Detailed Engineering Evaluation

Quantitative Assessment Report Buller X-Ray Building

Detailed Engineering Evaluation

Quantitative Assessment Report

Buller X-Ray Building

Prepared By

Jason Davidson
Structural Engineer, CPEng 229742

Reviewed By

Jan Stanway
Senior Structural Engineer, CPEng 222291

Approved for Release By

Mark Healey
West Coast Business Manager, CPEng 171989

Opus International Consultants Ltd
Greymouth Office
23 High Street
PO Box 365, Greymouth 7840
New Zealand

Telephone:	+64 3 769 9330
Facsimile:	+64 3 768 7498

Date:	29 January 2013
Reference:	WCAN1.02 / 155GG
Status:	FINAL1

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Executive Summary

The West Coast District Health Board appointed Opus International Consultants (Opus) to carry out a Detailed Engineering Evaluation (DEE) of the X-Ray Building at Buller Hospital in Westport. The key outcome required of this DEE was to ascertain the anticipated seismic performance of the structure and to compare this performance with current design standards. Opus was also asked to provide conceptual strengthening options to improve the building's seismic performance, with a target of meeting at least 67% of the new building standard (%NBS) for a building with Importance Level 2 (IL2).

Findings of the assessment are:

a. The building has a seismic capacity of 20%NBS in both directions (IL2). Therefore this building is Earthquake Prone, as defined by the Building Act, and is a High Risk building when classified in accordance with NZSEE [2].

   This building does not require strengthening in accordance with Buller District Council (BDC) policy [6], unless the building owner is to apply for a building consent or change of use application, or if the building is deemed dangerous by BDC. However, given the poor performance of the building, we strongly recommend strengthening be carried out. Strengthening to a minimum of 67%NBS is recommend in accordance with NZSEE [2].

   Note that if the building was assessed as an IL3 building, the seismic capacity would reduce to 15%NBS in both directions.

b. The foundations of the existing building are not expected to experience severe damage due to liquefaction. Some minor liquefaction induced damage to building foundations is likely in large earthquakes; this damage may include differential settlement of the floor, settlement and lateral displacement of timber piles, cracks to the perimeter footings and cracks to the brick cladding. This damage is expected to be repairable and not significantly disrupt hospital operations. Lateral spreading is not expected to occur.

c. A broad strengthening concept to bring the building up to 67%NBS has been considered and could include the following:

   » Strengthening of the unreinforced masonry walls by tying the two leafs of brickwork together with Helifix (or similar) ties. An alternative would be to remove these walls and replace them with timber framed walls.
   » Strengthen selected timber framed walls through removal of existing internal linings, installation of fixings at the base of the wall, and relining with Gib Braceline (or similar).
   » Strengthen subfloor through installation of
   - additional fixings between the timber floor and perimeter concrete wall.
   - additional fixings between timber subfloor elements (joists, bearers etc).
   - subfloor bracing.

   Further detail on possible strengthening techniques is discussed in this report.

Recommendations:

Although this building is Earthquake Prone, strengthening to improve the building performance is not required under BDC policy [6] unless the building owner is to apply for a building consent or change of use application, or if the building is deemed dangerous by BDC. However, this building is High Risk and strengthening to improve the seismic performance to a minimum level of 67%NBS is strongly recommended by NZSEE [2].

We recommend that a staged strengthening approach as detailed below is followed in order to understand and manage the economic impact of any proposed remedial actions. Specifically we recommend that:

a. The implications of the IL2 classification for this building be carefully considered prior to carrying out any future works on this building, noting that with an IL2 classification, this building is not expected to remain operational post-disaster.

b. An outline scheme for structural strengthening should be further developed followed by costing by a quantity surveyor.

c. A quantity surveyor is engaged to determine the costs for strengthening the building. We note that there is a risk that foundation strengthening and / or soil stabilisation may be required for strengthening however the extent and nature of this works cannot be fully quantified at this stage. Further geotechnical input will be required to further investigate this. For conceptual costing's we would recommend that the quantity surveyor allows a reasonable contingency for this possible cost risk.

d. Detailed design of a scheme for the strengthening of the structure is carried out.

1 Introduction

Opus International Consultants Limited (Opus) has been engaged by the West Coast District Health Board (WCDHB) to undertake a Detailed Engineering Evaluation (DEE) of the Buller X-Ray Building at Buller Hospital in Westport.

The purpose of the DEE is to determine the likely seismic performance of the building and also if the building is classed as being Earthquake Prone in accordance with the Building Act 2004.

The DEE and reporting have been undertaken based on the qualitative and quantitative procedures detailed in the Detailed Engineering Evaluation Procedure (DEEP) document (draft) issued by the Structural Engineering Society (SESOC) on 19 July 2011.

We have been advised by the WCDHB that the building is to be assessed as an Importance Level 2 (IL2) building.

Definitions of an IL2 building may be found in AS/NZS 1170.0:2002 (Structural design actions Standard). This designation will require the earthquake return period factor for the ultimate limit state of R_u = 1.0 (over an assumed building design life of 50 years) to be used. For the same design life an IL3 building has an earthquake return period factor of R_u = 1.3. Practically this means that an IL3 building is expected to withstand an earthquake of approximately 30% stronger than that expected of an IL2 building. Note also however that an IL3 building is expected to withstand an earthquake approximately 28% lower than an IL4 building (building with a special post disaster function). An IL4 building is also expected to remain operational following an earthquake event equivalent to an IL2 event.

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 New Zealand at present.

2.1 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 the 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 Buller District Council (BDC)) is satisfied that the building with a new use complies with the relevant sections of the Building Code 'as near as is reasonably practicable'.

This is typically interpreted by GDC as being between 67% and 100% of the strength of an equivalent new building.

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 loads 33% of those used to design an equivalent new building on the same site.

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.

2.2 Buller District Council Policy

Buller District Council adopted their Earthquake Prone, Dangerous and Insanitary Building Policy in 2006. This policy was amended in 2009 and an updated policy was adopted on 16 December 2009 [6].

The 2009 amendment includes the following:

» The identification of Earthquake Prone Buildings through the Building Consent process, Change of Use applications, or complaints to the Buller District Council.

2.3 Building Code

The New Zealand 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.

2.4 Institution of Professional Engineers New Zealand (IPENZ) Code of Ethics

One of the core ethical values of professional engineers in New Zealand is the protection of life and safeguarding of people. The IPENZ Code of Ethics requires that:

Members shall recognise the need to protect life and to safeguard people, and in their engineering activities shall act to address this need.

i. *Giving Priority to the safety and well-being of the community and having regard to this principle in assessing obligations to clients, employers and colleagues.*

ii. *Ensuring that responsible steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.*

All recommendations on building occupancy and access must be made with these fundamental obligations in mind.

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 loadings are in accordance with the current earthquake loading standard NZS1170.5 [1].

A generally accepted classification of earthquake risk for existing buildings in terms of %NBS that has been proposed by the NZSEE 2006 [2] is presented in Figure 3.1 below.

Description	Grade	Risk	%NBS	Existing Building Structural Performance
Low Risk Building	A or B	Low	Above 67	Acceptable (improvement may be desirable)
Moderate Risk Building	B or C	Moderate	34 to 66	Acceptable legally. Improvement recommended
High Risk Building	D or E	High	33 or lower	Unacceptable (Improvement required under Act)

Improvement of Structural Performance	
Legal Requirement	NZSEE Recommendation
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
	Not recommended. Acceptable only in exceptional circumstances
Unacceptable	Unacceptable

Figure 3.1: NZSEE Risk Classifications - Extracted from table 2.2 of the NZSEE 2006 AISPBE Guidelines [2]

Table 3.1 below 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)

Table 3.1: %NBS compared to relative risk of failure - Extracted from table 2.1 of the NZSEE 2006 AISPBE Guidelines [2]

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

3.1 Minimum and Recommended Standards

Based on governing policy and recent observations, Opus makes the following general recommendations:

3.1.1 Cordoning

- Where there is an overhead falling hazard or potential collapse hazard of the building, the areas of concern should be cordoned off to prevent access (for guidance with this issue refer to BDC guidelines on Dangerous Buildings [6]).

3.1.2 Strengthening

- Industry guidelines (NZSEE 2006 [2]) strongly recommend that every effort be made to achieve improvement to at least 67%NBS. A strengthening solution to anything less than 67%NBS would not provide an adequate reduction to the level of risk.
- The BDC policy [6] requires an assessment of the seismic strength of a building to be carried out when:

  » A building consent application is lodged.
  » A change of use application is lodged.
  » When the BDC receives a complaint about a building.

- BDC policy [6] requires Earthquake Prone buildings of Importance Level 2 (IL2) be strengthened to a minimum of 34% NBS. The policy does not specify timeframes for strengthening works to be completed, other than stating that strengthening works are to be carried out as part of any consented works. Note that an Earthquake Prone building of IL3 is to be strengthened to a minimum of 67% NBS.
- It should be noted that full compliance with the current building code requires building strength of 100%NBS.

3.1.3 Our Ethical Obligation

- In accordance with the IPENZ code of ethics, we have a duty of care to the public. This obligation requires us to identify and inform Buller District Council of potentially dangerous buildings; this would include earthquake prone buildings.

4 Background Information

4.1 Building Description

The X-Ray building is a single storey structure located at Buller Hospital in Westport. Buller Hospital serves the community of Buller and is located on the east side of Derby Street, in between Pakington and Cobden Streets. Figure 4-1 shows an aerial photo of Buller Hospital and the location of the X-Ray building within the hospital.

Figure 4-1: Aerial photo of Buller Hospital

There were no drawings (architectural or structural) available for the X-Ray building.

The X-Ray building joins the south side of a corridor linking the hospital buildings together. Figure 4-2 below shows an outline of the X-Ray building.

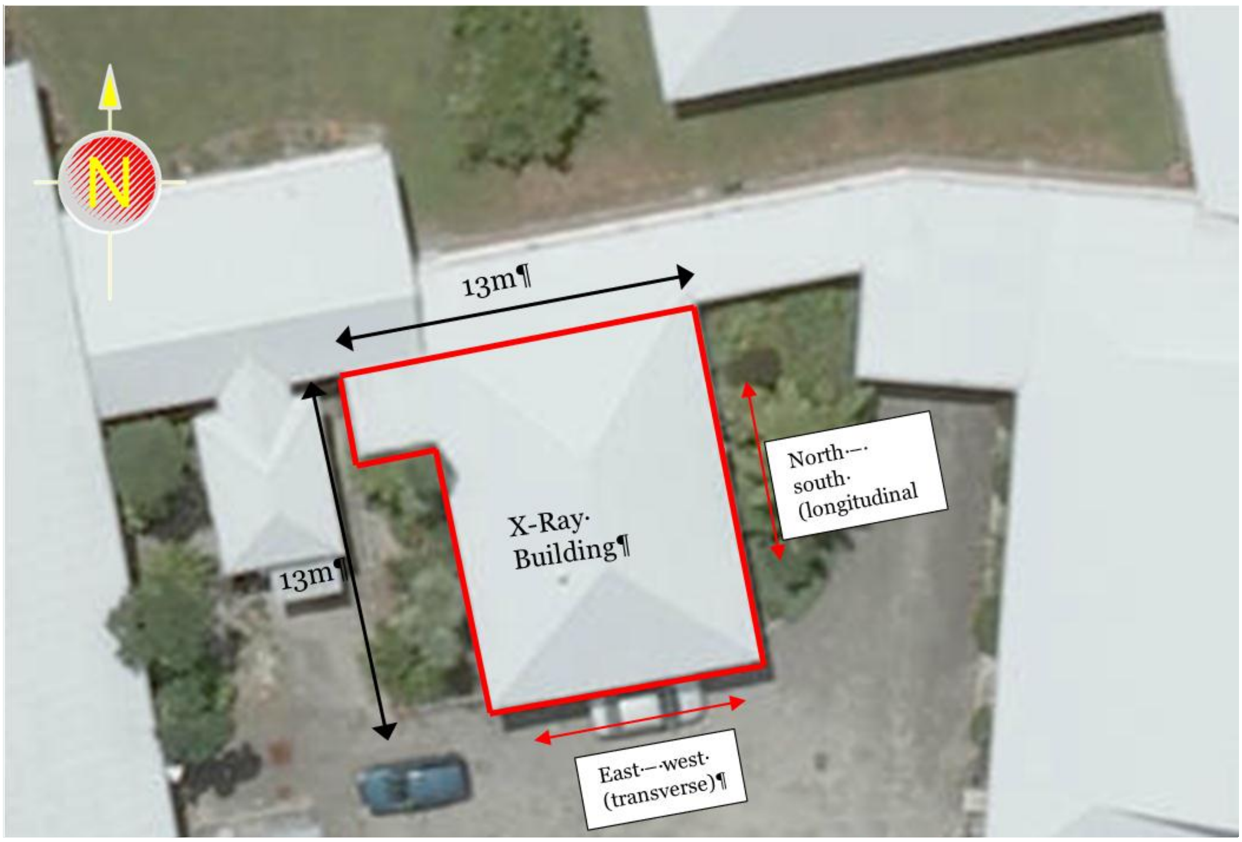

Figure 4-2: Buller X-Ray Building

The building has overall plan dimensions of approximately 13m long (N/S) x 13m wide (E/W) and is single storey.

There is a reinforced concrete services trench running north – south under the centre of the building, linking a services trench underneath the corridor.

The building consists primarily of timber framed walls lined with plasterboard (internally) and with a brick veneer on the exterior. There are some double skin Unreinforced Masonry (URM) walls near the north west corner of the building.

The hipped roof structure consists of timber trusses supporting a light weight roof cladding which may be asbestos. The roof is partially lined with timber sarking and the ceiling is fully lined with plasterboard.

The subfloor structure consists of reinforced concrete piles (internally) suppporting a timber framed floor structure. Around the perimeter of the building there is a reinforced concrete perimeter footing.

The age of the building is unknown.

A ground floor plan of the building is included below to assist with understanding the building layout.

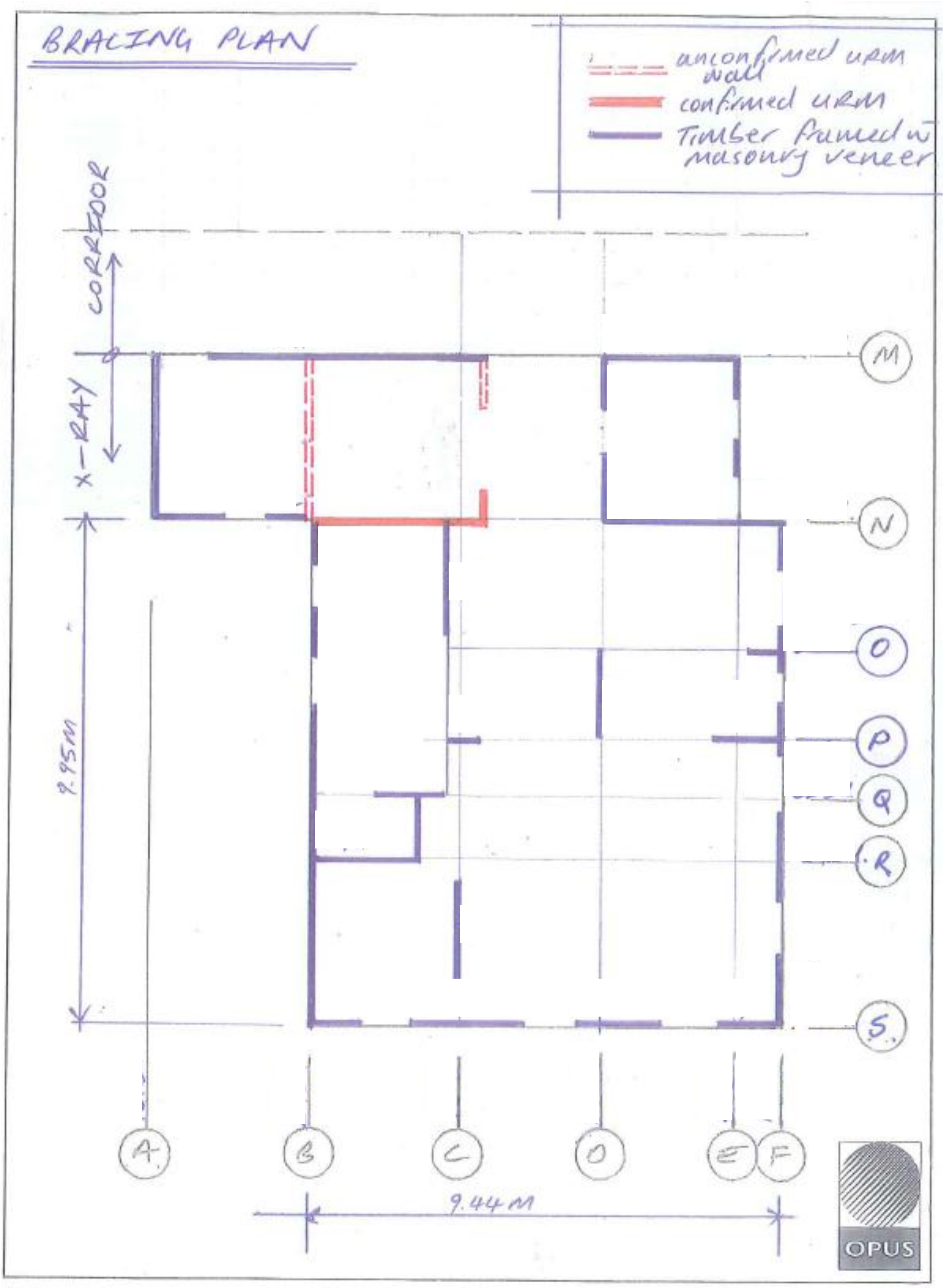

Figure 4-3: X-Ray Building –Floor Plan

4.2 Gravity Load Resisting System

Gravity loads are resisted by the internal and external timber framed and URM walls. Gravity loads are then transferred to the ground through the reinforced concrete piles and reinforced concrete perimeter foundation.

4.3 Lateral Load Resisting System

Lateral loads within the building are resisted primarily by the timber framed / plasterboard lined walls in the building. These walls provide resistance to racking through the in plane stiffness of the plasterboard lining. Some lateral loads are also resisted through the in plane strength of the URM walls.

The subfloor structure resists lateral loading through a combination of diaphragm action of the timber floor transferring in plane shear to the perimeter reinforced concrete foundation walls, and rocking of the reinforced concrete piles.

Lateral loads are resisted in the longitudinal and transverse directions as indicated below.

4.3.1 Longitudinal lateral load resisting elements

Location	Lateral Load Resisting Elements
Subfloor	• Diaphragm action of the timber floor structure and perimeter reinforced concrete foundation walls (in plane shear). Due to uncertainty regarding the connection capacity between the timber bearers and concrete piles, and uncertainty around the ability of the soil to allow the piles to rock, rocking response of the piles has not been assessed as a means of resisting lateral load on the building subfloor.
Ground floor	• URM walls (in plane and out of plane shear). • Timber framed, plasterboard lined walls (in plane shear).

4.3.2 Transverse lateral load resisting elements

Location	Lateral Load Resisting Elements
Subfloor	• Diaphragm action of the timber floor structure and perimeter reinforced concrete foundation walls (in plane shear). Due to uncertainty regarding the connection capacity between the timber bearers and concrete piles, and uncertainty around the ability of the soil to allow the piles to rock, rocking response of the piles has not been assessed as a means of resisting lateral load on the building subfloor.
Ground floor	• URM walls (in plane and out of plane shear). • Timber framed, plasterboard lined walls (in plane shear).

4.3.3 Foundations:

Loads at ground floor level are resisted through in plane shear of the reinforced concrete perimeter foundations. Rocking of the piles has not been considered in assessing the lateral capacity of the subfloor structure.

4.4 Original Documentation

There were no drawings available for the Detailed Engineering Evaluation of this building.

5 Building Inspection

5.1 Visual and Intrusive Inspection

A visual inspection of the building was carried out on Tuesday 15 and Wednesday 16 May 2012. The purpose of this visual inspection was to obtain sufficient information to enable a seismic evaluation of the building to be carried out.

This inspection involved obtaining the following information on the building:

» Dimensions of the building.
» Layout and position of bracing walls and piles.
» Information on construction details for the subfloor, roof and timber framed walls.

Some intrusive investigation was also carried out. This involved cutting holes in plasterboard linings to inspect wall construction and thickness of plasterboard.

5.2 General Observations

The following general observations were made during our inspections and assessment of this building:

» The building generally appears to be in a reasonable condition.
» Timbers are generally connected with nominal nailing, consistent with early New Zealand construction practices.
» There appears to be nominal tie wires between the external veneer cladding and the timber framed walls.

6 Detailed Seismic Assessment

This DEE has been based on the NZSEE 2006 [2] guidelines for the "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" together with the "Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure" [3] draft document prepared by the Engineering Advisory Group on

19 July 2011, and the SESOC guidelines "Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes" [5] issued on 21 December 2011.

6.1 Critical Structural Weaknesses

The term Critical Structural Weakness (CSW) refers to a component or structural feature of a building that could contribute to increased levels of damage or cause premature collapse of a building.

There were no potential CSW's identified in this building:

6.2 Quantitative Assessment Methodology

The probable seismic performance of the building has been assessed in accordance with the recommendations of the NZSEE publication "Assessment and Improvement of the Structural Performance of Buildings in Earthquakes" [2] dated June 2006 (Including Corrigendum No.1). The following sections in particular have been used in this assessment:

» Section 10 "Detailed Assessment of URM Buildings".
» Section 11 "Detailed Assessment of Timber Structures.

The performance of the timber floor diaphragm and URM walls have also been assessed in accordance with the recommendations of the NZSEE publication "Assessment and Improvement of Unreinforced Masonry Buildings for Earthquake Resistance" [18] dated February 2011. The following sections in particular have been used in this assessment:

» Section 2 "Material Properties of Masonry Walls".
» Section 3 "Material Properties of Flexible Timber Floor Diaphragms".
» Section 10 "Out-of-Plane Wall and Parapet Response".

The probable Earthquake loading for this building has been calculated from NZS 3604:2011 "New Zealand Standard – Timber Framed Buildings" [19].

The building has been classed as Importance Level 2 (IL2) in accordance with AS/NZS1170.0 as requested by the client. The client has advised that it is not critical for this building to remain operational post–earthquake.

The building has been assessed using a force based approach by applying the forces that may be expected to be applied to the building by the design earthquake. Calculations were performed on critical elements of the building in order to assess their likely performance in an earthquake. This performance has been measured as a %NBS (New Building Standard), that is as a percentage of the capacity that would be required for the design of an equivalent new building on this site.

Computer based modelling of this building was not carried out as part of this evaluation.

6.3 Limitations and Assumptions in Results

Our analysis and assessment is based on our inspections of the building which indicate the structure to be generally in sound condition.

The results have been reported as a %NBS and the stated value is that obtained from our analysis and assessment. Despite the use of best national and international practice in this analysis and assessment, this value contains uncertainty due to the many assumptions and simplifications which are made during the assessment. These include:

» The normal variation in material properties which change from batch to batch.
» Approximations made in the assessment of the capacity of each element.

6.4 Seismic Coefficient Factors

The following seismic coefficient factors have been used in the evaluation of this building:

» Design life of building = 50 years, refer NZS1170.5 [1].
» Soil class D (deep), refer NZS1170.5 [1] and Tonkin and Taylor Geotechnical Report [17].
» Building Importance Level 2, refer AS/NZS1170.0.
» Seismic risk factor Ru = 1.0.
» Seismic zone 3, refer NZS3604:2011, Figure 5.4; Zone z = 0.30, refer AS/NZS1170.5:2004.
» Ductility μ = varies (refer Table 6-1).

6.5 Material Properties

Assessments of material strengths are based on limited drawings and site inspections. Characteristic material properties have been typically based on NZSEE guidance [2], [7] and [8]. Probable material strengths have been used for the assessment of member capacities in accordance with NZSEE guidance [18].

The following nominal material properties have been used in the assessment:

» f'_j = 26.9MPa (average brick compressive strength).
» f'_b = 5.5MPa (average mortar compressive strength).

The in-plane bracing capacity of the plasterboard lined, timber framed walls was determined using the internal Opus guidance document: Guidelines for the Detailed Engineer Evaluation of Timber Buildings [20].

Refer to Appendix C for further detail on the assessment methodology.

6.6 Quantitative Assessment

A summary of the structural performance of the building is shown in the following table. Note that the values given represent the worst performing elements in the building, as these effectively define the building's capacity. Other elements within the building may have significantly greater capacity when compared with the governing elements. This will be considered further when developing the strengthening options.

Table 6-1: Summary of Seismic Performance

Structural Element/System	Failure mode or description of limiting criteria based on capacity of critical element	Critical Structural Weakness	% NBS based on calculated capacity
URM walls	Out of plane failure of double leaf URM walls.	No	20% ($\mu = 1$)
Timber floor diaphragm	Deformation capacity of floor diaphragm exceeded	No	20% ($\mu = 3$)
Plasterboard lined timber framed walls	In plane racking failure of timber framed, plasterboard walls.	No	22% ($\mu = 2$)
Reinforced concrete foundation walls	In plane shear. This assumes no contribution from rocking of reinforced concrete piles.	No	≥100%NBS ($\mu = 2$)

6.6.1 Building Drifts

As computer modelling of this building has not been performed, building drifts have not been assessed. However, as the building has been assessed in accordance with the design guidelines of NZS3604 [19], it is unlikley that drift limits will be exceeded prior to failure of structural elements within the building.

6.7 Discussion of Results

The quantitative assessment of this building indicates that the building has the following seismic capacity:

» Seismic capacity in transverse (east – west direction) = 20%NBS.
» Seismic capacity in longitudinal direction (north – south direction) = 20%NBS.

The capacity in both directions is governed typically by the out of plane capacity of the internal URM walls and the capacity of the timber floor diaphragm

Note that the seismic capacity of this building reduces to 15%NBS if the building is to be considered as an IL3 structure.

This building is Earthquake Prone. It is expected that the building will sustain significant damage under a design level earthquake (500year return period).

This building does not require strengthening in accordance with BDC policy [6] unless the DHB wish to apply for a building consent or change the use of the building.

7 Summary of Geotechnical Appraisal (Tonkin and Taylor Ltd)

7.1 General

A geotechnical assessment [17] has been completed by Tonkin & Taylor Ltd for the Canterbury District Health Board at Buller Hospital, Westport. The purpose of the investigation was to provide geotechnical recommendations for the proposed hospital development and evaluate the liquefaction risk for the existing buildings at the hospital campus. The assessment comprised:

- A review and compilation of geologic and geotechnical information, including data from T&T's database, pertaining to the site and surrounding vicinity,
- Four machine drilled boreholes to a maximum depth of 15.5m below ground level, and,
- Six Cone Penetration Tests (CPTs) to a maximum depth of 5.6 m below ground level.

Figure 7-1 below shows the location of the tests that were carried out across the site.

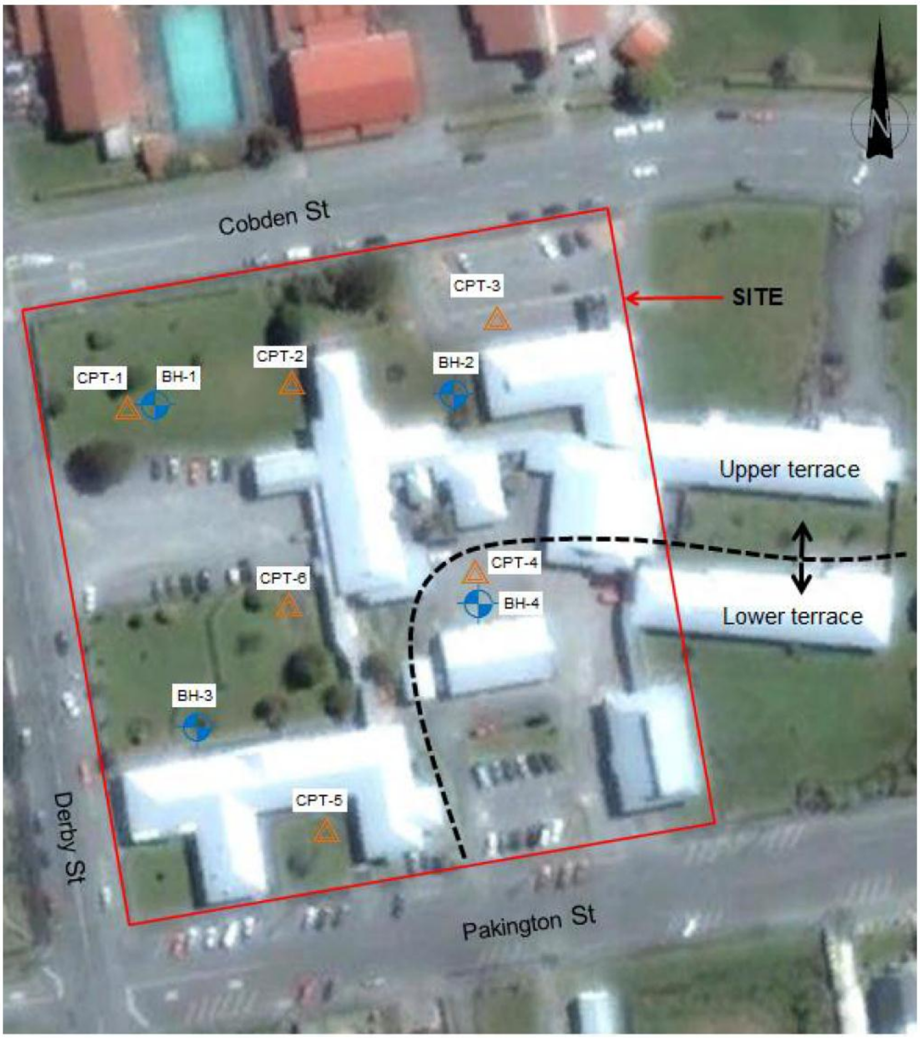

Figure 7-1: Geotechnical site plan

7.2 Geotechnical Appraisal

The soil profile consists of alternating layers of silt, sandy silt and sand overlying dense to very dense sand and gravel. The thickness of the silt, sandy silt and sand layers varies across the site; to the west they are 1.5 – 2.0m thick, and 4.0 – 5.0m thick to the east. Tables 7-1 and 7-2 give additional detail for the west and east portions of the site respectively. The west and east portions of the site have been defined as approximately halfway through the site, running parallel to Derby St.

Table 7-1: Geotechnical model for west of site

Soil layer	Description	Approximate depth to top of layer	Approximate thickness of layer
1	Silty FILL and SAND. Silty FILL is stiff, SAND is medium dense.	0m	0.7 – 1.0m
2	SILT and Sandy SILT. Firm to very stiff.	0.7 – 1.0m	0.8 – 1.3m
3	Interbedded Sandy GRAVEL and SAND layers. Dense to very dense.	1.5 – 2.0m	5.5 – 6.0m
4	SAND with PEAT/organic SILT lens. Very dense.	7.5m	8.0m +

Table 7-2: Geotechnical model for East of site

Soil layer	Description	Approximate depth to top of layer	Approximate thickness of layer
1	FILL: Gravelly, sandy and silty. Medium dense.	0m	0.7 – 1.7m
2	SAND and silty SAND. Loose to medium dense.	0.7 – 1.7m	1.9 – 2.0m
3	SILT. Soft to stiff.	2.6 – 3.7m	0.8 – 1.1m
4	Interbedded Sandy GRAVEL and SAND layers. Medium dense to very dense.	3.6 – 4.6m	4.4 – 5.4m
5	SAND. Very dense.	9m	6.5m +

7.3 Liquefaction Assessment

The liquefaction assessment indicates there is a risk of liquefaction induced damage in large earthquakes. This risk is variable across the site; the worst ground conditions are present in the north-east corner. Here, liquefaction induced ground damage is expected to be 'Moderate' in an ULS (1/1000 yr) earthquake. This corresponds to liquefaction occurring in layers of limited thickness, and ground deformation resulting in free field (i.e. away from buildings) settlements in the order of 100mm. For the remainder of the site, liquefaction induced ground damage is expected to be 'Mild' in an ULS (1/1000 yr) earthquake. This corresponds to liquefaction of relatively thin soil layers and minor ground deformation resulting in free field settlements in the order of 50mm.

No liquefaction is expected to occur in a SLS (1/25 yr) earthquake.

7.4 Geotechnical Summary

The foundations of the existing buildings are not expected to experience severe damage due to liquefaction. Some minor liquefaction induced damage to building foundations is likely in large earthquakes; this damage may include differential settlement of the floor, settlement and lateral displacement of timber piles, cracks to the perimeter footings and cracks to the brick cladding. This damage is expected to be repairable and not significantly disrupt hospital operations

8 Remedial Options

Possible strengthening concepts to improve the seismic performance of the building are included in Table 8-1 below.

Table 8-1: Possible Strengthening Techniques for Building

Structural Element/System	Possible strengthening techniques
Internal URM walls	• Remove and reinstate with timber framed walls, or • Tie the two leafs of brickwork together with Helifix (or similar) ties.
Timber floor diaphragm	• Improve connections bearer to pile, joist to bearer, bearer to reinforced concrete foundation wall, joist to reinforced concrete foundation wall. • Install anchor piles at select locations.
Plasterboard lined timber framed walls	• Remove internal linings on selected walls and install new hold down fixings. • Reinstate internal linings with Gib Braceline or similar to improve performance of wall.

9 Conclusions

The seismic performance of the X-Ray building has been assessed as:

- Seismic capacity in transverse (east – west direction) = 20%NBS.
- Seismic capacity in longitudinal direction (north – south direction) = 20%NBS.

There were no Critical Structural Weaknesses identified in the assessment of this building.

Note that if the building is to be considered as an IL3 building, then this capacity further reduces to 15%NBS.

Therefore the X-Ray building is classed as Earthquake Prone as it has a seismic capacity less than 33%NBS and the building is classed as a "high risk" building in accordance with NZSEE [2].

This building does not require strengthening in accordance with BDC policy [6], unless the building owner is to apply for a building consent or change of use application, or if the building is deemed dangerous by BDC. However, given the poor performance of the building, we strongly recommend strengthening be carried out. Strengthening to a minimum of 67%NBS is recommend in accordance with NZSEE [2].

10 Recommendations

A staged approach is recommended as follows in order to understand and manage the economic impact of any proposed remedial actions:-

a. The implications of the IL2 classification for this building should be carefully considered prior to carrying out any future works on this building, noting that with an IL2 classification, this building is not expected to remain operation post-disaster.
b. An outline scheme for structural strengthening – with a view to achieving at least 67%NBS should be further developed with sufficient information so that costing's can be put to the proposed works.
c. A quantity surveyor should be engaged to determine the costs for either strengthening the building or demolishing and rebuilding. There will be a certain risk element in these costings in that it will be necessary to allow for possible foundation strengthening or soil stabilisation works and the extent and nature of these will not be known until full investigations are carried out.
d. Carry out detailed design of a scheme for the strengthening of the structure.

11 Limitations

a. This report is based on a visual inspection of the structure of the X-Ray building, intrusive investigation at discrete selected locations, and a quantitative assessment of the building.
b. Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time.
c. This report is prepared for WCDHB to assist with assessing the seismic capacity of this building. It is not intended for any other party or purpose.

12 References

[1] NZS 1170.5: 2004, *Structural design actions, Part 5 Earthquake actions,* Standards New Zealand.

[2] NZSEE: 2006, *Assessment and Improvement of the Structural Performance of Buildings in Earthquakes,* New Zealand Society for Earthquake Engineering.

[3] Engineering Advisory Group, *Guidance on Detailed Engineering Evaluation of Earthquake Affected Non-residential Buildings in Canterbury, Part 2 Evaluation Procedure*, Draft Prepared by the Engineering Advisory Group, Revision 5, 19 July 2011.

[4] Engineering Advisory Group, *Guidance on Detailed Engineering Evaluation of Non-residential buildings, Part 3 Technical Guidance*, Draft Prepared by the Engineering Advisory Group, 13 December 2011.

[5] SESOC, *Practice Note – Design of Conventional Structural Systems Following Canterbury Earthquakes*, Structural Engineering Society of New Zealand, 21 December 2011.

[6] Buller District Council, *Dangerous, Earthquake Prone and Insanitary Buildings Policy,* Adopted 16 December 2009.

[7] NZSEE: *Assessment and Improvement of Building Foundations for Earthquake Resistance,* New Zealand Society for Earthquake Engineering, February 2011.

[8] NZSEE: *Assessment and Improvement of Unreinforced Masonry Buildings for Earthquake Resistance,* New Zealand Society for Earthquake Engineering, February 2011.

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[10] Buller District Council, *Lifelines Study,* Buller District Council, 2006.

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[14] NZS 3101: Part 2: 2006, *Concrete Structures Standard, Commentary on the Design of Concrete Structures*, Standards New Zealand.

[15] NZBC, *Clause B1 Structure, Verification Method B1/VM1*, Department of Building and Housing.

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[17] Buller Hospital, Westport, Geotechnical Report, Tonkin & Taylor Ltd for Canterbury District Health Board, October 2012. T&T Ref: 53147.

[18] NZSEE: *Assessment and Improvement of Unreinforced Masonry Buildings for Earthquake Resistance*, New Zealand Society for Earthquake Engineering, February 2011.

[19] NZS3604:2011: *New Zealand Standard – Timber Framed Buildings*, Standards New Zealand, 2011.

[20] *Guidelines for the Detailed Engineer Evaluation of Timber Buildings*, Opus International Consultants Ltd, 19 July 2012.

Appendix A

PHOTOGRAPHS

X-Ray Building – Buller Hospital	
No.	**Photo**
General	
1.	South elevation.
2.	South east corner of building.
3.	South west corner of building.
4.	Roof structure.
5.	External timber framed wall and brick veneer cladding.
6.	Plasterboard lining.
7.	Internal double leaf URM walls.
8.	Typical concrete piles and timber subfloor.

Photo 1: South elevation.

Photo 2: South east corner of building.

Photo 3: South west corner of building.


Photo 4: Roof structure.

Photo 5: External timber framed wall and brick veneer cladding.

Photo 6: Plasterboard lining.


Photo 7: Internal double leaf URM walls.


Photo 8: Typical concrete piles and timber subfloor.

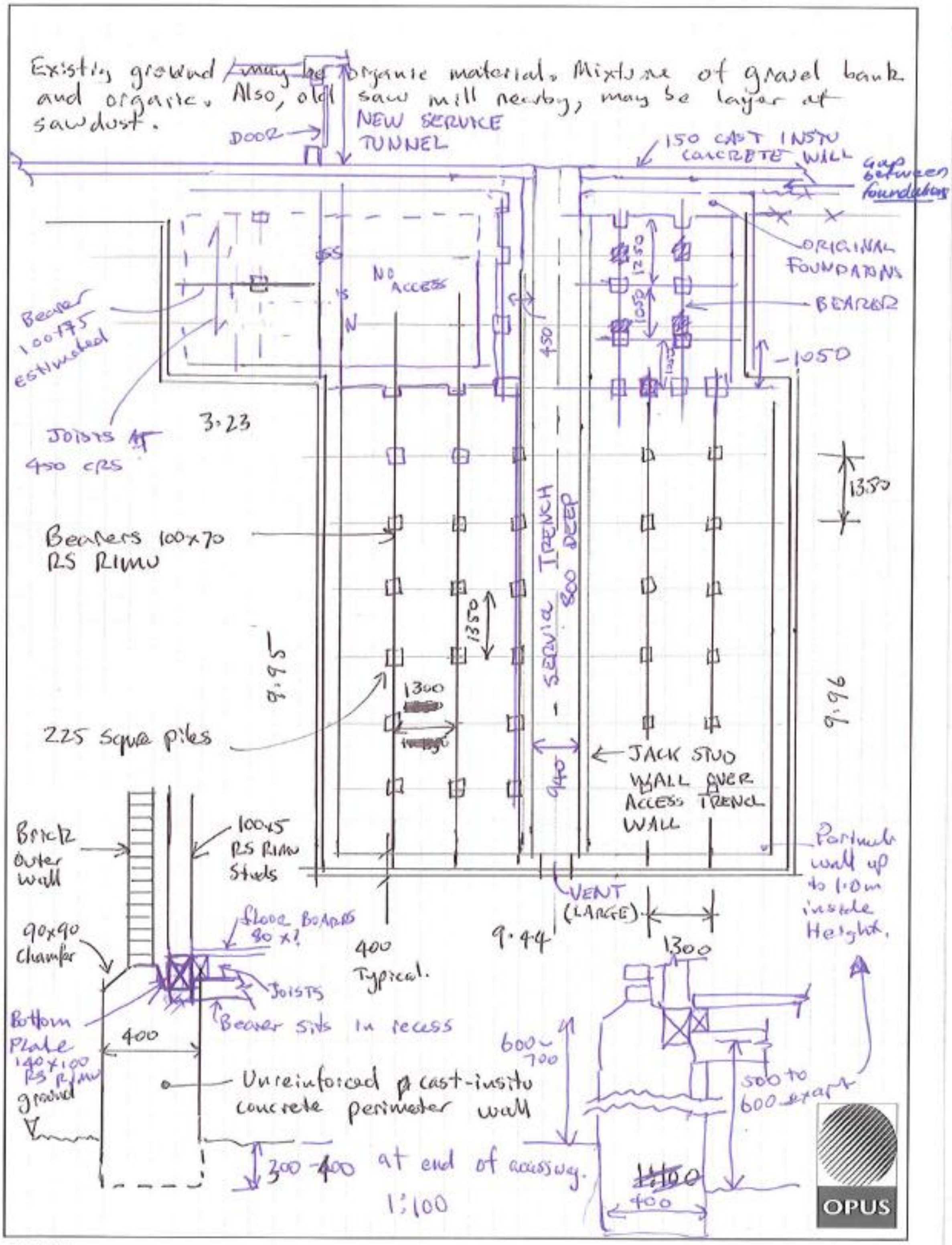
Appendix B

DRAWINGS

X-Ray Building – Buller Hospital	
No.	**Drawings**
General	
1.	Foundation Plan
2.	Foundation Details
3.	Roofing Details
4.	Roofing Plan
5.	Floor Plan

Calculation Sheet

Project/Task/File No:	Sheet No of
Project/Description:	Office:
	Computed: / /
X-RAY BUILDING – FOUNDATION PLAN	Checked: / /



CSF 400 (7/2600)

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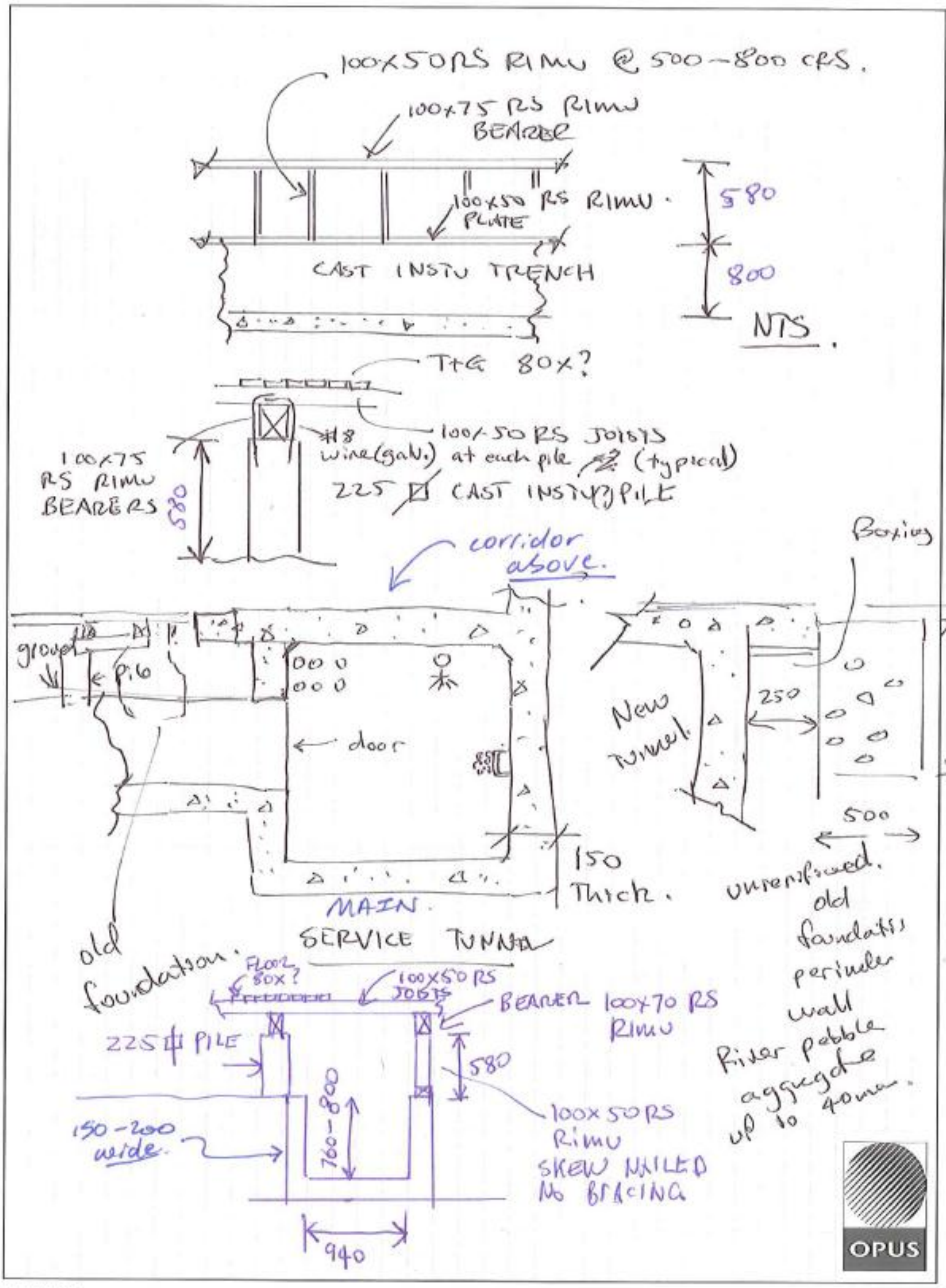

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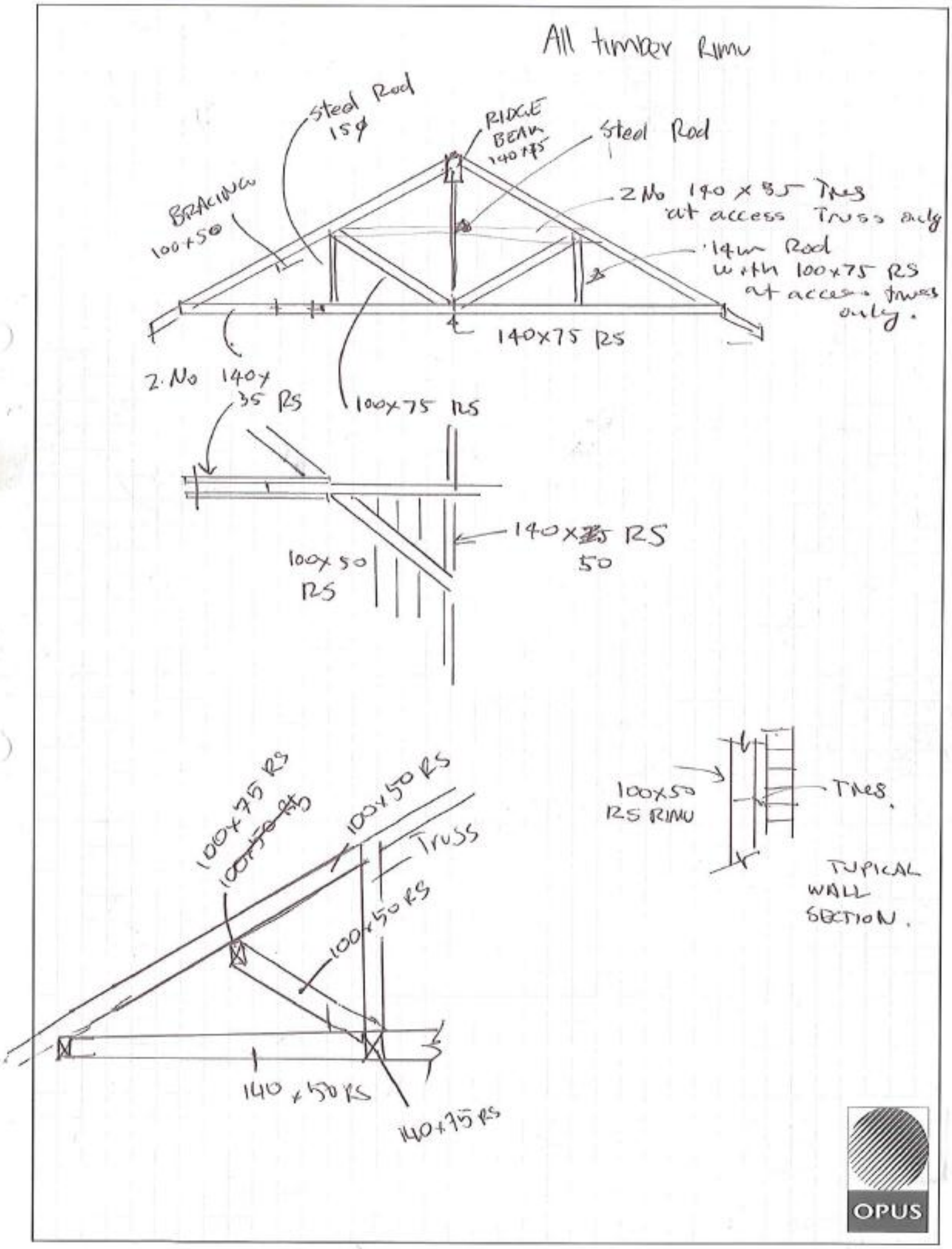
X-RAY ROOM – ROOFING DETAILS	Checked: / /



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Calculation Sheet

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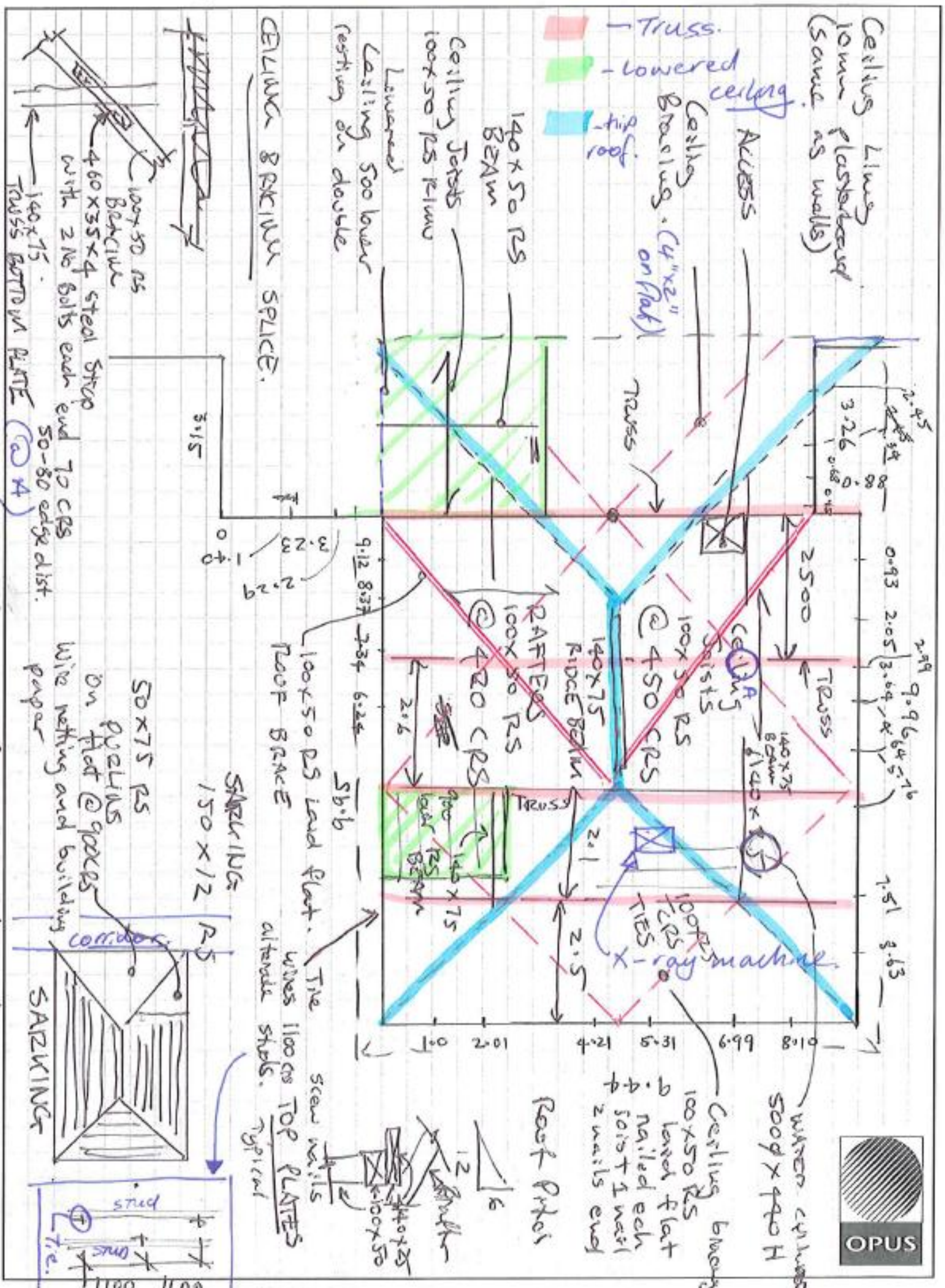
| Computed: / /
XRAY ROOM – ROOFING PLAN | Checked: / /



12.6
3.5
3.8

Calculation Sheet

Project/Task/File No: 6-WCAN1.02
Project/Description: BULLER HOSPITAL

XRAY ROOM – FLOOR PLAN

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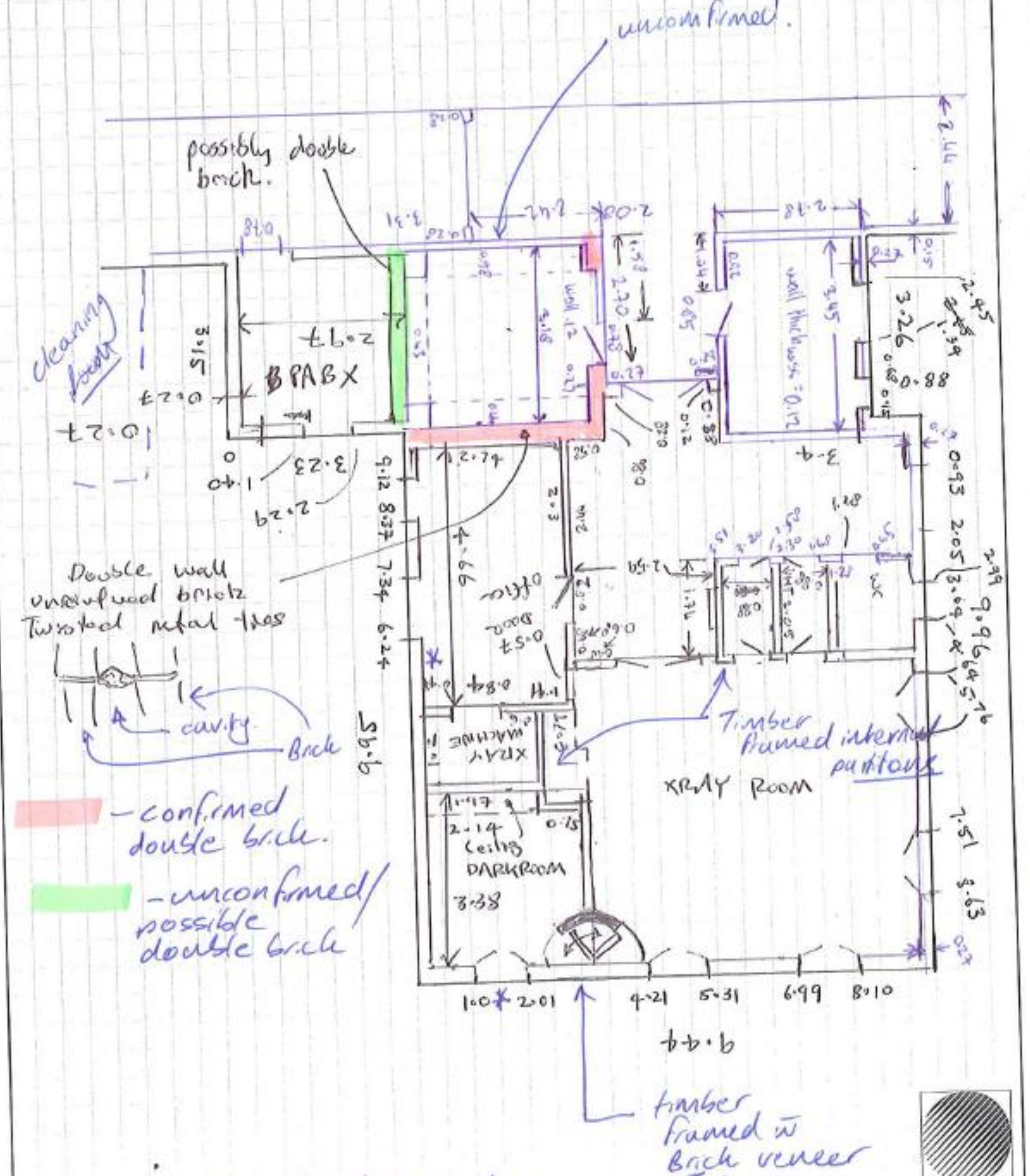
Wall ceiling height : 3.06m
Sill heights ≈ 0.8m



* - denotes location of core thru internal lining.

Appendix C

QUANTITATIVE ASSESSMENT METHODOLOGY AND ASSUMPTIONS

C1 Analysis Parameters

The following parameters are used for the seismic analysis:

HORIZONTAL SEISMIC COEFFICIENT:

» Site soil category — Cl. 3.1.3, NZS1170.5, Buller District Council Lifelines Study, June 2006, Final.
D (deep soil)

» Earthquake zone – Zone 3 — Figure 5.4, NZS3604: 2011
Earthquake zone factor z = 0.30 — NZS1170.5:2004 (Westport)

» Return period factor — Table 3.5, NZS1170.5
$R_u = 1.0$ (Importance Level 2 structure, 50 year design life)

» Ductility factor
μ varies (refer table 6-1)

» Fundamental Period — Study Report No. 168 (2007), The Engineering Basis of NZS3604, BRANZ.
$T_i \leq 0.45s$

» Material properties

Table C1: Analysis Material Properties

Average brick compressive strength, f'_b (MPa) [(1)]	26.9
Average mortar compressive strength, f'_j (MPa) [(1)]	5.5
URM wall, bed joint coefficient of friction, μ [(1)]	0.65

Notes:
1. Based on guidance from *NZSEE 2011,* Assessment and Improvement of Unreinforced Masonry Buildings for Earthquake Resistance, Section 2 – Material Properties of Masonry Walls.

LOAD COMBINATIONS:

» Earthquake load combination — Cl. 4.2.2, AS/NZS1170.0
$G + E_u + \Psi_E Q$

» Floor live loading — Table 3.1 Part B, AS/NZS1170.1
$Q = 3.0\ kPa$

» Earthquake combination factor — Table 4.1, AS/NZS1170.0
$\Psi_E = 0.3$

» Building seismic weight — Cl. 4.2, NZS1170.5
$W_t = G + \Psi_E Q$

BRACING CAPACITIES:

The bracing capacities of the timber framed walls have been taken from the Opus technical guidance document: “Guidelines for Detailed Engineering Evaluation of Timber Frame, July 2012”. These bracing capacities are noted in Table C2 below:

Table C2: Recommended Wall Bracing Units for Assessing Pre-1978 Light Timber Frame Buildings

Wall Lining	Capacity (BU/m)	Basis
Gypsum board one side (Gib board) (minimum length 600mm)	42	70% of Gib EzyBrace GS1-N allowing for not fully complying with nailing, etc.
Gypsum board both sides (Gib board) (minimum length 600mm)	57	70% of “Gib EzyBrace GS2-N” allowing for not fully complying with nailing, etc.
Plywood, compressed sheet ≥7mm thick (minimum length 600mm)	80	60% of “Ecoply EP1” allowing for not fully complying with nailing, anchors, etc.
Plywood, hardboard <7mm thick (minimum length 600mm)	40	50% plywood
Softboard (Pinex) (minimum length 1.2m)	10	Based on one timber brace at 4m crs
Lath and plaster (minimum length 1.2m)	10	Based on timber brace
Timber (match lining or weatherboard) (minimum length 1.2m)	20	From NZSEE 2011.

Using Table C2, internal walls within the building have been assigned a capacity of 57BU/m and external walls 42BU/m.

C2 Assessment Methodology

The seismic assessment was undertaken by calculating the wall bracing unit demand from NZS 3604:2011 and the capacities from Table 1 above. This assessment methodology was adopted as the distribution of bracing walls throughout the building is generally in accordance with NZS 3604.

NZS3604:2011 earthquake bracing demands are based on the "Equivalent Static Method" with a fundamental period $T_i \leq 0.45s$. The ductility has been varied as appropriate to suit the element being assessed.

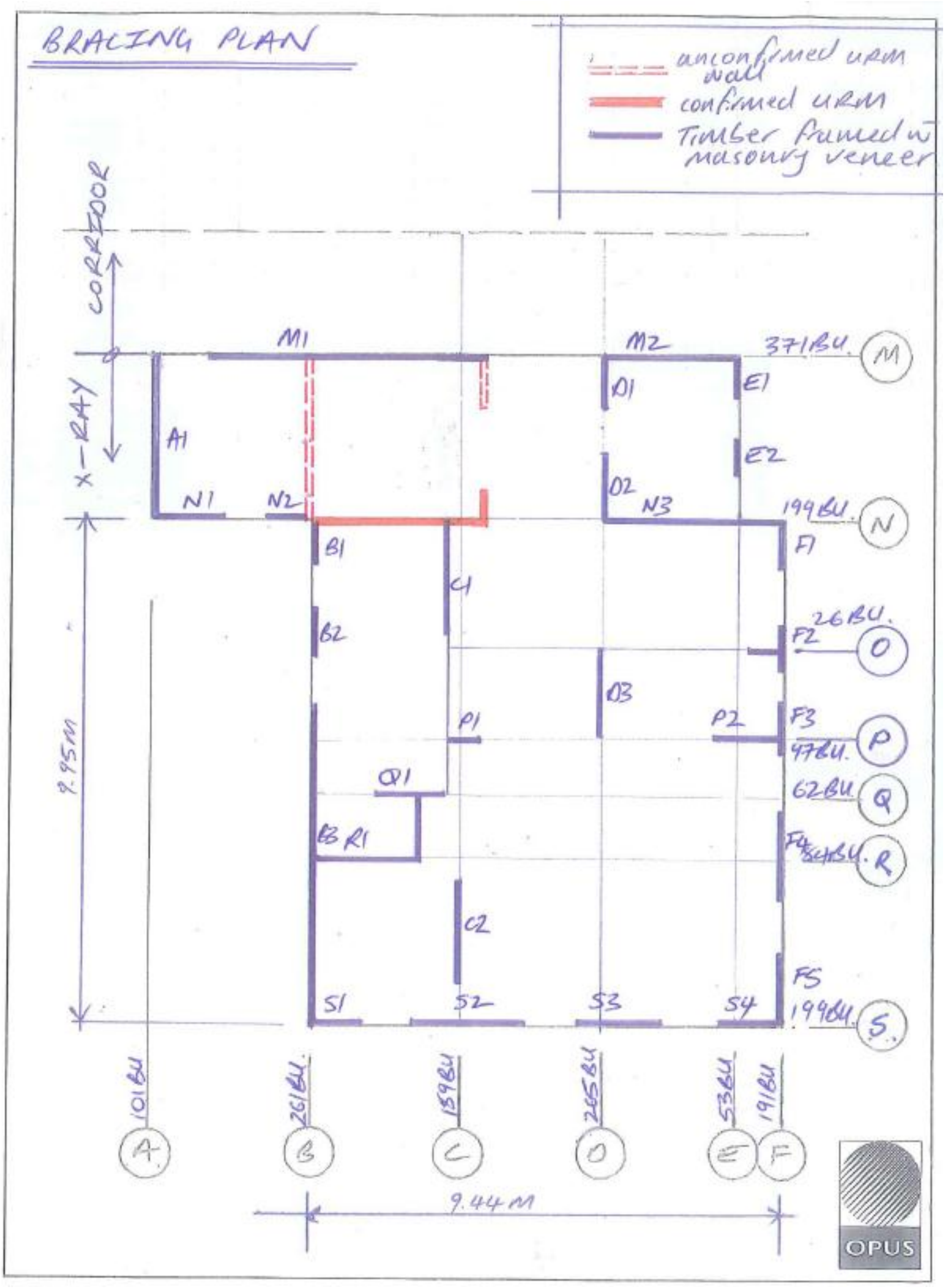


Figure D1: Buller X-Ray Building – Bracing Plan

The Earthquake Bracing Demands from NZS3604:2011 were calculated as noted in Table C3 below.

Table C3: Earthquake Bracing Demand

Direction	Walls	Subfloor
Longitudinal	3060BU	4029BU
Transverse	3060BU	4029BU

Opus International Consultants Ltd
23 High Street
PO Box 365, Greymouth 7840
New Zealand

t: +64 3 769 9330
f: +64 3 768 7498
w: www.opus.co.nz