The Close Spacing of Trusses

HEAVY timber trusses were commonly used in the roof systems of North American public buildings from the mid-17th century until about 1920 (Fig. 1). The most common forms were kingpost, queenpost and scissors, all with variations. The majority of these trusses are framed of large scantlings (a 50-ft. 12x14 for a bottom chord is not unusual) and spaced 8 to 16 ft. apart. Lateral stability between the trusses is provided by purlins and braces framed into the sides of the top chords (also called principal rafters in historic sources), which also carry the common rafters between or over the trusses, or by specifically designed girts and braces that join all or some of the posts within the attic space. The actual spacing of the trusses can often be identified from the exterior by the sagging of the roof plane that usually occurs between them, or by differential snow melt patterns (snow tends to stay longer right over the top chords themselves).

We associate close spacing with early English and Continental roof systems using complexly framed rafter couples 3 or 4 ft. apart (Fig. 2), or with modern light-framed trusses held together by glue and gusset plates (Fig. 3). Today's light trusses are true trusses, but they are too flimsy to stand much more than 2 ft. apart. The early rafter couples were similar in intention to trusses, in that their builders wished to produce a rigid frame that would not put outward pressure on the walls. But, in general, their engineering design (the arrangement of tension and compression members) and their joinery are such that, even if the sectional sizes of their members were greatly increased, the assemblies couldn't safely be spaced 12 ft. apart, and would depend upon redundancy or additional principal trusses for sufficient strength in the roof.

However, in recent years another group of trussed roofs has come to my attention in New England. In this group, substantial and traditionally joined timber trusses are spaced 3 to 5 ft. apart along an entire roof. The first examples were shown to me by Arron Sturgis in South Berwick, Maine, in two neighboring churches probably built by the same hand in the 1820s (Fig. 4). The roofs are framed with scissors trusses spanning 42 ft.: the scissor chords, all approximately 4½ x 9, are half-lapped to each other where they cross at a kingpost, and the rafters join the top of the kingpost with tenoned joints; original, hand-wrought iron strapping and bolts reinforce most joints. Unpinned tenons join the scissor chord ends and the undersides of the rafters.

I thought these trusses were archaic in inspiration or an idiosyncratic anomaly. Then, last year, I was called to examine the Strafford United Church (1830) in Strafford, Vermont, where I found kingpost trusses spaced 36 in. on center down the 50-ft. length of the roof. The trusses span 42 ft. and use 6x10 kingposts, 8x9 tie beams and 6x9 principal rafters. The following year, I examined Strafford United's sister, the South Strafford Universalist Society

Wayne Richardson

FIG. 3. SETTING LIGHT TRUSSES, NEWBURY, VT., 2002.

(1833), three miles down the road, where nearly identical trusses are roughly 39 in. on center down the 55-ft. length of the roof (Fig. 5). I was beginning to think I had been missing something.

I can physically visit only a certain number of truss roofs, and of course I can only visit surviving ones, so when investigating an aspect of framing I will often turn to documentary sources for help. I looked at a variety of 18th- and 19th-century builder's guides and found numerous truss designs and a little commentary on spacing, all of which coincided with my former expectations. William Bell's *Carpentry Made Easy* (1891) delineates many truss types and recommends (p. 82) they be spaced "10 to 14 ft. apart." Asher Benjamin, discussing church trusses in *The Practical House Carpenter* (1836), recommended (p. 80) that "the principal rafters should not be more than nine feet from center to center."

I struck gold in my collection of old lumber lists (credit the University of Vermont Special Collections). When John Johnson framed the courthouse in Burlington, Vt., in 1802, he laid two 64-ft. 12x11 long sills and five 40 ft. 12x11 cross sills, giving us the footprint of the building. For the roof system, he acquired 16 10-ft. 12x7 "King Posts in White Pine" and one 10-ft. 12x12 kingpost "in oak or yellow pine," along with proportionally sized tie beams, rafters and braces in the right numbers to make 17 trusses. The larger members probably formed a truss to help support the tower that is also specified in the list. Seventeen trusses produce 16 spaces and, if the gables are not trussed, there may be 18 spaces along 64 ft. of roof. Either way the trusses are on 3- or 4-ft. centers (Fig. 6).

In John Johnson's "Bill of Timber for the Meetinghouse," dated 1811 at Burlington, he specifies two 70-ft. sills and six 55-ft. sills,

Marcus Brandt

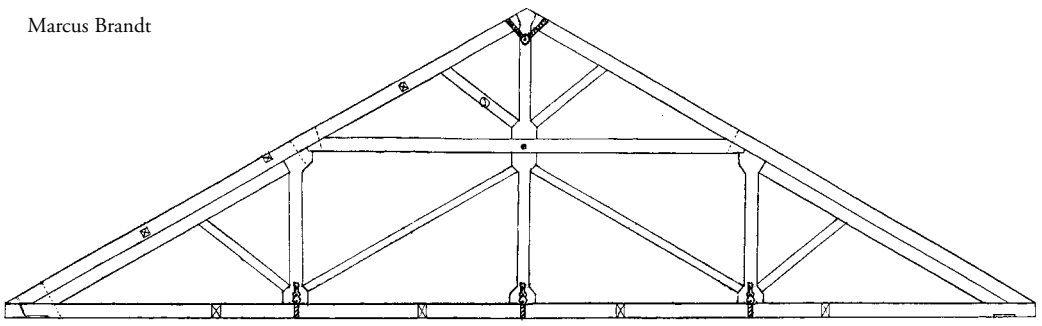

FIG. 1. PRINCIPAL TRUSS, CENTRAL MORAVIAN CHURCH, BETHLEHEM, PA., 1803, SPAN 60 FT.

John Winterbottom

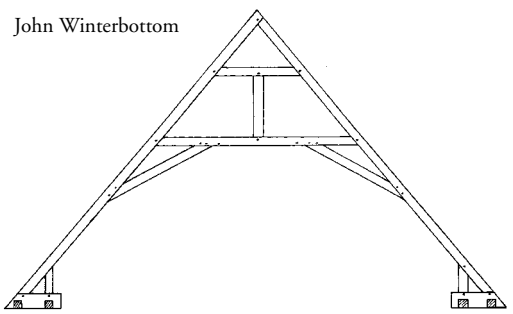

FIG. 2. INTERMEDIATE TRUSS, WINCHESTER CATHEDRAL, CA. 1310, SPAN 30 FT.

Ken Rower

Jan Lewandoski

FIGS. 4 AND 5. FIRST PARISH FEDERATED CHURCH, S. BERWICK, ME., 1825 (LEFT), AND S. STRAFFORD,VT., UNIVERSALIST SOCIETY, 1833.

giving us the footprint. Seventeen 57-ft. tie beams span the roof, including the "End & Tower Beams." Thirteen 16-ft. 16x7 kingposts are specified, with 33-ft. rafters and four pairs of 25-ft. rafters that probably functioned as queenpost main braces in the area of the 16-ft.-square tower, four of them using the four tower posts as queenposts, and the other four probably bearing on tower girts to produce the roof plane. The tower itself rose off sleepers on the tie beams, a pair of 30-ft. 12x12s called "tower sills" by Johnson. This shift at the tower from kingpost trusses to queenposts, with the tower posts as queens, is common in the late 18th and 19th centuries, but not universal. Both the Strafford churches have queens at the tower, but they imply no relationship to Johnson.

An additional survey of historic trusses is found in J. Frederick Kelly's *Early Connecticut Meetinghouses and Churches* (1948). The author and his assistants examined the structure and parish records of 87 pre-1830 churches and prepared a measured drawing of each accessible truss and some commentary on the roof systems. I read all of the entries and found spacing discussed only once: the 1820 contract for construction of the First Congregational Church of Derby specifies, "The roof to be framed of Ten principal Rafters" (p.97). This church is 50 ft. long with a tower, belfry and spire semi-engaged at the front. The trusses are scissors form, of hewn oak, and these probably don't support the tower, so the length is likely divided into 10 or more bays, 5 ft. wide or less. The truss sections are various depths of 7-in. timber, scanty for wide spacing.

Counter-evidence of close spacing is shown throughout Kelly's book. Trusses in most meetinghouses are drawn with connecting purlin sections in the area of 8x9, suggesting substantial spans between the trusses.

WHAT are the advantages and disadvantages of close spacing? When you first enter a church attic where 17 heavy timber trusses are ranked 3 ft. apart, you are impressed and mystified. It's a powerful roof system where a problem in any one truss will have little effect on the whole. But why expend so much timber and skilled labor in construction, and such effort to assemble so much framing in so little space? Part of the answer is that large timber was available and cheap in New England before 1850, and perhaps skilled artisans as well. On the other hand, since these trusses make up a small minority of roof systems, most framers probably agreed that it was easier to put up four or five trusses and connect them somehow.

The advantages of close spacing are numerous. The trusses duplicate each other (with the exception of those at the tower), and they can be built reasonably quickly. The immense quantity of wood involved is balanced by the absence of purlins, purlin braces, common rafters or any lateral bracing system running longitudinally in the attic, a significant savings in timber. The same 1-in. boarding found on any roof can board this one. While each truss requires long timber, it is of somewhat smaller cross-section (for which trees would likely be in greater supply) than the timber used in widely spaced trusses.

An additional advantage in this overall-stronger roof system is its ability to handle the endemic problem of depression of the first interior truss by steeple loading. In South Strafford, the kingpost trusses march from rear to front on 39-in. spacing until reaching the rear of the steeple, where the two tower posts are used as queenposts to form a truss. Two more kingpost trusses sit within the tower, respectively 42 in. and 86 in. forward of the rear queen, until the front posts of the tower seat themselves on the fully framed wall of the portico. There is evidence that the builders at South Strafford were aware of problems at rear steeple trusses. There are original square-section 1-in. wrought iron dogs assisting the joinery at the feet of the principal rafters where they mortise into the bottom chord, and at the shoulder where the principal rafters join the queenposts. In spite of all these precautions, there is a transverse crack in the plaster over the choir loft where that rear truss sags a little more than its neighbors.

In the 1811 Burlington meetinghouse mentioned earlier, the tower, incorporated into queenpost trusses, also sits on 30-ft. 12x12 "tower sills" lodged perpendicular to the trusses. This is a common arrangement but has small virtue when the trusses are far apart; the sill, or sleeper, over the 10- or 14-ft. span between trusses, just bends and loads the closest one. With close truss spacing and sleepers, however, the tower sills are supported by eight or 10 trusses with no room for bending in between. —JAN LEWANDOSKI