EXPERIMENTAL TEST ON THE CONCRETE WALLS WITH DIFFERENT PROPORTIONS OF FIBER WITHOUT REINFORCING STEEL IN THE WEB

Pedro Axel Sánchez Hernández[1] , Ángel Ponce Córdova[2], Rubén Méndez García[3], Roberto Uribe Afif[4] y Davidé Zampini [5]

ABSTRACT

This paper presents an experimental test of two concrete walls to full-scale with a typical geometric features housing, height 2400 mm and thick 100 mm, the concrete that was assessed had a compressive strength of 14,71 Mpa (150 kg/cm^2), each wall was reinforced with a different ratios of macro synthetic and micro fiber, both without reinforcing steel in the web. Underwent to a cyclic reversed lateral force. Show the test conditions that emerged during the assay, results were analyzed of each wall hysteresis curves and crack patterns, which consisted of cracks at 45 ° in both directions distributed mainly in the corners of the walls.

[1] Structrural engineer, Centro de Tecnología Cemento y Concreto, CEMEX, Tercera Cerrada de Minas No. 42, Col. Francisco Villa , 01280 México, D.F. Teléfono, (55) 5627-0288; fax: (55) 5526-8325; pedroaxel.sanchez@ext.cemex.com

[2] Structural engineered Manager, Centro de Tecnología Cemento y Concreto, CEMEX, Tercera Cerrada de Minas No. 42, Col. Francisco Villa , 01280 México, D.F. Teléfono, (55) 5626-8369; fax: (55) 5526-8325; angel.ponce@cemex.com

[3] Researcher Jr, Centro de Tecnología Cemento y Concreto, CEMEX, Tercera Cerrada de Minas No. 42, Col. Francisco Villa , 01280 México, D.F. Teléfono, (55) 5626-8365; fax: (55) 5526-8325; ruben.mendezgr@cemex.com

[4] Technical Director, Centro de Tecnología Cemento y Concreto, CEMEX, Tercera Cerrada de Minas No. 42, Col. Francisco Villa , 01280 México, D.F. Teléfono, (55) 5626-8326; fax: (55) 5526-8325; roberto.uribe@cemex.com

[5] Trends Construction Manager and Product Development, Centro de Desarrollo Tecnológico, CEMEX , Römerstrasse 13 , Brúgg, Suiza, Teléfono, (41) 323667872; davide.zampini@cemex.com

INTRODUCCTION

With the purpose of studying the use of new types of concrete walls, and to satisfy the growing demand for quality housing and low cost in Mexico, is being carried out experimental research where concrete walls tested scale with a geometry typical for this housing, in reference with the results reported in similar studies.

We know that for concrete walls used in common households up to two levels, Mexico seismic demand is low, depending mainly on the structure and density of walls presented in the projects, for this and according to studies conducted in this type of walls, it has been observed that the reinforcing steel required to resist shear is less than recommended by current regulations and applicable in our country. For this reason and due to the lack of a design methodology for concrete walls reinforced with fibers, started a research project which will evaluate the performance of different types and dosage of fibers.

This paper presents the conditions in which the assay is performed for two concrete walls, the first reinforced with a macro synthetic fiber and the second reinforced with a micro synthetic fiber, both without shear reinforcement steel in the web, we discuss the behavior of the two concrete walls and compares the maximum shear resistant with a theoretical shear in a concrete plain.

EXPERIMENTAL PROGRAM

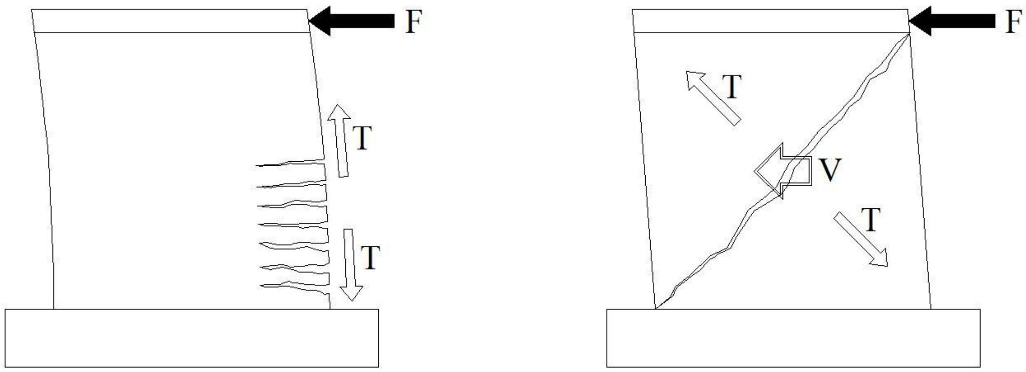
TEST DESCRIPTION

The test is as indicated by the normative Appendix A, in Mexican code for masonry, also supported in the test method ASTM E2126-11. In this literature, indicates that at least one specimen shall be tested for each configuration or feature wall, under a series of controlled deformation cycles.

An important aspect in this test, is able to represent the actual conditions of housing study, an example is the actions of the vertical load, for this situation the vertical force acting on the wall of 0.25 MPa (2.5 kg/cm2), in according a 2 levels housing.

The principal load to be submitted to the specimens, is a horizontal force cyclically reversible, which simulate the force induced by an earthquake, wherein for each load increment apply two cycles, where the first load is controlled by, which correspond to 25%, 50% and 100% of the calculated theoretical load of cracking, if the specimen stage satisfy this first load should be controlled under load distortion, to at least a distortion of 0.006.

In order to represent the phenomenon under study by this test, is necessary to bring the web of a shear wall product of cyclic load applied to the top of the specimens , so it is necessary to prepare such experimental models that the fault is not present by bending (see figure 1a), as is the nature of response of a vertical element subject to a horizontal, so that the geometry and reinforcement wall, as explained later in this article, you will need to provide an on steel reinforcement, strategically located in such a way to induce shear failure (diagonal tension) in the soul of the wall (see figure 1b).



a) Bending failure b) Shear failure

Figura 1 Falla por flexión y falla por tensión diagonal

FACILITIES AND EQUIPMENT

In the Structural Laboratory (see Figure 2), the Center for Technology CEMEX Cement and Concrete (CTCC), it has the infrastructure and equipment necessary to carry out such tests, adhering to the recommendations of the rules we are taking as a reference.

Figura 2 Structures Laboratory CTCC CEMEX

For the correct execution of this test, we have a 490.33 kN hydraulic actuator (50 t) (see Figure 3.) Capable of applying the reversible cyclic loading (tension and compression), placed horizontally to a modular wall reaction of 4000 mm high by 3000 wide (see figure 4.)

Figure 3 hydraulic actuator (50 t)

Figure4 Wall reaction

By a steel girder (head) of 2400mm long and 400mm wide, placed over the built slab in the wall, the horizontal load can be transmitted along the length of the wall

To secure the specimens in the test area, it has a reaction slab, with the ability to make any kind of arrangement in the position of the models. One important aspect of the test is to ensure embed simulation of the walls, for which it is in the reaction slab, where by means of the foundation beams on which the walls were made to be tested, are fixed by a post-tensioned slab such a reaction, the prior application of a high strength mortar, which serve to give a rough surface and maintain necessary verticality. Through multiple assays developed previously, this is the manner required to ensure no slippage or rotation of the walls, with the application of the load increases, correctly transmitting the reaction slab.

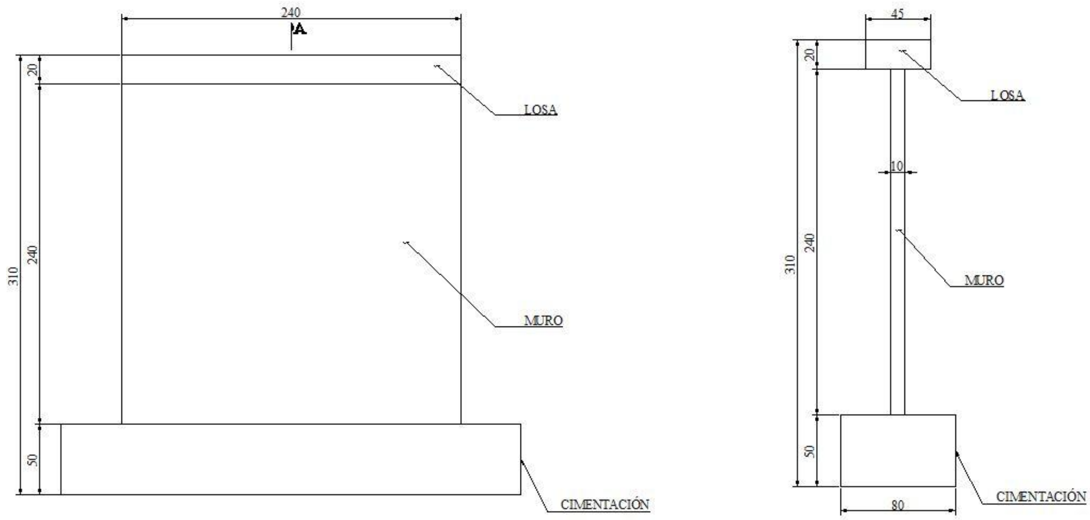
Is necessary to simulate the vertical load, we have a device for applying vertical load (see Figure 5), comprised of a steel beam that is placed crosswise on the head, this beam has the ends prepared for passage of rebar, for the test applies the load required to simulate a continuous vertical load and constant magnitude during the test.

Figure 5 Vertical Load

Figure 6   Overview test

WALL GEOMETRY

The construction of the walls (see Figure 7) corresponds mainly to maintain an aspect ratio of one to one, in order, the height and length of the wall were 2400 mm, square walls with aspect ratio H / L = 1. The wall thickness was 100 mm, which is also commonly used in the housing dimension. At the top was placed a concrete slab 200 mm thick, 450 mm width, this slab was used to support load the beam splitter, which as mentioned above, the horizontal load transferred to the web of the wall , by means of clamping screws 24 which pass through holes in 5cm diameter for the installation of these, previously prepared were left in the stage of casting.



a) Elevación Frontal b) Elevación Lateral

Figure 7 Wall Geometry

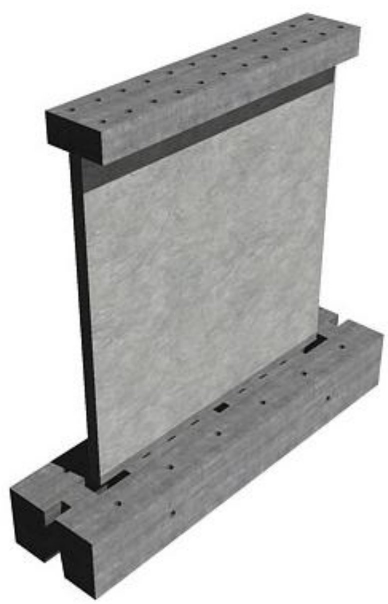


Figure 8 Wall Perspective

Embedment to simulate the walls of the foundation, foundation beams were used in 80 x 50 cm, in which by means of rods of # 3 @ 400 mm spaced walls were anchored so to ensure perfectly embedded.

For represent the effect of the shear force in the web of the walls, it was necessary to provide reinforcing steel at the ends of the walls (see figure 9), this is mostly so that said steel is to absorb the bending that occurs by the effect of horizontal force and parallel to the direction where the concrete will take the shear.

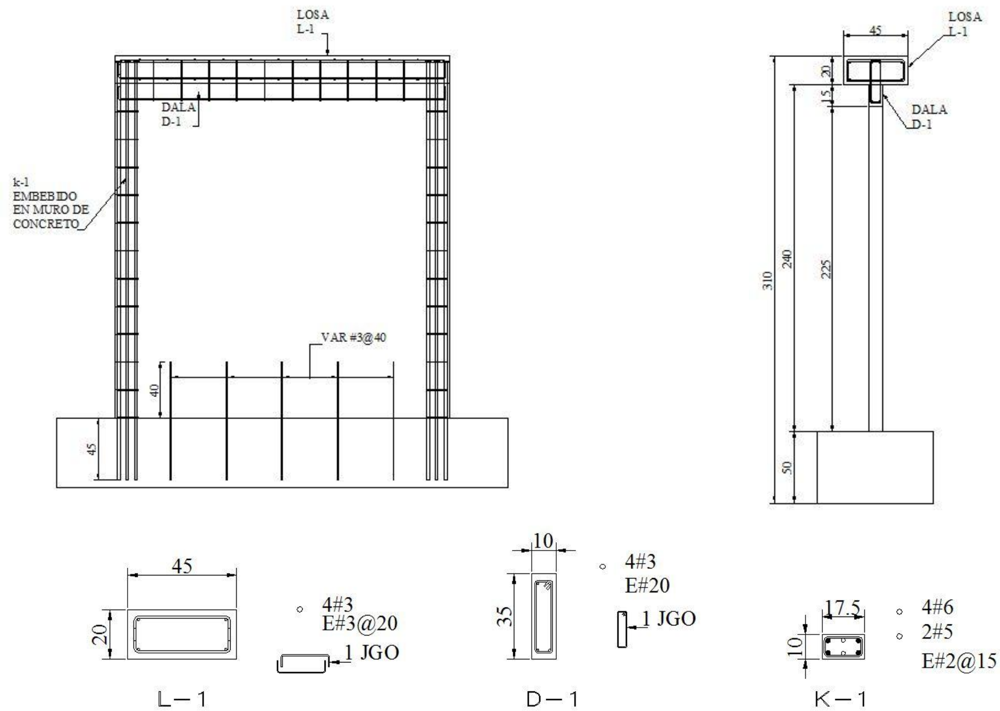


Figure 9 Wall Reinforcement

The correct fastening of the walls to the floor reaction plays an important role in the assay, since it must ensure the minimum displacement of the wall, in order to take the reading from net displacement, making it necessary that the foundation of wall (see figure 10), is sufficiently rigid to transmit force to the reaction slab.

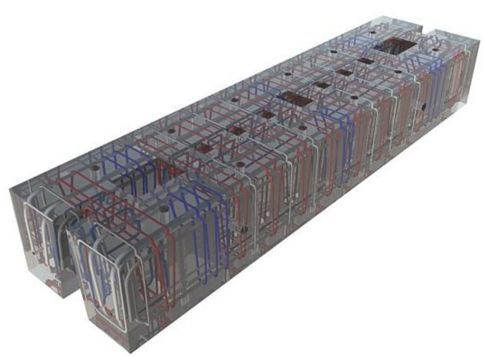


Figura 10 Foundation Reinforcement

MATERIAL PROPIERTIES

The material properties (see Table 1), is the main variable of the two walls studied in this project, these represent the beginning of a comprehensive program of research, which will explore concrete typically used in housing, whose resistance to compression is measured at 28 days.

Tabla 1 Material propierties

Wall	Concrete	f'c Mpa (Kg/cm^2)
M1	Plain Concrete	14,71 (150)
M2	Plain concrete	14,71 (150)

INSTRUMENTATION

The external instrumentation is only necessary for this test, in our case it was necessary to have measurements of:

1) Horizontal displacement at different heights
2) Rotation of the wall
3) angular deformities

In order to make these measurements on the wall was enough to have an external instrumentation, based transducers 12 (see Figure 11), of which 5 were used to determine the deflection of the wall, one to measure the slippage of the foundation , 6 for measuring the relative deformations of the sides and diagonals of the walls.

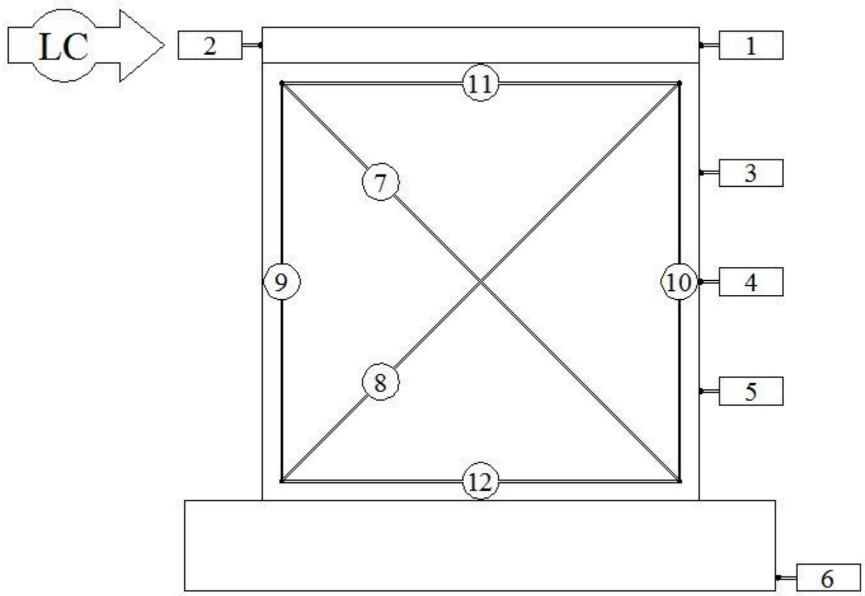


Figure 11 External instrumentation

The horizontal reading was taken through the installation of a load cell placed directly in the hydraulic actuator.

Data acquisition was achieved with the help of a TDS, which is connected to each of the measuring devices used, and by using a computer program, is as corresponding readings were taken as well as the graphs of hysteresis in real time.

ANALYTICAL PREDICTION OF SHEAR STRENGTH

The theoretical shear strength, was calculated as indicated in the current design codes and have a wide application in our country, as in the case of additional technical standards for the design and construction of concrete structures 2004 (NTC -DC-2004) and the American Concrete Institute (ACI 318R-08).

$$V_{cR}(NTC) = 0.85 \cdot F_R \cdot \sqrt{fc^*} \cdot t \cdot L \quad (1)$$

$$V_{cR}(ACI) = 0.53 \cdot \sqrt{fc'} \cdot b_w \cdot d \quad (2)$$

Where:

$V_{cR}(NTC)$	Shear strength (NTC-DC-2004)
$V_C(ACI)$	Shear strength (ACI 318R-08)
$fc*$	Nominal strength
t	Tickness
L	Length
fc'	Compressive strength of the wall at 28 days
b_w	Web

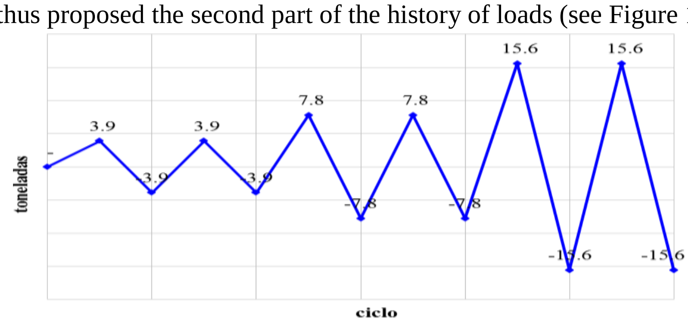
Two resistances were calculated shear (see Table 2), with the "ec. 1 and Eq. 2 ", which take us lower as the value of the ultimate strength of the wall in the assay, since this value is generated in the history of loads to be applied to each of the walls.

Tabla 2 Resistencia teórica a cortante

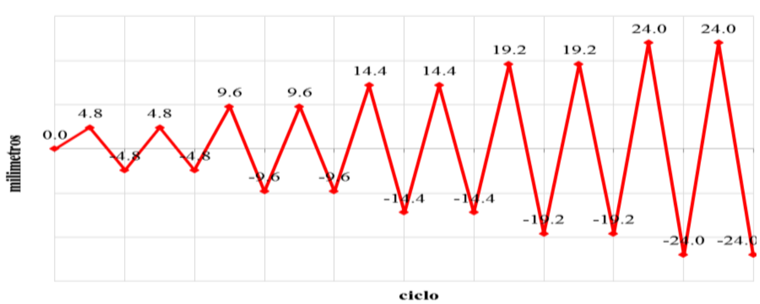
Muro	fc* Mpa (Kg/cm^2)	t mm	L mm	fc' Mpa (Kg/cm^2)	b_w mm	d mm	V_{cR} (NTC) kN (t)	V_{cR} (ACI) kN (t)
M-FPP	11,77 (120)	100	2400	14,71 (150)	100	2400	219,15 (22.347)	152.78 (15.579)
M-FPL	11,77 (120)	100	2400	14,71 (150)	100	2400	219,15 (22.347)	152.78 (15.579)

The load was applied to the walls, is determined from the information presented to perform this test, shown in Appendix A of the Supplementary Technical Standards for the design and construction of masonry structures, which take as cracking load, shear theoretical resistance of the walls, from here we calculated the required load history (see figure 12a)

For calculating the cycles per distortions take us increased 0.002 for each pair of cycles corresponding to the geometry of the walls thus proposed the second part of the history of loads (see Figure 12b)



a) Controlled by Load



b) Controlled by drifts

Figure 12 History Load

TEST RESULTS

DAMAGE EVOLUTION

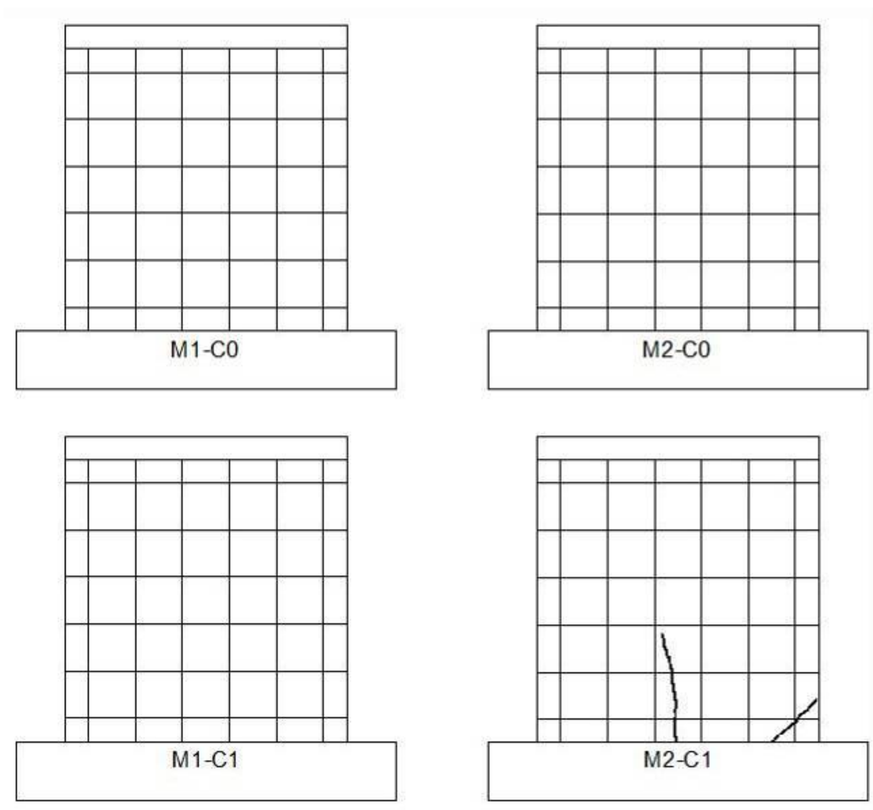
During the test run, it was taking graphic and photographic records, to assess the damage evolution presented (see Figure 13) for each of the cycles, which arose in the following manner:

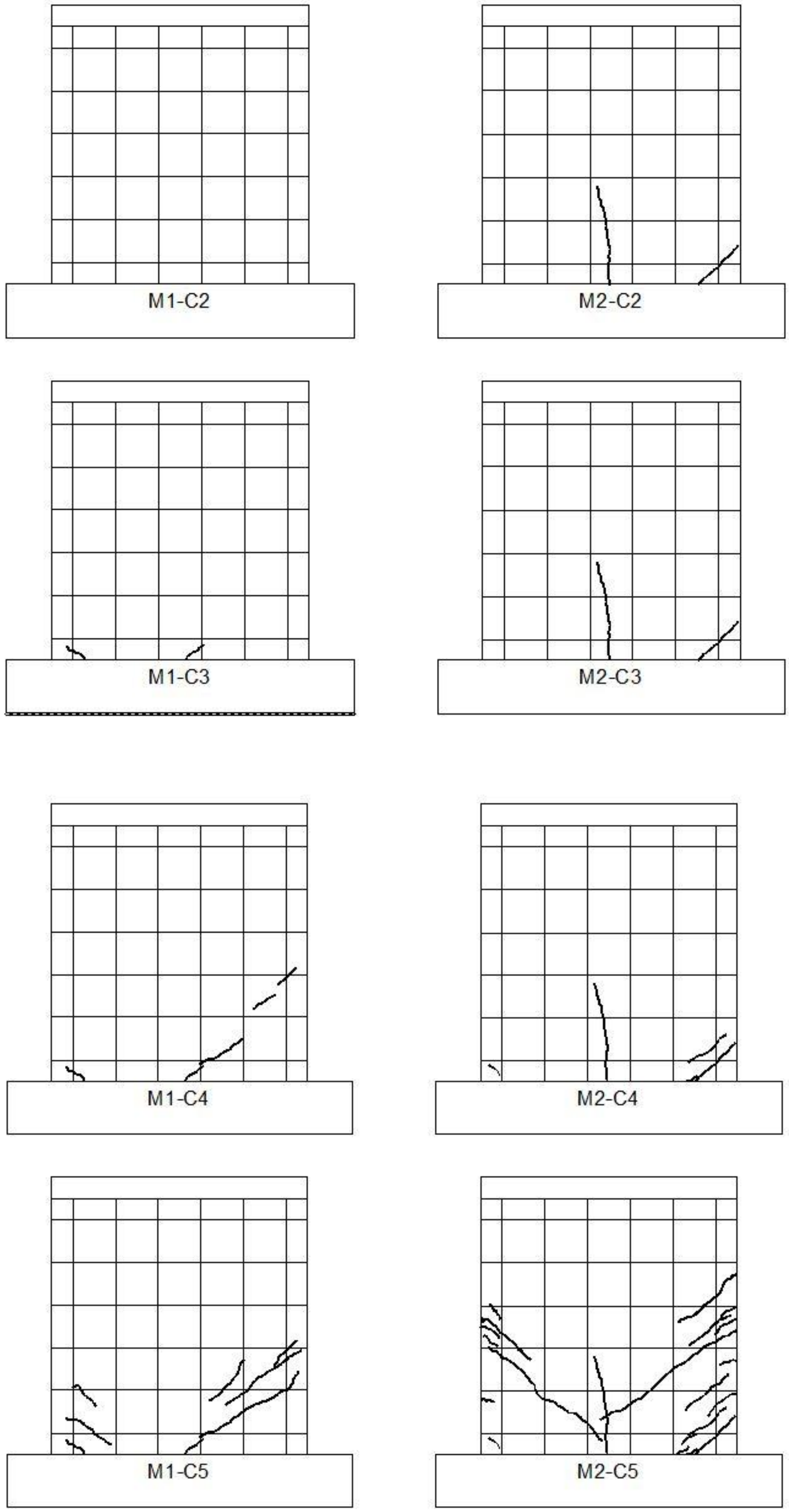
Evolution “M1”

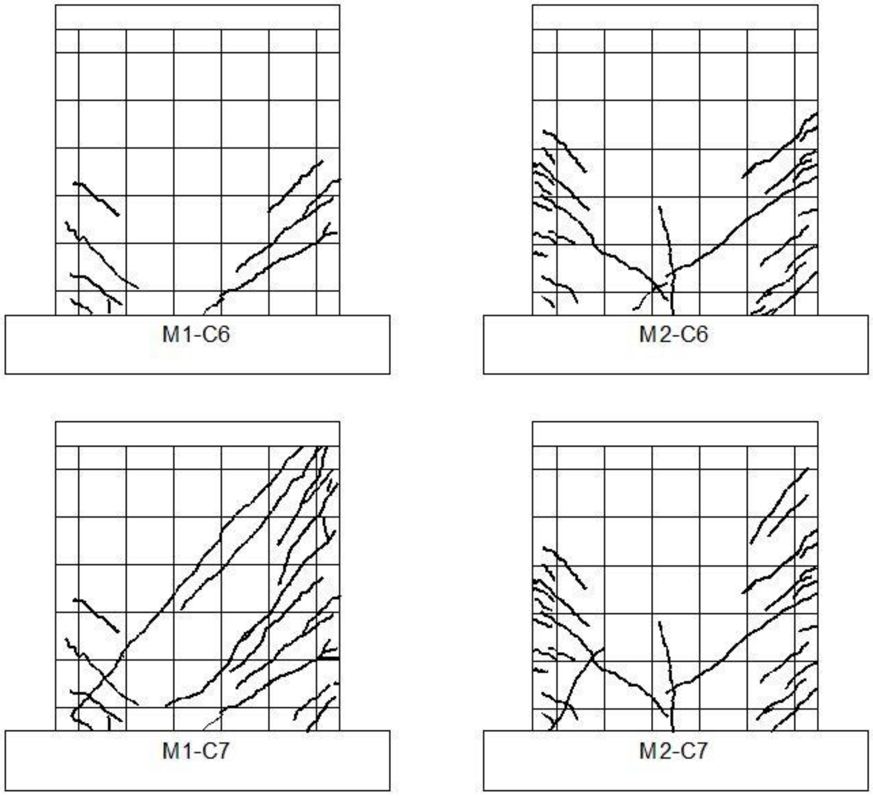
The damage in the first two cycles was practically zero, since the cycles corresponding to half the load resistance had arisen cracks in the bottom corners, then on the last charge cycle for damage moved closer to the soul the wall finally reached the diagonal tensile failure suddenly in the first cycle by distortion, with a crack 45 °

Evolution “M2”

Similar to M1, the wall showed little cracking during the first few charge cycles, starting from the bottom corners damage, as the load is increased for each cycle new cracks appeared, and spread some of the already present, approaching the soul with the same pattern of damage when passing by distortions cycles is when the cracks were increased, on the shore of the wall almost the entire height, leaving almost intact the center of the wall, to the time of the failure diagonal tension in the center and 45 °




M1-C2
M2-C2
M1-C3
M2-C3
M1-C4
M2-C4
M1-C5
M2-C5


M1-C6
M2-C6
M1-C7
M2-C7

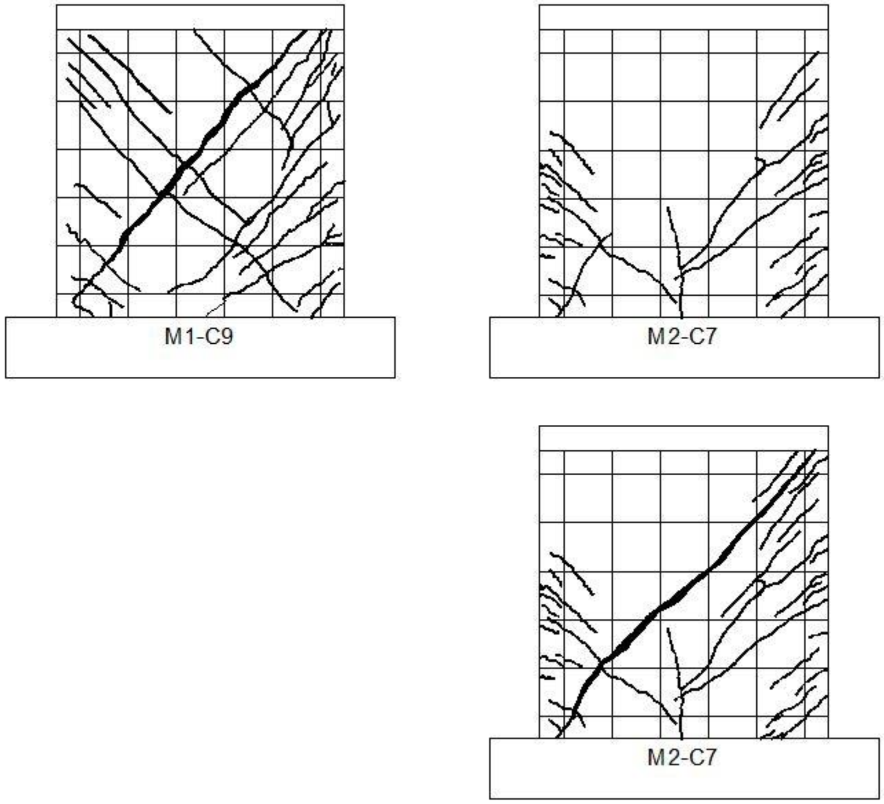
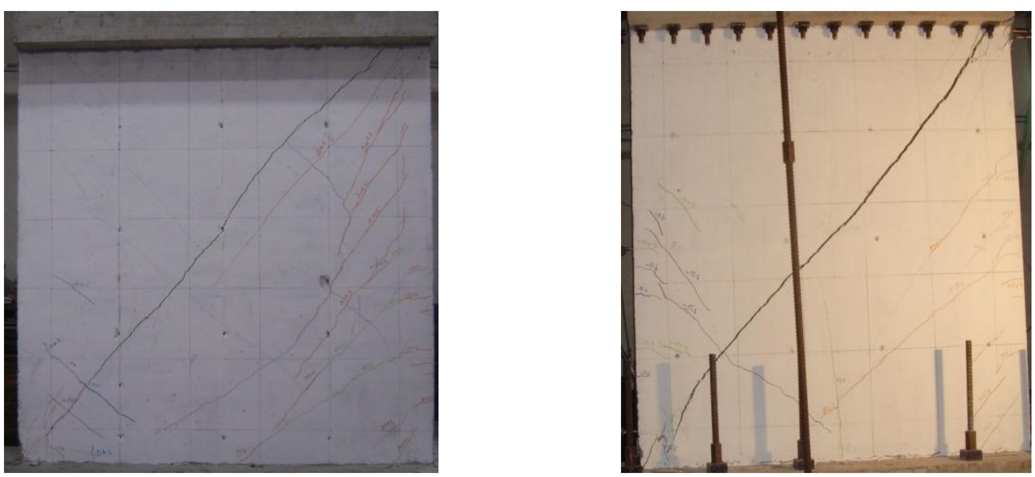


Figure 13 Damage evolution

FINAL APPEARANCE

The test ended when filing damage mechanism diagonal tension (see Figure 14)

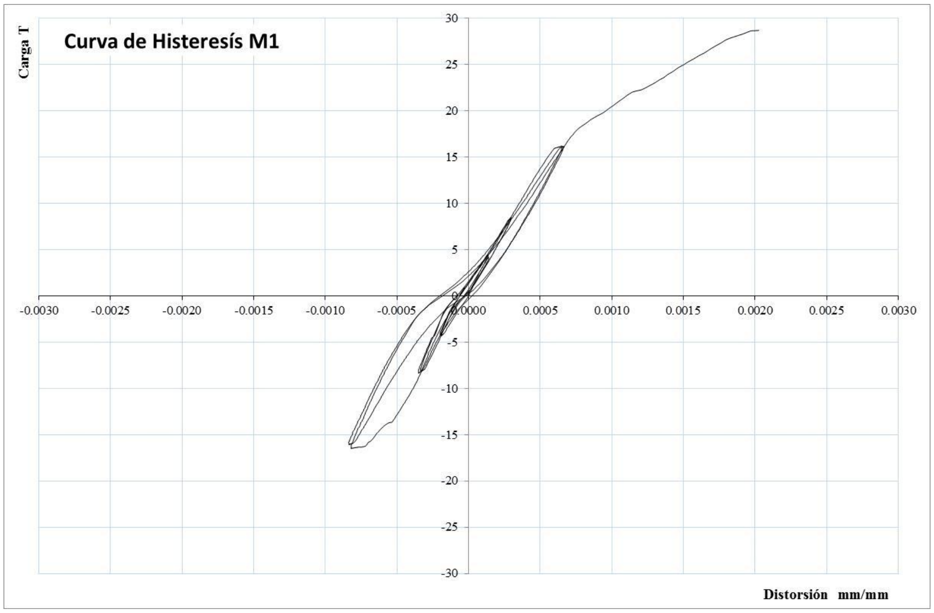


a) M1 *b) M2*

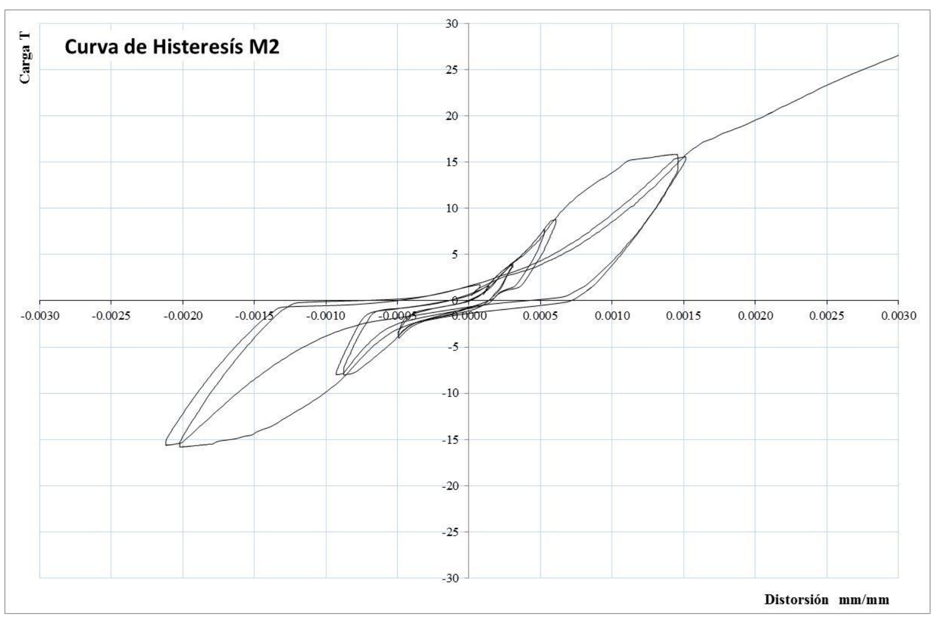
Figure 14 Final Apperence

HYSTERESIS LOOPS

The next hysteresis loops were obtained from data acquisition corresponding to the applied load and the deformation.



You can see that the behavior of the wall was rigid, because it retains the shape of the curves practically all rehearse, only up to a distortion of 0.0006, the stiffness changes, this is where there was greater wall cracking.



Wall behavior during the first cycles, maintaining the rigidity of the wall, as load increased, remarkable deformation is presented with this specimen achieving greater energy dissipation, reflected in the higher cracking presented.

CONCLUSIONS

According to the assays performed to date, we conclude that in the Structures Laboratory Technology Center of Cemex Cement and Concrete, we have the technical capacity well as the infrastructure needed to carry out the assay, obtaining reliable results.

Having evaluated the first two walls, with the type of concrete used, we analyze the possibility of creating alternative materials that allow us to provide reliable housing, comfortable and affordable, for this situation we have many work for next researches

From the results obtained, we evaluate the performance of the two walls dosed with macro and micro synthetic fiber, the behavior for the first wall was rigid throughout the assay, indicating that it was little fiber in the the second wall shows the energy dissipation before to the total failure.

From the experience obtained during the test, we conclude that it is very important to have a test run dominated, as any damage can lead to loss of important data for the evaluation of the walls studied; Similarly it is very important to control rigorous quality in the construction of the specimens since any variation in the mechanical properties of the materials, may not be representative theoretical calculations and predictions of the behavior.

AWARDS

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