W A Technology

The C8 Stingray Has Only Slight Wheel "Chatter" & No C7 "Hopping" When Cold on Sharp, Slow Turns

(Includes APPENDIX A, Why C7 Has Race Car Type Tires & APPENDIX B, Tech Issues)

The C7 Stingray, especially the Z51 with summer only tires, when making very sharp, slow speed turns, has a significant tire "chatter." It was so bad GM also referred to as "hopping," which it did on a full lock turn when cold! Much worse than my C6 Z51 with the same width tires.

The C7 Owner's Manual states, under a heading *Tire Chatter/Hop*:

"When driving at slow speeds and in very tight turns, the vehicle may have tire chatter/hop. This condition is normal, and the vehicle does not require service."

Why Were the C7 Z51 Tires So Bad?

With the introduction of the C8, Tadge Juechter, the Corvette Chief Engineer provided some perspective as to the reason the C7 was very bad, much worse that my C6 Z51 when below 50 F and especially at 40F. In a 1+ hour interview on Autoline Afterhours he said they knew they pushed the FE Corvette design as far as they could when they were concerned the 2009 C6 ZR1 with it's 638 hp supercharged engine was not able to even match the 0 to 60 time of the Z06 with only 505 hp! He said the added front weight of the ZR1 supercharger and intercooler added more weight on the front wheels and did not provide the needed traction for faster 0 to 60 times. He said the barely squeezed by using very special race car type, sticky tires! (*More info in Appendix A*.)

In a videotaped C8 intro, when asked about "Tire Chatter" Tadge said the C8 does not have the issue. He said they did not have to use race car type tire construction as used on the C7 to get the best performance! He also said they did not have to compromise the Ackerman steering compensation to get better performance with the C8. Tadge said even the summer, performance oriented Z51 C8 tires did not produce Tire Chatter.

C8 Has "Some" Chatter

I do feel some modest Chatter even at 60 F with the "full lock turn" must make after backing out of garage. At 41 F, Chatter was worse but NOT objectionable as with the C7 where I was making 'K" turns to avoid using full lock! My Grand Sport was literally *"Hopping,"* as GM called it, with full lock turns on cold mornings! No need for making a "K" turn to go down my driveway!

GUttrachi@aol.com

What Causes Chatter/Hopping?

With the C7 Stingray high performance, high lateral "g" capability, racecar handling tradeoffs were necessary. The racecar type tire compound/construction and low aspect ratio of the larger diameter front tires makes the slow speed "chatter" worse. Mild chatter can be felt even above 55 F and the GM word "hop" is more descriptive when the tires are below ~50 F. I consider it severe when the tires are below about 40 F. It's partly due to the Tread material, which GM states is, "the near racetrack tire compound heats sufficiently to achieve optimum performance in one lap on a racetrack." I find it heats up quickly (<5 miles) even in cold in road conditions.

This Unusual C7 "Chatter" Can Be Disconcerting:

Some folks are sufficiently surprised and concerned about the "chatter" and request the dealer, "*do something*." As GM dealers will tell them, *"The condition is normal."* However, that statement is not very comforting when that "chatter or hop" is felt, especially when the tires are cold. This picture review covers some key causes and why there are some performance benefits.

Solution, When Cold, Turn Wheel Less and Make "K" Turn:

There is a solution that reduces/eliminates the "chatter." *"Just don't turn as sharply when the tires are cold!"* Very important when below ~50 F if you have a friend in the car or they'll tell everyone what a "piece of junk" you bought! ☺

I use that approach and think about the high "g" force I achieve when it's warm as I take the extra time! Excess "chatter" is usually only encountered in cold weather when the tread gets stiffer and turning sharply as when entering or leaving a parking slot. It is not encountered in any normal driving on the road.

"When the OEM Tires are Cold (<50 F,) Use Less Than a Full Turning Radius, Make "K" Turns! I do to avoid the "hopping," even through it does no harm.

If living in colder climates buy winter or all-season tires. These tires have more normal "slip angles" and the rubber does not get as stiff as the OEM Michelins, which will reduce or eliminate "Chatter."

Are OEM C8 Z51 Michelin Pilot Sport 4S ZP Best Performer?

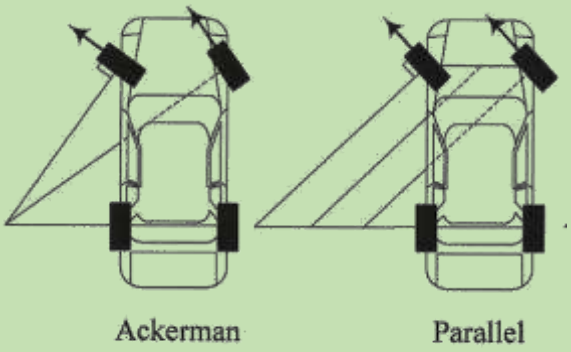
From Tadge's comments about not compromising with Race Car type construction like the C7 OEM Z51 Pilot Sport ZP probably not! There are also reports of better Tracking with Pilot Sport Cup 2 tires. But Michelin Cup 2 tires start with less tread and look warn when new! Not good for wet weather performance!

A Forum Poster said Goodyear Eagle F1 Supercar 3R tires (pic left) do "Chatter" on a C8 even when warm as the C7 tires did when cold. Quoting Goodyear: "*Supercar 3R's utilize polymers and resins previously only used for racing slicks. The two-ply Rayon casings and two wide steel belts with a polyamide reinforcement ply provide extreme lateral grip* "

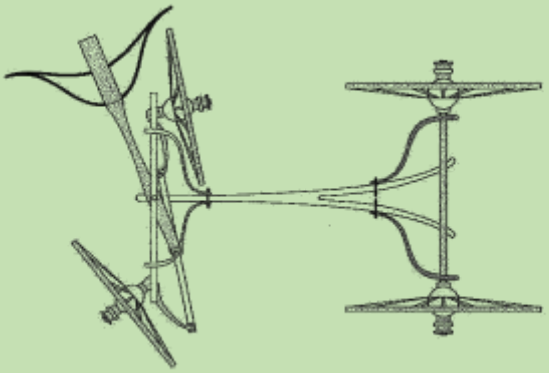
The following will show that Chatter is probably also due to race car tire, very low slip angle construction.

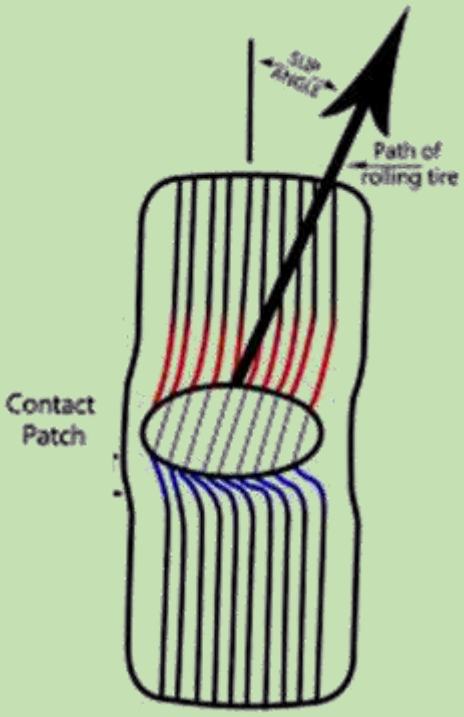
Photo Sequence

"Chatter," experienced when the C7 is turned sharply at low speeds is caused by less than "full" Ackerman steering employed. You can see in the left figure that when turning sharply the two tires turn at different radius causing, if parallel, one tire to scrub or "chatter" as it is dragged across the pavement. The solution is to have the tires turn at different radiuses. The sharper the turn desired the more the steering angle difference is needed! Note the C7 also has a 2-foot sharper turning radius then the C6, making the "chatter" more pronounced.

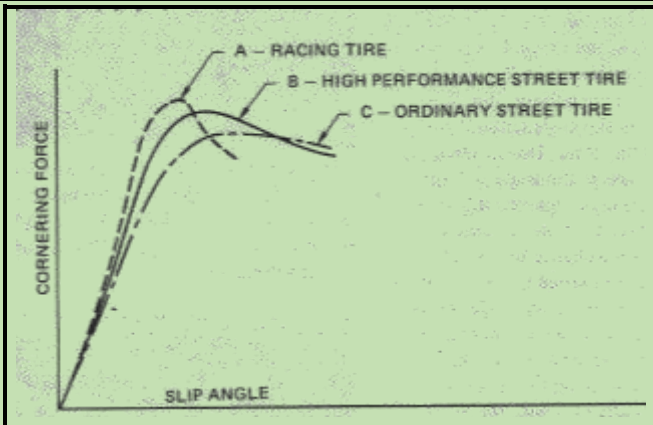


This Ackerman steering principle was developed around 1816 to improve the turning problem encountered in horse drawn carriages! As shown, a sharp turn requires a significantly different turning radius for each wheel if one is not to be dragged as the other moves smoothly. The stiff, iron faced wood rims were subjected to significant forces. Ackerman steering is used in most passenger cars to provide the needed different turning radiuses.



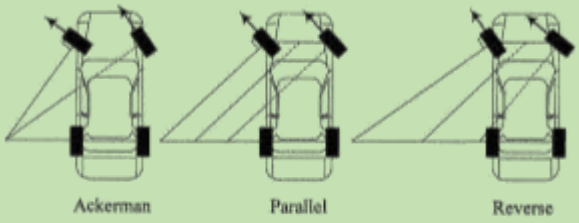


If on dirt, the chatter caused by scrubbing would be less or nonexistent compared to ridged pavement. With rubber car tires, a reduced amount of "theoretical" Ackerman steering is needed because the rubber flexes, which reduces the scrubbing forces when on a hard surface. The amount it deviates from a straight line is called slip angle. Therefore, to reduce the scrubbing-causing "chatter" will not require the full amount of Ackerman difference in turning radius between the front tires. Typically, for passenger cars, only enough Ackerman steering is built-in to provide acceptable "chatter" reduction when matched with the tire slip angle. ***Low slip angel tires would require more Ackerman geometry to avoid "chatter." Race car type tire construction has low slip angles and is a key reason for their handling benefits. See Appendix B.***



A tire's slip angle has a significant effect on the maximum cornering force. Maximum cornering force is achieved with tires having a low slip angle. The Michelin tires used in the C7 (especially Z51, Grand Sport and Z06) are closer to racing tires than even high-performance street tires. Therefore, the reduced slip angles mean the Ackerman steering angle would have to be increased to completely avoid slow speed "chatter" in sharp turns. What would be the downside?

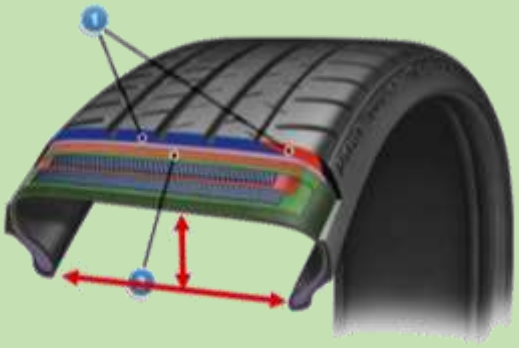
Although Ackerman steering is a correct condition at slow speeds, at high speeds there is significant lateral acceleration and the wheels operate at or near maximum slip angles. Furthermore, the loads on the inner wheels will be much lower than the outer wheels. When increasing the load, less slip angle is required to reach the peak of the lateral force. Under these conditions the inner front wheel of an Ackerman steering vehicle would be at a higher slip angle than required for maximum lateral force. Therefore, less Ackerman is desired.



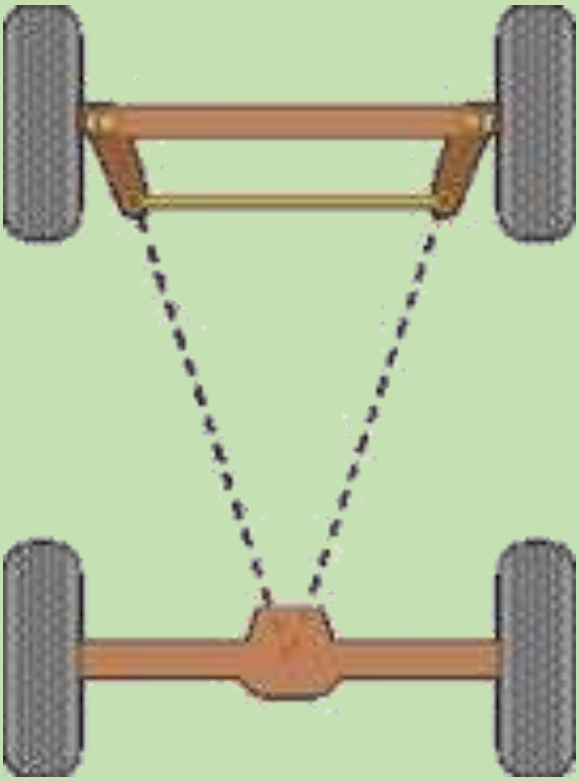
For optimum lateral g force performance, unfortunately less Ackerman steering is desirable, so low speed sharp turn performance is sacrificed!

The Michelin, very low profile, stiff, run flat, high performance tires have low slip angles. Quoting info from Michelin, the C7 Pilot Super Sport ZP tire features the next-generation of racetrack-born tread compounds found in the record-setting Pilot Sport Cup ZP of the C6 ZR1 and Z06. The Michelin tire features a custom dual-tread compound and pattern that achieves near-racing-slick grip and handling levels. When cold, the tires are even stiffer, and the compound causes more chatter. It's NOT "sticky tires" as some say it the problem! GM also states the "chatter" is worse when it is wet. On wet pavement the forces increasing slip angle are reduced so the tire will "drag" more. I've validated that issue.

Numerous Forum Members have posted C7 "chatter problems" go away with winter/all-season tires. These have higher, more normal slip angles! The rubber also does not get as stiff when below ~50 F!



Cold tire performance differences are also a factor for normal driving. There is significantly less traction until the tires are warm. With cold (<45/50 F) the OEM Michelin tires, when pulling onto a 4-lane highway near my home, the traction control will engage at less than ¼ throttle. When the tires are warm even ½ throttle can be used without it engaging! I find in ~5 miles of driving, they heat sufficiently with traction improved significantly.



Possible Ackerman Linkage

For The Curious:

One way to achieve Ackerman steering geometry can be generated by moving the steering pivot points inward. The steering pivot points can be part of a rack and pinion system. (*Leave the angle difference calculation to a geometry class!)* With perfect Ackerman, at any angle of steering, the center point of all of the circles traced by all wheels will lie at a common point. However, "full" Ackerman steering is not used for cars, partly because it ignores important dynamic, slip angle and different tire loading effects in a turn. The principle is really only sound for low-speed maneuvers. As noted, some race cars even used reverse geometry to compensate for the large difference in tire loads and slip angle between the inner and outer tires while cornering at high speed. Such geometry helps max attainable "g" force but compromises low-speed performance. See Appendix B.

Living with some "chatter" is a reasonable compromise for the smile the cars performance puts on my face on high "g" turns when it's normal warm weather! In Eastern SC that is most of the year.

There is a fountain at the end of my street where I can achieve those high peak "g" forces in a safe environment at moderate speed. No people within 1/4+ mile and grass field on right!

Some suggest GM fix the issue, labeling it a poor design! It is not a poor design and needed if you like the high "g" numbers and bragging about the C7 beating XYZ!

Those living where in winter it frequently gets below 40 F and if near freezing when they need to drive, should consider getting all-season tires and sacrificing some warm weather performance. Or change to winter tires like Pirelli Sottozero's when cold to have the best of both!

When I lived "Up North" I always had a set of "Snow Tires" mounted on another set of wheels. When living in CT 39 years ago had a Dodge Colt Turbo and bought Gislaved winter tires for all 4 wheels and switched to Pirelli P7s on plus 1 wheels when warm.

In Eastern SC I seldom have to drive when it's below about 35 F. No need to consider anything but the highest performance tires. I think of the smile on my face when taking the time to make "K" turns when cold needed to avoid "chatter!"

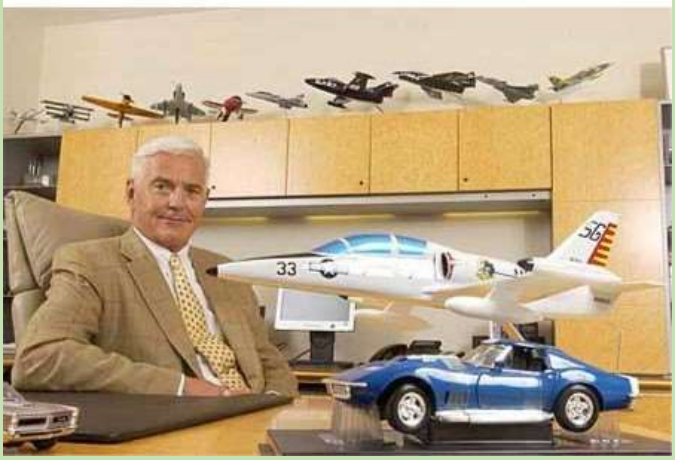
Appendix A (Why the C7 Has "Race Car Type Tires")

In a I+ hour interview in Autoline After Hours, Tadge Juechter, the Corvette Chief Engineer, provided the insight on why race car type tires were being used on the C7. It started with his background when he joined the Corvette team in 2009:

Juechter said when he started working on Corvettes in 2009 Bob Lutz was the "Top Dog.".

Lutz rejoined GM in 2001 as VP Product development, was a strong headed executive who had worked directly under Lee Iacocca when he was CEO at Chrysler.

According to Tadge, at that time Lutz said he would fire anyone working on a *Mid Engine* Corvette. Lutz said MEs were cool and exotic BUT not needed for a Corvette!



Tadge said he was working on the C6 Corvette ZR1 with it's 638 hp supercharged 6.2 liter engine. They were concerned they would not be able to get the 3400 lb car to match the 0 to 60 times of the 505 hp Z06 because of limited traction of that 52 front/ 48 rear weight distribution due to Turbo and Aftercooler weight! He said they barely squeezed by using very sticky special race car type tires! They saw the handwriting on the wall for the need for an ME.

Tadge said they had Pratt and Miller (*The Corvette Race Team Company)* work on developing the best car design for max performance. They defined there is a sweet spot at 60% rear weight for traction, low moment of inertia and performance! They have been in racing for 30 years and have extensive modeling software tools.

He said armed with that technical info and research from consumers on car shape, he made a presentation to upper management so they could work on a ME without being fired!

That was how the C8 ME Vette got approved. He said they hoped that the C7 would be an ME but the GM bankruptcy put it on hold!

APPENDIX B (Technical Issues re Ackerman, Anti-Akerman and Parallel Steering)

Kinematics: ***"The branch of mechanics concerned with the motion of objects without reference to the forces which cause the motion,"*** **is not new.**

Understanding kinematic principles goes back to the Greeks. But after Greek science came to a halt, it was taught late in Medieval times, in the schools of Oxford and Paris. Kinematics was revived by Leonardo DaVinci when he developed his own body of knowledge with striking resemblance in some areas with the kinematics of centuries after him rather than to that before him.

Lots written on the subject including one of my old Kinematics text used in college! Kept this book used in ~1963 because although the science related to cars is better understood today, the basics are the same. Looking through, it is filled with math equations, my favorite subject!

When reading how the C8 with 60% rear weight has "significant" Understeer could not understand as my modified '67 Corvair had significant Oversteer inherent with its 60% rear weight (similar to Porsche's of-the-day!) It wasn't power induced Oversteer; we didn't have much power! This was reinforced by Tadge Juechter's C8 comment that *"he came from a Porsche family and was pleased they were able to overcome the inherent Oversteer of the early Porsche's!"* Got out my old books, a few of which are shown here. Also, found a modern 2018 book by Professor Guiggiani that car manufacturer handling experts said was *"the handling bible*!" This ~$100, obvious textbook has, as expected, lots of mathematical equations but they are used to generate graphs and figures that make the results very easy to understand.

This is one review of the book:
"There is nothing different or special about the study of the motions of a vehicle under applied forces and moments, and it seems much of the lack of understanding comes from the fact that tires are highly non-linear force-producing devices. Fortunately, Professor Guiggiani addresses even this topic with ease and great clarity.
This is the only text I have seen which addresses the kinematics of vehicle cornering using the concept of the inflection circle, and other concepts borrowed from planar analysis. I feel very strongly that this approach will lead to a much greater understanding of the kinematics of both road and race cars then is currently applied in the respective industries.

Another book review; All were 5 Star:
"I'm currently writing my Master's Thesis on a Fully Autonomous Vehicle Cruise Control System and this book has given me a greater understanding of Vehicle Dynamics, all I know in that area I owe it to the author. My focus is Control Systems Engineering and had never taken a class on Vehicle Dynamics. If you have previously studied Kinematics and Dynamics, then this book should be extremely easy to follow and understand. I have read many books on Vehicle Dynamics, and this book excels in its area"

Quoting a Juechter Super Chevy C8 Interview:
"We knew all of the bugaboos that other brands had to discover and correct over a period of many generations. … We were always sensitive to the car's rear mass with the mid-engine placement. We had to do it right the first time. There were many little details we had to design into this chassis to correct that, but the driving experience is amazing. "
(Note: "bugaboos" obviously is referring to Porsche)

Bottom Line

If not purchasing the 550-page text, this short review re Akerman, anti-Akerman etc. uses info from this text and others providing a short summary! Plan another PDF on handing when my C8 arrives and I "digest" more of the text covering those areas.

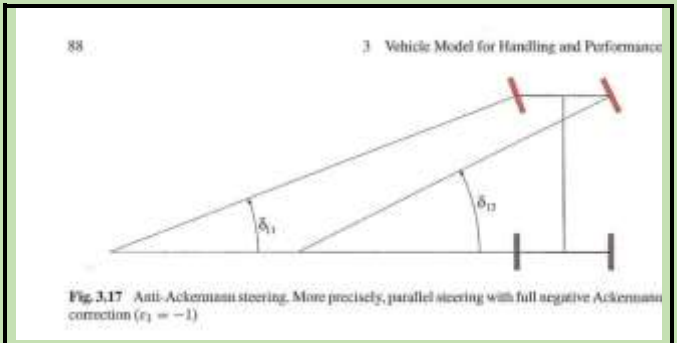


Fig. 3.17 Anti-Ackermann steering. More precisely, parallel steering with full negative Ackermann correction ($c_1 = -1$)

Understanding what the "experts say" about the use of anti-Akerman steering in some race cars helps define why the C7 Corvette with high performance OEM Michelin Pilot Super Sport ZP tires "chatter" when not warm and "hop" (as GM calls it) when below about 45F!

At high "g" forces Akerman steering compensation may not be useful. Race cars may use parallel (like rear tires) for the front tires or even anti-Ackerman which would make low speed "chatter" much worse!

Why Use Parallel or Anti-Akerman

Compared to the simple graphic presented in the above discussion on "chatter," Guiggiani shows the forces within the contact patch are very complex. Forces vary within the "patch." Especially at high "g" forces in race cars with high aero induced downforce the inside tire will have significantly less slip angle that the highly loaded outside tire. What is called "dynamic toe" is the tire toe or steering angle on a given wheel that due to changes suspension geometry including the degree of Ackerman steering compensation employed.

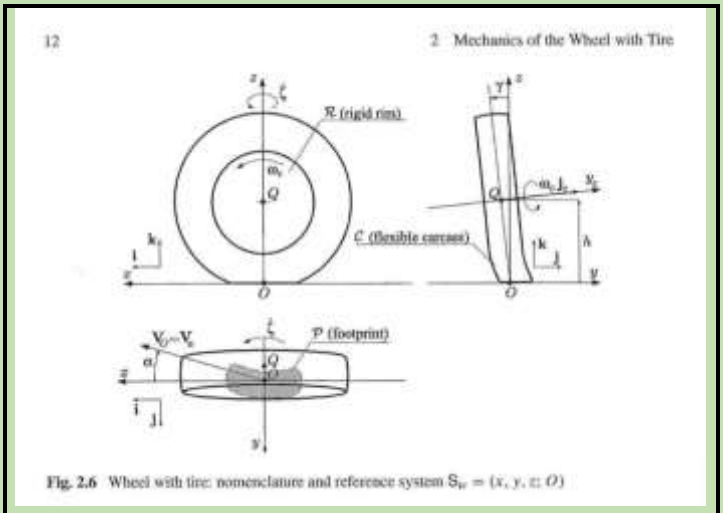


Fig. 2.6 Wheel with tire: nomenclature and reference system $S_w = (x, y, z; O)$

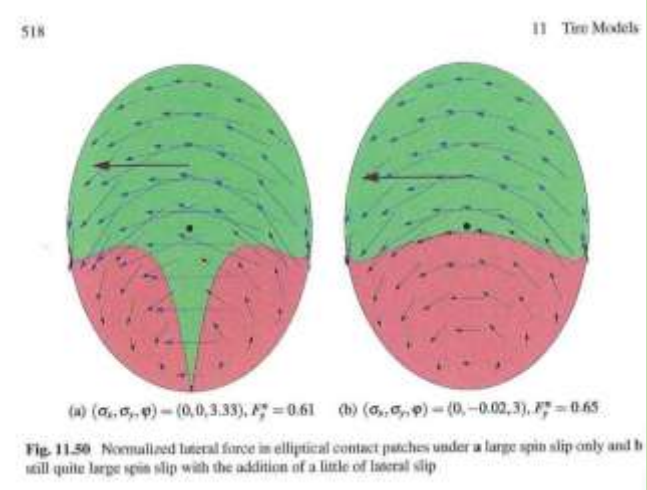


Fig. 11.50 Normalized lateral force in elliptical contact patches under a large spin slip only and b still quite large spin slip with the addition of a little of lateral slip

Forces within the tire contact patch vary when braking, going around a corner and accelerating. At speed, unlike slow speed, the forces on the inner and outer tire vary considerably. The highly load outside tire have more vertical load that the lightly loaded inside tire. At slow speeds tire loads, inside and outside are the same.

These tire patch forces will vary considerably when cornering braking and accelerating. As mentioned this summary won't cover the cornering or braking dynamics in this review just reinforce why GM may have decided to use less that the normal Akerman compensation for maximum lateral "g" performance sacrificing some slow speed high angle steering compensation. That results in chatter.

As mentioned the normal tire does NOT require "full Akerman compensation since the surface in slow speed turns will move slightly proving some compensation.

That is why most who install "all season" tires say "chatter" is eliminated or as significantly reduced. It's also why when it's wet and there is less traction between the tires and pavement, "chatter" is worse. Have validated that GM statement in my own case when using full lock after backing out of my garage to turn down the driveway. Chatter is worse on wet pavement.

Under some conditions the maximum lateral "g" cornering force may benefit from less Akerman compensation for the different tire turning radius in a turn. Might even be optimum with anti-Akerman!

Guiggiani presents and interesting way to define the various forces in a contact patch. It's referred to as the "Brush Model." He develops equations to define the forces at each "brush bristle tip!"

As with the other math equations the resulting graphs developed form the math model are what are important, not having to follow the derivations!

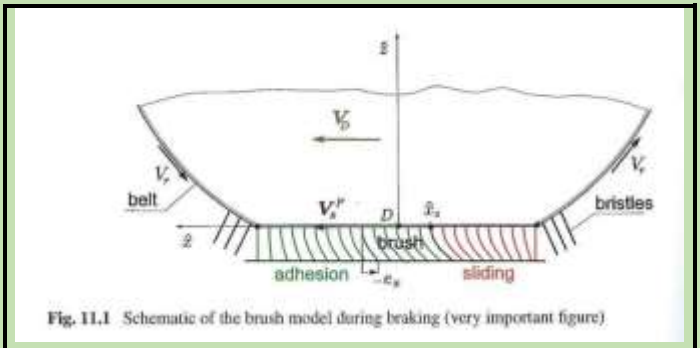


Fig. 11.1 Schematic of the brush model during braking (very important figure)


Fig. 2.10 Drum testing machine [11]

Ultimately even with Guiggiani theoretical solutions, testing is the way to define what is best!

He discusses methods and tools in tire testing to define the parameters such as sidewall stiffness, effects of loading and tread design on the tire's performance.

All factors need to be considered in the development of math models defining forces transmitted to the car.

Another Document Presented Research on What is Optimum for a Race Car

Dale Thompson from Race Car Technology has an interesting summary of Akerman, Anti-Ackerman or Parallel Steering in an Internet document. This is a short summary of parts of the 10-page discussion.

What Guru's Say:

Race & Sports Car Design (1961) "…a small amount of anti-Akerman is recommended." (*Funny, I have the 1967 publication of that book- see book pics at the Appendix B start!)*

Tune to Win (1978) "..race car steering angles are too small for Ackerman to build and in mid corner the inside tire is not sufficiently loaded to have much effect. For corner entry he preferred a small amount of static toe out."

Performance Handling (1991) "Anti-Akerman was used in early years but in -90's Akerman has returned…Akerman is a design element not a tuning tool.

Race Car Engineering & Mechanics (1992) "the lighter the tire loading the higher the slip angle required for peak cornering power."

Competition Car Suspension (1999) "any single thing that can help the contact patch… has to be worth the trouble to achieve. In another article he was keen on Akerman and did some testing on a hill climb car.

Race Car Engineering Magazine (2001) "one of the easiest ways to take advantage of yawing power is to use dynamic toe changes (is the inside tire drag is a bit more than the outside it will help turn the car in a corner.)

Optimum G Race Car Seminars "…static toe out or in creates an artificial slip angle. Toe out can help the inside tire grip. Negative camber can be optimized for the outside tire but works against the inside tire. The steering geometry preferred will be a function of the tire force vs slip angel curve. If the tire curve shows max force at reduced slip angle, anti-Akerman would be useful (***IMO, this is the Best Explanation***)

Need To Test

Dale discusses using a skid pad, perhaps at various radius. He suggests that anti-Akerman could help reduce the unwanted dynamic toe out. *It suggests to me that GM has tested the C7 Corvette with the OEM tires and defined the amount of Akerman that optimized the skid pad numbers and whatever ill effect it has on slow speed full lock turns was "acceptable!" They have no doubt done the same with the C8 and its OEM tires.)*

He Summarizes When To Possibly Use Ackerman, Anti-Akerman or Parallel in a Race Car

- **Toe out helps compensate negative camber on inside tire so more Akerman might be useful if large camber is used.**
- **To rotate the car in a corner, more inside tire drag is useful. More Akerman could be useful. However, if we started to lose outside tire grip, more lock would be applied, and the effect would be lost! *The oversteer torque desired would be overcome by the larger understeer torque***
- **If the car is faster with toe in anti-Akerman could be useful.**
- **Initial toe out would help turn in. The other setting to help initial turn in is a stiffer front shock.**
- **It is assumed that the outside wheel will always have the ideal trajectory (assume he means camber is set for the outside wheel) BUT if the car has a lot of caster it might have the effect of splitting some of the toe to the outside wheel. If the outside Toe does take on some of the toe out this will decrease slip angle and the outside wheel will lose grip.**

He ends with asking for folks who do make tests, report their findings.

MY BOTTOM LINE

As expected, this is a very complex Kinematic issue! Nothing short of testing with the specific tires and tire temp will define what is optimum including Oversteer or Understeer tendency in a specific radius corner! From my little NASCAR knowledge working as a sponsor with the Petty Team, it is also driver dependent! Some driving styles prefer the car Loose (the NASCAR Oversteering word) and some Tight (Understeer.) Recall some driver's, like Richard Petty who are technically very knowledgeable about what affects the car's performance, would say "One turn tighter on the right rear" at the upcoming pit stop (meaning that spring seat setting (which is on a lead screw) could be turned one turn clockwise.) However, for some drivers where the crew chief knew it was a tire pressure issue or just the driver's perception they might say OK and have the pit crew just go through the motions! Sure enough, after a lap or so the driver would say- yep that did it! LOL

Would seem logical that a car might be set-up differently for the slowest speed turn in a particular track to gain a few tenths lap time without it slowing in other turns. But Akerman, Toe, Camber, Caster, Shock setting (for a given suspension, springs and sway bars) are all variables to be considered.

My cousin (left) took this pic in 2018 at the Bristol NASCAR Track with Dale Inman Richard Petty's Chew Chief for many years. Dale (83 yrs old.) remembered an incident when we changed welding machine colors (*and brand name*) and I asked to get the sheet metal from the ~25 welding machines we provided and repaint. He convinced me to provide new machines! Dale & Richard are great folks!

Great experience working for ~15 years with the Petty Team in Level Cross. Me left after going ~165 mph at Charlotte MS!

WA Technology

"52" C8, 2017 Grand Sport & 2014 Z51 Stingray Mods, Info Available As PDFs:

52 PDFs discuss improvements or info about a C8, 2017 Grand Sport, 2014 Z51 Stingray function and/or esthetics. Some are minor and others, like the installing "Low Dust Brake Pads" on C8 & C7s, have detailed information.

Below are the PDF's available. Click on picture or Blue PDF link or copy and paste the PDF link (Blue type) into your browser. Or email me at GUttrachi@aol.com **and state the title desired, shown in Yellow:**

C8 Install High Wing ***How To Remove Rear Bumper- Install Wing*** **http://netwelding.com/C8_High_Wing.pdf**	
C8 FWD Hybrid ***WFWD Hybrid Provides More Power & MPG*** **http://netwelding.com/C8_FWD_Hybrid.pdf**	
Rusty GS/C7 Muffler ***Why the C7 muffler rusts way to turn matte black.*** **http://netwelding.com/Muffler_Rust.pdf**	
Change GS/C7 Oil ***WHY change your own oil and C7 Lifting Methods*** **http://netwelding.com/Changing_Oil.pdf**	
C8 Side Skirts & Splitter ***Install C7 Carbon side skirts & splitter on C8*** **http://netwelding.com/Side_Skirts.pdf**	
C7 Carbon Fiber Splitter w/End Plates ***How to install Splitter & Nylon bra fit*** **http://netwelding.com/CF_Splitter.pdf**	
C7 Removing GM Plastic Film ***How To Remove The Rocker Panel Film*** **http://netwelding.com/Rocker_Panel_Film.pdf**	

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C8/GS/C7 Mirror Proximity Alarm ***Limit switch alarm warns when close to door frame*** **http://netwelding.com/Mirror_Proximity_Alarm.pdf**	
Jacking Pads for C8/GS/C7 ***Manual says Jacking Pads 2 1/2 inch max OD..*** **http://netwelding.com/Jacking_pads.pdf**	
C8/GS/C7 Radar Power ***For C7 tapped rear fuse panel. For GS tapped mirror*** **http://netwelding.com/Radar_Detector_Power.pdf**	
GS/C7 Belt Rattle ***Passenger seat belt rattles against the seat back.*** **http://netwelding.com/Eliminate_Rattle.pdf**	
Aluminum C7 Chassis and Weld Repair ***The C7 aluminum chassis. Includes weld repair info.*** **http://netwelding.com/Aluminum_Chassis.pdf**	
C8 Z51, GS/C7 Z51Ceramic Brake Pads ***Performance Vettes have dusty brakes. These US made pads help!*** **http://netwelding.com/Ceramic_Pads.pdf**	
C8/GS/C7 Z51 License Plate Frame; **Must Meet South Carolina Law** **http://netwelding.com/License_Plate_Frame.pdf**	
Manage GS/C7 Spilled Gas & Door Lock ***Protect when filling gas. Preventing door lock failure.*** **http://netwelding.com/Manage_Spilled_Gas.pdf**	
GS/C7 License Plate & Cargo Lights ***LED license plate light & cargo area bulbs*** **http://netwelding.com/License_Plate_Light.pdf**	
GS/C7 Rear Cargo Area ***Rear cargo area storage device and rear protector*** **http://netwelding.com/Rear_Cargo_Area.pdf**	
GS Rear Diffuser (Fits Any C7) ***Rear Carbon Flash Composite Diffuser*** **http://netwelding.com/Rear_Diffuser.pdf**	
GS/C7 Door Panel Protector ***Black plastic protector prevents scuffing of door*** **http://netwelding.com/Door_Panel_Protector.pdf**	
GS/C7 Improved Cup Holder ***A solution to the cup holder spilling*** **http://netwelding.com/Improved_cup_Holder.pdf**	
C8/GS/C7 Wheel Chatter/Hop ***Why sharp, low speed turns with cold tires causes the front tires to chatter/hop.*** ***http://netwelding.com/Wheel_Chatter.pdf***	

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C7 Carbon Fiber Grille Bar ***Install genuine carbon fiber grille bar overlay*** ***http://netwelding.com/CF_Grille_Bar.pdf***	
Jacking a C8/GS/C7 Vette ***Safely jacking either front only or back & front*** ***http://netwelding.com/Jacking_A_C7.pdf***	
Deer Whistle Installed on C8/GS/C7 ***Do they work? Plus Install Info*** ***http://netwelding.com/Deer_Whistle.pdf***	
Replacing C7 Battery ***Tricks for installing battery!*** **http://netwelding.com/Battery_Issues.pdf**	
GS/C7 Window Valet ***Lower Windows With FOB Helps Latch Hatch*** **http://netwelding.com/Hatch_Latch.pdf**	
C8/GS/C7 Splash Guards ***GM splash guards. ACS Best Front Guards for GS.*** ***http://netwelding.com/Splash_Guard.pdf***	
GS/C7 Blind Spot Mirror ***Smaller rear and side windows cause C7 blind spots. Small "blind spot mirrors" help*** **http://netwelding.com/Blind_Spot.pdf**	
GS/C7 Skid Pad Protector ***After the air dam, the aluminum "skid pad" hits*** **http://netwelding.com/Skid_Pad_Protector.pdf**	
C8/GS/C7 Wheel Locks ***Wheel locks, help protect your expensive wheels.*** **http://netwelding.com/Wheel_Locks.pdf**	
GS/C7 OnStar Lights ***Rear view mirror OnStar LED's, at a quick glance, look like a police car flashing light! This is a fix.*** **http://netwelding.com/OnStar_Lights.pdf**	
GS/C7 Skip Shift Eliminator ***Skip Shift Eliminator install with suggestions on jacking a C7.*** **http://netwelding.com/Skip_shift_Eliminator.pdf**	

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GS/C7 Catch Can & Clean Oil Separator ***What is Coking and how to reduce the potential*** **http://netwelding.com/Catch_Can.pdf**	
GS MGW Flat Stick Shifter ***The MGW shifter shortens throw and is more precise*** **http://netwelding.com/MGW_Shifter.pdf**	
GS/C7 Round Shift Knob ***A round shift knob shortens throw on OEM shifter*** **http://netwelding.com/Shift_Knob.pdf**	
GS/C7 Stingray Sill Plate ***Stingray sill plate replaces original.*** **http://netwelding.com/Sill_Plate.pdf**	
GS/C7 Nylon Bra ***Nylon Bra Stops Bugs. Fits with Stage 3 Winglets*** **http://netwelding.com/Nylon_Bra.pdf**	
GS/C7 Clutch Fluid Change ***Clutch fluid after 3000 miles gets dirty*** **http://netwelding.com/Clutch_Fluid.pdf**	
C7 Carbon Fiber Hood Vent ***Replaces Plastic Hood Vent*** **http://netwelding.com/Hood_Vent.pdf**	
GS/C7 Cold Air Intake ***Low Restriction Air Filter & Duct*** **http://netwelding.com/Cold_Air_Intake.pdf**	
GS/C7 Soler Modified Throttle Body ***For Improved Throttle Response*** **http://netwelding.com/Soler_Mod_TB.pdf**	
Garmin GPS for GS Cubby ***Garmin Mounts in GS Cubby & Apple CARPLAY*** **http://netwelding.com/GPS_In_Cubby.pdf**	
GS Splitter Stage 3 Winglet ***Stage 3 Winglets Integrate with Spats*** **http://netwelding.com/Stage_3_Winglets.pdf**	
GS 2LT to 2.5 LT ***Red Upper Dash Pad Like 3LT*** **http://netwelding.com/Red_Dash_Pad.pdf**	
Jake Emblem/Decals for GS ***Jake Symbols Support GS Racing Image*** **http://netwelding.com/Jake_Emblems.pdf**	

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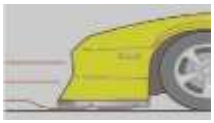
C8/GS Splitter Protector ***Scrape Armor Protection for Splitter*** **http://netwelding.com/Splitter_Protectors.pdf**	
GS Engine Compartment Mods ***Cosmetic Additions in Engine Compartment*** **http://netwelding.com/Engine_Compartment.pdf**	
GS Vitesse Throttle Controller: Fits All C7s ***Adjustable Throttle-by-Wire Control*** **http://netwelding.com/Throttle_Control.pdf**	
Boomy Bass Solution ***Use Presets to Adjust Bass etc Tone/Balance*** **http://netwelding.com/Boomy_Bass**	
GS/C7 Air Dam, Functions ***Why Missing from Z51, Some GS & Z06*** **http://netwelding.com/Air_Dam.pdf**	
C8 Engine Compartment Lights ***Multicolor Lights Remote operated*** **http://netwelding.com/Engine_Lights.pdf**	
C8 Edge Red Engine Cover ***Engine Cover Matches Valve Covers*** **http://netwelding.com/Engine_Cover.pdf**	
Engineering a ProStreet Rod ***How Our '34 ProStreet Rod Was Designed and Built*** **http://netwelding.com/Engineering%20Street%20Rod%203-08.pdf**	
Motorsports Welding Article ***Wrote a 5 Page Article for AWS March 2018 Journal Covers NHRA and NASCAR Chassis Design*** **http://netwelding.com/Motorsports_Welding_2018.pdf**	

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