Evaluation and Maintenance Priority for the Low Volume Flexible Pavements

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Abstract **The maintenance of roads is critical for ensuring safe and efficient transportation. In particular, low volume roads, which have lower traffic volumes than highways and major roads, are often neglected in terms of maintenance. However, even though they may not experience heavy traffic, low volume roads are still susceptible to failures and defects that can compromise their integrity and safety. In the Nagpur region, there are many low volume roads that are in need of maintenance. In order to ensure that these roads are properly maintained, it is important to study the failures and defects that are present on them, as well as their possible causes. By identifying the root causes of these issues, it is possible to develop effective maintenance strategies that prioritize repairs based on severity and current condition. Some common causes of failures and defects on low volume roads include poor drainage, inadequate road construction, and heavy vehicle traffic. These issues can result in cracks, potholes, and other damage that can cause safety hazards. By conducting regular inspections of these roads, it is possible to identify these issues early and prioritize repairs based on their severity and potential impact on road safety. To ensure the safety and maintenance of low volume roads like Godhnai Road in Nagpur, our thesis focuses on identifying and addressing failures and defects. By conducting a thorough study of the root causes of these issues and suggesting effective maintenance strategies, we can prioritize repairs based on severity and current condition.**

Keywords—Flexible Pavements, Distress, Maintenance, Cracks, Rutting, Reveling, failures, inspection, evaluation.

I. INTRODUCTION

Low volume flexible pavements are commonly used in rural areas of Nagpur, where traffic volumes and loads are low. Proper maintenance of these pavements is crucial to ensure their durability and safety. Inadequate maintenance can lead to failures and defects that significantly impact performance and safety. Therefore, the objective of this thesis is to study the failures, defects, and their causes on low volume flexible pavements in rural areas near Nagpur. By conducting regular inspections, early identification of issues such as inadequate drainage, poor construction quality, and heavy vehicle traffic is possible, enabling the development of effective maintenance strategies. The thesis will provide a comprehensive analysis of each issue's severity and impact, prioritizing repairs based on urgency and potential impact on pavement performance and safety. This research is significant as it contributes to the existing knowledge in pavement maintenance and offers practical implications for pavement management and policy.

Road maintenance is crucial for safe and efficient transportation, and low volume roads often receive less attention in terms of maintenance. However, even with lower traffic volumes, these roads are susceptible to failures and defects that compromise safety. In Nagpur, many low volume roads require maintenance. To address this, it is important to study the failures, defects, and their causes on these roads. By identifying root causes, effective maintenance strategies can be developed, prioritizing repairs based on severity and current condition. Common causes of failures and defects on low volume roads include poor drainage, inadequate construction, and heavy vehicle traffic. Regular inspections can identify these issues early and prioritize repairs to enhance road safety. Strategies such as pothole filling, crack repairs, and resurfacing can be employed by road maintenance crews. Prioritizing repairs based on severity and present condition reduces accidents and improves road safety. This study is critical for ensuring proper maintenance and safety on low volume roads near Nagpur by

addressing root causes, developing effective strategies, and prioritizing repairs based on severity and current condition.

II. METHODOLOGY

A. FIELD SURVEY AND DATA COLLECTION

For our research, we have chosen Godhani Road in the Nagpur district of Maharashtra, India. This road spans 5 km, and we have selected a 1 km stretch that is frequently used by local residents. To ensure a detailed analysis, this 1 km stretch has been divided into two equal sections of 500m each. This division allows for a comprehensive evaluation of the pavement condition, enabling us to accurately identify and prioritize maintenance requirements for each section. By subdividing the road into smaller sections labeled A to E, we can systematically categorize different types of defects, such as cracking and potholes, and gather precise data on their nature and severity. This data will form the basis for a maintenance prioritization plan based on defect severity. In addition to defect measurements, we have collected subgrade soil samples from sections prone to failures. These samples will undergo laboratory investigations to determine the possible causes of pavement failures, considering the significant impact of subgrade soil properties on pavement performance. Furthermore, a seven-day traffic volume study will be conducted on both road patches to gather data on the percentage of daily flow of commercial vehicles, further enriching our analysis.

B. LABORATORY INVESTIGATION

As part of the laboratory investigation, soil subgrade samples will be collected from the sections of the road that are highly prone to defects. These samples will be excavated by digging pits of two-meter depth in the road, and disturbed soil samples will be collected from 1 to 2 meters depth to represent the subgrade soil. The collected samples will undergo a battery of tests including sieve analysis, Atterberg limits and California Bearing Ratio (CBR) tests. These tests will provide critical data on the soil properties and help in classifying the soil, which will be useful in identifying the possible causes of pavement failures and developing maintenance strategies.

III. FIELD SURVEY

Godhani road, a vital transportation route between Nagpur and Godhani that is frequently used by local residents, has been selected for analysis due to its poor condition caused by heavy traffic and weather. Godhani road, Godhani Road is a 5 km long road located in the Nagpur district of the state of Maharashtra in India. It connects Nagpur city to the industrial town of Godhani and passes through several densely populated areas, commercial establishments, and residential colonies. The road is a low volume flexible pavement that was constructed several years ago and has been subjected to heavy traffic and weather conditions, resulting in various defects and failures. The road is vital for the transportation of goods and people between Nagpur and Godhani, and its poor condition has caused inconvenience and safety hazards for road users.

Figure 1: Godhani Road Patch 1

Figure 2: Patch 1 Satellite Image

During our visit to the first 500m road patch, our team conducted a comprehensive visual inspection of the pavement, diligently documenting all observed defects. To ensure accuracy, we divided this section into five equal parts of 100m each, labeled as A, B, C, D, and E. For each section, we meticulously recorded

the different types of pavement failures encountered, noting precise measurements such as length, width, and depth.

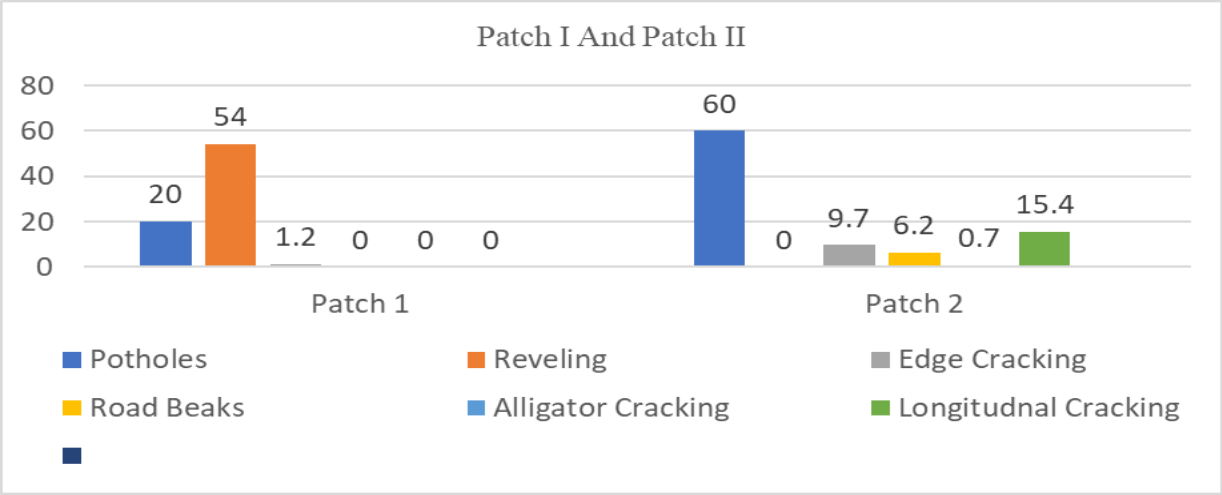
To assess the severity of each identified defect, our team adhered to established guidelines in the pavement engineering industry. These guidelines take into account various factors, including the size, depth, extent of the failure, and level of distress. By applying this systematic approach, we are able to categorize each failure according to its severity level. This classification will facilitate the prioritization of maintenance actions, ensuring the road's safety and usability.

Figure 3: Godhani Road Patch 2

Figure 4: Patch 2 Satellite Image

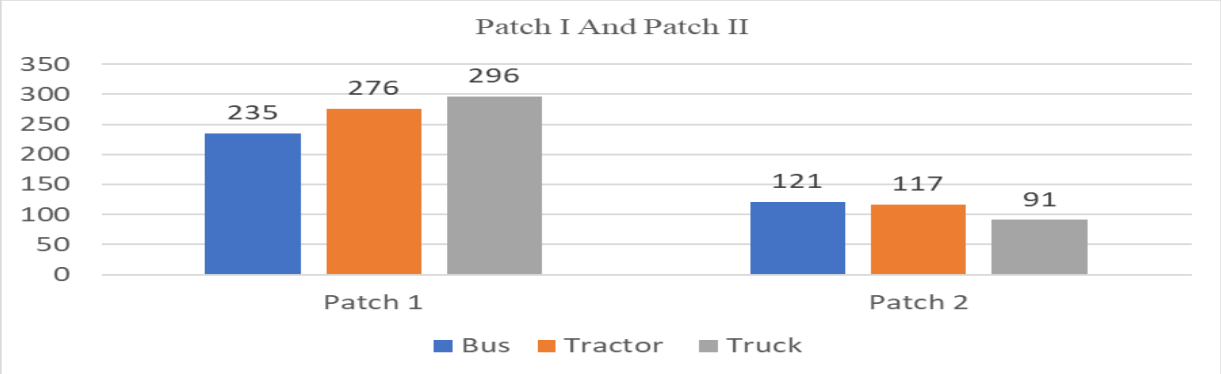
The distress quantity and coverage area were assessed to determine the extent of damage. By comparing this area to the total damaged area of the pavement sections, the distress percentage can be calculated.

Below graph illustrates the distribution of measured distresses as a percentage of the overall failed pavement area.



Graph 1: Distresses Percentage in Godhani road

In addition to the laboratory investigation, a traffic volume study was conducted over a period of seven days on both road patches from 9:00 am till 5:00 pm. This study provided us the data on the percentage of daily flow of commercial vehicles (vehicle load > 3 tones) on the road. Through the traffic volume study, we found out that the peak flow of traffic on the road or, to put it into other words, the number of vehicles traveling or using the road was at its maximum during 10:00 am to 11:30 am and 2:30 pm to 3:30 pm. This information will be useful in developing maintenance strategies that take into account the peak traffic hours on the road.



Graph 2: Traffic Volume in Godhani road

IV.EXPERIMENTAL WORK

A series of tests were conducted on three samples, including sieve analysis to determine the particle size distribution, Atterberg limits tests to evaluate the soil's plasticity, and California Bearing Ratio (CBR) tests to assess its load-bearing capacity.

The test results, which are presented in the provided table, offer valuable insights into the characteristics and behavior of the subgrade soil. These findings play a crucial role in understanding the underlying causes of distress in the road sections and aid in developing appropriate remedial measures and maintenance strategies.

Tests	**Soil from location 1**		**Soil from location 2**		**Soil from location 3**	
Liquid Limit Test	33.99%		27.80%		30.78%	
Plastic Limit Test	9.63%		9.51%		9.80%	
Plasticity Index	24.36%		18.26%		20.98%	
Shrinkage Limit	24.22%		25.26%		28.55%	
CBR	10.70%		11.92%		9.73%	
Sieve Analysis	Cu=20.12	Cc=0.77	Cu=16.47	Cc=1.54	Cu=19.88	Cc=1.07

Table1: Experimental Results

The soil samples' plasticity index (PI) values (24.36%, 18.26%, and 20.98%) indicate varying degrees of fine-grained and cohesive particles. A higher PI suggests a higher clay content and greater soil plasticity. In the context of subgrade soil in flexible pavement, a high PI can result in poor drainage, swelling and shrinkage, poor strength, and surface cracking.

The shrinkage limit values of the three soil samples (24.22%, 25.26%, and 28.55%) indicate the soil's moisture loss upon drying. Higher values suggest significant volume reduction and cracking. In flexible pavement subgrade soil, these higher shrinkage limit values can lead to dry shrinkage, causing cracks and uneven surfaces, moisture sensitivity with heaving and swelling, and surface cracking due to drying shrinkage and tensile stresses on pavement layers.

The CBR values for the soil subgrade samples are 10.70%, 11.92%, and 9.73%. These values indicate the soil's relative strength and bearing capacity. A CBR value of 10.70% and 11.92% suggests low strength, although it can bear some load. However, these values are relatively low for subgrade soils in pavement construction, indicating the need for additional measures. A CBR value of 9.73% suggests even lower strength and limited load-bearing capacity, requiring significant improvements. In the context of flexible pavement, lower CBR values can result in increased pavement deformation, leading to rutting and uneven surfaces.

From the sieve analysis, the values Cu = 20.12 and Cc = 0.77 provide important information about the grading and uniformity of the soil sample. Cu, or the coefficient of uniformity, is a measure of the range of particle sizes in the soil sample. A higher Cu value indicates a wider range of particle sizes, suggesting a poorly graded soil with a significant variation in

particle sizes. Cu value of 20.12 indicates that the soil sample has a wide range of particle sizes.

Cc, or the coefficient of curvature, provides information about the shape of the particle size distribution curve. A Cc value of 0.77 indicates a moderately well-graded soil, where the particle size distribution curve is neither too steep nor too flat.

In summary, the values Cu = 20.12 and Cc = 0.77 suggest that the soil sample is poorly graded, indicating a wide range of particle sizes, but moderately well-graded, indicating a reasonably balanced distribution of particle sizes.

Similarly, Cu = 16.47 and Cc = 1.54 suggests that the soil sample has a wide range of particle sizes with a well-balanced distribution. Cu = 19.88 and Cc = 1.07 suggests that the soil sample has a relatively wide range of particle sizes with a moderately well-balanced distribution.

V.CAUSES FOR THE FAILURES ON GODHNAI ROAD

- Drainage Problem: Improper drainage can cause pavement defects like potholes, cracking, and rutting. Signs of drainage issues include standing water, water flow across the pavement, soft pavement, erosion near edges, and vegetation in cracks.
- Soil Characteristics: Poor drainage or high-water content in surrounding soil can destabilize the pavement.
- Agricultural Land: Adjacent agricultural activities can lead to soil erosion, sediment deposition, and drainage problems, causing defects like rutting and cracking.
- Slope and Gradient: Improper slope and gradient can result in inadequate drainage, differential settlement, erosion, and pavement failures.
- Vegetation: Overgrown vegetation can hinder drainage and obstruct visibility, posing risks.
- Adjacent Structures: Nearby structures can impact drainage and cause differential settlements, leading to cracks and potholes.
- Heavy Traffic: Heavy vehicles can damage the pavement surface, causing cracks and potholes.

VI. MAINTENANCE PRIORITY

Based on the field survey and lab testing, Patch 1 on Godhani road requires immediate maintenance due to the following reasons:

- Higher Traffic Volume: Patch 1 has heavier traffic flow compared to Patch 2, making it essential for smooth transportation and the convenience of local residents.
- Severe Distress: Patch 1 exhibits more severe distress conditions than Patch 2, posing a greater risk to road users and requiring immediate attention to prevent further deterioration.
- Construction Activity: Recent construction near Patch 1 has increased the movement of heavy-loaded vehicles, leading to deformation. Prompt repairs are necessary to withstand the additional stress.
- Drainage Issues: Inadequate drainage, caused by nearby residential properties and their boundary walls, results in water accumulation and potential damage during the rainy season. Addressing the drainage problem is crucial to prevent pavement failures.
- Poor Soil Subgrade: Soil tests reveal high plasticity and poor grading in the subgrade of Patch 1, making it susceptible to volume changes and reduced stability. Reinforcing or improving the subgrade is necessary for overall pavement stability.
- Surrounding Conditions: Agricultural land alongside the pavement contributes to vegetation overgrowth and inadequate drainage, weakening sections with loose soil. Vegetation control and soil stabilization techniques are required to mitigate these effects.
- Lack of Maintenance: Neglecting proper maintenance has allowed pavement defects to escalate to a severe stage. Timely and regular maintenance is crucial to prevent major failures.

By prioritizing maintenance on Patch 1, including addressing distresses, improving drainage, reinforcing the subgrade, controlling vegetation, and implementing regular maintenance, the safety, functionality, and longevity of Godhani road can be significantly improved.

VII. SUITABLE MAINTENANCE

Suitable Maintenance for the defects and cracks

No.	Defects and Cracks	Suggested Treatment
1.	Alligator cracking	Strengthen the pavement or reconstruction, Strengthen the base, Improve drainage, Base recycling
2.	Edge cracking	Widen the pavement, Proper and efficient drainage, construct shoulders
3.	Potholes	Patching, Cut and Patch
4.	Raveling	Thin Bituminous Overlay
5	Longitudinal cracking	Cut and Patch, Reconstruction of joints

Table2: Suggested Maintenance

VIII. CONCLUSTION

This study aims to explore the causes of pavement failures and propose a comprehensive inspection and evaluation method. The key findings and conclusions are as follows:

- The developed method for investigating pavement failures is based on extensive prior experiences. It prioritizes the establishment of systematic guidelines that are both straightforward and adaptable to different scenarios.
- The pavement failure investigation method introduced in this study serves as a valuable resource for inspecting and evaluating pavement failures. By combining this method with the expertise of highway engineers and thorough material investigations, the root causes of pavement failures can be accurately identified and reliably determined.
- This research study employed a method to classify the road into distinct sections and assess their current condition, taking into account the severity of existing defects. The objective was to identify the underlying causes of these defects and develop appropriate maintenance strategies to address them. By implementing these strategies, the overall lifespan and performance of the road can be significantly improved.
- Road maintenance is a crucial aspect of the overall road system. Even with well-designed and constructed roads, regular maintenance is necessary. While repair and maintenance procedures cannot fix inherent design issues, they play a vital role in preventing degradation and minimizing the impact of such problems.
- The deterioration of Godhani road can be attributed to various factors, including inadequate drainage, soil characteristics, the presence of agricultural land nearby, improper slope and gradient, overgrown vegetation along the pavement, adjacent structures, and heavy traffic loadings. These factors contribute to the distress observed on the road.
- Based on the comprehensive field survey, lab testing of soil samples, and consideration of various factors, it is recommended that Patch 1 of Godhani road be prioritized for maintenance. This section exhibits severe distress, primarily caused by factors such as vehicle overloading, poor soil condition, inadequate drainage, and the presence of adjacent structures. Moreover, due to its high usage for daily commuting, addressing the maintenance needs of Patch 1 is crucial to ensure a comfortable and safe riding experience for road users.
- Apart from Godhani road, there are several other roads in the Nagpur region that require immediate maintenance. It is imperative to enhance the longevity and serviceability of these roads to ensure a safe and comfortable riding experience for users. To achieve this, the responsible authorities must take prompt and effective measures to address these maintenance issues. By prioritizing road maintenance, the authorities can contribute to the overall improvement of the transportation infrastructure and promote a better road network for the community.

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