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RIGID AIR BARRIER ASSEMBLIES

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EXECUTIVE SUMMARY

Canada Mortgage and Housing Corporation (CMHC) gave the mandate to Petrone architects to prepare a designer and builder guide to describe the methodes for installing rigid air barriers on building walls.

The goal here is to demonstrate that it is possible, in a simple and effective manner, to respect the requirements of the National Building Code 1995 as pertains to maximum permeability of air barrier systems.

The work done by the firm over the last twelve years made it possible to implement air tight systems in over fifty buildings in the Montréal area. The number of projects and the various conditions in which they were built led to the development of different types of air barriers. This report deals with one of these types, the rigid air barrier, made up of rigid panels the joints of which are air tight.

The characteristics of the various materials making up this air tight system were first of all set during laboratory tests conducted by Canada Mortgage and Housing Corporation (CMHC). This data, dealing in particular with the panels themselves, with the various types of membranes and scellants, was very important in assessing the theoretical performance of the various systems.

Implementing a air barrier system in a specific building requires, first of all, that the specific performance requirements of the system be defined. These requirements will determine the system and the materials to be used.

Designing the system per se means making provision for the assembly of the materials at the various critical joints. The objectives sought at the design stage include ensuring that the desired performance is attained, durability, cost and ease of execution. The report thus proposes a series of construction details specifying the procedures for assemblying the various components. Each series of details is applicable to one building type, whether this be a concrete, wood, steel, renovation, or new structure.

It is not until the work is actually being done that the full value of the construction details can be appreciated. A text commenting each detail presented in this report is included to ensure proper execution. Information such as that in the specifications are found here as well as critical elements that should be verified when supervising the work.

The value of the concepts presented cannot be properly assessed without verifying their performance. To reproduce as closely as possible actual implementation conditions, certain assemblies were tested on site. The results proved conclusive and corroborated, to a great extent, laboratory test results. The last section in this document thus deals with assembly performance verification methods and the results obtained.

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ACKNOWLEDGEMENTS

We wish to thank Canada Mortgage and Housing Corporation for the confidence which it showed in us by allowing us to undertake this study.

We would like to express our gratitude to Mr. Jacques Rousseau for his close collaboration and support while this was being prepared.

Our thanks also go out to Mr. Michael Macpherson for having guided this project so expertly.

We would be remiss if we did not mention the contribution by Mr. Pierre-Michel Busque who closely supervised the production of this document.

CHAPTER 1
INTRODUCTION

The National Building Code of Canada 1990 requires the installation of an effective air barrier system to prevent infiltration and of air through the building envelope. Moreover, the Associate Committee on the National Building Code set, as an objective for the NBCC 1995 edition, to revise the section dealing with air tightness to include quantitative criteria.

At the present time, designers and builders are being required to produce airtight buildings. Shortly, designers will have to hone their knowledge of airtightness to be in a position to produce air barrier systems which respect certain airtightness and structural resistance criteria as set forth in the Code.

This study was thus undertaken to familiarize designers and builders with a air barrier system for building walls making it possible to effectively respect the various requirements of the Code.

This system, referred to as a rigid air barrier system, is made up of rigid panels applied to the walls. These panels must be airtight and must resist any building movements and pressure differentials between the outside and inside. The rigid panels themselves are air barriers but the joints are not. A different material must thus be used to render the joints airtight. Strategies must be developed to make airtight the joints formed by disparate elements: air barrier + windows, etc.

In addition to a theoretical reminder as to the properties of materials and the basic principles, this document is designed as a practical guide for the installation of such a type of air barrier. To do so, case studies, based on projects which we have executed over the last ten years, will be presented.

This study also uses the results of on-site tests which we have conducted on such a system to assess its performances.

CHAPTER 2
DESCRIPTION OF AIR BARRIER MATERIALS

A large number of scientific publications deal with the properties of the different air barrier materials. These properties have been measured subsequent to tests conducted by agencies specialized in this field. This document, designed as a practical guide for installing a rigid air barrier system, adopts certain conclusions drawn in these publications to orient designers and builders in choosing materials to realize the concepts presented in the following chapter. A review of the documents listed in the bibliography will provide the reader with an overview of laboratory established performances for a wide range of materials and assemblies.

Rigid air barrier systems such as those described in the following chapters include three types of materials, namely: rigid air barrier materials, sealing membranes and sealants per se. In this summary, we will limit our study to the materials which we suggest to be used in the assemblies described in the following chapter.

1. Rigid Air Barriers

a) Average Air Flow:

The permeance of the materials being studied is the base characteristic used in deciding whether the materials can effectively act as air barriers. Indeed, this material shall have intrinsic qualities making it possible to act as a windbreak. CMHC's "Air Permeance of Building Materials" report provides measurements, for a number of materials, of the air flow through each of them under various differential pressures. Table 1 below shows the data from this report for materials which may be incorporated in the assemblies described herein. The pressure differential considered is 75 Pa.

TABLE 1

Materials	AIR FLOW $L/S\text{-}m^2$
12.7mm waterproof gypsum board	0.0091
16mm waterproof gypsum board	+/- 0.0091
12.7mm concrete panel	0.0000
9.5mm plywood sheathing	0.0000
metal siding	0.0000

b) Structural Performance:

Air barriers cannot be effective unless they are stationary and free from defects. As they are exposed to various loads, they have to be able to resist the latter while retaining all their properties. In addition to the loads induced by the other building components, rigid air barriers must be able to resist various air pressures. The latter are induced by the wind, by the chimney effect and, if applicable, by mechanical ventilation.

The materials' intrinsic structural resistance is a determinant factor in assessing the resistance of the various assemblies. Moreover, it seems that the crucial element in this type of assembly is the manner in which the latter is fastened to the support surface so that the assembly can transfer these loads to the building structure. Indeed CMHC's report entitled "Testing of Air Barrier Systems for Wood Frame Walls" mentions that, when ten samples were tested:

(Seven of the samples out of ten failed during certain stages of the test to resist structural loads at a positive pressure difference. Most of the failures occurred at the fastening points. In most cases, the samples would have performed satisfactorily with different fastening devices.)

Out of the ten samples tested, two can be used as reference bases to study the structural behaviour of a gypsum board rigid air barrier. Indeed, samples 3 and 7 were 13 mm drywall panels fastened to 38 mm x 89 mm wood studs at 305 o.c. The other was nailed, 152 mm o.c. along the edges of the board and at 305 o.c. on the intermediate supports. The other was fastened with screws, 203 o.c. along the edges of the board and at 305 o.c. on the studs. Both failed during the wind gust load tests. It is stipulated for sample 3 that (at a positive pressure difference of 2.3kPa, the top drywall sheet separated from the nails along the intermediate supports). Moreover, for sample 7, (at a positive pressure difference of 1.8kPa, the lower drywall sheet separated from the screws all along the intermediate supports and three short cracks were visible along the horizontal joints of the sheets). It would thus seem wise to specify reduced spacing for the fastening devices when drywall sheets fastened to studs are used, whether they be in metal or wood. Especially since the in situ test results provide abundant support for this. Refer to chapter 4 herein for details on this point.

When using air barrier systems provided and installed by one manufacturer in particular, it is thus possible to have the complete system analysed and tested by this manufacturer at the project design stage to meet the requisite level of structural resistance. Refer to case 3 in chapter 3 illustrating a steel air barrier.

For air barriers involving a number of different trades and for which more detailed data are not currently available, it is wise to pay particular attention to the spacing of the fastening devices, realizing that the ways in which these elements are fastened were not established in such a way as to respect the structural requirements with which these air barriers must comply.

c) Other Characteristics:

Certain air barrier materials have characteristics which may have a bearing on the decision to use them in certain areas. This is the case, in particular, of plywood which also has vapour barrier characteristics. They must then be used with judgement to avoid creating a second vapour barrier on the cold side beyond the dew point.

2. Air Barrier Sealing Materials

Rigid air barrier systems are made up of rigid airtight panels but the dimensions of the latter are limited. Particular attention will thus have to be taken with the joints between the panels and with the joints between these panels and other building components. Indeed, without filling in the joints between the panels, the air flow rate would be high, virtually cancelling out the airtight characteristics of the panels themselves. The goal here then is to aim at obtaining effective jointing to prevent air flow and which resists any movement in the building as well as various air pressures.

CMHC's report entitled "The Development of Testing Procedures and Methods to Evaluate Air Barrier Membranes for Masonry Walls" presents the assessment of 15 different products. The properties assessed are: initial airtightness of the membranes, their adherence properties in air gust situations, adherence of membrane in the presence of a sustained wind surcharge and its behaviour in the presence of the chimney effect.

In the concepts developed in the following chapters, strips of fusible, self-sealing membranes are used to execute the joints between the rigid air barrier panels as well as the joints between these panels and other building components. Thus, by extrapolation, we used the measurements of the various characteristics provided in CMHC's report to assess the probable behaviour of the self-sealing, fusible membranes used to execute the joints of rigid air barrier panels rather than on a masonry substrate. The following table presents the data taken from this report for the types of membranes used in the concepts presented in chapter 3.

TABLE 2

Type of Membrane	Wall type	Initial airtigh. ΔP=75Pa ($l/s.m^2$)	Airtigh. after gust ΔP=75Pa ($l/s.m^2$)	Airt. after sustained wind ΔP=75Pa ($l/s.m^2$)	Portion separated %
Polyester reinforced SBS bitumen with thermobonded plastic film. Fastened with torch. Primer coat on wall	1	0.00038	0.00025	0.00035	13.99
	2	0.01961	0.02002	0.0202	7.43
	3	undetected	undetected	undetected	2.11
SBS bitumen reinforced with glass coating with thermobonded plastic film Fastened with torch. Primer coat on wall	1	0.00012	undetected	7.97E-05	0.00
	2	0.00087	0.00123	0.00084	8.32
	3	undetected	undetected	undetected	0.00
Non-woven fiberglass reinforced SBS bitumen. Fastened with torch. Primer coat on wall.	1	undetected	undetected	undetected	3.74
	2	0.01214	0.01251	0.01261	0.00
	3	undetected	undetected	undetected	2.00
Non-woven fiberglass reinforced SBS bitumen. Fastened with torch. Primer coat on wall.	1	undetected	undetected	undetected	41.76
	2	0.02147	0.02540	0.02301	3.80
	3	undetected	undetected	undetected	32.73
Self-adhesive bitumen with modified thermoplastic polymers. Glued in place.Primer coat.	1	0.00256	0.00508	0.02660	100
	2	* sec. det.	* sec. det.	* sec. det.	100
	3	* sec. det.	* sec. det.	* sec. det.	100
Self-adhesive bituthane. Glued in place. Primer coat.	1	0.00043	0.00058	0.00027	<1
	2	0.04895	0.05072	0.05411	0.00
	3	0.00039	0.00044	0.00054	0.00
Polyester reinforced SBS bitumen. Glued in place. Primer coat.	1	0.00029	undetected	undetected	0.00
	2	0.02256	0.0237	0.0237	0.00
	3	0.00037	0.0003	0.0138	0.00
Multi-coat polyethylene with polyester modified asphalt. Glued in place. Primer coat.	1	undetected	undetected	undetected	21.65
	2	0.02707	0.02852	0.024883	58.13
	3	undetected	0.00048	0.00051	36.46

* section detached

The 3 types of walls described are as follows:
1: bare masonry wall
2: masonry wall with bonding staples
3: concrete block wall with hollow inner cavity 50 mm x 910 mm.

It is specified that a defect is considered as evident is the air leaks identified at 75 Pa are in excess of 0.15 L/S-m^2 or if the separated portion exceeded 15% of the total surface. The results presented in the table thus indicate that most of the materials have acceptable levels of airtightness. On the other hand, it is noted that the main risks of defect involve separation. In the concepts presented hereinafter, our preference focuses in general on the use of a fusible as opposed to a self-adhesive membrane. We have much confidence in the mechanical joint formed by melted bitumen on the membrane against the support material. In fact, site conditions, the level of employee skill and temperature changes are uncontrollable factors which can preclude good adhesion.

3. Sealants

As the air barrier has to retain its effectiveness throughout the building's useful life, one could hardly expect any exposed sealant to be considered as being an integral part of the air barrier system. Given our extreme climatic conditions as well as the risk of vandalism inside the building, we have to admit that their effectiveness in terms of air barriers will decrease rapidly over time. Moreover, it may prove necessary, in certain particular locations in the building envelope, to use a sealant where the latter is completely protected to ensure continuity of the air barrier along certain specific joints.

A number of characteristics must be analysed to choose a sealant to be used in conjunction with an air barrier system such as: adherence to support surfaces, resistance to movements and to aging, dimensions of joints, creep resistance, etc. As for this latter characteristic, it should be noted that the use of acoustic sealant should be totally ruled out due to its low resistance to continuous forces such as the chimney effect, and this is true even in cases where these forces are weak.

In addition to these general considerations which usually govern the choice of any sealant, the choice of the latter as a component of the air barrier will also depend to a large extent on its location within the wall. Indeed, a sealant located on the cold side of the wall will have to tolerate a temperature differential from -20^o C. to 65^o C. The "Air Tightness Tests on Components use to Join Different or Similar Materials of the Building Envelope" report analyses the air tightness test results of acrylic and silicone sealants after having submitted them to a pressure differential of 150 Pa for 6 months. This report indicates that a number of tears and cracks were observed on the acrylic based sealant samples when submitted to high temperatures (65^{o}C). It would thus be appropriate to limit their use to locations inside the building envelope.

The limited quantity of knowledge as to the structural properties of sealants as components of air barrier systems is sufficient reason for us to limit the use thereof to a minimum and to make use instead of membranes. Moreover, sometimes we have no other choice. For example, the concept described in case 2 in the following chapter shows the use of a sealant joint as a component of the air barrier window joint. Moreover, to ensure the structural resistance of the proposed detail, we had a test conducted on site to measure the structural resistance on this assembly. The assembly remained stationary in spite of the fact that it was submitted to a pressure differential of 1.5KPa. Refer here to chapter 4.

CHAPTER 3
APPLICATIONS

This part of the document focuses on the principles involved in installing rigid air barrier systems and on the assembly details for the different components.

Of course, assembly details will differ from one building to another. Depending of the building type, a number of variables will affect the manner in which rigid air barriers are executed. In particular, we will have to take into consideration whether this is a new construction or a renovation, the structure type (steel or concrete) and the wall assembly (wood or steel studs). Certain building specific constraints also have to be taken into consideration such as the geographical location, shape and the degree of interior humidity which is to be respected in winter. All these consideration will impact the choice of the materials and their assembly.

Since 1982, we have produced some fifty airtight buildings. Thus, it is based on our experience in this field that we have chosen, for the purposes of this study, four building types with which we are particularly familiar. These typical cases will make it possible for us to present below various methods of installing rigid air barriers in each of the types:

Case 1: New building with concrete structure
Case 2: Renovated building with concrete structure
Case 3: New building with steel structure
Case 4: New building with wood structure.

An analysis of each case will allow us to identify the performance requirements which have been defined when each project was being built. Next, there will be a description of the materials which were used or which may be recommended for each situation. A series of construction details will present the critical assembly points between rigid air barriers and other components. We will then study the methods to be used to attain the air barrier's structural resistance, its vapour barrier function and, lastly, certain points which seemed critical to us when we conducted our site supervision.

CASE 1
NEW BUILDING WITH CONCRETE STRUCTURE

1. Performance Requirements

Longevity:

Air barriers are to remain effective throughout the building's useful life to ensure the proper interior ambient conditions and to prevent the premature deterioration of the building envelope.

Air Tightness Level:

The document containing the proposed changes for Part 5 NBC describes as follows the level of air permeance of the airtight system: (Maximum permeability levels recommended for airtight systems in most communities in Canada are set as follows):

relative humidity warm side:	maximum permeability level recommended for systems:
% RH	1 L / S.m^2 at 75 Pa
< 27% à 21°C	0.15
27 @ 55% à 21°C	0.10
> 55% à 21°C	0.05

The concepts presented here apply to buildings with relative humidity rates between 27% and 55%. The maximum permeability rate required is thus 0.10 L/S-m^2 at 75 Pa.

Air Barrier Structural Resistance Level:

The document containing the proposed changes for Part 5 NBC describes as follows the load levels applying to air tightness systems:

"8) The airtight system submitted to wind induced loads, and other separation elements on which these loads exert pressure, must transfer these loads to the structure.)"

"9) Subject to paragraph 11, the airtight system for a projectsubmitted to wind induced loads must be designed and executed to resist the total loads specified, calculated in accordance with sub-section 4.1.8.)"

"10) Subject to paragraph 11), the degree of flexion of the airtight system and of the other separation elements exposed to wind induced loads must not affect the integrity of the non-structural elements where the wind induced loans are one and one-half times stronger than specified."

Paragraph 11) describes an exception for cases where it can be shown that the wind induced loads are less than the loads specified in sub-section 4.1.8.

These total loads, calculated in accordance with section 4.1.8 must be defined by an engineer specialized in this type of work. They reflect the standards in force, design requirements such as building type, expected building longevity and assembly types which will be defined by the architect and building specific characteristics such as location, height, area, shape, etc.

The concept analysed below was developed so that the air barrier respect design loads of 1 kPa, for a reference dynamic pressure (q) determined in accordance with an annual exceedance probability of 1:30.

2. Materials Used

Type of Rigid Air Barrier:

The following three materials: light concrete panels, plywood and waterproof gypsum board may be used under the concepts developed below. In the case of waterproof gypsum board, the rate of permeability will be over the maximum required of 0.10 L/S-m^2 at 75 Pa, (refer to chapter 4, case 2). The choice of one of these materials will be based on the performance desired as well as on budgetary considerations. See their reciprocal performances in chapter 2. All these materials are not considered as vapour barriers with the exception of plywood which will assume both functions: air and vapour barriers. See plywood specific recommendations in point 5 below. Where gypsum board is used, the risk of damage due to rainwater infiltration behind the masonry should not be minimized. The recommendation here is that a high density polyethylene siding be used. This will be applied on each rigid insulation strip and extend, in overlap position, under the following strip to act as flashing and thus reduce the risks of water infiltration behind the insulation.

Type of Jointing:

Fusible membranes may be used for virtually all cases with the exception of areas where it becomes impossible to use the torch for installation purposes without damaging adjacent components. Installing this membrane should also be avoided in areas where there is a danger of fire. It should be noted that installing such a membrane with a torch on gypsum board does not represent any risk of fire for experienced workers. Here we used an elastomer bituminous membrane with a polyester structure, applied on a primer bituminous and inflammable volatile solvant base coat with the addition of adherence enhancers.

We limit use of the self-adhesive membrane to specific areas where it is impossible to use the torch. This may mean, among other situations, a strategy designed to fasten the membrane directly to a window frame, as using a torch here would damage the frame. It should be pointed out that self-adhesive membranes can only be installed in mild weather. Minimum exterior temperature is 10ºC for most products.

In addition, self-adhesive membranes must be well supported to avoid separation. The fact of the matter is that, although the fusible membrane can cover orifices 50 mm in diametre (maximum) without any risk of separation, the same cannot be said of most self-adhesive membranes. Refer to chapter 2.

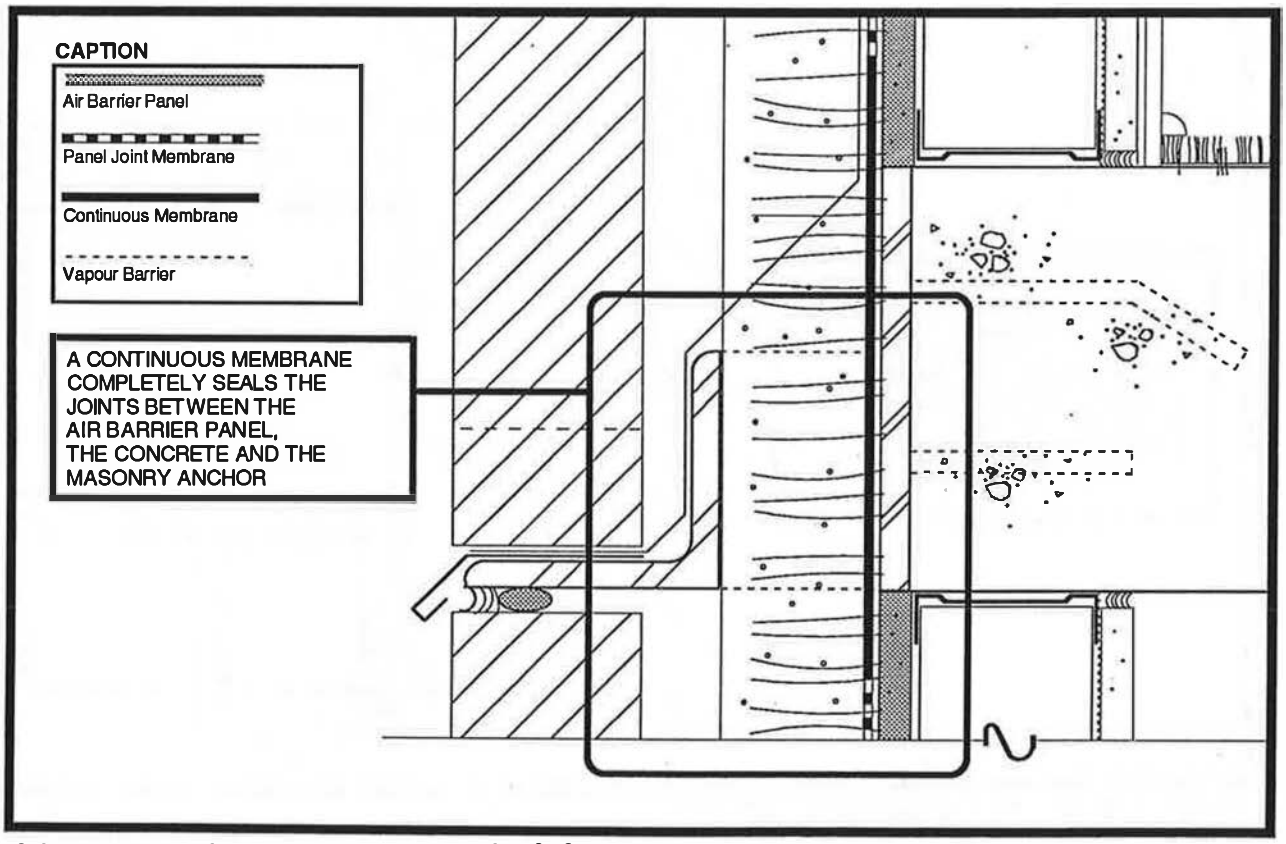
Fastening the Insulation:

The insulation must be mechanically fastened to ensure long term adherence. An adherence defect allowing for air to leak behind the insulation necessarily reduces the thermal resistance of the assembly drastically.

3. Continuity of Air Barrier

Along Floor Surfaces:

A number of obstacles make the installation of an air barrier along floor slabs complicated, particularly in buildings with masonry siding. The joint between the rigid panel and the less than smooth concrete surface, the angle iron fastened directly to the slab and the shelf angle supporting the masonry are both uneven surfaces around which airtight joints have to be made using a fusible membrane. Designers should provide minute details on the concept they are advocating considering all the elements which will be present in this crucial location in the building envelope.



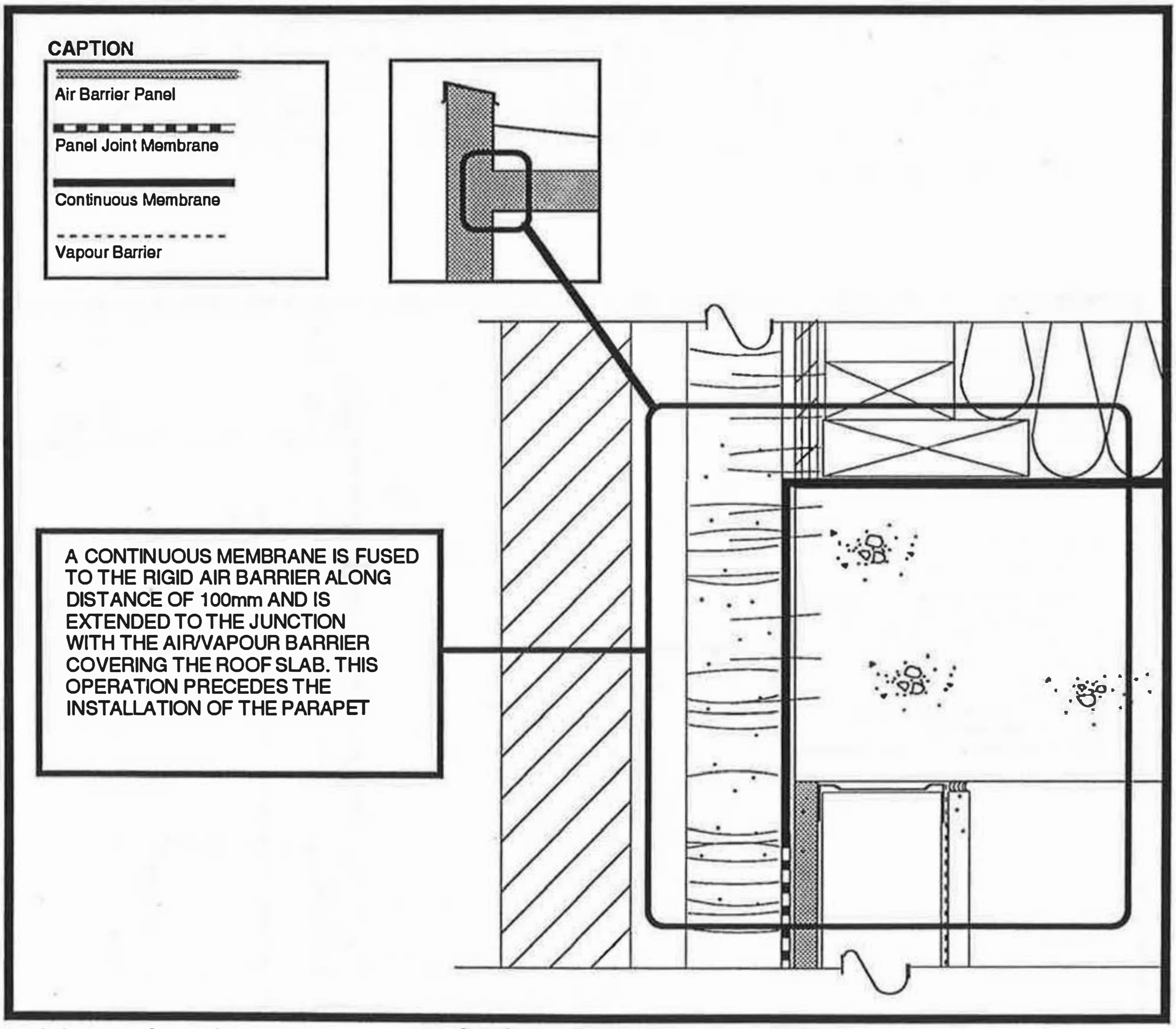
CONTINUITY OF AIR BARRIER ALONG SLAB

FIG.1

Figure 1 shows an anchor layout which facilitates the installation of the membrane. Moreover, it may be preferable, in certain cases, to completely recover certain surfaces with an underlay material such as gypsum board or plywood, to produce a smoother surface. Membrane strips can then be used to seal the joints between this underlay material and adjacent elements. This alternate method may make it possible, in certain situations, to facilitate the work and reduce the execution time.

Along Roof Lines:

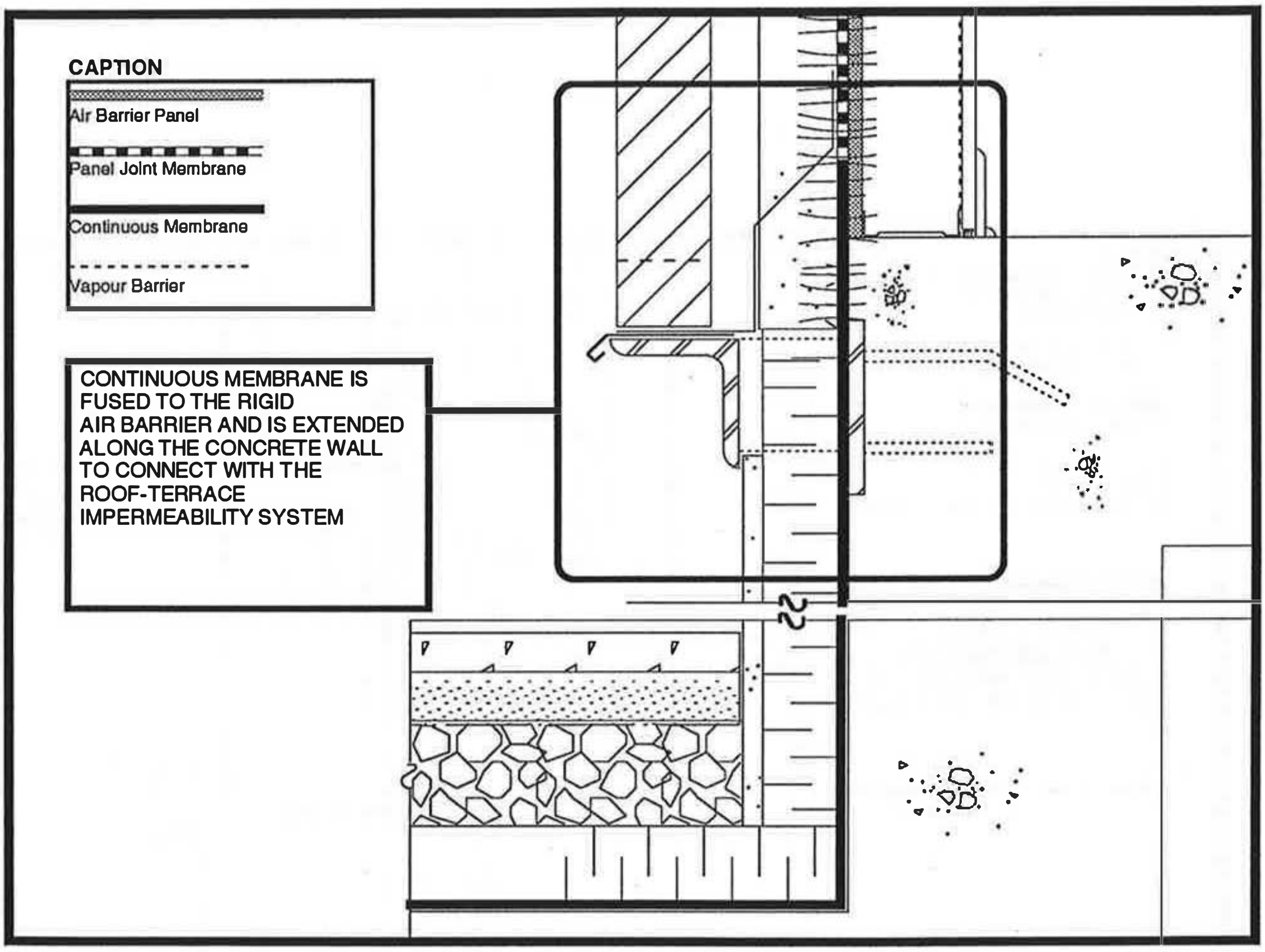
The roof on slab concept means that a continuous fusible membrane is imperative, to be used as an air barrier and a vapour barrier, i.e., applied to the whole slab surface and bonded continuously to the rigid air barrier covering the walls. Refer to figure 2.



ROOF AIR/VAPOUR BARRIER JUNCTION WITH WALL AIR BARRIER

FIG.2

A similar air/vapour barrier concept must be installed for roof terraces. Refer to figure 3.

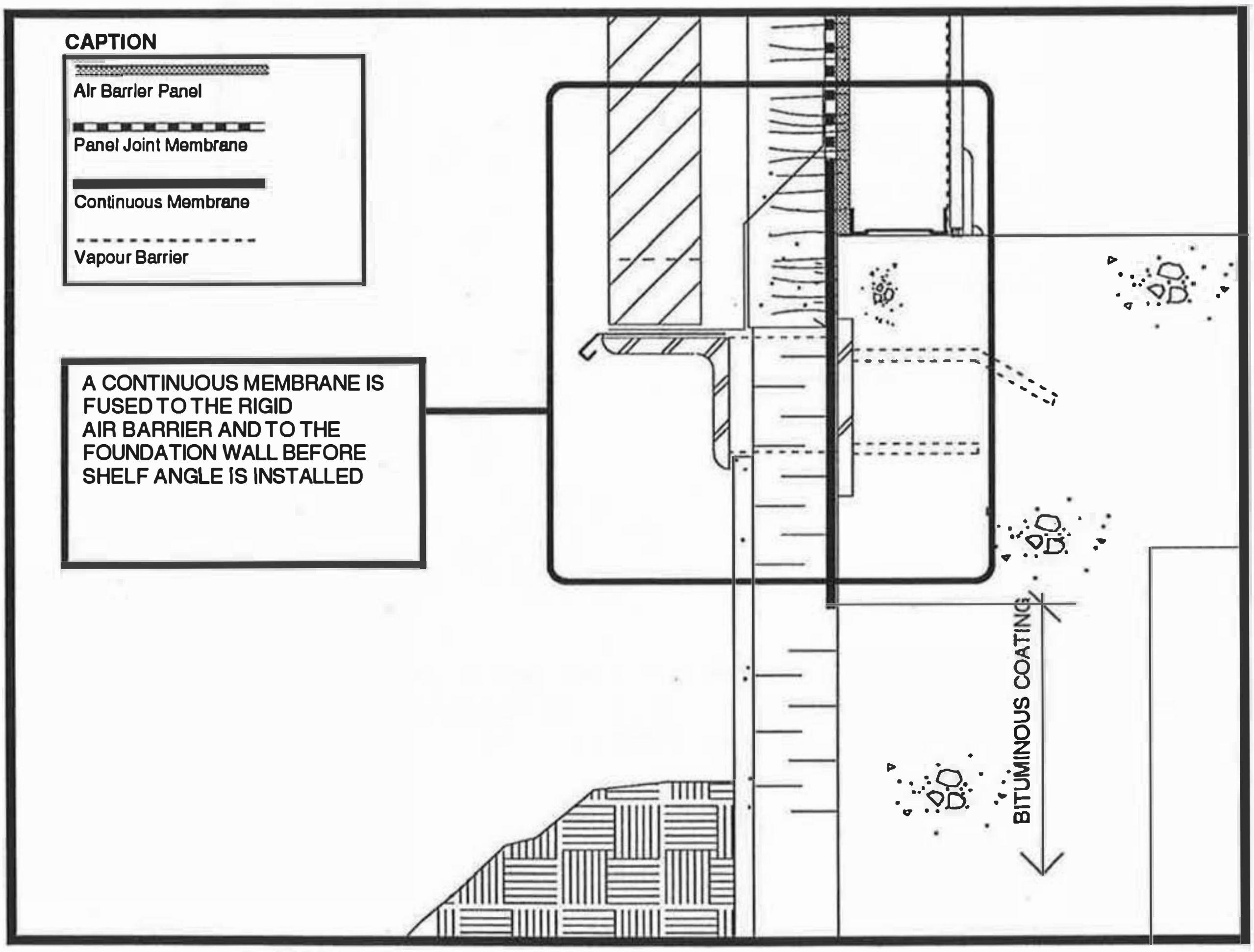


JUNCTION OF ROOF-TERRACE IMPERMEABILITY SYSTEM WITH WALL AIR BARRIER

FIG.3

Along Foundation Line:

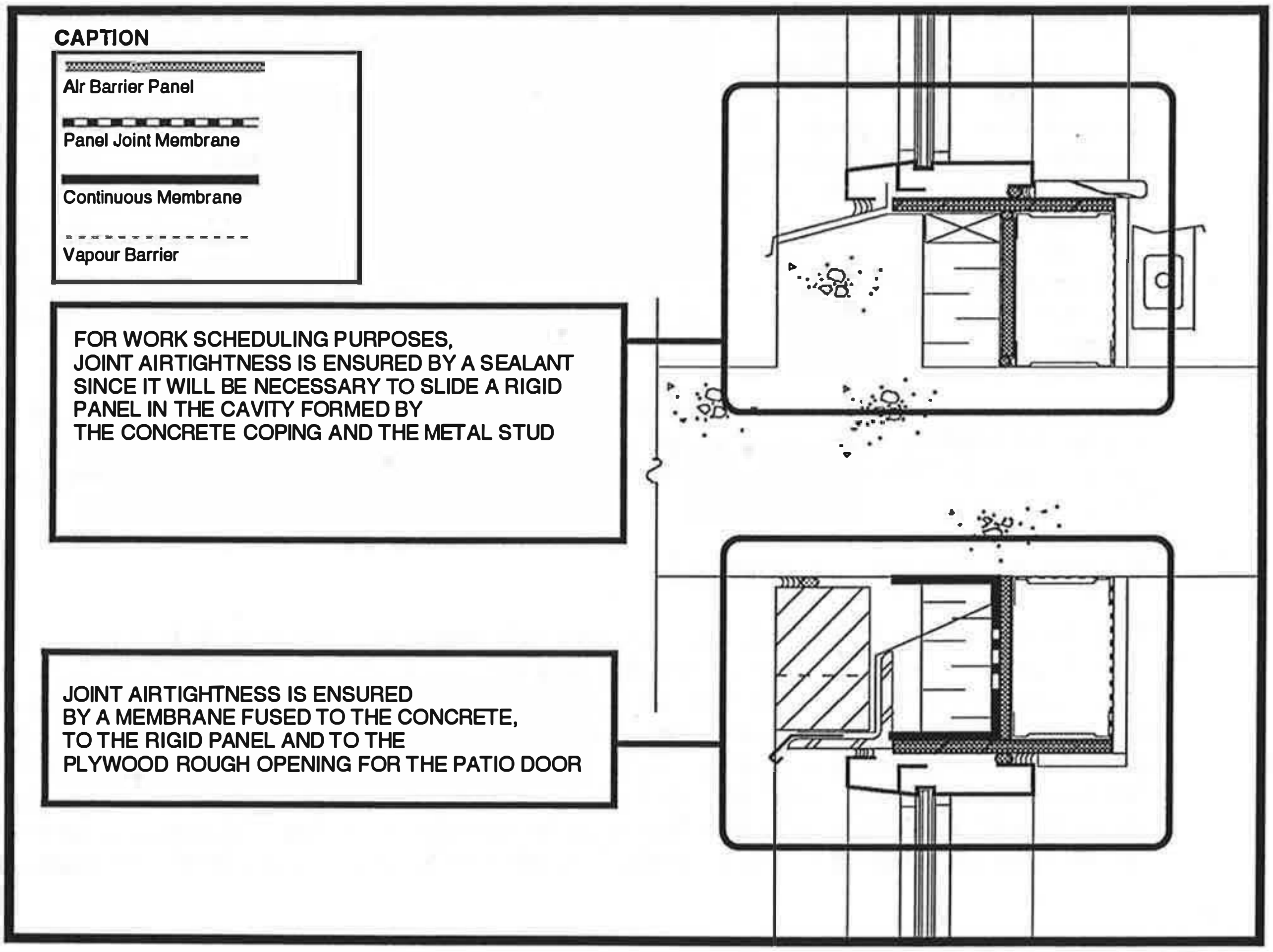
The thickness of the concrete foundation wall and the fact that it extends into the soil eliminates the need for an air barrier on it. On the other hand, the wall air barrier must be bonded firmly to the foundation with a membrane extending 150 mm down over it. The concrete surfaces must be thoroughly cleaned to ensure good adherence. Refer to figure 4. It is appropriate to note that in cases where the concrete slab and the foundation wall are not monolithic, it is necessary, using a fusible membrane, to install an airtight joint where these two elements meet.



WALL AIR BARRIER/FOUNDATION JUNCTION FIG.4

At Balconies:

The joint sealing between the portions of the wall air barrier and the concrete must be executed so as to produce an airtight joint. Figure 5 indicates two ways to proceed. The air barrier at the top of the patio door is executed using a fusible membrane producing the air barrier joint between the rigid air barrier material and the concrete. Airtightness between the plywood and the door frame is executed using a sealant. The air barrier at the bottom of the door is executed in another way: simply using a rigid air barrier material with sealants on joint backing.



CONTINUITY OF AIRTIGHTNESS AT BALCONY FIG.5

At the Windows:

The window extrusions should be studied so that there is an effective bond with the air barrier. The bonding plane must be analysed to avoid any possible infiltration between the different frame components. Refer to figure 10, case 2 for bonding with windows.

4. Structural Resistance of Air Barrier for Wind Loads

Wind Loads:

a) The structural resistance of rigid air barrier material depends on the type of material (gypsum board, plywood, light concrete panel) and its thickness. It also depends on the size, gauge and spacing of the metal studs. For example, in the case presented, the concept provides for the use of exterior gypsum board, 16 mm thick, installed on metal studs spaced 100 mm, gauge 18, installed at 400 mm o.c.

b) The mechanical resistance of the fastening devices bonding the rigid air barrier to the studs must ensure that there is no rupture or perforation in the barrier around the fastening devices when air pressure exerts an outward force. The spacing requirements for these devices will determine this resistance type. CMHC's reports entitled "Testing of Air Barrier Systems for Wood Frame Walls" and "Structural Requirements for Air Barriers" both indicate how, at the present time, the manner in which drywall is fastened in place is inadequate to obtain the desired structural resistance for the gypsum board air barriers. In our specifications, we prescribe the following spacing for the installation of gypsum board: 200 mm along the studs and 150 mm at bottom and top plates (doubled where the latter must allow for movement). In the absence of precise data on the tests carried out on light concrete and plywood panels, we prescribe the same spacing even if it is probable that wider spacings might be sufficient, given the greater rigidity of these materials compared to gypsum.

c) The membrane's separation resistance depends on its adherence and on the width of the strips. The material used is described in point 2. The width which we advocate for the sealant strips is 200 mm. Chapter 4 describes the results which we have obtained in in situ tests.

5. Vapour Barrier vs. Air Barrier

With the exception of plywood, the rigid materials installed to produce air barriers are not vapour barriers. Vapour barriers must thus be a part of the assembly and must be installed on the warm side of the insulation. As for plywood, it is a vapour barrier. The fusible membrane used to seal the joints is also a vapour barrier. It is thus possible to conclude that if the air barrier plane is very air tight, the air barrier can also assume the vapour barrier function and very effectively at that. On the other hand, choosing plywood necessarily means that no insulation can be installed on the warm side of the latter. Otherwise, the water vapour from the inside of the building will inevitably build up inside this insulation material.

6. Inspection

We were able to observe that a certain type of air barrier defect was quite frequent: open screw holes in panels. Indeed, screws are frequently inserted in the wrong spots in rigid air barriers. These screws are then removed and reinserted in their proper locations leaving gaping screw holes behind. This error may seem harmless and without any affect on the performance of the air barrier but such is not the case. In fact, a 625 mm^2 hole (1 sq. in.), (the sum total of 60 screw holes) allows an air volume of 2,600 m^3 to escape from a building over a period of one month assuming that there is a continuous pressure differential of 10 Pa, i.e., the equivalent of the chimney effect for a two storey building. It thus becomes important to inspect the air barrier against the light before installing the insulation to detect these holes and to cover them with 200 mm x 200 mm fusible membrane. Sealants should not be used since they could separate from the surface subsequent to pressure differential on the air barrier.

CASE 2
RENOVATED CONCRETE BUILDING

1. Performance Standards

Longevity:

The air barrier must retain its effectiveness throughout the building's useful life to ensure proper interior ambient conditions and to prevent premature deterioration in the building envelope.

Air Tightness Level:

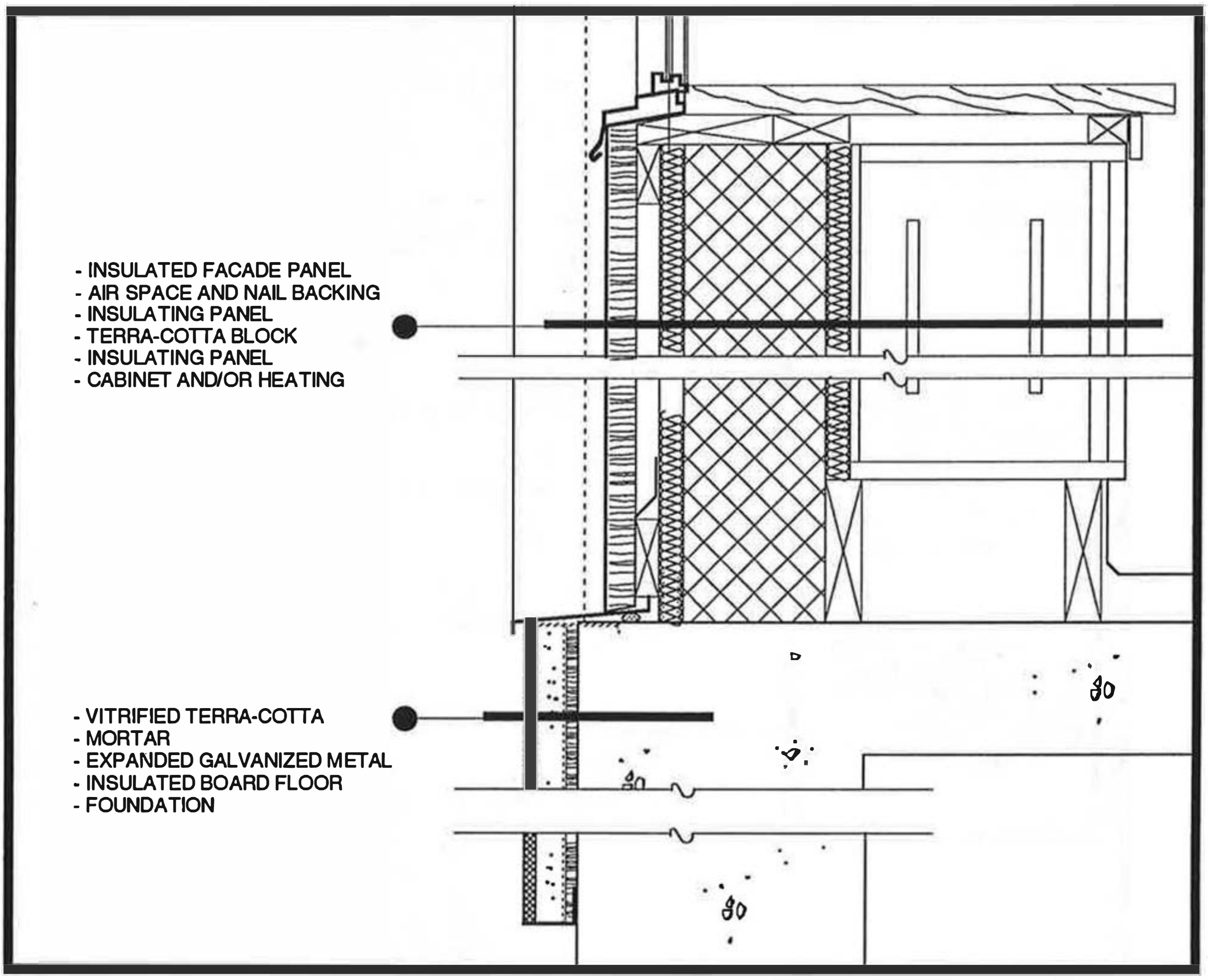
The concepts presented here apply to buildings with relative humidity rates below 27% at 21°C. According to preliminary documents for the 1995 edition of the National Building Code, it is recommended that the maximum permeability rate be 0.15 L/S-m^2 for this level of relative humidity, all this with a pressure differential of 75 Pa. Refer to case 1 for the different levels of airtightness depending of the requirements for the future code.

Air Barrier Structural Resistance:

The concept analysed here was developed to resist design loans of 1 kPA. Refer to case 1 for a complete description of the requirements making it possible to define this load.

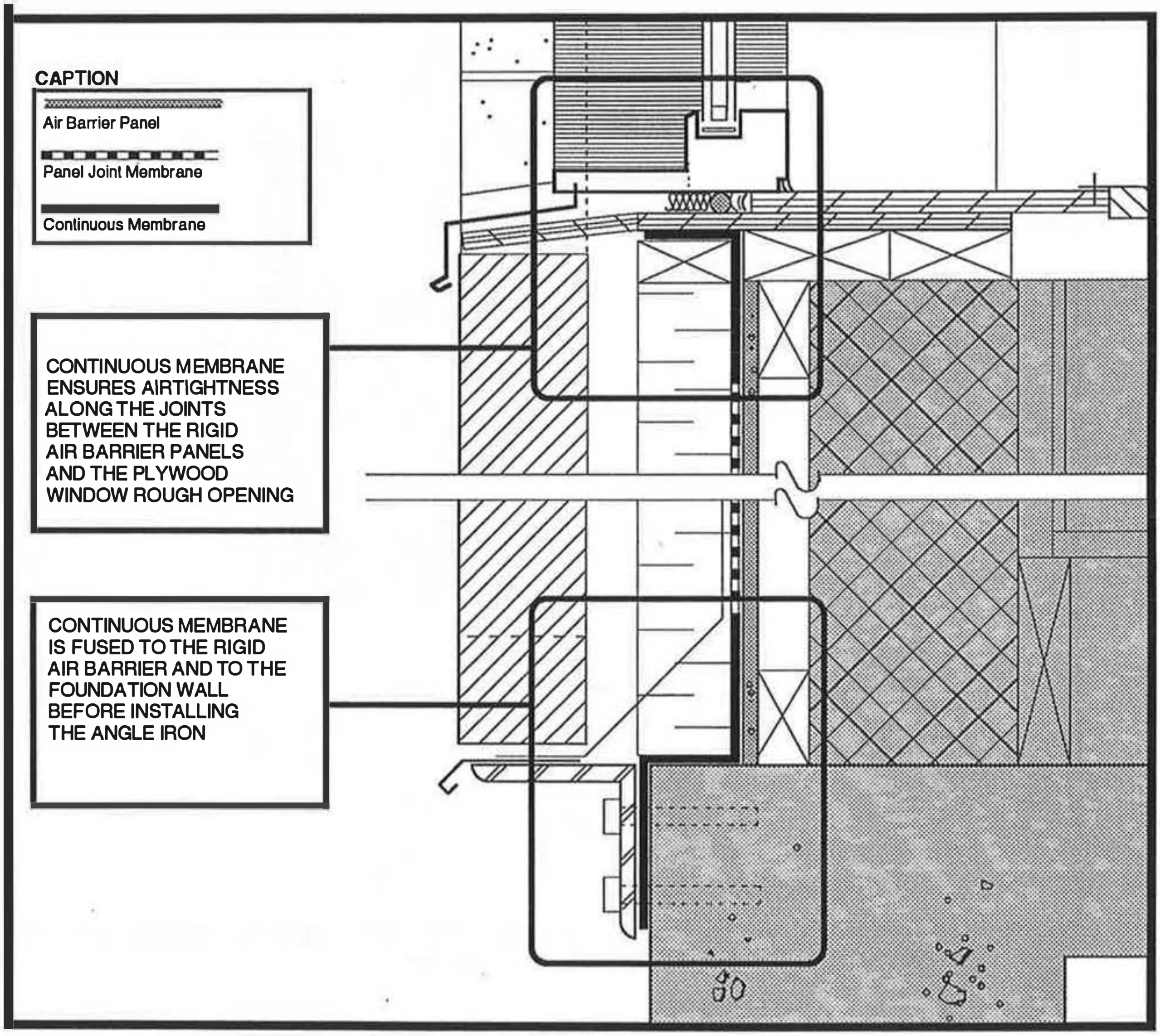
2. Materials Used

This project is typical of renovation work on exterior walls and windows where the glazing area is to be reduced to comply with energy conservation regulations currently in force. This thus includes removing the existing siding, insulation and windows. Then, a portion of the former window openings has to be incorporated in the new wall. An air barrier is installed on the new parts of the walls and on the existing walls. New insulation must then be added as well as new siding. Figures 6 and 7 show the before and after condition of the building.



WALL COMPOSITION BEFORE RENOVATION WORK

FIG.6



CONTINUITY OF AIR BARRIER ALONG THE FOUNDATION AND ALONG SIDES OF OPENING

FIG.7

Type of Rigid Air Barrier:

An on-site verification of the condition of the air barrier's support surfaces should be conducted first of all to determine the type of air barrier to be used. Indeed, in cases where infilling of existing walls is necessary using concrete blocks, it is possible to use a fusible membrane applied directly on the block. On the other hand, in this case an inspection showed that the infilling was effected using grooved terra cotta blocks. As the adherence surface was limited due to the grooves, there would have been a risk of separation had a fusible membrane been applied directly. This is why it was necessary to prepare an air barrier made up of sealed rigid panels rather than a single membrane applied to the whole surface of the existing substrate. This material may be waterproof gypsum board, plywood or light concrete panels.

Type of Jointing:

Refer to case 1 for the locations and conditions for using the different membranes.

Type of Insulation Fastening Device:

Refer to case 1.

3. Continuity of Air Barrier

Along Floor:

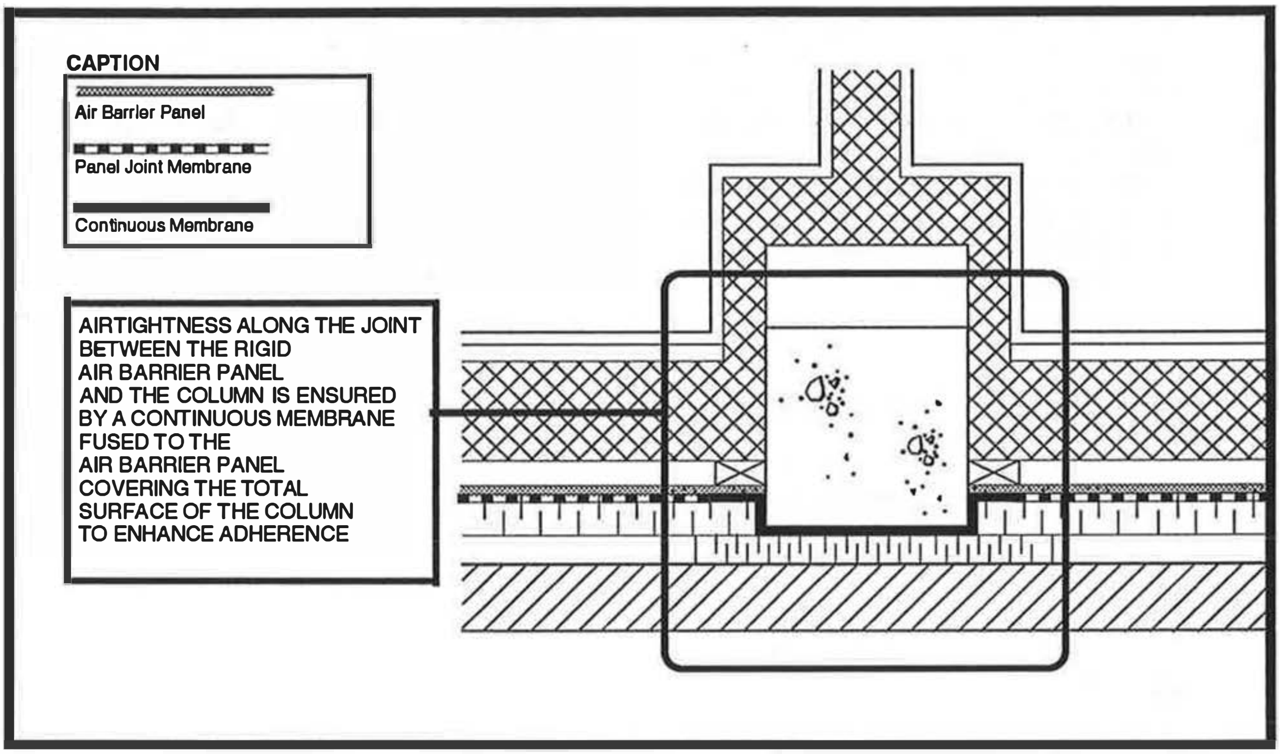
Refer to case 1, figure 1.

Along Foundation:

An angle iron had to be added to support the new masonry. In fact, the addition of an air barrier and an rigid insulation material on the existing building produces a horizontal projection of the building wall to the outside. Airtightness between the air barrier panel and the foundation wall is effected by applying the fusible membrane in an overlapping manner along the foundation wall and by extending this membrane behind the angle iron. This configuration makes it possible to protect the end of the membrane and to thus ensure its adherence. Refer to figure 7.

Along Concrete Columns:

Theoretically, it is possible to execute joints between rigid air barriers and concrete columns using 200 mm wide fusible strips. On the other hand, it is often simpler and more effective to extend the membrane over the whole concrete column surface to avoid adherence problems on anuneven surface which is often the case with poured concrete.
Refer to figure 8.



CONTINUITY OF AIR BARRIER ON FRONT SURFACE OF COLUMN.
TOP VIEW

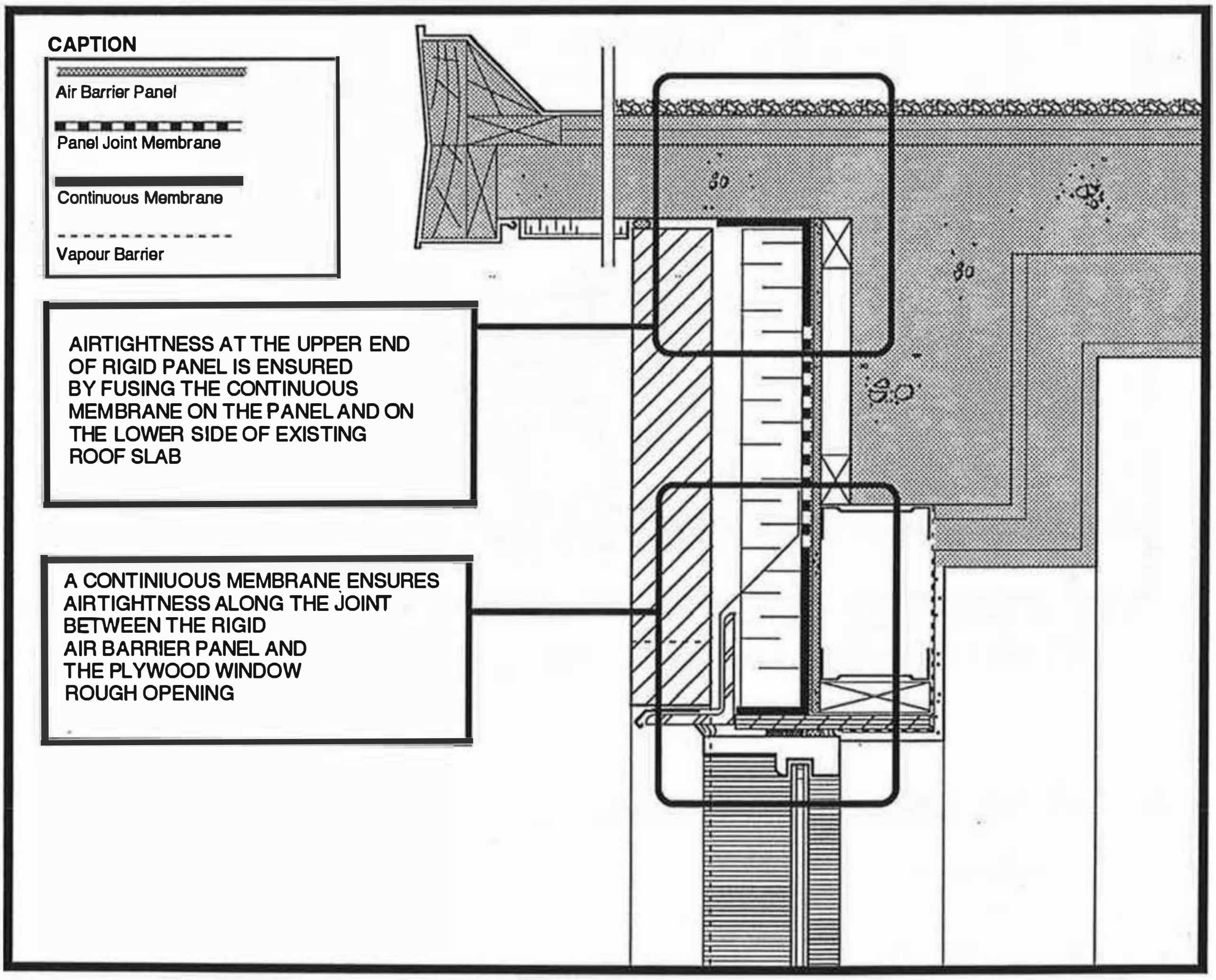
FIG.8

Along the Roof:

Where the façade is being renovated without any work being necessary on the roof, the possibility of bonding the wall air barrier with that of the roof is quite limited. On the other hand, the concept established must make provision for a continuous airtightness junction between the roof and the wall to be installed should future renovation work on the roof prove necessary. The existing configuration made it possible for us here to install a sealant under the roof slab and continuity of the airtight junction will be ensured in the event of renovation work on the roof, thus avoiding any infiltration. Refer to figure 9.

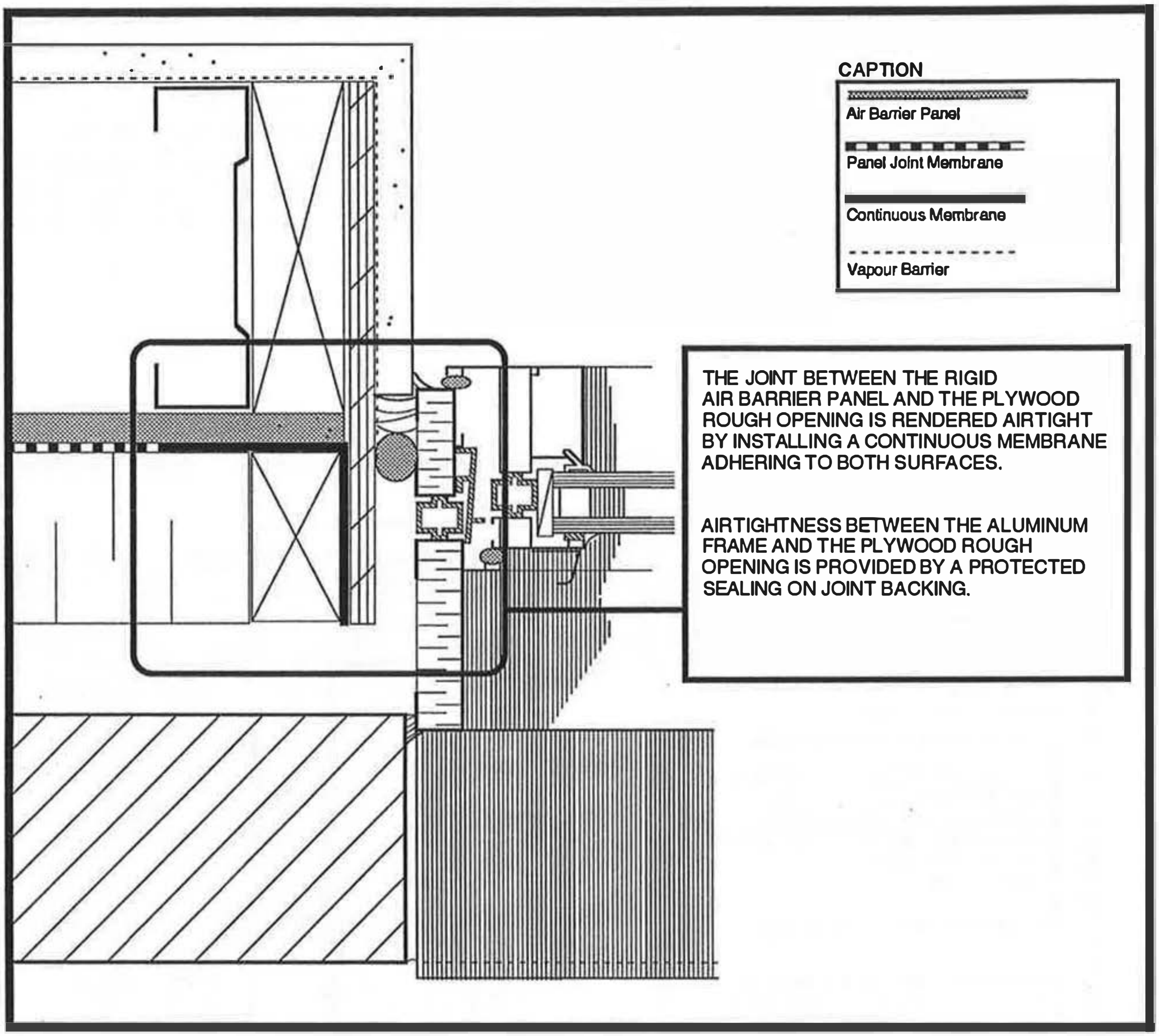
Around the Windows:

In this case, a study of the existing conditions and of the window extrusions required made it possible for us to observe the difficulties involved in installing an air barrier joint between the window and the rigid air barrier using the membrane applied directly to these two elements. In fact, no accessible window frame component provided sufficient adherence surface to avoid separation risks. This situation is quite frequent and certain manufacturers, on the short term, intend to add devices to their frame extrusions to allow the membranes to be attached directly thereto. In the meantime, building designers must get around this difficulty by specifying in their documents the strategy to be applied by builders in light of the constraints which the latter must cope with in executing their work. The case presented in figure 10 illustrates how airtightness can be ensured using a plywood enclosure around the sides of the opening. The joint between the rigid air barrier in the walls and this enclosure is executed using a fusible membrane. The jointing between the aluminum frame and the enclosure is formed by a sealant on joint backing. It is to be noted that this sealant is protected from temperature extremes, from ultraviolet rays and vandalism. It is to be covered with interior finish elements and exterior siding. The finish sealants are quite distinct from the air barrier sealants and their functions are different. Refer to chapter 2 for the choice of sealant type. Chapter 4 lists the results of the airtightness test obtained using a similar concept. The designer must pay particular attention to the sides of the openings to avoid trapping certain pieces of wood between two vapour barrier materials thus inducing wood rot. A precise analysis of air and water vapour permeance levels of the various existing materials must be conducted.



WALL/ROOF JOINT
(CONSERVATION OF EXISTING ROOF)

FIG.9



CONTINUITY OF WALL AIR BARRIER
ALONG ROUGH OPENING AND WINDOW FRAME
FIG.10

4. Air Barrier's Structural Resistance

Refer to case 1

5. Vapour Barrier vs. Air Barrier

Refer to case 1.

6. Inspection

The enclosed photos show the scheduling of the work at the different stages during demolition.

Photo 1: Installation of the metal studs, exterior gypsum board and nail backing around the new openings is underway. Here we see outer edge of the membrane extending down the wall under the rough opening. The sealing on the columns is very visible.

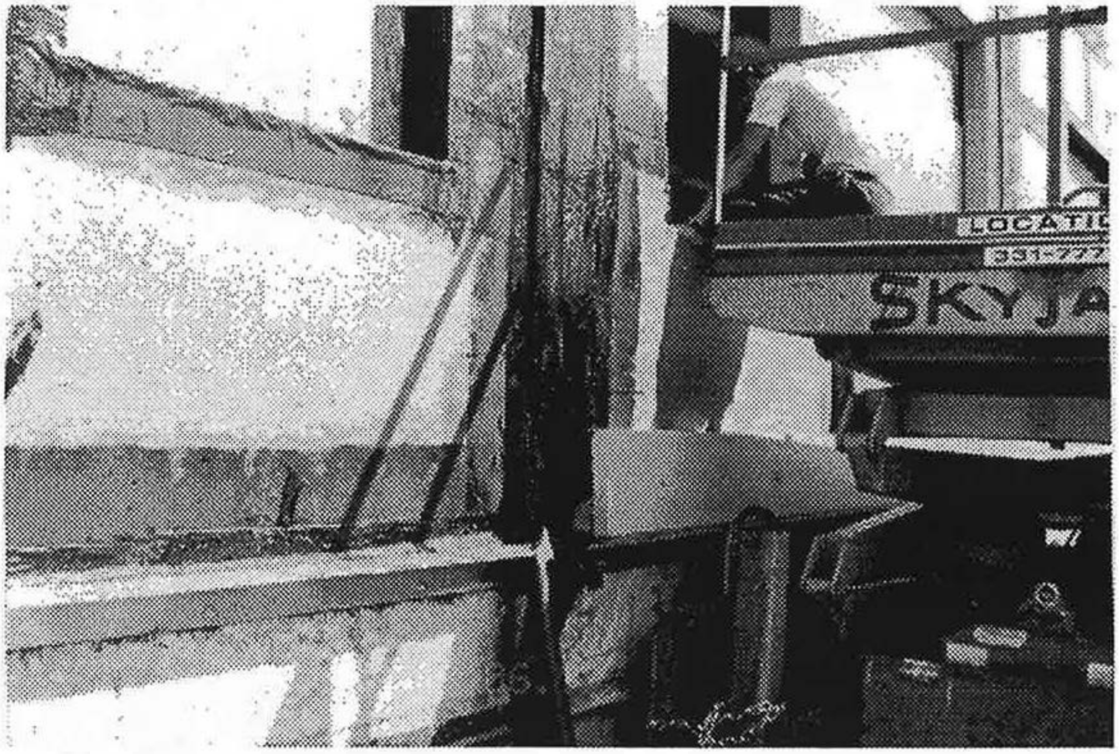


PHOTO 1

Photo 2: The sealing membrane is installed over the whole façade. Installing the windows is the subsequent step. It is noticed that the membrane is present in all joints between the different pieces of the rigid panel and along the sides of all the openings. It is important to be aware of how the contractor schedules the work to ensure that it will be possible to inspect all the air barrier surfaces. Covering over some sections with insulation too soon would prevent adequate inspection.

Photo 3: Here we see the window being put in place before installation of the sealing between window and air barrier. All sides of the opening are covered with the membrane. Shims are visible between the membrane and the aluminum frame. The space to be rendered airtight between the two is in the range of 15 mm.

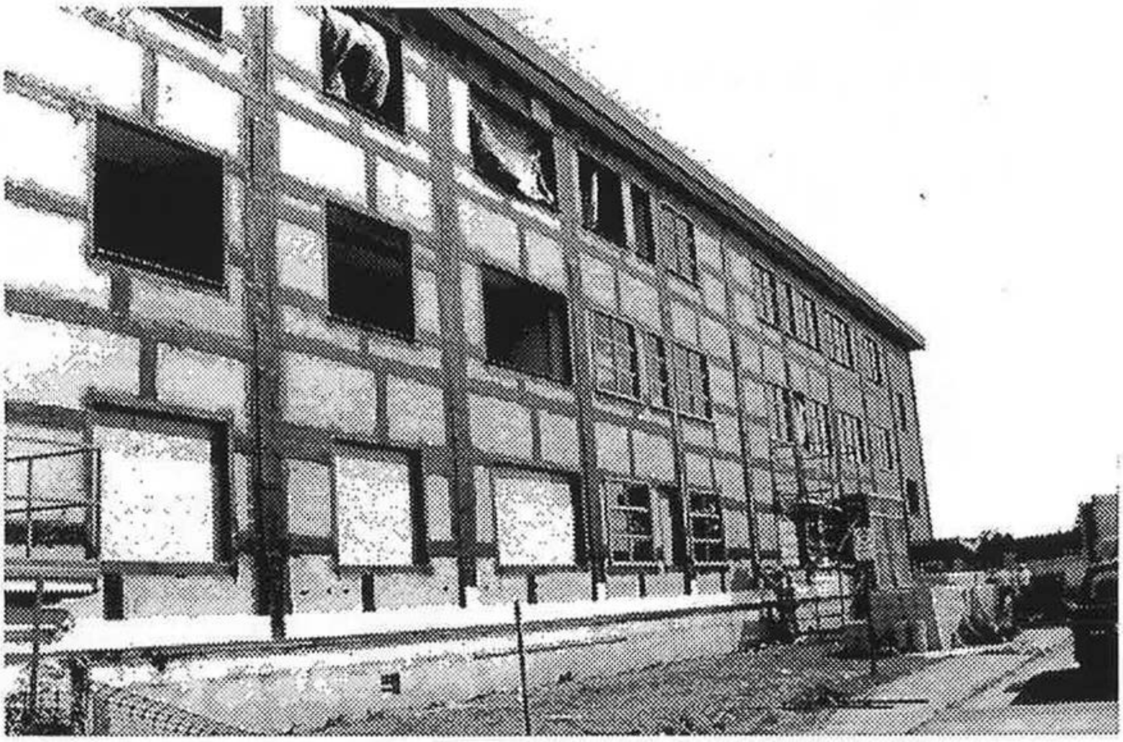


PHOTO 2

PHOTO 3

Photo 4: This photo shows the type of air barrier sealant which was executed here between the window frame and the membrane. An acrylic sealant on joint backing was installed in the joint. The sill will end up completely covering this sealant which will be protected inside the wall assembly.

PHOTO 4

CASE 3
NEW STEEL STRUCTURE BUILDING

1. Performance Requirements

Longevity:

The air barrier must retain its effectiveness throughout the building's useful life to ensure proper interior ambient conditions and to prevent premature deterioration of the building envelope.

Airtightness Level:

The concepts developed here apply to a type of building with a very high relative humidity rate. This constraint is very important in that it increases the airtightness requirements. According to the document containing the proposed modifications to Part 5 NBC 1995, the air infiltration level for buildings with relative humidity levels of over 55% is 0.05 L/S-m^2 at a pressure differential of 75 Pa. See the complete description of the text of the modification in case 1. This requirement applies both to curtain walls as well as to sandwich walls, to roofs and to foundation walls. Indeed, as the air barrier is not a material per se but rather an assembly comprising several elements.

Air Barrier's Level of Resistance:

The concepts analysed here were developed to meet design loads of 1.5 kPa. Refer to case 1 for the description of the requirements.

2. Materials Used

The concept developed uses as rigid air barriers metal encased sandwich panels.

Type of rigid air barrier:

Sandwich panels are formed, on the warm side, by steel facing coated on both sides with an anti-corrosive material, by an insulating core and by exterior prepainted steel facing. The steel facing, on the warm side, assumes the dual function of air barrier and vapour barrier. The steel itself has an air infiltration rate of nil and a vapour transmission rate of nil. The material in itself is thus perfect. The difficulty here is the joint work between the panels and around the fastening devices which go through the material.

Type of Joint Work:

Airtightness between the panels is ensured by the steel facing on the warm side. The materials used are as follows:

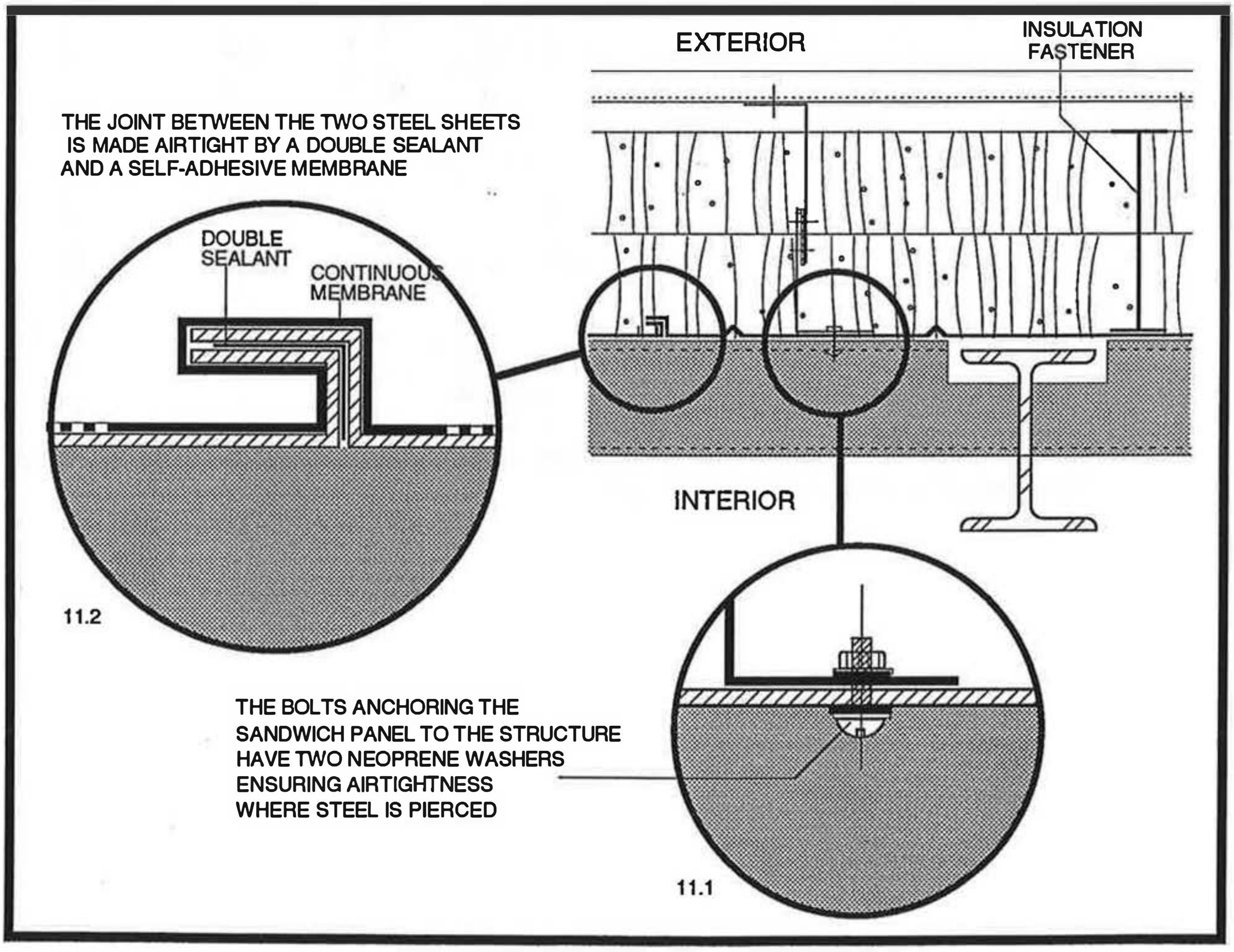
Two metal airtight washers with neoprene sections as added to bolt and nut assemblies holding the panels to the frame. One of these washers is located at the bolt head and the other under the nut. Refer to figure 11.1.

The joints between the panels are executed in the following way: the ends of both sheets of steel are held together with a 100% butyl-polyisobutylene tape. Refer to figure 11.2. This tape is also applied to the junction with the openings.

A self-adhesive membrane is then installed on the exterior face of the interior facing. Refer to figure 11.2.

Type of Insulation Fastening Device:

Semi-rigid rock wool insulation produced from a mixture of volcanic rocks and recycled steel clinker is used. It is attached mechanically to avoid any settling or separation. To avoid piercing the steel which acts as air and vapour barrier, the fastening devices are attached to the steel with an adhesive. Refer to figure 11.



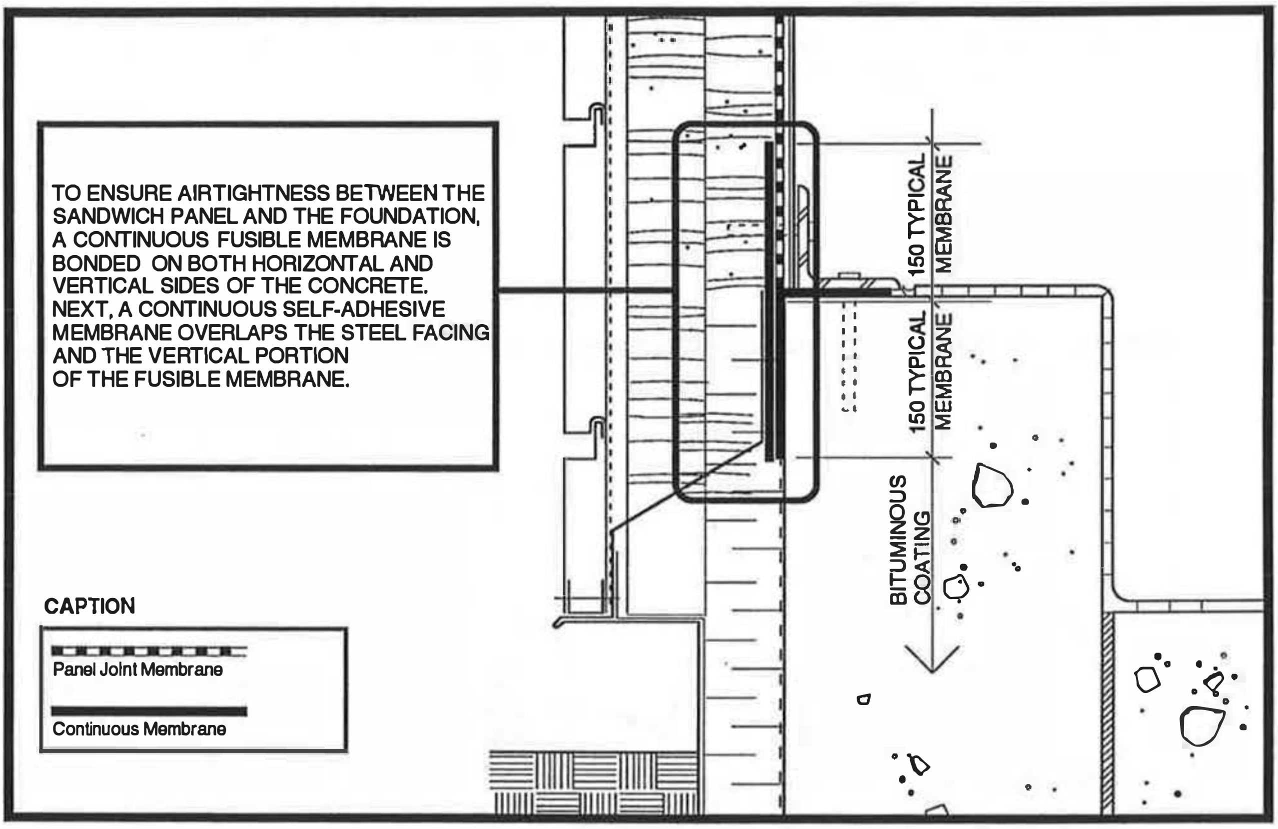
AIR BARRIER SANDWICH PANEL, CONTINUITY ALONG ITS JOINTS AND AROUND FASTENING DEVICES

FIG. 11

3. Air Barrier Continuity

Along the fondation:

An air barrier membrane overlaps the steel facing for a distance of 150 mm or is bonded to the curtain wall and is extended for 150 mm over the whole concrete surface. Refer to figure 12.

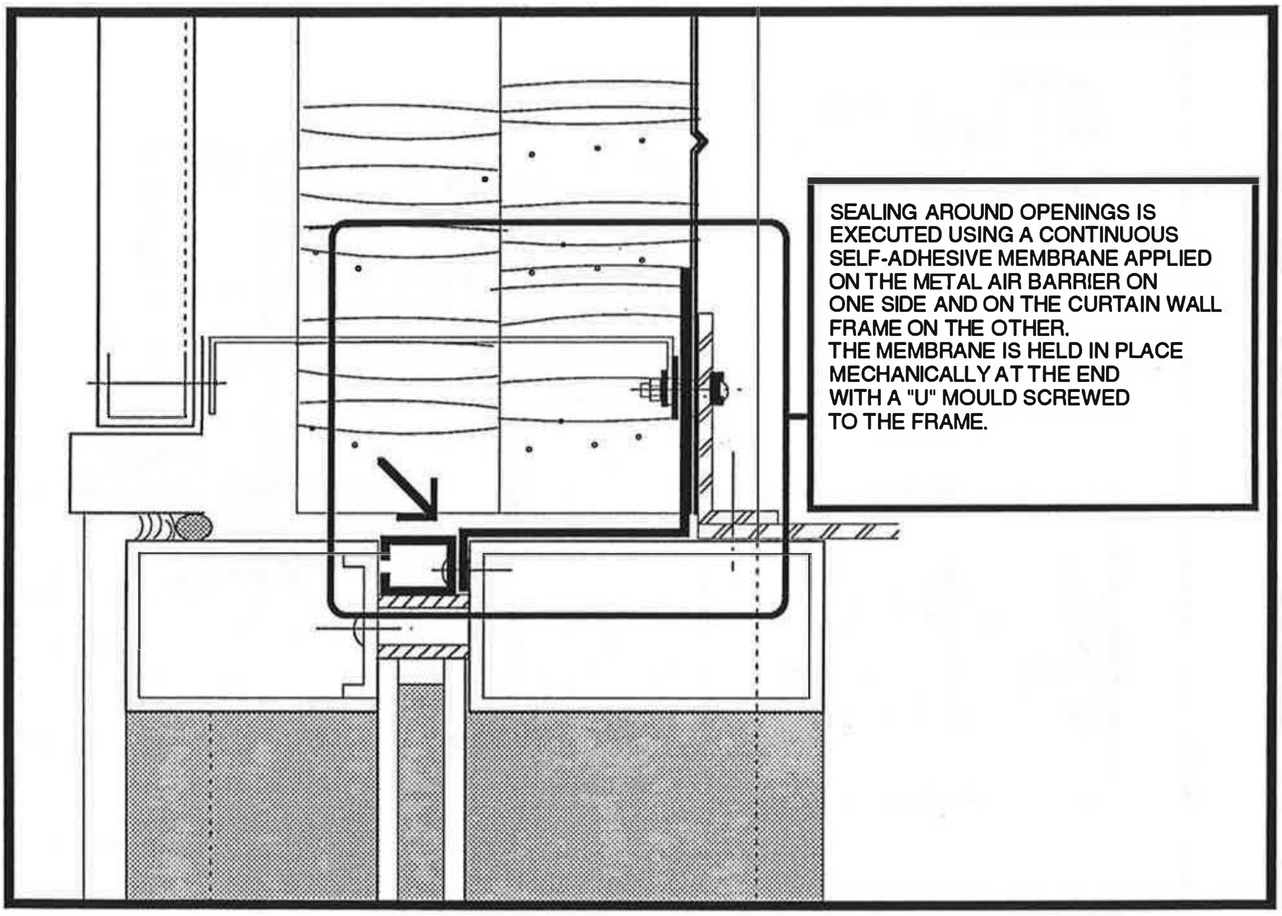


AIR BARRIER/FOUNDATION JUNCTION

FIG. 12

At the joint around openings:

In this case, the position of the components and the configuration of the curtain wall allow for sufficient surface adhesion on the aluminum to use a self-adhesive membrane along the joint between the sandwich panel and the curtain wall. To ensure that the end of the membrane remains in place, a "U" mould is used to exert pressure on the membrane located between the frame and the pressure plate. This mould is screwed to the frame. Refer to figure 13.

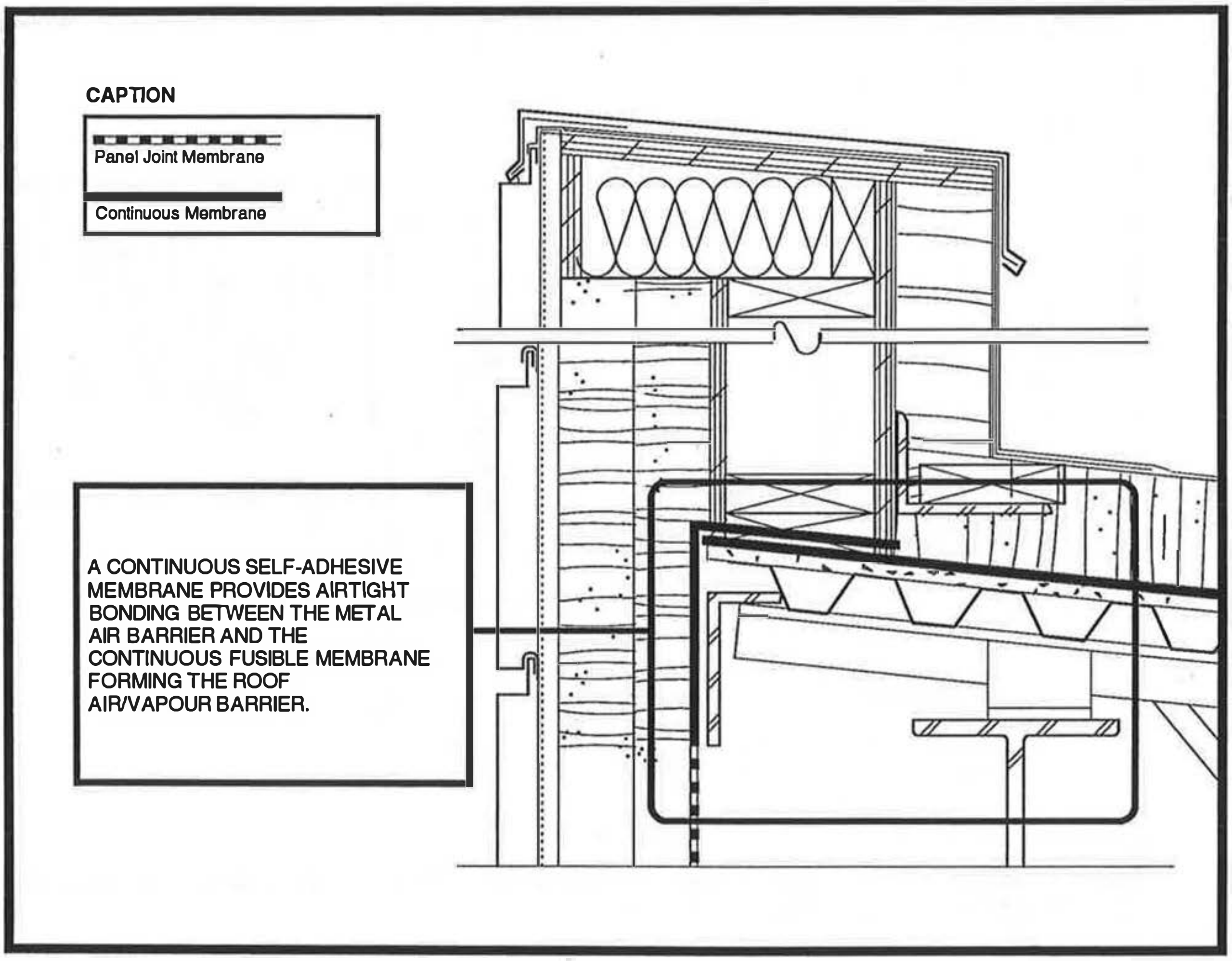


SANDWICH PANEL AIR BARRIER/CURTAIN WALL JUNCTION
TOP VIEW

FIG. 13

At Joint with Roof:

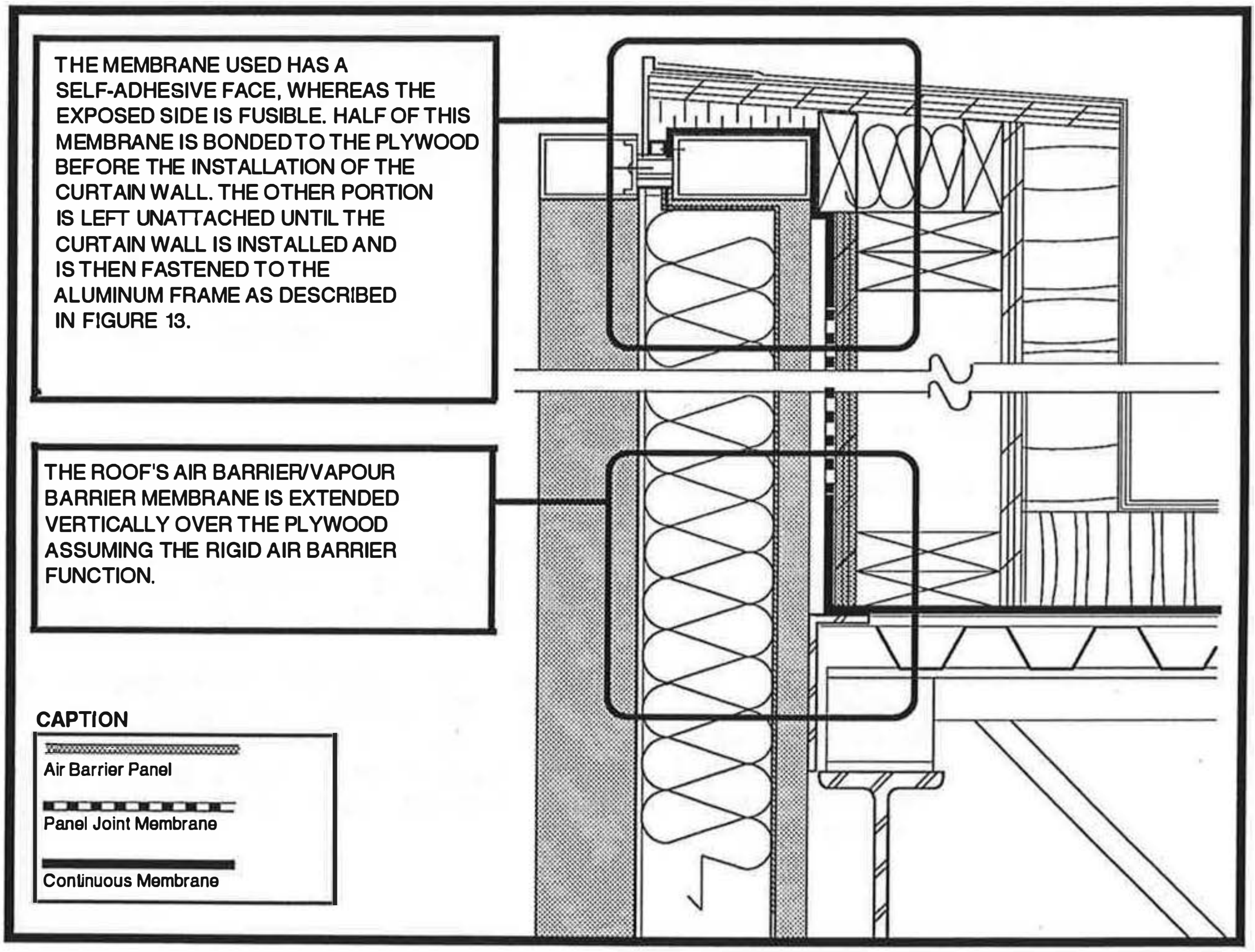
Figure 14 shows that it is necessary to discontinue the interior steel facing at a certain level to execute the joint between the sandwich panel air barrier and the roof air barrier.



CONTINUITY OF METAL AIR BARRIER WITH ROOF AIR/VAPOUR BARRIER

FIG. 14

Moreover, along the curtain wall, the air barrier joint has to be executed on the upper side of the parapet. Work scheduling constraints mean that the frame of the parapet must be built before the curtain wall is installed. The sealant membrane is applied beforehand on the exterior side of this frame and left there while the curtain wall is being installed. The following stage consists in sealing the portion of the membrane left free on the aluminum frame and then attaching the end of the membrane in the cavity between the frame and the pressure plate using the aluminum "U" mould. Refer to figure 15.



CONTINUITY BETWEEN
ROOF AIR BARRIER/VAPOUR BARRIER AND THE CURTAIN WALL

FIG. 15

4. Air Barrier Structural Resistance

Wind Loads:

a) The sandwich panel's structural resistance was calculated by the manufacturer's Engineering Department to meet the requirements as we had defined them. The metal guage as well as the spacing of the metal support furrings are the two parameters to be considered.

b) Joint system separation resistance: the system advocated by the manufacturer for steel sheet joints on the inner side was limited solely to butyls. We chose to add strips of sealant membrane over the joint between the two interior sheets. First of all, we developed a concept in which a fusible membrane was used. The membrane and steel manufacturers brought up fears as to the effect of heat produced by the blow torch on the prepainted steel siding. These fears were focused mainly on the possibility of the paint peeling or changing colour. Since this joint membrane is located on the warm side of the wall, we were able to accede to their request and to replace the fusible membrane with a self-adhesive one. In fact, the interior steel facing, for all intents and purposes, will not be exposed to any temperature variations. The expansion/contraction phenomenon induced by variations in temperature will be reduced. The tensile force exerted on the membrane will thus be reduced accordingly.

5. Vapour Barrier vs. Air Barrier

Here, we have a particular case illustrating that the air barrier and vapour barrier functions may be located on the same plane, using the same materials.

6. Inspection

The enclosed photos show different work stages.

Photo 1: The first interior metal panels are temporarily fastened to the horizontal plates to close the building off as rapidly as possible. These plates are bonded to the columns and regular spacing will ensure the structural resistance required.

Photo 2: The application of the self-adhesive air barrier membrane along thevertical joints formed by the metal panels. The application of a primer coat greatly increases the adherence of the air barrier membrane. The same sealing technique is applied to all the horizontal joints. It is noted that the metal furring is fastened with stainless steel bolts and separated from the plates by neoprene washers.

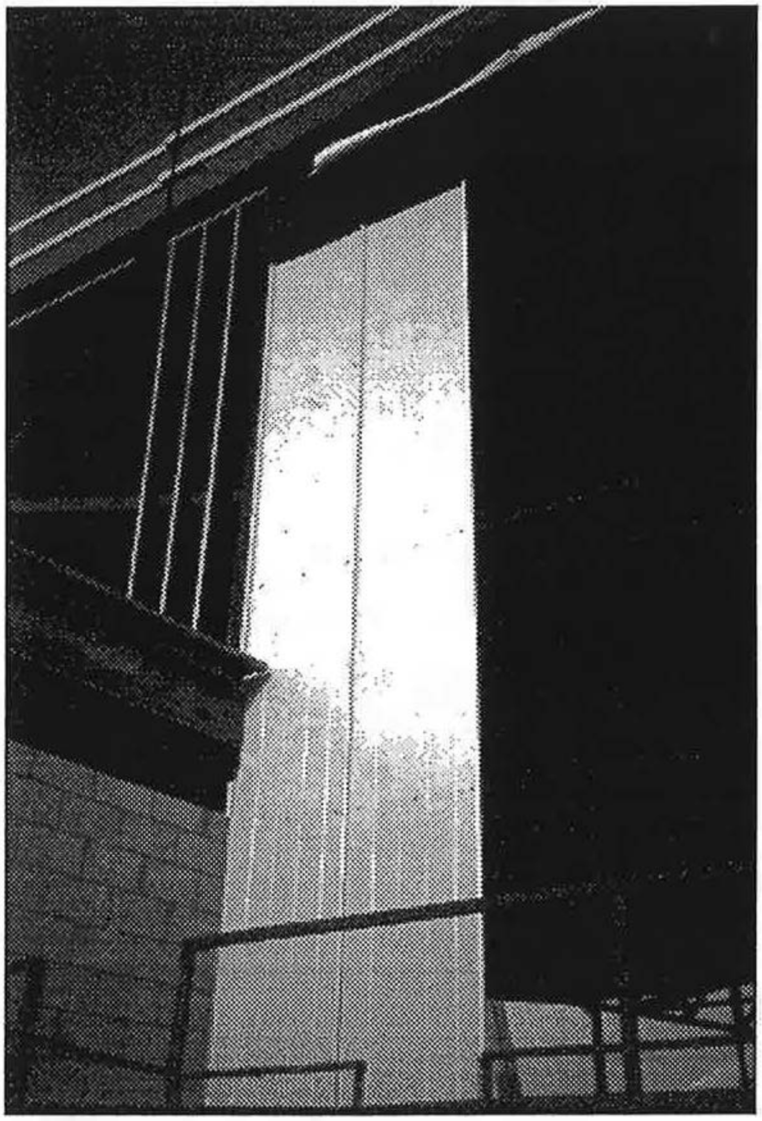


PHOTO 1

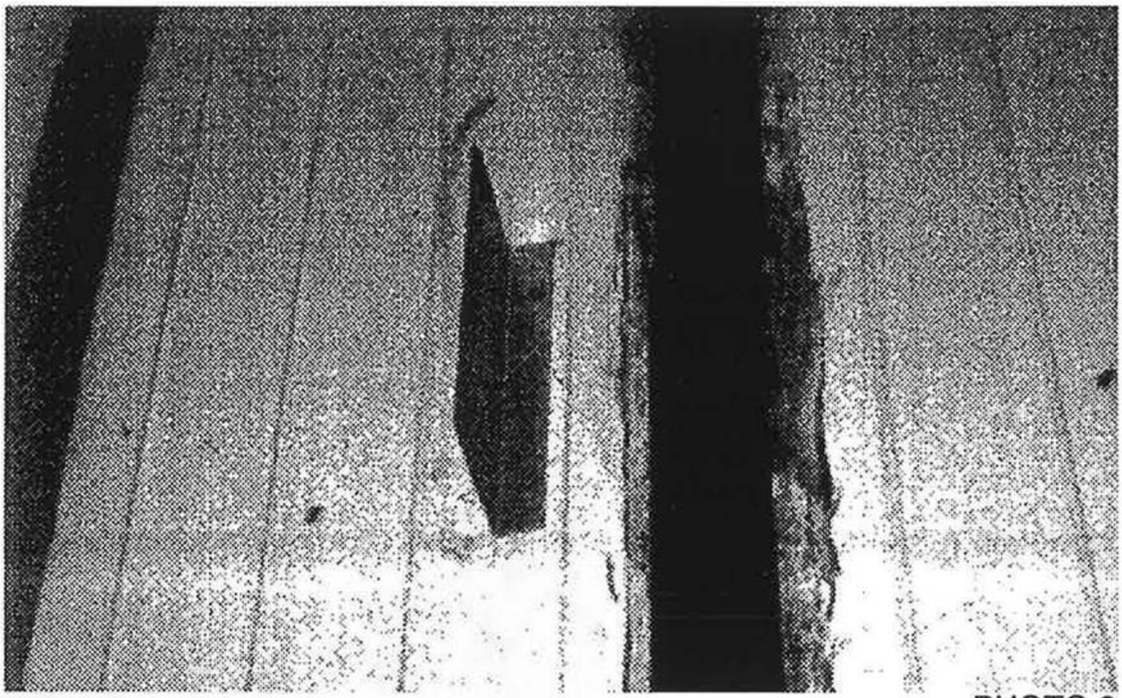


PHOTO 2

PHOTO 3: Installing, in a preordained manner, the self-adhesive anchoring devices which are to hold the exterior insulation in place. By slightly heating the base of theanchors, adhesion to the metal panel is increased.

PHOTO 3

CASE 4
NEW BUILDING WITH WOOD STRUCTURE

1. Performance Standards

Longevity:

The air barrier must retain its effectiveness throughout the building's useful life to ensure proper interior ambient conditions and to prevent premature deterioration of the building envelope.

Air Tightness Level:

The case which we explain here applies to a single-family house. Application of Part 5 of the NBC 1995 is not mandatory for this type of small building. We recommend that it be applied nevertheless. We evaluated that the percentage of relative humidity inside this type of building should be between 27% and 55%. According to preliminary documents on the NBC 1995, it is recommended that the maximum permeability rate be 0.10 L/S-m^2 for this relative humidity reading, all this in a pressure differential context of 75 Pa. Refer to case 1 for the different levels of airtightness in line with the requirements of the future code.

Air Barrier's Structural Resistance:

The concept presented below was developed to meet a design loan of 1 kPa in accordance with the requirements described in case 1.

2. Materials Used

Type of Rigid Air Barrier:

The following three materials: light concrete panels, plywood and waterproof gypsum board may be used under the concepts developed below. In the case of waterproof gypsum board, the rate of permeability will be over the maximum required of 0.10 L/S-m^2 at 75 Pa, (refer to chapter 4, case 2). The choice of one of these materials will be based on the performance desired as well as on budgetary considerations. See their reciprocal performances in chapter 2. All these materials are not considered as vapour barriers with the exception of the plywood which will assume the dual air and vapour barrier function. See plywood specific recommendations in point 5 below. Where gypsum board is used, the risks of damage due to rainwater infiltration behind the masonry should not be minimized. The recommendation here is that a high density polyethylene sheathing be used. This will be applied on each rigid insulation strip and extended under the following strip to act as flashing and thus reduce the risks of water infiltration behind the insulation.

Type of Jointing:

Fusible membranes may be used in virtually all cases with the exception of areas where it becomes impossible to use the blow torch for installation purposes without damaging adjacent components. Installing this membrane should also be avoided in areas where there is a danger of fire. It should be noted that installing such a membrane with a blow torch on gypsum board does not represent any risk of fire for experienced workers.

Here we used an elastomer bituminous membrane with a cloudy polyester structure, applied on a primer bituminous and inflammable volatile solvant base coat with the addition of adherence enhancers.

We limit use of the self-adhesive membrane to specific areas where it is impossible to use the blow torch. This may mean, among other situations, a strategy designed to fasten the membrane directly to a window frame, as using a blow torch here would damage the frame. It should be pointed out that self-adhesive membranes can only be installed in mild weather. Minimum exterior temperature is 10ºC for most products. In addition, self-adhesive membranes must be well supported to avoid separation. The fact of the matter is that although the fusible membrane can cover orifices 50 mm in diametre (maximum) without any risk of separation, the same cannot be said of most self-adhesive membranes. Refer to chapter 2.

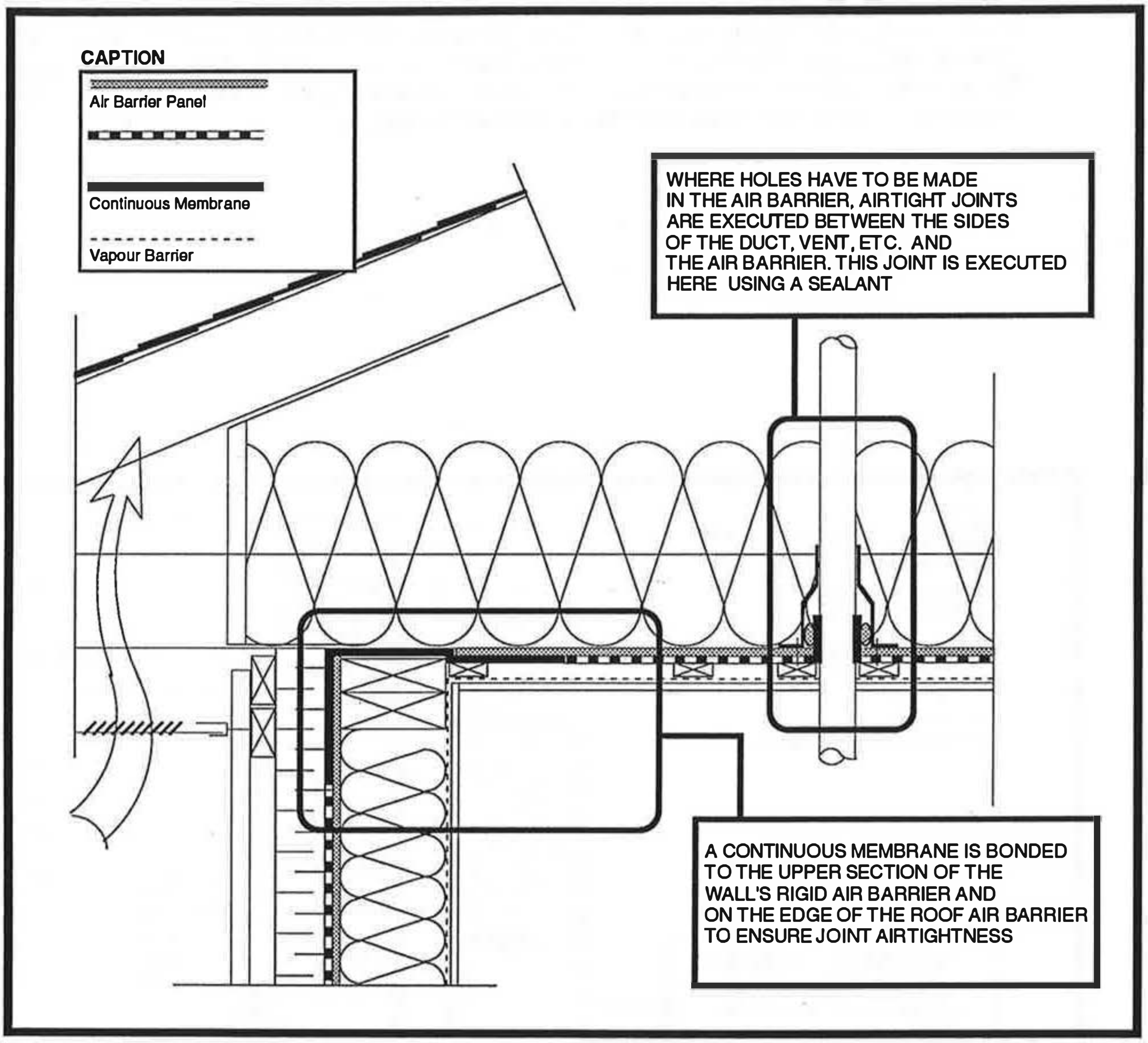
Type of Insulation Fastener:

The insulation must be mechanically fastened to ensure long term adherence. An adherence defect allowing for air to leak behind the insulation necessarily reduces the thermal resistance of the assembly drastically.

3. Continuity of Air Barrier

Along the Roof:

The concept presented here makes provision for a double application of the rigid air barrier. The first applies to the walls and the second to the ceilings. This concept is executed according to a very simple schedule: after having put up the structure for the exterior walls and the rigid air barrier covering the latter, the builder installs a strip of continuous membrane on the upper end of the walls. The lower portion of the membrane is fastened to the wall air barrier whereas the other section is left unattached on the inside of the walls. The roof trusses will then be installed and will be used as nail backing for the rigid roof air barrier. The unattached portion of the joint membrane will then be fastened to the ceiling air barrier material and all the joints in this material will be sealed. A finish gypsum board and a vapour barrier will then be installed to cover the ceiling air barrier. The vapour barrier function may be assumed by a paint with adequate vapour barrier properties . Our preference here, however, is for a separate vapour barrier film, applied before the finish gypsum is installed to ensure better work execution control. The designer must ensure that the builder is provided with all the guidelines making it possible to execute proper sealing around the holes which have to me made in the ceiling for vents, ducts, etc.
Refer to figure 16.

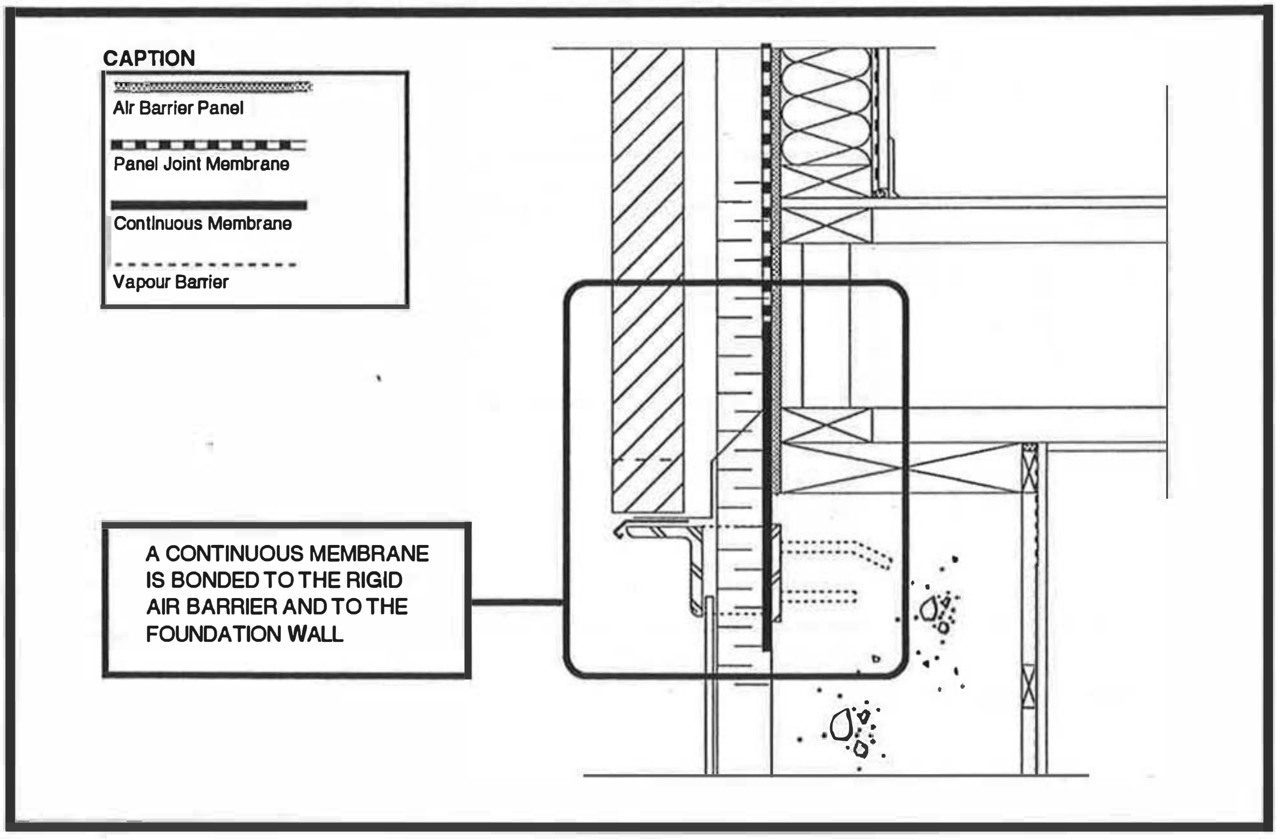


ROOF AIR/VAPOUR BARRIER IS BONDED TO WALL AIR BARRIER

FIG. 16

Along the Foundation:

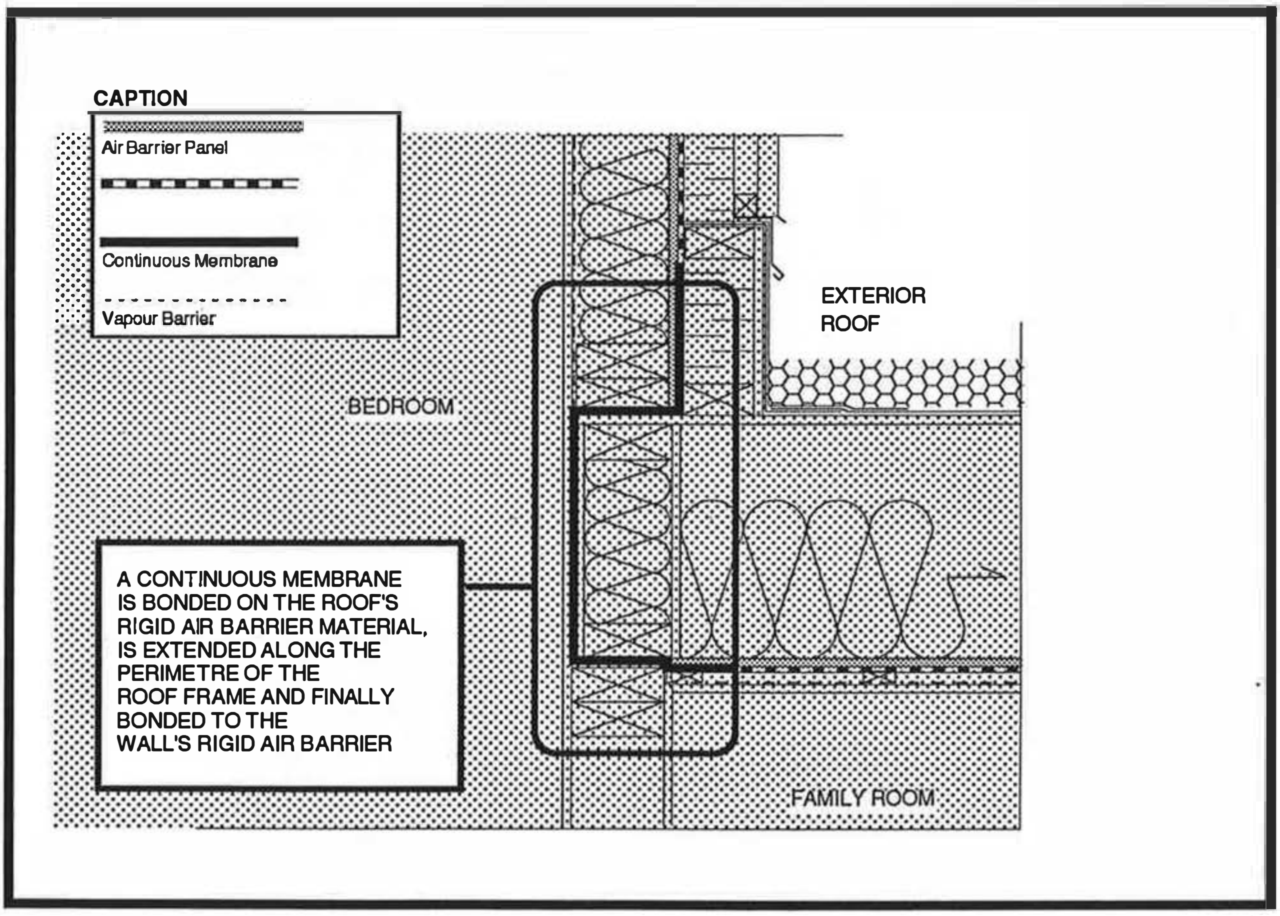
Figure 17 illustrates masonry siding supported by a galvanized shelf iron. In addition, the traditional method consists in supporting the masonry using a tie in the foundation wall. These two concepts make it possible to provide continual air tightness by the use of a 200 mm strip of membrane bonded to the wall's rigid air barrier and to the concrete foundation. In the lower part of the foundation wall, the latter may be considered itself as an air barrier given its thickness. We believe, moreover, that the support method indicated in figure 17 has numerous advantages since it ensures integral continuity of the insulation and reduces temperature spreads to which the foundation wall is exposed.



RIGID AIR BARRIER/FOUNDATION WALL JUNCTION FIG. 17

Roofs With Various Levels:

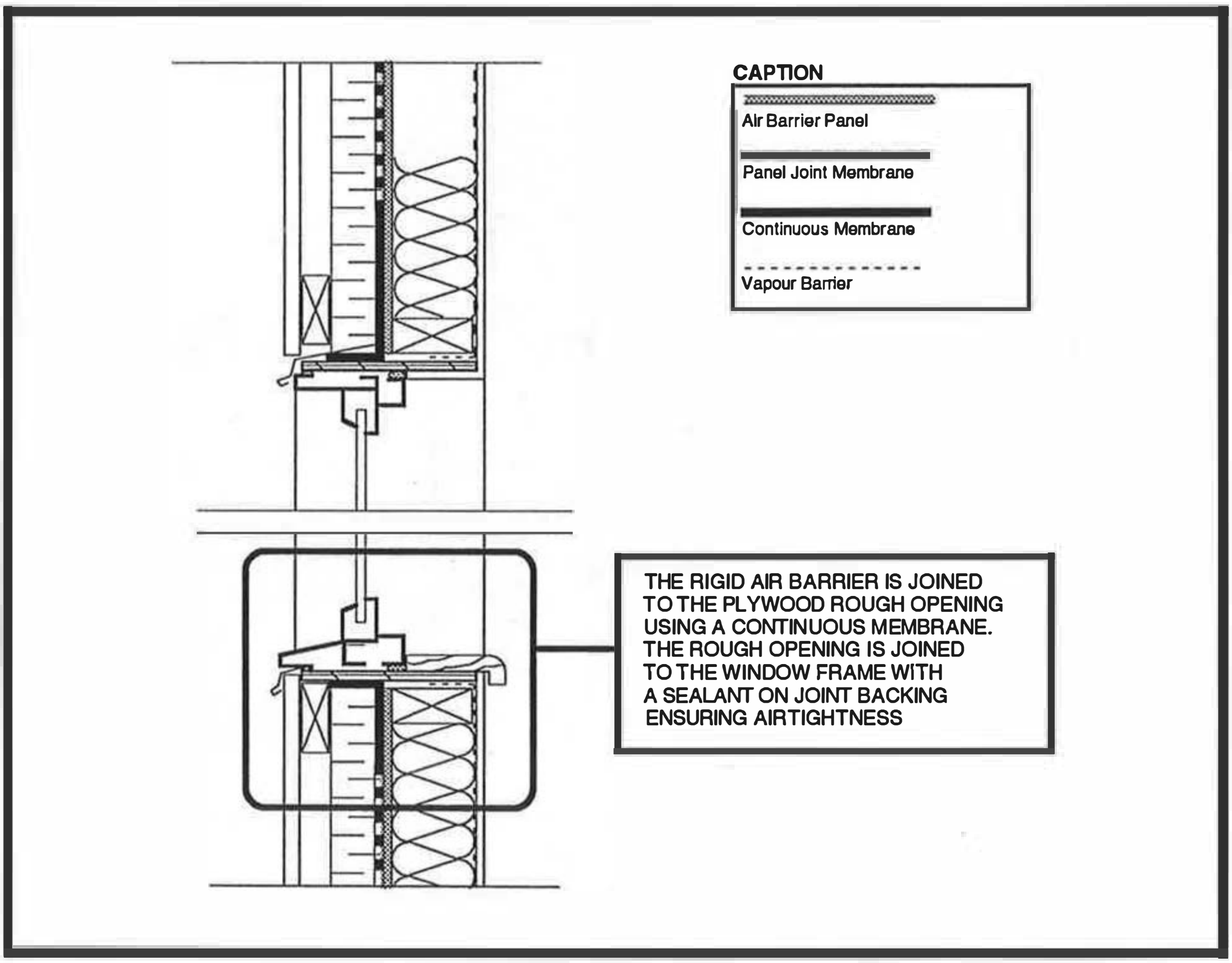
This type of building often has a number of recesses, overhangs, returns, etc. The air barrier must not be interrupted anywhere and its continuity must be ensured in all locations with potential for temperature differentials. Refer to figure 18.



CONTINUITY OF AIRTHIGHTNESS ALONG ROOF JOINT LOCATED AT THE LOWER LEVEL OF AN ADJACENT WALL. FIG. 18

Around Windows:

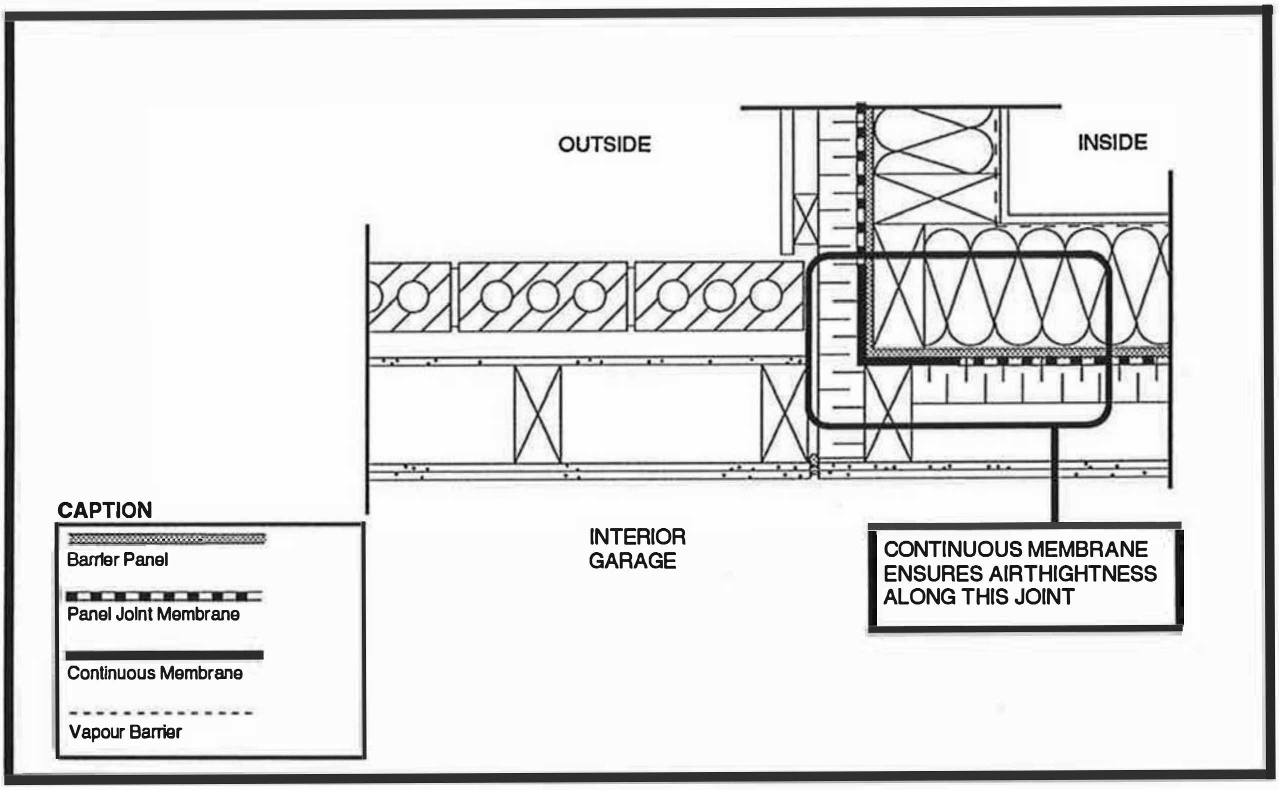
The window extrusions must be studied to ensure that the air barrier is effectively bonded. The bonding plane must be studied to avoid any possible infiltration between the various components of the frame. Refer to figure 19.



WALL AIR BARRIER/WINDOW FRAME JUNCTION FIG. 19

Unheated Spaces:

Particular attention is to be paid to areas between heated and unheated spaces such as garages. Refer to figure 20.



AIR BARRIER ALSO SEPARATES HEATED AND UNHEATED SPACES. - TOP VIEW

FIG. 20

4. Air Barrier's Structural Resistance

Refer to case 1.

5. Vapour Barrier vs. Air Barrier

With the exception of plywood, the rigid materials installed to produce air barriers are not vapour barriers. Vapour barriers must thus be a part of the assembly and must be installed on the warm side of the insulation. As for plywood, it is a vapour barrier. The fusible membrane used to seal the joints is also a vapour barrier. It is thus possible to conclude that if the air barrier plane is very air tight, the air barrier can also assume the vapour barrier function and very effectively at that. On the other hand, choosing plywood necessarily means that no insulation can be installed on the warm side of the latter. Otherwise, the water vapour from the inside of the building will inevitably build up inside this insulation material.

The sealant materials have as a characteristic to simultaneously assume the vapour barrier function. The principles of water vapour conveyance must be taken into consideration when working on the details. Installing the membrane in such a fashion as to trap water vapour contained in wood elements where the latter are located between the air barrier and the vapour barrier, and where the wood element is exposed to cold, is to be avoided.

CHAPTER 4
VERIFICATION OF IN SITU PERFORMANCE

The theoretical basis which we used to develop the concepts presented in chapter 3 is essentially grounded on reports presenting the results of laboratory tests conducted on materials separately or in relatively simple assemblies. By extrapolation, based on this theoretical data, we have been able, over the past ten years, to globally assess the behaviour of complex assemblies as they appear in real on site conditions. Today, to confirm with precision these performance hypotheses, we advocate the execution of tests directly on the assemblies which will be incorporated in the buildings which we produce. Generally, the application of this verification procedure means that part of the construction budget will be allocated to pay for these tests. Specialized companies will be mandated to conduct the tests and the architect will analyse these reports and recommend requisite corrective measures. Here we present two examples where such a procedure was developed.

The first example applies to a rigid air barrier made of sandwich panels with steel facing identical to that in the system presented in case 3 in the preceding chapter. In this example, the verification procedure was completely described in the specifications. On the other hand, unforeseeable budgetary constraints forced our client to abandon it. Thus the text which follows contains only the procedure which we specified without any results.

The second example applies to a rigid air barrier system similar to that presented in case 2 in the preceding chapter. Tests were conducted and comments provided on the results obtained.

EXAMPLE 1
SANDWICH PANELS WITH STEEL FACING

As specified in case 3 in the preceding chapter, the rigid air barrier is formed by the inner metal facing of the sandwich panel. Refer to figure 11.

The performance verification of the system was to be conducted in three stages described below. The performance criteria to be respected were defined as follows in collaboration with a specialized engineer;

1. Performance Criteria

a) Air Tightness: When tested against ASTM E283 for the laboratory tests and against ASTM E783 for the in situ tests, with a differential of 75 Pa, the air infiltration rate must not exceed 0.05 L/S-m^2.

b) Resistance to Wind Induced Loads: Respect the NBC requirement for a design load of 1.5 KPa. In negative or positive pressure, no permanent deformation or shearing of the anchoring devices shall be observed and, at 0.3 KPa, no canning effect shall be heard.

c) Sag: The steel panel shall withstand a load of 1KPa in twin span with a maximum sag of L/90.

2. First Verification Stage

At the design stage, we studied a number of air barrier systems before making our choice. Our analysis made it possible for us to assess that the sandwich panel with steel facings presented excellent possibilities for meeting the requirements at minimum cost. The main points of our analysis may be summarized as follows:

a) the particularly high humidity conditions in this building led us to choose a material which was entirely airtight, such as steel, to assume the air barrier function;

b) the materials chosen to execute airtight joints were assessed in a laboratory as possessing a level of airtightness above that required;

c) the air barrier is located on the warm side of the envelope. The joints between the various materials making up the air barrier system thus are not exposed to major movements due to temperature spreads;

d) engineering calculations made it possible to assess the panel's resistance and the spacing of the support elements making it possible to ensure the wall's integrity;

e) it was possible for us, at the detail design stage, to ensure that no load induced by another part of the building would rest on the air barrier;

f) wind loads will produce a deflection in the panel between the support points. Engineering calculations have made it possible to define that this sag would not threaten the solidity of the wall. On the other hand, a laboratory test carried out on a sample panel would have allowed us to verify precisely that this sag would not damage the airtight nature of the system. Indeed, too much sag may produce differential movements between the components of the air barrier system and thus induce partial separation of the sealant elements (membranes and others). A request thus appears on the specifications to require the manufacturer to conduct tests confirming compliance with the performance requirements before preparing the shop drawings.

3. Second Verification Stage

This second stage consisted in verifying the air barrier system's performance at the start of the construction work. The goal here is to verify the methods used to install a portion of the façade. This verification stage allows the general contractor to confirm with the architect that the methods which he intends to use are adequate and that they will make it possible to meet all the performance levels required under site conditions. The execution procedure for these tests is described in the specifications as follows:

a) tests shall be conducted on site on a wall section selected by the architect once the panels are installed and the joints sealed;

b) the contractor will hire the services of a testing laboratory recognized by the Standards Council of Canada (SCC); all the tests will be at the contractor's expense;

c) should the test results not satisfy the described requirements, the contractor shall take corrective measures and make the necessary repairs;

d) subsequent to the corrective measures, the contractor shall demonstrate compliance with the requirements by repeating, at his expense, the test(s) which were not passed at the first attempt; these tests shall demonstrate compliance at two locations as chosen by the architect.

4. Third Verification Stage

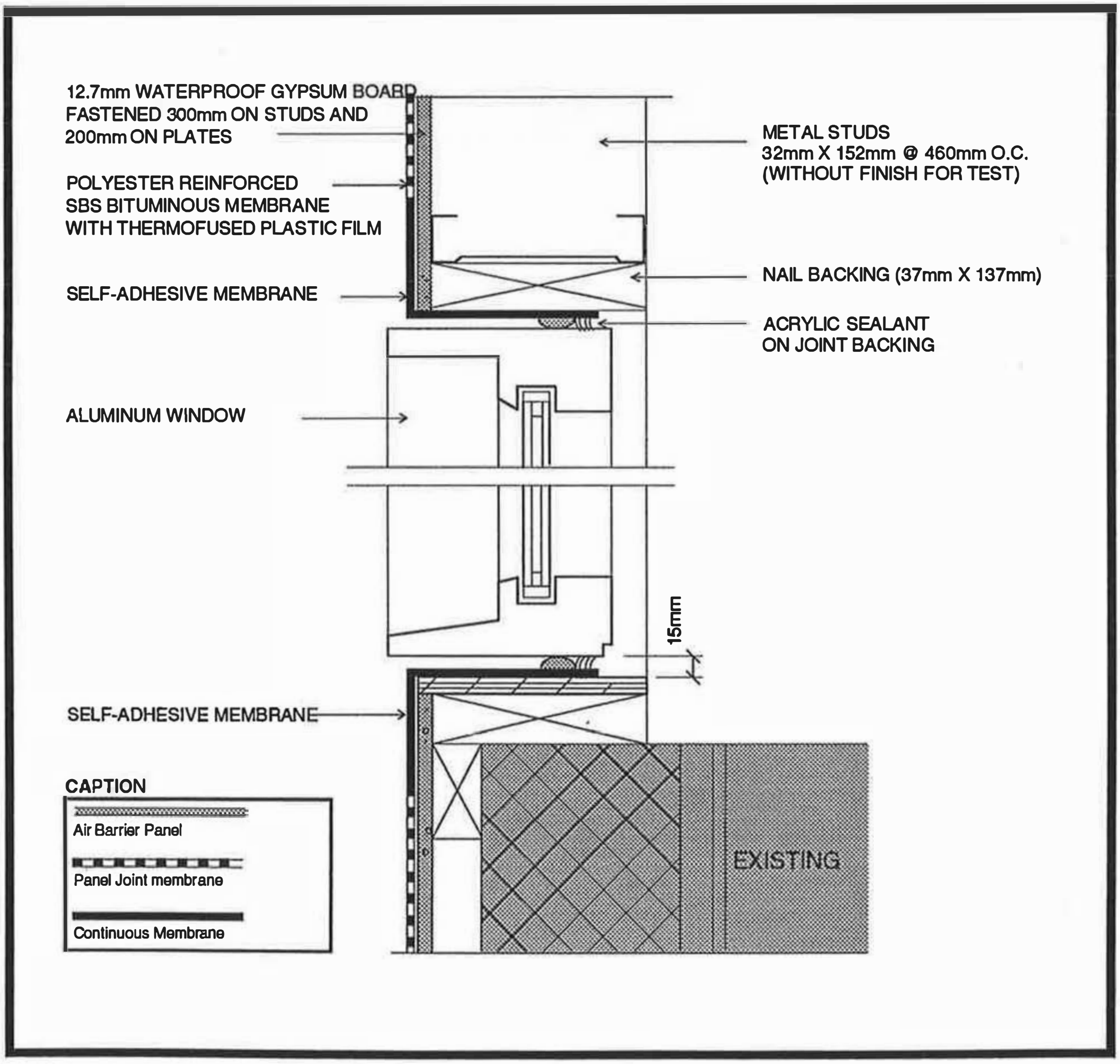
The third stage consisted in verifying, once the work was completed, the effectiveness of the air barrier on all the façades using a thermal analysis. The tests conducted on a prototype made it possible for us, based on an indepth analysis of an exterior wall section, to assess the installation procedures proposed by the contractor. It is still essential, however, to verify, once the work is completed, the quality of the work as a whole. This is why we asked in the specifications for a thermal analysis of all the façades at the end of the work. The indications provided by this analysis are quite revealing as to the air-tightness of the air barrier. They are sufficiently detailed to make it possible to determine whether defects are the result of a lack of insulation or of exfiltration of warm air. A thermal analysis of the whole envelope makes it possible to verify whether the contractor has consistently executed a high quality air barrier for each joint and for each façade.

EXAMPLE 2
SEALED WATERPROOF GYPSUM BOARD SIDING

Verification of the performance of this system is conducted in two stages:

1. **Evaluation of the Performance of the Air Barrier System at Start of Work**

   To proceed with the evaluation, a precise scheduling of the tasks was required. After demolishing the existing walls, the contractor, on one façade section, installed metal studs, gypsum board, membrane, new windows and masonry anchors. At this stage, no other insulation material, gypsum board finish or siding was installed.



COMPOSITION OF ASSEMBLY ON WICH AIR BARRIER TESTS WERE CONDUCTED — FIG. 21

Figure 21 shows a cross section of the assembly which was tested. Here are the components:

a) 32 mm x 152 mm @460 mm o.c. metal studs
b) 12,7 mm waterproof gypsum panels
c) gypsum board fastened every 300 mm on studs and at 200 o.c. on plates.

Note: Fastening interval on the prototype did not correspond to requirements in specifications stipulating an interval of 200 mm o.c. along the studs and at 150 mm o.c. at top and bottom plates. For the purposes of verifying our requirements, we agreed with the client and the contractor to conduct tests without modifying the prototype, i.e., without complying with the specifications.

d) Polyester reinforced SBS bituminous membrane with thermofused plastic film, bonded using a blow torch to the primer coat on wall. 200 mm wide strip applied on each joint and covering whole surface of concrete column.
e) self-adhesive membrane covering the nail backing, 37 mm x 137 mm, and extending 100 mm over the rigid air barrier.
f) Acrylic sealant on joint backing ensures air tightness between the window frame and the self-adhesive membrane applied on the rough opening.
g) adjustable brick anchors.

The prototype, measuring 3,048 mm in height and 4,471 in width, was located on the ground floor. It included a wall section, one column and a composite window. Refer to photo 1.

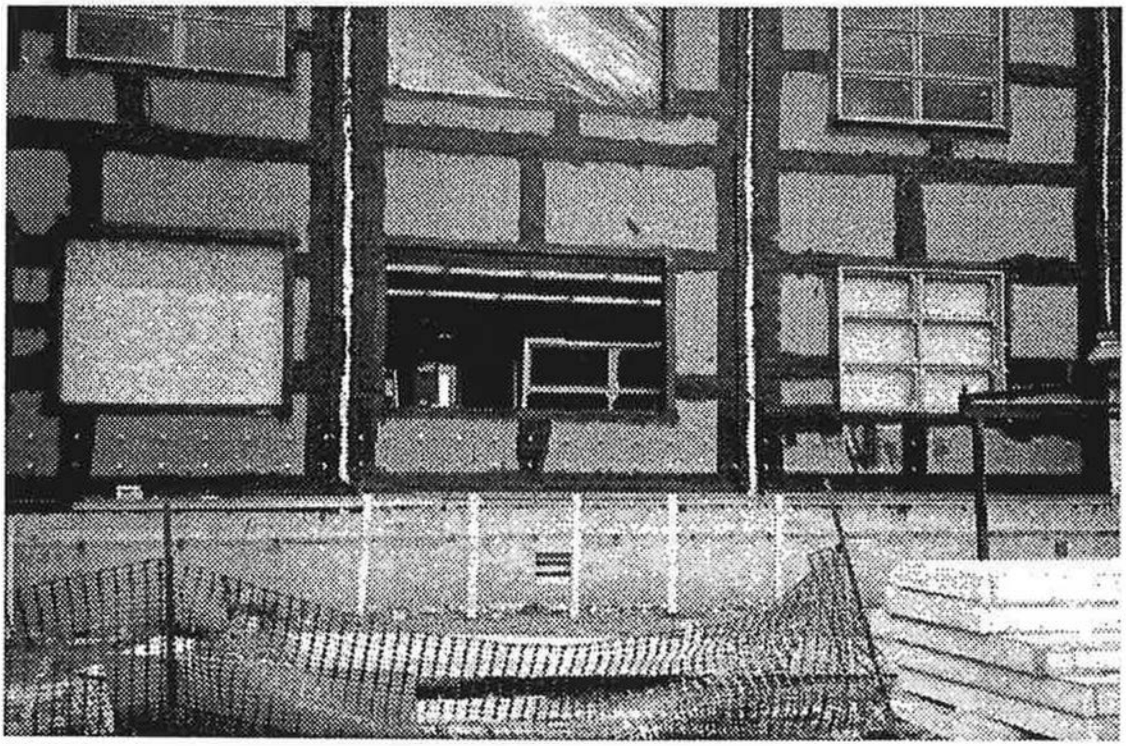


PHOTO 1

To run the tests, an airtight chambre was prepared to cover the sample area. This wood chambre, shown in photo 2, was to be rendered airtight and to be firmly fastened to the wall. It is coupled with a rotary blower which makes it possible to create pressure differentials.

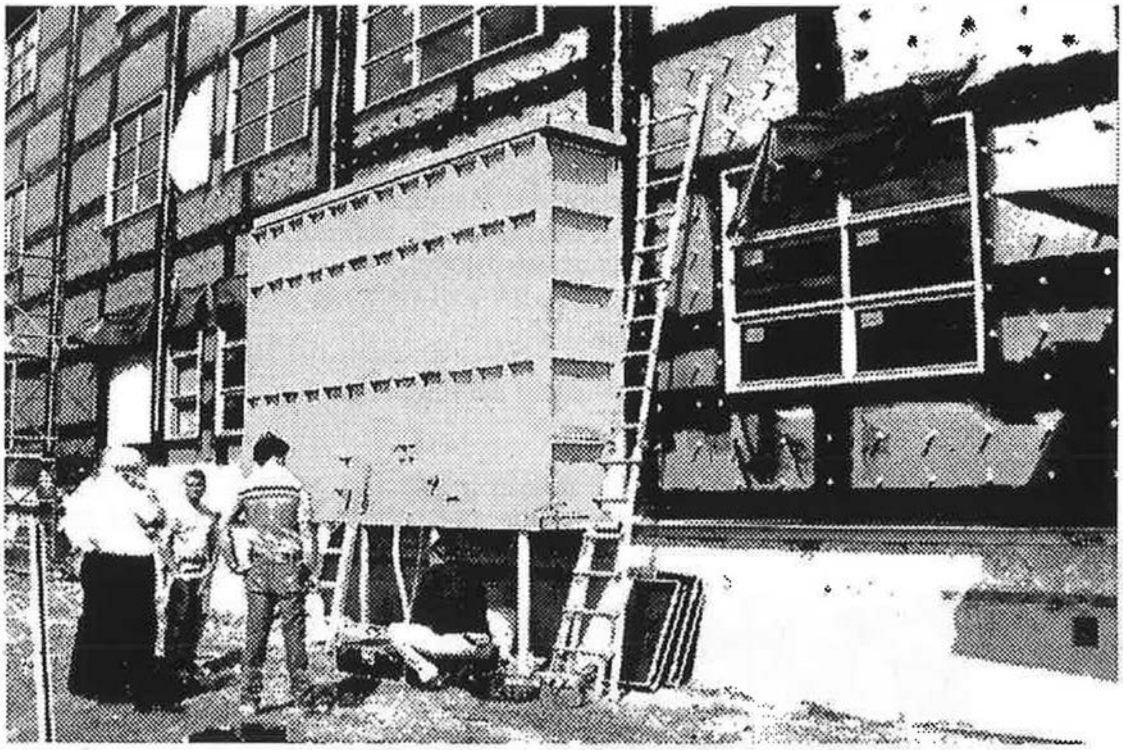


PHOTO 2

Photo 3 shows the sample seen from the inside. Electronic movement sensors are installed on the various components of the prototype.

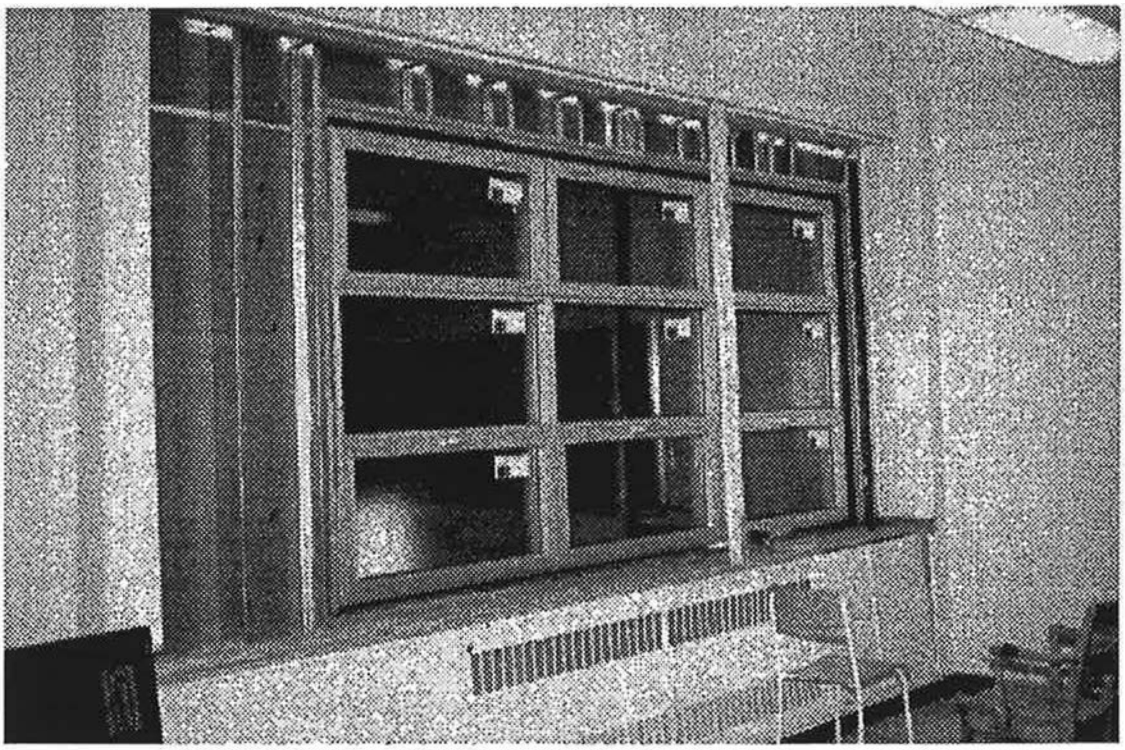


PHOTO 3

Once this chambre and the equipment is installed, the specialist proceeded to run 3 different tests: the window's performance was also tested but, in this document, we will limit our analysis to that of the rigid air barrier.

1st Test:

requirements: - air infiltration with pressure differential of 75 Pa as per standard ASTM E283.
- maximum air flow allowed as per specifications being $0.15\ L/S\text{-}m^2$.

results: - results showed an air infiltration rate of $0.147.\ L/S\text{-}m^2$. This measurement it thus very close to the $0.15\ l/s.m^2$ limit.

2nd Test:

requirements: -rigidity of metal studs with pressure differential of 1 kPa as per standard ASTM E330.
-maximum sag allowed in metal studs should be below their span over 175.

results: -sag in metal studs proved to be practically nil. In fact, as the studs only extended up approximately 2 m to fill in the existing openings, sagging of the studs is not a critical element. This is of course not the case when 100 mm deep studs are used over the full height of a storey.

3rd Test:

requirements: -system's mechanical resistance with a pressure differential of 1.5kPa as per standard ASTM E330.
-no permanent deformation in the system
-no delamination of the membrane
-no transfer of horizontal load on unanticipated elements to support these loads (masonry siding, for example).

results: -for the depression test, we observed separation in the gypsum board along fastening points. The test thus showed that fastener spacing at 300 mm o.c. along the studs and at 200 mm along the top and bottom plates is insufficient. No transfer of horizontal load or delamination of the membrane was noticed. We also observed that the sealant joint was able to resist a pressure differential of 1.5 kPa. Subsequent to these tests we were able to validate the performances of our concept as well as the contractor's installation methods. In addition, we had the spacing between the fasteners changed to comply with the specifications.

2. Thermal Analysis

Very often, the methods used for the thermal analysis cannot be used in mild weather. This is a problem in that it is not always possible to conduct the thermal analysis immediately after the execution of the air barrier. Since winter weather is necessary, the insulation and siding work are completed. The defects to be corrected subsequent to the thermal analysis report results will thus mean higher costs since the siding will have to be removed to undertake the corrective measures.

The thermal analysis conducted on this project made it possible for us to detect 4 defects, 2 of which were not visible to the naked eye. The contractor proceeded with the repairs and we are now sure that the air barrier is properly installed.

CHAPTER 5
CONCLUSION

Air barriers applied to walls represent a major factor ensuring building airtightness. A number of types of systems may be installed. The rigid air barrier system is one of these types and it has proven to be both effective and economical.

The reason for providing details on the application of this system in various typical situations and on the bonding details in this document is to assist in visually understanding how such a system is installed. These details cannot be used by designers without thorough understanding of the principles governing the application. These principles are described in detail in a number of publications dealing with the constraints inherent in the air barrier system and indicating the relevant rules of physics.

There is absolutely no doubt as to the necessity of installing air barriers in buildings. Airtightness is required under the National Building Code.

The preliminary documents prepared by Associate Committee on the NBC for the future 1995 edition inform of the requirement levels which will have to be respected shortly by builders and designers as pertains to the installation of these air barriers. As these performances have now been defined, they can be used starting immediately.

In addition, we will see develop, over this decade, numerous in situ tests making it possible to establish with precision the performances for a whole range of air barrier assemblies installed in buildings. Similarly, the laboratory tests, assessing existing materials as well as those to be developed in the future, will become crucial. This data will be necessary for us to ensure that the performance criteria prescribed in the 1995 edition of the National Building Code are applied.

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