TOYO TIRE TALK

No. 06-001 (TTT-181)

Technical Service Department Japan

Technical tips and information that may allow you to provide better customer service.

We would appreciate your input, please contact us.

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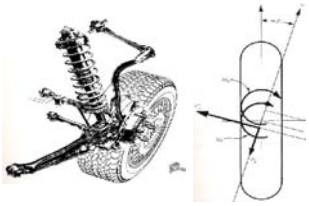
Date : 3rd February, 2006

Subject : Suspension and Tire Performance

-- Driving Performance and Sport Suspension



Introduction:

TTT-180 has technical information on 'Wheel Alignment'. This issue explains how tire performance is related to wheel alignment. Knowledge of this relationship is useful, especially for UHP sales and technical service people. In order to help understand this relationship, basic tire performance knowledge using a typical 'Sport Suspension' modification is explained. This knowledge can help with effective communication to UHP tire users and customers, by advise on the proper usage in order to help UHP tires perform best.

1. The Physics of Cornering.

(Tire Cornering Performance and its Mechanism).

As the driver steers during cornering, a slip angle is generated by the steering direction and the vehicle travel direction. When a slip angle occurs, the tire generates a cornering force to the centre of the turning radius. This cornering force leads to a vehicle's change in direction.

1-1. Cornering Force is Generated.

During a right turn,

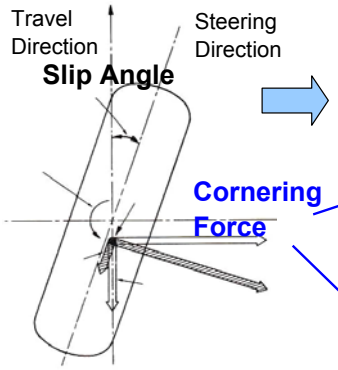


Figure 1. Tire drawing from the Upper Side Angle (Upper View)

A car doesn't travel in the steering direction immediately. This deviation between the Steering Direction and Travel Direction is the 'Slip Angle' .

A Side Force is generated according to this slip angle to the inner side (Figure 1).

The side force by the slip angle is called the 'Cornering Force' .

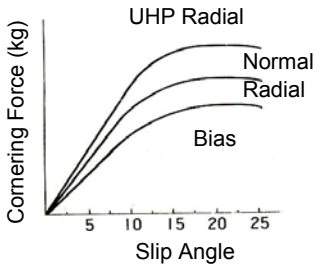
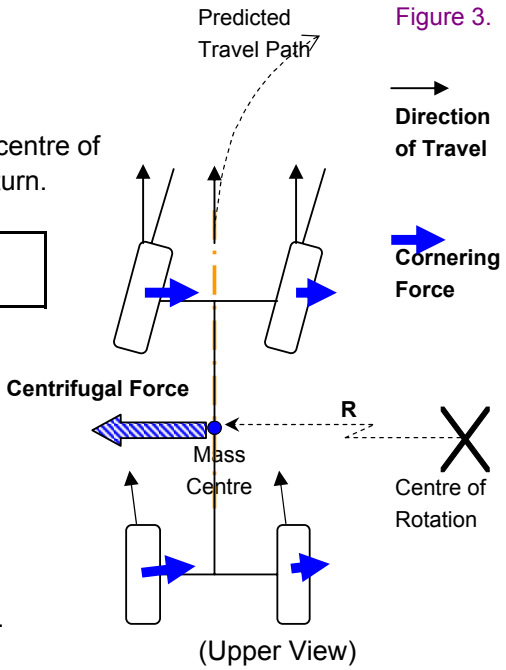


Figure 2.

UHP radial tires generally have a larger cornering force than normal radial tires.

So, how does the cornering force make the car turn?

Figure 3.



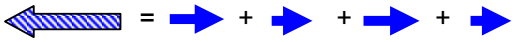
1-2. Car can Corner due to a Balance of Cornering Force and Centrifugal Force.

During a turn, **Centrifugal Force** is generated at the centre of the car's mass and is directed toward the outside of the turn.

Centrifugal Force = M V^2 / R

M = Mass (Weight) R = Turning Radius V = Velocity

The car is able to turn due to a balance between the Cornering Force and the Centrifugal Force.
Centrifugal Force = Sum of 4 wheel Cornering Forces



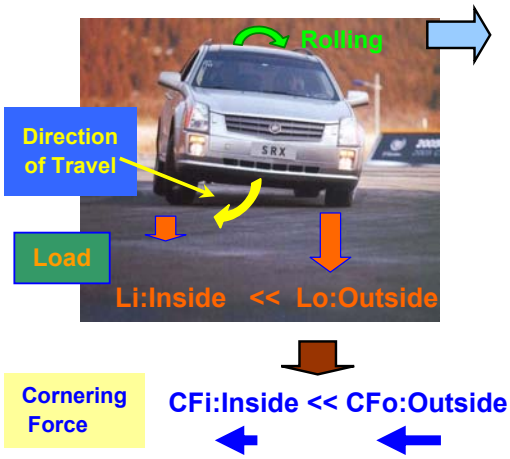
When cornering, for a sharp curve (R is small), the Centrifugal Force increases (according to the formula), so tires with high cornering performance should be used.

Tire Cornering Force makes the car turn!!

In this case we can actually see the car-rolling phenomena. Under these conditions, what is the difference of Cornering Force between tires?

1-3. Cornering Force on the Outside is Larger than on the Inside.

Figure 4.

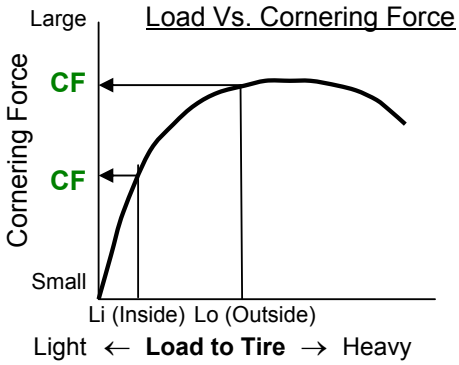


During cornering the load moves to the outside tires.

Cornering Force increases on the outside.

Cornering is mostly done with the outside tires!!

Figure 5.



The above has shown the basic tire features during cornering. The following will explain these same features during cornering in a car with a "Sport Tuned" Suspension.

2. The effect of a Tuned Suspension on Cornering Performance.

(Example of applying a typical 'Sport Tuned' Suspension).

By applying a 'Sport Tuned' Suspension, how is the wheel alignment altered?

2-1. Camber Adjustments when applying a Sport Suspension.

UHP users like to use sport suspensions that utilize a high tension springs and shorter spring lengths.

(Back View)

Normal Suspension → **Sport Suspension**

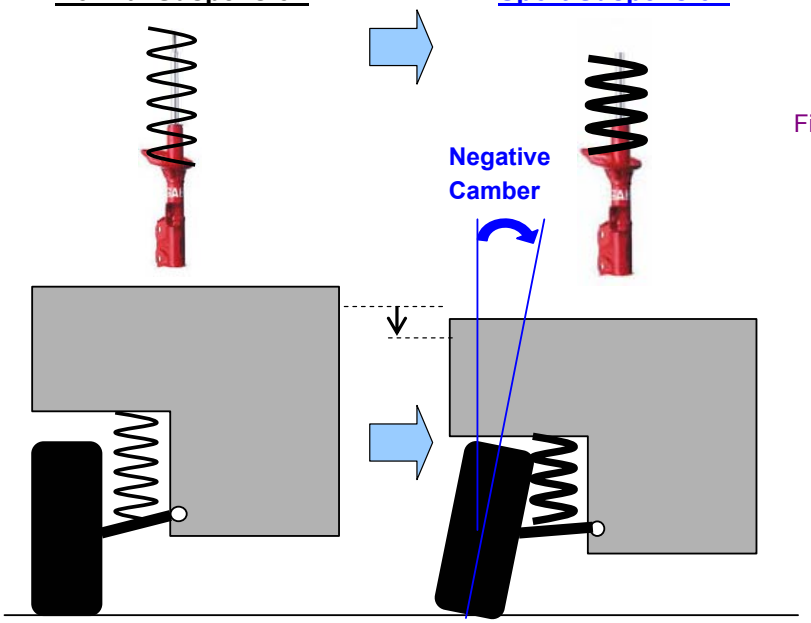
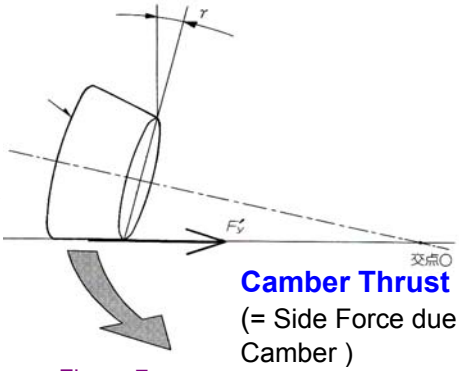


Figure 6.

Car height should be lower.
Camber should be negative.

Side Force (= Camber Thrust) is generated



Camber Thrust
(= Side Force due to Camber)

Figure 7.

Negative camber aids tire travel to the inside direction.

How is driving performance affected by this Camber Thrust with Negative Camber in actual driving conditions?

Reference : Camber

Definition of 'Positive Camber' and 'Negative Camber'.

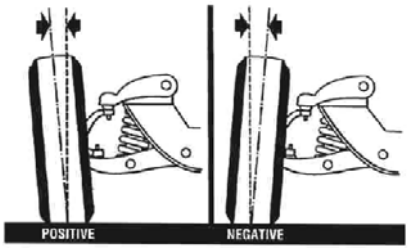


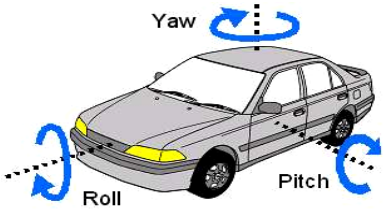
Figure 8. (Back View)

Continued on the next page.

2-2. Driving Performance Improvement by Negative Camber.

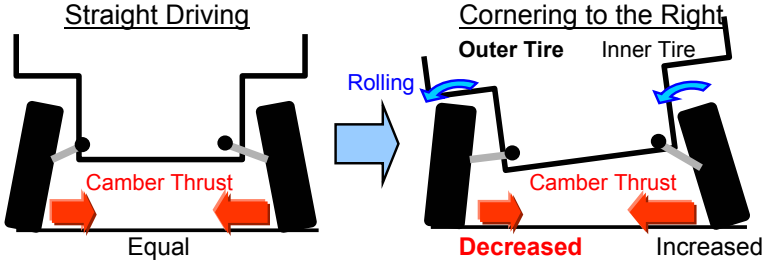
Pay attention to the outside tires (which are dominant during cornering as described in Sec.1-3). When cornering to the right, the car will roll to the left around the roll axle.

Figure 9.



1) Camber Thrust Change while Cornering.

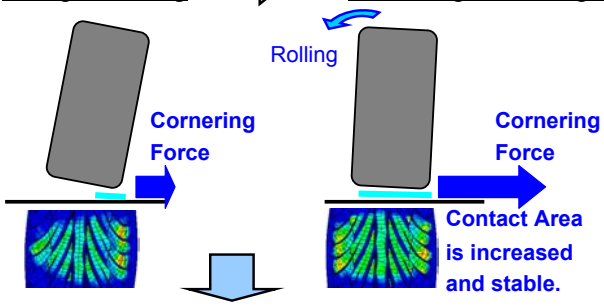
Figure 10. (Back View)



Rolling is reduced on cars with a shorter spring height.

2) Change of the Cornering Force (by Slip Angle).
(The drawing is from the back view).

Figure 11. Outside Tire (Back View)



Cornering Force is Increased while steering to the right side.

Outer Tire

Totally (Outer Tire)

1) Camber Thrust - Decreased
+
2) Cornering Force - Increased

Result : Side Force is Increased (Compared to normal camber condition).

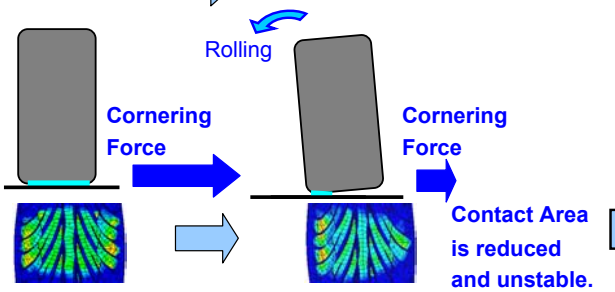
Cornering Performance with Negative Camber is greater than with Zero Camber!

On the contrary, how about the performance in the case of Zero or Positive Camber?

2-3. Driving performance with Zero Camber.

Change of the Cornering Force (by Slip Angle).
Outside Tire (Back View)

Figure 12. Case of Zero Camber



In the case of Positive Camber, the Contact Area is further reduced and is even more unstable.

Cornering Force is reduced with Zero Camber.

Negative camber improves cornering performance!!

3. Summary

Let's briefly consider tire cornering performance with UHP tires by reviewing the explanations described in previous sections.

In the case of a tire having a wide contact area, the cornering force is larger than on a narrow tire. UHP tires have a wider tread width and a larger contact area compared to normal (standard) tires. That means a car with UHP tires can corner at higher speeds and in a smaller radius.

When UHP tires are used in conjunction with a properly tuned sport suspension, the cornering performance is greatly improved.

Pay attention not to make excessive tuning changes, like high camber angles, which will lead to irregular wear or tire separation (which was described in TTT-180 in more detail).

As well for reinforced UHP tire sizes, especially those which have higher Load Indices compared to normal UHP sizes, tire pressures should be set higher according to the tire load carrying capacity table in the tire standards manuals. If not, such reinforced sized UHP tires may easily suffer from failures as described as in above in tuning conditions.