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THE EFFECT OF TYPE OF TIRE HEAVY VEHICLES ON THE ROAD PAVEMENT PERFORMANCE

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Heavy vehicles, visco-elasto-plastic model, numeric simulation.

ABSTRACT

Road pavements have been designed to support the traffic defined in the project which is composed by different type of vehicles with different axle configurations, load magnitudes, wheel types and tire inflation pressures. Heavy traffic overloads is the major source of pavement damage by causing fatigue, which leads to cracking and permanent deformation. Heavy vehicles do not cause equal damage because the differences in wheel loads, number and location of axles, types of suspensions and tires. Furthermore, the damage is specific to the pavement properties, operating conditions and environmental factors. This proposal presents a research program to improve the knowledge on the effect of heavy traffic overloads in the pavement performance, aiming to characterize traffic severity and to improve the definition of traffic characteristics to be considered in pavement design.

INTRODUCTION

Nowadays, the heavy vehicles have acquired new configurations of axles and suspensions, types of tires, and a greater inflation pressure, which significantly influences the state of stress/strain on the pavement. Traffic loads are the major source of pavement damage. Recently, the configuration of traffic loads have been the focus of many researches (Al-Qadi et al., 2002; Al-Qadi et al., 2005; Douglas et al., 2008). Many researches have investigated the impact of contact stress distribution from heavy load vehicle on the pavement responses (Blad e Harvey, 2002; Hua e White, 2002). This researches concluded that the loads are not equally distributed on the pavement. Elseifi et al. (2005) analyzed the pavement behavior when applied heavy vehicles with dual tires configuration (275/80R22,5) and wide-base tire configuration (445/50R22,5). This research concluded that the heavy vehicle with wide-base tire configuration presented a major damage than dual tire configuration. According to Soares et al. (2008), the dual tire configuration causes less damage than wide-base tire configuration on the pavement. This research simulated the effect of three tire configurations (single, dual and wide-base) using the finite element models to predict the mechanical behavior and performance life of road pavement.

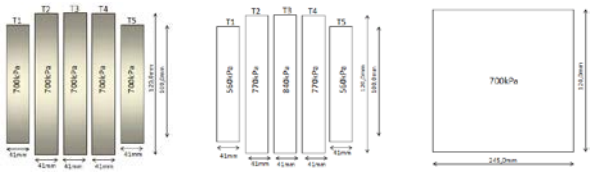
OBJECTIVE

The objective of the research presented in this report is to propose a model for predicting the mechanical behavior and performance life of Portuguese road pavements subjected to various tire configurations. This study will be supported by the monitoring of a trial section constructed and instrumented in a road subjected to real traffic. Furthermore, a numeric simulation, using 3D dynamic finite element modeling will be performed to simulate the effect of different tire configurations. The calibration of the FEM will be performed using the results of the laboratory testing applying the visco-elasto-plastic model. The testing program requires the developing of a visco-elasto-plastic model that consists of complex modulus, repetitive creep and relaxation testing for visco-elasto-plastic modeling of the asphalt mixtures. The analysis of the information obtained in situ and in laboratory with this research will be used to accomplish a more reliable modeling of the traffic loads for pavement design, especially in terms of different tire configurations and to minimize the effect of overloads in the pavement performance.

PROGRESS TO DATE

This research proposes a model for predicting the mechanical behaviour of flexible pavement subjected to heavy load vehicle with dual-tire configuration featuring 245 mm wide on each tire using a numerical simulation. In this research, a commercial finite element program (DIANA) was used to analyze flexible pavement cross-

sections subjected to different configuration of dual tire. Eight-nodes quadratic solid elements were used for the three-dimensional (3D) analysis. In general, a finer mesh is recommended for more detailed results. Therefore, to reduce the number of elements for a 3D model without compromising the analysis, a symmetrical geometry about the x-axis (perpendicular to the wheel path) has been used. To minimize the effect of boundary conditions, the pavement model dimensions have been used 4000 mm length by 4000 mm in width. The modeled pavement structure has been based on the dense-graded surfaced section. Material properties were determined through nondestructive deflection and seismic testing that consists of complex modulus, repetitive creep and relaxation testing as well as laboratory analysis. This research simulated on the pavement model three configurations of contact area pressure considering pressures of 700, 800, 900, 1200 and 1500 kPa (Figure 1). The results show that it is possible to observe significant differences in the state of stress/strain on the pavement, especially on the surface which is responsible for cracking originating at the surface.



(a) Uniform pressure – with tread ribs

(b) Non-uniform pressure – with tread ribs

(c) Continuos pressure – without tread ribs

Figure 1. Dual-tire configuration

FUTURE WORK

The trial sections, which will be built for in situ testing, subjected to real traffic, and for laboratory testing in the accelerated loading testing facility, will be instrumented with sensors to measure displacements, both in the asphalt and granular layers, compressive stresses in the granular layers, temperature in the asphalt layers and moisture in the granular layers. These variables, together with the properties of the tested structures, will be used as input in the 3D finite element simulations to define the effect of overloads in the pavement performance. During the trial sections layers construction, the thicknesses will be controlled by topography to have exact values as input in the finite element modeling. The quality of the materials of the pavement layers of all trial sections will also be evaluated. Some vehicles will be characterized in situ, especially their load level, footprint, inflation pressure and dimensions.

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