ABSTRACT

Service life extension of orthotropic steel deck bridges

In the past many Orthotropic Steel Deck (OSD) bridges have been built, the vast majority of them were built between 1960 and 1980. In the last decade several fatigue cracks have been detected in the welds connecting the troughs to the deck plate of these bridges, nearly always underneath the heavy vehicle lane. As evidenced in the case of the New Little Belt Bridge (*Nye Lillebæltsbro*), serving as a case study, these cracks tend to originate at the weld root and may propagate from the welds in the troughs, raising potential structural concerns.

The development of cracks in the welds, attributed to fatigue phenomena, can result in a decreased service life of the bridge. A futureproofing technique to postpone crack formation involves the fabrication of an additional fillet weld inside the trough to connect it to the deck plate, transforming a single-sided welded detail into a double-sided welded one. The intervention will lead to a more favorable stress distribution in the welds and therefore an increased fatigue life of the bridge.

To evaluate the stress state in the welds in both scenarios, a reference portion of the New Little Belt Bridge has been modelled using the FE software ABAQUS. The model has been loaded considering the Load Models and the Fatigue Load Models in accordance with the Eurocodes and several stress distributions in the welds before and after the intervention have been obtained.
The crack initiation points indicated by the model have been validated through a comparison with experimental results.

Stresses in the welds for fatigue assessment have been determined using rigorous methods from both the Eurocodes and the literature, taking into consideration the specific crack initiation points. Subsequently, by employing appropriate S-N curves, the number of cycles that each welded detail can endure is determined, and therefore is evaluated the effectiveness of the futureproofing technique proposed.

Furthermore, utilizing detailed traffic data recorded on the bridge, back analyses were conducted to identify the most frequent lorry most that may have caused the observed damage. The passage of one of the frequent lorries, as defined in the Eurocodes, was modeled, and the resulting stress signal was evaluated. For these analyses, the impact of mean stress has been assessed using formulations proposed in the literature.

The methodology employed to assess structural stresses in the welds and identify crack initiation points in the case of the New Little Belt Bridge has also been applied to an Italian highway overpass. In addition to utilizing Load Models from the Eurocodes, this case involved incorporating frequent vehicles obtained from weight-in-motion (WIM) systems to evaluate the fatigue life of the welded details.