McHenry

Accident Reconstruction

2000

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Cornering Stiffness And Static Margin

Cornering Stiffness

When a tire is orientated at an angle relative to its direction of motion (i.e., a slip angle exists), a side force acts perpendicular to the plane of the wheel. The relationship between the side force and the slip angle is nearly linear for small slip angles. The relationship makes use of a property defined as the tire cornering stiffness. Side forces can be calculated based on a nondimensional side force function whereby the small-angle properties of the tires become progressively "saturated" at larger angles (**Figure 2**).

The "friction circle" concept (**Figure 3**) can be used to approximate interaction between side and circumferential (braking and tractive) tire forces. The "friction circle" concept, which originated in automobile racing, provides a convenient means of visualizing the effects of interactions between side and circumferential (i.e., braking or tractive) tire forces. The concept (**Figure 3**) is based on the assumption that the maximum value of the resultant tire friction force is independent of its direction relative to the wheel plane. Thus, if the driving thrust or braking force is very near a maximum, the side force of a tire is reduced to a near-zero value.

Figure 3A shows a friction circle for combined traction and side-force. The radius of the circle represents the maximum possible friction force, which is equal to the product of the weight supported by the tire and the tire-pavement friction coefficient. With no traction applied to the wheel, the maximum side force can be equal to the radius of the friction circle. As traction is gradually increased, the maximum resultant friction force vector rotates toward the orientation of the wheel plane and the maximum side-force capability (perpendicular to the wheel plane) is reduced. With a tractive force equal to the maximum possible friction force (i.e., sufficient to produce wheel spin), the maximum resultant friction force vector is aligned with the wheel plane and the side force capability is reduced to zero. This condition corresponds to the familiar rear end "spinout" that occurs during cornering with a front-engine, rear-wheel-drive vehicle when excessive engine torque is applied to the rear wheels.

Figure 3B shows the friction circle for braking conditions. Again, the radius of the circle represents the maximum possible friction force, which is equal to the product of the weight supported by the tire and the tire-pavement friction coefficient. With no braking applied to the wheel, the maximum side force can be equal to the radius of the friction circle. As the braking force is gradually increased, the maximum resultant friction force vector rotates toward an orientation opposing the direction of vehicle motion, and the maximum side-force capability (perpendicular to the wheel plane) is reduced. With a brake force sufficiently large to stop rotation of the wheel, the maximum resultant friction force vector opposes the direction of vehicle motion and is independent of the orientation of the wheel plane. Thus, steering inputs have no effect on the direction or magnitude of the resultant friction force. This condition corresponds to the familiar tangential departure from a turning maneuver when excessive braking is applied in relation to the prevailing tire-pavement friction coefficient.

This general approach to the modeling of tire properties is patterned after that of **Reference 5** and is used in the SMAC computer program.

Typical values for the cornering stiffness in lbs. per degree of slip angle are generally in the range of 16-17% of the load on the tire. Inputs defined solely on this basis for each of the tires on a vehicle will produce cornering forces corresponding to a "neutral steer" vehicle.

The steering characteristics of vehicles in cornering maneuvers can be classified as being either oversteer, neutral steer or understeer. For most automobiles, the relationship between the distribution of tire cornering stiffnesses and the vehicle weight distribution is designed to produce understeer.

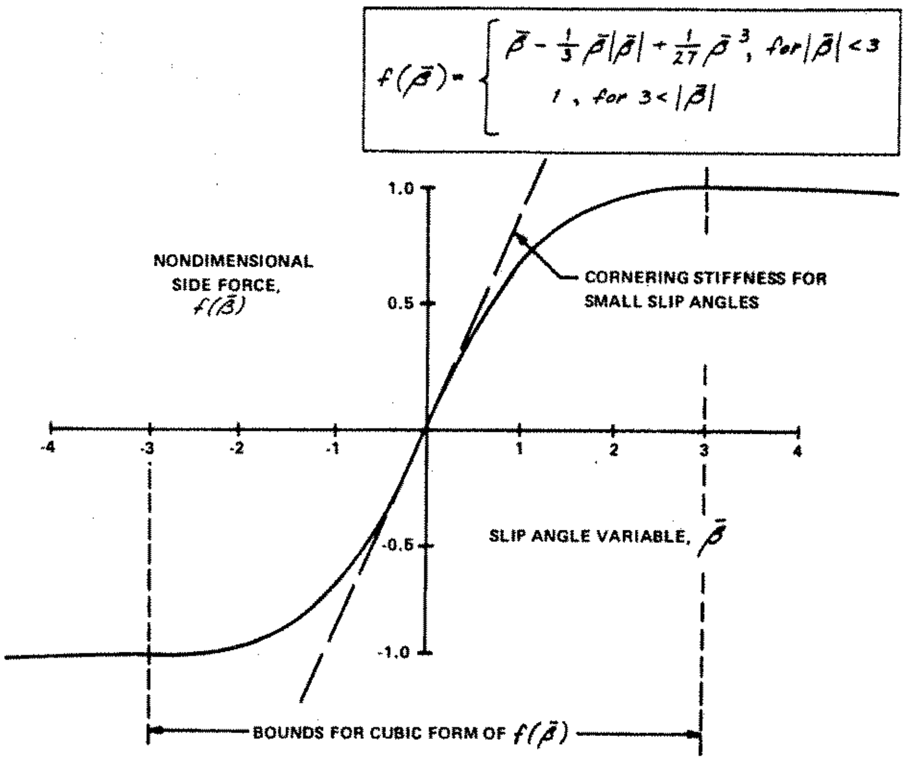

Figure 2 NonDimensional Tire Side-Force Curve

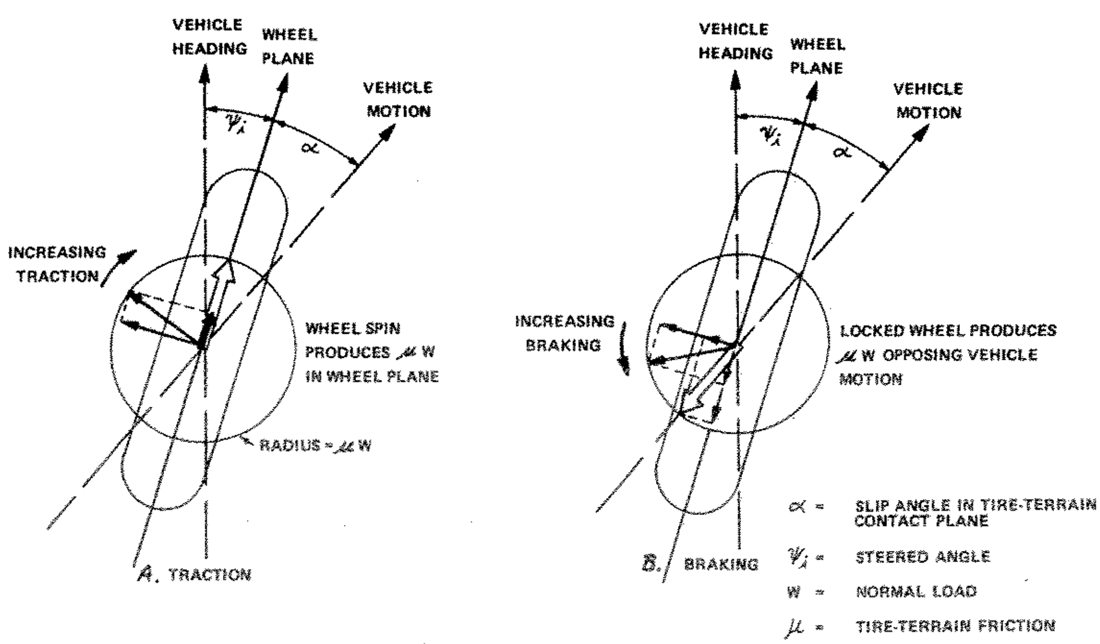

Figure 3 Friction Circle Concept, A. Traction, B. Braking