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Pullout capacity development of cast in place anchors with embedded studs

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HIGHLIGHTS

- Pullout capacity of cast in place anchors with the embedded studs around the anchored rebar was performed.
- Influence of number of embedded studs and distance between the studs and anchored rebar were studied.
- Unconfined tension test was performed according to the guideline of European technical approval of metal anchors for use in plain concrete.
- Embedded studs increased the pullout capacity of cast in place anchored rebar.

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ABSTRACT

In this study, an experimental investigation was conducted on normal strength concrete to examine the pullout capacity variation of cast in place anchors with the embedded circular surrounding studs around the anchored rebar under monotonic loading. Keeping constant the compressive strength of concrete, diameter and embedment length of anchored rebar, influence of number of embedded studs and distance between the circular surrounding studs and anchored rebar were chosen as the experimental parameters. Studs were embedded circularly around the anchored rebar with 10 and 20 cm diameter and number of studs was 4, 6 and 8 in each layer. For control purpose, anchored rebar without embedded studs were also tested. Unconfined tension test was performed according to the guideline of European technical approval of metal anchors for use in plain concrete. Test results revealed that embedded studs increased the pullout capacity of cast in place anchored rebar, increasing the number of studs increased the pullout capacity gradually; however, there was no meaningful difference in the pullout capacity of anchored rebar with the increase of stud layer.

1. Introduction

The pull-out test measures the force required to pull out a cast-in steel rod from the concrete element. With this measured force, bond strength is determined. Bond strength is an important structural property of reinforced concrete and refers to the adhesion between reinforcing steel and surrounding concrete which is responsible for transfer of axial force between these two materials thereby ensuring strain compatibility and their composite action [1]. Generally, in composite materials, forces are transferred between two materials through two types of actions: physicochemical (adhesion) and mechanical (friction and bearing action). These actions are activated by various states of stress. The relative importance of these actions depends on the characteristics of the reinforcement bar (geometry and steel type, and bar spacing), the surrounding matrix (packing grade, and fiber type and amount), concrete strength, concrete cover and confinement [2–9].

Existing reinforced concrete structures should be assessed according to their materials and structural performances under seismic loads, however, in Turkey and many other countries, existing constructions, especially in seismic areas, have been designed only for gravity loads and/or low strength concretes according to outdated seismic design codes, thus resulting low ductility and lack of sustainable structures. As explained earlier, physicochemical (adhesion) and mechanical (friction and bearing action) actions between the concrete and anchored rebar mainly depend on the characteristics of reinforcement rebar and concrete quality. However, as it is well known, existing constructions, especially older than the 25 years old, exhibit poor bond performances due to the low concrete strength and durability so to develop the bond performance of existing constructions only anchoring rebar might not be

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good solution for reinforced concrete structures retrofit. In the literature, researchers conducted several studies to improve the bond characteristics of the existing structures by changing the anchored rebar geometry and steel type, bar spacing, concrete cover, concrete strength and confinement. Alavi-Fard and Marzouk [10] studied the bond of high strength concrete under monotonic pullout loading. The range of compressive strengths tested was between 70 and 95 MPa. The influences of load history, confining reinforcement, bar diameter, concrete strength, reinforcement spacing and rate of pull out were investigated. The test results revealed that the bond strength of high-strength concrete is higher than the corresponding normal strength concrete. However, the bond behavior of high-strength concrete is more brittle in comparison with normal strength concrete. Al-Hammoud et al. [11] investigated the confinement effect on the bond behavior of beams under static and repeated loading. The test variables included the corrosion level of the tensile reinforcement, the anchorage length, the stirrup spacing and the fatigue load range. It was found that decreasing the stirrup spacing increased the bond capacity and changed the mode of failure under monotonic loading from splitting to pullout.

However, this paper describes research with intent to characterize the effects of embedding the one and two layer circular surrounding studs around the anchored rebar. Influences of embedded stud numbers and distance between the studs and anchored rebar on the pullout performance were investigated by keeping constant the concrete compressive strength, anchored rebar diameter and embedment length. For control purpose anchored rebar without embedded studs were also tested.

2. Test program

2.1. Details of pullout specimens

A large full-scale unreinforced pullout specimen (concrete block) produced with normal strength concrete was tested in this study. The specimen was 3500 mm length * 350 mm height * 600 mm width. Schematic view, section and top view of the specimen was presented in Fig. 1. Specimen was considered as divided to seven equal sets and each set had an centrically embedded rebar (ribbed 16 mm diameter) at the center; each embedded rebar had 250 mm in contact with the concrete and protruded 750 mm from the top of the pullout specimen. The 750 mm length protruded part was selected in order to have enough length to mount the hydraulic pullout jack, load cell, tripod and the end

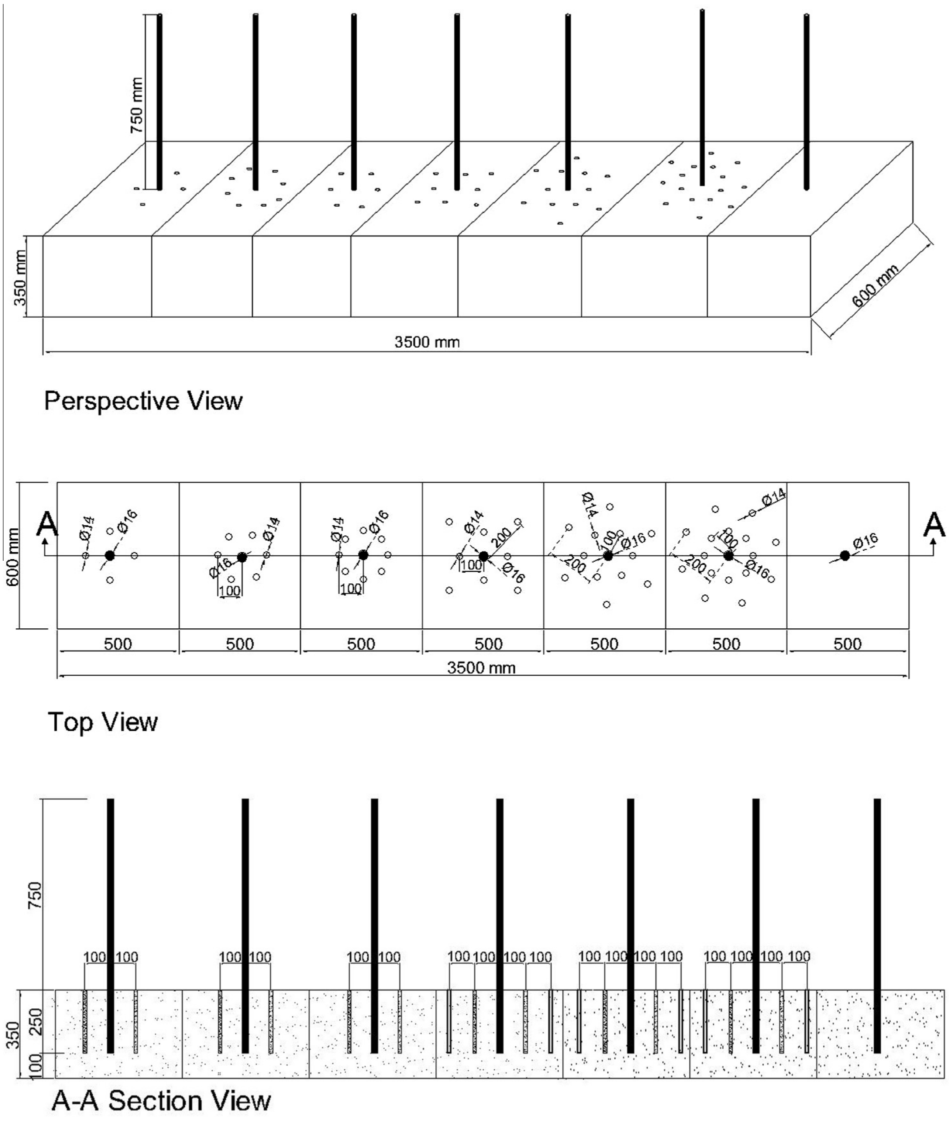

Fig. 1. Details of pullout specimen.