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Causes of Delay in Highway Construction Projects using Relative Importance Index Method

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Abstract: ***The objective of this paper is to assess the causes of delays in the completion of highway construction projects due to the failures of employer, consultant and contractor during the construction phase. Delays in highway construction projects are inevitable and may results in disputes, litigation, claims among different parties and adversely impact on project success in terms of time, quality, & cost.***
This research proposes a framework for contractor to analyze the delay factors before the bidding stage of the project by utilizing the relative importance index (RII) method. For this purpose a questionnaire has been developed after identifying 63 delay factors, categorized into 8 groups through a detailed literature review process as well as interviews with experts from highway construction industry.
The ranking of factors and groups have been demonstrated according to their importance level on delay. And finally some suggestions & recommendations have made to minimize and control delays in highway construction projects.
Author Keywords: Highway Construction Projects; Delay Factors; Relative Importance Index; Ranking of Delay Factors; Suggestion & Recommendations.

I. INTRODUCTION

The highway construction is an integral component of a nation's infrastructure & plays an significant role in economic development through multiple effects on other sector of economy. A construction project is commonly considered as successful, when it is completed within its budget, time, and targeted quality (Olawale and Sun 2013).
Construction delay defined as "the time overrun beyond completion date specified in the contract, or beyond the date that parties agreed upon for delivery of a project" (Assaf and Al-Hejji 2006). Delays in highway construction projects are considered to be one of the most recurring problems and usually accompanied by cost overrun. Delay may have negative effects to the project related parties.
The negative effects of delay are increase in cost & time of completion of project & decreases quality and productivity, disputes, and termination of contracts (Majid 2006; Mahamid et al. 2012). Delay for Owner means loss of revenue through lack of production facilities or a dependence on present facilities. Delay for contractor means higher overhead costs because of longer construction period, and higher material & labour costs due to inflation. Contractor should carefully quantify & analyses the delay factors for the purpose of securing project success.

II. OBJECTIVES OF RESEARCH

This research addresses the delay analysis in construction of highway projects with a focus on delay factors identification and ranking of delay factors. The main objective of this research include the following-

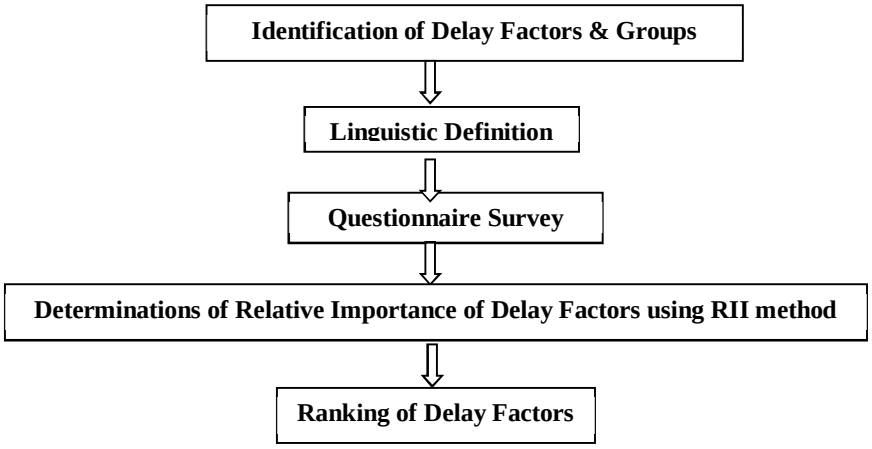
A. To identify & categorize causes of delay in highway construction projects.
B. To determine the relative importance of delay factors & groups, & demonstrate the ranking of delay factors and groups according to their level of importance on delay by using relative importance index method.
C. Demonstrate the factors and groups that are most likely to cause delay.
D. To propose some recommendation and corrective action to control & minimize delays in highway construction projects.

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III. RESEARCH METHODOLOGY

A. *Methodology Flow*



1) Step 1: Identification of delay factors

Total 63 delay factors were identified through literature review and discussion with highway construction experts. A questionnaire form is prepared in following format-

Table: 1 Questionnaire Form

Sr. No	Factors Causing delays	Respondent Score
1	Poor site management and supervision	
2	Inadequate contractor experience	
3	Rework due to errors	
4	Ineffective project planning and scheduling by contractor	
5	Conflict between contractor and other parties	
6	Difficulties in financing the project by contractor	
7	Frequent change of sub contractor	
8	Inappropriate construction method / Obsolete technology	
9	Lack of coordination and communication b/w contractor & other parties	
10	Delay in site mobilization /shifting of existing utilities	
11	Delay in approving major changes in scope of work by consultant /Frequent design change	
12	Delay in performing inspection and testing	
13	Inflexibility (rigidity) of consultant	
14	Inaccurate site investigation / pre design data	
15	Lack of experience of consultant in construction project	
16	Late in reviewing and approving design document by consultant	
17	Lack of coordination and communication b/w consultant and other parties	
18	Change order during construction	
19	Delay in progress payment by owner	
20	Suspension of work by owner	
21	Delay in revising & approving design documents	
22	Delay/slowness in decision making process	
23	Delay in site delivery to contractor(land acquisition)	
24	Unrealistic time estimation	

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25	Financial difficulties of owner/fund constraints	
26	Conflict between joint ownership	
27	Lack of coordination and communication b/w owner and other parties	
28	Labor shortage	
29	Low labor productivity	
30	Inexperienced /unqualified labors	
31	Personal conflicts among labors and management team	
32	Labors absenteeism	
33	Fluctuation of prices of materials	
34	Late delivery of material and equipment(soil, aggregate etc)	
35	Poor procurement of construction material	
36	Shortage of construction material in market	
37	Unreliable suppliers	
38	Frequent equipment breakdown	
39	Low productivity & efficiency of equipment	
40	Change in material types and specifications during construction	
41	Mistakes and discrepancies in design document	
42	Delay in producing design document	
43	Insufficient data collection and survey before design / Improper project feasibility study	
44	Misunderstanding of owner's requirement by design engineer	
45	Inadequate design team experience	
46	Poor use of advanced engineering design software	
47	Design changes by owner OR his agent during construction	
48	Original contract duration is too short	
49	Ineffective delays penalties	
50	legal dispute between project participants	
51	Unfavorable contract clauses	
52	Tender winning prices are unrealistically low (suicide tendering) /L1 model	
53	Project complexity	
54	Accidents during construction	
55	Unforeseen ground conditions (e.g high water table , soil)	
56	Delay in obtaining clearance (permits / NOC) from concern authority	
57	Change in government regulations and laws	
58	Global financial crisis	
59	Force majeure (flood, earthquake)	
60	Loss of time by traffic control and restriction at job site	
61	Unfavorable weather condition	
62	Delay in providing services from utilities (such as water ,electricity)	
63	Public agitation demanding other facilities/ Law and order problem	

2) Step 2: Linguistic Definition

After identification of delay factors a meeting was arranged with highway construction experts working on NH-234 (from Etawah to Kannauj, India) to define linguistic terms. The linguistic term of importance of each delay factors are “Very High”, “High”, “Medium”, “Low”, “Very Low”. Meaning of each linguistic term associated to all delay factors are given below.

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Table: 2 Linguistic Definition of delay factors importance

Linguistic Term	Delay in project duration
Very High Important (VH)	% project delay > 20
High Important (H)	15 < % project delay < 20
Medium Important (M)	10 < % project delay < 15
Low Important (L)	5 < % project delay < 10
Very Low Important (VL)	% project delay < 5

Table: 3 Crisp Rating used in questionnaire

Linguistic term	Crisp Rating
Very Low Important (VL)	1
Low Important (L)	2
Medium Important (M)	3
High Important (H)	4
Very High Important (VH)	5

3) Step 3: Questionnaire Survey

Delay analysis is done through Questionnaire survey. Total 33 questionnaire forms in online and offline mode in above questionnaire format (Table: 1) were filled by highway construction experts. Respondent profile is given in Table:

Table: 4 final respondents profile

Sr.No	Respondents Category	Total Respondents	Average Experience
1	Owner /Clients	14	21.07
2	Contractor	10	16.6
3	Consultant	9	10.78

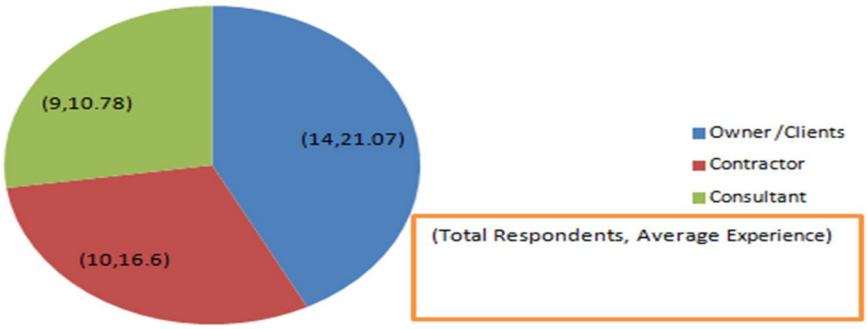


Figure: 1 Pie Chart representing Total Respondents and Average Experience

4) Step 4: Determinations of Relative Importance of Delay Factors using RII method

After performing questionnaire survey, responses from questionnaire are unified using Relative Importance Index Method to determine the relative importance of the each cause of delays, which is given by -

$$RII = \frac{\sum W}{A * N}$$

Where $\sum W$ = Sum of responses i.e. sum of crisp rating of factor given by respondents

A = Maximum value of crisp rating which is 5.

N = No. of respondents.

$0 < RII \leq 1$, higher the RII higher the importance of delay factor.

RII is calculated on the basis of owner, consultant, contractor and overall responses.

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5) Step 5: Ranking of Delay Factors using RII values

Ranking of delay factors is done on the basis of RII values from owner, consultant, contractor and overall responses.

a) Step 5.1: Rank Correlation

The Spearman's method is used for rank correlation, that indicate the agreement level on the ranking among different groups of respondents (i.e. owner, consultant, & contractor & overall) participating in the questionnaire survey. It is mathematically represented as

$$\rho = 1 - \frac{6 * \sum d^2}{(N^3 - N)}$$

Where ρ = Agreement level between different respondents groups ($0 \leq \rho \leq 1$).

d = difference of the ranking of a delay factor.

N = total number of pairs in rank (in this case 63, as the no. of delay factors).

IV. RESULTS & DISCUSSION

A. *Reliability of Questionnaire data*

Before starting of questionnaire data analysis, Reliability of questionnaire data is checked. That means degree of stability and internal consistency of data collected in the questionnaire survey is assessed by using Cronbach's alpha formula which is widely used that shows the internal consistency of data i.e. how much a set of data is closely related. These reliability results in term of cronbach's alpha are determined by using SPSS software Table 4.1 shows results of reliability test.

Table: 5 Data reliability test results

Respondents Category	Owner	Contractor	Consultant	Overall
Cronbach's Alpha	0.958	0.850	0.968	0.961

From the above results of cronbach's alpha according to the questionnaire filled by owner, contractor, consultant, & overall. The questionnaire data have excellent internal consistency. As shown in Table: 5, the reliability coefficient results are in the range from 0.850 to 0.968 this is considerably higher than the modest reliability in the range 0.50 - 0.60. The result ensures that the questionnaire data is reliable so we can further proceed to the next step of data analysis.

B. *Data Analysis*

The RII is calculated for each delay factor to identify the most and least important delay factors in the construction of highway projects. On the basis of calculated RII values from responses of consultant, contractor, owner, & overall, these delay factors are ranked. There are overall 35 responses that we have got through interviews as well online surveys of highway construction experts, in which 33 are found to be correct. Out of these 33 responses, 14 responses are from Owners, 10 responses are from contractors & 9 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 show factors of schedule delay, according to consultant, contractor, owner, & overall with computed RII's, and ranks.

Table: 5 Ranking of Factors Causing Delays according to Consultant, Contractor, Owner & Overall Responses

Sr. No	Factors Causing Delays	Owner			Contractor			Consultant			Owner		
		∑W	RII	RANK	∑W	RII	RANK	∑W	RII	RANK	∑W	RII	RANK
1	Poor site management and supervision	56	0.800	3	28	0.56	27	31	0.689	22	115	0.697	11
2	Inadequate contractor experience	51	0.729	10	30	0.6	22	34	0.756	15	115	0.697	11
3	Rework due to errors	36	0.514	56	28	0.56	27	36	0.8	10	100	0.606	30
4	Ineffective project planning and scheduling by contractor	54	0.771	6	41	0.82	3	41	0.911	2	136	0.824	3
5	Conflict between contractor and other parties	45	0.643	23	29	0.58	23	39	0.867	4	113	0.685	15
6	Difficulties in financing the project by	56	0.800	3	36	0.72	8	41	0.911	2	133	0.806	4
7	Frequent change of sub contractor	34	0.486	59	25	0.5	45	33	0.733	17	92	0.558	46

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8	Inappropriate construction method / Obsolete technology	43	0.614	32	26	0.52	42	29	0.644	33	98	0.594	33
9	Lack of coordination and communication b/w contractor & other parties	42	0.600	34	23	0.46	50	29	0.644	33	94	0.57	41
10	Delay in site mobilization	45	0.643	23	31	0.62	16	31	0.689	22	107	0.648	23
11	Delay in approving major changes in scope of work by consultant /Frequent design change	48	0.686	16	31	0.62	16	39	0.867	4	118	0.715	8
12	Delay in performing inspection and testing	46	0.657	20	27	0.54	36	29	0.644	33	102	0.618	26
13	Inflexibility (rigidity) of Consultant	36	0.514	56	20	0.4	58	21	0.467	52	77	0.467	58
14	Inaccurate site investigation / pre design data	49	0.700	14	27	0.54	36	36	0.8	10	112	0.679	17
15	Lack of experience of consultant in construction project	46	0.657	20	25	0.5	45	25	0.556	46	96	0.582	38
16	Late in reviewing and approving design document by consultant	49	0.700	14	28	0.56	27	33	0.733	17	110	0.667	20
17	Lack of coordination and communication b/w consultant and other parties	41	0.586	39	26	0.52	42	20	0.444	54	87	0.527	54
18	Change order during construction	50	0.714	12	37	0.74	6	29	0.644	33	116	0.703	9
19	Delay in progress payment by owner	47	0.671	18	40	0.8	4	27	0.6	40	114	0.691	14
20	Suspension of work by owner	42	0.600	34	33	0.66	13	19	0.422	55	94	0.57	41
21	Delay in revising & approving design	43	0.614	32	31	0.62	16	24	0.533	48	98	0.594	33
22	Delay/slowness in decision making process	45	0.643	23	28	0.56	27	23	0.511	49	96	0.582	38
23	Delay in site delivery to contractor(land acquisition)	59	0.843	1	44	0.88	1	42	0.933	1	145	0.879	1
24	Unrealistic time estimation	41	0.586	39	31	0.62	16	19	0.422	55	91	0.552	48
25	Financial difficulties of owner/fund	56	0.800	3	35	0.7	11	38	0.844	6	129	0.782	5
26	Conflict between joint ownership	44	0.629	27	27	0.54	36	30	0.667	25	101	0.612	27
27	Lack of coordination and communication b/w Owner and other parties	39	0.557	49	23	0.46	50	23	0.511	49	85	0.515	55
28	Labor shortage	46	0.657	20	28	0.56	27	36	0.8	10	110	0.667	20
29	Low labor productivity	41	0.586	39	27	0.54	36	30	0.667	25	98	0.594	33
30	Inexperienced /unqualified labors	42	0.600	34	21	0.42	55	18	0.4	58	81	0.491	57
31	Personal conflicts among labors and management team	25	0.357	63	17	0.34	63	15	0.333	62	57	0.345	63
32	Labors absenteeism	31	0.443	60	18	0.36	61	16	0.356	60	65	0.394	61
33	Fluctuation of prices of materials	42	0.600	34	29	0.58	23	17	0.378	59	88	0.533	51
34	Late delivery of material and equipment(soil, aggregate etc)	50	0.714	12	27	0.54	36	35	0.778	13	112	0.679	17
35	Poor procurement of construction material	54	0.771	6	23	0.46	50	33	0.733	17	110	0.667	20
36	Shortage of construction material in market	47	0.671	18	31	0.62	16	35	0.778	13	113	0.685	15
37	Unreliable suppliers	41	0.586	39	19	0.38	59	16	0.356	60	76	0.461	59
38	Frequent equipment breakdown	44	0.629	27	29	0.58	23	30	0.667	25	103	0.624	24
39	Low productivity & efficiency of equipments	40	0.571	45	23	0.46	50	38	0.844	6	101	0.612	27
40	Change in material types and specifications during construction	29	0.414	62	18	0.36	61	15	0.333	62	62	0.376	62
41	Mistakes and discrepancies in design	48	0.686	16	39	0.78	5	32	0.711	20	119	0.721	7
42	Delay in producing design document	38	0.543	52	26	0.52	42	30	0.667	25	94	0.57	41
43	Insufficient data collection and survey before design / Improper project feasibility study	54	0.771	6	37	0.74	6	37	0.822	8	128	0.776	6
44	Misunderstanding of owner's requirement by design engineer	39	0.557	49	21	0.42	55	28	0.622	37	88	0.533	51
45	Inadequate design team experience	38	0.543	52	19	0.38	59	34	0.756	15	91	0.552	48
46	Poor use of advanced engineering design software	36	0.514	56	25	0.5	45	27	0.6	40	88	0.533	51
47	Design changes by owner OR his agent during construction	40	0.571	45	27	0.54	36	27	0.6	40	94	0.57	41

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48	Original contract duration is too short	39	0.557	49	36	0.72	8	28	0.622	37	103	0.624	24
49	Ineffective delays penalties	45	0.643	23	28	0.56	27	26	0.578	43	99	0.6	32
50	legal dispute between project participants	54	0.771	6	32	0.64	14	30	0.667	25	116	0.703	9
51	Unfavorable contract clauses	42	0.600	34	22	0.44	54	30	0.667	25	94	0.57	41
52	Tender winning prices are unrealistically low (suicide tendering) /L1 model	51	0.729	10	34	0.68	12	30	0.667	25	115	0.697	11
53	Project complexity	37	0.529	54	25	0.5	45	22	0.489	51	84	0.509	56
54	Accidents during construction	30	0.429	61	21	0.42	55	21	0.467	52	72	0.436	60
55	Unforeseen ground conditions (e.g high water table , soil)	44	0.629	27	36	0.72	8	32	0.711	20	112	0.679	17
56	Delay in obtaining clearance (permits / NOC) from concern authority (Railway, municipal,	58	0.829	2	43	0.86	2	37	0.822	8	138	0.836	2
57	Change in government regulations and laws	44	0.629	27	29	0.58	23	19	0.422	55	92	0.558	46
58	Global financial crisis	41	0.586	39	28	0.56	27	28	0.622	37	97	0.588	36
59	Force majeure (flood, earthquake)	41	0.586	39	28	0.56	27	31	0.689	22	100	0.606	30
60	Loss of time by traffic control and restriction at job site	37	0.529	54	32	0.64	14	26	0.578	43	95	0.576	40
61	Unfavorable weather condition	40	0.571	45	31	0.62	16	30	0.667	25	101	0.612	27
62	Delay in providing services from utilities (such as water ,electricity)	40	0.571	45	24	0.48	49	26	0.578	43	90	0.545	50
63	Public agitation demanding other facilities/ Law and order problem	44	0.629	27	28	0.56	27	25	0.556	46	97	0.588	36

C. Rank Correlation Results

The Spearman's method is used for rank correlation that indicate the agreement level on the ranking among different groups of respondents (i.e. owner, consultant, & contractor & overall) participating in the questionnaire survey. Table: 7 showing the results of Spearman's rank correlation.

Table: 6 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	-	-	-

1) The highest correlation (86%) is found in between owner responses & overall responses. This signify that the owner really understand the overall/general situation in construction of highway projects, & owner alone can provide fairly accurate enough initial results in future pilot studies (regarding the highway construction industry at large), saving time , recourses, & efforts otherwise required for a full case study. This is an important methodological observation and a valuable suggestion for future researches.

2) The second highest correlation (81%) is found in between the consultant representatives & overall respondents, who strongly agreed with each other.

3) The poorest correlation (44%) is found in between design consultant respondents & contractor respondents. Consultant admits that their Professional output is not sufficient & is responsible for delay in construction of highway projects. They consider that a root cause of this is the low budget they receive, which do not motivate them to produce high quality designs that affect the quality of their work.

4) Similarly, the other correlations among various respondent groups are in range of 44-86%.

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Top 15 Most Important Factors Causing Schedule delay According to Overall Responses

Based on above overall ranking, the top fifteen (15) most significant factors that cause schedule delay in construction of highway projects are shown in Table: 8. & graphical representation of top 15 factor causing delay is shown in figure 2.

Table: 8 Top 15 most important delay factors in highway construction projects

Sr. No	Factors Causing Delays	Group of Factor	RII	RANK
23	Delay in site delivery to contractor(land acquisition)	Owner related	0.879	1
56	Delay in obtaining clearance (permits / NOC) from concern authority (Railway, municipal, environmental, & forest etc.)	External related	0.836	2
4	Ineffective project planning and scheduling by contractor	Contractor related	0.824	3
6	Difficulties in financing the project by contractor	Contractor related	0.806	4
25	Financial difficulties of owner/fund constraints	Owner related	0.782	5
43	Insufficient data collection and survey before design /	Design related	0.776	6
41	Mistakes and discrepancies in design document	Design related	0.721	7
11	Delay in approving major changes in scope of work by consultant /Frequent design change	Consultant related	0.715	8
18	Change order during construction	Owner related	0.703	9
50	legal dispute between project participants	Project related	0.703	9
1	Poor site management and supervision	Contractor related	0.697	11
2	Inadequate contractor experience	Contractor related	0.697	11
52	Tender winning prices are unrealistically low (suicide tendering) /L1 model	Project related	0.697	11
19	Delay in progress payment by owner	Owner related	0.691	14
5	Conflict between contractor and other parties	Contractor related	0.685	15
36	Shortage of construction material in market	Material related	0.685	15

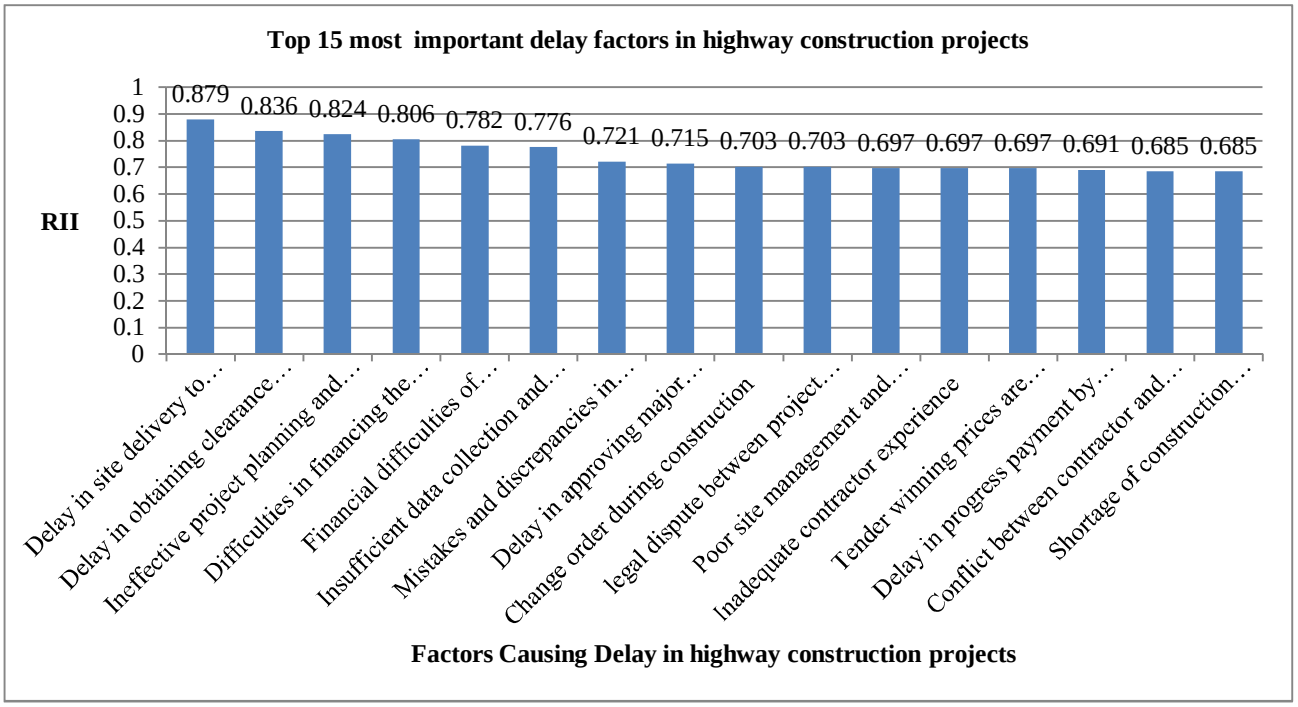


Figure. 2 Column Bar Chart Showing Top 15 Factors Causing Delays In Highway Construction Projects

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V. CONCLUSION & RECOMMENDATION

The aim of this research was to analyze the delay causing factors in highway construction projects. In this research 63 delay factors were identified through literature review and discussion with highway construction experts and a questionnaire survey was conducted among owners, contractors and consultants to elicit the information about the importance level of each delay factor in terms of crisp rating. To unify questionnaire responses Relative Importance Method (RII) method is used. Ranking of delay factors is done on the basis of RII values of delay factors to compare the relative importance of delay factors. The highway construction stakeholders have to focus on these research findings to avoid delay in the construction of highway project, considering the factors contributing most to the delays. According to research findings, by considering the list of the 15 most significant factors causing delays (Table 4.1), the following suggestions & recommendations can be made as to minimize and control delays in highway construction projects:

A. Delays in site delivery to contractor (land acquisition), is the most important delay factor that caused by owners. The site should be handed over to the contractors on time after awarding the project. That should be free from legal hurdles.
B. Delay in obtaining clearance (permits / NOC) from concern authority (Railway, municipal, environmental, & forest etc.) is the second most important delay factor. The owner should facilitate the contractor to obtain clearance from the concern authority. This should be done on priority base otherwise the project may delay very badly.
C. Ineffective project planning and scheduling by contractor is the third most important delay factor caused by contractor. The robust attention should be paid by contractors for effective planning and scheduling. Scheduling and planning may be revised during construction, if necessary.
D. Poor financial management by contractors in highway construction projects also affect the time of completion of the construction of highway projects. For proper financial management contractors are required to decide financing sources using scientific methods before the starting of construction of highway projects.
E. Financial difficulties of owner/fund constraints that leads to delay in construction of highway projects. Owners should open their budget in front of contractor & consultant for project financing and owners are required to keep the projects specifications within their budget.
F. Insufficient data collection and survey before design / Improper project feasibility study is also the most important delay factor that leads to delay in construction of highway projects. The owner should conduct some accurate preliminary survey with design consultancy for project feasibility requirement.
G. Mistakes and discrepancies in design document also leads to delay in construction of highway projects. The design consultancy should design the detailed design project reports with great efficiency and accuracy that avoid discrepancies in design documents.
H. Delay in approving major changes in scope of work by consultant also leads to delay in construction of highway projects. Approval of design documents should not be late, which may hinder the progress of work.
I. Change order during construction may leads to delay, claims &"disruption of work due to improper analysis of the project from its initial stages. Therefore, contract conditions related to change orders should be carefully evaluated. Clients should also consider their adverse effects on projects critical activities.
J. Legal dispute between project participants may also leads to delay in highway construction projects. Legal disputes can be mitigated or avoided by clearing the project's terms and condition through legal documentations.
K. Poor site management and supervision may also hinder the project progress. The contractor should made site supervision and management properly, & make the necessary arrangements to complete the projects within specific time limits while satisfying quality and cost requirements.
L. Tender winning prices are unrealistically low /L1 model may also leads to delay the project. Owner should conduct both technical and financial bid among contractors to evaluate composite score of each contractor. The contractor having highest composite score should be awarded the project. This process is called as best value selection.
M. Delay in progress payment by owner may also hinder the project progress. The owner should make the necessary arrangements so that contractor could be paid timely on basis of completed work.
N. The contractor should make necessary arrangement so that the construction materials on site should be delivered on time in order to execute the work properly.

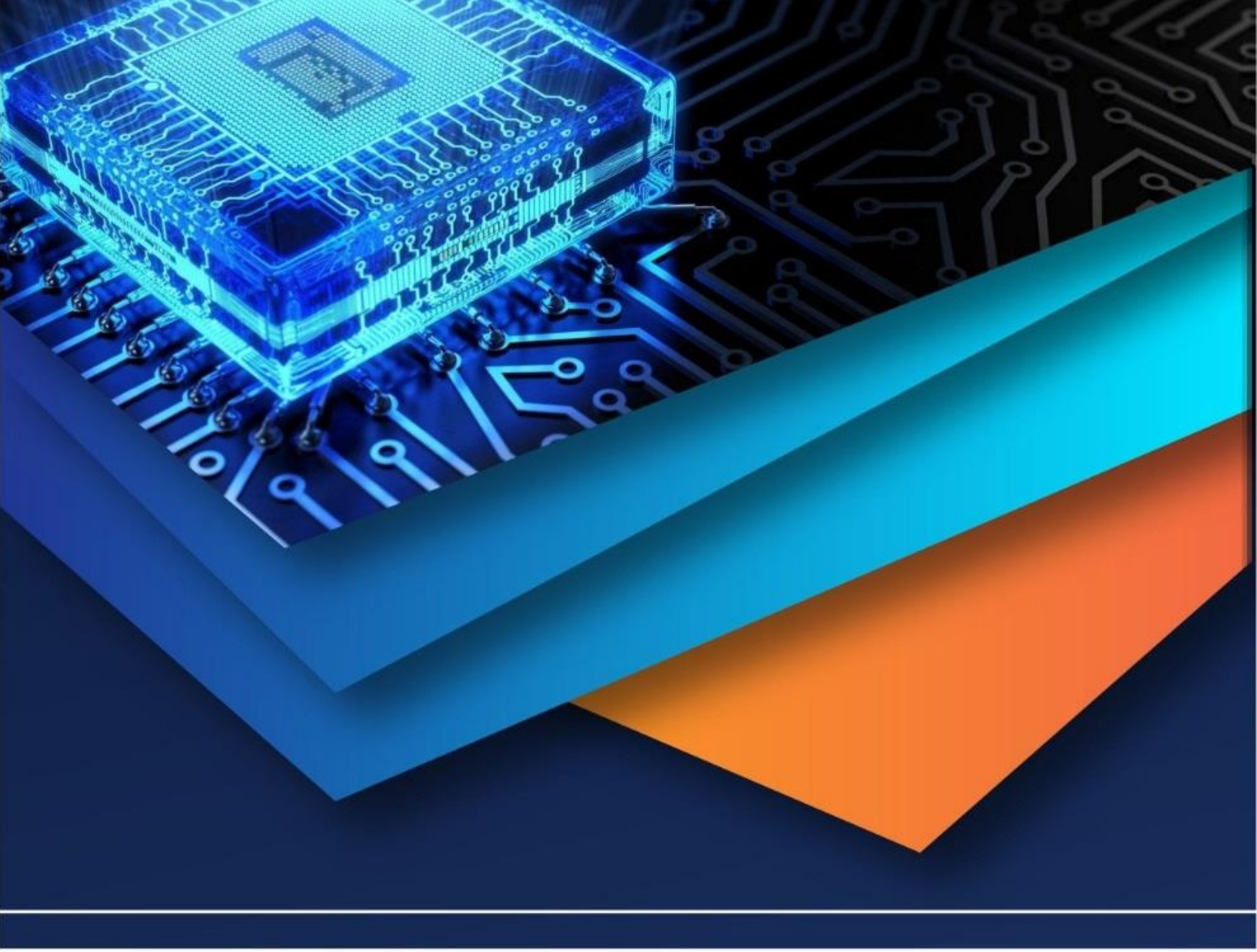
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Delays in highway construction projects can be mitigated or avoided when their causes are clearly identified. After the identification of most important delay factors a robust delay mitigation response strategy can be developed. A joint effort based on teamwork is required to mitigate delays in highway construction projects.

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