

Strengthening of Automobile Chassis

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Abstract

We know that a chassis to an automobile is like a skeleton to a body. Chassis stiffness is what separates a great car to drive from what is merely Ok. Every chassis is a compromise between weight, component size, complexity, vehicle intent and ultimate cost. And even with a basic design method, strength and stiffness can vary significantly, depending on the details. This paper lists some techniques which could be used to further strengthen the chassis of a car. A stiff and rigid chassis ensures enhanced controlling of the vehicle along with imparting higher safety and comfort levels to the occupants.

Keywords- Chassis, Flex, Roll Cage, Bars, Stiffening, Suspension

I. INTRODUCTION

Automobile chassis is basically the internal framework which consists of a frame supporting the vehicle and all other major units responsible for propelling and controlling of the vehicle. The major components of chassis are:

- 1) Engine
- 2) Transmission
- 3) Controls
- 4) Basic Structure
- 5) Electrical systems



Fig. 1: Motor vehicle chassis with its suspension, exhaust system, and steering box

The chassis of a car is more than the sum of its parts. On the surface, the chassis is the single largest part of the car, and really does so much that can be observed other than hold things together. The chassis first serves as an aero device, both by directing

air but also by supporting the deflection of other aero components. It does the same for the power train and suspension: holds the parts together with the ideal balance of stiffness and weight.

The chassis serves as the driver's centre of confidence. If the driver does not feel safe, either due to weak impact zones or flexy suspension feedback, he won't go fast. Arguably more importantly, he may be injured by an unsafe chassis. Finally, the driver must be entirely comfortable.

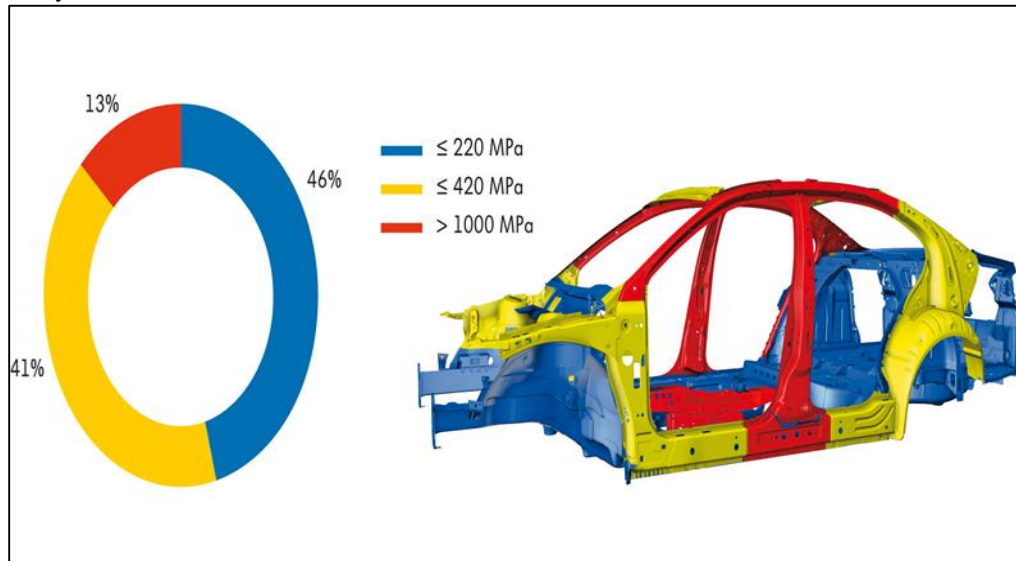


Fig. 2: 2011 Volkswagen Jetta Chassis Safety

Chassis systems determine many of the fundamentals of vehicle behaviour and "character", in particular ride comfort and noise levels on one hand, and the quality of steering, handling and road holding on the other. These are not, by and large, the qualities that influence the decision to buy, which is largely dependent on external appearance, visible features and price. They are, however, aspects that play a large part in determining customer satisfaction during vehicle operation - which may in turn influence the decision for or against a repeat purchase. Chassis engineering has provided one of the most effective means of determining the "character" of a vehicle.

Before listing methods of chassis stiffening we shall discuss why we need the chassis of our car to be strong. A strong and stiff has the following advantages: -

- 1) If the chassis is structurally sound and strong, it will ensure nothing breaks down under normal conditions.
- 2) It will maintain the suspension mounting locations so that handling is safe and consistent under high cornering and bump loads.
- 3) It will support the body panels and other passenger components so that everything feels solid and has a long, reliable life.
- 4) It will protect the occupants from external intrusion.

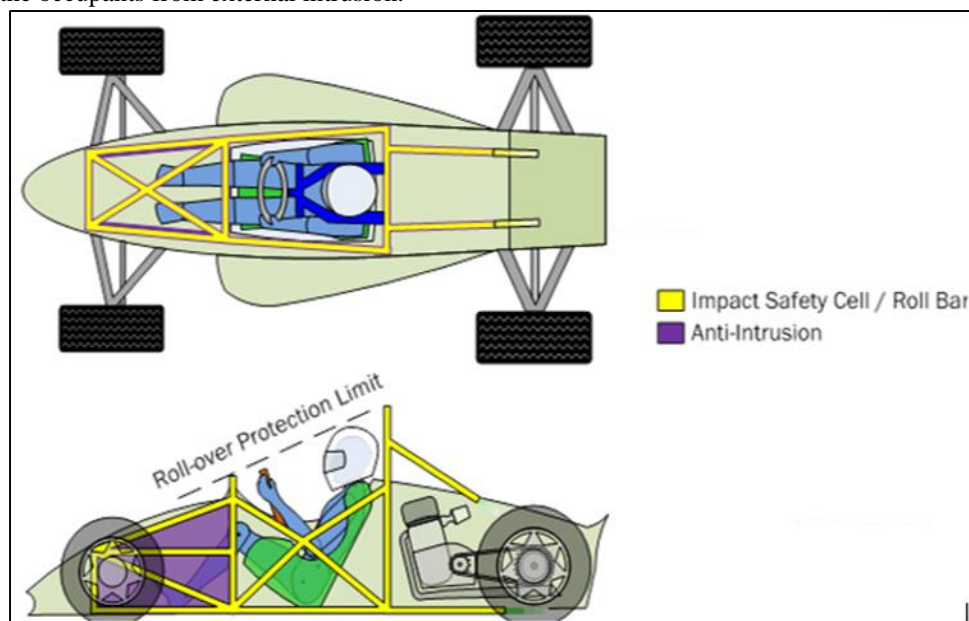


Fig. 3: Safety cell as chassis

II. AUTHOR GUIDELINES FOR MANUSCRIPT PREPARATION

Following arrangements are proposed for stiffening of car chassis: -

A. Roll Cages

Roll cages are probably one of the most essential safety devices especially in racing cars and sports coupes. Although they are rarely seen in the street cars they are an imperative part of the racing car safety systems. The role of roll cages is not just to protect the occupants of the vehicle but also the chassis.

Roll cages enforce the chassis giving it a more rigid base reducing the amount of suspension geometry change. Whenever a car goes through a sharp turn at high speeds, it undergoes a certain amount of lateral gravitational force. This gravitational force can introduce high amounts of stresses towards the vehicle chassis. This stress can cause the vehicle chassis to undergo chassis flex which can be reduced by roll cages.

Chassis flex can have detrimental effects on our vehicle handling and suspension. Chassis flex can cause the suspension's geometry to change. Chassis flex can change other suspension alignments like toe and caster. All these absurdities can be avoided by installing a roll cage that provides extra rigidity to the vehicle chassis.

There are two types of roll cage, these being bolt-in and weld-in. The difference is in the way the roll cage is fitted to the car. The cage design and fabrication are fundamentally the same. The bolt-in cage as the name implies is bolted into the car (thus making it easier to remove), the weld-in cage is welded into the car. A weld-in cage is lighter than a bolt-in cage and makes the car shell more structurally rigid. In addition, the world governing body (FIA) and country specific governing bodies (e.g.: MSA in the UK) mandate race cars must have weld-in roll cages.



Fig. 4: Roll cage in a sports car

Another added benefit of adding a roll cage in a car is the increased amount of safety that comes with the ride.

There are point systems when it comes to a roll cage. The normal manufacturer produces some that go, on average, from a four-point system all the way to fifteen-point system.

In a proper sports car or a hybrid vehicle roll cages become more valuable as there are no A/B/C pillars in them. So, basically there is zero lateral stiffness without the roll cage.

A roll cage has the benefit of stiffing the cars chassis which reduces body twist and roll. The decreased level of twist and roll results in improved handling and the cars suspension, caster, camber and toe settings can be made more precise which in turns makes the cars easier to drive, more consistent and reduces tyre and component wear.

1) Material Selection

One of the key decision about the roll cage is material selection as it has a great impact on safety, reliability and performance. To ensure the optimal selection of material extensive research is carried out and comparison between the chemical and mechanical properties are for various material is done. For selecting the material for the Roll cage, the important properties of the frame material to be considered include high rigidity, torsional stiffness, stability and low weight so as to satisfy the requirements of a race car.

Table no. 1 shows the comparison between the mechanical properties of AISI 1018 and AISI 4130. We can see that mostly all properties are same except the values of ultimate strength and yield strength.

Table 1: Comparing Mechanical properties of AISI 1080 and AISI 4130

Properties	Value	Value
	AISI 1018	AISI 4130
Density	7870 Kg/m ³	7870 Kg/m ³
Poisson's Ratio	0.29	0.29
S(ut)	450 Mpa	650 Mpa
S(yt)	365 Mpa	435 Mpa
Elasticity (E)	200 Gpa	200 Gpa

We can see that the ultimate tensile strength of AISI 4130 is twice the ultimate tensile strength of AISI 1018. It means that AISI 4130 provides high strength to weight ratio.

Table no. 2 and 3 shows chemical properties of AISI 4130 and AISI 1018 respectively.

Table 2: Chemical properties of AISI 4130

Carbon	0.28	- 0.33%
Chromium	0.8	- 1.1%
Manganese	0.7	- 0.9%
Molybdenum	0.15	- 0.25%
Phosphorous	0.035 max	
Silicon	0.15	- 0.35%
Sulphur	0.04 max	

Table 3: Chemical Properties of AISI 1018

Carbon	0.14-0.20 %
Iron	98.81-99.26 %
Manganese	0.6-0.9 %
Phosphorous	≤ 0.040 %
Sulphur	≤ 0.050 %

From Table no. 2 we can see that it consists of Chromium, Molybdenum and Phosphorous, so various properties like Machinability, chip formation and corrosion resistance is higher in AISI 4130.

B. Strut Braces

Strut braces are the most basic chassis stiffening devices. Many performance cars usually come with these as standards. These are simply bars that go between the top and sometimes also the bottom suspension mounts, helping resist suspension mount flex when hard cornering, keeping the geometry at optimum angles and generally sharpening up the handling.



Fig. 5: Strut Brace

In simple words a strut bar is a simple metal bar that connects the left and right strut tower. The idea is that by tying them together, we reinforce the frame of the car and therefore we reduce the chassis flex. The placement of the strut bar is particularly important as it is tying two of the most stressed points together and helping to prevent the body of the car from flexing due to a strong force to one side or the other.

For example, when we go over a raised bump with our right tire, the spring compresses as the wheel pushes up on the body. This force, if high enough, can cause the metal body of the car to move and twist. When this occurs, especially during high speed cornering, it can affect the suspension's alignment temporarily and make the car feel less stable and predictable.

Considering the enormous amount of flex that can occur in today's unibody chassis, these are a valuable add-on for any serious performance application. If the unibody design previously allowed a great deal of flex, the addition of a strut brace will be very noticeable in terms of stability and handling improvement. Even if the unibody originally exhibited minimal flex, the addition of a strut brace will always improve handling, since it reduces chassis flex and resulting wheel angle changes. This means that the grip of the tires can better make use of lateral energy instead of wasting it through excessive chassis flex.



Fig. 6: E39 Ultra Racing Strut Braces

C. Seam Welding

The stiffness of chassis is typically measured as torsional stiffness. To increase the torsional stiffness of a race car without adding significant weight, another critical factor in the performance of a race car, the builders weld all the panels fully together. This increases stiffness by making the bond between parts of the body much stronger, engaging more of the material in resisting torsion. This is effective because typical passenger cars have body panels that are spot welded together. Spot welders only weld small spots on each panel together in order to save time and money in assembly.

Spot welds will not hold together in a crash and the driver could get hurt badly. Also, it is easier to repair in the event of a crash involving that part of the car. The suspension is an integral part of driveability also. If the frame and other parts get bent the car will not drive right so the handling will be off, you will not be able to get up to maximum speed and the likelihood of crashing goes up.



Fig. 7: Seam welding in a car

To seam weld a car it needs stripping right back to a bare shell, and seam sealer would need to be scraped off. It's no easy task, and for that reason it's rarely done outside of full race builds.

D. Chassis Stiffening Bars

The chassis stiffening bars work in a similar way to strut braces, simply bolting on to existing points on the chassis, but rather than preventing the upper and lower suspension mounts from moving, these are designed to prevent other parts of the chassis from moving. Depending on the car, there are stiffening bars available for almost every part of the chassis imaginable, some highly

effective. While these bars aren't as effective as a good roll cage, and simply add rigidity to help handling, rather than also adding safety, they're a good option for a road car where you don't want a massive climbing frame of a roll cage filling your interior.



Fig. 8: Chassis stiffening bar in a car

III. CONCLUSION

The chassis of a car (or truck, or any other sort of wheeled vehicle) is the most important structural part of the vehicle. The more rigid it is, the better is the control and the occupants are more safe and at higher comfort. The stiffness of chassis of a car can be enhanced by addition of: -

- 1) Roll Cages
- 2) Strut Braces
- 3) Seam Welding
- 4) Chassis Stiffening Bars

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