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A rehabilitation study of sandwich GRC facade panels

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Abstract

Glass fibre-reinforced concrete (GRC) has been used for more than 30 years in the construction industry, especially in facade panels. In this paper, a rehabilitation case study is presented, of a building where cracking and excessive deformations were detected in the sandwich GRC facade panels due to thermal effects. The structural behaviour of the panels was simulated with a finite element method (FEM) model, validated by experimental tests performed on the facade, and then used to assess the efficiency of a repair technique, based on external insulation, which showed a good efficiency.

Keywords: GRC; Facade; Sandwich panels; Thermal effects; Defects; FEM; Rehabilitation; Repair

1. Introduction

Glass fibre-reinforced concrete (GRC) is a composite material that consists of a cementitious matrix in which short length glass fibres are dispersed [1]. The glass fibres confer the brittle matrix a more ductile behaviour, a much greater impact resistance and some tensile strength. These properties allow for the manufacture of thin walled elements, with important advantages when compared to alternative solutions such as reinforced concrete or steel plates.

This material has been used for more than 30 years in the construction industry in Europe, especially in facade panels, which are not usually designed as structural elements.

In early the GRC development, one of the problems of most concern was the durability of the glass fibres, which became fragile with time, due to the alkalinity of the cement mortar [1], leading to a reduced strength of the material. Since then, significant progresses have been made, and presently the problem is practically solved with the new types of alkali-resistant glass fibres and with mortar additives which prevent the processes that lead to the embrittlement of the GRC [2–4].

In this paper, a rehabilitation case study is presented, of a 20-year-old GRC building facade, where the ageing phenomenon was not taken into consideration in the manufacturing phase. At the time, no alkali-resistant fibres nor adequate additives were employed. Important defects were detected, namely extensive cracking and panel deformation. The facade is basically built with sandwich panels, of two outer GRC thin plates with insulation elements (expanded polystyrene and mineral wool) in between.

The finite element method (FEM) was used to assess the mechanical behaviour of the facade elements, taking into consideration the self weight and the temperature gradients. The numerical model was previously validated with results of experimental tests performed on the facade. The numerical analysis reproduced the defects

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detected in the facade inspection, leading to the identification of the respective causes.

To reduce the existing defects and prevent their evolution, several technical solutions were considered for the rehabilitation of the facade panels and simulated with FEM models. The results of the FEM simulations showed that the most effective repair measure was the use of an additional external insulating system.

2. Description of the facade geometry and pathologies

2.1. Facade geometry

The facade elements are 2.80 m wide and 3.25 m high sandwich panels (Fig. 1), with two external 10 mm thick GRC sheets, outside two 25 mm thick expanded polystyrene (EPS) sheets and a 30 mm thick mineral wool sheet in the middle (Fig. 2). The two external GRC sheets are connected by two vertical and two horizontal 10 mm thick interconnecting GRC laminas to provide global geometrical stability. The panels are supported at the bottom on the floor slabs with an identical 300 mm wide horizontal sandwich element. The facade panels have two vertical sandwich elements which are aligned with the vertical extremities of the window central opening and provide global stability of the facade. The facade panels are connected to the building pavement slabs (on the top and on the bottom) by means of bolted steel angles (Fig. 1).

The facade panels are 0.40 m distant from an interior 0.07 m thick brick wall (Fig. 2) next to the interior of the building where the ambient temperature has a constant value of 23 °C due to the air conditioning system.

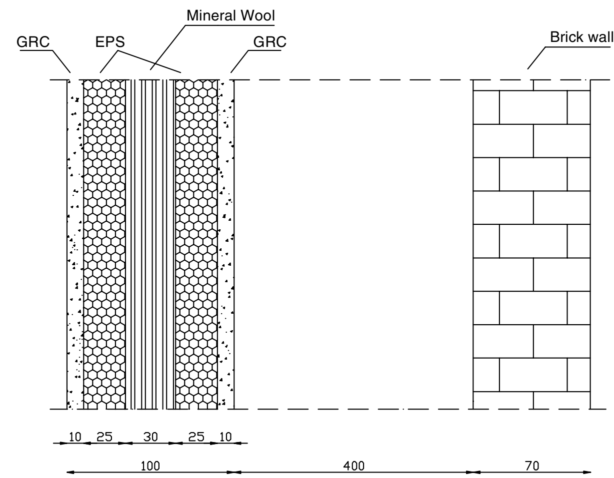

Fig. 2. Facade section (dimensions in mm).

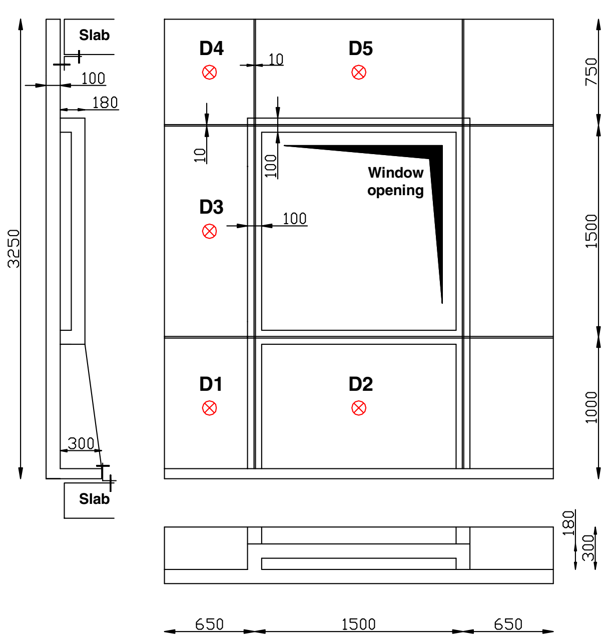

Fig. 1. Geometry of the facade panels – section, frontal view and plan (dimensions in mm).

2.2. Facade pathologies

The main defect detected in the facade panels consisted of extensive cracking with the following pattern: horizontal or vertical cracks near the window corners, coinciding with the GRC laminas (Fig. 3); vertical and horizontal cracks mainly in the upper zones of the panels; these cracks' openings are less than 1 mm and completely cross the GRC sheet thickness (Fig. 4).

In the interconnecting vertical laminas of the panels some cracking was also observed.

3. Experimental testing

Regarding the observed defects, two different effects were initially considered as potential causes, besides the degradation of the panels and their self weight, namely the thermal effects due to solar radiation and the inner water pressure (considering that the panels'

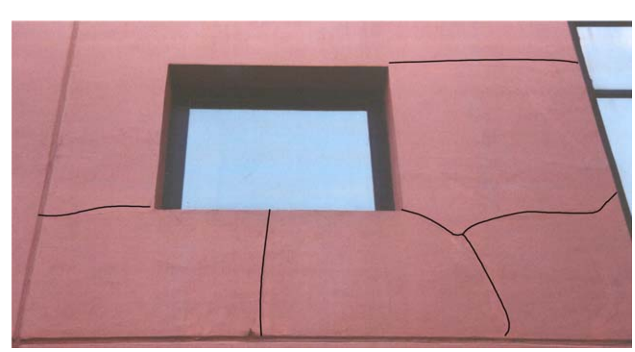

Fig. 3. Cracking pattern in the facade panels.