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BEHAVIOUR OF CONCRETE MASONRY UNITS IN COMPRESSION

BY

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Abstract. Compressive strength values obtained on concrete masonry units with vertical circular holes in comparisons with compressive strength values obtained on concrete masonry units with circular holes filled with mortar are presented. The experimental program was conducted at the Laboratory of composite Materials in frame of Faculty of Civil Engineering and Building Services, “Ghorghe Asachi” Technical University of Iasi. The authors present a comparison of the compressive strengths. The peak values of principal stresses have been checked by a numerical modelling.

Keywords: concrete masonry units (CMU), vertical circular holes (VCH), compressive strength, finite element analysis (FEA).

1. Introduction

Masonry buildings have an important role in energy consumption around the world. Comparative recent studies are based on the environmental

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impact analysis of the ceramic and concrete brick walls (Maia de Souza *et al*., 2016) obtained from different manufacturing methods and using local natural resources. One of the major drawbacks of unreinforced masonry structures is the fragility under the effect of a seismic actions (Rinaldin and Amadio, 2018). Mechanical behaviour of different types of brick, lightweight concrete or stone masonry shows all time a common feature a very low tensile strength.

When new building products are placed on the market, their mechanical characteristics must be carefully checked in accordance with international standards (C109/C 109 M-07, 2008), European standard (EN 772-6, 2001) or local standards (SR EN 12390-3, 2005; SR EN 196-1:2006).

Compressive strength of concrete masonry units is an important parameter required for the designing of vertical structural elements such as structural masonry walls, separating walls, structures for fences, chimneys, formwork for reinforced concrete columns or for the designing of horizontal member like lintels. In this paper, the authors tested a series of concrete bricks with circular hollows at compression and compared the values of concrete bricks with holes filled with cement mortar.

2. Experimental Tests

Concrete bricks are obtained in the factory in special molds by pressing. After 28 days of the VCHs filling with cement mortar, the concrete bricks were prepared for compression tests at 48 hours and 7 days. The two circular ribs of the concrete brick, Fig. 1*a*, were cut using an angle grinder, this operation being performed for a set of 6 samples. The filling of the holes Fig. 1*b* was done manually with a cement mortar with the following composition: cement /sand C/S = 0.33, water/cement W/C = 0.5.

a *b*

Fig. 1 –Preparation of concrete bricks: *a* – concrete bricks with two vertical circular holes; *b* – manually filling of the holes with cement mortar.

After calibration of the universal testing machine with 600 kN loading capacity, the concrete bricks were weighted by their average weight being 4,087.5 grams, being positioned between the machine steel plates. The test speed was 2.4 kN/s, the average value of the compression force for concrete bricks with VCH filled with cement mortar at two days was 618.2 kN and the compressive strength according to the area 250 × 125 mm is equal to 19.78 N/mm^2.

The failure modes revealed that the cracking initiation was performed in the area of the filled voids, Fig. 2, but also because the compressive strength of the hollow cylinders is greater than the compressive strength of the masonry unit with hollow concrete aggregates.

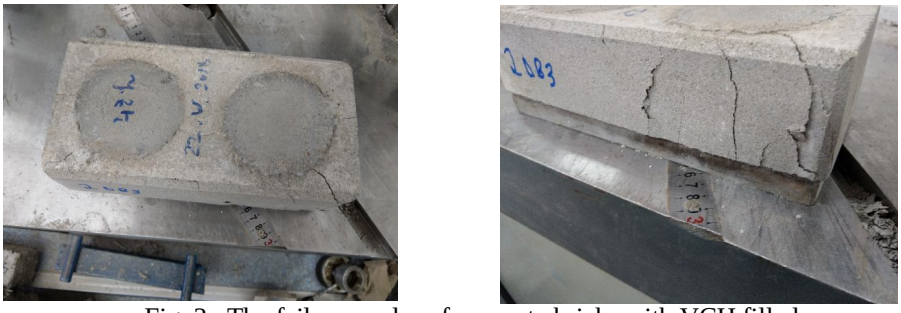


Fig. 2 –The failure modes of concrete bricks with VCH filled with cement mortar at two days.

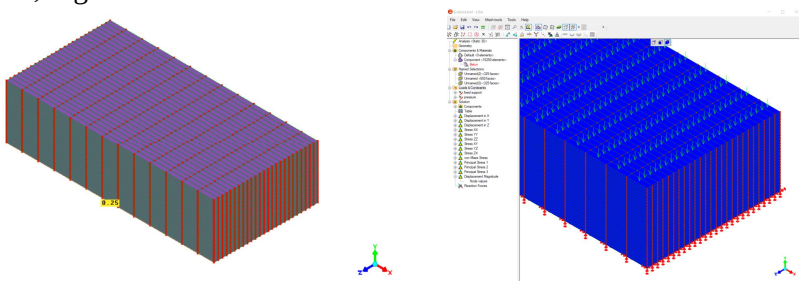
Since the capacity of the universal machine is 600 kN used to test the concrete bricks with VCH filled with cement mortar at two days (this being able to exceed its capacity by 15,...,20%) for the compression tests of concrete bricks with VCH filled with cement mortar at 14 days was used another universal testing machine Zwick ROEL, having a loading capacity equal to 1,000 kN, Fig. 3.

Fig. 3 – The failure modes of concrete bricks with VCH filled with cement mortar at 14 days.

The mean value of the compression force on concrete bricks with VCH filled with cement mortar at 14-day was 953.1 kN and the average compressive strength according to the 250 × 125 mm area was 30.49 N/mm^2.

3. Numerical Modelling of the Compression Concrete Brick Unit

The geometrical characteristics was based on the three-dimensional model of the concrete brick with VCH, Fig. 4 *a*. In the preprocessing stage the following data were entered: geometry of the concrete brick with VCH filled with mortar, meshing of the model, material properties, loading and boundary conditions, Fig. 4 *b*.



a *b*

Fig. 4 – The three-dimensional model of the concrete brick: *a* – meshing of the model; *b* – definition of loads and boundary conditions.

In the finite element analysis (FEA) the LISA-Finite Element Technologies v.8.0.0 software package (LISA, 2013) have been used, the principal stresses map was identified with a 31.3 N/mm^2 compressive strength, a close value to that obtained experimentally (Fig. 5).

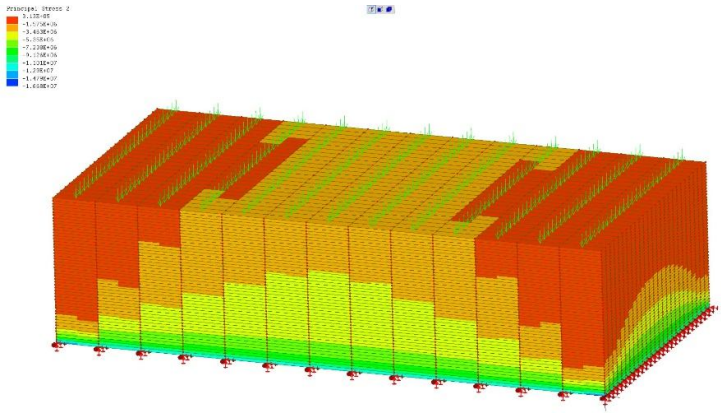


Fig. 5 – The principal stresses obtained on the concrete brick model with filled holes.

4. Conclusions

After the experimental testing of hollow or hollow concrete bricks, as well as the finite element analysis, the following points were relevant:

a) the class of the concrete brick resistance with two VCH is closed to the C 12/15 concrete class, the average value of compressive strength being 11.82 MPa;

b) the increase in compressive strength for concrete bricks filled with cement mortars at two days is 1.7 times higher than the compressive strength for concrete bricks with hollow concrete aggregates;

c) more higher values of the compressive strength for concrete bricks with filled with cement mortar at 14 days is 2.6 times higher than the compressive strength with two VCH.

d) through the numerical simulation, the failure modes of concrete bricks were identified, the trapezoidal shape with the large base down being identified in all tested samples.

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ANALIZA BLOCURILOR DE ZIDĂRIE DIN BETON LA COMPRESIUNE

(Rezumat)

Sunt prezentate valorile rezistenței la compresiune obținute pe unitățile de zidărie din beton cu goluri circulare verticale în comparație cu valorile rezistenței la compresiune obținute pe unitățile de zidărie din beton cu găuri circulare umplute cu mortar de ciment. Programul experimental a fost realizat la Laboratorul de Materiale Compozite din cadrul Facultății de Construcții şi Instalații, Universitatea Tehnică "Gheorghe Asachi" din Iaşi. Autorii prezintă o comparație a rezistențelor la compresiune, valorile de vârf ale tensiunilor principale fiind verificate printr-o modelare numerică.