THE PRACTICAL SIDE OF SILO SEALING

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ABSTRACT

The sealing of a 'horizontal' grain storage shed is described and practical details of the process are given. For a successful sealing, it is necessary to pay strict attention to many apparently insignificant items. These include very careful initial preparation of the surfaces to be treated, correct application of polyurethane foams for filling large voids in the structure, sealing of imperfections in the floor, and appropriate selection of sealing systems to treat problem regions such as around skylights and moving parts (eg. distributors for grain). Photographs are included illustrating the various features that require sealing in a horizontal storage.

INTRODUCTION

There are many types of silos : concrete vertical cells, welded or bolted metal cells, 'horizontal' storages made of concrete and sheet metal on a metal frame work or sheet metal supported by a wooden and metal structure. Each of these methods of construction can be used for a range of storage sizes and shapes. This paper gives details of sealing of a warehouse-type, 'horizontal' storage and describes problem areas encountered and how these areas can be treated. The information is based on the experience gained in the sealing of one such storage that was carried out successfully 3 years ago. Many of the problems met are similar to those found in other types of silo.

PRELIMINARY CONSIDERATIONS

The sealing system used must fulfill these criteria:

Must be flexible, and able to bridge and seal gaps up to 2 mm with no failure.

Must withstand high and low temperatures.

Must have good adhesion.

Must be suitable for use with foodstuffs.

Must not creep or perish.

Must be U.V. radiation resistant.

Must have good abrasion resistance.

Materials must be stable to fumigants.

Must be easily repairable.

Material and application costs must be reasonable.

Must have 10 year life or longer.

Several different products in combination can be used to achieve the seal.

Cleanliness of the structure is of utmost importance for good adhesion of the coating, so a complete, high pressure water or detergent wash, inside and out, is essential.

The type (galvanised, aluminium, colourbond etc.) and condition (new, weathered) of the metal cladding determine if primers must be used. There are many different products available for silo sealing. They may be water or solvent-based and have various specifications. Manufacturers of the products provide technical data sheets and application rates. The products may be applied to certain parts of the silo at rates exceeding the specification, as a double safeguard.

Polyurethane foam, foamed in situ, is used by all companies involved in silo sealing to fill the main voids and gaps in the structure and to strengthen and bridge weak areas. The foams used have fire-retardant properties. Internally, foam of 1kg m^{-3} density is used. Externally, 1.5 kg m^{-3} density foam is applied and, when used, flexible foam is applied at 0.5kg m^{-3}.

There are three general approaches to silo sealing : complete internal seal with external heat reflectant coating, complete external seal, and part internal and part external sealing. The latter method is lowest in cost and is most favoured.

After cleaning down, the following items must be attended to before sealing is attempted:

All nuts, bolts, screws to be checked. If missing, replaced.
All badly damaged, badly rusted, roof cladding to be replaced.
All gutters and downpipes checked. Replace any parts damaged or badly

rusted.

Any loose flashings, roof cladding, expansion joint covers, ridge capping etc. to be fixed firmly.

Extraction fans on roof to be removed and a cap fitted over the hole left.

Fibreglass skylights replaced or sealed where necessary.

Ridge vents, where fitted, to be capped.

Internal rubber door seals to be removed.

DETAILS OF SEALING PROCESS

<u>Filling of large gaps with polyurethane foam (internal treatment)</u>

The largest gaps and voids in a horizontal silo of the type discussed here are on top of the concrete wall where it meets the metal-clad curtain wall. (Fig. 1) Polyurethane foam is applied internally to the top of the wall to give a fillet which both seals this region and also is steep enough (45°) to shed grain, preventing the build-up of dust and grain residues that is normally a problem there.

When polyurethane foam is to be applied over large gaps, it is advisable to fill these first with pre-moulded, flexible polyurethane foam to prevent the uncured foam blasting through the gap. This also cuts material cost and reduces the cost of cleaning up afterwards.

The lap joins in the metal cladding and at the gable ends are sometimes foamed with polyurethane. This reduces total time for sealing and usage of material on external surfaces. The join between the curtain wall and roof cladding (Fig. 2) is foamed. It is recommended that the foam extend 20 cm down the wall and 20 cm onto the roof cladding to strengthen the area and reduce movement there.

The ridge line of the roof (Fig. 3) is filled with polyurethane foam to a depth of 10cm, extending between the top purlins on each side. This treatment not only seals but strengthens the region. The ridge is walked on frequently during the sealing operation.

The 'penthouse', where the grain conveyor enters the storage, has an abundance of problem areas to seal. It is coated completely internally with foam. This system also reduces temperature build-up.

Large voids and gaps around girders passing through the curtain walls are filled with foam. The region where the base plate holding the roof truss, and also the top section of the roof truss, goes partially through the wall should also be sealed.

Electrical conduits entering or leaving the silo should be sealed into the structure with foam. Electrical circuit check points or circuit panels should not be foamed, but should be fitted with rubber or silicone rubber gaskets so they are sealed, but openable.

The roof ventilation fans and ridge vents are removed and the holes left capped off using corrugated iron, fibreglass sheet or polystyrene foam. This capping is then sealed to the silo with polyurethane foam.

All exposed polyurethane foam is coated with a sealant membrane for protection against damage and degradation.

Other sealing carried out internally

The grain distribution chute (Fig. 4) is sealed by taping a heavy duty plastic sheet or bag over the end. The chain lines used for manual operation of the valve from outside are sealed with silicone rubber, butyl mastic or acrylic sealant from a cartridge gun at the point where the chains go through the penthouse wall.

Fibreglass skylights are lighter and flimsier than the roof cladding and should be fixed on all corrugations to avoid tearing under wind pressure or pressure resulting from temperature variation when the shed is sealed up.

At certain times of year condensation may build up on the underside of the metal roof cladding and the fibreglass skylights. It can then run down the cladding. If the horizontal lap joins between the roof sheets are not sealed, moisture can build up behind the external membrane there, bringing a danger of corrosion and possible membrane breakdown.

The concrete walls can be treated either internally or externally. Or, for best results, both internally and externally. The external application should be done first to avoid rain water passing through unsealed cracks and collecting between the internal membrane and the wall. A good primer is required giving excellent adhesion to concrete and capable of covering hairline cracks, pitted regions and both porours and shiny impervious areas. The top coat must have good flexibility and abrasion resistance and be applied at least 500 microns dry thickness. Experience has found thinner membranes to be unsuccessful.

External sealing operations

Skylights

Skylights should be fixed down with pop-rivets. A cloth, fibreglass or bitumen tape should be applied over the edges of the skylight to reinforce the membrane applied in this weak area (Fig. 5). Skylights may deteriorate badly under the intense sunlight of Western Australia. In some instances they must be replaced. Sometimes, it may be possible to repair them using a polyester resin coating to rebond the fibres. A heat reflectant coating over the pannel eliminates further deterioration. Hairline cracks in skylights are a problem. These are caused by incorrect fitting, rough handling and fixing with screws or bolts or damage from workmen standing on the skylight.

Penthouse

When treating the penthouse it is first necessary to ensure that all metal flashings and claddings are bolted or pop-riveted securely. Sealants applied by cartridge dispensers are very useful for preliminary sealing around window frames etc. before the sealing membrane is applied.

Polyurethane foam has been found to be a successful gap filler when used externally. Unfortunately in Australia the abundance of bird life, especially parrots, is a problem. They peck into it, removing the protective membrane and eventually exposing parts of the foam. This allows moisture to penetrate into the foam and leads to rapid deterioration under our sunlight.

The region where the penthouse fits into the main roof is a problem (Fig. 6). The full foaming internally eliminates most leaks. However the penthouse must also be sealed externally here (e.g. with a flexible membrane sealant with bitumen or cloth tape reinforcement) to prevent rain getting behind the foam inside.

Almost all the thermal movement in a storage takes place under the expansion joint cappings (Fig. 7) This makes the region particularly difficult to seal. Flexible polyurethane foam (0.5 kg m^{-3} density) can be sprayed into the joint from below and a flexible membrane (e.g. a styrene-acrylic emulsion system) applied with reinforcement over the top of the join. The foam provides a very good seal by itself.

Gable Ends

The gable ends can be sealed using a flexible spray-applied membrane externally. Unfortunately it may be necessary to apply several coats of sealant to achieve specified thickness because thick films tend to run on the vertical surface. The seams in the gable end may be sealed internally with polyurethane. In this case a thinner external coating is acceptable. The place where the metal cladding of the upper part of the gable end meets the concrete wall (Fig. 8) is filled with polyurethane foam completely. This removes a haven for birds, moths, spiders etc. and prevents wind damage to the sealing membranes. If this region is not filled it is possible for high winds to blow up into this region causing excessive movement of the cladding.

Roof

The region where the roof cladding joins the walls at the gutter line is a critical area for sealing and many of the problems encountered occur in this region (Fig. 9). Two systems of sealing have been used successfully there. After removal of the gutters, each lap join is unbolted, the top sheet is lifted and a piece of felt or reinforcing material, dipped in the membrane sealer used (eg. an acrylic), is placed between the two sheets. The cladding is then bolted down again. Alternatively bitumen sealing tape can be used in place of the felt. The tape should be at least 2mm thick. It should be applied so that it seals between the sheets for at least 15cm along the join and for 15cm across the sheets at the open ends. This sealing should be carried out before any polyurethane foam is applied to the region internally.

The main horizontal laps in the roof should be secured by additional screws or pop-rivets before sealing to ensure that the membrane applied does not split under stress and movement (eg. from wind pressures or traffic during the sealing or inspection). The sealing membrane should be reinforced there (eg. with woven fibreglass tape). All laps should be coated so that the sealing membrane extends for at least 12mm each side of the join and with a thickness of more than 2mm.

All regions subject to movement (eg. around the grain inloading conveyor, where the roof trusses protrude through the curtain wall) must be sealed using a combination of polyurethane foam and flexible spray applied membrane coatings, reinforced with fibreglass fabric or other material. Any polyurethane used externally is coated with a protective sealing coating to prevent degradation by UV-light. A fine steel mesh can be embedded in the coating to prevent damage to the foam by parrots.

<u>Doors</u>

Sealing of the doors is always difficult and has to be redone each season. The main entry doors can be sealed internally with reinforcing tapes coated with a spray-applied flexible membrane. Access doors can be sealed externally using the same system. A new, less awkward system is now under development for sealing doors. This uses a light weight false door made of polystyrene foam protected with fibreglass that clips over the door frame externally. The edges are sealed to the frame using the flexible membrane system and reinforcing tape.

<u>Floors</u>

The concrete floors have been found to leak significantly. After cleaning, the construction joins and cracks are coated with the flexible membrane system and the whole floor is then sealed with a penetrant concrete sealer to fill porosity and hairline cracks.

<u>Heat Reflectant Coat</u>

After sealing a heat-reflective white coating is applied over the whole storage. This not only reduces the fluctuation in internal temperatures but also reduces the thermal expansion and contraction of the structure reducing stress on the sealing membranes.

CONCLUSION

Many minor points have not been covered in this paper. However, using the techniques described above, most problems in silo sealing can be overcome.

The motto of the silo sealing industry is "All Silos are Sealable'.

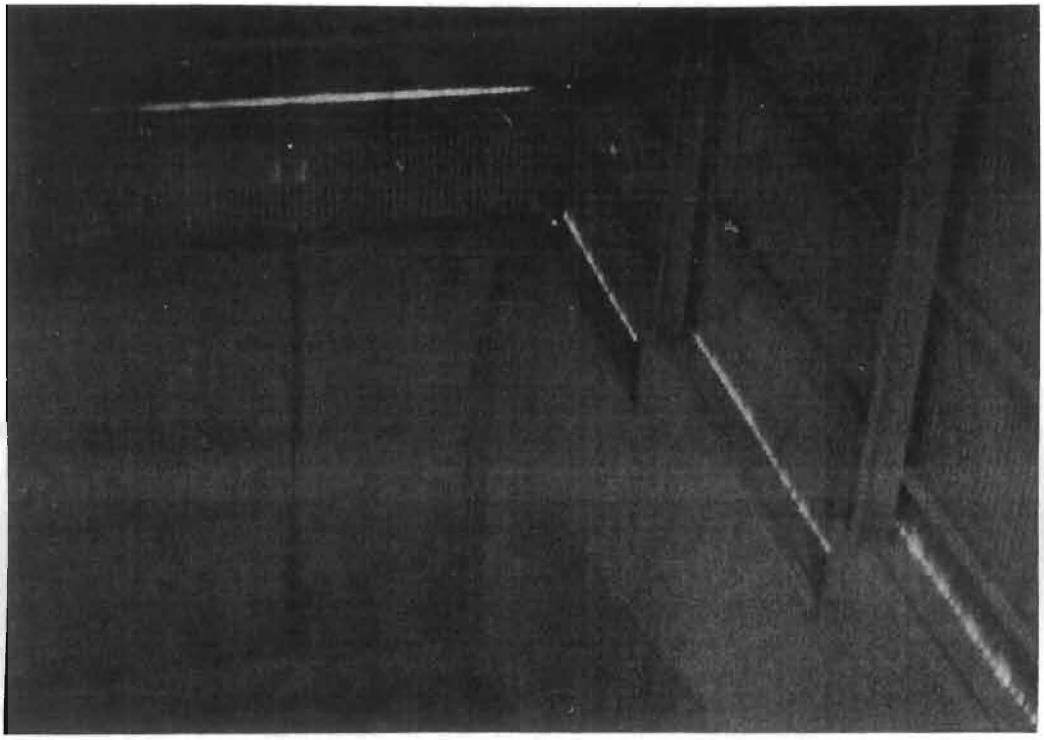

Fig. 1 The join between the concrete wall of the storage and metal cladding of the curtain wall, showing large gaps to be bridged before sealing.

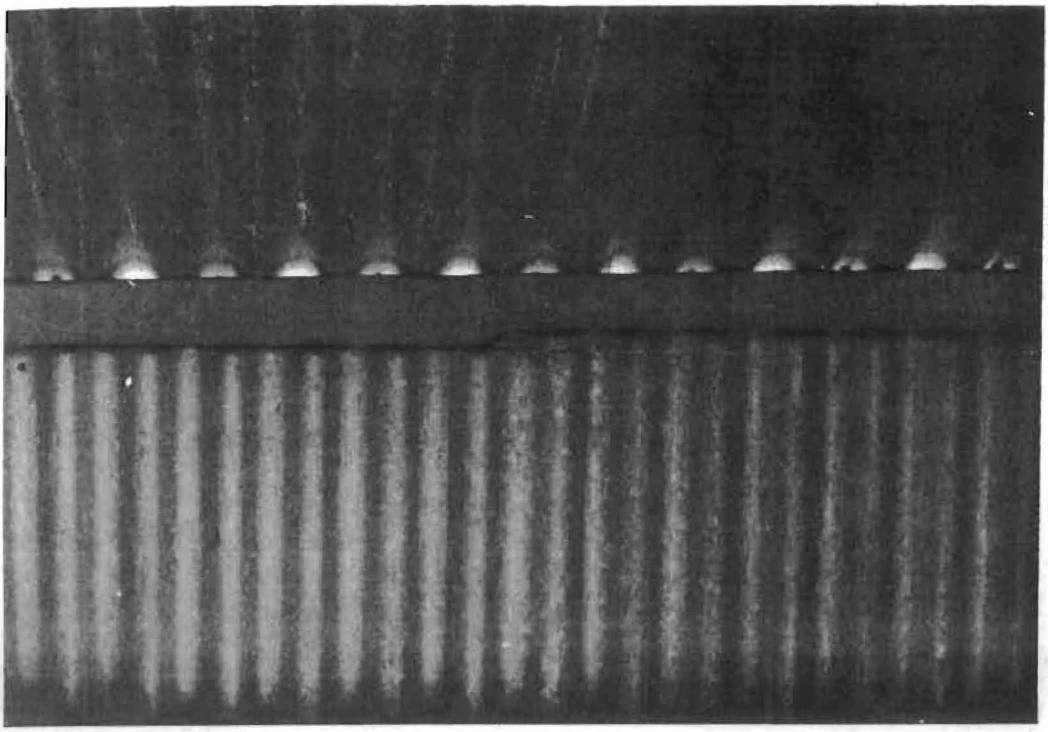

Fig. 2 Internal view of the wall-to-roof region.

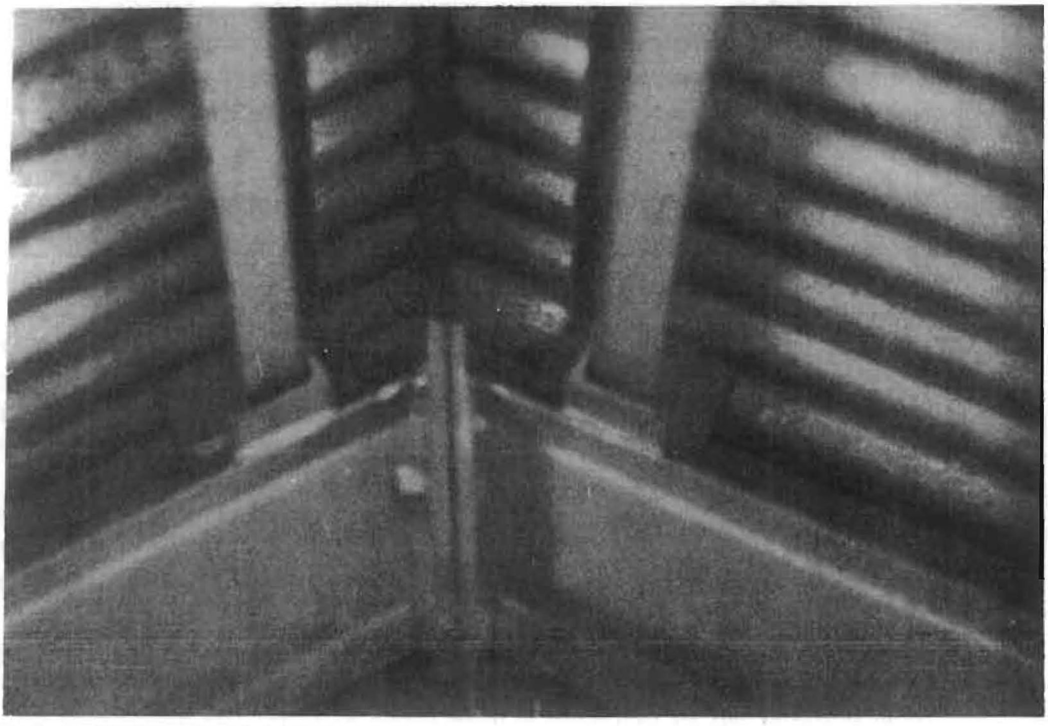

Fig. 3 Internal view of the ridge line of the roof in the penthouse.

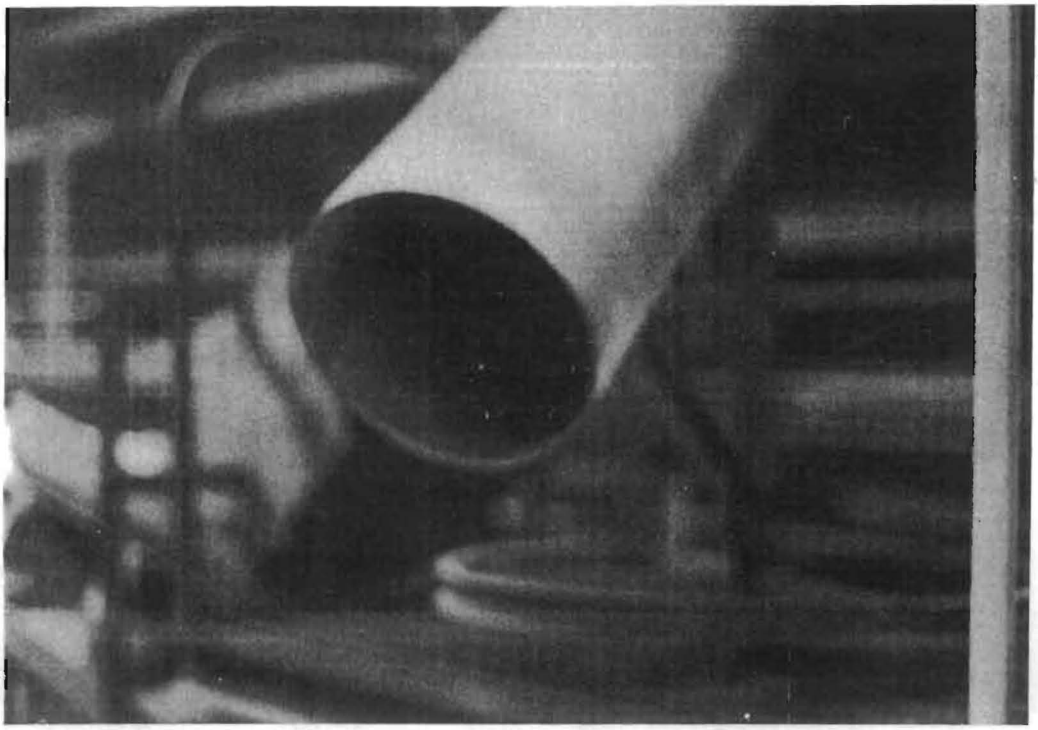

Fig. 4 Distribution chute for grain at the top of the storage.

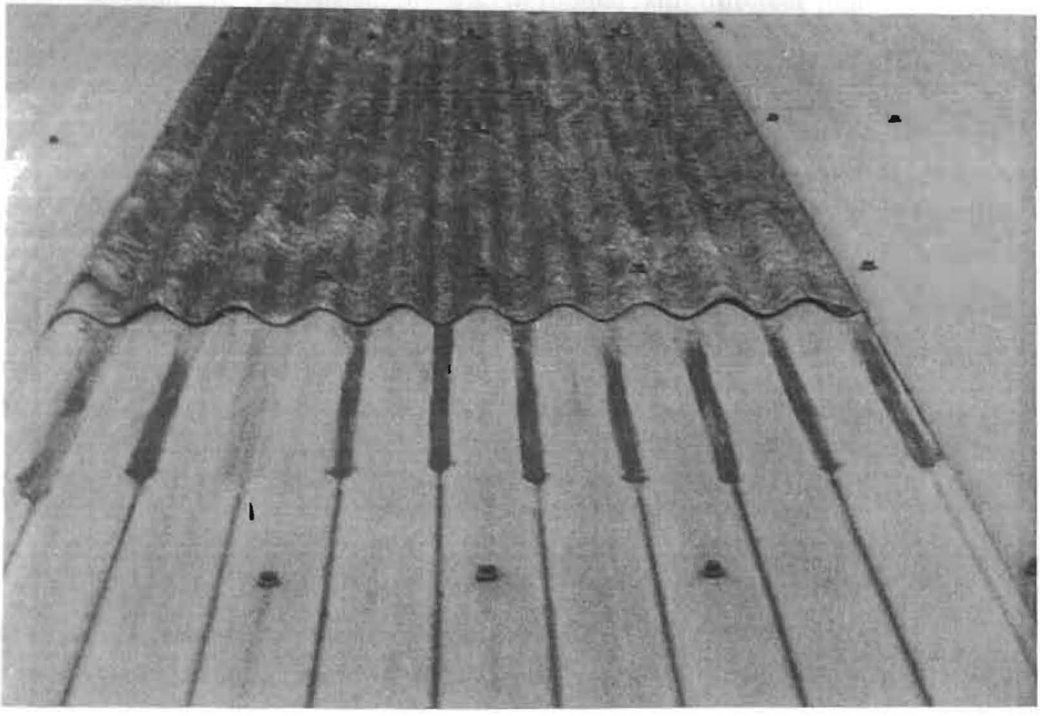

Fig. 5 Region of the roof where the skylight overlaps with the metal roof cladding.

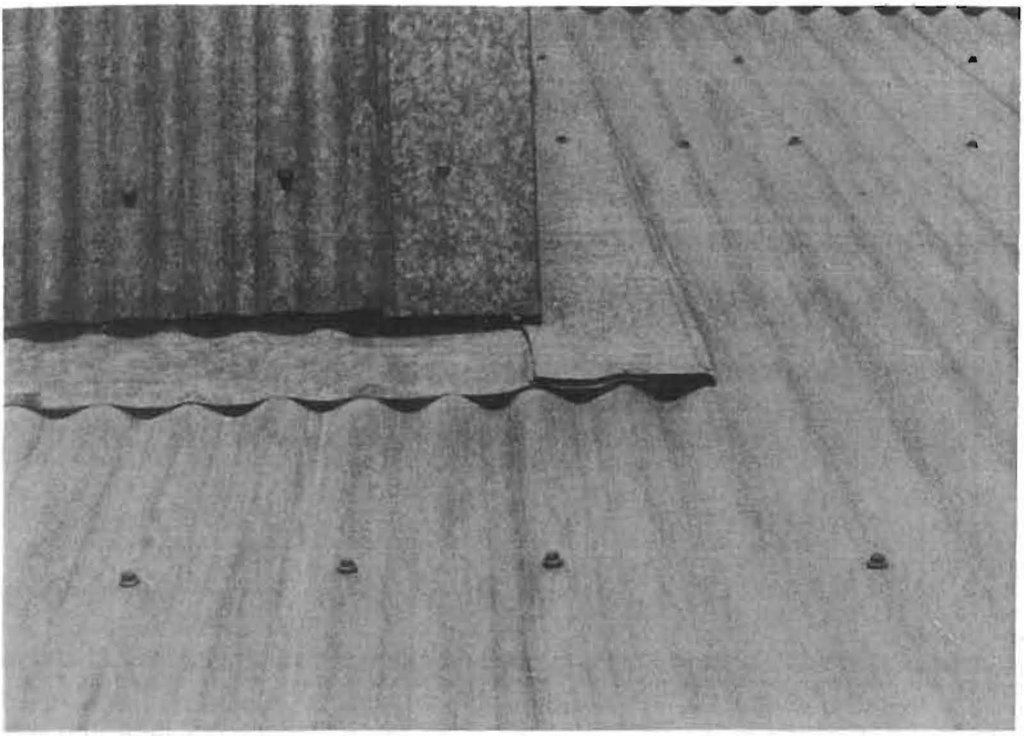

Fig. 6 The join between the penthouse and the storage roof.

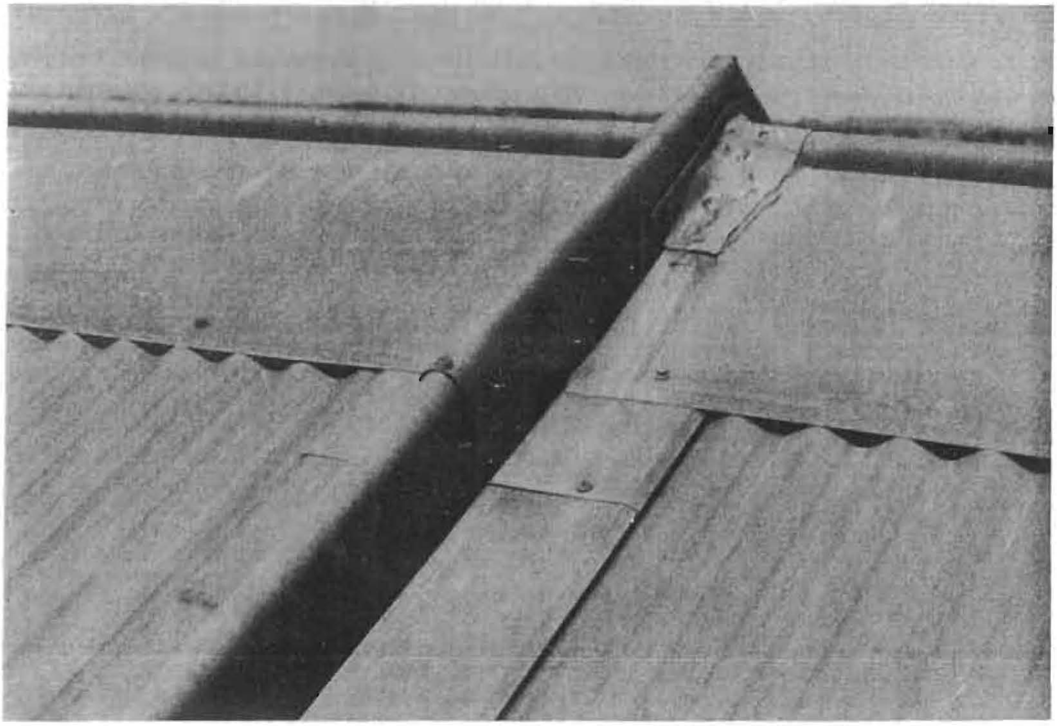

Fig. 7 An expansion join, at the place where it joins the roof ridge.

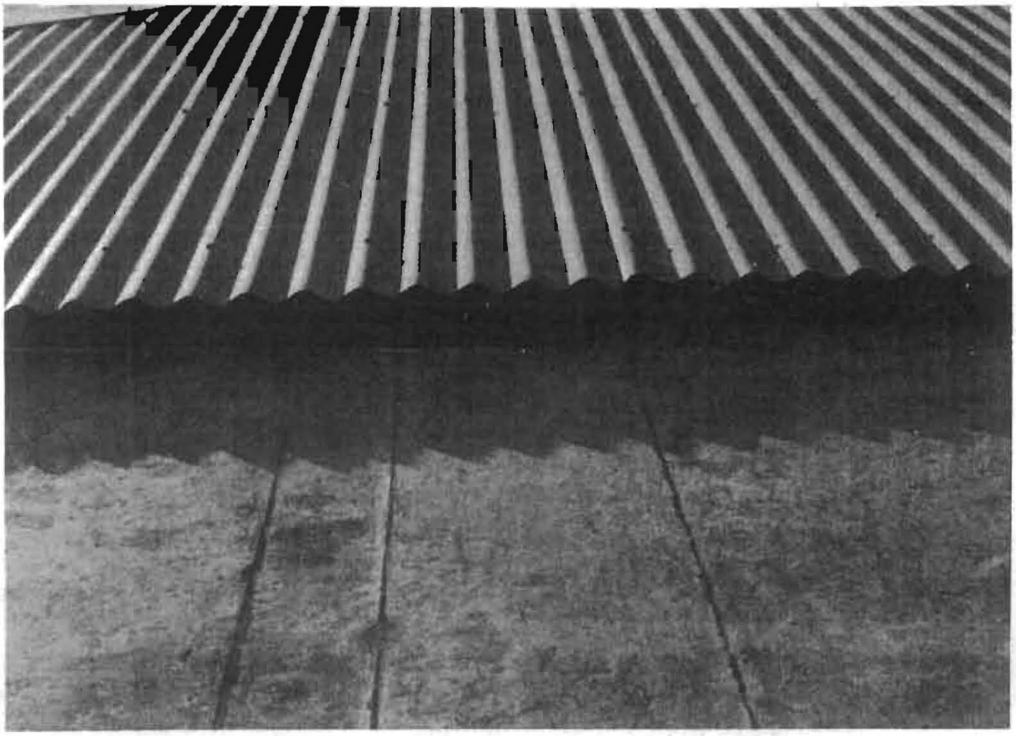

Fig. 8 The region of the gable end where the wall cladding overhangs the top of the concrete wall. Viewed from below.

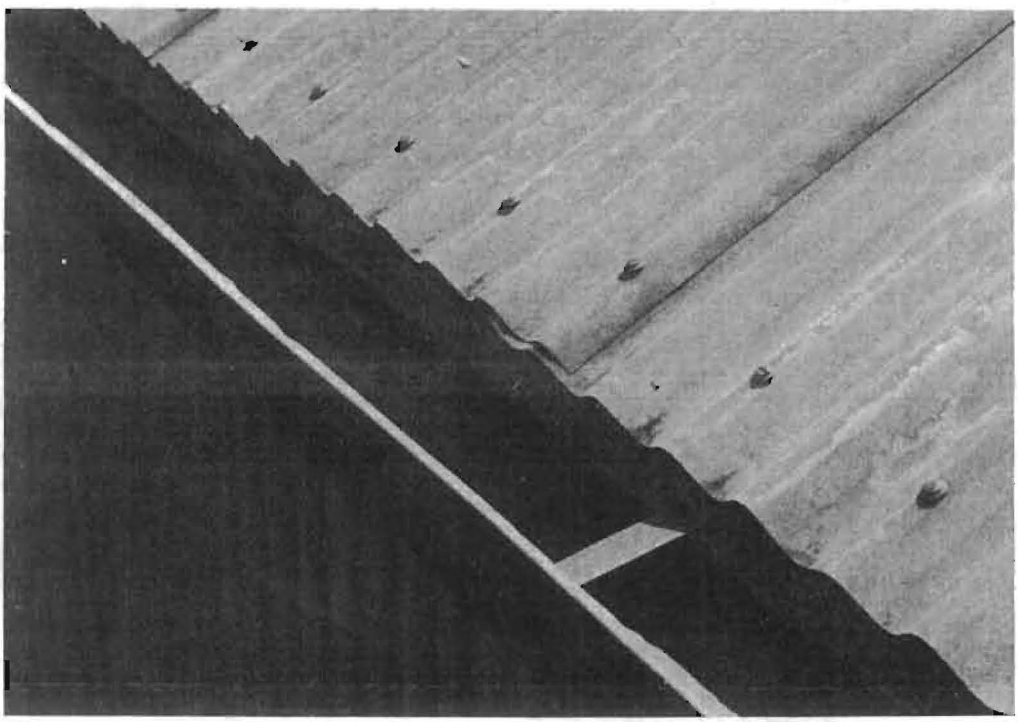

Fig. 9 The lower ends of the roof sheeting at the gutter line.