Abstract

The reduction of green-house gas emissions is one of the global challenges that our society is facing and the production of cement plays a major role because concrete is the most used material worldwide. For every 1000 kg of cement produced, 900 kg of CO_2, are released in the atmosphere. In addition, for structural concrete, the generous concrete cover, prescribed by current codes of practice, yields to robust but also to relatively heavy and massive members.

Textile Reinforced Concrete (TRC) is a novel building material made of high-strength fabrics embedded in a fine grained mortar matrix. The implementation of non-corrosive reinforcement materials allows to reduce drastically the concrete cover requirements. That empowers to cast extremely thin-walled structural elements and to reduce the structural dead-load up to 90 % (with respect to conventional Reinforced Concrete). In addition to substantial material savings associated to the structure and its foundations, low-clinker-content cements can be used, since no passivation of the reinforcement is required. That, reduces further the environmental footprint and allows to build more sustainable load-bearing structures. Despite its advantages, TRC is hardly implemented in current engineering practice. On one hand there is a lack of design regulations, but on the other, there is also a shortage of construction experiences. With the aim to promote the widespread of TRC, this work addresses both hurdles at three different levels of analysis:

First, the tensile response of TRC is investigated by means of an extensive experimental programme. It includes, tests on bare fabrics, the plain mortar and composite tension ties. On the basis of the experimental observations and the coaxial ring analogy, a mechanical model has been derived, allowing to predict the deformation capacity and resistance in a unified manner. That is fundamental to understand the effects of fabric-coating, impregnation, tie- and load introduction length on the load-bearing behavior at a micro-level.

More complex loading conditions have been investigated at a meso-scale. Full-scale load tests of thin-walled flanged members have been instrumented with external photogrammetric measurements. These have allowed to validate and adapt the Elastic-Cracked-Stress-Field approach for TRC linear members. The method allows to model beam- and discontinuity regions in a comprehensive manner as well as predicting the response under serviceability conditions and at failure in a unified way, while accounting for both, bending and shear.

Finally, the application potential of TRC is addressed at a macro-level. Starting from previous ferrocement works, different formworking materials, casting methods and connections of thin walled members have been explored. The obtained results have been condensed to design, build and erect a full-scale, demountable, prototype pavilion within a three-weeks workshop.

Eventually, a proper architectural language has been derived for light-weight structures made of thin-walled TRC members. The structural design can be performed in a comprehensive manner with the Elastic-Cracked-Stress-Field approach, while the resistance of the composite can be estimated with the coaxial ring model. That contributes to the development of code-like prescriptions for TRC and its future implementation in common construction practice for sustainable structures.