

Textile reinforced inorganic phosphate cement composites: from static loading to low velocity impact

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The increasing demand on the resistance of civil engineering structures under accidental loadings has led to an evolution in research, shifting the focus from a structural design level towards solutions on material level. The development of new high performance cementitious composites has opened new possibilities concerning building materials. However, the available data on the dynamical behaviour of these materials is presently insufficient.

The aim of this work is to generate missing knowledge regarding the global response of textile reinforced cementitious composites (TRCs) under low velocity mass impact loading. The problem will be approached from two separate points of view: on one hand TRCs can be used as structural elements in a construction which needs to resist to a certain impact loading with sufficient residual stiffness and strength to provide safety for humans present within and around the structure. This approach thus focuses on impact tolerance. The second approach starts from the viewpoint of a sacrificial structure, in which the residual material properties are of no importance. Indeed, the absorbed energy in this case, should be as high as possible in order to protect the underlying load bearing structure.

This work is divided into two main parts: the first part provides an overview of the state-of-the-art on fibre reinforced cementitious composites (FRCs) and textile reinforced cementitious composites (TRCs). Subsequently, the chosen inorganic phosphate cement matrix (IPC) is described and compared to other cementitious matrices. Next, the mechanical and physical properties of the different fibre types to be used as reinforcement are described. Furthermore, an overview is provided on the mechanical properties of the selected TRCs under compression, tension, shear and bending. This part will use data obtained from literature as well as from additional experimental work. Finally, before proceeding to impact loadings, the effect of strain rate on the compressive behaviour of the IPC matrix and on the tensile behaviour of the TRCs is investigated. Although the obtained strain rates are still lower than strain rates under low velocity impact, the results provide a good indication on the dynamic constitutive behaviour of these materials.

The second part of this work characterizes the low velocity impact of the selected TRCs. First, a general overview on the low velocity impact behaviour of composite materials is given. In this overview, the analytical background and commonly used testing techniques are described. The experimental work within this part is divided in two chapters according to two different testing techniques. The first testing technique is a Charpy pendulum impact test, which investigates the local impact behaviour of relatively short beams under flexural loading. The aim of this experimental part is to investigate whether the present standard test method for composite materials can be applied on TRCs. Further a series of tests using different fibre types is performed in order to rank the selected materials according to their energy absorption capacity. A more quantitative test method that is commonly applied in composite testing is a drop weight test. During the impact, the contact force and the central displacement of the plate are measured. The obtained force-deflection curves can be used for damage interpretation and to determine energy absorption, which is equal to the area under the curve. In this chapter, drop weight tests are performed on glass-fibre reinforced IPC composites with different fibre structures. In addition to the instrumentation of the test, high speed camera images are obtained to capture the different damage phenomena. Finally, a method to analyse the results is discussed and applied.

To finalise this work some insight is given on possible opportunities for applications of TRCs as impact resistant or impact tolerant components in civil engineering. Guidelines for design of impact resistant structures using TRCCs will be proposed and the possibility of using numerical software packages to optimize the energy absorption of these materials is suggested.