Design of flexible pavement

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Abstract- Flexible pavement is a primary component of modern transportation infrastructure, designed to distribute traffic loads through layered construction to ensure durability and serviceability. This study presents a comprehensive approach to the design of flexible pavement, focusing on the site-specific requirements near Safedabad. The core methodology involves systematic traffic volume analysis, subgrade soil investigation, and the determination of California Bearing Ratio (CBR) values in accordance with Indian Roads Congress (IRC:37-2018) guidelines. By integrating critical parameters such as design life, vehicle damage factors, and cumulative standard axles (MSA), the study calculates optimal layer thicknesses for bituminous surfacing, base, and sub-base courses. Structural analysis, facilitated by computational tools, ensures the pavement's resistance to fatigue cracking and rutting under anticipated traffic conditions. The findings demonstrate that adhering to rigorous material testing and compaction techniques significantly improves pavement lifespan and reduces long-term maintenance costs. Ultimately, this research provides a technical framework for engineering resilient road infrastructure capable of supporting modern traffic demands while maintaining safety and operational efficiency.

I.INTRODUCTION

Transportation networks serve as the backbone of economic and social development, with road infrastructure playing a crucial role in regional connectivity. Flexible pavements, characterized by their ability to transmit loads through layered action, remain the most widely adopted construction type due to their cost-effectiveness and flexibility under varying environmental conditions. A well-designed pavement must withstand dynamic traffic loads and climatic stressors over its projected design life, necessitating a scientific approach to material selection and structural composition.

The primary objective of this project is to apply engineering principles to design a robust flexible pavement structure for a site located near Safedabad. This research addresses the necessity of pavement design by evaluating key variables, including traffic composition, subgrade bearing capacity, and drainage requirements. By conducting field surveys and laboratory tests—such as bitumen penetration, ductility, and aggregate impact value—the study seeks to align empirical design methods with actual field conditions. Furthermore, this project adheres to established standards, specifically the IRC:37-2018 guidelines, to ensure that the proposed layers, from the sub-grade to the bituminous concrete, are engineered for optimal load transfer and structural integrity. This report details the methodology, testing procedures, and design calculations employed to create a reliable and sustainable road design, providing a scalable model for civil engineering applications.

II.LITERATURE REVIEW

IRC:37-2018: Guidelines for the Design of Flexible Pavements

This document serves as the primary technical code for the project. It provides the mandatory framework for the mechanistic-empirical design of bituminous-surfaced roads, applicable to national and state highways. Key elements covered include estimating cumulative traffic in Million Standard Axles (MSA), evaluating subgrade strength via CBR, and selecting pavement layers (e.g., GSB, DBM, BC). The 2018 revision emphasizes controlling specific structural distresses—fatigue cracking and rutting—by validating the design against performance-based limiting values.

IS: :73–2013: Specification. Bureau of Indian Standards.
This series of Indian Standards is referenced for the systematic laboratory evaluation of subgrade soil. It defines the standard procedures for critical soil characterization, including grain size distribution, Atterberg limits, Maximum Dry Density (MDD), Optimum Moisture Content (OMC), and the California Bearing Ratio (CBR) test. The accurate determination of these soil parameters is essential, as the subgrade strength directly dictates the required pavement thickness in the IRC design process.

IIT-PAVE Software Documentation
IIT-PAVE is utilized as a computational verification tool within the project to perform structural analysis of the pavement layers. Based on layered elastic theory, this software allows engineers
to calculate critical strain values at the bottom of the bituminous layer and the top of the subgrade. By comparing these calculated strains against the limiting criteria defined in IRC:37-2018, the software ensures that the proposed pavement design can safely withstand fatigue and rutting throughout its intended design life.

Shreddedt. wami (2012)
In this paper the Use of waste plastic in the construction of bituminous Road. They concluded that plastic waste conforming of carry bags, mugs and other employed plastic could be used as a coating over summations and this carpeted gravestone could be used for Road construction.

Debashish Kar (2013)
performed a exploration to learn about the effect of application of coconut fiber is used as modifiers or stabilizer in and added substance in BC was formerly decided via Marshall stability test is used for the good result. For assessing strength and characteristics of bituminous paving blend Marshall Mix design fashion is a standard exploration system, which is habituated world wide. From different test it's concluded that SMA with the operation of coconut fiber force veritably proper result and it is good and can be used in flexible pavement

Suresh.T et.al (2013)
conducted a exploration to find out about the effect of application of natural fiber as coconut fiber is employed as stabilizer in SMA & cumulative in BC used to be decided by means of Marshall check & verified accurate result. Marshall Mix graph is a trendy laboratory system, which is espoused transnational for relating & reporting the electricity & go with the inflow traits of bituminous paving composites. From exclusive take a look at it's concluded that SMA with the operation of sisal fiber provides veritably suitable end result & can be used in flexible pavement.

A.A Md. Maniruzzaman et.al (2015)
conducted research to recognize to look at the impact of cellulose oil palm fibers content material on the rheological homes of 80-100 penetration grade bitumen. Preliminary take a look at are carried out the comfortable the requirement of the study. Viscosity, softening factor and penetration check had been used to represent the asphalt binder. The conclusion derived from the learn about that the amendment of 80-100 binder with 0.4% COPF offers the choicest enchantment of rheological properties.

Sandip Karmakar and Tapas Kumar Roy (2016)
conducted a exploration to fete the application of waste plastic & waste tire rubber with bitumen for structure of roads in low – budget60/70 grade bitumen had been used as the base bitumen for polymer correction distinct commotional take a look at are carried out and the consequences that tattered recycled waste plastics is fiscal alternately than eating raw polymer for acclimate the bitumen. The goods point out that addition of 1 through weight of combined plastic and bedeck the trait of pavement.

Kalta Bhanuprasad et.al (2018)
carried out a lookup to fete the conduct of damage heat combine asphalt AS regulation power duos and can be used for all climates and caller conditions. The abecedarian take a look at of bitumen are performed and Marshall Fusions plan and humidity vulnerability check used to be carried out in agreement their performance. It's concluded that the modified bitumen combinations would be a choice answer for the protection of city roads and with lower pollution.

Ashpaq Majeed Naik, Dr. Rakesh Gupta (2018)
The study had two major and critical goals which

covered by considering the following three tasks, the first was the visual evaluation and inspection of existing flexible pavement conditions including the failures, the second to determine and find out the actual causes of these failures in the pavement, and the third is to select the most and effective treatments and maintenance types. As a case study, of Ambala Cantt to Saha road was selected for evaluation and inspection purposes. The field evaluation works were achieved on the existing flexible pavement conditions of the selected rural highway. The results were most of the damages and failures in the pavement are serious and extreme surface deformation, cracks, disintegration, and surface defects. These damages and failures are caused by fatigue and other types of failures resulted from the movement of heavy vehicles and trucks, poor drainage design, unsuitable pavement layers thickness design, and improper pavement mix design and selected materials.

Amit Kundal and Dr. Amit Goel (2019)
introduced a fashion to decide the advantages of use of naturally on hand fiber known as sisal fiber used as cumulative in Bitumen concrete organized after fixing the owner of admixture & colorful. Research skilled that sisal fiber performs advanced that different fiber. Marshall balance nice is considerably & in numerous cases used for pavement workshop. Through Marshall places stability, drift value, air used. In the check it's discovered that the use of fiber us a cumulative embellish the houses like places like, stability, energy and drop the drain down of bitumen concrete BC.

Rohit Raj, Ritesh Kumar Yadav, Km Esha Jaishwal, Dr. Shiv Kumar (2024)
The extensive use of plastic wrappers for items like betel nuts, chocolates, chips, handbags, and cold drink bottles presents significant environmental and economic challenges. The production and disposal of these wrappers consume substantial energy and resources, contributing to environmental harm. While industries Favor plastic for its lightweight, inexpensive, and sturdy qualities, a potential shift to alternative materials like paper and wood may worsen environmental issues. Polyethylene, Polystyrene, and Polypropylene, the main components of plastic, resist easy decomposition in the environment. This study emphasizes the importance of utilizing plastic in construction processes, particularly through the heating and coating of plastics on aggregates at 160˚C, minimizing air gaps and enhancing stability. Proper disposal of non-biodegradable plastic remains challenging due to insufficient landfills. Research suggests that incorporating waste plastics into road construction materials results in stronger, more damage-resistant, and cost-effective roads. In India, roads adhere to specific guidelines with bituminous concrete layers over a granular base, utilizing Bitumen Grade VG-30 and specific aggregate sizes. The addition of polymers to road materials offers advantages such as increased longevity, damage resistance, cost-effectiveness, reduced maintenance, effective insulation, and diminished noise pollution, contributing to a more sustainable construction approach.

III.METHODOLOGY

Methodology refers to the systematic procedure adopted to achieve the objectives of the project. In this project on Design of Flexible Pavement, the methodology explains the step-by-step process followed for data collection, analysis, design calculations, and final pavement thickness determination based on standard guidelines. The methodology has been developed in accordance with the recommendations of IRC:37-2018 and standard pavement engineering principles, ensuring accuracy, reliability, and practical applicability.

Traffic Data Collection The collected data was used to calculate the cumulative number of standard axles during the design life of the pavement.

Soil Sampling and Subgrade Investigation These properties helped in evaluating the strength and bearing capacity of the subgrade.

Determination of CBR Value the California Bearing Ratio (CBR) test was conducted as per IS:2720 guidelines. The test measures the resistance of subgrade soil to penetration, which directly influences pavement thickness.

Determination of Design Traffic This calculation forms the backbone of the pavement design process.

Selection of Design Life The design life for the flexible pavement was selected based on IRC recommendations and functional classification of the road.

Urban roads: 15 years
National highways: 20 years Rural roads: 10 – 15 years

Pavement Design Procedure Based on IRC:37-2018, the pavement design.

Structural Analysis Structural analysis was performed to ensure that the pavement can withstand imposed traffic loads and environmental conditions. Critical strains were checked at:

- Bottom of bituminous layer (fatigue cracking)
- Top of subgrade (rutting)
- Software tools such as IITPAVE were used for verification.

Result
Traffic near Safedabad shows clear peak-hour congestion trends Evening period is most critical Suggest:

- Signal control or roundabout improvement
- Lane widening
- Traffic police deployment during peak hours

PARAMETERS	OBSERVATION
Dominant Mode	2-Wheelers (~48%)
Peak Period	Evening (5 PM – 7 PM)
Heavy Vehicles	More during night hours
Congestion	High during evening peak
Traffic Nature	Mixed (local + through traffic)

The literature survey clearly indicates that flexible pavement design has evolved through various stages of innovation, supported by continuous research by renowned scientists and institutions. These contributions have transformed pavement engineering into a scientifically structured discipline that combines theory, experimentation, and practical field observations. This chapter forms the academic and technical basis for subsequent design procedures discussed in the following chapters.

IV.CONCLUSION

Survey work and testing form the foundation of scientific pavement design. Without accurate data regarding traffic, soil properties, and material characteristics, the pavement structure cannot be designed effectively. Proper implementation of surveys and tests ensures that the flexible pavement will perform satisfactorily under heavy traffic loads and varying environmental conditions throughout its design life. Therefore, comprehensive survey work and systematic testing are essential for achieving a durable, economical, and sustainable flexible pavement structure.

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