

Measurement of Three-Component Force Distribution in a Tire Contact Patch during Steering at Standstill Using Tread-Block Scanning

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During steering at standstill, substantial shear deformation occurs within the tire contact patch, resulting in a complex distribution of frictional forces between the tread blocks and the road surface. Understanding these forces is crucial for predicting steering effort and designing steering systems. In this study, a scanning measurement method was proposed to measure the three-component contact forces acting on individual tread blocks and to clarify the mechanical behavior within the tire contact patch during steering at standstill.

Figure 1 shows a schematic of the test setup. This study used an existing suspension tester to conduct steering standstill tests. A contact face with a built-in compact force and moment sensor was set on an X-Y stage under the tire contact patch. The X-Y stage was placed on a table that can move vertically and rotate, and steering standstill operation was reproduced by rotating the contact face with a vertical load applied to the tire. A 6-axis loadcell was also installed on the stage side to measure the three-component forces and the moments around three axes acting on the tire contact patch. This was mainly used to control the load and steering status acting on the entire tire in the tests. A contact plate corresponding to the shape of the tread blocks to be measured was attached to the compact force and moment sensor on the contact patch side. The forces acting on each position within the contact patch were scanned and measured by using the X-Y stage to sequentially move the contact plate to directly under each tread block with the specified vertical load applied, and repeating the same steering standstill test.

The test tire used a rally tire (205/65R15 94Q) with clearly separate tread blocks. Measurement of the contact patch pressure distribution confirmed that under a vertical load of 4000 N, 26 tread blocks made contact. The position of the compact force and moment sensor with contact plate attached was sequentially changed to correspond to each of these contact blocks, and the entire contact patch was scanned.

Figure 2 shows the three-component force waveforms at a typical tread block position under a vertical load of 4000 N. When the steer angle was varied in a cyclical manner with a vertical load applied, the longitudinal force F_{cx} and lateral force F_{cy} also changed cyclically according to the steer angle. Figure 3 shows the three-component force distribution within the contact patch at a steer angle of +3°.

The results showed that the in-plane shear-force vectors formed a vortex-like distribution around the center of rotation, with their magnitudes generally increasing from the central region toward the edges of the contact patch.

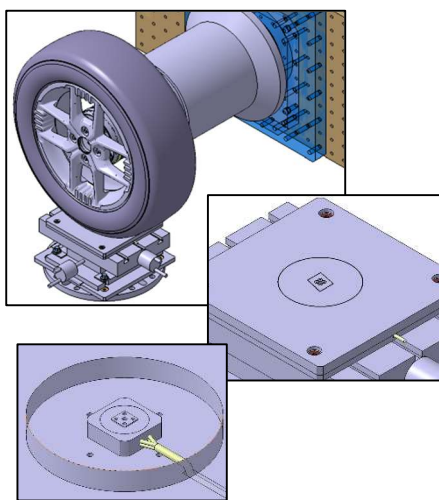


Fig.1 Test setup

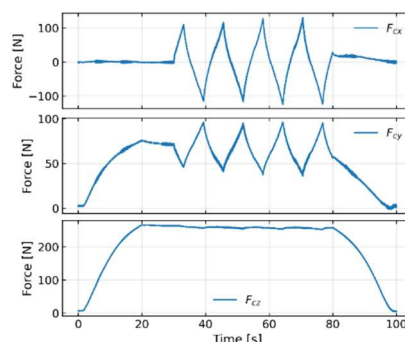


Fig.2 3-component forces

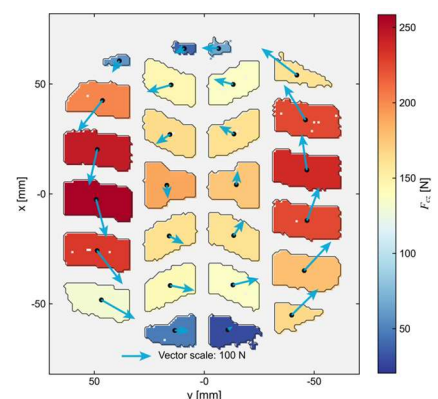


Fig.3 Contact force distribution