Risk Management Appraisal - A tool for successful Infrastructure project

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Abstract:

To accomplish project goals in terms of time, money, quality, and degree, it has been determined that managing risks is an essential management procedure for foundation development projects. Using a thorough analysis of agreement states, this research recognises dangers and divides them into eight categories. It is seen in a personal way. The project's objectives are believed to be most affected by risk analysis, social and political opposition, plan revisions, and work suspension. Several suggestions for reducing development project hazards, or mitigation techniques, have been found through this research. The contract agreements are used as a tool to manage risk, and the client, contractors, and financial backers or institutions that are sponsoring the project must outline any risks to the executive's plan during the project's lifespan. From the attainability stage onward, it is anticipated that clients, contractors, project workers, and governmental organisations will work together to resolve projected hazards in due course.

Keywords - Project Risk; Risk management; Risk distribution; Infrastructure projects; Contract document.

Introduction:

Risk in the Infrastructure development business is undeniable in view of the complicated powerful climate in which development work must be performed. As development exercises are unsure in nature, consequently, studies certify that development is a significantly risk slanted industry. This exploration centers around the risk included particularly in building and framework projects as it is an enormous piece of development industry. For the fruitful accomplishment of undertaking goals and targets, risk ought to be overseen in a successful way

Risk has numerous definitions and some are examined here. As indicated by project the executives establishment risk is characterized as "an unsure occasion whose results can adversely affect project targets". Essentially it tends to be characterized as chances of something awful occurring. Risk is characterized as chances of something happening that might influence the undertaking objectives or targets in a negative manner.

Initial phase in overseeing risk is recognizing risk without it we can't continue further. In this way, chance ought to be distinguished completely as it is vital to recognize every single risk included. The motivation behind risk ID isn't to get exact and correct expectations for risk occasions. Its motivation is to perceive every one of the potential risks with high effect. Hence, it gives an understanding to what risks are available or can be looked in future before it really happens. Subsequently, having sufficient opportunity to get ready for these risks. As risk and vulnerabilities continues to change hence distinguishing proof of chance is an iterative interaction with new risk arising during the lifecycle of a venture. Prior to overseeing risk factors, distinguishing them is important.

Risk Analysis:

When risk present is distinguished now the following significant step is to evaluate those chance elements as certain variables can be more basic than others. Examination of risk is the second step of the board interaction. The motivation behind this step is to totally evaluate the risk factor and to focus on them as examined before. This step assumes a significant part as risk alleviation measures are chosen in view of this step. Examination of risk can be comprehensively ordered into two classes for example quantitative and subjective risk investigation according to ISO 31000: 2009. Both

quantitative and 7 subjective risk examination procedures center around finding the risk factors present in development projects. Subjective risk examination comprises of organized and factual information and quantitative risk examination comprises of information in type of impressions, assessments, agendas, and so forth. Subjective procedure estimates risk as far as its criticality which gives better thought of chance component. By and large utilized technique for risk appraisal comprise of likelihood and seriousness of chance element. In this, the risk factors are examined in view of the likelihood and seriousness of the risk. As the general effect of chance will rely upon the likelihood for example how frequently it happens and seriousness for example its effect based on project goals in conditions of cost, time, and quality. Dissecting risk like this pursues choice making process more exact with genuine circumstances looked nearby. The motivation behind risk the board is to survey the result of occasions on the off chance that undertaking didn't continue as per arranged timetable and cutoff times. It gives an essential thought that a specific occasion it didn't continue as expected can influence this much. Factors recognized are focused on in light of their effect on project targets. Table 2 shows various techniques ordinarily utilized for investigation of chance elements.

Table 2: Methods Commonly Used For Analysis of Risk Factors

Quantitative methods	Qualitative methods
Monte Carlo Simulation	Assessment of Probability & Impacts of Identified risk.
Sensitivity Analysis	Probability and impact Matrix
Decision Tree Analysis	Relative importance index
Checklists	

Probability and Impact Assessment of Risk:

Likelihood of chance is characterized as recurrence of that occasion to happen, and seriousness of risk is characterized as effect of risk once the occasion has happened. Generally speaking, augmentation of this for example likelihood and seriousness give the worth of effect of chance which expresses the criticality of the risk. Recurrence of chance can be determined by utilizing condition number 1 and seriousness of risk utilizing equation number 2.

1. **Frequency index F.I** $=\sum an\ N*A \times 100$ …….. (1)

   Where,

   a = weight assigned by respondent

   n = responses probability

   N = total number of participants

   A = maximum weight

   (Source: Ibrahim Mahamid , Nabil Dmaidi., (2013) CONSULTANTS' VIEW TOWARD THE FACTORS AFFECTING TIME OVERRUN IN PUBLIC CONSTRUCTION PROJECTS)

2. **Severity index S.I** = $\sum an\ N*A \times 100$ ……..(2)

Where,

a = weight assigned by respondent

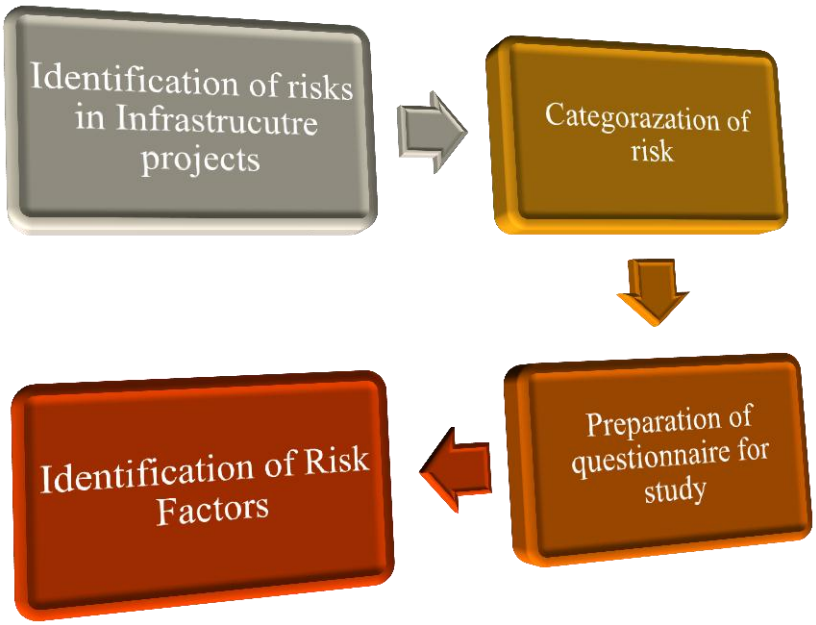
n = responses probability

N = total number of participants

A = maximum weight

(Source: Ibrahim Mahamid , Nabil Dmaidi., (2013) CONSULTANTS' VIEW TOWARD THE FACTORS AFFECTING TIME OVERRUN IN PUBLIC CONSTRUCTION PROJECTS)

Methodology:



Construction projects consists of internal and external risks which can be further divided into various categories. Classifying into categories is important because these projects contains various uncertainties and risks. To avoid these risks laws and regulations should be followed. Unfortunately, we can't avoid these risks but we can manage them to decrease their impact. By categorization of risk, we can optimize our risk management process and thus avoiding losses.

Many researchers classify risk in different categories based on various parameters and assumptions. Risk categorization also depends upon organizations as they classify risk according to their suitability. In this research risk categorization is done by in-depth study of risk categories and combining various categories where necessary. A try is done to cover all the possible risks under these categories. Various risk categories were joined like technical and construction risk categories were joined to form one category. Similarly, contractual and legal was joined to form one category. Resource and site-related category were joined to form one category. Economic category and finance category were joined to form one category. Safety and health category were joined to form one category.

A total of eight risk category were recognized.

1. **Management Risks:**

These are those risks which emerge because of fumble of occasions/assets by the supervisory crew. In this abilities, experience of supervisory group assumes a significant part. They need to take quick and precise choices for improved results. Any postponements or stops in direction can bring about colossal misfortunes.

Risk ID	Description of risk factor
RF1	Poor coordination or communication among various parties
RF2	Poor management skills
RF3	Lack of experience of the project team
RF4	Personal conflicts between different clients involved
RF5	Poor site management and supervision
RF6	Shortage of skillful managers and professional's
RF7	Improper project planning and budgeting
RF8	Change of top management
RF9	Inadequate quality planning and quality assurance
RF10	Lack of clarity over roles and responsibilities
RF11	Government restrictions on foreign companies

2. Technical and Construction Risk:

Specialized risks and development risk are likewise vital in project achievement. In specialized risk angles like details, innovation, plan, and designing are there. In development takes a chance with perspectives like expense/time overwhelms, quality, development strategies are there. For effective fruition of venture, these viewpoints ought to be overseen ideal.

Sr. No.	Risk ID	Description of risk factor
1	RF12	Design errors or design changes
2	RF13	Unclear and incomplete detailing in design drawings and specifications
3	RF14	Using poor construction techniques
4	RF15	Delay in design
5	RF16	Complexity of design
6	RF17	Inadequate experience of contractor in same projects
7	RF18	Construction errors and poor workmanship leading to rework
8	RF19	Approval and permit delays
9	RF20	Pressure to crash project duration (time constraints)
10	RF21	Using complex construction methods/techniques
11	RF22	Changing construction methods/techniques in between of work

3. Resource and Site-Related Risks:

Takes a chance with like accessibility of material, work, and gear are asset risk. Then again, site-related chances are those which are connected with site like unexpected underground circumstances, accessibility of fundamental things on location like power, availability of site, and so on.

Sr. No.	Risk ID	Description of risk factor
1	RF23	Low productivity and efficiency of equipment
2	RF24	Breakdown of plant and machinery
3	RF25	Shortage of skillful workers locally
4	RF26	Shortage or delay in delivery of expected materials
5	RF27	Unavailability or shortage of equipment
6	RF28	Low labour productivity
7	RF29	Adverse ground conditions
8	RF30	Unavailability of utilities on-site required for construction
9	RF31	Difficulties in accessing site due to topography of the region
10	RF32	Inadequate preliminary survey and tests of site
11	RF33	Delays in the site possession

4. Contractual and Legal Risks:

Authoritative and legitimate risks are those which are connected with questions in agreement archives, claims, and different issues connected with overall set of laws. It can emerge at any stage during development process. This can bring about significant deferrals and cost increment as in some cases choices from court are postponed for long time.

Sr. No.	Risk ID	Description of risk factor
1	RF34	Contradictions in the contract documents
2	RF35	Changes in project scope
3	RF36	Litigations and disputes retarding project progress
4	RF37	Contractual disputes and claims
5	RF38	Huge competition at the tendering stage
6	RF39	Change in codes and regulations
7	RF40	Unreliability of the legal system

5. Economic and Financial Risk:

This risk classification is connected with risk emerging because of expansion in charges, expansion, changing unfamiliar trade, presenting new financial strategies, and so forth these risks straightforwardly influences the monetary limit of the undertaking as these things are not considered while arranging of spending plan. Thus, these risks should be arranged at the beginning of the undertaking. In some cases project needs to endure a ton as far as culmination time because of financing issues. So monetary and monetary risks ought to be concentrated cautiously and unequivocally.

Sr. No.	Risk ID	Description of risk factor
1	RF41	Unpredicted changes in interest rates
2	RF42	Payment delays
3	RF43	Failure to meet revenue targets
4	RF44	Unpredicted changes in inflation rates
5	RF45	Inaccurate assessment of market demand
6	RF46	Project-funding problems
7	RF47	Fluctuation in exchange rate of currency

6. Socio-Political Risk:

Socio-political risks emerge because of social and political nature of the area in which venture is to be taken. Social risks are those which are connected with strict contrasts, various societies, and so on political risks are those which emerges because of progress of government, strategies, regulations, and guidelines. Now and again new codes or rules are forced in during progressing project.

Sr. No.	Risk ID	Description of risk factor
1	RF48	Unfavourable social environment
2	RF49	Political instability of the government
3	RF50	Compensation and land acquisition problems
4	RF51	Public opposition to the project
5	RF52	Different religious and cultural beliefs
6	RF53	Laws and policies revising in between of project
7	RF54	Labour disputes and strikes
8	RF55	Improper project feasibility study
9	RF56	Outbreak of hostilities (riots, revolutions & terrorism)

7. Environmental Risk:

Ecological risks are those which emerges because of progress in nature like avalanches, quakes, ceaseless precipitation, and so forth. These risks by and large stay inconspicuous till it happens in view of obscure nearby circumstances like climate. Natural risks can cost colossal deficiency of cash and time in the event that not arranged as expected.

Sr. No.	Risk ID	Description of risk factor
1	RF57	Pollution related to construction activities (dust, harmful gases, etc.)
2	RF58	Strict environmental rules and regulations
3	RF59	Changes in environmental standards
4	RF60	Legal proceedings due to wrong disposal of waste
5	RF61	Bad weather (snow, excess rain)
6	RF62	Natural disasters (floods, landslides, etc.)
7	RF63	Improper assessment of project impacts on environment

8. Health and Safety Risk:

Wellbeing and risks are those risks which are connected with wellbeing and security of individuals engaged with project. These incorporate different wellbeing guidelines, planning for mishaps and wounds happening nearby, and so on. More modest destinations and little development organizations a large portion of the times disregard wellbeing and security of individuals engaged with development exercises. Thus, government needs to make a few severe strategies in regards to wellbeing and risks alongside shock checks. Anybody found not observing wellbeing and security guidelines and guidelines ought to be fined with the goal that everybody in future follows these guidelines.

Sr. No.	Risk ID	Description of risk factor
1	RF64	Accidents occurring during construction
2	RF65	Inadequate safety measures
3	RF66	Changed labour safety laws or regulations
4	RF67	Epidemic illness
5	RF68	Damage to property due to unsafe operations
6	RF69	Lack of protection from enclosing area
7	RF70	Lack of knowledge
8	RF71	Effect of Pandemic

Questionnaire Structure:

The basic inspiration driving overview is to amass information from respondents. It contains destined plan of factors of chance recognized by documentation overviews, past experience of undertaking people, and context oriented examinations of pre-executed projects. Pilot study was done on survey to investigate its clearness and straightforwardness of sorting out questions as a matter of fact. Risk factors those were seen as not associated with study plan or those components which were found reiterated was killed or changed.

Result & Discussions

Frequency Analysis and Ranking:

When information assortment is finished from poll study following stage is to examine it Likelihood of risk is characterized as its capacity to rehash in a specific timeframe. In poll, overview likelihood was evaluated on three-point Likert scale. One implies low likelihood, two means moderate likelihood and three connotes high likelihood. The gathered information is examined for likelihood of chance utilizing relative significance file and is referred to as recurrence record as displayed in Table. The computation comprise of three sections first segment shows the chronic number of risk code and the risk factor, second section comprise of the recurrence on size of three and last segment demonstrate the recurrence estimation utilizing relative significance record with rank for recurrence. In this the positioning of risk factors is done in light of recurrence record as displayed in Table.

Table: Ranking of risk factors in relation with frequency

Sr. No.	Risk Factor	FI	Rank
1	RF28-Low labour productivity	2.44	1
2	RF38-Huge competition at the tendering stage	2.35	2
3	RF33-Delays in the site possession	2.33	3
4	RF7-Improper project planning and budgeting	2.29	4
5	RF25-Shortage of skilful workers locally	2.27	5
6	RF15-Delay in design	2.23	6
7	RF6-Shortage of skilful managers and professional's	2.22	7
8	RF20-Pressure to crash project duration (time constraints)	2.22	8
9	RF42-Payment delays	2.21	9
10	RF10-Lack of clarity over roles and responsibilities	2.19	10

11	RF43-Failure to meet revenue targets	2.19	11
12	RF18-Construction errors and poor workmanship leading to rework	2.18	12
13	RF19-Approval and permit delays	2.18	13
14	RF37-Contractual disputes and claims	2.18	14
15	RF50-Compensation and land acquisition problems	2.15	15
16	RF5-Poor site management and supervision	2.14	16
17	RF8-Change of top management	2.14	17
18	RF1-Poor coordination or communication among various parties	2.10	18
19	RF24-Breakdown of plant and machinery	2.10	19
20	RF26-Shortage or delay in delivery of expected materials	2.10	20
21	RF13-Unclear and incomplete detailing in design drawings and specifications	2.08	21
22	RF23-Low productivity and efficiency of equipment	2.06	22
23	RF46-Project-funding problems	2.06	23
24	RF44-Unpredicted changes in inflation rates	2.05	24
25	RF32-Inadequate preliminary survey and tests of site	2.04	25
26	RF2-Poor management skills	2.01	26
27	RF9-Inadequate quality planning and quality assurance	2.00	27
28	RF16-Complexity of design	2.00	28
29	RF29-Adverse ground conditions	1.97	29
30	RF12-Design errors or design changes	1.96	30
31	RF58-Strict environmental rules and regulations	1.96	31
32	RF14-Using poor construction techniques	1.95	32
33	RF36-Litigations and disputes retarding project progress	1.95	33
34	RF35-Changes in project scope	1.94	34
35	RF65-Inadequate safety measures	1.94	35
36	RF47-Fluctuation in exchange rate of currency	1.94	36
37	RF55-Improper project feasibility study	1.94	37
38	RF59-Changes in environmental standards	1.92	38
39	RF17-Inadequate experience of contractor in same projects	1.91	39
40	RF45-Inaccurate assessment of market demand	1.90	40
41	RF22-Changing construction methods/techniques in between of work	1.88	41
42	RF34-Contradictions in the contract documents	1.88	42
43	RF4-Personal conflicts between different clients involved	1.87	43
44	RF21-Using complex construction methods/techniques	1.85	44
45	RF27-Unavailability or shortage of equipment	1.85	45

46	RF63-Improper assessment of project impacts on environment	1.85	46
47	RF51-Public opposition to the project	1.83	47
48	RF64-Accidents occurring during construction	1.81	48
49	RF71 - Effect of Pandemic	1.81	49
50	RF31-Difficulties in accessing site due to topography of the region	1.78	50
51	RF49-Political instability of the government	1.78	51
52	RF61-Bad weather (snow, excess rain)	1.77	52
53	RF30-Unavailability of utilities on-site required for construction	1.76	53
54	RF41-Unpredicted changes in interest rates	1.76	54
55	RF70-Lack of knowledge	1.76	55
56	RF40-Unreliability of the legal system	1.73	56
57	RF48-Unfavourable social environment	1.72	57
58	RF54-Labour disputes and strikes	1.69	58
59	RF57-Pollution related to construction activities (dust, harmful gases, etc.)	1.69	59
60	RF68-Damage to property due to unsafe operations	1.68	60
61	RF39-Change in codes and regulations	1.68	61
62	RF53-Laws and policies revising in between of project	1.67	62
63	RF62-Natural disasters (floods, landslides, etc.)	1.65	63
64	RF67-Epidemic illness	1.65	64
65	RF60-Legal proceedings due to wrong disposal of waste	1.62	65
66	RF52-Different religious and cultural beliefs	1.60	66
67	RF69-Lack of protection from enclosing area	1.59	67
68	RF66-Changed labour safety laws or regulations	1.56	68
69	RF11-Restrictions on foreign companies	1.56	69
70	RF56-Outbreak of hostilities (riots, revolutions & terrorism)	1.56	70
71	RF3-Lack of experience of the project team	1.31	71

Severity Analysis and Ranking:

When recurrence list is determined subsequent stage is to compute seriousness utilizing relative significance file. Seriousness determined utilizing relative significance record is known as seriousness file (S.I). Seriousness is the proportion of chance figure terms of how extreme a risk can be whenever it has happened. In poll, seriousness was decided on five-point Likert scale. One shows extremely low seriousness, two demonstrate low seriousness, three demonstrate moderate seriousness, four demonstrate high seriousness and five show exceptionally high seriousness. Estimations for seriousness of chance is shown in Table 4.2.

Table 4.2 Ranking of risk factors in relation with severity

Sr. No.	Risk Factor	FI	Rank
1	RF56-Outbreak of hostilities (riots, revolutions & terrorism)	4.08	1
2	RF42-Payment delays	4.05	2
3	RF3-Lack of experience of the project team	3.91	3
4	RF6-Shortage of skilful managers and professional's	3.82	4
5	RF4-Personal conflicts between different clients involved	3.63	5
6	RF26-Shortage or delay in delivery of expected materials	3.60	6
7	RF33-Delays in the site possession	3.60	7
8	RF67-Epidemic illness	3.59	8
9	RF13-Unclear and incomplete detailing in design drawings and specifications	3.59	9
10	RF71 - Effect of Pandemic	3.55	10
11	RF37-Contractual disputes and claims	3.53	11
12	RF12-Design errors or design changes	3.50	12
13	RF23-Low productivity and efficiency of equipment	3.49	13
14	RF5-Poor site management and supervision	3.45	14
15	RF25-Shortage of skilful workers locally	3.44	15
16	RF64-Accidents occurring during construction	3.44	16
17	RF24-Breakdown of plant and machinery	3.42	17
18	RF43-Failure to meet revenue targets	3.42	18
19	RF2-Poor management skills	3.41	19
20	RF29-Adverse ground conditions	3.41	20
21	RF34-Contradictions in the contract documents	3.40	21
22	RF65-Inadequate safety measures	3.40	22
23	RF32-Inadequate preliminary survey and tests of site	3.37	23
24	RF55-Improper project feasibility study	3.37	24
25	RF38-Huge competition at the tendering stage	3.35	25
26	RF50-Compensation and land acquisition problems	3.35	26
27	RF35-Changes in project scope	3.33	27
28	RF7-Improper project planning and budgeting	3.33	28
29	RF27-Unavailability or shortage of equipment	3.32	29
30	RF9-Inadequate quality planning and quality assurance	3.31	30
31	RF36-Litigations and disputes retarding project progress	3.29	31
32	RF44-Unpredicted changes in inflation rates	3.26	32
33	RF62-Natural disasters (floods, landslides, etc.)	3.24	33

34	RF57-Pollution related to construction activities (dust, harmful gases, etc.)	3.23	34
35	RF63-Improper assessment of project impacts on environment	3.22	35
36	RF14-Using poor construction techniques	3.19	36
37	RF28-Low labour productivity	3.19	37
38	RF68-Damage to property due to unsafe operations	3.18	38
39	RF1-Poor coordination or communication among various parties	3.18	39
40	RF15-Delay in design	3.17	40
41	RF39-Change in codes and regulations	3.17	41
42	RF45-Inaccurate assessment of market demand	3.17	42
43	RF17-Inadequate experience of contractor in same projects	3.15	43
44	RF51-Public opposition to the project	3.14	44
45	RF58-Strict environmental rules and regulations	3.14	45
46	RF18-Construction errors and poor workmanship leading to rework	3.14	46
47	RF20-Pressure to crash project duration (time constraints)	3.10	47
48	RF49-Political instability of the government	3.10	48
49	RF59-Changes in environmental standards	3.08	49
50	RF31-Difficulties in accessing site due to topography of the region	3.08	50
51	RF70-Lack of knowledge	3.06	51
52	RF47-Fluctuation in exchange rate of currency	3.04	52
53	RF41-Unpredicted changes in interest rates	3.04	53
54	RF54-Labour disputes and strikes	3.04	54
55	RF8-Change of top management	3.03	55
56	RF61-Bad weather (snow, excess rain)	3.03	56
57	RF22-Changing construction methods/techniques in between of work	3.01	57
58	RF66-Changed labour safety laws or regulations	3.01	58
59	RF10-Lack of clarity over roles and responsibilities	3.00	59
60	RF30-Unavailability of utilities on-site required for construction	3.00	60
61	RF46-Project-funding problems	3.00	61
62	RF19-Approval and permit delays	2.96	62
63	RF53-Laws and policies revising in between of project	2.96	63
64	RF21-Using complex construction methods/techniques	2.94	64
65	RF60-Legal proceedings due to wrong disposal of waste	2.94	65
66	RF40-Unreliability of the legal system	2.92	66
67	RF48-Unfavourable social environment	2.92	67
68	RF16-Complexity of design	2.87	68
69	RF69-Lack of protection from enclosing area	2.74	69

70	RF52-Different religious and cultural beliefs	2.74	70
71	RF11-Restrictions on foreign companies	2.60	71

4.4 Analysis of Risk Potential:

When information assortment is finished from poll overview following stage is to examine risk capability of the variables recognized. Risk potential is determined by augmentation of recurrence record and seriousness list as talked about in research technique. Recurrence of a risk factor is characterized as its capacity to rehash in a specific timeframe. Seriousness of a risk factor is characterized as how extreme a risk variable can be whenever it has happened. Risk potential for various classes are determined in additional conversation. Characterizing risk factors as basic, moderate, low and positioning of risk variables will be finished based on risk effect and standardization of risk influence esteem. For computation of risk influence, ascertaining risk potential is significant first. As knowing recurrence, seriousness and chance capability of a risk assumes a significant part in administration of the risk calculate present task. Top three risk factors in every classification is examined in conversation of various classifications and for other risk factors present in a class, the computations can be track down in comparing tables.

In management category a total of 11 factors were there and top three risk factors in this category are discussed further. 'Shortage of skillful managers and professional's' was found to have maximum value of risk potential with (FI = 2.22, SI = 3.82 and RP = 8.47). It is seen that lack of required skills can be observed in locally available managers and professionals. Sometimes for quality and complicated work skilled professionals are necessary. To meet these criteria sometimes management, have to recruit people from other areas who are skilled in the work. This is time-consuming as well as costly process. For other management risk factors calculations of FI, SI and RP are shown in Table 4.3 and comparison of RP of management risk is shown in Figure 4.1.

Table 4.3 Calculation of FI, SI and RP for management category

Sr. No.	**Risk Factor**	**FI**	**SI**	**RP**
A	**Management Risks**			
1	RF1-Poor coordination or communication among various parties	2.10	3.18	6.69
2	RF2-Poor management skills	2.01	3.41	6.86
3	RF3-Lack of experience of the project team	1.31	3.91	5.11
4	RF4-Personal conflicts between different clients involved	1.87	3.63	6.79
5	RF5-Poor site management and supervision	2.14	3.45	7.38
6	RF6-Shortage of skilful managers and professional's	2.22	3.82	8.47
7	RF7-Improper project planning and budgeting	2.29	3.33	7.65
8	RF8-Change of top management	2.14	3.03	6.48
9	RF9-Inadequate quality planning and quality assurance	2.00	3.31	6.62
10	RF10-Lack of clarity over roles and responsibilities	2.19	3.00	6.58
11	RF11-Restrictions on foreign companies	1.56	2.60	4.07

Fig. 4.1 Comparison of RP of Management category

Next risk category is technical & construction related with 11 risk factors present in it and top three risk factors in this category are discussed further. All factors in this category are shown in Table 4.4 with frequency index, severity index and risk potential. In this category the most significant risk factor was 'Unclear and incomplete detailing in design drawings and specifications' with (FI = 2.08, SI = 3.59 and RP = 7.46). It is often seen that projects are delayed due to late approvals by various departments. Comparison of RP of technical & construction category is shown in Figure 4.2.

Table 4.4 Calculation of FI, SI and RP for technical & construction category

Sr. No.	Risk Factor	FI	SI	RP
	B.Technical and Construction Risks			
	RF12-Design errors or design changes	1.96	3.50	6.87
	RF13-Unclear and incomplete detailing in design drawings and specifications	2.08	3.59	7.46
	RF14-Using poor construction techniques	1.95	3.19	6.22
	RF15-Delay in design	2.23	3.17	7.06
	RF16-Complexity of design	2.00	2.87	5.74
	RF17-Inadequate experience of contractor in same projects	1.91	3.15	6.02
	RF18-Construction errors and poor workmanship leading to rework	2.18	3.14	6.85
	RF19-Approval and permit delays	2.18	2.96	6.45
	RF20-Pressure to crash project duration (time constraints)	2.22	3.10	6.88
	RF21-Using complex construction methods/techniques	1.85	2.94	5.42
	RF22-Changing construction methods/techniques in between of work	1.88	3.01	5.68

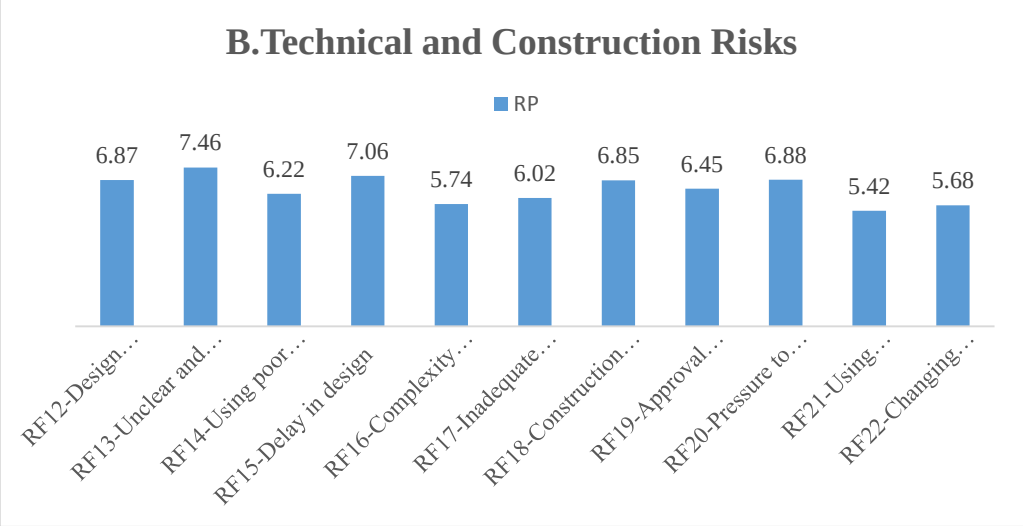


Fig 4.2 Comparison of RP of technical & construction category

Third risk category considered in this research is resource & site-related category. Top three risk factors with highest RP in this category are discussed here. This category involved factors related to site and resources. 'Shortage of skillful workers locally' was found to be a major factor with (FI = 2.27, SI = 3.44 and RP = 7.80). All other factors in this category are shown in Table 4.5 along with calculations for FI, SI and RP. Calculation for RP is shown in Figure 4.3.

Table 4.5 Calculation of FI, SI and RP for resource and site-related category

Sr. No.	Risk Factor	FI	SI	RP
C	**Resource & Site Related Risks**			
1	RF23-Low productivity and efficiency of equipment	2.06	3.49	7.20
2	RF24-Breakdown of plant and machinery	2.10	3.42	7.20
3	RF25-Shortage of skillful workers locally	2.27	3.44	7.80
4	RF26-Shortage or delay in delivery of expected materials	2.10	3.60	7.57
5	RF27-Unavailability or shortage of equipment	1.85	3.32	6.13
6	RF28-Low labour productivity	2.44	3.19	7.78
7	RF29-Adverse ground conditions	1.97	3.41	6.73
8	RF30-Unavailability of utilities on-site required for construction	1.76	3.00	5.27
9	RF31-Difficulties in accessing site due to topography of the region	1.78	3.08	5.48
10	RF32-Inadequate preliminary survey and tests of site	2.04	3.37	6.87
11	RF33-Delays in the site possession	2.33	3.60	8.41

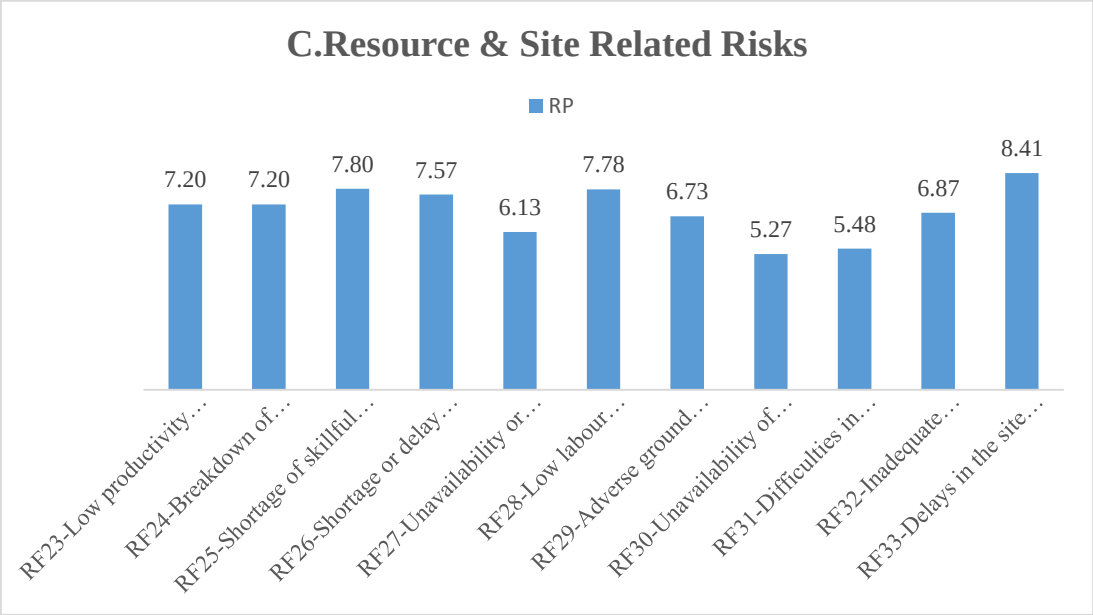


Fig 4.3 Comparison of RP of resource and site-related category

Fourth category used in this research is contractual and legal risks. This category deals with factors related to contracts and legal problems. This category consists of seven risk factors. Top three risk factors in this category are discussed further. Major factor identified in this category was 'Huge competition at the tendering stage' with (FI = 2.35, SI = 3.35 and RP = 7.85). It is generally seen that contract disputes and claims take years to make its final decision resulting huge loss to project. Calculation of FI, SI and RP for contractual and legal risks s shown in Table 4.6 and comparison of RI for contractual and legal risks is shown in Figure number 4.4.

Table 4.6 Calculation of FI, SI and RP for contractual and legal risks

Sr. No.	Risk Factor	FI	SI	RP
D	**D.Contractual & Legal Risks**			
1	RF34-Contradictions in the contract documents	1.88	3.40	6.40
2	RF35-Changes in project scope	1.94	3.33	6.45
3	RF36-Litigations and disputes retarding project progress	1.95	3.29	6.42
4	RF37-Contractual disputes and claims	2.18	3.53	7.68
5	RF38-Huge competition at the tendering stage	2.35	3.35	7.85
6	RF39-Change in codes and regulations	1.68	3.17	5.32
7	RF40-Unreliability of the legal system	1.73	2.92	5.06

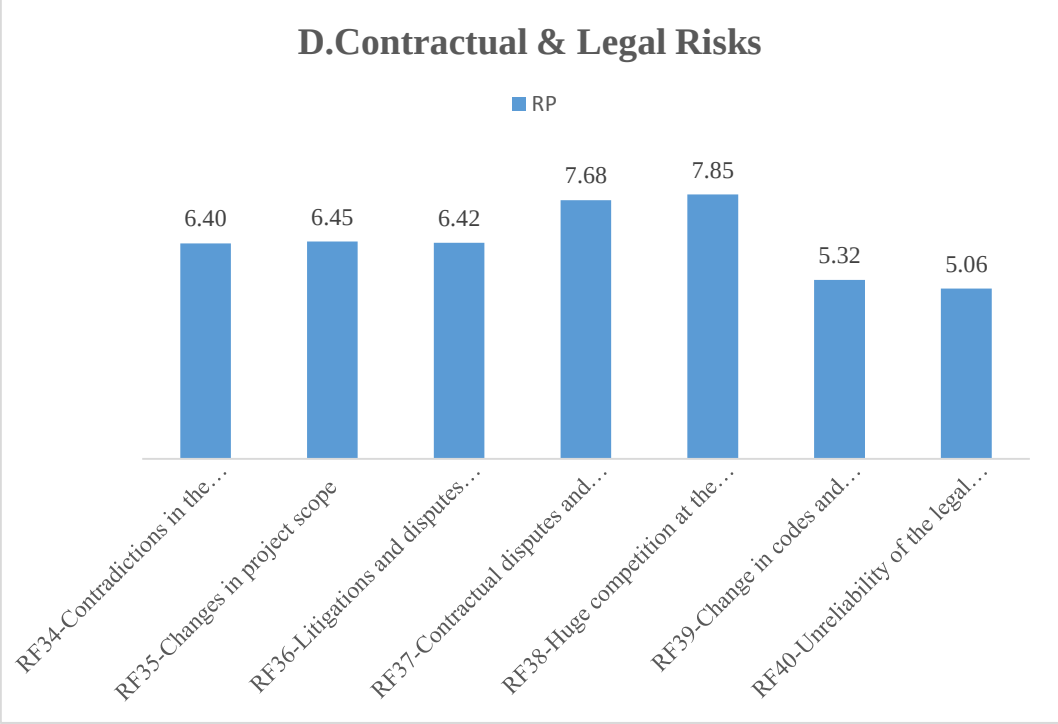


Fig 4.4 Comparison of RP of contractual and legal risk category

Fifth category considered in this research is economic and financial risk. In this category a total of seven risk factors are there and it deals with factors related to economics and finance. This factor is also important in deciding projects success or failure in building and infrastructure projects. Top risk factor for this category namely- 'payment delays' is the most significant risk factor identified in this category with (FI = 2.21, SI = 4.05 and RP = 8.93). Most of the times payments are delayed for the required work resulting in delays and cost overruns. All factors in this category are discussed in Table 4.7 along with FI, SI and RP. Comparison of RP of economic and financial risk category is shown in Figure 4.5.

Table 4.7 Calculation of FI, SI and RP for economic and financial risk

Sr. No.	Risk Factor	FI	SI	RP
E	**E.Economic & Financial Risk**			
1	RF41-Unpredicted changes in interest rates	1.76	3.04	5.34
2	RF42-Payment delays	2.21	4.05	8.93
3	RF43-Failure to meet revenue targets	2.19	3.42	7.50
4	RF44-Unpredicted changes in inflation rates	2.05	3.26	6.68
5	RF45-Inaccurate assessment of market demand	1.90	3.17	6.01

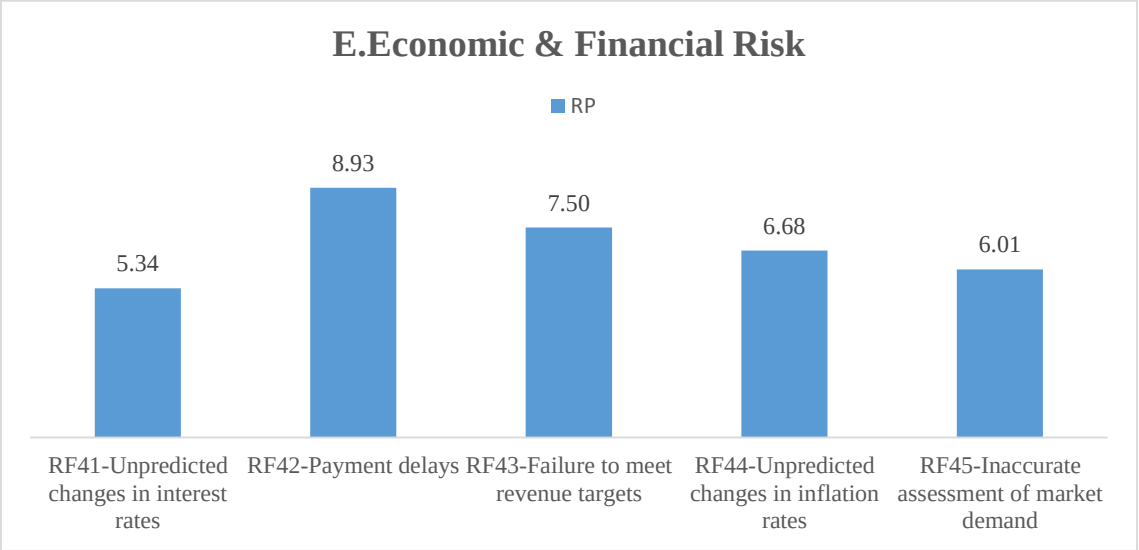


Fig 4.5 Comparison of RP of economic and financial risk category

Sixth Category used in this research is socio-political risk. A Total of ten risk factors are there in this category. This category deals with the social and political risks present in building and infrastructure projects. Topmost factor identified in this category was 'Compensation and land acquisition problems' with (FI = 2.15, SI = 3.35 and RP = 7.21). Most of the times contractors are not prepared for new policies and regulations. Laws and policies sometimes also change with change in government. In worst case even some projects have to shut down because of not able to follow new regulations. Other factors of this category with FI, SI and RP are discussed in Table 4.8 and comparison of RP of socio-political risk category is shown in Figure 4.6.

Table 4.8 Calculation of FI, SI and RP for socio-political risk

Sr. No.	Risk Factor	FI	SI	RP
F.	**Socio-Political Risks**			
1	RF46-Project-funding problems	2.06	3.00	6.19
2	RF47-Fluctuation in exchange rate of currency	1.94	3.04	5.88
3	RF48-Unfavourable social environment	1.72	2.92	5.02
4	RF49-Political instability of the government	1.78	3.10	5.53
5	RF50-Compensation and land acquisition problems	2.15	3.35	7.21
6	RF51-Public opposition to the project	1.83	3.14	5.76
7	RF52-Different religious and cultural beliefs	1.60	2.74	4.40
8	RF53-Laws and policies revising in between of project	1.67	2.96	4.94
9	RF54-Labour disputes and strikes	1.69	3.04	5.14
10	RF55-Improper project feasibility study	1.94	3.37	6.53
11	RF56-Outbreak of hostilities (riots, revolutions & terrorism)	1.56	4.08	6.38

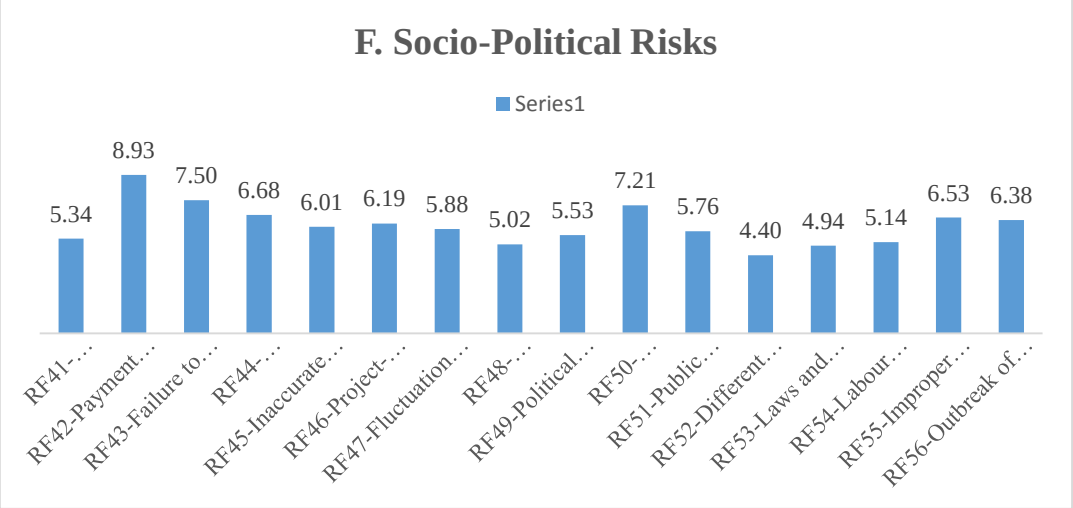


Fig 4.6 Comparison of RP of socio-political risk category

Environmental risk is the seventh category used in this study. This category consisted of seven risk factors. This category mainly deals with problems related with environment and effects of project on environment. Most significant risk recognized in this category was 'bad weather conditions' with (FI = 1.96, SI = 3.91 and RP = 7.66). This factor can result in huge losses if not recognized at right time as mostly it depends on local conditions of the area. Sometimes continuous bad weather can result in huge cost and time overruns. Second most significant risk factor identified in this category was 'natural disasters' with (FI = 1.82, SI = 4.02 and RP = 7.33). Natural disasters result in huge losses in terms of cost as well as time and it can be managed by mitigation measures like insurance, etc. We cannot plan for natural disasters but having knowledge regarding it will surely help in minimizing losses. Third major risk factor recognized was 'strict environmental rules and regulations' with (FI = 2.09, SI = 3.07 and RP = 6.41). Due to strict rules some companies might face problems because of their attitude of not following any regulations. Other factors in this category are discussed in Table 4.9 along with FI, SI and RP. Comparison of RP of environmental risk category is shown in Figure 4.7.

Table 4.9 Calculation of FI, SI and RP for environmental risk

Sr. No.	Risk Factor	FI	SI	RP
G.	**Environmental Risks**			
1	RF57-Pollution related to construction activities (dust, harmful gases, etc.)	1.69	3.23	5.47
2	RF58-Strict environmental rules and regulations	1.96	3.14	6.16
3	RF59-Changes in environmental standards	1.92	3.08	5.92
4	RF60-Legal proceedings due to wrong disposal of waste	1.62	2.94	4.74
5	RF61-Bad weather (snow, excess rain)	1.77	3.03	5.35
6	RF62-Natural disasters (floods, landslides, etc.)	1.65	3.24	5.36
7	RF63-Improper assessment of project impacts on environment	1.85	3.22	5.94

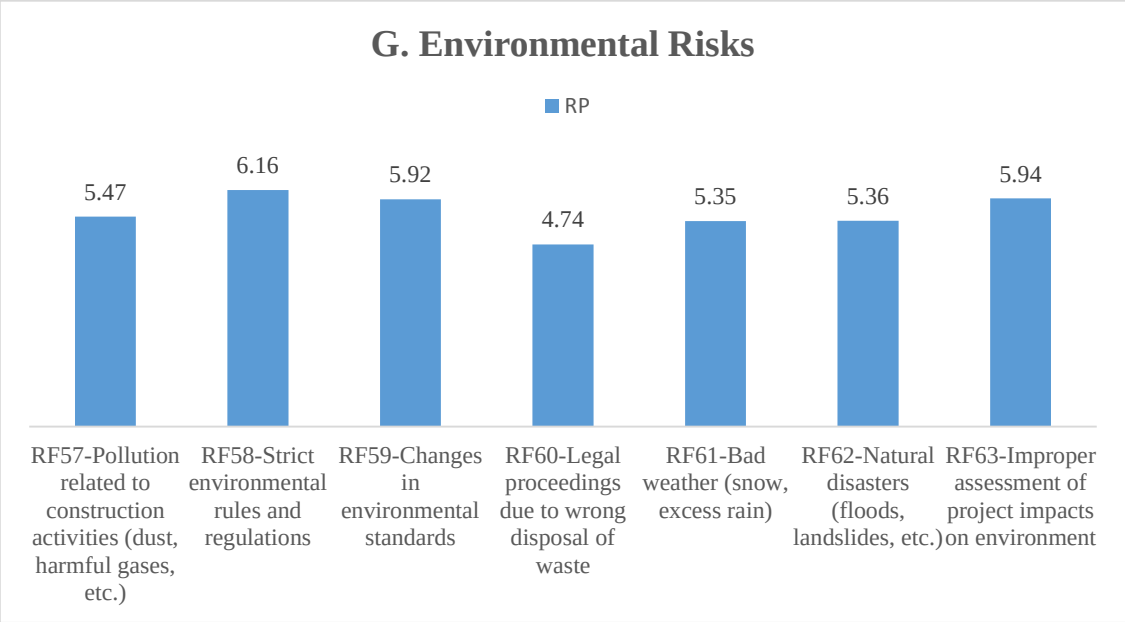


Fig 4.7 Comparison of RP of environmental risk category

Last category used for this study is related to health and safety. In this category a total of six risk factors were there. Very less attention is given towards health and safety of employees working in most of the projects especially projects on small scales. For factors of this category FI, SI and RP is shown in Table 4.10. Comparison of RP of health and safety risk category is done in Figure 4.8.

Table 4.10 Calculation of FI, SI and RP for health and safety risk

Sr. No.	Risk Factor	FI	SI	RP
H	**Health & Safety Risks**			
1	RF64-Accidents occurring during construction	1.81	3.44	6.21
2	RF65-Inadequate safety measures	1.94	3.40	6.58
3	RF66-Changed labour safety laws or regulations	1.56	3.01	4.71
4	RF67-Epidemic illness	1.65	3.59	5.94
5	RF68-Damage to property due to unsafe operations	1.68	3.18	5.34
6	RF69-Lack of protection from enclosing area	1.59	2.74	4.36
7	RF70-Lack of knowledge	1.76	3.06	5.38
8	RF71 - Effect of Pandemic	1.81	3.55	6.42

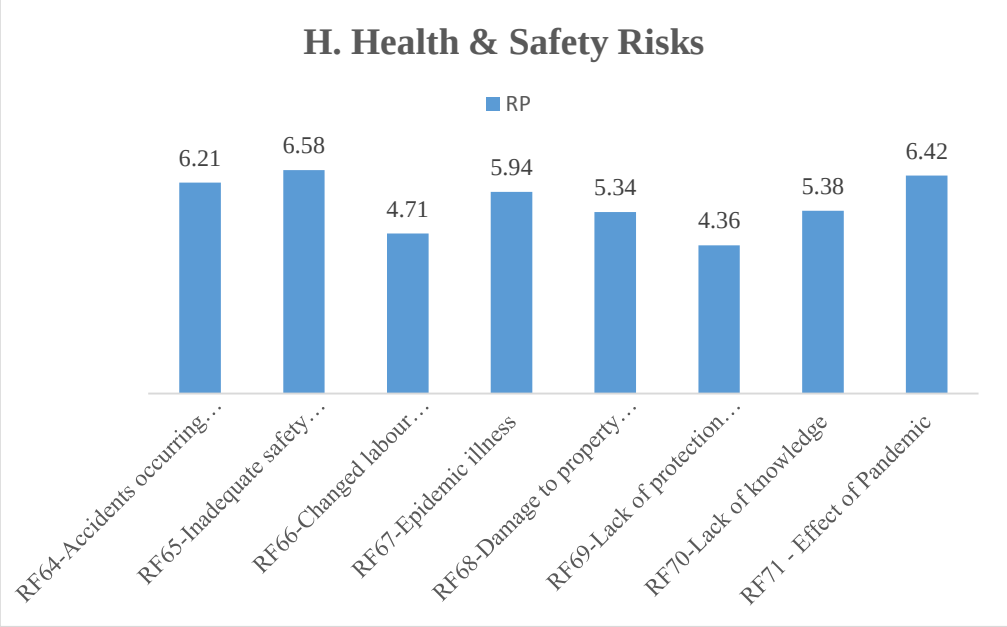


Fig 4.8 Comparison of RP of health and safety risk category

4.5 Analysis of Risk Impact and Ranking:

Subsequent to examining recurrence, seriousness and chance potential next we need to compute risk influence values utilizing condition number 6 as portrayed in research system. In view of the upsides of RI standardized values was determined and factors were positioned. Risk recognized in this examination was grouped into three levels to be specific basic, moderate and low. These levels were chosen in view of the standardized qualities. Basic risk factors are those having standardization esteem more than 0.50, moderate risk factors are those having standardization values from 0.25 to 0.50, okay factors are those having esteem under 0.25. Risk factors recognized in building and framework projects with positioning and level of criticality are talked about in Table 4.11.

Table 4.11 Risk factors ranking and level of criticality

Sr. No.	Risk Factors	RP	RI	NV	Rank	Criticality
1	RF42-Payment delays	8.93	2.99	1.00	1	CR
2	RF6-Shortage of skillful managers and professional's	8.47	2.91	0.92	2	CR
3	RF33-Delays in the site possession	8.41	2.90	0.91	3	CR
4	RF38-Huge competition at the tendering stage	7.85	2.80	0.81	4	CR
5	RF25-Shortage of skillful workers locally	7.80	2.79	0.80	5	CR
6	RF28-Low labour productivity	7.78	2.79	0.79	6	CR
7	RF37-Contractual disputes and claims	7.68	2.77	0.78	7	CR
8	RF7-Improper project planning and budgeting	7.65	2.77	0.77	8	CR
9	RF26-Shortage or delay in delivery of expected materials	7.57	2.75	0.75	9	CR
10	RF43-Failure to meet revenue targets	7.50	2.74	0.74	10	CR

11	RF13-Unclear and incomplete detailing in design drawings and specifications	7.46	2.73	0.73	11	CR
12	RF5-Poor site management and supervision	7.38	2.72	0.72	12	CR
13	RF50-Compensation and land acquisition problems	7.21	2.68	0.69	13	CR
14	RF23-Low productivity and efficiency of equipment	7.20	2.68	0.68	14	CR
15	RF24-Breakdown of plant and machinery	7.20	2.68	0.68	15	CR
16	RF15-Delay in design	7.06	2.66	0.66	16	CR
17	RF20-Pressure to crash project duration (time constraints)	6.88	2.62	0.62	17	CR
18	RF32-Inadequate preliminary survey and tests of site	6.87	2.62	0.62	18	CR
19	RF12-Design errors or design changes	6.87	2.62	0.62	19	CR
20	RF2-Poor management skills	6.86	2.62	0.62	20	CR
21	RF18-Construction errors and poor workmanship leading to rework	6.85	2.62	0.61	21	CR
22	RF4-Personal conflicts between different clients involved	6.79	2.61	0.60	22	CR
23	RF29-Adverse ground conditions	6.73	2.59	0.59	23	CR
24	RF1-Poor coordination or communication among various parties	6.69	2.59	0.58	24	CR
25	RF44-Unpredicted changes in inflation rates	6.68	2.58	0.58	25	CR
26	RF9-Inadequate quality planning and quality assurance	6.62	2.57	0.57	26	CR
27	RF65-Inadequate safety measures	6.58	2.56	0.56	27	CR
28	RF10-Lack of clarity over roles and responsibilities	6.58	2.56	0.56	28	CR
29	RF55-Improper project feasibility study	6.53	2.55	0.55	29	CR
30	RF8-Change of top management	6.48	2.55	0.54	30	CR
31	RF19-Approval and permit delays	6.45	2.54	0.54	31	CR
32	RF35-Changes in project scope	6.45	2.54	0.54	32	CR
33	RF36-Litigations and disputes retarding project progress	6.42	2.53	0.53	33	CR
34	RF71 - Effect of Pandemic	6.42	2.53	0.53	34	CR
35	RF34-Contradictions in the contract documents	6.40	2.53	0.53	35	CR
36	RF56-Outbreak of hostilities (riots, revolutions & terrorism)	6.38	2.53	0.52	36	CR
37	RF14-Using poor construction techniques	6.22	2.49	0.49	37	MR

38	RF64-Accidents occurring during construction	6.21	2.49	0.49	38	MR
39	RF46-Project-funding problems	6.19	2.49	0.48	39	MR
40	RF58-Strict environmental rules and regulations	6.16	2.48	0.48	40	MR
41	RF27-Unavailability or shortage of equipment	6.13	2.48	0.47	41	MR
42	RF17-Inadequate experience of contractor in same projects	6.02	2.45	0.45	42	MR
43	RF45-Inaccurate assessment of market demand	6.01	2.45	0.44	43	MR
44	RF63-Improper assessment of project impacts on environment	5.94	2.44	0.43	44	MR
45	RF67-Epidemic illness	5.94	2.44	0.43	45	MR
46	RF59-Changes in environmental standards	5.92	2.43	0.43	46	MR
47	RF47-Fluctuation in exchange rate of currency	5.88	2.43	0.42	47	MR
48	RF51-Public opposition to the project	5.76	2.40	0.39	48	MR
49	RF16-Complexity of design	5.74	2.40	0.39	49	MR
50	RF22-Changing construction methods/techniques in between of work	5.68	2.38	0.37	50	MR
51	RF49-Political instability of the government	5.53	2.35	0.34	51	MR
52	RF31-Difficulties in accessing site due to topography of the region	5.48	2.34	0.33	52	MR
53	RF57-Pollution related to construction activities (dust, harmful gases, etc.)	5.47	2.34	0.33	53	MR
54	RF21-Using complex construction methods/techniques	5.42	2.33	0.32	54	MR
55	RF70-Lack of knowledge	5.38	2.32	0.31	55	MR
56	RF62-Natural disasters (floods, landslides, etc.)	5.36	2.32	0.31	56	MR
57	RF61-Bad weather (snow, excess rain)	5.35	2.31	0.30	57	MR
58	RF68-Damage to property due to unsafe operations	5.34	2.31	0.30	58	MR
59	RF41-Unpredicted changes in interest rates	5.34	2.31	0.30	59	MR
60	RF39-Change in codes and regulations	5.32	2.31	0.30	60	MR
61	RF30-Unavailability of utilities on-site required for construction	5.27	2.30	0.28	61	MR
62	RF54-Labour disputes and strikes	5.14	2.27	0.26	62	MR
63	RF3-Lack of experience of the project team	5.11	2.26	0.25	63	MR
64	RF40-Unreliability of the legal system	5.06	2.25	0.24	64	LR

65	RF48-Unfavourable social environment	5.02	2.24	0.23	65	LR
66	RF53-Laws and policies revising in between of project	4.94	2.22	0.21	66	LR
67	RF60-Legal proceedings due to wrong disposal of waste	4.74	2.18	0.16	67	LR
68	RF66-Changed labour safety laws or regulations	4.71	2.17	0.16	68	LR
69	RF52-Different religious and cultural beliefs	4.40	2.10	0.08	69	LR
70	RF69-Lack of protection from enclosing area	4.36	2.09	0.07	70	LR
71	RF11-Restrictions on foreign companies	4.07	2.02	0.00	71	LR

Thirty-six critical risk factors were identified in building and infrastructure projects. Top ten critical risk factors identified were namely- Payment delays with (RI = 2.99), Shortage of skillful managers and professional's with (RI = 2.91), Delays in the site possession with (RI = 2.90), Huge competition at the tendering stage with (RI = 2.80), Shortage of skillful workers locally with (RI = 2.79), Low labour productivity with (RI = 2.79), Contractual disputes and claims with (RI = 2.77), Improper project planning and budgeting with (RI = 2.77), Shortage or delay in delivery of expected materials with (RI = 2.75), Failure to meet revenue targets with (RI = 2.74).

Highest value of (RI = 2.99) was observed and minimum value of (RI = 2.02) was observed. For critical risk factors RI ranged from (2.99 to 2.53), for moderate risk factors RI ranged from (2.49 to 2.26) and for low risk factors RI ranged from (2.24 to 2.02). Comparison of number of factors in critical, moderate and low risk level are shown in Table 4.12.

Table 4.12 Number of factors in each level

Sr. No.	Risk Rating	Number of Factors
1.	Critical	36
2.	Moderate	27
3.	Low	8

Risk Mitigation Model:

For managing risk in a compelling way this study proposes a risk relief model. This model comprises of seven significant boundaries. This model will doubtlessly assist with projecting directors, risk chiefs, engineers, supervisory group who needs to manage risk and vulnerabilities on location during development phases of the venture.

First boundary is ID of risk factors present in building and foundation project. It assumes a significant part in overseeing risk as without realizing which chance and vulnerabilities are available, we can't oversee it. Along these lines, distinguishing proof of risk ought to be would completely keeping all angles in care. Past examinations, explores, experienced workers can help in risk recognizable proof.

Second significant boundary is appraising of distinguished risk. This implies while managing risk it ought to be evident that the way in which basic risk can be regarding cost, time, quality, efficiency, and so forth. As certain risks need quick consideration when contrasted with other. In different terms a few risks are more basic when contrasted with others. Along these lines, risk can be evaluated by their capacity to influence project goals. Chance can be appraised as low, moderate, and high.

Third boundary in risk relief model is order of risk. Risk order likewise assumes a significant part to figure out which group engaged with undertaking ought to deal with a specific risk. This order of risk explains what segment needs to deal with a specific risk model: supervisory crew, specialized group, finance group, and so forth.

Fourth boundary is characterizing phase of risk at which it will happen. A specific risk can happen in single stage as well as in numerous stages. In this way, to oversee it appropriately there is need to know its capacity in various stages. Risk can arise at any stage so a constant check has to be there. Different phases of a task can be named possibility, obtainment, development, activity, and move.

Fifth boundary in risk alleviation model is risk portion. A large portion of the times while managing chances, parties don't get a sense of ownership with risk present and frequently state capable others for the board of that risk. To manage this chance designation ought to be there as it will characterize parties liable for the executives of risk present in projects. For a specific risk liability might lie with proprietor, project worker, expert or it very well may be shared by various gatherings. Portion ought to be done appropriately as it will help in viable administration of chance.

6th boundary of alleviation model is risk reaction. Answering risk implies how we intend to manage it to such an extent that its adverse consequences can be limited. Answering risk can be chosen by concerned specialists of organizations. Reaction to risk can be refreshed in the middle between of venture contingent upon need to adjust it.

Seventh boundary is checking and comments. In this, a consistent checking and control is there on the risk factors as well as on the moderation methodologies. It's critical to check whether our relief systems dealing with limiting the impacts of the risk or we want to alter it. At last, comments are composed in the event that any required.

5. CONCLUSION

A ton of building and framework projects needs to confront risk and vulnerabilities during development period bringing about gigantic misfortunes with regards to cost, time, quality, efficiency, and so forth. This examination expects to make mindfulness with respect to risk with the executives structure in development industry. The primary target of this study was to distinguish risk factors, rank them as per their criticality, and recommend relief measures to limit the impacts of chance present in building and framework projects.

At first, 71 risk factors were recognized through top to bottom investigation of writing connected with risk present in building and framework projects. These 71 risk factors were ordered into eight significant classes. A Risk profile was arranged comprising of these variables and information was gathered through survey overview. Seriousness list and recurrence record was determined utilizing RII (Relative Importance Index) Method. Most extreme worth of SI (Severity Index) was viewed as 4.08 and least worth of SI was viewed as 2.60. Top five elements for seriousness were specifically Flare-up of threats (riots, insurgencies and psychological oppression), Installment delays, Absence of involvement of the undertaking group, Deficiency of capable directors and expert's and Private matters between various clients included. Greatest worth of FI was viewed as 2.44 and least incentive for FI was viewed as 1.31. Top five variables for likelihood was to be specific Low work efficiency, colossal contest at the offering stage, Postpones in the site ownership, Ill-advised project arranging and planning and Deficiency of talented specialists locally.

After that RP and RI was determined for every one of the elements. Risk potential worth ran between 8.47 to 4.07. Risk influence esteem ran between 2.91 to 2.02. Standardized values for various risk factors was tracked down based on RI. Factors having standardized esteem more prominent than 0.50 are considered as basic risk factors. 36 risk factors were viewed as basic in building and foundation projects. Top ten basic risk factors found were in particular Installment delays, Installment delays, Defers in the site ownership, Immense rivalry at the offering stage, Lack of talented specialists locally, Low work efficiency, Legally binding debates and cases, Ill-advised project arranging and planning, Deficiency or postpone in conveyance of anticipated that materials and Disappointment should meet income targets. Factor investigation was performed on the basic risk factors recognized. Risk alleviation measures was additionally proposed in this exploration which are talked about further.

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