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Assessment of PMGSY/MMGSY Roads of Surat District

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Abstract- Rural *road infrastructure plays a vital role in connecting remote communities, promoting economic activities, and ensuring last-mile connectivity. This study focuses on the evaluation, condition assessment, and design of four low-volume rural roads located in Gujarat, India. A Visual Condition Survey was conducted in accordance with IRC:82-2015, and Pavement Condition Ratings (PCR) were assigned based on observed distresses. Roads were categorized under traffic classes T8 and T9, and pavement designs were developed following IRC:SP:72-2015, considering subgrade strength classes ranging from S3 to S5. Due to the absence of soil testing data, subgrade CBR values were adopted from local authorities. Layer-wise quantity estimation and a rate analysis sheet that included conveyance costs based on material lead distances were also used to conduct a thorough cost analysis. The findings demonstrated that variations in traffic volume and subgrade condition had a substantial impact on pavement design and cost. Under financial constraints, the study offers workable design solutions for sustainable rural road development and emphasizes the significance of PCR-based condition evaluation.*

Keywords: Rural Roads; Pavement Condition Rating (PCR); Visual Condition Survey; IRC:SP:72-2015; Subgrade CBR; Low-Volume Roads; Rate Analysis; Pavement Design; Cost Estimation; Traffic Classification

I. Introduction

For millions of people in India, especially in rural and impoverished areas, rural roads are their lifelines. They are essential for maintaining mobility, facilitating access to necessary services, and promoting socioeconomic growth. Numerous government programs, including the Pradhan Mantri Gram Sadak Yojana (PMGSY), have been introduced to improve and extend rural road networks in recognition of their significance. However, due to early failures, poor maintenance, and a lack of technical assessment, the sustainability of rural roads is still a concern despite tremendous progress.

Implementing an organized and economical methodology for the assessment and design of rural roads is crucial to addressing these issues. Methods for evaluating pavement performance, such as the Pavement Condition Rating (PCR) system, which is based on IRC:82-2015, offer a useful way to classify road conditions and gauge surface distress. Engineers and planners can better prioritize maintenance and redesign projects with the aid of these ratings.

Simultaneously, IRC:SP:72-2015 provides a thorough framework for low-volume flexible pavement structural design, based on factors such as subgrade strength (S1–S5) and traffic loading (T1–T9) that are determined from CBR values. These recommendations, when followed methodically, guarantee long-lasting, performance-based rural road designs that are appropriate for the area.

In this study, four rural road segments in Gujarat will be visually inspected for condition, categorized using PCR, and suitable pavement layers will be designed using IRC:SP:72-2015. Additionally, a thorough rate analysis was carried out using material transport data and field-relevant cost components, enabling a comparative comprehension of the financial ramifications of pavement design choices. The study's conclusions will help local organizations plan their rural infrastructure in an informed, data-driven manner.

II. Literature Review

Infrastructure engineering research has extensively examined the assessment and design of rural roads because of their socioeconomic importance and long-term performance issues. For low-volume roads, especially in environments with limited resources, a number of approaches have been put forth to evaluate pavement condition and optimize design.

Using data at the municipal level, Afridi et al. (2023) investigated the application of machine learning models to predict the Pavement Condition Index (PCI). The significance of visual inspection for prompt maintenance planning was reinforced by their study, which showed that pavement age and visible distress were significant predictors of pavement performance. Similar to this, Fortney et al. (2023) used principal component regression models to assess how traffic and local climate accelerate pavement degradation, emphasizing the importance of environmental influence in condition assessment.

For the rehabilitation of low-volume roads in Norway, Lou et al. (2023) illustrated a digital construction workflow utilizing COMSOL and BIM in the context of rural infrastructure. The significance of coordinated data modelling in pavement renewal was brought to light by their work. Regarding materials, research on stabilization methods and the effectiveness of various binder types under rural traffic loads was reviewed in studies like the ones compiled in Pavement Materials, Structures, and Performance (ASCE, 2022).

A nationally standardized method for designing rural pavements is offered by India's IRC:SP:72-2015, which divides roads into subgrade strength (S1–S5) and traffic volume (T1–T9). IRC:82-2015, on the other hand, describes methods for evaluating surface distress and classifying its severity, which makes it appropriate for rapid visual condition assessments on low-volume roads.

Additionally, decision support systems have become effective instruments for setting investment priorities. In order to facilitate state-level infrastructure grading, Amekudzi et al. (2023) created an Infrastructure Rating Tool (IRT) based on multi-attribute decision-making. Similarly, Yarnell (2022) demonstrated how municipalities can use asset condition tracking and GASB 34 frameworks to support maintenance decisions.

Notwithstanding these developments, there are still gaps in the integration of cost modelling and practical design recommendations with condition assessment in rural settings. This study expands on earlier research by integrating realistic cost estimation, IRC-guided pavement design, and PCR-based visual assessments to provide a comprehensive yet useful method for rural road planning and evaluation.

III. Methods

This study used a multi-phase methodology that included cost estimation, pavement layer design, pavement condition classification, and field condition assessment. The Indian Roads Congress's guidelines and real-world field considerations for low-volume rural roads served as the foundation for the techniques.

A. Study Area Selection

Based on their significance for local connectivity, the level of pavement distress, and their suitability for assessment and rehabilitation, four rural road segments in Gujarat, India, were chosen. Among the roads were:

- Khanjroli to Zab Patia (9.321 km),
- Orna to Jokha via Vaav (10.4 km),
- Akoti to Kanti Faliya via Mangroliya (6.5 km), and
- Puna Un Kosadi to Vareli Patna (14.5 km).

These roads predominantly serve light-to-medium rural traffic and had varying levels of surface distress at the time of survey.

B. Visual Condition Survey and Pavement Condition Rating (PCR)

In compliance with IRC:82-2015, a visual inspection survey was carried out for every road segment. Potholes, longitudinal, transverse, and alligator cracks, edge breaks, rutting, and patchwork were among the pavement distresses noted. Based on extent, depth, and surface impact, each type of distress was given a severity level: low, medium, or high.

Using this distress data, Pavement Condition Ratings (PCR) were assigned on a scale of 1 to 3:

3: Good condition

2: Fair condition

1: Poor condition

Each road segment was divided into logical stretches for localized rating.

C. Pavement Design Methodology

Pavement designs were created using IRC:SP:72-2015 guidelines for flexible pavements in low-volume roads, taking into account the assigned PCR ratings, subgrade classification, and estimated traffic volume (in CVPD). T8 to T9 categories were used to classify traffic, and local authorities assumed CBR values were used to calculate the subgrade strength:

S3 (CBR 3–5%) through S5 (CBR >7%).

For each T-S combination, layer thicknesses for Granular Sub-Base (GSB), Wet Mix Macadam (WMM), Bituminous Macadam (BM), and Bituminous Concrete (BC) were chosen from the IRC design catalogs.

D. Quantity Estimation and Rate Analysis

Cross-sectional dimensions for each layer were used to estimate material quantities on a per-kilometer basis. The Vadodara district's standard Schedule of Rates (SOR) was used to conduct a thorough rate analysis. A pre-structured Excel tool was used to calculate lead-based conveyance charges from the quarry to the construction site, which were added to the material costs. This gave each pavement design a reasonable cost estimate per kilometer.

IV. Results

Pavement condition ratings, chosen pavement designs for every road segment, and the cost estimation results from rate analysis are the ways in which the study's findings are displayed. The combined analysis demonstrates how traffic volume, subgrade strength, and road condition affect rural road projects' structural and financial aspects.

A. Pavement Condition Rating (PCR)

Following IRC:82-2015 guidelines, PCR values were allocated to each road segment based on the visual condition survey and distress classification. Below is a summary of the ratings:

Table 1: *Condition of Roads*

Road Section	PCR Rating	Condition Category
Khanjroli to Zab Patia	2	Fair
Orna to Jokha via Vaav	3	Good
Akoti to Kanti Faliya via Mangroliya (Karchka)	2	Fair
Puna Un Kosadi to Vareli Patna	2	Fair

The results indicate that most roads were in **fair condition**, with the Orna–Jokha road having the best surface quality at the time of inspection.

B. Pavement Design Results

The layer-wise pavement designs were chosen from IRC:SP:72-2015 using traffic categories (T8 or T9) and assumed subgrade CBR classifications (S3 to S5). Typical designs consist of:

- GSB: 200–250 mm
- WMM: 250 mm
- Bituminous Surfacing (BM + BC): 90–100 mm

According to its classification, each road segment was given a specially designed pavement structure, guaranteeing sufficient strength and longevity for the anticipated loading circumstances.

C. Cost Estimation Results

Using the determined quantities and current unit rates, a cost analysis was performed for every road. Based on the actual lead distances from quarry locations, conveyance costs were factored in. Below is a comparison of the estimated cost of construction per kilometer:

***Table 2** : Cost Estimation*

Road Section	Traffic Category	Subgrade Class	Estimated Cost/km (INR)
Khanjroli to Zab Patia	T8	S4	
Orna to Jokha via Vaav	T9	S5	
Akoti to Kanti Faliya via Mangroliya (Karchka)	T8	S3	
Puna Un Kosadi to Vareli Patna	T9	S4	

V. Discussion

The study's findings shed light on the opportunities and real-world difficulties associated with the assessment, design, and pricing of rural roads. The study presents a scalable framework for planning rural infrastructure by integrating visual inspection with PCR-based evaluation, IRC-compliant design standards, and real-world rate analysis.

A. Impact of Pavement Condition on Design

Without the need for specialized equipment, the Pavement Condition Ratings (PCR) provided a quick and accurate way to evaluate the state of the road surface. The single "Good" road (Orna–Jokha) needed little redesign, whereas roads rated as "Fair" (PCR = 2) usually needed moderate structural intervention. This backs up the use of PCR to prioritize resource allocation and rehabilitation, particularly in underfunded rural areas.

B. Role of Subgrade Strength and Traffic Classification

The thickness of the sub-base layer in the finished pavement design was greatly impacted by the subgrade classification (S3 to S5). To ensure durability, thicker granular layers were applied to roads with lower subgrade strength (S3). Despite being regarded as low-volume traffic categories, T8 and T9 demonstrated cost variation because higher traffic stretches necessitated surface layer enhancements.

This highlights how crucial it is to incorporate precise traffic estimates (CVPD) and CBR values early in the design process in order to maximize layer thickness and prevent over- or under-design.

C. Cost Implications and Optimization

The total cost of construction per km was shown realistically through the use of a lead-based rate analysis model. Costs were greatly impacted by conveyance distances, particularly for bitumen and aggregates. The significance of sourcing materials locally whenever possible was highlighted by the higher per-kilometer costs of roads with longer lead distances from quarry sources.

All roads were designed according to the same technical standard (IRC:SP:72-2015), but because of variations in terrain, traffic, subgrade, and material availability, their costs differed. This indicates that contextual flexibility must be balanced with design standardization.

D. Practical Implications

For District Rural Road Planning Authorities (DRRPA) or local PWD engineers, the study's methodology—PCR assessment, IRC-based layer selection, and integrated cost modeling—offers a replicable model. It makes use of scalable and easily accessible tools to enable technically sound pavement design, transparent prioritization, and justified budgeting.

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