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Strain angle and stiffness shear walls with openings made of AAC masonry units

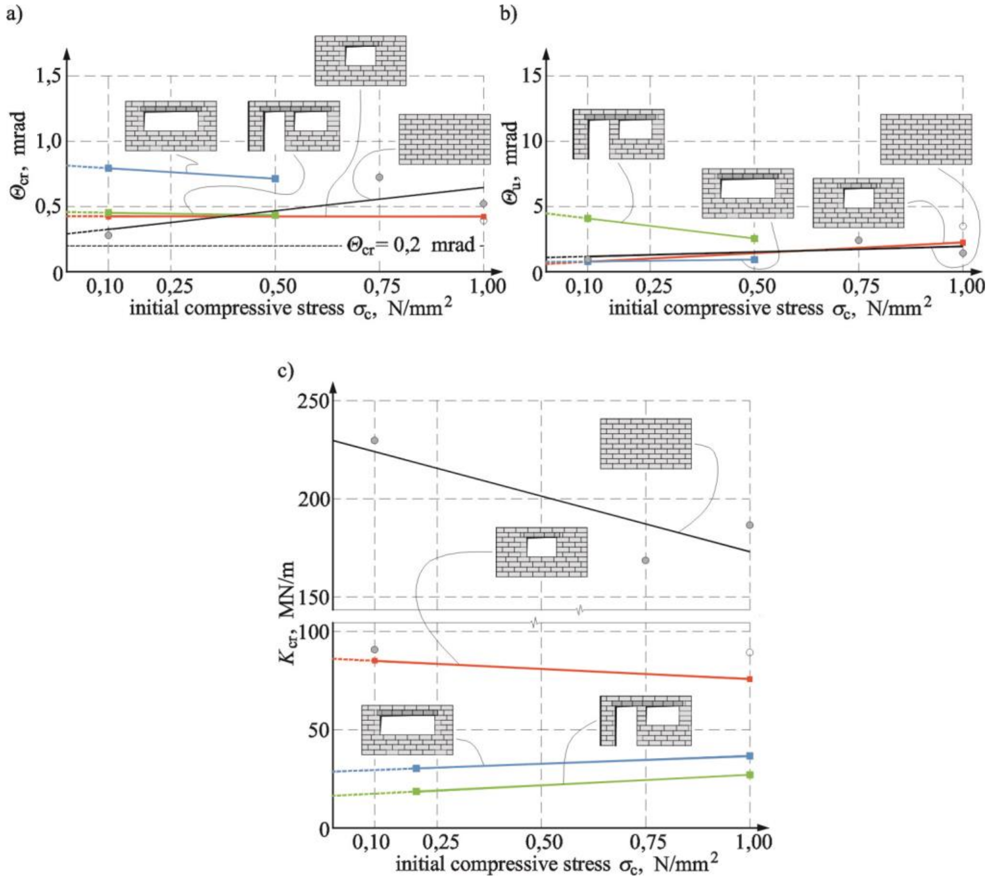
Abstract. The article presents of own results of the 10th walls (l × h × t = 4.43 × 2.43 × 0.18 m) subjected to shear loads made ofAAC masonry units. Three types of openings (A, B and C) were formed in the walls, different in terms of shape and dimensions. The elements were tested at different initial compressive stresses. The results of the research were analyzed in terms of the influence of initial compressive stresses on the non-dilatational strain angle at the time of cracking and the deformations angle obtained at the highest shear stress. Empirical shear stiffness of the wall with openings is also presented as a function of initial compressive stresses.

Keywords: AAC; shear walls; walls with openings; non-dilatational strain angle, deformation angle, shear stiffness.

Information from the articles [1, 2] on cracking morphology and shear stress at the time of cracking may somewhat describe the behaviour of stiffening walls (shear walls). Observations on formation and development of cracks can be useful for determining the stress state of a stiffening wall. The approach to determine the stress state on the basis of the deformation state - a change in the global angle of shear strain, seems to be safer in practice [3, 5, 6, 7]. This article presents results from testing shear deformation of stiffening masonry walls made of AAC. It also gives values of deformation and stiffness at the time of cracking and corresponding shear deformation values at the time of the highest shear stress values. Test results for walls with openings were compared to results for walls without openings tested under the same initial conditions. The article [1] describes a model structure, material properties and test techniques, and the article [2] presents stress values at the time of cracking and failure. Strain measurements The frame measurement system, adjusted in terms of size to cover the maximum wall area and simultaneously to neglect boundary disorders caused by the stand supports, was used to record changes in shear strain and deformation values. The terms global angle of shear strain or global angle of shear deformation at the post-cracking phase were used to describe the wall behaviour under horizontal loading. Knowing the global angle of shear strain and corresponding shear stress, we can determine the global wall stiffness K calculated from the following relationship:

$K = H/u = (\tau/\Theta)\,(A_h/h)$ (1)

where: K – shear stiffness; H – horizontal shearing force; u – relative horizontal displacement of upper and lower wall edges; τ – shear stress; Θ – angle of shear strain or deformation h – wall height; $A_h = l \times t$ – surface area of wall calculated for supporting plane.



Results of tests of stiffening walls as a function of initial compressive stresses: a) non-dilatational strain angle at the moment of scratching; b) angle of deformation; c) stiffness of walls at the time of cracking

Strain angle (non-dilatational) Θ_{cr} determined at the force H_{cr} (the force causing the visible formation of new cracks) was called the shear strain angle at the time of cracking, and called the deformation angle Θu at the strongest force H_u. The wall stiffness K_{cr} was determined at the time of observing first cracks. Test results and their analysis Figures a and b show values of shear strain angle Θ_{cr} and deformation angle Θ_u for walls with A and B-type openings of HAS-AAC, HBS-AAC and HCS-AAC series, and walls without openings of HOS-AAC series. Figure c illustrate a change in stiffness K_{cr} as the function of compressive prestresses. Prestress values had different impact on Θ_{cr}. In walls with A-type opening tested at compressive prestress of 1.0 N/mm^2, there was no increase in strain values in comparison to strain in the wall at minimum compressive stress. At the time of failure, there was nearly a 3-fold increase in values Θ_u. In walls with B-type opening, strain values at the time of cracking were lower by 10% than in a wall at minimum compressive stress. At the highest compressive stress values, shear deformation was greater than in the wall at minimum compressive stress. At the time of cracking walls with C-type opening displayed a tendency similar to the behaviour of models with B-type opening. In walls without an opening, shear strain was quite similar. A clear deviation was observed at the time of cracking in walls with B-type opening, and at the time of destruction in walls with C-type opening. This figure presents the acceptable value of shear strain angle Θ_{adm} = 0.2 mrad according to the standard PN-B-03002:2007 [4]. In all tested walls, cracks were observed at considerably greater strain values. Therefore, acting in line with national recommendations seems to be safe, and maybe too cautious. Stiffness at the time of cracking Kcr in the wall with A-type opening at maximum compressive stresses was lower than at minimum compressive stress. The wall without an opening (Figure c) displays a similar tendency. Stiffness in walls with B- and C-type openings clearly increased with increasing compressive stress values.

Conclusions

Test results show that:

- compressive prestresses caused, depending on the wall geometry, a change in shear strain angle value at the time of cracking and failure;
- the angle Θ_{cr} value at the time of cracking was greater than the limit value Θ_{adm} = 0.2 mrad set out in the standard [3];
- Θ_{adm} values can be helpful in practice to verify SLS conditions of stiffening walls, albeit too cautious for walls with openings;
- a change in shear strains caused a similar change in stiffness at the time of cracking.

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