CHAPTER-5

RESEARCH METHODOLOGY

5.1 OVERVIEW:-

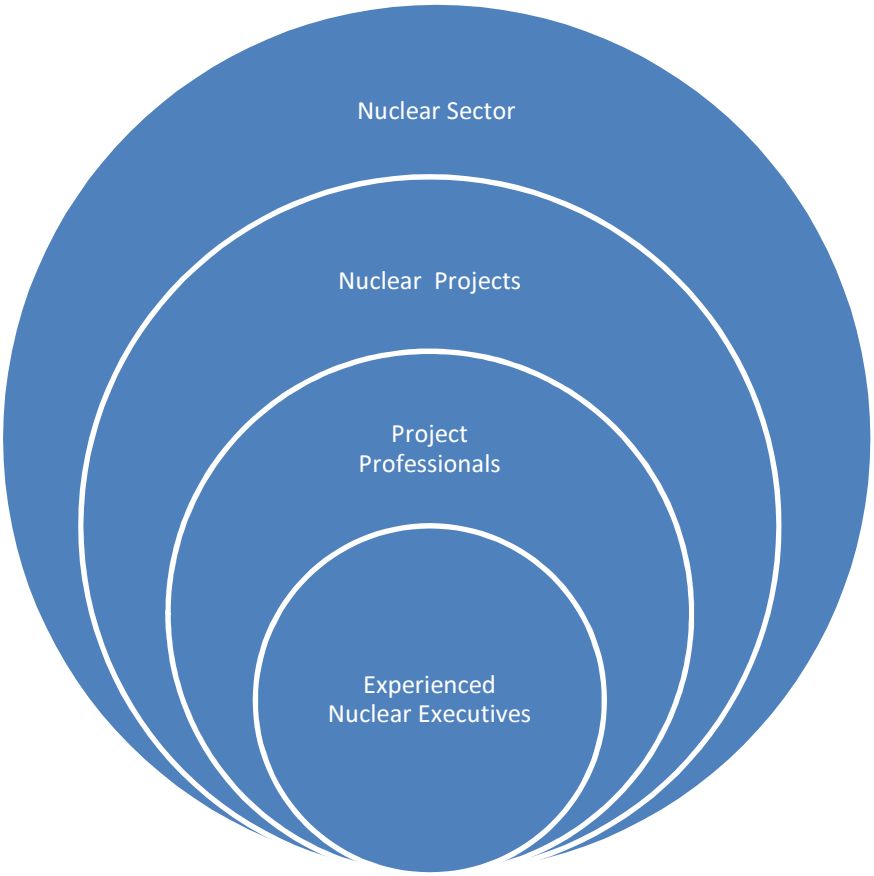
The chapter covers the sampling, questionnaires formation, data collection and data analyses. The testing for questionnaires, sample size and response bias are discussed. The responses are compiled in tabular form. A comparative study is carried out to check the applicability of in-practice models of construction sector in Indian Nuclear sector.

5.2 SAMPLING:-

Nuclear sector is a specialised sector among the construction sector. Limited manpower is working in this sector. Further nuclear projects have limited population in sampling point of view. In order to get the right representation, nuclear sector projects are taken as population. Experienced executives engaged in nuclear projects are the target respondents. The judgmental, a non-probability sampling is found most appropriate for collecting the data, assuming that there is an even distribution of characteristics to get more accurate and representative sample. The underlying assumption is that respondents are from nuclear sector executive and have sufficient project execution experience. To counter the biased nature of judgmental sampling, contactors and consultants are also included in the sample in addition to project authority.

Sampling space, sampling frame and sample is represented in Figure No. 5.1.

Figure No.-5.1:- Sampling

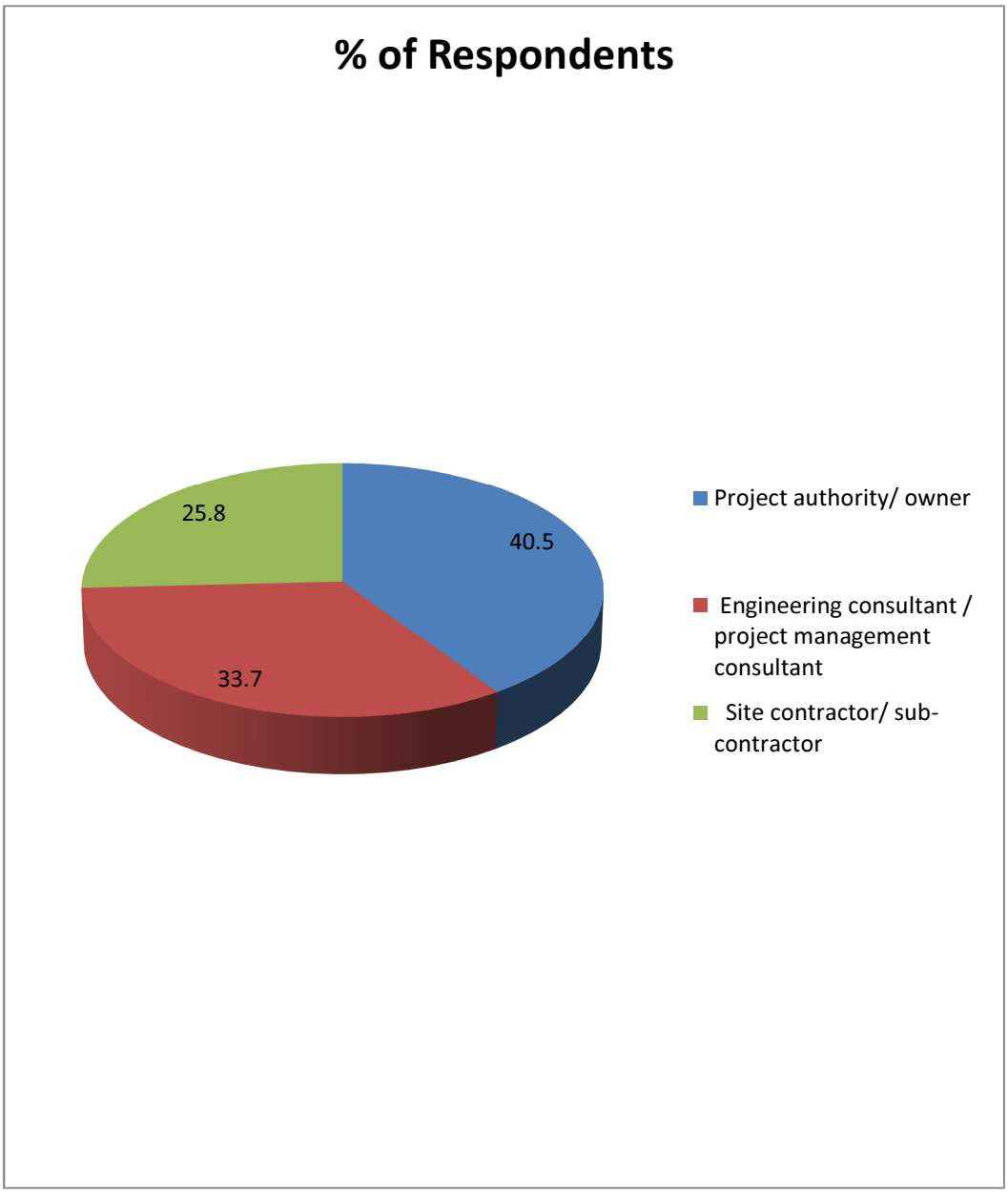


The questionnaires are sent & collected by post, email and personal delivery from project authority, consultants, and contractor. 555 valid responses are received and compiled. The responding mode is tabulated in Table no. 5.1 and percentage of responding mode is presented in Figure No.- 5.2 .

Table -5.1:- Responding Mode

Respondent profile	**Project authority/ owner**	**Engineering consultant / project management consultant**	**Site contractor/ sub-contractor**
Nos. of respondents	225	187	143

Figure No. 5.2:- Percentage of Responding Mode



SAMPLE SIZE: The professionals involved in projects execution in nuclear sector are limited. About 2000 GOI professional are involved in nuclear projects for various activities like design, planning & scheduling, procurement, construction & commissioning, operation& maintenance, research & development and QA etc. The professional from consultancy and construction firms, working for nuclear sector, are around 1500. So, total sample population size is 3500. Experienced executives involved in nuclear project execution activities are around 1000. The sample size of 1000 is targeted as respondents which was 29 % of the population. Samples are collected from the stake holders of nuclear energy sectors. 555 valid samples are collected. This represents 16% of the population and 55% of sample size.

On comparison the sample size with random sampling for 95% confidence level & +/-5% margin of error and 3500 as population, the sample response size should be more than 346. In this case it is 555.

The following firms/ departments those are related to nuclear sector are contacted for response;

Project authority/owners:-

i. Bhabha Atomic Research Centre(BARC)
ii. Nuclear Power Corporation of India Ltd. (NPCIL)
iii. Bharatiya Nabhikiya Vidyut Nigam Limited(BHAVINI)
iv. Heavy Water Board (HWB)

Consultant :-

i. M/S Rolta India Ltd.
ii. M/S Tata Consulting Engineers (TCE)

iii. M/S Stup India Ltd.

iv. M/S Development Consultancy Ltd. (DCL)

Contractor:-

i. M/S Larsen &Tuobro (L&T)

ii. M/S Godrej

iii. M/S Balchandnagar Industries

iv. Electronics Corporation of India Ltd. (ECIL)

v. M/S Avarsarla India Ltd.

vi. Hindustan Machine Tools (HMT)

vii. M/S Kay Bouvet

5.3 DATA COLLECTION:-

The objectives of the study are to identify the relative importance of delay and strategic factors attributes in Indian nuclear sector projects. The study is however restricted to Indian nuclear sector projects and respondents are from this sector only. Due to non-availability of earlier published/ entrusted document/data of nuclear projects in India, a questionnaire survey approach is considered to establish the impact of various attributes on project performance. Questions are framed to ascertain the impact of these attributes individually on project schedule parameters and strategic factors required for model formation.

5.3.1 QUESTIONNAIRES FORMATION :-

During the framing of questions relevant to nuclear sector project are taken from the literature for construction sector and reframed in accordance to nuclear sector. Total 38 samples of questions are prepared and sent for 30 targeted respondents. The responses are analysed. The questionnaires and the responses are discussed face to

face with 20 expert of the nuclear field. The discussions are held on following points;

i. Relevance of questions.

ii. Clarity in understating of questions.

iii. Overlapping/ repetition of subject in questions.

iv. Numbers of question to be included in questionnaires.

Finally 10 key attributes related to delay, eight attributes related to strategic factors and two cost- schedule relationship & coordination factors are identified under three categories namely project owner, consultant and contractor.

A five point Likert scale (1-strongly agree, 2-agree, 3-neutral, 4-disagree, 5 strongly disagree) is adopted where respondents are asked to rank the importance and impact of a particular attribute on delay and strategic factors.

5.3.2 Reliability Testing:- The collected responses are analyzed for reliability. The questions are tested for reliability by using SPSS (Statistical Package for Social Sciences). The Cronbach's Appha is calculated for internal consistency estimate of reliability.

Value of Cronbach's Alpha is .967, which comes under the excellent reliability category (High Stakes Testing).

Final Questionnaires prepared for getting the response are attached as annexure-III.

5.3.3 LIST OF VARIABLE:- The following ten variables were identified for Analyses of delay factors:

i. Delay due to poor / backward project planning & scheduling.

ii. Delay due to lack of communication among the involved agencies.

iii. Delay due to poor site coordination with other agencies.

iv. Delay due to external social & political factors.

v. Delay due to inefficient purchase & procurement system.

vi. Delay due to inefficient site management.

vii. Delay due to lack of clarity in project scope/process/ technology.

viii. Delay due to improper selection of contractor.

ix. Delay due to lack of commitment among contractor/ consultant professionals.

x. Delay due to lack of commitment among project authority/owner.

The following eight variables were identified for analyses of strategic factors:-

i. Professional management training shall be must for all engineers &staffs involved in project.

ii. There is need to create the agency to carry out the awareness activities among the society to address the social issues .

iii. Quality Assurance shall be kept as independence agency to meet the stringent safety requirement.

iv. MIS (Management Information System) can play a great role for coordinating & controlling the project schedule.

v. Use of professional management tools & practices will help to meet project cost & schedule.

vi. Research & development dept. shall be kept away during execution of project. They have to play role before project starting.

vii. Involving a professional management agency (third party) to take care of project monitoring & control will help in project execution.

viii. Involving an independent coordinating agency to take care of coordination, will help to meet the target cost & schedule.

5.4 DATA ANALYSIS TOOLS :-

Relative Importance Index (RII) has been used to analyse the relative importance of attributes. (Assaf , 1995; Faridi and El-Sayegh, 2006; Iyer and Jha, 2005; Kumaraswamy and Chan, 1998). (Hemanta , Anil, Iyer & Sameer , 2012).

Many researchers (Assaf , 1995; Faridi and El-Sayegh, 2006; Iyer and Jha, 2005; Kumaraswamy and Chan, 1998) have opinion that mean and standard deviation of each individual attribute is not a suitable measure to assess overall rankings as they do not reflect any relationship between them. And hence RII is used, which can be calculated using the following equation .(Iyer & Jha, 2005) .

$$RII = (\Sigma W) / (AxN)$$

Here

RII: Relative Importance Index

W: Weight given to each attribute by respondent

A: Highest weight

N : Total number of respondents.

The attributes are arranged in ascending order of ranks. The attribute with highest RII, is ranked as first. It indicates that it has the maximum impact on the delay/ strategic factors. While the attribute with lowest rank indicates that it has the lower impact on delay. (Hemanta , Anil, Iyer& Sameer , 2012).

5.5 RESPONDENTS PROFILE:-

Respondents are selected from a range of professionals engaged in the Indian nuclear project sector (project authority, consultants and contractors). All the respondents identified have experience in execution of nuclear projects. The sample consists of project

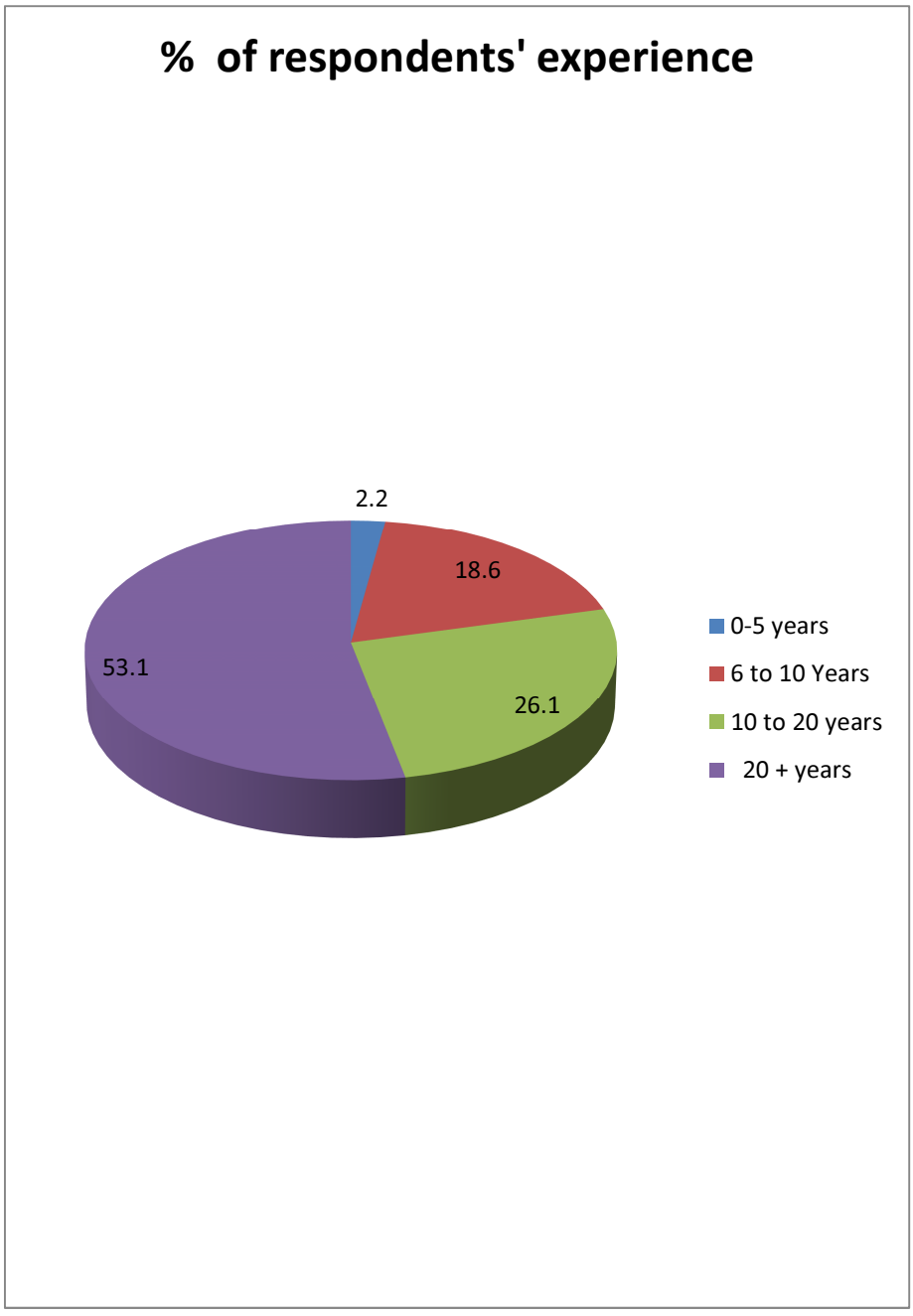
authority/owners, consultants and contractors/suppliers. The respondents' profiles in term of experience is tabulated in Table No.-5.2. A total of 1000 questionnaires are sent to targeted respondents. Out of which 555 valid responses are obtained with a response rate of 55%. The quality of the responses are considered to be highly reliable for the analysis due to relevant industry experiences, personal level interactions and clear understanding of the questionnaires among the respondents. The percentage of respondents' experience is represented in Figure No. 5.3.

The complied responses are annexed as Annexure-IV.

Table -5.2: Respondents, Experience

Year of experience	0-5 years	6 to 10 Years	10 to 20 years	20 + years
Nos. respondents	12	103	145	295

Figure No.-5.3 :- Percentage of Respondents' Experience



5.6 DATA ANALYSIS FOR DELAY FACTORS:

Ten selected factors responsible for project schedule delay are identified and analysed by using RII method. The responses are analysed separately for project owner, contractor, consultant and as well as combined. The results are tabulated as :

Response on Delay Factors from Project Authority:-Table No. -5.3

Response on Delay Factors from Consultant: - Table No. -5.4

Response on Delay Factors from Contractor:-Table No. -5.5

Combined Response on Delay Factors:- Table No.- 5.6.

Table No.-5.3:-Response on Delay Factors from Project Authority/ Owner

Sr. No.	Attribute	RII	Rank
1	Delay due to inefficient purchase & procurement system.	.751	1
2	Delay due to lack of communication among the involved agencies	.736	2
3	Delay due to improper selection of contractor	.724	3
4	Delay due to poor site coordination with other agencies	.717	4
5	Delay due to lack of clarity in project scope/process/ technology	.696	5
6	Delay due to poor / backward project planning & scheduling	.691	6
7	Delay due to external social & political factors	.682	7
8	Delay due to lack of commitment among contractor/ consultant professionals	.675	8
9	Delay due to inefficient site management	.674	9
10	Delay due to lack of commitment among project authority/owner	.657	10

Table No.-5.4 :- Response on Delay Factors from Consultant

Sr. No.	Attribute	RII	Rank
1	Delay due to poor / backward project planning & scheduling	.801	1
2	Delay due to external social & political factors	.776	2
3	Delay due to inefficient site management	.755	3
4	Delay due to lack of communication among the involved agencies	.754	4
5	Delay due to lack of clarity in project scope/process/ technology	.737	5
6	Delay due to lack of commitment among contractor/ consultant professionals	.730	6
7	Delay due to poor site coordination with other agencies	.729	7
8	Delay due to improper selection of contractor	.672	8
9	Delay due to inefficient purchase & procurement system.	.671	9
10	Delay due to lack of commitment among project authority/owner	.671	10

Table No-5.5 :- Response on Delay Factors from Contractor

Sr. No.	Attribute	RII	Rank
1	Delay due to poor / backward project planning & scheduling.	.770	1
2	Delay due to lack of communication among the involved agencies	.754	2
3	Delay due to poor site coordination with other agencies	.741	3
4	Delay due to inefficient purchase & procurement system.	.727	4
5	Delay due to inefficient site management	.725	5
6	Delay due to lack of clarity in project scope/process/ technology	.713	6
7	Delay due to improper selection of contractor.	.712	7
8	Delay due to external social & political factors.	.700	8
9	Delay due to lack of commitment among contractor/ consultant professionals.	.697	9
10	Delay due to lack of commitment among project authority/owner .	.685	10

Table No.-5.6 :- Combined Response on Delay Factors

Sr. No.	Attribute	RII	Rank
1	Delay due to poor / backward project planning & scheduling.	.749	1
2	Delay due to lack of communication among the involved agencies	.747	2
3	Delay due to poor site coordination with other agencies	.727	3
4	Delay due to external social & political factors.	.719	4
5	Delay due to inefficient purchase & procurement system.	.718	5
6	Delay due to inefficient site management	.715	6
7	Delay due to lack of clarity in project scope/process/ technology	.714	7
8	Delay due to improper selection of contractor.	.703	8
9	Delay due to lack of commitment among contractor/ consultant professionals.	.699	9
10	Delay due to lack of commitment among project authority/owner .	.699	10

5.6.1 INTERPRETATION OF ANALYSES FOR DELAY FACTORS:-

The comparative ranks for all three categories of respondents along with combined rank are tabulated in Table No.-5.7.

Table -5.7 :- Rank Comparison on Delay Factors.

Sr. No.	Attribute	Combined Rank	Rank as project owner	Rank as consultant	Rank as contractor
1	Delay due to poor / backward project planning & scheduling.	1	6	1	1
2	Delay due to lack of communication among the involved agencies	2	2	4	2
3	Delay due to poor site coordination with other agencies	3	4	7	3
4	Delay due to external social & political factors.	4	7	2	8
5	Delay due to inefficient purchase & procurement system.	5	1	9	4

Sr no.	Attribute	Combined Rank	Rank as a project owner	Rank as consultant	Rank as contractor
6	Delay due to inefficient site management	6	9	3	5
7	Delay due to lack of clarity in project scope/process/ technology	7	5	5	6
8	Delay due to improper selection of contractor.	8	3	8	7
9	Delay due to lack of commitment among contractor/ consultant professionals.	9	8	6	9
10	Delay due to lack of commitment among project authority/owner .	10	10	10	10

The comparative table shows that on some points respondents have same opinion and on other points they have different opinion. Some attributes are fully accepted by all and also some rejected strongly. The responses can be interpreted as:

i. Overall response shows that first main cause of delay is "delay due to poor/backward project planning & scheduling" which is accepted by both consultant and contractor respondents but not accepted by project authority respondents. This is because the project authority does not involve the others stake holders during planning and keeps on changing it, considering only his requirement during execution of the project. Project authority ignores the requirements of others during planning & scheduling. This response points out towards that the interest of all stake holders should be taken into account in planning & scheduling of project and as well as during the project execution. Realistic time of all activities should be taken during project scheduling. Overlapping & crashing of activities, alternate methods, new technique etc. methods/actions should be applied to reduce the project completion schedule instead of reducing individual activities time.

ii. Respondents as a consultant has different opinion about the attribute "Delay due to lack of communication among the involved agencies" as compared to project authority and contractor respondents. The lack of communication among the involved agencies has major effect on the project schedule and same is accepted by owner & contractor respondents. Consultant has little role in coordination, that's why his opinion is different from others. It is clear from this response that right communication mechanism has to be established & implemented in project model.

iii. The attribute "Delay due to poor site coordination with other agencies" has ranked as third major cause of delay. This attribute is ranked closely by respondents as contractor and project authority, but not

accepted by consultant. This is because the problem faced by contractor due to poor site coordination does not affect the consultant at all but has impact on project authority. The project authority passes-on the responsibilities to contractor for such delay. The contractor is most effected party for poor site coordination. Site coordination among the overall coordination is most important to control and reduce the construction time.

iv. Delay due to external social & political factors is ranked as four. This factor has direct & indirect effect on the project schedule. Nowadays this factor is becoming more and more prominent and need to be addressed positively and timely. Some social activists and political parties disturb the project activities to fulfil their interests. They also do not hesitate to use unawareness of public for their interest. Kundrakulam nuclear power project and Tata Nano unit in West Bengal are the examples for such delay/ closure of projects.

v. Only respondent as owners has ranked an attribute "Delay due to inefficient purchase & procurement system" at first place. In Government of India institutions number of rules & regulation and guidelines needs to be followed to carry out purchase & procurement. The files have to go through numbers of tables for clearances. This process is time consuming. Project authority is only responsible and most effected party. The contractor is also indirectly an effected party in terms of release of payment, various clearances etc.

vi. Improper selection of contactor is one of major causes of delay as told by project authority respondents. The reasons behind could be:

- **a.** Mandatory selection of lowest technically acceptable bidder as a GOI policy.
- **b.** Restrictions & limitations to import the items.
- **c.** Limited Indian contactors/ suppliers in nuclear field.

The above causes may also lead to selection of wrong contactors.

vii. All respondents have accepted in one voice "delay due to lack of commitment among project authority/owner is least important cause". This is a surprising fact that all respondents, consultant & contractor have shown the confidence with the project authority that "commitment from project authority" has least effect on delay of project schedule in nuclear sector. The reasons could be:

a. In India "Department of Atomic Energy (DAE)" is premier institution established by Shri Homi J. Bhabha, a visionary Indian nuclear scientist & ex. Chairman of Atomic Energy Commission and supported by Shri Jawahar Lal Nehru, first Prime Minister of India and TATA group.

b. Top scientist and engineers are selected by DAE through BARC training school.

c. Selection of scientist and engineers is based on merit only and free from bias of region, sex, caste etc.

d. An established system and healthy environment to carry out the jobs.

Overall response shows major attributes of delay are "delay due to poor/backward project planning & scheduling", "Delay due to lack of communication among the involved agencies", "Delay due to poor site coordination with other agencies" "Delay due to inefficient purchase & procurement system".

All respondents have accepted in one voice "delay due to lack of commitment among project authority is least important cause". This is a surprising fact that other respondents, consultant & contractor are also agreeing that commitment from project authority has least effect on delay of project schedule in nuclear sector. Literature review shows that this is one of the major causes of delay of project in other infrastructure, oil & energy sectors, but this is not accepted by all respondents in nuclear sector.

5.6.2 **COMPARISON WITH OTHER SECTORS:-** Hemanta, Sawhney & Iyersah (2012) carried out similar study in Indian construction sector and presented their study in a paper "analysing factors affecting delays in Indian construction sector". (Hemanta , Anil, Iyer & Sameer , 2012). Sadi Assaf & Hejji(2005) in their paper " Causes of delay in large construction projects" also presented about the project performance factors in infrastructure areas . (Sadi, Assaf & Hejji, 2005).

No such published study in nuclear field is available. A comparative study of nuclear sector with other construction sector is tabulated in Table No.-5.8 .

Table No.-5.8:- Comparative Table

Sr no.	Attribute	Rank as per this study (out of 10)	Rank as Hemanta (out of 7)	Rank as Assaf (out of 8)
1	Delay due to poor / backward project planning & scheduling.	1	4	
2	Delay due to lack of communication among the involved agencies	2	6	8
3	Delay due to poor site coordination with other agencies	3	3	
4	Delay due to external social & political factors.	4		7
5	Delay due to inefficient purchase & procurement system.	5	7	
6	Delay due to inefficient site management	6	2	4
7	Delay due to lack of clarity in project scope/process/ technology	7	5	3

Sr no.	Attribute	Rank as per this study (out of 10)	Rank as Hemanta (out of 7)	Rank as Assaf (out of 8)
8	Delay due to improper selection of contractor.	8		2
9	Delay due to lack of commitment among contractor/ consultant professionals.	9		5
10	Delay due to lack of commitment among project authority/owner .	10	1	1

Study shows that “Delay due to lack of commitment among project authority/owner” is accepted as main cause of delay by two authors of non-nuclear construction sector but rejected by respondents in nuclear sector.

“Delay due to poor / backward project planning & scheduling” is one of main causes of delay was accepted by Hemanta and nuclear sectors respondents.

“Delay due to inefficient site management”, “Delay due to lack of clarity in project scope/process/ technology” and “Delay due to lack of communication among the involved agencies” are have different opinion among all three.

On comparison of nuclear sector projects with the construction sector it is found that the causes of delays are not matching. Since delay is

the key element to measure the performance of a project, it can be interpreted that the causes of delays are different, applicable model shall be different.

The above analyses shows that the working model EPC, EPCM etc. are developed to control the delays are not directly workable in nuclear sector.

This is the first objective of the research. It can be concluded from the analysis that respondents agree with the fact that "EPC/EPCM models are not applicable in Indian nuclear sector and there is need to evolve the new model for Indian nuclear sector".

5.7 CONCLUSION ON RESEARCH METHODOLOGY:-

The comparative study shows that causes of delays in construction sector do not match with nuclear sector projects. The project execution models (EPC/EPCM) which are workable in construction sector and may not be workable in Indian nuclear field. It was interpreted that causes for delays are different so solution shall be different. This is the business problem and first objective of the research.

It can be concluded from the analysis that respondents agree with the fact that EPC/EPCM models are not applicable in Indian Nuclear sector and there is need to evolve the new model for Indian nuclear sector.