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Innovations on components and testing for precast panels to be used in reinforced earth retaining walls

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ABSTRACT

The present article introduces three innovations related to precast concrete panels to be used in reinforced earth retaining wall systems. These innovations concern the anchor system of the panel, the set-up of the pull-out test to assess the effectiveness of the anchors and the use of fibres as reinforcement. The viability of all this innovations has been proved by an experimental research program. Results show the advantages of these innovations in terms of performance and of production process.

1. Introduction

Reinforced earth retaining wall systems have proved their performance as a cost effective construction technique in a variety of applications (bridge abutments, mine dump walls, storage silos, haul road overpasses, containment dykes, dams, blast barriers, landscaping, among others).

The modern methods of soil reinforcement for retaining wall construction were pioneered by the French architect and engineer H. Vidal in the early 1960s. His research led to the invention and development of Reinforced Earth®, a system in which steel strips are used as the soil reinforcement element (see [1] and [2]).

Since the constitution of Reinforced Earth® several other proprietary and nonproprietary systems have been developed and used, see [3] for a partial summary of some of the current systems by proprietary name, reinforcement type, and anchor system.

Research and developments have taken several directions including: the use of galvanised steel mesh reinforcement, geosynthetic reinforcement, earth compacting systems, experimental contrasting methods and external appearance for improving its aesthetics [4]. However, the knowledge generated about the anchor of the panels has not been published due to the market strategies followed by manufacturers. Fig. 1 shows one of the most commonly used anchor system in Spain that appeared in the market in the lasts decades.

Cracking of precast panels may occur during the demolding, transport and storage tasks, as well as during the service life of the panels [4]. In that sense, some kind of reinforcement has to be provided in order to control the crack width. Up to date, the use of steel rebars has been the traditional option so as to resist these tensile stresses. However, new trends have appeared as alternatives to the traditional reinforcement. The structural fibres, both metallic and synthetic, might be one of the most important examples. Several remarkable applications related to the use of fibre reinforced concrete (FRC) have been reported in the international literature (see [5–7] for a summary of different applications). However, only a few examples related to the application of FRC in earth retaining structures have been previously published [7,8].

The main advantages offered by the use of fibres on these elements are:

- The control of the width of the superficial microcracks generated by the restrained shrinkage [9,10].
- The bridging effect of fibres in the cracks around the failure surface of the fastening elements. This phenomenon improves the internal behaviour to resist the punching shear action [11–13].
- A great capacity of energy absorption and deformability as well, to resist both static [14] and dynamic loads [15].
- The possibility of a partial or even a total substitution the steel rebars [16].

The mains goals of this article are: (1) study and also compare a new anchor system with the one traditionally used in Spain, (2)

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Fig. 1. U-shape anchor system.

present a new test set-up to measure the pull-out response of the anchorage and (3) present and discuss the results of an experimental campaign which involves several variables like the concrete cover of the anchor and different types and configurations of reinforcement (rebars and steel or polypropylene fibres).

2. Anchor system

The connection between the strip and the precast panel could be solved with a U-shape anchor, hereinafter RE (see Fig. 1). Its use requires interposed steel plates with a double joint holding the strips as illustrated in Fig. 2.

On the other hand, a pear-shape anchor (PS) (see Fig. 3) is being used by various precast panels manufacturers as an alternative to the traditional one. The new alternative presents the following related advantages in contrast with the RE anchor: (1) it requires a single pin for fastening the metal strip, which means time and cost reduction regarding the production of the panel; (2) the reduction of the number of joints leads to a decrease of the vulnerability facing the local forces originated as a consequence of incorrect manufacturing and accidental eccentricities (as it is presented in the Section 5).

Many different parameters may influence the structural response of the PS anchor; mainly: the inclination (φ) of the concrete failure surface, the concrete cover (c) and the maximum width of pear (s = 9.0 cm) (see Fig. 3). The average value of the angle φ ranges between 25° and 30° at failure for steel mesh reinforced slabs subjected to concentrated loads [17]. The improvement of the shear capacity and also the dowel action provided at FRC leads to an increase of φ [18,19]. Moreover, the experimental results show that c significantly affects the structural response of the anchorage system. In that sense, the less concrete cover the greater volume of concrete involved in the failure conical surface.

In the research herein presented, the strip was not considered as a variable because it was the same that is commonly used in the standard solution.

3. New test proposal

There are several test set-ups for assessing the capacity and performance of this kind of anchors. Fig. 4 shows the one used by the Eduardo Torroja Institute of Construction Science (IETcc) in Spain.

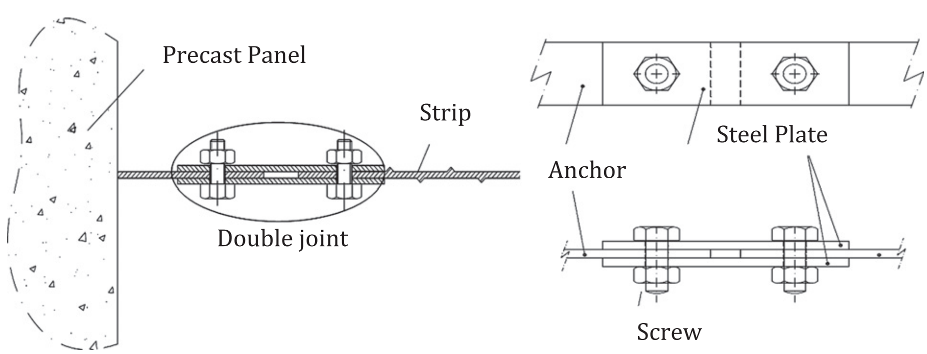

Fig. 2. Details of the RE anchor and its connection.

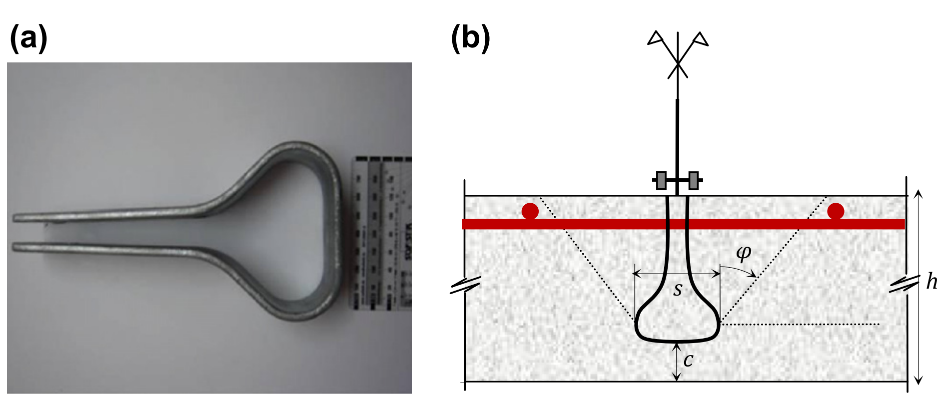

Fig. 3. (a) PS anchor analyzed and (b) anchorage failure mechanism.