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Standardization and Optimization of Orthotropic steel deck with Numerical modelling

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1 Abstract

In this paper, standardization and optimization of Orthotropic Steel Deck (OSD) is carried out to increase its usage as an essential bridge component. OSD's are more often used in the long span bridges because they considered expensive and more complex structure. There are fatigue crack complications associated with these type of steel decks due to their direct contact with the heavy cyclic loading. The idea of standardizing the OSD's is floating in the research industry for last two decades. To facilitate this concept numerical simulation study is carried out with and without additional cutouts with different deck thicknesses and span lengths. The Cross beams without stress relieving cutouts have been introduced which will reduce the labor cost for special cutouts preparation and increase the fatigue endurance of critical welded joints. Based on these numerical results; recommendations have been made. Standardization and optimization of OSD's will definitely increase their usage in bridges.

Keywords: Optimization, Orthotropic steel deck, Complex structure, Fatigue cracks, Numerical simulation, Stress relieving cutouts.

2 Introduction

The OSD's have load-carrying elements in both directions, i-e longitudinal stiffeners and transverse web stiffeners welded to a deck plate. This two way load distribution contributes to the overall bridge strength, which results in an extremely lightweight and durable deck concept. Therefore, these decks are often used in long span bridges. Due to their complexity and numerous welding operations, there are two major problems associated with the OSD's; first one is the fatigue performance, fatigue cracking is detected in a number of long span bridges, and, it is one of the greatest threats to the reliability of OSD's. These decks suffer from many sensitive crack locations. This shows that there is still lack of understanding in the real fatigue behavior of OSD's.

The other one is the increase in overall cost due to complex welding details and on site welding, which require highly skilled labor. These OSD's configuration require complicated welding details and costly fabrication work, especially near diaphragm cutouts. To mitigate these problems, various researchers have devised different types of diaphragm cutouts to optimize stress distribution and reduce stress concentration. These details have lessen fatigue susceptibility but considered difficult to manufacture due to complex cutout geometry [1, 2, 3].

Nowadays, research is more focused on reducing live load stresses without considering residual stresses [4]. Cracking generally initiates in the heat-affected zones (HAZ) at the welds, where residual stresses may reach yield stress. When a repeated live load is applied on the deck under such conditions, a likely stress/strain fluctuation at an initially yielded location adds to crack propagation. According to Roman Wolchuk experience, the

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