For cited: *Baskara, T., Cimendag, M. & Yılmaz Ulu, E. (2021). Analysis and Simulation of B-Pillar for a Vehicle. Journal of Current Research on Engineering, Science and Technology, 7 (1), 1-18.*

Journal of Current Research on Engineering, Science and Technology (JoCREST)
ISSN: 2651-2521

Year: 2021
Volume: 7
Issue: 1

Crossref doi: 10.26579/jocrest.67

Research Article/Araştırma Makalesi

Analysis and Simulation of B-Pillar for a Vehicle

Tayfun BASKARA[1], Muhammet CIMENDAG[2] & Eylem YILMAZ ULU[3]

Keywords
B-Pillar, Impact Simulation, Vehicle Crash Analysis, DP1000, ANSYS Analysis.

Abstract
Analysing automotive chassis parts is important to learn how to keep passengers safe in traffic accidents. Crash analyzes are conducted to create a safe traffic flow for vehicles, passengers and other creatures. Simulation programs applied instead of collision analysis are both faster and less costly. In this research, Solidworks, CES Edupack and Ansys were used to get information about the B-pillar impact test. Each different simulation standard has different results. In this study, the automotive industry's common side impact test standards were used in the B Pillar impact test simulation. All auto parts affect the safety of passengers, but the goal of this research is B-pillar. B-pillar design and material selection are of great importance in terms of simulation results and passenger safety in the automotive industry. In this study, simulations were made using the finite element analysis method and 140 kN was chosen as the impact force. In this research, two different designs were created for the B-pillar. As a result of the first analysis, B-pillar exceeded 1100 MPa selected as the tensile strength value and material rupture occurred. In the design made with DP1000, the B-pillar did not exceed 1100 MPa and the living space was not damaged.

Article History
Received
3 Apr, 2021
Accepted
15 May, 2021

NOMENCLATURE

$\boldsymbol{\tau_v}$: von mises stress, MPa
F : average impact force, kN
m : mass, kg
V : the initial speed, m/s
d : distance, mm
t : time, ms

SUBSCRIPTS

DP : dual phase
EuroNCAP : European new car assessment programme
NHTSA : National highway traffic safety administration
IIHS : Insurance institute for highway safety
k : Constant
$\boldsymbol{S_y}$: Simple tension elastic limit
$\boldsymbol{\tau_{oct}}$: Octahedral yield criterion
z,r,t : Axial
3D : Three dimensional
CAD : Computer aided design
FEA : Finite element analysis

[1] ORCID: 0000-0002-4634-1340. Pamukkale University, Faculty of Technology, Automotive Engineering, tayfun_baskara97@hotmail.com
[2] ORCID: 0000-0001-6418-5110. Pamukkale University, Faculty of Technology, Automotive Engineering, muhammedtcimendag@gmail.com
[3] Corresponding Author. ORCID: 0000-0001-6257-9845. Pamukkale University, Faculty of Technology, Automotive Engineering, eyilmaz@pau.edu.tr

1. Introduction

Security is always more important than money in motor vehicles market. When the car safety could not be provided, deaths and disability are coming out. Therefore, human life is negatively affected. The impact on the chassis must not reach the passenger during the accident. Car chassis parts are most important parts at this point.

The design of the chassis and sleepers forming the vehicle has a great role in absorbing incoming impacts (Baskara and Cimendag, 2018), (Askar, 2018), (Kajtaz, 2019). Different materials can be selected according to designs. Some materials do not have security values enough to use in automotive technology. Analyzes are made in accordance with these material selections. When creating design, Companies must care producing of design, cost of design, visual of design and comfort of design. Continuous devolopment of technology decrease cost of production and increase safety values. Although improving chassis strength is primarily related to passenger safety, it actually increases the safety of all parts in the vehicle (Baser, 2013). Chassis keep all parts of vehicle. Chassis parts design and materials must be selected carefully. The B-pillar serves as a supporting member to a car's roof panel and it is also mounted sideward at the mid-section of a car for latching the front door and installation of the inches for the rare door (Ariffin et al., 2014). For installation purpose, B-pillar is a vertically closed steel structure welded to the vehicle's rocker panel and floor pan at the base and to the roof panel at the top. As probably one of the most complex structural member that supports and maintains the geometry of a vehicle's roof, the B-pillar manufacturing may involve multi-layered assembly of various material strength and length (Tizzard, 1994). However, some vehicles are manufactured without a B-pillar and these are known as hardtops, which can be found in two or four doors such as sedans, wagons and coupes (Thomas et al., 2009). Moreover, some cars such as Limousines have more than two B-pillars which may be designated as B1, B2 etc. as a result of its lengthy physique (Carney, 2012). DP1000 was selected as a material for B Pillar in this research. In the World, there are many materials to use in automotive technology. Car producers apply crash analysis to their car many times. Because, life is more important than money in their company policies (Ozturk et al., 2017). In the World, there are lot of companies that are applying crash analysis like EuroNCAP, NHTSA, IIHS etc. Test scores that are giving by crash test centers to producers are great advertisement for producers. Crash analysis are performed in categories such as front impact, side impact and rollover (Baskara and Cimendag, 2018).

The most basic change is to strengthen the occupant compartment, and on nearly every vehicle studied at least one part of the door frame was beefed up. Extending the bumper and adding engagement structures allow some vehicles to move sideways away from the barrier after striking it. When this happens the dummy experiences less change in velocity but ends up further to the left side of the vehicle, increasing the risk that the head could miss the front airbag if the safety belts and airbags aren't modified to better control the dummy's movement. Among the vehicles whose structures held up best were those that have reinforced side frames tied into the main frame rail, providing an additional load path. Without such measures, crash forces generally go directly into the front wheel, suspension system and firewall.

Major intrusion into the occupant compartment typically results. One common problem in the small overlap front test is that the steering pillar moves to the right. When this happens, the front airbag moves as well, and the dummy's head slides off the left side of the airbag. In a few of the modified vehicles, this was addressed by changes explicitly meant to limit steering pillar motion. In others, reduced intrusion of the door frame and instrument panel was enough to increase steering pillar stability . The force of impact is 140kN. According to the tests, manufacturers are drawing a new path and progressing in that area. The number of people who died in accidents are reduced because test criterias are being harder (Ikpe et al., 2017). Nowadays, simulation programmes are giving right results about crash analysis. After simulations, design and material selection reviewed. If it is necessary, design and material selection are making again. A lot of research is done on vital parts, Solidworks, ANSYS and CES Edupack were used in this research. B pillar was drawn in solidworks. Model was be scaled. Ansys is one of the best simulation programme. Skewness criterion was used for meshing (Ansys, 2017). ANSYS explicit dynamic helped to get results in this research. Generaly, IHSS were using to produce B pillar but in this research DP1000 were used (Baskara and Cimendag, 2018)(Ozturk et al., 2017). CES Edupack is helpful to find material properties. CES Edupack gave us all the values about a material, making it easy to work with. On the CES Edupack program, comparative graphs were obtained and used for the study (Ashby et al., 2018)(Wieczorek, 2018). After first simulation B pillar were devoloped and second simulation were done. Results were compared.

2. B-Pillar

The B pillar begins at the passenger-side and driver-side windows on a car. This pillar is generally present on four-door and five-door vehicles, but some vehicles with two and three doors have them too. Someone can not see the B pillars until they open the car doors. The frames on the front-door windows of a car generally hide the B pillars when the doors are not open. These pillars are vertical and provide a place for the doors to hinge onto when someone closes the doors on a vehicle. This pillar also serves as a place the attach the mountings of the seat belts in the front seat of a car. B Pillar is the most complex component/structure of the vehicle body. This is because the front door closes on the B pillar while the rear door hinges onto it.

Figure 1. Location of B pillar (Nano, 2018)

The B pillar or the center pillar in vehicles is made of steel. It is welded to roof panel on top and the vehicle's floor pan at the bottom. This pillar provides structural support to the vehicle's roof. Manufacturers skip the B pillar while naming other pillars. Hence, there are some vehicles which do not have a B Pillar. The car makers term those cars as Hardtops. Instead, the vehicle specification shows the rearmost pillar as the C pillar. The manufacturers offer the Hardtops in nearly all the four-door body styles. They include from sedans, coupes, and wagons/MPVs. The cars without B pillars increase passenger's visibility. However, they have limited structural support and strength. General Motors later started providing B pillars in Hardtops. Thus, it created new vehicle body type and thereby, broadens the definition of Hardtops.

Figure 2. B pillar (Kirchoff, 2020)

The expected properties from B Pillar are:

- Absorption of impact forces.
- Reducing impact effect by transmitting to other parts.
- Ability to absorb maximum at minimum collapse.
- Low collapse speed.
- To minimize the impact on the living space in the vehicle.
- Parts are asked not to break in the collision, but to damp the incoming impact.

2.1. Impact Forces

The force of impact is the total force exerted on an object during a collision. To derive the impact force equation, you can consider the law of conservation of energy. At the beginning, a moving object possesses kinetic energy that reduces to zero after the collision (object stops). To fulfill the conservation law, the change of kinetic energy must be compensated by the work done by the impact force. It can be expressed with the impact force equation below:

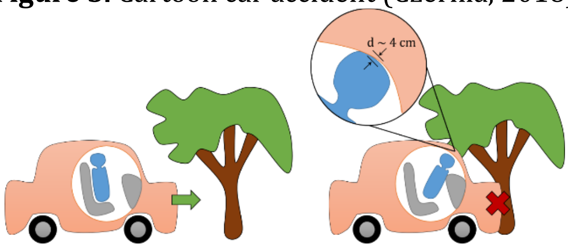
$$\frac{m\times V^2}{2\times d}=F \qquad (1)$$

F : the average impact force,
m: the mass of an object,
V: the initial speed of an object,
d : the distance traveled during collision
The equality can be rewritten as follows:

$$F = (V \times m)/t \quad (2)$$

This is a special case of impulse and momentum formula. Impact force formulas we used above describe an ideal collision between two objects. In the real situation of a car crash, the profile of force during the accident can be more extensive- e.g., you should take into account that car collapses and that a human is not a point mass but a complex body. At the first picture below, the driver sits in the car that is in constant motion with a speed V. Then, a car hits the tree and immediately stops. The driver flies forward due to the inertial force until he is stopped suddenly by the impact on the steering pillar or windshield. The stopping distance is very short because none of the colliding objects (including body and, e.g., windshield) are contractible enough. We can estimate it to be approximately 4 cm.

Figure 3. Cartoon car accident (Czernia, 2018)



The National Highway Traffic Safety Administration (NHTSA) is an agency that conducts traffic safety research around the world. It describes its mission as Save lives, prevent injuries, reduce vehicle-related crashes. The NHTSA states that "the maximum chest acceleration shall not exceed 60 g for time periods longer than 3 milliseconds". The accelerations during car crashes can be a lot higher than 60 g without fastened seat belts. NHTSA states that seat belts reduce death rates by 45% and reduce the risk of injury by 50%.

2.2. Von Mises Stress

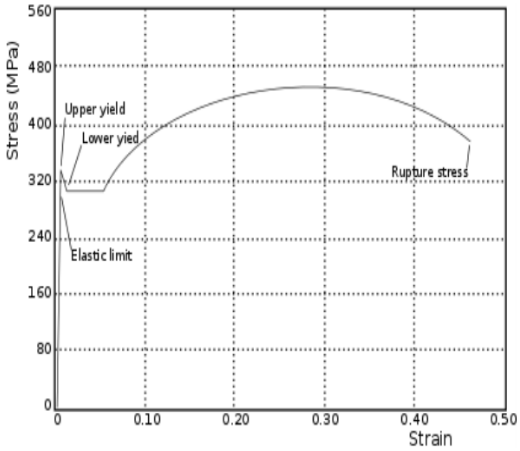
Von Mises stress is a value used to determine whether a particular material will come out. Mostly used for ductile materials. The von Mises value criterion specifies that if the stress of a material under load is equal to or greater than the yield limit of the same material under simple stress, then the material will yield. When a body in an initial equilibrium state or in a non-deformable state is subjected to forces or a surface load, it returns until a new mechanical equilibrium or deform in the body is reached at this time. The internal body forces, the result of a force control and the combination of surface forces. They are used in the production of the material.

Elastic Limit: Elastic limit defines the region where the energy is not lost during the stretching process. Damages that do not exceed the elastic limit are reversible. Deformations above this limit include an irreversible portion. The tensile value of the elastic limit is used herein as Sy.

Upper Yield and Lower Yield: If there is a critical point, it quickly drops back to the lower yield limit.

Rupture Stress: Rupture or fructure causes stress. Therefore, at this point, the body is expected to break. You can recognize ductile fracture. This means that the material becomes thinner and pressure is applied until it breaks.

Figure 4. Rupture Stress (What, 2018)



2.3. Von Mises Yield Criterion

The elastic limits discussed before are based on simple tension or uniaxial stress experiments. The maximum distortion energy theory originated from the observation that materials, especially ductile materials, behaved differently when a non-simple tension or non-uniaxial stress experiment was conducted, exhibiting resistance values that are much larger than the ones observed during simple tension experiments. A theory involving the full stress tensor was therefore developed.

The von Mises stress is a criterion for yielding, widely used for metals and other ductile materials. It states that yielding will occur in a body if the components of stress acting on it are greater than the criterion.

$$\frac{1}{6}[(\tau_{11}-\tau_{22})^2+(\tau_{22}-\tau_{33})^2+(\tau_{33}+\tau_{11})^2+6(\tau_{12}^2+\tau_{23}^2+\tau_{13}^2)]=k^2 \qquad (3)$$

The constant k is defined through experiment and τ is the stress tensor. Common experiments for defining k are made from an uniaxial stress, where the above expression reduces to:

$$\frac{\tau_y^2}{3}= k^2 \qquad (4)$$

If τy reaches the simple tension elastic limit, Sy, then the above expression becomes:

$$\frac{S_y^2}{3}= k^2 \qquad (5)$$

Which can be substituted into the first expression:

$$\frac{1}{6}[(\tau_{11}-\tau_{22})^2+(\tau_{22}-\tau_{33})^2+(\tau_{33}+\tau_{11})^2+6(\tau_{12}^2+\tau_{23}^2+\tau_{13}^2)]= \frac{S_y^2}{3} \qquad (6)$$

or, finally:

$$\sqrt{\frac{(\tau_{11}-\tau_{22})^2+(\tau_{22}-\tau_{33})^2+(\tau_{33}+\tau_{11})^2+6(\tau_{12}^2+\tau_{23}^2+\tau_{13}^2)}{2}}=S_y \qquad (7)$$

The von Mises stress, τv, is defined as:

$$\tau_v^2 = 3k^2 \qquad (8)$$

Therefore, the von Mises yield criterion is also commonly rewritten as:

$$\tau_v \geq S_y \qquad (9)$$

That is, if the von Mises stress is greater than the simple tension yield limit stress, then the material is expected to yield. The von Mises stress is not a true stress. It is a theoretical value that allows the comparison between the general tridimensional stress with the uniaxial stress yield limit.

The von Mises yield criterion is also known as the octahedral yield criterion. This is due to the fact that the shearing stress acting on the octahedral planes (i.e. eight planes that form an octahedron, whose normals form equal angles with the coordinate system) can be written as:

$$\frac{1}{3}\sqrt{(\tau_1 - \tau_2)^2 + (\tau_2 - \tau_3)^2 + (\tau_3 - \tau_1)^2} = \tau_{otc} \qquad (10)$$

Which, for the case of uniaxial or simple tension, simplifies to:

$$\frac{\sqrt{2}}{3}\tau_y = \tau_{otc} \qquad (11)$$

Again, if τy reaches the simple tension elastic limit, Sy, then the above expression becomes:

$$\frac{\sqrt{2}}{3}S_y = \tau_{otc} \qquad (12)$$

And, by applying this result in the octahedral stress expression:

$$\sqrt{\frac{(\tau_1 - \tau_2)^2 + (\tau_2 - \tau_3)^2 + (\tau_3 - \tau_1)^2}{2}} = S_y$$

Similarly to the result obtained for the von Mises stress, this defines a criterion based on the octahedral stress. Consequently, if the octahedral stress is greater than the simple stress yield limit, then yield is expected to occur. The von Mises stress can, for example, be applied in fields such as drilling of hydrocarbon reservoirs, where pipes are expected to be under high pressure and combined loading conditions. In this case, the von Mises stress can be written as:

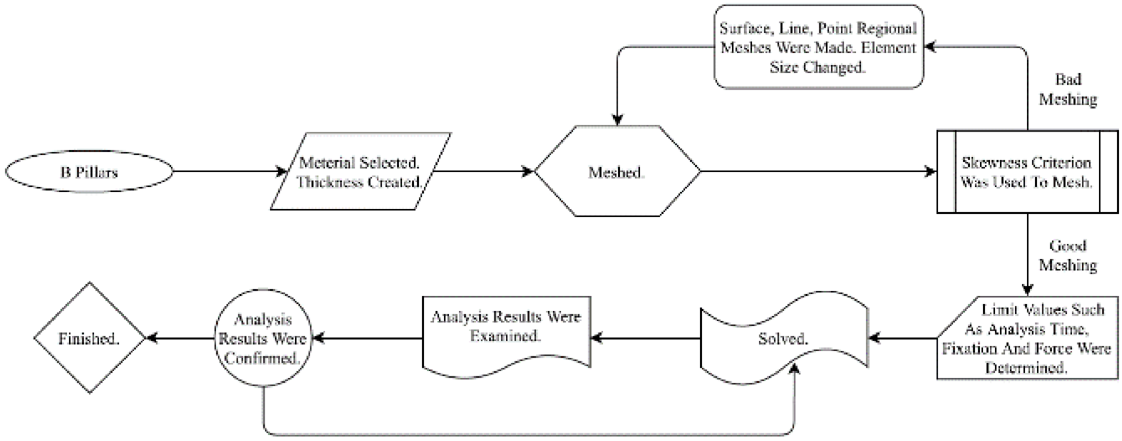
$$\sqrt{\frac{(\tau_z - \tau_t)^2 + (\tau_t - \tau_r)^2 + (\tau_r - \tau_z)^2}{2}} = \tau_v \qquad (13)$$

2.2. Methods and Materials

2.2.1. Analysis Steps

If finite element analysis is expressed as a cycle, it consists of the steps in the table. After selecting the model that is suitable for your analysis, it includes the steps to develop the product according to the result. This includes product development, testing models, testing, remodeling and evaluation.

Figure 5. Analysis steps



2.2.2. Ansys

Ansys is a general purpose software, used to simulate interactions of all disciplines of physics, structural, vibration, fluid dynamics, heat transfer and electromagnetic for engineers. So Ansys, which enables to simulate tests or working conditions, enables to test in virtual environment before manufacturing prototypes of products. Furthermore, determining and improving weak points, computing life and foreseeing probable problems are possible by 3D simulations in virtual environment. Ansys software with its modular structure as seen in the table below gives an opportunity for takingonly needed features. Ansys can work integrated with other used engineering software on desktop byadding CAD and FEA connection modules.

2.2.3. Finite Element Analysis

Finite element method; It is a numerical method that provides general solution by subdividing various engineering problems. In addition to software specially developed for finite element analysis, Ansys, MSC / NASTRAN, Algor, analysis modules integrated into CAD software such as Catia and SolidWorks are also used. It brings many advantages;

- Applied to all kinds of materials and complex geometry is superiority over other numerical methods.
- Especially in the aerospace, automotive and biomechanical industries, tests such as stiffness, strength and collision are visually experienced before the prototype and significantly reduce costs.
- It accelerates the transfer of engineering designs to the production stage.
- Provides more successful first design examples.
- Mathematically generalized can be used in the solution of different problems.

2.2.4. Meshing

Determining the dimensions of the finite element is important. Therefore, wrong size selection results in incorrect results. For elements with a large surface area, the areas are divided into tiny pieces and each of these tiny pieces is solved separately. Therefore, in order for the surface elements to be fully dissolved, these finite elements must be present on all sides of the surface. The finite element width is then selected to enter the bottom. After general and regional mesh settings, there are certain mesh evaluation criteria used by Ansys to determine the suitability level of meshing. Meshing should be evaluated according to these criteria. In this simulation, the appropriateness level of meshing was evaluated according to the Skewness Criterion.

2.2.5. Skewness Criteria

This mesh evaluation criterion is the most widely used and valid criterion. This criterion is calculated by the formula given below. There is two methods to determine Skewness:

Equilateral Volume Deviation: Applies only for triangles and tetrahedron

Skewness: (Optimal cell size – Cell size) / (Optimal cell size)

0.98 – 1 **:** Unacceptable mesh quality

0.80- 0.94 **:** Acceptable mesh quality

0.25- 0.50 **:** Good mesh quality

0- 0.25 **:** Excellent mesh quality

Table 1. Skewness mesh metrics spectrum (Mantovani, 2020)

Excellent	Very good	Good	Acceptable	Bad	Unacceptable
0-0.25	0.25-0.50	0.50-0.80	0.80-0.94	0.95-0.97	0.98-1.00

Normalized Angle Deviation: Where θe is the equiangular face/cell (60 for tets and tri's, and 90 for quads and hexas) Applies to all cell and face shape. Used for hexa, prisms and pyramids.

Skewness: $$max\left[\frac{\theta_{max}-\theta_e}{180-\theta_e},\frac{\theta_e-\theta_{min}}{\theta_e}\right] \quad (14)$$

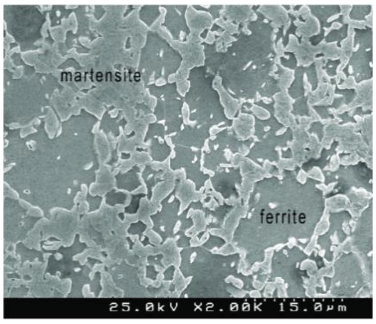
2.2.6. Material Selection

Chassis parts are an automobile component which is obtained by using precision materials and sometimes using steel material and aluminum material. Stainless steel and aluminum are generally used as chassis material. These two materials have almost equal forces. This means that they will operate in the same way under the same load.

Steel is many times harder and heavier than aluminum. Recently, fuel economy and cleanliness in the automotive industry have been reduced and overall impressive vehicle lightening efforts have accelerated. In this regard, ultra-high-strength steel sheets have a privileged position in the automotive industry in vehicle lightening.

It is expected that the usage of 1st and 3rd generation ultra high strength steel sheets in automotive industry will become widespread in a short time. Thus, it is inevitable to combine these two types of steel sheets together with electrical resistance spot welding. Therefore, work is underway to select the materials of the parts that form the frame in the best way and more and more focuses on composite and dual phase steels.

Figure 6. Electron microscope image of DP1000 (Xue et al., 2017)



DP1000 steel was selected in this research. Dual Phase Steels are the most widely used steel due to their high strength, high formability, good weldability, ease of market availability and cost advantages. DP steels have good formability, ductility and high strength due to their microstructure. Dual-phase steel is named after two phases in its microstructure. These are ferrite and martensite. Ferrite provides ductility to the structure and martensite provides high strength. DP600, DP800 and DP1000 steels are already used extensively in the automotive industry. You can see the DP1000 properties that we found using CES Edupack in the table below.

Table 2. Mechanical properties of DP1000 steel (CES, 2018)

Mechanical Properties	**Min**	**Max**	**Unit**
Young's modulus	200	221	GPa
Specific stifness	25,5	28,1	MN.m/kg
Yield strength	600	750	MPa
Tensile strength	980	1,1e3	MPa
Specific strength	76,4	95,6	kN.m/kg
Elongation	10	17	% strain
Compressive strength	600	750	MPa
Flexural modulus	200	221	GPa
Flexural strength	600	750	MPa
Shear modulus	76,9	84,8	GPa
Bulk modulus	167	184	GPa
Poisson's ratio	0,286	0,315	
Shape factor	37		
Hardness - Vickerss	290	323	HV
Elastic stored energy	863	1,33e3	kJ/m^3
Fatigue strength at 10^7 cycle	333	368	MPa
Fatigue strength model (stress range)	308	398	MPa

2.2.7. B-Pillar 1

When we started our research, our first goal was to show how B Pillar will absorb the forces that emerged during the accident and how to respond to the forces that occurred. While the first produced cars were not given so much importance to the B Pillar, the importance of the B Pillar was understood due to the increasing number of vehicle production. The first design used under this title is explained.

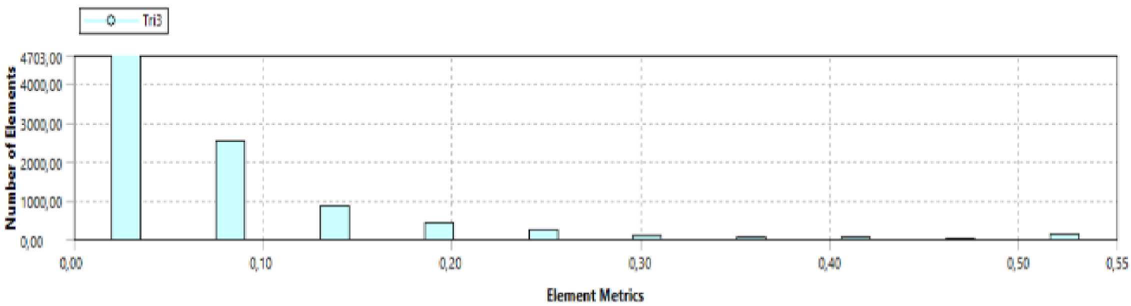
2.2.8. 3D Modelling of B-Pillar 1

As shown in the picture, B Pillar has a simple design. This B-pillar design is far from modern technology, does not have a very detailed design and does not use folding or support equipment. Ultra high strength steel is used as material selection. For this reason, it was not able to absorb the force.

Figure 7. Rendered image of B pillar 1 (Dassault, 2018)

During the analysis of the B Pillar 1, it went through the steps mentioned above. While the thickness was fixed to 2 mm, the material selection was DP1000, one of the ultra high strength steels with the properties specified in the table. Considering the skewness criterion during the meshing, the necessary improvements were made on the element size and shapes with the regional meshes to the surface, line to the point of the pillar and 0.53 value was reached according to the skewness criterion.

Figure 8. Element metrics – Number of elements (Ansys, 19.2)



This value was accepted as good mesh quality as seen in skewness spectrum. The analysis was carried out with a loading of 140 kN on the front side by fixing the B Pillar 1 to be analyzed from the connection points to the frame. The analysis results of the B Pillar 1 were analyzed by graphs and tables created in Ansys program.

3. Simulation Results

When we analyzed the result of the force applied in B Pillar 1, unwanted results occurred and the stress result was 1463,8 MPa. When we examined the values of DP1000 selected as material, we obtained with CES program, there was deformation and break in B Pillar 1. The criteria mentioned above in this B Pillar 1, to absorb enough, not to reach the force could not be achieved.

As stated at the beginning of this article, the results of the analysis are intended to absorb the load (140 kN) with a maximum deformation of 40 mm. According to the analysis results, the 140 kN load applied to B Pillar is a high value for B Pillar 1. As a result of the analysis, the tensile value is 1463.8 MPa. When this value is compared with the values obtained with CES Edupack program (DP1000 table), it is seen that there will be a rupture in B Pillar 1. The values in the table (DP1000 table) were placed on the hook curve and the analysis results were compared. Rupture against incoming loads in B Pillar 1 is undesirable. As a result of rupture, B Pillar 1 will transmit the incoming load to the chassis and sleepers forming the car outside the B Pillar 1 and will damage the drivers and passengers in the living area.

Figure 9. Analized image of B pillar 1 (Ansys, 19.2)

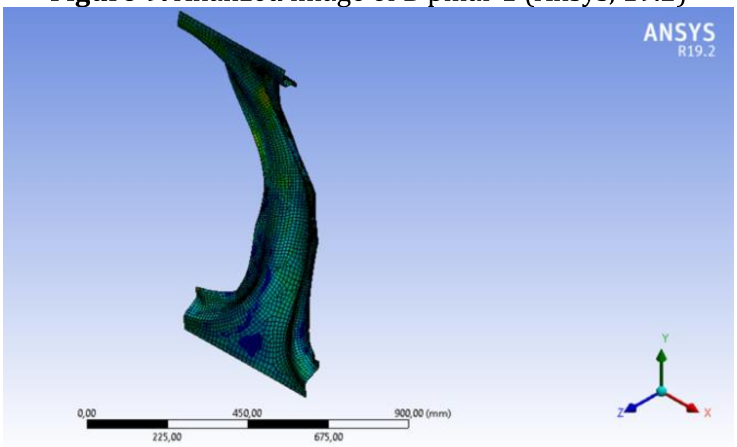
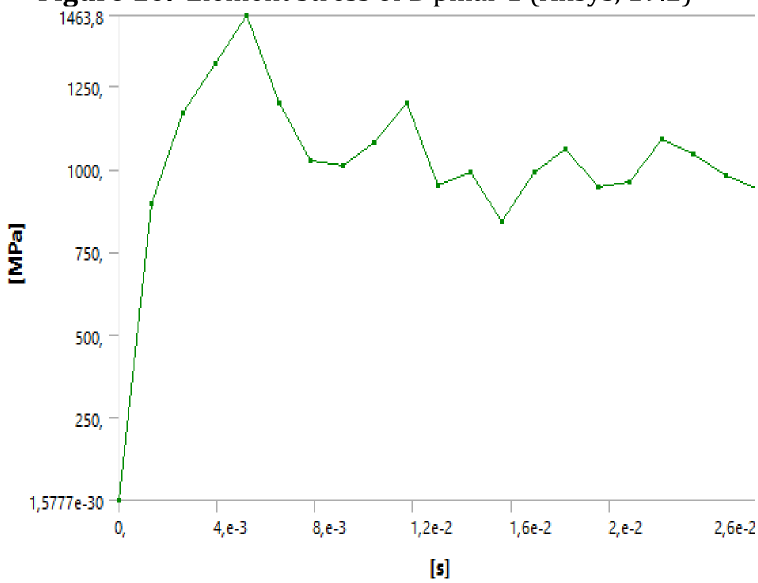


Figure 10. Element stress of B pillar 1 (Ansys, 19.2)



3.1. New B Pillar

As the expected efficiency could not be obtained from the first modeling, we focused on a new model. As you can see in the pictures, design changes were made on the model. The goal of this is to further absorb the load on B Pillar. It was aimed to reduce the impacts to reach the passengers and less damage to the vehicle.

3.1.1. 3D Modelling of new B Pillar

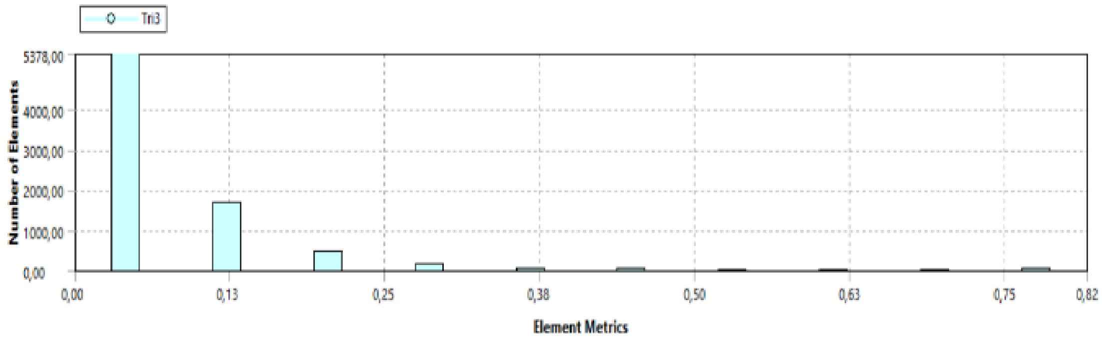
As shown in the picture, the new design is similar to that used in today's technology. Material selection was not changed and the DP1000 was used again. This is due to the fact that as we mentioned before, DP1000 is being given more importance in B Pillar. When the design change was made, it was aimed to see the increase of absrobe while the material selection remained the same. While the analysis of today's B Pillar was carried out, it went through the steps mentioned above in the Figure 4 as in the B Pillar 1. The thickness of New B Pillar varies between 1.25-2.0 mm. This change in the thickness of the pillar was due to the more modernized design and location, the material selection was DP1000, one of the ultra-high strength steels with the properties specified in the table (DP1000 table).

Figure 11. Rendered of New B pillar (Dassault, 2018)

Considering the skewness criterion during the meshing, the necessary improvements were made on the element size and shapes along with regional meshes to the surface, line to the point of New B Pillar and 0.77 value was reached according to the skewness criterion. This value is also considered to be good mesh quality when looking at the skewness spectrum from Table 1 as in the simple B Pillar.

Today's pillar to be analyzed is fixed at the connection points to the frame with a load of 140 kN on the front face of the analysis was performed. The analysis results of the simple B Pillar were analyzed by graphs and tables created in Ansys program.

Figure 12. Element metrics – Number of elements 2 (Ansys, 19.2)



New B Pillar to be analyzed is fixed at the connection points to the frame with a load of 140 kN on the front face of the analysis was performed. The analysis results of the B Pillar1 were analyzed by graphs and tables created in Ansys program.

3.1.2. New Simulation Results

The level of conformity to the mesh was re-evaluated according to the skewness criterion and simulation was performed accordingly. B Pillar is secured to the chassis ports. The force applied in the first simulation was reused. According to the results, the resulting stress was decreased. Stretching was obtained as 1100 MPa in this simulation.

As stated above, the analysis results are intended to absorb the load (140 kN) with a deformation of not more than 40 mm. According to the results of the analysis, it is seen that the 140 kN load applied to New B Pillar is a value that can be met by New B Pillar. As a result of the analysis, the tensile value is 819.9 MPa. When this value is compared with the values obtained with CES Edupack program (DP1000 table), it is determined that New B Pillar can easily absorb the incoming load. The values in the table (DP1000 table) were placed on the hook curve and the analysis results were compared. In New B Pillar, it is determined that it can absorb the incoming load at 18,39 mm while rupture against incoming loads is not detected. This value is below the specified limit (40mm). In addition, it was determined that the deformation does not endanger the living space of the driver and passengers.

Figure 13. Ansys solution of New B pillar (Ansys, 19.2)

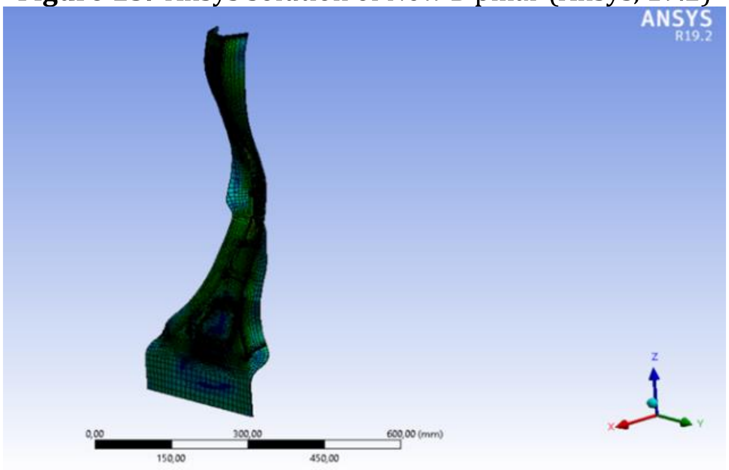


Figure 14. Element stress of new B pillar (Ansys, 19.2)

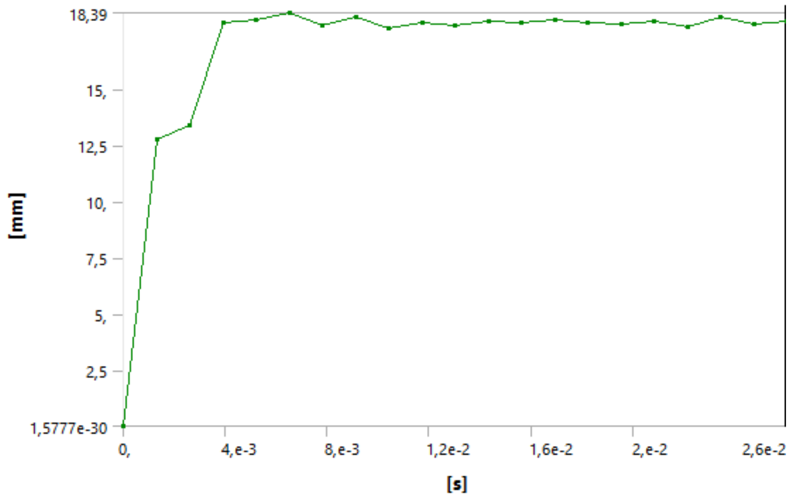
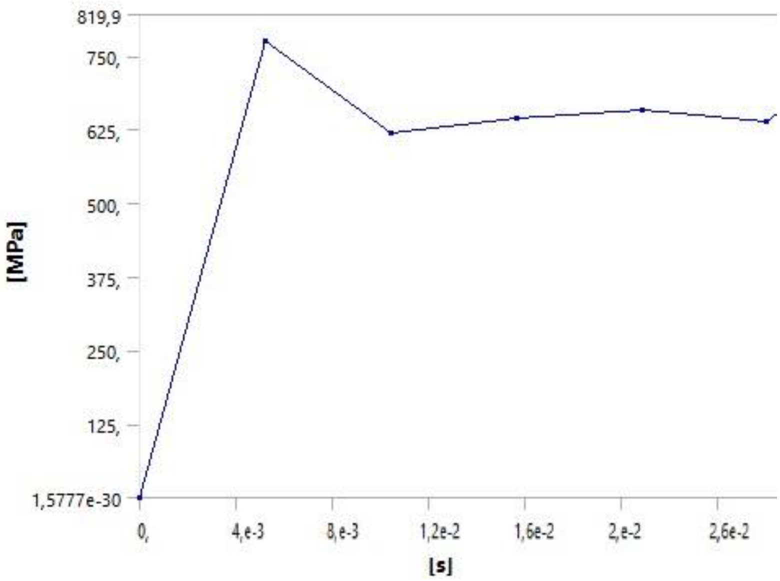


Figure 15. Maximum displacement of new B pillar (Ansys, 19.2)



4. Conclusion

In this article, all the simulations used in B Pillar analysis and their positive or negative effects on the development of B Pillar are tried to be shown by using simulation program.

Companies are trying to do their best to develop B Pillar according to their means. For this, they turn to different materials and create new designs. While there are many automobile, truck and bus factories in the world, it is normal to carry out analysis on vehicle chassis parts and B Pillar. The simulations give good results to manufacturers and have a positive impact on both security and profit. In this context, two different B Pillar were analyzed. The first values and results could not be obtained. This meant developing something new and it was worked on. Modifications were made in the second design. Material selection not changed. As a result of the second simulations, less stress value, better absorbance value, better safety values were obtained. These improvements always have to continue. Because our main subject is human life.

The change in design not only caused the visible part of the vehicle, but also changed the frame and crossmember parts of the vehicle. Chassis, sleeper and body parts, which were produced with limited opportunities in the past and which are very difficult to produce, can be produced very easily with today's technology. As it is seen in the B Pillars that we analyzed, B Pillar 1 have been used in old model vehicles for a long time.

According to the analysis, the thickness (2mm) was kept constant in the B Pillar 1, while the vehicle weight was improved by using different thickness values in today's B Pillar (1,25-2,0). Although the decrease in thickness seems to be a negative situation, it has been found that it can absorb the loads (140kN) coming to the vehicle in the desired manner by giving the correct thicknesses at the right places. It was obtained as a result of the analysis that B Pillar 1 can cause undesired results by showing a big stress of 1463.8 MPa in response to the incoming load, but New B Pillar will provide the desired results with this value such as 819.9 MPa. It was found that it can absorb the load at 18,39 mm in today's B Pillar while it shows fragment break in B Pillar 1.

References

Akay, K. S. (2005). Investigation of the physical properties of dual phase steels using in the automotive industry. *Uludağ University Instıtute of Science*.

ANSYS Meshing Advanced Techniques. (2017). *PADT Lunch & Learn Series.*

Ansys workbench student version 19.2.

Arcelor Mittal. Dual Phase Steels. https://automotive.arcelormittal.com/products/flat/first_gen_AHSS/DP.

Ariffin, A. H. Solah, M. S. Azhar, H. Isa, M. Hafzi, M. Rahman, M. K. & Anwar, K. (2014). Development of mobile deformable barrier for side impact crashworthiness evaluation in ASEAN new car assessment programme. *Applied Mechanics and Materials, Trans Tech Publications*, **663**, 562-566.

Armenàkas, A, E. Advanced mechanics of materials and applied elasticity. (2016). *CRC Press Taylor & Francis Group.*

Ashby, M. Melia, H. Figuerola, M. Philips, L. Gorse, S. The CES EduPack materials science and engineering package. (2018).

Aşkar, M, T. Automobile front bumper optimization with computer aided collision analysis. (2018). *Master Thesis SAÜ, Instıtute of Science. Department of Automotive Engineering.*

Başer, A, T. Aluminum alloys and their use in automobile industry. (2013). *Engineer and Machinery Magazine*. **635**. 51-58.

Başkara, T. Çimendağ, M. Crash tests and simulations. (2018). *Undergraduate Thesis PAÜ. Faculty of Technology. Department of Automotive Engineering.*

Bourgoyne Jr, A, T. Millheim, K, K. Chenevert, M. E. Young Jr, F. S. Applied drilling engineering. (1986). *Society of Petroleum Engineers.*

Capecchi, D. Ruta, G. Strength of materials and theory of elasticity in 19th century Italy. (2015). *Springer International Publishing*.

Carney, D. (2012). http://www.popularmechanics.com/cars/a8070/the-new-crash-test-that-will-chang-your-next-car11980742/.

CES edupack student version 2018.

Czernia, D. (2018). https://www.omnicalculator.com/physics/car-crash-force

Dassault systemes solidworks 2018.

Hooke, R. Papin, G, T, D. Sturmy, S. Young, J. Lectures de potentia restitutiva or of spring explaining the power of springing bodies. (1978). *London Printed for John Martyn Printer to the Royal Society.*

Ikpe, A, E. Orhorhoro, E, K. Gobir, A. Design and reinforcement of a b-pillar for occupants safety in conventional vehicle applications. (2017). *International Journal of Mathematical, Engineering and Management Sciences*. **2**. 37-52.

Kajtaz, M. (2019) Unconstrained shape optimisation of a lightweight side door reinforcing crossbar for passenger vehicles using a comparative evaluation method. *Int. Journal of Automotive Technology*, **20**. 157-168.

Kirchoff Automotive. (2020). https://www.kirchhoff-automotive.com/products/cars/b-pillar

Mantovani, J. (2020). https://studentcommunity.ansys.com/thread/what-is-the-source-of-mesh-quality-spectrum/

Nano Steel. (2018). https://nanosteelco.com/markets/automotive/high-strength-lightweight-b-pillars/

Ovalı, İ. Esen, C. (2018). *Ansys Workbench.* Kodlab Yayınevi.

Öztürk Yılmaz, İ. Bilici, A, Y. Aydın, H. (2017). Otomotiv sektöründe kullanılan farklı ultra yüksek mukavemetli çelik sacların elektrik direnç punta kaynağı. Beyçelik Gestamp Kalıp ve Oto Yan Sanayi, Uludağ Üniversitesi VI. Bilgilendirme ve Ar-Ge Günleri. DOI: 10.13140/RG.2.2.31786.72642

Shigley, J, E. Mischke, C, R. Budynas, R, G. (2015). *Mechanical engineering design*. McGraw-Hill.

Insurance Institute for Highway Safety. (2019). Status Report.

Tasan, C.C. Diehl, M. Yan, D. Bechtold, M. Roters, F. Schemmann, L. Zheng, C. Peranio, N. Ponge, D. Koyama, M. Tsuzaki, K. Raabe, D. (2015). An overview of dual phase steels: advances in microstructure-oriented processing and micromechanically guided design. *Annual Review of Materials Research.* 45. 391-431.

Thomas, A. Jund, M. Thomas, K, W. (2009). *Collision repair and refinishing: a foundation course for technicians*. Delmar Cengage Learning.

Tizzard, A. (1994). *An introduction to computer-aided engineering*. McGraw-Hill.

TÜBİTAK. (2008). Otomotiv endüstrisi ve çelik: yeni nesil çelikler.

What is von Mises (2018). https://www.simscale.com/docs/simwiki/fea-finite-element-analysis/what-is-von-mises-stress/

Wieczorek, P. (2018) Materials for Erasmus plus students of the subject: Design and selection of the materials. Czestochowa University of Technology.

Xue, X. Pereira, A, J, P. Amorim, J, M. Liao, J. (2017). Effects of pulsed Nd:YAG laser welding parameters on penetration and microstructure characterization of a DP1000 steel butt joint. *MDPI Metals*. 7. 1-18.