Historic England

Church Roof Replacement using Terne-coated Stainless Steel

Guidance Note

Summary

This technical advice note is aimed at parochial church councils and their architects, diocesan advisory committees, local authority conservation officers and other conservation professionals. It is designed to help with decisions following theft of lead from a historic church roof. Terne- coated stainless steel (TCSS) is the most durable alternative to lead and offers advantages over other options such as slate or tiles. However, there are a number of issues regarding the use of TCSS that are often raised by congregations, architects and advisory bodies when making decisions on roof replacement after lead theft from a historic church. To address these, 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 learnt and identify ways in which problems had been or could be overcome. It also commissioned laboratory testing of various TCSS roof assemblies to evaluate ways of reducing the noise of rain drumming on a TCSS roof.

This advice note considers nine design, specification and installation issues that frequently arise when considering the use of TCSS to replace stolen lead roofing. It presents the findings of the survey and laboratory tests, and provides technical guidance on addressing each of the issues.

For advice on preventing theft of lead from church buildings and what to do if theft occurs, see Theft of Metal from Church Roofs: Prevention and Response, and for Historic England's policy on alternative materials, see Theft of Metal from Church Roofs: Replacement Materials.

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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Front cover: Terne-coated stainless steel roof with round batten rolls
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1 Introduction

The theft of lead from church roofs in England continues to be reported despite active preventive measures. When lead roof coverings have been stolen, we understand it may be too risky to replace with the same materials. We have found that the most appropriate and long-lasting alternative is generally terne-coated stainless steel (TCSS), although for some buildings zinc, slates or tiles may be options.

Stainless steel is potentially the most durable alternative roofing metal; it has 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 is in Guildford and dates from 1978. 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.

TCSS offers a number of other advantages:

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

2 Stainless steel material choice

2.1 Past experience

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

2.2 Survey 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 per cent molybdenum content. An alternative is grade K44 that has 1.85 per cent molybdenum content whilst giving economic advantages through being a non-nickel bearing alloy. For aggressive environments such as in high airborne-salt areas within 10km of the coastline, specialist advice should be sought.

Stainless steel is more difficult to fold and form detail work than lead. However, whilst 0.5mm-thick stainless steel can be impractical to use for some detail work, 0.4mm-thick sheet has been folded and laid successfully.

2.3 Guidance

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

3 Terne coating

3.1 Past experience

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

3.2 Survey 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 for the original lead roofing. To overcome this, manufacturers have developed various low-reflective coatings. The generic name of the coating is taken from the French word ‘terne’, meaning ‘dull’.

An early coating that was widely used comprised 80 per cent lead and 20 per cent tin. However, manufacturers in Europe changed to 100 per cent tin electroplated coating more than two decades ago partly to comply with environmental restrictions on the use of lead. This finish has a silver coloured reflective appearance when first laid, but 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.

3.3 Guidance

Suggest a tin-rich electroplated surface coating.

4 Keeping the rain out: seams

4.1 Past experience

Standing seam metal roofs have leaked.

4.2 Survey findings

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

The 25mm 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 method of forming a side joint is to use a batten roll detail. The minimum finished slope for this type of joint is 3°. The sides of each stainless steel pan are dressed up the sides of a 50 x 50mm shaped timber batten. The up-turns at the sides of the panels are 40mm high, so there is less risk of rainwater entry than with a standing steam, whilst allowing the joint to breathe. The batten and up-turns are then protected with a separate stainless-steel capping strip dressed to shape and fitted over the batten.

Battens can be formed in different shapes. The round batten roll 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 a batten roll compared to a standing seam the risk of creating unevenness in the flat pan of the sheet, known as quilting or oil canning, is reduced.

4.3 Guidance

Suggest round batten-roll side seams.

Figure 1:
Standing seams

Figure 2:
Round batten rolls

5 Keeping the rain out: details

5.1 Past experience

Metal roofs have leaked.

5.2 Survey findings

Some rainwater ingress has been observed at verges and below sloping valleys where it has not been possible to form and dress irregular-shaped panels in stainless steel on site. 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. Although this could be attractive to a thief, on a typical roof more than 95 per cent of the roof covering would still be formed in the terne-coated stainless steel and at very low risk of theft.

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.

5.3 Guidance

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

Figure 3:
Awkward detail at verge with water running into upstand

Figure 4:
Lead used for flashings and access hatch capping

6 Reducing rain noises: seams

6.1 Past experience

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

6.2 Survey findings

A recurring concern has been reports during heavy rainfall of significant noise heard within churches caused by droplets of rain falling onto the thin metal roofing. There is a British Standard for the laboratory measurement of sound generated by rainfall on building elements, BS EN ISO 140 Part 18. Rain is simulated on a purpose-built rig at the acoustic laboratory. Droplets of water fall from a tank suspended 3.5m above small sample roofs and the sound intensity is measured within a test room directly below.

Acoustic tests were commissioned by Historic England to compare different roof constructions. The acoustic performance of the two different TCSS seam types - standing seam and round-batten rolls - was measured. The independent test results found that the average sound intensity below the batten roll roof was 1.3 dB quieter than beneath the standing seam roof.

6.3 Guidance

Suggest round batten-roll side seams as quieter in heavy rainfall.

Figure 5:
Standing-seam roof sample under test

Figure 6:
Round batten-roll roof sample under test

7 Reducing rain noises: underlay

7.1 Past experience

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

7.2 Results of laboratory testing

Another means of reducing rain drumming noise is to introduce a different type of underlay placed on top of the wooden deck and directly below the stainless-steel roofing.

There are two types. A spiral-mesh open-fibre mat approximately 8 mm thick with a breather membrane directly below. The shallow air gap helps to reduce noise transmission. Alternatively, a solid acoustic mat that is adhered to the underside of the flat pan of the roofing can be used. 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.

Independent tests carried out at the acoustic laboratory found that the addition of spiral-mesh open-fibre underlay reduced the sound intensity by 0.4 dB. The alternative solid acoustic mat reduced the sound intensity by 2.2 dB.

Figure 7:
Mats bonded to underside of sink to reduce dripping noises

7.3 Guidance

Suggest an acoustic mat adhered to the underside of the flat pan of the roofing as quieter in heavy rainfall.

Figure 8:
Spiral mesh underlay under test

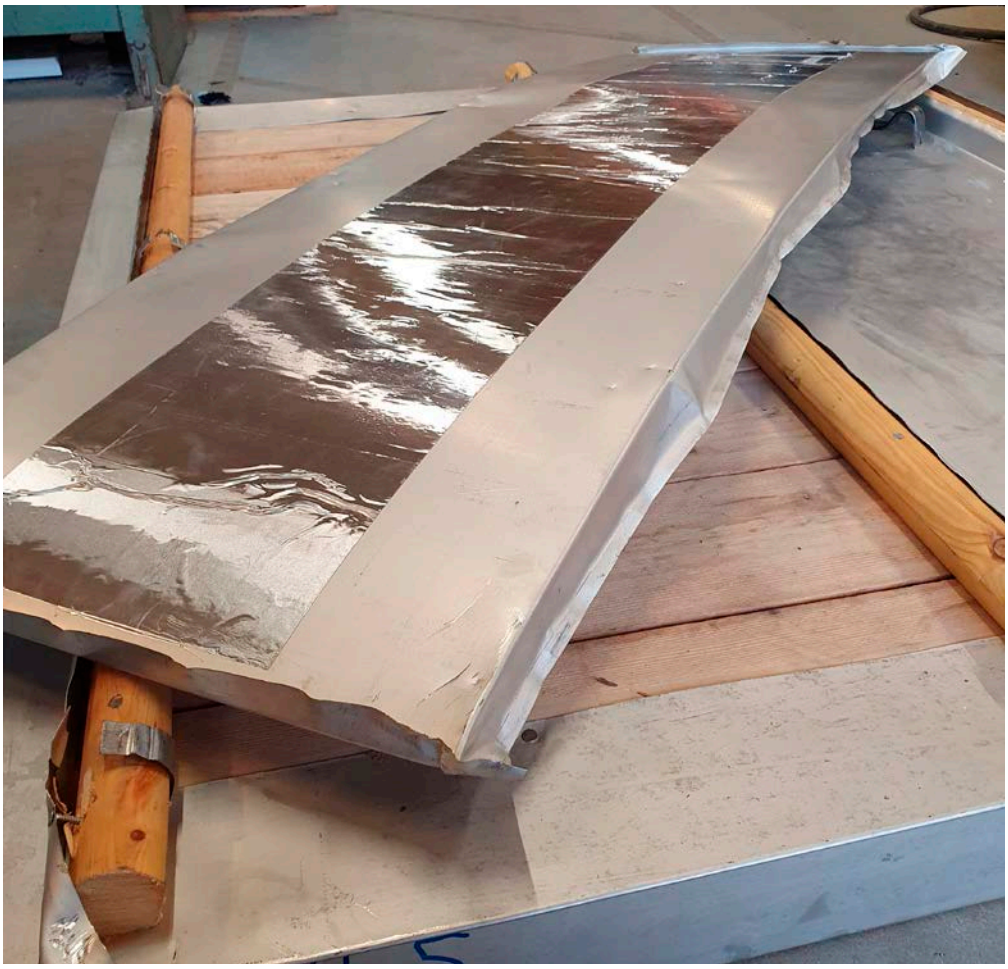

Figure 9:
Acoustic mat bonded to underside of roofing for acoustic test

8 Unacceptable appearance from ground level

8.1 Past experience

The detailing seen from ground level by church users can look unacceptable.

8.2 Findings

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

8.3 Guidance

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

Figure 10:
Straight verge fascia contrasts with uneven masonry

Figure 11:
End of fascia with acute corner and incomplete closure

9 Surface discolouration

9.1 Past experience

Some roof surfaces have a rusty appearance after several years.

9.2 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.

9.3 Guidance

If discolouration appears, wash down with recommended cleaning solution.

Figure 12:
Discolouration of lead-rich terne-coated stainless steel

Figure 13:
Stain successfully removed using weak phosphoric acid solution

10 Appropriate skills

10.1 Past experience

The job sometimes looks unsightly.

10.2 Findings

Using an experienced contractor is key to ensuring that a terne- coated stainless steel (TCSS) roof looks good and performs well. You therefore need to use a roofing contractor whose tradespeople are experienced in working with stainless steel and have the right specialist tools for the job.

All tools used when fitting a stainless steel roof must 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 f ire precautions in carrying out any hot works on the roof.

10.3 Guidance

Suggest using a member of the Federation of Traditional Metal Roofing Contractors (FTMRC). However, not all of its contractor members have sufficient experience of working with stainless steel, so you will need to make further enquires to make sure that they have the necessary skill. Ask to see examples of previous TCSS roofs they have installed. Some Lead Contractors Association (LCA) members with experience should also be considered, particularly for the lead detail works.

11 Further reading

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