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Clay Brick Compressive and Tensile Bending Strength

I. Žabičková [1], P. Padevět [2], T. Otcovská [2,*]

[1] *Brno University of Technology, Faculty of Architecture, Poříčí 273/5, 639 00 Brno, Czech Republic*
[2] *CTU in Prague, Faculty of Civil Engineering, Thakurova 7, 166 29 Prague 6, Czech Republic*
[*] *tereza.otcovska@fsv.cvut.cz*

Abstract: Clay as a traditional building material took the back seat in the constructional practice during the last century. It has caused a lack of reliable information about mechanical properties of this material. For contemporary clay structures the masonry and rammed constructions are of the greatest interest. Basic building element of the masonry constructions is a clay brick. Mechanical properties of clay bricks are dependent on the composition of used clay. The values for clay bricks we experimentally measured with common masonry clay are 6.5 MPa for compression strength and 2.5 MPa for tensile bending strength.

Keywords: Clay; Clay Brick; Compressive Strength; Tensile Bending Strength.

1 Introduction

An unburned clay as a traditional construction material was used for centuries. Until the second part of 20th century unburned clay was included in the Czech national standards. With the introduction of modern construction materials the unburned clay got to the background and as a consequence its material properties were not adequately examined and material characteristics and characteristics of constructions made of it not described. Any standards for unburned clay constructions does not exist and the building realization becomes nowadays considerably complicated. An interest for this classical construction material has risen again recently mainly for two reasons. First, the usage of clay is in accord with a sustainable development. Second, the clay constructions have positive impact on a microclimate of the buildings made of it and on the health of their inhabitants.

A survey of clay constructions and construction elements mechanical properties may bring even more noticeable change in point of view to this construction material and allow for grater expansion of clay building than it was heretofore. The most significant clay constructions for contemporary civil engineering are rammed and masonry constructions. This work concerns with mechanical properties of clay masonry elements, specifically the compression strength and tensile bending strength of clay bricks that represent basic construction unit of brick walls.

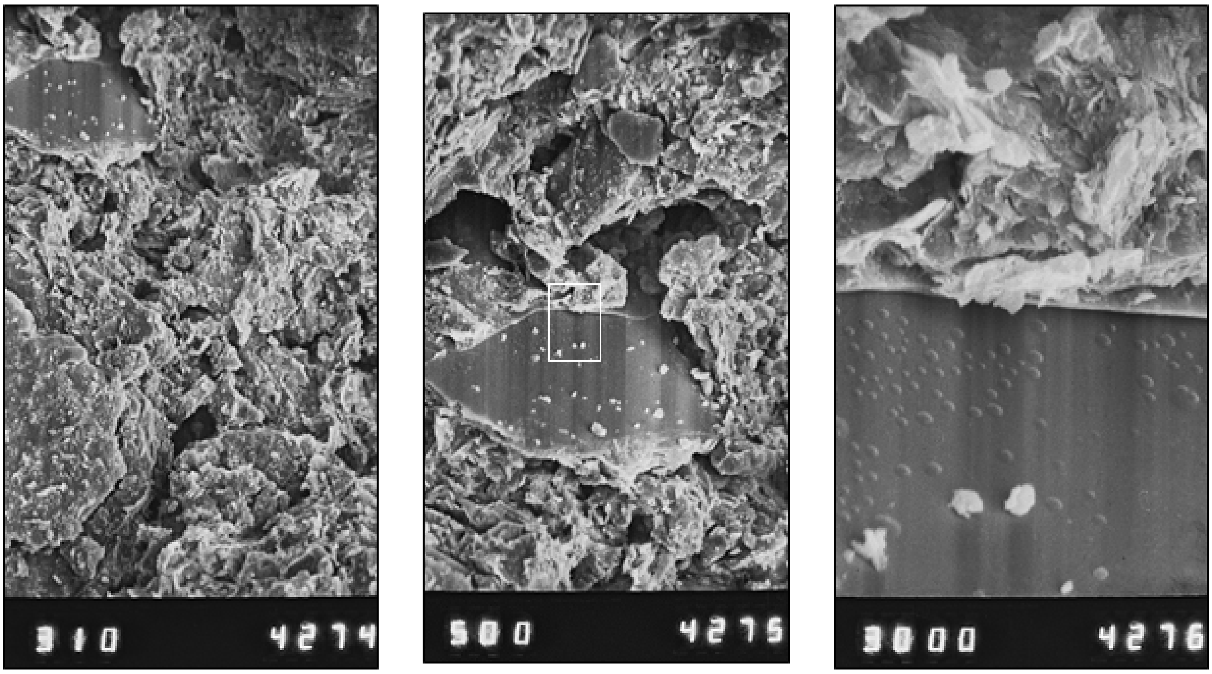
2 Tested Bodies

Tested bodies were supplied by the company Hliněnýdům, s.r.o. from Bořnov clay-pit. The tested bodies clay composition was 30 % of clay particles i.e. particles smaller than 0.002 mm. The rest was dust particles and sands i.e. particles bigger than 0.002 mm. In the clay component were minerals illite and kaolinite. Declared size of tested bodies was 290 × 140 × 65 mm. Average actual size was 281.8 × 137.3 × 62.4 mm. Average actual weight was 4892 g and density of 2028 kg.m^{-3}. The moisture content of the tested material was 4 % by weight. Every test was carried out on three bodies.

A microscopic structure was determined using scanning electron microscope (SEM). This method was used for study of texture and structure of clay grain and measured its size. We took pictures using various levels of magnification (see Fig. 1) and have found following:

- with magnification of 310× are visible large plate grains of clay minerals with size up to 50 μm, gray of mica can be seen too,

- with magnification of 500× dominant formation is grain of mica grown into neighbor matrix, silica grains and another grains of various sizes can be seen too,
- with magnification of 3000× air bubbles enclosed in the mass of mica, the size of mica particle is approx. 250 µm.



(a) magnification of 310× (b) magnification of 500× (c) magnification of 3000×

Fig. 1: The SEM pictures of microscopic structure of clay bricks (magnification of 310×, 500×, 3000×).

3 Test Methods

3.1 Tensile Bending Strength Test

The aim of the tests was to determine tensile bending strength and compressive strength of a clay brick. The tensile bending strength was determined using three-point bending test (see Fig. 2) where force load F was measured and the strength was determined by Eq. (1). The test is carried out on samples with axial distance l_{po} = 230 mm. Determination of tensile bending strength is defined in the standard ČSN 72 2605.

$$\sigma_{bs} = \frac{3Fl_{\mathrm{po}}}{2bh^2} \text{ [MPa]}, \tag{1}$$

where σ_{bs} represents the bending strength [MPa], F specimen break force [N], l_{po} axial distance of supports [mm], and finally b, h are width and height of the specimen [mm], respectively.

3.2 Compressive Strength Test

Strength of masonry element determination is again defined in the standard ČSN 72 2605. A tested sample is inserted between faces of a hydraulic press and slowly loaded (see Fig. 3). During the whole test is measured deformation of the sample until its breakage. Dependence of the compressive strength is calculated by Eq. (2). Its value and relative deformation of a sample are plot on a graph.

$$\sigma_{cs} = \frac{F}{A} \text{ [MPa]}, \tag{2}$$

where σ_{cs} represents the compressive strength [MPa], F ultimate compressive force [N], and A loaded cross-section area [mm^2].

Fig. 2: The tensile bending strength test of a brick.

Fig. 3: The compressive strength test of a brick.

Tab. 1: Experimentally measured strength of a clay masonry element.

Tested body	1	2	3
Tensile bending strength [MPa]	2.53	2.5	2.44
Compressive strength [MPa]	6.28	6.66	6.56

3.3 Data Evaluation

The three tested bodies had average tensile bending strength 2.49 MPa. The compressive strength was determined by a compression test. Three bodies were tested with measured average compressive strength of 6.6 MPa. The measured values of the tested bodies tensile bending strength and compressive strength are shown in Tab. 1 and Fig. 4. Strength of the sample varied no more than ±5 % between minimal and maximal value.

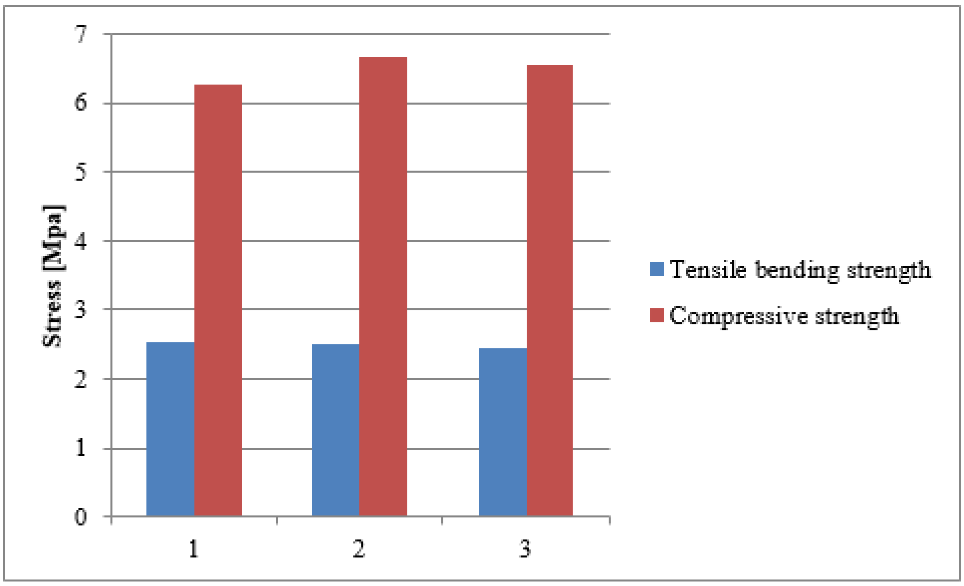


Fig. 4: An unburned clay brick strength.

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