IMPULSE TABLE TEST OF A “BIMSBLOCK” MASONRY STRUCTURE

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Abstract

Different methods have been used to understand earthquake behaviors of structures and structural elements. One of them is the application of dynamic horizontal loads with the help of shaking table to the structures or to quite a large scaled structural model. The most important feature of the impulse table tests is to provide the possibility of comparing the behavior of different masonry structures.

In this study, impulse table test of a masonry house, built by using CB-19 type pumiced bimsblocks produced by ISBAŞ company owned by Isparta Municipality, are made with the cooperation of University of Suleyman Demirel Technical Education Faculty, Earthquake Research Department.

The test indicated that the nominal shear strengths observed in this test for the pumiced bimsblock masonry house compared favorably with test results obtained in other impulse table test on clay brick masonry houses with clay blocks of various vertical perforation ratios.

1. INTRODUCTION

In earthquakes, the loads affecting the buildings are so called dynamic loads changing amplitude in the course of time. In addition, in earthquakes horizontal loads are more effective than vertical loads to buildings or buildings elements. Because, the buildings have normally an important amount of factor of safety against vertical loads, but not so much against horizontal loads. Because of these, any building systems or building elements must be tested under dynamic and horizontal loads similar to actual earthquake forces for determining their earthquake behavior.

Different methods are used to determine the earthquake behaviors of structures by applying dynamic horizontal loads to the buildings or building elements. One of these methods applies dynamic horizontal loads to building or a large scaled building model from its foundation similar to earthquakes by using a shaking table. This kind of shaking table applies horizontal loads similar to dynamical earthquake loads especially to one storied rural buildings and masonry building systems works computer controlled (Bayülke, N., others, 1986). Shaking tables due to their high complexity are very costly to built and operate. On the other hand, the impulse table applies an impulsive force on the model tested. It is much

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simpler and cheaper. While a "advanced" shaking table moves under the strong ground motion of a known earthquake ground motion, the model on the shaking table is subjected to the ground motion of an actual earthquake. The impulse table on the other is given an initial displacement and released, which creates inertial forces in the model resting on the table. (Bayülke, N., others, 1996). The derivation of element behavior from the material behavior and the structural behavior from the element behavior generally requires experimental data. Testing of the structure as a whole provides information on the interaction between the elements of the structure and its material within the whole entity of the building. Testing of different types one-story structure on the impulse table in terms of earthquake resistance provides data for comparison of structures with different details and materials (Bayülke, N., 1993).

Tests on the impulse table are more economic than those on the shaking table. Damages observed on a light weight aerated concrete wall panel house during March 13, 1992 Erzincan Earthquake and the behavior of a similar model house previously tested on the impulse table were very close to each other. This was considered as a proof of the reliability of the impulse table testing as a method of testing houses under conditions similar to real earthquakes (Bayülke, N., others, 1993).

The table has unidirectional horizontal motion. The net weight of the table is 20.5 tons and its dimensions are five by six meters. Models weighing up to 50 tons can be tested on this table. The natural period of vibration of the table varies between 0.15 to 0.30 seconds depending on the weight of the model tested (Bayülke, N., 1986).

2. CHARACTERISTICS OF MATERIALS

The test house were built by CB-19 type of pumiced bimsblocks produced in accordance with the Turkish Standard TS 2823. The unit weight of the bimsblocks are less than 1 kg/dm^3 and min shear load value of bimsblocks has 200 kgf/cm^2 (Gündüz, L., others, 1998). Dimensions of the CB-19 type of pumiced bimsblocks used in the model tested are as shown in Table 1.

Table 1. Dimensions of the bimsblocks

Width (mm)		190
Length		390
Height		185
Thickness	Lengthwise	30
	Breadthways	30
	Inside	30
Mortar Cavity	Breadth	120
	Depth	20

Surface Area (mm^2)	74100
Full Surface Area (mm^2)	50500
Hollow Surface Area (mm^2)	23600
Filled Ratio (%)	68.15
Failure Load (kgf)	19500
Compressive strength (kg/cm2)	32.99
Strength Factor	19.04

The average compressive strength of the pumiced bimsblocks were approximately 19.93 kg/cm^2.

- Mortar strength

Two cube specimens with dimensions 20x20x20 cm were taken from the mortar used in the construction of the walls of the model house and the 28th day compressive strength of these cube specimens were as given in Table 2 (Bayülke, N., others, 2000).

Table 2. Test results of mortar compressive strength

Specimen No.	Applied force at breaking moment	Strength (kg/cm^2)
1	7200	32
2	6800	30

3. CHARACTERISTICS OF THE MODEL STRUCTURE

The model structure had a weight of 15.6 tons. The plan of model tested are as given in Figure 1. An average quality of workmanship was used in the construction of the walls. A mortar layer of about 2cm thickness were placed and the open end of the bimsblock is pressed on to this mortar layer. A small portion of mortar layer may have introduced in to the hollow bottom of the bimsblock resulting in the formation of a small “shear key” of mortar. If this hollow bottom of the bimsblocks had been filled with a much larger mortar key the in plane shear strength of the wall might have been higher. The roof slab of the test house were made with ready mix concrete. The weight of the test house was approximately 15.6 tons (Bayülke, N., others, 2000).

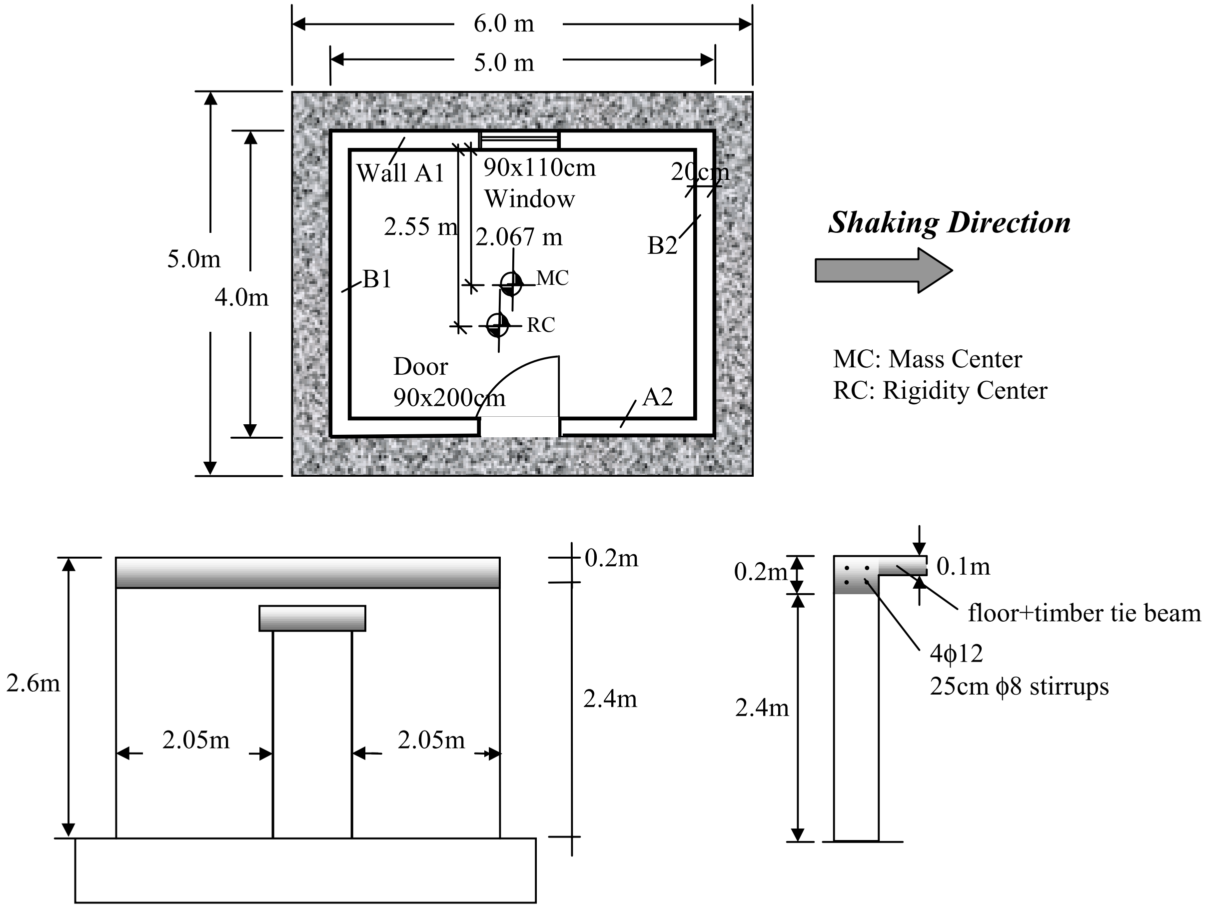


Figure 1. Various views of the model structure

4. TESTING

During the tests, various levels of increasing initial displacements were given repeatedly to the table with the recorded maximum table and roof accelerations. The duration of each shaking is about 1.0-1.5 seconds. The initial displacements applied to the table, the resulting maximum accelerations recorded on the table and the roof of the test structure for each test and forces effecting to building were as given in Table 3 (Bayülke, N., others, 2000).

Table 3. Max. Table and Roof Acceleration, and Forces Effecting to Building (Bayülke, N., others, 2000)

Load No.	Initial Displacement(mm)	Max. Table Acceleration (g)	Max. Roof Acceleration (g)	Force Acting on the Building (ton)
1	25	0.43	0.49	7.82
2	35	0.68	0.79	12.56
3	45	0.86	1.08	17.17
4	45	0.83	1.05	16.70
5	45	0.88	1.07	17.02
6	55	1.16	1.31	20.83
7	55	1.29	0.92	14.63
8	55	1.38	0.76	12.09
9	65	1.76	0.62	9.86
10	65	1.81	0.52	8.27
11	65	1.81	0.46	7.32

4.1. Nominal Shear Stresses in the Walls

The nominal shear stresses created in wall A1-A2 and B1-B2 in each test were as given in Table 5 and 6. It is assumed that the nominal shear stresses are taken over by the walls in the direction of shaking according to their “shear rigidity” This rigidity is proportional to the cross section area of the wall segments divided by the clear heights of these walls. The wall segments on both sides of the windows are more rigid due to the relatively shorter height of the window opening. This fact would be creating an eccentricity resulting in some amount of torsion in the test structure (Bayülke, N., others, 2000).

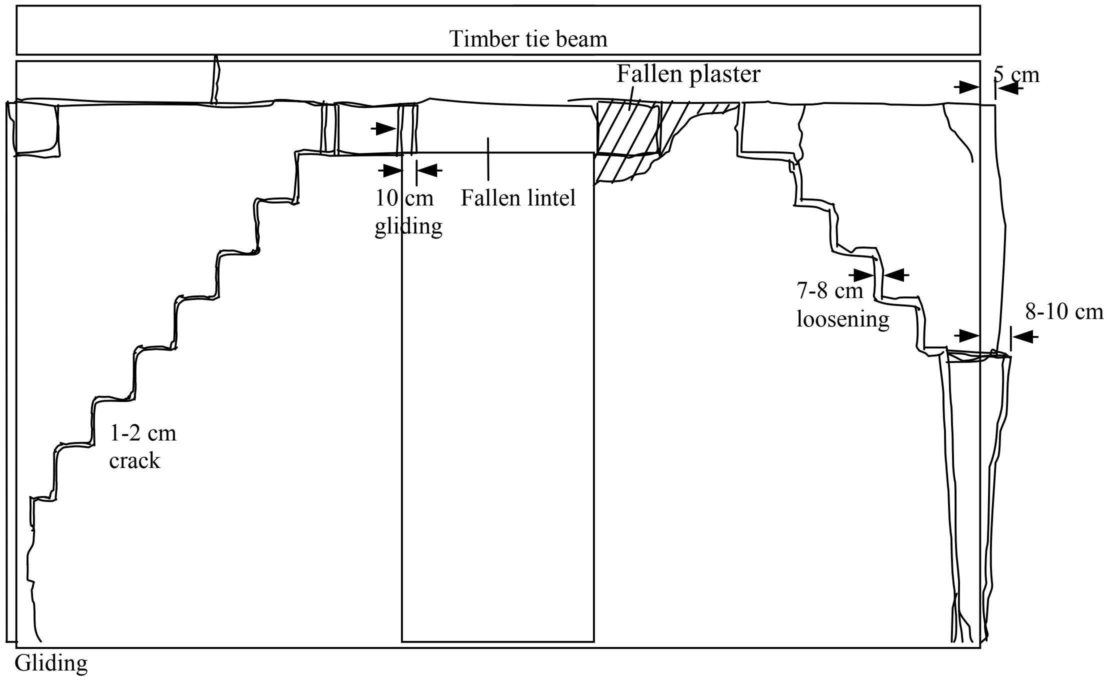
Table 4. Nominal shear stresses of A1-A2 walls (Bayülke, N., others, 2000)

Load No.	F(ton)	0.19xF(ton)	Surface (m^2)	Shear Stress (kg/cm^2)
1	7.82	1.49	0.41	0.36
2	12.56	2.39	0.41	0.58
3	17.17	3.26	0.41	0.80
4	16.70	3.17	0.41	0.77
5	17.02	3.23	0.41	0.79
6	20.83	3.96	0.41	0.97
7	14.63	2.78	0.41	0.68
8	12.09	2.30	0.41	0.56
9	9.86	1.87	0.41	0.46
10	8.27	1.57	0.41	0.38
11	7.32	1.39	0.41	0.39

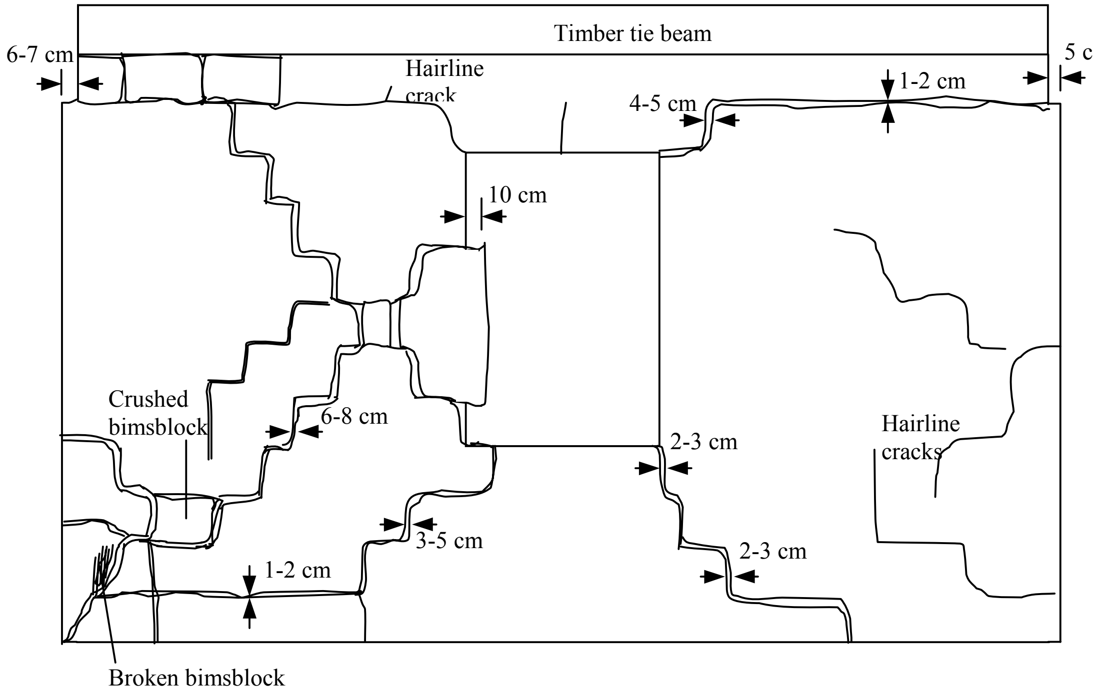
Table 5. Nominal shear stresses of B1-B2 walls (Bayülke, N., others., 2000)

Load No.	F (ton)	0.35xF (ton)	Surface (m^2)	Shear Stress (kg/cm^2)
1	7.82	2.74	0.41	0.67
2	12.56	4.44	0.41	1.08
3	17.17	6.01	0.41	1.49
4	16.70	5.85	0.41	1.43
5	17.02	5.96	0.41	1.45
6	20.83	7.29	0.41	1.78
7	14.63	5.12	0.41	1.25
8	12.09	4.23	0.41	1.03
9	9.86	3.45	0.41	0.84
10	8.27	2.89	0.41	0.70
11	7.32	2.56	0.41	0.62

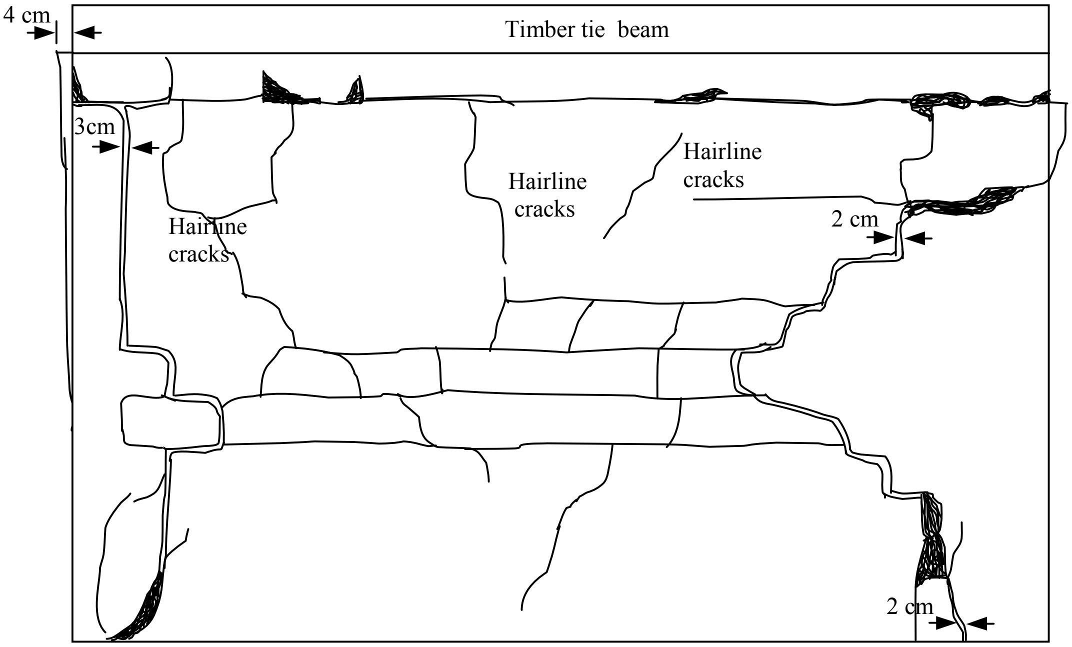
After 3rd loading, hairline cracks were observed especially in north side. These cracks became wide after the 6th loading approaching and exceeding cm level. After the 11th loading the test house were still standing but with severe cracks at various points in the building: 5.00cm wide cracks on the western side, crushing of a bimsblock, 2 cm wide cracks on the eastern side as well as numerous hairline cracks on this side, On the southward side where there is a window, wall segments on the sides of the window 10cm wide cracks, slippage and rotation of bimsblocks; hairline and 3-5 cm wide cracks under the tie beams were observed. On the north side wall where there is the door opening 10 cm wide slippage of bimsblocks 7-8 cm separation of bimsblocks fallen pieces of plaster or mortar were observed. Since the south side with a smaller window opening is more rigid than the north side where there is a larger door opening, torsional effects were created and south side received a greater force and there were more severe damage on the south side: cracks were wider, separation between the bimsblocks were more and individual bimsblocks rotated more as compared to north side. Damages in the model structure after test were as shown in Figure 2 (Bayülke, N., others, 2000).



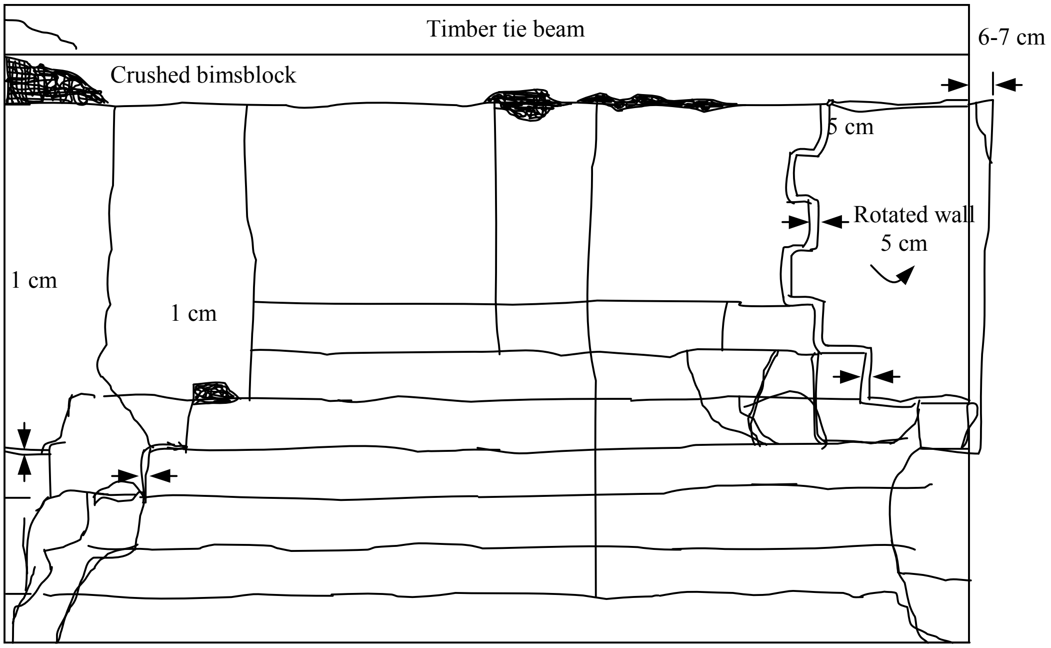
North Side



South Side



East Side



West Side

Figure 2. The views of the model structure after the tests (Bayülke, N., others, 2000)

5. RESULTS

The test provided valuable data about the probable earthquake behavior of the masonry house made from pumiced bimsblocks. Compressive strength of the bimsblocks and the amount of opening influence the shear strength of the masonry buildings. Presence of a small amount mortar intrusion inside the bimsblock would probably increased the shear strength of the walls. Once the adhesion strength between the mortar and the masonry bimsblock is reached cracks are formed between the mortar and the bimsblocks. Then the lateral force resistance of the wall is provided by the friction between the interface of the cracks.

One indicator of the masonry wall shear strength is the ratio between the maximum nominal wall shear stress measured in the test and the tensile strength of the mortar. The ratio observed in this test lies somewhere in between the maximum and minimum values observed in previous tests made on masonry houses.

The pumiced bimsblocks used in this test are produced for the filler walls of reinforced concrete frame buildings. Based on the observed behavior of the test building, positive contributions to the performance of reinforced concrete frame buildings can be achieved with this wall material: provided that a tick mortar layer is applied between the bimsblocks and a shear key of the mortar is obtained by applying a considerable pressure to the bimsblocks so that the sides of the bimsblock penetrates in to the mortar layer. Filler walls constructed in this manner would increase the latter rigidity of the frame structure, even contribute to the lateral load carrying capacity; and in case of a loss in vertical load carrying capacity of the vertical elements of the frame contribute to the vertical load carrying capacity of the structure.

The bimsblocks made from pumice are a lightweight material with considerable heat insulation capacity. Their use in reinforced concrete frame buildings would decrease the weight of the building and the earthquake forces coming to the building.

They can also be used as filler materials in timber frame buildings ,traditionally called “HIMIŞ”, where the frames are usually filled with adobe bimsblocks or rubble stone which are considerably heavier than pumiced bimsblocks. This filler lighter material would enhance their strength and make the houses lighter by the use of a better insulating material in thinner amounts.

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