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TRUCK SUPPORTIVE CHASSIS STRUCTURAL STATIC ANALYSIS

ABSTRACT: The vehicle chassis is a very important part of a vehicle system. During the vehicle projecting a lot of attention is devoted to the vehicle chassis, because it is exposed to strong statics and dynamics loads. In early projecting phases it is possible to get reliable information about the chassis material, dimensions and projecting solutions by static analysis. This paper presents a truck's supportive chassis structural static analysis of Mercedes Benz Ascot 2 truck. The paper also shows the comparison of static structural analysis and results of analytical calculation. The paper concludes with a discussion and guidelines for further work.

KEYWORDS: auxiliary chassis, frame, stress, strain

INTRODUCTION

Rapid growth of human population causes rapid development of transportation, as transportation of passengers and transportation of goods increases. Growth of human population cusses rapid development of transportation vehicles and it also cusses growth of their production. Growth of truck production raises questions of lowering their production costs.

One of the biggest challenges for companies today is certainly quick reaction to market demands. This is also a challenge for the truck industry. Significant lowering of expenses in product developing as well as in production is credited to computer and software development. Product development presents one of the main activities in the entire production process. Product development at the highest level of quality leads to large savings in production and exploitation.

One of the key parts of the truck is auxiliary chassis. Auxiliary chassis design must be according to the parameters of the technical requirements: material, outer overall dimensions, type of the steering unit, ergonomic and security requests, etc. Testing of prototypes can also be a problem, because the artificial conditions of testing cannot completely simulate real exploitation conditions. Those problems can be avoided by using modern software tools. By using this tools all the critical details are analysed carefully. Using of modern software tools can avoid almost every defect in the design phase.

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VEHICLE CHASSIS

The vehicle chassis is an assembly which is the main part which maintain stiffness of vehicles and enables mounting of other assemblies such as:

- powering unit,
- transmission,
- suspension,
- braking system,
- steering system and
- body.

Figure 1 presents a partially assembled vehicle chassis.

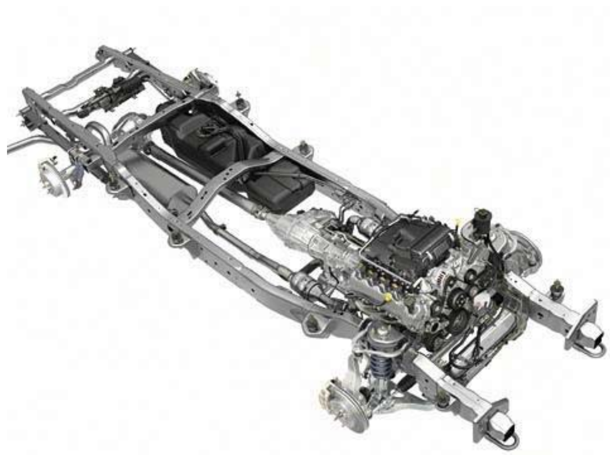

Figure 1 Vehicle chassis

According to type of vehicle, the chassis must be designed as light structure in order to maintain shape in exploitation conditions, [1]. The greatest load in exploitation conditions is from cargo mass, which is in the cargo box.

Shape of the chassis frame depends of its purpose. There is many chassis types used in practice. The most used types of the chassis are [1, 4]:

- Combined chassis,
- Platform chassis,
- Pipe chassis and,
- Length profiled chassis.

CALCULATION AND DESIGN OF TRUCK AUXILIARY CHASSIS

Truck auxiliary chassis is made from welded width and length profiles. Truck auxiliary cassis is bolted to the main chassis on the front and rear beam. Sides are connected to the main chassis with stirrups. Cross profiles are secured by perimeter trim. Figure 2 shows a technical drawing of the front and rear beam of the auxiliary chassis of the truck Mercedes Benz Ascot 2. The cargo box is mounted on this chassis.

Total mass of the truck is the greatest allowed mass, declared by the manufacturer. The greatest mass of the cargo is declared in order to avoid overloading any part or assembly of the vehicle under normal exploitation conditions, [6]. Total mass is mass of an empty truck plus the cargo mass.

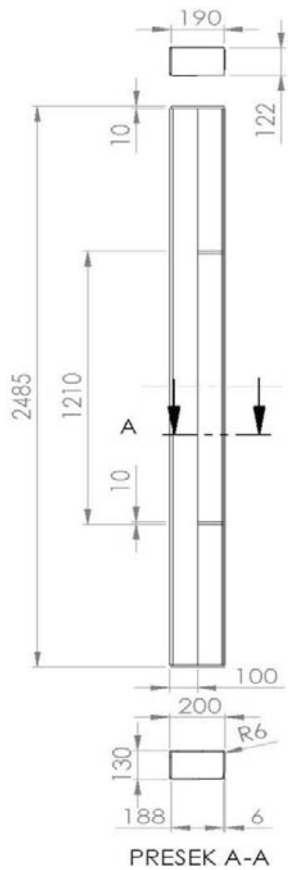

Figure 2 Rear and front beam

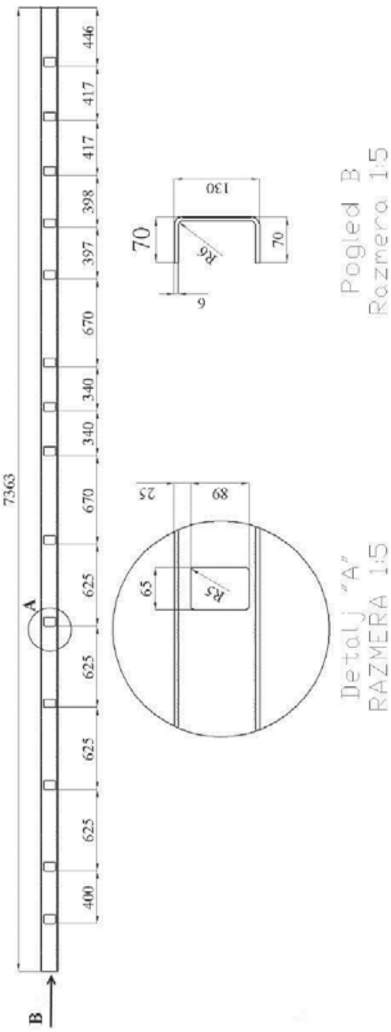

Figure 3 Cross profiles of the auxiliary chassis

Data of mass layout on the truck axes and maximum cargo mass for truck Mercedes Benz Ascot 2 2544L6x2 is taken from *TRAILE WIN* software.

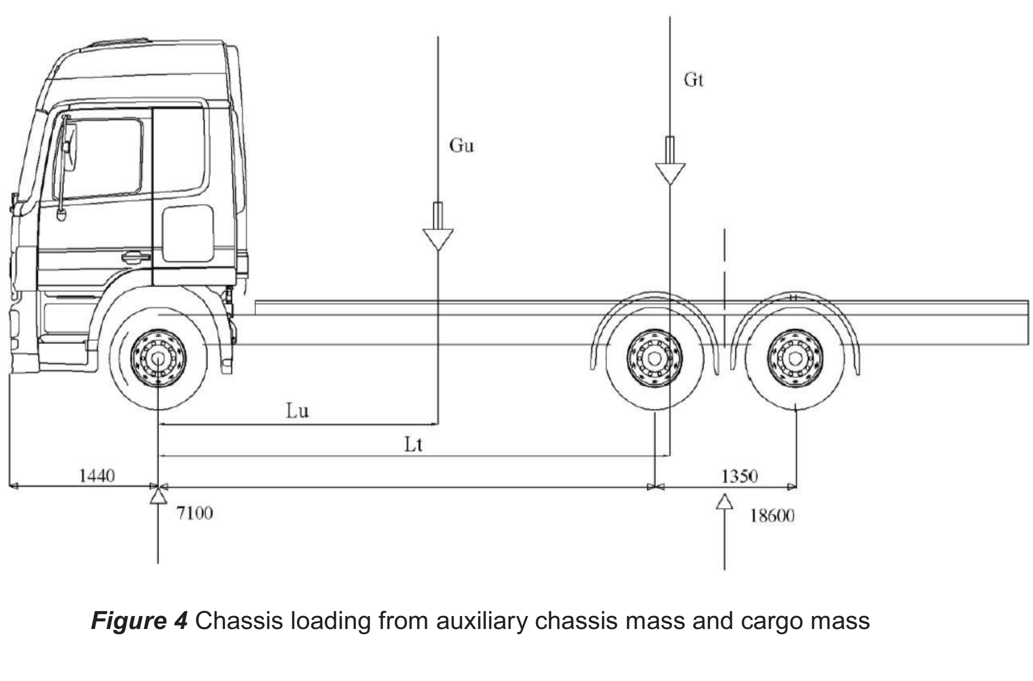

Figure 4 Chassis loading from auxiliary chassis mass and cargo mass

Mass of empty truck - front axis: m_p=5255 kg,
Mass of empty truck - rear axis: m_z=3305 kg,
Total mass of empty truck: m_u=8560 kg.

Based on this data as on distances presented on figure 4, maximum bending moment of main and auxiliary chassis can be calculated, [2].

Maximum bending stress of upper beam is:

$$\sigma_{max} = \frac{M}{I_x} \cdot y_{max} \tag{1}$$

where are I_x upper beam inertia moment of cross-section, and y_{max} largest distance from edge of cross section to neutral axis.

According to cross-section shown on figure 3, moment of inertia is calculated:

$$I_x = I_{1g} - I_{2g} = \frac{70 \cdot 130^3 - 64 \cdot 118^3}{12} = 4052996 \quad mm^4 \tag{2}$$

Farthest vertex from x-axis (Figure 3): y_{max}=65 mm.
Bending moment which loads auxiliary cassis,[2]: M=6045,512 Nm.
Based on this data, and using the expression (1), maximum bending moment of upper beam is calculated:

$$\sigma_{max} = 96{,}955 \quad MPa \tag{3}$$

which is less than the allowed beam bending stress(carbon structure steel S235 J2G3 1.0116 with yield stress R_{eH}=195 − 235 MPa), which is:

$$\sigma_{doz} = \frac{R_{eH}}{S} = \frac{235}{1{,}3} = 180{,}77 \quad MPa \tag{4}$$

That satisfies the condition: $\sigma_{doz} > \sigma_{max}$, which means that working stress is in allowable boundaries.

TRUCK AUXILIARY CHASSIS STRESS-STRAIN ANALYSIS

Software, Autodesk Inventor Professional 2014, has been used in purpose of analysing this model. Figure 5 presents a three-dimensional model of the analysed auxiliary chassis. Considering that the real chassis is made of cold rolled steel profiles, model is adapted to the original state. Namely, three-dimensional model is made of sheet metal components.

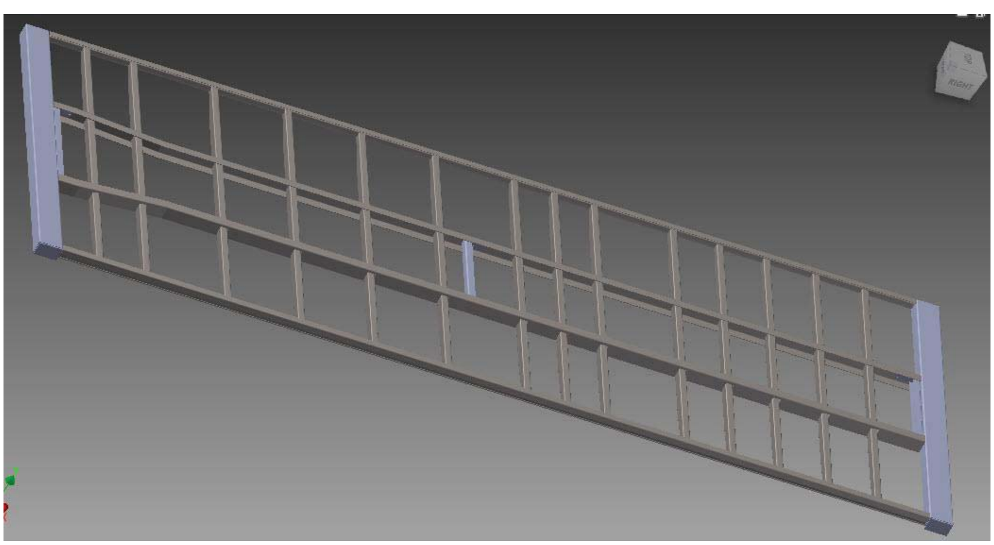

Figure 5 Three-dimensional CAD model of auxiliary chassis

Modelled auxiliary chassis of the truck Mercedes Bens Ascot 2 2544L 6x2, is loaded by mass of the cargo m_t=16440 kg. All data of the chassis has been taken from company ''Ema'' D.O.O Knić.

Basic idea of finite elements method is discretization of the physical model. That means breaking the structure into a finite number of elements of small dimensions. Space of continuum is breaking into mutually connected non overlapped geometric forms, elements. Those elements are called finite elements, [7]. Finite elements are mutually connected in characteristic points, nodes, in which figures finite number of calculation values.

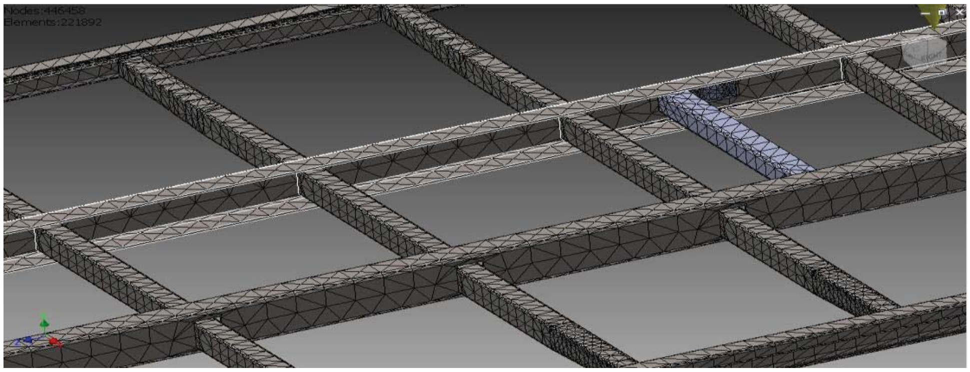

Figure 6 Finite elements mesh detail

In finite elements analysis, a problem is presented by a system of algebraic equations, which have to be solved, by direct or iterative method. By direct methods equations are solved using exact numerical techniques. Iterative methods are based on approximate techniques, where the iterations are repeated until their result is within acceptable error limits of tolerance [7].

By analysing the deformations it was concluded that the maximum displacement is 2,009 mm, and it occurs in the middle of the chassis (Figure 7).

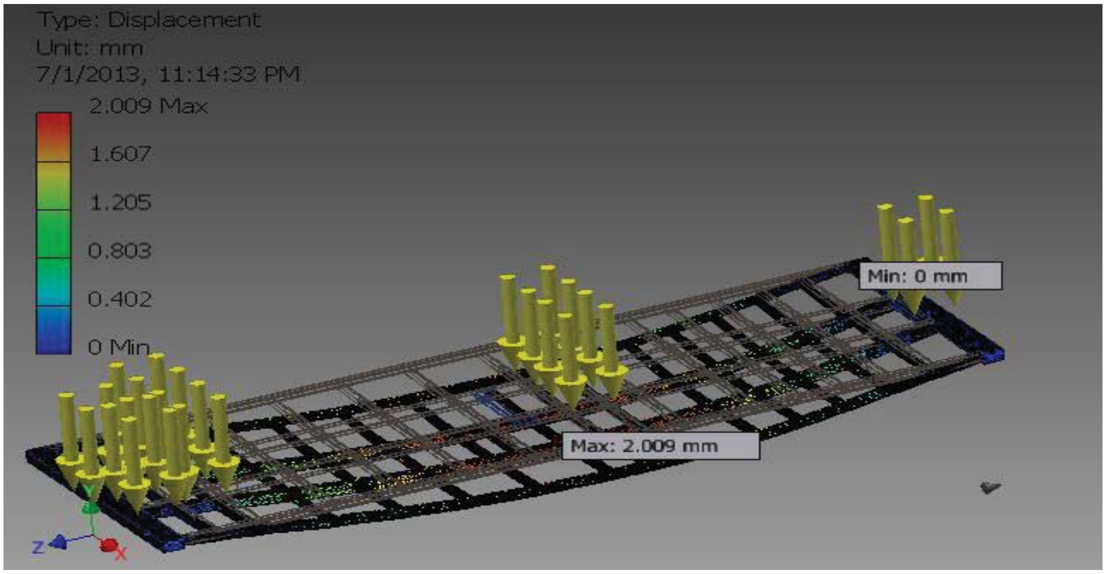

Figure 7 Deformation of truck auxiliary chassis, mm

Percentage difference between the maximum bending stress, which occurs in the analysed chassis, obtained analytically (96.955 MPa) and numerically (82.28 MPa) is 15.14%, which is quite a satisfactory agreement of results.

This difference in results occurs because of the simplification of the analytical method, and because of the selected size of finite elements in the numerical analysis.

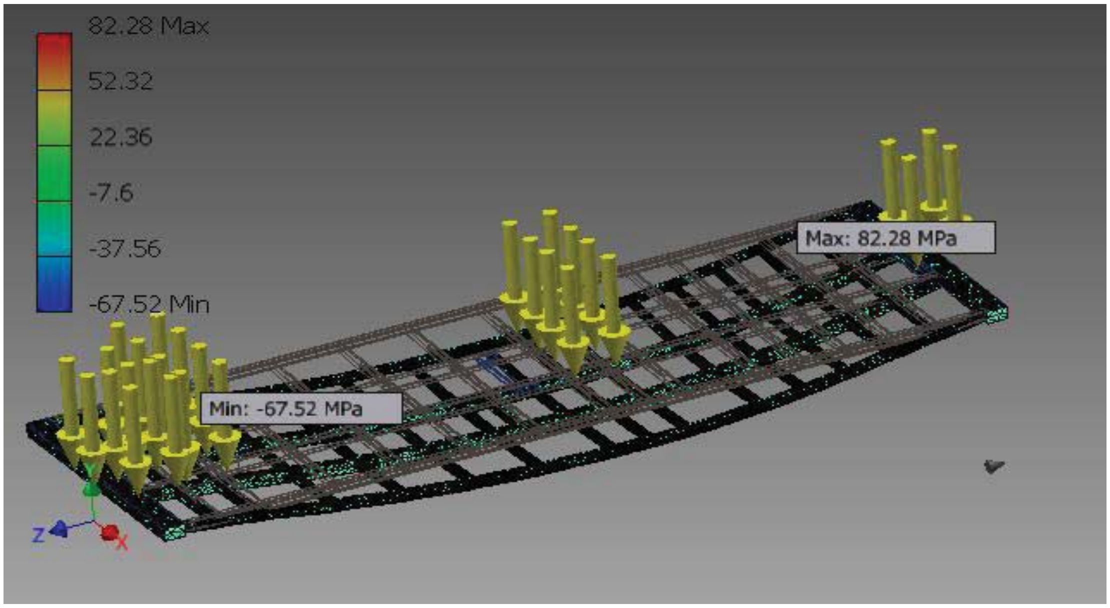

Figure 8 Bending stress of auxiliary chassis, MPa

CONCLUSIONS

Modern processes in designing auto industry parts are based on the application of computer technology, as well as their integration. Process of production and lowering costs is accelerated with automation and computers. Computers have enabled the automation of various processes which are significantly reduced errors, both in design and in production. Quality of product is raised and at the same time high flexibility of design and production is ensured.

Investigation of the static behaviour of truck chassis in the software package Autodesk Inventor had the main objective of determining the static stress analysis of the chassis and displacement, as well as comparisons with the deterministic calculation.

By analysing the calculation results, it was concluded that the greatest displacement is in the middle of the chassis and it is 2,009 mm.

The maximum values of bending stress of the chassis were determined by analytical and numerical methods. Stress, which is calculated by deterministic method is 46.37% less than allowed, while the stress is calculated by numerical method is 54.48% less than the allowable stress. The difference which is occurred in the usage of both methods is in an acceptable range.

Using numerical methods for the determination of stress and strain gives far more opportunities than deterministic methods. Implementation of numerical methods immediately provide amount of data of every wanted section. That in deterministic method is not possible. In deterministic method displacement must be calculated for every section separately. Both methods give satisfactory level of accuracy, but it is better to use numerical methods due to the larger range of results that they provide.

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