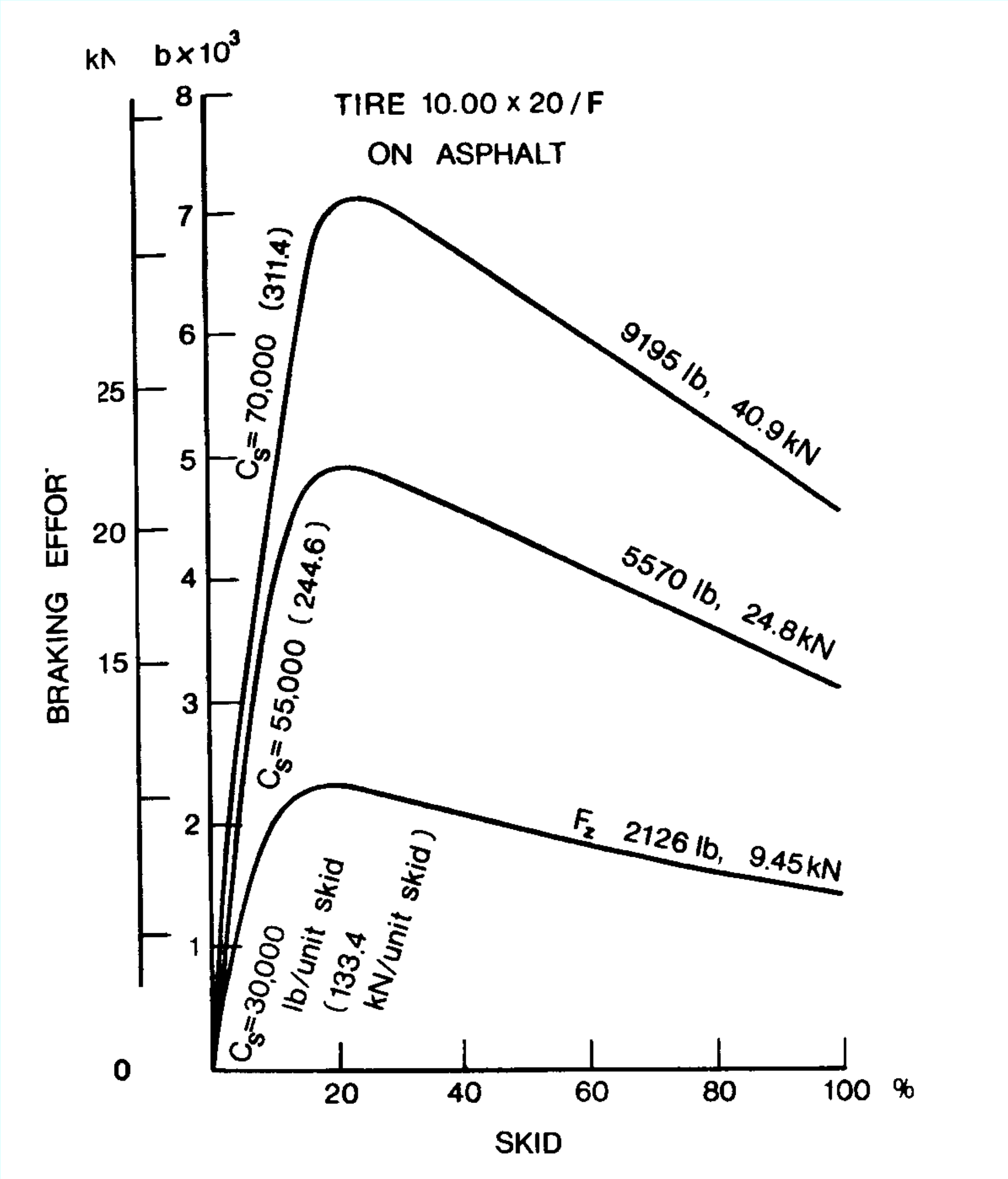
Cornering Properties of Tires

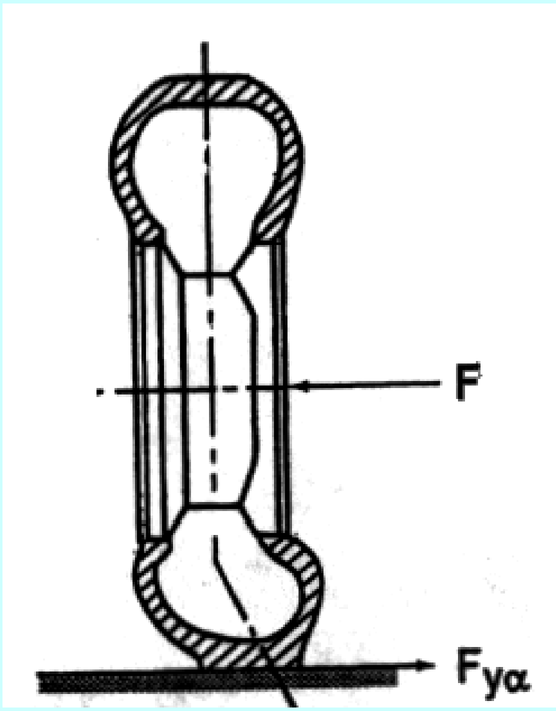
The Engineering behind Vehicle Design

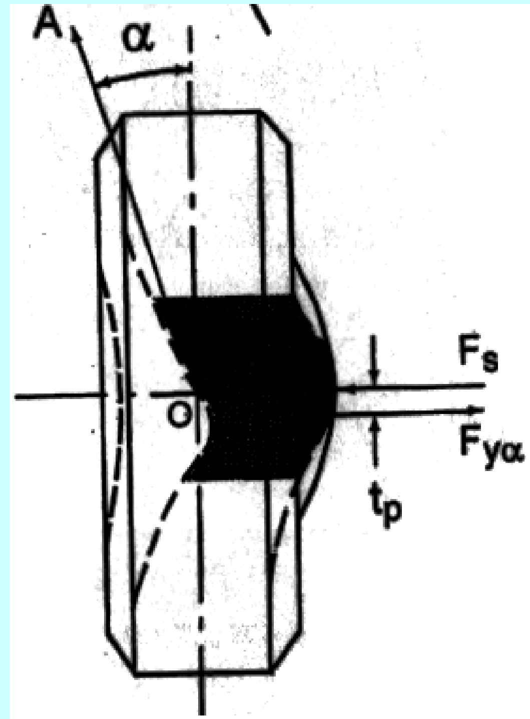
Normal load and braking performance



Effect of normal load on braking performance of a truck tire on asphalt

Tire subject to side force





Behavior of a tire subject to a side force

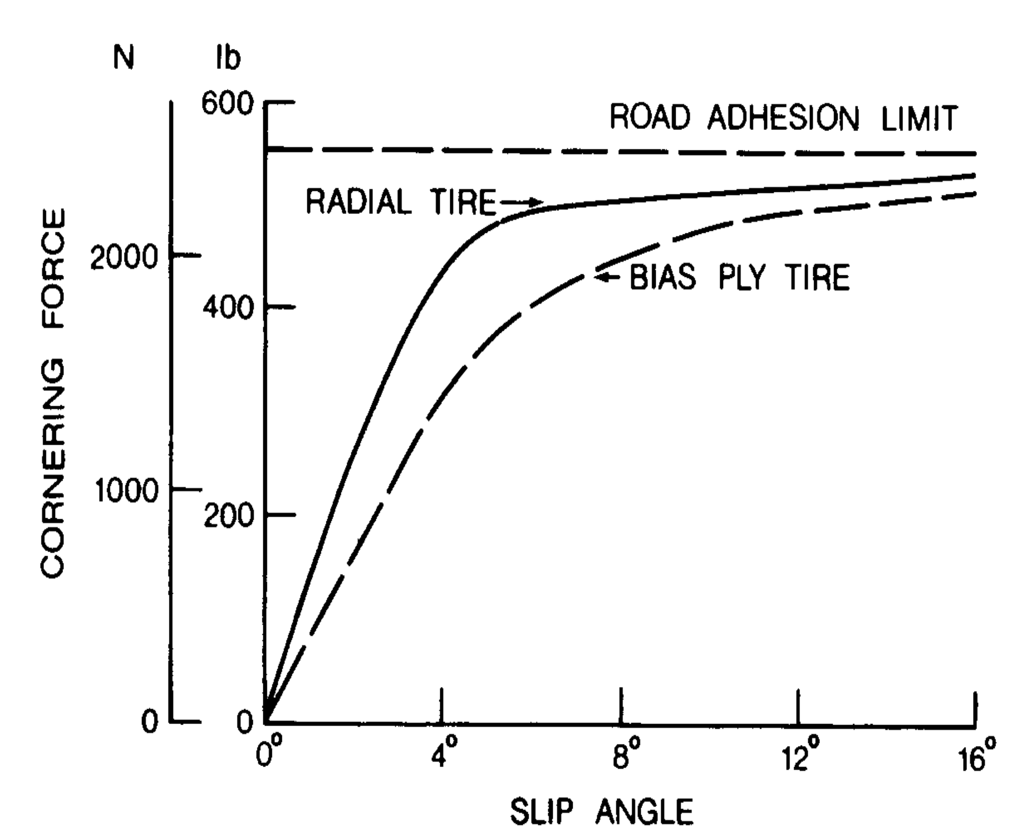
Coefficient of Road Adhesion

TABLE 1.3 Values of Coefficient of Road Adhesion for Truck Tires on Dry and Wet Concrete Pavement at 64 km/h (40 mph)

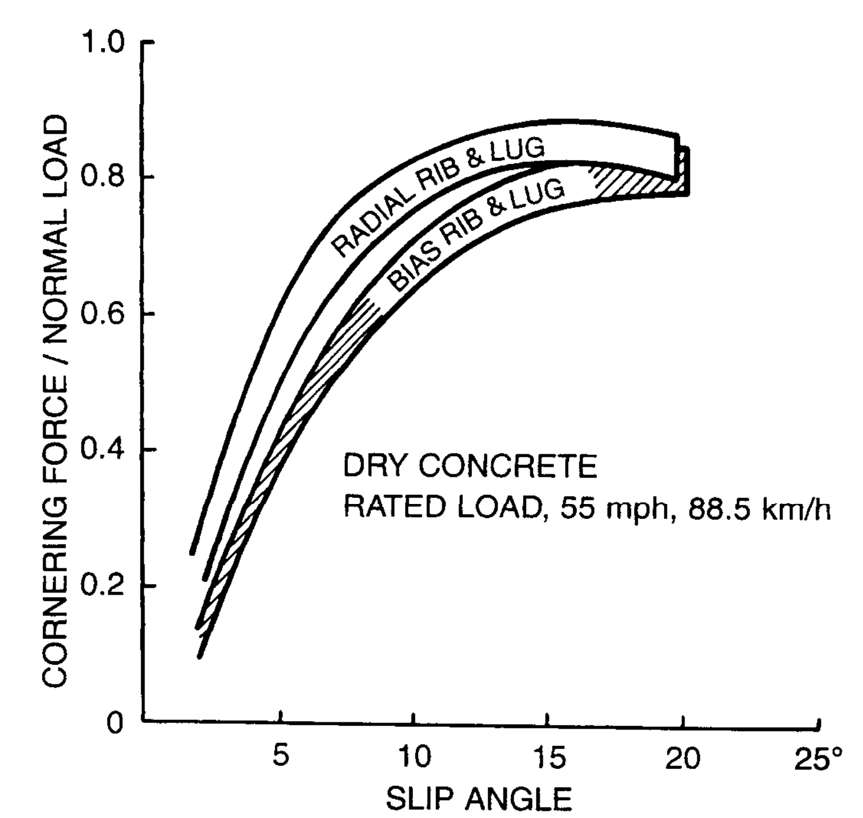
Tire Type	Tire Construction	Dry		Wet	
		μ_p	μ_s	μ_p	μ_s
Goodyear Super Hi Miler (Rib)	Bias-ply	0.850	0.596	0.673	0.458
General GTX (Rib)	Bias-ply	0.826	0.517	0.745	0.530
Firestone Transteel (Rib)	Radial-ply	0.809	0.536	0.655	0.477
Firestone Transport 1 (Rib)	Bias-ply	0.804	0.557	0.825	0.579
Goodyear Unisteel R-1 (Rib)	Radial-ply	0.802	0.506	0.700	0.445
Firestone Transteel Traction (Lug)	Radial-ply	0.800	0.545	0.600	0.476
Goodyear Unisteel L-1 (Lug)	Radial-ply	0.768	0.555	0.566	0.427
Michelin XZA (Rib)	Radial-ply	0.768	0.524	0.573	0.443
Firestone Transport 200 (Lug)	Bias-ply	0.748	0.538	0.625	0.476
Uniroyal Fleet Master Super Lug	Bias-ply	0.739	0.553	0.513	0.376
Goodyear Custom Cross Rib	Bias-ply	0.716	0.546	0.600	0.455
Michelin XZZ (Rib)	Radial-ply	0.715	0.508	0.614	0.459
Average		0.756	0.540	0.641	0.467

Source: UMTRI, reference 1.19.

Cornering characteristics

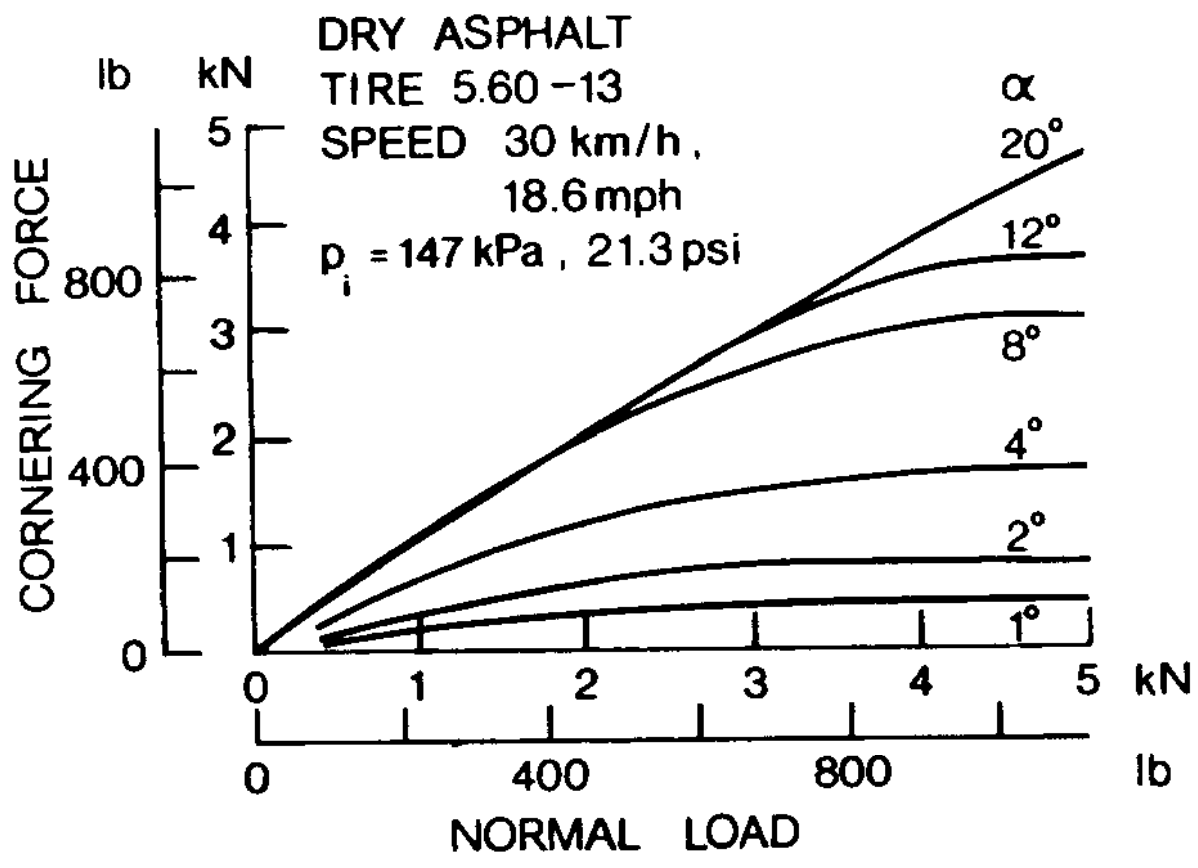


Cornering characteristics of a bias-ply
And radial-ply car tire

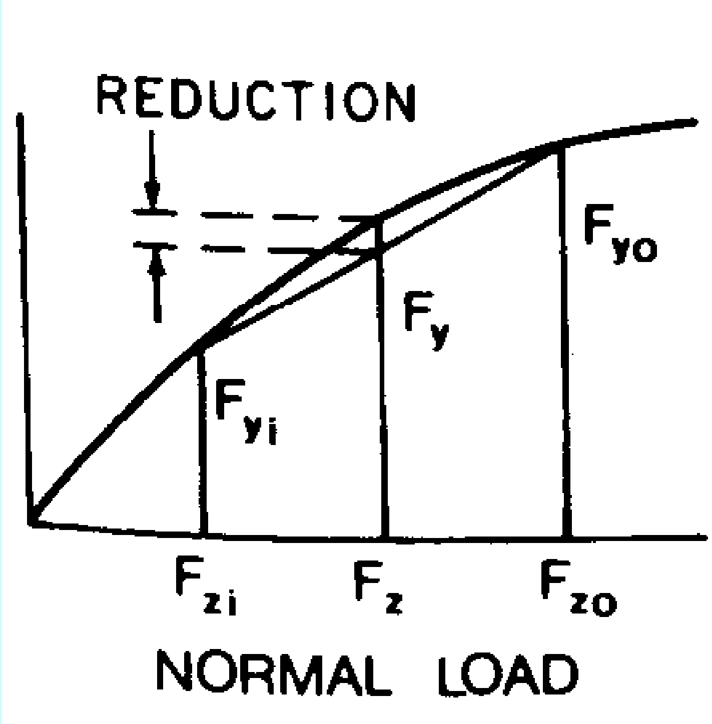


Cornering characteristics of a
bias-ply and radial-ply car tire
On dry concrete

Loads effect on cornering

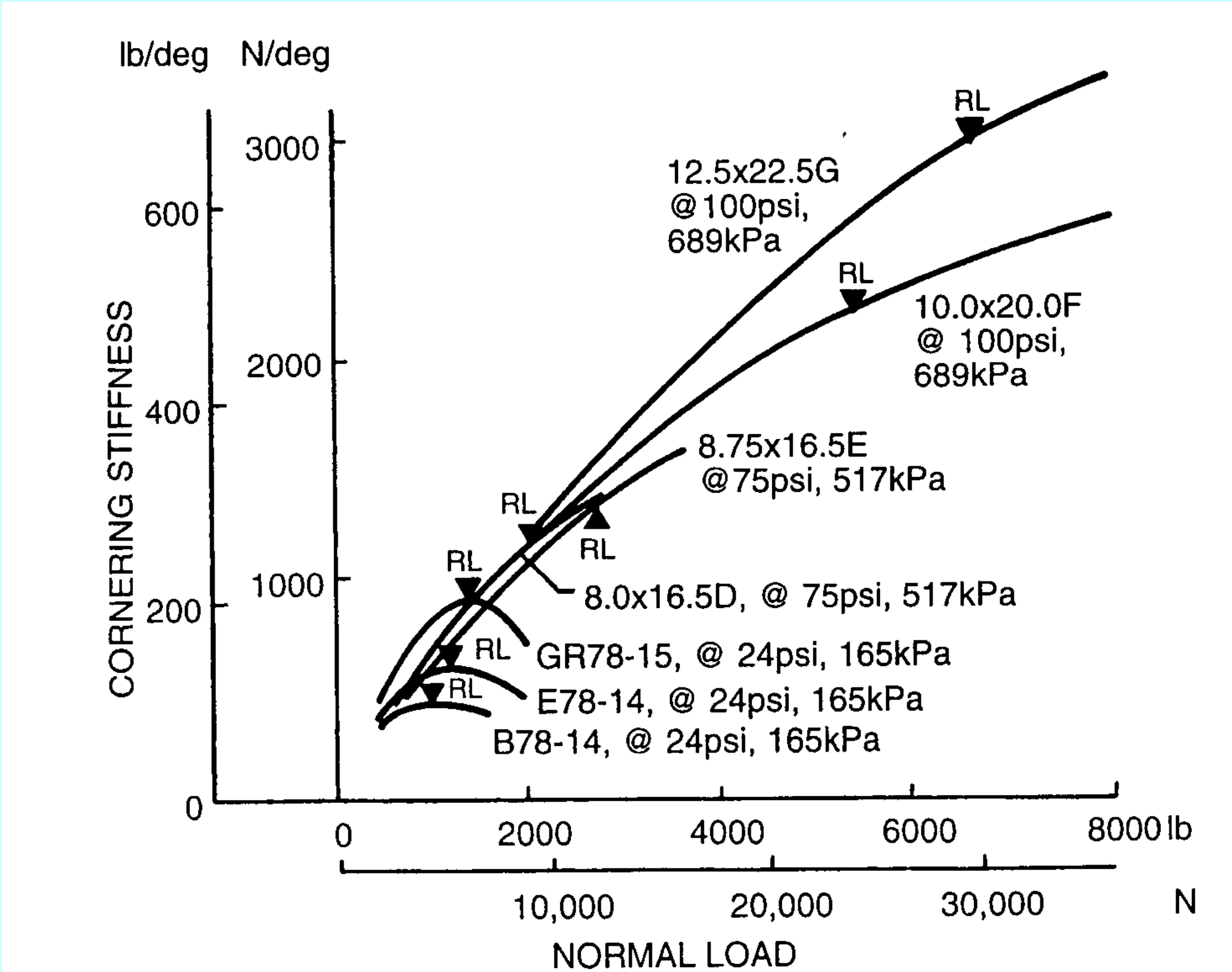


Effect of normal load on corner Characteristics of a car tire



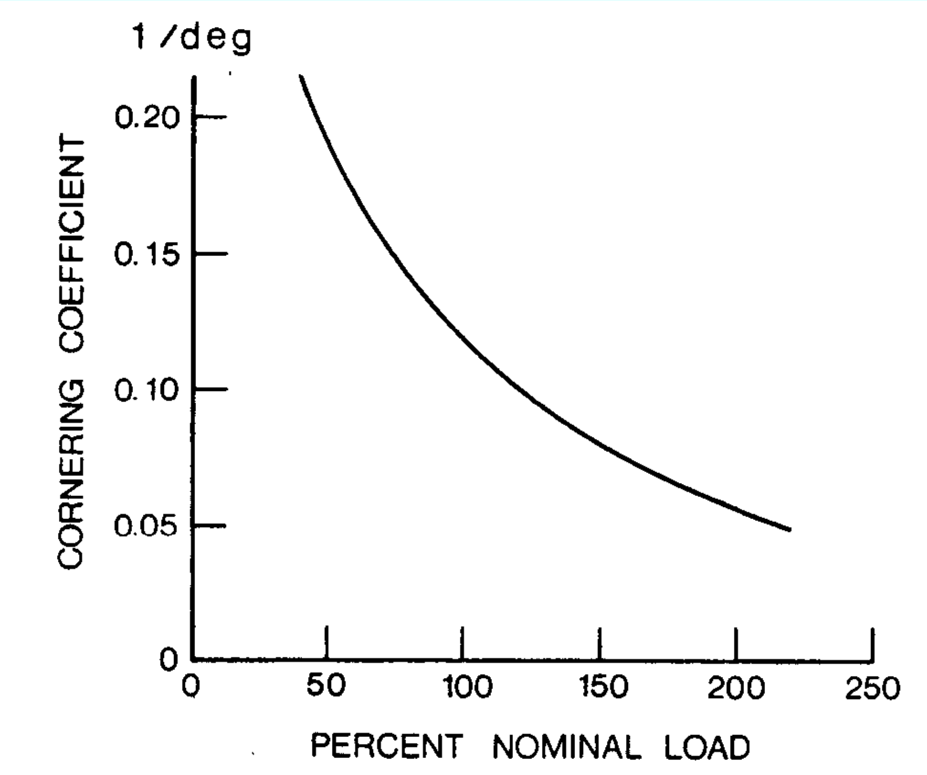
Effect of lateral load transfer on the cornering capability of a pair of tires on an axle

Cornering Stiffness

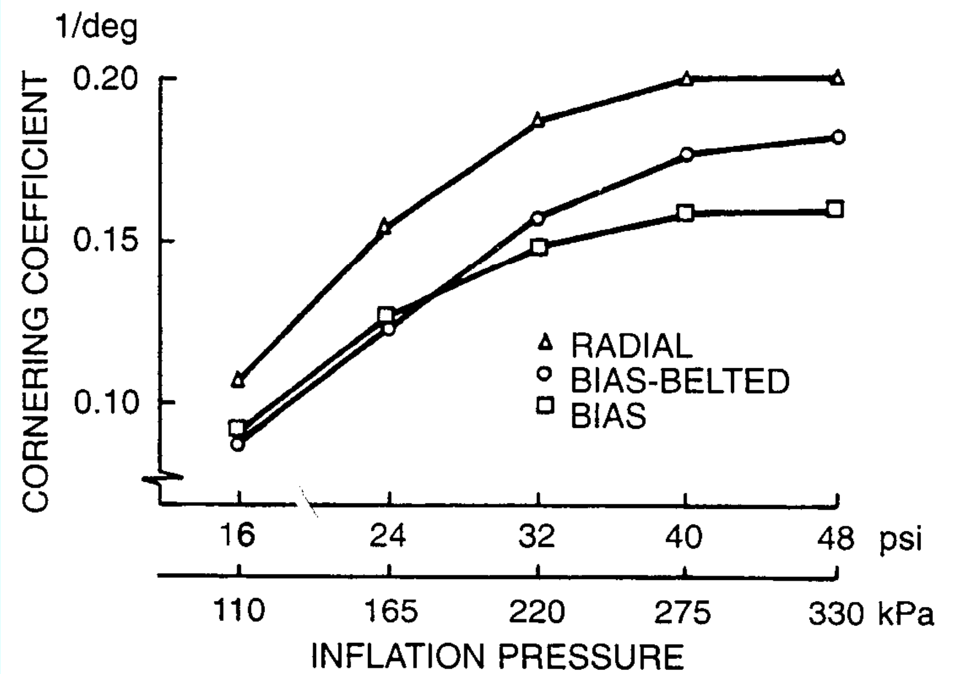


Comparison of cornering stiffness of car, light truck and heavy truck tires

Effects on cornering coefficient



Effect of normal load on cornering
Coefficient of a tire



Variations of cornering
Coefficient with inflation
Pressure for radial-ply, bias-ply
And bias-belted car tires.

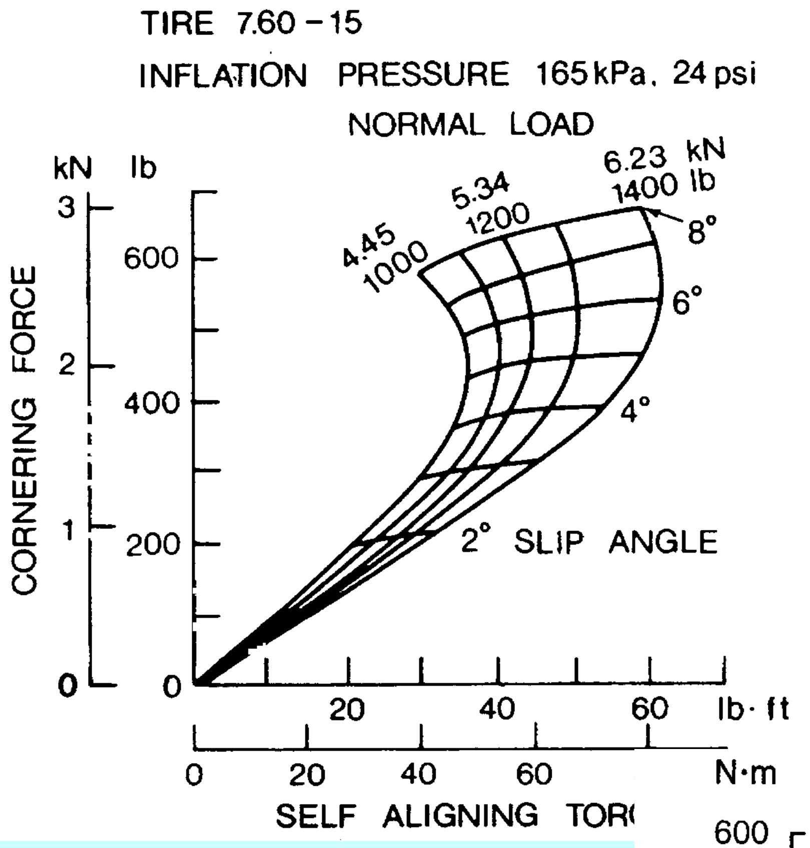
Cornering coefficient for truck tires at rated Loads and inflation pressures

TABLE 1.4 Cornering Coefficients for Truck Tires at Rated Loads and Inflation Pressures (Unless Specified)

Tire Type	Tire Construction	Cornering Coefficient (deg^{-1})
Michelin Radial XZA (1/3 Tread)	Radial-ply	0.1861
Michelin Radial XZA (1/2 Tread)	Radial-ply	0.1749
Michelin Pilote XZA	Radial-ply	0.1648
Michelin Radial XZA	Radial-ply	0.1472
Goodyear Unisteel G159, 11R22.5 LRF at 655 kPa (95 psi)	Radial-ply	0.1413
Michelin XZZ	Radial-ply	0.1370
Goodyear Unisteel 11, 10R22.5 LRF at 620 kPa (90 psi)	Radial-ply	0.1350
Goodyear Unisteel G159, 11R22.5 LRG at 792 kPa (115 psi)	Radial-ply	0.1348
Goodyear Unisteel 11, 10R22.5 LRF at 758 kPa (110 psi)	Radial-ply	0.1311
Firestone Transteel	Radial-ply	0.1171
Firestone Transteel Traction	Radial-ply	0.1159
Goodyear Unisteel R-1	Radial-ply	0.1159
Goodyear Unisteel L-1	Radial-ply	0.1121
Firestone Transport 1	Bias-ply	0.1039
General GTX	Bias-ply	0.1017
Goodyear Super Hi Miler	Bias-ply	0.0956
Goodyear Custom Cross Rib	Bias-ply	0.0912
Uniroyal Fleet Master Super Lub	Bias-ply	0.0886
Firestone Transport 200	Bias-ply	0.0789

Source: UMTRI and TRIF, reference 1.19.

Self aligning torque



Variations of self aligning torque
With cornering forces of a car tire
Under various normal loads

Variation of self-aligning
Torque with normal load
And slip angle for a bias-
Ply truck tire

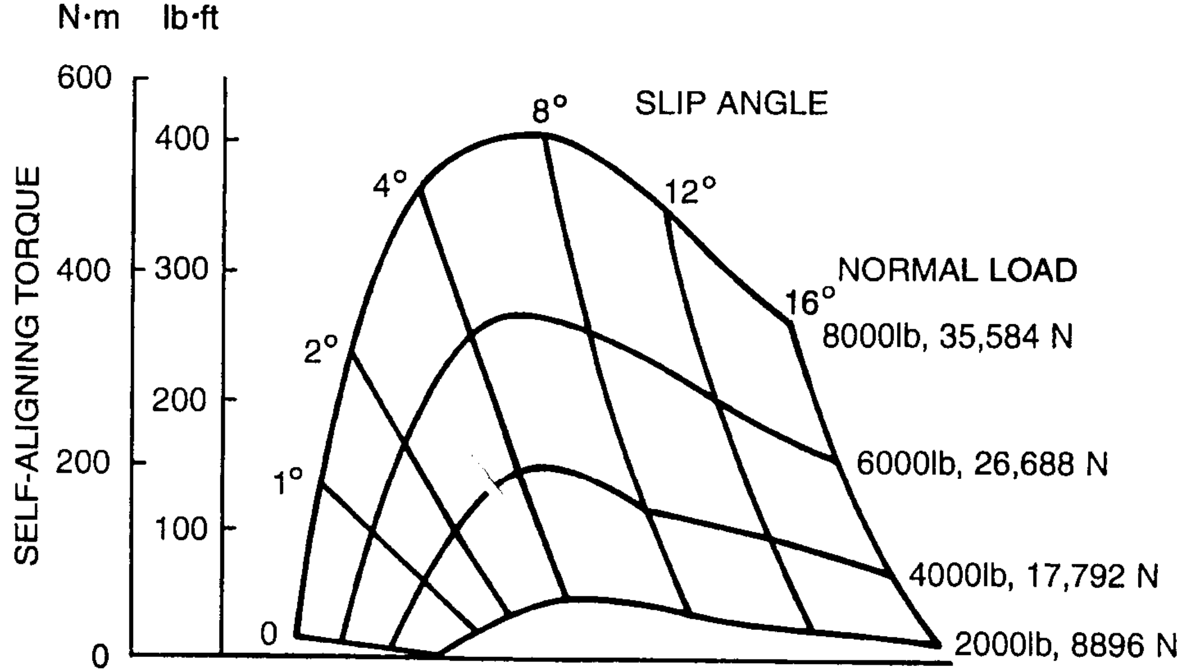
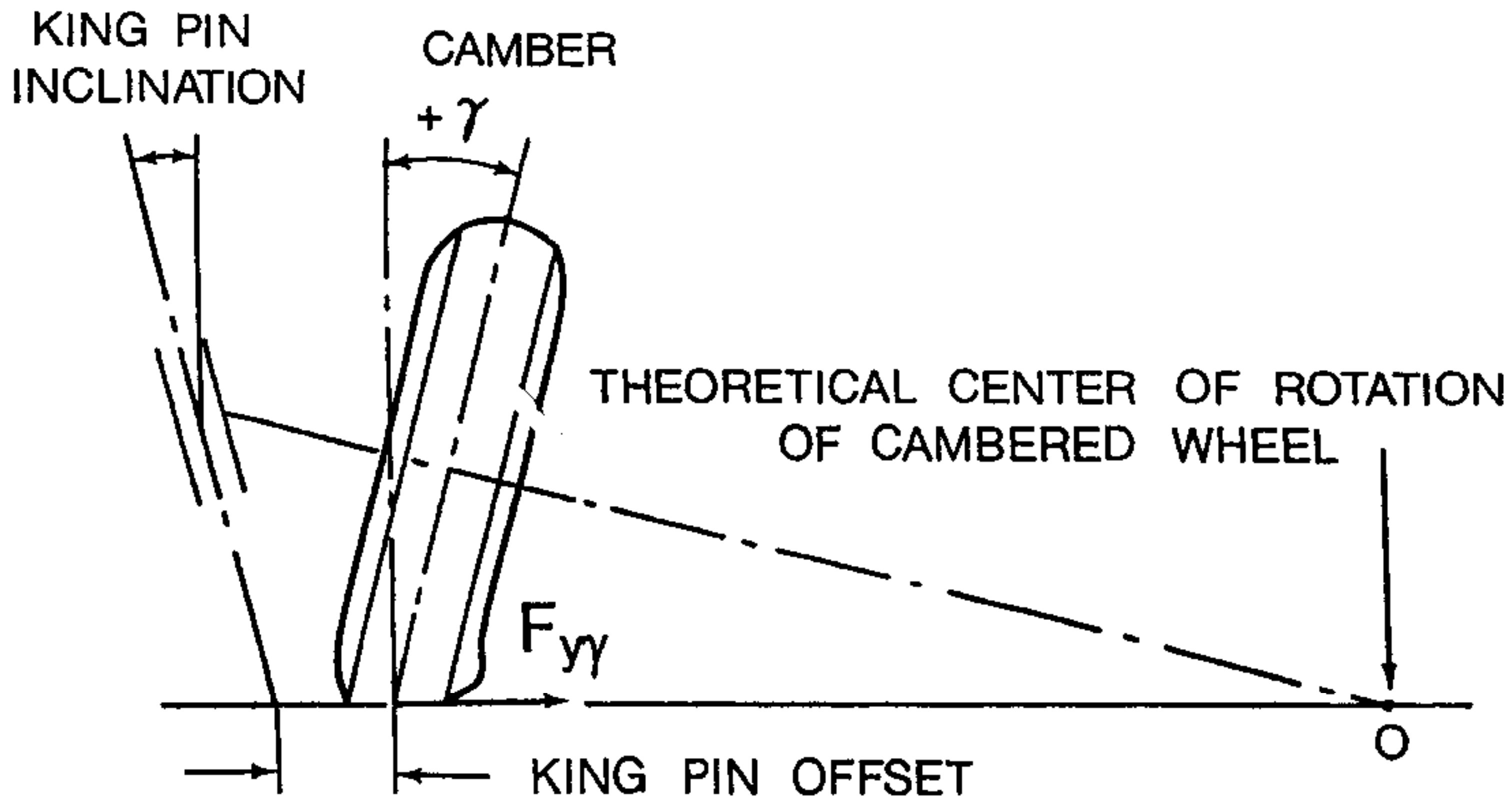


TABLE 1.5 Pneumatic Trails for Truck Tires at a Slip Angle of 1° under Rated Loads and Inflation Pressures (Unless Specified)

Tire Type	Tire Construction	Pneumatic Trails	
		cm	in.
Michelin Radial 11R22.5 XZA (1/3 Tread)	Radial-ply	6.17	2.43
Goodyear Unisteel II, 10R22.5 LRF at 620 kPa (90 psi)	Radial-ply	6.15	2.42
Michelin Radial 11R22.5 XZA (1/2 Tread)	Radial-ply	5.89	2.32
Goodyear Unisteel G159, 11R22.5 LRG at 655 kPa (95 psi)	Radial-ply	5.87	2.31
Michelin Radial 11R22.5 XZA	Radial-ply	5.51	2.17
Goodyear Unisteel G159, 11R22.5 LRG at 792 kPa (115 psi)	Radial-ply	5.46	2.15
Goodyear Unisteel II, 10R22.5 LRF at 758 kPa (110 psi)	Radial-ply	5.41	2.13
Michelin Radial 11R22.5 XZA	Radial-ply	5.38	2.12
Michelin Pilote 11/80R22.5 XZA	Radial-ply	4.62	1.82
New Unspecified Model 10.00-20/F	Bias-ply	5.89	2.32
Half-Worn Unspecified Model 10.00-20/F	Bias-ply	7.14	2.81
Fully-Worn Unspecified Model 10.00-20/F	Bias-ply	6.55	2.58

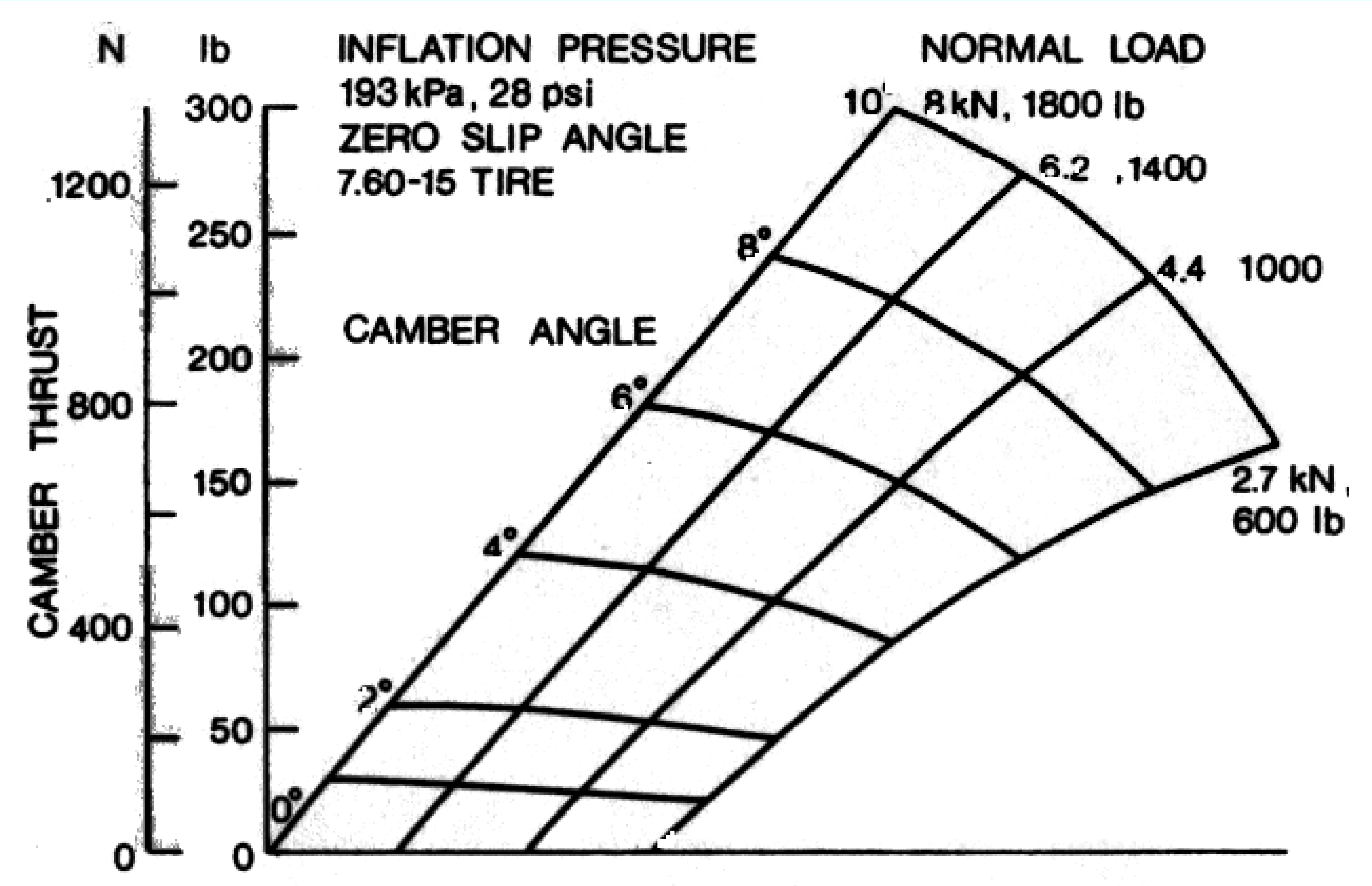
Source: UMTRI, reference 1.19.

Camber and Camber Thrust



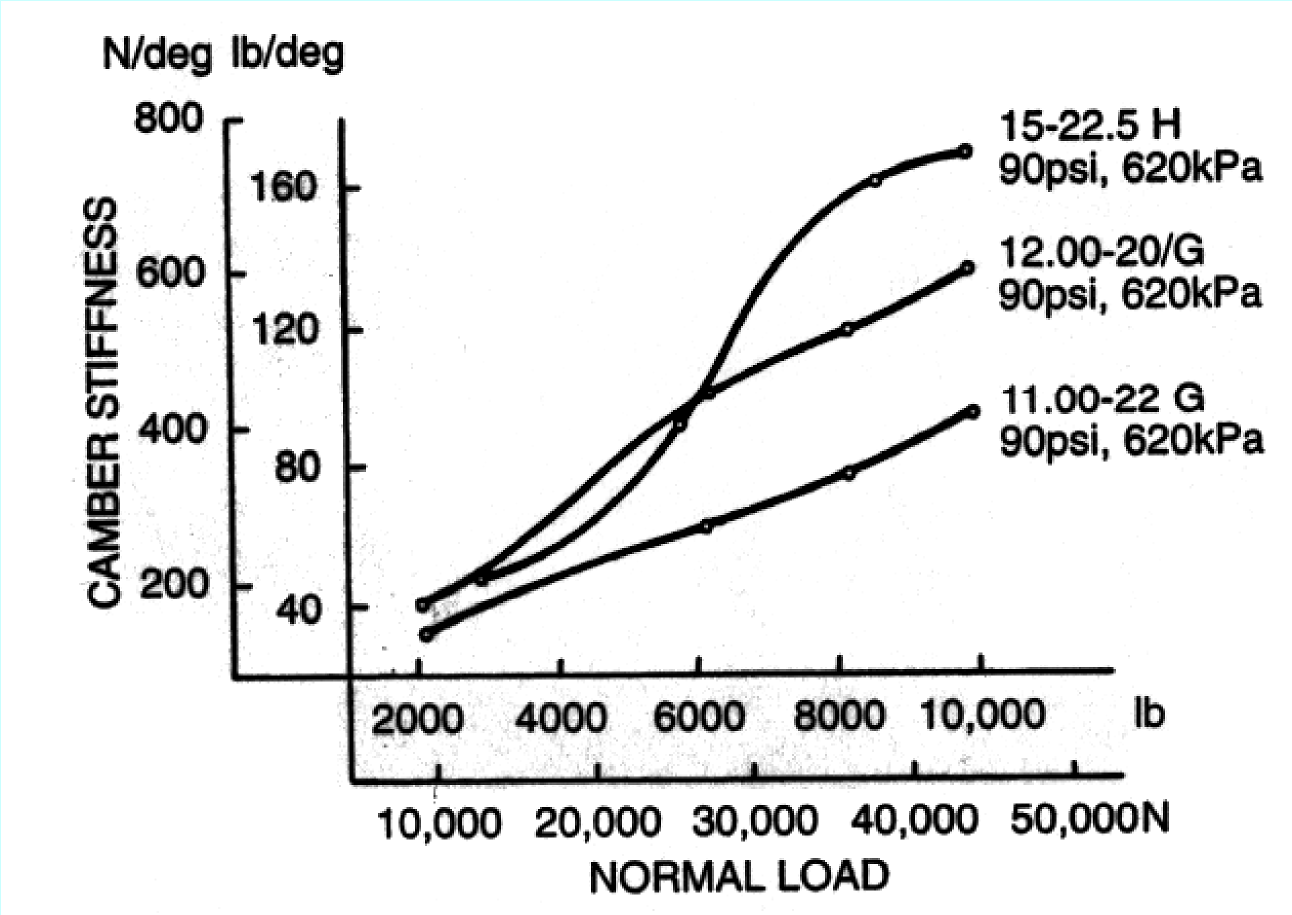
Behavior of a cambered tire

Camber thrust with camber angle



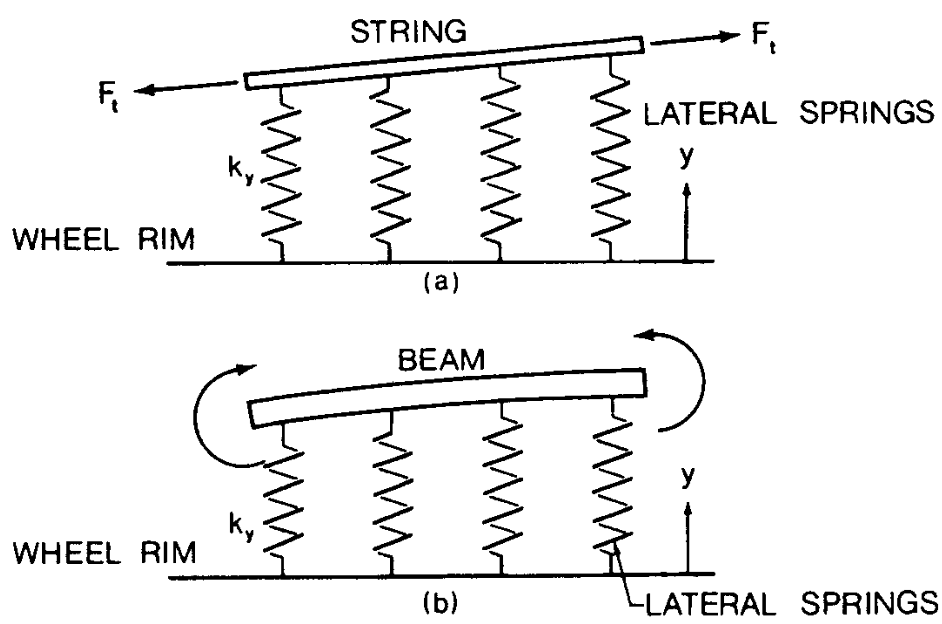
Variation of camber thrust with camber angle
and normal load for a car tire

Camber stiffness with normal load



Variation of camber stiffness with normal load for heavy truck tires

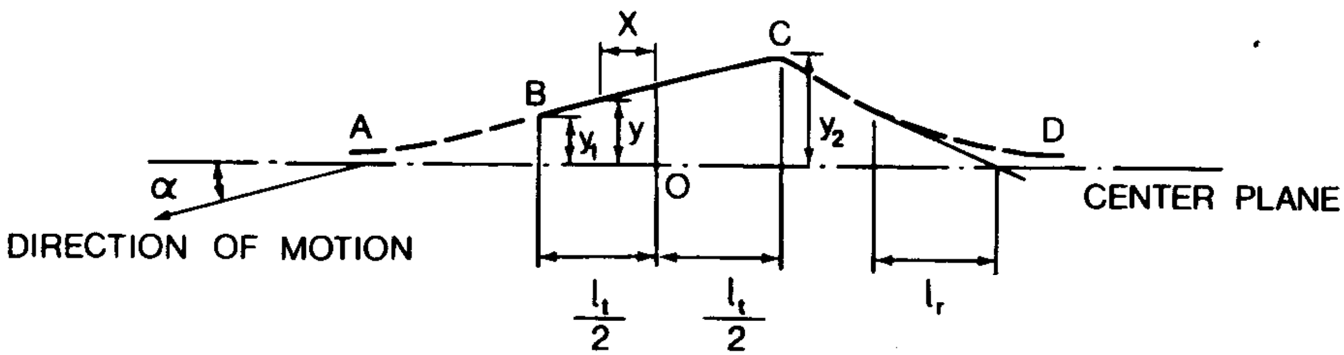
Characterization of cornering behavior of tires



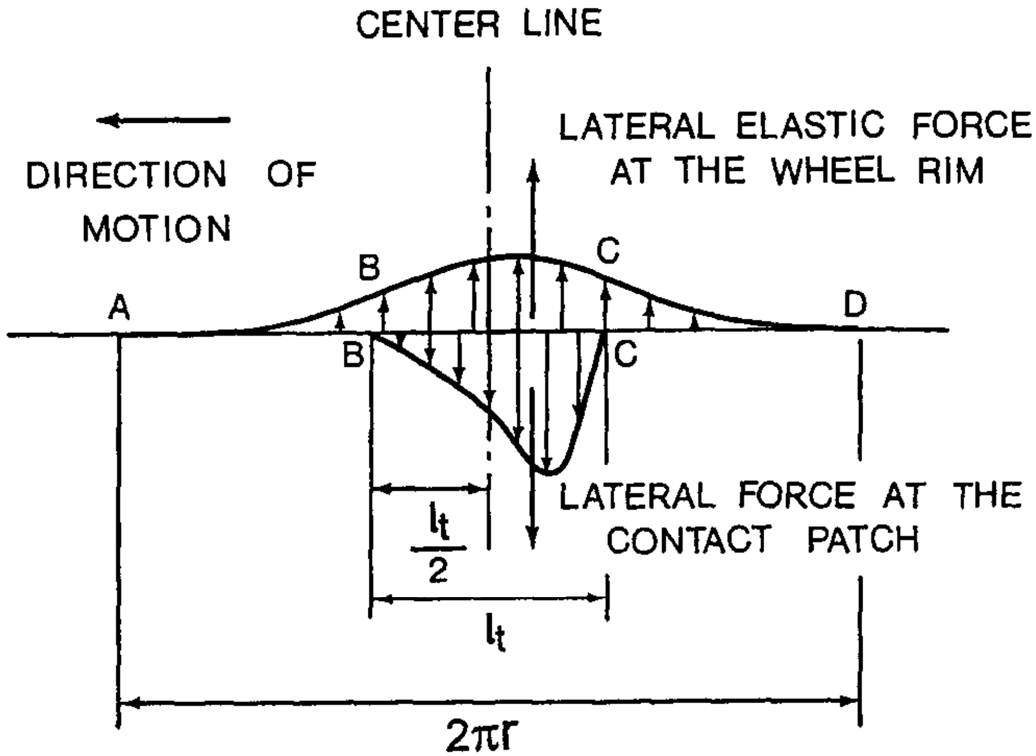
Models of cornering
Behavior of tires

a) Stretched String model

b) Beam on elastic foundati
model



Behavior of the
Equatorial line
Of a rolling tire
Subject to a side
force



$$F_y = k_y \int_{-l_t/2}^{l_t/2} \left(y - l_r^2 \frac{d^2 y}{dx^2} \right) dx$$

$$= k_y \int_{-l_t/2}^{l_t/2} y \, dx - k_y l_r^2 \left(\frac{dy}{dx} \right) \Big]_{-l_t/2}^{l_t/2}$$

$$= k_y (y_1 + y_2) l_t/2 + k_y l_r (y_1 + y_2)$$

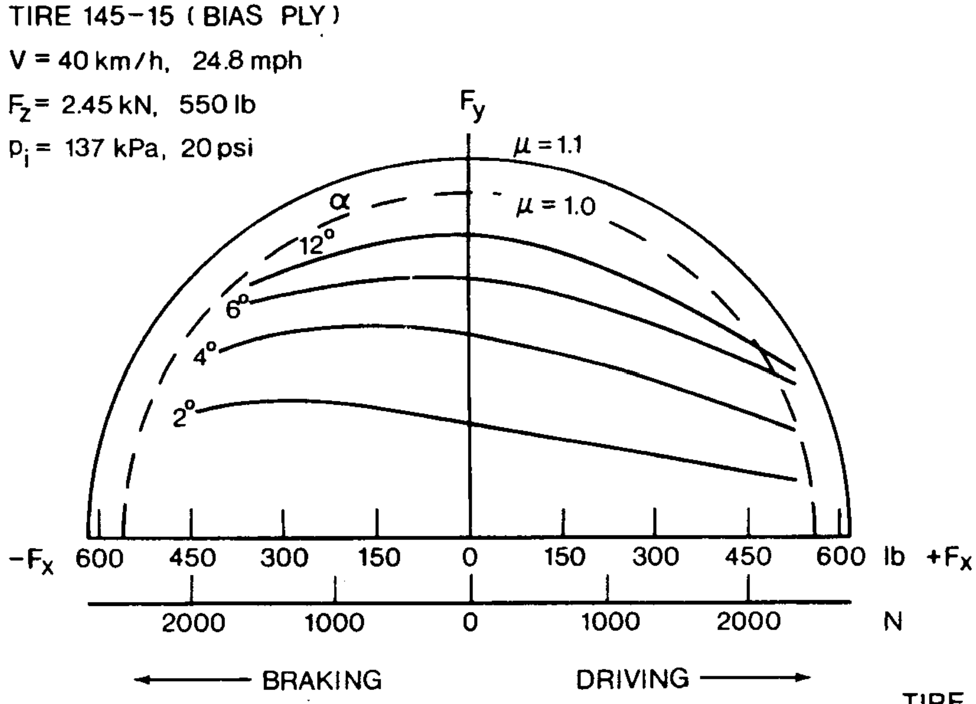
$$= k_y (y_1 + y_2)(l_r + l_t/2)$$

$$M_z = k_y \int_{-l_t/2}^{l_t/2} x \left(y - l_r^2 \frac{d^2 y}{dx^2} \right) dx$$

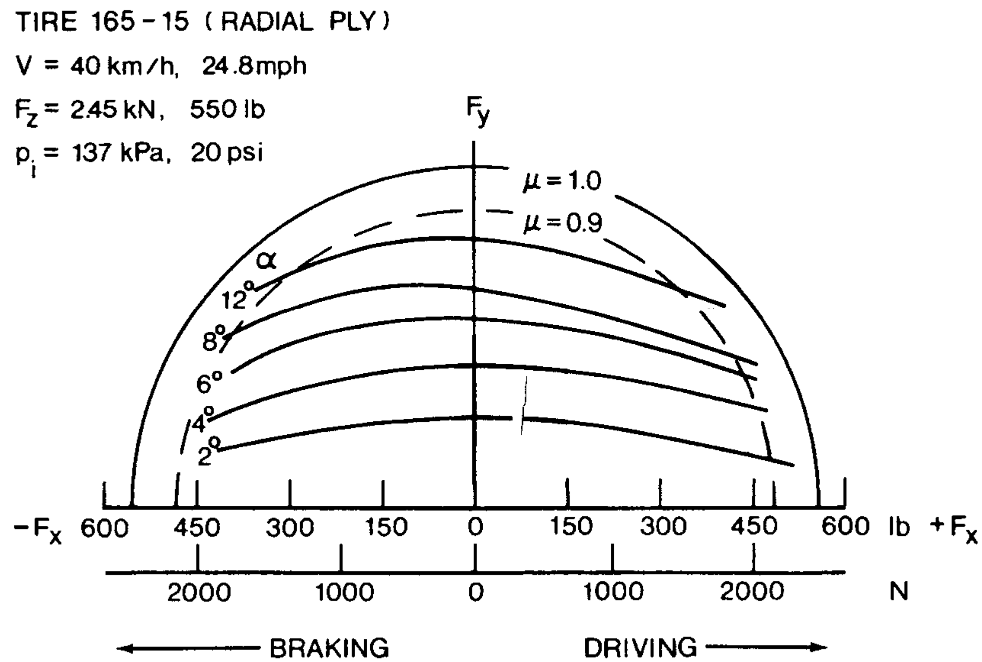
$$= k_y \int_{-l_t/2}^{l_t/2} xy \, dx - k_y l_r^2 \left. \left(x \frac{dy}{dx} - y \right) \right]_{-l_t/2}^{l_t/2}$$

$$= k_y \frac{(l_t/2)^2}{3} (y_1 - y_2) + k_y l_r \left(l_r + \frac{l_t}{2} \right) (y_1 - y_2)$$

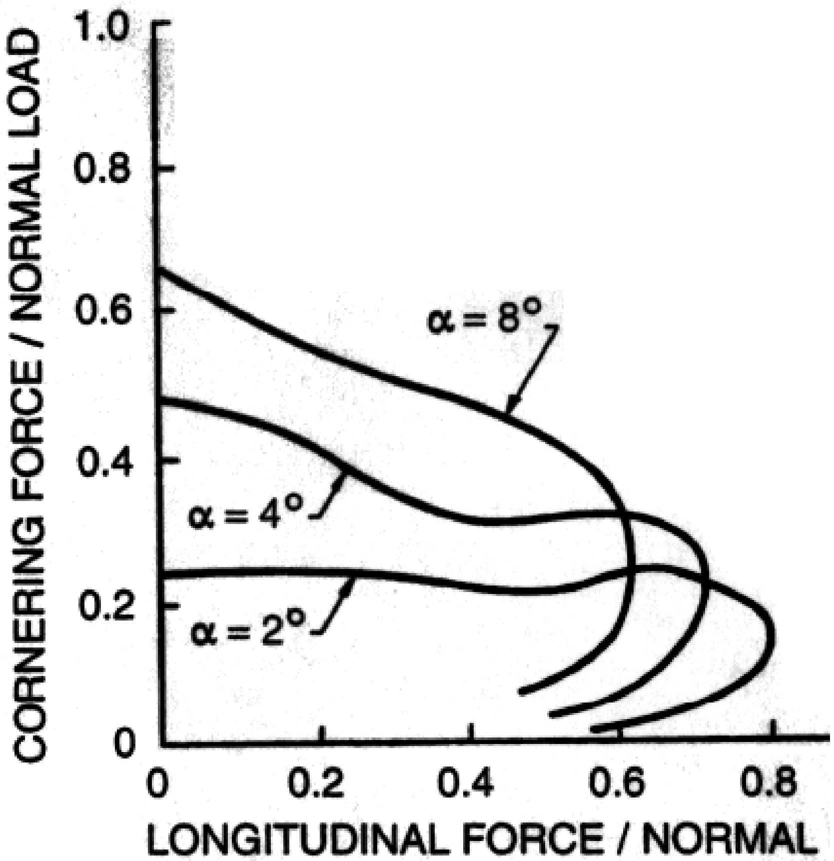
$$= k_y (y_1 - y_2) \left[\frac{(l_t/2)^2}{3} + l_r \left(l_r + \frac{l_t}{2} \right) \right]$$

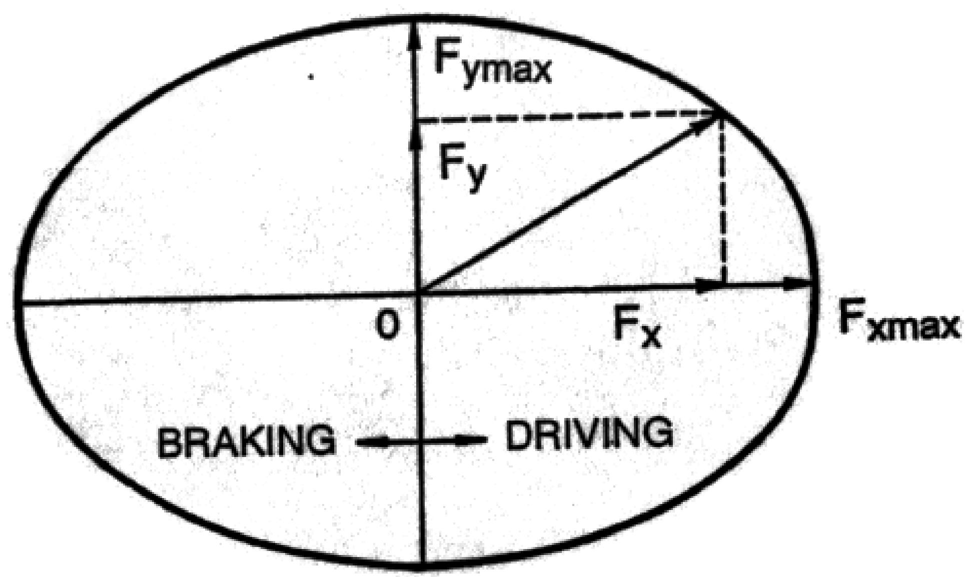

TIRE 145-15 (BIAS PLY)
V = 40 km/h, 24.8 mph
F_z = 2.45 kN, 550 lb
p_i = 137 kPa, 20 psi
F_y
$\mu = 1.1$
$\mu = 1.0$
α
12°
6°
4°
2°
$-F_x$
600
450
300
150
0
150
300
450
600
lb
$+F_x$
2000
1000
0
1000
2000
N
BRAKING
DRIVING

(a)


TIRE 165-15 (RADIAL PLY)
V = 40 km/h, 24.8 mph
F_z = 2.45 kN, 550 lb
p_i = 137 kPa, 20 psi
F_y
$\mu = 1.0$
$\mu = 0.9$
α
12°
8°
6°
4°
2°
$-F_x$
600
450
300
150
0
150
300
450
600
lb
$+F_x$
2000
1000
0
1000
2000
N
BRAKING
DRIVING

(b)


1.0
0.8
0.6
0.4
0.2
0
CORNERING FORCE / NORMAL LOAD
α = 8°
α = 4°
α = 2°
0
0.2
0.4
0.6
0.8
LONGITUDINAL FORCE / NORMAL


F_ymax
F_y
0
F_x
F_xmax
BRAKING
DRIVING