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Waimairi Community Centre
BU 0259-001 EQ2

Detailed Engineering Evaluation
Quantitative Report
Version FINAL

166 Waimairi Road, Christchurch

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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Quantitative Report
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166 Waimairi Road, Christchurch

Christchurch City Council

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Date
31/10/12

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Waimairi Community Centre

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Detailed Engineering Evaluation

Quantitative Report - SUMMARY

Version FINAL

166 Waimairi Road, Christchurch

Background

This is a summary of the Quantitative report for the building structure, and is based in general on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011, visual inspections conducted on 30th April and 4th May 2012 and on the available drawings.

Key Damage Observed

Overall, the building shows no severe damage due to the recent earthquake except for the following items:

- Minor cracks to internal wall linings as can be seen in Photograph 7 and 8, Appendix B of this report.
- Minor cracks to the perimeter strip footing at several locations around the building. This can be seen on Photograph 9, Appendix B of this report.
- Minor cracks to the external brick veneer as can be seen in Photograph 10, Appendix B of this report.

Building Capacity Assessment

Based on the quantitative assessment done for the structure, the overall building capacity achieved score of 39% NBS which occur in the "Along" direction. Table 5 of Section 9 shows the itemised wall element that falls below the 67% NBS benchmark.

Define below are the individual %NBS achieved for each of the structural element consider.

Timber Framed Walls

Wind

- All timber framed walls achieved over 100% NBS in both directions.

Seismic

- There are three wall bracing elements that fall below 67%NBS. All of which is at the “Along” direction. The most critical bracing element achieved a 51% NBS.
- Walls in the “Along” direction is 39% NBS while in the “across” direction, a 79% NBS is achieved.

Timber Framed Sub-floor

Wind

- All timber framed sub-floor achieved over 100% NBS in both directions.

Seismic

- All timber framed sub-floor achieved over 100% NBS in both directions.

Recommendations

GHD recommends that:

- Develop a scheme for strengthening the structure up to 100% NBS or to at least 67% NBS for all wall bracing elements particularly those that are listed in Table 5.
- Retain the green placard in place until such time that this recommendation have been satisfied.

1. Background

GHD has been engaged by Christchurch City Council (CCC) to undertake a detailed engineering evaluation of Waimairi Community Centre.

This report is a Quantitative Assessment of the building structure, and is based in general on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011.

A quantitative assessment involves analysis and checking of all structural members that forms part of the structure that contributes in resisting of horizontal and vertical forces that are subjected to it. Furthermore, it is also used to evaluate the existing conditions of the structure with respect to our prevailing industry codes and standards.

The main purpose of this procedure is to assess how the structure will respond upon application of external forces and to what extend will the damage may be with respect to its existing condition. Evaluating the capacity of the structure versus the applied loads, we can determine the structure's rating in terms of percentage of New Building Standards (%NBS) as per NZSEE requirements.

2. Compliance

This section contains a brief summary of the requirements of the various statutes and authorities that control activities in relation to buildings in Christchurch at present.

2.1 Canterbury Earthquake Recovery Authority (CERA)

CERA was established on 28 March 2011 to take control of the recovery of Christchurch using powers established by the Canterbury Earthquake Recovery Act enacted on 18 April 2011. This act gives the Chief Executive Officer of CERA wide powers in relation to building safety, demolition and repair. Two relevant sections are:

Section 38 – Works

This section outlines a process in which the chief executive can give notice that a building is to be demolished and if the owner does not carry out the demolition, the chief executive can commission the demolition and recover the costs from the owner or by placing a charge on the owners' land.

Section 51 – Requiring Structural Survey

This section enables the chief executive to require a building owner, insurer or mortgagee carry out a full structural survey before the building is re-occupied.

We understand that CERA will require a detailed engineering evaluation to be carried out for all buildings (other than those exempt from the Earthquake Prone Building definition in the Building Act). It is anticipated that CERA will adopt the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011. This document sets out a methodology for both qualitative and quantitative assessments.

The qualitative assessment is a desk-top and site inspection assessment. It is based on a thorough visual inspection of the building coupled with a review of available documentation such as drawings and specifications. The quantitative assessment involves analytical calculation of the buildings strength and may require non-destructive or destructive material testing, geotechnical testing and intrusive investigation.

It is anticipated that factors determining the extent of evaluation and strengthening level required will include:

- The importance level and occupancy of the building
- The placard status and amount of damage
- The age and structural type of the building
- Consideration of any critical structural weaknesses
- The extent of any earthquake damage

2.2 Building Act

Several sections of the Building Act are relevant when considering structural requirements:

Section 112 – Alterations

This section requires that an existing building complies with the relevant sections of the Building Code to at least the extent that it did prior to any alteration. This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council (CCC)) be satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'. Regarding seismic capacity 'as near as reasonably practicable' has previously been interpreted by CCC as achieving a minimum of 67% NBS however where practical achieving 100% NBS is desirable. The New Zealand Society for Earthquake Engineering (NZSEE) recommend a minimum of 67% NBS.

2.2.1 Section 121 – Dangerous Buildings

The definition of dangerous building in the Act was extended by the Canterbury Earthquake (Building Act) Order 2010, and it now defines a building as dangerous if:

- In the ordinary course of events (excluding the occurrence of an earthquake), the building is likely to cause injury or death or damage to other property; or
- In the event of fire, injury or death to any persons in the building or on other property is likely because of fire hazard or the occupancy of the building; or
- There is a risk that the building could collapse or otherwise cause injury or death as a result of earthquake shaking that is less than a 'moderate earthquake' (refer to Section 122 below); or
- There is a risk that that other property could collapse or otherwise cause injury or death; or
- A territorial authority has not been able to undertake an inspection to determine whether the building is dangerous.

Section 122 – Earthquake Prone Buildings

This section defines a building as earthquake prone if its ultimate capacity would be exceeded in a 'moderate earthquake' and it would be likely to collapse causing injury or death, or damage to other property. A moderate earthquake is defined by the building regulations as one that would generate ground shaking 33% of the shaking used to design an equivalent new building.

Section 124 – Powers of Territorial Authorities

This section gives the territorial authority the power to require strengthening work within specified timeframes or to close and prevent occupancy to any building defined as dangerous or earthquake prone.

Section 131 – Earthquake Prone Building Policy

This section requires the territorial authority to adopt a specific policy for earthquake prone, dangerous and insanitary buildings.

2.3 Christchurch City Council Policy

Christchurch City Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in 2006. This policy was amended immediately following the Darfield Earthquake of the 4th September 2010.

The 2010 amendment includes the following:

- A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
- A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
- A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
- Repair works for buildings damaged by earthquakes will be required to comply with the above.

The council has stated their willingness to consider retrofit proposals on a case by case basis, considering the economic impact of such a retrofit.

We anticipate that any building with a capacity of less than 33% NBS (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67% NBS of new building standard as recommended by the Policy.

If strengthening works are undertaken, a building consent will be required. A requirement of the consent will require upgrade of the building to comply 'as near as is reasonably practicable' with:

- The accessibility requirements of the Building Code.
- The fire requirements of the Building Code. This is likely to require a fire report to be submitted with the building consent application.

2.4 Building Code

The building code outlines performance standards for buildings and the Building Act requires that all new buildings comply with this code. Compliance Documents published by The Department of Building and Housing can be used to demonstrate compliance with the Building Code.

After the February Earthquake, on 19 May 2011, Compliance Document B1: Structure was amended to include increased seismic design requirements for Canterbury as follows:

- Hazard Factor increased from 0.22 to 0.3 (36% increase in the basic seismic design load)
- Serviceability Return Period Factor increased from 0.25 to 0.33 (80% increase in the serviceability design loads when combined with the Hazard Factor increase)

The increase in the above factors has resulted in a reduction in the level of compliance of an existing building relative to a new building despite the capacity of the existing building not changing.

3. Earthquake Resistance Standards

For this assessment, the building's earthquake resistance is compared with the current New Zealand Building Code requirements for a new building constructed on the site. This is expressed as a percentage of new building standard (%NBS). The new building standard load requirements have been determined in accordance with the current earthquake loading standard (NZS 1170.5:2004 Structural design actions - Earthquake actions - New Zealand).

The likely capacity of this building has been derived in accordance with the New Zealand Society for Earthquake Engineering (NZSEE) guidelines 'Assessment and Improvement of the Structural Performance of Buildings in Earthquakes' (AISPBE), 2006. These guidelines provide an Initial Evaluation Procedure that assesses a buildings capacity based on a comparison of loading codes from when the building was designed and currently. It is a quick high-level procedure that can be used when undertaking a Qualitative analysis of a building. The guidelines also provide guidance on calculating a modified Ultimate Limit State capacity of the building which is much more accurate and can be used when undertaking a Quantitative analysis.

The New Zealand Society for Earthquake Engineering has proposed a way for classifying earthquake risk for existing buildings in terms of %NBS and this is shown in Figure 1 below.

Description	Grade	Risk	%NBS	Existing Building Structural Performance	Improvement of Structural Performance	
					Legal Requirement	NZSEE Recommendation
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)	The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34%NBS.	100%NBS desirable. Improvement should achieve at least 67%NBS
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended		Not recommended. Acceptable only in exceptional circumstances
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement	Unacceptable	Unacceptable

Figure 1 NZSEE Risk Classifications Extracted from Table 2.2 of the NZSEE 2006 AISPBE

Table 1 compares the percentage NBS to the relative risk of the building failing in a seismic event with a 10% risk of exceedance in 50 years (i.e. 0.2% in the next year). It is noted that the current seismic risk in Christchurch results in a 6% risk of exceedance in the next year.

7

Percentage of New Building Standard (%NBS)	Relative Risk (Approximate)
>100	<1 time
80-100	1-2 times
67-80	2-5 times
33-67	5-10 times
20-33	10-25 times
<20	>25 times

Table 1 %NBS compared to relative risk of failure

4. Building Description

4.1 General

The Waimairi community centre is a single storey timber framed structure located at 166 Waimairi road and is in the middle of a residential community. The centre stands in a flat area with no significant changes in ground level. The building is composed of three structures separately constructed one after the other.

The first structure is composed of a chapel, hall, supper room and men and women toilet. It has a building footprint of 16.0m x 16.0m and was constructed in 1968. Notable distinction of this first structure is that it has a two different roof level, one that is covering the hall area with a height of approx. 4.80m from the finish floor line and the other one is at approx. 2.50m which basically covers the rest of the structure. Two glulam timber portal frames are also present in the hall area that serves as support for the higher roof. The wall is made of timber framed panels that serves as a lateral resisting system of the building. Plasterboards are used as lining for interior walls while asbestos cement board are used for the exterior walls. A cladding of brick veneer atop of the cement board will be seen from the front and left sides of the building. The ceiling is composed of acoustic ceiling tiles fixed to timber battens that serves as roof diaphragms. The roof is composed of lightweight galvanised sheet metal on 200mm x 50mm timber purlin. The floor consists of 100mm x 25mm timber t&g planks. This timber floor slab is raised by 600mm above natural ground level and is supported by 200x200mm precast concrete piles on 375x375x150mm pad foundation. A 125mm reinforced concrete walls on 200mm foundation wall supports all exterior walls and the hall area's perimeter walls.

On 1979, the second structure was constructed at the back of the building that serves as a storage room for the chapel. The new structure has a dimension of 2.80m x 4.00m with the same roof height of the chapel. The roof is composed of lightweight galvanised sheet supported by 75mm x 50mm timber purlins. Wall framing system is the same as the chapel. The floor consists of 20mm thk custom wood planks on 100mm x 50mm timber joists spaced at 450mm.o.c. The floor is supported by 100x75mm concrete piles and the wall is supported by a continuous concrete wall footing.

Another extension was constructed on 1988 at the right side of the building. It has a dimension of 4.00m x 11.00m and matches the roof height of the chapel roof. The structure is composed of two rooms which also serve as storage room for the hall area. The wall and the flooring system of the structure are the same as of the existing storage room and supported by precast concrete piles.

Figure 2 shows the floor plan layout of the whole structure and complete information mentioned above is shown in Appendix C.

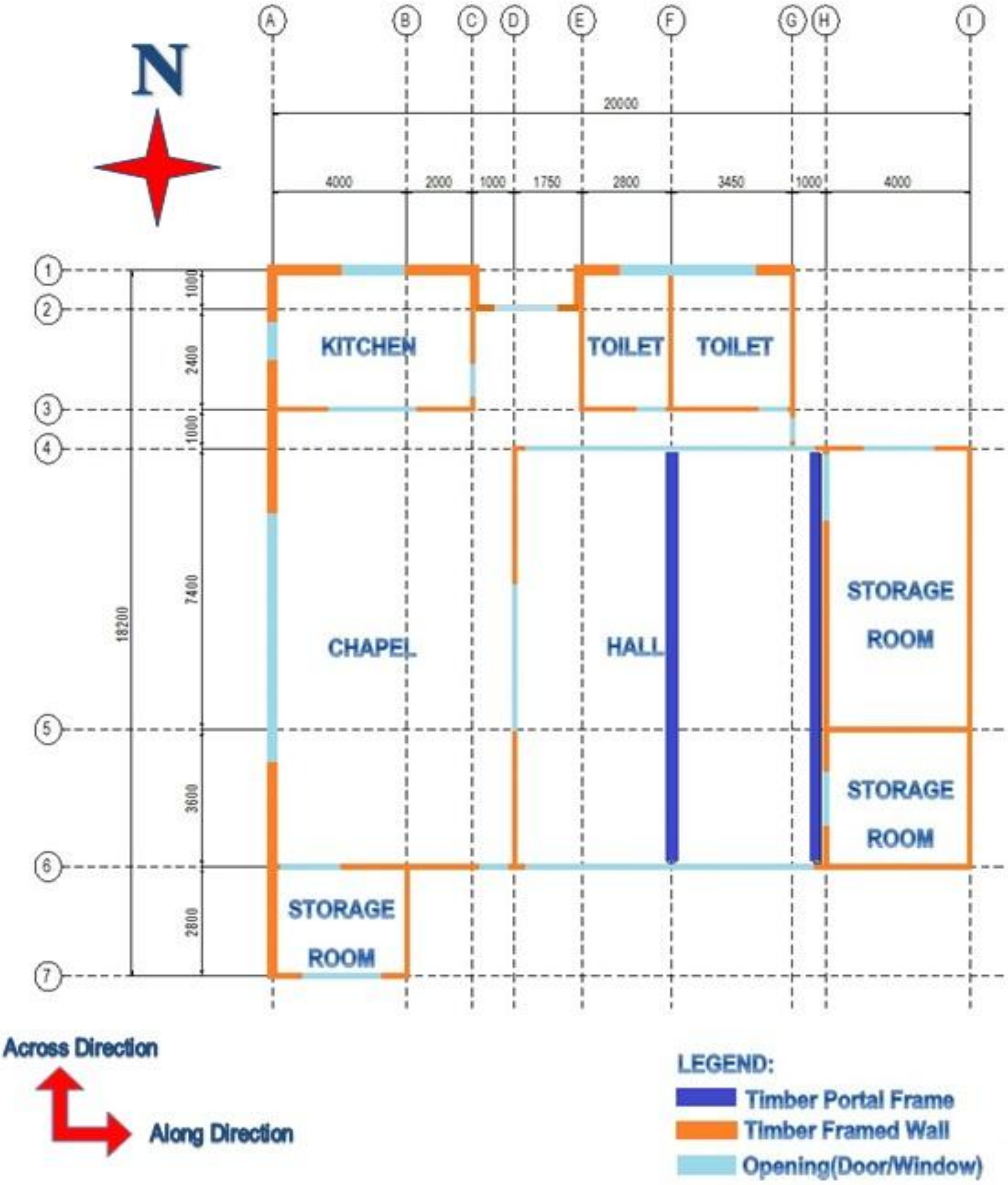


Figure 2 Floor Plan showing key structural elements

4.2 Gravity Load Resisting System

Gravity loads for this structure are resisted by glulam timber portal frames located at the hall area, along gridlines F and H (refer to Figure 2), and the timber framed walls which enclose the whole structure.

The roof structure of the building consists of galvanized iron sheet cladding supported by timber purlins on portal frame. These portal frames help the 100mm thick timber framed walls along gridline D and H to carry the gravity loads coming from the upper roof.

Gravity loads for the lower roof are carried by lightweight roof supported by timber framed walls.

Timber portal frames and timber framed walls transmit the gravity loads into the foundation by concrete pedestal and wall footing.

4.3 Lateral Load Resisting System

With thorough review and understanding of the available drawings and photographs taken, and with the aid of several site inspections, it was found out that the timber framed walls act as the lateral resisting system for the structure. This is even with the presence of those two glulam timber portal frame in the hall area. Several reasons are noted below on how this conclusion is made;

- The configuration and layout of the timber framed walls in the structure shows how they act together to resist lateral forces in both transverse and longitudinal directions. The 100mm thick timber framed walls are composed of plasterboard lining cladding on 100mm x 50mm studs (vertical member) spaced at 450mm o.c. and 125mm x 50mm dwangs (horizontal members) at 600mm o.c. See Figure 2 for base plan of the structure.
- There were no visible connections between the timber portal frames in the hall area along gridlines F and H and the timber framed wall along gridlines 4 and 6, thus no lateral resistance was assumed to be resisted by the timber portal frames.
- There are 50mm x 100mm diagonal timber roof bracing reflected in the drawings issued on 1968. This could be an additional lateral resistance for the structure but it was found during site inspection that the ceiling is directly attached to the underside of the purlins exposing the rafters of the timber portal frame without the roof bracing. Photograph 5 and 6 of Appendix B shows a partial view of the hall area.
- The 150mm x 25mm wall bracings were not considered as part of the lateral resistance for the structure since these were not verified on site. No opening up work done for this structure.

5. Assessment

5.1 Site Inspection

A visual inspection of the building was undertaken on the 30th of April 2012. A further inspection is conducted on 4th of May 2012. Both the interior and exterior of the building were inspected. The building was observed to have a green placard in place. No inspection of the foundations of the structure was carried out.

The inspection consisted of observing the building to determine the structural systems and likely behaviour of the building during an earthquake. The site was assessed for damage, including observing the ground conditions, checking for damage in areas where damage would be expected and noting general damage observed throughout the building in both for structural and non-structural elements.

Conduct random measurement of the structure, e.g. height of ceiling, length of walls, and the likes, just to verify the dimensions reflected on the available drawings.

A series of photograph was taken for the whole structure and its components for documentation and reference purposes. These are shown in Appendix B.

5.2 Investigation & Opening Up Work

No opening up work is done for this project.

5.3 Available Drawings

There are available existing drawings provided to GHD and are itemised below:

Item #	Title	Sheet No.	Date
1	Church Centre, Westburn, Christchurch for Presbyterian Church Drawings	1	Dec. 1968
2	Church Centre, Westburn, Christchurch for Presbyterian Church Drawings	2	Dec. 1968
3	Church Centre, Westburn, Christchurch for Presbyterian Church Drawings	3	Dec. 1968
4	Church Centre, Westburn, Christchurch for Presbyterian Church Drawings	4	Dec. 1968
5	New Storage Room for Avonhead Playcentre St Marks Presbyterian Church, Waimairi Road drawings	1	Dec. 1979
6	New Storage Room for Avonhead Playcentre St Marks Presbyterian Church, Waimairi Road drawings	2	Dec. 1979
7	Proposed Store Waimairi Road Community Centre Drawing	A/2	July 1988

5.4 Modelling

No software modelling was made for this structure.

5.5 Calculations

The seismic assessment of the structure is done only by using manual calculations and Excel spread sheets in reference to NZS3604:2011(New Zealand Standard for Timber-framed buildings).

The Total Bracing Demand, in Bracing Unit (BU), is determined for each direction (along and across) for both wind and seismic critical load combinations. The Total Bracing Demand was compared to the Total Bracing Capacity of the structure and %NBS was calculated accordingly.

Bracing demand and capacity ratio was also computed for each bracing line element.

A complete set of calculations is shown in Appendix D.

6. Damage Assessment

6.1 Surrounding Buildings

Waimairi Community Centre is located in a residential area with properties adjacent to the site. During the inspection, no damage to the surrounding buildings or adjoining properties was observed.

6.2 Residual Displacements and General Observations

No residual displacements of the structure were noted during the inspection of the building.

No damage was evident to the portal frames, beams and columns supporting the roof structure.

Minor cracking to the perimeter strip footing was observed, as seen in Photograph 9 in Appendix B.

Access to the sub-floor area of the structure was not evident.

Minor cracks were noted to the external brick veneer. These cracks can be seen in Photograph 10 in Appendix B.

Minor cracking to internal wall linings was noted.

6.3 Ground Damage

No ground damage was observed during the inspection of the site.

7. Analysis

7.1 Wind Parameters

The wind design parameters based on current design requirements from NZS1170.2:2011 and NZS 3604:2011:

Wind Region	:	A	(Fig. 5.1-NZS3604:2011)
Lee Zone	:	No	
Ground Roughness	:	Urban Terrain	
Site Exposure	:	Sheltered	
Topographic Class	:	T1	
Wind Zone	:	Low	

7.2 Seismic Parameters

The seismic design parameters used are based on current design requirements from NZS1170.5:2004, NZS 3604:2011:

Earthquake Zone	:	2
Site soil class	:	D (NZS 1170.5:2004, Clause 3.1.3, Soft Soil)
Applied floor live load	:	3.0 kPa

8. Geotechnical Consideration

The site is bordered by Waimairi Road to the west, with residential properties surrounding the carpark and green area. The site is predominantly flat at approximately 20m above mean sea level. The Waimairi Stream is approximately 500m to the northeast of the site, with the Avon River 700m to the southwest.

8.1 Published Information on Ground Conditions

8.1.1 Published Geology

The geological map of the area[1] indicates that the site is underlain by:

- Dominantly alluvial sand and silt overbank deposits, being Holocene soils of the Yaldhurst Member, sub-group of the Springston Formation.

8.1.2 Environment Canterbury Logs

Information from Environment Canterbury (ECan) indicates that two boreholes with lithographic logs are located within 200m of the site; however, both are less than 2m deep.

The logs indicate clay/silt to ~0.9m, underlain by gravel.

It should be noted the quality of soil logging descriptions included on the boreholes is unknown and were likely written by the well driller and not a geotechnical professional or to a recognised geotechnical standard. In addition strength data is not recorded.

8.1.3 EQC Geotechnical Investigations

The Earthquake Commission has not undertaken geotechnical testing in this area.

8.1.4 CERA Land Zoning

Canterbury Earthquake Recovery Authority (CERA) has zoned the site as Green, indicating repair and rebuild may take place.

CERA has published areas showing the Green Zone Technical Category in relation to the risk of future liquefaction and how these areas are expected to perform in future earthquakes.

The site is classified as Technical Category 1 (TC1) - future land damage from liquefaction is unlikely.

8.1.5 Post February Aerial Photography

Aerial photography taken following the 22 February 2011 earthquake (Figure 3) shows no signs of liquefaction outside the building footprint or adjacent to the site and the site inspection commented that there was no noticeable ground damage

[1] Brown, L. J. and Weeber J.H. 1992: *Geology of the Christchurch Urban Area*. Institute of Geological and Nuclear Sciences 1:25,000 Geological Map 1. Lower Hutt. Institute of Geological and Nuclear Sciences Limited.

Figure 3 Post February 2011 Earthquake Aerial Photography [2]

8.1.6 Summary of Ground Conditions

The anticipated ground conditions are that of alluvial material comprising predominantly sand and silt overlying gravels.

8.2 Seismicity

8.2.1 Nearby Faults

There are many faults in the Christchurch region, however only those considered most likely to have an adverse effect on the site are detailed below.

Table 2 Summary of Known Active Faults[3,4]

Known Active Fault	Distance from Site (km)	Max Likely Magnitude	Avg Recurrence Interval
Alpine Fault	127	8.3	~300 years
Greendale (2010) Fault	21	7.1	~15,000 years
Hope Fault	105	7.2~7.5	120~200 years
Kelly Fault	115	7.2	~150 years

[2] Aerial Photography Supplied by Koordinates sourced from http://koordinates.com/layer/3185-christchurch-post-earthquake-aerial-photos-24-feb-2011/

[3] Stirling, M.W, McVerry, G.H, and Berryman K.R. (2002): "A New Seismic Hazard Model for New Zealand", *Bulletin of the Seismological Society of America*, Vol. 92 No. 5, pp 1878-1903, June 2002.

[4] GNS Active Faults Database

Known Active Fault	Distance from Site (km)	Max Likely Magnitude	Avg Recurrence Interval
Porters Pass Fault	54	7.0	~1100 years

Recent earthquakes since 4 September 2010 have identified the presence of a previously unmapped active fault system underneath the Canterbury Plains, including Christchurch City, and the Port Hills. Research and published information on this system is in development and not generally available and average recurrence intervals are yet to be established.

8.2.2 Ground Shaking Hazard

The recent seismic activity has produced earthquakes of Magnitude-6.3 with peak ground accelerations (PGA) up to twice the acceleration due to gravity (2g) in some parts of the city. This has resulted in widespread liquefaction throughout Christchurch.

New Zealand Standard NZS 1170.5:2004 now quantifies the Seismic Hazard factor for Christchurch as 0.30, being in a moderate to high earthquake zone. This value has been provisionally upgraded recently (from 0.22) to reflect the seismicity hazard observed in the earthquakes since 4 September 2010.

8.3 Field Investigations

In order to further understand the ground conditions at the site, intrusive testing comprising one piezocone CPT investigation was conducted at the site on 2 April 2012.

The location of the test is tabulated in Table 3.

Table 3 Coordinates of Investigation Locations

Investigation	Depth (m bgl)	Easting (NZMG)	Northing (NZMG)
CPT 001	1.0	2475455	5743203

The CPT investigation was undertaken by McMillan Drilling Services on 2 April 2012, to a target depth of 20m below ground level. Please refer to the attached CPT results for detail (Appendix A).

Interpretation of output graphs[5] showing Cone Tip Resistance (q_c), Friction Ratio (Fr), Inferred Lithology and Inferred Liquefaction Potential confirm the presence of gravels from 0.5m depth with refusal at 1m depth in the dense gravel.

8.4 Ground Conditions Encountered

The result of the desk study and the field investigations confirm the site is underlain by dense gravel and are consistent with TC1 zoning.

[5] McMillans Drilling CPT data plots, Appendix A

8.5 Interpretation of Ground Conditions

8.5.1 Liquefaction Assessment

Based on an overall assessment of the following, the site is considered unlikely to be susceptible to liquefaction, confirming the CERA TC1 classification.

- the identified ground conditions confirmed by CPT; and,
- the minimal damage to ground (and building) caused by the Canterbury earthquake sequence evidenced by aerial and visual inspection.

8.5.2 Slope Failure and/or Rockfall Potential

The site is located within Ilam, a flat suburb in western Christchurch. Global slope instability risk is considered negligible. However, any localised retaining structures and/or embankments should be further investigated to determine the site-specific slope instability potential.

8.5.3 Foundation Recommendations

Following the guidance provided by the Department of Housing and Building[6] (DBH) in Section 4 for repairing of foundations for TC1 dwellings, the following geotechnical recommendations are provided.

- A site subsoil Class of **D**, Deep or Soft Soil, should be adopted for the site (in accordance with NZS 1170.5:2004).
- An allowable bearing Capacity of 100KPa can be used for standard shallow foundation solutions using timber and concrete floors, in accordance with New Zealand Building regulations and NZS 3604.
- If a re-build is deemed necessary a shallow investigation specific to the new building footprint should be undertaken with bearing capacity investigation. Shallow ground improvement is not required.

[6] Department of Building and Housing - Nov 2011: *Revised guidance on repairing and rebuilding houses affected by the Canterbury earthquake sequence*

9. Results of Analysis

9.1 Gravity Loads Check

Due to the geographical configuration of the structure, considering the type and the materials they used, we can say that gravity loads will not impose significant danger in the structure unlike for that with lateral loads. And as mentioned in the qualitative report and on section 6.0 (Damage assessment) of this report, there are no evident damage in the structure that maybe caused by gravity loads. The minor cracks that have been observed is likely due to the lateral movement of the structure during earthquake shaking. With this, no detailed calculation is performed, but instead an engineering judgement and code checking for minimum requirements are performed for this item.

9.2 Lateral Loads Check

Our analysis is applied live loads, superimposed dead loads in combination with both wind and seismic loads. Detailed analysis and calculations are shown in Appendix D. The outcome of the calculations and demand/capacity assessment is summarized in Table 4 and 5.

A diagrammatic plan is shown in Figure 4.

Table 4 Summary of Overall Capacity of Bracing Element for walls and subfloor

Structural Element	Force Description	Direction	% NBS based on calculated capacity
Timber Framed Walls	Wind	Along	> 100%
	Seismic		**39%**
	Wind	Across	> 100%
	Seismic		> 67%
Timber Framed Sub-floor	Wind	Along	> 100%
	Seismic		> 100%
	Wind	Across	> 100%
	Seismic		> 100%

Table 5 Summary of Bracing elements with <67% NBS rating

Bracing Line/Gridline Location	Bracing Element	Force Direction	Structural Element	Element Rating	%NBS
1	1	Along	Wall	< Min. bracing demand per element	**54%**
	2	Along	Wall	< Min. bracing demand per element	**54%**
5	1	Along	Wall	< Min. bracing demand per element	**51%**

9.2.1 Total Bracing System

Based on the seismic analysis, the overall bracing system of the structure achieved a score of 39% NBS. Critical element is the timber framed wall in the “Along” direction. Timber framed walls in the “Across direction achieved a score of over 67% NBS. The timber framed subfloor achieved scores of over 100% NBS. Overall wall bracing system falls in the “Earthquake Risk” category.

Overall Bracing System is structurally adequate to resist wind loadings having a %NBS score of over 100%.

9.2.2 Bracing Element

Relative to the overall bracing system capacity, analysis on each bracing line element was also carried out. Calculations showed that the critical bracing line element in the “Along” direction is located at Gridline 5/H to I. This bracing line achieved a score of 51% NBS. Bracing line along Gridline 1/A to B achieved a score of 54%. Therefore, the said wall bracing lines fall in the “Earthquake Risk” category.

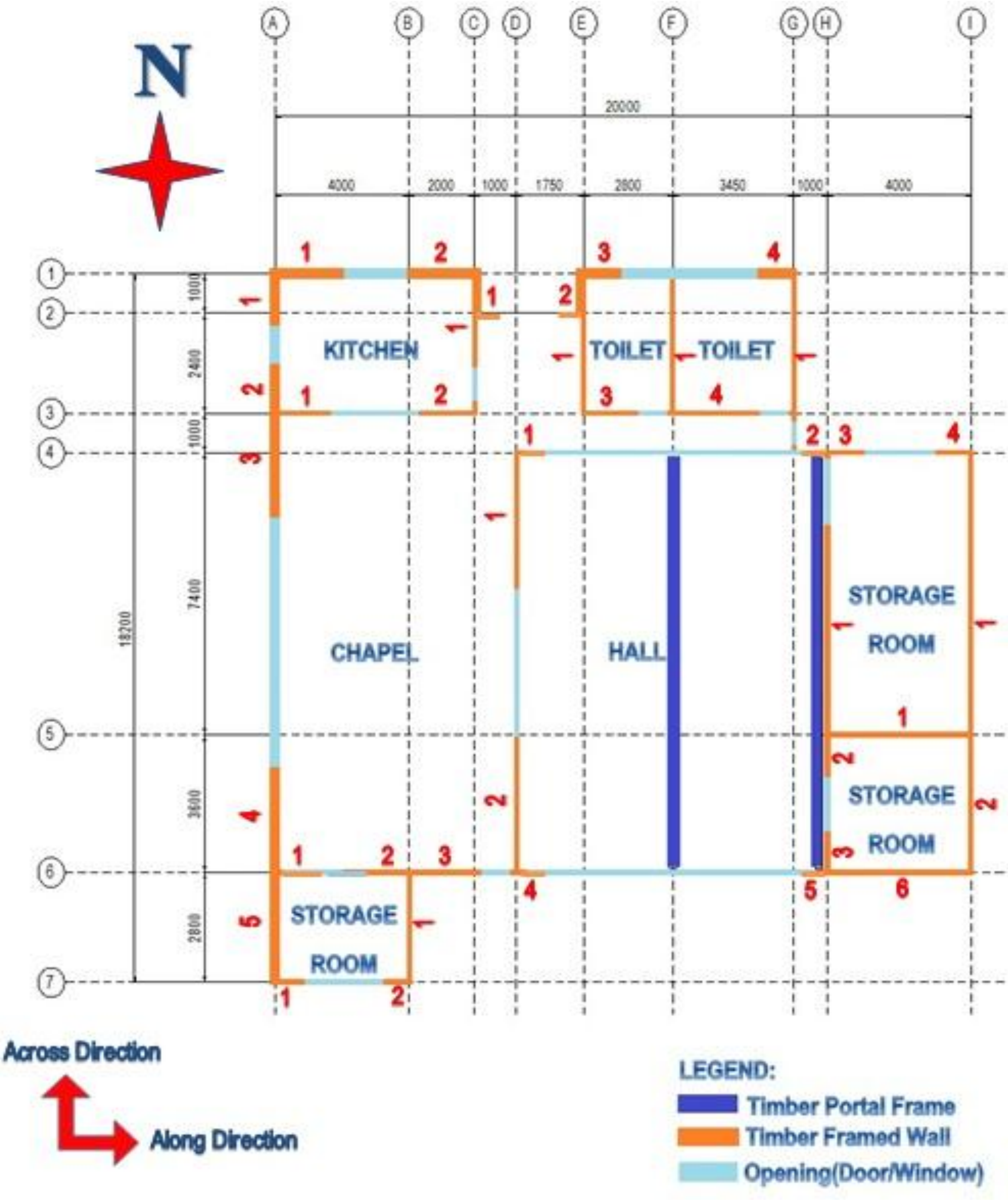


Figure 4 Plan sketch showing numbering sequence for bracing elements

10. Conclusions

Based on our quantitative assessment done for this structure, result shows that the building achieved less than 67% NBS and therefore classified as “Earthquake Risk” building. In particular, timber framed walls in the “along” direction which achieved a score of 39% NBS. This result is also in lined with the result of the qualitative report done on March 8, 2012, wherein the assessed seismic capacity, based on visual inspections, is 41% NBS.

Based on this result, analysis for each bracing line element found out that the most vulnerable elements are the wall bracing lines along Gridline 5/H to I and Gridline 6/A to B. these line elements achieved scores of less than 67% NBS.

11. Recommendations

Relative to Section 9 (Results) and 10 (Conclusions) of this report, the following recommendations are outlined for this structure:

1. The client may choose to consider strengthening the building to at least 67% NBS. Any strengthening to this level is likely to involve moderate cost since few elements fall below 67% NBS minimum requirement.
2. Repair all minor cracks that are found in the structure, as specified in the qualitative report summary and as shown on Photographs 7 to 10 of Appendix B of this report. This is to eliminate the doubts of the community that the structure is weakened by the previous earthquake.

The current green placard should remain in the structure until such time that Items 1 and 2 are satisfied.

12. Limitations

12.1 General

This report has been prepared subject to the following limitations:

- Available drawings as seen on Appendix C are used as reference.
- The foundations of the building were unable to be inspected
- No level or verticality surveys have been undertaken.
- No material testing has been undertaken.

It is noted that this report has been prepared at the request of Christchurch City Council and is intended to be used for their purposes only. GHD accepts no responsibility for any other party or person who relies on the information contained in this report.

12.2 Geotechnical Limitations

The data and advice provided herein relate only to the project and structures described herein and must be reviewed by a competent geotechnical engineer before being used for any other purpose. GHD Limited (GHD) accepts no responsibility for other use of the data by third parties.

Where drill hole or test pit logs, cone tests, laboratory tests, geophysical tests and similar work have been performed and recorded by others under a separate commission, the data is included and used in the form provided by others. The responsibility for the accuracy of such data remains with the issuing authority, not with GHD.

The advice tendered in this report is based on information obtained from the desk study investigation location test points and sample points. It is not warranted in respect to the conditions that may be encountered across the site other than at these locations. It is emphasised that the actual characteristics of the subsurface materials may vary significantly between adjacent test points, sample intervals and at locations other than where observations, explorations and investigations have been made. Subsurface conditions, including groundwater levels and contaminant concentrations can change in a limited time. This should be borne in mind when assessing the data.

It should be noted that because of the inherent uncertainties in subsurface evaluations, changed or unanticipated subsurface conditions may occur that could affect total project cost and/or execution. GHD does not accept responsibility for the consequences of significant variances in the conditions and the requirements for execution of the work.

The subsurface and surface earthworks, excavations and foundations should be examined by a suitably qualified and experienced Engineer who shall judge whether the revealed conditions accord with both the assumptions in this report and/or the design of the works. If they do not accord, the Engineer shall modify advice in this report and/or design of the works to accord with the circumstances that are revealed.

An understanding of the geotechnical site conditions depends on the integration of many pieces of information, some regional, some site specific, some structure specific and some experienced based. Hence this report should not be altered, amended or abbreviated, issued in part and issued incomplete in any way without prior checking and approval by GHD. GHD accepts no responsibility for any circumstances which arise from the issue of the report which have been modified in any way as outlined above.

13. References

1. Detailed Engineering Evaluation Qualitative Report for Waimairi Community Centre, March 08, 2012, GHD Pty. Ltd.
2. AS/NZS 1170.0:2002 Structural design actions, Part 0: General Principles, New Zealand Standards
3. AS/NZS 1170.0 Supplement 1:2002 Structural design actions - General principles - Commentary
4. AS/NZS 1170.1:2002 Structural design actions, Part 1: Permanent, imposed and other actions, New Zealand Standards
5. AS/NZS 1170.1 Supplement 1:2002 Structural design actions – Permanent, imposed and other actions - Commentary
6. AS/NZS 1170.2:2002 Structural design actions, Part 2: Wind actions, New Zealand Standards
7. AS/NZS 1170.2 Supplement 1:2002 Structural design actions – Wind actions - Commentary
8. NZS 1170.5:2004 Structural design actions, Part 5: Earthquake actions, New Zealand Standards
9. NZS 1170.5 Supplement 1:2004 Structural design actions –Earthquake actions – New Zealand - Commentary
10. NZS 3603:1993 Timber Structures Standard, New Zealand Standards
11. NZS 3604:2011 Timber-framed buildings, New Zealand Standards
12. NZSEE 2006, Assessment and Improvement of the Structural Performance of Buildings in Earthquakes, New Zealand Society for earthquake Engineering
13. Compliance Document for New Zealand Building Code Clause B1: Structure, Department of Building and Housing
14. Engineering Advisory Group, Guidance in Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure, Draft, issued by Engineering Advisory Group on 19 July 2011.

Appendix A

Geotechnical Investigation Reports and Analysis

CPT ANALYSIS NOTES

Soil Type

Interpretation using chart of Robertson & Campanella (1983). This is a simple but well proven interpretation using cone tip resistance (q_C) and friction ratio (f_R) only. No normalisation for overburden stress is applied. Cone tip resistance measured with the piezocone is corrected with measured pore pressure (u_C).

- sand (and gravel)
- silt-sand
- silt
- clay-silt
- clay
- peat

Liquefaction Screening

The purpose of the screening is to highlight susceptible soils, that is sand and silt-sand in a relatively loose condition. This is not a full liquefaction risk assessment which requires knowledge of the particular earthquake risk at a site and additional analysis. The screening is based on the chart of Shibata and Teparaksa (1988).

- high susceptibility
- medium susceptibility
- low susceptibility

High susceptibility is here defined as requiring a shear stress ratio of 0.2 to cause liquefaction with D_{50} for sands assumed to be 0.25 mm and for silty sands to be 0.05 mm.

Medium susceptibility is here defined as requiring a shear stress ratio of 0.4 to cause liquefaction with D_{50} for sands assumed to be 0.25 mm and for silty sands to be 0.05 mm.

Low susceptibility is all other cases.

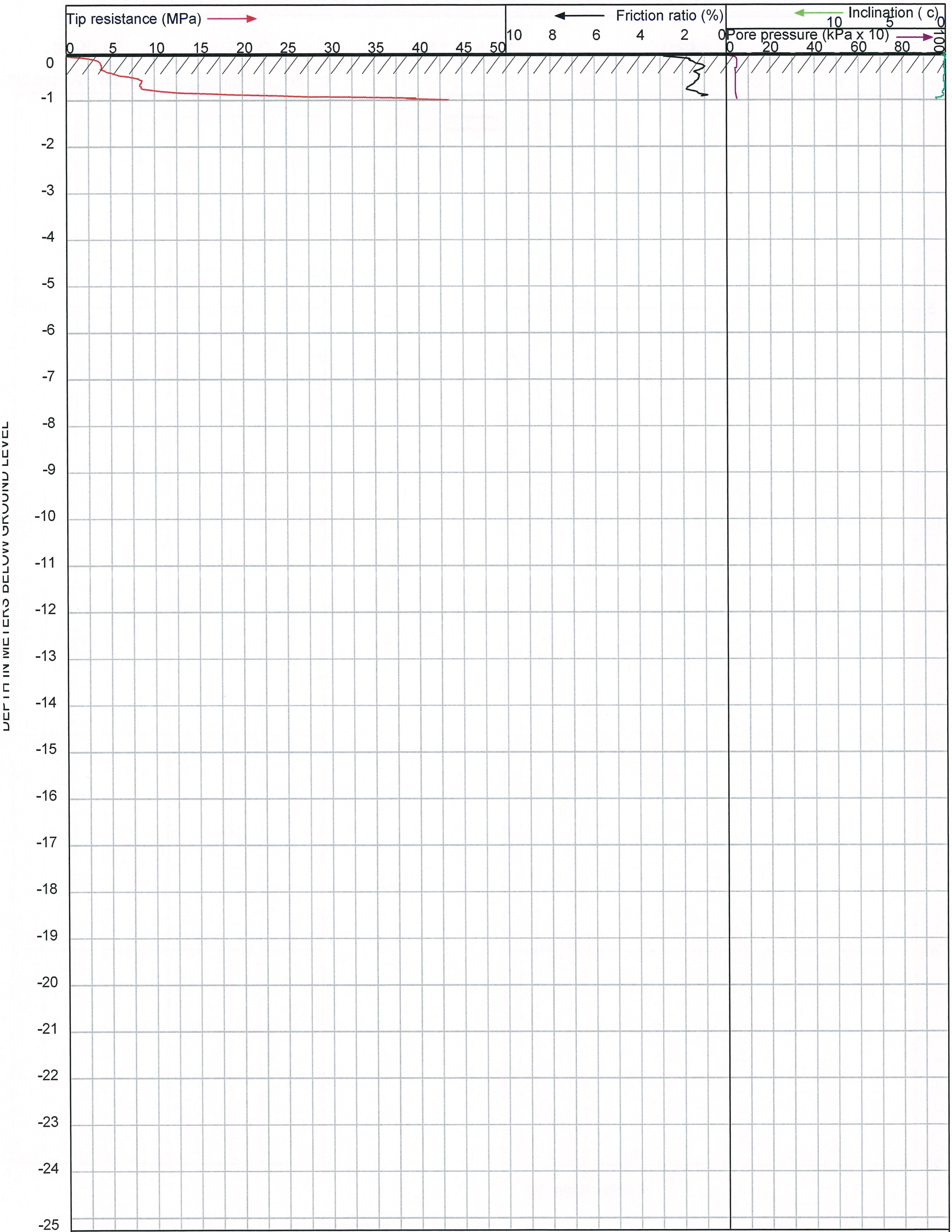
Relative Density (D_R)

Based on the method of Baldi et. al. (1986) from data on normally consolidated sand.

Undrained Shear Strength (S_U)

Derived from the bearing capacity equation using $S_U = (q_C - \sigma_{VO})/15$.

McMILLAN
DRILLING SERVICES

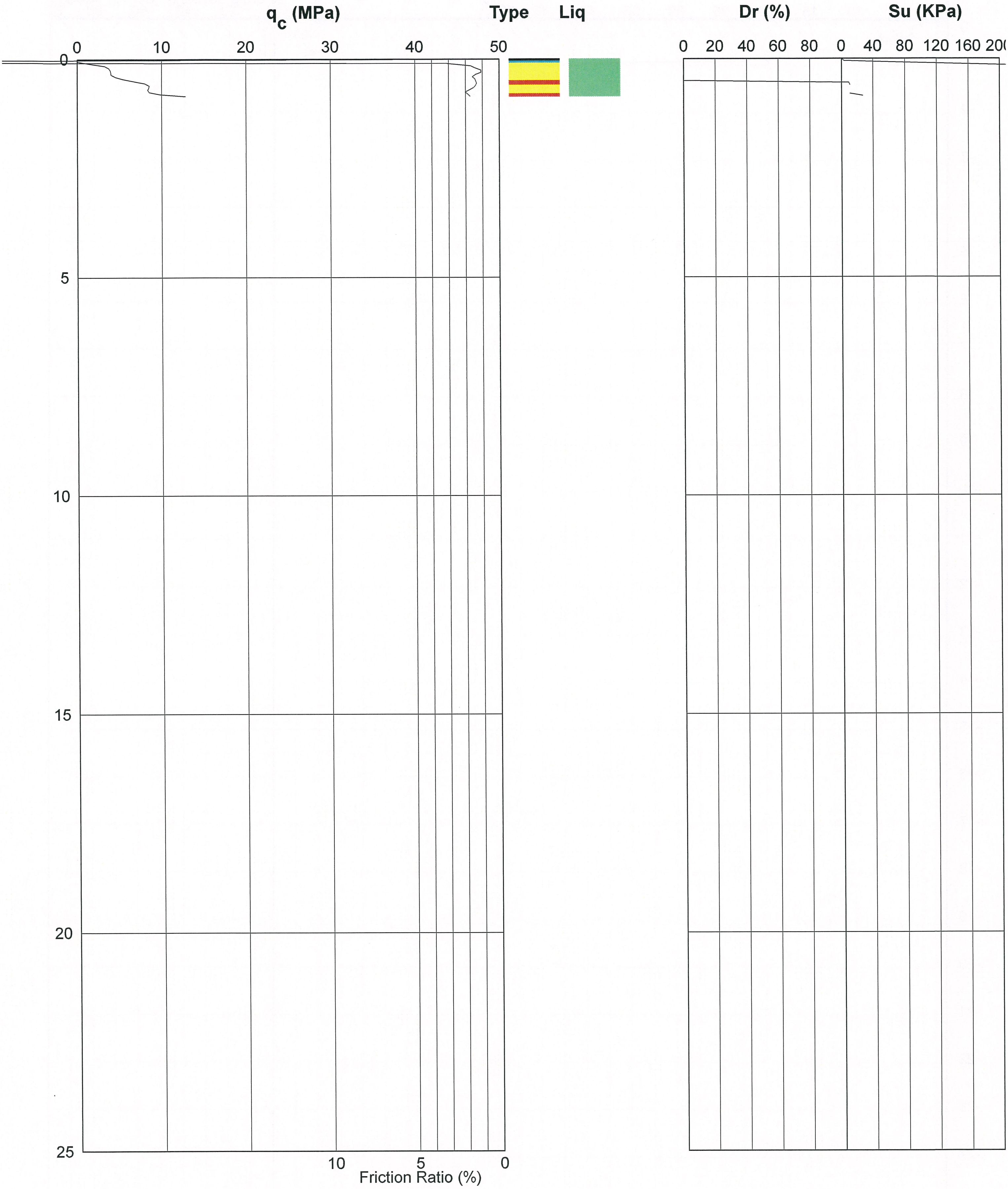


CLIENT	:	GHD
LOCATION	:	Christchurch Various (CCC Properties)
DATE	:	2-4-2012
OPERATOR	:	H. Pardoe
REMARK 1	:	CPTu02
REMARK 2	:	Effective Refusal

JOB # : 10386
TEST # : 2

McMILLAN
DRILLING SERVICES
120 High St Southbridge CANTERBURY NZ
Ph +64 3 324 2571 Fax +64 3 324 2431
www.drilling.co.nz

PIEZOCONE PENETROMETER TEST (CPTU) INTERPRETIVE REPORT



Job No:	10386	Date:	2-4-2012
CPT No:	CPTu02	Operator:	H. Pardoe
Project:	GHD	Remark:	Effective Refusal
Location:	Christchurch Various (CCC Properties)		

McMILLAN DRILLING SERVICES

Appendix B

Photographs

Photograph 1: Western front roadside elevation.

Photograph 2: South elevation showing extension added in 1979.

Photograph 3: View of the building with extension added in 1988 from the east.

Photograph 4: North side view of entrance and brick veneer cladding.

Photograph 5: Glulam timber portal frame.

Photograph 6: Suspended timber flooring with internal plasterboard wall linings.

Photograph 7: Minor cracks on timber framed walls at toilet.

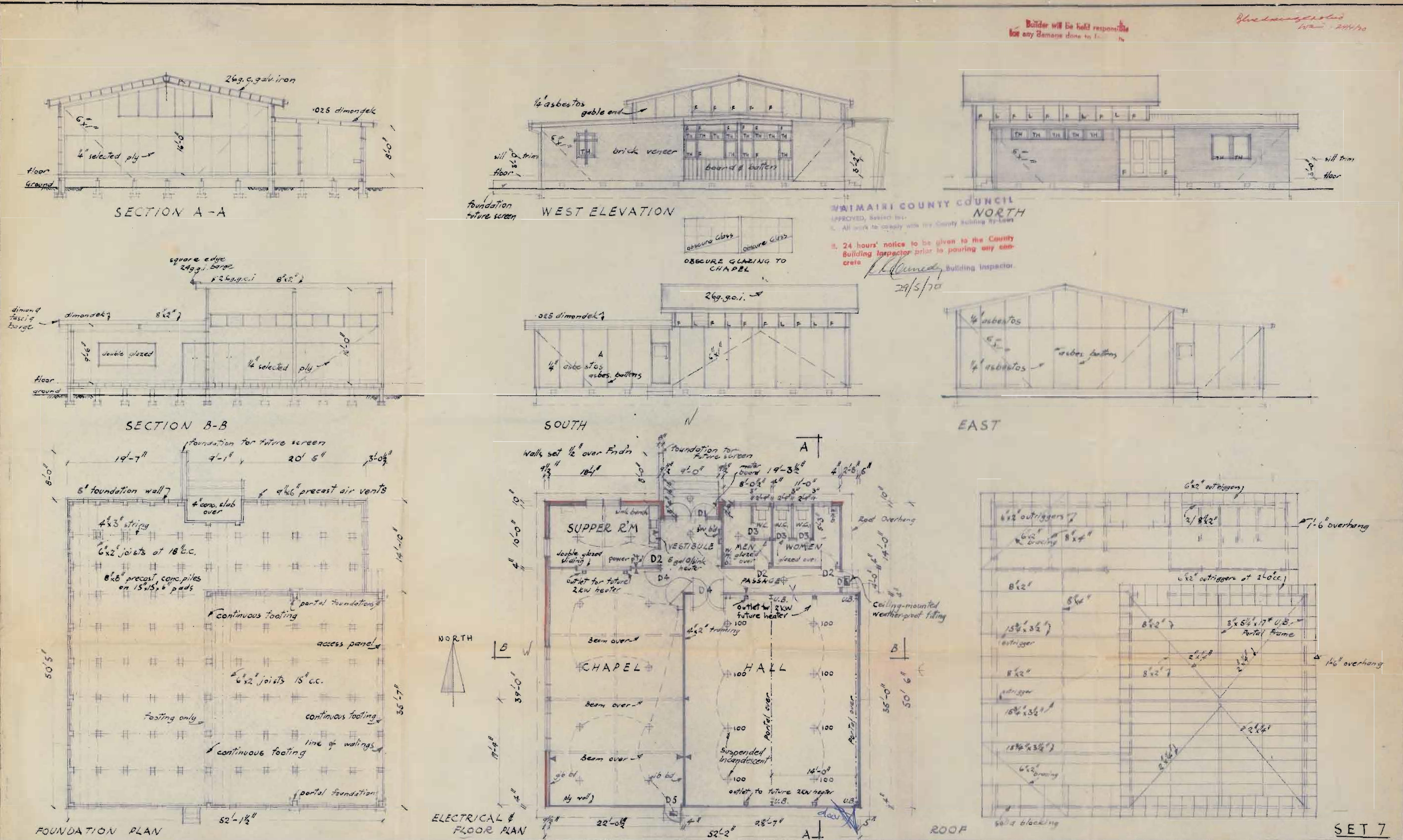
Photograph 8: Minor cracks on timber framed walls at chapel.

Photograph 9: Slight cracking to the perimeter strip footing.

Photograph 10: Minor cracking of the external brick veneer.

Appendix C

Existing Drawings



CHURCH CENTRE, WESTBURN, CHRISTCHURCH for PRESBYTERIAN CHURCH

ELEVATIONS
FOUNDATION PLAN, ROOF PLAN
FLOOR PLAN, ELECTRICAL PLAN

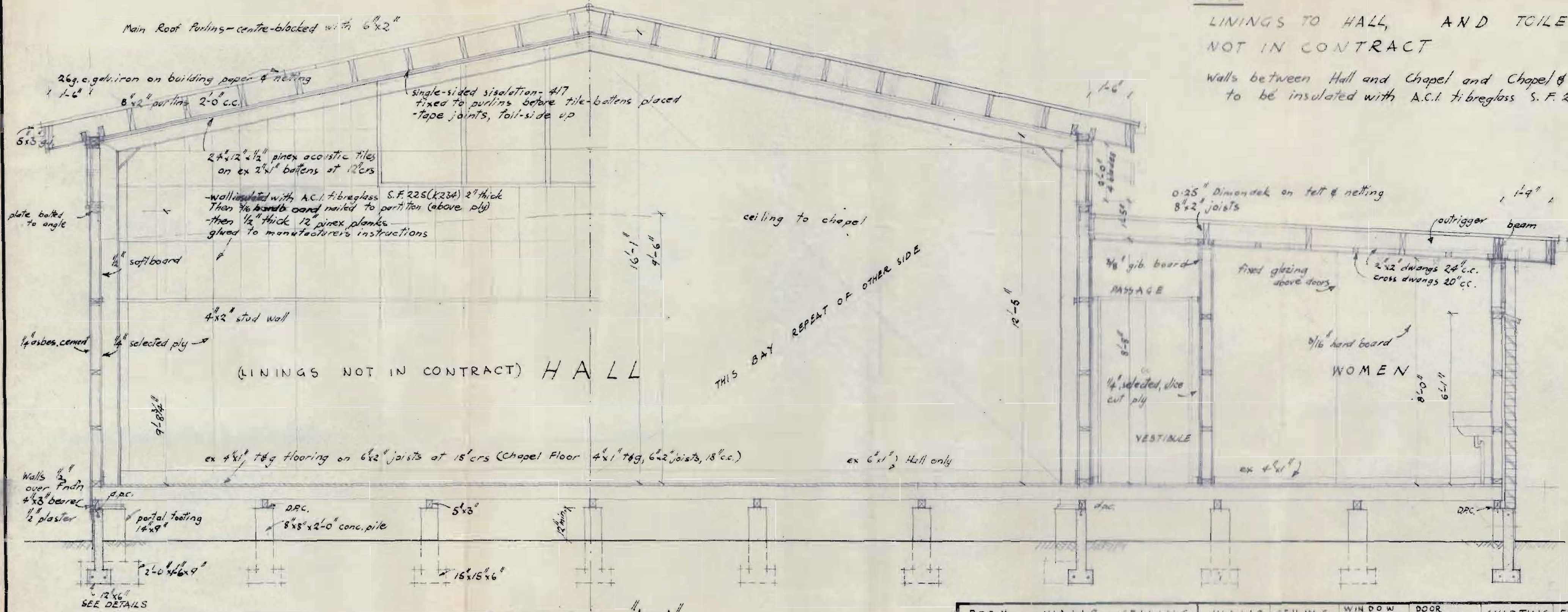
R.W.E.
Dec/68

1

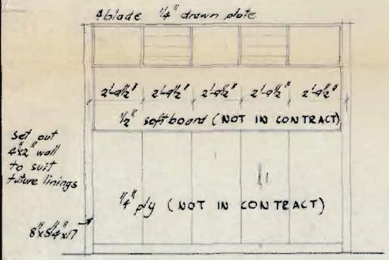
NOTE

LININGS TO HALL, AND TOILETS NOT IN CONTRACT

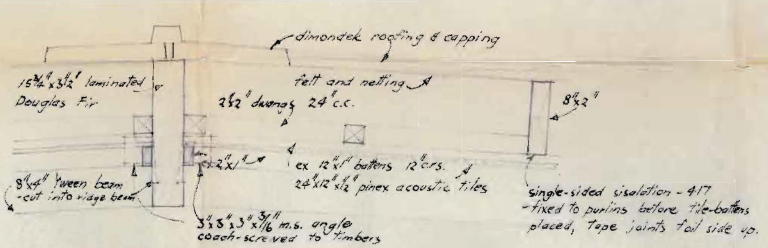
Walls between Hall and Chapel and Chapel & Supper Rm to be insulated with A.C.I. fibreglass S.F. 225 (K.234)



SECTION "A-A"



TYPICAL BAY NORTH & SOUTH
SHOWING FUTURE LININGS



RIDGE TO CHAPEL

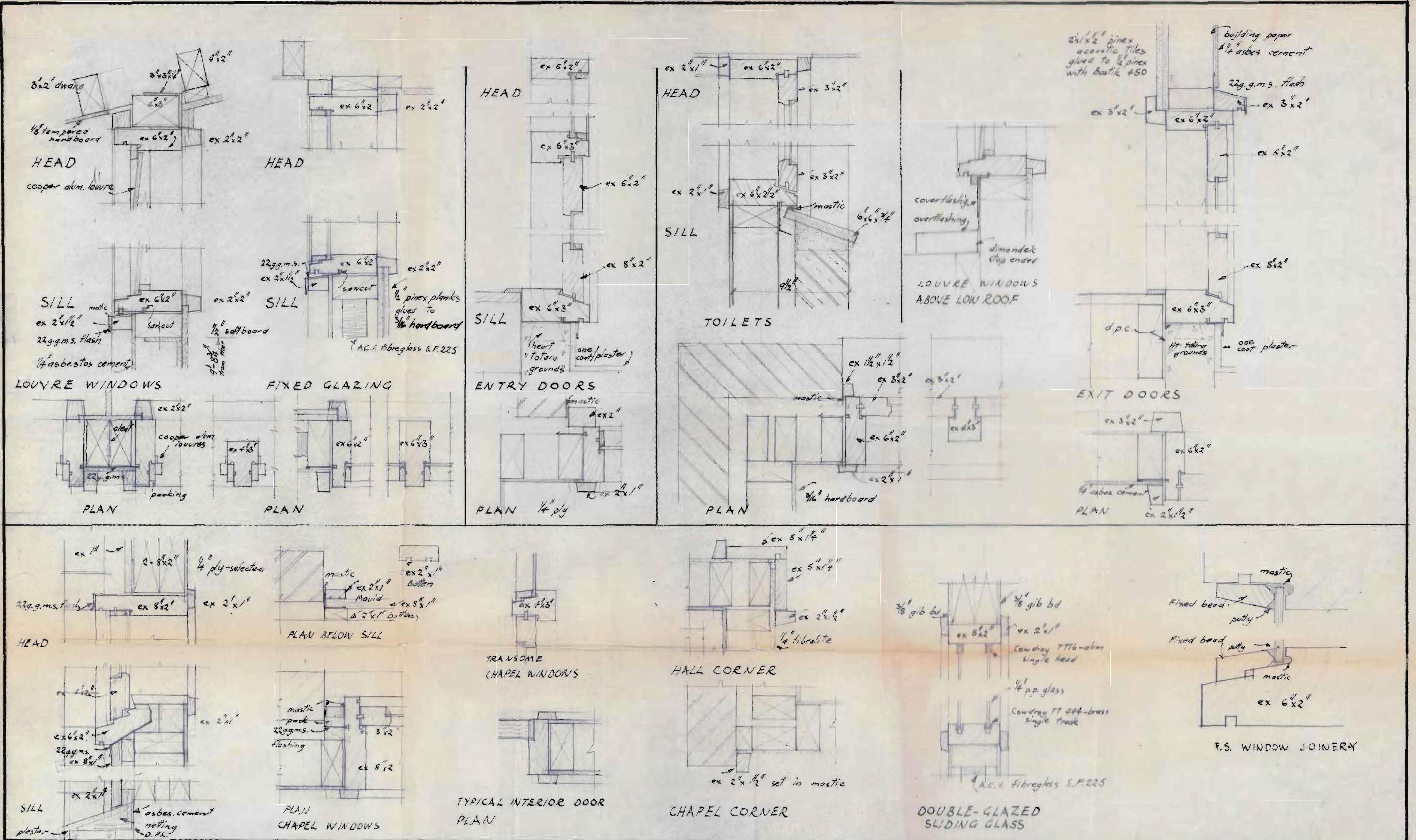
ROOM	WALLS	CEILING	WALLS	CEILING	WINDOW ARCHITRAVES	DOOR ARCHITRAVE	SKIRTING	FITTINGS
CHAPEL	South full hgt 1/4" selected ply	2'-0"x1'-0"x1/2" T&G	Satin Varnish	PVA flat	Semi-gloss	Satin Varnish	ex 4"x1"	Beams - two coats Satin Varnish
	Others - 3'-0" ply dado	Pinex acoustic tiles	ditto		enamel			
	-gib.b'd above	on 2"x1" battens	Wallpaper					
SUPPER ROOM	All walls 3'-0" ply dado gib. b'd above	ditto	Satin Varnish Wallpaper	ditto	ditto	ditto	ditto	Bench - Satin Varnish
VESTIBULE	1/4" selected ply	ditto	Satin Varnish	ditto	ditto	Satin V.	ditto	
PASSAGE	up to door hgt slice cut	ditto	Satin Varnish	ditto	ditto	Satin V.	ditto	
	Gib. b'd above		Wallpaper					
FOLLOWING - NOT IN CONTRACT								
MEN	3/16" hardboard	3/16" hardboard	Satin Enamel	ditto	ditto	ditto	ditto	
WOMEN	ditto	ditto	ditto	ditto	ditto	ditto	ditto	
HALL	1/4" selected ply to door hgt 1/2" softboard above	2'-0"x1'-0"x1/2" T&G Pinex acoustic tiles	Satin V. P.V.A. flat	ditto	ditto	ditto	ex 6"x1"	

CHURCH CENTRE, WESTBURN, CHRISTCHURCH for PRESBYTERIAN CHURCH

1/2" = 1'-0" SECTION
LINING & FINISHING SCHEDULE

R.W.E.
Dec/68

2



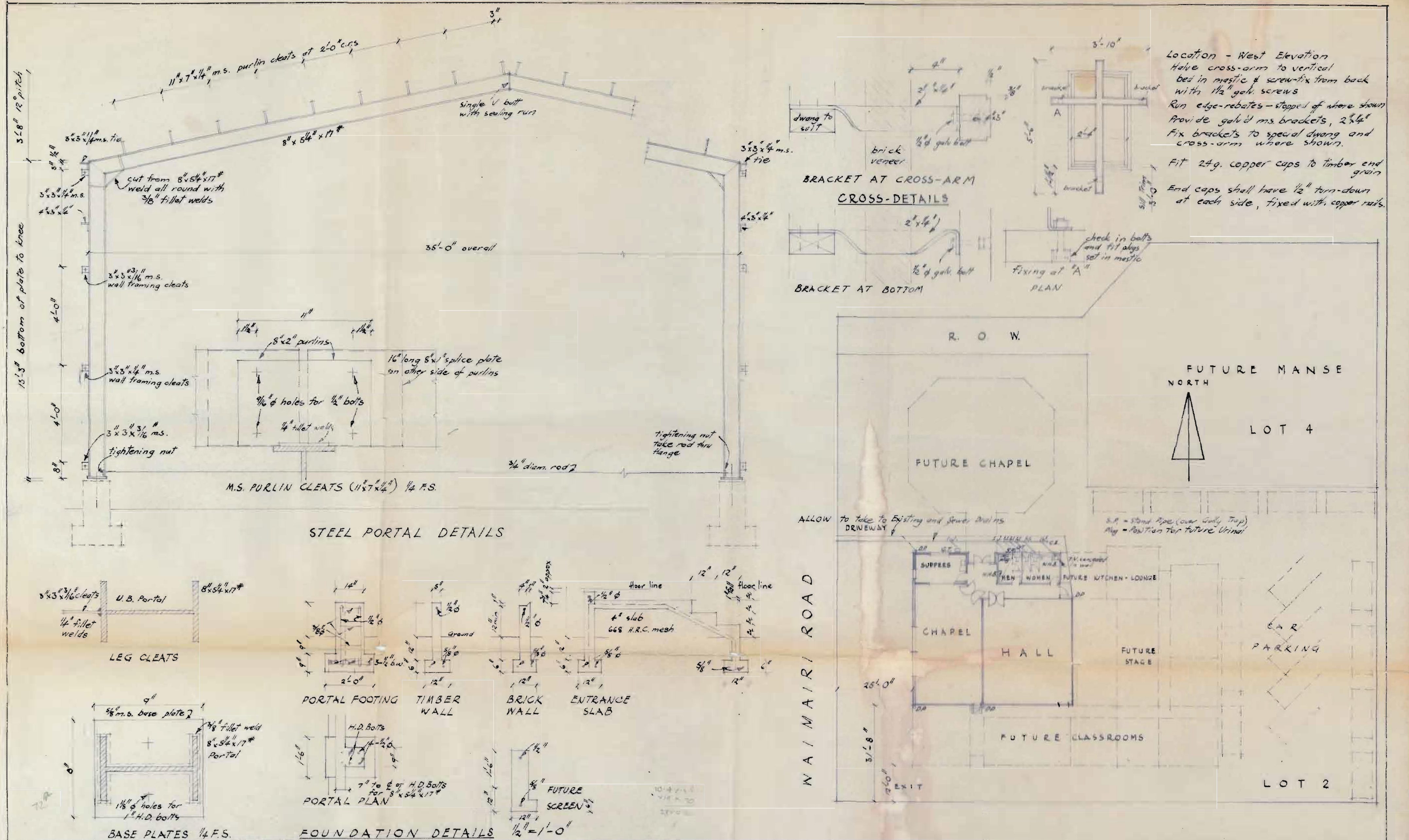
CHURCH CENTRE, WESTBURN, CHRISTCHURCH for PRESBYTERIAN CHURCH

JOINERY DETAILS

R.W.E.
Dec/68

32 THE TERRACE, WELLINGTON

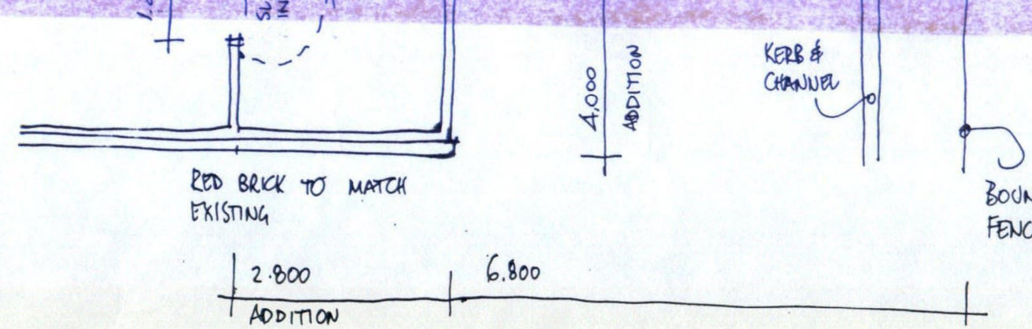
3



CHURCH CENTRE, WESTBURN, CHRISTCHURCH, for PRESBYTERIAN CHURCH

STRUCTURAL DETAILS
SITE & DRAINAGE PLAN

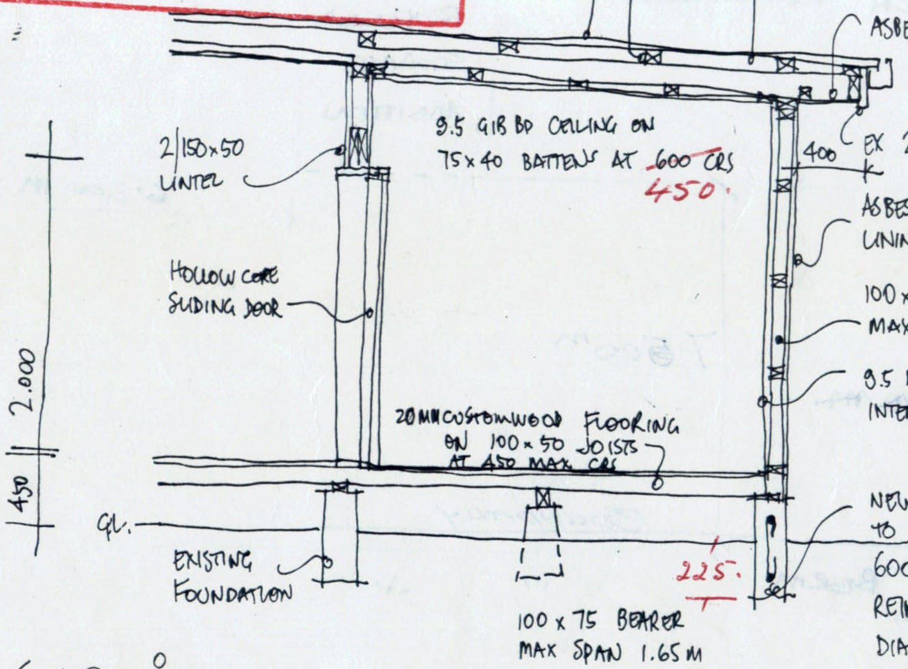
4



PLAN

1:100

NOTE: COUNCIL MUST BE GIVEN 24 HOURS NOTICE PRIOR TO POURING FOUNDATIONS



NEW CONTINUOUS FOUNDATION TO PERIMETER OF ADDITION 600 x 150 MIN – TIE IN TO EXISTING 230 mm under corners.

REINFORCE WITH 2/12 MM DIA. RODS WITH 6.5 MM LINKS AT 300 CRS

N.B. BUILD IN FLOOR VENTS AT MAX 1.8 M CENTRES 750 mm from corners.

Ventilation 3500 mm^2 per m^2 of floor area.

SECTION

1:50

WAIMAIRI COUNTY COUNCIL

APPROVED

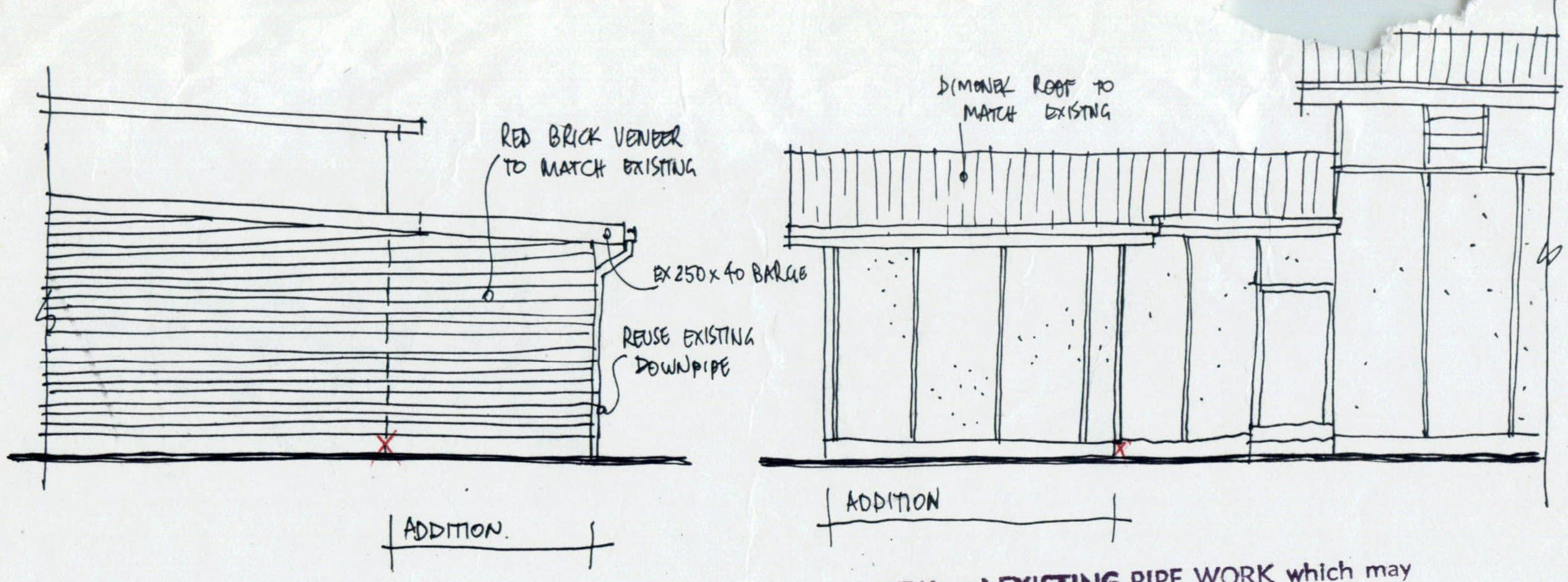
SUBJECT TO BY-LAWS

[signature] BUILDING INSPECTOR

20.12.79 DATE

PROPOSED STORAGE ROOM FOR AVONHEAD PLAYCENTRE

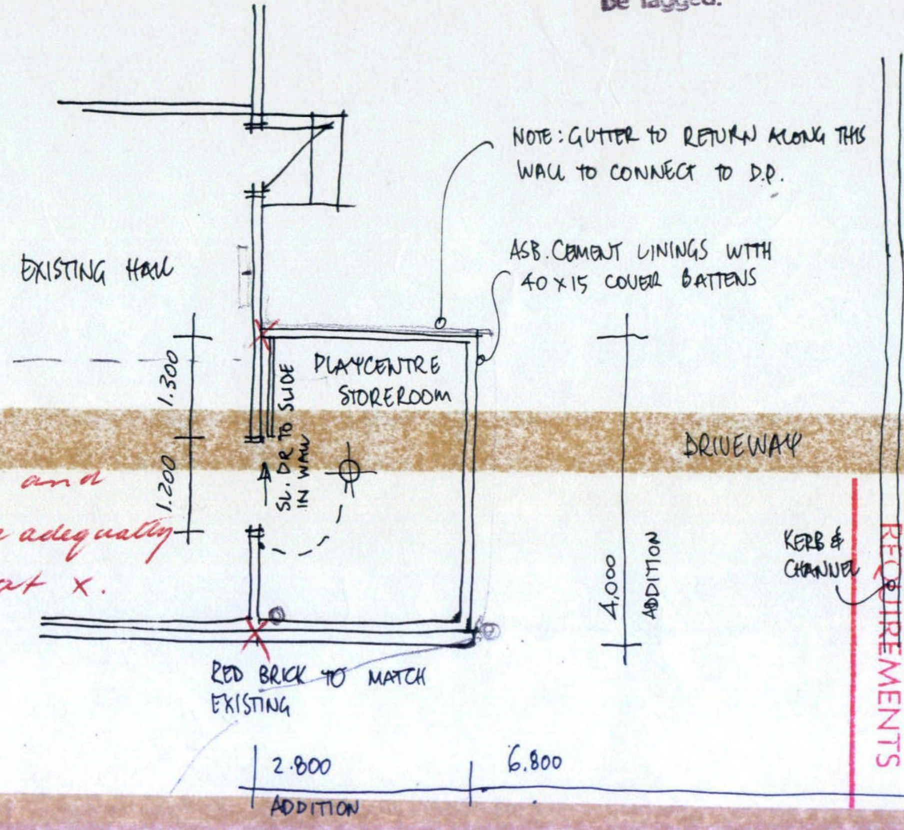
ST. MARKS PRESBYTERIAN CHURCH WAIMAIRI ROAD



ELEVATIONS

1:100

NEW and EXISTING PIPE WORK which may pass through foundation of new extensions to be lagged.



New reinforcing and foundation to be adequatly tied to existing at x.

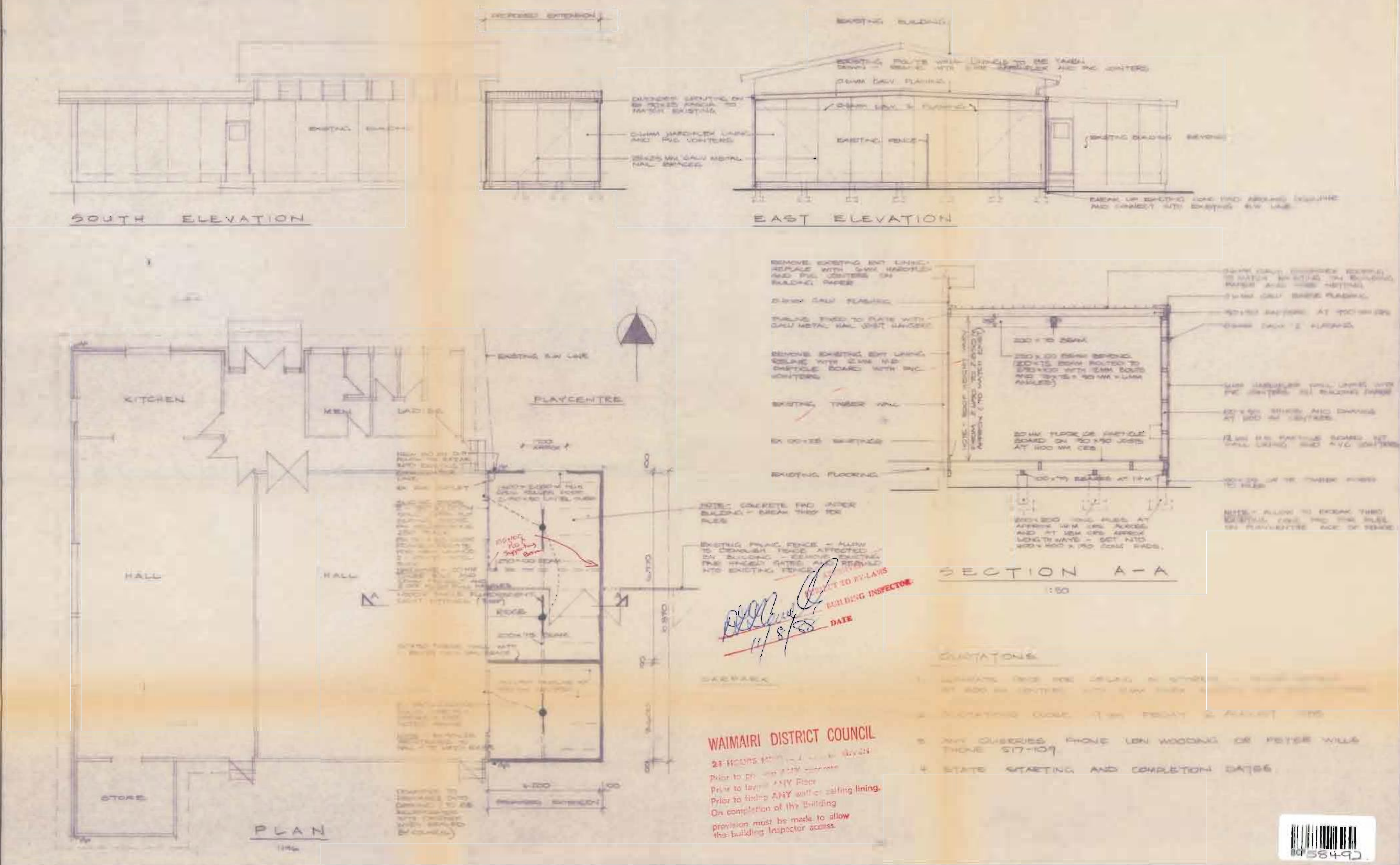
PLAN

1:100

BUILDER
PLEASE ENSURE THE
DRAINLAYER
SEES THE ABOVE
REQUIREMENTS

DRAINLAYER
NOTE STORM WAT...
...GE REQUIREMENTS
...TED TO PLANS.

PLAYCENTRE GROUP
ROAD



WAIMAIRI DISTRICT COUNCIL

DRAWING INFORMATION

SURVEYED		DATUM		SCALE
DRAWN	L. WOODING 7-85	BENCH MK.		1:96 (OLD 1/8" = 1'0")
TRACED	P. WILLS 7-85	LEVEL BK. NO.	P.	
CHECKED		FIELD BK. NO.	P.	1:50
DESIGNED	L. WOODING 7-85			
DES. CHK.				
APPROVED		0 1 2 3 4 5 10		

TITLE & NUMBER

PROPOSED STORE

WAIMAIRI RD. COMMUNITY CENTRE

7800/A/2

OF

GHD

Level 11, Guardian Trust House
15 Willeston street, Wellington 6011
T: 64 4 472 0799   F: 64 4 472 0833   E: wgtnmail@ghd.com

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Final	Jay Zeus Rivera	Stephen Lee		Nick Waddington		31/10/12