# The Christchurch Club rebuild and restoration project

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**ABSTRACT:** Post-earthquake Christchurch has seen the loss of many character buildings. Given the importance of built heritage to a city's landscape and culture; preservation of architecturally significant buildings is vital for the diversity of a city's fabric.

The Christchurch Club's experience is a testament to the complexities of dealing with heritage listed buildings. The Christchurch Club's Clubhouse (1861) was a Category One Heritage New Zealand listed, two story timber frame structure. In the 2011 Christchurch earthquake the Latimer wing of the Clubhouse collapsed and the remaining Mountfort building, including a tower, was left with significant damage. The Christchurch Club then embarked on the Rebuild and Restoration project.

In order to strengthen and repair the remaining building new foundations were a necessity – a piled solution was adopted. To construct these, the 150 year old, significantly damaged structure needed to be shifted (whilst avoiding protected trees) to a temporary location. New foundations were then constructed and the building was shifted back before the strengthening could commence.

This paper outlines the challenges facing the structural designers of this project including aspects of the original construction, the integration of extensions, earthquake damage, temporary works to shift the building and design issues of reinstating an iconic building.

The Christchurch Club Rebuild and Restoration project is an interesting case study of the difficulties facing the resilient seismic strengthening, repair and replication of colonial New Zealand timber frame structures.

## 1 BACKGROUND

The Christchurch Club (The Club) is a private members club established in 1856 by wealthy landowners from the Canterbury region. In 1861 The Clubhouse was erected on the current site at the corner of Latimer Square and Worcester Street. The original Clubhouse, a Category One Heritage New Zealand listed building, was designed in an Italian villa style by renowned architect Benjamin Mountfort.

For Mountfort, who is celebrated for his stone gothic revival style, the building is unusual in his design portfolio but quite a testament to his capabilities. Not only was The Clubhouse an elegant building with innate timber detailing, but the style aligns the establishment with its European contemporaries, fit to host parliamentarians and royals alike.

The Clubhouse was a two storey timber frame building (775 m$^2$) comprising two wings; the Mountfort building and the Latimer wing with a sub-basement cellar between. On the ground floor the Latimer wing contained the dining and social rooms whilst the Mountfort building housed an internal atrium, sitting room, and tower with water tanks. The rooms in the upper levels of the Clubhouse were a mixture of accommodation and meeting rooms. The building had a slate roof, timber flooring with marble finishes, decorated plaster walls, and carved timber door frames, balustrades and panelling. Since 1861 further alterations and extensions have been made to the original Clubhouse and grounds, including a notable extension of the Latimer wing in 1874 and alterations by Architects Warren and Mahoney at various time through the Clubs history.

This paper focuses on the structural complexities of the original Clubhouse post earthquake and the subsequent Rebuild and Restoration Project undertaken by The Club.  It does not touch on the intricate architectural detailing nor the difficulties for the contractor in reinstating a finish worthy of a heritage one structure.

**Figure 1: The Clubhouse photograph by Alfred Charles Barker dated 1861**

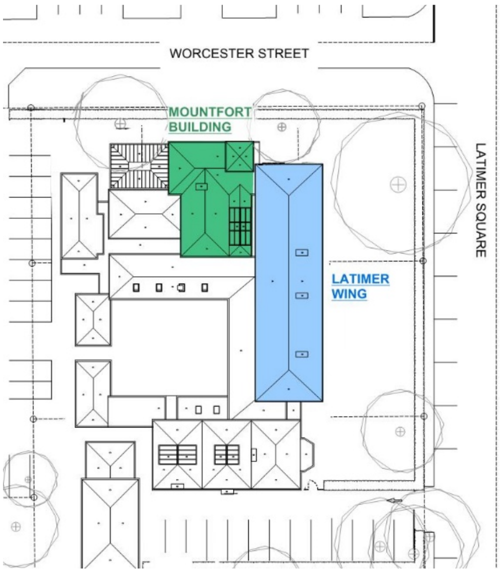


**Figure 2: plan of the Christchurch club site pre earthquake showing the original Clubhouse's two wings (Original background adapted from Warren and Mahoney 2012)**

**Figure 3: North Eastern photograph of club author unknown 1869**

**Figure 4: North eastern photograph of club showing Latimer wing extension (A.E Preece 1882)**

## 1.1 Earthquakes

The Darfield Earthquake in September 2010 caused extensive damage to the Clubhouse and it was closed. The damage was concentrated in the Latimer wing's lathe and plaster linings, the unreinforced masonry (URM) chimneys, URM foundation piles and timber beams.

Repairs to the Latimer wing were underway during the Christchurch earthquakes of 2011 and the wing collapsed. The Mountfort building suffered extensive damage.

The collapse of the Latimer wing was unusual in the respect that all of the main heavy elements had been removed from the building including a portion of the lath and plaster lining. The experience from the Christchurch earthquakes suggests typically light weight timber frame buildings do not collapse under reasonably high levels of ground shaking. In this instance the building was a two storey light weight timber frame structure with a medium / heavy roof with light weight wall cladding. Collapse would not normally be expected. The lateral load capacity of the original timber framed walls was provided by a continuous diagonal brace between the top and bottom plates, with the studs framed above and below the brace, and the in plane capacity of the lath and plaster wall lining. The internal lath and plaster had been partially removed for repairs after the September 2010 event, along with the heavy chimney elements. With no continuity of the studs between the top and bottom plates, and the connection between the top and bottom plates and the brace unable to sustain significant tension actions, the walls under repair at the time of the February 22 2011 earthquake are considered to have had little lateral load capacity even with the significant reduction in building mass.

**Figure 5: Aerial image of club showing collapsed Latimer wing (Canterbury maps 24 February 2011)**

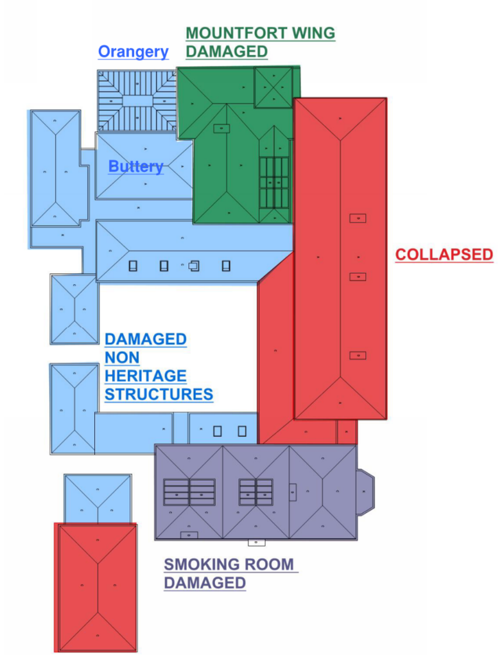


**Figure 6: Plan of club showing state of buildings post February 2011 Christchurch earthquake. (background Warren and Mahoney 2012)**

## 1.2 Aim of the Project

For The Christchurch Club, occupation and any use of the buildings and ground ceased as a result of the damaged condition of the remaining buildings and the partial and total collapse of other buildings on the site.

Restoration of the remaining Mountfort building was an important part of The Club as members placed a high value on its ‘anachronistic charm’. So the Rebuild and Restoration project was developed.

The aim of the project was to; strengthen the Mountfort building to 100%*NBS*, rebuild the Latimer wing in accordance with the original style, strengthen the buttery and orangery to 67%*NBS*, strengthen and relocate the managers flat, and construct new buildings on the rest of the site to allow for modern facilities and resilience.

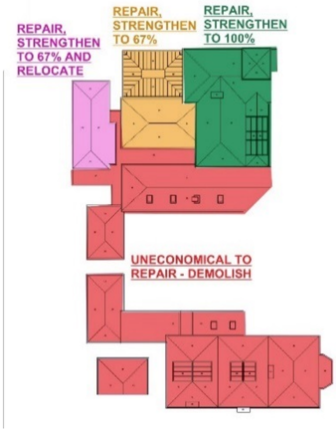


**Figure 7: Plan of club showing the “plan for existing buildings” ( original background Warren and Mahoney 2012)**

**Figure 8: conceptual render of the site showing proposed redevelopment (Warren and Mahoney 2013)**

## 2 THE HERIATGE BUILDINGS

### 2.1 The Mountfort Building

As original structural drawings were non-existent a thorough site investigation was required to establish the structural systems, damage sustained and the condition of the building.

The gravity system of the building was slate roofing (fully sarked) on timber truss roof framing supported by internal and external timber walls to ground. The floors were tongue and groove timber on sawn timber joists supported by either the walls or timber bearers. The foundation system was a stone perimeter wall, URM piles and URM cellar walls.

The lateral load system was not well defined with no clear reliable connections between the ceiling or floor diaphragms and the walls. The absence of a bottom plate above the timber T&G flooring and blocking between the joists and the studs suggested a poor connection with only nominal lateral load resistance.

The URM pile foundations provided little lateral load resistance with only the perimeter foundation wall providing any lateral load capacity.

### 2.2 Damage

The damage observed to the Mountfort building included:

- Damage to lath and plaster walls, and ceilings
- Ground settlement and spread
- Diaphragm disconnection (Wall bottom plate to timber floor connection)
- Cracking, spalling and dislodgment of bricks from URM piles, cellar walls and fireplaces
- Connection failure for the Timber beams supporting the tower water tanks
- In some of the timber framed walls the jack studs had displaced.

There was a degree of timber degradation encountered in the building which was expected to have exacerbated the level of damage observed. As further invasive inspections were undertaken and during the construction stages additional areas of degradation were encountered and placed are required.

**Figure 9: Jack studs in timber walls displaced**

**Figure 10: damage to lathe and plaster linings in atrium**

## 2.3 Original Construction

Undoubtedly one of the most interesting and complex parts of strengthening heritage buildings is discovering the original construction techniques and developing a flexible strengthening scheme that can adjust to requirements on site will trying to maintain the heritage values of the building. Below are some of the aspects of the building of note.

### 2.3.1 *Tower*

The iconic Mountfort building tower, originally built to house water tanks for reticulation, currently serves no functional purpose. During inspections two large (not completely empty) water tanks were found precariously perched on timber beams. The doweled connection between the timber beams and the tower framing had broken so the water tanks were ‘resting’ against the side of the tower. Surprisingly the tower sustained little damage.

### 2.3.2 *Floor Construction*

1860's in-floor acoustic insulation was found in the floor cavity between the timber floor boards and the lathe and plaster ceiling. Supported by an intermediate level of timber battens, the insulation was approximately 40mm deep and appeared to be a mixture of straw and dry pugging. Not only did this add additional mass to the structure but made removal of ceilings more difficult for the contractor and presented some health and safety risks.

In addition to the insulation, a 1980's retrofitted sprinkler system was found. Its installation had notched holes through the joists and in some locations left no more than 10mm of timber on a joist.

**Figure 11: 1860's In floor insulation**

**Figure 12: Underside of floor with ceiling removed. Timber battens supporting insulation visible**

### 2.3.3 *Wall Framing*

The framing of the 150 x 75 and 150x 50 (neat) walls appears to have been dictated by construction stability. The wall's external studs and a diagonal brace were erected first, creating a stable construction frame. The internal load bearing studs were then cut to suit each side of the brace and doweled into the main diagonal brace. The studs are connected to the plates with a mortise and tenon type connection with the floor joists bearing on the bottom plate between the studs and no plate provided above floor level and no blocking between the floor joists and the studs. The lateral load path at this connection is tenuous and the ability to transfer out of plane loads from the wall construction to the floors is limited and some displacement was observed.

The wall lining is lath and plaster with various ceiling linings of lath and plaster, fibrous plaster and more modern GIB plaster board type material.

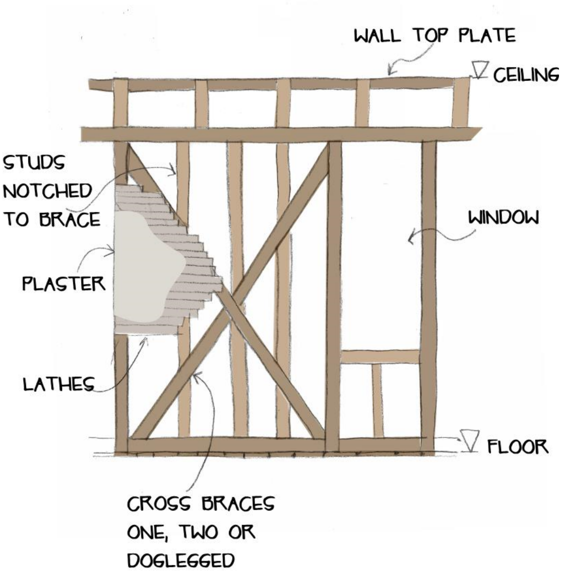


**Figure 13: Schematic of typical wall construction** **Figure 14: wall framing on first floor**

### 2.3.4 *Subfloor Framing*

The wall framing extended below the floor level to the bottom plate where this typically was supported directly on the bearers. The bearers were irregular in both size, orientation (flat/edge) and spacing. The bearers were then packed out to URM piles- which although were at regular spacing's, varied in width and height due to an uneven ground space. There had been a number of extensions and alterations to the Mountfort building at ground floor level with no regular layout of subfloor framing adding to the instability of the sub floor framing.

**Figure 15: Foundation system – bearers and wall bottom plates all of different sizes (note the packing off the piles), supported on URM piles.**

**Figure 16: Bottom plate to foundation 'chemical' anchor system.**

### 2.3.5 *Perimeter Foundation*

The perimeter foundation of the Mountfort buildings consisted primarily of shaped sections of stone butted together with no apparent continuity. However, the performance of the perimeter foundation appeared be adequate given that localised failure was not observed. There is no protection from differential settlement in this form of foundation.

The external wall bottom plates bear directly on the perimeter stone foundation beam. The connection into the beam was an innovative 1860s, 'chemical' anchor system. A hole was chiselled into the stone beam, an apparent molten lead was used to fill it and the bolt was cast in.

## 3 CAPACITY ANALYSIS

A rudimentary analysis of the building's capacity was undertaken using the 2006 New Zealand Society of Earthquake Engineering Assessment and Improvement of the Structural Performance of Buildings in Earthquakes guidelines for timber walls with lathe and plaster linings. This analysis takes a capacity per metre approach to determine the capacity of the structure based on the wall lining type and it was found that the building was less than 34% *NBS*. Regardless of the score the structure had some critical structural weaknesses; poor load paths, poor diaphragm connections and any excessive deflections could fail the timber gravity studs' dowelled connection.

The Latimer wing was demolished under a Canterbury Earthquake Recovery Authority (CERA) initiative with the loss of a significant portion of Heritage and Architectural record. It would have been useful to be able to forensically inspect the collapsed portion of the building to understand the performance of Heritage timber framed structures of this type.

## 4 DESIGN

In order to strengthen the Mountfort building to 100% *NBS*, clear load paths needed to be developed including new foundations. For any new foundation system to be constructed the building would have to be jacked and shifted.

The geotechnical site report described the soil as being "soft to very soft silts with minor sandier lenses overlying sand at 7 – 7.5m depth", with a high water table and liquefiable layers at 12m.Two foundation options were suggested; a deep engineered raft over whole site or piles. After consultation with the contractor and the design team, screw piles with reinforced concrete foundation beams were chosen. This system was deemed advantageous as:

- Piles are quick and simple to install
- Load capacity is confirmed during installation
- No vibration or noise impacts – reducing possibility of further damage to heritage buildings on site
- No spoil or tailings which were expensive to dispose of
- Negligible settlement during future earthquakes.
- Concrete beams and suspended timber floors allow flexibility for subfloor services
- Maximum flexibility for re-levelling floors
- Screw piles were considered the most cost-effective piling option

## 4.1 **Relocation and Reinstatement of the Mountfort Building**

In order to construct new foundations under the Mountfort building, the building would have to be raised or shifted from its location to install the new screw piles. Given that the screw piles are reasonably long, the lifting option was discounted early. The most feasible options was to disconnect the building from the foundations and “roll” the building sideways on small bogies and strong backs to allow the new foundations to be constructed on an unimpeded site. Although this methodology had been employed before in Christchurch to shift houses, the Montfort building presented a 150 year old damaged heritage building of some significance.

Notably the shifting of a damaged 150 year old structure is not without challenges. The building needed to have significant temporary strengthening for the shift and for the period of construction prior to it being moved to its final position. Due to the concern regarding the floor to wall connection, tie rods were tensioned through the building to prevent lateral spreading of the walls due to the lack of connection and discontinuous studs. Continuity of the floor diaphragms was extended over the entry atrium and some additional temporary ply bracing walls were introduced to the building to provide an additional degree of resilience with respect to the shifting stresses expected. Typically all of the existing wall linings were maintained prior to the shift

**Figure 17: Shifting beams set up on dunnage**

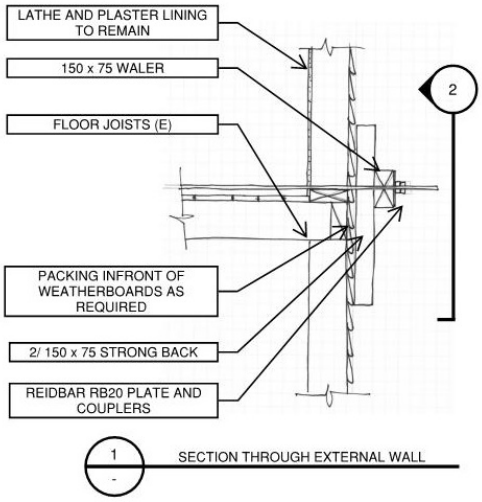


**Figure 18: First floor temporary works detailing for Reid brace floor diaphragm.**

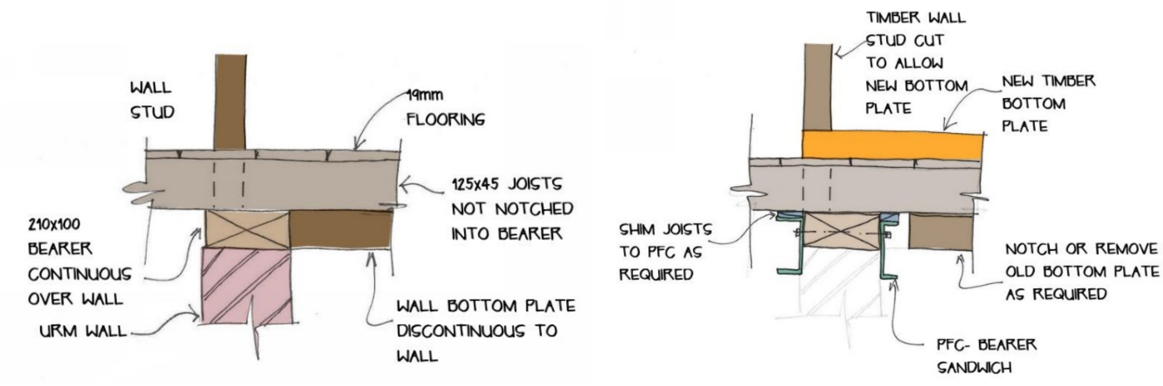
## 4.2 **Strengthening**

On completion of the screw piles and foundation beams, the Mountfort buildings was shifted back to its original position on the new foundations.

### 4.2.1 *Subfloor Strengthening*

The existing bearers needed to be strengthened to fit the new foundation beam spacing. Extra flexibility in the design was required due to the inconsistencies in the subfloor. The solution came in the form of two steel PFC’s sandwiched to the existing timber bearers. Figure 35 below illustrates the variation in the subfloor framing and the solution proposed

Subfloor bracing was provided by a series of concrete walls (with ventilation and crawl spaces) to line up with bracing walls and to break the ground floor diaphragm into smaller units.



**210 x 100 continuous bearer, joists unnotched existing (left), strengthened (right)**

**Figure 19: Schematic examples of subfloor framing variations and strengthening**

### 4.2.2 *First floor*

For the upper floors, which were designed to have accommodation rooms and meeting facilities, the number of walls meant that a simplified non-specific timber design bracing schedule could be utilised. So a ply wood and plaster board bracing scheme was developed in accordance with NZS3604 and adjusted for wall height. As the wall were stripped back to the framing it was possible to retro fit hold down cleats at the ends of the bracing panels.

Blocking was provided between the joists and the wall suds and further blocking was introduced between the studs at floor level in lieu of a bottom plate. Although the "bottom plate" was not continuous fixing was required for the new ply bracing panels to develop load transfer between the strengthened wall elements and the existing floors.

In order to preserve the mouldings, architraves and architectural features of the building 12mm ply was fixed to the existing timber framing with 13mm GIB plaster board over. This replicated the thickness of the original wall construction thus minimising any changes to the heritage detailing in the building.

### 4.2.3 *Ground floor - shear walls*

Strengthening was undertaken on the basis that all walls required to have the two layer ply / GIB system to preserve the heritage value of the trimmings by maintaining the thickness of the wall linings as close as possible to the thickness of the original lath and plaster. The capacity of the building would be a result of this replacement wall linings rather than a targeted %NBS standard. The degree of capacity achieved in this manner was up to 100% NBS.

Ceilings were reinstated with GIB plaster board type material. These combined with the T&G flooring over are considered to be effective flexible timber diaphragms. The new ply bracing walls were anchored to the floor diaphragms by the "Bottom Plate" solid blocking between the studs.

The plywood shear walls were designed in accordance with capacity design procedures for light weight ply clad shear walls. There was a nominal allowance for the over fixing of the GIB board lings with the hold down requirements being relatively conservative. The walls are timber framed, ply lined but have structural steel tension/ compression chords at the extremities and are continuous to the foundation level.

## 5 CONSTRUCTION

The significant challenges when recovering and strengthening a damaged timber framed heritage building is to maintain the heritage aspects of the building while also providing adequate capacity to the building to meet the project objectives.

The condition of the building after the earthquakes required that the building be completely relined to reinstate the damaged lath and plaster linings. Combined with the degradation of the timer framing throughout the building, replacement of timber members was required, which in turn is undertaken using modern construction techniques and materials. Any new timber introduced to replace degraded timber or to strengthen existing framing was provided as treated timber where the existing timber was not treated. The section sizes in the original construction were not typically comparable to that currently available which resulted in bespoke timber sections having to be procured for the project.

Obviously the “straightness” and “squareness” of the building was also a challenge even when setting the building out for relocation and for connection to the new build section of the project. The first floor was slightly warped from the ground floor footprint, which was not possible or practical to remedy hence specifically scribed and bespoke connections and mouldings were required.

## 6 CONCLUSION

The preservation of our built heritage in Christchurch has become topical primarily from the loss of so much heritage in the city due to the earthquakes. The preservation of this building has not strictly been in line with the desires on most heritage officials as such a large portion of the building fabric had to be replaced, irreversibly, that the heritage value of the retaining structure could be questionable.

Careful detailing and sympathetic construction restored the building to close to its original condition however, it should be recognised that the addition of strengthening elements and new materials is part of the new heritage of the building for its remaining life.

The redevelopment of the Christchurch Club involved the full reinstatement of the clubs facilities on the site including the restoration and strengthening of the Mountfort heritage building, the construction of a new accommodation wing and dining wing. If the redevelopment project did not include this 150 year old iconic building then there would be no depth to the site and appreciation of the new modern buildings would be lessened. The heritage of the Mountfort building is treasured by the members who use the space, whose families have been members of The Club for generations and for them the Rebuild and Restoration project has been a success.

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