The *i-Bridge*, an Industrial Bridge Concept, Feasibility Studies

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Summary

Feasibility studies on a novel bridge concept embracing industrial bridge engineering, conceptual design and finite element (FE) analyses have been carried out at Chalmers University of Technology. The *i-bridge* concept consists of v-shaped glass fibre reinforced polymer (GFRP) beams reinforced by carbon fibre reinforced polymer (CFRP) profiles. The deck consists of GFRP plates in composite action with ultra-high-performance steel-fibre reinforced concrete (UHPSFRC). In addition, an experimental study of the bond between UHPSFRC cast upon GFRP sheets was conducted to evaluate the best solutions for interfaces in the concept. Both shear and tension tests were performed. Furthermore, a laboratory load test and finite element analyses of a prototype bridge beam were carried out. The paper presents a general description of the bridge concept and the proposed the industrial characteristics as well as a summary of the conducted feasibility studies. The investigations performed indicate that the concept could be realised from a technical structural point of view.

Keywords: Bridge concept; UHPSFRC; GFRP, CFRP; FE analyses; Bond test; Load test

1. Introduction

This paper presents a brief summary of the feasibility studies conducted for a novel bridge concept, the *i-bridge*. The feasibility studies consist of conceptual design and laboratory tests, as been presented above, and they were carried out at Chalmers University of Technology. More detailed information can be found in Harryson [1].

The aim of industrial construction, and indeed for any industrial process, is to make products at a lower cost or alternatively to make products of higher quality at the same cost. The optimum is of course for both criteria to be fulfilled at the same time, i.e. make products of higher quality at lower cost. One of the most important requirements stipulated for the feasibility studies were that the concept must fit into an industrial process and industrial methods and developments were to be utilised. Hence, among the most essential issues focused upon were efficiency and industrial matters. The *i-bridge* concept should allow efficient industrial production of the bridge with large flexibility and variation, to be able to adapt to different situations and locations. The general idea is to combine and utilise appropriate materials and to exploit their entire capacity. The materials used in the concept are fibre reinforced polymers (FRP) in composite action with ultra-high-performance steel-fibre reinforced concrete (UHPSFRC). The large advantages of FRP, as stated in [2], are their excellent specific strength and that they can easily be formed into any shape, are largely corrosion-free and are largely resistant to fatigue. Among the main reasons for this choice of materials were durability concerns, since there was a wish to utilise more maintenance-free materials. It also seemed challenging to provide for composite action between the different materials, with similarity to research done to supply for composite action between steel plates and concrete; see e.g. [3]. Since both FRP and UHPSFRC are materials enabling a choice of tailored material parameters, i.e. engineered material, the main task for the designer is to specify the parameters to suit the design – rather than adapting a design to meet predetermined material performance, which is the common approach to design in construction. Obviously, it is not possible to cover all part of the bridge development and design in detail. Thus, there are details that are left out or not covered in depth. However, there has been an intention to adopt a holistic view in the study.

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2. Outline of the *i-bridge* concept

The bridge in the feasibility study is a freely supported road bridge with a span length of 25 m, which is a common intermediate span that can accommodate a magnitude of bridging situations. The superstructure of the *i-bridge* concept consists of v-shaped 1.5 m high GFRP beams reinforced by CFRP profiles, with a deck consisting of GFRP plates in composite action with UHPSFRC. The UHPSFRC used is CRC Compact Reinforced Composite), see e.g. [4]. The CFRP profile is placed inside the beams, mainly for aesthetic and protective reasons. The concept is outlined in Figure 1.

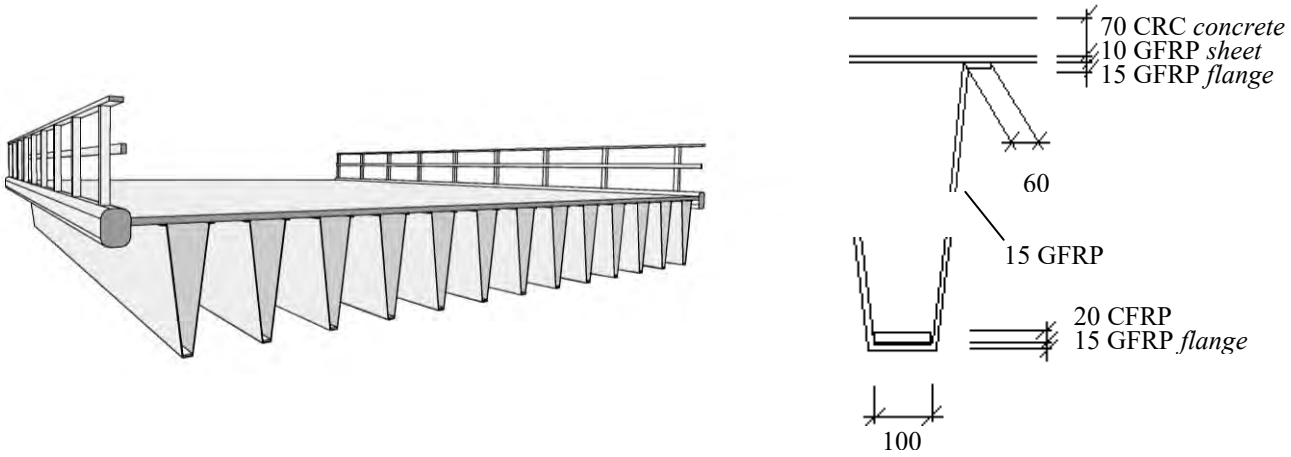

Fig. 1: Outline of the i-bridge concept, a perspective sketch illustrating the major components of the bridge and to the right some details of the deck and the bottom of the beams (dimensions in mm).

The feasibility of the bridge concept embraces industrial bridge engineering, conceptual design and finite element (FE) analyses. In addition, an experimental study of the bond between UHPSFRC cast upon GFRP sheets was conducted to evaluate the best solutions for interfaces in the concept. Both shear and tension tests were performed. Furthermore, a laboratory load test and finite element analyses of a prototype bridge beam were carried out

3. Concluding remarks

In summary, the investigations performed – although not covering all details – indicate that the bridge concept can be realised from a technical structural point of view. In addition, the industrial characteristics proposed aims at ensuring efficient production and operation of the bridge. The economic aspects, however, show that there is a need for large production series and decreasing costs for FRP relative to currently conventional construction materials, in order to make the bridge concept competitive in today's market. On the other hand, if life-cycle costs and benefits such as short construction time and improved working environment are taken into account the prospective for the bridge concept looks much better.

References

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