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Delay Analysis of Road Construction Projects using RII Method

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Abstract: ***The aim of this paper is to propose and recommend a tool for contractors before the bidding stage to calculate the effect of delay in road construction projects by finding the relative importance index (RII) method. Through a rigorous literature search and interviews with road construction professionals, 95 delay causes were discovered and classified into 9 broad groups for this purpose. The relative importance index approach was used to calculate the relative relevance of delay factors and groups. The ranking of these factors and groups were illustrated in terms of their impact on delay. The factors and groups that are most and least responsible for the delays were explored.***
Keywords: Delay, Road construction projects, RII, factors, groups.

I. INTRODUCTION

Construction industry is the second vital economic sector after agriculture that plays crucial role in social and economic development of India. Construction industry plays an important character in the social, economic, and political development of a country. Construction projects are time bounded. Each project has destined duration with defined initiating and completion time. Poor cost management and overrun are the huge problems and a veritably serious issue when they come to project time and cost in both developed and developing countries. In many different construction projects, delays are prevalent and can result in significant losses for project participants. The construction industry has a veritably poor reputation for managing delays. Delay analysis is either ignored or carried out subjectively by simply adding a contingency. As a result, numerous major projects fail to meet schedule deadlines. In a road construction project where time truly equals money, the management of time becomes very critical (Duran, O. (2006)), thus predicting the likelihood of delay might play a key role towards project success (Luu, et al. (2009). Delay means non-completion of the project within the prescribed duration agreed on contract. According to Kaming (1997), delay is the extended time beyond planned completion dates by the contractors during the contract. Elinwa (2001) defined delay as the period between the agreed completion data and the actual data of completion. Trigunarsyah, B. (2004) identified that only 47% of the projects in Indonesia were completed on schedule, 15% before scheduled time, and 38% were delayed.

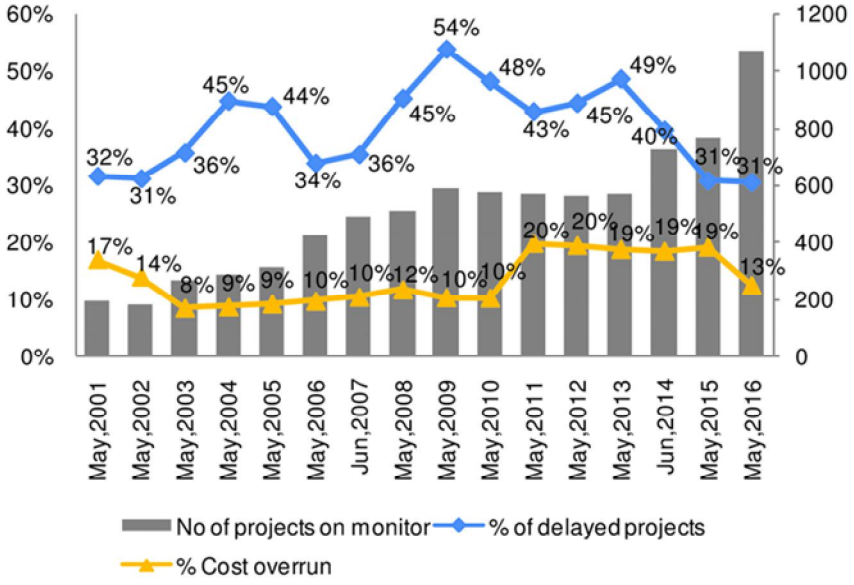


Fig. 1 Cost Overrun in Construction projects in India (Source: MoSPI)

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A. Need of the Study

In India, the road construction industry constitutes a very high percentage of the economy contract. Nevertheless, quite few studies have adopted the use of project management approaches to manage the delays. A significant factor which contributes to this problem is lack of application of project management approaches to tackle these delays. This has resulted in poor quality of works, loss of productivity, delayed projects' completion, and increase of total cost of project, unemployment, liquidation of construction firms, disputes, and litigations.

B. Objectives

1) To identify the delay factors in road construction project.
2) To compute relative importance of delay factors as well as groups and demonstrate the ranking of factors and groups according to their importance level.
3) To address the most contributing factors and groups to cause delays.

II. REVIEW OF LITERATURE

Some theoretical and analytical investigations performed in this field are presented in the following literature survey.

1) A survey was conducted by El Razek (2008) to identify the main causes of delays in Egyptian construction projects as seen by the owners, consultants, and contractors. To fit the Egyptian construction sector, they divided the thirty-two (32) reasons of timetable delays into nine (9) types. These categories included funding, materials, contractual ties, adjustments, rules and regulations, personnel, scheduling and control, tools, and reasons relating to the environment. According to their findings, the biggest contributing factors were lack of professional construction/contractual management and the following: financing provided by the contractor during construction, delays in the owner paying the contractor, design changes made by the owner or consultant during the construction phase.
2) Wiguna, I.P.A. and Scott, S. (2005) examined the dangers of delays to building schedules in the Indonesian cities of Surabaya and Denpasar. The most important variables, according to their analysis, were: high inflation/increased material prices; client-driven design changes; poor design; weather conditions; late payments on contracts; and poor construction performance.
3) Odeh, A.M. (2002) conducted a survey to determine the major reasons for delays in traditional type building projects. They divided the reasons for delays into the following seven key categories: contract-related, client-related, consultant-related, material-related, labor-related, equipment-related, and external-related delay factors. The survey's findings showed that the top ten (10) most critical reasons were interference, insufficient contractor experience, funding and payments, labour productivity, sluggish decision-making, poor planning, and subcontractors.
4) Frimpong, Y. et al. (2003) undertook a survey to determine the elements influencing cost and schedule overruns in groundwater development projects in Ghana. Twenty-six (26) elements that contributed to project schedule delays and expense overruns were evaluated and ranked. According to the study's findings, problems with monthly contractor payments from agencies, poor contractor management, issues obtaining materials, subpar technical performance, and an increase in material costs are the primary reasons of schedule delays and cost overruns in groundwater project development.
5) Koushki, P.A. et al. (2005) undertook a survey into the construction schedule delays related to private residential developments in the state of Kuwait. They identified three (3) primary factors: order changes, owner financial limitations, and owners' lack of expertise in the construction industry as the main reasons of timetable delays.
6) T. Subramani, P. S. Sruthi and M. Kavitha (2014) completed a research based on the Indian road construction projects. They discovered that the main contributing factors for the cost overruns of road construction projects in India were inadequate project formulation, poor field investigation, bad cost estimates, poor planning during execution stage, inadequate equipment supply plan, lack of project management during the stage of execution, insufficient working, changes in scope of work, and change in law and order.
7) Abdullah Alhomidan (2013) did an analysis based on the 41 primary causes of cost overruns in road projects and a survey to determine the elements that had the greatest influence. He concluded that the biggest influences on cost overrun were internal administrative issues, payment delays, poor communication among project partners, and delays in decision-making.
8) Ibrahim Mahamid (2013) performed study based on the 45 factors that might cause contractors in the West Bank of Palestine to postpone construction projects. He conducted a survey using a questionnaire and discovered that the main causes of time overruns in Palestine were the financial standing of the contractors, owner payment delays, the political climate and Western Bank's segmentation, a lack of communication between the project's parties, ineffective equipment, and intense bidding competition.

9) Eng. S. B. Wijekoon (2011) suggested doing study on the factors that most significantly affect cost overruns in Sri Lanka's northern and eastern provinces. He developed a questionnaire based on 19 criteria, and a thorough national survey was conducted. He concluded that the primary reasons for cost overruns in Sri Lankan projects were difficulties with site acquisition, cost inflation, payment delays, delays in transferring existing utilities, and design revisions made during construction.

10) Han, S. and Dikmen, I. et al. (2007) created a framework to apply the proposed technique and offered a fuzzy risk assessment methodology to evaluate cost delay risk in building projects. They predicted that a total of twenty-three (23) risk variables originating at the project and national levels result in the danger of cost overruns. Their risk model indicated that there were nine (9) factors influencing nation risk and fourteen (14) elements generating project risk. A multinational construction business created a computer programme, and real company and project data was used to demonstrate the system's applicability during risk assessment at the bidding stage.

11) Al-Momani, A. (2000) undertook a quantitative study of Jordan's 130 public building projects' construction schedule delays. According to the study's findings, designers, user changes, weather, site circumstances, late delivery, economic situations, and increases in quantity are the primary reasons of timetable delays in building projects.

12) According to Dinesh Bhatia et al. (2016), delays in decision-making, shoddy time estimation of project tasks and activities, unforeseen circumstances, internal conflicts within the project team, poor work organisation and planning, and a lack of proactive action by any of the parties involved are the main factors and reasons behind schedule and cost overruns in the construction of residential projects.

13) Abd El-Razek et al. (2008) studied delays in building construction projects in Egypt. A total of 32 delay causes were chosen and categorised under 9 groups, including financing, manpower, changes, contractual relationships, environment, equipment, rules and regulations, materials, scheduling, and control, depending on who was responsible (contractor, consultant, owner, and common responsibility). A Likert scale with four categories- very important, important, somewhat important, and not important-was used to rate each delay reason. They concluded that the most significant contributing factors were: financing provided by the contractor during construction; delays in the owner's payment of the contractor; design modifications made by the owner or his agent during construction; partial payments made during construction; and a lack of use of professional construction/contractual management.

14) Research by Bent Flyvbjerg, et al. (2004) used a sample of 258 road and rail infrastructure projects with a total cost of US$90 billion. They concentrated on three main causes of cost overruns. They focused on variables including the size of the project, the form of project ownership, and the duration of the project execution phase. They discovered that the project's size and longevity were the primary causes of cost overruns and associated hazards. They concluded that public ownership played a bigger role in the kind of ownership.

15) Rahman, Memon, and Karim (2013) sought to identify and categorise the critical factors that influence time and cost overruns in ground water projects. The components were divided into several groups. These groups were rated, and the order of significance of the elements was determined based on these rankings. These findings indicate that a variety of factors influence cost overruns in developing nations like Ghana. There are five key factors that have been agreed upon by the owners, contractors, and experts. They include frequent payment issues with agencies, poor contractor management, material procurement, subpar technical performance, and budget increases for material costs.

III.METHODOLOGY

This section introduces the methodology used in this study to accomplish the study's objectives. Basically, this research work includes four different phases. First phase of research covers review of literatures. Second phase of research includes development of framework of collected data for the ranking of delay in road construction projects. Third phase of research includes analysis of collected data and discussion on the comparing the result of ranking by RII technique. Here, relative importance index (RII) is calculated for each cause by using 5 likert ranking scale based on the questionnaire survey obtained from respondents of different construction companies in India.

RII = $\sum$**W / (A x N)** …… (*1*)

Where, W = weights given to each factor by the respondents (ranges from 1 to 5 relating 1 as very less severe and 5 as very high severe), A = highest weight in the rating scale (i.e., 5 in this case) and N = total number of responses. Fourth phase of research covers conclusion and recommendation part.

The data obtained from different personnel survey consists a total of 123 samples/ responses were obtained from questionnaire survey. Out of these, 16 responses were received from Project Owner, 24 responses from Contractors, 30 responses from Project Managers, 39 responses from Project Engineers/ Site Engineers and 14 responses from Consultant/ Architect.
TABLE I shows tabular list of delay factors according to their related group and their respective RII along with ranking of the listed factors.

IV. RESULTS ANALYSIS AND DISCUSSIONS

TABLE I shows tabular list of delay factors according to their related group and their respective RII along with ranking of the listed factors.

TABLE I List Of Delay Causes, Their Related Group, Rii And Ranking Of Each Factor

Sr. No.	Main Group	Factors		RII	Individual Category Rank	Overall Rank
1.	Project Owner related factors	1.	Change of scope order during construction	0.63	5	8th
		2.	Conflicts between joint ownership of the project	0.29	16	84th
		3.	Late in approval design document by the owner	0.72	2	2nd
		4.	Delay in progress payment by the owner	0.62	6	10th
		5.	Owner's failure to furnish and deliver the site to the contractor on time	0.30	14	79th
		6.	Improper feasibility study before project design	0.32	13	73th
		7.	Poor owner's representative	0.33	12	67th
		8.	Lack of owner experience in construction projects	0.36	11	57th
		9.	Unavailability of incentives to the contractor for finishing ahead of schedule	0.28	17	87th
		10.	Poor communication and coordination between consultant and owner	0.42	8	46th
		11.	Decision-making process is too slow	0.30	15	80th
		12.	*Suspension of work by owner*	*0.24*	18	*95th*
		13.	Inadequate planning	0.64	4	6th
		14.	Inappropriate contractual procedure	0.46	7	32nd
		15.	Land Acquisition	0.74	1	1st
		16.	Delay in approving shop drawings and sample material	0.71	3	3rd
		17.	Selecting inappropriate contractors	0.38	10	55th
		18.	Changing specifications of material after project progress is started	0.39	9	52nd
2.	Contractor related factors	19.	Subcontractors are frequently changed because of their poor performance	0.41	7	49th
		20.	Less experience of the contractor	0.42	5	47th
		21.	Improper construction method implemented by contractor	0.42	6	48th
		22.	Incompetent project team	0.34	10	66th
		23.	Ineffective project planning and scheduling	0.55	1	19th
		24.	Poor communication and coordination between contractor and consultant	0.43	4	44th
		25.	Poor site management and supervision	0.37	9	56th
		26.	Rework due to errors	0.28	12	88th
		27.	Unreliable subcontractors	0.32	11	74th
		28.	Inadequate site investigation	0.41	8	50th
		29.	Inappropriate contractor's policies	0.44	3	37th
		30.	Poor financial control on site	0.53	2	23rd
3.	Consultants/ Architects related factors	31.	Inadequate experience of consultant	0.44	2	38th
		32.	Conflict between consultant and design engineer	0.33	5	68th
		33.	Delay in approving major changes in the scope of work by consultant	0.56	1	16th
		34.	Delay in performing inspection and testing by consultant	0.29	8	85th
		35.	Inaccurate site investigation	0.30	7	81st
		36.	Inadequate Project Management assistance	0.32	6	75th
		37.	Late in reviewing and approving design documents	0.36	4	58th
		38.	Poor communication between consultant and others	0.43	3	45th
4.	Design related factors	39.	Complexity of project design	0.53	1	24th
		40.	Design changes by owner or his agent during construction	0.51	2	25th
		41.	Design errors and omissions made by designers	0.33	6	69th

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		42.	Insufficient data collection and survey before design	0.44	3	39th
		43.	Lack of design team experience in construction projects	0.41	5	51st
		44.	Mistakes and delays in producing design document	0.33	7	70th
		45.	Misunderstanding of owner's requirements by design engineer	0.28	10	89th
		46.	*Poor use of advanced engineering design software*	*0.27*	11	*93rd*
		47.	Unclear and inadequate details in drawings	0.32	8	76th
		48.	Incomplete project design	0.44	4	40th
		49.	Defective design made by designers	0.30	9	82nd
5.	Project related factors	50.	Complexity of project (project type, etc.)	0.39	2	53rd
		51.	Original contract duration is too short	0.44	1	41st
		52.	Ineffective delay penalties	0.28	5	90th
		53.	Legal disputes between the project participants	0.30	4	83rd
		54.	Unfavorable contract clauses	0.33	3	71st
6.	Material related factors	55.	Damage of sorted materials	0.51	5	26th
		56.	Delay in manufacturing materials	0.49	6	28th
		57.	Changes in material types and specifications during construction	0.45	7	33rd
		58.	Escalation of material prices	0.62	3	11th
		59.	Late delivery of materials	0.63	2	9th
		60.	Late procurement of construction materials	0.66	1	5th
		61.	Poor quality of construction materials	0.35	9	63rd
		62.	Shortage of construction materials	0.60	4	12th
		63.	Unreliable suppliers	0.36	8	59th
7.	Labor related factors	64.	Absenteeism of labors	0.45	4	34th
		65.	Low productivity level of labor	0.54	2	21st
		66.	Personal conflicts among labor	0.35	6	64th
		67.	Shortage of skilled labor	0.49	3	29th
		68.	Slow mobilization of labor	0.32	7	77th
		69.	Labor strikes	0.55	1	20th
		70.	Unqualified/Inadequate experienced labor	0.39	5	54th
		71.	*Labor injuries at site*	*0.28*	8	*91st*
8.	Plants, Machinery and Equipment related factors	72.	Equipment allocation problem	0.44	6	42nd
		73.	Machinery/Equipment/Plant breakdown	0.50	3	27th
		74.	Shortage of machinery and equipment	0.70	1	4th
		75.	Availability of machinery and equipment	0.45	5	35th
		76.	Low productivity and efficiency of the equipment	0.54	2	22nd
		77.	Lack of high technology mechanical equipment	0.36	7	60th
		78.	Unskilled equipment operator	0.47	4	30th
9.	External related factors	79.	Accidents during construction	0.58	3	14th
		80.	Changes in government regulation and law	0.60	2	13th
		81.	Delay in obtaining Permits of plants	0.57	4	15th
		82.	Forest and Environment Clearances from Municipality/Authority	0.56	5	17th
		83.	*Delay in performing final inspection by third party*	*0.28*	16	*92nd*
		84.	Late certification from third party	0.45	8	36th
		85.	Unavailability of utilities at site (water, electricity, telephone)	0.56	6	18th
		86.	Global financial crisis	0.29	15	86th
		87.	*Loss of time by traffic control and restriction at job site*	*0.26*	17	*94th*
		88.	Price fluctuations	0.47	7	31st
		89.	Problem with neighbors	0.35	12	65th
		90.	Slow site clearance	0.36	10	61st
		91.	Unexpected surface and subsurface conditions (soil, water table, etc.)	0.44	9	43rd
		92.	Unexpected natural disasters/calamities	0.36	11	62nd
		93.	Unfavorable weather conditions	0.64	1	7th
		94.	Inappropriate government policies	0.33	13	72nd
		95.	Thefts at site	0.32	14	78th

In TABLE I above, **bold items** show the top ten (10) delay factors from RII ranking and *italic items* represent the five (5) least critical delay factors.

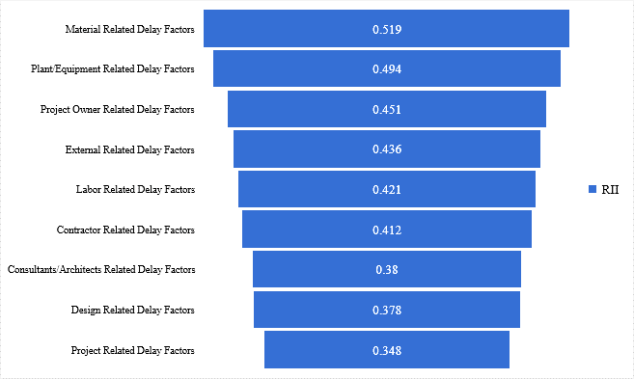


Fig. 2 Comparison of delay groups

As we can see from TABLE I, based on its degree to affect pre-planned project duration and how it can make project delay, the highest recorded value of RII rank is "Land Acquisition", "Late in approval design document by the owner" and "Delay in approving shop drawings and sample material" with RII of 0.74, 0.72 and 0.71 respectively. Following groups show the individual group-wise critical delay factors to look upon in future.

1) *Material:* The material related group of delay factors was the most important group to cause delays. This was mainly due to factors "Late procurement of construction materials (RII=0.66)", "Late delivery of materials (RII=0.63)", and "Escalation of material prices (RII=0.62)".
2) *Equipment:* Second important group was the equipment related group, having the factors "Shortage of machinery and equipment (RII=0.70)", "Low productivity of equipment (RII=0.54)", and "Machinery/Equipment/Plant breakdown (RII=0.50)".
3) *Project Owner:* After the equipment, the project owner related group of delay factors took place as the third most important group. The outstanding factors were "Land Acquisition (RII=0.74)", "Late in approval design document by the owner (RII=0.71)", and "Delay in approving shop drawings and sample material (RII=0.71)".
4) *External:* Following the project owner, the external factors group of delay factors ranks as the fourth most important group. The noticeable factors were "Unfavorable weather conditions (RII=0.64)", "Changes in government regulation and law (RII=0.60)", and "Accidents during construction (RII=0.58)".
5) *Labor:* Fifth important group was the labor related group. The prominent factors were "Labor strikes (RII=0.55)", "Low productivity level of labor (RII=0.54)" and "Shortage of skilled labor (RII=0.49)".
6) *Contractor:* After the labor, the contractor related group of delay factors took place as the sixth most important group. The outstanding factors were "Ineffective project planning and scheduling (RII=0.55)" and "Poor financial control on site (RII=0.53)".
7) *Consultants/Architects:* Following the contractor, the consultant related group of delay factors ranked as the seventh most important group. The noticeable factors were "Delay in approving major changes in the scope of work by consultant (RII=0.56)", "Inadequate experience of consultant (RII=0.44)", and "Poor communication between consultant and others (RII=0.43)".
8) *Design:* Eighth important group was the design related group. The prominent factors were "Complexity of project design (RII=0.53)" and "Design changes by owner or his agent during construction (RII=0.51)".
9) *Project:* The project related group of delay factors was the last and the least important group. The noticeable factors were "Original contract duration is too short (RII=0.44)", and "Complexity of project (project type, etc.) (RII=0.39)".

V. CONCLUSION

The ***first*** objective was to identify the delay factors in road construction projects. Through detailed literature review and interview with experts from a leading Construction Companies, a total of ninety-five (95) delay factors were identified.

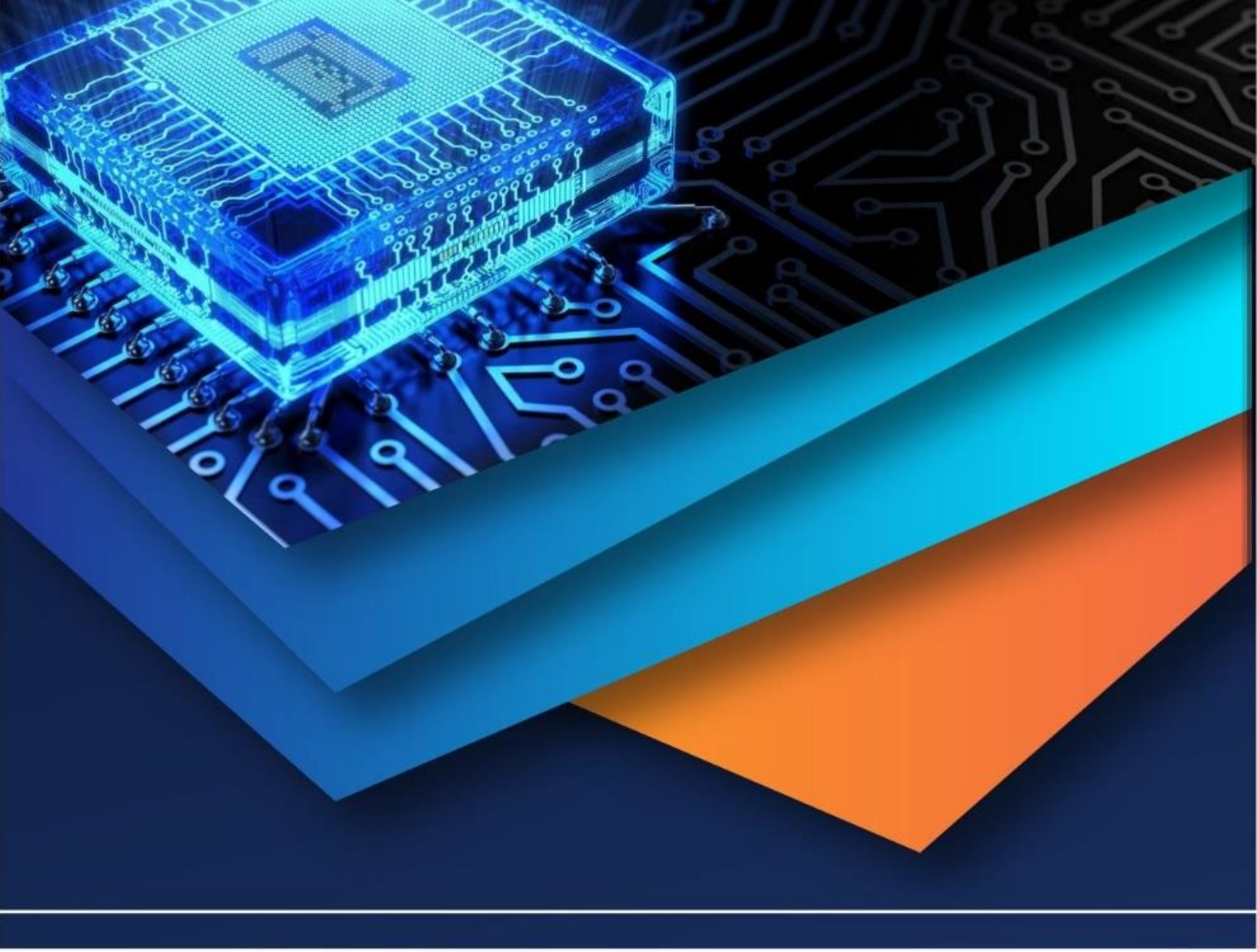
The ***second*** objective was to quantify relative importances of delay factors and demonstrate the ranking of the factors and groups according to their importance level. Through interviews with a committee of specialists, this objective was accomplished. Using the calculated relative importance indices, all factors and groupings were sorted in order of importance/severity. According to these rankings, the most and the least significant factor and group was also accomplished.

The ***third*** objective was to address the most contributing factors and groups to cause. This objective is shown above in Fig. 2 and below Fig. 2. The highest RII (0.519) for the groups was found as "Material related delay factors" and least RII (0.348) was for "Project related delay factors." For each group, the three (3) most contributing factors to cause delay were presented.

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