Appendix 3: Structural Engineer’s Statement and Calculations

New Building

Substructure

The new building will comprise as a single dwelling house for Mr and Mrs O'Toole. Accommodation will be arranged over basement, ground, first, second and third floors. The basement will be used for car-parking. There is no garden.

The basement will be formed of an insitu reinforced concrete "box" with a 350mm thick basement slab, 250mm thick concrete retaining walls and 200mm thick ground floor slab.

The party walls will be underpinned in a traditional hit and miss sequence to ensure they are not undermined by the construction and are founded below the depth of the proposed excavation.

The concrete retaining walls are designed to retain the basement in the temporary and permanent condition. This includes

- lateral loads arising from the retained earth,
- ground water (which will be taken at a conservative level of 1.0m bgl)
- a variable surcharge action of 10.0KPa and

Basement waterproofing

In considering the waterproofing protection for the basement, the following grades to BS 8102:2009 could be considered to apply:

- Grade 3 in the Residential and Common Space.
  Performance level: no water penetration; ventilation; dehumidification or air conditioning necessary appropriate to the intended use.

It is proposed the Grade 3 Environment is best achieved using a combination of two waterproofing systems as recognised within BS8102;

- Type B Water Resisting Concrete, and
- Type C drained cavity system

Superstructure

The above ground structure retains all the front, rear and party walls. The upper floors structural frame will be of isolated steel beams and timber floor joists.

The floors will be supported on the existing party walls and two internal steel columns. The floors will have lateral restraint straps to the surrounding walls and provide the horizontal diaphragm that transfers horizontal loads into the walls.

Lateral Stability

The building has been designed using the existing masonry walls that envelope it. These walls provide both vertical and lateral support. It is recognised that terraced properties dating from the late 1800's have shared party walls and that cumulative effects of thermal/lateral strains can induce issues with terrace end walls. No such impacts are likely for this development as the façade lengths are short.

As the front elevation contains significant openings between ground and first floors, steel columns and beams will be introduced to provide lateral stability.

Lateral loads are those that arise from wind and the notional effects that arise from pattern loads and imperfections within the structure.

The building has also been designed for notional or Equivalent Horizontal Forces (EHF's) in accordance with Eurocodes. These loads arise from the effects of vertical loads applied at an eccentricity associated with construction tolerances which are part of the construction of a framed structure. The EHF's are calculated as a percentage of the total floor loads at each level and applied horizontally at each level.

Design Performance Criteria and Standards

Loading

The following parameters have been adopted as design loads.

Permanent Actions (Dead Loads)

The dead load allows for the self-weight of the structure, floor screed, finishes and external cladding. These will be determined from NA to BS EN 1991-1-1.

Variable Actions (Imposed loads)

Imposed loads are defined as the load assumed to be produced by the intended occupancy or use, including the weight of moveable partitions and snow loads. The following parameters have been adopted in the design. These are BCO and Building Regulation compliant except where noted

Location	Use	Uniformly Distributed load	Allowance for Partitions
Basement	Residential	2.50 KN/m²	
Ground	Residential	1.50 KN/m²	1.0 KN/m²
First	Residential	1.50 KN/m²	1.0 KN/m²
Second	Residential	1.50 KN/m²	1.0 KN/m²
Third	Residential	1.50 KN/m²	1.0 KN/m²
Roof generally	Flat Roof	0.60 KN/m²	

Wind Loads

Calculated wind loads acting on the building structure and cladding in accordance with the "Standard" method of BE EN 1991-1-4 gives:

Basic Wind Velocity = 21.8m/s

Peak velocity pressure = 1.09 KN/m²

Maximum net roof pressure (incl pressure coefficients) = 2.25 KN/m² (uplift)

Maximum net wall pressure (incl pressure coefficients) = 1.36 KN/m²

Earth Pressure and Soil Surcharge Loads

The perimeter retaining walls are designed for lateral loads resulting from:

- lateral loads arising from the retained earth,
- ground water (which will be taken at a conservative level of 1.0m bgl).
- a variable surcharge action of 10.0KPa and

At rest pressure coefficients have been employed.

$K_0 = 1 - \sin(\Phi'_{r.d})$ = **0.540**

Balustrade Loading

Balustrades will be designed for the following performance criteria as defined in NA to BS EN 1991-1-1, Table N.A.8.

Category	Handrail Load	Infill Load
Residential Areas	0.74 KN/m	1.0 KN/m²

Fire Resistance

The fire resistance of the building structure is 60 minutes and determined in accordance with BS EN 1992-1-2.

Robustness and Disproportionate Collapse

The building is classed as a Class 2A to Building Regulations Approved Document A and Table A1 of BS EN 1991-1-7 as it is a single occupancy house exceeding four storeys.

Buildings within this category are required to have effective horizontal ties in order to reduce the sensitivity of the building to disproportionate collapse in the event of an accident. This condition is customarily met with traditional lateral floor straps.

Durability

The design life of new structural elements is taken as 50 years which falls within Category 4 in Table 2.1 of BS EN 1990: Basis of Structural Design and corresponds to a “normal” category of building.

Concrete shall be designed to provide sufficient cover to reinforcement commensurate with the conditions of exposure.

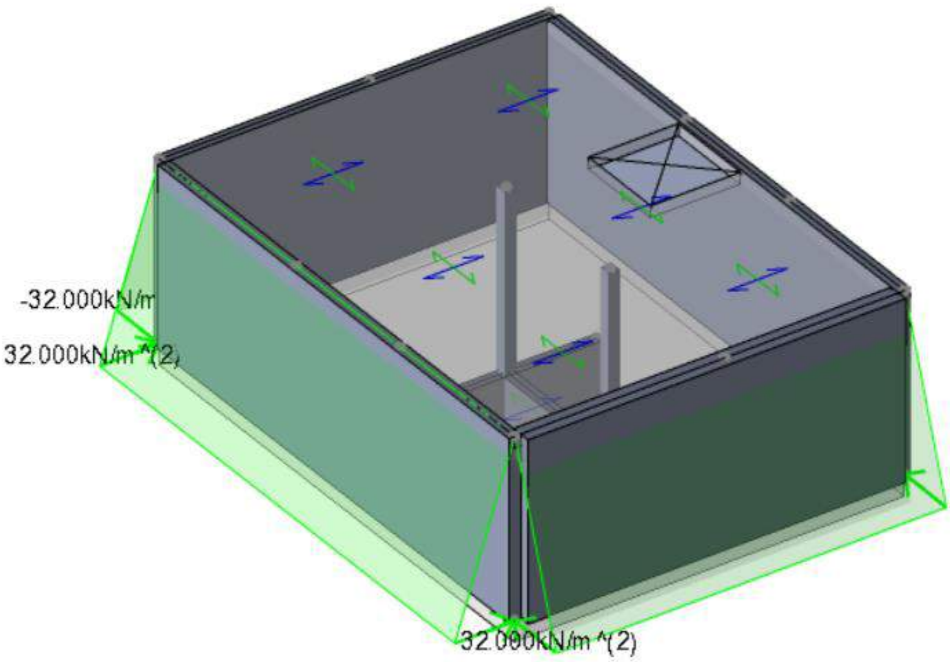
Structural Analysis and Design

The analysis and design has been carried out Using Tekla Structural Designer. This is a comprehensive three dimensional software system that combines analysis and code compliant design for both gravity and lateral analysis in a single finite element model.

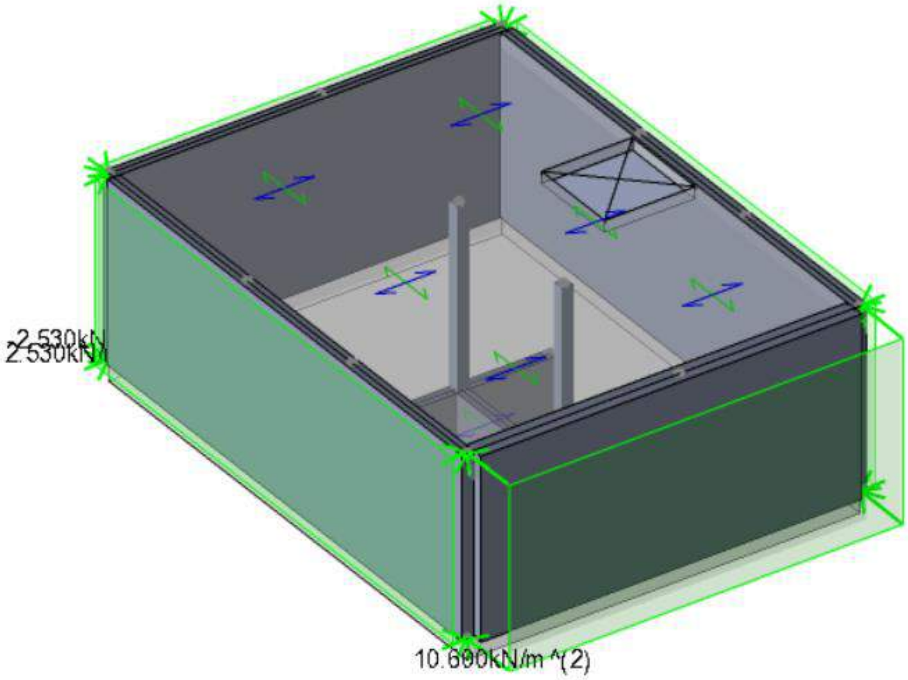
Gravity loads for the self-weight of the structural frame are calculated automatically. Wind loads are also calculated and applied automatically using the in built BREVe wind generator which calculates effective gust speeds and wind pressures for any National Grid reference. The wind forces loads are applied to wall and roof surfaces and EC1 pressure coefficients determined.

Variable actions are applied as individual pressure, point, line load as appropriate in either the x,y or z directions.

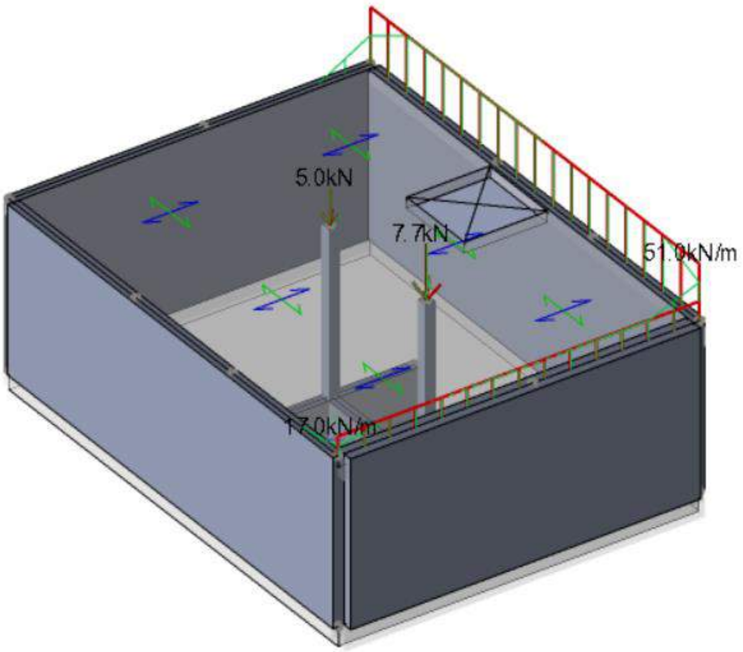
The software incorporates a powerful finite element engine that analysis model is used to assess the maximum bending, shear and axial forces together with vertical and lateral deflections. The model allows for moment connections between the columns and floor slabs/beams.



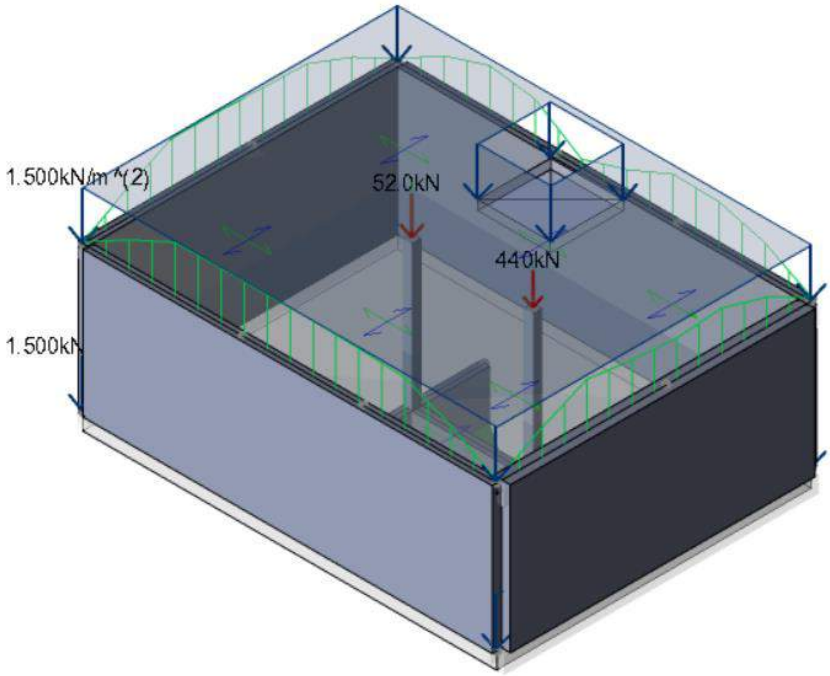
Earth Pressure Loads



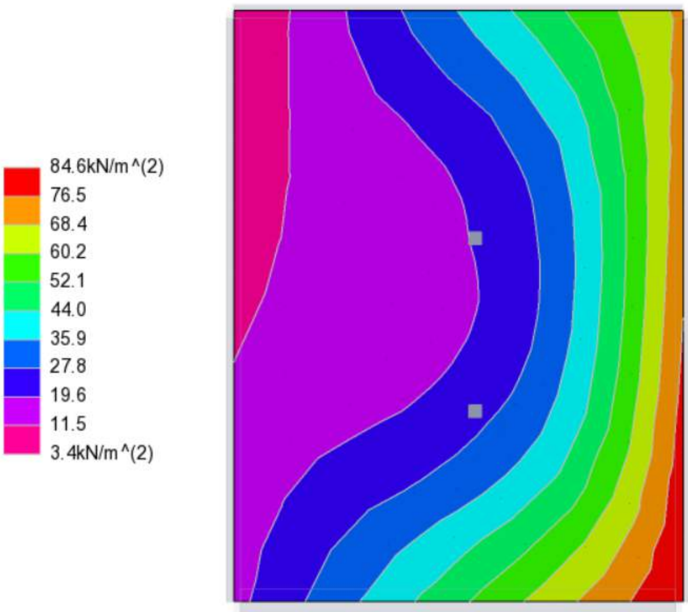
Surcharge Loads on retaining walls



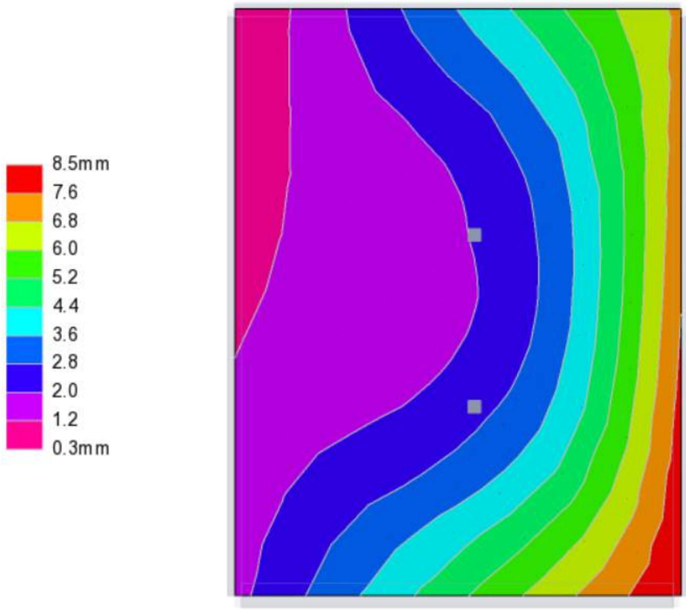
Line Loads from: Party wall with 28/31, front elevation and Point dead loads from Columns Above



Imposed Loads acting on ground floor and basement.



SLS Ground Bearing Pressures for full Dead, Imposed, Earth and Soil Surcharge Loads



SLS Basement Slab Vertical Deflections

Concrete

Slab/Mat Design per Plane

St. 1 (ground)

Slab/Mat Panels

Slab: S 1, Panel: Sl 2

Static

Reinforcement Design Summary

Reinforcement Layer	Reinforcement Provided	Area Provided [mm²/m]	Area Required [mm²/m]	Utilization
Bottom-X	10.0-200.0-B2	393	76	0.194
Bottom-Y	10.0-200.0-B1	393	73	0.186
Top-X	10.0-200.0-T2	393	328	0.836
Top-Y	10.0-200.0-T1	393	268	0.682

Slab: S 1, Panel: Sl 3

Static

Reinforcement Design Summary

Reinforcement Layer	Reinforcement Provided	Area Provided [mm²/m]	Area Required [mm²/m]	Utilization
Bottom-X	10.0-200.0-B2	393	106	0.270
Bottom-Y	10.0-200.0-B1	393	78	0.198
Top-X	10.0-200.0-T2	393	297	0.756
Top-Y	10.0-200.0-T1	393	263	0.670

Slab: S 1, Panel: Sl 4

Static

Reinforcement Design Summary

Reinforcement Layer	Reinforcement Provided	Area Provided [mm²/m]	Area Required [mm²/m]	Utilization
Bottom-X	10.0-200.0-B2	393	75	0.191
Bottom-Y	10.0-200.0-B1	393	16	0.040
Top-X	10.0-200.0-T2	393	345	0.877
Top-Y	10.0-200.0-T1	393	276	0.702

Slab: S 1, Panel: Sl 5

Static

Reinforcement Design Summary

Reinforcement Layer	Reinforcement Provided	Area Provided [mm²/m]	Area Required [mm²/m]	Utilization
Bottom-X	10.0-200.0-B2	393	68	0.174
Bottom-Y	10.0-200.0-B1	393	69	0.175
Top-X	10.0-200.0-T2	393	326	0.829
Top-Y	10.0-200.0-T1	393	269	0.685

Slab: S 1, Panel: Sl 6

Static

Reinforcement Design Summary

Reinforcement Layer	Reinforcement Provided	Area Provided [mm²/m]	Area Required [mm²/m]	Utilization
Bottom-X	10.0-200.0-B2	393	92	0.234
Bottom-Y	10.0-200.0-B1	393	71	0.182
Top-X	10.0-200.0-T2	393	303	0.771
Top-Y	10.0-200.0-T1	393	255	0.650

Slab: S 1, Panel: Sl 7

Static

Reinforcement Design Summary

Reinforcement Layer	Reinforcement Provided	Area Provided [mm²/m]	Area Required [mm²/m]	Utilization
Bottom-X	10.0-200.0-B2	393	101	0.257
Bottom-Y	10.0-200.0-B1	393	25	0.063
Top-X	10.0-200.0-T2	393	295	0.750
Top-Y	10.0-200.0-T1	393	242	0.616

St. Base (Base)

Slab/Mat Panels

Mat: MF 1, Panel: Sl 1

Static

Reinforcement Design Summary

Reinforcement Layer	Reinforcement Provided	Area Provided [mm²/m]	Area Required [mm²/m]	Utilization
Bottom-X	H12-150.0-B2	754	274	0.363
Bottom-Y	H12-150.0-B1	754	502	0.665

Reinforcement Layer	Reinforcement Provided	Area Provided [mm²/m]	Area Required [mm²/m]	Utilization
Top-X	H12-150.0-T2	754	383	0.508
Top-Y	H12-150.0-T1	754	258	0.342

Party Retaining Wall W3

Static

Vertical Bars Summary

Panel	Length	Thickness	Vertical Bars	Analysis	Combination	Critical position	Ratio	Status
1	8.450 m	200.0 mm	98H10 - 174	3D Building Analysis	2	Bottom	**0.604**	✓ Pass

Shear Summary

Panel	Horizontal Bars	Top support link legs	Span link legs	Bottom support link legs	Analysis	Combination	Ratio	Status
1	H12-400	-	-	-	3D Building Analysis	2	**0.335**	✓ Pass

Head code: United Kingdom (Eurocode), design code: BS EN 1992-1-1 + UK NA (2004)

Static

Panel 1 - Critical

Vertical Bars - Critical

3D Building Analysis - Critical

2 ULS dead + Earth + Imposed Surcharge - Critical

Bottom - Critical

Axial force	N_{Ed} = 180.9 kN
Moment about	M_{major} = -49.5 kNm
Moment about	M_{minor} = 181.5 kNm
Major moment	$M_{major,res} = M_{major,res,conc}$ +
Minor moment	$M_{minor,res} = M_{minor,res,conc}$ +
Moment	$\mathbf{M_{major}^2 + M_{minor}^2 / M_{major,res}^2}$ **+**

✓ Pass

Shear - Critical

3D Building Analysis - Critical

2 ULS dead + Earth + Imposed Surcharge - Critical

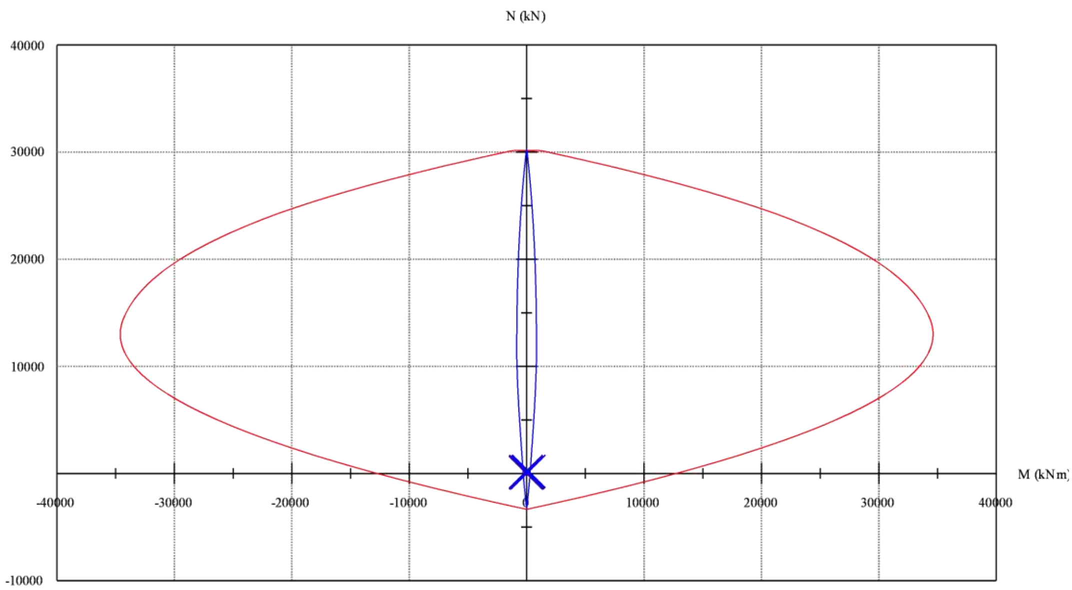
Minor Load Direction - Critical

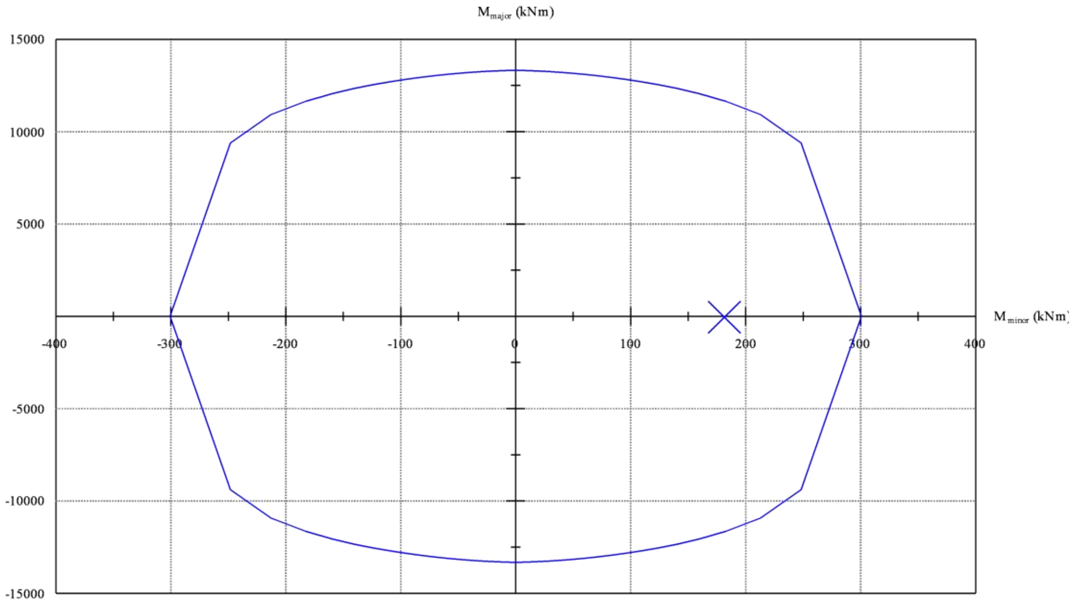
Unreinforced shear

✓ Pass

Interaction Diagrams

Static





M-M Interaction Diagram at N_{Ed} = 180.9 kN

Front Retaining Wall W4

Static

Vertical Bars Summary

Panel	Length	Thickness	Vertical Bars	Analysis	Combination	Critical position	Ratio	Status
1	6.300 m	350.0 mm	126H10 - 100	3D Building	2	Bottom	**0.351**	✓ Pass

Shear Summary

Panel	Horizontal Bars	Top support link legs	Span link legs	Bottom support link legs	Analysis	Combination	Ratio	Status
1	H16-400	-	-	-	3D Building	2	**0.355**	✓ Pass

Head code: United Kingdom (Eurocode), design code: BS EN 1992-1-1 + UK NA (2004)

Static

Panel 1 - Critical

Vertical Bars - Critical

3D Building Analysis - Critical

2 ULS dead + Earth + Imposed Surcharge - Critical

Bottom - Critical

Axial force	N_{Ed} = 457.7 kN
Moment about	M_{major} = -295.4 kNm
Moment about	M_{minor} = 249.6 kNm
Major moment	$M_{major,res} = M_{major,res,conc}$ +
Minor moment	$M_{minor,res} = M_{minor,res,conc}$ +
Moment	$\mathbf{M_{major}^2 + M_{minor}^2 / M_{major,res}^2 +}$

✓ Pass

Shear - Critical

3D Building Analysis - Critical

2 ULS dead + Earth + Imposed Surcharge - Critical

Minor Load Direction - Critical

Unreinforced shear

✓ Pass

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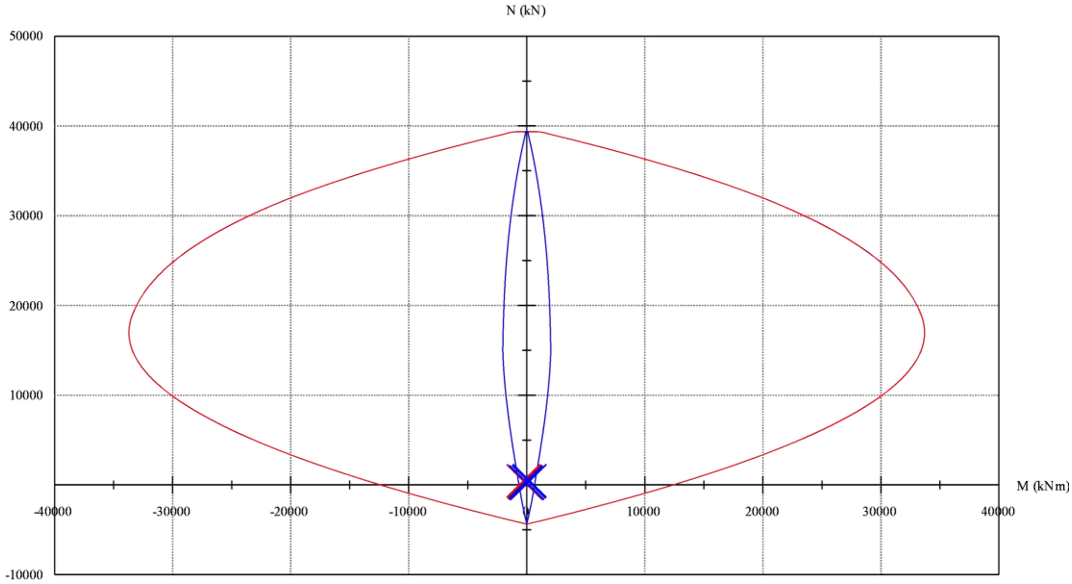
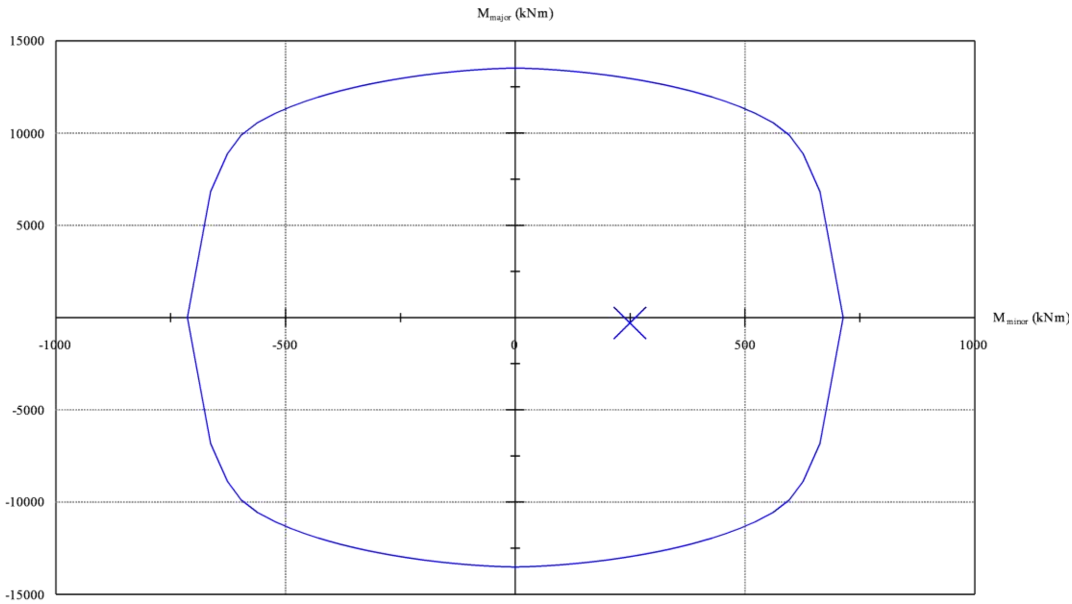
Interaction Diagrams

Static





M-M Interaction Diagram at N_{Ed} = 457.7 kN

Design Standards and Codes

The structural design is to comply with the Building Regulations. This is achieved by complying with the current issue of the Eurocodes as "approved documents" and the UK National Annexe. This includes:

Basis of Design

- BS EN 1990: Basis of structural design

Loading

- BS EN 1991-1-1: General Actions. Densities, self-weight, imposed loads for buildings
- BS EN 1991-1-3: General Actions. Snow actions or BS6399
- BS EN 1991-1-4: General Actions. Wind actions or BS6399
- BS EN 1991-1-5: General Actions. Thermal actions.
- BS EN 1991-1-6: General Actions. Actions during Execution.
- BS EN 1991-1-7: General Actions. Accidental actions.

Steel Design

- BS 5950, or
- BS EN 1993-1-1: General rules and rules for buildings
- BS EN 1993-1-2: General rules. Structural fire design
- BS EN 1993-1-5: Plated structural elements
- BS EN 1993-1-8: Design of joints

Timber design

- BS 5268: Structural Use of Timber

Concrete design

- BS EN 1992-1-1: General rules and rules for buildings

Materials

The following grades of new materials will be taken in the design of this project:-

- Superstructure Concrete C32/40 N/mm^2
- Reinforcement 500 N/mm^2
- Structural Steel S355