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Delay Analysis and Performance Evaluation of Highway Infrastructure Projects: A Case Study of NH-211 Yedashi –Aurangabad BOT Project

[1]Mr. Veerdhaval Pawar, [2]Amit.B.P.atil, [3]Prof. Vinayak. J. Yadav

[1]PG Student,, [2]Assistant Professor

[1]Civil (Construction Management), Tatyasaheb Kore Institute of Engineering and Technology, Warananagar, Pin – 416113, Maharashtra, India

[2]Civil (Construction Management), Tatyasaheb Kore Institute of Engineering and Technology, Warananagar, Pin – 416113, Maharashtra, India

[3]Civil (Construction Management), Tatyasaheb Kore Institute of Engineering and Technology, Warananagar, Pin – 416113, Maharashtra, India

Abstract: Highway infrastructure projects are highly capital-intensive and time-bound undertakings that demand effective coordination among multiple stakeholders. Despite advancements in project management techniques and adoption of Public–Private Partnership (PPP) models such as Build-Operate-Transfer (BOT), project delays continue to pose a major challenge in India's highway development sector. This research investigates the causes and impacts of delays in the NH-211 Yedashi –Aurangabad BOT Project, a crucial national highway link in Maharashtra. The study employs both qualitative and quantitative approaches, incorporating data obtained from project reports, site observations, and structured stakeholder surveys. Using analytical tools such as the Relative Importance Index (RII) and statistical evaluation, the most significant delay factors were identified and ranked. Key delay drivers include land acquisition issues, design revisions, financial constraints, inadequate coordination between concessionaire and government authorities, and delays in statutory approvals. The findings demonstrate that administrative and regulatory inefficiencies contribute more critically to project delays than technical or material-related factors. Based on the analysis, the study recommends proactive risk assessment, improved communication mechanisms, and efficient contract management strategies to mitigate future delays. The outcomes of this case study contribute valuable insights for policymakers, project managers, and private stakeholders engaged in BOT-based highway infrastructure projects, aiming to enhance time performance and ensure sustainable infrastructure delivery.

Index Terms **- Highway Construction; Project Delays; Build-Operate-Transfer; NH-211; Infrastructure Management; Time Overrun; Relative Importance Index (RII); Delay Analysis; Project Risk Factors.**

1. INTRODUCTION

Highway infrastructure development plays a pivotal role in the socio-economic growth and regional connectivity of a nation. In a rapidly developing country like India, highways form the backbone of transportation, enabling the efficient movement of goods, services, and people. However, despite substantial investments and advancements in construction technology, the sector continues to suffer from significant project delays, cost overruns, and quality issues. These delays not only hinder economic productivity but also disrupt public convenience, increase vehicle operating costs, and affect the overall sustainability of infrastructure programs.

Project delays in highway construction are multifaceted and arise from a complex interplay of technical, managerial, financial, environmental, and contractual factors. In most cases, such delays stem from inadequate planning and scheduling, slow land acquisition, design modifications during execution, shortage of skilled manpower, delayed material supply, and inefficient coordination among key stakeholders. The cumulative effect of these factors often leads to time overruns, escalation in costs, and loss of project credibility. Therefore, understanding the root causes and relative significance of delay factors is crucial for improving project management practices and achieving timely completion of highway infrastructure projects. The Build-Operate-Transfer (BOT) model, as adopted under India's National Highways Development Programme (NHDP), has been instrumental in involving private sector participation in highway development. While this Public–Private Partnership (PPP) approach has enhanced resource mobilization and operational efficiency, it has also introduced additional layers of complexity in project execution. These complexities include financial closure issues, risk-sharing imbalances, coordination between concessionaire and government agencies, and delays in obtaining statutory clearances. Consequently, even BOT-based projects, which are expected to deliver efficiency and timely completion, frequently face schedule deviations.

The present study focuses on NH-211 Yedashi –Aurangabad BOT Project, a critical stretch under the National Highway network in Maharashtra. The project was initiated with the objective of improving regional connectivity between Yedashi and Aurangabad districts, facilitating trade and transportation across Vidarbha and Marathwada regions. However, during its execution phase, the

project experienced considerable delays, resulting in time overruns and cost escalations. This case presents an opportunity to systematically analyze and quantify the underlying causes of delay within the specific operational and contractual framework of a BOT highway project.

Through a structured approach combining qualitative and quantitative analyses, this study aims to identify, categorize, and evaluate the major delay factors affecting the NH-211 Yedashi –Aurangabad project. The research methodology involves stakeholder surveys, data collection from project records, and application of statistical tools such as Relative Importance Index (RII) and Cause–Effect analysis to assess the impact and frequency of delay factors. The study also benchmarks the findings against established national and international literature on highway project management.

The insights derived from this case study are expected to contribute towards the formulation of mitigation strategies and management frameworks for future highway infrastructure projects. By highlighting the key technical, administrative, and financial bottlenecks encountered during execution, this research aims to support decision-makers, contractors, and concessionaires in enhancing time performance, optimizing resource utilization, and strengthening the overall project delivery mechanism in the Indian highway sector.

2. DELAY FACTORS

As indicated in Tables 5.1 to 5.15, there are 293 factors total that are divided into fifteen (15) major groups and are responsible for construction project delays. In table no 5.1 shows the delay factors related to Financing. Under the financing group, 15 causes are listed. In each causes rank correlation coefficient & relative importance index is calculated in table no 5.1. In following figure no 5.1 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & relative importance index.

Table No. 1 Delay Factors Related to Financing

Sr. No.	Delay Factor Description Related to Financing	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
1	Owner financial problems/client finance/economic ability for the project	115	0.04	0.92
2	Payment of completed work	93	0.17	0.74
3	Owner payments to contractors are delayed	101	0.08	0.81
4	Partial payments during construction/financing	80	0.13	0.64
5	Delay in honoring payment certificates	73	0.09	0.58
6	Accessing bank credit is difficult.	60	0.17	0.48
7	Financing by contractor during construction	62	0.17	0.50
8	Exchange rate (price) fluctuation/economic	53	0.10	0.42
9	Changing of bankers policy	57	0.22	0.46
10	Cash- flow problems during construction	50	0.18	0.40
11	Global financial crisis	31	0.02	0.25
12	Material and labor wage escalation (inflation)	43	0.06	0.34
13	Financial instability in markets	34	0.04	0.27
14	Difficulty in obtaining materials at official current prices	49	0.09	0.39
15	Late payment to subcontractor by the main contractor	37	0.10	0.30

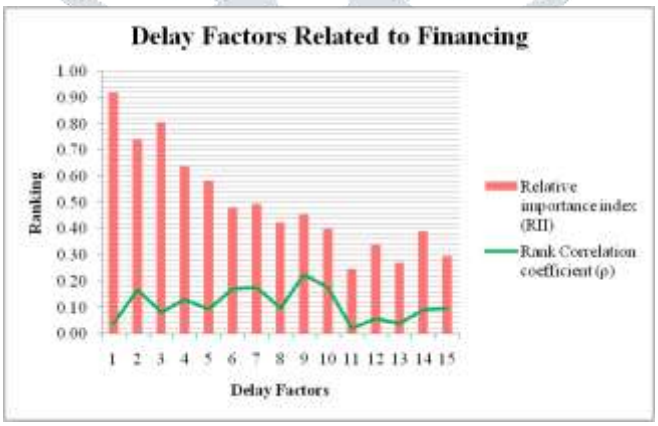

Figure No 1 Delay Factors Related to Financing

In above chart no 5.1 shows the delay factors related to financing. It is observed that in financial related cause group relative importance index is more i.e. 0.92 for Owner financial problems or client finance or economic ability for the project & less i.e. 0.25 for Global financial crisis. In case of rank correlation coefficient it is observed that changing of banker's policy is more at 0.22 & global financial crisis is less at 0.02. It is seen that relative importance index is more that factors affect more.

In table no 5.2 shows the delay factors related to Owner. Under the Owner related group, 23 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.2. In following figure no 5.2 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 2 Delay Factors Related to Owner

Sr. No.	Delay Factor Description Related to Owner	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
16	The unavailability of financial incentives for contractor to finish ahead of schedule	120	0.02	0.96
17	Slowness of the owner decision making process	104	0.05	0.83
18	Indication of suspension, postponement or delay of project by owner	57	0.15	0.46
19	Design changes by owner or his agent during construction	114	0.03	0.91
20	Change orders by owner during construction (variation)	41	0.08	0.33
21	Issues regarding client approval	96	0.09	0.77
22	Late issuing of approval of design documents by owner	89	0.13	0.71
23	Preparation and approval of shop drawings, samples	100	0.08	0.80
24	Waiting for sample material approval	67	0.19	0.54
25	Delay in approval of completed work by client/CM	29	0.01	0.23
26	Not definite about material	69	0.10	0.55
27	Main concern construction type	110	0.04	0.88
28	Poor scope definition	42	0.07	0.34
29	Improper selection of subsequent consultants	78	0.28	0.62
30	Lack of experience of owner in construction projects	82	0.24	0.66
31	Delay in material to be supplied by the owner	63	0.17	0.50
32	Unclear perception of demand	61	0.13	0.49
33	Changes in clients requirements	72	0.32	0.58
34	Slow land expropriation due to resistance from occupants	52	0.08	0.42
35	Unfinished client – furnished item	48	0.11	0.38
36	Complicated administration process of client	76	0.30	0.61
37	Frequent change of client managers	34	0.07	0.27
38	Specified sequence of completion	37	0.06	0.30

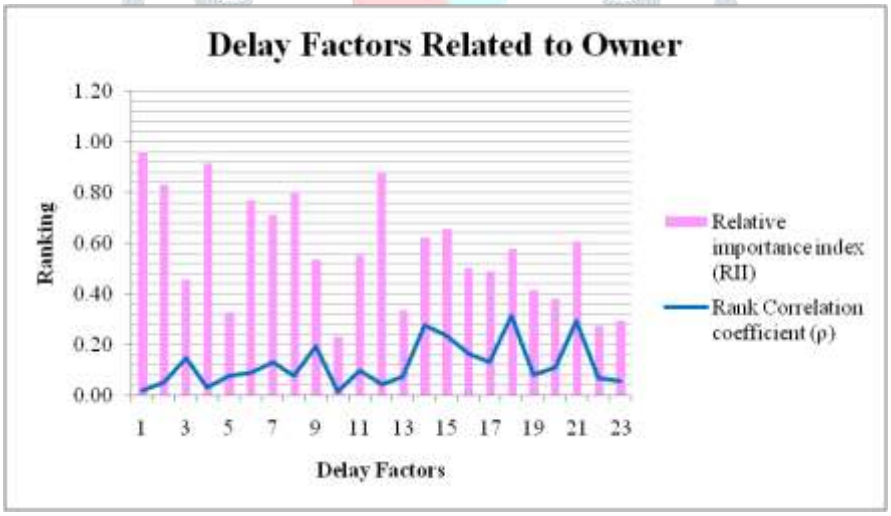

Figure No 2 Delay Factors Related to Owner

In above chart no 5.2 shows the delay factors related to Owner. It is observed that in Owner related cause group RII is more i.e. 0.96 for the unavailability of financial incentives for contractor to finish ahead of schedule & less i.e. 0.27 for Frequent change of client managers. In case of rank correlation coefficient it is observed that a change in client's requirements is more at 0.32 & Delay in approval of completed work by client/CM is less at 0.01. It is seen that relative importance index is more that factors affect more.

In table no 5.3 shows the factors of delay related to contractor. Under the contractor group, 20 causes are listed. In each causes rank correlation coefficient & RIIis calculated in table no 5.3. In following figure no 5.3 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 3 Delay Factors Related to Contractor

Sr .No.	Delay Factor Description Related to Contractor	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
39	Controlling subcontractors by general contractors in the execution of work	111	0.04	0.89
40	Poor subcontractor performance/delays	71	0.16	0.57
41	Often change of subcontractors	67	0.10	0.54

42	Construction methods	117	0.02	0.94
43	Rework because of errors during construction	35	0.04	0.28
44	Unreliable subcontractors	63	0.15	0.50
45	Poor site management and supervision by contractor	48	0.05	0.38
46	Delay in site mobilization by contractor	82	0.15	0.66
47	Poor resource management	53	0.16	0.42
48	Incompetent project team	77	0.12	0.62
49	Inadequate contractor experience (work) causing error	98	0.11	0.78
50	Non-adherence of material specifications provided by client	59	0.15	0.47
51	low ability of contractor to provide imported material	74	0.17	0.59
52	Delay in commencement	107	0.05	0.86
53	Poor qualification of the contractors technical staff	103	0.07	0.82
54	Obsolete technology	38	0.05	0.30
55	Unstable management structure and leadership style of contractor	93	0.12	0.74
56	Lack of trade's skill	44	0.04	0.35
57	Defective work	28	0.01	0.22
58	Time spent to find appropriate subcontractors for each task	87	0.14	0.70

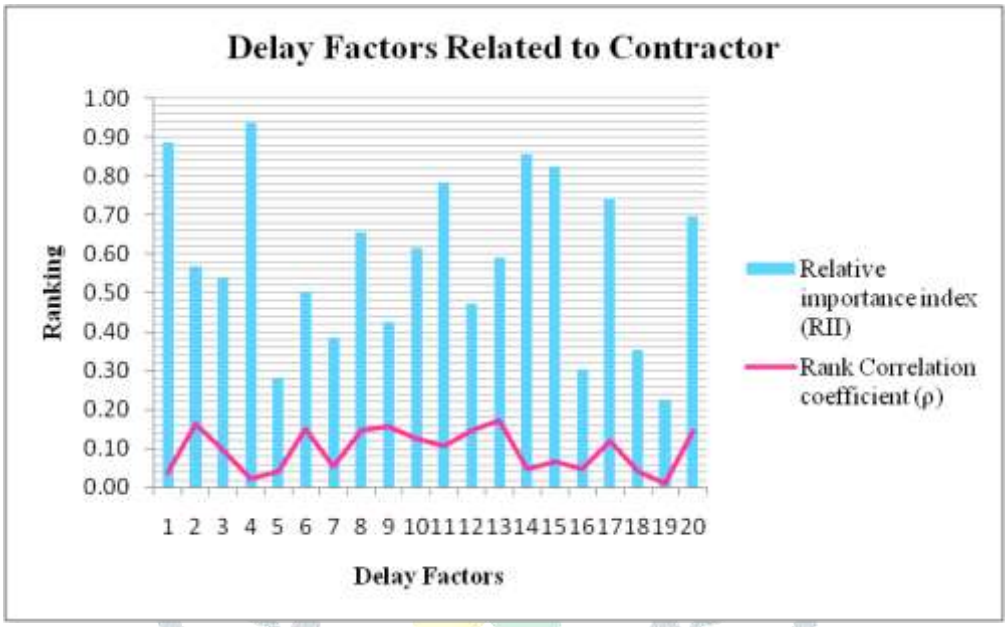

Figure No 3 Delay Factors Related to Contractor

In above chart no 5.3 shows the delay factors related to contractor. It is observed that in contractor related cause RII index is more i.e. 0.94 for construction methods & less i.e. 0.22 for defective work. In case of rank correlation coefficient it is observed that poor subcontractor performance/delays is more at 0.16 & Construction methods is less at 0.02. It is seen that relative importance index is more that factors affect more.

In table no 5.4 shows the delay factors related to labor. Under the labor related group, 15 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.4. In following figure no 5.4 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 4 Delay Factors Related to Labor

Sr. No.	Delay Factor Description Related to Labor	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
59	Shortage of labor	108	0.07	0.86
60	Labor skill	88	0.11	0.70
61	Nationality of laborers	33	0.06	0.26
62	Labor injuries	43	0.06	0.34
63	Labor disputes and strikes	38	0.04	0.30
64	Absenteeism of laborers	79	0.12	0.63
65	Low motivation and morale of labor	56	0.17	0.45
66	Slow mobilization of labor	66	0.09	0.53
67	Staffing problems	63	0.15	0.50
68	Shortage of unskilled labors	54	0.11	0.43

69	Shortage of technical personnel/staff	97	0.13	0.78
70	Insufficient (un qualified - inadequate experienced) laborers	73	0.18	0.58
71	Low productivity level work	49	0.10	0.39
72	Foreman incompetence	35	0.03	0.28
73	Severe overtime	45	0.16	0.36

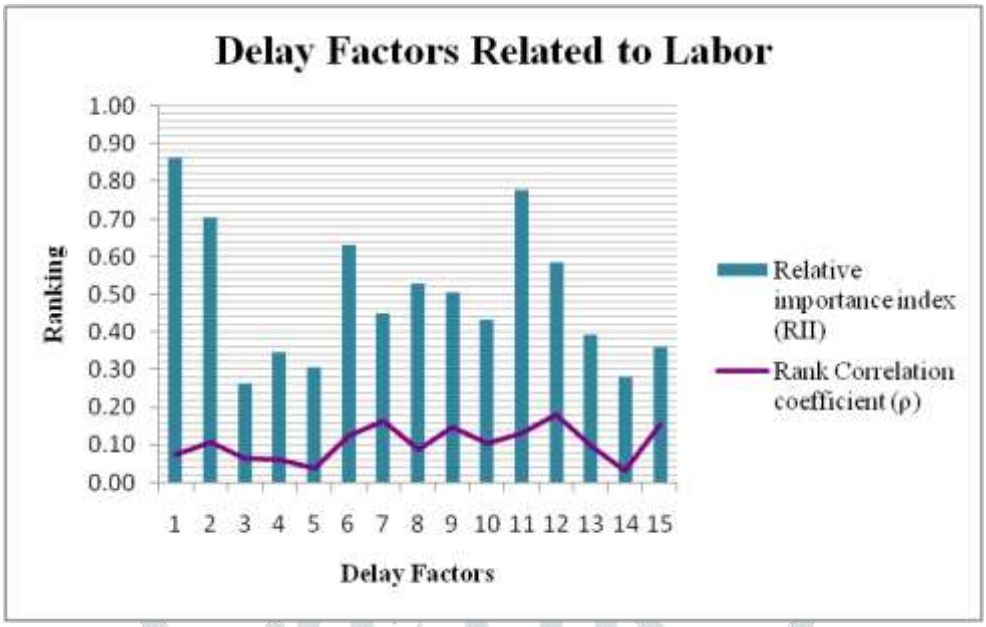

Figure No 4 Delay Factors Related to Labor

In above chart no 5.4 shows the delay factors related to labor. It is observed that in labor related cause group RII is more i.e. 0.86 for Shortage of labor & less i.e. 0.26 for nationality of laborers. In case of rank correlation coefficient it is observed that Insufficient (un qualified - inadequate experienced) laborers is more at 0.18 & foreman incompetence is less at 0.03. It is seen that relative importance index is more that factors affect more.

In table no 5.5 describe the delay factors related to design. Under the design related group, 26 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.5. In following figure no 5.5 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 5 Delay Factors Related to Design

Sr. No.	Delay Factor Description Related to Design	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
74	Design errors made by designers (due to unfamiliarity with local conditions and environment)	117	0.03	0.94
75	Lack of database in estimating activity duration and resources	83	0.07	0.66
76	Variation order in extra quantities	37	0.04	0.30
77	Design details unclear & inadequate	93	0.09	0.74
78	Complexity of project design	115	0.04	0.92
79	Slow response of designer	112	0.03	0.90
80	Build ability of design	109	0.07	0.87
81	Incomplete/conflicts of design drawings details and specifications	97	0.10	0.78
82	Unrealistic design duration imposed	107	0.06	0.86
83	Incompletely understanding of clients requirements	119	0.02	0.95
84	Wrong or improper (poor) (inappropriate) design	122	0.01	0.98
85	Slow decision making by designers	88	0.08	0.70
86	Inadequate experience of designers	105	0.07	0.84
87	Disagreement on design specifications	80	0.14	0.64
88	Insufficient training of designers	102	0.07	0.82
89	Change orders by deficiency design	53	0.19	0.42
90	Rework due to change of design or deviation order	49	0.05	0.39
91	Late design work	75	0.14	0.60
92	Unclear authority among designers	72	0.08	0.58
93	Slow information delivery between designers	69	0.11	0.55
94	Poor use of advanced engineering design software	67	0.16	0.54
95	Mistakes and delays in producing design documents	65	0.17	0.52

96	Insufficient or ill-integrated basic project data and survey	62	0.12	0.50
97	Non availability of drawing/design on time	58	0.11	0.46
98	Inadequate path design	77	0.12	0.62
99	Change in drawings & specifications	99	0.11	0.79

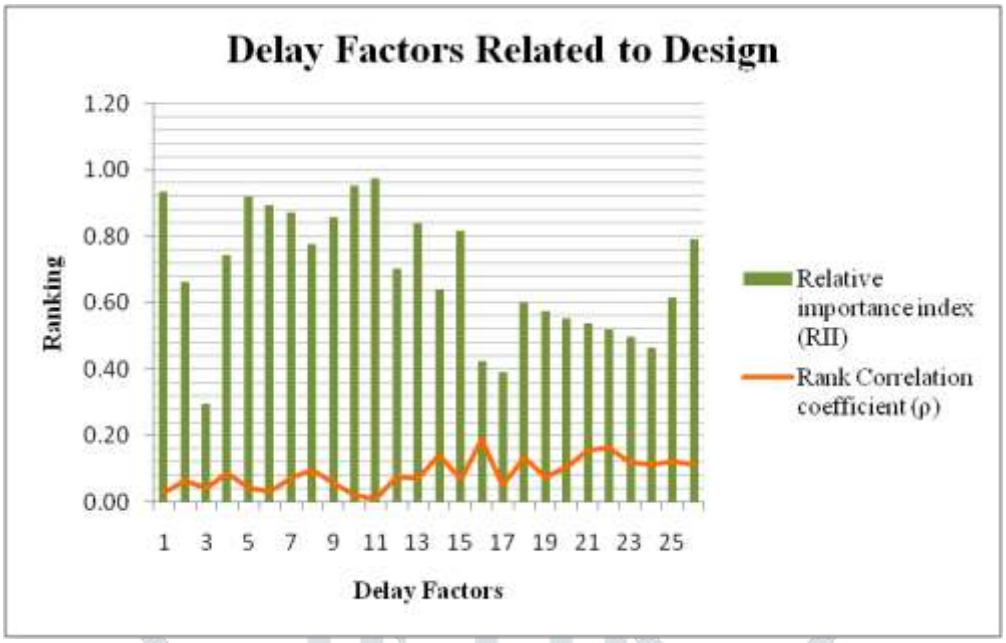

Figure No 5 Delay Factors Related to Design

In above chart no 5.5 shows the delay factors related to design. It is observed that in design related cause group relative importance index is more i.e. 0.98 for wrong or improper (poor) (inappropriate) design & less i.e. 0.30 for variation order in extra quantities. In case of rank correlation coefficient it is observed that change orders by deficiency design is more at 0.19 & wrong or improper (poor) (inappropriate) design is less at 0.01. It is seen that relative importance index is more that factors affect more.

In table no 5.6 shows the delay factors related to site. Under the site related group, 27 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.6. In following figure no 5.6 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 6 Delay Factors Related to Site

Sr. No.	Delay Factor Description Related to Site	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
100	Foundation conditions encountered in the field	104	0.08	0.83
101	Mistakes in soil investigation	74	0.08	0.59
102	Errors committed during field construction at job site	50	0.08	0.40
103	Effects of subsurface conditions (e.g., soil High water table, etc.)	99	0.07	0.79
104	Geological problems on site	103	0.08	0.82
105	Unexpected underground condition	95	0.06	0.76
106	Insufficient available utilities on site (water, electricity, telephone, etc.)	60	0.16	0.48
107	Different – unfavorable site conditions	91	0.09	0.73
108	Overcrowded work areas/confined site	67	0.15	0.54
109	Disturbance to public activity	66	0.15	0.53
110	Limited construction area	117	0.02	0.94
111	Inconvenient site area	114	0.04	0.91
112	Poor ground condition	85	0.09	0.68
113	Poor soil quality	83	0.12	0.66
114	Poor terrain condition	78	0.09	0.62
115	Traffic control regulation practiced in the site of the project	43	0.09	0.34
116	Statutory undertakers (gas, water, etc.)	57	0.18	0.46
117	Delay in providing services from utilities (water, electricity, etc.)	55	0.11	0.44
118	Inaccurate site investigation	107	0.07	0.86
119	Restricted access at site	110	0.05	0.88
120	Site accidents due to negligence	45	0.07	0.36
121	Site accidents due to lack of safety measures;	46	0.07	0.37
122	Inaccurate specification of site condition	87	0.06	0.70

123	Faulty soil investigation paper	71	0.13	0.57
124	Unsatisfactory site compensation	109	0.06	0.87
125	Late land handover by owner/slow site clearance	119	0.02	0.95
126	Poor site layout	53	0.07	0.42

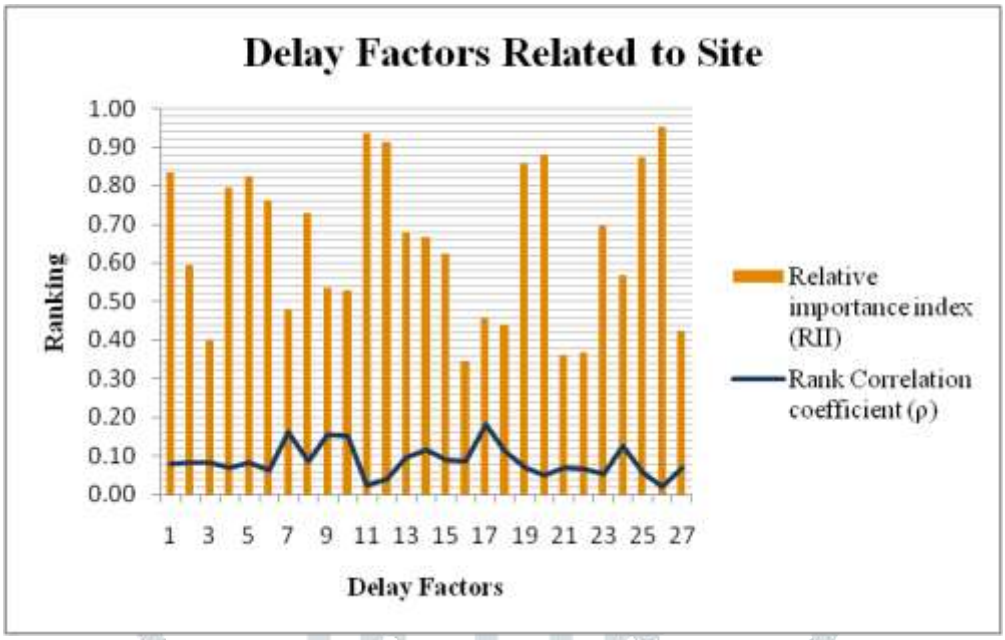

Figure No 6 Delay Factors Related to Site

In above chart no 5.6 shows the delay factors related to site. It is observed that in site related cause group RII is more i.e. 0.95 for late land handover by owner/slow site & less i.e. 0.34 for traffic control regulation practiced in the site of the project. In case of rank correlation coefficient it is observed that an insufficient available utility on site (water, electricity, telephone, etc.) is more at 0.16 & limited construction area & late land handover by owner/slow site is less at 0.02. It is seen that RII is more that factors affect more.

In table no 5.7 shows the delay factors related to contractual relationship. Under the contractual relationship related group, 28 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.7. In following figure no 5.7 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 7 Delay Factors Related to Contractual Relationship

Sr. No.	Delay Factor Description Related to Contractual Relationship	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
127	The relationship between different subcontractors schedules in the execution of the project	121	0.01	0.97
128	The conflict between contractor and other parties (consultant & owner)	117	0.02	0.94
129	Conflicts between consultant and design engineer	113	0.03	0.90
130	Poor organization of the contractor or consultant/ inappropriate overall organizational structure linking to the project)	123	0.01	0.98
131	Difficulty of coordination between various parties (contractor, subcontractor, owner, consultant) working on the project	119	0.02	0.95
132	No utilization of professional construction/-contractual management	111	0.03	0.89
133	Poor communication by consultant with other parties	95	0.11	0.76
134	Poor communication by contractor with other parties	103	0.08	0.82
135	Insufficient communication between the owner and designer or other parties in design phases	108	0.05	0.86
136	Legal/industrial disputes between various parties in the construction project (claims)	34	0.04	0.27
137	Conflicts between joint – ownership	89	0.16	0.71
138	Poor communication between designers	90	0.15	0.72
139	Laborers personal conflict	35	0.03	0.28
140	Unfair subcontractor relationships with employees	44	0.05	0.35
141	Previous working relationships of consultant	29	0.01	0.23
142	Personal conflict between laborers and management team	38	0.04	0.30
143	Conflict between owners and other parties	46	0.09	0.37
144	Deficiencies in organization	79	0.21	0.63
145	Deficiencies in coordination	75	0.19	0.60
146	Crew interfacing	27	0.01	0.22

147	Provision for ease of communication	69	0.09	0.55
148	Inadequate integration on project interfaces (involvement)	61	0.15	0.49
149	Insufficient communication between parties	58	0.09	0.46
150	Poor documentation	49	0.14	0.39
151	Uncooperative owners	51	0.12	0.41
152	Foundation conditions encountered in the field	55	0.09	0.44
153	Previous working relationship of owner	32	0.02	0.26
154	Lack of responsibilities	40	0.05	0.32

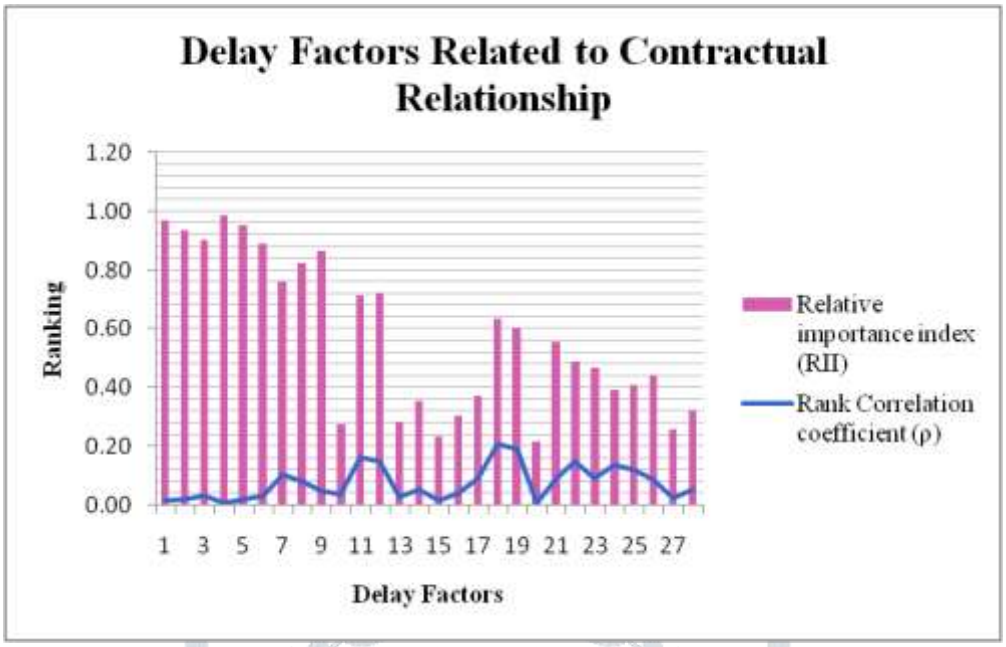

Figure No 7 Delay Factors Related to Contractual Relationship

In above chart no 5.7 shows the delay factors related to contractual relationship. It is observed that in contractual relationship related cause group RII is more i.e. 0.98 for poor organization of the contractor or consultant/ inappropriate overall organizational structure linking to the project) & less i.e. 0.22 for crew interfacing. In case of rank correlation coefficient it is observed that a deficiency in organization is more at 0.21 & the relationship between different subcontractors schedules in the execution of the project is less at 0.01. It is seen that RII is more that factors affect more.

In table no 5.8 shows the delay factors related to contract. Under the contract related group, 13 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.8. In following figure no 5.8 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 8 Delay Factors Related to Contract

Sr. No.	Delay Factor Description Related to Contract	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
155	Poor contract management	113	0.04	0.90
156	Mistakes and discrepancies in contract documents	45	0.06	0.36
157	Negotiations and obtaining of contracts	53	0.08	0.42
158	Contract modification/excessive contracts and subcontracts	40	0.07	0.32
159	Change orders of contract	35	0.03	0.28
160	Unrealistic contract price	83	0.14	0.66
161	Unrealistic (unreasonable) contract time (duration) & requirements imposed	79	0.16	0.63
162	Unclear contract conditions	108	0.06	0.86
163	Use of standard form of contract	91	0.11	0.73
164	Suitability of contract to project time	68	0.20	0.54
165	Inadequate and inconsistent contract terms	65	0.08	0.52
166	Unfavorable/inadequate contract clauses	59	0.11	0.47
167	No adherence to contract conditions	102	0.08	0.82

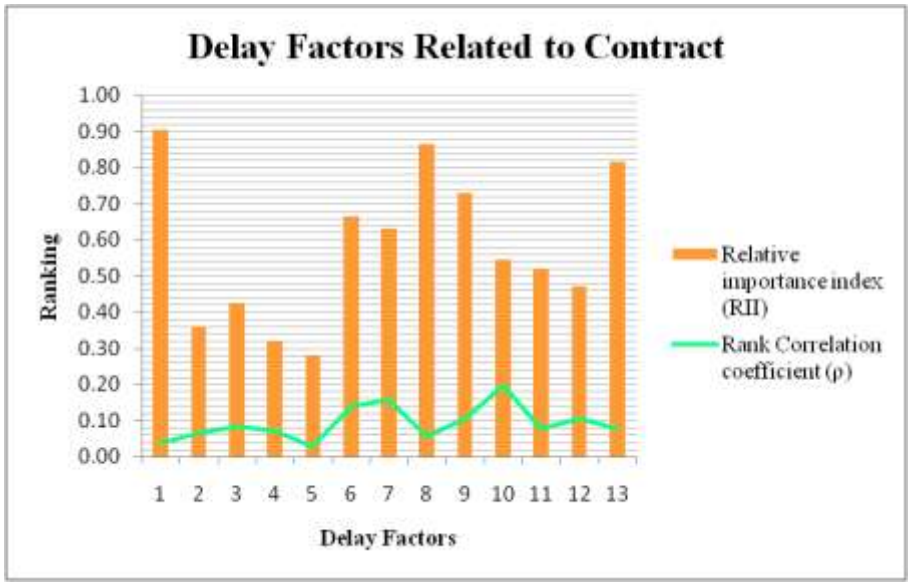

Figure No 8 Delay Factors Related to Contract

In above chart no 5.8 shows the delay factors related to contract. It is observed that in contract related cause group RII is more i.e. 0.90 for poor contract management & less i.e. 0.28 for change orders of contract. In case of rank correlation coefficient it is observed that a suitability of contract to project time is more at 0.20 & Change orders of contract is less at 0.03. It is seen that RII is more that factors affect more.

In table no 5.9 shows the delay factors related to project. Under the project related group, 14 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.9. In following figure no 5.9 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 9 Delay Factors Related to Project

Sr. No.	Delay Factor Description Related to Project	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
168	Project delivery systems used (design – build, general contracting, turnkey, etc.)	57	0.10	0.46
169	Category (public, private)	91	0.13	0.73
170	Complexity of project	88	0.14	0.70
171	Location of project	89	0.12	0.71
172	Unreasonable project time frame	59	0.10	0.47
173	Function or end use (office, residential, industrial)	39	0.07	0.31
174	Inadequate definition of substantial completion	85	0.16	0.68
175	Ineffective delay penalties	42	0.09	0.34
176	Improper project feasibility study	78	0.12	0.62
177	Type of project bidding and award (negotiation, lowest bidder)	75	0.10	0.60
178	Delay in finalization of rates for extra items	55	0.13	0.44
179	Increase in scope of work/notification of extra work	49	0.12	0.39
180	Poor means of contracting	74	0.20	0.59
181	Interfering of other projects	69	0.20	0.55

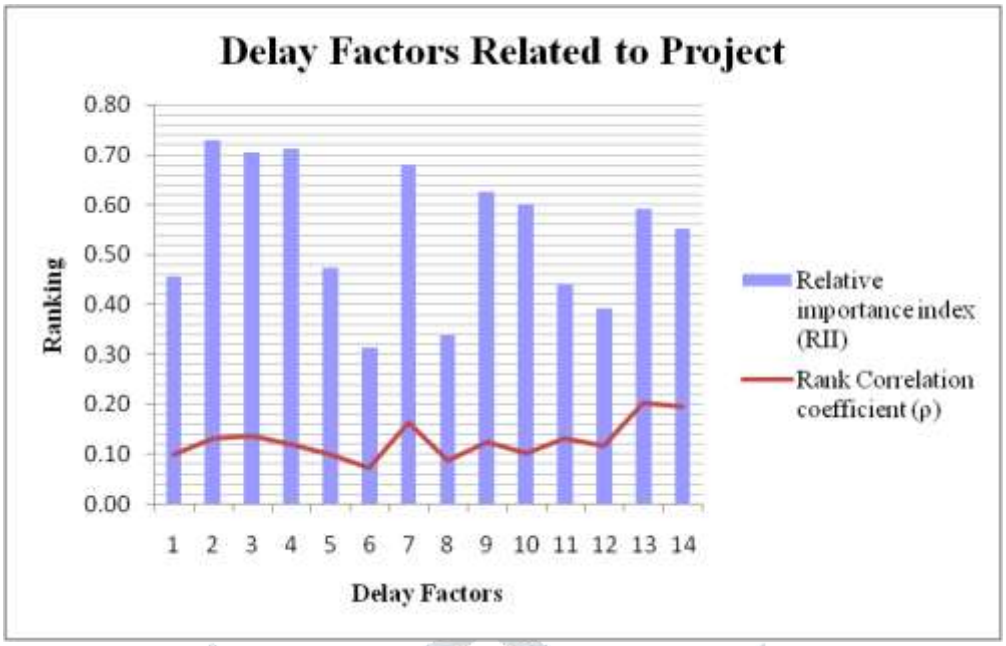

Figure No 9 Delay Factors Related to Project

In above chart no 5.9 shows the delay factors related to project. It is observed that in project related cause group RII is more i.e. 0.73 for category (public, private) & less i.e. 0.31 for function or end use (office, residential, industrial). In case of rank correlation coefficient it is observed that poor means of contracting & interfering of other projects is more at 0.20 & function or end use (office, residential, industrial) is less at 0.07. It is seen that RII is more that factors affect more.

In table no 5.10 shows the delay factors related to external. Under the external related group, 24 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.10. In following figure no 5.10 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 10 Delay Factors Related to External

Sr. No.	Delay Factor Description Related To External	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
182	Rain effect on construction activities	88	0.11	0.70
183	Wind damage	86	0.13	0.69
184	Fire	91	0.11	0.73
185	Social, religions and cultural factors	79	0.12	0.63
186	Accidents/mistakes during construction	108	0.06	0.86
187	Problems with neighbors	105	0.06	0.84
188	Infectious disease	62	0.13	0.50
189	Segmentation of the west bank and limited movement between areas	59	0.14	0.47
190	Natural disasters (earthquake, flood, etc.)	85	0.11	0.68
191	Hurricane	81	0.23	0.65
192	Weather conditions	111	0.05	0.89
193	Political situation	95	0.09	0.76
194	Physical obstructions	97	0.16	0.78
195	Conflict, war, revolution, riot, and public enemy	54	0.14	0.43
196	Public holidays	69	0.16	0.55
197	Vandalism – robbery (security)	115	0.02	0.92
198	Monopoly	74	0.16	0.59
199	Necessary variations	76	0.20	0.61
200	Unavoidable changes in construction/execution methods	116	0.03	0.93
201	Bribes (kickbacks) & personal interest (prejudices) ‘‘corruption”	50	0.10	0.40
202	Fraudulent practices	65	0.22	0.52
203	Poor government judicial system for construction dispute settlement	103	0.08	0.82
204	Warlords influence	47	0.07	0.38
205	Nepotism	28	0.01	0.22

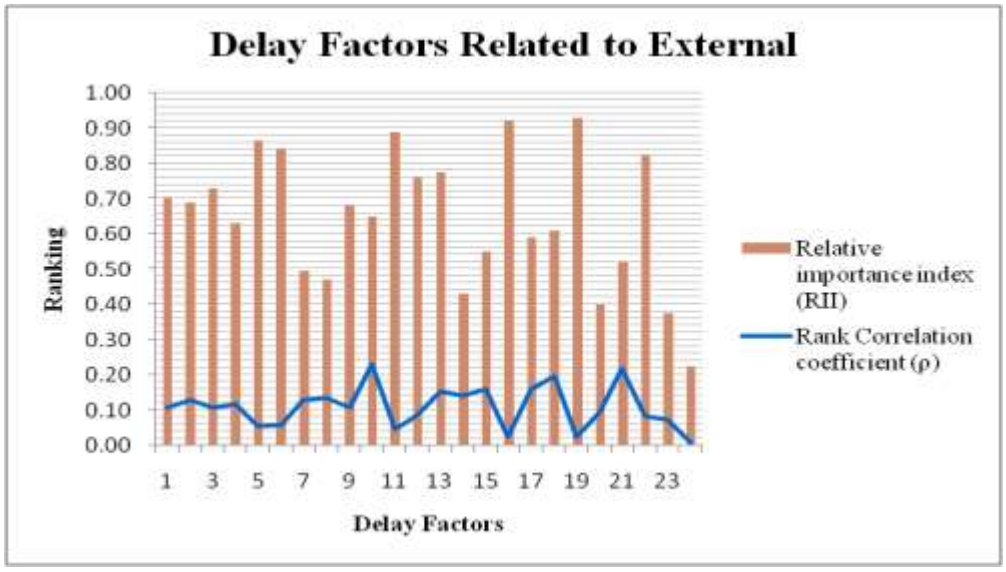

Figure No 10 Delay Factors Related to External

In above chart no 5.10 shows the delay factors related to external. It is observed that in external related cause group RII is more i.e. 0.93 for unavoidable changes in construction/execution methods & less i.e. 0.22 for nepotism. In case of rank correlation coefficient it is observed that a fraudulent practice is more at 0.22 & nepotism is less at 0.01. It is seen that relative importance index is more that factors affect more.

In table no 5.11 shows the delay factors related to equipment. Under the equipment related group, 10 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.11. In following figure no 5.11 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 11 Delay Factors Related to Equipment

Sr. No.	Delay Factor Description Related to Equipment	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
206	Shortage in equipment/insufficient numbers	104	0.08	0.83
207	Lack of skilled operators for specialized equipment	94	0.07	0.75
208	Equipment productivity (efficiency)	63	0.15	0.50
209	Equipment failure (breakdown)	87	0.13	0.70
210	Slow delivery (mobilization) of equipment	90	0.09	0.72
211	Lack of high-technology mechanical equipment	84	0.12	0.67
212	Equipment allocation problems	109	0.04	0.87
213	Tool availability	101	0.08	0.81
214	Improper equipment	96	0.09	0.77
215	Inadequate modern equipment	59	0.18	0.47

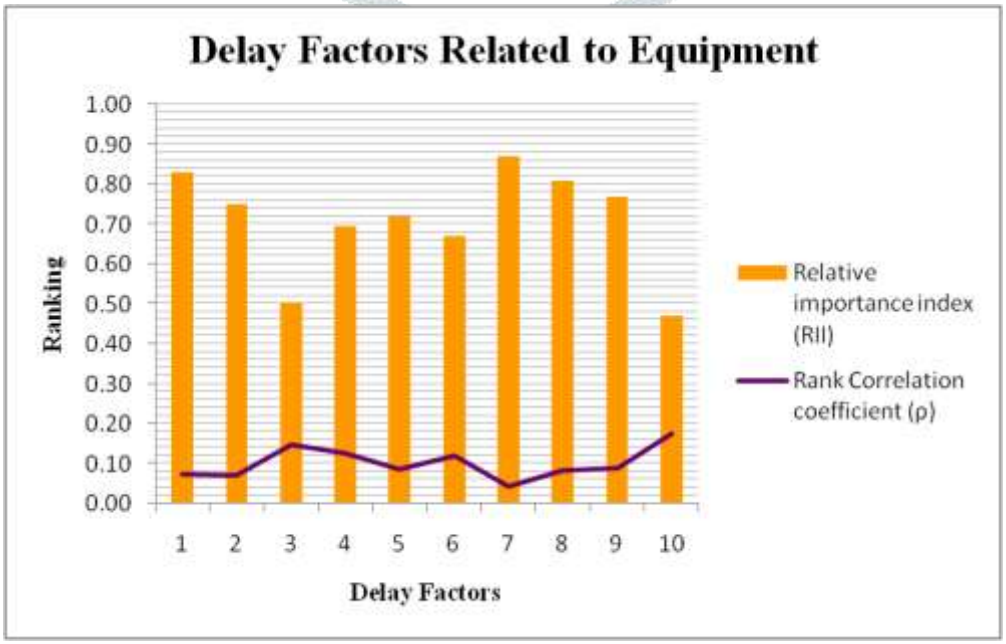

Figure No 11 Delay Factors Related to Equipment

In above chart no 5.11 shows the delay factors related to equipment. It is observed that in equipment related cause group RII is more i.e. 0.87 for equipment allocation problems & less i.e. 0.47 for inadequate modern equipment. In case of rank correlation coefficient it is observed that inadequate modern equipment is more at 0.18 & equipment allocation problems is less at 0.04. It is seen that RII is more that factors affect more.

In table no 5.12 shows the delay factors related to rules & regulations. Under the rules & regulations related group, 19 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.12. In following figure no 5.12 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 12 Delay Factors Related to Rules & Regulations

Sr. No.	Delay Factor Description Related to Rules & Regulations	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
216	Obtaining permits from municipality (government)	117	0.03	0.94
217	Excessive bureaucracy in project owned operation	113	0.03	0.90
218	Building permits approval process	119	0.02	0.95
219	Changes in laws and regulations	93	0.04	0.74
220	Safety rules	89	0.10	0.71
221	Occupational safety & health administration (OSHA) regulations	69	0.16	0.55
222	Building regulations in coastal regions	58	0.09	0.46
223	Coastal construction control line permit	51	0.10	0.41
224	Florida administrative code	43	0.04	0.34
225	Failure of RIBA plan of work application	63	0.16	0.50
226	National flood insurance program	74	0.08	0.59
227	Obtaining permits for laborers	35	0.04	0.28
228	Building codes used in the design of the projects	102	0.08	0.82
229	Permits (urban planning bureau & order of engineers) and access facilities	106	0.05	0.85
230	Change orders by code change	80	0.14	0.64
231	Regulations	84	0.12	0.67
232	Discrepancy between design specification and building codes	77	0.18	0.62
233	Environmental concerns and restrictions	99	0.10	0.79
234	Issues regarding permissions/approval from other stakeholders	109	0.03	0.87

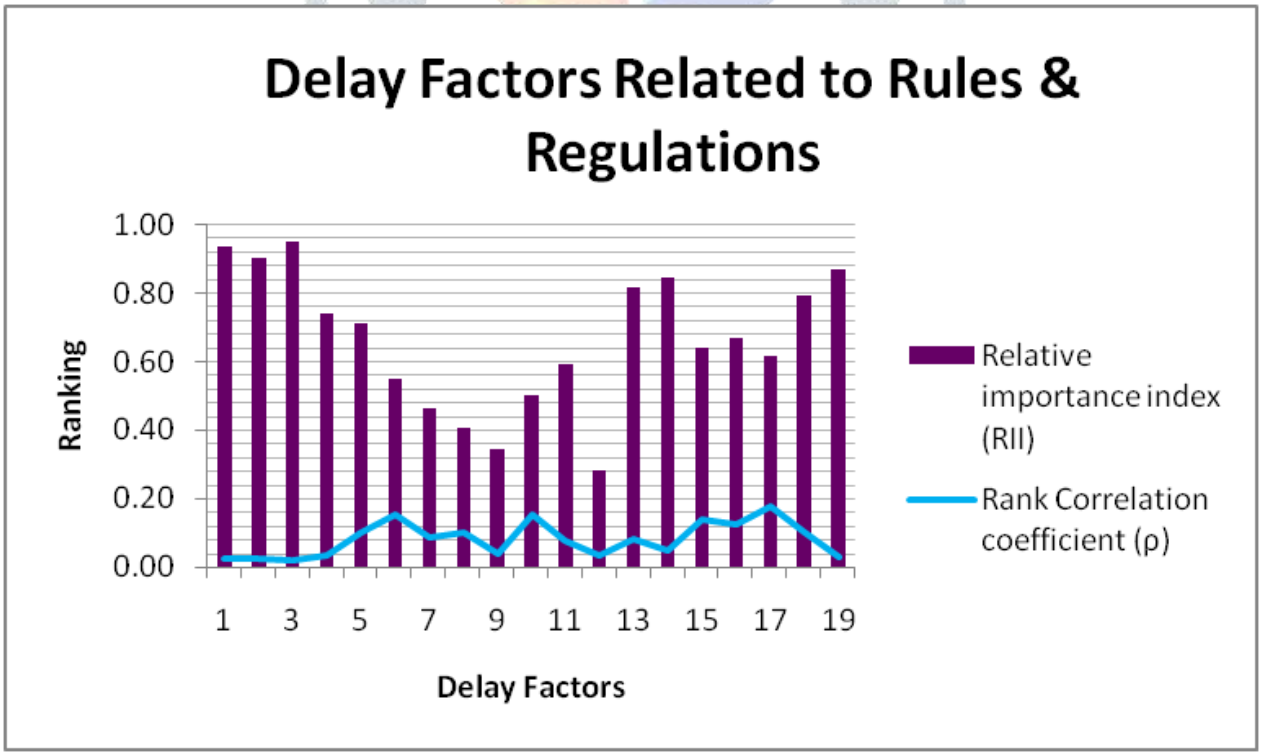

Figure No 12 Delay Factors Related to Rules & Regulations

In above chart no 5.12 shows the delay factors related to rules & regulations. It is observed that in rules & regulations related cause group RII is more i.e. 0.95 for building permits approval process & less i.e. 0.34 for Florida administrative code. In case of rank correlation coefficient it is observed that discrepancy between design specification and building codes is more at 0.18 & building permits approval process is less at 0.02. It is seen that RII is more that factors affect more.

In table no 5.13 shows the delay factors related to consultant. Under the consultant related group, 14 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.13. In following figure no 5.13 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 13 Delay Factors Related to Consultant

Sr. No.	Delay Factor Description Related to Consultant	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
235	Waiting instructions from consultant	99	0.09	0.79
236	Delay of design submittal from consultant	113	0.06	0.90
237	Incapable inspectors	88	0.09	0.70
238	Insufficient inspectors	82	0.09	0.66
239	Inflexibility of consultant	85	0.13	0.68
240	Uncompromising attitude of inspector	79	0.15	0.63
241	Inspection and testing procedures used in the project	95	0.13	0.76
242	Waiting time for approval of tests and inspection	91	0.10	0.73
243	Inspection delays (delay in performing inspection and testing by consultant)	74	0.22	0.59
244	Late in reviewing and approving design documents	111	0.04	0.89
245	Delay in approving major changes in the scope of work by consultant	66	0.10	0.53
246	Lack of experience of consultant in construction projects	108	0.05	0.86
247	Inadequate project management assistance	103	0.09	0.82
248	Consultant or architect's reluctance for change	71	0.13	0.57

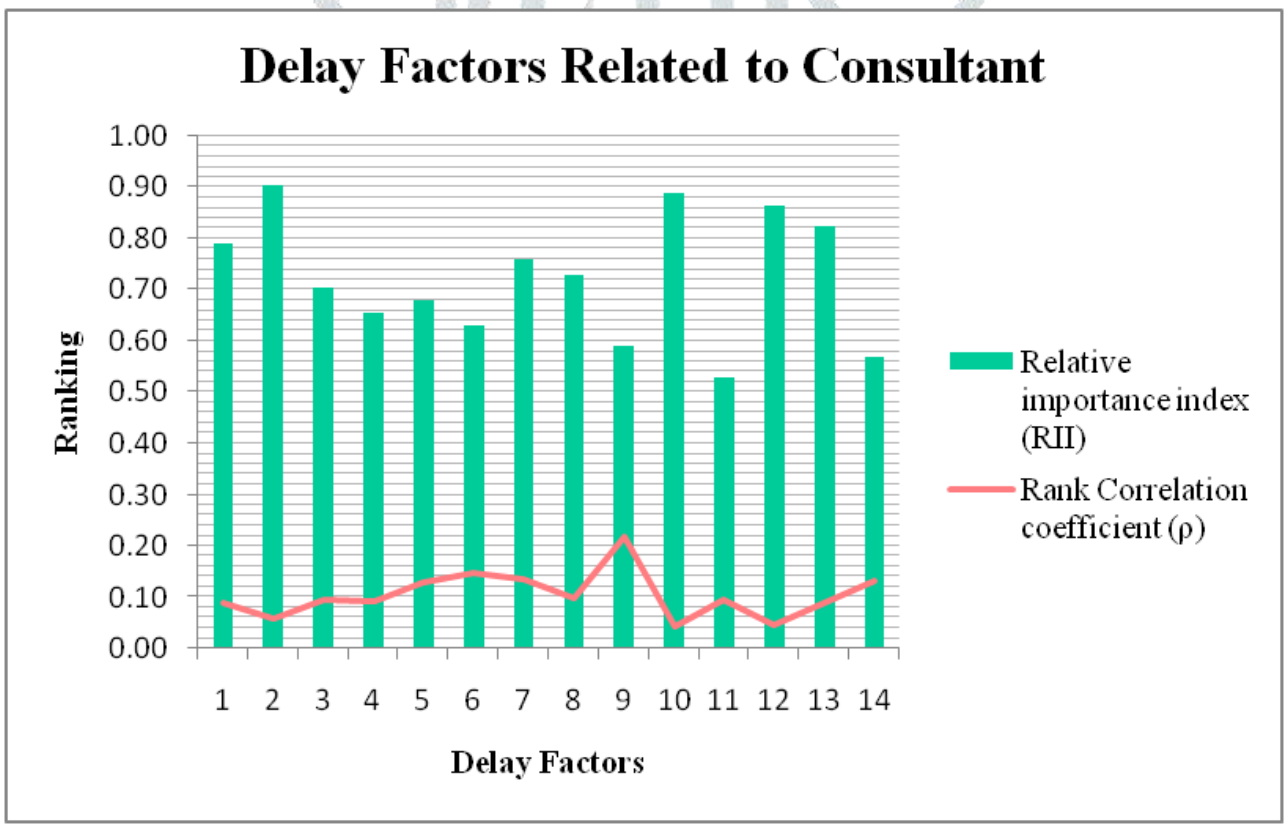

Figure No 13 Delay Factors Related to Consultant

In above chart no 5.13 shows the delay factors related to consultant. It is observed that in consultant related cause group RII is more i.e. 0.90 for delay of design submittal from consultant & less i.e. 0.53 for delay in approving major changes in the scope of work by consultant. In case of rank correlation coefficient it is observed that inspection delays (delay in performing inspection and testing by consultant) is more at 0.22 & late in reviewing and approving design documents is less at 0.04. It is seen that RII is more that factors affect more.

In table no 5.14 shows the delay factors related to scheduling & controlling. Under the scheduling & controlling related group, 30 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.14. In following figure no 5.14 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 14 Delay Factors Related to Scheduling & Controlling

Sr. No.	Delay Factor Description Related to Scheduling & Controlling	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
249	Lack of training personnel and management support to model the construction operation	65	0.15	0.52
250	Judgment and experience of the involved people in estimating time and resources	60	0.08	0.48
251	Overestimation/underestimation of the productivity	54	0.11	0.43
252	Inadequate early planning of the project	118	0.02	0.94
253	Preparation of scheduling networks and revisions by consultant while construction is in progress	35	0.02	0.28
254	Quality assurance/control	84	0.07	0.67
255	Unreasonable or unpractical initial plan	115	0.03	0.92
256	Incompetence of planning and control from contractor staff	106	0.03	0.85
257	Priority on construction time	80	0.09	0.64
258	Ineffective planning and scheduling of project by contractor	110	0.03	0.88
259	No planning before project starts	121	0.01	0.97
260	Damage to structure/liquated damage	38	0.02	0.30
261	Transportation delays	39	0.04	0.31
262	Inadequate progress review	30	0.01	0.24
263	Completeness & timeliness of project information	104	0.04	0.83
264	Not property time decision	78	0.09	0.62
265	Application of quality control based on foreign specifications	25	0.00	0.20
266	U Improper or wrong cost estimation	44	0.05	0.35
267	Delay in performing final inspection and certification by a third party	41	0.08	0.33
268	Lack of program of works	90	0.08	0.72
269	Poor professional construction management	99	0.05	0.79
270	Date of notice to proceed	103	0.05	0.82
271	Ambiguity in specifications & conflicting interpretation by parties	68	0.13	0.54
272	Inconsistence of technical specifications	76	0.14	0.61
273	Inadequate geotechnical investigations	73	0.13	0.58
274	Customer/end-user related issues	34	0.02	0.27
275	High turnover of skilled staff	50	0.05	0.40
276	Inappropriate owner's capable representative management style	96	0.13	0.77
277	Inefficient capability of contractor staff management;	94	0.15	0.75
278	Inadequate control procedures	97	0.05	0.78

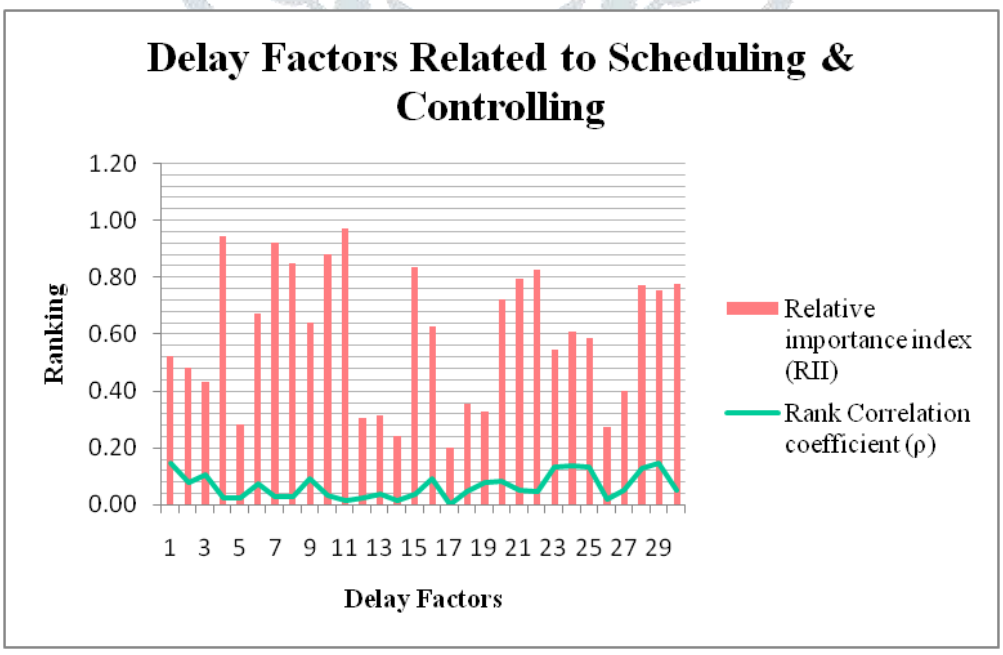

Figure No 14 Delay Factors Related to Scheduling & Controlling

In above chart no 5.14 shows the delay factors related to scheduling & controlling. It is observed that in scheduling & controlling related cause group RII is more i.e. 0.97 for no planning before project starts & less i.e. 0.20 for application of quality control based on foreign specifications. In case of rank correlation coefficient it is observed that lack of training personnel and management support

to model the construction operation & inefficient capability of contractor staff management is more at 0.15 & Application of quality control based on foreign specifications is less at 0.00. It is seen that RII is more that factors affect more.

In table no 5.15 shows the delay factors related to material. Under the material related group, 30 causes are listed. In each causes rank correlation coefficient & RII is calculated in table no 5.15. In following figure no 5.15 describe the graph of delay factors Vs ranking i.e. rank correlation coefficient & RII

Table No. 15 Delay Factors Related to Material

Sr. No.	Delay Factor Description Related to Material	Total	Rank Correlation Coefficient (ρ)	Relative Importance Index (RII)
279	Shortage (availability) in construction materials	110	0.04	0.88
280	Materials changes in types and specifications during construction	36	0.04	0.29
281	Slow delivery of materials	102	0.16	0.82
282	Damage of materials in storage	60	0.17	0.48
283	Imported materials and plant items	47	0.10	0.38
284	Low quality of construction materials	54	0.18	0.43
285	Materials management problem	76	0.30	0.61
286	Reworks due to defects in construction materials	31	0.02	0.25
287	Delay in manufacturing special materials	45	0.05	0.36
288	Unreliable suppliers	64	0.34	0.51
289	Poor procurement of material	62	0.17	0.50
290	Lack of water for hydrostatic test	50	0.13	0.40
291	Poor material handling on site	57	0.22	0.46
292	late in selection of finishing materials due to availability of many types in market	53	0.10	0.42
293	Inappropriate/misuse of material	56	0.27	0.45

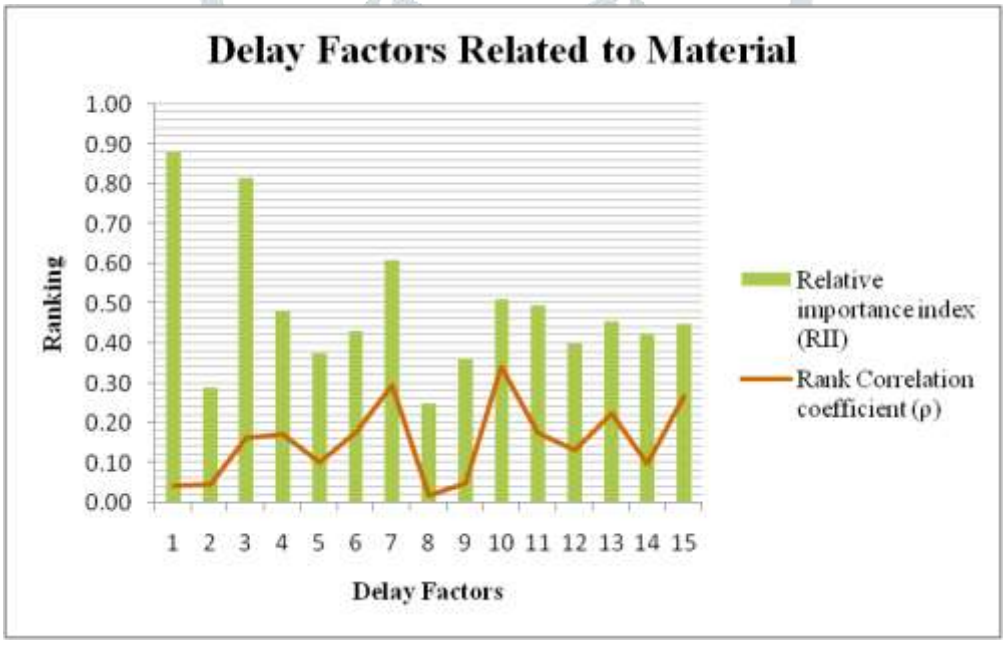

Figure No 15 Delay Factors Related to Material

In above chart no 5.15 shows the delay factors related to material. It is observed that in material related cause group RII is more i.e. 0.88 for shortage (availability) in construction materials & less i.e. 0.25 for reworks due to defects in construction materials. In case of rank correlation coefficient, it is observed that unreliable suppliers is more at 0.34 & reworks due to defects in construction materials is less at 0.02. It is seen RII is more that factors affect more.

3. CONCLUSIONS

1. It has been noted that a number of variables can cause delays in highway infrastructure projects. It is a chain process, which implies that one component affects other ones. When a project is delayed by any of these factors, the project's duration and cost both increase.
2. There are 293 reasons why infrastructure projects take longer than expected to complete. These reasons are divided into 15 major categories and include factors such as financing, owner, contractor, labour, design, site, contractual relationship, contract, project, external, equipment, rules and regulations, consultant, scheduling and controlling, and material.
3. The average correlation coefficients of causes of delay in highway infrastructure project are following;
   - The average correlation coefficient of delay factor related to material is 0.15.
   - The average correlation coefficient of delay factor related to project is 0.13.
   - The average correlation coefficient of delay factor related to owner is 0.12.

- The average correlation coefficient of delay factor related to financing, labour & external factors is 0.11.
- The average correlation coefficient of delay factor related to equipment & consultant is 0.10.
- The average correlation coefficient of delay factor related to contractor, design, site & contract is 0.09.
- The average correlation coefficient of delay factor related to contractual relationship and rules & regulation is 0.08.
- The average correlation coefficient of delay factor related to scheduling & controlling is 0.07.

4. The average RII of causes of delay in highway infrastructure project are following;

- Delay factor related to consultant is 0.72,
- Delay factor related to equipment is 0.71.
- Delay factor related to design is 0.69.
- Delay factor related to rules & regulation is 0.67.
- Delay factor related to site, & external factor is 0.65.
- Delay factor related to scheduling & controlling is 0.59.
- Delay factor related to contractor, & contract is 0.58.
- Delay factor related to owner, & contractual relationship is 0.57.
- Delay factor related to project is 0.54.
- Delay factor related to financing is 0.50.
- Delay factor related to labour is 0.49.
- Delay factor related to material is 0.48.

5. The average percentage cost growth rate for case studies is 15.36% and average actual cost percentage change for case studies is 26.63%.

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