Bearing capacity of anchors in thin aerated concrete masonry under tension and shear loading

Volodymyr Verba[1], Younes Charaf[1], Tahri Ouassim[1]

1. Department of Building Constructions and Bridges, Lviv Polytechnic National University, UKRAINE, Lviv, S. Bandery street 12, E-mail: volodymyr.b.verba@lpnu.ua

Abstract – This article is devoted to a problem of anchoring strength of anchors (wall plugs) in thin aerated concrete blockwork. Aim, research tasks and programme of experiment are represented.

Keywords – anchors in masonry, aerated concrete blockwork, frame anchors, tension, shear, research program

I. Introduction

Cellular concrete masonry systems are commonly used in civil and industrial construction. However these structures has to be fastened to reinforced concrete or metal frames in multi-storey buildings. In other hand in one- or two-storey buildings aerated concrete blockwork can be a base structural material. In both cases a suitable fastening should be guaranteed. For such reason anchors of different types are used.

Masonry is a heterogeneous base material. The hole being drilled for an anchor can run into mortar joints or cavities. Owing to the relatively low strength of masonry, the loads taken up locally cannot be particularly high. Futhermore, masonry made of aerated concrete which is manufactured from fine-grained sand as the aggregate, lime and/or cement as the binding agent, water and aluminium as the gas-forming agent with the density between 0.4 and 0.8 kg/dm³ and the compressive strength 2 to 6 N/mm² results in even lower strength of anchoring [1].

Many anchors obtain their holding power from a combination of three working principles: friction, keying, bonding. The weakest point in an anchor fastening determines the cause of failure and its mode. There are 4 main modes of failure which are as follows: 1) break-out; 2) anchor pull-away; 3) failure of anchor parts and 4) edge breaking.

The tensile strength of the fastening base material (aerated concrete in our study) is exceeded in the cases of break-out, edge breaking and splitting. Basically, the same modes of failure take place under a combined load. The mode of failure 1. break-out, becomes more seldom as the angle between the direction of the applied load and the anchor axis increases.

Generally, a shear load causes a conchoidal area of spall on one side of the anchor hole and, subsequently, the anchor parts suffer bending tension or shear failure.

The properties of the base material play a decisive role in selecting suitable anchor and determining its bearing capacity. Another factor that influence much is the length of anchoring. Thus the aim of current research became bearing capacity of anchors in thin aerated concrete masonry under tension and shear loading.

In order to reach aim of research we have to solve several tasks that are as follows:

– to do literature review ;
– to evaluate physical properties of aerated concrete by checking its compressive strength;
– to design and manufacture laboratory models of thin masonry that meets our aim and mount anchors of two types;
– to determine experimentally mode of failure and bearing capacity of anchors in blockwork thin specimens subjected to loadings which are parallel and perpendicular to the anchor axis;
– to test anchor metal screw with a hook in order to measure mechanical properties of steel used;
– to compare obtained results with other researches [1, 2, 3];
– to prepare some recommendations or amendments to current design code for aerated concrete masonry [3].

Following programme and methodology of experiments are proposed.

II. Experimental Programme and Methodology

For securing support frames, timber frames, fascade panels etc. frame plastic anchors with screws are used. We used KPR-12x100N nylon plug with Ø8 woodscrew with an O-shape hook for testing with loading applied parallel to anchor axis and PR-8x100 nylon plug with L square shape screw for testing under shear loading. Both were manufactured by Wkret-met (Poland) (see Fig. 1).

Fig.1 Shape of anchors used in research: a) KPR-12x100N; b) PR-8x100

For experiments we also prepared 4 masonry fragments, 2 per every type of loading. The shape of test specimens is shown on Fig. 2.

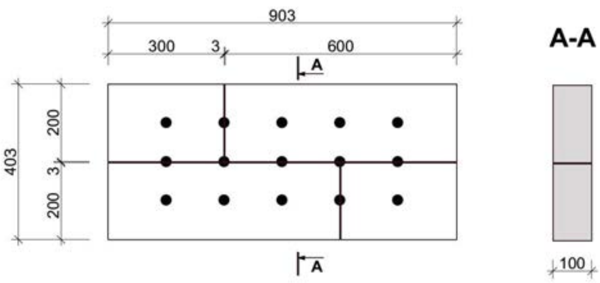

Fig.2 Shape of test masonry specimens

Each specimen consisted of two masonry rows with 1.5 blocks in a row. We used prefabricated autoclaved aerated concrete blocks AEROC Classic (D500 density grade) with declared compressive strength not less than C2.5 class. Nominal sizes of blocks were 600×200×100 mm.

Blockwork was made with thin mortar layers with the depth of the mortar set to 3 mm or less. Pre-mixed cement-based mortar produced by local manufacturer (TERMIT™ TK-16) was applied to the bed joints and perpends. Places where anchors were applied are marked on Fig. 2 as black dots. Holes were drilled with drill bit Ø12 mm for KPR-12x100N and Ø8mm for PR-8x100 without hammering. Length of both anchors were 100 mm.

After mounting the anchors specimens were tested. They were laying in horizontal position. Two supports were placed on specimen to create vertical tension loading on anchor's hook. The loading was done by talrep M12 with hooks and measured by ring dynamometer. PR-8x100 anchors were tested horizontally by the same devices. Measuring and loading devices were connected with anchor and support by metal chain. Loadings were applied in case of tension until anchor displacement was 10 mm and shear loading – until metal screw was bent so far that angular displacement became more then 45˚. The common view of experimental stand for two experiments is shown on Fig. 3 and Fig. 4.

After main experiments on anchors bearing capacity four cubes of 100 mm edge were sawn from blocks that were not damaged to obtain aerated concrete compressive strength. They were precisely measured and weighed to check declared density grade of blocks and compressed on laboratory press P-125 with 62.5 kN measuring scale. Aerated concrete moisture was measured by electronic testo™ 606-1 moisture meter by taking data from more then 10 points of several different blocks.

Fig. 3/ View of experimental stand for tension loading.

Fig.4 View of experimental stand for shear loading.

Expected characteristic resistance F_{Rk} for KPR-12x100N in masonry made or autoclaved aeretad concrete with density ≥350 kg/m³ and compressive strength class ≥2 MPa is 0.75 kN according to ETA-12/0272 [2]. Characteristic bending resistance of the screw in concrete and masonry for anchor Ø8 mm is $M_{Rs,k}$=9.3Nm with partial safety factor γ_{Ms}=1.25 for galvanized steel. Displacements under shear loading F=0.11 kN for anchor Ø8 mm should be δ_{NO}=0.21; $\delta_{N\infty}$=0.32 mm. Partial safety factor for use in autoclaved aerated concrete γ_{MAAC}=2.0 in absence of other national regulations.

Conclusion

Modern Ukrainian design code for cellular concrete blockwork construction [3] sets usage of anchors for fastening as common practice, the only limitation is that theirs bearing capacity under tension should exceed 0.25 kN. Other parameters should be measured by experiment. As for data written in above paragraph they were obtained for walls with minimum thickness 250 mm. We suppose there is a lack of data about bearing capacity of anchors in thin aerated concrete masonry thus we focuse on it in our research. Aim, research tasks, programme of experiment and methodology in details are presented in this thesis.

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