Stabilizing performance of corrugated metal deck forms in bridge application – what impacts did they have on the Y1504 Bridge and could a different execution have affected the failure?

Several composite bridges have recently collapsed due to lateral torsional buckling of the steel bridge girders during the construction phase. This type of failure can easily be prevented by taking the advantage of the shear stiffness of stay-in-place corrugated metal sheets that are often attached on the top flanges of the steel girders for the purpose of concreting the deck. Hopefully this study could be a part of establishing this method in the construction industry, to avoid unnecessary failures.

The Y1504 Bridge, a composite bridge having a trapezoidal steel girder failed in 2003 due to lateral torsional buckling during concreting of the deck. For this type of bridge, once the concrete deck has hardened, the concrete deck itself provides the steel cross section with sufficient lateral stiffness for preventing the lateral torsional buckling. However, during the concreting of the deck, the steel girder should be able to carry the construction loads including the wet concrete, steel portion of the bridge, and the formworks. Proper lateral bracings are often required to minimize a possible risk of failure due to lateral torsional buckling of the steel girders. In the Y1504 Bridge, typical metal decks were designed to act both as permanent form for the fresh concrete and as stabilizing system during the construction. However, the prescribed sheets were replaced with a similar alternative during construction. Such an error may occur in practice when the constructor involved seeks an alternative product which is cheaper or available in the market.

The use of metal decks, working as lateral restraints has not yet adopted by the current code specifications in the bridge application. Several different parameters can affect the resistance of a particular bridge. In the case of the Y1504 Bridge it was found that the number of screws attaching the deck was decisive along with the thickness of the sheets.

Through FE-studies where the Y1504 Bridge was modeled and analyzed, it was found that the thickness of the metal sheets was sufficient to avoid the failure. However, the failure occurred at the attachments points when the shear forces in the screws became too high. The employed arrangement of the attachments required a metal deck thickness of approximately 7 times the used thickness.

It was also found that the number of attachment points between the metal decks and the steel girders required more attention in design. Reducing the attachment points by 50%, the critical bending moment capacity of the steel girder involved was reduced by a factor of two-thirds, this requiring approximately twice the thickness of the sheet in order to avoid failure. It was also found that there was a rather large discrepancy between the shear stiffness of the prescribed metal deck TRP45 and the constructed metal deck PEVA45. The corresponding critical moment value for the TRP45 was 30% lower than for PEVA45 and that is enough to make that deck insufficient to restraint the loading from the concrete deck.