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Pavement Investigation and Design for NH-76

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A B S T R A C T

The present thesis discusses the project work in detail that involves widening the road of Chittorgarh-Udaipur Section of NH 76 from Design Chainage Km 214.870 to Km 308.370 in the State of Rajasthan (Length 93.500 Km). The project highway is being upgraded to six laning from existing four laned configuration. The carriageway is of bituminous type and to be overlayed after meeting strengthening requirements. Hence necessary field investigations are carried out to identify the need for strengthening and subsequently overlay of carriageway.

All site sections were investigated to identify the properties and surface quality.

The samples were analyzed to identify the strengthening requirements.

Determine the life of existing carriageway.

Strengthening of carriageways proposed at certain locations along with overlay.

Keywords:IRC, MorTH, IS ,FWD

1. INTRODUCTION

Road infrastructure is one of the major transport infrastructures in India that not only play a major role in improving any area accessibility and movement of the population but also contributed to a nation's growth and development. India is the second largest road network in the world with a total road network of 6.2 million kilometers. According to the Ministry of Road Transport and Highways, as of March 2021, India had about 151,019 kilometers (93,839 mi) of national highways and expressways, plus another 186,528 kilometers (115,903 mi) of state highways. It is observed that annually billions of rupees are lost to the economy due to constraints on road quality and capacity. Developing countries like India are now facing the challenge of fixing the ever-increasing congested roadways in rural areas. So widening existing roadways provides an effective solution to deal with traffic congestion in the roadway.

Based on the materials and layers used, pavements are mainly classified as flexible, rigid, and composite types. Flexible pavements are constructed with bituminous surfacing and are generally preferred over the other types because of their less initial cost, suitability for stage construction, and ease to repair. Flexible pavements are layer systems constituting surface, base, sub-base, and sub-grade layers with better quality materials at the top and locally available or marginal materials in the bottom layers.

Most of the roads in India do not meet the design life. They are subjected to fast deterioration even at very early stages leading to a huge loss in the

economy, in the form of repair and rehabilitation costs. So, there is a great need for adopting and implementing an advanced pavement design method for solving this problem. It is in this context that the present thesis discusses the project work in detail that involves widening the road of Chittorgarh-Udaipur Section of NH 76 from Design Chainage Km 214.870 to Km 308.370 in the State of Rajasthan (Length 93.500 Km). Under this project, a four-lane road is widened to a six-lane road. Widening of roads improves safety and road capacity.

2. LITERATURE REVIEW

This chapter focuses on the comprehensive review of literature related to flexible pavement design, site investigation, and the detailed study of the pavement. The primary purpose of a pavement's structure is to bear the weight imposed by traffic and safely distribute these loads to the foundation. A typical cross-section of a flexible pavement system is illustrated in Figure 2.1. This pavement consists of multiple layers of bituminous material placed on top of a road base (which can be either unbound or bound material), which in turn is placed on an unbound sub-base material situated on the natural subgrade. The term "flexible" is used to describe this pavement because the bituminous materials have the ability to flex slightly under the load of traffic. In thinly surfaced pavements, the road base often comprises unbound granular material. The base course, located immediately below the surface course, can be constructed using crushed stone, crushed slag, or other untreated or stabilized materials. The subbase course is positioned beneath the base course. The use of two different granular materials serves an economic purpose, allowing local and more affordable materials to be utilized as a sub-base course instead of using the pricier base course material for the entire layer (Huang, 2004), (Witczack and Yoder, 1975).

A significant pavement performance study was conducted in India between 1983 and 1993 [Research Schemes R-6, 1995; R-19 and R-56, 1999], which led to the development of a new standard for the design of flexible pavements by the Indian Roads Congress [IRC: 37, 2001]. This new design approach incorporates a mechanistic methodology to calculate the required pavement thicknesses.

The complete flexible pavement design includes soil and material investigations, pavement condition survey, pavement evaluation study, and finally the design of pavement is proposed based on this data. An extensive literature study was conducted prior to the project work and important literature related to the present work are reported below.

(a) Soil and material investigation

For a pavement evaluation, proper data collection is the most important and unavoidable step to follow. If the data collection and analysis effort is not managed properly, undue costs with little benefit can result. The various step involves are:

Soil Strata and Strength

In order to acquire crucial data regarding different soil types, it is necessary to conduct an investigation aimed at determining the physical properties of the soil.

Subsurface soil properties

An investigation of sub-surface soil properties determined the arrangement of different layers of the soil in relation to the proposed subgrade elevation.

Sampling

Collection of samples of different layers of soil

Testing

The testing of soil samples is essential to assess the physical properties of different soil materials, particularly in terms of compaction density and subgrade support at a specific location.

(b) Pavement Condition Survey

Pavement condition surveys are conducted to assess the serviceability of road pavements and evaluate the physical condition of the assets. These surveys involve collecting data to determine the ride quality and structural integrity of a road segment. Trained staff make visual observations and measurements to evaluate various factors, including pavement roughness, surface distress, skid resistance, and deflection, among others. These surveys provide valuable insights into the overall condition of the pavement and help identify areas that require maintenance or rehabilitation.

The types of defects in bituminous surfacing are grouped under four categories.

A. Surface Defects
B. Cracks
C. Deformation
D. Disintegration

A. Surface Defects

Surface-related issues in pavement condition surveys are often attributed to inadequate quality and quantity of bitumen.

Bleeding

A pavement surface that has a thin layer of excessive or free bituminous binder, resulting in a shiny, reflective surface that tends to become soft in hot weather and slippery in cold and wet conditions, is known as bleeding or a fatty bituminous surface. Over time, this condition can lead to reduced skid resistance.

The severity of bleeding or fatty surface can be classified into three categories: low, medium, and extensive. In the case of low severity, isolated spots measuring less than 5 m^2 in area per lane kilometer, and limited to a specific lane with a total area of less than 1%, are considered as low severity bleeding or fatty surface.

Smooth Surface

A smooth pavement surface with low skid resistance poses safety hazards, particularly on gradients, bends, and intersections, as it becomes highly slippery when wet. This condition increases the risk of accidents and reduces the ability of vehicles to maintain traction and control. When the road surface lacks sufficient texture to provide adequate friction between tires and the pavement, vehicles may experience reduced braking and maneuvering capabilities, leading to potential skidding or loss of control.

The severity level of the smooth surface may be defined by the skid number. A surface with a skid number in the range of 30 to 40 indicates low severity smooth surface while a skid number below 30 indicates high severity smooth surface.

Streaking

Streaking may occur in a lane or a carriageway.

Hungry Surface

A hungry surface refers to a pavement condition where there is a noticeable loss of fine aggregates from the surface or the appearance of a dry surface with fine cracks.

B. Cracks

Cracking of bituminous surfacing is a prevalent issue observed on many roads in India over time. To classify the severity of cracks, they are categorized into various types. It is crucial to address cracks promptly and take immediate action to seal them, preventing further widening. The ingress of water through cracks can be detrimental to the pavement structure and the performance of the bituminous surfacing.

C. Deformation

Deformation in pavement can occur in one or multiple layers of bituminous courses, or it may extend throughout the entire pavement structure and subgrade. Deformation refers to a change in the original shape of the pavement surface, and it can manifest in various forms such as slippage, rutting, corrugation, shoving, shallow depression, and settlement.

Shallow Depression

Shallow depressions in pavement refer to isolated low areas of limited size that dip approximately 25 mm or more below the pavement profile. These depressions create areas where water can accumulate and become stagnant. The presence of shallow depressions may or may not be accompanied by surface cracking.

D. Disintegration

There are some defects which, if not rectified immediately, result in the disintegration of the pavement into small and, loose fragments.

The rating of pavement assigned as per criteria given in IRC: 82-2015 is given in Tables

Pavement distress based rating for highway

Defects (type)	Range of Distress		
Cracking (%)	>10	5 to 10	<5
Ravelling (%)	>10	1 to 10	<1
Potholes (%)	>1	0.1-1	<0.1
Shoving (%)	>1	0.1-1	<0.1
Patching (%)	>10	1 to 10	<1
Settlement and Depression (%)	>5	1 to 5	<1
Rut depth (mm) using 3 m straight edge	>10	5 to 10	<5
Rating	1	1.1-2	2.1-3
Condition	Poor	Fair	Good

(c) Literature on Pavement Evaluation study- Flexible pavement

The evaluation of pavement involves assessing and documenting its condition, surface characteristics, and structural condition. There are two main forms of evaluation: functional and structural.

Research scheme MORTH R-81 used a dynamic loading type Falling Weight Deflectometer (FWD).

3. CONCLUSION

The study was conducted to assess the existing features of the road and how to improve the performance of the pavement in order to meet the requirements for six laning. The key highlight is the use of FWD tests to identify the condition of existing pavement crust layers. Further, the proposal of widening of the existing road was made based on the existing subgrade CBR therefore reducing the efforts in excavation of subgrade bottom and replacing with suitable borrow soil. The design of service road was based on the existing ground soil along with a consideration that subgrade shall be sourced from borrow area and effective CBR was considered accordingly. The entire design process is based on calculations instead of plate thicknesses specified in IRC 37 which has helped in accurately predicting the crust thicknesses and hence making the design more realistic. Further, the study also consists of different types of deformations or failures in the existing pavement and solutions to treat in line with MoRTH specifications.

Recommendation

Prior to the overlay as per requirements in IRC SP 87, the existing distresses are need to repair to avoid/ minimize the damage to upper layers in the future course of time. The repairing techniques are recommended as per IRC: 82-2015 along with other better engineering practices as specified below:

(c) Poor Condition Sections

In both the directions, wherever the road condition is conforming to poor condition is recommended for partial reconstruction by removing the existing bituminous layers and reconstruction of pavement with in-lay of bituminous layers by re-compacting the existing WMM layer to the desired density.

(d) Cracking

Cracking of bituminous pavements shall include all types of cracks stated earlier. The minimum requirement and criteria for crack sealing shall be as under.

If the width of the cracks is less than 3 mm and resulting into settlement of Pavement up to 10 mm in depth and exceeding in area more than 1 Sq.m at a place, such cracking shall be sealed by fog sealing.

If the width of the cracks is more than 3 mm and causing settlement of the pavement up to 10 mm and the area of cracked surface exceeds 0.5 sq.m at a place, such cracked surface shall be repaired by slurry sealing.

If the cracked portion has settled more than 10mm and it area exceeds 0.5sqm such areas shall be repaired by patching as per MOST Specifications.

(e) Rutting

If the depth of rut exceeds 10 mm with a length of 10 m at a place in the wheel track of pavement surface, the same shall be repaired by milling the exiting pavement up to the depth of 40mm and in laying the same thickness with bituminous concrete prior to the overlay.

(f) Local Settlement Spots

If the settlement and grade depressions exceed 1 sq m in area and their depth is within 10mm such defects shall be treated by patching. If the depth is more than 10mm such defects shall be treated by full depth patching.

(g) Ravelling

If the ravelling of bituminous pavement exceeds 1 sq .m in area slurry seal treatment shall be applied in accordance with the MOST Specification. However, as the project road is undergoing for structural overlay, it may not require any treatment at this stage.

(h) Pot holes

If the bowl shaped pot hole in the pavement exceeds 0.5 sq m in area and 10mm in depth irrespective of the numbers on the pavement shall be repaired by patching\pothole filling

(i) Bleeding or Flushing

Bleeding or flushing of the pavement irrespective of the area shall be repaired by application of hot sand.

The thickness calculated from this study has been consider in the proposed pavement design for new carriageways and widening along with design traffic is as detailed below in Table.

Recommended thicknesses for different type of carriageways

Type of Carriageway	Design Traffic in MSA	Effective CBR of Subgrade	Recommended Pavement Composition(mm)			
			BC	DBM	WMM	GSB
Main carriageway in New Construction/Bypass	50	15	50	70	250	200
Service Road	10	10	30	50	150	150
Main carriageway in widening	50	Varies	50	Varies	250	Varies

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