NRCA International Symposium

Improving roof reliability: Interim Report from CIB / RILEM Committee

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1. CIB / RILEM previous work
2. The importance of roof reliability
3. International examples
4. Substitution with care
5. Learning through experience
6. Tenets of reliable roofing

1. CIB / RILEM previous work

CIB: International Council for Research and Innovation in Building and Construction

RILEM: International Union of Testing and Research Laboratories for Materials and Structures

CIB W56 / RILEM Joint Roofing Committee founded in 1983 during NBS / NRCA Conference. The first Chairman was Bill Cullen.

1. CIB / RILEM previous work

- '*Elastomeric, Thermoplastic and Modified Bitumen Roofing: A Technical Report*', October 1986

- *'Thermal Analysis of Roofing Membrane Materials'*, July 1995

- *'International Index of Codes of Practice Related to Membrane Roofing Systems'* May 1996

- *'Towards Sustainable Roofing'*, July 2001

1. CIB / RILEM previous work

Representatives drawn from:

USA
Canada
Denmark
Germany
Israel
Japan
Korea
UK
Switzerland
India
Brazil
Romania
Turkey
Italy
Portugal
and more…

1. CIB / RILEM previous work

First meeting of CIB / RILEM Task Group on '**reliable roofing**'

– Phoenix, Arizona, March 2006

2. The importance of roof reliability

Some owners need a high degree of confidence that the building envelope will not leak.

Examples include:

- telephone exchanges, internet server rooms
- hospitals, operating rooms
- civic buildings, court houses
- cathedrals and churches
- nuclear facilities
- electrical power supplies

2. The importance of roof reliability

Industrial building – long valley gutters

2. The importance of roof reliability

Rainwater build up in level gutters

2. The importance of roof reliability

Internal building usage

2. The importance of roof reliability

Experienced roof tradesmen working on trial of over roof system

2. The importance of roof reliability

Over the past thirty years reliability engineering has developed:

- in the aerospace industry: the need to keep commercial airliners flying in the air

- in the car and electronics industries, particularly in Japan in the 1970’s

2. The importance of roof reliability

Defined as:

‘the probability that an item will perform a required function without failure under stated conditions for a stated period of time’

‘*assured quality for a given period of time’*

2. The importance of roof reliability

Collection buckets and stained ceiling tiles: *'not an unusual scene'*

2. The importance of roof reliability

bucket collecting rainwater

2. The importance of roof reliability

Definitions:

In the construction industry could be measured as

‘*the reduction in the number of* ***call backs*** *after completion*’

2. The importance of roof reliability

CIB / RILEM Task Group set out to identify specific actions that can improve reliability:

- co-ordination of details and specifications
- the need for competent workmen
- .....

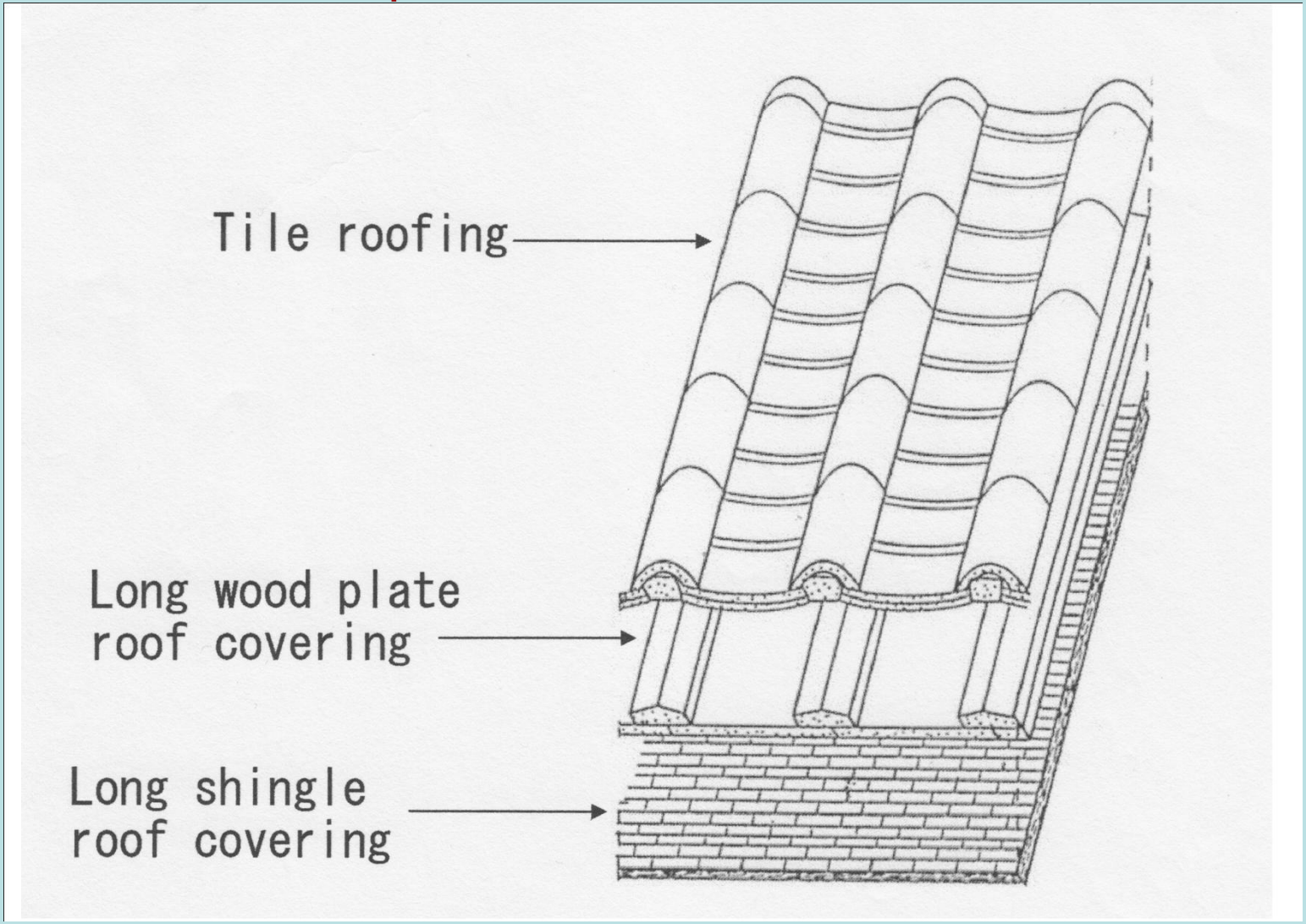
3. International experiences

Committee members asked to share experiences of long lasting roof systems that have given trouble free roofs

3. International experiences

Lecture Hall of the Shizutani School, built in 1666

3. International experiences



Multi layer roof system

3. International experiences

We learn that the multi layer roof system has in-built redundancy

This has been known for hundreds of years

We forget what previous generations have learnt!

4. Substitution with care

- Problems often stemmed from the late substitution with alternative products during the construction phase, often to save costs
- Different approaches in different countries
- In Israel a formal series of criteria are used for assessing the acceptability of a proposed substitution.

5. Learning through experience

- Constructive feedback after a project has been completed can lead to product development and innovation

- *For example*:

  Reports of intermittent rainwater leakage through laps in metal panel roof systems laid to shallow falls, particularly on long slopes in exposed locations

5. Learning through experience

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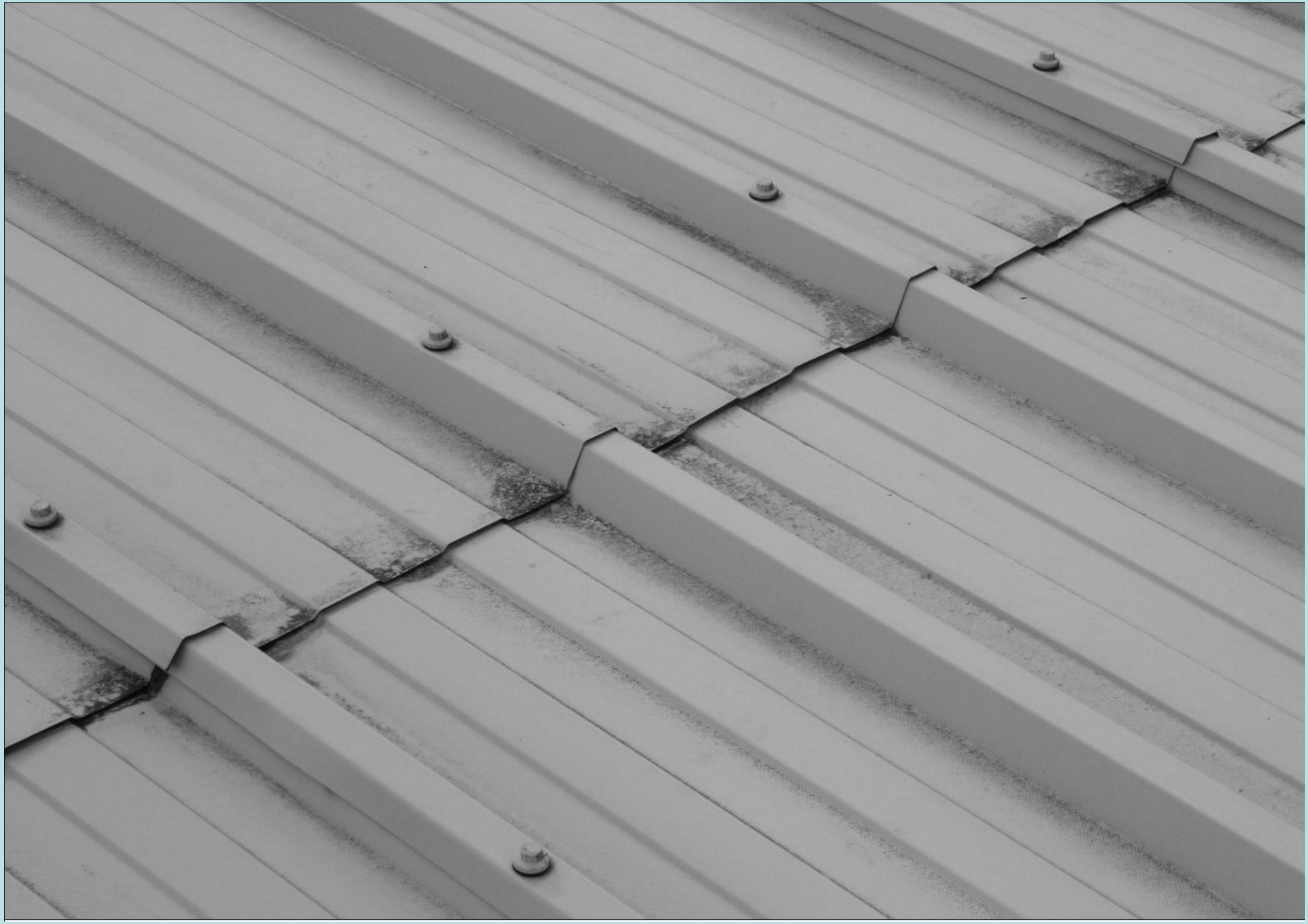
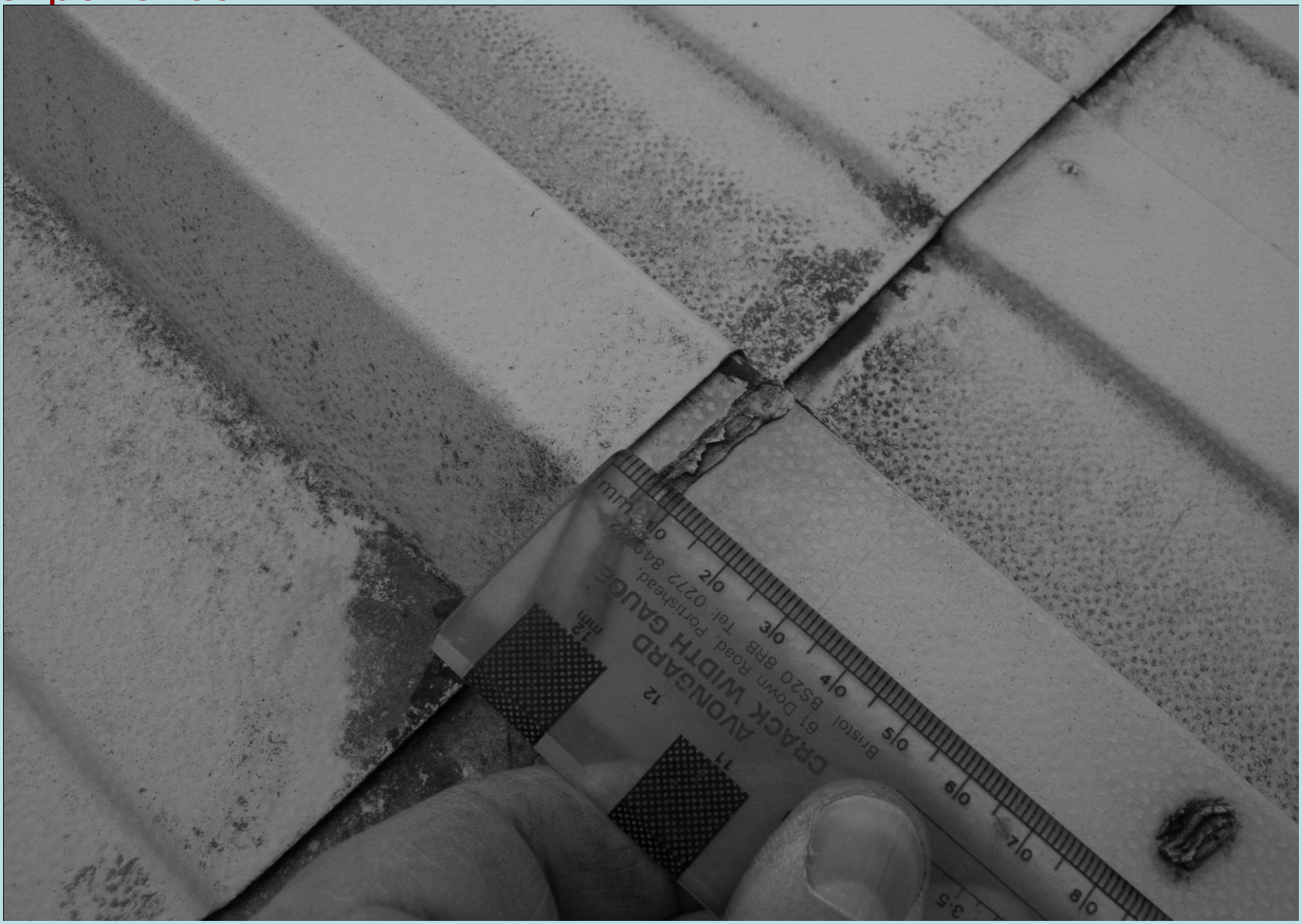


5. Learning through experience



5. Learning through experience

Appropriate methods of sharing information:

- Manufacturers' technical information
- Government sponsored publications
- Trade association information sheets
- Contractor in-house advisory services
- Published journals and conferences

5. Learning through experience

RCI TECHNICAL NOTE: 199

Learning from experience

Open seals within four way laps

One of the awkward junctions in metal roof cladding is forming the joints where four sheets come together at the intersection between end and side laps. This RCI Technical Note continues the series sharing feedback from multiple roof investigations, seeking to improve the reliability of the roofs we design and build

Examination of reported leak patterns in metal clad buildings sometimes shows leak positions at regular spacings directly below the intersections of the end and side laps. This has been observed on both built up metal and composite panel roof constructions.

In fibre cement sheeted roofs, where the thickness of the sheet is considerably greater, mitres are cut across the corners of the second and third sheets to be laid. This reduces the overall built up thickness of the lap and improves the weathering performance of the roof system. In contrast for thin metal sheeting there are no mitres. In the corners of each sheet there are small areas where there are four layers of metal on top of one another. Added to this is the thickness of the sealants in between, which have increased in size in recent years.

The issue

Rainwater leakage below four-way laps on metal sheeted roofs.

Findings

The roofs that suffer the greatest number of leaks below four-way laps are those built in severely exposed locations, with roof slopes that are shallow and long, increasing the amount of rainwater running over the laps. When there is a cross-wind the surface rainwater is blown up against and into the side laps.

From a close examination of a typical side lap the four different layers are built up in a sandwich with usually 6x5mm continuous butyl rubber sealant strips laid to one side of the crown, as shown in the figure. Immediately upslope and downslope of the four layer intersection there are often gaps which may extend for lengths of 300 to 450mm. It has been found that a flexible nylon cable tie can be pushed directly through the open side lap with ease. Where there is a translucent upper sheet these gaps are more readily apparent. They form an open leak path for rainwater running down the roof slope and blown against the side laps.

When the sealants are uncompressed, the depth of the gap is equivalent to the depth of the seal plus the thickness of the metal sheet. The introduction of a stitcher screw directly through the four-way lap tends to pull the four sheets together. For 5mm-thick sealant and 0.7mm-thick metal sheet, the degree of compression required in the seals within the four-way lap is more than 53%.

Compression of the sealant is temperature dependent. In cold weather conditions the butyl rubber sealant is relatively hard and greater force is required. It has been observed that roofs constructed during the winter months tend to have laps that are more 'gappy'.

The principal finding was that the side lap sealant had not been fully compressed at the four-way intersection to fill the gaps immediately up and downslope.

Publications

There is limited guidance currently published about four-way laps. Some manufacturers recommend an additional 150mm length of 6x5mm butyl rubber seal on the top of the third sheet on the side lap, under the end lap of the fourth sheet, and repeated onwards. In addition, a side lap stitching screw is installed 50mm up from the end of the sheet, which would be through the four-way intersection.

The NFRC Technical Bulletin 36 sets out a specification for sealants for use in end laps. This includes a requirement that the sealant should be compressible. Specifically, at 23°C the applied force to compress the sealant by 20% should be less than 1.5kg/cm². The Bulletin recognises that in cold conditions greater force is necessary.

Causation

With no compression of the sealant there will be gaps along the crown of the side lap where the built up thickness changes from three layers of metal plus two thicknesses of sealant, to two layers of metal plus one thickness of sealant. The greater the thickness of the seal, the larger the gap. The increase in seal thickness from 9x3mm to 6x5mm now recommended requires greater compression to close the gaps.

On exposed shallow pitch and long roofs, wind-driven rain can be blown up and into the side lap construction, allowing small volumes of rainwater to pass into the roof construction and down into the building below.

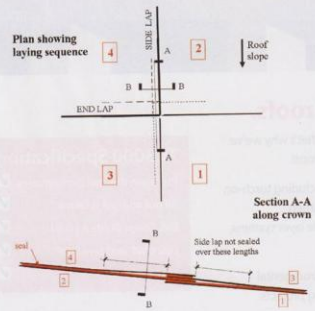
Guidance

When designing and constructing metal clad roofs with four-way laps, the following is offered as good practice to improve the reliability of the roof:

1. Reduce the number of four-way laps by specifying, where practical, longer sheets or panels with no end laps.
2. Discuss with the manufacturer the possibility of staggering adjacent tiers of sheeting to form three-way laps. This is not a common detail and would require more cut sheets at the verges.
3. Use a good quality sealant, Class A to NFRC Technical Bulletin 36, which has a service life of 20 years and good temperature stability. No sealants should be laid at air temperatures of 5°C or less.
4. Install a side lap stitcher screw to pull the four sheets together.
5. In severely exposed locations install a separate metal capping directly over the four-way lap and continuing over the lengths of the gaps to each side. Lay two lines of expanding foam filler to the underside of the capping to prevent wind driven rain being blown up into the side lap.

References

1. NFRC Technical Bulletin 36, *Performance standards for butyl strip sealants in metal clad buildings*, June 2003



Diagrammatic view of a typical four-way lap

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RCI Technical Note

5. Learning through experience

Appropriate methods of sharing information:

- Manufacturers' technical information
- Government sponsored publications
- Trade association information sheets
- Contractor in-house advisory services
- Published journals and conferences
- Internet discussion groups

6. Tenets of reliable roofing

A summary of common principles or points of best practice written down on single page.

Translated into common languages and widely circulated.

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Seeking to improve the reliability of the roof systems we design build and maintain.

Aim to cut down the number of call backs.

6. Tenets of reliable roofing

- **#4 Introduce element redundancy**

‘the fox leaves itself two ways to run’

Recognize the advantages of a double layer roof system

6. Tenets of reliable roofing

- **#4 Introduce element redundancy**

  'the fox leaves itself two ways to run'

- **#7 Substitute with care**

  follow 'intelligent caution' whilst encouraging innovation

6. Tenets of reliable roofing

- **#4 Introduce element redundancy**

  'the fox leaves itself two ways to run'

- **#7 Substitute with care**

  follow 'intelligent caution' whilst encouraging innovation

- **#12 Learn from experience**

  constructive feedback feeds the virtuous circle, encouraging product development and motivating innovation

7. Conclusion

By developing appropriate means to share feedback in a constructive way, we can learn from experience and improve the reliability of the roofs we design and build.

The CIB /RILEM Committee thank you for your attention and welcome your support

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