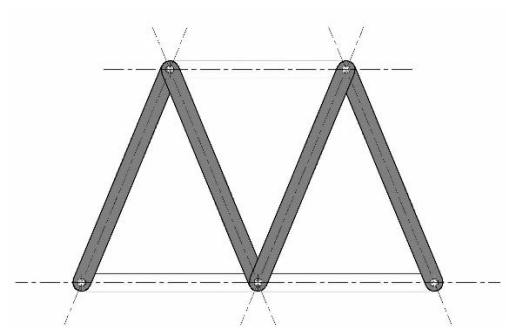




Morgan Structural Limited  
Blending Structure with Architecture

## **SRP1155: University Academy Long Sutton**

### **Structural Design Philosophy**

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| Author                                    | Signature   | Date       |
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## 1.0 Introduction

Morgan Structural have been appointed by Bowmer and Kirkland to provide Civil and Structural Engineering

Consultancy services for the University Academy Long Sutton project located on 84 Little London Spalding, PE12 9LF.

This report will identify the key considerations and design parameters associated with the specific site and the chosen solution.

### 1.1 Appointment

Scope of structural works includes foundations, suspended ground floor slabs, superstructure, below-ground drainage and external hard-standing design

## 2.0 The site

The development comprises of the proposed construction of a replacement 5FE Secondary School with existing sports facilities. The site is bordered by the Peele Leisure Centre. The surrounding areas comprise farms land as well as residential dwellings opposite to the site. The proposed facility is envisioned to accommodate a total of 720 pupils. The site is low-lying with a significant thickness of made ground. The proposed site incorporates associated buildings, hard landscaping areas, car park, playing fields and MUGA pitch.

## 3.0 Geo-Environmental

### 3.1 Geotechnical Assessment

Geotechnics Desk Study Ref PC228532 & Geotechnics Ground investigation Ref PC228532

General encountered strata:–

| Strata              |                   | Thickness (m)      | Comments                                                                     |
|---------------------|-------------------|--------------------|------------------------------------------------------------------------------|
| Top soil            |                   | 0.15 – 0.3         | N/A                                                                          |
| Made ground         |                   | 0.16 – 1.70        | Variable material and thickness                                              |
| Tidal Flat Deposits | Upper Silt Layers | 2.50 – 4.30        | Variable SPT values, a typical value of 26 being consistent with silt layers |
|                     | Lower Sand Layers | 6.90 – 9.90        | Variable SPT values                                                          |
| Glacial Till        |                   | 0.5 – 8.3 (proved) | Not proved in all locations                                                  |

Ground water was encountered within the Tidal flat Deposits, ie generally less than 1.5m below ground level.

The hierarchy of foundation solutions which have been considered.

| Solution                        | Comments                                                                                                                                                                  |
|---------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Strip/ pad Foundations          | Made ground unsuitable for founding.<br>The Upper Silt layers are unlikely to be economically due to low strength conditions.<br>The Glacial Till is too deep for strips. |
| Trench Fill or Pier foundations | Same as strip/ pad.                                                                                                                                                       |
| Ground Improvement              | Will require full treatment of the made ground and penetrate the competent underlying strata.<br>Specialist advice required.                                              |
| Piled Foundations               | Will need to hit the glacial till so potentially 20m depth, to be confirmed by further investigation and design by specialist piling contractor.                          |

Therefore:

The recommended solution is piling with piles of 450mm diameter of circa 20m length (length and diameter to be confirmed by specialist designer/ contractor).

Foundations will be kept as high as possible to be above the high-water table.

Additional ground investigation in terms of boreholes will be required under the proposed footprint as the glacial till has not been proved in this area.

### 3.2 Chemical testing

| Stratum                          | Design Sulphate (DS) Class | Aggressive Chemical Environment for Concrete (ACEC) Class |
|----------------------------------|----------------------------|-----------------------------------------------------------|
| Made Ground                      | DS-1                       | AC-1                                                      |
| Tidal Flat Deposits (Upper Silt) | DS-3                       | AC-3 *                                                    |
| Tidal Flat Deposits (Lower Sand) | DS-2                       | AC-2 *                                                    |
| Glacial Till (Clay Soil)         | DS-4                       | AC-4 *                                                    |

\* Based on oxidisable sulphides being present

### 3.3 Concrete Classification

Extract from GI report:

The report highlights that buried concrete within these strata's must meet these design classifications although the report does state the piles can be DS-1. However, this will form part of the specialist piling contractors design, and justification for any relaxation would be required at that stage.

This may also affect any below ground drainage and services if they extend below the made ground strata.

### 3.4 Flood Risk Assessment

The site is within Flood Zone 3 but is protected by defenses although less than a 1 in 150-year event.

To meet these criteria the finished floor levels will be set at 4.50m AOD with flood resilience up to 4.80m AOD.

This resilience will be by setting all services at a higher level and using water resistant materials below that level.

If though only 300mm difference and with the new location of the building it will be prudent to initially to look at raising the whole building to a higher level.

This will have the benefit of raising the foundations higher and avoiding the high-water table.

### 3.5 Environmental risk

There was a minor exceedance of the human health GAC for naphthalene for future site users in one soil sample.

One shallow soil sample composed of suspected sub-base installed prior to laying asphalt showed the presence of asbestos.

Therefore, there may be anticipated abnormal costs relating to the Asbestos encountered, at 0.002% in one Made Ground sample, and appropriate asbestos legislation and regulations will require implementation, including a risk assessment by the ground works / construction contractors.

### 3.6 Drainage

Refer to Civils Design Philosophy.

## 4.0 Structural Philosophy

### 4.1 Superstructure

The primary teaching building will consist of a braced steel frame, supporting precast concrete hollow-core planks acting compositely with primary steel beams. The floor system will act as a diaphragm distributing lateral forces to vertical braced bays. This is achieved through the tying of the precast planks to the steel frame/ each other and infill the concrete.

Gravity and Lateral forces will be distributed to the foundations via steel columns and the vertical braced bays.

The structure will comprise of primary down stand beams spanning across the classrooms. To facilitate cross ventilation solution, the perimeter beams and the beams spanning across the corridors will be set within the depth of the slab. SHS sections located within the depth of the slab will also be used around internal openings to provide connection points for balustrades, e.g. around the sports hall.

Due to the span direction of the precast concrete hollow-core planks being parallel with the corridor walls, the beams tying the corridor columns will be CHS's and set 100mm beneath the underside of the precast concrete hollowcore Floor and roof planks to minimise the potential for clashing with services serving the classrooms.

The external walls of the building will be formed using Hybrid Timber Panels supporting cladding. The timber panels will be supported by a precast ground beam spanning between pad foundation at ground floor level and via the 3rd floor perimeter steel beams. The effected beams have been designed for the self-weight of the Timber panels and the horizontal wind loading from the cladding.

The parapet will be formed using cold rolled Timber panels section fixed to the steel frame.

The roof over the teaching areas and corridors will consist of precast concrete plank construction. The precast planks will aid with the thermal performance of these spaces.

The roof over the sports hall will consist of purlins and insulated sandwich panels.

The lift pit will be formed from precast concrete lift shaft concrete walls.

Stairs will be precast concrete supported off the steel frame and positively fixed to the foundation below.

Refer to figure 4.1 below for the First Floor Layout Proposal.

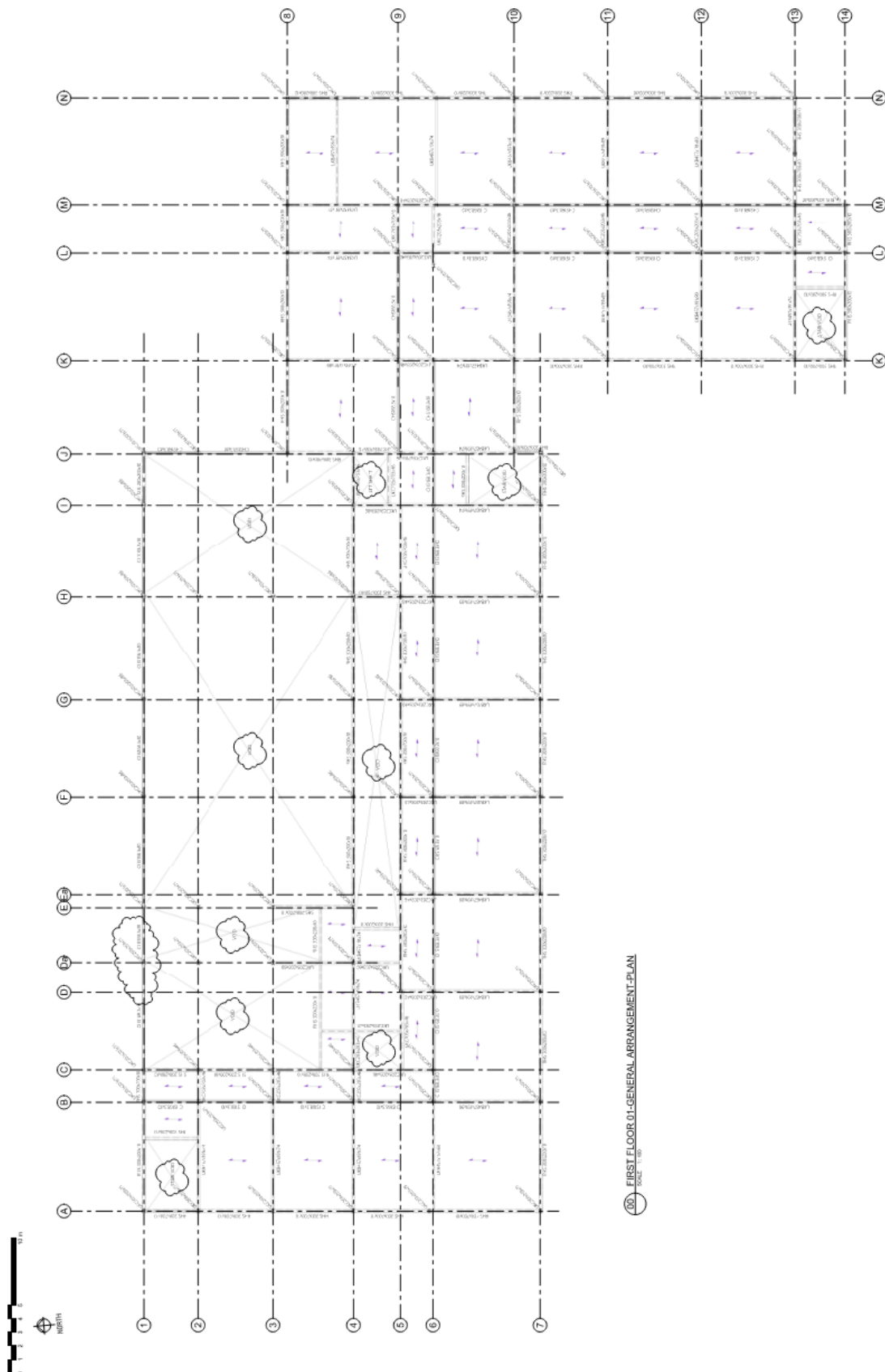


Figure 4.1 First Floor Layout

## 4.2 Disproportionate Collapse

The steel frame buildings will be constructed so that in the event of accidental damage, the building will not suffer collapse to an extent disproportionate to the cause. The structure is defined in Table 11 of “The Building Regulations 2010, Approved Document A3” as class 2B. This requires effective horizontal and vertical ties to be provided, or alternatively to check that upon the notional removal of each supporting column/wall and each beam/wall supporting one or more columns, the building remains stable and the area of floor at any storey at risk of collapse does not exceed 15% of the floor area of that story or 100m<sup>2</sup> (whichever is smaller) and does not extend further than the immediate adjacent storeys. The buildings have been designed with vertical and horizontal ties and precast floors anchored to the steel frame/each other to satisfy the disproportionate collapse requirements.

## 4.3 Vibration

The building will be designed to the following criteria as set out in BS:6472 to ensure that vibration of the floor structure does not have any adverse effects on the building's users

- Natural Frequency of floor slabs – Over 4.0Hz
- Natural Frequency of Stairs – Over 7Hz

## 4.4 Tolerances

As a minimum, the structures are to be built to tolerances stated in the National Structural Concrete Specification and the National Structural Steelwork Specification for Building Construction.

Construction tolerances for the timber frame superstructure will be to BS 5606, TRADA and STA Advice Notes (whichever is the most onerous).

## 4.5 Design life

The structural frame will be designed in accordance with BS EN 1992-1-1:2004, BE EN 1993-1-1:2005 and 1995-1-1:2004. The structural frame, foundations, floor slabs, roof and stairs will be designed to a minimum life expectancy of 50 years. Appropriate concrete cover for concrete elements (taking into consideration sulphates, fire, carbonation, chlorides and freeze/thaw attack) and paint/galvanising systems for steel elements will be specified as required to provide adequate protection. Periodic inspection and maintenance will be required throughout the life of the building to ensure protection measures are performing adequately.

## 4.6 Loading Schedule

In accordance with BS EN 1991-1-1:2002 Eurocode 1 - Actions on structures Part 1-1: General Actions

**\*\*Note** where on timber SIPS frames the superstructure dead loading should be confirmed by Innovare Systems Ltd. The below loads are therefore indicative only and indicated solely for an appreciation of the ultimate foundation loads.

### Permanent actions

| Roof | kN/m <sup>2</sup> |
|------|-------------------|
|------|-------------------|

|                                           |      |
|-------------------------------------------|------|
| **Photovoltaic panels                     | 1.00 |
| **Roofing system & insulation             | 0.25 |
| **Timber joists and boarding              | 0.40 |
| **Ceiling                                 | 0.20 |
| **Services                                | 0.25 |
| <b>Upper floors</b>                       |      |
| **Finish                                  | 0.10 |
| **75mm screed                             | 1.80 |
| **200mm precast hollowcore concrete plank | 3.10 |
| **Ceiling                                 | 0.20 |
| **services                                | 0.25 |

### Variable Actions

| <b>Roof</b>                       | <b>kN/m<sup>2</sup></b> |
|-----------------------------------|-------------------------|
| Access                            | 3.00                    |
| No access                         | 0.60                    |
| <b>Floors</b>                     |                         |
| Corridors, Stairs and Landings    | 4.00                    |
| Classrooms                        | 3.00                    |
| Library                           | 4.00                    |
| Storage                           | 5.00                    |
| Dining                            | 5.00                    |
| Sports Halls and Activity studios | 5.00                    |
| Plant rooms                       | 7.50                    |

### Snow Load Summary

Snow loads calculations are to be undertaken for all exposed roof areas by steel frame designer. Snowdrift load is to be considered where necessary.

- Characteristic Ground Snow Load to NA to BS EN 1991-1-3:2003, Figure NA.1 = 0.50kN/m<sup>2</sup>

### Wind Load Summary

The wind loading on the structure is to be calculated in accordance with BS EN 1991-1-4:2005+A1:2010 and the National Annex using the following criteria.

- Fundamental Basic Wind Velocity,  $v_b$ , map = 21.5 m/s
- Altitude, A = 18.65 m

### Equivalent Horizontal Forces (EHF)

Equivalent Horizontal Forces (EHF) are to be calculated and applied in accordance with BS EN 1993- 1-1, Clause 5.3.2 (7)

### 4.7 Deflection, Sway and Drift

The limits shown in the table below are to be used in the design of structural members. Where possibly affected, non-structural element, particularly glazing and masonry, must be designed to accommodate these movements.

| Element                                                      | Limit |
|--------------------------------------------------------------|-------|
| Beams/Floors                                                 | L/250 |
| Beams/Floors – Brittle finishes (due to variable action)     | L/500 |
| Beams/Floors – Non-brittle finishes (due to variable action) | L/360 |
| Building stability                                           | H/300 |

## 5.0 Design Standards

The building and associated works will be designed in accordance with the latest editions of the relevant Eurocodes, associated UK National Annex and Codes of Practice as listed and as appropriate to the form of construction used, but not limited to.

1. BS EN 1990:2002 Eurocode 0- Basis of structural design
2. BS EN 1991-1-1:2002 Eurocode 1 - Actions on structures Part 1-1: General Actions
3. BS EN 1991-1-3:2003 Eurocode 1 - Actions on structures Part 1-3: General actions – Snow Loads
4. BS EN 1991-1-4:2005 Eurocode 1 - Actions on structures Part 1-4: General actions – Wind Actions
5. BS EN 1992-1-1:2004 Eurocode 2 - Design of concrete structures Part 1-1:
6. BS EN 1993-1-1:2005 Eurocode 3 - Design of steel structures Part 1-1:
7. BS EN 1994-1-1:2004 Eurocode 4 - Design of composite steel and concrete structures Part 11:
8. BS EN 1995-1-1:2004 Eurocode 5: Design of timber structures.
9. BS EN 1996-1-1:2005 Eurocode 6 – Design of masonry structures Part 1-1:
10. BS EN 1997-1:2004 Eurocode 7: Geotechnical design Part 1: General Rules
11. Building Regulations Approved Document A

The following British Standards and design guides shall be used for storm water design purposes. Please note that this list is not exhaustive but covers the overall general drainage requirements.

1. BS EN 752 - Drain and Sewer Systems Outside Buildings
2. BS EN 12056-3 - Gravity Drainage Systems Inside Buildings – Part 3 Roof Drainage
3. BS EN 16933-2 - Drain and Sewer Systems Outside Buildings – Part 2: Design
4. The Code - Design and Construction Guidance for foul and surface water sewers offered for adoption under the code for adoption agreements for water and sewerage companies operating wholly or mainly in England
5. CIRIA C753 - The SuDS Manual
6. DEFRA/EA - Preliminary Rainfall Run Off Management for Developments (2013)
7. CIRIA - Interim Code of Practice for Sustainable Drainage (2004)
8. CIRIA C635 - Designing for Exceedance in Urban Drainage - Good Practice (2006);
9. HR Wallingford - Wallingford Procedure for Design and Analysis of Urban Storm Drainage
10. SSG 2019 - Sewer Sector Guidance (formerly Sewers for Adoption)
11. Building Regulations 2010 - Approved Document H – Drainage and Waste Disposal 2015

In accordance with Building Regulations 2010 Approved Document H, Section H5, separate foul and surface water systems shall be designed for the proposed development before connection into an existing combined Public Sewer.

The following British Standards and design guides shall be used for foul water design purposes. Please note that this list is not exhaustive but covers the overall general drainage requirements.

1. BS EN 752 - Drain and Sewer Systems Outside Buildings
2. BS EN 12056-2 - Gravity Drainage Systems Inside Buildings – Part 2 Sanitary Drainage
3. BS EN 16933-2 - Drain and Sewer Systems Outside Buildings – Part 2: Design
4. SSG 2019 - Sewer Sector Guidance (formerly Sewers for Adoption)
5. BW COP 4 - British Water Flows and Loads 4
6. Building Regulations 2010 - Approved Document H – Drainage and Waste Disposal 2015