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Widening and strengthening of a Other District Road Using IIT PAVE

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ABSTRACT: Widening roads is the answer to the problem of too much traffic and accidents on the roads. Transportation infrastructure is a problem that people all over the world have to deal with. As people's incomes rise, they switch from using two-wheeled vehicles to four-wheeled vehicles. The roads are built to handle the amount of traffic they have now, but as the number of cars on the roads grows, they need to be improved and widened. We focused on the different problems with widening roads and how they were fixed. We mostly looked at the road from Gajpur to Gagaha. Since pavements are built according to the standards and specifications of the design, they may not be safe, efficient, and cost-effective for the design period if the materials that make them up wear out too quickly. Many conventional aggregates are now being replaced with locally sourced, recycled, and designed marginal aggregates because to environmental concerns and legislation limiting quarrying. As a result of excessive horizontal tensile strain at the bottom of the bitumen layer and excessive vertical compressive strain at the top of the subgrade, fatigue cracking and rutting occur in asphalt pavement. Different composition materials used in the construction of a pavement make it simpler to use than standard granular base and sub-base.

KEYWORDS: Widening, Pavements, Legislation, Quarrying, Composition.

I. INTRODUCTION

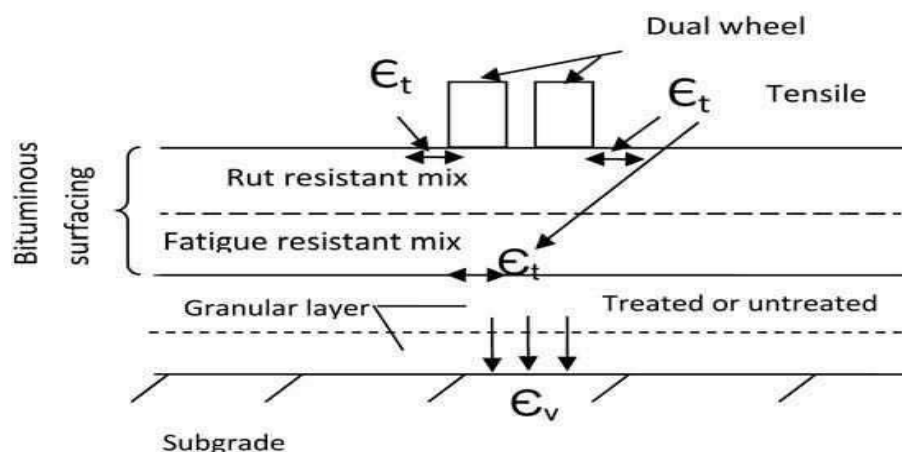
The state of a country's economic growth and development can be seen in its transportation infrastructure. Road accidents and traffic jams are less likely because of the way roads are built and how they are designed. Every day, there are more and more four-wheelers on the road. To deal with the current situation and make the best use of the space, the solution is to widen the roads.

For road widening, research and analysis are needed. Factors influencing this concept include traffic volume, current and anticipated road widths, excellent and bad aspects of current road design, and structural changes that must be made. A comparison of the present traffic volume to the design standard was done before the route was widened. The capacity, amount of traffic jams, and average daily traffic are all taken into consideration while expanding and reinforcing roadways. The enlarged section's calculations are based on an IRC 37-2018-compliant mechanistic flexible pavement design. The pavement's flexibility, the Pavement Evaluation, and the strengthening of the pavement are all taken into consideration in the design. Paving the way for people to go about is one of the most crucial aspects of a country's infrastructure. At the same time, flexible pavements lose both their function and their form.

In general, flexible pavements don't have much or any flexural strength and move a lot when they're loaded, making them ideal for pedestrians and cyclists. The typical lifespan of a flexible pavement is between ten and twenty years. Materials, traffic loads, the environment, and the pavement's life expectancy are all factors that determine the thickness of each layer of a flexible pavement. Non-traditional and traditional materials may be used in the basis, but only traditional materials can be used in the sub-base, according to IRC: 37- 2018. According to IRC and empirical software, the study's purpose is to assess the rutting and fatigue performance of flexible pavements based on various compositions of pavement materials such as cementitious subbase and crack relief layer of aggregates IITPAVE.

II. METHODOLOGY

The data were examined using the mechanistic-empirical technique. This technique stated that a pavement's design life should endure until fatigue cracking in the bituminous surface covered 20 percent of the pavement's surface area or rutting in the pavement reached the ultimate rutting depth of 20 mm, whichever happened first. To determine how the pavement responds, engineers employ the mechanistic empirical programme IIT-PAVE. IIT-flexible PAVE's pavement construction is studied using the multi-layer theory. Multilayered structures that are both rigid and pliable are used to represent flexible pavement. Deflections and stresses at the critical elasticity point With the use of IITPAVE's Stress Analysis programme, the stresses and strains in flexible pavements have been computed. Tensile strain, ϵ_t , at the bottom of the bituminous layer and the vertical subgrade strain, ϵ_v , on the top of the subgrade are conventionally considered as critical parameters for pavement design to limit cracking and rutting in the bituminous layers and non-bituminous layers respectively.



III. DESIGN AND ANALYSIS

Analyzing the data was done using the mechanistic-empirical approach.. Using this approach, a pavement's design life should persist until fatigue cracking in the bituminous surface covered 20 percent of the pavement's surface area, or until rutting had reached the ultimate rutting depth of 20 mm. The pavement's response is studied using IIT-PAVE, a mechanistic empirical programme. To find out how IIT-flexible PAVE's pavement's structure works, researchers turned to the multi-layer theory. Stiff and flexible pavements are conceptualised as multilayered structures. At the point of critical elasticity, there are stresses and deformations. The IITPAVE Stress Analysis programme has been used to calculate the stresses and strains in flexible pavements.

Design Traffic–Cumulative Million Standard Axles

The CMSA design traffic for a 15-year design period (n) is calculated using the aforementioned factors.

$$N_s = [365 * \{ (1+r)^n - 1 \} * A * D * F] / r$$

N_s : The cumulative number of standard axles to be catered for in the design in terms of MSA

A: Initial traffic in the year of completion of construction in terms of number of commercial vehicles per day.

D: Lane distribution factor.

F: Vehicle Damage Factor (VDF).

n: Design life in years.

r: Annual growth rate of commercial vehicles (for 5% annual growth rate $r=0.05$).

Forn=15 years

$$N_s = [365 * \{(1+0.05)^{15} - 1\} * 347 * 3.9 * 0.5] / 0.05$$

$$N_s = 5.33 \text{ msa.}$$

1) Fatigue model

An 80 percent reliability level and a 90 percent reliability level were used to fit two fatigue equations, one for which the computed strains in 80 percent of the actual data were higher than predicted by the model, and the other for which the computed strains in 90 percent of actual data were higher than predicted by the model. Here are the two equations for Marshall method bituminous mixtures:

$$N_f = 1.6064 * C * 10^{-04} * [1/\epsilon_t]^{3.89} * [1/M_R]^{0.854} \dots\dots(1)$$

$$N_f = 0.5161 * C * 10^{-04} * [1/\epsilon_t]^{3.89} * [1/M_R]^{0.854} \dots\dots(2)$$

Where,

N_f = fatigue life in number of standard axles,

ϵ_t = Maximum Tensile strain at the bottom of the bituminous layer,

M_R = resilient modulus of the bituminous layer.

Rutting model:

During the studies, data on the performance of the pavement at 80 and 90 percent reliability levels was used to calibrate the rutting model

Here are the two equations:

$$N = 4.1656 * 10^{-08} * [1/\epsilon_v]^{4.5337} \dots\dots(3)$$

$$N = 1.41 * 10^{-8} * [1/\epsilon_v]^{4.5337} \dots\dots(4)$$

Resilient Modulus: The subgrade is mostly elastic when traffic loads change, with only a small amount of permanent deformation in a single pass. Resilient modulus is a measure of how elastic it is, based on how much it can be bent and then go back to its original shape. The modulus is an important parameter for how a pavement is made and how well it works. The relationship between the CBR and the resilient modulus is given as:

$$M_R(\text{MPa}) = 10 * \text{CBR for CBR} \leq 5 \dots\dots(5)$$

$$M_R(\text{MPa}) = 17.6 * (\text{CBR})^{0.64} \text{ for CBR} > 5 \dots\dots(6)$$

$$\text{Where, } M_R = \text{Resilient modulus of subgrade soil } M_{R_granular} = 0.2 * h^{0.45} * M_{R_subgrade} \dots\dots(7)$$

Where, h = thickness of granular sub-base and base, mm.

The design thickness for several sorts of materials was discovered using the code's design library. Here are a few examples of many types of compositions,

Granular base and granular sub base (C-I)

Design Period	15 Years
Effective CBR	4.55 %
BC(mm)	30
DBM(mm)	110
WMM(mm)	235
GSB(mm)	140
TOTAL(mm)	515

Table 1 Horizontal and Vertical Strains

Location/ Type of Strain	Allowable Strain	Actual Strain From IITPAVE	Remarks
Horizontal Tensile Strain in Bituminous Layer	$\epsilon_t = 383.1 \times 10^{-6}$	303.4×10^{-6}	Safe
Vertical Compressive Strain on Subgrade	$\epsilon_v = 773.4 \times 10^{-6}$	571.4×10^{-6}	Safe

Cemented base and cemented sub base with crack relief layer (C-2)

Design Period	15 Years
Effective CBR	4.55 %
BC(mm)	60
Aggregate Inter - Layer (mm)	100
CT Base (mm)	120
CT Sub Base (mm)	245
TOTAL(mm)	525

Table 2 Horizontal and Vertical Strains

Location/ Type of Strain	Allowable Strain	Actual Strain From IITPAVE	Remarks
Horizontal Tensile Strain in Bituminous Layer	$\epsilon_t = 383.1 \times 10^{-6}$	208.3×10^{-6}	Safe
Vertical Compressive Strain on Subgrade	$\epsilon_v = 773.4 \times 10^{-6}$	25.62×10^{-6}	Safe

Cemented base and cemented sub base with SAMI (C-3)

Design Period	15 Years
Effective CBR	4.55%
BC(mm)	50
CT Base (mm)	175
CT Sub Base (mm)	215
TOTAL(mm)	355

Table 3 Horizontal and Vertical Strains

Location/ Type of Strain	Allowable Strain	Actual Strain From IITPAVE	Remarks
Horizontal Tensile Strain in Bituminous Layer	$\epsilon_t = 383.1 \times 10^{-6}$	64.62×10^{-6}	Safe
Vertical Compressive Strain on Subgrade	$\epsilon_v = 773.4 \times 10^{-6}$	83.89×10^{-6}	Safe

Foamed bitumen/ bitumen emulsion treated RAP/ aggregate over cemented base (C-4)

Design Period	15 Years
Effective CBR	4.55%
BC(mm)	50
Bitumen Emulsion treated RAP	120
CT Sub Base	215
TOTAL(mm)	385

Table 4 Horizontal and Vertical Strains

Location/ Type of Strain	Allowable Strain	Actual Strain From IITPAVE	Remarks
Horizontal Tensile Strain in Bituminous Layer	$\epsilon_t = 383.1 \times 10^{-6}$	202.2×10^{-6}	Safe
Vertical Compressive Strain on Subgrade	$\epsilon_v = 773.4 \times 10^{-6}$	54.64×10^{-6}	Safe

IV. CONCLUSION

The necessary design thickness decreases when the same subgrade qualities and design traffic are employed, but different composition materials are used in the pavement construction. It's also a lot more user-friendly. Additionally, with different compositions than granular base and sub-base, the bituminous layer's horizontal tensile strength is lower, resulting in the formation of fatigue fractures. Also, the vertical compressive strain that causes rutting is much less in different structures than it is in traditional granular base and sub base structures.

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