

REPORT

TO

DORION & FRERES LTEE
11555 PHILIPPE PANNETON
MONTREAL

ON

SPECIAL TESTS ON
EXPANDED POLYSTYRENE INSULATED
CONCRETE MASONRY WALLS
TYPE ISOBLOC

PREPARED

BY

L.I.E. CONTROLE-MONTREAL

O/FILE NO.: 86-C-802

JANUARY 1987

Distribution: 4 copies - Dorion & Frères Ltée
1 copy - L.I.E. Contrôle-Montréal

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1.0 OBJECT

Since 1984, Dorion & Frères Ltée have been manufacturing expanded polystyrene insulated concrete masonry units of standard dimensions. Each unit consists of a polystyrene core sandwiched between two concrete blocks. The different pieces are held together through dovetails (see Product Literature in APPENDIX 3).

ISOBLOC concrete masonry units meet all requirements stipulated for concrete masonry units by ASTM, CSA and BNQ (see Technical Data in 2.4).

When ISOBLOC concrete masonry units were first introduced on the market, L.I.E. Controle-Montreal was asked to perform a series of laboratory tests to define the physical properties of ISOBLOC masonry units and wall specimens assembled with ISOBLOC concrete masonry units (see Report 84-C-515, August 1984). Besides the standard physical properties of the concrete masonry units, the following tests were carried out on a wall assemblage: compression, fire resistance, thermal insulation and sound transmission.



The tests reported herein furthers the physical properties testing program on ISOBLOC concrete masonry wall specimens by investigating the structural properties of ISOBLOC walls as subjected to wind loads, earthquake loads and earth or water pressure.

This should provide a comprehensive set of physical and structural tests to enable architects and engineers to more fully understand the behavior of ISOBLOC concrete masonry units assemblages when submitted to various types of loading.

All the present tests were carried out in accordance with ASTM Standards and other recommendations such as those listed in publication TEK 108 "Testing Concrete Masonry Assemblages" of the National Concrete Masonry Association.

The tests reported herein are the followings:

- 1) Flexural Strength,
(Tensile Load), ASTM E 72, section 10
- 2) Impact Load,
ASTM E 72 and E 695
- 3) Racking Strength,
ASTM E 72, section 14



2.0 PHYSICAL PROPERTIES OF ISOBLOC CONCRETE MASONRY UNITS

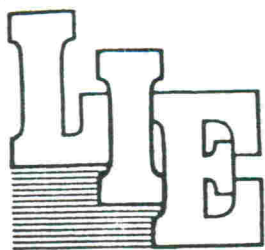
Six concrete masonry units were picked at random among those set aside for the assembly of the nine wall specimens which were to be tested under the present program.

Dimension and compressive strength tests were performed on three of these units and the results are reported in section 2.1.

Compressive strength tests were performed on samples of the mortar type M used in the wall specimen construction. Test results are reported in section 2.2.

The modulus of rupture was determined on three ISOBLOC concrete masonry units in accordance with ASTM Standard C 683 and the results are shown in section 2.3.

The results obtained in the first series of tests (our report 84-C-514) are summarized in section 2.4.



L.I.E. CONTRÔLE - MONTRÉAL

Contrôle Qualitatif

SOLS - BÉTON - ASPHALTE - ACIER

6775, BOMBARDIER, MONTRÉAL, QUÉBEC H1P 2W2 (514) 326-0130

File no. : 86-C-802

Date: January 29th, 1987

Report no.: 2.1

Submit to : Dorion & Frères Ltée
11555, rue Philippe-Panneton
Rivière-des-Prairies, QC
H1E 4M1

Project : Test on ISOBLOC Concrete Masonry Walls

Subject : Compressive Strength Tests of ISOBLOC Concrete Masonry Units

No. 30 - 24.2 x 19.1 x 39.2 cm

Net area: .047 m² - 19.1 MPa - 2767 psi
Gross area: .095 m² - 9.5 MPa - 1372 psi

No. 31 - 24.1 x 19.1 x 39.2 cm

Net area: .047 m² - 16.5 MPa - 2397 psi
Gross area: .094 m² - 8.2 MPa - 1194 psi

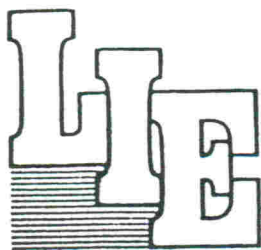
No. 32 - 24.2 x 19.1 x 39.3 cm

Net area: .047 m² - 19.9 MPa - 2882 psi
Gross area: .095 m² - 9.9 MPa - 1430 psi

Average:

Net area: 18.5 MPa - 2683 psi
Gross area: 9.2 MPa - 1334 psi

Rodrigue LeBlanc, eng.



L.I.E. CONTRÔLE - MONTRÉAL

Contrôle Qualitatif

SOLS - BÉTON - ASPHALTE - ACIER

6775, BOMBARDIER, MONTRÉAL, QUÉBEC H1P 2W2

(514) 476-0130

File no.: 86-C-802

Date: December 28th, 1986

Report no.: 2.2

Submit to : Dorion & Frères Ltée
11555, rue Philippe-Panneton
Rivière-des-Prairies, QC
H1E 4M1

Project : Test on ISOBLLOC Concrete Masonry Walls


Subject : Compressive Strength Tests of Mortar specimens

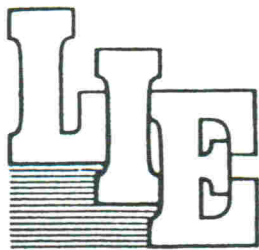
Date of sampling	: November 27th, 1986
Time of sampling	: 11h30
Project	: ISOBLLOC
Wall construction	: Walls nos 1 and 2, Racking
Type of Mortar	: Type M
Specified Strength	: 2400 psi
Temperature of Mortar	: 19 °C
Sampled by	: M. Thouin
Dimension of cubes	: 2" x 2" x 2"
Date received	: November 28th, 1986

RESULTS

Report no	Cube no	Tests		Compression Strength (psi)	Averages	
		Date	Age		psi	MPa
129-1	2495 A	Nov. 28/86	24 hours	1075	1057	7.3
	2495 B	Nov. 28/86	24 hours	1038		
	2495 C	Dec. 01/86	4 days	3088		
	2495 D	Dec. 01/86	4 days	3275	3182	21.9
	2495 E	Dec. 04/86	7 days	3600		
	2495 F	Dec. 04/86	7 days	3610	3605	24.9
	2495 G	Dec. 23/86	26 days	3925		
	2495 H	Dec. 23/86	26 days	4338	4250	29.3
	2495 I	Dec. 23/86	26 days	4500		

Samples were taken from 2nd batch, representing 1/3 of the mix used for the two walls.


Rodrigue LeBlanc, eng.



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6775, BOMBARDIER, MONTRÉAL, QUÉBEC H1P 2W2

(514) 376-0130

File no.: 86-C-802

Date: January 28th, 1987

Report no.: 2.3

Submit to : Dorion & Frères Ltée
11555, rue Philippe-Panneton
Rivière-des-Prairies, QC
H1E 4M1

Project : Test on ISOBL0C Concrete Masonry Walls

Subject : Modulus of Rupture (ASTM C-683)
Center-Point Loading Method

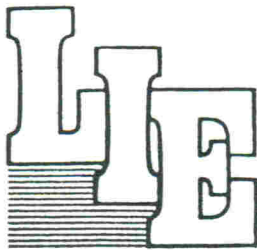
	<u>MODULUS OF RUPTURE</u>	<u>DEFORMATION AT FAILURE</u>
No. 33	R = 38 psi	---
No. 35	R = 29 psi	.104 in.
No. 36	R = 31 psi	.112 in.
<u>AVERAGE:</u>	R = 33 psi	

Note: $R = 3 w l / 2 b d^2$

where

R = Modulus of Rupture (psi)
w = Maximum applied load (lbf)
l = Span length (in.)
b = Average width of specimen
at the center of the specimen (in.)
d = Average depth of specimen
at the center of the specimen (in.)

Rodrigue LeBlanc, eng.



L.I.E. CONTRÔLE - MONTRÉAL

Contrôle Qualitatif

SOLS - BÉTON - ASPHALTE - ACIER

6775, BOMBARDIER, MONTRÉAL, QUÉBEC H1P 2W2

(514) 376-0130

File no.: 86-C-802

Date: January 28th, 1987

Report no.: 2.4

Submit to : Dorion & Frères Ltée
11555, rue Philippe-Panneton
Rivière-des-Prairies, QC
H1E 4M1

Project : Test on ISOBLLOC Concrete Masonry Walls

Subject : Technical Data (see report 84-C-515)

	<u>IMPERIAL UNITS</u>	<u>METRIC UNITS</u>
- Type	S/1000/A/M	S/7,5/A.M.
- Weight	40.2 lbf	18.3 kg
- Absorption	6.64 lb/ft ³	106.40 kg/m ³
- Fire resistance	2h50min.	2h50min.
- Heat transmission	CRS: 0,20	CRS: 0,20
- Equivalent thickness	4.8 in.	122 mm
- Density	137.17 lb/ft ³	2,198 kg/m ³


Rodrigue LeBlanc, eng.

3.0 COMPRESSION TEST ON WALL

3.1 Object

To test a concrete masonry wall assemblage making 4 ft in width and 8 ft in height and constructed with ISOBLOC concrete masonry units.

3.2 Wall Specimen

On March 25th, 1984, Dorion & Frères Ltée delivered a sufficient number of ISOBLOC concrete masonry units for the construction of such a wall specimen to the "Centre de Développement Technologique" of "Ecole Polytechnique de Montréal".

On May 4th, 1984, the wall specimen to be tested was constructed vertically, its base resting on a rigid steel support. The construction procedure followed strict State-of-the-Art techniques and was performed by a mason of Claude Charlebois Masonry Inc., a local specialty contractor.

3.3 Testing Frame

The ISOBLOC 4 x 8 ft wall assemblage was tested on an Amsler Testing Machine having a capacity of 1×10^6 lb. The top and bottom portions of the wall were covered with masonite.

3.4 Test Results

Two cycles of loading were applied. During the first cycle, buckling occurred under a load of 271,000 lb. After unloading no visible cracks were observed and the wall appeared in perfect condition.

During the second cycle of loading, a localized failure occurred at 214,000 lb: one side of one concrete masonry unit located at the top of the wall fissured. Visual inspection revealed no other weakness.

Report signed by: Prof. Richard Roux, eng.
Civil Engineering Department
Ecole Polytechnique de Montréal

4.0 FLEXURAL STRENGTH TESTS

4.1 Object

To obtain the load-deformation curve for ISOBLOC concrete masonry wall specimens when subjected to flexural loads.

4.2 Wall Specimens

Three wall assemblies were constructed on November 27 and 28th, 1986. Seated on a rigid steel base, the wall specimens were erected in accordance with State-of-the-Art techniques by an experienced mason of Dorion & Frères Ltée.

Mortar type M was used in the construction of the wall specimens. In section 2.2, the compressive strength of the mortar at 26 days was reported at 4250 psi (29,3 MPa). The wall specimens, 4 x 8 ft in nominal dimensions, were actually 3 ft 11 in. x 7 ft 10 3/8 in. with a thickness of 9 5/8 in..

Only two wall assemblies were actually tested: the third specimen had been damaged by a fork lift truck during

handling, and for this reason was discarded. The tests were carried out on January 15th, 1987.

4.3 Testing Apparatus

The testing machine was constructed by personnel from Dorion & Frères Ltée and was assembled for the vertical test as shown in Figure 3 of ASTM Standard E 72 (see APPENDIX 1). Photographs of the apparatus with a wall specimen ready for testing are shown at the end of this section. The exact location of the two back supports and the two loading rollers in the front of the specimen is shown on Sketch No. 86-C-802-2.

In order to measure the deflections, four dial gages were installed, two on each side of the wall specimen, as shown on Sketch No. 2. Doubling the readings at each point allowed measurement of possible variations due to the fact that there is no concrete continuity between the two faces of the ISOBLOC wall.

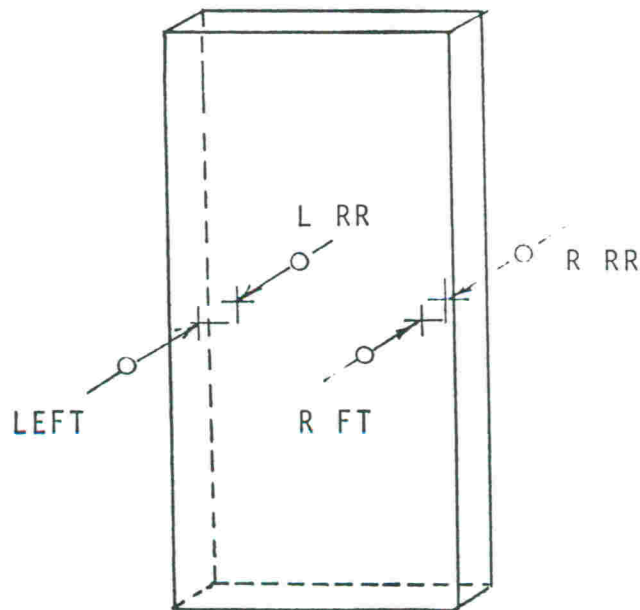
A 10 tons capacity hydraulic jack with a piston having a cross-section of 1.72 in.² was used. The jack was later calibrated in the laboratory.

4.4 Test Results

Wall specimen No. 1 : see Table No. 1

Wall specimen No. 2 : see Table No. 2

Load-deformation curve : see Graph No. 1



Sketch no. 2

4.5 Procedure and Wall Behavior

Each load increment was maintained for a period of five minutes. After each increment, the load was released completely for also five minutes. This procedure was followed until failure, indicated by a large departure from the curve at maximum load. Deformation readings were taken on all four dial gages and are reported on Tables Nos. 1 and 2, along with average calculations.

It is to be noted that no significant variations were observed in the readings of the corresponding front and back dial gages during load applications.

In test No. 2, a fissure appeared in the third joint from the top of the wall at a load of 578 lbf. When the load reached 875 lbf, the polystyrene core was damaged at that same location. In test No. 1, a single fissure appeared when the applied load reached 1050 lbf.

TABLE NO. -1
FLEXURAL STRENGTH
ISOBLOC WALLS

WALL NO.1 (PHOTOGRAPHS NOS. 1, 2 and 3)

LOAD (lbf)	READINGS (in.)								AVERAGES (in.)	
	WALL front				WALL back					
	LEFT deform.	set	RIGHT deform.	set	LEFT deform.	set	RIGHT deform.	set	deform.	set
100	.004	0	.010	0	.003	0	.009	0	.0065	0
291	.012	0	.030	0	.012	0	.029	0	.021	0
482	.028	.005	.055	.027	.027	.003	.054	.003	.0415	.003
674	.048	.008	.082	.005	.047	.007	.078	.004	.064	.006
865	.091	.021	.117	.014	.089	.021	.112	.013	.102	.017
1056	.213	.049	.247	.042	.212	.048	.240	.041	.228	.045

TABLE NO. 2
FLEXURAL STRENGTH
ISOBLOC WALLS

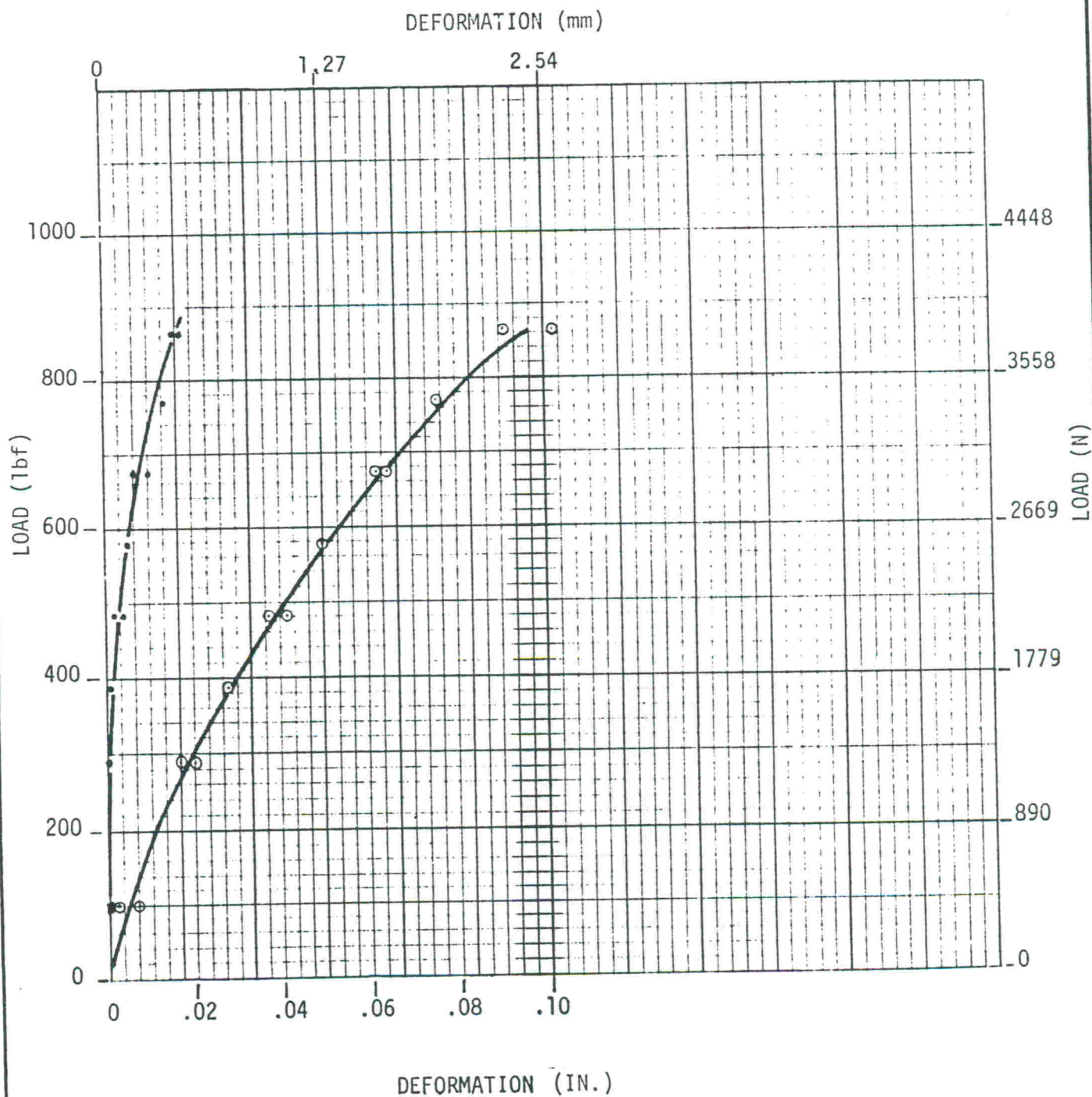
WALL NO. 2

LOAD (lbf)	READINGS (in.)								AVERAGES (in.)	
	WALL front				WALL back					
	LEFT		RIGHT		LEFT		RIGHT		deform.	set
	deform.	set	deform.	set	deform.	set	deform.	set	deform.	set
100	.002	.001	.000	.000	.003	.002	.001	.000	.002	.0008
291	.009	.002	.019	.000	.012	.000	.023	.001	.016	.0008
387	.015	.002	.038	.000	.018	.000	.042	.003	.028	.0013
482	.021	.000	.050	.002	.024	.001	.054	.005	.037	.002
578	.030	.000	.066	.006	.034	.003	.070	.010	.05	.0048
674	.044	.003	.080	.015	.043	.004	.082	.018	.062	.01
769	.056	.006	.096	.022	.057	.007	.096	.022	.076	.014
865	.070	.010	.110	.026	.072	.010	.110	.026	.091	.018

DOSSIER: 86-C-802

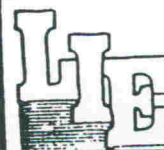
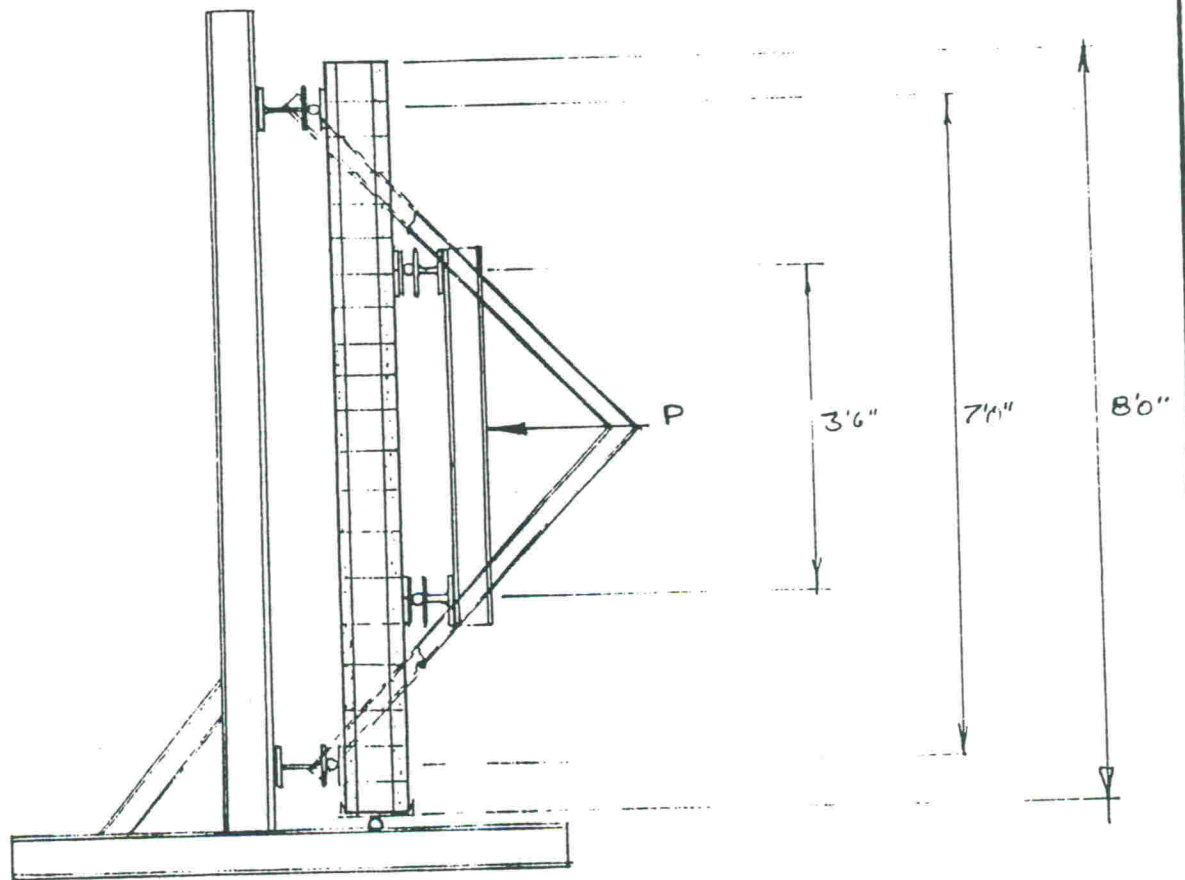
PROJET: Special Tests on ISOBLLOC Concrete

GRAPH NO. 1 - FLEXION



Set: ● ———

Deformation: ○ ———



L.I.E. CONTRÔLE - MONTRÉAL
6775 BOMBARDIER MONTRÉAL QUÉBEC H1P 2W2

ISOBLOC WALL

FLEXURAL STRENGTH TRANSVERSE
LOAD

Scale: App.

Feb. 1987

86-C-802-2

5.0 IMPACT LOAD TESTS

5.1 Object

To obtain the load-deformation curve for ISOBLOC concrete masonry wall specimens when subjected to impact loads.

5.2 Wall Specimens

Three wall assemblies were constructed on November 28 and 29th, 1986. Seated on a rigid steel base, the wall specimens were erected in accordance with State-of-the-Art techniques by an experienced mason of Dorion & Frères Ltée.

Mortar type M was used in the construction of the wall specimens. In section 2.2, the compressive strength of the mortar at 26 days was reported at 4250 psi (29,3 MPa). The wall specimens, 4 x 8 ft in nominal dimensions, were actually 3 ft 11 in. x 7 ft 10 1/4 in. with a thickness of 9 5/8 in..

The three impact load tests were carried out on January 15 and 16th, 1987, under the supervision of the technical staff of L.I.E. Controle-Montreal.

5.3 Testing Apparatus

The testing machine was constructed by personnel from Dorion & Frères Ltée and was assembled in accordance with Figure No. 2, IMPACT LOAD TEST (Specimen Vertical), ASTM Standard E 695. The testing frame assembly is shown on Sketch No. 86-C-802-3 and Photographs Nos. 7 to 12. The back supports are also shown on Sketch No. 86-C-802-3.

The leather bag used as impact load instrument was constructed in accordance with ASTM Standards E 695 and E 661. The bag was filled with round gravel, size 1/4 to 3/8 in.. Total weight, including the leather bag was set at 60 lb, in accordance with the recommended practice of the National Concrete Masonry Association stated in their publication TEK 108 "Testing Concrete Masonry Assemblages" and in conformity with ASTM Standard E 695 which states, in section 5.2.6, that "the mass of the bag may be adjusted to any specified mass, depending upon the in-

formation desired". Three pieces of foam rubber were placed on top of the gravel, inside the bag, to prevent spillage during testing.

The movable frame for adjusting the height of drop was attached to the roof structure of the testing room and assembled in such a way that it could rotate freely in the plane of impact. Hinged doors were provided on the frame assembly so that the leather bag could swing as a true pendulum when released from its holding cradle (see Photographs Nos. 7 to 10).

The supporting frame was constructed following the recommendations set forth in ASTM Standard E 72 and was anchored to the floor slab of the testing room. The deflectometer was installed in the back of the wall specimen, in line with the point of impact on the center of the wall assembly, as shown on Photograph No. 12. The test assembly for impact load testing is shown on Sketch No. 86-C-802-3.

5.4 Test Results

Impact load tests on
specimens A, B and C : See Table No. 3

Load-Deformation curve : See Graph No. 2

5.5 Procedure and Wall Behavior

Impact loads were applied to the middle of the face of the wall specimen by releasing the bag beginning with a height of drop of 6 in. and increasing the height of drop in 6 in. increments as shown on Sketch No. 86-C-802-3. The maximum height of drop was 11 ft 6 in..

In all three wall specimens tested, a fissure appeared in the middle horizontal mortar joint at impact under a height of drop of 12 in.. Fissures in vertical mortar joints appeared in wall specimen C, after impact under a height of drop of 54 in.. Concrete masonry units started breaking up under impact from a height of drop of 72 in. in wall specimens A and C, and under a height of drop of 78 in. in wall specimen B. Concrete blocks started falling from the back face of the wall specimens when the height of drop reached 132 in. or 11 ft.

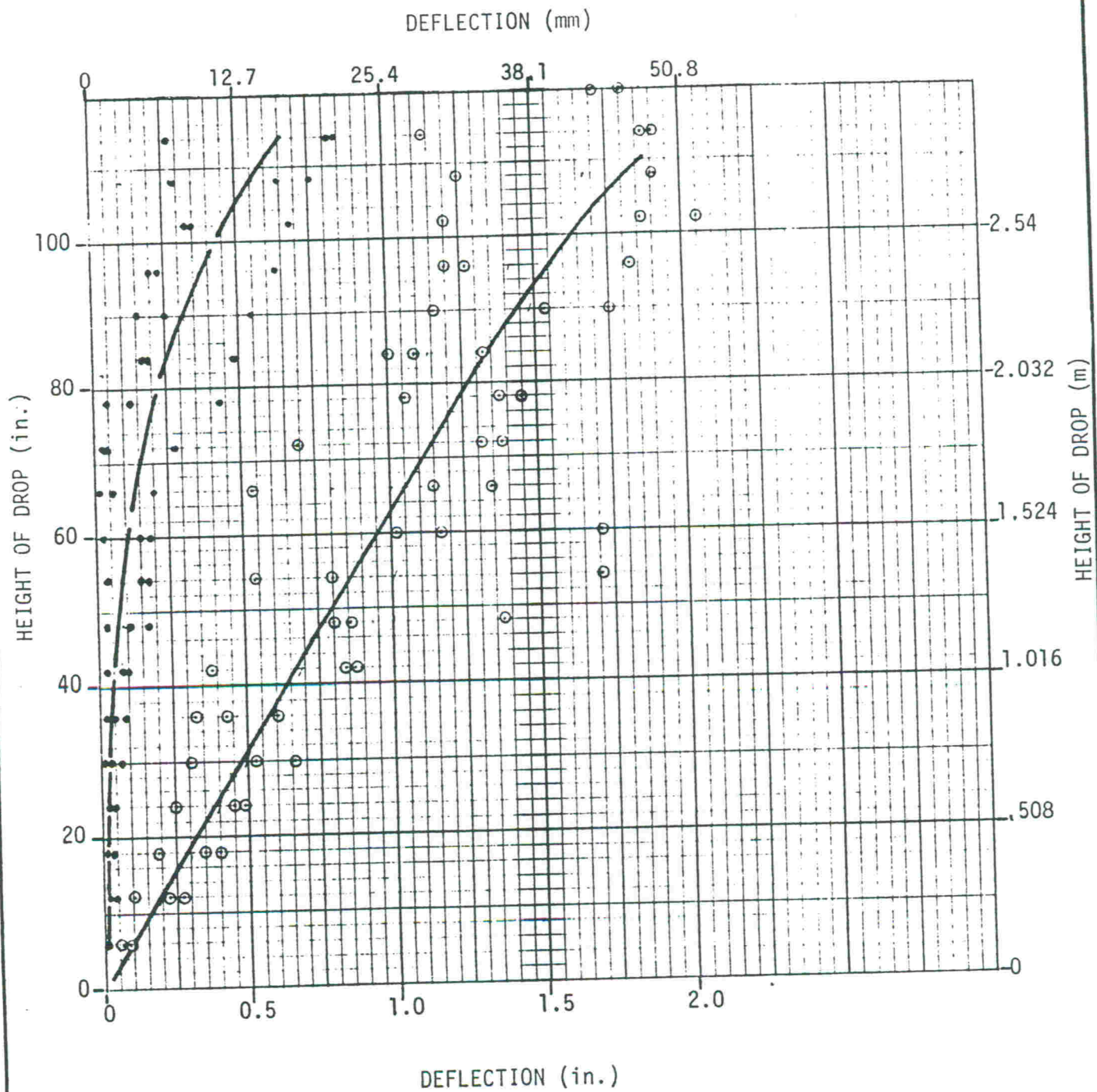
TABLE NO. 3
IMPACT LOAD TESTS
ISOBLOC WALLS
WALLS A, B AND C

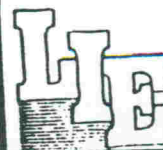
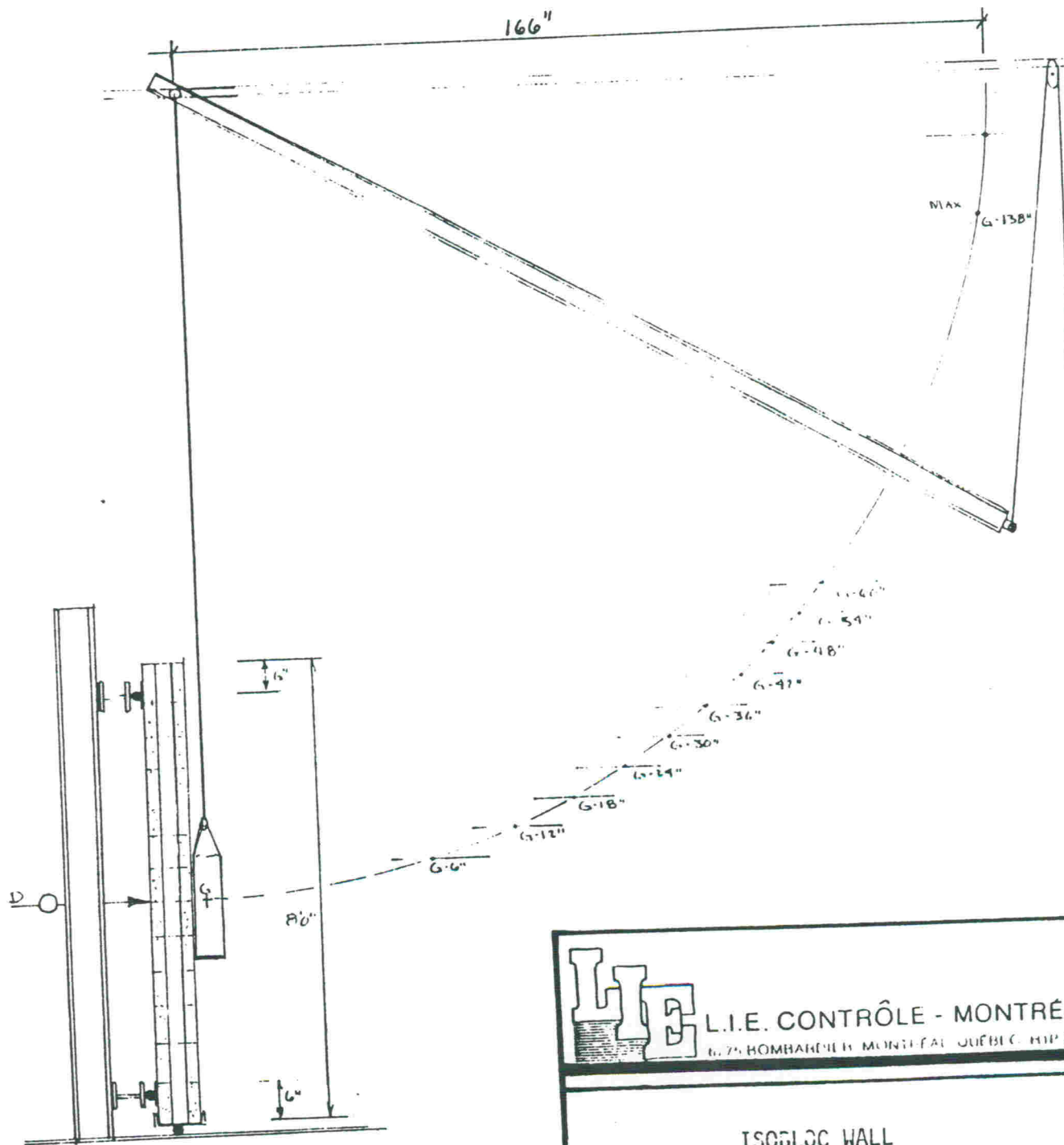
HEIGHT OF DROP	DEFLECTIONS (in.)				AVERAGES			
	WALL A		WALL B		WALL C			
	max.	set	max.	set	max.	set	max.	set
6	.058	.002	.060	0	.085	.010	.068	.011
12	.105	.037	.230	.005	.070	.020	.202	.021
18	.191	.037	.345	.032	.400	.015	.312	.028
24	.255	.022	.446	.032	.490	.025	.397	.026
30	.310	.012	.523	.065	.660	.025	.498	.034
36	.325	.017	.605	.090	.425	.050	.452	.052
42	.385	.017	.835	.080	.870	.100	.697	.066
48	.805	.028	1.365	.930	.855	.105	1.008	.354
54	.537	.038	1.711	.930	.800	.145	1.016	.371
60	1.085	.018	1.714	.905	1.165	.180	1.321	.368
66	1.145	.008	1.340	.810	.530	.200	1.005	.339
72	1.310	.043	1.375	.790	.685	.265	1.123	.366
78	1.445	.128	1.370	.711	1.055	.435	1.290	.425
84	1.320	.186	1.001	.580	1.085	.490	1.135	.419
90	1.537	.153	1.750	.501	1.155	.535	1.481	.396
96	1.265	.203	1.816	.530	1.180	.630	1.420	.454
102	1.855	.323	2.045	.415	1.180	.675	1.693	.471
108	1.895	.288	1.910	.110	1.245	.760	1.683	.386
114	1.872	.273	1.905	.700	1.125	.835	1.634	.603
120	1.801	.488	1.711	.230	--	--	--	--
126	2.060	.643	1.300	--	--	--	--	--
132	1.945	.513	--	--	--	--	--	--

DOSSIER: 86-C-802

PROJET: Special Tests on ISOBLOC Concrete Masonry Walls

GRAPH NO. 2 - IMPACT





L.I.E. CONTRÔLE - MONTRÉAL
6,75 HOMBARDEN MONTRÉAL QUÉBEC H3P 2W3

ISOGLUC WALL

IMPACT LOAD TEST

Scale: 3/8"=1'

Feb. 1987

86-C-802-3

6.0 RACKING LOAD TESTS

6.1 Object

To measure the resistance to a racking load such as would be imposed by winds blowing in a wall oriented at 90 degrees to the panel. This test is an adaptation of the method recommended in ASTM Standard E 72 which applies to a standard wood frame sheathed with sheet materials such as structural insulating board, plywood, gypsum board, etc..

6.2 Wall Specimens

Three wall assemblies were constructed on November 27 and 28th, 1986. Seated on a rigid steel base, the wall specimens were erected in accordance with State-of-the-Art techniques by an experienced mason of Dorion & Frères Ltée.

Mortar type M was used in the construction of the wall specimens. In section 2.2, the compressive strength of the mortar at 26 days was reported at 4250 psi

(29,3 MPa). The wall specimens, 8 x 8 ft in nominal dimensions, were actually 7 ft 10 3/8 in. in height by 7 ft 10 1/4 in. in width with a thickness of 9 5/8 in..

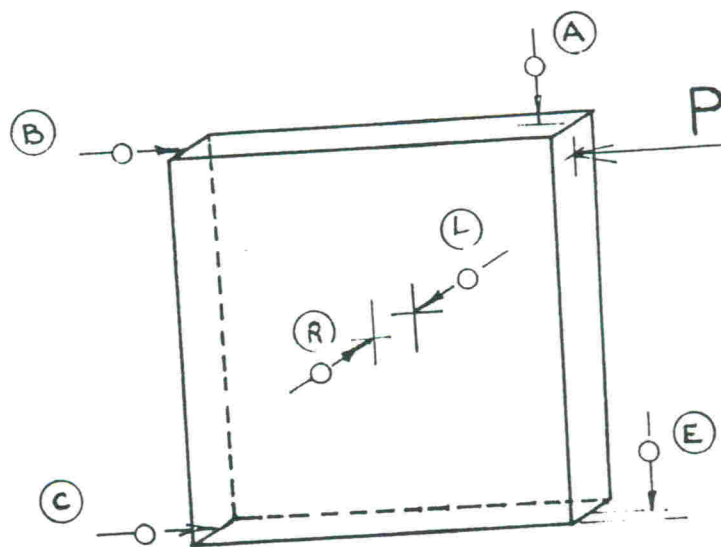
The three impact load tests were carried out on January 20th, 21st and 23rd, 1987, under the supervision of the technical staff of L.I.E. Controlo-Montreal.

6.3 Testing Apparatus

The testing frame was built in such a way that all exterior constraints could be removed in order to establish the load-deformation curve of ISOBLOC concrete masonry walls subjected to racking loads (see Photographs Nos. 13 to 18).

The reaction frame, to which the hydraulic jack was attached, is shown on Sketch No. 86-C-802-1. The exact location of the dial gages, as installed, is shown on Sketch No. 1 appearing on the next page.

Six dial gages were actually installed; they were identified as indicated in the coming Sketch No. 1.



Sketch no. 1

6.4 Test Results

Walls Nos. 1, 2 and 3 : See Table No. 5

Load-Deformation curve : See Graph No. 3

6.5 Procedure and Wall Behavior

Pre-established load increments were applied and maintained for a duration of four minutes. Unloading was allowed at $1/3$ and at $2/3$ of maximum load. Readings were made at regular intervals during each load increment.

Dial gages ^{L R} D and G were installed to indicate the amount of lateral movement. In fact, the lateral deformation proved to be very slight, remaining within 0.01 in. at maximum load.

Dial gages A and E indicated the vertical displacement at the extremity of the walls where the load was applied. The displacement was of the order of 0.9 in..

Deformation and set measurements appearing in Table No. 5 correspond to dial gage B reading, minus dial A reading, minus dial C reading (B-A-C).

The wall specimens performed very well under load. Diagonally stepped fissures appeared in the mortar joints at a load of 24,000 lbf in wall No. 1 and at a load of 20,000 lbf in wall No. 2. In wall No. 3, fissures occurred in the joints of the top rows of blocks at 20,000 lbf, but it took a load of 27,000 lbf to fully develop the stepped fissure pattern exhibited in the other two walls at 20,000 lbf.

The maximum loads applied to reach failure were 30,000 lbf for walls Nos. 1 and 3, and 27,000 lbf for wall specimen No. 2.

TABLE NO. 5
RACKING LOAD
ISOBLOC WALLS

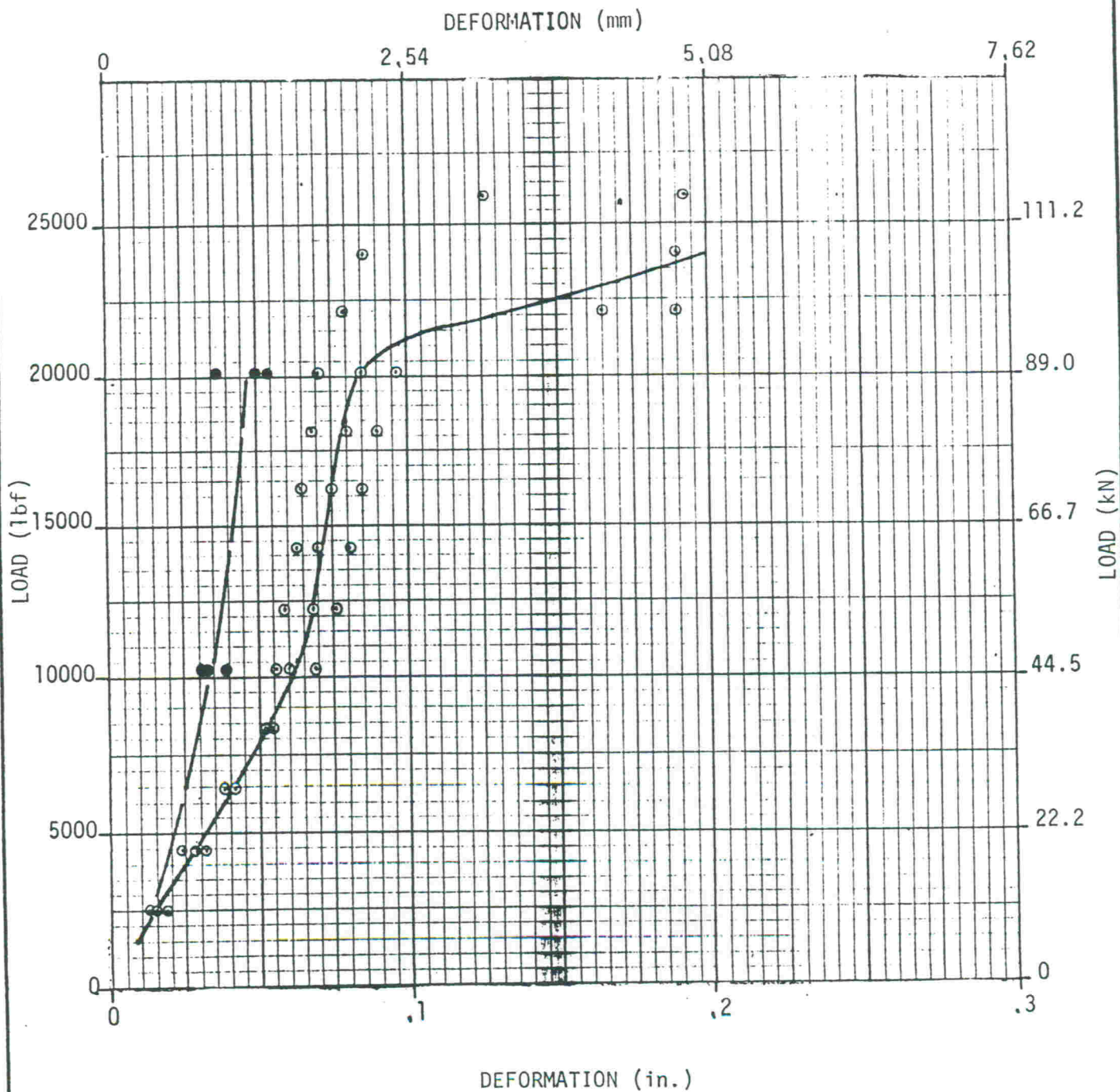
WALLS NO. 1, 2 and 3

APPLIED LOAD (lbf)	WALL 1		WALL 2		WALL 3		AVERAGES	
	deform.	set	deform.	set	deform.	set	deform.	set
2500	.028		.034		.034		.032	
4454	.074		.069		.071		.071	
6417	.108		.106		.123		.112	
8376	.167		.155		.200		.174	
10334	.208	.063	.211	.046	.277	.048	.232	.052
12293	.283		.282		.344		.303	
14251	.344		.363		.407		.371	
16210	.425		.433		.480		.446	
18168	.496		.511		.557		.521	
20127	.570	.142	.577	.062	.634	.067	.594	.090
22085	.642		.762		.822		.742	
24043	.715		1.294		.895		.968	
26002	.833		1.476		.978		1.096	
27690	.920		--		1.090		--	
29919	.998		--		1.164	.966	--	

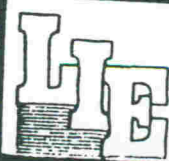
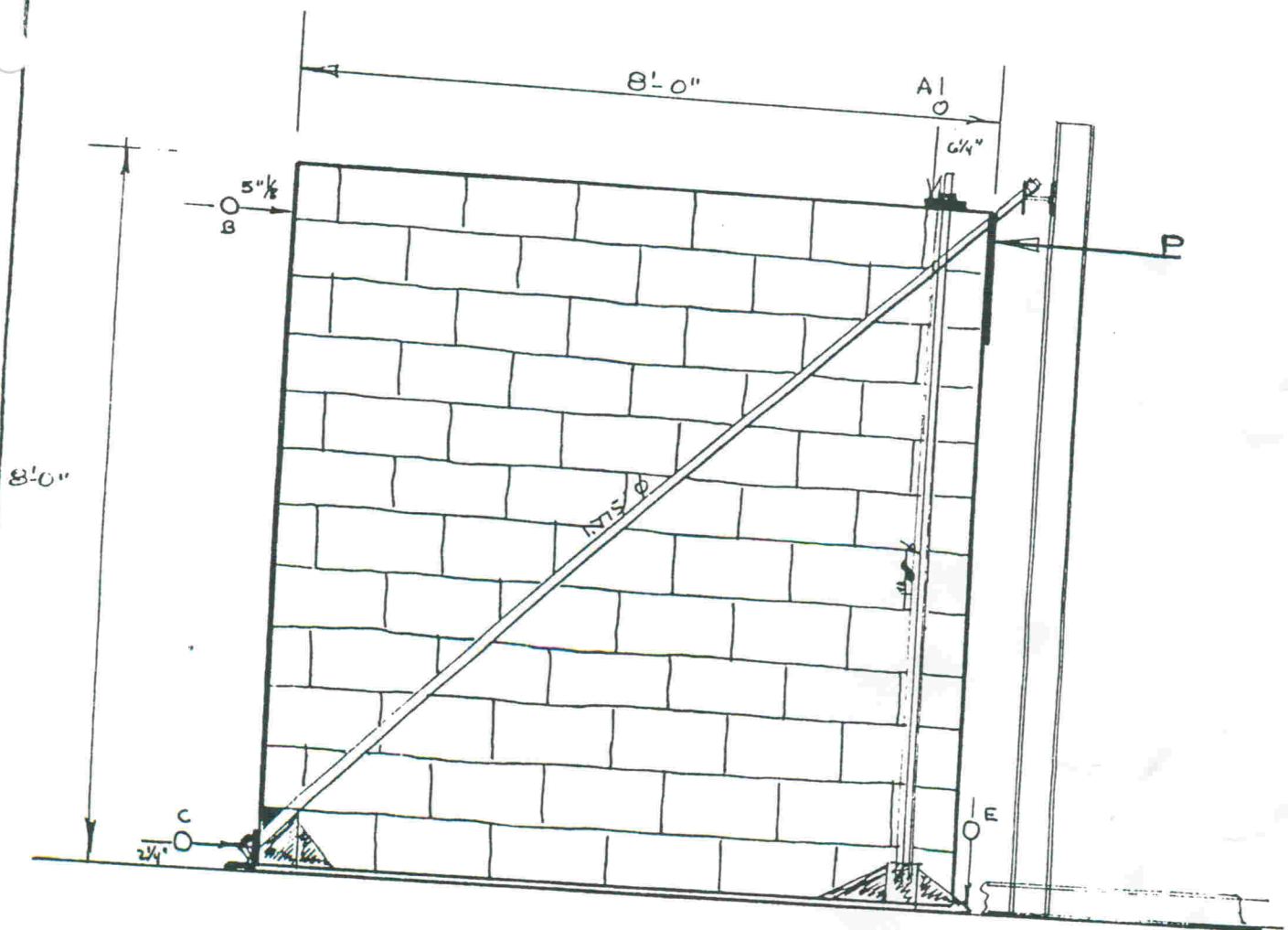
DOSSIER: 86-C-802

PROJET: Special Tests on ISOBLOC Concrete Masonry Walls

GRAPH NO. 3 - RACKING



Set:
Deformation:



L.I.E. CONTRÔLE - MONTRÉAL
6775 BOMBARDIER MONTRÉAL QUÉBEC H1P 2W2

ISOBLOC WALL

RACKING LOAD TEST

Scale: 1/2" = 1'

Feb. 1987

86-C-802-1