Risk Management and Analysis in Hydro-Electric Projects in India

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Abstract

Risks are very common in the construction of hydroelectric projects as hydro projects are very complex structures. Hydroelectric projects are susceptible to various technical, socio-political, construction and environmental risks. The track record of construction industry to deal with these risks has not been very good. This paper deals with identification of different risk factors and analyzing various risks involved in hydroelectric projects.Responses were collected from experts in different organizations through questionnaire survey and then collected data were analyzed to rank the different risk factors depending on their probability and impact to the hydroelectric projects. Main contributing risk factors in hydroelectric projects include land acquisition problems, resettlement & rehabilitation, flooding, complexity of project, non-availability of hydrological data.

Keywords — *Risk, Risk Management, Construction, Hydro-electricProjects.*

I. INTRODUCTION AND RESEARCH AIMS

Construction of hydroelectric projects is usually more complicated and risky due to nature of different activities involved. Hydroelectric projects are categorized as complex structures and occupy a huge amount of funds with a long running construction period. This situation imposes various uncertainty factors such as differing site conditions, unpredicted geological structure at tunneling sites, seepage problem from dam, landslides and environmental issues. No construction project is totally risk free. Risk plays an important role in the success of any construction project. Risk can be defined as any action which will affect the achievement of project objectives, such as time and schedule, cost, quality of work. The core element of project success is in time completion, within specific budget and requisite performance. The construction phase is identified as a critical phase in hydro power projects where many unforeseen factors occur. Failure to manage project risks leads to major problems for the client such as completion time delays and cost overruns. Risk can be managed, minimized, shared, transferred or accepted. It cannot be ignored. In the literature a vast research has been done on risk analysis in construction projects but risk analysis and management in hydroelectric projects is very limited. In order to manage a project, risk management is an important step to make it successful. The purpose of risk management is to achieve the objectives of hydroelectric project in terms of time, cost, quality, safety and environmental sustainability. Risk management is a process of identifying, classifying, analyzing, assessing and controlling of risks in hydroelectric project. Hydro plants have become more vulnerable due to increase in frequency of natural disasters in recent times. Risk mitigation has therefore become more challenging. It applies to any project to evaluate the various risks involved in the construction of hydro-electric projects so that in future it will be beneficial for hydro-electric projects. The basic aim of this paper is to identify and classify risks according to their nature and potential consequence in hydro-electric power projects and to analyze and manage risks in hydro power projects.

II. BACKGROUND

An extensive research has been undertaken in the field of risk management in construction projects in the past and a limited research has been conducted in risk management in hydroelectric projects. Al- Bahar and Crandall (1990), used influence diagramming technique and Monte Carlo simulation to analyze and evaluate project risks. According to Akintoye and Macleod (1997), formal risk analysis and management techniques are rarely used in construction industry due to lack of knowledge and doubts on the suitability of these techniques for construction industry activities. A critical literature review Barber (2005), concludes that, internally generated risks arise within a project management team or its host organization, culture and decisions. Internally generated risks are important and require special attention and to be managed effectively. Kansal and Sharma (2012), adopt risk significant index method for analyzing the risks. Author concludes that each risk assessment method has their limitations so this paper effort to device integrated risk assessment tools. Mahendra et al. (2013), introduces risk management technique which includes welldocumented procedures to control the risks likely to occur during any construction project lifecycle. It should be applied into any construction project to get maximum benefit of the technique. Relationship between emotions and risk- taking behavior of people working in the construction projects is described by Tixier et al. (2014). A principal component analysis (PCA) was performed to identify emotions among various groups of participants. Some tests were used to check the differences in risk perception between participants who belong to different emotional groups. A new approach for hydropower project risk assessment through the fuzzy set of concepts is introduced by Patel and Singhal (2015).Dharmapalan et al. (2015),introduces an online risk assessment tool titled as Safety in Design Risk Evaluator (SliDeRule) to evaluate safety risk of designs. Safety risk is present in multistory buildings.

III. RESEARCH METHODOLOGY

In this paper, at the outset, general focus has been made on the general concepts of project risk management. Literature provides the theoretical context about the project. The various risk factors involved in the construction of hydroelectric power projects are determined from literature review, telephonic conversations and from the past record of construction of hydroelectric projects and a questionnaire is designedand different risk factors were put into eight categories, with 12 risks related to financial problems, 21 related to construction, 6 related to environment, 11 related to socio-political risks, 11 related to management, 5 related to physical risks, 4 related to legal risks and 6 are technical risks. The questionnaire consisted of three sections. Section I consists information about the company profile and section II contains information about respondent. Section III carried a total of 76 risks associated with construction of hydroelectric projects and asked respondents to review and indicate the probability of these risks using five point scale ranging from 1 to 5 (rarely, sometimes, frequently, very frequently, mostly) and the level of impact on each project objective that would result in as very low, low, medium, high, and very high (1 to 5).To achieve the objectives of this paper, questionnaire was deemed to be the most helpful tool for collecting information. The general methodology of this study relies largely on the survey questionnaires, which were distributed through electronic mailing to 36 respondents (mainly people who work in hydroelectric projects who enjoy a leading role in planning and construction management, e.g., project managers, general managers, civil engineers) from government and construction companies in the defined area of study. Usable questionnaire were returned by 20 respondents consisting of 2 contract officers, 2 senior managers, 3 project managers, 4 construction managers, 9 engineers. Subsequently results from interviews and questionnaires are presented. Discussion is done on the results from the interview and then risks identified are analyzed and compared to theoretical framework. Finally the final recommendations are drawn up in the conclusion section.

A. Risk Management in Hydroelectric Projects

Risk management is an ongoing and iterative process which should be conducted throughout the lifecycle of a hydroelectric project. Risk management is a systematic way of identifying, analyzing and responding to risks to achieve the objectives of hydroelectric project in terms of time, cost, quality, safety and environmental sustainability. Risk management is probably the most difficult phase of project management. Managing risks in construction of hydroelectric projects has been recognized as a very important process in order to achieve project objectives.Risk management in hydroelectric projects includes: risk identification, risk analysis, risk response planning, risk monitoring and control.Risk identification is the first and most important step in risk management process as it identifies the source and type of risks. Risk identification develops the basis for next steps of risk management process. A large number of tools and techniques exist for risk identification such as:Brainstorming, Risk checklists, Interviews, Questionnaires, Past experience, Delphi techniques, Visit location, Historical data from similar projects, Study specialist literature (Kansal and Sharma, 2012). Identification of risks in hydroelectric projects relies mostly on questionnaire survey and past experience that should be used in upcoming projects.

B. Risk Analysis and Assessment

After the risks are identified they must be individually assessed as to their potential probability and consequence (Borge, 2001).Qualitative analysis of data for risk assessment can be done by risk assessment matrix and risk potential value method. Risk potential value method (A x B) is used to rank the risk exposure by assessing the subjective probability and impact of each risk event.

(A) Risk Probability$=\frac{\sum an}{N\times A}\times 100$

(Where a= constant expressing the weight assigned to each responses from 1 to 5, n= probability of each response, N= total number of responses, A= highest weight (i.e. 5 in this case)

(B) Risk Impact$=\frac{\sum an}{N\times A}\times 100$

(Where a= constant expressing the weight assigned to each responses from 1 to 5, n= impact of each response, N= total number of responses, A= highest weight (i.e. 5 in this case)

(C) Risk Potential = Risk Probability (A) x Risk Impact (B)

Then risk exposures can be ranked in descending order in order to select the major risk events requiring further analysis. A simple probability and impact matrix for each risk event is developed. Risk exposure can be categorized into four main categories as low, medium, high and critical. Quantitative method of risk assessment is done for potentially high exposure risks, which are ranked after the risk qualitative analysis method. The choice of risk quantification techniques will depend upon the nature of risk under consideration. There are various techniques used for quantitative risk analysis such as: Decision tree and decision network analysis, Sensitivity analysis, expected monetary value (EMV), Scenario analysis, Probabilistic analysis (MCS) and PERT network analysis technique.

IV. RESULTS AND DISCUSSIONS

During construction of hydroelectric project, risks can result from many circumstances. Based on the data analyzed earlier, a total of 7 sources of risks in hydroelectric projects are identified and analyzed. Once the risk factors in hydroelectric project are determined, risk probability and risk impact can be calculated as shown in Table 1. The risk assessment matrix illustrates a risk rating for individual risk factors in the identified risk categories. The risk assessment matrix shows the combination of probability and impact that in turn yield a risk priority (shown by red, orange, green and blue color). Risk with high probability and high impact such as C20(Unpredicted geological structure at tunneling sites), SP2(Land acquisition problems), SP3(Resettlement & rehabilitation), C4(Adverse geological conditions), C6(Labor strikes), C17(Access conditions), E1(Natural disasters), E4(Flooding), F10(Owner financial capacity), F11(Paucity of funds), M8(Time constraint), M9(Project delay) are required further analysis. According to risk potential value method (A x B) major risk factors can be identified among the factors which lie in the critical region in the risk assessment matrix.

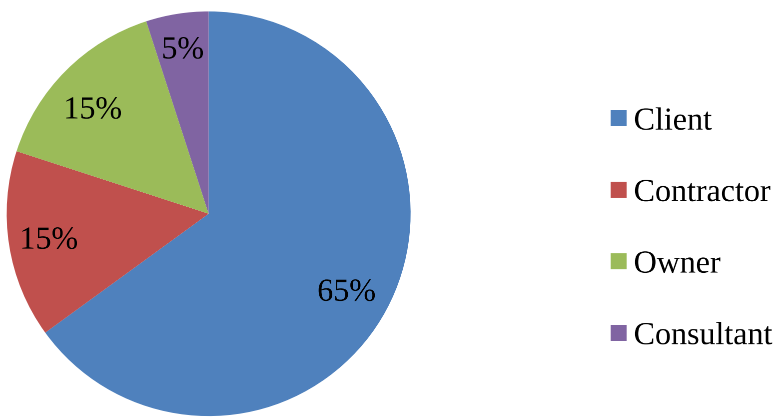

Fig 1.Responses from different questionnaire

Table I-Risk Categories

I.D	Risk Factors	Risk Probability(A)	Risk Impact (B)	Risk Potential (AxB)
	Financial Risks			
F1	Loss due to fluctuation of interest rate	0.41	0.38	0.16
F2	Low credibility of shareholder and lender	0.56	0.61	0.34
F3	Change in bank formalities and lenders	0.34	0.41	0.14
F4	Loss due to rise in fuel prices	0.4	0.42	0.17

F5	Increased material cost	0.65	0.78	0.51
F6	Insurances risk	0.55	0.61	0.34
F7	Improper estimation	0.62	0.8	0.50
F8	Payment delays	0.53	0.69	0.37
F9	Invoices delay	0.46	0.54	0.25
F10	Owner financial capacity	0.62	0.81	0.50
F11	Paucity of funds	0.65	0.82	0.53
F12	Tax rate	0.5	0.59	0.30
	Construction Risks			
C1	Labor availability	0.61	0.73	0.45
C2	Drop in labor productivity	0.58	0.72	0.42
C3	Differing site conditions	0.63	0.67	0.42
C4	Adverse geological conditions	0.77	0.81	0.62
C5	Faulty construction work at site	0.61	0.73	0.45
C6	Labor strikes	0.78	0.87	0.68
C7	Labor disputes	0.66	0.72	0.48
C8	Equipment quality	0.62	0.7	0.43
C9	Equipment maintenance	0.56	0.61	0.34
C10	Material delivery	0.66	0.76	0.50
C11	Material shortage	0.64	0.75	0.48
C12	Material procurement	0.54	0.67	0.36
C13	New technology	0.54	0.66	0.36
C14	Nominated vendors	0.53	0.55	0.29
C15	Delay in permits and licenses	0.54	0.64	0.35
C16	Site location (rural/urban)	0.7	0.72	0.50
C17	Access conditions	0.76	0.82	0.62
C18	Seepage problem from dam	0.62	0.69	0.43
C19	Blasting work	0.68	0.71	0.48
C20	Unpredicted geological structure at tunneling	0.83	0.88	0.73
C21	Design changes	0.68	0.72	0.49
	Environmental Risks			
E1	Natural disasters	0.66	0.84	0.55
E2	Earthquake	0.55	0.77	0.42
E3	Landslides	0.74	0.7	0.52
E4	Precipitation/Flooding	0.77	0.9	0.69
E5	Unpredicted weather conditions	0.6	0.69	0.41
E6	Adverse environmental conditions	0.58	0.66	0.38
	Socio-political Risks			
SP1	Changes in laws and regulations	0.5	0.64	0.32
SP2	Land acquisition problems	0.85	0.95	0.81
SP3	Resettlement & rehabilitation	0.84	0.91	0.76

SP4	Litigations	0.62	0.73	0.45
SP5	Pollution and safety rules	0.5	0.55	0.28
SP6	Bribery/Corruption	0.45	0.52	0.23
SP7	Language/Cultural barrier	0.47	0.48	0.23
SP8	Law and order	0.44	0.59	0.26
SP9	War and civil disorder	0.35	0.6	0.21
SP10	Social acceptance	0.54	0.65	0.35
SP11	Requirements for permits and their approval	0.54	0.69	0.37
	Management Risks			
M1	Change in top management	0.54	0.68	0.37
M2	No past experience in similar project	0.59	0.74	0.44
M3	Short tender time	0.47	0.63	0.30
M4	Internal management problem	0.57	0.69	0.39
M5	Improper project feasibility study	0.53	0.76	0.40
M6	Poor relation and disputes with partner	0.58	0.74	0.43
M7	Team work	0.56	0.73	0.41
M8	Time constraint	0.69	0.81	0.56
M9	Project delay	0.65	0.81	0.53
M10	Quality control process	0.63	0.71	0.45
M11	Type of contract	0.65	0.72	0.47
	Physical Risks			
P1	Damage to structure	0.53	0.73	0.39
P2	Damage to equipment	0.5	0.66	0.33
P3	Labor accidents	0.61	0.66	0.40
P4	Equipment breakdown	0.57	0.71	0.40
P5	Material theft & damage	0.58	0.57	0.33
	Legal Risks			
L1	Breach of contract by project partner	0.43	0.53	0.23
L2	Lack of enforcement of legal judgment	0.46	0.53	0.24
L3	Improper verification of contract document	0.49	0.59	0.29
L4	Uncertainty and unfairness of court justice	0.39	0.51	0.20
	Technical Risks			
T1	Incomplete design	0.52	0.7	0.36
T2	Inadequate specification	0.55	0.69	0.38
T3	Inadequate site investigation	0.6	0.72	0.43
T4	Change in scope	0.59	0.71	0.42
T5	Construction procedures	0.61	0.71	0.43
T6	Insufficient resource availability	0.61	0.77	0.47

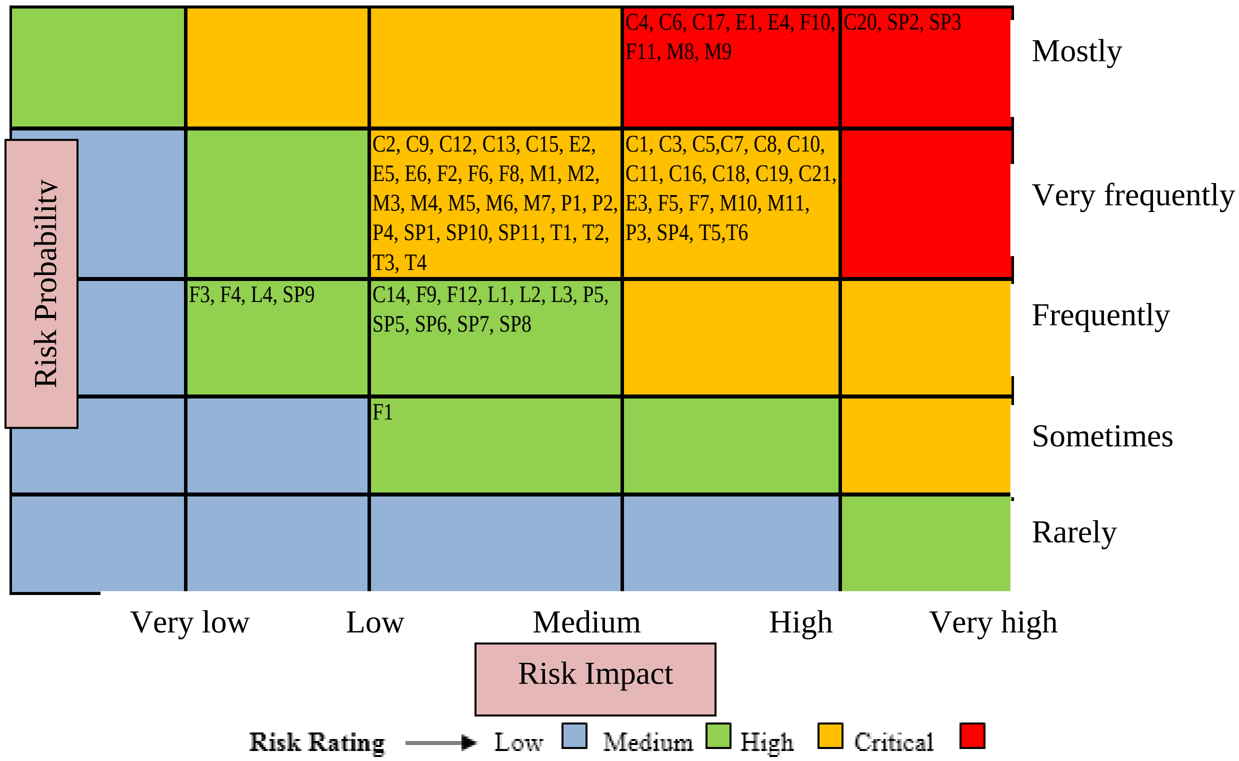

Figure 2. Risk assessment matrix

Table II - Ranking Of Risk Factors According To Risk Potential Value Method

Risk Factors	Rank
Land acquisition problems	1
Resettlement & rehabilitation	2
Unpredicted geological structure at tunneling sites	3
Precipitation/Flooding	4
Labor strikes	5
Adverse geological conditions	6
Access conditions	7
Time constraint	8
Natural disasters	9
Paucity of funds	10

V. CONCLUSION

Risk management in hydroelectric projects is done in a very informal manner. Questionnaires were found to be the most preferred method of risk identification in hydroelectric projects. Detail arrangement of risk identification, analysis and the resolution of risks can reduce the chances of time and cost over-run in a hydro-electric project. The research results obtained through questionnaire survey shows that environmental risks, construction risks and sociopolitical risks are the greatest risk categories in hydropower construction projects. Further the results reveal that ten risk factors such as: land acquisition problems, resettlement & rehabilitation, unpredicted geological structure at tunneling sites, precipitation/ flooding, labor strikes, adverse geological conditions, access conditions, time constraint, natural disasters, paucity of funds have high risk potential value. These risks commonly delays the completion time of construction of hydroelectric projects. So these types of risks should be managed in the hydroelectric project to avoid any delay and cost overrun. Majority of the hydropower construction projects have no systematic procedures to deal with the risks. Most of the companies do not have proper risk management procedure. Only few companies conducted risk management in different construction projects. More study is to be required on risk management in hydroelectric projects so that in future that can be incorporated for successfully completion of project.

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