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NUMERICAL DYNAMIC ANALYSIS OF THE INFLUENCE OF THE SUPPORTS AND INTERCONNECTIONS OF FIRE ENGINE STRUCTURAL PARTS

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Abstract. Two superstructures are interconnected and mounted on the chassis of a fire engine. In this paper, the dynamic analysis of the behaviour of fire engine structural parts is presented. Calculations were done using the finite element method, Program package KOMIPS (author Prof. dr Taško Maneski). The models of two superstructures were done using beam and thin plate finite elements. For all variations of the stiffnesses of supports and interconnections, the dynamic behaviour was obtained. Eigen-frequencies were calculated and presented together with the appropriate amplitudes. Forced damped vibrations in frequent and time domains were calculated. Dynamic method in analysing is a very reliable method if the reconstruction of a structures is needed.

1. Introduction

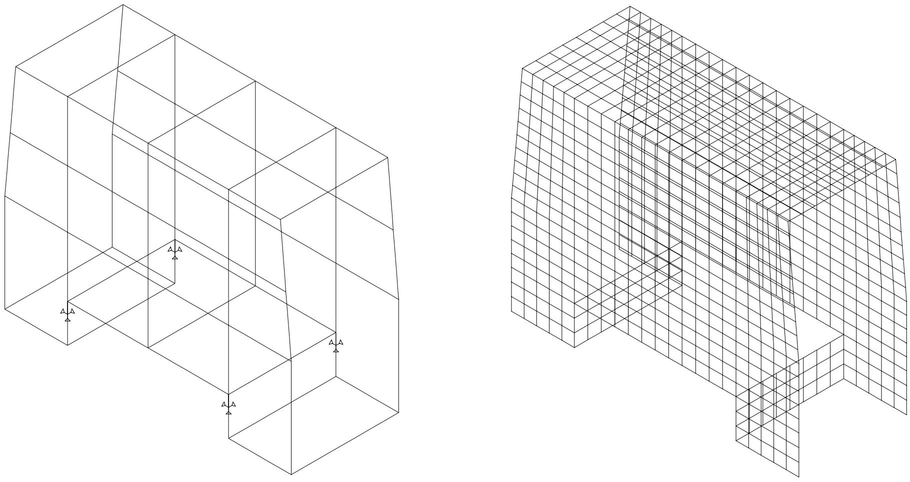
Dynamic analysis presented in paper was done for two aluminium superstructures mounted on the chassis of a fire engine by using finite element method. The models were created using beam finite elements and thin plate finite elements. The stiffness of the supports variated from 10 dN/mm to 100 dN/mm. Eigen frequencies were obtained in all cases of the supports. For any calculated mode of oscillation, appropriate amplitude field and the distribution of the difference between potential and kinetic energy was calculated and presented.

2. Numerical analysis

2.1. First type of aluminium-superstructure

First type of superstructure for the fire engine was modeled with 1050 nodal points, 450 beam and 944 plate finite elements. Material of all elements was aluminium with module of elasticity of 10^5 N/mm^2, Poisson's ratio of 0.3 and density of 2.7 10^{-6} N/mm^3. Cross-sections of beam elements mostly were boxes dimensions 80×40×4 mm and 40×40×4 mm and L 50×40×4 mm. The thickness of the plates was 3 mm.

The model for calculation of the consisted superstructure is presented in Figure 1. Beam finite elements and thin plate finite elements were presented separately.

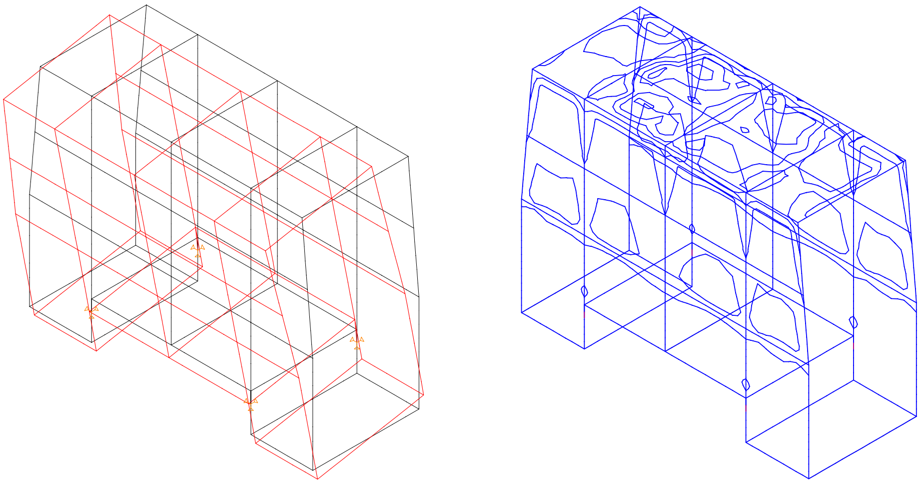


a) Beam finite elements with supports

b) Plate finite elements

Figure 1. Model of the first type of aluminium-superstructure of fire engine

The stiffness of the supports were varied from 10 dN/mm to 100 dN/mm and appropriate eigen-frequencies and the distribution of the difference between potential and kinetic energy were calculated and presented in next figures.



Amplitude field

Distribution of of the difference between potential and kinetic energy

Figure 2. First mode of oscillation

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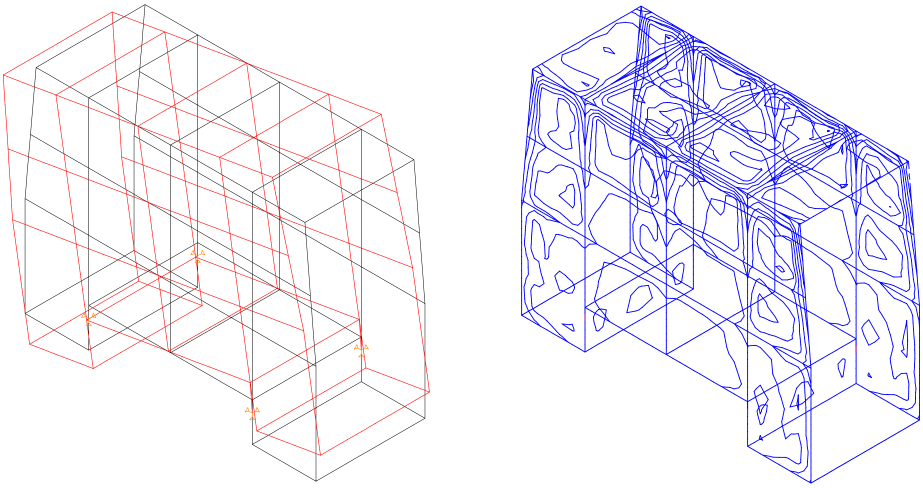

Amplitude field

Distribution of of the difference between potential and kinetic energy

Figure 3. Second mode of oscillation

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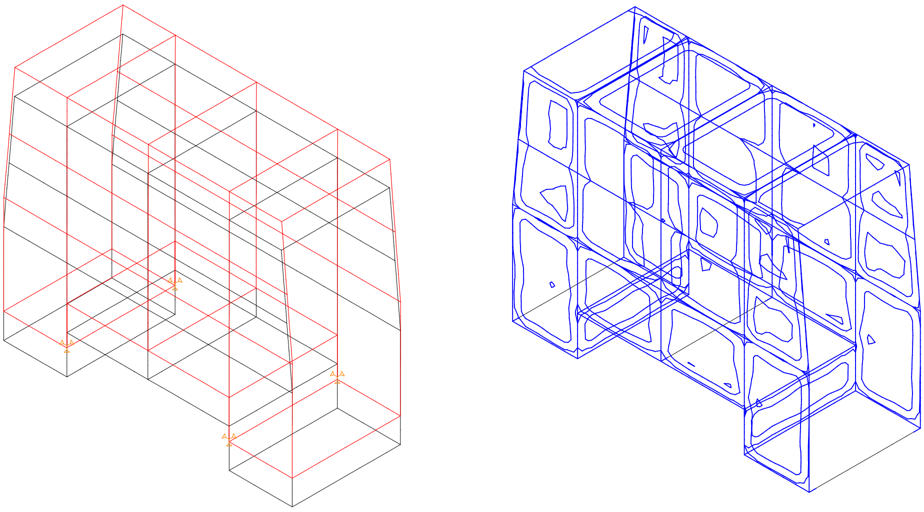


Amplitude field

Distribution of of the difference between potential and kinetic energy

Figure 4. Third mode of oscillation

For all values of the support stiffnesses maximal value of the amplitude in the first mode of oscillation is about 0.118 mm, in second mode about 0.121 mm and in third 0.08 mm.

Variation of the frequencies as a function of the support stiffnesses is presented in diagram from figure 5.

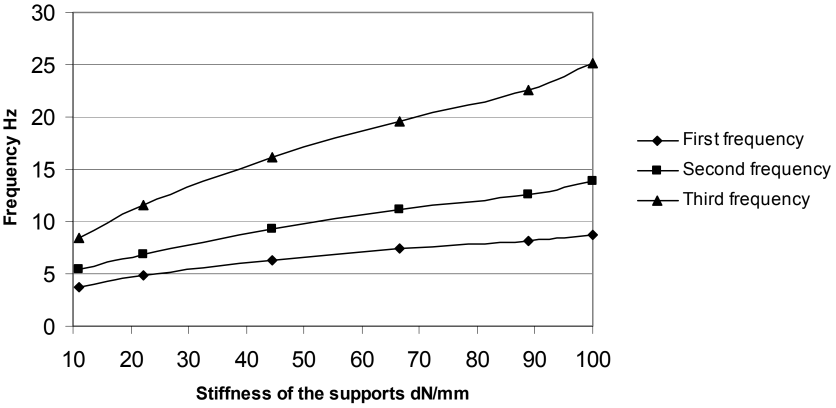
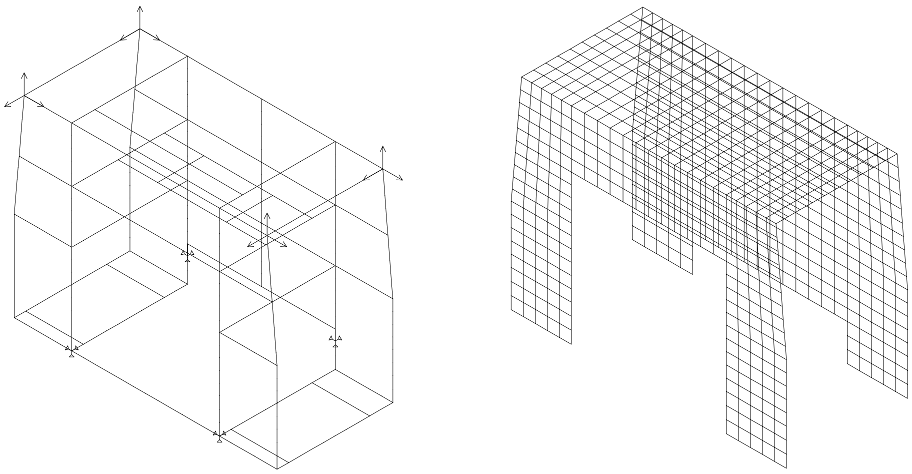


Figure 5. Frequency as a function of support stiffness

2.2. Second type of aluminium-superstructure

Second type of considered superstructure for the fire engine was modeled with 1034 nodal points, 509 beam and 820 plate finite elements. Material of all elements was alumunium with module of elasticity of 10^5 N/mm^2, Poisson's ratio of 0.3 and density of 2.7 10^{-6} N/mm^3. Beam finite elements had four cases of cross-sections, mostly boxes dimensions 80×40×4 mm and 40×40×4 mm. The thickness of the plates was 2 mm.



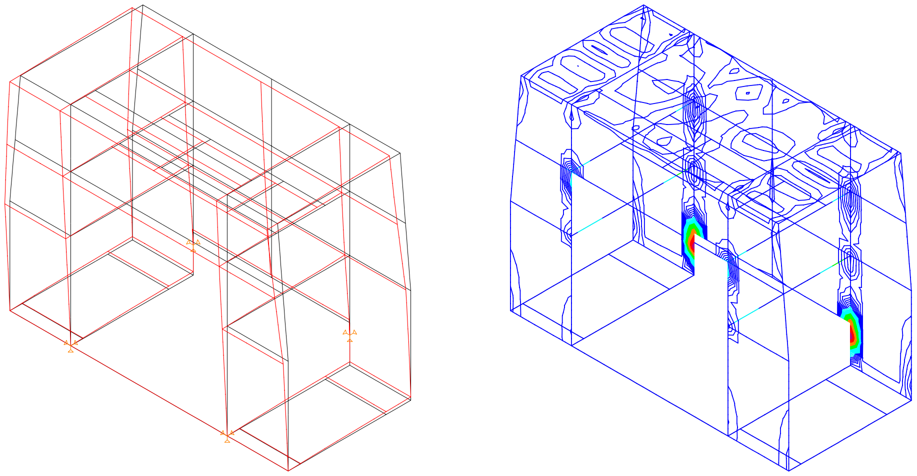
a) Beam finite elements with supports

b) Plate finite elements

Figure 6. Model of the second type of superstructure of fire engine

The model of the superstructure is presented in Figure 6. The beam elements with supports and masses are shown on the figure 6a and the plate finite elements on the figure 6b.
In four nodal points compulsive masses of 100 kg are placed in all three directions.

The stiffness of the supports were varied from 10 dN/mm to 100 dN/mm and calculated frequencies and the distribution of the difference of potential and kinetic energy were presented in figures 7, 8 and 9 for first three modes.



Amplitude field

Distribution of of the difference of potential and kinetic energy

Figure 7. First mode of oscillation

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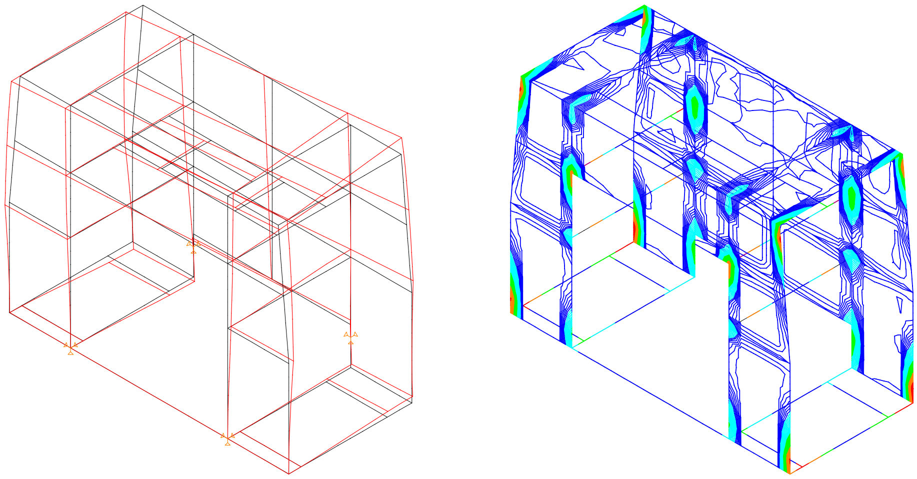

Amplitude field

Distribution of of the difference of potential and kinetic energy

Figure 8. Second mode of oscillation

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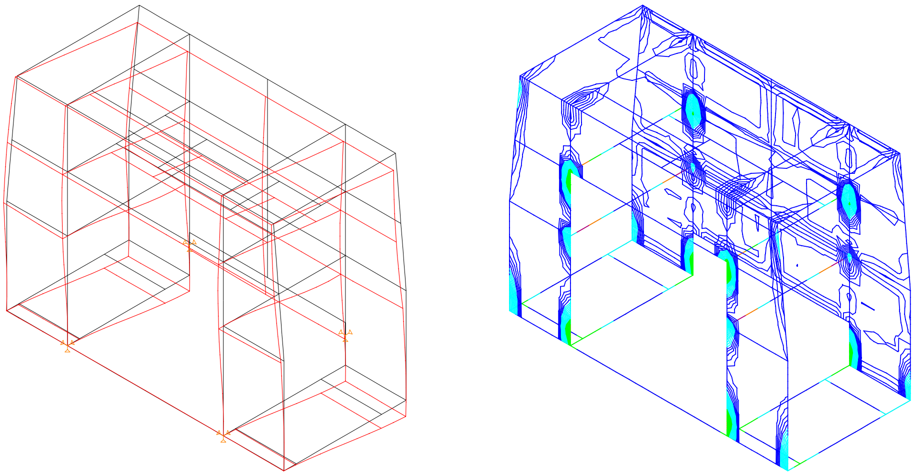

Amplitude field

Distribution of of the difference of
potential and kinetic energy

Figure 9. Third mode of oscillation

As it is presented on diagram from figure 10, first frequencies are almost constant in all cases of the supports stiffnesses but their values are too small, from 1.7 Hz to 2 Hz. Third frequency increases with the stiffness, from 7 to 14 Hz.

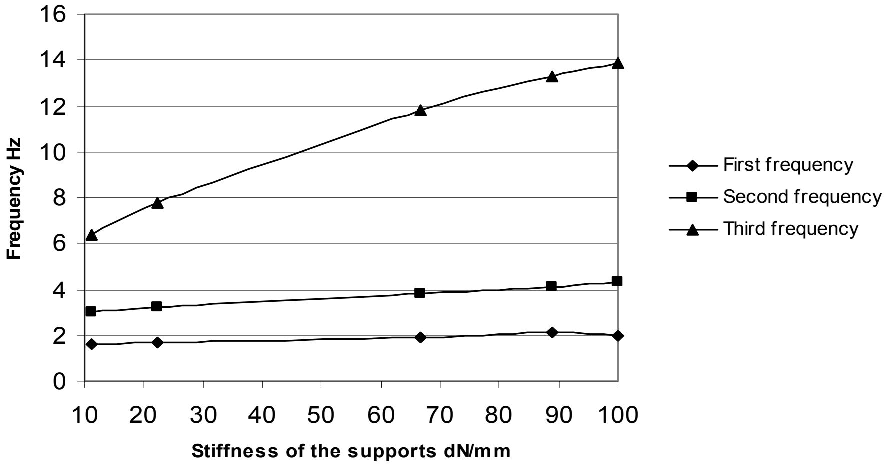

Figure 10. Frequency as a function of support stiffness

3. Conclusion

Two aluminium-superstructures are interconnected and mounted on the chassis of a fire engine. Dynamic calculations were done for both cases using the finite element method, Program package KOMIPS. The models of superstructures were done using beam and thin plate finite elements. For variations of the stiffnesses of supports from 10 dN/mm to 100 dN/mm, the dynamic behaviour was obtained. Eigen-frequences were calculated and presented together with the appropriate amplitudes and the distribution of the difference of potential and kinetic energy .

In the first case of the superstructure all eigen-frequencies increase with the support stiffness. The values of the appropriate amplitudes are satisfied. But, in the second case of the construction first and second frequencies are too law and they are almost independent of the support stiffness. Distribution of the difference of potential and kinetic energy presents critical places in the construction. So, the dynamic behaviour of this type of the superstructure is not satisfied and some interconnections have to be involved. Dynamic method in analysing is a very reliable method which is indicated the requirement of the reconstruction of a structures.

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