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Interfacial strength study between a concrete substrate and an innovative sprayed coating

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HIGHLIGHTS

- Light mortar based on a silica aerogel solution for thermal rehabilitation.
- Mechanical characterisation at the interface with its substrate.
- Influence of stress concentration on experimental results.

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ABSTRACT

This paper investigates the mechanical behaviour, at a local scale, of a solution of a thick thermal insulation pneumatically placed from the outside for refurbishment. In particular, this study shows the strength of the critical area: the interface with its concrete substrate. It is possible to define the failure criterion of this interface using the slant-shear test. However, due to a difference in rigidity between the concrete substrate and the insulating coating, a numerical study is necessary to better understand the experimental results and to assess the possible stress concentrations at this interface, which could distort the experimental results.

1. Introduction

To meet the thermal refurbishment level required by the current standards in buildings, the addition of an external layer of insulation directly on the structure can be a useful solution in terms of thermal bridges and the thermal inertia of structures [10]. A recently patented insulating coating based on silica aerogels (super)-insulating materials has been developed. The invention is a light mortar (approximately 300 kg/m^3) principally composed of a mineral binder and an insulating filler comprising granules of hydrophobic silica aerogel. This coating has a thermal conductivity of 0.027 W/(m K) [11].

If a direct surface contact between this layer and a structural wall is considered, a load transfer from the wall to the insulating layer through the interface can be assumed. This load transfer could first provoke local failures in the coating, which could deteriorate its thermal insulating performance. Secondly, a large surface of coating can experience debonding during seismic solicitations such as during the earthquake in Lorca (Spain) on 11 May 2011 [1]. To better understand this complex behaviour, the mechanical properties of the materials as well as their interfacial strength must be known.

During solicitations, this interface can be submitted to multiple stresses and therefore, the failure criterion must be determined to verify whether or not the interface can support them. To assess the failure criterion of the interface, it is necessary to determine a sufficient number of representative points of the behaviour law, which means soliciting the interface with different stress states. In the literature, many local-scale tests have been used to submit an interface to different stress states, in tension, shear, or a combination of normal and tangential stresses (Fig. 1). The patch test developed by [5] is also a very common and well-known bond test.

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According to [16], each of these tests gives partial information on the overall mechanical behaviour of the interface. However, due to differences between the specimen's geometry and/or the loading path, it can be difficult to directly compare these tests because the bond strength obtained is highly dependent on the tests chosen. For this study, the analysis is limited to two types of tests generally used. The uniaxial tension test, called the pull-off test (Fig. 1(a)), is not presented in this paper because the results could not be used: the core drilling needed prior to this test damaged the coating material and thus disturbed the results, particularly for the thermal insulating coating. The second test is the slant-shear test (Fig. 1(e)), which submits the interface to a combination of normal σ_n and tangential τ stresses. By varying the interface angle, the interface can be submitted to different stress states. By performing each test until failure, the couples obtained (σ_n, τ) should let us characterise the bond strength of this interface and the shape of its governing criterion in the compression area.

2. Bibliographic study: the slant-shear test

2.1. Background and parameters

This test was first presented by Kreigh [14] and used to measure the bond strength between two resinous base materials, [2,6]. However, it is also widely referenced in the literature to assess the bond strength between two cementitious base materials such as in [4,12,13,16,21,23] and in several international standards, such as [7]. It is generally used with a 30° bond angle α (Fig. 2) to test two different concretes or mortars in order to measure the shear strength of a structural repair or reinforcement. By applying a compression stress σ_0 to the specimen, it is possible to deduce the combination of average normal stress $\sigma_{n,moy}$ (Eq. (1)) and shear stress τ_{moy} (Eq. (2)) at the interface. Thus, it is possible, according to [4], to represent the corresponding state of stress in a Mohr landmark. [4] has already used this

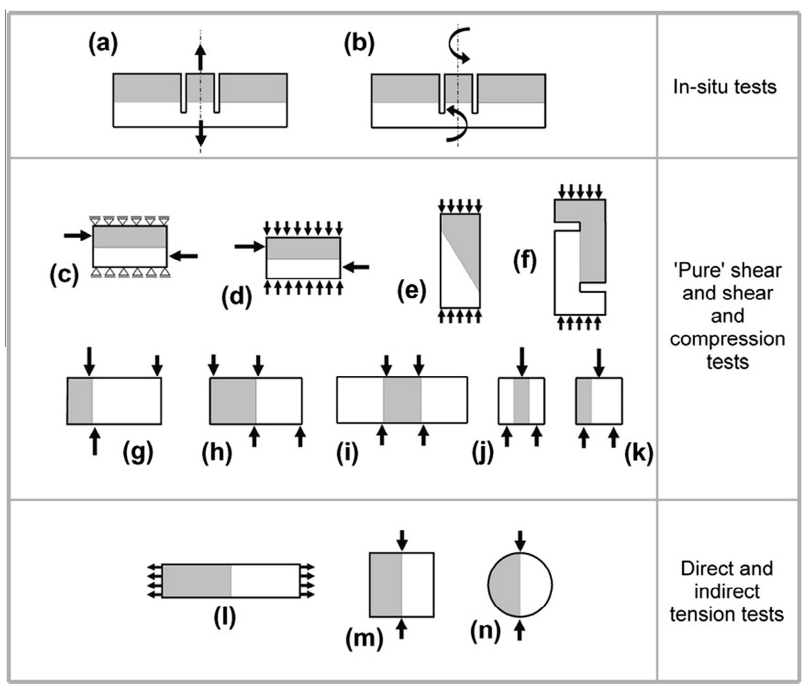

Fig. 1. Schematic description of different experimental tests to assess the bond strength between two materials, according to [8].

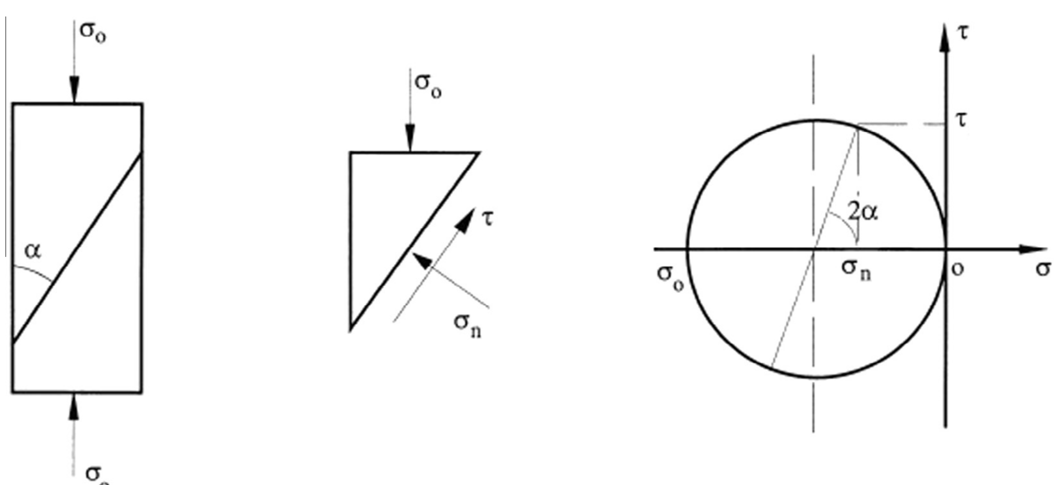

Fig. 2. Slant-shear test principle and state of stresses at the interface, deducted from the Mohr landmark, from [4].