#4307

Roof/Wall Intersections

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ABSTRACT

One of the highest percentages of moisture problems found in buildings is at the roof/wall intersection. This paper discusses the principles of good design practice for positioning air and vapour barriers at roof /wall intersections. Design principles for a number of types of roof and wall construction are discussed.

The building science principles of roof/wall intersection designs were first refined by the Air and Moisture Subcommittee of OBEC, the Ontario Building Envelope Council. A major roofer, an architect and a roofing inspector worked with the committee members refining designs submitted by designers and manufacturers.

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A. INTRODUCTION

The area of buildings with one of the highest percentages of moisture problems is the roof/wall intersection, that segment of construction always tied-in by "others". This paper discusses the principles of good design practice for positioning air and vapour barriers at this intersection. Tie-in details for a number of generic types of construction will be reviewed in light of the principles. It is recommended that the designer should designate responsibilities for tie-in installation within prebid specifications. Such an important construction aspect should not be left open to any misunderstanding!

Design recommendations in this paper are for the information of the project designer. The project designer, engineer or architect is responsible for the suitability and performance of a design. A few of the assembly designs contain insulated flashing design aspects subject to a pending patent, designers may contact the patentor, Douglas Fishburn at 416-878-1282.

B. SYMPTOMS

Buildings with tie-in problems at the roof/wall intersection may exhibit a number of symptoms. The most obvious is an air leakage plume of moisture over the parapet evident in cold weather. Many buildings show white efflorescence stains on the bricks at the top of the wall. Some old buildings with glazed surface bricks are subject to spalling in this area.

Other buildings show icicle formation at the air leakage cracks while a few develop leaks when accumulations of ice within the wall assembly melt.

C. BUILDINGS REQUIRE AN AIR BARRIER SEAL

1. Air Barriers are a Code Requirement:

Since National Building Code-1985, section 5.3 was adopted by all provincial Building Codes and is not proposed to be changed in NBC-1990, all designers and contractors are required to create or install a continuous air/vapour seal from footings to the roof all around a building to meet the intent of this Section.

National Building Code of Canada - 1985 states:

> "Section 5.3 - Control of Air Leakage
> Section 5.3.1 - Air Barriers
> 5.3.1.(1)
> Where a building assembly will be subjected to a temperature d a differential in water vapour pressure and a differential in due to stack effect, mechanical systems or wind, the assem designed to provide an effective barrier to air exfil infiltration, at a location that will prevent condensatio assembly, through
> (a) The materials of the assembly
> (b) Joints in the assembly
> (c) Joints in the components of the assembly, and
> (d) Junctions with other building elements."

Because of this new code requirement building owners may take legal recourse against designers and contractors who create leaky buildings!

2. Why is an AIR BARRIER needed?

Rick Quirouette (while he was at NRC, Ottawa) wrote in Building Practice Note 54 [1]: "The principle function of the air barrier is to stop outside air from entering the building through the walls, windows or roof, and inside air from exfiltrating through the building envelope to the outside. This applies whether the air is humid or dry, since air leakage can result in problems other than the deposition of moisture in cavities. Exfiltrating air carries away heating and cooling energy, while incoming air may bring in pollution as well as disable a rain screen wall system."

3. What is an AIR BARRIER?

Air barrier materials shall be structural elements of a building such as: precast concrete, metal panels, plywood, gypsum boards, or glass sheets. Flexible or built-up membranes supported by or fastened to structural elements may act as an air barrier system or as the tie-in between structural air barrier elements.

4. What must an AIR BARRIER do?

(1) The installed materials of the air barrier assembly must resist the highest expected air pressure load, inward or outward, without rupturing or detaching from the support.

This highest air pressure may come as:

(a) a wind gust load or suction, coupled with

(b) a stack effect (from the difference in density between warm inside air and cooler outside air a slight outward positive pressure occurs at the top of a building and a slight inward negative pressure occurs at the base) and

(c) fan pressurization or depressurization by ventilation equipment.

[Pressure loads are approximately: 1000 to 2500 Pa for wind gusts, 5 - 20 Pa for stack effects and about 5 - 10 Pa for fan equipment.]

(2) Tie-in membranes shall be structurally supported for the maximum area; unsupported membrane areas and adhered membranes shall have sufficient adhesion and long term strength, elongation and flexibility properties to carry out their functions for the life of the building.

(3) The materials must not creep away from a substrate or cause any opening of a joint under a sustained air pressure difference (e.g. stack effect or fan pressurization).

(4) Any bridged joints shall also be designed to take maximum joint movement.

(5) The deflection of the air barrier materials between supports must be minimized to prevent displacement of other materials (e.g. insulations).

5. Can Air and Vapour Barriers be Combined?

Wall, Roof and Intersection assemblies require an air barrier and possibly also a vapour barrier or retarder. They may or may not be the same material. But each combined system must meet the design requirements for both functions.

6. Air/Vapour Barrier Positioning

Principles:

(1) Ideally, all membranes and interior surfaces of structural materials forming part of the air/vapour seal should be inside the insulation or above the dew point temperature of air in the assembly all year round.

(2) Providing materials inside the continuity seal can absorb and handle the volume of moisture produced, portions of the year may have condensation within this seal.

(3) Flexible membranes adhered to or supported by moisture sensitive structural elements such as gypsum boards require the elements to be kept sufficiently dry. Accumulation of excessive moisture (e.g. due to high interior relative humidity from curing concrete in newly constructed buildings) in exterior sheets of drywall sealed with flexible membranes may be prevented by early installation of sufficient exterior insulation.

(4) Likewise, air barrier membranes and coatings adhered to the exterior surface of an interior masonry wythe should have exterior insulation installed to prevent water saturation and possible frost action, which might cause masonry deterioration or delamination of the membrane.

(5) Certain wall and parapet assemblies may be designed with air barrier seals exterior to the insulation and interior vapour retarder components. These, like the highly reliable conventional roof systems, depend on moisture insensitive components and the drying time being longer than the wetting period each year.

(6) Sometimes an adequate vapour retarder is no vapour retarder as the insulation and roof membrane can handle any quantities of deposited moisture during the heating season and this moisture dries out each year.

D. BUILDINGS SHALL BE DESIGNED TO PREVENT INGRESS OF WATER

1. National Building Code- 1985 (and 1990) Requires Water Control:

"Section 5.4 Control of Rain Penetration
All joints, openings, roofing, parapets and exterior wall cla be constructed to minimize the entrance of rain water into t assembly.

Subsection 5.4.3.1.(1) states:
Roofing shall be installed so as to
(a) shed or drain water effectively,
(b) reduce the likelihood, when the roofing is co overlapping units, of water backing up under the units damming or other cause, and
(c) be resistant to damage due to wind.

Subsection 5.4.4. Parapets states in 5.4.4.1.(1):
Where the top of a wall is exposed to the weather
(a) it shall be capped, and
(b) a through-wall flashing shall be installed immediat segmented or pervious cap, and at such other points as are necessary to divert rainwater to the outside."

Parapet walls shall be sloped towards main roof areas and flashed to prevent migration of moisture beyond any concealed flashings. Sloped parapet blocks shall not be absorbent or subject to water migration, which can cause efflorescence problems, even without moist air leakage.

E. ADDITIONAL DESIGN OBJECTIVES

1. Preservation Against Rot, Mildew, and Fungi Growth

Wood materials used as blocking, insulation stops and curbs, which may be subject to temporary wetting action due to condensation should be chemically treated to prevent deterioration. All saw cuts should be painted with preservative.

2. Be Aware of Frost Sensitive Materials

All materials which may be subject to water saturation and frost action shall not be frost sensitive. Be especially aware of mortars and blocks which may not be manufactured to standards defining this capability.

3. Insist on Satisfactory Compatibility of Tie-In Materials

Materials on tie-ins shall have satisfactory compatibility for use with both wall and roof materials they are in contact with and with any environmental pollutants which may be present.

4. Request Versatile and Easily Installed Designs

Materials and designs should be capable of installation with wall or roof construction being first (i.e. optional phased construction). A designer's motto should be: "Make it simple!". Sometimes too much detail is worse than not enough detail, when you are dealing with an experienced contractor!

F. ROOF/WALL INTERSECTION EXAMPLES:

Following are a number of generic designs based on drawings sent to the OBEC committee - submitted for or rendered from real jobs, or drawings forwarded by manufacturers. Each drawing will attempt to show some of the principles for a different type of construction of the roof/wall intersection:

Assembly #1- Steel Deck-Masonry Wall-Conventional Insulated System

Comments:

(1) Note the Continuous Metal Angle fastened to the steel deck, both wall and roof air barrier membranes are sealed to this angle. Thus either the wall or the roof system can be installed first.

(2) This roof assembly uses a membrane air/vapour barrier installed over the base layer of insulation. Perfect installation of this air/vapour barrier membrane gives a temporary waterproof system. About 1/3 of the insulation for this assembly can be below the air/vapour barrier (high interior relative humidity will reduce the amount of insulation permitted under the vapour retarder). An alternate approach could incorporate a minimum 12.7 mm gypsum board as the base for the air/vapour barrier.

(3) Note the structural support sandwiching of the wall air/vapour barrier membrane at the end of the deck panels.

(4) Alternative air/vapour barrier elastomeric mastic or coatings may be used instead of the flexible membrane on the exterior of the interior masonry wythe, although flexible membranes are used at expansion joints and cracks.

(5) Although this assembly shows a two ply modified bituminous membrane and flashings, other built-up-roof and single ply membranes could also be installed. Some membranes do not require installation of cants, while others require more wood blocking and anchoring of the membrane at the perimeter. Follow application instructions from the manufacturer supplying these components.

Assembly #2a Precast Concrete Parapet Section-Cast Concrete Roof

Comments:

(1) This is an exceptionally hard assembly to seal up properly. Although a metal cap is strongly preferred to prevent moisture from soaking into the precast panel (see CRCA Spec. FL-516), few architects will permit same, due to its appearance.

(2) Likewise, when the cap is left out, it is hard to prevent water for getting behind the reglet at the joints between precast panels. Regular maintenance of caulking is required because of the architect's vanity! Roofers should insist on the installation of a cap on these walls and they can use as backup Subsection 5.4.4.1.(1)(a) of the building code (shown on earlier slide) which says "Parapets ... shall be capped"

Assembly #2b Precast Concrete Parapet Section-Cast Concrete Roof

Comments:

(1) This drawing shows a number of improvements to the previous design(based on CRCA Flashing Spec. FL-516) (Note: Capping of precast panels)

(2) Some designers prefer to replace the cant strip (in the previous drawing) with a bent steel plate spanning the crack. The square-edge insulation is then extended out to the wall.

his, as all other protected membrane designs, requires sloping of the ast concrete deck towards drains, to prevent ponding within the system.

hen perimeters are flashed with flexible membranes(according to anufacturer's instructions), liquid-applied membranes can be incorporated into this roof design.

aulking (with a support metal angle) is required at the top of the gypsum wallboard to maintain the seal during settlement and differential movement between the wall and roof assemblies.

bly #3a- Insulated Concrete Deck (Conventional System)
(A/B over Parapet)

ents:
Since the concrete deck and parapet can move independently from the masonry brick wythe, the wood blocking on the parapet is anchored securely, to the masonry parapet.

A good wall design has venting near the top of the exterior masonry wythe at 24" o.c., to remove any moisture which may be able to penetrate the air/vapour seal and to dry out any moisture which is able to pass through the exterior wythe(rain screen).

Masonry does settle and a settlement space is left at the top of the inner wythe block wall. In buildings with low relative humidity and in a moderate climate, the insulation on the inner face of the parapet wall may be removed and the plywood is sufficient to prevent condensation within the masonry.

(4) Existing CRCA flashing designs recommend wood blocking and cants, for #15 and glass felt BUR membranes, utilizing built-up flashings. It is expected that modified bitumen membranes and glass felt BUR will be flashed with modified bituminous flashings, as shown. Any flashing sheets applied with hot bitumen shall be anchored with nails min. 200 mm, max. 300 mm above the deck surface. Ensure that side laps of sheets covered by metal counter flashing are sealed as well, to prevent ingress of wind-blown water.

Assembly #3b Concrete Deck-Masonry Wall-Conventional System

Comments:

(1) The previous assembly may be installed more easily, if instead of bringing the air/vapour barrier over the parapet, it becomes a through-wall flashing/membrane by being impaled over the steel connector rods before the parapet is cast-in-place.

(2) This version, with through-wall membrane tied-into wall and roof air/vapour barriers, will have no potential for condensation in the parapet and only requires insulation over the parapet(under plywood) to cut heat losses.

Assembly #4 Concrete Deck and Parapet-Masonry Wall-Protected BUR Membrane System

Comments:

(1) Four ply organic BUR and flashings may be used in this assembly design, however, four ply glass felt BUR with two ply modified bituminous flashings may be expected to have a longer service life in the moist environment under insulation boards.

(2) It is recommended that the wood cant and plywood for this assembly be pressure-treated wood and that at least an one ply vapour retarder be installed under the wood cant.

Assembly #5 Steel Building System Parapet

Comments:

(1) Single and two ply membrane systems are frequently installed without cant strips. Certain manufacturers recommend fastening or anchoring of the membrane sheets round the perimeter(as shown), this is especially required when the membrane is not adhered.

(2) Pavers around the perimeter carry out two functions: First, they hold some metal counter flashings in position at the inside base of the parapet wall and Second, they reduce scouring of ballast rock (to expose fabric and insulation), in the areas of maximum wind erosion.

(3) The continuous metal angle carries out several functions:

(a) It functions as the air seal between the roof and walls.
(b) The angle is a base for attachment or sealing of the waterproofing membrane, which in this system performs vapour retarder functions.
(c) The angle in this design performs a structural function, as one of the support members for the sandwich wall system which usually is insulated with blanket insulation.

(4) The steel sheet liner panels are sealed with strips of caulking and thereby perform both vapour and air barrier functions for this wall system.

Assembly #6 Steel Deck-Masonry Wall-Modified Protected Membrane System

Comments:

(1) This system offers the advantages of early close-in and waterproofing of a building, frequently before many phases of construction are completed. In this partial stage, a base layer of suitable rigid insulation (frequently 1/3 of the total assembly R-value) is fastened into position over the steel deck(or gypsum board, if required to meet certain fire ratings).

The waterproofing membrane and flashings are installed according to good construction practices, only no surfacing protection is installed.

Following completion of all building construction and the repair of any damaged areas of membrane, a layer of suitable rigid foam insulation is loose laid and covered with fabric and ballast or pedestals and pavers, according to design specifications.

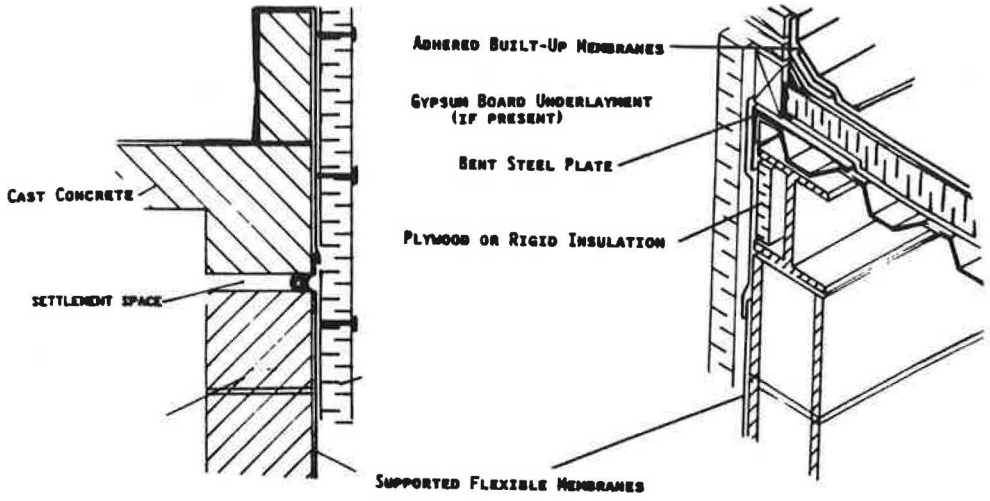
(2) Installation of a suitable vapour retarder under the base layer of insulation is required: (a) If greater than about 1/3 of total assembly thermal resistance is being installed in the base insulation layer. (i.e. dew point is below the installed waterproofing membrane) (b) If the base insulation layer cannot handle the volume of moisture deposited during building dryout prior to installation of the layer of insulation above the waterproofing membrane.

G. CONCLUSION

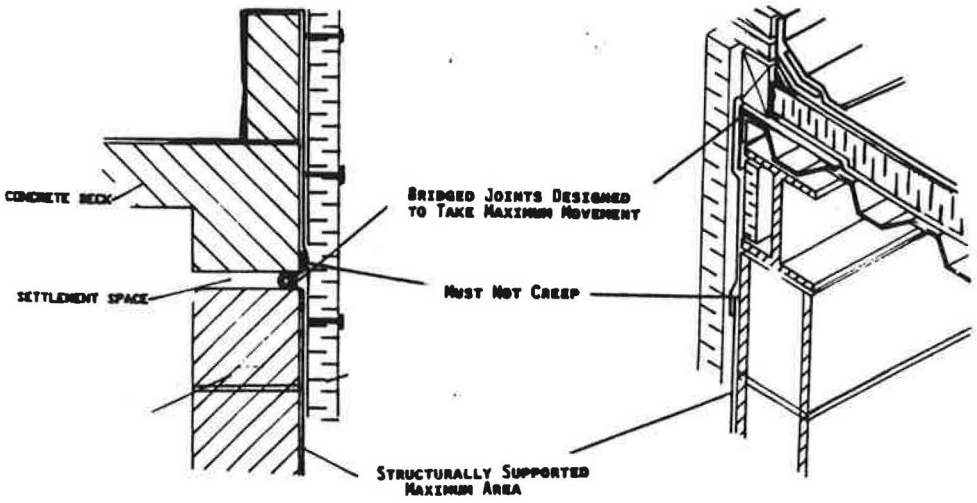
There would appear to be a number of alternate good methods of designing the roof/wall intersection for any type of building construction. Adherence to the mentioned principles should result in satisfactory designs which can be easily installed and should perform well.

H. REFERENCES:

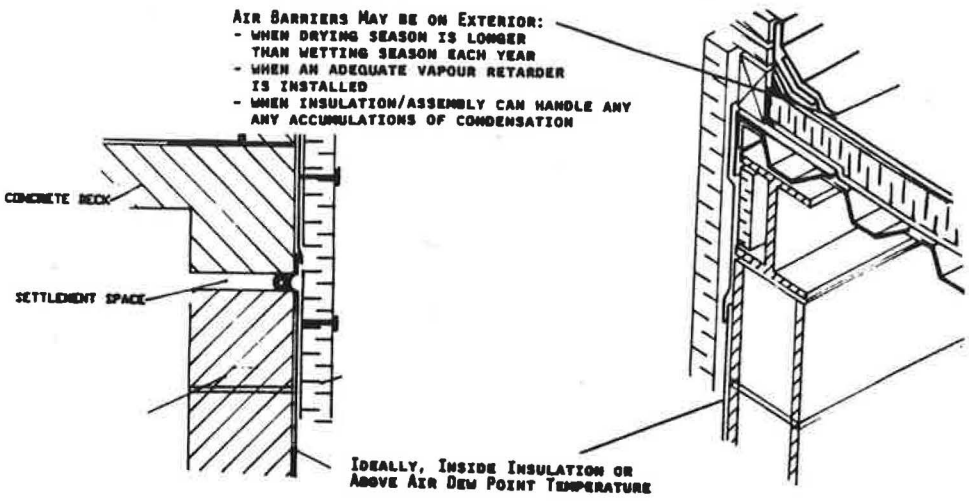
[1] Quirouette, R.L. "The Difference Between a Vapour Barrier and an Air Barrier", NRC Building Practice Note 54, July 1985.



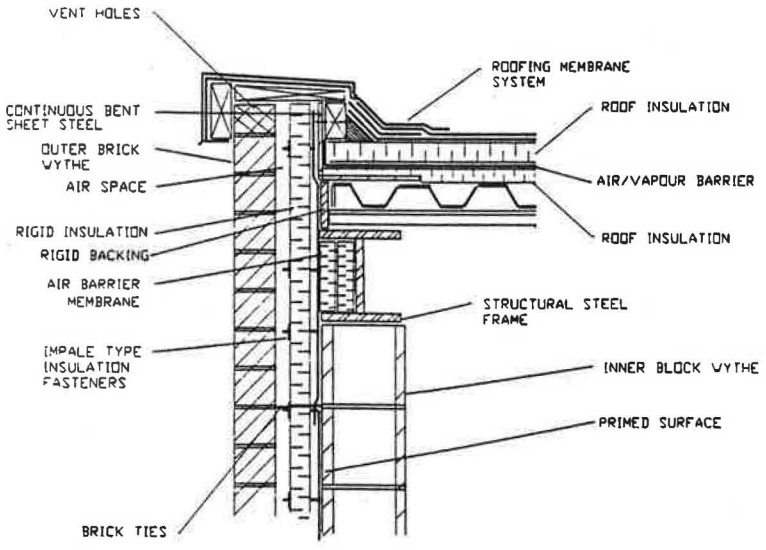
What is an Air Barrier?



What Must an Air Barrier Do?

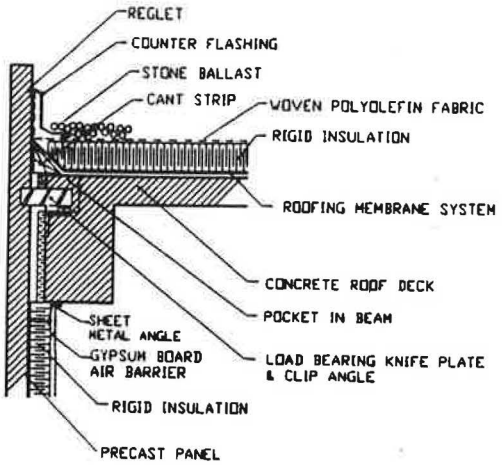


AIR/VAPOUR BARRIER POSITIONING?

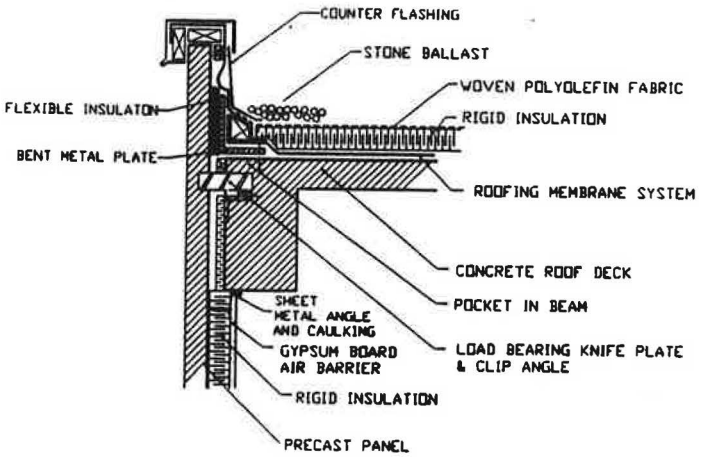


Assembly #1

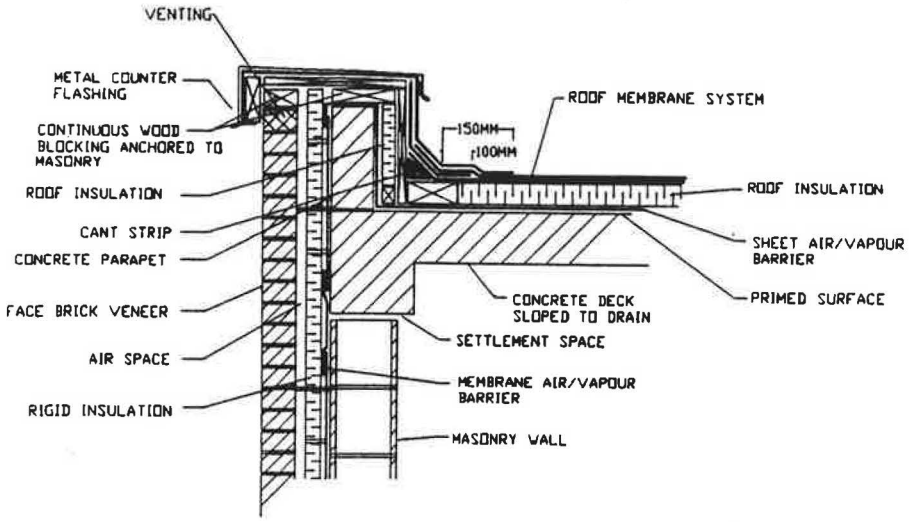
STEEL DECK - MASONRY WALL - CONVENTIONAL INSULATED SYSTEM



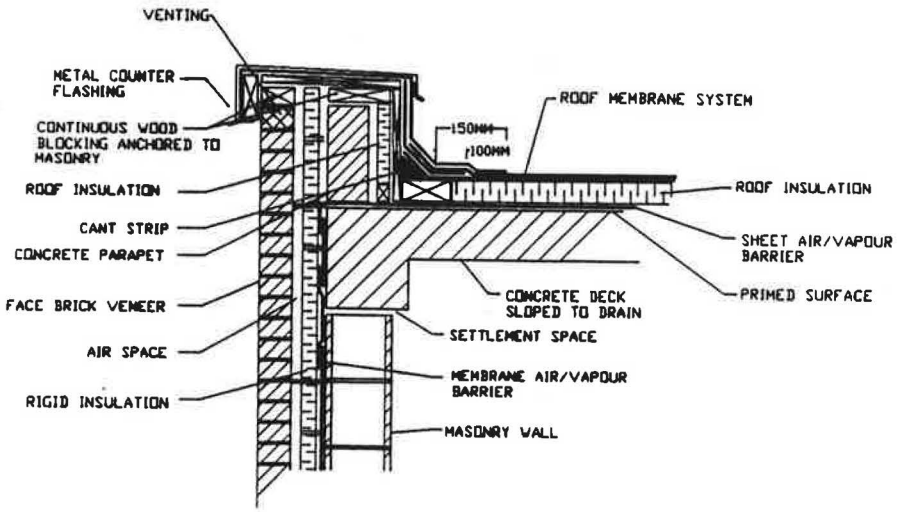
Assembly #2a PRECAST CONCRETE PARAPET SECTION CAST CONCRETE ROOF



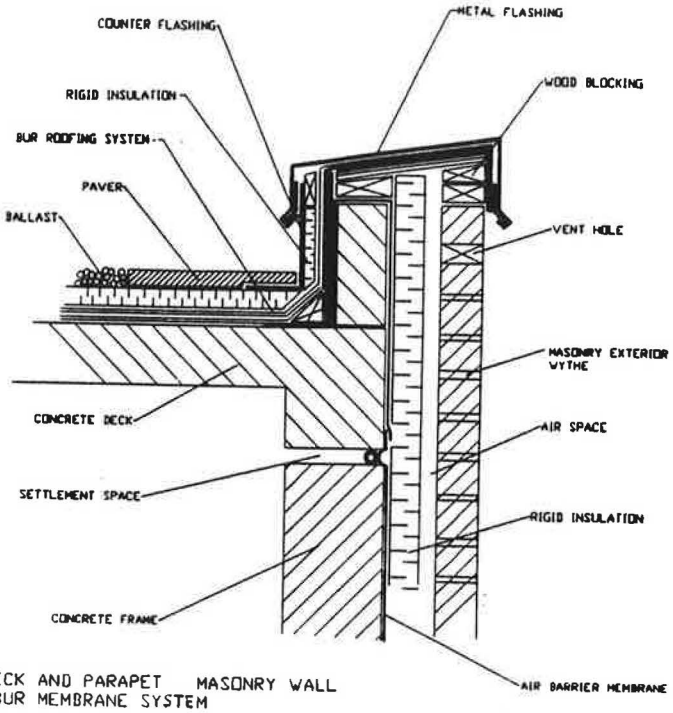
Assembly #2b PRECAST CONCRETE PARAPET SECTION CAST CONCRETE ROOF



Assembly #3a INSULATED CONCRETE DECK

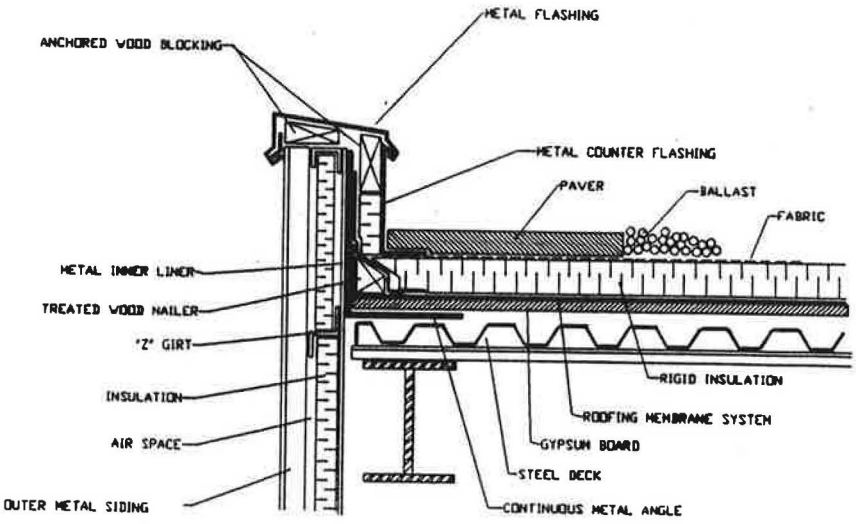


Assembly #3b CONCRETE DECK - MASONRY WALL - CONVENTIONAL INSULATED SYSTEM



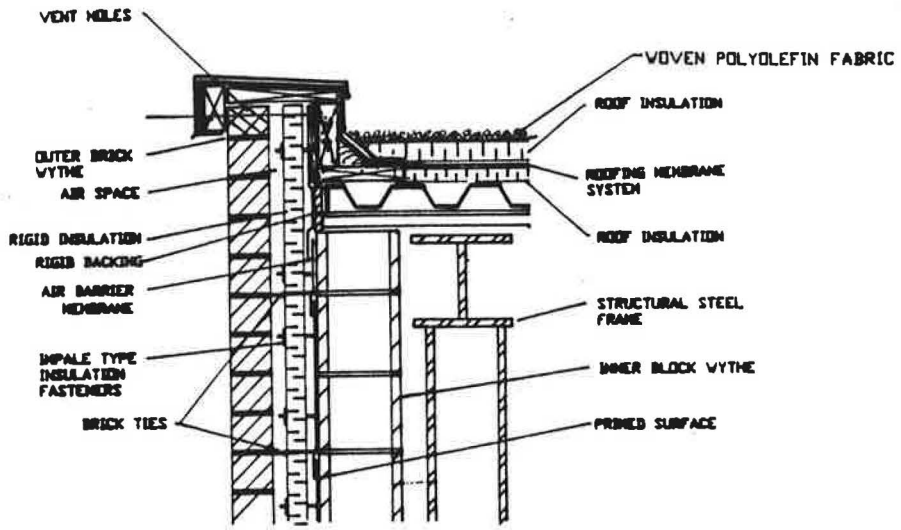
Assembly #4

CONCRETE DECK AND PARAPET MASONRY WALL
PROTECTED BUR MEMBRANE SYSTEM



Assembly #5

STEEL BUILDING SYSTEM PARAPET



Assembly #6 Steel Deck-Masonry Wall-Modified Protected Membrane System