# CMS SUPPLEMENTARY CALCULATIONS

4 Langland Gardens, NW3 6PY

Project Number: 2385

**Revision A**

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BLUE ENGINEERING

## INTRODUCTION:

This document is to be read in conjunction with all other documents forming the Construction Method Statement and all documents produced as part of the planning application.

## REFERENCES:

BS EN 1997-2 - 2007 - Ground investigation and testing
BS EN 1991-1-1 - 2002 - Densities, self-weight, imposed loads for buildings
BS EN 1991-1-4 - 2005 - Wind actions
BS EN 1992-1-1-2004 - General rules and rules for building
BS EN 1993-1-1 - 2005 - General rules and rules for buildings
BS EN 1997-1 - 2004 - General rules
BS EN 1997-2 - 2007 - Ground investigation and testing
BS EN 1997-2 - 2007 - Ground investigation and testing

## GROUND PRESSURE CALCULATIONS:

Ground investigations were carried out at the property which indicated that below the top substrate of made ground the strata is firm London Clay. Typical internal angle of shearing resistance for the strata is between 18-24°. For the purpose of these calculations the conservative value of 20° has been taken.

**Active Pressure:**

$K_a$ = 1-sin Φ/1+sin Φ: 1-sin20/1+sin20 = 0.49

**Passive pressure:**

$K_p = 1/K_a$ = 2.0

### Ground Pressures Acting on New Reinforced Concrete Wall:

From trial holes, ground is not cohesive

Φ = 20° $K_a$ = 0.49 $K_p$ = 2.0 c = 0 kN/m² Surcharge = 10.0 kN/m³

γ = 20 kN/m³ γ′ = 10 kN/m³ $\gamma_w$ = 10 kN/m³

The above values are estimated and are considered conservative. Water level has been taken at ground level

### Pressure at 0.0m depth:

Surcharge: 10*0.49 = 4.9 kN/m²

### Pressure at 4.0m depth:

| | |
|---|---|
| Surcharge: 10*0.49 | = 4.90 kN/m² |
| Active pressure Ground (Water Level below basement level): 20*0.49*4 | = 39.2 kN/m² |
| Active pressure Ground (below water): 10*0.49*4 | = 19.6 kN/m² |
| Passive pressure Ground (Water Level below basement level): 20*2*4 | = 160 kN/m² |
| Passive pressure Ground (below water): 10*2*4 | = 80.0 kN/m² |
| Water pressure: 10*4 | = 40.0 kN/m² |

## PERMANENT GLOBAL ANALYSIS

### Applied Sliding Force:

| | |
|---|---|
| Load from surcharge: 4.9 kN/m *4m | = 19.6 kN |
| Load from Ground (below water): 0.5*19.6 kN/m*4 | = 39.2 kN |
| Water: 0.5*40 kN/m*4 | = 80 kN |
| **Total Force Unfactored** | **= 138.8 kN** |

**Retaining Wall Checks:**

The calculations below check the global stability of 1 metre length of the retaining wall. This will include both the global stability against sliding and overturning.

The basement structure will be designed to be sufficiently stiff as to enable any lateral forces to be transferred from one side to the other where passive pressure will be mobilised to prevent any movement. The force on each side of the basement will be equal and opposite. Therefore the basement is in equilibrium and sliding cannot occur.

**Sliding Equilibrium Check:**

Reinforcement in retaining structure to be sized accordingly to allow mobilisation of ground on opposite side of property.

**Sliding force to be resisted** = 138.8*1.5 = 208.2 kN

**Resistance to sliding due to passive pressure**: 20 kN/m$^3$ *3.5m *2*3.5m*0.5*0.9 = 221 kN (factor of safety of 0.9)

*First 500mm of ground has not been considered to allow for the potential for the ground level to be reduced.*

**Uplift Check:**

There will be an upwards vertical force acting on the property due the ground water being displaced by the proposed basement construction.

Water displaced by basement construction:

4.0m *(deep)**278m$^2$ *(area)**10.0 kN/m$^3$

| | |
|---|---|
| Total uplift force | = 11120 kN |
| Total factored uplift force (*1.1) | = **12540 kN** |

**Permanent loading resisting uplift:**

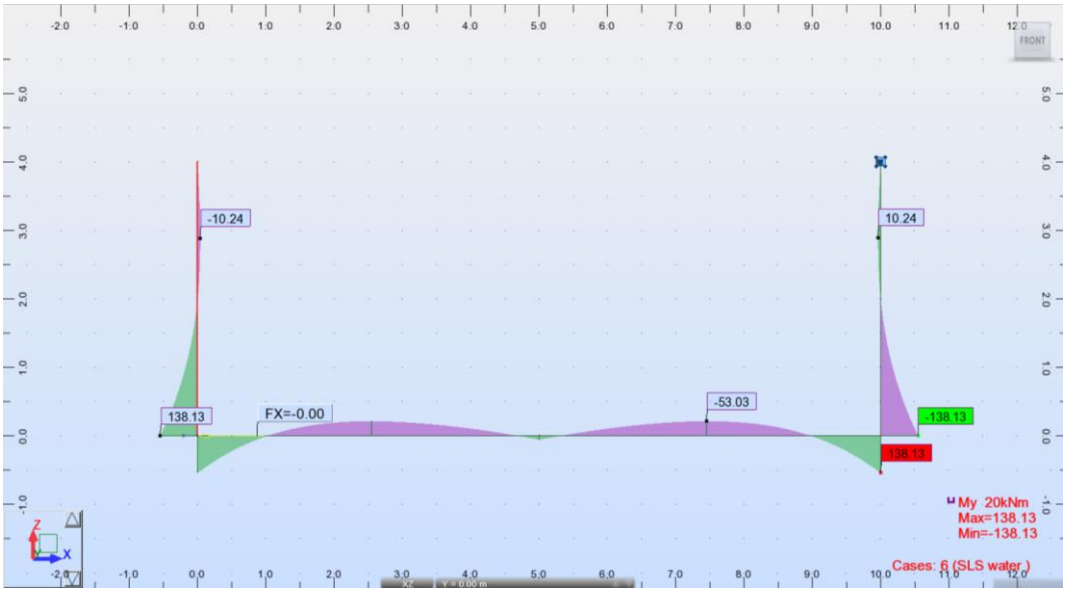
| | |
|---|---|
| Reinforced concrete slab @ 25.0 kN/m$^3$ @ 300mm thick @ 289.3m$^2$ total area | = 2170 kN |
| Reinforced concrete walls @ 25.0 kN/m$^3$ @ 3.7m height @ 26.6m$^2$ total area | = 2461 kN |
| Ground & first floor @ 0.75 kN/m$^2$ @ 195m$^2$ total area | = 292.5 kN |
| Second floor @ 0.75 kN/m$^2$ @ 146m$^2$ total area | = 109.5 kN |
| Roof Construction @ 1.0 kN/m$^2$@ 146m$^2$ total area | = 146 kN |
| External masonry wall construction @ 19.0 kN/m$^3$ | = 2078.3 kN |
| New cavity wall construction @ 14.0 kN/m$^3$ @ 3.0m height @ 0.2m thickness | = 570.1 kN |
| Weight of ground due to 750mm Heel @ 10.0 kN/m$^3$ @ 5.3m$^2$ @ 22m length | = 1166 kN |
| Weight of ground due to 1000mm Heel @ 10.0 kN/m$^3$ @ 6.2m$^2$ @ 10.1m length | = 620.0 kN |
| Weight of ground due to chamfered heel @ 10.0 kN/m$^3$ @ 2.7m$^2$ @ 160m length | = 4320 kN |
| Total force resisting uplift | = 13933 kN |
| Total factored force resisting uplift (*0.9) | = **12540 kN** |

## PERMANEND LOCAL ANALYSIS

**The calculations below calculate the reinforcement in the retaining structures able to resist the bending moment along the stem and allow transfer of forces and moment into the ground bearing slab.**

Use: **325mm thick Reinforced Concrete retaining wall constructed from RC40.**

**Bending Moment Diagram (Main Body Water present):**




Mx Hogging moment @ foot of stem and base of toe = 138.2 kNm (SLS) = 186.1 kNm (ULS) (GOVERNING)

Mx Sagging on stem of underpin = 10.24 kNm (SLS) = 14.4 kNm (ULS) (GOVERNING)

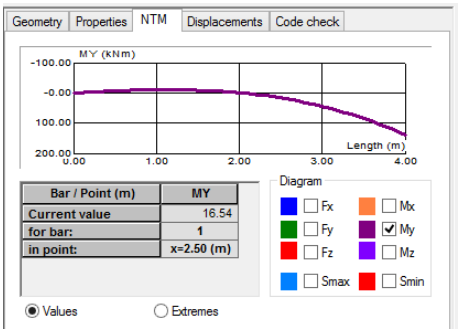
Mx Sagging Moment in ground bearing slab = 53.03 kNm (SLS) = 74.8 kNm (ULS ) (NOT GOVERNING)

**Local Design for basement structure (Main Body):**

The bending moment due to lateral forces is greatest at the foot of the stem and toe which reduces steeply in the stem, therefore the L shaped reinforced concrete underpins will have a base mesh with additional bars laced in at the foot of the wall.

**Base Mesh:**

Moment at stem of retaining wall = 16.54 kNm/m (Unfactored)
= 23.3 kNm/m (factored)
Thickness of wall = 325mm Minimum Cover to reinforcement = 35mm




Effective Depth (d): = 325 – 40 -8-6 = 271mm
K = 23.3E6 / (40*1000*271²) = 0.008 Therefore, z/d = 0.95
As req = 23.3E6 / (0.95*460*0.950*271) = 203mm² per metre
Minimum reinforcement: 325*1000*0.13% = 423mm² per metre

**Therefore, H12 @ 200mm c/c in both faces. (565mm²). Laps to be a minimum 480mm**

*Moment(sagging) on internal is less than hogging @ 1.5m from base of stem therfore by inspection internal face to have reinforcement as stated over*

**Base of stem and toe (1.5m):**

Moment at stem of retaining wall = 138.13 kNm/m (Unfactored) 194.6 kNm/m (factored)
Thickness of wall = 325mm Minimum Cover to reinforcement = 35mm

Effective Depth (d): = 325 – 32 -8 -10= 280mm
K = 186E6 / (40*1000*280²) = 0.05 Therefore, z/d = 0.950
As req = 186E6 / (0.915*460*0.950*280) = 1520mm² per metre -
Minimum reinforcement: 325*1000*0.13% = 423mm² per metre

**Therefore; H20 L bars @ 200mm c/c. (1571mm²). Laps to be a minimum 800mm**

**Maximum Shear Stress in stem**:

Maximum shear stress in stem of retaining structure has been calculated by using the maximum force calculated from the ground and water pressure build up

Shear Stress $\upsilon$ = 189e3 kN*1.35/(1000mm*280mm) = 0.911N/mm$^2$

Design concrete shear stress $\upsilon_c$:

100*1571/1000*280= 0.561 Therefore take 1.0 @ 280mm effective depth = 0.6 N/mm$^2$

*Values taken for shear stress are from table 3.8 BS:8110-1 :1997*

Form and Area of shear reinforcement, $\upsilon \leq \upsilon_c$+0.4:

0.91 ≤ 1.0 Therefore minimum link for whole length of Beam

*Values taken for shear stress are from table 3.8 BS:8110-1 :1997*

Area of shear reinforcement, Asv = 0.4*1000*325/0.95 460 = 290mm

**Therefore, use 2no 12 mm diameter steel link legs @ 200mm c/c. (293mm$^2$)**

## PROP FORCE :

**Below calculates the horizontal load on the retaining wall to define the temporary load in the props.**

**Borehole logs confirm the Ground Water Table is lower than the depth of the basement, therefore water pressure can be ignored in temporary works calculations.**

The worst scenario of the temporary works has been identified in the Stage no.3 of the Sequence of works.

**Applied Horizontal force:**

| | | |
|---|---|---|
| Load from surcharge: 4.9 kN/m *4m | | = 19.6 kN |
| Load from Ground: 0.5*39.2 kN/m*4 | | = 78.4 kN |
| | **Total Horizontal load (Unfactored)** | **= 98.0 kN** |
| | **Total Horizontal load (Factored)** | **= 147 kN** |

**Overturning Moment:**

| | | | |
|---|---|---|---|
| Moment from surcharge: 19.6 kN*4/2 | | | = 39.2 kNm |
| Moment from Ground: 78.4*4/3 | | | = 104.5 kNm |
| **Total Moment (Unfactored)** | **= 143.7 kNm Total Moment (Factored)** | **= 215.6 kNm** | |

It is assumed the top props are located at 1 meter deep from the ground level.

**Load applied per metre in the props to stop the overturning: 215.6/3 = 71.9 kN**

Therefore Use: **No.1 System 160 Prop per metre (Capacity @ L = 4.8m = 120 kN). Refer to attached document "System 160 Propping and Needling"** Therefore OK

# 6. Push Pull Props

## 6.1 Typical Arrangements

For general use a Factor of Safety of 2 is recommended. However, for controlled situations where the loading is predictable a Factor of Safety of 1.7 may be used.

The safe working loads shown in the table below are for props used in compression either vertically or horizontally. In horizontal applications, the props should always be used with the soldier webs/lightening holes in the vertical plane.

When used in tension the safe working load should not exceed 120 kN.

For props a recommended straightness tolerance is given below, indicated by Max Offset Dim (mm). Should the prop fall outside the range shown, the components should be checked for local damage to end plates.

All bolted joints require 6 No. S3/22 bolts.

Intermediate lengths may be obtained by adding 1 or 2 360mm Units (S3/1-360 or S3/24), or in some cases screw jacks can be fixed at each end.

Allowance to be made for elastic shortening of Push Pull Prop = 0.05mm/tonne/metre.

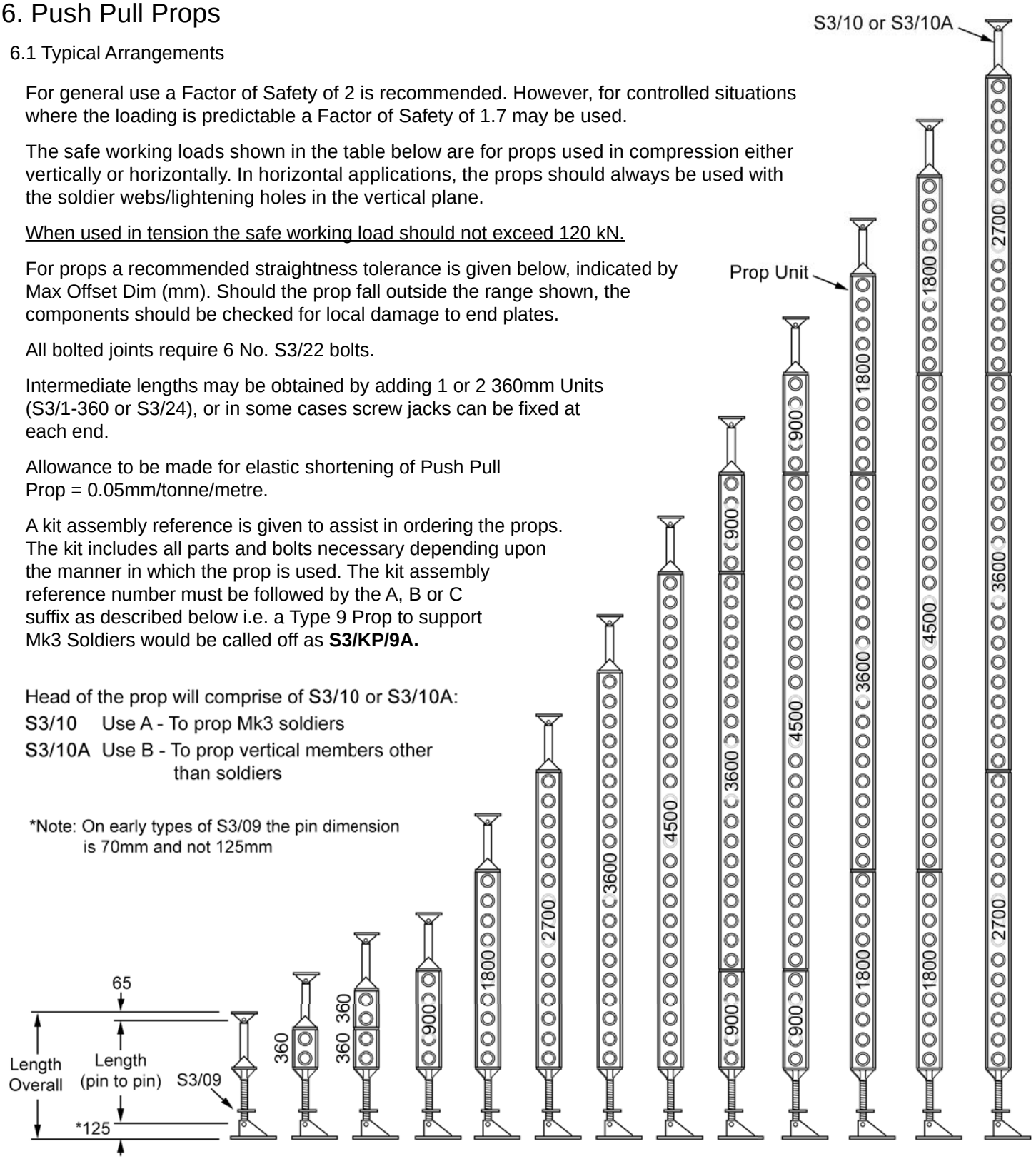
A kit assembly reference is given to assist in ordering the props. The kit includes all parts and bolts necessary depending upon the manner in which the prop is used. The kit assembly reference number must be followed by the A, B or C suffix as described below i.e. a Type 9 Prop to support Mk3 Soldiers would be called off as **S3/KP/9A.**

Head of the prop will comprise of S3/10 or S3/10A:

S3/10 Use A - To prop Mk3 soldiers

S3/10A Use B - To prop vertical members other than soldiers

*Note: On early types of S3/09 the pin dimension is 70mm and not 125mm




| PROP | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KIT ASSEMBLY REF | S3/KP/1 | S3/KP/2 | S3/KP/3 | S3/KP/4 | S3/KP/5 | S3/KP/6 | S3/KP/7 | S3/KP/8 | S3/KP/9 | S3/KP/10 | S3/KP/11 | S3/KP/12 | S3/KP/13 |
| MAX LENGTH Overall (mm) | 1279 | 1639 | 1999 | 2179 | 3079 | 3979 | 4879 | 5779 | 6679 | 7579 | 8479 | 9379 | 10279 |
| MIN LENGTH Overall (mm) | 830 | 1190 | 1550 | 1730 | 2630 | 3530 | 4430 | 5330 | 6230 | 7130 | 8030 | 8930 | 9830 |
| WEIGHT (kg) | 50 | 69 | 87 | 75 | 90 | 113 | 132 | 151 | 182 | 201 | 212 | 231 | 257 |
| LOAD CAPACITY (FOS 2.0) (kN) | 200 | 200 | 200 | 200 | 170 | 140 | 120 | 100 | 80 | 70 | 60 | 50 | 45 |
| LOAD CAPACITY (FOS 1.7) (kN) | 200 | 200 | 200 | 200 | 200 | 165 | 140 | 118 | 94 | 82 | 70 | 59 | 53 |
| MAX OFFSET DIM (mm) | 2.0 | 3.0 | 3.5 | 4.0 | 6.0 | 8.0 | 10.0 | 12.0 | 14.0 | 16.0 | 18.0 | 20.0 | 22.0 |