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SEISMIC PERFORMANCE OF COMPOSITE DECKS WITH FULL AND PARTIALL INTERACTION

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Steel-concrete composite bridges represent a very common, economical, and efficient structural solution, especially for short and medium span lengths (Itani et al., 2004). These bridges are generally constituted by a continuous steel-concrete composite deck supported by reinforced concrete piers (Itani et al., 2004), the latter usually providing the main seismic energy dissipation source, unless the seismic isolation technique is adopted (Carbonari et al., 2018). Most of the mass of steel plate girder bridge superstructures is concentrated in the reinforced concrete deck. During a seismic event, the inertia force that is generated in the reinforced concrete deck is transferred to the support cross frames through the headed stud connectors. Seismic analyses showed that these connectors are subjected to combined axial tension and shear forces. If not designed properly, these connectors may fail prematurely during an earthquake, altering the load path and subjecting other bridge components to forces they are not designed for (Bahrami, 2015). It is important to note in this argument that seismic design specifications for bridges do not require the explicit design of bridge superstructures (concrete or steel) for earthquake loads. The assumption is made that a superstructure that is designed for out-of-plane gravity loads has sufficient strength, by default, to resist in-plane earthquake loads. This assumption appears to be justified for structural concrete superstructures, which are heavier and stiffer than their steel counterparts, but may be unfounded for certain types of steel superstructures, such as trusses or slab-and-girder superstructures, both of which may be flexible in-plane. Improvement in the seismic performance of steel bridges is warranted, along with design guidelines for both steel sub- and super-structures. Better insight is required regarding the load path as well as the capacities of individual components and assembled systems (Itani et al., 2004).

Steel bridge girders have three types of interaction with respect to their deck: 1) Fully-composite, 2) Partially-composite, 3) Non-composite. These terminologies are used to describe whether the steel girder and the concrete deck above it act as a single unit or separately. In non-composite behavior, both the steel beam and the concrete deck bend separately. Therefore, there will be relative displacement between the two units defined as "slip". A girder is defined to be “fully-composite” when sufficient shear connectors are provided to develop the full flexural strength of the given cross-section. The number of shear studs for full composite strength, N_f, is the number of connectors which allows the composite girder to achieve its full ultimate strength and is obtained by calculating the force required to be transferred at the steel-concrete interface at the ultimate load state. A girder is defined to be “partially-composite” when the flexural strength of the girder is governed by the strength of the shear connectors. The ultimate strength of a partially-composite girder is less than that of a fully-composite girder because the concrete cannot achieve its full plastic strength, as the force in the slab is limited by the strength of the connectors. This decrease in flexural strength can be related to the degree of shear connection N/N_f, where N is the number of connectors actually used (Ghiami Azad, 2016).

In this paper, we investigate the seismic performance of shear connectors in composite and partially composite girders in bridges. The results show that it is important to consider the longitudinal and transverse seismic forces in the design of shear connectors, especially near the supports.

Three dimensional modelling of a three span deck with full and partially interaction in SAP software and applying the real time history of the earthquake which is applied to the deck of the bridge, shows that under transverse earthquake only a small number of shear connectors in the vicinity of the piers have considerable shear force and no force will be created during the span. Under longitudinal earthquake all shear connectors along the span have shear force. However, its amount is much lower than the force under transverse earthquake. Finally, with modelling a part of the deck in ABAQUS software, the behaviour of shear connectors under longitudinal and transverse seismic is investigated. The results show that under earthquake along the longitudinal directions of the bridge, in fully-composite steel-concrete beams, no seismic criteria need be considered and only in partially-composite steel-concrete beams, due to compressive or tensile failure of the concrete, it is necessary to investigate the seismic behavior of the deck. Under earthquake along the transverse directions of the bridge, due to compressive and tensile failure of concrete and yielding of shear connectors and steel beams in different areas, it is necessary to investigate the behavior and application of deck seismic criteria, in all fully and partially composite beams. Figure 1 shows the MISES stress distribution in composite beam, under earthquake along the longitudinal directions of the bridge.

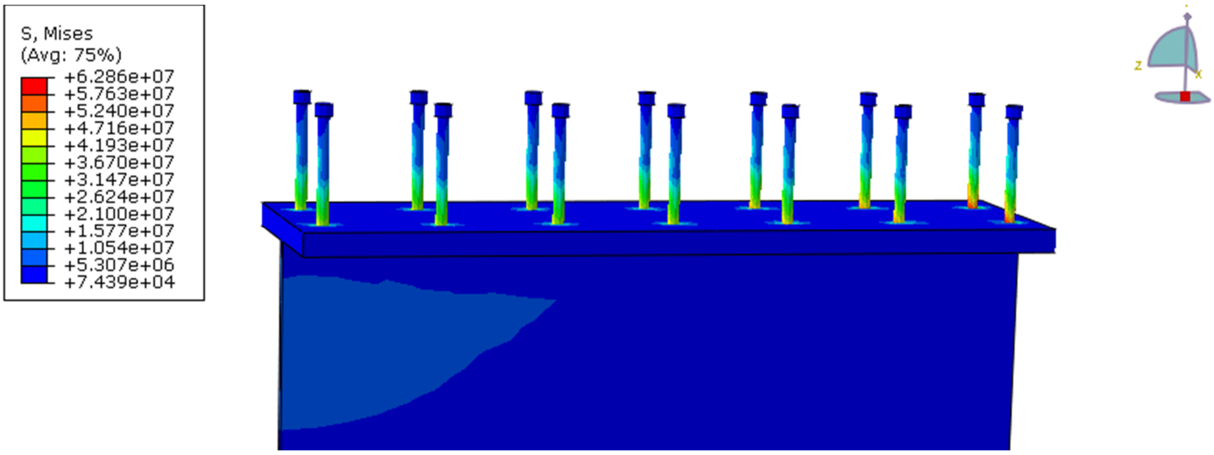

Figure 1. MISES stress distribution in composite beam.

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