Abstract

Combining the most recent technologies in concrete, Ultra-High-Performance Fibre-Reinforced Concrete (UHPFRC) arises as a promising material for the near future. UHPFRC have shown how flexible concrete can be to adapt to the ever-changing social and environmental demands. With its high flexibility composition and its mechanical properties, UHPFRC is full of both unexplored and unexploited possibilities. Engineers should take responsibility for this task. However, it is fair to acknowledge that this is not an easy task and it requires the development of reliable and widely accepted design standards provided by the scientific community.

It is a fact that the widespread use of new materials in civil engineering requires the development of specific guidelines. That became clear in the case of fibre-reinforced concrete at the beginning of the 21st century. Although this technology and the advantages of its application were already known since the early 70s, its extensive use in structural applications was restricted primarily due to the lack of a reliable and widely accepted design and characterisation standard. That should have been what researchers identified as a major drawback to be overcome at the end of the 20th century.

In 1995, the task of developing both a standard test methodology to determine the post-cracking behaviour of fibre-reinforced concrete and design guidelines in accordance with it, was assigned to the RILEM technical committee TC 162-TDF. Members of that committee were aware that both assignments were interrelated and had to be pursued together, otherwise, that work would have been doomed to fail. Thanks partly to that work, the use of fibre-reinforced concrete in civil engineering applications is now feasible and it is covered by international standards. Nevertheless, there is still a long way to go when dealing with new types of concrete.

A major concern about durability, long-lasting structures and reduction of maintenance cost, as well as the development of new concrete technologies, improved knowledge of fibre effect and a huge growth in the fibre industry accompanied by fibre price reduction have led, among other factors, to the development of new types of concrete whose mechanical behaviour substantially differs from conventional fibre-reinforced concrete. This is why current characterisation methodologies and design standards must be reviewed and adjusted to these newer materials. However, design standard revision cannot disregard former milestones achieved thanks to decades of hard work. It must offer an integrated view in which new types of concrete comprise existing ones in a broader group, because at the end of the day and despite having newer and improved properties, new types of concrete are still concrete. That is how it should be understood and how it must be reflected in newer codes and standards.

The work presented herein is focused on one of these recently developed materials that embraces major advanced technologies in concrete: Ultra-High-Performance Fibre-Reinforced Concrete (UHPFRC). This work is specifically focused on those crucial requirements for the development and widespread use of it, such as constitutive tensile characterisation and classification. This work includes a deep revision of the uniaxial tensile behaviour of concrete and its development as fibre technology has evolved. In addition, traditional characterisation standard methods as well as those recently developed for its specific use on UHPFRC are reviewed and called into question.

Throughout the document, the development of different methodologies to determine the uniaxial constitutive tensile behaviour of UHPFRC from bending tests are shown, together with a simplified characterisation proposal specially developed for being included in a standard. All developed methodologies presented herein are checked and validated. These methods are specifically designed for their application on experimental results obtained from a special type of four-point bending test, whose standardisation proposal for UHPFRC is also shown.

Finally, a classification proposal is presented as a function of more relevant UHPFRC tensile parameters necessary for design that can be directly obtained from the standard characterisation test method for UHPFRC suggested. Proposed classification encompasses the existing classification for conventional reinforced and fibre-reinforced concrete. In it, both plain concrete and fibre-reinforced concrete are presented as a particular case of a more general tensile constitutive response for concrete. Standard methodology and classification proposed are in accordance with the evolution of concrete and unify historic milestones achieved by the international research community.