### NEW BASEMENT

**STRUCTURAL DESIGN AND CONSTRUCTION.**

Introduction  
Existing Structure  
Proposal  
Potential Impact upon 58 St Helens Gardens and Surrounding Properties  
Subterranean Conditions  
General Brief Method Statement for Construction of Basement  
Design Principles  
Design Criteria  
Relevant Codes of Practice and British Standards  
Preliminary Calculations  
Drawings 13M10/01.

**Prepared by**

![Signature]

T. J. Vincent BSc C.Eng M.I.Struct. E.
Introduction

This document constitutes the Construction Method Statement (CMS) under the RBKC Subterranean Development Supplementary Planning Document SPD (1).

Vincent & Rymill will act as Consulting Engineers for the proposed development and will be responsible for the design of the permanent basement and super structure works. Vincent and Rymill will also undertake periodic site supervision of the works. It is envisaged that a specialist basement contractor is appointed for the basement works, this contractor will be responsible for the design and implementation of the temporary works necessary to build the basement, Vincent and Rymill will check these designs and comment as necessary.

Existing Structure

The property is a large semi-detached residential property constructed around the turn of the 19th/20th centuries. The property comprises 3 stories.

Generally the construction is typical of similar properties in London. The main walls are masonry on spread concrete foundations formed approximately 1.00m below external ground level. The ground floors are solid and ground bearing, the upper floors and roof is timber framed.

Proposal

The proposal involves the construction of a basement below the footprint of the original existing building and below the rear extension. The formation of the basement will be approximately 3.70m below existing ground level. The layouts are shown by the relevant Greenway Architects drawings.

Potential Impact Upon 58 St Helens Gardens and Surrounding Properties

The structural design of the basement, walls and bases, the design of all necessary temporary works, and the sequencing of the construction will take into account all the geotechnical aspects recorded, and also the locality of the adjoining properties. The formation of the basement walls and bases will be made in a sequential underpinning pattern adopting construction legs no wider than 1.20m, this will avoid undue stresses being applied to the walls being underpinned.
Works will follow the ‘Brief Method Statement for construction of A Basement’ as described in this design statement. This method is generally accepted for basement construction of this type. Adoption of this method statement will limit any movement to the existing fabric of 58 St Helens Gardens and adjoining properties to practically none, or at worst, ‘aesthetic’ as described by the BRE document for movement in buildings, or category of damage 0 or 1 under the Burland Scale.

**Subterranean Conditions**

Local ground conditions are known to comprise made ground over the London Clay. The London Clay will be present for over 50.0m depth below ground level.

A site investigation was carried out by Messrs Chelmer Site Investigations on 29 March 2014, a 10.0m deep borehole was made. The finding of the borehole was 1.0m of made ground over stiff becoming very stiff clay, no ground water was encountered. The formation of the new basement will be above any water table and no de-watering to form the basement will be required.

The soils at new basement formation level will be LONDON CLAY, and from previous experience of similar basement formations in this area we have assumed a safe bearing pressure on the clay of 150KN/m$^2$, this value should ensure that differential and total settlements are very minimal.

The basement works will not affect any public services or utilities.

There are no nearby trees that will be affected by the works.

The design of the basement walls and bases and temporary works to construct will take into account the locality of adjoining structures and any loading that may be imposed by these structures. The formation of the basement walls and bases will be made in a sequential underpinning pattern adopting legs no wider than 1.2m will ensure help to avoid undue distress to the walls being underpinned.
**Structural Design Principles**

**Basement Walls**

Basement walls are designed as propped cantilevers in reinforced concrete, the basement slab acting as the prop at base level. The walls are designed using parameters relevant to the London Clay. Even though no water table was found the walls will be designed for a water table 2.00m above the base of the stem in accordance with the relevant Code Of Practice.

The surcharge load allowed on the external walls of the property will be 10KN/m$^2$ i.e within the garden areas of the property. The party wall bounding will have a surcharge load of 10.00KN/m$^2$ for adjoining floor and partition wall construction and will also take into account any loads from adjoining foundations.

**Basement Slab**

The slab will be formed in reinforced concrete. It will be designed for either uplift due to water pressure below, or as a clear span as appropriate. The basement slab will act as a prop to the base of the basement walls.

**Design Criteria.**

Basement walls and bases are designed using the program ‘TEDDS’ parameters for the retained soils and bearing soils are as chosen for each particular project. The design is in accordance with BS 8002:1994.

The design adopts the coulomb theory in calculating the active and passive earth pressures. Pressure coefficients in the design adopt ‘at rest pressures’.

The wall and base in designed for the following
1. Vertical loads from walls above.
2. Party wall will be designed for a surcharge loading of 10kN/m$^2$.
3. Other external walls, will be designed with a surcharge load of 10.00KN/m$^2$. 
4. The design adopts a water head behind the wall to ¾ the height of the wall below ground in accordance with BS 8102. (EVEN THOUGH NO WATER TABLE WAS FOUND IN THE S.I.)

An allowable increase in bearing pressure at base formation on the LONDON CLAY will be taken at 150KN/m² this will limit settlements as noted above.

Concrete will generally be grade C35/40 and Class 1 to BRE Digest 363. Reinforcement will be grade 500N/mm².

Existing brickwork assumes 10N bricks in a lime mortar, CP.111 gives basic compressive stress for this makeup of 0.70N/mm², and therefore allowable bearing stress will be 0.70N/mm². Any bearings into existing external or party wall masonry will take account of this allowable stress.

Mortar will be class (ii) or (iii) as required.

**Relevant Codes of Practice and British Standards**

- B.S. 8004  Code of Practice For Foundations
- B.S. 6031  Code of Practice For Earthworks
- B.S. 8110  Structural Use of Concrete
- B.S. 5750  Structural Use of Steelwork in Buildings

**General Brief Method Statement For Construction of the Basement**

The exact sequence of works will be agreed with Main Contractor and Structural Engineer, a Contraction Method Statement for the works could be as follows.

a) The walls to the perimeter of the new basement will be underpinned in reinforced concrete. The underpins will take the vertical loads from the walls and horizontal loads from the earth. During their construction the walls and bases will require laterally propping in the temporary condition propping will be made against the central earth pudding.

b) Underpinning legs will be excavated in short sections not exceeding 1200mm in width.

c) The sequence of the underpinning will be in the 1, 4, 2, 5, 3 sequence and such that any given underpin will be completed, dry packed, and a minimum period of 48 hours lapsed before an adjacent excavation commenced to form another underpin.
d) In the event that the existing foundations to the wall are found to be unstable, sacrificial steel jacks will be installed underneath the foundation to prop the bottom few courses of bricks. These steel jacks will be left in place and will be incorporated into the concrete stem.

e) Whilst forming the wall and in the event that the vertical soil face is unstable, lateral propping will be provided as required to the excavation and to the sides of the working trench. The front and side faces of the excavation will be propped using a sacrificial inert board and acrow props as appropriate.

f) The wall and base may be formed in two separate drives. The first drive being the formation of a 1.50m portion of wall, these formed a maximum of 1200mm wide in a 1, 3, 5, 2, 4, sequence. The subsequent second drive forming the remainder of the wall and the base will be formed in the same sequence but lapping the 1st drive by at least 50% of the drive over.

g) Concrete will be chuted from the front into a ‘holding bath’ within the excavated basement and placed by wheelbarrow and/or bucket, or mixed on site. The exact arrangement will be finalised when works commence on site.

h) Excavation for an underpin section will be excavated in a day, and the concrete to the base poured by the end of the same day.

i) The concrete to the stem (or first drive) of the underpin will be poured the following day. This will be poured up to within 50 – 75mm of the underside of the existing wall foundations.

j) On the following day, the gap between the concrete and the underside of the existing foundation will be dry packed with a mixture of sharp sand and cement (ratio 3 : 1).

k) Once the dry pack has gained sufficient strength, any protrusions of the footings into the site will be carefully trimmed back using hand tools to avoid causing any damage to the foundation. The protrusions will be trimmed back to be flush in-line with the face of the wall above.

l) A minimum of 24 hours will be allowed before adjacent sections will be excavated to form a new underpin.

m) Once all pins are complete a temporary cross propping system will be introduced between the walls to allow bulk excavation will be carried out down to formation level.

n) The below – slab drainage for foul & ground water, sumps and pumps will then be installed. The pumps will discharge the foul / ground water into the sewer system to the front of the properties. The drainage layout will be designed in due course.

o) The basement slab will then be constructed, once cured this will provided the designed propping to the walls and the temporary cross propping can be removed.

p) A cavity drainage layer will be laid to the slabs and walls.

q) An arrangement of beams will be inserted at existing ground floor level to support the new ground floor over the constructed basement, either timber suspended or precast concrete beam and block.
Construction Sequence (Assuming NO occupancy of the property during the works)

1. The site is only accessible from St Helens Gardens, and therefore all site deliveries and operations will take place from here. This entrance will be manned throughout operational hours by a banksman to ensure construction deliveries do not pose a risk to other users of St Helens Gardens.

2. Construct site hoarding, entrance gates to provide protection to passers-by from site operations. Site accommodation including welfare facilities will be confined to the main building throughout the site works.

3. Terminate / protect any incoming services temporarily divert any active drainage.

4. Install any tree protection measures as necessary.

5. Carry out soft strip to ground floor areas.

6. Excavate for pins that will form supports for new ground floor beams, form these pins. Provide temporary support works to walls at ground floor and insert new steel beams to support these walls on initially formed pins.

7. The basement area to the front of the property will be constructed first to give conveyor plant access to the remainder of the works. The basement under the front drive will be constructed by initially forming a reinforced concrete wall / beam wall to the basement perimeter. Excavation will be made, to form the walls, to approximately 1.0 to 1.5 m depth, the wall will be cast in dimensioned formwork, and reinforcement will be driven down to form continuity with the section below that will be cast later. Once cured this wall will then be underpinned in the usual 1,4,2,5,3 sequence to form the remainder of the wall and its base. The base slab will then be cast to provide the lateral prop to the cantilever wall. Some temporary lateral propping of the walls will be required close to the top of the wall, the arrangement of this to suit the access and working of the front area.

8. Reduce internal ground levels to 100mm above existing foundation formation level.

9. Underpins will be carried out in the usual 1, 4, 2, 5, 3 underpinning sequence, the construction sequence for forming the pin will be agreed prior to commencement of the works. To provide temporary lateral support to the wall formed it will remain propped against the internal soil ‘dumping.’

10. On completion of all underpinning and fixing of the structural steelwork supporting the lower ground floor, cross propping of the pin walls will be erected to allow bulk excavation. The propping will be designed to suit the lateral loads behind the walls but generally takes the form of a series of horizontal slimlite props adequately laced and braced set approximately 1.5m from lower ground floor level.

11. Bulk excavation will be carried out down to basement slab formation level. Muck will continue to be removed from site via the conveyor belt.

12. The below – slab drainage for foul & ground water, sumps and pumps will then be installed. The pumps will discharge the foul / ground water into the sewer system to the front of the properties. The drainage layout will be designed in due course.

13. The basement slab (ground – bearing slab) will then be constructed.

14. The roof slab to the front portion will be cast.

15. After the new basement slabs have cured, the cross propping will be removed.

16. A drained – cavity layer will be laid to the slabs and walls.
17. Provide waterproofing to roof slab over front external areas.
1. PARTY WALL & FLANK WALL - RETAINING WALL AND BASE DESIGN

WALL LOAD
TAKE DEAD LOAD OF WALL ONLY AS THIS WILL GIVE LOWEST LOAD CASE AND LEAST RESTORING MOMENT TO WALL

WALL UDL = (3.5 X 6.8) + (8 X 4.6) = 60.6 kN/m

RETAINING WALL ANALYSIS & DESIGN (BS8002)

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Wall details
Retaining wall type: Cantilever
Height of wall stem $h_{stem} = 3100$ mm
Length of toe $l_{toe} = 1400$ mm
Overall length of base $l_{base} = 1900$ mm
Height of retaining wall $h_{wall} = 3450$ mm
Depth of downstand $d_{ds} = 0$ mm
Position of downstand $l_{ds} = 1325$ mm
Depth of cover in front of wall $d_{cover} = 0$ mm
Height of ground water $h_{water} = 2250$ mm
Density of wall construction $\gamma_{wall} = 23.6$ kN/m$^3$
Angle of soil surface $\beta = 0.0$ deg
Mobilisation factor $M = 1.5$

Wall stem thickness $t_{wall} = 350$ mm
Length of heel $l_{heel} = 150$ mm
Base thickness $t_{base} = 350$ mm
Thickness of downstand $t_{ds} = 350$ mm
Unplanned excavation depth $d_{exc} = 200$ mm
Density of water $\gamma_{water} = 9.81$ kN/m$^3$
Density of base construction $\gamma_{base} = 23.6$ kN/m$^3$
Effective height at back of wall $h_{eff} = 3450$ mm
Moist density \( \gamma_m = 21.0 \text{kN/m}^3 \) Saturated density \( \gamma_s = 23.0 \text{kN/m}^3 \)

Design shear strength \( \phi' = 24.2 \text{deg} \) Angle of wall friction \( \delta = 18.6 \text{deg} \)

Design shear strength \( \phi_b = 24.2 \text{deg} \) Design base friction \( \delta_b = 18.6 \text{deg} \)

Moist density \( \gamma_{mb} = 18.0 \text{kN/m}^3 \) Allowable bearing \( P_{bearing} = 150 \text{kN/m}^2 \)

Using Coulomb theory

Active pressure \( K_a = 0.369 \) Passive pressure \( K_b = 4.187 \)

At-rest pressure \( K_0 = 0.590 \)

Loading details

Surcharge load \( W_{dead} = 60.6 \text{kN/m} \) Vertical dead load \( W_{live} = 0.0 \text{kN/m} \)

Horizontal dead load \( F_{dead} = 0.0 \text{kN/m} \) Horizontal live load \( F_{live} = 0.0 \text{kN/m} \)

Position of vertical load \( l_{load} = 1575 \text{mm} \) Height of horizontal load \( h_{load} = 0 \text{mm} \)

Calculated propping force

Propping force \( F_{prop} = 35.1 \text{kN/m} \)

Check bearing pressure

Total vertical reaction \( R = 113.7 \text{kN/m} \) Distance to reaction \( x_{bar} = 771 \text{mm} \)

Eccentricity of reaction \( e = 179 \text{mm} \)

Bearing pressure at toe \( p_{toe} = 93.6 \text{kN/m}^2 \) Bearing pressure at heel \( p_{heel} = 26.1 \text{kN/m}^2 \)

Reaction acts within middle third of base

PASS - Maximum bearing pressure is less than allowable bearing pressure
Ultimate limit state load factors
Dead load factor $\gamma_f = 1.4$  
Live load factor $\gamma_f = 1.6$
Earth pressure factor $\gamma_p = 1.4$

Calculate propping force
Propping force $F_{prop} = 35.1$ kN/m

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

Material properties
Strength of concrete $f_{cu} = 40$ N/mm$^2$  
Strength of reinforcement $f_y = 500$ N/mm$^2$

Base details
Minimum reinforcement $k = 0.13$ %  
Cover in toe $c_{toe} = 50$ mm

Design of retaining wall toe
Shear at heel $V_{toe} = 143.3$ kN/m  
Moment at heel $M_{toe} = 183.9$ kNm/m
Compression reinforcement is not required

Check toe in bending
Reinforcement provided 16 mm dia. bars @ 125 mm centres
Area required $A_{s\_toe\_req} = 1546.9$ mm$^2$/m  
Area provided $A_{s\_toe\_prov} = 1608$ mm$^2$/m
PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe
Design shear stress $v_{toe} = 0.491$ N/mm$^2$  
Allowable shear stress $v_{adm} = 5.000$ N/mm$^2$
PASS - Design shear stress is less than maximum shear stress
$V_{toe} < v_{toe}$ - No shear reinforcement required

Concrete shear stress $v_{c\_toe} = 0.706$ N/mm$^2$

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

Material properties
Strength of concrete $f_{cu} = 40$ N/mm$^2$  
Strength of reinforcement $f_y = 500$ N/mm$^2$

Base details
Minimum reinforcement $k = 0.13$ %  
Cover in heel $c_{heel} = 50$ mm

Design of retaining wall heel
Shear at heel $V_{heel} = 18.6$ kN/m  
Moment at heel $M_{heel} = 4.8$ kNm/m
Compression reinforcement is not required

Check heel in bending
Reinforcement provided B785 mesh
Area required $A_{s\_heel\_req} = 455.0$ mm$^2$/m  
Area provided $A_{s\_heel\_prov} = 785$ mm$^2$/m
PASS - Reinforcement provided at the retaining wall heel is adequate

Check shear resistance at heel
Design shear stress $V_{heel} = 0.063$ N/mm$^2$  
Allowable shear stress $v_{adm} = 5.000$ N/mm$^2$
PASS - Design shear stress is less than maximum shear stress
$V_{heel} < v_{heel}$ - No shear reinforcement required

Concrete shear stress $v_{c\_heel} = 0.513$ N/mm$^2$
Design of reinforced concrete retaining wall stem (BS 8002:1994)

Material properties

Strength of concrete \( f_{cu} = 40 \text{ N/mm}^2 \)  
Strength of reinforcement \( f_y = 500 \text{ N/mm}^2 \)

Wall details

Minimum reinforcement \( k = 0.13 \% \)  
Cover in stem \( c_{stem} = 50 \text{ mm} \)  
Cover in wall \( c_{wall} = 50 \text{ mm} \)

Design of retaining wall stem

Shear at base of stem \( V_{stem} = 25.5 \text{ kN/m} \)  
Moment at base of stem \( M_{stem} = 147.1 \text{ kNm/m} \)

Compression reinforcement is not required

Check wall stem in bending

Reinforcement provided \( 16 \text{ mm dia. bars @ 150 mm centres} \)  
Area required \( A_{s, stem, req} = 1219.9 \text{ mm}^2/\text{m} \)  
Area provided \( A_{s, stem, prov} = 1340 \text{ mm}^2/\text{m} \)

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem

Design shear stress \( V_{stem} = 0.087 \text{ N/mm}^2 \)  
Allowable shear stress \( V_{adm} = 5.000 \text{ N/mm}^2 \)

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress \( V_{c, stem} = 0.706 \text{ N/mm}^2 \)

\( V_{stem} < V_{c, stem} - \text{No shear reinforcement required} \)
Indicative retaining wall reinforcement diagram

Toe bars - 16 mm dia.@ 125 mm centres - (1608 mm²/m)
Heel mesh - B785 - (785 mm²/m)
Stem bars - 16 mm dia.@ 150 mm centres - (1340 mm²/m)
2. REAR WALL – WALL AND BASE DESIGN

WALL UDL = 4 x 3.3 = 13.2 kN/m

RETAINING WALL ANALYSIS & DESIGN (BS8002)

RETAINING WALL ANALYSIS (BS 8002:1994)

TEDDS calculation version 1.2.01.06

Wall details
Retaining wall type Cantilever
Height of wall stem $h_{stem} = 2000$ mm Wall stem thickness $t_{wall} = 350$ mm
Length of toe $l_{base} = 1600$ mm Length of heel $t_{heel} = 150$ mm
Overall length of base $l_{base} = 2100$ mm Base thickness $t_{base} = 325$ mm
Height of retaining wall $h_{wall} = 2325$ mm
Depth of downstand $d_{ds} = 0$ mm Thickness of downstand $t_{ds} = 325$ mm
Position of downstand $l_{ds} = 1225$ mm
Depth of cover in front of wall $d_{cover} = 0$ mm Unplanned excavation depth $d_{exc} = 200$ mm
Height of ground water $h_{water} = 1500$ mm Density of water $\gamma_{water} = 9.81$ kN/m$^3$
Density of wall construction $\gamma_{wall} = 23.6$ kN/m$^3$ Density of base construction $\gamma_{base} = 23.6$ kN/m$^3$
Angle of soil surface $\beta = 0.0$ deg Effective height at back of wall $h_{eff} = 2325$ mm
Mobilisation factor $M = 1.5$
Moist density $\gamma_m = 21.0$ kN/m$^3$ Saturated density $\gamma_s = 23.0$ kN/m$^3$
Design shear strength $\phi = 24.2$ deg Angle of wall friction $\delta = 18.6$ deg
Design shear strength $\phi_b = 24.2$ deg Design base friction $\delta_b = 18.6$ deg
Moist density $\gamma_{mb} = 18.0$ kN/m$^3$ Allowable bearing $P_{bearing} = 150$ kN/m$^2$

Using Coulomb theory
Active pressure $K_a = 0.369$ Passive pressure $K_p = 4.187$
At-rest pressure \( K_0 = 0.590 \)

**Loading details**
- **Surcharge load**
  - Surcharge \( = 10.0 \text{ kN/m}^2 \)
- **Vertical dead load**
  - \( W_{\text{dead}} = 13.2 \text{ kN/m} \)
- **Horizontal dead load**
  - \( F_{\text{dead}} = 0.0 \text{ kN/m} \)
- **Position of vertical load**
  - \( l_{\text{load}} = 1775 \text{ mm} \)

**Calculate propping force**
- **Propping force**
  - \( F_{\text{prop}} = 17.7 \text{ kN/m} \)

**Check bearing pressure**
- **Total vertical reaction**
  - \( R = 54.0 \text{ kN/m} \)
- **Eccentricity of reaction**
  - \( e = 12 \text{ mm} \)
- **Bearing pressure at toe**
  - \( p_{\text{toe}} = 24.8 \text{ kN/m}^2 \)
- **Bearing pressure at heel**
  - \( p_{\text{heel}} = 26.6 \text{ kN/m}^2 \)

**Reaction acts within middle third of base**

**PASS - Maximum bearing pressure is less than allowable bearing pressure**
RETAINING WALL DESIGN (BS 8002:1994)

Ultimate limit state load factors
Dead load factor  $\gamma_d = 1.4$
Live load factor  $\gamma_i = 1.6$
Earth pressure factor  $\gamma_e = 1.4$

Calculate propping force
Propping force  $F_{prop} = 17.7 \text{kN/m}$

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

Material properties
Strength of concrete  $f_{cu} = 40 \text{ N/mm}^2$
Strength of reinforcement  $f_y = 500 \text{ N/mm}^2$

Base details
Minimum reinforcement  $k = 0.13 \%$
Cover in toe  $c_{toe} = 30 \text{ mm}$

Design of retaining wall toe
Shear at heel  $V_{toe} = 53.3 \text{kN/m}$
Moment at heel  $M_{toe} = 62.8 \text{kNm/m}$

Compression reinforcement is not required

Check toe in bending
Reinforcement provided  16 mm dia.bars @ 100 mm centres
Area required  $A_{s,toe,req} = 529.5 \text{ mm}^2/\text{m}$
Area provided  $A_{s,toe,prov} = 2011 \text{ mm}^2/\text{m}$

PASS - Reinforcement provided at the retaining wall toe is adequate

Check shear resistance at toe
Design shear stress  $v_{toe} = 0.186 \text{ N/mm}^2$
Allowable shear stress  $v_{adm} = 5.000 \text{ N/mm}^2$

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress  $v_{c,toe} = 0.713 \text{ N/mm}^2$

PASS - Reinforcement provided at the retaining wall toe is adequate

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

Material properties
Strength of concrete  $f_{cu} = 40 \text{ N/mm}^2$
Strength of reinforcement  $f_y = 500 \text{ N/mm}^2$

Base details
Minimum reinforcement  $k = 0.13 \%$
Cover in heel  $c_{heel} = 30 \text{ mm}$

Design of retaining wall heel
Shear at heel  $V_{heel} = 12.5 \text{kN/m}$
Moment at heel  $M_{heel} = 3.2 \text{kNm/m}$

Compression reinforcement is not required

Check heel in bending
Reinforcement provided  B785 mesh
Area required  $A_{s,heel,req} = 422.5 \text{ mm}^2/\text{m}$
Area provided  $A_{s,heel,prov} = 785 \text{ mm}^2/\text{m}$

PASS - Reinforcement provided at the retaining wall heel is adequate

Check shear resistance at heel
Design shear stress  $v_{heel} = 0.043 \text{ N/mm}^2$
Allowable shear stress  $v_{adm} = 5.000 \text{ N/mm}^2$

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress  $v_{c,heel} = 0.518 \text{ N/mm}^2$

PASS - Reinforcement provided at the retaining wall heel is adequate

Tedds calculation version 1.2.01.06
Design of reinforced concrete retaining wall stem (BS 8002:1994)

Material properties
Strength of concrete $f_{cu} = 40$ N/mm$^2$  
Strength of reinforcement $f_y = 500$ N/mm$^2$

Wall details
Minimum reinforcement $k = 0.13\%$
Cover in stem $c_{stem} = 30$ mm  
Cover in wall $c_{wall} = 30$ mm

Design of retaining wall stem
Shear at base of stem $V_{stem} = 7.1$ kN/m  
Moment at base of stem $M_{stem} = 48.0$ kNm/m

Compression reinforcement is not required

Check wall stem in bending
Reinforcement provided 16 mm dia. bars @ 100 mm centres
Area required $A_{s, stem req} = 455.0$ mm$^2$/m  
Area provided $A_{s, stem prov} = 2011$ mm$^2$/m

PASS - Reinforcement provided at the retaining wall stem is adequate

Check shear resistance at wall stem
Design shear stress $V_{stem} = 0.023$ N/mm$^2$  
Allowable shear stress $V_{adm} = 5.000$ N/mm$^2$

PASS - Design shear stress is less than maximum shear stress

Concrete shear stress $V_{c, stem} = 0.679$ N/mm$^2$

$V_{stem} < V_{c, stem}$ - No shear reinforcement required

Check retaining wall deflection
Max span/depth ratio $\text{ratio}_{\text{max}} = 14.00$  
Actual span/depth ratio $\text{ratio}_{\text{act}} = 6.41$

PASS - Span to depth ratio is acceptable
### Indicative retaining wall reinforcement diagram

- **Toe bars** - 16 mm dia. @ 100 mm centres - (2011 mm²/m)
- **Heel mesh** - B785 - (785 mm²/m)
- **Stem bars** - 16 mm dia. @ 100 mm centres - (2011 mm²/m)