Soil stress distributions under tractor tire: real size tests

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The previous investigations by many researchers have shown that the performance of an off-road wheel could be only determined by knowledge of the distribution of normal and shear stresses along the soil-wheel contact surface. In order to provide more real insight into the soil-wheel interactions, the distributions of radial and tangential stresses on the soil-tire interface were measured in situ for different moving conditions, tire loads, inflation pressures, and tire slip and soil conditions.

Three small pressure sensors were instrumented on the center line of the front tire, lug face and lug side near the center line of the rear tire for measuring the ground contact pressures and shear stress at contact surface between sandy clay soil and a 2WD tractor. The tractor moved on firm and tilled soils with 100kPa and 330kPa tire inflation pressure at two conditions in which no pulling force was generated and pulled force was applied to the rear drawbar (tilling and pulling another tractor). The tire loads were changed from 2.13kN to 1.54kN for front tire and 3.65kN to 4.91kN for rear tire by mounting and trailing the rotary tiller attached to the tractor, respectively. Three photo switches were used to measure the angular velocity of the tires and the ground speed of the tractor for calculating the tire slip, and also detect the lowest position of the pressure sensors. Two slip rings were mounted on the central parts of the front and rear tires for making the interface between the rotating tires and the data acquisition system. Field measurements were recorded on a portable computer at a sampling rate of 100Hz. The experimental data were processed and drawn by MATLAB.

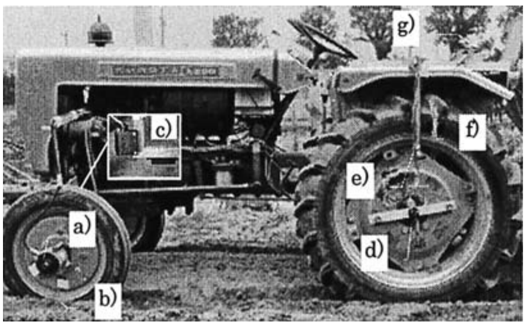

Fig.1. The test tractor: a, d) slip rings; b, f) pressure sensors; c, e) photo switches; g) data acquisition system

The experimental data in Fig. 2 indicates that the form of stress distribution depends on soil condition, tire characteristics, and the working condition of the tractor. In tilled soil, the sinkage of the tires is deeper than that in firm soil resulting in larger soil contact angle then smaller maximum normal stress. The maximum normal and shear stresses under tires with 300kPa inflation pressure always occur in entry contact surface, and it is found to be closer to the tire axle center line in the case of firm soil. For tires with 100kPa inflation pressure, the approximately uniform distributions of stresses occur both in entry and exit contact surface on firm soil due to uniform deformation of the tires, while the maximum stresses occur in entry contact surface in the case of tilled soil due to parabolic shape deformation of the tires. Furthermore, the shear stress increases as tire slip increases (Fig.2 c).

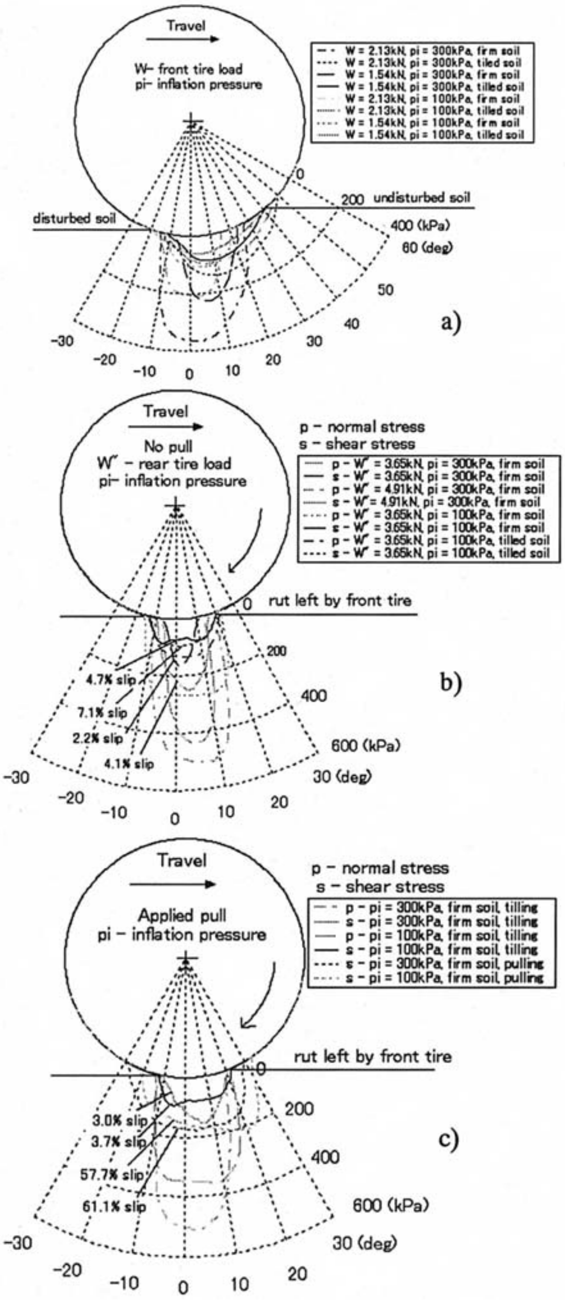

Fig.2. Distributions of stresses along soil-tire contact surface: a) front tire in no pull condition; b) rear tire in no pull condition; c) rear tire at applied pull condition

These experimental results also can be used for determining the Bekker soil constants for predicting sinkage, motion resistance, and drawbar pull of the tractor.