EVALUATION OF THE STRENGTH
OF A PROTOTYPE WALL WITH NO MORTAR

CRIQ File 670-PE17119

Technical report

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MONTREAL, JANUARY 16, 1996

The project ways conducted on December 19 and 20, 1995 in the CRIQ testing hall in the presence of Mr. Michel Bouchard and Mr. Marc Fortin of ALBA. The specimen bricks were delivered to CRIQ on December 13, 1995 and were identified by CRIQ number E004982.

The following people participated in the project:

- Christian Tardif, Chief Project Engineer,
- Daniel Carrier, Instrumentation Technician
- Michel Poulin, Mechanical Assembly Technician
- Gérard Poulin, Assistant Assembly Technician

No specific tolerance applies to the data reported herein.

Total number of pages: 11 including Appendix (4 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. INTRODUCTION

At the request of Alba Inc., CRIQ conducted a series of tests on the structural strength of a new product for use in the construction of walls with no mortar. This new product is a type of brick whose shape enables bricks to be fitted into each other in stable, vertical rows without mortar for the joints. Only regularly spaced screws are required. Tests were conducted on several screw patterns, consisting of applying a vertical downward load and simulating the vertical movements of earthquakes. The tests took place on December 19 and 20, 1995 in the CRIQ testing hall. The results are presented forth below.

2. SUMMARY OF THE WORK

The work consisted of assembling a mechanical unit enabling application of a vertical downward load on the top row of bricks in a wall 9 ft. high by 48 in. wide. A photo of this assembly appears in the appendix. The wall, built in the testing hall by Alba, was made of 6 ft. wall studs on 16 in. centers and a base consisting of joists and flashing, the same as in a section of flooring. Four 3 in. by 1 in. laths were applied to fiberboard panels for each wall stud. The bricks were installed, beginning with a steel ‘’starter’’ placed at the base of the wall. The bricks were held in place by screws.

The assembled unit consisted of a mechanical arch supporting two servo-hydraulic jacks of 11,000 lb capacity controlled in closed-loop. The two jacks were placed symmetrically at distances of 1/3 and 2/3 of the width of the wall.

The load applied to the wall corresponded to 2.5 times the nominal brick load carried by the wall, i.e. 2,540 lb. The load was applied gradually at the rate of 2,000 lb./minute; it was maintained for 2 minutes at the maximum level; it was then lowered to the nominal load for 15 seconds. At that moment, the effect of a zone 6 earthquake was simulated by applying a sinusoidal load of more or less 250 lb. around the nominal load for 10 cycles at 1 Hz; 20 cycles at 2 Hz; 50 cycles at 5 Hz; and 100 cycles at 10 Hz. The load was then brought back to 0 lb. to end the test. The earthquake simulation specifications were taken from the National Building Code of Canada (1990 edition), Commentaire J sur l'effet des séismes, tableau J-1 et l’article 11, page 217 (Comment J on the effect of earthquakes, Table J-1 and Section 11, page 217).

Several screw installation patterns were tested in a sequence going from what was presumed to be the most solid to the least solid to determine the specifications for safe installation.

3. INSTRUMENTS USED

The test control equipment consisted of a MTS model 810 servo-hydraulic controller equipped with two actuators and 11,000-lb. capacity load cells (s/n 4632 and s/n 4676). The operating software for this equipment was T/RAC, version 1.4.

4. RESULTS

The following wall arrangements were tested:

1) bricks screwed every 3 rows, 3,0 in. x no. 10 ϕ screws.
2) bricks screwed every 4 rows, 3,0 in. x no. 10 ϕ screws.
3) bricks screwed every 4 rows, 3,0 in. x no. 8 ϕ screws.
4) bricks screwed every 5 rows, 3,0 in. x no. 8 ϕ screws.
5) same as 4) with 1 in. Styrofoam.
6) same as 4) with 2 in. Styrofoam.
7) same as 6), tested to breaking point.

The visual observations made following each test showed no sign of permanent distortion in the screws, nor any relative displacement between the bricks, the furrings, the fiberboard and the Styrofoam. However, a non-permanent movement was visible during test 4), in the 3 or 4 upper rows, when the sinusoidal cycles representing the simulated earthquakes were applied.

The real load applied in the tests was 2,800 lb., i.e., 260 lb. more than the 2,540 lb. requested. The breaking-point test showed that arrangement 4) can resist a load of 7,850 lb. Breakage occurred by shearing off of the heads of the brick screws, first at the top of wall, then toward the base. The brick rows then gradually separated from the furring as the screws broke. We noted that these same screws were pushed downward under the vertical load and then assumed an angle of about 5 degrees from horizontal before breaking off. This phenomenon led to a downward movement of all the bricks of about 0.25 in. We noticed no other relative movement either in the furring, the Styrofoam, or the rear wall studs.

5. ANALYSIS

Of all the wall components, significant breakage of the screw occurred first. The wood furrings also underwent a downward enlargement of the screw holes. No damage of the other components was visible. In order to increase the resistance of the wall to vertical loads, one need only increase the number or caliber of the screws used.

The breakage of the screws occurred in two stages. The first was a downward bending from a point located near the middle of the furring (depth wise). This bending was not sufficient to cause breakage. While the vertical load increased further, as of a certain moment and owing to the new angle of the screws to the horizontal, the screws were placed under tension to the breaking point. This sequence of events was confirmed by observation of the breakages that occurred near the heads of the screws and not in the area where the screws bent.

The following calculations can confirm this point:

Ultimate load measured: 7,850 lb.

- number of screws in the first row: 4
- screw area: 0.0129 sq.in.
- material strength: 125,000 psi.

Theoretical ultimate load

- 125,000 x 4 x 0.0129 = 6,450 lb.

From this relationship between the theoretical calculations and the experimental data, it is possible to evaluate the strength of other screw patterns. In particular, the point raised during the tests on the influence of the width of the wall, i.e. the number of supporting screws in the first row, can be addressed. Indeed, we can increase this number from 4 to 5 for a wall width of 60 in. and make the following calculation:

New theoretical ultimate load

- 125,000 x 5 x 0.0129 = 8,075 lb.

Alternatively, we can apply the same ratio of 5:4 to the ultimate load measured (7,850 lb.), which brings it to 9,810 lb.

6. CONCLUSION

The tests conducted confirmed that all the arrangements tested have a safety factor well above 2.5 with respect to the planned use. This factor determined by a breakage test on the weakest screw pattern is 7.5. Furthermore, a relationship between the type of breakage and the results obtained will enable future strength simulations to be conducted by means of theoretical calculations.

APPENDIX

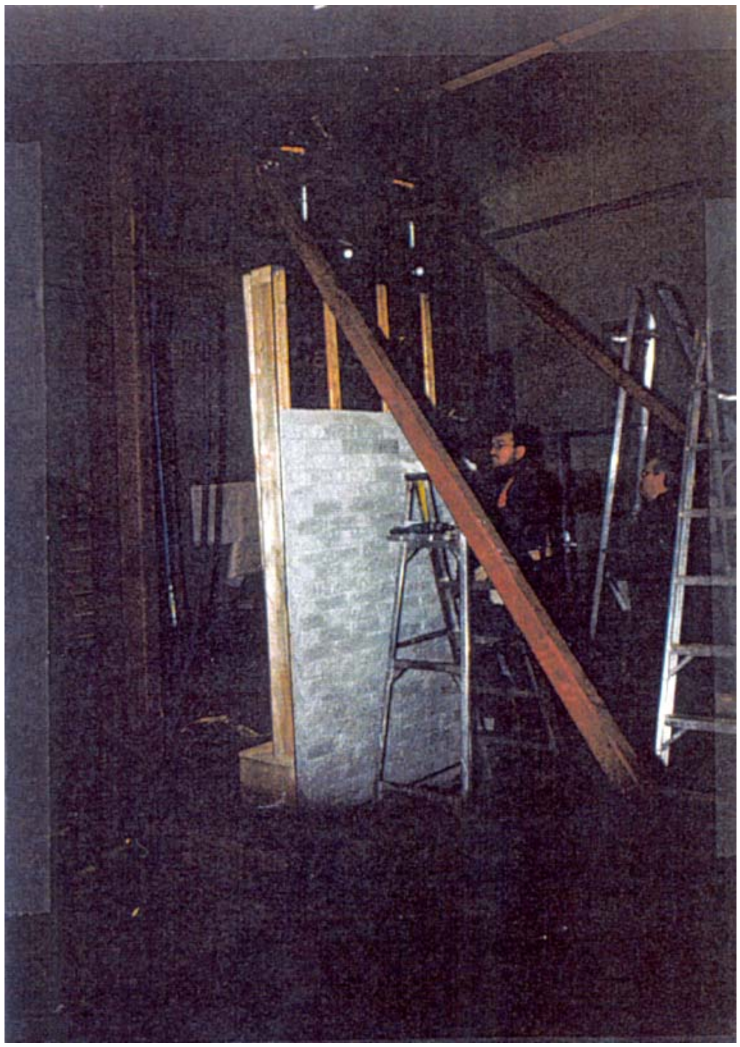

Photo 1- Test set-up

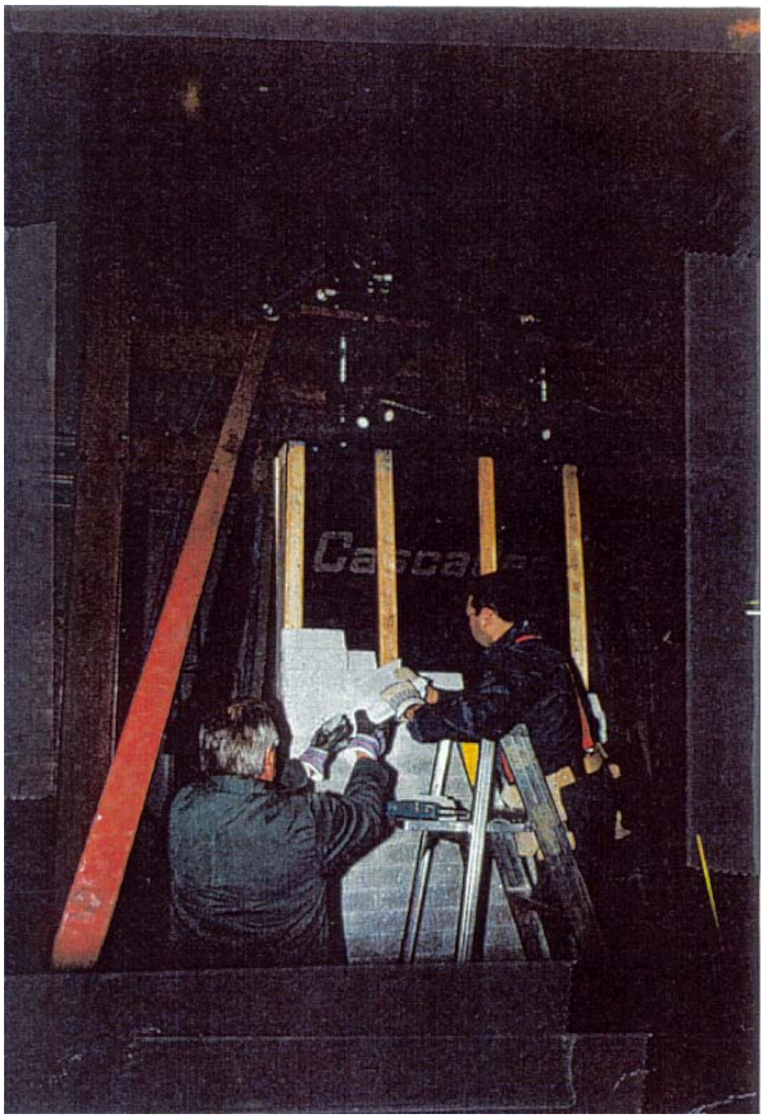

Photo 2 – Installation of bricks

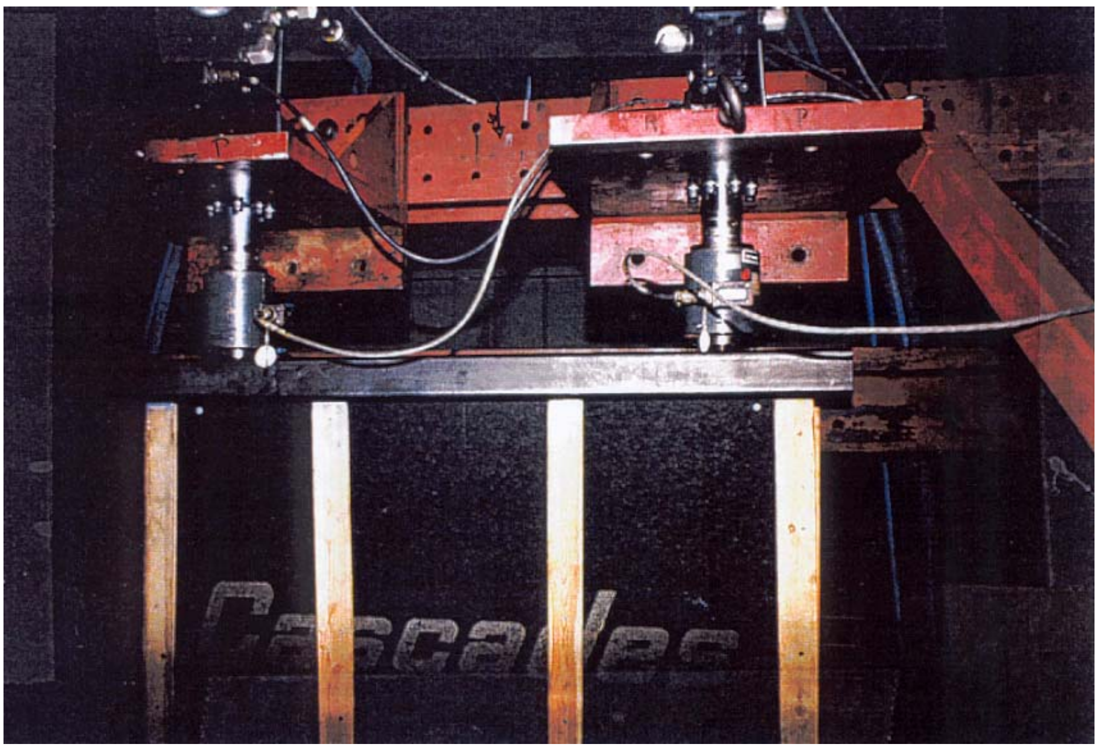

Photo 3 – Close-up view of hydraulic jacks

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MESSAGE

Michel,

The meaning of the seismic tests performed on your bricks at CRIQ in December 1995 is the following:

According to the Supplement to the Canadian National Building Code, the horizontal acceleration in a zone 6 is 0.32g (ref.: Table J-1, p. 214) and the mean vertical acceleration varies between 2/3 and 3/4 of the horizontal acceleration (ref.: point 11, p. 217). Therefore, the vertical acceleration is approximately equal to 2/3 of 0.32g, that is 0.21g.

The mass of the tested wall multiplied by a factor of security of 2.5 is 2540 lbs. This value has been considered to represent 1g, although it includes a factor of security. The desired vertical acceleration of 0.21g multiplied by 2540 lbs is approximately to 500 lbs. That is why a sinusoidal load of ±250 lbs has been applied.

If you have any question, do not hesitate to contact me.

Hélène Vaillancourt, P.Eng.

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