Historic England

Church Roof Replacement Using Terne-coated Stainless Steel

Guidance Note

Historic England

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Introduction

This Guidance Note has been produced by Historic England to address issues regarding the use of terne-coated stainless steel (TCSS) often raised by congregations, architects and advisory bodies when making decisions on roof replacement after lead theft from a historic church. Historic England commissioned an independent metal-roofing consultant to survey the TCSS roofs that have been installed on a number of churches in England over the past 25 years and to review their performance, summarise lessons learned and identify ways in which problems had been or could be overcome.

The Guidance Note considers eight design and specification issues that frequently arise when considering the use of TCSS to replace stolen lead roofing. It presents the findings of the survey and provides technical guidance on addressing each of the issues.

For advice on lead theft from church buildings and how to prevent it, and for Historic England's policy on alternative materials, see Historic England 2017 *Metal Theft from Historic Buildings*. Swindon. Historic England

Background

The theft of lead from church roofs in England continues to be reported despite active preventative measures. Replacement like-for-like with lead roofing is the best technical remediation, although where there is a means of access the risk of further theft remains. In such cases, TCSS is usually recommended by Historic England as an alternative roof covering.

Replacement of roofing using alternative materials that are of little salvage value has been used for many years. Stainless steel is potentially the most durable roofing metal with its high ductility and tensile strength making it more resistant to stresses associated with thermal movement and consequent fatigue problems. An early example of a church roof with a stainless steel covering dates back to 1978 in Guildford. The roof of the Chrysler Building in New York was laid in 1929 and is still serviceable. A properly detailed stainless steel roof should have a life of 80 to 100 years.

Fully supported stainless steel roofing does not experience reverse side corrosion. Rainwater running over the metal surfaces is not contaminated. Stainless steel is significantly lighter (3 kg/m^2) than lead (code 6 is 30 kg/m^2). The approximate cost of a stainless steel roof is similar to that of lead. It is cheaper than copper but more expensive than aluminium. Thinner gauge stainless is currently similar to zinc, although the market price for metals can vary significantly. At the end of its life stainless steel can be melted down and reused, a sustainable goal. However, as it is only 0.4mm or 0.5mm thick, it is relatively light and has a very low scrap value per square metre. It is also difficult to remove from the roof so it is not an attractive target for metal thieves.

1. Stainless steel material choice

Past experience

Some products have corroded. The hard metal is not malleable like lead and is difficult to form details.

Findings

Stainless steel is produced by slowly melting mixtures of iron, chromium and other metals in a large electric furnace to create ingots of metal alloy that are then heat treated, rolled and processed to ultimately create coils of thin sheet material. It is an expensive business. Consequently there are only a few manufacturers who offer a limited choice of finished products to the roofing industry.

Corrosion resistance is largely dependent upon chromium and molybdenum contents. Grade 316 is the highest quality material for roofing applications with 2.1 % molybdenum content. An alternative is grade K44 that has 1.85 % molybdenum content whilst giving economic advantages through being a non-nickel bearing alloy. For aggressive environments such as in high airborne salt areas within 10 km of the coastline, specialist advice should be sought.

A disadvantage with stainless steel in comparison to lead is that it is more difficult to fold and form detail work. 0.5 mm thick stainless steel can be impractical to use for some detail work. 0.4 mm thick sheet has been folded and laid successfully.

Guidance

Suggest 0.4 mm thick grade 316L (EN reference 1.4404) or grade K44 (EN reference 1.4521).

2. Terne coating choice

Past experience

Stainless steel can have a shiny appearance that would not be appropriate for an historic church.

Findings

Most stainless steel products have a bright shiny appearance, particularly when first exposed to the atmosphere. This would detract from the finished external appearance of the Church and be a poor match to the original lead roofing. To overcome this manufacturers have developed various low reflective finishes. The generic name of the coating is taken from the French word 'terne', meaning 'dull'.

An early coating widely used comprised of 80 % lead and 20 % tin. However, manufacturers in Europe changed to 100 % tin electroplated coating more than two decades ago partly to comply with environmental restrictions on the use of lead. This finish does have a silver coloured reflective appearance on first laying, and weathers to a dark grey matt finish over a six month to three year period. An advantage of the tin surface coating is that soldered joints can be formed with success.

Guidance

Suggest a tin rich electroplated surface coating.

3. Keeping the rain out: seams

Past experience

Standing seam metal roofs have leaked.

Findings

There are two common means of forming side joints in stainless steel metal roofing: a standing seam and a round batten roll.

The 25 mm high standing seam has a double welted top. The minimum finished slope for this type of joint is 5°. In some exposed locations with long shallow slopes water has found its way through the seams by capillary action or potentially by wind and thermal pumping action. This phenomenon is a result of wind pressure and temperature changes on partially sealed seams. Many contractors now apply a butyl seal within the seam before closing up. However the seal, which is inaccessible once the roof is properly formed, can have a relatively short life expectancy of typically 10 years.

The alternative side joint is to form a batten roll detail. The minimum finished slope for this type of joint is 3°. The sides of each stainless steel pan are dressed over a 50 x 50 shaped timber batten. The sides are 40 mm high with less risk of rainwater entry, whilst allowing the joint to breathe. Battens can be formed in different shapes. The round batten roll with a stainless steel cap batten closely resembles the traditional lead roll. An alternative preferred by some architects is a square batten with the capping held in place with welted edges, although this does not replicate the appearance of a traditional lead roll. Stainless steel cleats hold the sheets down and prevent detachment of the lightweight material in strong winds. The means of attachment also allow long lengths of sheet metal to expand and contract along the length of the roof slope. As there is less work hardening in forming the seams the risk of creating unevenness in the flat pan of the sheet, known as quilting or oil canning, is reduced.

Guidance

Suggest round batten roll side seams.

Standing seams

Round-batten rolls

4. Keeping the rain out: details

Past experience

Metal roofs have leaked.

Findings

Some rainwater ingress has been observed at verges and below sloping valleys where it has not been possible to site form and dress irregular shaped panels in stainless steel. This could be resolved by preparing a special panel in a workshop. Alternatively for relatively small areas the detail work around roof edges could be formed in lead. It is recognised that this could be attractive to a thief, although on a typical roof more than 95% of the roof area would still be formed in the terne coated stainless steel.

Other awkward details such as around pipe penetrations and access hatches could also be formed in lead. Lead remains the preferred material for flashings dressed into masonry. Where possible standard details should be adopted and agreed in advance.

Guidance

Suggest adopt standard traditional details, using lead in small quantities as appropriate.

Awkward detail at verge with water running into upstand

Lead used for flashings and access hatch capping

5. Reducing rain noises

Past experience

During periods of heavy rainfall or hail the roof is noisy.

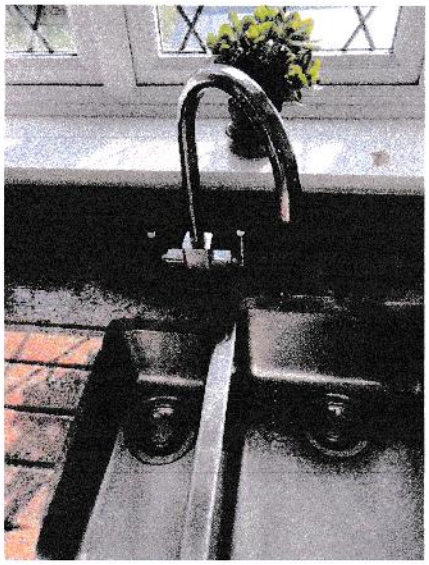
Findings

Several different techniques have been used to reduce noises heard within a Church due to heavy rainfall or hail impacting onto the outer stainless steel roofing. One technique is to use a structural underlay placed on top of the wooden deck and directly below the stainless steel roofing. This comprises of an open fibre mat approximately 8 mm thick with a breather membrane directly below. The manufacturer claims a noise reduction of up to 15 dB. However, concerns have been raised that the void directly below the metal roofing can act as a sound box potentially amplifying the drumming effect.

The alternative is to use a thicker solid strip that is factory adhered to the underside of the flat pan of the roofing. This uses the same technique as that used to reduce the noise of drops of water from a dripping tap falling into the bowl of a stainless steel sink. The mat bonded to the underside increases the stiffness of the metal, reducing the impact sounds.

Guidance

Suggest an acoustic mat adhered to the underside of the flat pan of the roofing.



Water dripping into a stainless steel sink

Mats bonded to underside of sink to reduce dripping noises

6. Unacceptable appearance from ground level

Past experience

The detailing seen by Church users gives an unacceptable appearance.

Findings

On occasion perimeter detailing to the stainless steel roofing can be readily seen from ground level and if not properly considered can give an unacceptable appearance.

Care is required in considering perimeter details that can be seen from ground level. Alternative details using traditional materials such as stone or rendered masonry may be feasible. Alternatively forming the verge in lead could be considered, although again this could be attractive to a potential thief.

Guidance

Suggest adopt standard traditional details, using lead in small quantities as appropriate.

Straight verge fascia contrasts with uneven masonry

End of fascia with acute corner and incomplete closure

7. Surface discolouration

Past experience

The roof surfaces have a rusty appearance after several years.

Findings

On a few stainless steel roofs with the old lead / tin terne coating a brown coloured residue formed after several years of exposure. On investigation it was found that there was no reduction in the overall thickness or pitting corrosion in the stainless steel roofing. Trials have shown that the discolouration can be permanently removed using a weak phosphoric acid solution that is commonly found in carbonated soft drinks, especially cola.

Guidance

If discolouration appears wash down with recommended cleaning solution.

Discolouration of lead rich terne coated stainless steel

Stain successfully removed using weak phosphoric acid solution

8. Reliable roofing tradespeople

Past experience

The job looks unsightly.

Findings

This is probably one of the most important decisions in finding and selecting a roofing contractor who has tradespeople who are experienced in working with stainless steel and have the right specialist tools for the job. All tools have to be made of stainless steel as any particles or residues from plain steel tools will result in staining.

The contractor is responsible for taking appropriate fire precautions in carrying out any hot works on the roof.

Guidance

Suggest using a member of the Federation of Traditional Metal Roofing Contractors (FTMRC), although not all of their contractor members have sufficient experience working with stainless steel. Some Lead Sheet Association (LSA) members with experience should also be considered, particularly for the lead detail works.

9. Further reading

- Martin, B and Wood, C (2018). 'English Heritage Practical Building Conservation: Roofing', Routledge.
- FTMRC, (2018). 'UK Guide to Good Practice in Fully Supported Metal Roofing and Cladding', 3rd Edition, FTMRC.
- BRE (1990). 'Stainless steel as a building material', Digest 349, BRE.
- Roberts, K, (2009). 'Leakage through shallow pitch stainless steel standing seam roofing', RCI Technical Note 186, Unity Media.
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- (-).'HFX Stainless for Roof and Façade: Designs', Roofinox.
- (2002) 'Stainless steel for roofing', Volume 4 of Building Series, Euroinox.

Disclaimer

This Guidance Note is a summary of current best practice. Historic England and their advisors do not take responsibility for consequences arising from the use of this document.

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