Critical Factors affecting Risk Management Strategy in Selected Brownfield Projects in Steel Plants

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By

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"No one who achieves success does so without acknowledging the help of others. The wise and confident acknowledge this help with gratitude."

Alfred North Whitehead

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Susmit Roy

Date

Place

ABSTRACT

The present study was undertaken to derive some understanding about risks in construction projects with particular reference to brownfield projects in steel plants. Apart from identifying risks the study further tried to explore the response options for these risks and the factors that affect them.

The study, at the first place was motivated by the fact that there were not enough studies in the area of construction project risks for steel plants. Moreover, the brownfield projects that are executed within the boundaries of a steel plants alongside the existing running facilities also provide some complexity which are absent in a new greenfield site. Secondly, several studies have been conducted both on the risks and complexity of projects respectively without any proposition for their linkage. Hence a necessity was felt to explore the relationship of these two aspects in construction projects particularly brownfield construction projects in steel plants. Further, studies have also discussed the several response options to respond to these risks. In a project set up, there are several measures which can affect the choice of these response options and action taken under these options. These measures are broadly classified under two major heads - Human Response Factors and Systemic Response Factors. It was felt necessary to explore the human and systemic factors on their relative dominance on the choice of risk response options and further their relationship with the project complexity and risk criticality.

In order to explore these relationships, the present study resorted to several methods like literature review and content analysis, discussion among focus groups, questionnaire surveys and finally expert interview in stages. The first stage consisted

of Literature Survey and Content Analysis to identify the type of risks in construction projects in existing steel plants. Focus Group Discussion (FGD), thereafter, was followed to identify and finalise the risks to be put for Pilot Survey. In the second stage, Pilot Survey questionnaire aimed at identifying major risks in consruction projects in brownfield setting in steel plants, followed by another focus group to finalise the risks for the next stage. Evaluation of attributes and indicators of Project Complexity through experts was also carried out at this stage. The Main Survey questionnaire, in the third stage delved deep into the issue of identification of critical risks and management of these risks. The choice of experts for focus group and evaluation of project complexity attributes and indicators had been done based on academic qualification as well as project experience of the experts. In order to validate the findings of the third stage, a structured expert interview was carried out in the fourth stage of this research. Apart from fulfilling the objective of validation of the results by the experts, this opportunity was also taken up to get their views on some risks those were suggested by the respondents in the main survey.

The findings of this study show that the brownfield construction project in steel plants have an overall risk which is in the range of medium to high. Respondents view also supported the hypothesis that the complexity of a project has a significant correlation with the criticality of risks in the project. In terms of their relative influence on the choice of Risk Response Options, the Risk Response Factors, both human and systemic, have shown statistically no difference for most of the risks. However, in some response option human response factors have shown dominance over the other factor.

The study has also found no significant correlation between Project Complexity and Risk Response Factors. On the other hand, significant correlation has been observed between Criticality of Risk and Risk Response Factors.

The experts, during a structured interview in the fourth stage, also supported these findings and have given their opinion on some risk events which has been raised during the main survey. Their considered opinion were also on the possible Response Options and the Risk Response Factors affecting these risks.

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List of Abbreviations

PMBoK®	:	Project Management Body of Knowledge
PMI	:	Project Management Institute, USA
RRO	:	Risk Response Option
RRF	:	Risk Response Factors
HRF	:	Human Response Factors
SRF	:	Systemic Response Factors
PESTEL	:	Political, Economic, Socio-Cultural, Technological, Environmental, Legal
SAIL	:	Steel Authority of India Limited
TATA	:	Tata Iron and Steel Company
RINL	:	RashtriyaIspat Nigam Limited
JSW	:	Jindal Steel Works
JSPL	:	Jindal Steel and Power Limited.
PO	:	Probability of Occurrence
SEV	:	Severity of Impact
RPS	:	Risk Potential Score
AHP	:	Analytic Hierarchy Process
EFA	:	Exploratory Factor Analysis
FGD	:	Focus Group Discussion
BE	:	Bachelor of Engineering
CR	:	Critical Risks
CRG	:	Critical Risk Group
Wts.	:	Weights

CHAPTER -1

INTRODUCTION

Introduction

1.1 Research Overview

Project and Project Management

A project is identified by its temporary nature and uniqueness. The project has to deliver a unique product or a service or a result or a unique combination of product or service or results which means a “deliverable” at the end. Thus, it involves certain actions directed to deliver that deliverable (Kliem et al, 1997; PMBoK®, 2017). *Projects cut across organizational and functional lines* as it requires skills and talents from different functions, professions and organisations. It is essentially a *process of working* which passes through several distinct phases, known as Project Life Cycle. (Nicholas and Steyn, 2012).

The term Project Management has been used by different organization in their work context. While some of them use it to describe the task of managing work others use it to define the field of work that is focused on the delivery of project results (Cooke and Tate, 2005). In a more generalized way PMBoK®(2017) defines it as“*the application of knowledge, skills, tools and techniques to project activities to meet the project requirements.The discipline of Project Management helps an individual or a group or an organization to take care of issues in managing project activities.”*

As the project passes through the project life cycle, the activities of the project are managed by the Project Management Processes. According to the Project Management

Body of Knowledge (PMBoK ®, 2017) these processes are classified into five process groups which are Initiating, Planning, Executing, Monitoring & Controlling and Closing Process groups.The planning process group is an important group which consists of several activities related to planning of project activities and includes risk management as one of its constituents.

Project Risks and their Management

Projects by their very nature are challenging and risky job. Risks are a permanent feature in projects and affect the cost, schedule and quality of the project. While these risks can vary in type and magnitude their presence can be felt from the very beginning of a project. Even after the project is complete, marketing of the product, financial performance and meeting the strategic objectives are all fraught with risks. This situation gets more complex as the projects are being executed in globally connected and fast-changing world of business of today. The organizations involved in projects also try to cope up with this demand by forming alliances, consortia and partnership which again add up to the risks that are already present. As a result risk in a large and complex project transcends the technological dimensions to encompass the social, cultural and organizational dimensions (Thamhain, 2013). Among several types of projects, construction project, is a discipline where these challenges and risks are further magnified due to the presence of several features like non-homogeneous character of project and uniqueness of the product, implementation of the project in a dynamic, uncertain and complex environment, different stakeholders having divergent viewpoints or requirements, changing climatic factors, long period of time through which the project develops and division of responsibilities of the involved agencies (De Azevedo et al, 2014).

Construction Projects in Steel Plants: Risks and their Management

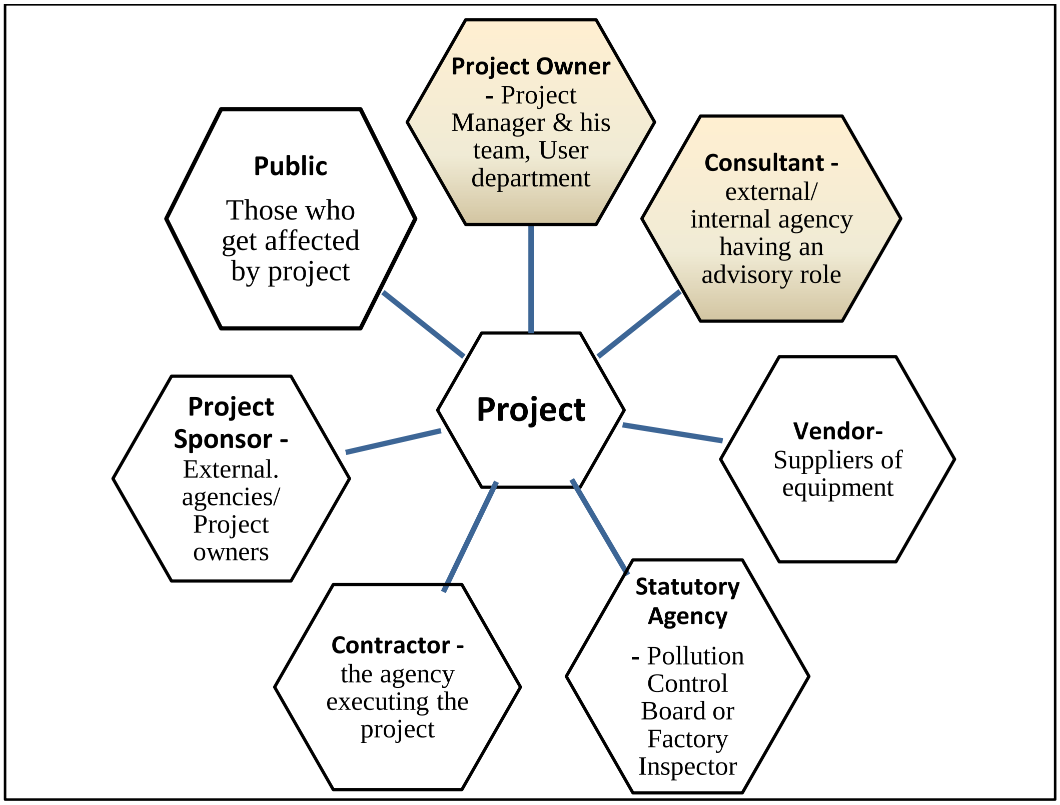
Construction projects in steel plants have some unique dimensions about them. The steel industry is capital as well as labour intensive industry and any project in steel plant involves a considerable amount of project cost and project time. Most of the steel plants in India have embarked upon expansion project to augment their existing capacity at different point of time. The projects that are undertaken within the confines of a working steel plant are termed as “brown-field project”(Joy, 1993) while any project taken up beyond the boundary of the existing plant at a new location is termed as “green-field project”. While the control is more in case of brown field projects, there are problems of interfacing/shutdown with respect to existing facilities, safety of existing plant and machinery as well as plant personnel. In case of green field project though the problem of infringement or shutdown or safety of existing plant and machinery are not there but the creation of some enabling facilities in order to start the project can run into major hurdle. Moreover acquisition of land can be a major bottleneck for this type of projects. Among several studies related to construction projects, literature relating to construction projects in steel plants is scarce. Study by Datta and Mukherjee (2001) has analysed risk and risk management based on cases of modernization projects in two steel plants.There have been several studies on risk management in construction projects but steel plants have by and large remained out of the periphery of the study. The present study is an attempt to unearth the risks and the factors affecting their management in the construction projects in existing steel plant with an assumption that it will add to the existing body of knowledge in a very specific and significant area.

Project Stakeholders and Project risks

For any project including construction project in steel plants, there are several parties whose interests are linked with the project outcome. The outcome of the project may either affect them or they may affect the outcome of the project. These interested parties, termed as "stakeholders" to the project, may include public, project sponsor, project owner, project executor i.e the contractor / subcontractor, suppliers or vendors, statutory agencies and user group or department. Another agency which is important in a project is the consultant. The following diagram in figure 1.1 shows the different stakeholders to the construction project in steel plant.

Each of these stakeholders have different perspectives towards the project and as a result their interest and power with respect to the project are quite different. Project sponsor is the entity which can be an independent financial institution that provides the necessary funds or it may be the project owner whose funds are generated out of the internal accrual.

Figure 1.1 – Construction Project in Steel Plant - Stakeholders



Source: as conceived by the Author

Project Owner is one of the key stakeholder who owns the project and is responsible for the management of the project in order to achieve the goals stated in terms of time, cost and quality. This also leaves the project owner with the responsibility of managing the risks associated with the projects.While the operational responsibility of the facility lies with the user department, the project planning and management responsibility lies with the project manager and his team from the project department. Thus these two departments constitute the stakeholder - **Project Owner**. Another important stakeholder is the **Consultant**. Consultant is the advisor to the project owner.Apart from design and engineering that is usually included in their scope of service they also advise the project owner in matters related to project. It is because of this role the consultant is included in the **Project Owner group** inspite of being an external agency in most of the project cases.The present research study will concentrate on the study of risk in the construction projects in existing steel plants only from the perspective of the Project Owner group.

Project Complexity

Complexity has, for long, been a major issue of any construction project. Therefore, understanding and managing project complexity assumes a great importance in driving the project successfully towards its objective. The idea of complexity in projects has developed over the years. While Baccarini (1996) defined it in terms of structural complexity involving "differentiation" and "interdependency" of "many varied interrelated parts". Other authors added several other attributes of complexity like uncertainty, dynamics, pace and socio-political factors (Geraldi, Maylor & Williams, 2011). These research ideas provide useful guidelines for the present study relating to risk and its relationship with project complexity for brownfield construction projects in steel plants.

1.2 Research Motivation

Several studies have identified number of risks in construction projects over the last few decades.While these studies have identified and assessed risks related to a whole range of construction projects starting from building construction to industrial construction and further to infrastructural construction there is dearth of documentation with respect to risks in the particular category of steel plant construction. These risks are categorized under some broad heads like Market, Political, Economic, Legal, Logistical, Organisational, Construction, Management, Environmental. Possibility exists that the risk or risk events identified in these research studies are also applicable to the construction projects in steel plants. However, brownfield construction projects i.e construction projects taking place within the existing boundaries of a working steel plant may have some risks which are typical of any construction project under similar circumstances.

The aspect of project complexity has found gradual recognition in several literatures over the years.The understanding about project complexity evolved from a single attribute construct to a multiple attribute construct during this time frame.

Literatures on project risk management have thrown more light on identifying risk in different construction projects but have not dealt specifically on the relationship between risk and the complexity of project.

Management of risks in project takes place through appropriate risk response. Existing literatures have indicated several actions to respond to the risks. However, these studies have not gone much beyond the actions, thus not throwing much light into the factors affecting these actions and their relationship with criticality of risks and complexity of projects.

These limitations of research in risks in brownfield projects, the relationship between the project complexity and the criticality of such risks as well as their relationship with the risk response factors has motivated the Author to take up this topic for research.

According to the Author the findings of this study will positively contribute to the existing body of knowledgein the area of construction project risk management.

1.3 Research Scope

This study is basically focused on the brown-field construction projects in steel plants in India. Thus it will concentrate on the study of criticality of risk, complexity of projects and risk response factors with their mutual relationship on the basis of brown-field construction projects in steel plants in India from the extended project owner group's perspective.

1.4 Outline of thesis chapters

Chapter 2 – Literature Review

This chapter presents review of literature pertaining to project especially construction projects and their management. The basic idea of the review is to understand the risks in construction projects and their management. This chapter also throws light on the literatures related to project complexity.The different attributes of project complexity have been discussed and attributes relevant to brown-field construction projects in steel plants are presented.

Chapter 3 – Research Methodology

This chapter presents the philosophy behind the research, the design and the methodology adopted to carry it out.The chapter also discussed about the process of instrument development, scales and samples selected for pilot survey, main survey and expert interview. The chapter also highlights the rationale behind the responses taken from both public and private sector organisations.

Chapter 4 –Data Analysis and Interpretation

This chapter details the analysis of data and interpretation of results of the pilot survey and the main survey. This chapter also elaborates on the focus group discussions carried out before the pilot survey and the main survey. The literature review and content analysis helped in identifying risks in brownfield construction projects in steel plants. The pilot survey assessment and the focus group discussion thereafter helped in identifying a consolidated list of "major risks" which is subjected to further assessment by project owner group to identify a select band of "critical risks". Further analysis was carried out to identify the overall risk potential of construction projects in steel plants. Apart from the risk identification another aspect that is investigated in this survey is the area of management of risk. There are strategies or options for responding to risks which are influenced by several "risk response factors". These response factors are broadly classified under two major heads- human and systemic. Effort has been made in this study to explore the relative level of influence of these two response factors on the risk response strategies. The data also helped in identifying the overall complexity of project and its relationship with the criticality of the risks. Further this chapter details the relationship of the response factors with the complexity of project and criticality of risks.

The chapter also includes the rationale, planning and analysis of the views and suggestions of project experts carried out after the main survey has been detailed. The idea of this expert interview is to validate the findings of this research study. Further it also tries to extract the views and suggestions from the experts with regard to some probable risk events and their characteristics as was suggested during the main survey.

Chapter 5–Results, Discussion and Conclusion

This chapter details out the summary of the findings from Main Survey and Expert Interview followed by the discussion on the findings. It also highlights the limitation of the present study and how the study has contributed to the existing body of knowledge from the theoretical, practical and social perspective. Lastly the chapter also contains recommendations for further research.

1.5 Summary

The chapter outlined the basic idea of this research study is to study the risk potential of the brownfield construction projects in existing steel plants. The study further endeavoured to investigate the relationship of the criticality of risk with the complexity of projects and the influence of the risk response factors in managing the risks as well as their relationship with the criticality of risk and complexity of project. The chapter started with an introduction giving the background and the theoretical basis of this study followed by the motivation for this study. The chapter also provided the an insight into the scope of this study and finally concluded with an overview of the other four chapters that followed.

CHAPTER 2

REVIEW OF LITERATURE

Review of Literature

2.1 Introduction

This chapter presents the review of different literatures in the area of Project Risk and Project Risk Management. Though risk is an omnipresent phenomenon in any project but the nature of risk and their magnitude varies with the type of project. The chapter unfurls with the concept of risk as an overarching concept. Thereafter the study moves towards literatures that deal with risk in a project setting and their management as part of the project management process. Construction projects typically are risk prone endeavors and risks in this particular type of projects are more magnanimous due to their inherent nature of involving huge amount of funds, diverse interacting agencies and long duration of project. Branching out among the several sectors where construction projects take place, steel plant is the specific area which this study proposes to cover. The assessment of project risks has been done in several ways and has found mention in different literatures. This chapter will throw light on the different methods of assessment of project risks as mentioned in different literature. The assessment of project risk is aimed at qualitatively determining the criticality or impact of individual risk or risk events in a project. The chapter thereafter focuses on the literatures dealing with the management of construction project risks. The management starts with the planning for risk response. Risk response options or methods have been studied in detail in different literatures to ascertain the factors those affect the choice of risk response and what the project manager or his team does in order to make the chosen response effective. The concept of complexity in general and project complexity in particular have been also considered in this chapter to assess the complexity of steel plant construction projects and their relationship with the risks and the risk response factors.

2.2 Literature Reviewed

2.2.1 Concept of Risk

Risk as a theoretical concept came up much later though the idea about potential loss or harm due to the occurrence of some event was already there for a very long time. In fact the origin of the word dates back to Latin, French, Portuguese, German and other literatures as per the Oxford English Dictionary. However, the Dictionary provided a more acceptable definition of risk as it is used in today's parlance under three different categories. Aven (2012) and Althaus (2005) defined "risk" from these three different perspectives:

a) Possibility of loss, damage, injury etc. (exposure related)
b) A hazardous journey, undertaking, course of action (hazard related)
c) A person or thing that can cause a good or bad /unwanted outcome(outcome related)

The exposure and outcome related definition also finds a place when Berg (2010) defined risk as "*uncertainty that surrounds future events and outcomes*" and is expressed in terms of "*likelihood and impact of an event with the potential to influence the achievement of an organisation's objectives*". This necessitates that risk be analysed in terms of two parameters. The likelihood of the risk event occurring and the severity of its impact once it takes place. As assessed in terms of likelihood and the severity of impact, risk can have an adverse consequence or advantageous consequence. In fact, as Akintoye (1997) pointed out that for construction industry several authors have indicated risk as economic loss or gain due to the construction process (Porter, 1981; Heale, 1982; Perry & Hayes, 1985). On the other hand some studies have only considered the negative aspect of loss for the risk only (Mason, 1973; Mosavenzadeh and Rossow, 1976). It is this negative consequence of risk or risk event that will be the focus of the present study.

2.2.2 Project Risks and their Management

Translating the concept of risk in the perspective of a project involves identifying risks or risk events having the potential of adversely affecting the project objectives. As defined by PMBoK® (2017) "*risk is any event the occurrence of which impacts the achievement of the project objectives*". This can be any uncertain event associated with the project work (Kendrick, 2010). In order to have a control in terms of the effect of risk or any uncertain event on project objectives it is necessary to have a project risk management in place and construction project is no exception.

Project risk management as a process consists of risk identification, risk assessment, risk response and risk control. Several literatures have discussed the project risk management process in terms of these four stages. Depending upon the type of industry the projects have identified risks, some of which are common to any other industry but also some risks which are typical to the concerned industry. With regard to risk assessment, literatures have shown different ways in which the authors have assessed the impact (in terms of loss) of risk events. While most of the literatures discussed about the broad options for responding to risk like escalate, avoid, transfer, mitigate and accept, some literatures went further in discussing specific actions to manage project risk. Following are brief descriptions of the stages of risk management and how the literatures discussed them.

a) **Risk Identification:** During this stage of the risk management process, the risks/ risk events are identified for the construction projects and documented according to their characteristics. There are several methods for identification of the risks/ risk events suggested and used by several authors (Weber, 1990; Smith et al., 2006; Lester, 2007; Kendrick, 2010; Xu et.al. 2010, Gajewska & Ropel, 2011, Kishan et al., 2014, Rehacek, 2017). Some of them are discussed below:

   Brainstorming

   According to Adams et al. (2007) this is an "*excellent way to identify keywords, especially in a group*". In this method the persons associated with the construction projects generate ideas about the risks associated with construction projects under the supervision of facilitator who also controls the process of brainstorming. There is always a possibility of generation of some unnecessary risks along with considerable number of actual risks. Facilitator reviews the risks and eliminate the unnecessary ones in discussion with the group.

   Delphi Technique

   In brainstorming the participants generate ideas in a group at a common place. In Delphi technique the participants are located at different places and do not know each other. The idea behind this technique is *to reach a consensus of experts* (PMBoK®, 2017). The risks are identified individually by each expert without any consultation. The facilitator in this case summarises the risks identified by the experts and circulated among the experts for further comment. Consensus usually takes place after few rounds.

PESTEL Analysis

It is a technique wherein the external project risks are identified by the experts. PESTEL is the acronym for political, economic, socio-cultural, technological, environmental and legal. In considering all the risks under these six categories one ensures that risks lying in the environment which can or has the potential to impact all the stakeholders to the project are taken into account.

Content Analysis

As indicated by Weber (1990), many words of texts can be put under fewer and specific "content categories". This technique summarises any form of content by counting the appearance of any particular aspect of interest in the content. The content can be any media report – printed or broadcasted, other writings, speeches, interviews, plays etc. From the construction project risk related literatures different risks have been identified for brownfield construction projects through this content analysis.

Expert Ideas

Expert ideas in some cases particularly for construction projects in steel plants where literatures are scarce is a very helpful technique for identifying risks which may be typical to the situations.

In the present study a combination of methods mentioned above has been applied to identify the external and internal risks for brownfield construction projects in steel plants.

b) **Risk Assessment:** The risks after being identified need to be assessed or evaluated. The evaluation of risks can be either done in a qualitative way in order to prioritise the risk for deciding on a course of action or in quantitative way to arrive at a specific measure of risk in order to *estimate schedule and /or budget reserves needed for risky projects* (Kendrick, 2010). According to Kendrick (2010) if the primary idea is to analyse risk in order to prioritise them and then determine the response or decide on further exploration of the risk, then qualitative analysis is the sufficient tool. However, if it requires more precision then quantitative risk assessment is necessary.

Kendrick (2010) stated that the evaluation of any risk event is carried out on the basis of two factors – the probability that the event will occur and the expected severity of consequences (in terms of loss) of the event, in case it occurs. The product of these two factors gives an estimate of the loss due to the risk event on the project. Therefore, Loss due to the risk event = Probability of occurrence of the risk event x Impact of the event (in terms of loss).

Similar concept was also given by Rehacek (2017) who clarified that the assessment of risk in terms of "PI Factor" which can be given as

PI Factor = Probability of risk x Impact of risk

The idea of Risk (in terms of loss) as a product of probability and impact has been coined in several studies. (Dumbrava & Iacob, 2013; Hillson & Hulett, 2004; Cobb, 2012; Mahendra, Pitroda & Bhavsar, 2013; Banaitiene and Banaitis, 2012; Zou , Zhang & Wang, 2007)

However, some studies (Xu et al., 2010; Deshpande and Rokade, 2017) have also suggested that the Impact of the risk event can be considered as geometric mean of these two factors, which stands thus:

$$\text{Impact of Risk event} = \sqrt{\text{(Probability of occurrence x severity of consequences)}}$$

Zou et al (2007) adopted a concept of risk significance index developed by Shen et al (2001) and calculated Risk Significance Index as

$r_{ij} = \alpha_{ij} \times \beta_{ij}$, where

α_{ij}= assessmentof probability of risk i by respondent j

β_{ij}= assessment of impact of risk i by respondent j

r_{ij} = significance score assessed by respondent j on impact of risk i on project objective k.

Finally Overall Risk Index, $Ri = \Sigma (\alpha_{ij} \times \beta_{ij})/n$, which gives the average risk significance index of risk event i taking into account all the responses.

Another approach to assessment of risk was suggested by Wiguna and Scott (2005) in their study of Project Performance in Indonesian Building Contracts wherein they adopted a weightage of importance of each risk on time and cost. According to them Risk Level of Time or Risk level of Cost is calculated as

RL=w x P x I, where RL = Risk Level of time / cost

w = weight of the importance of each risk on time/ cost

P = Probability that the risk would occur

I = Impact of risk on time/ cost

Though there are several methods of calculating the risk in a qualitative manner, the present study adopted the method applied by Xu et al.(2010) and Deshpande and Rokade (2017)in their study of risk assessment of PPP Highway projects in China and India respectively.

The concept of Risk Impact or Risk Index considered in the above mentioned articles have been considered as Risk Potential Score (RPS) in the present study As regards the consideration of risk impact or risk index as the square root of the product of probability of occurrence and severity of impact of the risk or risk event and the same formula being adopted for the Risk Potential Score (RPS) it can be said that the formula indicates that it is the geometric mean of the probability of risk and severity of risk. The justification of using the geometric mean as an indicator, according to Roenfeldt (2018) has got certain advantages:

i) Though a measure of central tendency, it lies at the direct centre of the values than arithmetic mean which has a tendency to move towards the higher value.

ii) Geometric means are preferable when looking at skewed data, scaled data, or when averaging ratios.

iii) Useful when working with smaller volume of data where arithmetic mean can be problematic.

The other justification of using geometric mean is that it helps in evaluation of risk potential in a similar scale as that of probability of occurrence and severity of impact.

c) **Risk Response:** The assessment of risk in terms of probability of occurrence of the risk event and the severity of impact helps to prioritise the risk and plan the responses. It basically consists of selecting from among the several options and developing action plans to materialize it. As explained by Wang & Chou (2003) and cited by Renault & Agumba (2016) as *"process of identifying/developing risk response options and determining actions for treating the risk, targeting enhancing opportunities and reducing any threats to projects objectives"*. The risk in general can have a negative effect, when it is called threat or it can have a positive effect when it is termed as opportunity. It has been seen that the construction projects have negative effects that far outreach the positive effects or opportunities. In the present study the negative effects are, therefore, considered for analysis. The response to any risk or risk event,which is a threat, can be executed in five ways (PMBoK®, 2017):

Escalate

This is the response undertaken by the project manager and his team when they feel that the response to the risk would exceed their authority. Thus under this option the risk is managed at higher level than the project level. The escalated threats are not monitored further by the project team after escalation. Therefore, in the present study this option is not considered.

Avoid

When the project owner or his representative acts to eliminate the threat or protect the project from its impact it is termed as risk avoidance. The strategy may involve actions like changing the project management plan or changing the objective in order to eliminate the risk in its entirety. Actions may also be directed towards eliminating the impact of the risk event if it occurs or isolate the project from the impact.

Transfer

The project owner may shift the ownership of actions and absorb the impact if it occurs to a third party. It can involve payment of a risk premium to the party which is accepting the risk. This option is adopted when the project owner feels that the party is more capable to handle such risk. Use of insurance can be one of several actions that can be taken under this option.

Mitigate/ Reduce

In risk mitigation option the project owner takes action to reduce either the probability of occurrence or the severity of impact of such risk. To reduce the probability of occurrence is usually the preferred choice. However, if that is not possible, actions are taken to reduce the severity of impact by addressing the factors that influence the severity.

Accept

Acceptance of the risk is the option when the project owner finds that it is not possible or cost effective to address the risk in any of the above mentioned ways. Acceptance can be either active or passive. In active acceptance a contingency reserve is provided for addressing the risk proactively. However, in case of passive acceptance no such proactive action is taken apart from monitoring the risk.

d) **Risk Control:** This is the last and an important stage in the Risk Management process. The main objective of this process is to track the risks that are identified for the project, ensure that the risk response actions are properly implemented and are effective, monitor the residual risks and identify any new risk. This process is continued throughout the project life cycle.

2.2.3 Construction Project Risks and their Management

Construction industry involves such diverse activities that the external boundaries become vague (Murdoch & Hughes, 2000) and as a result construction projects become more vulnerable to varieties of risks. Time overrun has been one of the most common occurrences in construction projects.

Chan and Kumaraswamy(1997) studied the risk factors contributing to project delays in Hong Kong from the perspective of three groups involved in construction projects viz. clients, consultants and contractors and found that poor site management and supervision, unforeseen ground condition, low speed of decision making involving all project teams, client initiated variations and necessary variations of works as five major contributors. Based on their study of large engineering projects Lessard and Miller (2001) found that Market related risks are the dominant risks followed by Completion Risks and Institutional / sovereign risks.

Classifying the risks in case of local and international projects, Wang et al (2004) explained that while internal risks largely remain unchanged for local or international projects, external risks for international projects generate mainly from the unawareness of social condition, economic and political scenarios, unknown procedural formalities, regulations etc.

Zou, Zhang and Wang (2007) identified risks related to several stakeholders. Out of these, their research identified 20 key risks, majority of them associated with contractors, clients and designers and a few of them related to government bodies, subcontractors/suppliers and external issues.

Out of 37 risk factors identified by Xu et al. (2010) to affect the Public Private Partnership (PPP) construction projects in China, they narrowed down to 17 critical risk factors under 6 critical risk groups and arrived at the overall risk level of PPP highway projects in China.

Krane, Olsson & Rolstadås (2012) have categorized risks in large construction projects as basically Strategic Risks and Operational Risks. The categorization is based on the risk affecting the project output in case of operational risk and the risk affecting the strategic objectives of the project.

Banaitiene & Banaitis, (2012) classified risk factors in construction projects under two major groups – internal and external. The internal risks are identified as Construction Risks, Design Risks and Project management risks. External risks, on the other hand are like Natural Forces, Inflation and interest rates, Fiscal policy, Political controls.

Thamhain (2013) in his research has studied risk in terms of three variables – Degree of Uncertainty, Project Complexity and Impact of Risk on Project and Enterprise. Studies have also been carried out on one of the major constraints – time.

In their study Doraisamy, Akash & Yunus (2015) admitted that the delays in construction projects has been a global phenomenon and cited studies by Sambasivam and Soon (2007) that suggested contractors improper planning, contractor's poor site management, contractor's lack of experience, clients inadequate finance and payments for completed work, problems with subcontractors, shortage of materials, shortage of labour supply, unavailability in equipment and its failure, communication barrier between parties and mistakes during construction work.

While discussing about the factors affecting Risk Management techniques in construction projects in India, Saminu , Prasad & Thamilarasu, (2015) found out that inadequate planning, poor site safety adoption, supply and use of defective material and poor resources management have contributed towards risk in construction projects.

On similar lines Jayasudha and Vidivelli, (2016)identified inadequate planning, poor adoption of site safety, supply and use of defective materials and poor resources management as the key risk factors affecting the construction projects.

Reiterating the finding of a previous study by Chan, Yeung, Yu, Wang & Ke (2011) on PPP project risk management, Xiong , Zhao, Yuan & Luo (2017) emphasized on both *ex ante* and *ex post* risk management for the risks in PPP infrastructure projects because of their extremely long duration i.e more than 5 years. The risks considered by them are broadly categorized into Systematic Risks like political risk, economic risk, legal risk, social risk and natural risk and Specific Project Risks comprising of Construction risk, Operation risk, Market risk, Relationship risk and others. They are of the opinion that due to the inherent nature of long duration planning for all the risks beforehand i.e *ex ante* is extremely difficult in these projects and it may require planning for management after these risks become imminent thus making it *ex post*.

Site Safety and Protection has also find mention in Heisler (2018) along with other risks like Aging workforce, Contractual Risk, Overburdened contractor sacrificing quality of work and safety, Fire and natural disasters, Regulatory changes, New technologies are some risk areas.

From the perspective of contractor, the study made by Nawaz et al (2019) suggested a framework for risk management in construction projects in developing countries based on various techniques under three main heads of Risk Identification, Risk Assessment and Risk Response and finally Risk Treatment. Among the several techniques studied by them the technique of " WBS (Work Breakdown Structure) and Expert judgment" has been used more frequently than the other techniques.

In the context of steel plant construction projects in India, Datta and Mukherjee (2001), identified project risks under two major heads of external and immediate to the project. While external risks consisted of technological risks generating from its novelty or newness, political risks depending on stability of situation at home and abroad, economic risks with factors like inflation, changes in currency rates affecting the project, risks associated with domestic climate; the immediate risks involve large and complex projects, conceptual difficulty in terms of its failure to be in line with the organisation's strategic objectives, risks of managing the project through external agencies, improper mode of contract and failure of contractors.

The above discussion based on the literatures on risk in construction projects suggest that construction project in steel plants can have most of these risks. However, depending on the typical scenario of steel plant and gamut of activities in the project it can have some risks which have a high risk potential than the other types of industry.

2.2.4 Brownfield Construction Projects in Steel Plants in India

Iron and steel industry in India has a very long background. Starting in the private sector way back in the early nineteen hundred the industry has progressed through ages to reach its present position as the second largest producer of steel in the world (WSA Report, 2019).The steel industry has played a key role in the industrial development of the country as it moved from a mere 22 Million tonnes capacity in 1991-92 to the present position with a crude steel production of 106.5 Million tonnes in 2018. Treading the path of growing demand in the industry and infrastructure area the increase in production was also largely guided by the National Steel Policies of 2005 and 2017. While the National Steel Policy 2005 (NSP 2005) primarily aimed towards self-sufficiency through sustained and efficient growth, the present policy strives to enable the steel industry achieve higher production with a focus on high end value added steel while being globally competitive (National Steel Policy, 2017).

There are several producers of steel in the Indian Iron and Steel market. Primarily they can be categorized as public sector steel plants and private sector steel plants. In the public sector Steel Authority of India Limited (SAIL) has been the largest integrated steel manufacturer in India followed by Rashtriya Ispat Nigam Limited (RINL). In the private sector TATA Steel (formerly known as TATA Iron and Steel Company Ltd.) spearheads the campaign of steel production followed by JSW Steel, Jindal Steel and Power Ltd. (JSPL), ESSAR Steel, Bhushan Steel Ltd. and others. Some of these steel plants were there before the liberalization regime of 1991 but most of them came into existence after that. These steel plants have planned for augmenting their capacity or modernizing their facility in order to primarily catch up with the demand in the domestic market as well as to foray into the export market. The older steel plants like SAIL, RINL, TATA & JINDAL Steel as well as the new players like RINL , JSW and others have augmented their capacity over the years in several stages.

Post liberalization most of the steel plants have envisaged capacity enhancement within their existing facilities. This in turn suggests that these steel plants have taken the brownfield route of expansion i.e adding new facilities or modernization within the existing plant boundary. This has also subjected their projects to the risks of brownfield construction projects. The brownfield nature of project entails some risks apart from the general risks in any construction projects, which are typical to these type of project like unforeseen ground condition with respect to the underground facilities that are existing and getting shutdown of existing operational facilities for the new construction. In general, the brownfield projects are to a large extent isolated from the risk of not getting land for construction of facilities and to a certain extent from the external social or political influences.

In the present study the 48 risks have been identified through literature survey, content analysis and expert ideas and are presented in the *Table 2.1 in Appendix A-1*.

The occurrence of risk or risk events in a construction project can adversely affect the objective of the project in terms of cost, time and quality. Thus there lies an importance of application of formal risk management in Construction Project. Based on their survey of general contractors and project management practices in construction industry Akintoye and MacLeod (1997) concluded that management of project risks is essential to "*minimizing losses and enhancing profitability*". As Hilson (2012) pointed out "*effective risk management minimizes threats, maximizes opportunities and optimizes the achievement of project objectives*" thus ensuring project success. However, several studies suggested that though it is important yet the risk management techniques are rarely applied in actual cases due to the lack of knowledge and experience in the area of construction projects (Ehsan , Mirza, Alam & Ishaque, 2010; Mahendra et al, 2013). While there are studies that suggested that avoidance, transfer, mitigation/reduction and retention/acceptance as the available risk response strategies some other studies referred to a combination of few response strategies (Zenghua, 2011; Dada, 2010; Smith, Merna & Jobbling, 2006).

<u>Risk Response Factors</u>

Several studies indicated about the probable actions towards risk response. PMBoK®(2017) suggested that in addition to the risk response strategies for the individual risks in a project there are strategies to address the overall project risk. These are:

- To cancel the project, if the overall risk level remains unacceptable.
- Set-up a business structure in which the customer and the supplier share the risk.
- Re-plan the project or change the scope and boundaries of the project
- Pursue the project in spite of its risk exposure.

Comparing them to the individual risks and response thereof we have the following table 2.2.

Table 2.2 – Response Strategies for Individual Risks and Overall Project Risks (Compiled by Author)

Individual Risks	Response strategy	Overall Project Risks
Take actions to ensure that the threat does not occur	**Avoid/ Cancel**	Cancel the project as a last resort
Transfer the risk to a third party	**Transfer/ Share**	Share the risk
Actions to reduce the probability of occurrence and / or impact of the individual risk.	**Mitigate/ Reduce**	Change the scope and boundaries of the project to reduce the chance or overall impact.
Take no action unless the risk occurs	**Accept**	Pursue the project despite risk

(Note- Escalation has not been considered as explained earlier)

The selection of risk response process should take into account the cost of such response/s, the impact of such response on the project objectives, uncertainty of outcomes and the residual risks and secondary risks that would be resulting if this action is undertaken. The consideration of all these issues in return will depend on several factors.

A risk management framework was suggested by Wang, Dulaimi & Aguria (2004) in their study of international construction projects in developing countries. Under this framework named "Alien Eyes" risk model they have identified 28 risks categorized under three major heads of country level, market level and project level. For each of the risks under each level they proposed several risk response actions which they termed as "mitigation measures". These actions while being identified as specific measures appropriate to each risk can be categorised under some broad group of actions. These broad group of actions are as given in table 2.3 below:

Table 2.3 – Risk Response Actions and their Categorisation (Compiled by Author)

Category of Response Actions	Mitigation measures for Country level risks	Mitigation measures for Market level risks	Mitigation measures for Project level risks
Developing Contractual provisions	Compliance of project with country's as well as local development plan Clauses for delays and extra payment, Dispute settlement , termination	Contractual provisions like dual currency contracts, Hedging for exchange rate Contractual provisions for inflation Letter of credit from local government to take care of inflation and interest rates. Specify extension and compensation clauses in contract for payment Provide comprehensive terms of default in contract	Contractual provisions regarding escalation, inflation, delays, extension & compensation, conflict resolution, notice provision & notice period, schedule delay & additional payment, technology transfer.
Development of Systems & Procedures	Feasibility report and other documents to be supplied in time	Visit/ check the factory or business regularly	Review plans j[illegible] Contd determine chan[illegible] Arrange and undertake site investigation Organise for drawing and design criteria approval by at least one independent agency Adopt proper quality control procedure Adopt proper safety control programme, management systems, supervision, incentive and preventive measures

Contd

Managerial actions	Develop contingency plans for political instability Set aside budget for unavoidable spending Be informed about of political developments Insure all insurable force majeure risks	Get accurate financial and other information Engage reputed third party consultant to forecast market demand. Conduct market study to obtain exact information about competitive projects Get information about local partners credibility from different sources	Planning with regard to facility to reduce design error, impact of weather on schedule Organise for site properly Control- benchmark and monitor construction activities Insurance for compensation to third party, design liability
Leadership actions	Maintain good relationship with local government. Establish joint ventures with local partners. Seek support from international contractor's home government. Cultural and commercial awareness training to management.	Maintain good relationship with top local govt. officials, local power sources, politicians. Insist on getting trustworthy people on key places Decide on recruitment and selection criteria with local partners Obtain local governments guarantees of exchange rate and convertability	Competent team comprising local staff, trustworthy people in the joint venture Study & implement local rules and regulations Contd
Knowledge and Skill related action		Offer training to new and existing staff Pay attention to contract translation	Intellectual Property Rights training to all key employees Limit the duration of technology transfer contract

(Source: Mitigating Actions under Country, Market and Project Level taken from Wang et. al, 2004)

According to Dey (2012) this framework suggested by Wang et al. (2004) is a "*weak integration across risk management*." Further Dey suggested a framework which is an extension of his earlier works in 2001 and therafter in 2010 wherein risk identification, analysis and response development using risk map and selecting mitigating measures using decision tree analysis. For risk responses in line with the principles related to avoid, transfer, reduce and absorb, several actions were suggested in the study and they have been put under broad categories of actions as below.

Table 2.4 – Risk Response Actions and their category

Risk Response Actions	Category
Carrying out detailed survey to ensure minimum change in scope and design	Managerial Actions
Selecting appropriate technology and methodology based on the expertise of consultants and other relevant factors	Leadership Actions
Executing as per selected technology and methodology	Managerial Actions
Selecting superior consultants, contractors and vendors	Leadership Actions
Scheduling the project considering seasonal exigencies	Managerial Actions
Planning for contingencies and acquiring insurance	Contractual Actions
Ensuring the availability of all statutory clearance before design and detail engineering	Leadership Actions

(Source : Risk Response actions taken from Dey, 2012)
(Compiled by Author)

Banaitiene and Banaitis (2012) in their study based on construction projects in Lithuania proposed that Performance Bonds, Warranties are the most favoured response options followed by Resource Reserve, Insurance, Risk Transference to other project party as the other favoured options.

Datta and Mukherjee(2001) in their study drawn a risk management matrix, as shown in figure 2.1, based on the levels of external and immediate project risks and suggested the risk response actions.

The suggested risk response encompasses actions that are either related to systems and procedures or are related to provisions in contract on one hand to the actions that are related to human aspects like leadership actions or managerial actions. The decision to choose among the several options of risk management suggested by Datta and Mukherjee (2001) calls for decision making ability of the project manager. The leadership capability of the project manager is also tested when through good communication, motivation and team development the project manager is able to take appropriate response to the risks. The knowledge about the project and/or technology associated with the project as well as the political environment and market dynamics are other aspects that help in taking decisions about risk response actions.

Figure 2.1- Interpretation of the Risk Management Matrix Nine Possible Scenarios

External Project Risk				
	High	**Segment I** Abandon the Project at this stage	**Segment II** • Abandon the Project at this stage • Reconsider the project proposal	**Segment III** • Reconsider the project proposal • Develop Alternatives • Transfer the Risks
	Medium	**Segment IV** • Abandon the Project at this stage • Reconsider the project proposal	**Segment V** • Reconsider the whole project proposal. • Develop Alternatives • Transfer Risks	**Segment VI** • Transfer Risks • Defer the risks • Reduce the Risks • Assign contingencies and Go for the project

Continued

Low	Segment VII	Segment VIII	Segment IX
	• Reconsider the whole project proposal. • Develop Alternatives • Transfer Risks	• Transfer Risks • Defer the risks • Reduce the Risks • Assign contingencies and Go for the project	Plan for Contingencies and Go for the project
	High	Medium	Low

Immediate Project Risk

(Source : Datta and Mukherjee, 2001)

Further analysis of these categories of actions help us to identify two broad heads/factors under which these actions can be clubbed. These two broad categories, in the present study have been termed as Human and Systemic Response Factors. These factors and their constituent actions are explained below:

Human response Factors (HRF)	Competency of Project Manager / Project team helps to select response & take action to respond to the risk. These factors relate to – - technical competency of project manager/ project team e.g domain knowledge, experience - managerial competency of project manager e.g planning, organizing and controlling - leadership competency of project manager e.g decision making, communication, motivation etc.
Systemic Response Factors (SRF)	Systems and processes/contractual provisions/ available project information data helps to select response &take action to respond to the risk. These factors relate to - – Proper Systems for monitoring, vendor selection, changes, approvals, payments -Appropriate Provisions in contract / specifications/ terms and conditions,. - Availability of proper information system.

While deciding on the risk response option for a particular risk the project manager may decide out of a set of options to address a particular risk and it is always possible that the suitable option of response which may consists of several actions will be actually influenced by both human and systemic response factors rather than by one of the factors alone. However, the relative level of influence of these factors on the choice of a risk response option may vary for each of the risk.

The steel plants in India, as discussed above, have gone for capacity expansion or modernization through brownfield route which involves construction in an operating steel plant. This unique condition may also generate some risk which are typical to this condition. Though literatures have established significant risk in construction projects in other industry, it remains to be seen that whether the brownfield condition also generates significant overall risk for these construction projects. As the literatures have not specifically pointed out about the effect of risk response factors on the risk response options in construction projects it comes out as a point of interest to find out the relative influence of these factors on the risk.

2.2.5 Concept of Complexity

Literature on complexity especially that of projects has developed due to the different concepts of complexity that emerges out of the Complexity Theory on one hand to the understanding of the term by different authors and Authors at different point of time. However, even with all these concepts, complexity is still more disputed than an agreed term (Corning, 1998; Ameen and Jacob, 2009). In fact Cicmil et al. (2009) pointed out that the term is so *common and wide-spread* in its usage that each and every person can have "*their own understanding of what the term means.*" Therefore, the term complexity and its underlying concept needs to be understood before this is applied for projects.

Complexity as a concept existed well before it was introduced into the arena of project. According to Oxford Dictionary the term defines something which is *"composed of two or more parts or composite or not simple".* Thus it characterizes two important aspects – multi-element construct and intricate relationship among components.

Authors have tried to explain complexity based on different dimensions. In his work Stacey (1996) tried to explain complexity in terms of *degree of certainty and level of agreement*. The matrix suggested that a system can be classified into simple, complicated, complex and anarchy depending on its proximity to these two dimensions. The study suggested the types of decision making involved in each these *"zones"* depending on the degree of certainty and level of agreement.

To assist the leaders in decision making in a complex situation, Snowden and Boone (2007) suggested their *"Cynefin Framework"* which explained five "*contexts"* of complexity – simple, complicated, complex, chaotic and disorder. As explained by Snowden and Boone (2007) these "*contexts"* have got their own "characteristics". Azim (2010) pointed out that a complex context is characterized by Flux and unpredictability, No right answers, Emergent instructive patterns, Unknown unknowns, Many competing ideas, A need for creative and innovative approaches, Pattern-based leadership. This framework thus helps in identifying the context and making decisions appropriate to the context.

Complexity theory, as described by Cicmil et al (2009) is the study of "*order, structure, pattern and novelty*" in the most complicated and apparently chaotic system on one side while the "*emergence of complex behavior and structure from simple underlying rules*" on the other side. Thus it is the study of nonlinear dynamic systems which gives a useful insight into the unpredictability of industries with the emergence of distinctive patterns (Cartwright 1991). Though developed originally for the physical and biological sciences, but over time several authors pointed out the applicability of this theory for social, ecological and economic systems which has the nonlinear relationship and complex interactions that evolve over time (Butler, 1990; Kiel & Elliot, 1996; Merry, 1995).

Complexity has been an issue for any system that stems out from the difficulty associated with describing it (Simon,1962). According to Simon (1962), in a complex system large number of multiple interacting parts makes it difficult to understand the behavior of individual components or predict the overall behavior of the system based on the knowledge of the starting conditions.

According to the study made by Geraldi and Adlbrecht (2007), complexity has been characterized by several other attributes– while number of elements is a significant contributor (Patzak, 1982; Ashby 1957), the heterogeneous nature and diversity of their relationships make them even more significant (Ashby, 1957; Klir, 1991; Simon, 1982).Apart from these variety of goals, perspectives, cultures, etc.; difficulty (Frame, 2002); uncertainty (Williams, 2002); dynamism (Kallinikos, 1998; Patzak, 1982); uniqueness (Klir, 1991); lack of clarity (Reither, 1997), or low degree of definition of goal, scope, and methods (Crawford, 2005) also contribute to the complexity.

Thus complexity of any system lies in the limitations of our ability in understanding and assessing it in terms of its build up from the components or the functional interaction of these components among themselves as also their integrated functioning as a more complex assembly (Botchkarev & Finnigan, 2015). While applying this concept to any project, it is evident that a project because of its multiple, diversified components and intricate interrelationship among these components can become a complex entity.

2.2.6 Project Complexity

Complexity has, for long, been a major issue of any construction project and more so for a construction project in an operating steel plant. Therefore understanding project complexity assumes a great importance in managing a project successfully. Kiridena and Sense (2016) explained the term complexity in the context of a project in the following way.

"The term "complexity" is increasingly cited in project management literature and often referred to by practitioners with connotations to the challenges related to managing projects in general, and the difficulties associated with delivering the desired project outcomes in particular. These challenges, in turn, have been linked to: the increasing scale and diversity of projects, greater expectations of stakeholders; and the difficulties in effectively managing a multitude of interfaces and interdependencies

between different parties and/or across different facets of projects , programs, and portfolios."

The concept of Goal -Method Matrix proposed by Turner and Cochrane (1993) to classify types of project has been used by many authors in subsequent times. It is the aspects of clarity and certainty of goals and methods that has been used by them to explain complexity and project complexity (Azim, 2010). According to Turner and Cochrane well-developed goals with well-developed methods to achieve them leads to the success of the project whereas the absence of any or both of them may lead to the failure.

Baccarini (1996) defined project complexity as "*consisting of many varied interrelated parts that can be operationalized in terms of differentiation and interdependency*". The concept of project complexity defined by Baccarini (1996) deals with two types of complexity – organizational complexity and technological complexity on the basis of differentiation and interdependency. Gidado (1996) has drawn an analogy between project and production process. Project activities, like complex production process are linked in a work flow to achieve the project outcome within budget and to a desired quality level without much conflict.

More in line with Baccarini (1996), the concept of complexity was further explained by Williams (1999) in terms of structural uncertainty and uncertainty as the two constituents of complexity.

Bertelsen (2003) considered project as a dynamic phenomenon in a complex and non-linear settings, where the stakeholders act in a collaborative manner inspite of their differing targets and objectives.

Gidado (2004) in a later study identified six main components of project complexity each made up of a number of intersecting factors and to a large extent follow the concept of structural complexity and uncertainty.

In their study of complexity of Megaprojects, Brockmann & Girmscheid (2007) defined complexity as manifoldness, interrelatedness and consequential impact of a decision field in projects.

Geraldi and Adlbrecht (2007) defined complexity patterns in terms of three factors – faith, fact and interaction. Dealing with high uncertainty, solving new problems or creation of a unique product is what the complexity of faith involves. It involves wide array of possibilities as semblance of solution. Complexity of Fact involves dealing with large volume of "interdependent information" within the constraints of time in the area of production, procurement and logistics of the project. Complexity of interaction denotes complexity that emerges out of the politics, ambiguity, multi-culturality involved in the interfaces between project locations. According to the Project managers, as cited by this study, complexity of interaction has been perceived asthe predominant type of complexity.

Another important dimension was added in the study of complexity when the concept of pace was introduced by Shenhar and Dvir (2007) in their proposed Diamond Model. According to them the uncertainty in projects has got four dimensions – novelty, technology, complexity and pace.

Brockmann and Kähkönen (2012) tried to quantify complexity of construction projects with five dimensions viz. task, social, cultural, operative and cognitive complexity. While task complexity is comprised of technical and organizational complexity, social complexity is composed of number and diversity of stakeholders. It is also their diversified culture that contributes towards the cultural complexity. The dynamics of the project is captured by two more complexity – cognitive and operative. Cognitive complexity indicates the "differentiated" thinking about the construction project among the stakeholders. Degree of freedom of the members for the operation of the project and with respect to project sponsors is an indicator of Operative Complexity.

Based on the systematic review of literatures on project complexity, Geraldi, Maylor and Williams (2011), suggested an integrated framework comprising of five dimensions to assess complexity- structural , uncertainty, dynamics, pace and socio-political complexity to assess project complexity.

Kian and Sun (2014) in their study of energy megaprojects identified 76 complexity indicators in the category of external and internal indicators and the respective subcategories to assess a composite complexity index in order to manage complexity.

In their study consisting of literature survey and expert interviews, Luo, He & Shu (2015) identified 27 key complexity factors and extracted 6 common factors like information complexity, task complexity, technological complexity, organizational complexity, environmental complexity and goal complexity as their framework of project complexity.

Dao, Shen, Anderson & Hare (2016) in their study of project complexity identified 37 complexity indicators under 23 complexity attributes which they categorized under eleven heads.

Based on their study of project complexity in Malayasian Construction Industry Abdoul Saed, Young & Othman (2017) categorized different project complexity factors into three broad categories of Technological Project Complexity Factors comprising of number of tasks, lack of resources, remoteness of location, environmental regulation etc., Organisational Project Complexity Factors like project duration, number of locations, interference between existing sites and Environmental Project Complexity Factors consisting of number and clarity of project goals, size of project team, uncertainty in methods etc.

De Rezende , Blackwell & Goncalves (2018) while studying the trends and findings of Project Complexity Research spanning prior to 1985 and after 2005 observed that "*Authors approach project complexity research questions from four perspectives: project complexity, capabilities, performance and concerns."* They observed that the project complexity perspective of research encompassed the dimensions of structural, uncertainty, novelty, dynamics, pace, socio-political and regulative complexity. According to the authors it is this perspective consisting of the above dimensions "*can be used to conceptualise project complexity as a condition of a project*".

2.3 Research Gap

Most of the literatures have identified risks pertaining to construction projects in specific areas like infrastructure, building construction, pipeline construction etc. Authors, in these literatures, have identified risks in their specific area of construction projects.The literatures authored by Indian Authors have also dwelt upon the construction project risks but have not specifically addressed any risk pertaining to brownfield construction projects in steel plants which may have some constraints of their own. Thus, this part of the study addresses the first objective of ascertaining the overall risk potential of the brownfield construction projects in steel plants.

The theoretical framework of project complexity as a multi-attribute construct has been established through several studies as indicated in the literature review. However, putting these attributes in the proper context of brownfield projects with their limitations due to site constraints, logistic difficulty etc. was conspicuously absent in these literatures. Further, these literatures have not specifically highlighted any relationship between the project complexity and the criticality of risks which has been identified as a gap for the present study. The study endeavoured to assess these attributes and their indicators to finally arrive at the overall project complexity and thereafter investigate the relationship between project complexity and criticality of risk. Thus this gap justifies the second objective of this study.

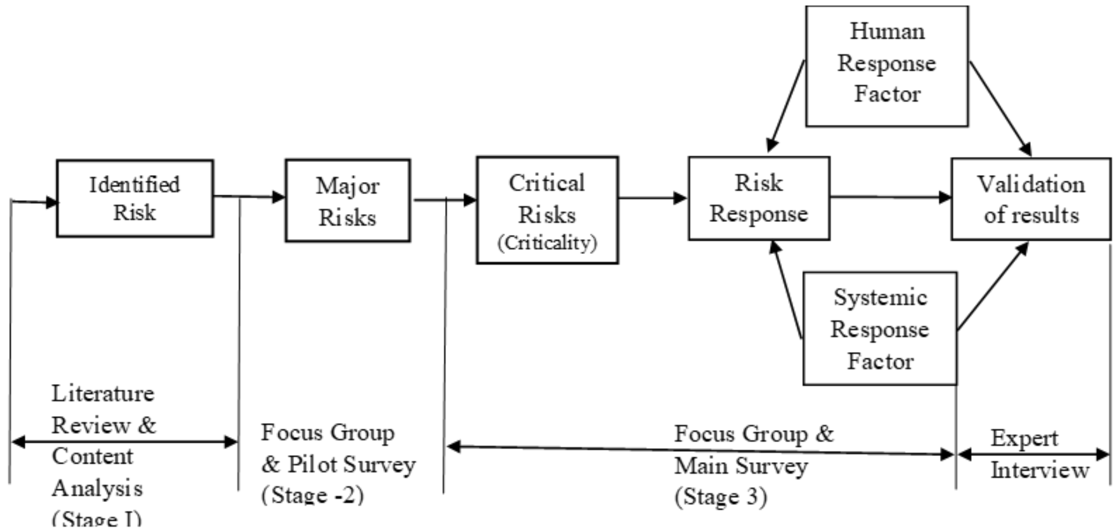
The literatures also suggested several actions to respond to risk or risk event appropriately. A careful study of these actions suggests that these actions are influenced by two distinct types of factors – one is the human response related factors and the other is systems and procedures related factors. Literatures have also widely discussed about the possible risk response options like avoid, transfer, mitigate and accept. However, these literatures have been silent on the question as to which of the factors influence these risk response options more. Further no mention is found whether these risk response factors have any relationship with either project complexity or with criticality of risk. This study has attempted to investigate these two gap areas – comparative influence of these response factors on risk response option and also their relationship with complexity of project and criticality of risk. This attempt has been reflected in the last two objectives of this study.

2.4 Conceptual Framework of Study

The earlier sections of this chapter have provided a background of risk, construction project risk and project complexity through the available literatures in these areas. The research gap above has also pointed out the deficiency of interlinkage between the construction project risk and the complexity of project. Based on these knowledge and ideas this section endeavours to provide a conceptual framework of the proposed study.

The risks are identified from literature survey, content analysis and expert opinion in the first stage. The identified risks were assessed in terms of their probability of occurrence and severity of impact in the second stage. The risk potential score (an indicator of criticality) for each risk obtained as a geometric mean of probability and severity was subjected to normalization. Based on normalization criteria the major risks were selected for further assessment by a group of project experts in the third stage in terms of the same components–probability of occurrence and severity of impact. The risk potential score obtained at this stage is further subjected to normalization and risks with normalization factor of 0.5 or more are considered as critical risks. These critical risks were subjected to further analysis for risk response and the influencing response factors. The framework of study for the identification and assessment of risks in brownfield construction projects in steel plants is given in figure - 2.2 below

Figure –2.2: Framework for risk identification and assessment



Literature survey on complexity in the first stage yielded several concepts of arriving at the project complexity from its components. However some of the components were discussed in focus group and subjected to survey responses in the second stage. Finally, for the present study, complexity attributes were considered based on the study made by Geraldi, Maylor and Williams (2011). These attributes and indicators were further discussed in the focus group and subjected to survey response in the third stage. However, indicators under each of these attributes have been decided based on the guidelines in the article as well as from the experience of brownfield construction projects in steel plants. The attributes and indicators and the rationale for their selection is explained below:

Structural Complexity of the project

a) Difficulty in equipment deployment – In existing steel plants more often construction projects are taken up either to install a new facility alongside the operating units which need to continue its operation during the execution of the project or an existing facility needs to be upgraded/ modernized. In both these cases deployment of construction equipment becomes difficult due to the restrictions resulting in increased complexity.

b) Space Restriction - Most of the steel plants face a severe space restriction when it comes to adding a new facility or upgradation of existing facility. This congestion at site add more to the already complex project. Further, construction projects in any existing plant face another difficulty in terms of underground facilities and structures which are there as part of the existing facilities. It gets more complicated when the information of such facility do not reach the design office in time.

c) Other running projects/ plants – The space restriction and the resulting complexity also increases when there are other projects/ plants running simultaneously in the vicinity of the proposed project creating problem in movement of materials and manpower.

d) Number of Agencies working in the project – More the number of agencies working in a project the more it contributes to the complexity of the projects. The contribution comes in the form of additional number of communication channels to be managed. Apart from this there can be problem of logistics.

Dynamics of the project

Dynamics is usually related to change in the projects. The change in the construction project can take place due to variety of reasons:

a) Change due to some additional requirement hitherto not envisaged.

b) Change due to some underground facility not envisaged before.

c) Change due to non-completion of work by contractor and subsequent award of balance job to other contractor.

In the present study it has been accounted for in the number of changes that has taken place in the project both major changes and minor changes.

Uncertainty in the project

Uncertainty is accounted for in this study through two factors – novelty of technology and lack of information.

a) In case of very new technology, the lack of knowledge about the new technology causes complexity about the possible steps in execution as well as the requirement of the new equipment under this new technology.

b) While the lack of information about the new technology or other requirement or linkages with other projects may contribute to uncertainty among the project manager and his team members.

Pace of the project

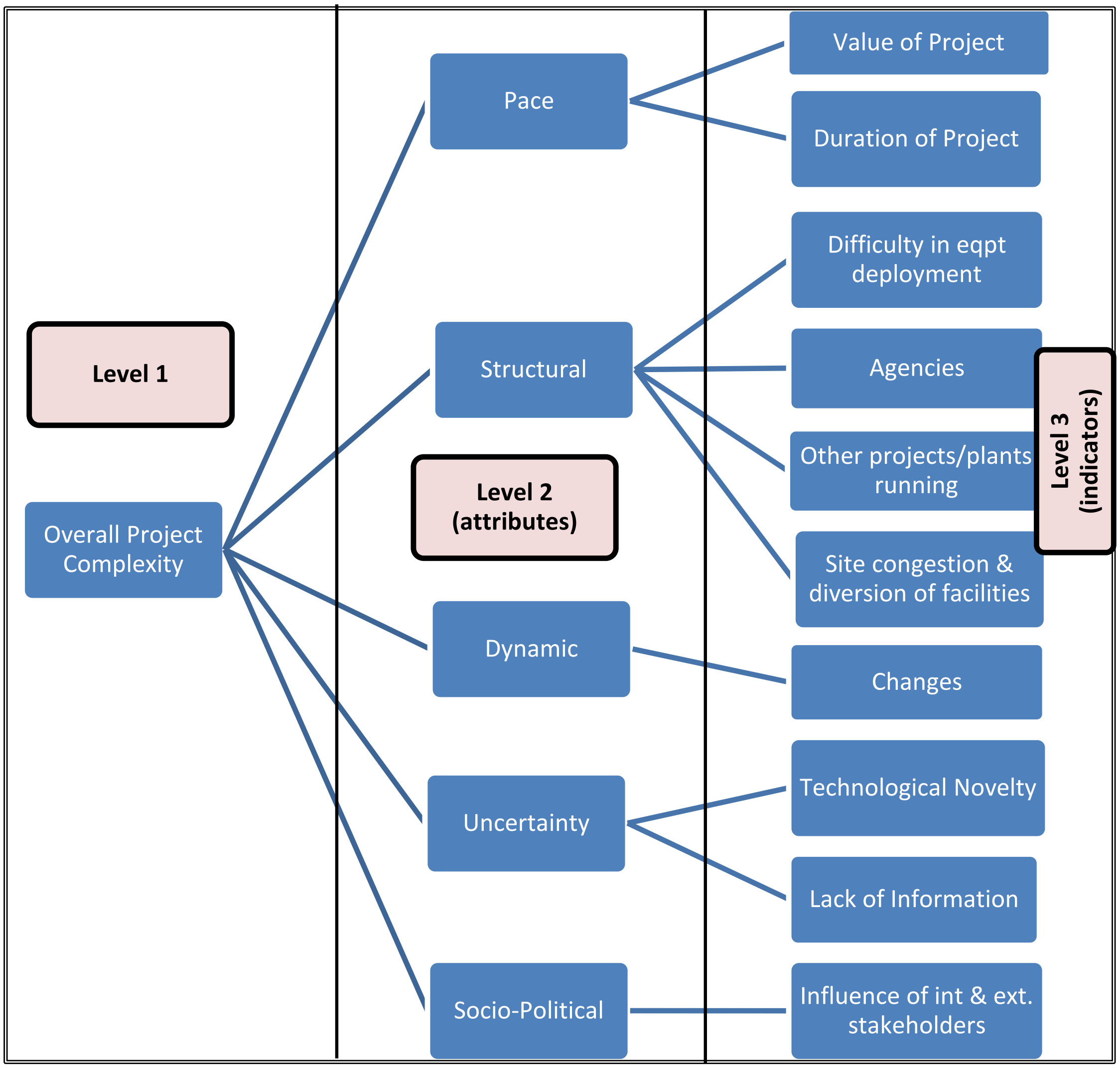
It is simply the speed with which the project is to be executed. It is defined in terms of the ratio of the value of project in rupees and the expected duration. In case of two same value projects the lesser duration project renders more complexity than the higher duration one.

Socio-political influence in the project

It was initially thought that in case of brownfield projects the influence of this factors will be very limited but it was decided in discussion with project experts that this factor need to be captured to assess the influence of this factor – both internal and external.

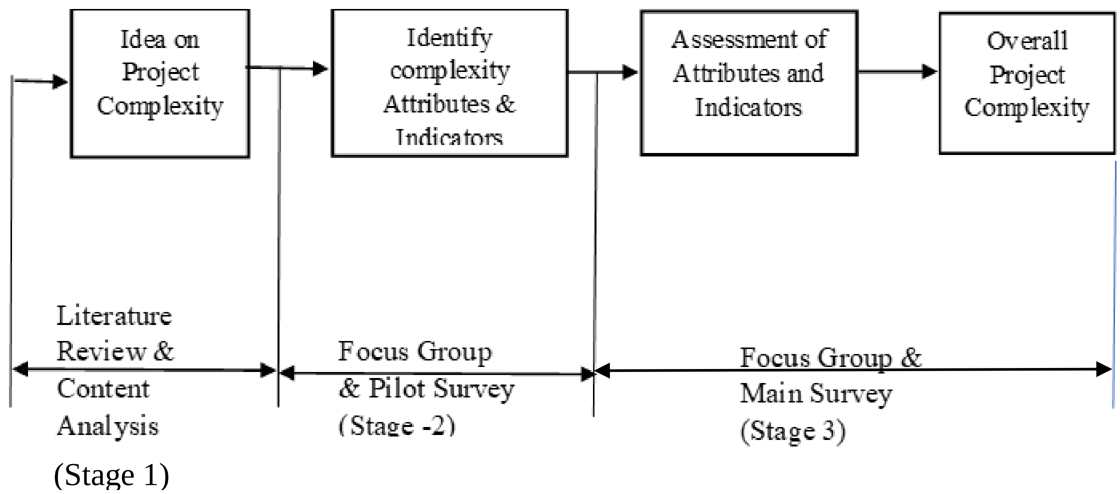
Thus for project complexity, the individual indicators are included in level 3 while the attributes come under level 2 which gives rise to the concept of overall complexity of the project at level 1. The figure 2.3 below explains the categorization at the different levels.

Figure - 2.3: Attributes and Indicators of Project Complexity



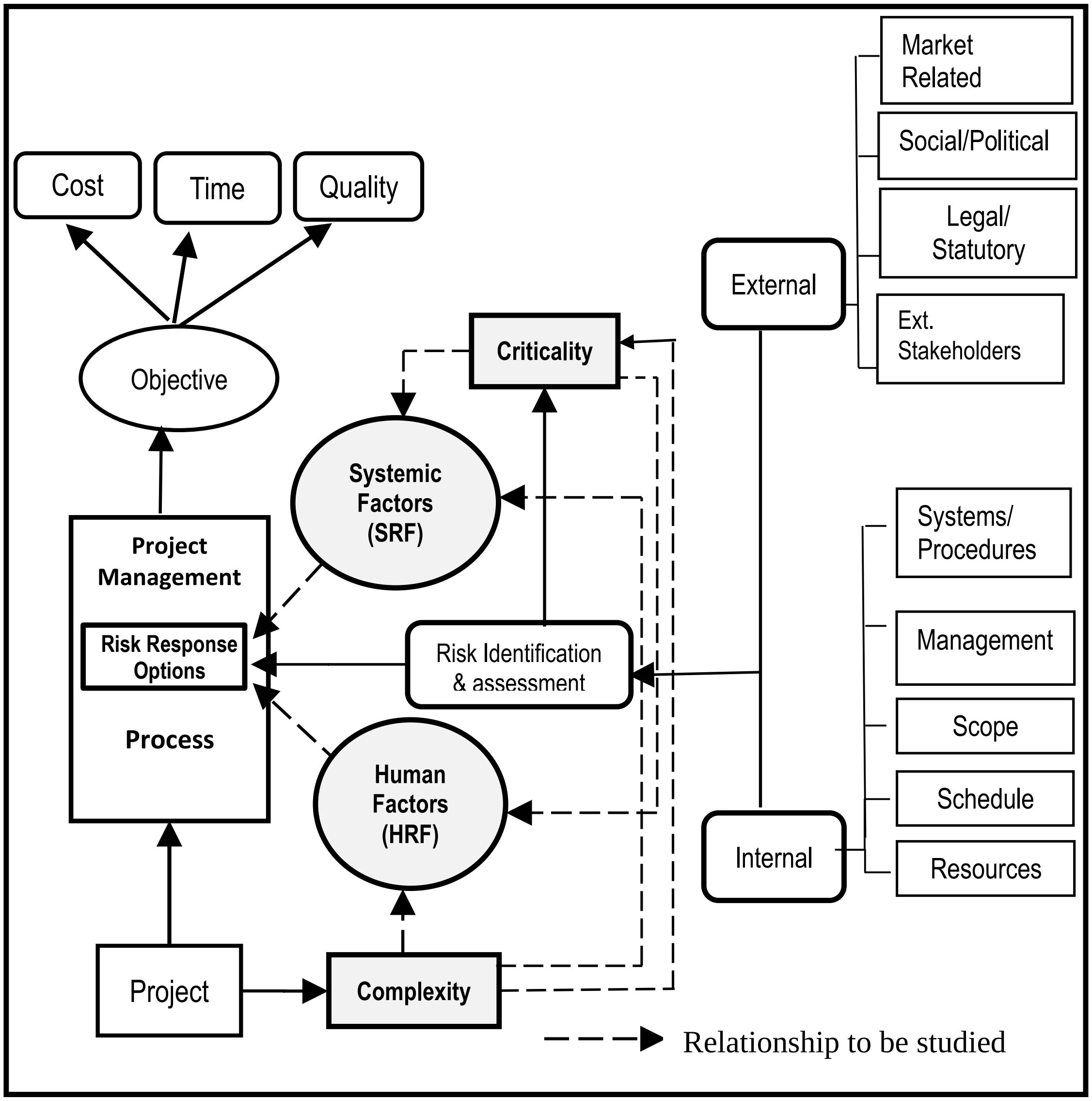
The relative weights of each attribute and indicator is calculated based on the experts opinion obtained through paired comparison and applying Analytic Hierarchy Method thereafter. These individual weights contribute to the overall project complexity. Responses were taken from the participants of the main survey in stage 3 on each of the indicators in a scale of 1 to 5. These responses on indicators were then multiplied with their respective weights and added to get the overall project complexity. The framework of study in Project complexity is shown in figure - 2.4 below:

Figure-2.4: Framework of study on Project Complexity



The present study proposes to examine the relationship between the identified critical risks and risk response factors and the project complexity. The figure 2.5 below indicates the integrated framework of study of these two aspects and their relationship.

Figure- 2.5:Integrated framework for the present study.



2.5 Summary

This chapter presents the review of the available literatures in the area of project risk, construction project risk and project complexity. The available literatures suggested several risks in the area of construction projects. Content analysis was carried out to ascertain their occurrence in different studies. However, there were certain risks which were taken into consideration after discussion with project experts associated with steel plant projects. Another part of the literature survey was devoted to determine the attributes and indicators of project complexity. Based on this literature survey the research gap was identified for the present study. The chapter, thereafter concluded with the conceptual framework of the proposed study.

CHAPTER 3

RESEARCH METHODOLOGY

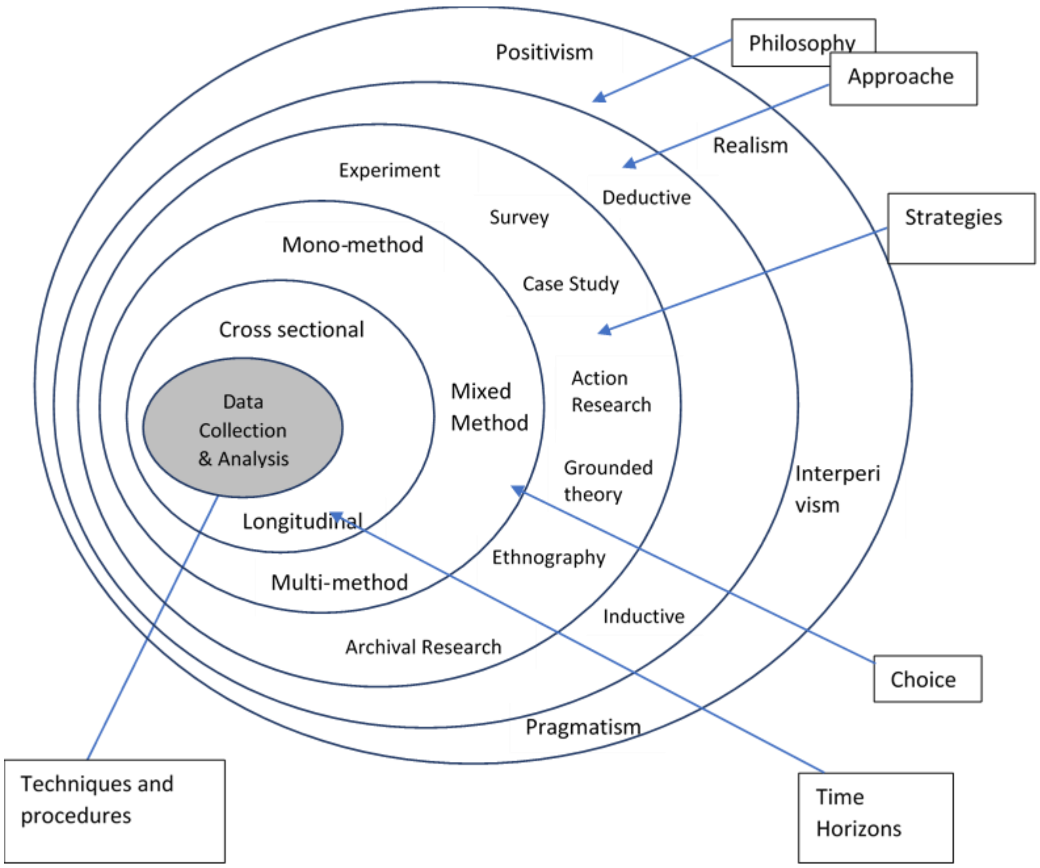
Research Methodology

3.1 Introduction

This chapter deals with the philosophy, approaches, design and methodology followed to address the research problem. The philosophy of research relates to the development of knowledge and the nature of knowledge (Saunders, Lewis & Thornhill, 2009). The approach to research can be either deductive which develops a theory based on certain hypothesis and these hypothesis are then tested for their rejection or acceptance or an inductive approach in which data and facts are collected to establish the theory (Cooper, Schindler & Sharma, 2012). The design or more popularly research design is the most significant task after defining the research problem. Various Authors have defined and classified Research Design. However none of these definitions could successfully capture all the aspects of Research Design. (Cooper et al, 2012). Both research methodology and research methods are completely different concepts and should not be used interchangeably. Method is a tool and technique used to make model sense of a problem, whereas methodology is a framework in which methods are placed as part of the broader research strategy (Azim, 2010).

The whole research process is shown in the "research process onion" suggested by Saunders et al., (2009) which is as given in Fig 3.1 below:

Figure 3.1 - The research "onion" (Source: Saunders et al., 2008)



3.2 Research Questions

The research questions in quantitative studies focus basically on the objective of the study.Thus, the objective of the research is to seek answer to the research questions. However, framing proper research question is not easy as improper question may elicit answers that are not appropriate or may deviate from the research objectives. The present study also tries to answer the following research questions:

i) What is the overall risk potential of Brownfield construction projects in steel plants and whether organizations follow proper risk management framework for these type of projects?

ii) Whether risks have a relationship with complexity of the projects?

iii) Whether the risk response factors (both human and systemic) have same level of influence for all the risk response options?

iv) Do these risk response factors have any significant relationship with the complexity of the project?

v) Do these risk response factors have any significant relationship with the criticality of risk?

3.3 Statement of the Problem

The studies mentioned in the literature survey have identified number of risks for construction projects but it is not clear whether these risks are all present in case of brownfield construction projects in steel plants or there can be some risks that are typical to steel plants and may not have found any mention in these literatures. Possibility also exists that these risk events may not impact the brownfield construction projects in the steel plants in the same way as they do in case of other construction projects.

In the first stage of the study identification of risks in brownfield construction projects in steel plant was taken up to address this issue. One important idea behind this identification stage was to identify any risk which is typical to brownfield construction project.

Though several literatures have identified different types of risks and their management but these literatures have not thrown much light on how the risk response factors/ influencers affect the risk management process in the construction projects leaving scope for assessment of their effects on the construction projects in steel plants.

In the second stage, the study concentrates on the Risk Management part. Management of project risk is primarily carried out with the purpose of the project achieving its objectives with respect to time, cost, quality and scope. The primary benefit of Project Risk Management is to create awareness of the probable ways in which the project can fail and ideas or plans that enables the project to significantly improve its chances of achieving success despite the odds.

There are several factors that affect risk management process in its different stages i.e during risk identification, risk assessment and risk response process. These factors, termed as risk response factors, are broadly classified under two major heads

a) Systemic Response Factors

b) Human Response Factors

Systemic response factors relate to the contracts/procedures / systems followed in the organization for the projects. These procedures / systems, if not followed, may give rise to risk events. Inclusion of some provisions in the contract or changes in some procedure or developing some new procedure or system may contribute towards successful management of risk.

Human response factors relate to human interface in the project. This may be related to Decision Making, Communication, Leadership, Motivation, Team Work and others.

None of the literatures reviewed so far has not thrown any light on how these Response Factors affect the risk response for brownfield projects in steel plants of India. It is also not evident whether these response factors influence the risk management options at the same level. Available literatures are also unable to throw any light on the relationship between these response factors and the criticality of risks and complexity of the project.

In this stage it was also the endeavor to get the responses from the executives associated with projects in terms of their perspective on these response factors and their relationship with risk and project complexity.

3.4 Objectives of the Study

The aim of this research is to create an understanding of risks in brown-field construction projects in steel plants, their criticality, factors that influences the choice of risk response and the relationship of these factors with the project complexity and criticality of risk. The objectives of the present study have been formulated as below:

a) To ascertain overall risk potential of brown-field construction projects in steel plants.

b) To investigate the relationship of criticality of risk with complexity of the project.

c) To explore the influence of Risk Response Factors on the Risk Response Options selected for the risk.

d) To determine the relationship of these factors with complexity of the project and criticality of risk.

3.5 Research Hypotheses Formulation

In research, hypotheses formulation is carried out as an instrument which guides a researcher into making relevant observation . In social science research, according to Kothari (2004), lack of information with regard to population parameter leads the researcher to formulate a hypothesis as a strategy to decide whether generalization can be made based on sample data. Thus, *"it is a proposition or a set of proposition"* which need to be tested during research.

The present research has formulated some hypotheses that are tested during this study.

Risk or risk events are there in any project and construction projects are no exception. Assessment of these risks is done through Risk Potential Score which is the geometric mean of the probability of occurrence of the risk event and the severity of its impact. In brownfield construction projects there are number of risks with their associated risk potential which may give rise to overall risk of the construction project. Thus it becomes imperative to know the level of overall risk potential of the construction project. Xu et. al (2010) in their study of Public Private Partnership

Highway projects have identified overall risk index of these projects. Based on his idea the first hypothesis is formulated.

H_{01}: There is no significant level of risk in brownfield construction projects in steel plants.

Construction projects are generally complex projects. This complexity is due to the different attributes contributing to it. Though the complexity and risk in a project has been subjects of independent study but there may be a relationship between complexity of project and criticality of risk. This idea has led to the next hypothesis.

H_{02}: There is no significant relationship between the criticality of risk events and the complexity of project

Management of Risk requires certain actions on the risk which are known as risk response. For risk response, the available options are avoiding the risk, transferring the risk to another party who is eligible to handle such risk, mitigating or reducing the risk and accepting the risk. Any option that is chosen and action taken under that option is influenced by several factors, which are termed as Risk Response Factors. These Risk Response Factors are broadly classified as Human and Systemic Response Factors. The question that arises is whether both these Response Factors influence the Risk Response options at the same level or there is a difference. This has prompted the third hypothesis as given below:

H_{03}: There is no difference in the influence of Risk Response Factors (RRF) on the Risk Response Options (RRO) for each Risk.

In brownfield construction projects two very prevalent risks are that of delay due to non-availability of shutdown of existing facility and resulting non-availability of workfronts for the contractors. The present study tries to investigate whether both the response factors have the same level of influence on risk response option for these two risks. This has prompted the fourth hypothesis that is given below:

H_{04}: For risks of non-availability of workfront/shutdown of existing facility both the response factors have same level of influence on the risk response options.

The risk of unforeseen ground condition (including the existence of underground facility unknown to project owners) can be a major bottleneck in the progress of project leading to both time and cost overrun. The risk response factors may have influence in the choice of response option for these risks. This has prompted the fifth hypothesis as below:

H_{05}: For the risk of unforeseen ground condition both the response factors have same level of influence on the risk response option.

Safety risk has been a big risk for any construction project with the potential to cause abnormal delays and associated cost overrun. For this risk whether the systemic and human response factors have the same level of influence on the risk response option need to be investigated. This has given rise to the following hypothesis:

H_{06}: For Safety related risk , both the risk response option have the same level of influence on the risk response options.

As the study tries to find out the existence of a relationship between project complexity and criticality of risk it is thought to investigate if there is a similar relationship that exists between project complexity and the level of risk response factor influence. This has given rise to the seventh hypothesis given below:

H_{07}: There is no significant relationship between the Risk Response Factors and the Complexity of the brownfield project.

The risk response factors are associated with risks. Therefore it is felt necessary to investigate whether there is any relationship between risk response factor influence and the criticality of risk. This has resulted in the eigth hypothesis as below:

H_{08}: There is no significant relationship between the Risk Response Factors and the Criticality of Risk for a brownfield project.

3.6 Research Design

Research design is essentially a written statement which explains what data will be collected, how these data will be collected and the source of the data (Easterby-Smith et al., 2015). Thus it is written account of the philosophy behind the research, process followed for the research, the approaches adopted and the methodology followed for answering "*the central questions of the research*".

3.6.1 Research Philosophy

The philosophical standpoint that characterise the world of research are broadly classified into two types – Positivist and Interpretivist (Greener, 2008). However, their application was usually made by the authors to explore the facts and truth about reality (Azim, 2010). Positivism as explained by Bryman and Bell (2011) is the "*application of the methods of the natural sciences to the study of the social reality and beyond."*

The major principles under this approach emphasises that any phenomena and the knowledge thereby which can be confirmed by the senses can be treated as knowledge. In contrast to the positivist approach, the interpretivist approach promotes the idea of subjective thoughts and ideas of people about subjective social world. Saunders (2003) points out that in practice, research does not get restricted into one of these philosophical domain discussed. This is basically to access the benefits of both the approaches with their proper utilisation. In the present study, both the approaches have been considered for taking the study to its logical end. In the present study, too, both the approaches have been considered for taking the study to its logical end.

For the present study "Interpretivist" approach is the best suit as the study aims at understanding the relationship between the criticality of risk and the complexity of project and further explores the different risk response options and the effect of risk response factors, broadly classified as Human Response Factors and Systemic Response Factors, on the selection of the risk response option. However, it is felt at certain stages a positivist approach will give the study the necessary objectivity. Thus a combination of both these approaches has been adopted for the present study.

3.6.2 Research Process

The research study is carried out in several stages. In the first stage literature survey and content analysis has been carried out to identify primarily the type of risk in construction projects. Then a focus group discussion with expert project managers of steel plants is carried out to finalise the risks or risk events which are a common occurrence in steel plant construction projects. The objective of the first stage of the study was to have a pragmatic perception about the risks/ risk events in construction projects in existing steel plants.

Based on the understanding developed in the first stage a pilot survey questionnaire is prepared and survey conducted in the second stage to gather preliminary insight about the major risks in existing steel plant construction projects and also to get idea about any other risk which the respondents felt should have been considered as major risks in this area. Respondents were asked to give their perception about each of the risks in terms of its *Probability of Occurrence(PO)*and the *Severity (SEV) of impact*, in case it occurs. Based on the responses the *Risk Potential Score (RPS)* is calculated which is the geometric mean of Probability of Occurrence and Severity of Impact. In this survey, some additional risks actually suggested by the respondents, which are considered based on the deliberation in the focus group discussion, in the main survey next stage.

Simultaneous to the assessment of major risks at this stage, literatures have also been reviewed in the area of complexity of projects. Attributes and indicators for measuring complexity have been identified. Experts and head of projects thereafter evaluated these attributes and indicators of project complexity. The basis of evaluation is Paired Comparison Method in which each of the attributes is compared with the other in order to create a hierarchy of attributes. Similar process is followed for the indicators. This is done in order to arrive at the relative weight of each of the attributes and indicators using Analytic Hierarchy Process.

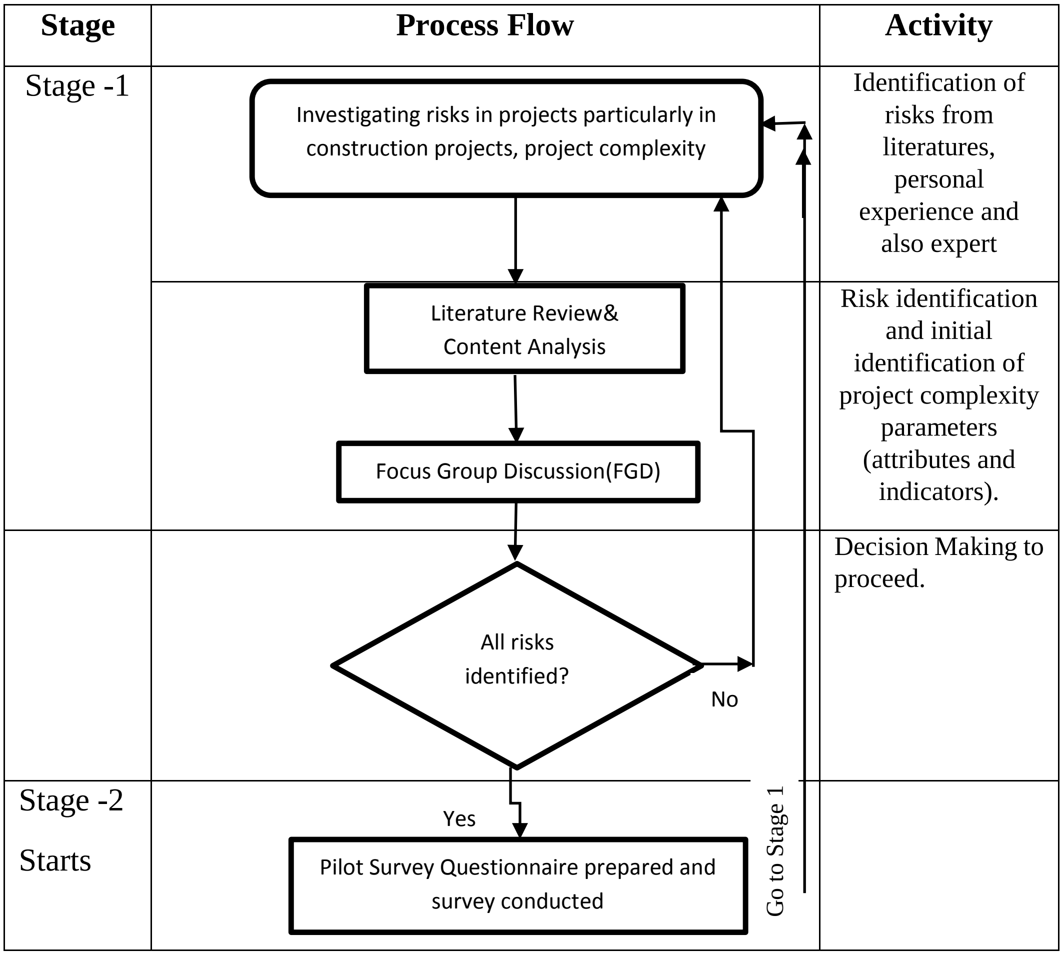
A Focus Group Discussion was also carried out at this stage to finalise the risks to be included in the main survey questionnaire as well as the scale for project complexity attributes and indicators.

In the third stage, responses were taken to evaluate the major risks and selecting critical risks on the basis of their *Risk Potential Score (RPS).* Responses were also taken on the complexity attributes and indicators in the main survey. Inputs regarding the framework followed in the organization with respect to identification and management of risks in the construction projects were also obtained at this stage.

In the last stage i.e. the fourth stage, expert opinion survey was undertaken to validate the findings of the main survey and to gain more insight on the steps a project owner may take to address the *Risk Response Factors (RRF)* to manage risks more effectively.

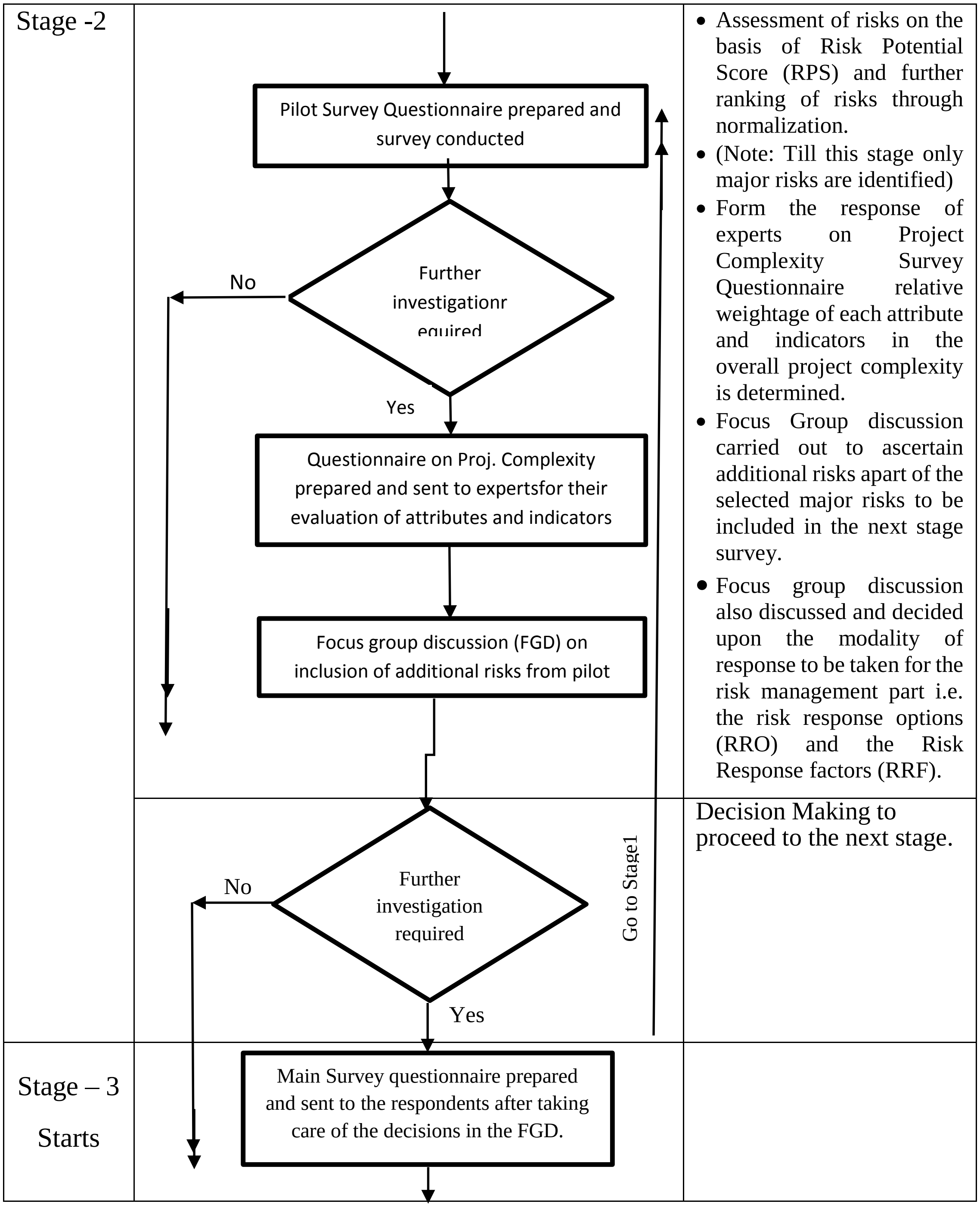
The process flow of this research work is shown in the figures 3.2, 3.2 (a) and 3.2 (b) below:

Figure 3.2 : Process Flow of Research Work (Stage-1)



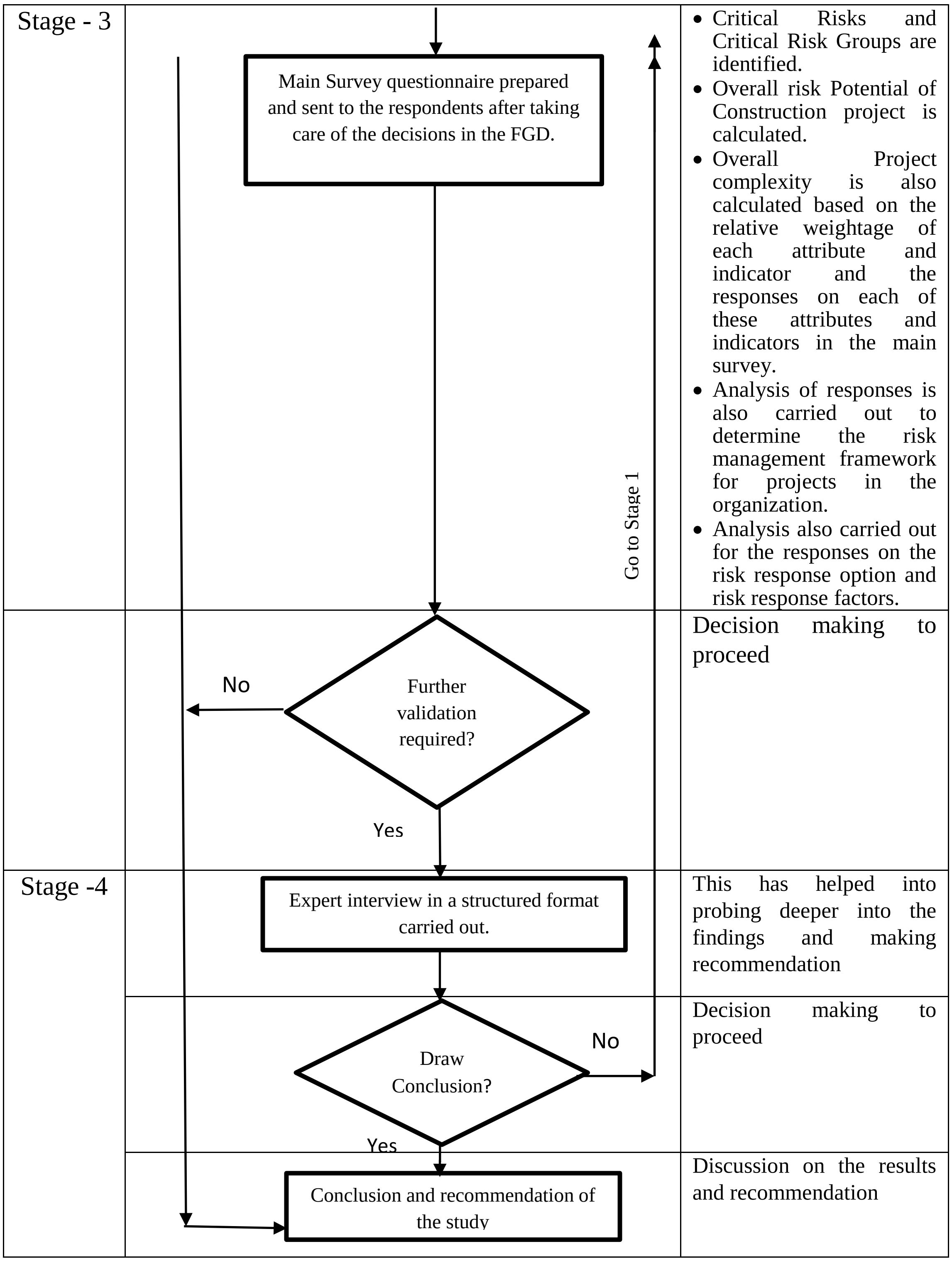
Contd.

Figure 3.2 (a) : Process Flow of Research Work (Stage-2)



Contd.

Figure 3.2 (b) : Process Flow of Research Work (Stage-3 & 4)



3.6.3 Research Approaches

As the philosophy of research becomes clear, it also becomes important to decide on the research approaches. Several Authors have studied different approaches and ascertained their strengths and weaknesses (Hackley, 2003, Gable, 1994, Easterby-Smith, Thorpe, Jackson & Lowe, 1991; Hussey & Hussey, 1997; Saunders et al., 2003; Azim, 2010). In fact both the positivist and interpretivist Authors applied these approaches depending on their research strategy (Oates, 2006).

Among the different approaches the most used ones are - qualitative and quantitative approaches. According to Creswell (2009), qualitative research involves gathering data from the actual setting, analysis and inferences or interpretations are built upon the "*meaning of data*". In an overall way it follows a "focus on individual meaning" and considering "*complexity of a situation*".

On the other hand quantitative research endeavours to find the relationship among variables. These variables, in turn do have some numerical measurements associated with them involving statistical procedures to arrive at a conclusion. Thus it involves enquiry of the assumptions or hypothesis to arrive at the findings.

Creswell (2009) also advanced another approach – Mixed method research, which combines approaches of both qualitative and quantitative forms. The mixed method, through its use of the two approaches in proper conjunction, derives its strength over qualitative or quantitative approaches (Creswell & Plano Clark, 2007).

In the light of the above discussion, a mixed method research approach has been considered in the present study with both quantitative and qualitative data are collected for various research questions as primary method and review of literature and discussion with project experts as secondary method. In the primary method Focus group discussion is also adopted while selecting the specific risks for the pilot and main survey. Even after arriving at the findings through statistical methods expert interview through a structured questionnaire is applied to probe further into the findings and also to validate them.

3.6.4 Research Methodology

As discussed above, the strategies or methodologies that are applied to research can encompass both qualitative and quantitative approach. However, as pointed out by the authors in this field that dependency on anyone approach may not only be a very simplistic approach but also may drift away from the truth under the specific context of the research. The choice thus becomes a factor of applicability and suitability of the strategy to the research questions and objectives (Thomas, 2004). Different methodologies usually adopted by various authors (Berg, 2001; Hackley, 2003; Bryman, 2012; Cooper et al., 2012) are explained below:

i) Content Analysis

It is a technique of making inferences by identifying specified characteristics of the message in a systematic and objective way (Holsti, 1969 p.14). This has been a more generalized version of definition given by Berelson, 1952, p.18) wherein he has indicated about the "quantitative description of manifest content" in place of "specified characteristics". For every content analysis the objective analysis can be done by formally establishing the "criteria of selection” and it should be sufficiently exhaustive to take care of the variations in the message content. As a method limited to “counts of textual elements “it is more reductionistic” and supports a more “positivistic approach”.Arguing against this Berg (2001) pointed out that though it a count of textual elements that helps in identifying, organizing, indexing and retrieving data but the once organized, the Author may consider the literal words in the text being so organized.

Depending on the requirement of the objective, a Author can classify the contents as manifest and latent. While manifest content can be “physically present and countable” the latent content the analysis will require more “interpretative reading” of the physical data.

The present study started with the content analysis by identifying the risks indicated in different literatures related to construction projects. The content analysis and subsequent focus group discussion helped in identifying the initial set of risks which were put for the pilot survey.

ii) Focus Group Discussion

This technique involves a group of people usually ranging from four to eight depending on the nature of the problem, the quality of participants, skill of the facilitator or a moderator. More specifically as process it is defined as guided or unguided discussions addressing a particular topic of interest or relevance to the group and the Author (Edmunds,1999). As suggested by Krueger (2002) the size limit for the focus group for a complex problem shall remain between six (6) and ten(10).

As a means of collecting qualitative data in some settings and situations Focus Group method is quite efficient (Berg, 2001). The method is very dynamic in nature and if administered properly can generate enough discussion among group members and also build up “synergistic group effect” (Stewart & Shamdasani, 1990; Sussman, Burton, Dent, Stacy & Flay, 1991).

In the present study focus group discussion is employed at two junctures. The first focus group discussion took place to identify the risks to be put up for pilot survey. The group consisted of five members that included two academics having experience of steel plant projects and the rest are having more than 30 years of project experience in steel plants.There were several risks which were identified to have occurred frequently among the construction projects as mentioned in the literatures and also from personal experiences. The second occasion when this method is applied, it is to clarify whether the economic risks (which are otherwise identified as low risks by the respondents in the pilot survey) to be included in the main survey questionnaire. In addition to the five members of the first group another member who is also an academic is included because of his association with projects as project owner in his initial career days. Apart from the decision on economic risks, the group also decided on the additional risks, which were identified by the respondents during the pilot survey, to be included in the main survey.

iii) Survey

The most predominantly used method of data collection under both qualitative and quantitative approach is to use a survey. Survey can be conducted through questionnaires, structured observations and structured interview. Survey is mainly conducted to gather large amount of data from a sizeable and relevant population in an economical way. This is done through a sample taken out from the relevant population to make certain inferences about the population (Hussey and Hussey, 1997). Authors find patterns in the data and subsequently they generalize the results (Oates 2006). Surveys can be carried out in person, over the phone, by post, through a website or via email (Easterby-Smith et al, 2002). Apart from the selection of sample in the survey method another critical aspect remains the mode of survey. The most common tool that is used is the questionnaire or interviews which tend to extract the views of each of the respondents to the same set of questions (Hussey & Hussey, 1997; Azim, 2010). Survey through questionnaire have some limitations as the questionnaire has to be kept simple and comprehensible to the respondents and as a result, restrict the wide coverage of ideas/ probing deep into the subject as can be possible by other strategies. Interviews may suffer from the limitation of interviewer bias and questionnaire through post or e-mail may suffer from non-response (Ghauri & Gronhaug, 2001)

In the present study survey is carried out in two stages- Pilot Survey and Main Survey.

a. **Pilot Survey**–A pilot survey is a small-scale research survey that collects data from respondents similar to those that will be used in the full-scale survey.

Rationale for Pilot Survey

Pilot survey can serve as a guide for the larger survey or examine specific aspects of the research to see if the selected procedures will actually work as intended. Pilot studies are critical in refining survey questions and reducing the risk that the full scale survey will be totally away from the research objective. Pilot surveys also often are useful in fine-tuning research objectives. In the first phase of this study the pilot survey was carried out with two primary purposes:

- To identify major risks/ risk events which have the probability of occurrence in the construction projects in existing steel plants.
- To identify further risks that has been suggested by the respondents and are important for inclusion in the list of risks in the main survey.

Pilot Survey Administration

Prior to the pilot survey through literature review, content analysis and focus group discussion 48 risks were identified for preliminary assessment in pilot survey. As with any questionnaire survey the selection of sample is of prime importance. For this pilot survey also there was discussion during the Focus Group stage to ascertain the right blend of project executives or plant executives associated with projects and even consultant executives who are exposed to construction projects in steel plants.

In the pilot survey, the questions were for each risk or risk event the respondents were asked to rate the risk both in terms of probability of occurrence and severity of impact. The rating for each of these factors had a scale of 1 to 5 where 1 represented "very low" , 2 represented "low", 3 represented "medium", 4 represented "high" and 5 represented "very high". The questionnaire for pilot survey is included in *Appendix A-4.*

Apart from indicating the ratings the respondents were also asked to indicate any risk that they have faced in their projects which were not included in the pilot survey questionnaire. The idea was to include the risks which the respondents thought should be included in the list of major risks in a steel plant projects.

In the present study the respondents are categorized into the different subgroups of project executives, plant executives and consultant executives that represent the project owner group. The details responses and their categorization is discussed in sample size under clause 3.7.3.

b. **Expert Survey for Project Complexity** - The objective of this survey was to ascertain the relative weights of each of the attributes and indicators in the calculation of the overall complexity of each project.

The questionnaire contained information about 5 complexity attributes and 9 complexity indicators. There were 17 pairs of comparison covering all the attributes and indicators. The experts were asked to give their views in terms of the superiority of one of the attributes or indicators above the other. The scale for comparison was as per the scale given by Saaty (1980).

There were 25 responses collected from experts . However, following the requirement of consistency of response 15 responses could not be accepted. The relative weightage of each attribute and indicator was thus determined through the responses of 10 experts.

c. **Main Survey** – In the present study the pilot survey was followed by Main survey among a larger group of project executives and plant executives related to projects as well as executives of consulting organisations.

Rationale for the Main Survey

As discussed and decided in the second Focus Group Survey the following points were taken for the main survey questionnaire.

- The risks with normalization factor of 0.5 (50%) has been escalated from pilot survey to the main survey. There are 29 risks considered in main survey based on this criterion.
- From the suggestion of additional risk by respondents in the pilot survey 4 more risks were considered after discussion in the focus group.
- As decided in the focus group 3 risks of economic nature were considered in the main survey even after being rated low by the respondents in the pilot survey.

The survey tried to record the response on the selection of risk response option and the effect of risk response factors on the selection of this option.

The survey also tried to assess the existence of risk management framework in organisations.

The survey endeavoured to get responses on the complexity indicators from the respondents of the survey.

The risks were not only assessed but also were ranked based on the risk potential score and the ranking of each risk. This also enabled the author to have a select band of critical risks for steel plant projects.

Main Survey Administration

Main Survey was conducted through survey questionnaire, which attempted to get responses in four specific areas:

a) Response about Complexity attributes and indicators in their respective projects
b) Response regarding risk identification and risk response framework for brownfield project in an organization.
c) Response for assessment of major risks selected from pilot survey in terms of probability of occurrence and severity of impact.
d) Response on choice of risk response option and the influence of the human and systemic response factors on this choice.

Response on Complexity attributes and indicators

Respondents were asked to respond to the questions relating to complexity indicators. Each of the indicators were assessed by the respondents based on their project in a scale of 1 to 5 where 1 represented the lowest in the scale for each of the indicators and 5 being the highest for the same. The survey requested the respondents to make their assessments on the basis of the project that they had considered while responding to the questionnaire.

Response on Risk identification and Risk Response Framework in the organisation

Questions regarding practice of identifying individual risks in projects were also included in the questionnaire to have an idea about the existence of a framework of identifying risks in projects and their monitoring. The responses were basically in a nominal scale with the response of yes or no.

Response for assessment of major risks

The risks selected based on the rating in the pilot survey and additionally on the basis of decisions in the second focus group discussion were subjected to assessment by the respondents of main survey. There were total 36 risks which were subjected to assessment based on the same two parameters of probability of occurrence and severity of impact with the same scale of 1 (very low) to 5 (very high) for both the parameters.The Risk Potential Score (RPS) was calculated on the basis of geometric mean of the probability of occurrence and severity of impact. The scales chosen for the two parameters and the Risk Potential Score along with their linguistic expression are given in table 3.1(a) below:

Table 3.1 (a) : Scales and their Linguistic expressions

Probability of occurrence (PO)	
Scale	Expression
1	Very Low
2	Low
3	Medium
4	High
5	Very High

Severity of Impact (SEV)	
Scale	Expression
1	Very Low
2	Low
3	Medium
4	High
5	Very High

Risk Potential Score (RPS)	
Scale	Expression
1	Very Low
2	Low
3	Medium
4	High
5	Very High

(For Probability of occurrence , Severity of Impact and Risk Potential Score)

Response on Risk Response Option, Human Response Factors and Systemic Response Factors

The respondents were asked to indicate their perception about the actual response option and the factors influencing each of the risks. The scale chosen for the risk response option varied from 1 to 5 with each of the digits representing an option. Similarly, the scales for both the Risk Response Factors and their linguistic expressions are listed in the table 3.1 (b)below.

Table 3.1 (b): Scales and their Linguistic Expressions

Option	Risk Response Option (RRO)
1	Avoid
2	Transfer
3	Mitigate/ Reduce
4	Accept (Active)
5	Accept (Passive)

Scale	Human Response Factor (HRF)	Systemic Response Factor (SRF)
1	Very Low	Very Low
2	Low	Low
3	Medium	Medium
4	High	High
5	Very High	Very High

(For Risk Response Options, Human and Systemic Response Factors)

For each risk the respondent based on his perception and experience about the risk in project can choose one out of the five response options. The questionnaire further required the respondent to indicate which factor(s) affect the choice and to what extent. This was to be indicated on the abovementioned scale for both the factors. The questionnaire for main survey is included in *Appendix A-6.*

The respondents of the main survey is also broadly categorized into same three groups of project executives, plant executives associated with projects and consultant executives. However, in this survey a further categorization is done in terms of the experience of the respondents as it is felt that representation of all levels of experience will give a better picture of the risk phenomena. The details of these categorization is also discussed under Sample Size in Cl. 3.7.3.

d. **Expert Interview** – A structured interview was planned with a select band of 5 project experts to get their views on the findings of this study. The idea is to probe deep into the findings to come with some concrete recommendation about project risk management.

As pointed out by Saunders et al. (2003) the questions used for this expert interview are based on a “pre-determined and standardised set” and this is a suitable approach as it is important to know the reason behind the research findings and further to understand the attitudes, motives and opinions behind the response.

In this study wherever possible a face to face interview was adopted. However, due to logistic issues some of the interviews are conducted through questionnaire followed by telephonic discussion.

iv) **Time Horizon** - The time horizon usually gets defined in the research question. The research question may require findings which is time-defined i.e the phenomenon should have been looked into at a particular time from the perspective s of more than one person or looking at the trend over a longer period of time. The first approach could be called a "snapshot" approach or a "cross-sectional" study while the other can be called a "diary" approach or "longitudinal" study (Greener, 2008).

The present study followed this "cross-sectional" approach with a time period spanning between the whole of 2017 and first half of 2018 due to the discrete nature of projects and the constraints of resources. The study endeavours to get a snapshot of the risk management scenario in construction projects in steel plants and the the influence of factors in addressing the risks.

3.7 Research Sampling

Collecting information about a large group of people or organisation is impossible due to the time and cost involved in such a massive exercise. In such a case, it is practicable to select a few people from the group or select a few organisation to extract that information. However, the correctness of such information depends on the selection of these representatives - be it people or organisation. This representative group is known as the sample and the technique of selecting these groups of few from a large group is termed as sampling (Walliman, 2006). The large group from which sample are drawn is termed as population.

3.7.1 Population

As defined by Bryman and Bell (2011) "*population is the universe of units from which the sample is to be selected*". Further, they clarified that the "units" is the generalised representation which may signify the universe of nations, cities, regions, firms and even people. Thus the population is a term used in a broader perspective.

For the present study, the population that has been accessed is the project executives in different steel plants both in public sector and private sector. The study has also made an effort to capture the responses of steel plant executives in the operations or other allied areas who are associated with the projects. Apart from these, responses are also captured from the executives of the consultant organisation. The rationale behind getting a response from this diverse collection of groups is that they have been considered as representative of the "project owner group" as explained in earlier chapters.

The target population of executives in steel plant project, whether they are project executives or plant executives associated with projects is difficult to determine as the steel plants are scattered all over India. This is further complicated when the number of executives of consultants associated with steel plant projects are added up to the existing pool of executives associated with projects. The reason being that some of the executives of the consultants are typically associated with more than one project at a time. From the data available for the steel makers in India and having some rough idea about the percentage of executives engaged in project activities it is estimated that considering the three categories of executives related to brownfield project activities in steel plants the number can be approximated as 5000 executives.

3.7.2 Sampling Technique

Selection of a technique is done with the basic objective of reducing data to be collected from all the possible cases (population) conforming to the set down criteria.

There are authors who pointed out that there are several techniques which are used at different stages of research (Saunders et al. , 2003; Thomas, 2004). The key consideration for selecting a particular method of sampling is based on the "*importance of the findings in relation to the decision that has to be made on them and the cost of acquiring them*" (Burns and Burns, 2008).

The present study followed some of the sampling techniques mentioned above. These are :

- Purposive or judgmental Sampling – In this type of sampling the samples are chosen by researcher based on the experience of respondents related to the research topic. This form of sampling is adopted when it becomes necessary to work with small samples but the participants response generate lot of information. In this study this sampling is carried out as the author has access to both project executives and plant executives who are associated with projects.

- Convenience Sampling – In convenience sampling the samples are easiest to obtain, thus it is the convenience of availability that guides the choice of samples. In the focus group discussions as well as evaluating the weights of attributes and indicators of project complexity the respondents or the experts are chosen through this method.

The following Table 3.2 will give the stagewise adoption of sampling technique and their justifications:

Table 3.2 : Stages of Research and Sampling Technique adopted

Stages	Sampling Technique	Justification
Pilot Survey	Convenience Sampling and purposive sampling	Convenience of getting the respondents is there. These methods are chosen because respondents need to be either project person or plant executive with project experience. Even some of the consultant executives are also easily available to author.
Expert Survey to decide on the weightage of the attributes and indicators of the Project Complexity	Purposive Sampling	Expert Project Managers/ Leaders are considered for this survey.
Main Survey	Purposive Sampling and Convenience Sampling	The purposive and stratified random sampling techniques are both used to take care of the research subject and to cover the project, plant and consultant executives for response.

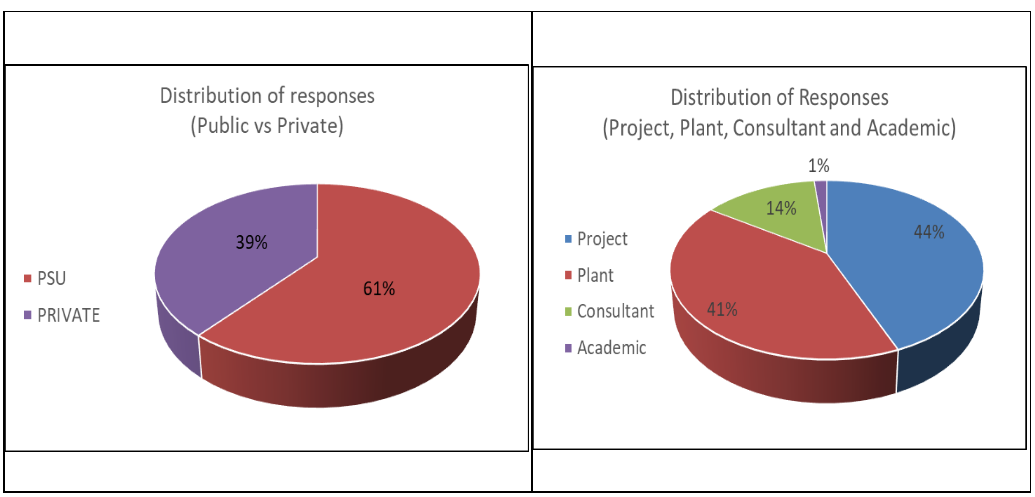
(Compiled by Author)

3.7.3 Sample Size

Getting a sample of large number of units may be desirable but at times this may not be feasible or practicable. It was further as pointed out by Hussey and Hussey (1997) that in view of this, research findings are also associated with some sort of uncertainty. Thus it becomes imperative to decide on the right sample size. Based on this idea the rationale behind the sample size selection at different stages of the present study is developed.

During the pilot survey administration, questionnaires are distributed to more than 200 executives of projects, plants and consultant. The questionnaires were given physically to about 100 respondents and through e-mail to approximately equal number. More 100 respondents are followed up and 64 respondents belonging to projects, plants and consultants in both public and private sector steel plants have given their responses. The distribution of respondents are shown in Figure 3.3 below:

Figure 3.3- Distribution of Responses in Pilot Survey



(Compiled by Author)

In the main survey, the questionnaire is distributed to about 600 respondents. The questionnaire is distributed by multiple means. Those respondents who can be accessed physically are given the questionnaire by hand. This mode of distribution covered about 300 executives of project, plant and consutant. Apart from this the questionnaire has also been sent by e-mail to more than 100 project, plant and consultant executives for their responses. Even the questionnaire is uploaded in Google Form and the link has been sent to further about 150 executives of similar classification as above. Repeated follow up is carried out for all the modes. However, due to several constraints (particularly in case of private sector projects) the number of actual follow up got restricted to about 300 respondents. The responses obtained through different modes are given in Table 3.3 below:

Table -3.3: Mode of Distribution and Valid Response in Main Survey

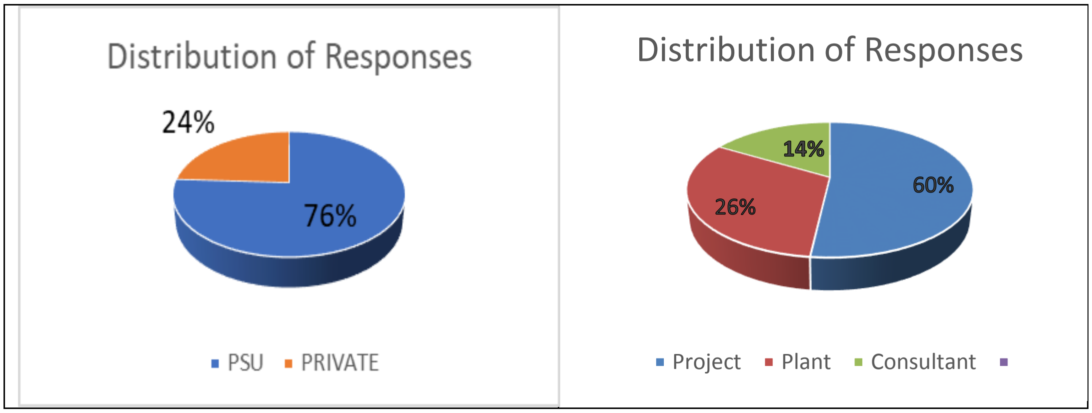
Mode of distribution	Initial Coverage	Follow up	Finally valid response obtained
Physically Distributed	305	~185	113
Distributed through e-mail	165	~ 75	47
Distributed through Google Form	140	~ 55	6

(Compiled by Author)

Though 200 responses were obtained in the process ultimately it is found that 166 responses are valid.

The distribution of these responses in terms of Public and Private sector project as well as respondent classification in terms of Project, Plant and Consultant is given in the figure 3.4 below:

Figure 3.4 - Distribution of Responses in Main Survey



(Compiled by Author)

Further, the distribution of responses in terms of the experience of the respondents in projects directly or association with project as plant executive is also recorded. The pattern has shown adequate distribution covering all segments. The Table 3.4 below shows the distribution according to designation and the range of experience of the respondents.

Table 3.4: Distribution of Respondents based on Designation and Experience in Main Survey

Designation	No. of Respondents	Experience
Below Manager	12	3- 8 yrs
Manager & Sr Manager	41	> 8 yrs
Asstt.GeneralManager	36	> 15 yrs
Dy. General Manager	58	> 20 yrs
General Manager and Above	19	> 25years

(Compiled by Author)

Calculation of Sample Size with Margin of Error

In research , calculation of sample size becomes necessary in some cases. As indicated by Saunders et al (2009) the calculation assumes that "*data will be collected from all cases in the sample*" with the following premise

- The level of confidence needed by the Author
- The accuracy needed by the Author
- The proportion of response that has the particular attribute

Based on the above premise the formula suggested by Saunders et al. (2009) as below is followed for calculation of sample size:

$Minimum\ sample\ size\ (n) = \frac{\text{Z x Z x p\% x } q\%}{\text{e x e}}$, where

Z = Z value =1.96 for Confidence Level of 95%

p%= proportion of population belonging to specified category

q% = proportion of population not belonging to the specified category

e = Margin of error required = 8%

(respondents are all associated with projects and their experience profile are more or less uniform. Therefore, a higher margin of error as assumed is justified)

The above formula, as suggested by Saunders et al. (2009) is applicable for infinite population (more than 10000). However, for finite population less than 10000, a smaller sample size is acceptable. This has been termed by him as "*adjusted minimum* *sample size*". This adjusted minimum sample size is calculated using the following formula:

$$Adjusted\ minimum\ sample\ Size\ (n') = \frac{\mathrm{n}}{1 + \left(\frac{\mathrm{n}}{\mathrm{N}}\right)}$$

Considering a margin of error as 8% the required sample size comes to n =150. After adjusting for minimum sample size, the requirement becomes n' = 146.

The actual number of valid response collected for this study has been 166 which contributes to a margin of error of about 7.55%. Further, this response rate in comparison to other similar studies appears to be adequate.

Characteristics of Sample Data

Before carrying out any analysis with the collected data it is necessary to determine if the data follows a normal distribution or not. The reason behind this is that the other test that would be carried out on this data set will vary depending upon the normality of this data.

In statistics there are several tests to address this normality of this data. They fall under two broad categories of Graphical and Statistical. The tests under these categories are as below:

Graphical

i. Q-Q Probability Plots
ii. Cumulative Frequency Plots (P-P Plots)

Statistical

1. Shapiro-Wilks Test
2. Kolmogorov-Smirnov Test
3. D'Augostino Test.

For the statistical tests the null hypothesis that is used is:

H_0 : The sample data are not significantly different than a normally distributed population

While testing, if the p-value is <0.05, the hypothesis is rejected with 95% confidence level.

For the present study the data collected from the 166 respondents are subjected to statistical testing of normality in SPSS. The following table 3.5 gives the result

Table 3.5 – Result of Kolmogorov-Smirnov and Shapiro-Wilk Test of Normality

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Inexperienced Contractor	0.150	166	0.000	0.947	166	0.000
Inadequate Workmen	0.092	166	0.002	0.965	166	0.000
Contractor's Financial Problem	0.090	166	0.002	0.959	166	0.000
Delayed Supply	0.119	166	0.000	0.964	166	0.000
Unforeseen ground condition	0.098	166	0.001	0.967	166	0.000
Inadequate Project Plan	0.119	166	0.000	0.967	166	0.001
Increase in Scope	0.108	166	0.000	0.966	166	0.000
Unrealistic Time Estimate	0.124	166	0.000	0.955	166	0.000
Improper Cost estimate	0.098	166	0.001	0.965	166	0.000
Delay in Approval	0.103	166	0.000	0.961	166	0.000

Contd.

Shutdown not avl.	0.101	166	0.000	0.966	166	0.000
Delay in construction eqpt	0.172	166	0.000	0.953	166	0.000
Inadequate safety	0.153	166	0.000	0.955	166	0.000
Poor Sub contractor	0.115	166	0.000	0.960	166	0.000
Checking Interface	0.092	166	0.002	0.970	166	0.001
Skilled Manpower	0.114	166	0.000	0.962	166	0.000
a. Lilliefors Significance Correction						

The results for each of the risks suggest that the data corresponding to those risks are not from a normally distributed population and hence they are also non-normal.

3.8 Data Collection Methods / Techniques

In any research the common pitfalls is that the focus remains on research question and samples to be studied or the methods to be applied but one vital question that usually escape a Authors mind is the type of data that one is looking for and how to analyse them.(Greener, 2008). As pointed out by Walliman (2006) the qualitative and quantitative approaches “imply” different methods of data collection. The requirement of use of statistical analysis for hypothesis testing in quantitative approaches often lead to the collection of numerical data whereas qualitative approach rely more on subjective data gathered in the form of language and their interpretation.

The present study adopted a mixed method research strategy. The data collection was carried out in two overlapping stages. In the first stage, the data with regard to risks in projects, particularly construction projects, project complexity, research methodology, statistical analysis is collected from secondary data sources like books on project risks, project complexity, research methodology and statistical analysis, articles related to project risk and complexity. Another predominant source of secondary data are the different online sources. Apart from these, data are also gathered through discussion with project experts. At the very initial stage of this study, expert advice was taken from project experts of steel plants as well as academics having experience of steel plant projects, for identifying risks in the construction projects in steel plants.

In the next stage the primary data collection methods are used, wherein a focus group discussion is adopted to finalise the risks or risk events for both pilot survey and the main survey. Thereafter questionnaire method is adopted for both at the pilot survey and main survey. A structured questionnaire is employed with project experts to evaluate the project complexity. A structured interview was also adopted at the end to validate the findings and also to get some more insight into the findings.

Questionnaire

A questionnaire is a research instrument consisting of a set of questions structured and articulated clearly so as to elicit response from the respondents. This will help to test the different relationship in the research study (Hussey & Hussey, 1997). The questionnaire survey method can be administered in two ways – mailing the questionnaire to the respondents either through postal or electronic mode (email) and the other, getting the respondents fill-up the questionnaire across the table. While "*mail surveys are advantageous in that they are unobtrusive, and they are inexpensive to* *administer*" the response rates tend to be quite low. This requires continuous monitoring by the Author.(Bhattacharjee, 2012)

Another method of conducting questionnaire survey is an online or web survey. These surveys use Internet. The respondents are requested through email to participate in the survey with a link given to the website where the survey can be undertaken.(Bhattacharjee, 2012)

Questionnaire can be designed in two types – open ended and closed types. In open ended type questionnaire the respondents are free to give their personal response or opinion while in closed questionnaire several alternative answers to the questions are provided (Dillman, 2007). On some occasions some choices are given and respondents are forced to select a choice. Thus it is extremely important to design a questionnaire after having a very good understanding of the research.(Hackley, 2003; Azim, 2010).

The present study combines questionnaire survey and structured interview of experts. The survey methods followed in both the stages are preceded by focus group discussions. The self-administered, closed type questionnaire in both pilot and main survey used Likert type rating scales to evaluate the probability of occurrence (scale of 1 to 5) and severity of the impact (scale of 1 to 5) of risk events. These ratings are further used to calculate the risk potential score of each risk. While this method of evaluating the risk is applied both in pilot and main survey , the main survey gathered some more information with regard to the risk response factors influencing the risk response option for each risk. The main survey findings are further subjected to deeper investigation for the root cause of the derived relationship through project experts.

Interview

Interview method, as suggested by Saunders, Lewis & Thornhill (2003) can be either structured or semi-structured/ unstructured. While a pre-determined and standardised set of questions mark the structured interview process semi-structured / unstructured interviews are mainly based on broad themes and questions. In this case the interviewee has a free-wheeling response about the event, behaviour, views and his belief with regard to the topic (Walliman, 2006; Azim, 2010).

In the present study the structured interview of project expert is carried out to have an in-depth understanding of the findings in relation to the construction project risks, their relationship with the project complexity, the influence risk response factors on the risk response options in managing the risks and the risk management framework for construction project risks in steel plants.

The basic idea of carrying out structured interview is to develop a deeper understanding about the "why" of the relationship in the present study.

3.9 Credibility of Research Findings

In order that the research design is reliable and valid, a researcher needs to focus and ensure that these two aspects are taken care of in the research design. (Saunders et al., 2003 & 2009).

Reliability of any research is ascertained from the fact that the research is equally applicable to other similar research settings which means they yield same results under same conditions, similar observation is reached by other observers and there is transparency on how the sense is made from raw data.

In the present study the methods of data collection and analysis that have applied followed the methods applied in similar type of research with similar type of information and measurement scale. During analysis the data is subjected to reliability test in the statistical software package to ensure their reliability. In order to address the respondent related errors/ biases the name of the respondents is kept optional and they are given sufficient time to respond to the questionnaire.

Validity refers to the extent to which the research findings accurately represent what is happening in the situation i.e. whether the findings are really about what they appear to be about (Saunders, Lewis & Thornhill, 2003, Saunders et al., 2009, Hussey & Hussey, 1997). If the question are not properly framed or they are not relevant for the research then the measurement will be faulty. This may happen even in case of highly reliable data and as a result the validity of the research will tend to become low.

For the present study, the questionnaire survey method is followed essentially to collect data both in pilot and main surveys. For both these questionnaires face validity and content validity is carried out to ascertain that the questionnaires yield valid data. The face validity is carried out by two experts- one from the academics and the other from industry. The content validity has been done with further two experts having experience in projects in steel plants. This has ensured that whatever questions that are raised in the questionnaire shall yield findings in line with the research questions.

The findings of the main survey have been placed before a group of project experts to validate these findings. This ensured that risks are identified and evaluated at two levels before being selected as critical risks and the relative influence of risk response factors on the choice of risk response options has also been endorsed.

CHAPTER -4

DATA ANALYSIS AND INTERPRETATION

Data Analysis and Interpretation

4.1 Introduction

In the previous chapter, there is a detailed discussion on the different methods adopted under mixed methodology of research. Under this methodology, the present study adopted Focus Group Discussion, Pilot survey, Project Complexity Survey, Main Survey and Expert Interview methods . This chapter will endeavor to provide specific details of each of these methods, participants profile, data analysis and discuss the findings.

4.2 First Focus Group Discussion

Though it is primarily a method under qualitative research but it has been used as a precursor to both the surveys which are basically quantitative in nature in this study. As pointed out by Bryman and Bell, (2011) Focus Group is employed when a "specific theme or topic" needs to be discussed. The presence of people who are knowledgeable about steel plant projects constitute a cohesive group which had a discussion about which risks or risk events can be included in the list of risks prevalent in the construction projects in steel plants.

Composition and size of the focus group becomes an important factor in deriving fruitful result form this method. Several authors opined that a number between three to ten is the desirable number in terms of getting useful results and also having a control over the group (Bryman & Bell, 2011; Blackburn & Stokes, 2000; Morgan, 1998). In the present study five experts constituted the focus group. Three of the experts were at very senior level having project management experience in steel plants of more than 25 years. There were also two academics who have been associated with management training in a public sector steel plant and had the experience of project risks in steel plant projects were also included in the group. The details of the group is given in table 4.1 below:

Table- 4.1. Focus Group Members and their experience

Focus Group Member No.	Age	Experience		No. of projects
		Academic	Management	
1.	60+	B E (Elect), F I E	33 yrs in a PSU Steel plant + more than 4years as Head of Projects in another steel plant	As head of large units in first phase associated with more than 5 projects. Later as Head of Projects in another steel plant was associated with more than 50 packages in a large modernization programme.
2.	60+	Post Graduate in Engg+ Certified PMP	38+ years of experience in executing projects largely in the Private Sector	As a leading project person he was associated with large metal mining projects in the area of steel, Copper, Aluminium etc.
3.	60+	Post graduate in Engineering	More than 35 years in Projects in PSU Steel Plants	He was associated with no. of projects in two steel plants as project executives and head of projects.
4.	50	PhD in Management	27 years of experience out of which more than 24 years in Management training in a Steel Plant	No direct association projects but has knowledge about steel plant projects

Contd.

5.	48	Masters in Management	25 years of experience out of which about 3 years in Steel plant Town Administration in a Steel plant and rest in Management Training in the area of project and systems.	No direct association with projects but has knowledge about steel plant projects

(Compiled by Author)

The focus group members, as evident from the above table have more than 25 years of experience of which a considerable period is in projects. The group worked with a given term of reference of

a) Identification of risks to be included in the list of risks for the pilot survey

b) To suggest about some factors for having an idea about complexity of projects

The group discussed among themselves at Ranchi , with two members joining through skype during March , 2017. The facilitation of the discussion was done by the Author and the group decided upon the two issues mentioned above.

Project risks : The group was unanimous about the 48 risks which can be taken up in the main survey for their assessment by a wider section respondents who are associated with projects. The list of risks considered for the pilot survey thus include the following risks in *Table 4.2 below*.

Table 4.2 :List of Risks selected for Pilot Survey based on Focus Group Discussion

Sl. No	Category	Risks/ Risk Events
1	Market related	Overall market demand of the product / service is down resulting in risk for the project.
2	Political	For global suppliers the political situation/stability of the supplier country affecting the project progress adversely
3		Changes in laws and regulation, political situation causing delay in project execution/ stoppage of project.
4		Local Governments attitude not conducive thereby affecting project progress.
5	Legal	Delay in getting statutory clearances delaying the project.
6	Logistical	Contractor is not experienced enough to handle the project causing project delay / stoppage.
7		Contractor having inadequate workmen to carry out work resulting in delay.
8		Contractor developed financial problems during the project causing delay.
9		Supplier of equipment/ equipment parts/ materials not being able to send the supplies in time for the project causing delay.
10		Unforeseen ground condition leading to delay in project schedule.
11	Organisational	Delay in getting a go-ahead for the project
12		Organisational policies and procedures are either time taking or not being followed properly.
13		Holding key decisions in abeyance by the project owner delay the project progress.
14		Top management support is not available at the time of requirement.
15	Planning	Inadequate Project Planning with poorly/ inadequately defined tasks and their requirement affecting the project.
16		Scope increases due to additional requirement from different stakeholders not considered leading to cost and time overrun.
17		Time schedule estimates for activities more on the optimistic side causing unrealistic duration of the project and subsequent time overrun.
18		Improper cost estimates (due to lack of knowledge/ information gap) resulting in cost overrun
19		Incomplete understanding of the scope of work resulting in delay and cost overrun.
20	Design	Delay in approval of design and drawings causing delay in project
21		Technology associated with the project is very new and untested, thereby affecting the progress or budget of the project adversely.
22		Defective (with error and omissions) / Non-executable Design may create scope creep resulting in time and cost overrun
23		The design of the project components and their integration is difficult to understand leading to time and cost overrun.
24		Design Changes (changes in product definitions, technical data, drawings etc.) causing delay
25	Construction	Slip in schedule due to non-availability of drawings or specifications in time.
26		Fronts/ shutdown not being made available in time causing delay

Contd.

27		Delay in arranging for necessary construction equipment/ cranes
28		Equipment got damaged during transit/ or at site due to exposure leading to delay in project
29		Poor Subcontractor performance leading to time and cost overrun.
30		Defective construction methods/work leading to rework or poor quality of construction and delay
31		Inadequate Safety provisions at Site leading to accidents and consequent delay and cost overrun
32		Improper resource sharing with other simultaneously running projects creating conflict and often resulting in delay. Contd.
33		Excessive variation in quantity causing difficulty in payment and resulting in delay Contd.
34	Management	Not adequate skilled manpower for the project manager leading to inadequate supervision resulting in lack of quality
35		Loss of people from/ frequent changes in the project team.
36		Absence of proper review/ control process leading to delay.
37		Improper communication among team members as well as with other stakeholders resulting in delay and additional cost.
38		Inadequate experience with project scheduling tools like MS PROJECT, PRIMAVERA etc. causing delay
39		Lacking information/ data causing delay of the project.
40		Incomplete understanding of the scope of work resulting in delay and cost overrun.
41		Delay in settlement of extra claim leading to delay
42		Non-availability of medical facilities of contractor workers affecting the project work.
43	Economic	Excessive exchange rate fluctuation adversely affecting project cost.
44		Uncertain Inflation rates adversely affecting the project cost.
45		Delay in payment to the contractor leading to delay
46		Changes in Taxes and duties leading to project cost overrun.
47	Environmental	Natural Disaster/ Force Majeure affecting the project progress .
48		Difficult Weather conditions leading to delay

(Compiled by Author)

Project complexity: Regarding project complexity the group was of the opinion that

- Project size and duration can be factors contributing towards complexity
- Number of agencies working in a project can also significantly affect the project complexity.
- Novelty or newness of the technology is a contributor

- Difficulty aspect of brownfield construction projects like difficulty in deployment of construction equipment, difficulty due to space constraint, difficulty due to other running projects in the vicinity came out as other important contributor.

It was discussed and decided that in getting a response towards each of the factors they will be explained as below in the pilot survey questionnaire:

a) Project size and duration: The respondents have been asked to indicate about the money value of the project and the duration in months. In some cases the respondents may be handling a small part or package/ sub-package of a large project (this small part is in itself a project) in which case they need to mention about the package / sub-package value and its duration.

b) No. of agencies working: Number of agencies working in the project can include vendors/ suppliers, contractors, sub-contractors, consultants, statutory agencies and so on. The more the number of agencies the morewill be the communication channel resulting in more chances of communication failure adding to more complexity.

c) Novelty of technology: Regarding novelty or newness of the technology it was decided in the focus group that it will be captured in the following format:

Table 4.3 :Stages of Novelty of Technology

	Stages in Novelty of Technology
I)	State of the art technology (being used by other units of your organization)- addition in capacity, modification/rectification
II)	Some improvement (indigenous)from the existing technology that is being used in your plant – up-gradation of facility/quality improvement in process/ statutory requirement
III)	Foreign technology for improving existing operation- up-gradation of facility/ process quality improvement
IV)	New technology(foreign/ indigenous) to supplement for old technology – modernization of existing operation
V)	New technology (foreign/ indigenous) for new operation – setting up a new facility with new technology not existing previously.

(Compiled by Author)

d) Difficulty aspect of Project: This factor has got several subfactors built in it. The pilot survey captured the data in the following format:

Table 4.4: Stages of Difficulty Contributing to Complexity of Project

	Stages of difficulty contributing to Complexity
I)	Usual machineries / equipment used with conventional construction methods under normal condition (no shutdown requirement)
II)	Usual machineries / equipment used with conventional construction method in a congested condition with occasional small shutdowns that may be required
III)	Some critical type of equipment like tower crane etc. used for construction with occasional shutdown requirement
IV)	Multiple critical equipment used for construction/ erection under congested condition with one or two major shutdown requirement.
V)	Multiple critical equipment used for construction / erection under congested condition with major shutdowns that may affect plant operation adversely.

(Compiled by Author)

With this input from the focus group discussion the present study entered into the Pilot Survey Stage. Response was collected for different attributes of project complexity at this stage with the idea that based on the inputs further moderation in attributes and their measurement can be made at the next stage. The next section describes the Pilot Survey data analysis.

4.3 Pilot Survey

The data collected in the pilot survey was analysed through SPSS software and the descriptive statistics was derived for each of the risks. The mean Risk Potential Score along with the normalization factor were also obtained.

4.3.1 Pilot Survey Data Analysis

A pilot survey questionnaire was distributed among the respondents who had the experience of steel plant construction projects by virtue of their direct or indirect association with such projects. The respondents based on their experience of the project either handled by them or they were associated with gave their responses. Of the 200 plus questionnaires distributed to the respondents only 64 valid responses were obtained. The respondents belong to both public sector (70%) and private sector (30%) enterprises covering project executives (41%), plant executives associated with projects (44%) and executives of consultants(14%) and academics (1%).

Figure 4.1 Distribution of Responses (Public Sector and Private Sector)

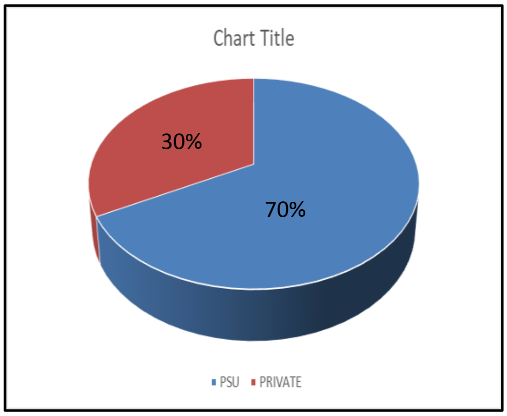
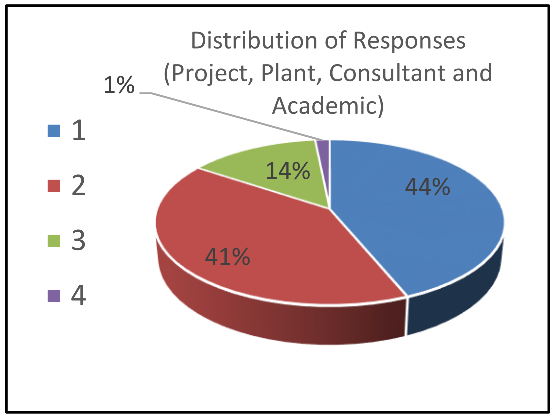


Figure 4.2 Distribution of Responses (Project, Plant, Consultant and Academic)



(Compiled by Author)

Based on the data gathered through main questionnaire survey the qualitative analysis of the individual risks were carried out. Each risk/ risk event was evaluated in terms of the average response on Probability of occurrence of the risk and severity of consequences if it takes place. The combined effect of these two parameters were given by their Geometric Mean (Xu et al, 2010; Shen, Wu & Ng, 2001 and Deshpande & Rokade, 2017). This geometric Mean is referred to as Risk Potential Score (also termed as "Impact" by Xu et al, 2010) is given by the formula :

$$\text{Risk Potential Score} = \sqrt{(\text{ Probability of occurrence x Severity of consequences})}$$

The risk or risk events and their risk potential score with normalization factor is shown in *Table 4.5 below*.

Table 4.5: List of Risks and their Risk Potential Score from Pilot Survey

Descriptive Statistics								
Risk Id No. (as in SPSS)	Risk	N	Min (RPS)	Max (RPS)	Mean (RPS)	Std. Deviation	Normalisation	Rank
Risk8	Supply not in time	64	1.00	5.00	3.47	1.12	1.00	1
Risk6	Contractor have inadequate Workmen	64	1.00	5.00	3.31	1.21	0.90	2
Risk24	Delay in approval of design and drg.	64	1.00	5.00	3.24	0.78	0.85	3
Risk26	Inadequate safety arrgt.	64	1.00	5.00	3.23	1.31	0.84	4
Risk7	Financial problem of Contractor	64	1.00	5.00	3.19	1.06	0.82	5
Risk25	Improper cost estimate	64	1.00	5.00	3.16	1.28	0.80	6
Risk44	Poor subcontractor performance	64	1.00	5.00	3.15	1.15	0.80	7
Risk18	Nonavailability of drgs&Docs	64	1.00	5.00	3.08	0.93	0.75	8
Risk11	Inadequate Project Planning	64	1.00	5.00	3.08	1.07	0.75	9
Risk5	Contractor not experienced	64	1.00	5.00	3.06	1.26	0.74	10
Risk28	Delay in statutory clearances	64	1.00	5.00	3.05	1.23	0.73	11
Risk17	Optimistic time schedule estimate	64	1.00	5.00	3.05	0.94	0.73	12
Risk40	Delay in payment	64	1.00	5.00	2.95	1.05	0.67	13
Risk23	Absence of proper review	64	1.00	5.00	2.95	1.15	0.66	14
Risk29	Defective construction methods	64	1.00	5.00	2.93	1.25	0.65	15
Risk36	Excessive variation in quantity	64	1.00	5.00	2.92	1.25	0.65	16
Risk21	Nonavailability of skilled manpower	64	1.00	5.00	2.89	1.08	0.63	17

Contd

Risk15	Incomplete understanding	64	1.00	5.00	2.83	1.30	0.59	18
Risk19	Fronts / Shutdown not available	64	0.00	5.00	2.83	1.02	0.59	19
Risk22	Permanent loss of people from team	64	1.00	5.00	2.82	1.16	0.58	20
Risk14	Scope increases	64	1.00	5.00	2.78	1.00	0.56	21
Risk35	Defective/ Non excutable design	63	1.00	5.00	2.76	1.10	0.55	22
Risk42	Lacking information	63	1.00	4.47	2.76	0.83	0.55	23
Risk16	Unforeseen ground condition	64	1.00	5.00	2.74	0.98	0.54	24
Risk12	No top mgmt support	64	1.00	5.00	2.73	1.20	0.53	25
Risk27	Eqpt damaged during transit or at site	64	1.00	5.00	2.71	1.17	0.51	26
Risk20	Delay in arrgConstn eqpt	64	1.00	5.00	2.70	0.94	0.51	27
Risk1	Market Demand	64	0.00	4.47	2.69	1.20	0.50	28
Risk13	Inadequate tech &mgrl capability of PM	64	1.00	5.00	2.69	1.05	0.50	29
Risk45	Natural Disaster	64	1.00	5.00	2.67	1.37	0.49	
Risk37	Design changes	64	1.00	5.00	2.65	1.09	0.47	
Risk43	Holding key decision in abeyance	63	1.00	5.00	2.56	0.84	0.42	
Risk33	New technology associated with project	63	1.00	5.00	2.54	1.02	0.41	
Risk9	Delay in go-ahead	64	0.00	5.00	2.54	1.05	0.41	
Risk47	Delay in settlement of extra claim	64	0.00	5.00	2.52	1.16	0.39	
Risk46	Difficult weather condition	63	1.00	5.00	2.50	1.21	0.38	
Risk30	Comm within team &betn stakeholder not proper	64	1.00	5.00	2.47	0.93	0.36	
Risk31	No exp of project scheduling software	64	1.00	5.00	2.42	0.87	0.33	

Contd.

Risk10	Organisational Policies	64	1.00	4.47	2.39	0.94	0.31	
Risk32	Other running projects	63	1.00	5.00	2.39	0.85	0.30	
Risk34	Improper Integration of components	63	1.00	4.00	2.38	0.95	0.30	
Risk4	Local Govt Attitude	64	1.00	4.47	2.31	1.15	0.26	
Risk48	Nonavailability of medical facilities	63	0.00	5.00	2.31	1.21	0.26	
Risk3	Changes in Laws	64	1.00	4.00	2.26	1.04	0.22	
Risk41	Changes in taxes and duties	63	1.00	5.00	2.23	1.07	0.21	
Risk38	Exchange rate fluctuation	64	1.00	5.00	2.11	0.89	0.13	
Risk39	Uncertain inflation rates	64	1.00	5.00	2.09	0.94	0.11	
Risk2	Political Situation	64	1.00	4.00	1.91	0.94	0.00	

(Compiled by Author)

Note: Normalisation Factor= (RPS_i- RPS_{min})/ (RPS_{max} - RPS_{min}). The risk with normalization factor of 0.5 or more has been ranked and the rank is mentioned in the last column.)

The table indicates that 29 risks which have got a normalization factor of 0.5 or above and have been selected for the main survey.

Further, it was felt that there are several risks that have been suggested by the participants of the pilot survey and can be included in the risk list for the main survey. A focus group discussion was organized to finalise the risks to be taken up for the main survey and also to capture data about organizational framework and project complexity.

4.4 Second Focus Group Discussion

The objective of this focus group discussion was to decide on the following:

i) risks suggested by the pilot survey respondents to be included in the main survey.

ii) the rating scale for the complexity indicators

iii) the rating scale for taking response on risk response factors

The discussion was organized with 6 experts which included three academics having knowledge about project and project management in steel plants. The other members of the group were the same project experts who were the members of the first focus group discussion. The reason behind keeping the group same was their knowledge about project risk as well as their familiarity with the process. The new member of the group was an academic having experience in project execution as a project owner for initial seven years and thereafter about ten years experience of project management teaching in a corporate training institute.

The group discussed among themselves at Ranchi on the sidelines of a Conclave organized in May , 2018 and finalised the following with regard to project risk and project complexity factors.

i) It was decided that risks with normalization factor more than or equal to 0.5 will be considered for the main survey.

ii) The economic risks like exchange rate fluctuation, uncertain inflation rate and changes in taxes and duties, though may not find their position in the list of 29 risks but may be considered once again in the main survey due to their importance in projects.

iii) The respondents of the pilot survey have also suggested some risks apart from giving their assessment on the 48 risks. These risks were compiled and it was decided in the focus group that these can be clubbed under three major risk events. These risks or risk events are categorized as below:

Table 4.6 Additional risks suggested by the respondents

Sl No.	Risk Suggested by respondents and collated
1	Inadequate checking or interfacing among different packages leading to delay
2	Improper interpretation or rigidity in interpretation of contract documents leading to delay
3	Absence of proper Quality Assurance Plan (QAP) leading to both cost and time overrun
4	Improper Billing Schedule and its adherence affects the schedule adversely

(Compiled by Author)

iv) It was also decided that the questionnaire should include questions that would generate information about the existence of project risk management framework in any organization and steel plants in particular.

The project complexity attributes as suggested by the Author were discussed and debated in detail in this focus group discussion. The discussion was facilitated by the Author.

The following were finalized in the discussion :

a) The attributes and indicators of complexity will have representation in the overall complexity of the project. However their relative weightage in calculating the overall complexity need to be established. It was decided along with the focus group team that Analytic Hierarchy Process (AHP) will be applied to ascertain the relative weightage of each attribute and indicator.

b) It was decided that a separate questionnaire seeking responses from 10 experts in a paired comparison among the attributes and indicators will be employed to ascertain the relative weightage of the attributes and indicators.

c) The decision was also taken that for each of the attributes and indicators responses will be taken from each respondent with respect to the level of these attributes and indicators in their particular project in a scale of 1 to 5.

d) The weighted sum of all the attributes will determine the overall complexity of the project. Weighted sum of indicators will give the value of the attribute.

4.5 Main Survey

Based on the discussion in the focus group, the main survey questionnaire was developed to identify the critical risks in steel plant projects, existence of the risk identification and management framework in projects as well as the influence of the risk response factors on the choice of risks.

4.5.1 Main Survey Data Analysis

The data obtained from main survey were analysed for all the aspects of main survey administration. The following are analysis and interpretation of data in terms of the different hypotheses formulated for this research.

4.5.1.1 Project Complexity Assessment

The assessment of overall complexity score was determined through relative weightage of each attributes and indicators. The idea was to determine the weightage of each attribute and indicator by putting them in a hierarchy based on their relative contribution to the overall complexity of the project. The methodology applied is Analytic Hierarchy Process. The process, developed by Saaty (1980), allows "*a decision maker to use data, experience, insight and intuition in a logical and thorough way*". The process takes care of "*both objective and subjective judgements*" in decision making while putting the complexity of the problem in a structured framework. (Forman, 1983).

The process uses pairwise relative comparisons and incorporating redundancy. This reduces the errors and provides a measure of consistency of judgements. The use of redundancy permits accurate priorities to be derived from verbal judgments even though the words themselves are not very accurate. By using this pairwise comparison weightages are derived from a set of judgements. These weights are measured in ratio scale.

AHP allows for inconsistencies in judgement. Respondents natural tendencies will be to be consistent. However due to human bias there are inconsistent results. AHP allows for a consistency ratio of less than 0.1 for the judgement to be considered as consistent. In the present study a questionnaire was designed to derive the weights of each of the attributes and indicators through pairwise comparison and applying AHP. The questionnaire is included in *Appendix A-5.*

Attributes and Indicators

In the present study the goal is to calculate overall project complexity. The overall project complexity is composed of attributes which are the determinants of complexity at the next level. They are again broken up into indicators at the subsequent level. The primary idea is to calculate the weight of each attributes in the calculation of overall project complexity.

The attributes and indicators of complexity are arranged in a hierarchical form as shown below. In level 1 the aim is to determine the overall complexity of the project. At level 2 are the attributes and at level 3 are the indicators.

The attributes considered for this study are as given below:

a) **Pace of the project** - In other words it is the speed of the project and is measured in terms of the ratio of the project value and the duration of the project. Two projects of same value in Rupee terms may have different pace because of their differing duration in months. The varying pace of different projects with which the respondents are associated are categorized under five different levels.

Pace of Project (Rs.in Lakhs / Month)	Level
0.1 to 10	1
>10 to 20	2
>20 to 30	3
>30 to 40	4
>40	5

b) Structural Complexity – It refers to a set of indicators which contributes to the structural complexity of the project. These are:

i) Number of agencies working in a project

ii) Site constraints and /or space restriction

iii) Difficulty due to construction machinery deployment

iv) Other running projects/ plant facilities in the area

The complexity that develops because of multiple agencies working in same project. Apart from contractors or sub-contractors there can be agencies like suppliers of equipment, statutory agencies and even agencies under the project owner. The complexity arises due to the multiple level of communication / instructions that follows within such agencies. The following table denotes the level of contribution of this indicator are

No. of agencies involved	Level of contribution
1 to 25	*1*
26 to 50	*2*
51 to 75	*3*
76 to 100	*4*
>100	*5*

Space restriction and /or existence of underground facilities like utility pipelines, cable trenches/ tunnels are usually a common phenomenon in a brownfield project and is another important contributor to the structural complexity. In many cases these facilities created problems/ design changes and modification of structures at the execution stage of the project. The respondents are required to give feedback in terms of how much this indicator is contributing to structural complexity. Another feature which evolves as a result of site congestion is the difficulty in deployment of construction machinery, particularly large construction equipment like cranes, earth movers etc. This becomes more acute when there is another running project in the vicinity and sometimes sharing the common facility or logistics.

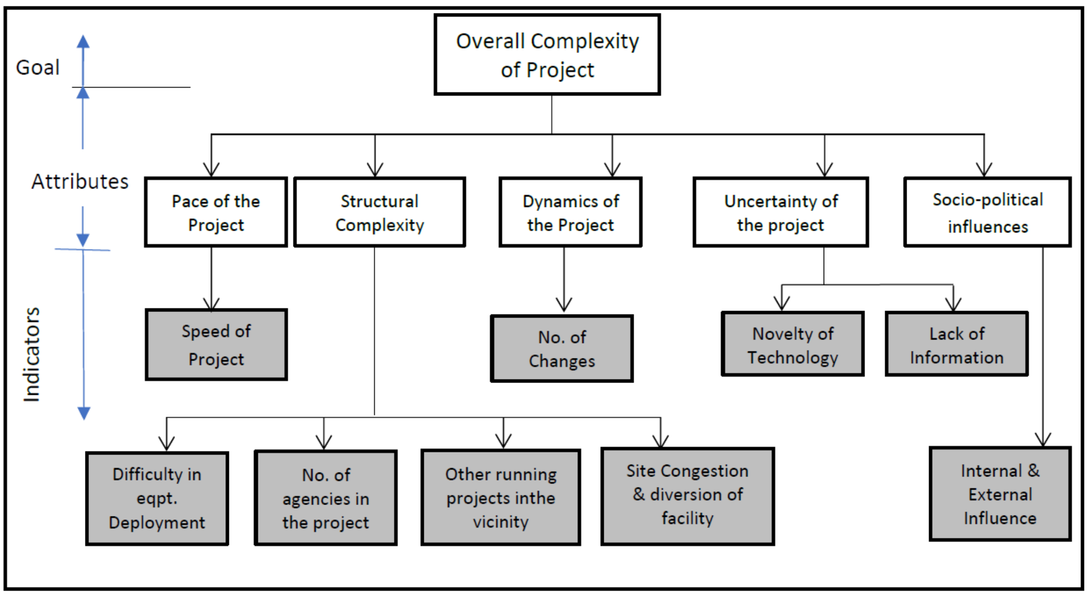
c) Dynamics of Project

Changes often take place in a project and in a big project like any steel plant project it is a common occurrence. While changes in the design stages contribute less to the dynamic nature of project it contributes more when such changes in scope occur during the execution stages in the project.To take care of such changes, change orders are issued by the project owner which most of the time involves additional cost and time. Hence the respondents are asked to evaluate their projects in terms of the number of changes in the project.

d) Uncertainty in project

This attribute consisted of two indicators – technological novelty of the project and lack of information. As discussed by Geraldi et al (2011) uncertainty can be classified under two heads – task uncertainty (Tatikonda and Rosenthal, 2000) and technological uncertainty (Dvir and Shenhar, 1998). In steel plant projects the level of novelty in technology contributes to the uncertainty in the project. This uncertainty is further compounded by the lack of information and also the knowledge gap. The information gap also exist about the real positioning / capacity of the parties carrying out the project. For a project owner this gap often creates complexity of huge proportion. The responses on these indicators can provide a definite indication about the uncertainty in the project.

Figure 4.3: Hierarchy of Complexity of Brownfield Projects



(Compiled by Author)

In order to calculate the relative weights of the attributes and indicators to finally arrive at the overall complexity of the brownfield construction project in steel plant twenty five experts were consulted and responses collected from them through a questionnaire based on paired comparison among the attributes and indicators. The responses were taken on the basis of a comparison scale devised by Saaty (1985). The scale is given in the Table 4.7 below:

Table 4.7: Comparison scale by Saaty (1985)

Intensity of scale	Definition	Explanation
1	Equal Importance	Both the complexity parameters are of equal importance.
3	Moderate Importance	Slightly favours one parameter than other
5	Essential or Strong Importance	Strongly favours one parameter over other
7	Demonstrated importance	Importance of one parameter over other is demonstrated in the project
9	Extreme Importance	One parameter is extremely favourable over the other in the project scenario.
2,4,6,8	Intermediate values	These in between values can be given when the importance of one parameter over other cannot be put clearly in the above intensity of scale but lies somewhere in between them.

Out of the 25 experts at the level of General Manager and above whose responses were taken only 10 found to be consistent based on the Consistency ratio <= 0.10. The relative weights of different attributes and indicators obtained from these responses were considered and the average weight of each of the attributes and indicators were taken up for calculating the overall complexity of each project.

The respondents of the main survey were asked to respond to each of the indicators in a rating scale of 1 to 5. These ratings were multiplied by the relative weights of the indicators to find out the rating of each attribute. This derived rating of each attribute is then multiplied again by the relative weight of that attribute to arrive the contribution of the attribute in the overall complexity of the project. The following formulae will give an idea about the way the overall complexity of project is derived.

At attribute level , weighted indicator rating score, $A_i = \Sigma B_j \times r_{wj}$

At an overall level, Overall Complexity Score = $\Sigma A_i \times R_{wi}$, Where, Bj = Rating score of the indicator j

Ai = Derived rating score of Attribute i

r_{wj}= relative weight of the indicator j

R_{wi} = relative weight of the attribute i.

The relative weights of each attribute and indicator based on the expert opinion is calculated and shown in table - 4.8 below.

Table 4.8: Expert Response on weights of attributes and indicators of Project Complexity

	Attribute Level Weights							Indicator Level Weights					
Expert	Pace of Project	Structural complexity	Dynamics	Uncertainty	Socio-political	Priority Vector	Consistency Ratio, Cr	Eqpt Deployment	Agencies	Other running projects	Site Congestion	Priority Vector	Consistency Ratio, Cr
	C1	**C2**	**C3**	**C4**	**C5**			**C2.1**	**C2.2**	**C2.3**	**C2.4**		
Expert 1	0.36	0.073	0.1	0.288	0.179	5.388	0.087	0.588	0.246	0.0524	0.113	4.26	0.095
Expert2	0.045	0.0685	0.157	0.22	0.5	5.469	0.1048	0.083	0.673	0.083	0.016	4.186	0.069
Expert 3	0.049	0.037	0.1945	0.173	0.545	5.403	0.09	0.088	0.65	0.088	0.171	4.136	0.050
Expert 4	0.053	0.040	0.119	0.321	0.466	5.3049	0.0686	0.214	0.501	0.079	0.206	4.28	0.105
Expert 5	0.033	0.076	0.248	0.158	0.484	5.469	0.1048	0.169	0.272	0.096	0.463	4.31	0.116
Expert 6	0.597	0.1994	0.081	0.084	0.038	5.491	0.109	0.1421	0.1514	0.1455	0.5608	4.392	0.145
Expert 7	0.110	0.4005	0.0449	0.137	0.3073	5.41	0.092	0.0522	0.1310	0.2252	0.5914	4.309	0.114
Expert 8	0.513	0.2305	0.0480	0.0884	0.1196	5.491	0.109	0.0902	0.303	0.303	0.303	4.384	0.142
Expert 9	0.412	0.357	0.036	0.105	0.088	5.397	0.088	0.528	0.264	0.1455	0.061	4.297	0.110
Expert 10	0.035	0.067	0.182	0.25	0.464	5.457	0.102	0.242	0.175	0.088	0.49	4.278	0.103
Average	**0.221**	**0.155**	**0.137**	**0.182**	**0.319**			**0.22**	**0.337**	**0.130**	**0.297**		

(Compiled by Author)

4.5.1.2 Project Risk Management Framework in the Organization

The response was also obtained on the existence of a formal system of risk identification and management in projects in organization. The respondents were asked five questions relating to the risk identification and risk response in their organization for project cases. A part of the question was also related to the documentation of the risks

The idea behind the queries was to ascertain whether a formal risk identification and management practice had been practiced in the organisations for brownfield projects. The criteria for an organization to be qualified in this category was to have all the practices and documentations in place for any project at any point of time. The responses of the survey participants individually signifies that some of the projects have identified some risks while others did not identify any risk whatsoever.

With respect to question on formal identification of risk in their respective projects about 72% respondents replied that they have identified some risks in their projects while the rest have not done it.

On the question of assessment of these risks about 66% answered that they have assessed the risks. This has let us with 6% of the respondents who have identified the risks in their projects but have not assessed it.

Going ahead about 63% responded that they have a response plan for managing these risks leaving 3% of the respondent who have assessed the risks but had no plan of managing them.

With respect to questions on the interval of monitoring the response plans the respondents have indicated varying periodicity of monitoring. It started from daily monitoring and went up to half-yearly monitoring. It also came out that for project where no formal risk response plan was developed also have monitoring.

Finally on the question of documentation only 39% of the respondents affirmed that they have documentation of their response plans.

The data indicates that not all the respondents have a formal risk identification and management practices that are followed in their projects. While there are incidents of risk identification and assessment in some of the project cases, it cannot be concluded that all the organizations maintain a risk identification and management as a systematic practice. Out of the 8 organisations from where the responses were received only one organization has a proper system of risk identification and management along with documentation in place.

Thus it can be concluded that organisations are following some informal methods of risk identification and assessment but it appears that a proper system of risk identification, assessment, periodic monitoring with updating of risk register is still not being followed in most project owner organisation.

This answers the first research question on proper system of risk identification and management in organization.

4.5.1.3 Criticality of Project Risks

<u>Risk Potential and Critical Risks</u>

Based on the responses, as the first stage of data analysis all the 36 risks were assessed in terms of probability of occurrence and severity of impact. The Risk Potential Score (RPS) was calculated for each of the risk/ risk events. The method of normalization was carried out to identify those select band of risks which can be termed as "critical" risks based on a normalization factor score of 0.5 or more. The assessment of critical risks in terms of Risk Potential Score was also separately carried out for the different project owner groups – Project executives, Plant executives and Consultant executives. The idea was to capture the difference in perception among these groups with regard to the critical risks in brownfield construction projects in steel plants. The assessment of Risk Potential Score for these groups is given in the Table 4.9 below:

Table 4.9: List of Critical Risks from the perception of Project Executives, Consultant Executives and Plant executives.

Sl. No.	Risks	Risk Id. No.	RPS for Project _Exec	RPS for Consultant Exec	RPS for Plant_ Exec	RPS for Overall Response
1	Delayed Supply of equipment/equipment parts causing delay	R1	3.54	3.47	3.23	3.42
2	Unrealistic time estimates of activities and duration of the project causing time overrun	R7	3.48	3.26	3.57	3.48
3	Delay in approval of design and drawings causing delay in project	R5	3.47	2.98	3.33	3.28
4	Contractor having inadequate workmen to carry out work resulting in delay.	R3	3.37	3.48	3.15	3.26
5	Poor Subcontractor performance leading to time and cost overrun.	R8	3.27	3.54	3.25	3.29
6	Work Fronts/ shutdown not being made available in time creating delay in the start of activity, finally resulting in time overrun.	R16	3.26	3.37	3.02	3.19
7	Inadequate checking and interfacing among different packages leading to rework and time overrun	R33	3.14	3.02	2.94	3.05
8	Contractor developed financial problems during the project causing delay.	R6	3.12	3.27	2.82	3.07
9	Inadequate Safety provisions leading to accidents and resulting in delay	R2	3.08	3.07	2.92	2.97

Contd.

10	Improper cost estimates (due to lack of knowledge/ information gap) resulting in cost overrun	R4	3.07	2.90	2.95	2.92
11	Inadequate Project Planning with poorly/ inadequately defined tasks and their requirement affecting the project.	R11	3.04	3.26	2.88	2.98
12	Increase in scope due to addl. Requirement causing cost and time overrun	R21	3.02	3.08	2.67	2.83
13	Unforeseen ground condition leading to delay in project schedule.	R20	2.99	2.87	2.68	2.87
14	Delay in arranging for necessary construction equipment/ cranes by the contractor.	R27	2.98	3.04	2.89	2.92
15	Inexperienced Contractor causing delay	R12	2.93	2.99	2.67	2.81
16	Not adequate skilled manpower available for the project manager in the project leading to inadequate supervision resulting in lack of quality	R17	2.90	2.93	2.47	2.82

(Note: In case of Overall response the normalization factor remained at 0.5 or above for only 16 risks hence the RPS of the last two risks not considered.)

From the above table it was evident that all the three categories of respondents have identified more or less the same risks as critical. While the risk potential of the 16 critical risks have been ascertained individually the study also endeavoured to assess the overall risk potential of the brownfield steel projects. The assessment was done on the basis of Exploratory Factor Analysis and Fuzzy Synthetic Analysis of 16 critical risks.

<u>Overall Risk Potential of Brownfield Steel Projects</u>

The data collected during the main survey were further analysed statistically in order to address specific research questions and hypothesis. The analysis was carried out through SPSS package. The statistical methods and the rationale for their selection are explained in the ensuing sections.

a. **Exploratory Factor Analysis (EFA)** – This statistical method was used to find out the underlying factors or Critical Risk Groups (CRG) within the 16 critical risks (CR). Initially the responses on the risks by the respondents were tabulated in MS Excel spread sheet and checked for any missing data.

   Before applying EFA the data need to be tested for their suitability to undergo Factor Analysis. The Risk Potential Score measured as product of Probability of Occurrence and Severity of Impact for the 16 critical risks were subjected to different tests before applying EFA. These test are as follows:

   i) Reliability Analysis – The Cronbach coefficient for the Risk Potential scores was calculatedas 0.901 indicating that the questionnaires show a high level of uniformity suggesting that the scale used is highly reliable (Field, 2009).

   ii) Bartlett Test of Sphericity – The value of Bartlett Test of Sphericity was calculated as 988.789 with an associated Significance level of 0.000 which suggested that the population correlation matrix is not an identity matrix (Norusis, 2008).

   iii) Kaiser-Meyer- Olkin (KMO) Measure – It measures the degree of inter correlation between variables and suggest if the data is suitable for Factor Analysis (Norusis, 2008; Hair (Jnr), Black, Babin & Anderson & Tatham, 2006). A value of KMO measure more than 0.5 suggests that the data is suitable. In the present study the value of this measure was calculated as 0.91 as given in Table 4.10 below:

Table 4.10: Kaiser-Meyer-Olkin Measure and Output of Bartlett Sphericity Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.910
Bartlett's Test of Sphericity	Approx. Chi-Square	988.479
	df	120
	Sig.	0.000

Exploratory Factor Analysis (EFA) was carried out to identify the underlying factors that have a representation of all the critical risks identified through Risk Potential Score and subsequent normalization. The factors were determined based on the explanation of total percentage of variations explained by each of them.

The factors were extracted through a method of Principal Component Analysis (PCA). PCA is *concerned only with establishing which linear components exist within the data and how a particular variable might contribute to that component* (Field, 2009).

To get a clear picture about the underlying factors, factor extraction and rotation is carried out as part of the method of factor analysis. In order to get principal factors, factor extraction with varimax rotation (orthogonal rotation) is considered with Kaiser Normalisation.

In the present study PCA was carried out and 5 factors were extracted. The various output of Factor Analysis as computed by SPSS are shown in Tables 4.11 to 4.14 below:

Table 4.11:. Descriptive Statistics from Factor Analysis

	Mean RPS	Std. Deviation
N = 166		
Inexperienced Contractor	2.74	1.153
Inadequate Workmen	3.21	0.988
Contractor developed Financial Problem	3.00	1.129
Delayed Supply of equipment	3.36	0.824
Unforeseen ground condition	2.82	1.018
Inadequate Project Plan	2.93	0.921
Increase in Scope	2.79	1.018
Unrealistic Time Estimate	3.43	1.001
Improper Cost estimate	2.86	1.066
Delay in Approval	3.24	0.993
Workfront / Shutdown not made available.	3.14	1.024
Delay in arranging construction eqpt	2.89	0.738
Inadequate safety Planning	2.92	0.856
Poor Sub contractor performance	3.25	1.070
Inadequate checking of interface	2.98	1.007
Skilled Manpower not available to PM	2.76	1.030

(As computed by Author)

Table 4.12. Factor / Component Extraction before Rotation

	Component				
	1	2	3	4	5
Inexperienced Contractor	0.656	-0.351	-0.062	-0.023	-0.130
Inadequate Workmen	0.663	-0.205	-0.097	0.160	0.287
Contractor's Financial Problem	0.720	-0.309	0.020	-0.096	-0.198
Delayed Supply	0.481	-0.280	0.380	0.615	-0.097
Unforeseen ground condition	0.518	0.593	-0.132	0.153	-0.265
Inadequate Project Plan	0.661	0.075	-0.088	0.167	-0.210
Increase in Scope	0.656	0.370	0.352	0.047	0.121
Unrealistic Time Estimate	0.630	-0.041	-0.360	0.035	0.450
Improper Cost estimate	0.591	0.119	0.302	-0.549	-0.013
Delay in Approval	0.664	-0.303	0.268	-0.160	0.057
Shutdown not avl.	0.641	0.234	-0.326	-0.038	-0.146
Delay in construction eqpt	0.663	0.272	-0.132	0.206	0.204
Inadequate safety	0.551	0.201	0.299	-0.059	0.451
Poor Sub contractor	0.633	-0.293	-0.377	-0.136	0.057
Checking Interface	0.697	0.054	-0.012	-0.189	-0.203
Skilled Manpower	0.732	-0.018	0.070	0.012	-0.296
Extraction Method: Principal Component Analysis.					
a. 5 components extracted.					

(As compiled by Author)

Table 4.13: Factor/ Component Extraction after Rotation

	Component				
	1	2	3	4	5
Inexperienced Contractor	**0.651**	0.130	0.295	0.039	0.211
Inadequate Workmen	0.329	0.109	**0.596**	0.213	0.280
Contractor's Financial Problem	**0.730**	0.179	0.213	0.122	0.193
Delayed Supply	0.251	0.097	0.083	0.116	**0.865**
Unforeseen ground condition	0.051	**0.834**	0.047	0.169	0.042
Inadequate Project Plan	0.386	**0.509**	0.215	0.088	0.245
Increase in Scope	0.154	0.422	0.110	**0.665**	0.228
Unrealistic Time Estimate	0.193	0.186	**0.787**	0.199	0.000
Improper Cost estimate	0.542	0.161	-0.031	**0.622**	-0.222
Delay in Approval	**0.621**	-0.034	0.204	0.398	0.215
Shutdown not avl.	0.335	**0.606**	0.321	0.071	-0.080
Delay in construction eqpt	0.091	**0.494**	0.484	0.311	0.175
Inadequate safety	0.081	0.111	0.323	**0.709**	0.118
Poor Sub contractor	**0.561**	0.145	0.557	-0.035	-0.050
Checking Interface	**0.563**	0.410	0.138	0.248	-0.003
Skilled Manpower	**0.583**	0.436	0.092	0.189	0.233
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.					
a. Rotation converged in 14 iterations.					

Note : Highest Factor loading have been highlighted

(As compiled by Author)

Table 4.14: Total Variance Output of Factor Analysis

Total Variance Explained									
Component (Risks)	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.515	40.720	40.720	6.515	40.720	40.720	3.119	19.496	19.496
2	1.198	7.489	48.209	1.198	7.489	48.209	2.267	14.170	33.667
3	0.960	6.000	54.209	0.960	6.000	54.209	1.997	12.480	46.147
4	0.898	5.610	59.819	0.898	5.610	59.819	1.842	11.513	57.660
5	0.881	5.504	65.323	0.881	5.504	65.323	1.226	7.663	65.323
6	0.749	4.683	70.006						
7	0.694	4.334	74.340						
8	0.666	4.162	78.502						
9	0.549	3.429	81.931						
10	0.529	3.303	85.234						
11	0.476	2.973	88.207						
12	0.471	2.946	91.153						
13	0.442	2.762	93.915						
14	0.364	2.273	96.188						
15	0.326	2.036	98.224						
16	0.284	1.776	100.000						
Extraction Method: Principal Component Analysis.									

(As compiled by Author)

The exploratory factor analysis was carried out for the 16 critical risks (CR) which were derived through the responses of the 166 respondents after calculating the Risk Potential Score for each critical risk and thereafter carrying out normalization. The normalization factor value of 0.5 or above was followed as criteria to arrive at these 16 risks.

The exploratory factor analysis produced 5 factors which were extracted after 14 iterations. The 5 factors accounted for more than 65% of the variances in the responses. The first four factors accounted for 19.496%, 14.17%, 12.48% and 11.51% respectively. The last factor contributed to 7.66% of the total variance. After rotation all the factor loadings are 0.5 or more. The extracted factors or Critical Risk Groups as they are termed in this study have been found to be reasonably consistent.

The Factors or the Critical Risk Groups and Critical Risks with their relative weights are shown in Table 4.15 below:

Table 4.15: Factor Loading of underlying risks and percentage of variance explained

Sl. No.	Critical Risk Group (CRG)	Underlying Critical Risks (CR) with (Risk Id No.)	Factor Loading	Percentage of variance explained	Cumulative percentage of Variance explained
1	Construction Agency and Process	Inexperienced Contractor (R12)	0.651	19.496	19.496
2		Inadequate Checking of interface (R33)	0.563		
3		Contractor developed Financial Problem (R6)	0.730		
4		Delay in approval of drgs and documents (R5)	0.621		
5		Poor subcontractor performance (R8)	0.561		
6		Lack of skilled Manpower (R17)	0.583		
7	Construction Site Condition & Logistics	Unforeseen ground condition (R20)	0.834	14.170	33.667
8		Inadequate project planning (R11)	0.509		
9		Non-availability of shut-down/ Work fronts (R16)	0.606		
10		Delay in arranging for construction equipment	0.494		
11	Construction Resources	Contractor having inadequate workmen (R3)	0.596	12.48	46.147
12		Unrealistic time estimate (R7)	0.787		
13	Construction Planning	Inadequate Safety (R2)	0.709	11.513	57.660
14		Improper Cost Estimate (R4)	0.622		
15		Increase in Scope (R21)	0.665		
16	Construction Supply	Delayed Supply (R1)	0.865	7.663	65.323

(As computed by Author)

b. Fuzzy Synthetic Analysis

In Fuzzy Synthetic Evaluation "*the elements or components of an evaluation are synthesized into an aggregate form; the whole is a synthesis of parts*." (Ross, 2004). This evaluation is applicable to both numeric and non-numeric expression of variables and fuzzy synthesis is carried out as part of synthetic evaluation. Several Authors used this method as a tool for multi-criteria decision making (Xu et al., 2010; Xia, Chan & Yeung, 2011). In this research study this method is used to calculate the Risk Potential Score of the Critical Risk Groups and further to determine the Overall Risk Potential Score for the brownfield construction projects in steel plants.

According to Xu et al. (2010), in order to apply Fuzzy Synthetic Evaluation three criteria need to be fulfilled.

i) A set of basic criteria which are the 16 risks in this case

i) A set of grade alternativesindicatingthe levels of risk- in this case the levels have been taken for both probability of occurrence and severity of impact respectively in a scale of 1 (very low) to 5 (very high).

ii) There is an evaluation matrix R which can be defined as R= $(r_{ij})_{m \times n}$, where r_{ij} is the degree to which the grade alternatives satisfiesthe criterion. With respect to the criteria there are several grade alternatives and they are usually represented by Fuzzy Membership Function.

The Fuzzy Membership function for each Critical Risk and Critical Risk Groups was determined. However this required an important step wherein the relative weightings of different critical risks and critical risk groups were determined. The table 4.16 below exhibits the relative weights of critical risks and critical risk groups.

Table 4.16: Weights of the Critical Risks and Critical Risk Groups

Risk Id No.	Critical Risks (CR)	Critical Risk Groups (CRG)	Probability of Occurrence				Severity of Impact			
			Mean PO	Wt. of each risk	Total Mean PO of each CRG	Wt. of Mean PO of each CRG	Mean SEV	Wt. of each risk	Total Mean SEV of each CRG	Wt. of Mean SEV of each CRG
R12	Inexperienced Contractor	Construction Agency and Process	2.53	0.15			3.11	0.17		0.37
R33	Inadequate checking of interface		2.89	0.17			3.23	0.19		
R6	Contractor developed financial problem		2.78	0.20	17.13	0.38	3.39	0.18	19.61	
R5	Delay in approval of drawings & docs		3.17	0.19			3.39	0.18		
R8	Poor sub-contractor perf.		3.11	0.19			3.49	0.18		
R17	Lack of skilled manpower		2.64	0.16			3.0	0.16		
R20	Unforeseen ground condition	Construction Site Condition & Logistics	2.58	0.24			3.18	0.25		0.24
R11	Inadequate project planning		2.71	0.25			3.28	0.26		
R16	Workfront/ shutdown not made available		3.0	0.28	10.96	0.24	3.39	0.26	12.518	
R27	Delay in arranging for Constneqpt		2.67	0.25			3.20	0.25		
R3	Contractor having inadequate workmen	Construction Resources	3.02	0.48	6.31	0.14	3.52	0.49	7.20	0.14
R7	Unrealistic time estimate		3.29	0.53			3.68	0.52		
R21	Increase in scope	Construction Planning	2.66	0.34			3.01	0.32		0.18
R2	Inadequate Safety		2.62	0.33	7.97	0.18	3.37	0.36	9.55	
R4	Improper Cost estimate		2.69	0.34			3.17	0.34		
R1	Delayed supply	Construction Supply	3.14	1	3.14	0.07	3.72	1	3.72	0.07
				Total	**45.51**				**52.61**	

(Compiled by Author)

Deriving the Membership Function of the Critical Risks and Critical Risk Groups

After identifying the 16 critical risks and 5 critical risk groups it becomes necessary to determine the membership function of each risk and each critical risk group. The membership function for each critical risk has been formed based on the responses obtained from respondents on Probability of Occurrence and Severity of Impact. To illustrate the membership function development we take one of the risk – “Delay in approval of drawing and documents” for which 7% of the respondent rated the probability of occurrence as 1=very low, 19% as 2 , 34% as 3, 27% as 4 and 12% as 5. Therefore the membership function for the probability of occurrence of risk (PO) is expressed as below.

$$PO_{R4} = \frac{0.07}{very\ low} + \frac{0.19}{low} + \frac{0.34}{medium} + \frac{0.27}{high} + \frac{0.12}{very\ high} = \frac{0.07}{1} + \frac{0.19}{2} + \frac{0.34}{3} + \frac{0.27}{4} + \frac{0.12}{5}$$

In a similar way the responses on severity is also expressed as below.

$$SEV_{R4} = \frac{0.06}{very\ low} + \frac{0.13}{low} + \frac{0.29}{medium} + \frac{0.39}{high} + \frac{0.13}{very\ high} = \frac{0.06}{1} + \frac{0.13}{2} + \frac{0.29}{3} + \frac{0.39}{4} + \frac{0.13}{5}$$

This has been followed for all the other Critical Risks (CR) and table for membership function for all the CRs and the following table 4.17 resulted.

Table 4.17: Membership Function for the Critical Risks and Critical Risk Groups (For Probability of Occurrence) -

Risk Id.No.	Critical Risks (CR)	Critical Risk Group (CRG)	Wgts. PO	Membership Function at level 3 (At Critical Risk Level)					Membership function at Level 2 (At Critical Risk Group Level)				
				1	2	3	4	5	1	2	3	4	5
R12	Inexperienced Contractor	Construction Agency and Process	0.15	0.23	0.35	0.18	0.14	0.10	0.15	0.26	0.30	0.22	0.11
R33	Inadequate checking of interface		0.17	0.12	0.25	0.31	0.25	0.07					
R6	Contractor developed financial problem		0.2	0.17	0.23	0.33	0.17	0.10					
R5	Delay in approval of drawings & docs		0.19	0.07	0.19	0.34	0.27	0.12					
R8	Poor sub-contractor performance		0.19	0.12	0.16	0.34	0.23	0.14					
R17	Lack of skilled manpower		0.16	0.16	0.33	0.28	0.16	0.07					
R20	Unforeseen ground condition	Construction Site Condition & Logistics	0.24	0.19	0.31	0.26	0.19	0.05	0.13	0.28	0.37	0.19	0.05
R11	Inadequate project planning		0.25	0.13	0.28	0.37	0.20	0.02					
R16	Workfront/ shutdown not made available		0.28	0.12	0.20	0.34	0.23	0.11					
R27	Delay in arranging for Construction equipment		0.25	0.07	0.31	0.49	0.11	0.01					
R3	Increase in scope	Construction Resources	0.48	0.09	0.22	0.37	0.22	0.10	0.09	0.2	0.33	0.29	0.13
R7	Inadequate Safety		0.53	0.08	0.17	0.28	0.33	0.14					
R21	Improper Cost estimate	Construction Planning	0.33	0.10	0.34	0.43	0.10	0.03	0.15	0.32	0.35	0.15	0.05
R2	Contractor having inadequate workmen		0.34	0.19	0.27	0.29	0.17	0.08					
R4	Unrealistic time estimate		0.34	0.14	0.33	0.33	0.16	0.05					
R1	Delayed supply	Construction Supply	1	0.06	0.18	0.37	0.33	0.05	0.06	0.18	0.37	0.33	0.05

(Compiled by Author)

In similar way the Membership function is derived for the critical risks and critical risk groups for Severity of Impact. The table 4.18 below indicates the membership function for the severity of impact.

Table 4.18: Membership Function for the Critical Risks and Critical Risk Groups (For Severity of Impact)

Risk No.	Critical Risks (CR)	Critical Risk Groups (CRG)	Wts. SEV	Membership Function at level 3 (At Critical Risk Level)					Membership function at Level 2 (At Critical Risk Group Level)				
				1	2	3	4	5	1	2	3	4	5
R12	Inexperienced Contractor	Construction Agency and Process	0.17	0.14	0.22	0.19	0.31	0.15	0.10	0.18	0.26	0.35	0.17
R33	Inadequate checking of interface		0.19	0.10	0.17	0.26	0.34	0.13					
R6	Contractor developed financial problem		0.18	0.13	0.11	0.23	0.30	0.23					
R5	Delay in approval of drawings & docs		0.18	0.06	0.13	0.29	0.39	0.13					
R8	Poor sub-contractor performance		0.18	0.04	0.17	0.23	0.36	0.19					
R17	Lack of skilled manpower		0.16	0.11	0.24	0.29	0.27	0.10					
R20	Unforeseen ground condition	Construction Site Condition & Logistics	0.25	0.08	0.19	0.28	0.37	0.08	0.06	0.16	0.35	0.35	0.10
R11	Inadequate project planning		0.26	0.07	0.14	0.33	0.35	0.11					
R16	Workfront/ shutdown not made available		0.26	0.05	0.15	0.31	0.34	0.15					
R27	Delay in arranging for Construction equipment		0.25	0.03	0.16	0.45	0.30	0.06					
R3	Increase in scope	Construction Resources	0.49	0.03	0.16	0.45	0.30	0.06	0.03	0.13	0.35	0.35	0.15
R7	Inadequate Safety		0.52	0.03	0.11	0.24	0.39	0.23					
R21	Improper Cost estimate	Construction Planning	0.36	0.08	0.11	0.31	0.34	0.16	0.10	0.15	0.30	0.33	0.14
R2	Contractor having inadequate workmen		0.34	0.11	0.15	0.32	0.28	0.13					
R4	Unrealistic time estimate		0.32	0.10	0.17	0.26	0.34	0.13					
R1	Delayed supply	Construction Supply	1	0.02	0.08	0.26	0.43	0.21	0.02	0.08	0.26	0.43	0.21

(Compiled by author)

Developing a Fuzzy Synthetic Evaluation Model for ascertaining Overall Risk in Brownfield construction projects in steel plants

For ascertaining the overall Risk Potential of brownfield construction projects in steel plants four models were considered.

For this study the membership function is derived at three levels. The lowest level i.e level 3 is for the Critical Risks (CR), level 2 is for the Critical Risk Groups (CRG) and the final level i.e level 1 is for Overall Risk Potential for the brownfield construction projects in steel plants.

A sample calculation at each level will illustrate how the membership function is derived at that level and shown in the tables 4.17 and 4.18 above.

Level 3 (At Critical Risk Level): The response from the main survey generated the following table 4.19 for the critical risk of "Delay in approval of Drawings and Documents". Similar method was followed for other critical risks.

Table 4.19: Type and Percentage of Response for "Delay in Approval of Drawings and Documents"

Response type	PO (Prob. Of Occurrence)		SEV (Severity of Impact)	
	No of Response	Percentage of Response (%)	No of Response	Percentage of Response (%)
1	12	7.23	10	6.02
2	32	19.28	22	13.25
3	57	34.34	48	28.92
4	45	27.10	65	39.16
5	20	12.05	21	12.65
Total	166	100	166	100

(Compiled by author)

Level 2 (At Critical Risk Group Level) : For calculation we consider the following Critical Risk Group of "Construction Agency and Process" and membership function for this Critical Risk Group is shown in table 4.20 below:

Table 4.20: Calculation of Membership Function at Level 2 (Sample for CRG 1 for Probability of Occurrence)

<table>
<tr><th rowspan="2">CR</th><th rowspan="2">CRG</th><th rowspan="2">Wts. of PO</th><th colspan="5">Membership Function at Level 3</th><th rowspan="2">Calculation of Membership Function of CRG at Level 2</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th></tr>
<tr><td>R12</td><td rowspan="6">Construction Agency and Process</td><td>0.15</td><td>0.23</td><td>0.35</td><td>0.18</td><td>0.14</td><td>0.10</td><td rowspan="6">For 1 = 0.23x0.15+.12x0.17+0.17x0.2+ 0.07x0.19+0.12x0.19+0.16x0.16 = 0.15
For 2 = 0.35x0.15+0.25x0.17+0.23x0.2+0.19x0.19+0.16x0.19 +0.33x0.16 =0.26
For 3 = 0.18x0.15+0.31x0.17+0.33x0.2+0.34x0.19+ 0.34x0.19+0.28x0.16 = 0.30
For 4 = 0.14x0.15+0.25x0.17+0.17x0.2+0.27x0.19+ 0.23x0.19+0.16x0.16 =0.22
For 5 = 0.10x0.15+0.07x0.17+0.1xx0.2+0.12x0.19+ 0.14x0.19+0.07x0.16 = 0.11</td></tr>
<tr><td>R33</td><td>0.17</td><td>0.12</td><td>0.25</td><td>0.31</td><td>0.25</td><td>0.07</td></tr>
<tr><td>R6</td><td>0.2</td><td>0.17</td><td>0.23</td><td>0.33</td><td>0.17</td><td>0.10</td></tr>
<tr><td>R5</td><td>0.19</td><td>0.07</td><td>0.19</td><td>0.34</td><td>0.27</td><td>0.12</td></tr>
<tr><td>R8</td><td>0.19</td><td>0.12</td><td>0.16</td><td>0.34</td><td>0.23</td><td>0.14</td></tr>
<tr><td>R17</td><td>0.16</td><td>0.16</td><td>0.33</td><td>0.28</td><td>0.16</td><td>0.07</td></tr>
</table>

Level 1 (At Overall Risk level) : The membership function for Probability of Occurrence and severity of impact at level 2 & 1 are given in tables 4.21 and 4.22 respectively.

Table 4.21: Membership Functions for Critical Risk Groups at Level 2 and 1 (Probability of Occurrence)

<table>
<tr><th>CRG</th><th>Wts of PO</th><th colspan="5">Membership Function at level 2 (At Critical Risk Group Level)</th><th colspan="5">Membership Function at Level 1 (At Overall Risk Level)</th></tr>
<tr><td></td><td></td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Construction Agency and Process</td><td>0.38</td><td>0.15</td><td>0.26</td><td>0.30</td><td>0.22</td><td>0.11</td><td>0.13</td><td>0.26</td><td>0.34</td><td>0.19</td><td>0.07</td></tr>
<tr><td>Construction Site Condition & Logistics</td><td>0.24</td><td>0.13</td><td>0.28</td><td>0.37</td><td>0.19</td><td>0.05</td><td colspan="5" rowspan="4"></td></tr>
<tr><td>Construction Resources</td><td>0.14</td><td>0.09</td><td>0.2</td><td>0.33</td><td>0.29</td><td>0.13</td></tr>
<tr><td>Construction Planning</td><td>0.18</td><td>0.15</td><td>0.32</td><td>0.35</td><td>0.15</td><td>0.05</td></tr>
<tr><td>Construction Supply</td><td>0.07</td><td>0.06</td><td>0.18</td><td>0.37</td><td>0.33</td><td>0.05</td></tr>
</table>

Level 1 (At Overall Risk Level): For Severity of Impact

Table 4.22… Membership Functions for Critical Risk Groups at Level 2 and 1 (Severity of Impact)

CRG	Wts. of SEV	Membership Function at Level 2 (At Critical Risk Group Level)					Membership Function at Level 1 (At Overall Risk Level)				
		1	2	3	4	5	1	2	3	4	5
Construction Agency and Process	0.37	0.10	0.18	0.26	0.35	0.17	0.07	0.16	0.30	0.35	0.15
Construction Site Condition & Logistics	0.24	0.06	0.16	0.35	0.35	0.10					
Construction Resources	0.18	0.03	0.13	0.35	0.35	0.15					
Construction Planning	0.14	0.10	0.15	0.30	0.33	0.14					
Construction Supply	0.07	0.02	0.08	0.26	0.43	0.21					

Calculation of Overall Risk Potential Score:

From the level 1 membership function the Overall Risk Potential Score is calculated based on the probability of occurrence and severity of impact score at the overall level.

Probability of Occurrence (Overall level) = 0.13 x 1+ 0.26 x 2 +0.34 x 3+0.19 x 4 + 0.07 x 5 = 2.78

Severity of Impact (Overall level) = 0.07 x 1 + 0.16 x 2 + 0.30 x 3+ 0.35 x 4+ 0.15 x 5 = 3.44

Hence , Overall Risk Potential Score = $\sqrt{\text{Probability of occurrence x severity of impact}}$

$= \sqrt{2.78 \times 3.44}$

$= 3.09$

This score suggests that overall risk of brownfield construction projects is 3.09 which according to the scale is in between medium to high level of risk.

This addresses the second hypothesis which states that :

H01: There is no significant level of risk in brownfield construction projects in steel plants.

The Risk Potential Score at overall level being between medium and high it can be inferred that the overall risk in brownfield construction project in steel plant is at a significant level.

Thus based on the above analysis we reject the hypothesis.

c. **Correlation Analysis**

Correlation Analysis is applied when there is a question in research that seeks to find out a relationship between two or more variables. Thus the existence of a relational hypothesis becomes necessary when we use correlation analysis. This analysis method indicates the strength, direction, shape and other features of a relationship (Cooper et al., 2015).

The relationship or measures of association between the variables are determined by several correlation analysis techniques. The two most commonly used methods for Bivariate Correlation are

i. Pearson’s Product-moment method

ii. Spearman’s Rank Correlation Method

i) Pearson’s Product-Moment Method

Pearson’s Correlation coefficient gives an estimate of the linear relationship among two variables based on sample data. The coefficient “r” indicates the magnitude and direction of relationship. As it varies between -1 to +1 through 0, the positive value indicates positive correlation and negative value indicates negative relationship. The value however indicates the degree of correlation. Pearson’s correlation requires data to be in interval and ratio scale and further the sample data are normally distributed.

ii) Spearman Correlation Coefficient

Spearman’s Correlation coefficient, r_s, is a nonparametric statistic and is used when the data does not follow the assumption of parametric data i.e their distribution is not normal. It initially ranks the data and then apply Pearson’s equation to those ranks (Field, 2009)

In the present study Spearman's correlation method is followed for analysing different relationship those have been hypothesized here.

Project Complexity has been calculated based on the weights and scores of each attribute and indicator of project complexity. The weight of each attribute was derived through the choice of experts using the Analytic Hierarchy Process. The scores on each of the indicators are thereafter collected from the responses in the main survey. The overall complexity of each project thus arrived on the basis of these responses.

The criticality of individual risk is measured in terms of Risk Potential Score (RPS) which is derived as the square root of the product of probability of occurrence of each risk and its severity of impact. For Overall Risk Criticality or Overall Risk Potential Score, the average/mean of the probability of occurrence of all the 16 risks are computed for each project. Similar operation is carried out for Severity of Impact. The Overall Risk Potential Score is thereafter calculated as the square root of the product of the average / mean probability of occurrence of each risk and its average / mean severity of impact of all the 16 risks in a project.The more is the RPS the more is the criticality.

The correlation is analysed at two levels in this study:

a. Project Complexity and Risk Potential Score of individual risk in each project
b. Project Complexity and Overall Risk Potential Score in each project.

Because of non-parametric nature of data the correlation was carried out through Spearman's Rank Correlation Method. The result of correlation analysis is given in Table 4.23 and 4.24:

Table 4.23. Correlation between Project Complexity and Risk Potential Score (Spearman's Rank Correlation Method)

Risk	Spearman's Rho	Significance (2 -tailed)
Project Complexity	1.000	
Inexperienced Contractor	.209**	0.007
Inadequate Workmen	.377**	0.000
Contractor's Financial Problem	.266**	0.001
Delayed Supply	.277**	0.000
Unforeseen ground condition	.333**	0.000
Inadequate Project Plan	.399*	0.000
Increase in Scope	.313*	0.000
Unrealistic Time Estimate	.237**	0.002
Improper Cost estimate	.252**	0.001
Delay in Approval	.269**	0.000
Shutdown not available	.225**	0.004
Delay in construction eqpt	.402**	0.000
Inadequate safety	.413**	0.000
Poor Sub contractor	.214**	0.006
Checking Interface	.214**	0.000
Skilled Manpower	.302**	0.000

** Correlation is significant at the 0.01 level (2-taiiled)
*Correlation is significant at the 0.05 level (2-tailed)
b. Listwise N =166

(Compiled by Author)

Table 4.24 :Correlation between Project Complexity and Overall Risk Potential Score in a project

			Proj Complexity	Total Risk
Spearman's rho	Proj Complexity	Correlation Coefficient	1.000	.434**
		Sig. (2-tailed)		0.000
	Total Risk	Correlation Coefficient	.434**	1.000
		Sig. (2-tailed)	0.000	
**. Correlation is significant at the 0.01 level (2-tailed).				
b. Listwise N =166				

(Compiled by Author)

The result from analysis through SPSS software shows a positive correlation between the risk potential score for individual risk as well as the overall risk potential score in a project. While in case of individual risks the correlation coefficients varies from 0.209 to 0.413 with a significance level well below 0.05 the correlation at the overall level is 0.434 with a corresponding significance level of 0.00.

This brings us to the second hypothesis of the present study which is as below:

H_{02}:There is no significant relationship between the criticality of risk events and the complexity of project .

Based on the correlation analysis this hypothesis is rejected.

The reason is that the result shows there is significant correlation between the risk potential for some risks (individually) and project complexity. Further the correlation between project complexity and the overall risk potential of the project is quite significant for any project. The overall risk potential score is calculated on the basis of average probability of occurrence and average severity of impact of all the 16 critical risks taken together for each project.

4.5.1.4 Risk Response Option

For management of any risk the risk response strategy is to be initiated which includes selection of a risk response option and plan for actions under that option in order to reduce the negative impact of that risk/ risk event and in some rare cases exploit the opportunity that may exist. The present study has restricted itself to the negative impact of risk. According to PMBoK® (2017), Risk Response strategy essentially includes three risk response options of "Avoid", "Transfer" and "Mitigate". Further a fourth option is also suggested as response option, which is "Accept". The choice of a particular response option depends on several factors apart from the probability of occurrence and severity of impact. A brief outline of each of these options is given in the table 4.25 below:

Table 4.25: Risk Response Options and Responsibility (Adapted from PMBoK, 2017, 6th Edition)

Response Option	Action under the Option	Responsibility
Avoid	Action is directed towards complete elimination of the risk or risk event by changing the Project Management Plan or change that project objective which may be in problem.	Project Owner Group
Transfer	Action is taken to transfer the risk to a third party together with ownership rights for the response. It does not absolve the Project Owner of his responsibility of the risk. It usually involves payment of some risk premium to the party handling the risk. Use of	Project Owner Group

Contd.

	Insurance, Performance Guarantee Bonds, warranties are some of the tools used for transfer.	
Mitigate	In this response action is taken to reduce either the probability of occurrence or the severity of impact of the risk/ risk event. Introducing redundancy into the system can help in mitigation at a future date.	Project Owner Group
Accept	In this response risk is acknowledged but no action is taken until the risk occurs. For a risk this strategy is adopted when no suitable and cost effective option is available to address the risk. It can be either active or passive. While **active acceptance** calls for a contingency reserve to account for the time, effort and cost involved, **passive acceptance** envisages no action till the risk occurs. However it includes documentation of risk and the planned responses.	Project Owner Group

In this research the respondents were asked to indicate the most suitable option of risk response for each of the risks based on their experience and perception for the projects they have handled. The responses against the 16 critical risks have been taken and the consolidated results of Risk Responses are given in the table 4.26 below:

Table 4.26: Risk Response Options chosen by respondents for Critical Risks

Sl. No.	**Critical Risks**	**Risk Response Option (RRO)** (all figures are in **percentage** of total response)				
		Avoid (1)	Transfer (2)	Mitigate (3)	Accept (Active) (4)	Accept (Passive) (5)
1	Delayed Supply of equipment/equipment parts causing delay	22.42	10.30	45.45	17.58	4.24
2	Unrealistic time estimates of activities and duration of the project causing time overrun	16.36	13.94	33.33	26.06	10.30
3	Delay in approval of design and drawings causing delay in project	19.28	14.46	44.58	18.67	3.01
4	Contractor having inadequate workmen to carry out work resulting in delay.	16.36	13.94	43.64	23.64	2.42

Contd.

5	Poor Subcontractor performance leading to time and cost overrun.	17.79	12.27	41.72	15.95	12.27
6	Work Fronts/ shutdown not being made available in time creating delay in the start of activity, finally resulting in time overrun.	20.12	16.46	34.76	21.34	7.32
7	Inadequate checking and interfacing among different packages leading to rework and time overrun	30.12	8.43	47.59	10.24	3.61
8	Contractor developed financial problems during the project causing delay.	25.30	7.83	29.52	25.30	12.05
9	Inadequate Safety provisions leading to accidents and resulting in delay	50.00	12.20	23.78	10.98	3.05
10	Improper cost estimates (due to lack of knowledge/ information gap) resulting in cost overrun	27.71	13.25	28.92	21.08	9.04
11	Inadequate Project Planning with poorly/ inadequately defined tasks and their requirement affecting the project.	19.39	32.73	24.24	12.12	11.52
12	Increase in scope due to addl. Requirement causing cost and time overrun	18.18	13.33	34.55	26.67	7.27
13	Unforeseen ground condition leading to delay in project schedule.	18.18	17.58	32.73	22.42	9.09
14	Delay in arranging for necessary construction equipment/ cranes by the contractor.	22.22	13.58	45.06	16.05	3.09
15	Inexperienced Contractor causing delay	33.13	12.05	33.13	14.46	7.23
16	Not adequate skilled manpower available for the project manager in the project leading to inadequate supervision resulting in lack of quality	18.67	18.67	37.95	17.47	7.23
	Average	**23.45**	**14.44**	**36.31**	**18.75**	**7.05**

(Computed by Author)

From the above results it is evident that each of the risk has all the five response options thus supporting the fact that depending on the circumstances as well as the knowledge of the project management process and domain knowledge, the respondents felt the need for responding to the same risk with different options. Further, it has been observed that most of the respondents prefer “Mitigation” (36.31%) as the response action to address the risk. Mitigation can include any action that is aimed either towards reduction of the probability of occurrence of the risk event or reduction in severity of impact of that risk event. After mitigation the next option of risk response preferred by the respondents is “Avoid” (23.45%) and Accept (Active) being the third (18.75%). However, at individual risk level there are other observations like for “Inadequate Safety leading to accidents and resulting in delay” (50%) and “Inexperienced Contractor causing Delay” (33.13%)have most of the respondent preferring to “Avoid”.There are certain other risks “Unrealistic time estimates of activities and duration of the project causing time overrun” (26.06%), Contractor having inadequate workmen (23.64%), “Work-fronts/ Shutdowns not being made available in time causing delay” (21.34%), “Increase in scope due to additional requirement….” (26.67%), Unforeseen ground condition leading to delay” (22.42%) where Active Acceptance has been the response option after either “Avoid” or “Mitigate”.

4.5.1.5 Risk Response Factors

Identifying the option of risk response does not end the risk response planning. The selection of response option and actions taken under those options are an important part of the Risk Response Planning. There are several factors that affect the choice of these response options and the actions. These factors are broadly classified under two major heads – Human Response Factors and Systemic Factors. The factors are briefly described below:

Human Response Factors

Human Response Factors relate to human interface in the project.The interface takes place primarily in three areas:

a) Project Managers leadership skills

b) Project Manager and the project team's managerial skills

c) Project Manager and project team members' domain knowledge as well as knowledge about project management processes.

Leadership skills requirement has changed over the years from the autocratic to servant leadership form. In terms of responding to risk through his team a Project manager may need to take decisions about how to handle the risk, communicate effectively with his team members and motivate them into taking effective action to respond to the risk (Bull, 2010). At times he may have to communicate effectively with other stakeholders with respect to the risk.

Planning, organizing and controlling are the managerial tasks which the project manager and his team members need to perform. Planning for response to the risk thus becomes an integral part of the project manager and his teams responsibility. Even monitoring and controlling the response also becomes a part of that responsibility.

Knowledge about the technology of the facility that is going to be built as well as the knowledge about the project management processes over and above the leadership and managerial skill becomes imperative for the project manager and his team as it helps in identifying and responding to the risks effectively.

Systemic Response Factors

Systemic Response Factors relate to the systems and procedures in the organisation and particularly in projects that lead to the response to project risks. These factors primarily encompass the following areas:

a) Proper systems for monitoring, vendor selection, changes, approvals, payments

b) Provisions in contract / specifications/ terms and conditions,.

c) Availability of proper information system.

Projects in steel plants are complex entities and involves processes for managing them. Risks may emerge from variety of areas including vendors and their selection, changes in the requirements during the ongoing project process, approvals and clearances at different stages as well as payment related issues. Having proper systems and processes in these areas helps in identifying and responding to the risks well in advance. Contracts, Contractual specifications and terms and conditions are the backbone of any project and particularly for complex brownfield projects in steel plants. Most of the risks emerge out of these contracts or because of their interpretations. Framing the contracts keeping all the major risks in purview can help in responding to the risks effectively.

Lack of information is a major source of risk in any project. Absence of proper system of generating and disseminating information among the project team and other stakeholders can be a source of information related risk. On the other hand having a proper information system helps in identifying and responding to the risks.

In the present study effort is made to explore the relative influence of these two factors on the choice of risk response option and actions taken under that option. Responses were taken for each of the risks on the risk response option selected by the respondent as well as the level of influence of each of these factors on the choice of the option and action taken under that choice based on his/ her perception of the risk. For each of the response factors the respondents had to select in a scale of 1 to 5 the level of influence that a particular factor has on the risk response option. The total response factor influence under each response option was calculated for both human and systemic response factors and the average taken out for both factors under each risk response option. The risk response option with the related level of influence of the risk response factors against each risk is given in the *Table 4.27 below*:

Table 4.27:. Overall Human and Systemic Factor Scores for Risk Response Options

Sl No.	Risk	Risk Response option	Percentage of Sample	Avg. Human Response Factors	Avg. Systemic Response Factors
1.	Delayed Supply of equipment/equipment parts causing delay	Avoid	22.42	2.79	3.54
		Transfer	10.3	2.73	3.60
		Mitigate	45.45	3.45	3.46
		Accept (Active)	17.58	2.96	3.17
		Accept Passive)	4.24	2.71	3.29
2.	Unrealistic time estimates of activities and duration of the project causing time overrun	Avoid	16.36	2.89	2.84
		Transfer	13.94	2.21	2.37
		Mitigate	33.33	3.57	3.24
		Accept (Active)	26.06	3.73	2.84
		Accept Passive)	10.30	4.07	3.43
3.	Delay in approval of design and drawings causing delay in project	Avoid	19.28	2.96	2.84
		Transfer	14.46	2.95	2.79
		Mitigate	44.58	3.68	3.35
		Accept (Active)	18.67	3.64	3.28
		Accept Passive)	3.01	3.40	1.40

Contd.

4.	Contractor having inadequate workmen to carry out work resulting in delay.	Avoid	16.36	2.86	3.05
		Transfer	13.94	3.00	2.67
		Mitigate	43.64	3.41	3.00
		Accept (Active)	23.64	3.23	3.07
		Accept Passive)	2.42	4.25	3.75
5.	Poor Subcontractor performance leading to time and cost overrun.	Avoid	17.79	2.40	2.68
		Transfer	12.27	2.81	2.69
		Mitigate	41.72	3.25	2.88
		Accept (Active)	15.95	3.38	2.76
		Accept Passive)	12.27	3.13	2.69
6.	Work Fronts/ shutdown not being made available in time creating delay in the start of activity, finally resulting in time overrun.	Avoid	20.12	3.00	3.08
		Transfer	16.46	3.27	3.18
		Mitigate	34.76	3.31	3.19
		Accept (Active)	21.34	3.31	3.00
		Accept Passive)	7.32	3.83	3.50
7.	Inadequate checking and interfacing among different packages leading to rework and time overrun	Avoid	30.12	3.15	3.13
		Transfer	8.43	1.75	2.83
		Mitigate	47.59	3.26	2.97
		Accept (Active)	10.24	3.29	3.36
		Accept Passive)	3.61	3.75	4.00
8.	Contractor developed financial problems during the project causing delay.	Avoid	25.3	2.63	2.70
		Transfer	7.83	2.45	2.09
		Mitigate	29.52	2.93	2.98
		Accept (Active)	25.30	2.89	3.09
		Accept Passive)	12.05	3.05	2.79
9.	Inadequate Safety provisions leading to accidents and resulting in delay	Avoid	50.00	3.55	3.43
		Transfer	12.20	2.65	2.53
		Mitigate	23.78	3.90	3.10
		Accept (Active)	10.98	3.73	3.33
		Accept Passive)	3.05	3.25	3.75
10.	Improper cost estimates (due to lack of knowledge/ information gap) resulting in cost overrun	Avoid	27.71	2.78	3.03
		Transfer	13.25	2.28	2.67
		Mitigate	28.92	3.11	3.06
		Accept (Active)	21.08	3.22	2.84
		Accept Passive)	9.04	3.08	3.15
11.	Inadequate Project Planning with poorly/ inadequately defined tasks and their requirement affecting the project.	Avoid	19.39	3.23	2.86
		Transfer	32.73	2.60	3.20
		Mitigate	24.24	3.60	3.00
		Accept (Active)	12.12	3.30	2.96

Contd.

		Accept Passive)	11.52	4.00	3.50
12.	Increase in scope due to addl. Requirement causing cost and time overrun	Avoid	18.18	2.50	2.50
		Transfer	13.33	2.72	3.00
		Mitigate	34.55	3.42	3.17
		Accept (Active)	26.67	3.16	3.21
		Accept Passive)	7.27	3.40	3.10
13.	Unforeseen ground condition leading to delay in project schedule.	Avoid	18.18	2.44	2.63
		Transfer	17.58	2.86	2.90
		Mitigate	32.73	2.85	3.07
		Accept (Active)	22.42	3.03	3.10
		Accept Passive)	9.09	2.71	2.57
14.	Delay in arranging for necessary construction equipment/ cranes by the contractor.	Avoid	22.22	2.50	2.77
		Transfer	13.58	2.90	2.50
		Mitigate	45.06	3.21	3.13
		Accept (Active)	16.05	2.95	2.82
		Accept Passive)	3.09	3.40	3.00
15.	Inexperienced Contractor causing delay	Avoid	33.13	3.04	2.80
		Transfer	12.05	2.69	2.88
		Mitigate	33.13	3.43	3.13
		Accept (Active)	14.46	3.81	3.13
		Accept Passive)	7.23	3.60	2.90
16.	Not adequate skilled manpower available for the project manager in the project leading to inadequate supervision resulting in lack of quality	Avoid	18.67	3.28	2.52
		Transfer	18.67	2.83	2.56
		Mitigate	37.95	3.31	3.17
		Accept (Active)	17.47	3.50	2.65
		Accept Passive)	7.23	3.11	2.67

(Compiled by Author)

The above table indicates the proportion of the respondents going for a choice regarding each risk response option. Further, the table also indicates the average level of influence of Human and Systemic Response Factors on the particular risk response option. However, what the table does not indicate is that whether these influence levels are same for each risk response option. In order to examine the relative level of influence of these factors Wilcoxon Signed Rank Test was carried out.

a. <u>Wilcoxon Signed Ranks Test</u>

Wilcoxon Signed Ranks Test is used to compare two sets of scores coming from the same respondents under two different condition. In the present study, the same respondent wereasked to respond to the level of influence of both Human Response Factors and Systemic Response Factors for each of the risk. Thus the idea was to find out if there is a difference between the influence of these two factors according to the perception of these respondents. The differences between scores in two conditions for each respondent are calculated. Once the differences are calculated, they are ranked irrespective of whether they are positive or negative. The statistic T (both positive and negative) are separately calculated and the minimum value is considered as the test statistic under each condition. Further the mean T value (T_m) and the standard error (SE_T) value are calculated as below:

$$T_m = \frac{n(n+1)}{4}$$

$$SE_T = \sqrt{\left\{\frac{n(n+1)(2n+1)}{24}\right\}}$$

With these values Z-score can be calculated for each condition. The equation for calculating Z-score is as below:

$$Z = (T - T_m) / SE_T$$

The null hypothesis for Wilcoxon Signed Ranks Test is as below:

H_0 :There is no difference between the two conditions.

For any of the conditions if the Z-score is more than 1.96 or less than -1.96 with a corresponding p-value less than 0.05, the Null Hypothesis is rejected with a confidence level of 0.05.

This test is performed on non-parametric data.

In the present study ,Wilcoxon Signed Rank Test was performed on the Risk Response Factor data corresponding to each risk and the resulting data is indicated in *Table 4.28* shown in subsequent pages.

Table 4.28: Relative Influence of Risk Response Factors on Risk Response Options

Risk Id. No. (as in SPSS)	Risk	Test Statistic	Avoid	Transfer	Mitigate	Accept (Act.)	Accept (Pas.)	Criteria	Explanation
			SRF1-HRF1	SRF2-HRF2	SRF3-HRF3	SRF4-HRF4	SRF5-HRF5		
R12	Inexperienced Contractor causing delay	Z-Value	-.932[b]	-.583[c]	-1.828[b]	-3.371[b]	-2.126[b]	b. Based on positive ranks.	Test Statistic suggests that for Accept (Active) and Accept (Passive) the null hypothesis that the influence of both systemic and human response factors are same, can be rejected,.
		Sig-Value	0.351	0.560	0.068	0.001	0.033	c. Based on negative ranks.	
R3	Contractor having inadequate workmen causing delay	Z-Value	-.837[b]	-1.069[c]	-2.058[c]	-1.142[c]	-.816[c]	b. Based on negative ranks.	Test Statistic suggests that for Mitigate Option, the null hypothesis that the influence of both systemic and human response factors are same can be rejected.
		Sig-Value	0.403	0.285	0.040	0.254	0.414	c. Based on positive ranks.	
R1	Delayed Supply of equipment/equipment parts causing delay	Z-Value	-2.547[b]	-2.481[b]	-.058[b]	-1.415[b]	-.730[b]	b. Based on negative ranks.	Test Statistic suggests that for Avoid and Transfer options the null hypothesis that the influence of both systemic and human response factors are same, can be rejected.
		Sig-Value	0.011	0.013	0.954	0.157	0.465		
R6	Contractor developed financial problems during project causing delay	Z-Value	-1.039[b]	-1.303[c]	-.149[b]	-.996[b]	-.574[c]	b. Based on negative ranks.	Test Statistics suggest that for all the options the null hypothesis that the influence of both systemic and human response factors are same, can be accepted.
		Sig-Value	0.299	0.193	0.882	0.319	0.566	c. Based on positive ranks.	
R16	Work Fronts/ shutdown not being made available in time creating delay in the start of activity, finally resulting in time overrun.	Z-Value	-.036[b]	-.351[c]	-.736[b]	-.574[b]	-1.027[b]	b. Based on positive ranks.	Test Statistics suggest that for all the options the null hypothesis that the influence of both systemic and human response factors are same, can be accepted.
		Sig-Value	0.971	0.726	0.462	0.566	0.305	c. Based on negative ranks.	

Contd.

R20	Unforeseen ground condition leading to delay in project schedule.	Z-Value	-.878b	-1.026b	-1.254b	-.790b	-.144c	b. Based on negative ranks.	Test Statistics suggest that for all the options the null hypothesis that the influence of both systemic and human response factors are same, can be accepted.
		Sig-Value	0.380	0.305	0.210	0.429	0.885	c. Based on positive ranks.	
R11	Inadequate Project Planning with poorly/ inadequately defined tasks and their requirement affecting the project.	Z-Value	-2.247b	-1.420c	-3.048b	-1.575b	-1.414b	b. Based on positive ranks.	Test Statistic suggests that for Avoid and Mitigate options, the null hypothesis that the influence of both systemic and human response factors are same, can be rejected.
		Sig-Value	0.025	0.156	0.002	0.115	0.157	c. Based on negative ranks.	
R21	Increase in scope due to addl. Requirement causing cost and time overrun	Z-Value	-.482b	-.479c	-1.986b	-.162c	-1.000b	b. Based on positive ranks.	Test Statistic suggests that for Mitigate option, the null hypothesis that the influence of both systemic and human response factors are same, can be rejected.
		Sig-Value	0.630	0.632	0.047	0.871	0.317	c. Based on negative ranks.	
R7	Unrealistic time estimates of activities and duration of the project causing time overrun	Z-Value	-.552b	-.758b	-2.202c	-3.596c	-1.725c	b. Based on negative ranks.	Test Statistic suggests that for Mitigate and Accept (Active) options the null hypothesis that the influence of both systemic and human response factors are same, can be rejected.
		Sig-Value	0.581	0.449	0.028	0.000	0.084	c. Based on positive ranks.	
R4	Improper cost estimates (due to lack of knowledge/ information gap) resulting in cost overrun	Z-Value	-.987b	-.367b	-1.009c	-1.424c	-.690b	b. Based on negative ranks.	Test Statistics suggest that for all the options the null hypothesis that the influence of both systemic and human response factors are same, can be accepted.
		Sig-Value	0.324	0.713	0.313	0.155	0.490	c. Based on positive ranks.	
R5	Delay in approval of design and drawings causing delay in project	Z-Value	-1.007b	-.074b	-2.240b	-1.695b	-1.826b	b. Based on positive ranks.	Test Statistic suggests that for Mitigate option, the null hypothesis that the influence of both systemic and human response factors are same, can be rejected.
		Sig-Value	0.314	0.941	0.025	0.090	0.068		

Contd.

R27	Delay in arranging for necessary construction equipment/ cranes by the contractor	Z-Value	-1.444[b]	-1.588[c]	-.150[b]	-.316[b]	-1.000[c]	b. Based on negative ranks.	Test Statistics suggest that for all the options, the null hypothesis that the influence of both systemic and human response factors are same, can be accepted.
		Sig-Value	0.149	0.112	0.881	0.752	0.317	c. Based on positive ranks.	
R2	Inadequate Safety provisions leading to accidents and resulting in delay	Z-Value	-.410[b]	-.412[b]	-3.321[b]	-1.308[b]	-1.732[c]	b. Based on positive ranks.	Test Statistic suggests that for Mitigate option the null hypothesis that the influence of both systemic and human response factors are same, can be rejected..
		Sig-Value	0.682	0.680	0.001	0.191	0.083	c. Based on negative ranks.	
R8	Poor Subcontractor performance leading to time and cost overrun	Z-Value	-1.194[b]	-.120[c]	-2.783[c]	-2.189[c]	-1.589[c]	b. Based on negative ranks.	Test Statistic suggests that for Mitigate and Accept (Active) options, the null hypothesis that the influence of both systemic and human response factors are same, can be rejected.
		Sig-Value	0.233	0.904	0.005	0.029	0.112	c. Based on positive ranks.	
R17	Not adequate skilled manpower available for the project manager in the project leading to inadequate supervision resulting in lack of quality	Z-Value	-2.528[b]	-.924[c]	-1.338[b]	-2.452[b]	-1.438[b]	b. Based on positive ranks.	Test Statistic suggests that for Avoid Option, the null hypothesis that the influence of both systemic and human response factors are same, can be rejected.
		Sig-Value	0.011	0.356	0.181	0.014	0.150	c. Based on negative ranks.	
R33	Inadequate checking and interfacing among different packages leading to rework and time overrun	Z-Value	-.537[b]	-2.214[b]	-2.672[c]	-.182[b]	-1.000[b]	b. Based on negative ranks.	Test Statistic suggests that for Transfer and Mitigate Options, the null hypothesis that the influence of both systemic and human response factors are same, can be rejected.
		Sig-Value	0.592	0.027	0.008	0.856	0.317	c. Based on positive ranks.	

(Compiled by Author)

The above results indicate that apart from risks R12 (Inexperienced Contractor), R3 (Contractor having inadequate workmen), R11 (Inadequate Project Planning), R21 (Increase in Scope), R7 (Unrealistic time estimate), R1 (Delay in supply of eqpt. Parts), R5 (Delay in Approval of drgs& docs.), R2 (Inadequate Safety provision), R8 (Poor Subcontractor), R17 (Not adequate skilled manpower) , R33 (Inadequate Checking of interface)for all other risks the test statistics (Z-value and p-value) suggest that we accept the null hypothesis mention above. This means that for these risks there is statistically no difference between the influence of systemic response factors and the human response factors for all the risk options. For Risks R12, R3, R11, R21, R7, R1, R5, R2, R8 , R17 and R33 there are some options where there are some differences between the two response factors but in case of other responses these factors do have same level of influence.

This brings us to our third hypothesis which stands as below:

H_{03}: There is no difference in the influence of Risk Response Factors (RRF) on the Risk Response Options (RRO) for each Risk.

Further to test the overall effect of human and systemic response factors for all the 16 risks taken together for each of the five risk response options, Wilcoxon test was again carried out. The value of the test statistic under this condition is given in table 4.29 below:

Table 4.29 : Influence of Overall Risk Response Factors for each Risk Response Option

Test Statistics[a]					
	Avoid	Transfer	Mitigate	Accept (A)	Accept (P)
	SRF1 - HRF1	SRF2 - HRF2	SRF3 - HRF3	SRF4 - HRF4	SRF5 - HRF5
Z	-.511[b]	-.595[b]	-2.250[c]	-2.534	-2.070
Asymp. Sig. (2-tailed)	0.609	0.552	0.024	0.011	0.038
a. Wilcoxon Signed Ranks Test					
b. Based on negative ranks.					
c. Based on positive ranks.					

The above test results suggest that for response options 1 (Avoid) and 2 (Transfer) there is statistically no difference between the influence of human and systemic response factors on the risk response (Z-value >-1.96 with corresponding p-value > 0.05).For other responses the Z-value <-1.96 with corresponding p-value <0.05 which signifies that there is a difference between human and systemic response factor influence.

Further the ranks of these three response options where there is a difference is given in table 4.30 below:

Table 4.30 : Ranks of Overall Risk Response Factors for different Risk Response Options (Part)

Ranks				
		N	Mean Rank	Sum of Ranks
SRF3 - HRF3 (Mitigate)	Negative Ranks	12[g]	9.29	111.50
	Positive Ranks	4[h]	6.13	24.50
	Ties	0[i]		
	Total	16		
SRF4 - HRF4 (Accept - Active)	Negative Ranks	11[j]	10.64	117.00
	Positive Ranks	5[k]	3.80	19.00
	Ties	0[l]		
	Total	16		
SRF5 - HRF5 (Accept – Passive)	Negative Ranks	12[m]	9.00	108.00
	Positive Ranks	4[n]	7.00	28.00
	Ties	0[o]		
	Total	16		

g. SRF3 < HRF3

h. SRF3 > HRF3

i. SRF3 = HRF3

j. SRF4 < HRF4

k. SRF4 > HRF4

l. SRF4 = HRF4

m. SRF5 < HRF5

n. SRF5 > HRF5

o. SRF5 = HRF5

(Note: The above table indicates only those Risk Response Options for which the influence of Risk Response Factors are different)

The Overall Response Factor ranks suggest that for the three response options above , the human factors have more influence than the systemic factors.

Based on the above statistical result, considering the overall response factors, the null hypothesis is rejected.

The results of the Wilcoxon test also helps in deciding about the following hypotheses.

Typical brownfield project related risks

For brownfield projects risk of getting the fronts for construction activity of the new project is a significant problem as the running plant always put greater importance on the production process and the associated running facilities. This results in delay in getting shutdown for carrying out the project activities. The options to respond to this risk can be varied. But the factors that influences the choice of response can be human or systemic or both.

The following hypothesis is tested to ascertain the relative level of influence of these factors on the risk response option.

H_{04}:For the risk of non-availability of workfronts/shutdown of existing facility both the response factors have same level of influence on the risk response options.

The test statistics for risks indicated in the table 4.31 below shows that for each of the options the Z-value is more than -1.96 with corresponding p-value greater than 0.05 for the risk.

Table 4.31: Influence of Risk Response Factors on the risk of Non-avalability of Workfront/ Shutdown

Risk No. (as per SPSS)	Risk	Test Statistic	Avoid	Transfer	Mitigate	Accept (Act.)	Accept (Pas.)	Criteria
			SRF1-HRF1	SRF2-HRF2	SRF3-HRF3	SRF4-HRF4	SRF5-HRF5	
R16	Work Fronts/ shutdown not being made available in time creating delay in the start of activity, finally resulting in time overrun.	Z-Value	-.036[b]	-.351[c]	-.736[b]	-.574[b]	-1.027[b]	b. Based on positive ranks.
		Sig-Value	0.971	0.726	0.462	0.566	0.305	c. Based on negative ranks.

(Compiled by Author)

This signifies that the null hypothesis cannot be rejected.

Based on the above results the null hypothesis is accepted.

The other important risk pertaining to brownfield construction projects is the condition that emerges out of unforeseen ground condition. This includes the lack of knowledge about the underground soil condition to a certain extent and the location and extent of underground facilities of the running plant which may intrude into the zone of new construction projects. Both the human and systemic response factors will have same level of influence on the choice of risk response.

This brings us to the next hypothesis which is stated as below:

H05: For the risk of unforeseen ground condition both the factors have same level of influence on the choice of Risk Response Option

The test statistics for this risk indicated in the table 4.32 below shows that for each of the options the Z-value is more than -1.96 with corresponding p-value greater than 0.05 for the risk. This signifies that the null hypothesis cannot be rejected.

Based on the above results the null hypothesis is accepted.

Table 4.32: Influence of Risk Response Factors on the risk of Unforeseen Ground Condition

R20	Unforeseen ground condition leading to delay in project schedule.	Z-Value	-.878[b]	-1.026[b]	-1.254[b]	-.790[b]	-.144[c]	b. Based on negative ranks.
		Sig-Value	0.380	0.305	0.210	0.429	0.885	c. Based on positive ranks.

(Computed by Author)

Safety related Risk

Construction projects by their very nature are prone to safety related risk and in case of a project in an existing steel that is running the risk gets magnified due to the prevailing condition. The accidents can cause huge delay in the time duration of any activity as well as cost implication for the project. Though avoidance is the most preferred option but sometimes depending of the human and systemic factor influence, other response options are also chosen. This leads to the following hypothesis that needs to be tested.

H_{06}: For Safety related Risk, Human Factors influences the Risk Response Option more than Systemic Factors

For Safety related risk – The Wilcoxon test results given in table 4.33 below:

Table 4.33: Influence of Risk Response factors on Safety related Risk

Risk No.	Risk	Test Statistic	Avoid	Transfer	Mitigate	Accept (Act.)	Accept (Pas.)	Criteria
			SRF1-HRF1	**SRF2-HRF2**	**SRF3-HRF3**	**SRF4-HRF4**	**SRF5-HRF5**	
R2	Inadequate Safety provisions leading to accidents and resulting in delay	Z-Value	-.410[b]	-.412[b]	-3.321[b]	-1.308[b]	-1.732[c]	b. Based on positive ranks.
		Sig-Value	0.682	0.680	0.001	0.191	0.083	c. Based on negative ranks.

(Compiled by Author)

In case of Safety we find that except for mitigate option the null hypothesis cannot be rejected which means that there is statistically no difference in the influence of both the response factors on these response options. However, in case of Mitigate option the results suggest that there is a difference. The following table 4.34 illustrates further:

Table 4.34…Ranks of Mitigation Response for Safety related Risks

Ranks				
		N	Mean Rank	Sum of Ranks
SRF3 - HRF3	Negative Ranks	17[g]	11.29	192.00
	Positive Ranks	3[h]	6.00	18.00
	Ties	19[i]		
	Total	39		
		g	SRF < HRF	
		h	SRF > HRF	
		i	SRF = HRF	

(Compiled by Author)

It is observed that the negative ranks are much higher than the positive ranks which signifies that the human factors are more influential than the systemic factors when the participants thought of mitigation or reduction as a response to the Safety related risk. **With this observation the above null hypothesis is accepted.**

Correlation between Risk Response Factor and Project Complexity

The present study endeavours to find out if the Project complexity has got any relationship with the risk response factors whether it is the human response factors or the systemic response factors. The correlation analysis was carried out for project complexity and the human response factors for each of the critical risks and the same was carried out for the systemic response factors and the project complexity. The results are given in *the tables 4.35 & 4.36 in Appendix A-2*.

The correlation was also determined at an overall level through SPSS and the results of correlation analysis at an overall level is indicated in Table 4.37 and 4.38 below:

Table 4.37: Correlation between Project Complexity and Overall Human Response Factors

Correlations-Complexity_AvgHRF				
			Project complexity	Overall Human Factor
Spearman's rho	Project complexity	Correlation Coefficient	1.000	.183*
		Sig. (2-tailed)		0.018
		N	166	166
	Overall Human Factor	Correlation Coefficient	.183*	1.000
		Sig. (2-tailed)	0.018	
		N	166	166
*. Correlation is significant at the 0.05 level (2-tailed).				

(Compiled by Author)

Table 4.38: Correlation between Project Complexity and Overall Systemic Response Factors

Correlations-Complexity_Overall SRF				
			Project complexity	Overall Systemic factor
Spearman's rho	Project complexity	Correlation Coefficient	1.000	.197*
		Sig. (2-tailed)		0.011
		N	166	166
	Overall Systemic factor	Correlation Coefficient	.197*	1.000
		Sig. (2-tailed)	0.011	
		N	166	166
*. Correlation is significant at the 0.05 level (2-tailed).				

(Compiled by Author)

The above tables indicate that there is very weak correlation between the project complexity and the Risk Response Factors – both Human and Systemic. This leads us to the seventh hypothesis which states:

H_{07}: There is no significant relationship between Risk Response Factors and the complexity of the brownfield project.

There is a weak level of correlation that could be seen either in case of Human Response Factors or Systemic Response Factors with maximum correlation coefficient of 0.169 for Human Response Factors and 0.198 for Systemic Response Factors in case of individual risks**.** At an overall level it is found that human response factors have a correlation of 0.183 with a significance level of 0.018 and systemic response factors have a correlation of 0.197 with a significance level of 0.011.

Hence the null hypothesis is accepted.

Correlation between Risk Response Factor and Criticality of Risk

The study also tried to establish a relationship between the risks and the risk response factors. The correlation analysis carried out between risks and the risk response factors leads us to the results shown in *Tables 4.39 and 4.40 in Appendix A-3***.**

The correlation was also studied in between Total Risk and the Average Response Factors and the result is shown in table 4.41 below:

Table 4.41: Correlation between Total Risk , Average Human Response and Average Systemic Response Factors

Correlations- Total Risk_Average HRF_Average SRF					
			Average Systemic factor	project risk_total	Average Human Factor
Spearman's rho	Overall Systemic factor	Correlation Coefficient	1.000	.435**	.667**
		Sig. (2-tailed)		0.000	0.000
		N	166	166	166
	project risk_total	Correlation Coefficient	.435**	1.000	.499**
		Sig. (2-tailed)	0.000		0.000
		N	166	166	166
	Overall Human Factor	Correlation Coefficient	.667**	.499**	1.000
		Sig. (2-tailed)	0.000	0.000	
		N	166	166	166
**. Correlation is significant at the 0.01 level (2-tailed).					

(Compiled by Author)

The above tables indicate that for individual risks the Human and systemic Response factors have a stronger correlation than project complexity varying from 0.2 to 0.4 (except for one or two risks). However when tested at an overall level the total risk has a significant correlation with the average Human Response Factor as well as Systemic Response Factor (value of coefficient 0.499 and 0.435 with p-value of 0.000 for both the cases respectively). This leads us to the last hypothesis which states that:

H_{08}: There is no significant relationship between the Risk Response Factors and the criticality of Risks.

The correlation results indicate that there is significant correlation between the total risk and the risk response factors.The individual risk response factors in some cases have shown some deviation in the relationship. However, at an overall level the correlation coefficient is significant.

Based on this result the above null hypothesis is rejected.

4.6 Expert Interview

4.6.1 Rationale for Expert Interview

The idea of conducting interview as part of research was discussed and supported by several authors in their studies. Interview, as process evolves around questions and answers about a certain topic (Lofland and Lofland, 1984). Charmaz (2014) further pointed out that these questions follow a particular purpose of exploring a particular topic or experience in depth. From the perspective of the present study, this is used to gain an understanding of the respondent's viewpoint and further, why this viewpoint is held by them (King, 2004).The pilot survey and the results obtained from it and the subsequent focus group discussion generated 36 major risks for brownfield construction projects in steel plants. These risks were further subjected to assessment in main survey by executives associated with projects may be as plant personnel or project personnel or representative of project consultant. Unlike the pilot survey, wherein the focus was to only identify major risks, the main survey went deeper into identifying the following aspects:

a) Assessment of major risks in terms of probability of occurrence and severity of impact and identifying the critical risks from amongst them.
b) Assessment of complexity of projects based on the attributes and indicators.
c) Risk response strategies for a risk and the relative influence of the risk response factors on these strategies.
d) These risk response factors bear any correlation either with project complexity or with the criticality of risk.

Since all these aspects were examined through the main survey responses only, it was felt necessary that views of experts may be obtained in order to validate the findings from different analysis and also to get their insights into the reasons of such findings. Further during the main survey certain risks and observations were made which it was felt that clarification may be sought from these experts on those risks or observations.

These experts have spent considerable time span in the planning and execution of brownfield projects in steel plants. Moreover some of them have experience as plant head to be closely associated with projects.

The interview questions were chosen to focus mainly on their observations related to the following areas:

a) Project Complexity and Criticality of Risk relationship.

b) Risk Response factors i.e Human Response Factors and Systemic Response Factors and their relationship with project complexity and criticality of risk.

c) Relative level of influence of the Human Response Factors and the Systemic Response Factors on the risk response option chosen for a critical risk.

d) Risks like "Reputation of the Contractor", "Integration of steel making technologies", "Not getting shutdown at the time of requirement in case of modernisation projects vis a vis expansion projects"

The guidelines and questions for the expert interview is included in *Appendix A-7***.**

4.6.2 Planning for the Expert Interview

The main survey results and the points raised during the survey followed by discussion with supervisors it was planned that this interview will cover two aspects. Firstly, the interview aimed towards getting a logical view based on experience to justify the findings of the research study. The interview questions tried to gather logical reasons behind:

- Why is there a significant positive correlation between project complexity and criticality of risk?

- Why is there a positive correlation between risk response factor and criticality of risk whereas the project complexity bears no such significant correlation with project complexity?
- Why is the influence of the risk response factors – Human and Systemic on the risk response option statistically same or in some cases the human factor is more predominant?

Lastly, the interview focused on the different points which were not specifically addressed in the main survey. These included getting a response from the experts on the following issues :

a) Risk related to the reputation of the contractor

b) Risk related to integration of different technologies in the project.

c) Level of risk in expansion project and that in modernisation project

For the first three questions as above, the respondents were allowed to express their insights in terms of some qualitative statements. For the other three questions the responses required were more decisive than illustrative.The idea was to derive whether the specific event is a risk event or not. If it is considered a risk then what is the preferred response option and which of the factors – Human or Systemic or both influence the response option more. The last question tries to ascertain the relative level of risk of not getting a shutdown in modernisation and expansion projects.

4.6.3 Sampling and Data Collection

For the present study, when the expert interview was planned , the theme of the interview was discussed with the supervisor and finalised after several rounds of discussion. The interview guide was prepared containing the theme of the research and the objective of interview. A sample size of 10 experts was decided in consultation with supervisor and they all have spent substantial years of their career in steel plant construction projects. The table 4.42 below indicates the profile of the experts in terms of their position and experience in handling projects.

Table 4.42:…. Profile of the Interviewees for Expert interview

Position Held	Age (in years)	Overall Experience	Project Experience
Former Executive Director (Projects) in PSU	62	More than 37 years	About 35 years
President and Chief of Projects in a Private Sector Steel Plant	64	More than 39 years in plants and Projects	More than 35 years in Projects mainly in Private sector
Former Executive Director and Presently Advisor to a PSU for their Projects	67	More than 37 years in plants and Projects	Associated with project for than 30 of which last more than 6 years in Projects out of which 4years as Head of ProjectsDeptt.
Former Executive Director (Proj) in a PSU	60	More than 37 years	More than 27 years in Projects
Dy. GM (Proj& Plant) in a Private Sector	55	More than 32 years	More than 25 years in Projects
Director (Proj) in a PSU	59	More than 37 years experience in both	More than 30 years in Projects

Contd.

		PSU and Private Sector	
Former Advisor on Projects in a Private Sector Steel Plant and Present Advisor in a PSU	72	About50years of experience in steel plants both Private and PSU	More than 45 years in Projects.

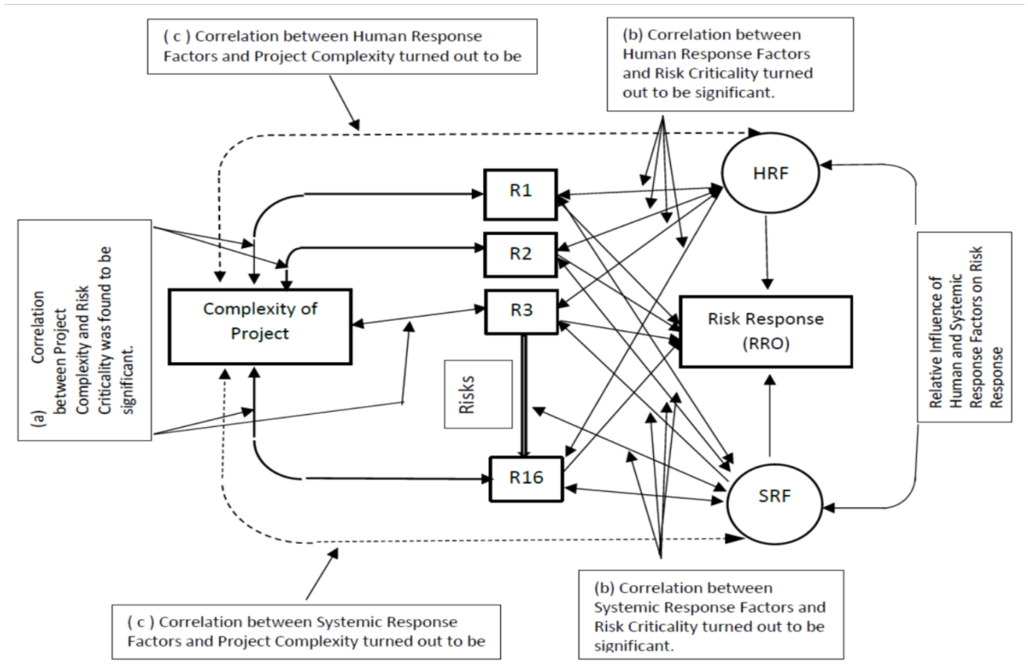
(Compiled by Author)

The profile of the interviewees is suggestive of their vast experience in projects and handling of risks in projects. All these experts are associated with the construction projects in existing steel plants and it is felt that their views on the observations/ findings of the study will be more logical and relevant to the present study. The interviewees were first given a brief about the study and its objective through a telephone call. Thereafter, a structured interview guideline with the questions were sent to them through mail. Upon getting their responses, they were again interviewed telephonically to get further clarification on their views and insights. This has also worked the other way where the respondents needed some clarification and modified their views. The interview method has a distinct advantage which was observed during the process is that the respondents could give their independent views and also provide clarity and reasoning for their views and insights.

4.6.4 Analysis of Interview Data

Based on the analysis results certain relationships are established and these relationships are validated through this expert interview. These relationships are diagrammatically represented in the figure 4.4 below.

Figure 4.4….Project Complexity, Risks, Risk Response Factors Correlation



(Compiled by Author)

The figure above indicates four relationship out of which points (a) , (b) and (c) talk about the correlation and point (d) indicates about the relative influence of the risk response factors on risk response option.The interview data have been analysed and the results are presented against the respective points . The results are as given below:

a) Correlation between Project Complexity and Criticality of Risk

The study has found that there is a positive correlation between project complexity and the criticality of risks. The interviewees were asked about the reason behind such positive correlation. The reason behind the positive correlation is explained by one of the experts.

"*As the complexity of the project increases the visibility reduces particularly if the project is of longer duration which induces time-related uncertainties.*"

The respondent also pointed out that "*complex project configuration with construction challenges*" particularly if being tried for the he first time, "*the risk potential multiplie*s."

Some of the respondents have taken out some of the attributes and held them responsible for increase in risk. One of them pointed out

"….. site congestion and other running projects may give rise to risks related to the handling of equipment and their erection."

Another expert has a view point which is more general in nature but indicating that the attributes of complexity either singly or in combination may generate risks. The opinion goes thus:

"Any one or some of the attributes of complexity may become constraint leading to risk with factors defining its criticality. The occurrence and severity will depend upon visibility of particular attribute of complexity. The positive relationship therefore exists."

Structural complexity in terms of number agencies associated and different constraints at the site in a brownfield project is another attribute of complexity which in the opinion of one expert contributes significantly to the complexity by adding to the uncertainty between inputs and outputs, resulting in the increase in risk potential. In his own words:

"As the project becomes more complex with the large number of elements, the relationships between the elements becomes nonlinear which makes the relationship between inputs and outputs unpredictable. With this the Risk Potential also increases."

Technology has been an important component of the uncertainty attribute. It contributes to complexity more when the knowledge about technology is kept a closely guarded secret which as a result increases the risk potential. This I expressed by one of the experts who pointed out :

"Lack of process knowledge / technology also plays a vital role in increasing risk potential if it is a closely held technology with limited public domain knowledge."

Thus the experts have a unanimous opinion that the attributes either individually or in combination contribute to project complexity which in turn affects the criticality of risks. According to a few of them, some risks are actually generated because of some attributes of project complexity. Thus indicating towards a causal relationship among some attributes of complexity and the criticality of risk.

b) Correlation between Risk Response Factor and Criticality of Risk

Risk Response Factors have been defined as those factors that influence the risk response. The risk response as explained earlier can be in any one of the five ways viz. avoid, transfer, mitigate/reduce, accept (active) and accept (passive). For each risk, the respondents depending on their experience and perception have identified different response options (obviously with different levels). The response factors – Human and Systemic have their individual level of influence on each of these options. The point of interest is to know whether these two factors bear any correlation with the criticality of risk. The analysis results indicated a strong positive correlation between these factors and the criticality of risk. The experts were approached to validate these findings.

Taking a holistic view of the project risk management one of the experts opined that both human and systemic factors have *"an important correlation"* citing human factors like "*well communicated members in a team with positive attitude*" helps systemic factors like "*proper mitigation plan and monitoring*" in encountering risks. Thus indicating some correlation between criticality of risk and the risk response factors.

In the opinion of one of the experts both the human and systemic factors have a complementary role in contributing to the risk potential. In his words

"*Risk becomes critical if its mitigation is not likely to be addressed by competence and organizational systems (HRF & SRF). Human as well as systems play defining role while addressing critical risks."*

From a different perspective it can be said that a good contribution by the Risk Response Factors (RRFs) can enhance the visibility of the project thereby affecting the risk. This is what that came out in one of the responses:

"However, RPS score could be influenced greatly by RRFs since it would eliminate many of the factors ………….by enhancing the visibility with respect to knowledge, selection of technology evenly balanced between technology and complexity, pre-identification of risks and configure the project to circumbhent them, better project management and good communication plan."

Echoing a similar sentiment, another expert based on his experience of completing several brownfield projects without time and cost overrun talked about several steps in manging brownfield projects successfully inspite of the risks. According to him, a strategy of "*comprehensive study and understanding*" followed by "*masterminding*" the project, then "*explaining the route map to team members and drawing up a workplan*" are the most important prerequisites to success. However, at the same time he emphasised that a "*systematic stringent review with consistency and command*"and an attitude of "*no room for failure*" significantlly reduces the probability of occurrence of risk events.

c) Correlation between Risk Response Factor and Complexity of Project

It was felt that the complexity of Project because of its correlation with the criticality of risk may have some correlation with the risk response factors. However, the analysis portrayed a different picture. While the risk response factors – human and systemic have a decent correlation with the criticality of risk but with the complexity it has a very weak correlation and in some cases almost no correlation. To this the experts have different reasons to offer:

One of the experts opined about Project complexity being a "….*characteristic of the particular project contributed by various attributes arising out of factors like the industry type, project business case and objectives, locational compulsions, process and technology selection etc. and therefore independent of or have limited dependence on RRF (Risk Response Factors)."*

In a response from another expert, though not explicit, but the idea was there that both response factors have some relation with complexity.

"Project complexity and risk response factors are two different entities. Responding to critical risks which are originated from project complexity, human as well as systems logically responds for mitigation."

Thus the experts views suggest that it is possible that the project complexity may not have a correlation with risk response factors or even if they have it may not be at a significant level at all. More than project complexity, it is the potential of risk that influences the response factors.

d) Relative level of influence of Human Response Factors (HRF) and Systemic Response Factors (SRF) on Risk Response Option (RRO).

With respect to the level of influence of these two factors on the risk response options the statistical analysis has indicated that both the factors have the statistically same level of influence on the risk response factors.

The expert opinion in one instance suggest that these factors are complementary and depending on the type of risk may vary. The response in actual is as below:
"For all RROs HRF and SRFs are complementary to each other. The measure of each factor complementing the other may vary depending on the type of risk to be responded to, whether critical or otherwise."
In case of another expert the opinion differs to a great extent in that it has vociferously established that human response factors predominantly affect the risk response.

On contrary to above, another expert puts in his view that the relative influence varies depending on the criticality of risks. His observation goes like this:

"For managing critical risks, HRF & SRF are interdependent and hence have same level of influence. Where risks are not critical, e.g. safety, changes in

technical parameters, payments, etc. HRF may be predominant due to decision making involved by human."

These observations confirm that both the factors have equal influence on the risk response options and in some cases the human response factors predominantly influence the response option.

Regarding the other part of this interview the data was collected on three other risks which were suggested during the course of the main survey. The idea of inclusion of these risks in the interview was to capture some amount of information about these events so that these can be included in the future studies. In the following sections, these risks are analysed.

- Risk related to the reputation of the contractor
- Risk related to integration of different technologies in the project.
- Level of risk in expansion project and that in modernisation project

<u>Risk related to the reputation of contractor</u>

In the project arena, a popular belief is that if you have reputed contractor then the project is half-done. This is because of the fact that reputed contractors always have their reputation at stake in any project. Most of the time they take care of the risks in such a way that the project owner need not think about those risk. On the other hand, if the party is new or does not have the necessary reputation the project owner have to take care of the risks. Thus the "reputation factor" becomes a risk element in the perception of the project owner. The opinion of the experts were taken on the following three aspects and presented in the table 4.43 below:

a. Whether this factor of reputation of contractor can be considered as risk

b. If yes, then what is the risk response option?

c. Which Response Factor(s) influences the Risk Response Option more.

Table 4.43... Expert opinion with respect to risk related to Reputation of Contractor

Expert	Whether Risk (Yes/ No)	Risk Response Option (Avoid/Transfer/ Mitigate/ Accept (A)/ Accept (P)	Risk Response Factor that influences predominantly
Expert 1	Yes	Mitigate the risk by taking suitable action against the contractor as per the provision of the contract	Both Human and Systemic
Expert 2	Yes	Avoid	Both Human and Systemic
Expert 3	No	Not responded	Both Human and Systemic
Expert 4	Yes	Mitigate	Human Factors
Expert 5	Yes	Avoid	Both Human and Systemic
Expert 6	Yes	Mitigate- Efforts to be made to have a stringent eligibility criteria to select reputed contractor.	Both Human and Systemic
Expert 7	Yes	Avoid	Both Human and Systemic

From the responses of the experts, it is seen that all of them consider the reputation of the contractor is a risk. However, while discussing with them it came out that risk perception of a contractor having a good track record of completing the project within the constraints of time, cost and quality is always low. As regards the response option, experts have the opinion that avoiding a contractor having a dubious record in the past is the best way. However, they felt that it requires a bold decision from the project owner side and suitable provisions in contract in terms of eligibility criteria can help avoid the participation of contractors with doubtful past records. One of the experts felt that this reputation factor is not a risk as all the human and systemic factors, in fact, is on the project owners side to help it in the selection of a good contractor with the good past record and thus this is not a risk.

Risk related to integration of different technologies in the project

It was suggested that whether integration or lack of it is a risk and if it is a risk what is the most suitable way to address it. Since this issue was raised after the main survey it was decided in consultation with the supervisor to take the views of the experts on this issue. It was further thought justified to get the views of the experts on the influence of the response factors on the response chosen. With regard to this risk the experts opinion is little divergent. While some of them has termed it as risk, others differed. The experts opinion on the above-mentioned three aspects are given in table 4.44 below

Regarding the event of integration of different technologies in a project as a risk event, most of the experts felt that this is not a potential risk event because of the fact that these aspects are taken care of while planning for the project. They felt that these aspects may contribute to some amount of complexity but affecting the objective of the project in terms of time schedule, cost or quality they may not have any effect. While discussing this issue they pointed out that the technology part in package cost and duration is usually taken care of during planning. However, they indicated that this can affect the running of the facility created by the project.

Table 4.44: Experts opinion with respect to Risk related to integration of different technologies

Expert	Whether Risk (Yes/ No)	Risk Response Option (Avoid/Transfer/ Mitigate/ Accept (A)/ Accept (P)	Risk Response Factor that influences predominantly
Expert 1	Yes	Mitigate by constant and proactive follow up, coordination and supporting the integrating work	Both Human and Systemic
Expert 2	No	Not responded	Both Human and Systemic
Expert 3	No	Not responded	Both Human and Systemic
Expert 4	This will depend on the selection criteria and under compelling situation it will remain as a risk.	Mitigate	Human Factors
Expert 5	No	Not Responded	Both Human and Systemic
Expert 6	No	Not responded	Not responded
Expert 7	No	Not Responded	Not responded

(Compiled by Author)

<u>Level of risk in expansion project and that in modernisation project</u>

The terms modernisation and expansion projects refer to such projects which modifies the existing facility as in modernisation project and adds to the facility that is existing. In case of brownfield construction projects any of these types of projects may take place. Whether it is an expansion or a modernisation project, it is taking place in an existing plant and may require shutdown of auxiliary facilities apart from the disturbance in the affected facility. The experts viewpoint also corroborated this idea as given in table 4.45 below:

Table 4.45: Experts opinion with respect to level of risk in expansion and modernisation projects.

Expert	**Whether risk of project delay because of not getting shutdown is more in case of modernization project or in case of expansion project?**
Expert 1	*The risk in case of modernization project is more as mentioned above because it disturbs the existing facilities.*
Expert 2	*In my opinion, this statement cannot be made as a rule. There are several factors influencing the risk potential in either case. Depending on the specific requirement of expansion and location of the new facility, a shutdown may still be required.* *Hence the risk of project delay for not getting a shutdown depends on the project configuration. However, in general risk of project delay associated with modernization seems to be little higher.*
Expert 3	*Risk of Project delay is same because of delay in shut down to complete either modernization project or expansion project, if shut down is necessary in both the cases.*
Expert 4	*In both the cases shut-down cannot be assessed as risk, since this has to be integrated in the project feasibility and should have no impact if it is planned diligently. However, prolongation of the shut-down due to reasons not controlled or monitored or unforeseen will remain as a risk*
Expert 5	*Whether the extent of shutdown in case of expansion project is less and in case of modernisation project is more cannot be stated as a rule. Depending on the project configuration and requirement this may vary. Generally it is seen that shutdown requirement is more in case of modernisation project.*
Expert 6	*Though the shutdown requirement will be less in case of expansion project than in modernisation project, but the extent of shutdown will be dependent on several factors.*
Expert 7	*The shutdown in case of expansion project is usually less than modernisation project. However, the location of the project may entail shutdown of other facilities of a running plant.*

(Compiled by Author)

The above opinions generally suggest that shutdown requirement in case of the modernisation project is more and as result probability of not getting shutdown at the required time is more than the expansion project. Therefore risk related to not getting shutdown and thereby causing project delay will vary depending on the probability of this risk event (not getting shutdown at the required time) happening and also its impact in terms of affecting other related project activities. It also came out from one of the experts that a properly planned out shutdown is never a risk but prolongation of shutdown because of no control or no monitoring can cause project delay and can therefore be a risk.

4.6.5 Summary

The expert opinion survey was conducted with the main objective of validating the findings of the research study. Though the main idea was to validate the findings but it was expanded to cover certain risks which were mentioned or discussed during the main survey.

The positive correlation between project complexity and risk criticality was endorsed by all the experts. Some even pointed out that complexity or the attributes of complexity may contribute negatively to the visibility of the project thereby adding to the perception of risk. It was also opined that the presence of large number of elements in a complex project build up a nonlinear relationship which increases the complexity and thereby affecting the visibility of the project. Hence the finding of the positive correlation between project complexity and the criticality of risk is established.

Regarding the correlation between the Risk Response Factors and the criticality of risks the experts indicated that the risk response factors do have some correlation with risk potential. Some even pointed out that both Human and Systemic factors are complementary to each other in terms of influencing the risks. As a result, a positive correlation exists between them.

On the other hand experts endorsed the finding that the complexity has either no correlation or a weak correlation with both the response factors stating that the attributes of complexity are somewhat independent of the response factors or *"two different entities"*.

Regarding the other three events as risk events the expert opinion on "Reputation risk", "Integration of technology risk" and "risk level in modernisation and expansion" have thrown light on their potential as risk and in the event of risk the logical way to respond to those risks.

CHAPTER 5

RESULTS, DISCUSSION AND CONCLUSION

Results, Discussion and Conclusion

5.1 Introduction

This chapter deals with the results obtained from different studies carried out during the course of this research. The results and analysis of these studies are discussed and summarized in this chapter with respect to their individual contribution and their overall contribution to the main research. No research work can conclude without discussing the limitations. This chapter aims at fulfilling this task too. Further, an attempt is made to assess the contribution of the study from an academic as well as from an industry perspective. The chapter ends with a recommendation for further research.

5.2 Summary – Findings of the survey and expert interview

The main objective with which this research study was undertaken was to have an understanding of the risk management framework in the organization as well as to identify the critical risks and their management in brownfield construction projects in steel plants. The study also endeavoured to find out if a correlation exists between the project complexity and the criticality of the risk. Further, an effort was also made to explore the effect of risk response factors and risk response options. The study was initiated through a literature survey in two specific areas of construction project risks and project complexity. Thereafter, the identified risks and project complexity attributes and indicators were subjected to questionnaire survey in different phases. The objective of the pilot survey was to identify the major risks that are present in brownfield construction projects in steel plants. The pilot survey was preceded by a focus group discussion which finalized the group of construction project risks which are relevant to construction projects in existing steel plants. The major risks identified from the pilot survey along with other suggested risks from the second focus group discussion were subjected to main survey to finally identify the select group of critical risks from the perception of the respondents. In the final stage, expert interview was conducted to validate the findings of the main survey and to have some insight about the relationship. The following Table 5.1 sketches the journey of the author from initiation to culmination.

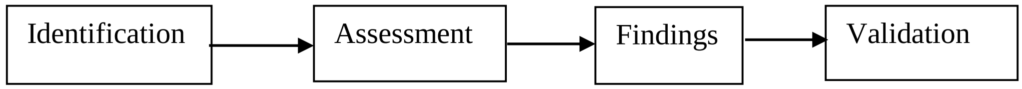
Table 5.1: Stages of Study and the research focus addressed

Focus of Research	1st Focus Group	Pilot survey	2nd Focus Group	Expert survey complexity attributes/ indicators	Main Survey	Expert Opinio n
Identification of major/ critical risks	√	√	√		√	
Identification of Project Complexity attributes/ indicators & their weights	√	√	√	√	√	
Relationship of Project complexity and criticality of risks					√	
Relationship of risk response factors with risk response options					√	
Relationship of Risk response factors and criticality of risks and complexity of projects.					√	
Assessment of Risk Management Framework in organisation					√	
Validity of research findings						√

(Compiled by Author)

From the above table it is clear that apart from expert interview all the other stages are mainly devoted in the identification of risks and complexity indicators. Thus all the stages basically aimed towards findings. The following figure 5.1 illustrates the movement of the study.

Figure 5.1: Flow of the Study



Each stage of research generated a new finding which k ept up the tempo of this academic task. The findings of the study in each of the stages and the fulfilment of research objectives is given in the table 5.2 below:

Table 5.2: Summary of findings of the study with fulfilment of Research Objective

Research Objectives	1st Focus Group	Pilot survey	2nd Focus Group	Expert survey to identify weights of complexity attributes/ indicators	Main Survey	Fulfilment of Objectives
To ascertain the overall risk potential of brownfield construction projects in steel plants	48 risks were identified for pilot survey.	Based on the Risk Potential Score and cut-off normalizatio n factor of 0.5 only 29 risks identified.	• Three risks of economic nature included in main survey. • Addl 4 risks were included as suggested by the respondents of pilot.		• 36 major risks assessed and 16 critical risks identified based on RPS and cut-off normalization factor of 0.5. • Overall Risk Potential of the brownfield construction project is assessed based on Fuzzy Synthetic Analysis. Overall Risk Potential found out to be between medium and high.	The critical risk events identified and the overall risk potential of brownfield construction projects in steel plant assessed.
To investigate the relationship of criticality of risk with the the complexity of project.	Some parameter s/ attributes of complexit y wereprim arily decided.	• Responses on these parameters taken. • No correlation studied between complexity and risk potential scores.	Complexity attributes and indicators finalized.	Weights of indicators finalized based on responses.	Responses on complexity indicators were taken and overall complexity of project assessed. Positive correlation exists between Project complexity and criticality of risk	Significant positive correlation exist between project complexity and risk criticality.

Contd.

To explore the effect of Risk Response Factors on the Risk Response Options selected for each risk.			• Risk Response Options nomenclature finalized • Risk Response Factors were discussed and their scales finalized.		• Risk Response Option and risk Response Factors against each risk evaluated. • Both the Response factors have statistically same level of influence on 3 risk response options • Human response factors have more influence in case of other 2 response options.	Influence of Risk Response factors on the risk response option studied and analysed.
To determine the relationship of these factors with the complexity of the project and criticality of risk.					• Positive Correlation exists between risk response factors and criticality of risks. • Positive Correlation exists in most cases between risk response factors and complexity of project.	While there is significant correlation between risk response factors with criticality of risks, it is weak in case of project complexity.

The findings of the study corresponding to each research area are discussed below:

iv) **Risk Management Framework in Organisations**

In the second focus group discussion it was decided that questions relating to the existence of a structured framework for project risk management are to be included. From the responses on the framework of risks identification and management in organization in the main survey it was found that part of the respondents agree that they have identified some risk in their projects. However, lesser proportion of them indicate that they have assessments made for those risks and further lesser proportion mentioned that they have a plan for responding to those risks. When asked about formal documentation, a far less number indicated that they have documentation of response plan for their risks. Among the 8 organisations from where the respondents have taken part only one organization has been found to have a proper framework and documentation of the risk response.

v) **Major Risk Events in Brownfield Construction Projects in steel plants.**

One of the main objectives of this study was to identify risks which are critical to brownfield construction projects in steel plants. With this objective the study arrived at the major risks after the pilot survey and finally arrived at 16 critical risks after the main survey. Based on the Risk Potential Score (RPS) at an overall level "*Unrealistic time estimates of activities….*" has topped the critical risk list followed by "*Delayed Supply of equipment…..*".The project owner group, which are the subject of this study consisting of project executives, plant executives associated with projects and consultant executives, have slightly differing view point about the top critical risk. While project and consultant executives felt that "*Delayed Supply of equipment…..*" is the top critical risk, the plant executive felt that "*Unrealistic time estimates of activities….*" is more important risk. Two more risks which are typical of brownfield construction projects have found place in this select list of critical risks. These are "*Work Fronts/ shutdown not being made available in time….*" and "*Unforeseen ground condition …*". These two risks have plagued the brownfield construction projects on many occasions in recent times. Apart from the individual effect of these critical risks, Fuzzy synthetic Analysis was carried out to identify the critical risk groups (CRG) and finally the overall risk potential of the brownfield construction projects in steel plants. The critical risk groups identified in this study are:

- Construction Agency and Process Group
- Construction Site Condition & Logistics Group
- Construction ResourcesGroup
- Construction Planning Group
- Construction Supply Group

The overall risk potential was calculated for the brownfield construction projects on the basis of Probability of Occurrence and Severity of Impact and was found to be in between medium to high level risk.

vi) **Relationship of Project Complexity and Criticality of Risk**

Overall complexity of each project/ package was calculated and the correlation between project complexity and individual risks is found to be positive. The highest correlation was exhibited by

"*Inadequate Safety provisions….*" With a correlation coefficient of 0.413 and p-value of 0.000. This is followed by "*Delay in arranging construction equipment…*" with a correlation coefficient of 0.402 and p-value of 0.000. The lowest correlation coefficient is found in "*Inexperienced Contractor causing* ….." with coefficient of 0.209 and p-value of 0.007. All other risks had a correlation in between this range. Correlation was also found out between project complexity and the overall risk potential for each project and it was found to be 0.434 with a p-value of 0.000. The experts were of the opinion that the increase in complexity affects the visibility of the project particularly for long term projects thus increasing its risk potential. This finding enables us to conclude that there is a significant correlation that exists between complexity of projects and the risk potential score which basically indicates the criticality of risk.

vii) **Influence of Risk Response Factors on Risk Response Options**

On the basis of the responses on Risk Response Factors – Human as well as Systemic, it was found that the response factors have statistically same level of influence. Apart from the risks R12 (Inexperienced Contractor), R3 (Contractor having inadequate workmen), R11 (Inadequate Project Planning), R21 (Increase in Scope), R7 (Unrealistic time estimate), R1 (Delay in supply of eqpt. Parts), R5 (Delay in Approval of drgs& docs.), R2 (Inadequate Safety provision), R8 (Poor Subcontractor), R17 (Not adequate skilled manpower) , R33 (Inadequate Checking of interface) all other risks have shown that there is statistically no difference between the two response factors on the risk response option. Even for these risks only in case of some of the response options there were statistical differences. For the two risks more prevalent in the brownfield projects i.e "*Work Fronts/ shutdown not being made available in time….*" and "*Unforeseen ground condition …*" it was found that for both the risk there is no statistical difference between human response factor and systemic response factors for all the response options. As far as the experts opinion is concerned the Risk Response Factors were complementary to each other and their measure depended on the type of risk to be responded. One of the experts was of the opinion that for critical risks both the response factors were interdependent and hence have same level of influence. This enabled the author to conclude that both the response factors were important when one made his/her choice of a risk response option.

viii) **Relationship of Risk Response Factors and Criticality of Risks**

Generally the risk response factors have shown a high level of correlation with the criticality of risks. However, in case of risks like "*Unforeseen ground condition ...*" and "*Delayed Supply of equipment ...*" have shown very insignificant correlation in case of systemic response factors. This may be due to the perception that systemic factors have a very limited influence with respect to these risks. It has also been observed that at an overall level the response factors have high correlation overall project risk (Avg. Systemic Factors it is 0.435 with p-value 0.000 and for Avg. Human Factors it is 0.499 with p-value 0.000). The interesting finding that comes out is that the correlation of Human Response Factors is more than Systemic Response Factors both at individual and overall level.

ix) **Relationship of Risk Response Factors and Project Complexity**

While studying the correlation between risk response factors and the complexity of project it has been found that there is very insignificant correlation both in case of Systemic and Human Response Factors. At an overall level Average Systemic Response Factors and Average Human Response Factors had low level of correlation with Project Complexity. The correlation coefficient for Average Systemic Response factors is 0.197 with a p-value of 0.011 and for Average Human

Factors is 0.183 with a p-value of 0.018. This finding suggests that there is a very insignificant level of correlation. This has also been supported by the experts one of whom observed that complexity arises out of various factors which are independent or have very limited dependence on risk response factors. Thus the correlation between these response factors and complexity remained low.

5.3 Conclusions and Discussion

The conclusion of the present study is based upon the information obtained from the literature and analysis of data collected in course of this research and finally supported by the opinion of experts. The study was carried out with the objective of developing some understanding about brownfield construction projects in steel plants in the following areas so that one can manage the steel plant construction projects better.The conclusion in each of these areas are given below:

- **Risks in Brownfield Construction Projects in Steel plants**

  The analysis finally identified 16 critical risks in the brownfield construction projects in steel plants. This included two risks which are mainly associated with brownfield projects. The overall risk potential of the brownfield construction project is found to be more than medium in the risk scale.

- **Project Complexity and Risk Criticality**

  Project Complexity has a significant correlation with individual critical risks as well as overall risk of a project. Thus for more complex project possibility exists that the criticality of the same risk will be more.

- **Risk Response Factors and Risk Response Options**

  There is statistically no difference in the relative influence of Risk Response Factors on Risk Response Options for some of the risks i.e irrespective of the chosen option the influence remains statistically same. However, for some risks there are differences in the influence of the two risk response factors for some of the risk response options but not in all the five options. Thus both the response factors are important for the selection of a choice and action under the choice of risk response action.

- **Risk Response Factors and Risk Criticality**

  Risk Response Factors have exhibited a high level of correlation with Risk Criticality which is determined by Risk Potential Score. Thus both Human Response Factors and Systemic Response Factors influence goes up with the increase in Risk Criticality. Further the higher level of correlation between Human response Factors and Risk Criticality suggest that the respondents felt that the Human Response Factors are more influential than Systemic Response Factors.

- **Risk Response Factors and Project Complexity**

  With respect to Project Complexity, the low correlation suggests that Response Factors are more independent of the Project Complexity. Extending the idea , it can be further concluded that the response factors are more sensitive to the criticality of risks in a project than the complexity of the project itself.

5.4 Limitations of the Study

The present study has been carried out to provide some understanding about the risk scenario of the construction projects in steel plants in India. As with any other research, the study too had its own limitations which needs to be outlined here for the benefit of the academicians and practitioners for posterity.

First limitation that was experienced was the general reluctance of executives of private sector projects in responding to the questionnaire survey. Had the responses been more from the private sector it could possibly have contributed more positively towards the research findings. Even multiple methods of data collection could not garner much response.

The study has also restricted itself to the brownfield construction projects in steel plants and accordingly the responses were taken both in pilot survey and main survey from the steel plant executives where brownfield construction projects have taken place. This has limited the scope and greenfield projects which are also coming up remained outside the periphery of this study.

The scope of the present study was limited to project owners of steel plants that consists of project and plant executives who are associated with projects and executives of consultant. The perspective of other stakeholders, like contractors, suppliers and others could have added further dimensions to risk management in brown-field steel plant construction projects .

5.5 Contribution of this research

This research study has endeavoured to make some significant contribution in the area of construction project risk management related to steel plants. The research was carried out with the objective of finding out and addressing the perceived gap in the area of construction project risk management and to a limited extent on the practices followed for risk management. The contributions are as detailed below:

A. Theoritical Contribution

The concept of project risk - its identification and assessment has been done according to the available theories and literature. The critical risks identified and assessed in the main survey includes risk which were also identified in the other studies conducted earlier. However, the study also identified some risks which are typical of brownfield project setting. The table 5.3 below shows the critical risks identified in the present study and their mention in other studies.

Table 5.3: Critical risks identified in the present study and their mention in other studies

Sl. No.	Risks	SPSS Risk Id. No.	Risks identified in literatures
1	Delayed Supply of equipment/equipment parts causing delay	R1	Chan & Kumarswamy, (1997), Zou, Zhang & Wang, (2006, 2007)
2	Unrealistic time estimates of activities and duration of the project causing time overrun	R7	Chan & Kumarswamy, 1997, Zou, Zhang & Wang, (2006), (2007), Banaitiene & Banaitis, (2012), Jayasudha&Vidivelli, 2016, Xiong et. al (2017) and Chan et. al (2011)
3	Delay in approval of design and drawings causing delay in project	R5	Zou, Zhang & Wang, (2006), 2007, Xu et al, (2010), Banaitiene&Banaitis, (2012), Jayasudha&Vidivelli, (2016), Xiong et. al (2017) and Chan et. al (2011),
4	Contractor having inadequate workmen to carry out work resulting in delay.	R3	Zou, Zhang & Wang, 2006, 2007, Doraiswamy et al, (2015) &Sambasivam& Soon (2007), Jayasudha&Vidivelli, 2016, Xiong et. al (2017) and Chan et. al (2011), Datta & Mukherjee, 2001
5	Poor Subcontractor performance leading to time and cost overrun.	R8	Zou, Zhang & Wang, (2006), 2007, Xu et al, (2010), Doraiswamy et al, 2015 &Sambasivam& Soon (2007)
6	Work Fronts/ shutdown not being made available in time creating delay in the start of activity, finally resulting in time overrun.	R16	Considered in discussion with experts
7	Inadequate checking and interfacing among different packages leading to rework and time overrun	R33	Suggested by respondents of pilot survey
8	Contractor developed financial problems during the project causing delay.	R6	Zou, Zhang & Wang, (2006), Banaitiene & Banaitis, (2012), Jayasudha&Vidivelli, (2016), Datta & Mukherjee, (2001)
9	Inadequate Safety provisions leading to accidents and resulting in delay	R2	Wang et al.2004, Zou, Zhang & Wang, (2006), Jayasudha &Vidivelli, (2016)
10	Improper cost estimates (due to lack of knowledge/ information gap) , resulting in cost overrun	R4	Wang et al.(2004), Zou, Zhang & Wang, (2006, 2007), Xu et al, (2010), Banaitiene & Banaitis, (2012), Xiong et. al (2017) and Chan et. al (2011)
11	Inadequate Project Planning with poorly/ inadequately defined tasks and their requirement affecting the project.	R11	Chan &K'swamy, (1997), Wang et al.(2004), Zou, Zhang & Wang, (2006, 2007), Doraiswamy et al, (2015) &Sambasivam& Soon (2007), Jayasudha&Vidivelli, (2016)
12	Increase in scope due to addl. requirement causing cost and time overrun	R21	Chan &K'swamy, (1997), Zou, Zhang & Wang, (2006, 2007), Doraiswamy et al, (2015) &Sambasivam & Soon (2007)

Contd.

13	Unforeseen ground condition leading to delay in project schedule.	R20	Chan &K'swamy, (1997), Jayasudha&Vidivelli, 2016, Considered in discussion with experts
14	Delay in arranging for necessary construction equipment/ cranes by the contractor.	R27	Doraiswamy et al, 2015 &Sambasivam& Soon (2007), Considered in discussion with experts.
15	Inexperienced Contractor causing delay	R12	Chan &K'swamy, (1997), Banaitiene&Banaitis, (2012), Doraiswamy et al, (2015) &Sambasivam & Soon (2007)
16	Not adequate skilled manpower available for the project manager in the project leading to inadequate supervision resulting in lack of quality	R17	Chan &K'swamy, (1997), Zou, Zhang & Wang, (2006, 2007), Doraiswamy et al, (2015) &Sambasivam & Soon (2007)

(Compiled by Author)

Most of the critical risks identified in this study have also found mention in other studies as is evident from the above table. However, risks like "*Workfronts/ Shutdown not being made available in time…*" and "*Unforeseen ground condition …*" are typical in a brownfield scenario which may not be encountered in greenfield projects. Large construction projects in steel plants are usually divided into a number of small projects/packages which are very much interlinked and in brownfield case such interlinking on many occasions are with the existing facilities. This interfacing or lack of it often generates risk. While identifying and assessing risks, the respondents felt that the risk of "*Inadequate checking of interface….*"is equally applicable and relevant to the brownfield projects in steel plants. Thus the study tried to address some of the characteristic risks of brownfield construction projects over and above the other common risks in construction projects.

The literatures in the area of construction project risks and project complexity have progressed well over the years. However, their respective progress have taken paths which are largely independent. Though some of the complexity attributes/ indicators have found their place in the consideration of risks but as concepts their linkages have not been observed in the available literature. Thus this study has made an effort to link these two theoretical concepts. The positive correlation suggests that projects with higher complexity will have their risks magnified .

The concept of risk response through the response strategies of Avoid, Transfer, Mitigate and Accept (both active and passive) is available in almost all the literatures relating to project risk management. In fact some of the literatures have even highlighted some actions covering the above mentioned strategies. The previous literatures on project risk management particularly in the area of construction projects have not dealt with the factors responsible for the choice of and action under a specific risk response. In categorizing the factors responsible for selection of a specific response strategy and working under that strategy into two broad areas of Human and Systemic, this study has made an attempt to visualize the relative importance of these factors in influencing these risk response strategies.

B. Practical Contribution

The present study has important contribution through its findings for the construction projects industry in general and brownfield construction projects in particular.

The findings of project risk management framework in organization has adequately highlighted the absence of structured project risk management framework in most of the organisations. The responses also highlighted the lack of documentation with respect to the response plan. It has also been observed from the responses that the periodicity of review of response plan has large variance- starting from no review to half yearly review clearly indicating non-uniform level of risk management. Only one organization out of the 8 organisations from where respondents are taken, have structured process of risk management. This highlights the need for proper risk management framework in organization for managing projects.

The fact that the results have shown similar importance for both systemic response factors and human response factors in responding to risk leads to put thrust in two major areas:

a) Skill Development
b) System Development

a) Skill development

The human factors in this study relates to three areas

i) Technical skill of the project manager and his project team – part of it is the domain knowledge in the specific technical area in which project is coming up. This may be possible either with the background of the project manager or his team member in same technological area or it can be developed through attending specific training programmes or through e-learning.

ii) Managerial skill of the project manager – this may be developed through structured project management training programmes. Mentoring by seniors may also be a helpful tool in this area of development.

iii) Leadership skill of the project manager – this may be developed through structured leadership training programme or through mentoring by a leader.

b) System development

This area is quite an overlooked area where in most of the organization either they lack a system or lack in proper implementation of the system. The present study has considered three areas under systemic factors which requires system development.

i) Proper Systems for monitoring, vendor selection, Changes, Approvals, Payments – systems need to be developed for monitoring of project in general and project risks in particular. Changes and Change Orders are frequent incidence in large scale brownfield projects for various reasons. Proper system for change and change order generation can help avoid or reduce major risks of delay. In similar way systems for timebound approval and payments upon completion can help in avoidance or reduction of several risks.

ii) Provisions in contract / specifications/ terms and conditions – proper provisions in contract or in terms and conditions can help in avoiding / reducing many of the risks .In case of "*Unforeseen ground condition…*" proper provisions in contract or a separate contract for ascertaining the existing ground condition and presence of any underground facility will help in reducing the probability and severity of impact of this risk substantially.

    Provsion of fines in respect of Safety Violation in the Contract / terms and Conditions will help in Avoiding / Mitgating the risk of Safety at Project Sites.

iii) Availability of proper information system – Developing a proper project information system and documentation can help in avoiding or successfully transferring or even reducing the risk. Most of the time it is the lack of documentation that leads to risk event taking place in projects. For the typical brownfield project risks like “*Unforeseen ground condition….*” , “*Workfront/ shutdown not being made available…*” as well as for “*Inadequate Checking of interface…*” development of proper information system can go a long way in reducing their risk potential.

Documentation containing linkages among different pacakges as well as existing facilities (in the form of Linkage Diagram) will help in managing the risk of *“Inadequate Checking of interface…..”*.

Documentation in the form of “Risk Register” identifying and updating risks in a project serves as a major tool for risk management. The presence of risk register also requires its continuous review and updating.

Proper documentation of the “Lessons learned” in executing a project with all risks encountered and actions taken to respond to the risks with the resources deployed need to be carried out for all the projects. These Lessons learned document provides a good support in identifying risks for similar types of projects in future.

C. Social Contribution

Though to a very limited extent but the findings of the study has got some implication at a larger social level. In the National Steel Policy, 2017 it has been envisaged that India has to achieve a production level of 300 Million tonnes by 2030-31. In order to achieve this the organisations will need to augment their existing production capacities, which can be made possible through brownfield projects. This is due to the fact that getting land for greenfield projects will gradually become impossible. Even the projects will be more complex in future involving more sophisticated technology with more agencies coming in. Therefore it will require more competent project managers and engineers and more robust system to handle risks in such projects. The findings of the influence of both human and systemic response factors on the choice of response is a significant indicator of the human and systemic development in the project management discipline to address this issue at a larger social or national level.

5.6 Recommendation for further research

The research study has tried to capture some aspects project risks in brownfield construction projects in steel plants but could not capture all the aspects of this type of construction projects due to lack of time and due to limited scope. The areas where this research can further span are given below:

i) The consideration of this research is based on brownfield construction project in steel plants which has made the study limited to one area of construction project. However, the validity of the findings can be extended by carrying out similar research in other construction projects. This may also help in finding out any possible variations in the results and the reasons thereof.

ii) This study has established a positive correlation between project complexity and criticality of risk. Further study can be conducted to analyse the causal factor behind this relationship.

iii) This study has made a comprehensive analysis based on the Human Response Factors and Systemic Response Factors at macro level. It will be interesting to carry out a similar study considering the component of these factors individually and finding out the influence of each of these components on risk response. This will help the organization to specifically address the relevant components effectively.

iv) The study has adopted project complexity as a lens through which it has studied the risk criticality and level of risk response factor influence for brownfield projects in steel plants. However, it is felt that more attributes or indicators relevant to other construction projects may be identified to have a better effectiveness of the same study in other construction projects.

The academic endeavor which began with the objective of identifying and managing risks in brownfield construction projects in steel plants is a long and arduous one. The present thesis is a miniscule attempt in contributing to the vast ocean of knowledge. Yet the research has brought forth interesting findings that can contribute positively to both the industry and academia at large. The thesis has tried to sustain the scope of study in the realm of steel industry.

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APPENDICES

Appendix

A-1.Content Analysis ofLiterature

Sl. No	Category	Risks/ Risk Events	Murdoch & Hughes, 2000	Chan &K'swamy, 1997	Lessard & Miller,2001	Wang et al.2004	Zou, Zhang & Wang, 2006, 2007	Xu et al, 2010	Crane et al, 2012	Banaitiene&Banaitis, 2012	Thamhain, 2013	Doraiswamy et al, 2015 &Sambasivam& Soon (2007)	Jayasudha&Vidivelli, 2016	Xiong et. al (2017) and Chan et. al (2011)	Datta & Mukherjee, 2001	Heisler (2018)	Expert Ideas	Total
1	**Mar**	Overall market demand of the product / service is down resulting in risk for the project.			√	√		√			√			√				5
2	**Political**	For global suppliers the political situation/stability of the supplier country affecting the project progress adversely			√	√								√	√			4
3		Changes in laws and regulation, political situation causing delay in project execution/ stoppage of project.			√	√		√		√	√		√	√	√	√		9
4		Local Governments attitude not conducive thereby affecting project progress.			√	√	√	√		√				√				6
5	**Legal**	Delay in getting statutory clearances delaying the project.				√	√						√	√				4
6	**Logistical**	Contractor is not experienced enough to handle the project causing project delay / stoppage.		√						√		√			√	√		5
7		Contractor having inadequate workmen to carry out work resulting in delay.					√					√	√	√	√	√		6
8		Contractor developed financial problems during the project causing delay.					√			√			√		√			4

9		Supplier of equipment/ equipment parts/ materials not being able to send the supplies in time for the project causing delay.		√			√			√								3
10		Unforeseen ground condition leading to delay in project schedule.		√									√					2
11	**Organisational**	Delay in getting a go-ahead for the project											√					1
12		Organisational policies and procedures are either time taking or not being followed properly.					√						√					2
13		Holding key decisions in abeyance by the project owner delay the project progress.										√					√	2
14		Top management support is not available at the time of requirement.									√		√					2
15	**Planning**	Inadequate Project Planning with poorly/ inadequately defined tasks and their requirement affecting the project.		√		√	√			√		√	√					6
16		Scope increases due to additional requirement from different stakeholders not considered leading to cost and time overrun.		√			√					√					√	4
17		Time schedule estimates for activities more on the optimistic side causing unrealistic duration of the project and subsequent time overrun		√			√			√			√	√				5
18		Improper cost estimates (due to lack of knowledge/ information gap) resulting in cost overrun				√	√	√		√				√				5
19		Incomplete understanding of the scope of work resulting in delay and cost overrun.				√									√			2
20	**Design**	Delay in approval of design and drawings causing delay in project					√	√		√			√	√				5
21		Technology associated with the project is very new and untested, thereby affecting the progress or budget of the project adversely.			√					√	√		√		√	√		5
22		Defective (with error and omissions) / Non-executable Design may create scope creep resulting in time and cost overrun				√		√		√		√		√				5

23		The design of the project components and their integration is difficult to understand leading to time and cost overrun.				√						√	√	√				4
24		Design Changes (changes in product definitions, technical data, drawings etc.) causing delay				√	√	√		√			√	√				6
25		Slip in schedule due to non-availability of drawings or specifications in time.															√	1
26		Fronts/ shutdown not being made available in time causing delay															√	1
27		Delay in arranging for necessary construction equipment/ cranes										√					√	2
28		Equipment got damaged during transit/ or at site due to exposure leading to delay in project															√	1
29	**Construction**	Poor Subcontractor performance leading to time and cost overrun.					√	√				√						3
30		Defective construction methods/work leading to rework or poor quality of construction and delay					√	√								√		3
31		Inadequate Safety provisions at Site leading to accidents and consequent delay and cost overrun				√	√						√			√		4
32		Improper resource sharing with other simultaneously running projects creating conflict and often resulting in delay.		√														1
33		Excessive variation in quantity causing difficulty in payment and resulting in delay															√	1

34	**Management**	Not adequate skilled manpower for the project manager leading to inadequate supervision resulting in lack of quality		√			√					√						3
35		Loss of people from/ frequent changes in the project team.					√				√	√					√		4
36		Absence of proper review/ control process leading to delay.						√										1
37		Improper communication among team members as well as with other stakeholders resulting in delay and additional cost.		√							√	√						3
38		Inadequate experience with project scheduling tools like MS PROJECT, PRIMAVERA etc. causing delay															√	1
39		Lacking information/ data causing delay of the project.		√			√											2
40		Incomplete understanding of the scope of work resulting in delay and cost overrun.													√		√	2
41		Delay in settlement of extra claim leading to delay					√	√				√						3
42		Non-availability of medical facilities of contractor workers affecting the project work.						√										1
43	**Economic**	Excessive exchange rate fluctuation adversely affecting project cost.				√		√					√	√				3
44		Uncertain Inflation rates adversely affecting the project cost.				√	√	√					√	√				4
45		Delay in payment to the contractor leading to delay															√	1
46		Changes in Taxes and duties leading to project cost overrun.			√			√					√	√				4
47	**Environmental**	Natural Disaster/ Force Majeure affecting the project progress .				√		√					√	√		√		5
48		Difficult Weather conditions leading to delay		√		√		√					√					4
		Total																

Table 2.1 Risks Identified through Content Analysis of Literature

Appendix A-2 :Correlations between Project Complexity and Risk Response Factors (Human and Systemic Factors)

		Project complexity	R12_SRF	R3_SRF	R6_SRF	R1_SRF	R20_SRF	R11_SRF	R21_SRF	R7_SRF	R4_SRF	R5_SRF	R16_SRF	R27_SRF	R2_SRF	R8_SRF	R17_SRF	R33_SRF
Project complexity	Correlation Coefficient	1.000	0.096	0.007	0.098	-0.045	0.112	0.004	0.151	0.074	0.090	0.039	.166*	0.114	0.152	.180*	.198*	0.074
	Sig. (2-tailed)		0.217	0.924	0.211	0.570	0.152	0.958	0.053	0.346	0.255	0.621	0.034	0.149	0.053	0.022	0.011	0.348
	N	166	166	165	166	165	165	163	165	165	162	164	164	161	163	162	163	161

Table 4.35... Correlation between Project Complexity and Human Response Factors (HRF) (Computed by Author)

		Project complexity	R12_HRF	R3_HRF	R6_HRF	R1_HRF	R20_HRF	R11_HRF	R21_HRF	R7_HRF	R4_HRF	R5_HRF	R16_HRF	R27_HRF	R2_HRF	R8_HRF	R17_HRF	R33_HRF
Project complexity	Correlation Coefficient	1.000	0.116	0.064	0.144	0.115	0.103	0.105	0.143	0.080	-0.039	0.018	.169*	0.134	0.042	0.100	0.136	.162*
	Sig. (2-tailed)		0.137	0.416	0.064	0.140	0.187	0.184	0.067	0.305	0.627	0.822	0.031	0.091	0.598	0.204	0.084	0.040
	N	166	166	165	166	165	165	163	165	165	162	164	164	161	163	162	163	161

Table 4.36:...Correlation between Project Complexity and Systemic Response Factors (SRF)

Appendix A-3 :Correlations-between Total Risk and the Risk Response Factors

		project risk_total	R12_SRF	R3_SRF	R6_SRF	R1_SRF	R20_SRF	R11_SRF	R21_SRF	R7_SRF	R4_SRF	R5_SRF	R16_SRF	R27_SRF	R2_SRF	R8_SRF	R17_SRF	R33_SRF
project risk_total	Correlation Coefficient	1.000	.361**	.155*	.307**	0.042	0.092	.225**	.237**	.297**	.253**	.228**	.245**	.221**	.278**	.348**	.208**	.280**
	Sig. (2-tailed)		0.000	0.046	0.000	0.596	0.240	0.004	0.002	0.000	0.001	0.003	0.002	0.005	0.000	0.000	0.008	0.000
	N	166	166	165	166	165	166	166	165	165	162	164	164	161	163	162	163	161

Table 4.39 : Correlation between Total Risk and Systemic Response factors

		project risk total	R12_SRF	R3_SRF	R6_SRF	R1_SRF	R20_SRF	R11_SRF	R21_SRF	R7_SRF	R4_SRF	R5_SRF	R16_SRF	R27_SRF	R2_SRF	R8_SRF	R17_SRF	R33_SRF
project risk total	Correlation Coefficient	1.000	.402**	.240**	.377**	.310**	.263**	.265**	.259**	.300**	.198*	.290**	.290**	.299**	.325**	.430**	.390**	.519**
	Sig. (2-tailed)		0.000	0.002	0.000	0.000	0.001	0.001	0.001	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	N	166	166	165	166	165	166	166	165	165	162	164	165	165	165	164	165	164

Table 4.40: Correlation between Total Risk and Human Response Factors

A-4.Questionnaire for Pilot Survey

Risk Identification for Brownfield Construction Projects in Steel Plants of India

This questionnaire survey is a part of the study on Risk Management in brownfield construction projects in steel plants of India. Risks are part and parcel of any project. Though an entire range of risks may be present in the construction project in steel industry but their effect on the objectives of the project i.e. **to deliver the product /service/ result within the stipulated time, within the budget and according to the desired quality** may be relatively different. This relative difference of their impact can be gauged from the **Risk Potential Score (RPS)** for each of these risks or risk events. The Risk Potential Score (RPS) is based on two factors – **a) Probability of Occurrence of the Risk or Risk Event and b) Severity of the impact of the Risk Event**. In this questionnaire a list of suggested risks is given which have been compiled from different literatures and books. Please indicate against each of these risks the score with respect to probability of occurrence and severity of its impact on the project objectives. There is a provision for adding on some risks that **may not have appeared in the list** but in your opinion they are quite significant for brownfield construction projects in steel plants.

Please indicate your responses on the questions below to help us identify the critical risks for the brownfield construction projects in steel plants of India.

Thanking You

Susmit Roy
Research Scholar, ICFAI University, Jharkhand

Personal Details:

Name.: ____ (Optional)

Designation: ____________________ Organisation:__________________

Deptt:__________

e-mail: ________________________________ Phone______________________

Project Details:

1. How long have you been associated with project activities?
   a) 1- 4 years b) 4 – 7 years c) 7 -10 years d) more than 10 years

2. What are the sizes of projects (packages) that you are associated with? (You may be associated with number of different projects)

Value of each project that you were associated	**Number of projects (packages) that you were/are associated with**
UptoRs. 20 crores	
More than Rs. 20 Crores uptoRs. 100 Crores	
More than Rs. 100 Crores	

3. On the basis of the **present project (package) that you are handling/ last completed project (package)** that you have been associated with, please indicate the following:
   a) Approximate value of the Project (Package)(In Rupees):
   b) Project (Package)duration:
   c) Approx. Value of the sub-package that you are associated with:
   (Note: In case you are responsible for the entire package then leave this space as blank)
   d) Duration of the sub-package that you are associated with:
   (Note: *Leave this as blank as in case of (c) if you are handling the total project*)
   e) Agencies involved in the project (package): *(Please indicate numbers)*

Consultant/ Designer	Contractors	Vendors	Subcontractors	Statutory Agencies	Others

   f) Any **new Technology** is involved in the outcome of your project : *(Please mark √ against the appropriate option)*

Whether the **facility** that is going to be created through this project will have		
I.	State of the art technology (being used by other units of your organization)- addition in capacity, modification/rectification	
II.	Some improvement (indigenous)from the existing technology that is being used in your plant – up-gradation of facility/quality improvement in process/ statutory requirement	
III.	Foreign technology for improving existing operation- up-gradation of facility/ process quality improvement	
IV.	New technology(foreign/ indigenous) to supplement for old technology – modernization of existing operation	
V.	New technology (foreign/ indigenous) for new operation – setting up a new facility with new technology not existing previously.	

Difficulty aspect in your project (Package) in terms of construction methods used : *(Please mark √ against the apprpriate option)*

In terms of the construction method used for speedier work or to tackle the site difficulty like:		
I.	Usual machineries / equipment used with conventional construction methods under normal condition (no shutdown requirement)	
II.	Usual machineries / equipment used with conventional construction method in a congested condition with occasional small shutdowns that may be required	
III.	Some critical type of equipment like tower crane etc. used for construction with occasional shutdown requirement	
IV.	Multiple critical equipment used for construction/ erection under congested condition with one or two major shutdown requirement.	
V.	Multiple critical equipment used for construction / erection under congested condition with major shutdowns that may affect plant operation adversely.	

Risk Identification:

Given below is a list of risk on which your response is needed. Your response should be based on your experience of the **present project (package)/ last completed project (package)** that you are associated with. Response will be a number in each column against each risk on the scale explained below.

(***Note: Though the Probability of occurrence and Severity of impact are for each of the risk, these two are quite independent of each other like probability of occurrence can be high while the severity may be low for any risk and vice versa)***

Probability of Occurrence scale: What is the probability of the risk occurring with the current level of management in place?

Scale	Probability of Occurrence
1	*Very Low Probability / May not occur during the tenure of the project*
2	*Low Probability*
3	*Moderate Probability*
4	*High Probability*
5	*Very High Probability/ the risk/risk event is almost certain to occur*

Severity scale: How much severe is the risk, if it occurrs. Severity will be assessed using the following:

Scale	Severity of Impact
1	*Very Low Severity / very low impact on project objectives*
2	*Low Severity*
3	*Moderate Severity*
4	*High Severity*
5	*Very High Severity/ very high impact on project objectives like the project is stalled*

Sl. No.	Risk / Risk Events	Probability of Occurrence *(Scale 1 to 5)*	Severity *(Scale 1 to 5)*
1	Overall market demand of the product / service is down resulting in risk for the project.		
2	For global suppliers the political situation/stability of the supplier country may affect the project adversely		
3	Changes in laws and regulation, political situation causing delay in project execution/ stoppage of project.		
4	Local Governments attitude and policies toward trade and investment may affect project progress.		
5	Contractor is not experienced enough to handle the project causing project delay / stoppage.		
6	Contractor having inadequate workmen and equipment for carrying out the project causing delay in execution.		
7	Contractor developed financial problems during the project causing delay.		
8	Supplier of equipment/ equipment parts/ materials not being able to send the supplies in time for the project causing delay.		
9	Delay in getting a go-ahead for the project		
10	Organisational policies and procedures are either time taking or not being followed properly.		
11	Inadequate Project Planning with poorly/ inadequately defined tasks and their requirement affecting the project.		
12	Top management support is not available at the time of requirement.		
13	Inadequate technical and managerial capability of Project Manager		
14	Scope increases because of additional requirement from different stakeholders/ user groups/ technically required items not considered leading to cost and time overrun.		
15	Incomplete understanding of the scope of work resulting in dealy and cost overrun.		

16	Unforeseen ground condition leading to delay in project schedule.		
17	Time schedule estimates for activities more on the optimistic side causing unrealistic duration of the project and subsequent time overrun.		
18	Slip in schedule due to non-availability of drawings or specifications in time.		
19	Fronts/ shutdown not being made available in time creating delay in the start of activity, finally resulting in time overrun.		
20	Delay in arranging for necessary construction equipment/ cranes by the contractor.		
21	Not adequate skilled manpower available for the project manager in the project leading to inadequate supervision resulting in lack of quality		
22	Permanent loss of people from the project team/ frequent changes in the project team.		
23	Absence of proper review/ control process for approval of changes in scope or schedule or specification may lead to delay.		
24	Delay in approval of design and drawings causing delay in project		
25	Improper cost estimates (due to lack of knowledge/ information gap) resulting in cost overrun		
26	Inadequate Safety provisions leading to accidents and resulting in delay		
27	Equipment got damaged during transit/ or at site due to exposure leading to delay in project		
28	Delay in getting statutory clearances like environmental clearance, CEA clearance, Explosives clearance affect the schedule of the project.		
29	Defective construction methods/work leading to rework or poor quality of construction		
30	Communication among team members as well as with other stakeholders not proper, leading to loss of information and resulting in delay and additional cost.		
31	Inadequate experience with project scheduling tools like MS PROJECT, PRIMAVERA etc.		
32	Other projects running simultaneously with this project may require same resources at the same point of time creating conflict and often resulting in delay.		
33	Technology associated with the project is very new and has not been tested extensively. This may affect the progress or budget of the project adversely.		
34	The design of the project components and their integration is difficult to understand and verify which leads to time and cost overrun.		

35	Defective (with error and omissions) / Non-executable Design may create scope creep resulting in time and cost overrun		
36	Excessive variation in quantity beyond the limit stipulated creating difficulty in payment and resulting in delay		
37	Design Changes (changes in product definitions, technical data, drawings etc.)		
38	Excessive exchange rate fluctuation may adversely affect the project.		
39	Uncertain Inflation rates may adversely affect the project cost/ budget.		
40	Delay in payment to the contractor adversely affects the progress of work.		
41	Changes in Taxes and duties adversely affect the project cost / budget.		
42	Lacking information (lack of supply information, Lack of design data, engineering data etc.) causing delay of the project.		
43	Holding key decisions in abeyance by the project owner delay the project progress.		
44	Poor Subcontractor performance leading to time and cost overrun.		
45	Natural Disaster/ Force Majeure affecting the progress of project work.		
46	Difficult Weather conditions leading to slow progress of the project.		
47	Delay in settlement of extra claim leading to delay in progress of work.		
48	Non-availability of medical facilities of contractor workers creating health hazards and subsequently affecting the project work.		
49			
50			

(Note: You may add risks in case you feel that they are important for steel plant projects but are not included in the list. Also indicate the respective scores for each of them.)

Thank you for your Time and Response

A-5.Questionnaire for determination of weights of Attributes and Indicators of Complexity

Questionnaire on Complexity of Brownfield Projects in Steel Plants

A study is being conducted for ascertaining the influence of certain **attributes** on the complexity of brownfield construction project in Steel Plants. The present study has identified some **attributes** and the **indicators** of those attributes. Expert opinion is being taken for ascertaining the relative weightage of each these attributes and indicators through paired comparison for calculating overall complexity of project. Kindly give your opinion based on the scale given below. The data will be used for academic purposes only.

Susmit Roy
Research Scholar, ICFAI University, Jharkhand

Attributes & Indicators

C1= **Pace of the project**

- **C1.1** = Speed of the Project, and is derived from the ratio of the value of the project and its duration

C2 = **Structural Complexity of the project**

- **C2.1 =** Difficulty in eqpt deployment
- **C2.2 =** No. of agencies involved in the project
- **C2.3 =** Other running projects
- **C2.4 =** Site congestion and Diversion of facility

C3 = **Dynamics of the Project**

- **C3.1** – No. of Changes or Change orders issued (both major and minor)

C4= Uncertainty in the Project

- **C4.1 =** Novelty of technology which the facility is going to use
- **C4.2 =** Lack of information

C5 = **Socio-political Influences in the project**

- **C5.1** = Level of Internal and external influences in the project

Scale for comparison

The scale for comparison between two parameters is as given below:

Intensity of scale	**Definition**	**Explanation**
1	Equal Importance	Both the complexity parameters are of equal importance.
3	Moderate Importance	Slightly favours one parameter than other
5	Essential or Strong Importance	Strongly favours one parameter over other
7	Demonstrated importance	Importance of one parameter over other is demonstrated in the project
9	Extreme Importance	One parameter is extremely favourable over the other in the project scenario.
2,4,6,8	Intermediate values	These in between values can be given when the importance of one parameter over other cannot be put clearly in the above intensity of scale but lies somewhere in between them.

Please indicate your observation for each of the following pairs (please tick the appropriate number on **any one side between 1 to 9**): (e.g numbers towards left from central position of 1 indicates favour towards "Pace of Project (C1)" and towards right favour towards "Structural Complexity (C2)". **If 7 is chosen on left**, it signifies "Pace of Project" is **extremely favourable/important** than "Structural Complexity")

a) Pace of Project (C1) 1 **Structural Complexity (C2)**

9 7 5 3 3 5 7 9

b) Pace of Project (C1) 1**Dynamics of Project (C3)**

9 7 5 3 3 5 7 9

c) Pace of Project (C1) 1 **Uncertainty in Project (C4)**

9 7 5 3 3 5 7 9

d) Pace of Project (C1) 1 **Socio-political Influence (C5)**

9 7 5 3 3 5 7 9

e) Structural Complexity (C2) 1 **Dynamics of Project (C3)**

9 7 5 3 3 5 7 9

f) Structural Complexity (C2) 1 **ncertainty in Project (C4)**

9 7 5 3 3 5 7 9

g) Structural Complexity (C2) 1 **Socio-political influence (C5)**

9 7 5 3 3 5 7 9

h) Dynamics of Project (C3) 1**Uncertainty in Project (C4)**

9 7 5 3 3 5 7 9

i) Dynamics of Project (C3) 1**Socio-political influence (C5)**

9 7 5 3 3 5 7 9

j) Uncertainty in Project (C4) 1**Socio-political Influence (C5)**

9 7 5 3 3 5 7 9

k) Diff. in eqpt. Deployment (C2.1) 1**No. of Agencies (C2.2)**

9 7 5 3 3 5 7 9

l) Diff. in eqpt. Deployment (C2.1) 1**Other running Projects (C2.3)**

9 7 5 3 3 5 7 9

m) Diff. in eqpt. Deployment (C2.1) 1**Site Congestion & diversion (C2.4)**

9 7 5 3 3 5 7 9

n)	**No. of Agencies (C2.2)**				1**Other running projects (C2.3)**					
9	7	5	3			3	5	7	9	
o)	**No. of Agencies (C2.2)**				1**Site Congestion & Diversion (C2.4)**					
9	7	5	3			3	5	7	9	
p)	**Other Running projects (C2.3)**				1**Site Congestion & Diversion (C2.4)**					
9	7	5	3			3	5	7	9	
q)	**Novelty of Technology (C4.1)**				1**Lack of Information (C4.2)**					
9	7	5	3			3	5	7	9	

Thank you for your time and cooperation

A-6. Questionnaire for Main Survey

A Study of Critical Factors affecting Risk Management in selected Brownfield Steel Projects in India

Dear Sir/Madam,
The objective of this survey is to identify the factors that affect the management of critical risks in selected brownfield construction projects in steel plants of India. Kindly spare out your valuable time to respond on the basis of the project that you have completed or presently handling in your organization. The findings of this survey will strictly be used for academic purposes only.

Susmit Roy
DGM (Academic) & Sr Faculty, MTI and Research Scholar, ICFAI University, Jharkhand

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Name: ____

(Optional)

Designation: ____________________ Organisation: _______________ Deptt: _______________

E-mail: ________________________ Phone____________________

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1. What is the project you that you have recently completed or presently handling:

   Name of Package/ Project: ____________________

   Main Project of which the above package is a part: ____________________

2. What is the value and duration of the package/project:

Package Value (Rs in Crores) :	Package Duration:
Main Project Value (Rs in Crores):	Main Project Duration:

3. **On the basis of this project** , please indicate the following:

   g) **Agencies involved** in the project (package): (Agencies include all consultant/ designer, vendor/supplier, contractor/sub-contractor and statutory agencies – *Please indicate total number of agencies*)

Total number of agencies involved in the project	

   h) **Types of changes and their effect** on your project:

   i) How many Changes/ Change Orders have been issued &implemented (*Please put √ mark against appropriate rows. There may be* *<u>multiple responses</u>* *indicating both major and minor changes*):

a. No Major/ Minor Changes or Change Orders	
b. Minor Changes/ Change Orders upto 5	
c. Minor Changes / Change Orders more than 5	
d. Major Changes/ Change Orders upto 3	
e. Major Changes/ Change Orders more than 3	

i) What is the **type of technology that the facility will be using** in your project :
(Pl. mark √ the appropriate choice)
a) Addition/Modification work with no involvement of technology _____
b) Existing Indigenous Technology ____
c) Foreign Technology available elsewhere in India ____
d) Latest Technology in India ____
e) Latest Technology in World ____

j) **Site and Execution Difficulty** in your project/ package in terms of types of construction machinery used, space restriction at site , socio-political influence, other projects:
(Please indicate on 5-point scale where 1-Very Low, 2-Low, 3-Moderate, 4-High and 5-Very High)

What is the difficulty level of your project :	
a) Difficulty in construction machinery deployment	1 2 3 4 5
b) Difficulty due to site congestion and diversion of existing facility	1 2 3 4 5
c) Difficulty due to other running projects/plants near your project	1 2 3 4 5
d) Internal / external socio–political influences causing difficulty	1 2 3 4 5
e) Difficulty in getting information/ clearance in time	1 2 3 4 5

4. **<u>Risk Management</u>**

4.1 Risk Management framework for your project

a. In your project have you formally identified any risk? Yes _____ / No _____

If yes, how many risks have you identified? *(Please indicate numbers)*____________

b. Did you have any assessment of those risks? Yes _____ / No _____

c. Did you have any response plan for managing these risks? Yes _____ / No _____

d. At what interval did you monitor your response plans? _______________
(Please mention weekly / monthly / quarterly / half-yearly/ none)

e. Do you have any formal documentationof these risks like Risk Register or others? Yes _____ / No _____

4.2 Risk Response Options(RRO) and Risk Response Factors (RRF)- For each of the identified risks indicate the most appropriate risk response and the risk response factors as explained below:

Types of **Risk Response Options (RRO)**& action thereof
1. Avoid – *eliminate the threat or protect the project from its impact.*
2. Transfer *– shift the risk event to other person or organisation together with the ownership of the response.*
3. Mitigate *– reduce the probability of occurrence or severity of impact of a risk event.*
4. Accept (active) *– acknowledge the risk, provide some contingency fund and use it when the risk occurs.*
5. ***Accept (passive) –*** *acknowledge the risk and not take any action unless the risk event occurs.*

There are several factors that influence these options. These factors are termed as **Risk Response Factors (RRF)**. For each risk response there can be Human Response Factor (HRF) influence **and/or** Systemic Response Factor (SRF) influence.

HRF	***Competency of Project Manager / Project team helps to respond to the risk –*** **-** *technical competency of project manager/ project team e.g domain knowledge, experience* - *managerial competency of project manager e.g planning, organizing and controlling* - *leadership competency of project manager e.g decision making, communication, motivation etc.*
SRF	***Systems and processes/contractual provisions/ available project information data helps respond to the risk*** *– ProperSystems for monitoring, vendor selection, Changes, Approvals, Payments* ***–*** *Provisions in contract / specifications/ terms and conditions,.* **-** *Availability of proper information system.*

As per experience of the **project that you have mentioned above**, kindly indicate the **Probability of Occurrence (PO)** and S**everity of impact (SI)**for each of the risks below in columns 3 and 4.

The **Risk Response Options (RRO)** those have been adopted in your project and the **Risk Response Factors (RRF)**those have influenced these risk responses are to be indicated in columns 5 and 6.

(Please indicate on the scales mentioned below, for the following columns 3 to 6 below)

1	2	3	4	5	6	
Sl No.	Risk / Risk Event	Risk **PO** (Scale 1-5)	Risk **SI** (Scale 1-5)	Risk Response Options (RRO) (1-5)	Level of Risk Response Factor (RRF) influence in a scale of 1 to 5, where 1 = Very Low, 2= Low, 3= Moderate, 4= High, and 5 = Very High	
		1- V. Low 2- Low 3- Moderate 4- High 5- V. High	1- V. Low 2- Low 3- Moderate 4- High 5- V. High	1-Avoid 2-Transfer 3-Mitigate 4-Accept (active) 5-Accept (passive)	**HRF** = Human Response Factor	**SRF** = Systemic Response Factor
1	Delayed supply of equipment/ equipment parts causing delay					
2	Inadequate Safety provisions at siteleading to accidents and resulting in delay					
3	Contractor having inadequate workmen and equipment causing delay					
4	Improper cost estimates causing cost overrun					
5	Delay in approval of design and drawings causing time overrun					
6	Contractor developed financial problems during the project causing delay					
7	Unrealistic time estimate of activitiesand duration of the project causing time overrun					
8	Poor Subcontractor performance causing both time and cost overrun.					
9	Excessive variation in quantity creating difficulty in payment causing delay and cost overrun					
10	Delay in getting statutory clearances like environmental clearance, CEA					

	clearance, explosives clearance					
11	Inadequate project planning with poorly defined tasks causing delay					
12	Inexperienced Contractor causing delay					
13	Delay in payment to the contractor resulting in delay in project					
14	Defective construction methods/ work causing cost and time overrun & affecting work quality					
15	Absence of proper review/ control process for approval of changes in scope or schedule or specification					
16	Work-fronts / shutdown not being made available in time causing delay.					
17	Not adequate skilled manpower available for the project manager for supervision causing delay.					
18	Natural Disaster/ Force Majeure causing delay and additional cost.					
19	Permanent loss of people from the project team/ frequent changes in the project team causing delay.					
20	Unforeseen ground condition causing time and cost overrun.					
21	Increase in scope due to additional requirement causing cost and/or time overrun.					
22	Top management support is not available at the time					

	of requirement causing delay.					
23	Inadequate technical and managerial capability of Project Manager while handling multiple projects causing time and cost overrun.					
24	Incomplete understanding of the scope of work causing time and cost overrun.					
25	Equipment got damaged during transit/ or at site causing delay and/or incurring cost.					
26	Defective (with error and omissions) / Non-executable Design causing delay and addl.cost.					
27	Delay in arranging for necessary construction equipment/ cranes by the contractor causing delay.					
28	Demand of the product / service falling down making project ineffective.					
29	Lacking information (lack of supply information, Lack of design data, engineering data etc.) causing delay.					
30	Excessive exchange rate fluctuation may adversely affect the project.					
31	Uncertain Inflation rates may adversely affect the project cost/ budget					
32	Changes in Taxes and duties adversely affect the project cost / budget.					
33	Inadequate checking or interfacing among different packages					

	leading to rework and time overrun.					
34	Improper interpretation or rigidity in interpretation of contract documents leading to delay.					
35	Absence of proper Quality Assurance Plan (QAP) leading to both cost and time overrun.					
36	Improper Billing Schedule and its adherence affects the schedule adversely.					

You may suggest any other risk and its management in steel plant projects, which has not been indicated above:

1.____

2.____

3.____

Thank you for your time and cooperation.

A-7 Expert Interview Guidelines & Questions

Expert Interview for the study of Critical Factors in Risk Management for Brownfield Construction Projects in Steel plants

Dear Sir/Madam,
A research study is being carried out by the undersigned on the above mentioned subject. The risk in a project is assessed in terms of **Risk Potential Score (RPS)**, which is measured as the geometric mean of **Probability of Occurrence (PO)** of the risk and the **Severity of consequences (SEV)** on project if they occur. Both of them are measured in a scale of 1 to 5. Further the objective of the present interview is to get your idea about the relationship of the complexity of the project and the criticality (measured on the basis of RPS) of risk in a project. Further, we would also like to have your idea on the **Risk Response Factors (RRF)** and their effect on the choice of **Risk Response Option (RRO)**. Kindly spare some of your valuable time to respond on the basis of your vast experience in handling **brownfield construction projectsin steel plants** in your respective organization. The responses of this survey will be strictly used for academic purposes only.

Susmit Roy
DGM (Academic) & Sr Faculty, MTI and Research Scholar, ICFAI University, Jharkhand

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Name: ____

Designation: ______________________ Organisation: _________________ Deptt: _________________

E-mail: ___________________________ Phone_____________________

Risk Response Options (RRO) adopted by the Project Manager or his project team can be several like Avoid, Transfer, Mitigate/ Reduce and Accept. **Risk Response Factors(RRF)** categorized as**Human Response Factors(HRF)**and **Systemic Response Factors(SRF)** have an effect on the choice of Risk Response Option and actions taken under this choice.

a) Risk Response Options are explained below:

Risk Response Options (RRO)	Description
Avoid	To eliminate the threat or the risk/ risk event from the project.
Transfer	To shift the impact of the risk event in the project to a third party
Mitigate	To reduce the probability of occurrence or impact of a risk event.
Accept	To acknowledge the risk and not take any action unless the risk occurs. Acceptance can be either active (with contingency reserve) or passive (without any provision).

b) Risk Response Factors – the factors that influence the Risk Response Option and classified as Human Response Factors (HRF) and Systemic Response Factors (SRF) are explained below:

HRF- Human Response factors	– technical competency, – managerial competency – leadership competency of project manager or his team.
SRF- Systemic Response Factors	– proper systems and processes for monitoring and review of risks, – provisions in contractual terms to take of such risks, – proper system of communication within project team and stakeholders, – data gathering and dissemination.

c) Complexity of a project is measured based on five attributes: i) Pace of the project measured in terms of value and duration, ii) Structural complexity of the project in terms of agencies involved, site congestion and equipment placement difficulty, other running projects, iii) Dynamics of the project in terms of no. of changes/ change orders, iv) Uncertainty in terms of technological novelty & lack of information and v) Socio-political influence in terms of influence from internal sources or external sources on the project.

Overall Complexity of a project is calculated based on the proportionate representation of the above five attributes.

Your insights on the following observations resulted from the study:

1. The study has identified that there is a positive correlation between project complexity and the criticality of risk (measured in terms of Risk Potential Score). **Why is there a positive relationship?**

2. The data analysis suggested that in responding to the risks, project complexity do not have any significant relationship with risk response factors but risk criticality (measured in terms of Risk Potential Score) has a positive correlation with the Risk Response Factors - both human as well as systemic response factors. **Why is it so?**

3. In terms of their relative influence on the Risk Response Option for managing risks, it has been found out from the responses that in case of the critical risks Human Response Factors and Systemic Response Factors have statistically the same level of influence. While in other cases the influence of Human response factor is predominant. **What is your opinion about these results?**

4. **Risk related to reputation of contractor:** If a contractor is having good track record it will succeed but in case the contractor is not having such past records it may fail.
   a) Is it a risk? Yes/ No
   b) In case, it is a risk, what is your preferred Risk Response Option?

Avoid	Transfer	Mitigate	Accept (active)	Accept (passive)

   c) Which Risk Response Factor influence the Risk Response Option more?

Human Factors	Systemic Factors	Both Human & Systemic

5. The **integration of different steel making technologies** is a risk for any construction project in steel plants
   a) Is it a risk? Yes/ No
   b) In case, it is a risk, what is your preferred Risk Response Option?

Avoid	Transfer	Mitigate	Accept (active)	Accept (passive)

   c) Which Risk Response Factor influences the Risk Response Option more?

Human Factors	Systemic Factors	Both Human & Systemic

6. In case of Modernisation and Expansion Projects the general idea goes that in modernization case the risk related to shutdown is a major risk since it disturbs the existing facility directly whereas in case of expansion it relates to some addition only to the existing facility and as such the risk of shutdown is not a major risk.
   Whether risk of project delay because of not getting shutdown is more in case of modernization project or in case of expansion project?

Thank You for your valuable time

A-8 List of Publication

- Published a paper titled “Managing Project Risks Through Effective Interaction Between Project Manager and Stakeholders” in the quarterly journal “Growth” (ISSN 2249 – 6394) by Management Training Institute, SAIL, Ranchi, Volume 42, Issue 4, Jan – March, 2015.
- Published a paper titled “Integration of Project and Change Management – Is it imperative for project success?” in the “IUJ Journal of Management” (ISSN : 2347 – 5080) published by ICFAI University Jharkhand, Volume 4, Issue 1, May 2016.
- Published a paper titled “Building Project Management Capability in a large Manufacturing Organisation- Does it contribute to Competitive Advantage” in the quarterly journal “Growth” (ISSN 2249 – 6394) by Management Training Institute, SAIL, Ranchi, Volume 44, Issue 1, Apr - June, 2016.
- Published a paper titled “Construction Projects in Steel Plants - A study of Project Owner’s Perception of Project Risks in relation to Project Complexity” in an edited book titled “Construction Management, Mechanization and Environmental Sustainability” published by White Falcon Publishing, ISBN - 978-93-86210-85-2, February 2017.
- Published a paper titled “Complexity of Construction Projects – Evolving Ideas and Applicability in Steel Plant Projects” in the quarterly journal “Growth” (ISSN 2249 – 6394) by Management Training Institute, SAIL, Ranchi, Volume 45, Issue 2, July - Sept, 2017.
- Written and presented a paper on “Study of the influence of project complexity on the criticality of risks in construction projects in steel plants – A Project Owner’s Perspective” Management Doctoral Colloquium and VGSOM Research Scholar Day, IIT Kharagpur on March 14, 2018.
- Published a paper on “Analysing Turnaround and its Process in the light of Project and Project Management Process” in the quarterly journal “Growth” (ISSN 2249 – 6394) by Management Training Institute, SAIL, Ranchi, Volume 46, Issue 1, Apr - June, 2018.
- Published a paper titled “Managing Construction Project Risks in Steel Plants – A Remedial Approach” in An international multidisciplinary peer-reviewed Quarterly Research Journal, ISSN 2277 – 5730, (UGC listed journal with Impact Factor/Indexing 2018 - 5.5), Volume VII, Issue – III, July-Sept, 2018.