Analysis of damage due to overloading of flexible pavement

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Abstract – *In India the bituminous pavements undergo premature failure much before their design life. There could be many reasons for this premature failure and these include inappropriate selection of materials, lack of dependable traffic and axle load data and limited information related to distresses for analysis. In this paper the nonlinearity in damage of flexible pavement due to overloading and the best tyre configuration for a load without failure were found. The stress-strain analysis of the flexible pavement was carried out using KENLAYER Software. Different tyre configurations were chosen for a particular section for the analysis.*

1. INTRODUCTION

Overloading is the most important cause of the deterioration of flexible pavements. In developing countries this is very critical, where transportation of heavy vehicles on city roads and highways is increasing. By studies it is found that this problem causes a great damage to road networks and results in high maintenance and repair costs. To overcome this problem one has to develop other branches of transportation such as rail roads, increase the bearing capacity of pavement for the heavier traffic loads, and improve the axle load distribution of overweight vehicles. Ticketing regulations for overweight vehicles can also be introduced so that the users either reduce their loads to the allowable limits or pay compensation fees or fines for the damage.

The stress-strain response of a bituminous pavement depends on the properties of materials used in different layers, traffic on the pavement and the environmental conditions prevalent in the location. In IRC: 37, rutting in subgrade and fatigue cracking initiated at the bottom of the bituminous layers are considered as the two important distresses. The pavements in India experience high temperature around 60°C and above. Using KENLAYER the stresses in the pavement layers due to overloading can be analyzed.

2. OBJECTIVES

a. To study the nonlinearity in damage to flexible pavement due to overloading

b. To study the effect of tyre configuration on damage to flexible pavement

3. SOFTWARE

KENLAYER computer program is a most applicable method. Developed by Huang in 1993 and is based on layer theory. KENLAYER together with input program LAYER INP and graphic program LGRAPH is part of a computer package called KENPAVE. Using this software the vertical and tensile stresses can be calculated.

4. OVERLOAD-DAMAGE ANALYSIS

A particular pavement section was selected to analyze the overloading-damage relationship. It includes the properties like

No. of layers : 3
Thickness of sub-base : 300mm
Thickness of surface layer : 100 mm
Modulus of elasticity
- Subgrade : 77000kPa
- Sub-base : 200000kPa
- Surface layer : 5000000kPa

Poisson's ratio
- Subgrade : 0.4
- Sub-base : 0.35
- Surface layer : 0.35

Contact radius : 107.7 mm

These data are given to the software. The load was varied as 8t, 16t, 25t, 40t, 50t, 60t, 70t, 80t, 90t, 100t. Even though we are getting stresses at different points of pavement we are choosing the maximum values in each load cases. The output obtained as

LOAD	TENSILE STRAIN	VERTICAL STRAIN
8	$1.972X10^{-4}$	$4.082X10^{-4}$
16	$3.945X10^{-4}$	$8.165X10^{-4}$
25	$6.166X10^{-4}$	$1.276X0^{-3}$
40	$9.866X10^{-4}$	$2.042X10^{-3}$
50	$1.233X10^{-3}$	$2.553X10^{-3}$
60	$1.48X10^{-3}$	$3.063X10^{-3}$
70	$1.726X10^{-3}$	$3.573X10^{-3}$
80	$1.973X10^{-3}$	4.084X10-3
90	$2.22X10^{-3}$	$4.594X10^{-3}$
100	$2.466X10^{-3}$	5.105X10-3

IRC: 37-2012 provides two empirical formulae to get the life of pavement.

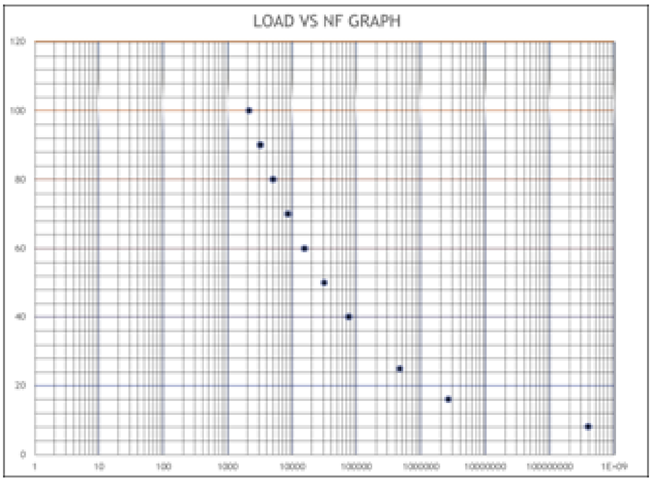
$$N_F = 2.21X10^{-4}(1/\mathcal{E}_t)^{3.89}\,(1/E)^{0.854}$$

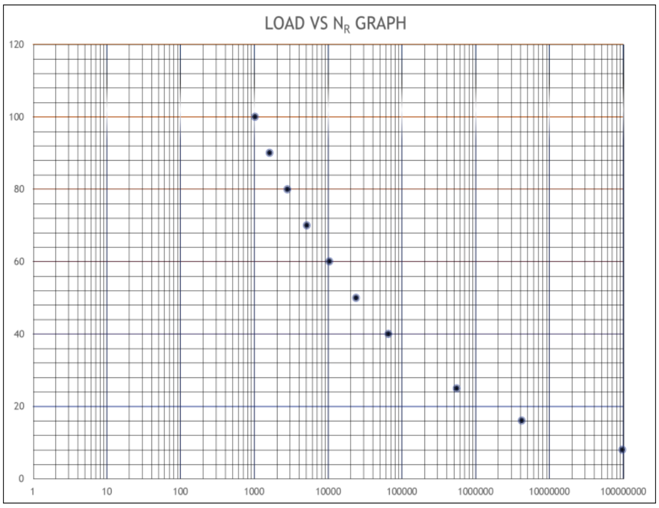
$$N_R = 4.1656X10^{-8}(1/\mathcal{E}_Z)^{4.5337}$$

Where,

N_F= Cumulative standard axle load repetition before
Pavement develops 20% fatigue cracking
$\mathcal{E}_t$= Tensile strain at the bottom of surface course
E = Modulus of elasticity of bituminous surfacing

4.1RESULTS AND DISCUSSIONS





From the Load VS N_F graph and Load VS N_R graph it is evident that non-linearity exists for the damages caused by the loads. The conventional way of collecting toll depends on the class of vehicle . For light weight vehicles the chances for overloading is very little when compared to the heavy vehicles like trucks. Since the damages caused by the overloaded trucks are non-linear. So changes should be brought in the conventional method of toll collection.

5. TYRE CONFIGURATION – DAMAGE ANALYSIS

The same pavement section was adopted for this and different tyre configurations were selected from the available list from the site Truck Science, the necessary details were also taken. The details were inserted into the software and the maximum strains were obtained for each configuration.

CONFIGURATION	VERTICAL STRAIN	HORIZONTAL STRAIN
DOUBLE AXLE-SINGLE TYRE	$1.16X10^{-4}$	$-6.529X10^{-5}$
FRONT AXLE-SINGLE TYRE REAR AXLE-DUAL TYRE	$8.948X10^{-5}$	$-3.931X10^{-5}$
TANDEM AXLE	$4.477X10^{-5}$	$-1.909X10^{-5}$
TRIDEM	$2.987X10^{-5}$	$-1.27X10^{-5}$

5.1RESULTS AND DISCUSSIONS

We analysed 4 tyre configurations and obtained the results showing the least strain for TRIDEM configuration which means the least damage is produced by this configuration itself.

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