

INVESTIGATION OF INFLUENCE REINFORCEMENTS IN CIRCUMSTANCES WHEN THE ASYMMETRIC LOAD ACTING ON GIRDER

ИССЛЕДОВАНИЕ ВЛИЯНИЯ УКРЕПЛЕНИЯ В УСЛОВИЯХ АСИММЕТРИЧНОЙ НАГРУЗКИ НА БАЛКУ

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Abstract: This paper presents an overview of materials used in the automotive industry for production of reinforcements to increase the rigidity of supporting structure. Also, in this paper influence of plastic mass on increase of structure stiffness without changes of shape of structure was considered. Shown is one solution for a critical car body joint. Plastic support was placed in junction of longitudinal and transversal girder of construction. Girders are thinwalled and with complex cross-section, and support is made of sheet and plastic mass BETACORE 5207. The effects of testing in circumstances when the asymmetric load acting on girder were shown. Numerical modeling was also done with finite elements method besides the experimental tests. We used a software package PAK. At the end of the paper points out the sources of errors of measurement in this method.

KEYWORDS: THINWALLED GIRDER, REINFORCEMENT, FINITE ELEMENT METHOD

1. Introduction

Car body involves cca 25% of motorcar price and an average share of car body into total motorcar weight is cca 32%. Body passenger car as the supporting structure, is one of the most important elements for its good functioning [1,2]. Car body as a supporting system primary task is to unite and connect all systems and assemblies into one unit, at exactly the specified distance in order to allow undisturbed work, and to receive and transmit all the loads that act on the car during its exploitation.

Bodywork passenger vehicle consists three basic parts: offenses accommodation propulsion aggregates, offenses accommodation passengers and offenses accommodation luggage. Appropriate researches and testing showed that aspect passive security part for accommodation passengers should ideally, represent coarse connection has considerably larger resistance remained two parts car. Front and rear part of car body, opposite middle part, should be deformation order its deforming when crash stifles entire kinetic energy thus protect middle part.

This so-called principle of differential strength in the construction of body patented by the company Daimler Benz, and applies to all manufacturers. The concept of passenger cars with deformability exposed parts of the body and solid passenger space travel is constantly improving.

Car body should provide protection in collisions from all directions. Much more likely is that the serious side collisions, rather than frontal, cause a breach of security cages, and entry into the passenger space. Rigid structure of the cabin has reinforced columns and transversal reinforcement elements of the roof. For protection against side impact side floor longitudinal beams are made of steel increased strength in the floor transverse elements are set to strengthen, while the doors are added protective tubes. To achieve longitudinal deformations carriers are making work that uses the kinetic energy of motion of the entire mass of the vehicle. Ideally, the side supports are very deformations. Therefore, the deformation work is realized on even side-mounted longitudinal deformation carriers.

The roof of passenger cars should be firm enough to receive for any vertical load in the event of vehicle rollover. Roof rigidity is achieved by using additional elements.

Modern motorcars are made of various material and semi finished products. Other material more and more replaces traditionally used material such as steel and cast iron. The body is a system that has undergone major changes (in the field of construction in the area of applied material).

Lighter material such as steel of higher strength, sandwich steel, aluminum steel, Mg alloys, Ti and its alloys, polymers etc. are used for car bodies. Depending on prevailed material, there are more types of car body structure: steel, Al marginal, steel marginal, car body made of more material, magnesium car body etc.

There is a clear trend to greater use of higher strength steels, especially the type of dual phase bakehardening for structural parts and ultra high strength steel for safety components in the examination of the impact. Figure 1 shows the trends in materials used for car body.

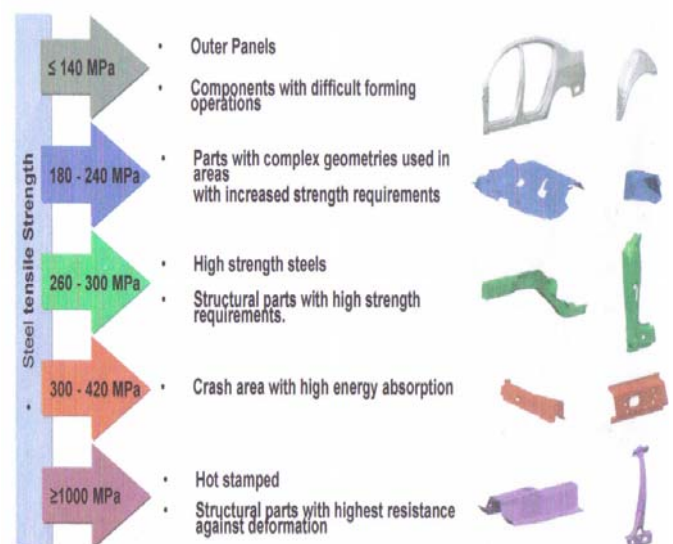


Figure 1. The trends in materials used for car body.

Figure 2 shows the reinforcement of many modern cars.

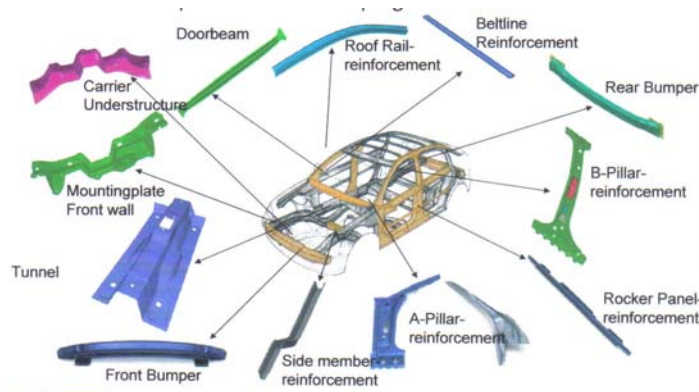


Figure 2. Various positions reinforced

Sheets increased strength is commonly used for various parts bearing shells and structures as follows: longitudinal and cross-carrier shells, door pillars, partitions, cap suspension, and suspension components, support of engines and so on.

2. Description car body joints and method of implementation

Automobile body structure is made of thin sheet metal stampings very various shapes and sizes. The main elements of the supporting structures are thin-walled beams with non uniform section, such as roof rails and rockers, lateral longitudinal floor beams, pillars, etc.. B pillar (center pillar) is one of the most important elements supporting body structure which has a large influence on the static and dynamic characteristics of the vehicle. Car bodies joints compounds are shown in Figure 3 Applicable regulations require the application of new materials to strengthen and increase the stiffness, in order to improve the supporting structure of the existing models of vehicles already in production. Reconstruction should be conducted with as little intervention in the serial sections. One way is to implement a new generation of plastic in order to increase the rigidity of sensitive circuits without changing stampings. For the analysis of the selected combination of pillar B, and lateral longitudinal supports, as a compound responsible for the behavior of the body in a side impact. Strengthening circuit is realized using special plastics Betacam 5207 to increase rigidity. This plastic mass is inserted into the critical combination of car bodies to increase the stiffness of the joints. By increasing the stiffness of individual joints and increases the rigidity of the body as a whole.

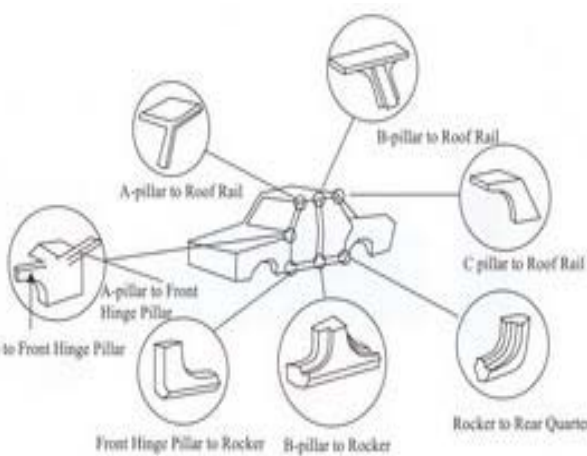


Figure 3. Car body joints

Detailed analysis and evaluation of increased stiffness of a critical car body joint using plastics was carried out based on the results of measuring behavior longitudinal suport for five different cases of loading (bending consoles, torsion consoles, bending beams,

bending and torsion the console, bending and torsion beams under action of side force) [3].

Study the impact of strengthening car body joint was carried out in static conditions, the symmetric and asymmetric loads. For the purposes of comparative analysis conducted three prototype circuit B pillar and the side longitudinal girder floor. Implemented structural changes had the task of strengthening car body joint fixtures in both the longitudinal and in transverse direction. In the modeling used different finite elements (beam superelement, shell and 3D).

In order to solve the presented critical car body joint- the joint of longitudinal side support and "B" beam, made a "T" the reinforcement has been done that is inserted into critical place (Fig. 4).



Figure 4. Reinforcement (with and without Betacor mass)

On the reinforcement of sheet metal, there is a Betacam mass that is fixed with screws and shaped at a temperature of 35°C. Material properties of mass 5207 Betacam company Gurit Essex are: modulus of elasticity $E = 400\text{N/mm}^2$ and Poasonov coefficient $n = 0.4$. Mass expansion during heating at a temperature of 150°C. In the case of analysis asymmetric load, shows the analysis of the effect of lateral forces acting on the girder. Concentrated force $F_x = 1000\text{N}$ acting perpendicular to the vertical girder (Figure 5).



Figure 5. Measurement point

The static analysis and determination of stress and deformation fields were made using program package PAK [4, 5, 6]. At testing on bending and torsion by side force, the model having inserted reinforcement is modeled by four groups of super beamed elements. In longitudinal direction there are twelve super beamed elements and in cross direction there are seven super beamed elements. Ten super beamed elements in longitudinal direction have twelve double junctions of 1D segment.

Two super beamed elements relating to longitudinal reinforcement are modeled by 506 segments of 2D and 639 junctions (figure 6). In cross direction six super beamed elements have ten double junctions of 1D segment. One super beamed element is added only in cross direction relating to reinforcement modeling (number 2D segments is 534 and number of junctions is 667 - figure 7). Two types of material are used: basic (steel) and Betacore 5207 mass. Displacement on the top of reinforced support is 2.559mm, meaning it is reached the reduce by 12.5% (figure 8). Stress reducing in girder joint is 25.2%. The maximal stress is on girder joint and it is 43.17N/mm² (Figure 9). Above analysis shows that inserting the "T" reinforcement in the critical combination of relief comes to design and reduce stress.

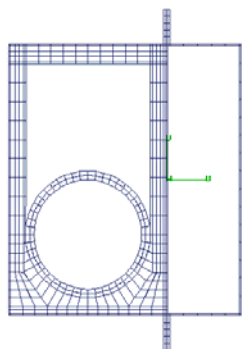


Figure 6. Finite elements net

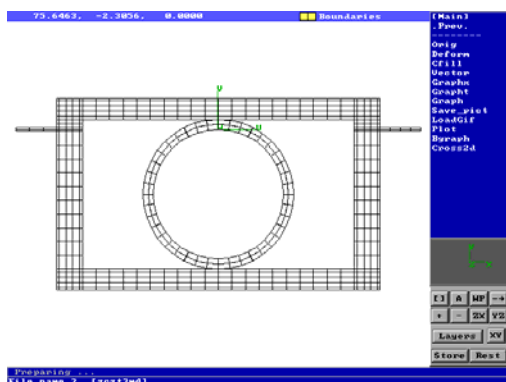


Figure 7. Finite elements net

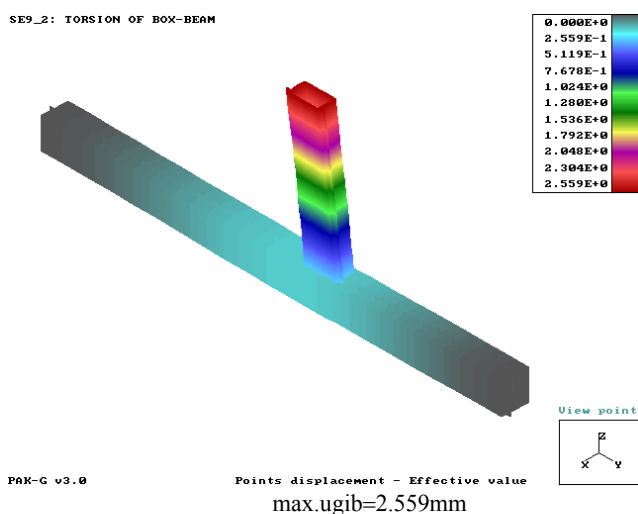


Figure 8. Field of displacement

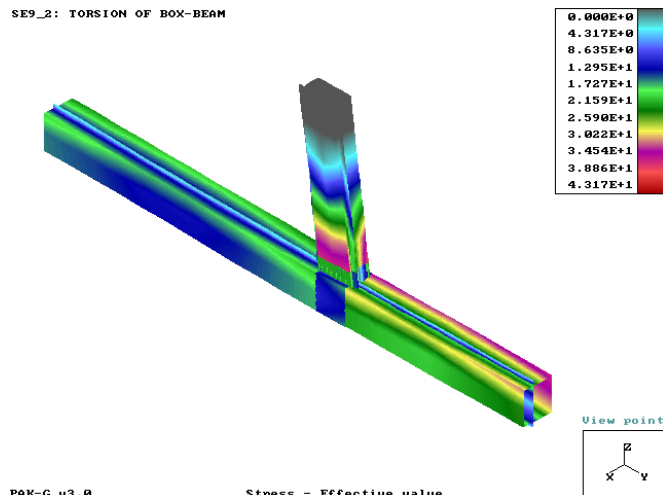


Figure 9. The field of effective stress

Table 1. Displacement - lateral force

Measurement point	displacement (mm)	PAK-numerical results for displacement (mm)
	F = 1000 N	F = 1000N
1(l=0)	0.00	0.00
2(l=170)	0.02	0.02193
3(l=340)	0.08	0.06979
4(l=510)	0.15	0.12815
5(l=680)	0.20	0.18154
6(l=850)	0.23	0.21452
20(l=970)	0.24	0.21757
7(l=1020)	0.23	0.21172
19(l=1070)	0.22	0.20364
8(l=1190)	0.19	0.16639
9(l=1360)	0.11	0.09713
10(l=1530)	0.04	0.03237
11(l=1700)	0.00	0.00

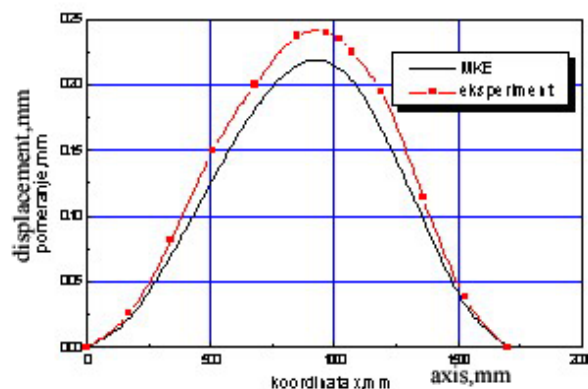


Figure 10. Numerical and experimental results (displacement - lateral force)

Numerical solution for bending of the beam loaded by side force of $F=1000$ N on the spot of longitudinal and cross joints is $u_x = 0.21172$ mm (measured 0.24 mm-table 1) meaning the deviation of 11.8% (figure 10).

The previous analysis shows that inserting "T"-reinforcement in joint of side member and crossmember reduce stress and unload the construction. Introducing reinforcement from pipes and plastic mass Gurit Essex increases stiffness of joint, which is the result of inserted mass hardening. Construction of circuit affects the bending and torsion stiffness characteristics of vehicles, as well as the oscillatory behavior of the entire body. Shows the way to improve the structural features of the body (stiffness and maximum stress). Comparative analysis of the stress and method of deformation fields supporting structure is noticed that the results of calculations show the same sensitive areas as well as the results of an experiment. At all measuring points is relatively deviation below the acceptable error of 25% and the results can be considered satisfactory. As a result of calculation obtained by the displacement and rotation of nodes. The integration points are obtained stress components and Mises's equivalent stress.

Sources of error in this method can be: error in idealization, some errors in the experiment, and others.

Errors in idealization are much more dangerous most especially that caused by the user. The errors in idealization can be classified: geometric errors, errors caused by material and boundary condition errors.

Geometric errors are: deviations of actual structure of the drawings, deviations thickness of sheet metal due to tolerance manufacture, collection sheet folds in pressing, dimensions of change for turning off the crop and their tolerance, radial surface of change due to increasing sheet after pressing, changes in cross-section because of overlapping sheets, and so on. By comparing the carrier section of mathematical model with the actual construction section, we see that are not described on the enclosed smaller round out on supports in aim to reduce the required number of input data.

Errors caused by material arising from: elasticity module variations due to tolerance of the chemical composition of materials, neglect of residual stress by deformation of material in the cold, changes in yield due to tolerances in content of carbon in the thermal processing and others. Materials for its characteristics and behavior more or less deviate from Hooke's law (for linear elastic material and isotropic). It is obvious (given the idealization of material behavior) that are already in the basic theory can not expect absolutely correct materials. The best possible materials have an error about 3%.

Errors in defining the boundary conditions are very important because it can significantly affect the results of calculation. Errors boundary conditions arising from neglect effects of compounds (spot welding). In simplified mathematical model that takes all welded rigid connection. In practice, the welding step is carried out from 50 to 70mm.

3. Conclusions

This paper presents the results of research to increase body rigidity of thin-walled carrier-standard and reinforced in the static loading conditions while not changing the existing structures. Based on the results and experience arising from this work can be done following conclusions:

- The body as a supporting structure of passenger cars is very important for the smooth functioning of the car. As one of the ways to solve problems of critical car body joints, and thus increasing the rigidity of the vehicle body as a whole, the implementation of the new generation of plastic with minimal changes to the construction.
- It is recommended the introduction of "T" reinforcement in the car body joint.
- It is known that the characteristic compounds of construction significantly affect the behavior itself and the whole car body as a whole. For these reasons, tends to be more adequately modeled the behavior car body connection. One of the reasons for the appearance of difference calculation and experiment is due to inadequate modeling of the zone circuit carrier.

4. Literature

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