Tire Science and Technology, TSTCA, Vol. 40, No. 4, October–December 2012, pp. 246–271

Morris De Beer [1,2] James W. Maina [1] Yvette van Rensburg [1] and Jan M. Greben [1]

[1] CSIR Built Environment, P.O. Box 395, Pretoria 0001, South Africa

[2] Presenter/Corresponding author. Email: mbeer@csir.co.za

Toward Using Tire-Road Contact Stresses in Pavement Design and Analysis

ABSTRACT:

Optimization of road pavement design, especially close to the surface of the pavement, requires a more rational approach, which will inevitably include modeling of truck tire-road contact stresses. Various road-surfacing failures have been recorded as evidence that the traditional road pavement engineering tire model idealized by a single uniformly distributed vertical contact stress of circular shape may be inadequate to properly explain and assist in the design against road surface failures. This article therefore discusses the direct measurement of three-dimensional (3D) tire pavement contact stresses using a flatbed sensor system referred to as the ‘‘Stress-In-Motion’’ (SIM) system. The SIM system (or device) consists of multiple conically shaped steel pins, as well as an array of instrumented sensors based on strain gauge technology. The test surface is textured with skid resistance approaching that of a dry asphalt layer. Full-scale truck tires have been tested since the mid-1990s, and results show that 3D tire contact stresses are non-uniform and that the footprint is often not of circular shape. It was found that especially the vertical shape of contact stress distribution changes, mainly as a function of tire loading and associated tire inflation pressures. In overloaded/underinflated cases, vertical contact stresses are the highest toward the edges of the tire contact patch. Higher inflation pressures at lower loads, on the other hand, result in maximum vertical stresses toward the center portion of the tire contact patch. These differences in shape and magnitude need to be incorporated into modern mechanistic-empirical road pavement design tools. Four different idealized tire models were used to represent a single tire type to demonstrate effects of tire modelling on the road pavement response of a typical South African pavement structure incorporating a relatively thin asphalt surfacing. Only applied vertical stress was used for the analyses. It was found that the fatigue life of the road surface layer can be reduced by as much as 94%and strain energy of distortion be increased by a factor of 2.8, depending on the characteristics of the tire model input selected for road pavement design and analysis.