The Apple Tree Public House
45 Mount Pleasant WC1X 0AE

Structural Engineering
Planning Report

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Job Number: **27610**

Date	Revision	Notes/Amendments/Issue Purpose
February 2020	0	

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1 Introduction

Price & Myers have been appointed by Phil Hunt to prepare a Structural Planning Report in relation to the Proposed refurbishment works at 45 Mount Pleasant that include the construction of a new section of lower ground below the existing ground floor rear external lightwell as well as the lowering of the existing lower ground floor slab everywhere else to provide a more comfortable floor to ceiling height. At ground floor over the new lower ground floor space, a new single storey construction with a new flat roof will be formed in place of the existing one. Other proposed structural works involve the introduction of new steel beams within the upper levels to allow the removal of some walls as well as the enabling works to allow the construction of a new service stair between lower ground and first floor.

2 The site

Photo 1 - View of the site from Mount Pleasant

The site is located at the junction between mount Pleasant and Warner Street and it is currently a Public House. The original Apple Tree public house along with the adjoining No. 2 and No. 4 Warner Street are thought to have be built in the 1720s. The three-storey front Apple Tree public house and single-storey kitchen were re-built in 1872. No2 and No4 Warner Street were re-built as a two-storey extension to the pub in 1925.

The following is the assumed sequence of site development:

1720s – Original Apple Tree Public House and original 2-4 Warner Street
1872 – 3-storey frontage and kitchen built within courtyard
1890s – Rosebery Square Buildings (the block of flats)
1925 – 2-4 Warner Street re-built
1987 – 1992 – Rosebery Square East and West modernised

The structure of the existing public house is typical of the Victorian period with solid masonry construction forming the external walls and part of the internal walls within the lower ground floor area and internal timber stud walls within the upper levels. A cast iron column is used to support the floor structure above the main ground floor room as it is typical of many public houses of the same period. The floor constructions at ground, first and second floor is formed with timber joists spanning between the external walls and the internal loadbearing elements. Three pitched roofs cover the building structure. They are of timber construction and span between the external walls and the internal loadbearing elements.

3 Neighbouring Buildings

The existing buildings bordering with our site are the following:

- 47 Mount Pleasant
- 20-23 Rosebery Square West
- 8-10 Warner Street

47 Mount Pleasant appears to be still in its original form as it can be seen from the Georgian features of the elevation. A search through the London Picture Archive has revealed two images: Photo 2 is from 1947 and Photo 3 a hand drawing from 1879. In both images 47 Mont Pleasant appears on the left with a small portion of our site just visible by the edge of the images. 47 Mount Pleasant has an existing lower ground assumed to be at approximately the same level of our site lower ground floor.
The Rosebery Square buildings constructed around 1890s appear to be constructed with loadbearing masonry walls supporting the internal filler joist floors. From the initial investigations these buildings do not appear to have a lower ground floor.
8-10 Warner Street is a double height building possibly originally built as a stable or garage with no lower ground.

Photo 2 - 47 Mount Pleasant 1947 (London Picture Archive)

Image 3 - 47 Mount Pleasant drawing from 1879 (London Picture Archive)

4 Ground Conditions

Geology

The results of the geotechnical investigation carried out by GEA (Report No J19092) show made ground overlying superficial deposits in turn overlain by London Clay. Part of the ground level had been raised above a historic floor level, typically using granular fill of rubble. Below this, the made ground consist of silty sandy gravelly clay with fragments of material such as brick and concrete. The thickness varies with the deepest at 3.2m below ground found in the location of Borehole 1. The superficial deposits are likely to extend across the full footprint of the basement, extending to a maximum depth of 3.6m. These soils are made up of soft to firm yellowish brown mottled orange-brown silty clay. The London clay was proved to the end of the borehole at a depth of 8.5m.

An idealised section through the proposed scheme with the ground model is shown below.

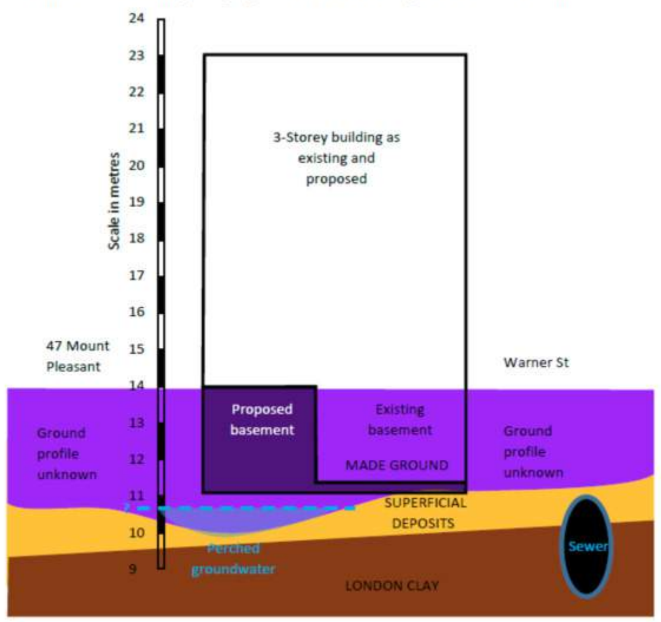


Image 4 - Section through the site ground formation showing the proposed extent of the new excavation

Ground Water and site Hydrology

Groundwater was encountered at a depth of 3m in Borehole 1. The trial pits were dry. Due to the nature of the soil, it was assumed that the water was perched over the reworked London Clay, as shown in the diagram below (extracted from GEA's report. Image 4)

We have further checked the Lost Rivers of London map that indicates the River Fleet running under Phoenix Place and then Warner Street. However as noted in the ground investigation report by GEA and as shown on the 1874 historic map the river Fleet is shown running to the south of the site possibly having been diverted to provide water to the Foundry located on the opposite side of Mount Pleasant. By that date the river had already been culverted as it can also be inferred from the hand drawing from 1879 (Image 3) where no river is visible.

Furthermore, GEA noted that it is understood that the river was eventually diverted into the Thames Water sewer with an invert level of approximately 6m below our site. It is therefore unlikely that the river Fleet would pose a problem to the proposed excavations.

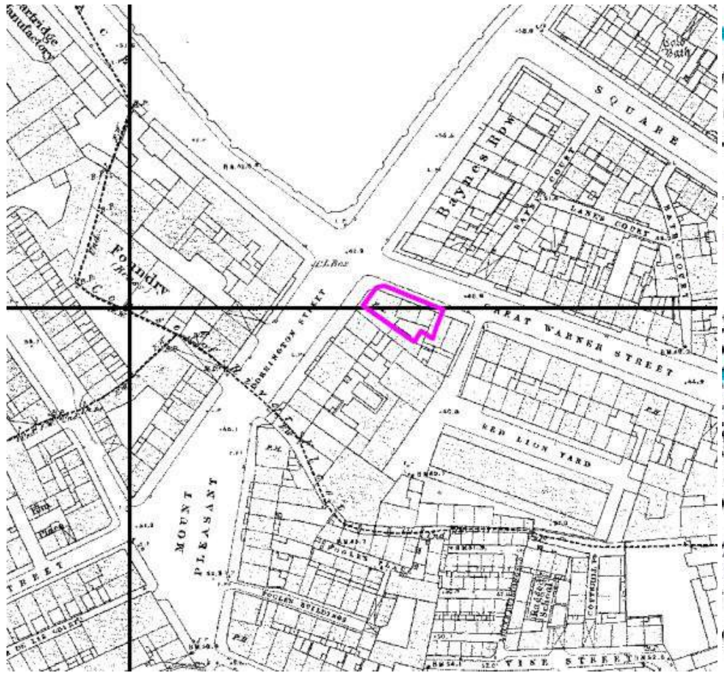


Image 5 - Extract from the 1874 historic map

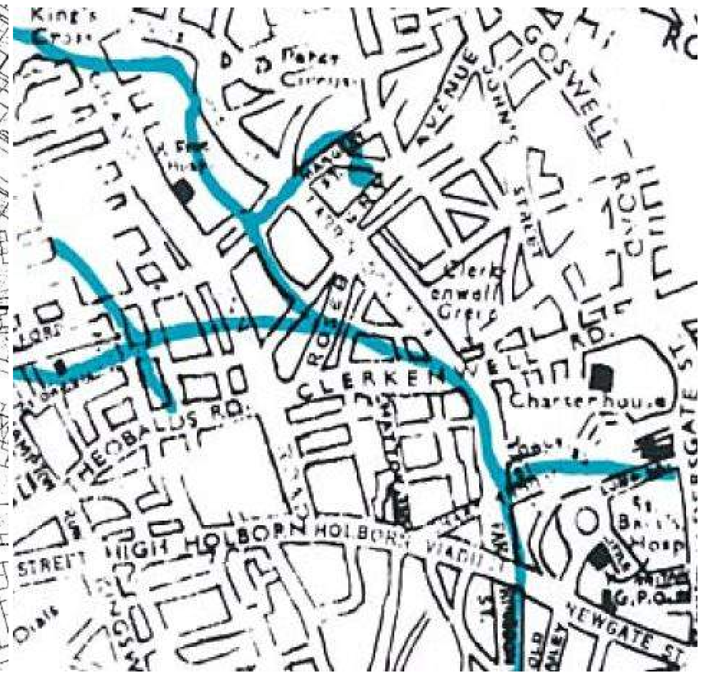


Image 6 - Extract from The Lost Rivers of London map

Bomb Damage

We have checked the WW2 LCC maps for the local area where it can be seen that, although a V1 Flying bombs was dropped further north along Grays Inn Road, the area surrounding the site remained largely unaffected suffering only minor blast damage (light yellow shading).

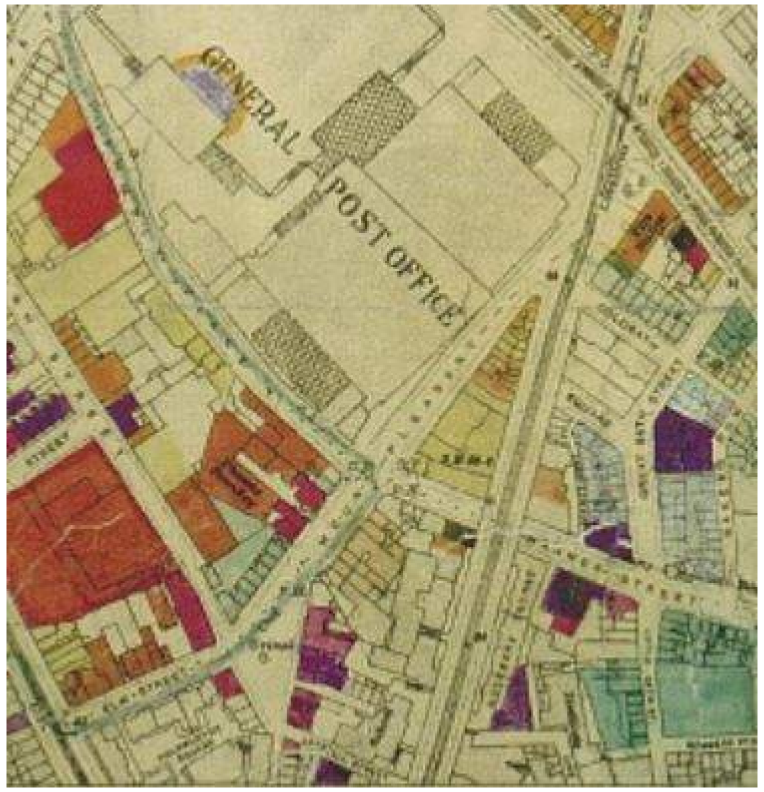


Image 7 - Extract from the WW2 LCC bomb damage maps

Other Underground Structures

The London Underground District and Circle Lines run to the north under Farringdon road and are far enough away not to be affected by our proposed works.
Thames Water record also shows an existing combined sewer along Warner Street with an internal dimension of 3124 x 2566mm and invert level of 7.83m. The exact setting out of the sewer is unknown however It is unlikely to be disturbed by the proposed works given its depth and the relatively shallow excavations.

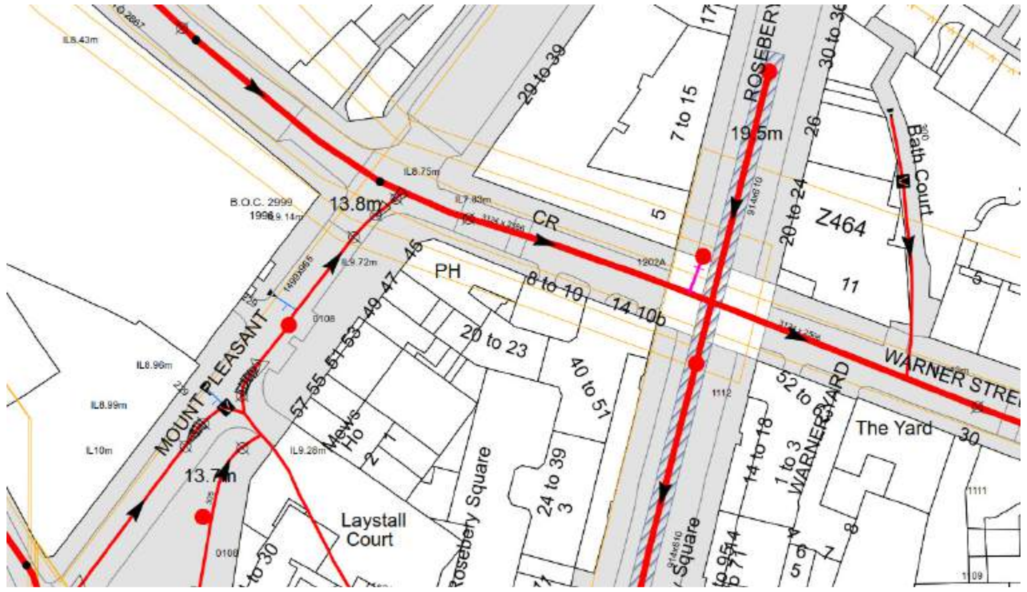


Image 8 - Extract from Thames Water sewer records

5 Proposed Structure

The proposal for the site consists in the enlargement of the existing lower ground by excavating the area under the rear lightwell to form a new kitchen and garden room at ground level. A new flat roof with lightwell will cover this new area. Additionally, it is proposed to lower the existing lower ground by approximately 340mm to improve the floor to ceiling height. With regards to the existing boundary conditions, we know that No 47 Mount Pleasant has an existing lower ground assumed to be at about the same level as ours. 8-10 Warner Street and the flats at 20-23 Rosebery Avenue do not have a lower ground floor. With regards to this area of the basement, it has been possible to establish from initial trial pits that the foundations of the corner of 20-23 Rosebery Avenue extends at least 2.1m below ground. Our new basement is expected to be lower than the base of the existing foundations and it is currently proposed to construct the new reinforced concrete wall about 1m away from the existing foundations. Section B-B on SK08 shows the proposal. Section A-A on SK07 shows the proposed underpinning of the two-storey party wall with 8-10 Warner Street.
Sections C-C and D-D on SK09 show the proposed relationship between the new lowered slab and the foundations of the existing perimeter walls. To prevent the rotation of the base of the existing retaining walls, it is proposed to form a reinforced concrete upstand connected to the main underpin. The new slab will then prop the base of the new underpins.

Above ground, the structural works are going to be small in nature and are shown on the proposed ground and first floor plan on SK05 and SK06.

The new basement will be founded at the top of the London clay with an allowable bearing capacity of 110KN/m^2 The new basement floor slab will be reinforced to withstand the expected heave pressures.
A ground movement analysis has been carried out by GEA and it is included with the site investigation report.

6 Proposed Construction Sequence

Given the site constraints, it is proposed to construct the basement entirely by hand following a typical underpinning sequence.

With reference to SK01, SK02 and SK03 the proposed construction sequence for the new basement is as follows:

Step 1 - Demolish existing single storey structures within internal courtyard

Step 2 - Assuming a two-stage underpinning sequence, begin the first stage pins forming the lining wall against N47 Mount pleasant. Each pin shall be formed as follows:

A) Excavate initial pit 1m x 1m x 1m, install props at top and bottom using scaffold boards as spreaders against the central soil mass.

B) Hand excavate pit to base of proposed pin constantly providing adequate propping. Install sacrificial expanded metal sheeting against the earth face to provide adequate propping

C) Introduce reinforcement to the wall face, introduce also dowel bars (H16 500 long @ 500c/c) to tie the pins together.

D) Install shuttering and cast pin

E) Wait 24 hrs and provide dry pack. Do not back fill upon completion. Leave pins open suitably propped against central soil mass

Step 3 - Similarly to Step 2 carry out first stage pins against corner of 20-23 Rosebery Avenue

Step 4 - Reduce level of central soil mass within rear courtyard enough to allow for the installation of the propping system(RMD Superslim props or similar). Props to be installed just below the level of the new ground floor slab.

Step 5 - Excavate central soil mass enough to allow the start of the second stage "L" pins. Leave enough soil to prop the base of the 1st stage pins.

Step 6 - Form the second stage "L" pins along 47 Mount Pleasant and 20-23 Rosebery Avenue.

Step 7 - At the same time as steps 1 to 6 form the shallow underpinning of the external walls by the front of the building following the proposed underpinning sequence. Do not undermine the pad to the existing central column.

Step 8 - Excavate down to formation level and install propping, similarly to upper level. props positioned just above new basement floor slab.

Step 9 - Cast reinforced concrete basement slab connected to the base of the "L" pins.

Step 10 - Cast ground floor suspended slab connected to the top of the pins (Halfen Kwikastrip could be used to form connection between top of pin and ground floor slab) On the side of the existing brick wall form full depth reinforced pockets to support the new ground floor slab along this edge.

Step 11 - Install new drainage and cast 250 RC basement slab to front of building leaving a section around the existing column base.

Step 12 - Starting from the demolition of wall A (see SK02) carefully excavate the ground to allow the start of the underpinning along Warner Street and the party wall with 8-10 Warner Street

Step 13 - Following a typical underpinning sequence form 1st stage pins of RC retaining wall against corner of 20-23 Rosebery Avenue.

Step 14 - Reduce level of central soil mass enough to introduce propping grid just above level of new ground floor slab.

Step 15 - Form RC "L" shaped lining wall in sections along 8-10 Warner Street and form 2nd stage "L" pins against 20-23 Rosebery Avenue.

Step 16 - Introduce lower level of props just above basement floor slab. Cast basement slab

Step 17 - Cast ground floor slab connected to new RC pins, the slab section under the courtyard previously formed and pocketed into the existing front wall along Warner Street

Step 18 - From underpins to remaining section of Warner Street. Reduce ground and cast new 250 RC basement slab connected to the other sections previously cast.

Step 19 - By the front of the building, provide temporary props to allow the removal of the basement column. cast new pad at lower level. introduce new column. Remove props and cast slab around new column.

Step 20 - Construct new roof structure over garden room. Form new stair opening and alterations above principal room.

Based on basement works of similar size we estimate that this basement can be safely formed in 4 months with an overall project program of about 12months.

7 Impact on Adjoining Buildings and Structures

The ground movement analysis carried out by GEA for the neighbouring buildings indicates mostly negligible damage (Category 0) with the exception of the corner of 20-23 Rosebery Avenue where the damage has been predicted to be very slight (Category 1). As noted in the report this analysis is conservative as the foundations have all been assumed to be 1m below ground while we know from trial pits carried out on site that in the corner of 20-23 Rosebery Avenue and along the party wall with 8-10 Warner Street the bases of the existing footings have been found between 1.5m to 2.0m below existing ground level.

A reinforced concrete wall formed in an underpinning sequence will serve as the new basement perimeter wall. This wall will be fully propped during the excavation to minimise potential ground movements as detailed in the proposed construction sequence shown in SK01-SK02-SK03.
With good workmanship and a properly designed and reviewed temporary works scheme, we would expect there to be very little impact on adjacent structures and buildings as a result of these works. The walls will remain propped until the permanent structure is in place and we therefore expect no ground stability issues.

During the construction of the basement, monitoring points will be set up to record any variable movements between properties. By using a system of targets, monitored and logged at regular intervals, any differential movements can be identified and the construction method and sequence altered accordingly to limit movements.

The proposed monitoring strategy is as follows:

3D reflective targets will be applied to all the neighbouring buildings and on the elevations of the pub. Locations to be agreed with the monitoring company to make sure measurements can be safely and easily taken.

Proposed frequency of measurements:

During demolition works – fortnightly.
During underpinning, excavation and until the RC ground slab is completed – weekly.
Upon completion of the ground floor slab – 1no fortnightly survey and then monthly surveys to the end of the project.

Proposed trigger values: for both vertical and horizontal movement

Amber ± 7mm
Red ± 10mm

8 Party Wall Matters

The proposed development falls within the scope of the Party Wall etc Act 1996. Procedures under the Act will be dealt with in full by The Employer's Party Wall Surveyor. The Party Wall Surveyor will prepare and serve necessary Notices under the provisions of the Act and agree Party Wall Awards in the event of disputes. The Contractor will be required to provide The Party Wall Surveyor with appropriate drawings, Method Statements and other relevant information covering the works that are notifiable under the Act. The resolution of matter under the Act and provision of the Party Wall Awards will protect the interests of all owners.
The design of the new basement will be developed so as not to preclude or inhibit similar, or indeed any, works on the adjoining properties. The Surveyors will verify this as part of the process under the Act.

The neighbours of 8-10 Warner Street, 47 Mount Pleasant and the block of flats on Rosebery Avenue at the back of the pub, have all been contacted and copies of the correspondence can be provided if requested.

9 Noise, Dust and Vibration

The Contractor shall undertake the works in such a way as to minimise noise, dust and vibration when working close to adjacent buildings to protect the amenities of the nearby occupiers.

Noise:

Noise is often a complaint from neighbours however this can be managed by:

- keeping a good relationship with the neighbours by informing them on when higher noise level may be generated. If these times were not acceptable to the neighbours then, within reason, a compromise should be found on when the works can be carried out.

-providing additional noise dampening barriers around the areas of noise generation.

-utilising modern equipment with a lower noise impact than older machinery.

-respecting the allowable hours of works as noted in the planning permission.

Dust:

The contractor must make sure that the site is suitably protected to prevent the spread of dust to the neighbouring properties. Most of the dust will be generated during the basement excavation and the zone generally affecting the neighbouring properties is the entrance area where spoil is taken out of the property via conveyor belts or wheelbarrows. Any dropped soil or waste material is then spread by wind and foot traffic onto the neighbouring properties. The contractor will therefore be required to keep the front area of the site clean at all times especially during windy days.

Vibration:

The contractor shall use power generators and compressors that will minimise noise. These shall be positioned in such a way as to reduce the transmission of vibration via the existing and new structural elements to the neighbouring properties. Suitable vibration isolators may need to be installed to the supporting bases of the most critical equipment. Wherever possible the breaking of existing structure such as concrete floors shall be carried out by saw cutting to minimise vibrations.

10 Design Criteria

Loading

Imposed loading (to BS 6399:part 1)

Café/Restaurant = 2.0 KN/m^2

Wind loading (to BS 6399:part 2)

Basic wind speed = 20 m/s

Overburden pressure for
retaining wall design generally =10.0 KN/m^2

Overburden pressure for
retaining wall design in front of
20-23 Rosebery Avenue =150 KN/m^2

Soil conditions Ko

Water assumed 1m below ground level

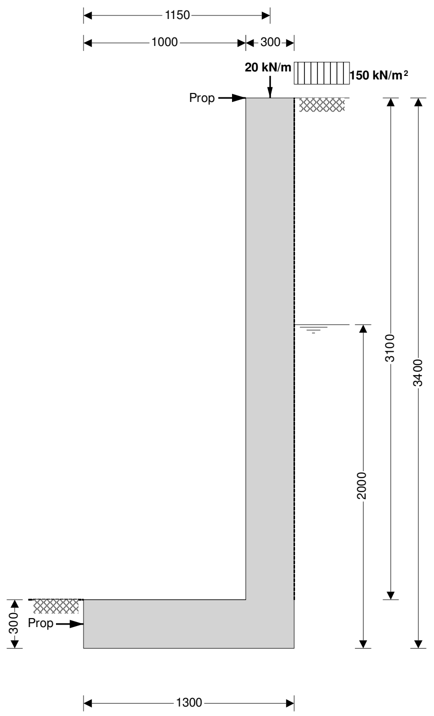
11 Design Risks

The primary design risks identified during the work done to this point are:

Unforeseen underground structures.
High or increasing water table across site.
Working in confined spaces during the underpinning process.

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06



Wall details

Retaining wall type	**Cantilever propped at both**
Height of retaining wall stem	h_{stem} = **3100** mm
Thickness of wall stem	t_{wall} = **300** mm
Length of toe	l_{toe} = **1000** mm
Length of heel	l_{heel} = **0** mm
Overall length of base	$l_{base} = l_{toe} + l_{heel} + t_{wall}$ = **1300** mm
Thickness of base	t_{base} = **300** mm
Depth of downstand	d_{ds} = **0** mm
Position of downstand	l_{ds} = **900** mm
Thickness of downstand	t_{ds} = **300** mm
Height of retaining wall	$h_{wall} = h_{stem} + t_{base} + d_{ds}$ = **3400** mm
Depth of cover in front of wall	d_{cover} = **0** mm
Depth of unplanned excavation	d_{exc} = **0** mm
Height of ground water behind wall	h_{water} = **2000** mm
Height of saturated fill above base	$h_{sat} = \max(h_{water} - t_{base} - d_{ds}, 0\text{ mm})$ = **1700** mm
Density of wall construction	γ_{wall} = **23.6** kN/m^3
Density of base construction	γ_{base} = **23.6** kN/m^3
Angle of rear face of wall	α = **90.0** deg
Angle of soil surface behind wall	β = **0.0** deg
Effective height at virtual back of wall	$h_{eff} = h_{wall} + l_{heel} \times \tan(\beta)$ = **3400** mm

Retained material details

Mobilisation factor	M = **1.5**
Moist density of retained material	γ_m = **17.0** kN/m^3

Tekla Tedds P&M	Project The Apple Tree Public House 45 Mount Pleasant				Job no. 27610	
	Calcs for Basement Retaining Wall				Start page no./Revision 2	
	Calcs by MG	Calcs date 29/01/2020	Checked by	Checked date	Approved by	Approved date

Saturated density of retained material — γ_s = **20.0** kN/m^3

Design shear strength — ϕ' = **23.4** deg

Angle of wall friction — δ = **18.0** deg

Base material details

Firm clay

Moist density — γ_{mb} = **17.0** kN/m^3

Design shear strength — ϕ'_b = **23.0** deg

Design base friction — δ_b = **18.0** deg

Allowable bearing pressure — $P_{bearing}$ = **110** kN/m^2

Using Coulomb theory

Active pressure coefficient for retained material

$$K_a = \sin(\alpha + \phi')^2 / (\sin(\alpha)^2 \times \sin(\alpha - \delta) \times [1 + \sqrt{(\sin(\phi' + \delta) \times \sin(\phi' - \beta) / (\sin(\alpha - \delta) \times \sin(\alpha + \beta)))}]^2) = \mathbf{0.381}$$

Passive pressure coefficient for base material

$$K_p = \sin(90 - \phi'_b)^2 / (\sin(90 - \delta_b) \times [1 - \sqrt{(\sin(\phi'_b + \delta_b) \times \sin(\phi'_b) / (\sin(90 + \delta_b)))}]^2) = \mathbf{3.854}$$

At-rest pressure

At-rest pressure for retained material — $K_0 = 1 - \sin(\phi') = \mathbf{0.603}$

Loading details

Surcharge load on plan — Surcharge = **150.0** kN/m^2

Applied vertical dead load on wall — W_{dead} = **20.0** kN/m

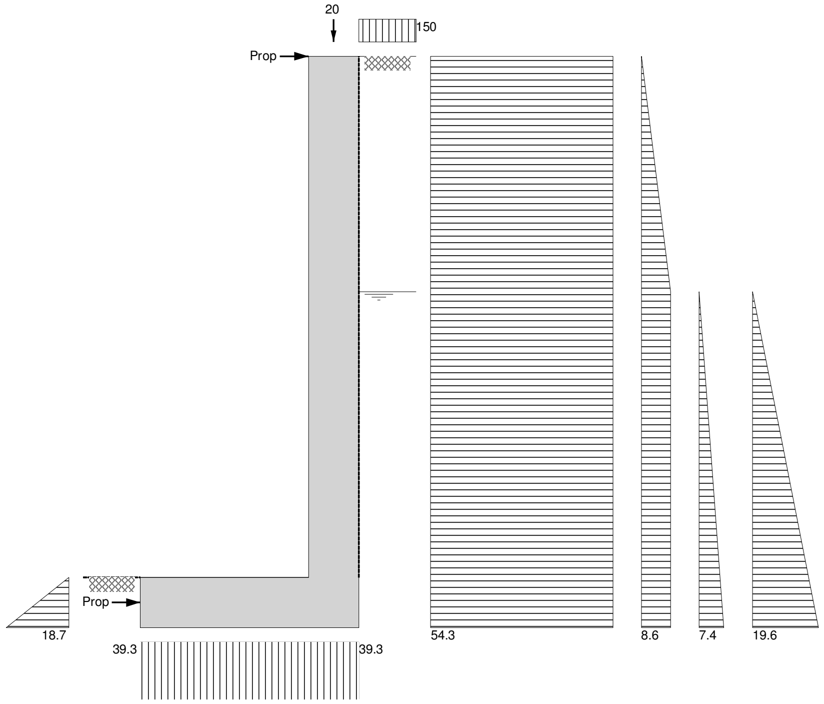
Applied vertical live load on wall — W_{live} = **0.0** kN/m

Position of applied vertical load on wall — l_{load} = **1150** mm

Applied horizontal dead load on wall — F_{dead} = **0.0** kN/m

Applied horizontal live load on wall — F_{live} = **0.0** kN/m

Height of applied horizontal load on wall — h_{load} = **0** mm



Loads shown in kN/m, pressures shown in kN/m^2

Vertical forces on wall

Wall stem $w_{wall} = h_{stem} \times t_{wall} \times \gamma_{wall}$ = **21.9** kN/m

Wall base $w_{base} = l_{base} \times t_{base} \times \gamma_{base}$ = **9.2** kN/m

Applied vertical load $W_v = W_{dead} + W_{live}$ = **20** kN/m

Total vertical load $W_{total} = w_{wall} + w_{base} + W_v$ = **51.2** kN/m

Horizontal forces on wall

Surcharge $F_{sur} = K_a \times \cos(90 - \alpha + \delta) \times Surcharge \times h_{eff}$ = **184.6** kN/m

Moist backfill above water table $F_{m\_a} = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water})^2$ = **6** kN/m

Moist backfill below water table $F_{m\_b} = K_a \times \cos(90 - \alpha + \delta) \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water}$ = **17.2** kN/m

Saturated backfill $F_s = 0.5 \times K_a \times \cos(90 - \alpha + \delta) \times (\gamma_s - \gamma_{water}) \times h_{water}^2$ = **7.4** kN/m

Water $F_{water} = 0.5 \times h_{water}^2 \times \gamma_{water}$ = **19.6** kN/m

Total horizontal load $F_{total} = F_{sur} + F_{m\_a} + F_{m\_b} + F_s + F_{water}$ = **234.8** kN/m

Calculate total propping force

Passive resistance of soil in front of wall $F_p = 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **2.8** kN/m

Propping force $F_{prop} = \max(F_{total} - F_p - (W_{total}) \times \tan(\delta_b), 0 \text{ kN/m})$

F_{prop} = **215.4** kN/m

Overturning moments

Surcharge $M_{sur} = F_{sur} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **313.8** kNm/m

Moist backfill above water table $M_{m\_a} = F_{m\_a} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **14.9** kNm/m

Moist backfill below water table $M_{m\_b} = F_{m\_b} \times (h_{water} - 2 \times d_{ds}) / 2$ = **17.2** kNm/m

Saturated backfill $M_s = F_s \times (h_{water} - 3 \times d_{ds}) / 3$ = **4.9** kNm/m

Water $M_{water} = F_{water} \times (h_{water} - 3 \times d_{ds}) / 3$ = **13.1** kNm/m

Total overturning moment $M_{ot} = M_{sur} + M_{m\_a} + M_{m\_b} + M_s + M_{water}$ = **363.9** kNm/m

Restoring moments

Wall stem $M_{wall} = w_{wall} \times (l_{toe} + t_{wall} / 2)$ = **25.2** kNm/m

Wall base $M_{base} = w_{base} \times l_{base} / 2$ = **6** kNm/m

Design vertical dead load $M_{dead} = W_{dead} \times l_{load}$ = **23** kNm/m

Total restoring moment $M_{rest} = M_{wall} + M_{base} + M_{dead}$ = **54.2** kNm/m

Check bearing pressure

Total vertical reaction $R = W_{total}$ = **51.2** kN/m

Distance to reaction $x_{bar} = l_{base} / 2$ = **650** mm

Eccentricity of reaction $e = \text{abs}((l_{base} / 2) - x_{bar})$ = **0** mm

Reaction acts within middle third of base

Bearing pressure at toe $p_{toe} = (R / l_{base}) - (6 \times R \times e / l_{base}^2)$ = **39.3** kN/m²

Bearing pressure at heel $p_{heel} = (R / l_{base}) + (6 \times R \times e / l_{base}^2)$ = **39.3** kN/m²

PASS - Maximum bearing pressure is less than allowable bearing pressure

Calculate propping forces to top and base of wall

Propping force to top of wall

$F_{prop\_top} = (M_{ot} - M_{rest} + R \times l_{base} / 2 - F_{prop} \times t_{base} / 2) / (h_{stem} + t_{base} / 2)$ = **95.571** kN/m

Propping force to base of wall $F_{prop\_base} = F_{prop} - F_{prop\_top}$ = **119.844** kN/m

RETAINING WALL DESIGN (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Ultimate limit state load factors

Dead load factor γ_{f_d} = **1.4**

Live load factor γ_{f_l} = **1.6**

Earth and water pressure factor γ_{f_e} = **1.4**

Factored vertical forces on wall

Wall stem $w_{wall\_f} = \gamma_{f\_d} \times h_{stem} \times t_{wall} \times \gamma_{wall}$ = **30.7** kN/m

Wall base $w_{base\_f} = \gamma_{f\_d} \times l_{base} \times t_{base} \times \gamma_{base}$ = **12.9** kN/m

Applied vertical load $W_{v\_f} = \gamma_{f\_d} \times W_{dead} + \gamma_{f\_l} \times W_{live}$ = **28** kN/m

Total vertical load $W_{total\_f} = w_{wall\_f} + w_{base\_f} + W_{v\_f}$ = **71.6** kN/m

Factored horizontal at-rest forces on wall

Surcharge $F_{sur\_f} = \gamma_{f\_l} \times K_0 \times Surcharge \times h_{eff}$ = **491.9** kN/m

Moist backfill above water table $F_{m\_a\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times \gamma_m \times (h_{eff} - h_{water})^2$ = **14.1** kN/m

Moist backfill below water table $F_{m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - h_{water}) \times h_{water}$ = **40.2** kN/m

Saturated backfill $F_{s\_f} = \gamma_{f\_e} \times 0.5 \times K_0 \times (\gamma_s - \gamma_{water}) \times h_{water}^2$ = **17.2** kN/m

Water $F_{water\_f} = \gamma_{f\_e} \times 0.5 \times h_{water}^2 \times \gamma_{water}$ = **27.5** kN/m

Total horizontal load $F_{total\_f} = F_{sur\_f} + F_{m\_a\_f} + F_{m\_b\_f} + F_{s\_f} + F_{water\_f}$ = **590.8** kN/m

Calculate total propping force

Passive resistance of soil in front of wall $F_{p\_f} = \gamma_{f\_e} \times 0.5 \times K_p \times \cos(\delta_b) \times (d_{cover} + t_{base} + d_{ds} - d_{exc})^2 \times \gamma_{mb}$ = **3.9** kN/m

Propping force $F_{prop\_f} = \max(F_{total\_f} - F_{p\_f} - (W_{total\_f}) \times \tan(\delta_b), 0\text{ kN/m})$

F_{prop_f} = **563.6** kN/m

Factored overturning moments

Surcharge $M_{sur\_f} = F_{sur\_f} \times (h_{eff} - 2 \times d_{ds}) / 2$ = **836.3** kNm/m

Moist backfill above water table $M_{m\_a\_f} = F_{m\_a\_f} \times (h_{eff} + 2 \times h_{water} - 3 \times d_{ds}) / 3$ = **34.7** kNm/m

Moist backfill below water table $M_{m\_b\_f} = F_{m\_b\_f} \times (h_{water} - 2 \times d_{ds}) / 2$ = **40.2** kNm/m

Saturated backfill $M_{s\_f} = F_{s\_f} \times (h_{water} - 3 \times d_{ds}) / 3$ = **11.5** kNm/m

Water $M_{water\_f} = F_{water\_f} \times (h_{water} - 3 \times d_{ds}) / 3$ = **18.3** kNm/m

Total overturning moment $M_{ot\_f} = M_{sur\_f} + M_{m\_a\_f} + M_{m\_b\_f} + M_{s\_f} + M_{water\_f}$ = **940.9** kNm/m

Restoring moments

Wall stem $M_{wall\_f} = w_{wall\_f} \times (l_{toe} + t_{wall} / 2)$ = **35.3** kNm/m

Wall base $M_{base\_f} = w_{base\_f} \times l_{base} / 2$ = **8.4** kNm/m

Design vertical load $M_{v\_f} = W_{v\_f} \times l_{load}$ = **32.2** kNm/m

Total restoring moment $M_{rest\_f} = M_{wall\_f} + M_{base\_f} + M_{v\_f}$ = **75.9** kNm/m

Factored bearing pressure

Total vertical reaction $R_f = W_{total\_f}$ = **71.6** kN/m

Distance to reaction $x_{bar\_f} = l_{base} / 2$ = **650** mm

Eccentricity of reaction $e_f = \mathrm{abs}((l_{base} / 2) - x_{bar\_f})$ = **0** mm

Reaction acts within middle third of base

Bearing pressure at toe $p_{toe\_f} = (R_f / l_{base}) - (6 \times R_f \times e_f / l_{base}^2)$ = **55.1** kN/m²

Bearing pressure at heel $p_{heel\_f} = (R_f / l_{base}) + (6 \times R_f \times e_f / l_{base}^2)$ = **55.1** kN/m²

Rate of change of base reaction $rate = (p_{toe\_f} - p_{heel\_f}) / l_{base}$ = **0.00** kN/m²/m

Bearing pressure at stem / toe $p_{stem\_toe\_f} = \max(p_{toe\_f} - (rate \times l_{toe}), 0\text{ kN/m}^2)$ = **55.1** kN/m²

Bearing pressure at mid stem $p_{stem\_mid\_f} = \max(p_{toe\_f} - (rate \times (l_{toe} + t_{wall} / 2)), 0\ kN/m^2) = \mathbf{55.1}\ kN/m^2$

Bearing pressure at stem / heel $p_{stem\_heel\_f} = \max(p_{toe\_f} - (rate \times (l_{toe} + t_{wall})), 0\ kN/m^2) = \mathbf{55.1}\ kN/m^2$

Calculate propping forces to top and base of wall

Propping force to top of wall

$F_{prop\_top\_f} = (M_{ot\_f} - M_{rest\_f} + R_f \times l_{base} / 2 - F_{prop\_f} \times t_{base} / 2) / (h_{stem} + t_{base} / 2) = \mathbf{254.463}\ kN/m$

Propping force to base of wall $F_{prop\_base\_f} = F_{prop\_f} - F_{prop\_top\_f} = \mathbf{309.175}\ kN/m$

Design of reinforced concrete retaining wall toe (BS 8002:1994)

Material properties

Characteristic strength of concrete $f_{cu} = \mathbf{40}\ N/mm^2$

Characteristic strength of reinforcement $f_y = \mathbf{500}\ N/mm^2$

Base details

Minimum area of reinforcement $k = \mathbf{0.13}\ \%$

Cover to reinforcement in toe $c_{toe} = \mathbf{50}\ mm$

Calculate shear for toe design

Shear from bearing pressure $V_{toe\_bear} = (p_{toe\_f} + p_{stem\_toe\_f}) \times l_{toe} / 2 = \mathbf{55.1}\ kN/m$

Shear from weight of base $V_{toe\_wt\_base} = \gamma_{f\_d} \times \gamma_{base} \times l_{toe} \times t_{base} = \mathbf{9.9}\ kN/m$

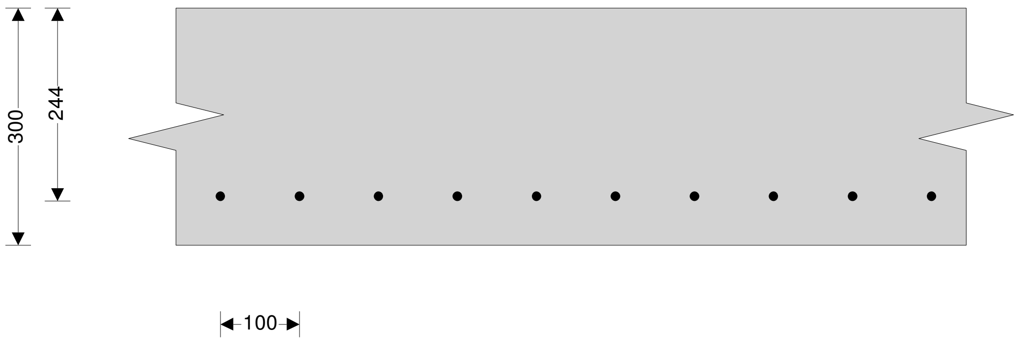
Total shear for toe design $V_{toe} = V_{toe\_bear} - V_{toe\_wt\_base} = \mathbf{45.2}\ kN/m$

Calculate moment for toe design

Moment from bearing pressure $M_{toe\_bear} = (2 \times p_{toe\_f} + p_{stem\_mid\_f}) \times (l_{toe} + t_{wall} / 2)^2 / 6 = \mathbf{36.4}\ kNm/m$

Moment from weight of base $M_{toe\_wt\_base} = (\gamma_{f\_d} \times \gamma_{base} \times t_{base} \times (l_{toe} + t_{wall} / 2)^2 / 2) = \mathbf{6.6}\ kNm/m$

Total moment for toe design $M_{toe} = M_{toe\_bear} - M_{toe\_wt\_base} = \mathbf{29.9}\ kNm/m$



Check toe in bending

Width of toe $b = \mathbf{1000}\ mm/m$

Depth of reinforcement $d_{toe} = t_{base} - c_{toe} - (\phi_{toe} / 2) = \mathbf{244.0}\ mm$

Constant $K_{toe} = M_{toe} / (b \times d_{toe}^2 \times f_{cu}) = \mathbf{0.013}$

Compression reinforcement is not required

Lever arm $z_{toe} = \min(0.5 + \sqrt{(0.25 - (\min(K_{toe}, 0.225) / 0.9))}, 0.95) \times d_{toe}$

$z_{toe} = \mathbf{232}\ mm$

Area of tension reinforcement required $A_{s\_toe\_des} = M_{toe} / (0.87 \times f_y \times z_{toe}) = \mathbf{296}\ mm^2/m$

Minimum area of tension reinforcement $A_{s\_toe\_min} = k \times b \times t_{base} = \mathbf{390}\ mm^2/m$

Area of tension reinforcement required $A_{s\_toe\_req} = \mathrm{Max}(A_{s\_toe\_des}, A_{s\_toe\_min}) = \mathbf{390}\ mm^2/m$

Reinforcement provided **12 mm dia.bars @ 100 mm centres**

Area of reinforcement provided $A_{s\_toe\_prov} = \mathbf{1131}\ mm^2/m$

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe

Design shear stress $v_{toe} = V_{toe} / (b \times d_{toe}) = \mathbf{0.185}$ N/mm²

Allowable shear stress $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1 \text{ N/mm}^2)}, 5) \times 1 \text{ N/mm}^2 = \mathbf{5.000}$ N/mm²

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress $v_{c\_toe} = \mathbf{0.647}$ N/mm²

$v_{toe} < v_{c\_toe}$ - No shear reinforcement required

<u>Design of reinforced concrete retaining wall stem (BS 8002:1994)</u>

Material properties

Characteristic strength of concrete $f_{cu} = \mathbf{40}$ N/mm²

Characteristic strength of reinforcement $f_y = \mathbf{500}$ N/mm²

Wall details

Minimum area of reinforcement $k = \mathbf{0.13}$ %

Cover to reinforcement in stem $c_{stem} = \mathbf{50}$ mm

Cover to reinforcement in wall $c_{wall} = \mathbf{25}$ mm

Factored horizontal at-rest forces on stem

Surcharge $F_{s\_sur\_f} = \gamma_{f\_l} \times K_0 \times \text{Surcharge} \times (h_{eff} - t_{base} - d_{ds}) = \mathbf{448.5}$ kN/m

Moist backfill above water table $F_{s\_m\_a\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat})^2 = \mathbf{14.1}$ kN/m

Moist backfill below water table $F_{s\_m\_b\_f} = \gamma_{f\_e} \times K_0 \times \gamma_m \times (h_{eff} - t_{base} - d_{ds} - h_{sat}) \times h_{sat} = \mathbf{34.1}$ kN/m

Saturated backfill $F_{s\_s\_f} = 0.5 \times \gamma_{f\_e} \times K_0 \times (\gamma_s - \gamma_{water}) \times h_{sat}^2 = \mathbf{12.4}$ kN/m

Water $F_{s\_water\_f} = 0.5 \times \gamma_{f\_e} \times \gamma_{water} \times h_{sat}^2 = \mathbf{19.8}$ kN/m

Calculate shear for stem design

Surcharge $V_{s\_sur\_f} = 5 \times F_{s\_sur\_f} / 8 = \mathbf{280.3}$ kN/m

Moist backfill above water table $V_{s\_m\_a\_f} = F_{s\_m\_a\_f} \times b_l \times ((5 \times L^2) - b_l^2) / (5 \times L^3) = \mathbf{5.8}$ kN/m

Moist backfill below water table $V_{s\_m\_b\_f} = F_{s\_m\_b\_f} \times (8 - (n^2 \times (4 - n))) / 8 = \mathbf{29.4}$ kN/m

Saturated backfill $V_{s\_s\_f} = F_{s\_s\_f} \times (1 - (a_l^2 \times ((5 \times L) - a_l) / (20 \times L^3))) = \mathbf{11.5}$ kN/m

Water $V_{s\_water\_f} = F_{s\_water\_f} \times (1 - (a_l^2 \times ((5 \times L) - a_l) / (20 \times L^3))) = \mathbf{18.4}$ kN/m

Total shear for stem design $V_{stem} = V_{s\_sur\_f} + V_{s\_m\_a\_f} + V_{s\_m\_b\_f} + V_{s\_s\_f} + V_{s\_water\_f} = \mathbf{345.5}$ kN/m

Calculate moment for stem design

Surcharge $M_{s\_sur} = F_{s\_sur\_f} \times L / 8 = \mathbf{182.2}$ kNm/m

Moist backfill above water table $M_{s\_m\_a} = F_{s\_m\_a\_f} \times b_l \times ((5 \times L^2) - (3 \times b_l^2)) / (15 \times L^2) = \mathbf{5.8}$ kNm/m

Moist backfill below water table $M_{s\_m\_b} = F_{s\_m\_b\_f} \times a_l \times (2 - n)^2 / 8 = \mathbf{16.2}$ kNm/m

Saturated backfill $M_{s\_s} = F_{s\_s\_f} \times a_l \times ((3 \times a_l^2)-(15 \times a_l \times L)+(20 \times L^2))/(60 \times L^2) = \mathbf{4.8}$ kNm/m

Water $M_{s\_water} = F_{s\_water\_f} \times a_l \times ((3 \times a_l^2)-(15 \times a_l \times L)+(20 \times L^2))/(60 \times L^2) = \mathbf{7.6}$ kNm/m

Total moment for stem design $M_{stem} = M_{s\_sur} + M_{s\_m\_a} + M_{s\_m\_b} + M_{s\_s} + M_{s\_water} = \mathbf{216.6}$ kNm/m

Calculate moment for wall design

Surcharge $M_{w\_sur} = 9 \times F_{s\_sur\_f} \times L / 128 = \mathbf{102.5}$ kNm/m

Moist backfill above water table $M_{w\_m\_a} = F_{s\_m\_a\_f} \times 0.577 \times b_l \times [(b_l^3+5 \times a_l \times L^2)/(5 \times L^3)-0.577^2/3] = \mathbf{5.4}$
kNm/m

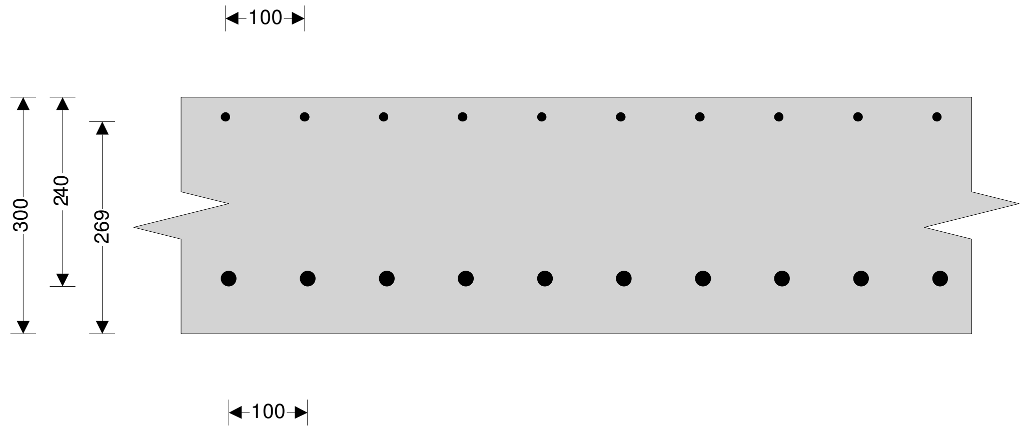
Moist backfill below water table $M_{w\_m\_b} = F_{s\_m\_b\_f} \times a_l \times [((8-n^2 \times (4-n))^2 /16)-4+n \times (4-n)]/8 = \mathbf{7.3}$ kNm/m

Saturated backfill $M_{w\_s} = F_{s\_s\_f} \times [a_l^2 \times x \times ((5 \times L)-a_l)/(20 \times L^3)-(x-b_l)^3 /(3 \times a_l^2)] = \mathbf{1.5}$ kNm/m

Water $M_{w\_water} = F_{s\_water\_f} \times [a_l^2 \times x \times ((5 \times L)-a_l)/(20 \times L^3)-(x-b_l)^3 /(3 \times a_l^2)] = \mathbf{2.5}$
kNm/m

Total moment for wall design $M_{wall} = M_{w\_sur} + M_{w\_m\_a} + M_{w\_m\_b} + M_{w\_s} + M_{w\_water} = \mathbf{119.1}$ kNm/m

Tekla Tedds P&M	Project The Apple Tree Public House 45 Mount Pleasant				Job no. 27610	
	Calcs for Basement Retaining Wall				Start page no./Revision 7	
	Calcs by MG	Calcs date 29/01/2020	Checked by	Checked date	Approved by	Approved date



Check wall stem in bending

Width of wall stem — $b = \mathbf{1000}$ mm/m

Depth of reinforcement — $d_{stem} = t_{wall} - c_{stem} - (\phi_{stem} / 2) = \mathbf{240.0}$ mm

Constant — $K_{stem} = M_{stem} / (b \times d_{stem}^2 \times f_{cu}) = \mathbf{0.094}$

Compression reinforcement is not required

Lever arm — $z_{stem} = \min(0.5 + \sqrt{(0.25 - (\min(K_{stem}, 0.225) / 0.9))}, 0.95) \times d_{stem}$

$z_{stem} = \mathbf{212}$ mm

Area of tension reinforcement required — $A_{s\_stem\_des} = M_{stem} / (0.87 \times f_y \times z_{stem}) = \mathbf{2353}$ mm^2/m

Minimum area of tension reinforcement — $A_{s\_stem\_min} = k \times b \times t_{wall} = \mathbf{390}$ mm^2/m

Area of tension reinforcement required — $A_{s\_stem\_req} = \mathrm{Max}(A_{s\_stem\_des}, A_{s\_stem\_min}) = \mathbf{2353}$ mm^2/m

Reinforcement provided — **20 mm dia.bars @ 100 mm centres**

Area of reinforcement provided — $A_{s\_stem\_prov} = \mathbf{3142}$ mm^2/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress — $v_{stem} = V_{stem} / (b \times d_{stem}) = \mathbf{1.440}$ N/mm^2

Allowable shear stress — $v_{adm} = \min(0.8 \times \sqrt{(f_{cu} / 1\text{ N/mm}^2)}, 5) \times 1\text{ N/mm}^2 = \mathbf{5.000}$ N/mm^2

PASS - Design shear stress is less than maximum shear stress

From BS8110:Part 1:1997 – Table 3.8

Design concrete shear stress — $v_{c\_stem} = \mathbf{0.919}$ N/mm^2

WARNING - Shear reinforcement required

Check mid height of wall in bending

Depth of reinforcement — $d_{wall} = t_{wall} - c_{wall} - (\phi_{wall} / 2) = \mathbf{269.0}$ mm

Constant — $K_{wall} = M_{wall} / (b \times d_{wall}^2 \times f_{cu}) = \mathbf{0.041}$

Compression reinforcement is not required

Lever arm — $z_{wall} = \mathrm{Min}(0.5 + \sqrt{(0.25 - (\min(K_{wall}, 0.225) / 0.9))}, 0.95) \times d_{wall}$

$z_{wall} = \mathbf{256}$ mm

Area of tension reinforcement required — $A_{s\_wall\_des} = M_{wall} / (0.87 \times f_y \times z_{wall}) = \mathbf{1072}$ mm^2/m

Minimum area of tension reinforcement — $A_{s\_wall\_min} = k \times b \times t_{wall} = \mathbf{390}$ mm^2/m

Area of tension reinforcement required — $A_{s\_wall\_req} = \mathrm{Max}(A_{s\_wall\_des}, A_{s\_wall\_min}) = \mathbf{1072}$ mm^2/m

Reinforcement provided — **12 mm dia.bars @ 100 mm centres**

Area of reinforcement provided — $A_{s\_wall\_prov} = \mathbf{1131}$ mm^2/m

PASS - Reinforcement provided to the retaining wall at mid height is adequate

Check retaining wall deflection

Basic span/effective depth ratio $ratio_{bas}$ = **20**

Design service stress $f_s = 2 \times f_y \times A_{s\_stem\_req} / (3 \times A_{s\_stem\_prov})$ = **249.7** N/mm²

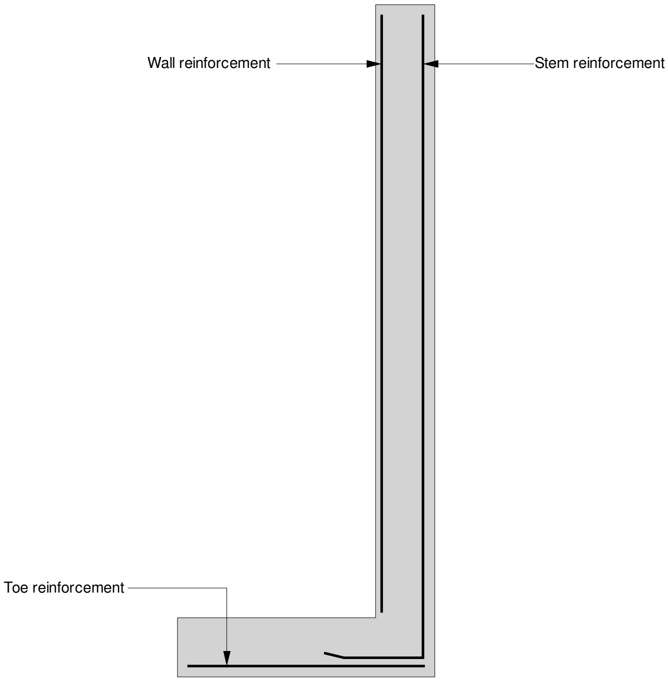
Modification factor $factor_{tens} = \min(0.55 + (477\ N/mm^2 - f_s)/(120 \times (0.9\ N/mm^2 + (M_{stem}/(b \times d_{stem}^2)))),2)$ = **0.96**

Maximum span/effective depth ratio $ratio_{max} = ratio_{bas} \times factor_{tens}$ = **19.13**

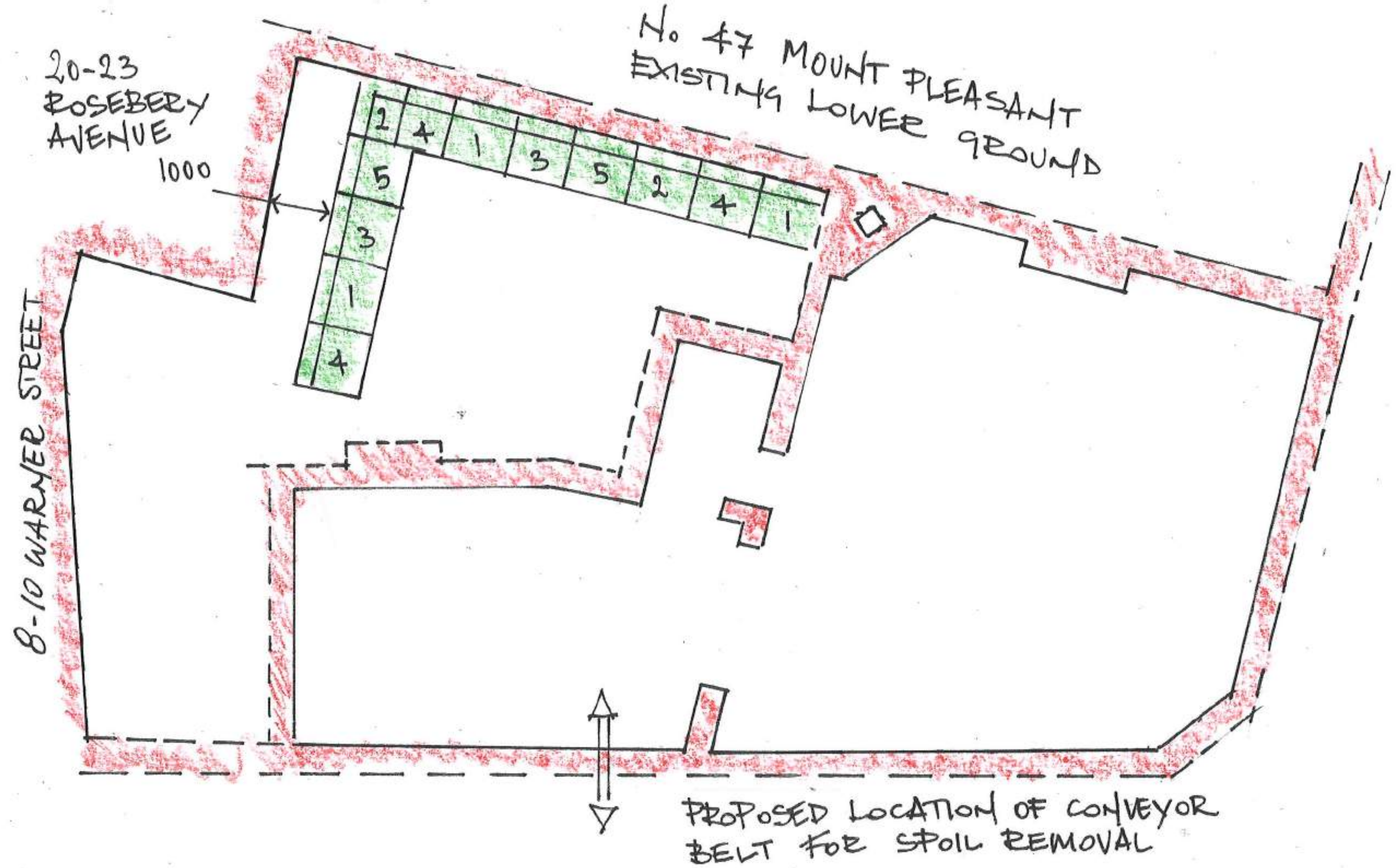
Actual span/effective depth ratio $ratio_{act} = h_{stem} / d_{stem}$ = **12.92**

PASS - Span to depth ratio is acceptable

Indicative retaining wall reinforcement diagram



Toe bars - 12 mm dia.@ 100 mm centres - (1131 mm^2/m)
Wall bars - 12 mm dia.@ 100 mm centres - (1131 mm^2/m)
Stem bars - 20 mm dia.@ 100 mm centres - (3142 mm^2/m)



④ REDUCE LEVEL OF CENTRAL SOIL MASS IN REAR COURTYARD ENOUGH TO ALLOW INSTALLATION OF PROPS BELOW LINE OF NEW TERRACE RC SLAB

⑤ EXCAVATE CENTRAL SOIL MASS ENOUGH TO START THE SECOND STAGE "L" PINS ALONG 47 MOUNT PLEASANT AND 20-23 ROSEBERY AVENUE

⑥ CARRY OUT 2ND STAGE "L" PINS LEAVING THE PINS OPEN AND SUITABLY PROPPED AGAINST THE CENTRAL SOIL MASS

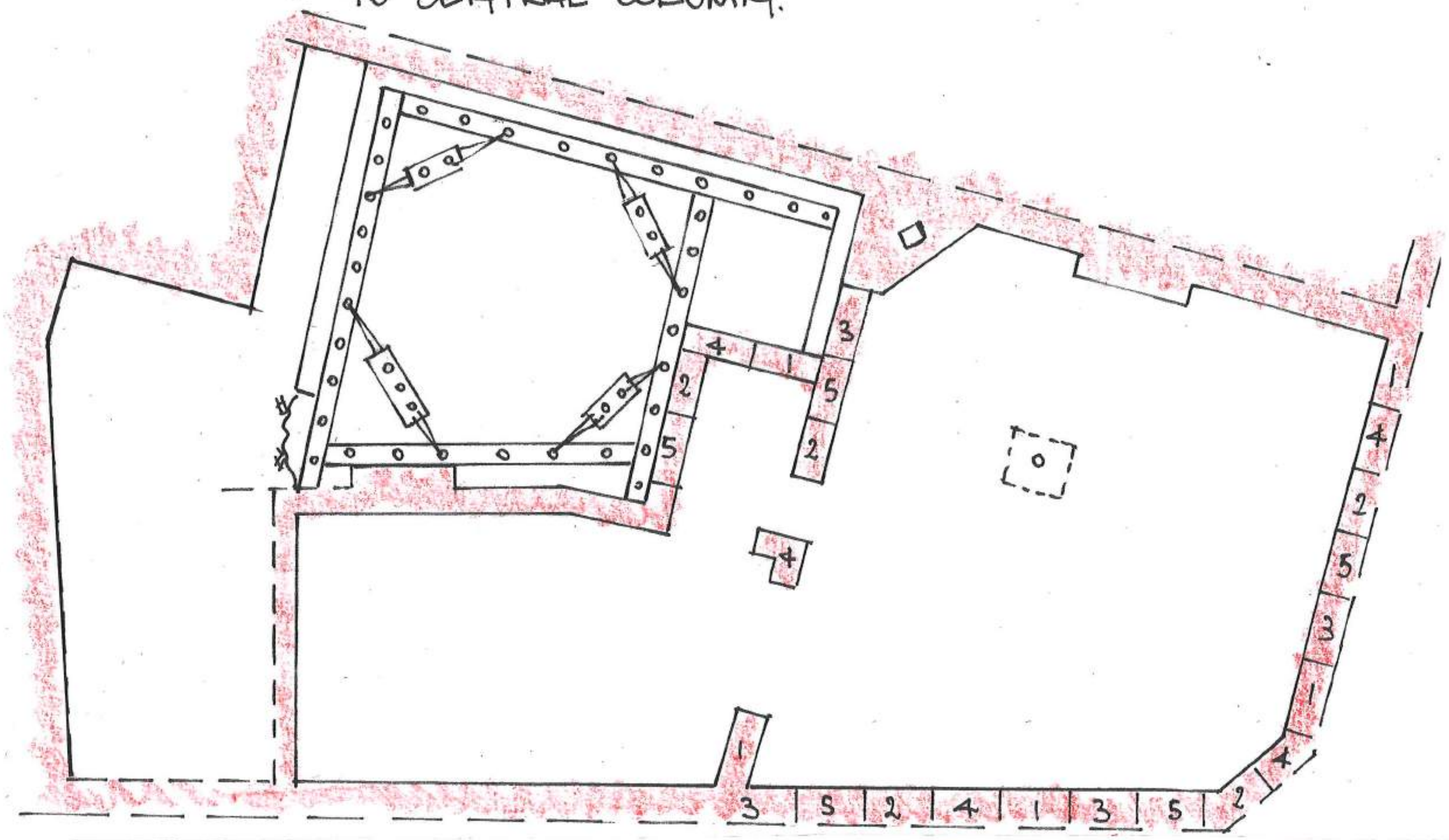
⑦ AT THE SAME TIME AS STEPS ① TO ⑥ THE SHALLOW UNDERPINNING OF THE EXTERNAL WALLS BY THE FRONT OF THE PUB CAN BE CARRIED OUT FOLLOWING A TYPICAL UNDERPINNING SEQUENCE THE WALLS BY THE EXISTING SERVICE STAIR CAN ALSO BE UNDERPINNED. DO NOT UNDERMINE PAD TO CENTRAL COLUMN.

PROPOSED CONSTRUCTION SEQUENCE

① DEMOLISH SINGLE STOREY BUILDINGS WITHIN REAR COURTYARD INCLUDING TOILET BLOCK

② BEGIN THE FIRST STAGE REINFORCED CONCRETE PINS FORMING THE LINING WALL AGAINST No. 47 MOUNT PLEASANT DO NOT BACK FILL UPON COMPLETION LEAVE PINS OPEN SUITABLY PROPPED AGAINST SOIL. CARRY OUT PINS FOLLOWING TYPICAL UNDERPINNING SEQUENCE

③ SIMILARLY TO STEP ② CARRY OUT FIRST STAGE PINS AGAINST CORNER OF 20-23 ROSEBERY AVENUE. PINS DEPTH ~ 1.5 m



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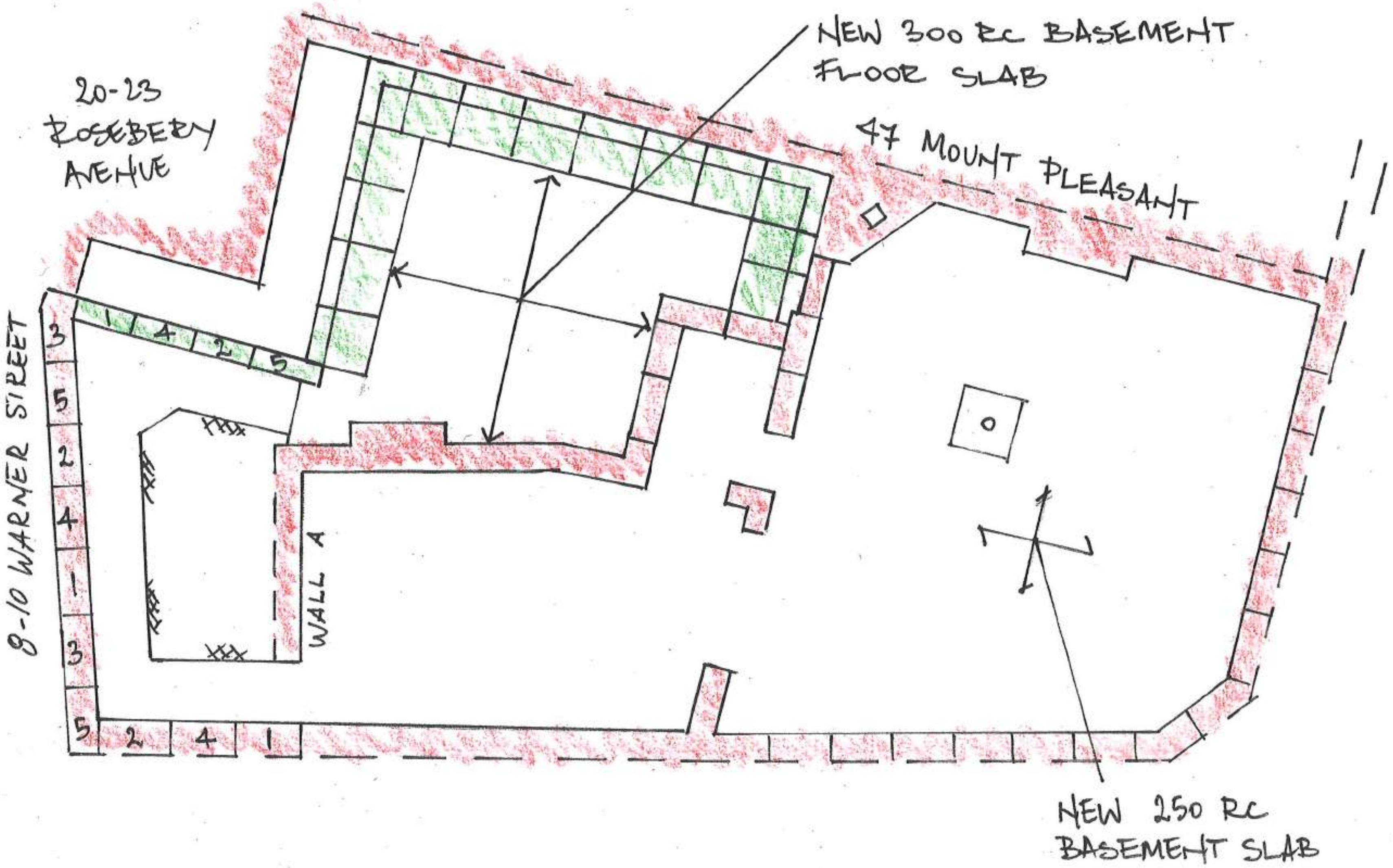


⑧ EXCAVATE DOWN TO FORMATION LEVEL AND INSTALL PROPPING SIMILAR TO UPPER LEVEL JUST ABOVE BASEMENT FLOOR SLAB

⑨ CAST REINFORCED CONCRETE BASEMENT SLAB CONNECTED TO THE BASE OF THE PINS

⑩ CAST GROUND FLOOR SUSPENDED SLAB CONNECTED TO THE TOP OF THE PINS AT ONE END AND POCKETED INTO THE EXISTING BRICK WALLS AT THE OTHER END

⑪ CAST 250 RC BASEMENT SLAB TO FRONT OF PUB LEAVING A SECTION AROUND EXISTING COLUMN BASE

⑫ STARTING FROM THE DEMOLITION OF WALL A CAREFULLY EXCAVATE THE GROUND TO ALLOW THE START OF THE UNDERPINNING ALONG WARNER STREET AND THE PARTY WALL WITH 8-10 WARNER STREET

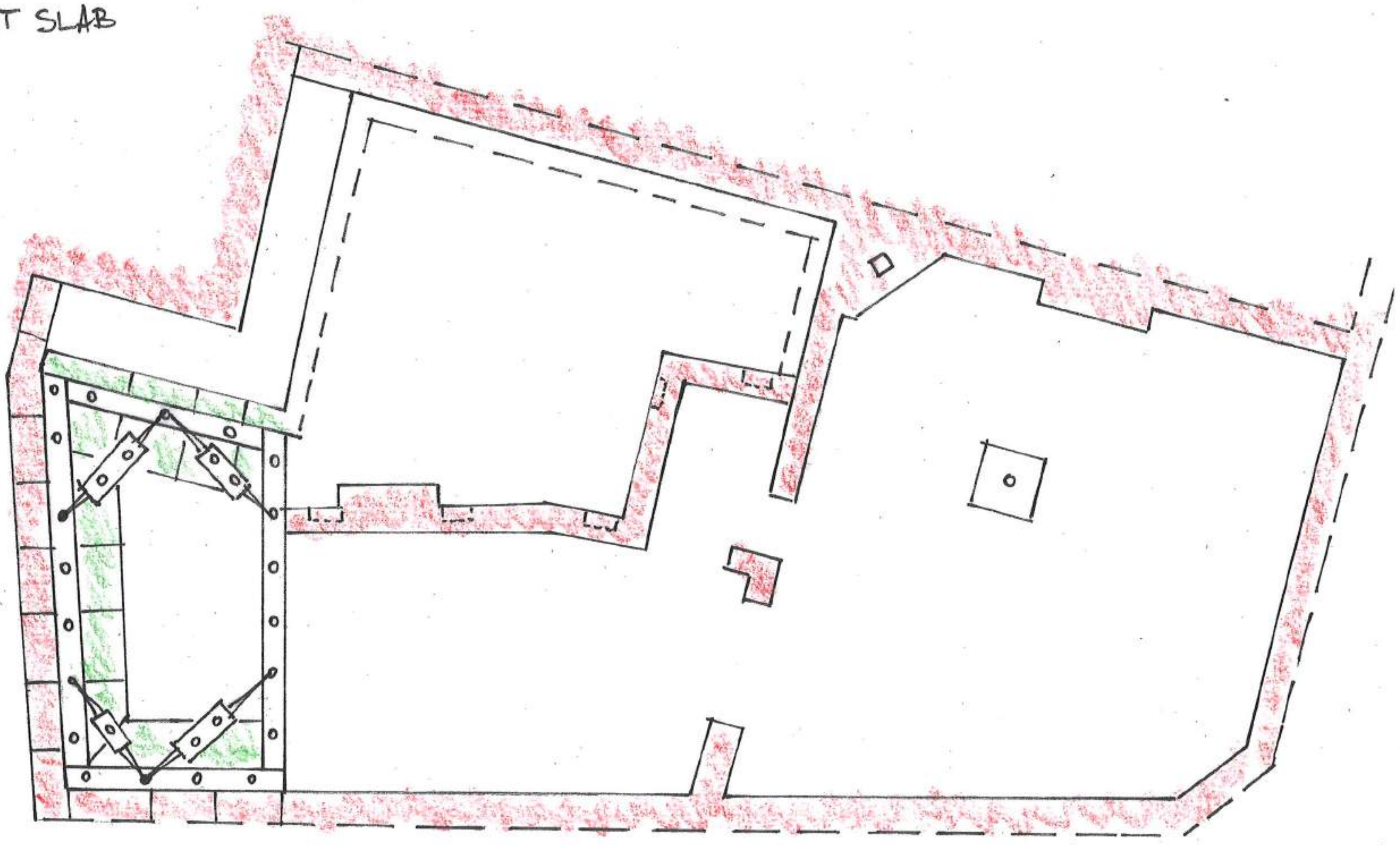
⑬ FOLLOWING A TYPICAL SEQUENCE FORM 1ST STAGE PINS OF RC RETAINING WALL AGAINST CORNER OF 20-23 ROSEBERY AVENUE. KEEP PROPS AGAINST SOIL MASS.

⑭ REDUCE LEVEL OF SOIL MASS ENOUGH TO INTRODUCE PROP GRID JUST ABOVE NEW GROUND FLOOR SLAB

⑮ FORM RC "L" LINING WALL IN SECTIONS ALONG 8-10 WARNER ST. AND FORM STAGE TWO "L" PINS AGAINST 20-23 ROSEBERY AVENUE

⑯ INTRODUCE LOWER LEVEL OF PROPS JUST ABOVE BASEMENT FLOOR SLAB. CAST BASEMENT SLAB

⑰ CAST GROUND FLOOR SLAB CONNECTED TO NEW RC PINS, THE SLAB SECTION PREVIOUSLY CAST AND POCKETED INTO EXISTING FRONT WALL ALONG WARNER ST.



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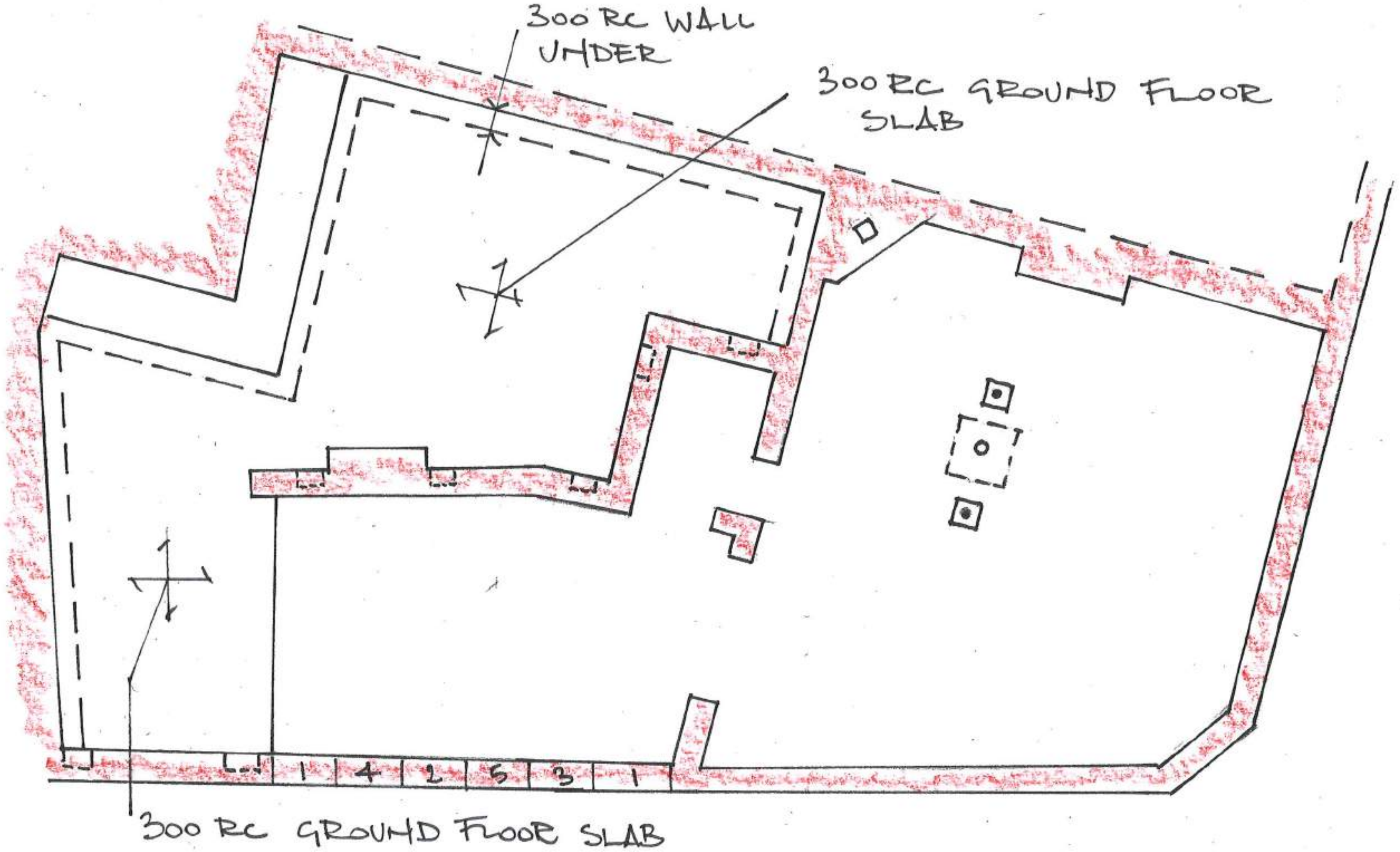

(18) FORM UNDERPINS TO REMAINING SECTION OF WARNER STREET. REDUCE GROUND AND CAST NEW 250 RC BASEMENT SLAB CONNECTED TO OTHER SECTIONS PREVIOUSLY CAST

(19) PROVIDE TEMPORARY PROPS TO ALLOW THE REMOVAL OF BASEMENT COLUMN. CAST NEW PAD. INTRODUCE NEW COLUMN. REMOVE PROPS AND CAST SLAB AROUND NEW COLUMN

(20) CONSTRUCT NEW ROOF STRUCTURE OVER GARDEN ROOM. FORM NEW STAIR OPENING AND ALTERATIONS ABOVE PRINCIPAL ROOM.

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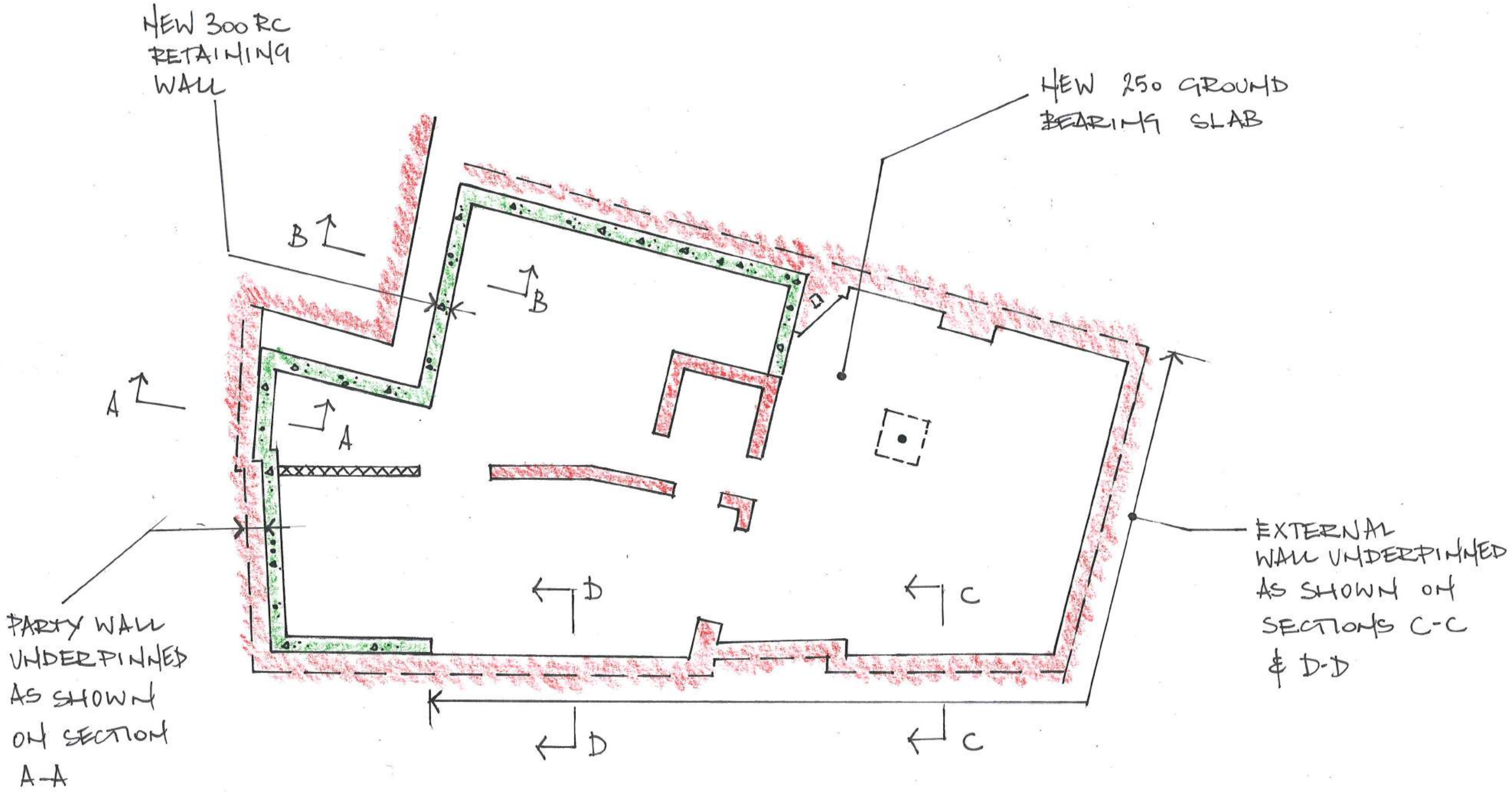

PROPOSED BASEMENT FLOOR PLAN

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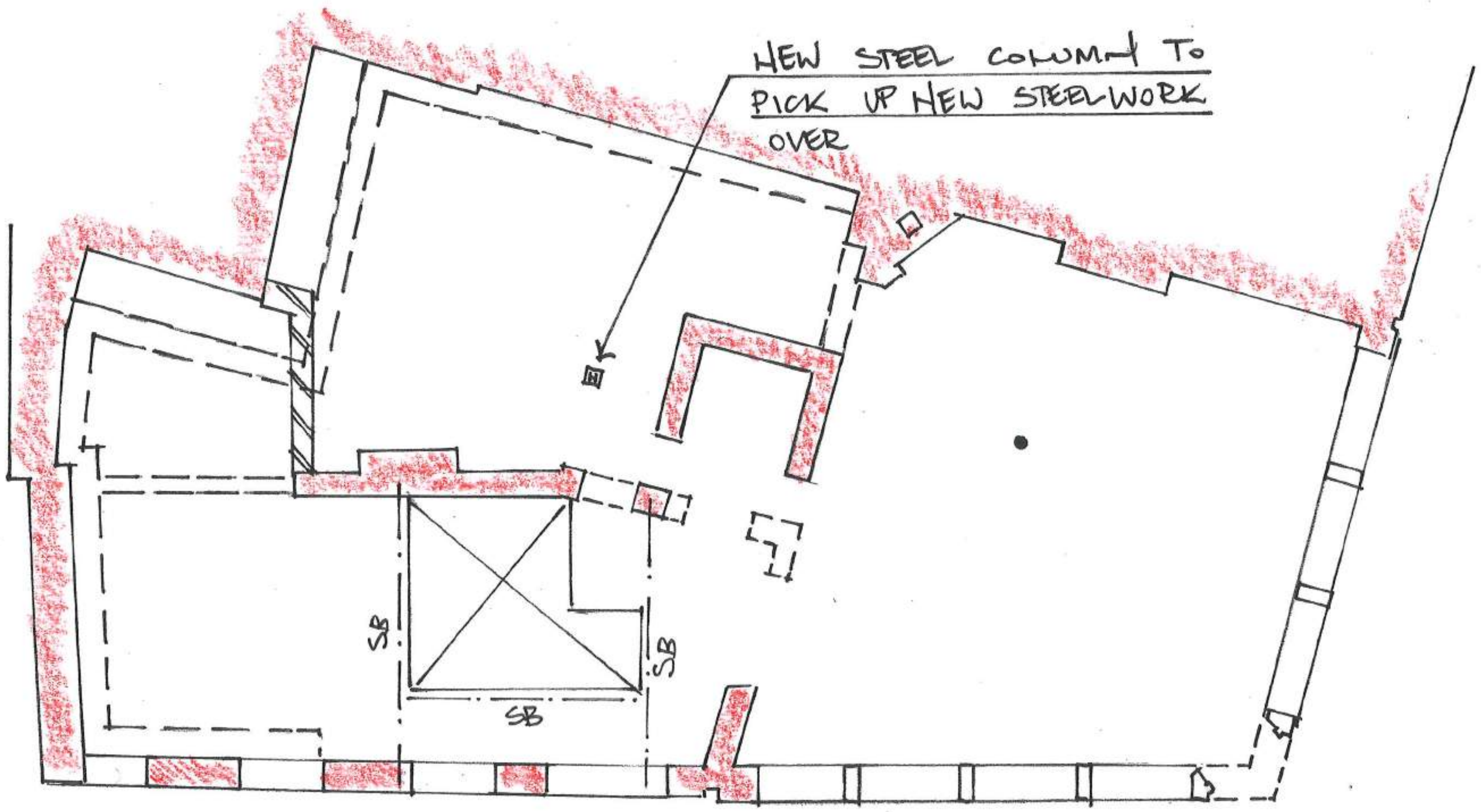

PROPOSED GROUND FLOOR PLAN

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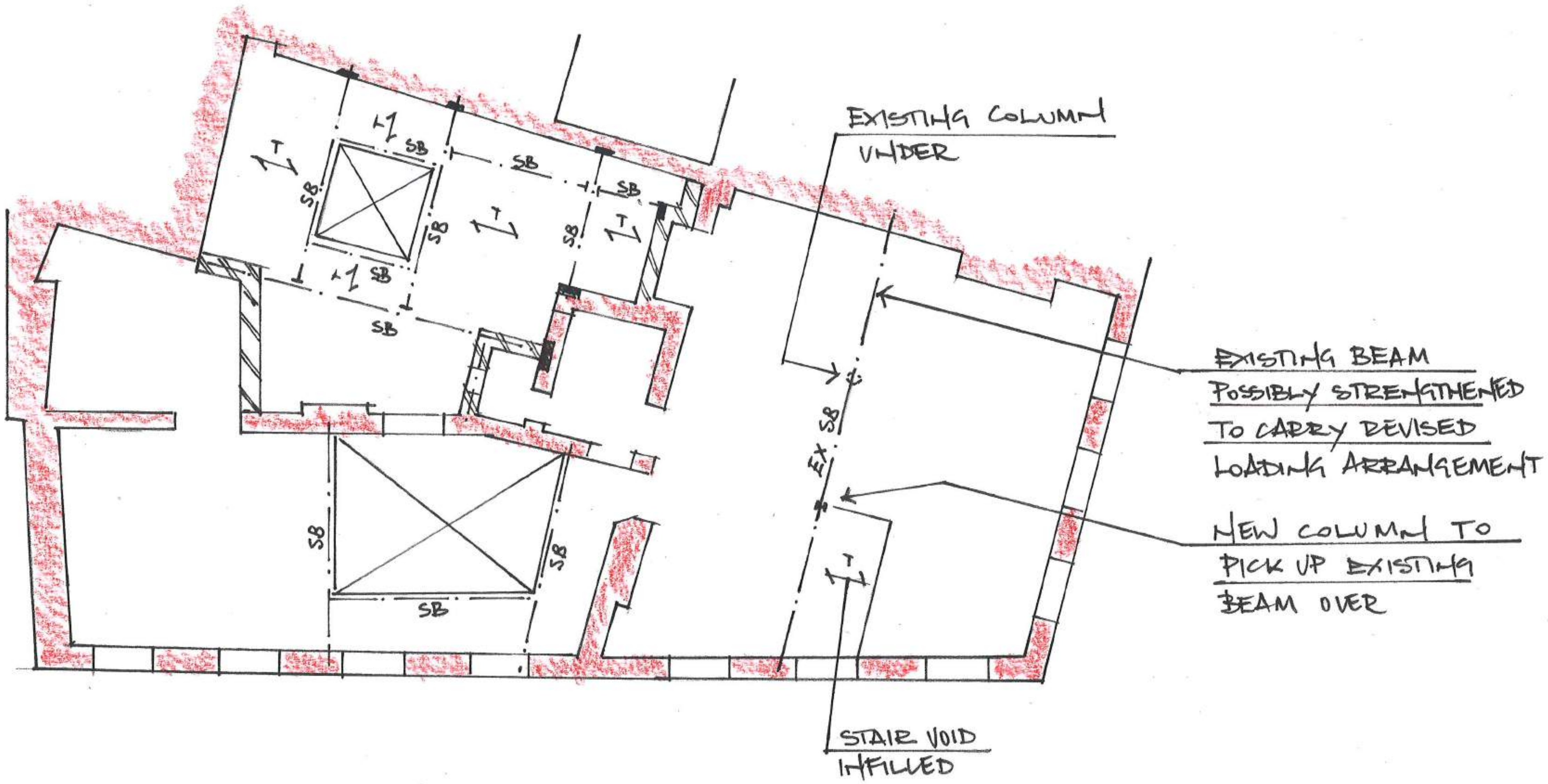

PROPOSED FIRST FLOOR PLAN

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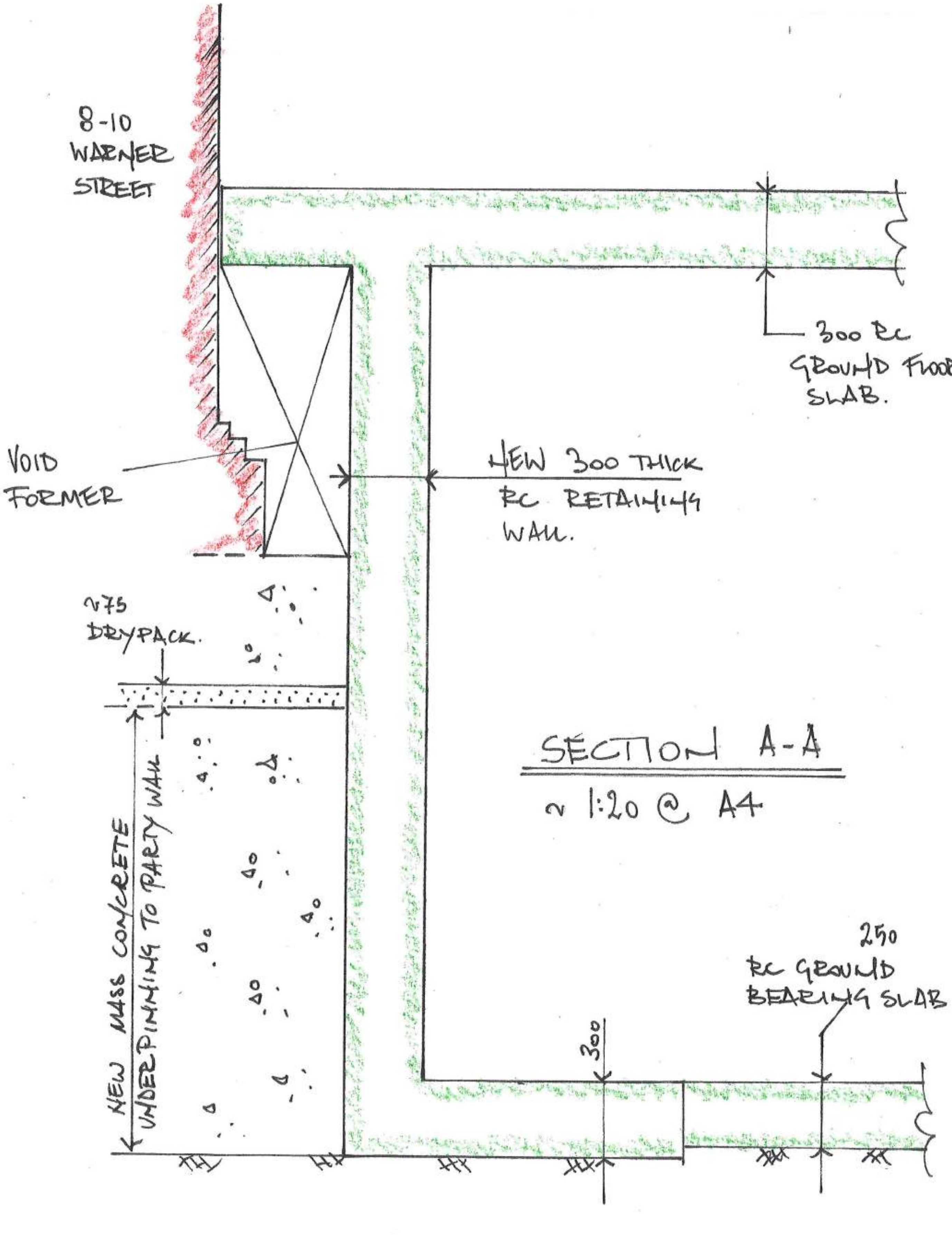

SECTION A-A
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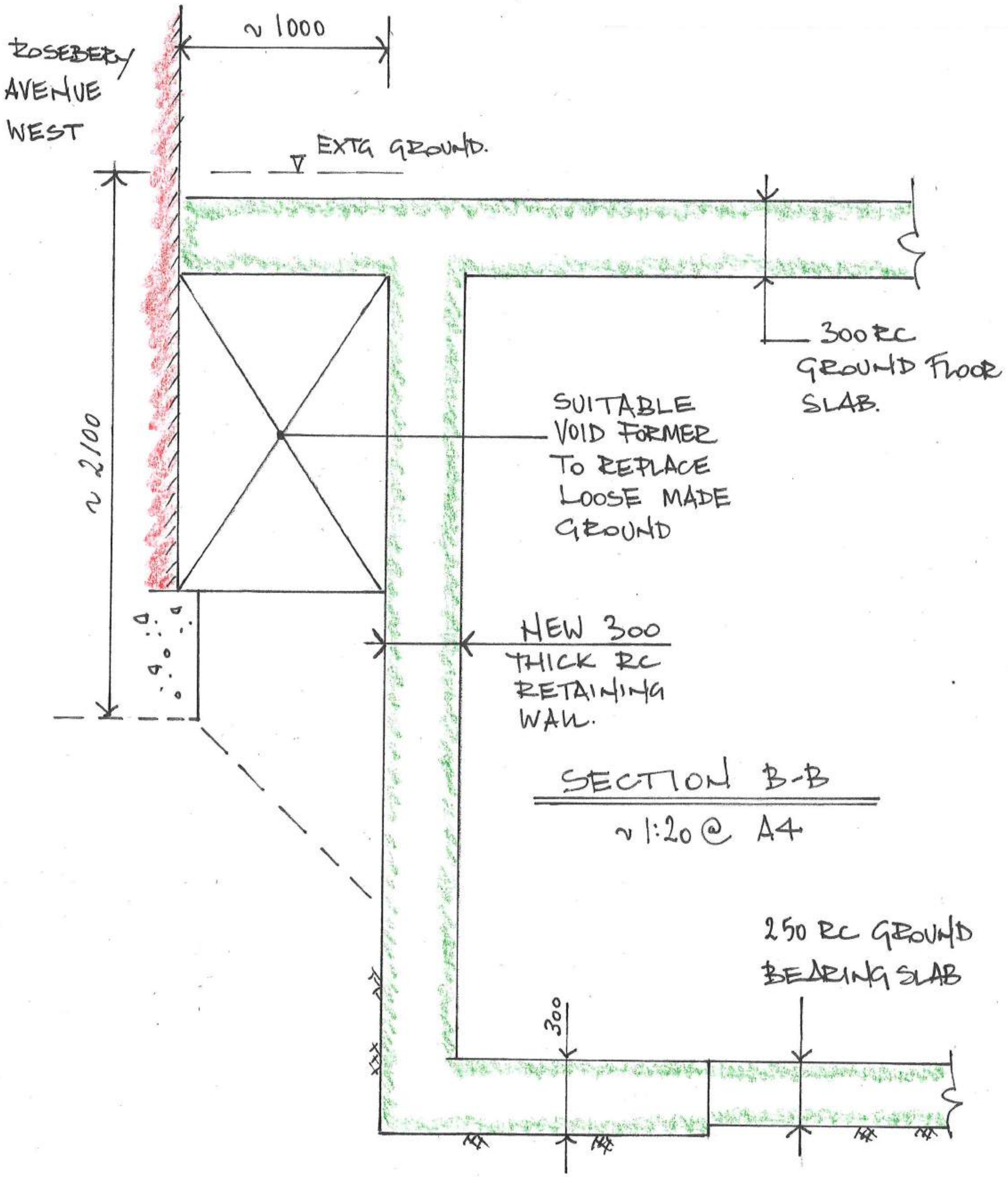

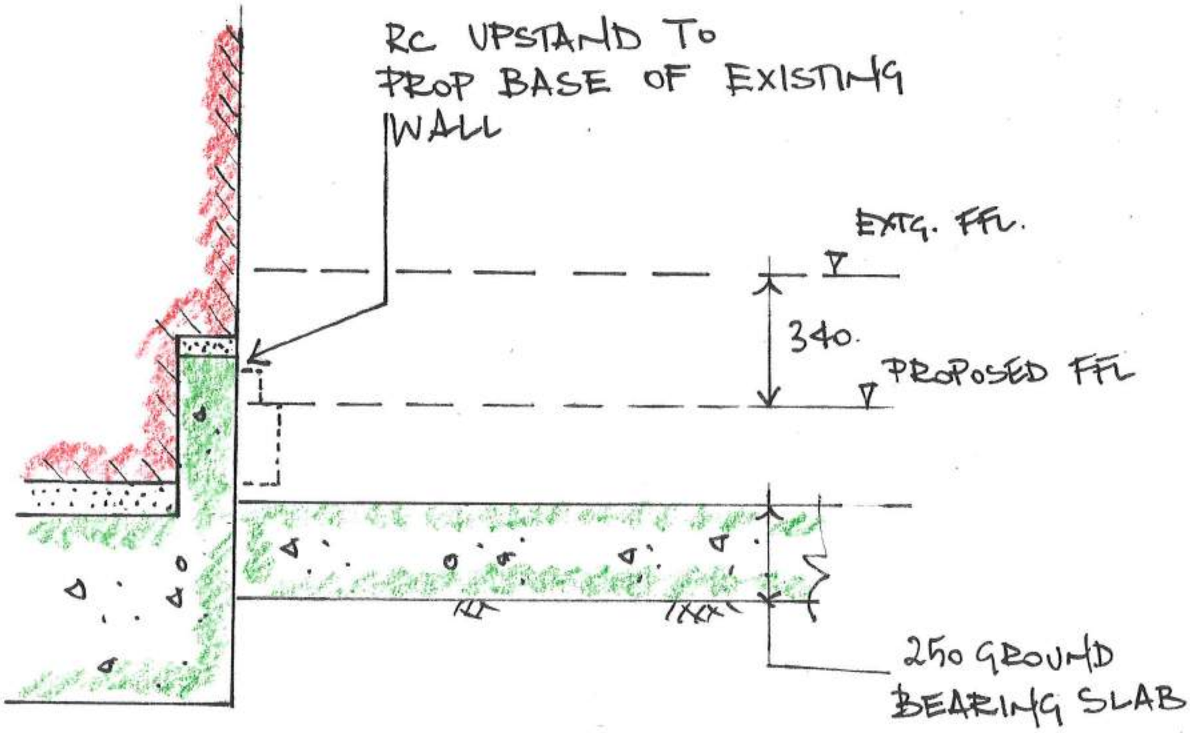

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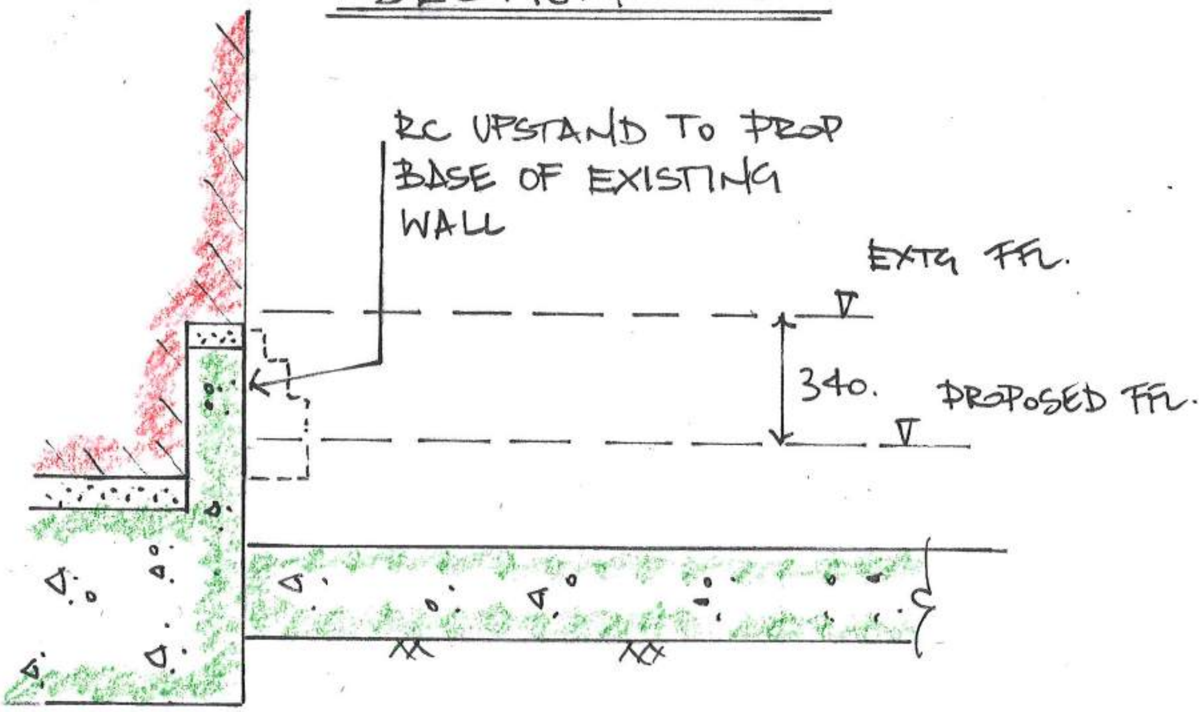

SECTION D-D

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