Mechanically Fastened Air Barrier System

Prepared for:

Canada Mortgage and Housing Corporation

Project Implementation Division

682 Montreal Road

Ottawa, Ontario

K1A OP7

Prepared by:

Mr. B. Shorney and Mr. G. Kappeler

This project was carried out with the assistance of a grant from Canada Mortgage and Housing Corporation under the terms of the Housing Technology Incentives Program (HTIP). The views expressed are those of the author and do not represent the officiaL views of the Corporation.

RESUME

SYSTEM DESIGNERS

BRUCE D.SHORNEY CET
- BORN IN WESTON, ONTARIO, CANADA, JAN. 7, 1954.
- GRADUATED FROM GRADE 12 OF THE PUBLIC SCHOOL SYSTEM.
- GRADUATE OF SENECA COLLEGE, CIVIL ENGINEERING TECHNICIAN.
- MEMBER OF THE ONTARIO ASSOCIATION OF CERTIFIED ENGINEERING TECHNICIANS AND TECHNOLOGISTS.
- 2 YEARS AS MATERIALS TESTING TECHNICIAN.
- 12 YEARS AS ESTIMATOR FOR A MASONRY CONTRACTING COMPANY.
- CO-INVENTOR OF MECHANICALLY FASTENED AIR BARRIER SYSTEM.

GERHARD O.KAPPELER
- BORN IN WEST GERMANY, JAN. 7, 1938.
- SERVED A BRICKLAYER APPRENTICESHIP IN WEST GERMANY, FRANCE AND SWITZERLAND.
- IMMIGRATED TO CANADA AND WORKED AS BRICKLAYER FOREMAN FOR 11 YEARS.
- FORMED KAPPELER MASONRY LIMITED IN 1966 AND HAS BEEN ITS PRESIDENT SINCE IT INCEPTION.
- SERVES ON THE APPRENTICESHIP COMMITEE.
- SITS ON THE BOARD OF DIRECTORS FOR C.M.C.A.
- PRESIDENT OF O.M.C.A. FOR THE PAST THREE YEARS.
- CO-INVENTOR OF MECHANICALLY FASTENED AIR BARRIER SYSTEM.

THE PROBLEM

ALTHOUGH AIR LEAKAGE CAN BE FOUND IN ANY OF THE CONSTRUCTION MATERIALS AND METHODS BEING USED TODAY, THIS INVENTION APPLIES AT THIS POINT IN TIME TO MASONRY CAVITY WALLS.

AIR LEAKAGE EXISTS WHEN THERE ARE CRACKS AND OPENINGS IN THE BUILDING ENVELOPE AND AN AIR PRESSURE DIFERENCE FROM THE INTERIOR OF THE BUILDING TO THE EXTERIOR. THE PRESSURE DIFFERENCE RESULTS FROM ONE OR MORE OF STACK EFFECT, WIND, FAN PRESSURIZATION.

AIR LEAKAGE AND THE CONDENSATION AND FREEZING OF THE MOISTURE CONTAINED IN THE AIR HAS BEEN FOUND TO BE THE MAJOR CAUSE OF BRICK OR BLOCK SPALLING, MORTAR JOINT DETERIORATION, EFFLORESCENCE AND CONDENSATION IN THE CAVITIES. AIR LEAKAGE ALSO MAKES IT DIFFICULT TO CONTROL THE TEMPERATURE AND HUMIDITY WITHIN A BUILDING.

BOTH OF THE ABOVE MENTIONED RESULT IN INCREASED COSTS TO THE OWNER BY WAY OF REPAIR AND RESTORATION OF THE MATERIALS DAMAGED BY AIR LEAKAGE AND BY HIGHER ENERGY COSTS AND THE HIGHER OUTPUT H.V.A.C. EQUIPMENT REQUIRED TO COMPENSATE FOR THE AIR LOST THROUGH THE WALL SYSTEM.

THE NATIONAL BUILDING CODE 1985 AND THE ONTARIO BUILDING CODE 1986 REQUIRE THAT BUILDINGS BE DESIGNED WITH AN AIR BARRIER. AN AIR BARRIER MUST BE OF AN AIR IMPERMEABLE MATERIAL, BE CONTINUOUS WITH NO GAPS OR HOLES, BE ABLE TO RESIST THE AIR PRESSURE DIFFERENCES FROM HIGH WINDS, SUSTAINED WINDS, STACK EFFECT AND FAN PRESSURIZATION. IT MUST BE CONNECTED TO OR SEALED AROUND THE ROOFING MATERIAL, DOOR AND WINDOW FRAMES, LOUVERS, CONDUIT, MASONRY TIES, STRUCTURAL STEEL COLUMNS / BEAMS / SHELF ANGLES OR OTHER ITEMS THAT PENETRATE OR MAKE UP THE BUILDING ENVELOPE.

ALTHOUGH A VALUE FOR AIR LEAKAGE HAS NOT HAS NOT YET BEEN SPECIFIED, A MAXIMUM LEAKAGE OF 0.1 1/S/SQ.M. HAS BEEN SUGGESTED.

AT PRESENT, THERE ARE THREE TYPES OF AIR BARRIER SYSTEMS BEING USED IN MASONRY CAVITY WALLS; A TROWELL APPLIED PRODUCT, A SELF ADHESIVE SHEET MEMBRANE WITH PEEL OFF BACK AND A PRIMER FOR THE SUBSTRATE, A TORCH ON SHEET MEMBRANE.

AS MASONRY CONTRACTORS, WE ARE CONSCIOUS OF THE SHORTCOMINGS OF THE ABOVE MENTIONED PRODUCTS AND HAVE DESIGNED THIS SYSTEM TO MEET THE FOLLOWING:

- ELIMINATE THE NEED TO PRIME THE SUBSTRATE.
- ELIMINATE THE NEED FOR A WARM OR DRY SUBSTRATE.
- ELIMINATE THE NEED FOR ADHESIVES THAT REQUIRE AMBIENT SURROUNDINGS TO SET UP, AS CONSTRUCTION IN THIS COUNTRY CONTINUES THROUGH THE WINTER MONTHS.
- MINIMIZE THE LABOR INTENSIVE JOB OF ON SITE SEALING AROUND PROTRUSIONS AND PENETRATIONS OF THE AIR BARRIER SYSTEM.
- MAKE THE SYSTEM EASILY INSPECTED.
- MAKE THE SYSTEM CAPABLE OF BRIDGING CRACKS, BEAMS, STEEL COLUMNS.
- MINIMIZE THE CHANCE OF FAILURE OF THE AIR BARRIER SYSTEM RESULTING FROM HUMAN ERROR OR SLOPINESS.
- LIMIT THE TRADESMENS EXPOSURE TO SOLVENTS, ADHESIVES AND OPEN FLAME.

THE SOLUTION

A MECHANICALLY FASTENED AIR BARRIER SYSTEM

DESIGN

SEVERAL METHODS OF SECURING A SHEET MEMBRANE TO A MATERIAL MOUNTED TO HORIZONTAL REINFORCING WIRE WERE CONSIDERED AND THE FINAL DESIGN NARROWED DOWN TO A SYSTEM COMPRISED OF TWO - "C' SHAPED ELONGATE PVC EXTRUSIONS (SEE DRAWING #1 ITEMS "A").THAT ARE DESIGNED TO SNAP TOGETHER TO PROVIDE A SECURE, AIRTIGHT SEAL. THESE EXTRUSIONS (APPROX. 9'-6" LONG) WILL BE ATTATCHED TO A SECTION OF HORIZONTAL MASONRY REINFORCING (APPROX. 10'-0" LONG) AND WITH THE USE OF HEAT IN THE AREA OF THE TIE, A SECURE AIRTIGHT SEAL WILL BE ASSURED. THIS WILL BE CARRIED OUT IN A FACTORY UNDER CONTROLLED CONDITIONS ELIMINATING THE SEALING ON SITE BY THE INSTALLER AT ALL OF THE MASONRY TIES (THIS IS WHERE LEAKAGE CAN RESULT IF THE INSTALLER IS NOT EXTREMELY CAREFULL AND TAKES HIS/HER TIME). A SECOND EXTRUSION THAT IS "L" SHAPED WITH AN ARROW SHAPED SECTION
(SEE DRAWING #1 ITEM "B") IS DESIGNED TO SNAP INTO THE "C" SHAPED EXTRUSION WITH THE AIR BARRIER MEMBRANE SANDWICHED BETWEEN (DRAWING #1 ITEM "C"), THUS SECURING IT IN PLACE.

DEVELOPMENT

A MANUFACTURER WAS SELECTED TO PROVIDE US WITH PROTOTYPE UNITS OF THE EXTRUSIONS OUTLINED ABOVE AND SHOWN ON DRAWING #1.

A PROCEDURE FOR MOUNTING THE PVC EXTRUSIONS TO THE HORIZONTAL WIRE WAS DEVISED AND AN EQUIPMENT MANUFACTURER SELECTED TO MODIFY A WELDING MACHINE THAT WOULD ENABLE US TO DO THIS.

A SOURCE FOR THE AIR BARRIER SHEET MEMBRANE WAS FOUND.

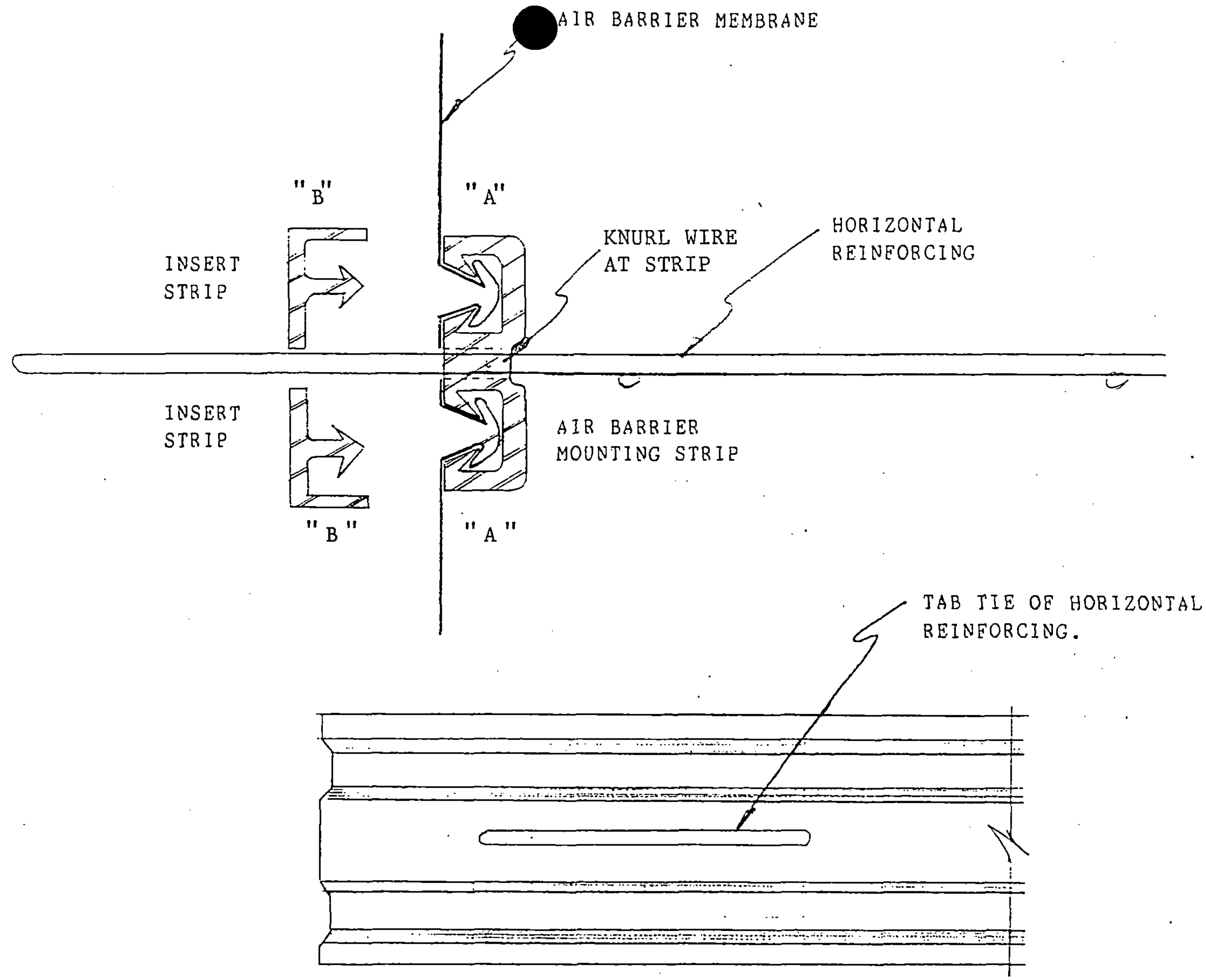
SEVERAL UNITS OF THE PVC EXTRUSIONS WERE SHIPPED TO US AND WITH THE MODIFIED WELDING MACHINE WERE MOUNTED TO THE HORIZONTAL REINFOCING WIRE. CORNER UNITS OF REINFORCING WIRE WITH THE MOUNTING STRIP ATTATCHED WERE MADE AND LENGTHS OF REINFORCING WIRE CUT TO SUIT THE TEST PANEL AND CHAMBER. A QUANTITY OF AIR BARRIER SHEET MEMBRANE WAS RECIEVED BY US AND CUT TO THE REQUIRED WIDTH.

A TEST PANEL WAS CONSTRUCTED TO TEST THE FEASIBILTY OF INSTALLING THE PROTOTYPE UNITS IN A MASONRY WALL AND THE INSTALLATION OF THE SHEET MEMBRANE WITH THE INSERT STRIPS.

OUR NEXT STEP WAS TO TEST THE STRUCTURAL CAPABILITY OF OUR SYSTEM AND A TEST CAHMBER APPROX. 2.4M x 1.2M x 1.6M WAS CONSTRUCTED WITH PROTOTYPE REINFOCING WIRE AND PVC MOUNTING STRIP ATTATCHED.

THE SHEET MEMBRANE WAS SECURED TO THE CHAMBER AND THE CHAMBER WAS PRESSURIZED TO 3000PA. THE SYSTEM WITHSTOOD THIS PRESSURE WITH NO FAILURE OF THE SECUREMENT STRIPS OR MEMBRANE. BILLOWING OF THE SHEET MEMBRANE DURING THE TEST WAS OBSERVED, IT WAS DECIDED THAT TO PREVENT THIS, SHEETS OF RIGID INSULATION, THAT WOULD BE PRESENT IN THE MASONRY CAVITIY WALL BE USED IN THIS SYSTEM TO LIMIT THE BILLOWING. A DADO WAS CUT INTO THE TOP AND BOTTOM EDGES OF THE INSULATION TO PERMIT THE MAJORITY OF THE INSULATION BOARD TO SIT TIGHT TO THE WALL AND THE EDGES TO SIT TIGHT TO OUR MOUNTING STRIPS. THE INSULATION WAS HELD IN PLACE WITH INSULATION WEDGES THAT ARE ON THE MARKET AT PRESENT.

THE SERVICES OF MORRISON HERSHFIELD LIMITED WERE ENGAGED AND IN CONSULTATION WITH THEM, A SERIES OF TESTS WERE PLANNED.


AIR BARRIER MEMBRANE
"B"
"A"
INSERT STRIP
KNURL WIRE AT STRIP
HORIZONTAL REINFORCING
INSERT STRIP
AIR BARRIER MOUNTING STRIP
"B"
"A"
TAB TIE OF HORIZONTAL REINFORCING.

DRAWING #1

TESTING

A 1.2M x 1.2M TEST PANEL WAS CONSTRUCTED. THE PANEL WAS TRANSPORTED TO MORRISON HERSHFIELD IN OTTAWA, ONT.
AT THIER FACILITY, THE SHEET MEMBRANE WAS SECURED TO THE MOUNTING STRIPS AND THE RIGID INSULATION WEDGED INTO PLACE.

THE PANEL WAS TESTED AND REPORTED ON AS OUTLINED IN THE ATTATCHED REPORT BY MORRISON HERSHFIELD LIMITED DATED OCT. 6, 1988.

NEXT,A TEST CHAMBER WAS CONSTRUCTED IN OUR SHOP. A MORRISON HERSHFIELD REPRESENTATIVE CAME TO OUR SHOP AND IN HIS PRESENCE THE AIR BARRIER MEMBRANE AND THE RIGID INSULATION WAS INSTALLED.

THE CHAMBER WAS TESTED AND REPORTED ON AS OUTINED IN THE ATTATCHED REPORT BY MORRISON HERSHFIELD LIMITED DATED NOV. 11, 1988.

REPORTING

PLEASE REFER TO THE ATTATCHED REPORTS PREPARED BY MORRISON HERSHFIELD LIMITED.

IN SUMMARY, THE SYSTEM HAD AN AIR LEAKAGE OF 0.022 l/s PER SQ. METER OF WALL AT A PRESSURE OF 75 PA, ON BOTH THE TEST PANEL AND THE TEST CHAMBER (WITH CORNERS, SEALING AT DAMPCOURSE FLASHING, SEALING AT ROOF MEMBRANE, SIMULATED STEEL COLUMN OBSTRUCTION AND TWO 38mm PIPE PROTRUSIONS). THE SYSTEM WAS PRESSURIZED TO 6500 PA AND WHEN RETESTED AT 75 PA SHOWED NO INCREASE IN THE RATE OF AIR LEAKAGE.

CONCLUSIONS

THIS MECHANICALLY FASTENED AIR BARRIER SYSTEMS OVERCOMES THE SHORTCOMINGS OF THE OTHER SYSTEMS AVAILABLE THAT WE HAVE OBSERVED AND NOTED PREVIOUSLY IN THIS REPORT BY WAY OF:

- ELIMINATING A PRIMER OR OTHER PREPARATIONS TO THE SUBSTRATE.
- NOT REQUIRING A DRY SUBSTRATE.
- NO TEMPORATURE RESTRICTIONS ON ITS USE.
- CAN BE COLOUR CODED FOR EASY INSPECTION.
- WILL READILY BRIDGE CRACKS, BEAMS, COLUMNS.
- ELIMINATES THE SLOW AND COSTLY JOB OF SEALING AROUND THE BRICK TIES AS THIS WILL BE COMPLETED IN A FACTORY UNDER CONTROLLED CONDITIONS AND THE SEAL AT THE TIES WILL BE ASSURED, THEREBY MINIMIZES THE CHANCE OF FAILURE OF THE SYSTEM RESULTING FROM HUMAN ERROR.
- USES PRE MADE AND SEALED SPECIALTY UNITS (CORNER BOOTS, COLLAR BOOTS) MINIMIZING THE NEED FOR ON SITE SEALING OF THESE POTENTIAL PROBLEM AREAS.
- CAN BE SECURELY ATTATCHED TO ANY OTHER MATERIAL BY EITHER HEAT WELDING THE AIR BARRIER TO THE OTHER MATERIAL OR IF IT IS NOT COMPATABLE WITH THE OTHER MEMBRANE, A MOUNTING STRIP (ASSEMBLED WITHOUT THE REINFORCING WIRE) CAN BE MECHANICALLY ATTATCHED AND THE AIR BARRIER MEMBRANE SECURED TO IT.

OUR INTERPRETATION OF THE ENGINEERS REPORT (COPY ATTATCHED) IS THAT THEY ALSO FEEL THIS MEETS THE REQUIREMENTS OF AN AIR BARRIER USING BUILDING PRACTICE NOTE 54 (BPN 54) PLUBLISHED BY THE INSTITUTE FOR RESEARCH IN CONSTRUCTION OF THE NATIONAL RESEARCH COUNCIL OF CANADA AS A POSSIBLE STANDARD.

Morrison Hershfield Limited
Consulting Engineers

October 6, 1988

Mr. Bruce Shorney
Kappeler Masonry (Conestogo) Ltd.
20 Grand Avenue
Kitchener, Ontario
N2K 1B3

Dear Mr. Shorney:

Re: Air Barrier Tests

Morrison Hershfield was requested to determine the air permeability of a new air barrier system by Kappeler Masonry as outlined in our proposal dated May 4, 1988 and authorized by letter dated August 17, 1988.

This letter is our report of the air leakage performance tests conducted on the Kappeler air barrier membrane system conducted at the Morrison Hershfield Construction Laboratory in Ottawa on October 3, 1988.

Kappeler Air Barrier System

This air barrier system designed for masonry cavity wall construction consists of a fibre reinforced polyvinyl chloride (PVC) sheet attached and sealed to the masonry using a system of vinyl anchor strips and retainers (mechanically connected) which are set into the mortar joints of the masonry block. The PVC sheet is then tighty sandwiched between the masonry block and the board insulation, Dow Styrofoam SM, using the Wedge-Lok fastener system produced by Blok-Lok Limited. The board insulation thus supports the PVC membrane under lateral suction loads.

Sample Wall and Air Barrier System

The sample wall was constructed by Kappeler Masonry and transported to Ottawa. This wall was constructed of 140mm lightweight concrete block with an overall dimension of 1200mm x 1200mm. The wall was reinforced with two 10M reinforcing bars set into mortar filled cores (Photo 1). The sample included three anchor strips and masonry reinforcement set into the mortar joints (Photo 1). The anchor strips were trimmed to slightly less than 1m to fit into the 1m x 1m pressure box. The PVC sheet was installed by Mr. B. Shorney to cover the full face of the masonry wall. The board insulation was 40mm thick with the edges notched to fit over the reinforcing strips. The insulation was fastened using a total of 9 Wedge-Lok fasteners.

1980 Merivale Road, Nepean, Ontario K2G 1G4, Telephone (613) 727-9802, Telex 06-986219 Fax (613) 727-8165

Test Setup

The pressure chamber was an airtight box with a 9mm clear acrylic top to allow visual observations. The sides of the wood framing were air sealed using a torch applied rubberized asphalt sheet air barrier membrane. The open face of the chamber was 1m x 1m square, anchored to the face of the wall sample using masonry anchors and 'C' clamps (Photo 2). The joint between the chamber and the wall was sealed with Emseal preformed precompressed asphalt impregnated gasket material and Tremco Dymonic sealant.

Air pressure was applied to the pressure chamber using a blower/suction fan. Air pressure was monitored using a Micromanometer manufactured by Air Ltd., model no. MP6KD.

Air flow was measured using a soap bubble volumetric flow meter. This flow meter consisted of a acrylic cylinder with 0.5 l gradations connected to the tubing between the pressure chamber and the fan as shown in Figure 1. The volumetric air flow was measured by timing the movement of a soap bubble introduced into the cylinder.

The airtightness of the test chamber was verified using smoke pencils along the joints and seals of the pressure chamber before and during the test.

Test Procedure

Test procedures generally followed the method outlined in ASTM E 283 - "Standard Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors". The rate of air leakage was measured under a positive pressure of 75 Pa and then under negative or vacuum pressure of 75, 100, 200, 300, 400, 500 and 1000 Pa, with 1000 Pa maintained for 1 hour and then reduced to 75 Pa. The pressure was then increased to 3000 Pa (vacuum) for 5 seconds to simulate gust wind loading and then the rate of air leakage was measured again at 75 Pa vacuum and 75 Pa positive pressure.

As discussed earlier the air tightness of the pressure chamber was verified using a smoke pencil along the exterior and watching for smoke entering the chamber.

At the end of the test the pressure chamber was removed and the condition of the air barrier system components was reviewed.

Discussions of Results

The results of the air leakage tests conducted are included in Table 1 and in Figure 2. The air temperature throughout the tests was 21^{o}C.

These air leakage tests revealed that there was no visible permanent deformation of the air barrier system components and the air leakage rate was unchanged following a wind load gust of 3000 Pa held for 5 seconds.

The air leakage rate measured was 0.02 l/s per m^2 of wall under a static air pressure differential of 75 Pa.

While allowable leakage rates for air barrier systems is not specified by the applicable building codes and standards a value of 0.1 l/s per m^2 of wall at 75 Pa is presented as a possible standard in Building Practice Note 54 published by the Institute for Research in Construction of the National Research Council of Canada.

The sample tested has a leakage rate under the recommended volume of 0.1 l/s per m^2, by BPN 54. It is therefore suitable as an air barrier system provided it has the required durability and appropriate details are developed for construction irregularities.

We trust that this is the information you require at this time.

Yours very truly,

J.A. Thompson, P.Eng.
Construction Laboratory Manager

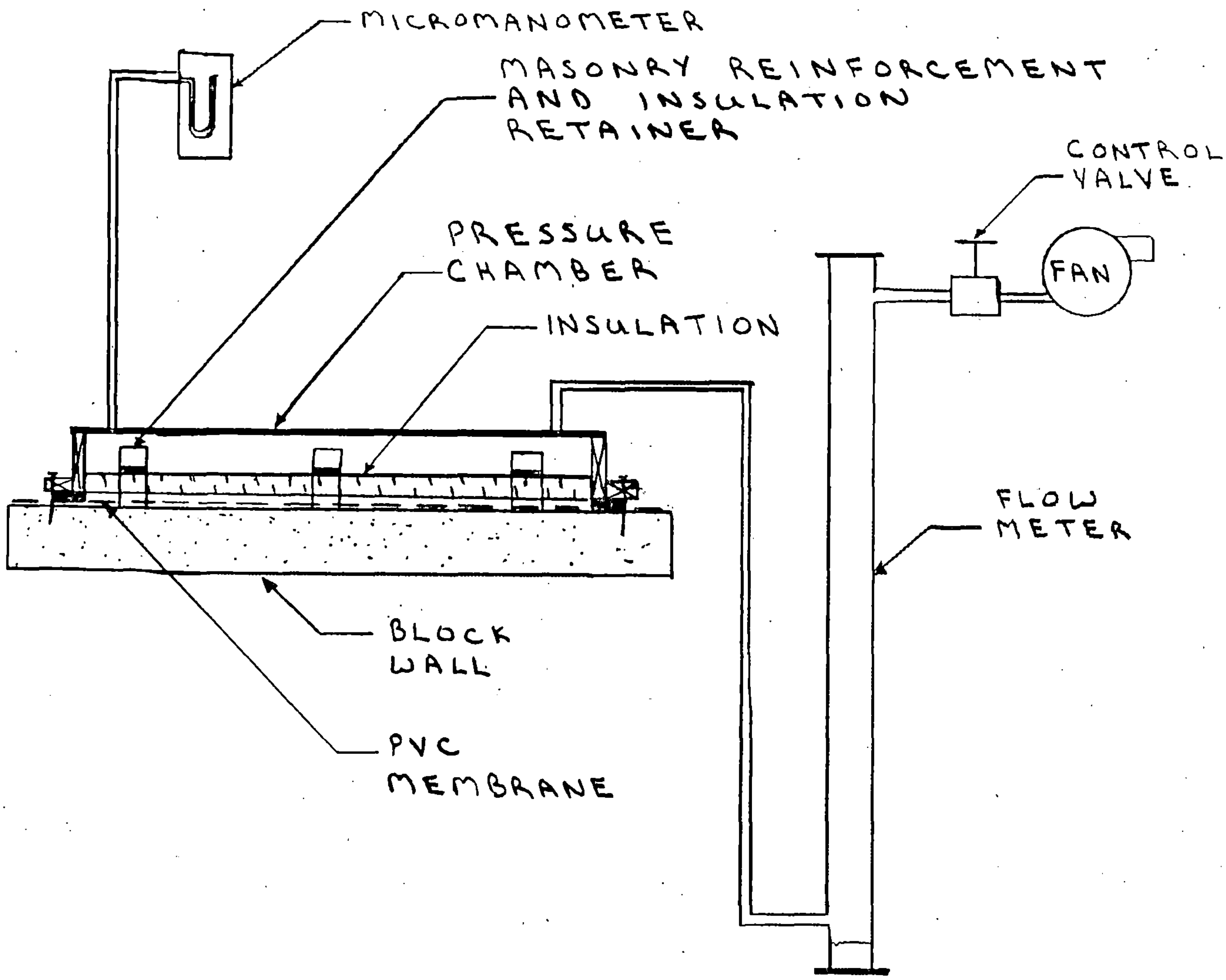
R.L. Quirouette, B.Arch.
Building Envelope Specialist

JAT:nhq
388-0578
[illegible] 88/10/07

TABLE 1: SUMMARY OF TEST RESULTS

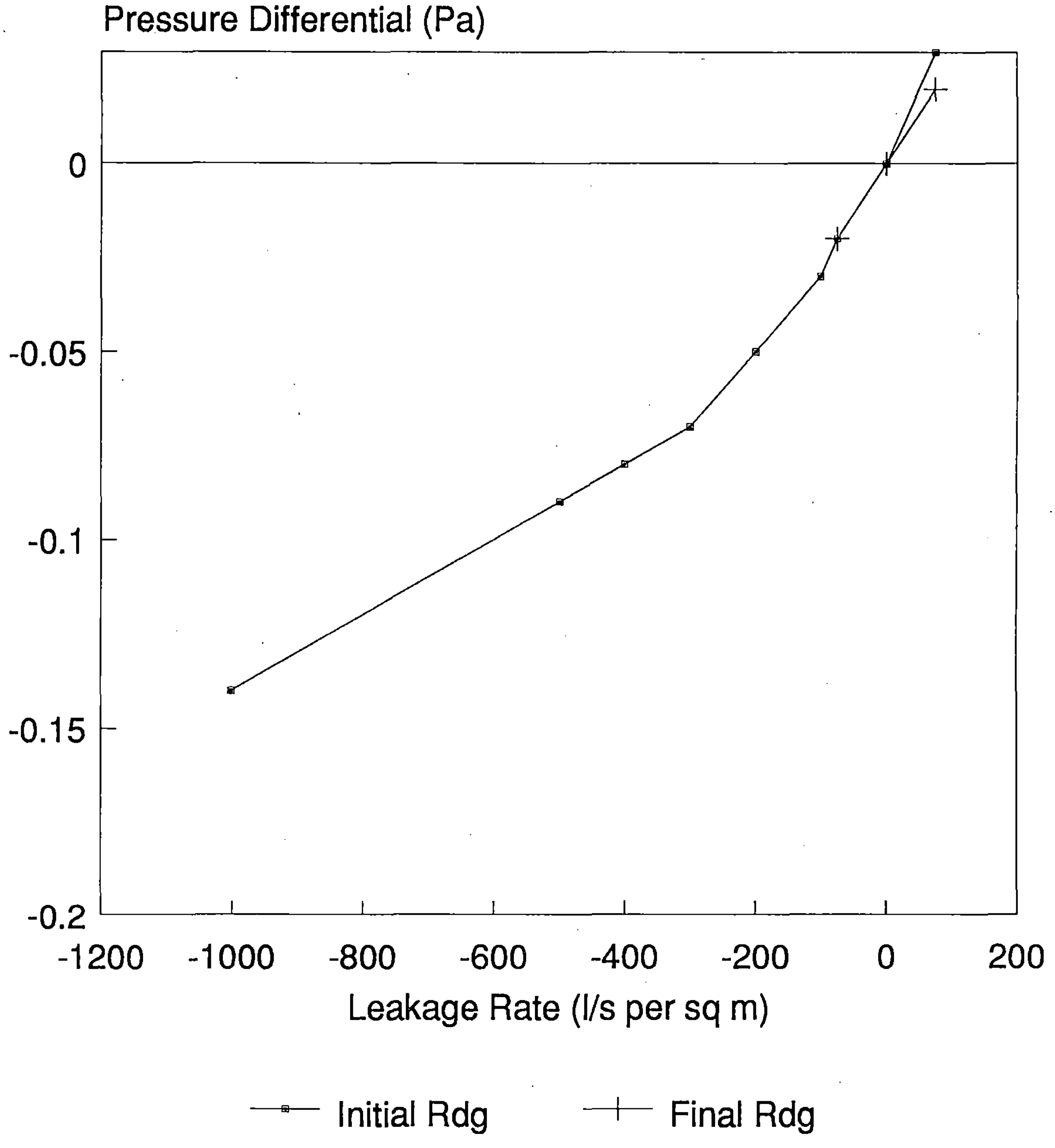
TIME	AIR PRESSURE (Pa)	AIR LEAKAGE RATE (l/s)	COMMENTS
12:30 pm	+75	0.03	
1:45 pm	-75	0.02	
1:50 pm	-100	0.03	
1:55 pm	-200	0.05	
1:57 pm	-300	0.07	
2:05 pm	-400	0.08	
2:11 pm	-500	0.09	
2:15 pm	-1000	0.14	- smoke pencil revealed a pin hole leak in chamber which was sealed with no measurable change in leakage rate
2:30 pm	-1000	0.14	
2:45 pm	-1000	0.13	
3:00 pm	-1000	0.13	
3:15 pm	-1000	0.13	
3:18 pm	-75	0.02	
3:25 pm	-3000	----	- no visible damage to insulation around Wedge-Lok fasteners
3:30 pm	-75	0.02	
3:40 pm	+75	0.02	

Note: Negative (-) air pressure refers to vacuum pressure in the pressure chamber or suction on the air barrier membrane.



Morrison Hershfield Limited Consulting Engineers	DESIGNED: JAT
	DRAWN: JAT
AIR BARRIER TEST SETUP	PROJ. ENG.:
	APPROVED:
	DRAWING NO.: 1
SCALE: NTS — DATE: 88/10/06	

FIGURE 2: Air Barrier Test *
Air Pressure / Leakage Rate Results



* Tests conducted at Morrison Hershfield
Construction Laboratory, Ottawa
Oct. 3, 1988

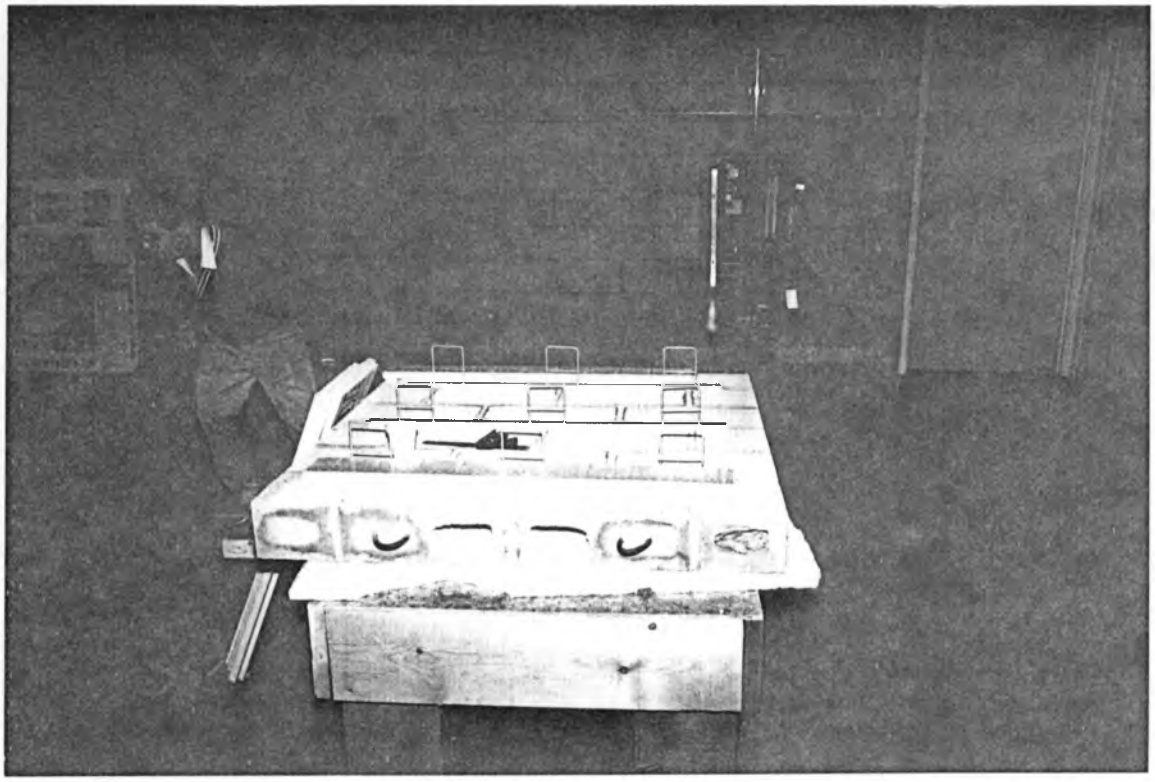


Photo 1
Masonry wall sample prior to installation of PVC air barrier system

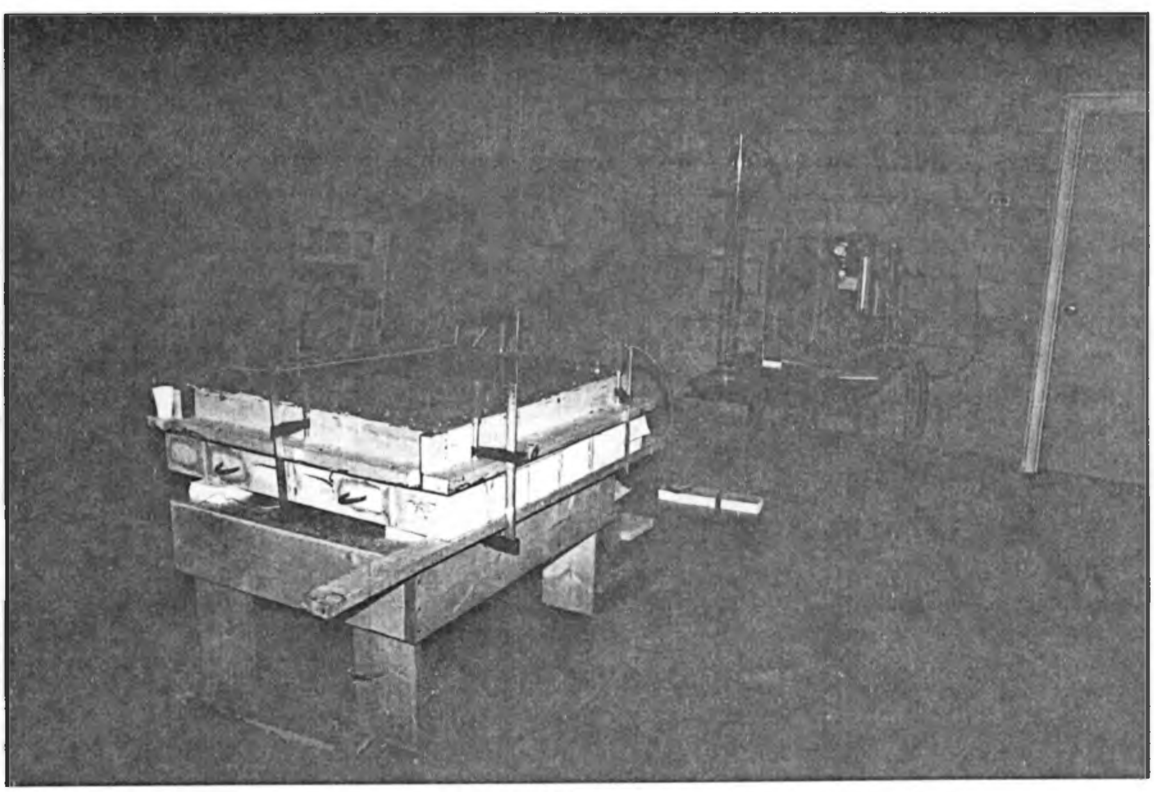


Photo 2
Test Set-up.

Morrison Hershfield Limited
Consulting Engineers

October 7, 1988

Mr. Bruce Shorney
Kappeler Masonry (Conestogo) Ltd.
20 Grand Avenue
Kitchener, Ontario
N2K 1B3

Dear Mr. Shorney:

Re: <u>Air Barrier Test Chamber</u>

From our previous discussion we understand that you wish to proceed with a larger scale test of your air barrier system in a test chamber constructed to model typical construction details at your Kitchener facility. While you have indicated that you will include outside corners and at least one window penetration in this test chamber, we feel that the following details should also be considered:

- masonry wall/concrete slab connections
- terminations at grade
- steel shelf angles and loose lintels
- masonry wall/concrete shear wall intersection
- masonry wall/curtain wall intersection
- inside corners of masonry walls
- connections with roofing membranes
- electrical conduit and plumbing penetration
- column face intersection
- steel framing penetrations
- expansion/control joints

As discussed we are prepared to provide development test services for this large scale test at your site on a time and expenses basis using our standard rates. Prior to construction of the test chamber we recommend that you send us drawings of the chamber setup for our review. We will provide our comments and suggestions to make the tests proceed the most effective and efficient way possible.

We trust that this is all the information you require at this time.

Yours very truly,

J.A. Thompson, P.Eng.
Construction Laboratory Manager

JAT:nhq
388-0578

Morrison Hershfield Limited
Consulting Engineers

November 11, 1988

Mr. Bruce Shorney
Kappeler Masonry (Conestogo) Ltd.
20 Grand Avenue
Kitchener, Ontario
N2K 1B3

Dear Mr. Shorney:

Re: Air Barrier Tests

Morrison Hershfield was retained to conduct air leakage and structural loading tests of a new air barrier system developed by Kappeler Masonry as authorized by letter signed by Mr. D. Kappeler and Mr. B. Shorney, dated October 18, 1988.

This letter is our report of the tests conducted on the Kappeler air barrier membrane system conducted at Kappeler Masonry's shop in Kitchener on November 1, 1988.

Kappeler Air Barrier System

This air barrier system designed for masonry cavity wall construction (Figure 1) consists of a fibre reinforced polyvinyl chloride (PVC) sheet attached and sealed to the masonry using a system of vinyl anchor strips and retainers (mechanically connected) which are set into the mortar joints of the masonry block. The PVC sheet is then sandwiched between the masonry block and the board insulation, Dow Styrofoam SM, using the Wedge-Lok fastener system produced by Blok-Lok Limited. The board insulation thus supports the PVC membrane under lateral suction loads.

Test Chamber and Air Barrier System

The test chamber was constructed by Kappeler Masonry in their shop in Kitchener, Ontario. The chamber was constructed of 200mm lightweight concrete block with overall dimensions shown in Figure 2. As shown in Figure 2, the 'L' shaped chamber incorporated five outside corners, one inside corner, two 89mm x 89mm wood posts to simulate a column and two 40 mm diameter pipe penetrations (Photo 1 and 2). The chamber included three levels of anchor strips and masonry reinforcement set into mortar joints. The PVC sheet was installed to cover the full face of the masonry with laps in the PVC sheet fused together with a hot air gun.

The base of the chamber was sealed by heat fusing the PVC membrane to a sheet of the same PVC material laid on the floor under the chamber. The top of the chamber was similarly sealed by fusing the PVC membrane to a sheet of PVC material laid on top of 19 mm plywood (Photo 3).

The simulated columns were sealed by cutting the masonry reinforcement on either side of the wood posts while passing the PVC anchor strips continuous across the face of the posts. and secured as in other areas.

The two pipe penetrations were sealed by installing a preformed PVC sheet boot on the pipe (Photo 3) and heat sealing the boot the wall membrane. The boot was then secured to the pipe with a pipe clamp (Photo 4).

The board insulation was 40mm thick with the edges notched to fit over the reinforcing strips (Photo 2). The insulation was held in place using Wedge-Lok fasteners and wire ties at 450 mm oc (Photo 6).

Based on the measured dimensions shown in Figure 2, the total wall area of the test chamber is 7.12 m^2. This area does not include the top or base area of the chamber.

Test Setup

Figure 3 shows the general test setup used for the air leakage tests. The structural test setup was similar to Figure 3 without the flow meter.

Air pressure was applied to the pressure chamber using a blower/suction fan manufactured by Airstream, model no. AS334-110. Air pressure was monitored using a Micromanometer manufactured by Air Ltd., model no. MP6KD.

Air flow up to 0.6 *l/s* was measured using a soap bubble volumetric flow meter. This flow meter consisted of an acrylic cylinder with 0.5*l* gradations connected to the tubing between the pressure chamber and the fan as shown in Figure 2. The volumetric air flow was measured by timing the movement of a soap bubble introduced into the cylinder. Air flow above 0.6 *l/s* was measured using a rotometer manufactured by S & K Co., model 4HCF.

Test Procedures

Test procedures followed the methods outlined in ASTM E 283 - "Standard Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors" and ASTM E330 - "Standard Test Method for Structural Performance of Exterior Windows, Curtain Walls and Doors by Uniform Static Air Pressure Difference".

The rate of air leakage was measured at air pressure differentials of 75, 100, 200, 300, 400, 500 and 1000 Pa, with 1000 Pa maintained for 1 hour and then reduced to 75 Pa. In all cases, the air pressure differential was applied with the chamber pressure higher than atmospheric pressure.

The structural test was conducted to attempt to determine the ultimate load capacity of the air barrier system. The load was applied by slowly increasing the air pressure until the ultimate load was reached. The pressure was applied so as to induce outward pressure on the air barrier system only. The rate of air leakage was then remeasured at 75 Pa to determine the extent of damage to the membrane and anchorage system.

Discussions of Results

The results of the tests conducted are included in Table 1 and in Figure 4. Figure 4 includes the results of previous tests conducted in our Ottawa laboratory plotted in a logarithmic scale to linearize the curve. The air temperature throughout the tests was 18°C and the relative humidity was 60%.

The initial air leakage rate measured was 0.025 l/s per m^2 of wall under a static air pressure differential of 75 Pa.

During the structural test the only significant damage observed was the failure of two wire ties (Photo 7). The maximum load achieved was 6500 Pa which was held for 15 seconds. At this point the test was ended as this pressure exceeded the safe capacity of the instrumentation. The rate of air leakage measured after the structural test was 0.022 *l/s* per m^2 of wall at 75 Pa air pressure.

Conclusions

The design requirements for air barrier systems is not specified by the applicable building codes and standards, however, guidelines for the design of air barrier systems are presented as a possible standard in Building Practice Note 54 (BPN 54) published by the Institute for Research in Construction of the National Research Council of Canada. These design requirements for an air barrier system can be summarized as follows:

- continuous throughout the building envelope.
- structurally adequate to resist peak wind loads without rupturing, creeping or displacing adjacent materials.
- highly air-impermeable with a suggested maximum leakage rate of 0.1 *l/s* per m^2 of wall system.
- durable and made of materials known to have a long service life.

The air barrier system installed on the test chamber described in this report satisfied the air leakage requirements presented in BPN 54, for continuity over the conditions presented and accommodated both inside and outside corners, pipe penetrations and continuity with the PVC "roof" membrane used on the test chamber. In the structural performance test the system withstood an outward air pressure differential of 6500 Pa which is equivalent to a reference wind speed of approximately 360 km/hr (based on equation referenced in NBC 1985). While, design pressures for the design of air barrier systems are not explicitly given in NBC 1985, one approach would be to use the design pressures assigned for the design of cladding elements. Considering the ultimate load test conducted this air barrier system exceeded unfactored design pressures typically in the range of 1000 to 2000 Pa used for the design of cladding elements. The air leakage rates measured in this test both before and after the structural load test also satisfied the requirements presented in BPN 54. The materials used in this system are commonly used construction materials with service records demonstrated both in the roofing and the window industries.

Provided that appropriate construction details are developed for construction irregularities, this air barrier system is appropriate for use as part of a building envelope air barrier system considering these test results presented with the air barrier system tested under air pressures which pushed outward on the air barrier system..

We trust that this is the information you require at this time..

Yours very truly,

LICENSED PROFESSIONAL ENGINEER
J. A. Thompson
PROVINCE OF ONTARIO

J.A. Thompson, P.Eng.
Construction Laboratory Manager

R.L. Quirouette, B.Arch, MOAA
Building Envelope Specialist

388-0578A
faxed 98/11/11

TABLE 1: SUMMARY OF TEST RESULTS

TIME	PRESSURE ΔP (Pa)	TOTAL AIR LEAKAGE Q (l/s)	AIR LEAKAGE Q/A (l/s m^2)	COMMENTS
9.35 am	75	0.18	0.025	
9:40 am	100	0.22	0.031	
9:45 am	200	0.35	0.049	
9:48 am	300	0.46	0.065	
9.50 am	400	0.53	0.074	
9:55 am	500	0.58	0.081	
10:10 am	1000	0.99	0.14	- pressure maintained for 1 hr.
11:10 am	1000	0.99	0.14	
11:20 am	75	0.16	0.022	
12.05 pm	3000	-	-	- insulation bulged with no visible permanent deformation
12:07 pm	5000	-	-	- one of the masonry tie/insulation retainers failed
12:09 pm	6500	-	-	- another tie failed
12:10 pm	0	-	-	- slight crushing of insulation at ties
12:20 pm	75	0.16	0.022	- air leakage retest

NOTE:

1) ΔP (Pa)

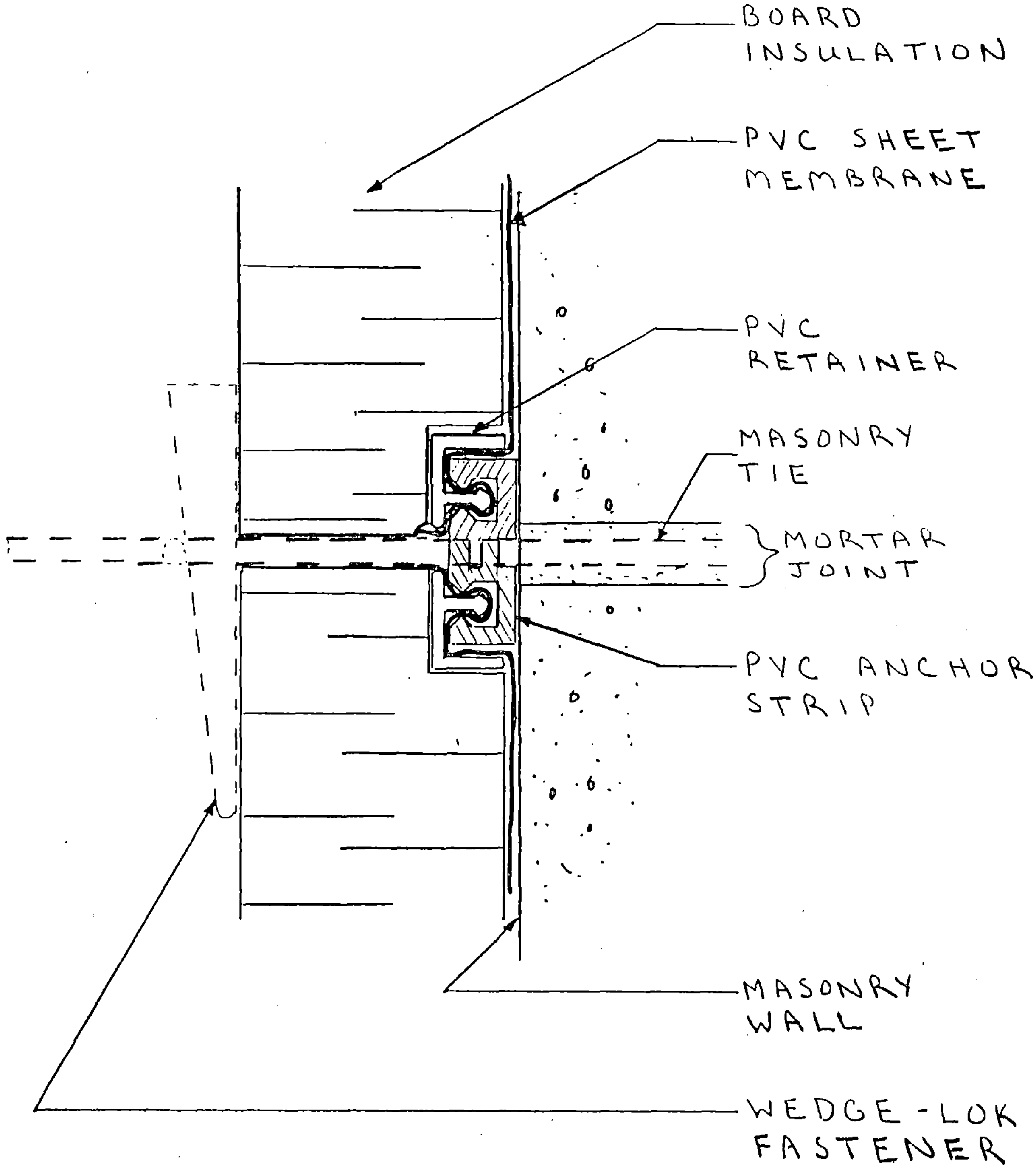
Chamber pressurized with air pressure higher than atmospheric, with air barrier membrane on exterior of chamber

2) Q (*l/s*)

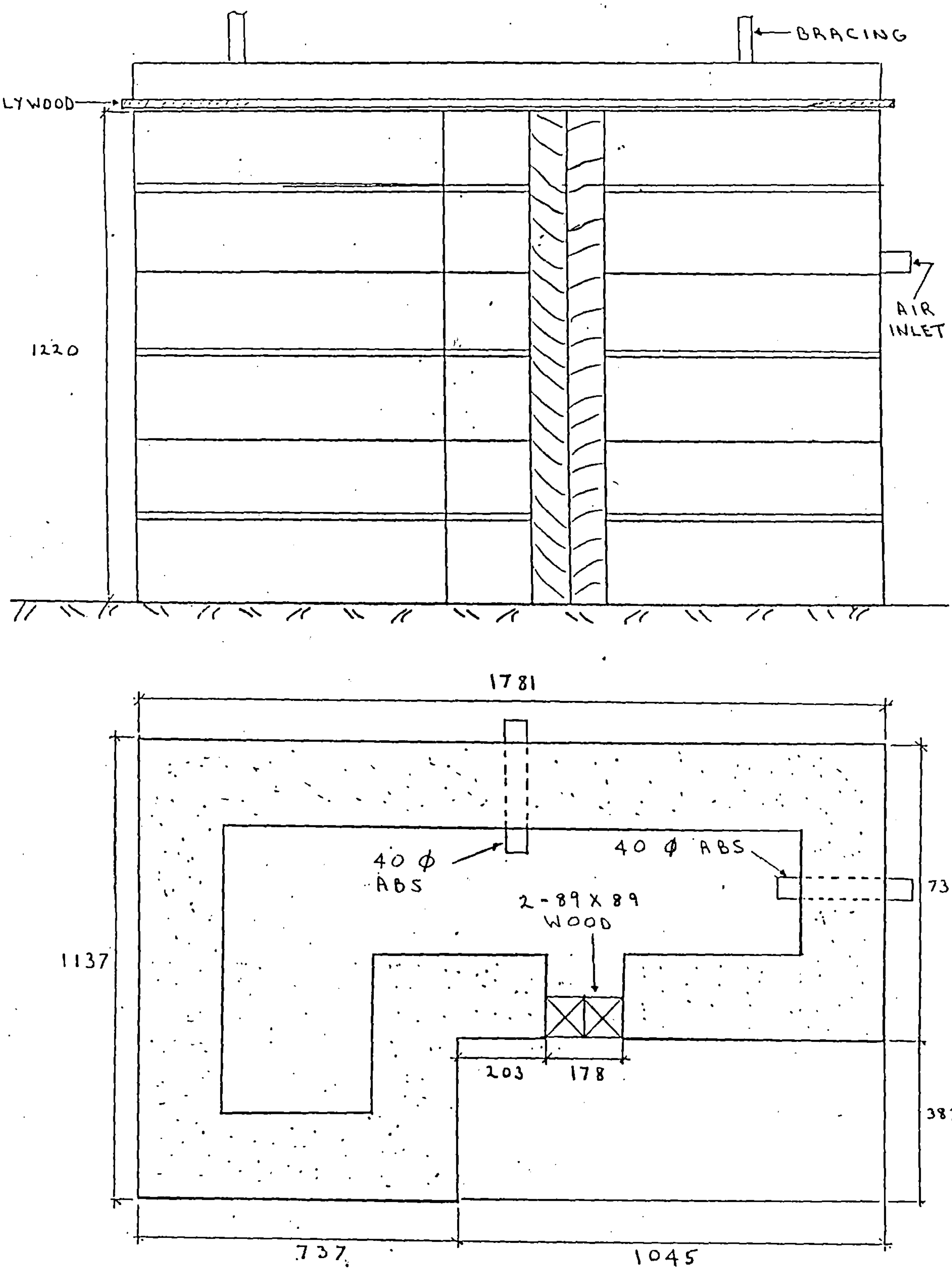
Total air leakage measured by measuring the total air flow supplied to chamber to maintain pressure.

3) Q/Air (*l/s* m^2)

Air leakage per unit area of chamber wall.
A = 7.12 m^2 (not including base or top of chamber)

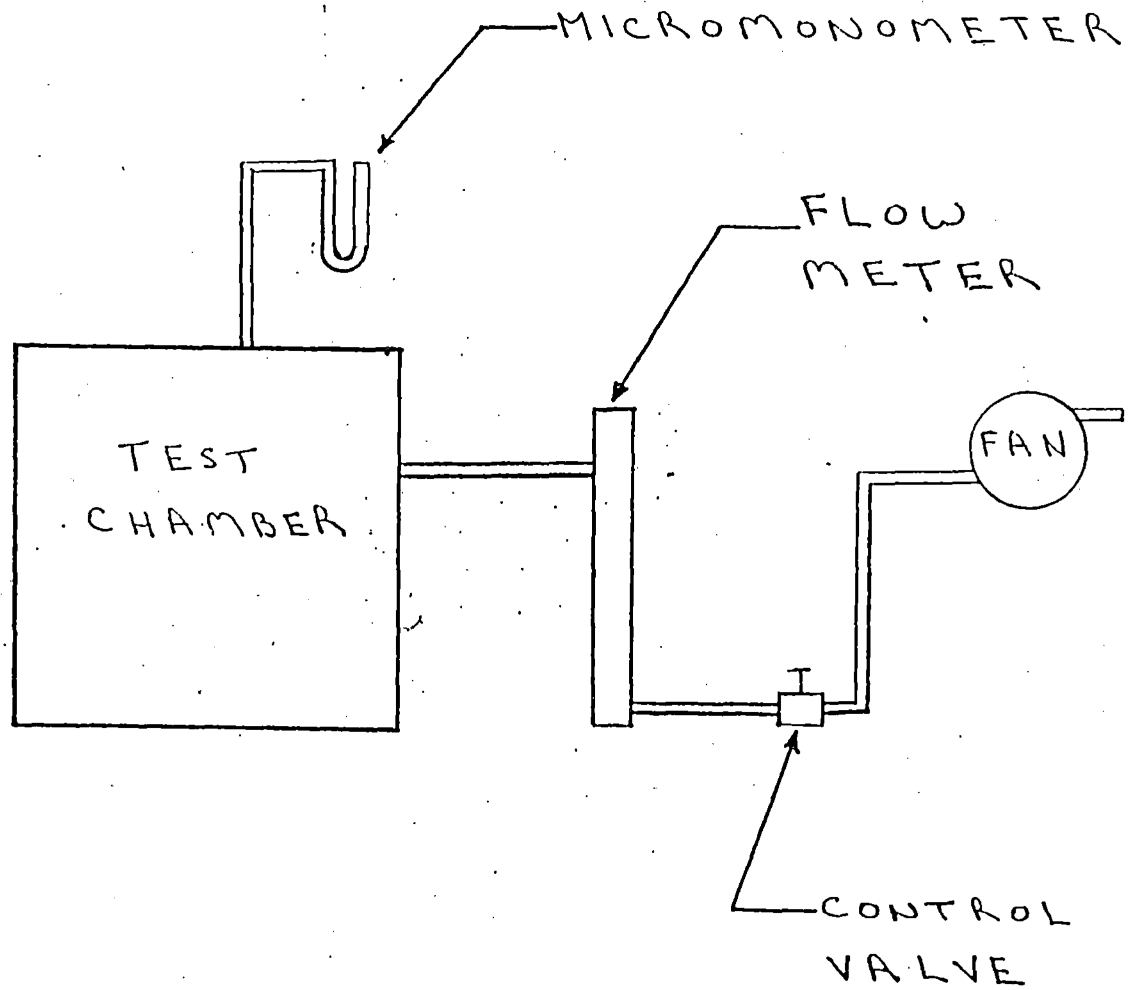


Morrison Hershfield Limited Consulting Engineers	DESIGNED:
	DRAWN:
DETAILS OF MEMBRANE ANCHORAGE	PROJ. ENG.: JAT
	APPROVED:
	DRAWING NO.: 1
SCALE: DATE:	



Morrison Hershfield Limited
Consulting Engineers

TEST CHAMBER	DESIGNED:
	DRAWN:
	PROJ. ENG.: JAT
	APPROVED:
	DRAWING NO.: 2
SCALE: NTS — DATE: 88/11/07	



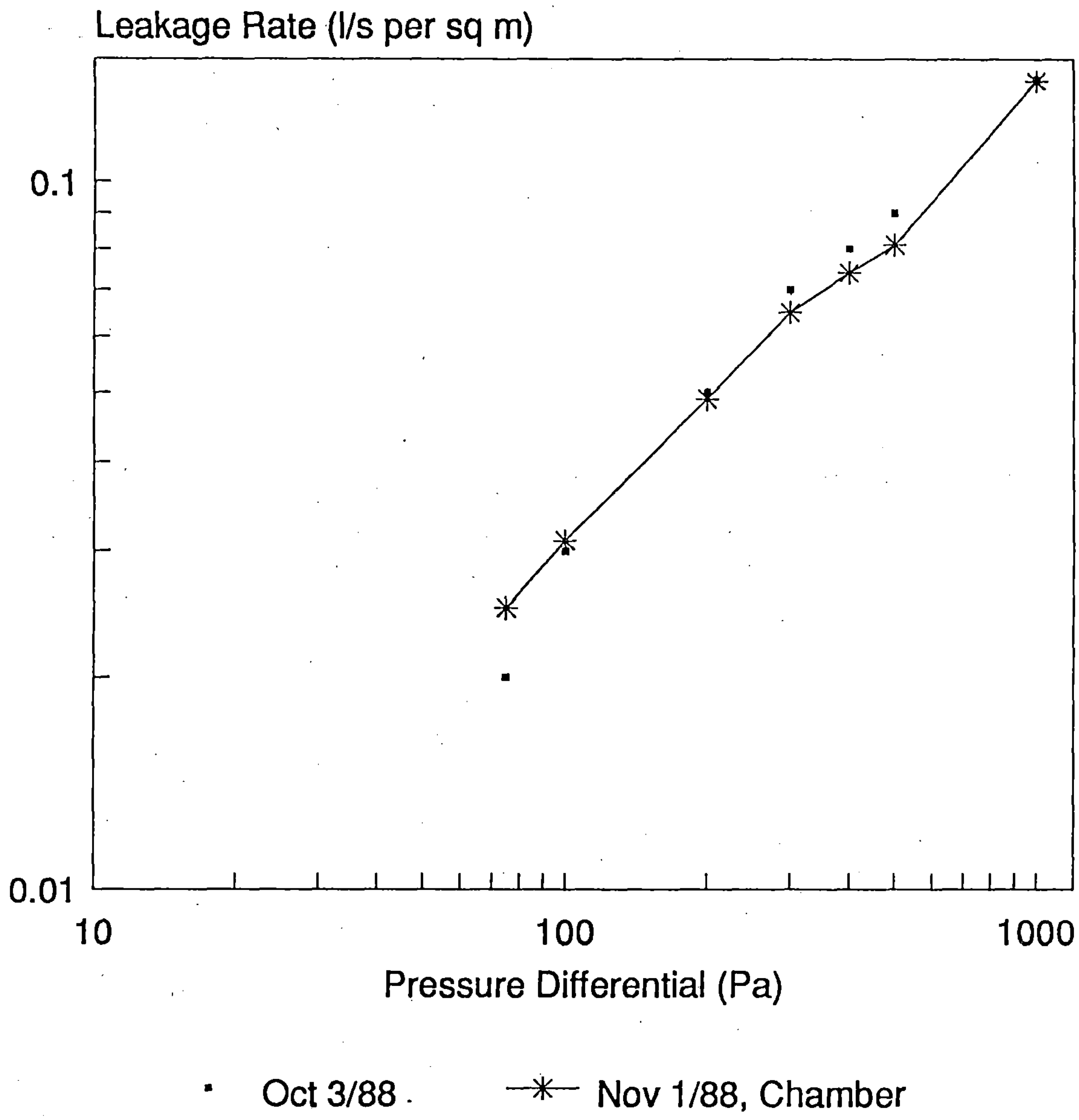
Morrison Hershfield Limited
Consulting Engineers

AIR BARRIER
TEST SETUP

DESIGNED:
DRAWN:
PROJ. ENG.: JAT
APPROVED:
DRAWING NO.: 3

SCALE: NTS
DATE: 88/11/07

FIGURE 4: Kappeler Air Barrier Test *
Air Pressure / Leakage Rate Results
(Logarithmic axis)



* Tests conducted by Morrison Hershfield
-Oct 3/88 test, Ottawa, Area=1.0 sq m
-Nov 1/88 test, Kitchener, Area=7.12 sq

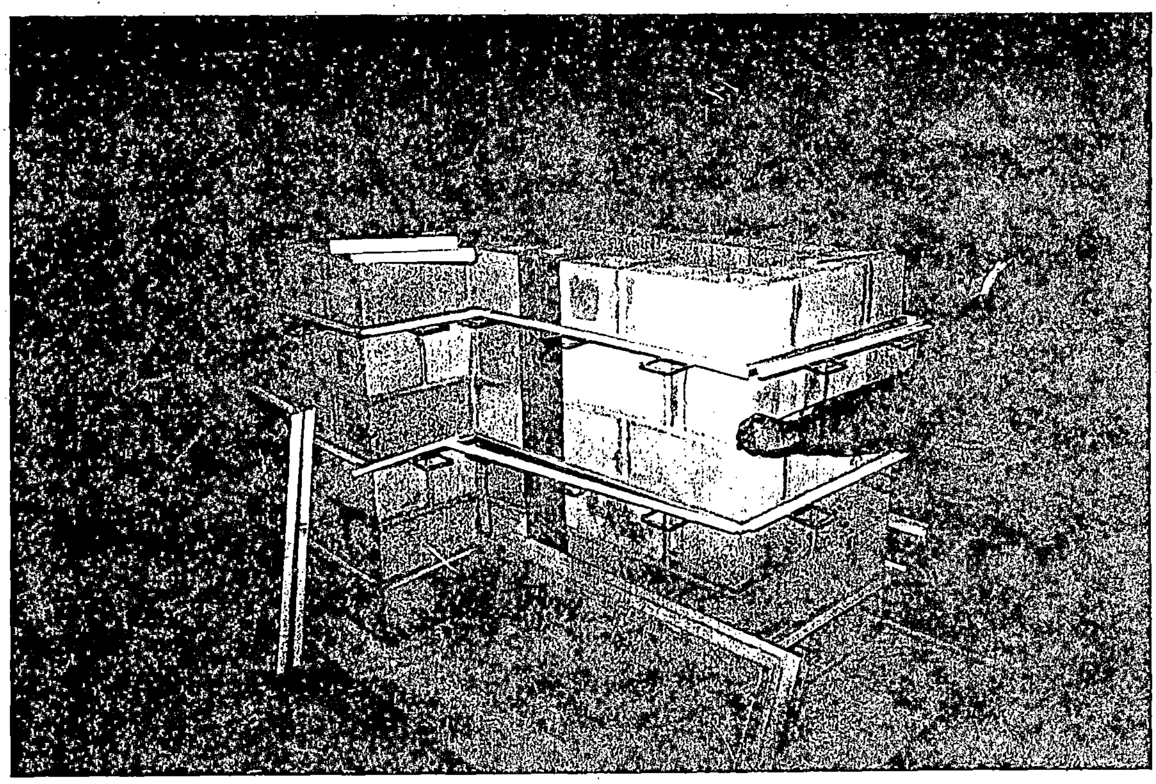


Photo 1
Test chamber, showing location of wood posts.

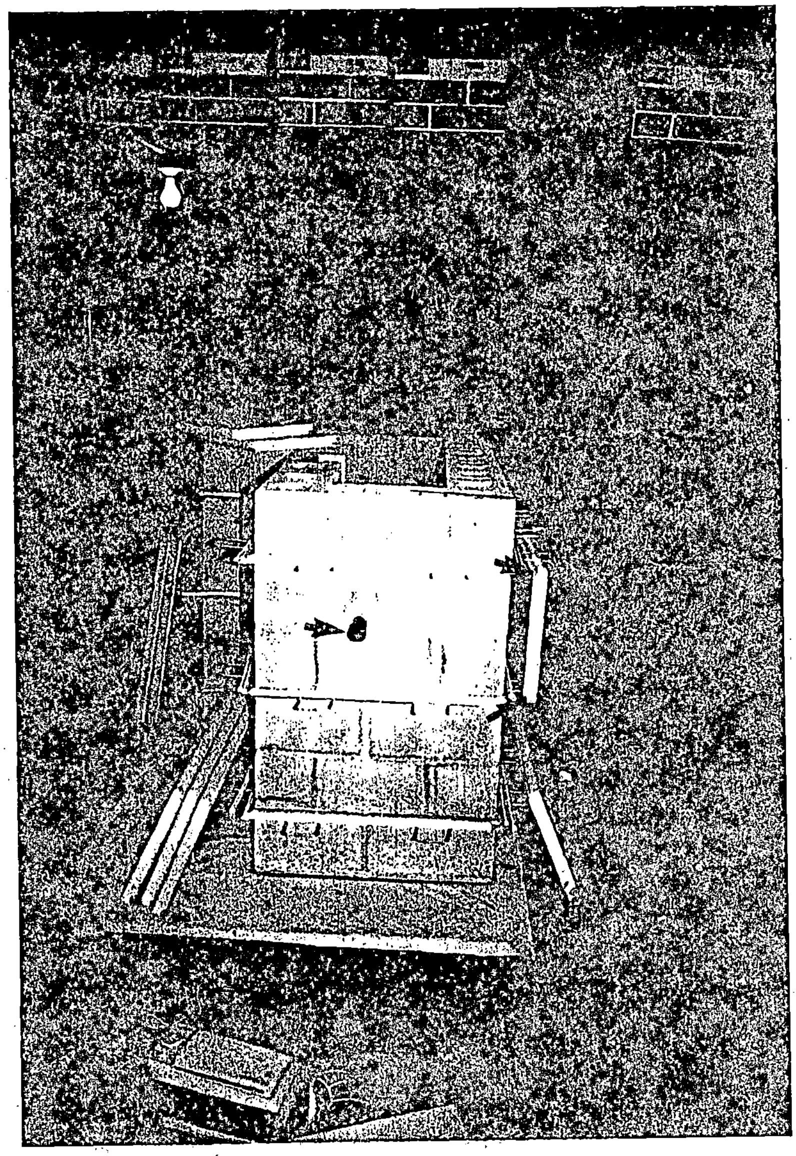


Photo 2
Test chamber, showing 40 mm diameter pipe penetration required to connect flow meter and fan.

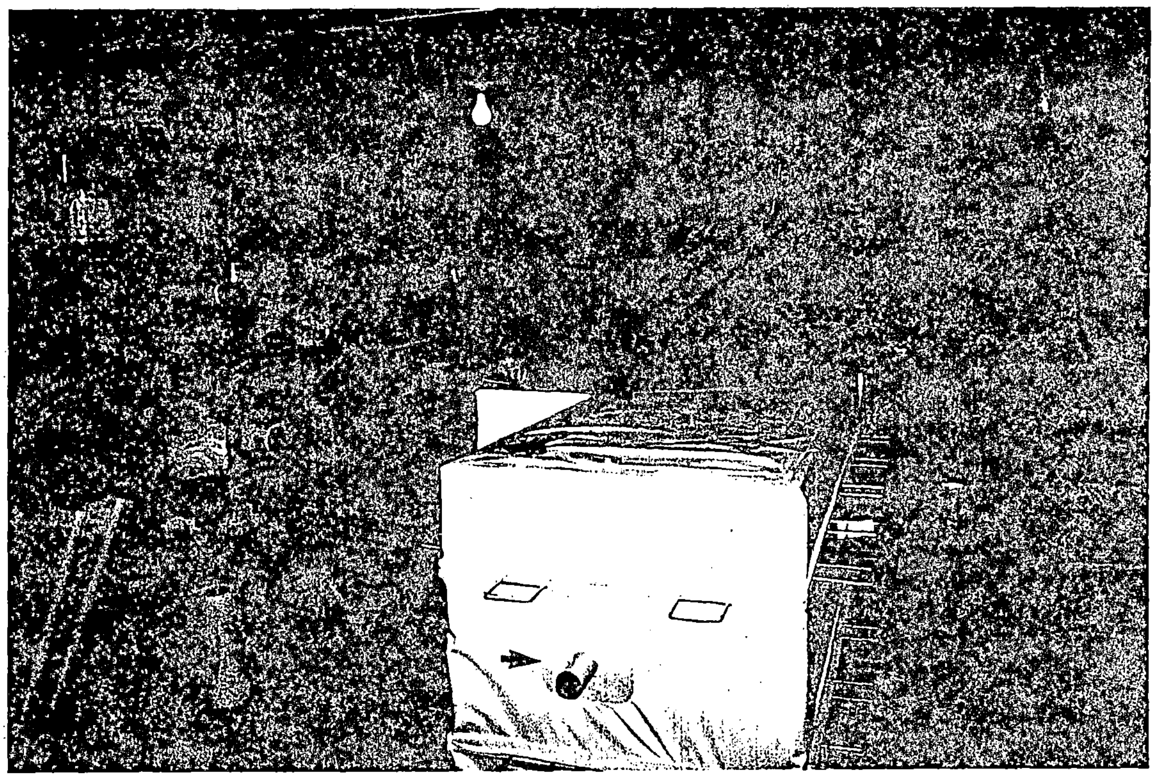


Photo 3
Heat fusing of membrane to top sheet, also, boot installed on pipe penetration.

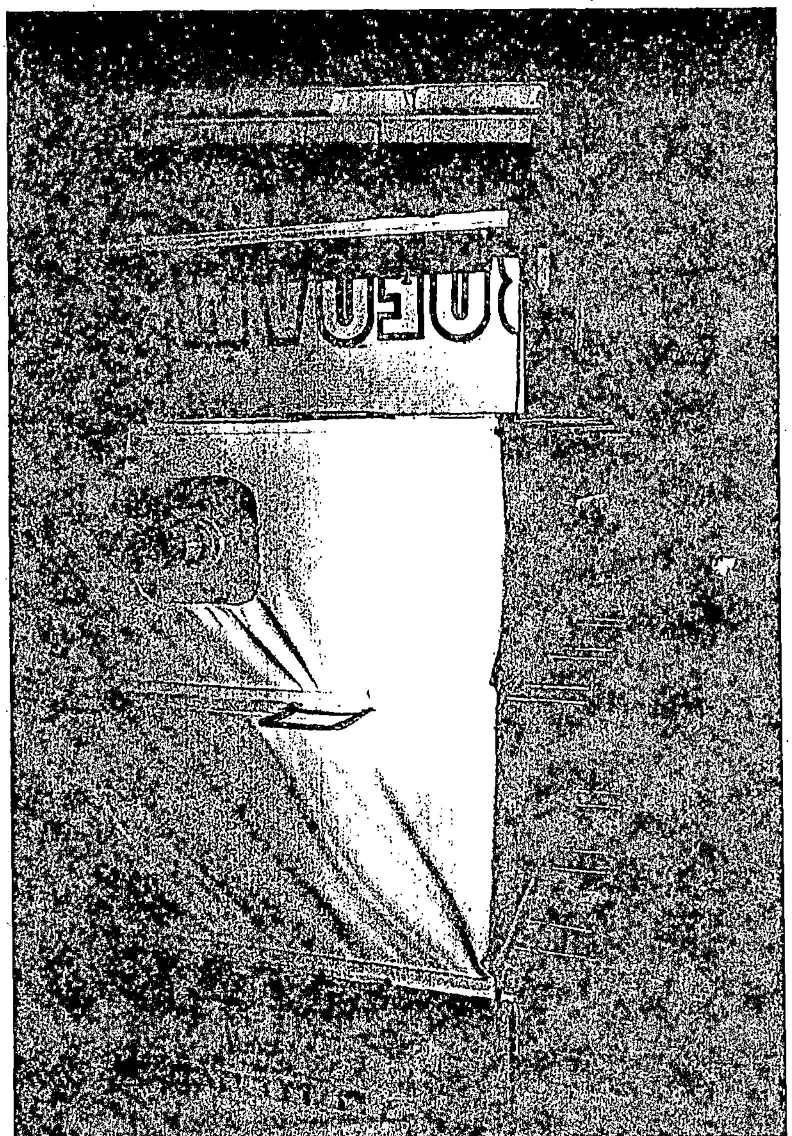


Photo 4
Installation of board insulation, also, clamps installed on pipe penetration.

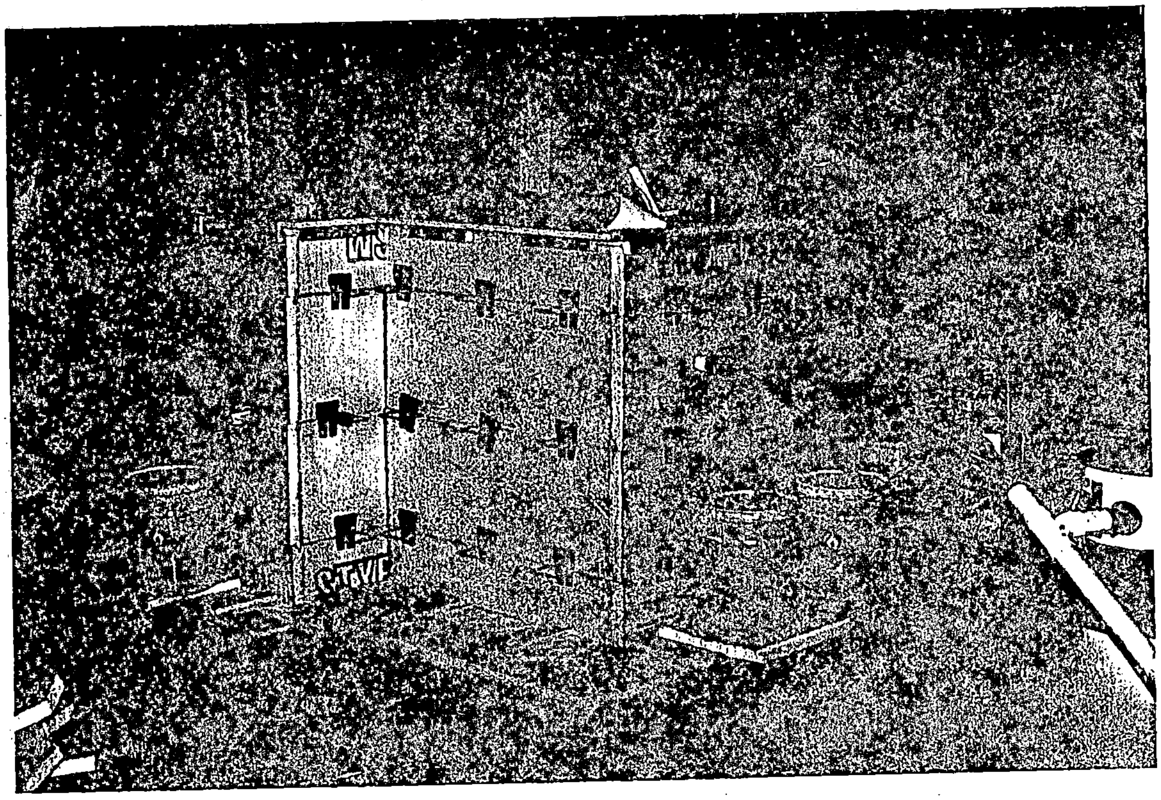


Photo 5
Chamber test setup.

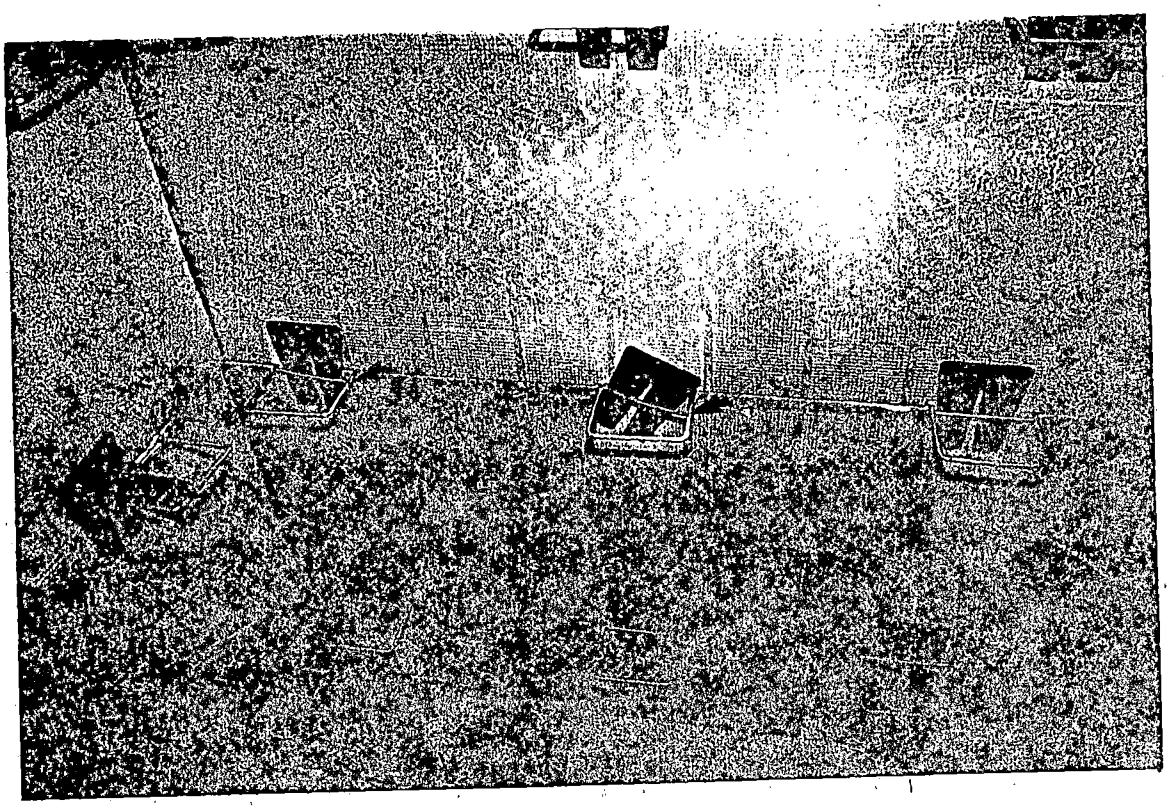


Photo 6
Wire tie failures.