The Roofs of Chichester Cathedral, England

By Keith Roberts, BSc, CEng, MICE, MIStructE

THOSE OF US who specify and oversee the refurbishment of an aged roof know it is helpful to understand how the building was originally built and subsequently modified to ensure that the design of new works is appropriate. For most of us, the buildings we refurbish typically date back no more than a generation or two, being perhaps 50 or 60 years old.

In England, we are blessed with many ancient monuments and buildings with long histories of refurbishment to extend service lives and adapt the structures to the needs of a particular time. Chichester Cathedral, which is located close to the south coast, is a good example of a historic structure that has been refurbished many times. The stories that can be told about its past offer lessons for the future.

MEDIEVAL HISTORY

Construction of Chichester Cathedral began in 1075 following the Norman Conquest and was first consecrated in 1108. Several of the original columns still stand that were formed in quarry stone, dressed using hand tools to form smooth faces, with rubble-filled cores laid in a lime matrix.

Figure 1. *Extensive temporary works protecting the nave of Chichester Cathedral.*

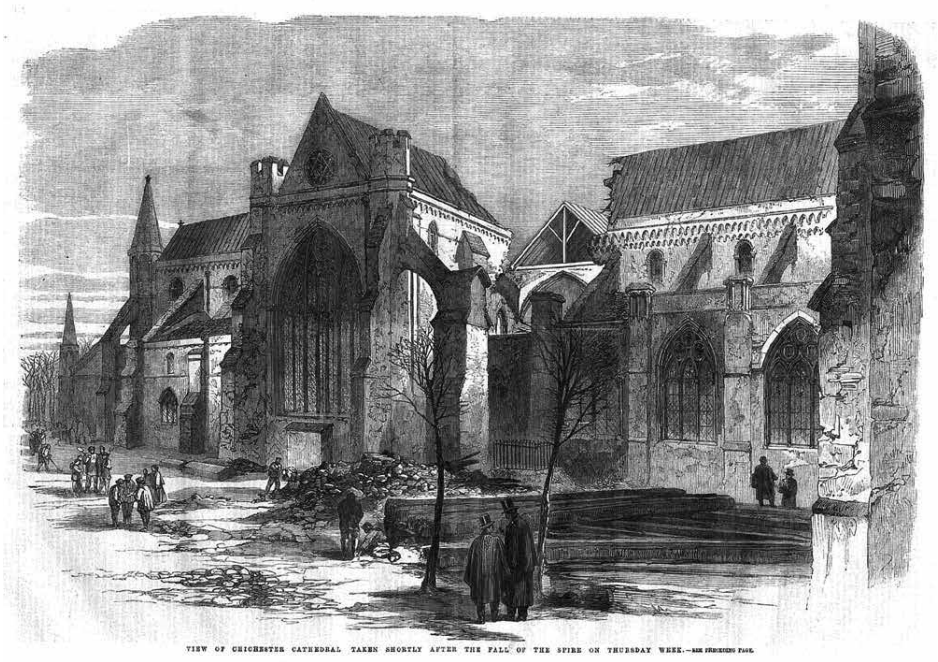

Figure 2. *View prepared shortly after the fall of the spire in February 1861.*

Figure 3. *The 1949 copper roofing with additional fasteners to reduce uplift and splitting.*
Source: Chichester Cathedral.

It has been said that the original flat roof had a wooden structure, although little is known of the original coverings. In 1114 and again in 1187, there were devastating fires and collapse. Protecting buildings from accidental fire has been a challenge for centuries.

On the command of King Richard I, 400 oak trees were felled, and a new timber roof structure was constructed under the direction of French carpenters. The remodeled cathedral was reconsecrated in 1199, and parts of the medieval timber structure still remain. Stone-vaulted internal ceilings were built later.

Around 1400, the cathedral's spire, cloisters, and campanile were built. Chichester has the only surviving detached medieval bell tower in England, although there are now concerns about the condition of its external building enclosure. This isolated structure is the subject of future fundraising and refurbishment.

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LESSONS FROM THE VICTORIAN BUILDING WORKS

In 1859, internal building works were undertaken to remove a masonry wall on the west side of the central spire to improve the lines of sight for the congregation seated in the nave. Within a few months of the removal of the ornate carved stone screen, cracks started to develop in the stone column in the southwest corner, which ultimately led to the collapse of the spire in 1861. Subsequent investigations into causation found that the shallowness of the medieval foundations combined with the inadequate compressive strength of the rubble-filled columns led to the catastrophic failure on the removal of the restraint from the adjoining internal wall.[1] Over the next six years, the spire was rebuilt, with the project requiring extensive work to the adjoining timber roof structure.

POSTWAR COPPER ROOF

When World War II ended, a great many English churches urgently needed repair, as projects to maintain or renovate these structures had been mostly suspended for years due to building restrictions, the rationing of materials, and a lack of funding. The lead roofs at Chichester Cathedral were in poor condition, and in 1949, the cathedral was one of the first ecclesiastical buildings to receive postwar repairs.[2] At the time, lead was in short supply and had a high salvage value; therefore, the cathedral's roofs were relaid in copper. To reduce construction costs, the distance between conical-shaped wood rolls was increased from 0.5 m to 0.8 m (1 ft 8 in. to 2 ft 8 in.), using 0.6-mm- (0.024-in.-) thick copper sheets that were 1.6 m (5 ft 3 in.) long.

Figure 4. *Rainwater staining of timber structure, including a replaced wall plate.*

Figure 5. *Medieval timber supporting the nave roof; with the external copper removed, daylight shines through penny gaps between sheathing boards.*

Unfortunately, the copper roofs have had a number of shortcomings. The cathedral is less than 10 km (6 mi) from the sea, such that the pitched roofs more than 20 m (65 ft) above ground level regularly experience high-wind-suction loading. With the exposed nature of the roof and the open form of the roof attic, the wider bays have not been fully able to withstand the wind forces lifting the pans of the sheets away from the roof slope. The movement in the copper has led to work hardening, fatigue, and splits developing along the centerline of the sheets and cross welts where two panels are joined with an interlocking single fold. This damage has, in turn, resulted in rainwater ingress and the need for local patch repairs.

NEW LEAD ROOF

Over the past five years a project has been in progress to replace the copper roof coverings at Chichester Cathedral with new, fully supported lead roofing with batten rolls. Extensive scaffolding has been erected to provide safe access together with a temporary roof to maintain weathertightness during the works. This has been

A breathable underlayment is not being used because it has been found to retain water and prevent adequate air movement to the underside of the lead, increasing the risk of reverse-side corrosion.

Figure 6. *Copper removed, 1949 sheathing boards retained.*

Figure 8. *Plywood to support new gutter with ventilation slots.*

Figure 7. *Batten roll wood battens fixed to sheathing, no underlay.*

Figure 9. *Lead cut to length and dressed on timber former.*

Figure 10. *Lead profile carried to hoist.*

Figure 11. *Lead dressed over timber batten rolls.*

Source: Chichester Cathedral.

Figure 12. *Completed lead roofing to chancel and transepts.*

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Figure 13. *Completed lead roofing to chancel and transepts.*

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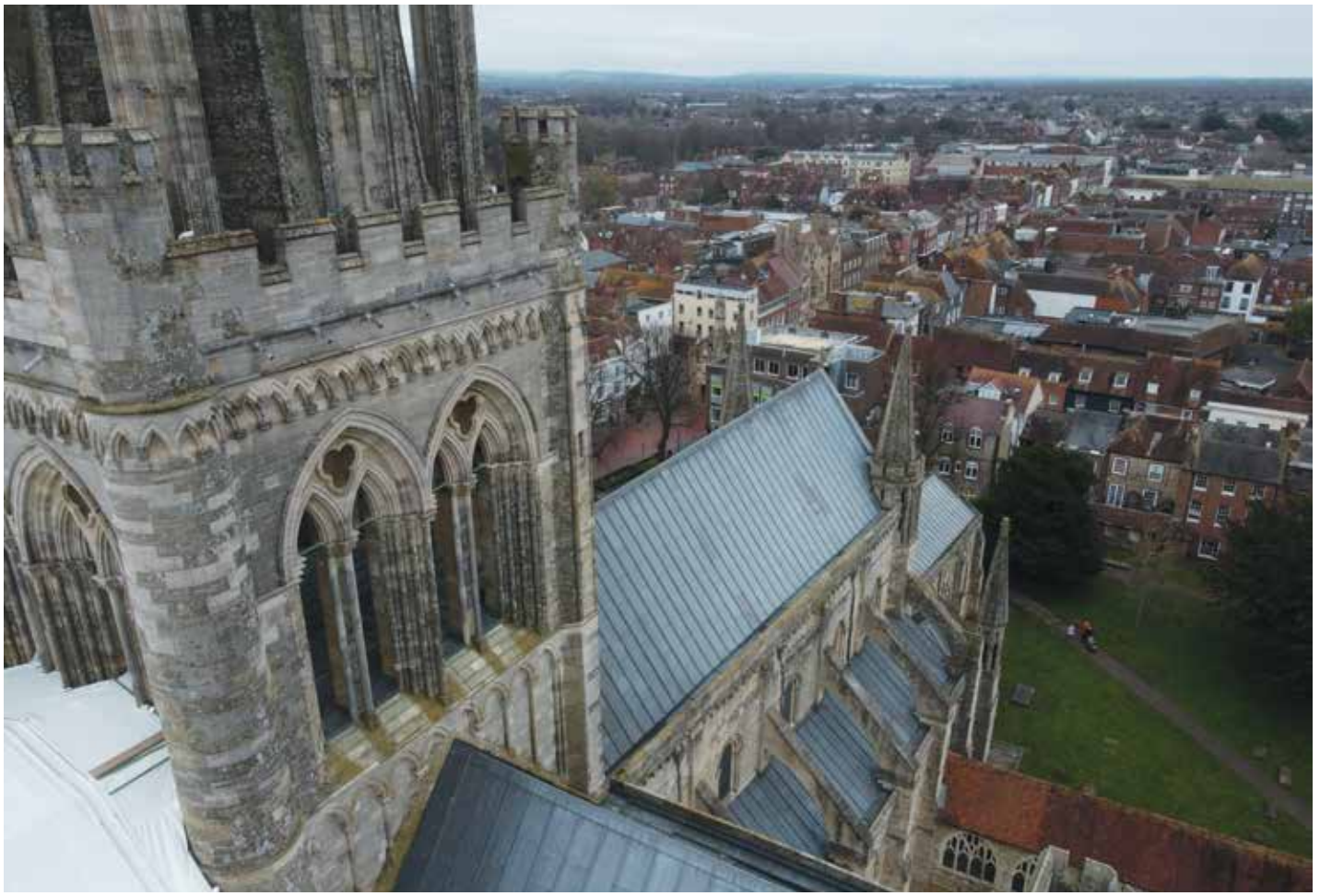

Figure 14. *Completed lead roofing to chancel and transepts.*

Source: Chichester Cathedral.

a major cost element, currently running at more than £70,000 ($90,000) per week in hire charges. The aged and split copper roofing has been removed and sent for salvage. The earlier softwood sheathing boards are being retained with penny gaps, typically 3 mm (0.118 in.) wide, to provide good ventilation to the reverse side of the new lead roofing. The lead to the pitched roofs is code 8 (3.5 mm [0.138 in.] thick) and in the parapet gutters the even heavier code 10 (4.23 mm [0.167 in.] thick).

The lead is laid directly onto the softwood and dressed over the batten roll—shaped timber battens. A breathable underlayment is not being used because it has been found to retain water and prevent adequate air movement to the underside of the lead, increasing the risk of reverse-side corrosion. This is a lesson learned from other roofing works on churches in England, which is being shared for the benefit of the future generations who will maintain our ancient buildings.

Work on the chancel and transepts has been completed, with the work on the nave scheduled to finish later in 2023. Further information about the ongoing and active work at Chichester Cathedral may be found at www.chichestercathedral.org.uk. Visitors from North America would be very welcome.

REFERENCES

1. Tappin, S. 2019. "The Roofs of Chichester Cathedral from the C12 to the Installation of Fire Compartmentation." Presented at the IStructE Conference, October 29, 2019. Video available at https://www.istructe.org/resources/case-study/the-roofs-of-chichester-cathedral.
2. Goode, J. 2015. "Aspects of Copper Roofing." *Context* 139 (May): 29–31. https://ihbconline.co.uk/context/139/28.

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