DETAILED SEISMIC ASSESSMENT FOR 38 NORMANDALE ROAD, MINOH HOUSE, LOWER HUTT.

DSA REPORT

Project alternative address:
91 WESTERN HUTT ROAD,
NORMANDALE, LOWER HUTT 5010

Client:
HUTT CITY COUNCIL

Project Ref:
P330

SEISMIC SOLUTIONS

RESIDENTIAL | COMMERCIAL | RETAINING WALLS & FOUNDATIONS | SEISMIC ASSESSMENT | SEISMIC STRENGTHENING | CONSTRUCTION MONITORING

DOCUMENT CONTROL RECORD

CLIENT:	Hutt City Council
PROJECT ADDRESS:	38 Normandale Road, Minoh House, Lower Hutt. 5010
PROJECT ALTERNATIVE ADDRESS:	91 Western Hutt Road, Normandale, Lower Hutt. 5010
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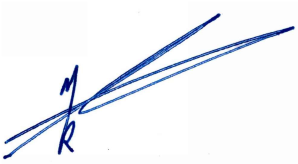

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EXECUTIVE SUMMARY

This assessment is intended to determine the building's seismic rating in terms of the percentage of the New Building Standard (%NBS) and propose structural work to maintain at least 40% NBS (IL2). The detailed seismic assessment is done by quantifying the strength capacities of the wall-framed bracing structural elements under imposed earthquake actions. The report does not assess the gravity load system, strength of roof and floor diaphragms, foundation capacity, or slope failure for the building of interest.

The assessed property is a two-storey light timber framed building with a light timber roofing system. The timber subfloor is supported by perimeter foundation walls and anchored piles. The building was constructed circa 1904 and then upgraded circa 1998. There have been several walls removed from the first floor during this upgrade without any replacement, which adversely affects the building's bracing capacity in the transverse direction. There are also two heavy/tall brick chimneys running from the ground level up to 2.5m above the ceiling level, making both of them considerably earthquake-prone.

The assessment is conducted using the document *The Seismic Assessment of Existing Buildings – Section C9 for timber buildings* issued in July 2017 by the New Zealand Society for Earthquake Engineering (NZSEE).

A recent initial seismic assessment (ISA) using the IEP method shows the presence of the chimneys poses a significant structural weakness bringing down the building scores to **<34% NBS (IL2)**, which corresponds to seismic grade **D (High Risk)** building. The reported %NBS score is below the threshold for Earthquake Prone Buildings (34%NBS), and thus structural improvement to increase seismic building performance is legally required.

A detailed analysis of the structure concludes that:

The existing building **(Option 1)** is rated < **34% NBS (IL2),** which correspond to seismic grade **D (High-Risk Building)**.

Two main factors contribute to this poor %NBS score: 1- Insufficient bracing capacity in the transverse direction on both ground and first floors for external walls along Grid A. 2- The existing earthquake-prone chimneys.

The addition of timber bracing walls along Grid A at both floors and the removal of chimneys above the ceiling level **(Option 3)** level would result in **43% NBS (IL2) >40%**, which is the given criteria by the client.

Additional bracing walls in the longitudinal direction at the ground floor **(Option 4)** can result in **53% NBS (IL2)**, which is recommended.

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1. INTRODUCTION

Seismic Solutions Limited has been engaged by **Hutt City Council** to perform a Detailed Seismic Assessment (DSA) of the building located at 38 Normandale Road, Minoh House, Lower Hutt. We have based our DSA on the following information sources:

- We obtained and reviewed archived drawings from Hutt City Council
- We reviewed the ISA reports issued on 28 July 2022 by Seismic Solutions Limited. The building exterior and interior inspection was already conducted on 11 July 2022.

2. DSA BACKGROUND

A Detailed Seismic Assessment (DSA) is based on Part A and C or the Seismic Assessment of Existing Buildings – Technical Guidelines for Engineering Assessments, by the New Zealand Society for Earthquake Engineering (NZSEE), Structural Engineering Society (SESOC), New Zealand Geotechnical Society (NZGS) and Ministry for Business, Innovation and Employment (MBIE)

A DSA is a quantitative procedure used to determine an earthquake rating for a building based on the minimum expectations and requirements for a new building. The information from a DSA may be used by the Territorial Authorities to determine whether or not a building is earthquake prone under the Building Act. A DSA should help building owners to understand and be able to improve the seismic safety of their buildings and, where necessary, prioritise any mitigation works. Critical elements within a building will be identified in a DSA and possible retrofits needs. The earthquake rating given in a DSA has a level of conservatism that is appropriate for the level of detail available at the time of the assessment.

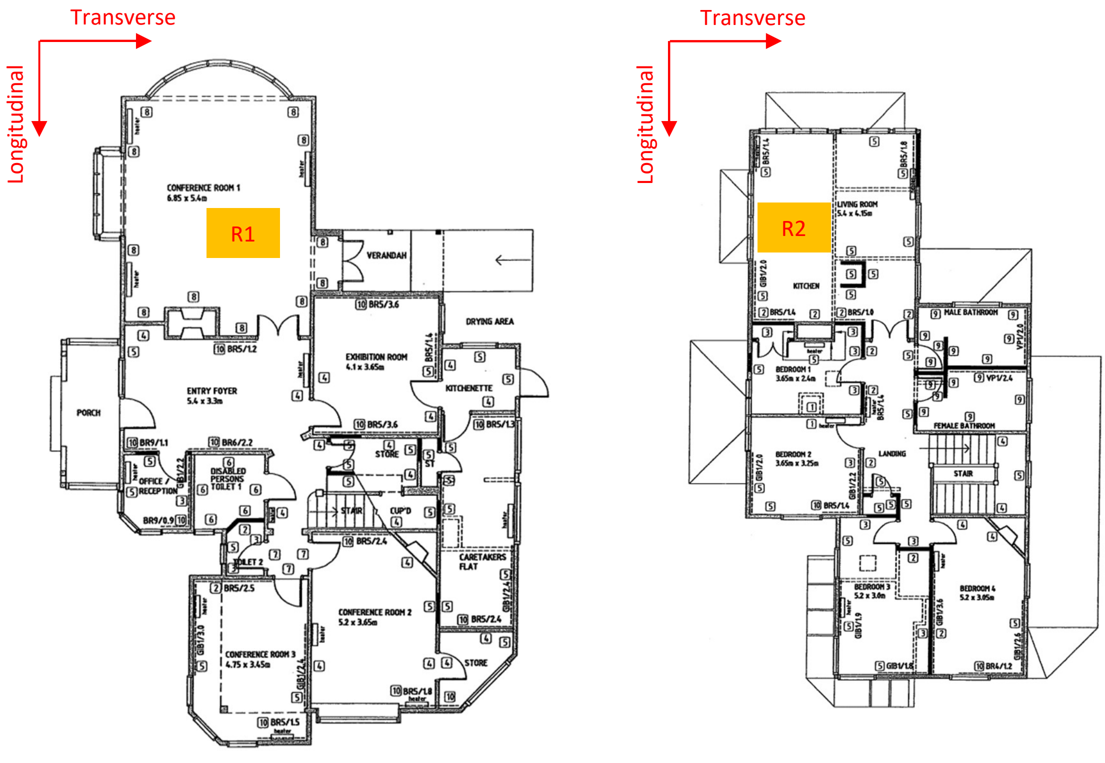
Any element that limits the earthquake rating to below 100% NBS is referred to as a structural weakness (SW). The SW that limits the earthquake rating of the building is referred to as the critical structural weakness (CSW). A Severe Structural Weakness (SSW) is defined as a structural weakness that is potentially associated with catastrophic collapse and for which the capacity may not be reliably assessed based on current knowledge.

3. BUILDING DESCRIPTION

3.1 GENERAL

The building of concern is a two-storey timber storey structure. According to the information from the Heritage New Zealand website, the building was built circa. 1904. The building was used as a residential until around the 1990s-2000s when the ground floor had a change of use to an event centre. Currently, the first floor (1F) of the building is used as a dwelling whichcontains bedrooms, living room, dining room, batrooms and kitchen. The ground floor (GF) of the building is open to the public for gathering, meetings, exhibitations, events, etc.

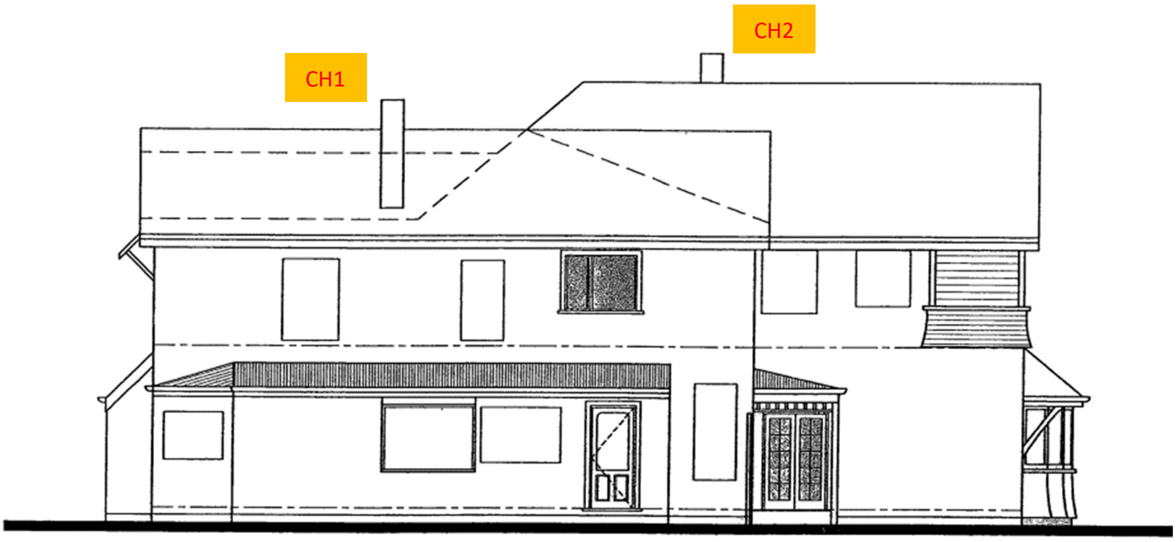
Figure 1 shows the first floor and ground foor plan proposed for the 1998 upgrades. The building has light timber frames with a light timber roof. The timber subfloor sits on top of perimeter foundation walls and anchored piles. In 1998 the building was upgraded, the wall linings were relined, and new timber subfloor, concrete piles and new concrete foundation walls were installed.



Ground Floor Plang **First Floor Plan**

Figure 1. Existing Plan of the property located at 38 Normandale Road, Minoh House, Lower Hutt.

As can be seen on Figure 1, several walls have been removed (shown with dashed line in the figure) due to the 1998 upgrade. There is no evidence in the HCC archives showing adequate compensating actions carried out after the wall removal, which would negatively affect the lateral bracing capacity of the building specifically along the transverse direction. This weakness can be a significant issue in regions R1 and R2 as marked in Figure 1. The presence of two heavy/tall brick chimneys (Figure 2), making them earthquake-prone non-structural elements, in the building can pose a life safety risk and can decrease the building score to values < 34% NBS (IL2) corresponding to seismic grade D (High Risk) buildings.Thus structural improvements to increase seismic building performance is legally required. The location of the property is shown in Figure 3.



North Eath Elevation

Figure 2. North east elevation of the property located at 38 Normandale Road, Minoh House, Lower Hutt, showing the chimneys marked CH1 and CH2.

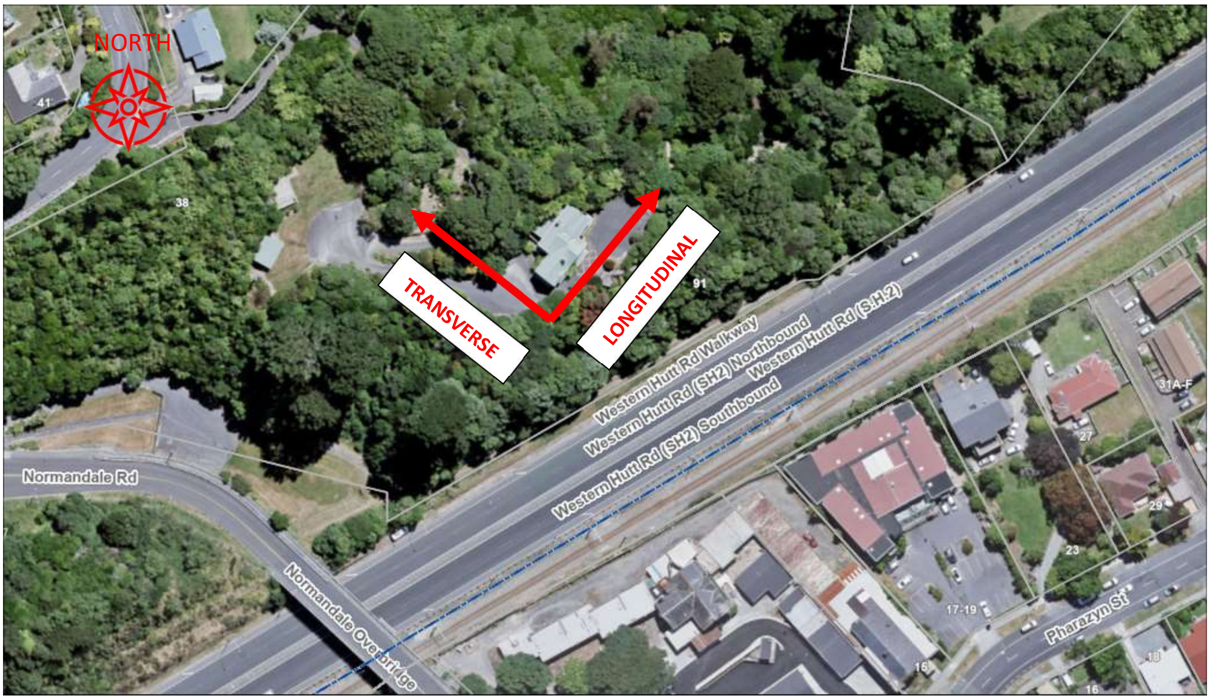


Figure 3. Location map for the building at 38 Normandale Road, Minoh House, Lower Hutt.

3.2 GEOGRAPHY AND GEOTECHNICAL ASPECTS

The location of Wellington fault line with respect to the building being assessed herein is shown in Figure 4. The Wellington fault is an oblique dextral strike-slip fault, expected to offset about 5 metres horizontally at the surface, and capable of generating a M_w 7.5 earthquake, with a probability of producing large earthquakes every 500 to 1000 years. The segment of Wellington fault last ruptured 710 to 870 years ago and has a probability to rupture of 11% in the next 100 years.

The building is roughly 200 m to the South-East of the Wellington Fault line trace. The estimated natural period of vibration of the building is less than 0.4 seconds and therefore is not sensitive to near-fault directivity effects as per provisions of the near-fault effects listed in AS/NZS 1170.5. Soil testing has not been completed as part of this DSA but reasonable data is available in technical literature, on NZGS database and our knowledge of working with buildings in the same area.

The underlying soil at the site is considered to be likely subsoil class B. Figure 5 shows a low risk for seismic slope failure at the location of the assessed building. Liquefaction analysis is outside the scope of this assessment. However, Figure 6 shows low liquefaction risk, and its likely impacts on the timber-framed structure supported by piles could be negligible to pose a life safety risk. Given the size and structural configuration of the building, the building's seismic response is likely to be dominated by the superstructure.

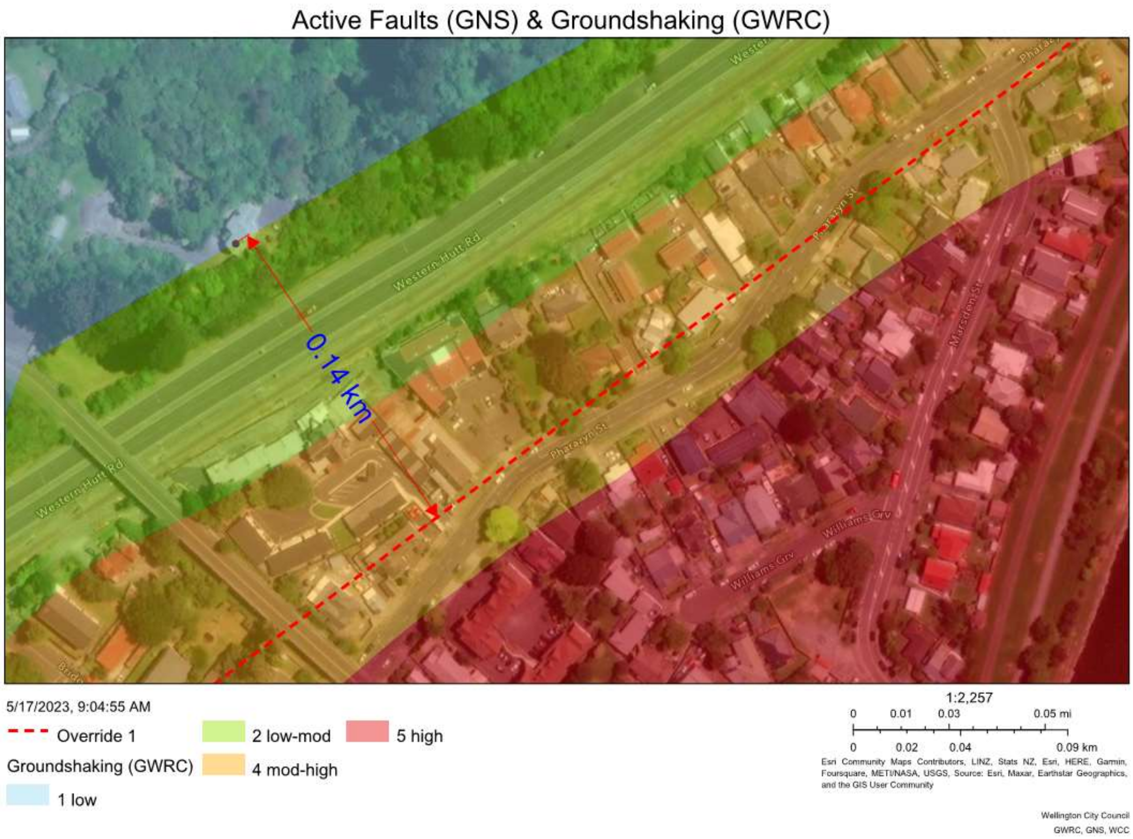


Figure 4. Location of the building and active fault (GWRC Webmap)

Figure 5. Location of the building and eismic slope failure (GWRC Webmap)

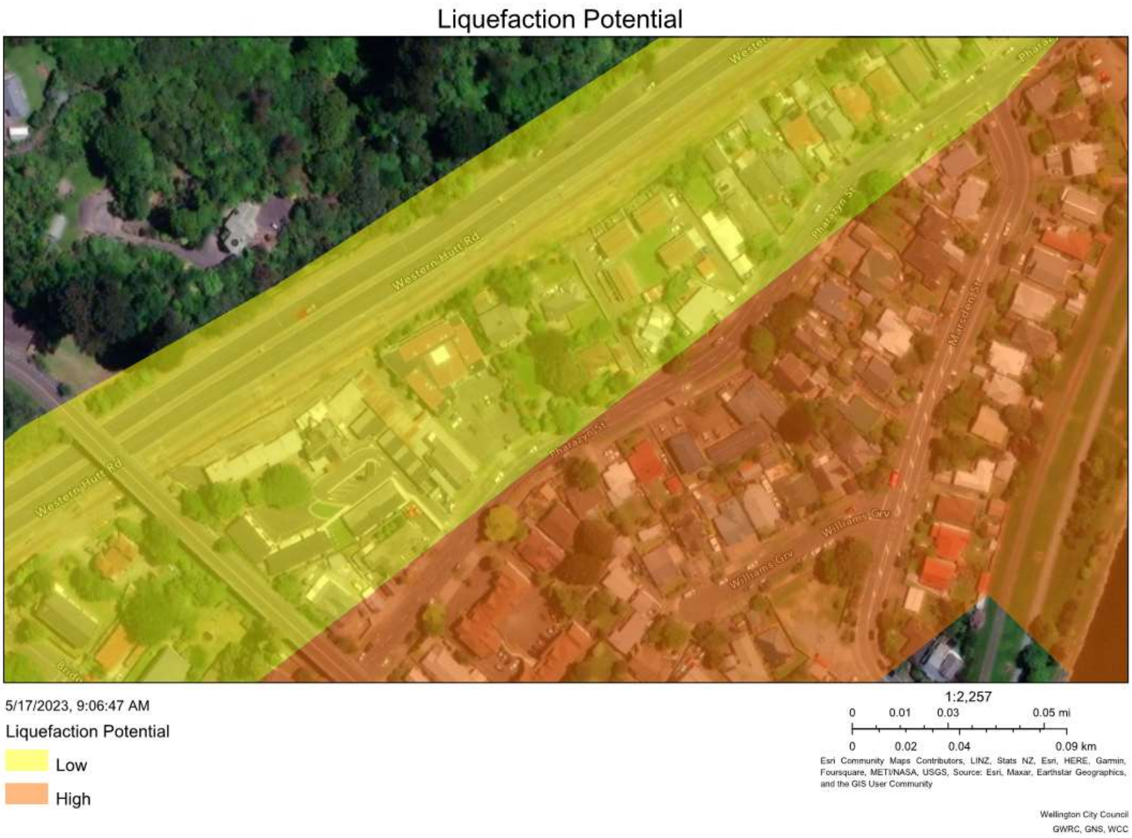


Figure 6. Location of the building and liquefaction risk (GWRC Webmap)

4. ASSESSMENT METHODOLOGY

4.1 PERCENTAGE NEW BUILDING STANDARD (%NBS)

The level to which a building can perform in an earthquake is quantified as a percentage of New Building Standard (NBS), which in this case relates to New Zealand Standard 1170.5:2004.

It should be appreciated that the %NBS is intended to reflect the degree to which a building is expected to perform in earthquake shaking from a life safety perspective, compared with the minimum performance prescribed for a new building in Clause B1 of the New Zealand Building Code.

The intention of the Building Code in this regard is that buildings remain structurally intact as far as necessary so that users are not put in danger. It does not consider whether a building will be able to be used for its intended purposes after a moderate to large earthquake.

4.2 DESKTOP REVIEW

We have reviewed the following documentation to collect information about the building. Please note that the documents listed below are only the ones related to the building structures.

- Building Resource Consent Application dated 19/11/1998
- Drawings by Design Group titled, “Norbury House Refurbishment” dated 14/09/1998.
- Drawings by Sawrey Lane Consulting Engineers titled “Norbury Restoration” dated 01/07/1998.
- Structural Design Calculations by Sawrey Lane Consulting Engineers titled “38 Normandale Road, normandale, Lower Hutt” dated 26/06/1998
- Information obtained from the Heritage New Zealand website.
- Geohazard information obtained from the GWRC website and based on our understanding of the regional geology.

The following are our key qualitative findings from the review:

- The building main structure was built circa 1904 with upgrads to it that was done in 1998.
- Regular layout, light timber frames with light timber roofing system. The timber subfloor sits on top of perimeter foundation walls and anchored piles.
- In 1998 upgrades, the wall linings were relined, and new timber subfloor, concrete piles and new concrete foundation walls were installed.
- Several wall removal during the 1998 upgrades probably reduce the bracing capacity of the building along the transverse direction in particular.
- In low liquefaction potential zone, however, this is not likely to pose a life safety risk due to the given size and structural configuration of the building.

4.3 FORCE BASED ASSESSMENT

The assessment was carried out by using a force-based assessment method. The main lateral load resisting system in each orthogonal direction was identified. Earthquake loading was calculated using provisions of C2 and C3, timber wall framed bracing capacities were calculated using provisions of C9 section of the assessment guidelines.

It was noted that the building is highly possible to undergo shear failure at ULS loading. This shear failure is expected to initiate along the transverse direction at Grid A in the marked-up plan for Option 1 (see APPENDIX B).

4.4 INPUTS AND ASSUMPTIONS

Table 1 lists the summary f seismic design parameters used in our detailed seismic assessment. Detailed calculations to support our assessment results are provided with this report. The following assumptions are made regarding the existing structure:

- The building has been constructed in accordance with the archived documents
- Where documents do not describe the structure, we have assumed detailing which was typical at the time of construction of the building
- Assessment of the gravity load system, the strength of roof and floor diaphragms, foundation capacity, or slope failure is outside the scope of this DSA report.

Table 1. Table showing the summary of seismic design parameters used in our assessment.

Parameter	Factor	Justification
Importance Level	IL2	Normal Importance Level, commercial occupancy
Return period factor	R = 1	For IL2 and 1/500 probability of exceedance
Ductility	Timber framed walls: $\mu = 3.00$	Assessment guidelines sections C9
Subsoil Class	B	Technical literature & our knowledge/ experience
Seismic Hazard Factor	Z = 0.4	Lower Hutt
Distance to the Nearest Seismic Fault	D < 0.2km T_1<0.4s >> N(D,T) = 1.0	Table 3.7 from NZS 1170.5:2004

5. RESULTS

5.1 SEISMIC RATING

The result of the Detailed Seismic Assessment for the existing structure (Option 1) is outlined in the table below:

Table 2. DSA results for the EXISTING structure (Option 1).

	Element	Description	Part Score	NZSEE Grade	Description of Failure
Transverse Direction (Option 1)					
First Floor	Total bracing	-	52% NBS	C	-
First Floor	Bracing per line	Insufficient bracing capacity - Grid A	<34% NBS	D	Shear failure Grid A
First Floor	Bracing external wall	Insufficient bracing capacity - Grid A	<34% NBS	D	Shear failure Grid A
Ground Floor	Total bracing	-	59% NBS	C	-
Ground Floor	Bracing per line	Insufficient bracing capacity - Grid A	<34% NBS	D	Shear failure Grid A
Ground Floor	Bracing external wall	Insufficient bracing capacity - Grid A	<34% NBS	D	Shear failure Grid A
Longitudinal Direction (Option 1)					
First Floor	Total bracing	-	62% NBS	C	-
First Floor	Bracing per line	-	100% NBS	A	-
First Floor	Bracing external wall	-	100% NBS	A	-
Ground Floor	Total bracing	Insufficient bracing capacity - Grid N	38% NBS	C	-
Ground Floor	Bracing per line	-	63% NBS	C	-
Ground Floor	Bracing external wall	-	100% NBS	A	-
Non-Structural Element (Option 1)					
The presence of two heavy earthquake-prone chimneys imposes life safety risk <34%NBS (IL2)					

5.2 COMMENTARY ON SEISMIC RISKS

The NZSEE Assessment Guidelines provides the basis of a proposed grading system for existing buildings, as one way of interpreting the percentage new building standard (%NBS) building score. Occupants in Earthquake Prone buildings (less than 34% NBS) are exposed to more than 10 times the risk that they would be in a similar new building. For buildings that are potentially Earthquake Risk (less than 67% NBS), but not Earthquake Prone, the risk is at least 5 times greater than that of an equivalent new building. Broad descriptions of the life-safety risk can be assigned to the building grades as shown in the table below.

The New Zealand Society for Earthquake Engineering (which provides authoritative advice to the legislation makers and should be considered to represent the consensus view of New Zealand structural engineers) classifies a building achieving greater than 67%NBS as “Low Risk Building” and having “Acceptable” building structural performance. Meanwhile a building achieving less than 33%NBS is classified as “Very High-Risk Building” and having “Unacceptable” building structural performance.

Table 3. %NBS values and corresponding seismic risk.

Building Grade	Percentage of New Building Strength (%NBS)	Approx. Risk Relative to a New Building	Life-safety Risk Description
A+	>100	<1	Low risk
A	80 to 100	1 to 2 times	Low risk
B	67 to 79	2 to 5 times	Low or medium risk
C	34 to 66	5 to 10 times	Medium risk
D	20 to 33	10 to 25 times	High risk
E	<20	More than 25 times	Very high risk

5.3 SECONDARY RISKS

Risk Presented by Non-Structural Building Elements

Recent experiences in Wellington following the Seddon and Kaikoura earthquakes have shown that non-structural elements such as glazing, suspended ceilings, partitions and overhead services (i.e., HVAC, sprinkler pipes etc.) constitute a significant hazard to building occupants and typically contribute heavily to shut down time and repair costs. Egress routes should also be regularly checked to ensure that they are kept clear and without obstacles. The scope of work does not include the assessment of these non-structural items. We recommend a survey of non-structural items be completed.

6. CONCLUSIONS

A detailed analysis of the structure concludes that the building is rated at:

<34% NBS (IL2) Seismic Grade D

7. LIMITATIONS

This report has been prepared for the benefit of Hutt City Council as our client. It shall not be relied upon for any other purpose. The reliance by other parties on the information or opinions contained in this report shall, without our prior review and agreement in writing, be at such parties' sole risk.

Opinions and judgments expressed herein are based on our understanding and interpretation of current regulatory standards and should not be construed as legal opinions. Where opinions or judgments are to be relied on, they should be independently verified with appropriate legal advice. Any recommendations, opinions, or guidance provided by Seismic Solutions Limited or its consultants in this report are limited to technical engineering requirements and are not made under the Financial Advisers Act 2008.

Seismic Solutions Limited have performed the services for this project in accordance with the standard agreement for consulting services and current professional standards. No guarantees are either expressed or implied.

This assessment is based on the information available to Seismic Solutions Limited at the time of our assessment and assumes the construction drawings supplied are an accurate record of the building. Further information may affect the results and conclusions of this assessment. The information used to undertake our assessment is listed in the inputs and assumptions section.

The inspections of the building discussed in this report have been undertaken to assist in the structural assessment of the building structure for seismic loads only. This assessment does not consider gravity. Nor did we carry out a comprehensive survey of building services or fire safety systems, building finishes, and glazing systems or consider weather tightness. This assessment does not include an assessment of the building condition or any repairs that may be required.

8. %NBS improvement options

The minimum requested seismic rating by the client is 40% NBS (IL2). DSA results show the current score is <34% NBS (IL2), which corresponds to grade D and high-risk buildings. This level of seismic performance is unacceptable and improvements are needed to achieve at least a 40% NBS score.

Table 4 compares different improvement options while suggesting Option 3 as the minimum mandatory option and recommending Option 4 for better seismic performance. It is worthwhile to mention options to achieve seismic ratings > 67%NBS are not recommended without a comprehensive analysis investigating material degradation, gravity load system sufficiency, foundation and pile capacities, slope failure, etc, which were beyond the scope of this DSA project.

Table 4. %NBS improvement options.

Options	Description	%NBS score	Building Grade	Life-safety Risk	Recommendations
Option 1	The existing structure without any improving actions	**<34%**	**D**	**High**	-Unacceptable seismic performance which improving actions are essential and urgant.
Option 2	Additional bracing walls along Grid A for both floors	38% but **<34%** due to the chimney hazard	**D**	**High**	-additional bracing walls help increase the ratio to 38%, but the presence of seismic-prone chimneys imposes significant life-safety risk and brings down the scores <34%NBS (IL2) -Chimney removal above the ceiling level is mandatory.
Option 3	Option 2 + Chimney removal	**43%**	**C**	**Medium**	-The chimney removal above the ceiling level eliminates the non-structural weakness -The chimney removal also decreases the seismic mass and thus increases the performance score to 43%NBS, which is in line with the minimum requested seismic performance -To achieve the minimum 40%NBS (IL2) defined by the client, Option 3 is mandatory.
Option 4	Option 3 + additional bracing walls along Grids M & N for ground floor	**53%**	**C**	**Medium**	- recommended for better seismic performance in the middle medium life safety risk range -%NBS rating is almost the same along both orthogonal directions (~53%-54%)

The result of the Detailed Seismic Assessment for the structure with improved seismic performance using additional bracing walls along Grid A at both floors (Option 2) is outlined in the table below:

Table 5. DSA results for the structure with additional walls along Grid A at both floors (Option 2).

	Element	Description	Part Score	NZSEE Grade	Description of Failure
Transverse Direction (Option 2)					
First Floor	Total bracing	-	58% NBS	C	-
	Bracing per line	-	78% NBS	B	-
	Bracing external wall	-	90% NBS	A	-
Ground Floor	Total bracing	-	63% NBS	C	-
	Bracing per line	-	46% NBS	C	-
	Bracing external wall	-	64% NBS	C	-
Longitudinal Direction (Option 2)					
First Floor	Total bracing	-	62% NBS	C	-
	Bracing per line	-	100% NBS	A	-
	Bracing external wall	-	100% NBS	A	-
Ground Floor	Total bracing	Insufficient bracing capacity - Grid N	38% NBS	C	Shear failure Grid N
	Bracing per line	-	63% NBS	A	-
	Bracing external wall	-	100% NBS	A	-
Non-Structural Element (Option 2)					
The presence of two heavy earthquake-prone chimneys impose life safety risk <34%NBS (IL2)					

The result of the Detailed Seismic Assessment after chimney removal (Option 3) is outlined in the table below:

Table 6. DSA results for the structure with additional bracing walls along Grid A at both floors and removed chimneys (Option 3).

	Element	Description	Part Score	NZSEE Grade	Description of Failure
Transverse Direction (Option 3)					
First Floor	Total bracing	-	74% NBS	C	-
	Bracing per line	-	99% NBS	B	-
	Bracing external wall	-	90% NBS	A	-
Ground Floor	Total bracing	-	71% NBS	C	-
	Bracing per line	-	53% NBS	C	-
	Bracing external wall	-	64% NBS	C	-
Longitudinal Direction (Option 3)					
First Floor	Total bracing	-	79% NBS	B	-
	Bracing per line	-	100% NBS	A	-
	Bracing external wall	-	100% NBS	A	-
Ground Floor	Total bracing	-	43% NBS > 40%NBS	C	Shear failure Grid N
	Bracing per line	-	72% NBS	B	-
	Bracing external wall	-	100% NBS	A	-
Non-Structural Element (Option 3)					
Chimneys are removed.					

The result of the Detailed Seismic Assessment for the structure with improved seismic performance along the longitudinal direction at the ground floor level using additional bracing walls in Grids M & N is outlined in the table below:

Table 7. DSA results for the structure with additional bracing walls along Grids M & N at the ground floor (Option 4).

	Element	Description	Part Score	NZSEE Grade	Description of Failure
Transverse Direction (Option 4)					
First Floor	Total bracing	-	74% NBS	B	-
	Bracing per line	-	99% NBS	A	-
	Bracing external wall	-	90% NBS	A	-
Ground Floor	Total bracing	-	71% NBS	B	-
	Bracing per line	-	53% NBS > 40%NBS	C	Shear failure Grid A
	Bracing external wall	-	64% NBS	C	-
Longitudinal Direction (Option 4)					
First Floor	Total bracing	-	79% NBS	B	-
	Bracing per line	-	100% NBS	A+	-
	Bracing external wall	-	100% NBS	A+	-
Ground Floor	Total bracing	-	54% NBS > 40%NBS	C	Shear failure Grid N
	Bracing per line	-	93% NBS	B	-
	Bracing external wall	-	100% NBS	A+	-
Non-Structural Element (Option 4)					
Chimneys are removed.					

APPENDIX A – ASSESMENT SUMMARY REPORT

The following table provides the Assessment Summary Report for seismic assessments undertaken using The Technical Guidelines for Engineering Assessments – as referred to in Section A8.5 of the Guidelines, which meets the requirements of Section 2.5 of the EPB methodology.

1. Building Information	
Building Name/ Description	Minoh House 2-storey light timber frame with light timber roof with timber subfloor supported by perimeter foundation walls and anchored piles. The building was built circa. 1904 and was upgraded in 1998.
Street Address	38 Normandale Road, Minoh House, Lower Hutt. 5010 Alternative address: 91 Western Hutt Road, Normandale, Lower Hutt. 5010
Territorial Authority	Hutt City Council
No. of Storeys	Two Storeys
Area of Typical Floor (approx.)	Approx. 300 m^2
Year of Design (approx.)	Circa. 1904 Upgraded 1998
NZ Standards designed to	Varies
Structural System including Foundations	Circa. 1904 – Two storey light timber frame building and light timber roof with timber subflooring supported by perimeter foundation wall and anchored piles. Upgraded 1998 – Wall linings were replaced with new linings. New timber subfloors were added, new perimeter foundation walls and new concrete piles were installed. In the 1998 upgrades, several internal walls were removed without adequate compensating actions which might negatively affect bracing capacity, especially in the transverse direction.
Does the building comprise a shared structural form or shares structural elements with any other adjacent titles?	N/A
Key features of ground profile and identified geohazards	The underlying soil is subsoil profile category B (Rock), non-liquefiable, and “low” risk earthquake-induced slope failure zone

Previous strengthening and/ or significant alteration	Significant alteration/upgrade to the 1904 building in 1998.
Heritage Issues/ Status	Listed as Historic Place Category 1 #7424
Other Relevant Information	N/A

2. Assessment Information	
Consulting Practice	Seismic Solutions Limited
CPEng Responsible, including: • **Name** • **CPEng number** • **A statement of suitable skills and experience in the seismic assessment of existing buildings**	Dr. Najif Ismail CPEng # 1013406 PhD in structural earthquake engineering, with more than 17 years of consulting and research experience in seismic-resistant design of building structures. Chartered member of Engineering New Zealand and Member of Structural Engineering Society of New Zealand. Recipient of the 2013 Best PhD thesis award by the Masonry Society for his work on seismic assessment and strengthening of masonry buildings. Contributing author to reports submitted to Royal Commission of Enquiry on Canterbury Earthquakes. Recipient of the 2020 EQC/New Zealand Society for Earthquake Engineering Ivan Skinner Award.
Documentation reviewed, including date/version of drawings/ calculations[1] and previous seismic assessments	• Building Resource Consent Application dated 19/11/1998 • Drawings by Design Group titled, “Norbury House Refurbishment” dated 14/09/1998. • Drawings by Sawrey Lane Consulting Engineers titled “Norbury Restoration” dated 01/07/1998. • Structural Design Calculations by Sawrey Lane Consulting Engineers titled “38 Normandale Road, normandale, Lower Hutt” dated 26/06/1998 • Information obtained from the Heritage New Zealand website. • Geohazard information obtained from the GWRC website and based on our understanding of the regional geology.

[1] Drawings and structural calculations retrieved from council database.

Geotechnical Report(s)	Not building specific. Review of online maps, existing building consent documentation, and NZG database.
Date(s) Building Inspected and extent of inspection	Building exterior and interior visual inspections on 11 July 2022 by NI for ISA.
Description of any structural testing undertaken and results summary	None. Our investigations only limited to visual inspection
Previous Assessment Reports	N/A
Other Relevant Information	N/A

3. Summary of Engineering Assessment Methodology and Key Parameters Used	
Occupancy Type(s) and Importance Level	Importance Level 2
Site Subsoil Class	B
Summary of how Part C was applied, including: • **Analysis methodology(s) used from C2** • **Other sections of Part C applied**	The assessment was carried out by using a force-based assessment method. The main lateral load-resisting system in each orthogonal direction was identified. Earthquake loading was calculated using provisions of C2 and C3, and timber wall framed bracing capacities were calculated using provisions of the C9 section of the assessment guidelines. Ductility – 3 The building was upgraded in 1998 to the current code at the time. The wall linings were relined, and new timber subfloors, new perimeter foundation walls, and new concrete piles were added. In the 1998 upgrades, several walls were also removed without adequate compensating actions which might negatively affect bracing capacity, especially in the transverse direction.
Other Relevant Information	The presence of two heavy earthquake-prone chimneys can impose life-safety risks and decrease % the NBS rating of the assessed building to values <34%.

4. Assessment Outcomes		
Assessment Status	Final	
Assessed *%NBS* Rating	<34%NBS (IL2)	
Seismic Grade and Relative Risk (from Table A3.1)	D	
Comment on the nature of Secondary Structural and Non-structural elements/ parts identified and assessed	The presence of two heavy earthquake-prone chimneys can impose life-safety risks and decrease % the NBS rating of the assessed building to values <34%. To improve the seismic performance and %NBS score > 40%, the chimneys above the ceiling level need to be removed.	
Describe the Governing Critical Structural Weakness	The governing critical structural weaknesses in the building are: -Insufficient bracing capacity along Grid A on both floors which seems intensified due to the internal wall removals during the 1998 upgrades. - the presence of two heavy/tall brick chimneys, which are earthquake-prone and impose life-safety risks.	
If the results of this DSA are being used for earthquake-prone decision purposes, and elements rating <34%NBS have been identified (including Parts):	**Engineering Statement of Structural Weaknesses and Location** As per report	**Mode of Failure and Physical Consequence Statement(s)** As per report

APPENDIX B – %NBS VALUE REPORT

Seismic Solutions
CONSULTING ENGINEERS

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Building Name:	Minoh House	**Job Code:**	P330
Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	%NBS Report	**Rev:**	

%NBS Report

Option 1: The original Structure with chimneys:

Floor	%NBS			
	Total Bracing		Bracing per line	Bracing external wall
	Wind	Earthquake		
First Floor (Along)	304%	62%	105%	107%
First Floor (Across)	151%	52%	0%	0%
Ground Floor (Along)	77%	38%	63%	158%
Ground Floor (Across)	72%	59%	0%	0%

%NBS= 0%

Option 2: The strengthened structure (strengthened at 1F & GF along the Grid A):

Floor	%NBS			
	Total Bracing		Bracing per line	Bracing external wall
	Wind	Earthquake		
First Floor (Along)	304%	62%	105%	107%
First Floor (Across)	165%	58%	78%	90%
Ground Floor (Along)	77%	38%	63%	158%
Ground Floor (Across)	77%	63%	46%	64%

%NBS= 38%

Option 3: The strengthened structure (strengthened at 1F-Grid A & GF-Grid A + Chimney removal):

Floor	%NBS			
	Total Bracing		Bracing per line	Bracing external wall
	Wind	Earthquake		
First Floor (Along)	304%	79%	134%	107%
First Floor (Across)	165%	74%	99%	90%
Ground Floor (Along)	77%	43%	72%	158%
Ground Floor (Across)	77%	71%	53%	64%

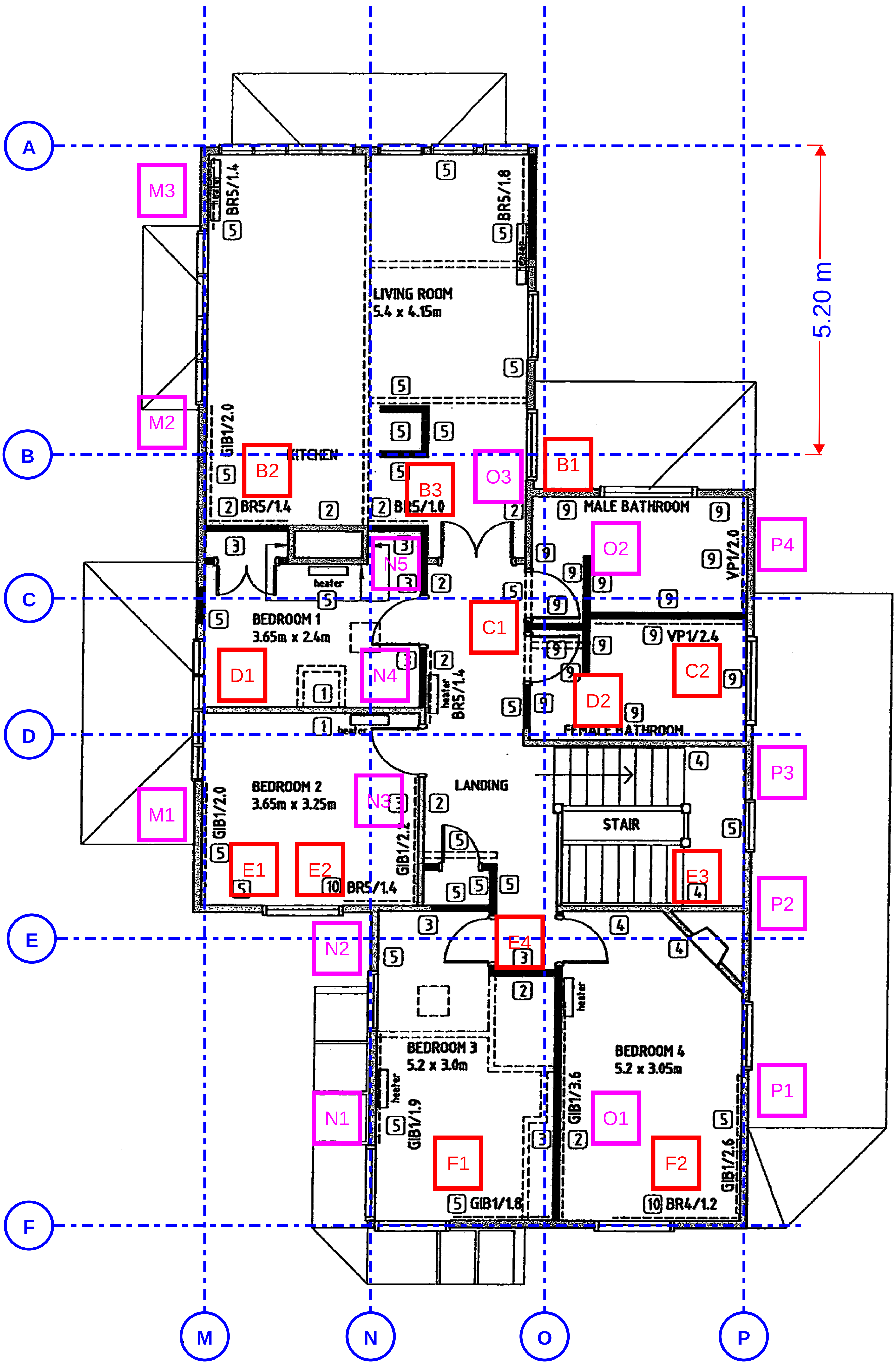
%NBS= 43%

Option 4: The strengthened structure (strengthened at 1F-Grid A & GF-Grids A&M&N + Chimney removal):

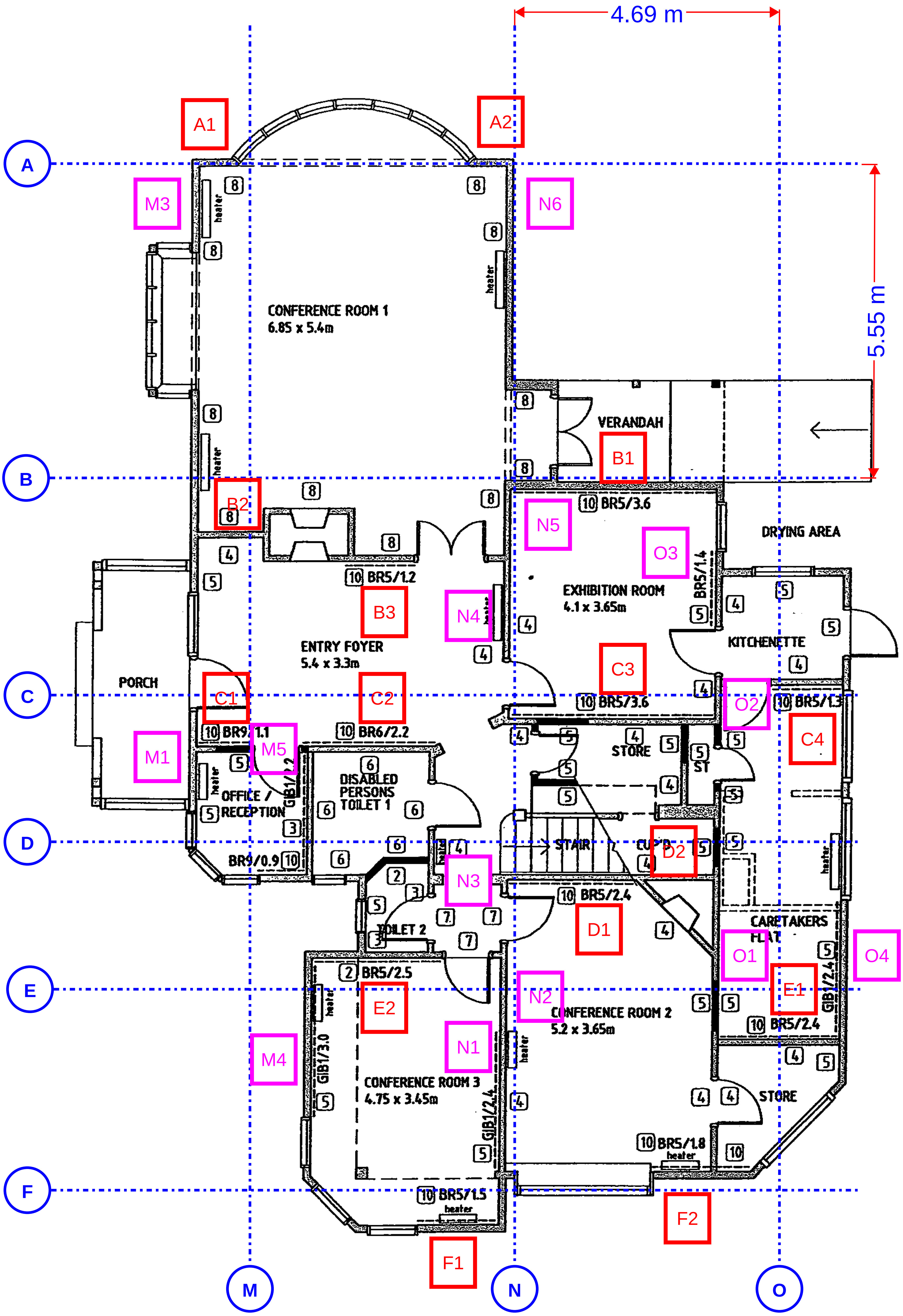
Floor	%NBS			
	Total Bracing		Bracing per line	Bracing external wall
	Wind	Earthquake		
First Floor (Along)	304%	79%	134%	107%
First Floor (Across)	165%	74%	99%	90%
Ground Floor (Along)	98%	54%	93%	158%
Ground Floor (Across)	77%	71%	53%	64%

%NBS= 53%

APPENDIX C – OPTION 1

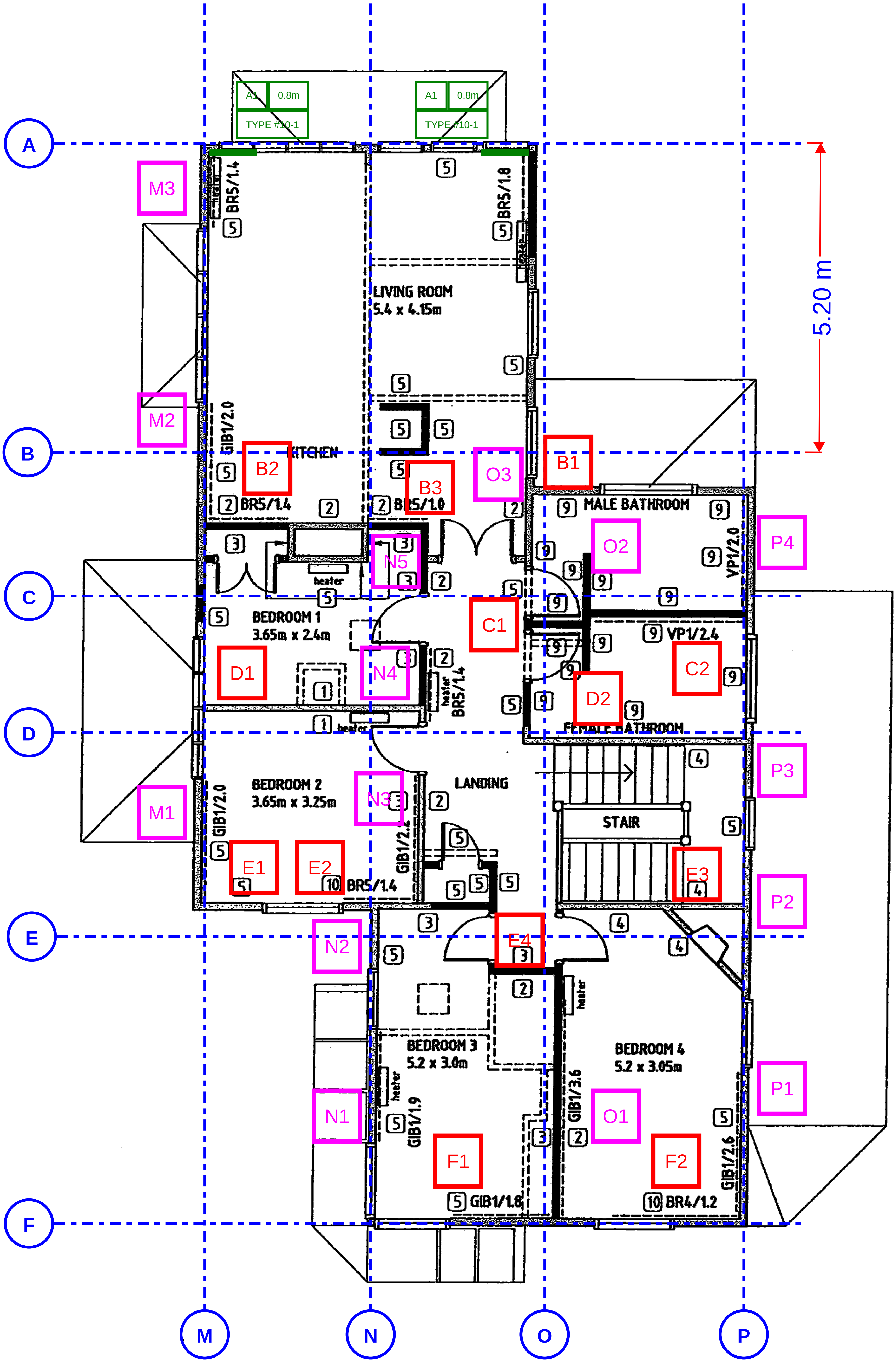


First Floor Bracing Mark-up Plan (Option 1)

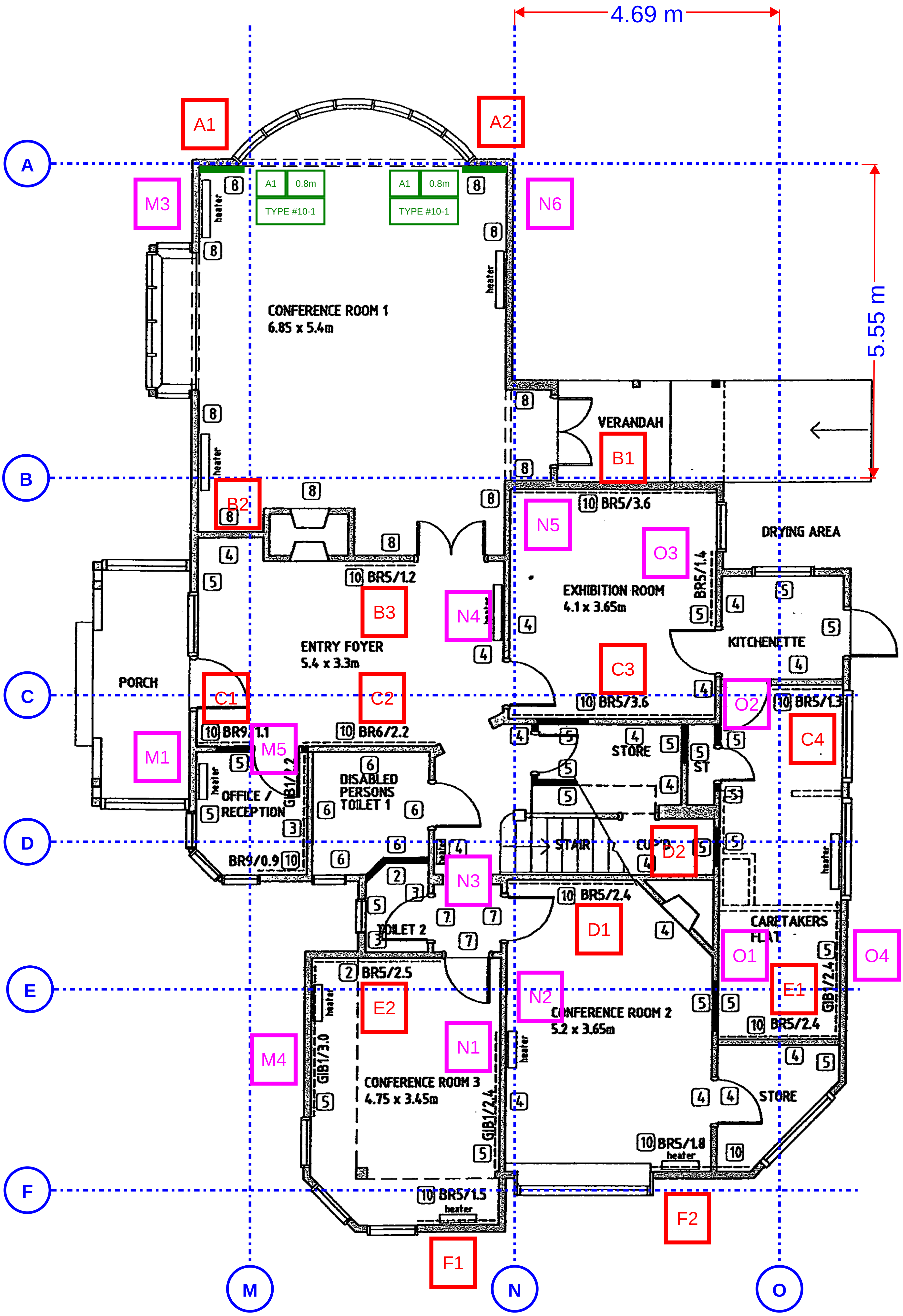


Ground Floor Bracing Mark-up Plan (Option 1)

APPENDIX D – OPTIONS 2 AND 3

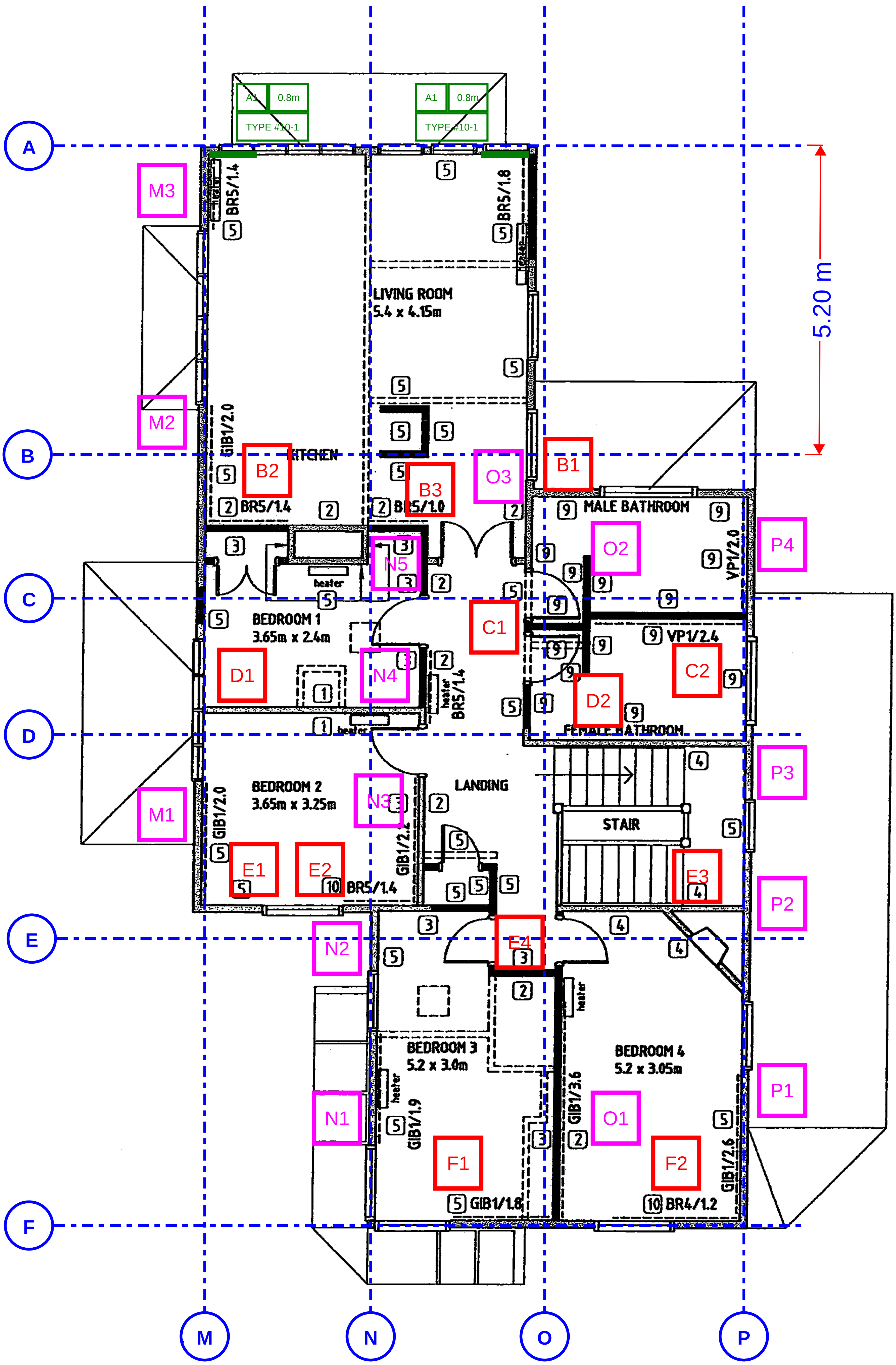


First Floor Bracing Mark-up Plan (Options 2 & 3)

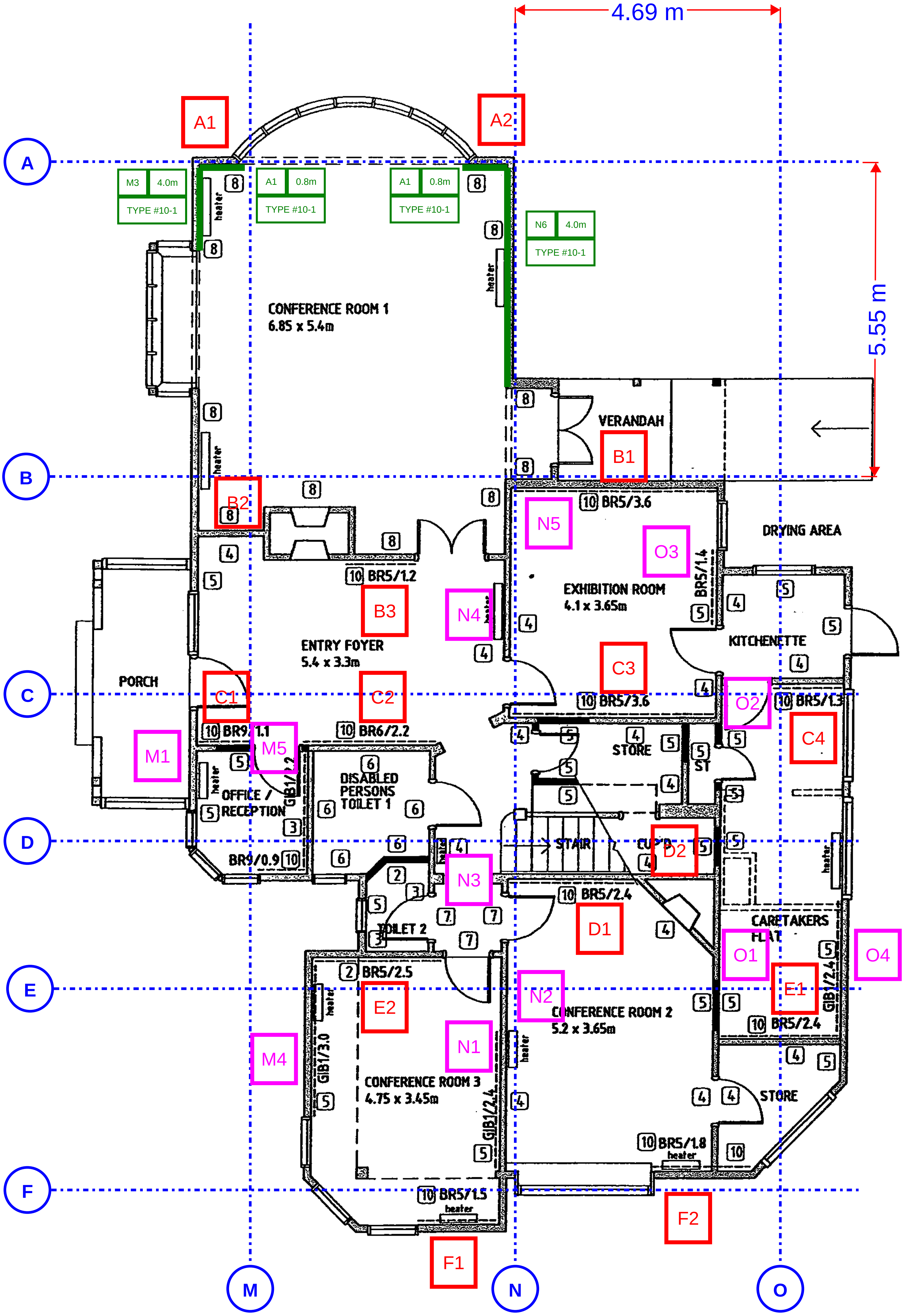


Ground Floor Bracing Mark-up Plan (Options 2 & 3)

APPENDIX E – OPTION 4

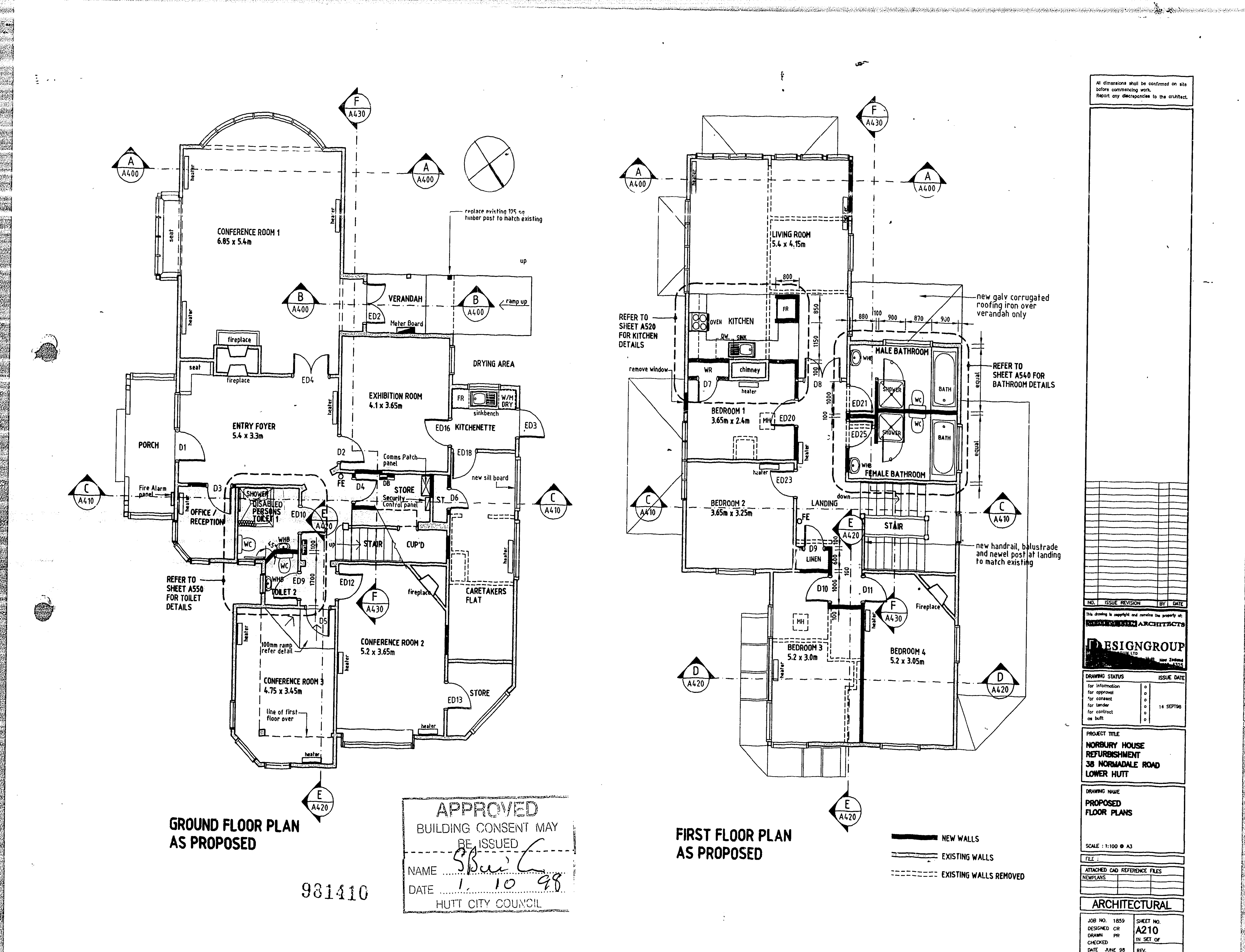


First Floor Bracing Mark-up Plan (Option 4)

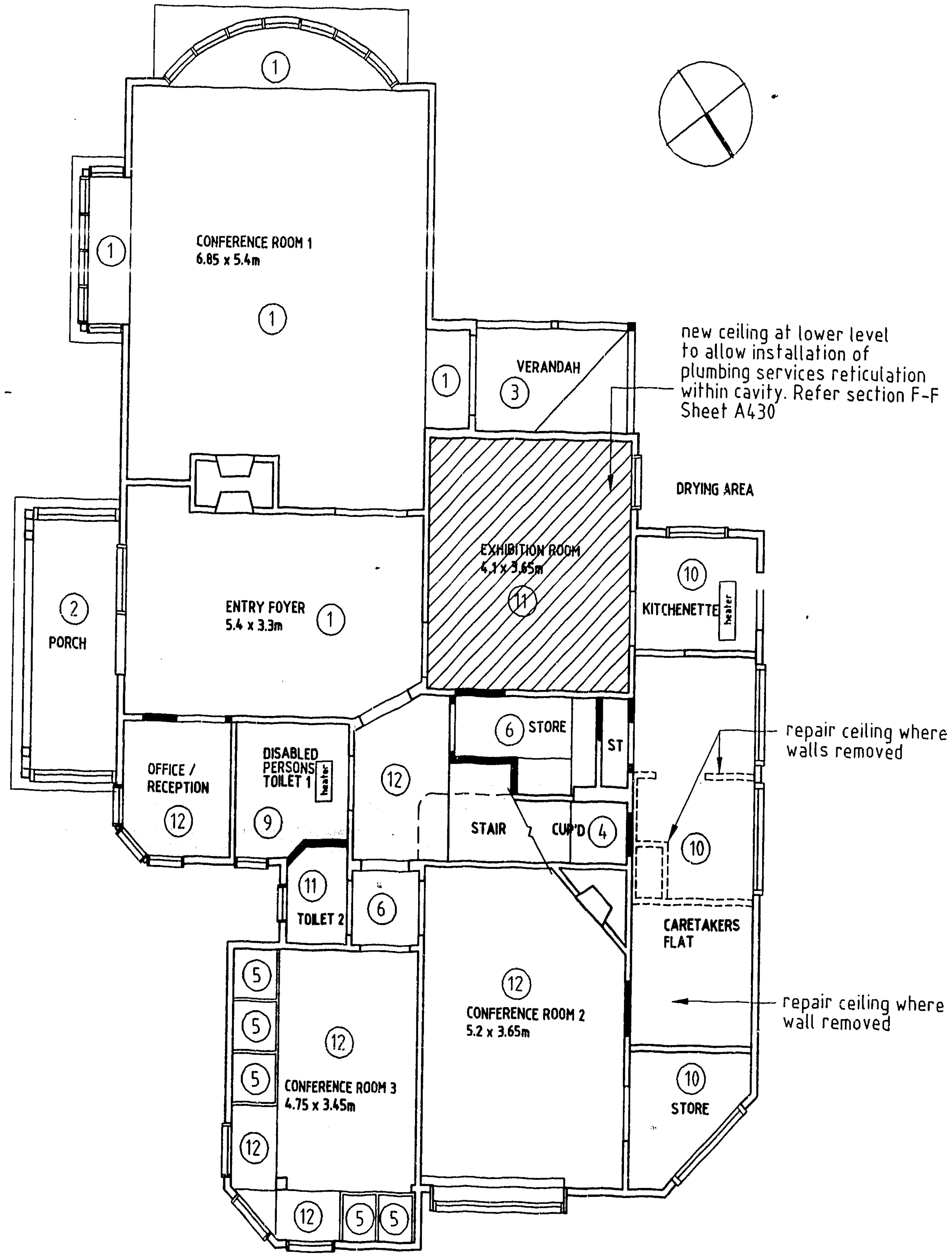


Ground Floor Bracing Mark-up Plan (Option 4)

APPENDIX G – SELECTED ARCHIVE DRAWINGS

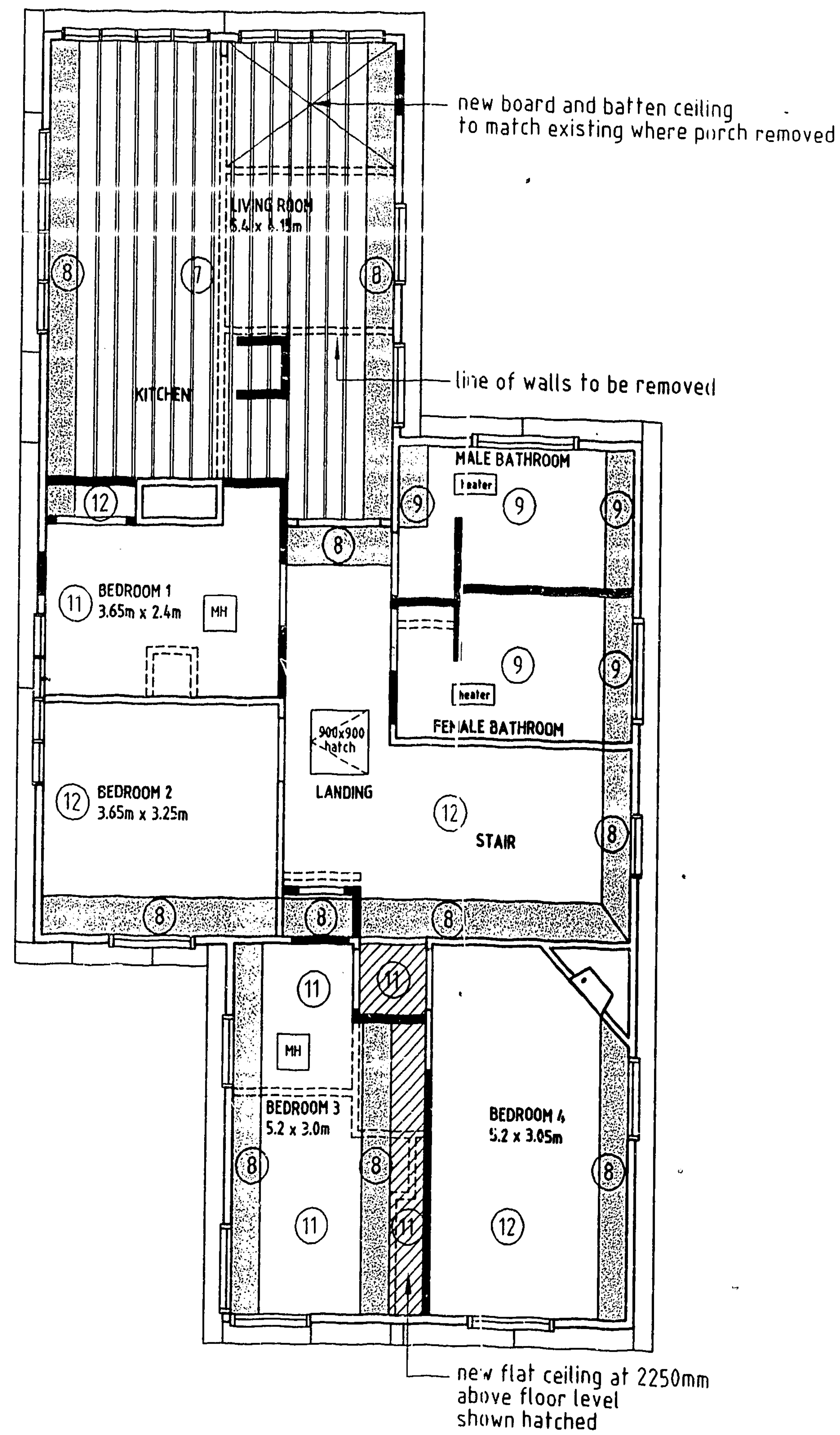


CONFERENCE ROOM 1
6.85 x 5.4m
seat
heater
replace existing 125 sq timber post to match existing
up
VERANDAH
ED2
Meter Board
ramp up
fireplace
seat
ED4
EXHIBITION ROOM
4.1 x 3.65m
DRYING AREA
FR
W/M DRY
sinkbench
ED16
KITCHENETTE
ED3
ED18
ENTRY FOYER
5.4 x 3.3m
PORCH
D1
D2
Comms Patch panel
new sill board
Fire Alarm panel
D3
FE
D4
DB
STORE
Security Control panel
ST
D6
SHOWER
DISABLED PERSONS TOILET 1
OFFICE / RECEPTION
ED10
STAIR
CUP'D
WC
WHB
TOILET 2
ED9
ED12
fireplace
CARETAKERS FLAT
REFER TO SHEET A550 FOR TOILET DETAILS
D5
100mm ramp refer detail
CONFERENCE ROOM 2
5.2 x 3.65m
CONFERENCE ROOM 3
4.75 x 3.45m
line of first floor over
ED13
STORE
heater
GROUND FLOOR PLAN
AS PROPOSED
LIVING ROOM
5.4 x 4.15m
KITCHEN
OVEN
DW
SINK
FR
REFER TO SHEET A520 FOR KITCHEN DETAILS
remove window
WR
chimney
D7
D8
new galv corrugated roofing iron over verandah only
MALE BATHROOM
SHOWER
WC
BATH
REFER TO SHEET A540 FOR BATHROOM DETAILS
ED21
ED25
FEMALE BATHROOM
BEDROOM 1
3.65m x 2.4m
MH
ED20
ED23
BEDROOM 2
3.65m x 3.25m
LANDING
down
STAIR
new handrail, balustrade and newel post at landing to match existing
D9
LINEN
D10
D11
Fireplace
BEDROOM 3
5.2 x 3.0m
BEDROOM 4
5.2 x 3.05m
FIRST FLOOR PLAN
AS PROPOSED
NEW WALLS
EXISTING WALLS
EXISTING WALLS REMOVED
APPROVED
BUILDING CONSENT MAY BE ISSUED
NAME
DATE 1. 10 98
HUTT CITY COUNCIL
981410
All dimensions shall be confirmed on site before commencing work. Report any discrepancies to the architect.
NO. ISSUE REVISION BY DATE
ARCHITECTS
DESIGNGROUP
DRAWING STATUS
ISSUE DATE
for information
for approval
for consent
for tender
for contract
as built
14 SEPT98
PROJECT TITLE
NORBURY HOUSE REFURBISHMENT
38 NORMADALE ROAD
LOWER HUTT
DRAWING NAME
PROPOSED FLOOR PLANS
SCALE : 1:100 @ A3
FILE :
ATTACHED CAD REFERENCE FILES
NEWPLANS
ARCHITECTURAL
JOB NO. 1859
DESIGNED CR
DRAWN PR
CHECKED
DATE JUNE 98
SHEET NO.
A210
REV.



GROUND FLOOR PLAN

981410



FIRST FLOOR PLAN

All dimensions shall be confirmed on site before commencing work. Report any discrepancies to the architect.

LEGEND

1. existing lath and plaster ceiling to be repaired to a paint quality finish
2. existing T,G & Vee ceiling to be sanded and any defects repaired ready for paint finish
3. paint finish over new roofing iron
4. existing finish
5. exist overhead glazing
6. existing timber lining
7. existing board & batten ceiling to be repaired and battens replaced as necessary for paint finish
8. existing coved ceiling spot repaired to level 5 Gib board finish
9. new 9.5mm Gib Aqualine ceiling to level 5 finish
10. new 9.5mm Gib Ultraline ceiling over exist fibrous lining to level 5 finish
11. new 9.5mm Gib Ultraline ceiling
12. existing plaster ceiling repaired to level 5 finish

NO.	ISSUE REVISION	BY	DATE

DESIGNGROUP

DRAWING STATUS		ISSUE DATE
for information	o	
for approval	o	
for consent	o	
for tender	o	14 SEPT 98
for contract	o	
as built	o	

PROJECT TITLE
NORBURY HOUSE REFURBISHMENT
38 NORMADALE ROAD
LOWER HUTT

DRAWING NAME
REFLECTED CEILING PLANS

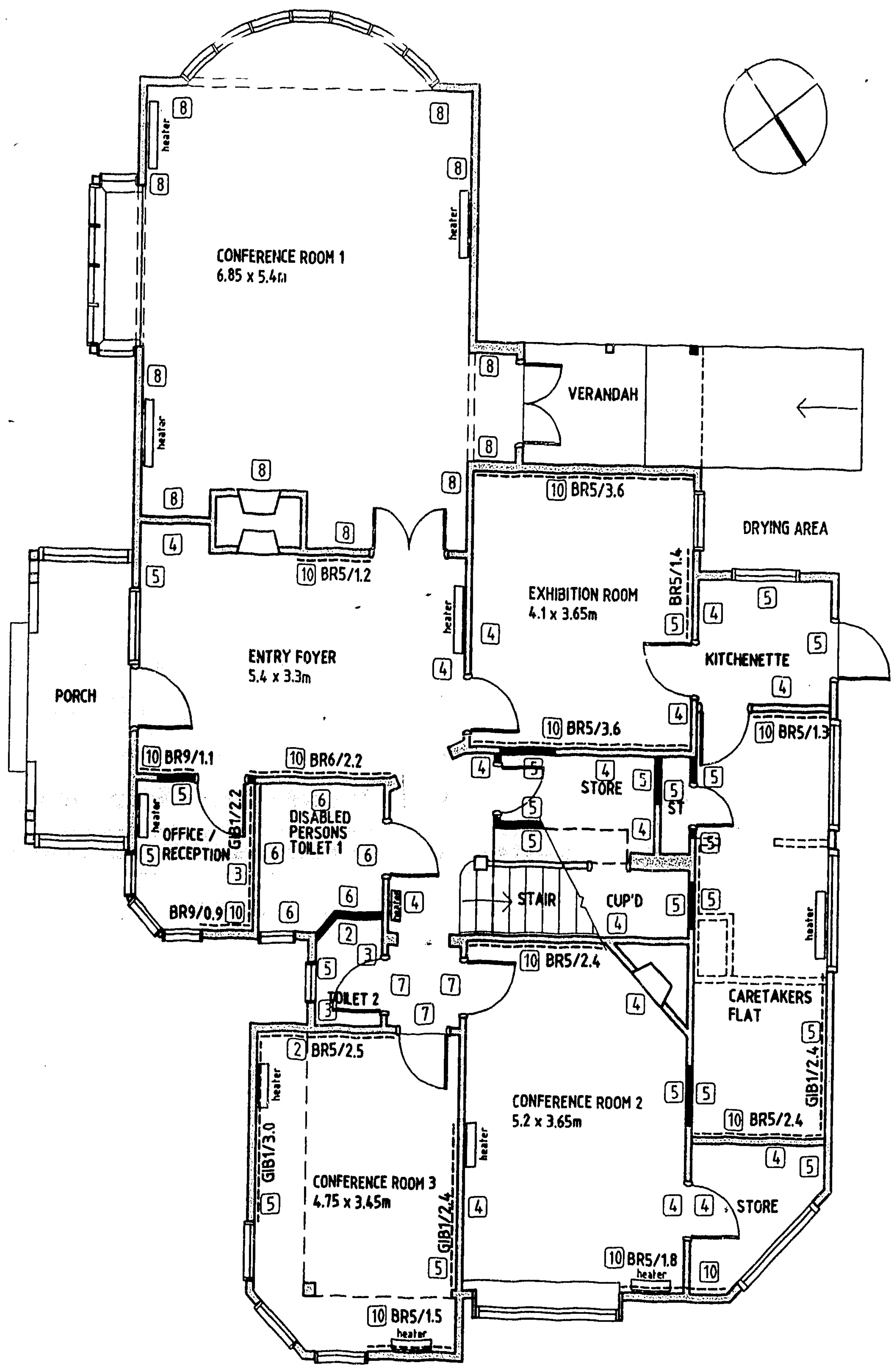
SCALE : 1:100 @ A3

FILE :

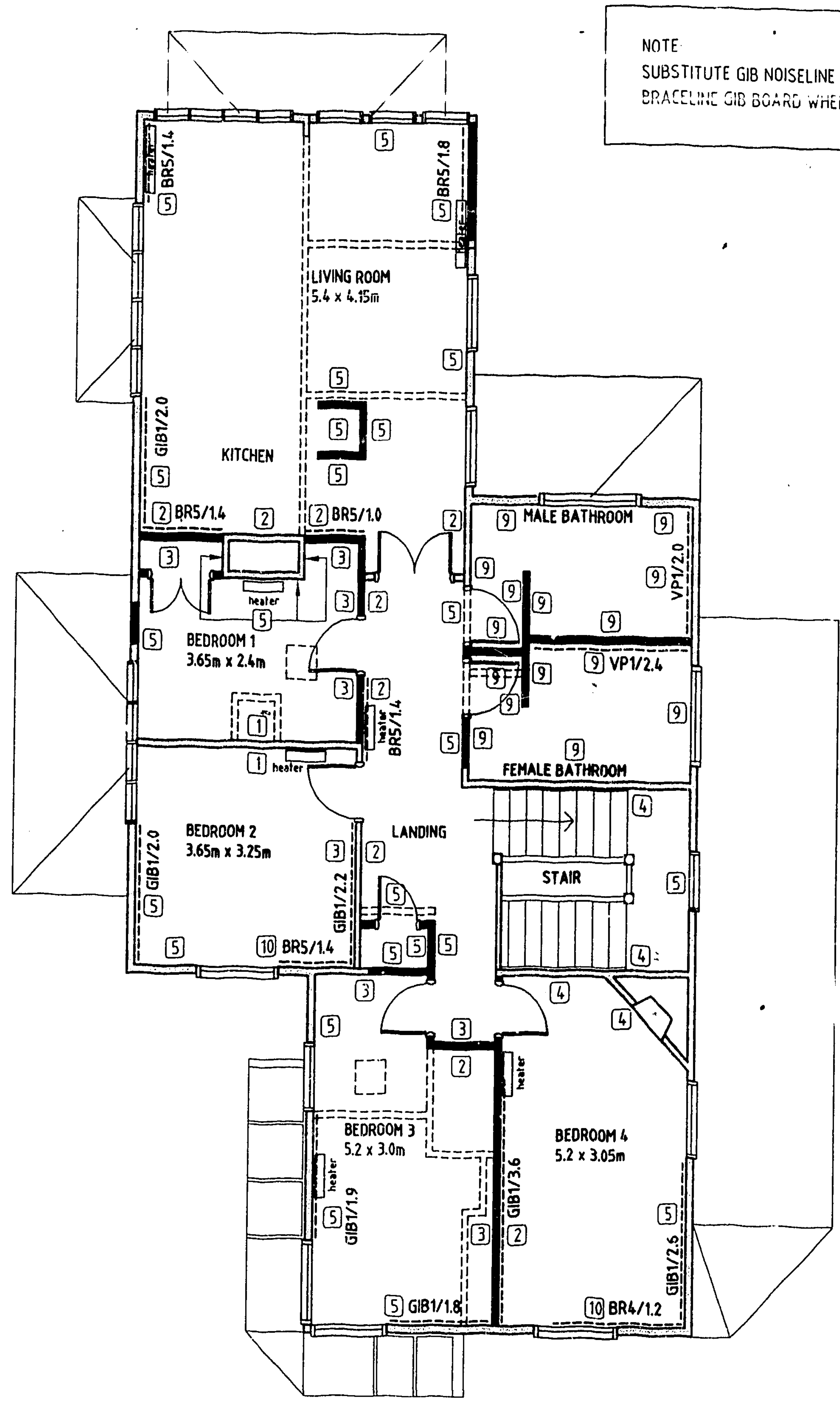
ATTACHED CAD REFERENCE FILES
NEWPLANS

ARCHITECTURAL

JOB NO. 1859	SHEET NO. A220
DESIGNED CR	IN SET OF
DRAWN PR	
CHECKED	
DATE JUNE 98	REV.



GROUND FLOOR PLAN



FIRST FLOOR PLAN

NOTE
SUBSTITUTE GIB NOISELINE FOR
BRACELINE GIB BOARD WHERE INDICATED

NEW WALLS
EXISTING WALLS
EXISTING WALLS REMOVED

APPROVED
BUILDING CONSENT MAY
BE ISSUED
NAME SBu-C
DATE 1-10-98
HUTT CITY COUNCIL

981410

All dimensions shall be confirmed on site before commencing work.
Report any discrepancies to the architect.

1. 1x layer 9.5 Gib Noiseline over existing plaster board lining
2. 1x layer 9.5 Gib Noiseline
3. 2x layers 9.5 Gib Noiseline
4. existing plaster board
5. 1x layer standard 9.5 Gib Board
6. 1x layer Formica Aquapanel over 9.5 Gib Aqualine
7. existing match lining
8. existing lath and plaster
9. 1x layer 6mm Hardies Villa Board
10. Braceline Gib Board

NO.	ISSUE REVISION	BY	DATE

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DESIGNGROUP
[redacted] LTD
[redacted] New Zealand [redacted]

DRAWING STATUS		ISSUE DATE
for information	o	
for approval	o	
for consent	o	
for tender	o	14 SEPT 98
for contract	o	
as built	o	

PROJECT TITLE
NORBURY HOUSE REFURBISHMENT
38 NORMADALE ROAD
LOWER HUTT

DRAWING NAME
WALL LINING PLANS

SCALE : 1:100 @ A3

FILE :

ATTACHED CAD REFERENCE FILES
NEWPLANS

ARCHITECTURAL

JOB NO. 1859
DESIGNED CR
DRAWN PR
CHECKED
DATE JUNE 98

SHEET NO.
A260
IN SET OF
REV.

SAWREY LANE
CONSULTING ENGINEERS

Norbury House

38 Normandale Road

Normandale, Lower Hutt

STRUCTURAL DESIGN CALCULATIONS

by

S.R.K. Sawrey (F.IPENZ)

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5140

Project: Norbury, 38 Normandale Rd **Project No:** 3555

By: Stephen Sawrey **Date:** 26/06/98

Section: 1

1.1

Loadings	Dead Load: G	Live Load: Q	kPa
Steel on sar	0.55	0.25	
Flat roof	0.45	0.25	
Wall	0.40	0.00	
Floor	0.45	1.50	
Wall	0.40	0.00	
Deck	0.45	2.50	

1.2 **Ultimate Limit State**

	1.2 G + 1.6 Q	1.4 G
Steel on sar	1.06	0.77
Flat roof	0.94	0.63
Wall	0.48	0.56
Floor	2.94	0.63
Wall	0.48	0.56
Deck	4.54	0.63

1.3 **Serviceability Limit State**

	G	Q	G + Qs Short term	G + Qs Long term
Steel on sar	0.55	0.25	0.73	0.55
Flat roof	0.45	0.25	0.63	0.45
Wall	0.40	0.00	0.40	0.40
Floor	0.45	1.50	1.50	1.05
Wall	0.40	0.00	0.40	0.40
Deck	0.45	2.50	2.20	1.45

Project: Norbury, 38 Normandale Rd — **Project No:** 3555
By: Stephen Sawrey — **Date:** 26/02/98

Section: **2** **Beam:** Timber beam over bed 3
Eccentric point load

Span =	4.10	metres
a =	2.05	metres
b =	2.05	metres

2 :1 **Timber Beam Properties**

Timber beam doubled 300 x 50 @ 400

2 :1:1 **Design Properties**

Number of parallel timbers fixed together	N =	2	
Depth of timber	D =	294	mm
Thickness of one member	B =	47	mm
Strength reduction factor	ϕ =	0.8	
Duration of load factors for strength	K_1 =	0.6	Permanent
	K_1 =	0.8	Medium
	K_1 =	1.0	Brief
Duration of load factors for deflection	K_2 =	3.0	>12 months. > 25% mc
	K_2 =	2.0	>12 months. < 18% mc
	K_2 =	1.0	< 2 weeks
Parallel support factor	$K_{4 \text{ or } 6}$ =	1.27	(1.14
Grid system factor	K_5 =	1.00	
Slenderness Factor	K_8 =	1.00	
Long term serviceability factor	ψ_l =	0.40	
	ψ_l =	0.00	Roof
Short term serviceability factor	ψ_s =	0.70	
	ψ_s =	0.70	Roof

N =	1	2	3	4	5	10
$K_{4 \text{ or } 6}$ =	1	1.14	1.2	1.24	1.26	1.33

Modulus of Elasticity	E =	8.0	GPa
Characteristic bending stress	f_b =	17.7	MPa
Second moment of sectional area	I =	19,906	cm^4

2 :2 **Ultimate Limit State**

2 :2:1 **Medium term loading.**

2 :2:1:1

	1.2 G + 1.6 Q (kPa)	**tributary width / height (metres)**	**ω^* (kN/m)**	**tributary area sq m**	**P* (kN)** mid-span
Roof	1.06	3.600	3.82	0.00	0.00
Wall	0.48	0.000	0.00	0.00	0.00
Floor	2.94	0.000	0.00	0.00	0.00
Wall	0.48	0.000	0.00		0.00
Deck	4.54	0.000	0.00		0.00
		ω^* =	3.82	**P* =**	0.00

2.2.1.2 **M*** = $\omega^* L^2/8 + P^*ab/L$ = 8.0 kN m

2.2.1.3 $\phi M_b = \phi N k_1 k_4 k_5 k_8 f_b Z$ = 19.5 kNm

Project:	Norbury, 38 Normandale Rd	**Project No:**	3555
By:	Stephen Sawrey	**Date:**	26/02/98
Section: **2**	**Beam:** Timber beam over bed 3	**Span =**	4.10 m

2 :2 Ultimate Limit State Continued

2 :2:2 Permanent loading.

2.2.2.1

	1.4 G (kPa)	tributary width / height (metres)	ω* (kN/m)	tributary area sq m	P* (kN) mid-span
Roof	0.77	3.600	2.77	0.00	0.00
Wall	0.56	0.000	0.00	0.00	0.00
Floor	0.63	0.000	0.00	0.00	0.00
Wall	0.56	0.000	0.00	0.00	0.00
Floor	0.63	0.000	0.00	0.00	0.00
		ω* =	2.77	P* =	0.00

2:2:2:2 **M* =** $\omega^* L^2/8 + P^*ab/L$ = 5.8 kN.m

2:2:2:3 **ϕMb =** $\phi N\ k_1 k_4 k_5 k_8 f_b Z$ = 14.6 kN.m

2 :3 Serviceability Limit State

Note deflections calculated on a mid span point load - conservative

2 :3:1 Consider deflections of the timber beam after initial creep has taken place.

Creep deflection (long term serviceability), $\Delta_L = G + \psi_L Q$

Additional short term deflection, $\Delta_\Delta = (\psi_S - \psi_L)Q$

Total deflection (short term serviceability), $\Delta_S = \Delta_L + \Delta_\Delta$

2 :3:2 Creep deflection (long term serviceability)

$K_2 =$ 2.0

$I =$ 19,906 cm^4

$E =$ 8.0 GPa

	G+ψLQ (kPa)	ψl	tributary width / height (metres)	ωs (kN/m)	tributary area sq m	Ps (kN) mid-span
Roof	0.55	0.00	3.600	1.98	0.00	0.00
Wall	0.40	0.40	0.000	0.00	0.00	0.00
Floor	1.05	0.40	0.000	0.00	0.00	0.00
Wall	0.40	0.40	0.000	0.00	0.00	0.00
Floor	1.45	0.40	0.000	0.00	0.00	0.00
			ωs =	1.98	Ps =	0.00

2.3.2.1 Creep deflection (long term serviceability), Δ_L for $G + \psi_L Q$

$$\Delta_L = \frac{P_s L^3}{48 EI} + \frac{5\, k_2\, \omega_S\, L^4}{384\, E\, I} = 9.1 \text{ mm}$$

$$= \frac{\text{Span}}{448}$$

2.3.2.2 Long term deflection limit for Ceiling ripple = $\frac{\text{Span}}{500}$

Project: Norbury, 38 Normandale Rd **Project No:** 3555
By: Stephen Sawrey **Date:** 26/02/98
Section: **2** **Beam:** Timber beam over bed 3 **Span =** 4.10 m

2 :3:3 **Additional short term deflection**

$\Delta_\Delta = (\psi_S - \psi_L)Q$

K2 = 1.0
I = 19,906 cm^4
E = 8.0 GPa

	$(\psi_S-\psi_L)Q$ (kPa)	ψ_s	ψ_l	tributary width / height (metres)	ω_s (kN/m)	tributary area sq m	Ps (kN) mid-span
Roof	0.18	0.70	0.00	3.600	0.63	0.00	0.00
Wall	0.00	0.70	0.40	0.000	0.00	0.00	0.00
Floor	0.45	0.70	0.40	0.000	0.00	0.00	0.00
Wall	0.00	0.70	0.40	0.000	0.00	0.00	0.00
Floor	0.75	0.70	0.40	0.000	0.00	0.00	0.00
				ω_s =	0.63	Ps =	0.00

2 :3:3:1 Additional short term deflection, Δ_Δ for $(\psi_S-\psi_L)Q$

$$\Delta_\Delta \quad \frac{P_s L^3}{48\,EI} + \frac{5\,k_2\,\omega_S\,L^4}{384\,E\,I} = 2.9 \text{ mm}$$

2 :3:4:1 **Total deflection (short term serviceability)**

$$\Delta_S = \Delta_L + \Delta_\Delta = 12.1 \text{ mm}$$

$$= \frac{\text{Span}}{340}$$

2 :3:4:2 Short term deflection limit for floor functionality = $\frac{\text{Span}}{400}$

2 :3:5 **Transient vibration serviceability**

2 :3:5:1 Transient vibration 1kN load Δ_1

$$\Delta_1 = \frac{k_1\,1\text{kN}\,L^3}{48\,E\,I} = 0.9 \text{ mm}$$

2 :3:5:2 Transient vibration 1kN load deflection limit = 1.0 mm

Along

Wall or Bracing Line		Bracing Elements Provided			Wind		Earthquake	
1	2	3	4	5	6 W	7 W	6 E	7 E
Line Label	Minimum BUs Required	Bracing Element No.	Bracing Type	Length Element (m) L	Rating BU/m W	BUs Achieved (BU/m x L) W	Rating BU/m E	BUs Achieved (BU/m x L) E
			GIB1	2.0	75	150	50	100
			GIB1	2.0	75	150	50	100
A			BRS	1.4	115	161	85	119
			GIB1	1.9	75	143	50	95
B			GIB1	2.4	75	180	50	120
			BRS	1.4	115	161	85	119
C			GIB1	3.5	75	263	50	175
			GIB1	2.6	75	195	50	130
D			VB1	1.8	80	144	60	108
E								

Totals Achieved	W	1547	E	1066
From Sheet A — Totals Required	W	648	E	585
Wreq/E req = 1.11 *				

*If Wreg/Ereq is 1 or less complete E column only
If Wreq/Ereq is 1.5 or more complete W column only
Otherwise complete both W and E

Across

Wall or Bracing Line		Bracing Elements Provided			Wind		Earthquake	
1	2	3	4	5	6 W	7 W	6 E	7 E
Line Label	Minimum BUs Required	Bracing Element No.	Bracing Type	Length Element (m) L	Rating BU/m W	BUs Achieved (BU/m x L) W	Rating BU/m E	BUs Achieved (BU/m x L) E
			BRS	1.6	115	184		
			BR4	1.0	100	100		
M			BR4	1.1	100	110		
N			BRS	2.4	115	276		
			GIB1	1.8	75	135		
O			BR4	1.2	100	120		
			Sarked Walls	10m+		77		
P								
Q								

Totals Achieved	W	935	E	
From Sheet A — Totals Required	W	1033	E	585
Wreq/Ereq = 1.76 *				

Job Details

box 1

Name Norbury House

Street and Number 38 Normandale R...

Lot and DP Number

City/Town/District Lower Hutt

Location of Storey: ~~single~~/upper of two/~~lower of two~~

Building height to apex	8.2 m	Roof weight	light/~~heavy~~
Roof height above eaves	2.2 m	Cladding weight	light/~~heavy~~
Stud height	2.7 m	Room in roof space	~~y~~/n
Average roof pitch	45°		
Building length BL =	17 m	Gross Building	
Building width BW =	9 m	Plan Area,	GPA = 130 m2

Note: *When the average roof pitch is over 25 degrees, use the eaves length and width to determine BL and BW.*

Note: *For heavy roofs use the roof plan at eaves level to determine GPA.*

Wind Zone

box 2

Region:		Terrain:		Exposure:		Topography:	
R1	0 ___	Inland	0 ✓	Sheltered	0 ✓	Gentle	0 ___
R2	1 ✓	Coastal	1 ___	Exposed	1 ___	Moderate	1 ✓
						Extreme	3 ___

Total points 2

Wind zone:
- ___ Low (0)
- ___ Medium (1)
- ✓ High (2)
- ___ Very high (3)
- ___ Specific Design (4)

Earthquake zone

box 3

From figure EQ1 select Earthquake Zone: A) B C

BUs required Wind

box 4

From Table W1A/W1B

W along = 64 BUs/m   2.7 / 2.4 = 1.125

W across = 54 BUs/m

Total wind load,

W ALONG:

W along x BW = 576 BUs x 1.125

W ACROSS

W across x BL = 918 BUs x 1.125

BUs required Earthquake

box 5

From Table EQ1

E = 4.0 BUs/m2

Note: For a room in the roof space use E+1

Total earthquake load,

EQ ALONG and EQ ACROSS:

E x GPA BUs = 520 BUs x 1.125

Job Details

box 1

Name Norbury House

Street and Number 38 Normandale Road

Lot and DP Number

City/Town/District Lower Hutt

Location of Storey: single/upper of two/lower of two

Building height to apex	6.2 m	Roof weight	light/heavy
Roof height above eaves	2.2 m	Cladding weight	light/heavy
Stud height	3.0 m	Room in roof space	y/n
Average roof pitch	45°		
Building length BL =	17 m	Gross Building	
Building width BW =	9 m	Plan Area,	GPA = 130 m2

Note: *When the average roof pitch is over 25 degrees, use the eaves length and width to determine BL and BW.*

Note: *For heavy roofs use the roof plan at eaves level to determine GPA.*

Wind Zone

box 2

Region:		Terrain:		Exposure:		Topography:	
R1	0 ____	Inland	0 ✓	Sheltered	0 ✓	Gentle	0 ____
R2	1 ✓	Coastal	1 ____	Exposed	1 ____	Moderate	1 ✓
						Extreme	3 ____

Total points ____

Wind zone:
- ____ Low (0)
- ____ Medium (1)
- ✓ High (2)
- ____ Very high (3)
- ____ Specific Design (4)

Earthquake zone

box 3

From figure EQ1 select Earthquake Zone: A B C

BUs required Wind

box 4

From Table W1A/W1B

$\frac{30}{2.4} = 1.25$

W along = 168 BUs/m

W across = 159 BUs/m

Total wind load,

W ALONG:

W along x BW = 1512 BUs x 1.25

W ACROSS

W across x BL = 2856 BUs x 1.25

BUs required Earthquake

box 5

From Table EQ1

E = 8.0 BUs/m2

Note: For a room in the roof space use E+1

Total earthquake load,

EQ ALONG and EQ ACROSS:

E x GPA BUs = 1040 BUs

x 1.25

Along

Wall or Bracing Line		Bracing Elements Provided			Wind		Earthquake	
1	2	3	4	5	6 W	7 W	6 E	7 E
Line Label	Minimum BUs Required	Bracing Element No.	Bracing Type	Length Element (m) l	Rating BU/m W	BUs Achieved (BU/m x L) W	Rating BU/m I	BUs Achieved (BU/m x L) E
A			BRS	1.8	115	207	85	153
			GIB	2.5	75	188	50	125
			BRS	1.6	115	184	85	136
B			GIB	3.0	75	225	50	150
			BRS	2.4	115	276	85	204
C			BRS	2.4	115	276	85	204
			GIB	4.0	75	300	50	200
D			GIB	2.4	75	180	50	120
			BRS	1.4	115	161	85	119
E								

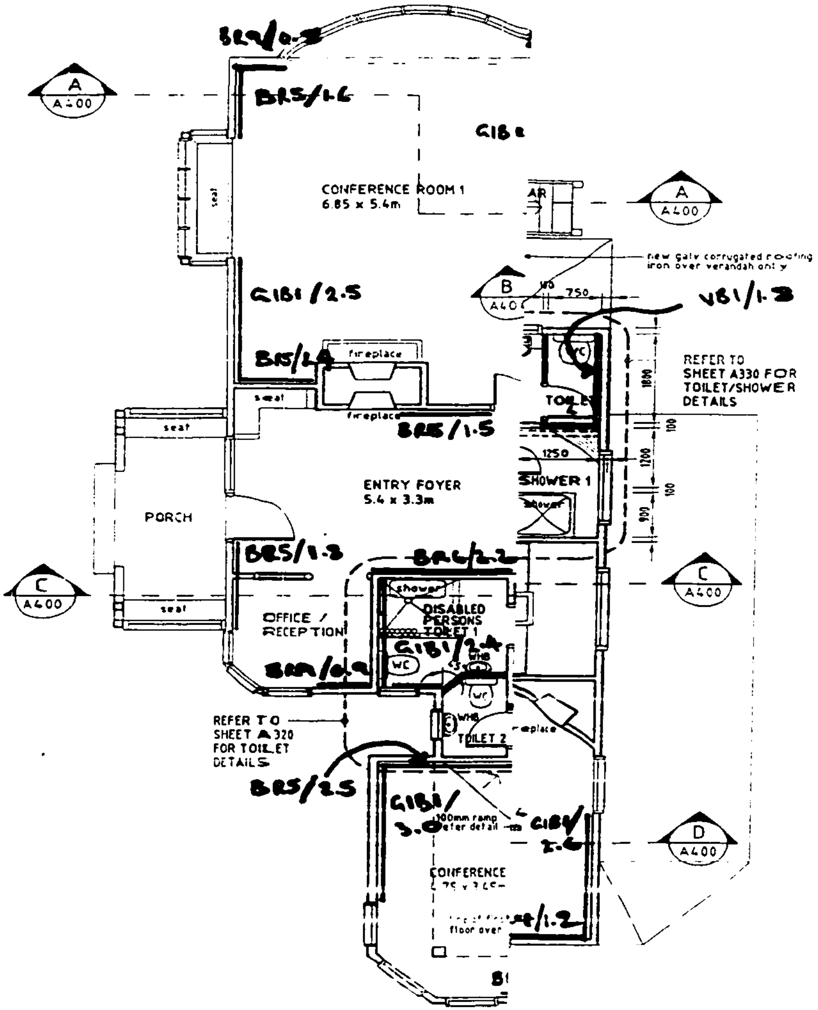
Totals Achieved	W	1997	E	1611
From Sheet A Totals Required	W	1890	E	1300
Wreq/Ereq = 1.45 *				

***If Wreg/Ereq is 1 or less complete E column only**
If Wreq/Ereq is 1.5 or more complete W column only
Otherwise complete both W and E

Across

Wall or Bracing Line		Bracing Elements Provided			Wind		Earthquake	
1	2	3	4	5	6 W	7 W	6 E	7 E
Line Label	Minimum BUs Required	Bracing Element No.	Bracing Type	Length Element (m) l	Rating BU/m W	BUs Achieved (BU/m x L) W	Rating BU/m E	BUs Achieved (BU/m x L) E
M			BR9	0.8	110	88		
			BR9	0.8	110	88		
N			BRS	1.4	115	161		
			"	1.5	"	173		
			"	3.9	"	449		
			"	3.9	"	449		
O			BR6	2.2	150	330		
			BR9	0.9	110	99		
			BRS	2.4	115	276		
P			"	2.5	"	288		
			"	2.4	"	276		
			"	1.5	"	173		
			"	1.8	"	207		
Q			BRS	1.2	"	140		

Totals Achieved	W	5250	E	
From Sheet A Totals Required	W	5510	E	1300
Wreq/Ereq = 2.7 *				



GROUND FLOOR PLAN AS PROPOSED

NEW WALLS
EXISTING WALLS
EXISTING WALLS REMOVED

All dimensions shall be confirmed on site before commencing work.
Report any discrepancies to the architect.

NO.	ISSUE REVISION	BY	DATE

DESIGNGROUP

DRAWING STATUS — ISSUE DATE

for information • 25 JUNE 98
for approval •
for consent •
for tender •
for contract •

PROJECT TITLE

NORBURY HOUSE REFURBISHMENT
38 NORMADALE ROAD
LOWER HUTT

DRAWING NAME

PROPOSED FLOOR PLANS

SCALE . 1.100 @ A3

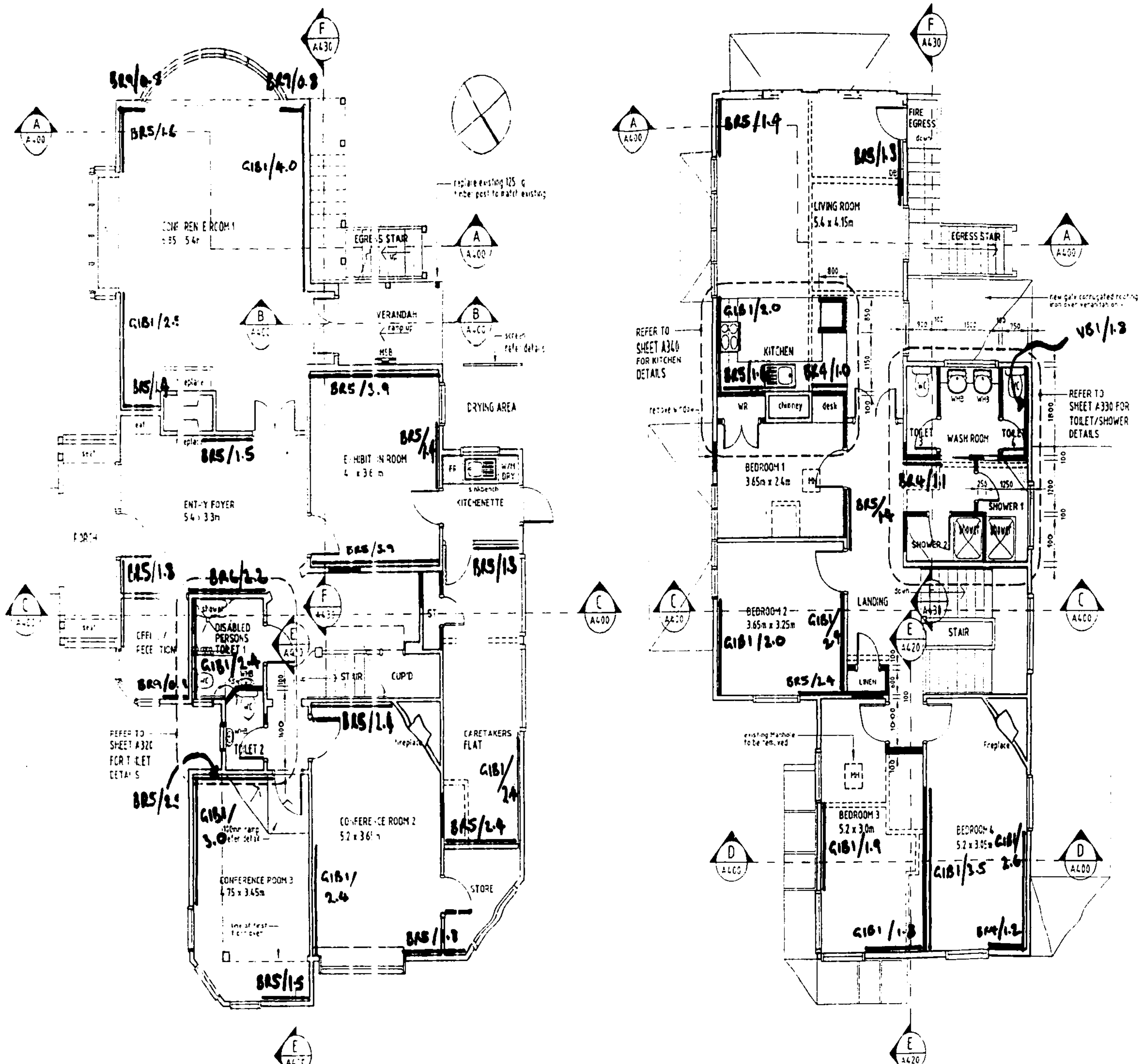
FILE :

NEWPLANS

ARCHITECTURAL

JOB NO. 1858
DESIGNED LH
DRAWN PR
CHECKED
DATE JUNE 98

SHEET NO. A210
IN SET OF
REV. C



GROUND FLOOR PLAN
AS PROPOSED

FIRST FLOOR PLAN
AS PROPOSED

NEW WALLS
EXISTING WALLS
EXISTING WALLS REMOVED

All dimensions shall be confirmed on site before commencing work.
Report any discrepancies to the architect.

NO.	ISSUE REVISION	BY	DATE

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DESIGNGROUP

DRAWING STATUS		ISSUE DATE
for information	•	25 JUNE 98
for approval	•	
for consent	•	
for tender	•	
for contract	•	
as built	•	

PROJECT TITLE
NORBURY HOUSE
REFURBISHMENT
38 NORMADALE ROAD
LOWER HUTT

DRAWING NAME
PROPOSED
FLOOR PLANS

SCALE : 1:100 @ A3

FILE :

ATTACHED CAD REFERENCE FILES
NEWPLANS

ARCHITECTURAL

JOB NO. 1898	SHEET NO.
DESIGNED CR	A210
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CHECKED	
DATE JUNE 98	REV. C

DETAILED SEISMIC ASSESSMENT FOR 38 NORMANDALE ROAD, MINOH HOUSE, LOWER HUTT.

STRUCTURAL ENGINEERING CALCULATIONS

Project alternative address:
91 WESTERN HUTT ROAD,
NORMANDALE, LOWER HUTT 5010

Client:
HUTT CITY COUNCIL

Project Ref:
P330

SEISMIC SOLUTIONS

Detailed Seismic Assessment- Detailed Seismic Assessment - Minoh House

DSA in this document follows the technical guidelines for engineering assessment titled, "The Seismic Assessment of Existing Buildings". The guidelines were published in Jul 2017 and provides the assessment component of the earthquake-prone building (EPB) regulations and EPB Methodology that came into force on 1 July 2017.

Project Title:	Detailed Seismic Assessment - Minoh House	**Job No:**	P330
Street Address:	91 Western Hutt Road, Normandale	**Engineer:**	MR
City:	Lower Hutt, 5010.	**Date:**	17/05/2023
Calculations for:	Preambles	**Sheet No:**	

TABLE OF CONTENTS

Disclaimer Statement

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Project Title:	Detailed Seismic Assessment - Minoh House	**Job No:**	P330
Street Address:	91 Western Hutt Road, Normandale	**Engineer:**	MR
City:	Lower Hutt, 5010.	**Date:**	17/05/2023
Calculations for:	Preambles	**Sheet No:**	

Summary of observations/ review

Project Scope: Perform a detailed seismic assessment of the building to assign a seismic rating (%ge NBS), and design of structural work to allow chimney removal and maintain at least 40% NBS (IL2)

Relevant Building Code Clauses Checked

B1 ☑ B2 ☐ B1/VM1 ☑ B1/VM4 ☐

New Zealand Building Standards/ References

- ☑ AS/NZS 1170: Structural Design Actions
- ☐ NZS 3404: Steel Structures Standard
- ☐ NZS 3101: Concrete Structures Standard
- ☑ NZS3603: Timber Structures Standard
- ☐ NZS 4230: Design of Reinforced Concrete Masonry Structures
- ☐ NZS 4229: Concrete Masonry Buildings not requiring specific engineering design
- ☑ NZS 3604: Timber framed buildings not requiring specific engineering design
- ☑ The Seismic Assessment of Existing Buildings (the Guidelines:)

Building type: Two-storey timber structure

Lateral LRS: Timber framed wall bracing system in both Longitudinal and Transverse directions

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Calculations for:	Preambles	**Sheet No:**	

Soil condition	The subsoil profile is B. Low liquefaction risk. Low seismic slope risk. Less than 200m distance from the closet active fault.

Subsoil profile as per NZS 1170.5 ☐ A ☑ B ☐ C ☐ D ☐ E

Foundations	Concrete footing below perimeter timber walls Timber piles
Good attributes	Good condition. Built circa 1904. Substantially upgraded circa 1998.
Bad attributes	No structural detail drawings Dissimilarities between the latest drawings available on HCC archive and onsite observations. Heavy brick chimneys Seems in the 1998 upgrade, several walls at the firs floor have been romoved adversely affect the bracing capacity in the transverse direction.

2.1-2.3

Seismic weight take-off

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Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Seismic weight take-off	**Rev:**	

Seismic Weight Calculations - NZS1170.1

Roof weight

Roof type	Light	$g_{roofing}$	0.2	kPa
Ceiling	Yes	$g_{ceiling}$	0.24	kPa
Roof space	Yes	g_{attic}	0.5	kPa
Total roof permanent actions		g_{roof}	0.94	kPa

Roof area	- GF (Galv. corrugated roofing)	$A_{roof\ GF}$	26.5 m^2	$G_{galv\ roofing}$	0.2 kPa
	- 1F	$A_{roof\ 1F}$	149 m^2		

Roof imposed actions

Roof GF access	Inaccessible	$q_{roof\ GF}$	0.25	kPa
Roof 1F access	Inaccessible	$q_{roof\ GF}$	0.25	kPa

Suspended Floor

Floor type	Timber	g_{floor}	0.60	kPa
Ceiling	Yes	$g_{ceiling}$	0.12	kPa
Allowance for partitions	Yes	$g_{patition}$	0.20	kPa
Total floor permanent actions		g_{floor}	0.92	kPa

Floor area	-. 1F	$A_{floor\ \ 1F}$	130 m^2
		$A_{balcony\ \ 1F}$	0 m^2
		q_{floor}	1.50 kPa
		$q_{balcony}$	2.00 kPa

$G_{1F\ Floor + GF\ Roof}$	124.90 kN	$Q_{1F\ Floor + GF\ Roof}$	201.63 kN
$G_{1F\ Roof}$	140.06 kN	$Q_{1F\ Roof}$	37.25 kN

Walls

Wall type	Light	$g_{framing}$	0.30	kPa
Fixture + lining		g_{lining}	0.10	kPa
Total wall weight - External Walls		g_{walls}	0.40	kPa

	Ground Floor	1st Floor
Wall height	3.5 m	2.4 m
Wall lengths	65 m	55 m
Total Wall Weight	**91.0 kN**	**52.8 kN**

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Building Name:	Minoh House	**Job Code:**	P330
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City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Seismic weight take-off	**Rev:**	

The orignal chimneys

Chimney #1	Ground Floor	1st Floor	Above roof
Chimney hights	3.5	3	2.5
Weight per length	22	16	16
Total Chimney Weight	**77 kN**	**48 kN**	**40 kN**

Chimney #2	Ground Floor	1st Floor	Above roof
Chimney hights	3.5	3	2.5
Weight per length	16	16	16
Total Chimney Weight	**56 kN**	**48 kN**	**40 kN**

The moodified chimneys: chimneys above ceiling level have been removed.

Chimney 1	Ground Floor	1st Floor	Above roof
Chimney hights	3.5	3	0
Weight per length	22	16	16
Total Chimney Weight	**77 kN**	**48 kN**	**0 kN**

Chimney 2	Ground Floor	1st Floor	Above roof
Chimney hights	3.5	3	0
Weight per length	16	16	16
Total Chimney Weight	**56 kN**	**48 kN**	**0 kN**

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Subject:	Seismic weight take-off	**Rev:**	

The original structure with the chinmneys

Seismic Weight	G	+	$\Psi_E.Q$	=	W_E	
1F	311	+	59	=	**369.8**	**kN**
Roof	294	+	0	=	**294.5**	**kN**
			W_{Total}	=	**664.26**	**kN**

The structure with the modified chimneys

Seismic Weight	G	+	$\Psi_E.Q$	=	W_E	
1F	311	+	59	=	**369.8**	**kN**
Roof	214	+	0	=	**214.5**	**kN**
			W_{Total}	=	**584.26**	**kN**

Seismic Weight ratios *(modified/original ratios)*

1F	**100**	**%**
Roof	**73**	**%**
Total	**88**	**%**

3.1-3.4 (a)

Earthquake actions

structure with chimneys

3.1(a)

Detailed Seismic Assessment - Minoh House, Lower Hutt.

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City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Earthquake Actions - New Zealand	**Rev:**	

Earthquake Actions - NZS1170.5

Annual Probability of Exceedance

Structure design life: 50 years — P_{ULS} 0.002
R_{ULS} 500 years

Importance level (1 Low - 4 Exceptional): 2 — P_{SLS} 0.04
R_{SLS} 25 years

Site Hazard Spectra

Spectral shape factor

Subsoil profile category: A/B - Strong rock/rock

First mode period of vibration T 0.4 secs

$C_h(T)$ 1.89

Select location of the building: Hutt Valley–south of Taita Gorge

Hazard factor	Z	0.4	
Return period factor	R_u	1.00	
Return period factor	R_s	0.25	
Distance to mapped fault	D	<0.2 km	1.9 km North West of Wellington Fault
Near fault factor	$N(T,D)$	1.00	$N_{max}(T)$ = 1.00
	$C(T)_{ULS}$	0.76	
	$C(T)_{SLS}$	0.19	

Estimated period of vibration T_1 0.40 secs — $T_1 = 1.25\, k_t\, h_n^{0.75}$ = 0.28 secs

Use the conservative 0.40 secs

Structural Characteristics: Elastic

Structural ductility factor	μ_{ULS}	1.00	μ_{SLS} 1
Structural performance factor	S_p	1.00	
Seismic force reduction factor	k_μ	1.00	

Design Earthquake Actions (Elastic)

Ultimate Limit State	$C_d(T_1)$	**0.76**	1/500 years Design earthquake
Serviceability Limit State	$C_d(T_1)$	**0.19**	1/25 years Design earthquake

3.2(a)

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Subject:	Earthquake Actions - New Zealand	**Rev:**	

Horizontal Design Actions Coefficients for Different Ductility Values

μ	S_p	k_μ	$C_h(T)$	$C(T)$	$C_d(T_1)$	System
3.5	0.70	2.43	1.89	0.76	0.22	Ductile
3	0.70	2.14	1.89	0.76	0.25	Ductile
2.5	0.70	1.86	1.89	0.76	0.28	Limited Ductile
2	0.70	1.57	1.89	0.76	0.34	Limited Ductile
1.25	0.93	1.14	1.89	0.76	0.61	Nominal Elastic
1	1.00	1.00	1.89	0.76	0.76	Elastic

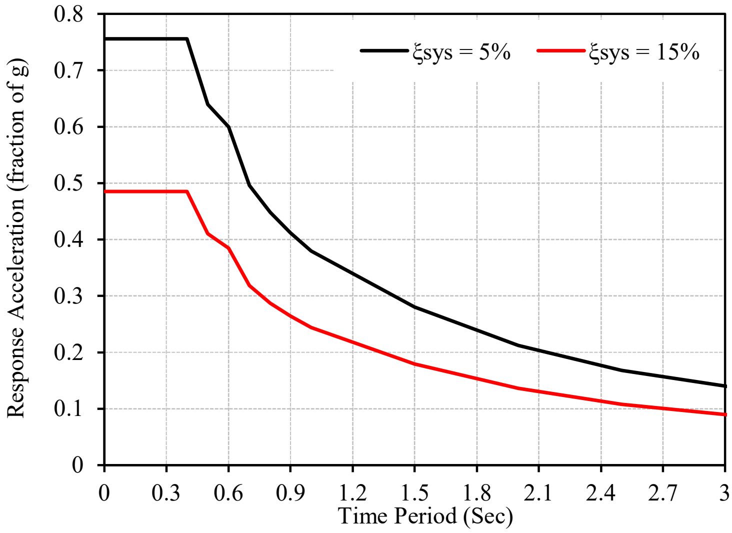

Figure . Damped design response spectra generated as per Clause 5.2.2.1 of NZS 1170.5:2004

ULS	Earthquake Design Action Coefficient	$C_d(T_1)$	0.25
	Total Weight of the Building	W_T	664.3 kN
	Seismic Base Shear at the Base	$V = C_d(T).W_T$	166.1 kN

Basement Garage portion

Floors	h_i	W_i	$h_i.W_i$	F_i	V_i	V_i	M_{oi}
	m	kN	kN.m	kN	kN	BU's	kN.m
1	3.5	369.8	1294	56.5	166.1	**3321**	198
Roof	7.5	294.5	2208	109.6	109.6	**2192**	822
Σ		**664**	**3503**	**166**			**1020**

V_i = **166.1 kN**

Detailed Seismic Assessment - Minoh House, Lower Hutt.

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Subject:	Earthquake Actions - New Zealand	**Rev:**	

SITE HAZARD SPECTRA - PARTS AND PORTIONS

Spectral shape factor

Period of vibration for the part	T_p =	0.1	secs	
	$C_h(0)$ =	1		
Seismic hazard factor	Z =	0.4	See above	
Return period factor	R_u =	1.0		
Near fault factor	N(T,D) =	1.00	$N_{max}(T)$ =	1.00
	C(0) =	0.40	$C(0) = C_h(0).Z.R.N(0,D)$	

STRUCTURAL CHARACTERISTICS

Structural ductility factor for the part

	μ_p =	1	

Structural performance factors

Part category		P.1	Table 8.1 NZS 1170.5
Part risk factor (R_p) =		1	Table 8.1 of NZS 1170.5
Total height of the building (h_n) =		7.5	
Part height of attachment (h_i) =		9 m	
	$0.2h_n$ =	1.5	
Floor height coeficient	C_{hi} =	2.5	Sec. 8.3 of NZS 1170.5
Part spectral shape factor $C_i(T_p)$ =		2	Sec. 8.4 NZS 1170.5
Part response coefficient $C_p(T_p)$ =		**2.00**	$C_p(T_p) = C(0).C_{Hi}.C_i(T_p)$
Part horizontal response factor	C_{ph} =	1	Sec. 8.6 NZS 1170.5
	$C_p(T_p).C_{ph}.R_p$ =	2.00	or max 3.6
	$C_p(T_p).C_{ph}.R_p$ =	**2.00**	

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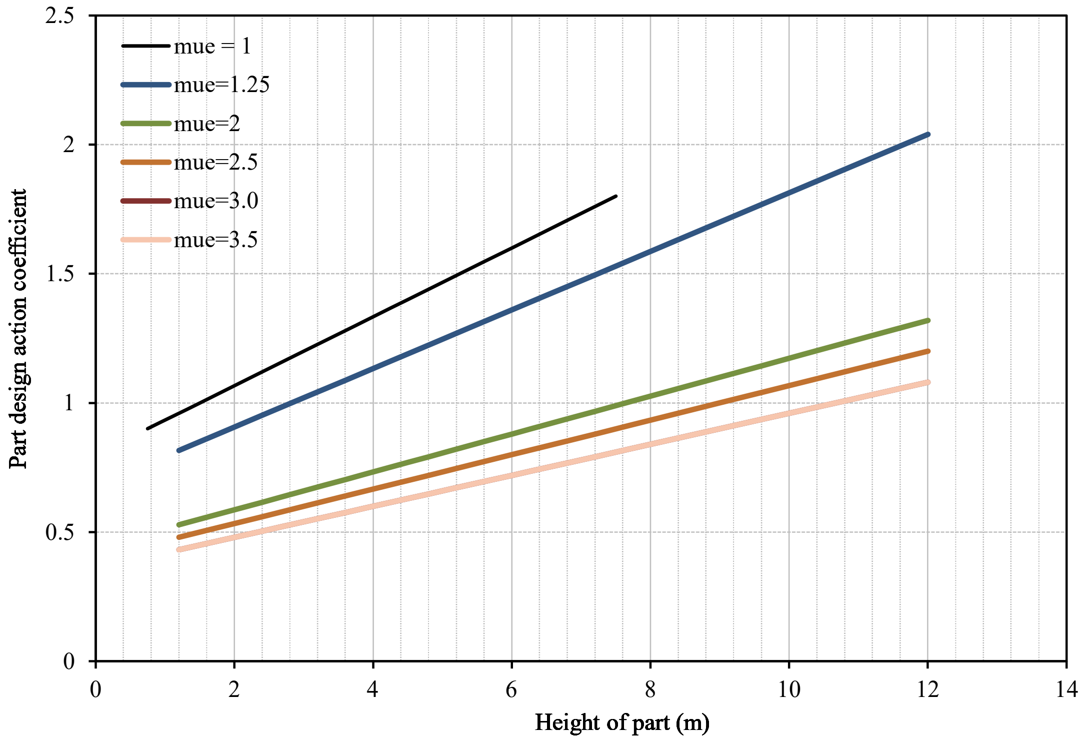
Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Earthquake Actions - New Zealand	**Rev:**	

Horizontal Design Actions Coefficients for Different Ductility Values - Parts and Portions

μ	$C_p(T_p)$	R_p	C_{ph}	$C_p(T_p).C_{ph}.R_p$	System
3.5	2.00	1.00	0.45	0.90	Ductile
3	2.00	1.00	0.45	0.90	Ductile
2.5	2.00	1.00	0.50	1.00	Limited Ductile
2	2.00	1.00	0.55	1.10	Limited Ductile
1.25	2.00	1.00	0.85	1.70	Nominal Elastic
1	2.00	1.00	1.00	2.00	Elastic

CHART - Parts and Portion Design Action Coefficient (fraction of g) variation with ductility and height

Part Ductility	Height of the component							
	0.75	1.50	2.25	3.00	3.75	4.50	6.00	7.50
3.5	0.41	0.45	0.50	0.54	0.59	0.63	0.72	0.81
3	0.41	0.45	0.50	0.54	0.59	0.63	0.72	0.81
2.5	0.45	0.50	0.55	0.60	0.65	0.70	0.80	0.90
2	0.50	0.55	0.61	0.66	0.72	0.77	0.88	0.99
1.25	0.77	0.85	0.94	1.02	1.11	1.19	1.36	1.53
1	0.90	1.00	1.10	1.20	1.30	1.40	1.60	1.80



3.1-3.4 (b)

Earthquake actions

structure without chimneys

Detailed Seismic Assessment - Minoh House, Lower Hutt.

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Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Earthquake Actions - New Zealand	**Rev:**	

Earthquake Actions - NZS1170.5

Annual Probability of Exceedance

Structure design life	50 years	P_{ULS}	0.002
		R_{ULS}	500 years
Importance level (1 Low - 4 Exceptional)	2	P_{SLS}	0.04
		R_{SLS}	25 years

Site Hazard Spectra

Spectral shape factor

Subsoil profile category		A/B - Strong rock/rock
First mode period of vibration	T	0.4 secs
	$C_h(T)$	1.89

Select location of the building: Hutt Valley–south of Taita Gorge

Hazard factor	Z	0.4		
Return period factor	R_u	1.00		
Return period factor	R_s	0.25		
Distance to mapped fault	D	<0.2 km		1.9 km North West of Wellington Fault
Near fault factor	$N(T,D)$	1.00	$N_{max}(T)$ =	1.00
	$C(T)_{ULS}$	0.76		
	$C(T)_{SLS}$	0.19		
Estimated period of vibration	T_1	0.40 secs	$T_1 = 1.25\, k_t\, h_n^{0.75}$ =	0.28 secs

Use the conservative 0.40 secs

Structural Characteristics: Elastic

Structural ductility factor	μ_{ULS}	1.00	μ_{SLS}	1
Structural performance factor	S_p	1.00		
Seismic force reduction factor	k_μ	1.00		

Design Earthquake Actions (Elastic)

Ultimate Limit State	$C_d(T_1)$	**0.76**	1/500 years Design earthquake
Serviceability Limit State	$C_d(T_1)$	**0.19**	1/25 years Design earthquake

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City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Earthquake Actions - New Zealand	**Rev:**	

Horizontal Design Actions Coefficients for Different Ductility Values

μ	S_p	k_μ	$C_h(T)$	$C(T)$	$C_d(T_1)$	System
3.5	0.70	2.43	1.89	0.76	0.22	Ductile
3	0.70	2.14	1.89	0.76	0.25	Ductile
2.5	0.70	1.86	1.89	0.76	0.28	Limited Ductile
2	0.70	1.57	1.89	0.76	0.34	Limited Ductile
1.25	0.93	1.14	1.89	0.76	0.61	Nominal Elastic
1	1.00	1.00	1.89	0.76	0.76	Elastic

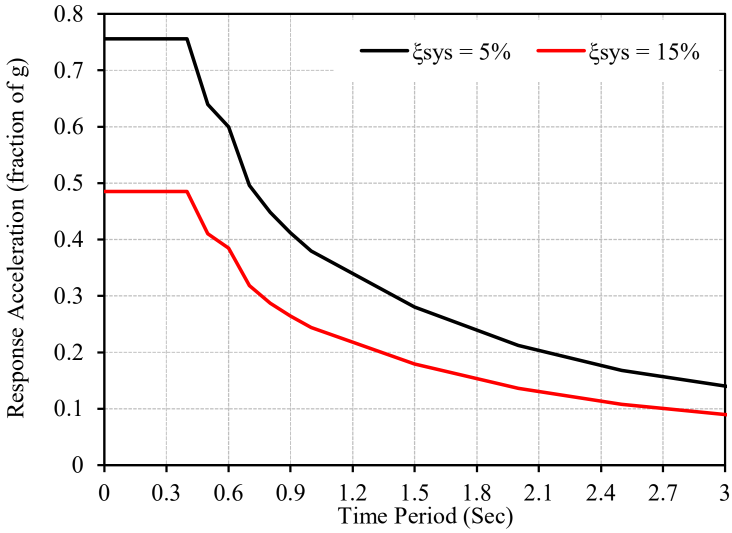

Figure . Damped design response spectra generated as per Clause 5.2.2.1 of NZS 1170.5:2004

ULS	Earthquake Design Action Coefficient	$C_d(T_1)$	0.25
	Total Weight of the Building	W_T	664.3 kN
	Seismic Base Shear at the Base	$V = C_d(T). W_T$	166.1 kN

Basement Garage portion

Floors	h_i	W_i	$h_i.W_i$	F_i	V_i	V_i	M_{oi}
	m	kN	kN.m	kN	kN	BU's	kN.m
1	3.5	369.8	1294	59.9	146.1	**2921**	210
Roof	7.5	214.5	1608	86.1	86.1	**1723**	646
Σ		**584**	**2903**	**146**			**856**

V_i = **146.1 kN**

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Subject:	Earthquake Actions - New Zealand	**Rev:**	

SITE HAZARD SPECTRA - PARTS AND PORTIONS

Spectral shape factor

Period of vibration for the part	T_p =	0.1 secs		
	$C_h(0)$ =	1		
Seismic hazard factor	Z =	0.4	See above	
Return period factor	R_u =	1.0		
Near fault factor	N(T,D) =	1.00	$N_{max}(T)$ =	1.00
	C(0) =	0.40	$C(0) = C_h(0).Z.R.N(0,D)$	

STRUCTURAL CHARACTERISTICS

Structural ductility factor for the part

	μ_p =	1		

Structural performance factors

Part category		P.1	Table 8.1 NZS 1170.5	
Part risk factor (R_p) =		1	Table 8.1 of NZS 1170.5	
Total height of the building (h_n) =		7.5		
Part height of attachment (h_i) =		9 m		
	$0.2h_n$ =	1.5		
Floor height coeficient	C_{hi} =	2.5	Sec. 8.3 of NZS 1170.5	
Part spectral shape factor $C_i(T_p)$ =		2	Sec. 8.4 NZS 1170.5	
Part response coefficient $C_p(T_p)$ =		**2.00**	$C_p(T_p) = C(0).C_{Hi}.C_i(T_p)$	
Part horizontal response factor	C_{ph} =	1	Sec. 8.6 NZS 1170.5	
	$C_p(T_p).C_{ph}.R_p$ =	2.00	or max	3.6
	$C_p(T_p).C_{ph}.R_p$ =	**2.00**		

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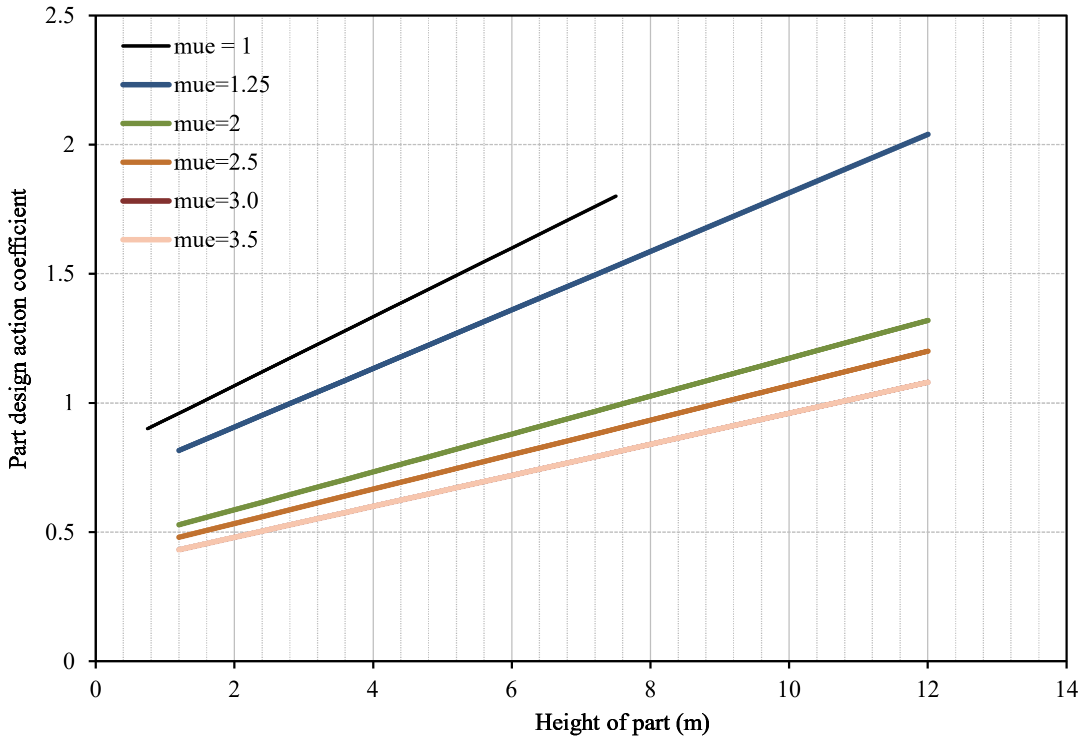
Horizontal Design Actions Coefficients for Different Ductility Values - Parts and Portions

μ	$C_p(T_p)$	R_p	C_{ph}	$C_p(T_p).C_{ph}.R_p$	System
3.5	2.00	1.00	0.45	0.90	Ductile
3	2.00	1.00	0.45	0.90	Ductile
2.5	2.00	1.00	0.50	1.00	Limited Ductile
2	2.00	1.00	0.55	1.10	Limited Ductile
1.25	2.00	1.00	0.85	1.70	Nominal Elastic
1	2.00	1.00	1.00	2.00	Elastic

CHART - Parts and Portion Design Action Coefficient (fraction of g) variation with ductility and height

Part Ductility	Height of the component							
	0.75	1.50	2.25	3.00	3.75	4.50	6.00	7.50
3.5	0.41	0.45	0.50	0.54	0.59	0.63	0.72	0.81
3	0.41	0.45	0.50	0.54	0.59	0.63	0.72	0.81
2.5	0.45	0.50	0.55	0.60	0.65	0.70	0.80	0.90
2	0.50	0.55	0.61	0.66	0.72	0.77	0.88	0.99
1.25	0.77	0.85	0.94	1.02	1.11	1.19	1.36	1.53
1	0.90	1.00	1.10	1.20	1.30	1.40	1.60	1.80



4.1-4.4

Wind actions

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WIND ACTION CALCULATIONS TO AS/NZS 1170.2:2002

ANNUAL PROBABILITY OF EXCEEDANCE

Structure Design Life: 50 years

$P_{U.L.S.}$ = 0.002

$R_{U.L.S.}$ = 500 years

Importance Level (1 Low - 4 Exceptional): 2

$P_{S.L.S.}$ = 0.04

$R_{S.L.S.}$ = 25 years

REGIONAL WIND SPEEDS

Site Location: Region = W

Regional wind speed

$V_{U.L.S.}$ = 51 m/s

$V_{S.L.S.}$ = 43 m/s

SITE EXPOSURE MULTIPLIERS

Terrain/Height Multiplier

Terrain category: cat = 2/3

Height (average roof height): z = 7.50 m

M(z,cat) = 0.89

Directional Multiplier: Md = 1.00

Sheilding Multiplier

Ms = 1.00

Topographic Multiplier

Mt = 1.10 T1 per NZS3604

In this table	Gentle = Low = Mild = Moderate = Steep =	Gradient Gradient Gradient Gradient Gradient	< 0.05 0.05 < 0.1 0.1 < 0.15 0.15 < 0.2 > 0.2	i.e. slope max. i.e. slope max. i.e. slope max. i.e. slope max. i.e. slope max.	1:20 1:10 1:6.7 1:5 1:5

Table 5.3 – Determination of topographic class

Topography	Gentle	Low	Mild	Moderate	Steep
Crest	T1	T2	T3	T4	T4
Outer	T1	T1	T2	T2	T3

All sites outside the outer and crest zones are topographic class T1 except that:

(1) Sites within valleys which are known to have accelerated wind flows within them because of their shape and exposed mouths shall be classed as T4.

(2) Sites in areas with undulations of less than 10 m in height, and gradients less than 1:20 shall be classed as T1.

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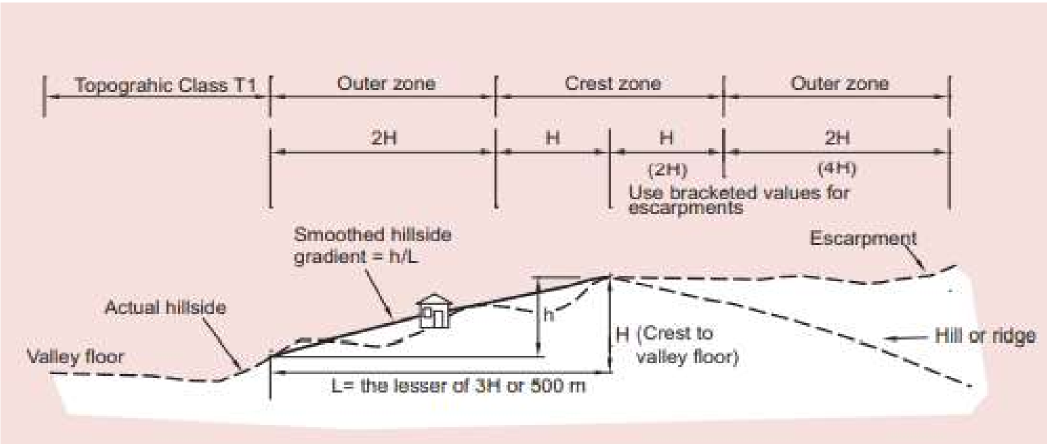

SITE WIND SPEEDS AND PRESSURES

Site wind speed	U.L.S.	V_{site} =	50	m/s
	S.L.S.	V_{site} =	42	m/s
Site wind pressure	U.L.S.	p_{site} =	1.49	kPa
	S.L.S.	p_{site} =	1.08	kPa

COMPARISON TO BRANZ MAP for NZS 3604 Wind Region

Wind Zone Medium

Site wind speed	U.L.S.	V_{site} =	37	m/s
	S.L.S.	V_{site} =	32	m/s
Site wind pressure	U.L.S.	p_{site} =	0.82	kPa
	S.L.S.	p_{site} =	0.61	kPa

Table 5.4 of NZS 3604 - footnote

Wind speeds below are the maximum ultimate limit state wind speed for each wind zone.
L = Low wind speed of 32 m/s
M = Medium wind speed of 37 m/s
H = High wind speed of 44 m/s
VH = Very high wind speed of 50 m/s
EH = Extra high wind speed of 55 m/s
SED = Specific engineering design (not covered by this Standard)

Winds in lee zones shall be increased as follows:
Low wind becomes High
Medium wind becomes Very high
High wind, and above become SED

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DESIGN WIND ACTIONS

Cladding, purlins, and girts

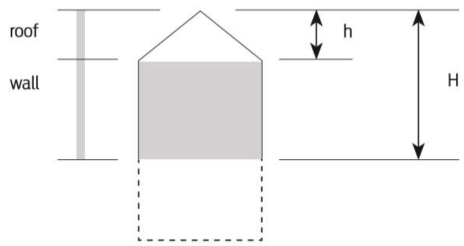
		K_l =	1.50	(local pressure factor)
		Cpe =	-0.9	
	U.L.S.	**p =**	**-1.11**	**kPa**
	S.L.S.	**p =**	**-1.46**	**kPa**

Structural elements collecting loads from larger areas

		K_aK_c =	0.80	(Min product of K_aK_c = 0.8)
	U.L.S.	**p =**	**1.19**	**kPa**
	S.L.S.	**p =**	**0.49**	**kPa**

BUILDING BRACING DEMAND INTERPRETATION FROM SED WIND LOAD CALCULATIONS

First Floor Wind Bracing Demand



Across

$$D = 0.6\,V_{des}^2 \times \left[C_{pw}\left(\frac{H-h}{2}\right) + C_{pr}(h) \right] \times 20 \times 0.8$$

Along

$$D = 0.6\,V_{des}^2 \times \left[C_{pw}\left(\frac{H}{2}\right) \right] \times 20 \times 0.8$$

h =	0.90	m
H =	3.90	m
C_{pe} (h) =	0.29	
C_{pw} =	1.2	

ACROSS	**D =**	**49**	BUs/m			
ALONG	**D =**	**56**	BUs/m			
	ALONG			ACROSS		
ALONG	W =	9.50	m	18.00	m	
	V_{wind} =	531	Bus	886	BUs	
	V_{wind} =	26.56	kN	44.29	kN	

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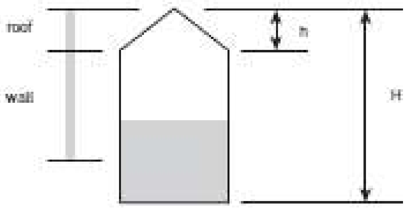
Ground Floor Wind Bracing Demand



Across

$$D = 0.6\,V_{des}^2 \times \left[C_{pw}\left(\frac{3H}{4} - \frac{3h}{4}\right) + C_{pe}(h) \right] \times 20 \times 0.8$$

Along

$$D = 0.6\,V_{des}^2 \times \left[C_{pw}\left(\frac{3H}{4} - \frac{h}{4}\right) \right] \times 20 \times 0.8$$

	h =	0.90 m		
	H =	7.50 m		
	C_{pe} (h) =	0.29		
	C_{pw} =	1.2		
ACROSS	**D =**	**149** BUs/m		
ALONG	**D =**	**155** BUs/m		
	ALONG		ACROSS	
ALONG	W =	12.00 m		19.00 m
	V_{wind} =	1858 BUs		2828 BUs
	V_{wind} =	92.91 kN		141.39 kN

5.1-5.2

Typical wall framed bracing systems

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Bracing Capacity of typical Wall Types

Wall Type	**Description**			**Min. wall length (2.4m height) BUs/m**			
				Wind		**Earthquake**	
				0.6 m	**1.2 m**	**0.6 m**	**1.2 m**
GS1-N	GIB 10/13	1 side	no holddn	50	70	55	60
GS2-N	GIB 10/13	both sides	no holddn	70	95	65	85
GS2-NOM	GIB 10/13	both sides	no holddn	50	50	50	50
GSP-H	GIB 10/13	Plywood 7	holddn	100	150	150	150
BL1-H	Braceline	1 side	holddn	90	125	100	105
BLG-H	Braceline	GIB 10/13	holddn	110	150	115	145
BLP-H	Braceline	Plywood 7	holddn	120	150	135	150

James Hardies							
HPgn	4.5 HRAB	GIB 10	no holddn	73	69	66	58
HPg	4.5 HRAB	GIB 10	holddn	127	164	137	138
JHDgn	6 RABB	GIB 10	no holddn	69	86	64	72
JHD	6 RABB		holddn	99	154	107	140

Ecoply							
EP1	EP 7,9,12	-	holddn	95	120	105	135
EP2	EP 7,9,12	EP 7,9,12	holddn	105	105	115	115
EPG	EP 7,9,12	GIB 10/13	holddn	100	150	115	150

Metal Craft SIP Panel Bracing Walls						
MC-T	Metecno 100 PIR	holddn	105	116	148	158
MC-M	Thermospan 100 EPS	holddn	98	109	161	175

Notes:
MC walls rating based on report provided by Airey Consultants interpreting the P21 test results by BRANZ
all walls tested showed more than 3.5 ductility and satisfied the requirements
Typical Holddown details to be followed given in literature by Metal Craft
Report noted that the behaviour controlled by rocking and holddown capacity would givern the BU rating
Up to 2m apart walls consider as one bracing line, with 0.5D/n bracing per line
15BUs/ m for external walls
Wall bracing capacity x 2.4/H for taller walls
Timber floor 120BUs/m max. and 150 BUs/m for concrete floor
Max. spacing for bracing lines - 6 m for Gib standard - 7.5 m with dragin ties/sheet braces and 12 m with GIB diaphragm (refer GIB ceiling Diaphragm technical note) or Ecoply diaphragm.
15BUs/m on each end of the diaphragm, with length maximum 12 m for pitch up to 25 and 7.5 for 45 (diaphragm req.) aspect ratio idealy 1

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Table 5.1 – Bracing capacity of panels (bracing units) (continued) (see 5.1.1)

20 Series Solid Fill														
Panel height (m)	**Panel length** (m) **0.8**	**1.2**	**1.6**	**2.0**	**2.4**	**2.8**	**3.2**	**3.6**	**4.0**	**4.4**	**4.8**	**5.2**	**5.6**	**6.0**
0.8	395	665	1040	1480	2010	2605	2625	3245	3920	4925	5780	6320	7250	8240
1.0	340	575	905	1285	1745	2265	2285	2825	3415	4290	5035	5510	6320	7190
1.2	285	485	765	1090	1485	1925	1945	2405	2910	3655	4285	4700	5395	6135
1.4	255	435	690	980	1340	1735	1760	2170	2630	3300	3870	4250	4880	5550
1.6	225	390	610	875	1195	1550	1570	1940	2350	2940	3460	3800	4365	4965
1.8	205	355	560	805	1100	1430	1445	1790	2170	2720	3195	3515	4040	4595
2.0	185	325	515	735	1005	1310	1325	1640	1990	2495	2930	3230	3710	4220
2.2	175	305	480	690	940	1225	1240	1540	1865	2335	2745	3030	3480	3960
2.4	160	280	445	640	875	1145	1160	1440	1740	2180	2560	2830	3255	3700
2.6	150	265	420	605	830	1080	1100	1360	1650	2065	2425	2685	3085	3515
2.8	145	250	395	575	780	1020	1035	1285	1560	1950	2295	2540	2920	3320
3.0	135	235	380	545	750	975	990	1230	1495	1860	2190	2430	2795	3180

6.1 (a)

Project's bracing types & governing demands structure with chimneys

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BRACING CAPACITY CHECK

Wall Type	Wall Height	Min. wall length (BUs/m)			
		Wind		Earthquake	
		0.6 m	1.2 m	0.6 m	1.2 m
#1	2.4 m	50.0	70.0	55.0	60.0
#2	2.4 m	50.0	70.0	55.0	60.0
#3	2.4 m	70.0	95.0	65.0	85.0
#4-1 (one side)	2.4 m	20.0	20.0	20.0	20.0
#4-2 (two side)	2.4 m	40.0	40.0	40.0	40.0
#5	2.4 m	50.0	70.0	55.0	60.0
#6	2.4 m	80.0	80.0	60.0	60.0
#7	2.4 m	25.0	25.0	25.0	25.0
#8	2.4 m	30.0	30.0	30.0	30.0
#9	2.4 m	80.0	80.0	60.0	60.0
#10-1 (one side)	2.4 m	90.0	125.0	100.0	105.0
#10-2 (two side)	2.4 m	110.0	150.0	115.0	145.0

Wall Type	Description
#1	**1 x layer 9.5 Gib Noiseline over existing plaster board lining**
#2	**1 x layer 9.5 Gib Noiseline**
#3	**2 x layer 9.5 Gib Noiseline**
#4-1 (one side)	**existing plaster board**
#4-2 (two side)	**existing plaster board**
#5	**1 x layer standard 9.5 Gib Board**
#6	**1 x layer Formica Aquapanel over 9.5 Gib Aqualine**
#7	**existing match lining**
#8	**existing lath and plaster**
#9	**1 x layer 6mm Hardies Villa Board**
#10-1 (one side)	**Bracing Gib Board**
#10-2 (two side)	**Bracing Gib Board**

Demand Summary - 1F

			Wind		Earthquake	
GOVERNING DEMAND - EQ =	2192	BUs	ALONG	ACROSS	ALONG	ACROSS
n - across =	6					
n - along =	4	TOTAL	531	886	2192	2192
Min. bracing per line = 0.5d/n =		PER LINE	66	74	274	183
Min. bracing from external wall = 15 x L =		EXTE. WALL	270	143	270	143

Demand Summary - GF

			Wind		Earthquake	
GOVERNING DEMAND - EQ =	3321	BUs	ALONG	ACROSS	ALONG	ACROSS
n - across =	6					
n - along =	3	TOTAL	1858	2828	3321	3321
Min. bracing per line = 0.5d/n =		PER LINE	310	236	554	277
Min. bracing from external wall = 15 x L =		EXTE. WALL	285	180	285	180

6.1 (b)

Project's bracing types & governing demands structure without chimneys

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Subject:	Wind Loading and Bracing Calculations	**Ref:**	

BRACING CAPACITY CHECK

Wall Type	Wall Height	Min. wall length (BUs/m)			
		Wind		Earthquake	
		0.6 m	1.2 m	0.6 m	1.2 m
#1	2.4 m	50.0	70.0	55.0	60.0
#2	2.4 m	50.0	70.0	55.0	60.0
#3	2.4 m	70.0	95.0	65.0	85.0
#4-1 (one side)	2.4 m	20.0	20.0	20.0	20.0
#4-2 (two side)	2.4 m	40.0	40.0	40.0	40.0
#5	2.4 m	50.0	70.0	55.0	60.0
#6	2.4 m	80.0	80.0	60.0	60.0
#7	2.4 m	25.0	25.0	25.0	25.0
#8	2.4 m	30.0	30.0	30.0	30.0
#9	2.4 m	80.0	80.0	60.0	60.0
#10-1 (one side)	2.4 m	90.0	125.0	100.0	105.0
#10-2 (two side)	2.4 m	110.0	150.0	115.0	145.0

Wall Type	Description
#1	1 x layer 9.5 Gib Noiseline over existing plaster board lining
#2	1 x layer 9.5 Gib Noiseline
#3	2 x layer 9.5 Gib Noiseline
#4-1 (one side)	existing plaster board
#4-2 (two side)	existing plaster board
#5	1 x layer standard 9.5 Gib Board
#6	1 x layer Formica Aquapanel over 9.5 Gib Aqualine
#7	existing match lining
#8	existing lath and plaster
#9	1 x layer 6mm Hardies Villa Board
#10-1 (one side)	Bracing Gib Board
#10-2 (two side)	Bracing Gib Board

Demand Summary - 1F

			Wind		Earthquake	
GOVERNING DEMAND - EQ =	1723	BUs				
n - across =	6		ALONG	ACROSS	ALONG	ACROSS
n - along =	4	TOTAL	531	886	1723	1723
Min. bracing per line = 0.5d/n =		PER LINE	66	74	215	144
Min. bracing from external wall = 15 x L =		EXTE. WALL	270	143	270	143

Demand Summary - GF

			Wind		Earthquake	
GOVERNING DEMAND - EQ =	2921	BUs				
n - across =	6		ALONG	ACROSS	ALONG	ACROSS
n - along =	3	TOTAL	1858	2828	2921	2921
Min. bracing per line = 0.5d/n =		PER LINE	310	236	487	243
Min. bracing from external wall = 15 x L =		EXTE. WALL	285	180	285	180

7.1-7.4

Bracing calculations

for option 1

Detailed Seismic Assessment - Minoh House, Lower Hutt.

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Building Name:	Minoh House	**Job Code:**	P330
Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

First FLOOR - ALONG DIRECTION — **WALL HEIGHT =** **2.7 m**
(Refer to bracing plan) — **RF** 0.89

Bracing Wall Type	Line	Element	Length (m)	Modified Length (m)	Wind BU/m	Wind Bus Ach.	Earthquake BU/m	Earthquake Bus Ach.
#5	M	M1	2.00	1.78	70	124	60	107
#5		M2	2.00	1.78	70	124	60	107
#5		M3	1.40	1.24	70	87	60	75
Total						336		288
#5	N	N1	1.90	1.69	70	118	60	101
#5		N2	1.00	0.47	50	24	55	26
#3		N3	2.20	1.96	70	137	60	117
#2		N4	1.40	1.24	70	87	60	75
#2		N5	1.40	1.24	70	87	60	75
Total						453		394
#2	O	O1	3.60	3.20	70	224	60	192
#9		O2	2.00	1.78	80	142	60	107
#2		O3	1.50	1.33	70	93	60	80
Total						460		379
#5	P	P1	2.60	2.31	70	162	60	139
#4-1		P2	2.50	2.22	20	44	20	44
#4-1		P3	1.20	0.89	20	18	20	18
#9		P4	2.00	1.78	80	142	60	107
Total						366		307
					TOTAL	1615		1368

		Demand		Capacity	Result
Total Bracing Check:	Wind	531	<	1615	OK
	EQ	2192	<	1368	NOT OK
Bracing Per Line Check:		274	<	288	OK
Bracing External Wall Check:		270	<	288	OK

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City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

First FLOOR - ACROSS DIRECTION — **WALL HEIGHT = 2.7 m**
(Refer to bracing plan) — **RF** 0.89

Bracing Wall Type	Line	Element	Length (m)	Modified Length (m)	Wind BU/m	Wind Bus Ach.	Earthquake BU/m	Earthquake Bus Ach.
	A		0.00	0.00	0	0	0	0
STRENGTHENING								
Total						0		0
#9	B	B1	1.10	0.68	80	55	60	41
#2		B2	1.40	1.24	70	87	60	75
#2		B3	1.00	0.47	50	24	55	26
Total						165		142
#9	C	C1	1.00	0.47	80	38	60	28
#9		C2	2.60	2.31	80	185	60	139
Total						223		167
#1	D	D1	3.70	3.29	70	230	60	197
#9		D2	3.70	3.29	80	263	60	197
Total						493		395
#5	E	E1	1.00	0.47	50	24	55	26
#10-1		E2	1.40	1.24	120	149	105	131
#4-1		E3	3.20	2.84	20	57	20	57
#3		E4	1.00	0.47	70	33	65	31
Total						263		244
#5	F	F1	1.80	1.60	70	112	60	96
#10-1		F2	1.20	0.89	90	80	100	89
Total						192		185
					TOTAL	1336		1132

		Demand		Capacity	Result
Total Bracing Check:	Wind	886	<	1336	OK
	EQ	2192	<	1132	NOT OK
Bracing Per Line Check:		183	<	0	NOT OK
Bracing External Wall Check:		143	<	0	NOT OK

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Building Name:	Minoh House	**Job Code:**	P330
Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

Ground FLOOR - ALONG DIRECTION **WALL HEIGHT =** **3 m**
(Refer to bracing plan) **RF** 0.8

Bracing Wall Type	Line	Element	Length (m)	Modified Length (m)	Wind BU/m	Wind Bus Ach.	Earthquake BU/m	Earthquake Bus Ach.
#5	M	M1	1.80	1.44	70	101	55	79
#8		M2	2.50	2.00	30	60	30	60
#8		M3	1.50	1.20	30	36	30	36
#5		M4	3.00	2.40	70	168	55	132
#3		M5	2.20	1.76	95	167	85	150
Total						532		457
#5	N	N1	2.40	1.92	70	134	60	115
#4-2		N2	1.30	0.82	40	33	40	33
#4-2		N3	1.20	0.64	40	26	40	26
#4-2		N4	1.70	1.36	40	54	40	54
#8		N5	1.30	0.82	30	25	30	25
#8		N6	4.00	3.20	30	96	30	96
Total						368		349
#5	O	O1	5.20	4.16	70	291.20	60	249.60
#4-2		O2	1.20	0.64	40	25.73	40	25.73
#5		O3	1.40	1.01	70	70.56	60	60.48
#5		O4	2.40	1.92	70	134.40	60	115.20
Total						522		451
					TOTAL	1422		1257

		Demand		Capacity	Result
Total Bracing Check:	Wind	1858	<	1422	NOT OK
	EQ	3321	<	1257	NOT OK
Bracing Per Line Check:		554	<	349	NOT OK
Bracing External Wall Check:		285	<	451	OK

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Building Name:	Minoh House	**Job Code:**	P330
Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

Ground FLOOR - ACROSS DIRECTION — **WALL HEIGHT =** **3 m**

(Refer to bracing plan) — **RF** 0.8

Bracing Wall Type	Line	Element	Length (m)	Modified	Wind		Earthquake	
				Length (m)	BU/m	Bus Ach.	BU/m	Bus Ach.
#8	A	A1	0.70	0.00	30.0	0	30.0	0
#8		A2	0.70	0.00	30.0	0	30.0	0
STRENGTHENING								
Total						0		0
#10-1	B	B1	3.60	2.88	120.0	346	105.0	302
#8		B2	1.15	0.54	30.0	16	30.0	16
#10-2		B3	1.20	0.64	110.0	71	115.0	74
Total						433		393
#10-2	C	C1	1.10	0.46	110.0	50	115.0	53
#10-2		C2	2.20	1.76	120.0	211	120.0	211
#10-2		C3	3.60	2.88	120.0	346	120.0	346
#10-2		C4	1.30	0.82	120.0	99	120.0	99
Total						706		708
#10-2	D	D1	2.40	1.92	120.0	230	120.0	230
#4-1		D2	1.20	0.64	20.0	13	20.0	13
Total						243		243
#2	E	E1	2.50	2.00	70.0	140	60.0	120
#10-2		E2	2.20	1.76	120.0	211	120.0	211
Total						351		331
#10-1	F	F1	1.50	1.20	120.0	144	105.0	126
#10-1		F2	1.80	1.44	120.0	173	105.0	151
Total						317		277
					TOTAL	2050		1952

		Demand		Capacity	Result
Total Bracing Check:	Wind	2828	<	2050	NOT OK
	EQ	3321	<	1952	NOT OK
Bracing Per Line Check:		277	<	0	NOT OK
Bracing External Wall Check:		180	<	0	NOT OK

8.1-8.4

Bracing calculations

for option 2

Detailed Seismic Assessment - Minoh House, Lower Hutt.

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Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

First FLOOR - ALONG DIRECTION — **WALL HEIGHT =** **2.7 m**
(Refer to bracing plan) — **RF** 0.89

Bracing Wall Type	**Line**	**Element**	**Length (m)**	**Modified Length (m)**	**Wind BU/m**	**Wind Bus Ach.**	**Earthquake BU/m**	**Earthquake Bus Ach.**
#5	M	M1	2.00	1.78	70	124	60	107
#5		M2	2.00	1.78	70	124	60	107
#5		M3	1.40	1.24	70	87	60	75
Total						336		288
#5	N	N1	1.90	1.69	70	118	60	101
#5		N2	1.00	0.47	50	24	55	26
#3		N3	2.20	1.96	70	137	60	117
#2		N4	1.40	1.24	70	87	60	75
#2		N5	1.40	1.24	70	87	60	75
Total						453		394
#2	O	O1	3.60	3.20	70	224	60	192
#9		O2	2.00	1.78	80	142	60	107
#2		O3	1.50	1.33	70	93	60	80
Total						460		379
#5	P	P1	2.60	2.31	70	162	60	139
#4-1		P2	2.50	2.22	20	44	20	44
#4-1		P3	1.20	0.89	20	18	20	18
#9		P4	2.00	1.78	80	142	60	107
Total						366		307
					TOTAL	1615		1368

		Demand		Capacity	Result
Total Bracing Check:	Wind	531	<	1615	OK
	EQ	2192	<	1368	NOT OK
Bracing Per Line Check:		274	<	288	OK
Bracing External Wall Check:		270	<	288	OK

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City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

First FLOOR - ACROSS DIRECTION | **WALL HEIGHT =** **2.7 m**
(Refer to bracing plan) | **RF** 0.89

Bracing Wall Type	**Line**	**Element**	**Length (m)**	**Modified Length (m)**	**Wind BU/m**	**Wind Bus Ach.**	**Earthquake BU/m**	**Earthquake Bus Ach.**
	A		0.00	0.00	0	0	0	0
STRENGTHENING								
#10-1		**A1**	**0.80**	**0.71**	**90**	**64**	**100**	**71**
#10-1		**A2**	**0.80**	**0.71**	**90**	**64**	**100**	**71**
Total						128		142
#9	B	B1	1.10	0.68	80	55	60	41
#2		B2	1.40	1.24	70	87	60	75
#2		B3	1.00	0.47	50	24	55	26
Total						165		142
#9	C	C1	1.00	0.47	80	38	60	28
#9		C2	2.60	2.31	80	185	60	139
Total						223		167
#1	D	D1	3.70	3.29	70	230	60	197
#9		D2	3.70	3.29	80	263	60	197
Total						493		395
#5	E	E1	1.00	0.47	50	24	55	26
#10-1		E2	1.40	1.24	120	149	105	131
#4-1		E3	3.20	2.84	20	57	20	57
#3		E4	1.00	0.47	70	33	65	31
Total						263		244
#5	F	F1	1.80	1.60	70	112	60	96
#10-1		F2	1.20	0.89	90	80	100	89
Total						192		185
					TOTAL	1464		1274

		Demand		Capacity	Result
Total Bracing Check:	Wind	886	<	1464	OK
	EQ	2192	<	1274	NOT OK
Bracing Per Line Check:		183	<	142	NOT OK
Bracing External Wall Check:		143	<	128	NOT OK

Detailed Seismic Assessment - Minoh House, Lower Hutt.

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City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

Ground FLOOR - ALONG DIRECTION — **WALL HEIGHT =** **3 m**

(Refer to bracing plan) — **RF** 0.8

Bracing Wall Type	Line	Element	Length (m)	Modified Length (m)	Wind BU/m	Wind Bus Ach.	Earthquake BU/m	Earthquake Bus Ach.
#5	M	M1	1.80	1.44	70	101	55	79
#8		M2	2.50	2.00	30	60	30	60
#8		M3	1.50	1.20	30	36	30	36
#5		M4	3.00	2.40	70	168	55	132
#3		M5	2.20	1.76	95	167	85	150
Total						532		457
#5	N	N1	2.40	1.92	70	134	60	115
#4-2		N2	1.30	0.82	40	33	40	33
#4-2		N3	1.20	0.64	40	26	40	26
#4-2		N4	1.70	1.36	40	54	40	54
#8		N5	1.30	0.82	30	25	30	25
#8		N6	4.00	3.20	30	96	30	96
Total						368		349
#5	O	O1	5.20	4.16	70	291.20	60	249.60
#4-2		O2	1.20	0.64	40	25.73	40	25.73
#5		O3	1.40	1.01	70	70.56	60	60.48
#5		O4	2.40	1.92	70	134.40	60	115.20
Total						522		451
					TOTAL	1422		1257

		Demand		Capacity	Result
Total Bracing Check:	Wind	1858	<	1422	NOT OK
	EQ	3321	<	1257	NOT OK
Bracing Per Line Check:		554	<	349	NOT OK
Bracing External Wall Check:		285	<	451	OK

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Subject:	Wind Loading and Bracing Calculations	**Ref:**	

Ground FLOOR - ACROSS DIRECTION **WALL HEIGHT =** 3 m
(Refer to bracing plan) **RF** 0.8

Bracing Wall Type	**Line**	**Element**	**Length (m)**	**Modified Length (m)**	**Wind BU/m**	**Wind Bus Ach.**	**Earthquake BU/m**	**Earthquake Bus Ach.**
#8	A	A1	0.70	0.00	30.0	0	30.0	0
#8		A2	0.70	0.00	30.0	0	30.0	0
STRENGTHENING								
#10-1		**A3**	**0.80**	**0.64**	**90.0**	**58**	**100.0**	**64**
#10-1		**A4**	**0.80**	**0.64**	**90.0**	**58**	**100.0**	**64**
Total						115		128
#10-1	B	B1	3.60	2.88	120.0	346	105.0	302
#8		B2	1.15	0.54	30.0	16	30.0	16
#10-2		B3	1.20	0.64	110.0	71	115.0	74
Total						433		393
#10-2	C	C1	1.10	0.46	110.0	50	115.0	53
#10-2		C2	2.20	1.76	120.0	211	120.0	211
#10-2		C3	3.60	2.88	120.0	346	120.0	346
#10-2		C4	1.30	0.82	120.0	99	120.0	99
Total						706		708
#10-2	D	D1	2.40	1.92	120.0	230	120.0	230
#4-1		D2	1.20	0.64	20.0	13	20.0	13
Total						243		243
#2	E	E1	2.50	2.00	70.0	140	60.0	120
#10-2		E2	2.20	1.76	120.0	211	120.0	211
Total						351		331
#10-1	F	F1	1.50	1.20	120.0	144	105.0	126
#10-1		F2	1.80	1.44	120.0	173	105.0	151
Total						317		277
					TOTAL	2165		2080

		Demand		Capacity	Result
Total Bracing Check:	Wind	2828	<	2165	NOT OK
	EQ	3321	<	2080	NOT OK
Bracing Per Line Check:		277	<	128	NOT OK
Bracing External Wall Check:		180	<	115	NOT OK

9.1-9.4

Bracing calculations

for option 3

Detailed Seismic Assessment - Minoh House, Lower Hutt.

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City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

First FLOOR - ALONG DIRECTION **WALL HEIGHT =** **2.7 m**
(Refer to bracing plan) **RF** 0.89

Bracing Wall Type	Line	Element	Length (m)	Modified Length (m)	Wind BU/m	Wind Bus Ach.	Earthquake BU/m	Earthquake Bus Ach.
#5	M	M1	2.00	1.78	70	124	60	107
#5		M2	2.00	1.78	70	124	60	107
#5		M3	1.40	1.24	70	87	60	75
Total						336		288
#5	N	N1	1.90	1.69	70	118	60	101
#5		N2	1.00	0.47	50	24	55	26
#3		N3	2.20	1.96	70	137	60	117
#2		N4	1.40	1.24	70	87	60	75
#2		N5	1.40	1.24	70	87	60	75
Total						453		394
#2	O	O1	3.60	3.20	70	224	60	192
#9		O2	2.00	1.78	80	142	60	107
#2		O3	1.50	1.33	70	93	60	80
Total						460		379
#5	P	P1	2.60	2.31	70	162	60	139
#4-1		P2	2.50	2.22	20	44	20	44
#4-1		P3	1.20	0.89	20	18	20	18
#9		P4	2.00	1.78	80	142	60	107
Total						366		307
					TOTAL	1615		1368

		Demand		Capacity	Result
Total Bracing Check:	Wind	531	<	1615	OK
	EQ	1723	<	1368	NOT OK
Bracing Per Line Check:		215	<	288	OK
Bracing External Wall Check:		270	<	288	OK

Detailed Seismic Assessment - Minoh House, Lower Hutt.

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Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

First FLOOR - ACROSS DIRECTION — **WALL HEIGHT = 2.7 m**
(Refer to bracing plan) — **RF** 0.89

Bracing Wall Type	Line	Element	Length (m)	Modified Length (m)	Wind BU/m	Wind Bus Ach.	Earthquake BU/m	Earthquake Bus Ach.
	A		0.00	0.00	0	0	0	0
STRENGTHENING								
#10-1		**A1**	**0.80**	**0.71**	**90**	**64**	**100**	**71**
#10-1		**A2**	**0.80**	**0.71**	**90**	**64**	**100**	**71**
Total						128		142
#9	B	B1	1.10	0.68	80	55	60	41
#2		B2	1.40	1.24	70	87	60	75
#2		B3	1.00	0.47	50	24	55	26
Total						165		142
#9	C	C1	1.00	0.47	80	38	60	28
#9		C2	2.60	2.31	80	185	60	139
Total						223		167
#1	D	D1	3.70	3.29	70	230	60	197
#9		D2	3.70	3.29	80	263	60	197
Total						493		395
#5	E	E1	1.00	0.47	50	24	55	26
#10-1		E2	1.40	1.24	120	149	105	131
#4-1		E3	3.20	2.84	20	57	20	57
#3		E4	1.00	0.47	70	33	65	31
Total						263		244
#5	F	F1	1.80	1.60	70	112	60	96
#10-1		F2	1.20	0.89	90	80	100	89
Total						192		185
					TOTAL	1464		1274

		Demand		Capacity	Result
Total Bracing Check:	Wind	886	<	1464	OK
	EQ	1723	<	1274	NOT OK
Bracing Per Line Check:		144	<	142	NOT OK
Bracing External Wall Check:		143	<	128	NOT OK

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Building Name:	Minoh House	**Job Code:**	P330
Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

Ground FLOOR - ALONG DIRECTION **WALL HEIGHT =** **3 m**

(Refer to bracing plan) **RF** 0.8

Bracing Wall Type	**Line**	**Element**	**Length (m)**	**Modified Length (m)**	**Wind BU/m**	**Wind Bus Ach.**	**Earthquake BU/m**	**Earthquake Bus Ach.**
#5	M	M1	1.80	1.44	70	101	55	79
#8		M2	2.50	2.00	30	60	30	60
#8		M3	1.50	1.20	30	36	30	36
#5		M4	3.00	2.40	70	168	55	132
#3		M5	2.20	1.76	95	167	85	150
Total						532		457
#5	N	N1	2.40	1.92	70	134	60	115
#4-2		N2	1.30	0.82	40	33	40	33
#4-2		N3	1.20	0.64	40	26	40	26
#4-2		N4	1.70	1.36	40	54	40	54
#8		N5	1.30	0.82	30	25	30	25
#8		N6	4.00	3.20	30	96	30	96
Total						368		349
#5	O	O1	5.20	4.16	70	291.20	60	249.60
#4-2		O2	1.20	0.64	40	25.73	40	25.73
#5		O3	1.40	1.01	70	70.56	60	60.48
#5		O4	2.40	1.92	70	134.40	60	115.20
Total						522		451
					TOTAL	1422		1257

		Demand		Capacity	Result
Total Bracing Check:	Wind	1858	<	1422	NOT OK
	EQ	2921	<	1257	NOT OK
Bracing Per Line Check:		487	<	349	NOT OK
Bracing External Wall Check:		285	<	451	OK

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Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

Ground FLOOR - ACROSS DIRECTION — **WALL HEIGHT =** **3 m**

(Refer to bracing plan) — **RF** 0.8

Bracing Wall Type	Line	Element	Length (m)	Modified	Wind		Earthquake	
				Length (m)	BU/m	Bus Ach.	BU/m	Bus Ach.
#8	A	A1	0.70	0.00	30.0	0	30.0	0
#8		A2	0.70	0.00	30.0	0	30.0	0
STRENGTHENING								
#10-1		**A3**	**0.80**	**0.64**	**90.0**	**58**	**100.0**	**64**
#10-1		**A4**	**0.80**	**0.64**	**90.0**	**58**	**100.0**	**64**
Total						115		128
#10-1	B	B1	3.60	2.88	120.0	346	105.0	302
#8		B2	1.15	0.54	30.0	16	30.0	16
#10-2		B3	1.20	0.64	110.0	71	115.0	74
Total						433		393
#10-2	C	C1	1.10	0.46	110.0	50	115.0	53
#10-2		C2	2.20	1.76	120.0	211	120.0	211
#10-2		C3	3.60	2.88	120.0	346	120.0	346
#10-2		C4	1.30	0.82	120.0	99	120.0	99
Total						706		708
#10-2	D	D1	2.40	1.92	120.0	230	120.0	230
#4-1		D2	1.20	0.64	20.0	13	20.0	13
Total						243		243
#2	E	E1	2.50	2.00	70.0	140	60.0	120
#10-2		E2	2.20	1.76	120.0	211	120.0	211
Total						351		331
#10-1	F	F1	1.50	1.20	120.0	144	105.0	126
#10-1		F2	1.80	1.44	120.0	173	105.0	151
Total						317		277
					TOTAL	2165		2080

		Demand		Capacity	Result
Total Bracing Check:	Wind	2828	<	2165	NOT OK
	EQ	2921	<	2080	NOT OK
Bracing Per Line Check:		243	<	128	NOT OK
Bracing External Wall Check:		180	<	115	NOT OK

10.1-10.4

Bracing calculations

for option 4

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Building Name:	Minoh House	**Job Code:**	P330
Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

First FLOOR - ALONG DIRECTION — **WALL HEIGHT = 2.7 m**

(Refer to bracing plan) — **RF** 0.89

Bracing Wall Type	Line	Element	Length (m)	Modified Length (m)	Wind BU/m	Wind Bus Ach.	Earthquake BU/m	Earthquake Bus Ach.
#5	M	M1	2.00	1.78	70	124	60	107
#5		M2	2.00	1.78	70	124	60	107
#5		M3	1.40	1.24	70	87	60	75
Total						336		288
#5	N	N1	1.90	1.69	70	118	60	101
#5		N2	1.00	0.47	50	24	55	26
#3		N3	2.20	1.96	70	137	60	117
#2		N4	1.40	1.24	70	87	60	75
#2		N5	1.40	1.24	70	87	60	75
Total						453		394
#2	O	O1	3.60	3.20	70	224	60	192
#9		O2	2.00	1.78	80	142	60	107
#2		O3	1.50	1.33	70	93	60	80
Total						460		379
#5	P	P1	2.60	2.31	70	162	60	139
#4-1		P2	2.50	2.22	20	44	20	44
#4-1		P3	1.20	0.89	20	18	20	18
#9		P4	2.00	1.78	80	142	60	107
Total						366		307
					TOTAL	1615		1368

		Demand		Capacity	Result
Total Bracing Check:	Wind	531	<	1615	OK
	EQ	1723	<	1368	NOT OK
Bracing Per Line Check:		215	<	288	OK
Bracing External Wall Check:		270	<	288	OK

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City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

First FLOOR - ACROSS DIRECTION | **WALL HEIGHT =** **2.7 m**
(Refer to bracing plan) | **RF** 0.89

Bracing Wall Type	Line	Element	Length (m)	Modified	Wind		Earthquake	
				Length (m)	BU/m	Bus Ach.	BU/m	Bus Ach.
	A		0.00	0.00	0	0	0	0
STRENGTHENING								
#10-1		**A1**	**0.80**	**0.71**	**90**	**64**	**100**	**71**
#10-1		**A2**	**0.80**	**0.71**	**90**	**64**	**100**	**71**
Total						128		142
#9	B	B1	1.10	0.68	80	55	60	41
#2		B2	1.40	1.24	70	87	60	75
#2		B3	1.00	0.47	50	24	55	26
Total						165		142
#9	C	C1	1.00	0.47	80	38	60	28
#9		C2	2.60	2.31	80	185	60	139
Total						223		167
#1	D	D1	3.70	3.29	70	230	60	197
#9		D2	3.70	3.29	80	263	60	197
Total						493		395
#5	E	E1	1.00	0.47	50	24	55	26
#10-1		E2	1.40	1.24	120	149	105	131
#4-1		E3	3.20	2.84	20	57	20	57
#3		E4	1.00	0.47	70	33	65	31
Total						263		244
#5	F	F1	1.80	1.60	70	112	60	96
#10-1		F2	1.20	0.89	90	80	100	89
Total						192		185
					TOTAL	1464		1274

		Demand		Capacity	Result
Total Bracing Check:	Wind	886	<	1464	OK
	EQ	1723	<	1274	NOT OK
Bracing Per Line Check:		144	<	142	NOT OK
Bracing External Wall Check:		143	<	128	NOT OK

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City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	Wind Loading and Bracing Calculations	**Ref:**	

Ground FLOOR - ALONG DIRECTION — **WALL HEIGHT =** **3 m**
(Refer to bracing plan) — **RF** 0.8

Bracing Wall Type	Line	Element	Length (m)	Modified	Wind		Earthquake	
				Length (m)	BU/m	Bus Ach.	BU/m	Bus Ach.
#5	M	M1	1.80	1.44	70	101	55	79
#8		M2	2.50	2.00	30	60	30	60
STRENGTHENING								
#10-1		**M3**	**1.50**	**1.20**	**120**	**144**	**105**	**126**
#5		M4	3.00	2.40	70	168	55	132
#3		M5	2.20	1.76	95	167	85	150
Total						640		547
#5	N	N1	2.40	1.92	70	134	60	115
#4-2		N2	1.30	0.82	40	33	40	33
#4-2		N3	1.20	0.64	40	26	40	26
#4-2		N4	1.70	1.36	40	54	40	54
#8		N5	1.30	0.82	30	25	30	25
STRENGTHENING								
#10-1		**N6**	**4.00**	**3.20**	**120**	**384**	**105**	**336**
Total						656		589
#5	O	O1	5.20	4.16	70	291.20	60	249.60
#4-2		O2	1.20	0.64	40	25.73	40	25.73
#5		O3	1.40	1.01	70	70.56	60	60.48
#5		O4	2.40	1.92	70	134.40	60	115.20
Total						522		451
					TOTAL	1818		1587

		Demand		Capacity	Result
Total Bracing Check:	Wind	1858	<	1818	NOT OK
	EQ	2921	<	1587	NOT OK
Bracing Per Line Check:		487	<	451	NOT OK
Bracing External Wall Check:		285	<	451	OK

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Subject:	Wind Loading and Bracing Calculations	**Ref:**	

Ground FLOOR - ACROSS DIRECTION — **WALL HEIGHT =** **3 m**
(Refer to bracing plan) — **RF** 0.8

Bracing Wall Type	**Line**	**Element**	**Length (m)**	**Modified Length (m)**	**Wind BU/m**	**Wind Bus Ach.**	**Earthquake BU/m**	**Earthquake Bus Ach.**
#8	A	A1	0.70	0.00	30.0	0	30.0	0
#8		A2	0.70	0.00	30.0	0	30.0	0
STRENGTHENING								
#10-1		**A3**	**0.80**	**0.64**	**90.0**	**58**	**100.0**	**64**
#10-1		**A4**	**0.80**	**0.64**	**90.0**	**58**	**100.0**	**64**
Total						115		128
#10-1	B	B1	3.60	2.88	120.0	346	105.0	302
#8		B2	1.15	0.54	30.0	16	30.0	16
#10-2		B3	1.20	0.64	110.0	71	115.0	74
Total						433		393
#10-2	C	C1	1.10	0.46	110.0	50	115.0	53
#10-2		C2	2.20	1.76	120.0	211	120.0	211
#10-2		C3	3.60	2.88	120.0	346	120.0	346
#10-2		C4	1.30	0.82	120.0	99	120.0	99
Total						706		708
#10-2	D	D1	2.40	1.92	120.0	230	120.0	230
#4-1		D2	1.20	0.64	20.0	13	20.0	13
Total						243		243
#2	E	E1	2.50	2.00	70.0	140	60.0	120
#10-2		E2	2.20	1.76	120.0	211	120.0	211
Total						351		331
#10-1	F	F1	1.50	1.20	120.0	144	105.0	126
#10-1		F2	1.80	1.44	120.0	173	105.0	151
Total						317		277
					TOTAL	2165		2080

		Demand		Capacity	Result
Total Bracing Check:	Wind	2828	<	2165	NOT OK
	EQ	2921	<	2080	NOT OK
Bracing Per Line Check:		243	<	128	NOT OK
Bracing External Wall Check:		180	<	115	NOT OK

11.1

%NBS report

Detailed Seismic Assessment - Minoh House, Lower Hutt.

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Address:	91 Western Hutt Road, Normandale	**By:**	MR
City:	Lower Hutt 5010	**Date:**	17/05/2023
Subject:	%NBS Report	**Rev:**	

%NBS Report

Option 1: The original Structure with chimneys:

Floor	%NBS			
	Total Bracing		Bracing per line	Bracing external wall
	Wind	Earthquake		
First Floor (Along)	304%	62%	105%	107%
First Floor (Across)	151%	52%	0%	0%
Ground Floor (Along)	77%	38%	63%	158%
Ground Floor (Across)	72%	59%	0%	0%

%NBS= 0%

Option 2: The strengthened structure (strengthened at 1F & GF along the Grid A):

Floor	%NBS			
	Total Bracing		Bracing per line	Bracing external wall
	Wind	Earthquake		
First Floor (Along)	304%	62%	105%	107%
First Floor (Across)	165%	58%	78%	90%
Ground Floor (Along)	77%	38%	63%	158%
Ground Floor (Across)	77%	63%	46%	64%

%NBS= 38%

Option 3: The strengthened structure (strengthened at 1F-Grid A & GF-Grid A + Chimney removal):

Floor	%NBS			
	Total Bracing		Bracing per line	Bracing external wall
	Wind	Earthquake		
First Floor (Along)	304%	79%	134%	107%
First Floor (Across)	165%	74%	99%	90%
Ground Floor (Along)	77%	43%	72%	158%
Ground Floor (Across)	77%	71%	53%	64%

%NBS= 43%

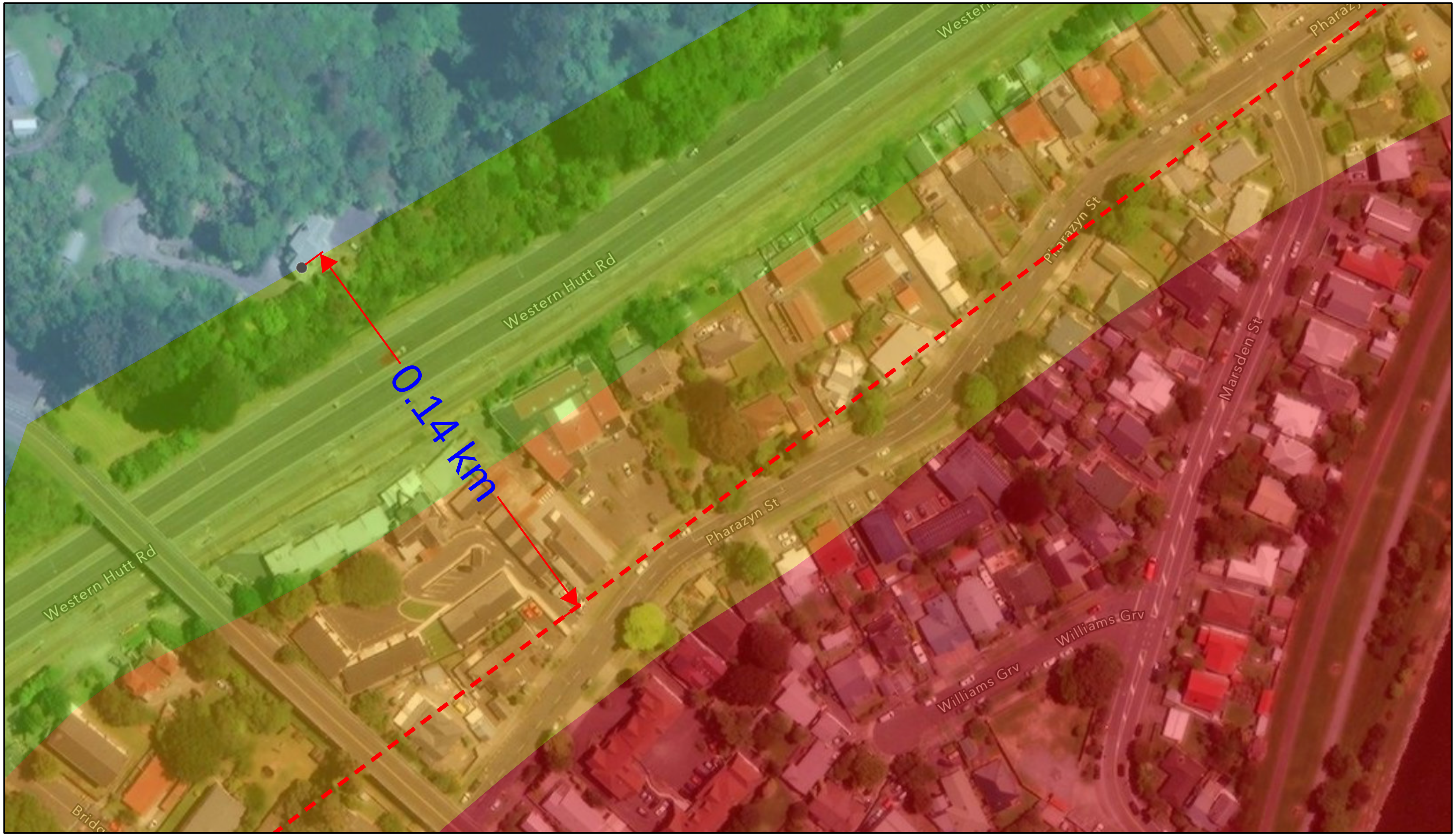
Option 4: The strengthened structure (strengthened at 1F-Grid A & GF-Grids A&M&N + Chimney removal):

Floor	%NBS			
	Total Bracing		Bracing per line	Bracing external wall
	Wind	Earthquake		
First Floor (Along)	304%	79%	134%	107%
First Floor (Across)	165%	74%	99%	90%
Ground Floor (Along)	98%	54%	93%	158%
Ground Floor (Across)	77%	71%	53%	64%

%NBS= 53%

ANNEX A

Active Faults (GNS) & Groundshaking (GWRC)



5/17/2023, 9:04:55 AM

Override 1

Groundshaking (GWRC)

1 low

2 low-mod

4 mod-high

5 high

1:2,257

0 0.01 0.03 0.05 mi

0 0.02 0.04 0.09 km

Esri Community Maps Contributors, LINZ, Stats NZ, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Wellington City Council
GWRC, GNS, WCC

ANNEX B

Seismic Slope Failure

5/17/2023, 9:08:10 AM

Seismic Slope failure (GWRC)

- 1 low
- 2
- 3 moderate
- 4

1:2,257

0 0.01 0.03 0.05 mi

0 0.02 0.04 0.09 km

Esri Community Maps Contributors, LINZ, Stats NZ, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Wellington City Council

GWRC, GNS, WCC

ANNEX C

Liquefaction Potential

5/17/2023, 9:06:47 AM

Liquefaction Potential

Low

High

1:2,257

0 0.01 0.03 0.05 mi

0 0.02 0.04 0.09 km

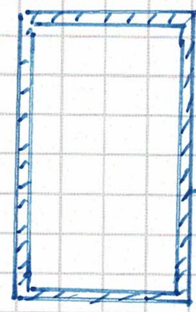
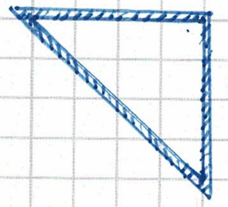
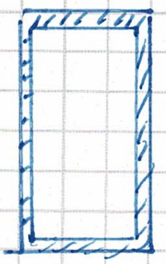
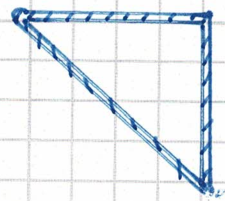
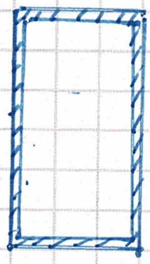
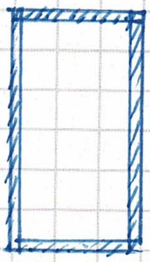
Esri Community Maps Contributors, LINZ, Stats NZ, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

Wellington City Council

GWRC, GNS, WCC

ANNEX D

Chimney @ Different Levels

Level		
GF 0 – 3.5 m 3.5m length	 1600 x 1000 x 120 mm w/length = 1900 x 0.76 (Area) w/length = 11 kN/m w/length = 22 kN/m 2 brick thk	 1550 x 1550 x 120 mm w/length = 1900 x 0.34 w/length = 7 kN/m say 8 ✓ w/length = 16 kN/m 2 brick thk
1F 3.5 – 6.5 m 3m length	 1350 x 700 x 120 mm w/length = 8 kN/m w/length = 16 kN/m 2 brick thk	 1550 x 1550 x 120 mm w/length = 1900 x 0.34 w/length = 7 kN/m say 8 ✓ w/length = 16 kN/m 2 brick thk
Above Roof 6.5 – 9 m 2.5m length	 1350 x 700 x 120 mm w/length = 8 kN/m w/length = 16 kN/m 2 brick thk	 1350 x 700 x 120 mm w/length = 8 kN/m w/length = 16 kN/m 2 brick thk

Assume brick wall chimney $\rho_{brick} = 1900\ kg/m^3$

And two-brick thk (thickness)

ANNEX E

Table C9.2: Probable strength values for existing timber framed wall bracing systems (based on 2.4 m wall height)

Bracing type	Probable strength values
150 x 25 mm let-in brace at 45º	2.0 kN
150 x 25 mm let-in brace at 45° and sheet material* one face	2.5 kN
150 x 25 mm let-in brace at 45° and sheet material* both faces	3.7 kN
90 x 45 mm fitted brace both ways at 45º	2.0 kN
90 x 45 mm fitted brace both ways at 45º and sheet material* one face	2.5 kN
90 x 45 mm fitted brace both ways at 45º and sheet material* both faces	3.7 kN
90 x 45 mm dog leg brace (600 mm wall length)	0.75 kN
Timber framed stud walls with wood or metal lath and plaster	1.5 kN/m each side
Timber framed stud walls with diagonal braces and wood or metal lath and plaster	2.8 kN/m
Gypsum plasterboard one side, and fixed at 300 mm centres (no diagonal timber braces included)	1.0 kN/m
Gypsum plasterboard one side, and fixed at 150 mm centres (no diagonal timber braces included)	2.5 kN/m
Gypsum plasterboard two sides, and fixed at 300 mm centres (no diagonal timber braces included)	2.0 kN/m
Gypsum plasterboard two sides, and fixed at 150 mm centres (no diagonal timber braces included)	3.0 kN/m
Match lining on one or both faces (no diagonal timber braces included)	1.25 kN/m
3.2 mm tempered hardboard fixed with clouts at 200 mm centres	3.0 kN/m
Horizontal board sheathing	1.0 kN/m
Horizontally oriented corrugated steel sheets	2.0 kN/m
Vertically oriented corrugated steel sheets	1.50 kN/m
140 x 20 mm bevel back weatherboard	0.30 kN/m

Note:

*Sheet material is defined as having a density of not less than 450 kg/m^3. It may be a wood-based material not less than 4.5 mm thick or a gypsum-based material not less than 8 mm thick, both fixed to framing members not closer than 10 mm from sheet edges.

When determining the probable wall bracing capacity using the values in Table C9.2 the capacity of each bracing element should be calculated by multiplying by the length of the bracing element and adjusting for height in accordance with the following equation:

$$\frac{2.4}{\text{element height in metres}}$$

This equation is applicable for framing with sheet bracing products attached (and therefore it is not applicable for bracing systems such as horizontal sarking). Elements less than 2.4 m in height should be rated as if they are 2.4 m high. Walls of varying height should have their bracing capacity adjusted using the average height.

Where bracing units are used in place of force units (e.g. kNs), a conversion of 1 kN = 20 bracing units should be used.

Consideration should also be given to the aspect ratio of the wall element; i.e. its overall height to length ratio. If published indicative bracing ratings are being relied on, it should be ensured that the length of the element is applicable for the published value. This is because failure mechanisms can change with aspect ratio, resulting in altered ratings per unit length. For narrow elements (height: length ratio > 2) consideration should be given to reducing the published capacity. It is suggested that a linear reduction of strength is applied from 1 times the published data for ratios of 2:1 to zero for ratios equal and greater than 3.5:1.

Note:

The bracing units apply to the capacity of an individual wall panel. Any weak links or issues with the stiffness of the diaphragms which may limit or determine the extent to which individual panels are able to contribute to the overall building capacity should be identified.

C9.6.3 Roof and floor diaphragms

C9.6.3.1 General

The probable strength of timber diaphragms should be taken as the probable capacity of the diaphragm assembly determined from a rational assessment of the individual elements. The effects of openings in timber diaphragms also need to be considered. The presence, or lack, of chords and collectors will affect the load carrying capacity of the diaphragm. Connections between diaphragms and other components including shear walls, drag struts, collectors, cross ties, and out-of-plane anchors also need to be considered.

The behavior of horizontal wood diaphragms is influenced by the type of sheathing, size and spacing of fasteners, existence of perimeter chord or flange members, and the ratio of span length to width of the diaphragm. The presence of anything other than small openings in diaphragms will cause a reduction in the stiffness and capacity of the diaphragm due to a reduced length of diaphragm available to resist lateral forces. Special analysis techniques and detailing are required at the openings.

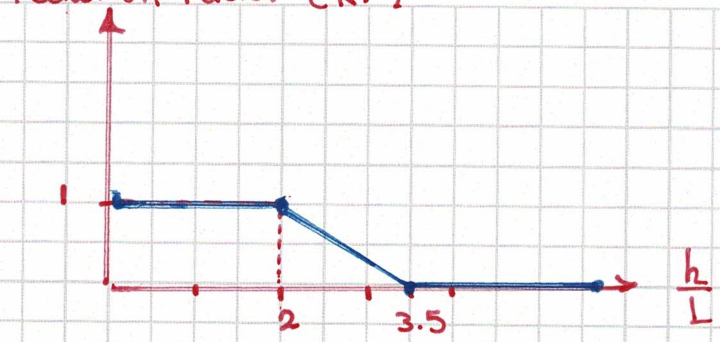
The presence or addition of trimming members around the openings will reduce the loss in stiffness of the diaphragm and limit damage in the area of the openings. The presence of chords at the perimeter of a diaphragm will significantly reduce diaphragm deflections due to bending, and will increase the stiffness of the diaphragm over that of an unchorded diaphragm. However, the increase in stiffness due to chords in a single straight sheathed diaphragm is minimal due to the flexible nature of these diaphragms.

Note:

The actions on the individual elements of a diaphragm will depend on the relative stiffness of the diaphragm compared with the lateral stiffness of the connected vertical elements. The relative stiffness will change if the vertical elements are loaded into the nonlinear range, at which point a timber diaphragm could be considered as rigid. The analysis of diaphragms is discussed further in Section C2 and for URM buildings in Section C8.

ANNEX F

Reduction factor (RF)



h → wall height
L → wall Length

$RF_{aspect\ ratio} = -(1/1.5)\cdot(\frac{h}{L}) + (3.5/1.5) \leq 1$

Wall aspect ratio $= \frac{h}{L} = \frac{height}{Length}$

h/L	RF	L-GF h = 3m	L-1F h = 2.7m
2	1	1.5	1.4
2.25	0.83	1.3	1.2
2.5	0.67	1.2	1.1
2.75	0.5	1.1	1
3	0.33	1	0.9
3.25	0.17	0.9	0.8
3.5	0	0.9	0.8

Ignore this RF just $\frac{2.4}{\text{wall height}}$

Refer to NZ Guideline for DSA of Timber Buildings C9

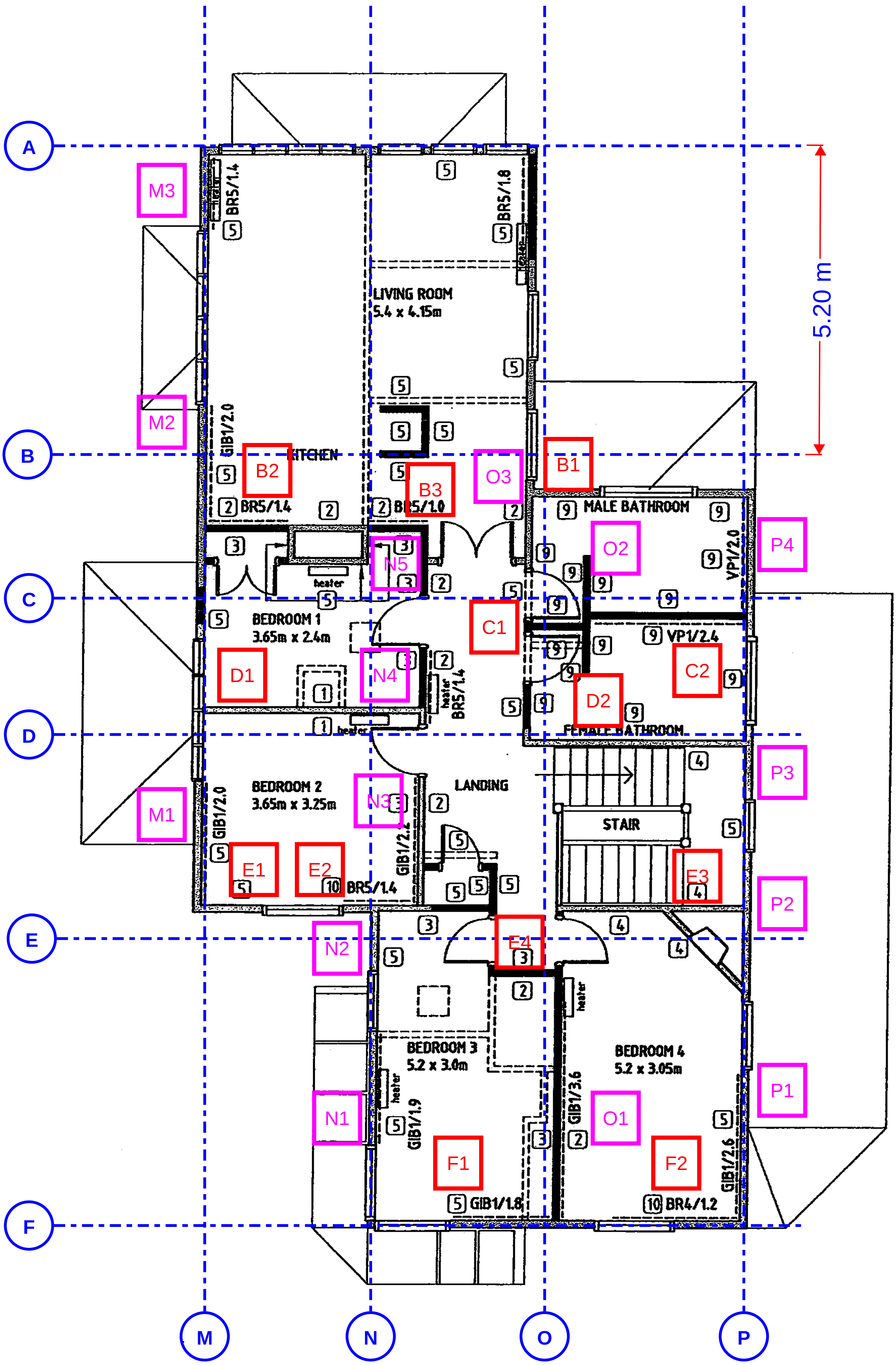
See ANNEX E

$RF_{height} = 2.4/height \leq 1$

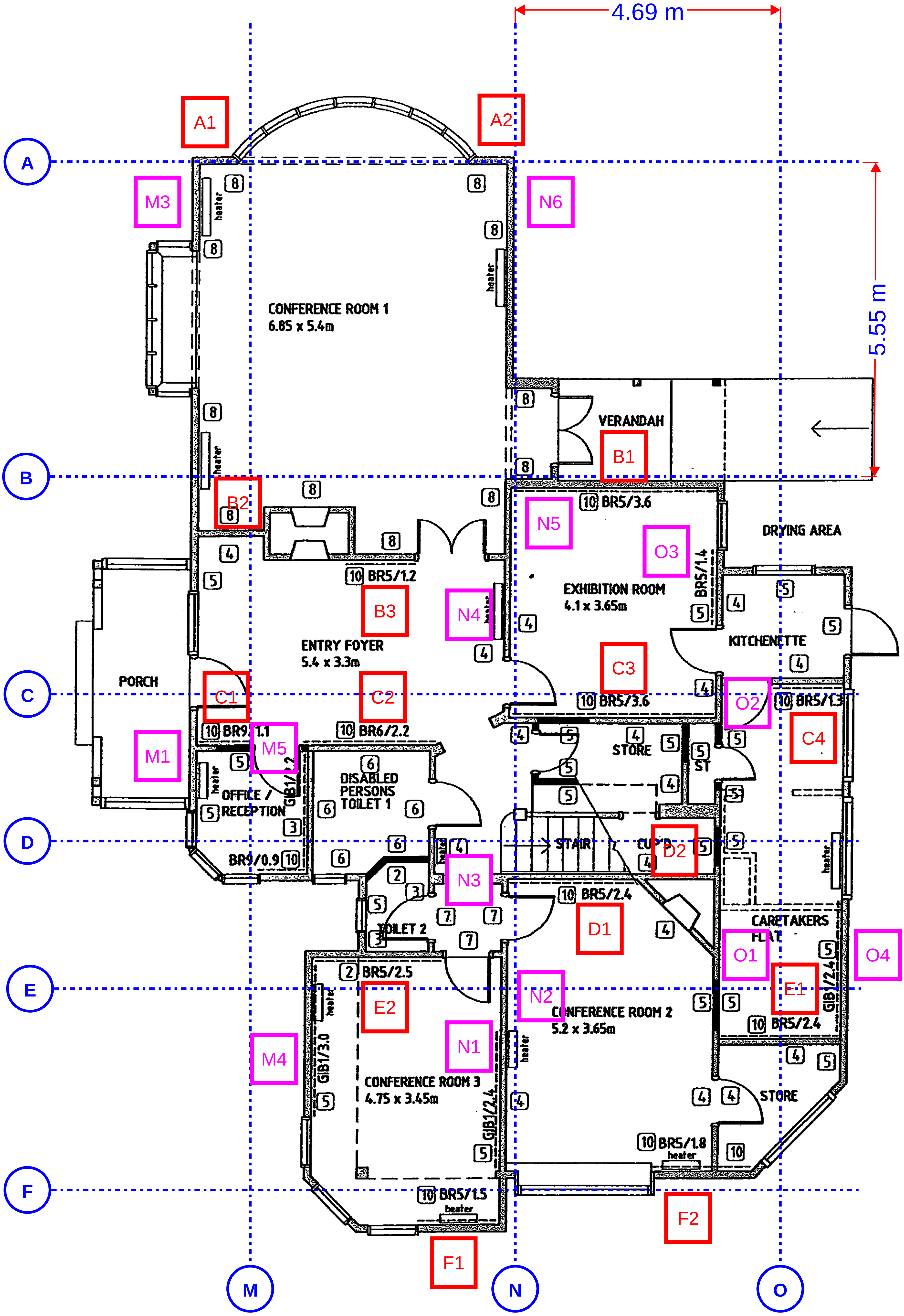
$RF_{total} = RF_{height} \times RF_{aspect\ ratio}$

{Modified length of wall = RF_{total} × length of wall

ANNEX G

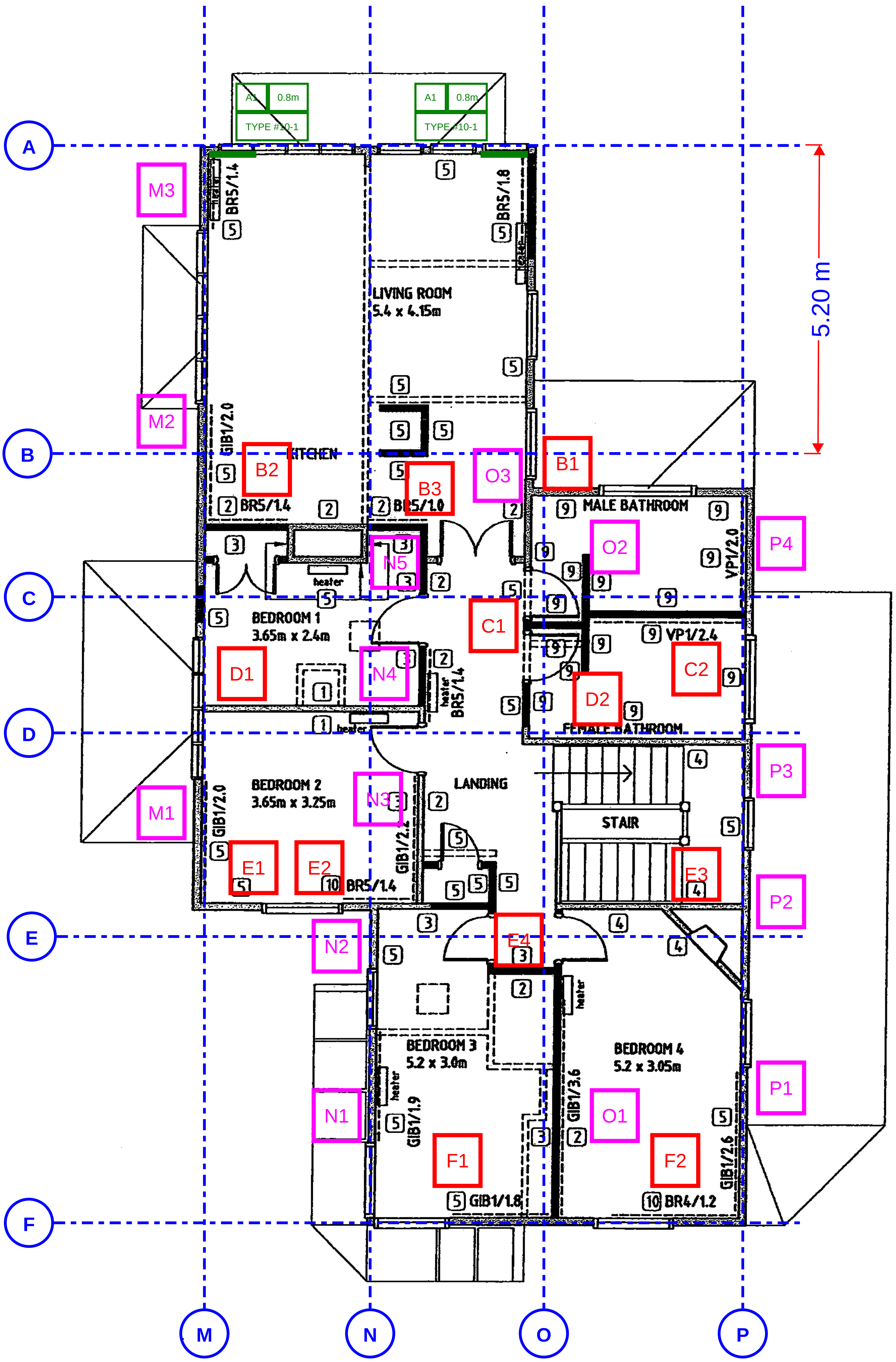


First Floor Bracing Mark-up Plan (Option 1)

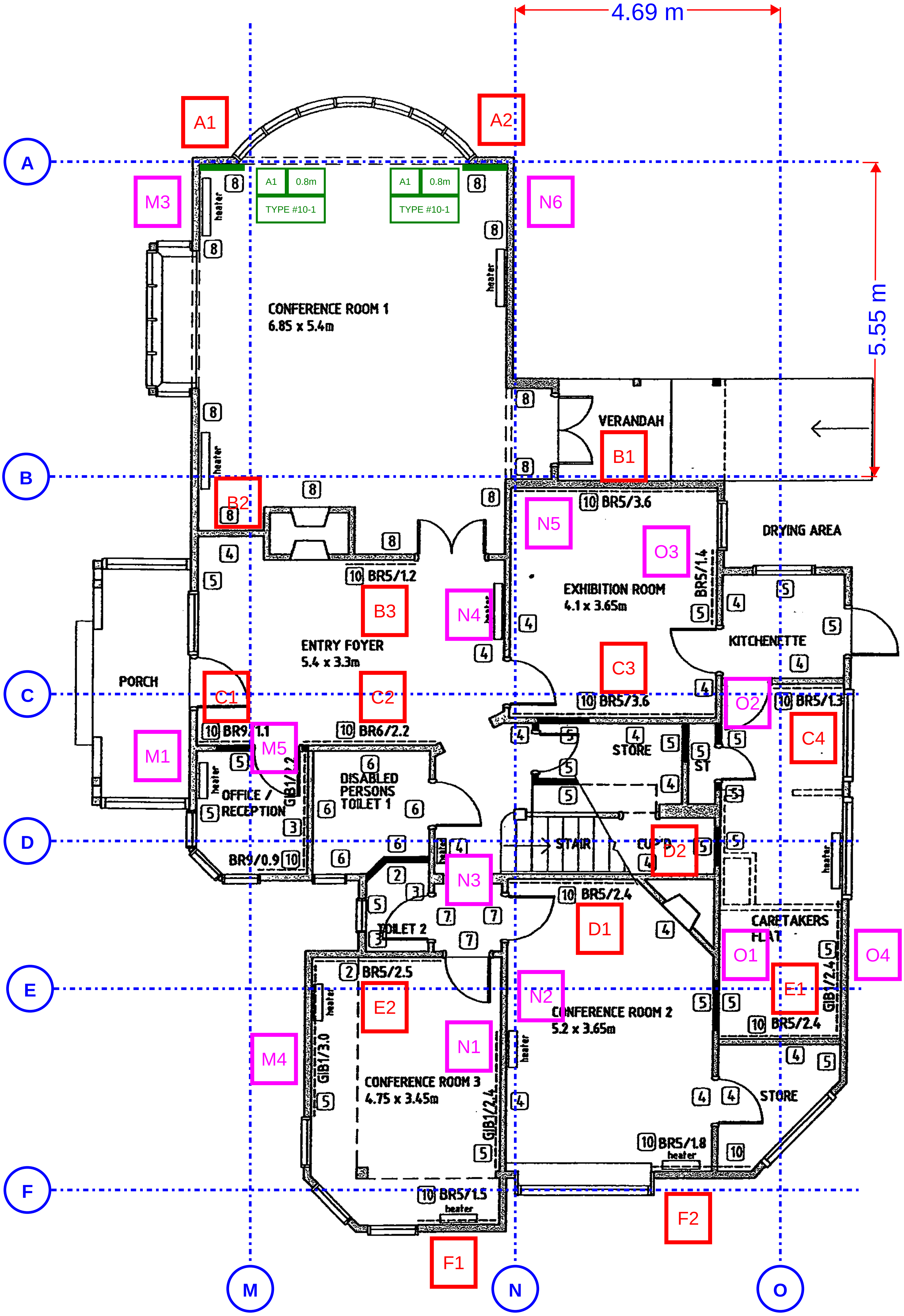


Ground Floor Bracing Mark-up Plan (Option 1)

ANNEX H

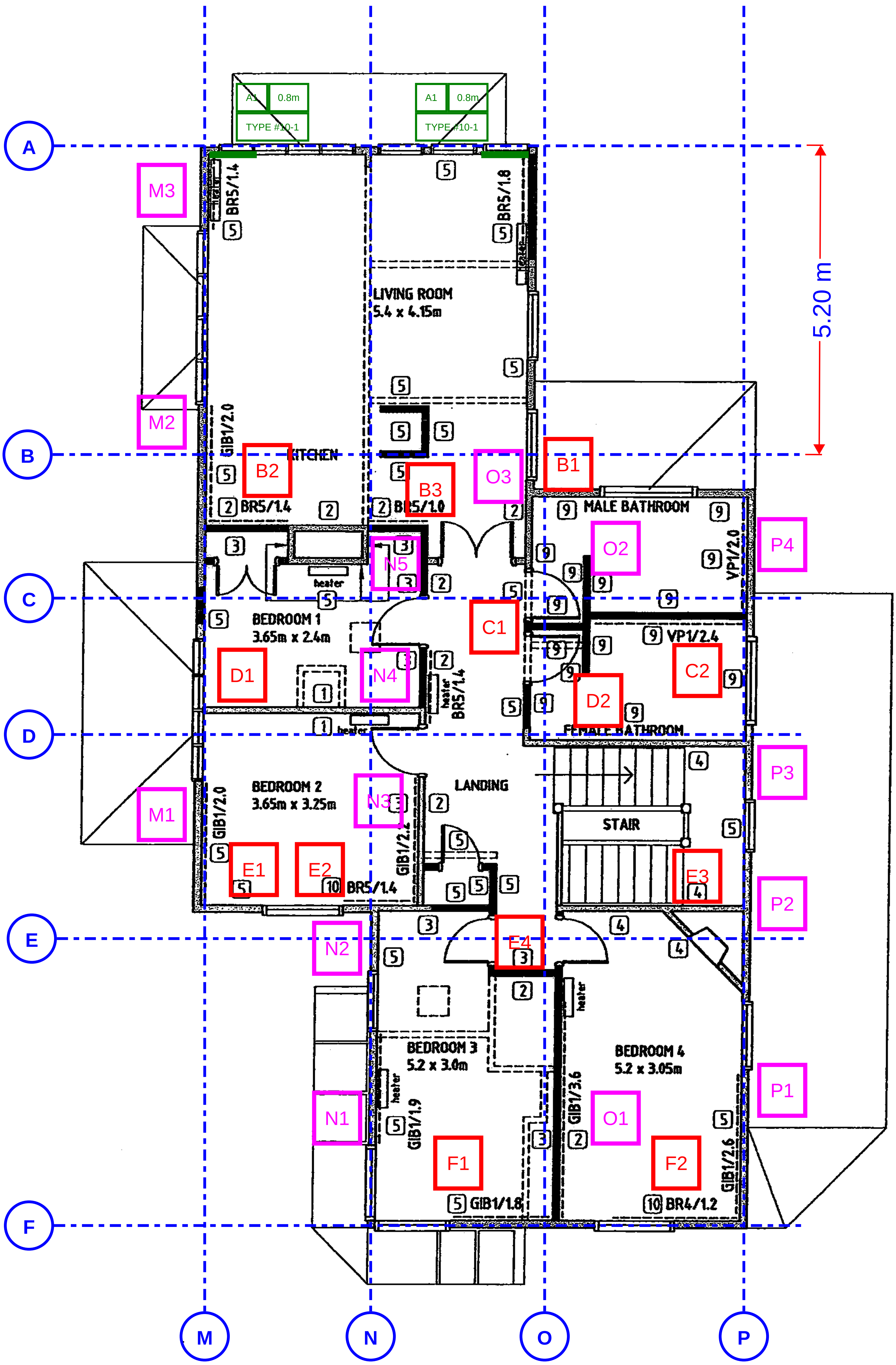


First Floor Bracing Mark-up Plan (Options 2 & 3)

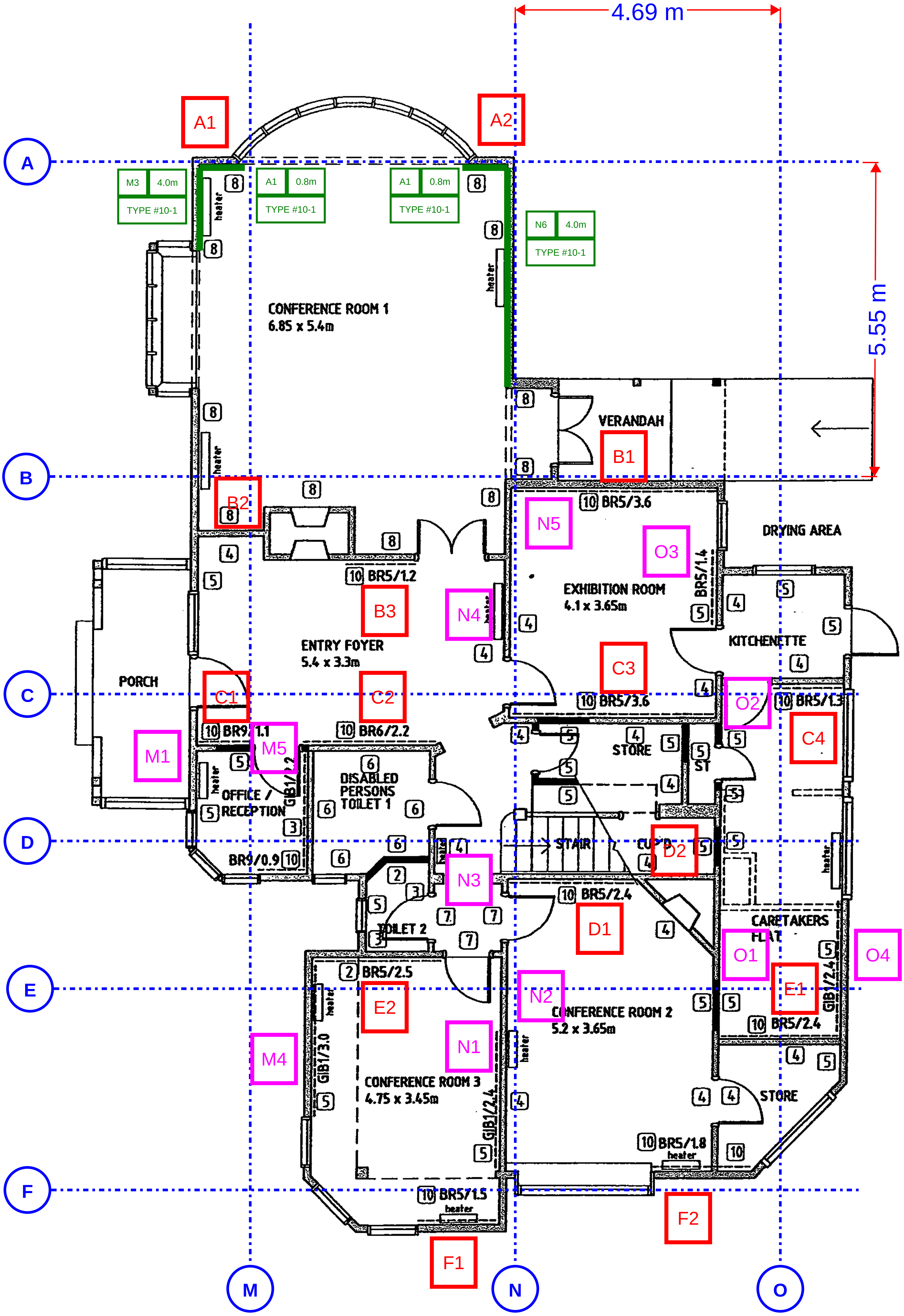


Ground Floor Bracing Mark-up Plan (Options 2 & 3)

ANNEX I



First Floor Bracing Mark-up Plan (Option 4)



Ground Floor Bracing Mark-up Plan (Option 4)