7 Assessment of Options for Approach Spans

The key issues for the approach spans are visual continuity with the cable stayed bridge and long spans to reduce the numbers of piers to be constructed in the environmentally sensitive channel and inter-tidal zone.

An important factor in achieving visual continuity is that the approach spans will be constant depth structures. A span length of approximately 90 m has been selected as being suitable for achieving a balance between aesthetics, economy and environmental impact.

7.1 Deck

7.1.1 Composite Box Girder

The assumed construction method of the composite box girder is by incremental launching with assembly of the deck behind the abutments. It has been assumed that temporary support brackets may be provided on the piers – therefore the launching process is not taken to govern the size of the pier head.

The box girder option has been designed to provide a reasonable balance of aesthetics and cost. The key driver for aesthetics is of course visual continuity with the cable stayed bridge and whilst this cannot be perfectly achieved due to a change in cross section, certain measures can be adopted in the design which provide for a reasonable synergy between the cable stayed bridge and the approaches:

- Continuity of visually striking edge detail
- Constant structural depth (i.e. no haunches)
- Structural depth of approaches and cable stayed bridge to be the same if possible

Conventional twin box girder solutions have been developed. For the Two Corridor functional cross section the box girders would be separated by an air gap whereas for the Single Corridor functional cross section the boxes would be stitched together. Some variation from conventional cross section shapes may be possible during the next stage of development provided the selected form is an economic solution.

The approach bridge for this option is illustrated in Drawing FRC/C/076/D2M/301 in Appendix D.

7.1.2 Concrete Box Girder

The span length of the concrete option suggests that one of the following construction methods would generally be expected:

- In-situ balanced cantilever
- Precast segmental balanced cantilever

Although in-situ span by span construction is feasible for this span length it would require a very heavy erection gantry which makes it unlikely to be economical compared to balanced cantilever construction.

The span length is also beyond the range which has in the past proven to be economical for incremental launching of a concrete box girder. However, incremental launching could still be possible, either with temporary intermediate supports or else with an innovative construction method which allowed longer spans to be achieved. The arrangements for an intermediate support around the Port Edgar Barracks would be difficult but not impossible. Whilst incremental launching is not expected, ideally the design should not preclude the contractor from adopting it.

There is a current UK moratorium on the use of internal tendons with precast segmental construction. This effectively prohibits the use of precast segmental construction since an economical segmental solution with only external tendons is unlikely to be practical.

The assumed construction method is therefore in-situ balanced cantilever construction. Internal tendons are assumed for the cantilever construction with external span and continuity tendons also used.

As for the composite box girder option, visual continuity with the main span is achieved by continuity of the edge detail and maintaining a constant structural depth. Similarly, whilst conventional twin box solutions have been developed at this stage, some variation of the cross section shape may be possible during the next stage of development provided the selected form is an economic solution.

The approach bridge for this option is illustrated in Drawing FRC/C/076/D2M/321 in Appendix D.

7.1.3 Composite Plate Girder

Composite plate girders are also considered for the approach bridge. As for the composite box-girder, the assumed construction method is incremental launching.

For the Two Corridor functional cross section, a pair of ladder beams is assumed with each ladder beam consisting of longitudinal edge girders connected by simply supported cross beams. Precast participating formwork planks are assumed for the deck slab between edge girders with either in-situ or precast cantilevers. This form of construction is conventional and generally economical in the UK.

For the Single Corridor functional cross section the width of the deck results in two possible solutions for a plate girder deck. Either a multiple girder with transverse spanning slab could be adopted or a wide ladder beam. The wide ladder beam would probably be most economical if transverse steel cantilevers were adopted to reduce the spacing between the longitudinal beams. For the current assessment multiple girders are assumed but this will be reviewed in the next stage of development.

The approach bridge for this option is illustrated in Drawing FRC/C/076/D2M/341 in Appendix D.

7.2 Piers

The piers of the approach bridge play an important part in achieving visual continuity with the cable stayed bridge. On the southern approach, from the south tower towards the shore there will be one side span pier in the cable stayed bridge, one transition pier between cable stay and approach and then seven approach piers with the final three being on land with a significant reduction in the pier height. Ensuring a common language and rhythm for these piers plays a key role in the aesthetics of the bridge. The issues to be addressed are:

- Relationship between pier form and tower form
- Cable stayed bridge side span piers read as a continuation of the approach bridge piers

- Any pier widening necessary to accommodate movement joints to be carefully considered with a view to the movement joint pier being visually similar to the typical pier
- Rhythm of the pier spacing
- Accommodation of the large variation in pier height when the approach bridge is over land.

Another design aim for the piers is to have a single foundation per pier in order to reduce costs.

7.3 Assessment of Options

(a) Visual continuity with cable stayed bridge

Considering the large number of cable stay bridge and approach bridge permutations as well as the possibility of refinement of cross section shapes at the next stage of development it is difficult to judge conclusively on which approach bridge options provide the best visual continuity. However, in general it is believed that a better aesthetic solution will be achieved with box girder forms of construction for the approaches.

(b) Maintenance

In terms of future maintenance an all concrete box girder solution is expected to be the most favourable since re-painting will not be required. Although there are some inspection and maintenance requirements for prestressing tendons this is not expected to be as onerous. To avoid any unacceptable consequences of unforeseen tendon deterioration several measures will be adopted:

- Use of internal tendons kept to a minimum (e.g. cantilever prestress only)
- External tendons will be a replaceable system
- Space provided for future additional tendons

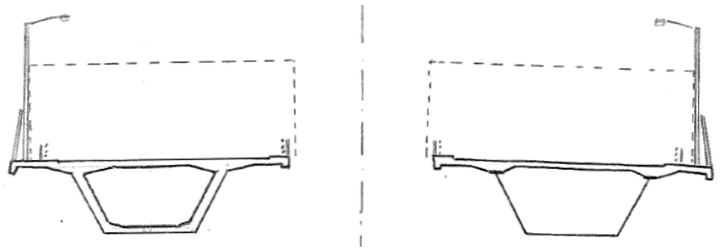
The composite plate girder solutions are expected to have the most onerous maintenance requirements due to the greater external painted area and more complex surfaces and crevices compared to the composite box girder solution. For the box girder, internal dehumidification is assumed.

(c) Open material choice

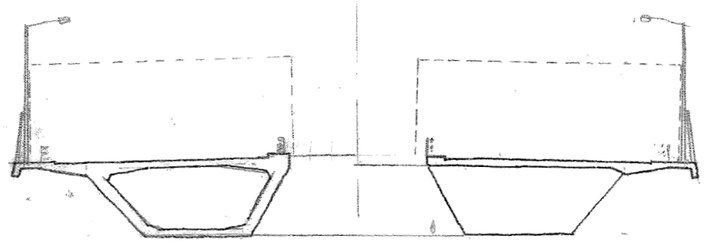
Box girder solutions which have been developed for the cable stayed bridge have been designed to allow both orthotropic and composite solutions to be tendered with the final choice of material left open to the contractor in order to receive the most competitive tenders.

The same principle could be followed for the approach viaducts with a box girder solution developed that would allow both composite and concrete solutions to be tendered.

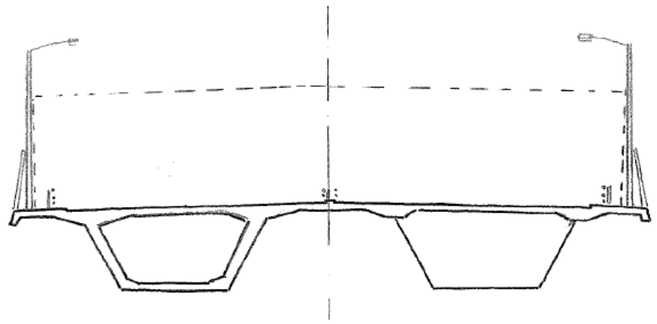
Example girder arrangements that could be considered are illustrated below:



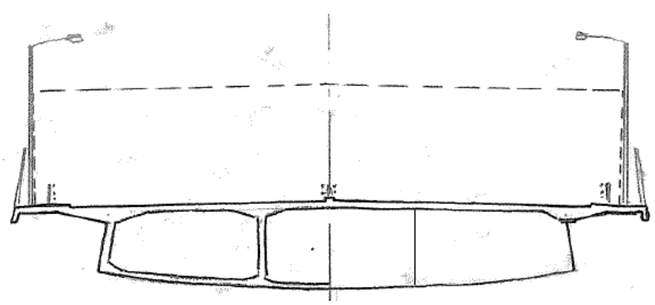
Two Corridor Layout – conventional solution



Two Corridor Layout – possible modified solution for improved visual continuity



Single Corridor Layout – conventional solution



Single Corridor Layout – possible modified solution for improved visual continuity

7.4 Conclusion

The box girder solutions are anticipated to be more aesthetically pleasing and have lower maintenance requirements than the plate girder solution. Furthermore the box girder solution lends itself to providing a choice of materials to the tendering contractor which is anticipated to bring economy in terms of increased competitiveness and hedging against fluctuations in steel prices during the procurement process.

Therefore, given that the plate girder solution is not estimated to be significantly cheaper than the box girders, it is recommended that a box girder solution with open material choice be progressed for further development.

Once the form of the cable stayed bridge is determined, it is recommended that the cross section be investigated in more detail to determine the best way to achieve good visual continuity with reasonable economy.