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RESISTANCE TO WATER PENETRATION TESTING

"NOVABRIK" BRICK CLADDING

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1. BACKGROUND

The primary objective of this experimental study is to verify the resistance to water penetration of a "NOVABRIK" brick cladding assembly as a function of the air permeability of back-up wall components and the differential pressure to which the wall assembly (brick cladding + back-up wall) is subjected to.

For a given air permeability of the wall assembly, it is desirable that water infiltration not occur up to a maximum static differential pressure of 700 Pa (equivalent to the static pressure generated by a wind of 122 km/h perpendicular to the exterior face of the building). This positive pressure differential of 700 Pa corresponds to the maximum classification required to satisfy all Canadian residential applications (reference: CAN/CSA-A440-M90).

2. DESCRIPTION OF TEST PROTOTYPE

A) BRICK CLADDING

The "NOVABRIK" brick cladding was installed by Air-Ins Inc. personnel, in conformance with the manufacturer's requirements. The assembly of the wall installation consisted of the following steps:

- Install a 1" x 6" horizontal plank at the base of the wall;
- Install an asphalt flashing over the horizontal plank extending 6" up the back-up wall. An adhesive tape was applied over the joint.
- Fasten 1" x 3" furring strips to the framing with #10 screws (2" long) at 10" c/c;
- At the top portion of the wall, a horizontal furring is installed between the vertical furring strips;
- Install and level the metal starting strip to the 1" x 6" plank at the base of the wall;
- Drill two (2) holes in each brick of the first row in accordance with the manufacturer's recommendations;
- Install the first row of NOVABRIK onto a metal starting strip and fasten each brick with two (2) #8 screws (2" long);
- Install the following rows of bricks (rows 2, 3 and 4) in a running bond pattern;
- For rows 5, 9, 13, 17…fasten each brick to the furring strips with one (1) #8 screw (2½" long);
- The other rows (6, 7, 8, 10, 11, 12…) are laid over the lower row in a running bond pattern.

The nominal dimensions of the brick cladding prototype is 8'-0" x 8'-0" (2.4m x 2.4m). Photographs no. 12 to 21 illustrate the installation process for the brick cladding.

B) BACK-UP WALL

The back-up wall consists of a 2" x 4" stud wall spaced at 16" c/c, with a transparent vinyl film installed on the interior side of the wall. The transparent film allows visual access to the back face of the brick cladding. In addition, each of the six (6) vertical cavities between the studs is compartmentalized.

The vertical compartmentalization is necessary to control and to uniformly distribute the airflow across the back-up wall when it is subjected to a differential pressure.

Control of the airtightness of the back-up wall is made possible by openings (orifices) which perforate the vinyl film in each of the six (6) cavities (as illustrated in Photographs no. 10 and 11).

The initial ¼" ϕ orifice represents the air tightness of a wall which satisfies the recommendations of Part 5 of the 1995 NBC, when internal conditions do not exceed 27% relative humidity during the winter period (0.15 Ls-m^2 @ 75 Pa or ≈ 0.03 ft^3/min-ft^2 @ 1.56 lb/ft^2).

The total equivalent leakage area of the sum of the ¼" ϕ and ½" ϕ orifices represents the air tightness of an average airtight back-up wall (≈ 0.75 L/s-m^2 @ 75 Pa or ≈ 0.15 ft^3/min-ft^2 @ 1.56 lb/ft^2).

The total equivalent leakage area for the sum of the ¼" ϕ, ½" ϕ and 1" ϕ orifices represents the airtightness of a mediocre back-up wall (≈ 3.2 L/s-m^2 @ 75 Pa or ≈ 0.63 ft^3/min-ft^2 @ 1.56 lb/ft^2).

The total equivalent leakage area for the sum of ¼" ϕ, ½" ϕ and three (3) 1" ϕ orifices represents the airthightness of a very poor back-up wall (≈ 8.1 L/s-m^2 @ 75 Pa or ≈ 2.7 ft^3/min-ft^2 @ 1.56 lb/ft^2).

C) INTERIOR CONDITIONS

The cavity contained between the perforated vinyl film and the continuous vinyl film (refer to drawing no. 1) represents the interior building condition. With the exception of the orifices perforated on the exterior vinyl film, this cavity is considered airtight.

In order to create a positive pressure differential (towards the interior environment) as well as air infiltration across the wall assembly (brick cladding and backup wall), a measured airflow is drawn through the continuous vinyl film. Air evacuation is made possible via two openings in the continuous vinyl film. The first opening (1 ½" ϕ) is used only in the case where the evacuated airflow is lower than to 40 ft^3/min (20 L/s) whereas the second opening (5½" ϕ) is used when the evacuated airflow is greater than 40 ft^3/min (20 L/s). The connection flanges (1½" ϕ and 5½" ϕ) are each connected to conduits which direct air to air flowmeters and vacuum blowers.

3. TEST APPARATUS

Drawing no. 2 illustrates the different variables measured during a typical water infiltration test.

The variables measured are:

- The differential pressure across the brick cladding (ΔP_1);
- The differential pressure across the wall assembly (ΔP_2);
- The flow rate of the water stream over the exterior face of the brick cladding.
- The water flow rate per unit surface area is maintained constant at 5 US gal/hr-ft^2 (2.3 L/min-m^2). It corresponds to a heavy rain of 8 in./h (200 mm/h) of water on a horizontal surface.
- The airflow rate through the assembly.

3.1 AIR FLOWMETERS

The airflow evacuated from the test chamber is measured with one of the following instruments:

- Range: 0 to 0.08 ft^3/mn (0 - 3.78 x 10^{-5}m^3/s)
  Laminar flow meter (Meriam - model 50 MJ10 -½ type 14)

- Range: 0 to 2 ft^3/mn (0 - 94.5 x 10-5m3/s)
  Laminar flow meter (Meriam - model 50 MJ10 - ½ type 13)

- Range: 0 to 8 ft^3/mn (0 - 377 x 10-5m3/s)
  Laminar flow meter (Meriam - model 50 MH10-1-NT)

- Range: 0 to 40 ft^3/mn (0 - 1890 x 10-5m3/s)
  Laminar flow meter (Meriam - model 50 MW20-2)

- Range: 20 to 66 ft^3/min
  1½" diameter orifice

- Range: 37 to 117 ft^3/min
  2" diameter orifice

- Range: 83 to 264 ft^3/min
  3" diameter orifice

3.2 WATER FLOWMETER

- Range: 0 to 5 US gal/min
  Dwyer - model VFC – 121

3.3 DIFFERENTIAL MANOMETER

All the differential manometers are of the same type (Air Instrument Resources Ltd. - model MP6KD).

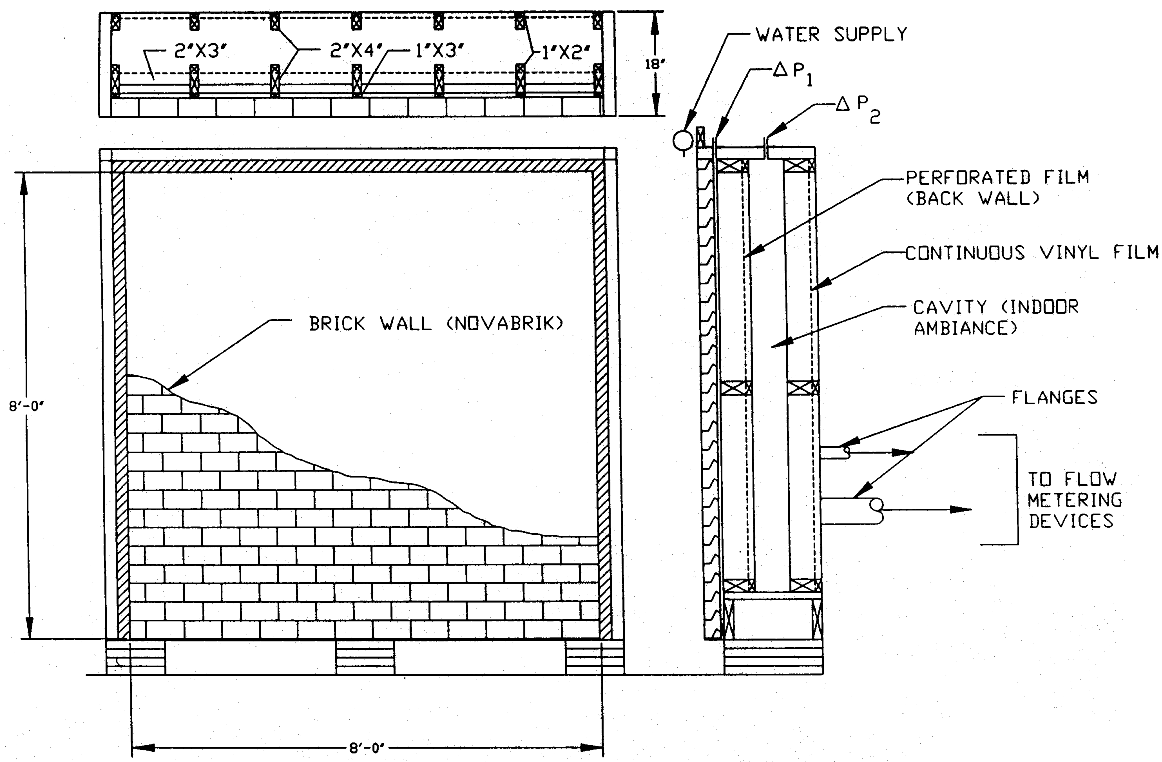
3.4 TEMPERATURE PROBE

To determine the actual airflow across the flow meter, the upstream air temperature is necessary.

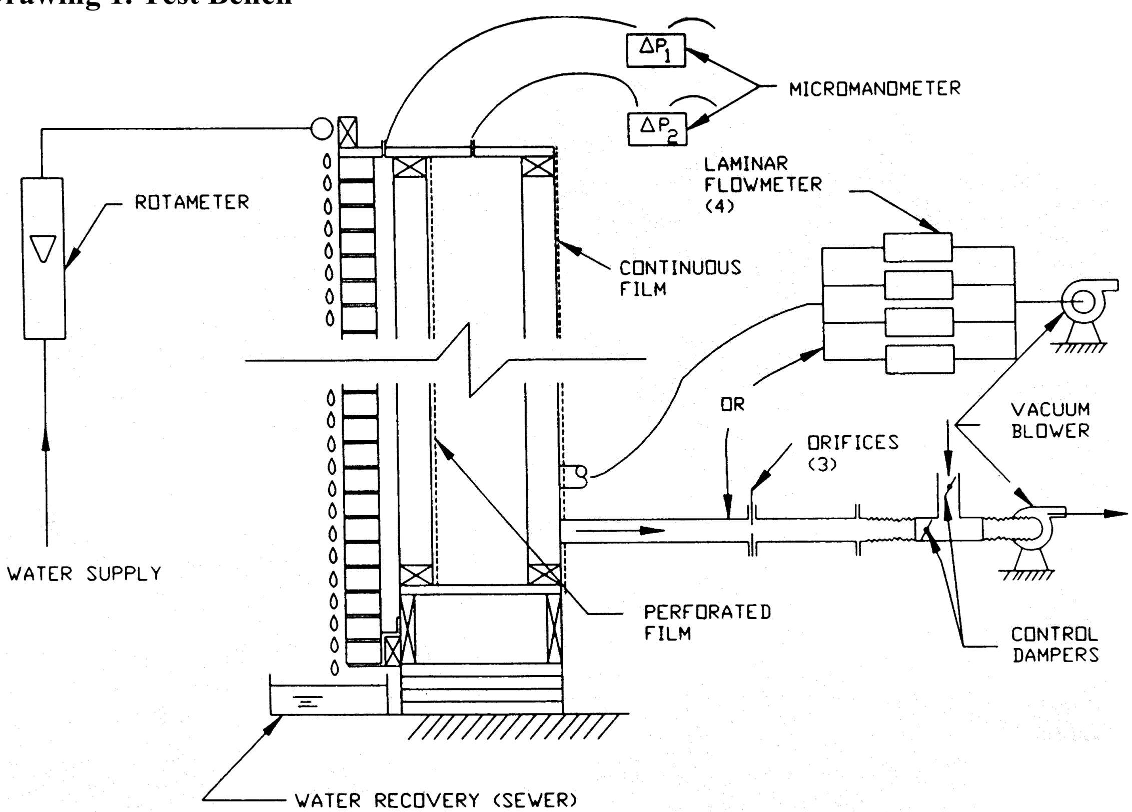
Temperature readings are obtained through the use of chromel-alumel type thermocouples connected to a digital display.

3.5 BAROMETRIC PRESSURE

Barometric pressure readings are obtained from Environment Canada (St-Hubert meteorological station).



Drawing 1. Test Bench



Drawing 2. Test Apparatus

4. METHODOLOGY

The test procedure is as described in the ASTM-E514-90 Standard.

For a given air permeability of the back-up wall, the test consists essentially of:

- Maintaining a stream water flow rate of 5 US gal./h-ft^2 (2.3 L/min-m^2) on the exterior face of the brick cladding;

- Maintaining a constant differential pressure across the wall assembly (brick cladding and back-up wall, i.e. ΔP_2) during a period of fifteen (15) minutes;

- Verify for the presence of water on the components of the back-up wall.

For the test to be successful, no water should be present on either surface of the back-up wall components.

The performance of the brick cladding with respect to resistance to water penetration is defined by the maximum differential pressure at which the wall assembly is resistant to water penetration for a given air permeability of the wall assembly.

In order to determine the performance of the brick cladding as a function of increasing air permeability of the wall assembly, several tests were undertaken.

1st Series of tests

- Low air permeability of back-up wall.

  - ¼" ϕ orifice in the vinyl film (back-up wall) for each cavity.

- Test pressure differentials:

  150, 200, 250, 400, 500, 600 and 700 Pa.

2nd Series of tests

- Average air permeability of back-up wall.

  - two orifices (¼" ϕ and ½" ϕ) in the vinyl film for each cavity.

- Test pressure differentials:

  150, 200, 250, 400, 500, 600 and 700 Pa or until water infiltration occurs.

3rd Series of tests

- Poor air permeability of back-up wall
  - three orifices (¼" ϕ + ½" ϕ + 1" ϕ) in the vinyl film for each cavity.
- Test pressure differentials:

  150, 200, 250, 400, 500, 600 and 700 Pa or until water infiltration occurs.

4th Series of tests

- Air permeability comparable to a back-up wall of very poor quality.
  - Five orifices (¼" ϕ, ½" ϕ and three (3) 1" ϕ) in the vinyl film for each cavity.
- Test pressure differentials:

  150, 200, 250, 400, 500, 600 and 700 Pa or until water infiltration occurs.

5. TESTS RESULTS

Table 1 illustrates the principal water infiltration test results for the "NOVABRIK" brick cladding in function with the quality of the back-up wall and the test pressure differential across the wall assembly (brick cladding and back-up wall).

TABLE 1: TEST RESULTS

QUALITY OF BACK-UP WALL	PRESSURE DIFFERENTIAL ACROSS WALL ASSEMBLY (ΔP_2)	EQUIVALENT WIND SPEED	PRESSURE DIFFERENTIAL ACROSS BRICK CLADING (ΔP_1)	AIR PERMEABILITY OF WET WALL ASSEMBLY		RESISTANCE TO WATER PENETRATION	
	Pa	km/h	Pa	L/s-m^2	ft^3/min-ft^2	Pass	Fail
Air tight (ϕ = ¼")	150	56.5	2.2	0.32	0.065	v	
	200	65.3	2.9	0.37	0.074	v	
	250	73.0	3.5	0.41	0.083	v	
	400	92.4	5.3	0.524	0.105	v	
	500	103	6.6	0.59	0.118	v	
	600	113	7.9	0.64	0.127	v	
	700	122	9.5	0.70	0.139	v	
Average (ϕ = ¼" + ½")	150	56.5	25	1.86	0.372	v	
	200	65.3	29	2.04	0.408	v	
	250	73	33	2.59	0.519	v	
	400	92.4	43	2.92	0.583		v (1)
Mediocre (ϕ = ¼" + ½" + 1")	150	56.5	6	3.19	0.64	v	
	200	65.3	80	3.69	0.74		v (2)
	250	73	89	4.22	0.84		v (3)
	400	92.4	120	5.48	1.09		v (4)
Very poor (ϕ = ¼" + ½" + 3 x 1")	150	56.5	118				v (5)

Notes:

1) Water projected across the air space (≈ ½ teaspoon)
2) Water projected across the air space (≈ ½ teaspoon)
3) Water projected across the air space (≈1 teaspoon)
4) Water projected across the air space (≈ 2 teaspoons)
5) Water projected across the air space and through the orifices in the back-up wall.

6. ANALYSIS OF TEST RESULTS

6.1 AIRTIGHT BACK-UP WALL (ϕ = ¼" per cavity measuring 16" x 96")

With an airtight back-up wall (i.e. satisfying the recommendations of part 5 of the 1995 NBC with regards to air permeability), the results in Table 1 illustrate that there will be no water penetration across the ¾" air space situated at the back of the brick cladding for positive pressure differentials up to 700 Pa (122 km/h).

The only observation for the back face of the brick cladding was the presence of localized damp areas at the vertical joint between two bricks. Photographs no. 25 to 28 illustrate the damp areas at the end of the water penetration tests, at a pressure differential of 700 Pa (122 km/h).

We can also note that in the case where the permeability of the back-up wall is excellent, the pressure differential across the brick cladding is very small in comparison with the total pressure subjected to the whole wall assembly, which is approximately 1.5% of ΔP_2.

6.2 AVERAGE BACK-UP WALL (ϕ = ¼" + ½" per cavity measuring 16" x 96"; ϕ equiv. to 0.56")

With a back-up wall construction of average air permeability, the results in Table 1 demonstrate that there will be no water infiltration across the ¾" air space situated behind the brick cladding for positive pressure differentials up to 250 Pa (73 km/h). During these tests, a small-localized flow of water was observed on the back face of the brick cladding (refer to photographs no. 29 - 40). The photographs also illustrate that there is an increase water flow rate at their points of origin.

Photographs no. 41 to 48 illustrate the back face of the brick cladding at the end of the water infiltration test, at a pressure differential of 400 Pa. In photographs no. 43 and 47, we are able to visualize water projection across the air space in the form of fine water droplets on the perforated vinyl film (back-up wall). The total amount of water accumulated at the base of the wall at the end of the 15-minute test period is estimated at approximately ½ teaspoon. The main water flow originated from a localized opening (≈ 3/16" wide) between two bricks situated near the top right corner of the test specimen (back view).

The results in Table 1 also demonstrate that the portion of the total pressure differential across the brick cladding is much larger when the wall construction comprises a back-up wall with average air permeance. The pressure differential across the brick cladding was determined to be approximately 11 to 16% of the pressure differential exerted across the entire assembly.

6.3 MEDIOCRE BACK-UP WALL (ϕ = ¼" + ½" + 1" per cavity measuring 16" x 96"; ϕ equiv. of 1.14")

With a back-up wall construction of mediocre air permeability, the results in Table 1 demonstrate that there will be no water infiltration across the ¾" air space situated behind the brick cladding for pressure differentials up to 150 Pa.

For pressure differentials greater than 150 Pa across the wall assembly, we can note an increase in water projection as the pressure differential is increased. The remarks in Table 1 illustrate the importance of the quantity of water projected during a typical 15-minute test.

We can also note that the pressure differential across the brick cladding varies between 30 to 45 % of the total pressure differential exerted across the entire wall assembly.

6.4 BACK-UP WALL OF VERY POOR QUALITY (ϕ = ¼" + ½" + 3 x 1" per cavity measuring 16" x 96"; ϕ equiv. of 1.82")

The only test undertaken at a pressure differential of 150 Pa demonstrated that for a back-up wall of very poor quality, water is projected from several areas of the back face of the brick cladding. Furthermore, projection of water droplets also occurred across the orifices in the vinyl film (back-up wall) up to the interior of the building. Photographs no. 44 to 56 illustrate the condition of the back-up wall (rear view) and the different points of water projection.

The pressure differential across the back-up wall was measured to be 78 % of the total pressure differential across the wall assembly. This implies that the airtightness of the wall assembly is principally controlled by the brick cladding.

7. CONCLUSIONS

7.1 GENERAL

The "Novabrik" brick cladding system may be used for all Canadian constructions (airtight back-up wall, average back-up wall, mediocre back-up wall and back-up wall of very poor quality) where the building height is equal or lower than 3 stories, provided that the back-up wall satisfies the requirements of the National Building Code of Canada (NBCC).

7.2 AIRTIGHT BACK-UP WALL

The "airtight" classification is given to a back-up that satisfies the air permeability requirement set by Part 5 of NBCC-95, i.e. a rate of air leakage lower than 0.15 L/s-m^2 at a pressure difference of 75 Pa. Such air permeability requirement corresponds to a back-up wall having an equivalent leakage area equal or lower to an orifice of ¼" ϕ for each wall cavity of 16" x 96".

For this type of construction, the brick cladding "Novabrik" can be used for all Canadian buildings (residential, commercial, industrial) whichever the height, without risk of water penetration across the air gap behind the brick cladding.

7.3 AVERAGE BACK-UP WALL

The "average" classification is given to a back-up wall having an air permeability which is included between 0.15 and 0.75 L/s-m^2 at a pressure difference of 75 Pa. Such classification also corresponds to a back-up wall having an equivalent leakage area of a 0.56" ϕ orifice for each wall cavity of 16" x 96" . A back-up wall which satisfies this requirement is recognized as superior to the state of the art.

For this type of construction, the brick cladding ("Novabrik") can be used for all Canadian buildings situated in areas where the wind driven rain index is less than 400 Pa (92.4 km/h), without risk of water infiltration across the air space behind the brick cladding.

For buildings in a locality where the wind-driven rain index is higher than 400 Pa, the installation of building paper (or equivalent) installed under the 1" x 3" furring on the back-up wall must be considered. The localities where the wind driven rain index is higher than 400 Pa are: Masset (B.C.), all of P.E.I. localities, Argentia (N.F.), Bonavista (N.F.), Cape Harrison (N.F.), Cape Race (N.F.), Channel-Port-aux-Basques (N.F.), Grand Bank (N.F.), St-John (N.F.), Stephenville (N.F.) and Wabana (N.F.).

7.4 MEDIOCRE BACK-UP WALL

The "mediocre" classification is given to a back-up wall having an air permeability which is included between 0.75 and 3.2 L/s-m^2 at a pressure difference of 75 Pa. Such classification also corresponds to a back-up wall having an equivalent leakage area to a 1.14" ϕ orifice for each cavity of 16" x 96". A back-up wall which satisfies this requirement corresponds to the state of the art.

For this type of construction, the brick cladding ("Novabrik") can be used for all Canadian buildings situated in areas where the wind-driven rain index is less than 150 Pa (56.5 km/h), without risk of water infiltration across the air space behind the brick cladding.

For applications where the wind-driven rain index is higher than 150 Pa, the installation of building paper (or equivalent) installed under the 1" x 3" furring on the back-up wall must be considered.

7.5 BACK-UP WALL OF VERY POOR QUALITY

For this type of construction, the brick cladding ("Novabrik") must be used in conjunction with a building paper (or equivalent) installed under the 1" x 3" furring on the back-up wall.


7


8


5


6


10
1/4" Φ
1/2" Φ
1" Φ
2 x 1/2" Φ
2 x 1" Φ


11
1/4" Φ


9
RUBAN DE BUTYLE
ENTRE FILM ET OSSATURE


12
BASE


15
1er RANG DE BRIQUE


16
FIXATION DU 5e RANG


13
BASE + MEMBRANE + RUBAN ADHÉSIF


14
BANDE DE DÉPART


19

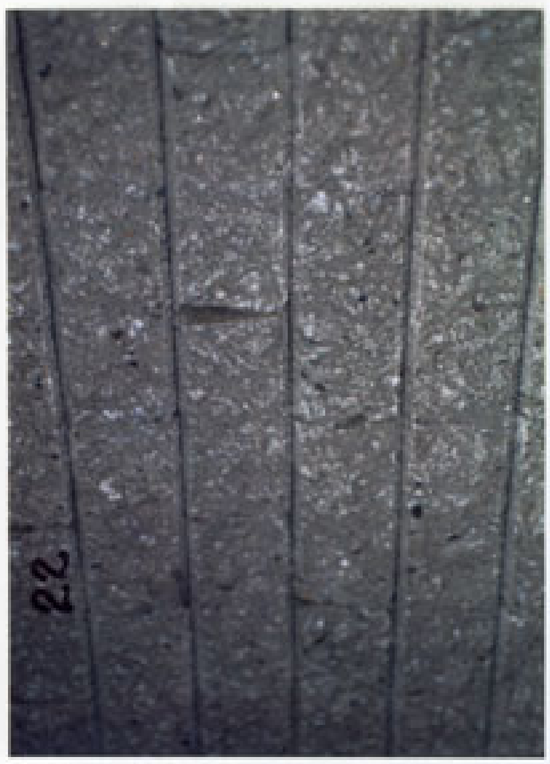

DISPOSITIF DE
GICLAGE DE L'EAU
20


18


23
ΔP PAREMENT
ΔP PAR.+MUR DE FOND


24


VUE EXTÉRIEURE DU PAREMENT
21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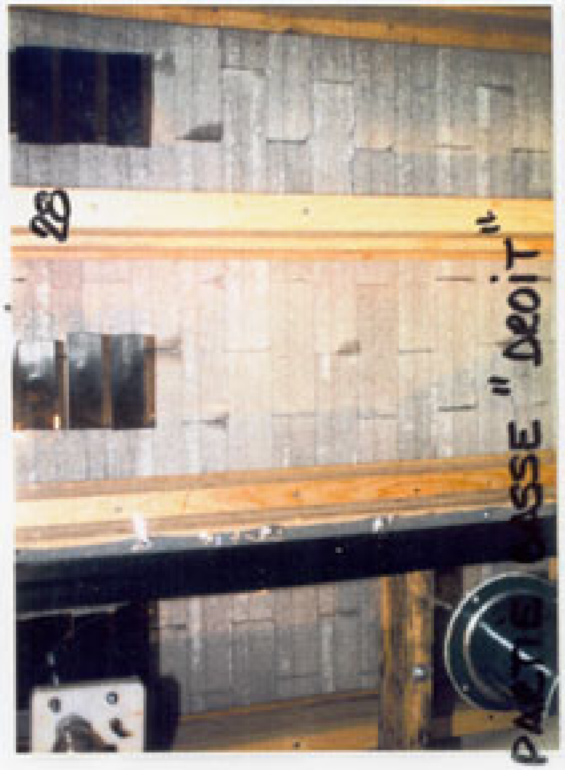
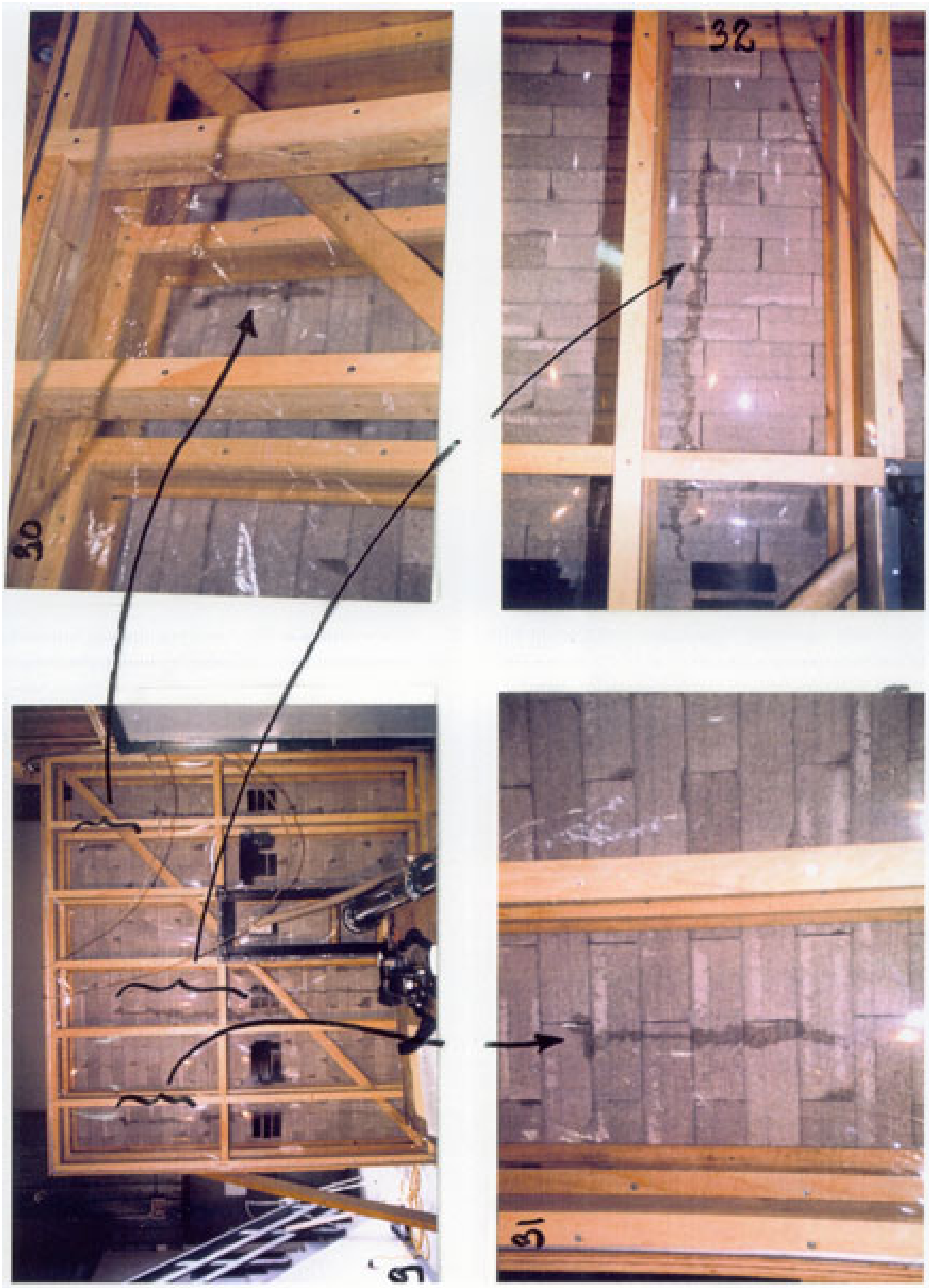
27
PARTIE HAUTE "DROIT"


28
PARTIE BASSE "DROIT"


25
PARTIE HAUTE "GAUCHE"


26
PARTIE BASSE "GAUCHE"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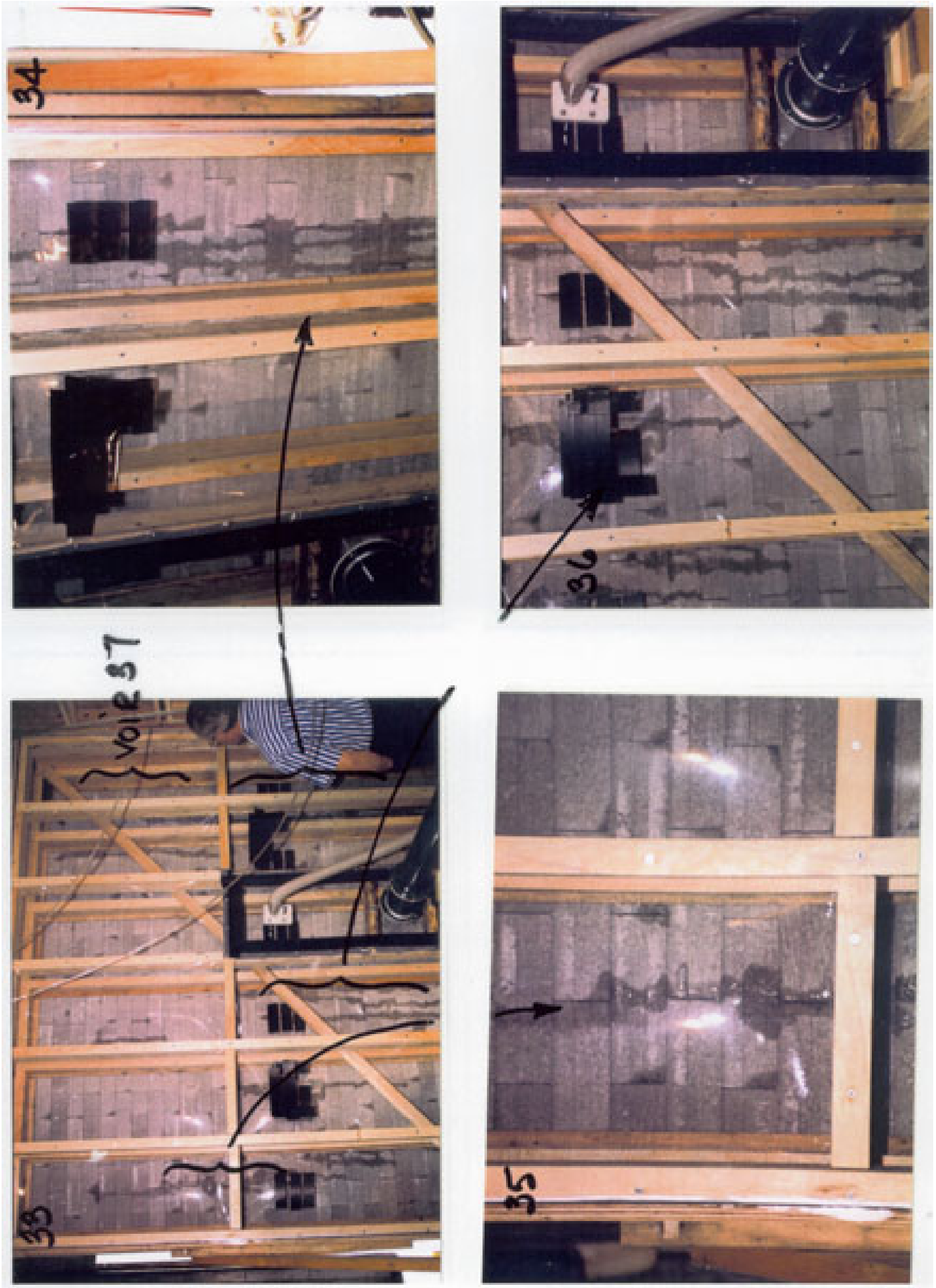
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36
VOIR 37
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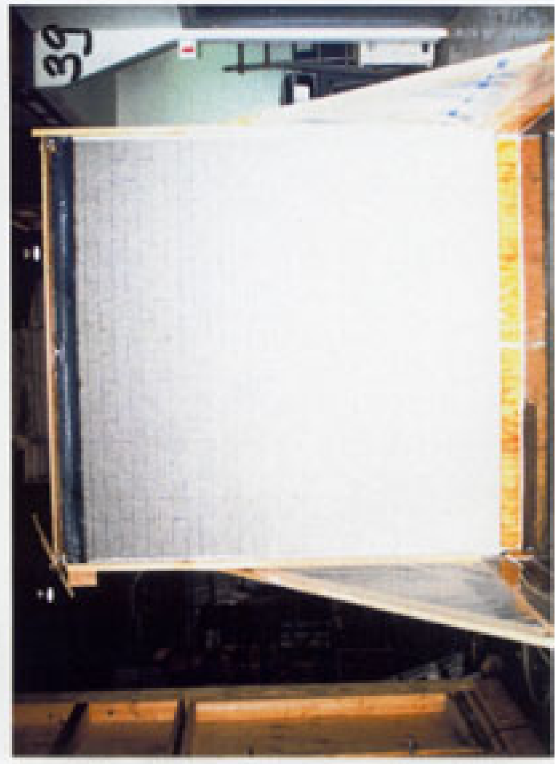

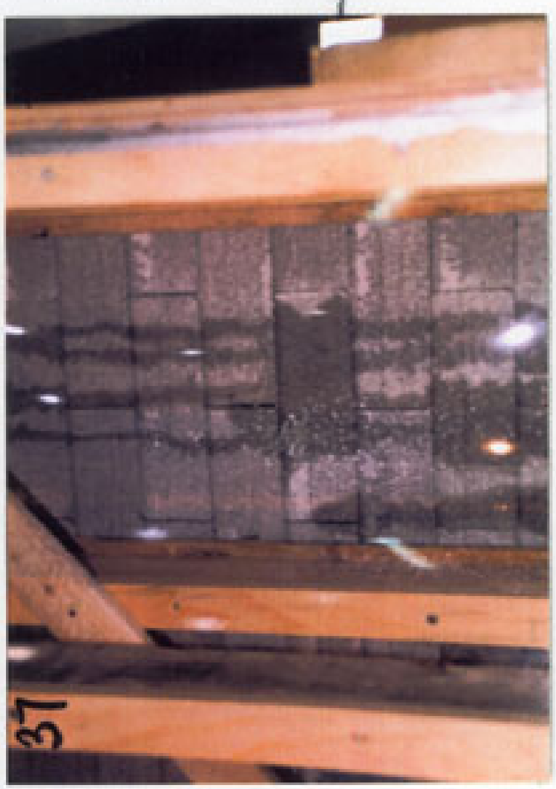


ΔP = 200 Pa


PROTEC-
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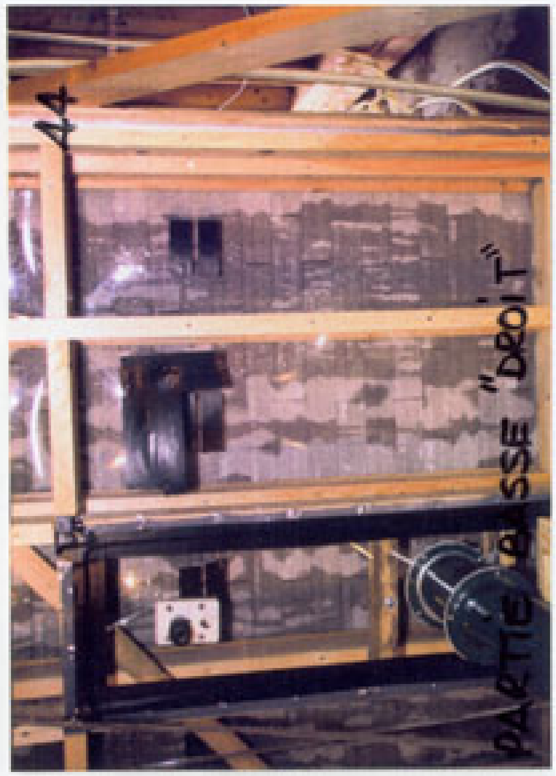
43
PARTIE HAUTE "DROIT"

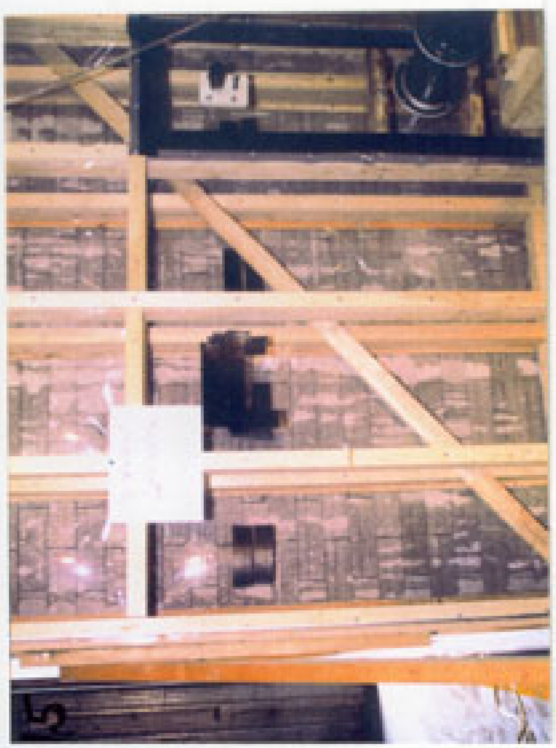

44
PARTIE BASSE "DROIT"


ARTIE HAUTE "GAUCHE"


ARTIE BASSE "GAUCHE"


47
PARTIE HAUTE "DROIT"
PULVÉRIS
TION D'EA


48
PARTIE BASSE "DROIT"

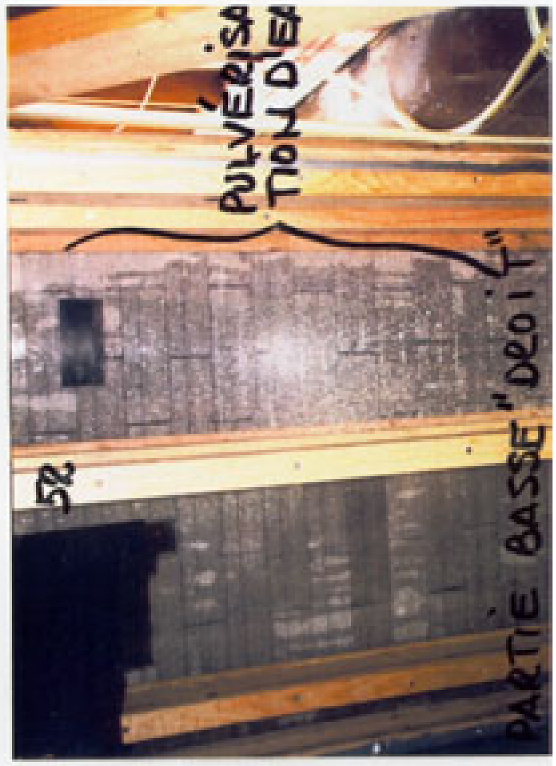



PARTIE BASSE "GAUCHE"


49
Φ = 1/4" + 1/2" + 3x1"
ΔP = 150 Pa


51
PULVÉRISA-TION D'EAU
PARTIE HAUTE "DROIT"


50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PARTIE BASSE "DROIT"


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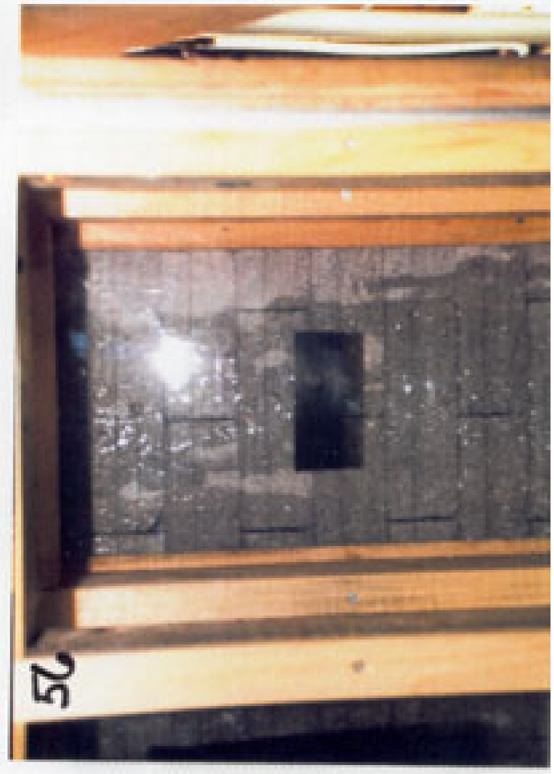
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