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Influence of surface shape of glued anchors on their load capacity

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Abstract

The surface shape of the anchorages and their effect on the adhesion stress were analyzed. Anchors made of plain and threaded rods were put together. It was assessed whether a smooth bar in this type of anchorages could ful fill the actual role of a connector. Groups of anchors in various anchor systems were put together and smooth anchorages compared to threaded anchors. Four types of diameters were considered: ⌀ 8 mm, ⌀ 10 mm, ⌀ 12 mm and ⌀ 20 mm.

Keywords: anchors, adhesion stress

1 Introduction

The issue of steel adhesion to concrete has already been the subject of consideration over 100 years ago ([6]. Currently, these types of issues are dealt with, among others [5, 7, 12]. There are various methods for checking the adhesion of steel to concrete. It depends mainly on steel, namely whether steel bars (anchors) are smooth, ribbed, or threaded anchors. It also depends on how the anchor is installed, namely whether it is concreted (only in laboratory conditions) or anchored in concrete via resin. The topics discussed are based on pilot studies conducted by the author (D. Tomaszewicz) and main studies, whose assumptions at least in the pilot part concerned the testing of samples in various systems: as uniformly concrete, three-layer without reinforcement and three-layer with mapped reinforcement. Tests which, in addition to testing the adhesion of rods / anchors in concrete, included the safety of installations in dry and wet ground, behaviour under constant load, operation in freezing / thawing conditions (anchoring in difficult conditions), anchoring to the maximum depth, proper resin injection, taking into account cleaning of the holes , with the task of demonstrating that glued bars behave like concreted bars. Before performing new anchorages, after a specified period of time and continuous storage of the samples (they constituted a section of the three-layer wall of a large-panel building) in the open ground, which was constantly exposed to the effects of weather conditions, a scan of mapped reinforcement from the three-layer wall of a multi-panel building was carried out. Then reinforcement scanning was repeated with a reinforcement detector with additional glued anchors installed. The results of these tests were used for subsequent analyses of the durability of new anchorages and their impact on the operation of the structural system, in this case external three-layer walls in multi-panel buildings [1, 3, 9, 10].

2 Shaping of bonded anchors and their impact on load capacity in concrete

The location of the place of glued anchor has a significant impact on the formation of the connection in contact zones in the relationship: resin - concrete and resin - steel anchor. This article shows several adhesive anchor systems that can be used in concrete, available on the Polish market. One of the solutions offered by Polish producers of anchoring systems is the HAS-5.8 anchor rod (Fig. 1).

The adhesion of a steel element to concrete depending on its shape was already described before the outbreak of World War II [4]. Bonded anchors, regardless of their shape, have the advantage of not transferring initial stress to the substrate. Therefore, they can be mounted close to the edge of a concrete base, which can also be relatively thin. A very interesting solution of glued anchoring is the Fischer Highbond system (Fig. 2). The shape of the anchor

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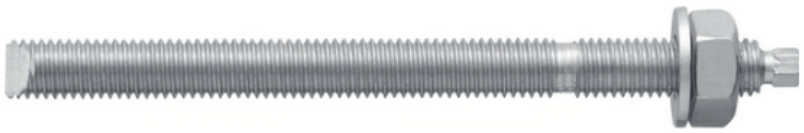

Figure 1. Anchor rod HAS-5.8 M12 x 110/128 (www.hilti.pl)

causes additional circumferential pressure on the surface of the hole made in concrete when it is pulled out in cracked concrete.

Figure 2. View of the Fischer Highbond FHB II-A Linjectionanchor (www.fischerpolska.pl)

In the context of three-layer walls of large-panel buildings, this is important because in the event of unfavourable work of the slab in the wall and the increase in the width of the cracks, the resin is compressed causing pressure on the widening hole. This situation causes a lot of resistance when trying to pull out.

One of the most popular systems for strengthening the outer sandwich walls of large-panel buildings are reinforcements in the form of K2 anchors (Fig. 3), fixed in a C12 / 15 concrete base. The K2 anchor has ITB Technical Approval KOT-2018/0495 edition 1 and is used only as a horizontal fastening.

Figure 3. View of the K2 anchor for reinforcing three-layer walls (www.inwestbud.com.pl)

The COPY-ECO system is a very well-known system for strengthening the walls of three-layer large-panel buildings. This system consists of two connectors in the form of a horizontal anchor and a diagonal anchor (Fig. 4). By the nature of the work, this system reflects the work of the three-layer buildings of large-panel hangers existing in the walls.

The COPY-ECO system has technical approval has the Technical Approval ITB AT-15-6916 / 2014.

3 Stresses occurring during testing of the pull-out strength of the anchor

Stresses during testing the load capacity of tensile bonded anchors can be divided into stages [8]. In the work [11], a model of destruction of the adhesive connection in the form of a certain formula was developed, which is the first step to build more accurate models for anchoring systems. The approximate formula for predicting the strength of pulling out an anchor stuck from concrete was developed on the basis of own research [2]. In this article, standard glued threaded anchors were considered as systems for new additional connections, strengthening the durability of three-layer elements as one unit's work, and smooth bars that corresponded in the walls of three-layer large-panel buildings, elements of reinforcement joining layers of panels in the walls with each other, i.e. "Hangers". Adhesion stresses for threaded anchors are determined according to the formulas known in the literature (1, 3):

Figure 4. View of the COPY-ECO anchor system strengthening the external wall panels of large-panel buildings: a) horizontal M12 x 190 mm anchor, b) M12 x 330 mm diagonal anchor

Adhesion stress for threaten anchors:

- breaking the resin-steel anchor connection:

$$\tau_{anchor} = \frac{P}{\pi \cdot d_{anchor} \cdot h_{ef}} \left[N/mm^2\right] \tag{1}$$

where:

τ_{anchor} - steel anchor adhesion stress, $\left[N/mm^2\right]$

P - anchor pulling force, $[N]$

d_{anchor} - steel anchor diameter, $[mm]$

h_{ef} - effective depth of anchoring in the construction layer of the solid element (bottom solid element)

Adhesion stresses for smooth anchors:

- breaking the resin-steel anchor connection:

$$\tau_{anchor} = \frac{\frac{P}{\pi \cdot d_{anchor} \cdot h_{ef}}}{1.5} \left[N/mm^2\right] \tag{2}$$

where:

τ_{anchor} - steel anchor adhesion stress, $\left[N/mm^2\right]$

P - anchor pulling force, $[N]$

d_{anchor} - steel anchor diameter, $[mm]$

h_{ef} - effective depth of anchoring in the construction layer of the solid element (bottom solid element)

1.5 - estimated value of the reduction coefficient determining the adhesion stress for smooth anchors

Adhesion stress for threaded anchors:

- breaking the resin-concrete connection:

$$\tau_{hole} = \frac{P}{\pi \cdot d_{hole} \cdot h_{ef}} \left[N/mm^2\right] \tag{3}$$

where:

τ_{hole} - adhesion stress of the binding agent (resin), N/mm^2

P - anchor pulling force, $[N]$

d_{hole} - hole diameter, $[mm]$

h_{ef} - effective depth of anchoring in the construction layer of the solid element (bottom solid element)

Adhesion stresses for smooth anchors:

- breaking the resin-concrete connection:

$$\tau_{hole} = \frac{\frac{P}{\pi \cdot d_{hole} \cdot h_{ef}}}{1,5} \left[N/mm^2\right] \tag{4}$$

whre:

τ_{hole} - adhesion stress of the binding agent (resin), $\left[N/mm^2\right]$

P - anchor pulling force, $[N]$

d_{hole} - hole diameter, $[mm]$

h_{ef} - effective depth of anchoring in the construction layer of the solid element (bottom solid element)

1,5 - estimated value of the reduction coefficient determining the adhesion stress for smooth anchors

4 Comparison of load capacity for pulling out smooth and threaded anchors

Four diameters of threaded and smooth anchors were analysed. Based on the formulas (1, 2, 3 and 4) a graphical interpretation was created (Fig. 5) comparing the load capacity of tensile bonded anchors with a threaded surface and a smooth surface.

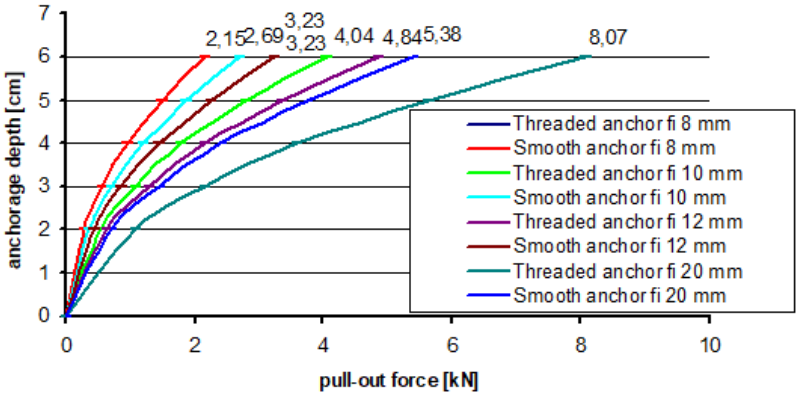

Figure 5. Dependence of the pull-out force of the anchor on its diameter and anchorage depth

Analysing the graph in Figure 5, it can be concluded that the use of smooth anchors is not practical, at least due to the fact that the adhesion stress obtained during the pulling tests is much lower than in the case of threaded anchors. In order to achieve better or comparable reinforcement effects, two times more smooth rods than threaded rods should be used. To ensure safe transfer of shear loads caused by the weight of the façade layer, the additional texture should not be used for anchoring additional bonded anchors with a diameter less than 12 mm.

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