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INFLUENCE OF WATER ABSORPTION BY CAPILLARY ON THE MECHANICAL CHARACTERISTICS OF CONCRETE BRICKS

BY

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Abstract. Technical approval of building materials like concrete bricks requires a series of investigations that relate to dimensions and tolerances, flatness, density, adhesion, compressive strength, water absorption through capillary, thermal conductivity, frost-thaw resistance, and reaction to fire. The authors conducted a series of experimental tests to study the effect of water absorption on compressive strengths and tensile strength from bending on concrete bricks. Thus, comparative graphs were plotted to highlight the differences; the specimen failure modes were also identified.

Keywords: concrete bricks; water absobtion; compressive strength; tensile strength from bending.

1. Introduction

Concrete bricks are obtained in the factory using special steel molds by hydraulic pressing. The composition of the concrete bricks utilised in this

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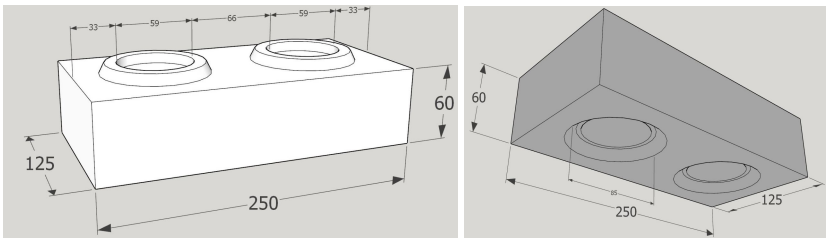
research project was based on: cement, calcium filler, sand and water. Previous experimental tests with concrete bricks with holes and filled holes have shown that the increase in compressive strength for concrete bricks filled with cement mortars at two days was 1.7 times higher than the compressive strength for concrete bricks with hollow concrete aggregates; higher values of the compressive strength for concrete bricks with filled cement mortar at 14 days was 2.6 times higher than the compressive strength of the concrete bricks with two holes (Oprişan *et al.*, 2018).

Concrete bricks may expand or contract if they are exposed to increases or decreases in moisture content. It is not excluded the hypothesis that the absorbtion of water vapour from the atmosphere can produce irreversible expansion of the concrete bricks (Bingel & Bown, 2009). If these concrete bricks are used for mansonry in rooms with a moisture content of 65 ... 75%, it is recommended to protect them with a primer coat, 3 layers of film and 1 or 2 layers of paint (Romanian Norm C 14-82, 1982).

In this paper, the authors conducted a series of experimental tests to study the effect of water absorption on compressive strengths and tensile strength from bending on concrete bricks.

2. Experimental Tests and Results

According to Eurocode 6 part 1.1 (SR EN 1996-1-1, 2006) and specification for masonry units (SR EN 771-3+A, 2015) the type of masonry units is classified as *aggregate concrete units* (ACU). Concrete bricks are obtained in the factory in special steel molds by pressing, with less then 25%. volume of holes (as % of the gross volume) Fig. 1 has been grouped as *Group 1*.



a *b*

Fig. 1 – Isometric view of the concrete bricks with 2 holes:
a – main dimensions and the top component parts;
b – main dimensions and bottom component parts.

As the deviations permitted according to SR EN 771-3 + A1: 2015 are adhered to, the concrete block tolerance class is D3. Determination of capillary water absorption was performed according to SR EN 772-11 and SR EN 771-3 + A1: 2015. The six specimens were weighed and then placed in the ventilated

oven, and maintained for 48 hours at a temperature of 70°C. After cooling, the differences in face sizes (SR EN772-16) were calculated; the gross area A_s was calculated. They were immersed in water up to a depth of 5 mm ± 1 for 10 ± 0.2 minutes.

The water absorption coefficients were calculated due to the capillary action of the concrete masonry units with the following relation:

$$c_{w,s} = \frac{m_{s_0,s} - m_{\text{dry},s}}{A_s \sqrt{t_{s_0}}} \times 10^6, \quad [\text{g}/(\text{m}^2\text{s}^{0.5})], \tag{1}$$

where: $m_{\text{dry},s}$ is the mass of the specimen after drying, in grams, [g]; $m_{s0,s}$ – mass of the specimen after immersion in time t, in grams, [g]; A_s – gross area of the water-immersed specimen face, [mm^2]; t_{s0} – immersion time, [s]; $c_{w,s}$ – coefficient of water absorption due to the capillary action of aggregate, artificial stone and natural stone masonry elements, [$g/(m^2s^{0.5})$] or [$g/(m^2 s)$].

In Fig. 2 are presented 6 specimens placed in the oven made by Memmert (www.memmert.com, 2018) with air ventilation system and external temperature of the oven being 20.3°C, after that were achieved the measurement of dimensions and weighing of samples in accordance with SR EN 772-11: 2011, Table 1.

Fig. 2 – Placing of the specimens in the oven (left)
and keep them at + 70°C for 48 hours (right).

Before attempting the compression test of the samples, the coupling ribs at the top level of the specimens were cut, Fig. 1 *a* and the parallelism of the surface was checked. For the compression test, the instructions were followed step by step in accordance with SR EN 771-3 + A1: 2015, Chapter 5.5.1 and for

tensile strength from bending both norms SR EN 771-3 + A1: 2015, Chapter 5.5.2 and SR EN 772-6. Sample counting was done from 1-3 for dry samples and from 4-6 for immersed samples. All failure modes in compression and bending have been identified, Fig. 3 and processing experimental data have been introduced in Table 2.

Table 1
Determination of the Absorption Coefficient

Characteristics unit measurement		$m_{dry,s}$ grame	$m_{s0,s}$ grame	t_0 sec	A_s mm^2	Length mm	Width mm	$c_{w,s}$ Absobtion coefficient $g/(m^2*s^{0.5})$	$c_{w,s}$ Absobtion coefficient $g/(m^2*s)$
Number of the specimens	S_1	3105	3150	600	12050	241	50	1524.57	62.25
	S_2	3055	3105	600	12240	240	51	1667.68	68.09
	S_3	3060	3140	600	12240	240	51	2668.28	108.95
	S_4	3075	3130	600	12050	241	50	1863.37	76.08
	S_5	3050	3130	600	12291	241	51	2657.21	108.50
	S_6	3065	3155	600	12000	240	50	3061.86	125.02
	Average value of the absorption coefficients							**2240.50**	**91.48**

Fig. 3 – Compression failure mode of the concrete bricks (left) and bending failure mode (right).

The concrete brick with calcium filler aggregates has a high rate value of water absobtion coefficient c_w, which is 91.48 g/m^2s. Different mechanical behaviours of dry and wet samples were noticed, rapid failure of the wetted samples in comparison with dry samples. A comparison between the compression and tensile strength for dry and wet samples is illustrated in Fig. 4 and Fig. 5. Thus, major differences can be observed in case of tensile strengths and it is recommended to protect exposed surfaces of the concrete bricks at flooding, rain or humidity factors with vapour barrier.

Table 2

Characteristics Determined in the Experimental Tests

Characteristics	Symbol	Unit	Experimental test results					
			1	2	3	4	5	6
Peak value of the compression force	N_c	N	299200	314800	385800	266400	299020	295400
Peak value of the force in case of three point loading test	N_t	N	5053	4441	4982	3400	2794	2886
Net area of the specimen without holes	A_u-A_v	mm^2	28742.61	28731.06	28694.24	28699.11	28756.82	28734.78
Void area	A_v	mm^2	2773.49	2748.82	2780.50	2772.56	2759.51	2743.25
Compressive strength of the speciments	f_{ck}	N/mm^2	10.41	10.96	13.45	9.28	10.40	10.28
Average compressive strength of samples	f_{ckav}	N/mm^2	11.60			9.99		
Tensile strength from bending	f_{tk}	N/mm^2	3.87	3.40	3.82	2.61	2.14	2.21
Average tensile strength of samples	f_{tkav}	N/mm^2	3.70			2.32		

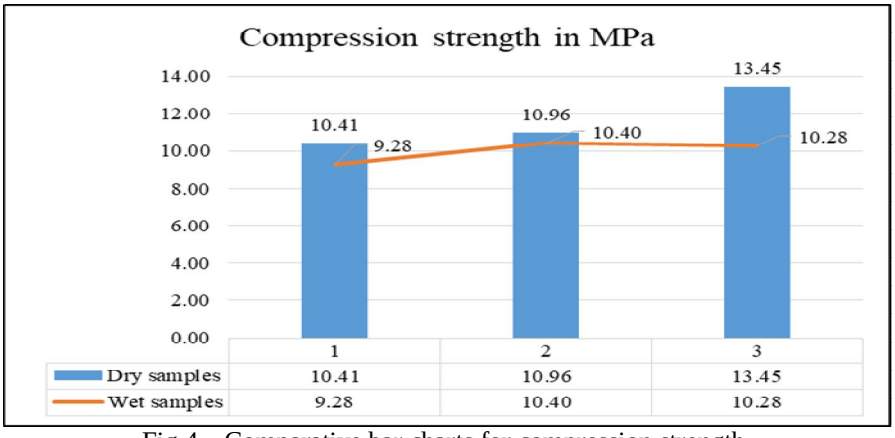


Fig.4 – Comparative bar charts for compression strength.

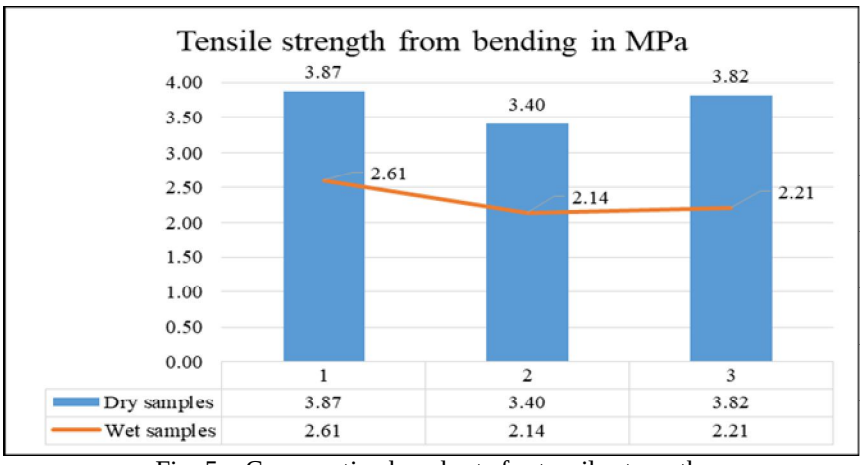


Fig. 5 – Comparative bar charts for tensile strength.

Previous Romanian norm (C14-82, 1982) recommends plastering of the masonry concrete blocks. More than that for the internal faces of the external walls, for example in case of rooms with permanent humidity ranging between 65,...,75% and accidentally up to 85%, the following layers will be provided: 1 layer of primer, 3 film layers and 1-2 paint layers.

3. Conclusions

After the experimental testing of hollow concrete bricks, the values for the absorbtion coefficient, compressive strengths and tensile strengths from bending were obtained.

All experimental tests were made after 14 days sample casting. It was observed that the average values of the compressive strengths of the dried samples numbered with 1, 2 and 3 are 13.93% higher than the average values of the compressive strengths of the wet samples numbered with 4, 5 and 6. Also average values of the tensile strengths from bending of dry samples are 37.28% higher than the average values of tensile strengths from bending for wet samples.

To avoid the moisture in concrete brick it is recommended to protect the masonry made with concrete blocks throught pastering and paint.

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* * * *Metode de încercare a elementelor pentru zidărie*. Partea 6: *Determinarea rezistenţei la tracţiune prin încovoiere a elementelor pentru zidărie de beton cu aggregate*, SR EN 772-6:2002, ASRO, 2002.

* * * C14-82 *Normativ pentru folosirea blocurilor mici din beton cu agregate usoare la lucrarile de zidarie*, 1982.

* * * www.memmert.com

INFLUENŢA ABSORBŢIEI APEI PRIN CAPILARITATE ASUPRA CARACTERISTICILOR MECANICE DE TIP REZISTENŢA LA COMPRESIUNE ŞI REZISTENŢA LA ÎNTINDERE DIN ÎNCOVOIERE ALE CARAMIZILOR DIN BETON

(Rezumat)

Agrementarea tehnică a materialelor de construcţie de tipul cărămizilor din beton necesită o serie de investigaţii care se referă la dimensiuni şi toleranţe, planeitate, densitate, aderenţă, rezistenţă la compresiune, absorbţia de apă prin capilaritate, conductivitate termică, rezistenţă la îngheţ-dezgheţ, reacţie la foc. Autorii au realizat o serie de încercări experimentale în vederea studierii efectului absorbţiei de apă asupra rezistenţelor la compresiune şi la întindere din încovoiere pe cărămizi din beton. Astfel au fost trasate grafice comparative pentru evidenţierea diferenţelor identificându-se şi modurile de cedare ale epruvetelor.