City Impact Church - Queenstown

(Robin Frengley, Engineer)

Introduction:

The City Impact Church at Queenstown is in Hansen Road situated just off State Highway 6 (Frankton – Ladies Mile Section) opposite Joe O'Connell Drive, the turnoff road leading to the Events Centre. It is a 2 storey building with offices and function rooms on both floors at the front and sides surrounding a central 750 two tier seat (400 downstairs and 350 upstairs) auditorium extending to the rear wall where the stage and curtain antrium is situated.

The original design was inspired by the Albary Tennis Centre in Auckland which utilized curved steel framing. But for Queenstown, laminated timber was the preferred material because of cost and aesthetic appeal. The design concept was developed both in-house and in conjunction with Kurt Lehman Architects (ex Queenstown and now Christchurch). Mark L Batchelor Consulting carried out an alternative design to enable the Glulam manufacturers to price it. On Hunter Laminates becoming the preferred supplier, the writer as their Consultant, was asked to undertake the final design to the requirements of Mark Hillary Design and Hunters (1998) Ltd.

Fig.1

Fig.2

Main Frames:

There are four curved main internal beams of 765 x 135 size running longitudinally through the building 7.5 m apart rising up from abutments at ground level out from the front and rear of the building and flattening out through the central section with the lower sections of the beams extending below the ceiling through the auditorium. This is over a span of 45metres.The curvatures range from 14.0m radii at the steeper ends to 56m through the flatter central section which also includes a straight section. Along each main curved frame line there are supports either by columns or cantilevered beam extensions off columns at 4 positions other than the hinged abutments. These positions being the front and rear walls as well as two internal columns coinciding where possible with wall positions. However this was not possible through the main central auditorium area as the two central internal columns have to rise up from the rear upper seating closer together to provide a clearer unobstructed viewing area. A cross beam runs over the top of these columns and cantilevers out to support the main beams on their faces. The crossbeam and the flatter curved and straight sections of the main beams all had precamber specified. The sections of main beams which are exposed outside the building and above the roof being the first sections from the hinged abutments up to the first joint were formed from CCA H4 treated timber.

Two exterior perimeter frames also at 7.5m spacing from the four inner main frames form the external side walls and are of glulam beam and post construction with the 315 x 90 beams mirroring the curvature of the internal main frames on the invert of the main beams. This means that the roof on the two outer bays on each side of the 3 main roof bays is 400mm lower. The side wall columns are at right angles to the side walls to take the lateral wind loading.

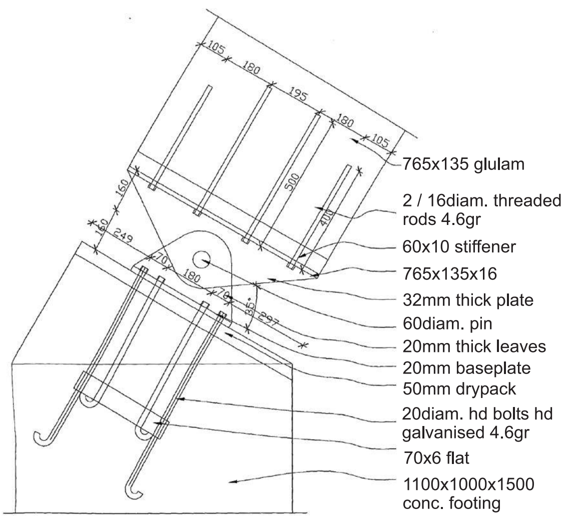

Fig.3 Typical glulam / footing detail

Fig.4

Fig.5

Fig.6

Fig.7

Loading and Secondary Systems:

Maximum loading cases were snow and wind on the main frames and earthquake and wind laterally. Diagonal bracing was used to take the lateral loading while the main frames themselves transferred the longitudinal thrust down into the abutments. The side walls are separately braced in the longitudinal direction.

Of the 5 bays across the building the 2nd and 4th bays have diagonal Reidbar bracing between the beams in the curved plane of the roof running from front to rear walls to take the lateral loading. (ref. Fig. 11) At these walls the diagonal bracing continues vertically down the inside of the walls to the base of the columns. The front wall is mostly windows and the diagonal bracing is seen through these windows.

The side and rear walls are of 100mm Bondor insulated panels and in the side walls from first floor up to roof level these provide the longitudinal bracing for the side walls. However at ground floor level there are plenty of doors and windows leading out of the several function rooms and there was insufficient panel area to provide this bracing. Therefore using 540 x 90mm portal frames and steel nail plates provided additional longitudinal support. These are positioned between the external wall columns, in the plane of the walls at right angles to the wall columns. (ref. to Fig 5) The beam section of the portals also carried the first floor loading from the LVL floor joist system.

The roof purlins are of 360 x 45 LVL throughout the auditorium area but reduced to 240 x 63 size at closer centres as the ceiling height of the first floor offices required the reduced depth.

Connections:

The main beam joints and column to beam joints were of bolted steel side plates. (ref. Fig. 5) The main beam joints of which there were three to ensure the individual beam lengths were able to be transported by truck from Nelson to Queenstown were positioned to minimize the bending moment sustained. The first joints from the abutments were beyond the end walls so that the first two sections of bracing bays complete with purlins and blocking could be assembled on the floor attached to the hinged abutment joint and lifted into position and propped off the end wall columns. The hinged abutment joint had to allow for this extent of movement. The central pin of the hinged joint is of 60mm diameter medium tensile smooth drawn steel. (ref. to Fig.3) The centre of the ends of the rods are internally threaded to take a 12 diameter bolt which holds a circular cover plate in position to prevent dirt and corrosion getting into the rod and surrounding anchor plate hinging surfaces. There are two 20mm thick anchor plates from the abutment side and one central 32mm thick anchor plate from the main beams hinging on the rods. The anchor plates are attached to the main glulam beams with eight glued 16 diam. threaded rods which extend longitudinally into the beams. (ref. to Fig. 6) The base plate of the anchors has a steel plate upstand which encloses the ends of the beams. The concrete bases of the abutments run back underground to connect up to the end wall pads and foundations.

A similar glued threaded bolted connection was used to connect the cantilevered cross beam connection to the sides of the internal auditorium main beams. A steel end plate was rebated into the end of the cross beam and anchored longitudinally into the cross beam with threaded rods. These threaded rods in turn had internal threaded ends so that after the braced bay roof sections had been lowered into position sitting on a steel ledge on the bottom of the end plate, bolts through the width of the beams anchored the beams to the cross beam.

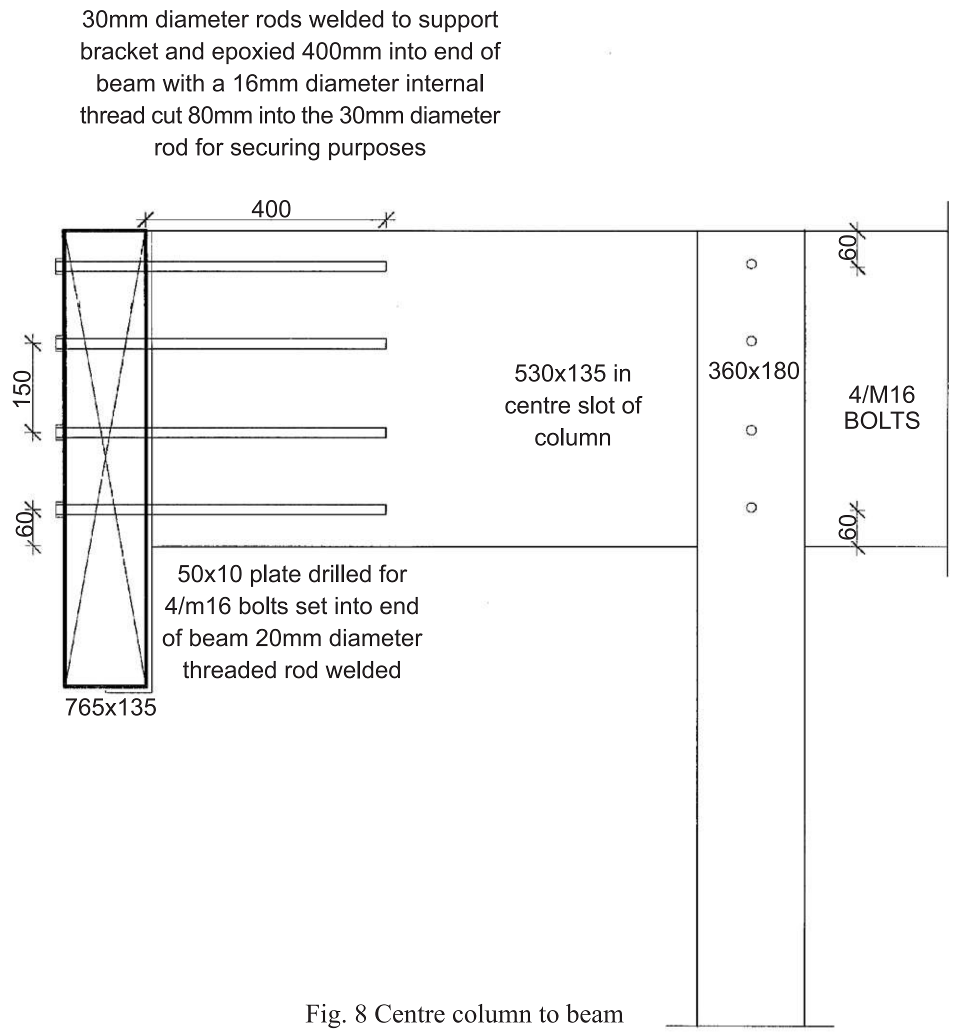

Fig. 8 Centre column to beam

NOTE: 60mm diameter washer to be used on bolts against timber

Most of the other joints were of the bolted side plate type such as at the column bases or angled bolted connections between roof beams and columns. The steel nail plates were used for the ground floor side wall portal frames rather than plywood gussets because of the need to retain the portals within the width of the side walls.

Fig.9

Two sections of the main roof bays had to have supplementary cross bracing between laterally held nodes. These occurred within the curtain antrium area above the stage where because of the increased height there was no roof purlin bracing and the other was at the front of the building where the main beams rise above the ground floor roof and are still exposed before meeting the first floor roof line. Steel 100mm SHS were used with elongated stiffened bolted ends to prevent beam twisting. Several node purlin connections in the auditorium area had extended brackets to the lower edge of the main beams to prevent twisting as the lower edge being exposed below the ceiling line did not have lateral support.

Fig.10

Construction:

The assembly and lifting of the main roof beam bay sections into place were carried out without any difficulties despite this part of the construction extending into winter.

Robin Frengley CPEng MIPENZ.
Robin Frengley Consulting Engineer Ltd

Architectural Designer: mark hillary design.
Glulam manufacturer: Hunter Laminates (1998) Ltd.
LVL Purlin Manufacturer: Nelson Pine Industries Ltd.
Contractor: Jenkins Enterprises Ltd.
Civil Engineering Design: Foundations and first floor internal design,
Bernard Witham (Dunedin).

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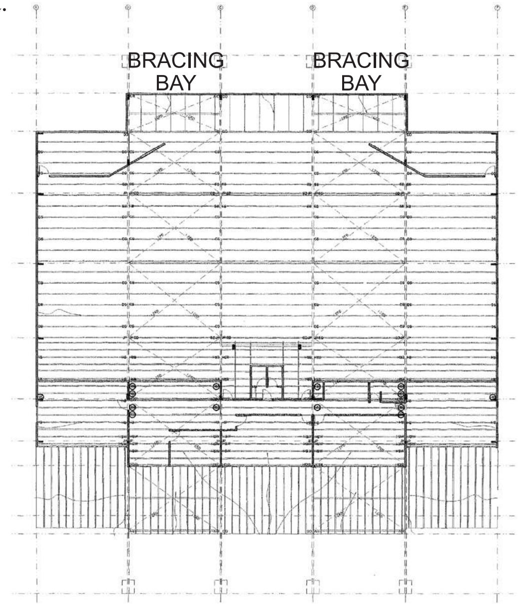

Fig.11 Roof framing plan

Fig.12