# CASE STUDIES: EARTHQUAKE RISK BUILDINGS

## 1. STRENGTHENING OF STATE TRINITY CENTRE, CHRISTCHURCH

D.S. Evans*

1. INTRODUCTION:

Trinity Church is located at the intersection of Manchester and Worcester Streets one block from Christchurch's Cathedral Square. It is one of the finest examples of non-conformist church architecture in New Zealand and one of the most important pieces of built history in the City.

2. HISTORY AND DESCRIPTION:

The church was designed by B.W. Mountfort, a leading New Zealand architect of the colonial period, and built by D. Reese for £ 3,173 in 1874-5 for the Congregational Church. At the time it was described as being of Norman or early English style. The plan is perhaps best described as octagonal (incorporating the transept) with the nave extending from the north side. There is a tower at the north-east corner. The church is quite small, 28 metres from north tower face to the south (organ) wall and 18 metres across the transept. The main roof ridge height is 12 metres and the tower height 15 metres. There is a gallery above the north end of the nave. The church was capable of seating approximately 500. Construction is of stone with a slate roof on timber trusses. Four large timber-moulded columns within the "octagon" give vertical support to the main double-barrel vaulted roof. Of all Mountfort's church interiors this is considered the best and most stimulating.

Following amalgamation of the Congregational Church Union with St Paul's Presbyterian Church, Trinity Church became surplus to their requirements in 1974. The church was then designated as being of the highest priority for preservation under the Christchurch City Council's proposed new district planning scheme. An active campaign to save Trinity Church developed; the end result being purchase by the State Insurance Office to strengthen and preserve the building and adapt it for public use.

3. INITIAL CONDITION AND STRENGTHENING CONCEPT:

A detailed measure of the church was made to analyse loads. The stone building possessed negligible seismic strength. Examination showed most of the timber floor structure was rotten (the carpet sometimes being the stronger membrane), stone walls were badly cracked in places, some timber truss members severely borer-infested and most truss joints very sub-standard. The Christchurch City Council required the building to be strengthened to comply with Section 301A of the Municipal Corporations's Act.

Fortunately Mountfort's drawings were in the possession of the Canterbury Museum and these proved to be valuable.

Internal stone wall faces were plastered - on one side solid plaster approximately 50 mm thick and on the other lath and plaster with plaster face approximately 100 mm from stone face. It became apparent that if the plaster was removed and 75 mm of reinforced high-strength shotcrete attached to the stone walls we could achieve a strong box-like structure with channel-shaped walls at the side of the octagon (transept walls) possessing good shear and flexural strength. By temporary removal of some of the stone-work at the top of the walls we could cast an in-situ tie band around the perimeter. At the front of the gallery we could place a tie across the width of the nave hidden within the gallery railing and an attempt could be made to apply a small compressive stress in the tower stone walls by installing a "pre-stressing system" from tower roof to foundation level.

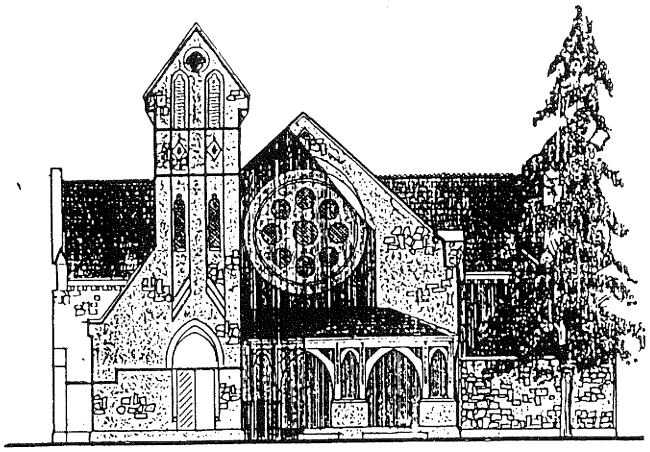
4. CONSTRUCTION WORK:

The timber floor and soft soil to good bearing were removed, no fines hardfill placed and a new reinforced concrete floor cast leaving pockets around the main roof supporting columns and a gap between the walls. In stages at the base of the walls the stonework was cut back to enable a shear key to be formed between slab and wall (in effect temporarily "undermining" the wall), reinforcing placed and floor sections cast.

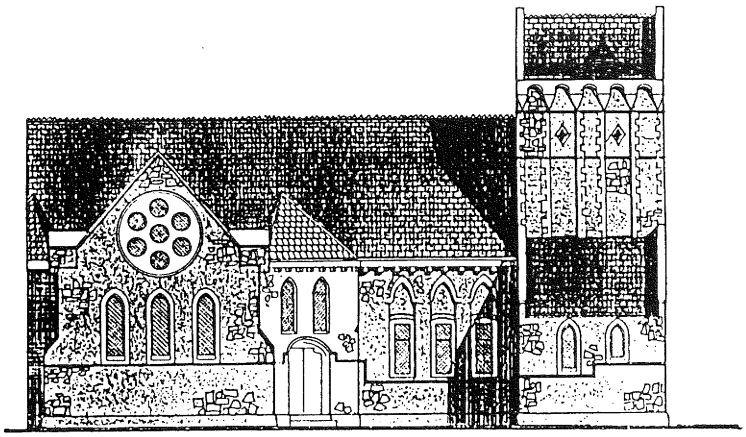
Scaffold towers were erected at main columns one by one to support the roof load whilst rotten timber below columns was removed and they were underpinned with concrete.

Walls were then stripped of plaster and pockets formed on a 1.5 metre grid so as to enable the stonework and new concrete walls to be tied together. Forming of pockets effectively dovetailed was not difficult. Mesh was fixed over the face of all walls and additional trimming bar reinforcing placed around all openings. Because of the difficulty in cleaning the stonework of plaster dust and very loose mortar it was decided to steam clean the walls. This was most effective and produced an excellent surface for the shotcrete to be applied to. (Important to notify the Fire Brigade before commencing!) 75 mm of shotcrete was then applied to the walls and they were later hand-plastered. In stages an in-situ band was cast to tie walls at high level. Truss joints were strengthened by addition of bolted steel side plates. Most joints being different necessitated

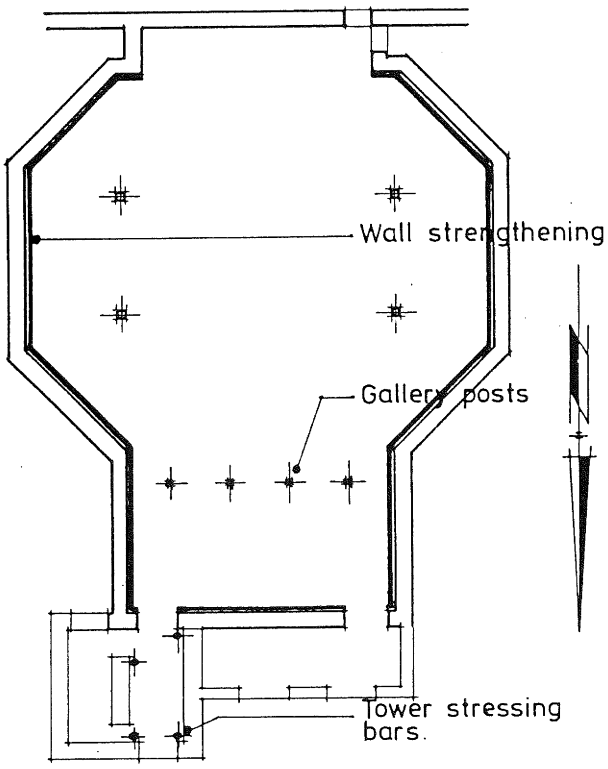
*Principal, Hardie, Evans, Douglas, Christchurch



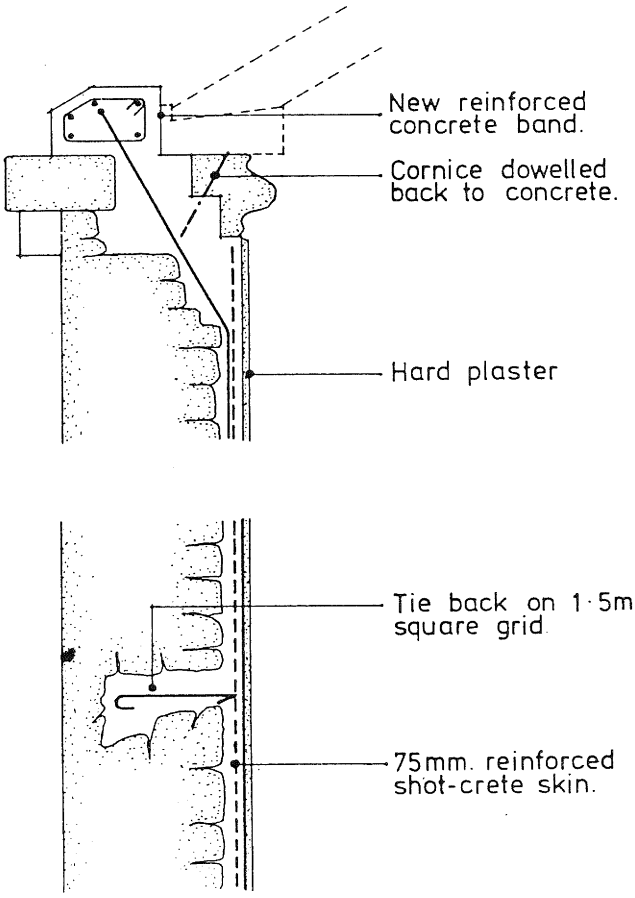
NORTH ELEVATION

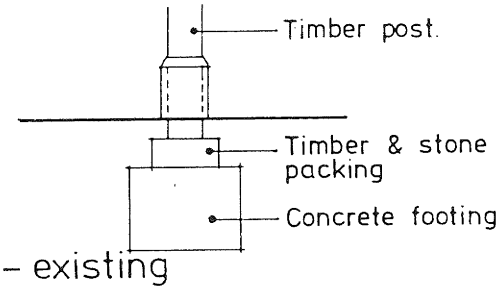


EAST ELEVATION




FLOOR PLAN

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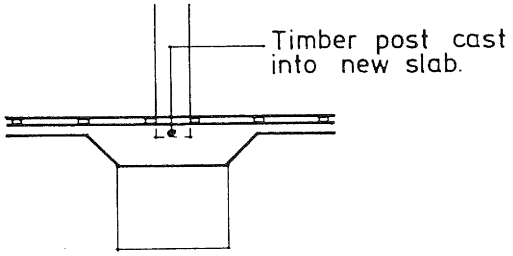


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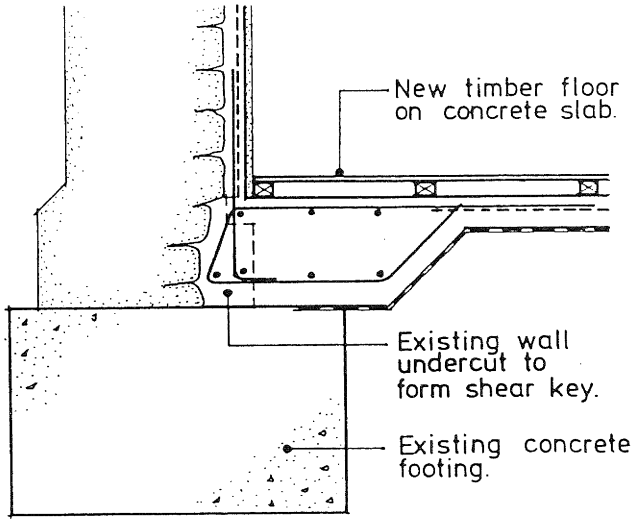
POST SEATING DETAIL




WALL STRENGTHENING DETAILS

many templates being made. A large rectangular frame was positioned at the top of the tower and anchored to the foundation via four Macalloy bars fitted into rock anchors set in the tower foundation. These were tensioned until a small compressive stress was induced in the stonework.

5. OBSERVATIONS/COMMENTS ON HOW IT WORKED:

5.1 The new concrete floor proved to be an excellent work platform e.g. when supporting roof loads at time of underpinning columns, wall plaster and stonework removed could be dropped and simply shovelled away.

5.2 The steam cleaning of the stonewalls was very successful.

5.3 There are lots of surprises when the work is "opened up" and engineer/architect/contractor must be able to make quick site decisions.

5.4 Things that are impossible to accomplish on new projects are accomplished with a "devoted to the cause" work-force on an historic restoration project. The enthusiasm of the steel-workers getting the steel frame to the top of the tower by hand and ropes, and the help given by other trades present; I have rarely seen on other jobs.

5.5 The "stressing of the tower" is doubtful. With time stress level in stonework may diminish. During tensioning it was necessary to inspect stonework as well as one could to ensure no movement at stone joints. Inspection was done with fingers crossed.

5.6 A lot of effort (and expense) was required to protect building from construction damage e.g. special ply shutters had to be made to protect the stained glass windows, care taken to ensure steam did not come into contact with barrel vaulting (even significant change in moisture level could have had a disastrous effect on very dry ceiling timbers), great care when welding or using power tools in roof space as lots of dust, bird nests, etc. were present. Smoking inside the church was prohibited with no great protest.

6. CONCLUSION:

I am sure all parties involved in the strengthening and restoration work found this project to be most enjoyable, just as I did. In my opinion it is imperative that the strengthening work affects the architectural character of an historic building to the minimum extent possible. Except for one wall being 25 mm or so wider than it was previously (not discernible) and the four Macalloy bars exposed in the tower (in lieu of a brass plaque for the engineers), little has changed on the surface.

State Trinity Centre is most successful and is used regularly for many community purposes, music recitals, poetry reading, intimate theatre, etc.

ACKNOWLEDGEMENTS:

"A Plan to Save Trinity Church" Report to the Trinity Church Preservation Steering Committee, R.K. McAnergney, D.E. Donnithorne, J.R. Allison.

COST:

Structural strengthening work $42,000

Client: State Insurance Office, Christchurch

Contractor: Collins, Hunt & Loveridge, Christchurch

Structural Engineers: Hardie & Anderson (now Hardie, Evans, Douglas), Christchurch

Quantity Surveyors: F.W. Shipston, Davies & Partners, Christchurch