Stress and Deformation Analysis of Portable Bridge

F. Trebuňa, F. Šimčák, J. Bocko[a], M. Pástor, P. Lengvarský

Technical University of Košice, Faculty of Mechanical Engineering, Department of Applied Mechanics and Mechanical Engineering, Letná 9, 042 00 Košice, Slovakia
[a]jozef.bocko@tuke.sk

Abstract: The paper is devoted to description of strength analysis of bridge structure. Two models of bridges were assessed – original bridge with width 3040 mm and modified structure with functional width 3260 mm. The structure of the bridge is portable, positioned on truck. The bridge can be folded and positioned for passing of belt carriages and wheeled cars. The stresses and deformations in both structures were determined for basic as well as combined loadings. The bridge structures fulfill all demands from the point of view of deformations and strength.

Keywords: supporting bridge structure, pass of vehicles, finite element method, stress analysis.

1 Introduction

Portable steel bridge structure is used for preparation of ways for vehicles during floods, damages of old bridges or badly crossing ditches. They are used especially in situations where it is not economical to build new compact bridge and they are used mainly by military forces (Fig. 1).

Fig. 1: Portable bridge.

The authors analyzed stress state of original bridge structure with the width 3040 mm and modified supporting structure with width 3260 mm. The aim was to check original structure and to modify it in order to allow its folding and passing belt and wheeled carriages [1-5].

2 Analysis of the bridge

The analysis was accomplished for loading due to self-loading, transverse loading due to weight of vehicle, with the predefined parameters of axle bases. The analysis comprises also quasi-static loading due to acceleration or braking. The number of carriage crossings through the bridge were considered, too. The bridge will be loaded by vehicles with the following parameters:

- maximal allowed velocity of belt carriage – 20 km/h,
- maximal allowed velocity of wheeled vehicle – 40 km/h,
- acceleration of belt carriage 0-32 km/h – 10 s.

The contact of belt carriage with bridge is shown in Fig. 2, total mass is 50 000 kg, length of undercarriage 6 900 mm, width without boundaries 3 400 mm, distance between belts 2 790 mm and belt width 580 mm.

The whole mass of whole equipment is 29 500 kg; the mass without bulldozer equipment is 28 200 kg. In Fig. 3 are given positions and dimensions of contact forces of vehicles with the bridge.

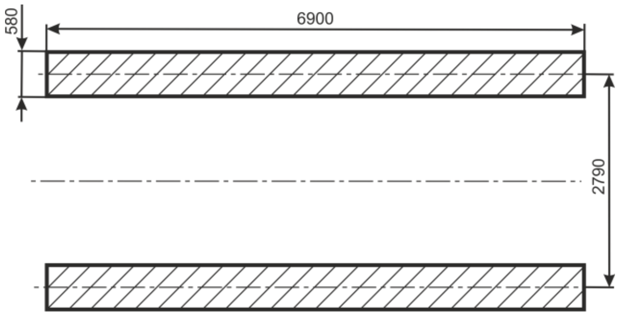


Fig. 2: Geometry and dimensions of contact surfaces of belt carriage with the bridge.

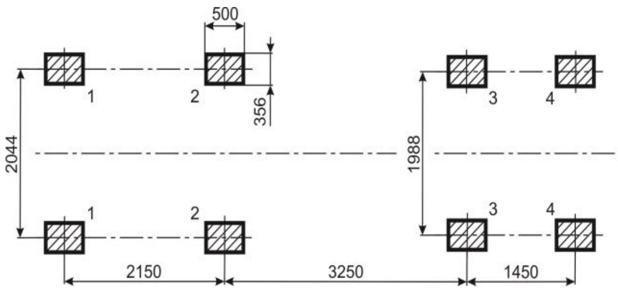


Fig. 3: Contact surfaces of wheeled car with the bridge.

In order to compute stress and deformation fields in original and new proposed bridge structures there was necessary to mesh the model of supporting structure. The computation was realized for both vertical as well as horizontal loading and the forces corresponds to loading by tank or truck. From the analysis of internal force quantities results that the highest loading due to bending moment arises in case if the tank or truck are positioned in the middle of the bridge, but the horizontal loading lead to higher stresses if the tank and truck are positioned on the boundary of bridge.

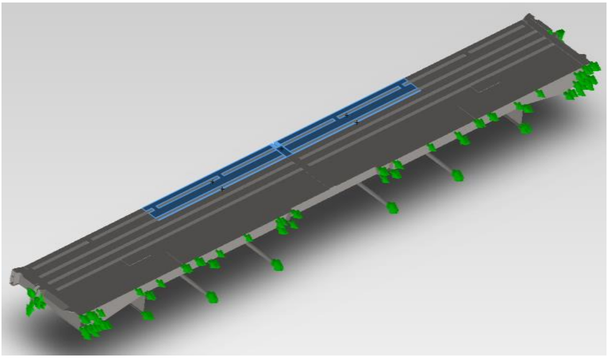


Fig. 4: Boundary conditions for vertical and horizontal loading for position of tank in the middle of the bridge.

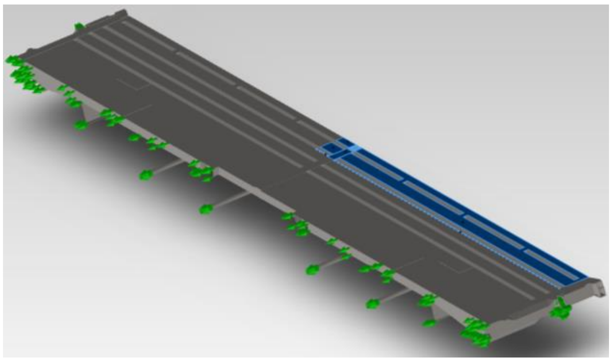


Fig. 5: Boundary conditions for vertical and horizontal loading for position of tank on the boundary of the bridge.

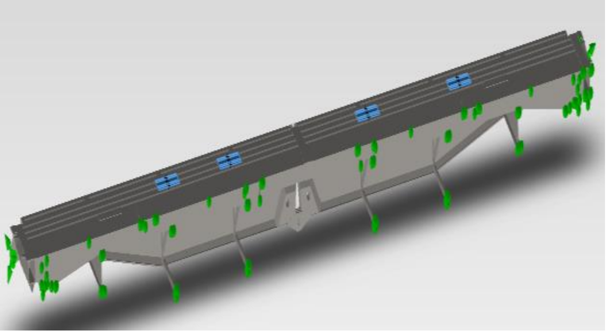


Fig. 6: Boundary conditions for vertical and horizontal loading for position of truck in the middle of the bridge.

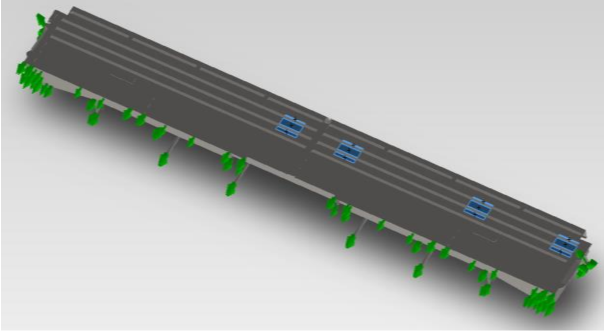


Fig. 7: Boundary conditions for vertical and horizontal loading for position of truck on the boundary of the bridge.

2.1 Stress fields due to combined loading by self-weight of the bridge, loading by tank in horizontal and vertical direction in the middle of the bridge

The original structure of the bridge was loaded by self-weight of bridge, weight of tank including dynamic loadings in horizontal and vertical directions. The boundary conditions for loading of bridge structure are obvious from Fig. 4. In Fig. 8 and Fig. 9 are given fields of equivalent stresses and displacements of individual points of structure, respectively, due to loading by weight of tank.

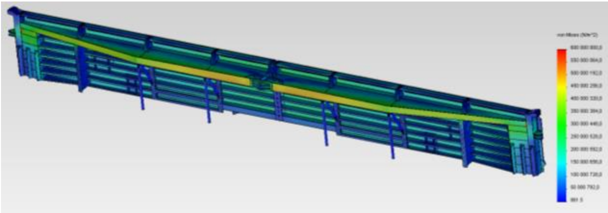


Fig. 8: Field of equivalent stresses for combined loading.

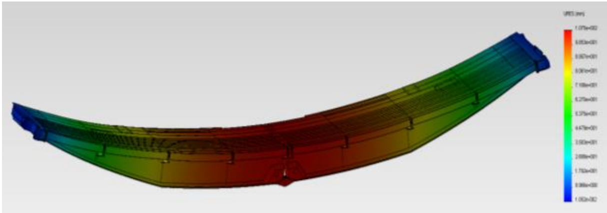


Fig. 9: Displacements of points of structure for combined loading.

New supporting structure of the bridge was in this case loaded by self-weight of bridge, weight of tank including dynamic loadings in horizontal and vertical directions. The boundary conditions for loading of bridge structure are given in Fig. 4. In Fig. 10 and Fig. 11 are given fields of equivalent stresses and displacements of individual points of structure, respectively, due to loading by weight of tank.

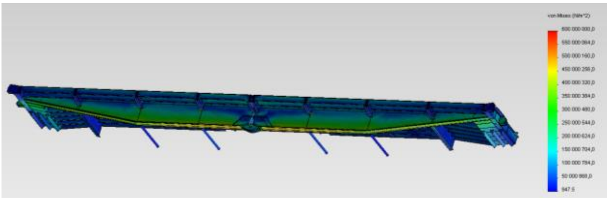


Fig. 10: Field of equivalent stresses for combined loading.

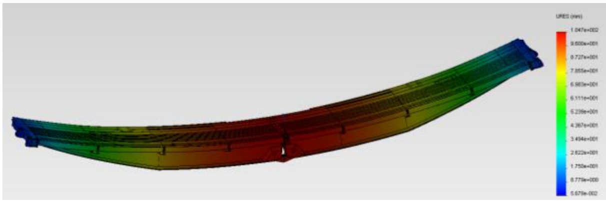


Fig. 11: Displacements of points of structure for combined loading.

2.2 Stress fields due to combined loading by self-weight of the bridge, loading by tank in horizontal and vertical direction on the boundary of the bridge

The original structure of the bridge was loaded by self-weight of bridge, weight of tank including dynamic loadings in horizontal and vertical directions. The boundary conditions for loading of bridge structure are given in Fig. 5. In Fig. 12 and Fig. 13 are given fields of equivalent stresses and displacements of individual points of structure, respectively, due to loading by weight of tank.

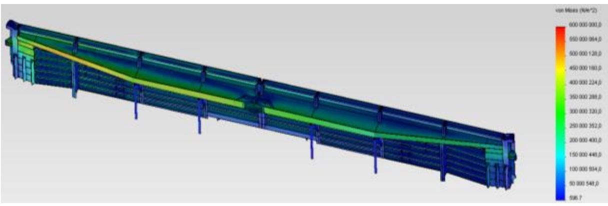


Fig. 12: Field of equivalent stresses for combined loading.

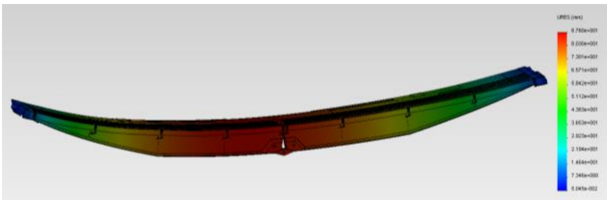
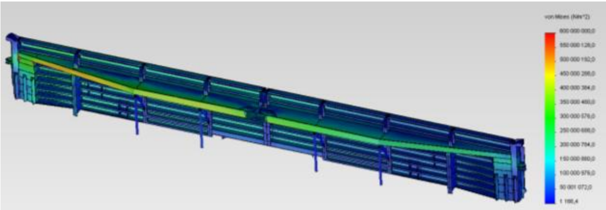


Fig. 13: Displacements of points of structure for combined loading.

New supporting structure of the bridge was in this case loaded by self-weight of bridge, weight of tank including dynamic loadings in horizontal and vertical directions. The boundary conditions for loading of bridge structure are given in Fig. 5. In Fig. 14 and Fig. 15 are given fields of equivalent stresses and displacements of individual points of structure, respectively, due to loading by weight of tank.



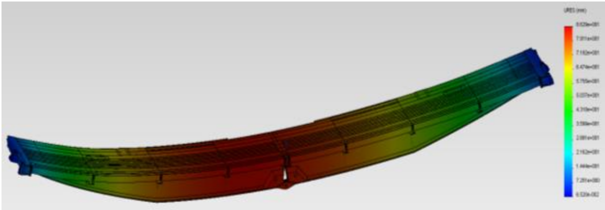
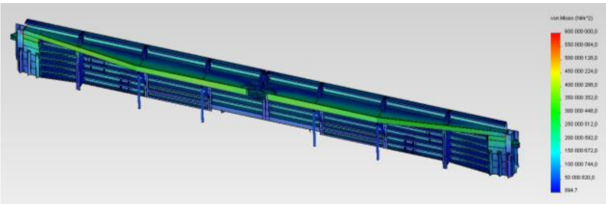


Fig. 14: Field of equivalent stresses for combined loading.

Fig. 15: Displacements of points of structure for combined loading.

2.3 Stress fields due to combined loading by self-weight of the bridge, loading by truck in horizontal and vertical direction in the middle of the bridge

The original structure of the bridge was loaded by self-weight of bridge, weight of truck including dynamic loadings in horizontal and vertical directions. The boundary conditions for loading of bridge structure are given in Fig. 6. In Fig. 16 and Fig. 17 are given fields of equivalent stresses and displacements of individual points of structure, respectively, due to loading by weight of truck.



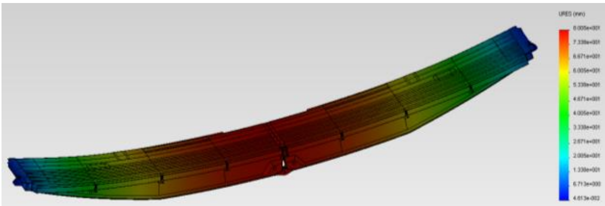
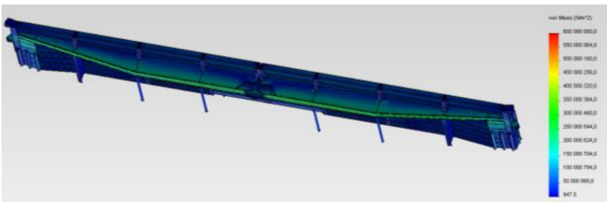


Fig. 16: Field of equivalent stresses for combined loading.

Fig. 17: Displacements of points of structure for combined loading.

New supporting structure of the bridge was in this case loaded by self-weight of bridge, weight of truck including dynamic loadings in horizontal and vertical directions. The boundary conditions for loading of bridge structure are given in Fig. 6. In Fig. 18 and Fig. 19 are given fields of equivalent stresses and displacements of individual points of structure, respectively, due to loading by weight of truck.



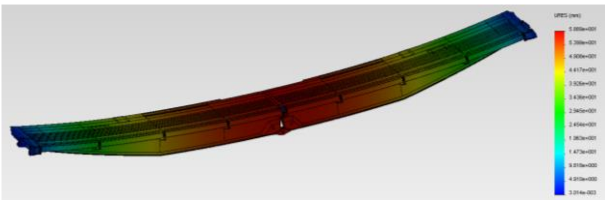


Fig. 18: Field of equivalent stresses for combined loading.

Fig. 19: Displacements of points of structure for combined loading.

2.4 Stress fields due to combined loading by self-weight of the bridge, loading by truck in horizontal and vertical direction on the boundary of the bridge

The original structure of the bridge was loaded by self-weight of bridge, weight of tank including dynamic loadings in horizontal and vertical directions. The boundary conditions for loading of bridge structure are given in Fig. 7. In Fig. 20 and Fig. 21 are given fields of equivalent stresses and displacements of individual points of structure, respectively, due to loading by weight of tank.

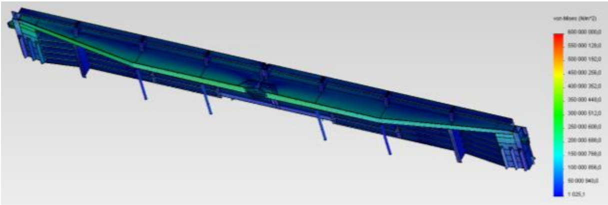


Fig. 20: Field of equivalent stresses for combined loading.

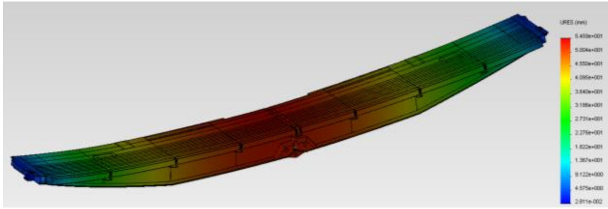


Fig. 21: Displacements of points of structure for combined loading.

New supporting structure of the bridge was in this case loaded by self-weight of bridge, weight of truck including dynamic loadings in horizontal and vertical directions. The boundary conditions for loading of bridge structure are given in Fig. 7. In Fig. 22 and Fig. 23 are given fields of equivalent stresses and displacements of individual points of structure, respectively, due to loading by weight of truck.

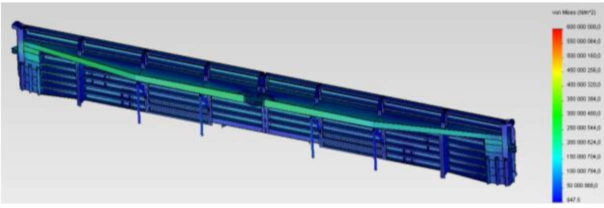


Fig. 22: Field of equivalent stresses for combined loading.

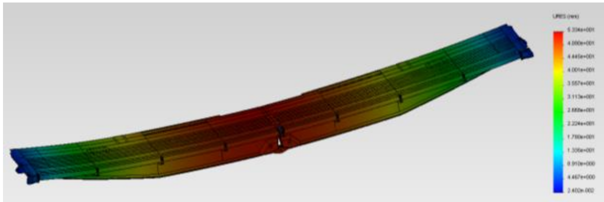


Fig. 23: Displacements of points of structure for combined loading.

3 Results and discussion

In sections 2.1 and 2.2 during analysis of combined loading due to self-weight as well as horizontal and vertical loading was found out (Figs. 10 and 14) that the stresses exceed the strength of material.

Accordingly, the authors by individual steps proposed modification of supporting structure by adding eight vertical reinforcements and triangular reinforcements between new vertical reinforcement and original flanges. These modifications led to the removing of dangerous stress levels not only in webs of main beams, but also on bottom flanges. The modifications can be seen in Fig. 24. In Fig. 25 is the field of equivalent stresses after realization of modifications. The figures clearly documents decreasing of stress levels to the allowed values in webs as well as in flanges of main beams. The vertical reinforcements and triangular elements are made of sheet of thickness 4 mm, material S700.

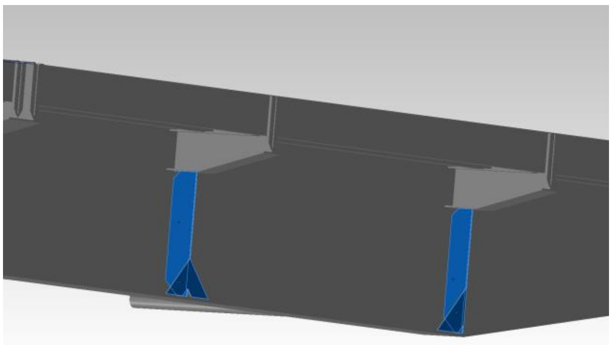


Fig. 24: Model of the bridge after modification of main beams.

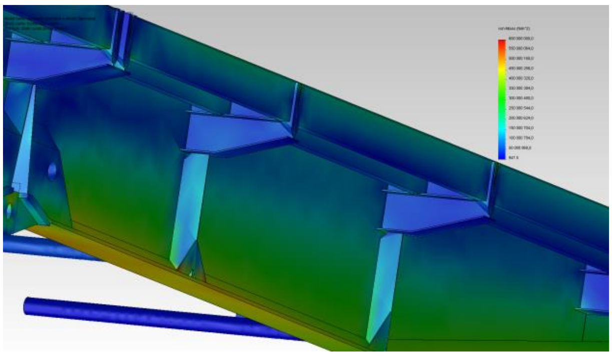


Fig. 25: Fields of equivalent stresses after modification of bridge.

4 Conclusion

The analysis had shown that the highest bending stresses and deformations are in case when the tank or truck are positioned in the middle of bridge. On the other side, the horizontal loading are in case if the vehicles are positioned at the boundary of bridge. The computations of original and modified bridges were not accomplished into details, but they conclude that the main parts of left as well as right side of the bridge fulfill all demands for such structures. The stresses do not exceed yield points of materials. However, the computations do not cover all details of the bridge nor the fatigue analysis.

Acknowledgement

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