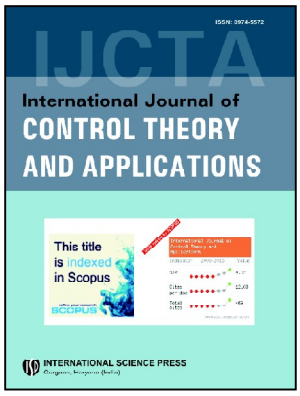

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Analysis of Factors Which Cause Delay in Road Construction Projects In Mysuru Region, India

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Abstract: Managing a road construction projects in India are highly complex and are affected by various constraints. Numerous problems arise on a daily basis in the road construction sector, which are attributed to delays. Identifying these delays which are significantly influencing the projects and sorting it based on its importance is of great use in planning and managing the projects. Thus, the focus of this paper is to identify, rank, and assess the major delay cause factors in road construction projects based on the perception of the contractors who are involved in road constructions in the Mysore region, India. The data required for analysis was collected using a questionnaire survey among the contractors (82 responses). The identified delay cause factors and sub-delay factors were arranged in a hierarchical structure, which was then prioritized using two distinct methods viz. Analytic Hierarchy Process (AHP) and Relative Important Index (RII).

Keywords: Analytic Hierarchy Process, Relative Importance Index, Delay Causes Factor, Road Construction

I. INTRODUCTION

Road development in any country is one of the prime aspect which has a significant impact on the economic growth. The complexities involved in road constructions are so high that the completion of the projects generally gets delayed, resulting in various complications and losses. Any projects generally gets affected by various delays, thus delay management has been looked into as one of the essential aspect of project management and thus in road construction projects. Research on project delays which focused on understanding the reasons for wastefulness in road construction projects revealed that, one delay generally adds to the development of different others delays resulting in extension of the project schedule.

Normally, a road construction projects are affected by various delays but it is to be noted that the impact of these delays varies depending on the location and type of projects. Contractors normally find difficulties in managing these delays effectively. Most projects fail to meet the deadlines and/or end up overshooting the budget. Hence there is always a higher scope for research in this area which will help in managing these risk in projects effectively. Delay assessment and delay management are vital in project management which was not taken very seriously in the Indian construction scenario. Most contractors are not experienced enough to predict

and assess the impact and consequences of a particular delay. Also, delay factors vary on the basis of location and also based on the project size (type of contractors) resulting in higher complexity to manage these projects. Thus, the prioritized chart of delay cause factors considering these aspects would be of great use for contractors in effectively managing these delays in the future projects.

This study is carried out in the Mysore region which is considered as one of the oldest city with a very rich historical background. It is the third most populous city in the state and is just 146 Km away from the state capital Bengaluru. Since, the urbanization in the Bengaluru city is at the maturity, the corporate companies and other Industrialist are looking into Mysore as their next alternative. This has resulted in a rapid growth in the city and thus higher demand for road developments. According to the KPWD Mysuru Circle Office, construction projects are frequently getting delayed in Mysuru circle, resulting in higher costs. Thus, the outcomes of this research would be a valuable source of information for the road construction companies/contractors in managing the projects effectively.

In India, all states maintain a separate department to oversee the construction and maintenance of roads. In Karnataka, the Karnataka Public Works, Ports & Inland Water Transport Department constructs and maintains the roads. KPWD is divided into several circles to ease work, of which Mysuru circle covers Mysuru city, and the districts of Mysuru, Mandya, and Chamrajnagara. As per the KPWD, contractors are divided into three categories according to their limits viz. Class I, Class II, and Class III contractors. Class III contractors have a limit of INR 10 lakhs and account for about 28 percentage of the total contractors in Mysuru circle, Class II contractors have a limit of INR 20 lakhs and account for about 27 percentage of the total contractors in Mysuru circle, and Class I contractors have a no limit. They account for about 45 percentage of the total contractors in Mysuru circle.

The focus of this work is to identify, rank, and analyze the major delay factors based on the perception of the contractors in Mysore region. This would result in the creation of a plan which basically gives the information on important delays cause factors in the study location which would help in project delay management.

II. LITERATURE REVIEW

Project delay management is of interest to researchers as every project in the practical field undergoes certain amount of delay. A number of literatures have emphasized potential delay factors, and the effects of delay from a contractor perspective in road construction projects. Since the context of this study is within India, sufficient care has been taken to include some relevant studies and literatures within the Indian context. Based on previous studies, a framework was also formulated for the present study. The delay cause factors and its effects were identified from past studies which are relevant for the current study.

A number of studies have been conducted to identify the causes of delay in construction projects. Ravisankar *et al.* (2014), in their research studied about the quantification of delay factors in the construction business. The focus of the paper was on finding the important causes of construction delays and their effects. The overall results indicated that the Shortage of Labour, Design changes by the owner or his agent during construction, Fluctuations of prices, and High waiting time for availability of work teams are prime factors of delay [1]. Also Ram and Paul (2015), conducted a research in order to find the Construction Sequence Delay in Road Construction Projects. Using Relative Importance Index (RII) top significant causes of road construction projects were ranked. Some these delays were, Delay due to land acquisition, Environmental issues, Delay in progress payment, Ineffective project planning and scheduling, Rework due to errors, Delay in approving design documents, Poor coordination between owners and other parties, Poor site management and supervision, Financial closure, and Change order by clients [2].

Seboru (2015), investigated the Factors Causing Delays in Road Construction Projects in Kenya region. The study captured the perception of consultants and contractors regarding important causes of delay in the

completion of road construction projects within the due date. The overall important causes of delay determined by contractors and consultants were, Slow decision-making and bureaucracy in the client organization, Payment by the client, Claims, Inadequate planning / scheduling, and Rain [3].

Smbasivan and Wen-Soon (2007), in their paper concentrated on finding the causes and effects in the Malaysian construction industry. They captured the perceptions of contractors, clients, and consultants through a questionnaire survey. The causes were sub -graded into eight groups, namely, Client related factors, Contractors related factors, Consultant related factors, Material related factors, Locker and equipment related factors, Contract related factors, and Contract relationship related factors [4]. James *et al.* (2014), investigated the causes and effect of delay on project construction delivery time. The identified major factors were, Lack of money, Drawing changes, Lack of communication, Lack of data from consultants, Slow decision making, Inefficiency in project management, Lack of documentation, Fluctuation in prices, and Weather [5].

Kolhe and Darade (2014), made a detailed analysis on Delay in Construction Projects. The main objectives of the study were, to identify the factors of delay in construction projects, to study cost of delay, to study the effects of delay, analyze the information gathered from the ongoing construction projects, and discuss and give suggestions for minimizing the effects of delay for construction projects. They identified delay causes were, Owner related problems, Project related problem, Design problems, Material related problems, and Labour related problems. The top effects were Time overrun, Cost overrun, Legal problems, Abandonment, and Arbitration [6]. Adhikari et al., in their research ranked the thought-about factors in terms of severity and frequency. The analysis of the data indicated that the highest risks poignant time overrun in construction in Palestine comes from money standing of the contractors, payment delays by the owner, the political state of affairs and segmentation of the geographic area, poor communication between construction parties, lack of kit potency, and high competition in bids [7]. Megha and Rajiv (2013), found that delays are one of the most important problems that construction firms face these days. Delays can result in many negative effects like lawsuits between householders and contractors, exaggerated costs, loss of productivity and revenue, and contract termination [8]. A similar study was conducted in UK with an aim to study the client related factors and its influence on project performance [9].

Ranking and prioritization of delay is the most common and useful study performed which help managers in managing the risks and delays involved in projects efficiently. The two important methods used for this purpose are Analytic Hierarchy Process (AHP) and Relative Importance Index (RII). The Analytic Hierarchy method was developed by Saaty (2008). It is a multi-criteria decision analysis methodology, which is both flexible as well as robust [10]. Perera and Sutrisna (2010), in their paper, focused on developing a model for selection of most appropriate delay analysis method under a set of specific circumstances of a project. They have developed a conceptual model using AHP analysis, which is suitable to analyze the delay claims in construction [11]. RII is a type analysis where the factors related to a particular problem are sorted as per their significance [12].

With the help of these literatures and based on the location and nature of projects, relevant factors were considered and a conceptual framework for the current study is developed (Table 1). Further, the identified factors are prioritized using, Analytic Hierarchy method (AHP) and Relative Importance Index (RII). Thus, the results obtained will give us a chart of delay cause factors, which are significantly influencing the projects in the current study location. This information can be used by project managers in their decision in order to eliminate or minimize the delays in the future projects. Thus, form these literature survey relevant factors for the current study are listed as shown in Table 1.

Table 1
List of factors and sub factors considered for the current study

Consultant Related Factors	Contractor Related Factors	Design Related Factors
1. Inaccurate site investigation 2. Inadequate project management assistance 3. Late in reviewing and approving design documents 4. Poor communication and coordination with other parties 5. Lack of experience of consultant in construction projects 6. Conflicts between consultant and design engineer 7. Delay in approving major changes in the scope of the work by the consultant 8. Delay in performing inspection and testing	1. Inadequate contractor experience 2. Inappropriate construction methods 3. Slowness in decision making 4. Incompetent project team 5. Ineffective project planning and scheduling 6. Obsolete technology 7. Poor communication and coordination with other parties 8. Poor site management and supervision 9. Rework due to errors 10. Inadequate cash flows due to nonpayment	1. Complexity of project design 2. Design changes by client or his agent during construction 3. Design errors made by designers 4. Insufficient data collection and survey before design 5. Mistakes and delay in producing design documents 6. Misunderstanding of client requirements by design engineer 7. Poor use of advanced engineering design software 8. Unclear and inadequate details in design drawings
Labor Related Factors	**Equipment Related Factors**	**Project Related Factors**
1. Absenteeism 2. Low motivation and morale of labor 3. Low productivity of labor 4. Personal conflicts among labors 5. Shortage of labors 6. Slow mobilization of labor 7. Strikes 8. Unqualified/inadequate experienced labors	1. Equipment allocation problem 2. Frequent equipment breakdown 3. Improper equipment 4. Inadequate modern equipment 5. Low efficiency of equipment 6. Shortage of equipment 7. Slow mobilization of equipment	1. Complexity of the project 2. Inadequate definition of substantial completion 3. Ineffective delay penalties 4. Legal disputes between project participants 5. Original contract duration is short 6. Unfavorable contract clauses
Material Related Factors		**Sub-Contractor Related Factors**
1. Changes in material types and specifications during construction 2. Damage of materials 3. Delay in manufacturing materials 4. Escalation of material prices 5. Late delivery of materials	6. Poor procurement of construction materials 7. Poor quality of construction materials 8. Shortage of construction materials 9. Unreliable suppliers	1. Inadequate contract experience of sub-contractor 2. Inappropriate construction methods by sub-contractors 3. Unreliable sub-contractors 4. Frequent change of sub-contractors

External Related Factors		Client Related Factors
1. Accidents during construction 2. Changes in government regulations and laws 3. Conflicts and discontentment from the general public 4. Delay in obtaining permits from municipality 5. Delay in performing final inspection and certification by a third party 6. Delay in providing services from utilities (such as water and electricity) 7. Global financial crisis 8. Loss of time by traffic control and restriction at job site	9. Natural disasters (flood, earthquake) 10. Price fluctuations 11. Problems with the inhabitants of the community 12. Compensation delays to the affected property owners 13. Unexpected ground conditions (such as soil, high water table) 14. Unfavorable weather conditions	1. Change orders 2. Conflicts between joint ownership 3. Delay in approving design documents 4. Delay in payments 5. Delay in site possession 6. Improper project feasibility study 7. Lack of capable representative 8. Lack of experience of clients in construction projects 9. Lack of incentives for contractors to finish ahead of schedule 10. Poor communication and coordination with other parties 11. Slowness in decision making 12. Suspension of work by client

III. METHODOLOGY

3.1. Sampling and Data Collection

All the relevant information pertaining to the study was collected from primary and secondary data sources. Primary data sources refer to information obtained from questionnaires that were distributed among the three classes of contractors in Mysuru circle. The decision problem is represented in a hierarchical structure for each class of contactorsand the delays are prioritized using the AHP and RII techniques. The results obtained from these methods aimed to prioritize and rank the delay cause factors, based on their likelihood of occurrences. The targeted respondents were drawn using the random sampling from a list of the contractors doing road construction projects in the Mysuru circle. Random sampling was used so as to eliminate any form of bias and stratified sampling technique was adopted since the population was split into non-overlapping portions. A total of 82 responses was collected during the data collection [13].

A structured questionnaire was generated in order to collect relevant data required for the analysis. Prior to the administration of the questionnaire, it was validated through a panel of experts to ensure its content validity and then reliability analysis was performed through pilot study whose results were satisfactory [14] . The responses were collected using a five point likert scale (1-very low, 2-low, 3-medium, 4-high, 5-very high) and the identified factors is as shown in Table 1. In order to ascertain the delay scores for each delay, the RII was calculated using equation (1).

$$RII = \frac{\Sigma W}{A * N} \tag{1}$$

Where, W is the weighting given to each factor by the respondents starting from 1 to 5, A is the highest weight in the scale which is 5, and N is the total number of respondents. These RII values were then used to evaluate the priority values using AHP technique.

The demographic profile of the 82 respondents to whom the questionnaire was sent is as shown below in Table 2.

Table 2
Demographic details of respondents

Type of Contractor	*No. of Respondents*	*Percentage*	*Experience of Contractor*	*No. of Respondents*	*Percentage*
Class 1	28	34.14	≤ 5 years	55	67.07
Class 2	27	32.92	6-10	7	8.54
Class 3	27	32.92	11-15	6	7.32
			<15 years	**14**	**17.07**

3.2. Pair- Wise Comparison Using AHP

AHP allows prioritization and ranking of delay factors by consideration of both objective as well as subjective factors in the process. The most important step in AHP is to convert the decision problem into a hierarchical structure. It makes use of Saaty's nine-point scale for performing pair-wise comparisons (Table 3).

After completion of the hierarchy framework as shown in the conceptual framework, prioritization procedure to determine the Relative Important Index of each element of level two is initiated. The Relative Important Index of the elements of level two are pair-wise compared. The decision maker can judge between the two elements and determine if they are equally important or if one element is more important as compared to the other. This is then repeated with the subsequent levels of the hierarchy.

Table 3
Scale of Relative Importance for Pair-wise Comparison

Corresponding Intensity on AHP Scale	*Definition*
1	Equal importance
2	Weak or slight
3	Moderate importance
4	Moderate plus
5	Strong importance
6	Strong plus
7	Very strong
8	Very, very strong
9	**Extreme importance**

In this study, a rating scale of one to five was used to depict the importance of delay. When the RII was calculated for each delay category, it was observed to be in the range of 0.557 to 0.792 (Table 4). Thus, this was chosen as the rating scale for the RII. The span of the AHP rating scale of relative importance is made equal to the span of the chosen scale of the RII [11 & 15].

Table 4
Mean RII values of delay categories for different classes of contractors

Delay Category	*RII value*		
	Class 1	*Class 2*	*Class 3*
Consultant related factor	0.709	0.659	0.653
Contractor related factor	0.702	0.621	0.651
Sub-contractor related factor	0.707	0.639	0.654
Design related factor	0.702	0.653	0.657
Equipment related factor	0.707	0.659	0.644
External related factor	0.679	0.632	0.649
Labour related factor	0.691	0.635	0.646
Material related factor	0.708	0.652	0.652
Client related factor	0.707	0.655	0.646
Project related factor	**0.700**	**0.626**	**0.651**

Using the information obtained from the respondents' answers and from scale of relative importance (Table 3), separate pair- wise comparisons were done between the different delay factors on level two of the hierarchy for all the three contractor classes. The output was used to develop a decision matrix for all the three class of contractors as shown in Table 6 to Table 8. The weightage was calculated by finding the Geometrical Mean (GM) and Priority value was calculated using weightage [11]. From the priority values, the rank for each delay factor can be determined. Pairwise comparison was constructed with the help of Table 5.

Table 5
Pair wise comparison sample

	F1	*F2*	…….	*Fn*	*GM*
F1	F1/F1	F1/F2	…….	F1/Fn	(F1/F1*F1/F2…F1/Fn)1/n
F2	F2/F1	F2/F2	……..	F2/Fn	(F2/F1*F2/F2…F2/Fn)1/n
…….	…….	…….	…….	…….	…….
Fn	**Fn/F1**	**Fn/F2**	**…….**	**Fn/Fn**	**(Fn/F1*Fn/F2…Fn/Fn)1/n**

Table 6
Pairwise comparison of Class I contractors

	F1	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*	*F8*	*F9*	*F10*	*GM*	*Weight (normalized)*
F1	1.00	1.50	1.29	2.25	1.29	9.00	4.50	1.13	1.80	3.00	2.06	0.173
F2	0.67	1.00	0.86	1.50	0.86	6.00	3.00	0.75	1.20	2.00	1.37	0.115
F3	0.78	1.17	1.00	1.75	1.00	7.00	3.50	0.88	1.40	2.33	1.60	0.134
F4	0.44	0.67	0.57	1.00	0.57	4.00	2.00	0.50	0.80	1.33	0.92	0.076
F5	0.78	1.17	1.00	1.75	1.00	7.00	3.50	0.88	1.40	2.33	1.60	0.134
F6	0.11	0.17	0.14	0.25	0.14	1.00	0.50	0.13	0.20	0.33	0.23	0.019
F7	0.22	0.33	0.29	0.50	0.29	2.00	1.00	0.25	0.40	0.67	0.46	0.038
F8	0.89	1.33	1.14	2.00	1.14	8.00	4.00	1.00	1.60	2.67	1.83	0.153
F9	0.56	0.83	0.71	1.25	0.71	5.00	2.50	0.63	1.00	1.67	1.14	0.096
F10	**0.33**	**0.50**	**0.43**	**0.75**	**0.43**	**3.00**	**1.50**	**0.38**	**0.60**	**1.00**	**0.69**	**0.057**

Table 7
Pairwise comparison of Class II contractors

	F1	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*	*F8*	*F9*	*F10*	*GM*	*Weight (normalized)*
F1	1.00	9.00	2.25	1.29	1.13	4.50	3.00	1.80	1.50	4.50	2.33	0.191
F2	0.11	1.00	0.25	0.14	0.13	0.50	0.33	0.20	0.17	0.50	0.26	0.021
F3	0.44	4.00	1.00	0.57	0.50	2.00	1.33	0.80	0.67	2.00	1.04	0.085
F4	0.78	7.00	1.75	1.00	0.88	3.50	2.33	1.40	1.17	3.50	1.82	0.149
F5	0.89	8.00	2.00	1.14	1.00	4.00	2.67	1.60	1.33	4.00	2.07	0.170
F6	0.22	2.00	0.50	0.29	0.25	1.00	0.67	0.40	0.33	1.00	0.52	0.043
F7	0.33	3.00	0.75	0.43	0.38	1.50	1.00	0.60	0.50	1.50	0.78	0.064
F8	0.56	5.00	1.25	0.71	0.63	2.50	1.67	1.00	0.83	2.50	1.30	0.106
F9	0.67	6.00	1.50	0.86	0.75	3.00	2.00	1.20	1.00	3.00	1.56	0.128
F10	**0.22**	**2.00**	**0.50**	**0.29**	**0.25**	**1.00**	**0.67**	**0.40**	**0.33**	**1.00**	**0.52**	**0.043**

Table 8
Pairwise comparison of Class III contractors

	F1	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*	*F8*	*F9*	*F10*	*GM*	*Weight (normalized)*
F1	1.00	1.60	1.14	0.89	4.00	2.00	4.00	1.33	2.67	1.60	1.77	0.156
F2	0.63	1.00	0.71	0.56	2.50	1.25	2.50	0.83	1.67	1.00	1.10	0.098
F3	0.88	1.40	1.00	0.78	3.50	1.75	3.50	1.17	2.33	1.40	1.55	0.137
F4	1.13	1.80	1.29	1.00	4.50	2.25	4.50	1.50	3.00	1.80	1.99	0.176
F5	0.25	0.40	0.29	0.22	1.00	0.50	1.00	0.33	0.67	0.40	0.44	0.039
F6	0.50	0.80	0.57	0.44	2.00	1.00	2.00	0.67	1.33	0.80	0.88	0.078
F7	0.25	0.40	0.29	0.22	1.00	0.50	1.00	0.33	0.67	0.40	0.44	0.039
F8	0.75	1.20	0.86	0.67	3.00	1.50	3.00	1.00	2.00	1.20	1.32	0.117
F9	0.38	0.60	0.43	0.33	1.50	0.75	1.50	0.50	1.00	0.60	0.66	0.058
F10	**0.63**	**1.00**	**0.71**	**0.56**	**2.50**	**1.25**	**2.50**	**0.83**	**1.67**	**1.00**	**1.10**	**0.098**

Where, F1= Consultant related factors, F2= Contractor related factor, F3= Sub-contractor related factors, F4= Design related factors, F5= Equipment related factors, F6= External related factors, F7= Labour related factors, F8= Material related factors, F9= Client related factors, F10= Project related factors, and GM= Geometrical Mean.

IV. RESULT AND ANALYSIS

After the pair-wise comparison of all the elements on level two, similar pairwise comparison of all the elements on level three of the hierarchy is performed. This level includes the sub- delays of all the delay factors. Overall one matrix for the delay factors and 30 matrices for the sub-delay factors are formed in this manner for each class of the contractors. The relative importance of the delay factors and sub-delay factors are computed as components of the matrices. The priorities of the delay factors and the local and global percentage of each sub- delay for Class I contractors is calculated from the matrix (Table 6) and is as shown in Table 9a.

The local percentages (LP) are obtained by pair- wise comparison of all the sub- delays corresponding to each delay factor. The Global Percentage (GP) is determined by multiplying the LP of each delay with that of the relative importance of the respective delay- factor. The overall priority or importance of a delay is determined by summing up the GP values. Those sub-delays, whose overall weight is less than 10%, were omitted because their weights are negligible to the overall outcome [16]. Similarly, the priority values of the delay factors and the local and global percentage of each sub- delay for Class II and Class III contractors were calculated (Tables 9b and 9c).

4.1. AHP Analysis on Class I Contractor

Among Class I contractors, Consultant related delays have the overall priority of 0.141, followed by Sub-contractor's delay with an overall priority of 0.135 (Table 9a). Among the different consultant delays, the sub-delay F1-1 "Inaccurate site investigation" had the highest relative importance or LP of 0.238. The results show that for Class I contractors, Consultant related delays are given the highest priority in terms of their level of severity, and hence, allotted rank one, similarly based on this overall priority ranks have allotted for various factors of delay which is as shown in Table 9a.

Table 9a
Priorities of Delay Factors, Sub- factors, and Overall Rank of Delays of Class I Contractors

Delay Factors	*Priority Values*	*Sub- delays*	*LP*	*GP*	*Overall Priority*	*Rank*
Consultant related factors	0.173	F1-1	0.238	0.041	0.141	1
		F1-2	0.158	0.027		
		F1-5	0.110	0.019		
		F1-7	0.110	0.019		
		F1-8	0.199	0.035		
Contractor related factors	0.115	F2-1	0.149	0.017	0.082	5
		F2-3	0.166	0.019		
		F2-7	0.115	0.013		
		F2-8	0.132	0.015		
		F2-9	0.149	0.017		
Sub-contractor related factors	0.135	F3-1	0.269	0.036	0.135	2
		F3-2	0.204	0.027		
		F3-3	0.372	0.050		
		F3-4	0.155	0.021		
Design related factors	0.077	F4-1	0.169	0.013	0.067	7
		F4-3	0.104	0.008		
		F4-4	0.104	0.008		

contd. table 9a

Delay Factors	*Priority Values*	*Sub- delays*	*LP*	*GP*	*Overall Priority*	*Rank*
		F4-6	0.104	0.008		
		F4-7	0.206	0.016		
		F4-8	0.188	0.014		
Equipment related factors	0.135	F5-2	0.177	0.024	0.112	4
		F5-4	0.197	0.027		
		F5-5	0.197	0.027		
		F5-6	0.130	0.018		
		F5-7	0.130	0.018		
External related factors	0.019	F6-2	0.117	0.002	0.012	10
		F6-5	0.104	0.002		
		F6-6	0.104	0.002		
		F6-8	0.117	0.002		
		F6-10	0.104	0.002		
		F6-14	0.104	0.002		
Labour related factors	0.038	F7-2	0.111	0.004	0.026	9
		F7-3	0.222	0.009		
		F7-4	0.139	0.005		
		F7-6	0.194	0.007		
Material related factors	0.154	F8-2	0.179	0.028	0.114	3
		F8-4	0.128	0.020		
		F8-7	0.128	0.020		
		F8-8	0.179	0.028		
		F8-9	0.128	0.020		
Client related factors	0.096	F9-2	0.121	0.012	0.068	6
		F9-4	0.106	0.010		
		F9-5	0.121	0.012		
		F9-6	0.106	0.010		
		F9-11	0.121	0.012		
		F9-12	0.136	0.013		
Project related factors	0.058	F10-1	0.238	0.014	0.049	8
		F10-3	0.286	0.016		
		F10-5	0.143	0.008		
		F10-6	**0.190**	**0.011**		

Where, F1= Consultant related factors, F2= Contractor related factor, F3= Sub-contractor related factors, F4= Design related factors, F5= Equipment related factors, F6= External related factors, F7= Labour related factors, F8= Material related factors, F9= Client related factors, and F10= Project related factors

4.2. AHP Analysis on Class II Contractor

Among Class II contractors, labour related delay have highest overall priority of 0.833, followed by consultant related delays with an overall priority of 0.173 (Table 9b). Among the different project related delays, the sub-delay F7-6 "slow mobilization of labour" had the highest relative importance or LP of 0.22. The results show that for Class II contractors, labour related delays are given the highest priority in terms of their level of severity, and hence, allotted rank one. Similarly based on this overall priority ranks have allotted for various factors of delay which is as shown in Table 9b.

Table 9b
Priorities of Delay Factors, Sub- factors, and Overall Rank of Delays of Class II Contractors

Delay Factors	*Priority Values*	*Sub- delays*	*LP*	*GP*	*Overall Priority*	*Rank*
Consultant related factors	0.191	F1-1	0.290	0.056	0.173	2
		F1-2	0.226	0.043		
		F1-4	0.258	0.049		
		F1-5	0.129	0.025		
Contractor related factors	0.021	F2-1	0.157	0.003	0.017	10
		F2-2	0.103	0.002		
		F2-3	0.140	0.003		
		F2-5	0.175	0.004		
		F2-6	0.103	0.002		
		F2-9	0.103	0.002		
Sub-contractor related factors	0.085	F3-1	0.155	0.013	0.085	6
		F3-2	0.204	0.017		
		F3-3	0.372	0.032		
		F3-4	0.269	0.023		
Design related factors	0.149	F4-3	0.161	0.024	0.075	8
		F4-4	0.142	0.021		
		F4-7	0.197	0.029		
Equipment related factors	0.170	F5-2	0.197	0.033	0.141	3
		F5-3	0.154	0.026		
		F5-4	0.130	0.022		
		F5-5	0.197	0.033		
		F5-6	0.154	0.026		
External related factors	0.043	F6-1	0.105	0.004	0.022	9
		F6-5	0.105	0.004		
		F6-8	0.105	0.004		
		F6-10	0.105	0.004		
		F6-14	0.105	0.004		
Labour related factors	0.064	F7-3	0.111	0.111	0.833	1
		F7-4	0.139	0.139		
		F7-5	0.167	0.167		
		F7-6	0.222	0.222		
		F7-8	0.194	0.194		
Material related factors	0.106	F8-4	0.190	0.020	0.084	7
		F8-5	0.190	0.020		
		F8-6	0.119	0.013		
		F8-7	0.119	0.013		
		F8-9	0.167	0.018		
Client related factors	0.128	F9-2	0.114	0.015	0.091	5
		F9-3	0.114	0.015		
		F9-5	0.114	0.015		
		F9-8	0.128	0.016		
		F9-11	0.114	0.015		
		F9-12	0.128	0.016		
Project related factors	0.043	F10-1	0.238	0.0102	0.092	4
		F10-2	0.190	0.0081		
		F10-3	0.286	0.0122		
		F10-6	**0.143**	**0.0061**		

Where, F1= Consultant related factors, F2= Contractor related factor, F3= Sub-contractor related factors, F4= Design related factors, F5= Equipment related factors, F6= External related factors, F7= Labour related factors, F8= Material related factors, F9= Client related factors, and F10= Project related factors

4.3. AHP Analysis on Class III Contractor

Among Class III contractors, Consultant related delays have overall priority of 0.192, followed by Sub-contractor's delays with an overall priority of 0.137 (Table 9c). Among the different consultant delays, the sub- delay F1-1 "Inaccurate site investigation" had the highest relative importance or LP of 0.296. The results show that for Class III contractors, Consultant related delays are given the highest priority in terms of their level of severity, and hence, allotted rank one. Similarly based on this overall priority ranks have allotted for various factors of delay which is as shown in Table 9c.

Table 9c
Priorities of Delay Factors, Sub- factors, and Overall Rank of Delays of Class III Contractors

Delay Factors	*Priority Values*	*Sub- delays*	*LP*	*GP*	*Overall Priority*	*Rank*
Consultant related factors	0.157	F1-2	0.296	0.046	0.192	1
		F1-3	0.222	0.035		
		F1-4	0.148	0.023		
		F1-5	0.185	0.029		
		F1-6	0.111	0.017		
		F1-8	0.259	0.041		
Contractor related factors	0.098	F2-3	0.166	0.016	0.059	6
		F2-4	0.132	0.013		
		F2-5	0.166	0.016		
		F2-7	0.132	0.013		
Sub-contractor related factors	0.137	F3-1	0.146	0.020	0.137	2
		F3-2	0.226	0.031		
		F3-3	0.277	0.038		
		F3-4	0.351	0.048		
Design related factors	0.176	F4-3	0.192	0.034	0.122	3
		F4-5	0.192	0.034		
		F4-7	0.152	0.027		
		F4-8	0.152	0.027		
Equipment related factors	0.039	F5-1	0.125	0.005	0.033	9
		F5-3	0.148	0.006		
		F5-4	0.169	0.007		
		F5-5	0.207	0.008		
		F5-6	0.189	0.007		
External related factors	0.078	F6-3	0.108	0.009	0.043	7
		F6-5	0.108	0.009		
		F6-7	0.108	0.009		
		F6-8	0.108	0.009		
		F6-9	0.108	0.009		
Labour related factors	0.039	F7-1	0.111	0.004	0.037	8
		F7-2	0.194	0.008		
		F7-3	0.167	0.007		
		F7-4	0.222	0.009		
		F7-7	0.111	0.004		
		F7-8	0.139	0.005		

contd. table 9c

Delay Factors	*Priority Values*	*Sub- delays*	*LP*	*GP*	*Overall Priority*	*Rank*
Material related factors	0.118	F8-2	0.214	0.025	0.084	5
		F8-4	0.167	0.020		
		F8-7	0.119	0.014		
		F8-8	0.214	0.025		
Client related factors	0.059	F9-3	0.110	0.006	0.030	10
		F9-4	0.126	0.007		
		F9-5	0.142	0.008		
		F9-6	0.126	0.007		
Project related factors	0.098	F10-1	0.233	0.023	0.085	4
		F10-2	0.167	0.016		
		F10-3	0.300	0.029		
		F10-6	**0.167**	**0.016**		

Where, F1= Consultant related factors, F2= Contractor related factor, F3= Sub-contractor related factors, F4= Design related factors, F5= Equipment related factors, F6= External related factors, F7= Labour related factors, F8= Material related factors, F9= Client related factors, and F10= Project related factors

4.4. Analysis of Relationship between Contractor Class and Delay Category –

The means and standard deviations of the different delay categories were computed for each class of the contractors separately (Table10). The grand mean for each class was found out. It is seen that for Class I contractors, F1 had the highest mean score of 0.709. This score lies between somewhat important and fairly important on the ranking scale. In the case of Class II contractors, F-7 had the highest mean score of 0.665 this also lies between somewhat important and fairly important. In Class III contractors, the highest mean score was observed to be for F1. It had a mean score of 0.653 that lies between somewhat important and fairly important on the ranking scale.

Table 10
Means and Standard Deviations for the Respondents' Answers According to Contractors' Class

CC		*F1*	*F2*	*F3*	*F4*	*F5*	*F6*	*F7*	*F8*	*F9*	*F10*	*G M*
I	M	0.709	0.702	0.707	0.702	0.707	0.680	0.691	0.708	0.702	0.700	0.701
	SD	0.051	0.043	0.032	0.045	0.026	0.044	0.055	0.051	0.044	0.047	
II	M	0.660	0.621	0.639	0.653	0.659	0.632	0.665	0.652	0.655	0.662	0.647
	SD	0.056	0.022	0.046	0.031	0.031	0.028	0.047	0.033	0.033	0.059	
III	**M**	**0.653**	**0.651**	**0.652**	**0.652**	**0.644**	**0.649**	**0.646**	**0.652**	**0.646**	**0.651**	**0.650**

Where, F1= Consultant related factors, F2= Contractor related factor, F3= Sub-contractor related factors, F4= Design related factors, F5= Equipment related factors, F6= External related factors, F7= Labour related factors, F8= Material related factors, F9= Client related factors, F10= Project related factors, CC= Contractor Class, GM= Great Mean, M= Mean, and SD= Standard Deviation.

V. CONCLUSION

From the results obtained, for class 1 contractors the most important and probable delay that they had to encounter was Consultant related delay, which had a mean of 0.709 and the same was highlighted through pair- wise comparison of delay factors and sub- delay factors by the AHP method, it had a highest priority value of 0.141 and was ranked one. The Class I contractor normally handled large- scale projects which involves a lot of consultant related works. Among the various Consultant related delays, sub-delay factor inaccurate site investigation had the highest priority value of 0.238.

The Grand Mean of the Class II contractors was 0.647. These contractors work on both big and small scale projects. The most important delay factor according to the Class II contractors was labour related delay, which scored a mean of 0.665 and it had a priority values were calculated using the AHP method, it was seen that

labour related delay had a priority value of 0.833. This indicated that the Class II contractors faced a lot of labour related delays resulting in overshoot of the project schedule. Among labour related delays, "slow mobilization of labour" had the highest priority value of 0.222.

The Grand Mean of Class III contractors was 0.650. The most important delay factor according to the Class III contractors is Consultant related delay, which scored a mean of 0.653 and priority values of 0.192 with AHP which is the highest. This indicates that although many contractors belonging to Class III took on small scale projects, not all were able to successfully complete their projects on time due to the Consultant related delay. Among the Consultant related delay, the sub- delay, "Inadequate project management assistance" had the highest relative priority of 0.296. Hence, in Class III contractors, Consultant related delay was ranked one. Also it can be observed that the grand mean score is highest for the class 1 contractor and lowest for the class 3 contractor indicating the relationship between impacts of delays with the size of the projects. Finally rank chart for various delay factors among different classes of contractors is prepared (Appendix 1), which will help the contractors to get an idea about the possible delays they might face, with the help of which they can adopt appropriate strategies to eliminate or minimize these delays.

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Appendix 1
Rank list of Delay and sub-delay factors with respect to contractor class

	Class of contractor	*I*	*II*	*III*
				Rank
	Consultant related factors	1	2	1
1	Inaccurate site investigation	1	1	7
2	Inadequate project management assistance	3	3	1
3	Late in reviewing and approving design documents	7	8	3
4	Poor communication and coordination with other parties	6	2	5
5	Lack of experience of consultant in construction projects	4	4	4
6	Conflicts between consultant and design engineer	8	7	6
7	Delay in approving major changes in the scope of work by the consultant	5	5	8
8	Delay in performing inspection and testing	2	6	2
	Contractor related factors	5	10	6
1	Inadequate contractor experience	2	2	8
2	Inappropriate construction methods	10	4	7
3	Slowness in decision making	1	3	1
4	Incompetent project team	7	9	3
5	Ineffective project planning and scheduling	6	1	2
6	Obsolete technology	8	5	5
7	Poor communication and coordination with other parties	5	8	4
8	Poor site management and supervision	4	7	10
9	Rework due to errors	3	6	9
10	Inadequate cash flow, due to non-payment	9	10	6
	Sub-contractor related factors	2	6	2
1	Inadequate contractor experience of sub-contractor	2	4	4
2	Inappropriate construction methods by sub-contractor	3	3	3
3	Unreliable sub-contractors	1	1	2
4	Frequent change of subcontractors	4	2	1
	Design related factors	7	8	3
1	Complexity of project design	3	5	5
2	Design changes by client or his agent during construction	7	7	6
3	Design errors made by designers	4	3	1
4	Insufficient data collection and survey before design	5	4	7
5	Mistakes and delays in producing design documents	8	6	2
6	Misunderstanding of client requirements by design engineer	6	8	8
7	Poor use of advanced engineering design software	1	1	3
8	Unclear and inadequate details in design drawings	2	2	4
	Equipment related factors	4	3	9
1	Equipment allocation problem	7	6	5
2	Frequent equipment breakdowns	3	1	6
3	Improper equipment	6	3	4
4	Inadequate modern equipment	1	5	3
5	Low efficiency of equipment	2	2	1
6	Shortage of equipment	4	4	2
7	Slow mobilization of equipment	5	7	7
	External related factors	10	9	7
1	Accidents during construction	7	1	6
2	Changes in government regulations and laws	1	7	12
3	Conflict, war, and discontentment from the general public	11	10	1

4	Delay in obtaining permits from municipality	10	8	7
5	Delay in performing final inspection and certification by a third party	3	2	2
6	Delay in providing services from utilities (such as water, electricity)	4	6	9
7	Global financial crisis	12	13	3
8	Loss of time by traffic control and restriction at job site	2	3	4
9	Natural disasters (flood, hurricane, earthquake)	13	11	5
10	Price fluctuations	5	4	10
11	Problem with the inhabitants of the community	8	12	11
12	Compensation delays to affected property owners	14	14	8
13	Unexpected ground conditions (such as soil, high water table)	9	9	13
14	Unfavourable weather conditions	6	5	14
	Labour related factors	9	1	8
1	Absenteeism	7	6	5
2	Low motivation and morale of labour	5	8	2
3	Low productivity of labour	1	5	3
4	Personal conflicts among labour	4	4	1
5	Shortage of labour	6	3	8
6	Slow mobilization of labour	2	1	7
7	Strike	8	7	6
8	Unqualified / inadequate experienced labour	3	2	4
	Material related factors	3	7	5
1	Changes in material types and specifications during construction	7	6	7
2	Damage of materials	1	8	1
3	Delay in manufacturing materials	6	9	6
4	Escalation of material prices	3	1	3
5	Late delivery of materials	8	2	8
6	Poor procurement of construction materials	9	4	9
7	Poor quality of construction materials	4	5	4
8	Shortage of construction materials	2	7	2
9	Unreliable suppliers	5	3	5
	Client related factors	6	5	10
1	Change orders	9	9	7
2	Conflicts between joint-ownership	2	3	10
3	Delay in approving design documents	10	4	4
4	Delay in payments	5	8	2
5	Delay in site possession	3	5	1
6	Improper project feasibility study	6	7	3
7	Lack of capable representative	11	11	12
8	Lack of experience of client in construction projects	8	1	11
9	Lack of incentives for contractor to finish ahead of schedule	7	10	9
10	Poor communication and coordination with other parties	12	12	8
11	Slowness in decision making	4	6	5
12	Suspension of work by client	1	2	6
	Project related factors	8	4	4
1	Complexity of the project	2	2	2
2	Inadequate definition of substantial completion	6	3	3
3	Ineffective delay penalties	1	1	1
4	Legal disputes between project participants	5	5	6
5	Original contract duration is short	4	6	5
6	**Unfavourable contract clauses**	**3**	**4**	**4**