



SUSPENSION MULTIBODY SIMULATION

SUSPENSION KEY PERFORMANCE INDICATOR COMPARISON REPORT



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1 Statement of Non-liability

RACE software provided by race.software is intended as a suspension concept development tool. It is designed to help you to understand the performance of your suspension system. This report contains information on the performance of a suspension system as specified by the inputs you have supplied to the RACE software programme. Race.software has no control over the inputs chosen by you and takes no responsibility for the performance of your suspension system. You are the owner of your suspension system and you are responsible for its performance. The results of the RACE software should be used only to improve your understanding of its operation, not as a guaranteed prediction of how it will perform. It is your responsibility as the user of RACE software to interpret the results it provides and to make your own judgement as to how your suspension will perform in real life.



2 Suspension Key Performance Indicator Summary

2.1 RACE Kinematics KPIs

KPI	Units	Base	P12+Z10	P6+X10
ROLL MOTION				
Roll camber	deg/m	-12.2	-13	-12.4
Roll steer - on centre	deg/m	-5.5	5.6	-4.8
Roll steer - 25mm bump	deg/m	-4.8	6.5	-4
Roll steer - 25mm rebound	deg/m	-6.8	4.3	-6.2
Wheel rate in roll	N/mm	78.3	78.2	78.1
ARB rate at droplink (opposite wheel travel)	N/mm	114.8	114.9	114.9
ARB rate at droplink (single wheel travel)	N/mm	57.4	57.4	57.4
STATIC GEOMETRY				
Static camber	deg	-0.09	-0.09	-0.09
Static toe	deg	0.19	0.19	0.19
Track width at contact patch	mm	1501.8	1501.8	1501.8
Damper ratio	mm/mm	0.96	0.96	0.96
Spring ratio	mm/mm	0.96	0.96	0.96
Spring installed load	N	3992	3992	3991
Spring installed length	mm	252.9	252.9	252.9
ARB ratio	mm/mm	0.65	0.65	0.65
STEERING INPUT				
Kingpin inclination - with steer	deg	10.5	10.5	10.5
Castor angle - with steer	deg	4.1	4.1	3.4
Castor trail - with steer	mm	14.1	14.1	1.7
Scrub radius - with steer	mm	11.6	11.6	11.9
Wheel centre longitudinal offset - with steer	mm	-7.8	-7.8	-15.9
Wheel centre lateral offset - with steer	mm	67.6	67.6	67.7
Steering ratio - on-centre	deg/mm	0.38	0.37	0.36
Static toelink load	N	-93.9	-93	-26.2
Steering rack travel - centre to full lock	mm	55	55	55
Lock angle at full right rack travel	deg	20.9	20.6	19.7
Lock angle at full left rack travel	deg	-21.4	-21.2	-20
Percent ackermann at full rack travel	%	11	13	9
VERTICAL MOTION				
Bump camber	deg/m	-11.8	-12.6	-11.9
Bump steer - on centre	deg/m	-6.2	4.9	-5.6
Bump steer - 25mm bump	deg/m	-4.8	6.5	-4.2
Bump steer - 25mm rebound	deg/m	-7.5	3.6	-6.9
Bump castor (knuckle rotation)	deg/m	9.7	7.6	9.6
Kinematic wheel centre recession	mm/m	-4	-17.5	-4.9
Contact patch lateral migration	mm/m	72.4	75.3	74.9
Wheel rate - on centre	N/mm	28.8	28.7	28.7
Wheel rate - 25mm bump	N/mm	30.6	30.5	30.5
Wheel rate - 25mm rebound	N/mm	27.3	27.2	27.2



2.2 RACE Compliance KPIs

KPI	Units	Base	P12+Z10	P6+X10
BRAKING FORCE				
Brake steer	deg/kN	-0.272	-0.273	-0.277
Braking castor compliance (knuckle rotation)	deg/kN	-0.238	-0.237	-0.236
Contact patch longitudinal compliance	mm/kN	4.41	4.41	4.41
Front anti-dive; Rear anti-lift	N/N	0.056	0.059	0.057
LATERAL FORCE				
Roll centre height - wheel load variation	N/N	0.076	0.079	0.079
Camber compliance in-phase 0mm trail	deg/kN	0.104	0.104	0.104
Contact patch compliance in-phase 0mm trail	mm/kN	0.96	0.958	0.947
Lateral compliance steer in-phase 0mm trail	deg/kN	-0.18	-0.175	-0.175
Lateral compliance steer in-phase 30mm trail	deg/kN	-0.21	-0.205	-0.205
TRACTION FORCE				
Traction steer	deg/kN	0.237	0.236	0.239
Traction castor compliance (knuckle rotation)	deg/kN	-0.139	-0.14	-0.139
Wheel centre longitudinal compliance	mm/kN	2.37	2.37	2.38
Front anti-lift; Rear anti-squat	N/N	0.004	0.017	0.005
TYRE ALIGNING TORQUE				
Aligning torque toe compliance in-phase	deg/kNm	1.012	0.988	0.985



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Comparison Summary

- Simulation ID Base: -0.09 deg
- Simulation ID P12+Z10: -0.09 deg
- Simulation ID P6+X10: -0.09 deg

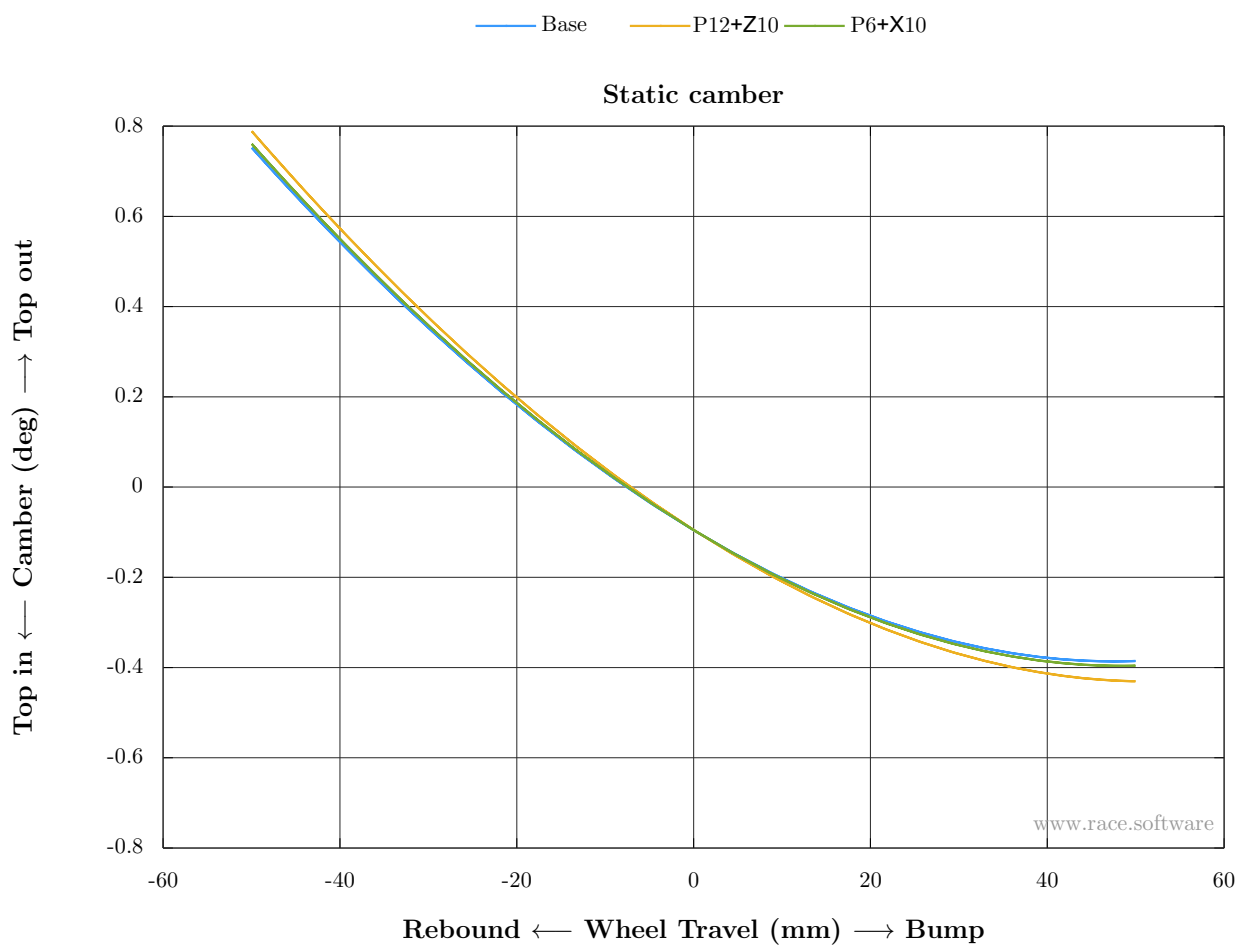


Figure 1: Vertical test: Static camber

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Comparison Summary

- Simulation ID Base: 0.19 deg
- Simulation ID P12+Z10: 0.19 deg
- Simulation ID P6+X10: 0.19 deg

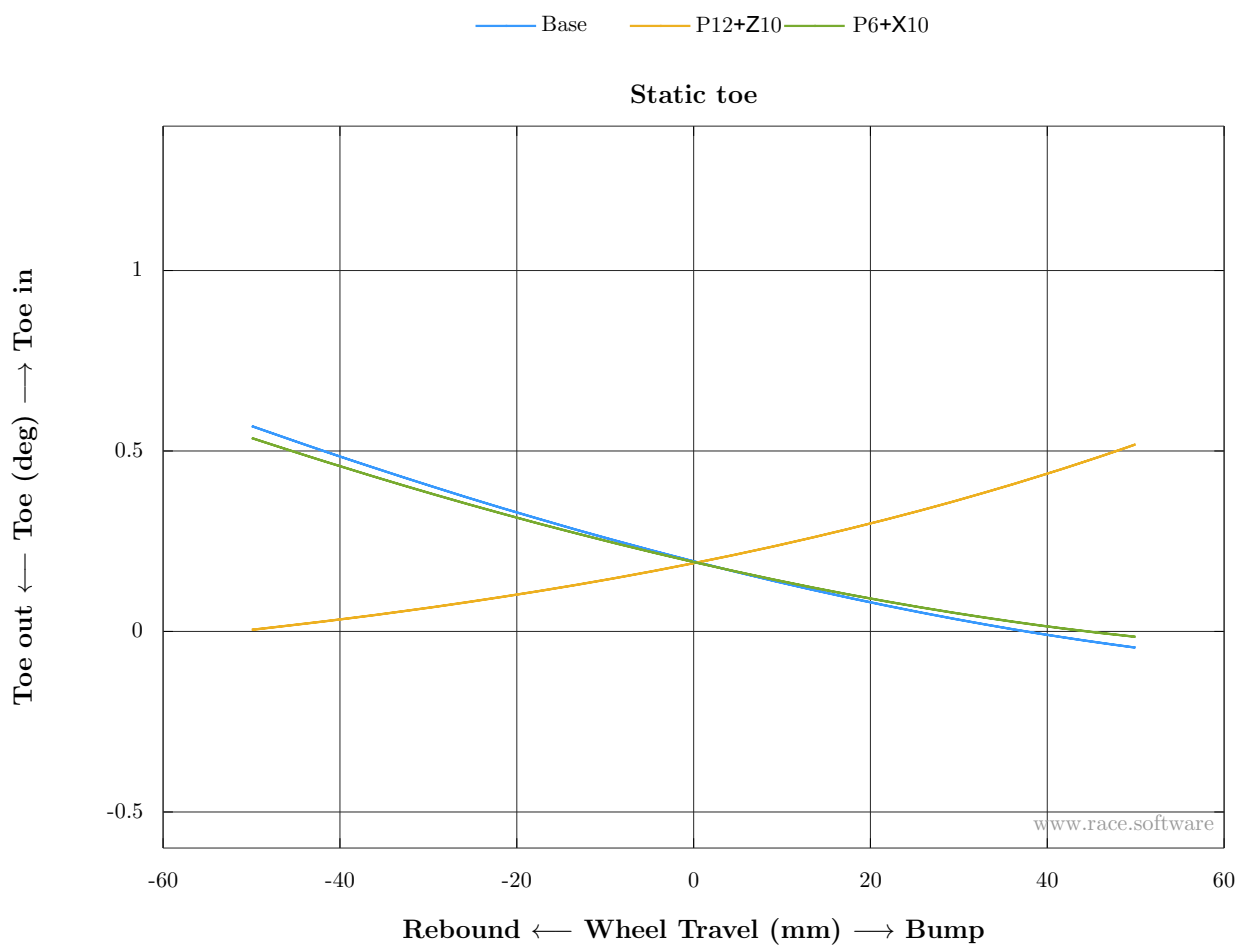


Figure 2: Vertical test: Static toe

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 1501.8 mm
- Simulation ID P12+Z10: 1501.8 mm
- Simulation ID P6+X10: 1501.8 mm

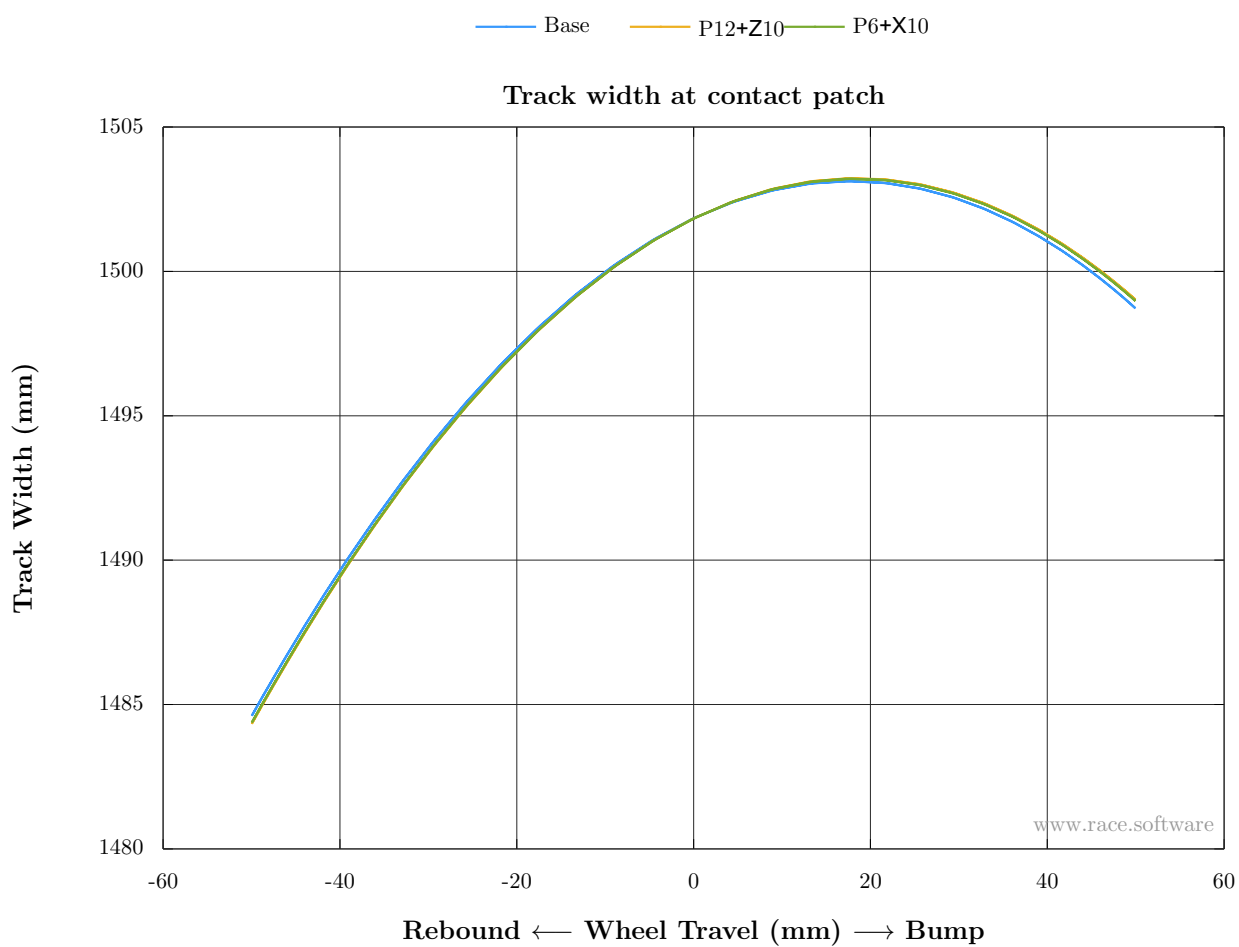


Figure 3: Vertical test: Track width at contact patch

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 0.96 mm/mm
- Simulation ID P12+Z10: 0.96 mm/mm
- Simulation ID P6+X10: 0.96 mm/mm

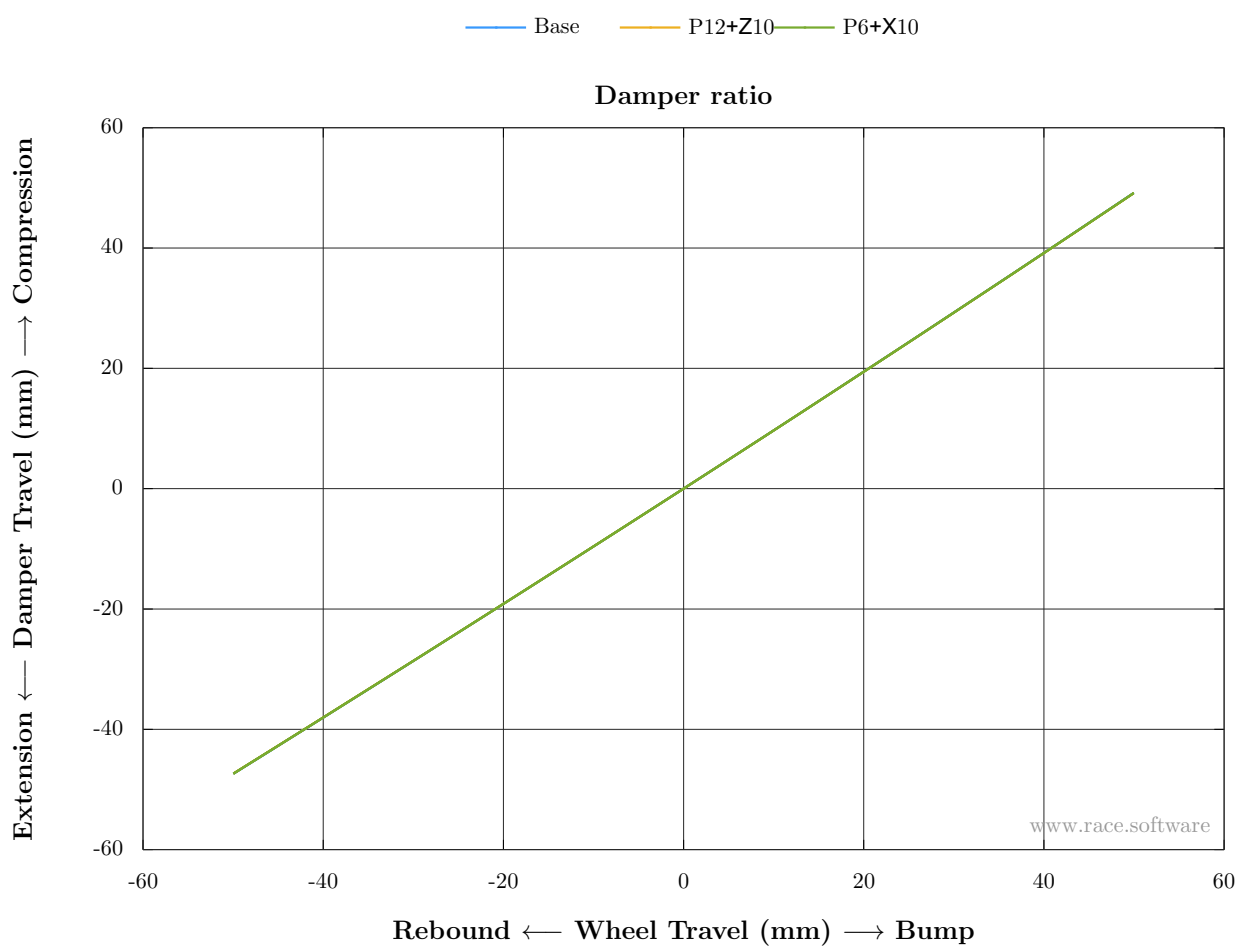


Figure 4: Vertical test: Damper ratio

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 0.96 mm/mm
- Simulation ID P12+Z10: 0.96 mm/mm
- Simulation ID P6+X10: 0.96 mm/mm

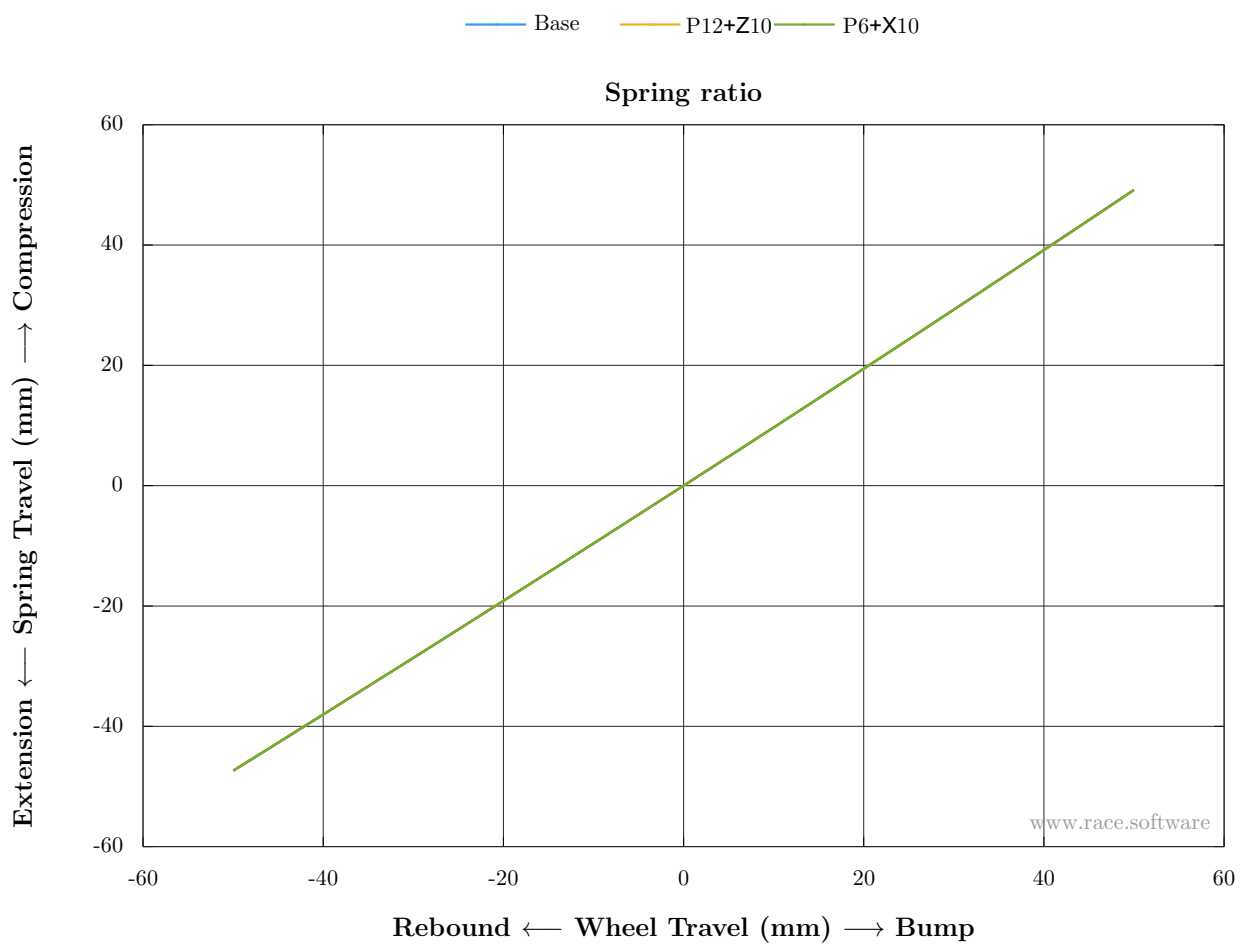


Figure 5: Vertical test: Spring ratio

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 3992 N
- Simulation ID P12+Z10: 3992 N
- Simulation ID P6+X10: 3991 N

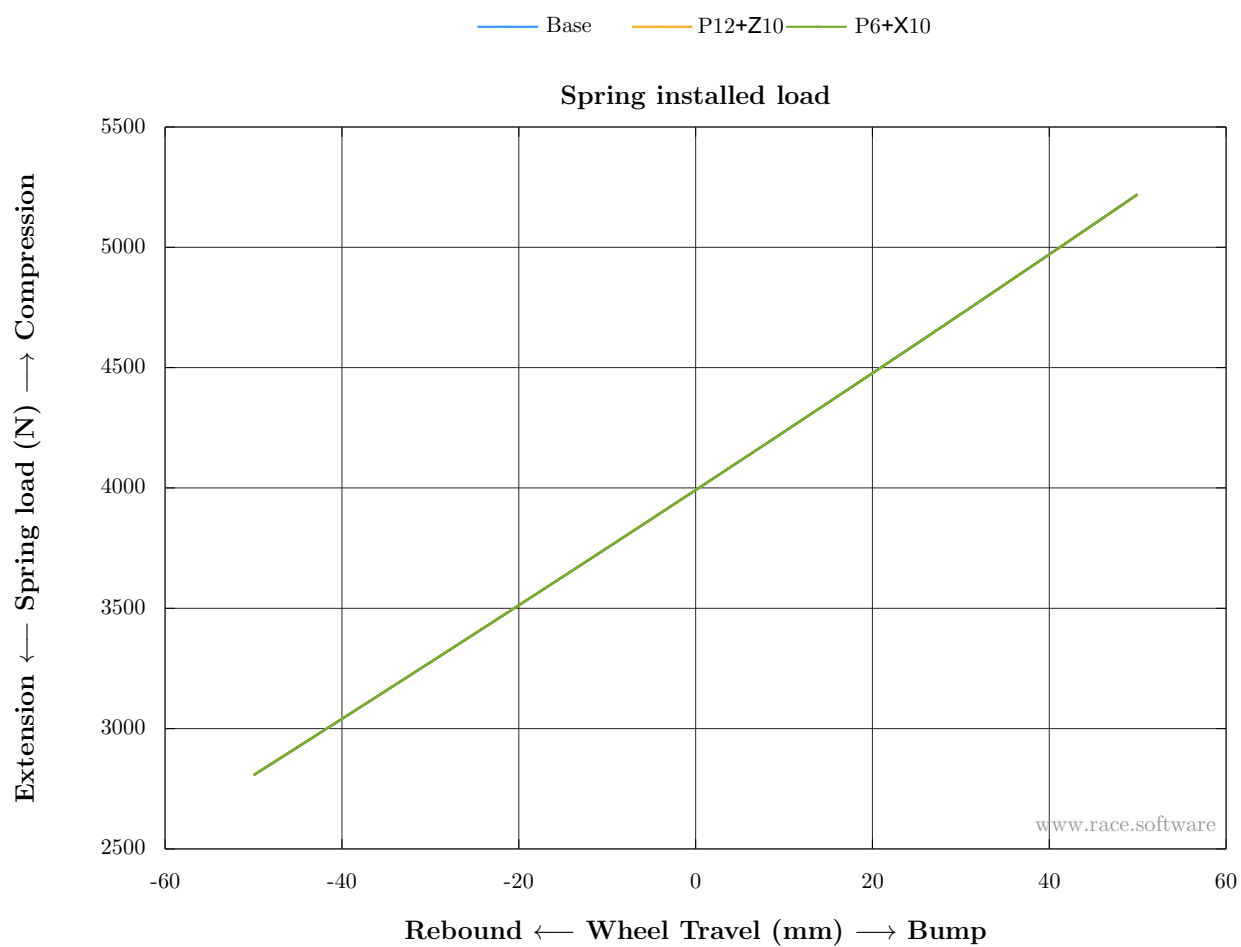


Figure 6: Vertical test: Spring installed load

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 252.9 mm
- Simulation ID P12+Z10: 252.9 mm
- Simulation ID P6+X10: 252.9 mm

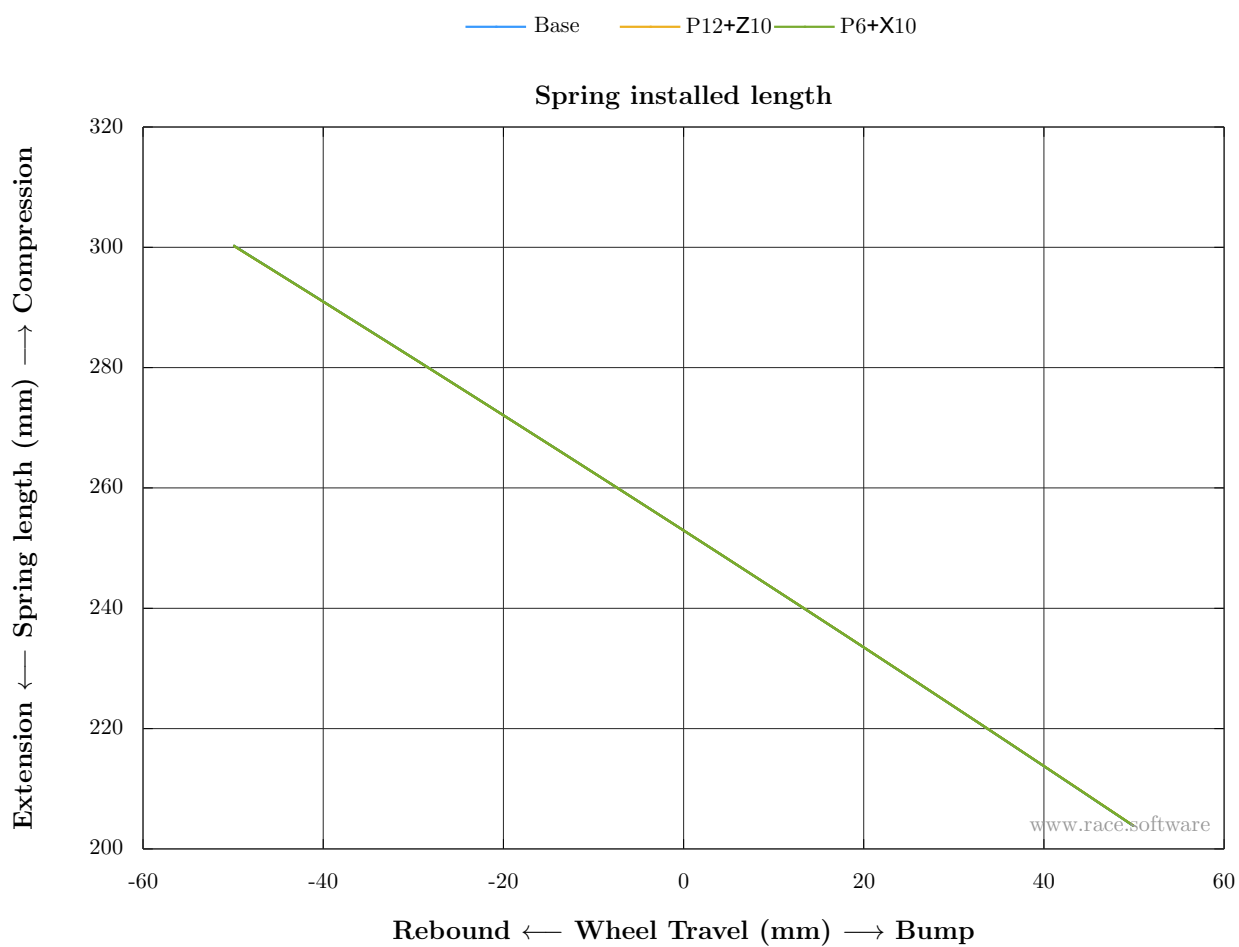


Figure 7: Vertical test: Spring installed length

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -11.8 deg/m
- Simulation ID P12+Z10: -12.6 deg/m
- Simulation ID P6+X10: -11.9 deg/m

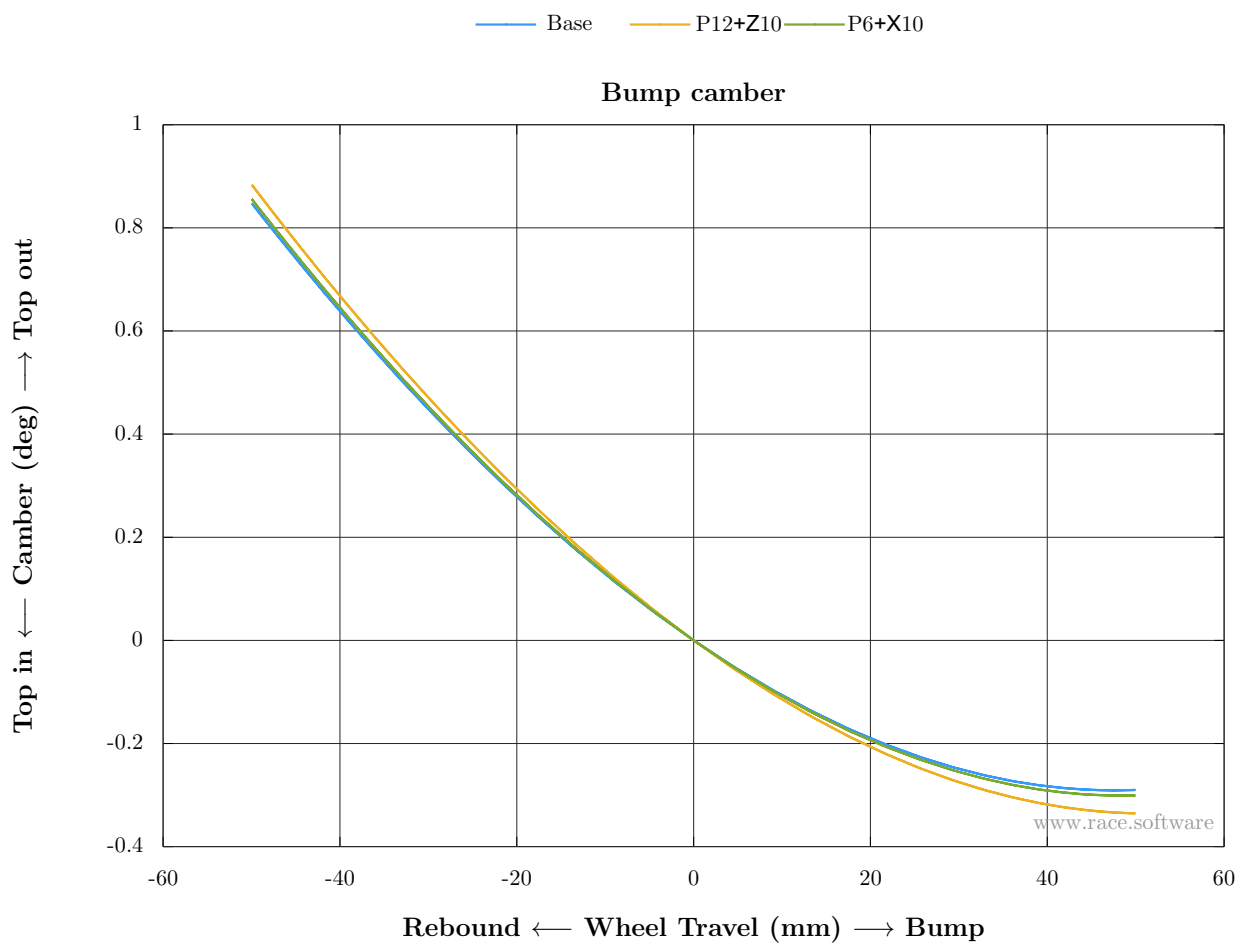


Figure 8: Vertical test: Bump camber

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -6.2 deg/m
- Simulation ID P12+Z10: 4.9 deg/m
- Simulation ID P6+X10: -5.6 deg/m

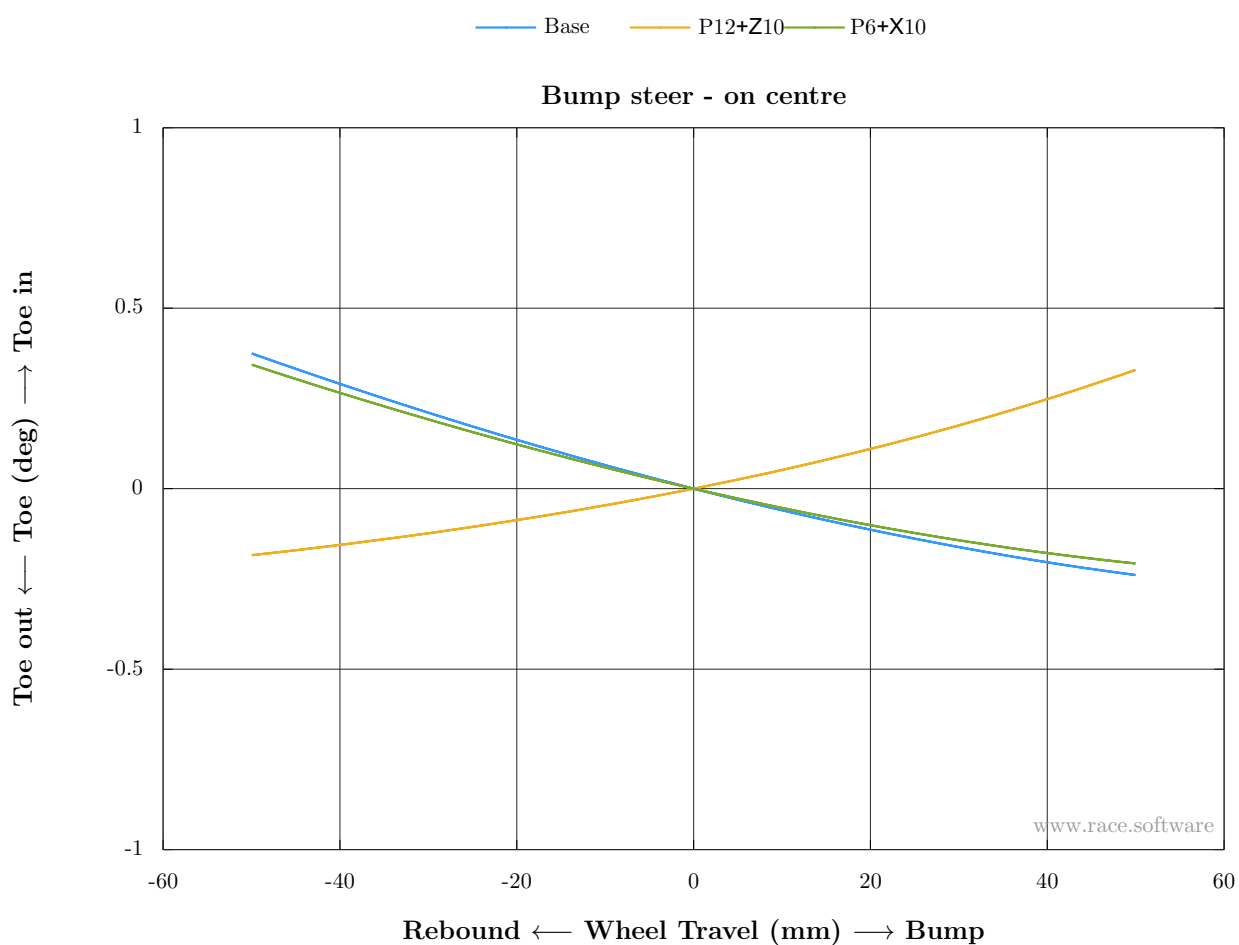


Figure 9: Vertical test: Bump steer - on centre

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -4.8 deg/m
- Simulation ID P12+Z10: 6.5 deg/m
- Simulation ID P6+X10: -4.2 deg/m

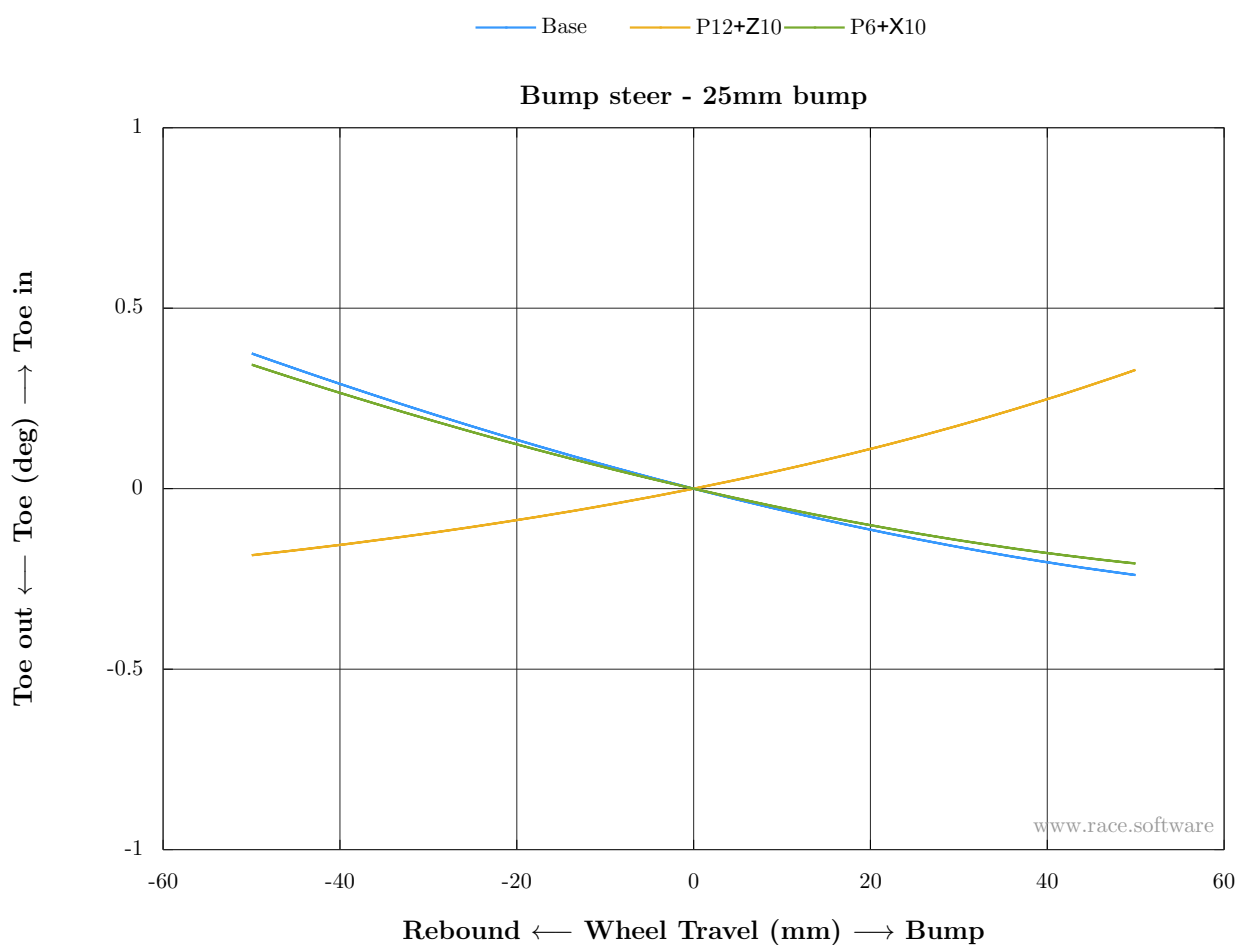


Figure 10: Vertical test: Bump steer - 25mm bump

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -7.5 deg/m
- Simulation ID P12+Z10: 3.6 deg/m
- Simulation ID P6+X10: -6.9 deg/m

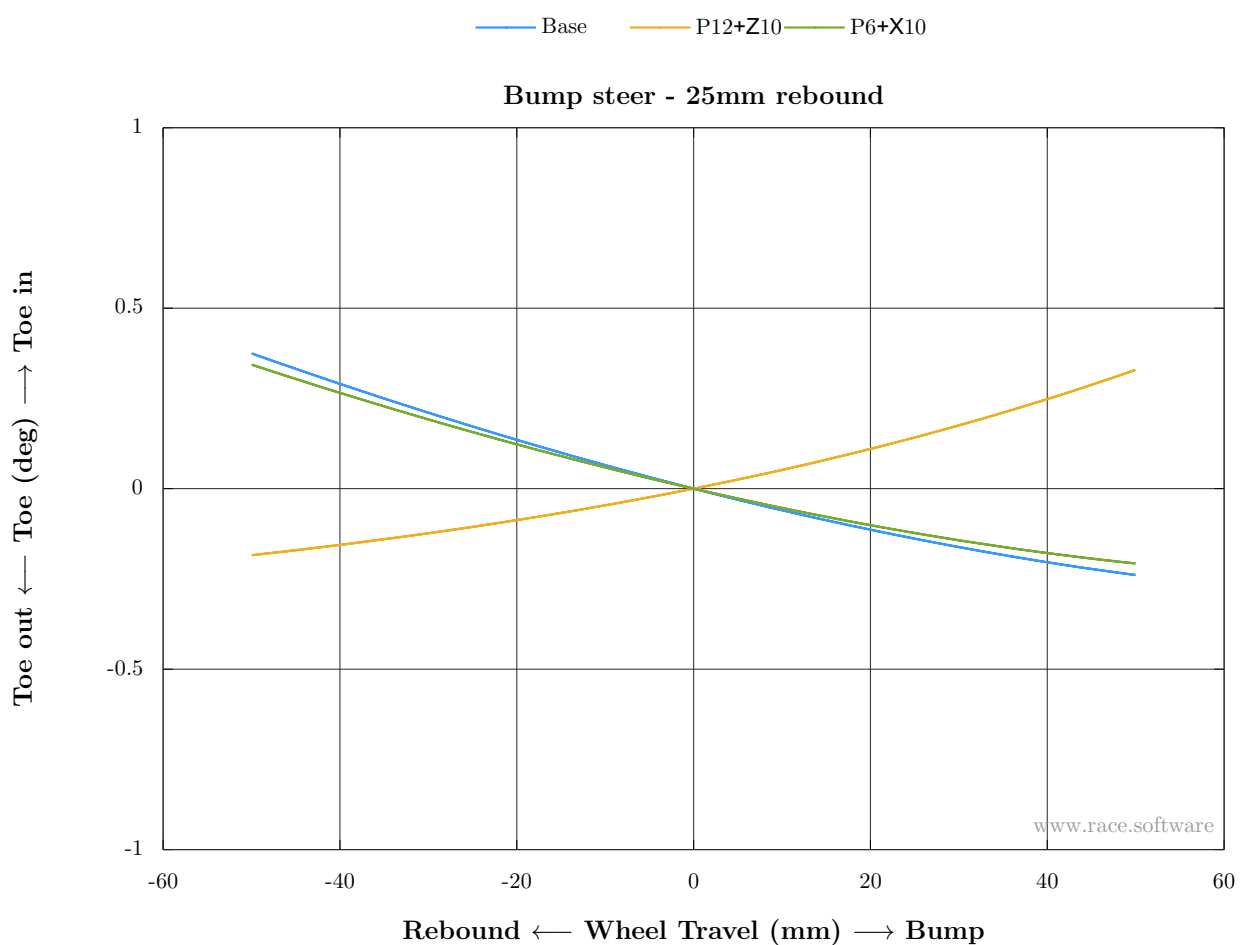


Figure 11: Vertical test: Bump steer - 25mm rebound

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 9.7 deg/m
- Simulation ID P12+Z10: 7.6 deg/m
- Simulation ID P6+X10: 9.6 deg/m

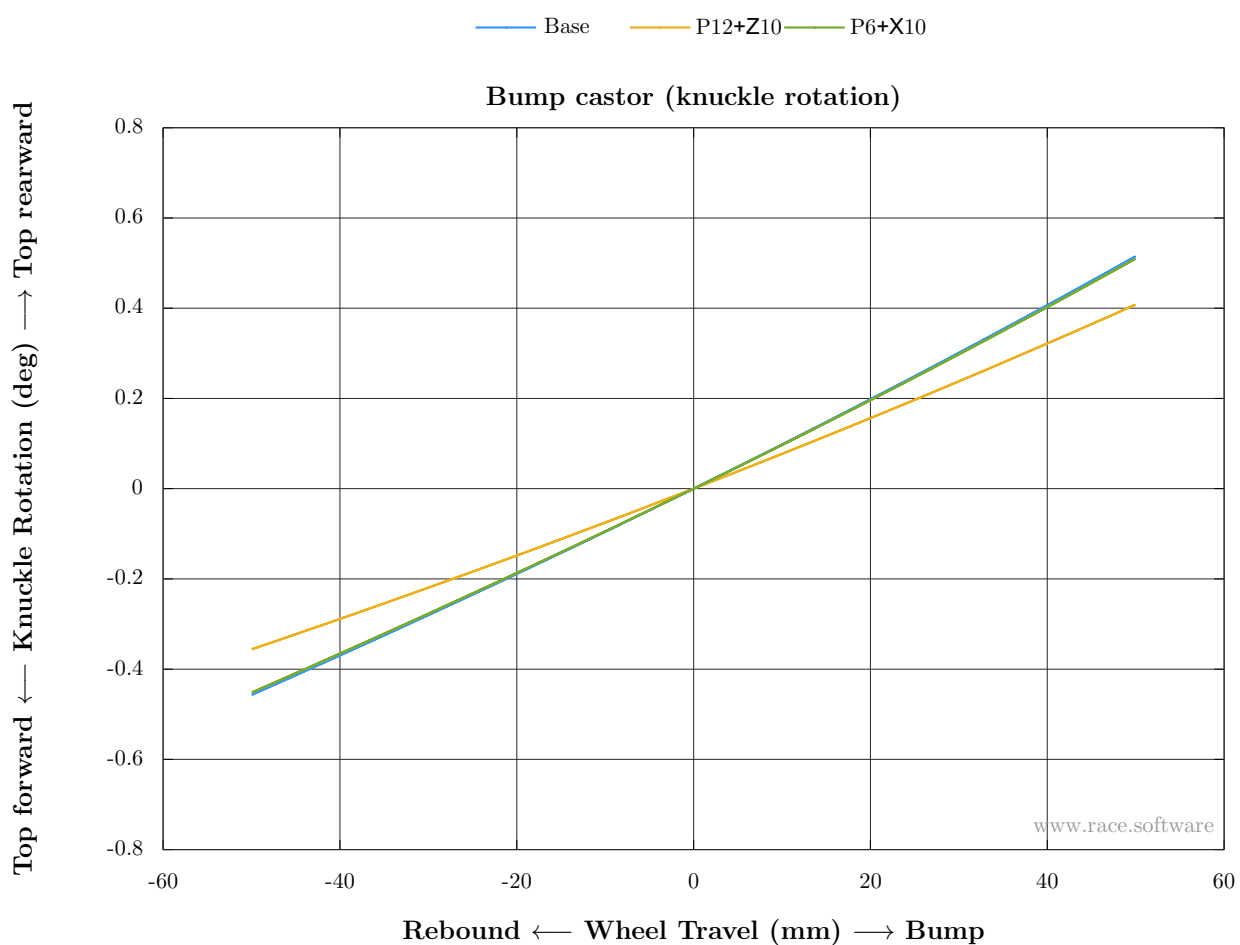


Figure 12: Vertical test: Bump castor (knuckle rotation)

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -4 mm/m
- Simulation ID P12+Z10: -17.5 mm/m
- Simulation ID P6+X10: -4.9 mm/m

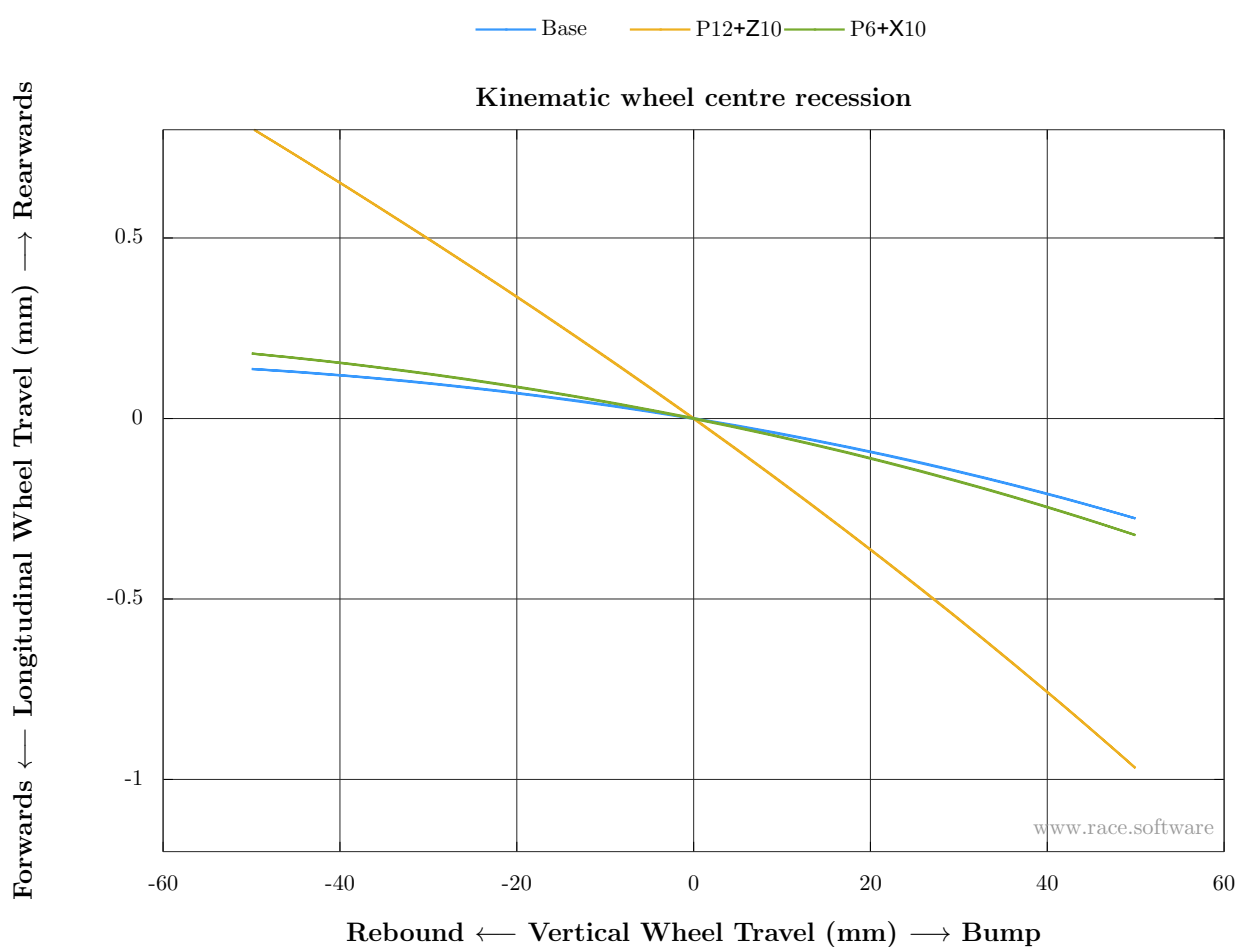


Figure 13: Vertical test: Kinematic wheel centre recession

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 72.4 mm/m
- Simulation ID P12+Z10: 75.3 mm/m
- Simulation ID P6+X10: 74.9 mm/m

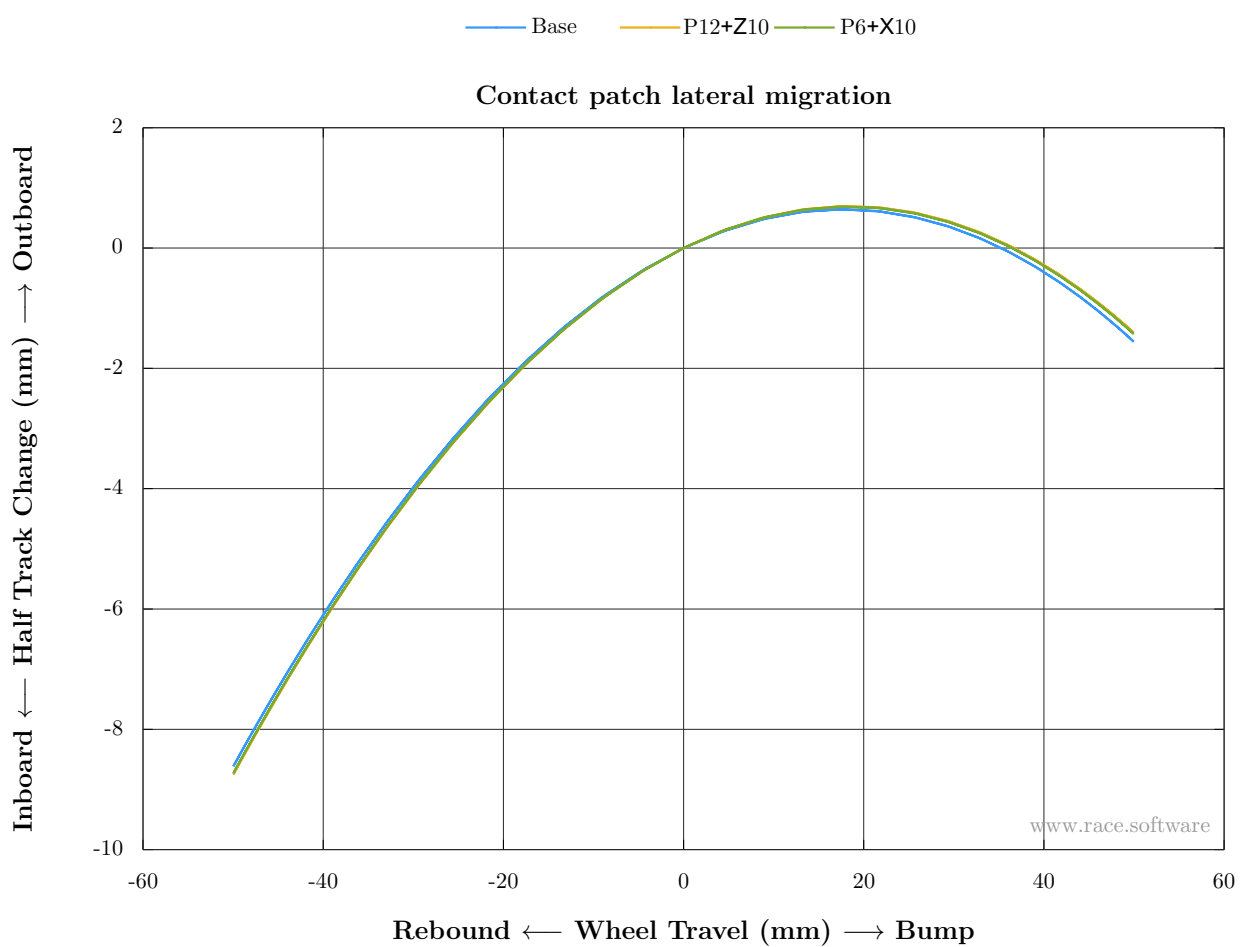


Figure 14: Vertical test: Contact patch lateral migration

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 28.8 N/mm
- Simulation ID P12+Z10: 28.7 N/mm
- Simulation ID P6+X10: 28.7 N/mm

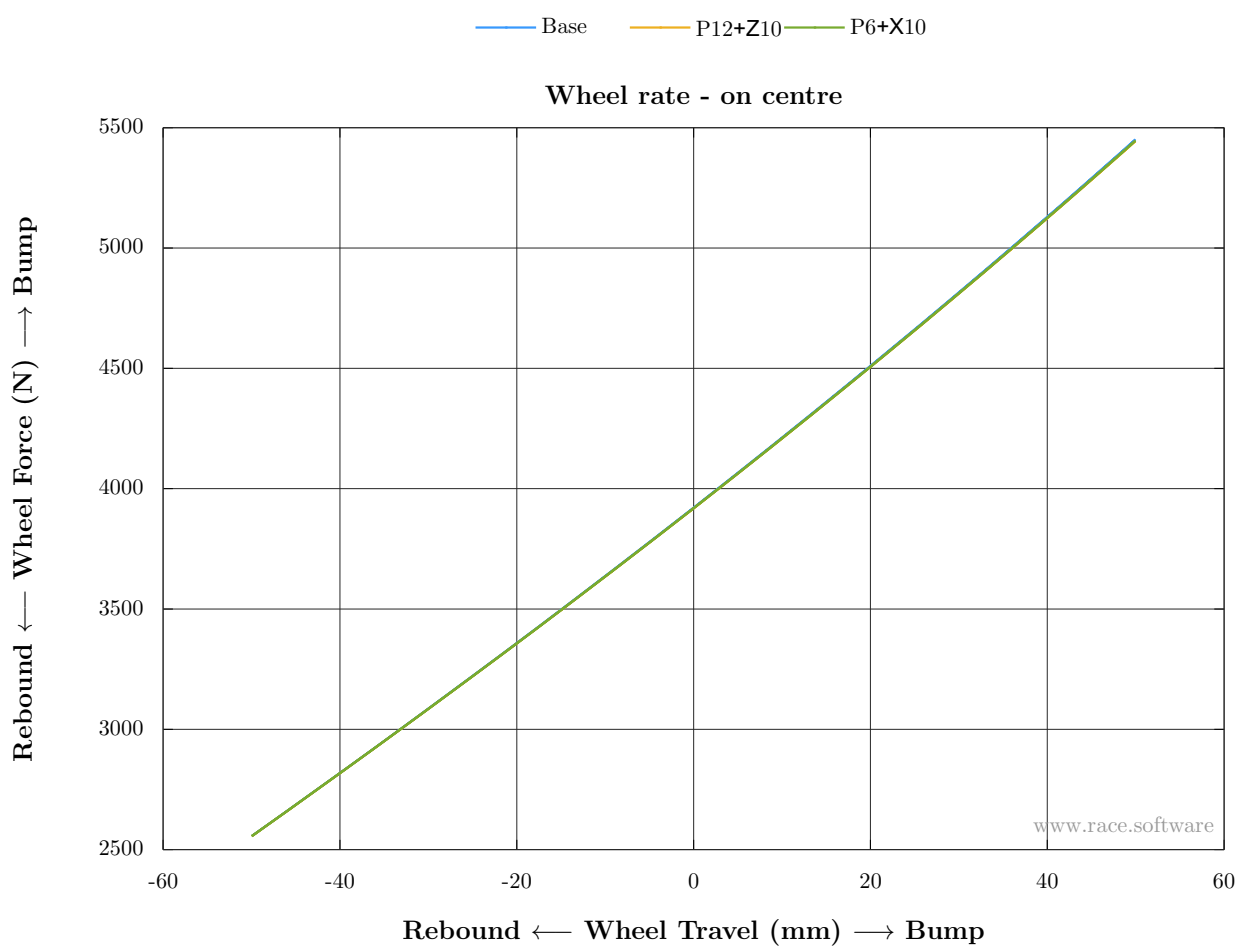


Figure 15: Vertical test: Wheel rate - on centre

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 30.6 N/mm
- Simulation ID P12+Z10: 30.5 N/mm
- Simulation ID P6+X10: 30.5 N/mm

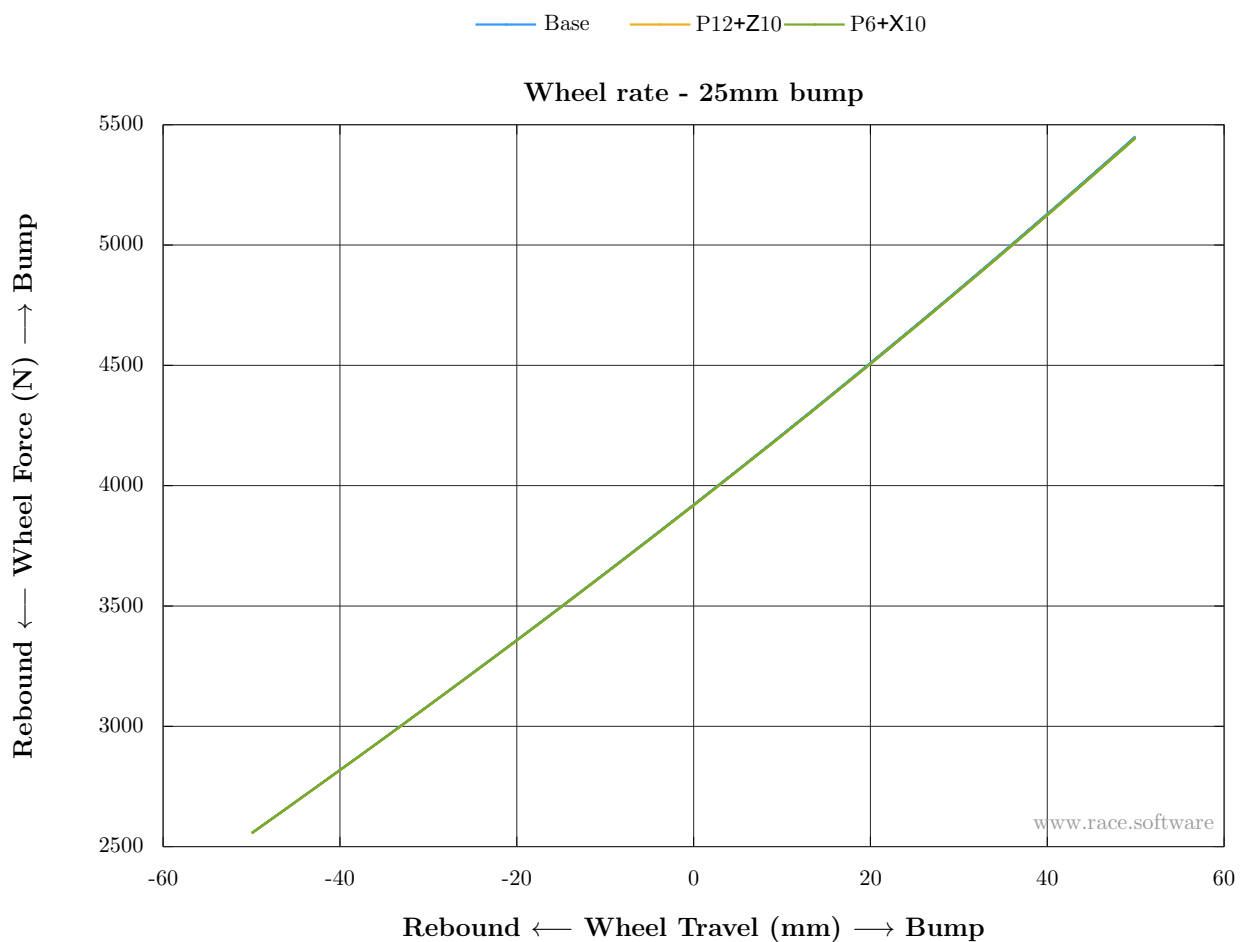


Figure 16: Vertical test: Wheel rate - 25mm bump

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 27.3 N/mm
- Simulation ID P12+Z10: 27.2 N/mm
- Simulation ID P6+X10: 27.2 N/mm

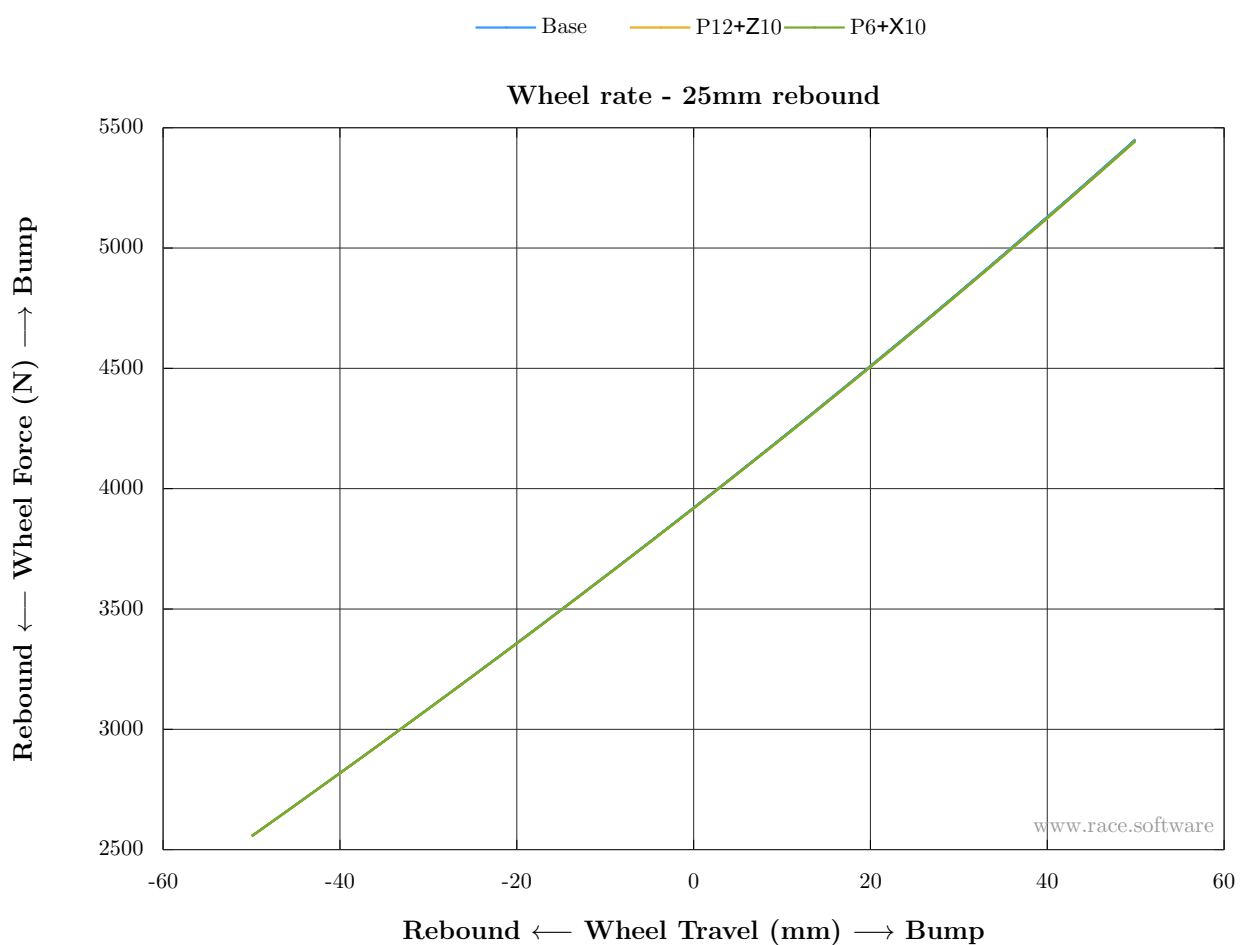


Figure 17: Vertical test: Wheel rate - 25mm rebound

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 0.65 mm/mm
- Simulation ID P12+Z10: 0.65 mm/mm
- Simulation ID P6+X10: 0.65 mm/mm

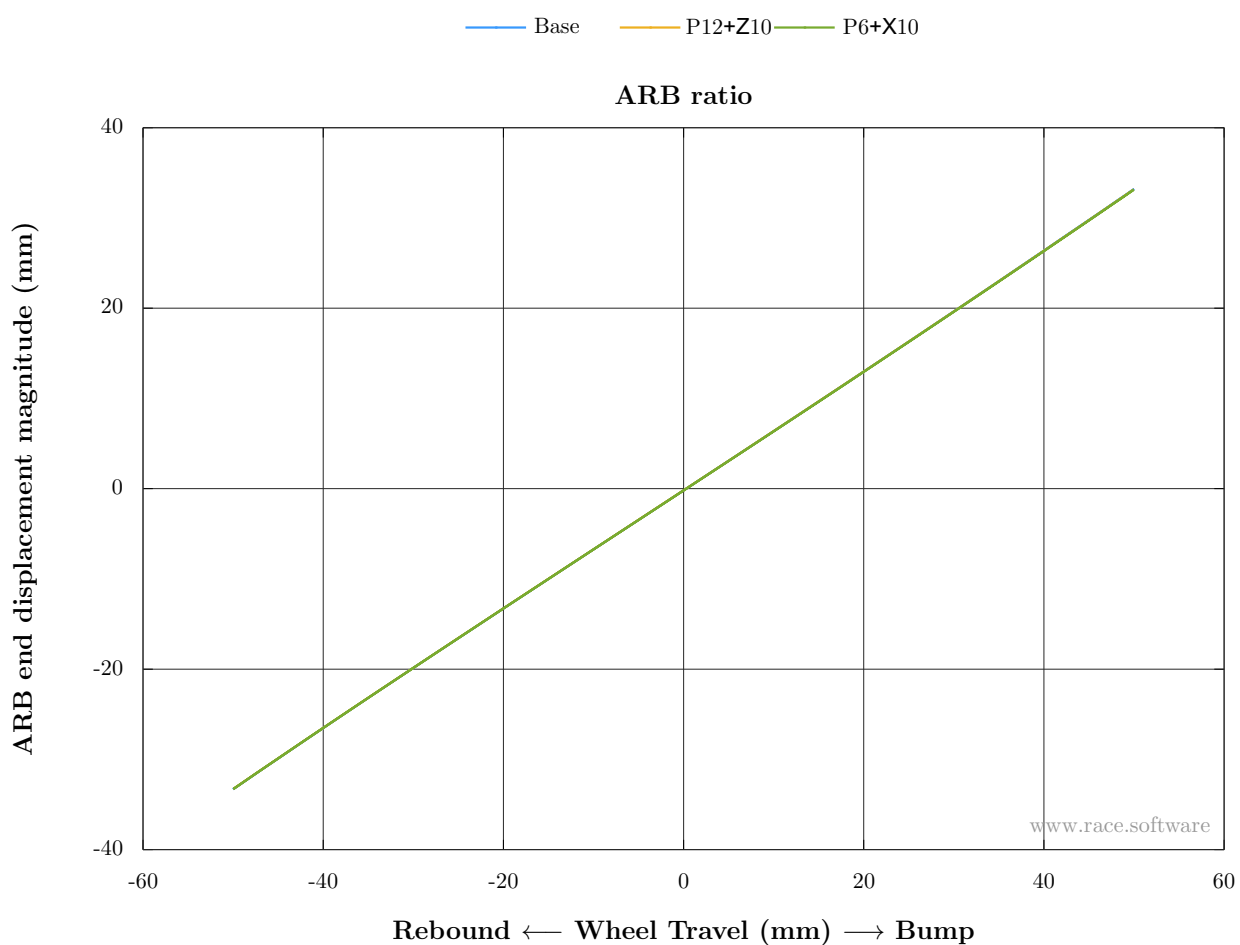


Figure 18: Roll test: ARB ratio

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -12.2 deg/m
- Simulation ID P12+Z10: -13 deg/m
- Simulation ID P6+X10: -12.4 deg/m

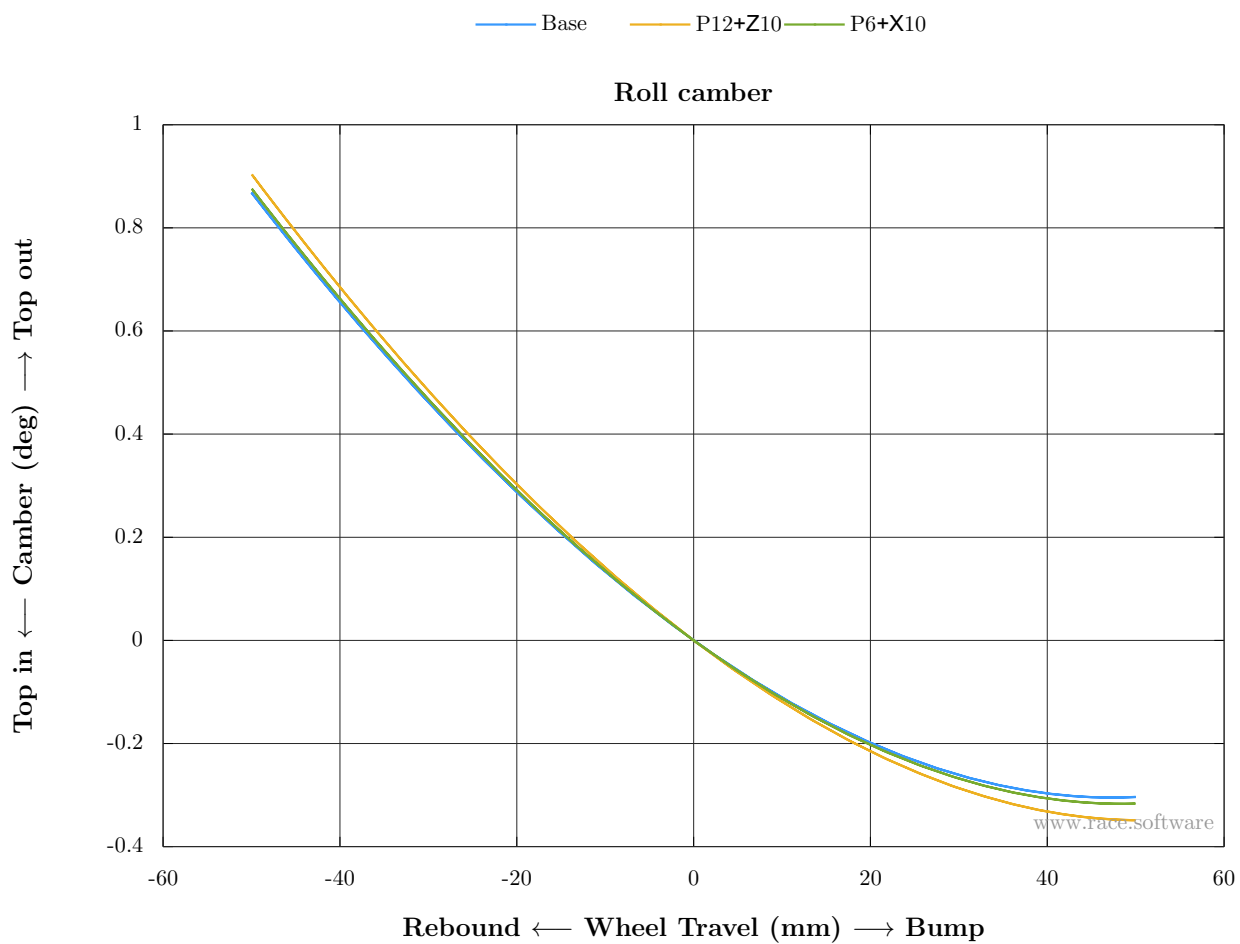


Figure 19: Roll test: Roll camber

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -5.5 deg/m
- Simulation ID P12+Z10: 5.6 deg/m
- Simulation ID P6+X10: -4.8 deg/m

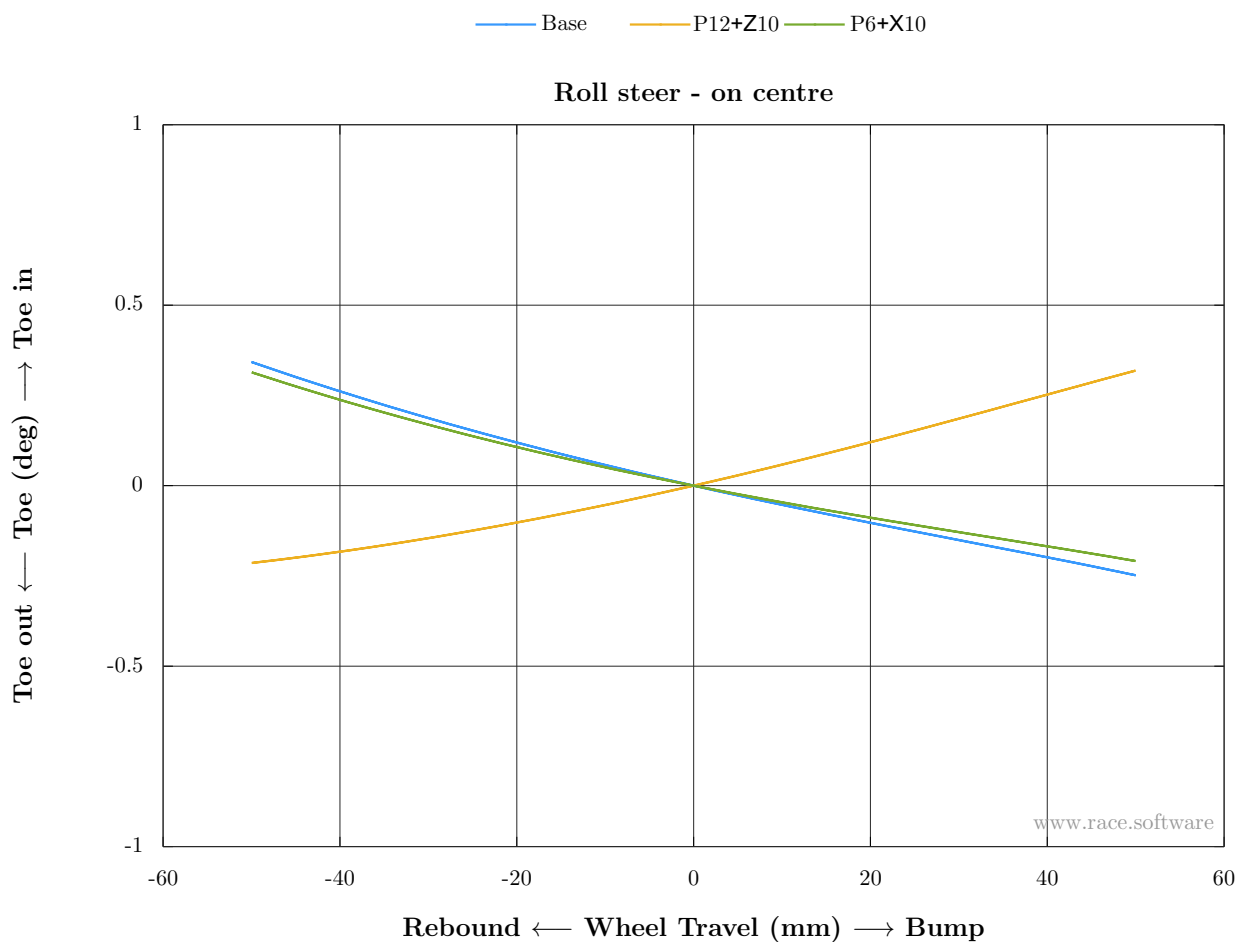


Figure 20: Roll test: Roll steer - on centre

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -4.8 deg/m
- Simulation ID P12+Z10: 6.5deg/m
- Simulation ID P6+X10: -4 deg/m

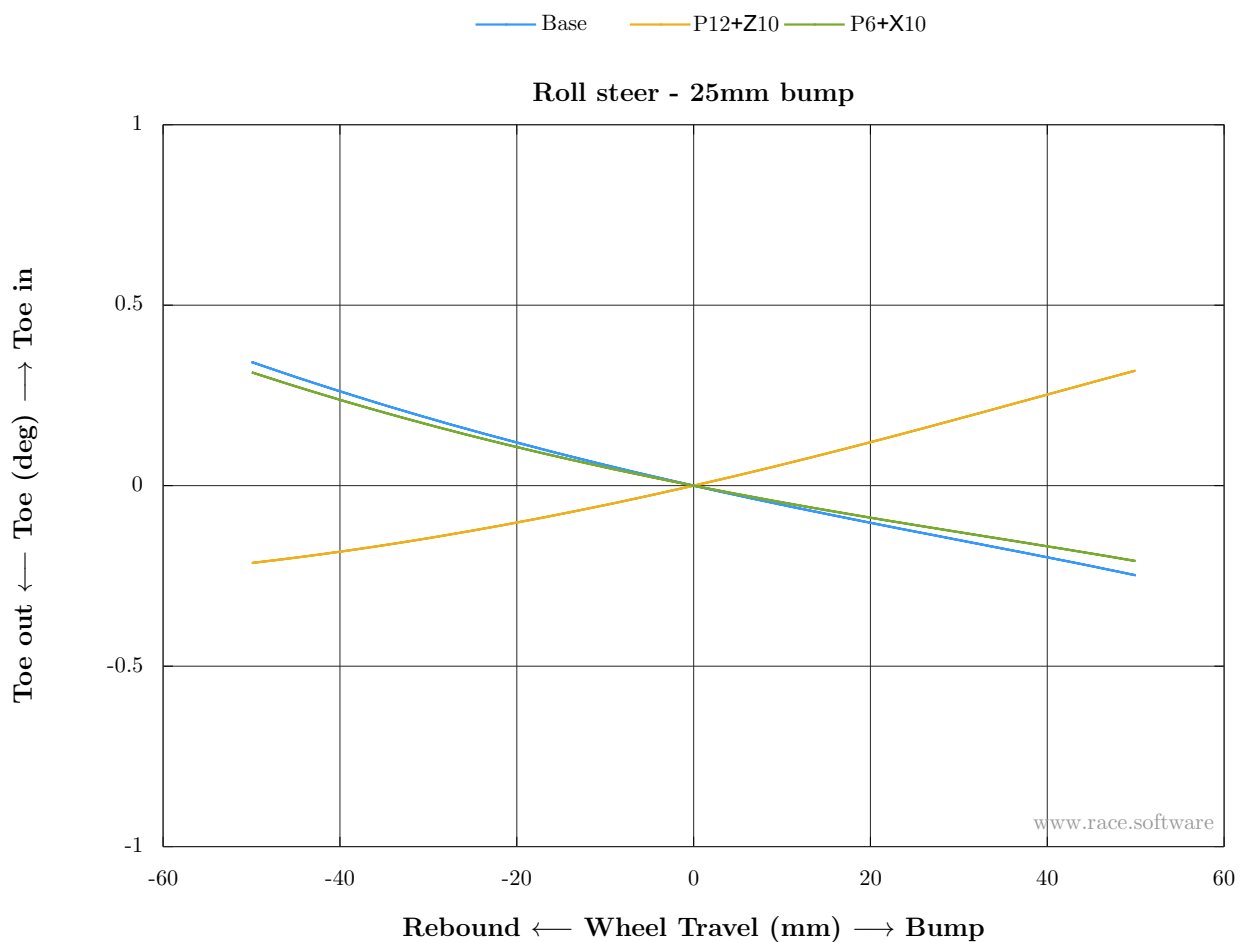


Figure 21: Roll test: Roll steer - 25mm bump

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -6.8 deg/m
- Simulation ID P12+Z10: 4.3 deg/m
- Simulation ID P6+X10: -6.2 deg/m

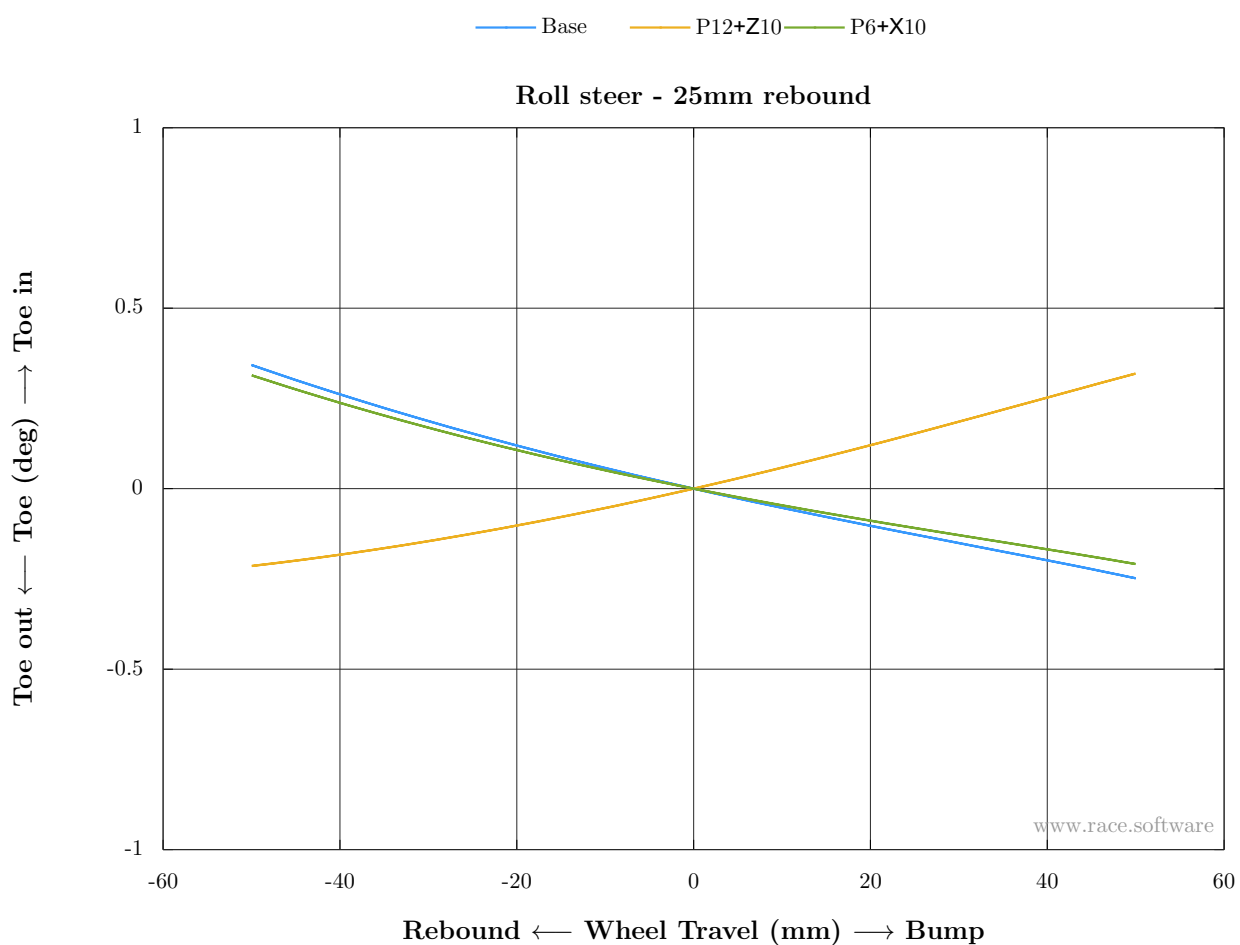


Figure 22: Roll test: Roll steer - 25mm rebound

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 78.3 N/mm
- Simulation ID P12+Z10: 78.2 N/mm
- Simulation ID P6+X10: 78.1 N/mm

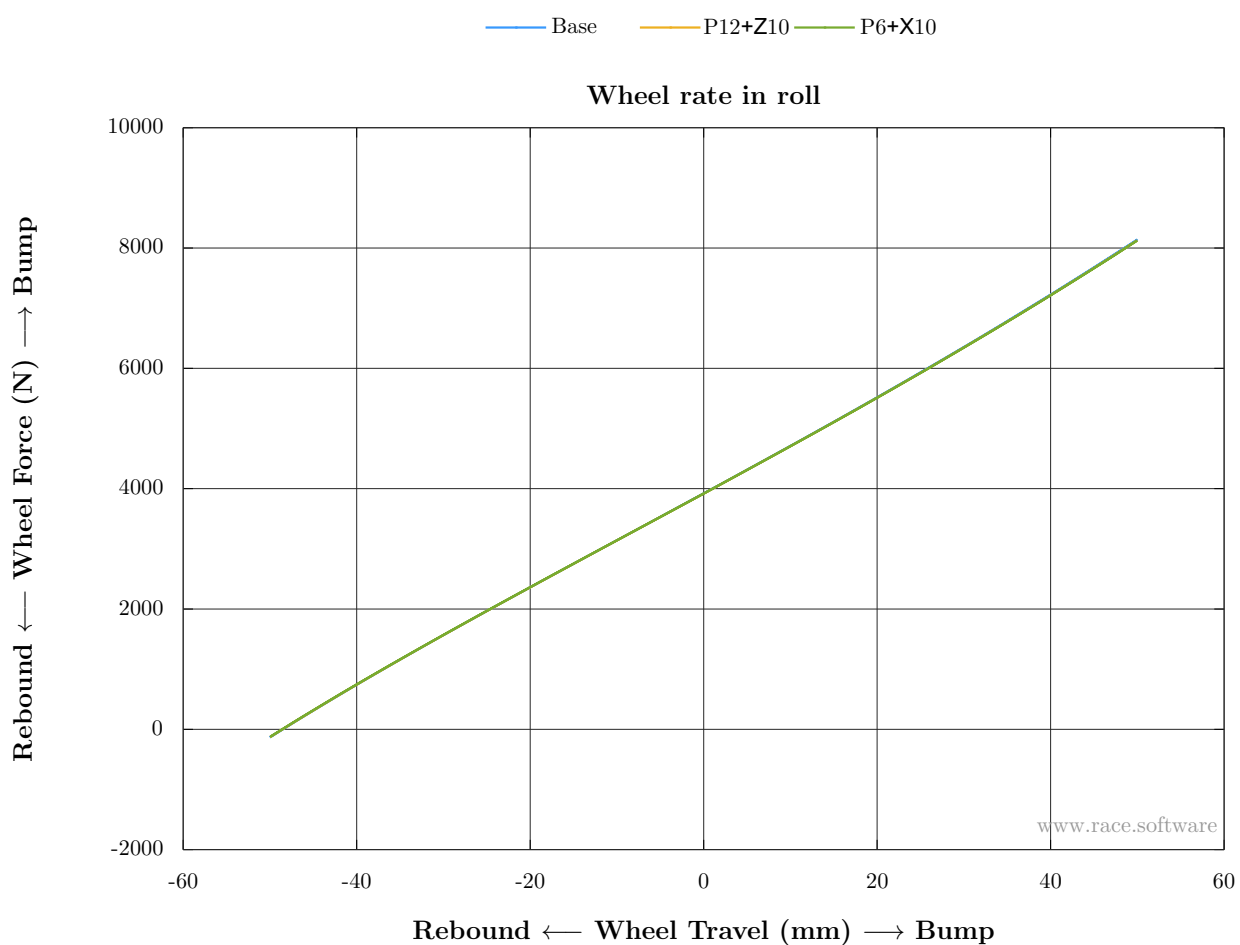


Figure 23: Roll test: Wheel rate in roll

⇐ Back to KPI Summary

Comparison Summary

- Simulation ID Base: 114.8 N/mm
- Simulation ID P12+Z10: 114.9 N/mm
- Simulation ID P6+X10: 114.9 N/mm

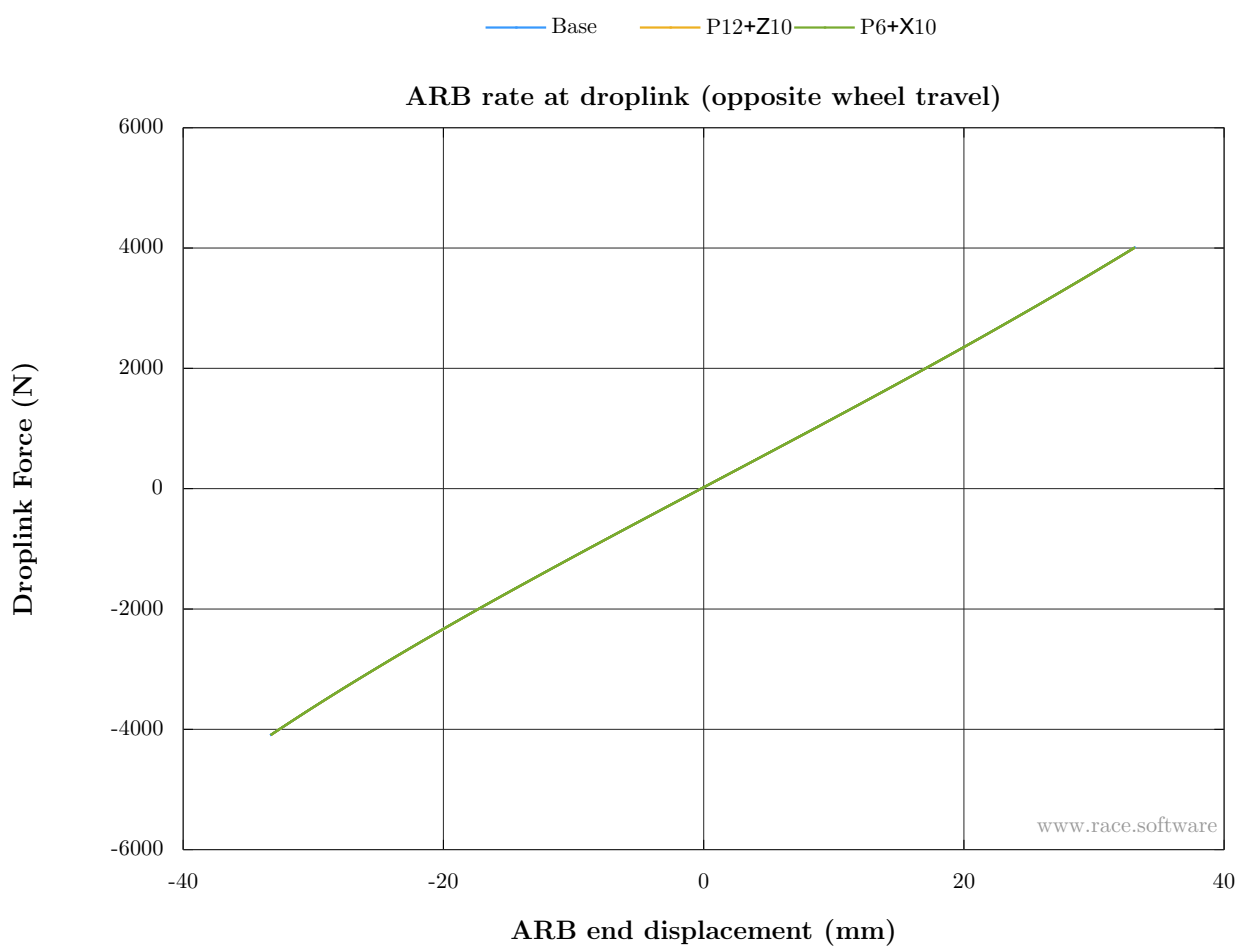


Figure 24: Roll test: ARB rate at droplink (opposite wheel travel)

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 57.4 N/mm
- Simulation ID P12+Z10: 57.4 N/mm
- Simulation ID P6+X10: 57.4 N/mm

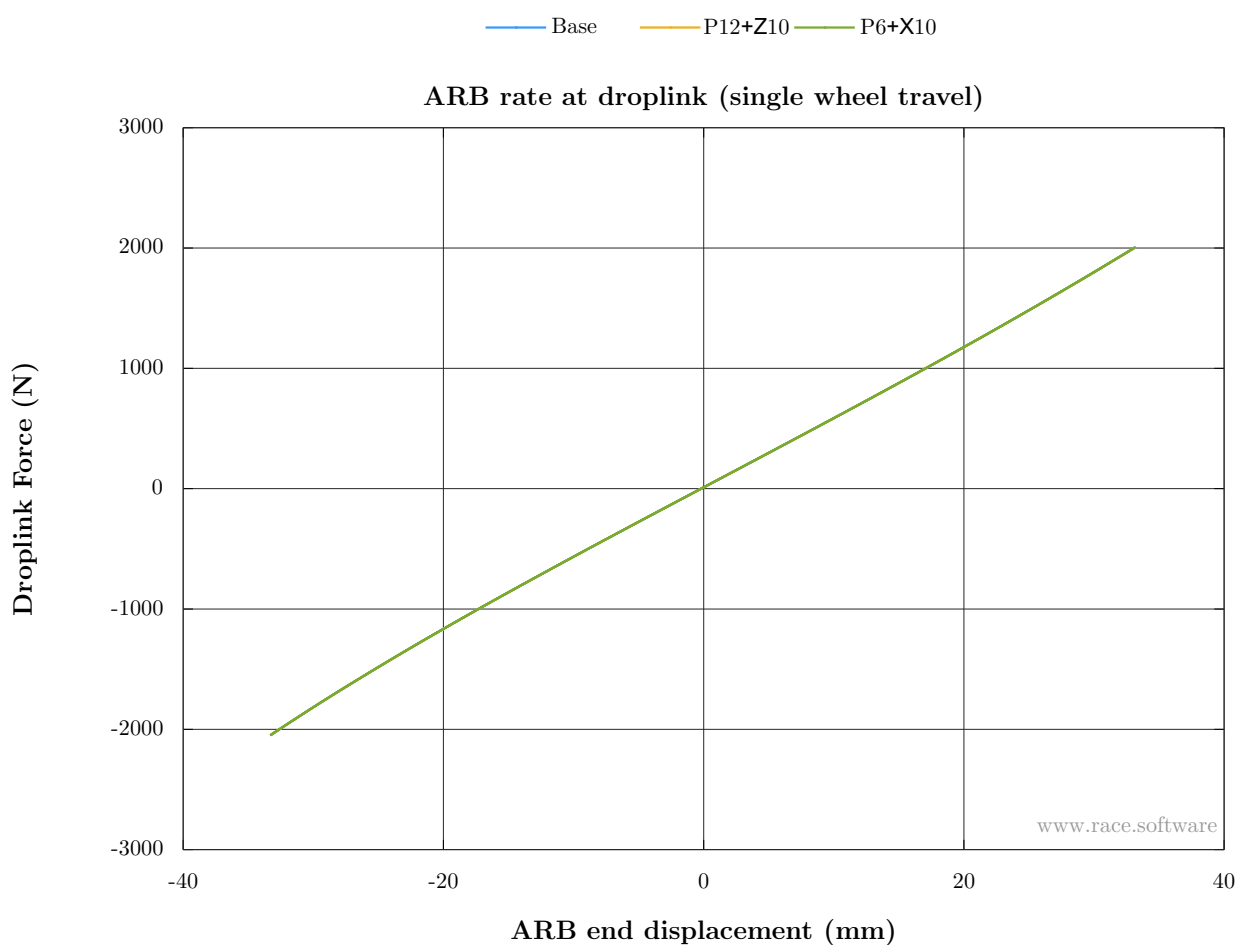


Figure 25: Roll test: ARB rate at droplink (single wheel travel)

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 10.5 deg
- Simulation ID P12+Z10: 10.5 deg
- Simulation ID P6+X10: 10.5 deg

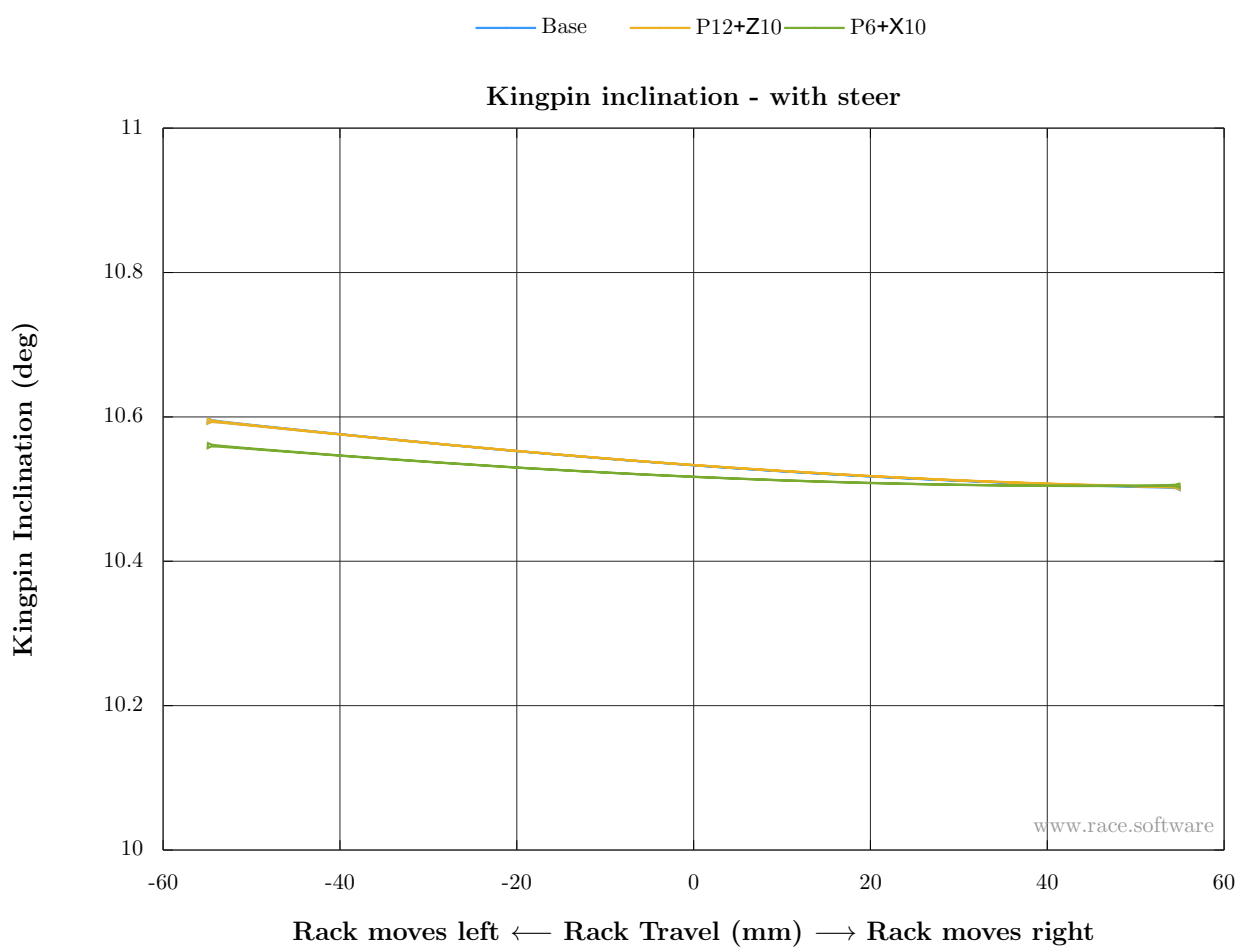


Figure 26: Steering test: Kingpin inclination - with steer

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 4.1 deg
- Simulation ID P12+Z10: 4.1 deg
- Simulation ID P6+X10: 3.4 deg

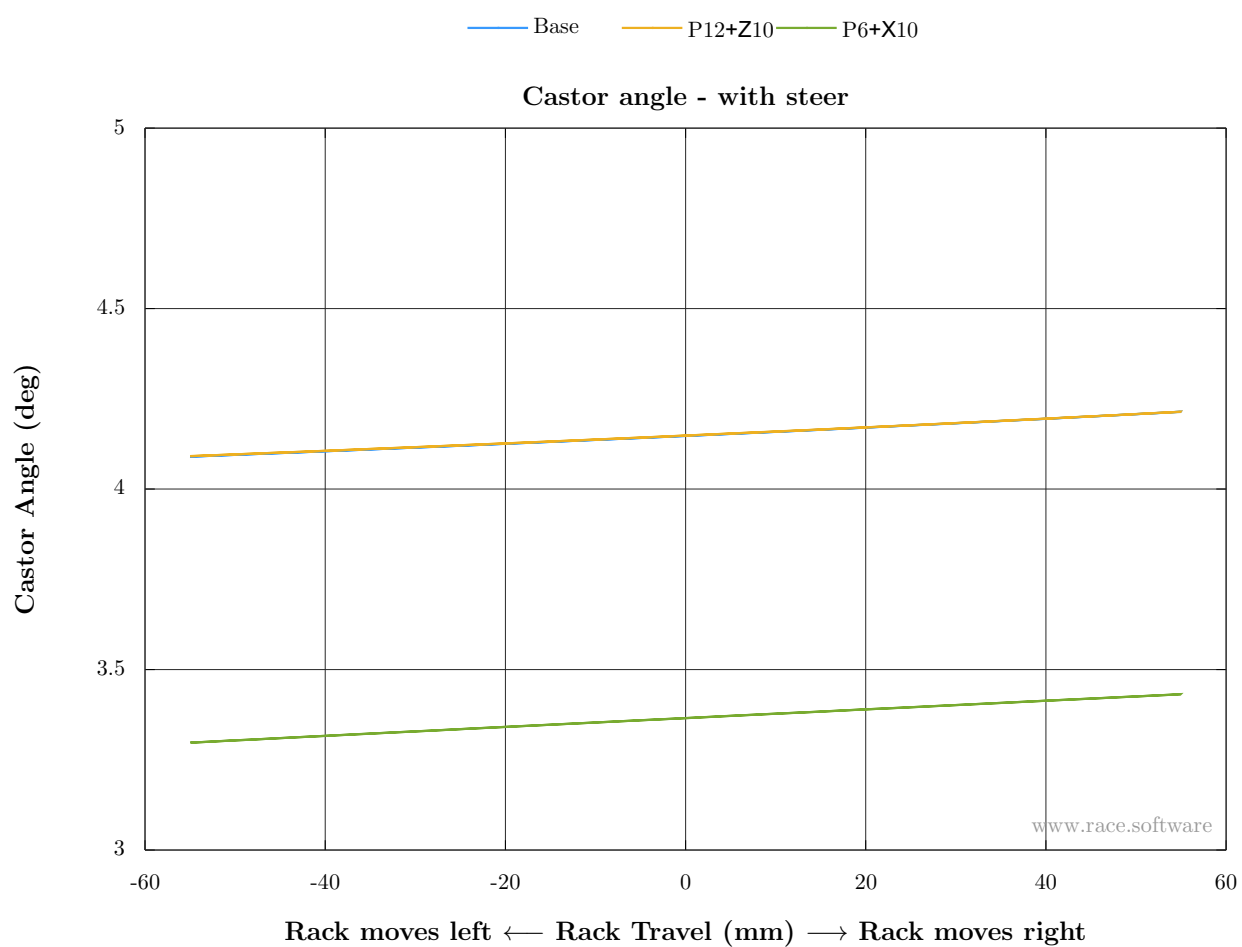


Figure 27: Steering test: Caster angle - with steer

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 14.1 mm
- Simulation ID P12+Z10: 14.1 mm
- Simulation ID P6+X10: 1.7mm

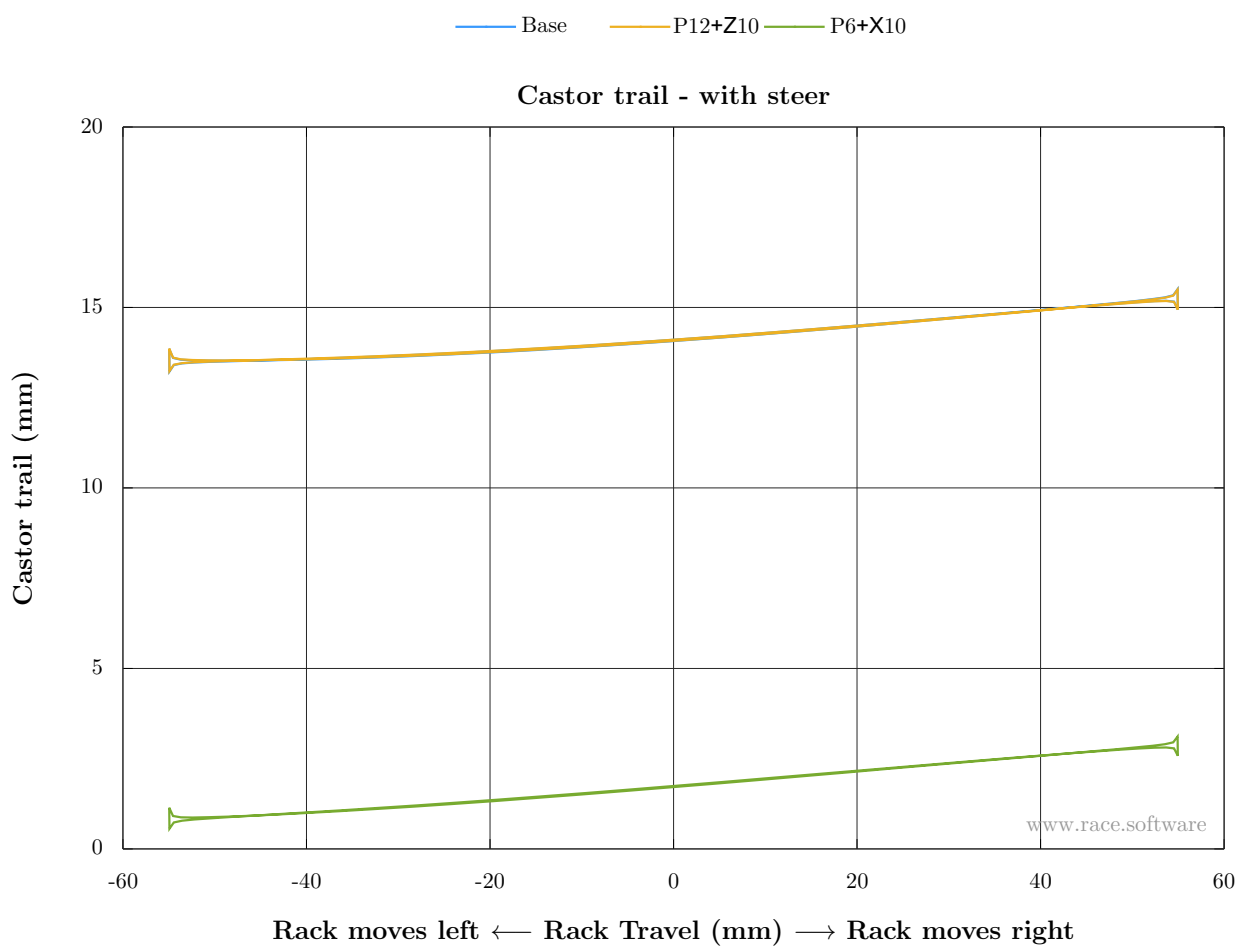


Figure 28: Steering test: Castor trail - with steer

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 11.6 mm
- Simulation ID P12+Z10: 11.6 mm
- Simulation ID P6+X10: 11.9 mm

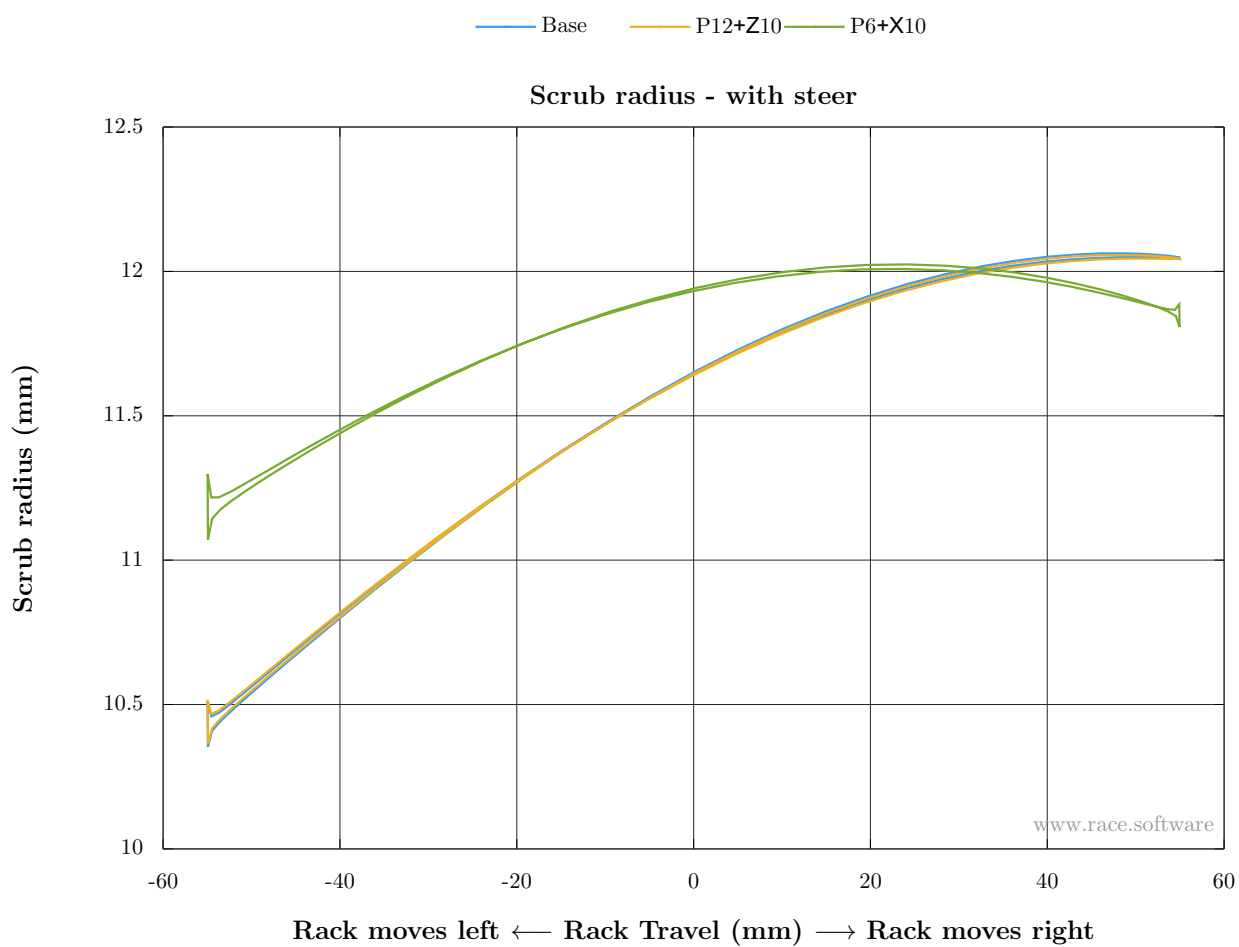


Figure 29: Steering test: Scrub radius - with steer

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -7.8 mm
- Simulation ID P12+Z10: -7.8 mm
- Simulation ID P6+X10: -15.9 mm

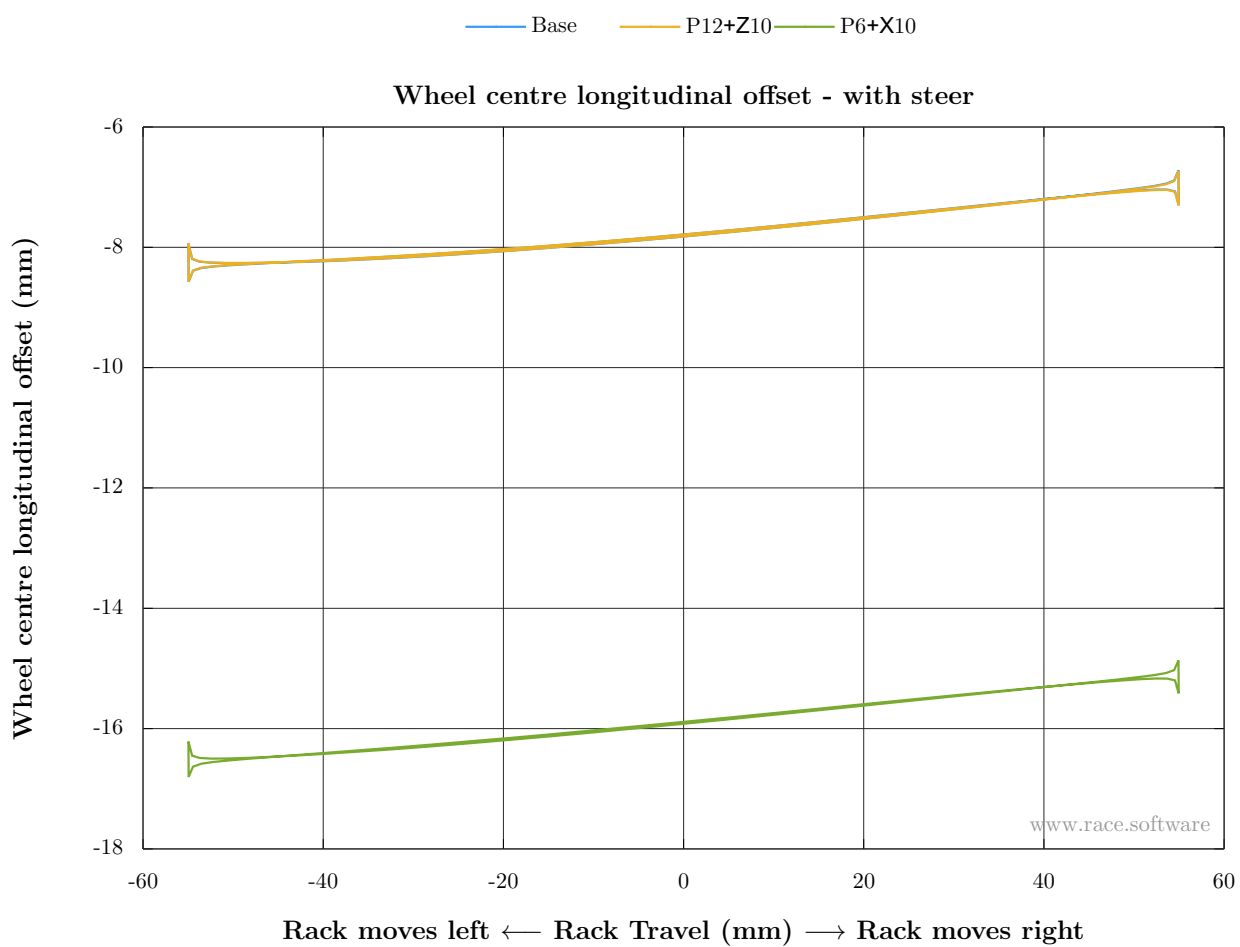


Figure 30: Steering test: Wheel centre longitudinal offset - with steer

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 67.6 mm
- Simulation ID P12+Z10: 67.6 mm
- Simulation ID P6+X10: 67.7 mm

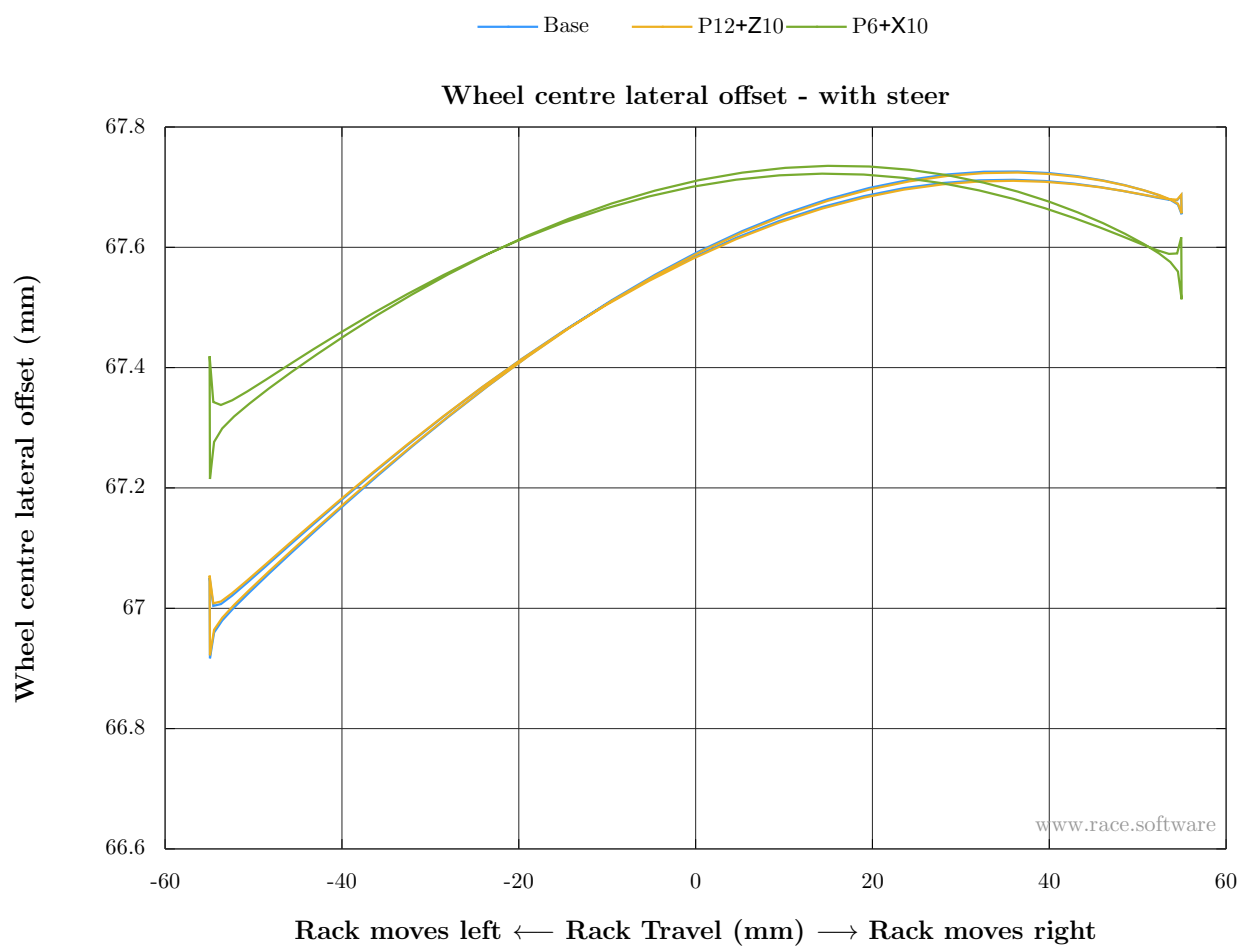


Figure 31: Steering test: Wheel centre lateral offset - with steer

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 0.38 deg/mm
- Simulation ID P12+Z10: 0.37 deg/mm
- Simulation ID P6+X10: 0.36 deg/mm

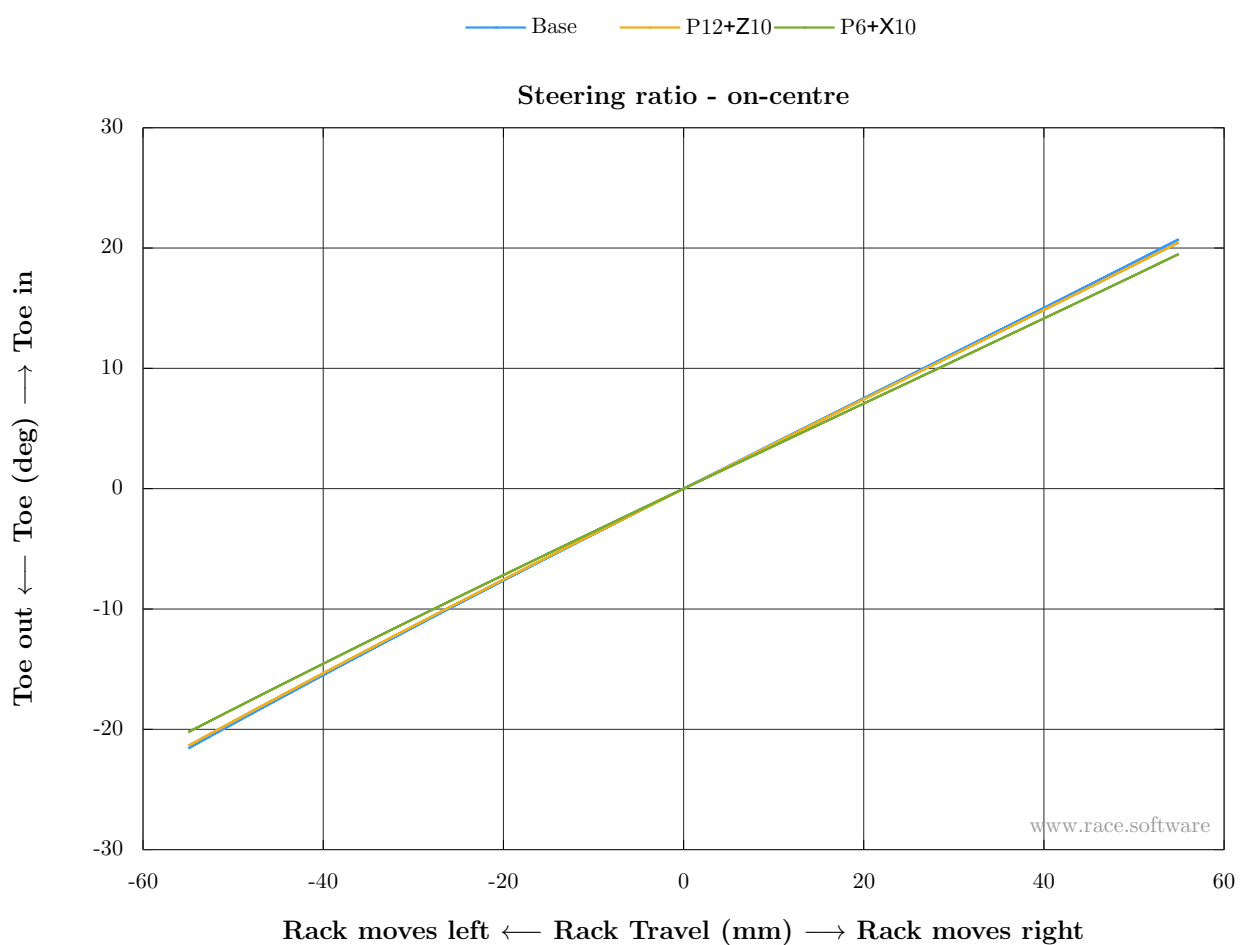


Figure 32: Steering test: Steering ratio - on-centre

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -93.9 N
- Simulation ID P12+Z10: -93 N
- Simulation ID P6+X10: -26.2 N

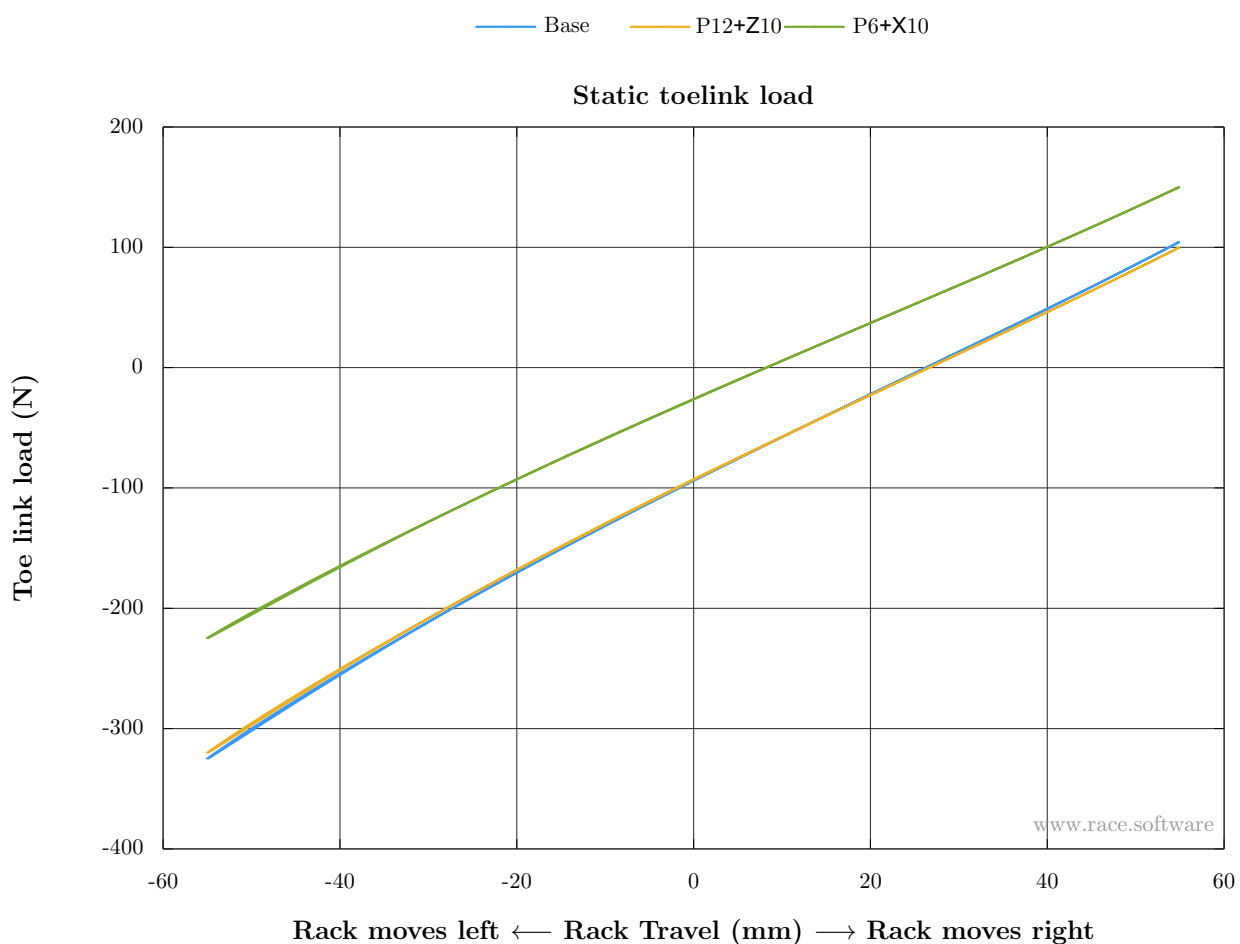


Figure 33: Steering test: Static toelink load

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 55 mm
- Simulation ID P12+Z10: 55 mm
- Simulation ID P6+X10: 55 mm

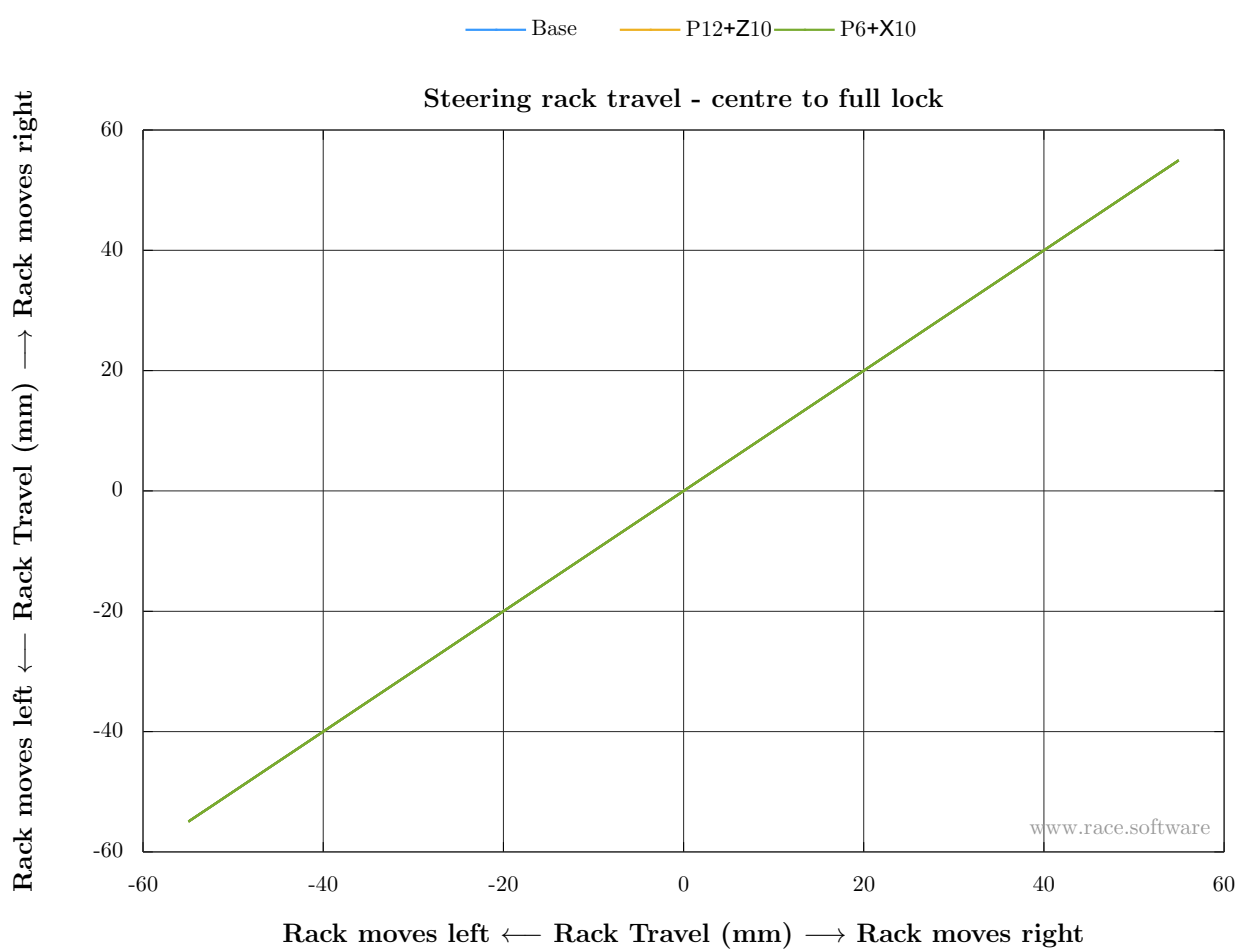


Figure 34: Steering test: Steering rack travel - centre to full lock

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: 20.9 deg
- Simulation ID P12+Z10: 20.6 deg
- Simulation ID P6+X10: 19.7 deg

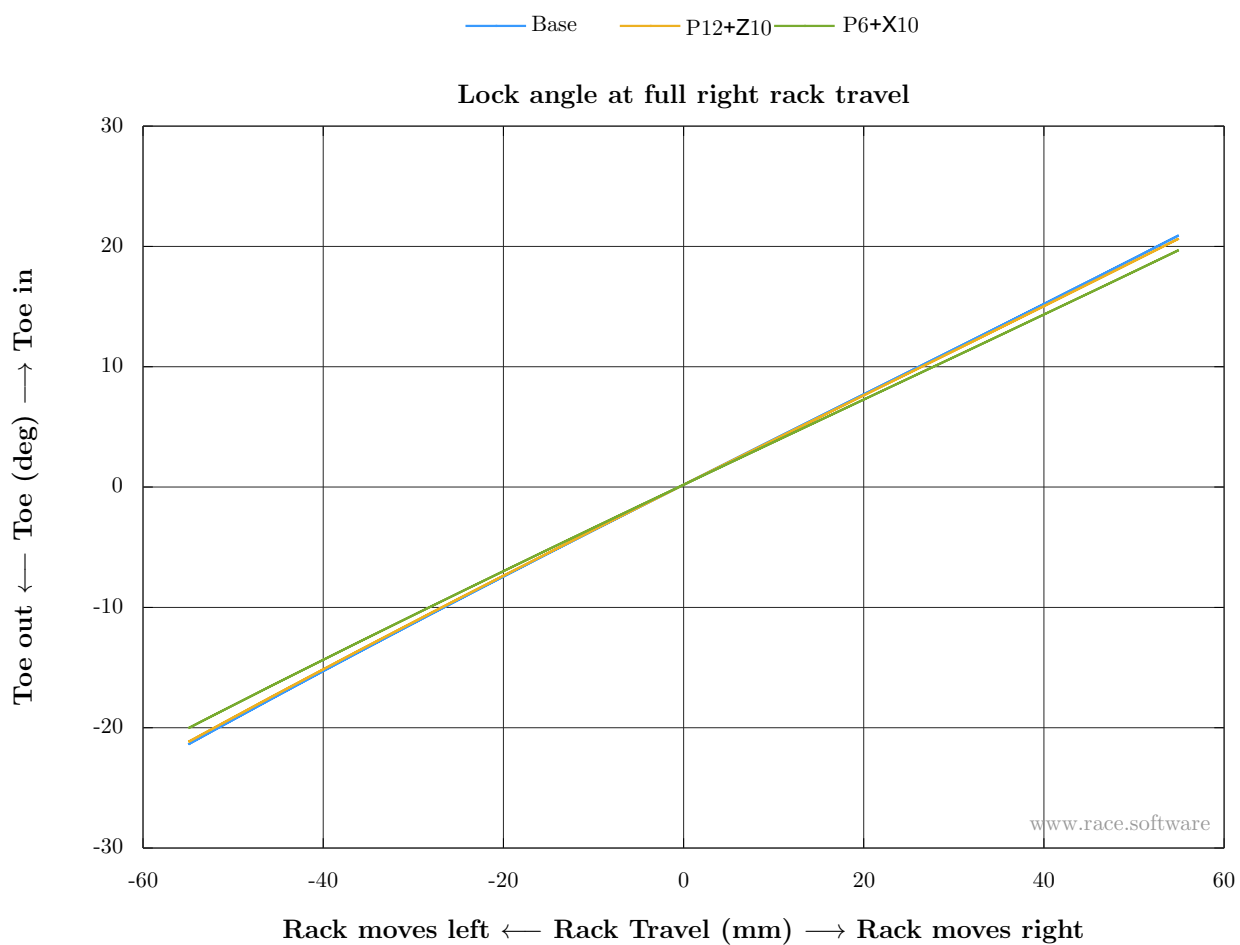


Figure 35: Steering test: Lock angle at full right rack travel

← Back to KPI Summary

Comparison Summary

- Simulation ID Base: -21.4 deg
- Simulation ID P12+Z10: -21.2 deg
- Simulation ID P6+X10: -20 deg

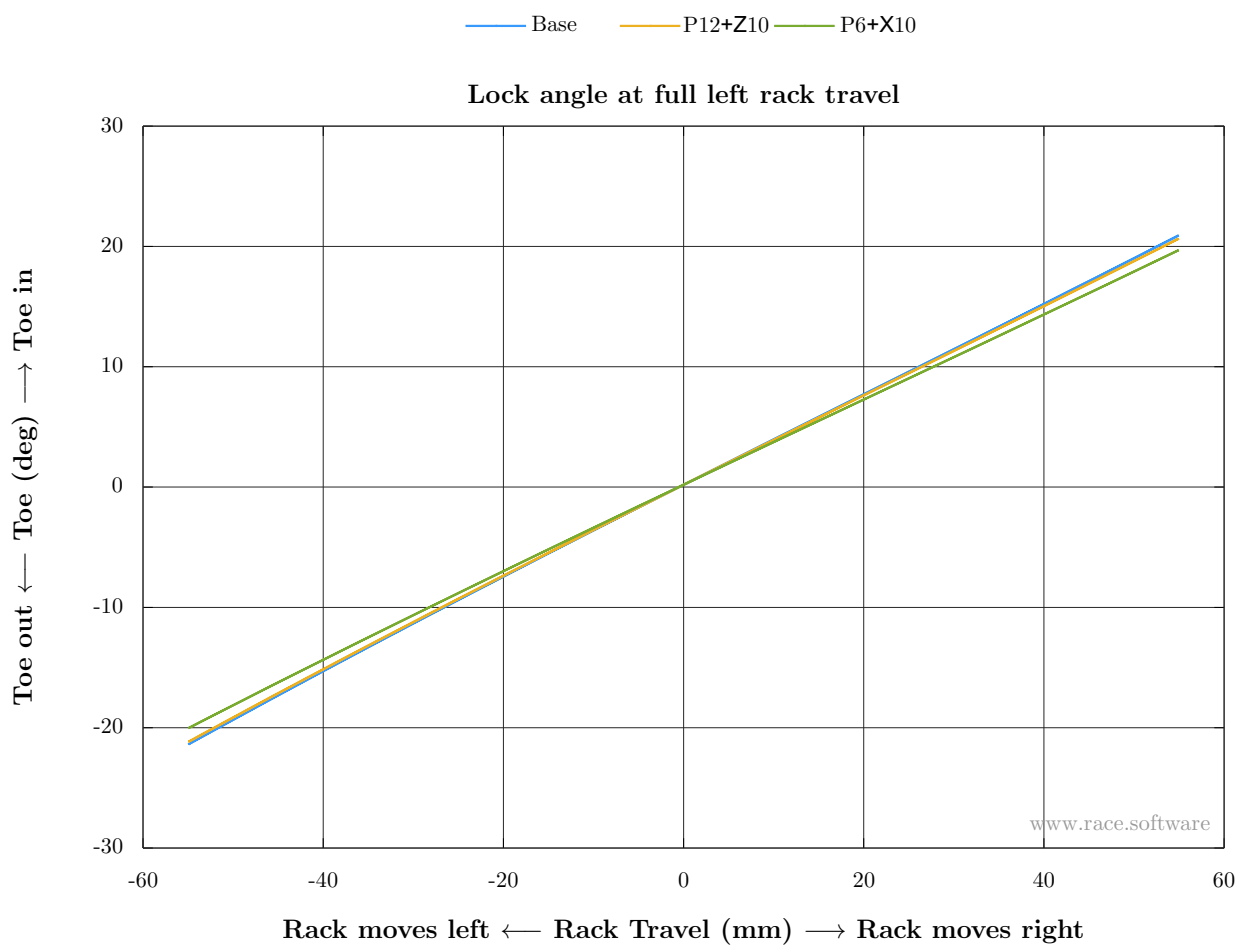


Figure 36: Steering test: Lock angle at full left rack travel

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Comparison Summary

- Simulation ID Base: 11 %
- Simulation ID P12+Z10: 13 %
- Simulation ID P6+X10: 9%

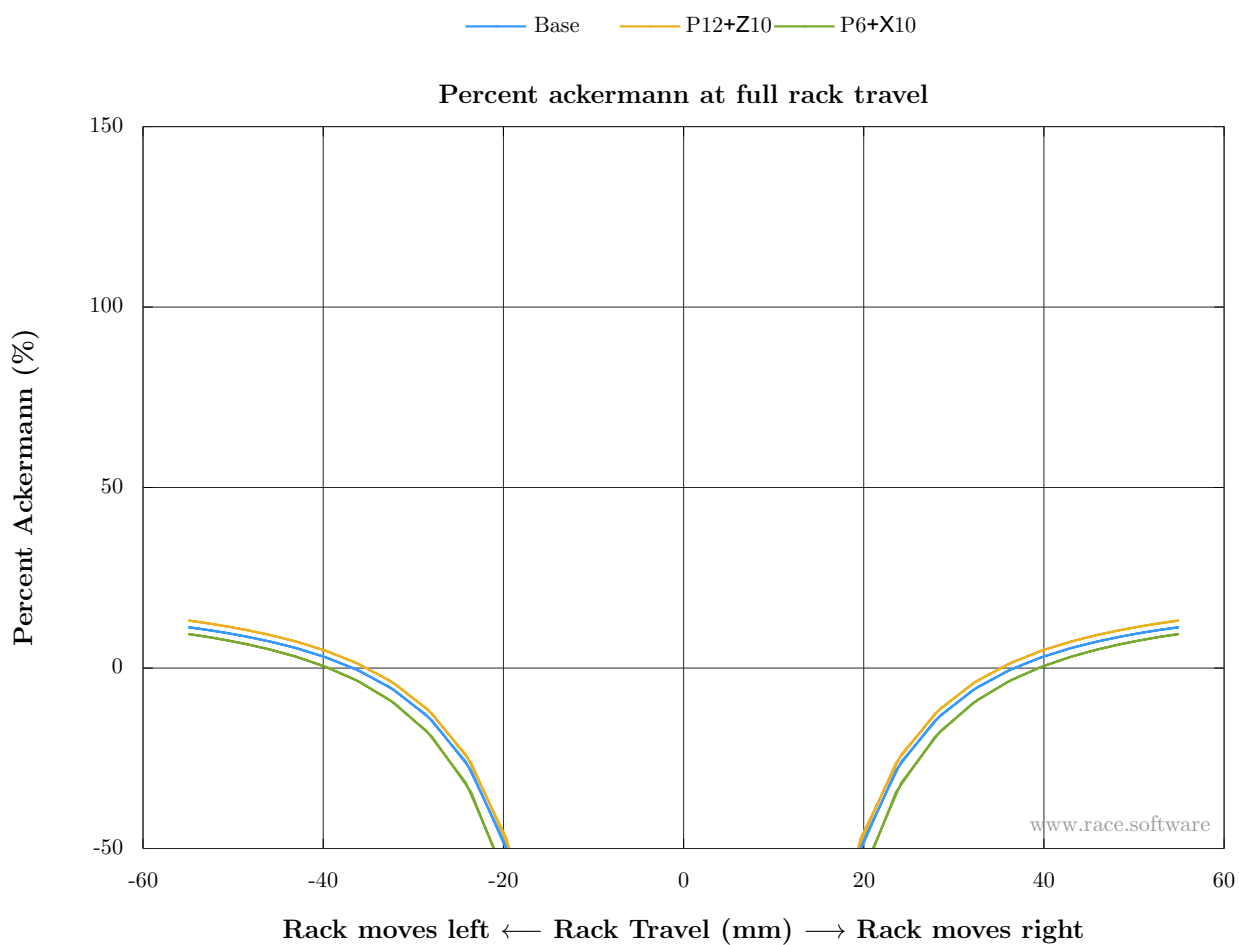


Figure 37: Steering test: Percent ackermann at full rack travel

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Comparison Summary

- Simulation ID Base: 0.076 N/N
- Simulation ID P12+Z10: 0.079 N/N
- Simulation ID P6+X10: 0.079 N/N

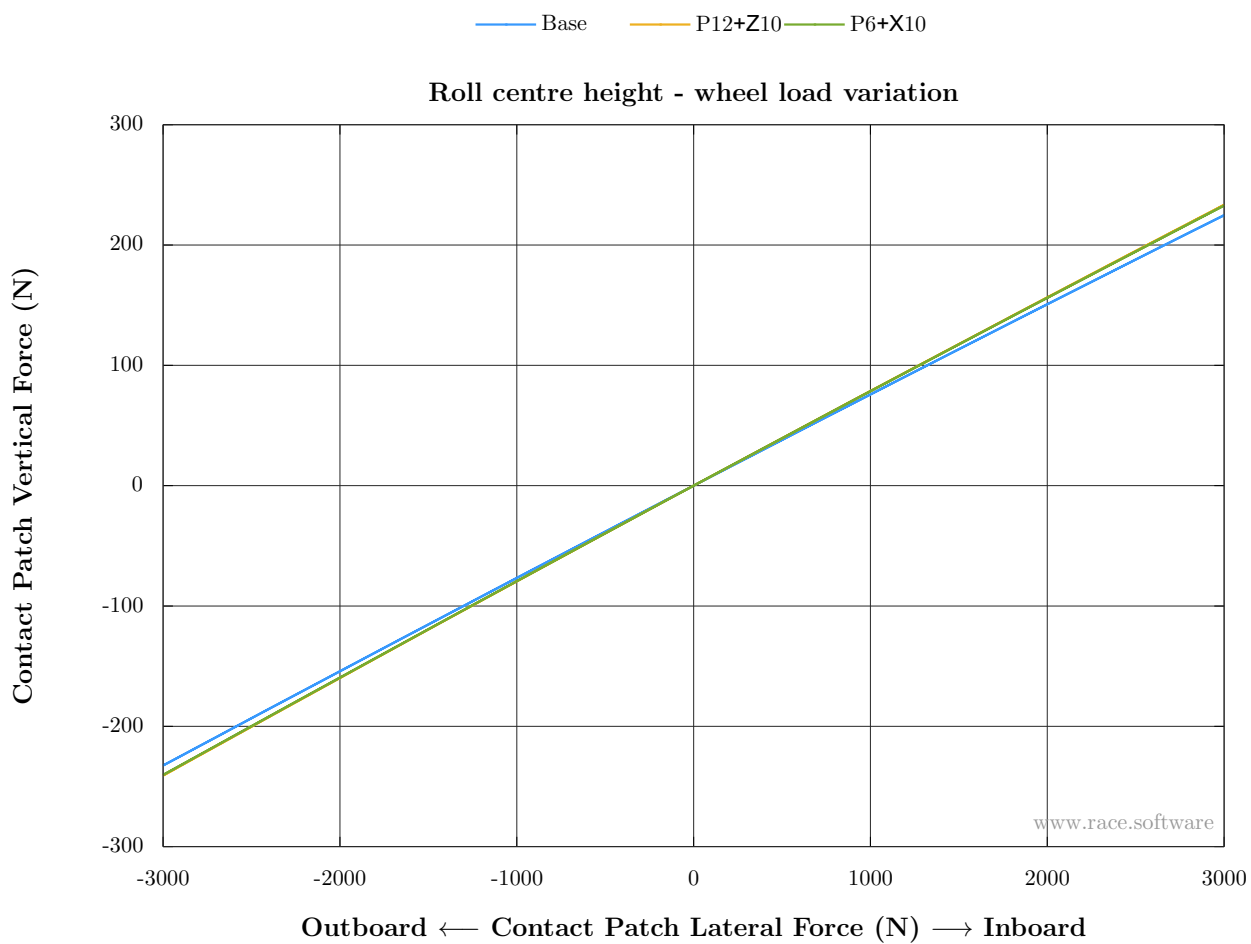


Figure 38: Lateral test: Roll centre height - wheel load variation

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Comparison Summary

- Simulation ID Base: 0.104 deg/kN
- Simulation ID P12+Z10: 0.104 deg/kN
- Simulation ID P6+X10: 0.104 deg/kN

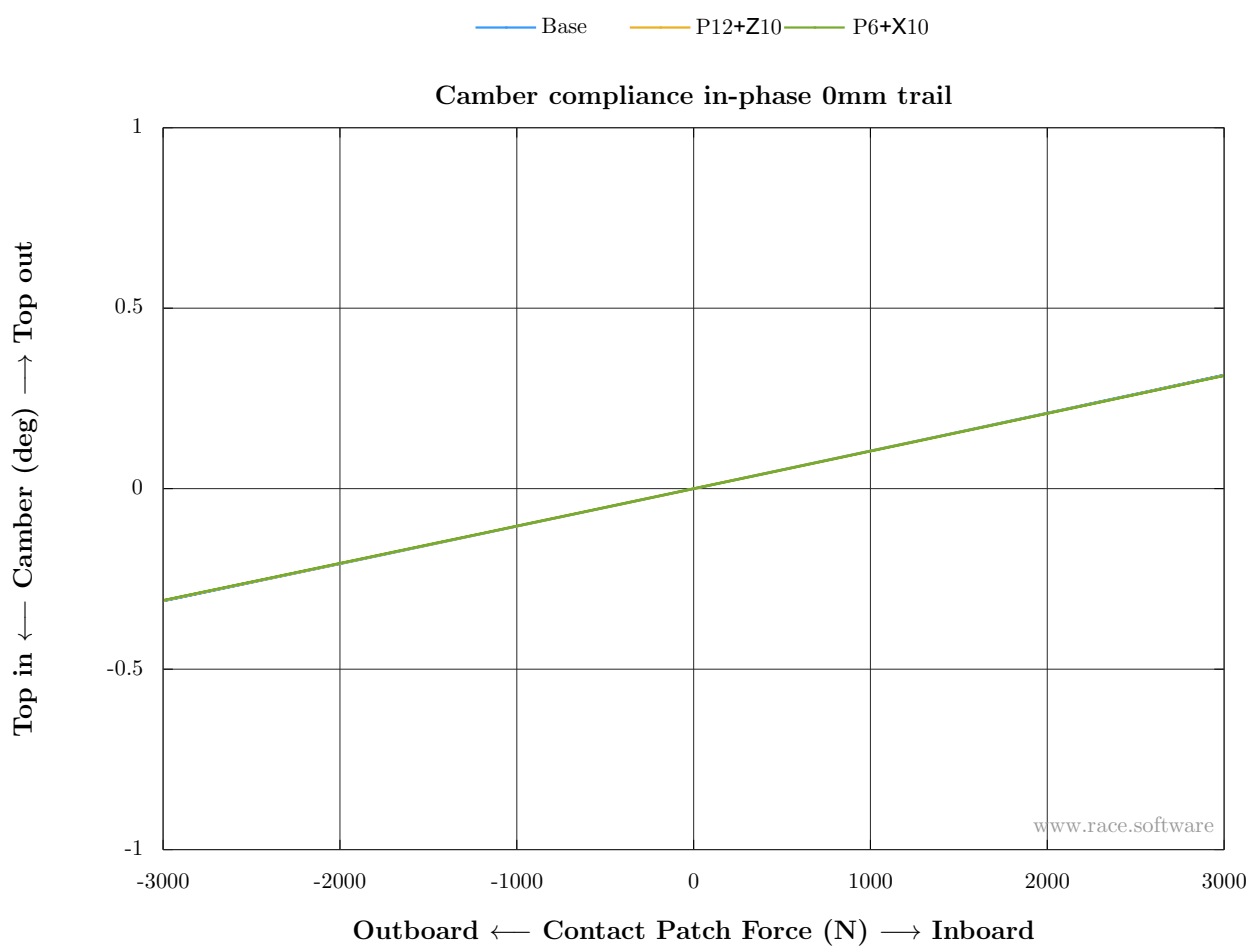


Figure 39: Lateral test: Camber compliance in-phase 0mm trail

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Comparison Summary

- Simulation ID Base: 0.96 mm/kN
- Simulation ID P12+Z10: 0.958 mm/kN
- Simulation ID P6+X10: 0.947 mm/kN

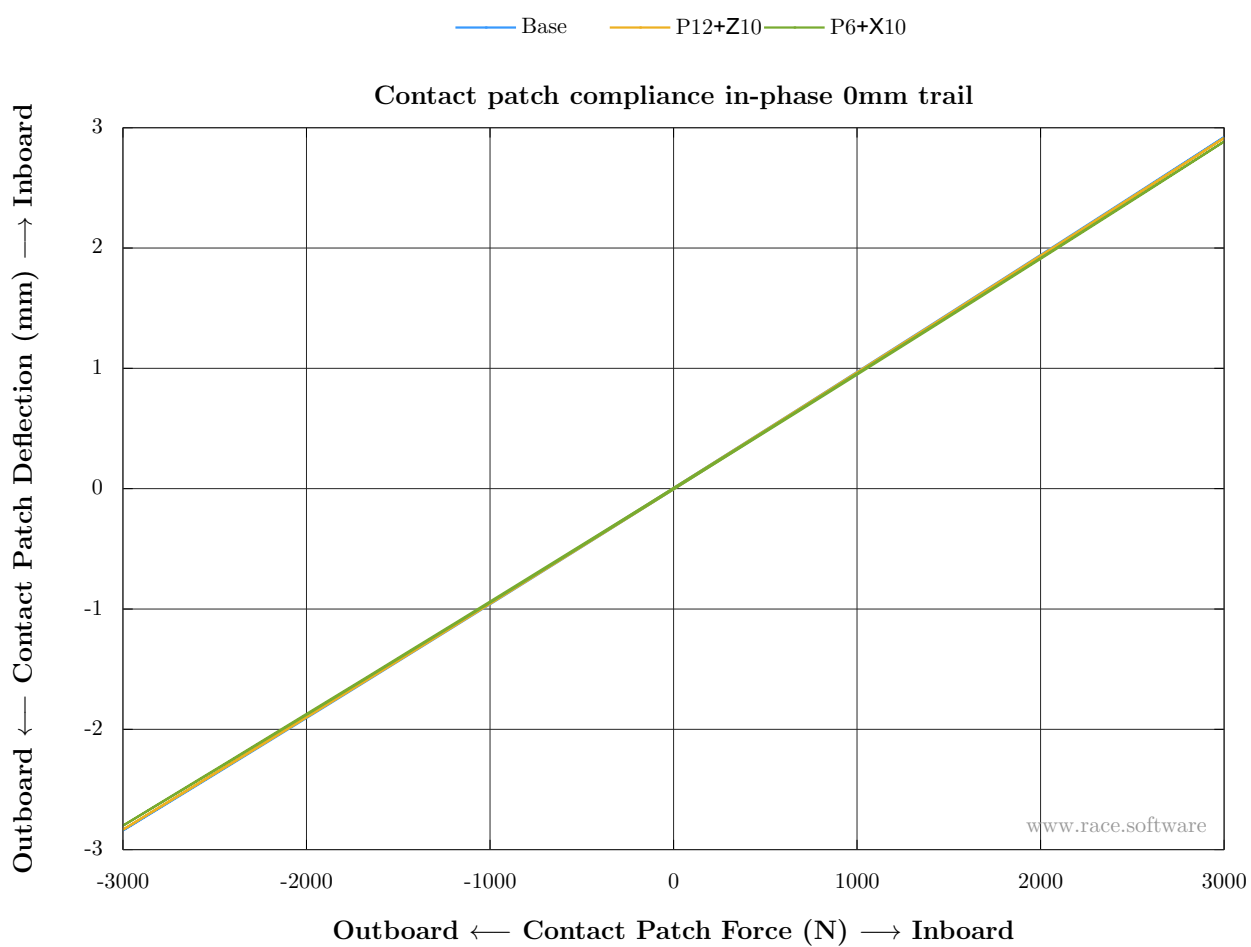


Figure 40: Lateral test: Contact patch compliance in-phase 0mm trail

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Comparison Summary

- Simulation ID Base: -0.18 deg/kN
- Simulation ID P12+Z10: -0.175 deg/kN
- Simulation ID P6+X10: -0.175 deg/kN

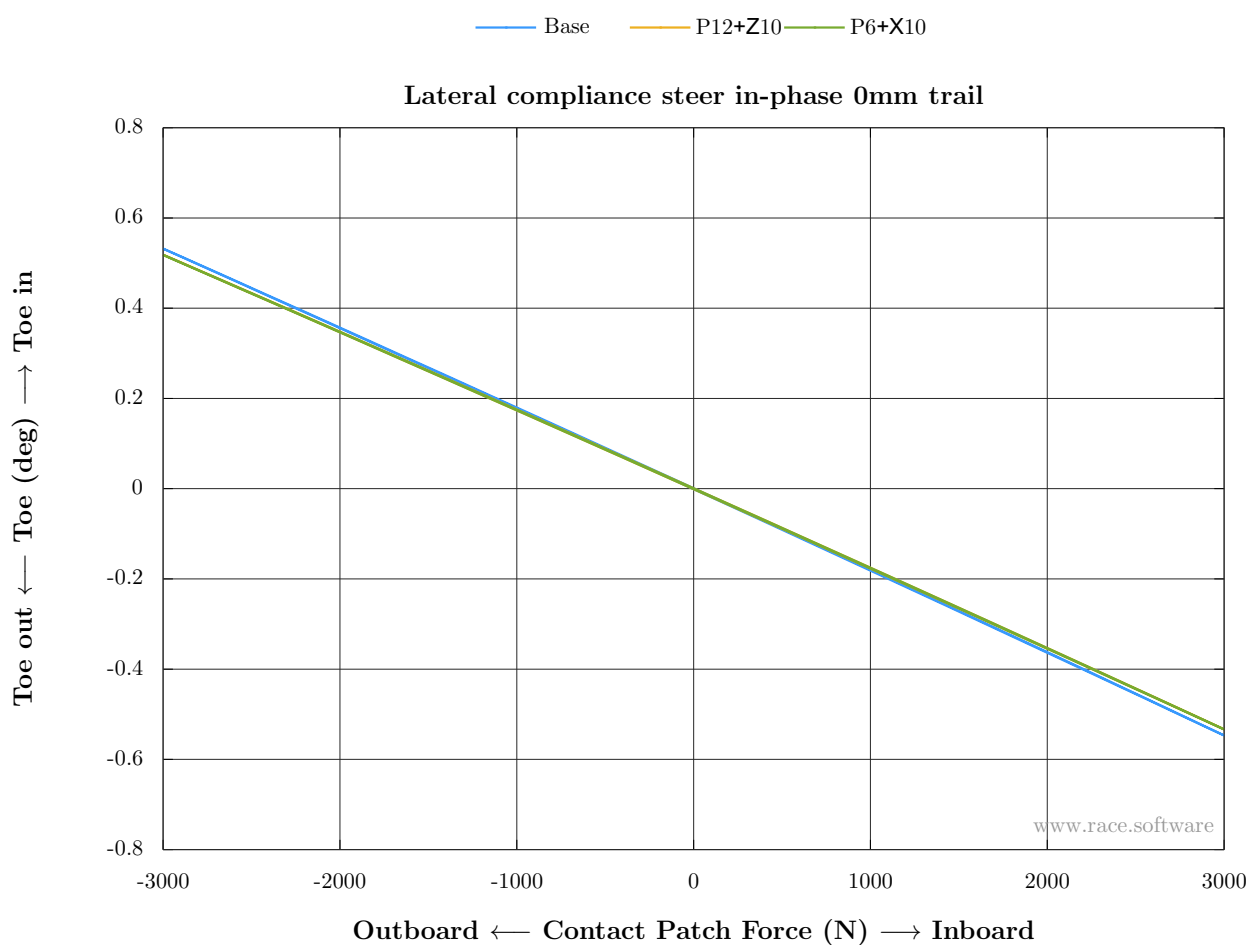


Figure 41: Lateral test: Lateral compliance steer in-phase 0mm trail

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Comparison Summary

- Simulation ID Base: -0.21 deg/kN
- Simulation ID P12+Z10: -0.205 deg/kN
- Simulation ID P6+X10: -0.205 deg/kN

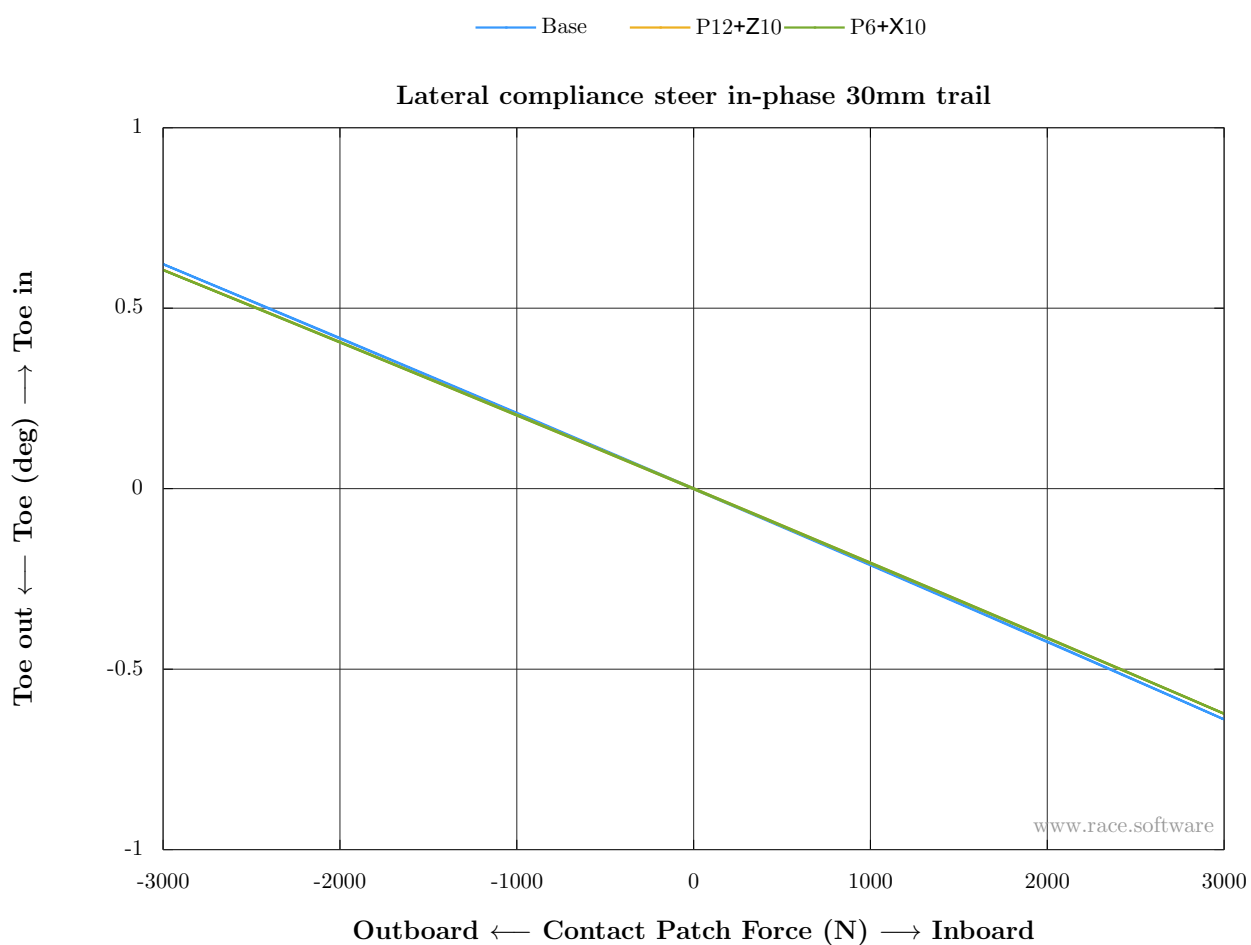


Figure 42: Lateral test: Lateral compliance steer in-phase 30mm trail

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Comparison Summary

- Simulation ID Base: 1.012 deg/kNm
- Simulation ID P12+Z10: 0.988 deg/kNm
- Simulation ID P6+X10: 0.985 deg/kNm

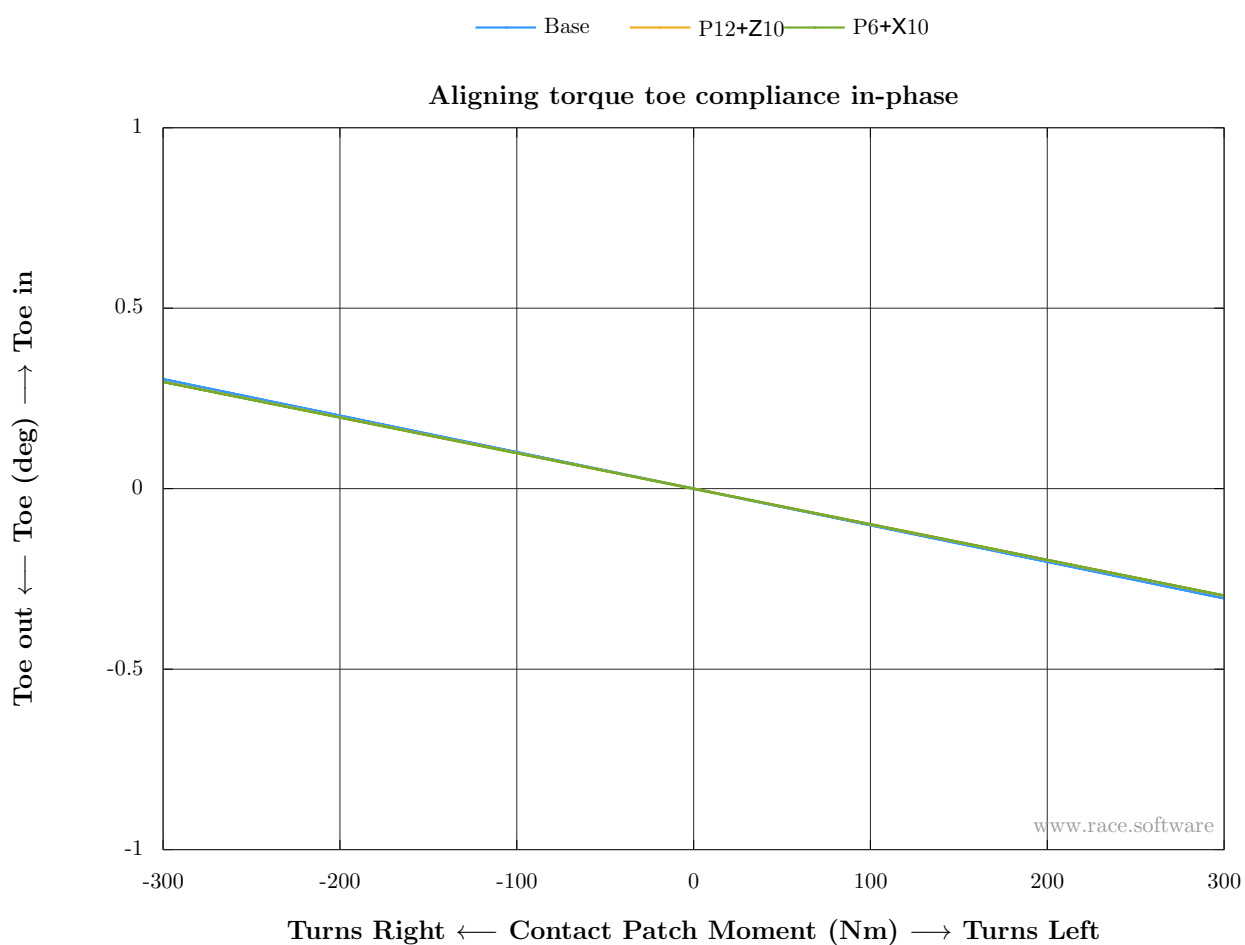


Figure 43: Aligning test: Aligning torque toe compliance in-phase

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Comparison Summary

- Simulation ID Base: -0.272 deg/kN
- Simulation ID P12+Z10: -0.273 deg/kN
- Simulation ID P6+X10: -0.277 deg/kN

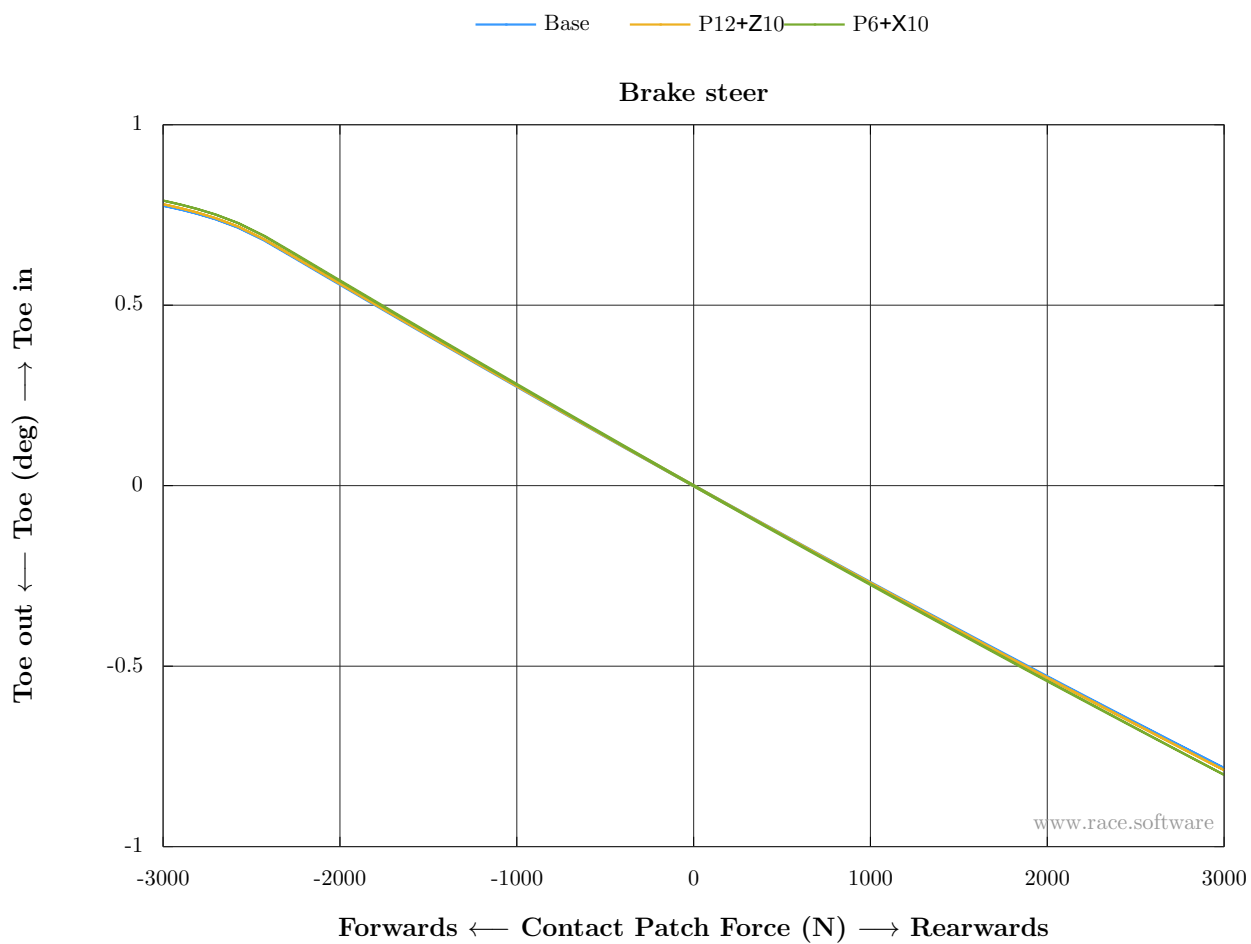


Figure 44: Braking test: Brake steer

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Comparison Summary

- Simulation ID Base: -0.238 deg/kN
- Simulation ID P12+Z10: -0.237 deg/kN
- Simulation ID P6+X10: -0.236 deg/kN

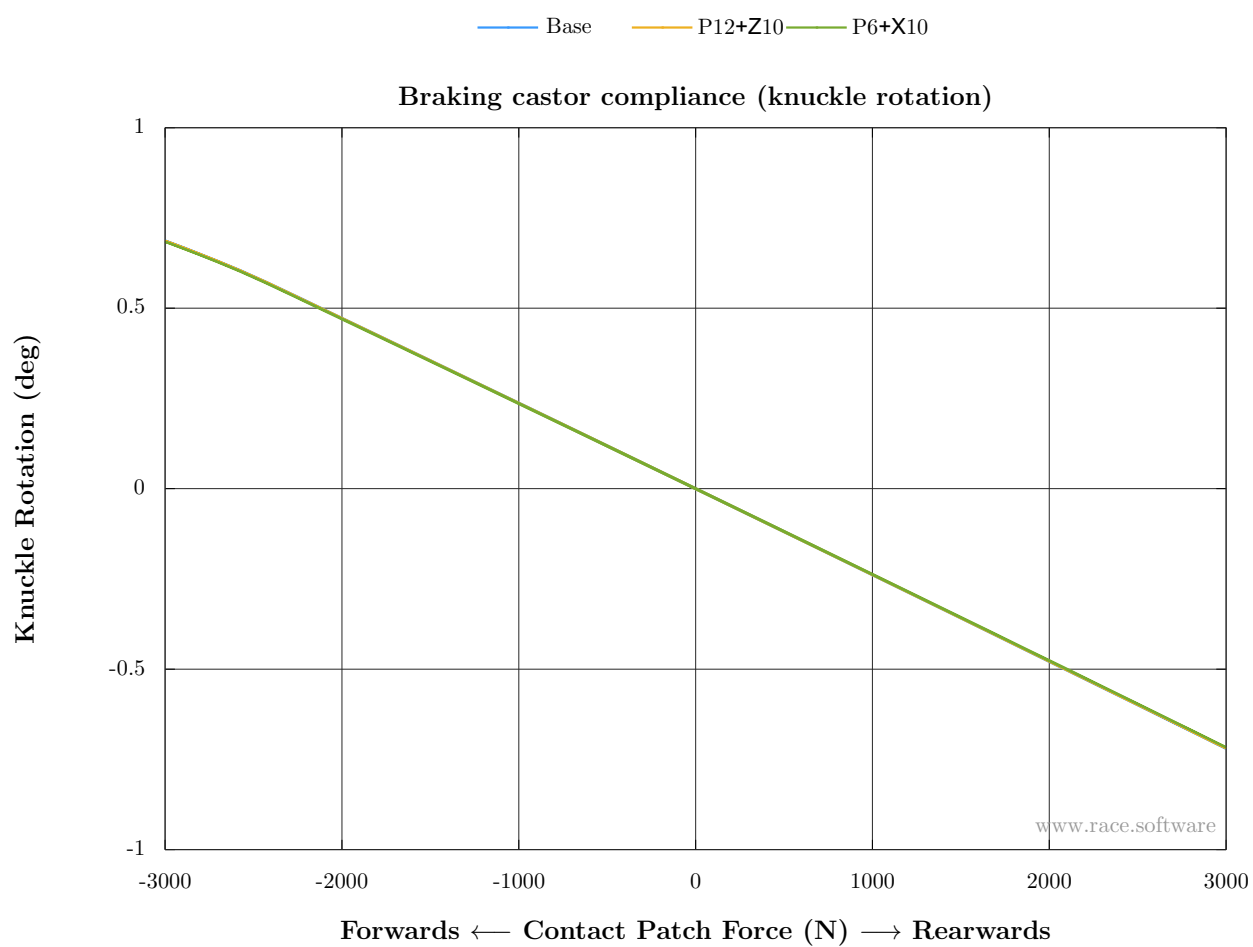


Figure 45: Braking test: Braking castor compliance (knuckle rotation)

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Comparison Summary

- Simulation ID Base: 4.41 mm/kN
- Simulation ID P12+Z10: 4.41 mm/kN
- Simulation ID P6+X10: 4.41 mm/kN

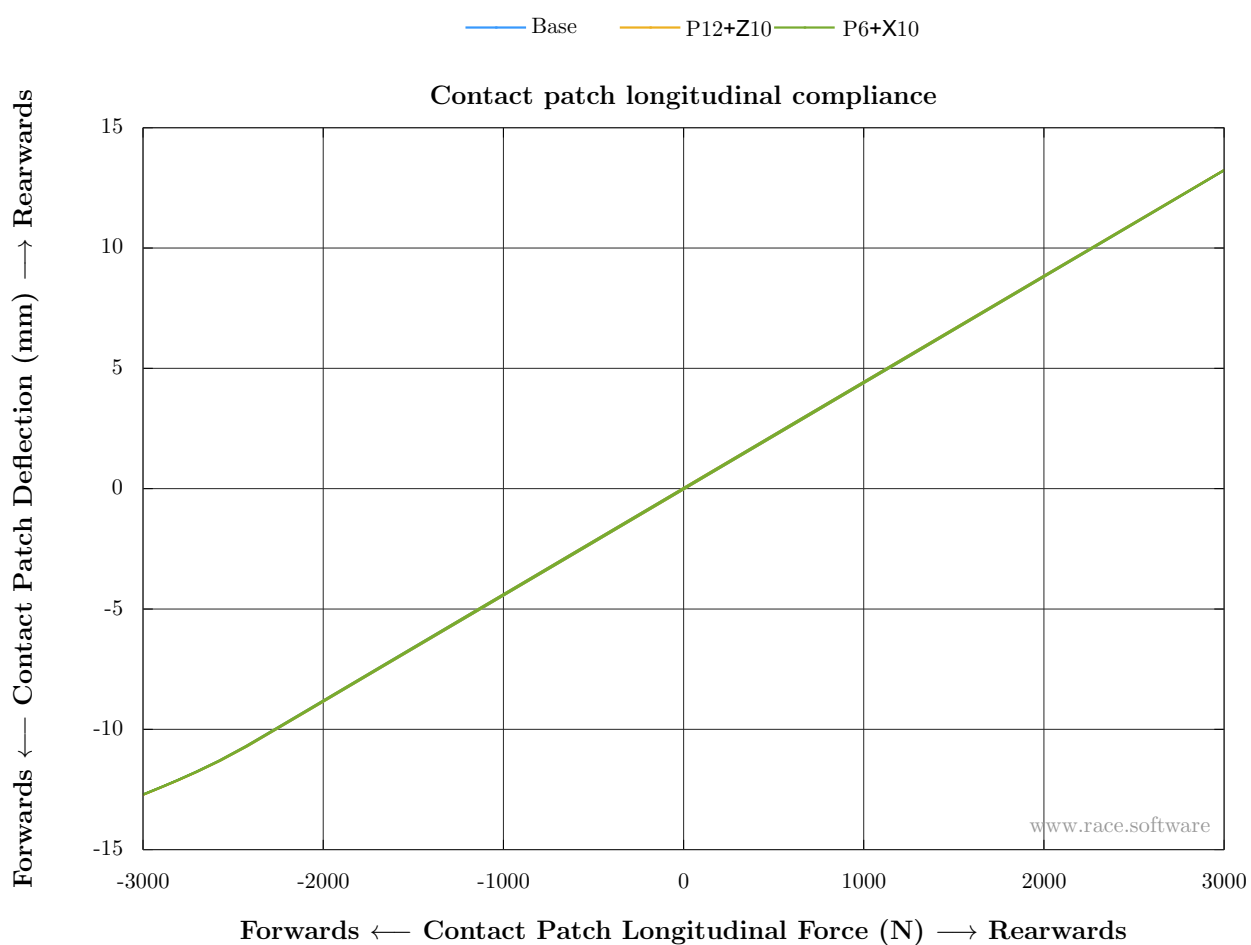


Figure 46: Braking test: Contact patch longitudinal compliance

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Comparison Summary

- Simulation ID Base: 0.056 N/N
- Simulation ID P12+Z10: 0.059 N/N
- Simulation ID P6+X10: 0.057 N/N

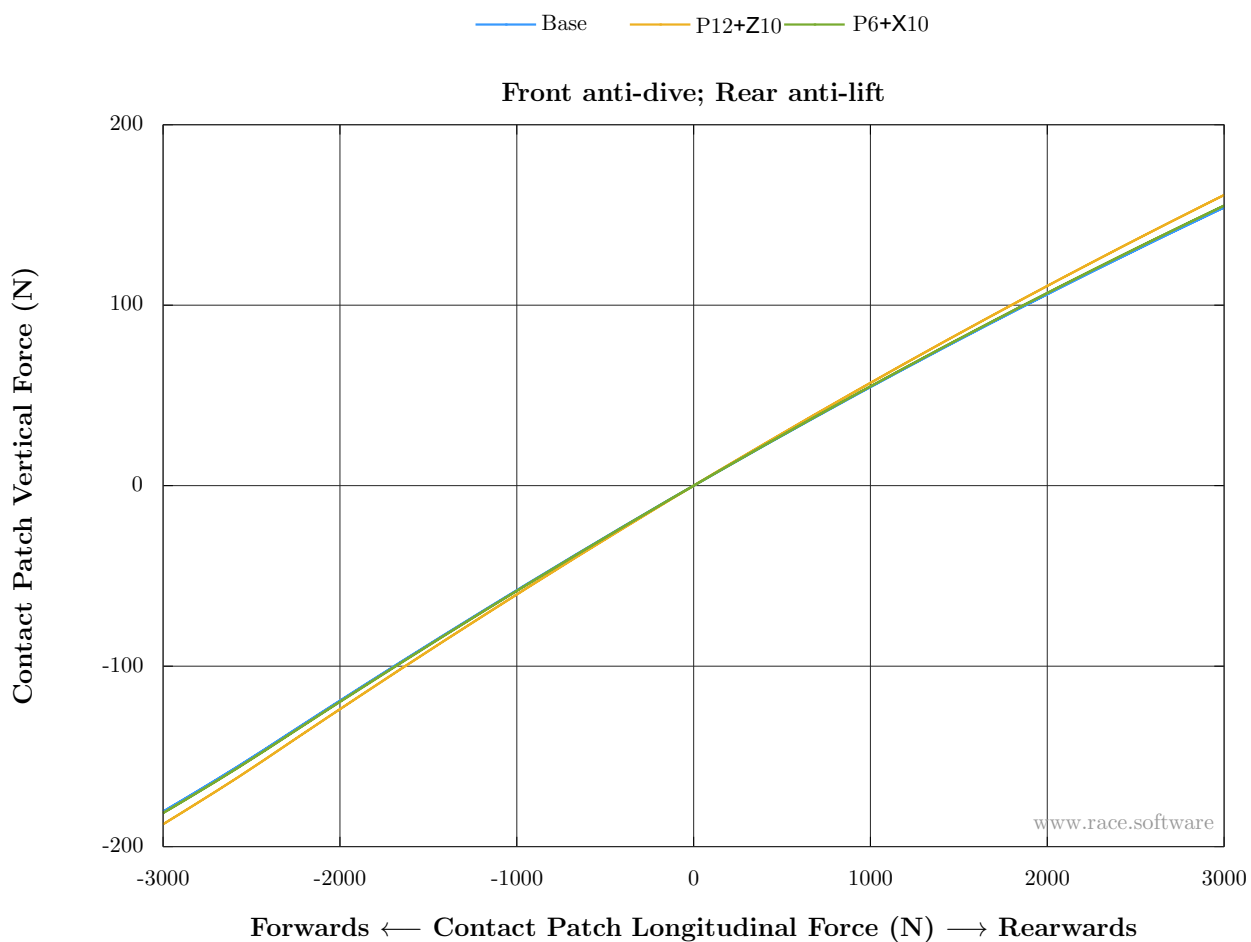


Figure 47: Braking test: Front anti-dive; Rear anti-lift

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Comparison Summary

- Simulation ID Base: 0.237 deg/kN
- Simulation ID P12+Z10: 0.236 deg/kN
- Simulation ID P6+X10: 0.239 deg/kN

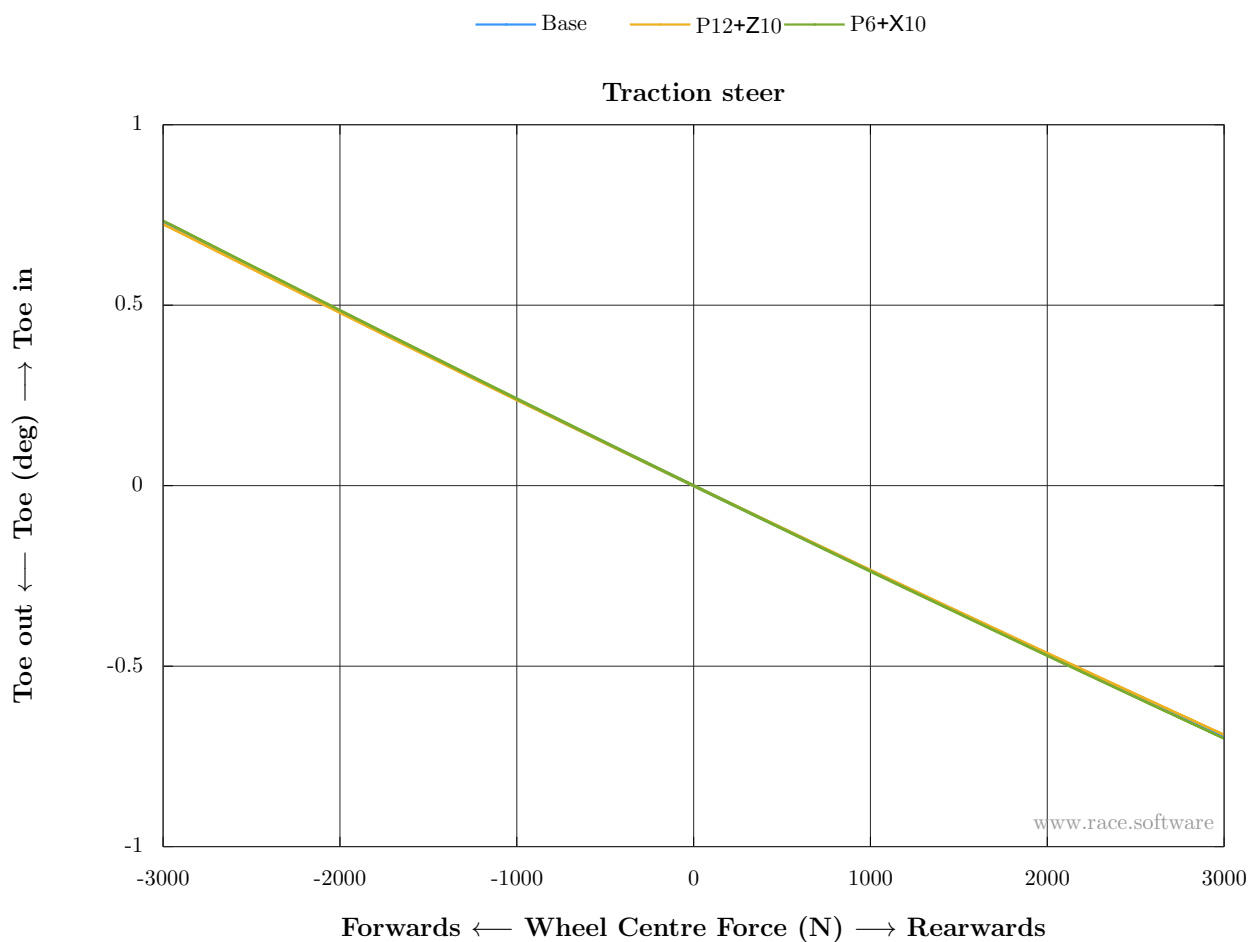


Figure 48: Traction test: Traction steer

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Comparison Summary

- Simulation ID Base: -0.139 deg/kN
- Simulation ID P12+Z10: -0.14 deg/kN
- Simulation ID P6+X10: -0.139 deg/kN

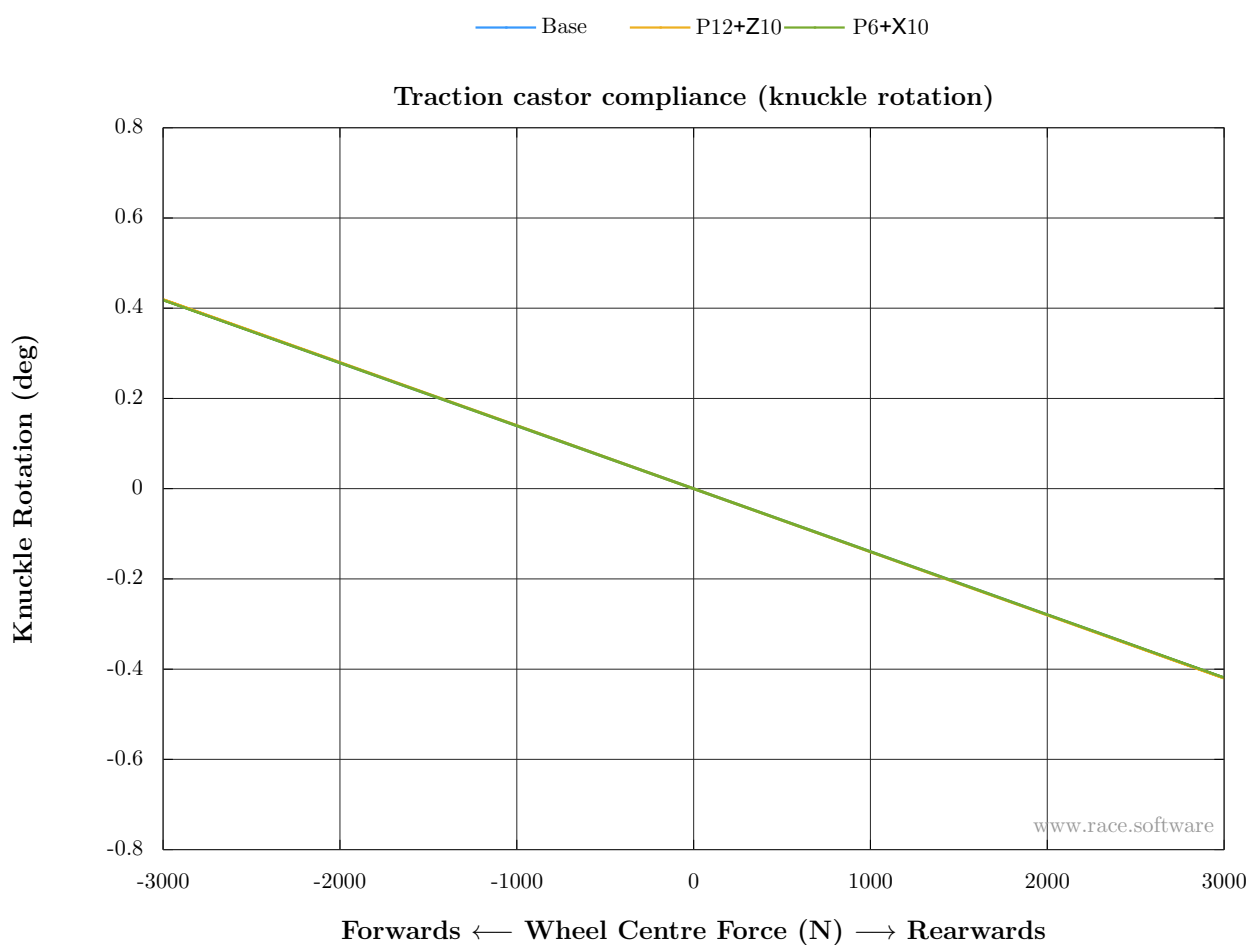


Figure 49: Traction test: Traction castor compliance (knuckle rotation)

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Comparison Summary

- Simulation ID Base: 2.37 mm/kN
- Simulation ID P12+Z10: 2.37 mm/kN
- Simulation ID P6+X10: 2.38 mm/kN

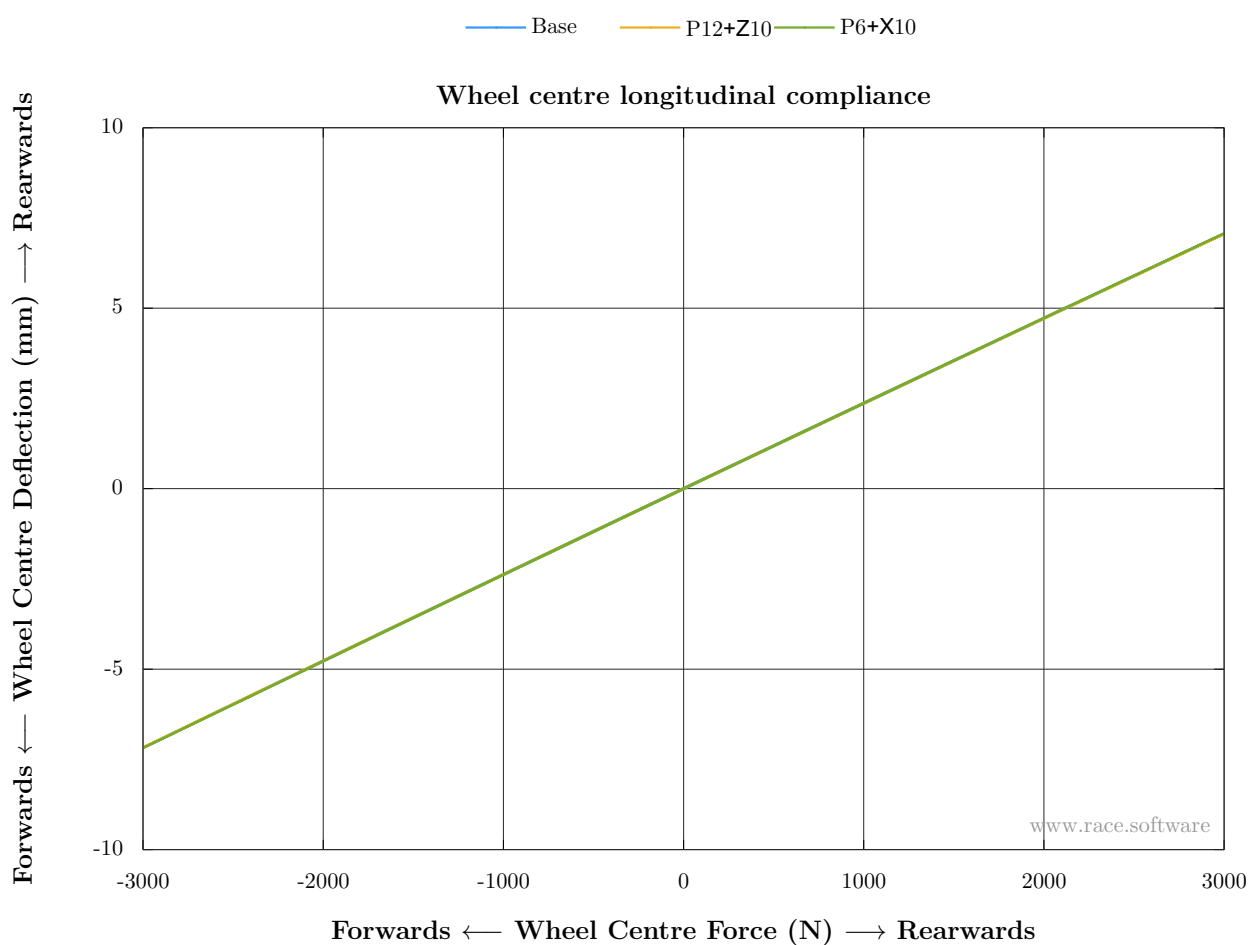


Figure 50: Traction test: Wheel centre longitudinal compliance

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Comparison Summary

- Simulation ID Base: 0.004 N/N
- Simulation ID P12+Z10: 0.017 N/N
- Simulation ID P6+X10: 0.005 N/N

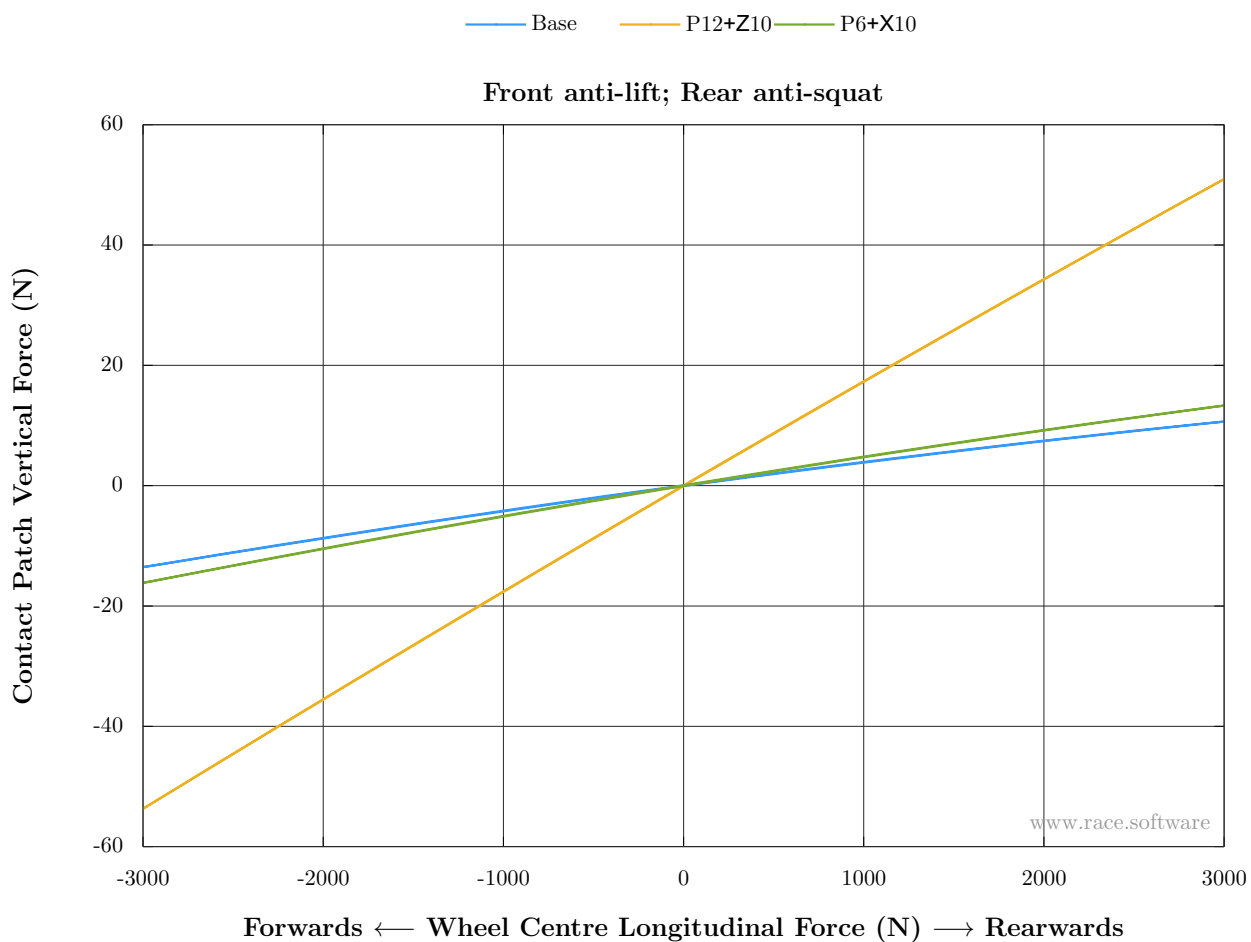


Figure 51: Traction test: Front anti-lift; Rear anti-squat



4 Key Performance Indicator Sign Conventions

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KPI	Unit	Positive metric sign meaning
BRAKING FORCE		
Brake steer	deg/kN	toe in under braking
Braking castor compliance (knuckle rotation)	deg/kN	castor angle increase under braking
Contact patch longitudinal compliance	mm/kN	rearward contact patch deflection under braking
Front anti-dive; Rear anti-lift	N/N	anti-dive (front axle); pro-lift (rear axle)
LATERAL FORCE		
Roll centre height - wheel load variation	N/N	roll centre above ground
Camber compliance in-phase 0mm trail	deg/kN	top of wheel outboard with lateral force
Contact patch compliance in-phase 0mm trail	mm/kN	contact patch deflection inboard
Lateral compliance steer in-phase 0mm trail	deg/kN	toe in with lateral force
ROLL MOTION		
Roll camber	deg/m	top of wheel outboard with bump travel
Roll steer - on centre	deg/m	toe in with bump travel
STATIC GEOMETRY		
Static camber	deg	top of wheel outboard
Static toe	deg	front of wheel inboard (toe in)
STEERING INPUT		
Kingpin inclination - with steer	deg	top of axis is inboard
Castor angle - with steer	deg	top of axis is rearwards
Castor trail - with steer	mm	kingpin ground intersect forward of whl centre
Scrub radius - with steer	mm	kingpin ground intersect inboard of whl centre
Wheel centre longitudinal offset - with steer	mm	kingpin axis is ahead of wheel centre
Wheel centre lateral offset - with steer	mm	kingpin axis is inboard of wheel centre
Static toelink load	N	toelink in compression
Lock angle at full right rack travel	deg	Wheel is steering to the right
Lock angle at full left rack travel	deg	Wheel is steering to the right
Percent ackermann at full rack travel	%	Pro-Ackermann (100% is perfect ackermann)
TRACTION FORCE		
Traction steer	deg/kN	toe in under acceleration
Traction castor compliance (knuckle rotation)	deg/kN	castor angle increase under traction
Wheel centre longitudinal compliance	mm/kN	rearward wheel centre deflection for an impact
Front anti-lift; Rear anti-squat	N/N	anti-lift (front axle); pro-squat (rear axle)
TYRE ALIGNING TORQUE		
Aligning torque toe compliance in-phase	deg/kNm	toe change in the direction of the moment
VERTICAL MOTION		
Bump camber	deg/m	top of wheel outboard with bump travel
Bump steer - on centre	deg/m	toe in with bump travel
Bump castor (knuckle rotation)	deg/m	top of wheel rearward in bump
Kinematic wheel centre recession	mm/m	rearward wheel travel in bump
Contact patch lateral migration	mm/m	contact patch inboard migration in bump