Maintenance Wooden Roof Trusses

Problems with wooden structural members that support roofs are common and call for the experience of a structural engineer.

Have you every looked up during a sermon and wondered how the roof was held in place?

Well, as your spirits are being lifted, the roof above you is typically being supported and held in place by massive wooden beams and rafters . They may be elaborate exposed trusses with carved tracery or simple frameworks hidden behind plaster ceilings. Employed since Roman times in buildings ranging from basilican churches to French Gothic cathedrals, the roof truss is a relative youngster compared to the arch, dome, and vault. Engineering advances in roof and bridge trusses in the 19th century permitted the elimination of unnecessary members, standardization of efficient forms, and the use of trusses for wider spans or heavy loads. Trusses of wood with iron or entirely of iron were also introduced in the 19th century.

Wooden roof trusses provide the structural framework between columns and/or bearing walls that support the roof of a building. Straight or curved members are connected in a generally triangular arrangement. Every roof truss has two top chords (compression members), one or more bottom chords (tension members), and web members which connect the top and bottom.

A scissors truss has sloping bottom chords which produce a large horizontal outward thrust and often require buttressed walls (Fig. 2). The so-called hammer-beam truss, pervasive in Gothic Revival architecture, actually functions as an arch (Fig. 3). A good introduction to roof trusses is provided Inspecting and Maintaining Religious Properties See Resources.

Moisture deterioration from the failure of a roof covering is the single biggest cause of decay in wooden roof truss members. Leaking gutters, flashings, and mortar joints above beam ends raisethe moisture content of wood, inviting rot, fungal growth, and insect attack. Maintaining a watertight roof and the adequate ventilation of roof spaces to keep the moisture content of the wood low will inhibit fungal attack, notes John and Nicola Ashurst in their book Practical Building Conservation See Resources

"Most failures occur at bolted connections that were either inadequately engineered at the time of construction or that have since failed due to deterioration," says J. Thomas Ryan, P.E., a consultant with Ryan-Biggs Associates, P.C. of Troy, NY. A less obvious fault may lie in deteriorated masonry walls which move and put unreasonable loads on the truss members.

The first sign of a structural failure may be severe bowing, or fresh cracks or splits. Mr. Ryan observes that most failures in roof trusses occur in the bottom chord, or in bolted connections where the edge and end distance from the bolts is insufficient. The inspection guide at right lists problems to watch for in annual inspections of wooden roof trusses.

A structural engineer who specializes in historic buildings should always be consulted promptly if problems are seen in roof trusses. A preliminary inspection will typically be followed by a proposal for a more detailed survey and analysis, if required. Inspections by engineers may involve a visual survey and the use of hand tools, measuring devices, moisture meters, and other diagnostic instruments. In some buildings, a compact lift can be driven into the sanctuary to aid close-up inspection of trusses. Nondestructive investigative methods, such as fiberscope and x-ray radiography, are emphasized to avoid damage to historic building materials. Inexpensive tell-tale devices can be installed to monitor structural movement. Hidden areas susceptible to fungal growth can be monitored with built-in moisture meters or spy holes for fiber-optic inspection. Physical probes are sometimes undertaken by restoration contractors. Computers are often used to calculate the load-carrying capacity of structural members and determine the amount of reinforcement that may be necessary.

Investigations culminate in a written report with an assessment of the conditions and recommendations. If structural repairs or modifications need to be made, the engineer prepares drawings and specifications and can recommend contractors. Often the work is performed as part of a larger restoration project with an architect or preservation consultant overseeing contracts, retaining the engineer as part of the team.

Many wooden truss members were originally oversized, and despite considerable decay in areas, may still perform adequately. However, in some cases, decay or damage may so weaken a member as to make the building unsafe for occupancy.

The purpose of repair is to restore the structural strength of the member and joints which connect it to the frame, the Ashursts explain. The heavy-handed "belts and braces" approach has been replaced by an emphasis on preserving the authenticity of the wooden frame. This is done by retaining as much original material as possible and avoiding extraneous reinforcement with steel or other non-historic materials.

Repair methods depend on whether a member is hidden or exposed, in compression or tension, subject to bending stress, or failing at a joint. For compression members, cutting out decayed sections and gluing in matching replacement wood is feasible. For tension members, the damaged portion can be entirely cut out and replaced with new wood. A beam subject to bending stress may be repaired by scarfing a new portion to the old at the ends or with a wooden plate. Replacement wood is preferably secondhand, or if unavailable, new wood should match in quality, grain, and moisture content.

Although wood should be replaced with wood, in some cases repairs using steel are the most practical. Steel should be hidden if a member is exposed. A common type of repair is the reinforcement of a wood beam end using a steel flitch plate. Epoxy resins also have structural uses, including in situ repair of beam ends, and the filling in of wood sections diminished by fungal and insect attack, often with reinforcement with stainless steel or glass-reinforced plastic rods.

At the Serbian Orthodox Cathedral of St. Sava, New York, NY (Richard M. Upjohn, 1851-54), water infiltration caused extensive rot at the truss ends. Related problems caused by the rot and identified by engineer Anthony M. Giudice include movement of the trusses, opening of joints at the wall, distortion of truss members, and cracking. Truss stabilization and repairs to the roof and drainage system are being planned and supervised by building conservator William Stivale with financial assistance from the Landmarks Conservancy's Sacred Sites Program and Historic Properties Fund.

This past summer, a fire destroyed hammer-beam trusses at St. Philip Neri Church in the Bronx (1899). According to designs by engineer John J. Flynn and Drazen & Cackovic Architects, P.C.of Nyack, NY, fourteen trusses are being replaced with newly

fabricated 52-foot long trusses to match the originals made of kiln-dried Douglas fir.

The best way to prevent deterioration from water and insect damage is to maintain the roof, perimeter drainage system, and exterior walls. Annual inspections of wooden roof trusses by an informed layperson or building professional should note any changes in conditions. Problems should be investigated by a structural engineer who specializes in historic buildings.

Inspecting Roof Trusses

Structural problems are common in roof trusses of older buildings. An informed layperson or building professional should inspect wood trusses annually and the entire structural system of a building every three years. A structural engineer should inspect the entire structural system at least once every ten years. When performing the annual inspection of roof trusses look for:

Physical deformities, such as horizontal and vertical deflection (bending in one direction or another) and bowed members

Loose or separated connections New cracks or splits in wood members (particularly at connections)

Shrinkage checks (small cracks running parallel to the grain of wood)

Moisture deterioration

Fungus or insect infestation