

Conceptual design and construction of lightweight R-UHPFRC bridges

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Abstract

This paper is addressed to structural engineers motivated to design and build R-UHPFRC structures as cost-effective lightweight structures of original aesthetic expression. Basic principles and essential UHPFRC properties are outlined first. The conceptual design is illustrated by means of two designs in precast segmental construction, one for a railway bridge and one for a footbridge. The footbridge has been built in Switzerland and is in service since 2015.

Keywords: Ultra High Performance Fibre Reinforced Cementitious Composite materials (UHPFRC), R-UHPFRC, lightweight structure, footbridge, railway bridge, conceptual design, segmental construction, accelerated construction.

1 Introduction

“UHPFRC” stands for Ultra-High Performance Fibre Reinforced Cementitious Composite materials that are composed of cement and other reactive powders, additions, hard fine particles, low amount of water, admixtures and very high amount of relatively short and slender steel fibres.

UHPFRC materials have been developed over the last 30 years. Today, the best UHPFRC have significant tensile strain hardening behaviour and relatively high resistance both in tension and compression. To enhance the structural behaviour and resistance, it is advantageous to complement UHPFRC with reinforcing bars and prestressing. UHPFRC is a very compact material and is thus waterproof and crack-free under service stresses, thus providing a robust protection against water and chloride ion ingress.

These properties allow for the design and construction of lightweight structures that are effectively durable and have enhanced structural resistance when compared to concrete and steel structures. In addition, the environmental impact of lightweight UHPFRC structures is limited.

UHPFRC does not comply with the definition of “concrete”. UHPFRC is a fibre reinforced composite material and should thus not be called “concrete”. It is fundamental to understand UHPFRC as an independent material with specific properties. This is the first basic principle when designing with UHPFRC to build new structures, as it is the language and the terminology that makes a concept. The second basic principle is that UHPFRC shall be complemented in a targeted manner with steel reinforcing bars and prestressing in order to enhance structural performance, safety and robustness as well as economy of structural applications. Subsequently, the term reinforced UHPFRC (or short: R-UHPFRC) is used.

Today, the state-of-knowledge is sufficient to establish rational design rules for the application and implementation of “Structural UHPFRC” in structural engineering. Several standards exist already, for example, in Switzerland the Technical Leaflet SIA 2052 [1].

Persistent over-conservatism in structural engineering, over-regulated design and construction procedures and lack of incentives for structural engineers are the reasons why