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A Study to Understand the Influence of Axle Load and Tyre Pressure on Flexible Pavement Surface Deflection using Fabricated Benkelman Beam

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Abstract—*Pavement surface deflection basins provide valuable information for the structural evaluation of flexible pavements. Surface deflection measurements are rapid, inexpensive, and nondestructive and are used frequently as an indicator of pavement structural capability and performance potential. In this project an attempt has been made to study the pavement surface deflections using Benkelman beam under the influence of different tyre pressures and different axle loads. The surface deflections are compared for varying tyre pressures under constant axle load and varying axle loads and constant tyre pressure. The shape of the deflection bowl was drawn with the Benkelman beam test data at 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 meters from the point of application of load, i.e., from the centre portion of the two tyres on one side of rear axle/load axle. The pavement surface deflections were measured on StateHighway-38 from Vizianagaram to Anandapuram by stopping the trucks on the road and measuring the tyre pressure and axle load. With this data some correlation was established between tyre pressure and characteristic deflection at constant axle load and between axle load and characteristic deflection at constant tyre pressure. Key words: Deflection bowl, characteristic deflection, Benkelman beam*

1. INTRODUCTION

INDIA is approximately 3,060,500 sq km in area and has a road network of over 3,315,231 km. The road system carries 87% and 65% respectively of passengers and freight. Pavement damage is a risk to capital invested and, if a high level of deterioration is allowed to develop, structural repairs may be required. Hence, the amount, and consequently, the cost of time-consuming maintenance, will depend on the potential evaluation of pavement damage. Maintenance of flexible pavement is, therefore, an important task in keeping the transport system, and the economy, of the country running. Pavement surface deflection measurements are the primary means of evaluating a flexible pavement structure, thus surface deflection is an important pavement evaluation method because the magnitude and shape of pavement deflection is a function of load (traffic type and volume), pavement structural section, temperature affecting the pavement structure and moisture affecting the pavement structure. Surface deflection is measured as a pavement surface's vertical deflected distance as a result of an applied (either static or dynamic) load. Flexible pavement structural capacity or remaining service life of pavement can be estimated based on pavement surface deflections measured using Benkelman beam method or Falling Weight Deflectometer method. In Falling Weight Deflectometer, a standard weight falls from a standard height to create a particular frequency (at which pavement is analyzed) to create a pavement deflection bowl, i.e., set of deflection values measured radially outward at a particular interval or spacing. From these deflection values the layer coefficients are back calculated assuming the layer thicknesses. But FWD method is costly.

In Benkelman beam method usually the central deflection is measured, i.e., the deflection at the centre of loading and in most cases the deflection measure is rebound deflection as it is easier to measure. This rebound deflection gives only the elastic component of deflection and from this the characteristic deflection is obtained after applying the necessary corrections.

These correction methods are explained in detail in IRC-81, code for design of flexible overlay based on the central deflections of Benkelman beam over existing pavement. The central deflection alone will not be sufficient to estimate the structural adequacy of different existing layers. To bridge this deflection bowl is measured including the radius of influence of the external load. These deflections are measured systematically at equal spacing to understand the behavior of different pavement layers. So the rebound deflections are measured at every half meter interval. Here the correlations between tyre pressure and pavement deflection bowl curvature are observed under the influence of a particular load. Similarly correlations between axle load and deflection bowl curvature are observed under constant tyre pressure.

Sample deflection bowls at 6.3 tonnes axle load at tyre pressure of 110 psi and 120 psi are shown here. These are uncorrected, direct field values.

Chart-1: Deflection bowl for 6.3 tonne axle load at 110 psi

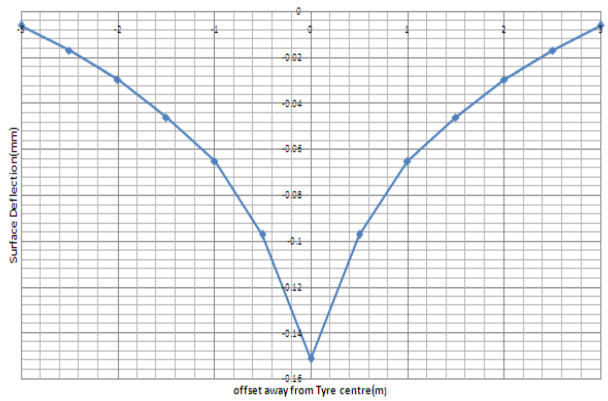
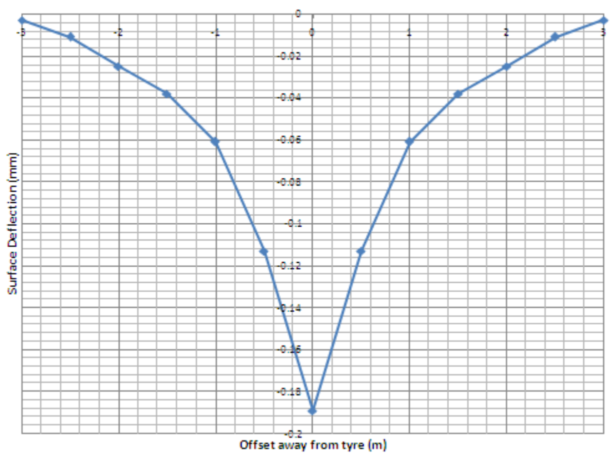


Chart-2:Deflection bowl for 6.3 tonne axle load at 120 psi



As can be seen from the above two charts the deflection increased from 0.15 mm to 0.19 mm when the tyre inflation pressure increased from 110 psi to 120 psi. That means less than 10% increase in tyre pressure increased surface deflection by more than 25%.

For calculating the characteristic deflection the necessary corrections were applied, for temperature based on the measured pavement temperature and moisture content based on field moisture content, soil plasticity index.

Randomly trucks were stopped on the highway and the axle loads and tyre pressures were measured and then the pavement rebound deflections were measured using benkelmaan beam. The data so collected is then sorted out to get the proper correlations. This approach was adopted as most of the truck drivers refused to alter the inflation pressure and changing the axle load is a big task.

The collected data is presented here in maltliple charts.

The following three charts represent the variation of characteristic deflection under the influence of inflation pressure at constant axle load.

Chart-3: Axle load 6.3 Tonnes

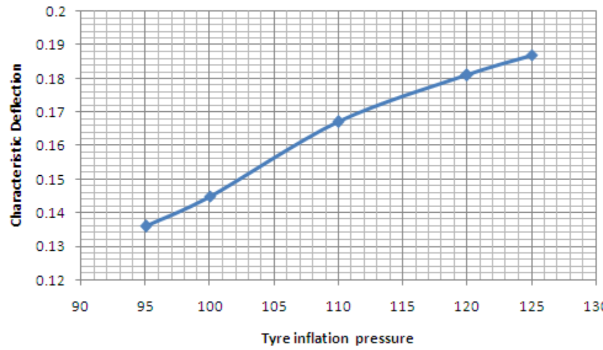


Chart-4: Axle load 7 Tonnes

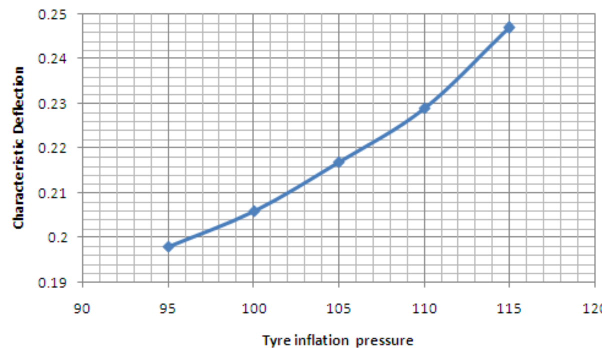
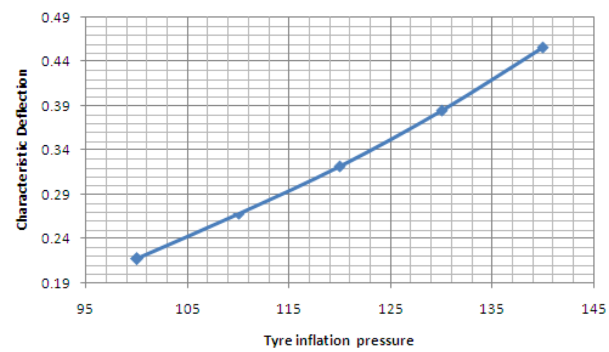


Chart-5: Axle load 8.4 Tonnes



From the above 3 charts it can be seen that the increase in characteristic deflection is slightly more than proportional when the inflation pressure is increased keeping the axle load constant.

This clearly shows the significance of tyre pressure on the pavement deflection bowl. Apart from this, it is observed that most of the truck drivers are maintaining higher inflation pressures and they are giving the reason that when the load is more the pressure should be more to get fuel efficiency. But they do not know the amount of damage it causes to the pavement.

The following three charts represent the variation of characteristic deflection under the influence of axle load at constant tyre inflation pressure.

Chart-6: Inflation pressure of 110 psi

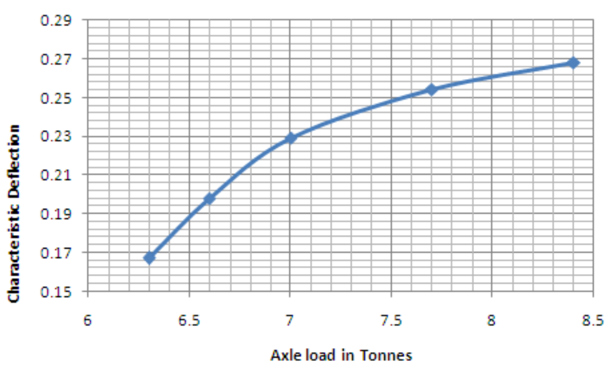


Chart-7: Inflation pressure of 120 psi

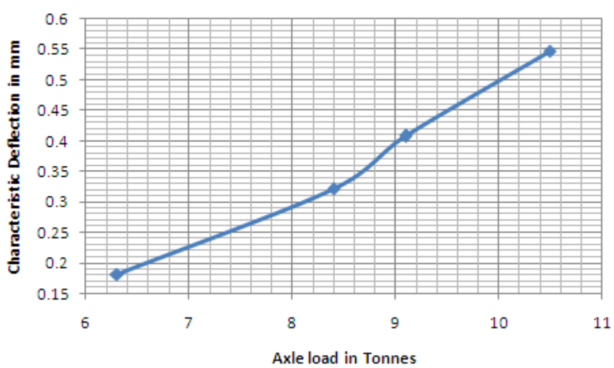
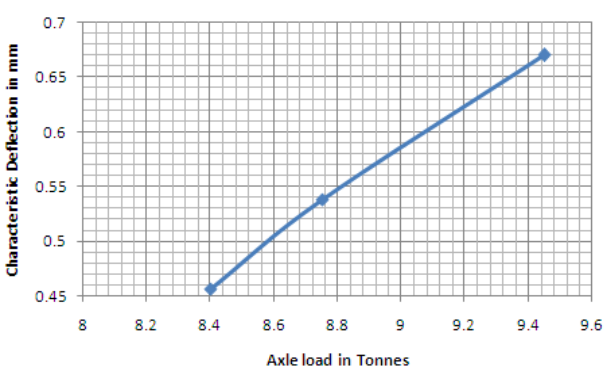


Chart-8: Inflation pressure of 140 psi



From the above three charts it can be seen that the increase in characteristic deflection is slightly less than proportional when the axle load is increased keeping the inflation pressure constant.

The data presented here is the average value of a minimum of 3 values. If characteristic deflections for a particular tyre pressure and a particular axle load are available for a minimum of 3 samples then the data is considered and presented here as the average value.

2. CONCLUSIONS

1. The pavement surface deflection was observed to be extending beyond 3m so the front legs of the Benkelman beam fall in the deflection bowl in majority of cases
2. The curvature of the deflection bowl is observed to change with respect to loads and tyre pressures with higher curvatures observed where the tyre pressure is more, compared to higher axle load.
3. The characteristic deflection values were found to increase with increase in truck loading but slightly less than proportionality.
4. The characteristic deflection values were found to increase with increase in tyre pressures at rate slightly more than proportionality.
5. Most of the trucks plying on the highway are maintaining tyre inflation pressure in excess of 100 psi, which is more than the legally allowed. This could be because of the modern tyres which are capable of withstanding higher pressures and at the same time offering better road grip.
6. In the IRC method of Pavement design the Vehicle Damage Factor considered is only based on the axle load, and does not take into account tyre inflation pressure which when maintained in excess is equally detrimental to the pavement service life. So there is a need to re-evaluate the Vehicle damage factor concept incorporating the tyre inflation pressure too.

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