

THE DESIGN AND CONSTRUCTION TECHNIQUES OF EIGHTEENTH CENTURY TIMBER ROOFS IN SCOTLAND: GLASGOW TRADES HALL AND TWEEDDALE HOUSE IN EDINBURGH

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Abstract

The few open roofs mentioned in literature seem to represent an exception rather than the rule: most Scottish timber roofs are hidden behind timber or plaster ceilings and characterised by a much simpler common rafter form. From the eighteenth century onwards they presented hipped and trussed arrangements as well as other more complex solutions developed to meet the requirements of evolving architecture. This paper attempts to shed some light on the design and construction techniques of eighteenth century Scottish timber roofs with the preliminary results obtained from the creation of a relational database of 1250 buildings (including structures, professionals, dates), related mapping, survey of 29 roofs across Scotland and a more detailed study of those at Tweeddale House in Edinburgh, and Glasgow Trades Hall. Both buildings have roofs from the period in which the Adam brothers worked on them as architects. The original sixteenth century Tweeddale House was remodeled by the Adams in 1752-3 and almost forty years later Robert Adam designed the Glasgow Trades Hall (1791/4), although the building was completed after his death with a modified design. Archival research combined with surveys has allowed to make an initial appraisal of the design and construction processes involved in the two projects. Many questions arise concerning the specific involvement of architects and wrights in the successive transformations of the roofs and an attempt to identify local and foreign influences has been carried out by analyzing the typology of roofs and joints.

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INTRODUCTION

Scottish roof structures seem to have been a neglected area within the construction history studies. Emerging research (Hanke 2006, Newland 2010, Crone and Mills 2012) has started to shed some light, although it is still fragmented. The main focus so far has been on spectacular open structures (Stell and Baillie 1993) or on roof structures up to 1647 in a restricted geographical area (Hanke 2006).

Our ongoing research considers a more comprehensive geographical area (Scotland) and chronological period (seventeenth and eighteenth centuries). This paper presents some initial results on the design and construction techniques of eighteenth century Scottish timber roofs. From an extensive relational database of 1250 buildings, a selection of 29 groups of buildings has been surveyed throughout Scotland. From these, Tweeddale House in Edinburgh, and Glasgow Trades Hall, both with a distinctive construction phase by the Adam family, have been identified as suitable case studies to start understanding the origin, development, influences and authorship of Scottish roof structures.

SEVENTEENTH CENTURY TIMBER ROOFS IN SCOTLAND

Although the evidence for medieval Scottish carpentry is scarce, the few surviving roofs seem to testify Scotland was aligned with the English tradition of hammer-beam roofs (Hanke 2006). From the sixteenth century onwards, as suggested by Hanke and confirmed by our own surveys, most Scottish roofs are gabled with a simple, closely spaced, common rafter form and their structure is hidden behind timber or plaster ceilings. They are A-shaped frames of square uniform scantling with no distinction between principal and common rafters. There is absence of wall-plates, tie-beams and purlins. The longitudinal rigidity is assured by the gable walls and the sarking: two layers of sawn deals that run horizontally and vertically and comprise in-between a sort of fleece for insulation. Additional rigidity is sometimes provided by the rafter foot whose ashlar post is extended downward on the masonry. Joints are mortice and tenon, or lapped. Dovetail joints appeared in Scotland only by the end of the seventeenth century.

This common rafter form is part of the Romanesque Northwest European school of carpentry. The use of sarking and the rafter foot, and the absence of wall-plates and purlins, are nevertheless distinctive Scottish features (Hanke 2006). Remarkably, this characteristic common rafter form is found in Scotland up to the eighteenth century, whilst side purlins and queen/king struts in England (Hewett 1980) and trestle-based structures in Continental Europe (Ostendorf 1908, in Hanke 2006) had already been introduced since the thirteenth century.

THE INTRODUCTION OF THE TRUSSED ROOF IN SCOTLAND

Before classical architecture became the norm in Britain, both English and Scottish wrights (carpenters) understood timber elements in roofs as behaving in compression and refrained from using tension-absorbing elements to counteract the tie-beam deflection, as was instead common practice in Italy (Valeriani 2005). With the introduction of classical architecture in England by Inigo Jones (1573-1652) hipped roofs, mansard roofs, domes and other complex arrangements started being used. Gable walls disappeared and roofs had to be shallower and cover bigger spans; local traditional roofing methods became inadequate and the trussed roof had to be adopted (Yeomans 1992). The simpler trussed roof form, the king-post truss, has a central vertical element suspended from the apex of the 'timber arch' formed by the principal rafters; in this way the post acts as a tie and supports the tie-beam, preventing its deflection. Whilst the first

English trussed roofs can be seen in Jones' buildings, Sir Christopher Wren's later designs were undoubtedly the most innovative and influential (Yeomans 1992). They were both influenced by Italian treatises (Valeriani 2006).

Classical architecture arrived in Scotland in the seventeenth century with Sir William Bruce and James Smith who built the first hipped and mansard roofs but still using common rafter roofs. Since they often remodeled old buildings, they benefited from intermediate spine walls reducing the roof span, as in Holyrood Palace (1671-9) or Dalkeith House (1702-11). The first known drawing of a trussed roof for a Scottish building is the 1720's William Adam's New College Library in Glasgow (Hanke 2012) with a simple king-post roof (fig. 1). The joggles shown at the top and base of the king-post can also be found in English roofs of the period (Yeomans 1992). Joggles are shown in some Italian treatises: 1449 Mariano di Jacopo (Barbisan and Laner 2003) and 1600 Serlio. Since William did not visit London until 1727, it is likely that his reference was the copy of Serlio's treatise he owned (Rowan 1990), which illustration also shows the post dovetailed in the tie-beam (fig. 2). Unfortunately the building has now disappeared so it is not possible to see if this design was realised. Other of Adam's buildings of the period, such as Duff House (1735-40) and Arniston House (1726-33), do not have trussed roofs. This brings to the hypothesis that Adam's design intention to build trusses clashed with the lack of familiarity of local wrights with these emerging structures.

The earliest trussed roofs we have identified so far in Scotland are Oakshaw Trinity church in Paisley (1754-6), a queen-post roof (approx. 20m), whose arrangement suggests an inspiration from Wren's St Michael's Paternoster Royal (1690), and Auchinleck House (1755), a king-post roof (approx. 10m) with a curious 'bulb' shape at the top of the post (fig. 6).

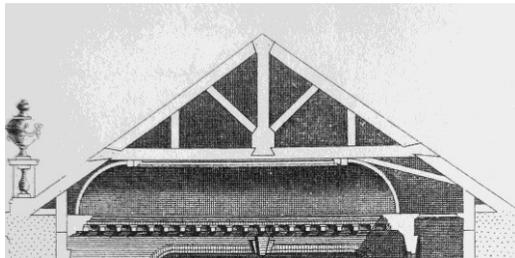


Figure 1: W. Adam's design for the Glasgow New College Library, 1720 (Adam 2011)

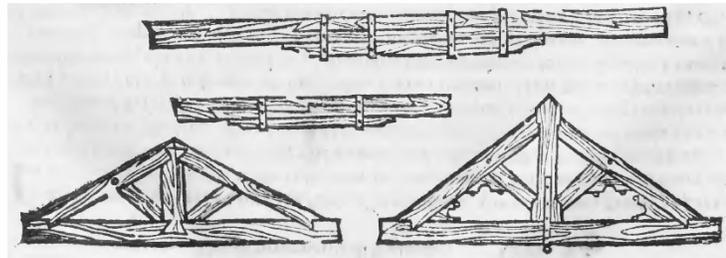


Figure 2: A post with joggles and a post dovetailed in the tie-beam as shown in Serlio (1600)

Common rafter roofs anticipating the trussed system: Tweeddale House in Edinburgh

The introduction of the trussed system in Scotland was slow and gradual: many eighteenth century roofs still show a common rafter form. A good example is Tweeddale House's roof. The house was built in sixteenth century as a small rectangular single pile mansion, with a projecting stair tower, and around 1600 it was extended to the north, transforming it into a double pile (Gifford 1984). Throughout the seventeenth century it was renovated and in 1750-6 the 4th Marquess of Tweeddale commissioned its reconstruction to John and Robert Adam (Gifford 1984). Deacon Thomas Dunlop, who had previously done other works for the Marquess (NRS CS96/2243), was the wright and contractor. The roof was completely dismantled and rebuilt (NLS MSS.14665). Some repair works were done later in 1779-82 (NLS MSS.14680) and in 1791 the house was extended to the west (fig. 3).

Although only partly visible today we can appreciate that the structure is the one reconstructed by Dunlop in 1750-6. Additional rafters (fig. 3, f) have been later added on top of

it, perhaps as part of the 1779/82 works to stop water ingress from damaging the bottom part of Dunlop's rafters, which had in fact to be substituted with prosthesis during the works in 1980s.

Tweeddale's roof retains many features of seventeenth century common rafter roofs. The pitch is steep (40°) compared to contemporary trussed roofs, such as Oakshaw Trinity church (34°) (fig. 4). The frames are very closely spaced (50cm max) and they do not have tie-beams nor wall-plates, like in Balcaskie House (1668). Though the span is quite wide (11.4m), due to its double pile configuration, a spine wall reduces it to 6.2m, just like in Holyrood Palace (1671).

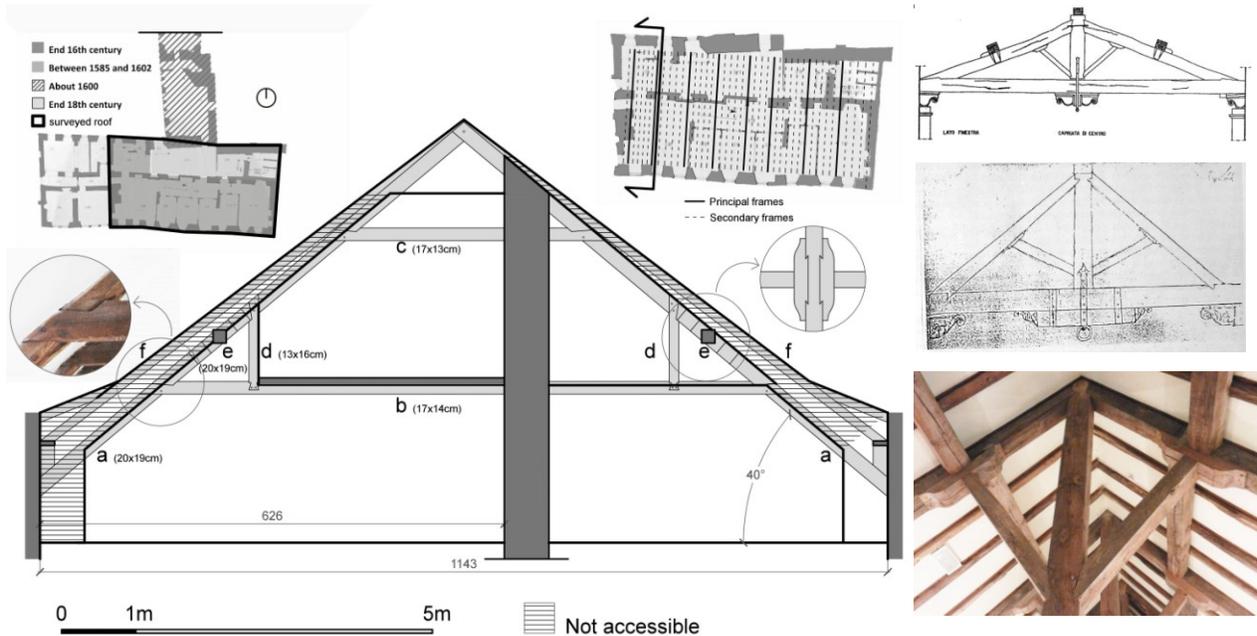


Figure 3: On the left the transversal section of Tweeddale house roof structure with reference plan (Anna Serafini); on the right from top to bottom cleats used in church of Sant'Agata di Mugello in Scarperia, Florence (Tampono 2001), a truss drawn by Mariano di Jacopo (1449 in Munafò 2002), Brodie Castle Stables (Anna Serafini)

Other features of the roof anticipate the emerging trussed system. The frames are divided in principal and secondary frames. Two purlins (fig. 3, c), one on each side, connect the principal frames together: they are tenoned in cleats (fig. 3, d) that are in turn dovetailed on the sides of the rafters to reinforce their section where the purlins abut. Whilst purlins are normally employed in trussed roofs, cleats seem to be a more common feature in Italy, in both buildings and treatises (fig. 3). In Scotland we have identified them also in Oakshaw Trinity church and in Brodie Castle stables (end 18C) (fig. 3). Other interesting features are the two vertical struts (fig. 3, e), one on each side, hanging from the rafters and giving additional support to the raised tie-beam. These tension-absorbing members suggest an awareness of the problem of beam deflection, and can be seen as an antecedent of king/queen-posts (Hanke 2008). They appear also in Stirling Castle Palace (Hanke 2008 suggests beg. 18C) and Newhailes House (1730). However, the solution does not show a full understanding of their role as they create additional load on the rafters. The use of dovetail joints shows awareness that the jointed elements act in tension.

We do not know who designed this roof. John and Robert Adam, the architects in charge, were also working at Yester House for the Marquess at the time (Dunbar 1972) and this could explain why Dunlop had a wider commission in the building, as wright and masonry contractor (NLS MSS.14665). Dunlop had been apprentice to John Montgomery in Mary's Chapel, the incorporation of masons and wrights, from 1700 to 1711 (ECA SL 34/4/2). He was probably one

of the foremost wrights in Edinburgh at the time: he was Deacon of the incorporation and had eight apprentices through his life (ECA SL 34/4/2). The exact role of wrights in Scottish projects at the time needs further research. The word ‘wright’ has disappeared from English construction vocabulary, superseded by ‘carpenter’ (for heavier structural work) and ‘joiner’ (for furniture and fittings). The Oxford English Dictionary defines ‘wright’ as a generic “constructive workman” or “one who deals with wood, a carpenter, a joiner”. In fact wrights in Scotland used to deal with all the timber work, from roofs, to flooring, to windows, furniture, etc., and started working as contractors in the seventeenth century (Dunbar 1976, Newland 2010), just like carpenters in England (Yeomans 1992). Their role was increasingly important in the construction site, and they outnumbered masons in the incorporation (ECA SL 34/4/2). It is therefore reasonable to think that in case of minor works, such as Tweeddale House, the roof structure was both designed and built by Dunlop.

Scottish trussed roofs: Glasgow Trades Hall

The brothers Adam’s earliest trussed roofs known in Scotland are in Fort George: the Museum and Staff block (1762), the Ordnance Store (1759/61) and the Chapel (1763) (fig. 4). In all of them, the purlins are misplaced as they should be where the struts meet the rafters, in order to avoid additional load. Again it is not easy to conclude who might have designed these roofs. At the time only John was in Scotland, Robert, James and William were in London. William had died in 1748 but he may have brought skilled English carpenters from his London trip. Lewis (2006) noted that in 1760s-70s his son Robert hired men in London whose names are found in the Edinburgh New Town ten years later. Another possible source could have been Price’s new treatise (1733) at the Adams’ library (Rowan 1990). This could explain the misplaced purlins, since Price never showed the purlins’ location in his drawings.

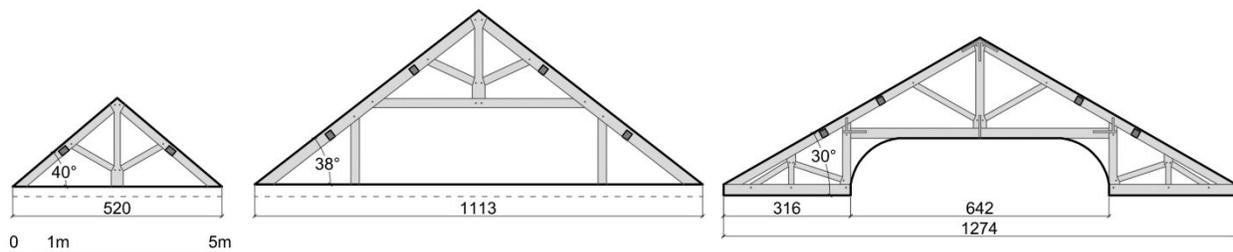


Figure 4: Roofs at Fort George, from left to right: Staff block (1762); Ordnance Store (1759/61); Chapel (1763) (Anna Serafini); the graphic scale relates to all drawings.

Further considerations can be made by comparing Robert Adam’s design for Glasgow Trades Hall (1791-4) with the structure built after his death in 1792 (fig. 5). Adam’s design was chosen by the Trades Incorporations in 1791 through an invited competition between him, James Jaffray and John Craig (GCA T-TH 1/1/7). The extra land required for Adam’s additional lateral wings was never bought: the design for a building ca. 33.5m long had to be adapted to a plot only 30.5m long. If we compare Adam’s drawings with the present structure (fig. 5) we can see the overall proportions distorted and the diameter of the dome dramatically decreased (Sutherland 2005). After Robert’s death, the wright John Brown was appointed contractor under the supervision of James and William Adam (GCA T-TH 1/1/7) who did not seem to have been involved in the design process. It seems therefore reasonable to think Brown took on a leading role in the works.

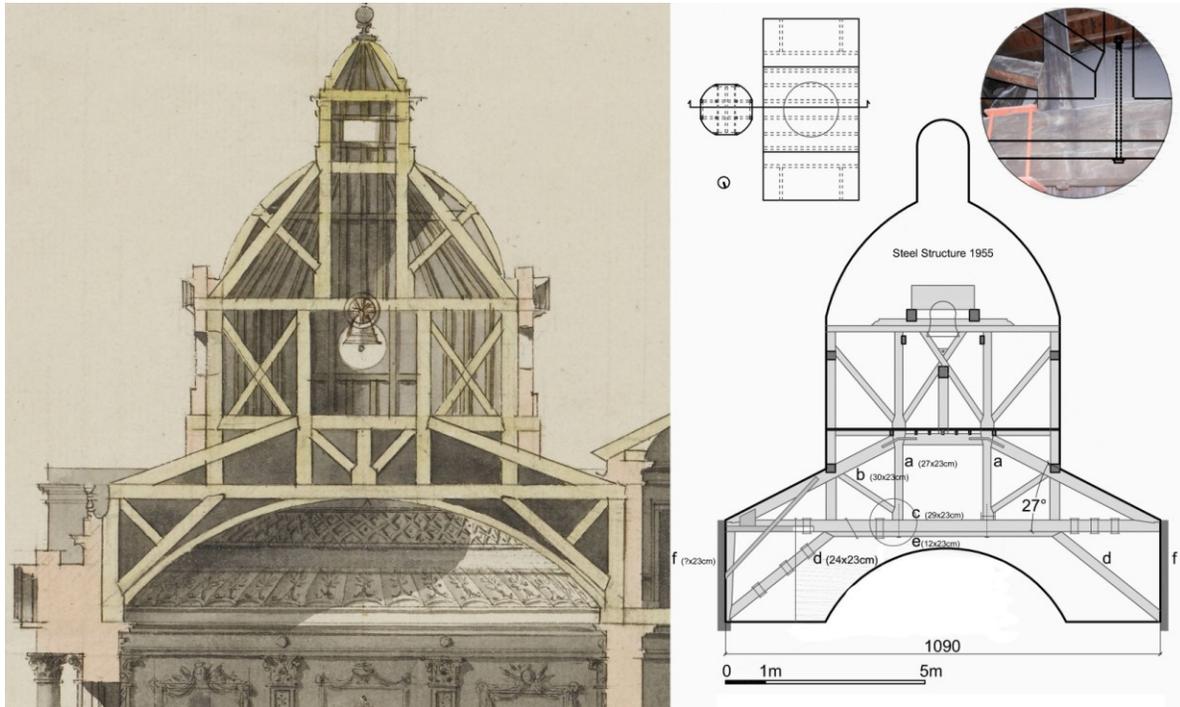


Figure 5: Transversal section of the roof structure at Glasgow Trades Hall, as designed by R. Adam on the left (SM Adam vol.48/25), and as built on the right (Anna Serafini); the graphic scale relates to both drawings.

The present structure (fig. 5) is composed of 8 parallel queen-post trusses; the 4 middle ones support a drum, dome and lantern above, and leave space for a dome below (originally wider). The span is not excessively wide (10.9m) but the structure is quite tall (10.5m below the lantern). The joints are correctly designed with joggles and iron straps so that the queen-posts (fig. 5, a) hang from the principals (fig. 5, b) and support the tie-beam (fig. 5, c). The bottom of the post is connected to the tie-beam with a system of cotters and folding wedges passing through the elements (fig. 5): a detail developed in England at the beginning of the nineteenth century, according to Yeomans (1992). It could thereafter be one of the very first uses of this device. The trusses sit on a lower 'arch' system, formed by two slanted braces (fig. 5, d) and a horizontal beam (fig. 5, e). The slanted braces spring from the base of timber posts (fig. 5, e) that are partly (on the left) or completely (on the right) embedded in the walls. On these posts sit the tie-beams.

This is one of the two weak points of the structure. The lateral posts and the wall-heads behind them are unable to counteract the horizontal thrust coming from the truss above. The lower 'arch' system partially opened in time and wooden wedges had to be inserted between the slanted braces and the horizontal beam. The wall-head was reconstructed and steel rods and plates were added with the same purpose. The other weak point is the insufficient longitudinal rigidity. Even though the sarking is still employed, the trusses do not rest on wall-plates - or if they do, they are embedded in the wall and therefore probably rotten - and they only have a few purlins connecting one to the other. This is probably why the dome structure had to be replaced in 1950s with a new steel structure (GCA Box 152 Drawing T6/7).

The structure drawn by Robert Adam in 1791 (fig. 5) shares the above mentioned critical points and also shows an improper design of the joints, which causes the posts to behave in compression, enhancing the tie-beam deflection instead of counteracting it. The built structure has some faults but it shows a better understanding of the trussed system and its construction

details. We do not have evidence of who designed this dome, the first in Glasgow, and little information could be found on John Brown, the wright/contractor at the Trades Hall, from whom no other building seems to remain. Brown was member of the Glasgow incorporation of wrights from 1790 until his death in 1816 (GCA T-TH 9/4/2 and T-TH 9/4/3). His appointment as contractor for such a major work as the Trades Hall only one year after becoming a member of the incorporation suggests he could have been brought from elsewhere by the Adams.

CONCLUSIONS

The existence of an independent Scottish school of carpentry has been denied by scholars such as Ostendorf (1908, in Hanke 2006) and Yeomans (1992). Overall conclusions are hindered by the lack of a more systematic research about the roof structures of the period. However, an outlined picture is emerging which shows characteristic patterns and practices in Scotland.

Hanke (2006) has identified distinctive Scottish features in sixteenth and early seventeenth centuries roof structures: the persistent use of the common rafter form, the sarking, the rafter foot, the absence of purlins and tie-beams. Thanks to the survey of the 29 groups of buildings, and the further research and study of Tweeddale House in Edinburgh and Glasgow Trades Hall, both by the Adam family, some initial conclusions can be tempted on the development of roofs in Scotland in eighteenth century, including when, how and by whom trussed roofs were introduced. Trussed roofs start slowly appearing from mid eighteenth century in Scotland. Whilst there is an unquestioned English influence in their arrangements, some details seem to indicate other sources. The ‘joggle’ detail, found in most Scottish structures, has been always considered a distinctively English feature but could originate from Serlio (1600). Moreover, examples as Brodie Castle Stables, show that notches were used as well as joggles (fig. 3). The characteristic Scottish sarking remains in use, even though butt-purlins are introduced. Cleats, extensively used in Italy too, reinforce the elements’ section in critical points. King-posts sometimes have a “bulb” shape at the top, a detail whose origin remains uncertain so far (fig. 6).

The Adams knew the trussed roofs thanks to treatises and pattern-books in their library, and to their travels to London and Italy. Nevertheless, their drawings often show little understanding of the trussed system. William was the first to draw a trussed roof for a Scottish building in 1720, but none of the Adams buildings in the first half of the eighteenth century has trussed roofs. This brings to the hypothesis that, at least in the case of the Adam family, the design of roof structures was responsibility of the wright, rather than the architect. Although architects aspired to build trusses, it seems that at the beginning wrights were unable or unwilling to construct them. An external influence, from England and/or beyond, was necessary for the eventual establishment of trussed roofs in Scotland, as suggested by the heterogeneity of solutions and details.



Figure 6: The “bulb” shape at the top of the posts in (from left to right) Auchinleck House (1755); Stirling Tolbooth (1785); Culzean Castle (end 18th century) (Anna Serafini)

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