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Study of mode II fracture on fibre-reinforced gypsum notched specimens

Fernando Suárez[1,*], Javier Fernández-Aceituno[1], Jesús Donaire-Ávila[2].

[1] Departamento de Ingeniería Mecánica y Minera. Universidad de Jaén. Campus Científico-Tecnológico de Linares. Avda. de la Universidad (Cinturón Sur) 23700-Linares (Jaén)

*corresponding author: fsuarez@ujaen.es

Introduction: Fracture on quasibrittle materials, such as concrete or gypsum, has been under study for decades. These studies have helped to understand what are the fracture mechanisms and the parameters that drive this phenomenon, giving rise to numerical models that can reproduce it using methods such as the finite element analysis. Nevertheless, mode I is clearly the best known fracture mode, since it has attracted much experimental work and has been used to define the formulation of some of the most successful numerical models. Nevertheless, in some occasions fracture results from a combination of modes I and II. In this regard, mode II fracture has been studied less often and not many examples can be found in the literature, partly because mode I fracture is more usual and partly because it is harder to experimentally induce fracture under mode II conditions. In this contribution, mode II fracture is studied on fibre-reinforced gypsum (FRG) specimens using two experimental setups; one defined by the Japanese standard JSCE-G 553-1999 [1] and another one corresponding to a push-off test, recently used with success for analysing shear fracture in fibre-reinforced-concrete [2].

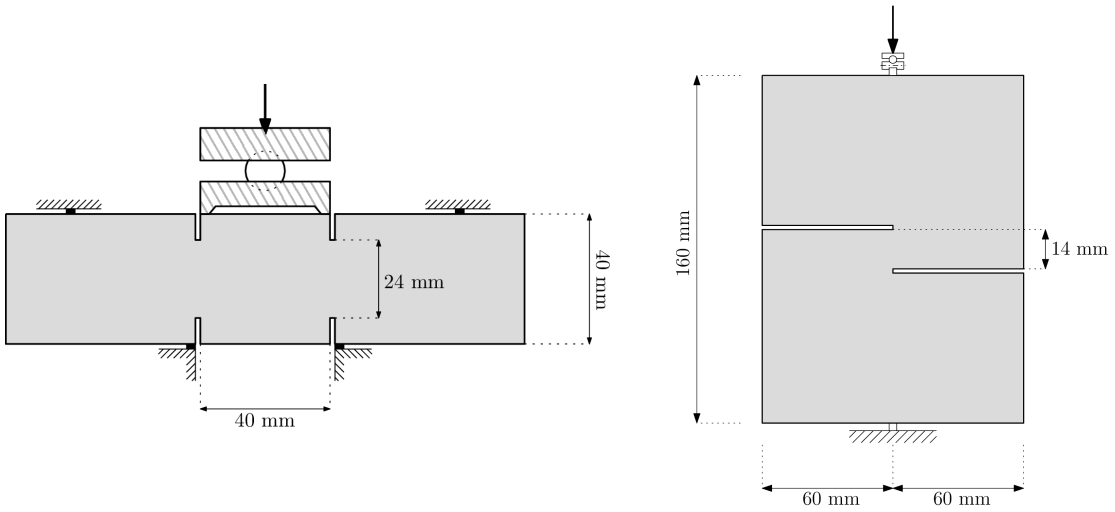

Figure 1. Japanese test (left) and push-off test (right) setups.

Materials and methods: FRG specimens are prepared using polypropylene microfibers, which reinforce the gypsum matrix in a homogeneous form, producing an isotropic material. As mentioned in the introduction, two setups are used, one described by a Japanese standard [1] to study fibre-reinforced concrete (FRC) under shear, and another one, the push-off test, carefully used with success to study polyolefin-fibre reinforced concrete (PFRC). Both methods test notched specimens and use carefully designed setups to guarantee that mode II is correctly induced. In both cases, tests are monitored by means of digital image correlation (DIC) techniques, which allow obtaining full-field evolution of strains during the tests [3].

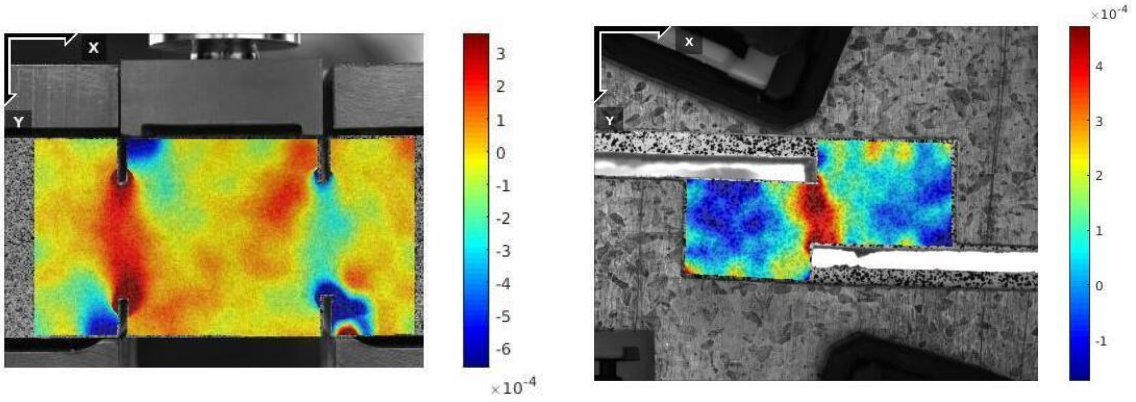

Figure 2. Shear strain (ε_{xy}) just before fracture starts in a specimen tested with the Japanese test (left) and with the push-off test (right).

Results: Polypropylene fibres clearly increase the shear behaviour of gypsum, as expected. FRG specimens have a more ductile behaviour than plain gypsum specimens and notably increase their fracture energy before collapsing.

Conclusions: Results obtained with the Japanese test do not provide an easy interpretation. Push-off tests prove to provide reliable results, although in some cases mode II is not reached, but an indirect mode I induced by flexural deflections in specific regions of the specimens. DIC techniques prove to be extremely useful when studying mode II in this type of materials, since they help measuring different strain components (ε_{xx}, ε_{yy} and ε_{xy}), which allows identifying the mechanisms involved in the eventual failure.

References:

[1] JSCE-G 553-1999. 2005. Test method for shear strength of steel fiber reinforced concrete. Standard Specifications for Concrete Structures, Test Methods and Specifications, Japan Society of Civil engineers (JSCE), Tokyo.

[2] Picazo Á., Gálvez J.C., Alberti M.G., Enfedaque A. "Assessment of the shear behaviour of polyolefin fibre reinforced concrete and verification by means of digital image correlation", Construction and Building Materials, 181; 565-578 (2018)

[3] Sutton MA, Orteu JJ, Schreier H. Image correlation for shape, motion and deformation measurements: basic concepts, theory and applications. Springer Science & Business Media; (2009)