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Ultra-High Performance Concrete and High Performance Construction Materials

Proceedings of HiPerMat 2020
5th International Symposium on
Ultra-High Performance Concrete and
High Performance Construction Materials
Kassel, March 11–13, 2020

Edited by
B. Middendorf
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Introduction

The ongoing development of construction materials, more precise analytical methods, and viewpoints from other disciplines enhanced their influence on construction and material sciences in the last years. Consequently, the knowledge about high performance materials and the possibilities for architects and structural engineers have leapt ahead significantly and will increase in the future. UHPC is one of the products that arose from this synthesis of interests, as there are new opportunities for innovative architectural designs, conductive concrete elements, photocatalytic cleaning of surfaces, self-healing potential of building blocks, smart construction materials, or new binders, to name a few. UHPC in particular has recently come to fruition as the worldwide efforts for standardisation will soon allow the regular application of this innovative material. Its widespread use will permit the design of sustainable concrete structures such as wide-span bridges, filigree shells, and high-rise towers and opportunities for spectacular architectural designs.

Every four years since 2004, we and our retired colleague Prof. Michael Schmidt provided a forum for the exchange of knowledge around UHPC and other advances in construction material science for the scientific and civil engineering community. Since then, we have decided to introduce these symposia as HiPerMat, referring to High Performance Materials in construction, their development, and their application with a more general scope.

With HiPerMat 5 on March 11-13, 2020 the 5th International Symposium on Ultra-High Performance Concrete and High Performance Construction Materials documents the actual state of development of application in the fields of:

- Material Science and Development
- Composite Concrete Materials
- Strength and Deformation behaviour of UHPC
- Durability and Sustainability of UHPC
- Design and Construction with UHPC
- Structural Modelling and Optimisation
- Lightweight Concrete Structures
- High-Precision Manufacturing for Pre-Fabrication
- Nanotechnology for Construction Materials
- Innovative Applications
- Smart Construction Materials

This volume contains the short versions (two pages) of all contributions that have been accepted for publication at HiPerMat 5.

Kassel, in February of 2020

Prof. Dr. rer. nat. Bernhard Middendorf

Prof. Dr.-Ing. Ekkehard Fehling

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Floating UHPFRC rafts for shellfish farming

Esteban Camacho, Juan Ángel López, Hugo Coll, Fernando Galán
Co-founders of Research and Development Concretes SL and Prefabricados Formex SL, Spain

1 Introduction

Nearly 45% of the EU mussel is produced in Spanish estuaries using a floating raft system made with eucalyptus wood. This 540 m^2 structure has a reduced lifetime and a high carbon footprint associated to the protection coatings. In 2015 the company RDC developed a raft (Utility Model nºES1147609U) made with Ultra-High-Performance Fiber-Reinforced-Concrete (UHPFRC) precast prestressed beams. The peculiarity of this application, under continuous movement in Aggressive Exposure Environment (EAE), made very convenient the installation of continuous site monitoring to control the evolution of its durability. In 2019, there are already more than 5.000 m^2 under operation and proving high resiliency and very low maintenance costs.

2 UHPFRC floating rafts

Design

Wooden rafts are used in Spain since 1900 due to their reduced purchase cost, lightness and flexibility. The structure produces up to 100 tons/year. However, its use has three main disadvantages: (i) Economic: it has an average durability of 12 years and needs periodic investment in maintenance. (ii) Industrial: each raft is built manually through a high-risk job in the inter-tidal zone using hammers. (iii) Environmental: it implies intense deforestation and the degradation of the wood and the products used to protect it cause water pollution.

A UHPFRC structure was designed with the same geometry as the wooden raft (20x27 m, Fig. 1), with 6 primary beams and 10 secondary beams (slenderness of 89 and 120 respectively) and with comparable weight (56 t), mechanical capacity and flexibility, but with the required resistance to the Aggressive Exposure Environment of the sea (XS2, XS3). The connection between the beams is bolted through a polyethylene prism that provides certain degree of flexibility, necessary to reduce the stresses produced by the continuous stochastic actions. Besides of the capacity under service, the design of the beam geometry and prestressing is constrained by several factors: (i) The release of the strands in production 18 h after casting, (ii) The handling of the beams during the assembling, (iii) The need of a minimum width to have a safe corridor for the farmers, (iv) The potential impact of a boat with the surface.

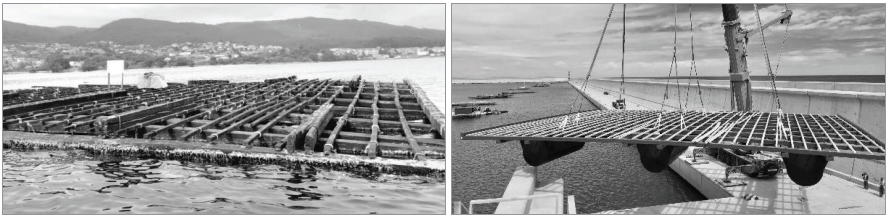

Figure 1: Traditional wooden raft (left) and UHPFRC raft floated in Valencia port (right)

The elements are produced at the precast company PREFFOR. The top face of the beams is textured to avoid slipping and the beam edges are rounded to reduce the friction with the ropes (Fig.2, left). The self-compacting UHPFRC fulfils the mechanical and durability requirements defined at the French Norm NF P18-470.

Figure 2: Detail of a connection (left) and placing of a beam (right)

UHPFRC rafts under service

The first raft was floated in October 2016. The sensors are proving no risk of corrosion in the beams, providing a resistivity more than 100 times higher than the value of the reference (a 25 MPa concrete beam on the raft). Periodic inspections to the farms have proven that the beams remain uncracked, as defined in the design, and only small rust spots are appreciated due to the corrosion of the fibers in contact with the surface. The UHPFRC connections have proven that they do not need retightening of the bolts as required for the wooden structures.

Future

In 2019, the European Commission launched the Blue Economy Report to support the sustainable development of the Blue Growth economy. The development of resilient and affordable infrastructures for the sectors of energy and aquaculture in open waters is crucial. Considering this, RDC is adapting now the design of the UHPFRC floating structure in the project OpenMode-863562 (co-funded by the European Maritime & Fisheries Fund (EMFF)). The new floating module has 140 m^2 and is adapted for open waters, connectable and sensor-equipped. The modules will measure remotely up to 14 parameters, correlating durability, mechanical, weather and water quality data. The project will test the capacity with eight pilots floated in five countries across three EU sea basins.

3 Conclusions

UHPFRC is an optimum material for a raft, a structure that needs to be light, slender and durable. The Integrated Sensor Network and cameras are proving their resiliency, so they are demanded by the Galician farmers because they are proving to minimize the operating expenses, being the most economical solution from the mid-term. The progress of the production experience curve for the aquaculture sector has led to a further development of the structure for multi-marine uses in open waters, which is now being tested under different marine, water and climate conditions.

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