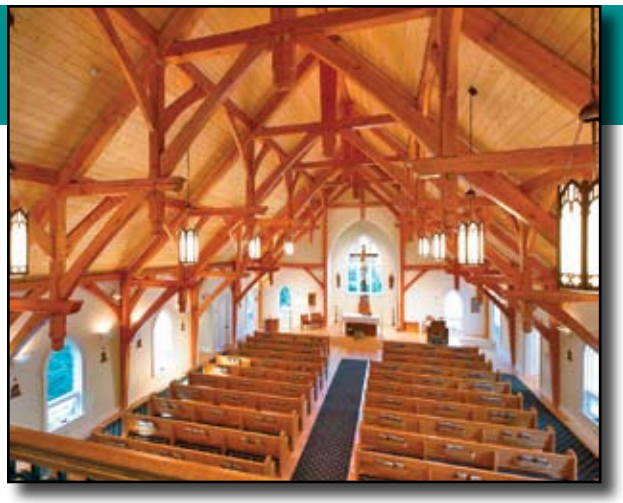
Saint Patrick Church

By Kevin H. Chamberlain, P.E.



Church interior with exposed timber frame. Courtesy of Olson Photographic, LLC.

Saint Patrick Church in Redding Connecticut faced a challenge. With more families moving into town, their cozy 1880 mission church was bursting at the seams. The time had come for a new church to serve the growing parish. The challenge was to achieve an inspirational design that complemented the vernacular of the old church, all on a modest budget.

The design was a collaboration of Daniel Conlon Architects and DeStefano & Chamberlain, Structural Engineers. After the program and building size were defined, options for structural systems were discussed. A long steep gable roof over the main sanctuary space could create either an exciting space or a bland one. An architecturally exposed structural system would shape the interior of the massive roof surface. Timber hammerbeam trusses were selected, an adaptation of a classical form tracing its roots to the medieval cathedrals of Europe. DeStefano & Chamberlain turned to Westminster Hall in London, England for inspiration.

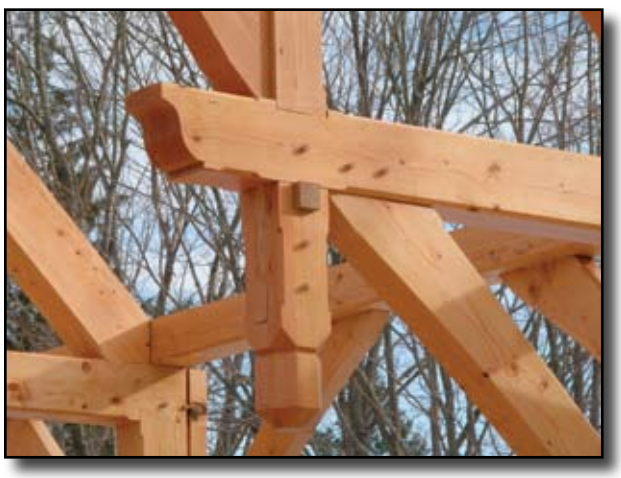
The hammerbeam truss is named for the hammer shape formed by a short post that tenons through a beam, much like a wooden handle passing through a wooden mallet. A series of these hammerposts and hammerbeams, propped up by knee braces, corbel from the eave up to the ridge. Much like an arch, all of the members are held in compression under gravity loads. Medieval church roofs relied on massive stone buttresses to resist the outward thrust of the trusses. Such a design would be too expensive and impractical for 21st century Connecticut. Could this classical structural form be engineered for modern building codes with commercially-available timbers, and be within budget?

The design began with a 3D finite elements model of the trusses and other frame members. Several configurations of truss geometry were attempted, refined, and re-analyzed. The tricky thing about any timber frame structure, particularly a hammerbeam truss, is to configure members to transfer forces in bearing and to avoid, or at least minimize, tension joints. Unbalanced snow loading and lateral forces on the trusses caused stress reversals that had to be considered. Unlike the old cathedrals, the final design iteration required 3 tiers of hammerbeams, instead of 2, to balance the forces most efficiently.

> *"It is not merely a pleasant part of the architectural landscape. The new church, like the one before it, will continue to serve for generations to come."*
> *– The Most Reverend William E. Lori, S.T.D., Bishop of Bridgeport*

The most critical connection in the truss is the first hammerbeam/hammerpost joint in from the eave. Axial forces from the upper and lower braces cause significant shear forces through both the post and beam, which dictated the minimum dimensions through the diminished cross-section where the post tenons through the beam. In place of those cumbersome masonry buttresses, a gunstock post (named because it resembles a rifle stock), borrowed from early American timber frames, was used as the primary column, carrying predominantly flexural stresses from the bottommost brace of the truss.

Out of plane bracing is crucial with a hammerbeam truss. Many members are in compression but are disengaged from the roof diaphragm. The hammerposts are braced with knee braces that join to the bottom of roof purlins. The main lateral system for the building is knee bracing on the timber frame, in conjunction with plywood sheathing panels on the stud walls.



Hammerbeam joint. Courtesy of Kevin H. Chamberlain.

The 3D model was not retired after the calculations were complete. A Building Information Model (BIM) of the timber frame was created, which served as the basis for the construction drawings. After the bids were awarded and a timber framer was on board, the electronic files were made available for their 3D shop drawing set.

Pieced together from solid-sawn timbers no bigger than 8x12s, the hammerbeam trusses are spaced 14 feet on center, and clear-span the 45-foot width of the church sanctuary. Douglas Fir from the Pacific Northwest was used for all the truss members due to its availability, high allowable stresses, and dark patina which lends a formal appearance to the frame and contrasts well with the pine ceiling boards.

The completed church was a resounding success. The project was delivered on schedule and within budget, with no structural change orders or RFIs. Total construction cost was $1.4 million. The church was dedicated in October 2006.

DeStefano & Chamberlain, Inc. received a *2008 Engineering Excellence Award* from the American Council of Engineering Companies (ACEC)/Connecticut for this project.▪

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