Soft	1100	1	3300	3300	3300	3300	3300
Estimated Drilling in Rock	2100	1	14700	14700	14700	14700	14700
Test	4800	8					
Mobilization	50000	1					
Reports	20000	1					
Trail Pit	1500	16					
Actual depth in Soil			0.5	0.8	0.8	0.5	3
Rock			9.5	9.2	9.2	9.5	7
Soil			550	880	880	550	3300
Actual Drilling Hard Soil			19950	19320	19320	19950	14700
Total Estimated Cost			**252400**				
Total Actual Cost			**266350**				
Cost Overrun			**13950**				

NSK 70B	**Unit Cost**	**No**				
Boreholes			**6**	**7**	**8**	**Total Amount**
Estimated Depth			10	10	10	
Estimated Drilling in Soft	1100	1	3300	3300	3300	**26400**
Estimated Drilling in Rock	2100	1	14700	14700	14700	**117600**
Test	4800	8				
Mobilization	50000	1				
Reports	20000	1				
Trail Pit	1500	16				
Actual depth in Soil			0.5	3.45	0.5	
Rock			9.5	6.55	9.5	
Soil			550	3795	550	**11055**
Actual Drilling Hard Soil			19950	13755	19950	**146895**
Total Estimated Cost						
Total Actual Cost						
Cost Overrun						

8.2 Closure

This chapter presents the mitigation strategy and techniques for NSK 70B. Based information cost for topographical and geotechnical survey has been tracked.Comparative anlysis with five case studies is done .

Chapter 9

RESULTS AND DISCUSSION

The project were analysed from the point of view of cost for various survey and design activities for 5 case studies mentioned in Table no.9.1 The cost overrun were obtained for various case studies and were compared with case study of NSK 70B.The cost overrun for activities of topography survey, geotechnical investigation and design activities of highway were less in case of NSK 70B as compared to that of other case studies.. The mitigation plan was suitably implemented in case of NSK 70B which reduced the cost overrun considerably. Percentage overrun for Topography survey has been done in Table no. 9.2 and Figure no. **??**

Table 9.1: NSK 70B: Cost Tracking for Topo Survey

NSK 70B						
Activities	**Total Km**	**Estimated Days**	**Actual Days**	**Delay**	**Estimated Cost**	**Actual Cost**
WO	65					
GPS	65	6	6		30000	30000
TBM fix	65	5	5		31500	31500
Traversing	65	6	8		30000	40000
TBM shift	65	6	6		30000	30000
Topo	65	30	33		150000	165000
Inventory	65	5	5		25000	25000
Total		58	63	5	296500	**321500**

Table 9.2: Percentage Overrun in Cost for Topographical Survey

Project	Percent Overrun in Cost
Au100B	20.9541779
Au102	17.3965149
Au109	22.38617201
Au115	20.06745363
Au116	22.22928704
NSK70	8.4317

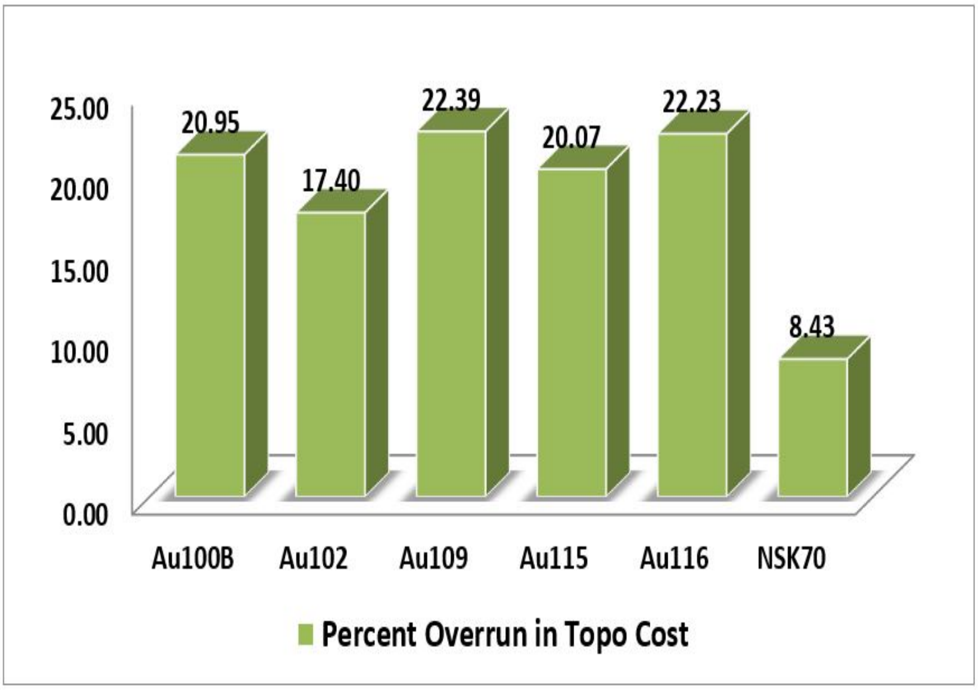

Figure 9.1: Percentage Overrun in Topography

Percentage overrun in Topography cost for NSK 70b is 8.43 which is comparatively less than other five projects. To reduce the overrun we adopted the mitigation techniques and plan in stages .Traversing and topo stages are given special attention.

The project were analysed from the point of view of cost for various survey and design activities for 5 case studies mentioned in Table no.9.3

Table 9.3: Cost Tracking for Geotechnical Survey

NSK 70B	**Unit Cost**	**No**	**Bridge Boreholes**				
Boreholes			**1**	**2**	**3**	**4**	**5**
Estimated Depth			10	10	10	10	10
Estimated Drilling in Soft	1100	1	3300	3300	3300	3300	3300
Estimated Drilling in Rock	2100	1	14700	14700	14700	14700	14700
Test	4800	8					
Mobilization	50000	1					
Reports	20000	1					
Trail Pit	1500	16					
Actual Depth in Soil			0.5	0.8	0.8	0.5	3
Rock			9.5	9.2	9.2	9.5	7
Soil			550	880	880	550	3300
Actual Drilling Hard Soil			19950	19320	19320	19950	14700
Total Estimated Cost			**252400**				
Total Actual Cost			**266350**				
Cost Overrun			**13950**				

NSK 70B	**Unit Cost**	**No**	**Bridge Boreholes**			
Boreholes			**6**	**7**	**8**	**Total Amount**
Estimated Depth			10	10	10	
Estimated Drilling in Soft	1100	1	3300	3300	3300	**26400**
Estimated Drilling in Rock	2100	1	14700	14700	14700	**117600**
Test	4800	8				
Mobilization	50000	1				
Reports	20000	1				
Trail Pit	1500	16				
Actual Depth in Soil			0.5	3.45	0.5	
Rock			9.5	6.55	9.5	
Soil			550	3795	550	**11055**
Actual Drilling Hard Soil			19950	13755	19950	**146895**
Total Estimated Cost						
Total Actual Cost						
Cost Overrun						

Percentage overrun in Geotechnical survey cost for NSK 70b is 5.52 which is comparatively less than other five projects. We done site investigation in which we identified structures and strata type and prepared the cost estimate which help to reduce the cost . Percentage overrun for geotechnical survey has been done in Table no. 9.4.

Table 9.4: Percentage Overrun in Cost for Geotechnical Activities

Project	Estimated Cost	Actual Cost	Percent overrun in Cost
AU 100B	402800	475106	17.95
AU 102	735600	827399	12.48
AU 109	902000	989047	9.65
AU 115	673200	728755	8.25
AU 116	818800	915565	11.81
NSK70B	252400	266350	5.52

The percentage overrun in Geotechnical Survey in shown in Figure no. 9.2

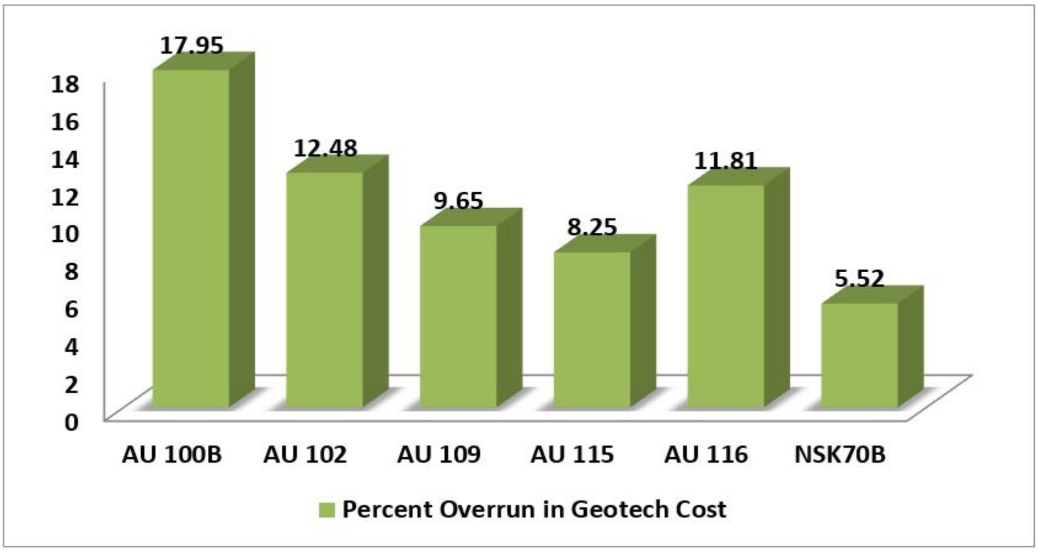

Figure 9.2: Percentage Overrun in Geotechnical Survey

Accuracy in survey helps to reduce the mistakes in design. Design is purely based on the Topography and geotechnical survey. Coordination between site team and designer helps to avoid revision in drawings. For NSK 70B we revised the drawing twice ,which is within the scope of designer and extra cost is not incurred. Percentage overrun for Design has been given in Table no. 9.5.

Table 9.5: Percentage Overrun in Cost for Design Activities

Description	AU 100B	AU 102	AU 109	AU 115	AU 116	NSK70B
Road Geometric Design	5	0	5	5	0	0
Structural design	10	5	15	10	5	0

The percentage overrun in design activities is shown in Figure no. ??

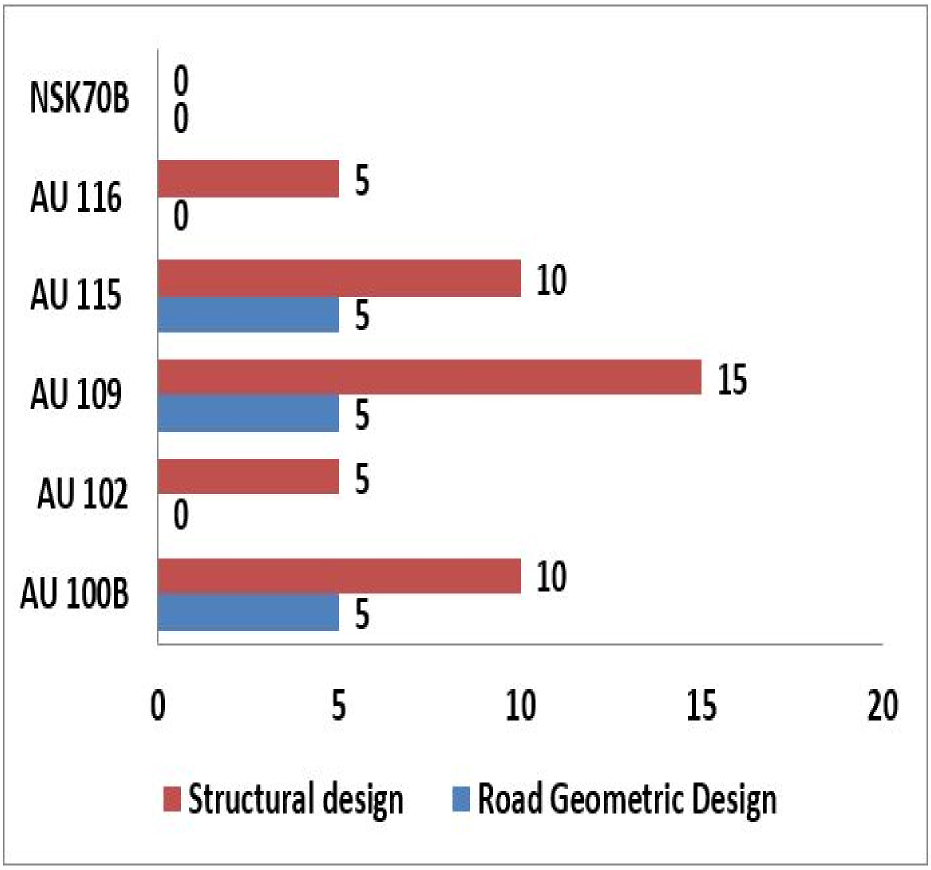

Figure 9.3: Percentage Overrun in Design Activities

Chapter 10

CONCLUSION

The risks have been identified for various activates of Survey and design for highway project carried out in India. The risks have been assessed in terms of occurrences during ongoing implementation of project life cycle. Based on the implementation and study,the risk response strategy has been prepared. The suitable mitigation techniques were developed which have been implemented on the case study NSK 70B.The cost overrun were identified in each case and compared with case study of NSK 70B.The cost overrun was found to be less in case of NSK 70B. The mitigation techniques for survey and design activities has been successfully implemented on the highway case study .

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LIST OF PUBLICATIONS ON PRESENT WORK

[1] Kamble K. K. and Patil D. S., "Risk Analysis and Mitigation for Survey and Design Stages Of Highway Project ", *Journal of the Institution of Engineers (India): Series A*, 2019. (Under review)

[2] Kamble Ketan K. and Patil Dhananjay S., "Risk identification and Mitigation for Survey and Design Stages Of Highway Project " *International Research Journal of Engineering and Technology*, Vol.8, Issue:07, pp.2394-1529, March 2019.(Published)

"Risk Identification and Mitigation for Survey and Design Stages of Highway Projects"

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ABSTRACT

Project Risk Analysis and Management is a process which enables the analysis and management of the risk associated with a project. Risk forecasting really helps in decision making and identification of an area of concern for project stakeholder. In this research the risk were identified on the highway projects for topography survey work. Risks will be identified on 5 highway case study projects. The data of occurrence of risks were collected on live case studies andoccurrences of identified risk were quantified in term of cost. The schedule of cost and time were prepared for 5 live case studies and time delays and cost overruns were monitored during ongoing project. The impacts of risk on individual activities of topography survey wereidentified and their contributions to increase in cost were noted. The further research includes the suggestion of suitable mitigation techniques for individual risk identified based on impact caused by risk.

Keywords: Risk identification, Risk assessment, cost overrun, schedule overrun

1.INTRODUCTION

Risk management in construction industry on each phase is limited to research, practical use and assessment of the risk is very rare in industry. But risk assessment in projects helps to enhance quality of work. The main barrier to effective Management is the lack of the availability of joint risk management system.(Iqbal et al., 2013). Management can be carried out effectively by investigating and identifying the sources of risk associated with different activities of the project.

Highway pre bid surveys are very important phase of execution. Design of highway is totally dependent on these surveys. These surveys are having major four types: Topographic Survey, Inventory Survey, Geotechnical Survey, and Traffic Survey. Topographic survey helps to design the plan and profile of proposed road. Every factor affecting progress of survey leads to schedule and cost overrun. Mitigation plan to minimize the cost overrun and schedule delay should be prepared before design work. Risk identification and analysis is key points while preparing mitigation plan.

International Journal of
Science Technology and Management
ISSN (O):2394-1537 ISSN (P):2394-1529

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Risk Analysis and Mitigation for Survey and Design Stages of Highway Projects

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Abstract—Highway Projects are having various phases Planning, Scheduling, Preliminary Surveys & Designing, Execution.Highway surveys are very important phase before designing. Highway Project Development has many risks as they are having a major impact on issues related to cost, time and quantity of project delivery.Consequences of uncertainty and its exposure in project is risk.Risk analysis in the construction industry on each phase is limited to research, practical use and very rare in the industry. But it is observed that risk assessment in projects helps to enhance the quality of work. Risk mitigation is a risk response strategy whereby the project team acts to reduce the probability of occurrence and impact of risk. Mitigation plan can be carried out effectively by investigating and identifying the sources of risk associated with different activities of the project. There is less work done for mitigation of risk involved in highway design activities or highway construction design surveys. Therefore this projects aims to conduct risk analysis & mitigation research for survey and design stages of highway construction projects.The risk identified for the construction projects are the similar to risk in all types of worldwide projects, hencein proposed work it is decided to identify the risk in the highway projects for survey and design phase. Risks were identified from the ongoing projects for survey work like topography, geotechnical investigation and, design of highway projects. Also, some previous research papers were studied to identify probable risks can occur in survey and design work.After the risk is identified, the suitable assessment was done for the identified risk based on data collected on ongoing casestudies.After the assessement of risk, the risk were classified for risk response plan and suitable risk mitigation plan will be proposed and same was implemented on one of the ongoing projects. It was observed that the considerable saving can be observed in term of cost and time after implementation of mitiation plan.

***Keywords*— Risk identification; Risk Assessment; Risk Mitigation;Risk Response Plan**

I. Introduction

Highway Projects are having various phases such as Planning, Scheduling, Preliminary Surveys & Designing, Execution. Highway surveys are very important phase before designing. Design of highway is totally dependent on these surveys. These also developed by scimago: SCIMAGO INSTITUTIONS RANKINGS

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A

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Submitted By,

Mr. Ketan Kailas Kamble

1727006

Under the Guidance Of

Prof.D.S.Patil

&

Co-guide

Mr. Vijay Raghojiwar

Civil Engineering Department

In partial fulfillment of the degree M- TECH

Kasegaon Education Society's

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SYNOPSIS OF M. TECH. DISSERTATION

1. Name of Program : M. Tech (Civil-Construction Management).

2. Name of Student : Mr. Ketan Kailas Kamble. (1727006)

3. Date of Registration : August 2018.

4. Name of Guide : Prof. D.S.Patil
: Mr. Vijay Raghojirao (Co-guide)

5. Sponsor Details : Innovision Technologies.

6. Proposed Title : **"Risk Analysis and Mitigation for Survey and Designing Stages of Highway Projects."**

7. Synopsis of Dissertation Work:

7.1 Introduction and Relevance:-

Highway Projects are having various phases Planning, Scheduling, Preliminary Surveys & Designing, Execution. Highway surveys are very important phase before designing. Design of highway is totally dependent on these surveys. These surveys are having major four types: Topographic Survey, Inventory Survey, Geotechnical Survey and Traffic Survey. The topographic survey helps to design the plan and profile of the proposed road. Geotechnical investigation survey required for designing of major bridges, culverts and also for plan and profile of the road. Highway Project Development has many risks as they are having a major impact on issues related to cost, time and quantity of project delivery. Consequences of uncertainty and its exposure in project is risk. (Vidivelli, et al.2017).

Risk analysis in the construction industry on each phase is limited to research, practical use and very rare in the industry. But it is observed that risk assessment in projects helps to enhance the quality of work. Risk mitigation is a risk response strategy whereby the project team acts to reduce the probability of occurrence and impact of risk. It implies a reduction in probability or impact of an adverse risk to be within an acceptable threshold limit. Mitigation plan can be carried out effectively by investigating and identifying the sources of risk associated with different activities of the project. The main barrier to effective Management is the lack of the availability of joint risk analysis by various stakeholder. (Iqbal et al., 2013).

From the literature it was found that financial risk was a major factor in affecting the cost and schedule of the project. Risk forecasting really helps in decision making and identification of an area of concern for project stakeholder. So project manager should conduct a risk analysis to identify potential threats at the early stage of construction. (Choudhry et al., 2014). Even though every construction project has its own specific conditions, professionals can still obtain certain useful information from the research findings for their local and global construction projects because the risk identified for the construction projects are the similar to risk in all types of worldwide projects, hence in proposed work it is decided to identify the risk in the highway projects for survey and design phase. Risks will be identified from the ongoing projects for survey work like topography, geotechnical investigation and, design of highway projects. Also, some previous research papers were studied to identify probable risks can occur in survey and design work. After the risk is identified, a risk mitigation plan will be proposed and same will be implemented on one of the ongoing projects.

7.2 Present theories and practices:-

1. Abhinaya, K., (2017) "Risk management in highway construction using Risk Priority Matrix and SPSS Software."

In this paper forty eight risks are identified through detailed literature review. Detail questionnaire is developed .Risk analysis is done by Risk Priority matrix (RPM) in excel and by using of Statistical Packages for Social Sciences (SPSS) .Improper project group causes risk in highway project and it is having high impact on construction.

2. Vidivelli, B., (2017) "Risk Analysis in Bridge Construction Projects."

This thesis seeks to identify the risk factors that affect the performance of bridge projects as a whole and analyze by using appropriate tools and techniques and to develop a risk management. Qualitative analysis is done by questionnaire preparation, demographic analysis, T test and one way Anova (Analysis of variance).These paper helps project professional to focus on a few risk factors and get the optimum result.

3. Choudhry, R.M., (2014) "Cost and schedule risk analysis of bridge construction in Pakistan : Establishing Risk Guidelines."

They have used Monte Carlo simulation results on primavera pertmaster V8 to quantify impact of risk on a project schedule and cost. Comparison between primavera results and actual Time and cost completion data had been done; along with Qualitative risk analysis by questionnaire was done. They found that financial risk were major factor in affecting the cost and schedule of the project. Risk forecasting really helps in decision making and identification of area of concern for project stakeholders.

4. Choudhry, R.M., (2013) "Identification of risk management system in construction industry in Pakistan."

This is empirical survey based study of risk management. In this paper questionnaire survey and interviews of key participants in construction industry had taken. Statistical techniques like sample population mean and ranking and sperman rank correlation are used. Financial and economic factors are most important risk faced by the construction industry, followed by quality. Risk management standard for risk analysis techniques, Risk Response Techniques, Risk Monitoring Techniques and Maturity Level of system are required to be developed.

5. Li, Q. and Zhang ,P., (2013) "Risk identification for the Construction phases of the large bridge based on WBS-RBS."

In this paper introduced new method of risk identification with modular analysis based on WBS-RBS (Work Breakdown structure-Risk Breakdown structure).For that establishing WBS-RBS, the BCICS (Bridge Construction Information Classification System of (ISO)) used. NGT (Nominal Group Technique) is used for judgement of matrix element of the RBM (Risk Breakdown Matrix) to identify the risk information of large bridges in construction phase. This study helps for the modularized computer storage of the risk information of large bridges in construction phase.

7.3 Gap analysis:

Researches above show that various methods and tools are available for risk analysis and mitigation on heavy bridge construction project. There is less work done for mitigation of risk involved in highway design activities or highway construction design surveys. Therefore this projects aims to conduct risk analysis & mitigation research for survey and design stages of highway construction projects.

7.4 Problem Statement:

To analyze the various risk involved in survey and design stages of highway development projects and develop risk mitigation techniques and strategies for same.

7.5 Objectives:-

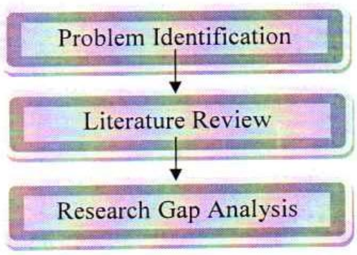
1) To identify and analysis the risks for survey and design stages of highway development projects.
2) To do comparative risk analysis of projects.
3) To develop Risk Mitigation Techniques and Strategies for survey and design stages of new highway development project.
4) To analyse the impact of developed mitigation techniques on new project.

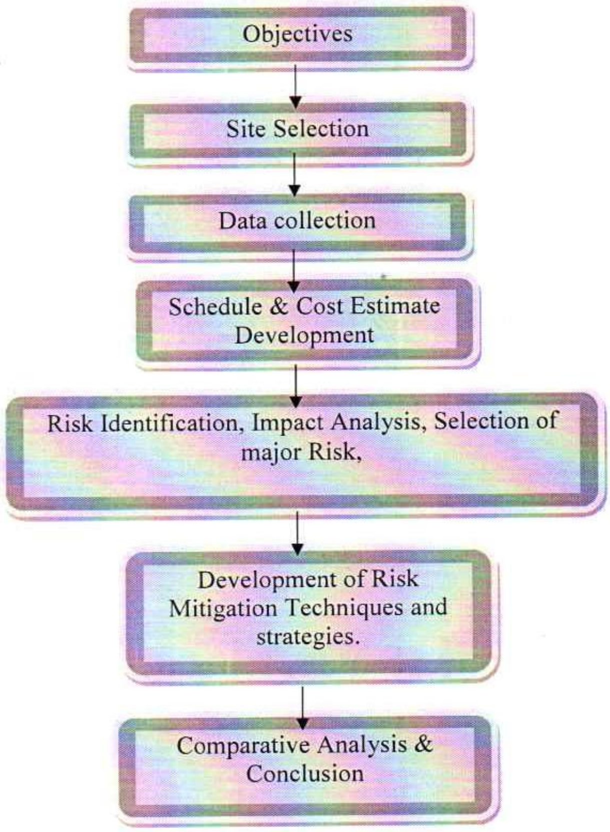
7.6 Scope:-

This project work will be limited to analyse five (5) ongoing projects and implementation of developed mitigation techniques to one new/ongoing project.

7.7 Methodology:-

All objectives will be achieved by following methodology:





7.8 Proposed work

In this dissertation work it is proposed to carry out risk analysis for survey and design stages of Highway development projects.

The proposed work is planned in following phases:

Phase I- (Sep 2018)

- Literature survey.
- Site selection.
- Collection of data.

Phase II – (Oct-Nov 2018)

Risk Assessment and Scheduling.

- Identify the various risk involved to rank them accordingly and make risk assessment plan for five sites.
- Scheduling and Cost Estimating for Project.

Phase III – (Dec- March 2018)

- Mitigation Techniques and Strategies.
- Implementation.

Phase IV – (April-May 2018)

- Result and Conclusion

7.9 Facilities available:-

The following facilities to carry out dissertation work are available at Rajarambapu Institute of Technology, Rajaramnagar.

1. Primavera P6

7.10 Expected date for completion of work: - May 2019

7.11 Approximate expenditure of project: - 10,000/-

7.12 References:

Abhinaya, K. and Nidhu, S., (2017) " Risk management in highway construction using Risk Priority Matrix and SPSS Software." SSRG International Journal of Civil Engineering-(ICETM-2017),Special Issue,7-11.

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Jayasudha, K .,Vidivelli, B. and Vidyasagar, E., (2017) "Risk Analysis in Bridge Construction Projects." International Journal of Innovative Research in Science Engineering and Technology (IJIRSET) 6, no.5.

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The Association For Project Management. (2000). "Project Risk Analysis and Management Guide."

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