The concrete frame strength test is filled with brick against horizontal loads with several types of column beam joints and several types of brick wall connection frames

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The concrete frame strength test is filled with brick against horizontal loads with several types of column beam joints and several types of brick wall connection frames

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Abstract. Damages occurred in brick walls in a simple structure because of an earthquake show that walls also withstand the load. The damages may occur due to a lack of quality in the materials and the joint between each element of the wall. Therefore, this research aimed to examine the connections between the wall elements in order to investigate the strength of the walls with ductile and non-ductile connections and its crack behavior. The connection investigated in this study was the connection between the brick wall and beam, the brick wall and column, also the beam and column. The ductile wall connections were built according to the SNI brick walls, and anchors were put on the wall-to-beam and wall-to-column connection. The brick walls were then given load in a horizontal direction. Based on the results, the ductile walls with anchor had the greatest strength with 2.204 kg whereas the ductile walls without anchor had lower strength with 1.929 kg. On the other hand, the strength of the non-ductile walls was 1.653 kg. In conclusion, the absence of anchors that bind the wall-to-column and wall-to-beam reduced the strength by 12.5% whereas the use of non-ductile connections reduced the strength by up to 25%.

1. INTRODUCTION

In general, walls have only been considered as a room divider in a building. Walls as a non-structural component is also stated in SNI 03-2487-2002 showing that the strength of walls is never considered in the building design. In fact, walls are formed from bricks and cement which have strength and stiffness. In addition, walls consist of beams and columns as the surrounding elements that work together as a whole on the structure. Therefore, a good connection between these elements on the wall will produce a maximum strength of the structure in holding loads and reducing the occurring cracks.

Several studies have been conducted previously, one of which was done by the authors which investigated walls built by different qualities of brick materials. Other materials that can be used for building walls are paving blocks. Paving bricks mixed with aggregate materials of the concrete makers can withstand loads better than bricks from clay materials [1]. In addition to various wall fillings, another thing that can affect the strength of the structure, especially in a simple one-story building, is the presence of structure with infill wall and open frame. The walled structure has a smaller deformation than the open frame structure [2]. A column-to-beam connection which consists of ductile reinforcement will reduce the occurrence of drift. In other words, more tighten reinforcement will have less drift[3].

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In this study, several samples were designed according to SNI and produced better strength than the non-ductile SNI designs. Similar results were also concluded from a survey conducted in several simple houses in Malang city [4]. The samples in this study were not plastered to obtain a maximum strength by the effect of brick material through installation of rebar. The presence of mortar from cement affects the strength of the brick walls [5].

2. METHODS

2.1 Materials

The samples used was clay brick walls whose specification was in accordance to the SNI brick specification. The size of the brick wall was 2 x 3 m. The K-175 concrete was used in the casting of beams and columns. The beams and columns had a size of 20 x 20 cm. Three samples used in this study were brick walls with beams and columns frame. The difference between the three samples lies in its connection, either wall-to-beam, wall-to-column, or beam-to-column. The first sample was a wall with ductile beam-column connections according to the SNI regulation, and anchors were added to the wall-to-beam and wall-to-column connection. The second sample was opposite to the first sample; it was a wall with a non-ductile beam-to-column connection without the addition of anchors. The third sample was similar to the first sample, namely a wall according to the SNI regulation with a ductile beam-to-column connection but without the addition of anchors.

The form of the three samples can be seen in Figure 1, Figure 2, and Figure 3 as follows.

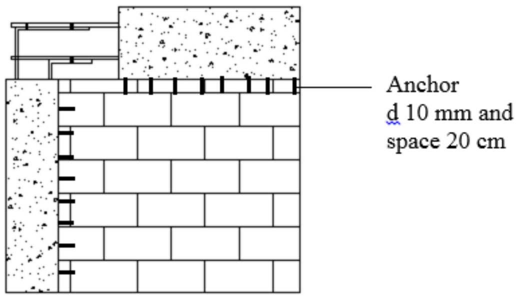

Figure 1. Sample 1: a strong beam-to-column connection according to SNI and with anchors.

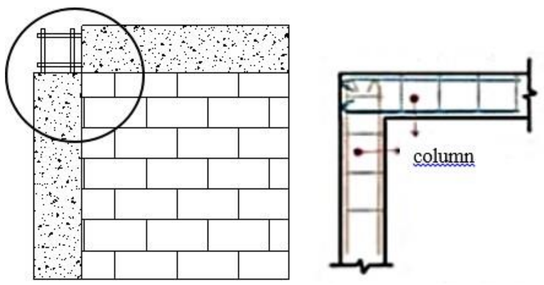

Figure 2. Sample 2: non-standard beam-to-column connection with details

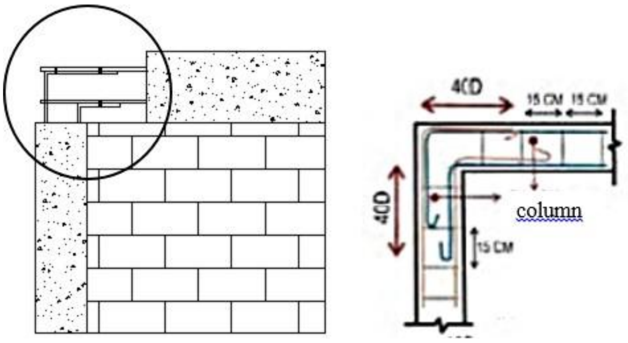

Figure 3. Sample 3: a strong beam-to-column connection according to SNI without anchors.

2.2 The testing equipment

The equipment used in this study was a hydraulic jack tool commonly used to give load from a vertical direction. However, due to the need for this research, the tool was assembled in such a way without reducing its function so that it can still apply forces but from a horizontal direction.

2.3 Methods

In the initial stage of constructing the walls, a spread footing foundation was used along the wall. The depth of the foundation was 1 m, and the K-175 concrete was used. After the casting of the foundation was done and the foundation has been dried completely, the next step was reinforcement steel bar work. Rebar installation of the beams and columns used concrete steels with a diameter of 10 mm and confinement bars with a diameter of 8 mm. For the installation of the anchors, reinforcement steel was placed every 20 cm between the stones assembled on the top and side of the wall. The next step was bricklaying. The size of the wall in this study was 2 x 3 m. After the brick walls were built, the process was continued to the installation of rebar for the columns and beams and the installation of the anchors. After the installation of rebar was finished, the next step was the casting of the beams and columns. After 28 days, the brick wall samples were tested. Some processes of preparing the samples can be seen in Figure 4, Figure 5, and Figure 6.

Figure 4. The process of digging soil and bowplank work

Figure 5. Rebar work

Figure 6. The process of casting

3. RESULTS AND DISCUSSION

The results of the horizontal load testing were the maximum strength of the wall. The maximum strength value of the wall was obtained from the dial gauge reading. The results of the maximum horizontal Load for all samples are presented in a diagram which can be seen in Figure 7.

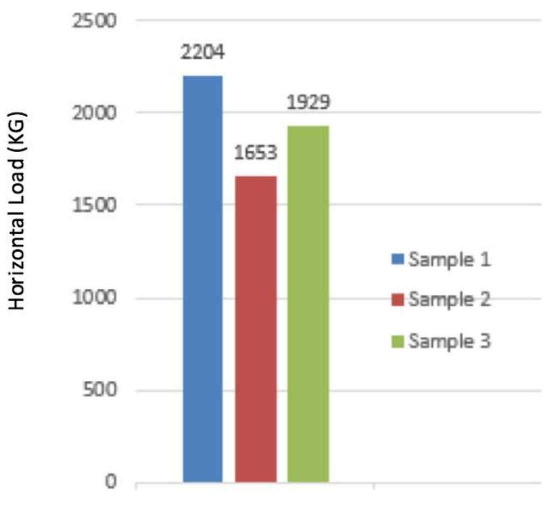

Figure 7. Diagram of maximum horizontal Load

The results of the dial gauge reading and the horizontal load of the walls are shown in the following Table 1.

Table 1. Dial reading – horizontal Load

Sample	Dial reading (psi)	Horizontal Load (kg)
Sample 1	1600	2204
Sample 2	1200	1653
Sample 3	1400	1929

Based on the above diagram, the horizontal load of the wall that occurred in the three samples varied because the connections to the wall were built differently for each sample. The results of calculations to obtain the wall strength can be seen from the following description.

Surface area = 19.6 cm^2

Force 1 unit = 1 psi = 0.0703 kg

Thus, the load calculation is:

$$f = \frac{P}{A}$$

$$0.0703 = \frac{P}{19.6}$$

P = 1.3778

Horizontal Load = Dial reading x P

Sample 1

Horizontal load = 1600 x 1.3779
= 2204 kg

Sample 2

Horizontal load = 1200 x 1.3778
= 1653 kg

Sample 3

Horizontal load = 1400 x 1.3778
= 1929 kg

The horizontal load difference between sample 1 and sample 3 was due to the anchors. Sample 1 had a ductile connection with anchors whereas sample 3 had a ductile connection without anchors. Anchors that bind between bricks-to-columns and bricks-to-beams have a considerable influence. This can be seen from the decrease in the percentage of the sample strength reaching 12.5%. The strength difference between sample 1 and sample 2 which was a non-ductile connection without anchors was up to 25%. This is due to the reduced bonds between brick-to-column and brick-to-beam. In addition, the non-standard brick-to-column connection caused the load transfer did not run perfectly.

4. CONCLUSION

Walls are categorized as a non-structural component; thus, walls are considered to have little effect when an earthquake occurs. The present study was conducted in a laboratory to explore the effect of wall connections. Based on the push-out test results with horizontal load, it can be concluded that:

1. Sample 1 which was a wall with a ductile beam-to-column connection and was given anchors on the wall-to-beam and wall-to-column connection had the greatest wall strength with 2.204 kg.
2. Sample 3 which was a wall with a ductile beam-to-column connection but without anchors had a smaller wall strength than sample 1 with 1.929 kg.
3. Sample 2 which was a wall with a non-standard beam-to-column connection had the smallest wall strength result with 1.653 kg.
4. The crack model occurred in all samples were similar, namely the crack caused by the shear force with a transverse pattern.
5. The absence of anchors that bind the wall-to-column and wall-to-beam reduced the strength by 12.5% whereas the use of non-ductile connections reduced the strength by up to 25%.

REFERENCES

[1] Oscar C, David J, Carlos A and Ximena A Production and quality levels of construction materials in Andean Regions; a case study of Chimborazo Ecuador *J. Construction in Developing Countries* 2017 **1** pp 115-136

[3] Olivia S, Bonny M, Ointu, Winny J, Tamboto and Ronny R Kajian uji laboratorium nilai modulus elastisitas bata merah dalam sumbangan kekakuan pada struktur sederhana *Jurnal Sipil Statik* 2013 **1** pp 797-800

[3] Jogi S, Ari W, Lilya S Pengaruh variasi jarak tulangan horizontal dan kekangan terhadap pola retak dan momen kapasitas dinding geser dengan pembebanan siklik (quasi-statis) 2017

[4] Mia A, Wisnumurti, Agoes S Study of fulfilment technical requirements brick masonry wall on non-engineered building in Malang 2018
[5] Nebojsa, et. al., Probability and structural reliability assessment of mortar joint thickness in load-bearing masonry walls *Journal of Structural Safety* 2015 B **52** pp 209-218
[6] Anonym 1997 *Guideline for European Technical Appropal of Metal Anchors for Use in Concrete (ETAG-001)* (Europe: European Organisation for Technical Approvals)
[7] Anonym 2002 *Baja Tulangan Beton SNI 07-2052-2002* (Indonesia: Departemen Pekerjaan Umum Republik Indonesia)
[8] Anonym 2002 *Tata Cara Perhitungan Struktur Beton untuk Bangunan Gedung SNI 03-2847-2002* (Indonesia: Departemen Pekerjaan Umum Republik Indonesia)
[9] Anonym 2005 *ACI Standard: Qualification of Post-Installed Mechanical Anchors in Concrete (ACI 355.2-04) and Commentary (ACI 355.2R-04)* (America: *American Concrete Institute)*
[10] Anonym 2008 *ACI Standard: Building Code Requirements for Structural Concrete (ACI 318-08) and Commentary* (America: *American Concrete Institute)*

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