Strength And Elastıcıty Of Brick Masonry Prisms

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ABSTRACT

Structural design in masonry requires a clear understanding of the behaviour of the composite unit-mortar material under various stress conditions.
The characteristics of brick masonry are influenced by the properties of bricks and mortar. This study has been investigated in two parts. Firstly, this paper, attempts at studying the properties of brick masonry using different bricks of Turkey with various types of mortars. The strength and elastic modulus of brick masonry under uniform concentric vertical loads have been evaluated for strong-brick soft-mortar and soft-brick strong-mortar combinations. Various sizes of panels have been tested during these experiments to study the size effect and different bonding arrangements. The failure mechanisms of such specimens have been studied. Attempts are also made to derive empirical relationships for masonry strength as a function of brick and mortar strength in the Turkey context.

Keywords: **:** *Brick, brick masonry, mortar, masonry compressive strength, modulus of elasticity.*

INTRODUCTION

Masonry walls are used in almost all types of building construction in many parts of the world because of low cost material, good sound and heat insulation properties, easy availability and locally available material and skilled labor. Mathematical modeling of structures with masonry walls requires the material properties and constitutive relationships of masonry and its constituents, i.e., bricks and mortar, which are not easily available because of scarcity of controlled experimental tests and significant variation in material properties geographically.

The study is concerned with the uniaxial monotonic compressive stress-strain behavior and other characteristics of three type of brick which are horizontal coring bricks, solid press bricks and hollow press bricks, two type of mortar and unreinforced masonry panels.(brick infill panel)

In the comprehensive experimental study, tests were performed on 6 type of mortar cube specimens (with two different strength as weak and strong) two different grades and 10 specimens of masonry panels (combination of three bricks and two mortar types). Based on the experimental results and observations, stress strain curves have been developed for

Bricks, mortar and masonry and simple relations have been suggested for estimation of modulus of elasticity of bricks, mortar and masonry from their corresponding compressive strengths.

COMPRESSIVE BEHAVIOR OF MASONRY

Masonry is typically a nonelastic, nonhomogeneous and anisotropic material composed of two materials of quite different properties; stiffer bricks and relatively softer mortar. Under lateral loads, masonry doesn't behave elastically even in the range of small deformations. Masonry is very weak in tension because it is composed of two different materials distributed at regular intervals and the bond between them is weak. Therefore, masonry is normally provided and expected to resist only the compressive forces. During compression of masonry panels constructed with stronger and stiffer bricks, mortar of the bed joint has a tendency to expand laterally more than the bricks because of lesser stiffness. However, mortar is confined laterally at the brick–mortar interface by the bricks because of the bond between them; therefore, shear stresses at the brick-mortar interface result in an internal state of stress which consists of triaxial compression in mortar and bilateral tension coupled with axial compression in bricks. This state of stress initiates vertical splitting cracks in bricks that lead to the failure of the prisms. (1)

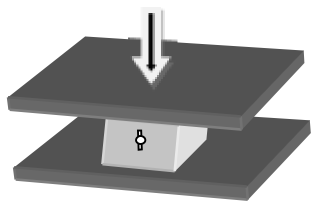


Figure1 Test setup for mortar cube

MODULUS OF ELASTICITY OF MASONRY WALL

Elasticity modulus of masonry wall,which is effected the wall rigidity, is great important at behaviour of masonry wall on the frame systems Modulus of elasticity different from each side (horizontal, vertical and diagonal) because of nonhomojeneus of wall. Elasticity modulus of masonry wall is changed with compressive strength of material, material height, compressive strength of the mortar and layer of mortar line.

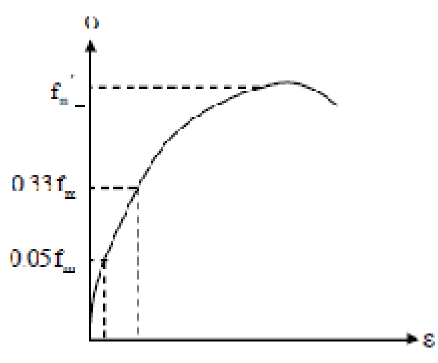


Figure 2. Stress- Strain relationship of the infill walls according to Prism test

$$E_m = \frac{\sigma_{0.33} - \sigma_{0.05}}{\varepsilon_{0.33} - \varepsilon_{0.05}}$$

Where

$\varepsilon_{0.33}$: Strain corresponding to the stress ($\sigma_{0.33}$) which is the compressive prism strength of 33% of masonry.

$\varepsilon_{0.05}$: : Strain corresponding to the stress ($\sigma_{0.05}$) which is the compressive prism strength of 5% of masonry.

FEMA 306 (Fema 1999) $E=550*(f_m')$ (4.3)

Paulay ve Prestly $E=700*(f_m')$ (4.4)

Canadian Management Code $E=850*(f_m')$ (4.5)

f_m': Compressive prism strength of masonry

EXPERIMENTAL PROGRAM

In the present experimental study, several tests were carried out in order to evaluate the uniaxial compressive stress-strain curves of masonry panels constructed with different combinations of mortar grades. Local bricks were manufactured by Turkish manufacturers. Different grades of mortar used in the study. Masonry panels were subjected to monotonically increasing displacement loading (strain controlled) at their top which was applied vertically by a 550 kN load and ±10 mm displacement capacity hydraulic actuator in Hi-Tech Magnus loading frame. (Fig.8) However, mortar cubes were tested in a 2,500 kN ELE Press testing machine under stress controlled loading. The specimens were built on 25 mm thick steel plates and cured under damp condition for 28 days. The specimens covered with wet jute sacks to maintain damp condition. The specimens were built on 25 mm thick steel plates and cured under damp condition for 28 days. The specimens covered with wet jute sacks to maintain damp condition.

PROPERTIES OF BRICK

Bricks which are horizontal coring bricks were used in constructing masonry panels. The bricks were manufactured by Adana brickyard, and had approximate length,width and height as 190x190x135 mm.

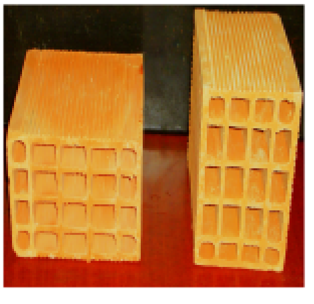


Figure 3. Appearance of horizontal coring brick

PROPERTIES OF MORTAR

Two different grades of mortar (cement:sand by volume) used in the study, 1:0:6 (weak), 1:0:3 (strong), and mortar cubes of 150 mm size were tested after 28 days of casting to obtain their compressive stres-strain curves. The procedure for obtaining the compressive strength of mortar cubes is given in TS 24.

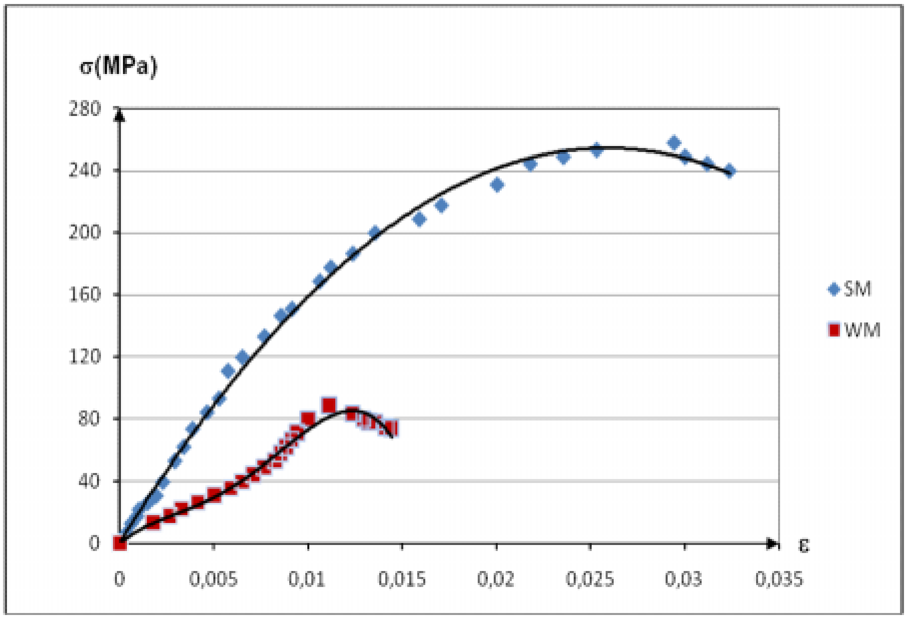


Figure 4. Comperasion of compressive stress-strain curves for strong mortar cubes with weak mortar cube

TYPE AND DIMENSIONS OF SPECIMENS

6 masonary panels have been laid properly from weak and strong mortars as 100x100 cm size as four horizontal coring bricks and these masonary panels have been washed and protected until 28-day-cure time.

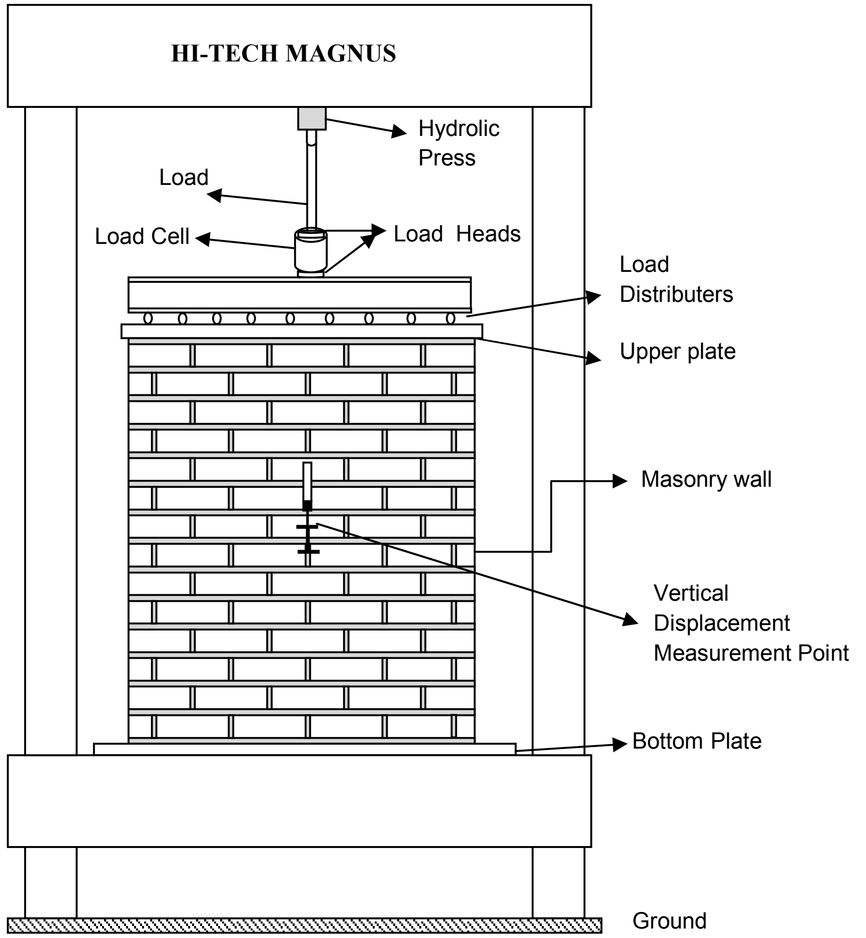
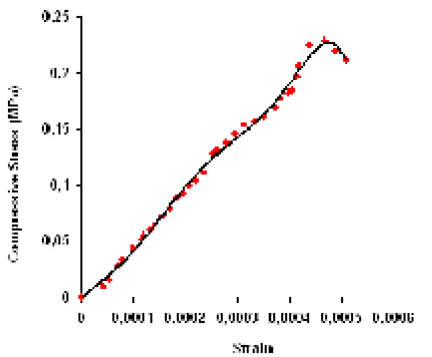
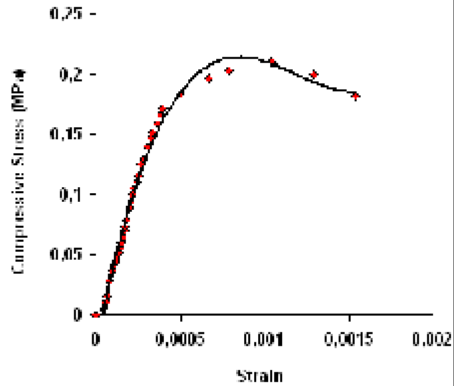


Figure 5. Test Setup

<table>
<tr><th></th><th>Compressive stress-strain curve for brick masonry panel</th><th></th><th>Compressive stress-strain curve for brick masonry panel</th></tr>
<tr><td>PG1</td><td>
</td><td>PZ1</td><td>
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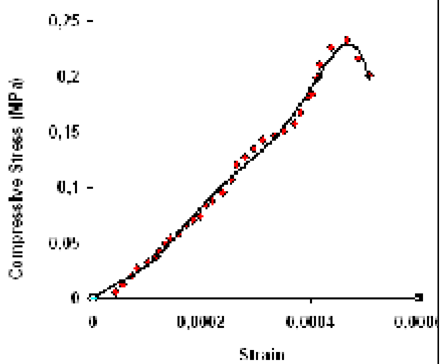
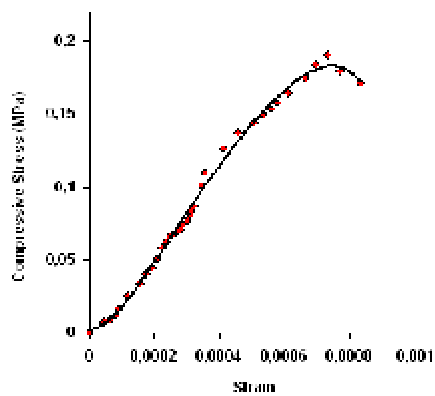
<tr><td>PG2</td><td>
</td><td>PZ2</td><td>
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Figure 6. Compressive Stress-Strain curves for brick masonry panel for brick masonry panel with strong mortar and weak mortar

Sample	Brick Masonry Panel With Strong Mortar	Sample	Brick Masonry Panel With Weak Mortar
PG1		**PZ1**	
PG2		**PZ2**	

Figure 7. Appereance cracking of brick masonry panel with strong and weak mortars after loading

Table 1. Elasticity modulus of masonry panels for different ways

Panels	Methods	E(Mpa)	Panels	Methods	E(Mpa)
PG1	**Experiment Result**	490	**PZ1**	**Experiment result**	202,05
	TDY	1000		**TDY**	1000
	Fema	126		**Fema**	115,77
	Paulay and Prestly	160		**Paulay and Prestly**	147,33
	ACI	490		**ACI**	202,05
	C.M.C	194		**C.M.C**	179
	Çıtıpıtıoğlu	228,67		**Çıtıpıtıoğlu**	210,47
PG2	**Experiment result**	499,52	**PZ2**	**Experiment result**	190,76
	TDY	1000		**TDY**	1000
	Fema	128,21		**Fema**	115,77
	Paulay and Prestly	163,18		**Paulay and Prestly**	133,53
	ACI	499,52		**ACI**	190,76
	C.M.C	198,14		**C.M.C**	162,14
	Çıtıpıtıoğlu	233,11		**Çıtıpıtıoğlu**	190,76

CONCLUSION

Uniaxial compressive testing of 4 masonry panels was conducted using four different bricks and two mortar grades. Based on experimental observations, modulus of elasticity of masonry is found between 120 and 1000 values. The results discussed in the present study may be valid only for the Turkish brick industry. However, the proposed models are generalized and may be implemented for other regions with slight modifications in input parameters. Further experimental verification may be required for extension of these results for bricks found in other regions, and mortar of different grades

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