# SHEAR TESTS CONDUCTED ON NOVABRIK BRICKS ATTACHED TO A CONCRETE BLOCK WALL

**CRIQ File 670-PE20888**

**Technical Report**

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MONTREAL, NOVEMBER 3, 1997

The tests were conducted on October 21 and 22, 1997 in the CRIQ testing hall in Montréal, in the presence of Mr. Michel Bouchard and Mr. Marc Fortin of ALBA. The samples were delivered to the CRIQ on October 10, 1997.

The following people participated in the project:

- Hélène Vaillancourt, Chief Project Engineer
- Daniel Carrier, Technician
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- René Schmidt, Assistant Technician

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Total number of pages: 23 including appendices 13 pages.

The results presented in this report refer only to the products described in this report.

The equipment and instrumentation used during this test were verified and/or calibrated. The calibration certificates are retraceable to the National Research Council of Canada (NRC) and/or to the American National Institute of Standards and Technology (NIST) standards and can be provided on request.

**CRIQ is registered ISO 9001, certificate no. 167-0075-18. Tests department is also accredited by the National Council of Canada, certificate no. 138.**

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# 1. PURPOSE OF THE STUDY

At the request of both Alba Inc. and BPR *Ingénieurs-conseils*, CRIQ conducted a series of shear resistance tests on two "Novabrik" walls composed of bricks with no mortar, attached to a wall made of concrete blocks. Metal furrings were used for the first wall and the aim of the test was to check the shear resistance of the brick-furring fastening system. The second test was conducted on a wall on which wood furrings were fastened and it aimed at measuring the resistance of the brick-lath-concrete block device.

The test parameters were developed by the BPR *Ingénieurs-conseils* firm. The description of these parameters can be found in Appendix A. Certain test conditions have been adapted and modified. These changes are described in this report.

# 2. SHEAR TESTS

## 2.1 Description of the Samples

Alba Inc. supplied the concrete blocks for the original wall, the insulating material, screws and bricks. CRIQ supplied the wood and metal furrings. The brick pallet used is sample no. E007542.

A C-shaped concrete block wall was raised by a bricklayer on October 8, 1997, that is to say, 2 weeks before testing began. This lapse was needed in order to make sure that the mortar was dry for the period of testing. The sides of the C-shape were used to hold up the walls in case a tremendous amount of flexion occurred during testing. The surface of some of the blocks used was rough. These blocks had been position so that the smooth side was on the interior of the C-shape where the brick wall was to be built. A change was made to the initial study to allow for an additional test on a brick wall with metal furrings. The exterior surface of the C-shape therefore needed to be used. Consequently, Alba Inc. had to polish the blocks that had a rough surface.

Two brick walls measuring 8 feet high and 4 feet long were raised on the original concrete block wall. These walls were raised by Alba Inc. on October 21, 1997 according to the following:

<u>Brick Walls with Steel Furrings (Figures 1 and 2)</u>

Gauge-20 steel furrings were used. Two were screwed horizontally several inches from the base of the wall. The other furrings were screwed vertically at 16-inch intervals. In addition, a steel "starter" furring was screwed above a horizontal furring to support the first course of bricks. The Gauge-20 steel furrings are C-shaped and have flat blades on the side. They were screwed into the concrete with the blades, alternating from the right side to the left side at 10-inch intervals. TapCon 3/16 by 1 ¼-inch concrete screws were used. The bricks were then attached to the furrings with the help of Reliable 3/16 by 4-inch concrete screws. Longer screws were used so the ends would penetrate at least 1 1/4 inches into the concrete. The C-shape in which these bricks were attached was hollow. The screws thus passed successively through the brick, the furrings, an empty space and the concrete. All the bricks in the first course were fastened to the horizontal furring with 2 screws. For the rest of the wall, the bricks were fastened at 16-inch intervals in the vertical furrings at every fourth course. However, the bricks were fastened at every third course in order to end up with the second-to-last course. The top course was not attached and was kept in place by a brick interlock system by "Novabrik". For this specific course, Alba Inc. developed a special brick with a surface that is flat and larger than that of a standard brick. The purpose was to increase the surface area in contact with the point of application of the force.

Brick Walls with Wood Furrings (Figures 3 and 4)

Two inches of rigid insulation were placed on the concrete wall. A 6 by ¾ inch wood furring was installed in a horizontal position several inches from the base of the wall and 4 by ¾ inch wood furrings were placed in a vertical position at 16-inch intervals. The furrings (and insulation) were fastened into the concrete at 10-inch intervals with Reliable 3/16 by 4-inch concrete screws, allowing for a 1 ¼-inch screw-length in the concrete. In addition, a steel "starter" furring was fastened above the horizontal wood furring to support the first course of bricks. The bricks were then fastened into the wood furring (and insulation) with #8 by 2 ½ -inch treated wood screws, that did not reach into the concrete blocks. The bricks were fastened in the same way and at as many intervals as was the wall with the steel furrings.

## 2.2 Method and test set-up

A mechanical arch was placed above a wall to support a hydraulic jack installed atop and in the center of the brick wall. The vertical downward load was applied along the entire length (4 feet) of the top course of bricks using a steel surface 3 inches high by 4 feet long. A plywood board ¾ inches thick was placed between the steel beam and the brick.

The displacement of the hydraulic jack was used to evaluate the vertical displacement of the beam applying the force. A charge cell with a capacity of 22,000 lbs was installed on the hydraulic jack.

The jack was then placed atop the wall of bricks with metal furrings on which the first test was conducted. It was then slipped under the arch and fastened above the brick wall with wood furrings and the second test was held. For each test, the force was applied at a rate of 2,000 pounds per minute until a force of 2,150 pounds was reached. This force was maintained for 30 seconds. It corresponds to 2.5 times the load capacity, or the weight of the brick. For the 4 by 8-foot wall, the weight of the brick is about 860 pounds. The force was then increased by a steady rate of 2,000 pounds a minute until rupture or until the client asked us to stop.

During the tests, the following instruments were used:

- MTS hydraulic actuator, 20 inches, model 204-63, s/n 1053;
- MTS load cell, 22 kips, model 661.21A-03, s/n 1074;
- Instron controller, model 8580, s/n H0009/2.

## 2.3 Summary of the work

Wall with metal furrings

A minor load of 300 pounds was applied before the start of the test. This force was not taken into consideration before establishing the value of the force during the 30-second stop. As a result, the force was maintained at 2,450 pounds instead of 2,150 pounds, a more critical case than expected.

No movement of the brick wall was noticed (to the naked eye) during the exertion to 2,450 pounds and during the 30-second stop. Afterwards, the force was increased to 15,300 pounds without any obvious ruptures. At this value easily surpassing 2.5 times the load capacity, the client asked us to stop the test.

The displacement and force results are presented in Table 1 and graphic form in Fig. 5. The recorded displacement is very weak (0.04 of an inch) and it remained stable during the pause at 2,450 pounds. The maximum value recorded at a force of 15,300 pounds is 0.38 of an inch. The resistance of this wall is quite significant.

**Table 1**
Sample E007542 with steel furrings, Test no 1
Vertical shear force applied to a top row of bricks.

| Force (lbf) | Displacement (in) | Force (lbf) | Displacement (in) |
|---|---|---|---|
| 300 | 0.00 | 8010 | 0.14 |
| 1000 | 0.01 | 9001 | 0.16 |
| 2005 | 0.03 | 10,014 | 0,19 |
| 2450 | 0.04 | 11,007 | 0.21 |
| 2450 | 0.04 | 12,007 | 0.24 |
| 3001 | 0.05 | 13,003 | 0.27 |
| 3999 | 0.07 | 14,008 | 0.31 |
| 4999 | 0.08 | 15,012 | 0.35 |
| 6002 | 0.10 | 15,304 | 0.38 |
| 7019 | 0.12 | | |

The bricks were unscrewed the morning following the test. The top of the wall after the bricks forming the last course were removed is shown in Figure 6. No rupture was noticed in the unscrewed bricks. Three screws fastening the brick to the furrings and the concrete block broke, and one of these inside of the brick. It's possible that these three screws had been ruptured during installment. The other screws fastening the bricks bent only a couple of degrees at the junction of screw and furring. Many screwed bricks were ruptured or cracked but the range of damage was more significant at the top rather than at the bottom of the wall. Likewise, the screws were less bent at the bottom of the wall than at the top and the enlargement of the screw holes in the furrings was more significant at the top. No rupture of screw or brick was noticed in the lower row where all the bricks were fastened with two screws.

The results of the force on displacement and the observations show that the support offered by this system is excellent. The ruptures were much more significant at the top of the wall than at the bottom, which indicates that a large part of the force was transmitted to the concrete block wall by the screws. The force was only partially transmitted to the bottom and the last course of bricks was only slightly disturbed by this load case. The furrings and the damaged screws have been sent to the client for closer analysis.

Wall with wooden furring

For this test, a minor load of 100 pounds was applied at the start of the test. This minor load was taken into consideration for determining the value of the force during a 30-second pause. The force was maintained to a value of 2.5 times that of the load capacity (the weight of the bricks), or 2,150 pounds.

At the start of the test up until the application of the force of 2,150 pounds, no rupture was detected. A cracking noise would have been heard if one of the screws had broken. The force was maintained without any manifestation of movement. The displacement was 0.13 inches, as indicated in Table 2. However, a slight displacement of 0.01 inches was recorded during the pause. Afterwards, the force was increased again, and, at about 7000 or 8000 pounds, some cracking noises caused by ruptures were heard. The frequency of the ruptures increased with the amount of force. The test was stopped after numerous cracking noises were heard and the wall had sunk a little more than an inch. The maximum force applied was 10,000 pounds, which easily surpasses 2,150 pounds, or 2.5 times the load capacity.

**Table 2**
Sample E007542 with wooden furring, Test no 2
Vertical shear force applied to a top course of bricks

| Force (lbf) | Displacement (in) | Force (lbf) | Displacement (in) |
|---|---|---|---|
| 103 | 0.00 | 5516 | 0.37 |
| 500 | 0.04 | 6013 | 0.42 |
| 1002 | 0.08 | 6499 | 0.47 |
| 1500 | 0.10 | 7017 | 0.53 |
| 2005 | 0.13 | 7505 | 0.59 |
| 2154 | 0.13 | 7999 | 0.70 |
| 2150 | 0.14 | 8505 | 0.78 |
| 2503 | 0.15 | 9002 | 0.87 |
| 3006 | 0.17 | 9511 | 0.98 |
| 3501 | 0.21 | 10,010 | 1.29 |
| 3999 | 0.25 | 10,009 | 1.34 |
| 4512 | 0.29 | 8073 | 1.72 |
| 4999 | 0.33 | | |

The force applied as displacement is presented in graphic form by Figure 7. We see that the force reached a peak of about 10,000 pounds and that it decreased afterwards, while the displacement continued to increase. This indicates that the wall's maximum capacity was reached during this test. However, because of the method of control of the force during the test, the peak and the decrease of the force occurred in only a few seconds while the increase of the force from 0 to 10,000 pounds lasted about 5 minutes.

After the test, the materials forming the wall were positioned in a shingle. The concrete wall obviously remained sturdy, the insulation was slightly weakened, the wooden furrings had sunk approximately 1 inch compared to the concrete block wall and the bricks were positioned a little lower.

The wall was dismantled and some observations were made. In all the unscrewed courses, the bricks were intact except for one that was most likely broken under the impact when the brick above was ruptured. In the courses that were screwed, it turns out that that a little more than half of the screws were broken and that the other screws had been bent. They were bent about 75° at the top of the wall (see fig. 8), the angle becoming weaker and weaker further down towards the bottom of the wall. The bricks were broken when the screws holding them had bent while the majority of bricks remained intact in the places where the screws were broken. Therefore, the resistance of the bricks is about the same as the resistance of the screws.

At the bottom course, where all the bricks were fastened with 2 screws, the screws and bricks remained intact after the test. However, the insulation was broken behind the horizontal furrings and the furring-concrete block screws were either bent or broken (see Figure 9). A few had been fastened to the mortar instead of the concrete, which may have weakened the resistance of the furring concrete block device.

With the exception of the lower course, the screws used to fasten the furrings (and the insulation) to the concrete block were intact. However, there was an enlargement of the screw holes in the wood furrings, which explains the weakening of the furrings with respect to the concrete-block wall.

The furrings and the screws were sent to Alba Inc. for further analysis.

## 3. SUMMARY

The shear force tests on this brick interlock system by "Novabrik" were conducted by CRIQ. Two brick walls were constructed by Alba Inc. on a foundation of concrete blocks using either metal or wood furrings. The test with the metal furrings was conducted to determine the resistance of the brick interlock system, while the goal of the wood furrings test was mainly to check the resistance of the concrete block-furring-brick interlock system.

The brick wall with metal furrings offers excellent support. The shear force test on the wall shows that a force of more than 15,000 pounds caused certain ruptures to the brick interlock system. The displacement of the brick wall was less than 0.4 inches. The screws were slightly bent and the screw holes in the furrings had enlarged. Only a few screws had been broken. However, the majority of bricks held by screws were either cracked or broken. The screws were more bent at the top of the wall than at the bottom, which indicates that there was an effective transfer of force to the concrete block wall by the screws. The displacement of the wall by a force 2.5 times that of the load capacity was very weak.

The shear force test on the wall with wooden furrings was stopped at a force of 10,000 pounds after numerous cracking noises caused by screw breakages were heard. A little more than half of the screws fastening the bricks to the furrings were broken. The bricks held by these screws were generally intact. The other screws were bent and the bricks were broken. The materials forming the wall were weakened in shingles (insulation, furring, brick). The displacement of furrings was caused by the enlargement of the screw holes fastening the furrings to the concrete block. However, the screws remained intact. The displacement with a force of 2.5 that of the load capacity was more significant than that obtained for the other wall with metal furrings, however, the wall remained sturdy when the force was maintained for 30 seconds.

The tests held as part of this project were conducted according to the device designed by BPR Ingénieurs-conseils (Appendix).

The results of these tests have been sent to BPR for further analysis.

# ANNEX A

## DRAFT OF TEST PROPOSED BY BPR *INGENIEURS-CONSEILS*

**ALBA PRODUCTS INC.**

**NOVABRIK BRICKS**

**REFERENCE: S95-0023 (440)**

**ALBA NOVABRIK BRICKS-STRUCTURAL TEST REQUIRED**

**Test title**

Fastening of brick in a concrete-block foundation wall

**Goal of the test**

Check the resistance to force of the attachments of the brick fastened to its concrete block.

**Description of set-up**

The set-up to employ is described in the enclosed outline.

**Method**

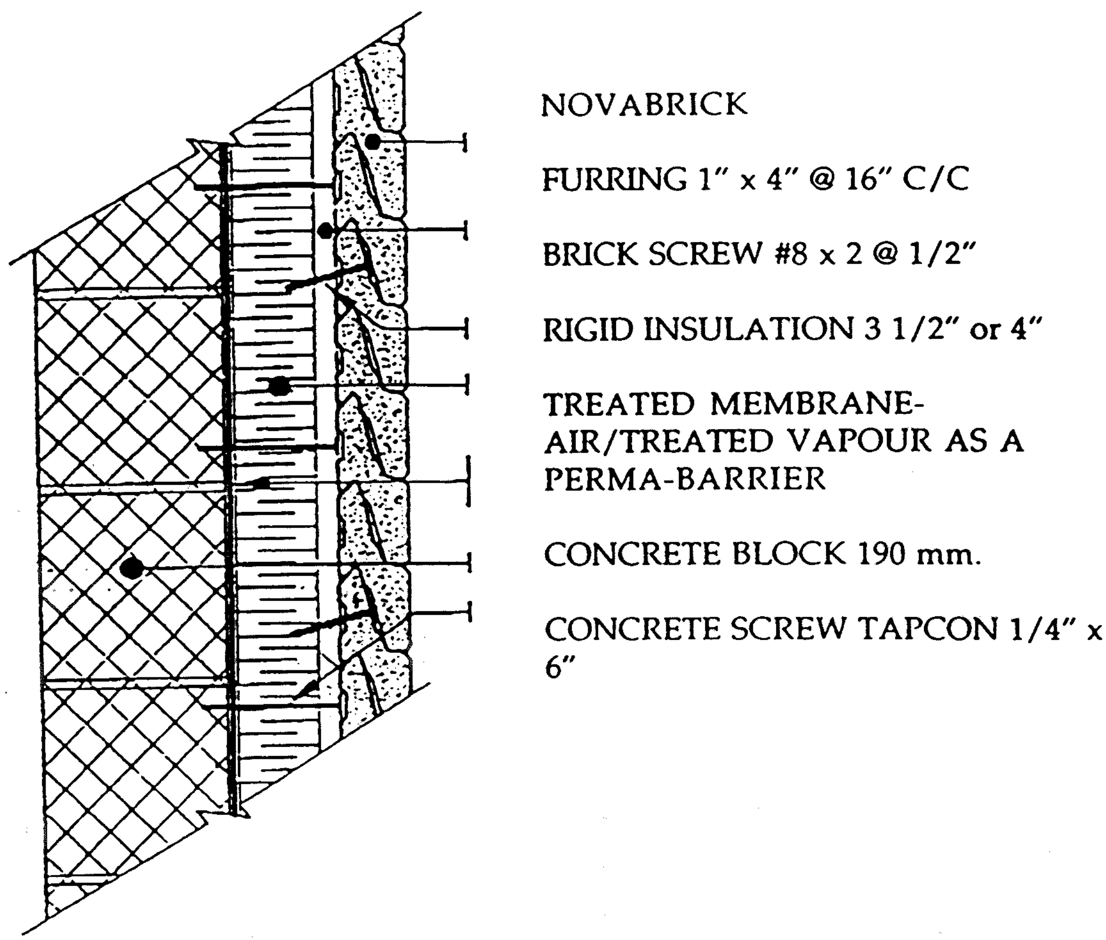
Apply in five (5) steps a concentrated force on the last row of bricks at a rate of 2000 lbs total/minute until rupture of one of the components of the framework. Measure the displacement as a function of applied force.

**Results**

Present the ultimate capacity of the assembly (the rupture point) and the displacement curve in terms of the force applied. This will show what force may be applied on the framework before the obvious deformations occur.

Québec, May 9, 1997.

*BPR Ingénieurs-conseils*




**CUT-OUT SAMPLE**
**FOUNDATION WALL OF CONCRETE BLOCKS**

# ANNEX B

# FIGURES

**Figure B1. Assemblage of a brick wall with steel furrings.**

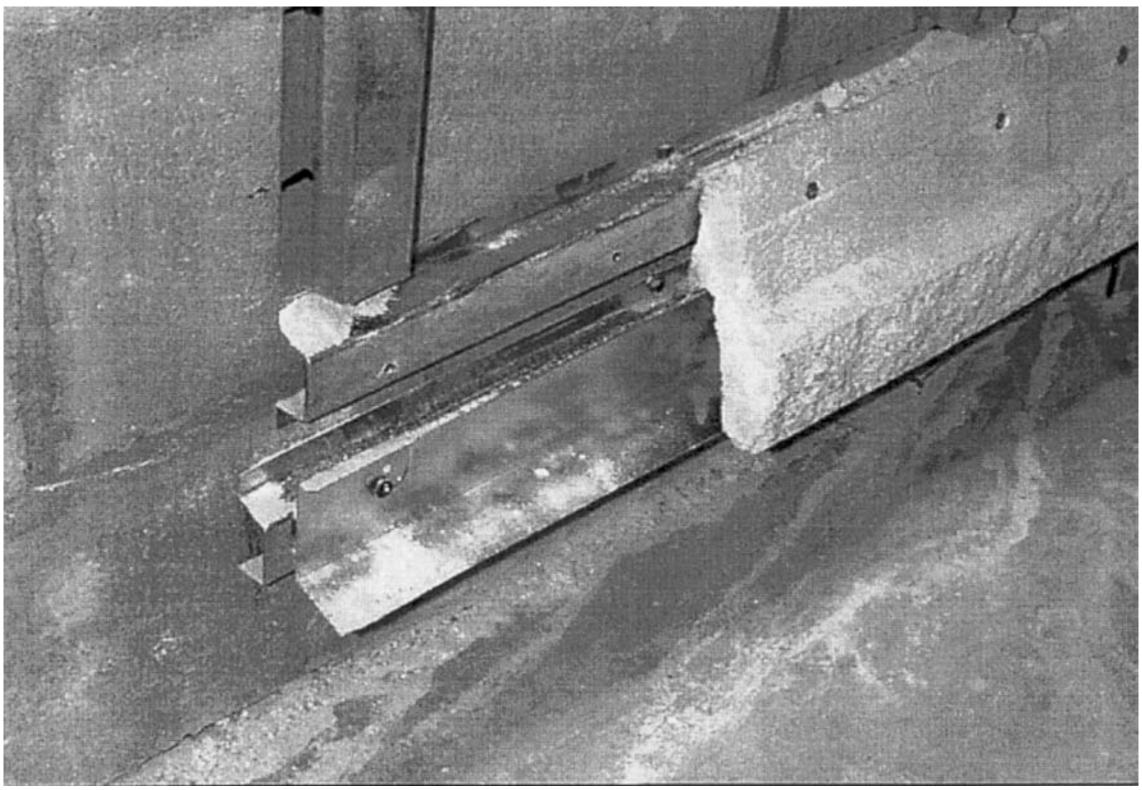


**Figure B2. Wall base with steel furring : 2 horizontal furrings, 1 vertical furring and the ‘’starter furring’’**

**Figure B3. Brick wall with wood furring and the thermal insulation in assembly process**

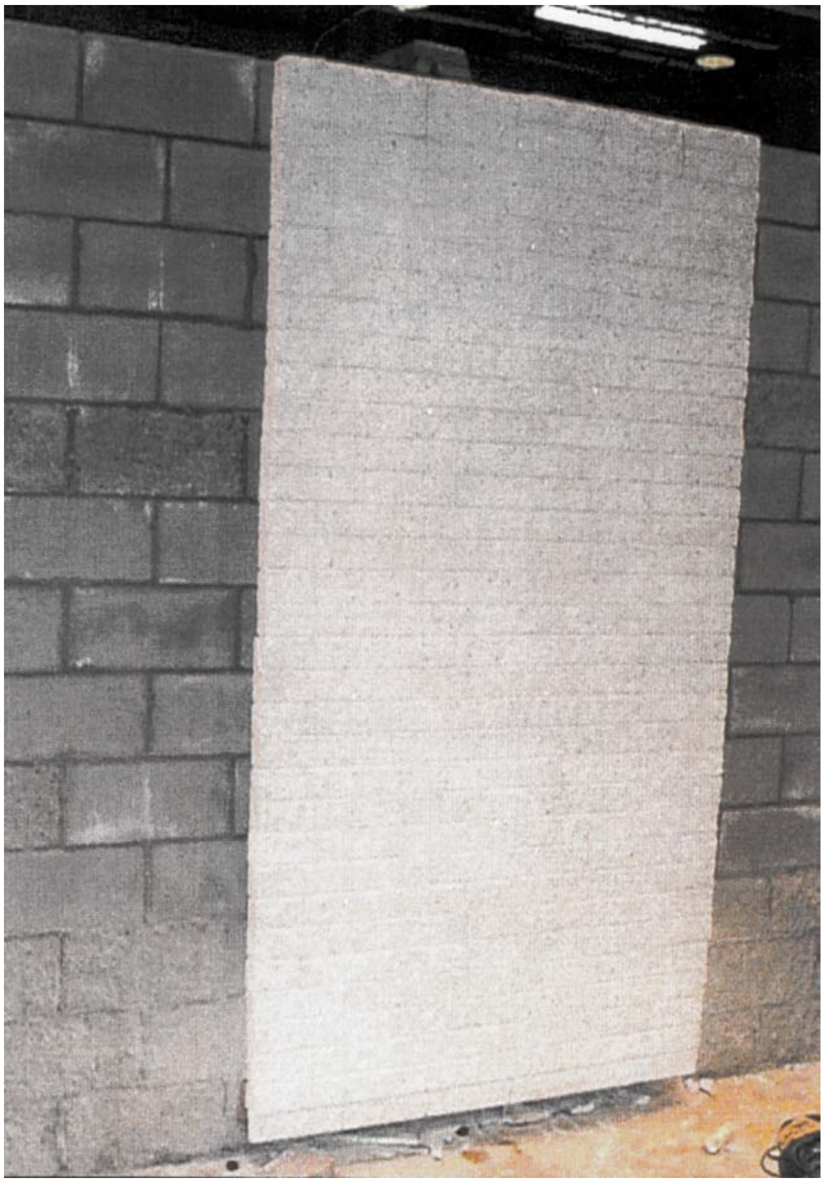


**Figure B4. Brick wall with wood furrings**

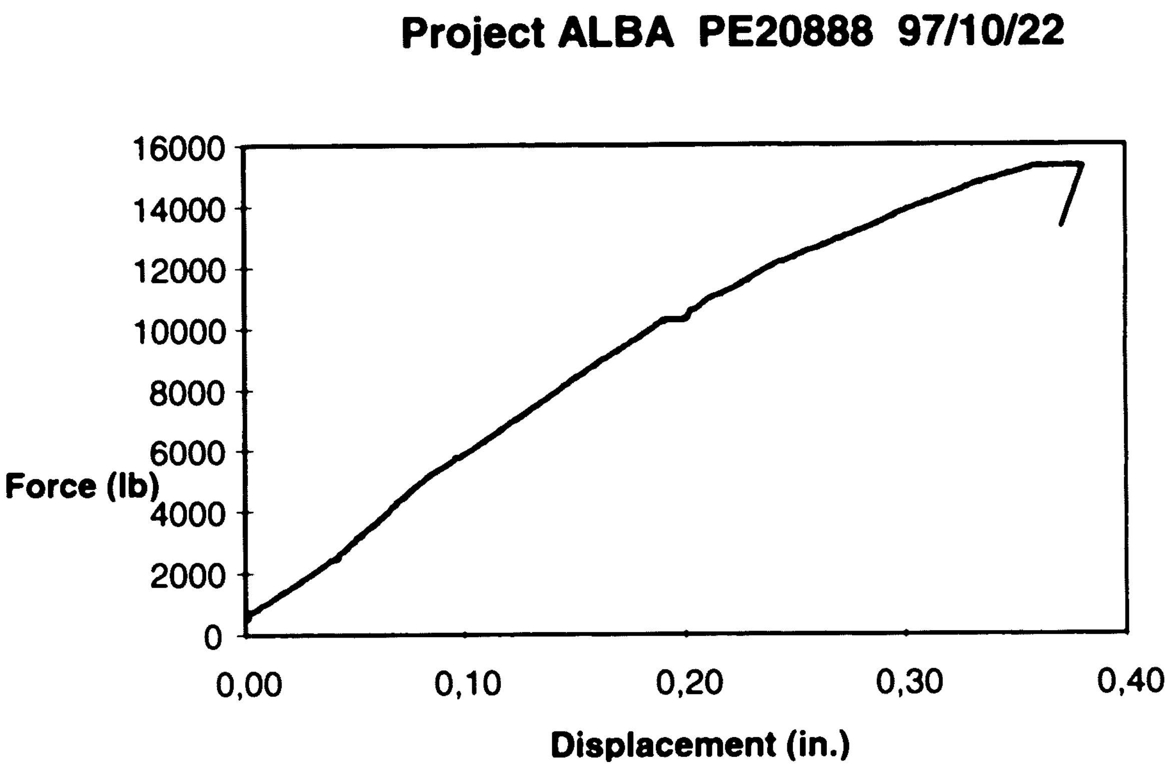



**Figure B5. Vertical shearing load according to displacement. Sample E007542 with steel furring. Test no. 1.**

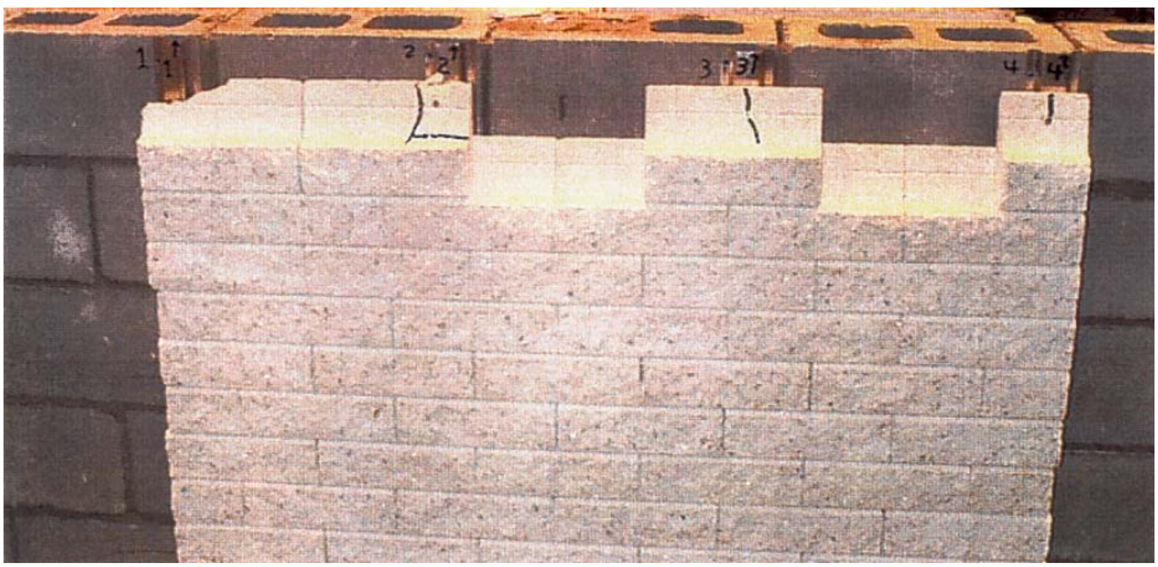


**Figure B6. Top of brick wall with steel furrings after testing.
The top row has been removed.**

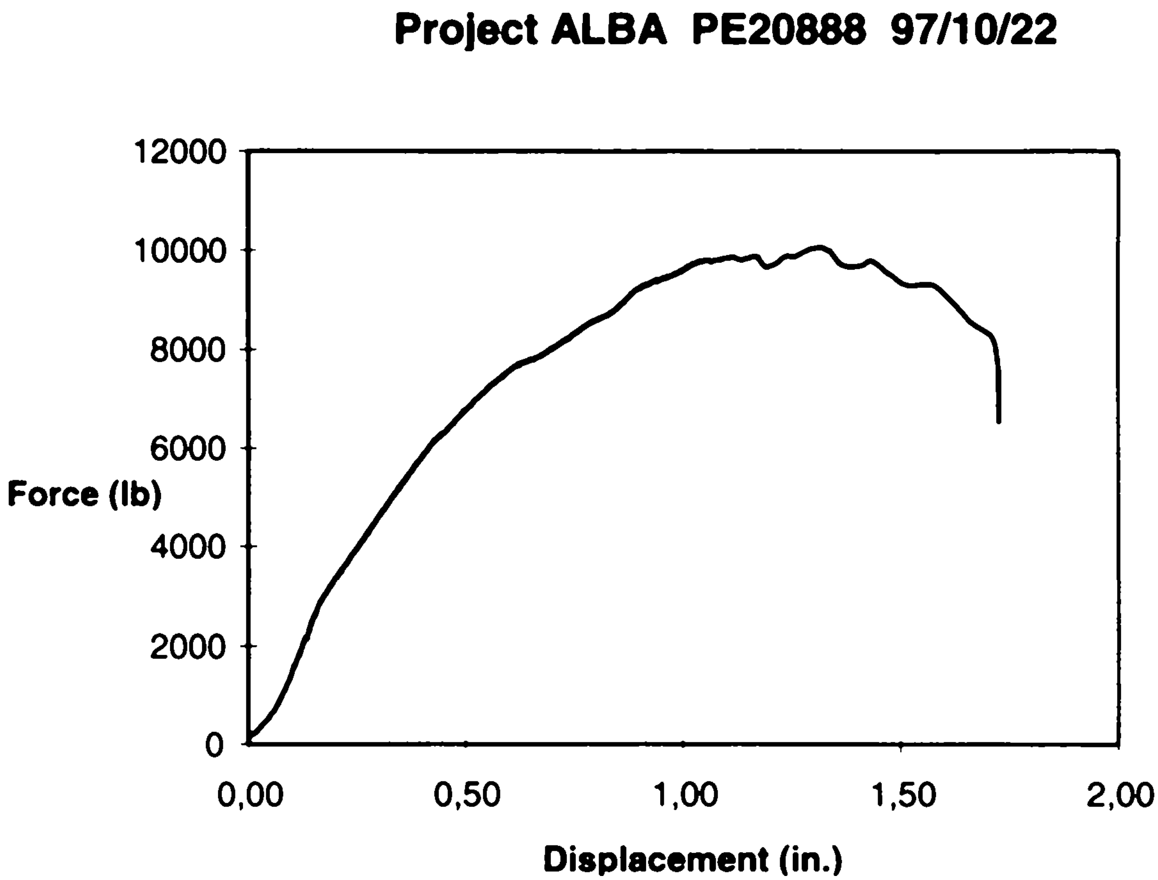



**Figure B7. Vertical shearing load according to displacement. Sample E007542 with wood furrings. Test no. 2.**

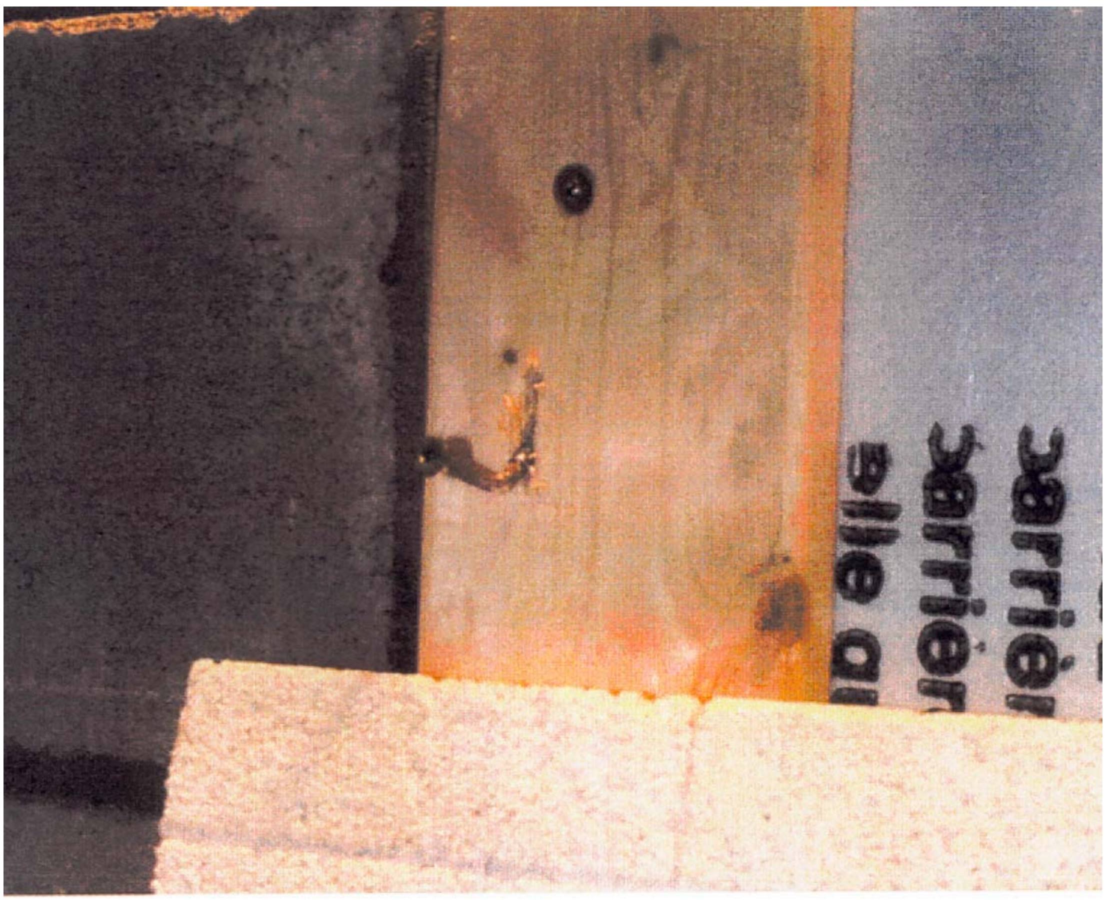


**Figure B8. Brick wall with wood furrings after testing.**

**Figure B9. The foot of brick wall with wood furrings after testing.**