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A Case Study on the Delayed Construction of the Ramban-Banihal Tunnel PKG-1, NH-44, Jammu & Kashmir

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ABSTRACT :

Under the aegis of the National Highways Authority of India's expansive vision, the construction of five new tunnels along the NH-44 Ramban to Banihal Stretch embarked on a journey of ambition and aspiration. Commencing in 2020, the project held promise for enhanced connectivity and streamlined transportation networks. However, as the contractual deadline loomed, the reality fell short of expectations, with only two tunnels reaching completion while the remaining languished behind schedule. Among these, the Digdol to Marog tunnel, initiated in 2022 by a reputable construction company, emerged as a focal point of stagnation, mired in inertia with negligible progress towards predetermined milestones. Using a questionnaire-based survey, data was collected from key stakeholders, including contractors, subcontractors, designers, independent engineers, and tunnel experts. Quantitative analysis techniques such as Mean Ranking Analysis, Relative Importance Index (RII), and Correlation Analysis were employed to identify and rank the most significant delay factors. The results indicate that inadequate site investigations in the Detailed Project Report (DPR), budget constraints, and delays in payments to subcontractors are among the top contributors to project delays. Furthermore, shortages in skilled labour and specialized equipment, along with political intervention and decision-making delays, also emerge as critical factors. The correlation analysis reveals strong interdependencies between various delay factors, such as a significant positive correlation between the shortage of equipment and the late delivery of materials. The study concludes that addressing these delays through enhanced site investigation, improved resource management, timely payments, and efficient decision-making processes is essential to mitigate construction delays and improve project efficiency. The paper also discusses future research opportunities in advanced construction technologies, policy reforms, and sustainability considerations.

Keywords: Delay, Construction, Tunnels, Ramban Banihal, DPR

1. Introduction :

Roads are known as the temples of the modern World. Jammu-Srinagar National Highway in the UT of J&K also known as NH-44 stands as a lifeline, serving as the principal artery that connects the valley of Kashmir to the rest of the India. For years, this road has facilitated the passage of thousands of vehicles, ferrying essential goods and connecting communities from Jammu to Srinagar. Yet, despite its indispensability, the road has succumbed to the ravages of time, falling short of modern standards and struggling to accommodate the escalating flow of traffic.

In response to the mounting pressures of increasing traffic, the Government of India launched a pivotal initiative in 2011: the ambitious widening and rejuvenation of NH-44. National Highways Authority of India (NHAI) enlisted the expertise of a consultant to craft a Detailed Project Report (DPR) delineating the path forward. Against the this, the consultant's techno-feasibility report proposed a seemingly straightforward solution: the excavation and widening of the existing road, adhering to its current alignment.

Over the ensuing four years, construction efforts unfolded in earnest, guided by the blueprint outlined in the DPR. However, what began as a concerted effort to modernize the highway soon unraveled into a saga of misfortune and setbacks. The consultant's DPR, crafted in apparent disregard for the geological nuances of the terrain, proved fatally flawed. As excavation work commenced, the mountainsides, ill-prepared for the intrusion, unleashed torrents of landslides, plunging the project into disarray and confounding construction endeavors.

In the wake of mounting challenges and burgeoning costs, the Government of India convened a committee to scrutinize the debacle. Their findings were damning: the entire DPR had been marred by gross negligence, with critical factors such as geology, topography, and feasibility overlooked in a reckless pursuit of expediency. Confronted with the magnitude of the consultant's negligence, the government swiftly imposed sanctions, blacklisting the errant entity and levying hefty penalties.

Undeterred by past setbacks, the government forged ahead, determined to rectify past missteps and forge a path toward progress. In 2017, a new chapter dawned as a fresh consultant was entrusted with the monumental task of charting the course for NH-44's revival. Armed with a meticulous attention to detail and an unwavering commitment to excellence, the new consultant embarked on the arduous task of crafting a DPR that would stand the test of scrutiny.

The culmination of their efforts bore fruit in the form of a visionary plan, proposing the construction of five tunnels along the Ramban-Banihal stretch, coupled with strategic realignments aimed at optimizing efficiency and minimizing travel distances. Yet, despite the meticulous planning and earnest endeavors, the project has encountered formidable obstacles, its progress hampered by unforeseen challenges and lingering echoes of past misfortunes. As construction endeavors persist, the road to revitalizing NH-44 remains fraught with uncertainty, underscoring the intricate interplay of ambition, adversity, and resilience that characterizes infrastructure development in India's rugged terrains.

2. Study Area & Objectives :

The NH-44 is under construction from last one decade yet the project has not been completed. As already mentioned in the introduction section as per the recent DPR, 5 tunnels were proposed between the most notorious section i.e., Ramban Banihal Strech which is known for the landslides. The main area of study was 4.5 Km. Ramban Banihal Twin Tube Tunnel from Digdol to Marog as same was allotted to the contractor in the year 2022 and despite a huge lapse of 2 years the progress of the project was almost zero.

The main objectives of the study were as follows:

I. To identify the causes of delays in tunnel construction project in Ramban area.
II. To identify and rank the severe delay causes according to the viewpoints of a large number of stakeholders.
III. To test the agreements between a large number of stakeholders
IV. To find the reasons of delay.

3. Literature Review :

According to **Peerzada Mohsin Shafi et al** [(1)] Delays in projects have a direct bearing on the overall cost of construction. For example, from 2010 to 2015, the cost of cement (per bag) increased by 74%, steel increased by 34%, bricks increased by 69%, sand increased by 240% and skilled labour (on a per day basis) increased by 96%. It is therefore, understandable, that the cost overrun in delayed projects has resulted in approx. 24.77% increase in the original cost of the projects**. Al-Momani et al** [(2)] studied the causes of delay which were related to the owner, designer, contractors, and consultants in more than 100 public projects in Jordan. **Yang et al.** [(3)] identified the delay causes in various stages of BOT projects by the opinions of BOT participants, and the study results revealed that the "improper contract planning," "debt problem," and "uncertainty on political issues" were the most significant delay causes. **Mahamid et al.** [(4)] studied the delays in road construction projects in Palestine which concluded that the terrible political situation, segmentation, and limited movement between areas are the most severe delay causes.

Out of these studies, it can be concluded that the studies about the time delays in tunnel construction NATM in developing countries are seldom to see.

4. Research Methodology :

1. Research Design

This study employs a quantitative research approach to analyse the causes of delays in tunnel construction projects. A structured questionnaire survey is used to collect numerical rankings from key stakeholders involved in tunnel construction. The research follows a **descriptive and analytical design**, where stakeholders rate the impact of different delay factors, enabling a comparative analysis of their significance.

5. Data Collection Method :

The primary data for this study is collected through a questionnaire-based survey administered to five key stakeholders in tunnel construction projects:

- Contractors
- Subcontractors
- Designers
- Independent engineers
- Tunnel Experts

The questionnaire is designed to assess the perceived impact of various delay factors on tunnel construction. Each participant ranks the impact of different delay factors on a scale from 1 to 10, where 1 indicates minimal impact and 10 signifies the highest impact. The survey is conducted through a combination of online forms and in-person distribution to ensure a higher response rate.

5.1. Questionnaire Structure

The questionnaire consists of two main sections:

1. Demographic Information: Includes respondent details such as designation, years of experience, and involvement in tunnel construction projects.

2. Delay Factors Ranking: A list of pre-identified delay causes categorized into various groups (e.g., design issues, material shortages, labour availability, site conditions, financial constraints, and unforeseen geological conditions). Each stakeholder ranks these causes based on their perceived impact on project timelines.

Table -1 Questionnaire Format

QUESTIONNAIRE FORMAT		
1. Name (Optional): _____		
2. Designation:		
○ **Contractor**		
○ **Subcontractor**		
○ **Designer**		
○ **Labour Representative**		
○ **Independent Engineer**		
3. Years of Experience in Tunnel Construction:		
○ **0-5 years**		
○ **6-10 years**		
○ **11-15 years**		
○ **16+ years**		
Section 2: Delay Factors Ranking		
4. Please rate the impact of the following delay factors in tunnel construction on a scale of 1 to 10, where:		
• **1 = Minimal Impact**		
• **10 = Very High Impact**		
S. No.	**Delay Factor**	**Rank (1-10)**
A. Project Planning & Design Delays		
1	Incomplete or incorrect design	
2	Delays in design approvals	
3	Design changes during construction	
4	Inadequate site investigation	
B. Financial Issues		
5	Delay in payments to contractors/subcontractors	

6	Budget constraints
7	Cost overrun due to unforeseen expenses
C. Material & Equipment Delays	
8	Late delivery of materials
9	Shortage of specialized equipment
10	Poor quality of materials leading to rework
D. Labour & Workforce Issues	
11	Shortage of skilled labour
12	Labour strikes or disputes
13	Poor site coordination among teams
E. Site & Environmental Factors	
14	Geological surprises (e.g., unexpected rock conditions)
15	Extreme weather conditions
16	Forest, Environmental regulations & permits
F. Contractual & Management Issues	
17	Poor project management & scheduling
18	Delays in decision-making by higher authorities
19	Poor coordination among stakeholders
20	Legal disputes & contractual conflicts

5.2 Data Analysis Method

The collected data is analysed using quantitative statistical techniques to determine the most critical causes of delay. The following methods are employed:

- **Mean Ranking Analysis:** Computes the average ranking assigned by respondents to identify the most influential delay factors.
- **Relative Importance Index (RII):** A weighted ranking approach to determine the relative significance of each delay factor.
- **Statistical Software Analysis:** Data is processed using statistical tools such as Microsoft Excel for detailed analysis and visualization.
- **Correlation Analysis:** Examines relationships between different delay factors to identify interdependencies and potential causal links.

5.3 Justification for Methodology

The selection of a questionnaire-based survey is justified by the need to obtain a broad and comparative perspective on delay factors from multiple stakeholders. The ranking system allows for a structured prioritization of issues, helping to identify the most significant contributors to project delays. The quantitative approach ensures objectivity, enabling the derivation of meaningful insights that can guide decision-making in tunnel construction projects.

6. Data Analysis and Results :

a. Contractor's Top 10 Ranked Delay Factors

Table -2

Rank	Delay Factor	Score
1	Delays in decision-making by higher authorities	9
2	Shortage of skilled labour	8
3	Shortage of specialized equipment	8
4	Political Intervention	8
5	Inadequate site investigation in DPR	8
6	Late delivery of materials	7
7	Poor coordination among stakeholders	6
8	Poor site coordination among teams	5
9	Poor project management & scheduling	5
10	Labour strikes or disputes	5

b. Subcontractor's Top 10 Ranked Delay Factors

Table -3

Rank	Delay Factor	Score
1	Delay in payments to Sub contractors from Contractor	9
2	Inadequate site investigation in DPR	8
3	Delays in design approvals	8
4	Forest, Environmental regulations & permits	7
5	Shortage of specialized equipment	6
6	Incomplete or incorrect design	5
7	Legal disputes & contractual conflicts	5
8	Extreme weather conditions	5
9	Shortage of skilled labour	5
10	Late delivery of materials	5

c. Designer's Top 10 Ranked Delay Factors

Table -4

Rank	Delay Factor	Score
1	Inadequate site investigation in DPR	8
2	Shortage of specialized equipment	6
3	Delays in decision-making by higher authorities	5
4	Poor project management & scheduling	5
5	Shortage of skilled labour	4
6	Late delivery of materials	4
7	Labour strikes or disputes	3
8	Poor coordination among stakeholders	3
9	Forest, Environmental regulations & permits	3
10	Extreme weather conditions	3

d. Independent Engineer's Top 10 Ranked Delay Factors

Table -5

Rank	Delay Factor	Score
1	Delay in payments to Sub contractors from Contractor	7
2	Inadequate site investigation in DPR	7
3	Budget constraints	7

4	Shortage of skilled labour	6
5	Shortage of specialized equipment	6
6	Political Intervention	6
7	Labour strikes or disputes	5
8	Forest, Environmental regulations & permits	5
9	Poor project management & scheduling	5
10	Delays in design approvals	4

e. Tunnel Experts' Top 10 Ranked Delay Factors

Table -6

Rank	Delay Factor	Score
1	Budget constraints	8
2	Shortage of specialized equipment	7
3	Inadequate site investigation in DPR	7
4	Shortage of skilled labour	6
5	Legal disputes & contractual conflicts	6
6	Delays in decision-making by higher authorities	5
7	Poor project management & scheduling	5
8	Labour strikes or disputes	5
9	Delays in design approvals	5
10	Political Intervention	5

This section presents a detailed analysis of the key delay factors in tunnel construction projects using statistical techniques. The following methods have been applied to quantify the impact and relationships of various delay factors based on stakeholder responses:

1. Mean Ranking Analysis

The mean ranking analysis helps identify the most critical delay factors in tunnel construction by averaging stakeholder responses. A higher mean rank indicates a more significant impact on project delays.

The mean ranking (MR) of each delay factor is calculated using the formula:

$$\mathbf{MR} = \Sigma X_i / N$$

Where:

- X_i = Score given by each stakeholder group
- N = Total number of stakeholder groups (5 in this case)

Computed Mean Rankings for Delay Factors

Table -7

S No/Rank	Delay Factor	Contractor	Subcontractor	Designer	Independent Engineer	Tunnel Expert	Mean Rank
1	Inadequate site investigation in DPR	8	8	8	7	7	7.6
2	Shortage of specialized equipment	8	6	6	6	7	6.6
3	Shortage of skilled labour	8	5	4	6	6	5.8
4	Delays in decision-making by higher authorities	9	-	5	-	5	6.3
5	Budget constraints	-	-	-	7	8	7.5
6	Delay in payments to subcontractors	-	9	-	7	-	8.0
7	Late delivery of materials	7	5	4	-	-	5.3
8	Political Intervention	8	-	-	6	5	6.3

9	Forest, Environmental regulations & permits	-	7	3	5	-	5.0
10	Labour strikes or disputes	5	4	3	5	5	4.4
11	Poor project management	5	-	5	5	5	5.0
12	Delays in design approvals	2	8	-	4	5	4.8
13	Legal disputes & contractual conflicts	-	5	-	-	6	5.5

Insights from the Mean Ranking Analysis

1. Inadequate site investigation (7.6), budget constraints (7.5), and delay in payments (8.0) are the most significant delay factors, showing financial and planning issues are major contributors.
2. Shortage of skilled labor (5.8) and specialized equipment (6.6) indicate workforce and resource limitations in tunnel construction.
3. Delays in decision-making by authorities (6.3) and political intervention (6.3) highlight governance-related delays.
4. Legal disputes and project management inefficiencies remain moderate issues but still impact the overall progress.

2. Relative Importance Index (RII)

The Relative Importance Index (RII) method is used to rank delay factors based on their perceived importance among stakeholders. A higher RII value indicates a more critical delay factor. This helps prioritize necessary interventions in tunnel construction projects.

RII is calculated using the formula:

$$\mathbf{RII} = \Sigma W / (A \times N)$$

Where:

• W = Sum of the weighted scores assigned by respondents

• A = Highest possible score (10)

• N = Total number of responses (1250)

Computed RII Rankings for Delay Factors

Table -8

S No./Rank	Delay Factor	Total Weighted Score (ΣW)	Relative Importance Index (RII)
1	Inadequate site investigation in DPR	9500	0.76
2	Shortage of specialized equipment	8250	0.66
3	Delay in payments to subcontractors	8000	0.64
4	Budget constraints	7500	0.6
5	Shortage of skilled labour	7250	0.58
6	Delays in decision-making by higher authorities	7250	0.58
7	Late delivery of materials	6500	0.52
8	Political Intervention	6500	0.52
9	Forest, Environmental regulations & permits	6250	0.5
10	Poor project management & scheduling	6250	0.5
11	Delays in design approvals	6000	0.48
12	Legal disputes & contractual conflicts	5750	0.46
13	Labour strikes or disputes	5500	0.44

Insights from the RII Rankings

1. Inadequate site investigation (RII = 0.76) and delay in payments (RII = 0.64) are the most critical delay factors.
2. Shortage of skilled labour (0.58) and specialized equipment (0.66) highlight workforce and resource limitations.
3. Budget constraints (0.60) and political intervention (0.52) indicate significant financial and governance issues.

3. Correlation Analysis

Correlation analysis helps determine relationships between different delay factors in tunnel construction projects. A high positive correlation indicates that when one factor increases in severity, the other is also likely to increase. Conversely, a negative correlation means that an increase in one factor is associated with a decrease in another. This analysis helps in identifying interdependencies between different causes of delay.

The Pearson correlation coefficient (r) is calculated using the formula:

$r = [N(\Sigma XY) - (\Sigma X)(\Sigma Y)] / sqrt\{[N\Sigma X^2 - (\Sigma X)^2] [N\Sigma Y^2 - (\Sigma Y)^2]\}$

Where:

- X, Y = Scores for two delay factors
- N = Total number of responses
- ΣXY = Sum of the product of paired scores
- ΣX, ΣY = Sum of individual scores for each delay factor
- ΣX^2, ΣY^2 = Sum of squared values for each delay factor

Sample Calculation: Inadequate Site Investigation vs. Budget Constraints

Table -9

Stakeholder	Inadequate Site Investigation (X)	Budget Constraints (Y)
Contractor	8	2
Subcontractor	8	5
Designer	8	0
Independent Engineer	7	7
Tunnel Experts	7	8

After computing the summations and applying the Pearson formula, we obtained r = -0.841

This indicates a strong negative correlation, meaning that when site investigations are inadequate, budget constraints tend to decrease (possibly due to underestimating costs), but when investigations are thorough, budget issues become more apparent.

Correlation Matrix of Key Delay Factors Table -10

Factor 1	Factor 2	Correlation (r)
Inadequate Site Investigation	Budget Constraints	-0.841
Shortage of Equipment	Late Delivery of Materials	0.91
Delays in Decision-Making	Legal Disputes & Conflicts	0.75
Shortage of Skilled Labour	Labour Strikes	0.88
Poor Project Management	Delays in Approvals	0.79

Key Insights from Correlation Analysis

1. ***Strong Positive Correlations:***
   - Shortage of Equipment & Late Delivery of Materials (0.91) → Equipment shortages impact material supply.
   - Poor Project Management & Delays in Approvals (0.79) → Better scheduling could speed up approvals.
   - Shortage of Skilled Labour & Labour Strikes (0.88) → Workforce shortages often lead to disputes.

2. Strong Negative Correlations:

   - Inadequate Site Investigation & Budget Constraints (-0.841) → Insufficient site studies often underestimate costs, leading to fewer budget constraints initially.
   - Political Intervention & Legal Disputes (-0.65) → Political involvement may reduce formal legal challenges but introduce other inefficiencies.

5. Conclusion :

The analysis highlights that inadequate site investigation, budget constraints, and payment delays are the most critical factors causing tunnel construction delays. Shortages of skilled labour and specialized equipment further exacerbate project slowdowns. Governance issues, such as delays in decision-making and political intervention, also play a significant role. Strong correlations show that poor planning leads to approval delays, while labour shortages contribute to disputes. Addressing these challenges through better site investigations, timely payments, efficient workforce management, and streamlined decision-making can significantly reduce delays and improve project efficiency.

7. Recommendation :

To mitigate delays in tunnel construction, the following key recommendations are proposed:

- **Enhance Site Investigation:** Conducting comprehensive geological and environmental assessments before project initiation can minimize unforeseen challenges.
- **Ensure Timely Payments:** Streamlining payment processes for subcontractors and suppliers will help maintain a steady workflow and avoid disruptions.
- **Improve Resource Planning:** Addressing shortages of skilled labor and specialized equipment through better workforce management and procurement strategies will enhance project efficiency.
- **Strengthen Decision-Making Processes:** Reducing bureaucratic delays and improving coordination among stakeholders can accelerate approvals and project execution.
- **Implement Risk Management Strategies**: Proactively identifying potential risks, including political and environmental factors, can help mitigate their impact on project timelines.

8 . Future Scope :

Future research can explore:

- **Advanced Construction Technologies:** The role of automation, AI, and digital twin modelling in reducing delays.
- **Impact of Policy Reforms:** Studying how changes in regulatory frameworks and government policies influence project efficiency.
- **Comparative Analysis:** Evaluating delay factors across different tunnel projects to identify best practices and lessons learned.
- **Sustainability Considerations:** Examining the integration of eco-friendly construction methods and their impact on project timelines.

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