Gloucester Courts Blocks B & C
BU 2373-002 EQ2, BU 2373-003 EQ2

Detailed Engineering Evaluation

Quantitative Report

Version FINAL

254 Gloucester Street, Christchurch

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254 Gloucester Street, Christchurch

Christchurch City Council

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Date
14/11/2012

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Quantitative Report - SUMMARY

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254 Gloucester Street, Christchurch Central

Background

The two 3 storey apartment buildings at 254 Gloucester Street, Christchurch Central have been assessed for their safety during an earthquake. We have assessed the structures of the buildings to determine the current level of safety they afford during an earthquake, and have compared that level to the legal requirements.

This is a summary of the Quantitative report for the building structures, and is based in part on the Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011, visual inspections on 06th March 2012 and Qualitative report version draft issued on 12th April 2012.

Building Description

North Building (Block B)

Gloucester Courts North Building is a 3-storey apartment building consists of resident's storage and parking spaces at the ground floor level and the upper floors house six residential units. It appears that no alterations have been made to the buildings since its construction. The building is approximately 18.40 m in length, 7.40 m wide and 9.50 m in height.

The roof is constructed of lightweight metal cladding on timber purlins and roof trusses. Perimeter walls from ground to 2nd floor level consist of filled reinforced concrete masonry blockwork and from 2nd floor to roof are timber framed walls. The partitions across the building separating the units are concrete filled masonry block walls.

The suspended floor slabs are 150 mm thick Unispan precast concrete flooring. They comprise 75 mm precast reinforced concrete slab units with 75 mm in-situ concrete screed topping reinforced with mesh.

There are six balconies at the upper floors, protruding out from the building, which are cantilevered from the internal floor slabs. Steel reinforcement connects the cantilevered balconies into the in-situ concrete topping of the precast floor slabs.

Two precast Concrete staircases at rear part of the building are supported by top and bottom cast in-situ concrete landings connected to the masonry block walls.

The building has a reinforced concrete ground slab and the foundations consist of reinforced concrete strip footings.

South Building (Block C)

Gloucester Courts South Building is a 3-storey apartment building consists of resident's storage and parking spaces at the ground floor level and the upper floors house four residential units. It appears that no alterations have been made to the buildings since its construction. The building is approximately 17.40 m in length, 7.40 m wide and 9.50 m in height.

The roof is constructed of lightweight metal cladding on timber purlins and roof trusses. Perimeter walls from ground to 2nd floor level consist of filled reinforced concrete masonry blockwork and from 2nd floor to roof are timber framed walls. The partitions across the building separating the units are concrete filled masonry block walls.

The suspended floor slabs are 150 mm thick Unispan precast concrete flooring. They comprise 75 mm precast reinforced concrete slab units with 75 mm in-situ concrete screed topping reinforced with mesh.

There are four balconies at the upper floors, protruding out from the building, which are cantilevered from the internal floor slabs. Steel reinforcement connects the cantilevered balconies into the in-situ concrete topping of the precast floor slabs.

One precast Concrete staircase located at the rear part of the building which is supported by top and bottom cast in-situ concrete landings connected to the masonry block walls.

The building has a reinforced concrete ground slab. Foundations consist of reinforced concrete strip footings.

Key Damage Observed

Key damage observed in both buildings includes:

- Minor cracks in the walls above the exterior doors
- Minor cracks in the first floor slab near the staircase

Building Capacity Assessment

GHD finds that the Gloucester Courts Block B achieves overall 35% New Building Standard (NBS) while the Gloucester Courts Block C achieves overall 36% NBS with a Seismic Grade of C and therefore both buildings fall within the "Earthquake Risk" category. A building with a % NBS score in this order range 34% to 67% NBS is between 5 to 10 times more likely than a similar building constructed to current loading standards to cause loss of life or serious injury during a seismic event.

Recommendations

It is recommended for each of the buildings that:

- A strengthening scheme is developed to increase the seismic capacity of the building to at least 67% NBS.
- The current placard status of the building of green to remain as is.
- The building can remain occupied as per CCC's policy to occupy "Earthquake Risk" buildings.

1. Background

GHD has been engaged by the Christchurch City Council (CCC) to undertake a detailed engineering evaluation of Gloucester Courts Blocks B and C Buildings. Each of these buildings is a three storey apartment block.

This is a Quantitative Assessment Report of the building structures; Quantitative Assessment involves full seismic review of the existing structure, which is discussed in this report. The structural investigation has been carried out in accordance with the requirements of the relevant New Zealand Standards and the New Zealand Society for Earthquake Engineering (NZSEE) Guidelines for the Assessment and Improvement of the Structural Performance of Buildings in Earthquakes.

2. Compliance

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

2.1 Canterbury Earthquake Recovery Authority (CERA)

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

Section 38 – Works

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

Section 51 – Requiring Structural Survey

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

CERA now requires a detailed engineering evaluation to be carried out for all buildings (other than those exempt from the Earthquake Prone Building definition in the Building Act). The Detailed Engineering Evaluation Procedure document (draft) issued by the Structural Advisory Group on 19 July 2011 has been adopted by CERA for evaluations. This document sets out a methodology for both qualitative and quantitative assessments.

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

Factors determining the extent of evaluation and strengthening level required include:

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

2.2 Building Act

Several sections of the Building Act 2004 are relevant when considering structural requirements:

Section 112 – Alterations

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

Section 115 – Change of Use

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

2.2.1 Section 121 – Dangerous Buildings

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

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

Section 122 – Earthquake Prone Buildings

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

Section 124 – Powers of Territorial Authorities

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

Section 131 – Earthquake Prone Building Policy

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

2.3 Christchurch City Council Policy

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

The 2010 amendment includes the following:

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

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

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

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

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

2.4 Building Code

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

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

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

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

3. Earthquake Resistance Standards

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

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

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

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

Improvement of Structural Performance	
Legal Requirement	NZSEE Recommendation
The Building Act sets no required level of structural improvement (unless change in use) This is for each TA to decide. Improvement is not limited to 34% NBS.	100% NBS desirable. Improvement should achieve at least 67% NBS
	Not recommended. Acceptable only in exceptional circumtances
Unacceptable	Unacceptable

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

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

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

Table 1: % NBS compared to relative risk of failure

4. Building Description

4.1 General

Gloucester Courts Block B (Block D on the original plans) and Block C (Block E on the original plans) are located at 254 Gloucester Street, Christchurch Central. The buildings are located 400 m southeast of the Avon River and 8 km west of the coast (Pegasus Bay). The buildings were constructed in 1998.

The site is relatively flat and surrounded by residential properties and bordered to the north by Gloucester Street. The nearest building is Gloucester Courts Block A to the west.

Refer to Appendix C for the drawings for the two buildings.

4.2 Block B

Summary of Buildings key structural features:

- Block B is a 3-storey building consists of resident's storage and parking spaces at the ground floor level and the upper floors house six residential units. It appears that no alterations have been made to the building since its construction.
- The building is approximately 18.40 m in length, 7.40 m wide and 9.50 m in height.
- The roof is constructed of lightweight metal cladding on timber purlins and roof trusses.
- Perimeter walls from ground to 2nd floor level consist of filled reinforced concrete masonry blockwork and from 2nd floor to roof are timber framed walls.
- The partitions across the building separating the units are concrete filled masonry block walls.
- The foundations consist of reinforced concrete strip footings.
- The suspended floor slabs are 150 mm thick Unispan precast concrete flooring. They comprise 75 mm precast reinforced concrete slab units with 75 mm in-situ concrete screed topping reinforced with mesh.
- The building has a reinforced concrete ground slab.
- Two precast concrete staircases at rear part of the building are supported by top and bottom cast in-situ concrete landings connected to the masonry block walls.
- There are six balconies at the upper floors, protruding out from the building, which are cantilevered from the internal floor slabs. Steel reinforcement connects the cantilevered balconies into the in-situ concrete topping of the precast floor slabs.

Figure 2 shows the Floor Plan Layout.

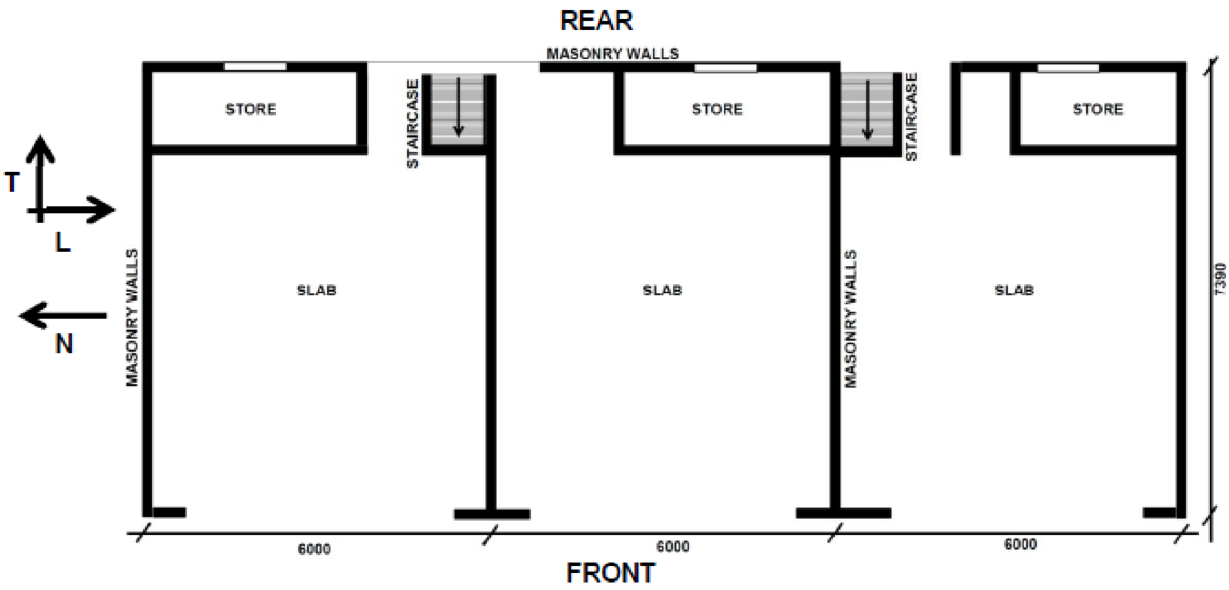


Figure 2: Plan Layout Showing Key Structural Elements of Block B

4.3 Block C

Summary of Buildings key structural features:

- Gloucester Courts Block C is a 3-storey building consists of resident's storage and parking spaces at the ground floor level and the upper floors house four residential units. It appears that no alterations have been made to the building since its construction.
- The building is approximately 17.40 m in length, 7.40 m wide and 9.50 m in height.
- The roof is constructed of lightweight metal cladding on timber purlins and roof trusses.
- Perimeter walls from ground floor to 2nd floor level consist of filled reinforced concrete masonry blockwork and from 2nd floor to roof are timber framed walls.
- The partitions across the building separating the units are concrete filled masonry block walls.
- The foundations consist of concrete strip footings.
- The suspended floor slabs are 150 mm thick Unispan precast concrete flooring. They comprise 75 mm precast reinforced concrete slab units with 75 mm concrete screed topping reinforced with mesh.
- The building has a reinforced concrete ground slab.
- One precast concrete staircase located at the rear part of the building which is supported by top and bottom cast in-situ concrete landings connected to the masonry block walls.
- There are four balconies at the upper floors, protruding out from the building, which are cantilevered from the internal floor slabs. Steel reinforcement connects the cantilevered balconies into the in-situ concrete topping of the precast floor slabs.

Figure 3 shows the Floor Plan Layout.

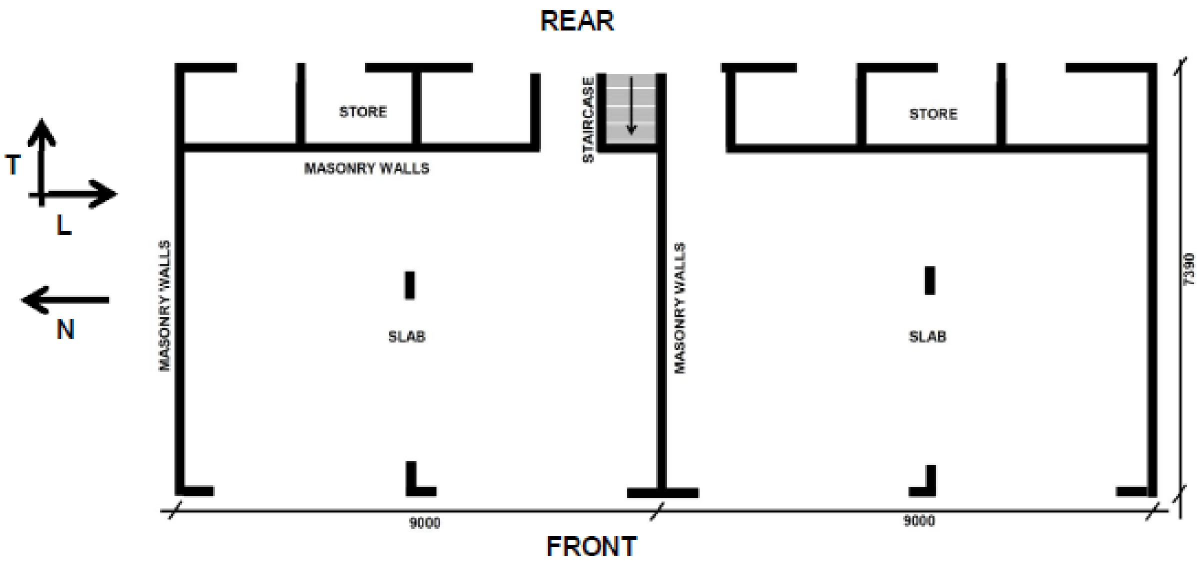


Figure 3: Plan Layout Showing Key Structural Elements of Block C

4.4 Gravity Load Resisting System

Gravity loads for blocks from the lightweight metal roof cladding are supported by the timber purlins spanning onto the timber roof trusses. The roof trusses are supported by the timber framed walls.

The gravity loads on the first and second floors are carried by to the concrete floor slabs spanning to the reinforced concrete masonry walls and reinforced concrete frames.

Loads are transferred through the walls and the frames down to the foundations.

4.5 Lateral Load Resisting System

The lateral loads from the roofs of both blocks are transferred through the diaphragm action of the ceiling and of the roof cladding to the braced timber walls. These lateral forces are then taken by the concrete masonry block walls below.

Lateral loads from ground level to level 2 are distributed via the diaphragm action of the RC floor slabs to the concrete masonry block walls and stair core walls in both longitudinal and transverse directions of the buildings. From there they transfer down to the footings.

5. Assessment

5.1 Site Inspection

An inspection of the buildings was undertaken on the 6th March 2012. Both the interior and exterior of the buildings were inspected. The main structural components of the buildings were able to be viewed however details of the roof structure could not be observed. It should be noted that no inspection of the foundations of the structures was able to be undertaken.

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

5.2 Investigation and Opening Up Work

No opening up work was undertaken

5.2.1 Available Drawings

Copies of the following construction drawings were provided by CCC:

Item	Title	Sheet No.	Date
1	Site Plan	1	19/06/98
2	Ground Floor Plans	2	18/08/98
3	First Floor Plans	3	18/08/98
4	First Floor Plans – Amendments	3	09/10/98
5	Second Floor Plans	4	18/08/98
6	Second Floor Plans - Amendments	4	09/10/98
7	Elevations – Block D and E	6	18/08/98
8	Section	7	18/08/98
9	Section	8	19/06/98
10	Drainage Plan	D1	19/06/98
11	Ground Floor Plans	67-5/1	07/98
12	First Floor Plans	67-5/2	07/98
13	Second Floor Plans	67-5/3	07/98

14	Block D – Block Wall Elevations	67-5/13	07/98
15	Block D – Block Wall Elevations	67-5/14	07/98
16	Block D – Block Wall Elevations	67-5/15	07/98
17	Block D – Block Wall Elevations	67-5/16	07/98
18	Block D – Block Wall Elevations	67-5/17	07/98
19	Block D – Block Wall Elevations	67-5/18	07/98
20	Block E – Block Wall Elevations	67-5/19	07/98
21	Block E – Block Wall Elevations	67-5/20	07/98
22	Block E – Block Wall Elevations	67-5/21	07/98
23	Block E – Block Wall Elevations	67-5/22	07/98
24	Block E – Block Wall Elevations	67-5/23	07/98
25	Blocks A to E - Details	67-5/24	07/98
26	Blocks A to E - Details	67-5/25	07/98
27	Blocks A to E - Details	67-5/26	07/98
28	Blocks D and E – Precast Stair Details	67-5/28	07/98

The drawings have been used to confirm the structural systems, investigate potential critical structural weaknesses (CSW) and identify details which required particular attention.

Some specification information was also supplied but no structural calculations for the buildings are available.

Drawings are included in Appendix C of this report.

5.3 Analysis and Modelling Methodology

The seismic assessment procedure determines the capacity of the structure to withstand seismic loading (as defined in the current New Zealand Standard 1170.5:2004) through structural analysis. The seismic capacity of the structure is measured as a proportion of New Building Standard (% NBS), the standard to which a new building must perform in terms of current design codes and standards. The weakest structural element of the structure is the element which governs the seismic capacity of the overall structure.

The methodology and approach adopted for the analysis and assessment is presented in the following sections.

5.3.1 Building Modelling

There were two separate model analysis carried out for each of the buildings. The upper level timber wall structure was modelled to determine the loads to be transferred to the lower masonry wall structure. Each structure was modelled as a three-dimensional space frame, using finite elements, with joints and nodes selected to model the stiffness and inertia effects of the structure. The structural software ETABS v.9.7.2 has been used for the general modelling and analysis of the structures. The stairs and roof were not included in the model but the weights of these were loaded onto supporting members. The foundations were assumed to be pinned in the 3D model.

Figure 4 to 7 shows the 3D model developed in Etabs for both buildings.

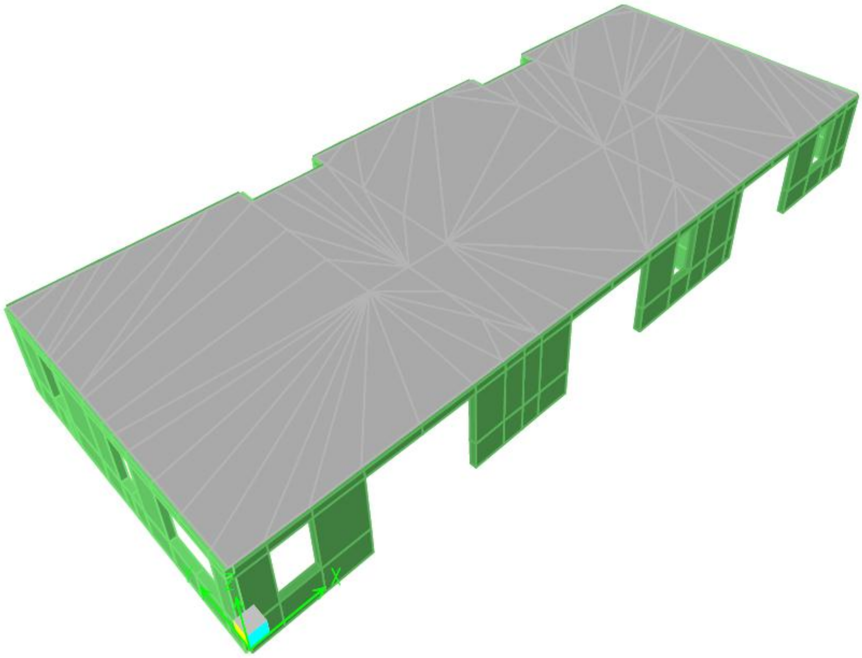


Figure 4: 3D Model of the building developed in Etabs - Timber wall (North Building – Upper Storey)

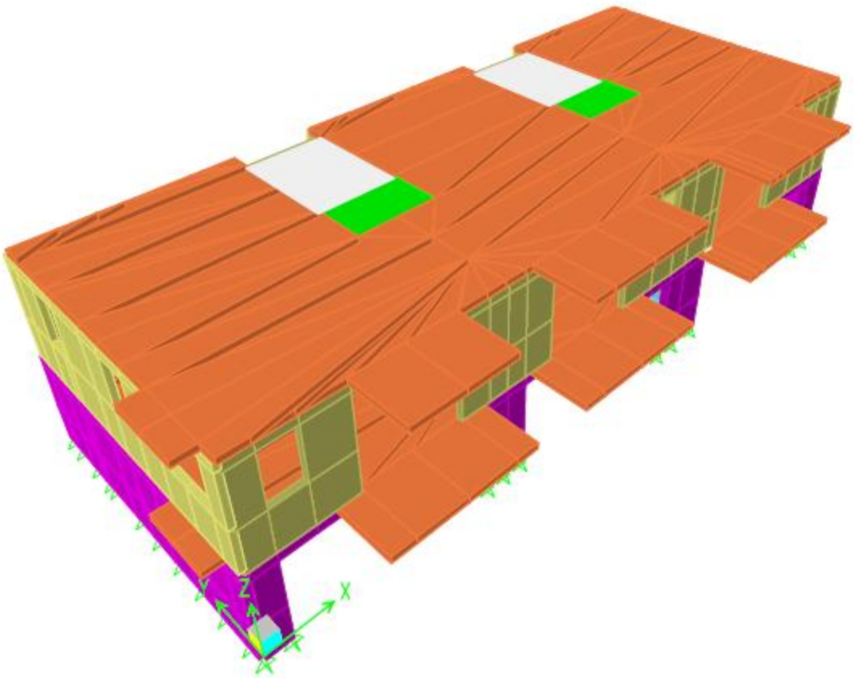


Figure 5: 3D Model of the building developed in Etabs - Masonry Wall (North Building – Lower 2 Storeys)

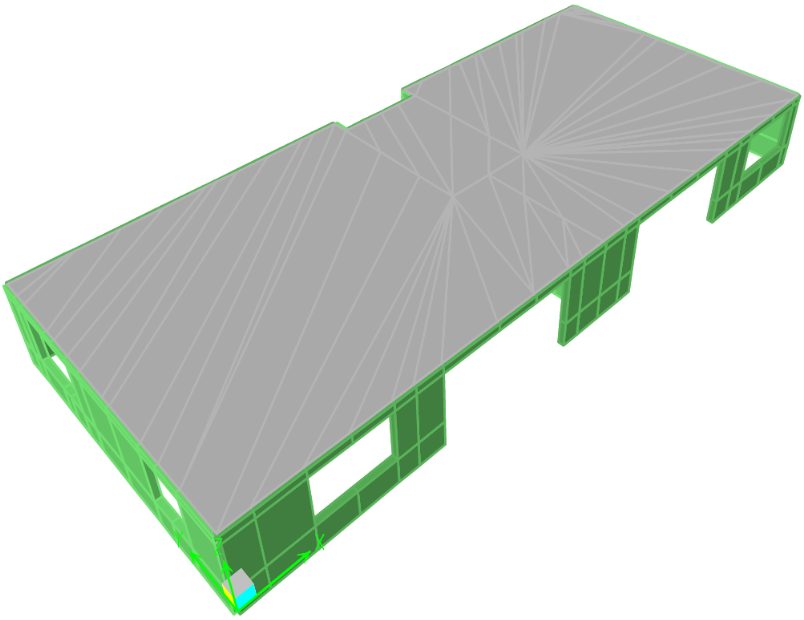


Figure 6: 3D Model of the building developed in Etabs - Timber Wall (South Building – Upper Storey)

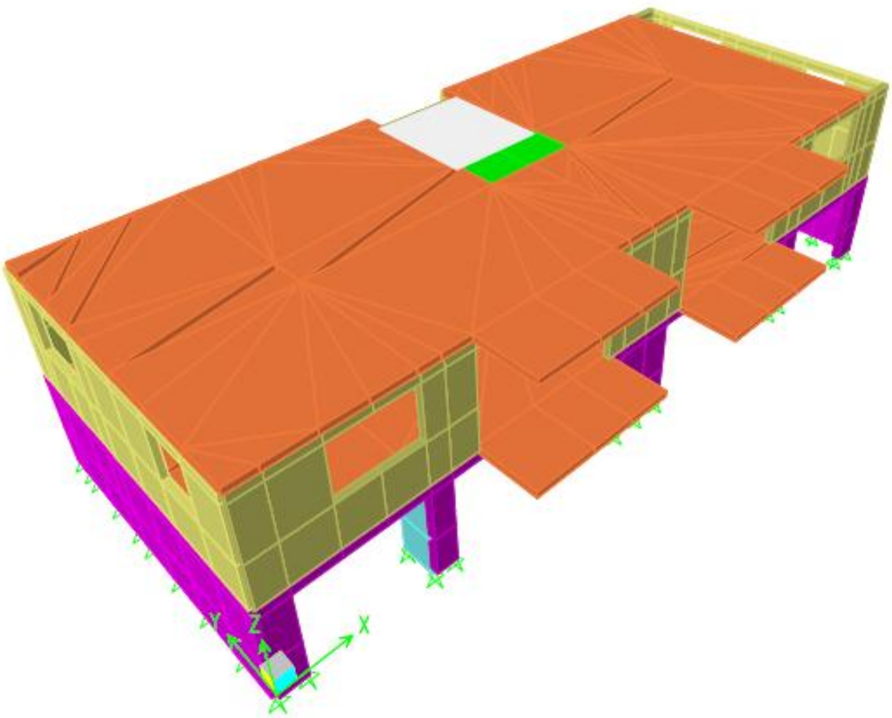


Figure 7: 3D Model of the building developed in Etabs - Masonry Wall (South Building – Lower 2 Storeys)

5.3.2 Structural Calculations

The seismic assessment for each building was undertaken using the equivalent static method as described in Clause 6.2 of the NZS 1170.5 by using the 3D model created in Etabs.

The capacity of the existing structure and its components under ultimate loading conditions (earthquake) were obtained based on determined critical load combinations. The capacity to demand ratio of each member was computed and the capacity expressed as a percentage of New Building Standard (% NBS).

For the Masonry Assessment, GHD used the Design of Reinforced Concrete Masonry for Specific Design (NZS 4230:2004) instead of the Non-Specific Design (NZS 4229:1999) because each building was greater than 2-storeys and is constructed on a Class D Soil (Soft Soil) which is outside the limitation in NZS 4229:1999.

6. Damage Assessment

6.1 Surrounding Buildings

Gloucester Courts Blocks B and C Buildings are surrounded by Gloucester Courts Block A to the west and residential apartments to the south. The apartments and commercial units that were present to the west of Block A have been demolished following the 22^{nd} of February 2012 seismic events. The Gloucester Courts Block A appears to have suffered only minor damage, and poses no structurally detrimental influence to either of the blocks.

6.2 Residual Displacements and General Observations in Both Buildings

There were no residual displacements of the buildings noted during the inspection.

However in both buildings:

- Minor cracks were observed in walls above the exterior doors.
- Minor cracks were observed in the first floor slab near the staircase.

It is believed that the cracks mentioned above are due to localised stresses in the floors and walls during earthquake shaking.

6.3 Ground Damage

There was no evidence of ground damage on the property.

7. Seismic Analysis

7.1 Seismic Parameters

Seismic loads were applied based on criteria specified by the New Zealand Code (NZS 1170.5:2004) and New Zealand Society of Earthquake Engineering (NZSEE).

The seismic assessment parameters are as tabulated below:

Site Classification	D
Importance Level	2
Hazard factor, (Z) (Table 3.3, NZS 1170.5:2004)	0.30 (Christchurch)
Annual Probability of Exceedance (Table 3.3, NZS 1170.0:2002)	1/500 (ULS)
Annual Probability of Exceedance (Table 3.3, NZS 1170.0:2002)	1/25 (SLS)
Return Period Factor (R_u), (Table 3.5, NZS 1170.5:2004)	1.0 (ULS)
Return Period Factor (R_s), (Table 3.5, NZS 1170.5:2004)	0.33 (SLS)
Ductility Factor (μ) (Section 4.3.1.1, NZS 1170.5: 2004)	1.50
Performance Factor (S_p) (NZS 3101 Section 2.6.2.2.1)	0.871
Liquefaction Potential	minor to moderate

An increased Z factor of 0.3 for Christchurch has been used in line with requirements from the Department of Building and Housing resulting in a reduced % NBS score.

8. Geotechnical Consideration

The subject site is located within the Christchurch Central Business District, at approximately 5 m above mean sea level. It is surrounded by commercial and medium-density residential properties. The site is situated approximately 400 m southeast of the Avon River, and 8 km west of the coast (Pegasus Bay).

8.1 Published Information on Ground Conditions

8.1.1 Published Geology

The geological map of the area indicates that the site is underlain by Holocene alluvial soils of the Yaldhurst Member, sub-group of the Springston Formation, comprising alluvial sand and silt overbank deposits.

8.1.2 Environment Canterbury Logs

Information from Environment Canterbury (ECan) indicates that there are eight boreholes are located within a 200 m radius of the site. Of these boreholes, four contain a lithographic log.

The conditions described within the logs indicate the geology to be layers of sand and clay/silt to ~9 m bgl, underlain by layers of gravel, sand and clay. Layers containing peat and organic matter are indicated to be present between 24 m and 65 m bgl.

Table 2 ECan Borehole Summary

Bore Reference	Log Depth	Groundwater	Distance & Direction from Site
M35/1931	128 m	'artesian'	120 m W
M35/12095	3.05 m	-	120 m E
M35/12811	3.66 m	-	200 m W
M35/17504	4 m	-	150 m SW

It should be noted that the boreholes were sunk for groundwater extraction and not for geotechnical purposes. Therefore, the amount of material recovered and available for interpretation and recording will have been variable at best and may not be representative. The logs have been written by the well driller and not a geotechnical professional or to a geotechnical standard. In addition strength data is not recorded.

8.1.3 EQC Geotechnical Investigations

The Earthquake Commission has not undertaken geotechnical testing in the area of the site.

8.1.4 CERA Land Zoning

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

The site is classified as Green Zone Technical Category 2; yellow (TC2, yellow). This means that minor to moderate land damage from liquefaction is possible in future significant land damage.

Land is generally suitable to be repaired and rebuilt on; land damage may be present but this can be repaired on an individual basis as part of the normal insurance process. Specific engineering foundation design is required.

8.1.5 Post-Earthquake Aerial Photography

Aerial photography taken following the 22 February 2011 earthquake shows signs of liquefaction in adjacent properties, particularly those to the northwest across Gloucester Street (see Figure 8). However, little to no effect can be observed on the site itself.

Figure 8 Post February 2011 Earthquake Aerial Photography

8.1.6 Summary of Ground Conditions

From the information presented above, it is anticipated that the site is underlain by stratified alluvial deposits, consisting of layers of gravel, sand, silt and clay, typical of the Springston formation.

8.2 Seismicity

8.2.1 Nearby Faults

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

Table 3 Summary of Known Active Faults[1,2]

Known Active Fault	Distance from Site	Direction from Site	Max Likely Magnitude	Avg Recurrence Interval
Alpine Fault	120 km	NW	~8.3	~300 years
Greendale (2010) Fault	30 km	W	7.1	~15,000 years
Hope Fault	107 km	N	7.2~7.5	120~200 years
Kelly Fault	115 km	NW	7.2	150 years
Porters Pass Fault	54 km	NW	7.0	1100 years

Recent earthquakes since 22 February 2011 have identified the presence of a previously unmapped active fault system underneath Christchurch City and the Port Hills. Research and published information on this system is in development and not generally available. Average recurrence intervals are yet to be estimated.

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

8.2.2 Ground Shaking Hazard

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

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

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

[2] GNS Active Faults Database

8.3 Slope Failure and/or Rockfall Potential

The site is located on flat land within Central Christchurch. Global slope instability is considered negligible. However, any localised retaining structures and/or embankments should be further investigated to determine the site-specific slope instability potential.

8.4 Field Investigations

In order to further understand the ground conditions at the site, intrusive testing comprising two piezocone CPT investigations was conducted at the site on 25 June 2012.

The locations of the tests are tabulated in Table 4 and illustrated in Figure 9.

Table 4 Coordinates of Investigation Locations

Investigation	Depth (m bgl)	Easting (NZMG)	Northing (NZMG)
CPT 001	15.29	2481302	5741852
CTP 002	16.32	2481300	5741869

The CPT investigations were undertaken by McMillans Drilling Ltd, typically to a target depth of 20 m below ground level. However, refusal was reached at depths of 15.3 m and 16.3 m due to the presence of dense sands.

Figure 9: Intrusive Investigation Location

8.5 Ground Conditions Encountered

Interpretation of output graphs[3] from the investigation showing Cone Tip Resistance (qc), Friction Ratio (Fr) and Inferred Lithology are presented in Table 5 .

[3] McMillans Drilling CPT data plots, Appendix A.

Summary of CPT-Inferred Lithology

Table 5 Summary of CPT-Inferred Lithology

Depth (m)	Lithology [1]	Cone Tip Resistance q_c (MPa)	Friction Ratio Fr (%)	Relative Density Dr (%)
0 – 6.0	SILT Mixtures	0.5 – 5	1 – 8	(Su ≥ 40 kPa)
6.0 – 11.0	SAND	3 – 22	0.5 - 3	60 – 80
11.0 – 12.0	SILT Mixtures	1 – 5	2 - 3	(Su ≥ 80 kPa)
12.0 – 15.0	SAND	5 – 34	0.5 – 1	40 – 100

Groundwater was inferred to be at levels of 1m below ground level.

8.6 Liquefaction Assessment

Due to the anticipated presence of loose/soft alluvial soils a more comprehensive liquefaction analysis has been undertaken.

8.6.1 Parameters used in Analysis

Assumptions made for the analysis process are as follows:

- D50 particle sizes for the site soil (sands) from CPT soil analysis;
- Importance Category 2, post seismic event (50-year design life);
- PGA 0.35g

The following equation has been used to approximate soil unit weight from the CPT investigation data: [4]

$$\gamma = \frac{\gamma_w Gs}{2.65}\left(0.27 \log Fr \; + \; 0.36 \log\left(\frac{qc}{p_{atm}}\right) + 1.236\right)$$

This typically gave values ranging between 16 and 21 kN/m3 (saturated).

The liquefaction analysis process has been conducted using the methodology from Robertson & Wride5, and from the NZGS Guidelines6. Settlements have been estimated using the procedure described in Zhang et al7, as recommended by Appendix C of the DBH guidelines (April 2012).

[4] Robertson P.K., & Cabal K.L. 2010: *Estimating soil unit weight from CPT*. Gregg Drilling & Testing Inc.: Signal Hill, California, USA.

[5] Robertson P.K. & Wride C.E. (1998): *Evaluating cyclic liquefaction potential using the cone penetration test.* Canadian Geotechnical Journal, 35: pp. 442–459.

[6] Cubrinovski M., McManus K.J., Pender M.J., McVerry G., Sinclair T., Matuschka T., Simpson K., Clayton P., Jury R. (2010): Geotechnical earthquake engineering practice: *Module 1 – Guideline for the identification, assessment and mitigation of liquefaction hazards*. NZ Geotechnical Society

[7] Zhang G., Robertson P.K., & Brachman R.W.I. (2002): *Estimating liquefaction-induced ground settlements from CPT for level ground*. Canadian Geotechnical Journal, Vol 39, pp. 1168-1180

8.6.2 Results of Liquefaction Analysis

The results of the liquefaction analysis, as outlined in Table 6, indicate that several layers are considered highly liquefiable. Specifically this includes three pockets between 0.6 to 6m, Sand from 6 to 7.2m and 9.8 to 10m, and Sand/Silt Mixtures from 11 to 16m.

Please refer to Appendix A for further detail.

Table 6 Summary of Liquefaction Susceptibility

Depth (m)	Lithology	Triggering Factor F_L	Liquefaction Susceptibility [8]
0 – 6	SILT Mixtures	0.4 – 0.8	Isolated pockets susceptible
6 – 7.2	SAND	0.5	High
7.2 – 9.8	SAND	>1.2	Low
9.8 – 10	SAND	0.5	High
10 – 11	SAND	>1.2	Low
11 – 12	SILT Mixtures	0.4	Severe
12 - 16	SAND	0.5 - 2	High

Settlement estimates for the CPT points are between 107mm and 126 mm for ULS conditions.

Please refer to Appendix D for further details.

8.7 Interpretation of Ground Conditions

8.7.1 Liquefaction Assessment

Overall, the site is considered to be moderately susceptible to liquefaction. This is based on:

- Evidence of liquefaction at the surface in the post-earthquake aerial photography;
- Estimated settlements from the CPT results (107 mm to 126 mm) are in excess of the 100 mm limit for TC2 classification, indicating the site should be considered in line with TC3 guidelines; and,
- The layers of 6 m to 7.2 m and 9.8 m to 10 m and 11 m to 12 m are indicated to be highly susceptible, as outlined in Table 6**.**

8.7.2 Slope Failure and/or Rockfall Potential

The site is located on flat land within Central Christchurch. Global slope instability is considered negligible. However, any localised retaining structures and/or embankments should be further investigated to determine the site-specific slope instability potential.

8.7.3 Foundation Recommendations

Based on the information presented above, we recommend the following for the subject site:

[8] Table 6.1, NZGS Guidelines Module 1 (2010)

- The soil class of D (in accordance with NZS 1170.5:2004) recommended in Section 8 of the Qualitative DEE is still believed to be appropriate; and,
- Any remedial works to foundations (or proposed new structures) be undertaken in accordance with DBH’s guidelines for TC3 land, due to the high levels of estimated settlement; and,
- All significant repairs to and proposed new foundations be specifically-designed by a suitably qualified and experienced geotechnical engineer.

9. Results of Analysis

9.1 Summary of Results (North Building)

The outcome of the three-dimensional model analysis and demand/capacity assessment is summarised below in Table 7. Note that the values given represent the critical elements in the building, as these effectively define the building's capacity. Other elements within the building will have significantly greater capacity when compared with the governing elements.

A diagrammatic plan is shown in Figure 10.

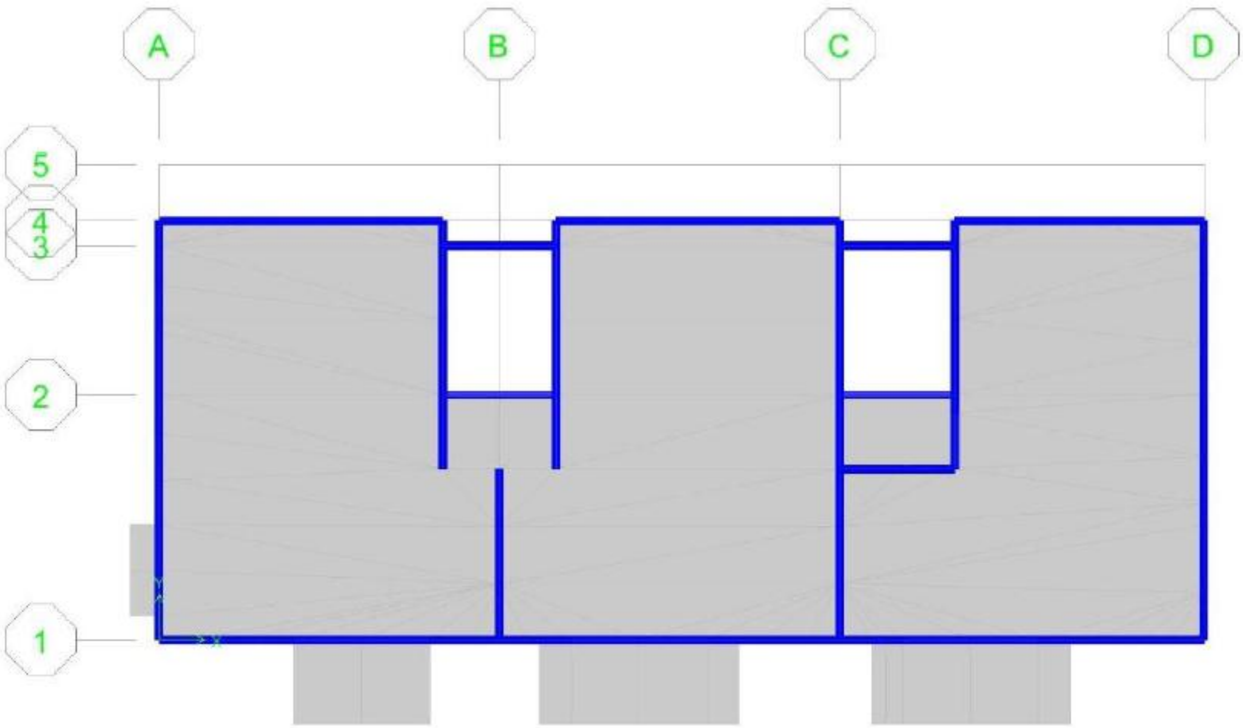


Figure 10: Plan Showing Gridlines (North Building)

Table 7: North Building Element to % NBS

Level	Direction	Element	(% NBS)
Second – Roof Level	Transverse	Timber Wall	76%
	Longitudinal	Timber Wall	46%
First – Second Floor	Transverse	Masonry Wall RC Beam (First Floor)	35% >100%
	Longitudinal	Masonry Wall	37%
Ground – First Floor	Transverse	Masonry Wall	>100%
	Longitudinal	Masonry Wall	97%

9.1.1 RC Beams

All concrete beams are more than 67% NBS.

9.1.2 Masonry Walls

Based on the analysis, the masonry block walls in the transverse direction were assessed to be the critical structural weakness of the building having the lowest NBS scores of 35% on Gridline D at First to Second floor level. In the longitudinal direction, a masonry block wall achieved a rating of 37% NBS, along Gridline 4 at First to Second floor level. There are substantial numbers of masonry block walls that achieved NBS scores less than 67% NBS. These fall within the ‘Earthquake Risk’ category.

9.1.3 Timber Walls

Calculations showed that the overall bracing capacity of the timber walls achieved a score of 58% NBS on the longitudinal direction. Overall the bracing capacity of the timber walls in the transverse direction achieved over 100% NBS. Because of the longitudinal direction weakness the bracing system falls within the “Eathquake Risk” category.

9.1.4 Inter-Storey Drift

The maximum calculated inter-storey drift occurs at roof level in longitudinal direction. The inter-storey drift for all levels is more than 100% NBS. A full summary table of deflections and drifts for each storey is included in Table 8.

Table 8: Inter Storey Drift (North Building)

Floor Level	Max Displacement m	Drift Modification Factor	Direction	Load	Modified Drift/floor mm	Storey height m	Allowable (2.5% limit) mm
ROOF	0.012	1.20	Longitudinal	EQX	6.6	2.16	54.0
STOREY 2	0.005	1.20	Longitudinal	EQX	0.5	2.56	64.0
STOREY 1	0.005	1.20	Transverse	EQY	4.6	2.36	59.0

9.1.5 Stairs

Two precast concrete staircases are present providing access to the upper levels. These stairs are supported by top and bottom in-situ cast concrete landings at the floor levels and at midheight. It is unlikely that the stairs will contribute a significant detrimental stiffness concentration in this part of the complex.

Based on the displacement result from Etabs, the maximum ultimate movement of the structure is 0.20 mm in transverse direction at second floor. Given the detailing of the connection between stairs and landings, the stairs appear to be adequately anchored to the supporting reinforced concrete slabs. It is not expected that the stairs would become dislodged during a seismic event. The calculated % NBS of Stairs is more than 67 % NBS.

9.1.6 Flooring

The building slab is typically “Unispan” concrete precast slab with an overall thickness of 150 mm – this thickness is composed of 75 mm precast concrete slab with 75 mm concrete topping. These slabs are supported by concrete masonry block walls at first floor level and a combination of masonry walls and reinforced concrete frames at second floor level.

This precast slab has a typical wire mesh reinforcement of HRC 665 mesh. The precast floor system is connected to the supporting walls and beams HRC 665 wire mesh reinforcement and D12 reinforcement with a typical spacing of 600 mm.

All the slabs perform satisfactorily under seismic loading having an NBS over 100%.

9.1.7 Foundations

The existing structure is supported on reinforced strip footings. Due to the nature of the ground floor structure relatively stiff concrete masonry walls and no signs of significant land damage or settlement around the building, it is not believed that the foundations are an “Earthquake Risk”.

9.2 Summary of Results (South Building)

The outcome of the three-dimensional model analysis and demand/capacity assessment is summarised below in Table 9. Note that the values given represent the critical elements in the building, as these effectively define the building’s capacity. Other elements within the building will have significantly greater capacity when compared with the governing elements.

A diagrammatic plan is shown in Figure 11.

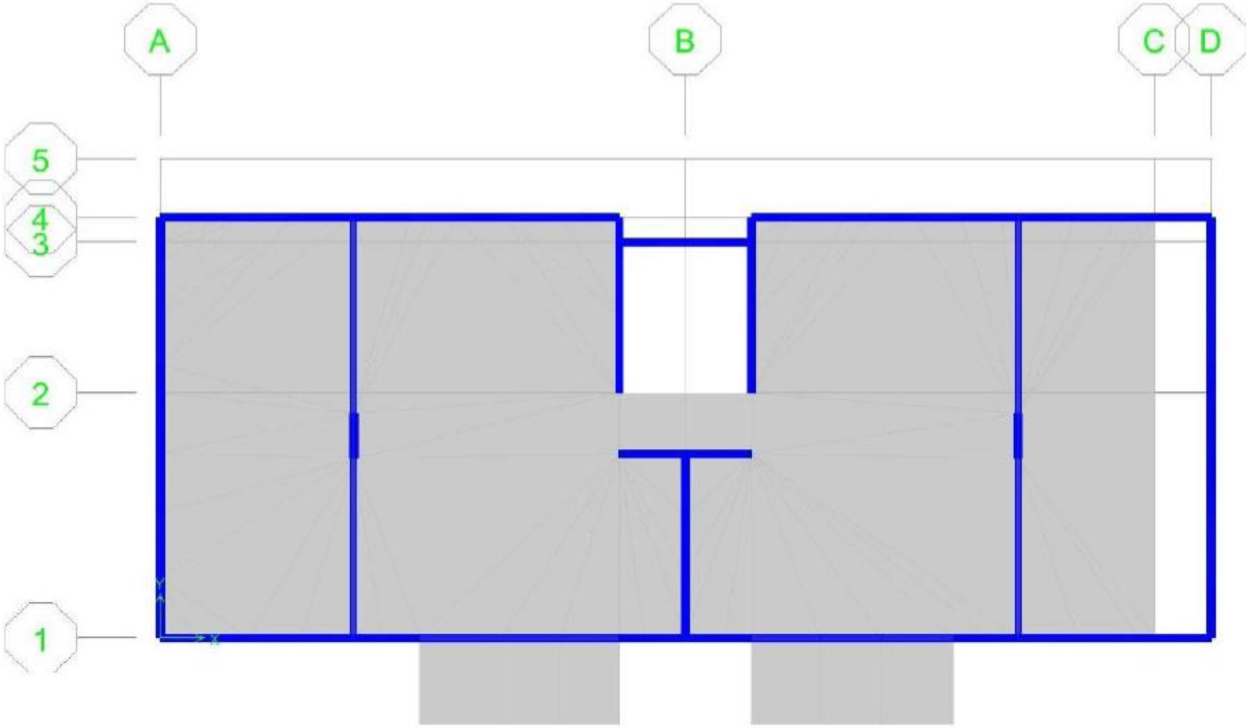


Figure 11: Plan Showing Gridlines (South Building)

Table 9: South Building Element to % NBS

Level	Direction	Element	(% NBS)
Second – Roof Level	Transverse	Timber Wall	88%
	Longitudinal	Timber Wall	36%
First – Second Floor	Transverse	Masonry Wall RC Beam (Second Floor)	71% 89%
	Longitudinal	Masonry Wall	57%
Ground – First Floor	Transverse	Masonry Wall RC Beam (First Floor)	>100% 77%
	Longitudinal	Masonry Wall	>100%

9.2.1 RC Beams

All concrete beams are more than 67% NBS.

9.2.2 Masonry Walls

Based on the analysis, the masonry block walls in the longitudinal direction were assessed to be the critical structural weakness of the building having the lowest NBS scores of 57% on Gridline 4 at First to Second Floor Level. In the transverse direction, masonry walls achieve ratings greater than 67% NBS. There are substantial numbers of masonry walls that achieved NBS scores less than 67% NBS in the longitudinal direction. These fall within the “Earthquake Risk” category.

9.2.3 Timber Walls

Calculations showed that the overall bracing capacity of the timber walls achieved a score of 36% NBS in the longitudinal direction. Overall the bracing capacity of the timber walls in the transverse direction achieved over 67% NBS. Because of the longitudinal direction weakness the wall bracing system falls within the “Earthquake Risk” category.

9.2.4 Inter-Storey Drift

The maximum calculated inter-storey drift occurs at second floor in transverse direction. The inter-storey drift for all levels is more than 100% NBS. A full summary table of deflections and drifts for each storey is included in Table 10.

Table 10: Inter-Storey Drift (South Building)

Floor Level	Max Displacement m	Drift Modification Factor	Direction	Load	Modified Drift/floor mm	Storey height m	Allowable (2.5% limit) mm
ROOF	0.020	1.20	Transverse	EQY	7.0	2.16	54.0
STOREY 2	0.013	1.20	Longitudinal	EQX	7.7	2.56	64.0
STOREY 1	0.005	1.20	Transverse	EQY	4.8	2.36	59.0

9.2.5 Stair

One precast concrete staircase is present providing access to the upper levels. These stairs are supported by top and bottom in-situ cast concrete landings at the floor levels and at midheight. It is unlikely that the stair will contribute a significant detrimental stiffness concentration in this part of the complex.

Based on the displacement result from Etabs, the maximum ultimate movement of the structure is 0.30 mm in transverse direction at second floor. Given the detailing of the connection between stairs and landings, the stair appears to be adequately anchored to the supporting reinforced concrete slabs. It is not expected that the stairs would become dislodged during a seismic event. The calculated % NBS of Stairs is more than 67 % NBS.

9.2.6 Flooring

The building slab is typically “Unispan” concrete precast slab with an overall thickness of 150 mm – this thickness is composed of 75 mm precast concrete slab with 75 mm concrete topping. These slabs are supported by concrete masonry block walls at first floor level and a combination of masonry walls and reinforced concrete frames at second floor level.

This precast slab has a typical wire mesh reinforcement of HRC 665 mesh. The precast floor system is connected to the supporting walls and beams by HRC 665 wire mesh reinforcement and D12 reinforcement with a typical spacing of 600 mm.

All the slabs perform satisfactorily under seismic loading having an NBS over 100%.

9.2.7 Foundations

The existing structure is supported on reinforced strip footings. Due to the nature of the ground floor structure relatively stiff concrete masonry walls and no signs of significant land damage or settlement around the building, it is not believed that the foundations are an “Earthquake Risk”.

10. Conclusions

Our detailed seismic assessment shows that the Gloucester Courts Blocks B and C Buildings achieved an overall 35% NBS and 36% NBS respectively. The buildings therefore fall within the “Earthquake Risk” category. A building with % NBS score in the range 34% to 67% NBS is between 5 and 10 times more likely than a similar building constructed to current loading standards to cause loss of life or serious injury during a seismic event.

The client may choose to consider strengthening the building to 67% NBS, i.e. beyond Earthquake Risk. The scope of work would likely include strengthening of few timber and masonry walls or possibly the addition of extra bracing walls.

11. Recommendations

Based from the results acquired in the quantitative analysis performed, the following recommendations can be endorsed for each of the Gloucester Courts B North and South buildings:

- It is recommended that the current placard status of the building of green remain.
- The building can remain occupied as per CCC's policy to occupy "Earthquake Risk" buidlings.
- A strengthening scheme is developed to increase the seismic capacity of the building to at least 67% NBS.

12. Limitations

12.1 General

This report has been prepared subject to the following limitations:

- Visual inspections of the roof space were limited to the vicinity of the access hatch and due to its non-central location; the entirety of the roof space could not be inspected visually.
- No level or verticality surveys have been undertaken.
- No material testing has been undertaken.
- This report is prepared for CCC to assist with assessing the remedial works required for council buildings and facilities. It is not intended for any other party or purpose.

12.2 Scope and Limitations of Geotechnical Investigation

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

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

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

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

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

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

13. References

- Drawings and Specifications for Residential Units Inner City preferred by Bryndwr Builders Ltd.
- Gloucester Courts Block B, BU 2373-002 EQ2, Detailed Engineering Evaluation, Qualitative Report, Version Draft; April 04, 2012, GHD Pty Ltd. – Christchurch

New Zealand Standard

- NZS 1170.0:2002 Structural Design Actions Part 0: General Principles
- NZS 1170.1:2002 Structural Design Actions Part 1: Permanent, Imposed and Other Actions
- NZS 1170.1:Supplement 1:2002 Structural Design Actions: Permanent, Imposed and Other Actions-Commentary
- NZS 1170.5:2004 Structural Design Actions Part 5: Earthquake Actions – New Zealand
- NZS 3101: Part 1: 1995 Concrete Structures Standard
- NZS 4230: 2004 Design of Reinforced Concrete Masonry Structures
- NZS 3604:2011 Timber Framed Buildings
- New Zealand Society of Earthquake Engineering Guidelines for Assessment and Improvement of the Structural Performance of Buildings in Earthquakes
- Department of Building and Housing (DBH) Practice Advisory 13 – for staircase assessment.

Appendix A

Geotechnical Investigation Results and Analysis

Borelog for well M35/12811

Gridref: M35:81126-41894 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.75 +MSD
Well name : CCC BorelogID 986
Drill Method : Not Recorded
Drill Depth : -3.66m Drill Date :

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
		-0.30m	topsoil	
		-2.13m	silty sand	
		-3.05m	clay	
		-3.35m	wet silty sand	
		-3.66m	saturated sandy silt and clay	

Scale: -0.2, -0.4, -0.6, -0.8, -1, -1.2, -1.4, -1.6, -1.8, -2, -2.2, -2.4, -2.6, -2.8, -3, -3.2, -3.4, -3.6

Unknown No: M35/17504
Well Name: CCC BorelogID 7539
Owner: CCC borelog

Environment Canterbury
Your regional council

Street of Well:		**File No:**	
Locality:		**Allocation Zone:**	Christchurch/West Melton
NZGM Grid Reference:	M35:81229-41737 QAR 3		
NZGM X-Y:	2481229 - 5741737		
Location Description:		**Uses:**	Foundation/Investigation Bore
ECan Monitoring:			
Well Status:	Filled in		

Drill Date:	19 Dec 1997	**Water Level Count:**	0
Well Depth:	4.00m -GL	**Strata Layers:**	6
Initial Water Depth:	-2.50m -MP	**Aquifer Tests:**	0
Diameter:		**Isotope Data:**	0
		Yield/Drawdown Tests:	0
Measuring Point Ait:	7.67m MSD QAR 4	**Highest GW Level:**	
GL Around Well:	0.00m -MP	**Lowest GW Level:**	
MP Description:		**First Reading:**	
		Last Reading:	
Driller:		**Calc. Min. GWL:**	
Drilling Method:		**Last Updated:**	27 Mar 2008
Casing Material:		**Last Field Check:**	
Pump Type:			
Yield:		**Screens:**	
Drawdown:		**Screen Type:**	
Specific Capacity:		**Top GL:**	
		Bottom GL:	
Aquifer Type:			
Aquifer Name:			

Borelog for well M35/17504

Gridref: M35:81229-41737 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.67 +MSD
Well name : CCC BorelogID 7539
Drill Method : Not Recorded
Drill Depth : -4m Drill Date : 19/12/1997

Environment Canterbury Regional Council

Depth(m)	Full Drillers Description	Formation Code
-0.20m	brown topsoil	
-0.60m	brown silt	
-0.90m	brown / orange mottled moist silt	
-1.80m	brown sand	
-1.95m	brown / mottled orange and grey silt	
-4.00m	blue / grey silt	

Borelog for well M35/1931

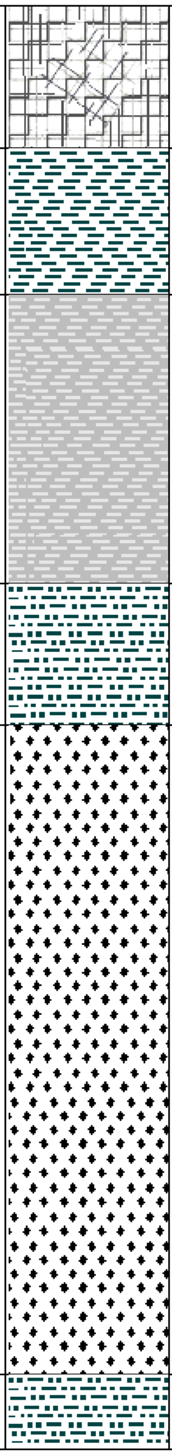
Gridref: M35:812-418 Accuracy : 4 (1=high, 5=low)
Ground Level Altitude : 6 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -128m Drill Date :

Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	-1.50m	Clay	sp?
	-9.10m	Clay	sp?
	- 13.7m	Gravel	sp?
	- 26.5m	Sand (Peat at 24.3m)	ch
	- 44.8m	Gravel	ri
	- 53.6m	Sand & gravel	br
	- 59.4m	Clay (Peat at 54.5m)	br
	- 62.1m	Gravel	li-1
	- 67.9m	Clay (Peat at 65.5m)	li-2
	- 75.2m	Gravel	li-2
	- 78.3m	Clay	li-2
	- 84.4m	Gravel	li-3
	- 86.8m	Sand	he
	- 89.9m	Gravel	he
	- 97.5m	Sand & gravel	he
	- 97.6m	Clay	
	- 105.7m	Gravel	bu
	- 123.4m	Sandy clay	sh
	- 128.0m	Gravel	wa

Scale(m): -10, -20, -30, -40, -50, -60, -70, -80, -90, -100, -110, -120

Borelog for well M35/12095

Gridref: M35:81415-41896 Accuracy : 3 (1=high, 5=low)
Ground Level Altitude : 7.62 +MSD
Well name : CCC BorelogID 87
Drill Method : Not Recorded
Drill Depth : -3.05m Drill Date : 1/01/1972



Depth(m)	Full Drillers Description	Formation Code
-0.30m	road metal	
-0.61m	black silt	
-1.22m	grey silt	
-1.52m	sandy silt	
-2.89m	running sand	
-3.05m	sandy silt	

Scale(m): -0.2, -0.4, -0.6, -0.8, -1, -1.2, -1.4, -1.6, -1.8, -2, -2.2, -2.4, -2.6, -2.8, -3

Water Level

CPT ANALYSIS NOTES

Soil Type

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

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

Liquefaction Screening

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

- high susceptibility
- medium susceptibility
- low susceptibility

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

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

Low susceptibility is all other cases.

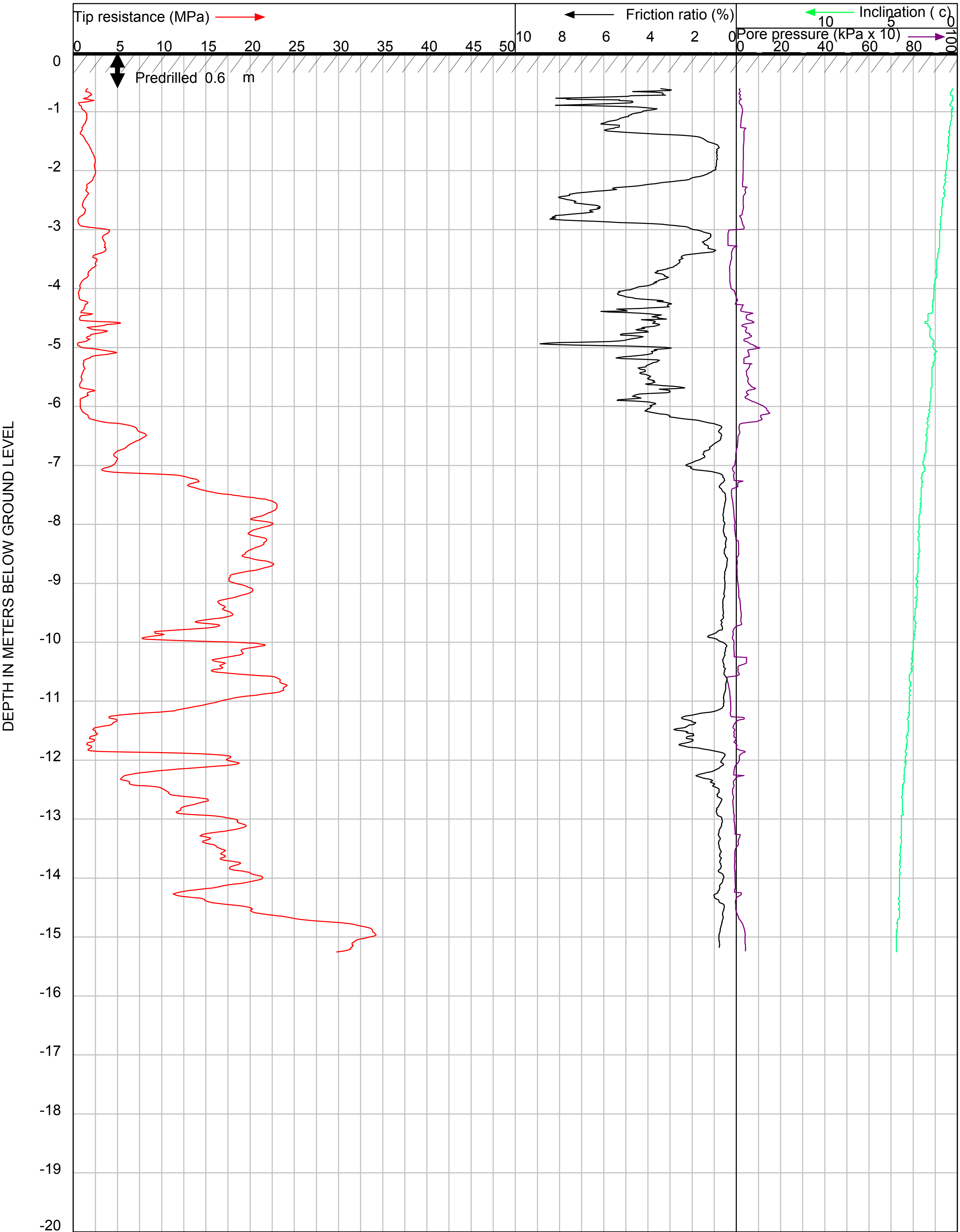
Relative Density (D_R)

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

Undrained Shear Strength (S_U)

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

McMILLAN
DRILLING SERVICES

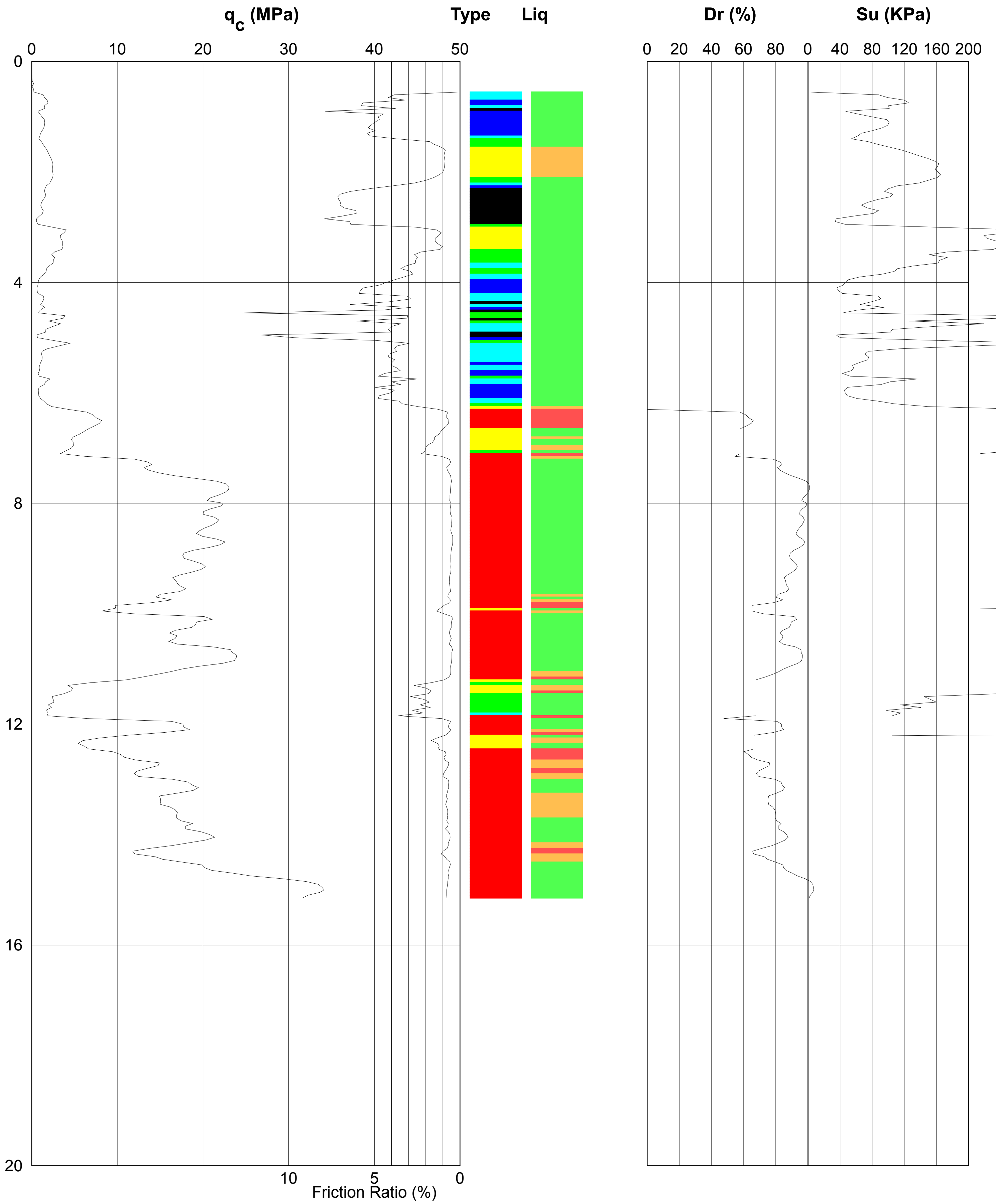


CLIENT : GHD NZ Ltd
LOCATION : 250 Gloucester Street, Christchurch
DATE : 25-6-2012
OPERATOR : S.Cardona
REMARK 1 : CPTu001
REMARK 2 : Effective Refusal

JOB # : 10680
TEST # : 1
CONE TYPE/SERIAL #: I-CFXYP20-10/ 071017T

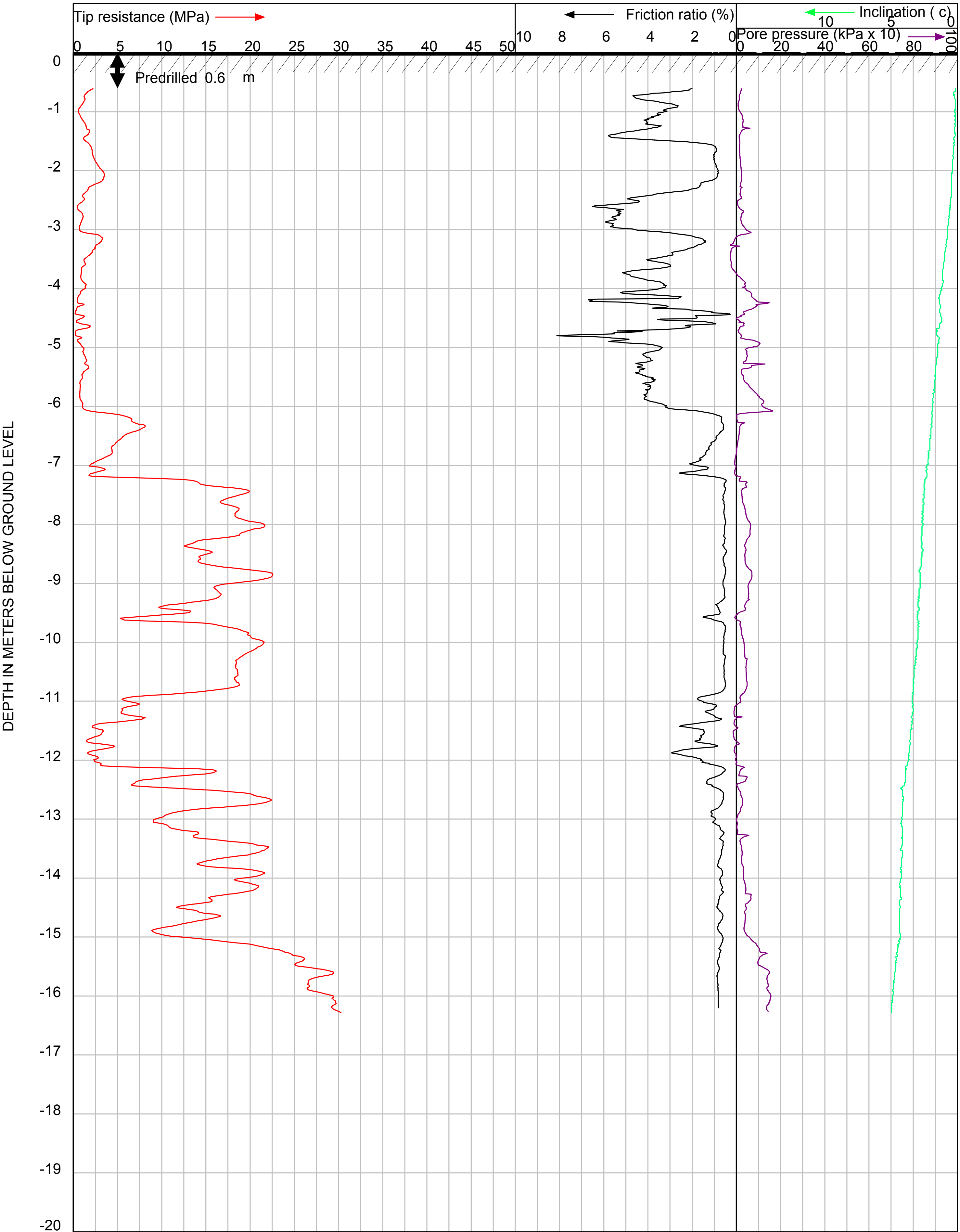
McMILLAN DRILLING SERVICES
120 High St Southbridge CANTERBURY NZ
Ph +64 3 324 2571 Fax +64 3 324 2431
www.drilling.co.nz

PIEZOCONE PENETROMETER TEST (CPTU) INTERPRETIVE REPORT



Job No:	10680	Date:	25-6-2012
CPT No:	CPTu001	Operator:	S.Cardona
Project:	GHD NZ Ltd	Remark:	Effective Refusal
Location:	250 Gloucester Street, Christchurch		

McMILLAN DRILLING SERVICES

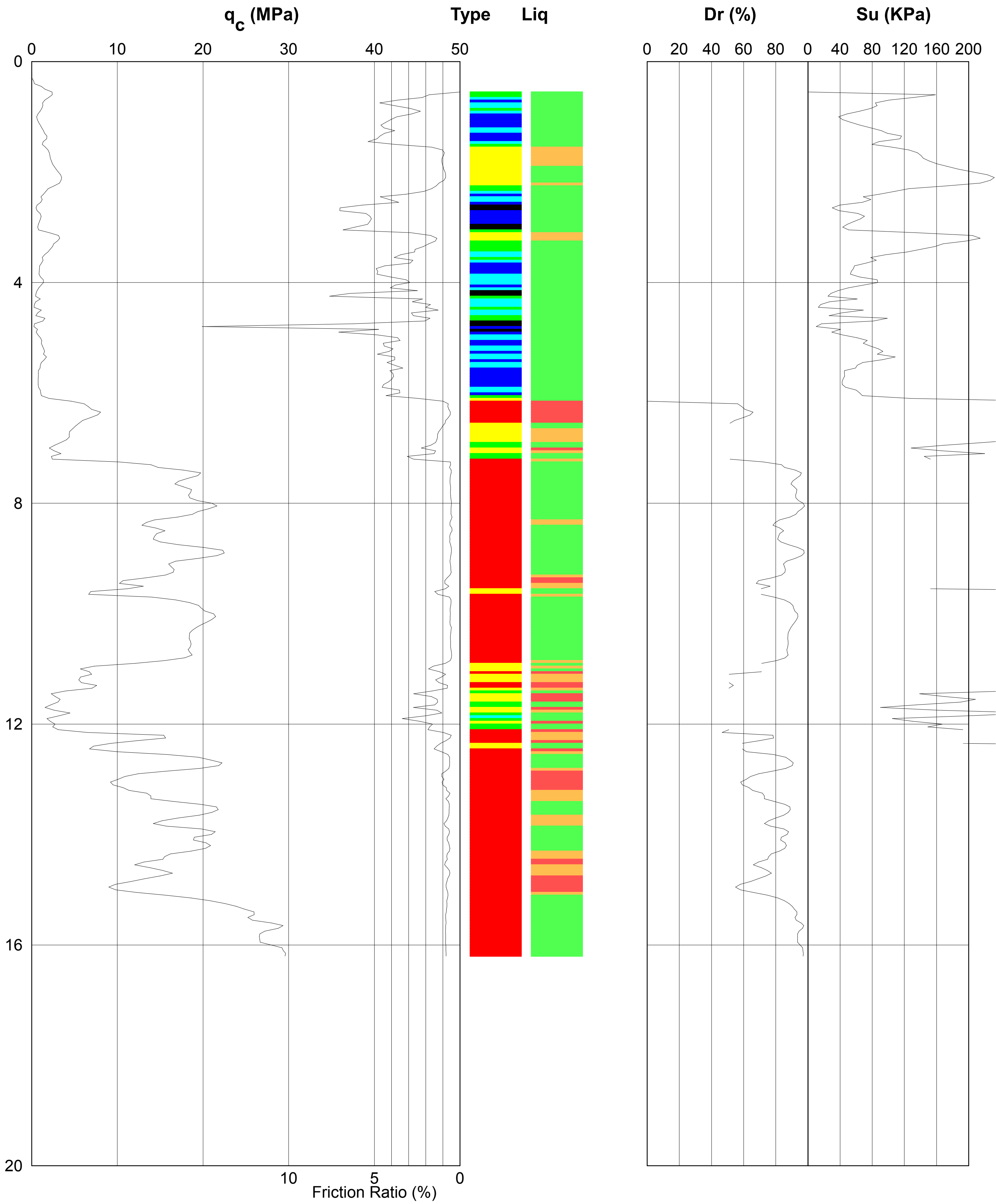


CLIENT : GHD NZ Ltd
LOCATION : 250 Gloucester Street, Christchurch
DATE : 26-6-2012
OPERATOR : S.Cardona
REMARK 1 : CPTu002
REMARK 2 : Effective Refusal

JOB # : 10680
TEST # : 2
CONE TYPE/SERIAL #: I-CFXYP20-10/ 071017T

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

PIEZOCONE PENETROMETER TEST (CPTU) INTERPRETIVE REPORT



Job No: 10680

CPT No: CPTu002

Project: GHD NZ Ltd

Location: 250 Gloucester Street, Christchurch

Date: 26-6-2012

Operator: S.Cardona

Remark: Effective Refusal

McMILLAN DRILLING SERVICES

CIVIL CONSTRUCTION OVERVIEW

- 5 x Piling Rigs (20 to 80 tonne);
- 4 x Tieback/Micro-Piling Rigs (0.5 to 20 tonne);
- Sheet Piling & Injection Grouting;
- Dewatering;
- 26 x Drilling Rigs Company wide.

A NEW ZEALAND FIRST METHOD – INTRODUCED TO THE MARKET BY MCMILLAN'S:

Provisionally Patented Vibration Free Stone Column Method:

- Can be used next to sensitive buildings;
- No mess (dry);
- Cost effective (minimal setup times);
- Further savings possible for building construction – i.e. ground beams, deep rafts, pile starters, boxing to piles;
- No corrosion issues, all natural materials;
- Reliance on individual piles, and the risk of differential settlement is reduced.

Fully Instrumented Continuous Flight Auger / Displacement Auger Piling:

- Cost effective;
- Sizes 350mm to 900mm and 19m depth;
- Fast (150m of 600mm diameter reinforced concrete pile can be installed per day);
- Lateral load capacity of RC piles exceed some other piling methods;
- Quiet & vibration free;
- Fully reinforced concrete piles, with no corrosion issues.

McMILLAN'S ALSO OFFER THE FOLLOWING SERVICES:

- Screw Piles;
- Conventional Bored Concrete Piles;
- Mini & Micro Piles;
- Retaining Walls;
- Sheet Piling;
- Anchors & Tiebacks.

Please contact us to find out more information or visit our website www.drilling.co.nz

McMILLAN
DRILLING SERVICES

SOIL LIQUEFACTION SUSCEPTIBILITY ASSESSMENT

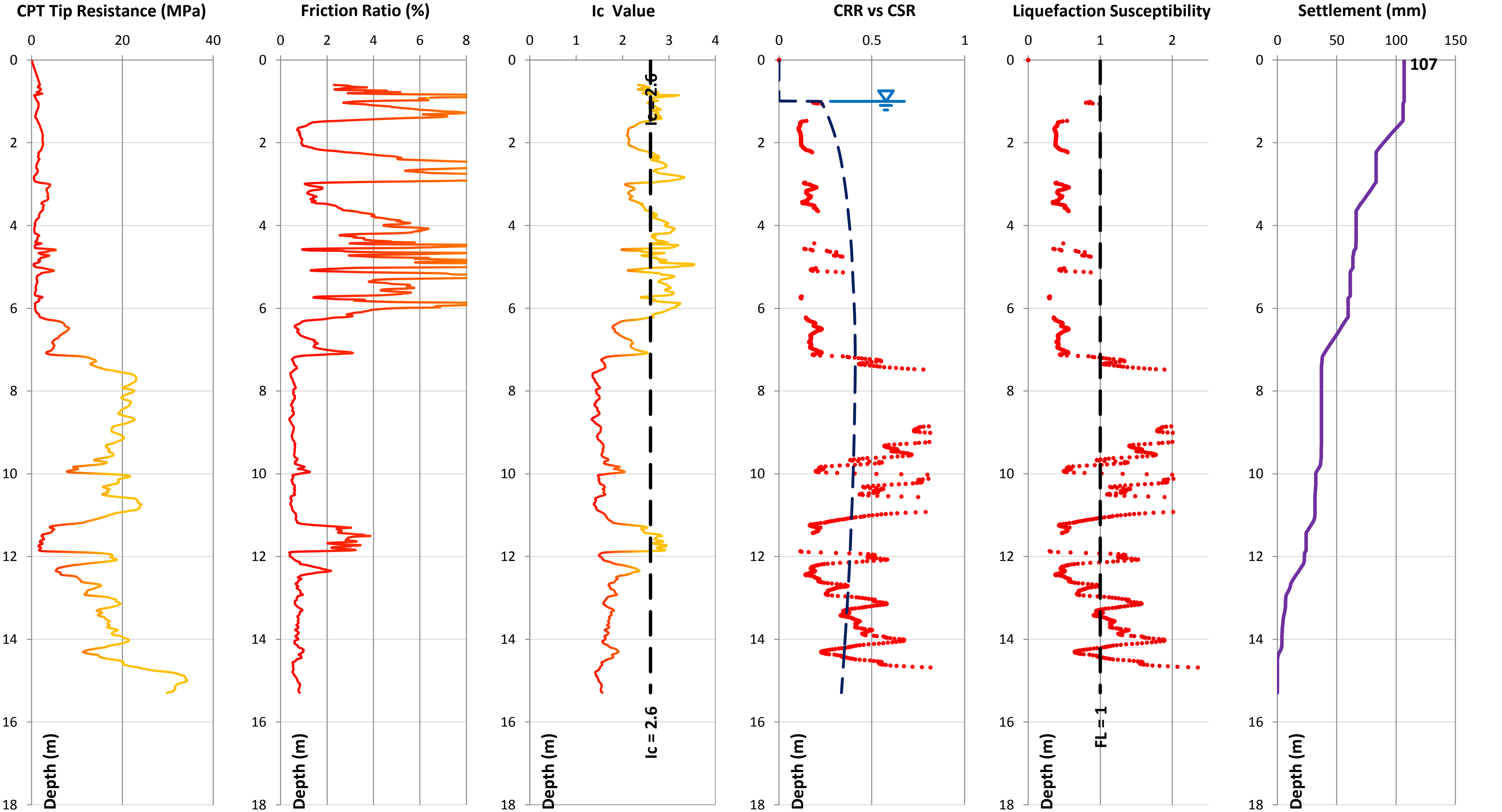
LOCATION :	CPT 01	SHEET :	1 (ULS)
PROJECT :	Gloucester Courts	CALCULATED :	HNN/DW
JOB NO :	51 30596 36	CHECKED BY :	JR
TEST DATE :	25 Jun 2012	DATE :	22 Aug 2012

GHD

PGA (a_{max}):	0.35 g	Groundwater Level (m bgl):	1.0	Bore depth (m):	15.29
EQ Magnitude:	7.5	Atmospheric Pressure (kPa):	101	Test data step (m):	0.01

Total Estimated Settlement (mm)

107



N:\NZ\Wellington\Projects\51\30596\36 Gloucester Courts Block A\Investigation\Geotech Investigation\Liquefaction Analyses\Liquefaction and Settlement Analysis CPT 01

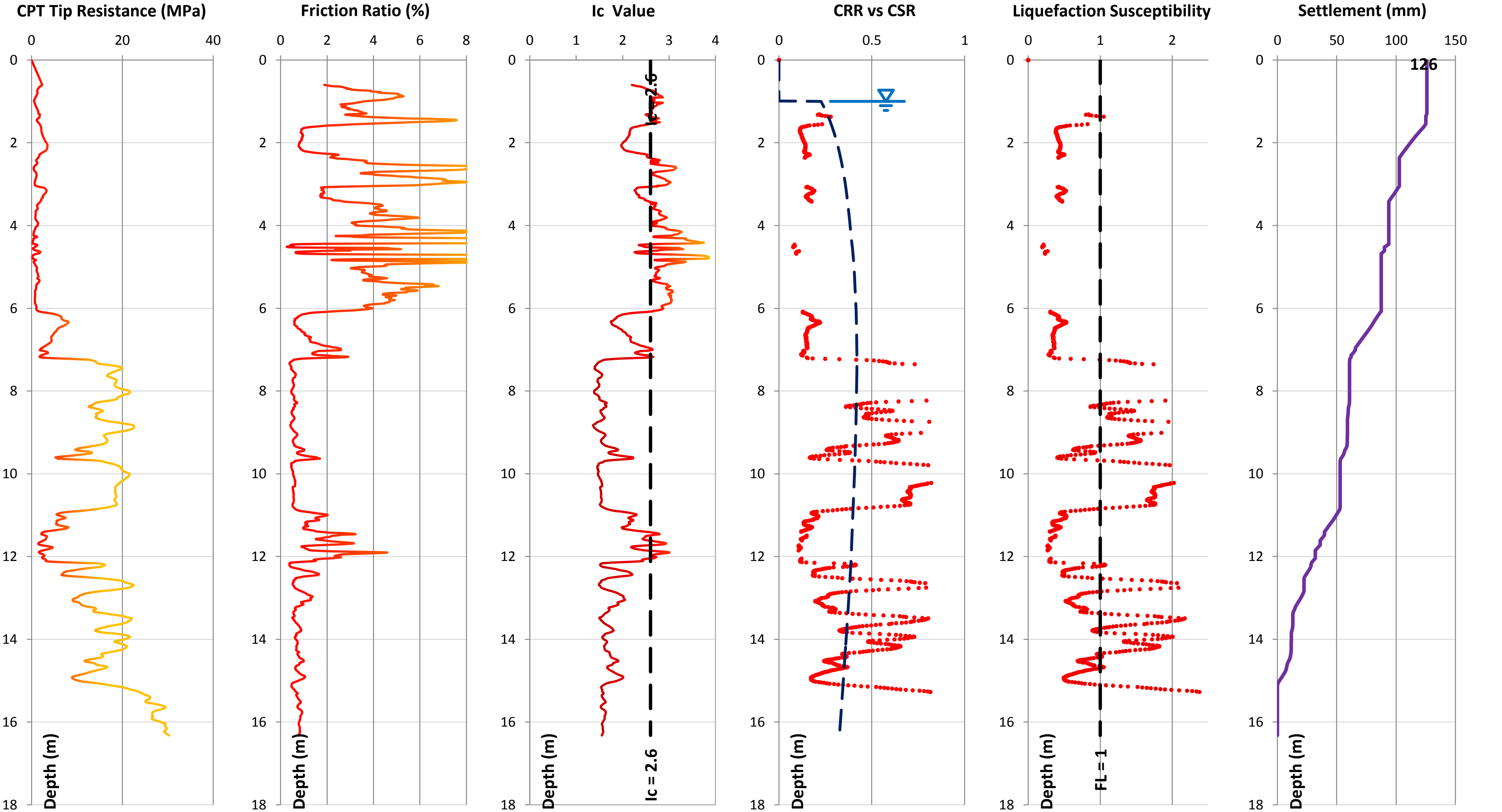
SOIL LIQUEFACTION SUSCEPTIBILITY ASSESSMENT

LOCATION :	CPT 02	SHEET :	1 (ULS)
PROJECT :	Gloucester Courts	CALCULATED :	HNN/DW
JOB NO :	51 30596 36	CHECKED BY :	JR
TEST DATE :	25 Jun 2012	DATE :	22 Aug 2012

PGA (a_{max}):	0.35 g	Groundwater Level (m bgl):	1.0	Bore depth (m):	16.32
EQ Magnitude:	7.5	Atmospheric Pressure (kPa):	101	Test data step (m):	0.01

Total Estimated Settlement (mm)

126



N:\NZ\Wellington\Projects\51\30596\36 Gloucester Courts Block A\Investigation\Geotech Investigation\Liquefaction Analyses\Liquefaction and Settlement Analysis CPT 02

Appendix B
Photographs

Photograph 1 Aerial photograph showing the location of Gloucester Courts Blocks B and C

Photograph 2 Gloucester Courts Block B – Front View

Photograph 3 Gloucester Courts Block B– Rear View

Photograph 4 Gloucester Courts Block B – Side View

Photograph 5 Gloucester Courts Block C – Front View

Photograph 6 Gloucester Courts Block C – Rear View

Photograph 7 Gloucester Courts Block C – Side View

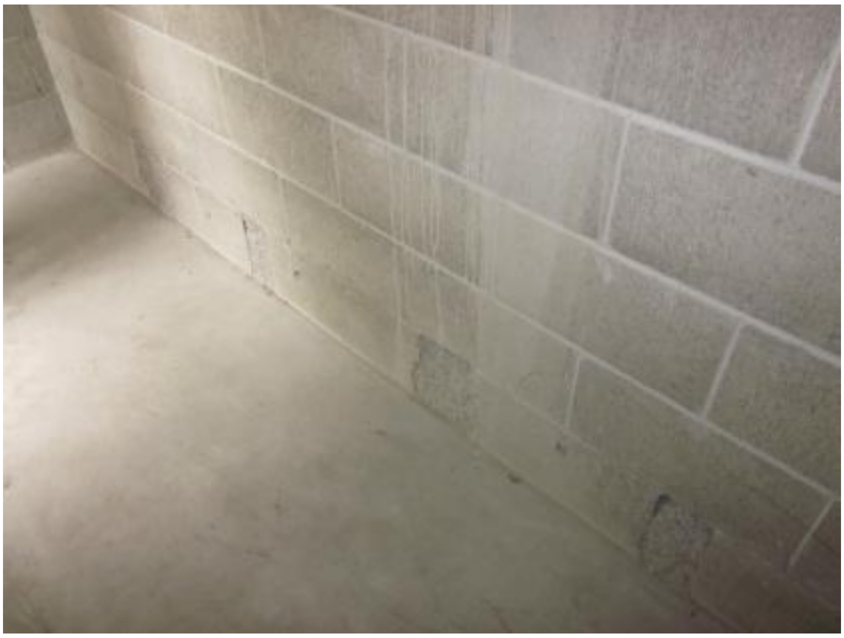
Photograph 8 View of interior of building (Photo taken facing north).

○

Photograph 9 Minor cracks to the wall above the exterior door

Photograph 10 Minor cracks at 1st floor slab near the staircase.

Photograph 11 View of concrete masonry walls and precast floor slab.



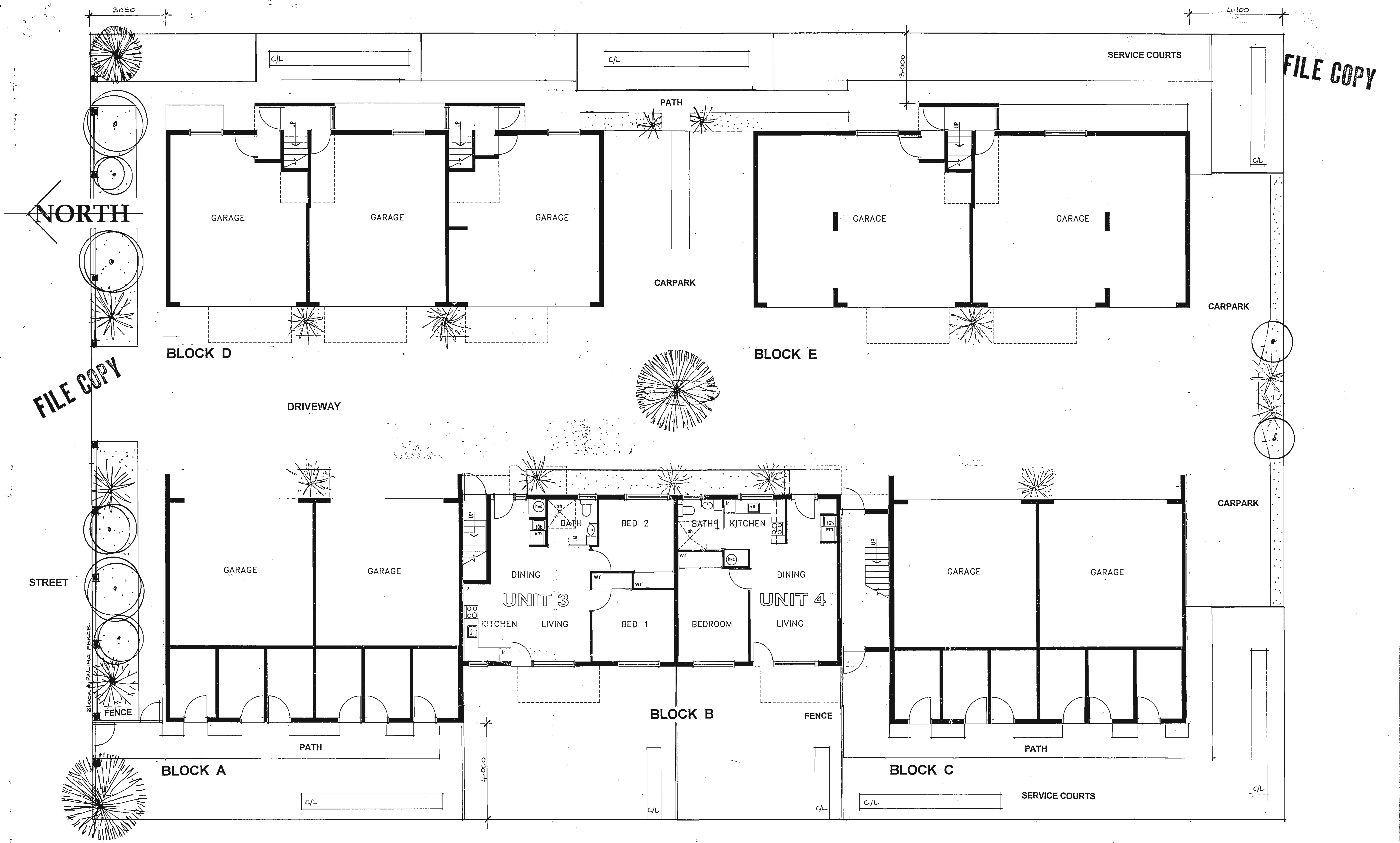
Photograph 12 View of concrete masonry walls.

Photograph 13 View of parking space at ground floor (Block C).

Photograph 14 View of Lightweight metal roof cladding of Gloucester Courts Block A – indicative of building style that may have been used for Gloucester Courts Blocks B and C.

Photograph 15 View of timber roof trusses of Gloucester Courts Block A – indicative of building style that may have been used for Gloucester Courts Blocks B and C.

Appendix C
Original Drawings



SITE PLAN

SCALE 1:100

BCP

98002450

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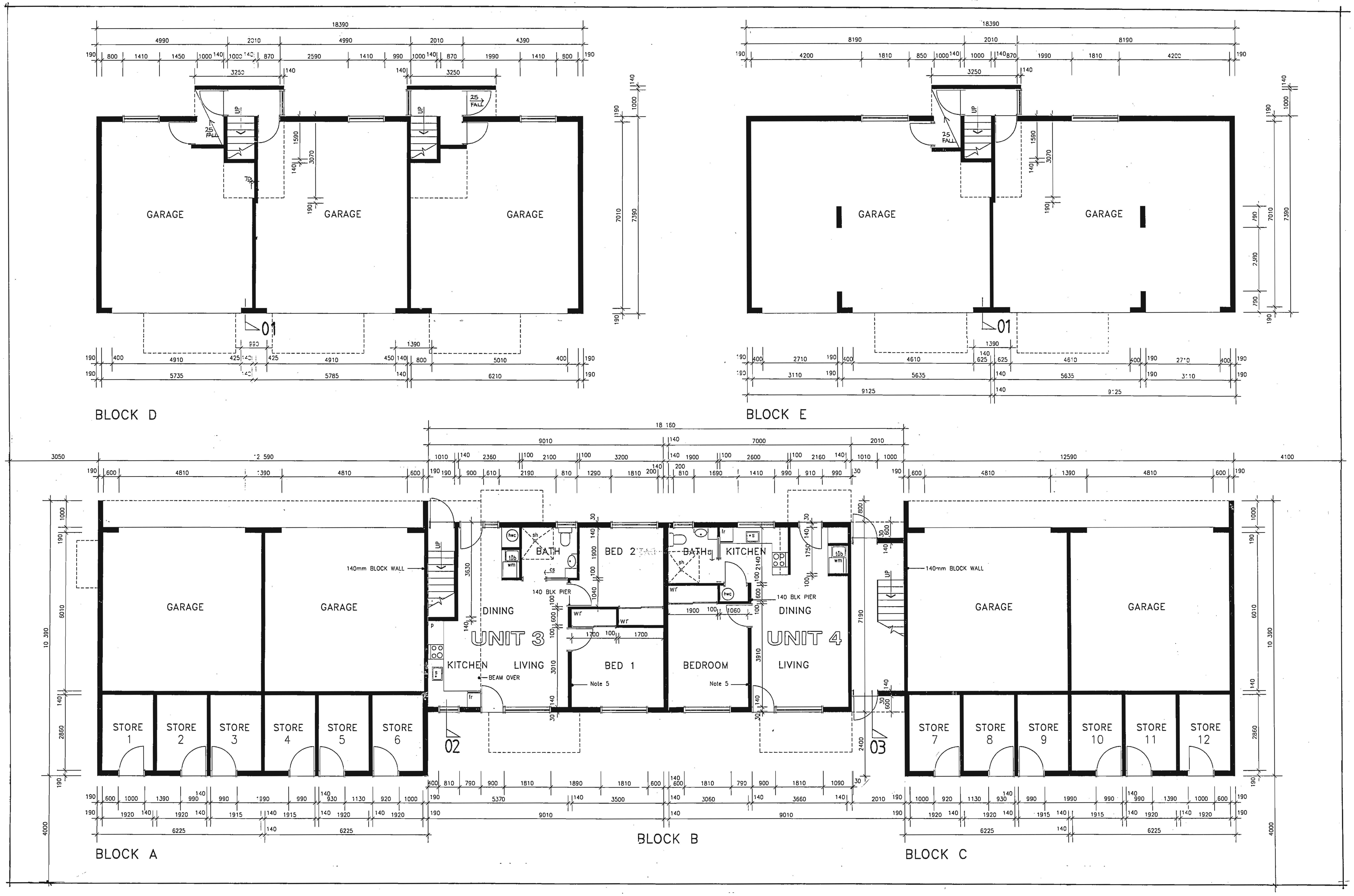
SHEET 01
DATE 19/06/98
ISSUE A



GROUND FLOOR PLANS

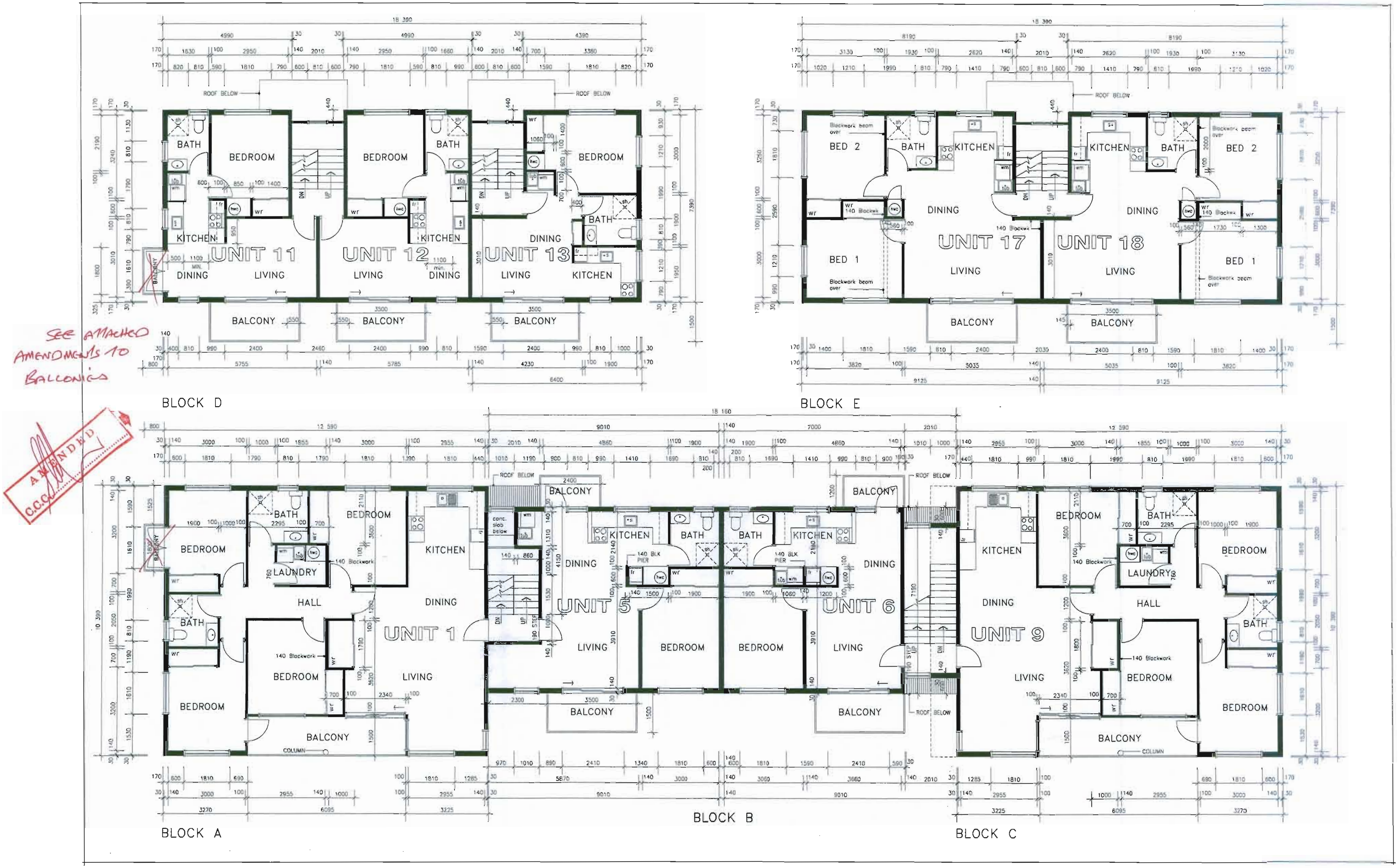
SCALE 1:100

1. Contractor shall verify all dimensions before starting work.
2. Refer to Engineer's drawings for blockwork and foundation details.
3. External walls dimensioned as 170mm are constructed of 140mm blockwork and 30mm polystyrene.
4. Most units are similar but handed as shown. Unit features are typical to each unit and shall be repeated to each unit.
5. 140mm blockwork beam above 140mm timber frame wall - refer Eng. Drawings.

PROPOSED RESIDENTIAL DEVELOPMENT BY BRYNDWR BUILDERS LTD.

SHEET 02

DATE 18/08/98



FIRST FLOOR PLANS

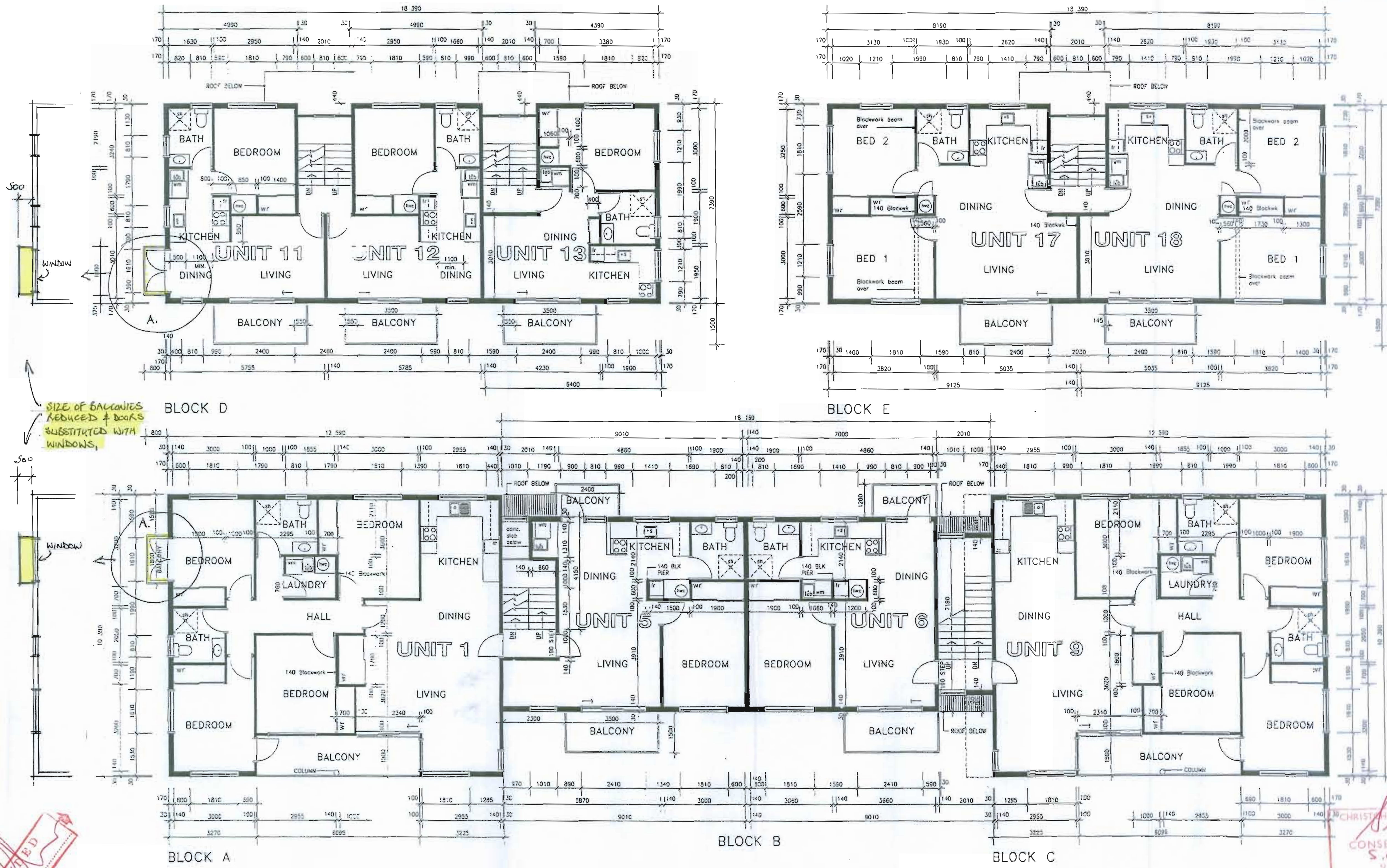
SCALE 1:100

1. Contractor shall verify all dimensions before starting work.
2. Refer to Engineer's drawings for blockwork and foundation details.
3. External walls dimensioned as 170mm are constructed of 140mm blockwork and 30mm polystyrene.
4. Extract fan to Block A and C laundries shall be ducted at top of wardrobe to exterior wall.

PROPOSED RESIDENTIAL DEVELOPMENT BY BRYNDWR BUILDERS LTD.

SHEET 03

DATE 18/08/98



FIRST FLOOR PLANS

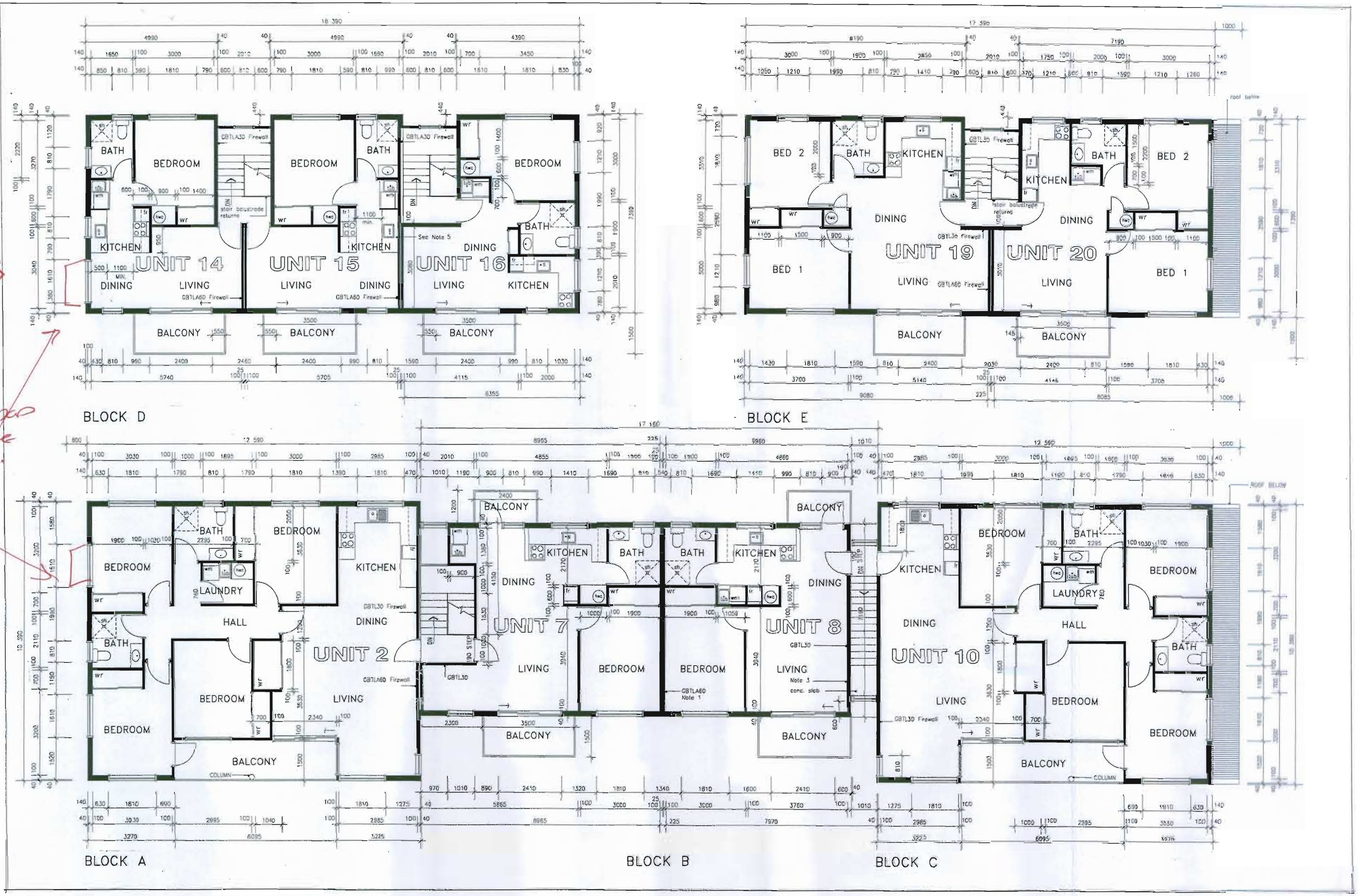
SCALE 1:100

1. Contractor shall verify all dimensions before starting work.
2. Refer to Engineer's drawings for blockwork and foundation details.
3. External walls dimensioned as 170mm are constructed of 140mm blockwork and 30mm polystyrene.
4. Extract fan to Block A and C laundries shall be ducted at top of wardrobe to exterior wall.

AMENDMENTS	
A. BALCONY SIZE REDUCED & DOORS SUBSTITUTED WITH WINDOWS.	9.10.98.

PROPOSED RESIDENTIAL DEVELOPMENT BY BRYNDWR BUILDERS LTD.

SHEET 03
DATE 18/08/98



AMENDED C.C.C.

BALCONIES ADDED IN HERE SEE ATTACHED

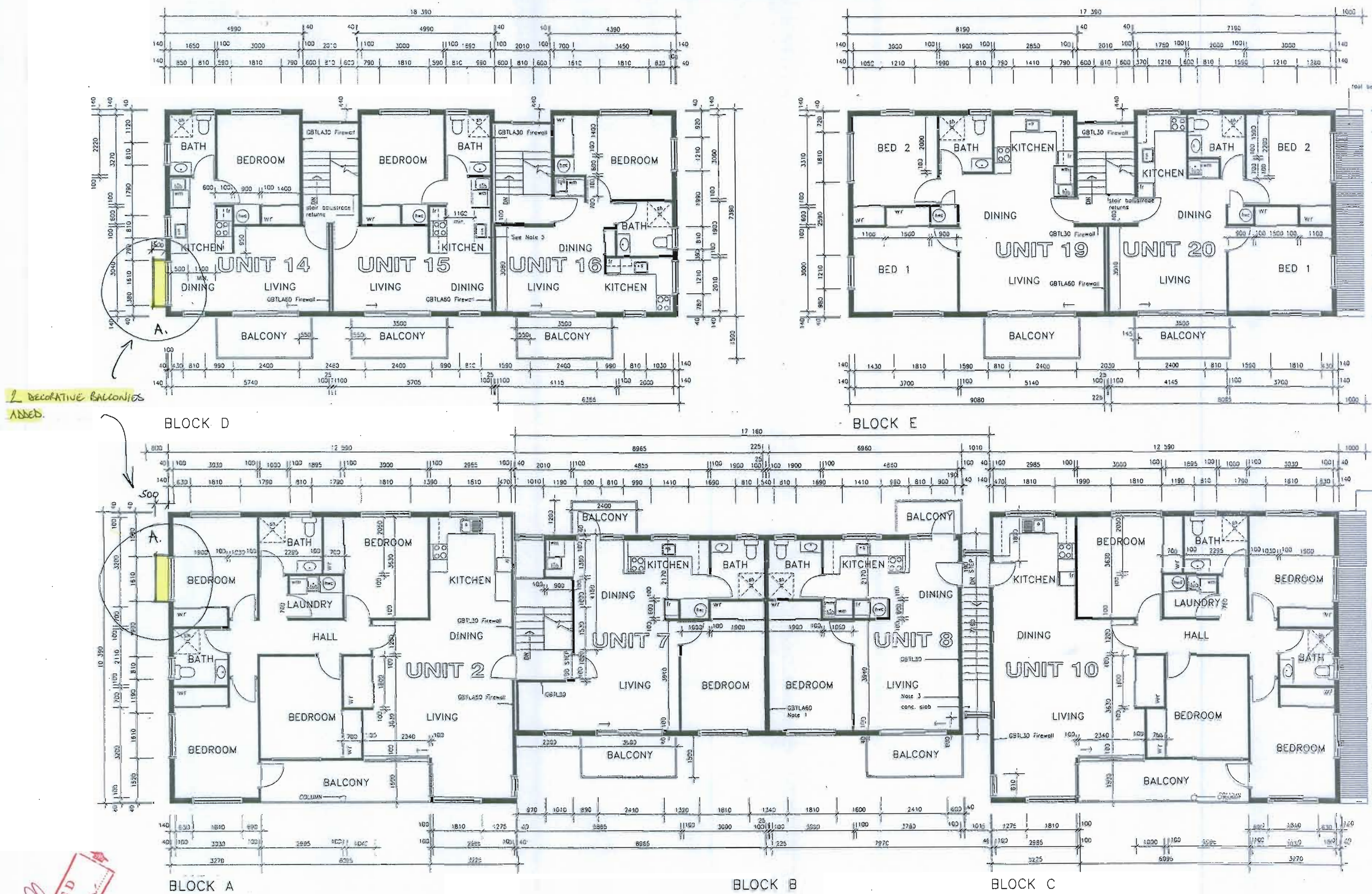
SECOND FLOOR PLANS

SCALE 1:100

1. GBTLA60 Firewalls between units. GBTL30 Firewalls to stairs.
2. External walls dimensioned as 140mm are constructed of 100mm timber framing and 40mm polystyrene.
3. 40mm packing to stair walls Block A and C
4. Extract fan to Block A and C laundries shall be ducted at top of wardrobe to exterior wall.
5. Unit 15 sink piping not to be installed in sound rated wall to Unit 16.

PROPOSED RESIDENTIAL DEVELOPMENT BY BRYNDWR BUILDERS LTD.

SHEET 04
DATE 18/08/98



AMENDED C.C.C.

SECOND FLOOR PLANS

SCALE 1:100

1. GBTLA60 Firewalls between units. GBTL30 Firewalls to stairs.
2. External walls dimensioned as 140mm are constructed of 100mm timber framing and 40mm polystyrene.
3. 40mm packing to stair walls Block A and C
4. Extract fan to Block A and C laundries shall be ducted at top of wardrobe to exterior wall.
5. Unit 15 sink piping not to be installed in sound rated wall to Unit 16.

AMENDMENTS,

A. 2 DECORATIVE BALCONIES ADDED. 9.10.98.

PROPOSED RESIDENTIAL DEVELOPMENT BY BRYNDWR BUILDERS LTD.

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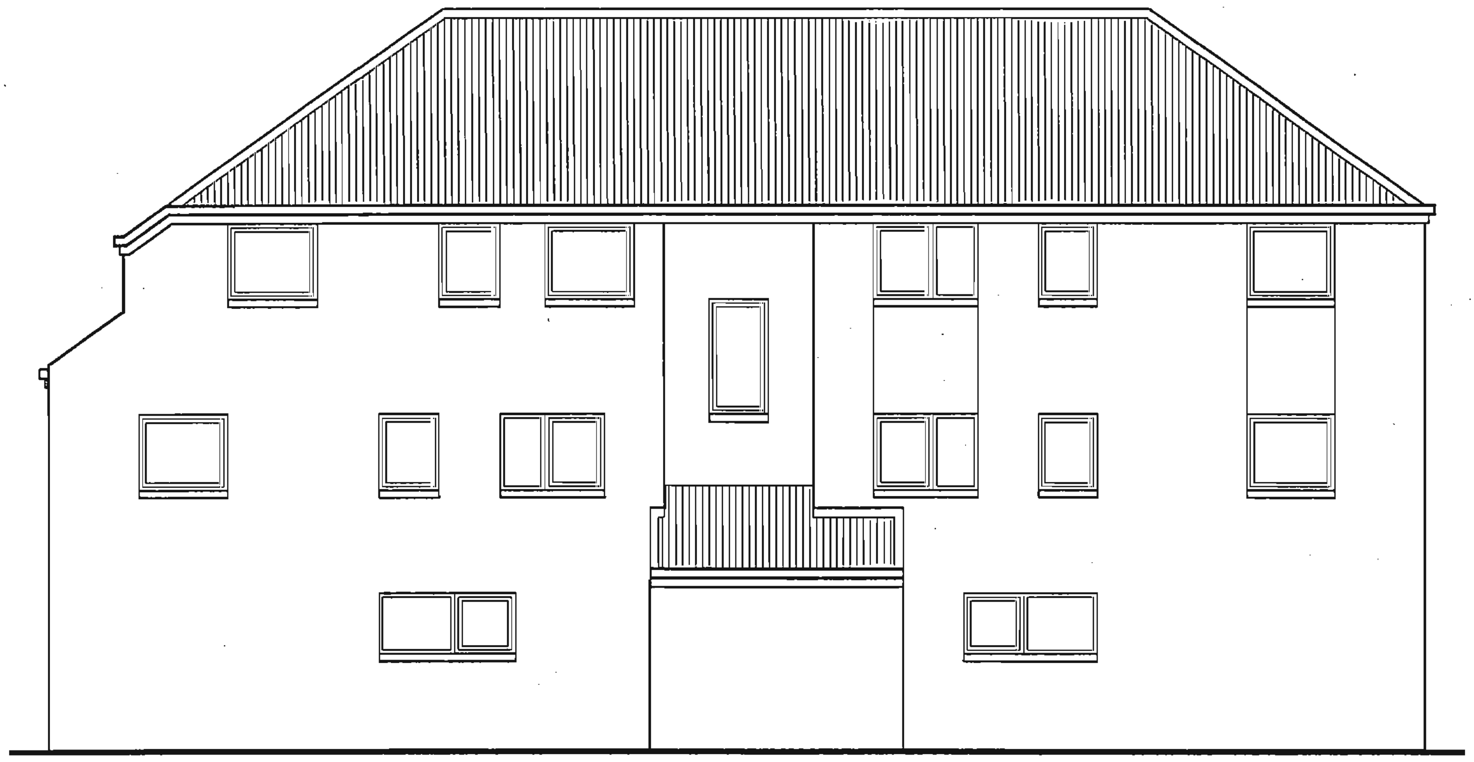
SHEET 04

DATE 18/08/98

CHRISTCHURCH CITY COUNCIL
CONSENT DOCUMENT
S.C. CARRINGTON
9 - OCT 1998

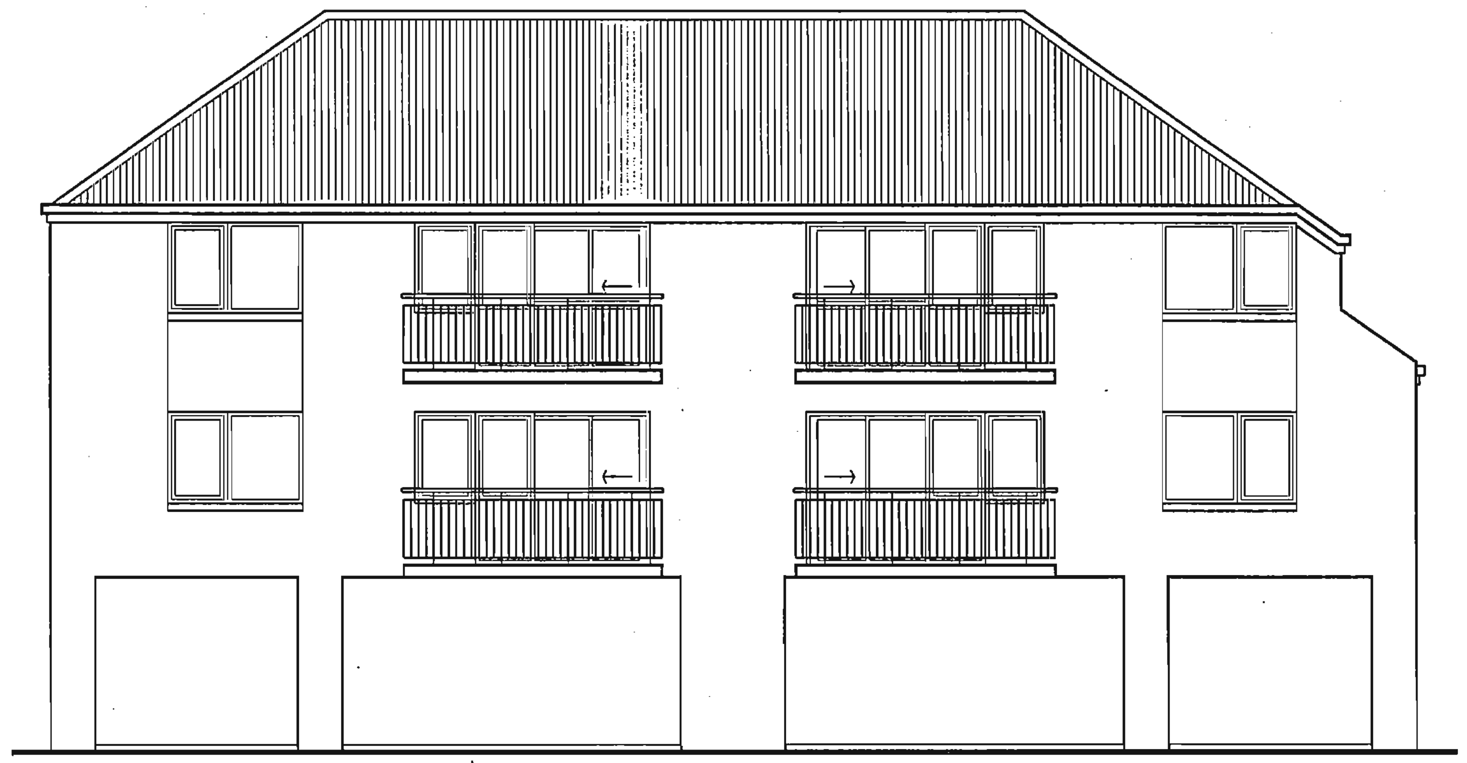
98002450



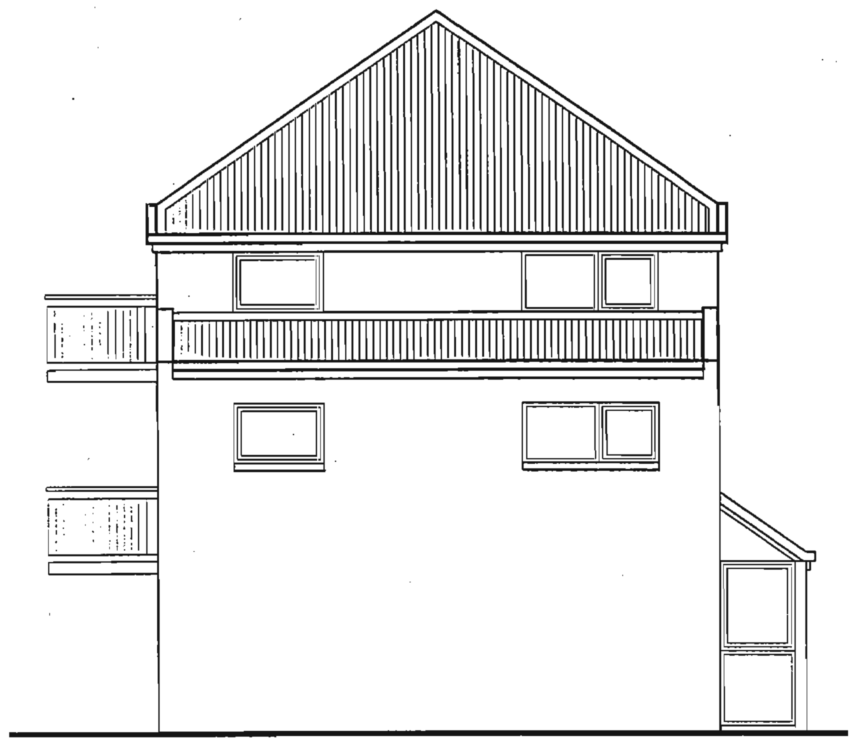
EAST

NORTH

BLOCK E



WEST



SOUTH

CLADDINGS:
1. Exterior cladding - Rockcote acrylic plaster system (BTL/AP4/97) with Armourglaze zero ignitability surface finish on polystyrene insulation where indicated. No polystyrene to ground floor garages. On completion the licensed applicator will provide a certificate to the T.A. stating that the cladding has been installed to the manufacturer's specification.
2. Harditex cladding to stairwells and panels under windows as shown.

WINDOWS:
3. Windows to be powder coated aluminium, colour confirmed with Owner.

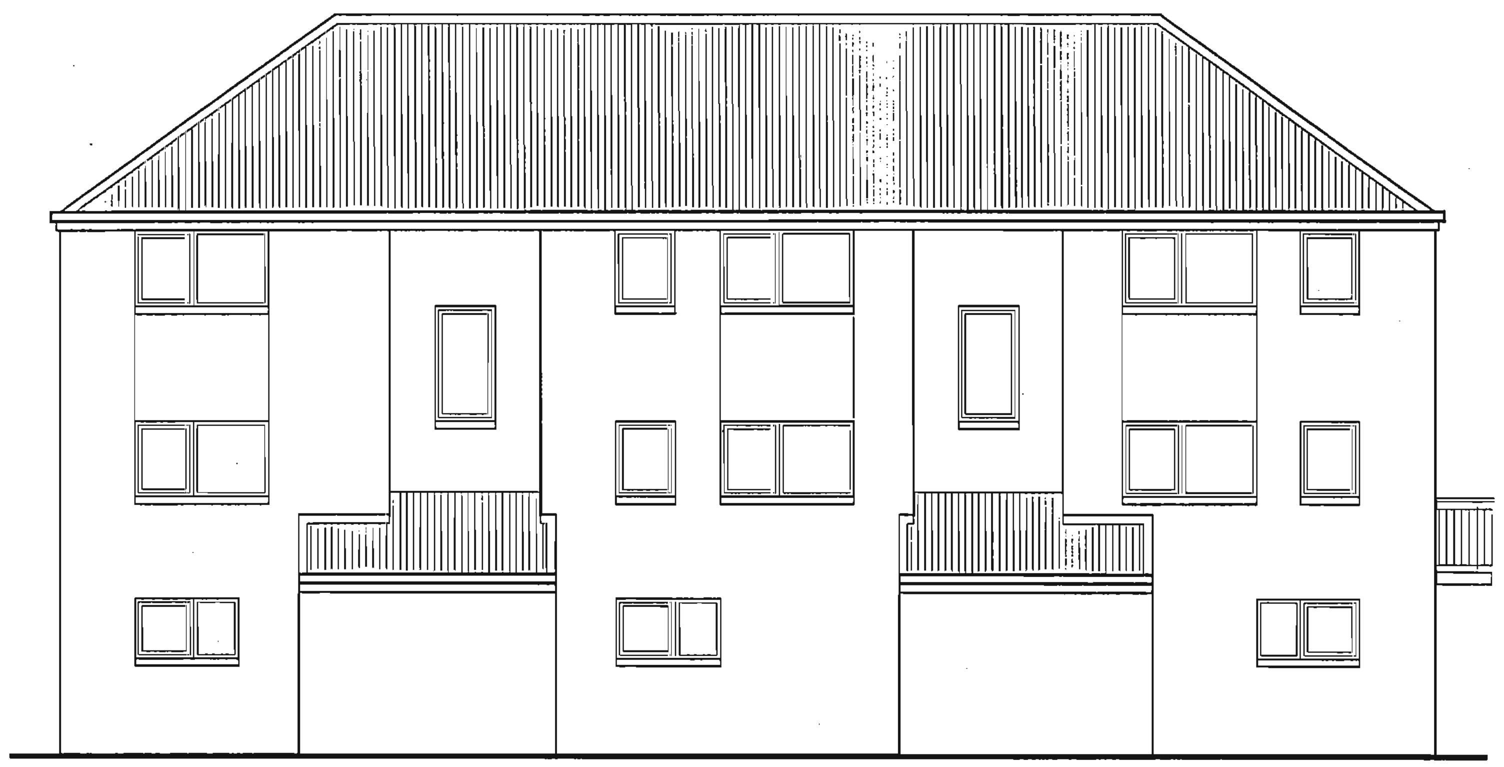
ROOFING:
4. 0.40 B.M.T Corrugated galvanised Colorsteel.

GENERAL:
5. For balcony details refer to cross sections and separate drawing.
6. No opening windows shall be installed with the sill below 760mm from floor level and therefore no restricting stays are required.

NORTH

BLOCK D

WEST



EAST

SOUTH

ELEVATIONS

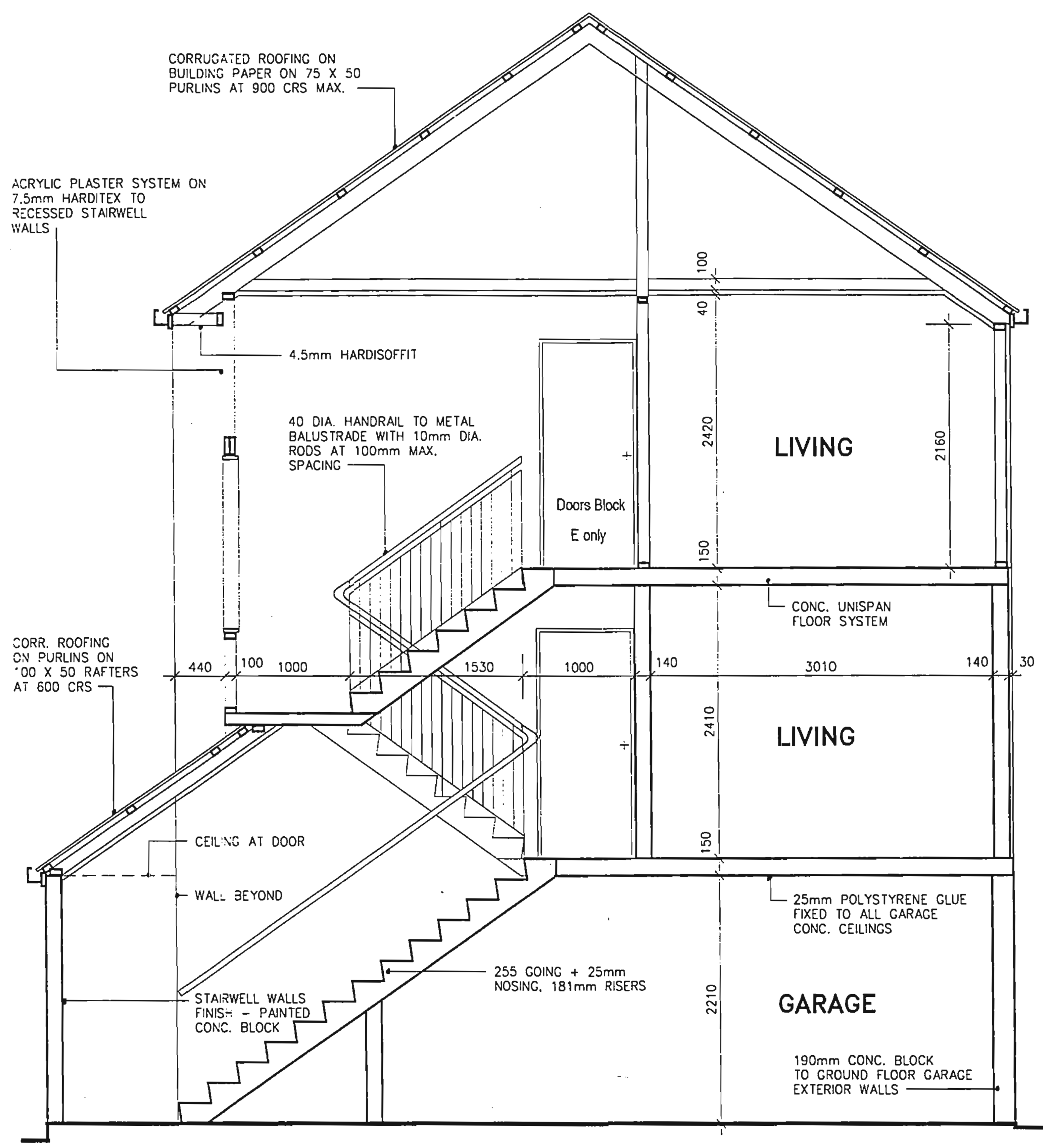
SCALE 1:100

SHEET 06
DATE 18/08/98

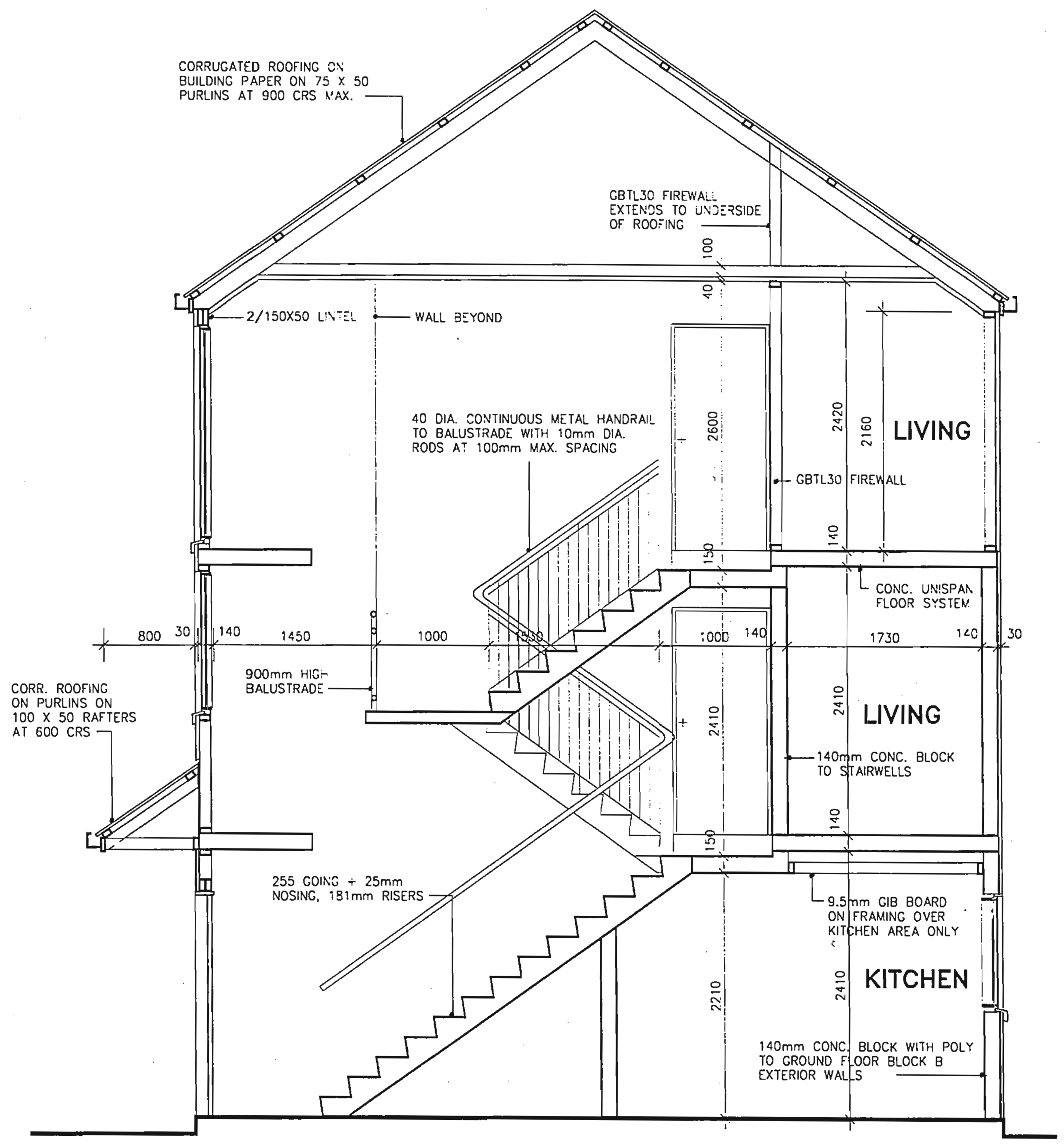
PROPOSED RESIDENTIAL DEVELOPMENT BY BRYNDWR BUILDERS LTD.

ROOFING:
1. 0.40 B.M.T Corrugated galvanised Colorsteel.
2. Colorsteel barge flashing (in long lengths).
3. Colorsteel ridge flashing (in long lengths)
4. Lay selected roofing on building paper.
5. Stratco metal fascia and gutter or similar approved.
6. Prefabricated factory designed and certified roof trusses with suitable chords at 900 crs maximum spacing. Pitch 35 degrees.
7. 75 x 50 purlins at 900 mm crs maximum.
8. 15mm H3 treated plywood under waterproofing membrane to flat roof over Block A and C.
9. 4.5 mm Hardisoffit lining on 75 x 50 eave bearers at 900 crs.

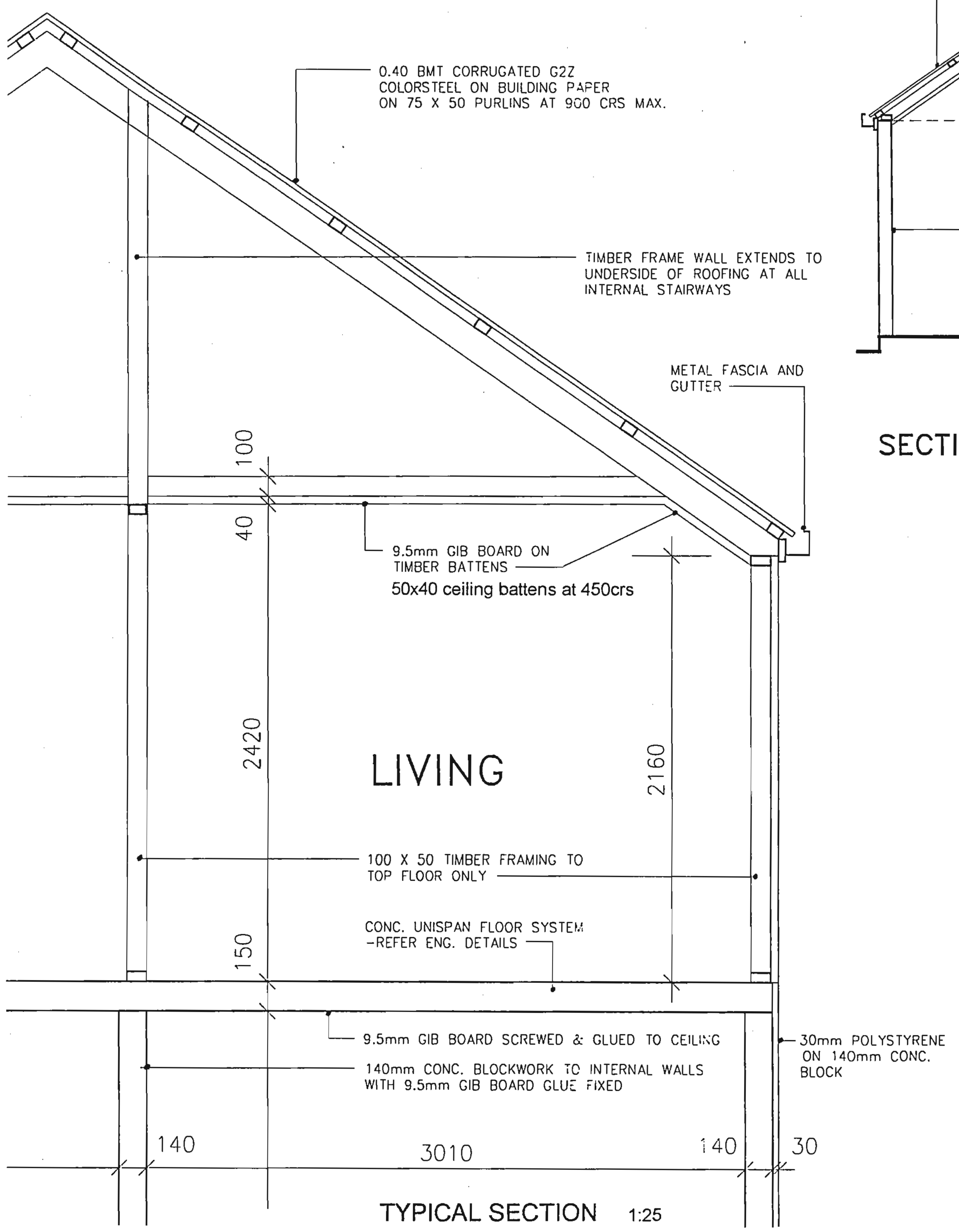
WALLS:
10. Wall Framing - to top floor and internal walls where shown 100 x 50 studs at 600 crs, dwangs -800 crs min.
11. Building paper to walls shall be Heavy duty standard building paper.



SECTION 01 1:50



SECTION 02 1:50



TYPICAL SECTION 1:25

CLADDINGS:
12. Exterior cladding -Rockcote plaster system (with zero ignitability) on polystyrene insulation where indicated. Polystyrene glue fixed to conc block in accordance with Rockcote specifications.

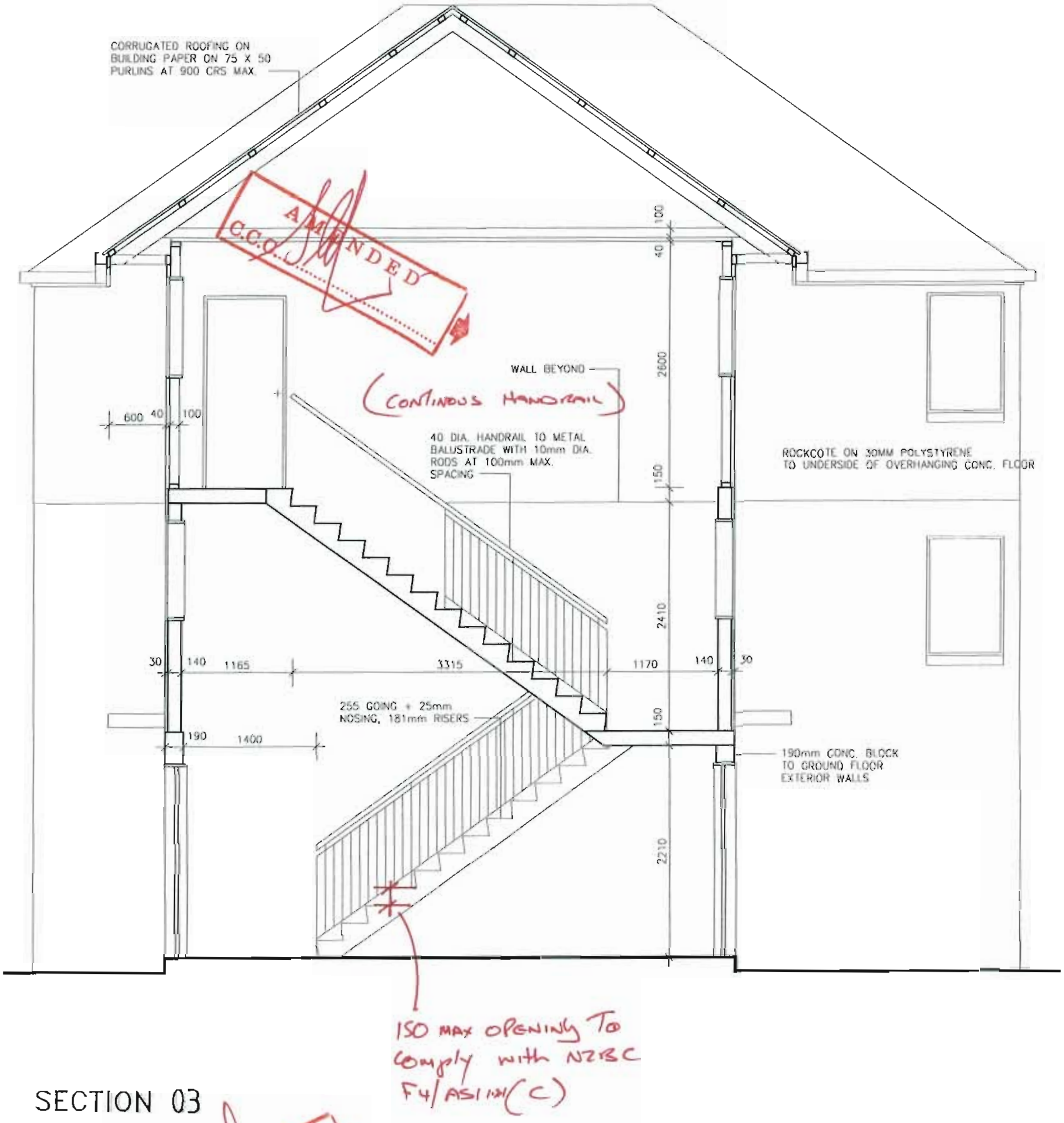
FOUNDATIONS & FLOORS:
13. 100mm thick concrete slab with H.R.C. mesh as shown. Refer to Engineer's drawings for foundations.
14. D.P.C. on Granular hardfill to comply with Appendix E N.Z.S. 3604.

WINDOWS:
15. Windows to be powder coated aluminium, colour confirmed with Owner.
16. Aluminium windows with condensation channels. Frames to be ex 25mm timber reveals rebated for wall linings.

LININGS:
17. 9.5mm gib board lining glue fixed to external conc. Blockwalls.
18. R1.8 fibreglass insulation to ceilings 2nd floor.
19. 25mm polystyrene insulation glue fixed to underside of first floor concrete slab.
20. Note: Insulation should form a continuous envelope around the building.

21.BALCONY:
Balustrade top rail 40 diam. galv. pipe on 20 diam. verticals at 1.2 m max crs.

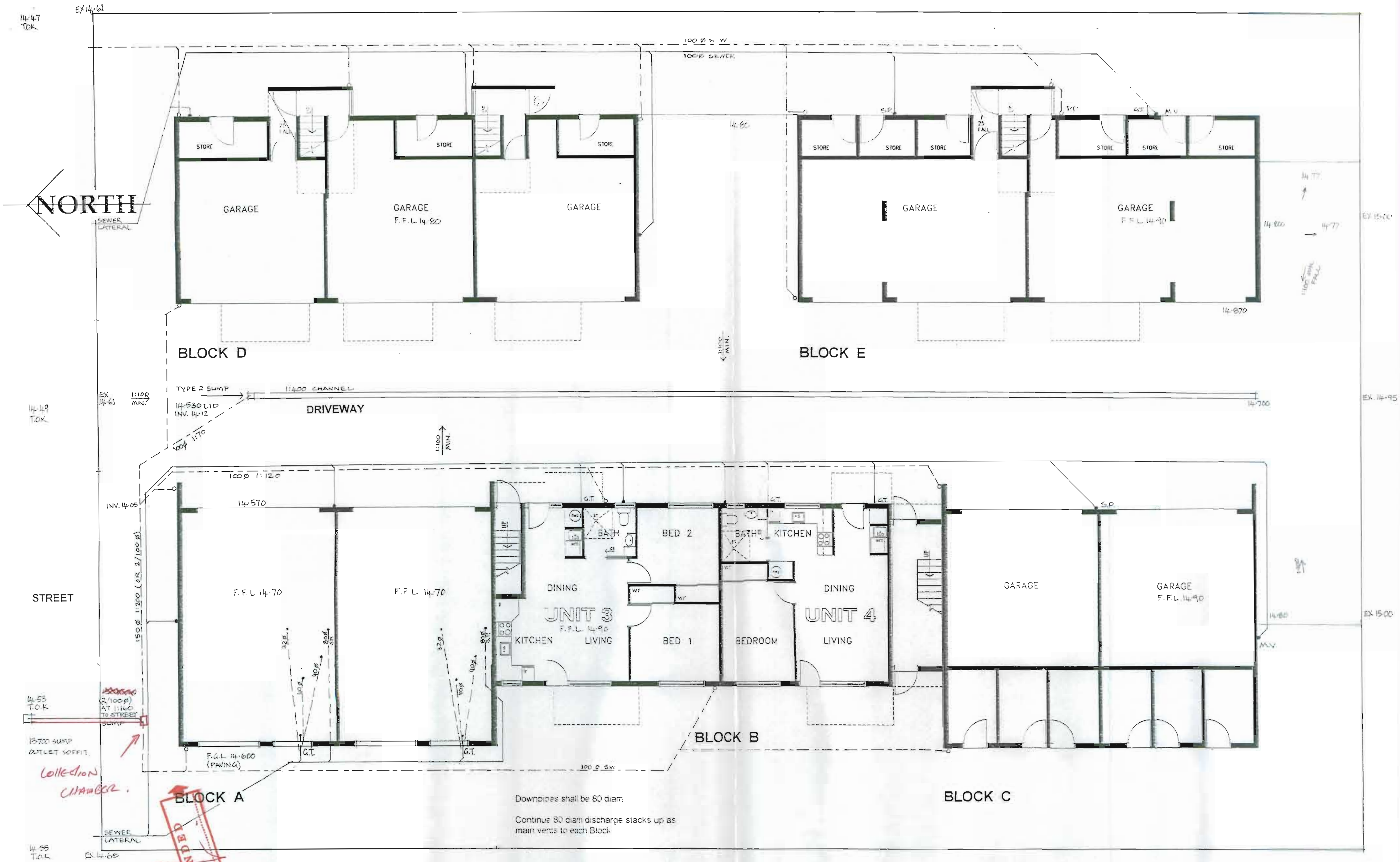
SHEET 07
DATE 18/08/98



SECTION 03

AMENDED
C.C.C.

SHEET 08
DATE 19/06/98



DRAINAGE PLAN

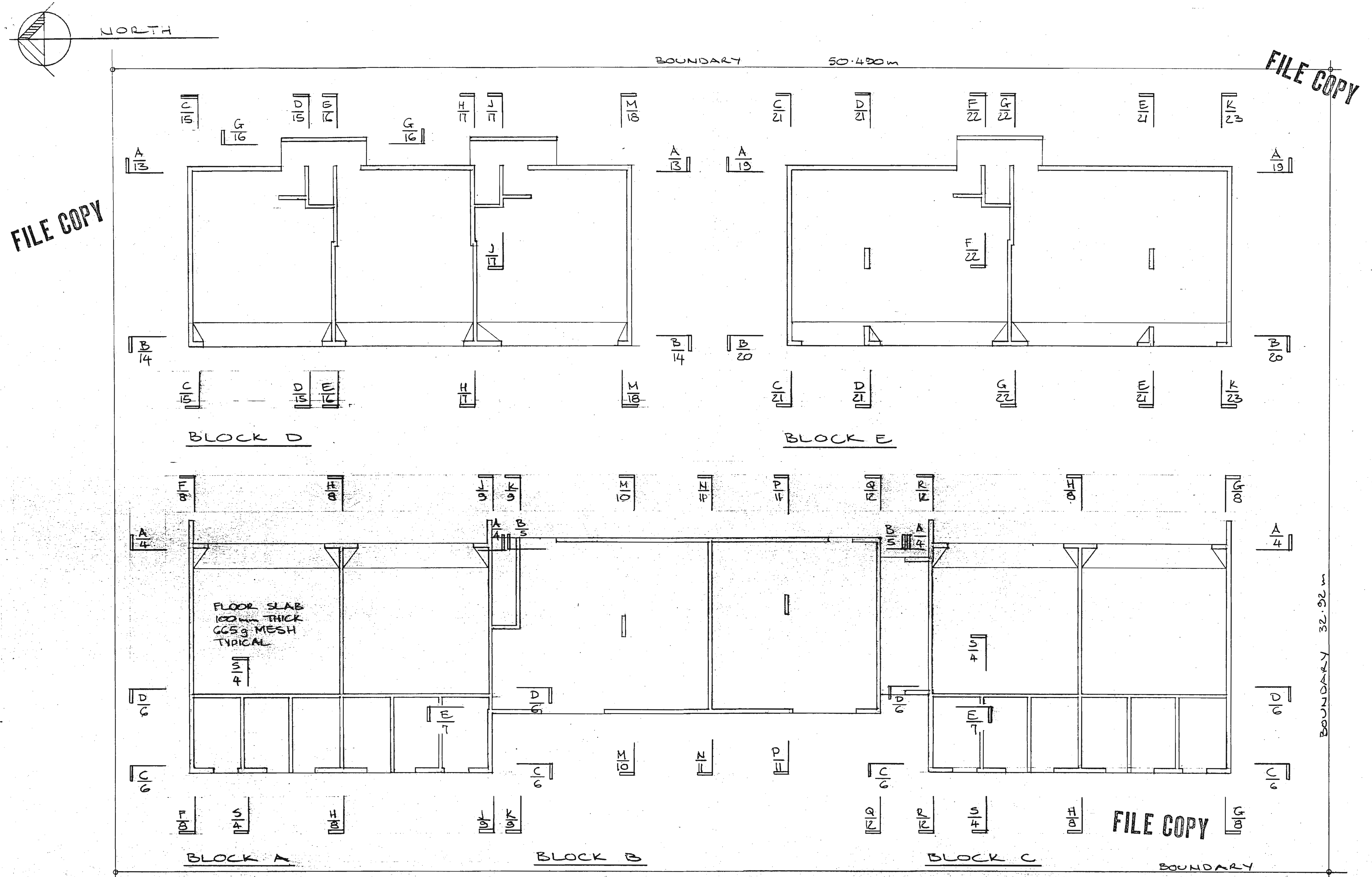
SCALE 1:100

AMENDMENTS -14/09/98

- Block A F.F.L lowered to 14.700
- Driveway sump relocated
- Block A Level 1 soil fixture pipes added
- Block A Store areas relocated to Block D and E

PROPOSED RESIDENTIAL DEVELOPMENT BY BRYNDWR BUILDERS LTD.

SHEET D1
DATE 19/06/98



NOTE: · THESE DRAWINGS TO BE READ IN CONJUNCTION WITH THE ARCHITECTURAL DRAWINGS
· FOR ALL DIMENSIONS REFER TO ARCHITECTURAL DRAWINGS

RESIDENTIAL DEVELOPMENT

AT

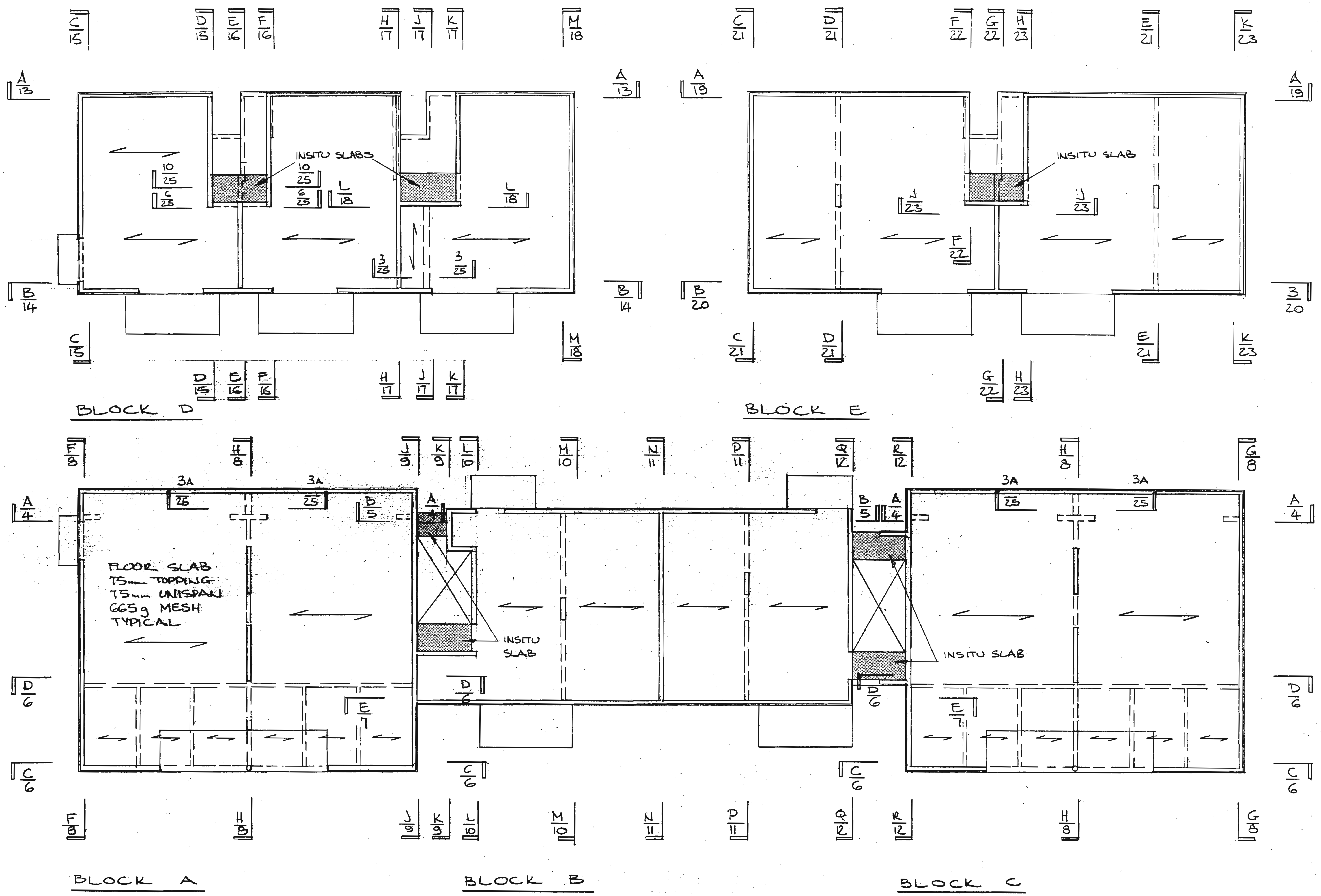
GROUND FLOOR PLANS

FOR BRYNDWR BUILDERS LTD

HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER

47 HEREFORD ST., PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH

JULY 1998 - - SCALE 1:100 - JOB N° 67-5/1



NOTE: FOR STAIR DETAILS REFER TO SHEETS 27 & 28
FOR STAIR LANDINGS REFER TO SHEET 25

RESIDENTIAL DEVELOPMENT
AT
FIRST FLOOR PLANS
FOR BRYNDWR BUILDERS LTD

HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
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JULY 1998 - - SCALE 1:100 - JOB N° 67-5/2

RESIDENTIAL DEVELOPMENT
AT
SECOND FLOOR PLANS
FOR BRYNDWR BUILDERS LTD

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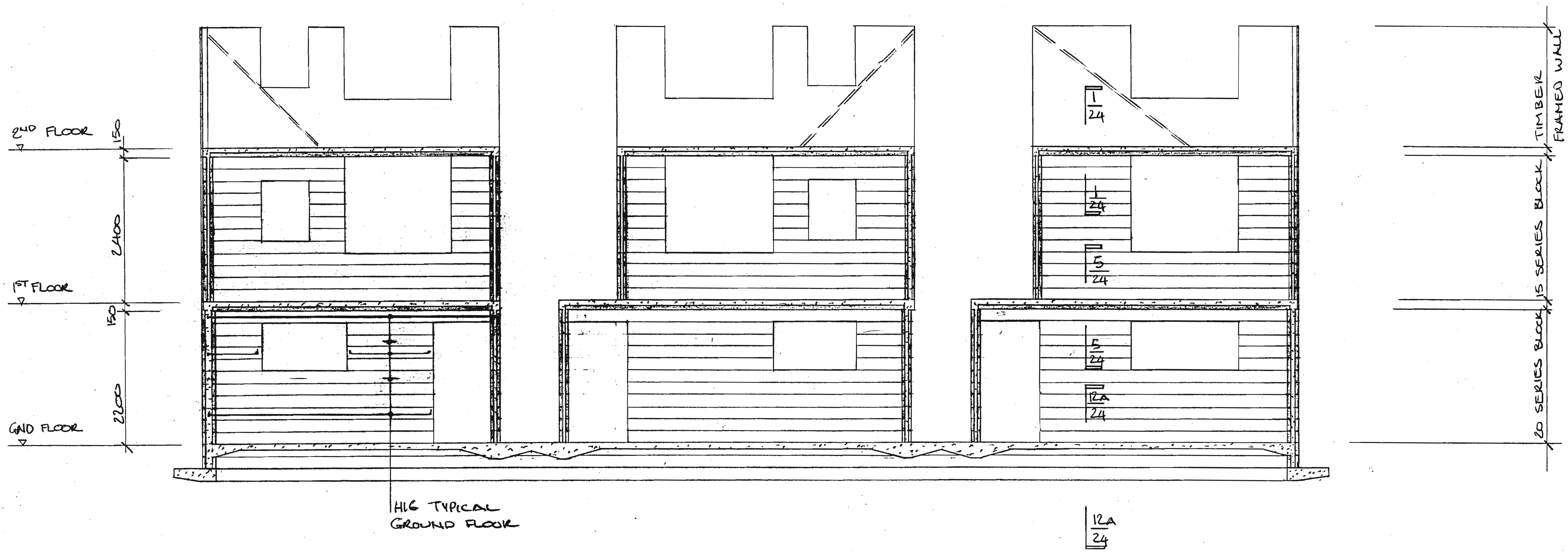
JULY 1998 - - SCALE 1:100 - JOB Nº 67-5/3



BLOCK D - ELEVATION A - A

RESIDENTIAL DEVELOPMENT

BLOCK D - BLOCK WALL ELEVATIONS
FOR BRYNDWR BUILDERS LTD

HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
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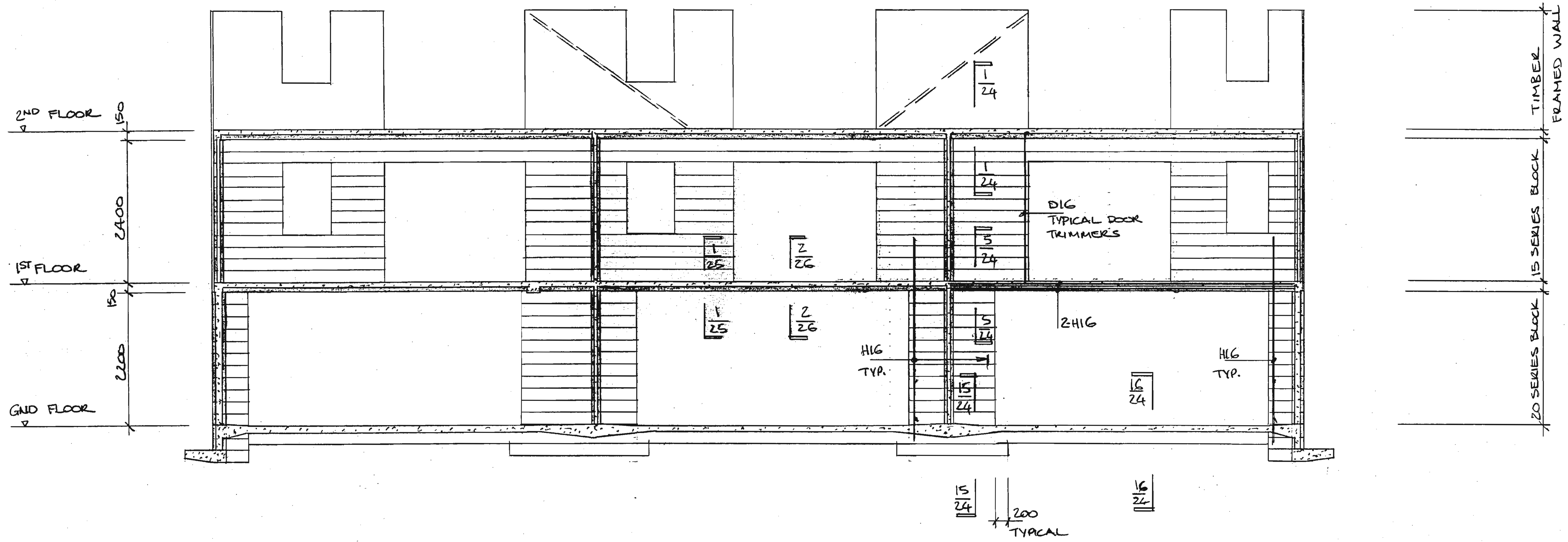
JULY 1998 - - SCALE 1:50 - JOB N° 67-5/13



BLOCK D - ELEVATION B - B

RESIDENTIAL DEVELOPMENT

BLOCK D - BLOCK WALL ELEVATIONS
FOR BRYNDWR BUILDERS LTD

HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
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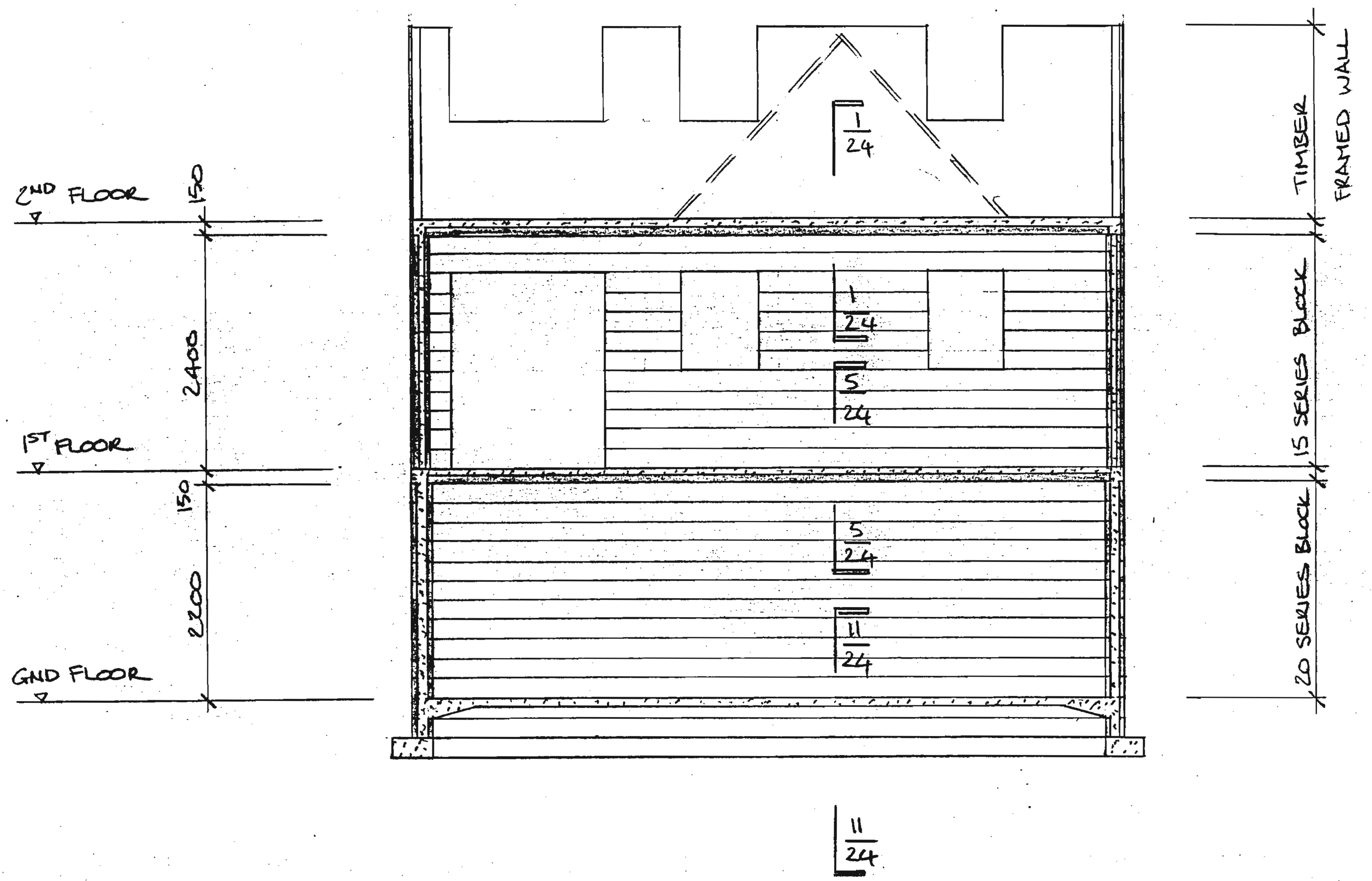
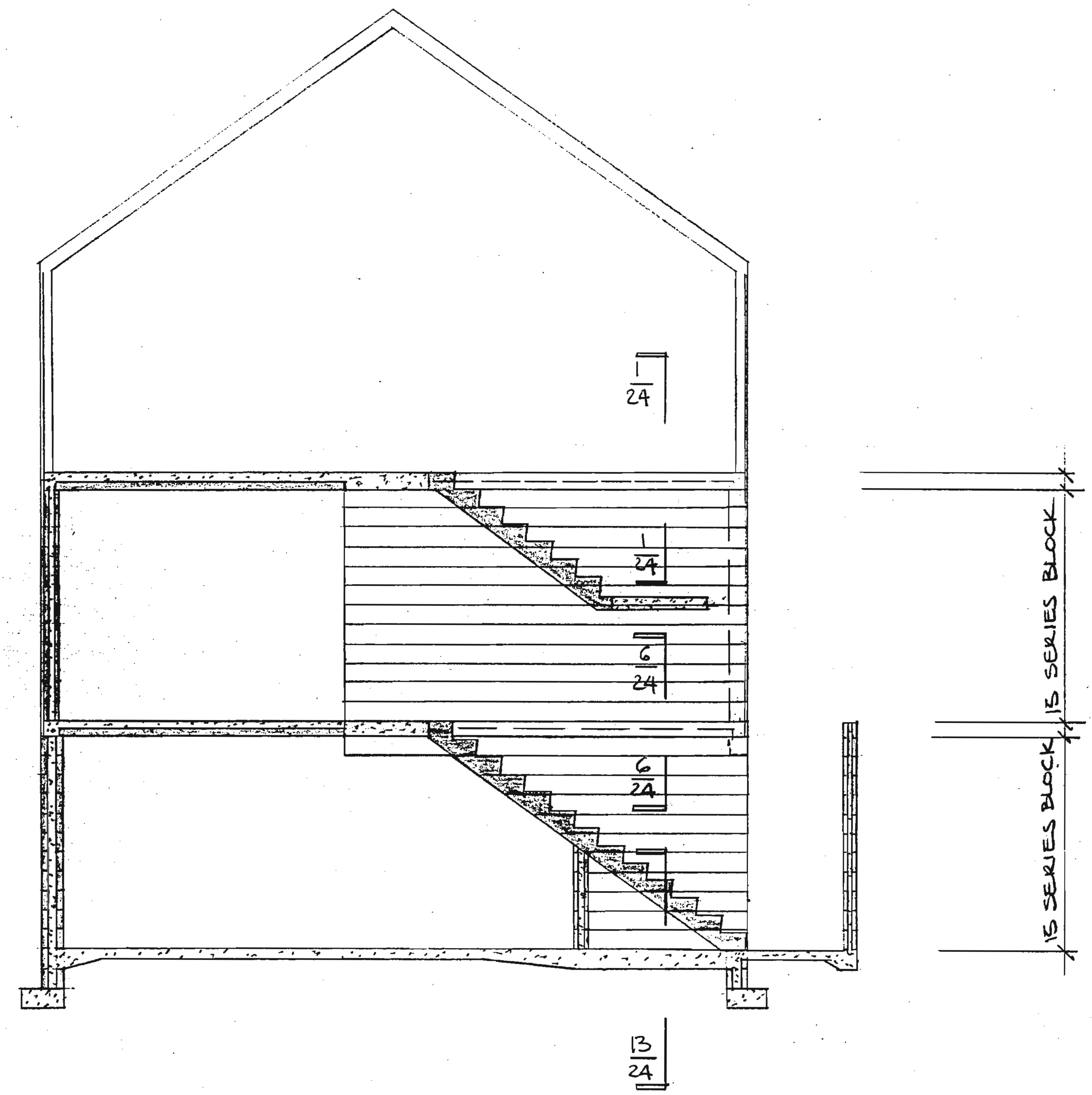


BLOCK D - ELEVATION C - C



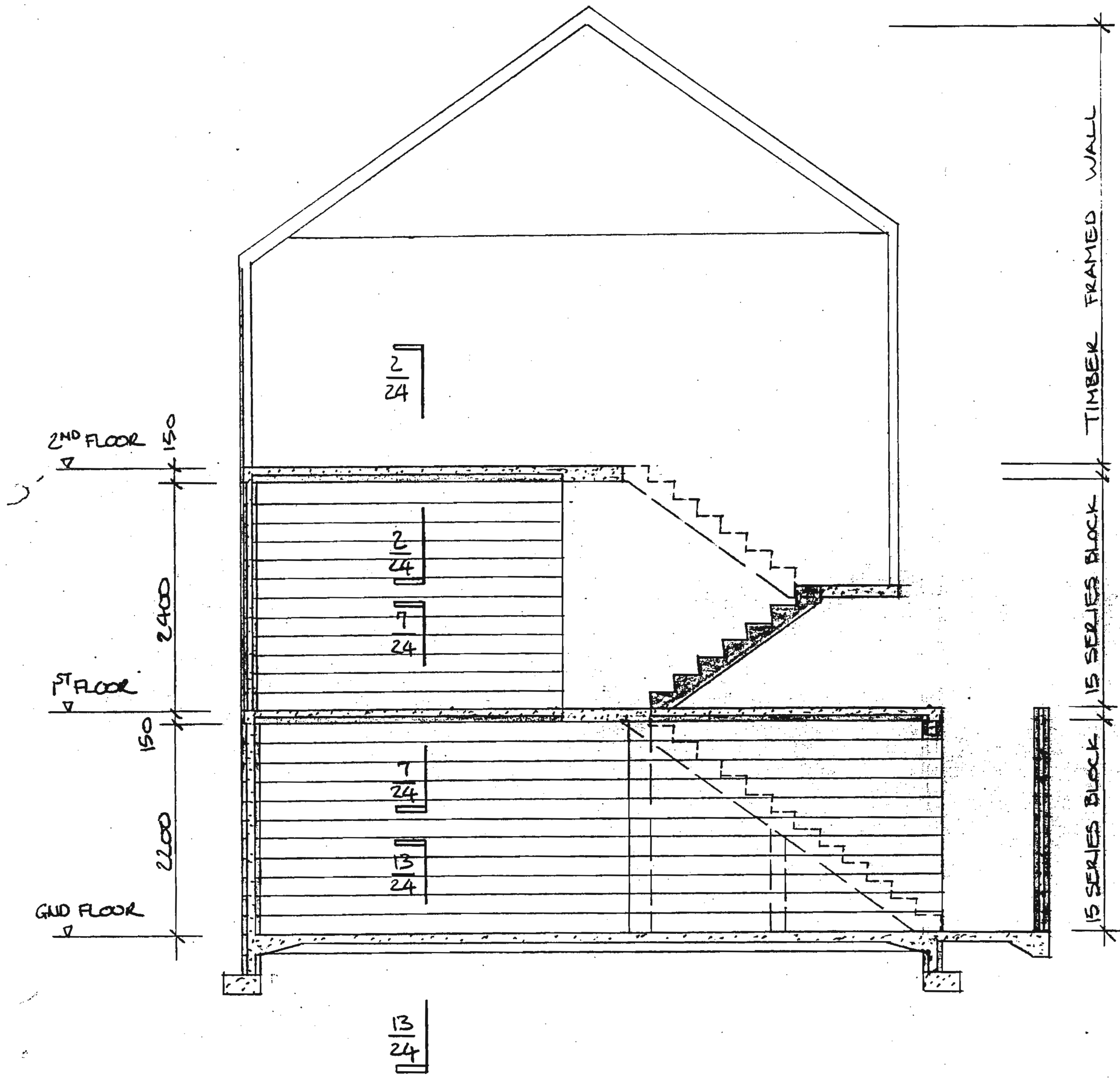
BLOCK D - ELEVATION D-D

RESIDENTIAL DEVELOPMENT

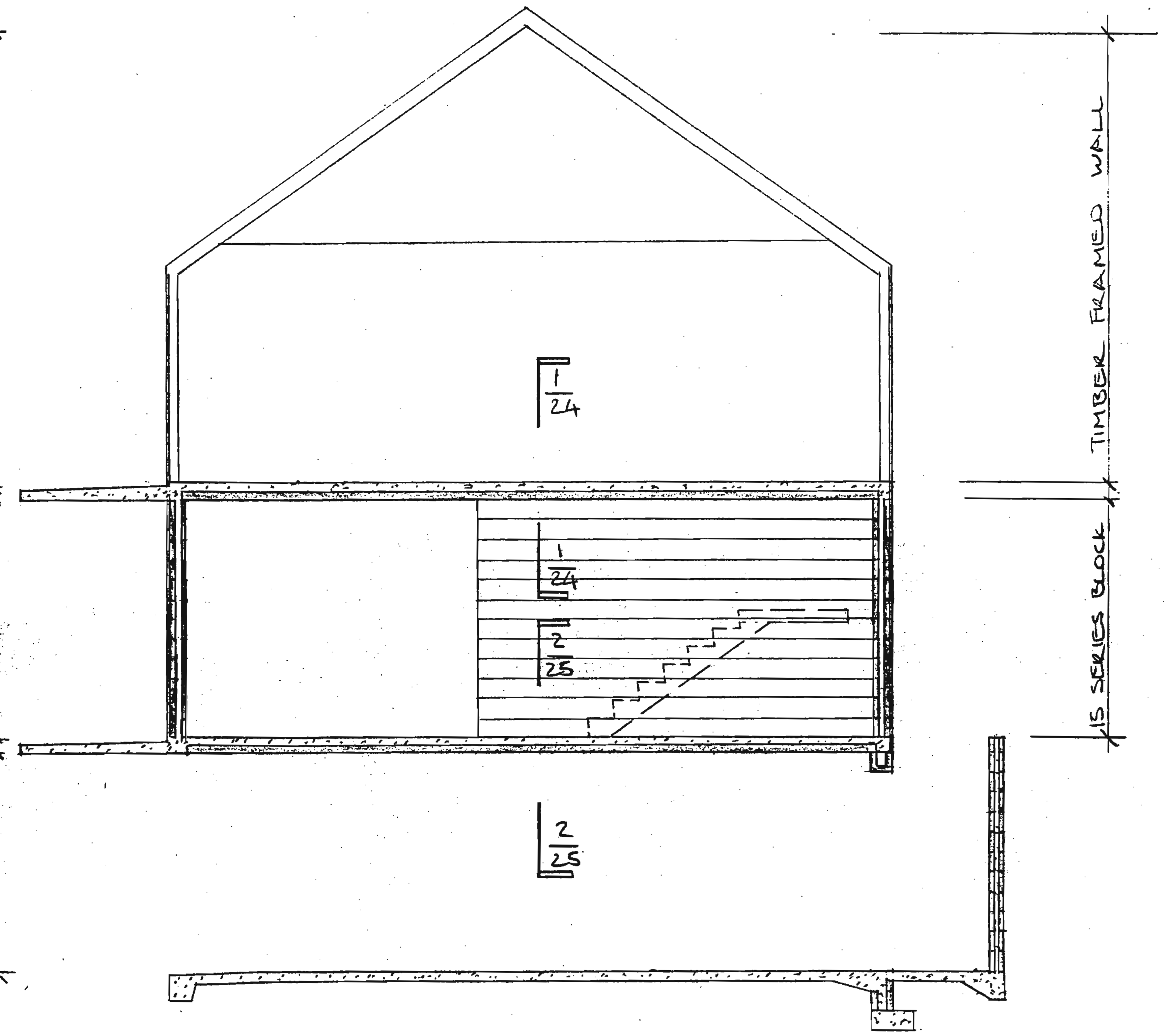
BLOCK D - BLOCK WALL ELEVATIONS
FOR BRYNDWR BUILDERS LTD

HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
47 HEREFORD ST., PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH

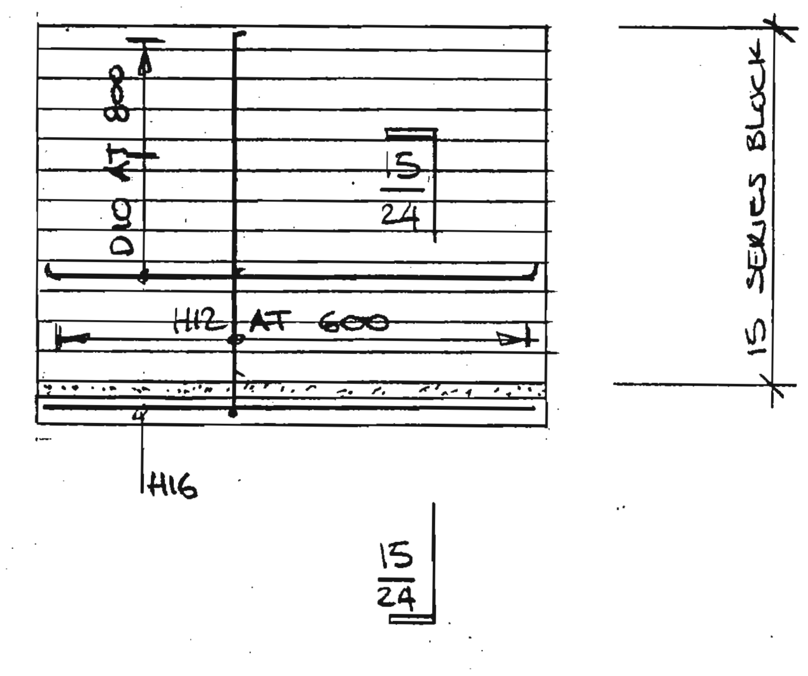
JULY 1998 - - SCALE 1:50 - JOB No 67-5/15



BLOCK D - ELEVATION E-E



BLOCK D - ELEVATION F-F



ELEVATION G-G

RESIDENTIAL DEVELOPMENT

BLOCK D - BLOCK WALL ELEVATIONS
FOR BRYNDWR BUILDERS LTD

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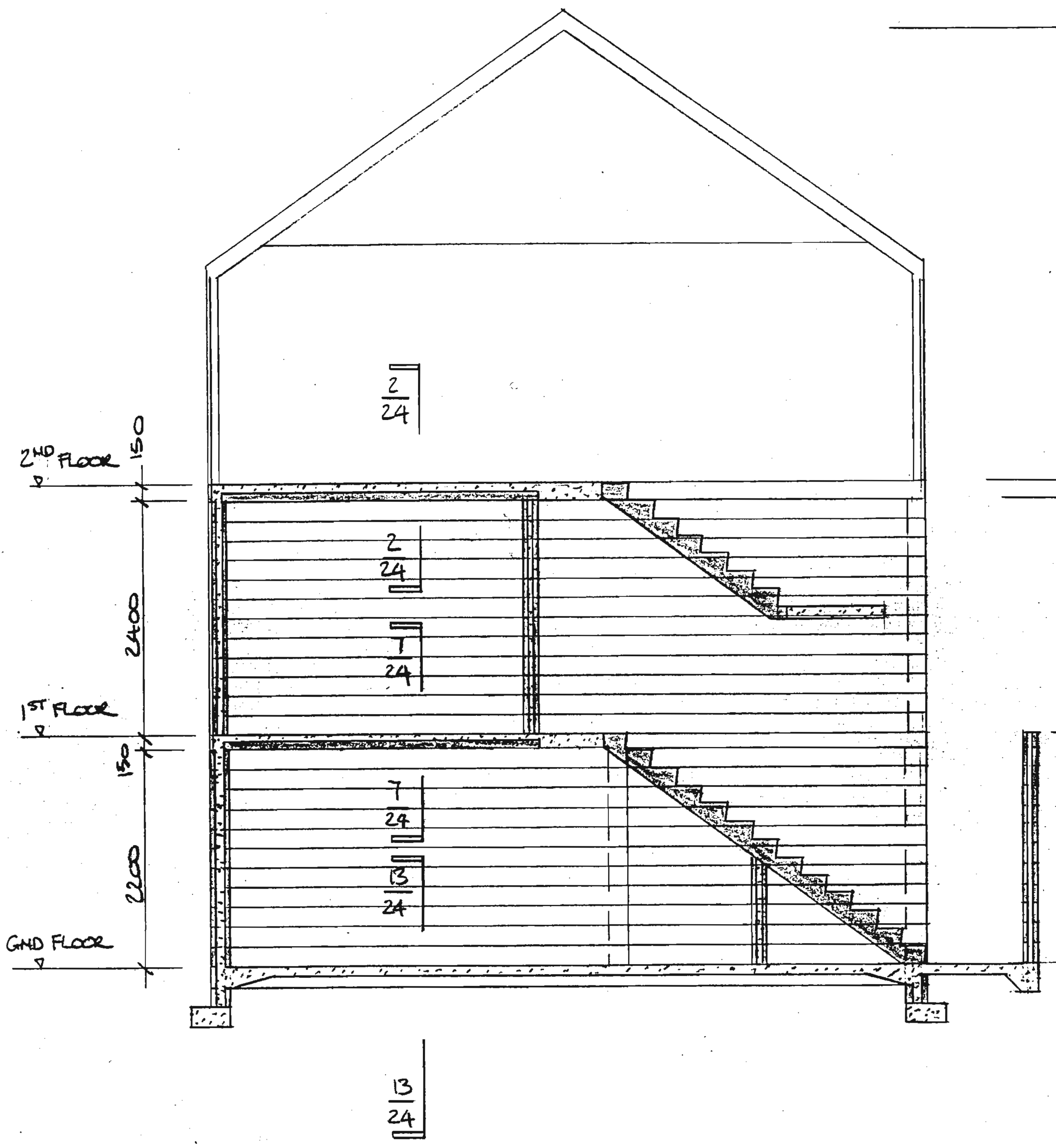
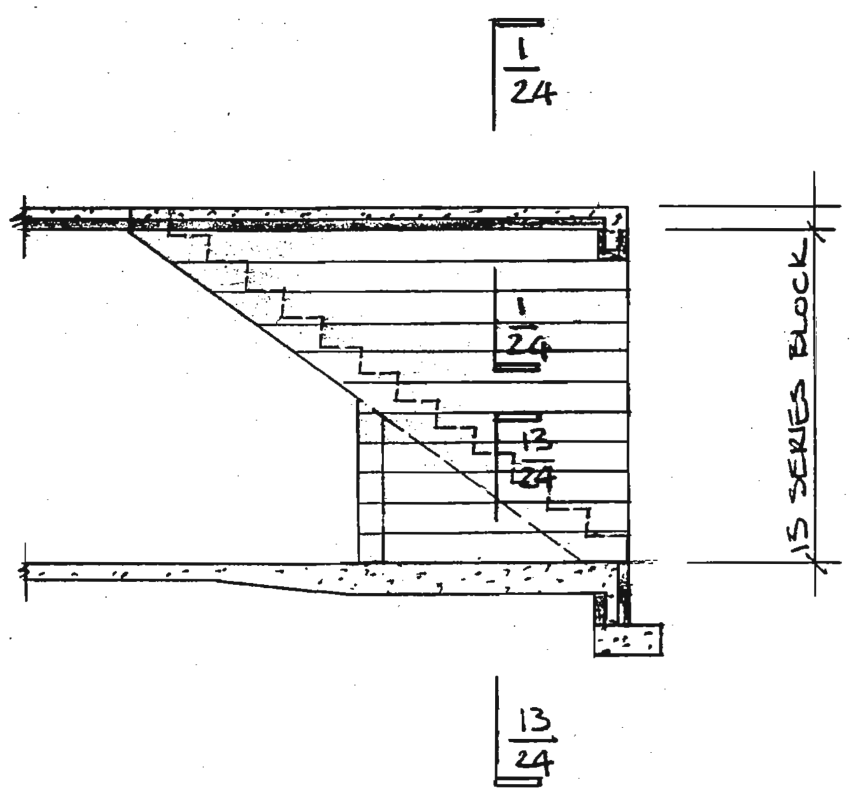
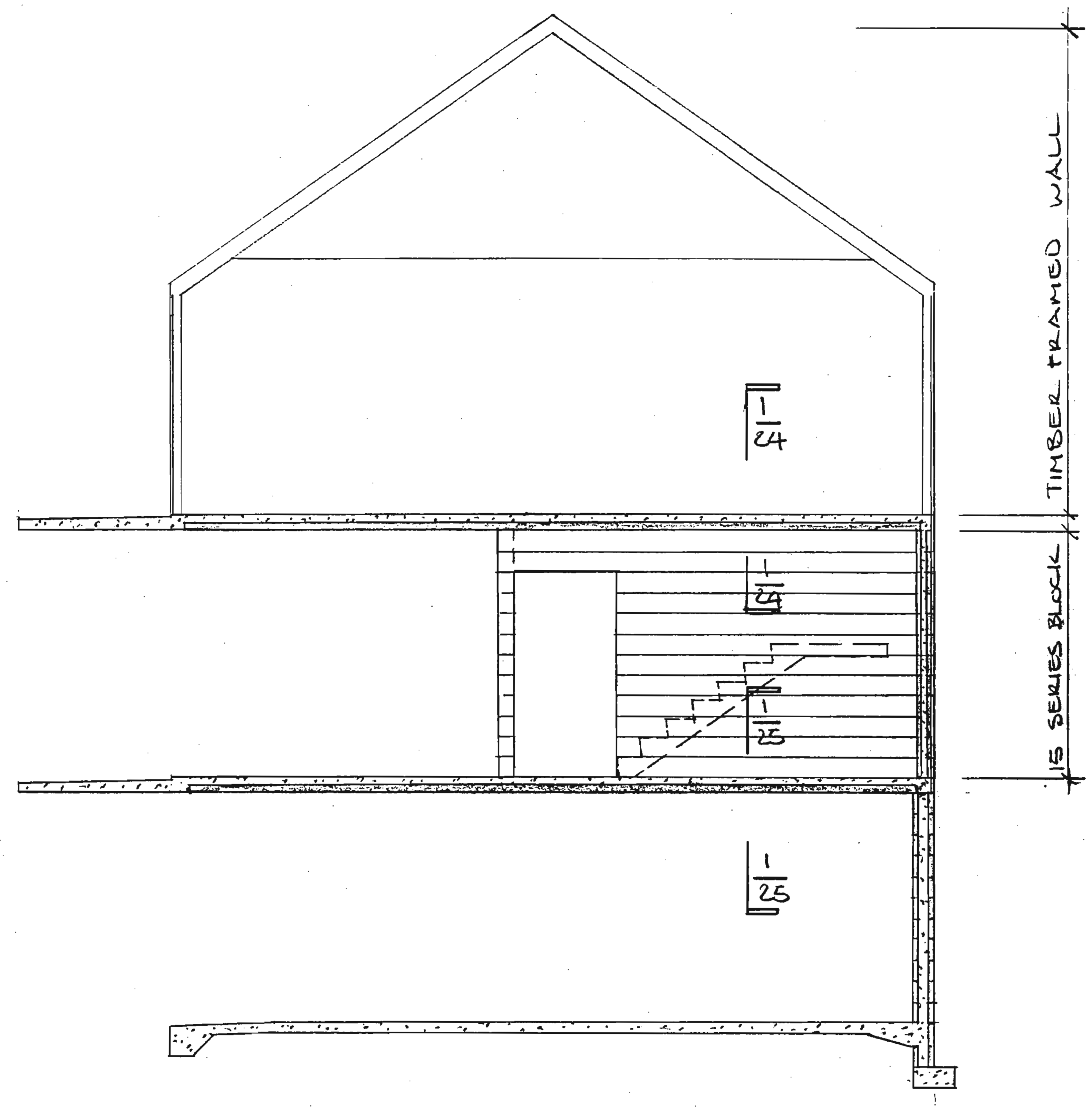
47 HEREFORD ST., PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH
JULY 1998 - SCALE 1:50 - JOB Nº 67-5/16



BLOCK D - ELEVATION H-H



ELEVATION J-J



BLOCK D - ELEVATION K-K

RESIDENTIAL DEVELOPMENT

BLOCK D - BLOCK WALL ELEVATIONS
FOR BRYNDWR BUILDERS LTD

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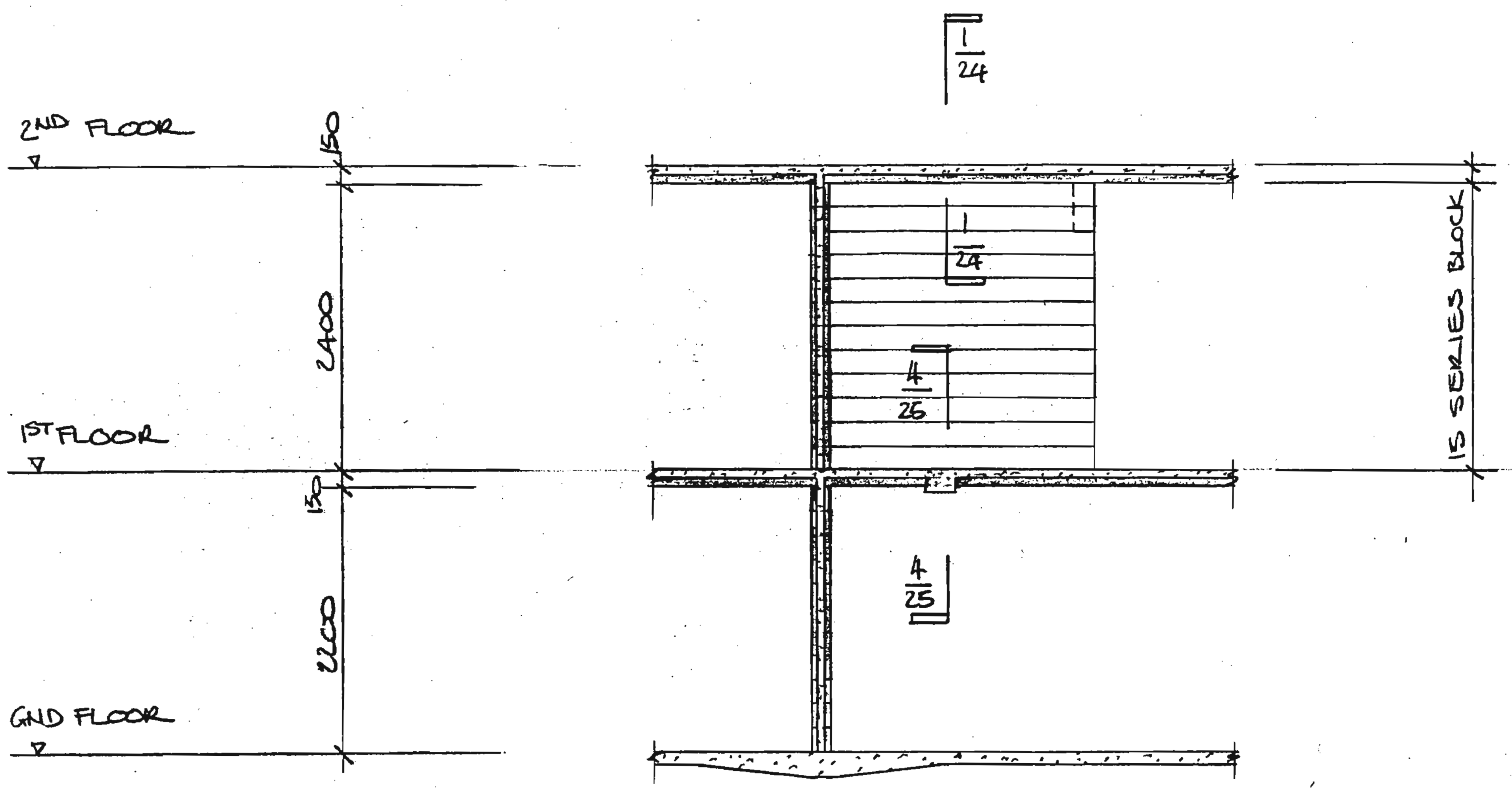
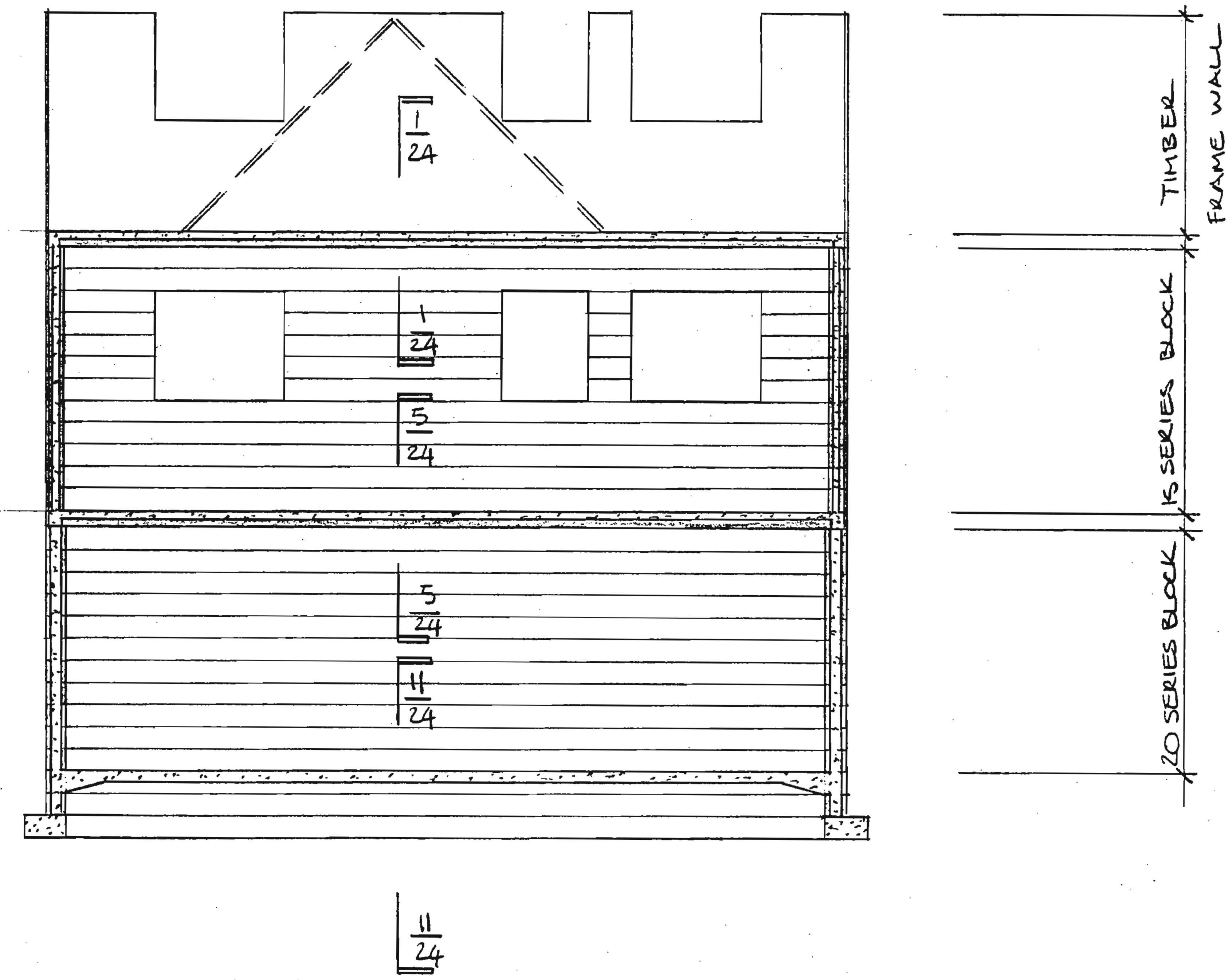


ELEVATION L - L



BLOCK D - ELEVATION M-M

RESIDENTIAL DEVELOPMENT

BLOCK D - BLOCK WALL ELEVATIONS
FOR BRYNDWR BUILDERS LTD

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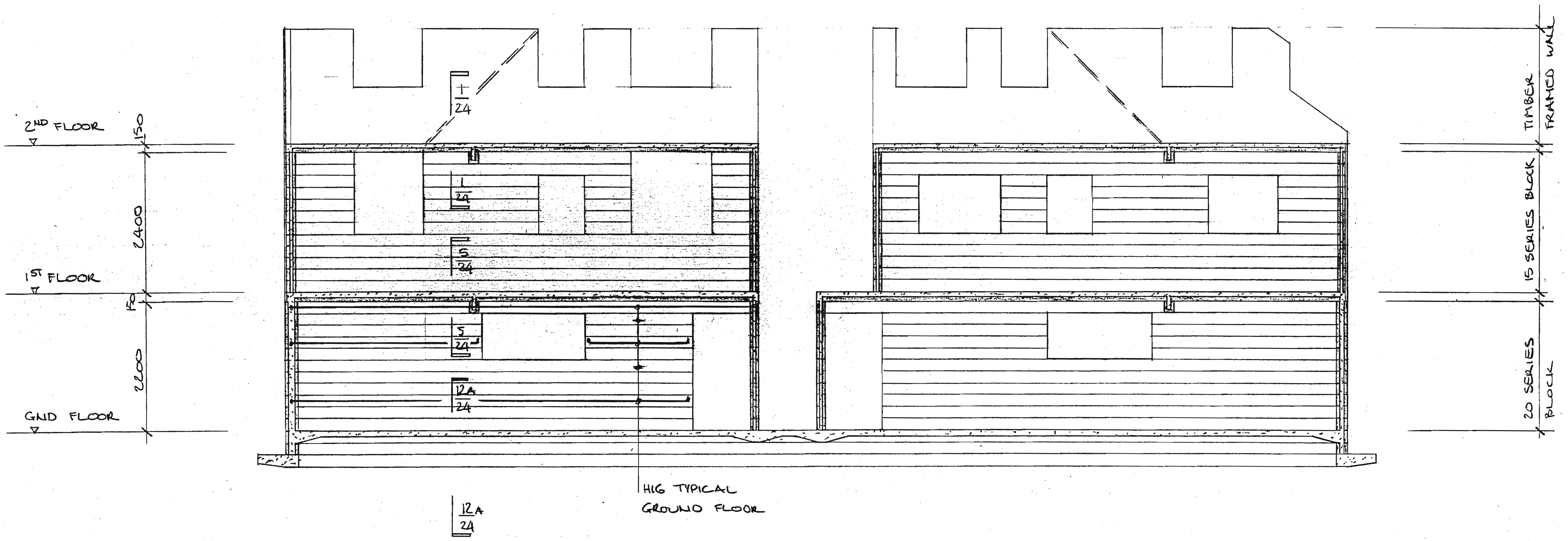
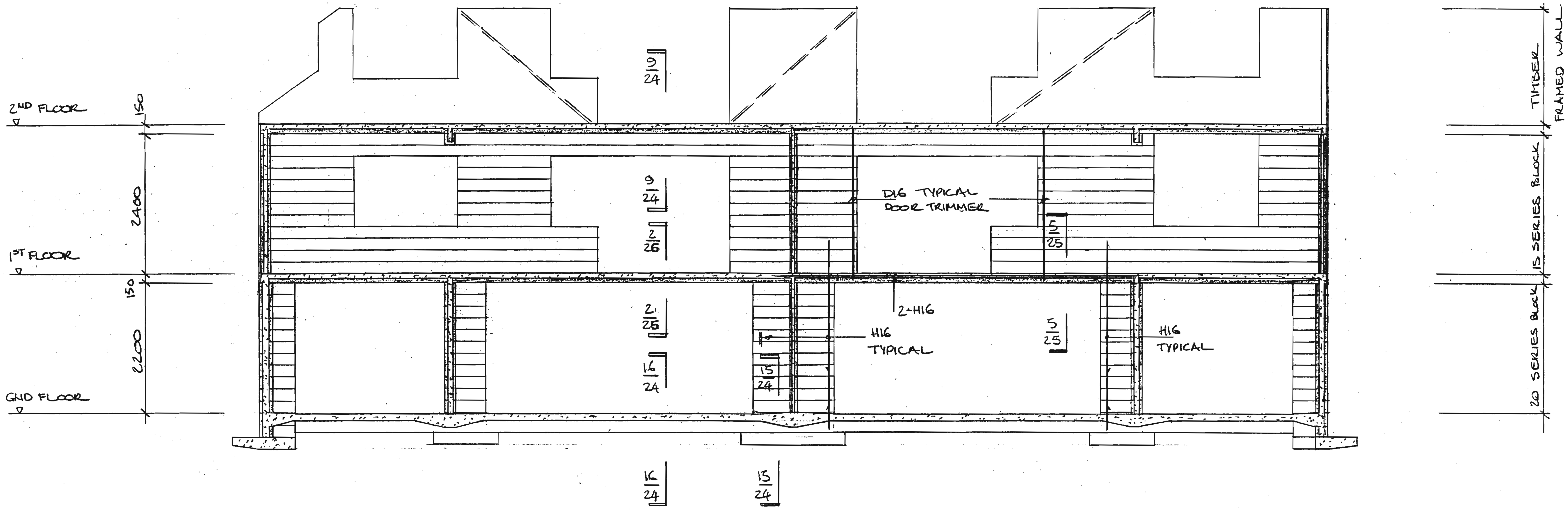


BLOCK E - ELEVATION A-A

RESIDENTIAL DEVELOPMENT

BLOCK E - BLOCK WALL ELEVATIONS
FOR BRYNDWR BUILDERS LTD

HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
47 HEREFORD ST, PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH
JULY 1998 - SCALE 1:50 - JOB Nº 67-5/19

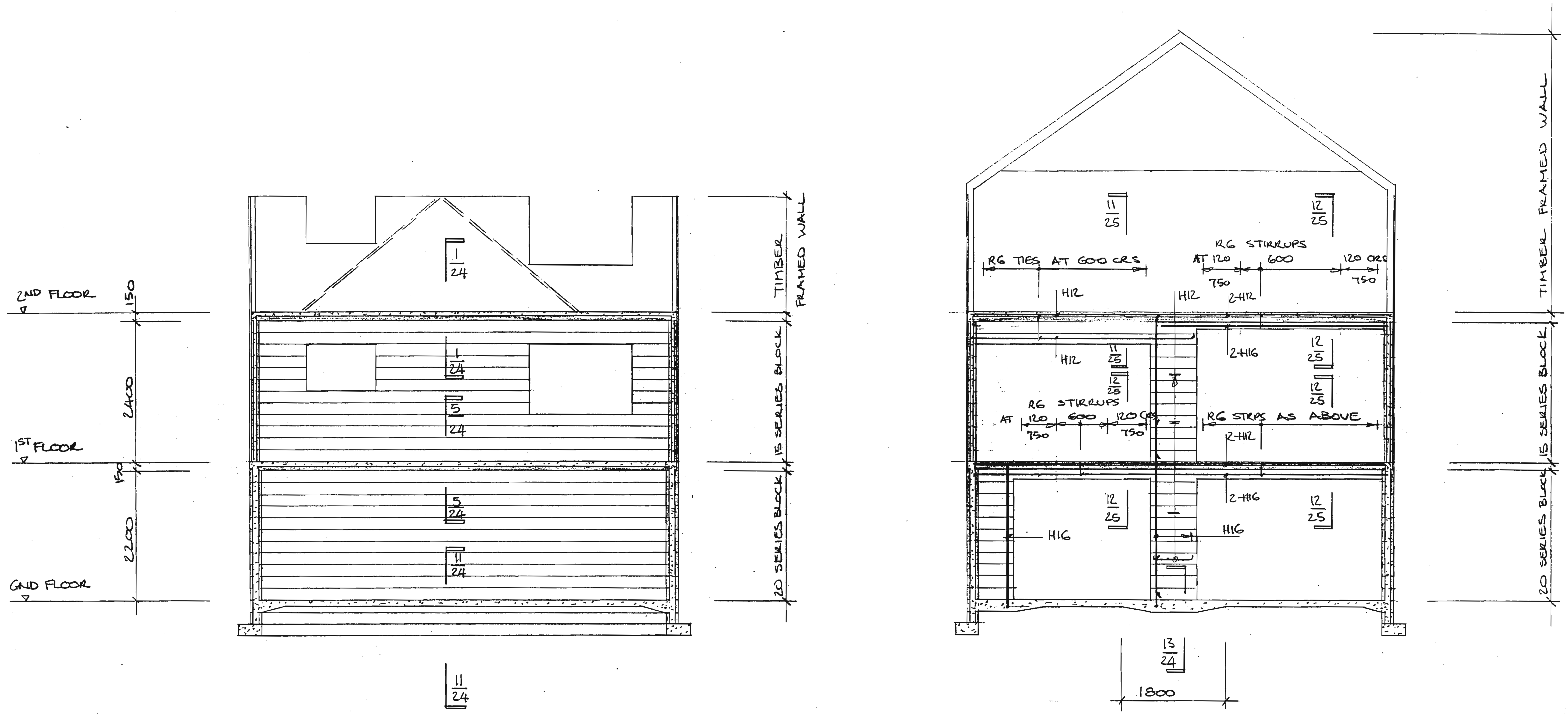


BLOCK E - ELEVATION B-B

RESIDENTIAL DEVELOPMENT

BLOCK E - BLOCK WALL ELEVATIONS
FOR BRYNDWR BUILDERS LTD

HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
47 HEREFORD ST., PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH
JULY 1998 - CONSTRUCTION ISSUE - SCALE 1:50 - JOB No 67-5/20



BLOCK E - ELEVATION C - C

BLOCK E - ELEVATION D - D

ELEVATION E - E SIMILAR

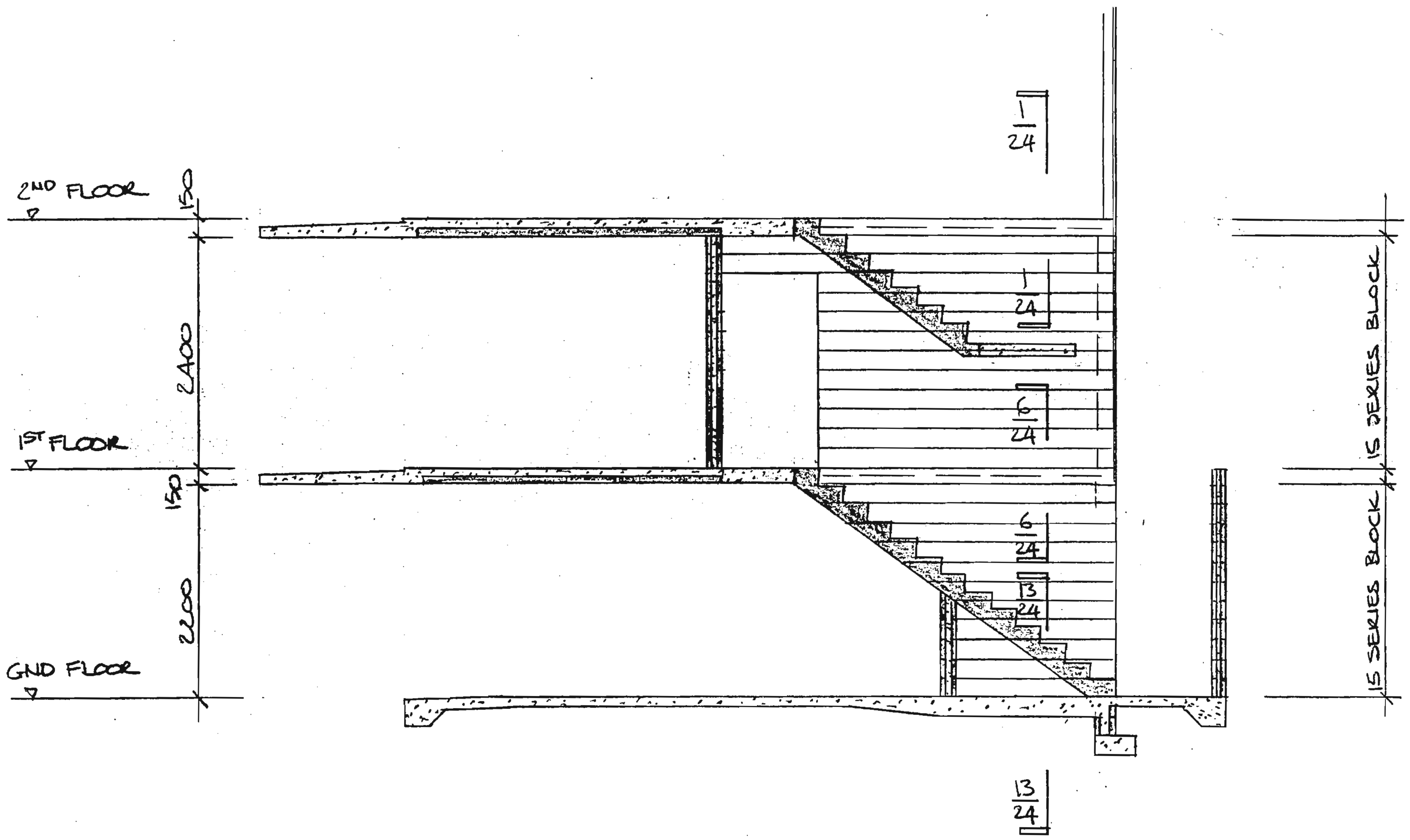
RESIDENTIAL DEVELOPMENT

BLOCK E - BLOCK WALL ELEVATIONS

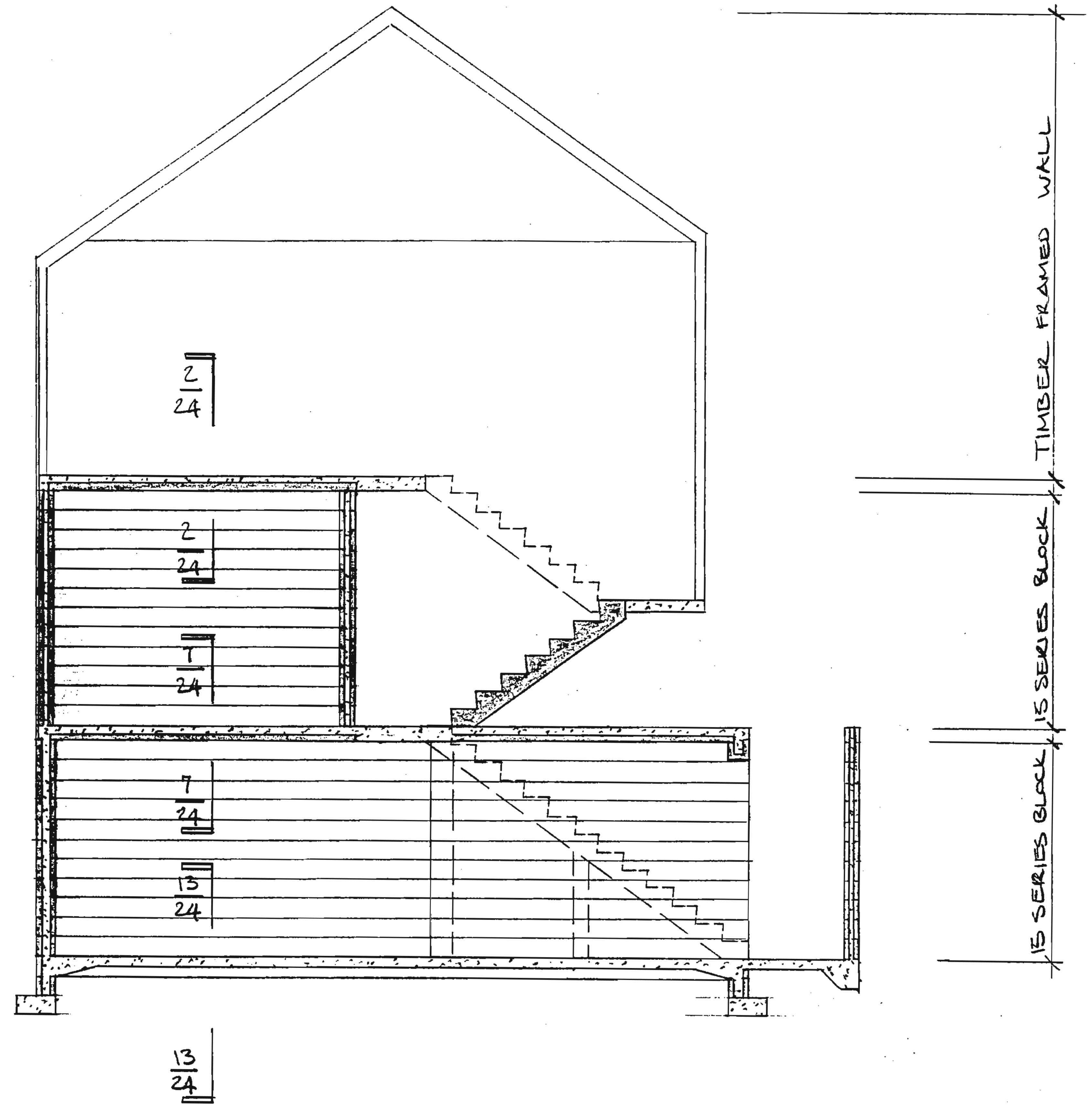
FOR BRYNDWR BUILDERS LTD

HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
47 HEREFORD ST., PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH

JULY 1998 - CONSTRUCTION ISSUE - SCALE 1:50 - JOB N° 67-5/21



BLOCK E - ELEVATION F-F

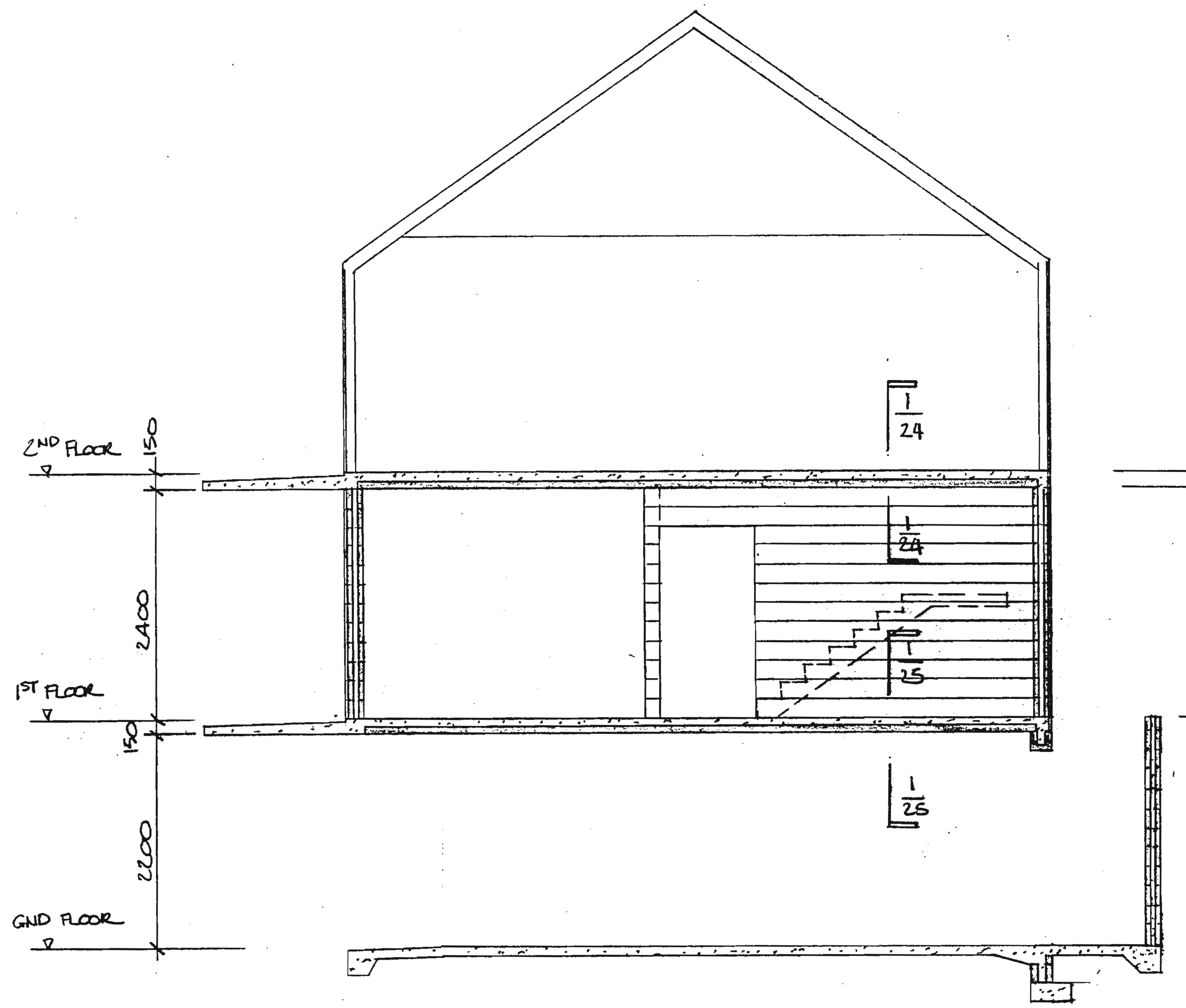


BLOCK E - ELEVATION G-G

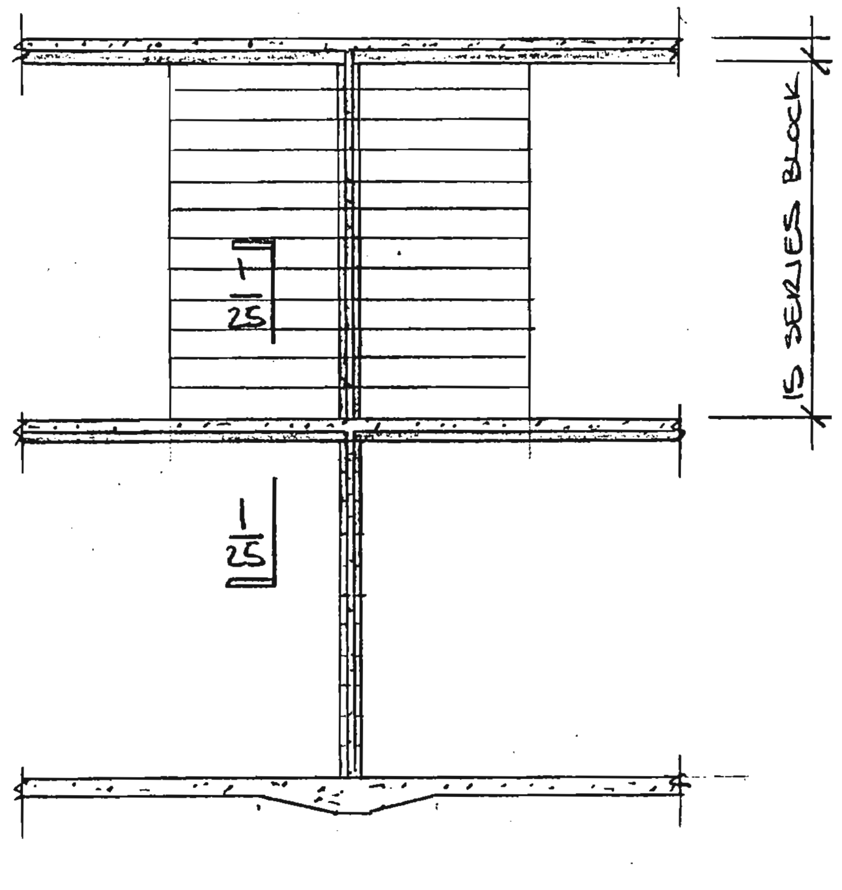
RESIDENTIAL DEVELOPMENT

BLOCK E - BLOCK WALL ELEVATIONS
FOR BRYNDWR BUILDERS LTD

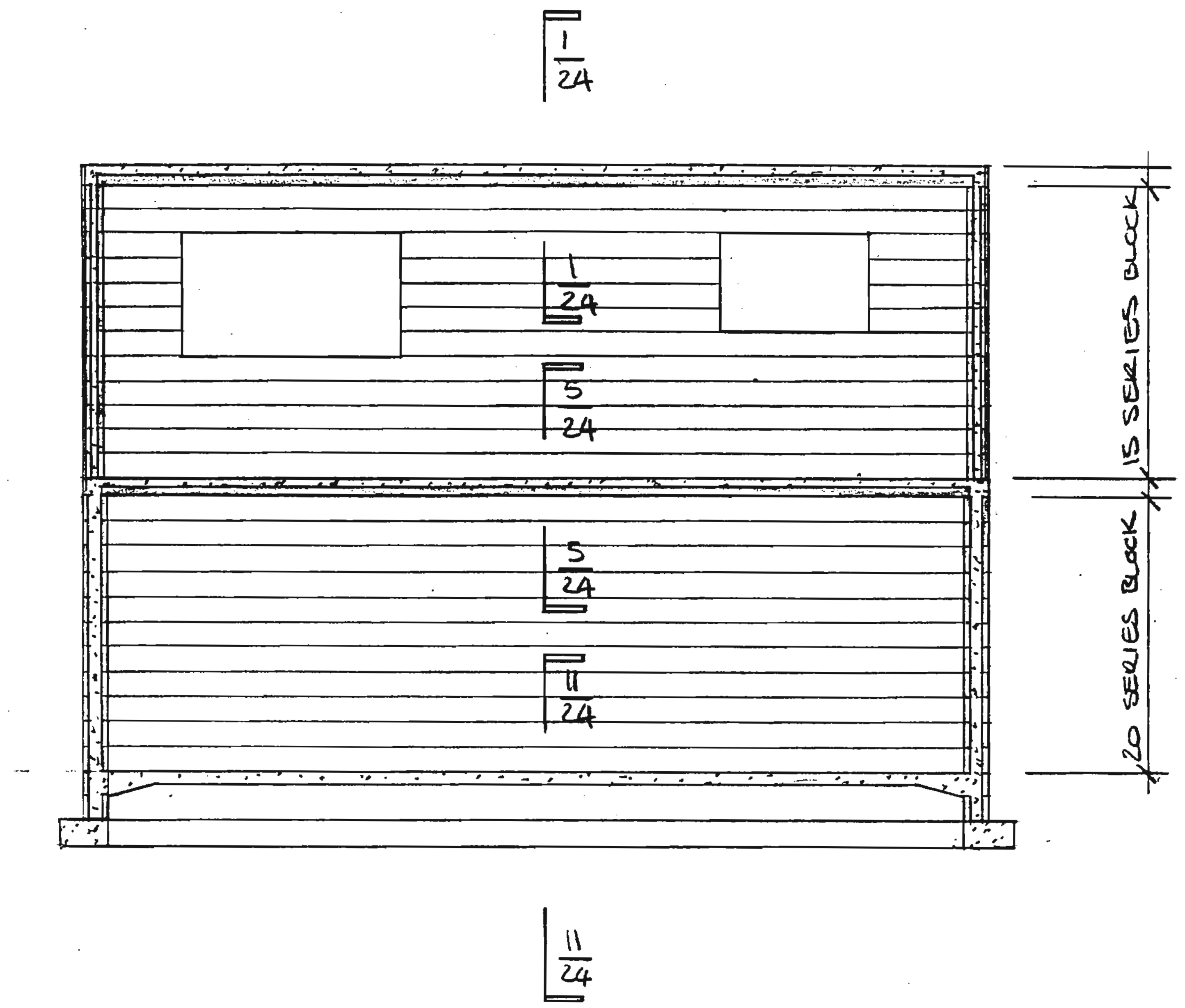
HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
47 HEREFORD ST, PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH
JULY 1998 - - SCALE 1:50 - JOB Nº 67-5/22



BLOCK E - ELEVATION H - H



ELEVATION J - J

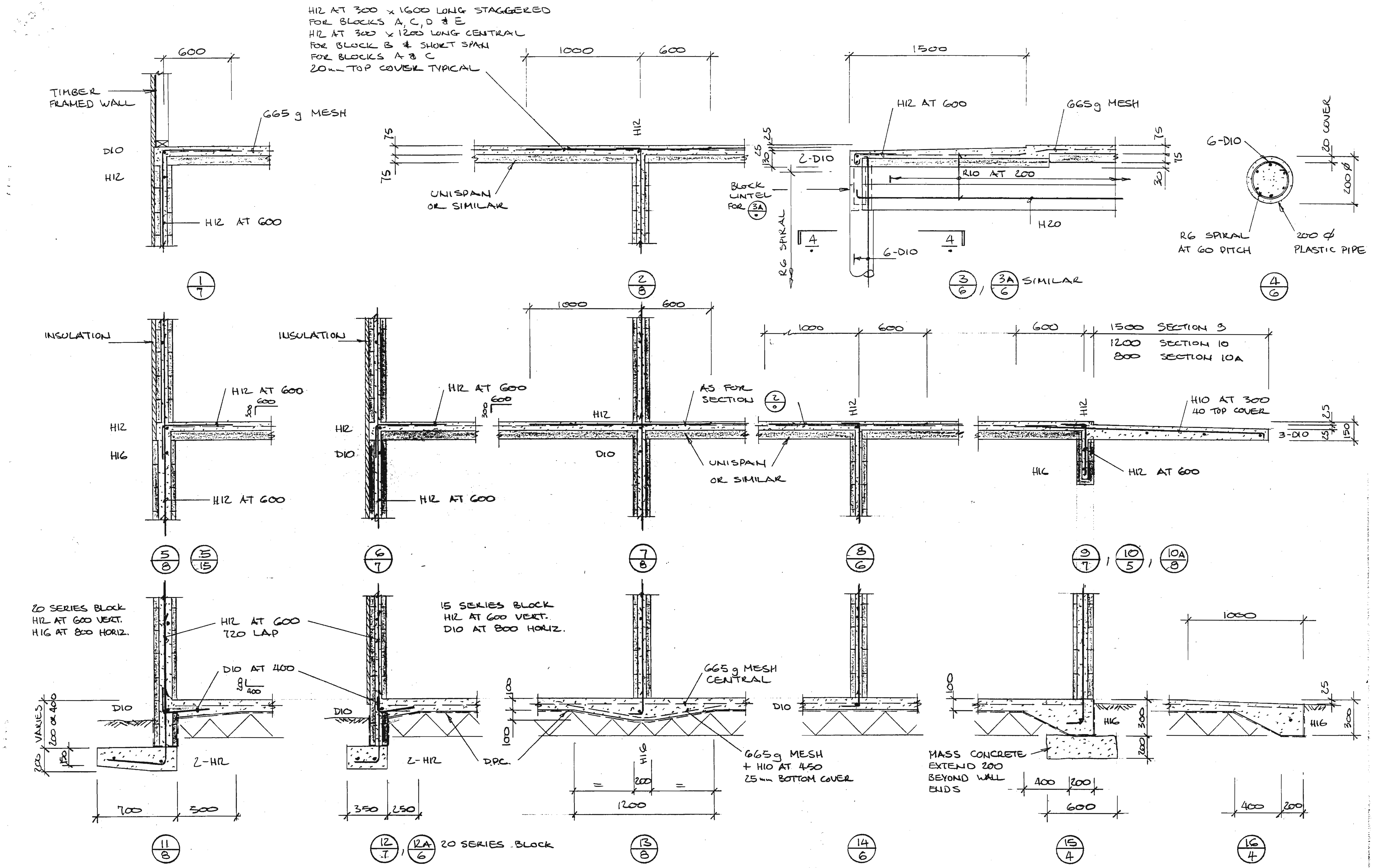


BLOCK E - ELEVATION K - K

RESIDENTIAL DEVELOPMENT

BLOCK E - BLOCK WALL ELEVATIONS
FOR BRYNDWR BUILDERS LTD

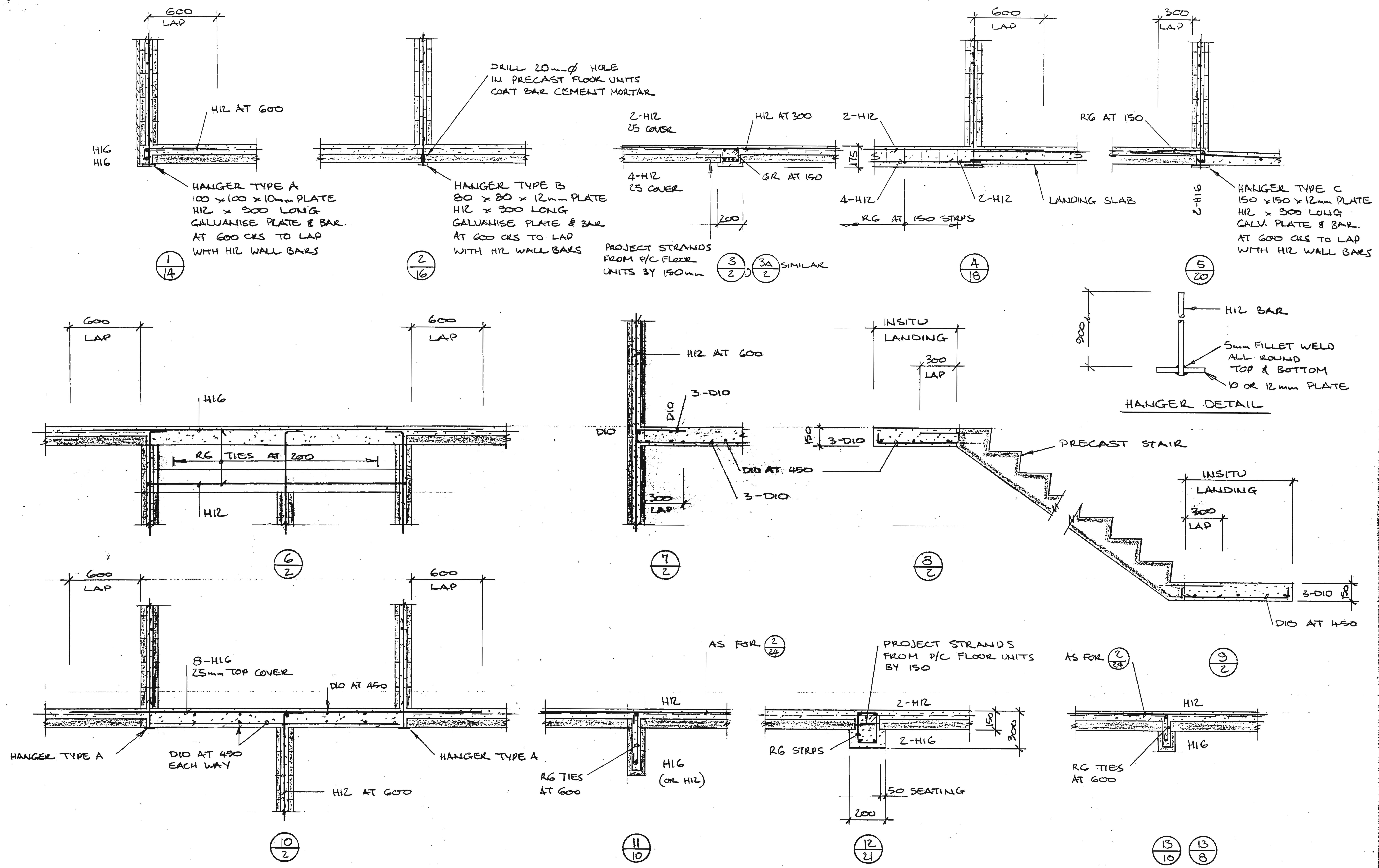
HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
47 HEREFORD ST., PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH
JULY 1998 - - SCALE 1:50 - JOB No 67-5/23



RESIDENTIAL DEVELOPMENT

BLOCKS A TO E - DETAILS
FOR BRYNDWR BUILDERS LTD

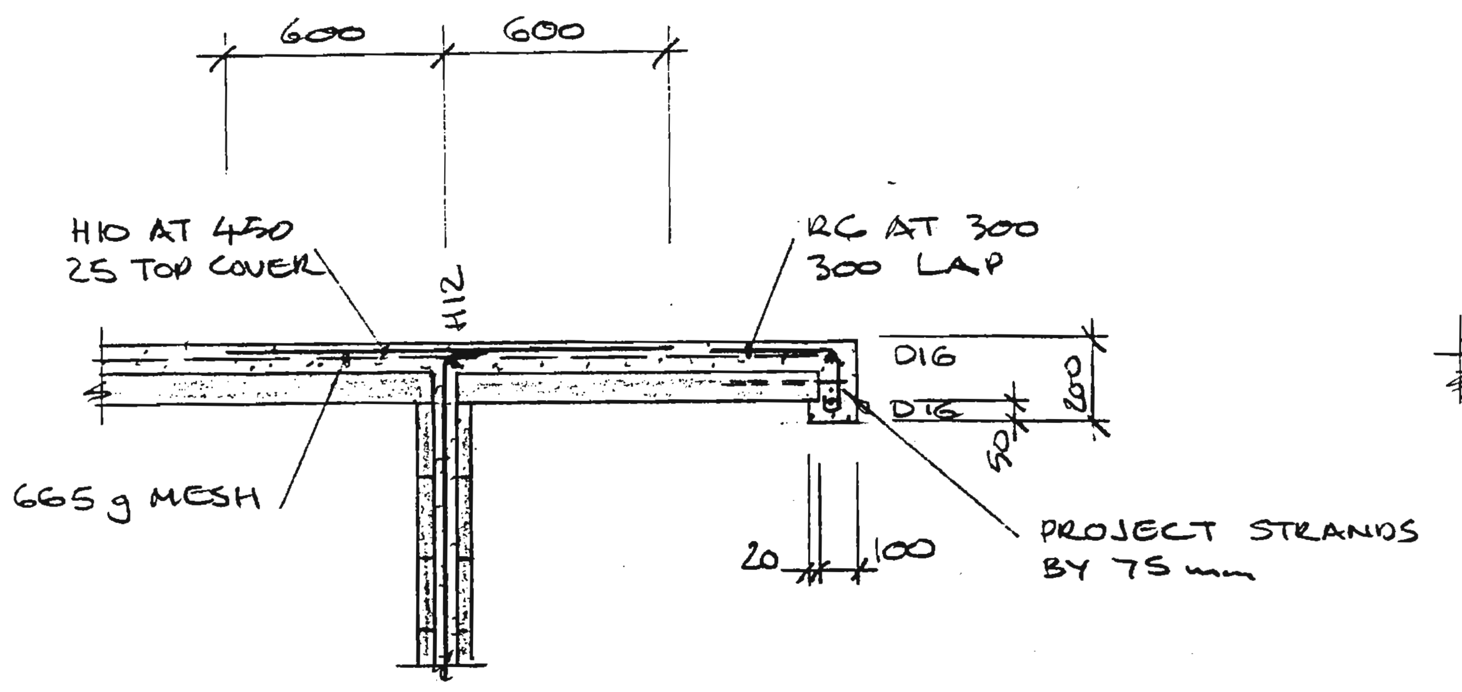
HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
47 HEREFORD ST., PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH
JULY 1998 - SCALE 1:20, 1:10 - JOB No 67-5/24



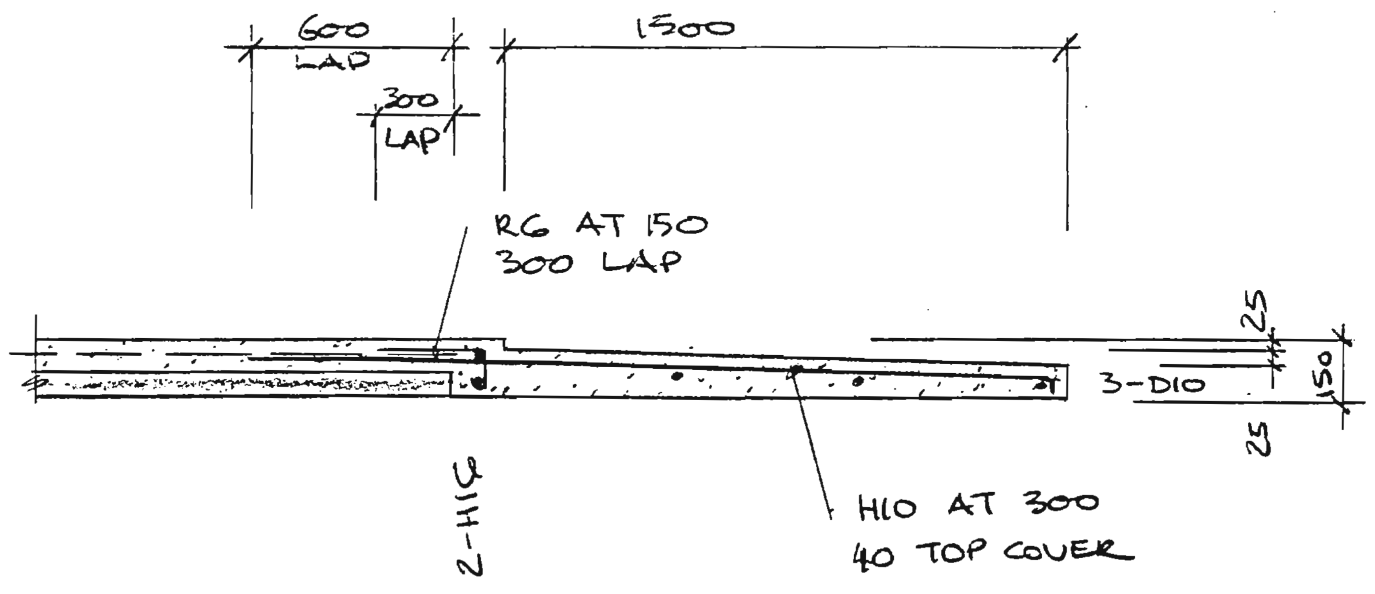
RESIDENTIAL DEVELOPMENT

BLOCKS A TO E — DETAILS
FOR BRYNDWR BUILDERS LTD

HARMAN HALLIDAY — CONSULTING CIVIL & STRUCTURAL ENGINEER
47 HEREFORD ST., PO BOX 2313 — PH 3653697, FAX 3664575 — CHRISTCHURCH
JULY 1998 — — SCALE 1:20 — JOB N° 67-3/25



1/3



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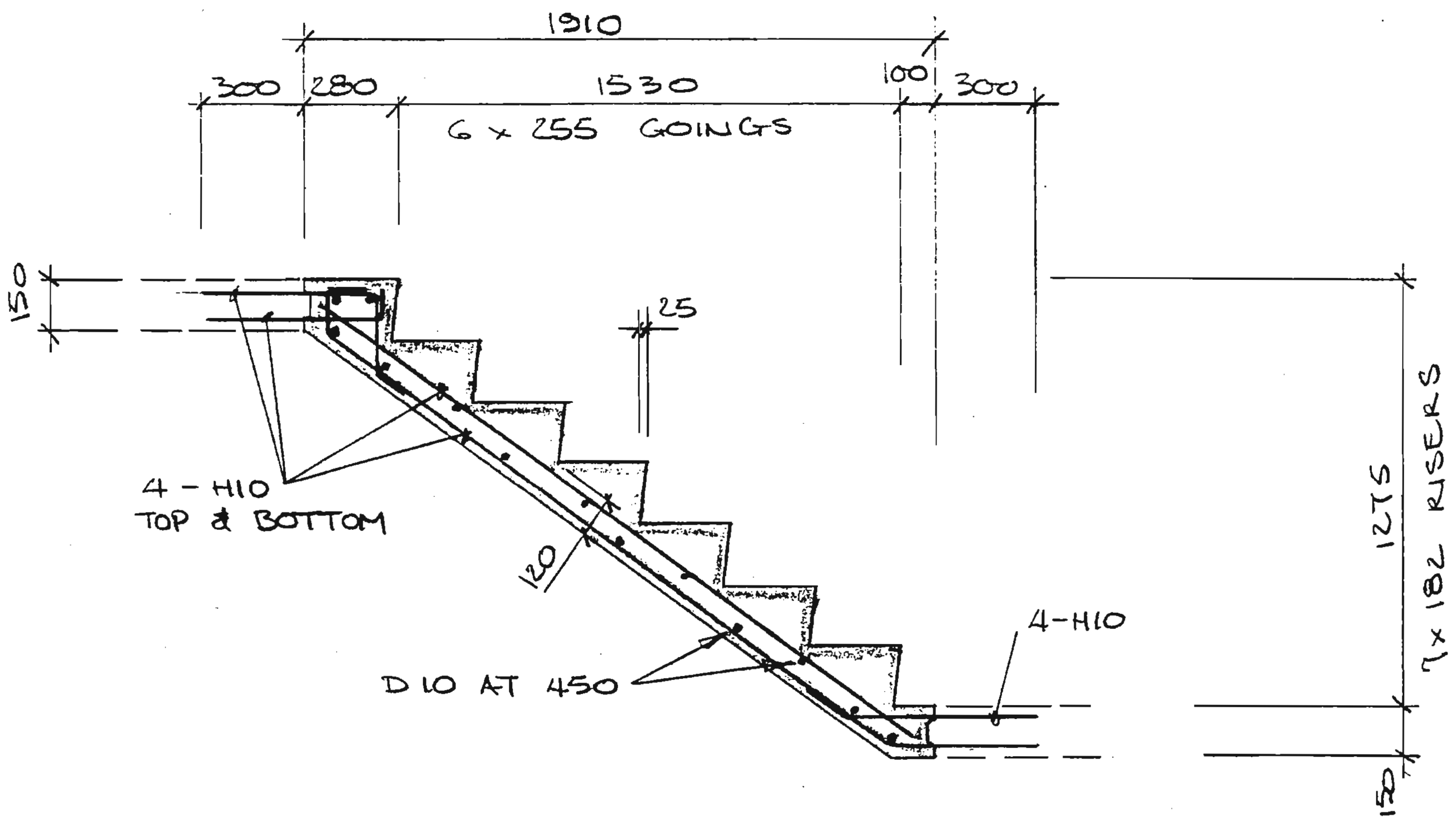
RESIDENTIAL DEVELOPMENT

BLOCKS A TO E - DETAILS

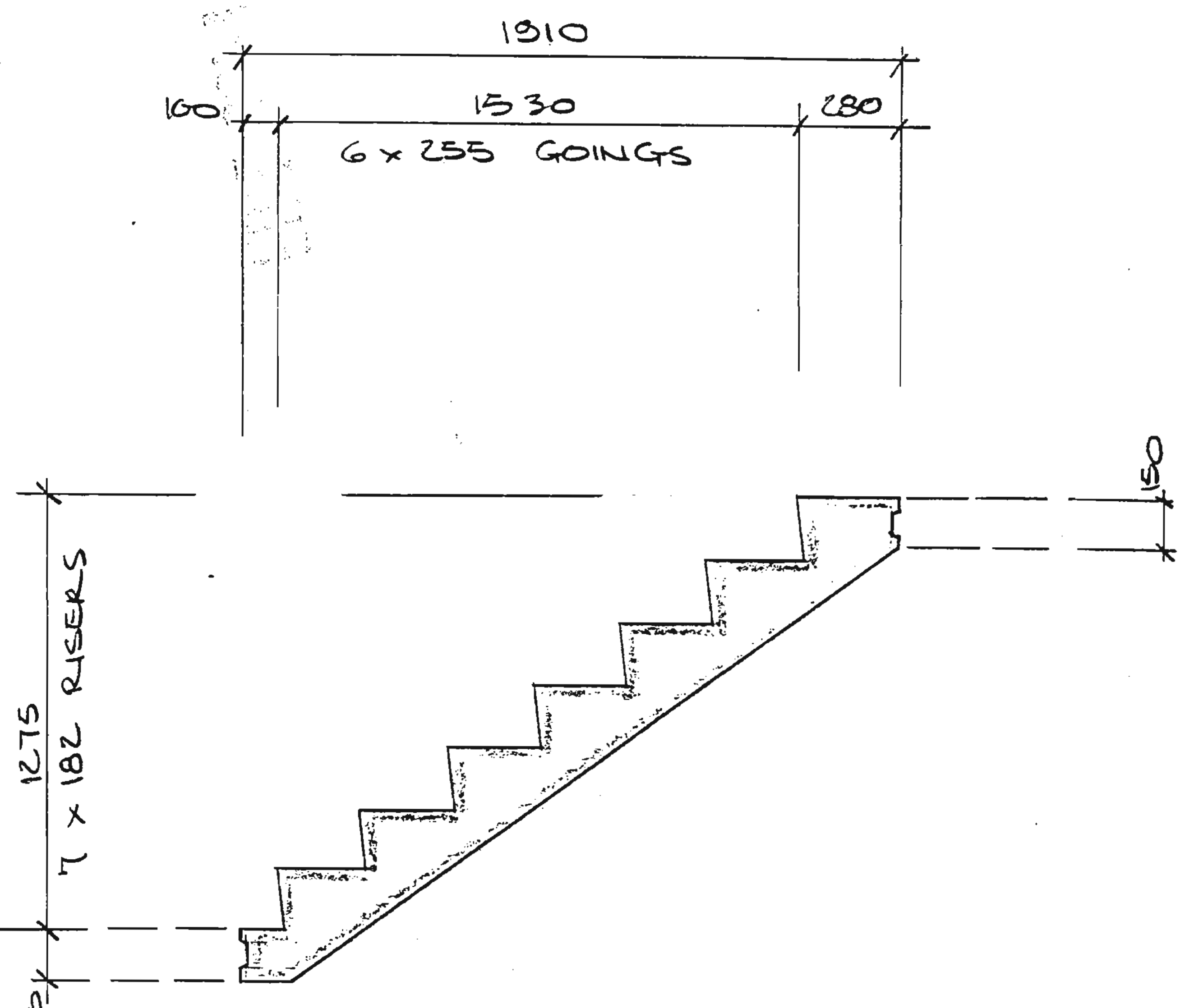
FOR [illegible] BUILDERS LTD

HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER
47 HEREFORD ST, PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH

JULY 1998 - - SCALE 1:20 - JOB N° 27-5/26

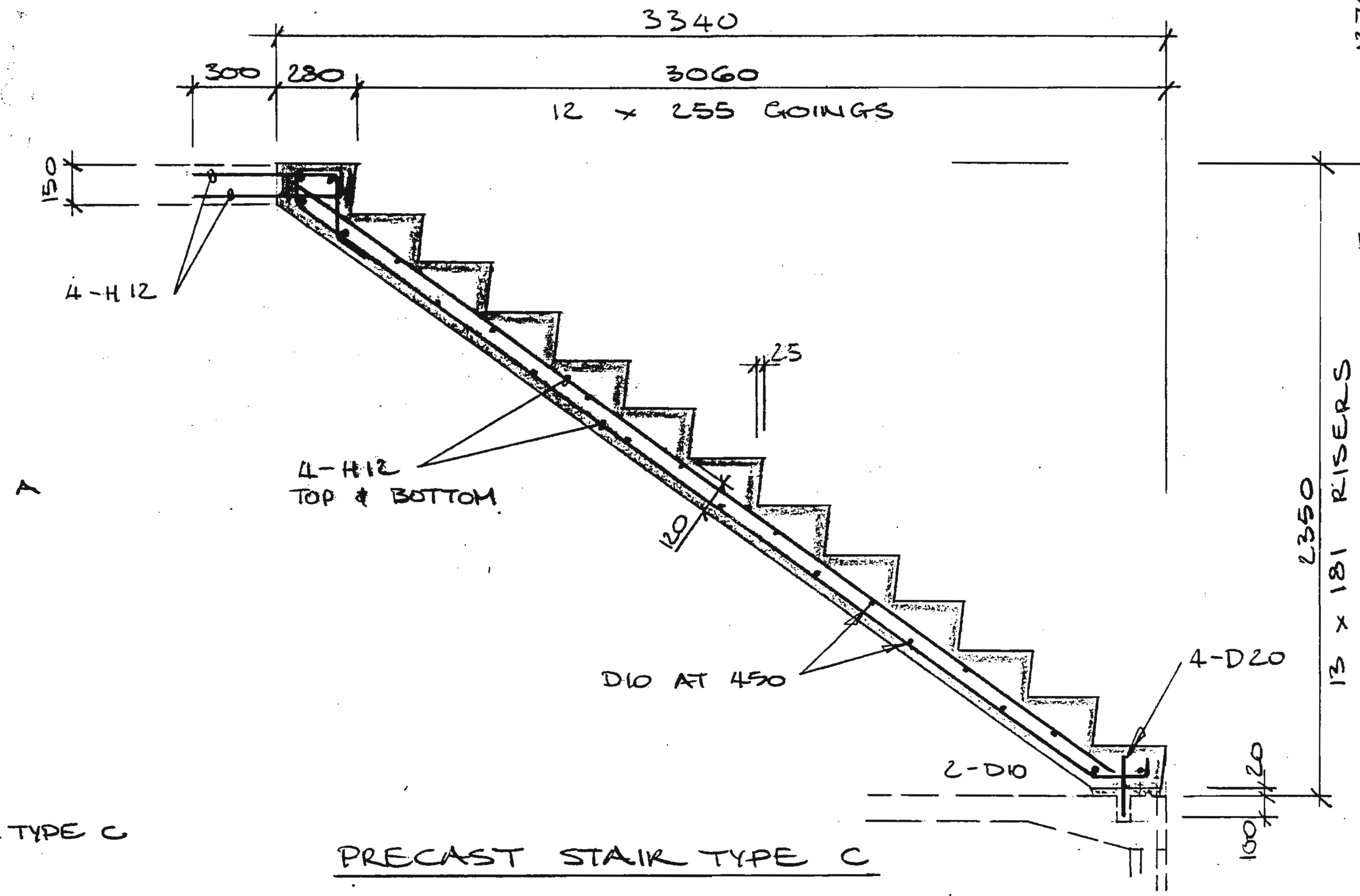


PRECAST STAIR TYPE A

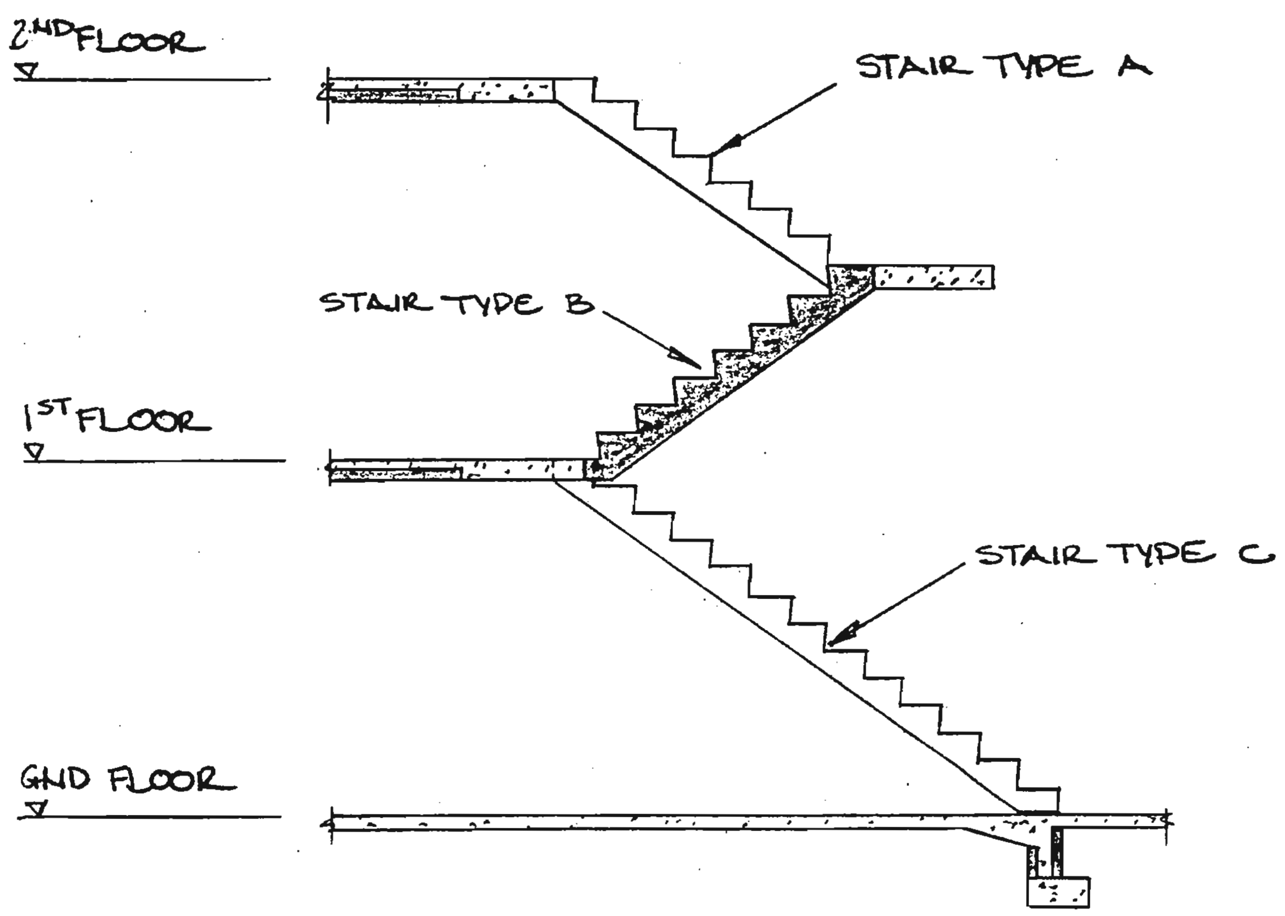


PRECAST STAIR TYPE B

DETAILS AS FOR STAIR TYPE A

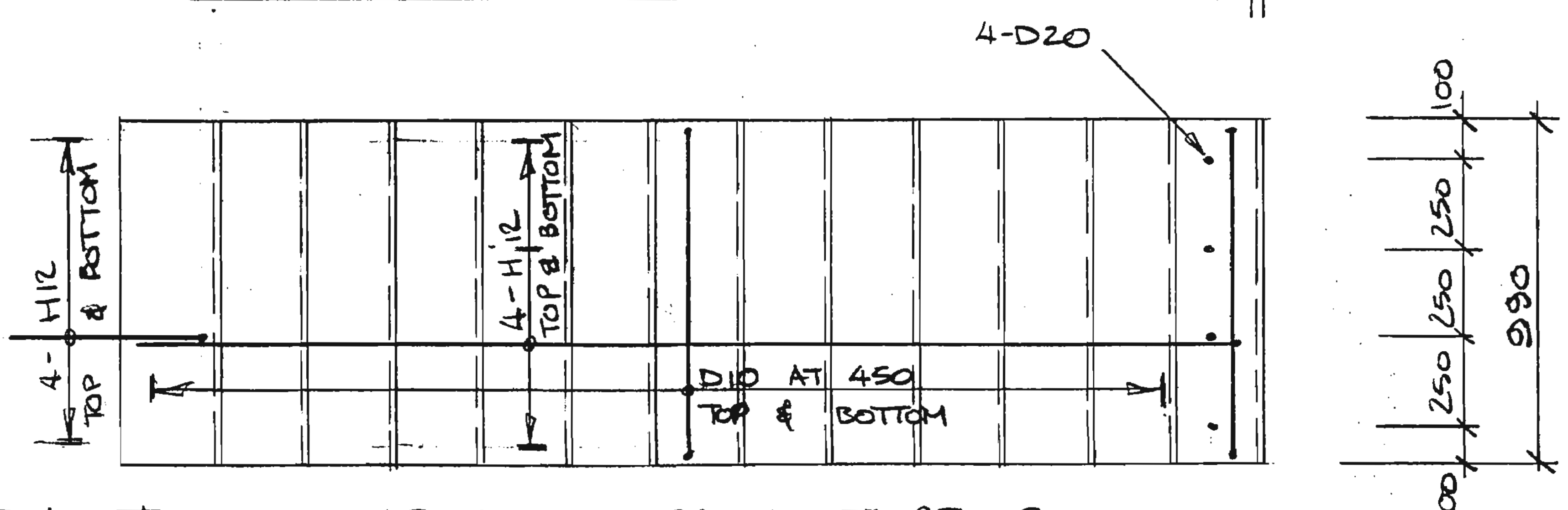


PRECAST STAIR TYPE C

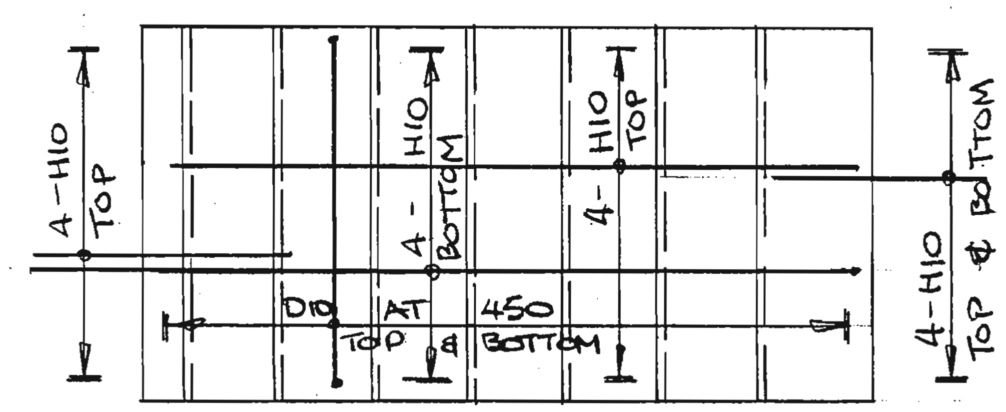


PRECAST STAIR ELEVATIONS

BLOCKS D & E



PLAN STAIR TYPE C



PLAN STAIR TYPE A & B

SIDENTIAL DEVELOPMENT

LS D & E PRECAST STAIR DETAILS

BRYNDWR BUILDERS LTD

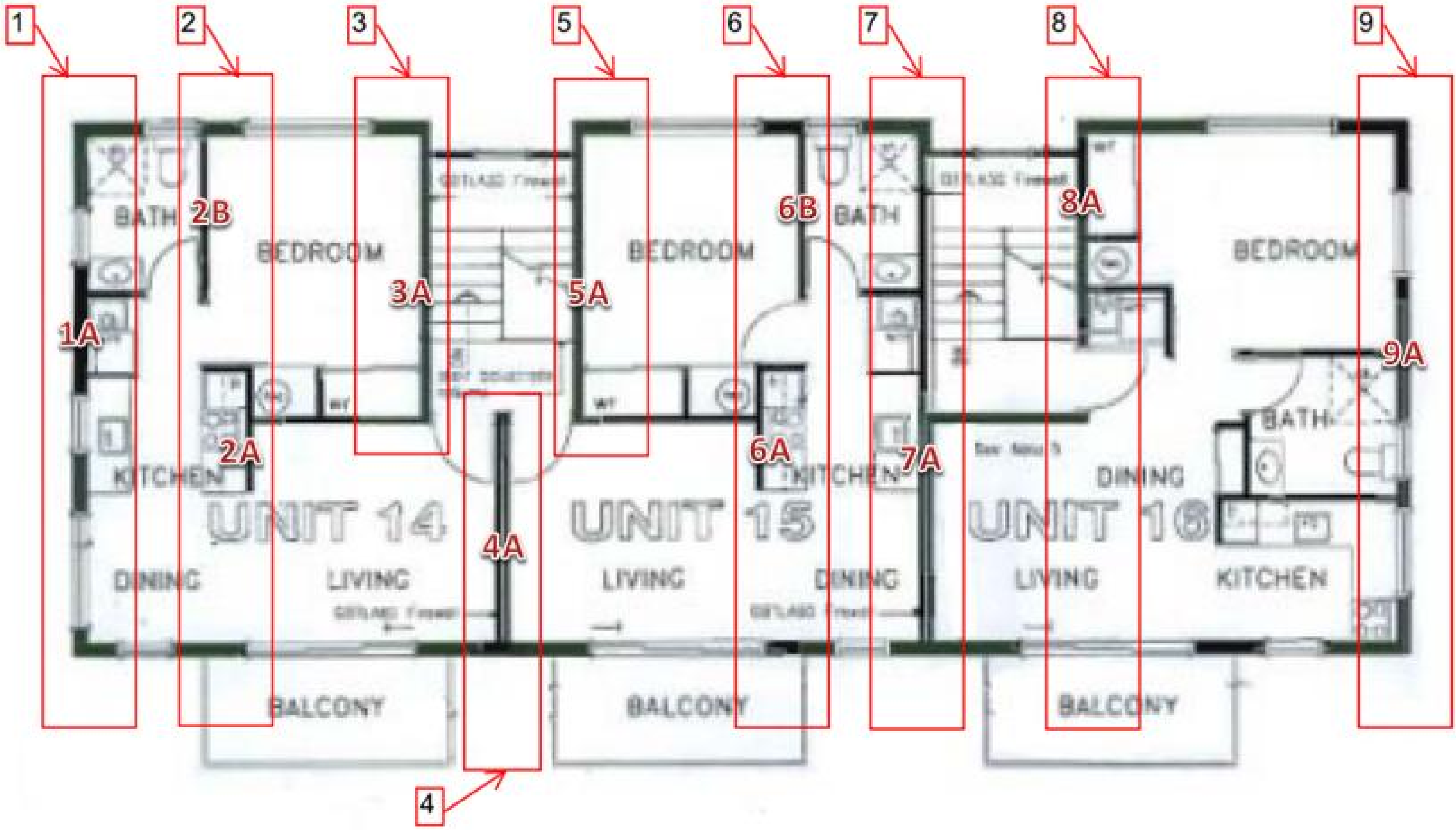
HARMAN HALLIDAY - CONSULTING CIVIL & STRUCTURAL ENGINEER

47 HEREFORD ST., PO BOX 2313 - PH 3653697, FAX 3664575 - CHRISTCHURCH

JULY 1998 - - SCALE 1:30, 1:20 - JOB Nº 67-5/28

Appendix D

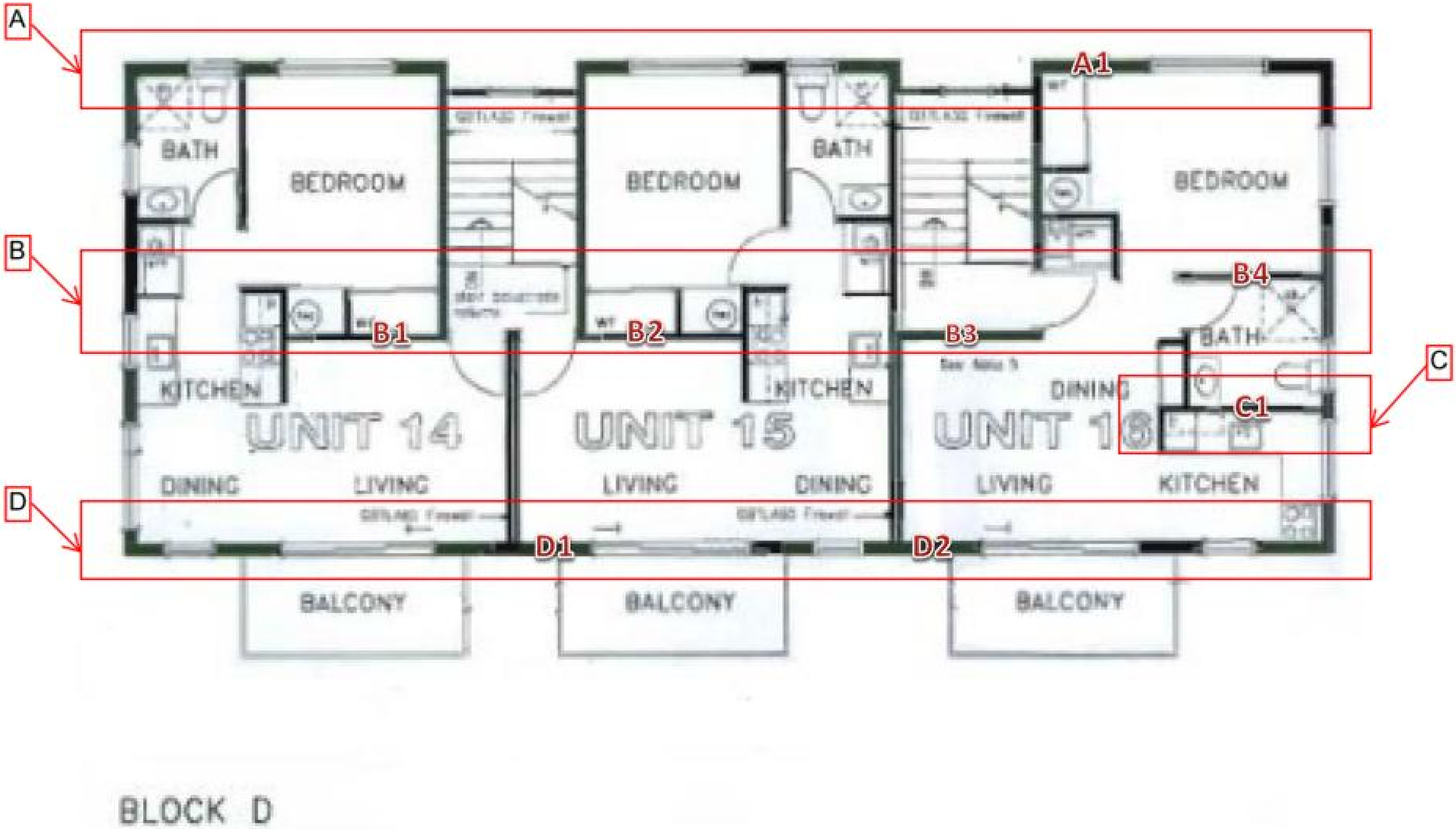
Key Drawings (Gloucester Courts Block B – North)



BLOCK D

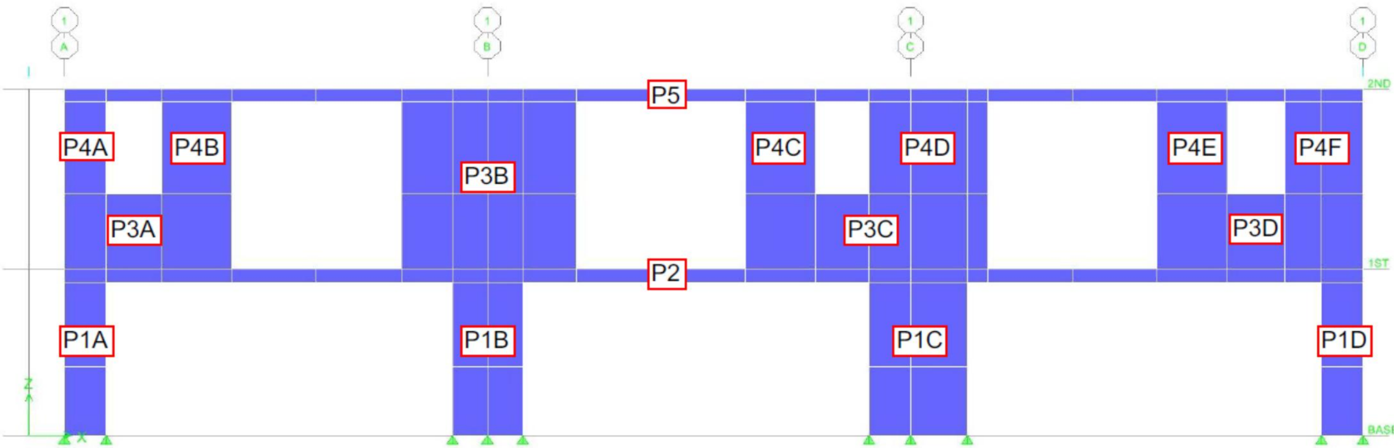
SECOND FLOOR PLAN
WALL BRACING DESIGNATION - ACROSS

NOTE: WALL LESS THAN 1.80M IN LENGTH NOT INCLUDED IN CALCULATIONS

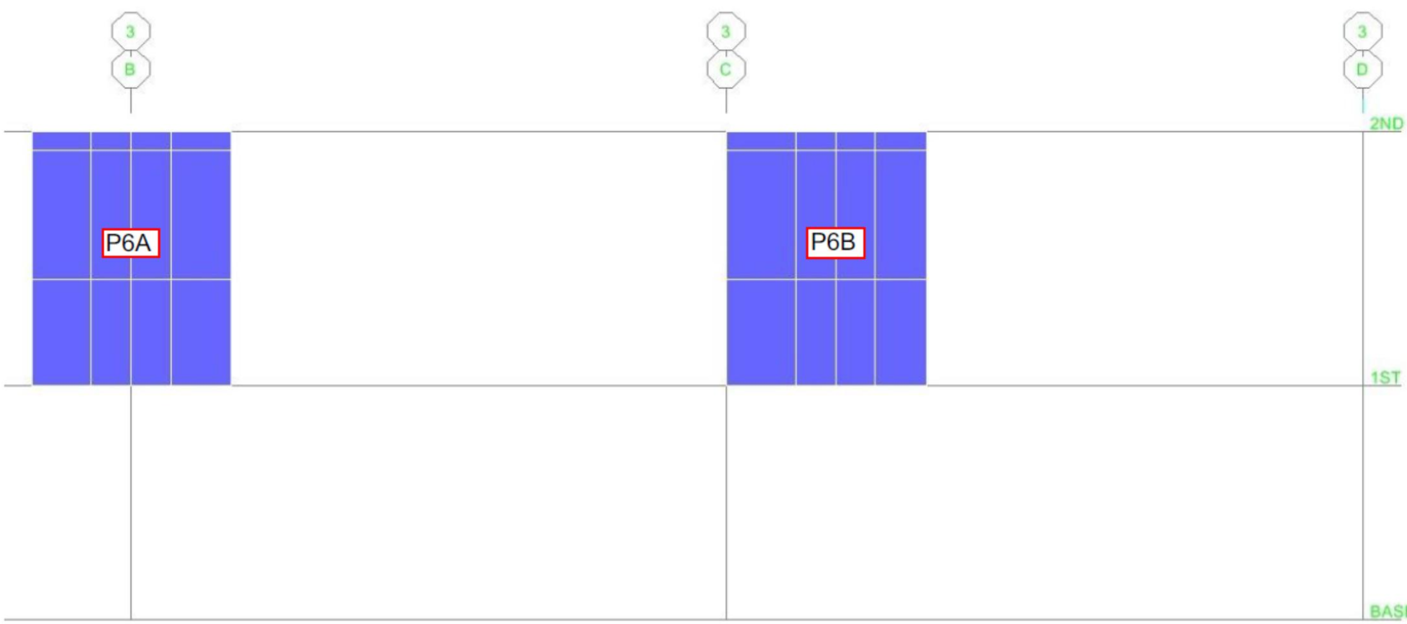


SECOND FLOOR PLAN
WALL BRACING DESIGNATION - ALONG

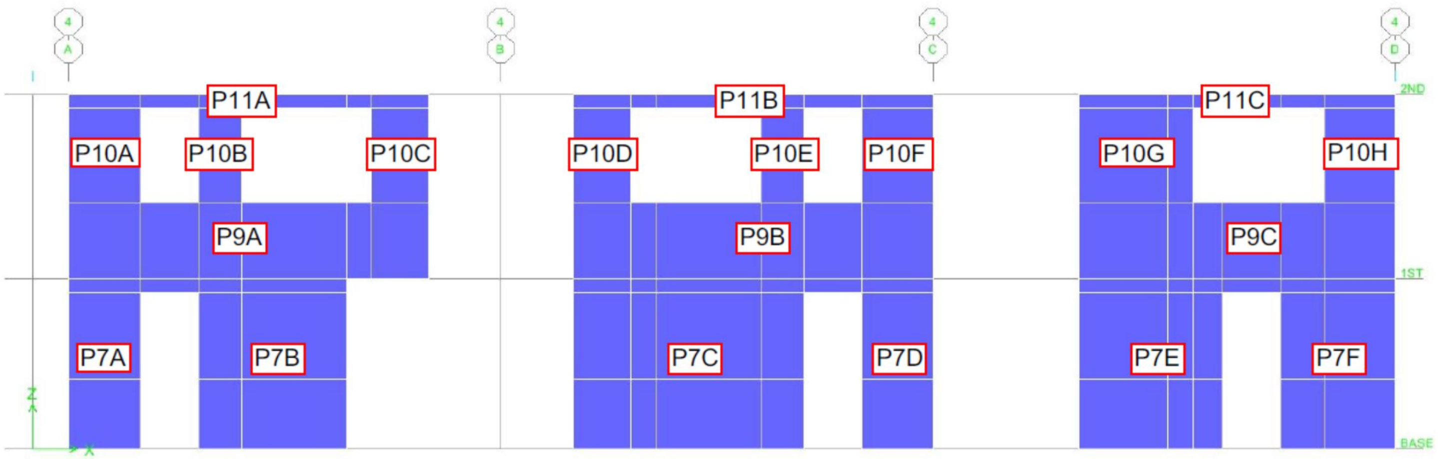
NOTE: WALL LESS THAN 1.80M IN LENGTH NOT INCLUDED IN CALCULATIONS



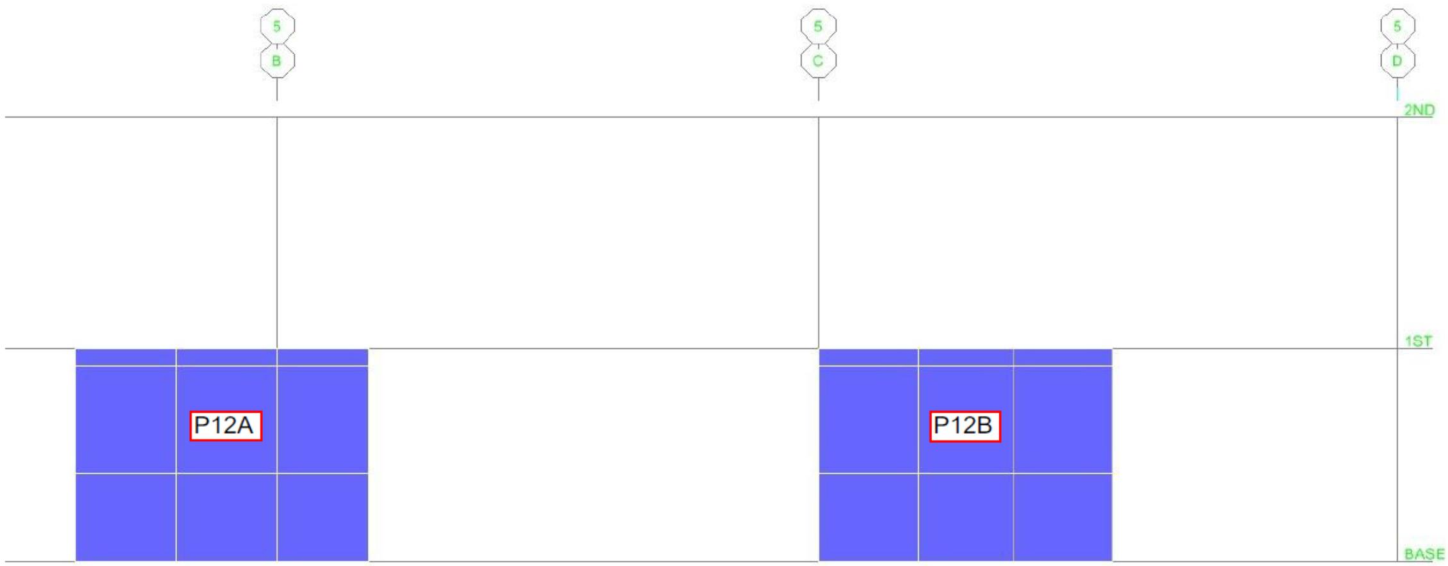
WALL AT GRIDLINE 1



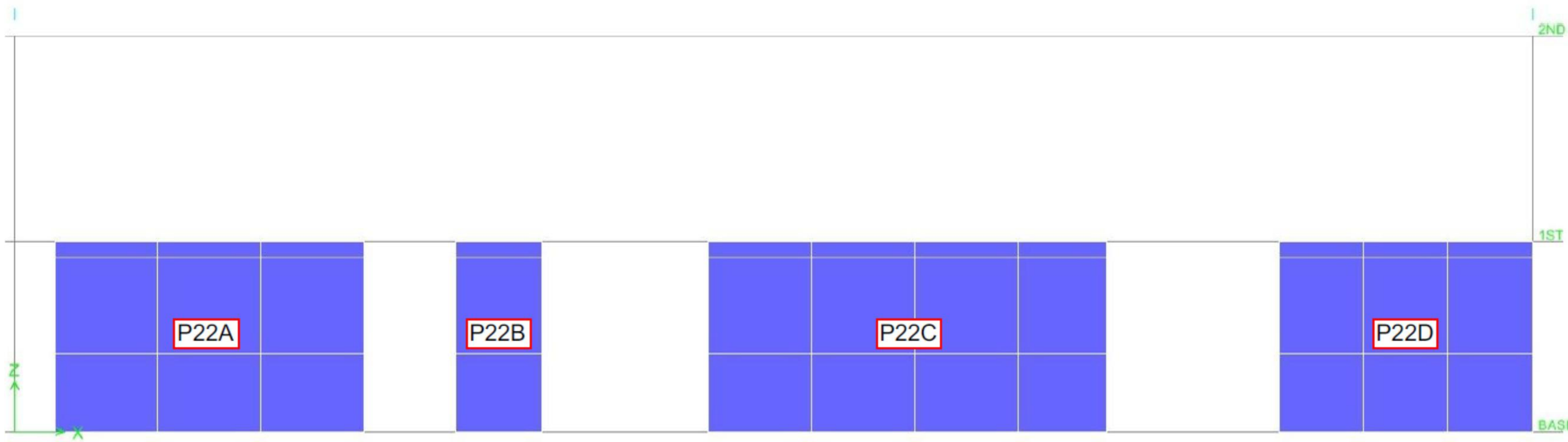
WALL AT GRIDLINE 3



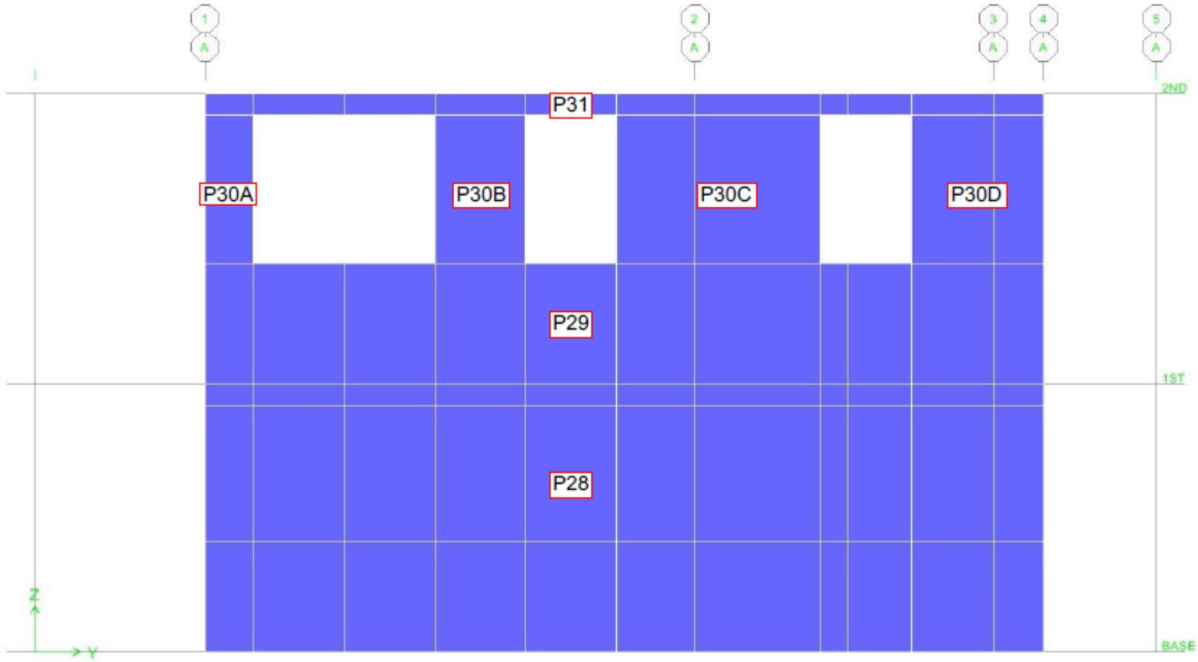
WALL AT GRIDLINE 4



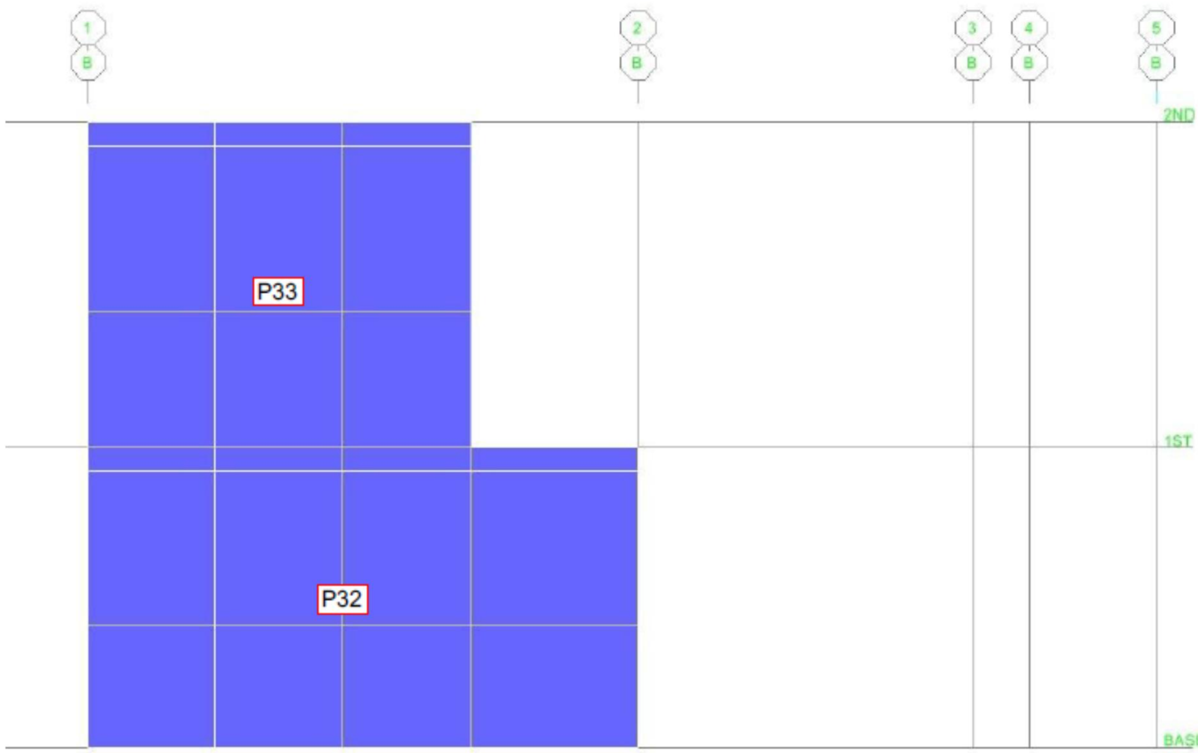
WALL AT GRIDLINE 5



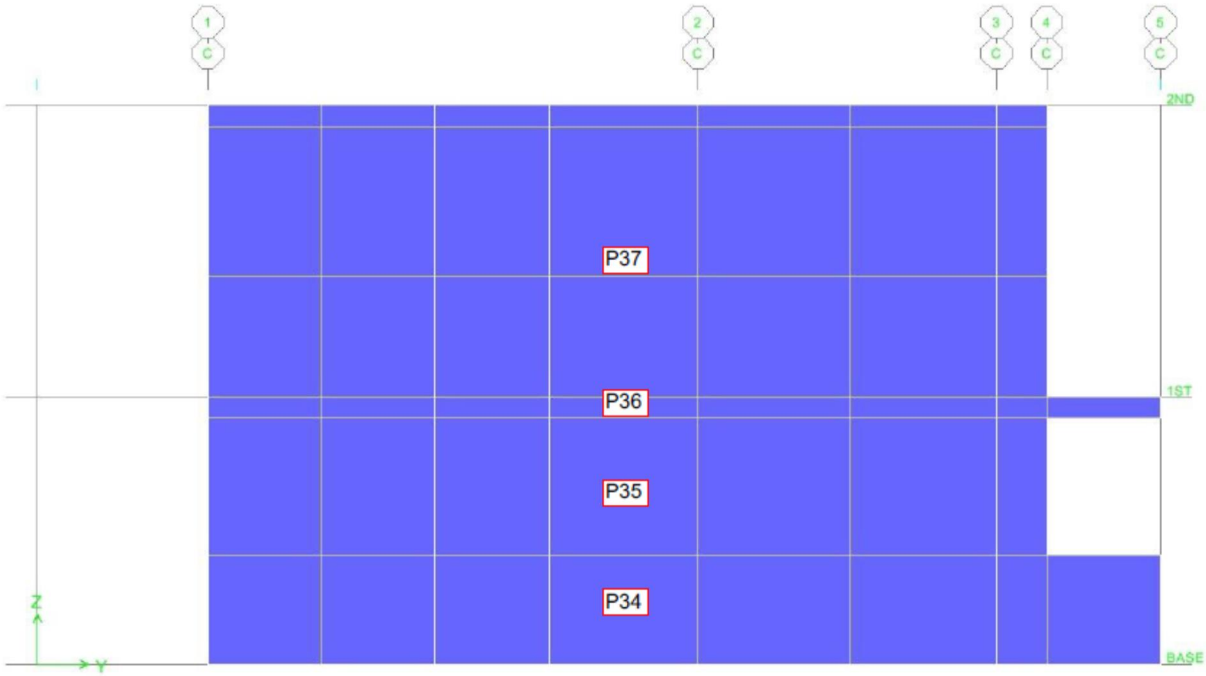
WALL AT PARTITION
(BETWEEN GRIDLINE 2 AND 3)



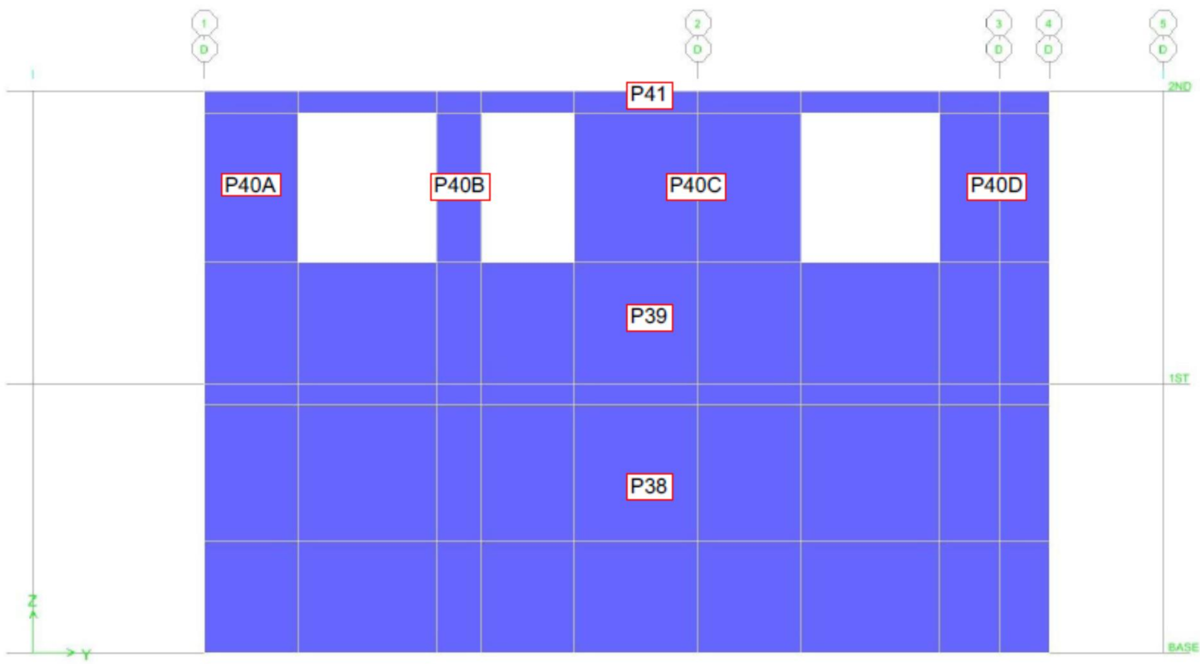
WALL AT GRIDLINE A



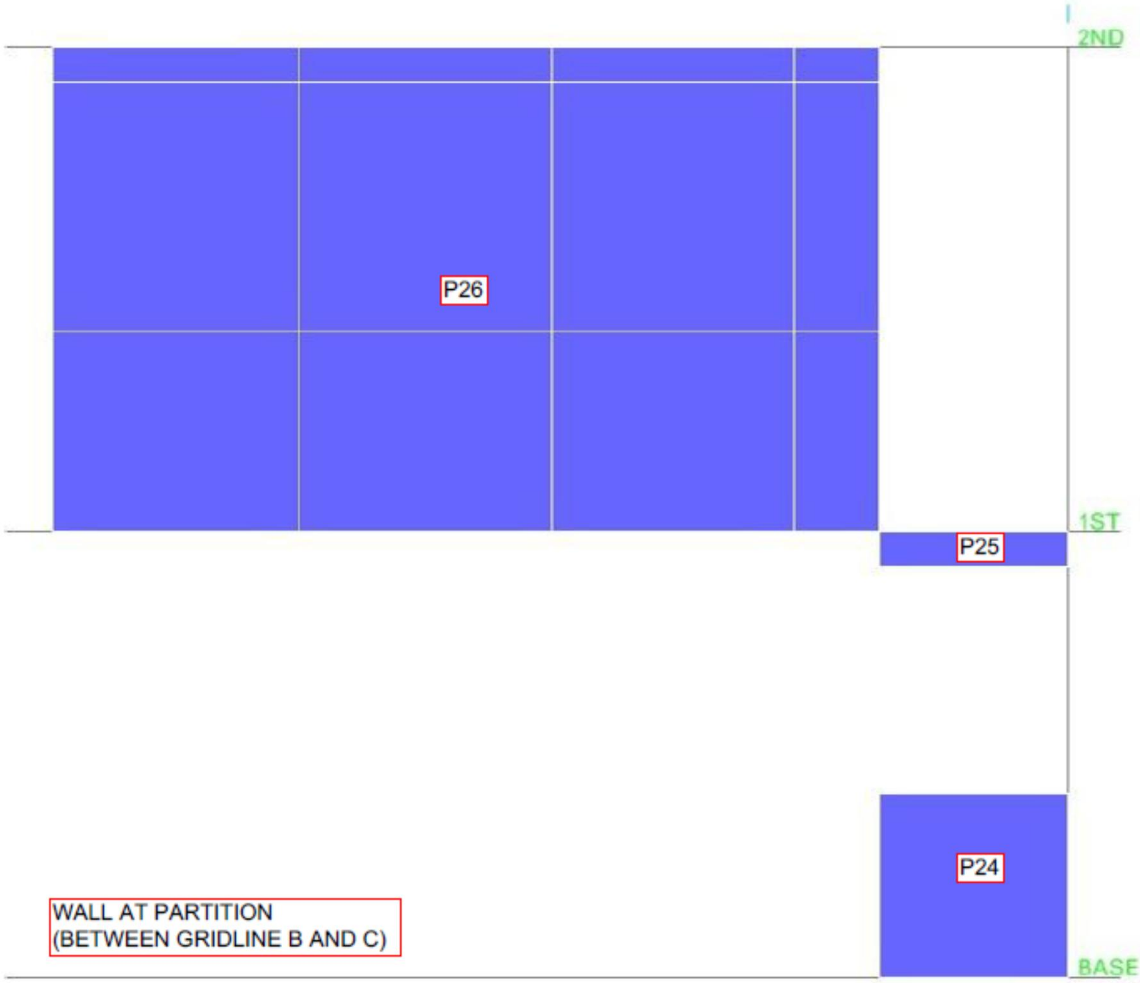
WALL AT GRIDLINE B

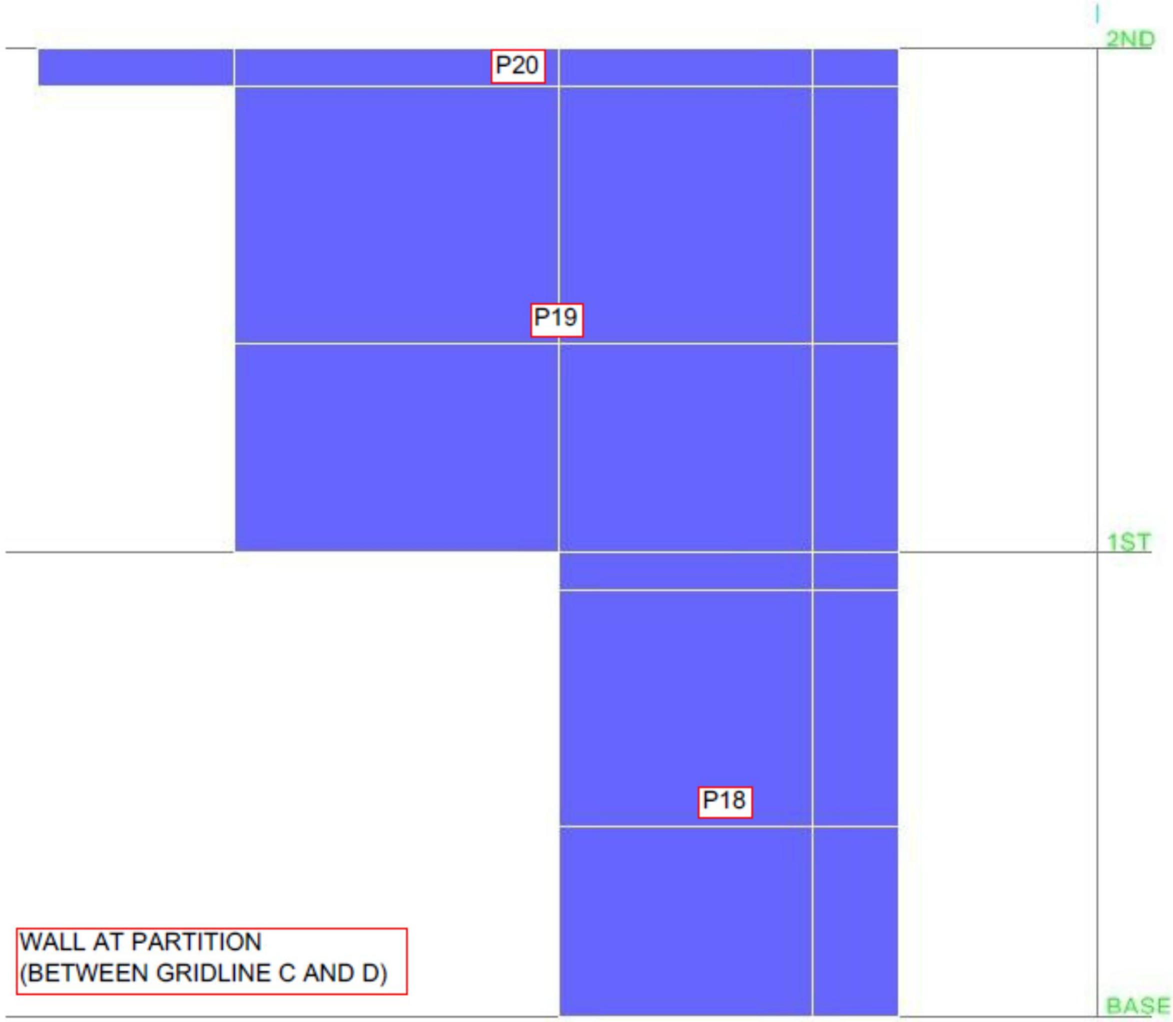


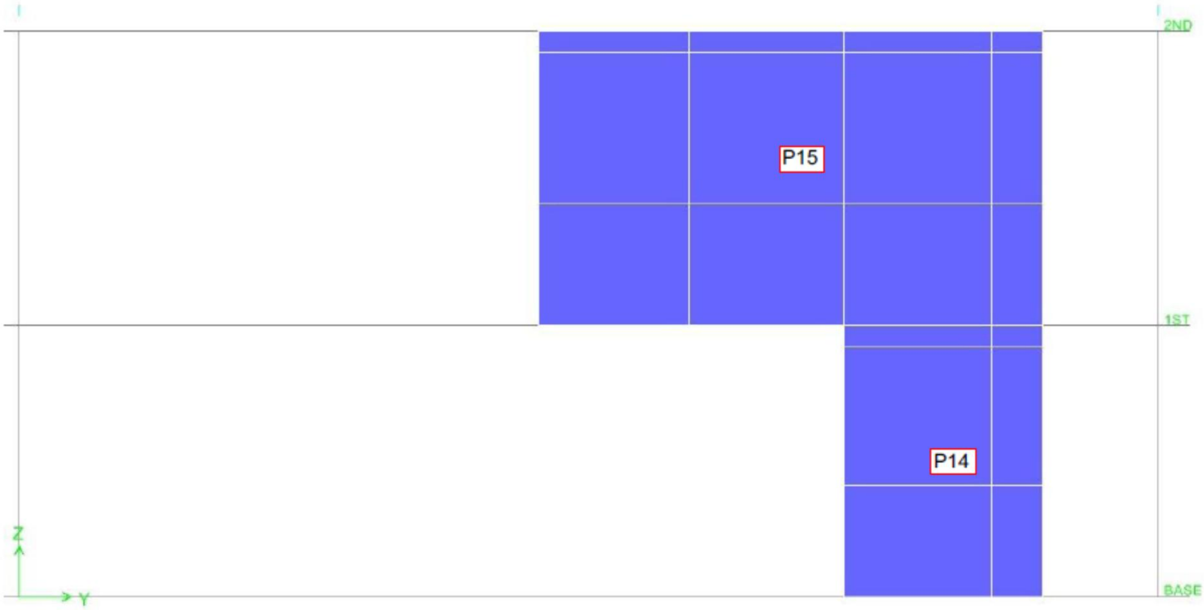
WALL AT GRID C



WALL AT GRIDLINE D


2ND
P26
1ST
P25
P24
WALL AT PARTITION
(BETWEEN GRIDLINE B AND C)
BASE

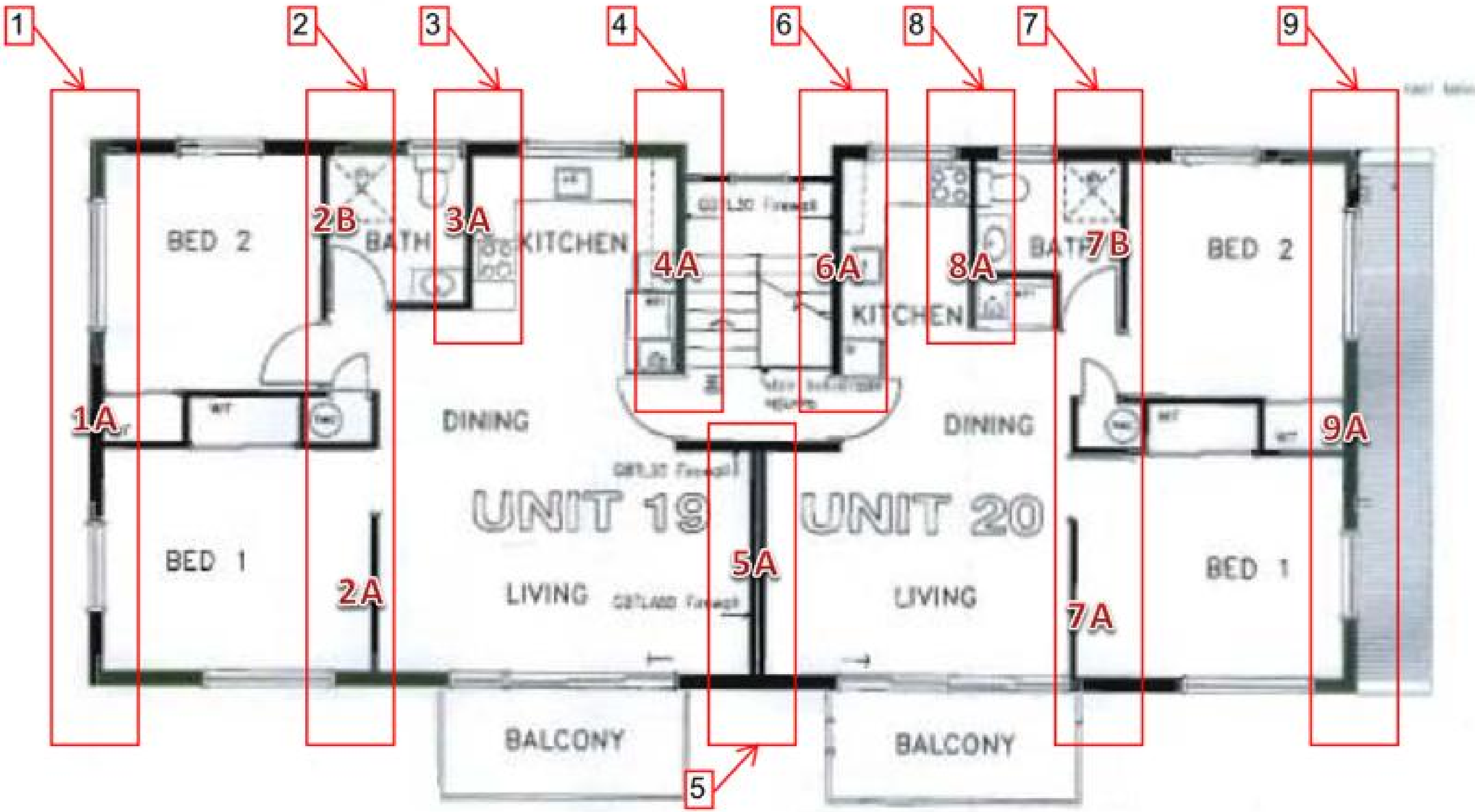

2ND
P20
P19
1ST
P18
WALL AT PARTITION
(BETWEEN GRIDLINE C AND D)
BASE



WALL AT PARTITION
(BETWEEN GRIDLINE A AND B)

Appendix E

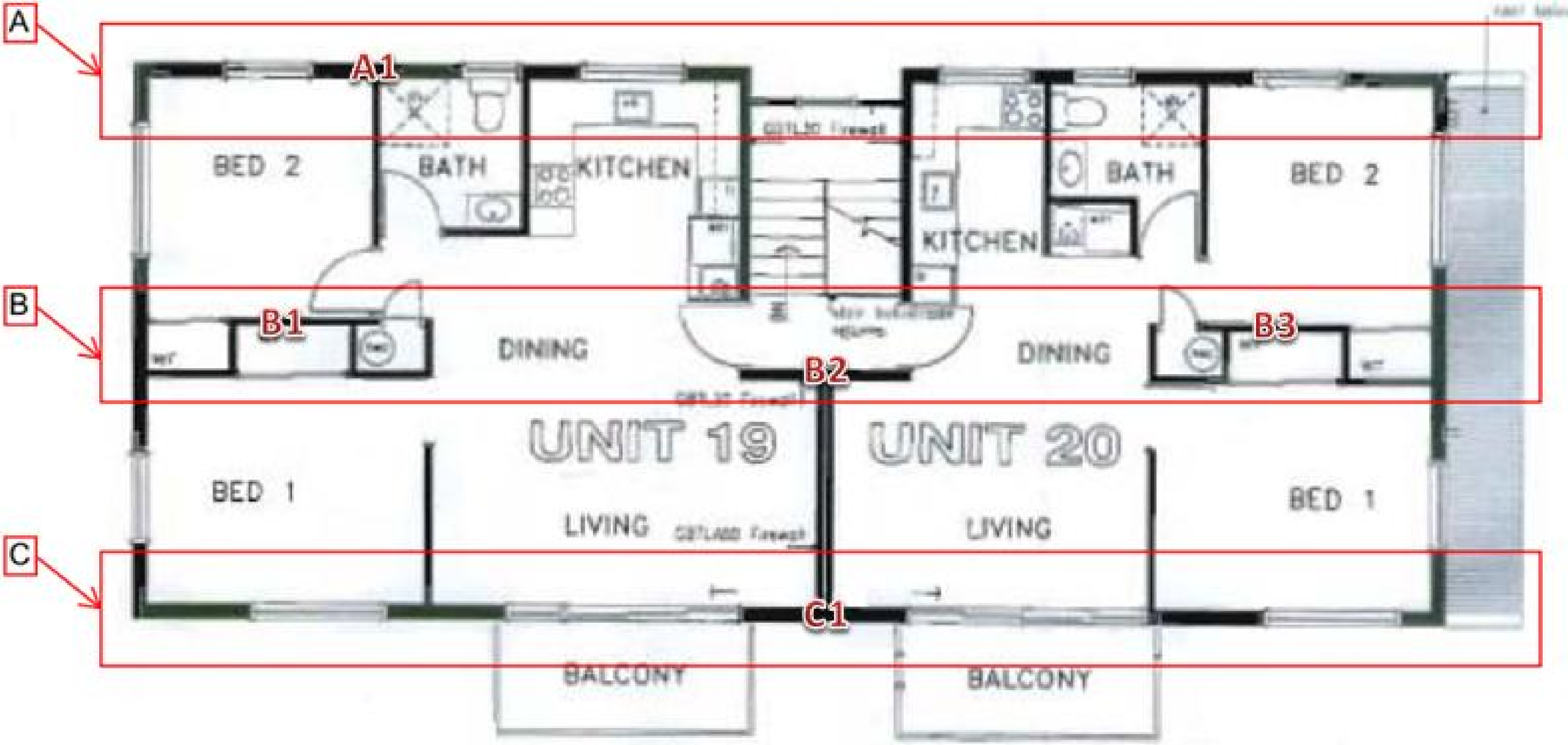
Key Drawings (Gloucester Courts Block C – South)



BLOCK E

SECOND FLOOR PLAN
WALL BRACING DESIGNATION - ACROSS

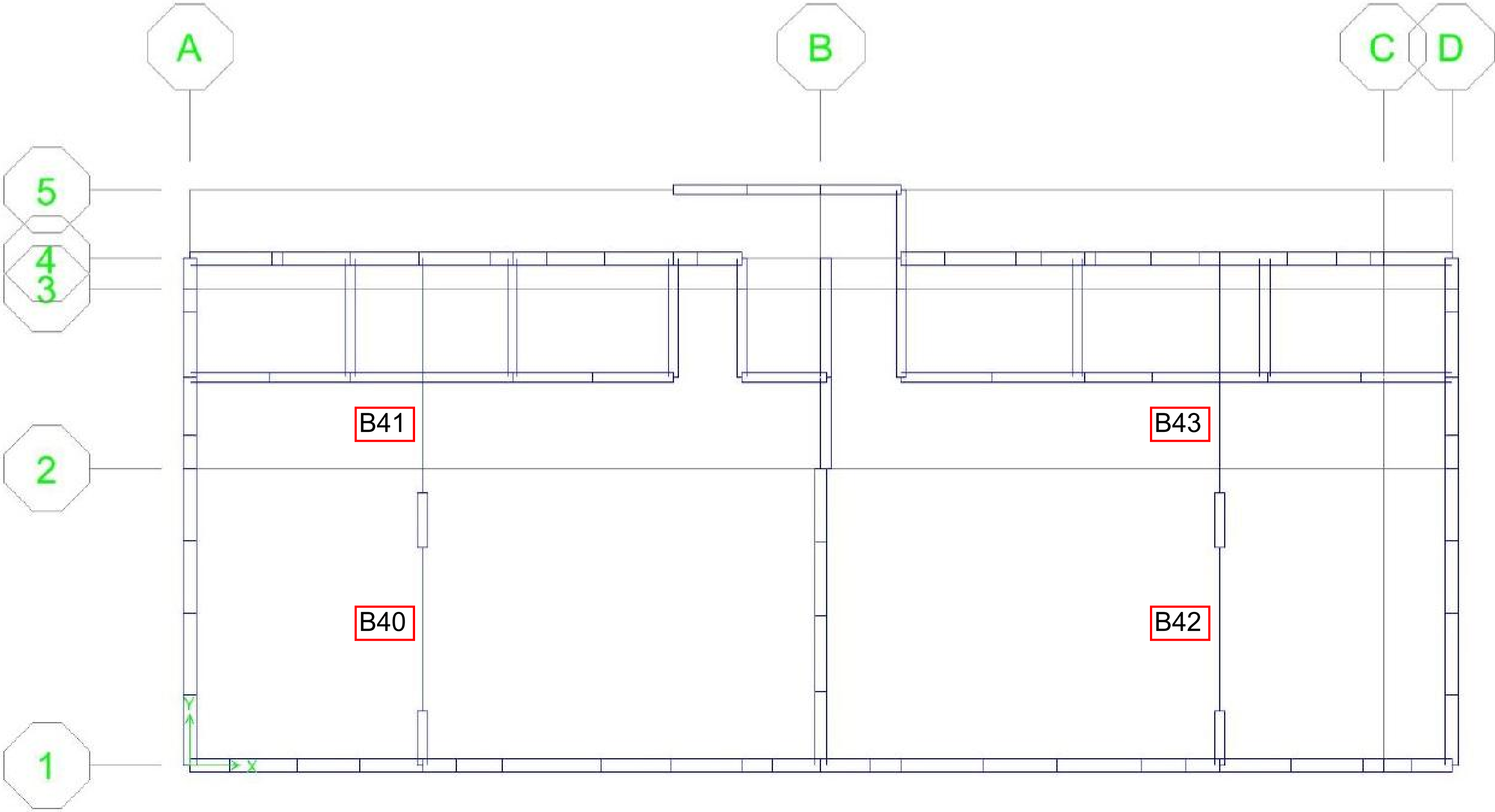
WALL LESS THAN 1.80M IN LENGTH NOT INCLUDED IN CALCULATIONS



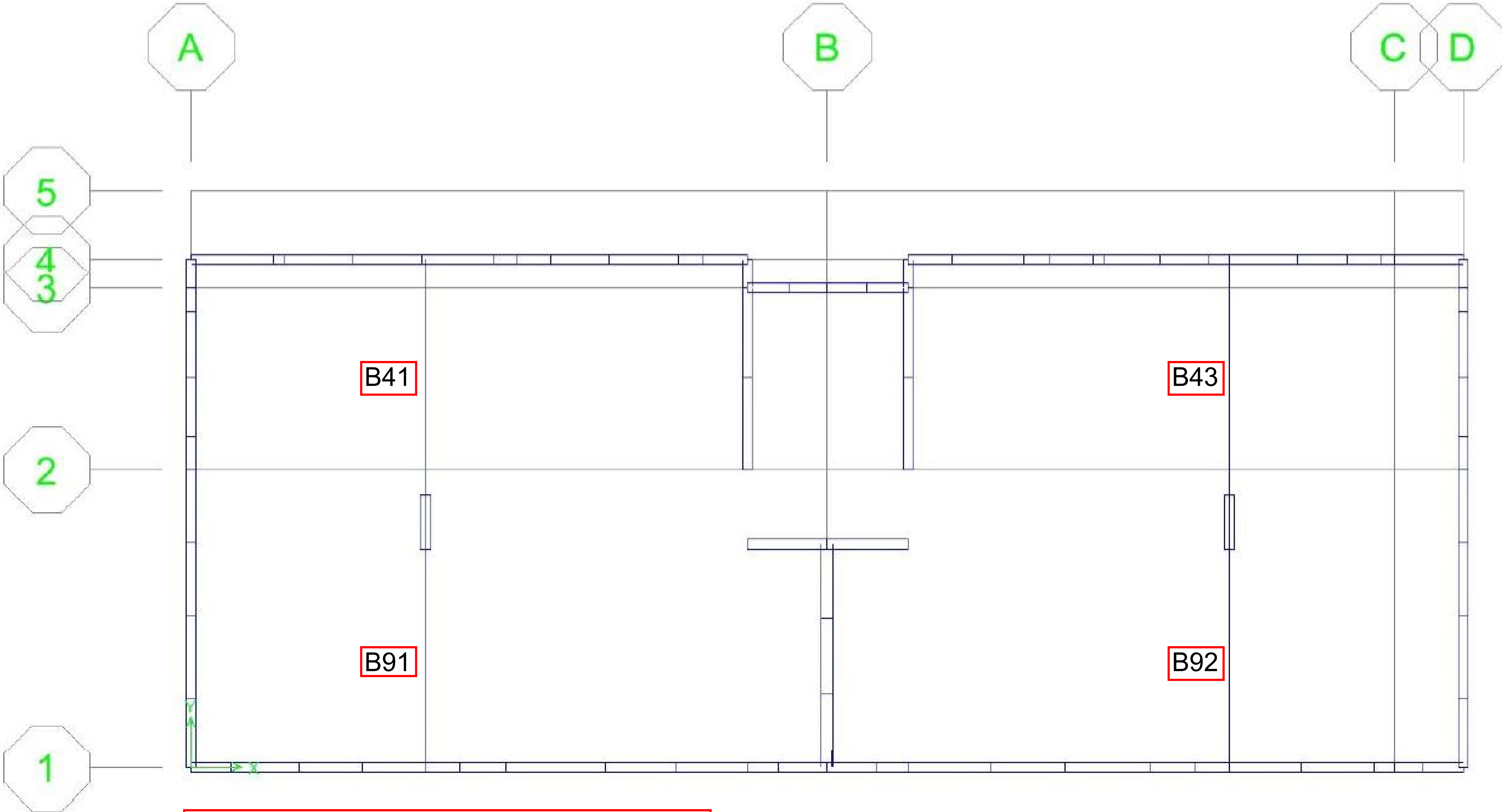
BLOCK E

SECOND FLOOR PLAN
WALL BRACING DESIGNATION - ALONG

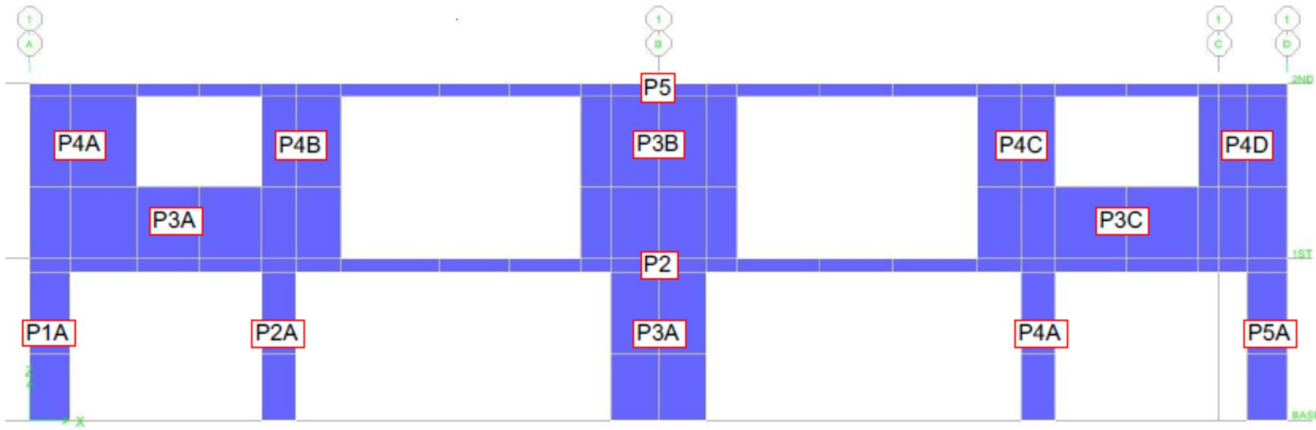
WALL LESS THAN 1.80M IN LENGTH NOT INCLUDED IN CALCULATIONS



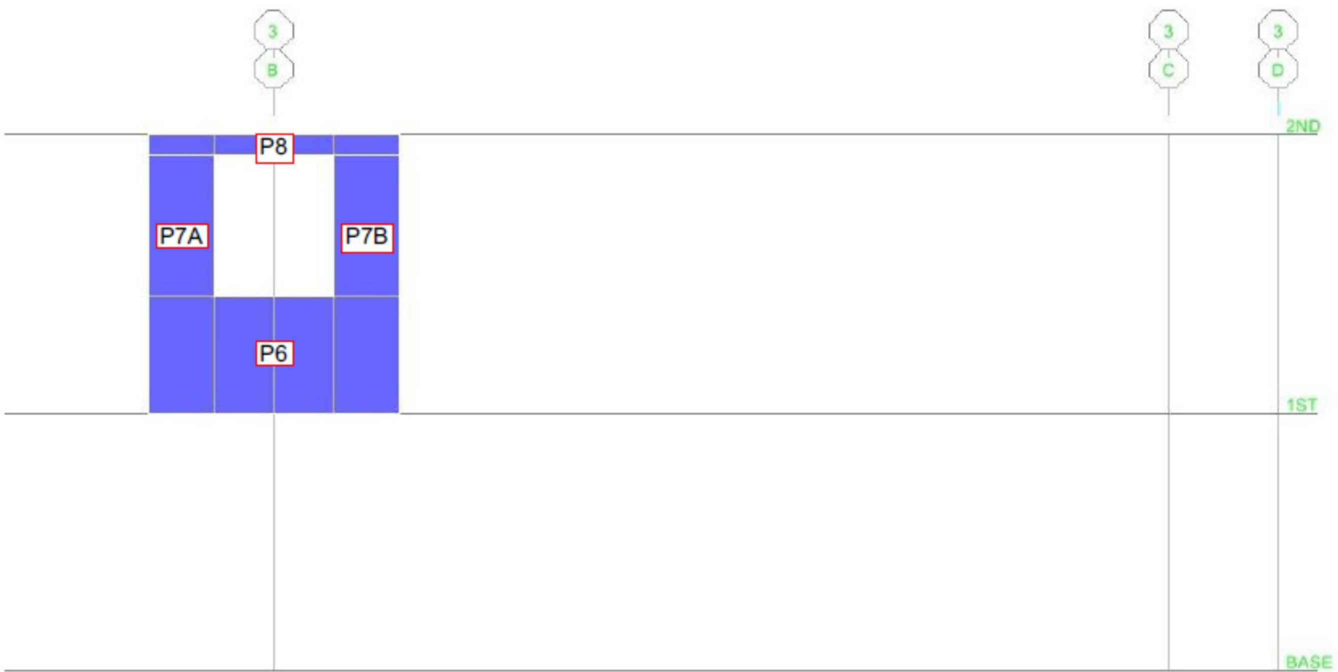
BEAMS AT FIRST FLOOR
GLUOCESTER COURT BLOCK B - SOUTH



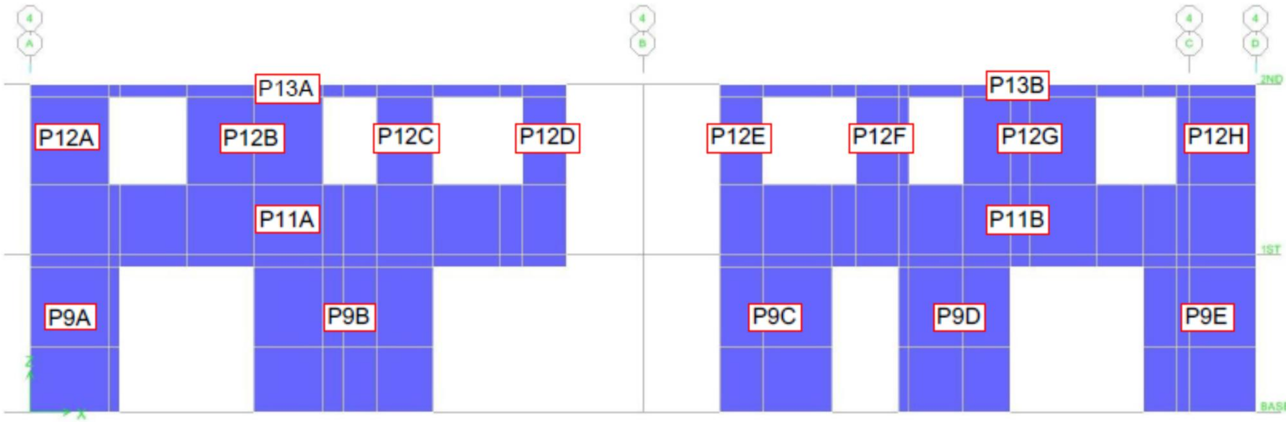
BEAMS AT SECOND FLOOR
GLUOCESTER COURT BLOCK B - SOUTH



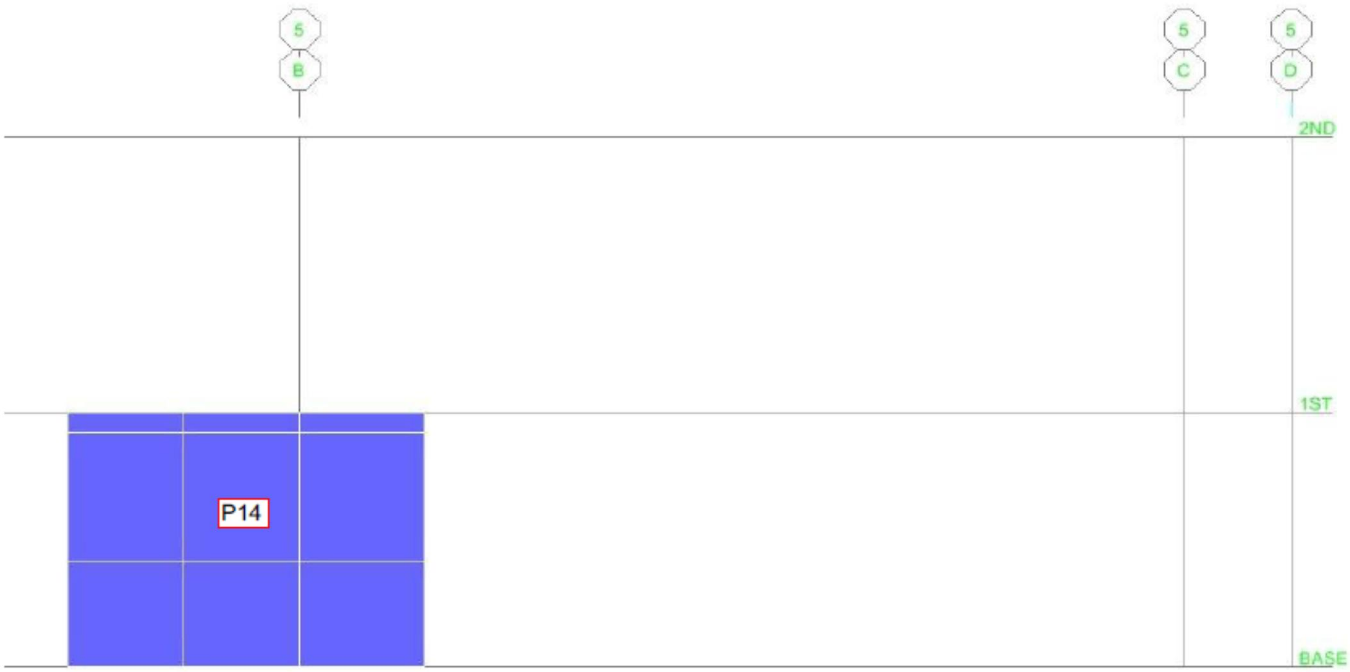
WALL AT GRIDLINE 1



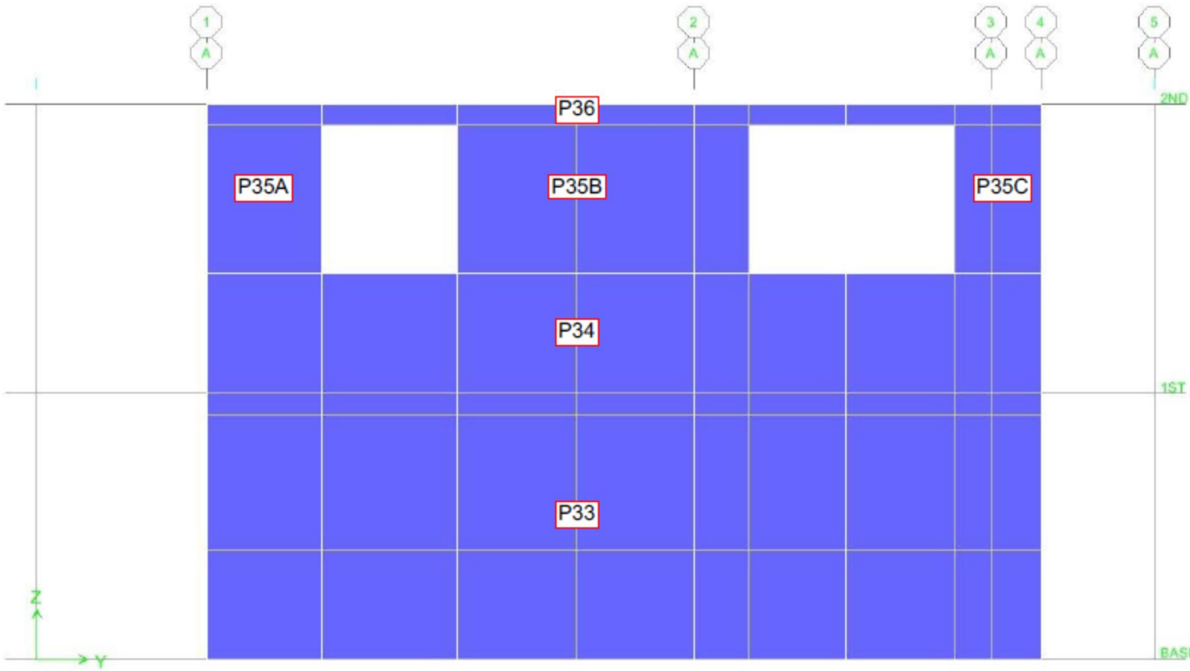
WALL AT GRID 3



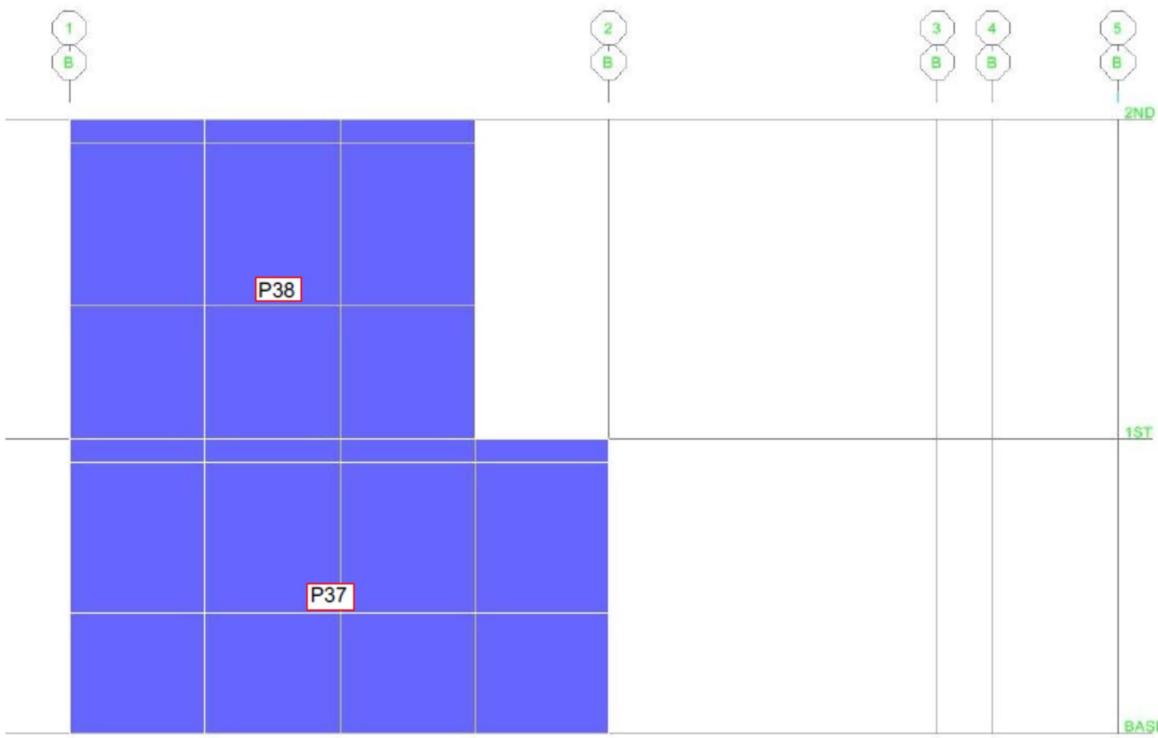
WALL AT GRIDLINE 4



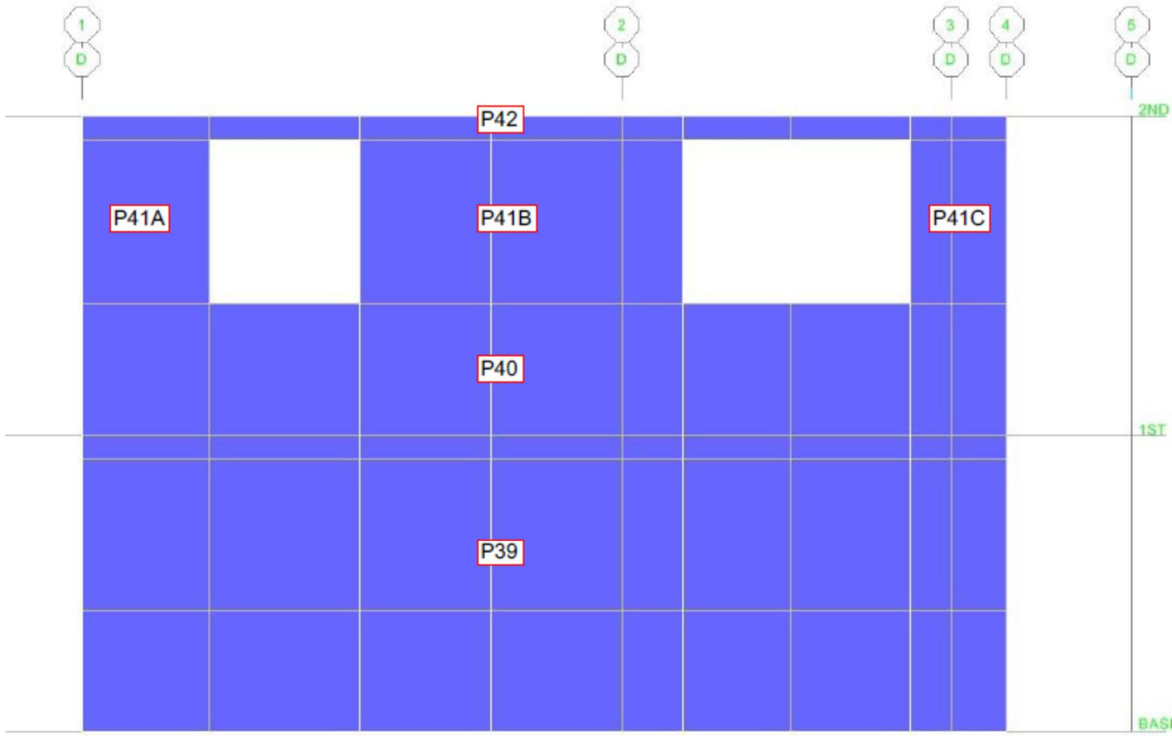
WALL AT GRIDLINE 5



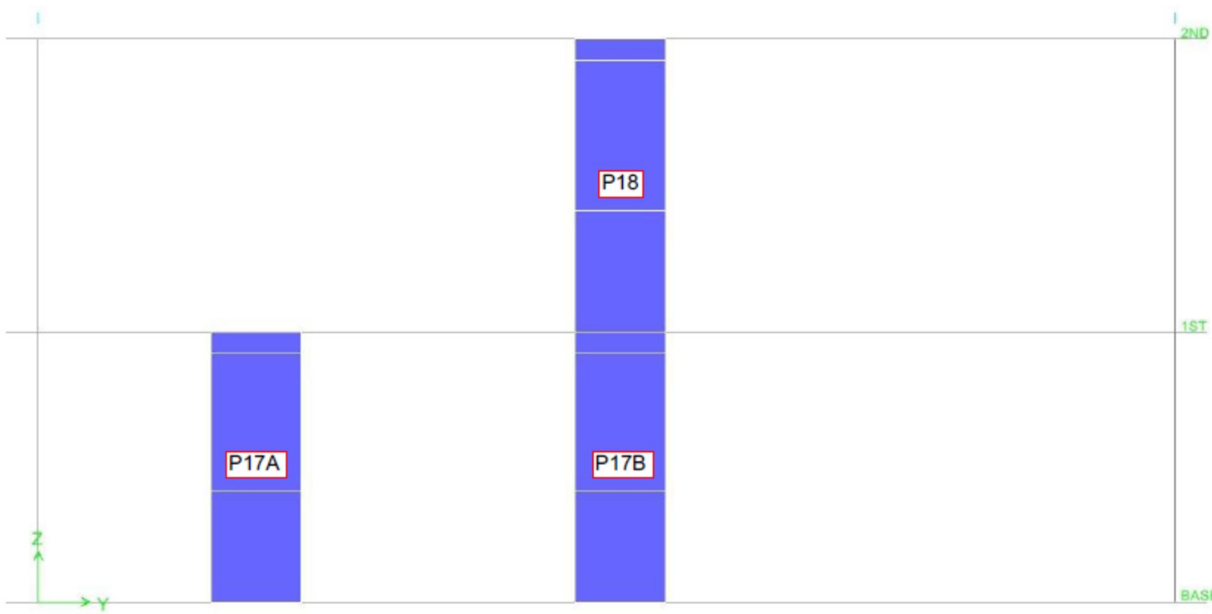
WALL AT GRIDLINE A



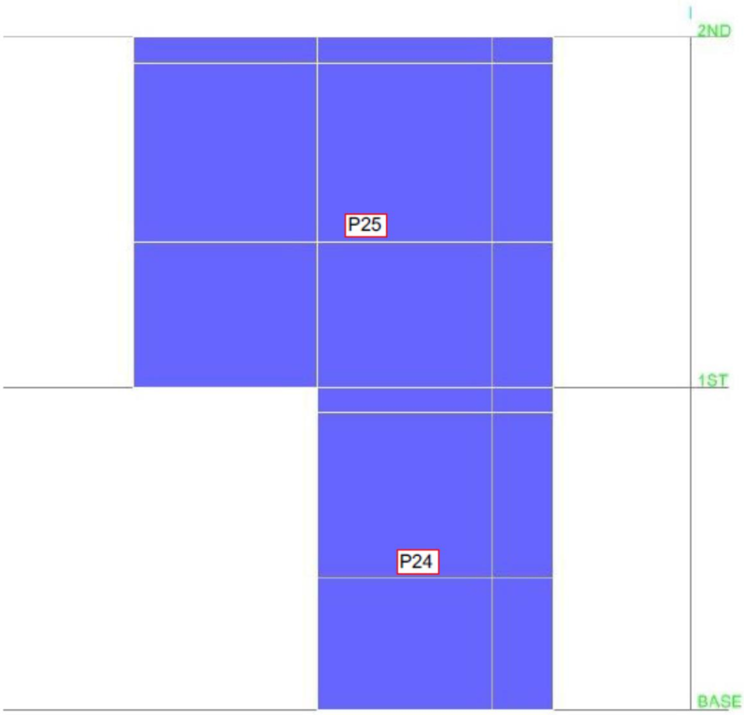
WALL AT GRIDLINE B



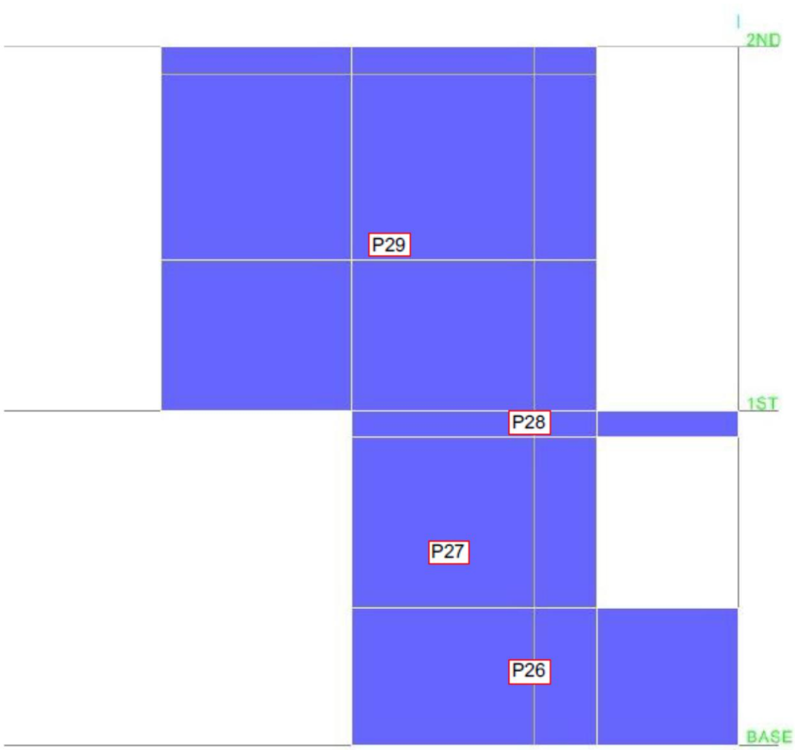
WALL AT GRIDLINE D



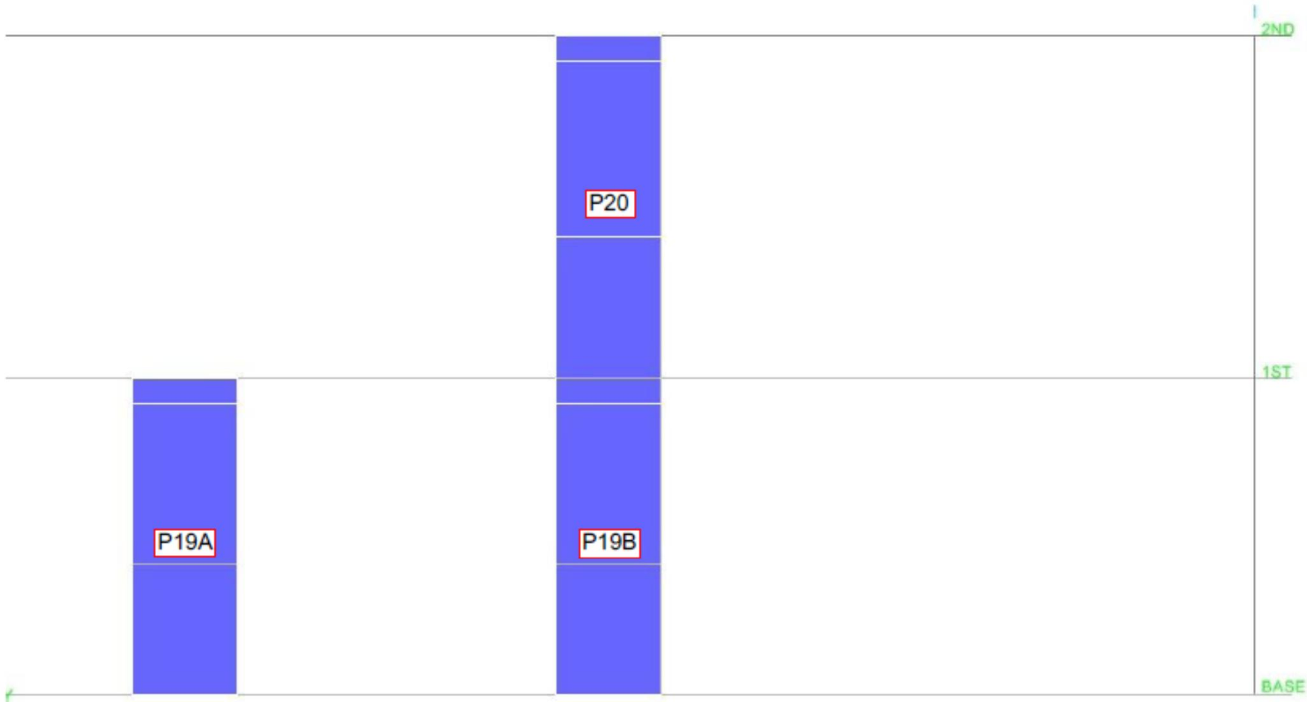
WALL AT PARTITION
(BETWEEN GRIDLINE A AND B)



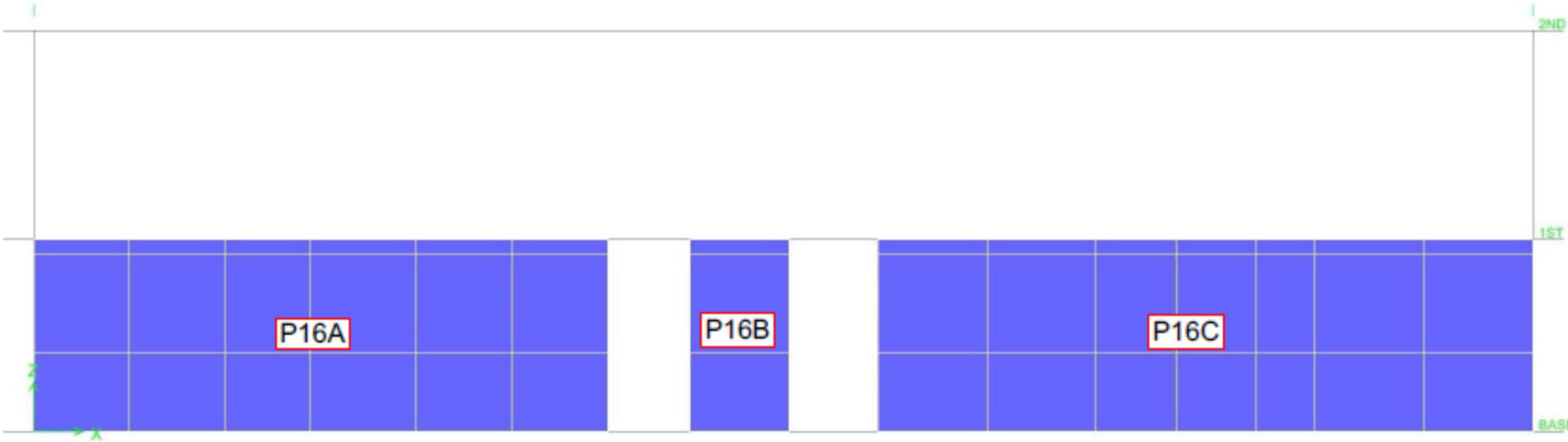
WALL AT PARTITION
(BETWEEN GRIDLINE A AND B)



WALL AT PARTITION
(BETWEEN GRIDLINE BA ND C)



WALL AT PARTITION
(BETWEEN GRIDLINE B AND C)



WALL AT PARTITION
(BETWEEN GRIDLINE 2 AND 3)

GHD

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Document Status

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