Brougham Village Blocks A to E
Detailed Engineering Evaluation
Quantitative Report

Christchurch City Council

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Detailed Engineering Evaluation Quantitative Report

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Brougham Village Blocks A to E
BU 1072-002 EQ2 to BU 1072-006 EQ2

Detailed Engineering Evaluation
Quantitative Report - SUMMARY
Version 4 - Final

356 to 400 Brougham Street, Sydenham, Christchurch

Background

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Brougham Village Blocks A to E, located at 356 to 400 Brougham Street, Sydenham, following the M6.3 Christchurch earthquake on 22 February 2011. The key outcome of this assessment was to ascertain the anticipated seismic performance of the structures and to compare their performance with current design standards. In addition, Opus was tasked with providing conceptual strengthening options to improve the building's seismic performance, with a target of meeting at least 67% of the new building standard (%NBS).

The structures under assessment have been grouped into three primary categories, namely:

- Single Storey Unit;
- 2-Storey Unit – Garage and Residential Units;
- 3-Storey Unit – Residential Units over external stairs

Key Damage Observed

Significant land damage has been observed on site including settlement of up to 100mm, lateral spread of 50mm+ and liquefaction sand boils. The land damage which has occurred on site has caused differential settlement of slab foundations, settlement of walls, and separation of wall joints between units. Significant cracking of reinforced concrete beams and slabs has occurred in the 3 storey sections of the complex.

Critical Structural Weaknesses

The following critical structural weaknesses have been identified:

- Diaphragm collector to lateral resistance system for the 3-storey units
- Land instability

A number of potential collapse hazards have also been highlighted within the document.

Indicative Building Strength

The findings of the assessment are:

Undamaged state

The seismic performance of the single storey unit has expected strength of 40%NBS and is not Earthquake Prone as defined by legislation. It is considered to be a Grade C - moderate risk structure in accordance with NZSEE guidelines.

The seismic performance of the 2-storey unit has an expected strength of 48%NBS and is not Earthquake Prone as defined by legislation. It is considered to be a Grade C - moderate risk structure in accordance with NZSEE guidelines.

The seismic performance of the 3-storey unit has an expected strength of 22%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade D - high risk structure in accordance with NZSEE guidelines.

Damaged state

The ratings provided in this report are based on the undamaged state of the structures. However, there has been significant ground movement in the area of Blocks A to E resulting in considerable differential settlement between units. The differential settlement has caused excessive cracking to occur between wall elements, has caused rotation at the base of a number of walls, has resulted in the failure of some connections between orthogonal walls and will have introduced additional forces into structural elements for which they have not been designed.

The seismic performance of a damaged single storey unit has expected strength of 25%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade D - high risk structure in accordance with NZSEE guidelines.

The seismic performance of a damaged 2-storey unit has an expected strength of 30%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade D - high risk structure in accordance with NZSEE guidelines.

The seismic performance of a damaged 3-storey unit has an expected strength of 14%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade E - high risk structure in accordance with NZSEE guidelines.

Where damage was considered severe enough to comprise the integrity of the affected structural elements it is our understanding that the relevant units have been closed – refer to Appendix E for identification of affected units.

The site, in general, is susceptible to future liquefaction and lateral spreading. Future liquefaction of foundations would cause further structural and non-structural damage. Due to the unpredictable effects of liquefaction, the reported building strength does not include a reduction factor for differential settlement induced forces.

Recommendations

The recommendations for the development include:

- A strengthening works concept scheme be developed to increase the seismic capacity of the single storey and 2-storey to at least 67% NBS; this will need to consider compliance with accessibility and fire requirements;
- The 3-storey units pose a potential collapse hazard. Currently, the lateral restraint to the upper two levels of the units is provided by the out-of-plane capacity of the upper storey and a single in-plane wall on the first floor. Failure of the lateral resisting system will result in a high risk of collapse of the upper storeys onto the surrounding properties. The potential hazard zone includes the residential units on either side of the 3-storey unit. Measures to mitigate against the potential hazard will have to be undertaken;
- A full level survey of the site be undertaken to aid any repair work that may be implemented;
- Several geotechnical investigations be undertaken to quantify the liquefaction potential of the site and determine the soil shallow bearing strength of the existing foundations.

Contents

1 Introduction

Opus International Consultants Limited has been engaged by Christchurch City Council (CCC) to undertake a detailed seismic assessment of the Brougham Village Blocks A to E, located at 356 to 400 Brougham Street, Sydenham, following the M6.3 Christchurch earthquake on 22 February 2011.

The purpose of the assessment is to determine if the buildings are classed as being Earthquake Prone as defined by legislation

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

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 to carry out a full structural survey before the building is re-occupied.

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

It is anticipated that a number of factors, including the following, will determine the extent of evaluation and strengthening level required:

1. The importance level and occupancy of the building.

2. The placard status and amount of damage.
3. The age and structural type of the building.
4. Consideration of any critical structural weaknesses.

Any building with a capacity of less than 34% of new building standard (including consideration of critical structural weaknesses) will need to be strengthened to a target of 67% as required by the CCC Earthquake Prone Building Policy.

2.2 Building Act

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

Section 112 - Alterations

This section requires that an existing building complies with the relevant sections of the Building Code to at least the extent that it did prior to the alteration.

This effectively means that a building cannot be weakened as a result of an alteration (including partial demolition).

Section 115 – Change of Use

This section requires that the territorial authority (in this case Christchurch City Council (CCC)) is satisfied that the building with a new use complies with the relevant sections of the Building Code ‘as near as is reasonably practicable’.

This is typically interpreted by CCC as being 67% of the strength of an equivalent new building. This is also the minimum level recommended by the New Zealand Society for Earthquake Engineering (NZSEE).

Section 121 – Dangerous Buildings

This section was extended by the Canterbury Earthquake (Building Act) Order 2010, and defines a building as dangerous if:

1. 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
2. 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
3. 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
4. There is a risk that other property could collapse or otherwise cause injury or death; or
5. 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 (EPB) if its ultimate capacity would be exceeded in a 'moderate earthquake' and it would be likely to collapse causing injury or death, or damage to other property.

A moderate earthquake is defined by the building regulations as one that would generate loads 33% of those used to design an equivalent new building.

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 on 4 September 2010.

The 2010 amendment includes the following:

1. A process for identifying, categorising and prioritising Earthquake Prone Buildings, commencing on 1 July 2012;
2. A strengthening target level of 67% of a new building for buildings that are Earthquake Prone;
3. A timeframe of 15-30 years for Earthquake Prone Buildings to be strengthened; and,
4. 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.

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.

On 19 May 2011, Compliance Document B1: Structure was amended to include increased seismic design requirements for Canterbury as follows:

- 36% increase in the basic seismic design load for Christchurch (Z factor increased from 0.22 to 0.3);
- Increased serviceability requirements.

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

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

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

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

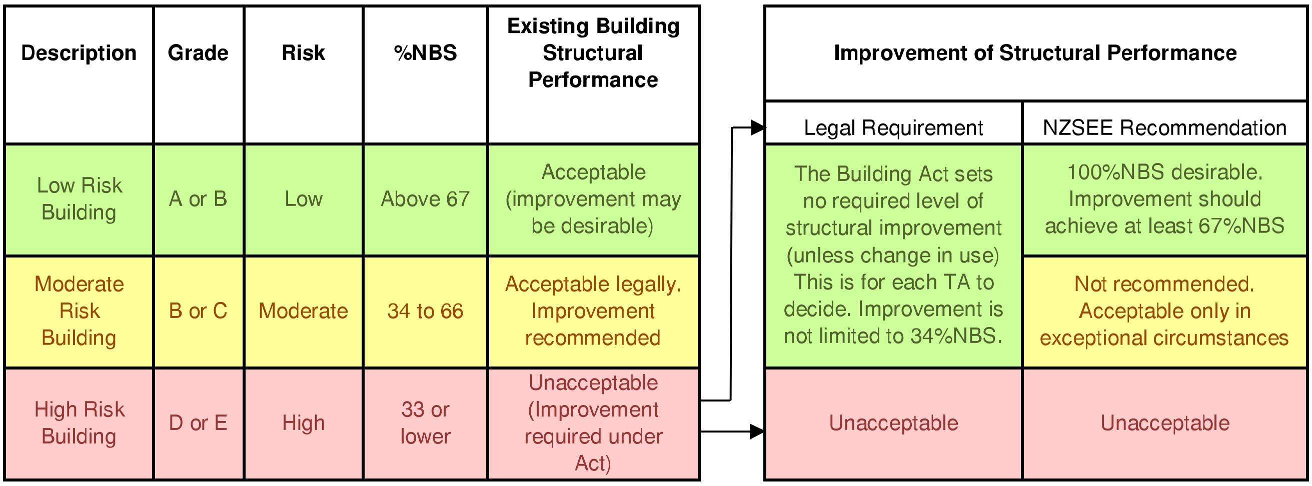
1.2 Ensuring that responsible steps are taken to minimise the risk of loss of life, injury or suffering which may result from your engineering activities, either directly or indirectly.

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

3 Earthquake Resistance Standards

For this assessment, the building's earthquake resistance is compared with the current New Zealand Building Code requirements for a new building constructed on the site. This is expressed as a percentage of new building standard (%NBS). The loadings are in accordance with the current earthquake loading standard NZS1170.5 [1].

A generally accepted classification of earthquake risk for existing buildings in terms of %NBS that has been proposed by the NZSEE 2006 [2] is presented in Figure 1 below.



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

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

Figure 3.1: NZSEE Risk Classifications Extracted from Table 2.2 of the NZSEE 2006 AISPBE Guidelines

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

Table 1: %NBS compared to relative risk of failure

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

3.1 Minimum and Recommended Standards

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

3.1.1 Occupancy

- The Canterbury Earthquake Order[1] in Council 16 September 2010, modified the meaning of "dangerous building" to include buildings that were identified as being EPB's. As a result of this, we would expect such a building would be issued with a Section 124 notice, by the Territorial Authority, or CERA acting on their behalf, once

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[1] This Order only applies to buildings within the Christchurch City, Selwyn District and Waimakariri District Councils authority

they are made aware of our assessment. Based on information received from CERA to date, this notice is likely to prohibit occupancy of the building (or parts thereof) until its seismic capacity is improved to the point that it is no longer considered an EPB.

3.1.2 Cordoning

- Where there is an overhead falling hazard, or potential collapse hazard of the building, the areas of concern should be cordoned off in accordance with current CERA/Christchurch City Council guidelines.

3.1.3 Strengthening

- Industry guidelines (NZSEE 2006 [2]) strongly recommend that every effort be made to achieve improvement to at least 67%NBS. A strengthening solution to anything less than 67%NBS would not provide an adequate reduction to the level of risk.

- It should be noted that full compliance with the current building code requires building strength of 100%NBS.

3.1.4 Our Ethical Obligation

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

4 Building Description

4.1 General

The Brougham Village Blocks A to E refers to the buildings located from 356 to 400 Brougham Street (Fig. 4.1). Blocks A to E refer to nine distinct sub-blocks which are structurally independent. The buildings, which were designed in 1977, are located along the north boundary of the Brougham Village complex. The buildings are a mix of tiered single storey units to the north, and 2 to 3 storey units to the south. Refer to Appendix E for location plans identifying the aforementioned blocks and the varying storey heights.

For the purposes of this report the structures have been separated into three primary building types, namely:

- Single storey unit;
- Garage with residential units above (2-storey);
- 3-storey residential unit.

The buildings are typically reinforced masonry construction with timber framed roofs. The roofs comprise pitched and flat roof areas. The two and three storey buildings have reinforced concrete intermediate floors. The ground level of the multi-level units house the garage and utility areas for the residents of the local sub-block. Local access points are provided in between the sub-blocks in the form of external concrete stairs founded at grade.

Each sub block is approximately 24m long in the north-south direction and 22m wide in the east-west direction.

The formation levels of the buildings have been constructed using cut and fill methods to form tiered levels up to 2m above existing ground level with engineered hardfill.

Figure 4.1: Brougham Village Blocks A-E

4.2 Gravity Load Resisting System

The pitched roof is clad in heavy clay tile, on Woodtex proprietary panels on exposed timber truss rafters. The flat roof areas are constructed using proprietary Woodtex panels on timber roof joists. The timber frame members are fixed to the reinforced masonry walls via bolted steel cleats. The two and three storey buildings have intermediate reinforced concrete floors which are tied into the reinforced masonry walls with specific reinforcement detailing.

The walls are reinforced concrete masonry with an approximate height of 2.25 - 2.4m throughout.

The walls are founded on narrow ground beam footings. The floor consists of an unreinforced concrete ground slab with local thickenings to cater for the masonry pier elements.

4.3 Seismic Force Resisting System

Seismic forces in both principal directions are resisted by the in-plane and out-of-plane capacity of the reinforced masonry walls. The single storey units lack a sufficient diaphragm and therefore lateral forces have been apportioned on a tributary area basis, assuming that timber roof joists act as collectors to a moderate extent.

The suspended slab floors are mesh reinforced concrete and are assumed to provide a rigid diaphragm which can distribute lateral forces to the wall bracing elements.

5 Survey

Copies of the following drawings were referred to as part of the assessment:

- A set of architectural and structural drawings by D A Cowey Associates. Registered Architects, titled “Brougham Street Urban Renewal 1. Stage 1”.

No copies of the design calculations have been obtained for this building.

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

6 Structural Damage

Typical damage to the buildings includes:

- Differential settlement of the slab foundations (Photo 5).
- Separation of the slab foundations at the interface with adjacent units (Photo 5).
- Settlement of walls and separation of walls at the interface with adjacent units (Photos 4 and 5).
- Cracking and displacement of concrete beams and suspended slab floors in the 2 to 3 storey sections (Photo 6).
- Separation of bond beams from top of reinforced masonry walls (Photo 4).
- Failure of wall due to excessive loading (Photo 10).
- Rotation of reinforced masonry piers to front of garage due to soil movement (Photos 8 and 9).

Surrounding Area Damage:

- Heaving due to ground movement – pavement cracking etc
- Lateral spread and settlement of built-up ground

7 General Observations

Blocks A through E have suffered significant damage primarily due to lateral spread, liquefaction and differential settlement of the land. The extent of damage varies along the site with slight land damage at the extreme west end of the site which increases through the centre and east of the site. Refer to Appendix E – Site Damage Plan for general overview of damaged and evacuated structures.

The sub-blocks to the east of the area under consideration have suffered significant structural damage, in particular the 2 and 3-storey units. Damage to the 2 and 3 storey sections includes the simply supported floor slabs moving off their supporting walls due to wall rotation, the reinforced masonry walls failing due to excess loading, and the masonry piers rotating due to settlement and ground movement.

The sub-blocks to the west of the area under consideration have suffered less significant structural damage, but it is expected that were they subject to the same settlement issues as the eastern end a similar pattern of damage would be observed.

8 Detailed Seismic Assessment

8.1 Critical Structural Weaknesses

As outlined in the Critical Structural Weakness and Collapse Hazards draft briefing document, issued by the Structural Engineering Society (SESOC) on 7 May 2011, the term 'Critical Structural Weakness' (CSW) refers to a component of a building that could contribute to increased levels of damage or cause premature collapse of the building.

We have identified the following Critical Structural Weaknesses in Blocks A to E:

- Diaphragm collector to lateral resistance system for the 3-storey units – The lateral resistance in the east-west direction of the 3-storey units is limited by the capacity of the collector element to transfer the load to the shear wall. The collector element consists of 2 no. 12mm dia bars from the shear wall bond beam which extend into the concrete floor diaphragm. The failure of the collector element in tension may cause premature failure of the upper storey walls due to out-of-plane motion.

- Land instability – It has been noted that the built-up areas of the site have suffered from lateral spreading, which has resulted in amplified settlements occurring to particular areas, most notably the east end of Blocks A to E.

8.2 Potential Structural Hazards

The following are potential structural hazards which have been identified in the structure. The nature of a structural hazard is to cause localised failure and damage but not influence the structure beyond the immediate area.

- Inadequate precast slab bearing lengths – From the movement observed on site it appears that the simply supported precast slab elements, which span over the external staircases to form the first floor of the 3-storey units, have insufficient bearing length. A number of post-completion installed angles were observed on site which is sufficient in resolving the issue. Where the angles have not been installed and the slabs have pulled away from the supporting wall there is a high risk of collapse. It was noted on site that a number of these occurrences were addressed with temporary propping.

- Inadequate foundations – The foundations to the walls of the single storey and 2-storey units are narrow strip footings typically 160-190mm wide. The effect of such narrow foundations is to dramatically increase the possibility of shear failure of the soils local to the foundations, resulting in excessive settlements and the introduction of forces to the frame for which it was not designed.

- Brittle construction - Site observed inadequate filling of masonry wall cells may result in the premature failure of affected reinforced masonry shear walls due to brittle behaviour of non-grouted masonry blocks.
- First floor slab cantilever – There are a number of locations where the first floor slab cantilevers beyond the final pier of a unit, it proceeds to step back and forms a re-entrant corner before bearing onto the next pier support. Whilst additional reinforcement has been provided in this area, site observation indicates that the slabs have insufficient capacity to cater for the loads applied during a seismic event.

8.3 Seismic Coefficient Parameters

The seismic design parameters based on current design requirements from NZS1170.5:2004 and the NZBC clause B1 for this building are:

- Site soil class D, clause 3.1.3 NZS 1170.5:2004;
- Site hazard factor, Z = 0.3, B1/VM1 clause 2.2.14B;
- Return period factor R_u = 1.0 from Table 3.5, NZS 1170.5:2004, for an Importance Level 2 structure with a 50 year design life;
- μ_{max} = 2.0 for reinforced masonry walls to 2-storey and 3-storey units – due to detailing and construction practices;
- μ = 1.25 for reinforced masonry walls to single storey units;
- All units have been assessed using the equivalent static method as outlined in NZS 1170.5 – 2004.

8.4 Detailed Seismic Assessment Results

Blocks A to E consist of 9 sub-blocks each typically comprising four single storey units and a garage structure with two residential units above. Located in the area between the sub-block units and over the external stairwell is the 3-storey unit (the stairwell is considered as one floor).

There are 3 primary building types assessed in this report. These are:

- Single storey unit;
- Garage with residential units above;
- 3-storey residential unit.

A summary of the structural performance of the buildings are shown in the following tables. Note that the values given represent the worst performing elements in the building, as these effectively define the building's capacity. Other elements within the building may have significantly greater capacity when compared with the governing element.

Figure 8.1 provides a reference plan at ground floor level for a typical sub-block. The structural performance tables reference the wall numbers for the single storey structure and the wall line numbers for the garage unit.

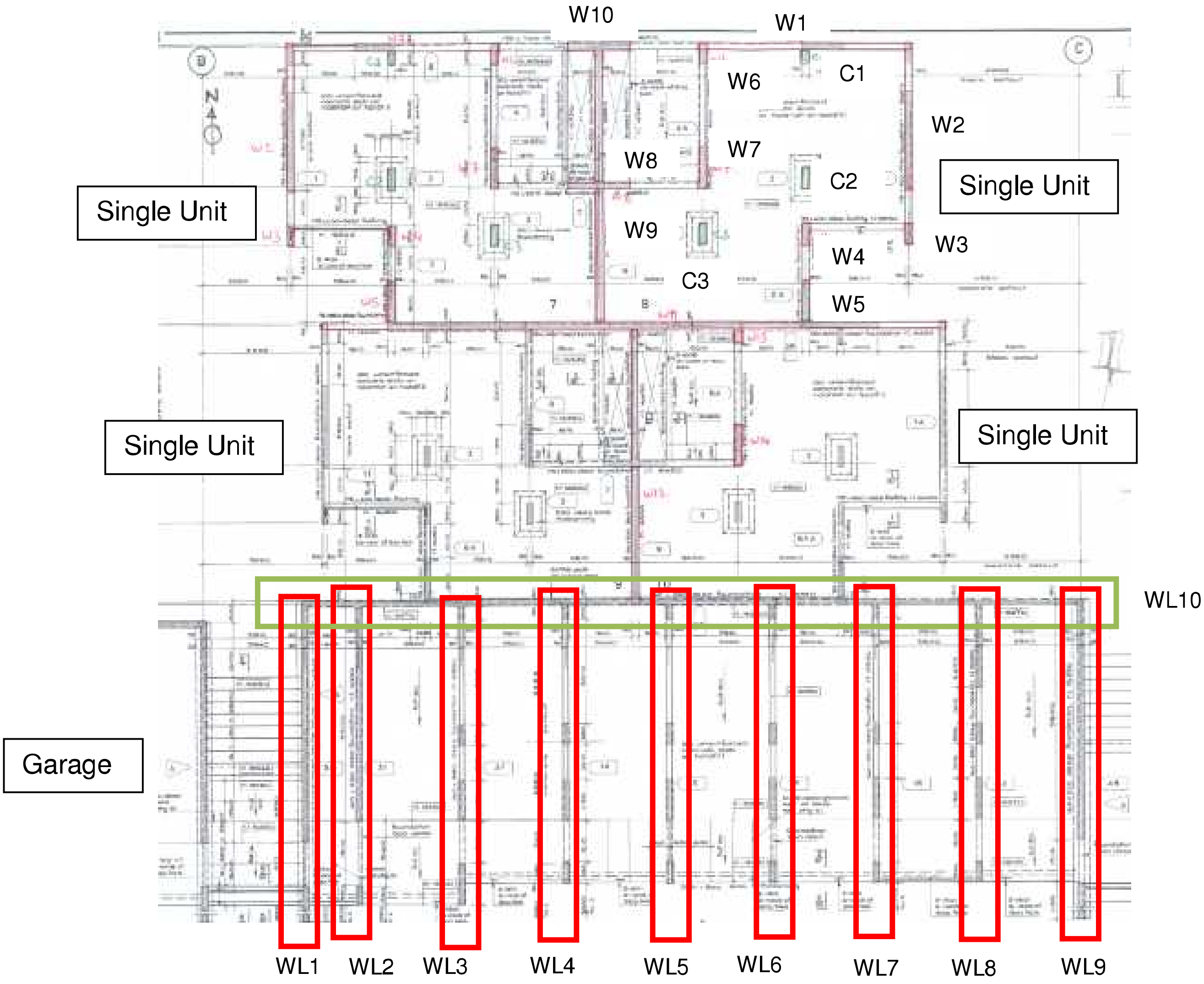

Figure 8.1: Sub-Block Ground Floor Reference Plan

8.4.1 Single Storey Unit Assessment Methodology

With the lack of a flexible or rigid roof diaphragm the single storey unit has been assessed on the basis of tributary area loading. The walls have been assessed in the two primary orthogonal directions. The timber joists have been utilised as collector elements where the connection details and capacity of the sections allow.

Table 2: Summary of Seismic Performance – Single Storey Unit

Structural Element/System	**Failure mode and description of limiting criteria**	**% NBS based on calculated capacity**
Reinforced masonry Wall W1	In-plane Bending Capacity of wall	47%
Reinforced masonry Wall W2	Out-of-plane Bending Capacity of wall	40%
Reinforced masonry Walls W3 & W4	Out-of-plane Bending Capacity of wall	86%
Reinforced masonry Wall W6	In-plane Bending Capacity of wall	52%
Reinforced masonry Wall W7	Out-of-plane Bending Capacity of wall	87%
Reinforced masonry Pier C2	In-plane Bending Capacity of pier	78%

8.4.2 Two Storey Unit Assessment Methodology

The 2-storey unit has been assessed in the two primary orthogonal directions. The following is a brief description of the methodology adopted for each direction.

North-South:

Due to the lack of a flexible or rigid roof diaphragm the first floor structure loads are assigned at the first floor level and are distributed with the lower level loads through the first floor slab diaphragm to the walls on a relative stiffness basis. The torsional effects resulting from the application of the 10% eccentricity of load and the 30% of seismic load applied in the orthogonal direction, in accordance with NZS1170.5, have been allowed for.

East-West:

Due to the lack of a flexible or rigid roof diaphragm the first floor structure loads are assigned at the first floor level and are distributed with the lower level loads through the first floor slab diaphragm to the walls on a relative stiffness basis. The torsional effects resulting from the application of the 10% eccentricity of load and the 30% of seismic load applied in the orthogonal direction, in accordance with NZS1170.5, have been allowed for. This results in large in-plane loads to the walls spanning in the north-south direction. The walls are assessed based the resultant loadings.

Table 3: Summary of Seismic Performance – 2-Storey Unit

Structural Element/System	**Failure mode and description of limiting criteria**	**% NBS based on calculated capacity**
NORTH - SOUTH DIRECTION		
Reinforced masonry Wall	In-plane Bending Capacity of primary shear wall	85%
EAST - WEST DIRECTION		
Reinforced masonry Wall Line W10	In-plane Shear Capacity of wall	<100%
FIRST FLOOR DIAPHRAGM		
Reinforced Concrete Diaphragm	Diaphragm – Deep Beam Check	96%
Reinforced Concrete Diaphragm	Shear Capacity of wall and slab interface in transfer of horizontal loadings – North-South direction	48%
Reinforced Concrete Diaphragm	Shear Capacity of wall and slab interface in transfer of horizontal loadings – East-West direction	83%

8.4.3 Three Storey Unit Assessment Methodology

The 3-storey unit has been assessed in the two primary orthogonal directions. The following is a brief description of the methodology adopted for each direction.

North-South:

Due to symmetrical layout in the north-south direction the equivalent static loads are assigned evenly between the two shear wall elements.

East-West:

There is a lack of shear walls on the upper floor in the east-west direction; therefore the orthogonal walls are assessed for out-of-plane loading. The sole shear wall on the first floor is hence heavily loaded and an assessment of the wall capacity has been undertaken.

Table 4: Summary of Seismic Performance – 3-Storey Unit

Structural Element/System	**Failure mode and description of limiting criteria**	**% NBS based on calculated capacity**
NORTH - SOUTH DIRECTION		
Reinforced masonry Wall – Full height	In-plane Bending and Shear Capacity of wall	>100%
EAST - WEST DIRECTION		
Reinforced masonry Wall – 2nd Floor	Out-of-plane Bending Capacity of 2nd floor wall	22%

Reinforced masonry Wall – 1st Floor	Capacity of connection of wall to floor diaphragm	49%

8.5 Discussion of Results

As per the approach in Section 8.4 the discussion of the results is addressed in three sections. The results outlined in the previous section are an assessment of the structure in an undamaged state.

A) Single Storey Units

The assessment has assumed the timber joists have the capacity to transfer lateral loads and that the wall footings possess some base capacity against out-of-plane rotation. The calculated seismic capacity of the structure is 40% NBS, which is limited by the lowest capacity of a laterally loaded wall. The lack of a roof diaphragm and hence the isolated nature of the walls results in the calculated %NBS values being specific to each wall as detailed in Table 2.

In addition to the calculated capacities, the site has sustained extensive damage due to the underlying soil issues. A number of walls have separated from orthogonal walls, noticeable differential settlement has occurred between units and bond beams have suffered localised damage around connection points. This may result in a reduction of the calculated capacity of the affected walls.

The seismic performance of a damaged single storey unit has expected strength of 25%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade D – high risk structure in accordance with NZSEE guidelines.

B) 2-Storey Units

The assessment of the structure in its undamaged state provides calculated capacity of 48% NBS. This capacity is limited by the out-of-plane bending capacity of the upper storey shear walls.

The settlement which has occurred around Blocks A to E has exacerbated the calculated weaknesses and introduced further issues arising from localised heave and/or settlement of the ground resulting in the rotation of a number of masonry piers, the loss of bearing to the edge of the precast floors over the external stairwells and the addition of loading to various structural elements.

The seismic performance of a damaged 2-storey unit has an expected strength of 30%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade D - high risk structure in accordance with NZSEE guidelines.

C) 3-Storey Units

The 3-storey units pose a potential collapse hazard. Currently, the lateral restraint to the upper two levels of the units is provided by the out-of-plane capacity of the upper storey and a single in-plane wall on the first floor. Failure of the lateral resisting system will result in a high risk of collapse of the upper storeys onto the surrounding properties. The potential hazard zone includes the residential units on either side of the 3-storey unit

The settlement which has occurred around Blocks A to E has exacerbated the calculated weaknesses and introduced further issues arising from localised heave and/or settlement of the ground resulting in additional loading to the various structural elements.

The seismic performance of a damaged 3-storey unit has an expected strength of 14%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade E - high risk structure in accordance with NZSEE guidelines.

8.6 Limitations and Assumptions in Results

Our analysis is based on a quantitative assessment of the building in its undamaged state. The damage observed on-site to structural elements has been considered qualitatively in this report as it difficult to accurately quantify, as a %NBS, the detrimental effect of this damage. Where damage was considered severe enough to comprise the integrity of the affected structural elements it is our understanding that the relevant units have already been closed. There may have been additional damage to the buildings that was unable to be observed during assessments that could cause the capacity of the buildings to be reduced; therefore the current capacity of the buildings may be lower than that stated.

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

- Simplifications made in the analysis, including boundary conditions such as foundation fixity;
- Assessments of material strengths based on limited drawings, specifications and site inspections;
- The normal variation in material properties which change from batch to batch;
- Approximations made in the assessment of the capacity of each element, especially when considering the post-yield behaviour.

9 Geotechnical Assessment

9.1 Introduction

This section summarises the findings of a Geotechnical Desk Study and Site Walkovers completed on 10 May 2011 and 26 July 2012. The purpose of this desk study is to provide an initial appraisal of the suitability of the land and the future bearing capacity, in accordance with CCC email request of 18 April 2011.

9.2 Ground Conditions

A desk study of geotechnical investigations in the area from Environment Canterbury and EQC identified four logs and five CPT tests within 200m of the site, refer to Location Plan Appendix A. Drill Hole M36/0964, drilled in 1899, was performed adjacent to Unit 402 Brougham Street.

A geological cross-section completed by EQC has been identified adjacent to the site along Brougham Street.

The borehole records, CPT test results and the geological cross-section are included in Appendix A.

The geological cross-section summarises the ground conditions in the area, which are Silty SAND from surface to a depth of 5m below ground level (bgl); SAND and GRAVEL to 7.5m bgl; Sandy GRAVEL to a depth of 11m bgl; Sandy SILT to a depth of 12m bgl; Gravelly SAND to a depth of 23.5m bgl and Sandy GRAVEL to a depth of 27.5m bgl.

The sloping ground, as indicated by the as built drawings is man-made. A specification for the hardfill material that comprises the sloping ground indicates that well graded, face-cut pitrun with a maximum grain size of 75mm has been used in conjunction with a crushed, “no fines” fill with a size range of 25mm and 40mm.

9.3 Ground Damage and Ground Induced Building Damage

As-built drawings have been provided and indicate that the foundation system for the Brougham Village is strip footings to varying depths between 250mm and 700mm bgl. The floor slab is unreinforced concrete, varying in thickness between 100mm and 250mm.

An inspection of an open excavation adjacent to Unit 396 identified that the hardfill is not face-cut, and is sub-rounded to rounded in nature with a maximum size of 100mm, refer to photographs.

No signs of foundation subsidence were observed. A maximum of 50mm to 100mm of horizontal and vertical displacement was observed in the tiled areas around units 356 to 400 Brougham Street, refer to photographs in Appendix D. The land movement has generally been downslope towards Brougham Street.

A number of units located at 356 – 400 Brougham Street have suffered significant structural damage, particularly the section of structure supporting the third storey. In contrast, there appears to be no structural damage to units 95 and 97 Hastings Street East. There has been significant damage to the buried services throughout the site.

There is evidence of moderate liquefaction throughout the site. Surface disruption and ground heave up to 100mm vertically was recorded at two locations on the asphalt driveway and also a service trench to the north of Unit 402.

It was recommended in May 2011 that the ground floor slabs within all the garages are checked for subsidence and liquefaction. Also the foundations for the 4 units at 131 Hastings Street East should be inspected as unit 2 was yellow stickered due to severe liquefaction. These proposed ground investigations have not yet been undertaken.

9.4 Liquefaction Hazard

The 2003 ECAN Liquefaction study[2] indicates Brougham Village as having a moderate to high liquefaction potential under high groundwater conditions. Based on a low groundwater table, ground damage is expected to be moderate, subsidence likely to be between 100mm and 300mm.

No liquefaction was reported following the Darfield Earthquake of 4 September 2010.

Liquefaction was identified on site following both the 22 February 2011 and 13 June 2011 earthquake events, by both road observations and interpretation of aerial photos by Tonkin & Taylor[3]. The liquefaction identified was stated as moderate to severe.

Brougham Village is bounded by residential properties to the east, south and west that are located in the CERA "green" zone. The "green" zone has been further categorised into technical categories by the Department of Building and Housing (DBH). This site is bounded by both "Technical Category 2" (TC2) and "Technical Category 3" (TC3) sites. The DBH technical categories are guidelines for residential foundations, however are likely to be used as a guideline by the Christchurch City Council for building consent. TC2 identifies the area may be subject to minor to moderate land damage from liquefaction in future large earthquakes, whilst TC3 identifies the area may be subject to moderate to significant land damage from liquefaction in future large earthquakes.

9.5 Appraisal

In summary, minimal damage to building foundations has occurred as a result of liquefaction following the 22 February 2011 earthquake. The slab on grade and shallow foundations appear to have performed adequately with only minor damage being reported.

The site is comprised of imported fill material that slopes gently towards Brougham Street. The sloped ground profile has caused lateral spreading of the fill material on top of a liquefied soil layer. This is evident from cracks in the ground between buildings at the north-eastern corner of the site and indicates approximately 50mm of lateral movement. There

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[2] ECan, The Solid Facts on Christchurch Liquefaction

[3] Project Orbit, 2011, Interagency/Organisation Collaboration Portal for Christchurch Recovery Effort, http://canterburyrecovery.projectorbit.com/sitepages/home/aspx

are no streams or open watercourses within close proximity of the site that enhance the risk of lateral spreading.

GNS Science[4] indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the 4 September 2010 earthquake. Recent advice (Geonet) indicates there is a 14% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. It is expected that the probability of occurrence is likely to decrease with time, following periods of reduced seismic activity. However, similar ground damage to that experienced in February 2011 could re-occur if a future earthquake generated similar or greater intensity ground shaking at this site.

This report has identified a significant risk that liquefaction will occur again in the life of the buildings. This risk could be quantified with additional analysis to provide a risk based assessment of the expected future performance of the land.

9.6 Proposed Geotechnical Investigations

It is recommended that as a minimum, the following geotechnical inspections are undertaken for the repair of the buildings.

- Inspect the ground floor slabs within all the Garages for units 356 to 400, to check for subsidence and liquefaction damage;
- Excavate and inspect foundations in key areas to confirm there has been no damage or ground disruption;
- Undertake a Level Survey of the buildings.

To determine the liquefaction potential of the site in future earthquakes and to identify the Technical Category of the site, the following site investigations (across the entire Brougham Village site) are recommended:

- 12 static Cone Penetration Tests (CPT) to confirm liquefaction potential.
- 2 boreholes to a depth of about 25m, with Standard Penetration Tests at 1.5m depth intervals, and install piezometer to monitor groundwater level.
- Assessment and reporting.

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[4] GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury- quakes/aftershocks/ updated on 9 July 2012.

10 Remedial Options

The buildings require strengthening, with a target of increasing the seismic performance to as near as practicable to 100%NBS, and to at least 67%NBS. Our concept strengthening scheme to achieve this would include:

- Addressing the issues with single storey units:
    - Repair all minor cracks using appropriate methods – epoxy grout injection techniques etc.;
    - Where walls have experienced major cracking and have evidently lost their structural integrity as indicated on a damage plan (to be provided by the Engineer), break out affected areas and replace to the Engineers specification;
    - Where indicated on the damage plan (to be provided by the Engineer), install adequate fixing between the north-south spanning walls which intersect the primary east-west spanning north elevation wall of the 2-storey unit to eliminate the out-of-plane issues with the walls;
    - Where differential or excessive settlement has occurred between adjacent walls, remove wall sections, break out foundations and replace with newly built footings on suitable bearing strata;
    - To increase the bracing capacity of the units install a diaphragm in the roof structure to eliminate the effect of out-of-plane bending on the walls.
- Addressing the issues with the 2-storey units:
    - Repair all minor cracks using appropriate methods – epoxy grout injection techniques etc.;
    - Where walls have experienced major cracking and yielding of reinforcement, break out affected areas and replace to the Engineers specification;
    - Where differential or excessive settlement has occurred between adjacent walls, remove wall sections, break out foundations and replace with newly built footings on suitable bearing strata;
    - To increase the bracing capacity of the units install a diaphragm in the roof structure to eliminate the effect of out-of-plane bending on the walls.
    - Install a permanent corner support to the cantilevering slab area;
- Addressing the issues with the 3-storey units:
    - There is a potential hazard posed by the 3-storey units. To mitigate the hazard a strengthening scheme will have to be developed to increase the capacity of the east-west lateral restraint system. Additional shear walls and load paths to the foundations maybe required to facilitate this requirement. Following an appraisal by a Quantity Surveyor it may be the case that it is more economically viable to remove the units
- Addressing the issues with the foundations:

- Locally, excessive settlement may occur as a result of the narrow existing footings when subject to the full seismic induced lateral loads. Where excessive settlement has occurred under affected shear walls it may be pertinent to upgrade the footings by widening the footing base to the Engineers specification.

  Globally, the lateral spread has resulted in an amplification of the expected damage to the structures. It is expected that ground improvement measures and building re-levelling will be required to rectify the settlement issues encountered.

- A full geotechnical investigation of the site should be undertaken to determine the full extent of the lateral spread and differential settlement and to provide sufficient information to enable any strengthening works that will be required.

11 Conclusions

The seismic performance of an undamaged single storey unit has an expected strength of 40%NBS. The seismic performance of a damaged single storey unit has an expected strength of 25%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade D - high risk structure in accordance with NZSEE guidelines.

The seismic performance of the 2-storey unit has an expected strength of 48%NBS. The seismic performance of a damaged 2-storey unit has an expected strength of 30%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade D - high risk structure in accordance with NZSEE guidelines.

The seismic performance of the 3-storey unit has an expected strength of 22%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade D - high risk structure in accordance with NZSEE guidelines. The seismic performance of a damaged 3-storey unit has an expected strength of 14%NBS and is Earthquake Prone as defined by legislation. It is considered to be a Grade E - high risk structure in accordance with NZSEE guidelines.

There has been significant ground movement in the area of Blocks A to E. The foundations to the structure are typically narrow strip footings which have not performed satisfactorily and the resulting differential settlement between units has significantly increased the expected level of damage.

There is a significant risk that liquefaction will occur again in the life of the buildings.

12 Recommendations

All the recommendations are subject to the assumptions made during the quantitative assessment being qualified. The following recommendations are provided:

a) Occupancy of the buildings should be reviewed based on the increased risk of failure of the buildings as outlined in the conclusions;

b) The strengthening works concept scheme be further developed to increase the seismic capacity of the single storey and 2-storey to at least 67% NBS; this will need to consider compliance with accessibility and fire requirements;

c) There is a potential hazard posed by the 3-storey units. To mitigate the hazard a strengthening scheme will have to be developed to increase the capacity of the east-west lateral restraint system. Following an appraisal by a Quantity Surveyor it may be the case that it is more economically viable to remove the units;

d) Several geotechnical investigations be undertaken to quantify the liquefaction potential of the site and determine the soil shallow bearing strength of the existing foundations.

13 Limitations

a) This report is based on an inspection of the structure with a focus on the damage sustained from the 22 February 2011 Canterbury Earthquake and aftershocks only. Some non-structural damage is mentioned but this is not intended to be a comprehensive list of non-structural items.

b) Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at the time.

c) This report is prepared for the CCC to assist with assessing remedial works required for council buildings and facilities. It is not intended for any other party or purpose.

14 References

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

[2] NZSEE: 2006, *Assessment and improvement of the structural performance of buildings in earthquakes,* New Zealand Society for Earthquake Engineering.

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

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

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

Appendix A – Photographs

Photo 1: West elevation of block A

Photo 2: South elevation of block A

Photo 3: View of a typical 3 storey section of building

Photo 4: 50mm settlement of a masonry wall 4 at the interface with adjacent unit

Photo 5: 60mm settlement with 40mm lateral displacement of slab and wall at the interface with adjacent unit

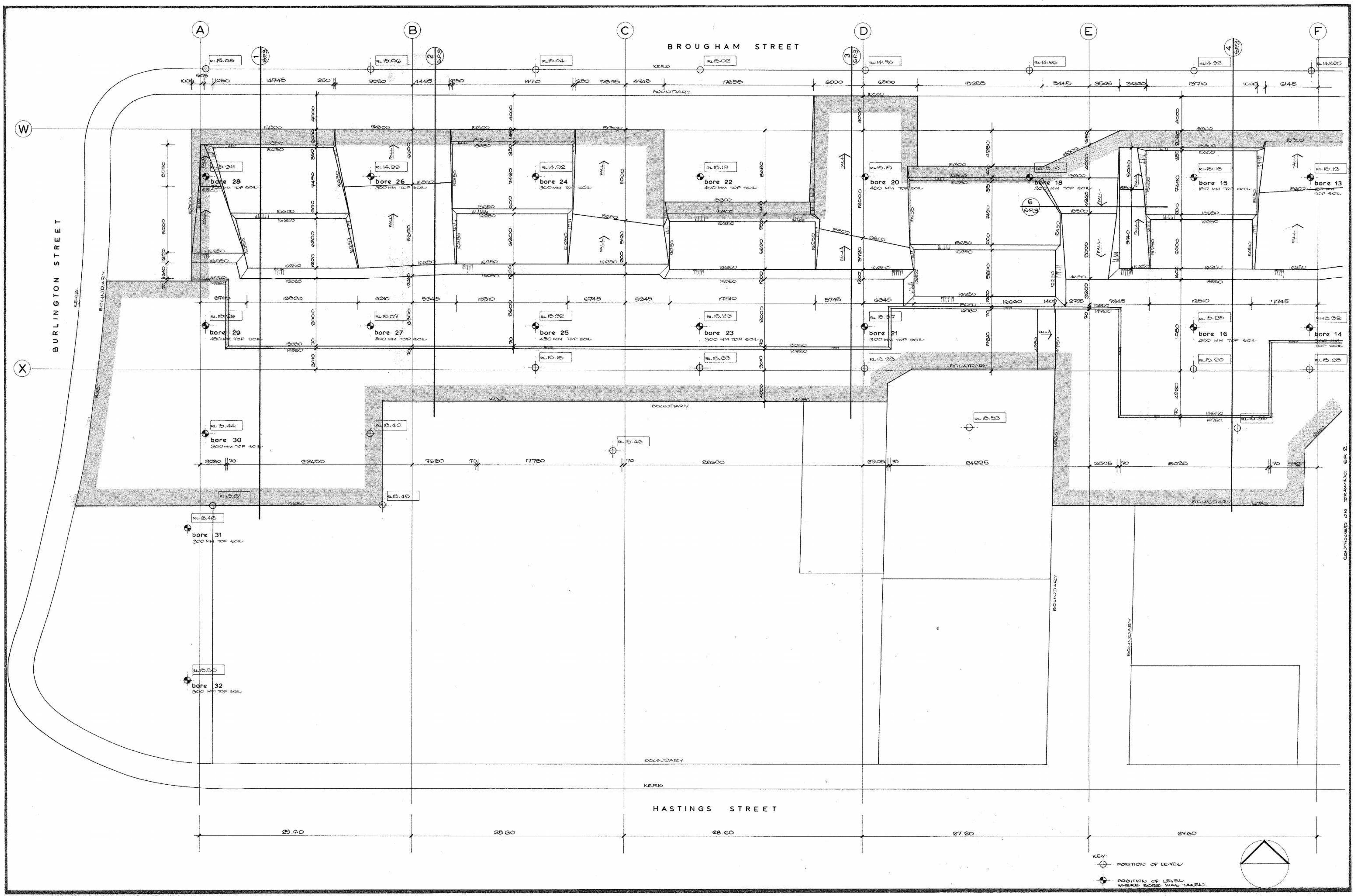
Photo 6: Cracking of suspended slab

Photo 7: Unfilled concrete masonry void

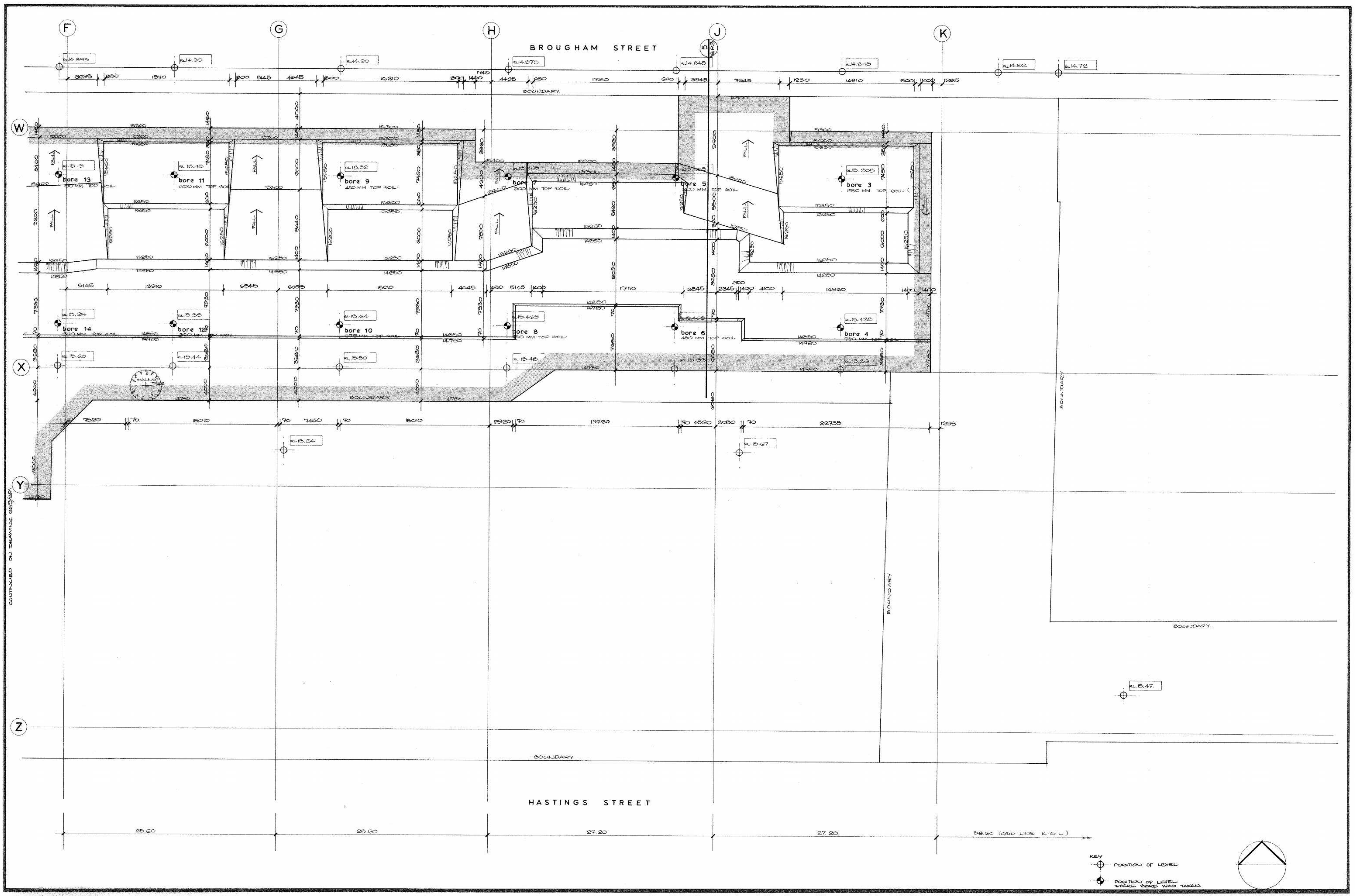
Photo 8 and 9: Masonry piers out of plumb due to differential settlement and lateral spread

Photo 10: Failure of wall cover concrete due to excess loading

Appendix B – Floor Plan



D A COWEY ASSOCIATES REGISTERED ARCHITECTS CHRISTCHURCH	HOLMES WOOD POOLE & JOHNSTONE CONSULTING ENGINEERS CHRISTCHURCH	BROUGHAM STREET — URBAN RENEWAL 1 — STAGE 1	DESIGN	SCALES	DATE	SITE PREPARATION (1)	FILE	DRAWING
			DRN : M.C.J. TRD : M.C.J. CHD : APD :	1 : 200	July 75	CONTRACTOR SHALL VERIFY ALL DIMENSIONS BEFORE STARTING WORK	629	S.P1



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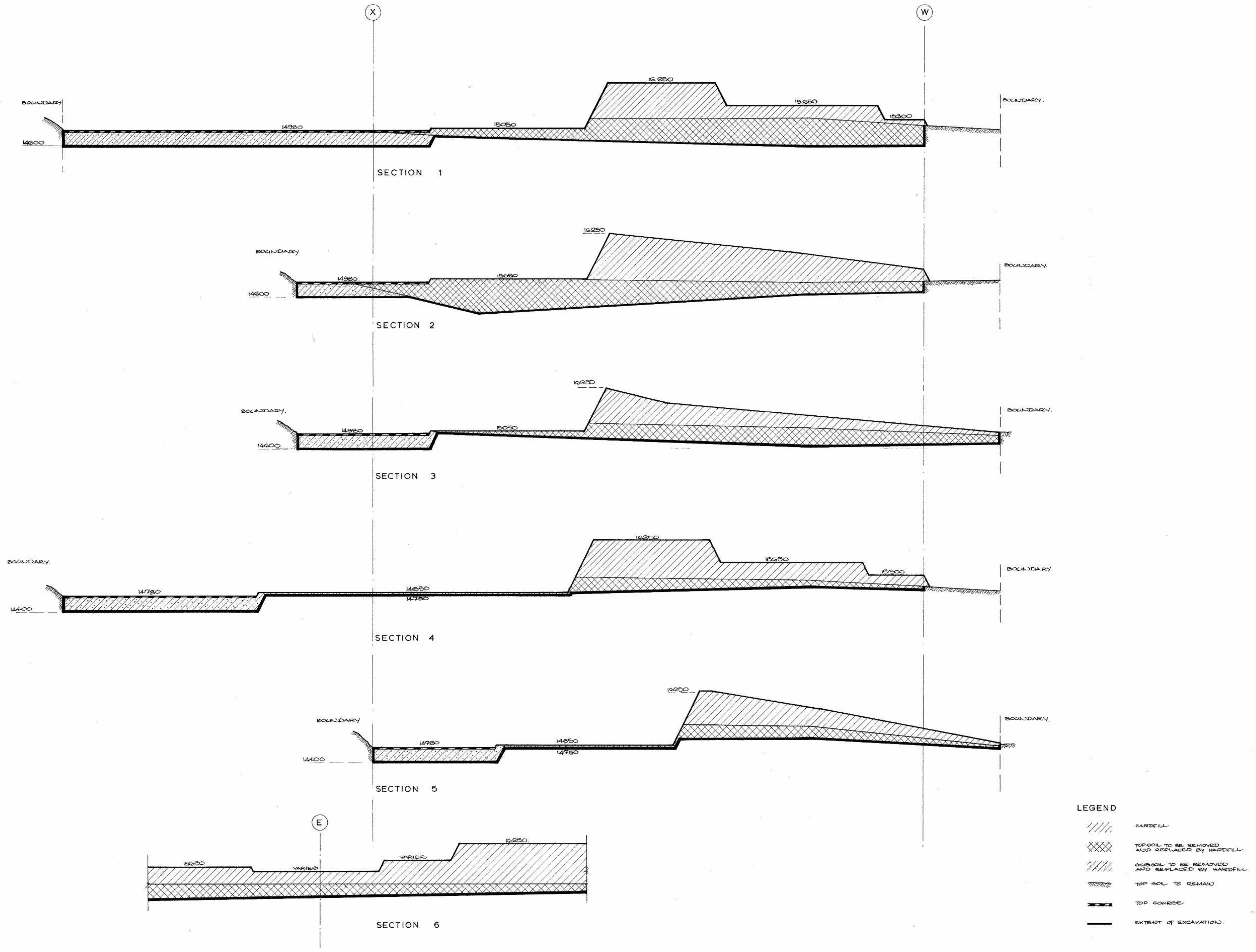
CHRISTCHURCH

HOLMES WOOD POOLE
& JOHNSTONE
CONSULTING ENGINEERS
CHRISTCHURCH

BROUGHAM STREET — URBAN RENEWAL 1 — STAGE 1

DESIGN	SCALES	DATE		FILE	DRAWING
DRN : M.C.J. TRD : M.C.J. CHD : APD :	1 : 200	JULY '75	SITE PREPARATION (2)	629	S.P. 2

CONTRACTOR SHALL VERIFY ALL DIMENSIONS BEFORE STARTING WORK



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CHRISTCHURCH

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& JOHNSTONE
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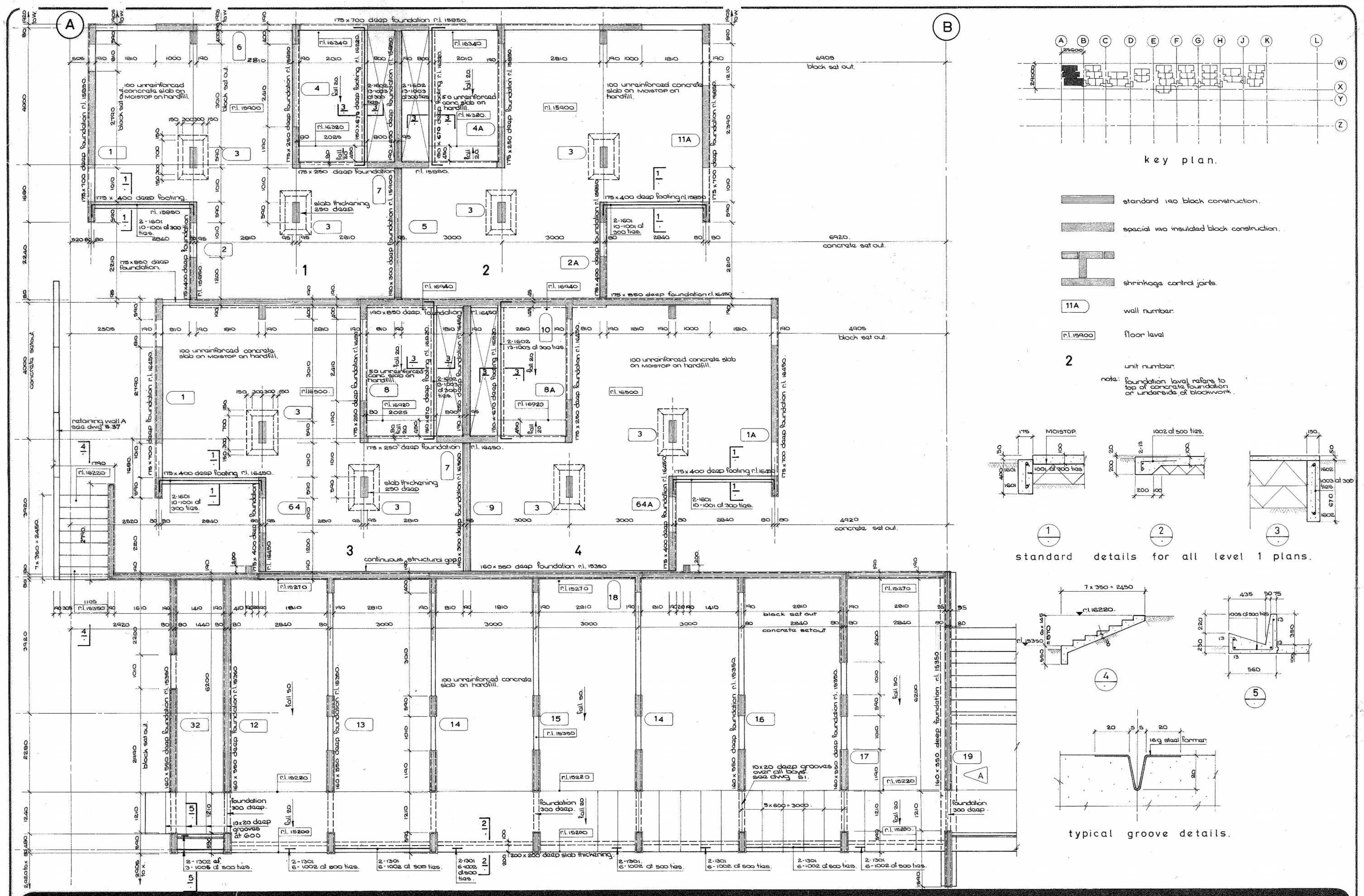
DESIGN	SCALES	DATE
DRN : M.C.J. TRD : M.C.J. CHD : P.E.B. APD : R.G.P.	HORIZONTAL 1 : 100 VERTICAL 1 : 50.	JULY '75.

SITE PREPARATION - SECTIONS

FILE	DRAWING
629	S.P. 3

CONTRACTOR SHALL VERIFY ALL DIMENSIONS BEFORE STARTING WORK



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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

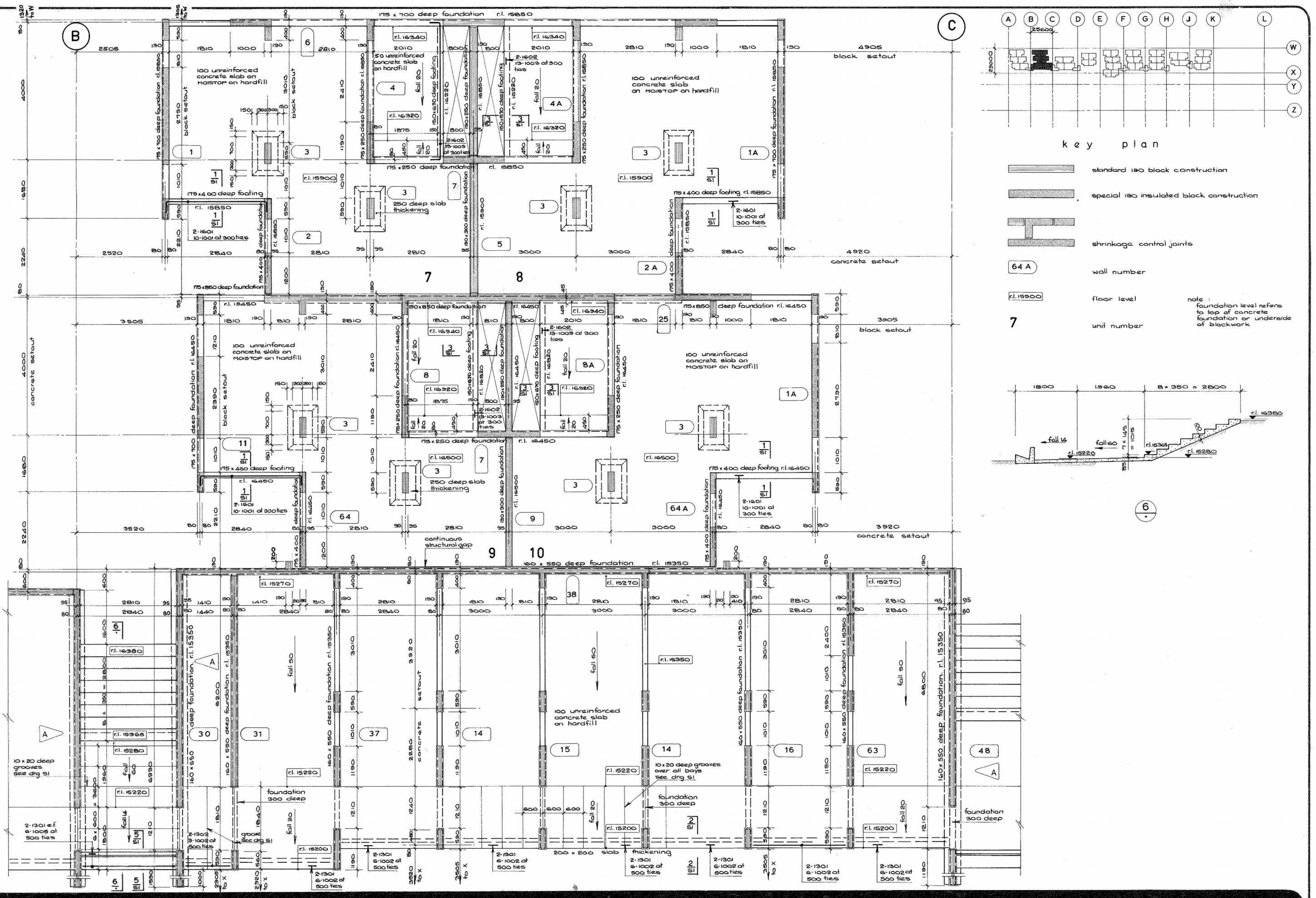
FLOOR PLAN.
LEVEL 1, A-B.

Scale 1 : 50
1 : 20
Drawn S. J. K.
Traced S. E. P.
Approved

D
C
B
A 2:2:76 footing wall 19
2.9.75 Contract

629/S1A

The Contractor shall verify all dimensions prior to commencing work



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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

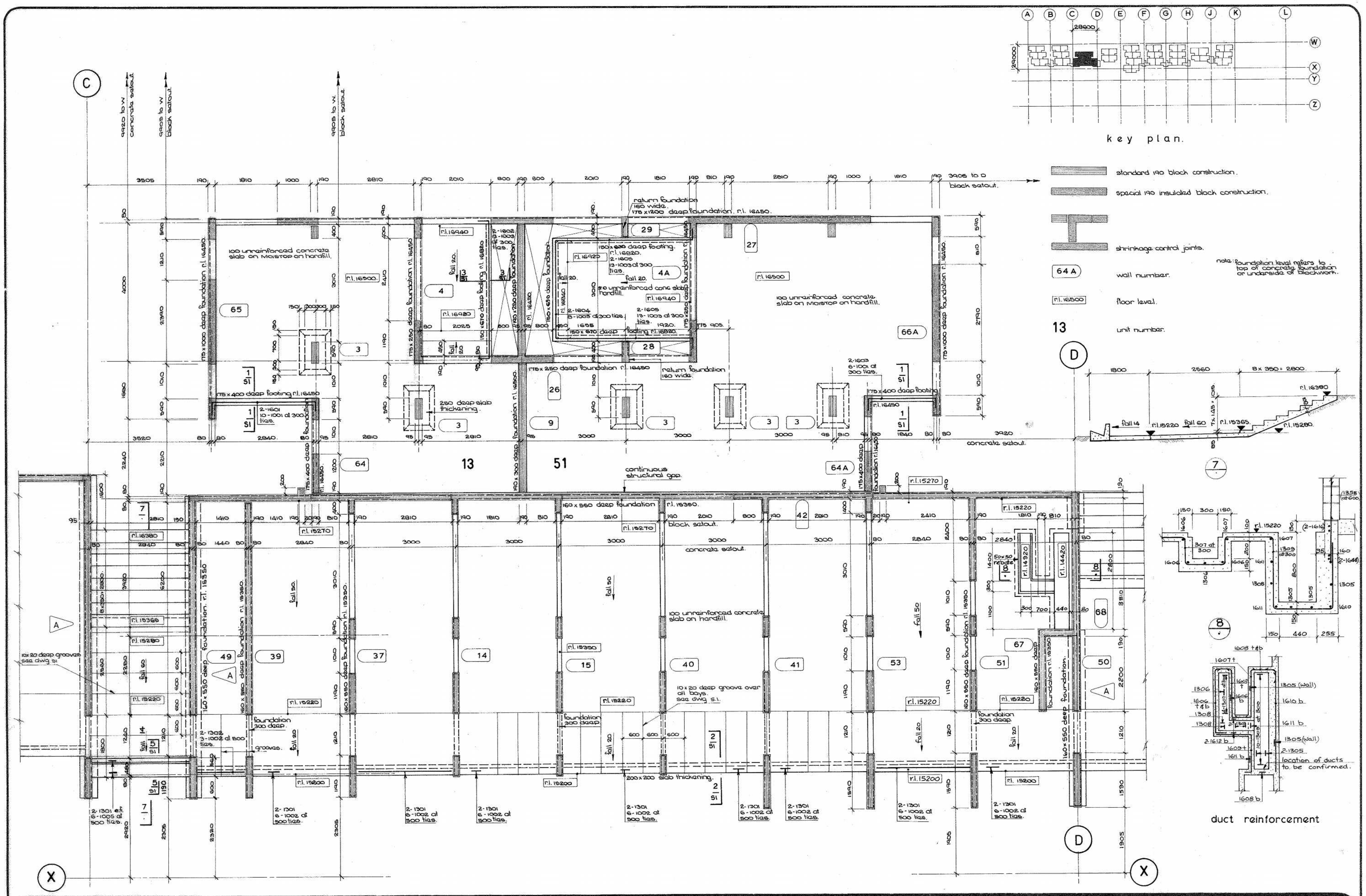
FLOOR PLAN
LEVEL 1, B - C

Scale 1 : 50
1 : 20
Drawn S.J.K.
Traced D.K.R.
Approved

D
C
B
A 2:2:76 footing - walls 19, 30 & 48
2.9.75 Contract

629/S2A

The Contractor shall verify all dimensions prior to commencing work



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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

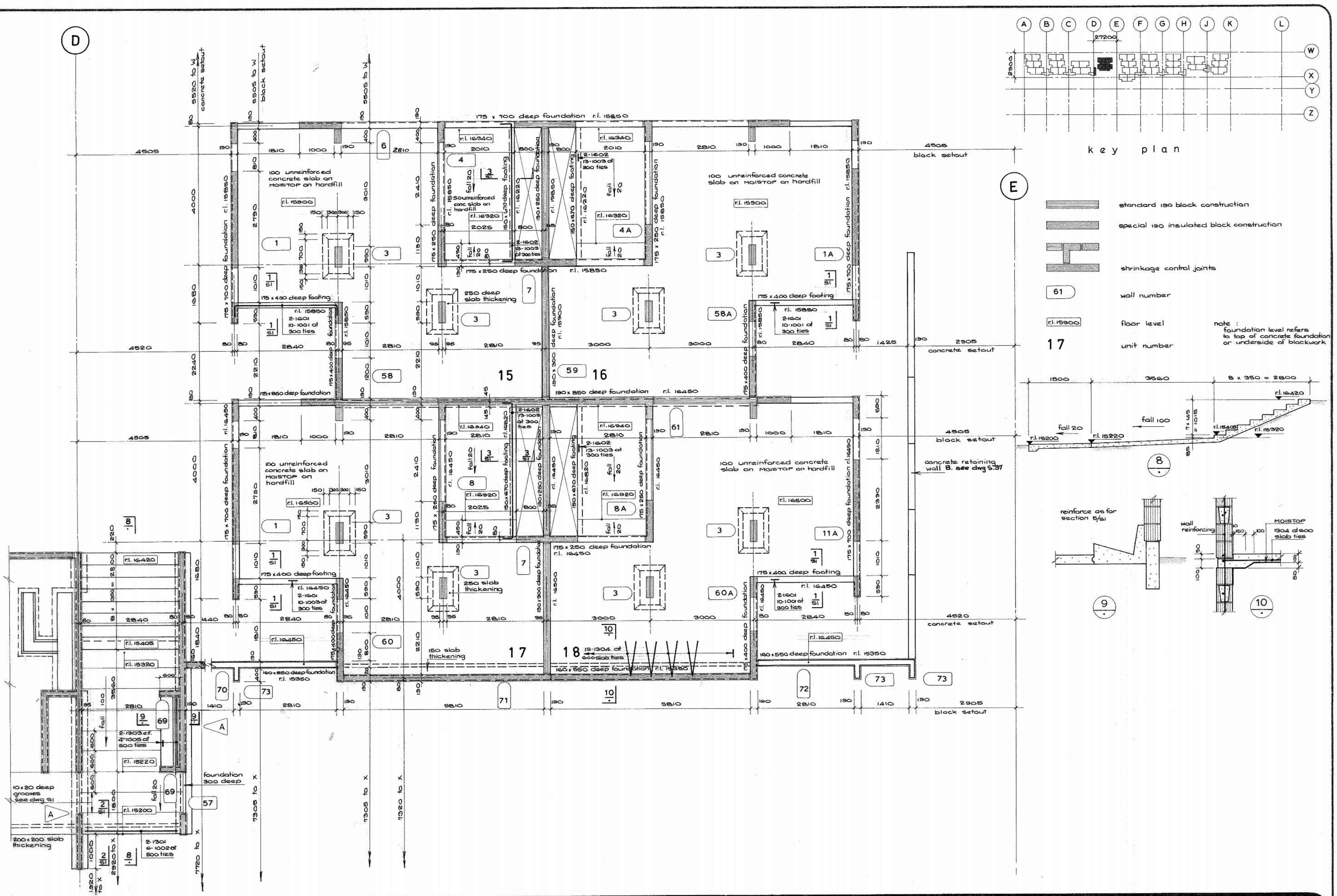
FLOOR PLAN
LEVEL 1, C–D.

Scale	1 : 50 1 : 20
Drawn	S.J.K.
Traced	S.E.P.
Approved	

D
C
B
A 2:2:76 footing walls. 48, 49 & 50
2.9.75 Contract

629/S3A

The Contractor shall verify all dimensions prior to commencing work



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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

FLOOR PLAN
LEVEL 1, D - E

Scale 1 : 50
1 : 20
Drawn S. J. K.
Traced D. K. R.
Approved

D
C
B
A 2:2:76 footing walls 50 & 57
2.9.75 Contract

629/S4 A

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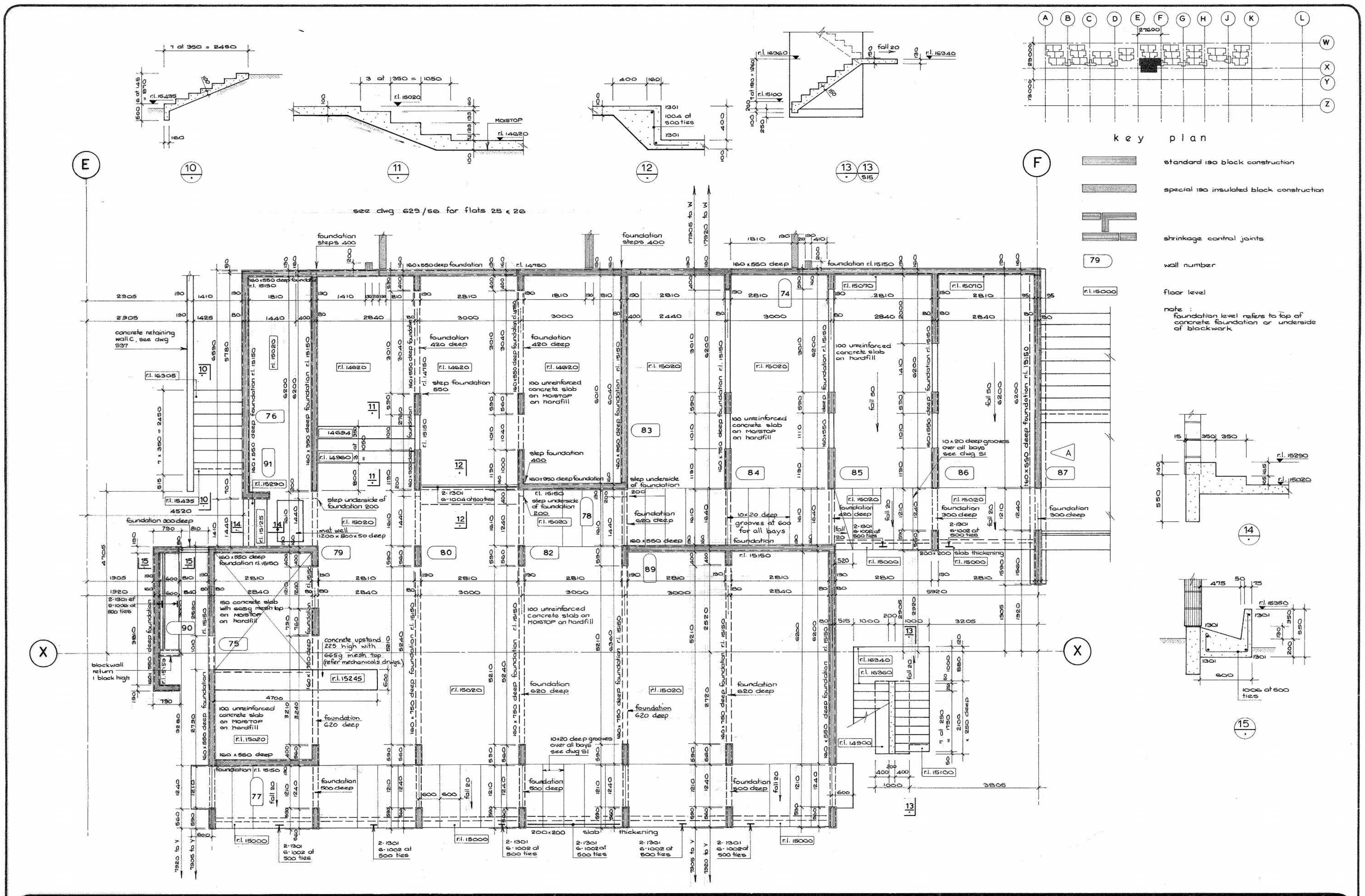

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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

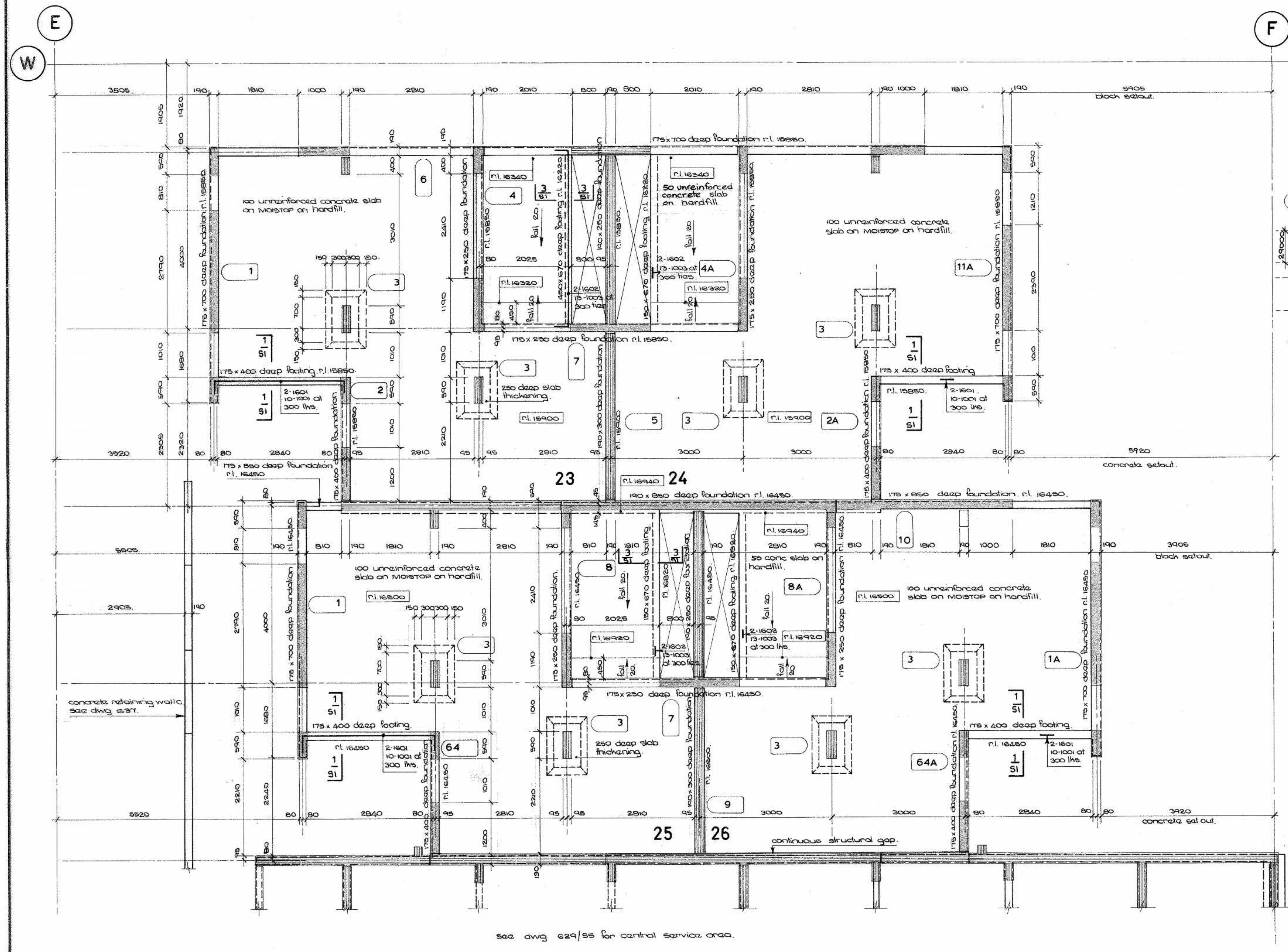
FLOOR PLAN
LEVEL 1, E-F
CENTRAL SERVICE AREA

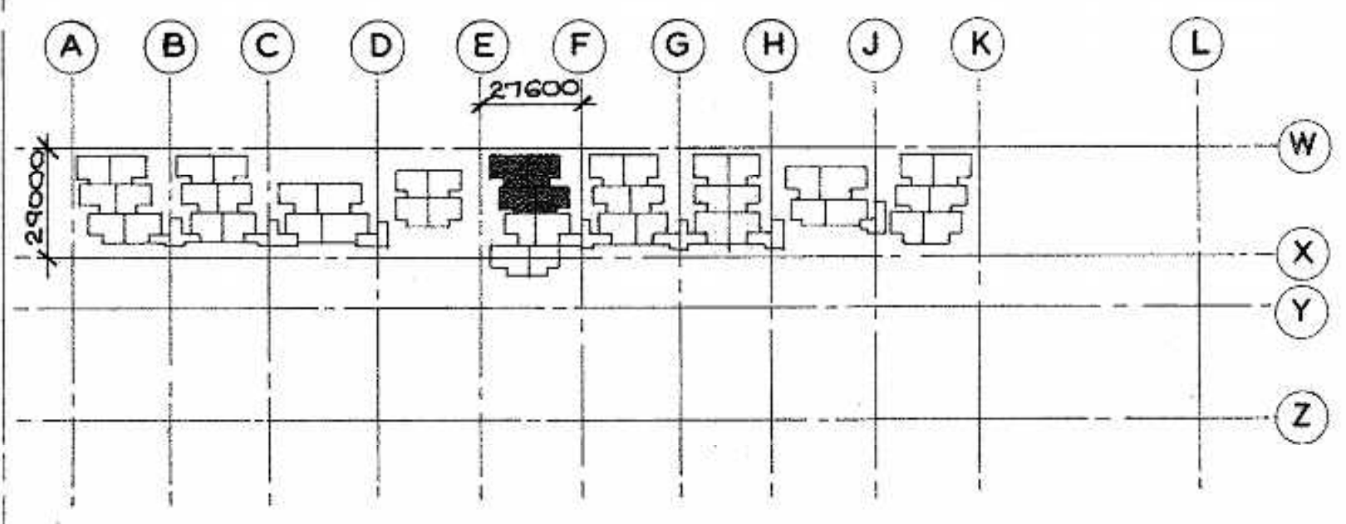
Scale	1 : 50 1 : 20
Drawn	S.J.K.
Traced	D.K.R.
Approved	

D
C
B
A 2:2:76 footing wall 87
2·9·75 Contract

629/S5 A

The Contractor shall verify all dimensions prior to commencing work





key plan.

▤	standard 190 block construction.
▨	special 190 insulated block construction.
┳	shrinkage control joints.
11A	wall number.
r.l. 15900	floor level.
23	unit number.

note: foundation level refers to top of concrete foundation or underside of blockwork.

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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

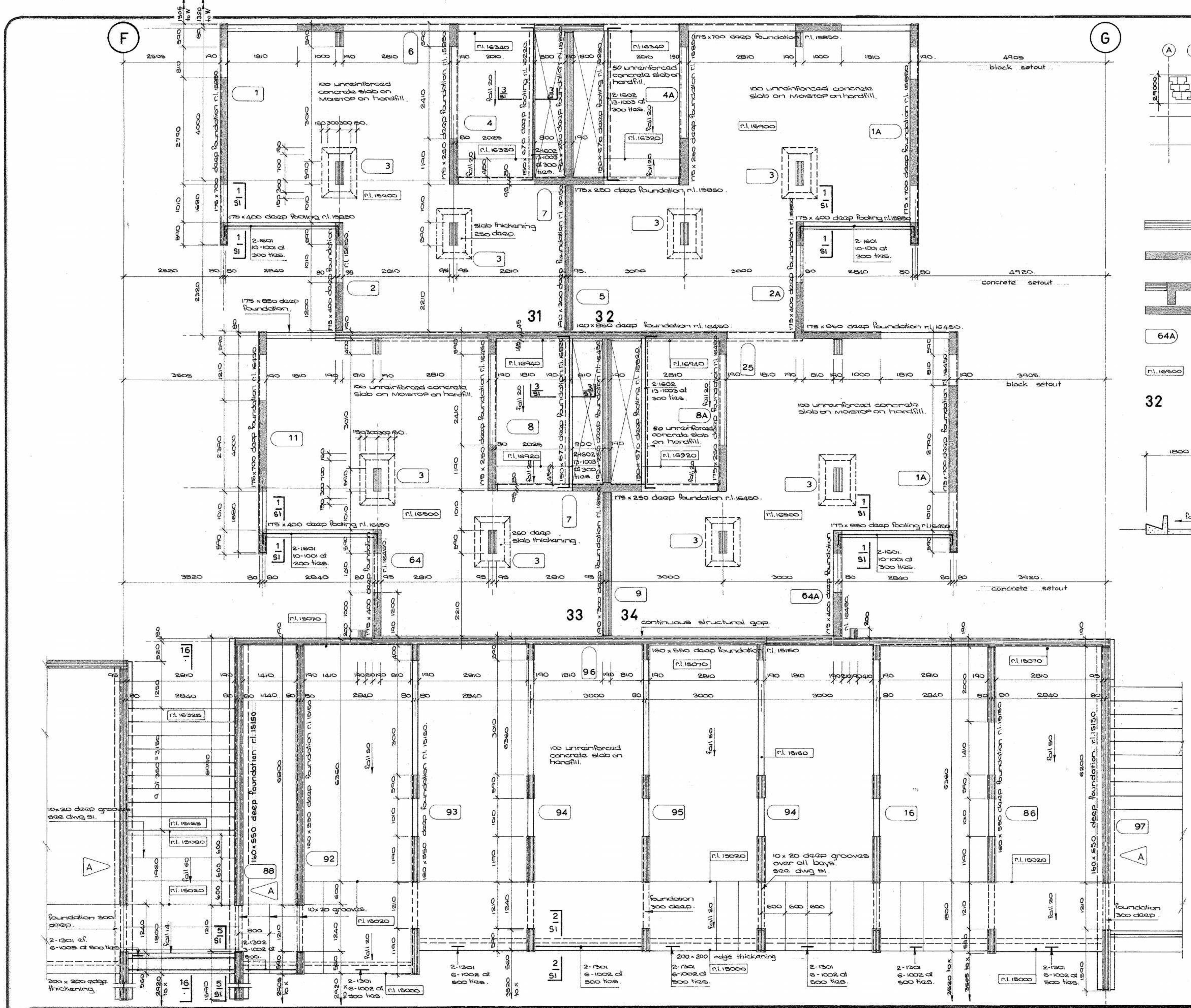
FLOOR PLAN
LEVEL 1, E–F
UNITS 23, 24, 25, 26.

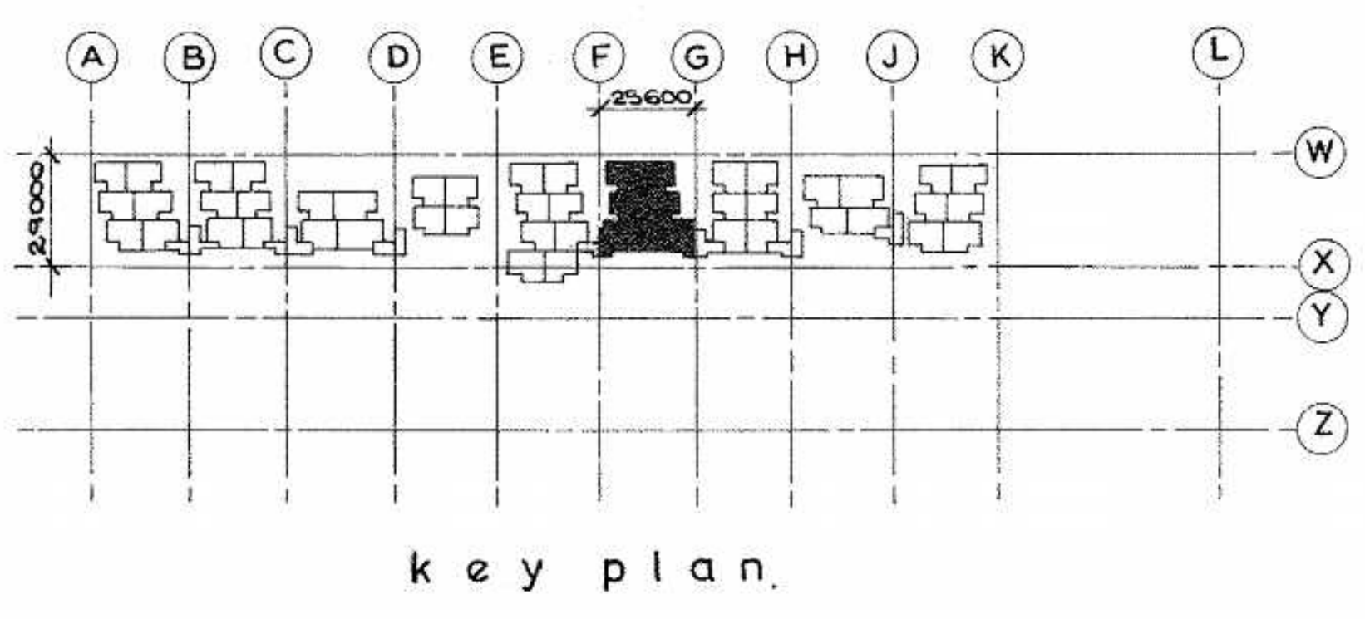
Scale 1 : 50
Drawn S.J.K.
Traced S.E.P.
Approved

D
C
B
A
2·9·75 Contract

629/S6

The Contractor shall verify all dimensions prior to commencing work

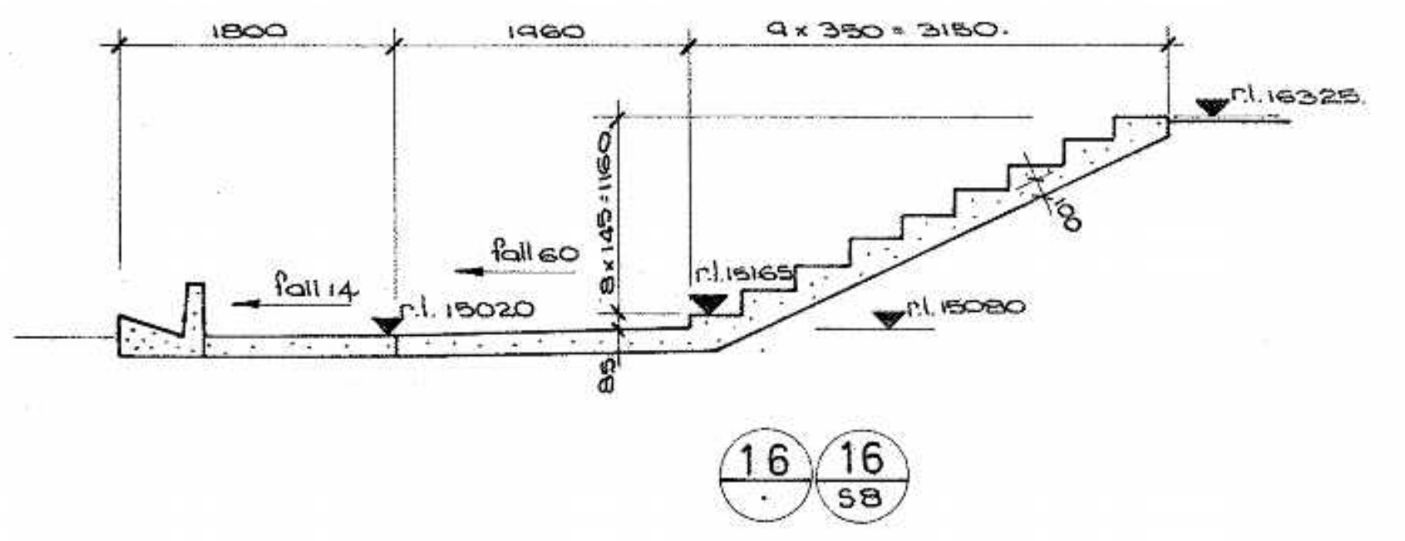




key plan.

▤	standard 190 block construction.
▨	special 190 insulated block construction.
▤▨	shrinkage control joints.
64A	wall number.
r.l. 16500	floor level
32	unit number.

note. foundation level refers to top of concrete or underside of blockwork.



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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

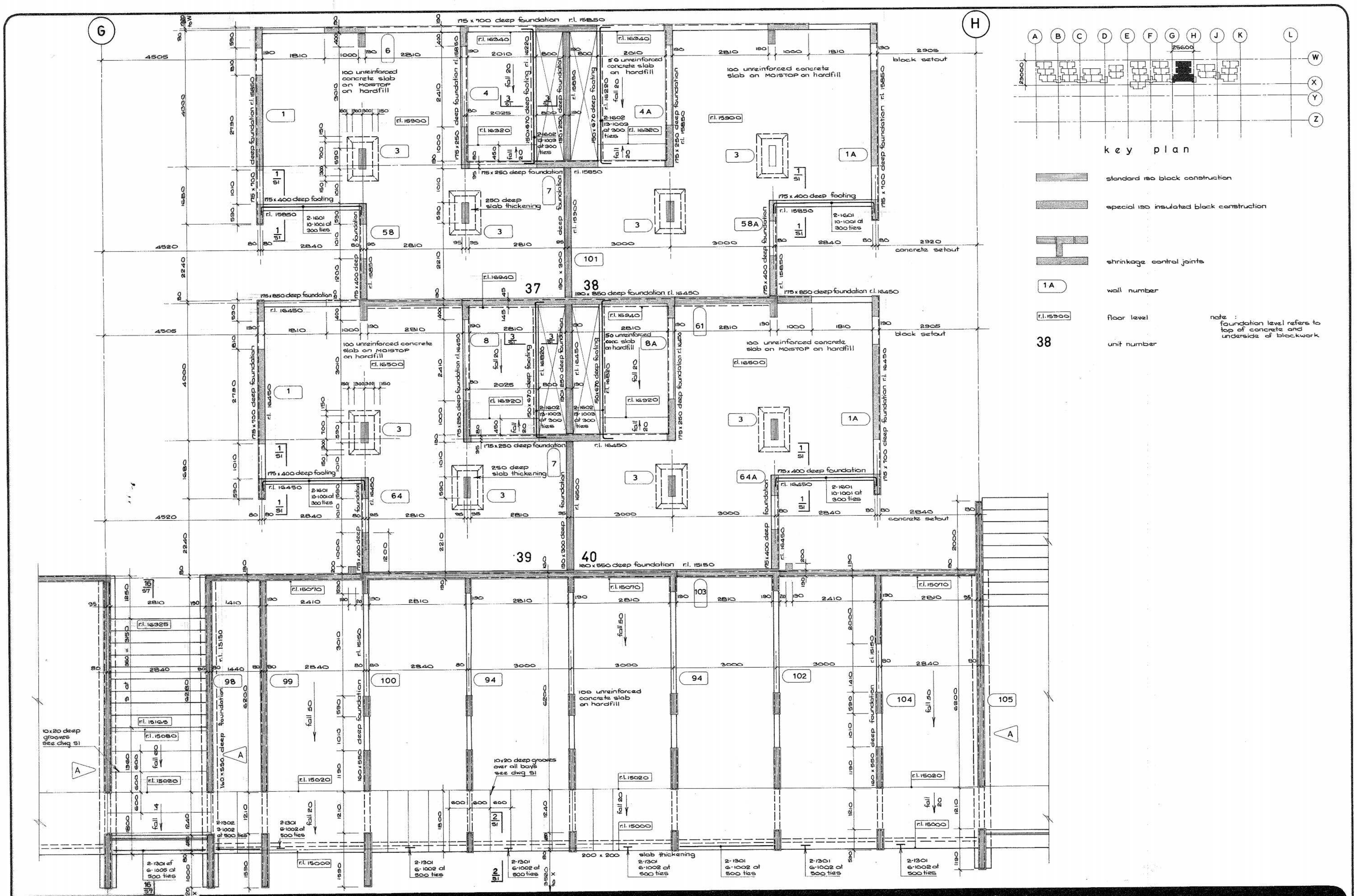
FLOOR PLAN
LEVEL 1, F-G.

Scale 1 : 50
Drawn S.J.K.
Traced S.E.P.
Approved

D
C
B
A 2:2:76 footing-walls 87, 88 & 97
2.9.75 Contract

629/S7A

The Contractor shall verify all dimensions prior to commencing work



standard 190 block construction

special 190 insulated block construction

shrinkage control joints

1A wall number

r.l.15900 floor level

38 unit number

note :
foundation level refers to top of concrete and underside of blockwork

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Christchurch & Wellington

BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

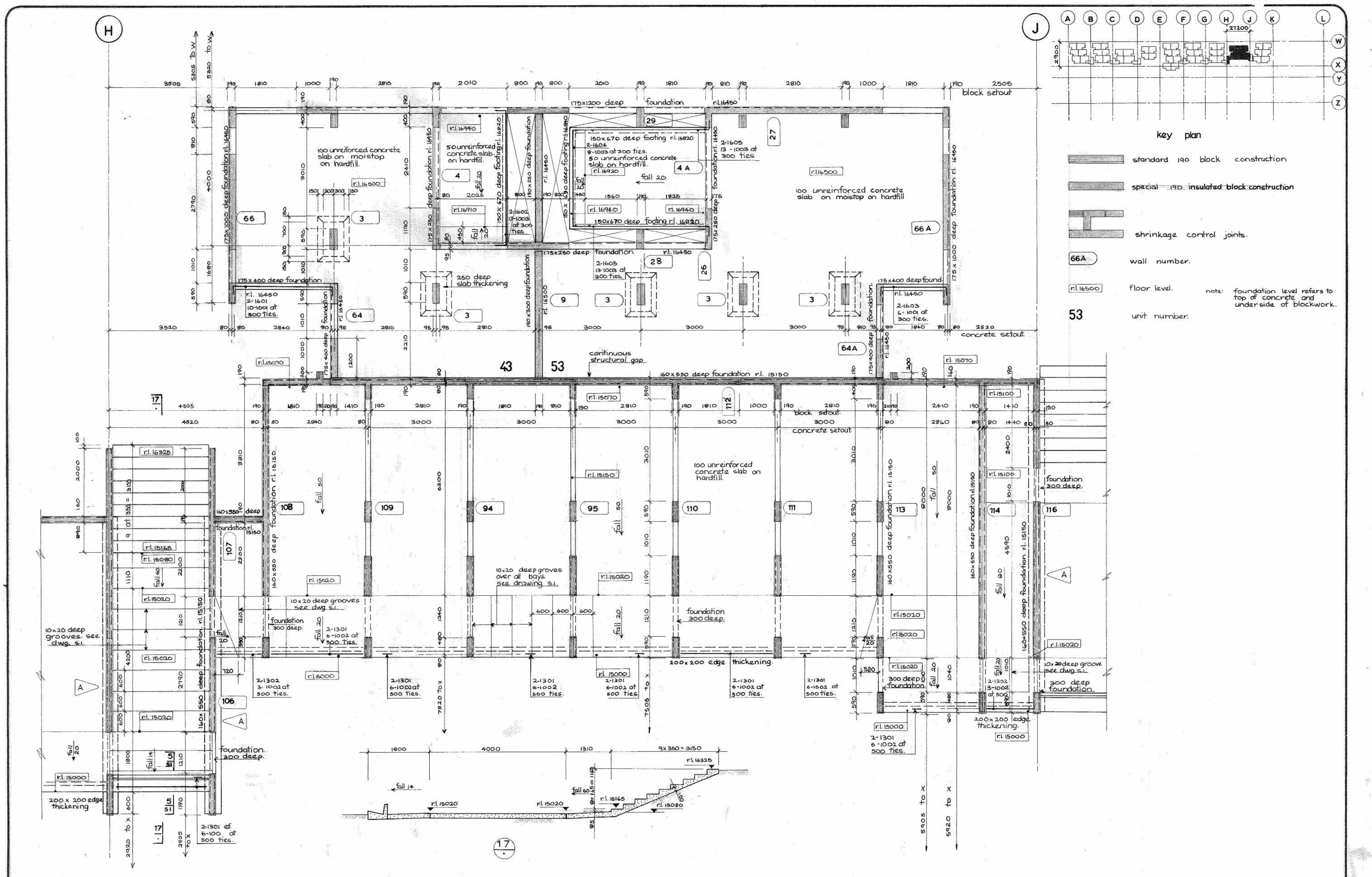
FLOOR PLANS
LEVEL 1, G—H

Scale 1 : 50
Drawn S.J.K.
Traced D.K.R.
Approved

D
C
B
A 2:2:76 footing-walls 97, 98 & 105
2.9.75 Contract

629/S8A

The Contractor shall verify all dimensions prior to commencing work



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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

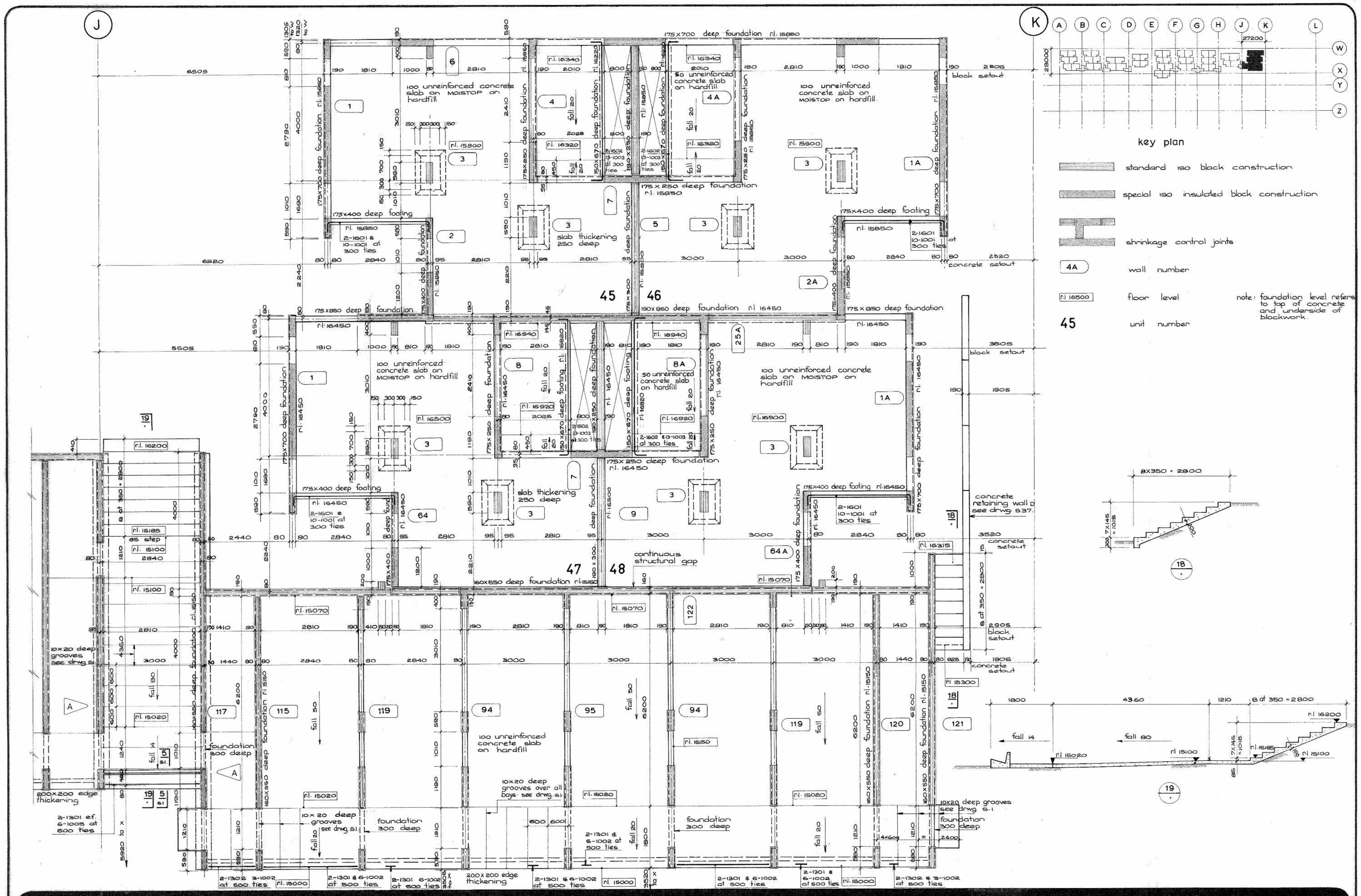
FLOOR PLAN
LEVEL 1, H-J

Scale 1:50
Drawn S.J.K
Traced K.A.L.
Approved

D
C
B
A 2:2:76 footing - walls 105, 106 & 116
2:9:75 Contract

629/S9A

The Contractor shall verify all dimensions prior to commencing work



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Christchurch & Wellington

BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

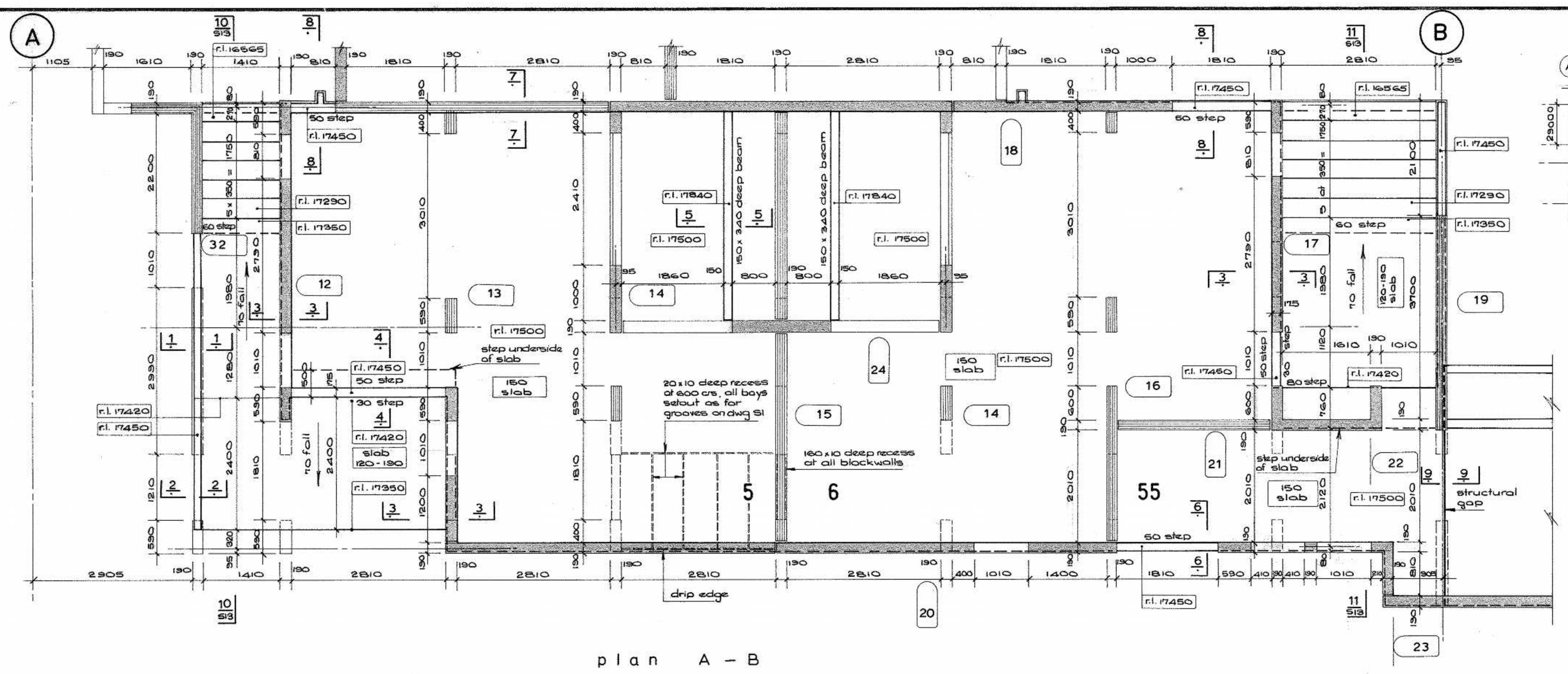
FLOOR PLAN
LEVEL 1, J – K

Scale 1 : 50
Drawn S. J. K.
Traced H. M. N.
Approved

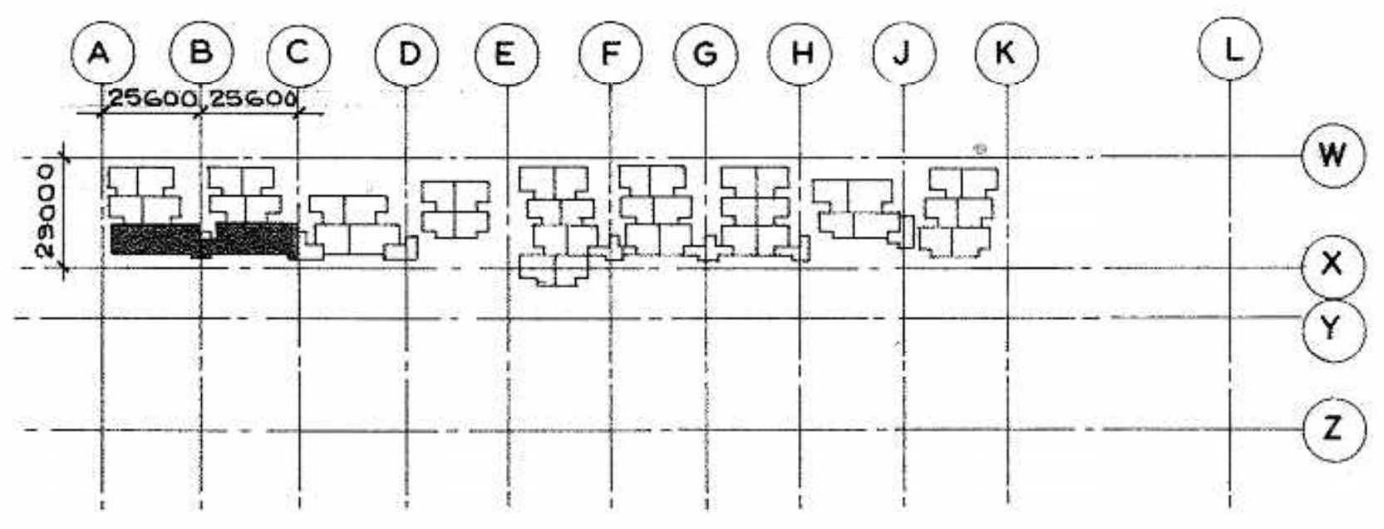
D
C
B
A 2: 2: 76 footing - walls 116 & 117
2.9.75 Contract

629/S10A

The Contractor shall verify all dimensions prior to commencing work

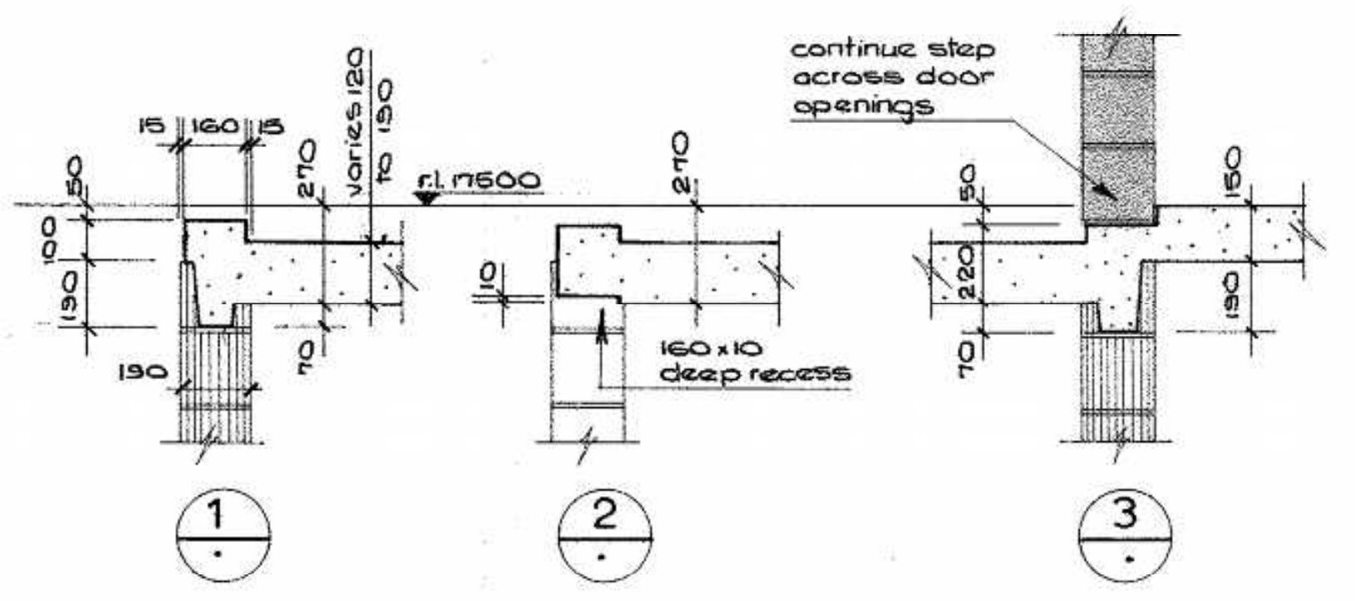


plan A – B

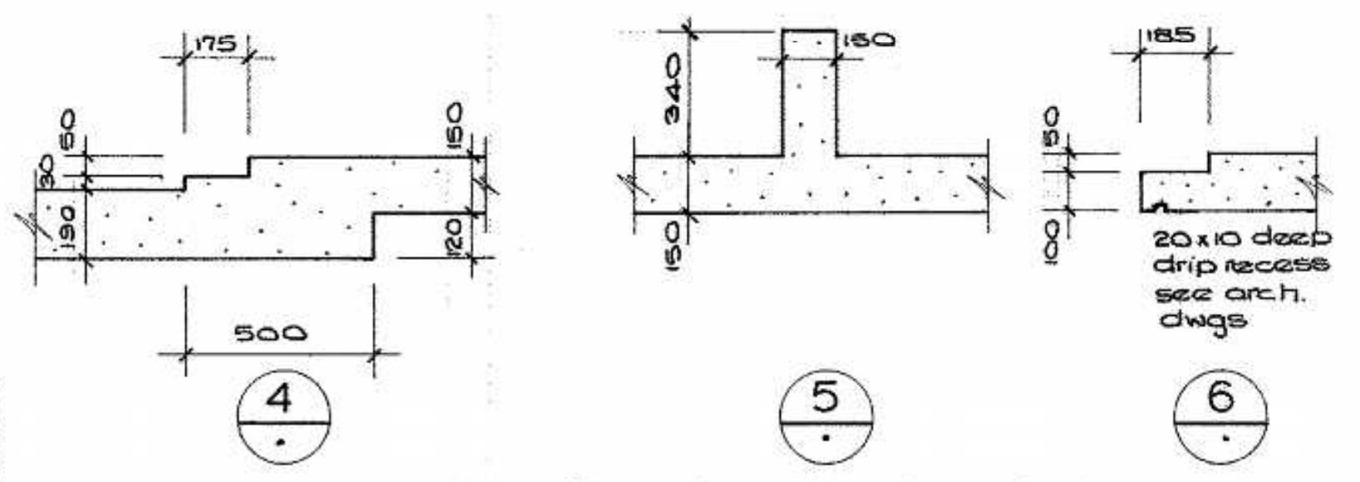


key plan

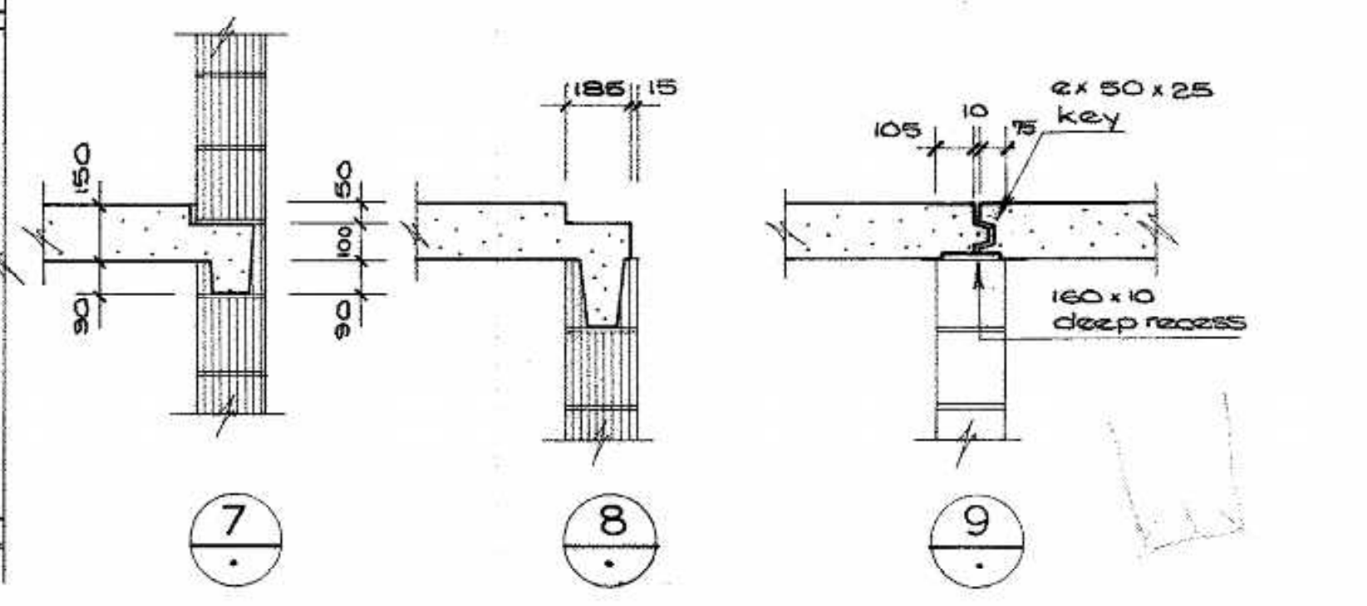
▬	standard 190 block construction
▬	special 190 insulated block construction
⊣	shrinkage control joints
14	wall number
r.l. 17500	floor level
12	unit number



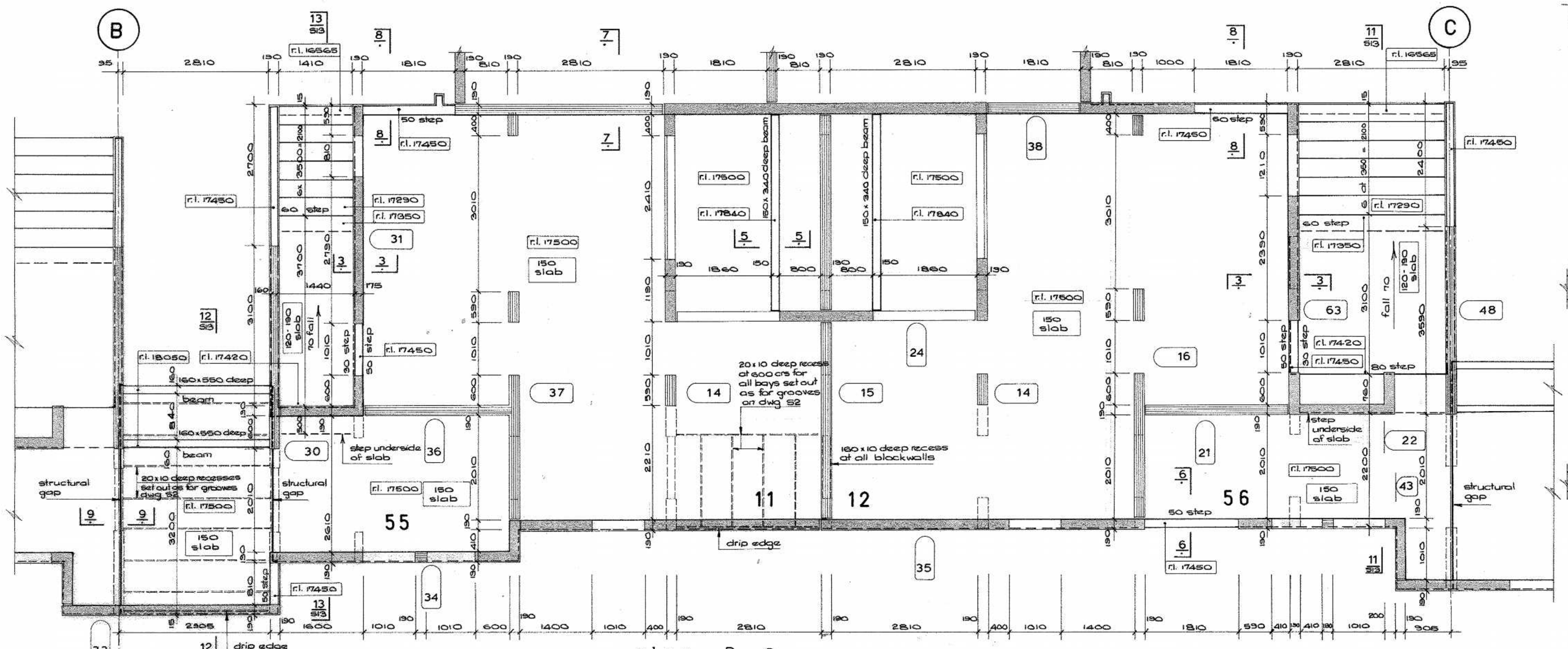
standard details level 2 slabs



standard details level 2 slabs



standard details level 2 slab



plan B – C

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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

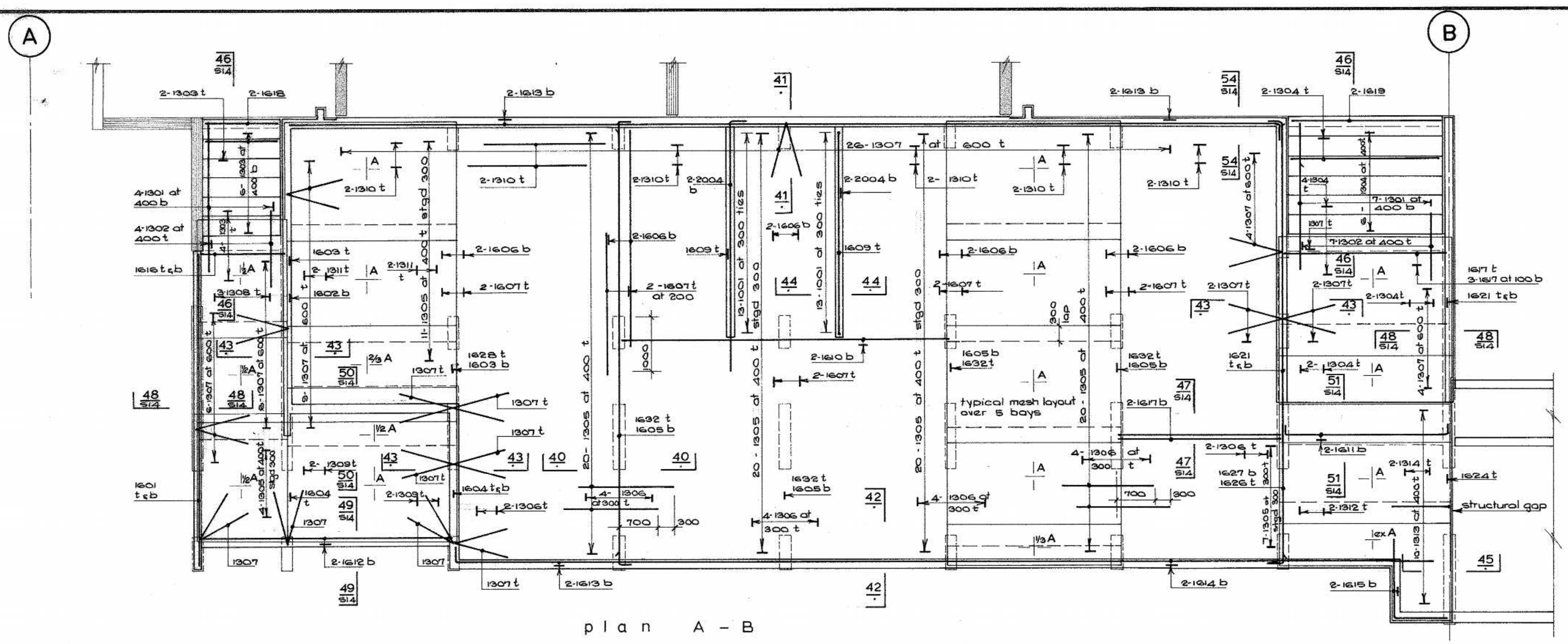
FLOOR PLAN – CARCASS
LEVEL 2, A - B, B - C

Scale 1 : 50
1 : 20
Drawn S. J. K.
Traced D. K. R.
Approved

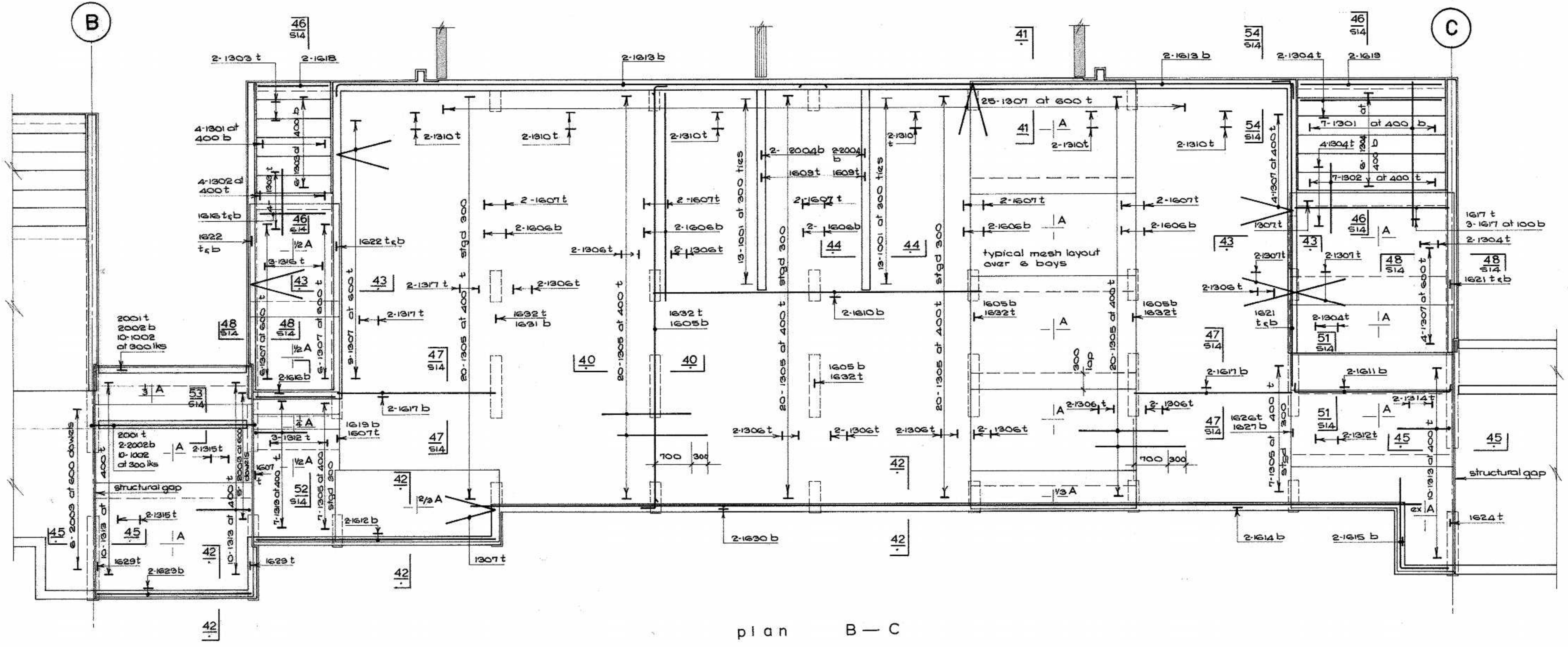
D
C
B
A
2·9·75 Contract

629 / S11

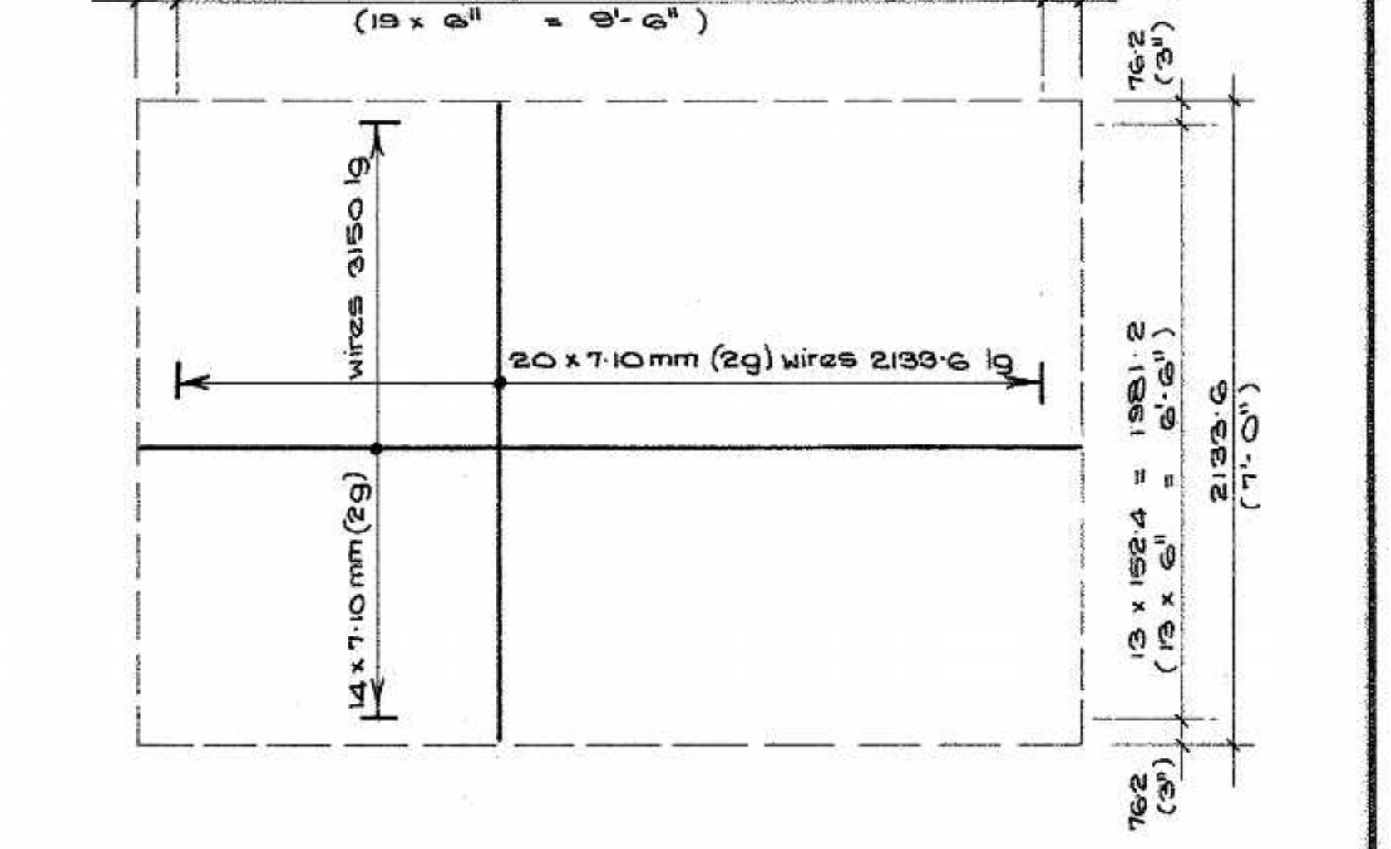
The Contractor shall verify all dimensions prior to commencing work



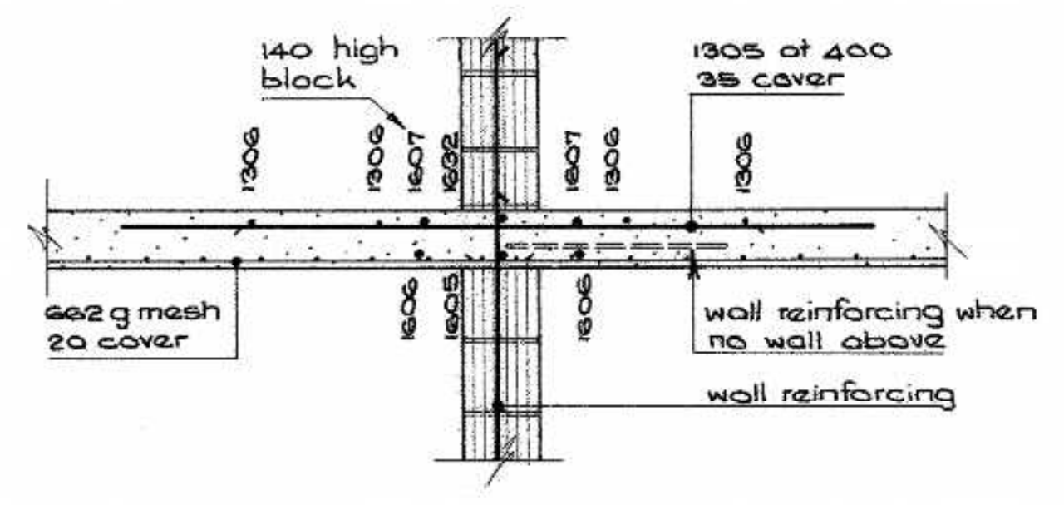
plan A – B



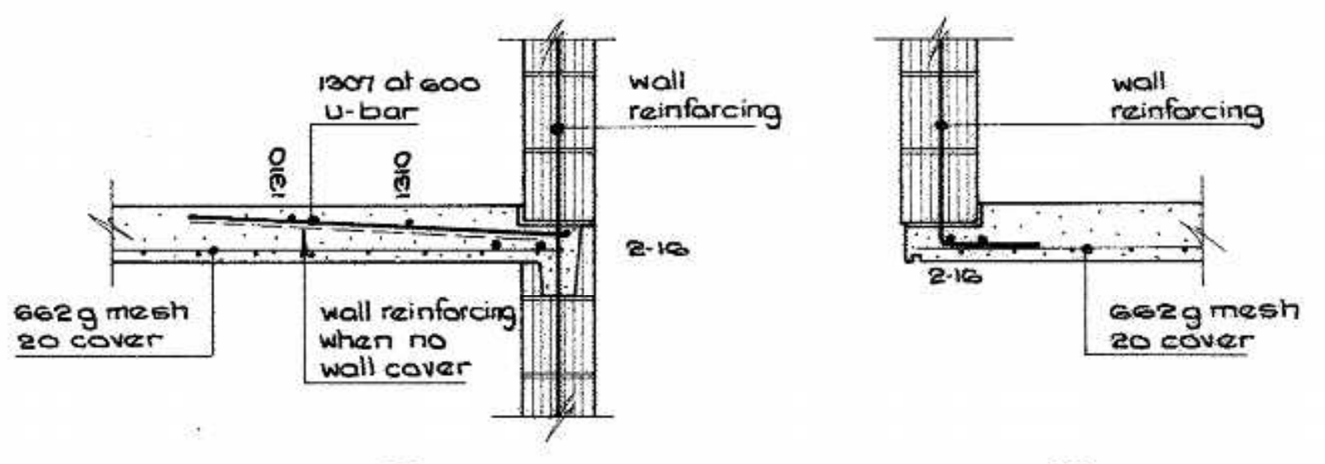
plan B — C



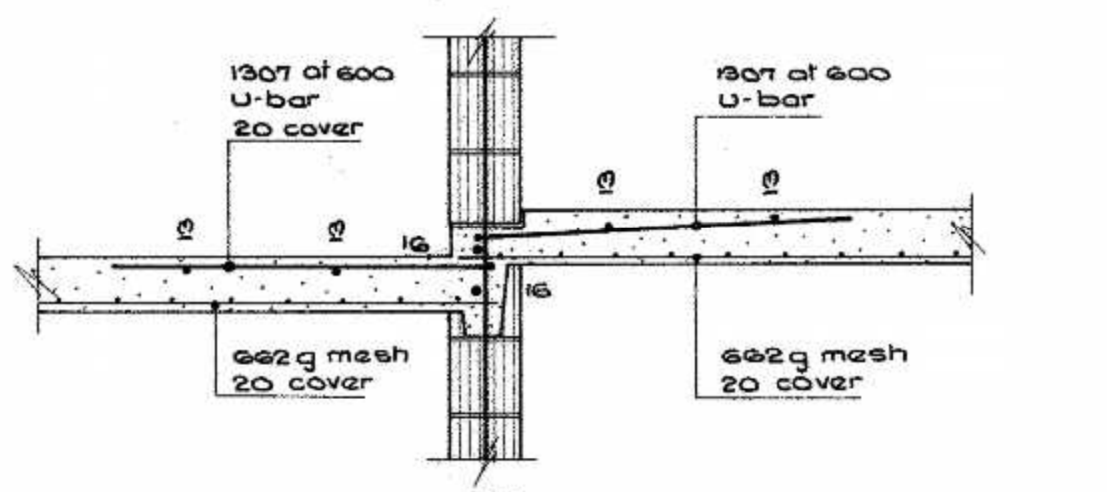
mesh sheet type A : 333 off



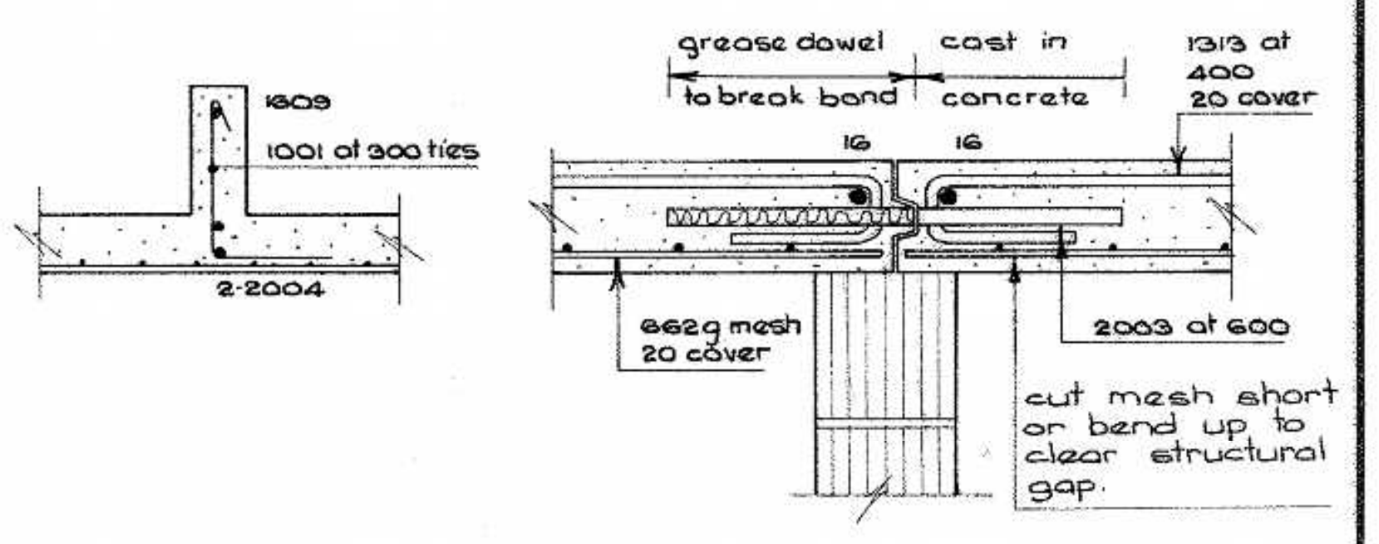
40 standard detail



41 standard details 42



43 standard detail



44 standard details 45

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Christchurch & Wellington

BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

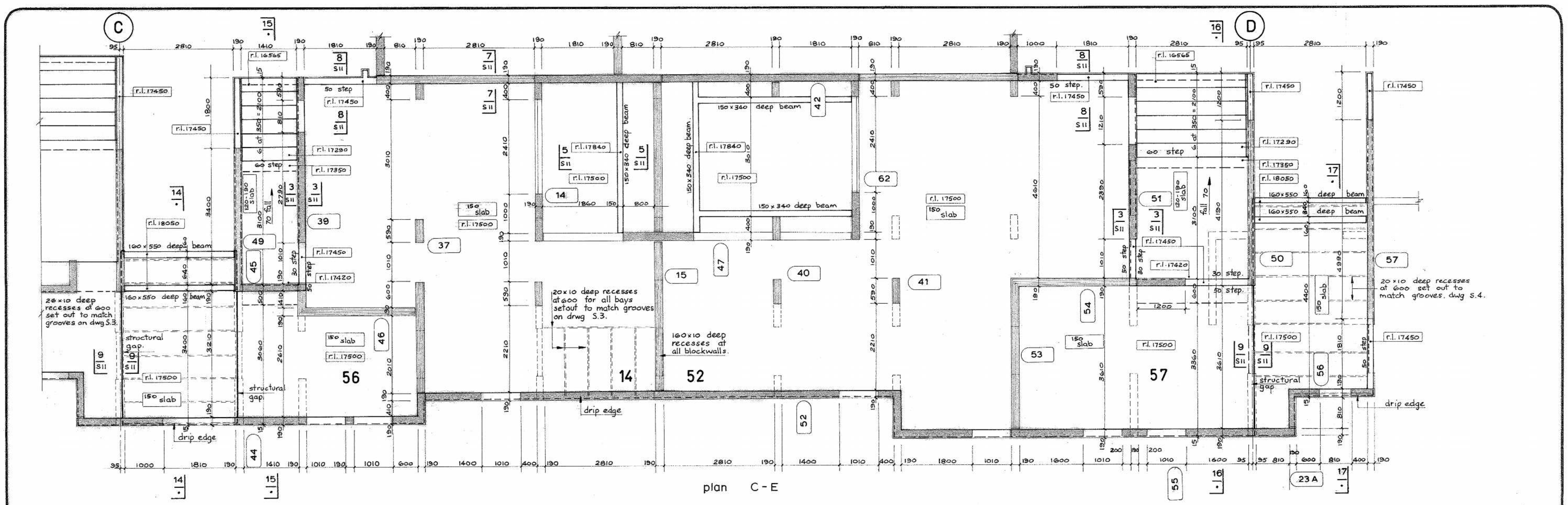
FLOOR REINFORCEMENT
LEVEL 2, A-B, B-C

Scale 1 : 50
1 : 20
1 : 10
Drawn S. J. K.
Traced D. K. R.
Approved

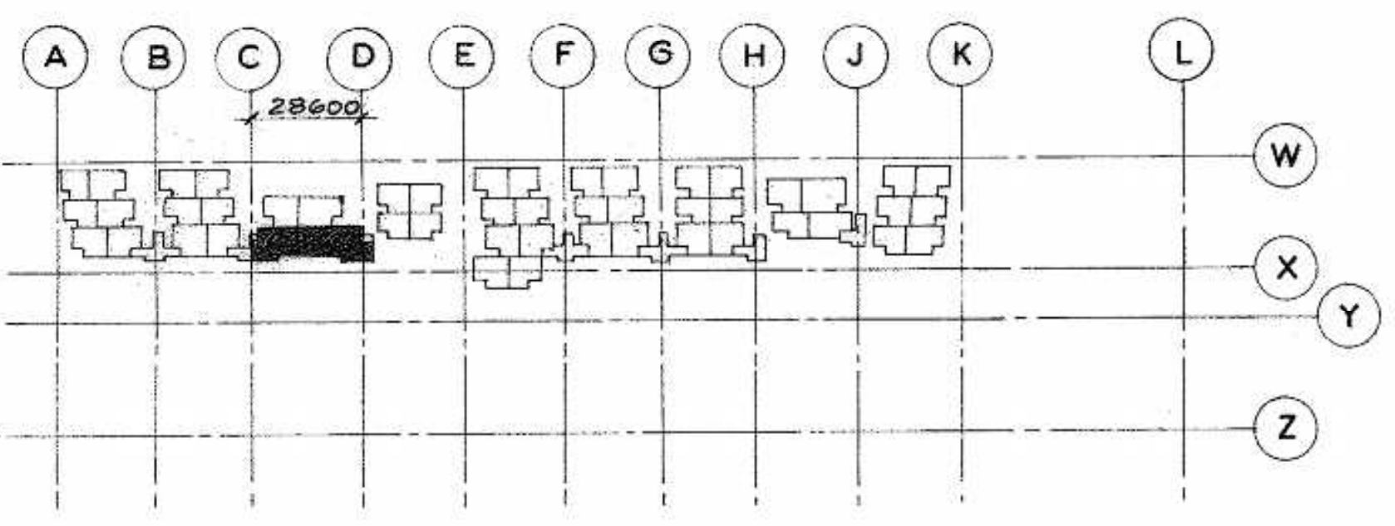
D
C
B
A
2·9·75 Contract

629 / S12

The Contractor shall verify all dimensions prior to commencing work

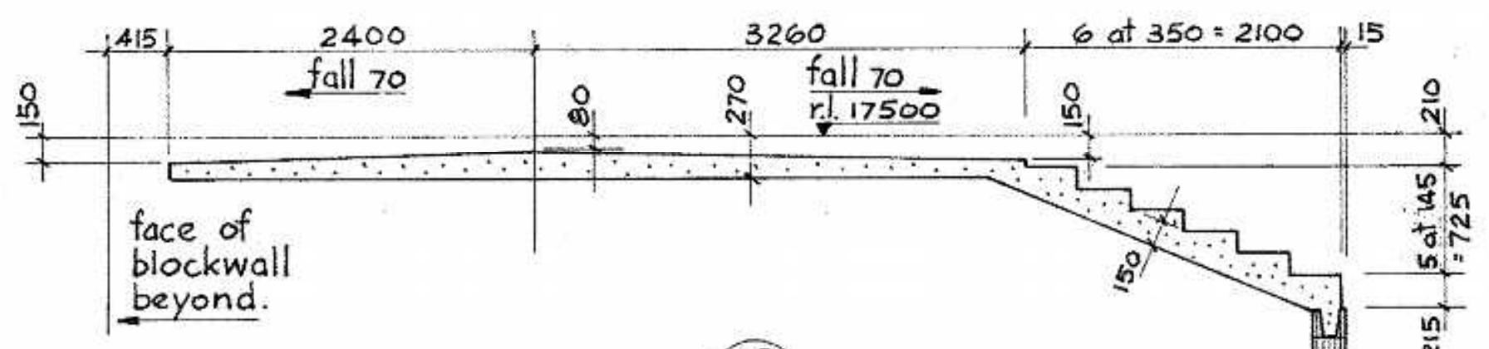


plan C-E

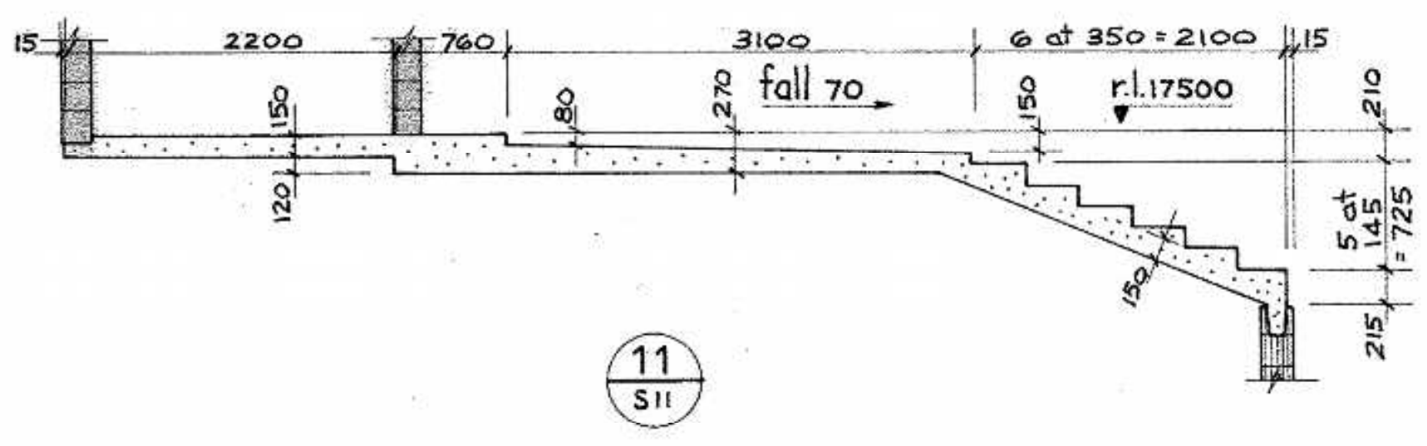


key plan

- ▭ standard 190 block construction
- ▨ special 190 insulated block construction
- shrinkage control joints
- 37 wall number
- r.l. 17920 floor level
- 52 unit number



10
S11



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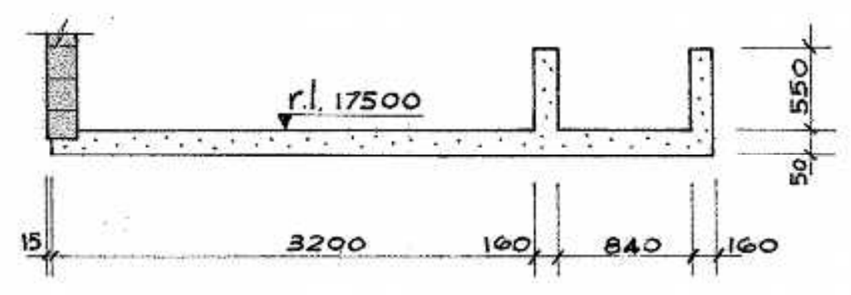
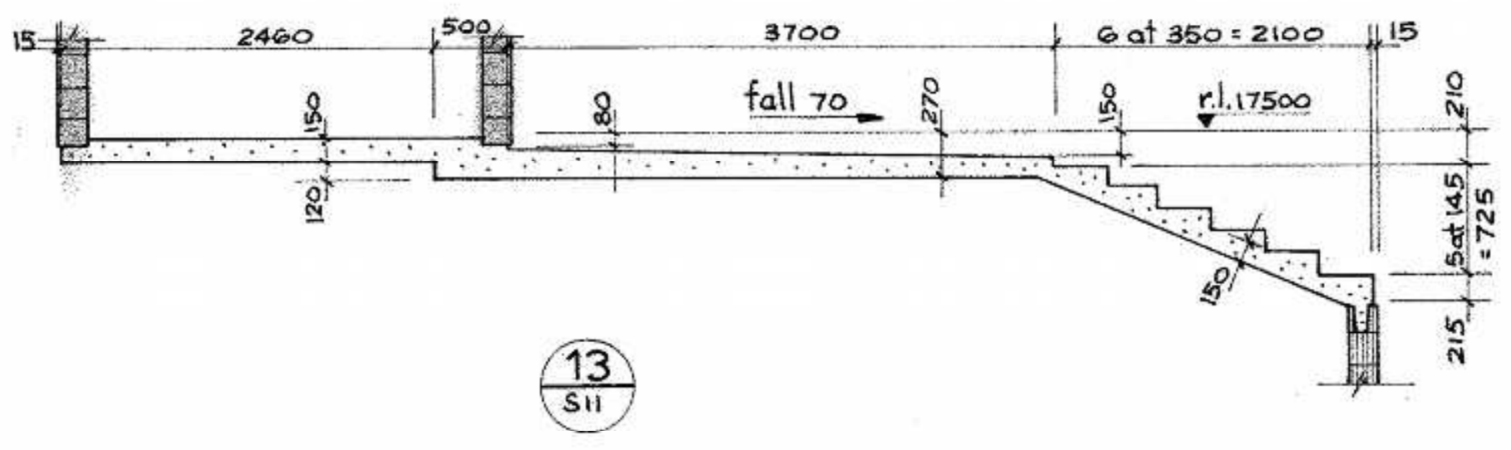
S11



12
S11



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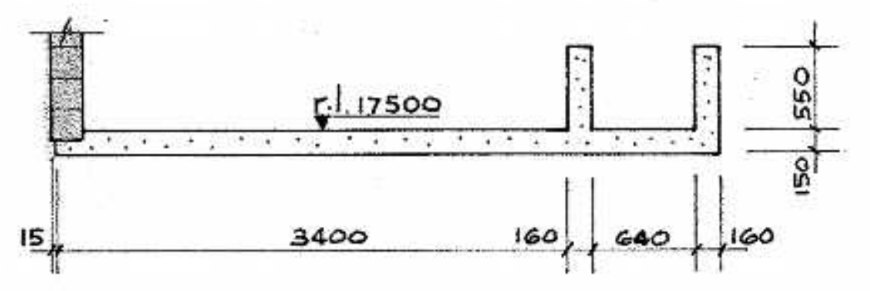
S11



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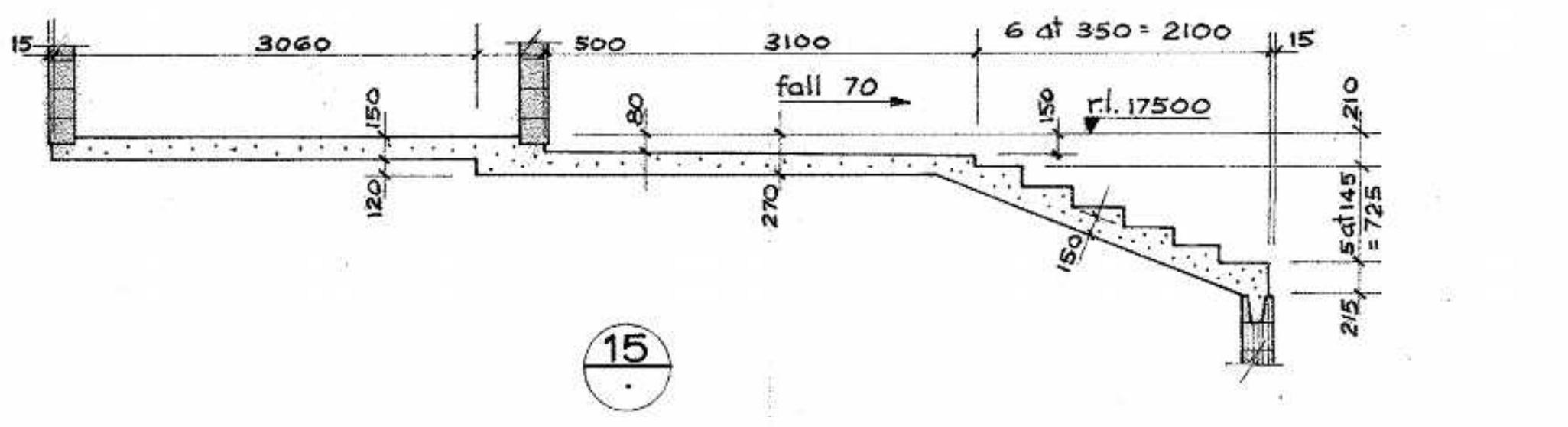

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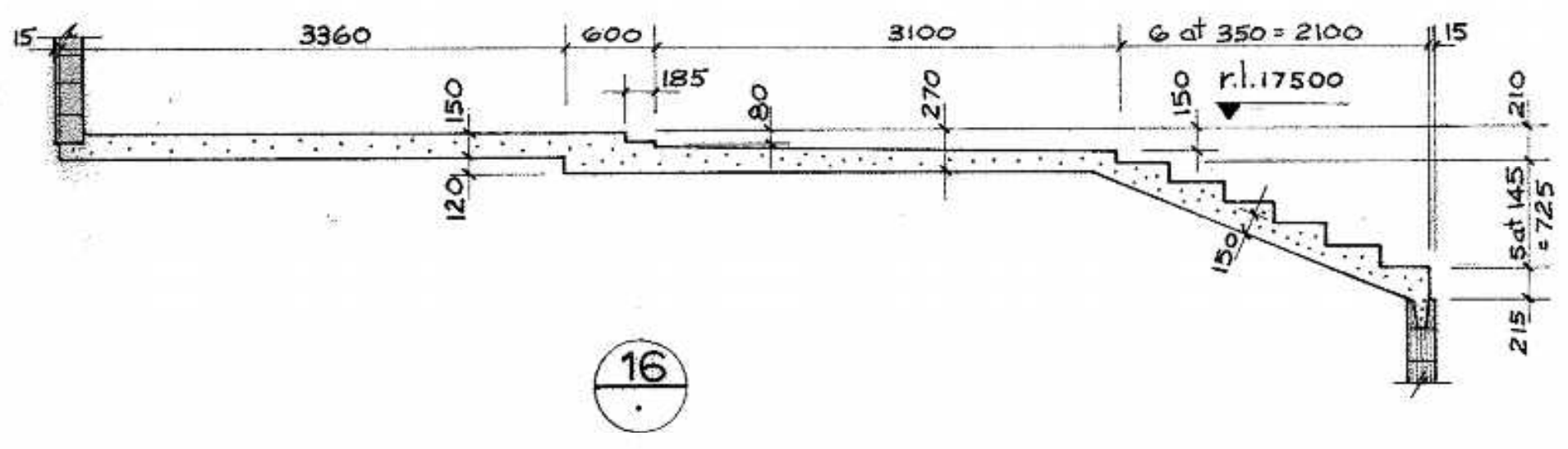

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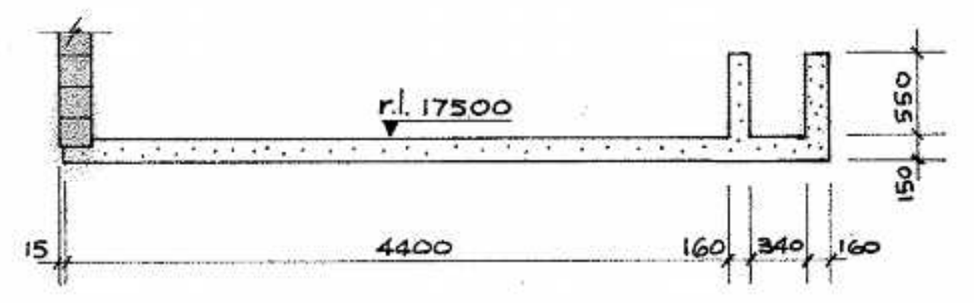

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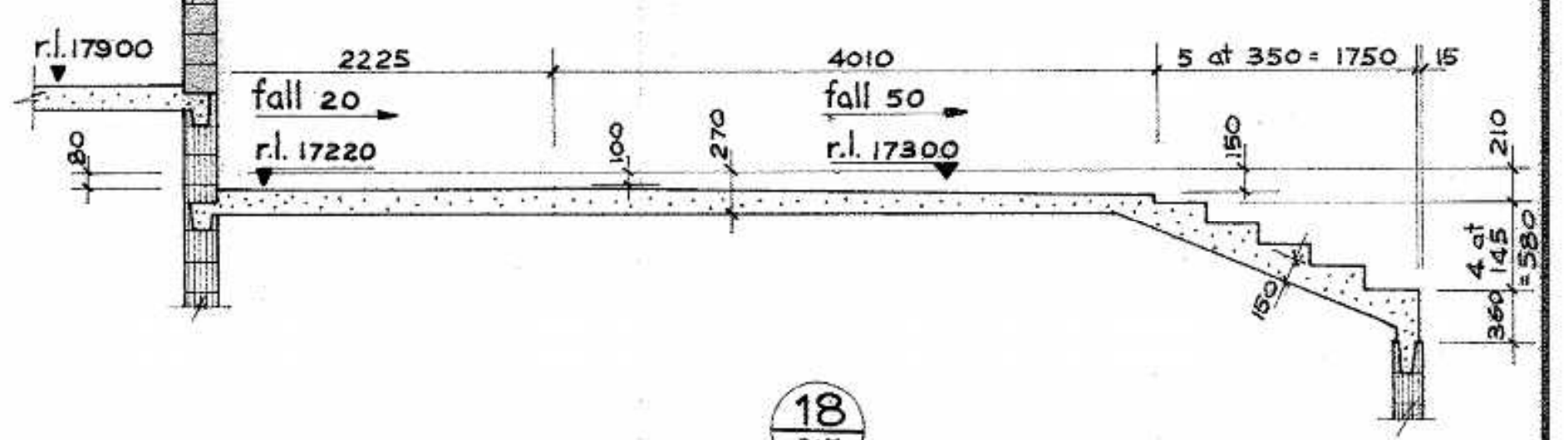
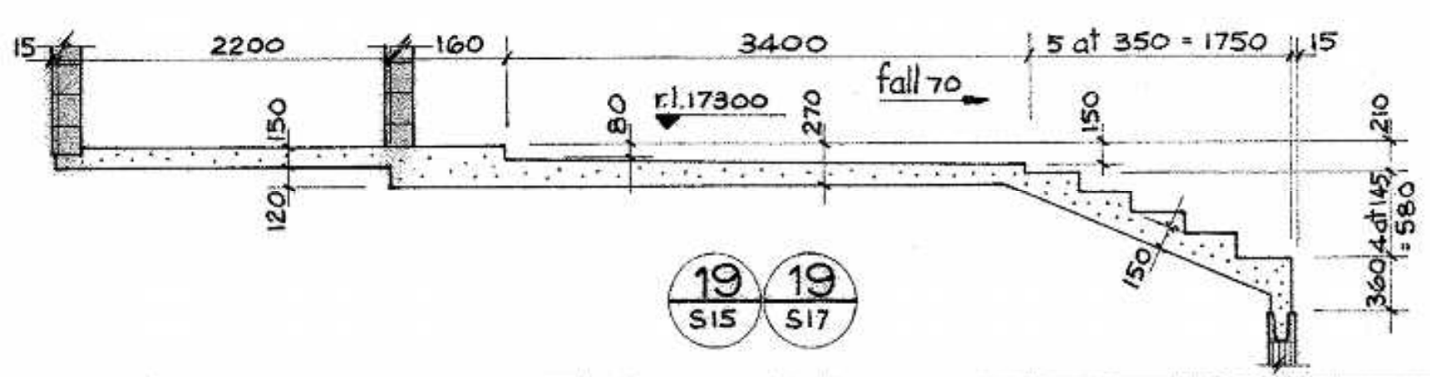
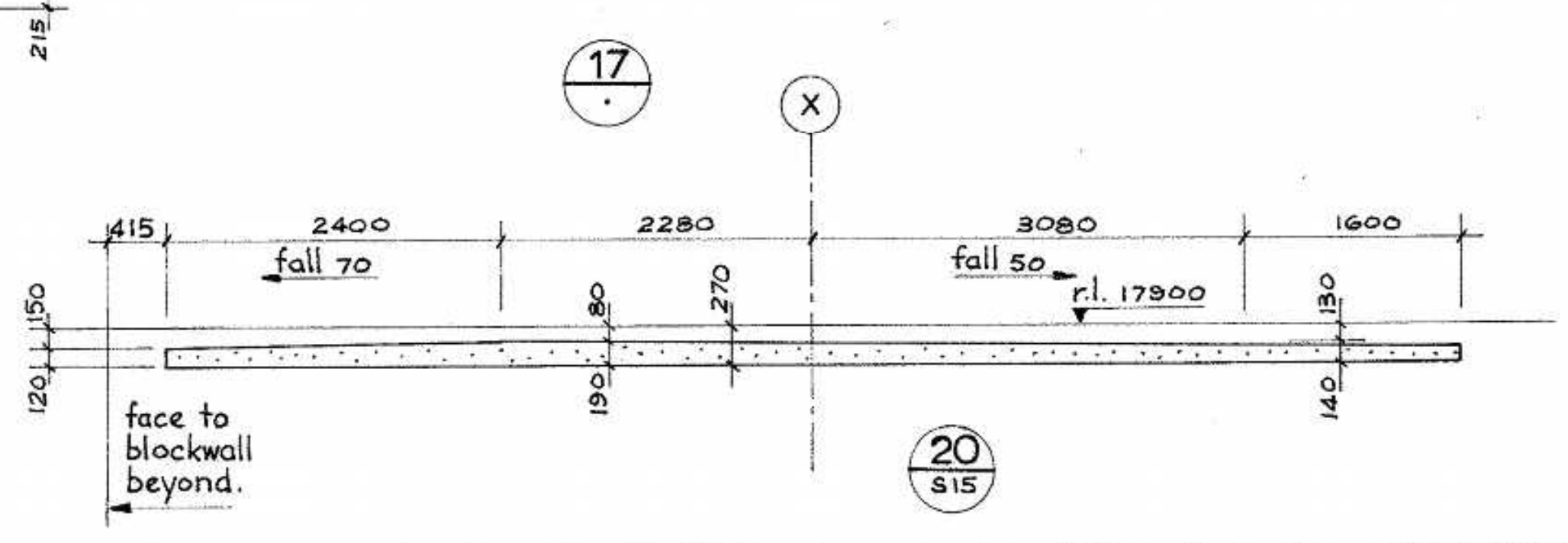


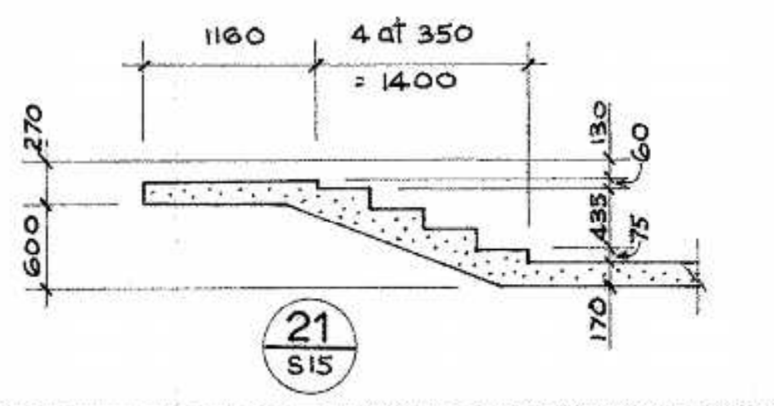
18
S15



19 S15 19 S17



20
S15



21
S15

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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

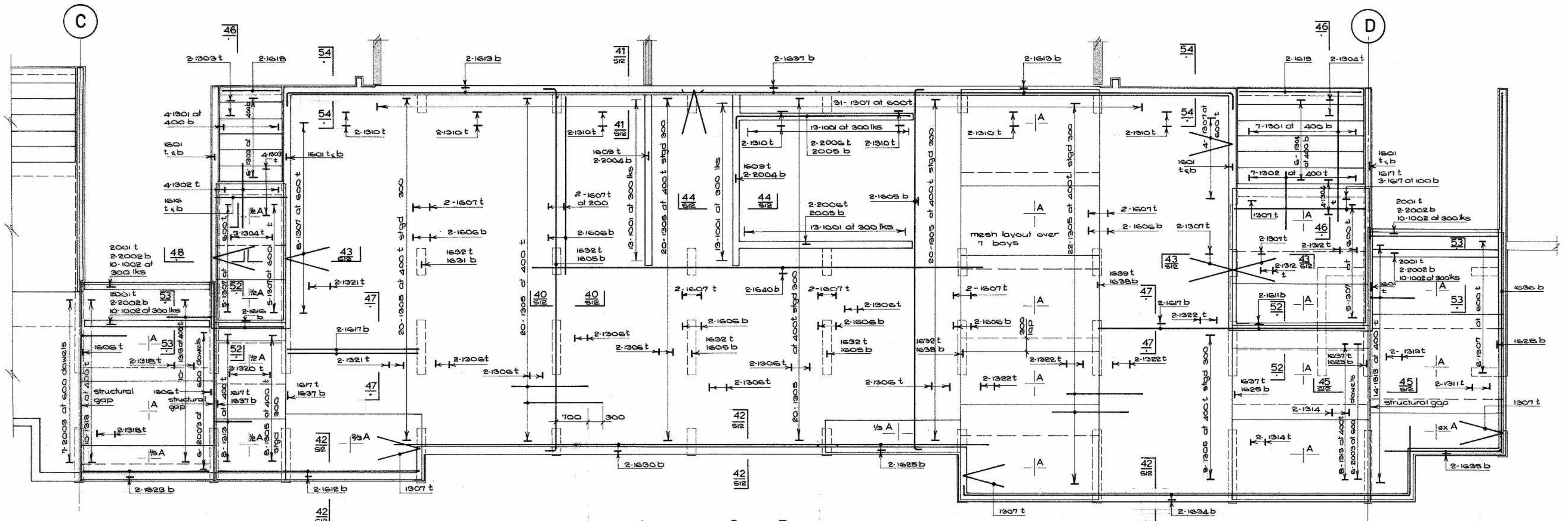
FLOOR PLANS — CARCASS
LEVEL 2, C-E

Scale 1:50
Drawn S.J.K.
Traced C.C.P.
Approved

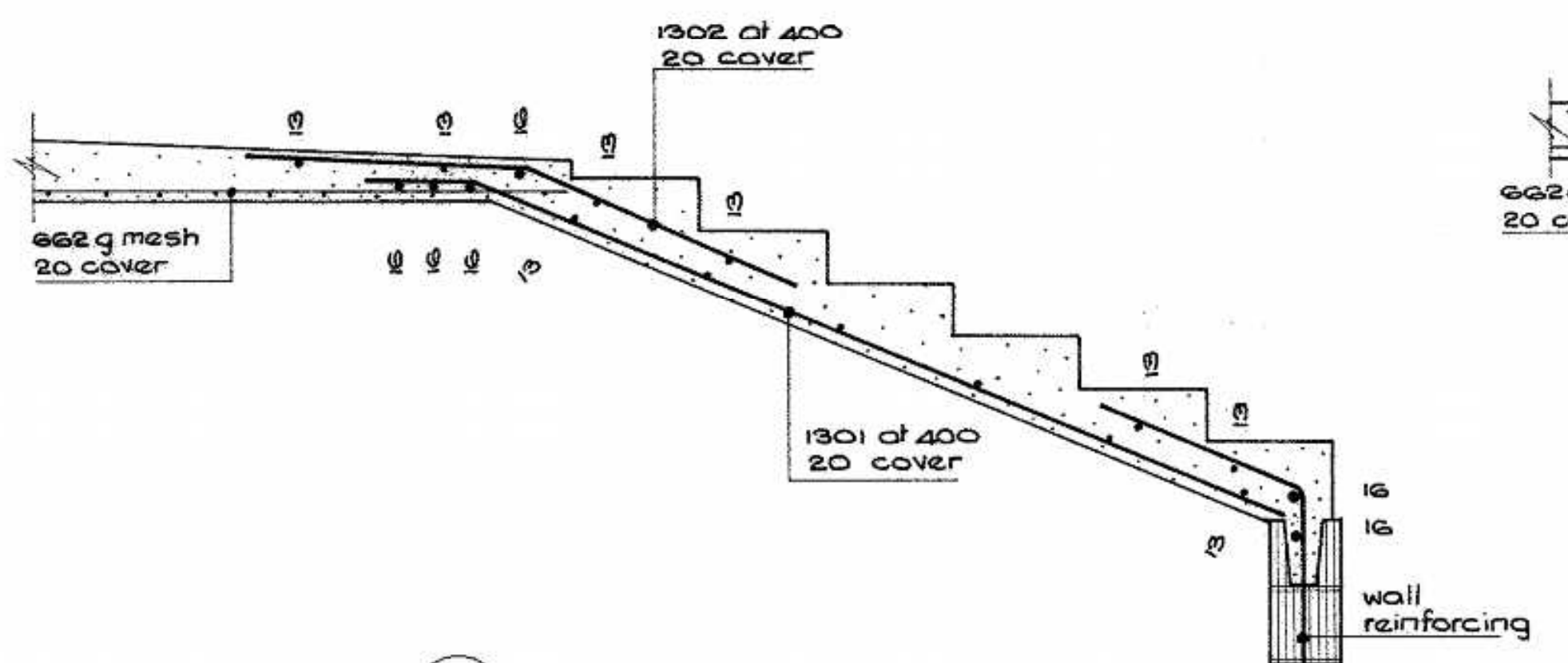
D
C
B
A
2.9.75 Contract

629/S13

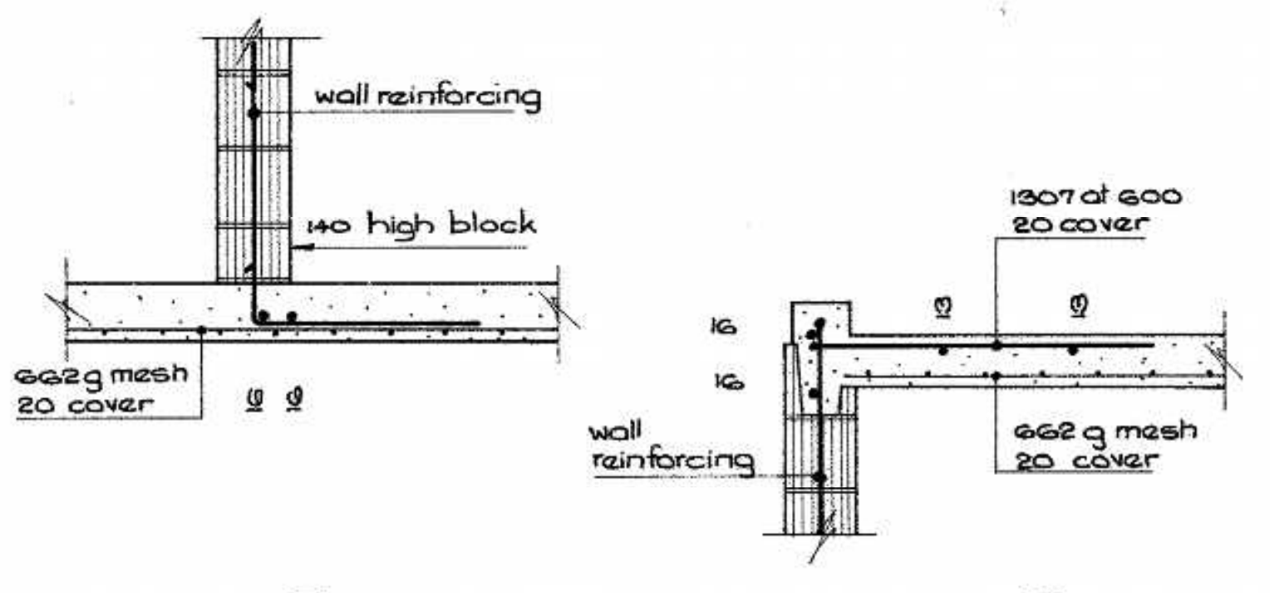
The Contractor shall verify all dimensions prior to commencing work



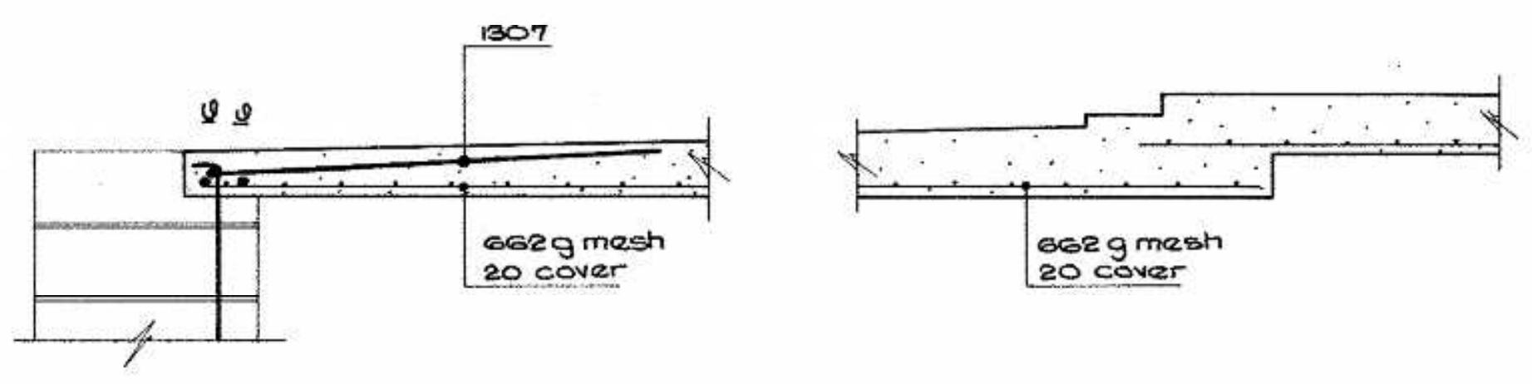
plan C – E
(see dwg S12 for typical mesh sheet type A)



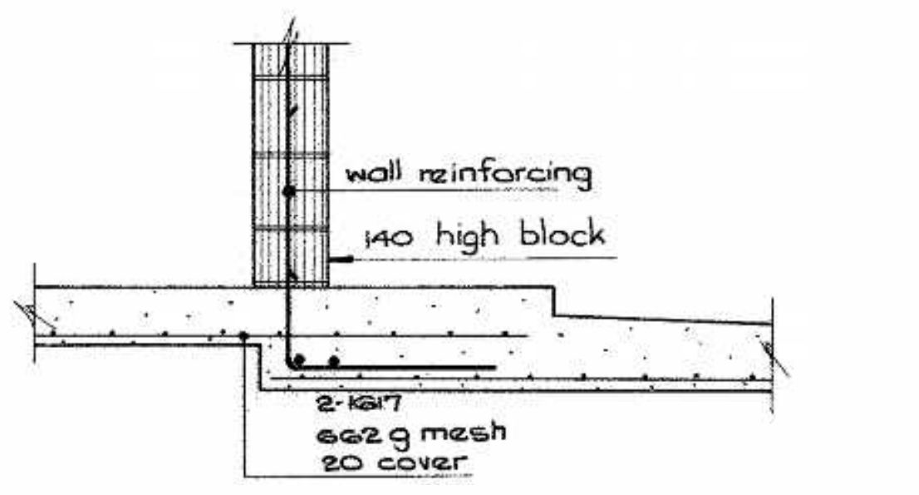
46 standard detail



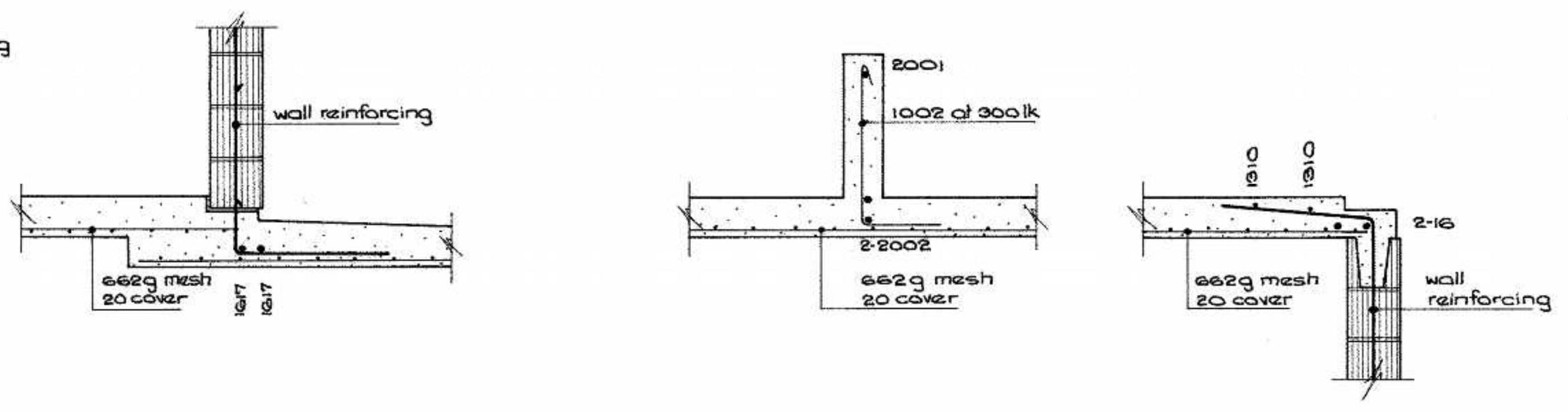
47 standard details 48



49 standard details 50



51 standard detail



52 standard details 53 54

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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

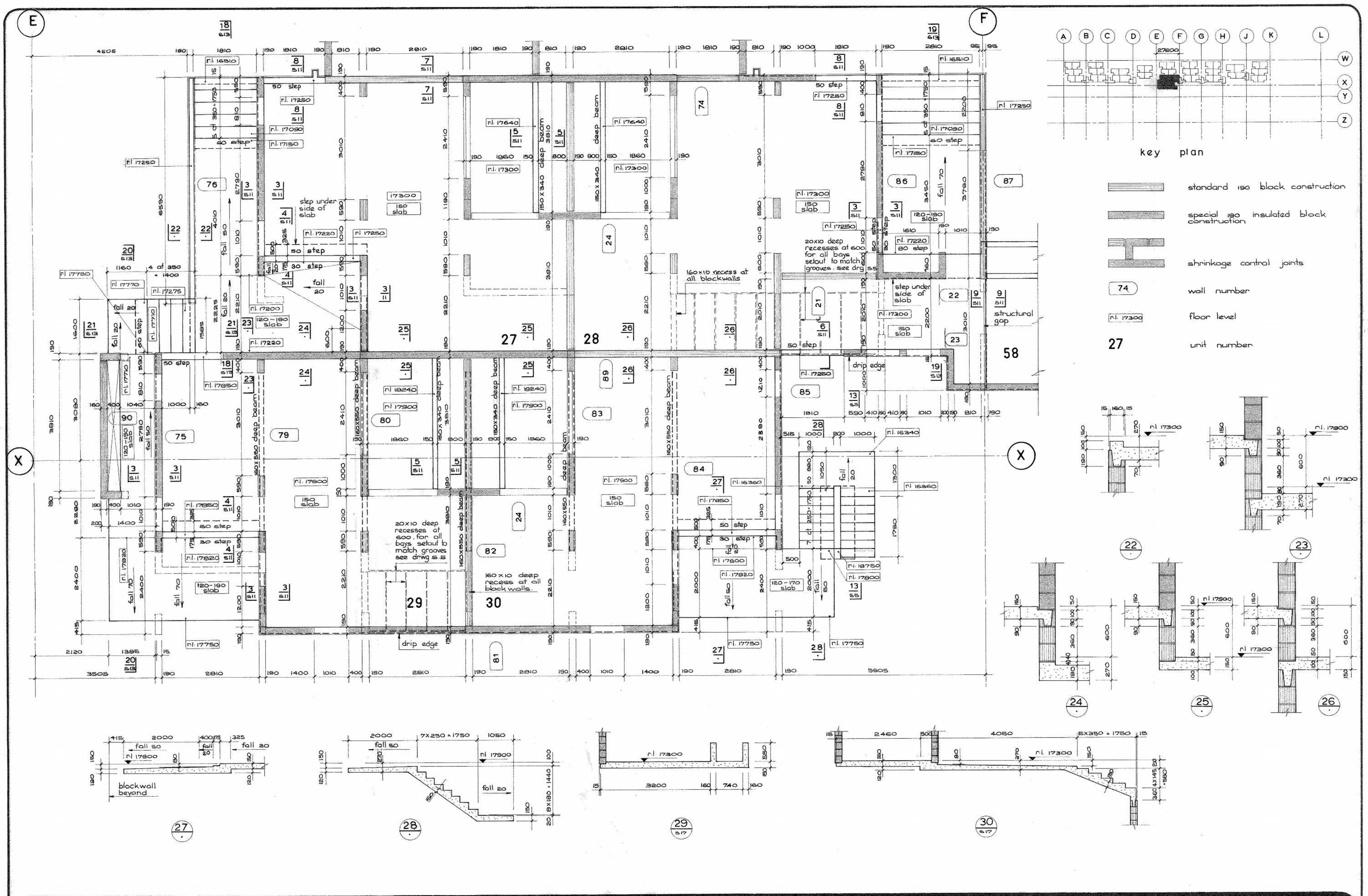
FLOOR REINFORCEMENT
LEVEL 2, C-E

Scale 1 : 50
1 : 20
Drawn S.J.K.
Traced D.K.R.
Approved

D
C
B
A
2.9.75 Contract

629 / S14

The Contractor shall verify all dimensions prior to commencing work.



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BROUGHAM STREET
URBAN RENEWAL 1 — STAGE 1

FLOOR PLAN — CARCASS
LEVEL 2, E — F

Scale 1 : 20
1 : 50
Drawn S.J.K.
Traced H.M.N.
Approved

D
C
B
A
2·9·75 Contract

629 / S15

The Contractor shall verify all dimensions prior to commencing work

Appendix C – DEE Spreadsheet

Detailed Engineering Evaluation Summary Data

V1.11

Location

Building Name: Single Storey Units
Building Address: 356-400 Brougham St. (Unit / No: / Street)
Legal Description:
GPS south: Degrees 43, Min 32, Sec 52.00
GPS east: Degrees 172, Min 38, Sec 35.00
Building Unique Identifier (CCC): BE 1072 EQ2

Reviewer: John Mitchell
CPEng No: 1006738
Company: Opus International Consultants
Company project number: 6-QUCCC.92
Company phone number: 09-3559500
Date of submission: 1/10/2012
Inspection Date: Jul-12
Revision: Final V3
Is there a full report with this summary? yes

Site

Site slope: flat
Soil type: mixed
Site Class (to NZS1170.5): D
Proximity to waterway (m, if <100m):
Proximity to clifftop (m, if < 100m):
Proximity to cliff base (m,if <100m):

Max retaining height (m): 0
Soil Profile (if available): n/a
If Ground improvement on site, describe:
Approx site elevation (m): 16.00

Building

No. of storeys above ground: 1 — single storey = 1
Ground floor split? no
Storeys below ground 0
Foundation type: strip footings
Building height (m): 4.20
Floor footprint area (approx): 50
Age of Building (years): 36

Ground floor elevation (Absolute) (m): varies
Ground floor elevation above ground (m): varies
if Foundation type is other, describe:
height from ground to level of uppermost seismic mass (for IEP only) (m):
Date of design: 1965-1976

Strengthening present? no
If so, when (year)?
And what load level (%g)?
Brief strengthening description:

Use (ground floor): multi-unit residential
Use (upper floors):
Use notes (if required):
Importance level (to NZS1170.5): IL2

Gravity Structure

Gravity System: load bearing walls
Roof: timber framed — rafter type, purlin type and cladding: mixed joist sizes up to 200mm deep
Floors: other (note) — describe sytem:
Beams: none — overall depth x width (mm x mm):
Columns: load bearing walls — typical dimensions (mm x mm): 600x190
Walls: fully filled concrete masonry — #N/A

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along: fully filled CMU — note total length of wall at ground (m):
Ductility assumed, μ: 1.25 — wall thickness (m):
Period along: 0.40 ##### enter height above at H31 — estimate or calculation? estimated
Total deflection (ULS) (mm): — estimate or calculation?
maximum interstorey deflection (ULS) (mm): — estimate or calculation?

Lateral system across: fully filled CMU — note total length of wall at ground (m):
Ductility assumed, μ: 1.25 — wall thickness (m):
Period across: 0.40 ##### enter height above at H31 — estimate or calculation?
Total deflection (ULS) (mm): — estimate or calculation?
maximum interstorey deflection (ULS) (mm): — estimate or calculation?

Separations:

north (mm): — leave blank if not relevant
east (mm):
south (mm):
west (mm):

Non-structural elements

Stairs:
Wall cladding:
Roof Cladding: Other (specify) — describe Woodtex Panels
Glazing: aluminium frames
Ceilings: none
Services(list):

Available documentation

Architectural none — original designer name/date
Structural partial — original designer name/date Holmes, Wood, Poole & Johnstone
Mechanical none — original designer name/date
Electrical none — original designer name/date
Geotech report — original designer name/date

Damage

Site: (refer DEE Table 4-2)

Site performance: Poor — Describe damage: Lateral Spread and differential settlement

Settlement:	25-100m	notes (if applicable): Estimate (geotech report not available)
Differential settlement:	1:350-1:250	notes (if applicable): Estimate (geotech report not available)
Liquefaction:	2-5 m²/100m³	notes (if applicable): Estimate (geotech report not available)
Lateral Spread:	0-50mm	notes (if applicable): Estimate (geotech report not available)
Differential lateral spread:	1:400-1:100	notes (if applicable): Estimate (geotech report not available)
Ground cracks:	none apparent	notes (if applicable): Estimate (geotech report not available)
Damage to area:	moderate to substantial (1 in 5)	notes (if applicable):

Building:

Current Placard Status: green

Along — Damage ratio: 38% — Describe how damage ratio arrived at: refer to report
Describe (summary): Damage ratio varies across units from worst case 38% to 0%.

Across — Damage ratio: 38%
Describe (summary): Damage ratio varies across units from worst case 38% to 0%.

$$Damage\_Ratio = \frac{(\%NBS\ (before) - \%NBS\ (after))}{\%NBS\ (before)}$$

Diaphragms — Damage?: no — Describe:
CSWs: — Damage?: no — Describe:
Pounding: — Damage?: no — Describe:
Non-structural: — Damage?: yes — Describe:

Recommendations

Level of repair/strengthening required: significant structural — Describe: refer to report
Building Consent required: yes — Describe:
Interim occupancy recommendations: partial occupancy — Describe: Units closed by CCC are 25,26,33,34,37,39,40,43,44,45,47

Along — Assessed %NBS before: 40% ##### %NBS from IEP below — If IEP not used, please detail assessment methodology: DEE Assessment
Assessed %NBS after: 25%

Across — Assessed %NBS before: 40% ##### %NBS from IEP below
Assessed %NBS after: 25%

IEP

Use of this method is not mandatory - more detailed analysis may give a different answer, which would take precedence. Do not fill in fields if not using IEP.

Period of design of building (from above): 1965-1976
h_n from above: m

Seismic Zone, if designed between 1965 and 1992:
not required for this age of building
not required for this age of building

	along	across
Period (from above):	0.4	0.4
(%NBS)nom from Fig 3.3:		

Note:1 for specifically design public buildings, to the code of the day: pre-1965 = 1.25; 1965-1976, Zone A =1.33; 1965-1976, Zone B = 1.2; all else 1.0: 1.00
Note 2: for RC buildings designed between 1976-1984, use 1.2: 1.0
Note 3: for buildngs designed prior to 1935 use 0.8, except in Wellington (1.0): 1.0

	along	across
Final $(\%NBS)_{nom}$:	**0%**	**0%**

2.2 Near Fault Scaling Factor

Near Fault scaling factor, from NZS1170.5, cl 3.1.6:

	along	across
Near Fault scaling factor (1/N(T,D), **Factor A**:	#DIV/0!	#DIV/0!

2.3 Hazard Scaling Factor

Hazard factor Z for site from AS1170.5, Table 3.3:
Z_{1992}, from NZS4203:1992
Hazard scaling factor, **Factor B**: #DIV/0!

2.4 Return Period Scaling Factor

Building Importance level (from above): 2
Return Period Scaling factor from Table 3.1, **Factor C**: 1.00

2.5 Ductility Scaling Factor

	along	across
Assessed ductility (less than max in Table 3.2)	1.00	1.00
Ductility scaling factor: =1 from 1976 onwards; or =kμ, if pre-1976, fromTable 3.3:		
Ductiity Scaling Factor, **Factor D**:	0.00	0.00

2.6 Structural Performance Scaling Factor:

Sp:		
Structural Performance Scaling Factor **Factor E**:	#DIV/0!	#DIV/0!

2.7 Baseline %NBS, $(NBS\%)_b = (\%NBS)_{nom} \times A \times B \times C \times D \times E$ — $\%NBS_b$: **#DIV/0!** **#DIV/0!**

Global Critical Structural Weaknesses: (refer to NZSEE IEP Table 3.4)

3.1. Plan Irregularity, factor A: 1
3.2. Vertical irregularity, Factor B: 1
3.3. Short columns, Factor C: 1
3.4. Pounding potential — Pounding effect D1, from Table to right 1.0
Height Difference effect D2, from Table to right 1.0
Therefore, Factor D: 1
3.5. Site Characteristics 1

Table for selection of D1	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Alignment of floors within 20% of H	**0.7**	**0.8**	**1**
Alignment of floors not within 20% of H	**0.4**	**0.7**	**0.8**

Table for Selection of D2	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Height difference > 4 storeys	0.4	0.7	1
Height difference 2 to 4 storeys	0.7	0.9	1
Height difference < 2 storeys	1	1	1

3.6. Other factors, Factor F

	Along	Across
For ≤ 3 storeys, max value =2.5, otherwise max valule =1.5, no minimum		
Rationale for choice of F factor, if not 1		

Detail Critical Structural Weaknesses: (refer to DEE Procedure section 6)
List any: — Refer also section 6.3.1 of DEE for discussion of F factor modification for other critical structural weaknesses

3.7. Overall Performance Achievement ratio (PAR)	**0.00**	**0.00**
4.3 PAR x (%NBS)b: PAR x Baselline %NBS:	**#DIV/0!**	**#DIV/0!**
4.4 Percentage New Building Standard (%NBS), (before)		**#DIV/0!**

Detailed Engineering Evaluation Summary Data

V1.11

Location

Building Name: 2-Storey Units

	Unit	No:	Street
Building Address:	356-400 Brougham St.		
Legal Description:			

	Degrees	Min	Sec
GPS south:	43	32	52.00
GPS east:	172	38	35.00

Building Unique Identifier (CCC): BE 1072 EQ2

Reviewer: John Mitchell
CPEng No: 1006738
Company: Opus International Consultants
Company project number: 6-QUCCC.92
Company phone number: 09-3559500

Date of submission: 1/10/2012
Inspection Date:
Revision: Final V3
Is there a full report with this summary? yes

Site

Site slope: flat
Soil type: mixed
Site Class (to NZS1170.5): D
Proximity to waterway (m, if <100m):
Proximity to clifftop (m, if < 100m):
Proximity to cliff base (m,if <100m):

Max retaining height (m):
Soil Profile (if available): n/a
If Ground improvement on site, describe:
Approx site elevation (m): 15.00

Building

No. of storeys above ground: 2 single storey = 1
Ground floor split? no
Storeys below ground 0
Foundation type: strip footings
Building height (m): 6.50
Floor footprint area (approx): 181
Age of Building (years): 36

Ground floor elevation (Absolute) (m): varies
Ground floor elevation above ground (m): varies
if Foundation type is other, describe:
height from ground to level of uppermost seismic mass (for IEP only) (m):
Date of design: 1965-1976

Strengthening present? no
Use (ground floor): parking
Use (upper floors): multi-unit residential
Use notes (if required):
Importance level (to NZS1170.5): IL2

If so, when (year)?
And what load level (%g)?
Brief strengthening description:

Gravity Structure

Gravity System: load bearing walls
Roof: timber framed
Floors: concrete flat slab
Beams: cast-insitu concrete
Columns: load bearing walls
Walls: fully filled concrete masonry

rafter type, purlin type and cladding mixed joist sizes up to 200mm deep
slab thickness (mm) 150
overall depth x width (mm x mm) 400x190
typical dimensions (mm x mm) varies
#N/A

Lateral load resisting structure

Lateral system along: fully filled CMU
Ductility assumed, μ: 2.00
Period along: 0.40 ##### enter height above at H31
Total deflection (ULS) (mm):
maximum interstorey deflection (ULS) (mm):

Note: Define along and across in detailed report!

note total length of wall at ground (m):
wall thickness (m):
estimate or calculation?
estimate or calculation?
estimate or calculation?

Lateral system across: fully filled CMU
Ductility assumed, μ: 2.00
Period across: 0.40 ##### enter height above at H31
Total deflection (ULS) (mm):
maximum interstorey deflection (ULS) (mm):

note total length of wall at ground (m):
wall thickness (m):
estimate or calculation?
estimate or calculation?
estimate or calculation?

Separations:

north (mm):
east (mm):
south (mm):
west (mm):

leave blank if not relevant

Non-structural elements

Stairs: precast, full flight
Wall cladding:
Roof Cladding: Other (specify)
Glazing: aluminium frames
Ceilings: plaster, fixed
Services(list):

describe supports
describe Woodtex Panels

Available documentation

Architectural	none	original designer name/date	
Structural	partial	original designer name/date	Holmes, Wood, Poole & Johnstone
Mechanical	none	original designer name/date	
Electrical	none	original designer name/date	
Geotech report		original designer name/date	

Damage

Site:
(refer DEE Table 4-2)

Site performance: Poor
Describe damage: Lateral Spread and differential settlement

Settlement:	25-100m	notes (if applicable):	Estimate (geotech report not available)
Differential settlement:	1:350-1:250	notes (if applicable):	Estimate (geotech report not available)
Liquefaction:	2-5 m²/100m³	notes (if applicable):	Estimate (geotech report not available)
Lateral Spread:	0-50mm	notes (if applicable):	Estimate (geotech report not available)
Differential lateral spread:	1:400-1:100	notes (if applicable):	Estimate (geotech report not available)
Ground cracks:	none apparent	notes (if applicable):	Estimate (geotech report not available)
Damage to area:	moderate to substantial (1 in 5)	notes (if applicable):	

Building:

Current Placard Status: yellow

Along Damage ratio: 38%
Describe (summary): Damage ratio varies across units from worst case 38% to 0%.

Describe how damage ratio arrived at: refer to report

Across Damage ratio: 38%
Describe (summary): Damage ratio varies across units from worst case 38% to 0%.

$$Damage\_Ratio = \frac{(\%NBS\ (before) - \%NBS\ (after))}{\%NBS\ (before)}$$

Diaphragms	Damage?: no	Describe:	
CSWs:	Damage?: yes	Describe:	
Pounding:	Damage?: no	Describe:	
Non-structural:	Damage?: yes	Describe:	

Recommendations

Level of repair/strengthening required: significant structural and strengthening
Building Consent required: yes
Interim occupancy recommendations: partial occupancy

Describe: refer to report
Describe:
Describe: Units closed by CCC are 42 and 44. Units open are 5,6,11,1

Along Assessed %NBS before: 48% ##### %NBS from IEP below
Assessed %NBS after: 30%

If IEP not used, please detail assessment methodology: DEE Assessment

Across Assessed %NBS before: 48% ##### %NBS from IEP below
Assessed %NBS after: 30%

IEP

Use of this method is not mandatory - more detailed analysis may give a different answer, which would take precedence. Do not fill in fields if not using IEP.

Period of design of building (from above): 1965-1976

h_n from above: m

Seismic Zone, if designed between 1965 and 1992:

not required for this age of building
not required for this age of building

	along	across
Period (from above):	0.4	0.4
(%NBS)nom from Fig 3.3:		

Note:1 for specifically design public buildings, to the code of the day: pre-1965 = 1.25; 1965-1976, Zone A =1.33; 1965-1976, Zone B = 1.2; all else 1.0 1.00
Note 2: for RC buildings designed between 1976-1984, use 1.2 1.0
Note 3: for buildngs designed prior to 1935 use 0.8, except in Wellington (1.0) 1.0

	along	across
Final (%NBS)$_{nom}$:	**0%**	**0%**

2.2 Near Fault Scaling Factor

Near Fault scaling factor, from NZS1170.5, cl 3.1.6:

	along	across
Near Fault scaling factor (1/N(T,D), **Factor A**:	#DIV/0!	#DIV/0!

2.3 Hazard Scaling Factor

Hazard factor Z for site from AS1170.5, Table 3.3:
Z_{1992}, from NZS4203:1992
Hazard scaling factor, **Factor B**: #DIV/0!

2.4 Return Period Scaling Factor

Building Importance level (from above): 2
Return Period Scaling factor from Table 3.1, **Factor C**: 1.00

2.5 Ductility Scaling Factor

	along	across
Assessed ductility (less than max in Table 3.2)	1.00	1.00
Ductility scaling factor: =1 from 1976 onwards; or =kμ, if pre-1976, fromTable 3.3:		
Ductiity Scaling Factor, **Factor D**:	0.00	0.00

2.6 Structural Performance Scaling Factor:

Sp:		
Structural Performance Scaling Factor **Factor E**:	#DIV/0!	#DIV/0!

2.7 Baseline %NBS, (NBS%)$_b$ = (%NBS)$_{nom}$ x A x B x C x D x E

%NBS$_b$:	**#DIV/0!**	**#DIV/0!**

Global Critical Structural Weaknesses: (refer to NZSEE IEP Table 3.4)

3.1. Plan Irregularity, factor A: 1

3.2. Vertical irregularity, Factor B: 1

3.3. Short columns, Factor C: 1

3.4. Pounding potential
Pounding effect D1, from Table to right 1.0
Height Difference effect D2, from Table to right 1.0

Therefore, Factor D: 1

Table for selection of D1	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Alignment of floors within 20% of H	**0.7**	**0.8**	**1**
Alignment of floors not within 20% of H	**0.4**	**0.7**	**0.8**

Table for Selection of D2	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Height difference > 4 storeys	0.4	0.7	1
Height difference 2 to 4 storeys	0.7	0.9	1
Height difference < 2 storeys	1	1	1

3.5. Site Characteristics 1

3.6. Other factors, Factor F

	Along	Across
For ≤ 3 storeys, max value =2.5, otherwise max valule =1.5, no minimum		
Rationale for choice of F factor, if not 1		

Detail Critical Structural Weaknesses: (refer to DEE Procedure section 6)
List any: Refer also section 6.3.1 of DEE for discussion of F factor modification for other critical structural weaknesses

3.7. Overall Performance Achievement ratio (PAR)	**0.00**	**0.00**
4.3 PAR x (%NBS)b: PAR x Baselline %NBS:	**#DIV/0!**	**#DIV/0!**
4.4 Percentage New Building Standard (%NBS), (before)		**#DIV/0!**

Detailed Engineering Evaluation Summary Data

V1.11

Location

Building Name: 3-Storey Units
Building Address: 356-400 Brougham St. (Unit / No: / Street)
Legal Description:
GPS south: 43 (Degrees) 32 (Min) 52.00 (Sec)
GPS east: 172 (Degrees) 38 (Min) 35.00 (Sec)
Building Unique Identifier (CCC): BE 1072 EQ2

Reviewer: John Mitchell
CPEng No: 1006738
Company: Opus International Consultants
Company project number: 6-QUCCC.92
Company phone number: 09-3559500
Date of submission: 1/10/2012
Inspection Date: Jul-12
Revision: Final V3
Is there a full report with this summary? yes

Site

Site slope: flat
Soil type: mixed
Site Class (to NZS1170.5): D
Proximity to waterway (m, if <100m):
Proximity to clifftop (m, if < 100m):
Proximity to cliff base (m,if <100m):

Max retaining height (m): 0
Soil Profile (if available):
If Ground improvement on site, describe:
Approx site elevation (m): 16.00

Building

No. of storeys above ground: 2 — single storey = 1
Ground floor split? no
Storeys below ground: 0
Foundation type: strip footings
Building height (m): 10.00
Floor footprint area (approx): 24
Age of Building (years): 36

Ground floor elevation (Absolute) (m):
Ground floor elevation above ground (m):
if Foundation type is other, describe:
height from ground to level of uppermost seismic mass (for IEP only) (m):
Date of design: 1965-1976

Strengthening present? no
Use (ground floor): other (specify)
Use (upper floors): multi-unit residential
Use notes (if required):
Importance level (to NZS1170.5): IL2

If so, when (year)?
And what load level (%g)?
Brief strengthening description:

Gravity Structure

Gravity System: load bearing walls
Roof: timber framed — rafter type, purlin type and cladding: mixed joist sizes up to 200mm deep
Floors: concrete flat slab — slab thickness (mm): 150
Beams: cast-insitu concrete — overall depth x width (mm x mm): 400x190
Columns: load bearing walls — typical dimensions (mm x mm): varies
Walls: fully filled concrete masonry — #N/A

Lateral load resisting structure

Note: Define along and across in detailed report!

Lateral system along: fully filled CMU — note total length of wall at ground (m):
Ductility assumed, μ: 2.00 — wall thickness (m): 190
Period along: 0.40 ##### enter height above at H31 — estimate or calculation?
Total deflection (ULS) (mm): — estimate or calculation?
maximum interstorey deflection (ULS) (mm): — estimate or calculation?

Lateral system across: fully filled CMU — note total length of wall at ground (m):
Ductility assumed, μ: 2.00 — wall thickness (m): 190
Period across: 0.40 ##### enter height above at H31 — estimate or calculation?
Total deflection (ULS) (mm): — estimate or calculation?
maximum interstorey deflection (ULS) (mm): — estimate or calculation?

Separations:

north (mm): — leave blank if not relevant
east (mm):
south (mm):
west (mm):

Non-structural elements

Stairs: precast, full flight — describe supports
Wall cladding:
Roof Cladding: Other (specify) — describe Woodtex Panels
Glazing: aluminium frames
Ceilings: plaster, fixed
Services(list):

Available documentation

Architectural: none — original designer name/date
Structural: partial — original designer name/date: Holmes, Wood, Poole & Johnstone
Mechanical: none — original designer name/date
Electrical: none — original designer name/date
Geotech report: — original designer name/date

Damage

Site:

(refer DEE Table 4-2)

Site performance: Poor — Describe damage: Lateral Spread and differential settlement
Settlement: 25-100m — notes (if applicable): Estimate (geotech report not available)
Differential settlement: 1:350-1:250 — notes (if applicable): Estimate (geotech report not available)
Liquefaction: 2-5 m²/100m³ — notes (if applicable): Estimate (geotech report not available)
Lateral Spread: 0-50mm — notes (if applicable): Estimate (geotech report not available)
Differential lateral spread: 1:400-1:100 — notes (if applicable): Estimate (geotech report not available)
Ground cracks: none apparent — notes (if applicable): Estimate (geotech report not available)
Damage to area: moderate to substantial (1 in 5) — notes (if applicable):

Building:

Current Placard Status: red

Along — Damage ratio: 50% — Describe how damage ratio arrived at:
Describe (summary): Damage ratio varies across units from worst case 50% to 0%.

Across — Damage ratio: 36%
Describe (summary): Damage ratio varies across units from worst case 36% to 0%.

$$Damage\_Ratio = \frac{(\%NBS\ (before) - \%NBS\ (after))}{\%NBS\ (before)}$$

Diaphragms — Damage?: no — Describe:
CSWs: — Damage?: yes — Describe: shear wall collector and bond beam damage
Pounding: — Damage?: no — Describe:
Non-structural: — Damage?: yes — Describe:

Recommendations

Level of repair/strengthening required: significant structural and strengthening — Describe: refer to report
Building Consent required: yes — Describe:
Interim occupancy recommendations: do not occupy — Describe: All units are closed - Units 55,56,57,58,59,60 and 61.

Along — Assessed %NBS before: 100% ##### %NBS from IEP below — If IEP not used, please detail assessment methodology: DEE Assessment
Assessed %NBS after: 50%

Across — Assessed %NBS before: 22% ##### %NBS from IEP below
Assessed %NBS after: 14%

IEP

Use of this method is not mandatory - more detailed analysis may give a different answer, which would take precedence. Do not fill in fields if not using IEP.

Period of design of building (from above): 1965-1976
h_n from above: m
Seismic Zone, if designed between 1965 and 1992:
not required for this age of building
not required for this age of building

	along	across
Period (from above):	0.4	0.4
(%NBS)nom from Fig 3.3:		

Note:1 for specifically design public buildings, to the code of the day: pre-1965 = 1.25; 1965-1976, Zone A =1.33; 1965-1976, Zone B = 1.2; all else 1.0: 1.00
Note 2: for RC buildings designed between 1976-1984, use 1.2: 1.0
Note 3: for buildngs designed prior to 1935 use 0.8, except in Wellington (1.0): 1.0

	along	across
Final $(\%NBS)_{nom}$:	**0%**	**0%**

2.2 Near Fault Scaling Factor

Near Fault scaling factor, from NZS1170.5, cl 3.1.6:

	along	across
Near Fault scaling factor (1/N(T,D), **Factor A**:	#DIV/0!	#DIV/0!

2.3 Hazard Scaling Factor

Hazard factor Z for site from AS1170.5, Table 3.3:
Z_{1992}, from NZS4203:1992
Hazard scaling factor, **Factor B**: #DIV/0!

2.4 Return Period Scaling Factor

Building Importance level (from above): 2
Return Period Scaling factor from Table 3.1, **Factor C**: 1.00

2.5 Ductility Scaling Factor

	along	across
Assessed ductility (less than max in Table 3.2)	1.00	1.00
Ductility scaling factor: =1 from 1976 onwards; or =kμ, if pre-1976, fromTable 3.3:		
Ductiity Scaling Factor, **Factor D**:	0.00	0.00

2.6 Structural Performance Scaling Factor:

Sp:		
Structural Performance Scaling Factor **Factor E**:	#DIV/0!	#DIV/0!

2.7 Baseline %NBS, $(NBS\%)_b = (\%NBS)_{nom} \times A \times B \times C \times D \times E$

$\%NBS_b$:	**#DIV/0!**	**#DIV/0!**

Global Critical Structural Weaknesses: (refer to NZSEE IEP Table 3.4)

3.1. Plan Irregularity, factor A: 1
3.2. Vertical irregularity, Factor B: 1
3.3. Short columns, Factor C: 1
3.4. Pounding potential
Pounding effect D1, from Table to right: 1.0
Height Difference effect D2, from Table to right: 1.0
Therefore, Factor D: 1
3.5. Site Characteristics 1

Table for selection of D1	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Alignment of floors within 20% of H	**0.7**	**0.8**	**1**
Alignment of floors not within 20% of H	**0.4**	**0.7**	**0.8**

Table for Selection of D2	Severe	Significant	Insignificant/none
Separation	0<sep<.005H	.005<sep<.01H	Sep>.01H
Height difference > 4 storeys	0.4	0.7	1
Height difference 2 to 4 storeys	0.7	0.9	1
Height difference < 2 storeys	1	1	1

3.6. Other factors, Factor F

	Along	Across
For ≤ 3 storeys, max value =2.5, otherwise max valule =1.5, no minimum		
Rationale for choice of F factor, if not 1		

Detail Critical Structural Weaknesses: (refer to DEE Procedure section 6)
List any: — Refer also section 6.3.1 of DEE for discussion of F factor modification for other critical structural weaknesses

3.7. Overall Performance Achievement ratio (PAR)	**0.00**	**0.00**
4.3 PAR x (%NBS)b: PAR x Baselline %NBS:	**#DIV/0!**	**#DIV/0!**
4.4 Percentage New Building Standard (%NBS), (before)		**#DIV/0!**

Appendix D – Geotechnical Desk Study

July 2012

Christchurch Office
20 Moorhouse Avenue
PO Box 1482, Christchurch Mail Centre,
Christchurch 8140, New Zealand

Tel +64 3 363 5400
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TO	Lindsay Fleming
COPY	Greg Saul, Sheryl Keenan
FROM	Graham Brown/Danielle Belcher
DATE	27 July 2012
FILE	6-QUCCC.92/105SC
SUBJECT	Brougham Village - Geotechnical Desk Study Revised

1. Introduction

This memo summarises the findings of a Geotechnical Desk Study and Site Walkovers completed on 10 May 2011 and 26 July 2012. The purpose of this desk study is to provide an initial appraisal of the suitability of the land and the future bearing capacity, in accordance with CCC email request of 18 April 2011.

This is the first geotechnical inspection undertaken at this site, following previous Structural Assessments completed by Opus.

2. Description of Facility

The Brougham Village comprises the following units,

- Units 356 – 400 Brougham Street, up to 3 storeys.
- Units at 402 Brougham Street, single storey.
- Units 95 and 97 Hastings Street East, up to 3 storeys.
- Units 131 Hastings Street East, single storey.

Refer to the annotated Site Plan Appendix B.

The site is relatively flat and low lying and is bounded to the north by Brougham Street and to the south by Hastings Street East. The ground profile slopes gently down towards Brougham Street and the ground floor units are approximately 0.5m to 0.75m above footpath level. The buildings range from one storey to three story structures and are formed of masonry block. The structures are estimated to have been built in the 1960's or 70's.

The site between the buildings is covered extensively with asphalt and paving stones. There are some grassed areas along the Brougham Street frontage and to the west of the units at 131 Hastings Street.

3. *Desk Study Results*

3.1 Ground Conditions

A desk study of geotechnical investigations in the area from Environment Canterbury and EQC identified four logs and five CPT tests within 200m of the site, refer to Location Plan Appendix A. Drill Hole M36/0964, drilled in 1899, was performed adjacent to Unit 402 Brougham Street.

A geological cross-section completed by EQC has been identified adjacent to the site along Brougham Street.

The borehole records, CPT test results and the geological cross-section are included in Appendix A.

The geological cross-section summarises the ground conditions in the area, which are Silty SAND from surface to a depth of 5m below ground level (bgl); SAND and GRAVEL to 7.5m bgl; Sandy GRAVEL to a depth of 11m bgl; Sandy SILT to a depth of 12m bgl; Gravelly SAND to a depth of 23.5m bgl and Sandy GRAVEL to a depth of 27.5m bgl.

The sloping ground, as indicated by the as built drawings is man-made. A specification for the hardfill material that comprises the sloping ground indicates that well graded, face-cut pitrun with a maximum grain size of 75mm has been used in conjunction with a crushed, “no fines” fill with a size range of 25mm and 40mm.

3.2 Ground and Building Damage

As built drawings have been provided and indicate that the foundation system for the Brougham Village is strip footings to varying depths between 250mm and 700mm bgl. The floor slab is unreinforced concrete, varying in thickness between 100mm and 250mm.

An inspection of an open excavation adjacent to Unit 396 identified that the hardfill is not face-cut, and is sub-rounded to rounded in nature with a maximum size of 100mm, refer to photographs.

No signs of foundation subsidence were observed. A maximum of 50mm to 100mm of horizontal and vertical displacement was observed in the tiled areas around units 356 to 400 Brougham Street, refer to photographs. The land movement has generally been downslope towards Brougham Street.

A number of units located at 356 – 400 Brougham Street have suffered significant structural damage, particularly the section of structure supporting the third storey. In contrast, there appears to be no structural damage to units 95 and 97 Hastings Street East. There has been significant damage to the buried services throughout the site.

There is evidence of moderate liquefaction throughout the site. Surface disruption and ground heave up to 100mm vertically was recorded at two locations on the asphalt driveway and also a service trench to the north of Unit 402.

It was recommended in May 2011 that the ground floor slabs within all the garages are checked for subsidence and liquefaction. Also the foundations for the 4 units at 131

Hastings Street East should be inspected as unit 2 was yellow stickered due to severe liquefaction. To date this has not been done.

3.3 Liquefaction Hazard

The 2003 ECAN Liquefaction study[1] indicates Brougham Village as having a moderate to high liquefaction potential under high groundwater conditions. Based on a low groundwater table, ground damage is expected to be moderate, subsidence likely to be between 100mm and 300mm.

No liquefaction was reported following the Darfield Earthquake of 4 September 2010.

Liquefaction was identified on site following both the 22 February 2011 and 13 June 2011 earthquake events, by both road observations and interpretation of aerial photos by Tonkin & Taylor[2]. The liquefaction identified was stated as moderate to severe.

Brougham Village is bounded by residential properties to the east, south and west that are located in the CERA "green" zone. The "green" zone has been further categorised into technical categories by the Department of Building and Housing (DBH). This site is bounded by both "Technical Category 2" (TC2) and "Technical Category 3" (TC3) sites. The DBH technical categories are guidelines for residential foundations, however are likely to be used as a guideline by the Christchurch City Council for building consent. TC2 identifies the area may be subject to minor to moderate land damage from liquefaction in future large earthquakes, whilst TC3 identifies the area may be subject to moderate to significant land damage from liquefaction in future large earthquakes.

4 Appraisal

In summary, minimal damage to building foundations has occurred as a result of liquefaction following the 22 February 2011 earthquake. The slab on grade and shallow foundations appear to have performed adequately with only minor damage being reported.

There are no streams or open watercourses within close proximity of the site, this minimises the potential for lateral spreading. However the site falls gently to Brougham Street as the units have been built on a man-made rise. This rise may provide a potential for lateral spreading which has resulted in the cracks between buildings at the north-eastern corner of the facility which indicates approximately 50mm of lateral movement.

GNS Science[3] indicates an elevated risk of seismic activity is expected in the Canterbury region as a result of the earthquake sequence following the 4 September 2010 earthquake. Recent advice (Geonet) indicates there is a 14% probability of another Magnitude 6 or greater earthquake occurring in the next 12 months in the Canterbury region. It is expected that the probability of occurrence is likely to decrease with time, following periods of reduced seismic activity. However, we would expect that similar

---

[1] ECan, The Solid Facts on Christchurch Liquefaction

[2] Project Orbit, 2011, Interagency/Organisation Collaboration Portal for Christchurch Recovery Effort, http://canterburyrecovery.projectorbit.com/sitepages/home/aspx

[3] GNS Science reporting on Geonet Website: http://www.geonet.org.nz/canterbury- quakes/aftershocks/ updated on 9 July 2012.

ground damage to that experienced could re-occur in a future earthquake, dependent on the location of the epicentre.

This report has identified a significant risk that liquefaction will occur again in the life of the buildings. We consider that this risk could be evaluated to inform CCC of the expected future performance of the land.

5 Proposed Geotechnical Investigations

It is recommended that as a minimum, the following geotechnical inspections are undertaken for the repair of the buildings.

1. Inspect the ground floor slabs within all the Garages for units 356 to 400, to check for subsidence and liquefaction damage.
2. Excavate and inspect foundations in key areas to confirm there has been no damage or ground disruption.
3. Undertake a Level Survey of the buildings.

To determine the liquefaction potential of the site in future earthquakes and to indentify the Technical Category of the site, the following site investigations are recommended:

1. Static Cone Penetration Tests (CPT) 12 No to confirm liquefaction potential.
2. Borehole 2 No – to a depth of about 25 m, with Standard Penetration Tests at 1.5 m depth intervals, and install piezometer to monitor groundwater level.
3. Assessment and reporting

Attachments:

Appendix A – Location Plan, BH and CPT Records

Appendix B – Annotated Site Plan

Photos showing liquefaction and site damage, Units 356 to 372 Brougham Street

South Elevation of Units 356 – 372

North Elevation of Units 356 – 372 from Brougham Street

View East, damage to Asphalt

General View

Structural Damage to 2nd and 3rd Storey at Unit 364

Ground Heave at footing adjacent to Unit 364


10mm crack, movement towards Brougham Street at Unit 368


Another example

Units 372 to 400 Brougham Street

South Elevation including

Heave and damage to driveway.

Garage 33 near Unit 388 crack in floor slab and liquefaction

Typical Structural Damage

10mm settlement of patio tiles

Typical damage to buried services

Open excavation showing rounded pit run.

Units 402 Brougham Street

General View 402 Brougham

Ground Heave above service trench

Units 131 Hastings Street East

No visible damage, unit 2 yellow stickered due to severe liquefaction

Units 95 and 97 Hastings Street East

Southern Elevation

Western limit, no damage visible

Northern elevation unit 95

Eastern Elevation

Key:
Red Line: Outline of Brougham Village
Red Circle: Boreholes from ECan and EQC
Yellow Triangle: CPT

Opus International Consultants Ltd
Christchurch Office
20 Moorhouse Ave
PO Box 1482
Christchurch, New Zealand
Tel: +64 3 363 5400 Fax: +64 3 365 7857

Project: Brougham Village
Geotechnical Desktop Study

Project No.:

Client: Christchurch City Council

Previous Investigations Plan

Drawn: Engineering Geologist

Date: 26-Jul-12

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds
SHEET 1 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5739961.63 m
2481450.24 mE
R.L. 5.58 m
DATUM NZMG

DRILL TYPE: Direct Push
DRILL METHOD: Sonic Vibration
DRILL FLUID: N/A

HOLE STARTED: 1/8/11
HOLE FINISHED: 2/8/11
DRILLED BY: DC
LOGGED BY: TH
CHECKED: GSH

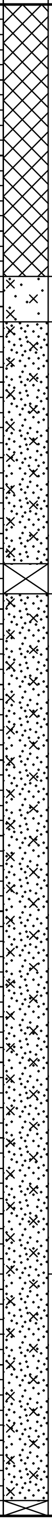
GEOLOGICAL / ENGINEERING DESCRIPTIO

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASI G	TESTS	SAMPLES	CLASSIFICATIO SYMBOL	MOISTURE CO DITIO / WEATHERI G	STRE GTH/DE SITY CLASSIFICATIO	SHEAR STRE GTH (kPa) 10 25 50 100 200	COMPRESSIVE STRE GTH (MPa) 1 5 20 50 100 250	DEFECT SPACI G (mm) 50 250 1000 2000	SOIL DESCRIPTIO Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTIO Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
HAND DIG FILL. (Potholed for services check and backfilled.)			0	HAND DUG										FILL: Borehole drilled through pre-dug and backfilled pothole.
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)			100	SV				ML	M	F				SILT with some sand, orange mottled brown. Firm, moist, low plasticity. Sand is fine.
								SP	M	L				Silty, fine SAND with trace rootlets,orange mottled brown Loose, moist.
				SPT		2/2/2 N=4	■ ■							
			50	SV										1.85 to 1.95m no recovery
			100	SONIC VIBRATION				ML	M	F				SILT with trace sand, bluish grey. Firm, moist, low plasticity. Sand is fine.
														- with minor interbedded sand. Interbedding is extremely closely spaced.
				SPT		1/3/3 N=6	■ ■							
			100	SONIC VIBRATION		✱FC								- fine to medium sand bed 50mm thick
								SW	M	F				Fine to medium SAND with some silt, bluish grey. Firm, moist.
				SPT		2/3/5 N=8	■ ■							- with some fine to coarse gravel. Gravel is subrounded to subangular

R.L. (m): 5.5, 5.0, 4.5, 4.0, 3.5, 3.0, 2.5, 2.0, 1.5, 1.0

DEPTH (m): 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5

GRAPHIC LOG



TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds
SHEET 2 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5739961.63 m
2481450.24 mE
R.L. 5.58 m
DATUM NZMG

DRILL TYPE: Direct Push
DRILL METHOD: Sonic Vibration
DRILL FLUID: N/A

HOLE STARTED: 1/8/11
HOLE FINISHED: 2/8/11
DRILLED BY: DC
LOGGED BY: TH
CHECKED: GSH

GEOLOGICAL
GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.

ENGINEERING DESCRIPTION

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

GEOLOGICAL UNIT: YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)

DEPTH (m)	CORE RECOVERY (%)	METHOD	TESTS
4.9 – 6.0	86	SONIC VIBRATION	✱FC
6.0 – 6.45		SPT	5/9/12 N=21
6.45 – 7.5	100	SONIC VIBRATION	✱FC
7.5 – 7.95		SPT	9/16/24 N=40
7.95 – 9.0	100	SONIC VIBRATION	✱FC
9.0 – 9.45		SPT	3/7/12 N=19
9.45 – 10	100	SONIC VIBR.	✱FC

DEPTH (m)	R.L. (m)
5.5	0.0
6.0	-0.5
6.5	-1.0
7.0	-1.5
7.5	-2.0
8.0	-2.5
8.5	-3.0
9.0	-3.5
9.5	-4.0

DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION
4.95 – 5.1				4.95m to 5.1m no recovery
5.1 – 5.7	GW	M	D	Sandy fine to coarse GRAVEL, bluish grey. Dense, moist. Gravel is rounded to sub-rounded. Sand is fine to coarse.
5.7 – 7.0	SP	M	MD	Fine SAND with some silt and trace organi fragments, grey. Medium dense, moist. - sand becoming fine to coarse
7.0 – 8.2	GW	M	D	Sandy, fine to coarse GRAVEL with rare cobbles, bluish grey. Dense, moist. Gravel is subrounded. Sand is fine to coarse. 7.85 to 7.95m no recovery
8.2 – 9.0	ML	M	F	Sandy SILT interbedded with sand lamina, grey. Firm, moist, low plasticity. Sand is fine to medium. Sand interbedding is extremely closely spaced.
9.0 – 10	SW	M	MD	Fine to coarse SAND with trace silt, bluish grey. Medium dense, moist. 9.35 to 9.45m no recovery - becoming gravelly SAND. Gravel is fine to coarse, rounded to subrounded.

SHEAR STRENGTH (kPa): 10 25 50 100 200
COMPRESSIVE STRENGTH (MPa): 1 5 20 50 100 250
DEFECT SPACING (mm): 50 250 1000 2000

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds

SHEET 3 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5739961.63 m
2481450.24 mE
R.L. 5.58 m
DATUM NZMG

DRILL TYPE: Direct Push
DRILL METHOD: Sonic Vibration
DRILL FLUID: N/A

HOLE STARTED: 1/8/11
HOLE FINISHED: 2/8/11
DRILLED BY: DC
LOGGED BY: TH
CHECKED: GSH

GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	CORE RECOVERY (%)	METHOD	TESTS	R.L. (m)	DEPTH (m)	CLASSIFICATIO SYMBOL	MOISTURE / WEATHERI G CO DITIO	STRE GTH/DE SITY CLASSIFICATIO	SOIL DESCRIPTIO
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)				-4.5		GW	M	MD	Sandy, fine to coarse GRAVEL, bluish grey. Medium dense, moist. Gravel is subrounded. Sand is fine to coarse.
		SPT	4/9/8 N=17	-5.0	10.5				- contains minor gravels
									10.85 to 10.95m no recovery
	100	SONIC VIBRATION		-5.5	11.0				
				-6.0	11.5				
		SPT	3/6/15 N=21	-6.5	12.0				- contains trace fine gravels - sand becoming fine to medium
	100	SONIC VIBRATION		-7.0	12.5	SW	M	MD	Fine to medium SAND, grey. Medium dense, moist.
				-7.5	13.0				
		SPT	3/4/9 N=13	-8.0	13.5				
	100	SONIC VIBRATION		-8.5	14.0				
			✱FC	-9.0	14.5				
					15	GW			

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds

SHEET 4 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5739961.63 m
2481450.24 mE
R.L. 5.58 m
DATUM NZMG

DRILL TYPE: Direct Push
DRILL METHOD: Sonic Vibration
DRILL FLUID: N/A

HOLE STARTED: 1/8/11
HOLE FINISHED: 2/8/11
DRILLED BY: DC
LOGGED BY: TH
CHECKED: GSH

GEOLOGICAL
ENGINEERING DESCRIPTIO

GEOLOGICAL UNIT,
GENERIC NAME,
ORIGIN,
MINERAL COMPOSITION.

FLUID LOSS | WATER | CORE RECOVERY (%) | METHOD | CASI G | TESTS | SAMPLES | R.L. (m) | DEPTH (m) | GRAPHIC LOG | CLASSIFICATIO SYMBOL | MOISTURE CO DITIO / WEATHERI G | STRE GTH/DE SITY CLASSIFICATIO | SHEAR STRE GTH (kPa) 10 25 50 100 200 | COMPRESSIVE STRE GTH (MPa) 1 5 20 50 100 250 | DEFECT SPACI G (mm) 50 250 1000 2000

SOIL DESCRIPTIO
Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTIO
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

Geological unit	Core recovery (%)	Method	Tests	R.L. (m)	Depth (m)	Classification symbol	Moisture condition	Strength/density	Description
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)		SPT	3/5/8 N=13	-9.5 -10.0	15.5	GW	M	MD	Sandy, fine to coarse GRAVEL, grey. Medium dense, moist. Gravel is subrounded. Sand is fine to coarse. 15.15 to 15.6m no recovery
	86	SONIC VIBRATION		-10.5 -11.0	16.0 16.5				
		SPT	8/11/23 N=34						16.65 to 16.95m no recovery
CHRISTCHURCH FORMATION (MARINE & ESTUARINE)	100	SONIC VIBRATION	*FC	-11.5 -12.0	17.0 17.5	SW	M	MD	Fine to medium SAND with trace gravel, bluish grey. Medium dense, moist. Gravel is fine to medium, rounded.
		SPT	4/7/18 N=25	-12.5	18.0				
	100	SONIC VIBRATION		-13.0 -13.5	18.5 19.0				- contains some fine to coarse gravel, subrounded.
		SPT	4/5/7 N=12	-14.0	19.5 20	ML	M	St	Sandy SILT, bluish grey. Stiff, moist, low plasticity. Sand is fine.

TONKIN & TAYLOR LTD

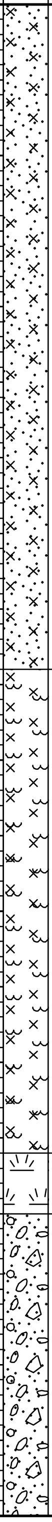
BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds

SHEET 5 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE	LOCATION: CENTRAL CITY	JOB No: 52000.3400
CO-ORDINATES 5739961.63 m 2481450.24 mE	DRILL TYPE: Direct Push	HOLE STARTED: 1/8/11
	DRILL METHOD: Sonic Vibration	HOLE FINISHED: 2/8/11
R.L. 5.58 m		DRILLED BY: DC
DATUM NZMG	DRILL FLUID: N/A	LOGGED BY: TH CHECKED: GSH

GEOLOGICAL — ENGINEERING DESCRIPTION



GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION.	FLUID LOSS	WATER	CORE RECOVERY (%)	METHOD	CASING	TESTS	SAMPLES	R.L. (m)	DEPTH (m)	CLASSIFICATION SYMBOL	MOISTURE CONDITION / WEATHERING	STRENGTH/DENSITY CLASSIFICATION	SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour. ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.
YALDHURST MEMBER OF THE SPRINGSTON FORMATION (ALLUVIAL)			100	SONIC VIBRATION				-14.5 -15.0	20.5	ML	M	St	Sandy SILT, bluish grey. Stiff, moist, low plasticity. Sand is fine.
				SPT		1/1/3 N=4	■	-15.5	21.0			F	- becoming firm
			100	SONIC VIBRATION				-16.0 -16.5	21.5 22.0				
										OL	M	St	Organic SILT, brownish grey. Stiff, moist, low plasticity.
				SPT		2/4/5 N=9	■	-17.0	22.5				
			100	SONIC VIBRATION				-17.5 -18.0	23.0 23.5				
										PT	M	F	PEAT, dark brown. Firm, moist, fibrous.
RICCARTON GRAVELS				SPT		4/11/19 N=21	■	-18.5	24.0	GW	M	MD	Sandy, fine to coarse GRAVEL with trace rootlets, bluish grey. Medium dense. Gravel is subrounded. Sand is fine to coarse.
			86	SONIC VIBR.				-19.0	24.5 25				- contains trace cobbles

SHEAR STRENGTH (kPa): 10 25 50 100 200 — COMPRESSIVE STRENGTH (MPa): 1 5 20 50 100 250 — DEFECT SPACING (mm): 50 250 1000 2000

TONKIN & TAYLOR LTD

BOREHOLE LOG

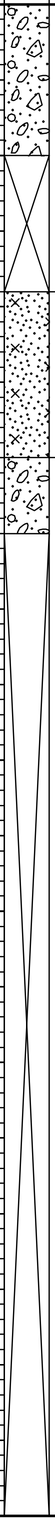
BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds
SHEET 6 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE	LOCATION: CENTRAL CITY	JOB No: 52000.3400
CO-ORDINATES 5739961.63 m 2481450.24 mE	DRILL TYPE: Direct Push	HOLE STARTED: 1/8/11
	DRILL METHOD: Sonic Vibration	HOLE FINISHED: 2/8/11
R.L. 5.58 m		DRILLED BY: DC
DATUM NZMG	DRILL FLUID: N/A	LOGGED BY: TH CHECKED: GSH

GEOLOGICAL: GEOLOGICAL UNIT, GENERIC NAME, ORIGIN, MINERAL COMPOSITION. FLUID LOSS, WATER, CORE RECOVERY (%), METHOD, CASING, TESTS, SAMPLES, R.L. (m), DEPTH (m)

ENGINEERING DESCRIPTION: GRAPHIC LOG, CLASSIFICATION SYMBOL, MOISTURE CONDITION / WEATHERING, STRENGTH/DENSITY CLASSIFICATION, SHEAR STRENGTH (kPa) 10 25 50 100 200, COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250, DEFECT SPACING (mm) 50 250 1000 2000

SOIL DESCRIPTION: Soil type, minor components, plasticity or particle size, colour.
ROCK DESCRIPTION: Substance: Rock type, particle size, colour, minor components. Defects: Type, inclination, thickness, roughness, filling.



Depth (m)	R.L. (m)	Geological unit	Core recovery (%)	Method	Tests	Classification symbol	Moisture condition	Strength/density	Description
	-19.5	RICCARTON GRAVELS				GW	M	D	Sandy, fine to coarse GRAVEL with trace rootlets, bluish grey. Dense. Gravel is subrounded. Sand is fine to coarse.
25.5	-20.0			SPT	15/19/28 N=47				25.5 to 25.95m no recovery
26.0	-20.5		76	SONIC VIBRATION	✱FC	SW	M	D	Fine to coarse SAND with trace silt, brown. Dense, moist.
26.5	-21.0					GW	M	D	Sandy, fine to coarse GRAVEL, brown. Dense, moist. Gravel is subrounded. Sand is fine to coarse. 26.75 to 30.07m no recovery.
27.0	-21.5			SPT	24/25/27 N=52			VD	- becoming very dense
27.5	-22.0		0	SONIC VIBRATION					
28.0	-22.5								
28.5	-23.0			SPT	50 for 90mm N>50				
29.0	-23.5		0	SONIC VIBRATION					
29.5	-24.0								
30									

TONKIN & TAYLOR LTD

BOREHOLE LOG

BOREHOLE No: CBD 42
Hole Location: Cnr Brougham & Waltham Rds
SHEET 7 OF 7

PROJECT: CHRISTCHURCH CITY 2011 EARTHQUAKE
LOCATION: CENTRAL CITY
JOB No: 52000.3400

CO-ORDINATES 5739961.63 m
2481450.24 mE
R.L. 5.58 m
DATUM NZMG

DRILL TYPE: Direct Push
DRILL METHOD: Sonic Vibration
DRILL FLUID: N/A

HOLE STARTED: 1/8/11
HOLE FINISHED: 2/8/11
DRILLED BY: DC
LOGGED BY: TH
CHECKED: GSH

GEOLOGICAL

GEOLOGICAL UNIT,
GENERIC NAME,
ORIGIN,
MINERAL COMPOSITION.

FLUID LOSS
WATER
CORE RECOVERY (%)
METHOD
CASING
TESTS
SAMPLES
R.L. (m)
DEPTH (m)

ENGINEERING DESCRIPTION

GRAPHIC LOG
CLASSIFICATION SYMBOL
MOISTURE CONDITION / WEATHERING
STRENGTH/DENSITY CLASSIFICATION
SHEAR STRENGTH (kPa) 10 25 50 100 200
COMPRESSIVE STRENGTH (MPa) 1 5 20 50 100 250
DEFECT SPACING (mm) 50 250 1000 2000

SOIL DESCRIPTION
Soil type, minor components, plasticity or particle size, colour.

ROCK DESCRIPTION
Substance: Rock type, particle size, colour, minor components.
Defects: Type, inclination, thickness, roughness, filling.

METHOD	TESTS	R.L. (m)	DEPTH (m)	DESCRIPTION	
SPT	50/70mm N>50	-24.5		**End of borehole at 30.07mbgl.** Open standpipe piezometer installed. Please see attached diagram in Appendix F.	
		-25.0	30.5		30.5
		-25.5	31.0		31.0
		-26.0	31.5		31.5
		-26.5	32.0		32.0
		-27.0	32.5		32.5
		-27.5	33.0		33.0
		-28.0	33.5		33.5
		-28.5	34.0		34.0
		-29.0	34.5		34.5
			35		

T+T DATATEMPLATE.GDT eek

Borelog for well M36/0964 page 1 of 2

Gridref: M36:814-399 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.2 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -95.3m Drill Date : 6/05/1899

Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	-2.09m	Soil	sp
	-6.09m	Clay	sp
	- 21.6m	Gravel (Bl)	sp
	- 24.4m	Blue sand & clay	ch
	- 25.3m	Blue clay & peat	ch
	- 36.9m	Gravel (Br) wl +0.3m	ri
	- 38.3m	Peat	br
	- 39.3m	Clay (Bl)	br
	- 42.0m	Gravel (Br) wl +0.6	br
	- 51.8m	Sand br	br

Borelog for well M36/0964 page 2 of 2

Gridref: M36:814-399 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.2 +MSD
Driller : Job Osborne (& Co/Ltd)
Drill Method : Hydraulic/Percussion
Drill Depth : -95.3m Drill Date : 6/05/1899

Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
-50	Artesian	- 51.8m	Sand br	br
		- 53.9m	Clay y	br
-55 -60 -65		- 69.5m	Gravel Brown wl +1.2m	li
-70		- 70.1m	Peat	li-2
-75		- 75.9m	Clay (Bl)	li-2
		- 79.2m	Gravel (Br) wl +2.1m	li-3
-80		- 81.7m	Yellow sandy gravel	li-3
		- 82.9m	Clay sandy y	he
		- 84.7m	Sand y	he
-85		- 85.6m	Gravel br	he
-90		- 90.2m	Yellow sand	he
		- 93.9m	Sand & clay y	he
-95		- 95.3m	Gravel Brown wl +7.9m	bu

Borelog for well M36/1048 page 1 of 2

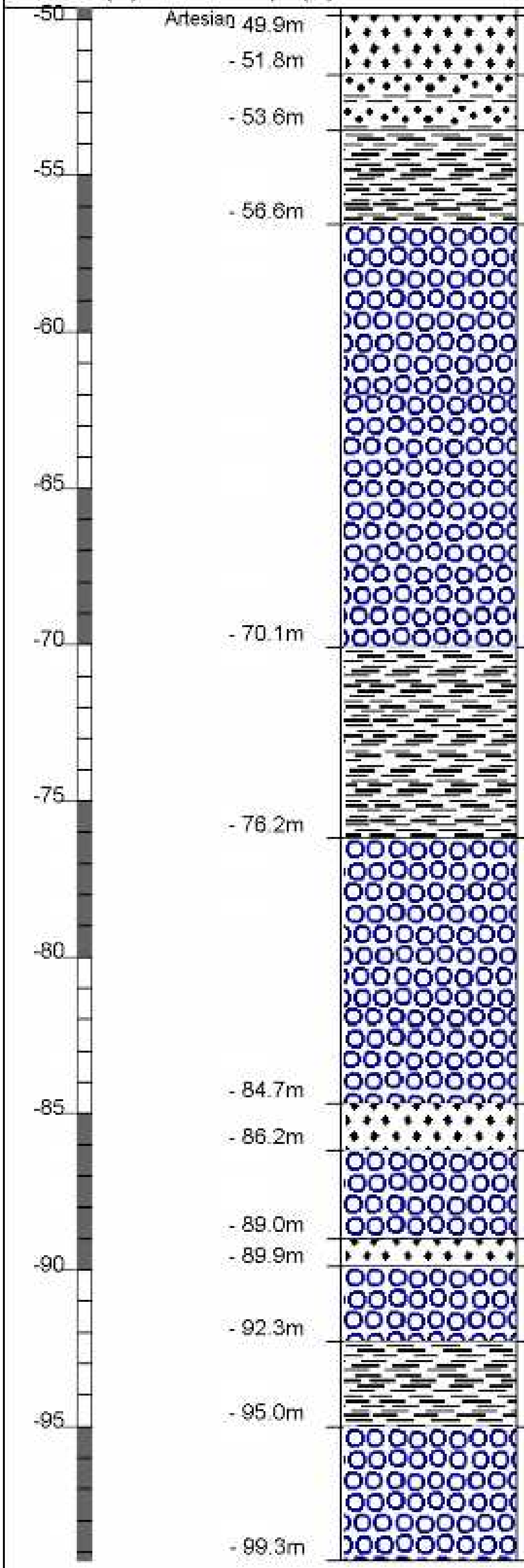
Gridref: M36:815-398 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.3 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -99.3m Drill Date :

Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	-1.20m	Surface soil & sand	sp
	-6.00m	Blue shingle	sp
	-7.59m	Blue clay	sp
	- 15.2m	Blue sand	ch
	- 21.3m	Blue shingle	sp
	- 27.4m	Blue clay	ch
	- 39.6m	Brown shingle	ri
	- 40.8m	Blue clay & peat	br
	- 42.0m	Brown shingle	br
	- 49.9m	Brown sand	br

Scale(m): -5, -10, -15, -20, -25, -30, -35, -40, -45

Borelog for well M36/1048 page 2 of 2

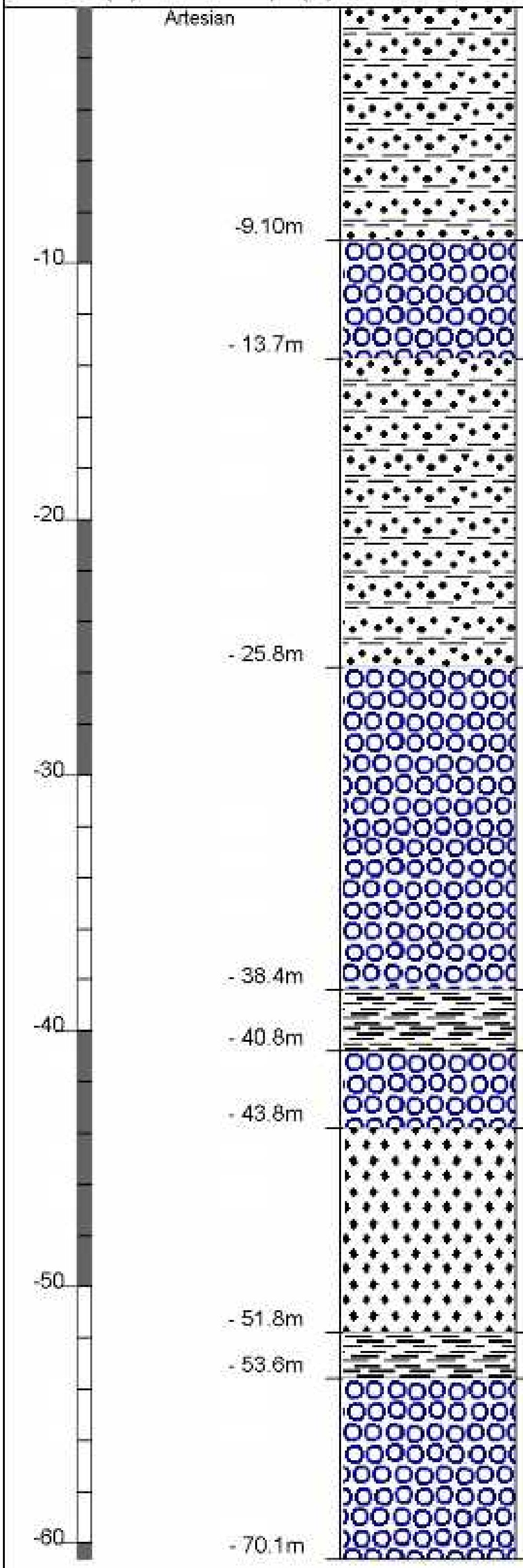
Gridref: M36:815-398 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.3 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -99.3m Drill Date :



Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	49.9m	Brown sand	br
	- 51.8m	Blue sand	br
	- 53.6m	Blue sand & clay	br
	- 56.6m	Blue clay	br
	- 70.1m	Brown shingle	li
	- 76.2m	Blue clay	li-2
	- 84.7m	Brown shingle	li-3
	- 86.2m	Brown sand	he
	- 89.0m	Brown shingle	he
	- 89.9m	Brown sand	he
	- 92.3m	Brown shingle water rises 1.8m	he
	- 95.0m	Yellow clay	he
	- 99.3m	Brown shingle water rises 6.0m	bu

Borelog for well M36/1086 page 1 of 2

Gridref: M36:814-399 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.2 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -121.3m Drill Date :



Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	-9.10m	Clay & sand	sp
	- 13.7m	Blue shingle	sp
	- 25.8m	Clay & sand	ch
	- 38.4m	Brown shingle, water rises to surface	ri
	- 40.8m	Blue clay	br
	- 43.8m	Brown shingle, water rises to surface	br
	- 51.8m	Brown sand	br
	- 53.6m	Yellow clay	br
	- 70.1m	Brown shingle, water rises to 0.6m at 68.5m	li

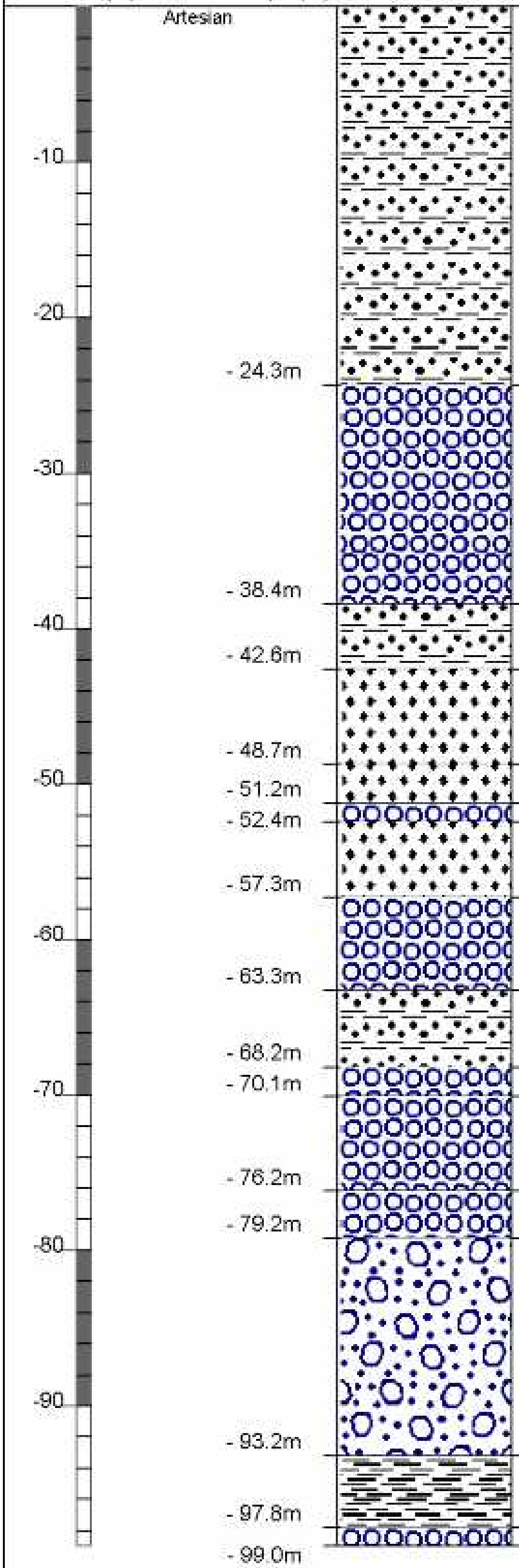
Borelog for well M36/1086 page 2 of 2

Gridref: M36:814-399 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.2 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -121.3m Drill Date :

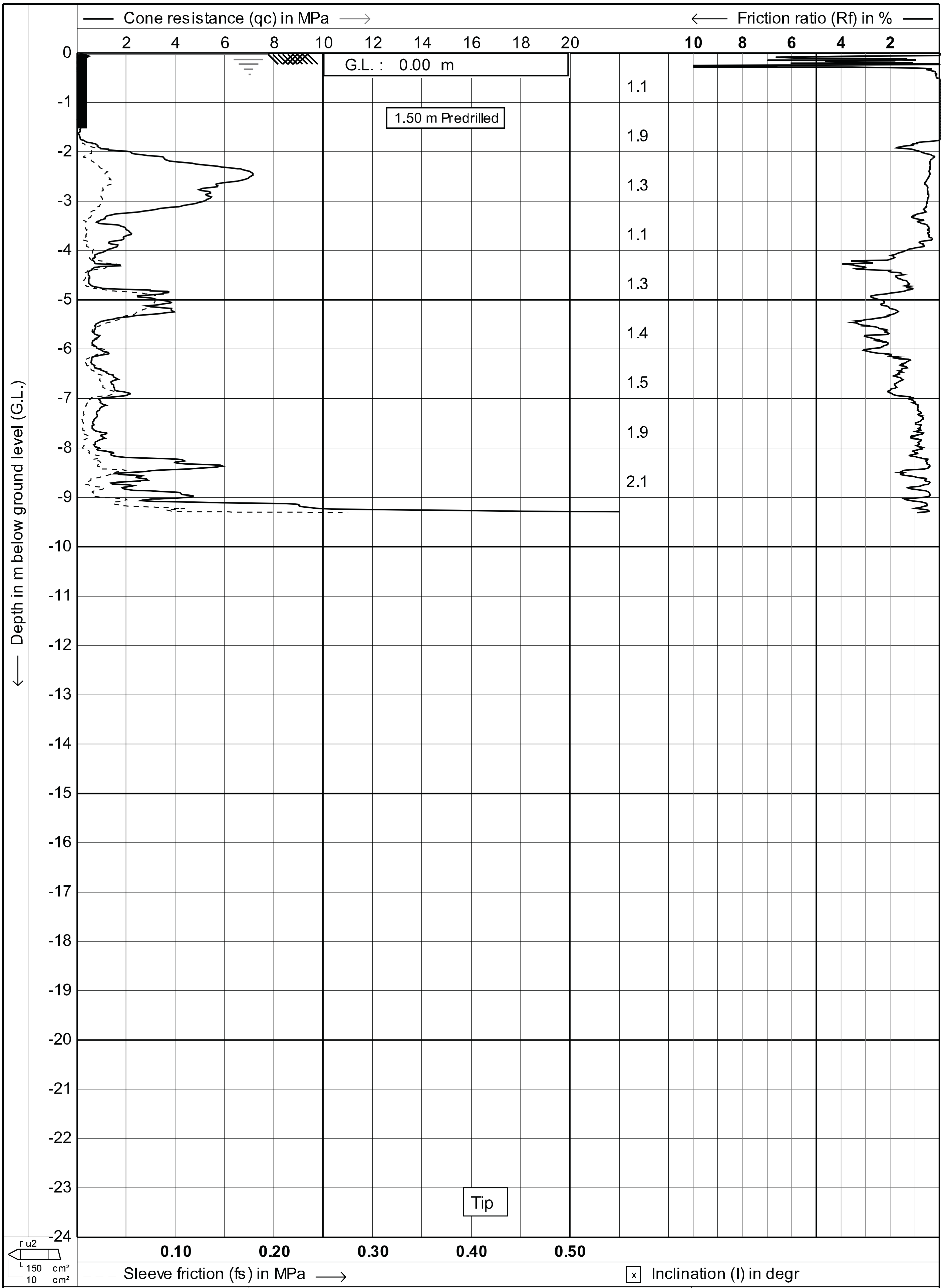
Scale(m)	Water Level	Depth(m)	Full Drillers Description	Formation Code
-70	Artesian	- 70.1m	Brown shingle, water rises to 0.6m at 68.5m	li
		- 71.9m	Yellow clay	li-2
-80		- 81.0m	Brown shingle, water rises 1.2m at 73.1m	li-3
-90		- 91.4m	Brown sand	he
		- 94.4m	Yellow clay	he
		- 99.3m	Brown shingle, flow at 97.5m water rises 4.2m	bu
-100		- 102.4m	Yellow clay	sh
		- 105.4m	Blue clay & sand	sh
		- 107.2m	Yellow clay	sh
-110		- 117.3m	Brown shingle, flows at 109.7m & 112.7m, rises 5.1m	sh
		- 118.8m	Yellow clay	sh
-120		- 121.3m	Brown shingle flows at 262.0m3/d at the surface & rises 7.6m	wa

Borelog for well M36/1097

Gridref: M36:813-398 Accuracy : 4 (1=best, 4=worst)
Ground Level Altitude : 6.6 +MSD
Driller : not known
Drill Method : Unknown
Drill Depth : -99m Drill Date : 12/02/1913



Water Level	Depth(m)	Full Drillers Description	Formation Code
Artesian	- 24.3m	Clay & sand	sp-ch
	- 38.4m	Brown shingle	ri
	- 42.6m	Blue clay & sand	br
	- 48.7m	Blue sand	br
	- 51.2m	Brown sand	br
	- 52.4m	Blue shingle	li-1
	- 57.3m	Blue sand	li-1
	- 63.3m	Brown shingle	li-2
	- 68.2m	Blue clay & sand	li-2
	- 70.1m	Blue shingle	li-2
	- 76.2m	Blue shingle	li-3
	- 79.2m	Brown shingle, water rises 1.8m	li-3
	- 93.2m	Brown sand & shingle	he
	- 97.8m	Yellow & Blue clay	he
	- 99.0m	Brown shingle, water flows 196.5m3/d & rises 6.7m	bu



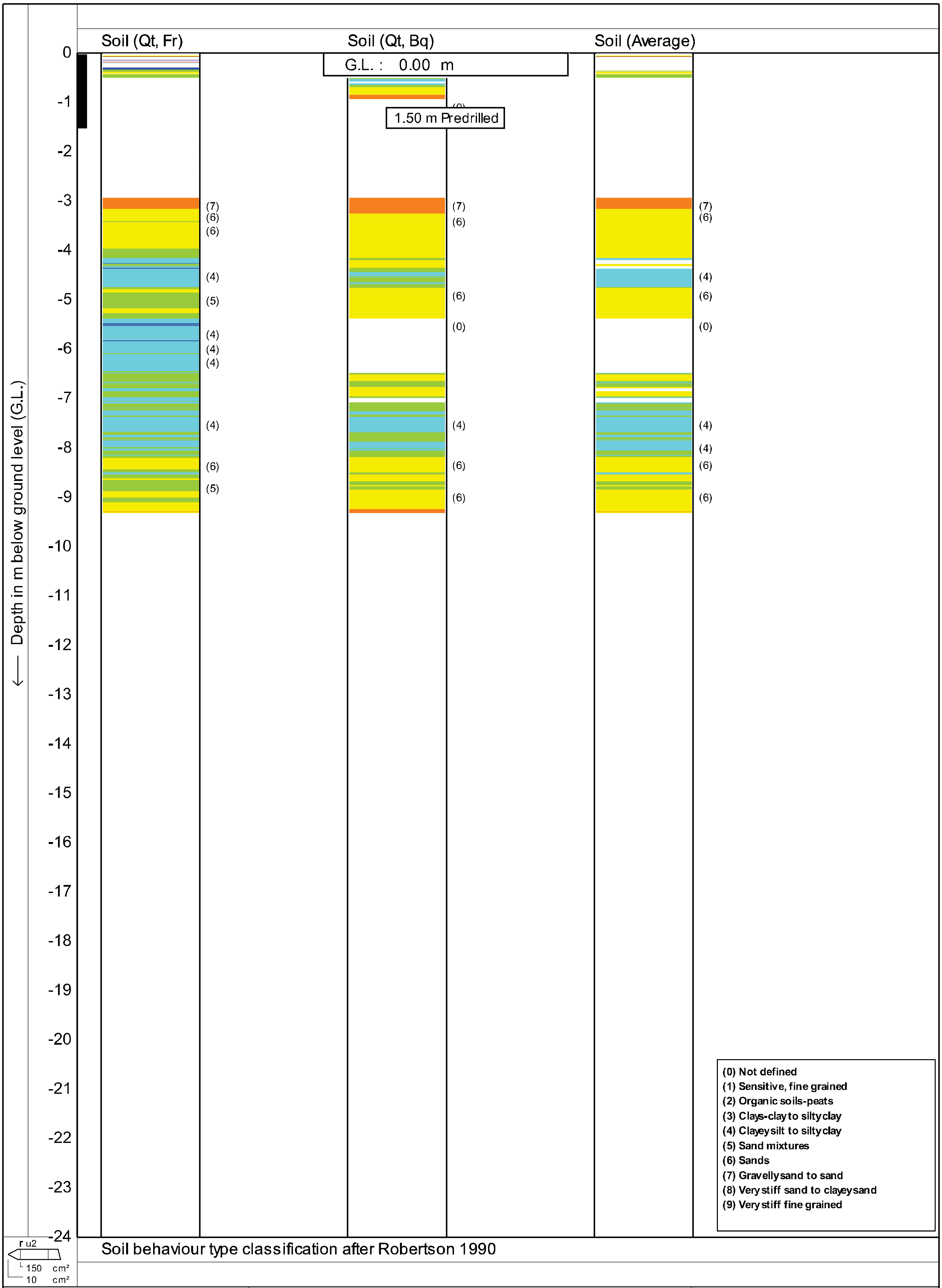
CPTask V1.25

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **CBD - Christchurch City**

Date : **30-8-2011**
Cone no. : **C10CFIIP.F56**
Project no. : **01TT26**
CPT no. : **CBD-137** **1/14**



(0) Not defined
(1) Sensitive, fine grained
(2) Organic soils-peats
(3) Clays-clay to silty clay
(4) Clayey silt to silty clay
(5) Sand mixtures
(6) Sands
(7) Gravelly sand to sand
(8) Very stiff sand to clayey sand
(9) Very stiff fine grained

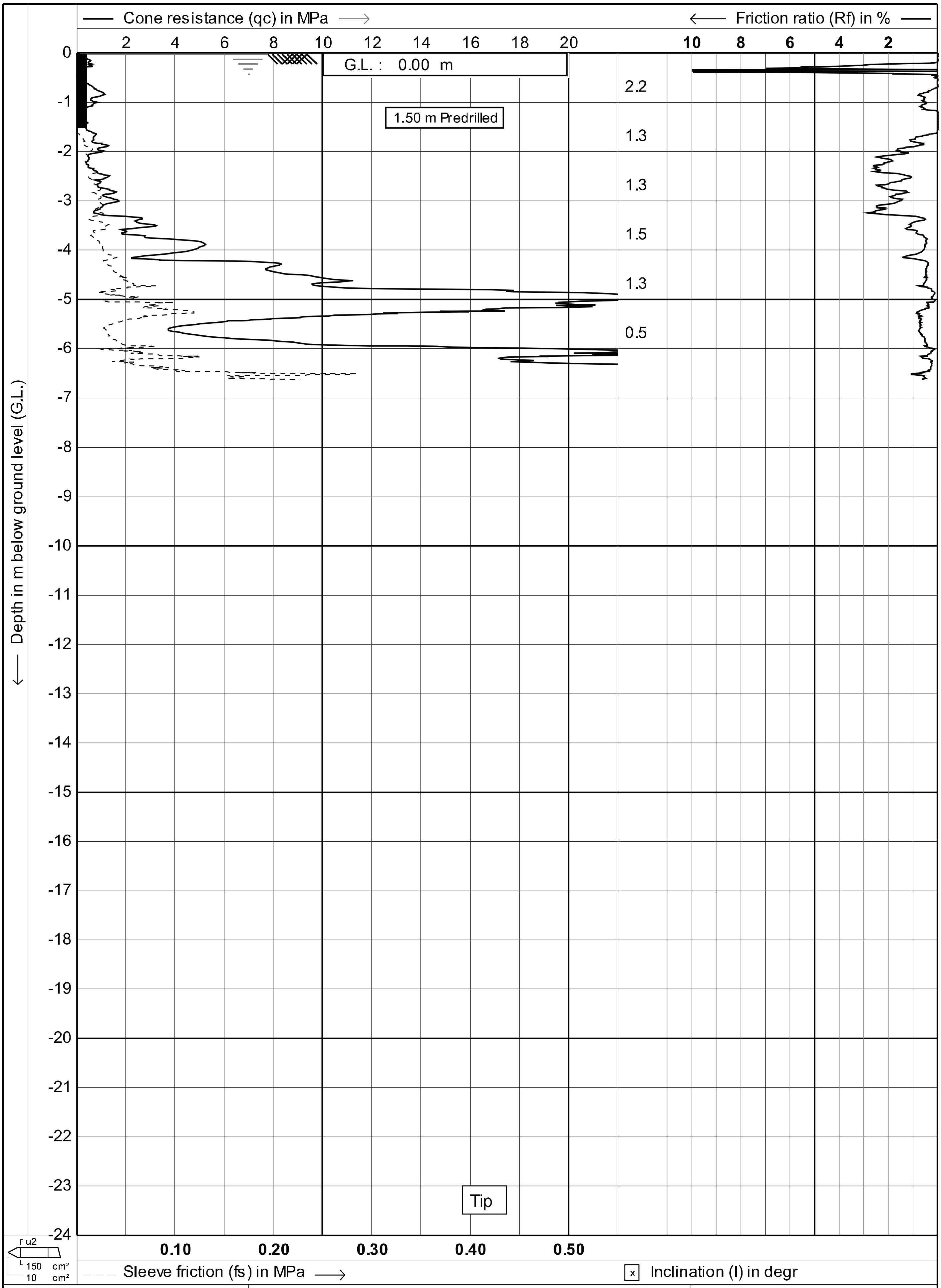
Soil behaviour type classification after Robertson 1990

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **CBD - Christchurch City**

Date : **30-8-2011**
Cone no. : **C10CFIIP.F56**
Project no. : **01TT26**
CPT no. : **CBD-137**



CPTask V1.25

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

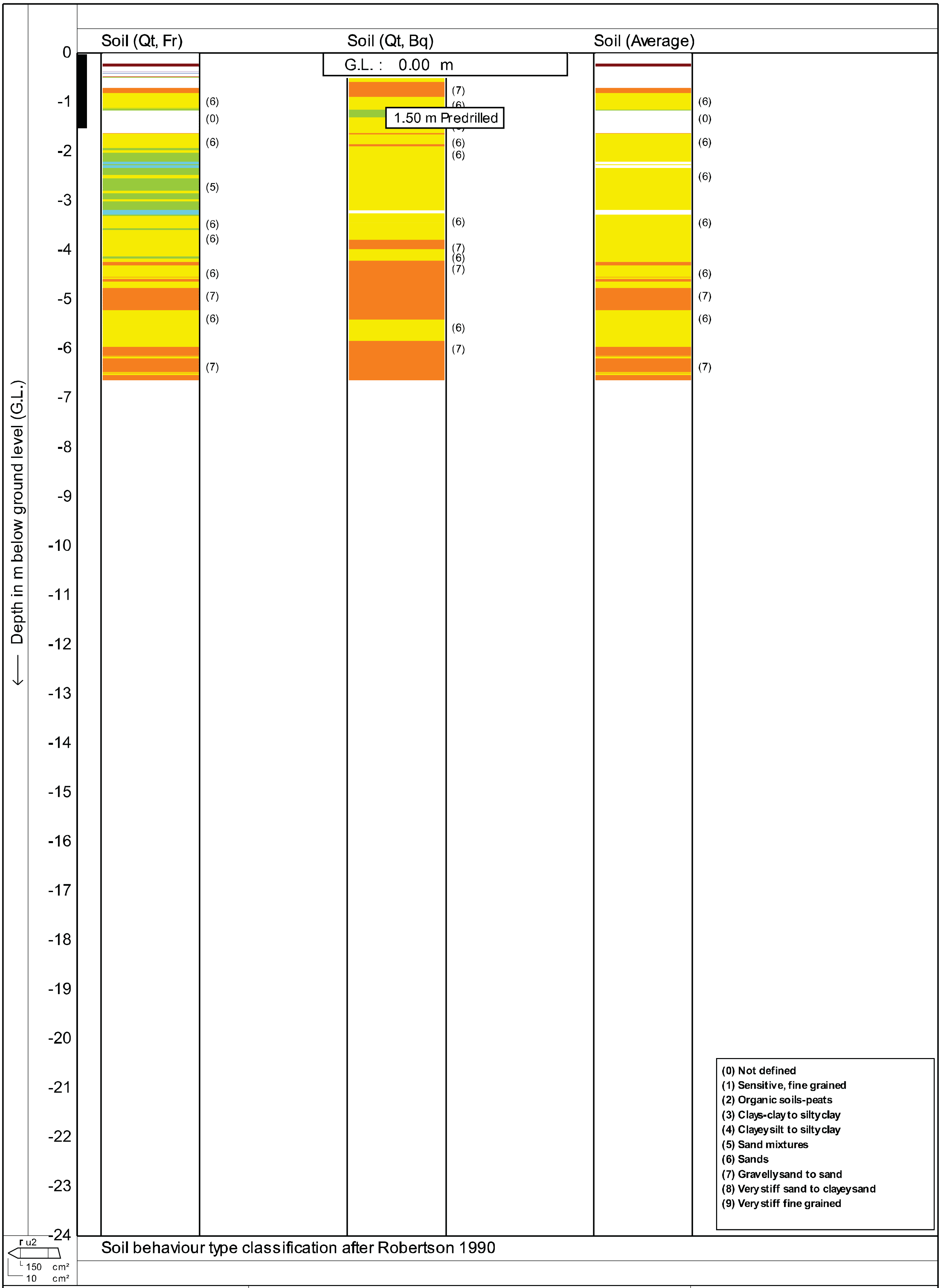
Location: **CBD - Christchurch City**

Date : **30-8-2011**

Cone no. : **C10CFIIP.F56**

Project no. : **01TT26**

CPT no. : **CBD-138** **1/14**



Soil behaviour type classification after Robertson 1990

CPTask V1.25

Perry DRILLING GEO PROBE Ground Drilling and Environmental Specialists

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

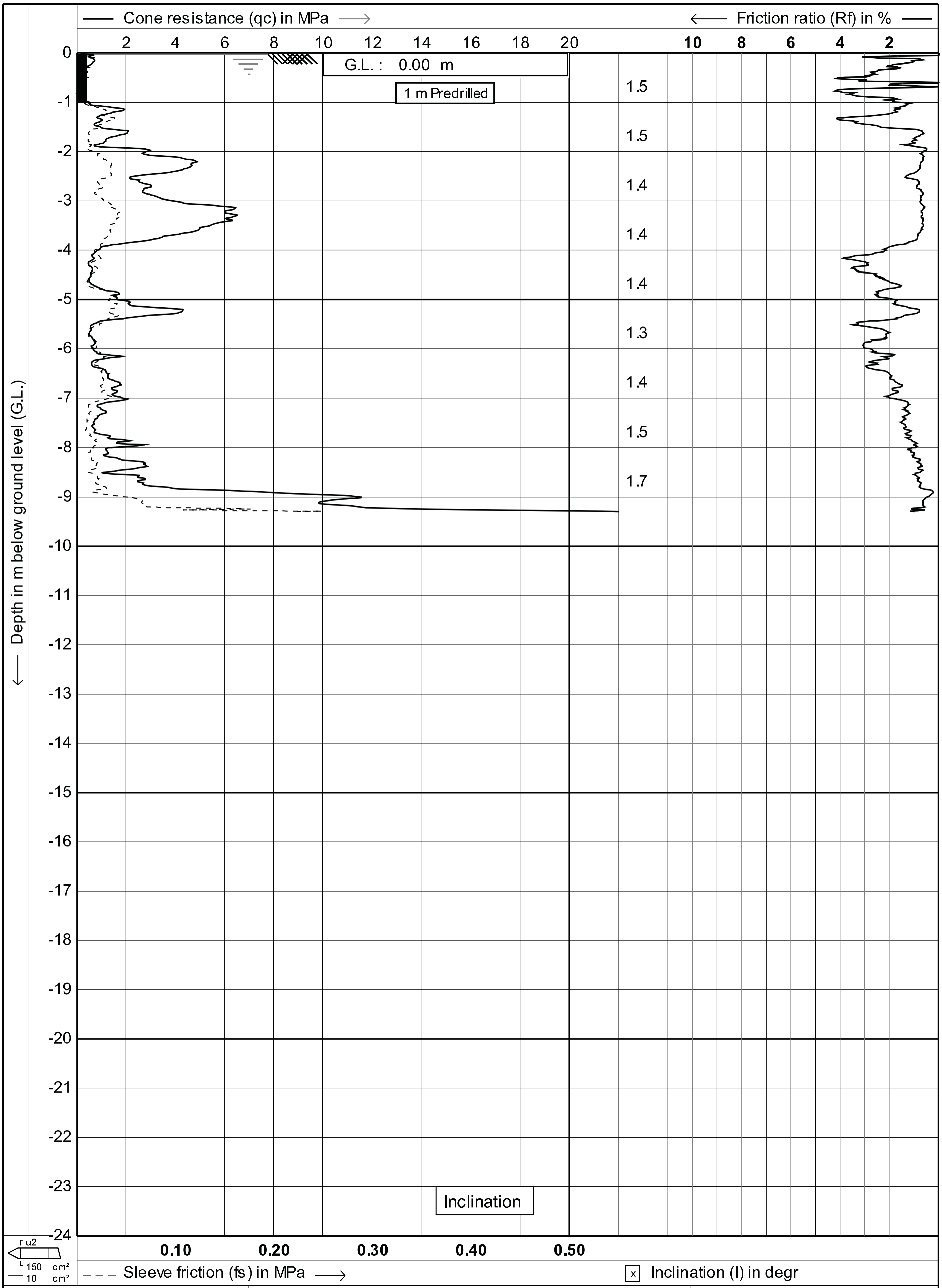
Location: **CBD - Christchurch City**

Date : **30-8-2011**

Cone no. : **C10CFIIP.F56**

Project no. : **01TT26**

CPT no. : **CBD-138** **13/14**



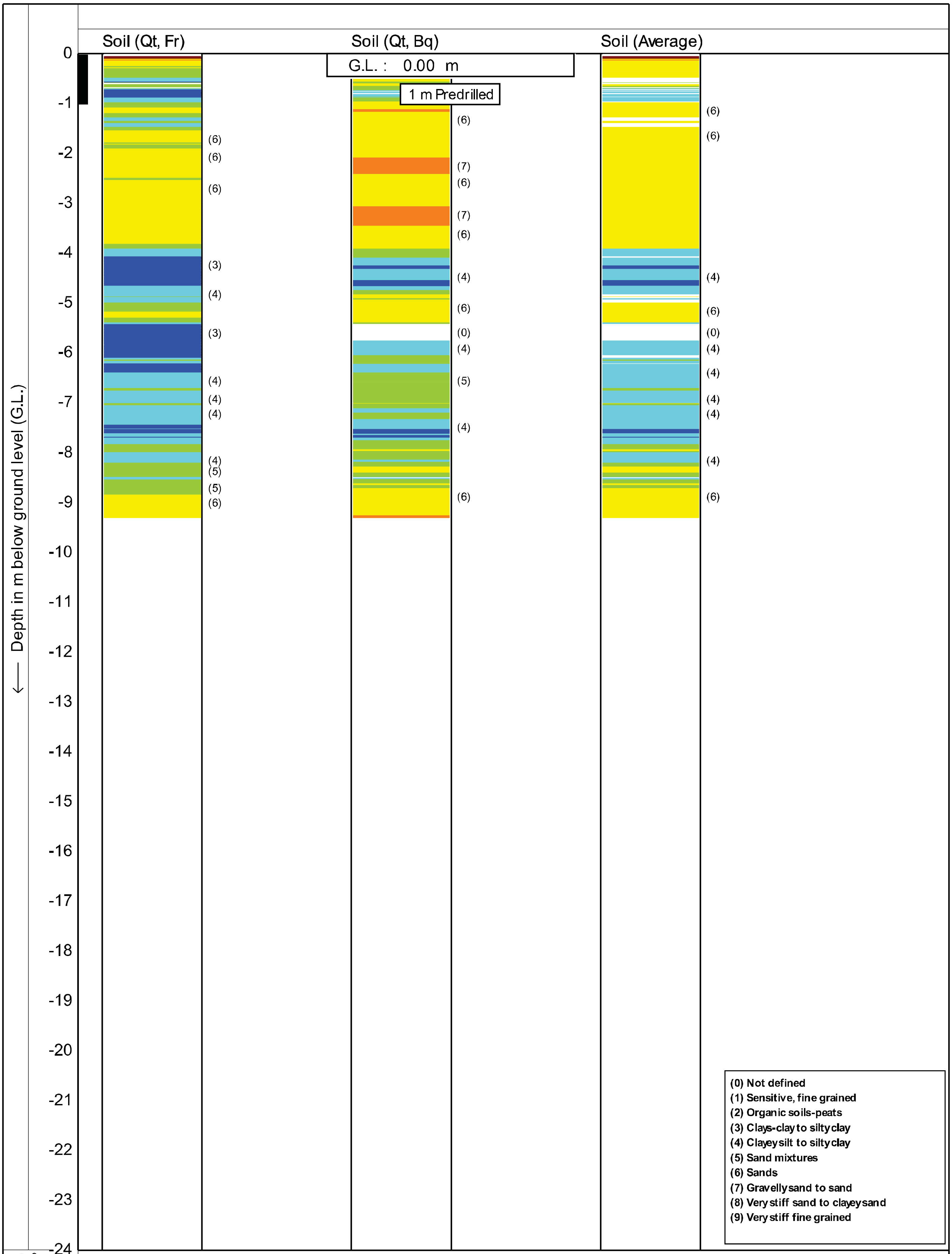
Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **Sydenham - Christchurch City**

Date	: **6-5-2011**
Cone no.	: **C10CFIIP.F14**
Project no. :	**01TT10**
CPT no.	: **SYD-02**
	1/14

CPTask V1.25



Soil behaviour type classification after Robertson 1990

r u2
150 cm²
10 cm²

CPTask V1.25

Perry DRILLING GEO PROBE Ground Drilling and Environmental Specialists

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **Sydenham - Christchurch City**

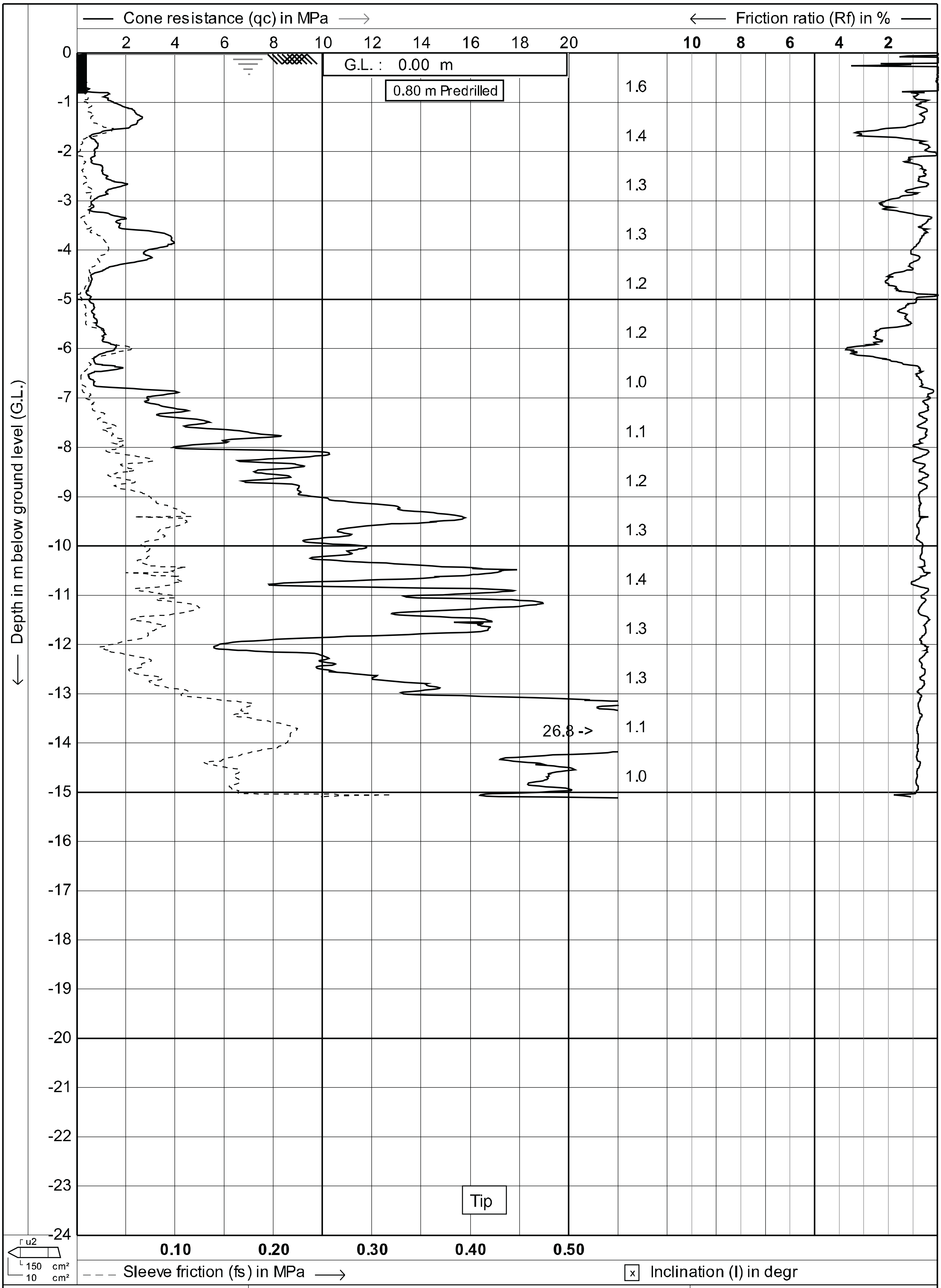
Date : **6-5-2011**

Cone no. : **C10CFIIP.F14**

Project no. : **01TT10**

CPT no. : **SYD-02**

13/14



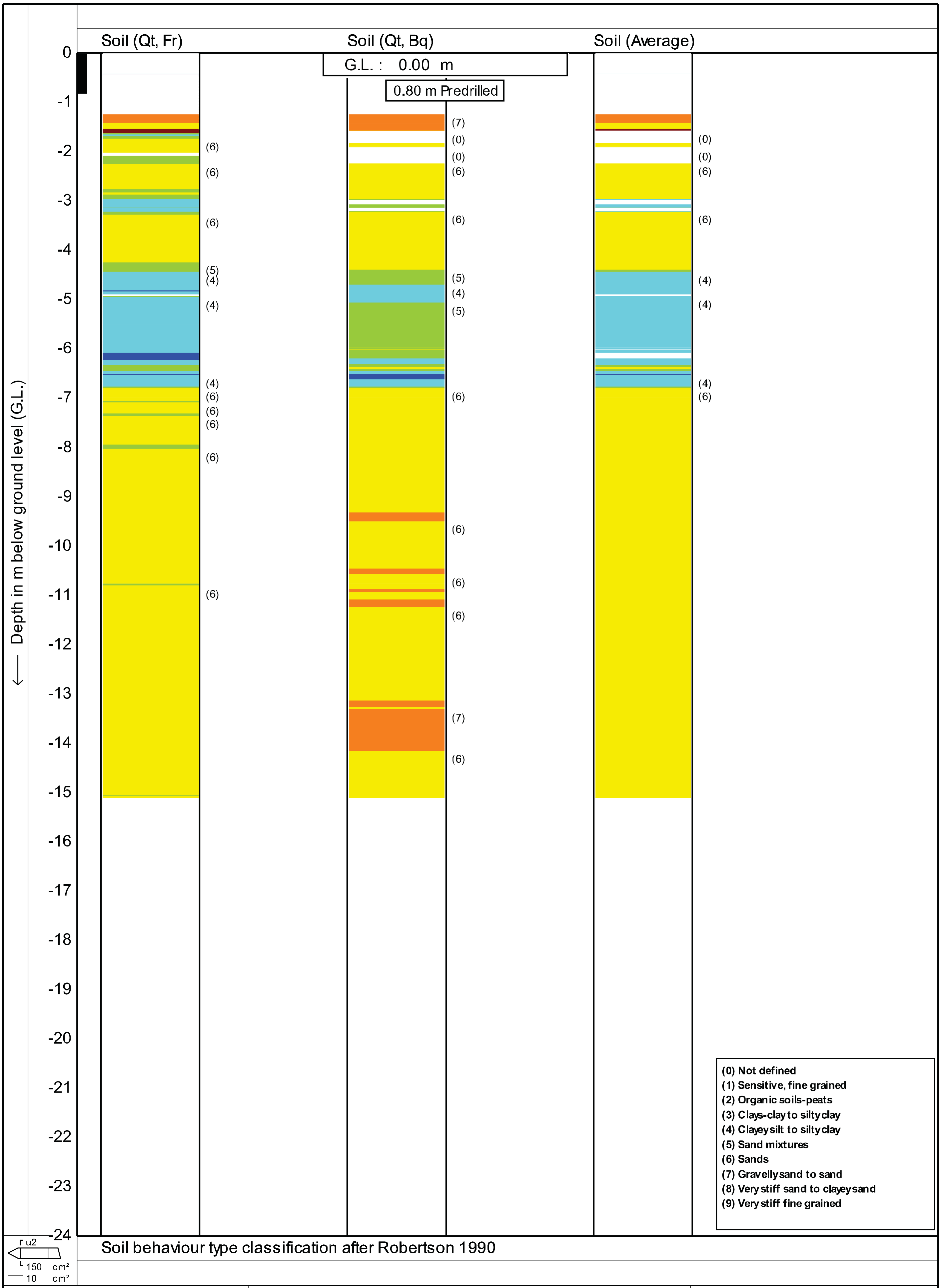
Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **Sydenham - Christchurch City**

Date	: **6-5-2011**
Cone no.	: **C10CFIIP.F14**
Project no. :	**01TT10**
CPT no.	: **SYD-03** **1/14**

CPTask V1.25



(0) Not defined
(1) Sensitive, fine grained
(2) Organic soils-peats
(3) Clays-clay to silty clay
(4) Clayey silt to silty clay
(5) Sand mixtures
(6) Sands
(7) Gravelly sand to sand
(8) Very stiff sand to clayey sand
(9) Very stiff fine grained

Soil behaviour type classification after Robertson 1990

CPTask V1.25

Perry DRILLING GEO PROBE
Ground Drilling and Environmental Specialists

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

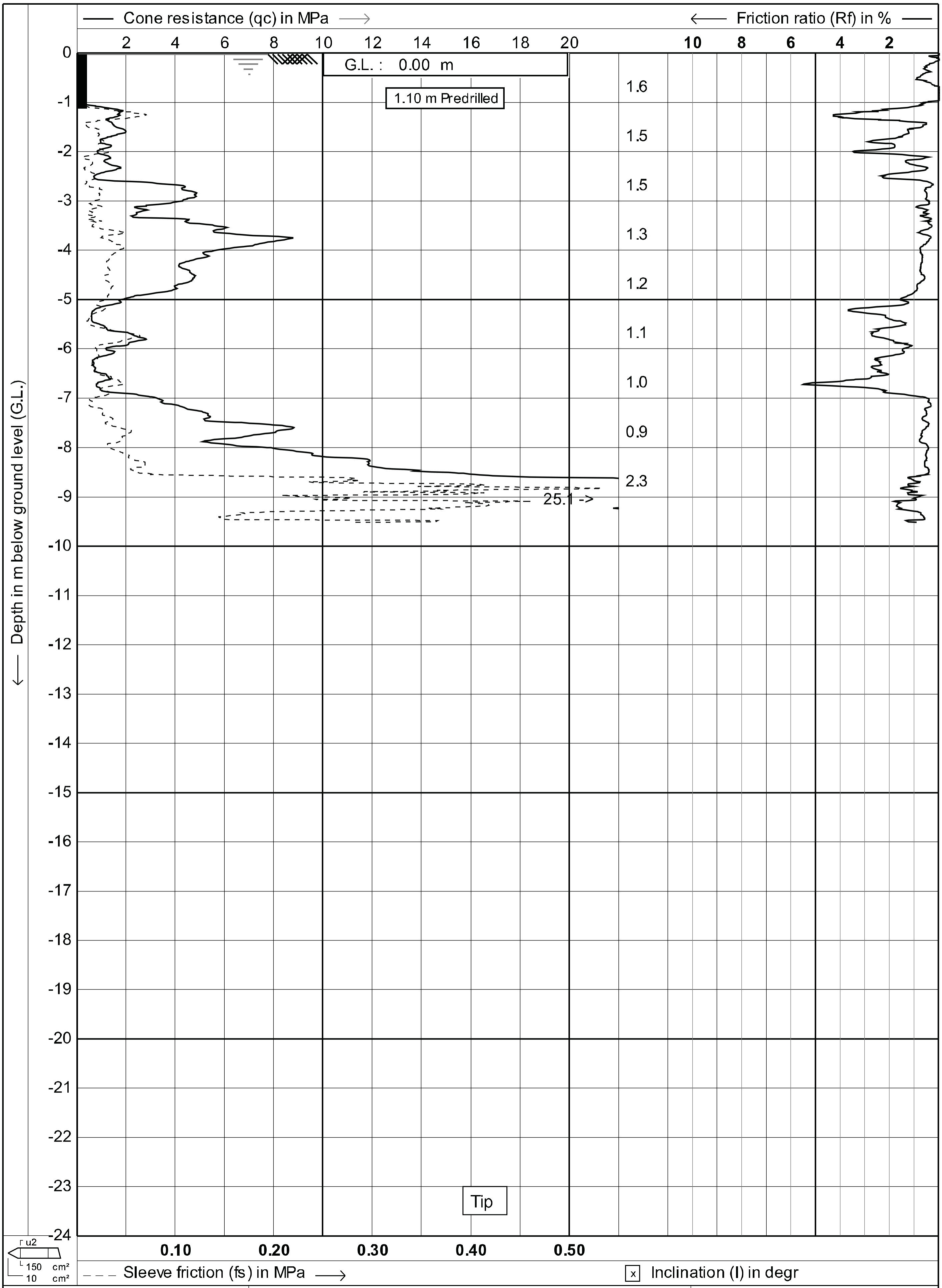
Location: **Sydenham - Christchurch City**

Date : **6-5-2011**

Cone no. : **C10CFIIP.F14**

Project no. : **01TT10**

CPT no. : **SYD-03**



CPTask V1.25

Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

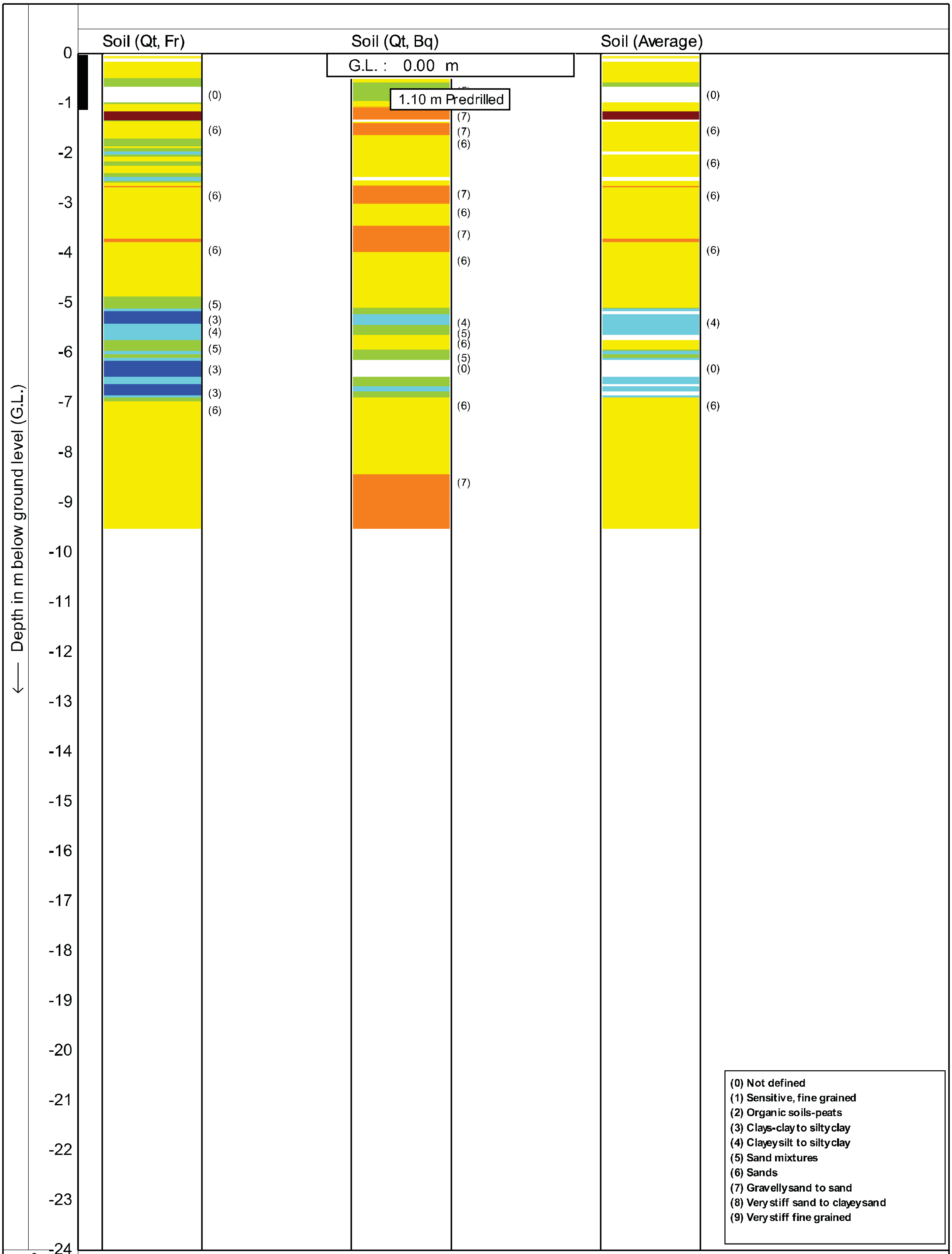
Location: **Sydenham - Christchurch City**

Date : **6-5-2011**

Cone no. : **C10CFIIP.F14**

Project no. : **01TT10**

CPT no. : **SYD-04** **1/14**



Soil behaviour type classification after Robertson 1990

CPTask V1.25

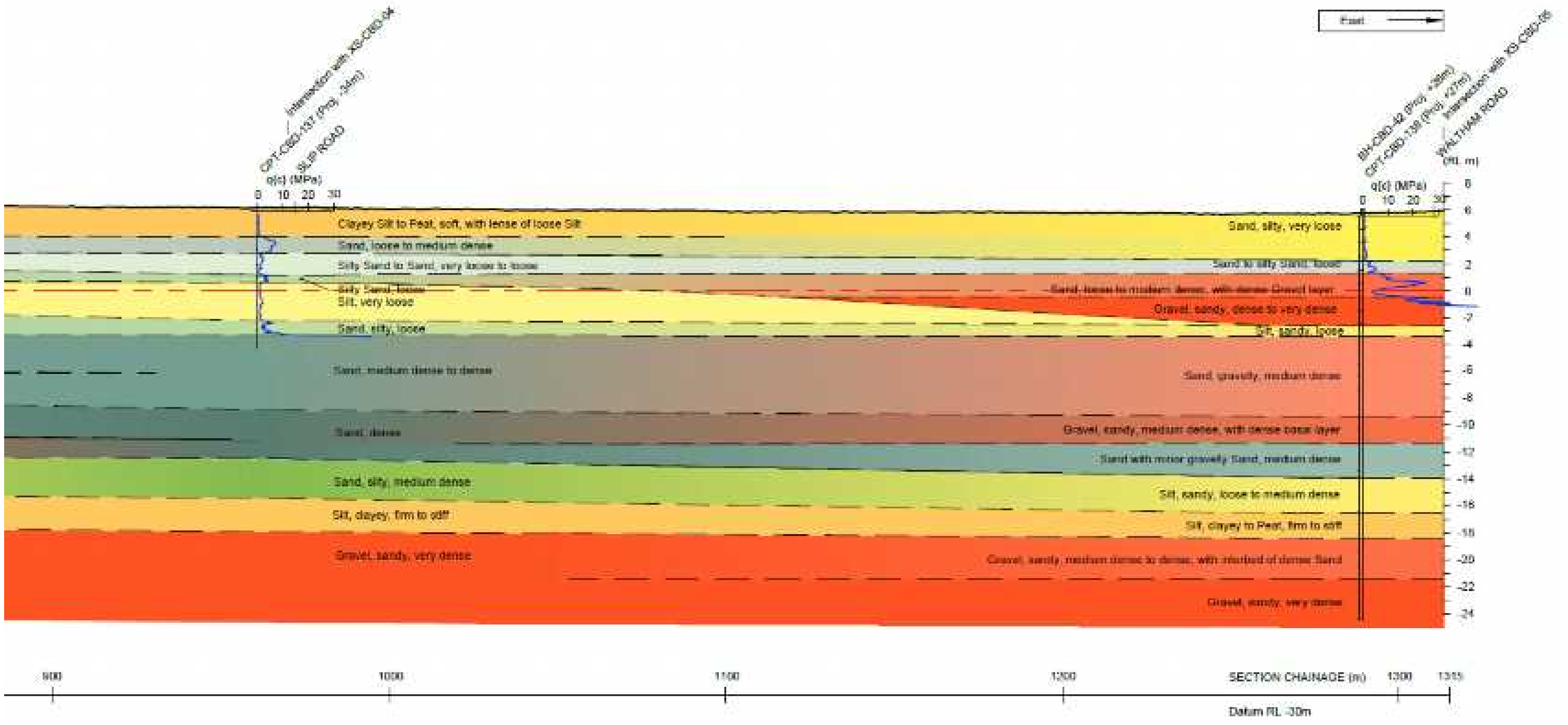
Test according A.S.T.M. Standard D 5778-07

Project : **Site Investigations**

Location: **Sydenham - Christchurch City**

Date	: **6-5-2011**
Cone no.	: **C10CFIIP.F14**
Project no. :	**01TT10**
CPT no.	: **SYD-04**

13/14



Notes:
1. Subsurface conditions are inferred from borehole logs and correlations from CPT data. The nature and continuity of the subsoils away from the the investigation locations are inferred and it must be appreciated that actual ground conditions could vary from the assumed model.
2. Strength and density descriptions follow NZ Geotechnical Society "Guidelines for the Field Classification and Description of Soil & Rock for Engineering Purposes" (December, 2005).
3. No data available in top 1.2m due to services pre-drill.
4. Ground surface profile inferred from LiDAR data flown by NZ Aerial Mapping 8-10 March 2011 where available.
5. CPT and borehole elevations are relative to Lyttelton Datum (mean sea level).
6. Soil material type, density and strength have been inferred from CPT data using methodologies published in Lunne, Robertson & Powell (1997).

Christchurch City Council

Tonkin & Taylor
Environmental and Engineering Consultants
[illegible]
www.tonkin.co.nz

COMPILED & DRAWN	[illegible]	[illegible]
REVIEWED	[illegible]	[illegible]
DRAFTING CHECKED	[illegible]	[illegible]

GXS-CBD-18 Plan.dwg
SCALES (AT A3 SIZE)
1:2000 horizontal
1:200 vertical

Sheet 1 of 1

CHRISTCHURCH CITY COUNCIL
GEOLOGICAL INTERPRETATIVE REPORT
CHRISTCHURCH CENTRAL CITY
GXS-CBD-18 (Brougham Street)

Fig. No. C 23

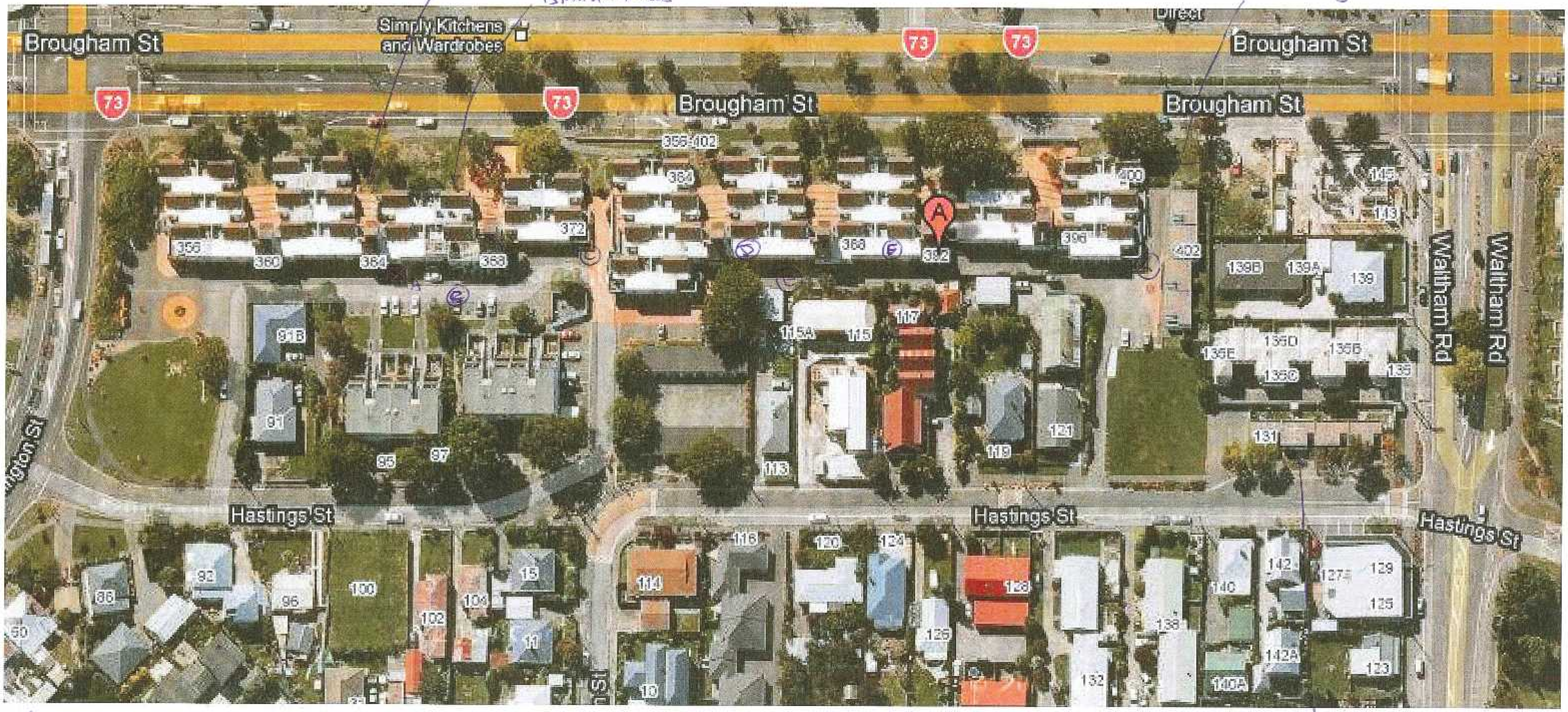
Rev. 1

APPENDIX B - SITE PLAN walkround notes 10/05/11 Graham Brown.

20mm gap in tiles

15mm GAP in tiles

100mm of ground heave.

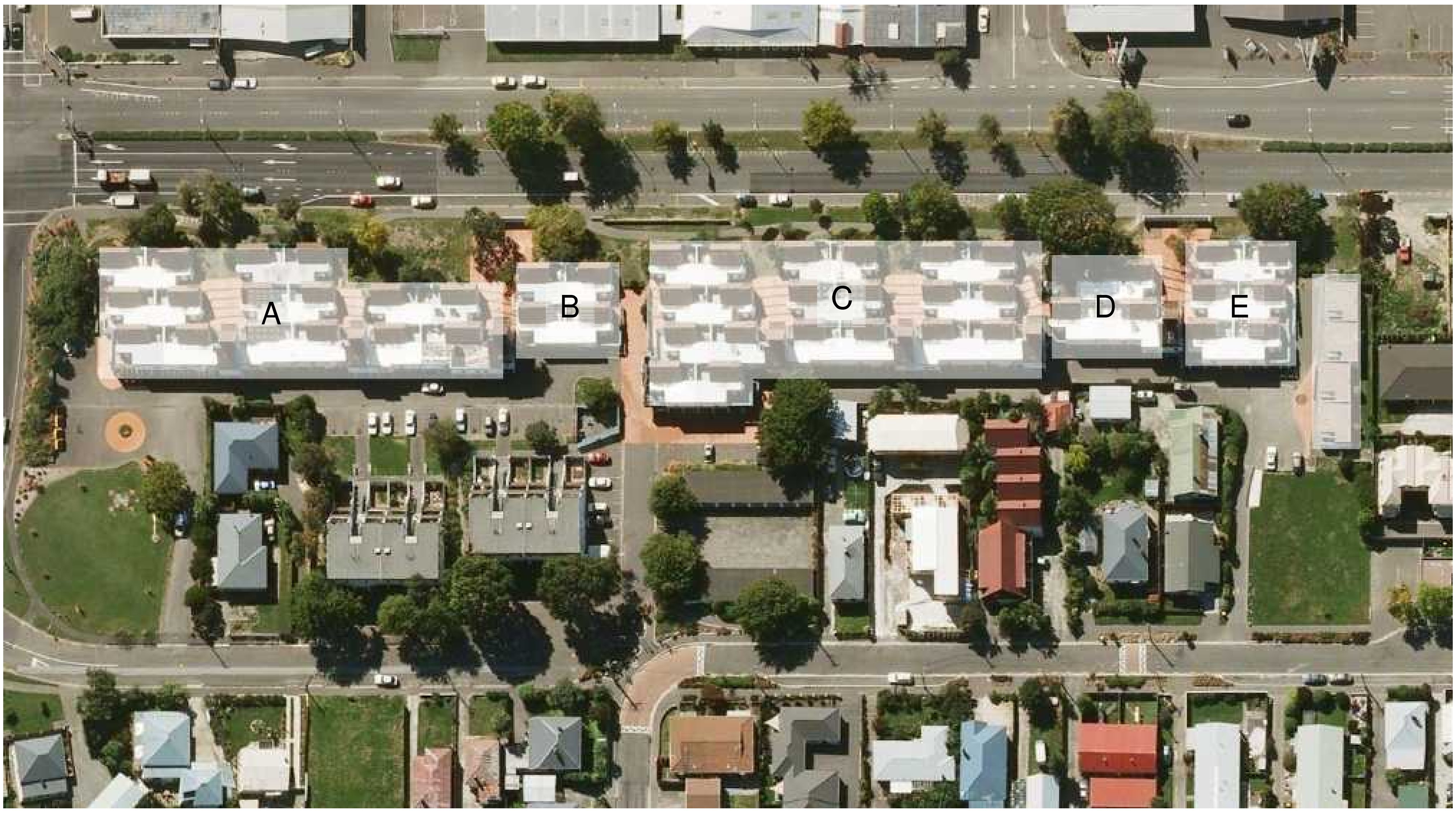


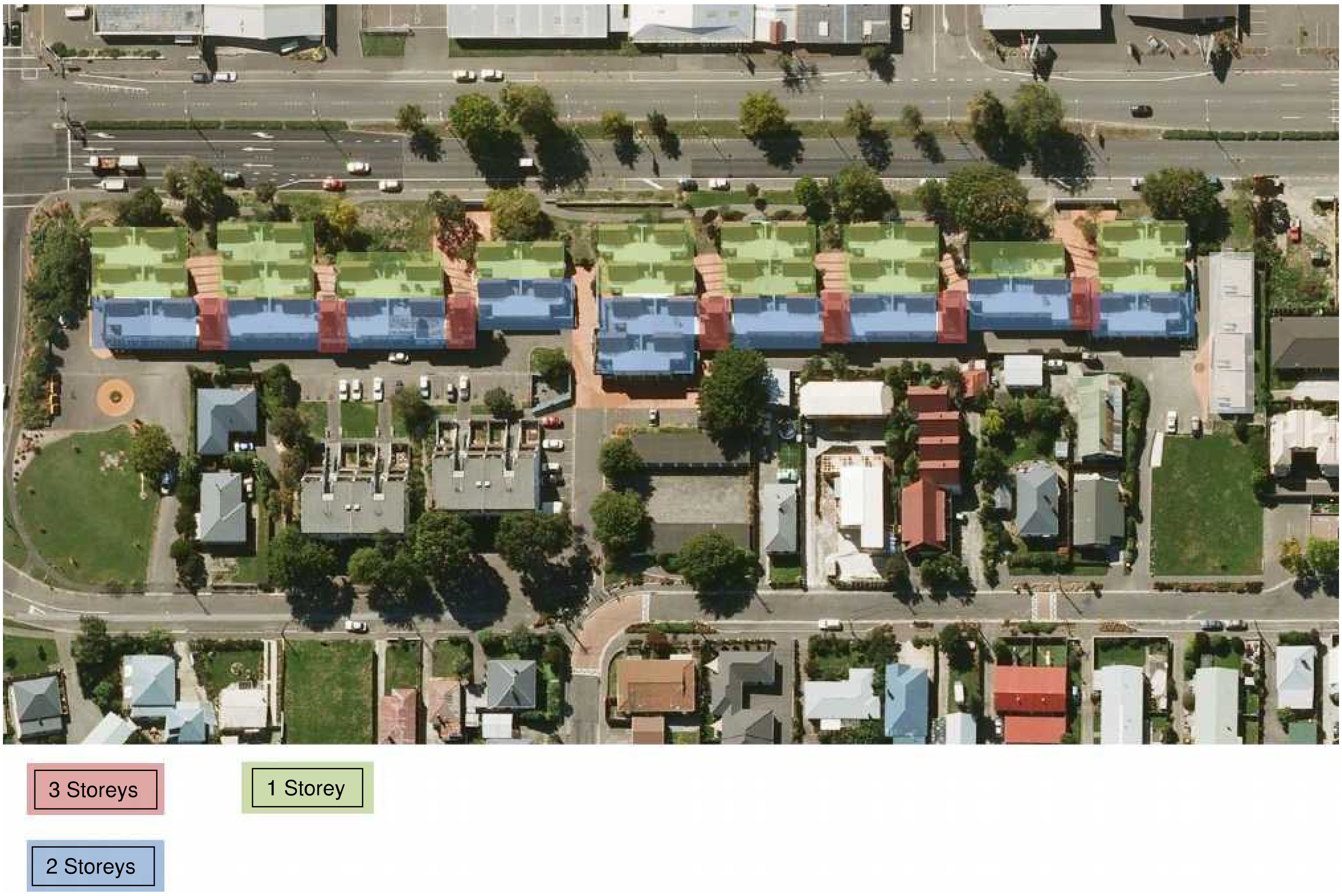
Unit 2 Yellow sticker severe liquefaction

Record of Damage

- Ⓐ Ground heave 80mm
- Ⓑ Damage to carpark Area
- Ⓒ Damage to buried services
- Ⓓ Severe cracking in 1st Floor Slab.
- Ⓔ Heave in driveway 100mm
- Ⓕ Garage 33 Cracking in ground floor Slab.
- Ⓖ Damaged services.

Appendix E – Site Location and Damage Plan


A
B
C
D
E


🟥 3 Storeys
🟩 1 Storey
🟦 2 Storeys

🟨 - ≥10mm lateral spread

🟧 - ≥20mm lateral spread

🟪 - Closed by council due to damage H&S risk

XX% - Post EQ %NBS for Unit.

* - denotes unit where 'stand-alone' %NBS is to be replaced by 3-storey %NBS due to collapse hazard.

ASSOCIATED DWGS SITE WORKS 70 - 72

D A COWEY ASSOCIATES
REGISTERED ARCHITECTS
P O BOX 1887 CHRISTCHURCH

DRAWN P.W.L.M.
TRACED P.W.L.M.
CHECKED
DATE 22.4.75

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SERVICES, ROADING
CITY ENGINEERS DEPT

SCALES 1:200
CONTRACTOR SHALL VERIFY ALL DIMENSIONS BEFORE STARTING WORK

CONTENTS
PART SITE PLAN G.L. A TO E
LOCATION

PROJECT 416
BROUGHAM STREET
URBAN RENEWAL 1 STAGE 1

DRAWING REFERENCE
L 2-1 02

A 938 → 118/829/93-103

ASSOCIATED DWGS SITE WORKS 70-72

- ≥ 10mm lateral spread

- ≥ 20mm lateral spread

- Closed by council due to damage and H&S risk

XX% - Post EQ %NBS of unit.

* - denotes unit where 'stand-alone' %NBS is to be replaced by 3-storey %NBS due to collapse hazard.

D A COWEY ASSOCIATES
REGISTERED ARCHITECTS
P O BOX 1687 CHRISTCHURCH

DRAWN P.W.L.M.
TRACED P.W.L.M.
CHECKED
DATE 22 4 79

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CITY ENGINEERS DEPT.

SCALES 1:200
CONTRACTOR SHALL VERIFY ALL DIMENSIONS BEFORE STARTING WORK

CONTENTS
PART SITE PLAN G L & TO K
LOCATION

PROJECT .416
BROUGHAM STREET
URBAN RENEWAL I STAGE I

DRAWING REFERENCE
L [2-] 03

OPUS