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Tailor made bridge design with Ultra-High-Performance Concretes

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ABSTRACT: Since the early nineties different manufacturers can produce different concrete mixes with compressive strengths over 150 MPa. These mixes have not only very high strengths but there overall performance, such as resistance against aggressive agents, is much higher then for normal concrete. (i.e. strength classes C30/37 to C50/63) In the last years many studies and designs in the Netherlands and in the world have shown the great possibilities for these Concretes for bridge structures. Many types of bridges for various types of traffic and with various spans have been investigated or realised. Even existing bridges are strengthened or adapted to resist heavier loads or to expand there life cycle. In the paper different studies and designs are described. From these studies and designs some general conclusions can be drawn in relation to the possibilities for these new Ultra-High-Performance Concretes (UHPC) for there practical and cost effective use in structures.

1 FIRST APPLICATIONS

1.1 *Pedestrian bridge*

In bridge construction the first use of Ultra High Performance Concrete is in the Sherbrooke Pedestrian Bridge. See Figure 1. This pedestrian/bicycle bridge provided the opportunity for early experimental use of UHPC in 1997. The construction consists of a single 60 meter long span with an only 3 cm thick deck with stiffening ribs.

1.2 *Road bridge*

The worlds first road bridges in UHPC were completed in 2001 on the Bourg-les-Valences bypass in France. See Figure 2. The cross-sections of the two identical decks are assembled of five π-shaped prefabricated beams. Both bridges are based on a conventional overpass design with two spans of about twenty meters and a continuity slab at central pier.

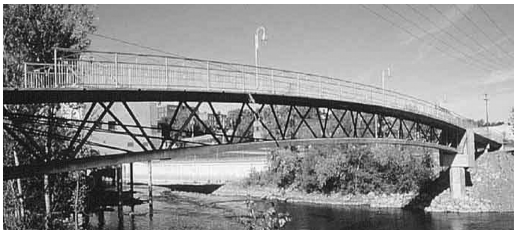

Figure 1. Pedestrian bridge at Sherbrooke (Canada).

1.3 *Composite bridge*

As a replacement of the existing wooden deck of a movable bridge, in the Dutch motorway 44, a solution with prefab panels (Fig. 3) made of heavy reinforced Ulta-High Performance Concrete was chosen. The thickness of the panels was only 45 mm thick, containing three layers of ordinary steel reinforcement. A cover of only ten millimetres was enough to ensure a durable solution. Because of the high abrasion resistance of UHPC, omitting Asphalt layer is possible. Therefore the solution has almost the same deadweight as the original wooden deck with Asphalt.

1.4 *Rehabilitation steel orthotropic bridge deck*

In the Netherlands heavy-reinforced UHPC (known as C.R.C.) was used to rehabilitate the orthotropic

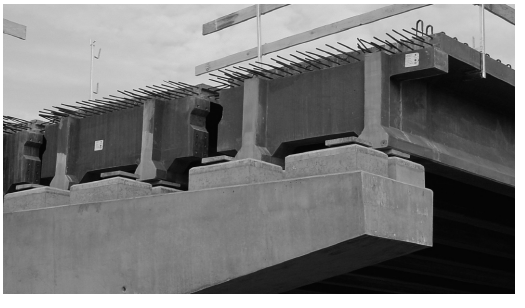

Figure 2. Road bridge at Bourg-les-Valences (France). Central pier during placing of π-shaped beams.

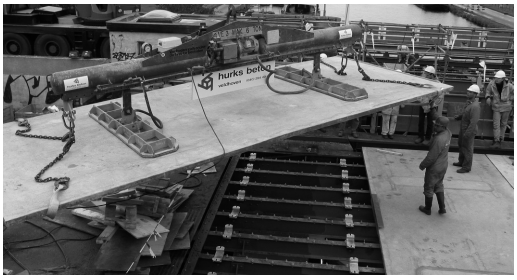

Figure 3. Placing of heavy-reinforced UHPC panel in motorway 44 near Sassenheim. (the Netherlands).

Figure 4. Sunyudo Pedestrian Bridge at Seoul (Korea).

steel bridge deck of the Caland bridge. Many steel orthotropic steel decks in the Netherlands have cracks caused by fatigue due to the traffic loads. By applying a thin layer of approximately 70 mm thick, steel stresses were reduced up to 80%.

2 FURTHER BRIDGE APPLICATIONS

In the last decade more applications of Ulta-High Performance Concrete were realized. Most of the applications were in pedestrian/bicycle bridges:

- Sunyudo Pedestrian Bridge (Korea) completed in 2002 which has currently the largest single span of 120 metres; (Fig. 4)
- Sakata Mirai pedestrian bridge Japan in 2002;
- Papatoetoe (2004) and Penrose (2006) Footbridges in Auckland, New Zealand;
- Footbridge at the Chryso plant in Sermaises, France;
- Yokemuri footbridge in Japan (2004), built using the principle of a square box girder frame;
- The Gärtnerplatz Pedestrian/Bicycle Bridge in Kassel Germany completed in 2007 is a composite steel-UHPC bridge with a main span of 136 metres; (Fig. 5)

Some recent erected road bridges in UHPC are:

- Shepherds Creek Road Bridge in Australia; (2005)
- Optimised RPC Prototype Bridge in Washington, USA; (2004)
- Wapello County Bridge in Iowa, USA (2005)

In the Netherlands a few steel orthotropic bridge decks have been rehabilitated and/or strengthened using Compact Reinforced Composite (C.R.C.) such as the large Moerdijkbridge. See Figure 6.

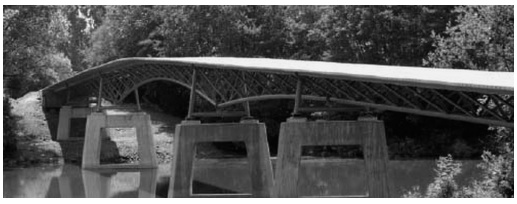

Figure 5. Gartnerplatzbridge composite steel-UHPC bridge at Kassel (Germany).

Figure 6. Moerdijkbridge (the Netherlands) at rehabilitation and new design in UHPC.

3 STUDIES AND GRADUATION PROJECTS

Many students from Delft University of Technology have made a design in Ultra-High Performance Concrete for there graduation project. Mentioned are:

- Design (1999) of deck of movable road bridge and optimized design in 2004;
- Design of large single 100 metres span box girder (case study at Moerdijk) for a 43 metres wide multilane motorway. See upper right corner of Figure 6.
- Alternative design in UHPC for steel railway bridges.

4 CONCLUSIONS

Ultra-High performance concrete can both technical and economical replace steel in bridge design. Even existing (mostly steel) bridges can economical be rehabilitated with UHPC.

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