Criteria for the Design and Installation of Double Skin Insulated Steel Roofs

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CANADIAN
SHEET STEEL
BUILDING INSTITUTE

PREFACE

One of the objects of the CSSBI and its members is the development of standards which promote safety, performance and good practice.

This bulletin is intended to assist designers and installers of double skin insulated steel roof systems by providing guidelines on good practice.

The material presented has been prepared for the general information of the reader. While the material is believed to be technically correct and in accordance with recognized good practice at the time of publication, it should not be construed as obviating the need to secure competent advice with respect to its suitability for a given situation. Neither the Canadian Sheet Steel Building Institute nor its Members warrant or assume liability for the suitability of the material for any general or particular application.

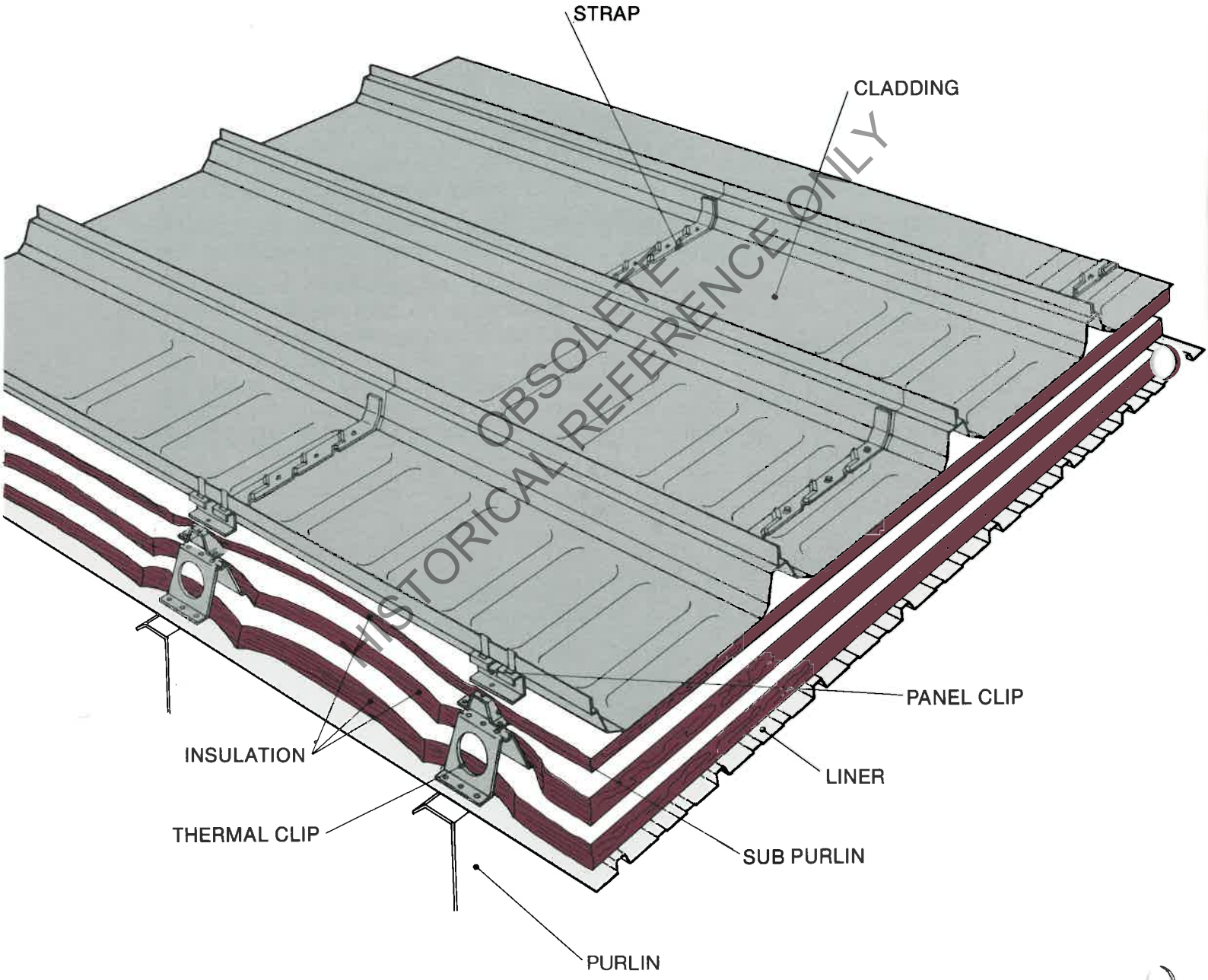
INTRODUCTION

Double skin insulated steel roofs can provide many years of service when properly designed and installed. The purpose of this Bulletin is to provide guidelines on good design and installation practice so that the roof system will provide the best performance possible. Part I deals with individual components of the system, while Part II addresses some specific construction details which may require special attention.

CONTENTS

SCOPE

This Bulletin applies to roof systems consisting of a steel liner and a profiled sheet steel exterior cladding separated by sub-purlins and containing thermal insulation. It applies to field assembled roof systems only and therefore does not pertain to factory manufactured, foam core insulated sandwich panels.



TYPICAL COMPONENTS OF A DOUBLE SKIN INSULATED STEEL ROOF
(Standing Seam System Illustrated)

GOOD DESIGN PRACTICE

DESIGN CRITERIA

Structural

The appropriate Building Code should be consulted when specifying the load carrying requirements of the roof system, i.e. dead and live loads, including wind or seismic loads. Refer to CSSBI Bulletin No. 7 "Snow Load Design Criteria For Steel Building Systems" and No. 10 "Wind Load Design Criteria For Steel Building Systems" for methods of calculation. The deflection criteria are to be specified by the designer. CSSBI recommends a maximum live load deflection of span/180 for sheet steel roof cladding. The same limit is often applied to structural framing members (beams, joists, purlins) supporting "elastic" roof coverings. More restrictive limits may be warranted for specific roof assemblies or where non-structural elements may be damaged by large roof deflections.

Provision for drainage should be made so that ponding does not occur. A roof slope should be provided to promote drainage, washoff of debris, and control of rainwater. The minimum slope is a function of the roof system deflection and the type of panel used. Roof slopes in the industry start as low as 1 in 48 for standing seam roofs. For other types of roof panels, a minimum slope of 1 in 20 is recommended. Deflection considerations may require a higher slope to eliminate ponding.

Functional

To act as a *weather barrier*, the roof system must keep out the elements — rain, snow, wind, dust and other airborne debris, etc.

To act as a *thermal barrier,* the roof system must reduce the transfer of heat into the building interior during summer, and out of the building interior during winter. Due to the presence of elements such as sub-purlins the R-value of the roof assembly may differ from the "nominal" R-value of the insulation. When comparing different roof systems, the designer should distinguish between the insulation R-value and the assembly R-value. Ongoing testing by the CSSBI of the thermal performance of steel wall and roof assemblies has resulted in an improved method of calculating assembly R-values. The manufacturer may be consulted for information on the thermal performance of his roof assemblies.

To act as an *air barrier*, the roof system must prevent the flow of air into and out of the building. It also must prevent the movement of moisture carried by the air into the roof assembly. In doing so, the roof system helps to reduce the cost of maintaining a comfortable interior environment, and minimizes the possibility of condensation in the roof assembly. Moisture buildup in the building envelope can reduce its thermal performance and shorten its expected life.

To act as a *vapour retarder,* the roof system must minimize the diffusion of water vapour, which is contained in the air, into the building envelope. Steel, with a permeability of zero, is a perfect vapour retarder.

COMPONENTS

1. **Liner**

The liner can serve several functions:

(a) As an air barrier.
(b) As a vapour retarder.
(c) As fire protection for foam plastic insulation.
(d) As a work surface for subsequent erection work.
(e) As an aesthetic interior finish.
(f) As a structural element.

The intended function(s) of the liner should be communicated to the manufacturer so that an appropriate system can be selected. In general, both an air barrier and a vapour retarder are required to minimize condensation in the roof cavity, but the liner can be designed to serve both functions. Where required to act as an air barrier and/or vapour retarder, the liner should be designed so that all joints and edges can be sealed in order to provide a continuous barrier against air leakage and/or vapour diffusion into the roof cavity.

Fasteners which will provide the intended seal should be selected and specified on the drawings. If the liner is to be used as a work surface for subsequent erection work it must be designed to carry the construction loads without damaging the seal at side and end laps.

It is important to design the wall/roof interface such that continuity of the air barrier and vapour retarder is maintained.

2. **Sub-Purlin**

The sub-purlin essentially serves two functions:

(a) As a stuctural member.
(b) To create the cavity for installing insulation.

The sub-purlin, as a thermal bridge, influences the assembly R-value of the roof system. A thermal break or a perforated sub-purlin may be used to reduce the amount of heat conducted.

3. Insulation

The designer should specify the required insulation R-value as well as the thickness. Insulation manufacturers publish descriptions of their products which include the type, density and R-value per unit thickness.

Examples of various types of insulation used in double skin roofs are:

(a) Mineral fiber — glass fiber
— rock wool

(b) Foamed plastic — expanded polystyrene
— extruded polystyrene
— polyurethane/ polyisocyanurate
— phenolic foam

Both the insulation and building manufacturers may be consulted for additional information on the suitability of a particular material for the intended application.

4. Exterior Cladding

The exterior cladding essentially serves three functions:

(a) As a structural member.

(b) As a weather barrier.

(c) As an aesthetic exterior surface.

The design of the exterior cladding may require provisions for thermal expansion and contraction. This depends on such factors as the length of the sheet, the amount of temperature difference between the cladding and the structure, and the colour of the cladding. The manufacturer should be consulted for his recommendations on how to accommodate thermal movement. Fasteners should be selected so that the three intended functions of the exterior cladding are met.

5. Coatings

Coatings for bare steel may be metallic, painted or laminated. Due consideration should be given to both the exterior and interior environments when selecting coatings. Severe conditions such as high humidity or chemical fumes will also affect the most appropriate choice of coatings.

Exterior cladding is available with the following metallic coatings:

- Z275 Zinc Coated Steel
- AZ150 or AZ180 Aluminum-Zinc Alloy Coated Steel

Liner sheets are available with the following metallic coatings:

- ZF75 (Zinc-Iron Alloy Coat), Z180 or Z275 Zinc Coated Steel
- AZ150 or AZ180 Aluminum-Zinc Alloy Coated Steel
- ZincGuard 102-C Electrogalvanized Steel

In addition to the above metallic coatings, several paint systems are available. Manufacturers should be consulted for their recommendations on the various coatings. The drawings should clearly specify the metallic coatings and, where applicable, the paint systems.

6. Caulking and Sealants

Caulking and sealants are an integral part of the weather/air/vapour protection systems. Their primary function is to seal joints, thereby maintaining the integrity of the air barrier, vapour retarder and weather barrier. Careful choice of caulking and sealants of suitable quality is important and the selection should be shown on the drawings. The selection of caulking should be consistent with the intended life of the roof system. The exterior sheet is often caulked at side and end laps. The manufacturer's details should clearly indicate where and what caulking is required.

DETAILS

1. Penetrations

While it is recognized that penetrations are necessary, the quantity should be minimized.

The roof cavity should not be used to accommodate services.

Details for penetrations should be clearly shown on the drawings. Most manufacturers have standard methods for handling penetrations and these should be followed as closely as possible. These details will show proper methods for sealing both the liner and the exterior cladding around the penetration. The type and location of flashing, caulking and sealants should be clearly shown on the drawings.

Many penetrations are made by other trades (for example the mechanical contractor) rather than the erector. It is the responsibility of these other trades to ensure that their penetrations do not compromise the integrity of the liner sheets, exterior sheets and insulation.

Some penetrations (such as high temperature pipes and heat emitting devices) require special consideration (such as minimum insulation clearance and special sealing details).

It is desirable to raise roof-top mechanical equipment above the surface of the exterior cladding on legs which transfer the load directly to the structural members.

The designer should consider the effects of thermal expansion and contraction around penetrations. The manufacturer should be consulted for his recommendations.

Large rectangular penetrations should be flashed with curbs which promote drainage (such as deflectors) in order to eliminate standing water upstream of the penetration.

Reinforcement of roof openings around penetrations may be necessary to maintain the structural integrity of the roof system and to facilitate sealing. Where reinforcement is required, it should be clearly shown on the drawings.

2. **Eave and Ridge**

The designer should ensure that the continuity of the air barrier and vapour retarder is maintained, especially at the eave and ridge. The drawings should clearly show what is required to join the barriers in the roof to the barriers in the wall. An air barrier should be provided at the eave to ensure that any warm, moist air in the wall system does not enter the roof cavity. The thermal insulation must also provide complete coverage at the junction of the two roof places as well as between the walls and the roof.

If gutters are required, they should be located so that water cannot back up inside the building envelope due to ice dams or heavy rain.

3. **Air Spaces**

In conjunction with a carefully sealed air barrier and vapour retarder, a vented air space above the insulation may help to dissipate any accumulation of moisture in the roof cavity. This may be required for applications involving high interior humidity. The drawings should indicate the eave and ridge details and any roof vents required for the movement of ventilation air through the air space.

GOOD INSTALLATION PRACTICE

COMPONENTS

1. Liner

Often the liner is designed to be an air barrier and/or vapour retarder. If so, the liner sheets must be installed to ensure that a complete seal at side and end laps is obtained. Damaged side or end laps should be repaired or replaced before installation. Specified fastener spacings should be followed to maintain the seal. The specified fasteners must be used. All fastener holes must be filled. Fasteners with neoprene bonded washers should be used to seal any fastener holes made in error.

Not all liners can be used as a working surface. Care should be taken during installation so that the seals at side and end laps are not broken (see Figure 1). Where specified on the erection drawings, walk boards must be used. If it is not known whether the liner is intended to serve as a work surface, the installer must check this with the manufacturer.

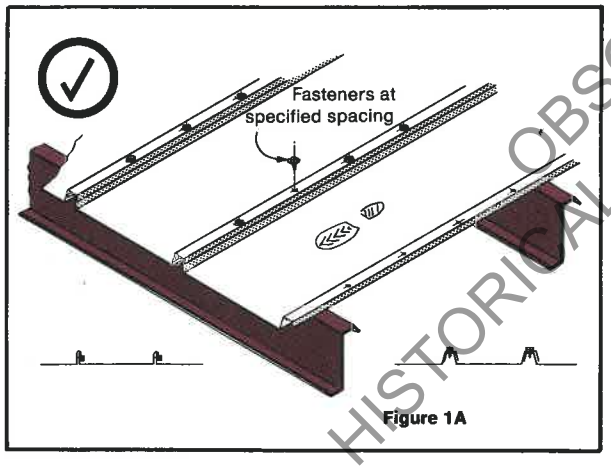


Figure 1A

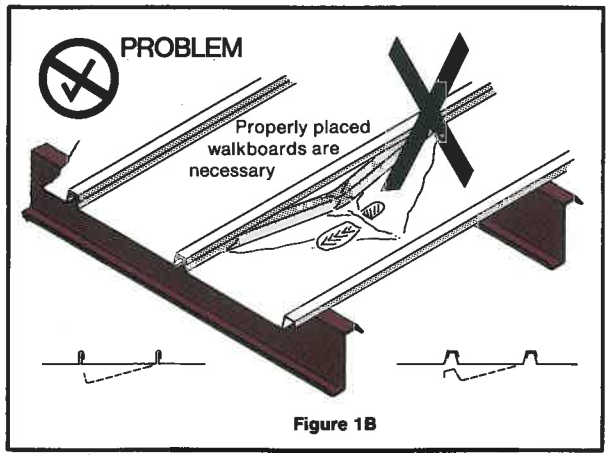


Figure 1B

It is important to maintain the continuity of the air barrier and vapour retarder where the roof meets the side and end walls and at the ridge. Caulking should not be substituted for the proper flashings and trim (see Figure 2).

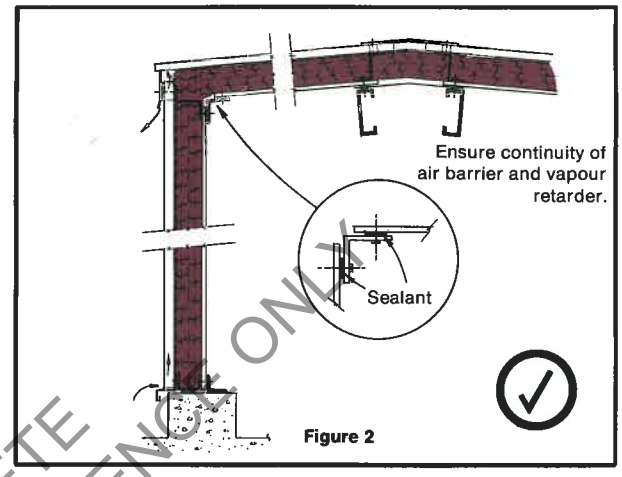


Figure 2

2. Sub-Purlin

Care should be taken to install the sub-purlins at the specified spacing and parallel with each other in order to avoid creating gaps in the insulation.

The erector should follow drawings carefully to ensure that a thermal break is included where called for.

3. Insulation

The insulation should be kept dry before, during and after installation. The insulation manufacturer's recommendations for on-site storage should be followed. Damaged insulation should not be used. Where the insulation type and thickness are specified on the drawings, the erector should ensure that these are adhered to. Where this information is not specified on the drawings, or if changes are required, the erector should obtain clarification.

Insulation should be installed to provide complete coverage over the intended area, fitting snugly against structural members, services and other penetrations. Particular attention should be paid to fill all voids. Edges should be butted tightly together, and not overlapped. Where multiple layers of insulation are required, butt joints should be staggered (see Figure 3).

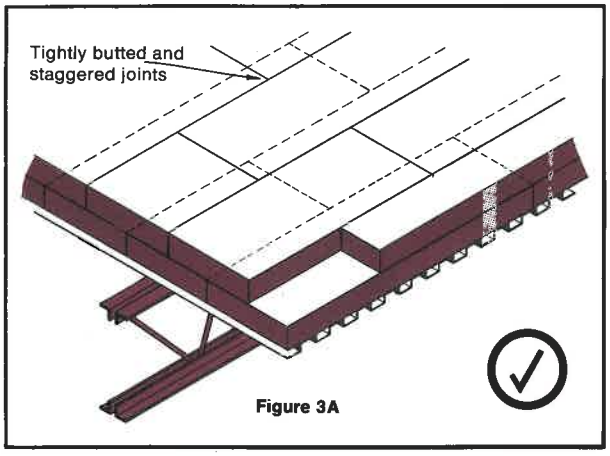


Figure 3A

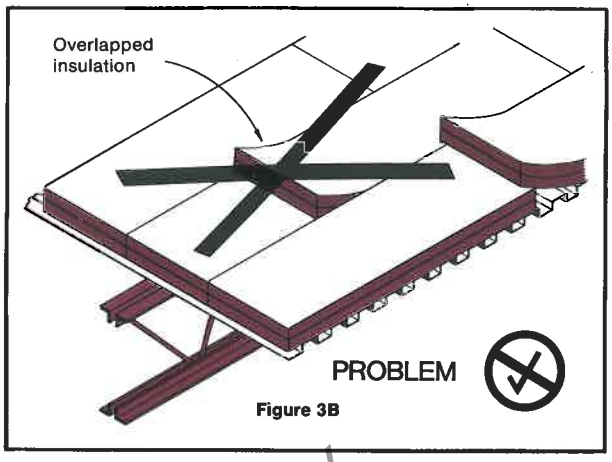


Figure 3B

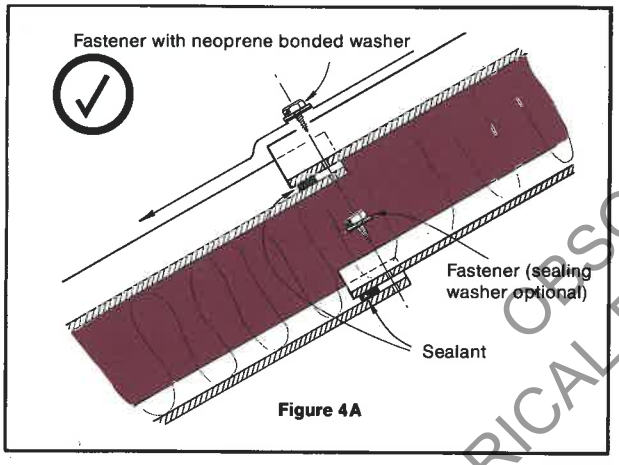


Figure 4A

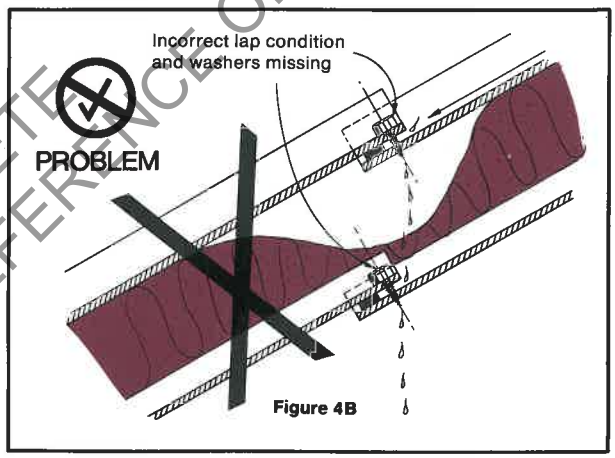


Figure 4B

The insulation should fill the full thickness called for in the drawings. Where an air space has been specified for ventilation above the insulation, the erector should ensure that this space is maintained.

4. Exterior Cladding

The exterior cladding is both a weather barrier and a structural member. It is important during installation to maintain the continuity of the cladding, in particular the seal at side and end laps (see Figures 4 and 5). Damaged side or end laps should be repaired or replaced before installation. Caulking should not be substituted for the proper flashings and trim. Specified fastener spacings should be followed to maintain the seal and to resist wind uplift forces, especially at side laps.

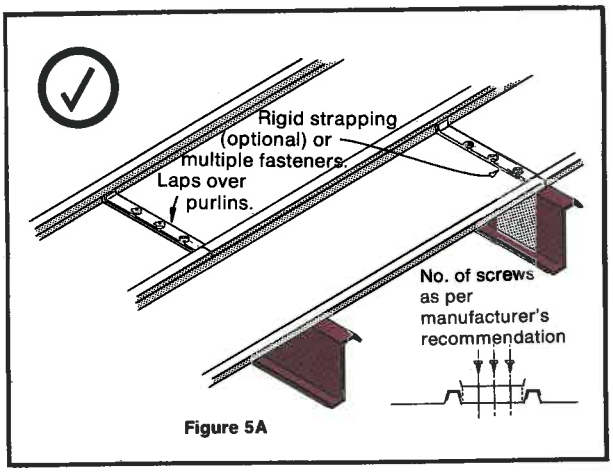


Figure 5A

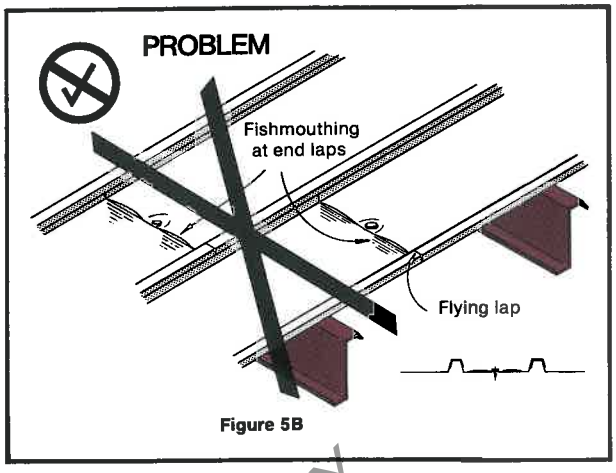


Figure 5B

The erector should ensure that proper tools are used for installing screws. It is important to maintain the correct torque setting so that screws are not over-driven or under-driven. Care should be taken not to damage the sheet surface adjacent to the intended hole during screw-driving. The specified fasteners must be used. All fastener holes must be filled. Fasteners with neoprene bonded washers should be used to seal any fastener holes made in error.

Certain roof systems such as standing seam roofs are designed to accommodate the expansion and contraction of the roof cladding due to temperature changes. The drawings should be checked to ensure that these details are not compromised on-site (see Figure 6).

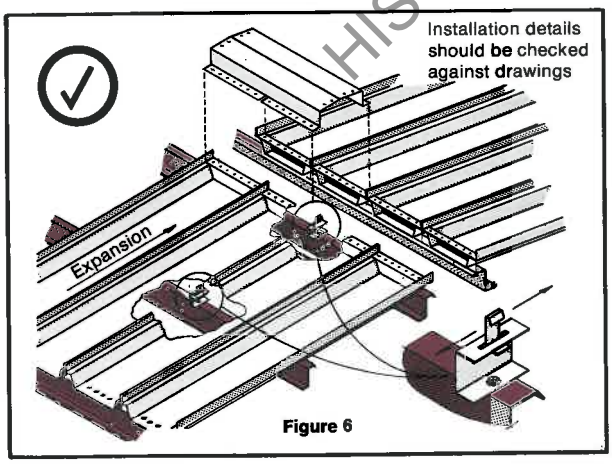


Figure 6

Heavily trafficked areas of the exterior cladding should be protected by walk boards.

5. Coatings

Metallic coatings such as zinc (galvanized) and aluminum-zinc alloy (Galvalume) and prefinished paint systems are specified by the designer to protect the steel components against corrosion and thereby extend their service life. Care should be taken during handling and installation so that the coating is not damaged.

For proper handling of prefinished sheets, refer to CSSBI Bulletin No. 9 "Care and Maintenance of Prefinished Sheet Steel Building Products".

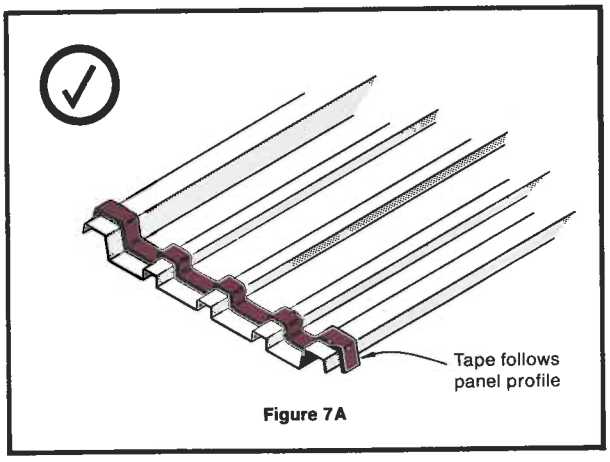


Figure 7A

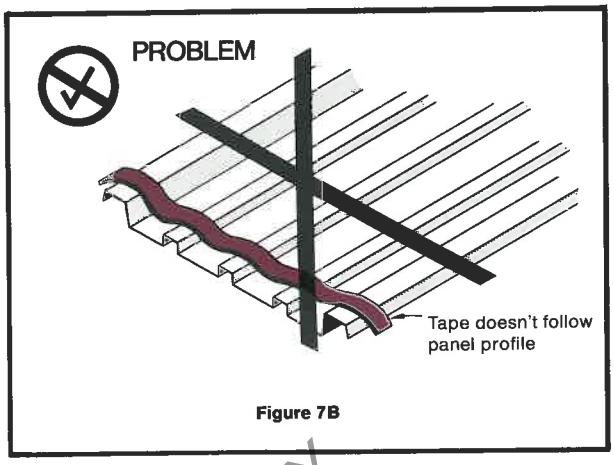


Figure 7B

6. Caulking and Sealants

The primary functions of caulking are to prevent weather penetration and air and moisture movement through the roof assembly. It is not to be used to fill excessive voids or oversized spaces due to undersized or damaged sheets. It is not to be used as a substitute for proper flashings, trim and closures.

Proper application of caulking and sealants following manufacturers' recommendations will enhance the performance of the roof system. Where components have been precaulked by the manufacturer it is important to verify this caulking and to repair skips, gaps and damage before installing the component.

Where tape-type sealants are used at end laps, their installation should follow the contour of the profile (see Figure 7). Caulking and sealants used at end laps should be located near the line of fasteners.

The type and location of field applied caulking and sealants are specified on the drawings and should be followed.

DETAILS

1. Penetrations

It is important that both the liner and the exterior cladding are sealed around all penetrations. It is the responsibility of all trades making penetrations to ensure that they follow appropriate details, including reinforcement around the opening where required, and the proper use of flashings and sealants (see Figures 8 and 9). This is an area where good workmanship is important to maintain the integrity of the roof system.

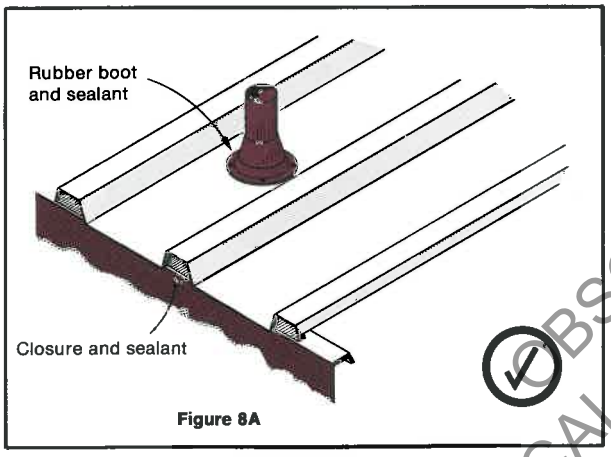


Figure 8A

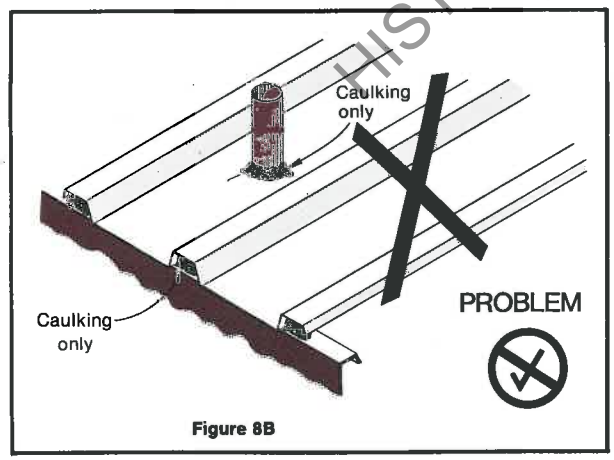


Figure 8B

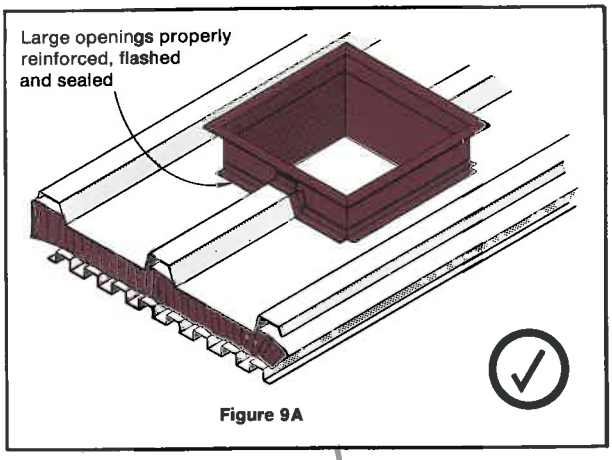


Figure 9A

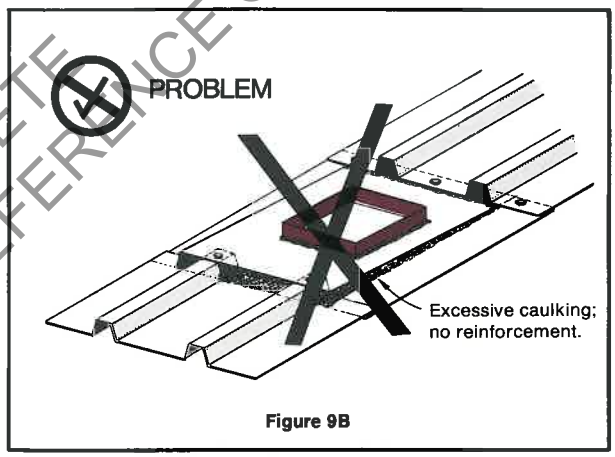


Figure 9B

2. **Eave and Ridge**

Particular attention is required at the eave and ridge to ensure continuity of the air barrier and vapour retarder. The contractor must coordinate the trades so that this barrier continuity is achieved.

Thermal insulation must provide complete coverage at the eave and ridge (see Figure 10).

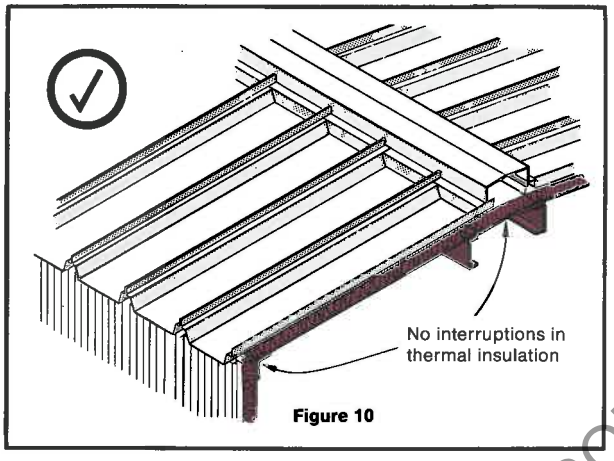


Figure 10

3. **Air Spaces**

Where an air space between the exterior cladding and the insulation is shown on the drawings, the erector should ensure that air passages, inlets and outlets are kept clear to promote the intended flow of air.

APPENDIX — DEFINITIONS

Air Barrier — An air-impermeable material (or combination of materials) in the assembly which prevents the movement of air through the building envelope.

Vapour Retarder — A material with low vapour-permeability in the assembly which minimizes the diffusion of water vapour through building materials into the building envelope.

Thermal Bridge — A discontinuity in the thermal insulation typically caused by a member within the building envelope which connects the interior and exterior surfaces and is a relatively good conductor of heat.

Thermal Break — An insulating material placed in series with a thermal bridge to reduce the heat flowing through the thermal bridge.

CANADIAN SHEET STEEL BUILDING INSTITUTE

The Canadian Sheet Steel Building Institute, the national association of the structural sheet steel industry, promotes the use of sheet steel in building construction through engineered design and standards of quality and performance. Activities focus on sheet steel building products and steel building systems for commercial, industrial and institutional applications and similar products and systems for farm applications.

The institute provides information regarding the standards of design, fabrication and erection, and offers technical assistance in the use of cold formed and pre-engineered steel products. The CSSBI also represents its members in technical matters connected with government, and provides liaison with organizations such as Canadian Standards Association and National Research Council.

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