

# 6033 - Steel Museum

## Preliminary Structural Calculations

Ace Capital Projects Ltd

29th April 2024

0002



# Notice

This document and its contents have been prepared and are intended solely as information for Ace Capital Projects Ltd and use in relation to Structural Properties.

Blueprint Construction assumes no responsibility to any other party in respect of or arising out of or in connection with this document and/or its contents.

## Document history

Document title: Preliminary Structural Calculations

Document reference: 0001

| Revision | Purpose description  | Originated | Checked | Reviewed | Authorised | Date       |
|----------|----------------------|------------|---------|----------|------------|------------|
| 1.0      | To Present to Client | M.C.       | J.L.    | A.W.     | ALL        | 30/04/2024 |
|          |                      |            |         |          |            |            |
|          |                      |            |         |          |            |            |
|          |                      |            |         |          |            |            |
|          |                      |            |         |          |            |            |
|          |                      |            |         |          |            |            |
|          |                      |            |         |          |            |            |
|          |                      |            |         |          |            |            |
|          |                      |            |         |          |            |            |
|          |                      |            |         |          |            |            |

## Client signoff

|                       |                                                           |
|-----------------------|-----------------------------------------------------------|
| Client                | Ace Capital Projects Ltd                                  |
| Project               | 6033 - Steel Museum                                       |
| Job number            | 6033-ACECP-CD-XX-CA-S-0002-Rev01- STRUCTURAL CALCULATIONS |
| Client signature/date |                                                           |

# Contents

| Chapter                                                                                | Page     |
|----------------------------------------------------------------------------------------|----------|
| <b>Introduction</b>                                                                    | <b>4</b> |
| <b>1. Introduction</b>                                                                 | <b>5</b> |
| 1.1. Ground Floor                                                                      | 6        |
| 1.2. First Floor                                                                       | 10       |
| 1.3. Second Floor                                                                      | 15       |
| 1.4. Imposed Load Through Column & Piles                                               | 20       |
| <br><b>Figures</b>                                                                     |          |
| Figure 1-1 - Unit Mass Schedule of Building materials as per BS 648                    | 5        |
| Figure 1-2 - Ground Floor structural grid outlining preliminary Calculations location. | 6        |
| Figure 1-3 - Close up of Grid Location and Dimensions                                  | 7        |
| Figure 1-4 - Reactions, Bending moment & Shear force Diagrams.                         | 8        |
| Figure 1-5 - First Floor structural grid outlining preliminary Calculations location.  | 10       |
| Figure 1-6 - Close up of Grid Location and Dimensions                                  | 12       |
| Figure 1-7 - Reactions, Bending moment & Shear force Diagrams.                         | 13       |
| Figure 1-8 - Second Floor structural grid outlining preliminary Calculations location. | 15       |
| Figure 1-9 - Close up of Grid Location and Dimensions                                  | 17       |
| Figure 1-10 - Reactions, Bending moment & Shear force Diagrams.                        | 18       |
| Figure 1-11 - 3D Elevation view of structure showing Column Dimensions                 | 20       |

# Introduction

Blueprint Constructions preliminary  
Calculations outlined below.

# 1. Introduction

Preliminary calculations have been undertaken, to show feasibility of structural design for the columns, beams, and piled foundations of the steel museum structure. Please note that this is preliminary design and further structural calculation will be needed to interpret suitability of structural design for the full structure. The dead and imposed loads for the structure have been calculated and highlighted for the beams, columns and piled foundations in selected areas which are also highlighted on the structural grids. The table has been used to work out dead loading materials:

| Schedule of unit masses of building materials (based on BS 648) |                                    |                                         |                          |
|-----------------------------------------------------------------|------------------------------------|-----------------------------------------|--------------------------|
| <b>Asphalt</b>                                                  |                                    | <b>Plaster</b>                          |                          |
| Roofing 2 layers, 19 mm thick                                   | 42 kg m <sup>-2</sup>              | Two coats gypsum, 13 mm thick           | 22 kg m <sup>-2</sup>    |
| Damp-proofing, 19 mm thick                                      | 41 kg m <sup>-2</sup>              | <b>Plastics sheeting (corrugated)</b>   |                          |
| Roads and footpaths, 19 mm thick                                | 44 kg m <sup>-2</sup>              |                                         | 4.5 kg m <sup>-2</sup>   |
| <b>Bitumen roofing felts</b>                                    |                                    | <b>Plywood</b>                          |                          |
| Mineral surfaced bitumen                                        | 3.5 kg m <sup>-2</sup>             | per mm thick                            | 0.7 kg m <sup>-2</sup>   |
| <b>Blockwork</b>                                                |                                    | <b>Reinforced concrete</b>              |                          |
| Solid per 25 mm thick, stone aggregate                          | 55 kg m <sup>-2</sup>              |                                         | 2400 kg m <sup>-3</sup>  |
| Aerated per 25 mm thick                                         | 15 kg m <sup>-2</sup>              | <b>Rendering</b>                        |                          |
| <b>Board</b>                                                    |                                    | Cement: sand (1:3), 13 mm thick         | 30 kg m <sup>-2</sup>    |
| Blockboard per 25 mm thick                                      | 12.5 kg m <sup>-2</sup>            | <b>Screeding</b>                        |                          |
| <b>Brickwork</b>                                                |                                    | Cement: sand (1:3), 13 mm thick         | 30 kg m <sup>-2</sup>    |
| Clay, solid per 25 mm thick medium density                      | 55 kg m <sup>-2</sup>              | <b>Slate tiles</b>                      |                          |
| Concrete, solid per 25 mm thick                                 | 59 kg m <sup>-2</sup>              | (depending upon thickness and source)   | 24–78 kg m <sup>-3</sup> |
| <b>Cast stone</b>                                               |                                    | <b>Steel</b>                            |                          |
|                                                                 | 2250 kg m <sup>-3</sup>            | Solid (mild)                            | 7850 kg m <sup>-3</sup>  |
| <b>Concrete</b>                                                 |                                    | Corrugated roofing sheets, per mm thick | 10 kg m <sup>-2</sup>    |
| Natural aggregates                                              | 2400 kg m <sup>-3</sup>            | <b>Tarmacadam</b>                       |                          |
| Lightweight aggregates (structural)                             | 1760 + 240/-160 kg m <sup>-3</sup> | 25 mm thick                             | 60 kg m <sup>-2</sup>    |
| <b>Flagstones</b>                                               |                                    | <b>Terrazzo</b>                         |                          |
| Concrete, 50 mm thick                                           | 120 kg m <sup>-2</sup>             | 25 mm thick                             | 54 kg m <sup>-2</sup>    |
| <b>Glass fibre</b>                                              |                                    | <b>Tiling, roof</b>                     |                          |
| Slab, per 25 mm thick                                           | 2.0–5.0 kg m <sup>-2</sup>         | Clay                                    | 70 kg m <sup>-2</sup>    |
| <b>Gypsum panels and partitions</b>                             |                                    | <b>Timber</b>                           |                          |
| Building panels 75 mm thick                                     | 44 kg m <sup>-2</sup>              | Softwood                                | 590 kg m <sup>-3</sup>   |
| <b>Lead</b>                                                     |                                    | Hardwood                                | 1250 kg m <sup>-3</sup>  |
| Sheet, 2.5 mm thick                                             | 30 kg m <sup>-2</sup>              | <b>Water</b>                            |                          |
| <b>Linoleum</b>                                                 |                                    |                                         | 1000 kg m <sup>-3</sup>  |
| 3 mm thick                                                      | 6 kg m <sup>-2</sup>               | <b>Woodwool</b>                         |                          |
|                                                                 |                                    | Slabs, 25 mm thick                      | 15 kg m <sup>-2</sup>    |

Figure 1-1 - Unit Mass Schedule of Building materials as per BS 648

## 1.1. Ground Floor

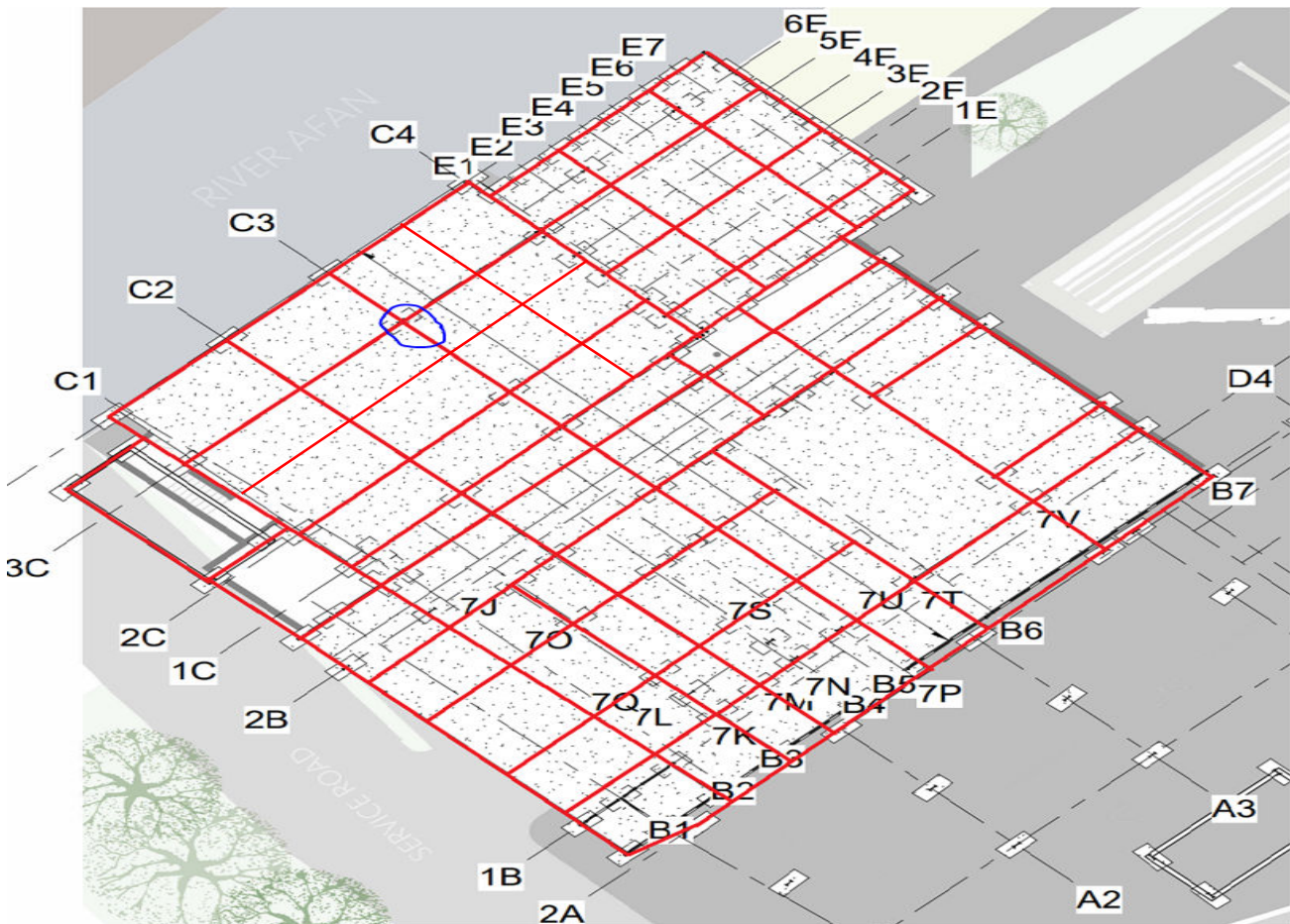


**Figure 1-2 - Ground Floor structural grid outlining preliminary Calculations location.**

### 1.1.1. Dead Loads Applied

12mm thick Hardwood sheets –  $1250\text{kg/m}^3 \times 0.012\text{m} = 15\text{kg/m}^2$

$$- 15\text{kg/m}^2 \times 10 = 150\text{N/m}^2 = \underline{\underline{0.15 \text{ kN/m}^2}}$$

100mm Thick Concrete floor -  $2400\text{kg/m}^3 \times 0.1\text{m} = 240\text{kg/m}^2$

$$- 240\text{kg/m}^2 \times 10 = 2400\text{N/m}^2 = \underline{\underline{2.40 \text{ kN/m}^2}}$$

$$\text{Total} = 2.4\text{Kn/m}^2 + 0.15\text{Kn/m}^2 = \underline{\underline{2.55\text{KN/m}^2}}$$

Increase dead load by 20% to account for weight of steel – **Total Dead Load = 2.55 x 1.2 = 3.06 kN/m<sup>2</sup>**

### 1.1.2. Imposed Loads Applied

An imposed load of **3Kn/m<sup>2</sup>** can be assumed as per BS 6399 PART 1: 1984.

Dead and imposed loads added together to make total service load.

$$\text{Total service load} = 3\text{Kn/m}^2 + 3.06\text{Kn/m}^2 = \mathbf{6.06\text{Kn/m}^2}$$

### 1.1.3. Beam Bending Moment & Shear Diagram

Dimensions for the chosen grid are as follows:

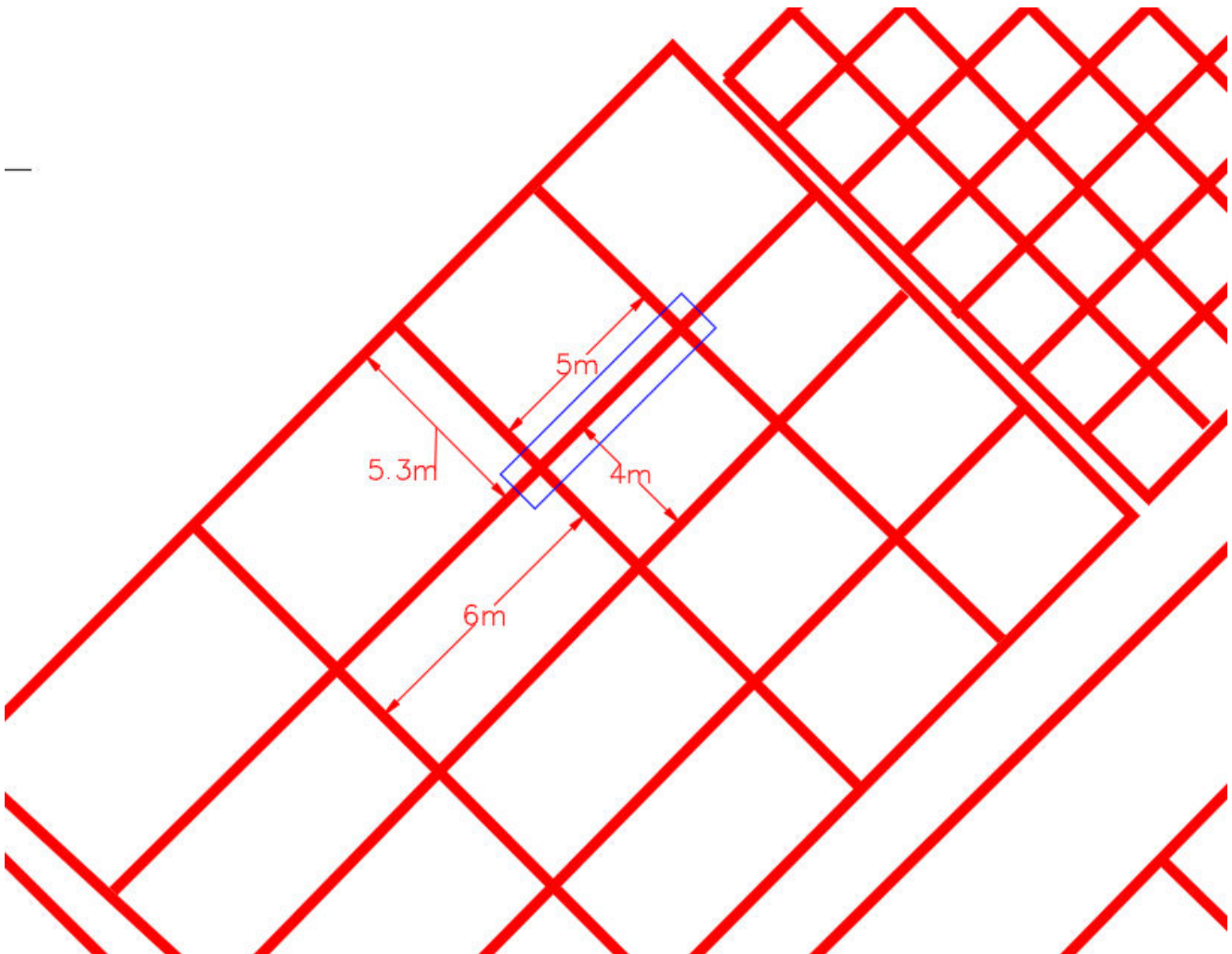


**Figure 1-3 - Close up of Grid Location and Dimensions**

$$\text{Factored (ultimate) loads} = 1.35 \times \text{dead} + 1.5 \times \text{imposed} = 1.35 \times 3 + 1.5 \times 3.06 = \mathbf{8.64 \text{ kN/m}^2}$$

Load carried by the selected beam (assuming uniformly distributed load):

$$w = (0.5 \times 5.3 + 0.5 \times 4) \times 8.64 = \mathbf{26.4 \text{ kN/m}}$$

Another Figure shows the results along with the Shear force diagram and Bending moment diagram, the calculations then follow this:

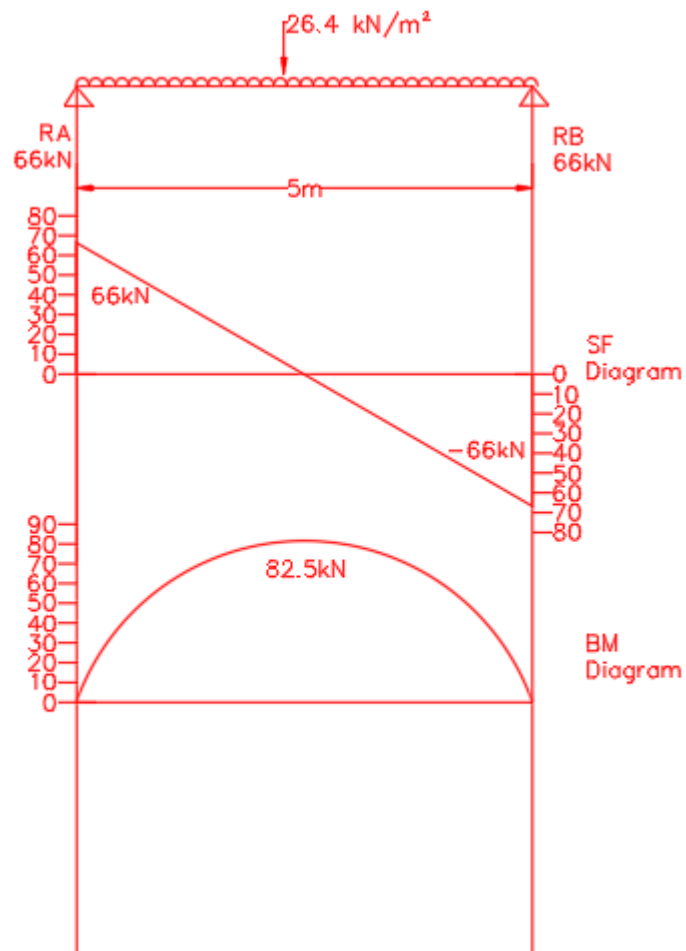


**Figure 1-4 - Reactions, Bending moment & Shear force Diagrams.**

### **Reaction forces**

$$R_A = R_B$$

$$= w \times L / 2 = 26.4 \times 5 / 2 = \underline{\underline{66 \text{ kN}}}$$

### **Shear Force**

$$\text{Max Shear Force} = wL/2$$

$$= w \times L / 2 = 26.4 \times 5 / 2 = \underline{\underline{66 \text{ kN}}}$$

### **Bending Moment**

Max moment at mid span:

$$M_{\max} = w \times L^2 / 8 = 26.4 \times 5^2 / 8 = \underline{\underline{82.5 \text{ kN.m}}}$$

### **Strength Classification**

Flange thickness = 9.7mm, Steel grade S275. Therefore  $y = 275 \text{ N/mm}^2$

### **Section Selection**

As per Blue books buckling resistance moment with S275 Steel it is proposed a **356 x 171 x 45 UB** is used as the buckling resistance moment is 112kN/m

## 1.2. First Floor

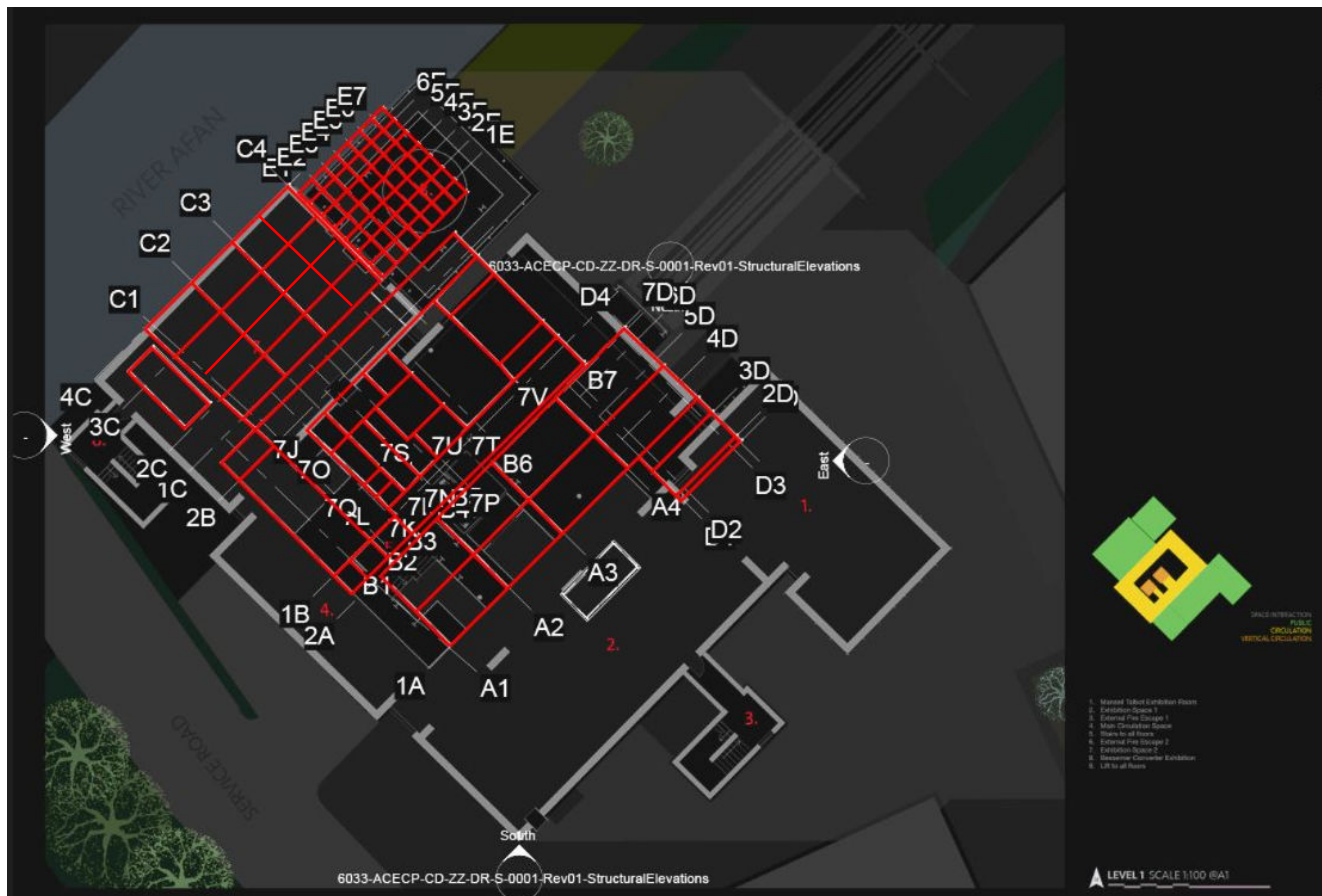


Figure 1-5 - First Floor structural grid outlining preliminary Calculations location.

### 1.2.1. Dead Loads Applied

$$12\text{mm thick Hardwood sheets} - 1250\text{kg/m}^3 \times 0.012\text{m} = 15\text{kg/m}^2$$

$$- 15\text{kg/m}^2 \times 10 = 150\text{N/m}^2 = \mathbf{0.15 \text{ kN/m}^2}$$

$$100\text{mm Thick Concrete floor} - 2400\text{kg/m}^3 \times 0.01\text{m} = 240\text{kg/m}^2$$

$$- 240\text{kg/m}^2 \times 10 = 2400\text{N/m}^2 = \mathbf{2.40 \text{ kN/m}^2}$$

$$\mathbf{\text{Total} = 2.4\text{Kn/m}^2 + 0.15\text{Kn/m}^2 = \mathbf{2.55\text{KN/m}^2}}$$

Increase dead load by 20% to account for weight of steel – **Total Dead Load =  $2.55 \times 1.2 = 3.06 \text{ kN/m}^2$**

### 1.2.2. Imposed Loads Applied

An imposed load of **3Kn/m<sup>2</sup>** can be assumed as per BS 6399 PART 1: 1984.

Dead and imposed loads added together to make total service load.

Total service load = **3Kn/m<sup>2</sup>** + **3.06Kn/m<sup>2</sup>** = **6.06Kn/m<sup>2</sup>**

### 1.2.3. Beam Bending Moment & Shear Diagram

Dimensions for the chosen grid are as follows:

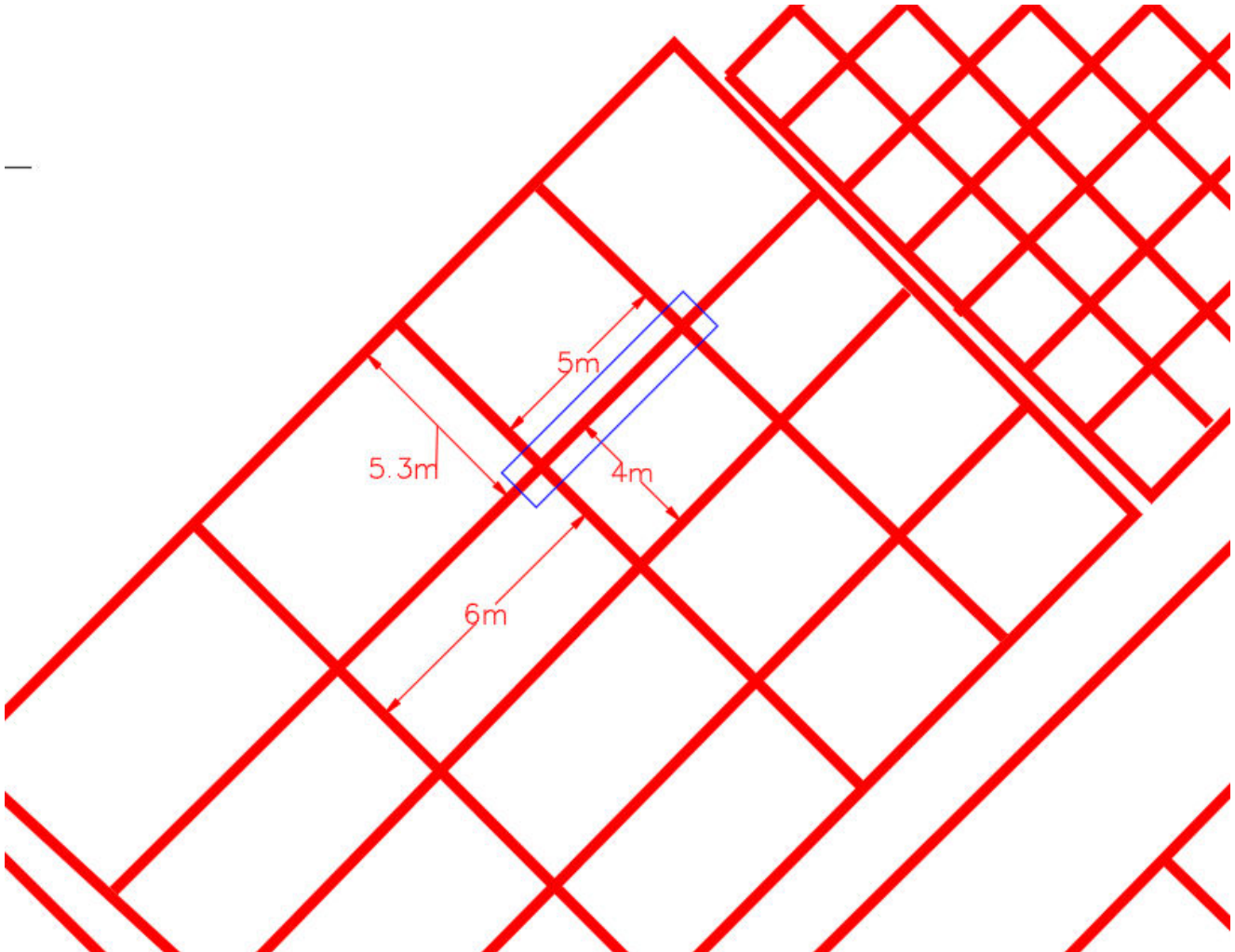


**Figure 1-6 - Close up of Grid Location and Dimensions**

Factored (ultimate) loads =  $1.35 \times \text{dead} + 1.5 \times \text{imposed} = 1.35 \times 3 + 1.5 \times 3.06 = \underline{\underline{8.64 \text{ kN/m}^2}}$

Load carried by the selected beam (assuming uniformly distributed load):

$$w = (0.5 \times 5.3 + 0.5 \times 4) \times 8.64 = \underline{\underline{26.4 \text{ kN/m}}}$$

Another Figure shows the results along with the Shear force diagram and Bending moment diagram, the calculations then follow this:

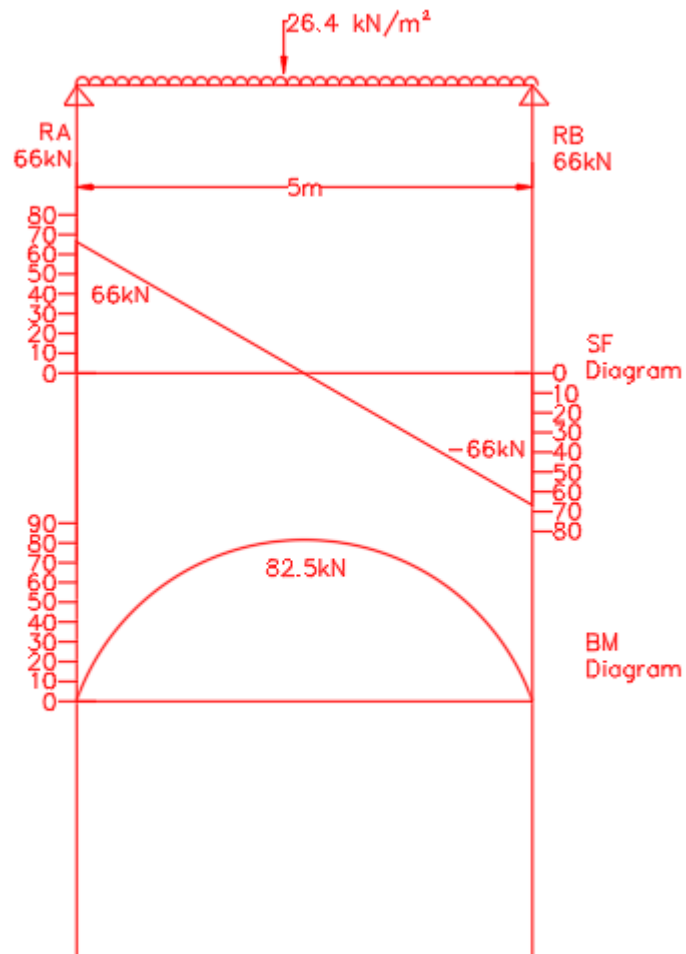


**Figure 1-7 - Reactions, Bending moment & Shear force Diagrams.**

### **Reaction forces**

$$R_A = R_B$$

$$= w \times L / 2 = 26.4 \times 5 / 2 = \underline{\underline{66 \text{ kN}}}$$

### **Shear Force**

$$\text{Max Shear Force} = wL/2$$

$$= w \times L / 2 = 26.4 \times 5 / 2 = \underline{\underline{66 \text{ kN}}}$$

### **Bending Moment**

Max moment at mid span:

$$M_{\max} = w \times L^2 / 8 = 26.4 \times 5^2 / 8 = \underline{\underline{82.5 \text{ kN.m}}}$$

### **Strength Classification**

Flange thickness = 9.7mm, Steel grade S275. Therefore  $y = 275 \text{ N/mm}^2$

### **Section Selection**

As per Blue books buckling resistance moment with S275 Steel it is proposed a **356 x 171 x 45 UB** is used as the buckling resistance moment is 112kN/m



### 1.3.2. Imposed Loads Applied

An imposed load of **3Kn/m<sup>2</sup>** can be assumed as per BS 6399 PART 1: 1984.

Dead and imposed loads added together to make total service load.

$$\text{Total service load} = 3\text{Kn/m}^2 + 3.06\text{Kn/m}^2 = \textcolor{red}{\underline{6.06\text{Kn/m}^2}}$$

### 1.3.3. Beam Bending Moment & Shear Diagram

Dimensions for the chosen grid are as follows:

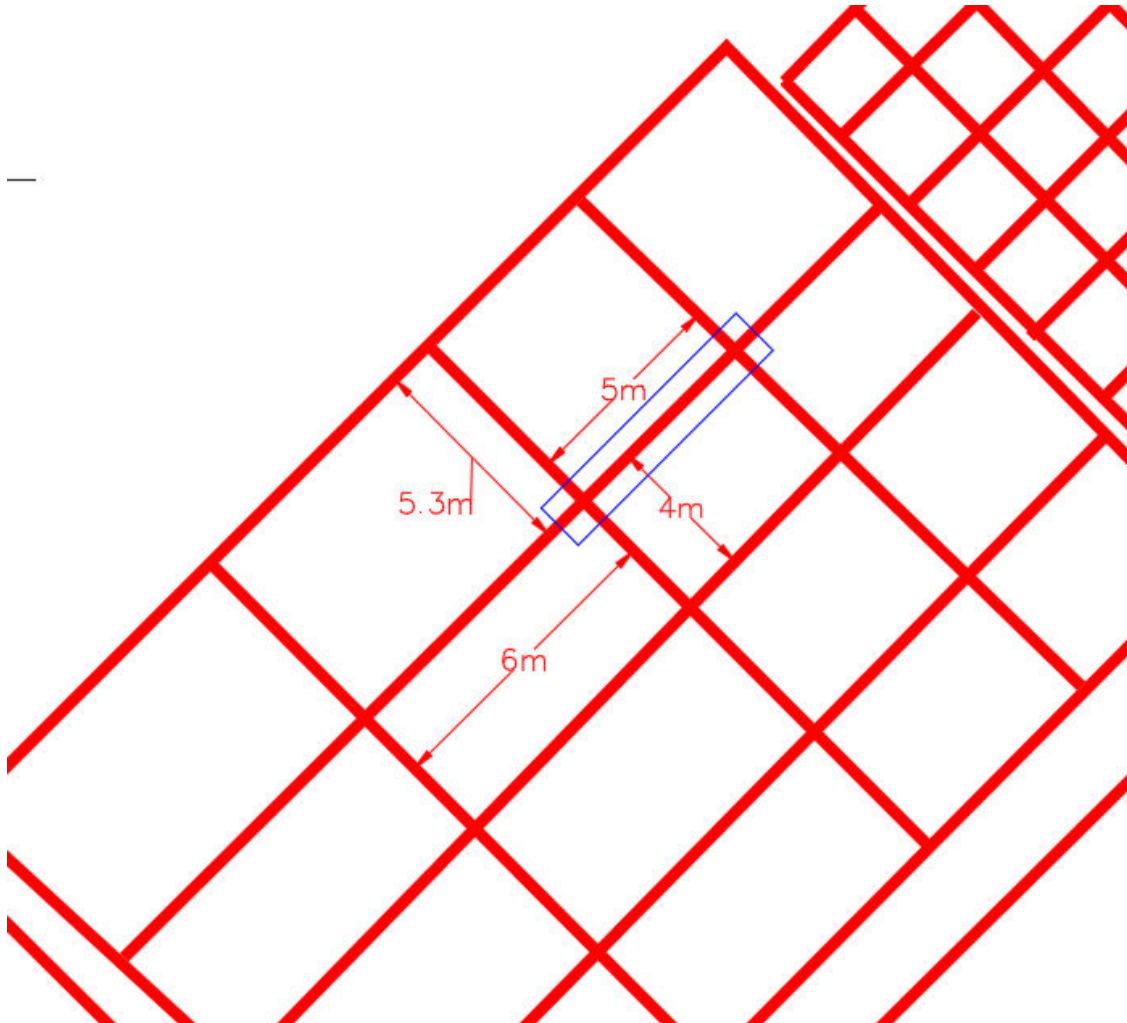


**Figure 1-9 - Close up of Grid Location and Dimensions**

Factored (ultimate) loads =  $1.35 \times \text{dead} + 1.5 \times \text{imposed} = 1.35 \times 3 + 1.5 \times 3.06 = \underline{\underline{8.64 \text{ kN/m}^2}}$

Load carried by the selected beam (assuming uniformly distributed load):

$$w = (0.5 \times 5.3 + 0.5 \times 4) \times 8.64 = \underline{\underline{26.4 \text{ kN/m}}}$$

Another Figure shows the results along with the Shear force diagram and Bending moment diagram, the calculations then follow this:

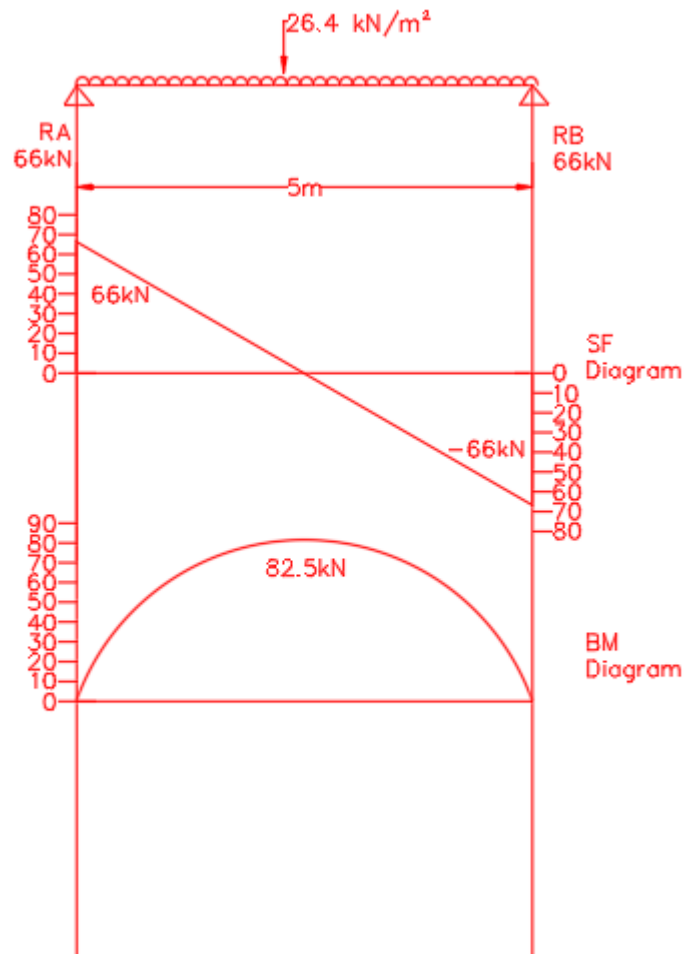


**Figure 1-10 - Reactions, Bending moment & Shear force Diagrams.**

### **Reaction forces**

$$R_A = R_B$$

$$= w \times L / 2 = 26.4 \times 5 / 2 = \underline{\underline{66 \text{ kN}}}$$

### **Shear Force**

$$\text{Max Shear Force} = wL/2$$

$$= w \times L / 2 = 26.4 \times 5 / 2 = \underline{\underline{66 \text{ kN}}}$$

### **Bending Moment**

Max moment at mid span:

$$M_{\max} = w \times L^2 / 8 = 26.4 \times 5^2 / 8 = \underline{\underline{82.5 \text{ kN.m}}}$$

### **Strength Classification**

Flange thickness = 9.7mm, Steel grade S275. Therefore  $y = 275 \text{ N/mm}^2$

### **Section Selection**

As per Blue books buckling resistance moment with S275 Steel it is proposed a **356 x 171 x 45 UB** is used as the buckling resistance moment is 112kN/m

## 1.4. Imposed Load Through Column & Piles

An elevation view of the structure showing dimensions through the column:

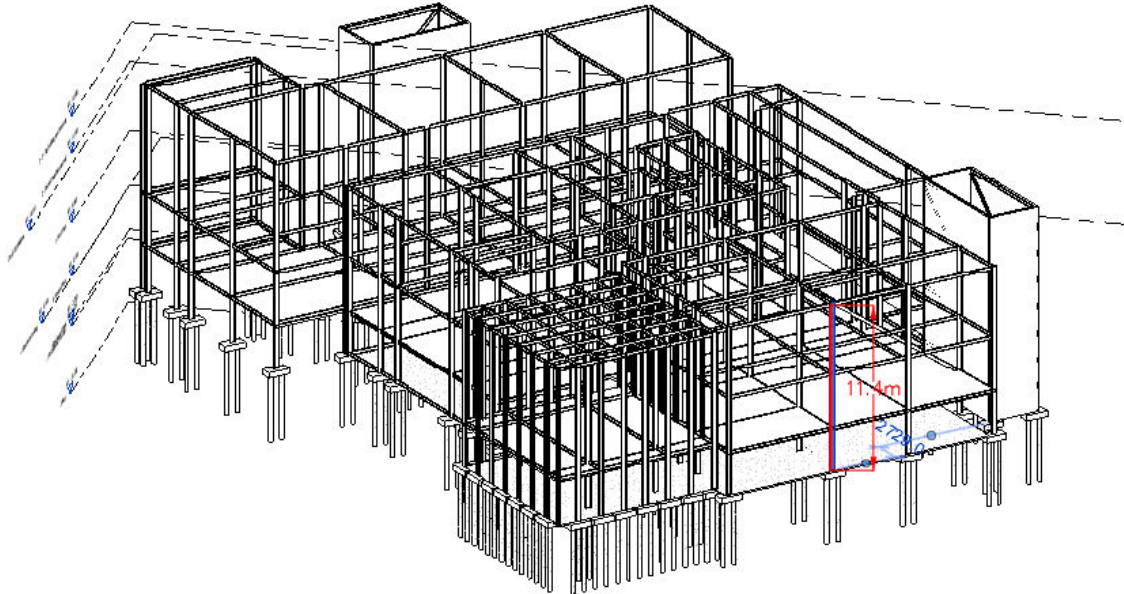


**Figure 1-11 - 3D Elevation view of structure showing Column Dimensions**

3 No. Structural Columns at 3.8m each totalling to the full height of 11.4m.

3 No. reactions of 66kN at each floor height =  $66\text{kN} \times 3 = \mathbf{198\text{kN}}$

Following this from the ground report of the site looking at Table 3 below:

| Pile Length (m) | Safe Working Capacity (kN) |                |                |                |
|-----------------|----------------------------|----------------|----------------|----------------|
|                 | 300mm diameter             | 450mm diameter | 600mm diameter | 750mm diameter |
| 10              | 265                        | 505            | 810            | 1150           |
| 12              | 360                        | 670            | 1070           | 1550           |

### Floor slabs

Considering the final finished level of the development platform and variable nature of the Made Ground across the site, it is recommended that a suspended floor slab is chosen unless ground improvement is adopted.

We can assume 1 Pile will be needed per column at 10m in length and 300mm in diameter.