ISSN No:-2456-2165

Delay Analysis in Water Supply Projects

Shreyansh Singhal[1],
M.E. Student (Construction Technology & Management),
Civil Engineering Department,
Madhav Institute of Technology and Science (M.P.), India

Dr. Rajeev Kansal[2]
Professor, Civil Engineering Department,
Madhav Institute of Technology and Science,
Gwalior (M.P.), India

Abstract:- Delays in construction projects are inevitable & result in disputes, litigations, and claims among different parties and poorly influence scheme accomplishment in respect of the duration of time, quality & price. Most huge schemes are finished with a delay than the parties' agreed-upon dates for several reasons. These sorts of delays can have a crucial financial influence on the scheme. In general, delays are a basic loss condition: All the parties lose one way or the other and there are no actual winners. The statuses of each party are at stake as well.

For the evaluation of delay causes and their effects on construction schemes, a detailed study is done on the causes of delays in construction projects and techniques for analyzing them and approaches to evaluate. To evaluate the major delays observed by Project Manager, Proprietor, Consultant, and Contractor during the construction phase a questionnaire is prepared and circulated among 40 nos. of industry-related persons (30 nos. working at the site). The questionnaire was prepared with the help of a comprehensive literature review as well as with the help of industry project experts. From the response to the questionnaire, it is identified that there are majorly 9 groups (such as Contractor, Architect, Project Team, Proprietor, Consultant, Equipment, Material, Labor & external factors) under which there are 67 delay causes are found.

For evaluating the main reason for delay a method is developed on ranking accordingly as per the results obtained through questionnaire surveys dependent on the relative importance index method. Through questionnaire results, we got a clear picture that most delaying factors are repeated in every project such as financial issues, shortage of material, labor, improper supervision, communication, real-time changes, etc. To avoid delay, certain recommendations are also given accordingly.

***Keywords*:-** *Inevitable, Har Ghar Jal, Disputes, Litigations, Questionnaires,*

I. INTRODUCTION

A. Jal Jeevan Mission

Jal Jeevan Mission is an initiative started by the central government of India. For this, the central government supports the state government for supply of water which started basically in 1972 with the introduction of the Accelerated Rural Water Supply Program (ARWSP). In 2009, Accelerated Rural Water Supply Scheme was renamed as National Rural Drinking Water Program (NRDWP). The scheme was centrally sponsored, with fund sharing between the center and the state. NRDWP was restructured and continued to make it more focused, result oriented via establishing a well monitored system with the help of state departments.

In 2019, NRDWP once again restructured to Jal Jeevan Mission (JJM) with the mission offering 55 LPCD functional household tap connection which is known as FHTC by 2024 to every rural household known as Har Ghar Jal (HGJ). The Ministry of Jal Shakti is executing, monitoring, and running the whole Jal Jeevan Mission.

In the Jal Jeevan Mission, the pattern of funding is different for different states. For the union territories, the funding ratio is 100:0, for the Himalayan& North-Eastern States the funding ratio is 90:10 while for remaining states the ratio is 50:50.**(Source: JJM Guidelines)**

Despite continuous remainders and alarms to the government of states and union territories from central government, the work covered under the Jal Jeevan Mission is far lagging due to which the completion date of Jal Jeevan Mission was revised twice. The root cause for delay is COVID-19 pandemic due to which everything suffered and accordingly delay occurred in completion. In continuation of same, it is necessary to study the impact of various delay factors apart from COVID-19 in completion of Jal Jeevan Mission through delay analysis.

B. Fuzzy Logic

Fuzzy logic is utilized in those exploration regions where one can't direct huge number of examinations as done in likelihood hypothesis to build PDF, NDF and so forth. Utilizing Fuzzy Logic, appraisals of the issue can be inspired from specialists as linguistic terms, for example, "extremely low", "low", "medium", "high", "exceptionally high". Fuzzy logic has capacity to appoint membership values μ(x) communicating the degree (0 for completely unfit to completely fit 1) to which a specific estimation of a variable fits a linguistic idea. Membership function characterizes how each point in the information space is mapped to level of membership.

C. Fuzzy Model Development

Following steps describes the proposed delay assessment model using fuzzy logic in construction of water supply projects:

➢ *Definition of Input and Output Variables*

"Factors causing delay and groups that discovered will be basic input of this delay assessment model. These basic inputs, factors causing delay and groups are used to develop the delay assessment model shown in table 1**.** To simplify the delay factors (DF) & groups, the acronym of delay factors and groups have also demonstrated in the same table and the final output is schedule delay probability (SDP)."

Table 1 Delay Assessment Model

S. No.	Factors Causing Delays	Acronyms for delay factors	Group of Factors	Final Output
1	Duration of Contract is short	DF1	Project Related Factors (PRF)	Schedule Delay Probability (SDP)
2	Parties having legal disputes	DF2		
3	Insufficient definition of considerable achievement	DF3		
4	Penalties on delay which are ineffective	DF4		
5	Different categories of contract used in construction	DF5		
6	Categories under Project Bidding Process	DF6		
7	Delay in disbursement by owner	DF7	Owner Related Factors (ORF)	
8	Postponement in providing and delivering the location of work to the Contractor by Proprietor	DF8		
9	Real Time changes throughout construction	DF9		
10	Delayed approval of documents by Proprietor	DF10		
11	Delayed approval of drawings and trial material	DF11		
12	Absence of contact between proprietor and contractor	DF12		
13	Slow process of decision making	DF13		
14	Struggles in carrying out joint venture of the scheme	DF14		
15	Absence of bonuses for contractor for concluding the work in advance of plan	DF15		
16	Holdup of work by proprietor	DF16		
17	Problems in funding scheme by contractor	DF17	Contractor Related Factors (CRF1)	
18	Fights in subcontractor agenda in implementation of the scheme	DF18		
19	Revision of work due to faults during construction phase	DF19		
20	Fight between contractor and other teams involved	DF20		
21	Lack of management on site and its supervision	DF21		
22	Lack of Communicational skills and synchronization with worker and subprime contractor	DF22		
23	Unproductive planning and scheduling of scheme by contractor	DF23		
24	Inappropriate method for construction applied by contractor	DF24		
25	Postponement in work to be done by subcontractor	DF25		
26	Absence of Information	DF26		
27	Recurrent change of secondary contractors because of their incompetent work	DF27		
28	Underprivileged criterion of technical team	DF28		
29	Postponement in mobilization of site related to secondary contractor	DF29		
30	Postponement in execution of review and testing	DF30	Consultant Related Factors (CRF2)	
31	Postponement in approval of main changes in the extent of work	DF31		
32	Rigidity of consultant	DF32		
33	Underprivileged communiqué among consultant and other parties	DF33		
34	Delay in review, approval of documents	DF34		
35	Dispute between consultant and architect	DF35		
36	Insufficient skill & experience	DF36		
37	Design documents having mistakes	DF37	Architect Related Factors (ARF)	
38	Postponement in making design documents	DF38		
39	Indistinct and insufficient detailing in drawing	DF39		
40	Inadequate collection of data & survey before execution	DF40		
41	Misinterpretation of owner's necessity	DF41		
42	Unused advanced design software	DF42		
43	Scarcity of material	DF43	Materials Related Factors	
44	Modification in type & specification of material during realistic	DF44		

ISSN No:-2456-2165

S. No.	Factors Causing Delays	Acronyms for delay factors	Group of Factors	Final Output
	time		(MRF)	
45	Material delivered late on site	DF45		
46	Damage of arranged material while needed immediately	DF46		
47	Interruption in manufacturing superior building material	DF47		
48	Delayed procurement	DF48		
49	Shortage of particular material accessibility in marketplace	DF49		
50	Equipment shortage	DF50	Equipment Related Factors (ERF)	
51	Equipment failure	DF51		
52	Least operator skill to handle equipment	DF52		
53	Least output & effectiveness of the equipment	DF53		
54	Absence of latest technology equipment	DF54		
55	Labor scarcity at site	DF55	Labor Related Factors (LRF)	
56	Short output level of labor	DF56		
57	Individual fights among labor	DF57		
58	Shortage of Knowledge	DF58		
59	Absence of Communication	DF59		
60	Deficiency of trained labor	DF60		
61	Poor condition of soil	DF61	External Related Factors (ERF)	
62	Interruption in getting permits	DF62		
63	Weather Conditions	DF63		
64	Absence of basic convenience services at site	DF64		
65	Accident during construction	DF65		
66	Variations in government parameter & law	DF66		
67	Interruption in execution of final review & certification from third party.	DF67		

➢ *Fuzzy Logic Toolbox Summary*

"By using Fuzzy Logic Toolbox of the MATLAB Program Software, firstly, input and output parameters are defined. Secondly, the shapes of all membership functions associated with each variable are defined. Thirdly, list of rules is defined. Fourthly, outputs were generated and plots were displayed. Finally, a delay assessment model to estimate the probability of the scheduled delay is completed which may help the decision maker (Project Manager or Project management Team) to determine a reliable time contingency before bidding stage in order to achieve project success.'

D. Objectives

Main objective of the study is to identify, categorize and rank the causes of delay in water supply projects.

II. LITERATURE REVIEW

- Sadi, Sadiq (2006), investigated that main causes of delay are found out by field survey: to avoid delay owner changes order during construction, improper planning and scheduling, shortage of labor, all the parties (contractor, owner and client) is involved.
- Diana Binti (2012), the major reason for delay of projects is due to contractor, client, third party or acts of God. The delays in project can be curtailed only after analyzing the causes. In her research, she focused on questionnaire survey and literature review. The major sources due to which delay happens are insufficient number of equipment's, poor on site management, lack of materials, inappropriate planning and scheduling of items, inappropriate project teams, financial difficulties for contractors.
- Ali and Mohammad Al Mohsin (2013), identified the causes that lead to delay in completion of projects on time by doing field survey on no. of construction projects in Muscat. Two groups were made from data collected, first group consist of construction projects that were done in 2007-08 and second group consist of construction projects that were done in 2008-09. About 40% delay was observed in the completion of project in both the groups. The most effective reason for delay is the causes related to owner.
- Shruti and S. Dinish (2014), investigated that delays can only be minimized when the delays ae identified. Different groups are categorized according to causes of delay to prepare a set of questions for questionnaire survey on contractor, owner, labor, equipment, material respectively. They also discussed about delay effects such as dispute between owner and contractor, delay in work progress due to payments, reduction of profit for contractors, time out situations. Two techniques were used for analyzing the impacts of delays: (I) Importance index technique (II) Relative importance index technique.
- Tsegay Gebrehiwet, Hanbinluo (2017), analyzed the data collected from 77 respondents, in the form of questionnaire consisting of 52 causes and 5 effects of delay. The significant causes of delay are: unavailability of resources at site, price rises, degraded material quality, late approval of design and drawing, procurement of material is slow, underprivileged site management and performance, delayed in releasing

funds. The serious effect of delay analysis was cost overrun, time overrun, and termination of contract.

- Ankush C. Khona, Ashish Jayshinpure (2018), explained the right way to further reduce delays. A series of predefined steps is given by the which are as follows:

✓ To perform advocate initial planning,
✓ Write down a well-defined work breakdown structure,
✓ Select appropriate suppliers and evaluate them,
✓ Daily tracking and monitoring, communication should be done in clear and continuous form.
✓ Carrying out a project in the manner described above will help reduce delay projects.

From the aforementioned literature review, it is clearly evident that previous researchers mainly focused on identification of delay factors and ranking of delay factors on the basis of importance level using RII formula. Very few studies have been conducted over mathematically delay computation in Water Supply Projects. It was seen in literature review that some researchers utilized simulation techniques, method of probability and deterministic method to calculate delay probability in execution of water supply projects. But these methods have their own limitations in delay probability calculations and many times these methods are not found suitable in specific construction projects. From literature it as also concluded that, in water supply industry lesser researchers had conducted for delay probability calculation.

To fill this gap, this study is conducted for delay probability calculation in construction of water supply projects. In this study fuzzy logic is utilized to aggregate the expert judgments for delay probability calculation. Utilization of fuzzy logic overcomes the limitations of previous researches conducted on delay probability calculation. This study integrates the RII vales with fuzzy logic to calculate delay probability in execution of water supply projects.

The ability of fuzzy logic is to represent the problem in normal language that may provide a model to investigate how human experts (decision makers) estimate the necessary time contingency in the real-world construction projects.

III. RESEARCH METHODOLOGY

A. Identification of Delay Factors

"Total 67 Factors causing delay are identified through literature review and discussion with water supply experts. These delay factors are categorized into 9 groups. After identifying the delay factors and groups that may cause delay in construction of water supply projects, a questionnaire form to elicit information about importance level of each delay factor from water supply experts was prepared in the format given in Table –1."

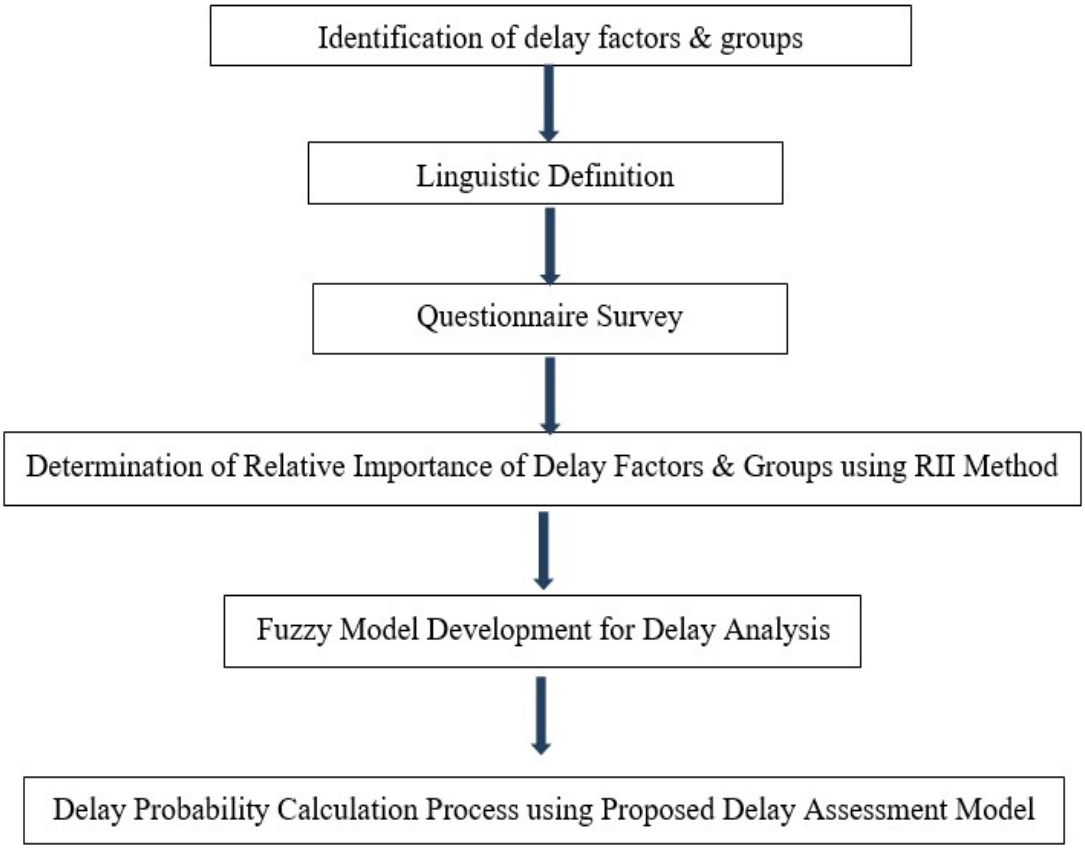

Fig 1 Methodology Flow Diagram

ISSN No:-2456-2165

Table 2 Identified Delay Factors and Groups (Questionnaire)

S. No	Group	Causes of Delay	A	O	S	R	Nil
1	Project Team	Duration of Contract is short					
2		Parties having legal disputes					
3		Insufficient definition of considerable achievement					
4		Penalties on delay which are ineffective					
5		Different categories of contract used in construction					
6		Categories under Project Bidding Process					
7	Owner	Delay in disbursement by owner					
8		Postponement in providing and delivering the location of work to the Contractor by Proprietor					
9		Real Time changes throughout construction					
10		Delayed approval of documents by Proprietor					
11		Delayed approval of drawings and trial material					
12		Absence of contact between proprietor and contractor					
13		Slow process of decision making					
14		Struggles in carrying out joint venture of the scheme					
15		Absence of bonuses for contractor for concluding the work in advance of plan					
16		Holdup of work by proprietor					
17	Contractor	Problems in funding scheme by contractor					
18		Fights in subcontractor agenda in implementation of the scheme					
19		Revision of work due to faults during construction phase					
20		Fight between contractor and other teams involved					
21		Lack of management on site and its supervision					
22		Lack of Communicational skills and synchronization with worker and subprime contractor					
23		Unproductive planning and scheduling of scheme by contractor					
24		Inappropriate method for construction applied by contractor					
25		Postponement in work to be done by subcontractor					
26		Absence of Information					
27		Recurrent change of secondary contractors because of their incompetent work					
28		Underprivileged criterion of technical team					
29		Postponement in mobilization of site related to secondary contractor					
30	Consultant	Postponement in execution of review and testing					
31		Postponement in approval of main changes in the extent of work					
32		Rigidity of consultant					
33		Underprivileged communiqué among consultant and other parties					
34		Delay in review, approval of documents					
35		Dispute between consultant and architect					
36		Insufficient skill & experience					
37	Architect	Design documents having mistakes					
38		Postponement in making design documents					
39		Indistinct and insufficient detailing in drawing					
40		Inadequate collection of data & survey before execution					
41		Misinterpretation of owner’s necessity					
42		Unused advanced design software					
43	Materials	Scarcity of material					
44		Modification in type & specification of material during realistic time					
45		Material delivered late on site					
46		Damage of arranged material while needed immediately					
47		Interruption in manufacturing superior building material					
48		Delayed procurement					
49		Shortage of particular material accessibility in marketplace					
50	Equipment	Equipment shortage					
51		Equipment failure					

52		Least operator skill to handle equipment					
53		Least output & effectiveness of the equipment					
54		Absence of latest technology equipment					
55	Labor	Labor scarcity at site					
56		Short output level of labor					
57		Individual fights among labor					
58		Shortage of Knowledge					
59		Absence of Communication					
60		Deficiency of trained labor					
61	External Factors	Poor condition of soil					
62		Interruption in getting permits					
63		Weather Conditions					
64		Absence of basic convenience services at site					
65		Accident during construction					
66		Variations in government parameter & law					
67		Interruption in execution of final review & certification from third party.					

- *Note: 1. Force Majeure includes those unforeseen events which can't be controlled by any project related parties.*

➢ *Table -2 shows the above nomenclature used for abbreviation and rating.*

Table 3: Rating used in Questionnaire

Linguistic Term	Short Term	Rating
At all times or always	A	5
Repeatedly or often	R	4
Occasionally or sometimes	O	3
Infrequently or rarely	R	2
Nil	Nil	1

B. Questionnaire Survey

Rating of delay factors on Likert Scale of five point, ranged from 1 (Nil) to 5 (Always) which was commonly used in previous literature is adopted in this study. The questionnaire contained of two parts P-1 & P-2. P-1 contains the respondents' details. P-2 contains group and factors causing delay in water supply projects."

"In questionnaire survey 5 characteristics were decided for choosing respondents:

- Respondent should be water supply expert.
- Respondent should be client/ contractor/ consultant.
- Minimum qualification should be graduation
- Minimum experience should be greater than 4 years in water supply field.
- Respondent should be currently working in water supply project.

➢ *Sample size of questionnaire survey*

Individual of sample size is called as respondents and information elicited from respondents is called as response in this study.

Target population of water supply experts is not definable and countable. So, to calculate the sample size, for questionnaire survey Cronbach's formula is used which is mathematically represented as:"

$$n_0 = \frac{Z^2 pq}{e^2}$$

where n_0= Sample size

Z (Standard Normal Deviation set at 90% confidence level) = 1.64

e (Sampling error, consider ±15%) = 0.15

p = degree of variability, consider 0.5 for maximum variability,

q= 1 - p = 1 - 0.5 = 0.5

Table 4: Final Respondent Profile

S. No.	Respondents Category	Total Respondents	Average Experience
1	Owner/ Clients	13	21.07
2	Contractor	13	16.60
3	Consultant	9	10.78

IV. RESULTS AND DISCUSSIONS

A. *Reliability of Questionnaire Data*

Questionnaire data is checked for it's reliability before initiating the survey through questionnaire for getting information for delay analysis. After the collection of data (degree of stability & internal consistency of data), the assessment of data is done taking into consideration of Cronbach's alpha formula.

This shows the data internal consistency i.e. how much a set of data is closely related.

Table 5 Reliability Data

Respondents Category	Owner	Contractor	Consultant	Overall
Cronbach's Alpha	0.958	0.956	0.968	0.961

Aforementioned values of Cronbach's alpha is calculated using IMB SPSS Modeler tool, which provides the inbuilt formulation for the formula.

B. *Ranking of Factors Causing Delay According to Owner, Contractor & Consultant response.*

There are overall 40 responses that we have got through interviews as well as through online surveys of water supply experts, in which 35 are found to be correct. Out of these 35 response, 9 responses are from owners, 13 responses are from contractors & 13 responses are from consultants. The RII value had a range from 0 to 1 (0 not inclusive), higher the value of RII, more important is the cause of delays.

Table 5 shows delay factors and groups of factors, according to consultant, contractor, owner with computer RII's and ranks.

Table 6 Ranking of Factors Causing Delays according to Owner, Contractor & Consultant Responses

S. No.	Group of factors	Factors causing Delay	Owner			Contractor			Consultant		
			∑W	RII	Rank	∑W	RII	Rank	∑W	RII	Rank
1	Project Team	Original Contract Duration is too short	37	0.557	51	36	0.72	8	28	0.622	40
2		Legal Disputes between parties	54	0.771	6	32	0.64	14	30	0.667	25
3		Inadequate definition of substantial completion	37	0.529	52	25	0.5	45	22	0.489	53
4		Ineffective delay penalties	45	0.643	24	28	0.56	27	27	0.578	43
5		Types of construction contract	42	0.6	33	22	0.44	54	30	0.667	26
6		Type of Project Bidding	51	0.729	11	34	0.68	11	30	0.667	27
7	Owner	Delay in progress payment by owner	47	0.671	19	40	0.8	4	27	0.6	44
8		Delay to furnish and deliver the site to the contractor by owner	59	0.843	1	44	0.88	1	42	0.933	1
9		Change order during construction	50	0.714	13	37	0.74	6	29	0.644	36
10		Late in approval design document by owner	43	0.614	31	31	0.62	16	24	0.533	50
11		Delay in approving shop drawings and sample material	41	0.586	37	31	0.62	17	19	0.422	59
12		Lack of communication between owner and contractor	39	0.557	46	23	0.46	50	23	0.511	51
13		Slowness in decision making process	45	0.643	25	28	0.56	28	23	0.511	52
14		Conflicts between joint ownership of the project	44	0.629	28	27	0.54	34	30	0.667	28
15		Unavailability of incentives for contractor for finishing ahead of schedule	56	0.8	3	35	0.7	10	38	0.844	7

16		Suspension of work by owner	42	0.6	34	33	0.66	12	19	0.422	60
17	Contractor	Difficulties in financing project by contractor	56	0.8	4	36	0.72	9	41	0.911	2
18		Conflicts in subcontractor schedule in execution of the project	54	0.771	7	41	0.82	3	41	0.911	3
19		Rework due to errors during construction	36	0.524	56	28	0.56	23	36	0.8	12
20		Conflict between contractor and other parties	45	0.643	26	29	0.58	23	39	0.867	4
21		Poor site management and supervision	56	0.8	5	28	0.56	30	31	0.689	23
22		Poor Communication and coordination with labor and subcontractor	42	0.6	35	23	0.46	51	29	0.644	17
23		Ineffective planning and scheduling of project by contractor	54	0.771	8	33	0.66	13	38	0.844	8
24		Improper construction method implemented by contractor	43	0.614	32	26	0.52	40	29	0.644	38
25		Delay in subcontractor work	41	0.586	38	27	0.54	35	28	0.56	41
26		Lack of Knowledge	36	0.514	57	26	0.52	41	39	0.867	5
27		Frequent change of subcontractor because of their inefficient work	34	0.486	60	25	0.5	46	33	0.733	19
28		Poor qualification of technical staff	51	0.729	12	30	0.6	22	34	0.756	17
29		Delay in site mobilization related to subcontractor	45	0.643	27	31	0.62	18	31	0.689	24
30	Consultant	Delay in performing inspection and testing by consultant	46	0.657	21	27	0.54	36	29	0.644	39
31		Delay in approving major changes in the scope of work by consultant	48	0.686	17	31	0.62	19	39	0.867	6
32		Inflexibility of consultant	36	0.514	58	20	0.4	61	21	0.467	54
33		Poor communication between consultant and others	41	0.586	39	26	0.52	42	20	0.444	58
34		Late in reviewing & approving design document by consultant	49	0.7	15	28	0.56	31	33	0.733	20
35		Conflict between consultant and architect	49	0.7	16	27	0.54	37	36	0.8	13
36		Inadequate experience of consultant	46	0.657	22	25	0.5	47	25	0.556	49
37	Architect	Mistakes in design document	48	0.686	18	39	0.78	5	32	0.711	22
38		Delay in producing design documents	38	0.543	49	26	0.52	43	30	0.667	29
39		Unclear and inadequate details in drawing	38	0.543	50	19	0.38	62	34	0.756	18
40		Insufficient data collection & survey before doing	54	0.771	9	37	0.74	7	38	0.822	9
41		Misunderstanding of owner's requirement	39	0.557	47	21	0.42	55	28	0.622	42
42		Unused of advanced design software	36	0.541	59	25	0.5	48	27	0.6	45
43	Materials	Shortage of material	39	0.557	48	19	0.38	63	30	0.667	30

44		Change in material type &specification during construction	29	0.414	65	18	0.36	64	15	0.333	65
45		Delay in material delivery	50	0.714	14	27	0.54	38	35	0.778	15
46		Damage of sorted material while they are needed urgently	40	0.571	41	21	0.467	56	30	0.667	31
47		Delay in manufacturing special building material	47	0.671	20	31	0.62	20	35	0.778	16
48		Late procurement of material	54	0.771	10	23	0.46	52	33	0.733	21
49		Lack of selected material availability in market	40	0.571	42	28	0.56	32	15	0.333	66
50	Equipment	Shortage of equipment	17	0.34	67	21	0.467	57	30	0.429	32
51		Equipment breakdown	44	0.629	29	29	0.57	24	30	0.667	33
52		Low level of equipment operator skill	31	0.443	61	21	0.467	58	17	0.34	63
53		Low productivity & efficiency of the equipment	40	0.571	43	23	0.46	53	38	0.844	10
54		Lack of high technology mechanical equipment	37	0.529	53	29	0.58	25	26	0.578	46
55	Labor	Shortage of labor	46	0.657	23	28	0.56	33	36	0.8	14
56		Low productivity level of labor	41	0.586	40	27	0.54	39	30	0.667	34
57		Personal conflicts among labor	25	0.357	66	17	0.34	66	15	0.333	67
58		Lack of Knowledge	42	0.6	36	21	0.42	59	18	0.4	62
59		Lack of Communication	31	0.443	62	18	0.36	65	16	0.356	64
60		Lack of skilled labor	30	0.429	63	26	0.578	44	21	0.42	55
61	External Factors	Poor soil condition	37	0.529	54	17	0.34	67	21	0.467	56
62		Delay in obtaining permits	58	0.829	2	43	0.86	2	37	0.822	11
63		Climatic factor	40	0.571	44	31	0.62	21	30	0.667	35
64		Unavailability of utilities in site (water, electricity, telephone)	40	0.571	45	24	0.48	49	26	0.578	47
65		Accident during construction	30	0.429	64	21	0.42	60	21	0.467	57
66		Changes in government regulation and law	44	0.29	30	29	0.58	26	19	0.422	61
67		Delay in performing final inspection and certificate by third party.	37	0.529	55	32	0.64	15	26	0.578	48

C. Ranking of Factors Causing Delay & Groups According to Overall Responses

There are overall 35 responses that we have got through interviews as well as online surveys of water supply experts. The overall RIIs of factors causing delay & Average RII's of groups of factor assigned as the fuzzy rules' weights to construct "Delay Assessment Model using fuzzy logic in water supply construction projects" are computed. Table 7 shows delay factors and groups of factors according to overall responses with computed RII's and ranks.

Table 7 Overall Ranking of Factors Causing Delays with computed RII's.

S.No.	Group of factors	Factors causing Delay	Overall		
			∑W	RII	RANK
1	Project Team	Original Contract Duration is too short	101	0.55	26
2		Legal Disputes between parties	116	0.63	10
3		Inadequate definition of substantial completion	84	0.45	56
4		Ineffective delay penalties	100	0.54	31
5		Types of construction contract	94	0.51	40
6		Type of Project Bidding	115	0.62	12
7	Owner	Delay in progress payment by owner	114	0.62	15
8		Delay to furnish and deliver the site to the contractor by owner	145	0.78	1
9		Change order during construction	116	0.63	11
10		Late in approval design document by owner	98	0.53	33

ISSN No:-2456-2165

11		Delay in approving shop drawings and sample material	91	0.49	47
12		Lack of communication between owner and contractor	85	0.46	55
13		Slowness in decision making process	96	0.52	36
14		Conflicts between joint ownership of the project	101	0.55	27
15		Unavailability of incentives for contractor for finishing ahead of schedule	129	0.70	5
16		Suspension of work by owner	94	0.51	41
17	Contractor	Difficulties in financing project by contractor	133	0.72	4
18		Conflicts in subcontractor schedule in execution of the project	136	0.74	3
19		Rework due to errors during construction	100	0.54	32
20		Conflict between contractor and other parties	113	0.61	11
21		Poor site management and supervision	115	0.62	13
22		Poor Communication and coordination with labor and subcontractor	94	0.51	42
23		Ineffective planning and scheduling of project by contractor	125	0.68	7
24		Improper construction method implemented by contractor	98	0.53	34
25		Delay in subcontractor work	96	0.52	37
26		Lack of Knowledge	101	0.55	28
27		Frequent change of subcontractor because of their inefficient work	92	0.50	44
28		Poor qualification of technical staff	115	0.62	14
29		Delay in site mobilization related to subcontractor	107	0.58	23
30	Consultant	Delay in performing inspection and testing by consultant	102	0.55	25
31		Delay in approving major changes in the scope of work by consultant	118	0.64	9
32		Inflexibility of consultant	77	0.42	59
33		Poor communication between consultant and others	87	0.47	54
34		Late in reviewing & approving design document by consultant	110	0.59	20
35		Conflict between consultant and architect	112	0.61	18
36		Inadequate experience of consultant	96	0.52	38
37	Architect	Mistakes in design document	119	0.64	8
38		Delay in producing design documents	94	0.51	43
39		Unclear and inadequate details in drawing	91	0.49	48
40		Insufficient data collection & survey before doing	129	0.70	6
41		Misunderstanding of owner’s requirement	88	0.48	51
42		Unused of advanced design software	88	0.48	52
43	Materials	Shortage of material	88	0.48	53
44		Change in material type & specification during construction	62	0.34	66
45		Delay in material delivery	112	0.61	19
46		Damage of sorted material while they are needed urgently	91	0.49	49
47		Delay in manufacturing special building material	113	0.61	17
48		Late procurement of material	110	0.59	21
49		Lack of selected material availability in market	83	0.45	57
50	Equipment	Shortage of equipment	68	0.37	64
51		Equipment breakdown	103	0.56	24
52		Low level of equipment operator skill	69	0.37	63
53		Low productivity & efficiency of the equipment	101	0.55	29
54		Lack of high technology mechanical equipment	92	0.50	45
55	Labor	Shortage of labor	110	0.59	22
56		Low productivity level of labor	98	0.53	35
57		Personal conflicts among labor	57	0.31	67
58		Lack of Knowledge	81	0.44	58
59		Lack of Communication	65	0.35	65
60		Lack of skilled labor	77	0.42	60
61	External Factors	Poor soil condition	75	0.41	61
62		Delay in obtaining permits	138	0.75	2
63		Climatic factor	101	0.55	30
64		Unavailability of utilities in site (water, electricity, telephone)	90	0.49	50
65		Accident during construction	72	0.39	62
66		Changes in government regulation and law	92	0.50	46
67		Delay in performing final inspection and certificate by third party.	95	0.51	39

Table 8 Spearman's Rank Correlation between different Groups of Respondents

Respondent Group	Owner (%)	Consultant (%)	Contractor (%)	Overall (%)
Overall	86	81	79	100
Contractor	64	44	100	-
Consultant	58	100	-	-
Owner	100	-	-	-

The aforementioned values of Spearman's rank correlation is calculated using IBM SPSS Statistics software, which has used the values given by the contractor, consultant & owner.

D. Validity of Proposed Delay Assessment Model

The developed delay assessment model is tested in real project. A final interview was conducted to assess the understanding of a Water Supply Company to test the proposed delay assessment model considering the latest project running its initial phase of construction.

The company M/s Larsen & Toubro Ltd. is serving in water supply sector since 1946. Based on 50+ years' experience, company is considered as an expert in water supply field. The Company was requested to perform following tasks for validation of proposed Delay Assessment Model."

Table 9 Details of Water Supply Construction Company & Project

Project Details	Agar Malwa Multi village Rural Water Supply Scheme
Contractor Company (Name)	M/s Larsen & Toubro Ltd.
Project Cost	250 Crore
Project Duration	24 months
Expected delay range for the project	30-50%

To get the validation done, company has formed a group of three (3) decision makers' members including site manager, chief project manager and technical office engineer.

Table 10 Probability Evaluation Form filled by members of L&T

S.No.	Group	Causes of Delay	Evaluation of Factors
1	Project Team	Original Contract Duration is too short	35
2		Legal Disputes between parties	45
3		Inadequate definition of substantial completion	22
4		Ineffective delay penalties	30
5		Types of construction contract	24
6		Type of Project Bidding	38
7	Owner	Delay in progress payment by owner	42
8		Delay to furnish and deliver the site to the contractor by owner	60
9		Change order during construction	37
10		Late in approval design document by owner	30
11		Delay in approving shop drawings and sample material	39
12		Lack of communication between owner and contractor	35
13		Slowness in decision making process	38
14		Conflicts between joint ownership of the project	40
15		Unavailability of incentives for contractor for finishing ahead of schedule	30
16		Suspension of work by owner	55
17	Contractor	Difficulties in financing project by contractor	40
18		Conflicts in subcontractor schedule in execution of the project	35
19		Rework due to errors during construction	24
20		Conflict between contractor and other parties	20
21		Poor site management and supervision	35
22		Poor Communication and coordination with labor and subcontractor	28
23		Ineffective planning and scheduling of project by contractor	45
24		Improper construction method implemented by contractor	30
25		Delay in subcontractor work	30
26		Lack of Knowledge	23
27		Frequent change of subcontractor because of their inefficient work	25
28		Poor qualification of technical staff	32

29		Delay in site mobilization related to subcontractor	50
30	Consultant	Delay in performing inspection and testing by consultant	30
31		Delay in approving major changes in the scope of work by consultant	45
32		Inflexibility of consultant	40
33		Poor communication between consultant and others	25
34		Late in reviewing & approving design document by consultant	55
35		Conflict between consultant and architect	30
36		Inadequate experience of consultant	30
37	Architect	Mistakes in design document	25
38		Delay in producing design documents	35
39		Unclear and inadequate details in drawing	19
40		Insufficient data collection & survey before doing	28
41		Misunderstanding of owner's requirement	18
42		Unused of advanced design software	22
43	Materials	Shortage of material	23
44		Change in material type & specification during construction	10
45		Delay in material delivery	30
46		Damage of sorted material while they are needed urgently	22
47		Delay in manufacturing special building material	25
48		Late procurement of material	28
49		Lack of selected material availability in market	24
50	Equipment	Shortage of equipment	20
51		Equipment breakdown	23
52		Low level of equipment operator skill	25
53		Low productivity & efficiency of the equipment	20
54		Lack of high technology mechanical equipment	27
55	Labor	Shortage of labor	35
56		Low productivity level of labor	20
57		Personal conflicts among labor	16
58		Lack of Knowledge	16
59		Lack of Communication	15
60		Lack of skilled labor	30
61	External Factors	Poor soil condition	25
62		Delay in obtaining permits	55
63		Climatic factor	45
64		Unavailability of utilities in site (water, electricity, telephone)	20
65		Accident during construction	20
66		Changes in government regulation and law	35
67		Delay in performing final inspection and certificate by third party.	30

Output delay probability of the case study is determined by using proposed delay assessment model which is shown in table 11."

Table 11 Case Study Results of Schedule Delay Probability

Inputs **Group of factors**	**Output** **Delay Probability (0 to 100)**
Project related factors	32.33
Owner related factors	40.60
Contracator related factors	32.08
Consultant related factors	36.42
Architect related factors	24.50
Material related factors	23.14
Equipment related factors	23.00
Labor related factors	22.00
External related factors	32.86
Overall Project Delay	**30.71**

E. Result according to case study of schedule delay probability

➢ *Project Related Factor Group*

Probability Output of this group is determined as 32.33% demonstrating a low-medium probability. The most significant factors that contribute for this group's probability are: "Legal Disputes between parties" having 45*(low-medium probability*), "Type of Project Bidding" having 38 (*low-medium probability*), "Original Contract Duration is too short" having 35 (*low-medium probability*).

➢ *Owner Related Factor Group*

Probability Output of this group is determined as 40.60% demonstrating a low-medium probability. The most significant factors that contribute for this group's probability are: "Delay to furnish and deliver site to the contractor by owner" having 60(*high probability*), "Suspension of work by owner" having 55(*medium-high probability*), "Delay in progress payment by owner" having 42 (*low medium probability*).

➢ *Contractor Related Factor Group*

Probability Output of this group is determined as 32.08% demonstrating a low-medium probability. The most significant factors that contribute for this group's probability are: "Delay in site mobilization related to subcontractor" having 50(*low medium probability*), "Inefficient planning & scheduling of project by contractor" having 45(*low medium probability*), "Difficulties in financing project by contractor" having 40 (*low medium probability*).

➢ *Consultant Related Factor Group*

Probability Output of this group is determined as 36.42% demonstrating a low-medium probability. The most significant factors that contribute for this group's probability are: "Late in reviewing and approving design document by consultant" having 55 (*medium high probability*), "Delay in approving major changes in the scope of work by consultant" having 45 (*low medium probability*), "Inflexibility of consultant" having 40(*low medium probability*).

➢ *Architect Related Factor Group*

Probability Output of this group is determined as 24.50% demonstrating a low-medium probability. The most significant factors that contribute for this group's probability are: "Delay in producing design document" having 35 (*low medium probability*), "Insufficient data collection & survey before doing" having 28 (*very low probability*), "Mistake in design document" having 25 (*very low probability*).

➢ *Material Related Factor Group*

Probability Output of this group is determined as 23.14% demonstrating a low-medium probability. The most significant factors that contribute for this group's probability are: "Delay in material delivery" having 30 (*low medium probability*), "Late procurement of material" having 28 (*very low probability*), "Delay in manufacturing special building material" having 25 (*very low probability*).

➢ *Equipment Related Factor Group*

Probability Output of this group is determined as 23.00% demonstrating a very-low probability. The most significant factors that contribute for this group's probability are: "Lack of high technology mechanical equipment" having 27(very-low probability), "Low level of equipment operator skills" having 25 (very-low probability), "Equipment breakdown" having 23 (very-low probability).

➢ *Labor Related Factor Group*

Probability Output of this group is determined as 22.00% demonstrating a very low probability. The most significant factors that contribute for this group's probability are: "Shortage of labor" having 35 (*low-medium probability*), "Lack of skilled labor" having 30 (*low-medium probability*), "Low productivity level of labor" having 20 (*very low probability*).

➢ *External Related Factor Group*

Probability Output of this group is determined as 32.86% demonstrating a low-medium probability. The most significant factors that contribute for this group's probability are: "Delay in obtaining permits" having 55 (*low-medium probability*), "Climatic factors" having 45 (*low medium probability*), "Changes in government regulation & law" having 35 (*low medium probability*).

➢ *Probability of Delay*

Overall schedule delay probability output for this specific project is determined as 30.71% demonstrating a **low-medium** probability.

Since the commission members also evaluated a range of 30-40% for the probability of schedule delay for that project & we found that result of schedule delay probability is in between this evaluated range that shows our results are satisfactory & reliable. Therefore, as the case study result, it is appropriate to say that the assessment model outputs are acceptable & adequate for the purpose.

V. CONCLUSIONS

By their very nature, construction schemes are very hard to control due to its active and multifaceted atmosphere, resulting in recurrent deviations, delays and excess expenditure. The capability to evaluate the effect of field events on construction projects is critical to preparing and processing claims. Complaints about delays are one of the main sources of dispute in the civil construction engineering industry today, & one of the hardest to resolve. Accordingly, to deal with this issue of delay a delay assessment model is prepared using Fuzzy MATLAB system combined and developed with RII method which is validated by L&T personnel's on a live running project.

LIMITATIONS OF RESEARCH

- Instead of using Crisp rating 1-5, improvement of result may be seen on changing the scale range to 1-10.
- 35 no. of respondents was responded for the questionnaire, Questionnaire was prepared at 15% sampling error & 90% confidence level, to improve the result sampling size shall be increased (in terms of respondents), confidence level and reducing sampling error.
- The case study shall be done on high delay project instead of low-medium delay probability.

SUGGESTIONS AND RECOMMENDATIONS TO PREVENT DELAY IN WATER SUPPLY PROJECTS

Table 12 Prevent Delay in Water Supply Projects

S. No.	Delay Causing Conditions	Recommendations
1.	Climatic Conditions	To carry out detailed investigations according to field conditions and previous weather data.
2.	Outside factors	To recognize and document the delays outside the control, work done by the earlier contractors must be considered.
3.	Shortage of money	For execution of the project, make sure that requisite fund is available and also make sure that flow of cash is optimized accordingly to meet the requirements.
4.	Schedule Deviation	For easy & controlled scheduled execution, detailed and accurate schedule is developed.
5.	Improper Communication	Management Information System (MIS) is planned and applied accordingly.
6.	Bad process of decision making	For improving the process of decision making, in-routine meeting is to be done. So that a proper procedure is followed throughout.
7.	Absence of synchronization/Erroneous entrustment of specialist	Develop a good, simple and understandable system to standardize unit coordination procedures and responsibilities. Create an organizational chart with detailed job descriptions of the responsibilities and roles of each functional unit.
8.	Absence of check	For detecting and making record of the risks in the project and to mitigate them, a technical staff is to be kept for site inspection on site at a regular interval as specified to monitor the whole work in progress including all the works such as drawing submission, availability of resource, flaws in methodologies etc.
9.	Lack of Planning	Understand supply and demand levels to develop detailed plans and timelines. Implement automated machine work to avoid manpower shortage such as such as automatic plastering machine, murals, precast concrete walls, etc.
10.	Absence of Expertise	For reducing time slab of activities or of labor force, regarding new technologies and techniques the contractor must be aware of.
11.	Absence of conveniences at site	Detailed study in respect of site condition is to be done so that management of site is done in a manner that resources can be used in a proper way as well as to increase productivity basic facilities are to be provided to workers.
12.	Wrong supplier selection	For avoiding interruption and fights with supplier, do check their daily stock as well as quality of material before selecting supplier.
13.	Scarcity of labor	For managing the risks of project labor effectively, initial planning is necessary for both proprietor and contractor. To increase the quality of work as well as productivity of workers, they can be awarded with incentives like best employee of the week/ month/ year.
14.	Shortage of qualified labor	The unskilled labor is provided with training and session of skill up gradation so that they can use new techniques and technologies to increase their productivity.

The water supply stakeholders have to emphasis on these study discoveries to avoid delay in the scheme, considering the factors contributing most of the delays.

SCOPE FOR FUTURE RESEARCH

- Using proposed methodology of this study, further delay assessment can be done for reliable time contingencies in other specific projects like railway, airport, buildings, highways & dam schemes.
- Upcoming studies can be planned by using different model parameters such as: different no. & set of scheduled delay factors, linguistic variables, membership functions, fuzzy rules, weight of rules, aggregation & defuzzification methods.
- This study opens up a domain of opportunities where upcoming analysts can deliver additional powerful, user-friendly software that can evaluate all the probable schedule delay factors, making fast and reliable results. This is very important for the success of the project and should be considered before the bidding stage by developing and utilizing the findings of this study."

REFERENCES

[1]. Abouorban, Hoda1,2, Hosny, Ossama1, Nassar, Khaled1, Eltahan, Rania (2018) "Delay Analysis Techniques in Construction Projects". Building Tomorrow's Society, Bâtir la Société de Demain Fredericton, Canada .June 13 – June 16, 2018/ Juin 13 – Juin 16, 2018
[2]. Alaghbari, W., Kadir, M. R. A., Salim, A., and Ernawati, A. (2007). "The significant factors causing delay of building construction projects in Malaysia."Eng. Constr. Archit. Manage. J., 14(2), 192–206.
[3]. Albinu, A. A., and Jagboro, G. O. (2002). "The effects of construction delays on project delivery in Nigerian construction industry." Int. J. Project Manage.,20(8), 593–599.
[4]. Al-Khalil, M. I., and Al-Ghafly, M. A. (1999). "Delay in public utility projects in Saudi Arabia." Int. J. Project Manage., 17(2), 101–106.
[5]. Al-Momani, A. (2000). "Construction delay: A quantitative analysis." Int. J. Project Manage., 20(1), 51–59.
[6]. Al Sehaimi, A., Koskela, L., and Tzortzopoulos, P. (2013). "Need for alternative research approaches in construction management: Case of delay studies." J.Manage. Eng., 0000148.
[7]. Anastasopoulos, P. C., Labi, S., Bhargava, A., and Mannering, F. L. (2011). "Empirical assessment of the likelihood and duration of highway project timedelays." J. Constr. Eng. Manage., 138(3), 390–398.
[8]. Anuradha Arya., and Dr. Rajeev Kansal (2016). "Analysing Delays of Construction Projects in India: Causes and Effects." IJSTE - International Journal of Science Technology & Engineering | Volume 3 | Issue 06 | December 2016ISSN (online): 2349-784X.
[9]. Ar. Meena. V, and Ar. K. Suresh Babu (2015). "Study on Time Delay Analysis for Construction Project Delay Analysis" International Journal of Engineering Research & Technology (IJERT)ISSN: 2278-0181, Vol. 4 Issue 03, March-2015.
[10]. Assaf, S. A., Al-Khalil, M., and Al-Hazmi, M. (1995). "Causes of delay in large building construction projects." J. Manage. Eng., 11(2), 45–50.
[11]. Assaf, S. A., and Al-Hejji, S. (2006). "Causes of delay in large construction project." Int. J. Project Manage., 24(4), 349–357.
[12]. Atkinson R. (1999) Project management: cost, time and quality, two best guesses and phenomenon, it's time to accept other success criteria, International Journal of Project management, 17(6),pp. 337-342
[13]. Bryman A. (2001), Social Reasearch Methods, Oxford University press, United Kingdom, pp 177-487.
[14]. Chan D.W.M and Kumaraswamy M. M. (1997), A comparative study of causes of time overruns in Hong Kong construction projects. International Journal of project management, 15(1), pp 55-63.
[15]. El Razek, M. E., Basssioni, H. A., and Mobarak, A. M. (2008). "Causes of delay in building construction projects in Eygpt." J. Constr.
[16]. El-Sayegh, S. M., and Mansour, M. H. (2015). "Risk assessment and allocation in highway construction projects in the UAE." J. Manage.Eng.,10.1061/(ASCE)ME.1943-5479.0000365, 04015004.
[17]. Faridi, A,; El-Sayegh, S. 2006. Significant factors causing delay in the UAE construction industry, Construction Management and Economics 24(11):1167-1176.
[18]. Flynn et al., 1994: B. B. Flynn, R. G. Schroeder, and S. Sakakibara, A framework for quality management research and an associated instrument, Journal of Operations Management 11 (4) (1994), pp.339-366.
[19]. Flyvbjerg, B., Holm, M. S., and Buhl, S. (2002) "Underestimating Costs in Public Works Projects, Error or Lie" Journal of the American Planning Association, 68(3), pp 279-292.
[20]. Frimpong, Y., Oluwoye, J., and Crawford, L. (2003). "Causes of delay and cost overruns in construction of groundwater projects in a developing countries; Ghana as a case study." Int. J. Project Manage., 21(5),321-326.
[21]. Fugar, F. D., and Agyakwah-Baah, A. B. (2010). "Delays in building construction projects in Ghana." Aust. J. Constr. Econ. Build., 10(1–2),103– 116.
[22]. Fujimoto, T. (1989) Organizations for Effective Product Developments: The Case of the Global Automobile Industry, unpublished DBA dissertation, Harvard Business School, Boston, MA.
[23]. Fynes, B., de Burca, S. and Voss, C., 2005. Supply chain relationship quality, the competitive environment and performance, International Journal of Production, 43, 16, 3303-3320.
[24]. Gaddis, P. O. (1959). The project manager. In N. R. Augustine (Ed.), Managing projects and programs (pp. 145-162). Boston: Harvard Business School Press.
[25]. G. Sweis, R. Sweis, A. Abu Hammad, A. Shboul (2007), "Delay in construction projects': The case of Jordan" International Journal of Project Management26 (2006) 665-674.
[26]. Handa, V. and Adas, A. (1996). Predicting the level of organizational effectiveness: a methodology for the construction firm, Construction Management and Economics, 14, 341-352.
[27]. Haseeb, M. (2011). "Problems of projects and effects of delays in the construction industry of Pakistan." Aust. J. Bus. Manage. Res., 1(5), 41–50.
[28]. Hendrickson C., Au T., (2003), Project management for construction: Fundamental Concept for Owner, Engineers, Architects and Builders, Version 2.1,Pittsburgh available online: http://www.ce.cmu.edu/pmbook
[29]. Howes, R., and Robinson, H. (2005). Infrastructure for the built environment: Global procurement strategies, Butterworth-Heinemann, Oxford, U.K.
[30]. Kaliba, C., Muya, M., and Mumba, K. (2009). "Cost escalation and schedule delays in road construction projects in Zambia." Int. J. Project Manage.,27,522–531.

[31]. Karau, Steven J.; Williams, Kipling D., "Social loafing: A mata-analytic review and theoretical integration". Journal of Personality and Social Psychology, Vol 65(4), Oct 1993, 681-706. http://dx.doi.org/10.1037/0022-3514.65.4.681.
[32]. Kerzner, H. (1998), In Search of Excellence in Project Management: Successful Practices in High Performance Organizations, Van Nostrand Reinhold, New York, NY.
[33]. Larsen, J. K., Shen, G. Q., and Lindhard, S. M. (2015). "Factors affecting schedule delay, cost overrun, and quality level in public construction projects." J. Manage. Eng., 0000391.Bahru, Malaysia. Association, Templeton College, Oxford.
[34]. Leroy C. Olsen (1971), "Ethical standard for group leaders". Journal of Counseling & Development, Volume 50, Issue 4, Page 288.
[35]. Liu A.M.M. and Walker A, (1998), "Evaluation of project Outcomes", Construction Management and Economics, 16, pp 209-219.
[36]. Lo and Yeung, 2004: V. H. Y. Lo and A. H. W. Yeung, Practical framework for strategic alliance in Pearl River Delta manufacturing supply chain: A totalquality approach, International Journal of Production Economics 87 (3) (2004), pp. 231-240.
[37]. Long, N. D., Ogunlana, S., Quang, T., and Lam, K. C. (2004). "Large Construction projects in developing countries: A case study from Vietnam." Int.J. Project Manage., 22(7), 553–561.
[38]. Lo, T. Y., Fung, I. W. H., and Tung, K. C. F. (2006). "Construction delays in Hong Kong civil engineering projects." J. Constr. Eng. Manage., 132(6), 636–649.
[39]. Mahamid, I., Bruland, A., and Dmaidi, N. (2012). "Causes of delay in road construction projects." J. Manage. Eng., 28(3), 300–310.
[40]. Majid, I. A. (2006). "Causes and effect of delays in Aceh construction industry." Master's thesis, Univ. of Technology Malaysia, Johor
[41]. Morris, P. W. G., & Hough, G.H. (1986). The preconditions of success and failure in major projects, Technical Paper#3, Major Projects
[42]. Nkhata L. (1997), Methodological options in Policy Relevant Social Research, Study Fund, Lusaka, pp 77-170.
[43]. Odeyinka, H. A., and Yusif, A. (1997). "The causes and effects of construction delays on completion cost of housing project in Nigeria." J. FinancialManage Property Constr., 2(3), 31–44.
[44]. Ogunlana, S. O., Promkuntong, K., and Jearkjirm, V. (1996). "Construction delays in a fast-growing economy: Comparing Thailand with other economies."Int. J. Project Manage., 14(1), 37–45.
[45]. Peerzada Mohsin Shafi, "A Study on Delayed Highway Projects in the UT of Jammu & Kashmir (India)", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181 IJERTV9IS100037, Vol. 9 Issue 10, October-2020
[46]. Sambasivan, M., and Soon, Y. W. (2007). "Causes and effects of delays in Malaysian construction industry." Int. J. Project Manage., 25(5), 517–526.
[47]. Sweis, G., Sweis, R., Abu Hammad, A. and Shboul, A. (2008). Delays in construction projects: The case of Jordan. International Journal of Project Management, 26(6):665-674. doi: 10.1016/j.ijproman.2007.09.009.
[48]. Santoso, D. S., Joewono, T. B., Wibowo, A., Sinaga, H. P. A., and Santosa, W. (2012). "Public-private partnerships for tollway construction and operation: Risk assessment and allocation from the perspective of investors." J. Constr. Dev. Countries, 17(2), 45–66.
[49]. Schwab, K., and Sala-i-Martin, X. (2013). "The global competitiveness report 2013-2014: Full data edition." World Economic Forum, Geneva.
[50]. Sangiambut, M. (2014). "Booming Cambodia beckons investors." Bangkok Post, Bangkok, Thailand.
[51]. Semple, C., Hartman, F., and Jearges, G. (1994). "Construction claims and disputes: Causes and cost/time overruns." J. Constr. Eng. Manage., 120(4), 785–795.
[52]. Toor, S. U. R., and Ogunlana, S. O. (2008). "Problems causing delays in major construction projects in Thailand." Constr. Manage. Econ., 26(4), 395–408.
[53]. Trauner, D. A., Ballantyne, A., Chase, C., & Tallal, P. (1993). Comprehension and experession of affect in language-impaired children. Journal of Psycholinguistic Research, 22, 445-452.
[54]. Waqar Ahmad Paray, Chitranjan Kumar (2020), "DELAY ANALYSIS IN CONSTRUCTION PROJECTS". International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 10 | Oct 2020.
[55]. Yates, J., and Epstein, A. (2006). "Avoiding and minimizing construction delay claim disputes in relational contracting." J. Prof. Issues Eng. Educ. Pract.,132(2), 168–179.