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The Value of the Diagonal Shear Stress of the Masonry on Laboratory Testing

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Abstract: The earthquake resulted in structural, non-structural damage, material and non-material losses and even death. Material losses in the form of damage to houses, household furniture, loss of property. Non-material losses in the form of loss of peace, comfort. The above damage is anticipated by increasing the brick wall elements which contribute well to increasing its capacity to carry the combined external forces that occur during the earthquake. In particular, increasing the strength of a brick wall can be done by selecting the quality of the wall constituent materials and designing the brick wall. This research is addressed to investigate the value of the diagonal shear stress of the masonry brick due to the external forces. The testing was carried out as laboratory testing by using the preference model and method. The results of this study is that normal bricks reach 1500 to 1800 Kgf, and the normal diagonal shear stress reaches 1.6603788 Kg/cm2, while initial cracking at 400 to 800 Kgf, later cracking at 800 to 1,000 Kgf and failing at 1,500 – 1,800 Kgf.

Keywords: masonry wall; structure capacity; masonry behavior

INTRODUCTION

The earthquake resulted in structural, non-structural damage, material and non-material losses and even death. The above damage is anticipated by increasing the brick wall elements which contribute well to increasing its capacity to carry the combined external forces that occur during the earthquake. In particular, increasing the strength of brick walls can be done by selecting the quality of the wall constituent materials and designing the brick walls (Chopra, 2012; Kumar, n.d.).

The forces acting on the brick wall cause internal forces and deformation of the structure. The amount of internal force and deformation is limited so that the structure meets safety and serviceability requirements. The external force carried exceeds the force capacity of the structure, so the building is damaged. The capacity of the building structure (frame building) in carrying external forces can be identified from the behavior (response) of the structure when receiving external forces as shown in Figure 1.7. In this figure there are two curves, namely the upper part of the curve of the concrete portal wall filled with brick masonry and the lower part of the concrete portal wall without filled with brick masonry. Both are in structural condition when receiving lateral forces acting on the crest. The failure of seismic performance when receiving forces is reflected in the damage pattern of brick walls when subjected to lateral forces as seen in figure 1 (Dawe and Seah;, 1989). Reinforced concrete structures with brick masonry will be stronger than reinforced concrete structures without brick masonry (Bakhteri et al., 2007; Cetisli, 2015; Farooquddin, 2000; Holmes, 1961; Roberts, 1986).

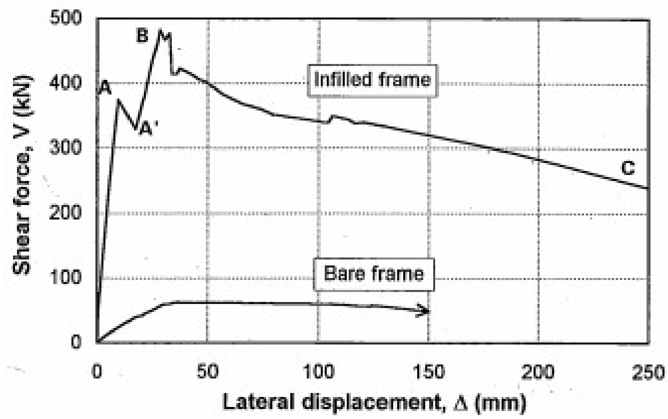

Figure 1. Dawe and Seah Capacity Curve

METHODOLOGY

The test is carried out by making a 60cm square test object (Ahmad, 2008; Page, 1981; Raharja et al., 2013; Torres et al., 2020) then applying pressure in the diagonal direction. At the time of setting up the test object is done carefully and thoroughly. The test object is positioned perpendicular to the diagonal direction. The test object is placed absolutely perpendicular and is given a load until it is completely damaged. The loading method is by applying a force that increases regularly until the structure experiences a complete collapse (Frapanti & Tarigan, 2017; Giannopoulos, 2009; Rana, 2004). Some examples of the setup for testing the shear diagonal test object are shown in the figure 2 and figure 3 below.

(a) (b)

Figure 2. Set Up of Diagonal Shear Test Objects (Torres et al., 2020)

Figure 3. Set Up of Diagonal Shear Test Objects (Ullah et al., 2022)

The diagonal shear stress is calculated from laboratory shear tests using the formula (ASTM E 519-02, 2002)

$$\tau = \frac{0{,}707\, P}{\frac{w+h}{2} t n} \quad (1)$$

Information:
τ= shear stress (MPa)
P= maximum force sustained (N)
w= the diagonal of the test object
h= test object height
t= the thickness of the test object
n= open test object ratio

RESULTS AND DISCUSSION

Testing of brick walls can be carried out at the age of 28 days after the manufacture of the specimen is complete (A.W Hendry and FM Khalaf, 2001; Binda, 2008; Chopra, 2012; Priestley & Paulay, 1992). The test was carried out according to the ASTM 2005 standard. The load was given in stages starting from 50 kg and increasing by 50 kg until the test object was damaged. Every time the load of the test object is increased, all events that occur are observed and the number of changes is recorded on the dial gage. Pushover has a way of working by providing a force that increases regularly until the structure experiences a complete collapse (Frapanti & Tarigan, 2017; Giannopoulos, 2009; Rana, 2004).

The test results are recorded and documented for the calculation of the diagonal shear stress. Diagonal shear stress of brick wall masonry can be calculated by laboratory shear stress using the formula (ASTM, 2005)

The framework in this research is built based on research that has been done by previous researchers. Previous research as a step guide in filling in research perfection. The framework for thinking that researchers can make is as follows in Figure 4.

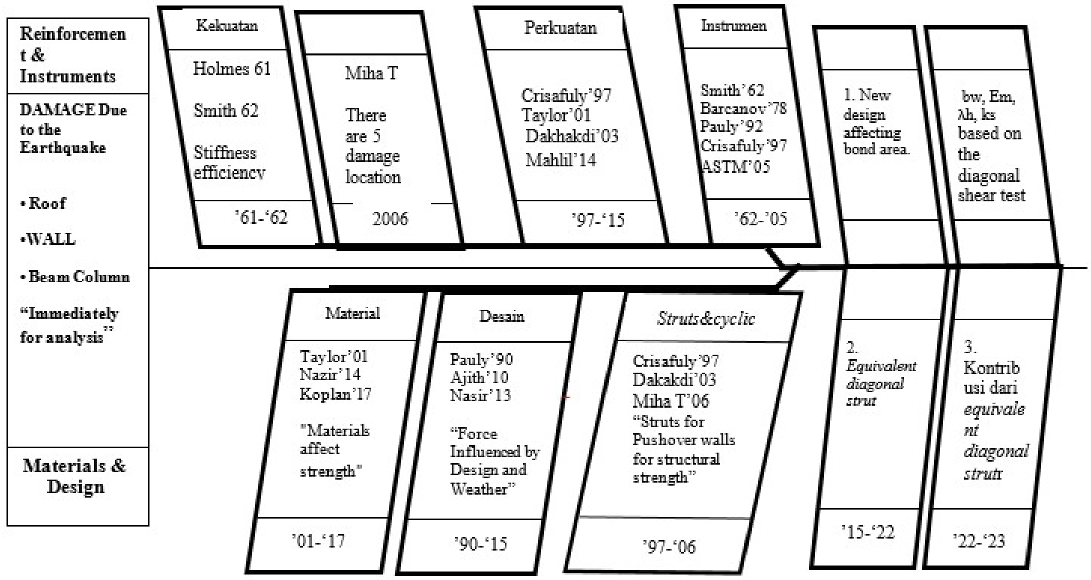

Figure 4. Figure Thinking Framework

According to (El-dakhakhni, 2017) there are several models of damage due to lateral loads in the laboratory, namely:

a) (Corner Crushing/CC) Corner Crushing Model;
b) (Sliding Shear/SS) Model of Sliding Damage;
c) (Diagonal Compression/DC) Center Diagonal Damage Model
d) (Diagonal Cracking/DC) Diagonal Cracking Model;
e) (Frame Failure/FF) Frame Failure Model.

The results of the brick shear stress test are demonstrated as figure 5 bellow and the detail of working forces as well as its reaction to the specimens are recorded as table 1 and table 2. While for the figure 6 is the graph for the testing result.

Figure 5. The laboratory specimen after the shear test

Table1. The results of the first test specimen bricks

Weight (Kg)	Large Shear Force (F)	Right Dial (mm)	Left Dial (mm)	Information
69,32		**0 = 0,36**	**0 = 0,99**	
50		0,36	0,99	
100,2		-0,25	1,12	
150,1		-0,21	1,18	
200		-0,2	1,18	
250		-0,2	1,28	
300		-0,99	1,47	
350,2		-0,99	1,48	
400,1		-0,98	1,46	
450		0	1,4	
500		0,3	1,31	
550,2		0,3	1,24	
600		0,8	1,18	
650		0,11	1,12	
700		0,24	1,7	
750,7		0,33	1,1	
800		0,36	0,98	
850		0,39	0,76	Top Crack (1)
900		0,41	0,75	
950,3		0,41	0,72	
1000		0,43	0,65	Sound (1)
1050,1		0,43	0,64	
1100,4		0,43	0,6	
1150,3		0,43	0,49	
1200,2		0,43	0,34	
1250		0,47	0,18	Sound(2)
1300		0,47	0,1	
1350,8		0,47	0,4	
1400		0,61	**0 = 1,96**	
1450,1		0,61	1,97	Bottom Crack (2)

1500		0,89	2	
1550		0,89	2	
1600,3		0,89	2	Sound (3)
1650		0,94	1,88	Bottom Crack (3)
1700		0,2	1,87	Sound (4)
1750		0,4	1,82	Top Crack (4) = 5cm
1800		1,19	1,71	Crack on left side

Table 2. The results of the second test object bricks

Weight (Kg)	Large shear force (F)	Right dial (mm)	Left Dial (mm)	Information
57,56		**0 = 2,19**	**0 = 3,35**	
50		2,27	2,25	
100		2,67	3,05	
150		2,9	2,78	
200,5		2,09	2,84	
250		2,09	3,3	
300		2,09	3,2	
350		3,2	3,08	
400		3,24	3,14	Front Top Crack (1)
450		3,23	3,25	Front Bottom Crack (2)
500,3		3,25	3,2	
550		3,3	3,25	
600		3,48	3,35	
650		3,58	3,3	
700		4,87	2,9	
750		4,92	2,54	
800,1		4,94	**0 = 2,56**	
850		4,18	2,5	
900,4		4,28	2,45	
950		4,35	2,45	
1000		4,51	2,4	
1050		4,65	2,4	

1100,2		4,65	2,41	
1150		4,68	2,4	Sound 1
1200		4,73	2,42	
1250		4,75	2,43	
1300,4		5,79	2,44	
1350		5,79	2,44	
1400		5,79	2,42	
1450,6		5,79	2,39	Back Bottom Crack
1500		5,79	2,3	Broken Right Side Down

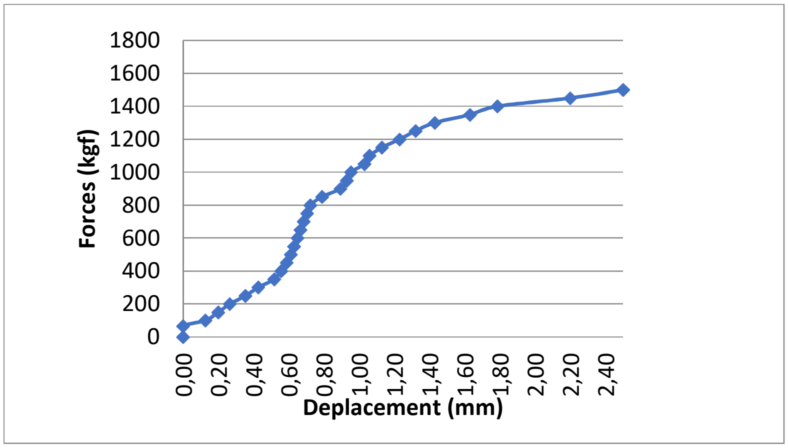

Figure 6. Results of the diagonal shear stress test

CONCLUSIONS

The conclusion of this study is that normal bricks reach 1500 to 1800 Kgf, and the normal diagonal shear stress reaches 1.6603788 Kg/cm2.

Initial cracking at 400 to 800 Kgf, later cracking at 800 to 1,000 Kgf and failing at 1,500 – 1,800 Kgf.

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