INDEPENDENT ASSESSMENT ON EARTHQUAKE PERFORMANCE
OF
204 Manchester Street
(Iconic Bar)

FOR
Royal Commission of Inquiry into building failure caused by the Canterbury Earthquakes

Report prepared by Peter C Smith and Jonathan W Devine
OF
Spencer Holmes Ltd

December 2011

Introduction

This report has been commissioned by the Royal Commission of Inquiry into building failure caused by the Canterbury Earthquakes to review the performance of the building at 204 Manchester Street, Christchurch during the Canterbury earthquake sequence. The building was constructed circa 1930 - 1940.

The report is based on documentation provided by the Royal Commission of Inquiry into building failure caused by the Canterbury Earthquakes. No inspection of the building was possible prior to demolition.

Location of Site

The location of the site in the Christchurch CBD is shown on the aerial photographs in Appendix 1. The location of the site relative to the epicentres of the 4th September, 2010 and 22nd February, 2011 earthquakes is shown on an aerial photograph of Christchurch in Appendix 1.

Description of Building

The property at 204 Manchester Street is a corner site with street frontages to Manchester Street and Gloucester Street. The Iconic Bar occupied two buildings constructed on separate lots adjoining a common party wall. Each building measured approximately 20.5m x 20.5m. The use of the buildings had been amalgamated so that there were openings between the two buildings through the common party wall. Some of the openings had been trimmed with reinforced concrete.

The western building was of two storey construction while the eastern building was a single level building.

The two-storey building was constructed of un-reinforced masonry with a plaster finish and walls were approximately 400mm thick. The building had a timber ground and first floor. The two-storey building had a lightweight corrugated roof with timber sarking. The bottom chords of the trusses were seated into/onto the brick walls. (Refer record plans Appendix 2).

The Christchurch City Council records include plans of alterations to the single storey building on the site in 1948. These plans show a building with un-reinforced masonry perimeter walls and timber trusses spanning between the north and south walls. The east and west walls were gable end walls. (Refer plans in Appendix 2) The single storey building had a lightweight corrugated roof supported on timber purlins and timber trusses.

Gravity System

The roof loads for the two storey building were carried by the timber roof trusses that used to span from the Gloucester Street frontage to the southern un-reinforced masonry wall at the rear. The first floor was of timber construction with three spans of timber floor joists supported on the north and south walls and two reinforced concrete frames. All foundations were shallow pad or strip footings, typical of older buildings in Christchurch.

Gravity loads in the single storey building were carried by the timber roof trusses supported on the north and south walls. The east and west walls were gable walls.

Seismic System
The seismic resisting system to the roof of the two storey building consisted of an arrangement of structural steel compression-tension ties within the roof plane transferring the lateral loads from the roof and the out of plane walls of the building to the in plane walls either side of the building. Similarly, the loads from the out of plane walls at first floor were distributed through the first floor diaphragm to the in-plane walls either side of the first floor diaphragm.

The two concrete frames located along the lines of the original party walls provided some assistance in resisting lateral loads in the east- west direction.

The single storey building relied on the roof system transferring lateral loads to the in-plane walls in each direction.

History of Building Alterations

Documentation provided establishes that the two storey building was originally constructed with 3 separate tenancies on the ground floor, with un-reinforced masonry walls along the line of each of the existing concrete frames to the lower storey. The internal walls do not appear to have extended above first floor level. Documentation for replacing the northern internal party wall with a reinforced concrete frame dates this work as having been undertaken in 1947. The other frame was installed in 1949 and this frame had two central columns. (Refer plans Appendix 2) New concrete stairs were also constructed to provide access to the first level.

Documentation for the single storey building records that the original building pre dated 1946 and that a concrete ground floor was installed in 1946.

In 1963 parapets were cut down along both street facades of the two storey building and new reinforced concrete lintels were installed to the arches of the existing window openings along each façade. A new concrete frame was also constructed to allow a new opening to be formed in the common wall between the two structures.

Seismic upgrades of both buildings were carried out in 1993. Holmes Consulting Group Ltd undertook a structural assessment as part of a change of use of the two storey building from a furniture showroom to a restaurant. The building was assessed in accordance with the NZNSEE Earthquake Risk Buildings Red Book (December 1985) for an occupy 2 building and the building was strengthened to 2/3 of the requirements of the standard NZS 4203 : 1984. The seismic design base coefficient adopted was 0.42g.

Strengthening work consisted of:

- Providing steel roof bracing fixed to the underside of the bottom chords of the timber roof trusses on the two-storey building
- Providing a steel angle to the exterior walls of the building attached to the brick with dowels epoxied into the un-reinforced masonry walls;
- Fixing 9mm ply on the underside of the existing timber first floor;

- Securing a new edge angle to the perimeter of the first floor, with threaded dowels epoxied into the un-reinforced masonry walls;
- Securing gable walls to the roof plane bracing by way of drilled epoxied dowelled connections;
- Providing a reinforced concrete frame from the ground to first floor on the west wall.
- Removal of mezzanine floor against north wall.

There is uncertainty as to the shape of the original trusses in the building. It is considered unlikely that the truss originally had a stepped bottom chord. It is more likely that the northern portion of the truss was modified in order to create the mezzanine floor over that portion of the building. These alterations are likely to have occurred prior to 1965.

A Code Compliance Certificate was issued in June 1996.

In 2004 further alterations were proposed to be carried out to the building at both ground level and to the first level. The building was converted into a two-storey bar, with a pool hall occupying the single storey building. The structural work was designed by Lewis and Barrow Ltd.

The documentation prepared in 2004 included strengthening of the trusses along the southern side of the building and modification of the roof bracing to the two storey building. Although Holmes Consulting Group's plans referred to removal of the mezzanine, this work is also included in Lewis & Barrows plans indicating that it did not take place in 1993.

Compliance

Building Consent (9306593) was submitted to the Christchurch City Council for the restaurant fit-out in June 1993. The Christchurch City Council issued a Code Compliance Certificate for this work on the 5th June, 2005.

Building Consent (ABA10047885) was submitted to the Christchurch City Council for the bar fit-out in August, 2004. The Christchurch City Council issued a Code Compliance Certificate for this work on the 17th March, 2005.

A Building Consent was applied for on 22nd November, 2010 for an addition of a new structural floor and roof braces. This application was recorded by the Christchurch City Council as being placed on hold soon after the application.

As the above consents appear to be in order and the building was constructed prior to the introduction of the Building Act 1991, the building is expected to have complied with the requirements of the Building Act.

Christchurch City Council Policy on Earthquake Prone Buildings

We understand that the Christchurch City Council applied for and was granted powers under Section 301A of the Municipal Corporation Act and the Christchurch City Council generally adopted a passive approach to the upgrading of earthquake risk buildings.

There appear to be no records of any communication between the Christchurch City Council and the building owners with respect to any Seismic Risk Building-Survey or Hazardous Appendage-Survey.

The Christchurch City Council records contain documentation for the alteration and seismic upgrade carried out in 1993 designed by Holmes Consulting Group. The strengthening was designed to 2/3rds of the requirements of NZS4203:1984.

Further alterations in 2004 were recorded by the Christchurch City Council. These were designed by Lewis and Barrow Limited. This work was designed to the same seismic coefficient as the 1993 alterations, and included modification and strengthening of the trusses and their connections to the perimeter brick walls.

The Christchurch City Council's first policy in respect of earthquake-prone, dangerous and insanitary buildings policy was introduced in 2006.

This policy was reviewed in early 2010.

Events Subsequent to September 2010 Earthquake

The building appears to have performed adequately in the 4th September, 2010 earthquake without significant damage. An inspection was made by Holmes Consulting Group on the 8th September, 2010 which recorded "minor cracking to skim coat on exterior - minor cracking to pointing along south wall. No other visible damage." The assessment is likely to have been undertaken for the Iconic Bar and assigned the building a green placard. The Christchurch City Council have subsequently advised that this assessment may not have been received by the Christchurch City Council until the 18th or 19th October, 2010.

A further Rapid Assessment-Level 1 was undertaken on the 10th September, 2010 which noted cracking to parapets, assigned the building a green placard and recommended a detailed structural assessment. There is no record of a further structural assessment. There is a Christchurch City Council enforcement team operation notice advising that the building had been assigned a red placard and confirming that a s124(1) (c) notice had been fixed to the building on the 28th October, 2010. Christchurch City Council have subsequently indicated that this may have been an error.

The building is recorded as having suffered damage in the 26th December, 2010 earthquake. A Rapid assessment-Level 2 was undertaken on the 26th December, 2010. The front sheet of the rapid assessment records that the east gable was badly damaged while the second sheet refers to the west wall being badly damaged. The Rapid Assessment-Level 2 assigned a red placard and recommended a detailed structural assessment. The rapid assessment did not require barriers to be erected. The Christchurch City Council wrote to the owner and declared the building unsafe on 27th December, 2010. There is a further Rapid Assessment-Level 1 undertaken on the 27th

December, 2010 which refers to "stress fractures in plastered brick walls-upper areas mainly above where roof trusses connect-parapets".

The rapid assessment assigned a red placard and referred to barriers in place. A USAR assessment of the 27th December, 2010 assessed damage to the building as severe.

Lewis and Barrow assessed the damage and directed securing works immediately following the earthquake. In an email from Chris Gordon of Lewis and Barrow to CD Rescue dated 30th December, 2010, Mr Gordon refers to the building being red stickered after the 26th December, 2010 earthquake due to damage to the east wall. Mr Gordon then comments that further investigation revealed damage to the gable end wall.

The Lewis and Barrow's report of 28th December, 2010 advises that the building was visually inspected within the roof space. "The brick wall from the ceiling to roof level to the east wall had bowed out by 50 to 100mm. The parapet above roof level had collapsed at the apex." Instructions were given to remove all collapsed bricks at the apex parapet area, to provide 20mm H5 plywood to the outside face of the east wall from truss bottom chord level to the top of parapet and to fix with existing bolts and washers at roof level. M16 bolts at 400 centres were to be provided into the truss bottom chord with 100 x 100 washers to brick and timber. Solid blocking was to be placed between the brickwork and truss. 150mm x 45mm joists at 450 centres were to be provided between the truss bottom chords to the east end trusses and a 12mm plywood lining was to be placed over these joists to prevent any falling brick coming through the suspended ceiling. This was assessed by Lewis & Barrow as adequate temporary support to make the building safe for normal use.

The report commented that the brick wall above the truss bottom chord level would be required to be removed and re-built with suitable structure for long term support.

The building was re-inspected by Lewis & Barrow on 29th December, 2010 when the work had been completed. Further instructions were issued to "Provide 100 x 75 x 8mm MSL vertic..... to outside face of wall on top of plywood fixed to existing bolts to rafters at top".

The site reports of the 28th and 29th December, 2010 appear to only refer to the repair of the east wall. A request to remove the red sticker was made by Chris Gordon of Lewis & Barrow on the 30th December, 2010. As Christopher Gordon was not a Chartered Professional Engineer, a subsequent statement by Simon Gifford of Lewis and Barrow was made to the Christchurch City Council in order for the red sticker to be uplifted.

Christchurch City Council Engineers Re-inspection of Damaged Buildings form records an inspection of the building on the 9th February, 2011. The re-inspection form notes " Recommend contacting the eng for a confirmation of the works as lateral load capacity may not exist. Also get comments on the cracking (likely just in the paint)"

It also required protective fencing to rear corner parapet on Gloucester Street. The Christchurch City Council did not appear to have followed up on this re-inspection concern.

Significant damage occurred to the unreinforced masonry walls in the 22nd February, 2011 earthquake. This damage occurred largely above first floor of the building. The external walls above first floor level along the Manchester Street and Gloucester Street frontages fell outward onto the street leaving the roof largely unsupported along the external walls. There were also un-

reinforced masonry failures to the east and south walls. The building was red stickered after the 22nd February, 2011 earthquake and has subsequently been demolished.

Structural Failure

The external walls above first floor level to the Manchester Street (West) and Gloucester Street (North) facades fell outward under the severity of shaking that occurred during the 22nd February, 2011 earthquake. It is unclear from the photos of the extent of damage to or failure of the east wall. The north, and west walls appear to have disintegrated under the severity of shaking leaving the epoxy fixings projecting from the steelwork at roof level. This failure mechanism varies from that of the section of south wall alongside the ladies toilet which appears to have slipped off its supports largely intact. The east wall appears to have collapsed through the roof of the single storey building.

The code lateral load coefficient for a façade to an elastic responding two storey structure in Christchurch at the time of the earthquake sequence was 0.86g. The analysis of un-reinforced masonry construction is not covered in the NZ Building Code. The industry uses the New Zealand Society for Earthquake Engineering guidelines 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes' 2000, and Assessment and Improvements of Un-reinforced Masonry Buildings for Earthquake Resistance' 2011. Calculations using these documents indicated that a sound 225mm thick un-reinforced masonry wall spanning 3m from first floor level to roof level and effectively restrained at roof level would meet code requirements. The building was strengthened to a lateral load coefficient of 0.42g. Based on GNS Science records of measurements of accelerations in the Christchurch CBD during the 22nd February, 2011 earthquake, the building was likely to have been subjected to a ground accelerations of 0.9g. This level of ground acceleration equates to an acceleration of 1.25g at first floor level. The analysis assumes no vertical acceleration occurs when the wall is subjected to the horizontal acceleration. It is known that significant vertical acceleration occurred during the 22nd February, 2011 earthquake. The street façade also had significant penetrations that affect both the weight and strength of the façade. The above figures demonstrate that the earthquake shaking experienced during the 22nd February, 2011 earthquake was significantly higher than the design load. Failure to the exterior façade under the severity of shaking that occurred on the 22nd February, 2011 was to be expected.

The 100 x 100 x 6 MS angle spanning between the trusses or the horizontal 100 x 100 RHS bracing around the perimeter of the roof space was insufficiently stiff to develop the tensile strength of the anchors. A progressive failure of the anchors, commencing at the connection of the chords of the bracing elements and migrating towards the centre span of the angles would be expected under face loading of the wall. Examination of the photos taken after the 22nd February, 2011 earthquake indicates that this mode of failure was evident along the south wall. The mode of failure does not appear evident to the north or west walls. Significantly, the steel angle to the north and west walls is still relatively straight with the connecting bolts left exposed in the angle.

From the photographic evidence available it would appear that the north and west walls (apart from the section of wall by the ladies toilet) essentially disintegrated under the severity of shaking on the 22nd February, 2011, leaving the fixings exposed in the angle without the distortion of the angle.

Issues arising from Review

Repairs undertaken following the 26th December, 2010 earthquake.
The Rapid Assessment-Level 2 undertaken on the 26th December, 2010 identified on the front sheet, the east gable wall badly damaged and on the second sheet, the west wall damaged, especially apex, loose bricks could fall in or outwards. Under heavy damage the Rapid Assessment-Level 2 referred to west wall damage.

The Christchurch City Council notice under Section 124(1)(c) of the Building Act 2004 refers only to the east gable wall. Christchurch City Council have subsequently advised that their officers omitted to review the second page of the assessment form when issuing the Section 124 Building Act notice.

It is uncertain from information supplied by Lewis & Barrow as to whether any work was undertaken on the west wall. There is concern that a lack of thoroughness in filling out the rapid assessment forms, and in particular, the failure to fill out the sketch on the third page of the rapid assessment, noted in the assessment form as optional, has resulted in the damage identified by the assessor of the Rapid Assessment-Level 2 not being addressed. It is equally possible that the assessor confused the east and west walls while filling in the form.

We also note that a Christchurch City Council Engineers Re-inspection of Damaged Buildings form filled out on the 9th February, 2011 noted "Loss of bricks on rear wall – stabilised for the moment with plywood" and commented "Engineer has apparently reviewed the requirements for stabilising the rear wall in which 6 bricks fell from the apex. Recommend contacting the engineer for a confirmation of the works as lateral load capacity may not exist. Also get comments on the cracking (likely just in the paint)."

We understand that the apparent concerns raised by the re-inspection were not followed up on by the Christchurch City Council. The form also notes protective fencing required to the rear corner parapet on Gloucester Street. The Christchurch City Council have subsequently advised that this inspection was made in error, because, although the building had been previously issued with a Building Act notice, the necessary remedial works had been completed and the red sticker removed at the time of the inspection.

The re-inspection still raises concerns over the ability of the building to withstand a moderate aftershock.

Performance of strengthened building
A significant aspect of the earthquake damage to the building is the failure of the street facades above first floor level in the 22nd February, 2011 earthquake.

The performance of the building under the earthquakes on the 4th September, 2010 and 26th December, 2010 demonstrate that the strengthening work reduced damage levels and achieved an acceptable performance in moderate earthquake shaking. The substantial damage that occurred in the 22nd February, 2011 earthquake demonstrated the vulnerability of these buildings to severe earthquake shaking.

GNS Science record that the displacements, velocities and accelerations imposed by the 22nd February, 2011 earthquake significantly exceed the requirements of 67% NZS 4203. Given the brittle nature of the un-reinforced masonry walls, the failure that occurred was probably inevitable under the severity of shaking that occurred on 22nd February, 2011.

While strengthening of un-reinforced masonry buildings to 2/3 of the requirements of NZS 4203 is expected to significantly improve the performance of those buildings in a moderate earthquake, these buildings will remain vulnerable to severe earthquake shaking.

Vertical acceleration effects

It is likely that the significant vertical accelerations that occurred in the 22nd February, 2011 earthquake contributed to the failure of the un-reinforced masonry elements. It is suggested that good practice include consideration of vertical acceleration effects on un-reinforced masonry walls, particularly in the upper level of un-reinforced masonry buildings. Vertical acceleration effects can significantly alter the out of plane strength of un-reinforced masonry walls.

Criteria for occupancy

The criteria for occupancy of un-reinforced masonry buildings after a damaging earthquake requires further consideration. It is particularly important that engineers have a clear brief when assessing the condition of un-reinforced masonry buildings damaged in earthquake. It is suggested that the controlling authority should nominate minimum strength levels that engineers assess un-reinforced masonry buildings to, prior to occupancy or public access within the fall zone of facades.

Epoxy Fixings

The photos in the Police Operation Earthquake records clearly show that the dowels that connected the perimeter 100x100x6 MSL along the Manchester Street and Gloucester Street frontages to the brick façade were left projecting from the 100x100x6 MSL. Noticeably, the steel angle is relatively straight and the majority of dowels do not have any masonry attached, but the epoxy surrounding the dowels is clearly evident.

Note: Several dowels closest to the corner of the building do have masonry attached. (Refer photos Appendix 4)

The separation of the epoxied dowels from the un-reinforced masonry wall appears to have occurred with minimal distress to the 100x100x6 MSL at roof level indicating that the fixings either had a low strength or that the wall effectively disintegrated under the severity of shaking. Unfortunately the Police photos were taken after the debris from the failed wall had been removed, so that the integrity of the failed wall, and therefore the failure mechanism cannot be reliably established. It is appropriate to record that the axial load in the upper floor un-reinforced masonry walls is relatively low and that these walls are more susceptible to vertical acceleration effects under out of plane failure.

It is possible that workmanship may have been a factor in the failure of the connection between the external walls and the strengthening works. Workmanship is an important aspect in the use of epoxy based fasteners. The Ramset technical information on Epoxy Chemset fasteners requires the holes to be cleaned with a hole cleaning brush and to remove all debris using a hole blower. The hole may be damp but no water present. The installation criteria are for the epoxy mortar to be between 15 to 30 degrees Celsius and the substrate to be between 0 to 43 degrees Celsius. The installation of Epcon anchors is even more restrictive requiring installation temperatures of the mortar to be between 18 to 35 degrees Celsius and the substrate to be between 5 to 40 degrees Celsius. (Refer Ramset Technical Data sheets Appendix 5).

If the Chemset epoxy was not placed in accordance with the manufacturers installation requirements, workmanship may have contributed to the failure of the north and west walls.

Heightened industry awareness of the importance of workmanship and temperature in the use of epoxy fixing systems is suggested and increased construction monitoring or proof testing for quality assurance of these fixings seems justified.

Research

The extent of un-reinforced masonry buildings that exist throughout New Zealand justify further research into economic methods of improving the earthquake performance of these buildings.

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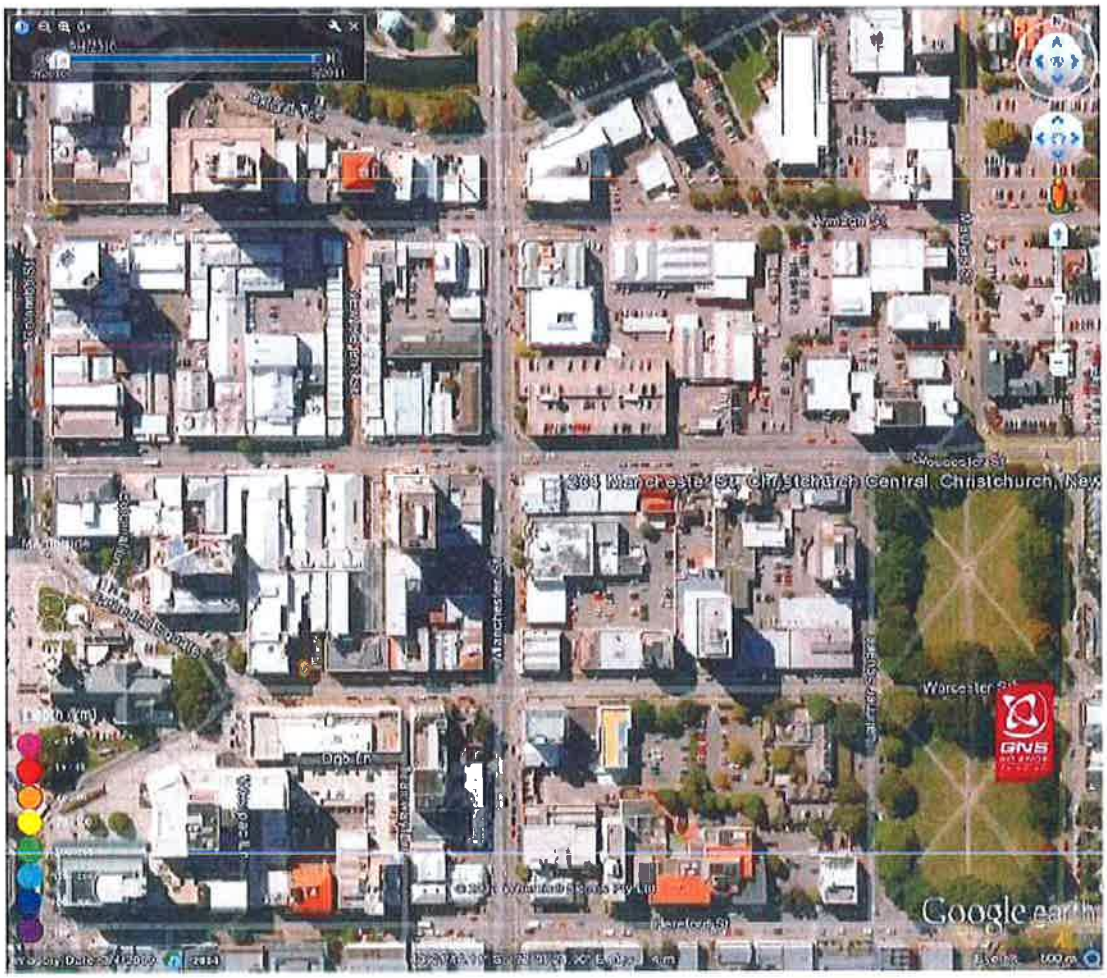
Director

G:\110604 – 204 Manchester St Iconic Bar – DEC '11

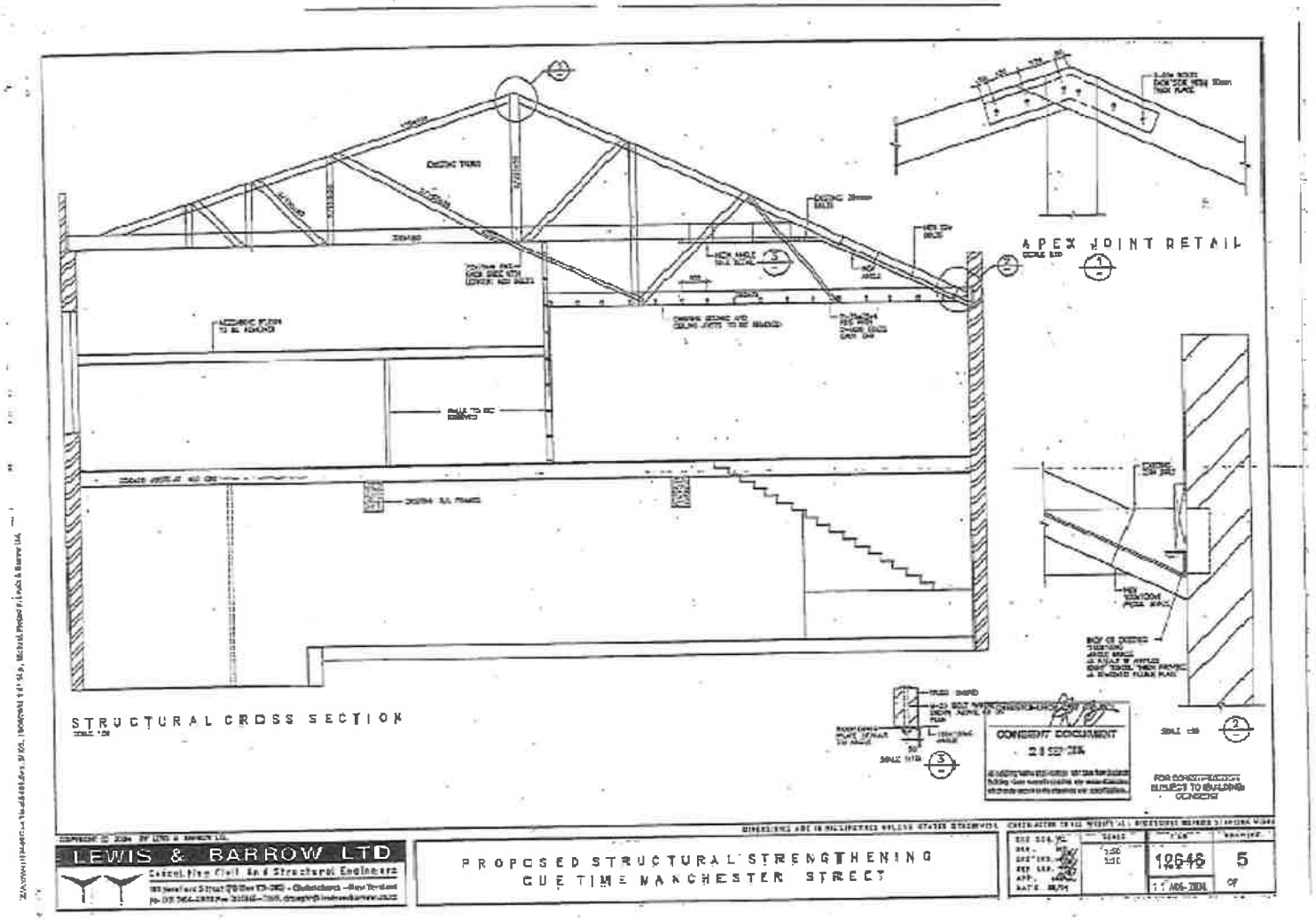
APPENDIX 1:

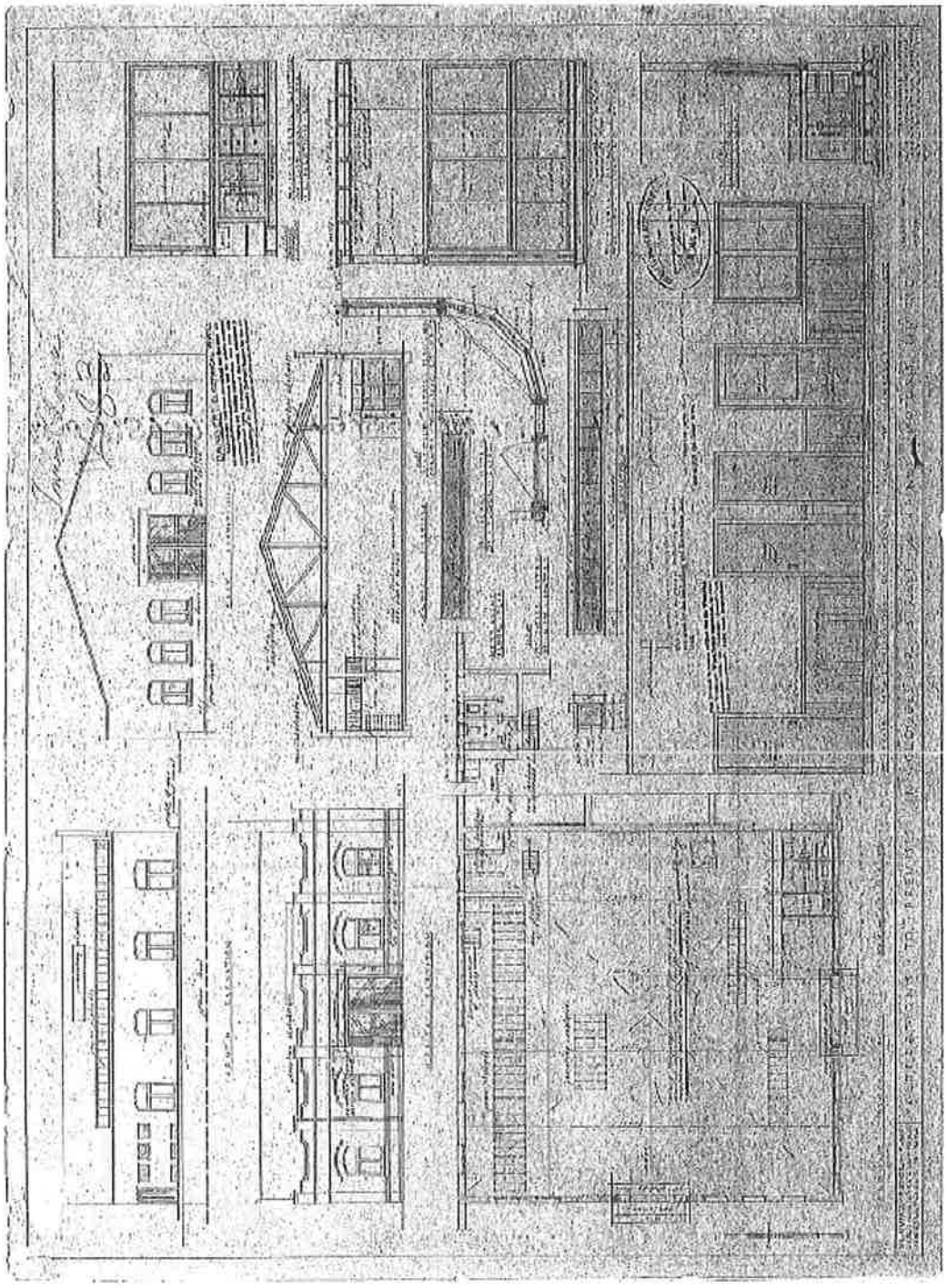
- **Location of building in Christchurch CBD.**
- **Location of Earthquake Epicentres of 4 September 2010 and 22nd February 2011 relative to Building at 204 Manchester Street Christchurch**

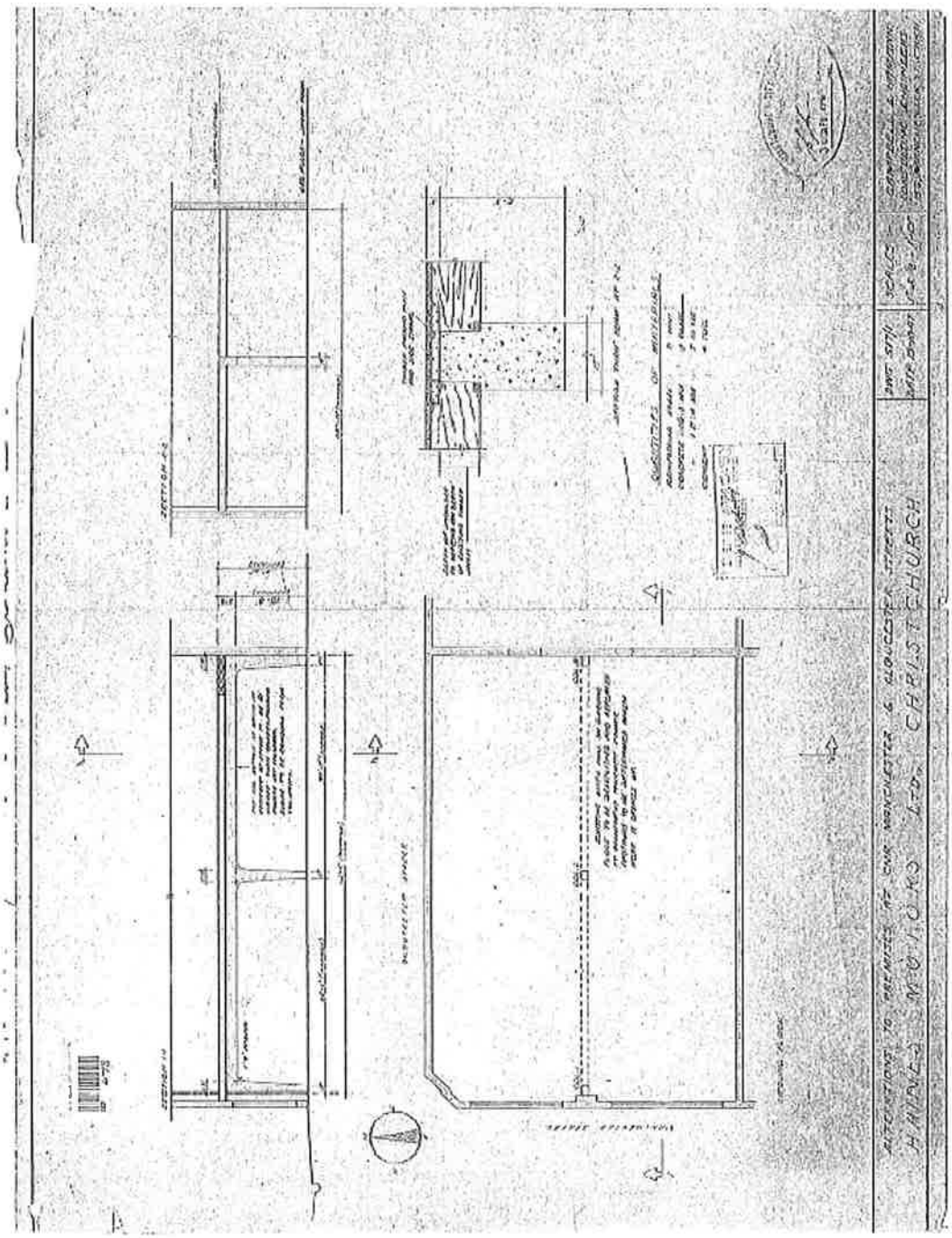

Manchester St
Worcester St
Google earth

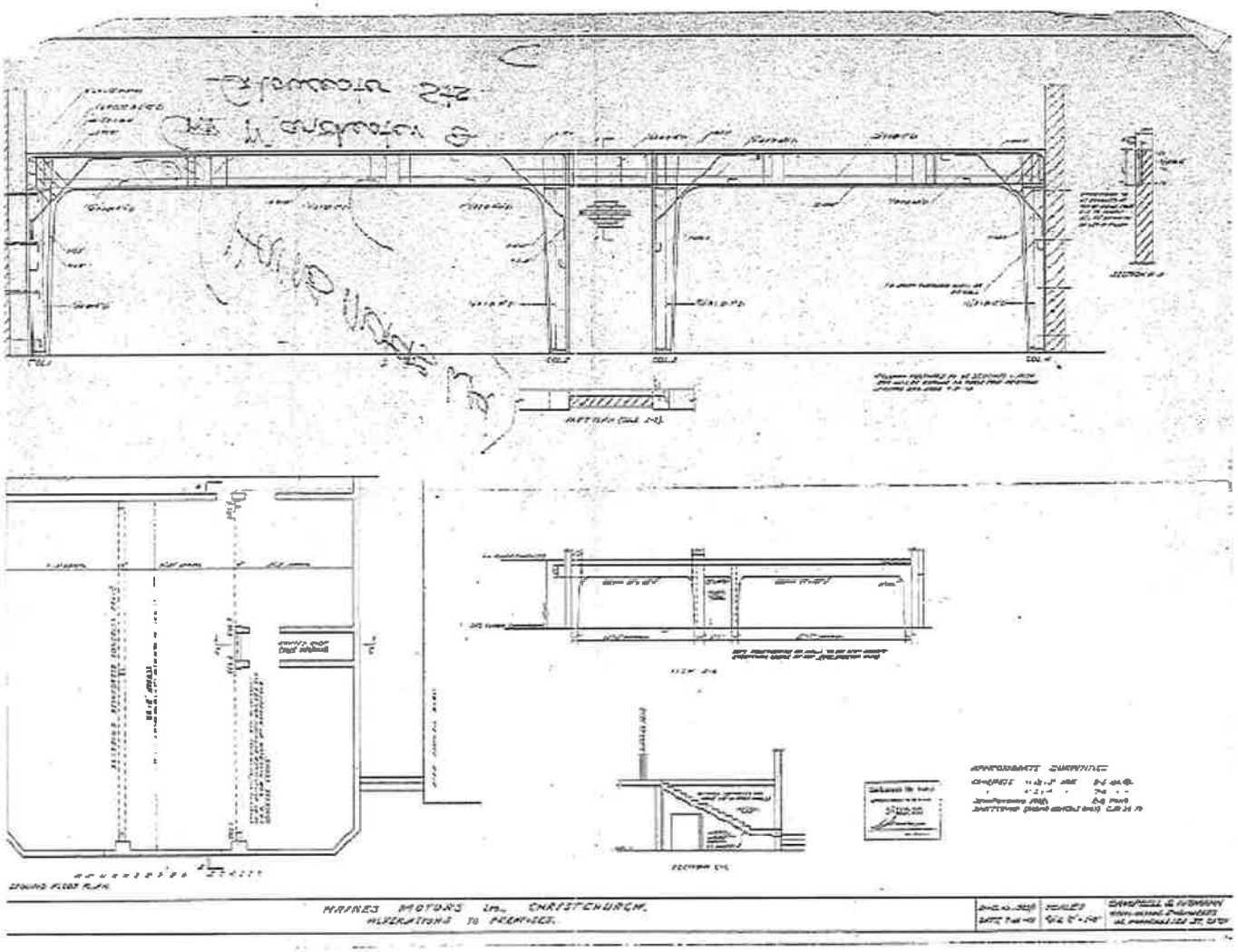
APPENDIX 2:

Record Drawings for Buildings


APEX JOINT RETAIL
STRUCTURAL CROSS SECTION
CONSENT DOCUMENT
LEWIS & BARROW LTD
Consulting Civil and Structural Engineers
PROPOSED STRUCTURAL STRENGTHENING
CUE TIME MANCHESTER STREET
12646
5



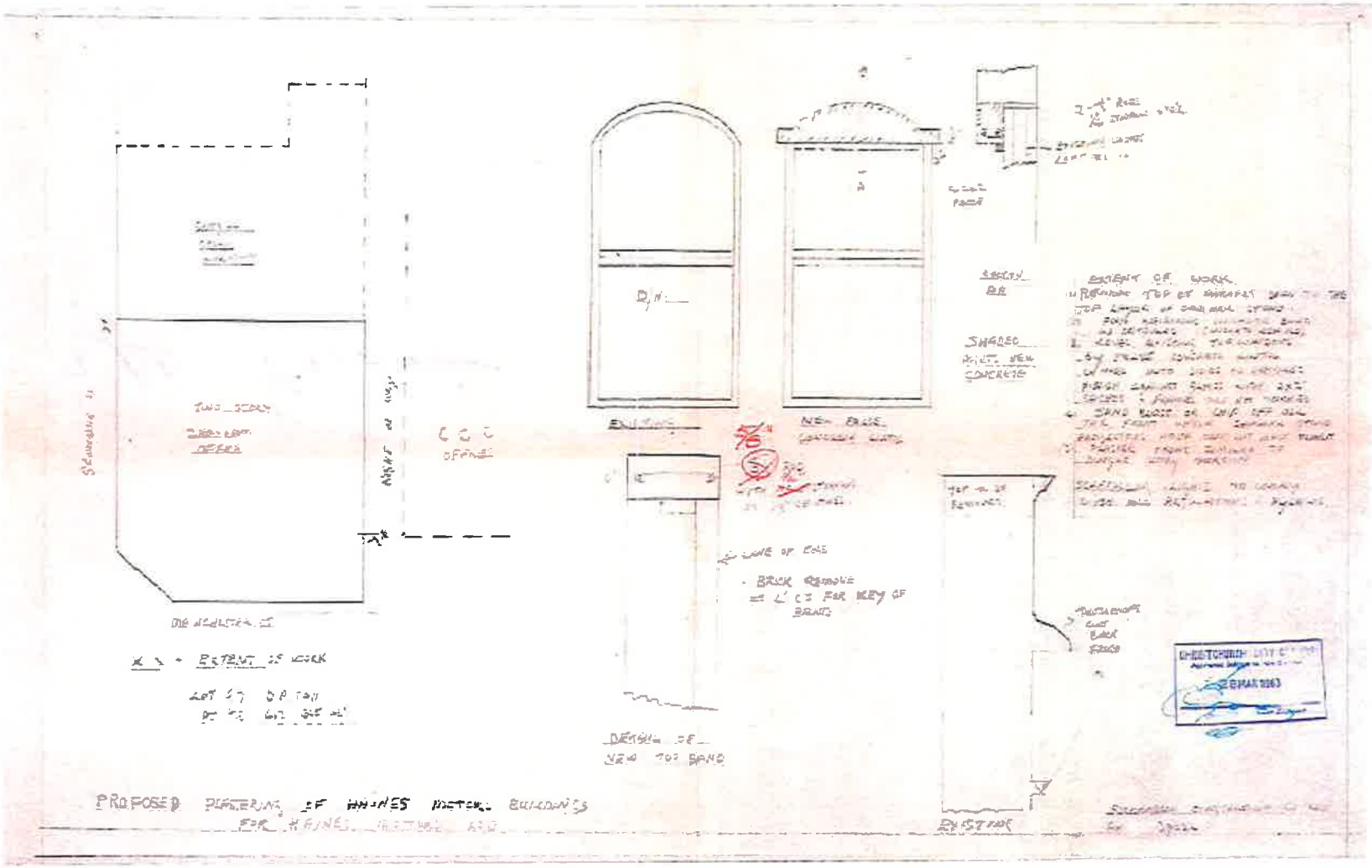



MARINES MOTORS Ltd. CHRISTCHURCH.
ALTERATIONS TO PREMISES.

APPENDIX 3:

Richardson Construction Co Ltd

- **Proposed Plastering of Haines Motors Buildings (dated Christchurch City Council Approved 28 March 1963)**


EXTENT OF WORK
SHADED
NEW BRICK
DESIGN OF
NEW TOY BOND
PROPOSED PAINTING OF WINDOWS
EXISTING

APPENDIX 4:

Photos Taken for 22nd February, 2011 Earthquake

APPENDIX 5:

Ramset Technical Data Sheets
- Chemical Anchoring

Ramset™

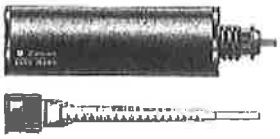
Chemical Anchoring

Epcon™ C6 Series

General Information

Product

Epcon C6 Series are a chemical anchor system based on epoxy mortar. The two parts are dispensed and mixed in one action through a static mixing nozzle, which allows accurate mixing with no mess.



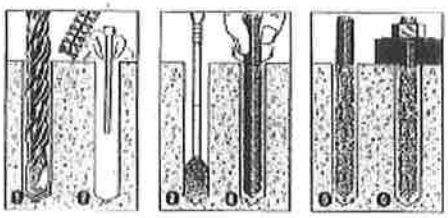
Features

- Superior strength in shallow embedment.
- Close to edge, stress free anchoring.
- Suitable for use with zinc plated, hot dipped galvanized or stainless steel Chemset Anchor Studs.
- Resistant to cyclic loading and vibration.
- Resistant to alkaline conditions.
- Suitable for use in core drilled holes.
- Superior strength with grade 5.8 steel Chemset Anchor Studs.
- Suitable for underwater installations.

Principal Application

- Structural beams and columns.
- Bottom plate and bolted fixing.
- Installing slings, handrails, balustrades and gates.
- Racking.
- Safety barriers.
- Stadium seating.
- Machinery and heavy plant hold down.

Installation



1. Drill recommended diameter and depth hole.
2. Clean hole with hole cleaning brush. Remove all debris using hole blower. Hole must be dry.
3. Insert mixing nozzle to bottom of hole. Fill hole to ¾ the hole depth slowly, ensuring no air pockets form.
4. Insert Ramset Chemset Anchor Stud/rebar to bottom of hole while turning.
5. Epcon to cure as per setting times.
6. Attach fixture.

Installation temperature limits:
Substrate: 5°C to 40°C.
Mortar: 18°C to 35°C

Load should not be applied to anchor until the chemical has sufficiently cured as specified.

Setting Times

Substrate Temperature	C6 Gel Time (mins)	C6 Loading Time (hrs)
40°C	–	–
30°C	4.5	1
25°C	5.5	1
20°C	7	1
10°C	20	2
5°C	40	3

Note: Cartridge temperature minimum 15°C.

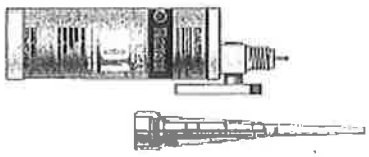
Ramset™ Chemical Anchoring

Chemset™ Injection 100 Series

General Information

Product

Chemset Injection 100 Series is a chemical anchor system based on polyester mortar. The two parts are dispensed and mixed in one action through a static mixing nozzle, which allows accurate mixing with no mess.



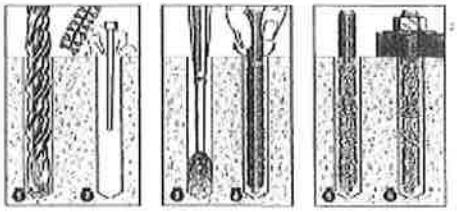
Features

- Close to edge, stress free anchoring.
- Close anchor spacing.
- Suitable for use with zinc plated, hot dipped galvanized or stainless steel Chemset Anchor Studs and Injection Rod
- Resistant to cyclic loading.
- Overhead installation.
- Fast cure.

Principal Application

- Structural beams and columns.
- Batten fixing.
- Installing signs, handrails, balustrades and gates.
- Racking.
- Safety barriers.
- Machinery hold down.

Installation



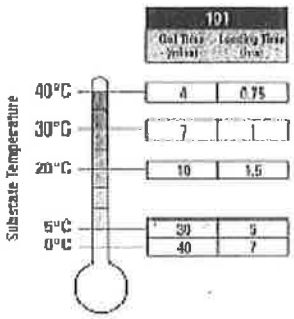
1. Drill recommended diameter and depth hole.
2. Clean hole with hole cleaning brush. Remove all debris using hole blower. Hole may be damp but no water present.
3. Insert mixing nozzle to bottom of hole. Fill hole to ¾ the hole depth slowly, ensuring no air pockets form.
4. Insert Ramset Chemset Anchor Stud/rebar to bottom of hole while turning.
5. Chemset Injection to cure as per setting times.
6. Attach fixture.

Installation temperature limits:
Substrate: 0°C to 43°C.
Mortar: 15°C to 35°C

Load should not be applied to anchor until the chemical has sufficiently cured as specified in the following diagrams.

Service temperature limits:
-10°C to 80°C.

Setting Times



Note: Cartridge temperature minimum 15°C.