HISTORIC AMERICAN TIMBER JOINERY

A Graphic Guide

VI. Scarf Joints

THIS article is last in a series of six to discuss and illustrate the joints in American traditional timber-framed buildings of the past, showing common examples with variations as well as a few interesting regional deviations. The series was developed under a grant from the National Park Service and the National Center for Preservation Technology and Training. Its contents are solely the responsibility of the author and do not represent the official position of the NPS or the NCPTT. Previous articles, which appeared consecutively in TF 55-59, covered Tying Joints: Tie below Plate, Tying Joints: Tie at Plate, Sill and Floor Joints, Wall and Brace Joints, and Roof Joinery Excluding Trusses.

WE are often amazed at the lengths of timbers found in old American structures. Plates 40 ft. long are common. Fifty-footers are encountered occasionally, and timbers 60 and 70 ft. long are not unheard of. In the great old-growth forests that once stood on this continent, trees of sufficient straightness and height were in abundance. The older structures in a given area reflect the original forest. Unbroken straight timbers run the length of the structure. For example, in a typical 18th-century New York State Dutch barn measuring 50x50, there would be 13 timbers 50 ft. long. Such timbers were obviously not difficult to procure from the original forest.

However, as the original forest was replaced by second-growth forest, and sawmills, especially those with the new, faster circular saws, replaced hewers and the relatively slow up-and-down mills, it became more economical to join or *scarf* timbers together to make the necessary long sills, plates and purlin plates. Scarfing had been common practice in Europe for several hundred years, where the original forest was long gone.

STRUCTURAL CONSIDERATIONS. Two timbers joined end to end cannot match the strength and stiffness of a single member of the same dimensions. Some ingenious scarfs have been devised that aim to do so, but the majority of joints are fairly simple, and they are limited in the forces they can resist. Scarf joints can be subjected to a number of forces.

Axial Compression. This force, acting parallel to the grain of the member and along its axis, is perhaps the easiest to resist. A simple butt joint will work. A scarfed post would sustain axial compression.

Axial Tension. Plates and tie beams must resist moderate tension. Some truss components, such as lower chords, are subject to heavy tension loading. Tension-resisting scarfs are typically longer and more complex than others.

Shear. Rarely a concern in solid members, this force becomes a consideration when timbers are notched, as in scarf joinery. A shear force develops when one side of a scarf, for example the lower part of a simple half-lap, supports the other side. Shear forces cause splitting at the notches. Splayed scarfs, which taper to produce greater depth of material under the notches, generally handle shear forces better than halved ones.

Torsion (Twisting). Scarf joints are typically subjected to only minor torsion loads. Spiral grain in an unseasoned member causes twisting as it dries. A scarf joint that is not capable of resisting twisting will open up as the timbers season. As its abutments disengage, its ability to resist other forces will be diminished.

Bending. This is the most difficult force for a scarf to resist. Members subject to bending would include plates, tie beams and spanning beams supporting floor or roof loads. Sometimes a member must resist bending from two directions. A plate, for instance, is subjected to bending in the horizontal plane from wind loads and bending in the vertical plane from the roof load. The conscientious builder locates the scarf where bending forces are low.

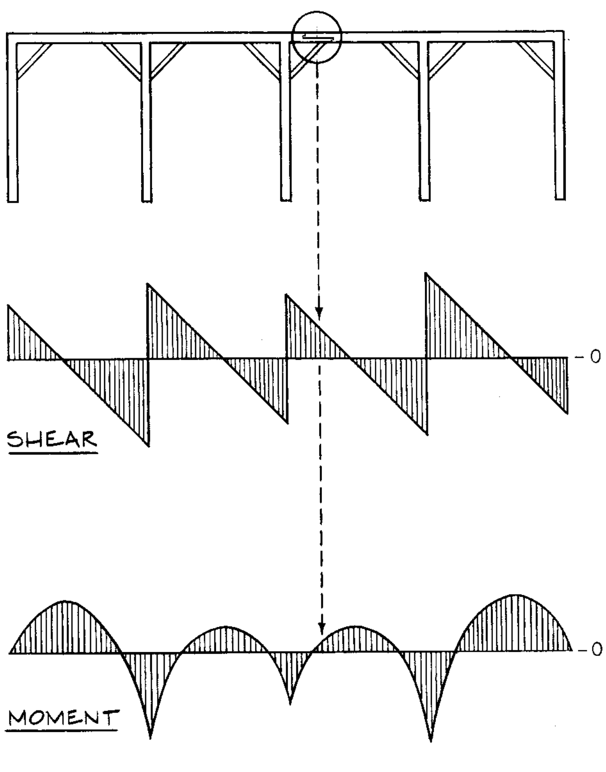


Fig. 1. Elevation of a plate continuous over five posts, showing a typical scarf location. Diagrams show resultant shear and moment values, both positive and negative, with horizontal line at zero force.

A member such as a plate or purlin plate that continues over multiple supports is much stiffer and stronger than one spanning between only two supports. The locations of the maximum and minimum moment (bending) forces are different in the continuous member. In a simple spanning member, the greatest moment occurs in the center of the span. In a continuous member, it occurs over the posts (Fig. 1, facing page).

Since it is difficult to create a scarf that handles bending forces as well as a solid timber, it makes sense to locate the scarf at a point where moment is the lowest. That is precisely where the majority of scarfs are located in old buildings. As in the illustration, the joint, additionally supported by the brace, is located where both shear and moment are low. Locating the scarf over the post, where stresses are at their maximum, would cause the plate to act like simple spanning members. Thus the plate would require a larger cross-section. Scarf location is also affected by available timber lengths and by the raising sequence of a building.

SCARF TYPES. In simplest terms, there are three classes of scarf: halved, splayed, and bridled. A halved scarf is a lap whose surfaces are parallel with the timber's. A splayed scarf has the lapped surfaces sloping. A bridled scarf takes the form of a tongue-and-fork or open mortise and tenon. Counting variations and combinations, I have found 23 different scarfs. Period builder's guides illustrate at least another ten that are likely to be found in a structure somewhere. Examples illustrated here show the common orientation found in old structures. Some examples are also turned on edge. These will be noted.

Halved Scarf. A basic halved scarf or half-lap (Fig. 2) is probably the simplest to fashion and thus the most abundant. It performs well in axial compression but depends solely on pins or bolts to resist tension and torsion. It has moderate shear strength but little bending strength. It is often found where it receives continuous support, as in a sill, or where the carpentry is of the quickly executed variety, and many such joints open up over time. The half-lap is also commonly used in repairs made to buildings *in situ*.

Halved and Undersquinted. To improve bending strength and resistance to seasoning twist, the ends of a scarf can be undersquinted (Fig. 3 below left). The angle most often encountered for the squint is 1 in 2. Shallower angles are more time consuming to cut and increase the likelihood of splitting at the notch. This joint is only slightly more work than the unsquinted version, but a considerable improvement. Pins are essential to the joint's effectiveness.

Halved and Bladed. This common scarf is found in all periods and locales. Though most often used as depicted in Fig. 4, in early Massachusetts Bay frames it is frequently found on edge. The barefaced tenons prevent twisting and improve bending and tensile strength. Some builders added extra pins in the central lapped portion. Overall length is commonly four times the depth of the timber. Variations of this scarf may present stub tenons without pins or a shortened lapped portion. In one variation, the topmost and bottommost cuts are aligned vertically and the tenons lengthened (see Cummings, Fig. 86 and Hewett, Fig. 271). Tenons are typically 1½ in. or 2 in. thick, and 4 in. or 6 in. long.

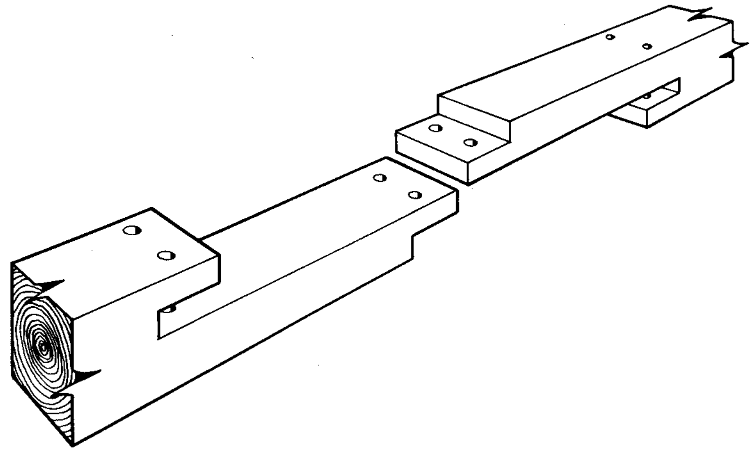


Fig. 4. Halved and bladed scarf with pinned tenons. Pins are often fitted additionally or alternatively in the central lapped portion.

Bladed and Cogged. In this unusual scarf (only one historic example found, though modern ones exist), a cog is provided in the T-shaped stub tenon (Fig. 5). This helps align the scarf and increases its bending strength against horizontal loads (such as rafter thrust), while adding some cutting time.

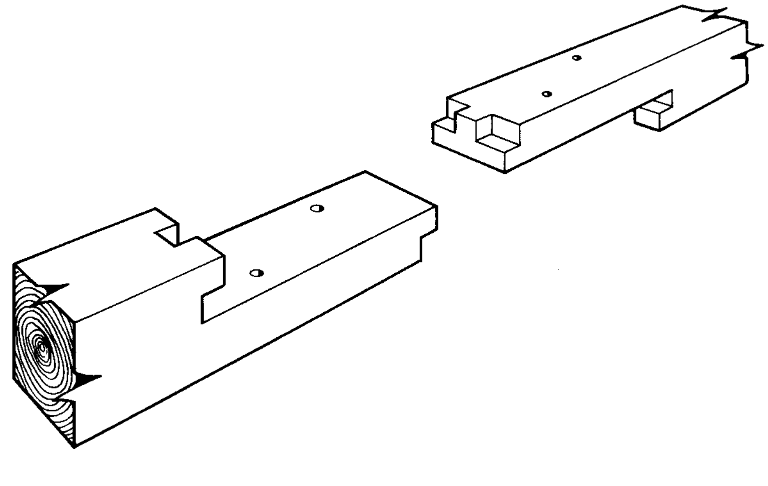
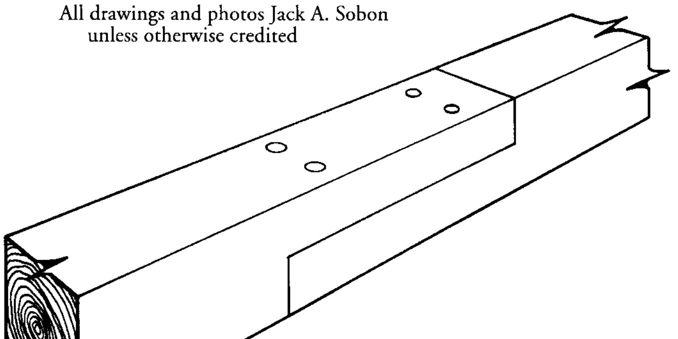
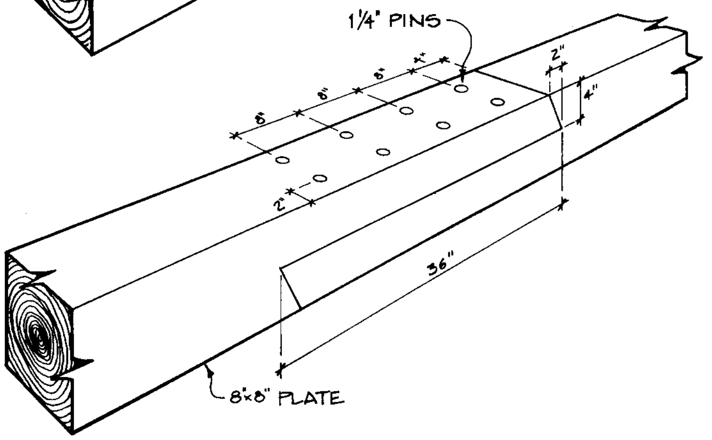


Fig. 5. Bladed and cogged scarf found in a barn along the Mohawk River in New York State. Drawn from memory.

All drawings and photos Jack A. Sobon unless otherwise credited





Figs. 2 and 3. At top (2), a halved scarf with four pins. Above (3), halved and undersquinted scarf found in an early-19th-century barn in Monterey, Massachusetts, the barn's only scarf, perhaps necessitated by some oversight in timber procurement. It has held up well despite its location in the center of the span. Note the 1-in-2 angle of the squint.

Halved and Tabled. With its center "table," this joint (Fig. 6) adds tensile capacity to the basic half lap. An iron bolt prevents twisting and displacement.

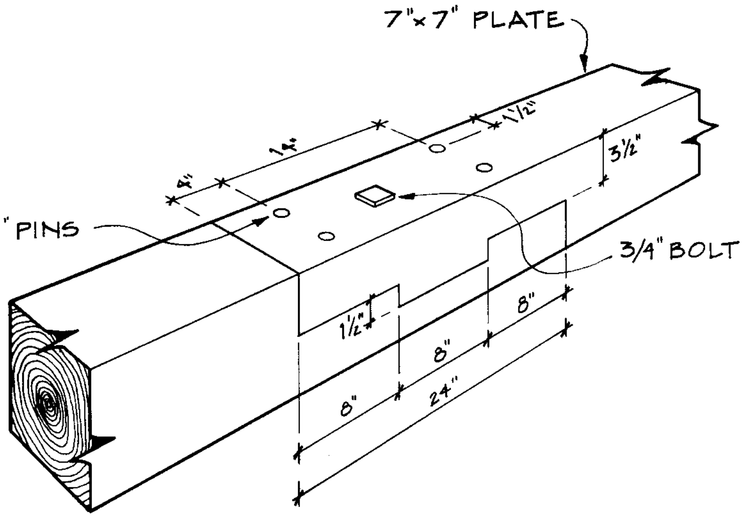
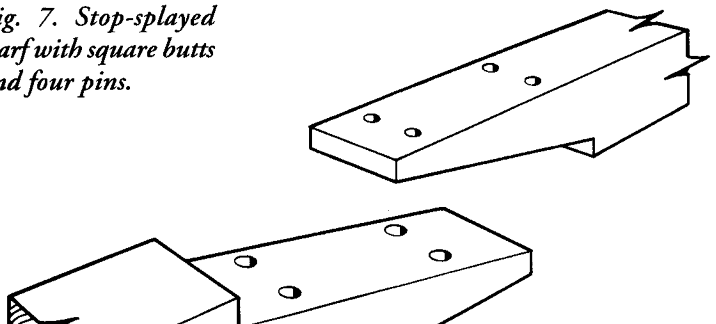


Fig. 6. Halved and tabled scarf in a 25x35-ft. three-bay 1860s barn in Windsor, Mass. This simple, effective joint relies on one bolt to keep it together.

Splayed and Stop-Splayed. In its most basic form, this scarf is simply a pair of complementary straight sloping cuts secured to each other with pins, nails or bolts. Nicknamed the *whistle cut*, it works wonderfully in shear but relies upon fasteners for resisting axial loads and twisting. (See TF 59, page 13.) In its more common form, the sloped, lapped portion is stopped before it feathers out to nothing (Fig. 7). Compared with the half-lap, shear strength is vastly improved by the sloped surface. The square abutments, typically 1½ in. or 2 in., resist axial compression. The pins provide tensile and torsion resistance.

Fig. 7. Stop-splayed scarf with square butts and four pins.



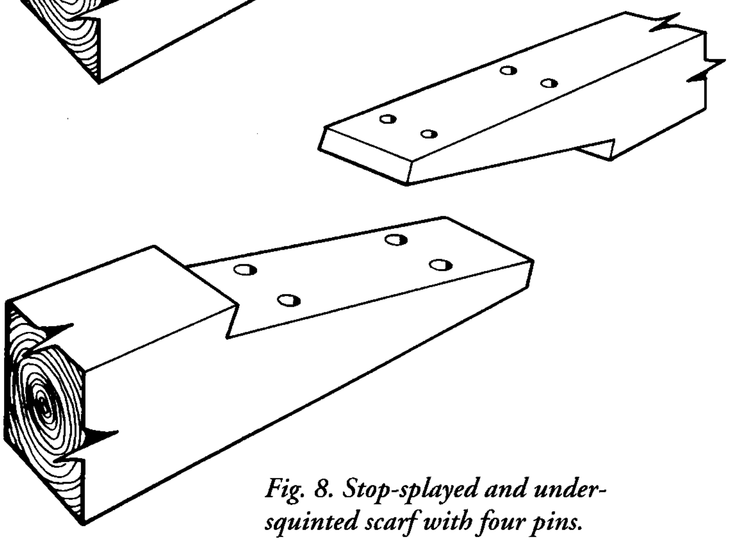


Fig. 8. Stop-splayed and undersquinted scarf with four pins.

Stop-Splayed and Undersquinted. Again by undersquinting the butts, the stop-splayed scarf (Fig. 8) is made more resistant to twisting. This scarf performs well, considering its ease of cutting.

Stop-Splayed Scissors. While based on the stop-splayed and undersquinted scarf, this variation is much stronger (Fig. 9). However, it is disproportionately more time consuming to fabricate, which accounts for its rarity.

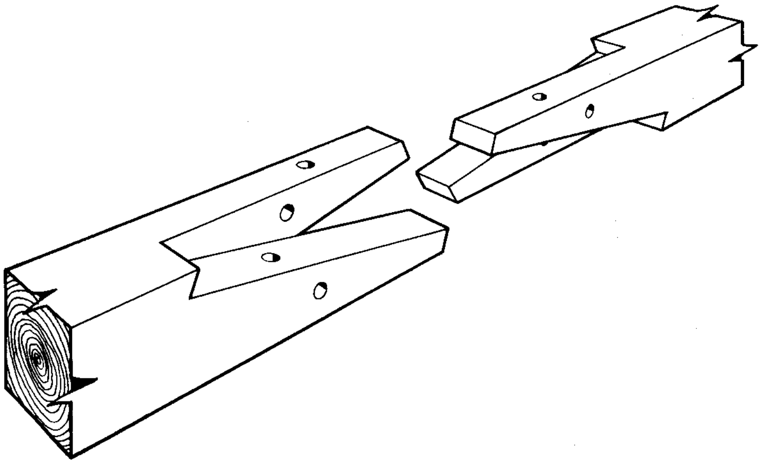


Fig. 9. Stop-splayed scissors scarf with two pins in each direction. The only known example is a 1927 repair to a house in Nantucket, Mass.

Stop-Splayed, Undersquinted and Cogged. Adding a cog to the stop-splayed and undersquinted scarf improves its bending strength in the secondary direction (Fig. 10). Only one example has been found of this type.

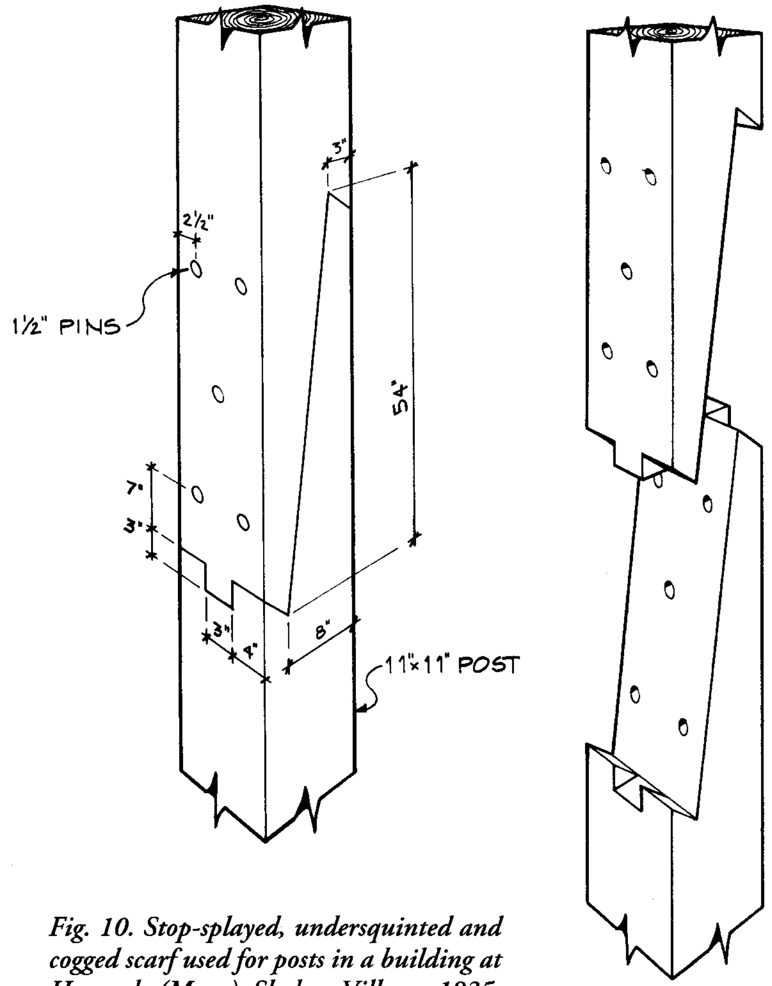


Fig. 10. Stop-splayed, undersquinted and cogged scarf used for posts in a building at Hancock (Mass.) Shaker Village, 1835. Apparently original, these joints are still tight. Note squint angle of 1 to 1.

Stop-Splayed, Undersquinted and Tabled with Wedges. A very strong scarf results when tabling and wedges are added (Fig. 11). The tensile capacity, torsion, and bending strength in both directions are greatly increased. The pins position the halves while the opposing wedges are driven and increase the joint's overall performance. The wedge thickness and the depth at the butts are usually the same, typically 1½ or 2 in. The butts need not be undersquinted. An example found at Jack's Valley, Nevada, has square butts, and bolts hold the scarf together.

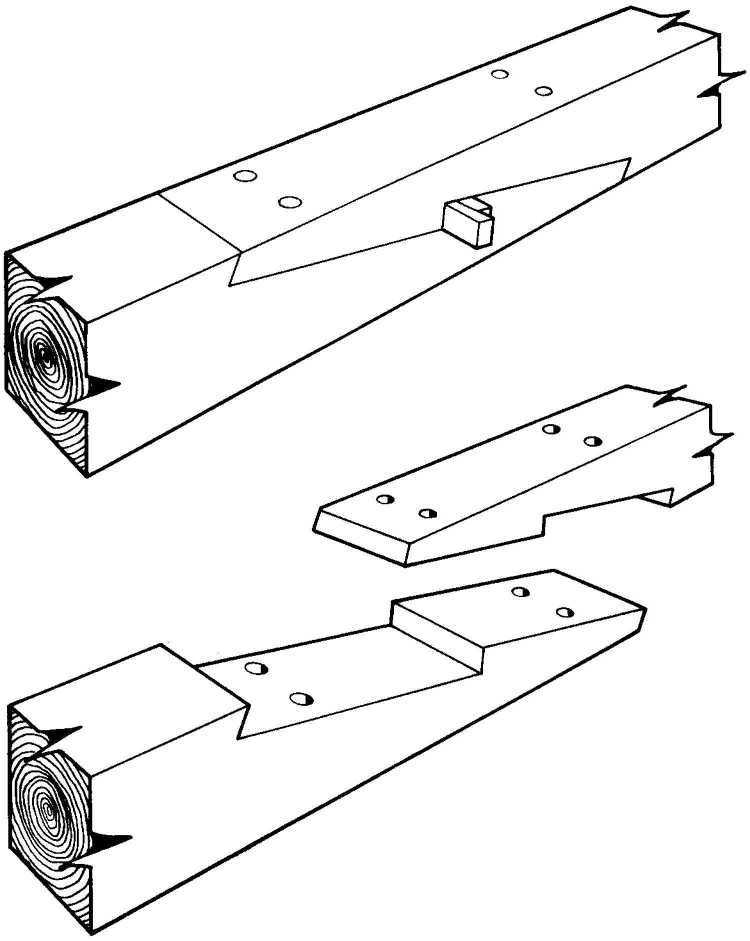


Fig. 11. Assembled and exploded views of stop-splayed, undersquinted and wedged scarf with four pins. Folding wedges pre-stress the joint.

Stop-Splayed with Wedges and Multiple Tables. By drawing out the scarf, additional tables can be added to increase tensile capacity (Fig. 12). The complexity of this scarf precludes its use except in members under great tensile loads, as in the lower chords of long-span trusses.

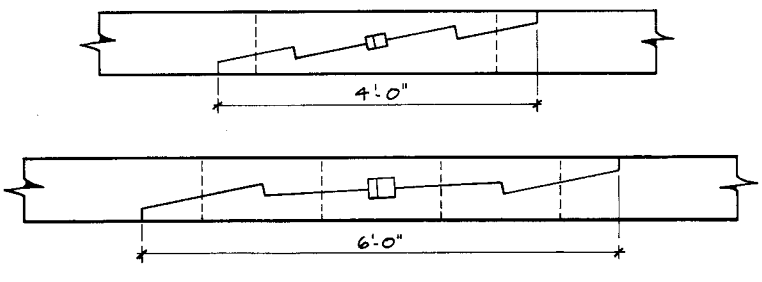


Fig. 12. Examples of the stop-splayed scarf with wedges and multiple tables, both taken from lower chords of trusses. The 4-ft. scarf was found on a late-19th-century building 40 ft. wide in Clayton, New York. The 6-ft. scarf was used in a ca.-1882 locomotive shop in Jamaica, N.Y., 64 ft. wide and 520 ft. long, and cut from 7½ x 9½ hard pine timber. Both scarfs use 1-in. bolts to keep the multiple bearing surfaces engaged. Both are designed for high tension loads.

Stop-Splayed and Bladed. By combining the bladed form with the splayed, the capacity of each is improved (Fig. 13). The tenons can be stub or long enough to be pinned. Compare Fig. 4.

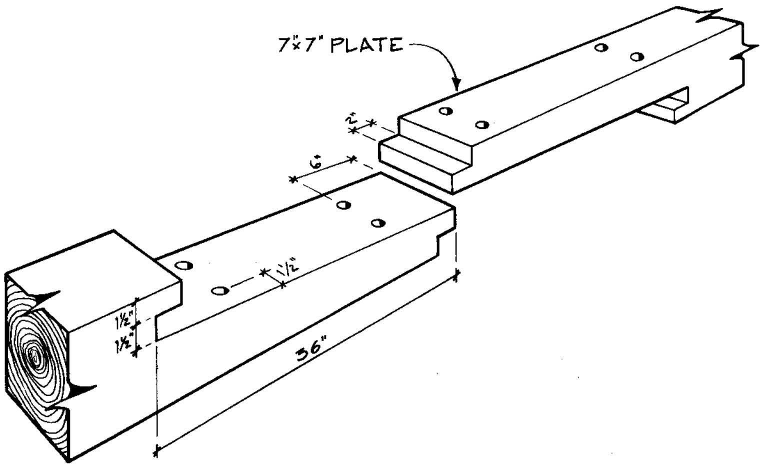


Fig. 13. Stop-splayed and bladed scarf in a late-19th-century 40x48-ft. barn in Windsor, Massachusetts, with stub tenons and four 1-in.-dia. turned pins. The slope of the splay is only 1 in 36.

Bridled. The simplest bridled joint is a tongue and fork or open mortise and tenon (Fig. 14). Though it doesn't handle loads other than axial particularly well, it still has advantages. Because it is typically fairly short, it uses less timber and can fit better between other joints. It is commonly found in ridge beam splices where the close spacing of the rafter mortises leaves little room for a conventional scarf.

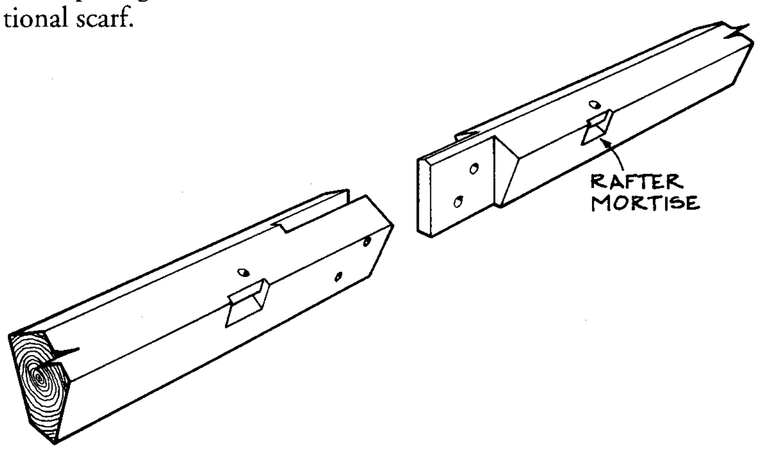


Fig. 14. Typical bridled scarf in a ridge beam. This short scarf works well where it receives frequent support from the rafters and must fit in the relatively short space between them.

Bridled and Squinted. The joint is improved by making the tenon blind on one edge and angling the abutment (Fig. 15). This

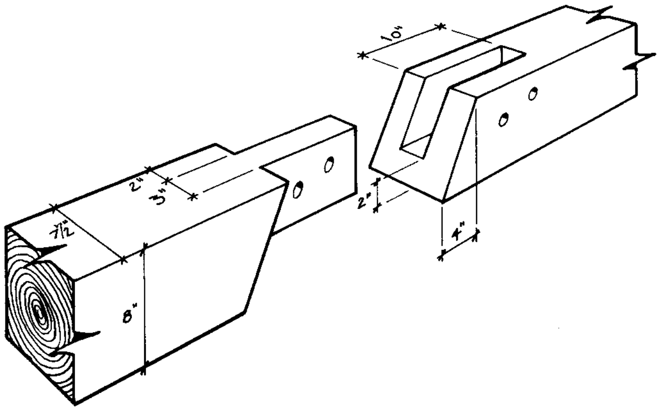


Fig. 15. Bridled and squinted scarf used (or reused) in the tie beams of the Harlow Old Fort House, Plymouth, Mass., ca. 1677.

joint is also found where the abutment slopes the opposite way (see Cummings, Fig. 87), and in that form occurs in one of the oldest timber-framed buildings in England, as a sill scarf in the Barley Barn at Cressing Temple, ca. 1200 (see Hewett, Fig. 273). The use of this particular joint in the roof of Harlow Old Fort House in Plymouth, Mass., is odd: the scarfs, which do not perform well in bending, are located about 4 ft. from the ends of 27-ft. tie beams. But tradition says the house was framed of timbers taken from the original fort in the settlement, hence the scarfs.

Tapered Bridle. This bridled scarf (Fig. 16), set flatwise, improves the shear capacity of the scarf. While it resists compression, moderate tension, and torsion, it is limited to locations where bending forces are minimal.

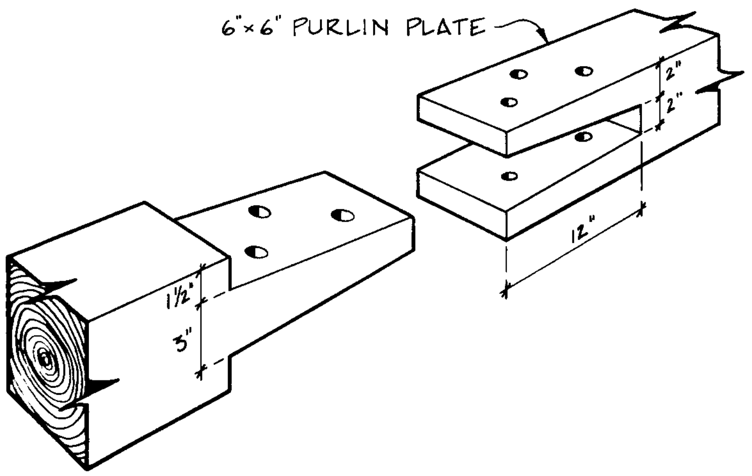


Fig. 16. Tapered bridle scarf in the purlin plates of a barn in Holliston, Massachusetts.

Tabled and Bridled with Key. Lengthening the bridle to provide a table and key improves the tensile and bending performance of the scarf (Fig. 17). Its rarity seems to indicate that the extra strength is not sufficient to warrant the extra cutting work.

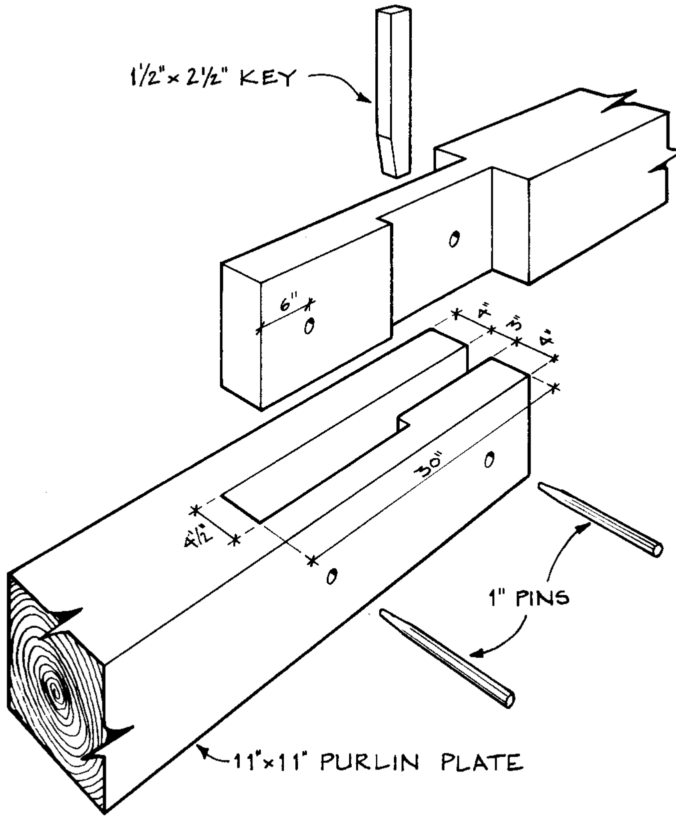


Fig. 17. Tabled and bridled scarf with key, 5-bay barn, 62x81 ft., Genoa, Nevada, ca. 1858.

Stop-Bridled Halving. Only one example of this type (Fig. 18) has been located. Though it works moderately well in most conditions, weakness in bending limits its applications.

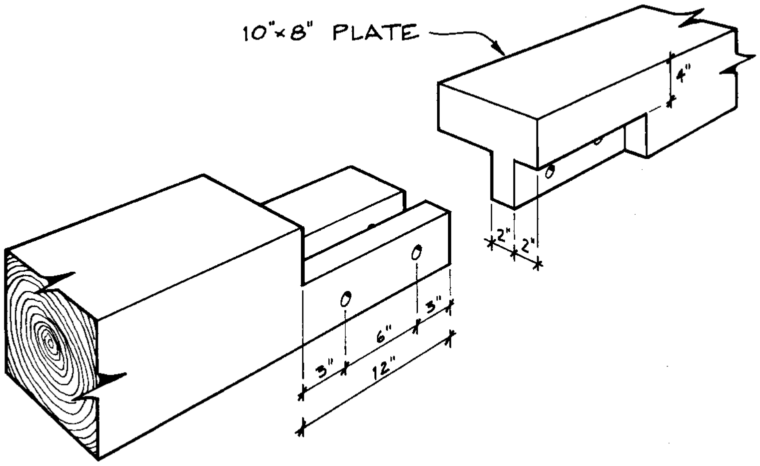


Fig. 18. Stop-Bridled Halving in a German barn, Myerstown, Penn. Located a very short distance from a post, it carried mostly shear force.

Halved and Bridled. This not uncommon form (Fig. 19) works moderately well in all ways and yet is straightforward to fabricate and assemble. Undoubtedly there are splayed varieties of this scarf as well.

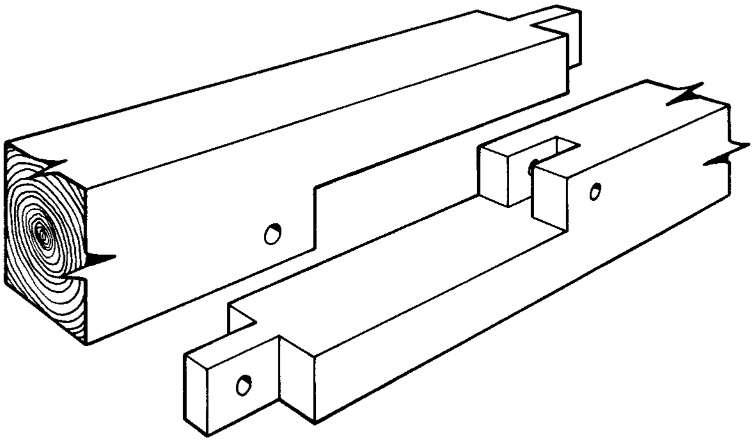


Fig. 19. A typical halved and bridled scarf. Additional pins may secure the lap.

Bridled Repair Techniques. When early carpenters encountered posts with decayed bottoms, the simplest way to replace a short section of damaged wood was with the bridle. In this position, the joint was subjected to primarily axial compression. This short, easy to fabricate joint (Fig. 20, facing page), was more than adequate. If only the tenon was decayed, it could be replaced with a *free tenon* (Fig. 20), also called a slip tenon or faux tenon. The use of a free tenon also permitted members tenoned at both ends to be inserted into an already erect frame. In a few cases where a carpenter mistakenly cut a timber off at the shoulder rather than the end of the tenon, a free tenon allowed the piece to be saved.

METHODS FOR JOINING STRUCTURES. Often enough, early builders added to existing structures or moved an existing structure and attached it to another. The frames needed to be anchored to each other to prevent displacement at the roof, walls and floors.

If both frames could stand independently of each other, then a simple free tenon was used to join adjacent posts (Fig. 21). The mortises were typically cut right through for convenience during