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INVESTIGATION OF MATERIAL PROPERTIES OF MASONRY UNITS USED IN BRICK WALLS

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Abstract: *Walls are used as load-bearing wall and partition wall in structures systems. In masonry structures, the walls are carriers. Load-bearing walls carry loads such as beams, columns, foundations and slabs. In some structures systems, walls are used only to separate spaces without carriers. In masonry structures where the walls are carriers, the masonry unit and the mortar unit are very important. If the properties of these two units are known correctly, the properties of the load-bearing wall can be estimated approximately. In this study, the studies that determine the material properties of the brick unit (compressive strength, dimensions, water absorption percentage and unit volume mass) experimentally will be examined in detail. An evaluation will be made between the studies for the change of each material properties. The relationship of different material properties with each other will also be studied.*

Keywords*: Brick unit; Masonry structure; Material properties*

1. Introduction

Mankind has used various bond and binding materials to serve as walls in the structures it has construction to meet the need for shelter. Previously, walls made from tree branches and stumps were built, and with the progress in the construction sector and the development of technology, wall construction was started using different materials [1].

In different type's structure systems, the vertical building element formed by the interlocking of elements such as stone and brick with mortars is called a wall. In the past, while the number of masonry structures with load-bearing walls was quite high, this number gradually decreased due to the perception that the earthquake behavior of masonry structures was low. Masonry structures have been replaced by reinforced concrete structures.

Masonry walls are classified according to the material used, load-bearing condition and applied location (Figure 1).

Within the scope of this study, the brick walls are frequently used in reinforced concrete structures as used in masonry structures will be examined.

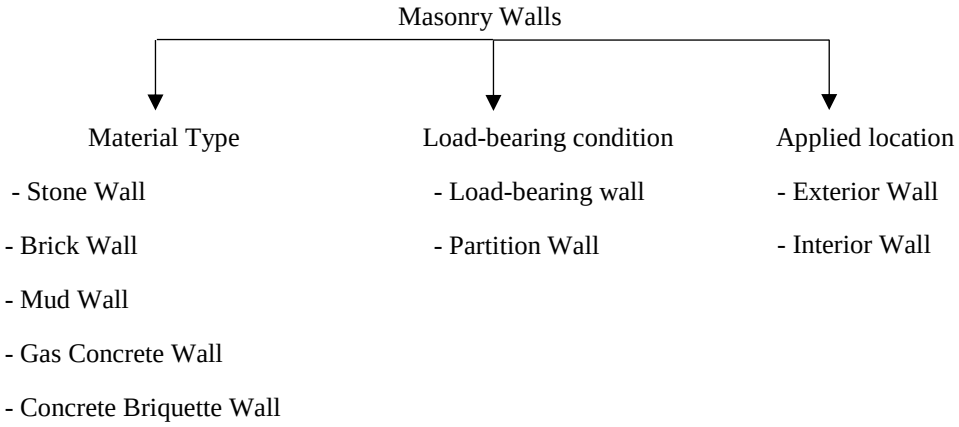


Figure 1. Classification of masonry walls

2. Brick Walls

The masonry units made from clay or other clay soil by firing at high temperatures sufficient to obtain a ceramic bond with or without the addition of sand or other powder additives are called bricks [2].

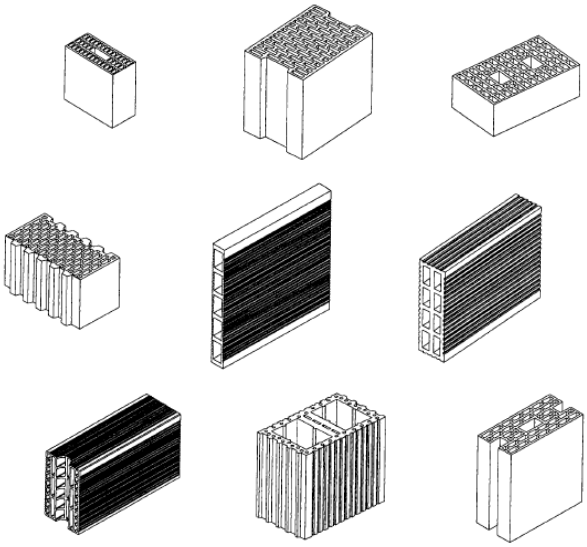
Bricks have been used frequently in the structure sector since ancient times. Bricks are very useful due to its cheap and easy production, superior properties such as sound insulation and thermal insulation. Today, although new materials have been produced alternative to brick, it is one of the most preferred walling materials due to its features and advantages. Therefore, the properties of the bricks to be used must be well known.

Bricks are produced by the factories in different geometries including hollow unit, frogged unit and solid unit. These bricks are divided into two according to unit volume mass TS EN 771-1: 2011 + A1 standard [2]. The masonry units with low unit volume mass are called LD and the masonry units with high unit volume mass are called HD. Brick samples for LD and HD units are given in Figure 2.

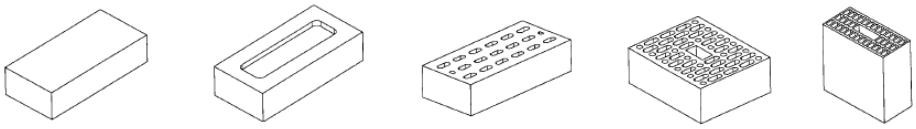
Bricks are expected to have the following characteristics:

- Homogeneous.
- Low porosity
- Low and fine grain
- Well cooked
- Mold the edges and surfaces to be smooth
- No cracks, crevices or gaps
- No burns.
- Should not be separated into more than two pieces when left on a stiff ground from a height of 1.5 m.
- Have not absorbed more than 20% water when kept in water for 12 hours [3].

Bricks, with their dimensions and layouts, give the appearance of the wall a distinctive feature. For example, in Traditional Islamic Architecture, bricks were used in rich geometric layouts and impressive decorative values were obtained [4].



a) LD units



b) HD units

Figure 2. Examples for LD and HD units [2]

3. Material Properties of Bricks

The most important parameters affecting the behavior of masonry structures against earthquakes etc. loads are masonry unit and joint mortar. If these parameters are determined, the behavior of masonry structures can also be estimated. Many experimental techniques have been developed for the determination of material properties. The purpose of these experiments is to control the homogeneity of structural elements and to determine the material properties such as compressive, tensile and shear strength, poisson ratios, deformation properties and elasticity modules of materials of masonry unit and mortar. In addition, it is important to determine the permeability, cavity structure, color, crack structure and width and surface damage of the structural elements. When determining material properties; destructive and non-destructive methods are used. Non-destructive tests generally don't give an absolute result. However, more accurate results will be obtained if material properties are determined by laboratory experiments [5-6].

In this study, the studies carried out by using clay bricks were examined (Figure 3). It has been paid attention that the related studies have been carried out in the laboratory environment. The material properties determined by the researchers for the clay brick are given in Table 1.

Figure 3. Clay brick

In Table 1; the experimentally determined compressive strength, length, width and height dimensions, water absorption percentages and unit volume mass values are given for each different clay brick. It has been paid attention that the studies presented have been carried out by different countries. The compressive strength tests were performed by all researchers, but the water absorption percentage and unit volume mass tests were performed by some researchers. If the test results are considered, it will be seen that the compressive strength values are close to each other. The water absorption percentage values of the bricks were in the range of 10-15% on average.

Table I. Clay brick material properties

Publication	Compressive Strength (MPa)	l (length) (mm)	w (width) (mm)	h (height) (mm)	Origin	Water Absorption (%)	Unit Volume Mass (g/cm3)
Behavior of unreinforced masonry piers strengthened using centercore method; experimental investigation [7]	9.73	210	104	65	Iran	13.2	-
Experimental seismic performance evaluation of unreinforced brick masonry buildings [8]	12.431	400	400	225	Pakistan	23	1.495
Plane and vaulted masonry elements strengthened by different techniques – testing, numerical modelling and nonlinear analysis [9]	12.5	250	120	60	Egypt	-	-
Strengthening of masonry walls against out-of-plane loads using fiber-reinforced polymer reinforcement [10]	8.2	230	100	70	Singapore	-	-
Experimental study on scale effects in clay brick masonry prisms and wall panels investigating compression and shear related properties [11]	13.1	220	105	70	New Zealand	-	-
Suitability of half-scale burnt clay bricks for shake table tests on masonry walls [12]	21.9	230	110	70	India	13.4	1.7735
Tarihi tuğla duvarların tekstil donatılı harç (TRM) ile güçlendirilmesi [13]	9.05	235	115	70	Turkey	12.24	1.545
Brick-mortar interaction in masonry under compression [14]	27	212	99	51	Netherlands	13.6	1.75
	19	210	99	50	Netherlands	-	1.75
	33	208	98	50	Netherlands	17.4	1.88
	27	206	96	50	Netherlands	15.5	1.63
Bond strength and compressive stress-strain characteristics of brick masonry [15]	10.1	230	110	75	India	14.42	-
	13.34	200	100	100	India	12.19	-
	8.24	150	50	15	India	13.65	-
Experimental study of solid and hollow clay brick masonry walls retrofitted by steel fiber-reinforced mortar coating [16]	12	230	110	50	Italy	-	1.9
Finite element analysis for the response of URM walls supporting RC slab [17]	13.21	240	115	75	Iraq	-	-
Strength characteristic of novel mesh embedment technique for new brick construction with least expensive material [18]	12.6	225	105	82	India	11.33	-
Experimental and numerical assessment of in-plane monotonic response of ancient mortar brick masonry [19]	10.02	210	100	63	Iran	13.7	-
Experimental investigations of the joint-mortar behaviour [20]	19.47	220	106	54	France	-	-
A joint fatigue–creep deterioration model for masonry with acoustic emission based damage assessment [21]	22.6	213	100	65	United Kingdom	-	2.127
Determination of shear strength of historic masonries by moderately destructive testing of masonry cores [22]	19.3	250	120	55	Italy	13.9	-
Experimental work for mechanical properties of brick and masonry panel [23]	11.12	230	110	50	Nepal	-	-
Calibration of partial safety factors for earth block masonry under compression loading [24]	5.65	240	115	71	Germany	-	1.809
Flexural behaviour of FRP strengthened brick cavity walls [25]	13	230	110	76	Australia	-	-
Dynamic deformability evaluated by series of shaking table tests of full-scale models of masonry houses [26]	4.6	210	100	50	Japan	-	-
	14.7	230	100	50	Japan	-	-
	29.8	210	100	50	Japan	-	-

4. Conclusions and Assessment

One of the most important parameters affecting the behavior of masonry structures against earthquakes etc. loads are masonry unit. In this study, material properties of masonry unit were investigated. In the literature, experimentally determined material properties were examined. Clay brick was selected as the brick material.

When the experimentally determined values of the researchers were examined in detail, it was seen that the compressive strength, water absorption percentage and unit volume weight values were close to each other. It is thought that a multiple relationship can be established between these material properties.

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