

# THE INFLUENCE OF HIGH TENSILE BOLTS STIFFENING ON COUPLED CONNECTION BEHAVIOR

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## 1. Introduction

Utilization of bolts have such a long history; it is believed that first wooden bolts were used in the water rising devices around 240 B.C. in the ancient Greece. Some experts differ in opinion, if bolts were not developed even earlier, in the ancient Egypt before the Archimedes. On the basis of their considerations first wooden bolts were used for land irrigation and to bilge the water from ships [1]. In the XV century bolts and screws were used by Gutenberg in his printing devices, whereas at fall of XV/XVI century first draft designs of screw-cutting machine were drawn.

The most intense development of thread bolts and screws fall over last one hundred years. Both classic mathematical methods and experimental studies were carried out to determine bolts load bearing capacity. Mentioned test concerned different materials, bolt head shape, thread shape etc. Further, world technological development lead to boundary problem solving with Finite Element Method (FEM) approach. Hu et al. [2] performed numerical simulation with the use of finite element method and experimental tests of high-strength bolts under tension. Through the analysis it was shown some discrepancy in load-displacement relationship and also failure mechanism could be observed. Bolts failure mechanism with the FEM utilization was also the subject of interest of Grimsmo et al. [3], who showed that nut location has significant influence on failure mode. Fire conditions and their influence on high-strength bolts was studied by Guo et al. [4]. It was stated that preload has insignificant effect of endplate in the fire conditions.

In this paper the static behavior of high tensile bolt in a coupled connection has been discussed. Section of steel tubes at coupled connection with introduced high tensile bolts has been adopted. Two different parameters have been taken into considerations i.e. coupled connection and single bolt deformation/stress – both under introduced tightening torque and torsion momentums. Stated problem has been solved with the utilization of SolidWorks software.

## 2. Model geometry and results

For the model geometry an assemblage of two steel tubes with  $\phi 305$  external diameter and length of 200 mm have been adopted. Thickness of each tube has been assumed as 10 mm. Connection have been realized via end-plate welded to the host tube, for which external diameter of  $\phi 505$  mm, thickness of 24 mm and internal circular cut with diameter of  $\phi 285$  mm have been adopted, respectively. Eight M24 10.9 grade bolts have been introduced into connection. In order to increase the rigidity of connection special ribs from metal sheet have been provided. Overall connection shape and dimensions of adopted section of structure have been presented in Fig. 1.

For the analysis purposes of single static bolt behaviour under applied compressive preload, geometry of M24 high-strength bolt have been adopted on the basis of DIN 931 standard, assuming that the length of the bolt is equal 100 mm.

Two different loads have been investigated – bolts preload and torsion momentum applied to the tubes section. Single bolt deformations and stress results under applied maximum allowable preload force has been presented in Fig. 2.

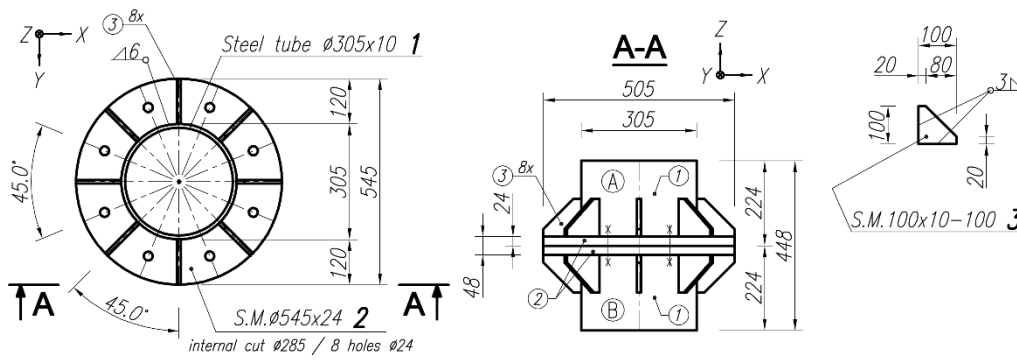


Fig 1: Planar view of steel column structure.

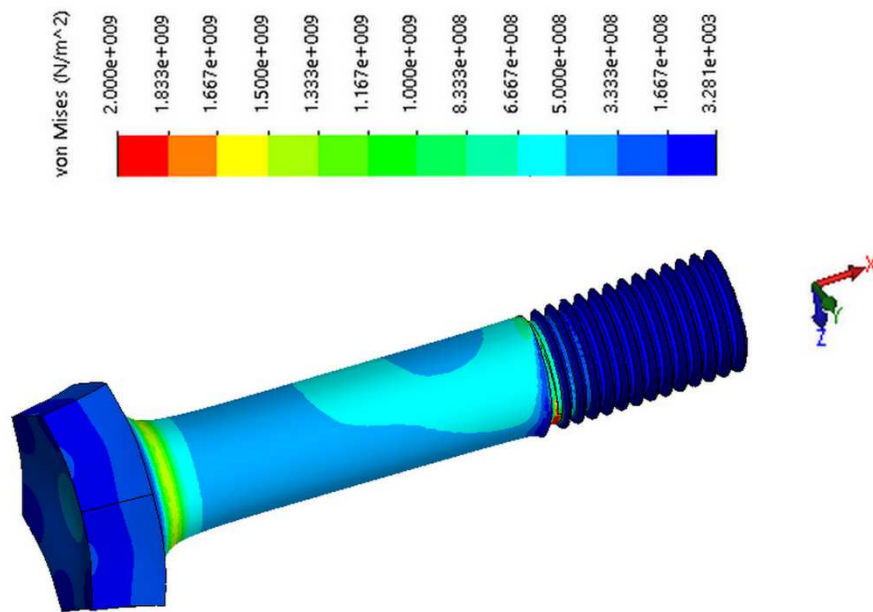


Fig 2: Deformation and Mises stress in the metric M24 high tensile bolt subjected to the stiffening force.

### 3. Conclusion

Through the numerical analysis performed in SolidWorks software deformations and stresses could be observed in both: high-strength bolt and coupled connection. Moreover, it was shown that for the analyzed coupled connection configuration applied value of torsion momentum had only small effect onto stress distribution in bolts and under the bolt head. Mentioned small effect of torsion momentum has been the result of circular shape of endplate, tubes utilized as columns as well as additional metal ribs welded between endplate and tube to increase the connection rigidity.

### References

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 [2] Y. Hu, L. Shen, S. Nie, B. Yang and W. Sha, FE simulation and experimental tests of high-strength structural bolts under tension, *Journal of Constructional Steel Research*, 126, 2016.  
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 [4] Z. Guo, N. Lu, F. Zhu and R. Gao, Effect of preloading in high-strength bolts on bolted-connections exposed to fire, *Fire Safety Journal*, 90, 2017.