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A Study of the Relationship between Road Maintenance and Commuter Safety in Thane District

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Abstract

Road maintenance and infrastructure development play a critical role in ensuring commuter safety, particularly in rapidly urbanizing regions. Thane District, characterized by increasing population density, rising vehicular movement, and large-scale infrastructure projects such as metro construction and real estate development, faces persistent challenges related to road quality and commuter safety. While infrastructure development is essential for long-term urban growth, its short-term disruptive effects such as frequent road digging, delayed restoration,
and uneven road surfaces can adversely affect road usability and increase safety risks for daily commuters. The present study examines the relationship between road maintenance quality and commuter safety, with infrastructure development acting as a mediating variable. Adopting a descriptive and analytical research design, the study is based on primary data collected from 150 commuters in Thane District using a structured questionnaire and a five-point Likert scale. Demographic variables such as gender, age, and primary mode of transportation are also considered to capture mode-wise and group-wise differences in perception. Data analysis employs descriptive statistics, Pearson correlation, and comparative techniques to assess relationships among the variables. The findings reveal significant variation in perceived road maintenance quality across modes of transport and indicate a strong negative relationship between infrastructure development activities and commuter safety. Ongoing construction projects and poor inter-agency coordination were found to deteriorate road conditions and reduce commuters' sense of safety, especially among two-wheeler and public transport users. The study highlights the need for integrated planning, timely road restoration, and safety-focused infrastructure management to balance development goals with commuter well-being

Introduction:

Background

Rapid urbanization and economic growth have led to a significant expansion of transport infrastructure in metropolitan regions across India. In districts such as Thane, increasing population density, rising vehicle ownership, and large-scale infrastructure projects including metro rail construction, road widening, and real estate development have intensified pressure on existing road networks. While road maintenance plays a crucial role in ensuring smooth traffic

flow and reducing accident risks, frequent excavation, delayed repairs, and poor coordination among multiple agencies often deteriorate road quality. These conditions disproportionately affect daily commuters, particularly vulnerable road users such as two-wheeler riders and public transport users, who are more exposed to unsafe road conditions.

At the same time, infrastructure development is essential for long-term urban mobility and economic sustainability; however, its short-term disruptive effects on road usability and safety cannot be overlooked. Ongoing construction activities can lead to uneven road surfaces, inadequate signage, traffic congestion, and reduced visibility, thereby increasing the likelihood of accidents and lowering commuters' perceived safety. Despite the importance of this issue, limited empirical research has examined the combined influence of road maintenance and infrastructure development on commuter safety at a district level. Therefore, this study focuses on Thane District to analyze how road maintenance quality and infrastructure development activities interact and influence commuter safety, providing insights that can inform more balanced and safety-oriented urban transport planning.

Research Gap

Despite extensive international research establishing links between pavement condition, work zones, and road safety, a clear research gap exists in understanding how ongoing infrastructure development activities such as metro construction and real estate expansion mediate the relationship between road maintenance quality and commuter safety, particularly in rapidly urbanizing Indian cities. Most existing studies rely on secondary accident data or focus on isolated factors like skid resistance or crash severity, with limited attention to commuter perceptions, mode-wise differences (two-wheelers, public transport, private cars), and the short-term disruptive effects of infrastructure projects on road usability and safety. Moreover, there is a lack of district-level empirical evidence from regions like Thane District, where simultaneous road maintenance and large-scale development coexist. This gap highlights the need for a perception-based, mediation-focused study that integrates road maintenance quality, infrastructure development disruptions, and commuter safety within a single analytical framework.

Objectives of the Study

Objective-1: To Study the quality of road according to category of commuters in thane district.

Objective-2: To study the impact of Infrastructure Development on commuters safety.

Scope of the Study:

The present study focuses on examining the relationship between road maintenance quality, infrastructure development activities, and commuter safety within Thane District. The scope is limited to daily commuters using different modes of transportation, including two-wheelers, four-wheelers, and public transport such as buses and auto-rickshaws. The study assesses commuters' perceptions of road maintenance practices, the disruptive effects of infrastructure development projects like metro construction and real estate expansion, and their implications for road safety. By adopting a cross-sectional approach and using primary data collected through structured questionnaires, the study provides a snapshot of prevailing conditions during the period of investigation.

Further, the study emphasizes perception-based safety assessment rather than relying solely on secondary accident statistics. It incorporates demographic variables such as age, gender, and primary mode of transportation to analyze variations in safety perception among different commuter groups. The geographical scope is confined to Thane District, and hence the findings may not be generalized to other regions without contextual consideration. Nevertheless, the analytical framework and methodology used in this study can serve as a reference for similar urban infrastructure and safety studies in other metropolitan areas.

Importance of the Study

The study is significant as it highlights the critical link between road maintenance practices and commuter safety in a rapidly urbanizing district. By identifying how infrastructure development activities can negatively impact road quality and safety in the short term, the research draws attention to an often-overlooked aspect of urban development. The findings provide valuable insights for urban planners, municipal authorities, and transport agencies to improve coordination among departments, ensure timely road restoration, and integrate safety considerations into infrastructure planning.

Moreover, the study contributes to academic literature by empirically examining infrastructure development as a mediating factor between road maintenance and commuter safety. It provides evidence-based inputs that can support policy formulation aimed at reducing accident risks and improving commuter

confidence. The outcomes of this research can assist policymakers in designing more sustainable and commuter-centric transport systems, while also serving as a foundation for future studies on infrastructure management and road safety in urban India.

Review of Literature

1. Li, Carriquiry & Pawlovich (2013), In the research paper titled "Impact of pavement conditions on crash severity". This study shows that pavement condition is not just a comfort issue it is strongly linked with how severe crashes become. The authors report that poor and very poor pavement conditions tend to coincide with more severe crashes, suggesting that road maintenance (surface repair, distress reduction, better pavement quality) can contribute to safety outcomes by lowering the probability that a crash escalates into serious injury or fatality.

2. Mkwata et al. (2022), In the research paper titled "Effect of pavement surface conditions on road traffic accident". This work synthesizes evidence that surface defects (e.g., roughness, potholes, uneven texture, reduced friction) raise accident risk by reducing vehicle control and increasing stopping distance, especially in adverse conditions. The review emphasizes that systematic monitoring and timely maintenance of surface condition are essential to reduce crash likelihood, particularly for vulnerable road users such as two-wheeler riders.

3. Vinayakamurthy & Mamlouk (2017), In the research paper titled "Effect of Pavement Condition on Accident Rate". The paper highlights a measurable association between pavement quality and accident rate, noting that maintaining better pavements can reduce accidents (even if pavement is not the only factor). It also reinforces that road roughness is linked with higher crash rates, implying that maintenance programs targeting roughness and distress can deliver safety benefits alongside mobility improvements.

4. Ding et al. (2021), In the research paper titled "Study on the influence of skid resistance on traffic safety considering alignment and weather conditions" This study finds that skid resistance (the friction a road provides) is related to crash occurrence, particularly when combined with factors like alignment and weather. The implication for road maintenance is direct: maintaining adequate friction through surface treatment, drainage management, and timely resurfacing supports safer braking and cornering, thereby reducing accident occurrence.

5. McCarthy et al. (2021), In the research paper titled "Impact of skid resistance on dry and wet weather crashes". This work links pavement friction/skid resistance with crash risk, emphasizing that low skid resistance can be particularly problematic in wet conditions. It supports maintenance policies that prioritize friction testing and surface interventions (micro-surfacing, resurfacing, texture restoration) as part of a road safety strategy, not merely an asset management activity.

6. Nnaji (2020), In the research paper titled "Improving construction work zone safety using technology". The study reviews how work zones introduce unique safety risks and how technology (warning systems, sensing, connected devices, monitoring) can reduce crashes and injuries. For infrastructure development contexts (metro work, major construction), the key message is that safety improves when work zones are actively managed through better traffic control, visibility measures, enforcement support, and real-time communication with commuters.

7. Wang et al. (2023), In the research paper titled "Evaluation of Work Zone Schemes for Monorail Construction". This paper underlines that work zone design and management significantly influence traffic performance and safety around construction sites. It shows that structured evaluation of work-zone schemes (lane management, diversions, signage placement, operational planning) is necessary to reduce disruption and safety hazards; this is directly relevant to metro/large infrastructure projects that often degrade road quality and raise commuter risk.

8. Bock et al. (2021), In the research paper titled "Pavement Damage Reduces Traffic Safety and Speed". This paper emphasizes that pavement damage is not only an infrastructure quality concern but can produce measurable impacts on traffic outcomes. It supports the broader argument that deteriorated pavement can impose safety and efficiency costs on road users, strengthening the case for proactive maintenance and better coordination during repairs and lane closures to reduce adverse safety spillovers.

Research Methodology

Research Design and Approach

The study adopts a descriptive and analytical research design with a cross-sectional approach to examine the relationship between road maintenance quality, infrastructure development, and commuter safety in Thane District. This design is appropriate as it allows the researcher to systematically describe existing road conditions and commuter safety perceptions while also analyzing the

interrelationships among key variables. An empirical approach is used to capture real-world commuter experiences, making the study suitable for assessing infrastructure-related issues in an urban context.

Data Collection Methods

The research primarily employs a quantitative method using structured questionnaires to collect primary data from commuters, including two-wheeler users, four-wheeler users, and public transport users. The questionnaire is based on a 5-point Likert scale to measure perceptions of road maintenance quality, infrastructure development impacts, and commuter safety. In addition, limited qualitative inputs in the form of informal discussions and open-ended responses are used to gain contextual understanding of specific issues such as metro construction disruptions and road restoration delays. Secondary data are collected from government reports, transport authority publications, and previous research studies to support and contextualize the primary findings.

Analytical Tools and Techniques Used

The collected data are analyzed using descriptive statistics (frequency, percentage, mean, and standard deviation) to summarize demographic characteristics and key variables. Inferential statistical techniques such as Pearson correlation analysis are applied to examine relationships between infrastructure development and commuter safety, while ANOVA is used to compare perceptions across different modes of transportation. Where applicable, regression and mediation analysis are employed to assess the influence of infrastructure development on the road maintenance–commuter safety relationship. Statistical analysis is carried out using tools such as SPSS, ensuring reliability, validity, and robustness of the results.

Data Analysis

The following table indicates the demographic factor of the study:

Table 1: Demographic Factor

Sr.no	Demographic Factor	Category	Frequency	Percent
1	Gender	Male	92	61.3
		Female	58	38.7
2	Age Group	Below 25 years	40	26.7
		26–35 years	69	46.0
		36–45 years	29	19.3
		Above 45 years	12	8.0
3	Primary Mode of Transportation	Two-Wheeler	53	35.3
		Four-Wheeler	39	26.0
		Public Transport (Bus/Auto)	58	38.7

The demographic profile of the respondents indicates a balanced yet diverse representation of commuters in Thane District. In terms of gender, a majority of respondents are male (92), while female respondents account for 58, suggesting relatively higher male participation in daily commuting activities. Regarding age distribution, the largest group falls in the 26–35 years category (69 respondents), followed by those below 25 years (40), indicating a predominantly young and economically active commuter population. Respondents aged 36–45 years (29) and above 45 years (12) form a smaller proportion, reflecting comparatively lower participation from older age groups. With respect to the primary mode of transportation, public transport users (Bus/Auto) constitute the largest group (58 respondents), followed closely by two-wheeler users (53), highlighting heavy reliance on shared and two-wheel mobility. Four-wheeler users (39) form the smallest segment, suggesting limited private car usage among the sample. Overall, the demographic distribution reflects realistic urban commuting patterns and provides a strong foundation for analyzing variations in road maintenance perception and commuter safety across different population segments.

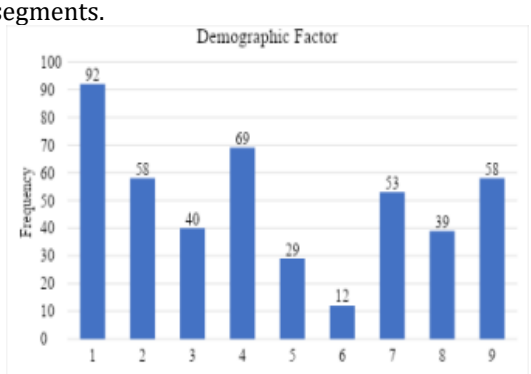

Figure 1: Demographic Factors

Objective-1: To Study the quality of road according to category of commuters in thane district.

Null Hypothesis H_{01}: There is no significant difference in quality of road according to category of commuters in thane district.

Alternate Hypothesis H_{11}: There is a significant difference in quality of road according to category of commuters in thane district.

To test the above null hypothesis, ANOVA and F-test is applied and results are as follows:

Table 2: ANOVA for quality of road according to category of commuters in thane district

ANOVA					
Road Maintenance Quality					
	Sum of Squares	df	Mean Square	F	P-value
Between Groups	4436.002	2	2218.001	18.524	.000
Within Groups	17601.332	147	119.737		
Total	22037.333	149			

Interpretation: The above results indicate that calculated p-value is 0.000. It is less than 0.05. Therefore ANOVA and F-test is rejected. Hence Null hypothesis is rejected and Alternate hypothesis is accepted.

Conclusion: There is a significant difference in quality of road according to category of commuters in thane district.

Findings: To understand the findings, mean scores are obtained and presented as follows:

Table 3: Report for quality of road according to category of commuters in thane district

Report			
Road Maintenance Quality			
Primary Mode of Transportation	Mean	N	Std. Deviation
Two-Wheeler	47.85	53	11.176
Four-Wheeler	52.41	39	9.572
Public Transport (Bus/Auto)	60.34	58	11.566
Total	53.87	150	12.161

The mean scores indicate a clear variation in Road Maintenance Quality perceptions across different primary modes of transportation. Public transport users (Bus/Auto) report the highest mean score (60.34), suggesting that they perceive road maintenance conditions to be relatively better, possibly because they frequently travel on main arterial roads and bus corridors that receive priority maintenance. Four-wheeler users show a moderate mean score (52.41), reflecting an average level of satisfaction with road conditions, as car users are more sensitive to surface quality and minor defects. In contrast, two-wheeler users record the lowest mean score (47.85), indicating lower satisfaction with road maintenance, likely due to their higher vulnerability to potholes, uneven surfaces, and poor drainage. Overall, the findings suggest that perceptions of road maintenance quality differ significantly by mode of transport, with more exposed road users expressing greater dissatisfaction.

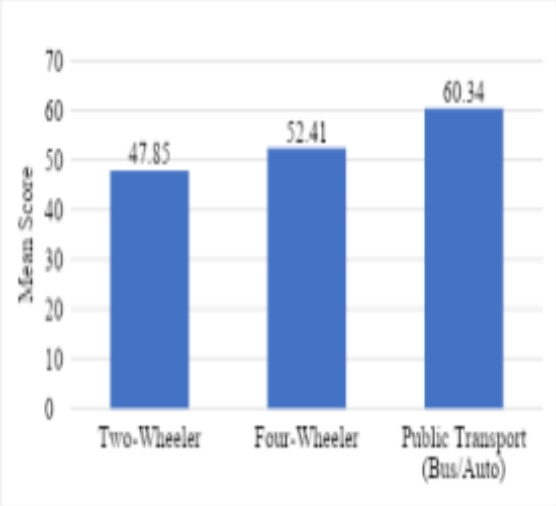

Figure 2: Quality of road according to category of commuters in thane district 9

Objective-2: To study the impact of Infrastructure Development on commuters safety.

Null Hypothesis H_{02}: There is no impact of Infrastructure Development on commuters safety.

Alternate Hypothesis H_{12}: There is an impact of Infrastructure Development on commuters safety.

To test the above null hypothesis, Pearson Correlation test is applied and results are as follows:

Table 4: Correlation of Infrastructure Development on commuters safety

Correlations			
		InfrastructureDevelopment	Commuter Safety
Infrastructure Development	Pearson Correlation	1	-.788**
	P-value		.000
	N	150	150
Commuter Safety	Pearson Correlation	-.788**	1
	P-value	.000	
	N	150	150
**. Correlation is significant at the 0.01 level (2-tailed).			

Interpretation: The above results indicate that calculated p-value is 0.000. It is less than 0.05. Therefore Pearson Correlation test is rejected. Hence Null hypothesis is rejected and Alternate hypothesis is accepted.

Conclusion: There is an impact of Infrastructure Development on commuters safety.

Findings: The Pearson correlation analysis reveals a strong negative relationship between Infrastructure Development and Commuter Safety ($r = -0.788$, $p = 0.000$, $N = 150$). This indicates that higher levels of infrastructure development activities such as ongoing metro construction, real estate projects, and frequent road digging are associated with lower levels of perceived commuter safety. The statistically significant p-value ($p < 0.01$) confirms that this relationship is not due to chance. The negative correlation suggests that while infrastructure development is essential for long-term urban growth, its short-term disruptive effects can adversely impact road conditions and increase safety risks for commuters. This highlights the need for better planning, coordination, and timely restoration of roads during infrastructure development to minimize safety concerns for daily road users.

Conclusion and Recommendations

Summary of key findings: The study finds a clear relationship between road maintenance, infrastructure development, and commuter safety in Thane District. Perceptions of road maintenance quality vary significantly across modes of transport, with two-wheeler users expressing the lowest satisfaction and public transport users reporting comparatively higher scores. Infrastructure development activities such as metro construction and real estate projects show a strong and statistically significant negative correlation with commuter safety, indicating that ongoing development work adversely affects road conditions and increases safety risks in the short term. Overall, the findings highlight that while infrastructure development is essential, inadequate coordination and delayed road restoration undermine commuter safety.

Implications for theory: From a theoretical perspective, the study supports infrastructure–safety linkage models by demonstrating the mediating and disruptive role of infrastructure development in the road maintenance–safety relationship. Practically, the findings emphasize the need for better coordination among civic bodies, contractors, and utility agencies to ensure timely road repairs and minimize commuter inconvenience. From a policy standpoint, urban authorities should enforce stricter guidelines for post-construction road restoration, adopt integrated infrastructure planning, and prioritize safety audits during large-scale development projects to balance long-term growth with short-term commuter safety.

Suggestions for future research: Future studies may extend this research by incorporating objective indicators such as accident records, traffic flow data, and road condition indices alongside perceptual measures. Comparative studies across different districts or metropolitan regions could provide broader generalizability of findings. Further research may also examine additional mediating or moderating variables such as traffic management efficiency, enforcement of road safety regulations, and technological interventions (smart traffic systems) to develop a more comprehensive understanding of infrastructure development and commuter safety dynamics.

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