1-1 Basic Tire Function

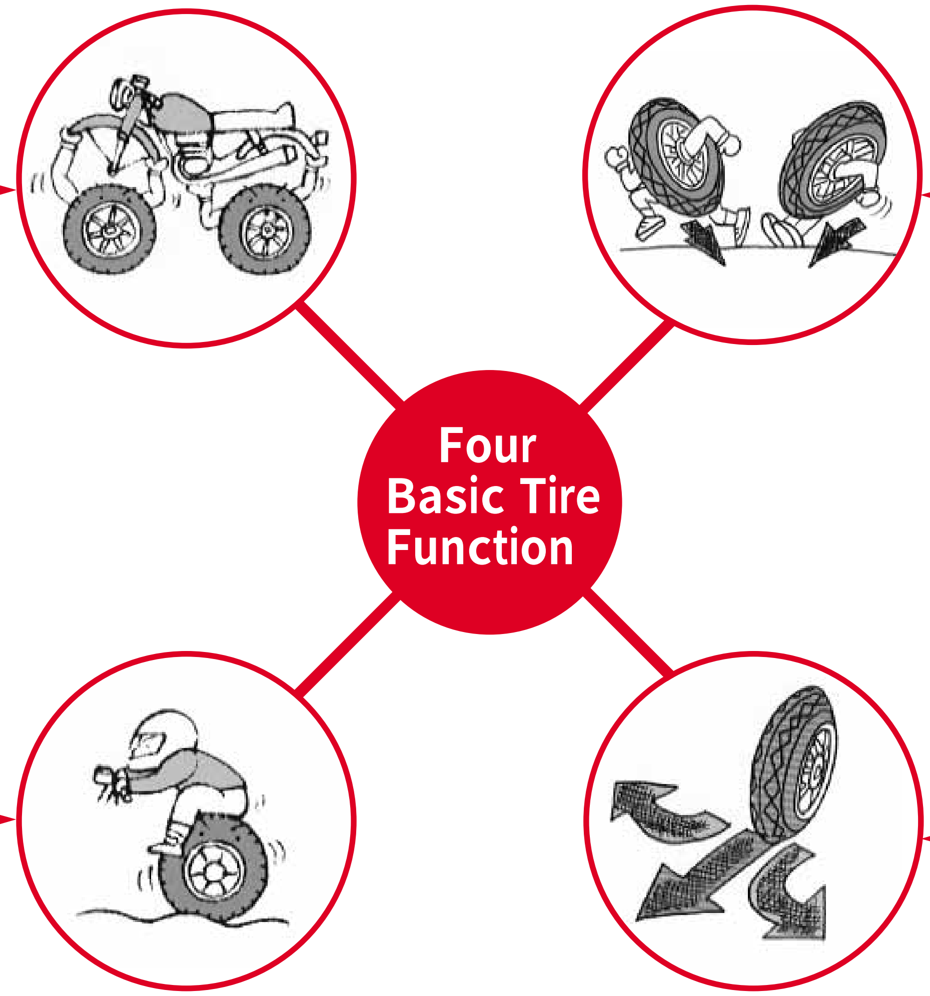
Motorcycle tires must perform main functions:

1・They must support vehicle load.

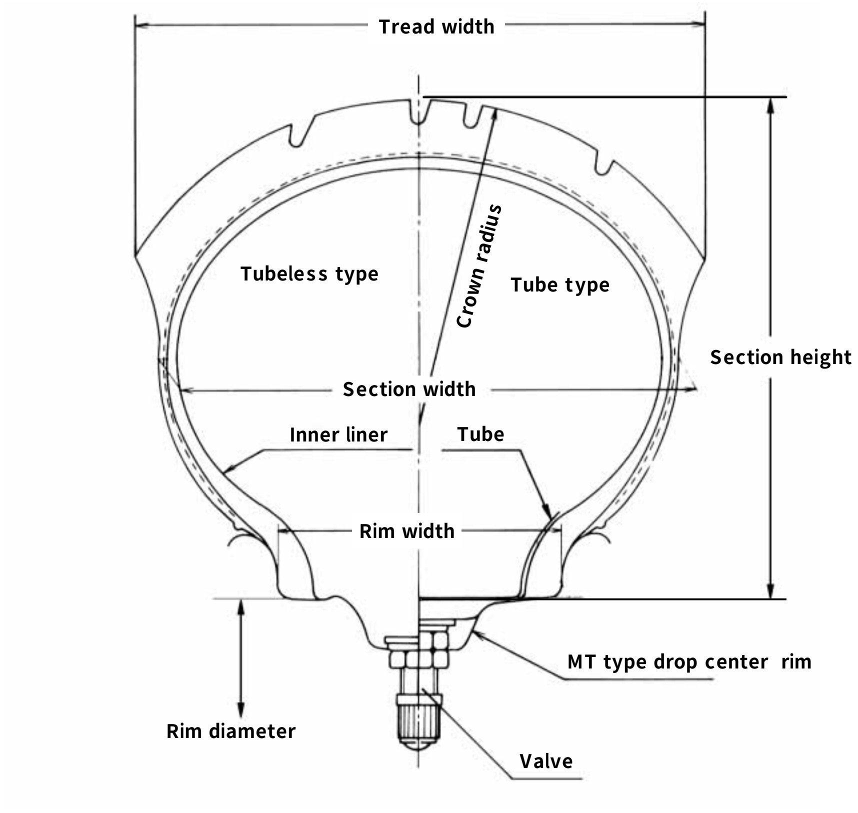
2・They must transmit traction and braking forces to the road surface.

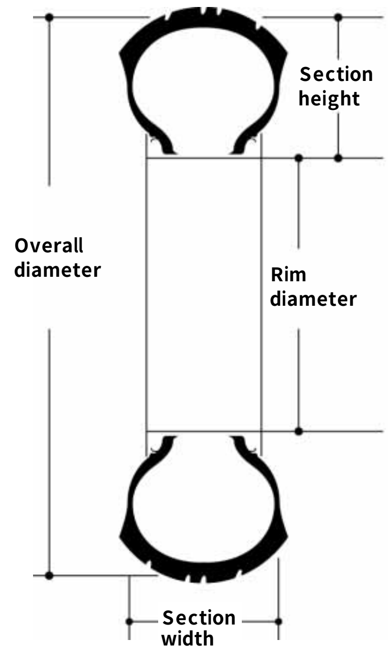
3・They must absoring shocks from the road surface.

4・They must Changing & maintaining the direction of travel.



1-2 Motorcycle Tire Dimensions



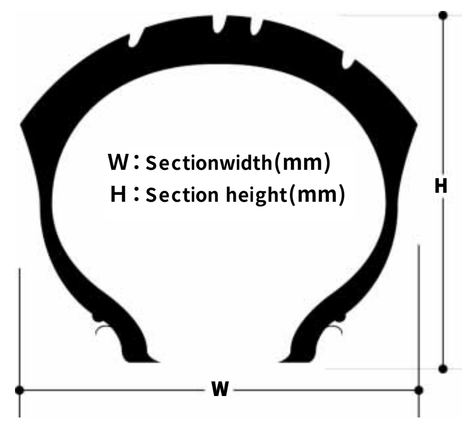


The simensions of a motorcycle tire are indicated here.In contrast to other types of tires,the tread width of motorcycle tires is normally wider than the section width.The section width included in the size marking of tires.A tire marked "120/90-18" means that the section width of the tire is 120 mm.

Most motorcycle rims used tod are MT type drop center rims.We call this a "hmp-up" type of rim.this type of rim is used for tubeless tires because it helps keep the bead portion of the tire in place even if the tire is punctured.About ten years ago we did not have this type of rim because most of the motorcycle tires still tube type.

Other important dimensions include the overall diameter,section height,crown radius rim diameter.

The "Aspect Ratio"is defined as the ratio of the section height divided by the section width multiplied by one hundred.



$$\text{Aspect Ratio} = \frac{\text{Section height}}{\text{Section width}} \times 100$$

1-3 According to Size Designations

*Inch designations

4.00 H 18 4PR

- 4PR: Casing strength (ply rating)
- 18: Rim diameter
- H: Speed rating
- 4.00: Tire width (inches)

* Metric designations

130 / 80 - 18 66 H

- H: Speed rating
- 66: Load rating
- 18: Rim diameter (inches)
- 80: Aspect ratio (80%)
- 130: Tire width (mm)

* Alhabetical designations

M T 90 - 16 LOAD RANGE B

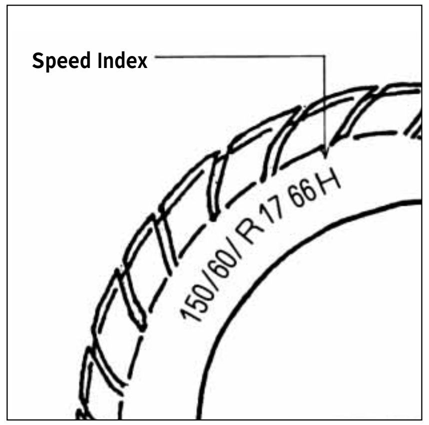
- LOAD RANGE B: Load rating
- 16: Rim diameter (inches)
- 90: Aspect ratio (90%)
- T: Tire width code
- M: Motorcycle code

* Racing tire designations (for Bridgestone)

180 / 630 - 17

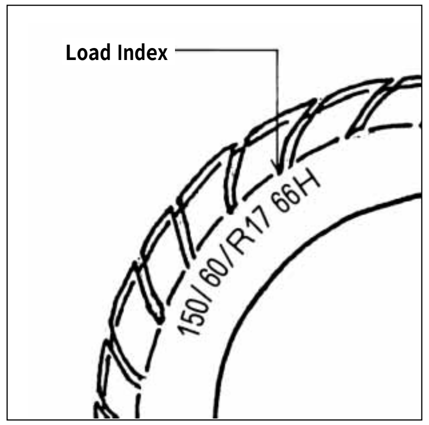
- 17: Rim diameter (inches)
- 630: Overall diameter
- 180: Tire width (mm)

1-4 Speed Index



Speed Index	Maximum Speed Km/h	Speed Index	Maximum Speed Km/h	Speed Index	Maximum Speed Km/h	Speed Index	Maximum Speed Km/h
A1	5	B	50	L	120	U	200
A2	10	C	60	M	130	H	210
A3	15	D	65	N	140	V	240
A4	20	E	70	P	150	Z	240over
A5	25	F	80	Q	160	W	270
A6	30	G	90	R	170	(W)	270over
A7	35	J	100	S	180		
A8	40	K	110	T	190		

1-5 Correlation between Laod Index (LI) and Tire Load-Capacity (TLCC)



LI	TLCC (kg)	LI	TLCC (kg)	LI	TLCC (kg)	LI	TLCC (kg)	LI	TLCC (kg)	LI	TLCC (kg)
		30	106	40	140	50	190	60	250	70	335
21	82.5	31	109	41	145	51	195	61	257	71	345
22	85	32	112	42	150	52	200	62	265	72	355
23	87,5	33	115	43	155	53	206	63	272	73	365
24	90	34	118	44	160	54	212	64	280	74	375
25	92,5	35	121	45	165	55	218	65	290	75	387
26	95	36	125	46	170	56	224	66	300	76	400
27	97,5	37	128	47	175	57	230	67	307	77	412
28	100	38	132	48	180	58	236	68	315	78	425
29	103	39	136	49	185	59	243	69	325	79	437

1-6 According to speeds

Type		Maximum speed(km/h) km/h	(mph)
Motorcycle use	On-road N type	150**	93
	On-road S type	180	112
	On-road H type	210	130
	On-road V type	>210**	>130**
Scooter use		100	62
Flotation type(low I.P)		80	50

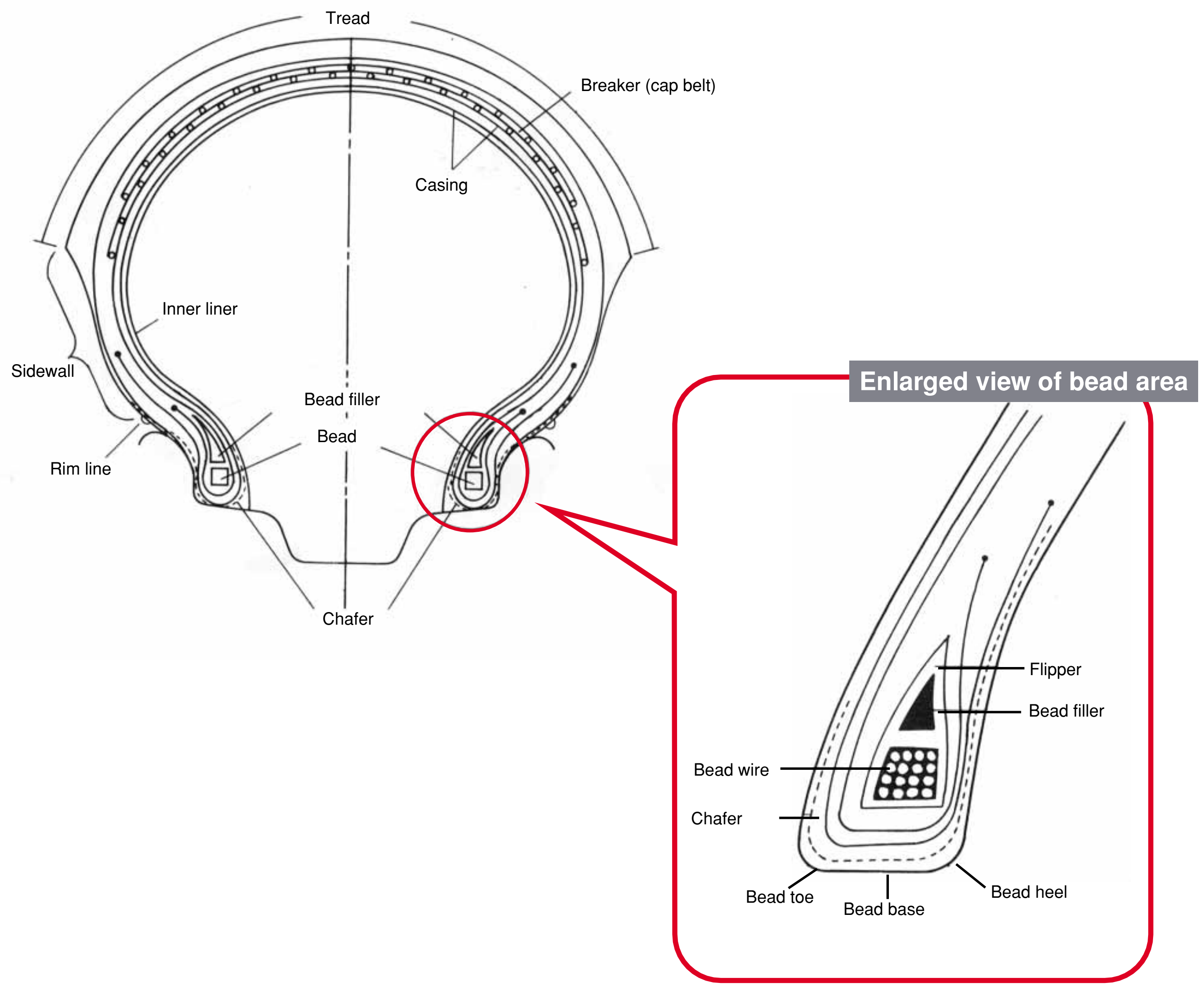
*Tire with2.00,2.25 & 2.50 nomonal section widths are for 120 km/h.(75 Mile/h)
**On-road V type tires are made for export.

1-7 According to Aspect Ratios

Aspect ratio	Size	Indentification
Standard(94～100)	2. $\boxed{00}$ -14	Numbers in box:00,25,50,75
100 Series	80/ $\boxed{100}$ -18	100=aspect ratio
90 Series	120/ $\boxed{90}$ -18	90=aspect ratio
80 Series	4. $\boxed{6}$ OH18	Numbers in box:1,6
70 Series	140/ $\boxed{70}$ -18	70=aspect ratio

1-8 Motorcycle Tire Parts

Motorcycle Tire Parts



The construction of motorcycle tires is basically the same that of passenger and light truck tires. The unique difference, however, is its shape-the crown area of a motorcycle tire is quite rounded.

The casing of the tire in this illustration begins on the inside and is turned up around the beads. Two actual casing plies are shown here which would normally correspond to a four ply rating. On the top of the casing and underneath the tread area of the tire, the breakers or belts are applied. Breakers are usd for bias ply construction tires and belts for radial construction tires. The term "breaker" evolved from the fact these layers of reinforcing material were meant to break the impact of shocks in the tread area of the tire, protecting the casing. Breakers are normally made of nylon while belts for radial tries are usually steel or aramid cord.

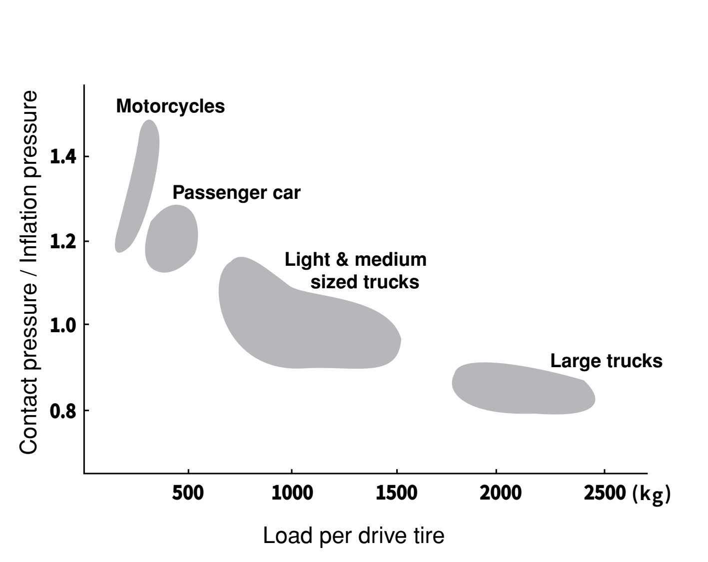
In the enlarged drawing of the tire's "bead area", you can see the bead wire the bead filter. The bead filter increases tire stiffness in the bead area. If, for example, the stiffness of this area is insufficient, the motorcycle will not be stable when cornering and tire vibration might occur. A hard rubber compound is used for the bead filter. A protecting ply called a "chafer" is wrapped around the bead area the bead area to protect it from being damaged by rubbing (or "chafing") on the rim.

1-9 Special Features of Motorcycle Tires

Use conditions

Motorcycle tires exhibit several characteristics according to their application. One of these features can be seen in this graph. The vertical axis shows the ratio of contact pressure to inflation pressure while the horizontal axis shows the load per drive tire. Note that the drive tires of trucks support about 2000 kilograms per tire and that the contact pressure to inflation pressure ratio is about 0.8 Motorcycle tires, however, are on the other end of the scale. The load per tire is around 250 kilograms but the ratio of the contact pressure to the inflation pressure can exceed 1.4- almost twice the value for truck tires. This means that the load per square centimeter for motorcycle tires is very concentrated.

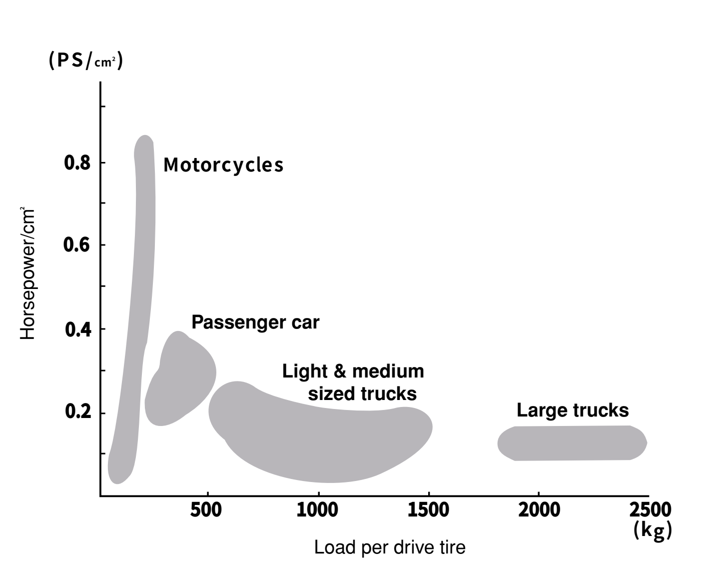
Load on drive tires vs.ratio of contact pressure to inflation pressure



The ratio off the contact pressure to the inflation pressure is relatively high for the tire load.

Motorcycle tires are used under very different conditions than other types of tires.

Horsepower per unit of contact pressure



Horsepower per unit of contact area is very high (2X's the maximum level for passener cars and about 5X's that for trucks).

Motorcycle tires are used under very different conditions than other types of tires.

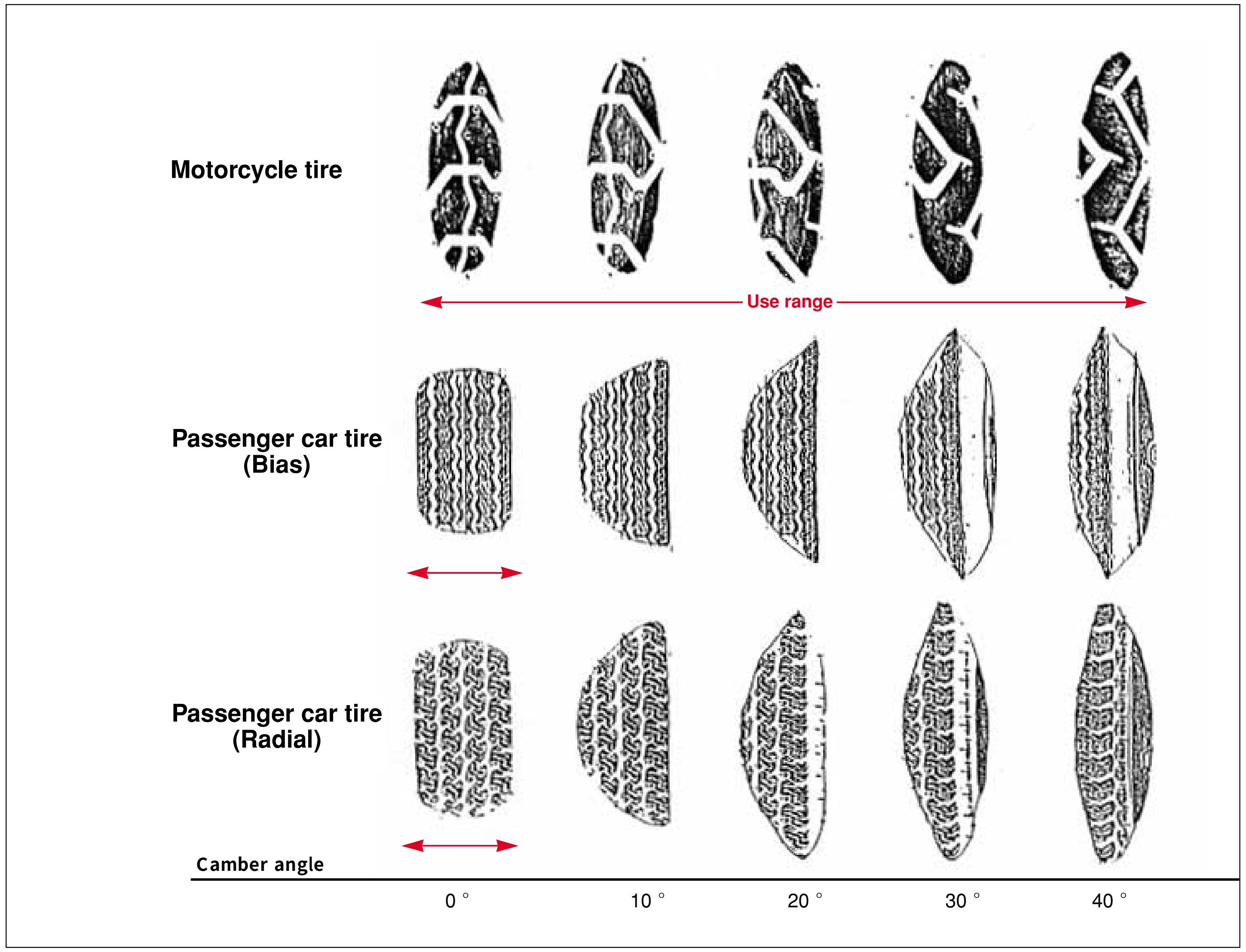
We can also see that the horsepower per unit of contact area is very high as compared to other types of tires-nearly twice as high as the maximum value for passenger cars and five times that for trucks. The large variation in the amounts is due to the many different sizes of motorcycles. Larger motorcycles would be on the upper end of the scale. The horsepower acting on one unit area of tread for motorcycles is much higher than that for trucks.

1-10 Special Characteristics of Motorcycle Tires

Change of contact area with camber angle

A Large Camber Angle Is Used When Turning

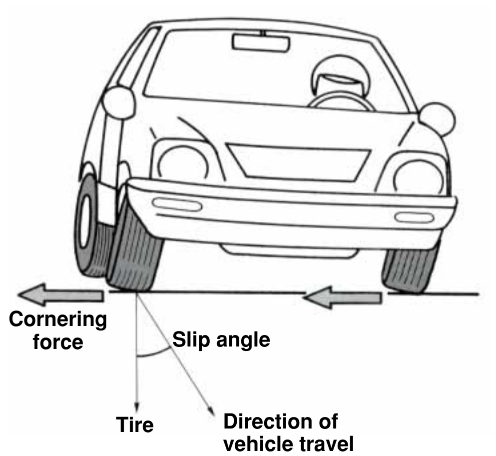
Another special characteristic of motorcycle tires is the use of large camber angles when tuning. For passenger tires, the maximum camber angle is normally 5, but for motorcycles, it can be as 50 in corners. Although it c not occur under normal operating conditions, when a passenger car tire has a camber angle of around 30 or more, it is running on the sidewall. Motorcycle tires, however, are designed so that the contact area will not chance when high camber angles are used. This is done by extending the tread surface from sidewall to sidewall.



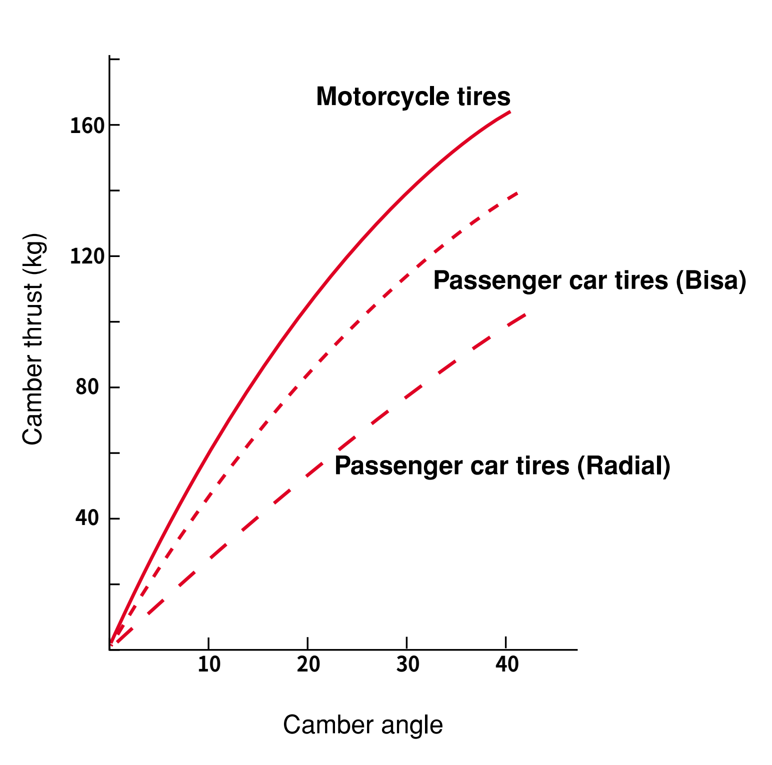
Motorcycle tires have acrown contour and basic construction which produces a minimal change in contact area when turnig.

The Effect of Camber Thrust Is Large

When a motorcycle is cornering, the camber thrust produced by the tire in response to the camber angle is quite high and offsets the centrifugal force. For passenger car tires, however, the camber thrust is much lower. Aradial passenger car tire will produce only about 50 kilograms of camber thrust at a camber angle of 20. A motorcycle tire will produce around two times that amount at the same angle. For this reason, the sidewall area of motorcycle tires must be very stiff to endure this amount of camber thrust. This is one reason why we use the cap layer construction.

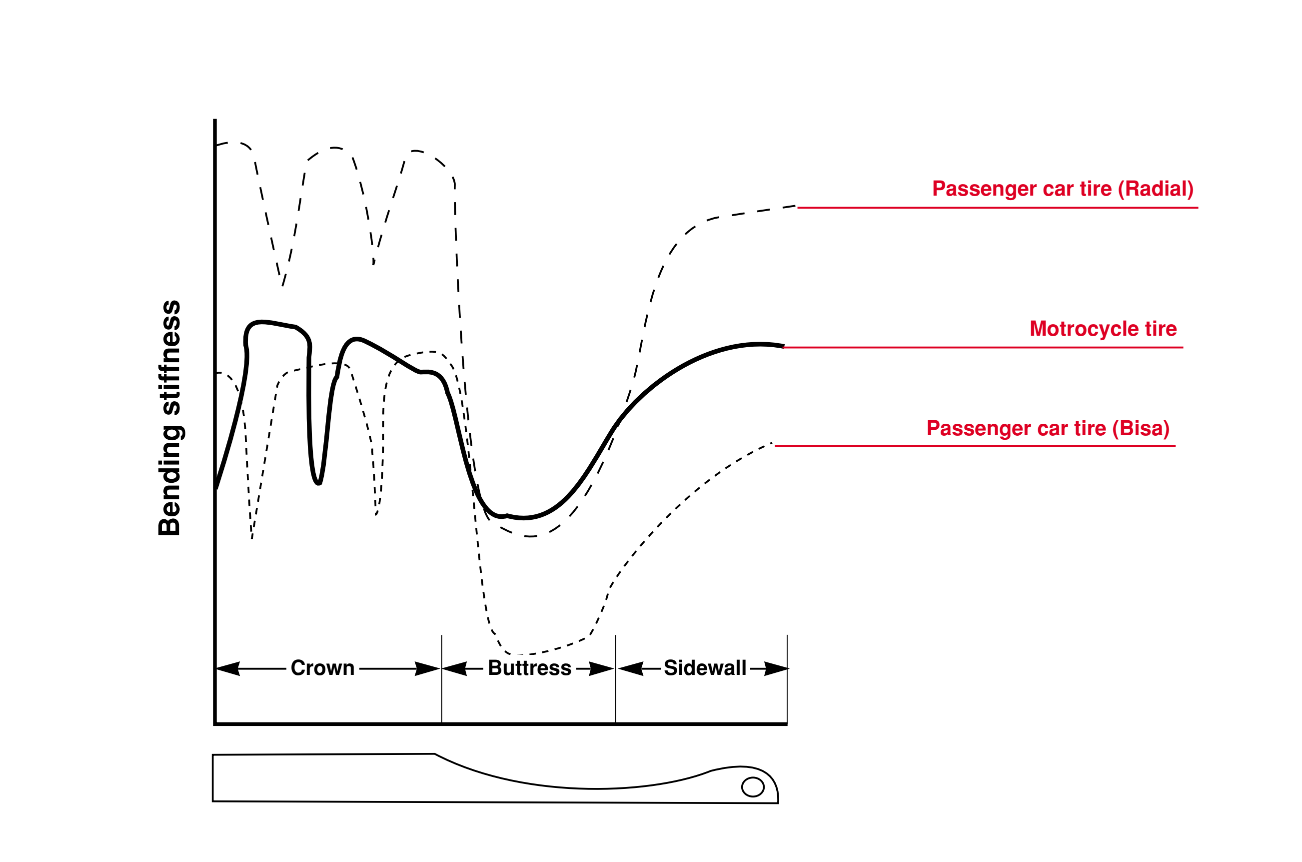


Tire type vs.camber thrust



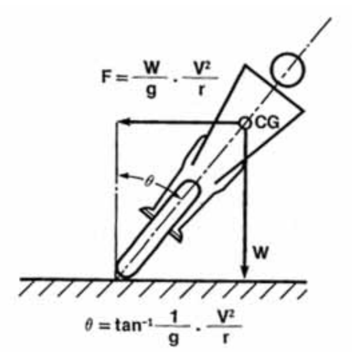
High and Uniformly Distributed Casing Stiffness

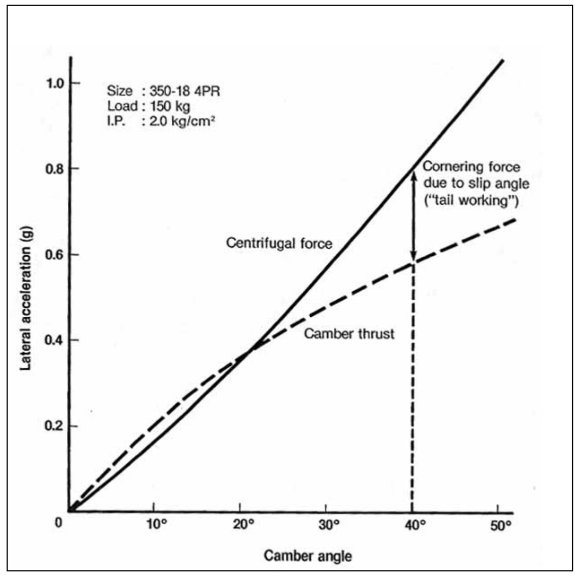
If radial motorcycle tires were constructed the same way radial passenger car tires are, the sidewalls would be too soft. This would mean that the tire would not be able to produce the necessary amount of camber thrust. To counteract this, we apply an extra-hard bead filler, one or two "cap-layers" which extend down the sidewall, and several other components such as special chafers and/or flippers to increase the stiffness of the sidewall. These additional materials increase the overall cost of the tire to about two times that of a bias motorcycle tire of the same size. This is one of the biggest problems confronting us.



The graph on page 5-006 is included to illustrate the fact that not all of the cornering force for motorcycles can be classified as camber thrust. Additional cornering force due to a slip angle is also present-much like the case for passenger cars. This type of cornering force therefore makes up the rest of the overall cornering force. This is often called "tail work - ing".

θ :Camber angle(angle of bank)
W:Overall weight(rider plus vehicle)
V :Speed
r :Cornering radius
g :Acceleration of gravity





Glossary of Terms

The technical terms found here are useful for standardizing the nomenclature used to describe various aspects of motorcycle performance factors.

1. Shimmy is usually related to steering and is sometimes called "Steering shimmy". It is defined as "left and right vibration of the steering of the assembly while driving in a straightline". Shimmy is direly related it the match of the motorcycle and tires. An example of a difficult matching problem can be seen in the newly developed Suzuki GSXR750. The frame of this motorcycle is very light for its engine size and therefore the horsepower to weight ratio is quite high. Usually the weight of a 750 cc motorcycle would be around 220-240 kilograms but the weight of the Suzuki GSXR750 is less than 200 kilograms. This makes matching a tire to the machine very difficult.

2."Wobble" affects both the steering alone and the motorcycle frame. Wobbling is normally caused by ununiformity of the tires. For example, each tire may not be perfectly round or the rim may be bent. As a result, vibration of the motorcycle may occur. Various tire related factors are also listed. Casing stiffness means that the stiffness of the casing around the circumference of the tire is nor even.

3."Rain grooves" are grooves cut in the road surface which channel away rain water, preventing tire from hydroplaning. If the tread pattern happens to be designed so that two or more of the grooves in the line up with two or more the grooves in the road, forces are generated which make the tire pull to one side. This can cause directional instability. Bridgestone always considers this when designing tires for the U.S.A. Often a zig-zag type pattern is implimented to overcome the problem.

1.Shimmy

Left and right vibration of the steering assembly while driving in a straight line.

Low speed shimmy

Occurs when coasting down from around 80km/h, peaks at around 45-50km/h. (vibration frequency: 3-5Hz)

High-speed shimmy

Occurs at around 110-120km/h, the magnitude is small (vibration frequency: 10-15Hz)

Cause

A phase difference between the corning force and the self aligning toque.

Tire related factors

Wear stage, inflation pressure (high inflation pressure is better as it reduces the contact area), tread gauge, tread compound characteristics, casing stiffness, cord angle, etc.

2.Wobble

Left and right vibration of the motorcycle frame at high speeds. Occurs both on straight-aways and in corners and arises mainly from the rear wheel. (Vibration frequency: 2-3Hz)

Cause

Resonant vibration of the front and rear of the motorcycle caused by side forces arising from outside disturbances. In corners it is due to the imbalance of side forces from camber thrust, oversteer moment, cornering force and centrifugal force.

Tire related factors

Wear stage, inflation pressure, tread gauge, tread compound characteristics, casing stiffness, cord angle, balance of front and rear sizes.

3.Rain Grooves

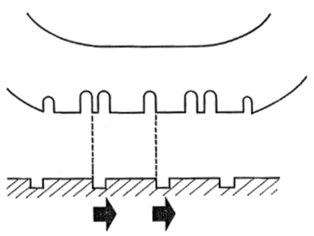
Rain grooves are grooves cut in the road surface for safer driving on wet surfaces. Some types are parallel to the vehicle direction of travel and others are perpendicular to it. In the U.S. the U.S. these are mainly found in California but their use is spreading to other states as well.
Left and right vibrations are caused which are transmitted to the motorcycle frame and steering assembly, leading to instability.

Cause

Tire tread pattern edges on the groove edges, forcing the tire to one side or the other.

Tire related factors

The contact of a number of tread pattern edges with the rain grooves at the same time must be prevented therefore "zig-zag" type patterns are used along with designs that equally distribute the contact pressure.



Special Motorcycle Terms

Wobbling and weaving are quite similar. Note that they both have frequencies in the same range (1-3 Hz).
Pitching occurs more frequently than wobbling or weaving. It is similar to the pitching of a ship and not very comfortable for the rider.

The term "slippery feeling" is rather difficult to describe but notice that not refer to the movement of the tire with respect to the road but rather to a shift due to deflection of the tire itself. It is similar to yawing in some ways.

Term	Phenomenon
Shimmy	Left and right vibration of the steering assembly Low speed shimmy: Occurs when coasting down from around 80km/h and peaks at around 45-50km/h. It can have various magnitudes and its frequency is about 6-5 Hz. High speed shimmy: Occurs at about 110-120km/h.Its magnitude is small and it has a frequency of about 10-15Hz.
Wobble(wobbling)	Left and right vibrations of the frame at high speeds (a yawing movement). It mainly arises from the rear and has a frequency of about 2 to 3 Hz.
Tail Working	Movement of the rear of the motorcycle during cornering-not skidding. The frequency range is around 1-3 Hz.
Pitching/Judder	Vertical vibrations in the same direction as the or travel. Similar to the phenomenon experienced when using tires with poor uniformity.
Sloppiness	A type of movement occurring during cornering and arising from the rear wheel. Although the tire follows the normal oath, the rim and suspension move in a slightly different path.
Slippery Feeling	A feeling that the motorcycle is just about break away. It is caused by growth of the tire overall diameter or load shifting toward the rear wheel.

Motorcycle Tire Demanded Performance

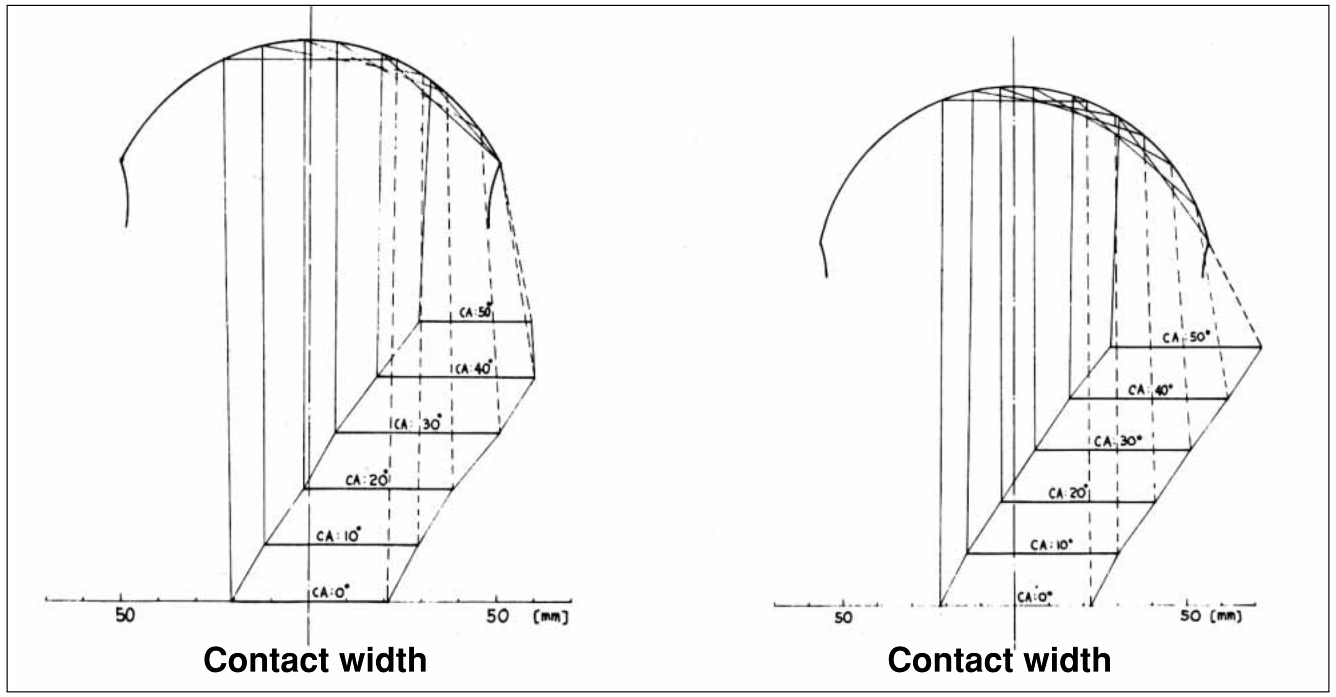
Motorcycle riders demand better handling and better mileage. To design tires, however, we need more detailed classifications of performance.
Straightaway stability, cornering stability and low-speed turning all refer to handling performance. Overall performance is actually a combination of these. What we to know are the smaller classifications. If riders mention handing, we must know what aspect of handling they are referring to.
Straightaway stability. When traveling in a straight line, the motorcycle will be stable even if the wind is blowing, etc. This term refers to outside influences. Some tires have poor stability when changing lanes to pass a car, etc. This could be the result of two influences. Stability with regard to outside influences and stability of the tire itself (e.g. when changing lanes).
Cornering stability. Taking a corner at high speeds can result in poor cornering stability. Steering must then be corrected. When a tire has good cornering stability, we can keep a constant steering angle.

Straightaway stability	Reduction of the influence of shock, etc. arising from outside influences (such as the road surface, wind, etc.) for smooth & stable straightaway performance
Cornering stability	Minimization of outside disturbances for stable and precise cornering
Low-speed turning	Ease and stability of turning at very low speeds
Grip	Balancing of front and rear grip at a high level during braking and cornering
Rain groove performance	Stable travel over rain grooves
Wear life	Resistance of tread rubber to wear.
High-speed durability	Sufficient durability at high speeds
Air holding & run flat performance	Resistance to air leakage during use, rim retention after sudden air loss
Pattern noise	Low noise generation level

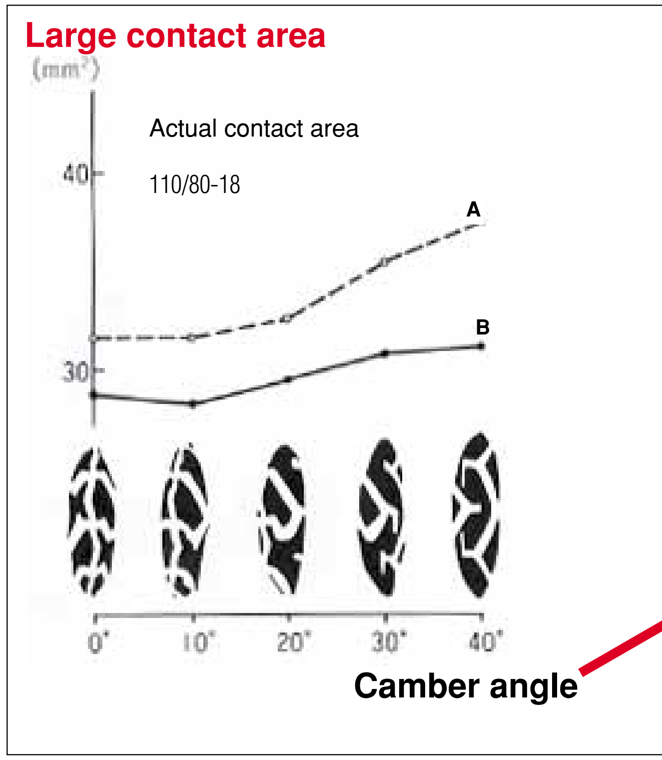
1-12 Motorcycle Tire Design

Shape

The contact width is shown here. If a tire is not designed well, its contact width will suddenly change when the bike leans over-in other words, when a camber angle is applied. When this happens during cornering, the grip is decreased and the bike becomes very hard to control. To solve this problem, we design the tires so they can maintain a constant contact width. Ten years ago the footrests of motorcycles would touch the ground at a camber angle of 35 to 40 degrees. Nowadays, however, riders can lean their bikes up to 50degrees-which often happens during circuit-type racing. We make tires so the contact patch will become large when bike is learning, increasing safety and stability.



Smooth transition of contact width with in camber angle

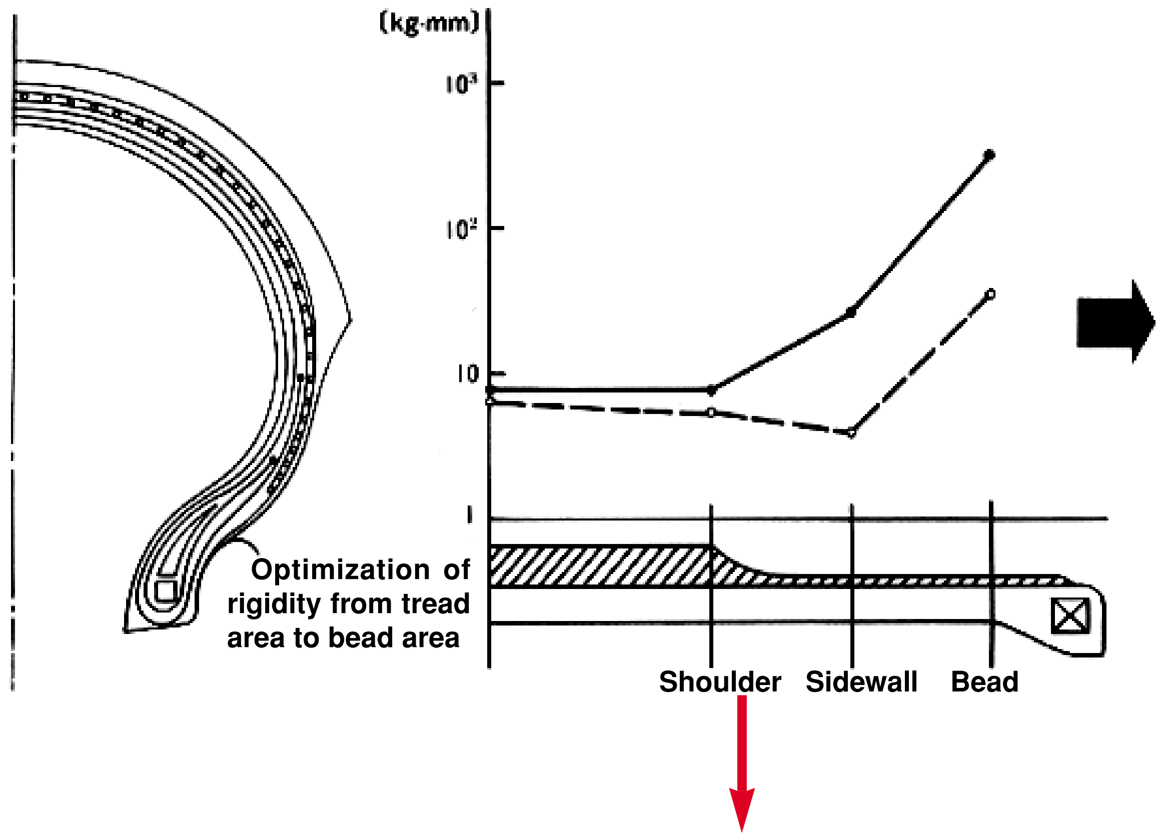


Gradual increase in contact area

Construction

The rigidity (bending stiffness) of normal tires is the same from the tread all way to the sidewall (i.e. the stiffness of the tread and buttress areas). For high performance motorcycle tires, however, engineers increase the stiffness of the shoulder and sidewall areas for better cornering and stability.

Proper stiffness distribution



Proper matching with the motorcycle

Materials

Grip is often referred to generally but if it is analyzed in detail, we find that there are two main kinds. One kind is the grip caused by friction-this refers to bonding or "sticking" that takes place between rubber molecules and the molecules and the road surface. This is due to adhesion.

Another kind of grip is caused by hysteresis loss which occurs when the tire deforms because of uneven read surfaces. This rubber deformation causes a loss of energy in the tires. For example, if 100% of the engine power is actually transmitted to the road surface, then there would be no loss of energy. If, however, due to deformation, five to ten percent of the power is lost before it reaches the road surface, this is called a hysteresis loss and results in generation of grip.

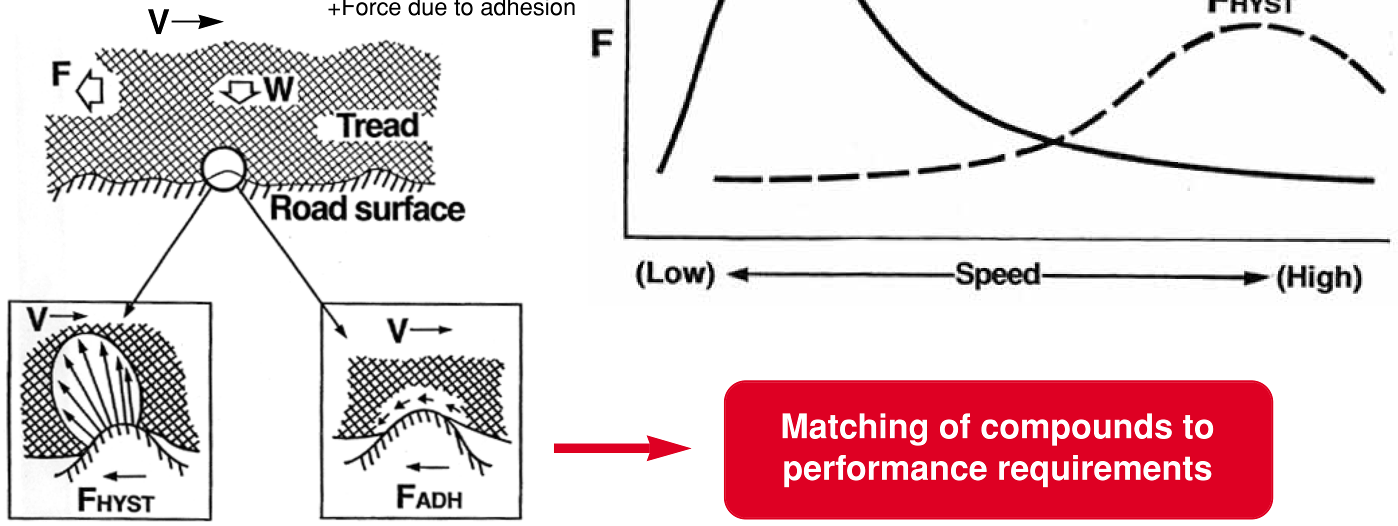
As can be seen in this graph, when motorcycle speed is low, the force of adhesion is quite large, but at higher speeds, the force generated by hysteresis loss becomes the main factor. For high performance tires, the grip factor related to hysteresis has to be quite large to produce better grip at higher speeds. This is accomplished through compounding. If we use NR, for example, grip will be high because of the rubber's softness but the tire's wear resistance will be quite low. To overcome this dilemma, we mix in synthetic rubber. There are types of synthetic rubber with high hysteresis loss but since they are very expensive, we can them together with other polymers. At this time we are applying a racing-type compound to the Spitfire tire.

Soft, high loss tread compound

Friction Forces (Pneumatic Tire Friction by D.F. More)

$F = F_{HYST} + F_{ADH}$

Friction force=Force due to hysterisis loss
+Force due to adhesion



Matching of compounds to performance requirements

Pattern

Usually when we design a new pattern, we don't start with the pattern itself but rather with the basic product concept that we are pursuing. For example, if we are aiming at a tire for a sports or a touring bike, we would come up with an image of what the tire tread would look like. At this point, since we are still dealing with an image, we must consider whether the performance of the pattern will be good or not. For example, if we design the pattern in the center of the tire, the wet performance may not be accpetable because the grooves are very narrow. We would therefore modify the tread design.

Pattern design method

Design concept → Performance + Appearance → Differentiation according totire applications

Battlax/Spitfire(SE-02)

Example

Desired Image

Dynamic
Fast
Impressive } Lightning