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The innovative bearing solution engineered for the Forth Road Bridge's modified deck-to-tower connections

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Abstract

Opened in 1964 as the longest-span suspension bridge outside the USA, the Forth Road Bridge is a crucial connection between south-east and north-east Scotland. Greatly increased traffic loading caused a fatigue fracture, in December 2015, in one of its eight truss end links which support the deck ends at the towers, resulting in the closure of the bridge. Following implementation of an emergency repair to enable the bridge to re-open quickly, it was necessary to implement a reliable long-term fix to avoid a re-occurrence at any link location. An innovative solution was developed, incorporating free-sliding bearings designed to resist high uplift forces and accommodate large deck movements and significant rotations, with adequate durability considering the bearings' very long cumulative sliding path of 16 km per year. The bearings were also required to be pre-fitted with structural health monitoring sensors. The challenge and the solution are described.

Keywords: Forth Road Bridge; Truss End link; repair; bearing; integrated SHM.

1 Introduction

The Forth Road Bridge (total length 2512 m, main span 1006 m) across the Firth of Forth estuary in Scotland – one of the United Kingdom's greatest obstacles to land transportation – was opened to traffic in 1964 having been designed for the traffic standards of the day. Fifty years later, traffic volumes had more than doubled to approximately 70,000 vehicles per day, with design vehicle loading also doubling from the 22-tonne rigid truck of the time to today's 44-tonne articulated truck. In December 2015, following many years of service, subjected to this greatly increased loading, an element of the steel deck's superstructure was found to have failed and the bridge was closed to traffic. The element was a so-called Truss End Link, which linked the bottom of a section of steel deck truss, at its end, to the tower that supported it. With two truss end links (one at each side of the deck) at each side of each of the

two bridge towers, the total number of truss end links was eight. One of these elements is shown in Figure 1.

Following the carrying out of emergency measures to enable the bridge to be re-opened to traffic as quickly as possible – for which Amey plc, under a five-year contract from Transport Scotland to manage and maintain the bridge, received the prestigious *Greatest Contribution to Scotland Award* at the 2016 Saltire Society Civil Engineering Awards – it was necessary to implement a long-term solution. Following the evaluation of various options, it was decided not to replace the truss end link with a similar element, but rather to develop a more reliable solution with the bottom of the partially renewed truss supported by a bearing. This solution is illustrated in Figure 2, and the eight relevant locations are shown in Figure 3.