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UWTSD



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1. Vehicle structure History

Vehicle structures have come a long way since the first automobiles were introduced in the late 19th century. From the earliest vehicles, which were little more than horse-drawn carriages with an internal combustion engine, vehicle structures have evolved to meet the changing needs and demands of consumers. Today, vehicle structures are designed to be lightweight, strong, and safe, and they are an integral part of the overall performance and efficiency of a vehicle. There are many things which must be considered when designing BIW today such as:

- Torsion
- Bending
- Aerodynamics
- Crash requirements

All of which will be discussed through the report.

One of the earliest developments in vehicle structures was the use of steel frames to support the body of the vehicle. These frames provided a strong and rigid foundation for the vehicle, and allowed for the attachment of the engine, suspension, and other mechanical components. As vehicles became more complex, the steel frame was supplemented with additional structural elements, such as cross members and side rails, to provide additional support and rigidity.

As the internal combustion engine became more powerful and efficient, vehicle structures were designed to be able to withstand the increased stresses and loads that were placed on them. As well as this there was a need to make cars safer. With the emergence of Euro NCAP in 1997 it was now more accessible for consumers to easily compare their cars to others in class. This led to the development of stronger and more durable materials, such as high-strength steel and aluminium, which were used to construct the body and chassis of vehicles

The design and construction of vehicle structures has evolved significantly over the past century, and this is likely to continue as electric vehicles become more common. With the increasing emphasis on reducing weight and improving efficiency, we can expect to see the use of advanced materials and construction techniques, as well as the integration of additional structural elements and systems, in the vehicle structures of the future.

2. Material development

In recent years, there has been a growing trend towards the use of lightweight materials in vehicle structures. This is driven by the need to reduce fuel consumption and emissions, as well as to improve the overall performance and handling of vehicles. Some of the materials that are commonly used in modern vehicle structures include carbon fibre, magnesium, and advanced high-strength steels. These materials are much lighter than traditional materials such as steel, and they can provide the same level of strength and rigidity.

As well as decreasing emissions and lowering fuel consumption the weight and materials used on car chassis also greatly impacts passenger safety. The use of these materials allows for them to absorb more energy on impact and thus reduce the risk of injuries to passengers. As well as this the use of these materials allow for the manufacturer to complete the bulk of the structure in one-piece. The entire car can take shape with the chassis and then body panels can be added to this. This is evident in figure 1.



Figure 1- A figure showing a modern BIW

This modern chassis (monocoque) allows for the body panels to be added in order to create crumple zones which in turn absorb more energy. This chassis is also designed to ensure that the impact force of the crash is diverted away from the occupants of the vehicles. The vast framework also allows impacts to be absorbed better from various angles. The sides have much better crash protection than a chassis that can be found in figure 2.



Figure 2- A figure showing a chassis system.

3. Electric vehicle future advancements

With the increasing popularity of electric vehicles, the design and construction of vehicle structures is likely to change significantly in the coming years. One of the main challenges with electric vehicles is the weight of the battery packs, which can add a significant amount of weight to the vehicle. Although there is additional weight it can be easily distributed. Instead of having one large ICE at the front of the vehicle the batteries can be laid flat and across the floor. This will be further discussed below.

To compensate for the additional weight of the batteries, vehicle structures will need to be designed to be even lighter and more efficient. This is in order to compete with traditional vehicle overall performance and handling.

One way in which vehicle structures for electric vehicles may change is through the use of new materials and construction techniques. For example, the use of advanced materials such as carbon fibre and magnesium may become even more widespread. With the continued research and development of materials it is assumed that vehicle structures will always become lighter and more efficient. As these materials can provide the necessary strength and rigidity while also being lightweight. Additionally, new manufacturing techniques, such as 3D printing, may be used to create customized and optimized vehicle structures that are tailored to the specific needs of individual vehicles.

Another way in which vehicle structures may change with the widespread adoption of electric vehicles is through the integration of additional structural elements and systems. For example, the use of advanced active suspension systems, which can automatically adjust the ride height and stiffness of the vehicle, may become more common. These systems can help to improve the overall stability and handling of the vehicle, and may also be used to optimize the weight distribution of the vehicle.

As well as this there is no need to have a large space for the internal combustion engine at the front of the chassis.

Firstly, the absence of an ICE allows for a more efficient distribution of weight within the vehicle. The ICE is typically a heavy component, and in traditional ICE vehicles it is often located at the front of the vehicle, which can cause a significant imbalance in the weight distribution. Removing the ICE allows for the weight to be more evenly distributed across the vehicle, which can improve the vehicle's overall stiffness.

Second, the removal of the ICE allows for the design of the vehicle's structure to be optimized for stiffness without the need to accommodate the engine and its associated components. This can allow for the use of materials and design features that are specifically chosen to improve the vehicle's stiffness.

Finally, the absence of an ICE allows for the use of electric drivetrains, which can be packaged more compactly and efficiently than traditional ICE drivetrains. This can allow for the design of a vehicle that has a lower centre of gravity, which can improve its overall stability and stiffness.

4. Torsional Stiffness and Bending Stiffness

Torsional stiffness refers to the resistance of a vehicle's structure to twisting forces, also known as torsional loads. These forces can be caused by a variety of factors, including cornering, acceleration and braking. Improving torsional stiffness can have a number of benefits for a vehicle, including better handling and ride comfort, as well as improved safety. In recent years, there have been a number of developments in vehicle structure design that have helped to improve torsional stiffness.

The bending stiffness of a vehicle structure refers to its resistance to deformation when subjected to external loads. It is an important factor in the design of vehicle bodies and chassis as it determines the stability and handling of the vehicle. A vehicle with a high bending stiffness will be less prone to body roll and have more predictable handling, while a vehicle with low bending stiffness may feel unstable and less responsive to driver input.

Torsional stiffness and bending stiffness have greatly improved over the last 100 years. As cars have become faster and more powerful there has been a need to increase torsional and bending stiffness in order to accommodate the higher loads.

One way that torsional and bending stiffness has been improved is through the use of advanced materials that have been discussed above. The use of these materials has allowed manufacturers to create stiffer and lighter chassis. This has allowed vehicle manufacturers to improve stiffness while also reducing weight, which can have a number of benefits including improved fuel efficiency and performance.

Another way that stiffness has been improved is through the use of advanced manufacturing techniques. By using techniques such as hydroforming and roll bonding, it is possible to create vehicle structures that are more precise and have improved stiffness properties. These techniques can also be used to create complex shapes and geometric features that can further enhance torsional stiffness.

In addition to these advances in materials and manufacturing, there have also been developments in vehicle structure design that have helped to improve stiffness. For example, the use of structural adhesive bonding can help to improve the strength and stiffness of a vehicle's structure by bonding together different components. Similarly, the use of advanced simulation tools has allowed vehicle designers to optimize the design of a vehicle's structure for improved stiffness.

This can be evident in the difference between figure 1 and figure 2. Using modern technology it is now possible to create more complex chassis shapes which have great benefits to the vehicle occupants.

5. Aerodynamic impacts

The development of vehicle structures has had a significant impact on the aerodynamics of vehicles. Aerodynamics refers to the study of how air flows around and over an object, and it is an important factor in the design of vehicles as it can affect their performance, fuel efficiency, and stability.

Traditionally, vehicle structures were designed with a focus on strength and stiffness, rather than aerodynamics. This meant that vehicles often had simple, box-like shapes with few curves or contours. While these shapes were effective at providing the necessary structural support, they were not particularly aerodynamically efficient. As a result, vehicles tended to be less fuel efficient and have higher levels of drag, which could affect their performance and stability.

In recent years, however, there has been a shift towards designing vehicle structures that are both strong and aerodynamically efficient. Engineers have developed new materials and manufacturing techniques that allow for the creation of structures with more complex shapes and smoother surfaces. These designs can help to reduce drag and improve fuel efficiency by allowing air to flow more smoothly over and around the vehicle.

6. Crash requirements

Crash requirements are safety standards that vehicles must meet in order to be deemed safe for use on the road. These requirements are put in place to protect vehicle occupants and pedestrians in the event of a collision, and they have had a significant impact on the design and construction of vehicle chassis.

One of the main ways that crash requirements have affected chassis design is by imposing strict strength and rigidity requirements. Chassis must be able to withstand significant forces and deformations in a collision in order to protect the occupants of the vehicle. This has led to the use of stronger and more rigid materials, such as high-strength steel and aluminium, in the construction of chassis. It has also led to the use of more advanced design techniques, such as the use of computer simulations to optimize the layout and shape of the chassis for maximum strength and rigidity.

Another way that crash requirements have impacted chassis design is through the use of crumple zones. Crumple zones are areas of the chassis that are designed to absorb and dissipate the energy of a collision, thereby reducing the forces experienced by the occupants of the vehicle. This has led to the use of more complex chassis designs that incorporate multiple crumple zones in different areas of the vehicle. Allowing the energy to dissipate through the chassis of the car means the passengers feel less of the energy. This will directly result in a safer car.

7. Simple Surface Structure

In figure 3 you will see that there is an example of a van in torsion. Along with this is a list of given values. From these values we can use a number of equations in order to calculate the force of torsion.

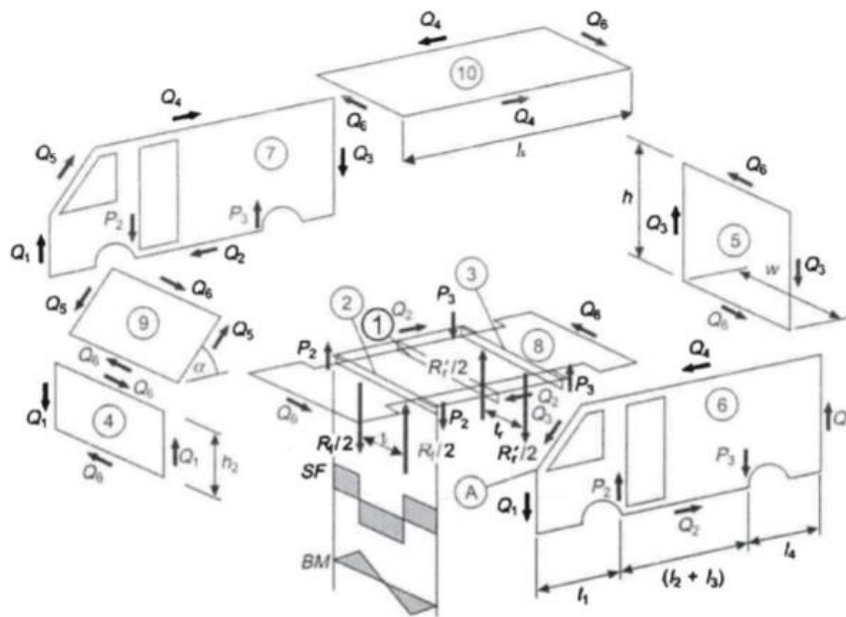


Figure 3- A figure showing an example of a Van in torsion

The list of values to calculate off is:

$$W=2.1M$$

$$h=2.5M$$

$$h_2=1M$$

$$l_1=2m$$

$$l_2+l_3=3.5$$

$$l_4=1m$$

$$\text{Overall Weight}=3500kg$$

$$\text{Weight Distribution}=50:50$$

$$T_f=1.5$$

$$T_r=1.5$$

$$\alpha=45$$

$$R_r=R_f=5KN$$

Firstly, we must calculate P_2 and P_3 .

P2=

$$\frac{Rfxtf}{2W}$$

$$\frac{5000 \times 1.5}{2 \times 2.1}$$

This gives us this figure of 1785.7N. This is equal to P3 in magnitude as they act at the width of the vehicle and the torque at the front and rear must be equal.

P3=1785.7N

Following this Q6 can then be calculated.

Q6=

$$\frac{w(l1 + l2 + l3) - P2 - h1}{h1(l1 + l2 + l3 + l4) + l5(h1 - h2) + h2(l1 + l2 + l3 + l4)}$$

When all necessary figures are substituted in to this equation it can then be simplified into:

$$\frac{2.1(1785.7 \times 4)}{30.25}$$

This gives us the figure of 495.87N. This can then be substituted into a number of equations in order to get figures for Q1-Q5. The equations and their substituted values can be found below.

Q1=

$$\frac{Q6h2}{w}$$

=

$$\frac{495.87 \times 1}{2.1}$$

=236.12N

Q2=

$$\frac{Q6(l1 + l2 + l3 + l4)}{W}$$

=

$$\frac{495.87(2 + 3.5 + 1)}{2.1}$$

= 1534.84N

Q3=

$$= \frac{Q6h1}{w}$$

$$= \frac{495.87 \times 2.5}{2.1}$$

=590.32N

Q4=

$$= \frac{Q6l5}{w}$$

$$= \frac{495.87 \times 5}{2.1}$$

=1180.64N

Q5=

$$= \frac{Q6(h1 - h2)}{w \sin 45}$$

$$= \frac{495.87(2.5 - 1)}{2.1 \sin 45}$$

=500.9N

These are all the values of Q1-Q6.

If the vehicle in figure 3 was to have an interchangeable battery there would a number of implications that would have to be considered. In order to allow access to the battery compartment, which will be placed under the floor, the join between Panel 5 (Rear panel) and Panel 8 (Floor Panel) will be compromised.

Firstly, the structural integrity of the vehicle will be affected. The join between the floor and rear panel is an extremely important structural element that helps to support the weight of the vehicle. If the join is compromised it will affect the overall stability and integrity of the vehicle. Over time this could lead to fatigue fail as the other panels will have higher loads on them.

As well as structural integrity problems there will also be an increase in additional noise and vibration through the other surfaces of the vehicle. This would be disadvantageous as the driver and passengers of the vehicle will be able to feel the difference.

References

P.S. Madhu and T.R. Venugopal, "Static Analysis, Design modification and Modal Analysis of Structural Chassis Frame," International Journal of Engineering Research and applications Vol.4 – May 2014

A.J. Robertson, S.T. Serpento and J.C. Brown "Motor Vehicle Structures: concepts and fundamentals" 2002

A. Sasidharan "Automotive chassis design – v2" Slide share – November 28 2014

<https://www.slideshare.net/aanonline/3-automotive-chassisdesignv2>

Kersten, T. Gies. S (2015). Modern chassis development as a result of skilfully combining testing and simulation