TOYO TIRE TALK

No. 05-012 (TTT-180)

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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17th November, 2005

Subject : Wheel Alignment

--- Basic Knowledge for Passenger Cars ---

Introduction

Tires can achieve their optimum performance when many influencing factors are married and maintained properly. One very important factor is the vehicle's 'Wheel Alignment'.

UHP tire users, especially, like to have excessive alignment settings to improve driving performance. TOYO has been very active in sales of UHP tires recently, so we should have some basic knowledge of 'Wheel Alignment'.

As wheel alignment is related with a car's suspension, and both affect driving performance, we shall at first briefly explain car suspension.

(Different types of suspension are not explained here.)

1. What is Suspension? - General Information

Suspension : Spring & Damper

Sprung Weight

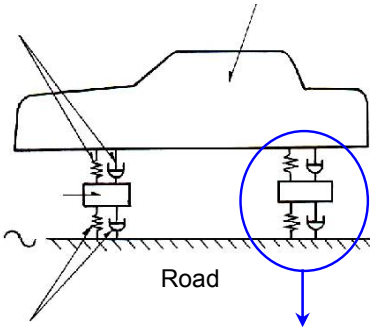


Figure 1.

Basic Function :

1. To support the vehicle's weight.
2. To avoid vehicle body shake by absorbing vibrations on rough road conditions.
3. To make the tire/wheel achieve designed performance - traction or braking - by pressuring them to the ground.
4. To ensure driving stability by setting a most suitable position against several forces from the tire/wheel and car body.

More detailed information shall be explained in the next section.

2. Suspension Components

The suspension consists of several components, as follows :

1) Spring --- To reduce vibration.
2) Shock Absorber --- To suppress free vibration (suppress vibrations quickly).
3) Arm --- To support 1) and 2), and set the car body and wheel/tire in position.
4) Rubber Bush --- To set link structure between others.

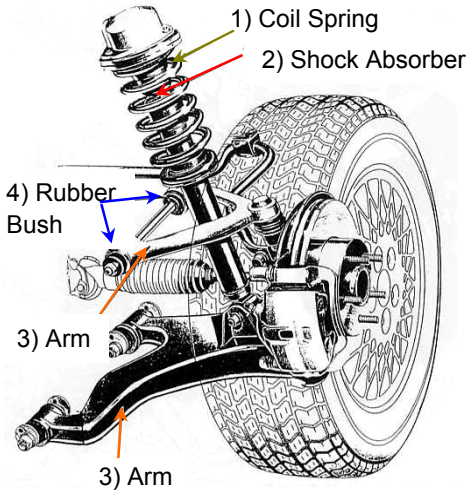


Figure 2.

Suspension performance consists of the combination of these components, and is also related to 'wheel alignment'.

Wheel alignment is necessary to ensure driving performance.

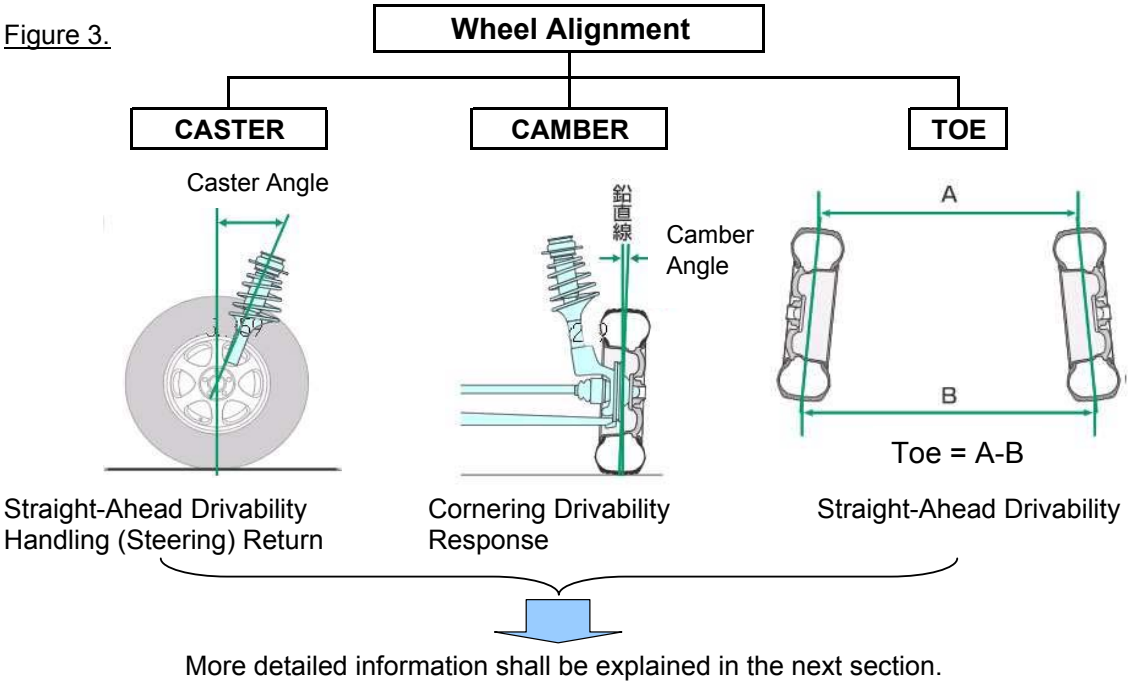
We shall explain 'Wheel Alignment' as an important factor in tire performance.

3. Wheel Alignment : Abstract of Three Fundamental Elements

A tire is set in position due to a combination of the three following elements, the purpose being to ensure driving stability.

The relative driving performance of each element is described briefly.

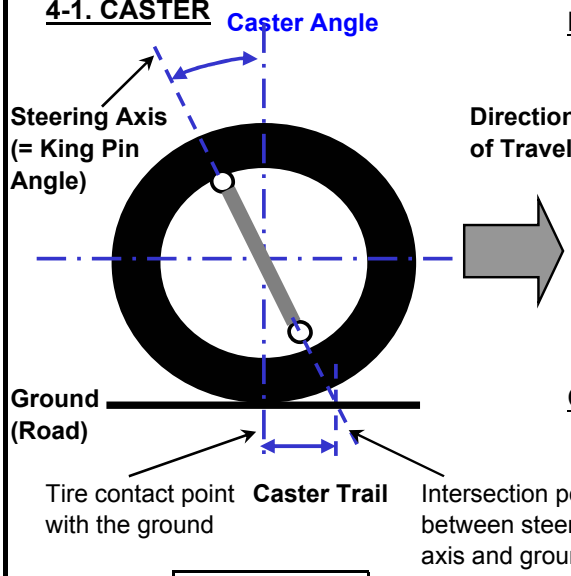
Figure 3.



More detailed information shall be explained in the next section.

4. Wheel Alignment : The Faculty of Three elements

4-1. CASTER



Side View

Purpose:

The King Pin is usually set so that tire contact point with the ground is behind the intersection point between the steering axis and the ground.

↓

This forces the tire to always go ahead.

↓

This improves Straight-Ahead Drivability, and improves Handling/Steering Return.

Characteristics:

Larger Caster Angle -

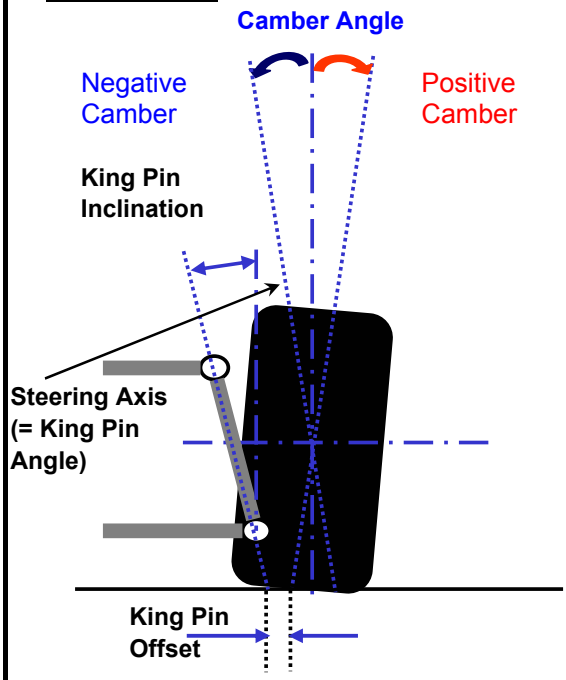
- Merit - Better Straight-Ahead Drivability
  Better Steering Wheel Return
- Demerit - Heavier Steering

Caster Angle - rough guide:

FF type vehicle = 1 to 3 degrees
FR type vehicle = 3 to 10 degrees } Picked from car catalogues

(There are no special national standards. We should refer to the setting indications in each car catalogue).

4-2. CAMBER



Back View

King Pin Offset : Distance between the centre of tire contact and Steering Axis

Purpose:

1. Improve Steering Control Performance (which is related with King Pin Offset).
2. Improve Cornering Performance.

Characteristics:

Larger Positive Angle (King Pin Offset is smaller)

- Merit - Better Handling Control
  Better Handling/Steering Return
- Demerit - Reduced Cornering Capacity *

Larger Negative Angle (King Pin Offset is larger)

- Merit - Better Initial Handling Response
  Better Cornering Capacity *
- Demerit - Reduced Handling Control

(* Cornering Capacity - Safety on Cornering Speed or Radius)

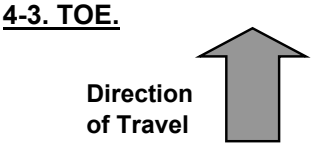
Camber Angle - rough guide:

Excessive camber angle induces tire troubles. Refer to the indications in each car catalogue. Regulations are only seen in the ETRTO Standards Manual.

→ Refer to Section 5 for more detail.

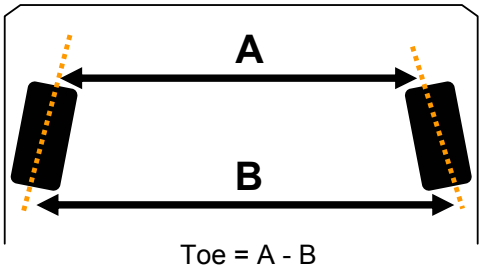
The effects on driving performance by Camber will be introduced in more detail in a following

4-3. TOE.



Upper View

A < B = Toe-In
A > B = Toe-Out



Toe = A - B

Purpose:

By setting the most appropriate Toe condition with the correct Camber condition, driving performance is well arranged to :

1. Improve Straight Drivability.
2. Improve Handling Response.

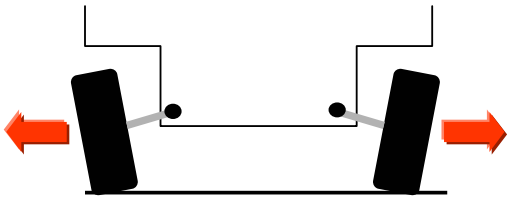
The Case.

According to the Camber condition, the Toe-In or Toe-Out settings are adapted as follows to :

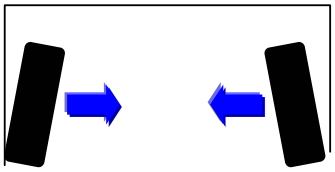
- avoid irregular wear, and
- balance side forces by Camber and by Toe for high speed driving performance.

Back View **Upper View**

Camber : Positive → Toe : In



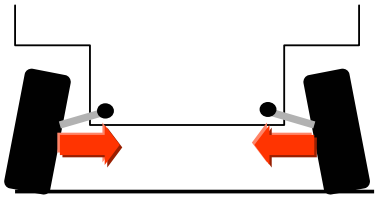
Positive Camber generates
Side Force to the outside.



Toe-In generates
Side Force to the inside.

Balanced
Side Force.

Camber : Negative → Toe : Out



Negative Camber generates
Side Force to the inside.

Toe-Out generates
Side Force to the outside.

Balanced
Side Force.

Toe Amount - rough guide:

Generally :

Toe-In is set for general passenger cars.
Toe-Out is set for competition cars.

The effects on driving performance by Side Force will be introduced in more detail in a following TTT.

5. Notes on Setting Excessive Camber by Tuning

In the case of excessive camber, some tire failures occur whether the camber angle is positive or negative.

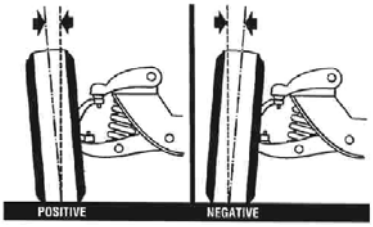


Figure 4.

5-1. Irregular Wear

Excessive camber condition will cause shoulder wear at an early stage of tread wear.

Excessive camber angle condition.

⇩

Increased contact pressure on the tire shoulder area, yielding "Drag Force" on tire shoulder area.

⇩

Leads to shoulder wear →

Figure 5. **Severe Shoulder Wear**

This is similar to the phenomena caused by hard driving.

5-2. Braking Performance

In straight travelling, excessive camber condition reduces the tire contact area, which in turn **decreases braking performance** (braking distance is longer and/or unstable).

5-3. Endurance

Generally high angle camber conditions will decrease tire endurance performance, especially **a large decrease in high speed endurance.**

5-4. Regulation

Camber angle is specified by the car manufacturer for each model. These can be seen in car manuals. ETRTO (The European Tyre and Rim Technical Organisation) also stipulates general recommendations on camber in relation to tires (see the following).

'ETRTO Standards Manual' Reference Information.

Information on camber angle and other related conditions:

1) General recommendation : Should not be greater than 4 degrees
2) Vehicle speed in excess of 270 km/h : Should not be greater than 3 degrees including any tolerance.
3) Maximum camber angles for different aspect ratios :

Aspect Ratio	50 and above	45	40	35	30	25	20
Maximum Camber Angle (degrees)	4	3	3	2	2	2	2

Other requirements:

4) The standard correction (reduction) in Tire Load Carrying Capacity should be applied for tires operating above 160km/h.
5) To compensate for camber angle, instead of a reduction in tire load capacity, inflation pressure may be increased to a maximum of 350 kPa.

→ For further details refer to the 'ETRTO Engineering Design Information' Manual, or contact Toyo's Technical Service Department.

This ETRTO Standards information is a helpful guidance to avoid tire troubles, like irregular wear, tire separation and tire burst.

Finally, we request you inform your customers on the proper settings, and tire use, to maximize our tire's performance!!