Forth Replacement Crossing: Scheme design of the bridge

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Summary

The Forth Replacement Crossing will be built across the Firth of Forth in Scotland to maintain and enhance a vital transport link in the country. The wide estuary will be crossed by a pair of 650 m main spans with crossing cable stays employed to stabilise the central tower, a unique design feature for a bridge of this scale.

The scheme design of the crossing, being carried out by the Jacobs-Arup JV, aims to provide a fitting 21st century icon, standing alongside existing 19th and 20th century Grade A listed bridges.

Keywords: cable-stayed bridge; design.

1. Introduction

The Firth of Forth is a dramatic fjord which separates the Scottish capital of Edinburgh from the Kingdom of Fife to the north. The downstream crossings of the Forth at Queensferry are a pair of historic bridges, the famous cantilever rail bridge constructed in the 1880's and the Forth Road Bridge, Britain's first long span suspension bridge, which was opened in 1964.

In spite of constant maintenance through its lifetime, the Forth Road Bridge is showing signs of deterioration as a result of increased traffic and the influence of weather and climate over its 40 years of service. A comprehensive study into the future cross-Forth travel needs concluded that a replacement crossing is required to maintain this crucial link for the economies of Fife, Edinburgh and the East coast of Scotland.

The replacement bridge will be slightly to the west of the existing bridges, making use of Beamer Rock, a natural dolerite outcrop in the middle of the Forth, which allows the wide estuary to be crossed by a pair of 650 m cable stayed spans. The unique aspects of a multi-span cable stayed bridge have proved influential to the design.

Fig. 1: Three centuries of engineering in the Firth of Forth

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2. General Arrangement

The total length of the bridge is 2,638 m. Although the bridge is divided into a cable stayed bridge and a southern approach viaduct the structure is continuous from abutment to abutment with no intermediate expansion joints. Longitudinal fixity is provided by a monolithic connection at the central tower located on Beamer Rock with transverse support provided at all towers and piers.

The towers are vertical reinforced concrete elements located in the centre of the deck with two planes of stay cables anchored centrally in the "shadow" of the tower. The stay cables overlap in the centre of the main spans to provide support to the central tower. The deck itself is a streamlined box girder of either orthotropic or composite construction.

Considering the centrally anchored stay cables, studies have been carried out to investigate the torsional behaviour of the deck under a number of different traffic scenarios to establish appropriate design criteria for the twist of the deck and confirm that the design meets the requirements.

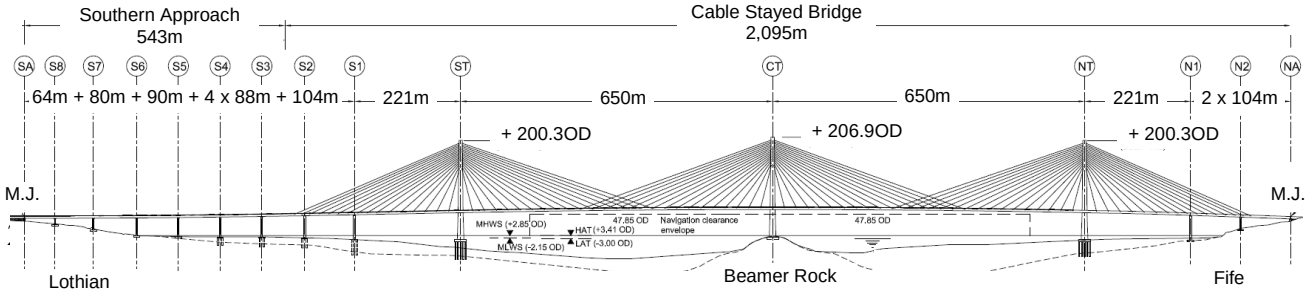

Fig. 2: General arrangement

3. Scheme Development

The preferred scheme for the bridge combines elegance and economy. The scheme was selected after developing a range of options in sufficient detail to allow a thorough comparison of costs, construction duration and operation & maintenance issues as well as considering the aesthetic requirements of the site.

Technical studies have included wind tunnel testing and a marine collision risk assessment to define the ship impact loads which govern the foundation design.

The functionality of a refurbished Forth Road Bridge was considered and it demonstrated that in the future it could be adapted to carry a light rail or tram system. This was vital in showing that a refined, narrower Replacement Crossing would still provide all the benefits required for the project.

Fig. 3: The Forth Replacement Crossing

4. Acknowledgements

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