Investigation of Tire-pavement Interaction Based on Non-smooth Contact Dynamics Method

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A deeper understanding of tire-pavement interaction is essential for exploring the degradation mechanisms of pavement surface layers. In this study, the non-smooth contact dynamics (NSCD) method is introduced to investigate the tire-pavement interaction. The tire's modeling strategy and its calibration are detailed. The results show that the NSCD method can reproduce the tire contact stresses regarding sensor measurements. The stress distribution analysis found that the tire-pavement contact area is close to a rectangle. The contact stresses are not uniform across this contact area and the high-stress concentration is located at the edge of the tire.

Keywords: tire-pavement interaction, contact stress distribution, non-smooth contact dynamics method, finite elements method.

1. Introduction

With the ageing road networks and decreasing resources for maintenance of these networks, a deeper understanding of tire-pavement interaction is essential for investigating the degradation mechanisms of pavement surface layers. The tire-pavement interaction mechanism is studied by finite elements method. The NSCD method is introduced here to enforce the contact condition between the tire and pavement because of its good accuracy in non-linear system simulation, in comparison with the traditional penalty method [1].

2. Methods

The tire model can be divided into two parts: a deformable part that models the rubber tire itself inflated with air, which interacts with the pavement directly, and a rigid rim serving as the driven system that supports the loading, acceleration, braking, and following the tire motion, as shown in figure .

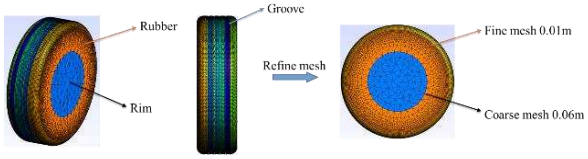
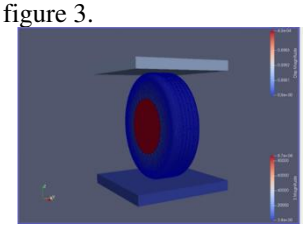
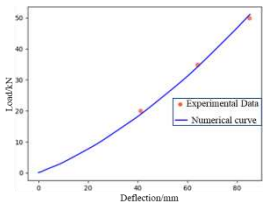


Fig1. Tire model and mesh refinement

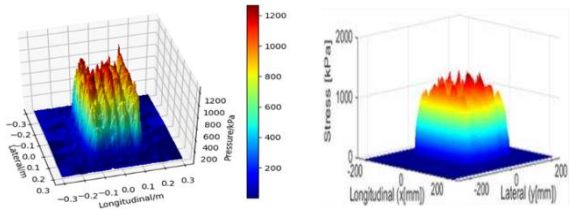
Tire load-deflection curves from experimental compression tests and pressure results from sensor measuring [2] are used to calibrate the tire model parameters. The open-source software lmgc90 (https://git-xen.lmgc.univ-montp2.fr/lmgc90/lmgc90_user/-/wikis/home) is adopted, where the NSCD method is completely implemented. The test results are shown in figure 2 and figure 3.



Numerical press test



Stress-deflection curve



Numerical results (50kN) Sensor measurments (50kN)

Fig2. Comparison between numerical and measured [2] results

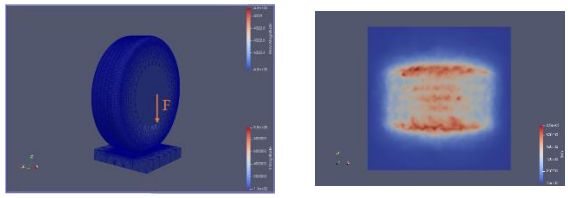


Fig3. von-Mises stress distribution under tire load (50kN)

3. Discussion

The parameter sensitivity analysis in the tire calibration tests provides a more precise and efficient calibrating method for numerical tire models. The vertical stress results show that the tire-pavement contact area is close to a rectangle rather than circular in conventional assumption. The contact stresses are not uniform across the tire-pavement contact area. von-Mises stress distribution illustrates that the high contact stresses concentrate at the tire edge, which seems critical for pavement near-surface distresses. The NSCD method's potential in simulating tire-pavement contact problems is revealed, which is beneficial for pavement design optimization.

4. References

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[2] Manyo, Edem Yawo, et al. "Towards fast modelling of the tire-pavement contact." European Journal of Environmental and Civil Engineering (2019): 1-17.