Master's Thesis Engineering Technology

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Design of hybrid steel bridges resorting to high strength steel by investigating the bending and shear buckling resistance of hybrid steel girders

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BACKGROUND

- Structural steel is a very versatile but heavy material for construction.
- High strength steel (HSS) has better properties and less weight, but there is a lack in knowledge and the cost is very high.
- Hybrid HSS girders, see figure 1, are less expensive because only the flange are made from HSS, but there are no specific design rules in Eurocode 3.

OBJECTIVES

Verification of Eurocode 3 happens in **three segments**:

- Homogeneous and hybrid girders;
- Cross-section classes – 1 or 2, 3 and 4;
- Several steel grades – S355, S460, S690 and S960.

A comparison of values is made with numerical simulations in **Ansys**, combined in bending moment and shear force interaction.

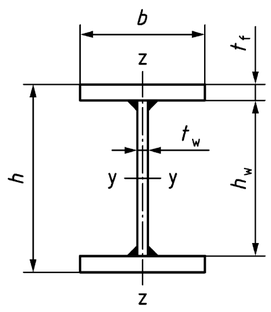

Figure 1: Example welded hybrid I-girder [1]

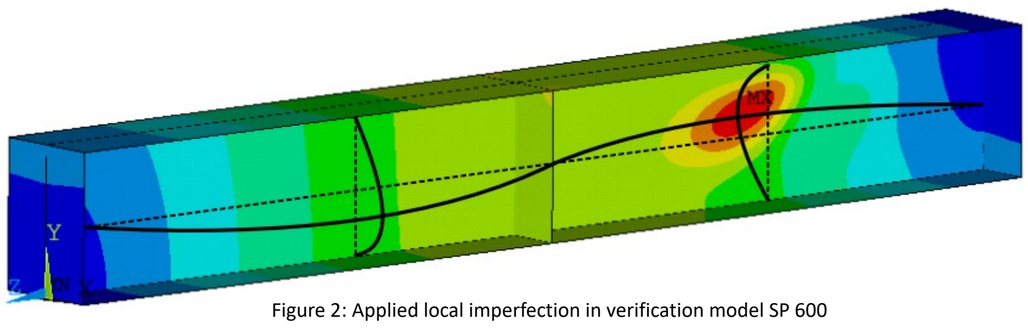

Figure 2: Applied local imperfection in verification model SP 600

METHOD

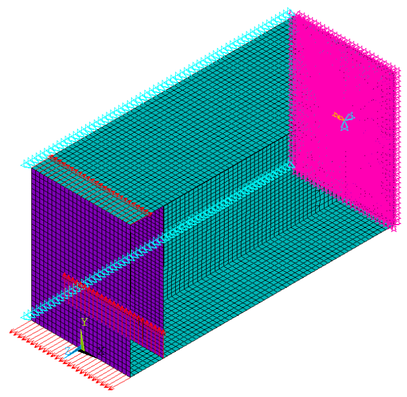

Figure 3: 3D-view of M-V interaction model in Ansys Mechanical APDL

The first step was to perform a verification using an existing study. This model, see figure 2, became the base for the **bending** and **shear interaction** model, see figure 3.

The interaction model was used to perform two kinds of simulations with a variation in:

- Steel grades;
- Cross-section classes.

The results of the simulations were compared with **Eurocode 3** calculations, including bending and shear interaction curves.

RESULTS

Figure 4 shows the results located below the interaction reference curve, which means that the structures are **unsafe** and premature failure will occur before reaching design resistance.

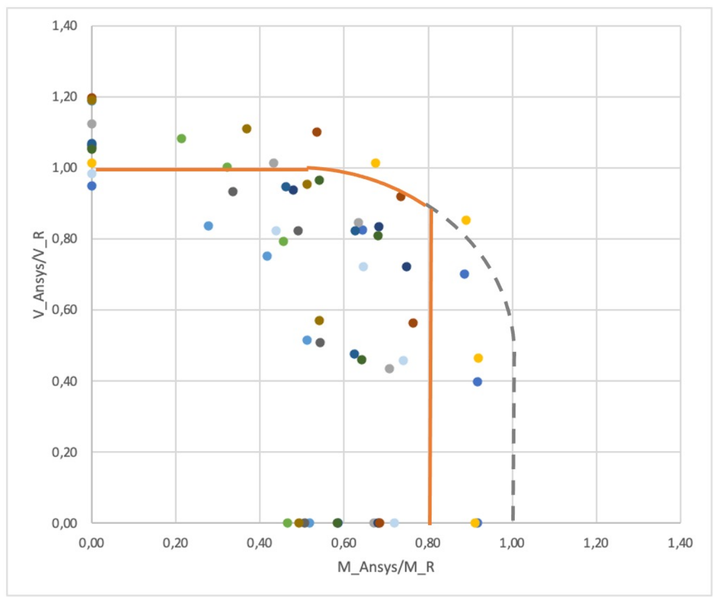

Figure 4: Bending and shear interaction for hybrid girders of cross-section class 1 or 2

Figure 5 shows the results located above the interaction reference curve, which means that the structures are **safe**, but the design resistance is much lower than the numerical resistance.

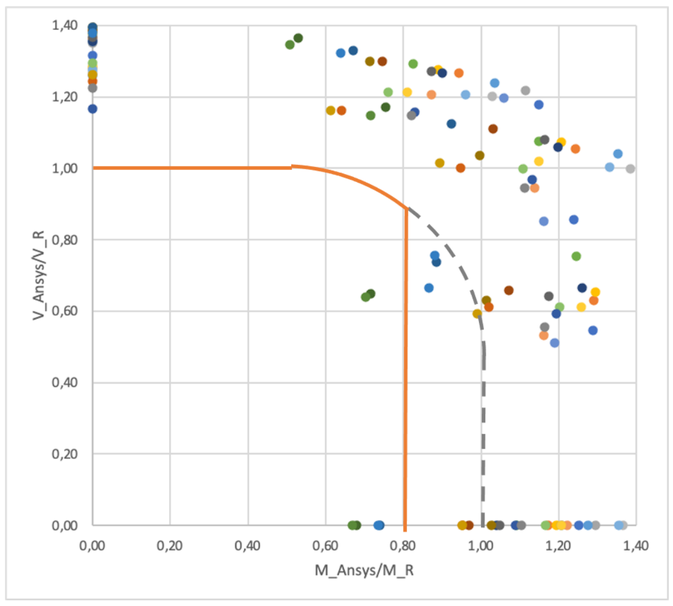

Figure 5: Bending and shear interaction for hybrid girders of cross-section class 3 and 4

Figure 6 shows the results for hybrid girders made from HSS flanges (S960) and HSS web (S690). There is still some discrepancy on the ratio in numerical value to EC3 value, therefore the **design rules are not applicable** in this case.

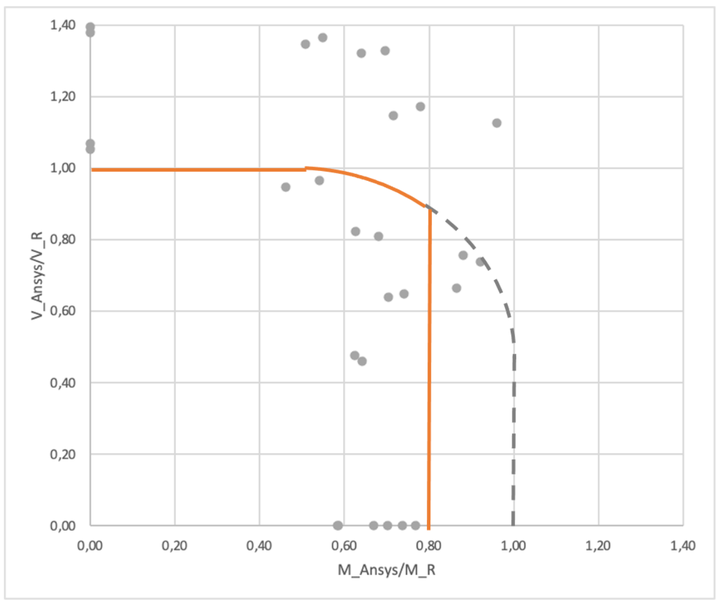

Figure 6: Bending and shear interaction for hybrid girders with flange S960 and web S690

CONCLUSION

A general conclusion for the shear buckling resistance is that in the numerical values, the contribution of the flanges was considered for cross-section classes 3 and 4, for classes 1 and 2 however, they were not included. Furthermore, there was concluded that the design rules of Eurocode 3 can not be used for hybrid girders with cross-section classes 1 or 2, but they can be used for hybrid girders with cross-section classes 3 and 4, but not for steel grades higher than S690. Lastly, there was some discrepancy about the girders where both web as flanges were made from HSS. All these conclusions lead to the need of a review of the design rules of Eurocode 3. In addition, there should be further research on steel grades greater than S700.

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