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3. Orwell Bridge (England)

Owner: Department of Transport, Eastern Road Construction Unit

Consulting Engineer and Designer: Sir William Halcrow & Partners, London

Contractor: Stevin Construction BV, Beverwijk, Holland

Construction: 1979-1982

Orwell Bridge, an eighteen span structure with a total length 1286 m, has the largest prestressed concrete span in UK, 190 m long, over the main navigation channel of the River Orwell.

The bridge forms part of the Ipswich By-Pass, a new dual carriageway road to enable traffic going to and from the ports of Felixstowe and Ipswich to avoid the town centre. The line of the new road crosses the River Orwell downstream of the Ipswich port and container terminal. A high level structure was therefore required to allow ships to pass under the bridge. A special study of the dimensions of ships using the port at present and in the past resulted in a navigational "goalpost" 41 m high above mean sea level and a main span over the navigation channel of 190 m. Another requirement of the shipping interests was that no temporary or permanent works should intrude upon the "goalpost". A cast in situ balanced cantilever design in prestressed concrete was therefore adopted, using 106 m long anchor spans adjacent to the 190 m span.

The approach viaducts to the navigation spans are of constant span length of 59 m except for the first span of 46 m and the span adjacent to the anchor span which is 72 m. These viaducts are also in prestressed concrete cast in situ.

Upon completion the whole length of 1286 m is made continuous with expansion joints only at each abutment.

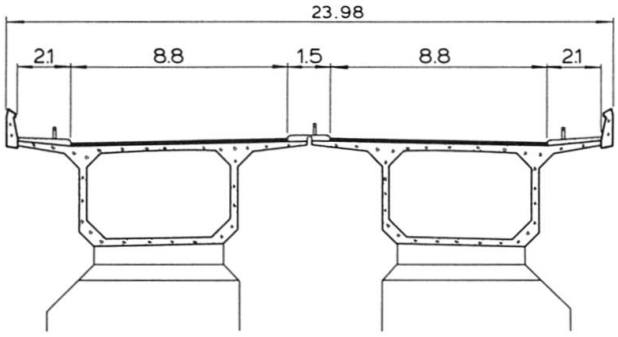
As can be seen from the elevation the spans to be built in cantilever have a depth which varies from 12 m at the main piers to 4 m at midspan and at the ends of the anchor spans. The approach viaducts have a constant depth of 4 m throughout. The bridge has two separate box girders, one beneath each carriageway.

Foundations

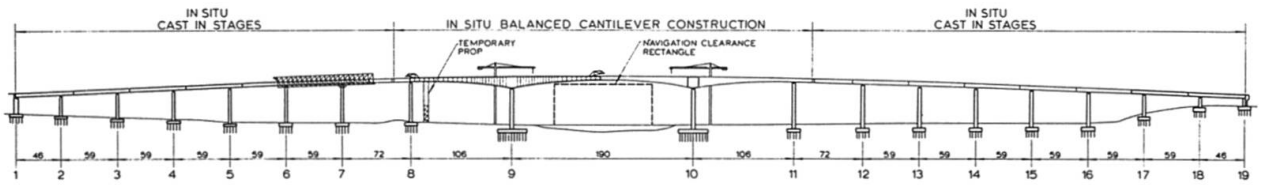
The geology of the site is stiff clay and sands which form the sides of the river valley and overlie a horizontal surface of chalk.

Large scale site investigations involving over seventy boreholes were used during the design stage of the bridge to assess the quality and variability of the chalk. As a result of the investigations all piers have bored pile foundations up to 40 m deep. The total length of piling is 31,170 m formed from 1138 piles 1050 mm diameter.

All piles are excavated and concreted below ground water level. To assist with the design and to demonstrate to bridge tenderers which construction techniques were likely to be successful, a £60,000 test pile contract was carried out in advance of the main bridge contract. Results of the test pile contract together with a description of the plant used were given to bridge tenderers.



Cross section of bridge on viaduct superstructure

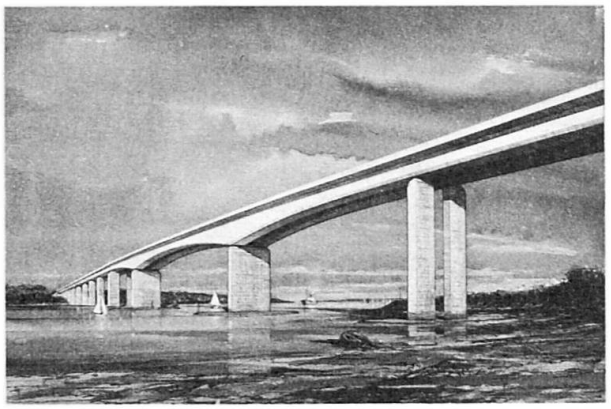


Sectional elevation

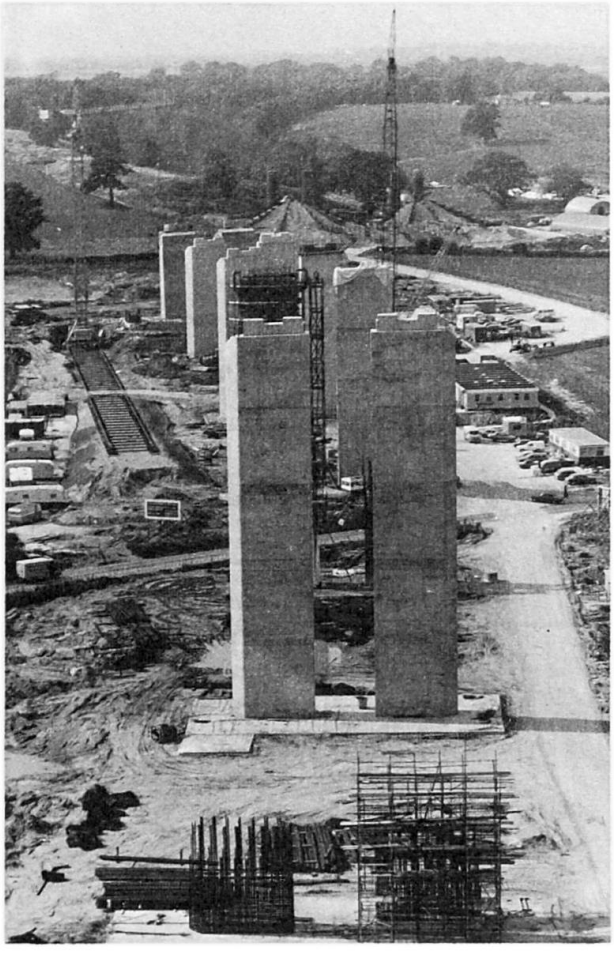
Pilecaps and piers

Pilecaps on all viaduct piers are of constant 2.25 m depth, thus allowing repetitive use of formwork. The two large pile caps under piers 9 and 10 adjacent to the navigation channel are 4 m deep and contain 3600 m^3 of concrete in each. Insultated formwork and thermal quilts are used to control the cooling rate of the concrete. Pile caps are cast in one continuous pour with thermocouples built in to monitor temperature gradients.

Twin stalk viaduct piers, up to 40 m high, are of solid reinforced concrete built with a steel form using the landing ring principle. The piers on each side of the navigation channel are hollow walls built by conventional formwork.



Artist's impression of completed structure



Viaduct piers – August 1980

Superstructure – balanced cantilever spans

The balanced cantilever spans are single cell box girders with constant width vertical webs. The head of the bridge is 12 m long and then cast in situ sections of 3.5 m and 5 m are progressively added. The top flange, with its 2.725 m side cantilevers is of constant section throughout, the bottom flange varies in depth from 1500 mm to 250 mm. Four travelling forms, designed and fabricated by Hosveis A.S. of Norway, are provided and both boxes are built on one side of the river before transferring to the other main pier. The 51.5 N/mm^2 concrete is prestressed longitudinally by VSL 6-19 tendons of GKN super strand for cantilevering tendons and VSL 5-31 tendons for continuity at mid span. The webs are prestressed with vertical McAlloy bars 32 mm diameter. There is no transverse prestressing in the deck.

Substantial steel tube temporary props have been used as a supporting system for concreting the heads of the bridge and these are retained in position to take the out of balance forces during cantilevering. A temporary prop is required in each anchor span.

The bearings on piers 9 and 10 are fabricated by Maurer in Germany. The fixed rockers on pier 10 and the steel roller bearings on pier 9 have a maximum load of 55,000 kN. Provision has been made in the design for jacking the bridge if ever required in the future to replace any bearing.

Superstructure – viaducts

The design of the viaducts is such that a moveable gantry can be used fifteen times to cast in situ a length of 59 m. Two steel truss type gantries which support the formwork beneath the side cantilevers are by specialist UK formwork manufacturer Coneybeare. The viaducts have constant section top flanges but varying web and bottom flange thicknesses and are curved in plan. Diaphragms are provided over each pier position with an opening in them sufficiently large to allow the inside formwork to be rolled forwards without dismantling.

Concrete in the viaduct is 45 N/mm^2 and no web or transverse prestressing is provided. Longitudinal prestressing is VSL 5-31 tendons of GKN super strand.

Contractual situation

The bridge is of significance in that it is the first occasion that a contractor from outside UK has won a prestige bridge project within UK. The European Economic Community rules allow contractors from one country to bid for work in the other member countries. Many firms within the Community will be therefore monitoring the performance of Orwell Bridge.

(M. S. Fletcher)