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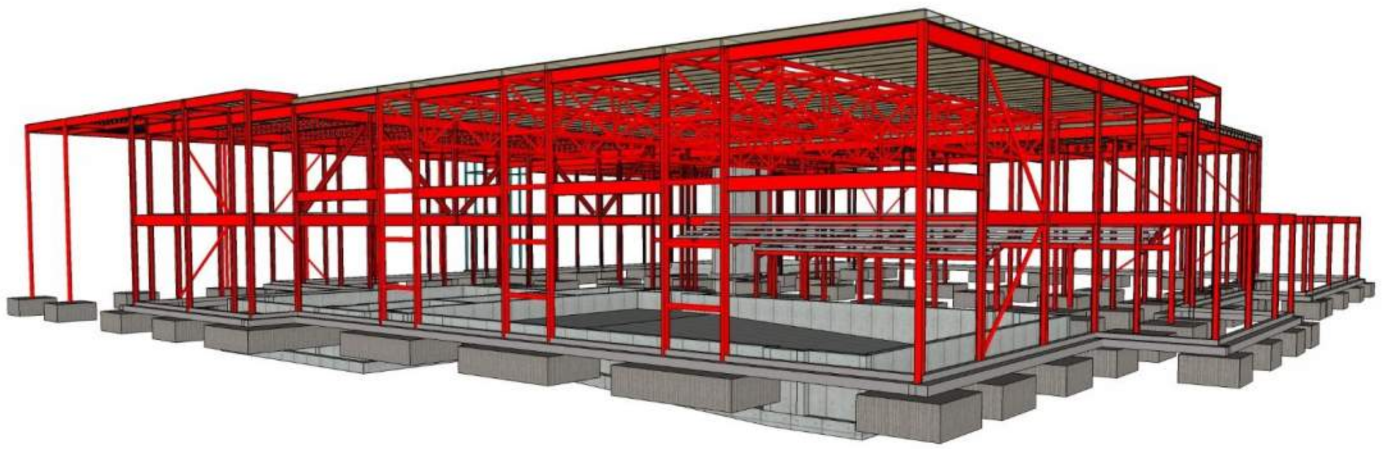

DOVER LEISURE CENTRE

STRUCTURAL & CIVIL ENGINEERING RIBA STAGE 2 REPORT

for

GT3 Architects

17th June 2016

634-S-REP-001
Rev 0

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STRUCTURAL & CIVIL ENGINEERING RIBA STAGE 2 REPORT

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Revision History

Rev	Date	Purpose/Status	Document Ref.	Comments
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1 EXECUTIVE SUMMARY

1.1.1 Engenuiti has been appointed by GT3 Architects to provide civil and structural engineering design services for the proposed new leisure centre for Dover.

1.1.2 The purpose of this Structural & Civil Engineering Feasibility RIBA Stage 2 Report is to describe the civil & structural engineering concept design of the proposed development to support the preliminary cost estimates for the project.

1.1.3 The proposed leisure centre is located in Whitfield, Dover. The site postcode is CT16 3FH. The site location is south of Honeywood Parkway and east of The Glenmore Centre.

1.1.4 The site is currently a greenfield location bounded by Honeywood Parkway and a spur road to the east of the site.

1.1.5 The proposed leisure centre is a new build facility. The new facility will be designed around the following accommodation mix:

- 8 lane 25m pool
- Learner pool with moveable floor
- Wet changing village
- Activity zone around a new café space
- 4 court sports hall with associated changing
- Treatment rooms
- Gymnasium
- 2 large dance studios
- Spinning studio.

1.1.6 The proposed building superstructure can be conceptually split into four key components as follows:

- Long-span roof structures over swimming pools, sports hall and studios (column free areas)
- Floor slabs to studio and office spaces supported on an regular grid of vertical support
- Secondary structure to façade and building envelope
- Swimming Pool structures

1.1.7 Several structural framing solutions can be applied to the proposed architectural form. The long span roofs can be framed using cellular steel beams, steel trusses or glulaminated timber beams or trusses. The floor slabs to studio and office areas can be frames using steel columns and beams with composite reinforced concrete slabs cast on metal deck or using precast concrete soffit panel systems. Cross Laminated Timber (CLT) floor options are also possible.

1.1.8 Secondary structural framing to building envelope can be through the use of metal decks, timber cassettes, composite panel systems, concrete block walls, cold formed steel backing systems and CLT panels.

1.1.9 The swimming pool structure can be constructed out of in situ reinforced concrete, stainless steel systems or sprayed concrete.

1.1.10 The British Geological Survey (BGS) online map indicates that the sites bedrock geology is Margate Chalk Member. The sites superficial deposits are of Clay with flints formation, consisting of clay, silt sand and gravel.

1.1.11 Based on the desktop study of the local geology and borehole data available on the BGS website we suggest that the proposed structure and ground conditions may be suitable for shallow pads and ground bearing slabs founded on the chalk.

1.1.12 Our experience of leisure centre construction suggests that shallow foundations and a ground bearing pool structure are the most favoured starting point from a cost perspective but that allowance should be made for a piled foundation solution until further ground information is available.

1.1.13 Applications and consultation will be required to Southern to agree a method of discharge and flow rate from the swimming pools. Additional applications will be required to Southern Water if connecting to the public sewer network and also to the Environment Agency if the final proposal incorporates discharge to ground.

1.1.14 As the development is considered "Major", the Local Lead Flood Authority: Kent County Council SuDS pro-forma will need to be completed as part of the planning application process.

1.1.15 We will investigate the feasibility of discharging surface water to ground through a soakaway, incorporating results from infiltration testing. Additional SuDS measures will also be studied and considered further at the next design stage.

1.1.16 At this stage we suggest using a baseline structural option of a steel frame with long span truss over the swimming pool and long span cell beam roof, shallow RC foundations and in situ RC swimming pool. We have progressed the cladding design using a timber cassette envelope solution.

2 INTRODUCTION

2.1 General

2.1.1 Engenuiti has been appointed by GT3 Architects to provide civil and structural engineering design services for the proposed new leisure centre for Dover District Council.

2.1.2 The purpose of this Structural & Civil Engineering Feasibility RIBA Stage 2 Report is to describe the civil & structural engineering concept design of the proposed development to support the preliminary cost estimates for the project.

2.1.3 This report has been produced for the exclusive use of GT3 Architects and should not be used in whole or in part by any third parties without the express permission of Engenuiti in writing.

2.1.4 This report should not be relied upon exclusively for decision making purposes and should be read in conjunction with other documents and drawings produced by the design team.

2.2 Proposed Development

2.2.1 The proposed leisure centre is located in Dover, Kent. The site location is near the Whitfield Interchange just south of the main A2 road and is bounded by Honeywood Parkway.

2.2.2 The site is currently a greenfield location bounded by Honeywood Parkway and a spur road to the east of the site.

2.2.3 The proposed leisure centre is a new build facility. The new facility will be designed around the following accommodation mix:

- 8 lane 25m pool
- Learner pool with moveable floor
- Wet changing village
- Activity zone around a new café space
- 4 court sports hall with associated changing
- Treatment rooms
- Gymnasium
- 2 large dance studios
- Spinning studio.

Figure 2.1: Architectural Concept Design Proposal View 1

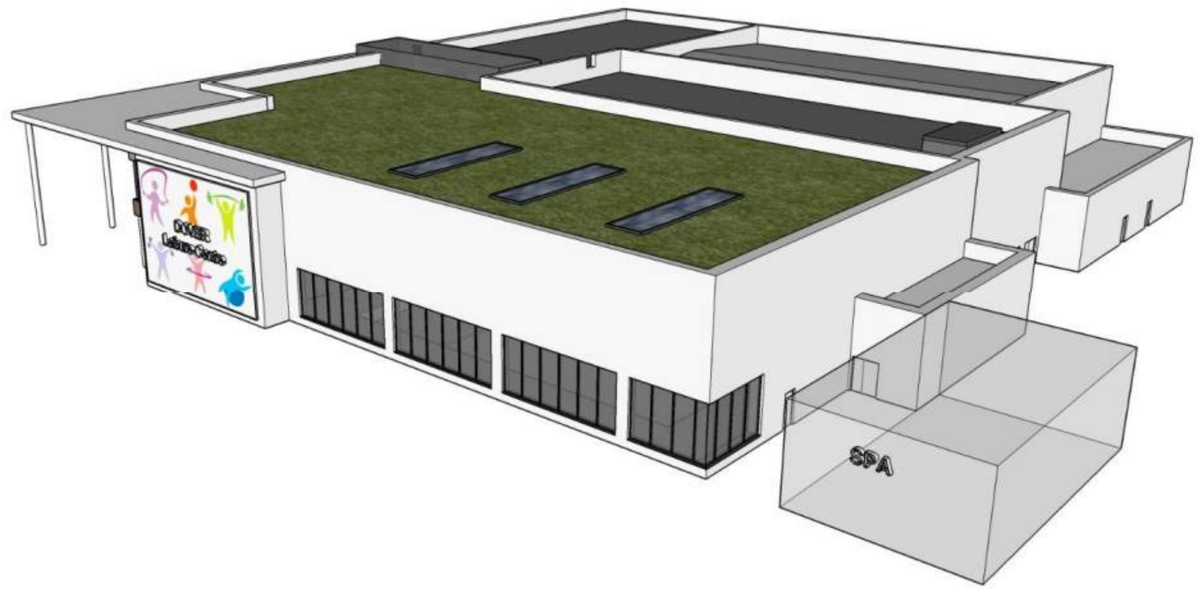


Figure 2.2: Architectural Concept Design Proposal View 2

3 DESIGN BRIEF & STRUCTURAL FRAMING OPTIONS

3.1 Development of Key Structural Design Criteria

3.1.1 From an understanding of the Architect's (GT3 Architects) aspirations a list of key structural questions have been developed as shown in Table 3.1 below.

Driver	Comments
Aesthetics	Long span roof structures above the Swimming Pool and Sports Hall are to designed and detailed to high aesthetic standards. Steel and Timber options to be considered.
	Sports Hall and gymnasia roof soffits to be expressed and provide acoustic performance. Swimming pool roof to feature timber ceiling cassette roof, acoustic metal deck or similar.
	Façade Glazing – standard high quality system for clear edges to swimming pool hall.
Cost	Lowest cost for required quality.
Flexibility	Administration and studio spaces to be flexible for future configurations, consider structural grids to minimise layout impact.
	Imposed load for general areas 4 kN/m^2 (3+1), with studio and gymnasia spaces designed as 5 kN/m^2.
	Fabricated steel sections with 300 / 350mm dia. openings are provided in central change and entrance areas at high-level ground floor and first floor for services distribution.
	Swimming Pool plant room located adjacent to pool hall building to avoid building a basement if possible.
Programme	Procurement route unknown at this stage
Restrictions	Early consultation with local specialists to ensure swimming pool tanks and roof structure options are detailed to most economic solutions.
	The studio and party room areas are required to achieve an 8.4Hz system frequency as these areas will be subject to rhythmic dance activities.
	Consideration of the chalk ground conditions
Sustainability	Sustainability should be an important consideration balanced with cost implications.

Table 3.1: Key Structural Questions

3.1.2 From these key design questions/criteria the primary structural requirements developed are:

- Cost is key to each design consideration – best cost for required quality.
- Aesthetics are very important especially with the desire to create an expressive and efficient long span roof structure. This spans approximately 28m in the swimming pool area.
- Sustainability design criteria are likely to be key, but subject to further development (including consideration of Capital Cost Vs Whole Life Cost Vs Low Carbon Design).

3.2 Structural Framing Concept

3.2.1 The proposed building superstructure can be conceptually split into four key components as follows:

- Long-span roof structures over swimming pools, sports hall and studios (column free areas).
- Floor slabs to studio and office spaces supported on a regular grid of vertical support.
- Secondary structure to façade and building envelope.
- Swimming Pool structures.

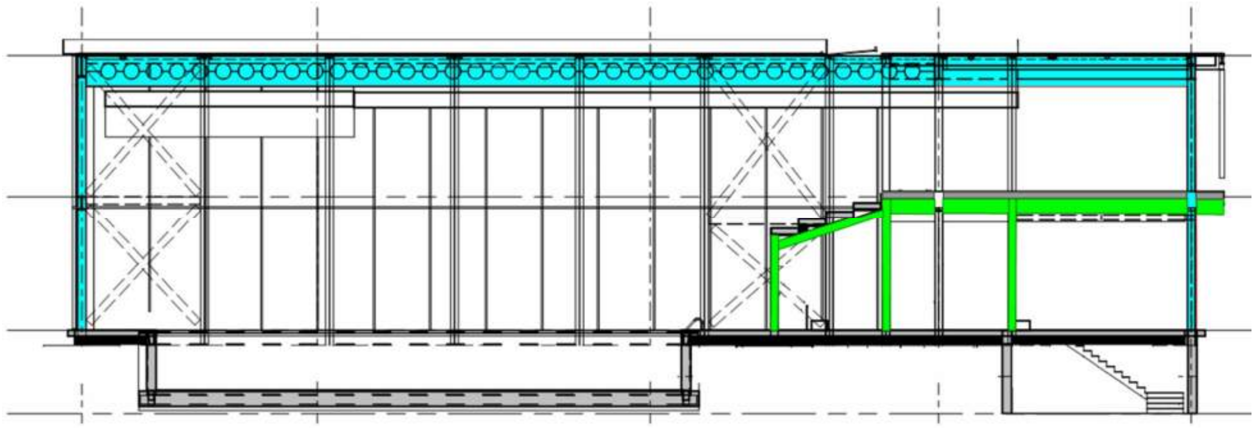


Figure 3.1: Structural Framing Concept – Long Span enclosure (blue) over traditional framed floor structures (green)

3.2.2 The sports hall and swimming pool are effectively covered with long-span structures (steel or timber).

3.2.3 The first floor deck (studios and offices) is generally supported by a regular grid of columns or walls (spanning to first floor only) allowing a wide variety of efficient floor structures to be considered in steel, concrete, timber, or hybrid combinations.

3.2.4 Column free areas beneath first floor slabs can be formed with additional transfer structures (steel or timber).

3.3 Long-Span Roof Structures

3.3.1 The architectural proposal for the sports hall and swimming pools suggests a flat roof with some allowance for roof lights. There are several structural options for framing these types of roofs but a driving factor will be an ambition to make the structure as economic as possible and to try to reduce the main span of the roof beams by adding intermediate columns on major wall lines.

3.3.2 Deep steel beams can be used to form the primary beams. These could be fabricated steel beams or beams with cellular openings. By increasing the depth of the steel beams, a lighter section can generally be used, though deeper beams may reduce natural daylighting to the areas below. Provision of beams with cellular openings provides an efficient primary support structure and allows services to pass through the cells of the beams.

3.3.3 Similar structural framing can be formed with fabricated steel trusses. These provide a lighter visual appearance (and generally require a lower tonnage of steel compared to solid beam sections, which can make this a cost-competitive option). Trusses can be delivered to site in sections with splices formed on site, to ease transportation difficulties. Services can more easily co-ordinated with the open structural form.

3.3.4 The use of glu-laminated solid timber beams over the swimming pool may be considered as it provides the major benefit of significantly reduced maintenance programme as timber does not require sacrificial protection against corrosion. This choice of structural material is also a major consideration in low carbon design. Glu-laminated beams would be designed on the basis that the moisture and temperature levels within the pool would be controlled ('service class 2'), to be discussed further with the design team.

3.3.5 The secondary roof structure spanning between the main roof beams can be provided in several ways including secondary steel purlins, metal deck cassettes, solid timber CLT roof panels and also timber roof cassettes.

3.3.6 A more detailed appraisal of some of the long-span roof options discussed above is found in Appendix C ('Long Span Roof Studies', June 2016)

Figure 3.2: Timber / Steel Long-Span Roof Options

3.4 Floor Decks and structural framing: Studios and Offices Studio Spaces

3.4.1 The first floor slabs (studios and offices) can be primarily framed in steel, in situ concrete or timber glu-laminated beams supported on steel or in situ concrete columns or timber (CLT walls).

3.4.2 Floor decks can be formed in in situ concrete (on falsework or steel decking), pre-cast concrete decks or solid timber (cross laminated timber structures) depending on function, durability issues, visual aspirations and cost.

3.4.3 Columns would be provided on an open grid to allow circulation around changing rooms, entrance halls etc. Closer column grids could provide a thinner and lighter overall structure, but would impact these areas and their future ability to be altered.

3.5 Steel Framed Floor Decks

3.5.1 A steel frame either with fabricated beams (with cellular openings or with services running under standard beams) is an economic framing solution for leisure centre structures as it has great flexibility for creating clear spans over secondary layouts such as changing areas and entrance foyers.

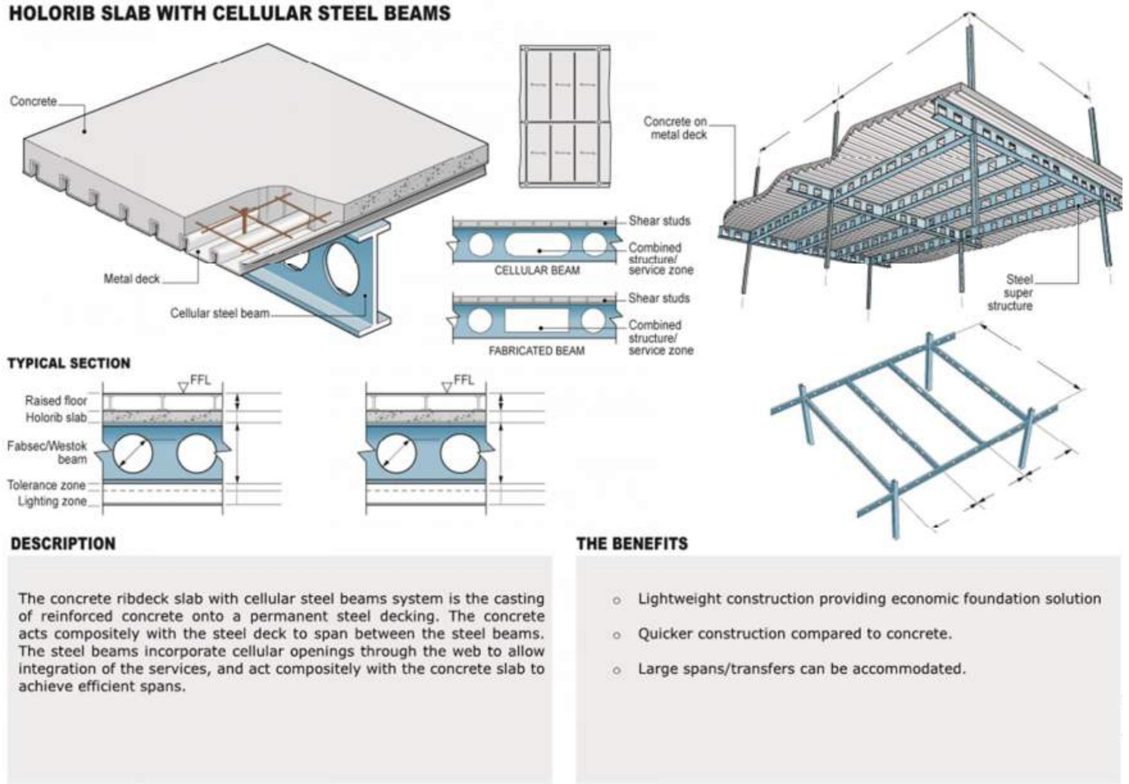


Figure 3.3: Structural Slab options – Composite concrete / steel decks on steel frame

3.5.2 The negative issues with steel frames and composite decks are primarily concerned with long-term corrosion protection in the "wet-areas" of the buildings.

3.5.3 In conjunction with a steel frame, a slab may be formed using either composite decking or pre-cast RC units (omnia deck) with a structural concrete topping. The corrosive atmosphere requires special measures to be taken where composite decks are used, where in situ concrete, omnia decks or timber panels would be best suited.

3.5.4 Composite decks sometimes require temporary propping during construction, which we would aim to avoid. This is feasible with a trapezoidal deck profile. Propped floor solutions are generally avoided due to the detrimental effect on construction programming.

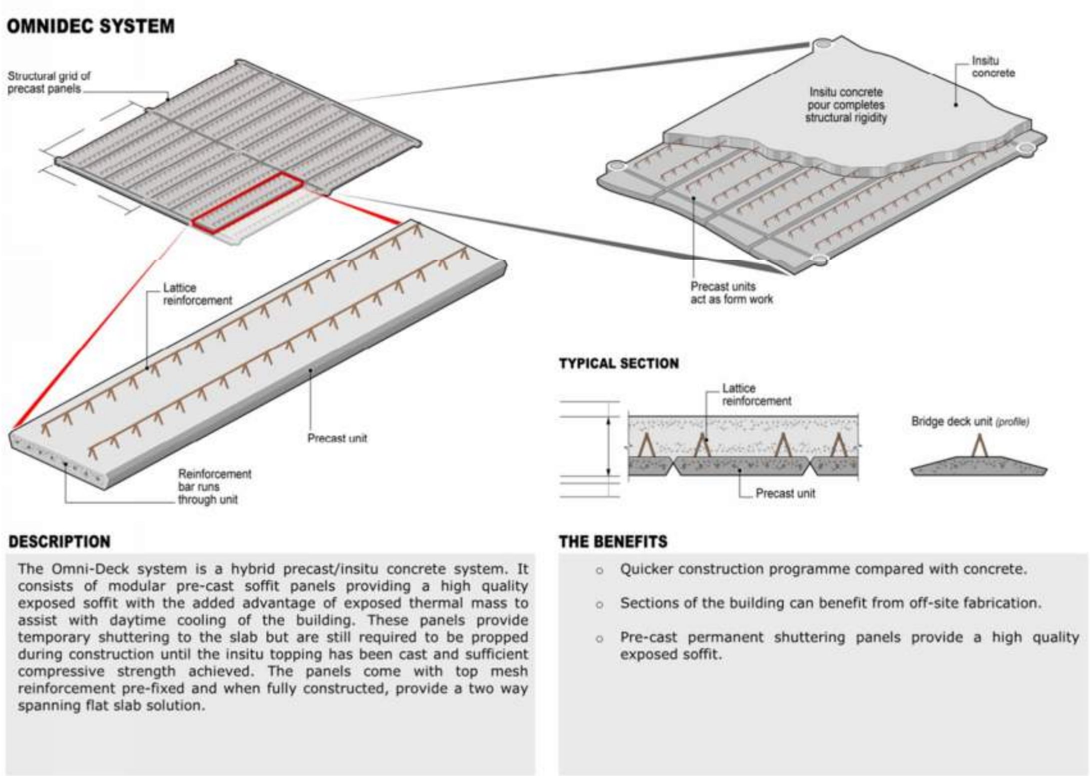


Figure 3.4: Structural Slab options –Omnia pre-cast concrete decks with structural topping (below)

3.5.5 Steel framed floor decks on a regular grid of columns will provide a fairly lightweight structure which is likely to suit a pad foundation strategy.

3.5.6 Column free areas can be easily formed by using deeper cellular beams or by forming upstand trusses connecting the first floor and roof steel beams.

3.6 In situ reinforced concrete frame with flat slabs

3.6.1 An in-situ reinforced concrete flat slab on in-situ columns typically has several advantages:

i The damp and potentially corrosive atmosphere in the wet change area would result in expensive protection requirements to the steel. With a concrete flat slab the required protection can be achieved by increasing the cover to protect the reinforcement.

ii The lack of downstand beams facilitates the distribution of services.

iii The concrete will offer an improved vibration and acoustic performance below the fitness suite over and above a steel/concrete composite option.

iv It offers the option of an exposed concrete slab over the reception area, with the associated exposed thermal mass to regulate heating and cooling.

3.6.2 An in situ concrete frame (flat slab construction) would be suitable for some areas of the first floor structure but the requirement for large column free areas could make this solution unfeasible over the training pool and atrium areas.

3.7 Hybrid Options

3.7.1 A variety of schemes can be offered which follow a hybrid approach to combine the advantages of each material. An example of this would be the use of CLT floor slabs and walls at first floor with additional steel beams and columns to provide additional rigidity and stability.

3.8 Disproportionate Collapse & Overall Stability

3.8.1 The structural building design will consider the requirements to prevent disproportionate collapse in accordance with the relevant guidance, either by the key element design method or by designing appropriate ties as necessary.

3.8.2 For steel framed structures (including composite steel/timber) braced bays could be used to provide stability. Where open facades are to be uninterrupted by vertical bracing, this could be replaced with moment frames and plan bracing (as detailed on the feasibility proposals). Omission of bracing would generally be considered a less economical solution, but has large advantages in terms of the architectural merit of the building and may also allow improved daylighting to certain spaces.

3.8.3 The use of RC walls and cores could also be considered as an alternative to some braced bays.

3.8.4 Global stability of the long-span roof structures needs to be considered carefully in the final detailing of the building.

4 SWIMMING POOL CONSTRUCTION OPTIONS

4.1 Swimming Pool Construction

4.1.1 The approach to the construction of the swimming pools is a key consideration in the design of any 'wet side' leisure centre. Likewise, careful consideration must be given to the implications of chlorinated pool water in selecting structural materials and protection systems for the pool hall structural framing. These issues are further discussed below.

4.2 Types of Swimming Pool Construction

4.2.1 The types of pool construction most likely to be suitable for a ground floor level pool in a leisure centre context are:

1(a) Shuttered in-situ reinforced concrete to BS 8007 / BS EN 1992, part 3.
This is reinforced concrete which is detailed so that it is capable of acting as a water-retaining structure. This detailing extends to the use of hydrophilic strips or waterbars at joints and the arrangement of reinforcement to restrict crack widths (usually to 0.2mm). A water resisting additive may also be employed in the concrete mix.

1(b) Sprayed concrete (shotcrete or gunite)
This is concrete which is applied pneumatically through the use of a pump or hose or nozzle. The wet concrete is sprayed over the reinforcement cage to form a continuous wall with minimal construction joints. Mixes with lower water content can be employed than is the case for conventional cast in-situ concrete, enabling the use of fewer joints.

2(a) Stainless steel side walls, with structural steel back framing, bolted down onto reinforced concrete slab and lined internally with PVC membrane. An example of this is the system supplied by *Myrtha*.

2(b) Stainless steel side walls and floors, with structural steel back framing and welded seams.

4.2.2 Other forms of pool construction which are unlikely to be appropriate in the leisure centre context include:

3 Concrete blockwork formwork filled with reinforced concrete
Used primarily for private and hotel pools. Robust detailing would depend on specialist input.

4 Reinforced concrete, not designed to BS 8007, but internally tanked
Not recommended due to potential risk of damage to internal membrane, e.g. via thermal shock

4.2.3 Options 1a, 1b, 2a, and 2b are compared in the following table. This table is derived from the 'Pool Tank Constructions' table provided in **Sport England; Swimming Pools Design Guidance Note; February 2011; revision 003**. Additional comments which do not derive from this reference document are provided in italics

	1a. Reinforced Concrete In-situ	**1b. Sprayed Concrete**	**2a. Stainless Steel Side Walls and PVC Liner**	**2b. Stainless Steel Walls and Floor with Welded Seams**
Structural	Monolithic design for whole of tank and pool surrounds when constructed from in-situ water retaining concrete to BS 8007 / BS EN 1992 Part 3 gives a highly stable structure.	Gunnite sprayed reinforced concrete. Usually with integrated transfer channel. Fixtures and fittings need to be integrated into the tank design. *Particularly efficient method for pools with curved and irregularly shaped edges. Requires an experienced subcontractor.*	Stainless steel side walls incorporating structural back framing fixed to a reinforced concrete floor.	Polished stainless steel side walls and floors incorporating structural back framing and welded seams. Stainless steel panels usually available up to depths not greater than 3m. Junction with pool surrounds and floor structure requires special care.
Waterproofing	Inherent if pool well constructed and detailed in accordance with BS 8007 / BS EN 1992 Part 3. Can be augmented by waterproof liner and/or render.	*Inherent if constructed correctly, and with the benefit that there are fewer joints (weak points) than is the case in a conventional cast in-situ walls.*	Typically factory applied PVC facing to wall panels and loose PVC floor liner with seas thermally welded.	*Inherent.* Bare polished stainless steel wall and floor panels with welded joints.
Finishes	Ceramic tiles on render backing recommended.	Ceramic tiles on render backing recommended.	PVC as described above. Can apply tile finishes on top.	No finish or ceramic tile options to upper wall sections subject to design and stiffening.
Robustness	Robust – minimal risk of damage from vandalism or pool hall activities. Durable. Stable construction. Workmanship critical.	Robust – minimal risk of damage from vandalism or pool hall activities. Durable. Stable construction. Workmanship critical.	PVC lining is liable to mechanical damage from sharp objects e.g. puncture resulting in leakage. Potential movement issues at junctions with loose linings and more rigid surrounds. Workmanship critical.	*Junctions between stainless steel tank and surround is obvious weak point. Workmanship critical.*
Service Life	Proven long service life. Examples c.100 years+.	*Method only in common usage since 2000, so extent of lifetime not yet proven, but would expect long lifetime if workmanship adequate.*	Periodic replacement of liners required (c.10 years). Oldest examples c.40 years.	Oldest examples c.40 years.
Maintenance	Minimal long term maintenance of structure. *Inspection and cleaning of grout anticipated on 5-7 year cycle.* Re-grouting of ceramic tiles may be required at c.20 year intervals. Life of finishes will depend on quality of materials, maintenance of pool water quality, wave action and chemicals utilised.	Minimal long term maintenance of structure. *Inspection and cleaning of grout anticipated on 5-7 year cycle.* Re-grouting of ceramic tiles may be required at c.20 year intervals. Life of finishes will depend on quality of materials, maintenance of pool water quality, wave action and chemicals utilised.	Regular inspection and quick repair of PVC liner damage required. Annual inspection of stainless steel structure to check for pitting/corrosion.	Annual inspection of stainless steel structure to check for pitting/corrosion.

Construction	Long construction period for concrete shell. Wet trade for pool finishes require an extensive period for application and curing. Lack of long term warranty.	extensive period for application and curing. Lack of long term warranty.	Lengthy off-site design and prefabrication time requires early placement of contract. Short installation period. Maximum warranty period 15 years. Reductions in programme time are possible compared with a concrete pool.	Lengthy off-site design and prefabrication time requires early placement of contract. Short installation period. Maximum warranty period 15 years. Reductions in programme time are possible compared with a concrete pool.
Quality Control	Resolution of severe defects and leakage can be complex requiring potential drainage of pool and resulting in extended closure. Dimensional control dependent on quality of workmanship on site.	Resolution of severe defects and leakage can be complex requiring potential drainage of pool and resulting in extended closure. Dimensional control dependent on quality of workmanship on site *(allow zone of finishes for tolerance).*	Resolution of severe defects and leakage can be complex requiring potential drainage of pool and resulting in extended closure. Dimensional control achieved through factory prefabrication and site control.	Resolution of severe defects and leakage can be complex requiring potential drainage of pool and resulting in extended closure. Dimensional control achieved through factory prefabrication and site control.
One stop shop for Responsibility	No	Not fully	Yes	Yes
Cost	Usually used as benchmark option for costing. Allowance needs to be made for cost of periodic closures for repairs to tiles and grouting (e.g. tile replacement from 25 years onwards).	Allowance needs to be made for cost of periodic closures for repairs to tiles and grouting (e.g. tile replacement from 25 years onwards).	Can be cheaper in terms of capital costs and short term expenditure. Allowance needs to be made for cost of periodic closures for repairs (e.g. replacement of lining from 10 years onwards).	*Usually expected to be more expensive up front than option 2a. No need for liner replacement but ultimate tank lifetime unproven.*

4.2.4 Reinforced concrete, cast in situ, remains the most common and tried-and-tested approach to the construction of leisure centre swimming pools. It relies on good workmanship that, if achieved, can result in durable tank structures with a surface which can be relatively easily finished. This remains the team’s recommended starting point for leisure centre pool construction, and this will be the approach that is adopted as the design progresses unless obvious project specific factors act to drive the design strategy in another direction.

5 SITE CONDITIONS

5.1 Background

5.1.1 A preliminary desk- top study of the geology has been undertaken for the site based on historical and current topographic maps and British Geological Society borehole records.

5.1.2 A detailed site investigation including boreholes, in situ and laboratory geotechnical testing and testing for any potential ground contamination has not been undertaken at this stage.

5.2 Site Location & Existing Use

5.2.1 The proposed leisure centre is located in Dover, Kent. The site location is near the Whitfield Interchange just south of the main A2 road and is bounded by Honeywood Parkway.

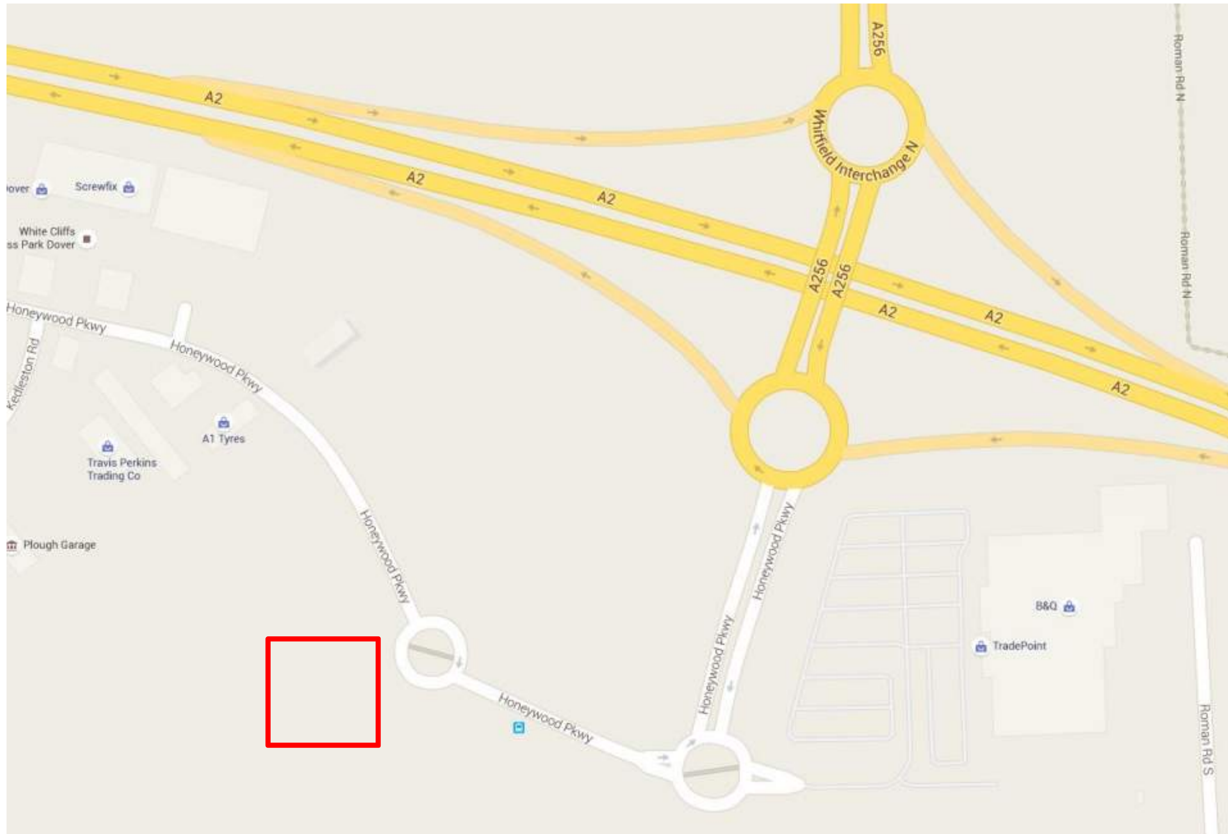


Figure 5.1: Site location (extract from Google Maps)

5.2.1 The site is currently a greenfield location bounded by Honeywood Parkway and a spur road to the east of the site.

Figure 5.2: Site Photograph with indicative redline boundary (Google Earth)

5.3 Geotechnical Considerations

5.3.1 The British Geological Survey (BGS) online map indicates that the sites bedrock geology is Margate Chalk Member. The sites superficial deposits are of Clay with flints formation, consisting of clay, silt sand and gravel.

5.4 Underground Services and Structures

5.4.1 A services search must be commissioned by the client in order to confirm the location of all the services in the areas where excavations are to take place.

5.5 Geo-environmental Risk Assessment

5.5.1 A ground contamination Preliminary Risk Assessment has not yet been undertaken.

5.6 Unexploded Ordnance Risk

5.6.1 An unexploded ordnance risk assessment has not yet been undertaken.

5.7 Ground Investigation

5.7.1 A ground investigation (GI) comprising fieldwork and corresponding laboratory testing will be required to assess and mitigate the geotechnical issues and risks associated with the construction of the proposed leisure centre and to assess the potential for contamination related risks.

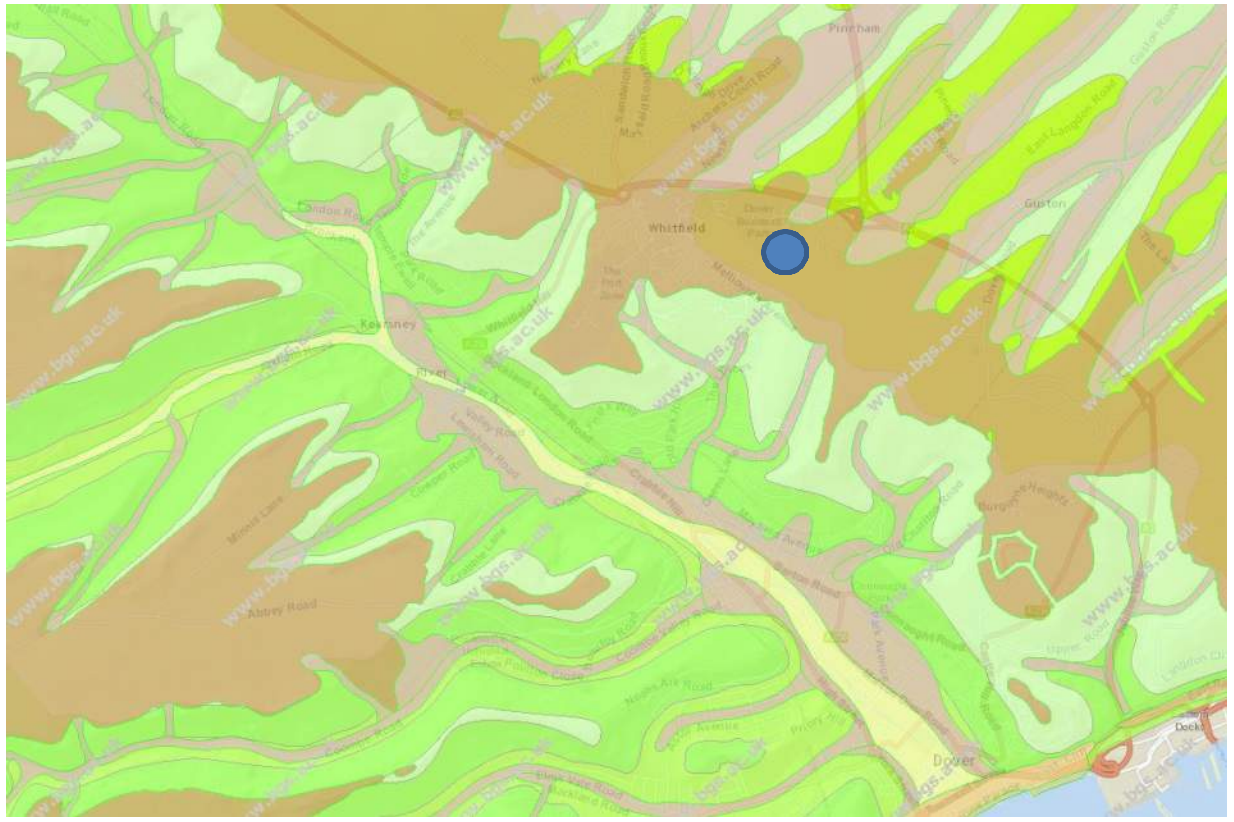


Figure 5.3: Superficial & Bedrock Geology (BGS)

6 SUBSTRUCTURE & FOUNDATIONS

6.1 Foundation Solutions

6.1.1 Based on the desktop study of the local geology and borehole data available on the BGS website we suggest that the foundation solution may be suitable for shallow pads and ground bearing slabs founded on the chalk.

6.1.2 Our experience of leisure centre construction suggests that shallow foundations and ground bearing pool structure are the most favoured starting point for foundation solutions from a cost perspective. From a cost perspective, allowance should be made for a piled foundation solution until further ground information is available.

6.2 RC Ground Bearing Slabs, Edge Beams & Upstands

6.2.1 At this stage of the design, a 200mm RC ground bearing slab with two layers of reinforcement has been assumed, to take account of any soft spots that may exist. This slab would have cut joints at regular bay centres to avoid cracking of architectural finishes.

6.2.2 The slab would be isolated from columns and pad foundations. A minimum 200mm zone is to be provided between underside of pad and foundation. In general areas the slab would be placed on a minimum of 300mm layer of engineered backfill, type 6F2, compacted in layers of 150mm. The final thickness of the engineering fill needs to be reviewed depending on the agreed site strip level and also depends on areas that might be over-dug to allow for ease of construction of substructure elements such as the pool.

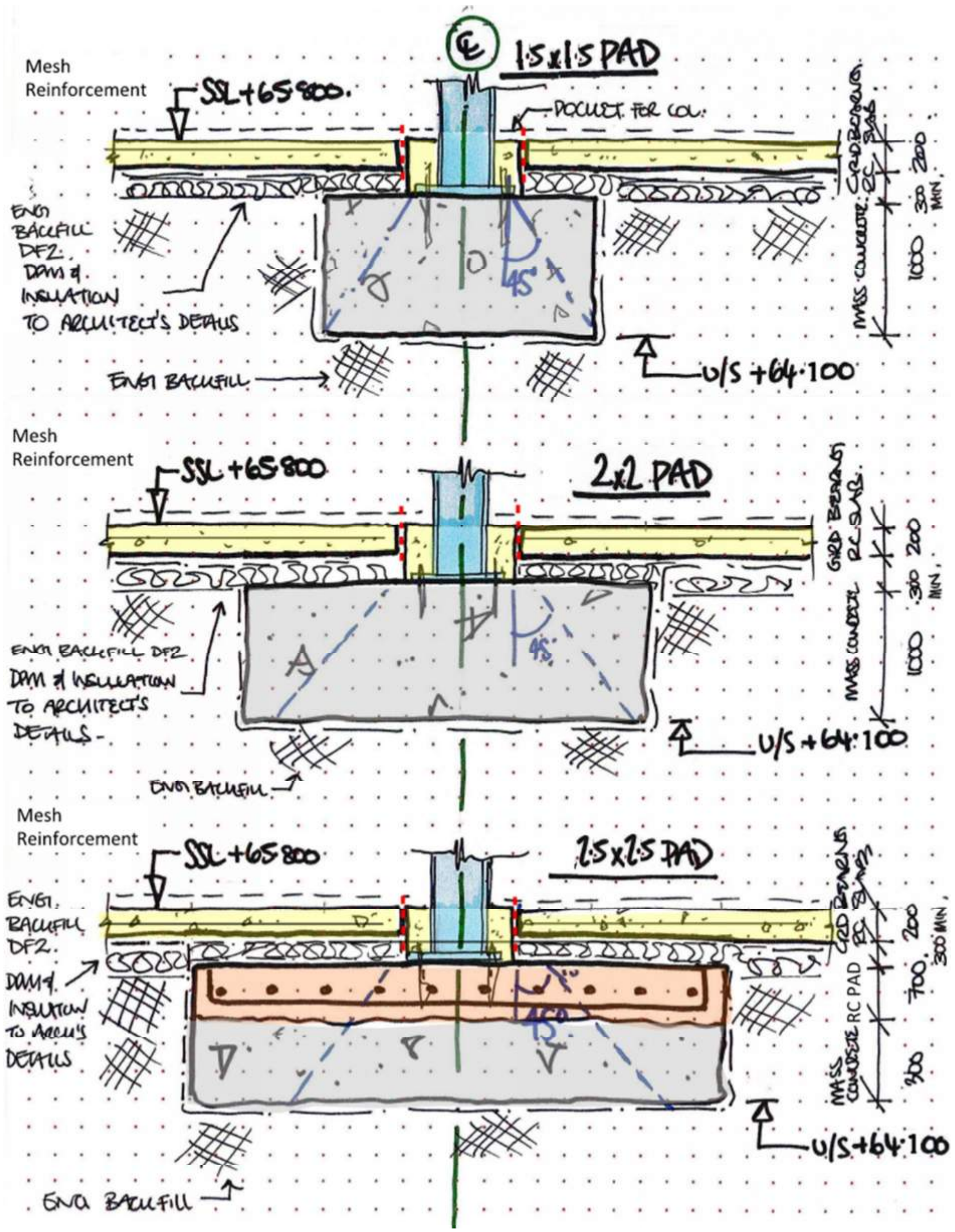


Figure 6.1: Typical Foundation Pad Options

6.2.3 The architectural finishes will determine the founding level of the slab. These typically range from 15mm for a skimming screed up to 300mm in changing areas. Where the slab changes level a 300mm RC thickening is to be provided. The final level of slabs will be coordinated at design Stage 4a.

6.2.4 The perimeter of the building has an in-situ ground beam that incorporates a step for masonry support. This spans between pad foundations is tied into the ground bearing slab. This edge beam can also be constructed in precast concrete if required for programme reasons.

6.2.5 The swimming pool area and changing village will require RC upstands and bunds to separate different areas. At this stage of the project typical details are provided by the Architect and should be allowed for in the cost plan.

6.3 Swimming Pool RC Walls and Slabs

6.3.1 We suggest that subject to ground conditions the swimming pool walls and base slab are to be built as in-situ reinforced concrete with a tiled finish.

6.3.2 The in-situ reinforced concrete option has been suggested at this design stage on the basis that it is a tried-and-tested method, with good availability of ground workers who can complete the works. Crack control will be managed through reinforcement scheduling. It should be noted that the concrete specification will have higher workmanship tolerances to ensure that the clear distances are achieved. These RC boxes will be designed to limited crack widths to provide water tightness without the need for any additives, however options for additives can be considered if thought to be advantageous from a programme perspective.

6.3.3 The swimming pool reinforced concrete walls generally vary from approximately 1.0m to 2.5m depth. The walls are typically 300mm thick and local areas will be thickened to 450mm to allow for scum channels to be incorporated in the wall. A horizontal movement joint is to be provided between the pool walls and ground bearing slab.

6.3.4 The base of the swimming pool is to be a 300-400mm thick reinforced concrete ground bearing slab. This thickness is required to enable reinforcement to lap from the wall into the base to resist bending from backfill placed behind the wall. The base slab will also be subject to hydrostatic pressures from the water table. As the pool depth is to be approximately 2.5m in the deepest location it is anticipated that by providing a 300-400mm base thickness will be approximately equal to the hydrostatic uplift forces.

6.3.5 Generally the pool construction is a programme critical activity. Given this, it is assumed that the reduced dig to formation level of the swimming pool will be one of the first works packages. It is assumed that the ground will be reduced and battered back to allow for the in-situ formwork to be erected. It is understood that foundations in close proximity to the pool tanks will be constructed at this lower level.

Figure 6.2: In-situ Reinforced Pool Tank Design at Grade

7 SUPERSTRUCTURE

7.1 Structural Framing

7.1.1 At this stage we suggest using a baseline structural option of a steel frame with long span truss over the swimming pool and long span cell beam roof, shallow RC foundations and in situ RC swimming pool. We have progressed the cladding design using a timber cassette envelope solution.

7.1.2 Other options to be explored include substituting the long span steel cell beam roof structure with steel trusses, glu-laminated beams or glu-laminated/steel truss combinations. Hybrid options incorporating cross laminated timber for floors, roofs and façade secondary elements can also be considered.

7.1.3 A more detailed appraisal of some of the long-span roof options discussed above is found in Appendix C ('Long Span Roof Studies', June 2016)

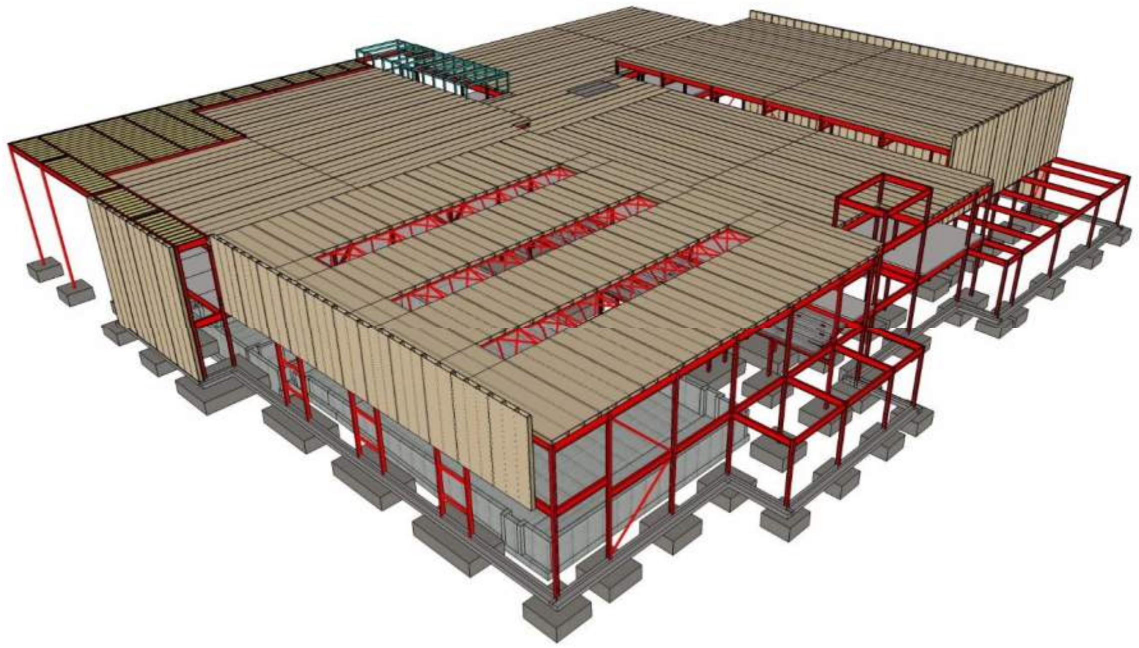


Figure 7.1: Baseline Option - Steel Frame with Timber Cassette Envelope

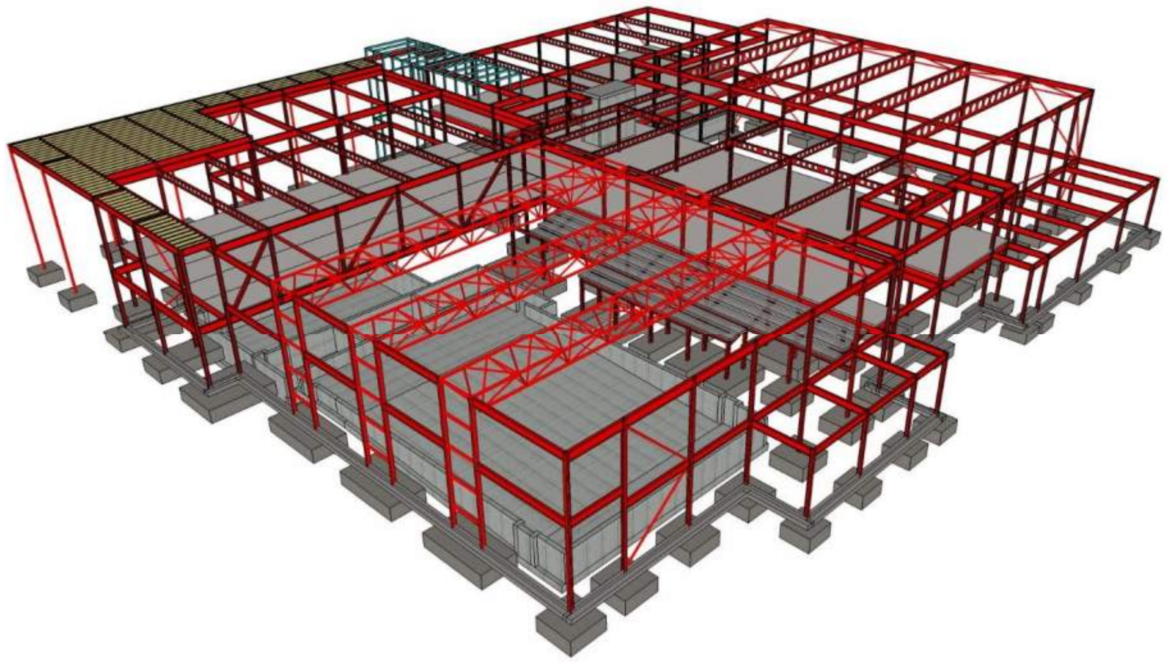


Figure 7.2: Baseline Option - Steel Frame with Truss & Celluar Beams

8 BUILDING ENVELOPE

8.1 Overview

8.1.1 The building envelope is a key structural component in all buildings. The coordination of external and internal skins provides an efficient building envelope solution and there are several structural components to the envelope.

8.1.2 The building envelope for leisure centres generally comprises of the following components:

- Roof Options – Timber cassette, Cross laminated Timber (CLT), and light weight steel and aluminium decking.
- Sports Hall & Swimming Pool high level cladding - Lightweight cladding panels (Kingspan) with secondary steel cold form backing system, timber cassettes
- Open elevations – glazed curtain walling with secondary steel cold form fixings as required.
- Sports Hall & Swimming Pool low level cladding – concrete block / brick masonry cavity system or other cladding material. Blockwork for solid wall construction.
- It should be noted CLT panels can also be used for wall elevations in lieu of blockwork and secondary steel systems.

Figure 8.1: Timber Cassette System – Typical Details

8.2 Timber Cassette

8.2.1 Timber cassette panel with a high quality aesthetic to the soffit. This system typically spans multiple bays and is delivered to site as a sandwich panel with insulation and top ply board. The width of cassettes can be customised but typically are in widths of 2.4m to enable efficient stacking on transportation.

8.2.2 The deck consists of timber joists within the sandwich system that can normally span up to distances of 7.5m (though longer spans can sometimes be achieved with careful design). A weatherproof membrane is laid down upon an insulation layer and then finished with a zinc standing seam roof or other finish such as sarnafil etc.

8.3 Sports Hall Roof - Lightweight Steel Metal Deck

8.3.1 A lightweight metal deck panel is a common solution to large roofs over such buildings. The deck is fritted so that it can provide acoustic performance, as specified by the project acoustician. The deck is shot fired onto support structure to provide lateral restraint to the top flange. The deck span varies from 3m for the Tata Steel D100 profile to up to 8.5m for the Tata Steel D210 profile.

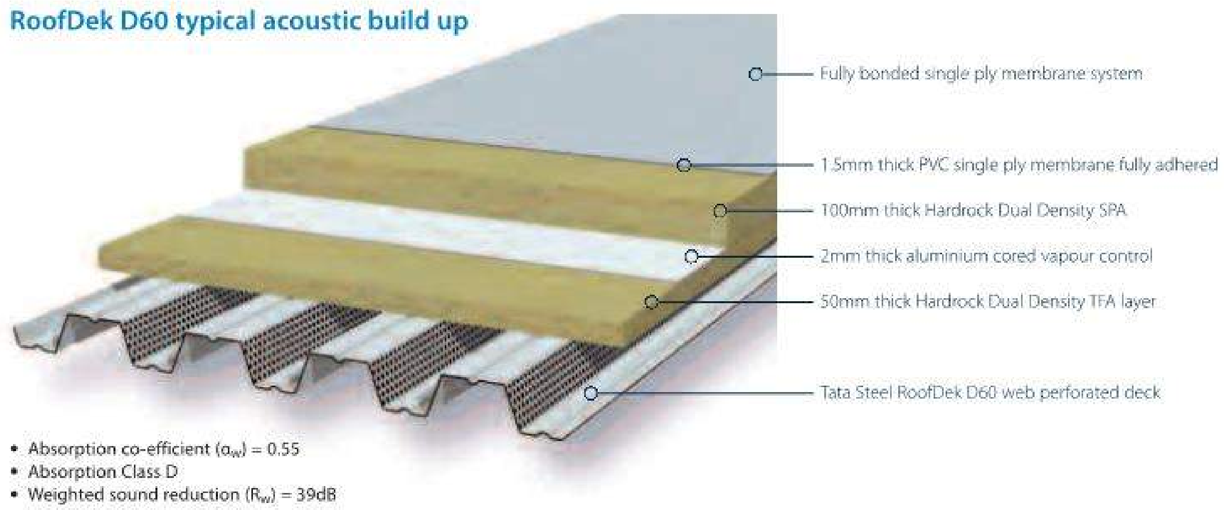


Figure 8.2: Steel Metal Liner Tray – Typical Details

8.4 Lightweight Cladding Panels

8.4.1 At high level in the swimming and sports hall areas a light-weight cladding panel system can be used to provide an efficient and quick to erect envelope. The Kingspan KS1000 (or similar) can span vertically or horizontally up to 5.0m, over multiple bays, to provide an effective cladding system.

8.4.2 The Kingspan panels can be used above the masonry zone in both halls, enclosing up to 6m between the top of the cavity wall and the underside of the roof structure. Trimming steels are included within the primary steelwork package to ensure the cladding panels have adequate support and lateral headers.

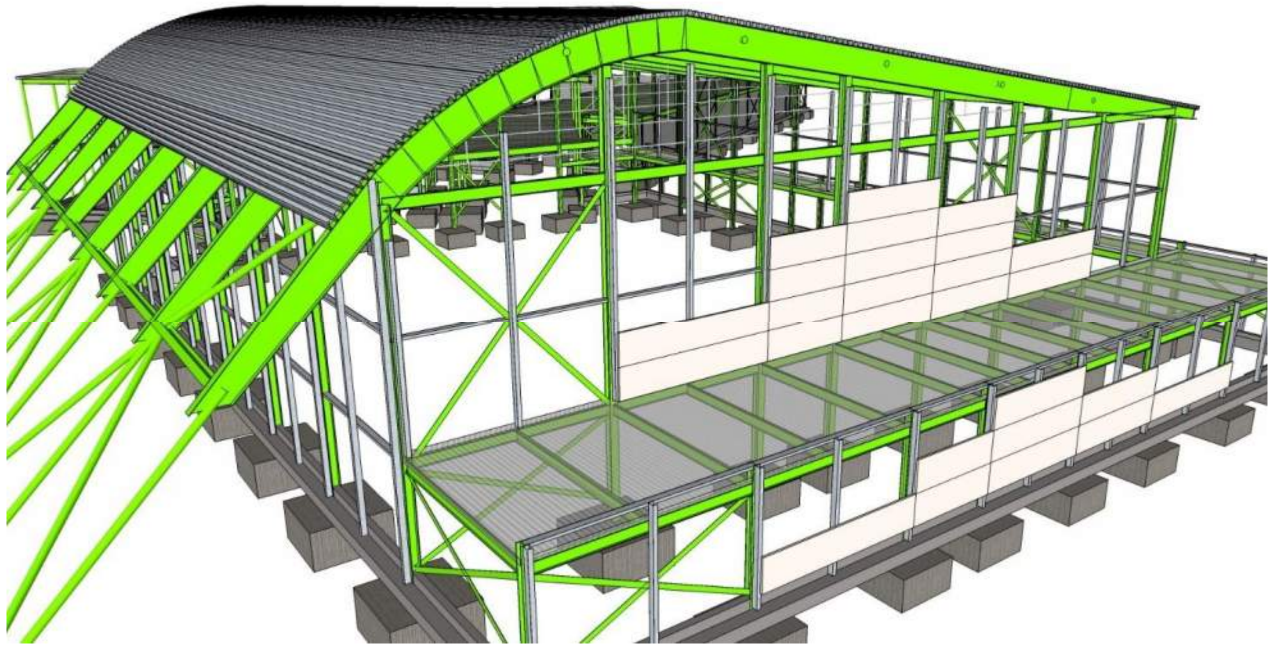


Figure 8.3: Suggested layout for Kinspan KS100 system with vertical secondary steelwork

8.5 Curtain Walling

8.5.1 The open zone features a glazed curtain wall system that wraps around the front elevation. This is supported from mullions and transoms at regular centres that hold the glazed panels in place. This secondary system is supported by the primary steelwork above and floor slab below.

8.5.2 The steelwork at first floor and roof will be designed for a deflection of span/500 to limit deflection for cladding sensitive areas.

Figure 8.4: Typical Façade System for Glazing

8.6 Block work and Brick Masonry

8.6.1 To provide a robust and durable façade at ground a masonry cavity system is generally proposed by the Architect.

8.6.2 This will feature a facing lignacite concrete outer skin and a lightweight concrete inner block, such as the Acheson and Glover A308 block. Masonry ties and windposts will be provided at regular centres transferring lateral loads back the primary frame.

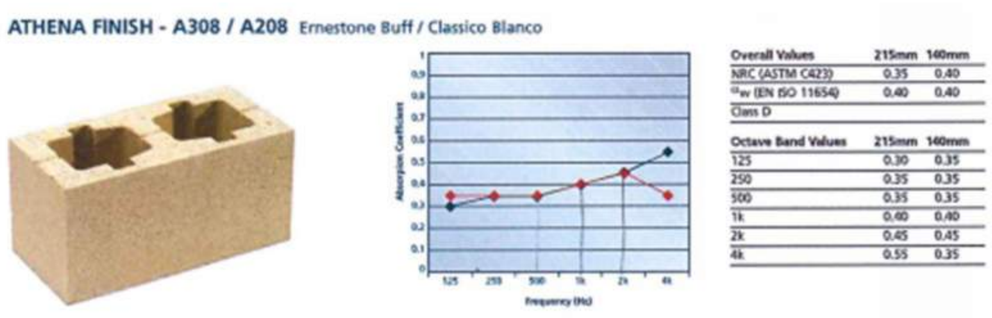


Figure 8.5: Typical lightweight Blockwork

9 CIVIL ENGINEERING WORKS

9.1 Hydrology

9.1.1 The Dour River is sourced approximately 1.5km to the south west of the site and is classified as an Environment Agency 'River' which is served by a catchment of 24.531 km^2. The stream joins the Kent South Coastal Water downstream.

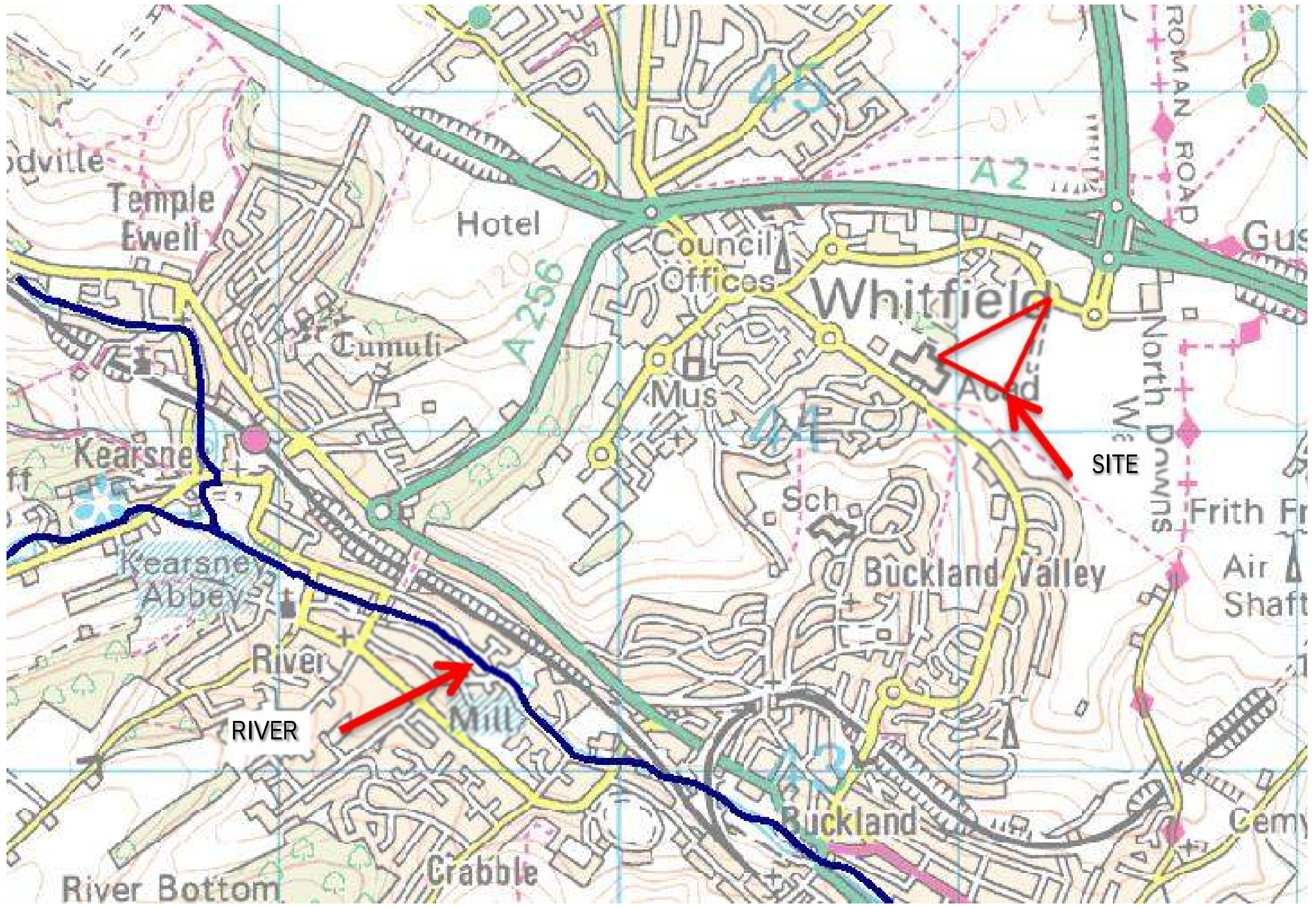


Figure 9.1: Site location to Salt Hill Stream (extract from OS Online Maps)

9.1.2 The Environment Agency groundwater map shows that the site is located in the total catchment (Zone 3) ground water protection zone and the groundwater vulnerability zone map shows the site located in a major aquifer intermediate area.

9.2 Geology

9.2.1 The British Geological Survey (BGS) online map indicates that the sites bedrock geology is Margate Chalk Member. The sites superficial deposits are of Clay with flints formation, consisting of clay, silt sand and gravel.

9.2.2 A detailed site investigation will be carried out to establish the sites local geology and ground conditions to determine if infiltration can be used as a method for disposal of clean surface water from the proposed development site.

9.3 Flood Risk

9.3.1 A review of the Environment Agency web based Flood Zone map indicates the development site does not fall within a dedicated flood zone, which means that the potential for flooding from rivers or sea is 0.1% (1 in 1000 year) or less. However as the site is over 1 hectare a site specific flood risk assessment will be required to support the site planning application.

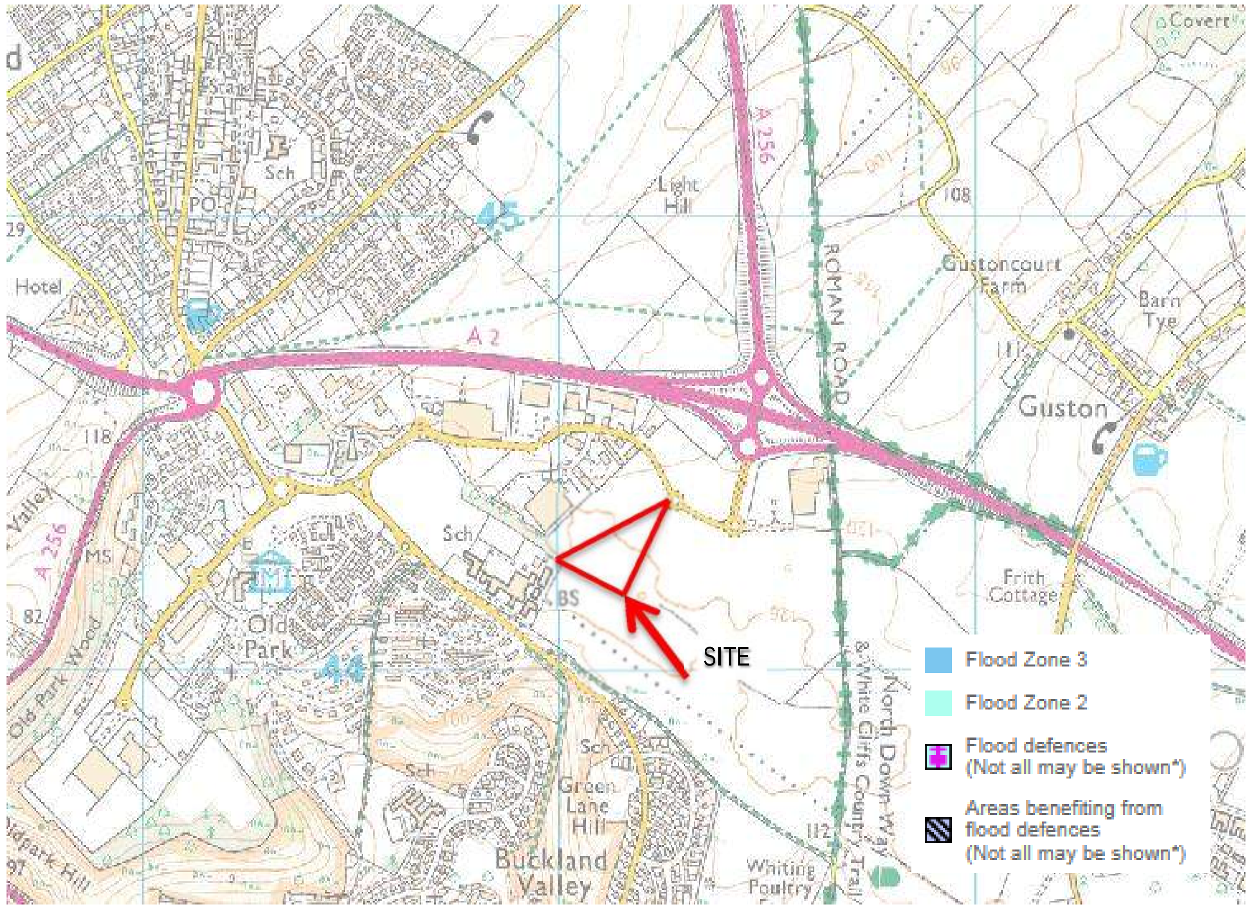


Figure 9.2: Environment Agency Flood Zone Map

9.4 Foul & Surface Water Drainage Strategy

9.4.1 The operational aim of the drainage infrastructure is to design a system that will meet the following minimum requirements:

- The required design life and structural integrity will be achieved for the new drainage system.
- The entire system is operational at all times and functions within the design performance requirements set out by the relevant statutory undertakers and end users.
- Meet current design standards as well as statutory and health and safety requirements.
- The operation of the system is safe, environmentally acceptable and economically efficient.
- To separately drain foul and surface water to an appropriate point of connection.

- To provide points of connection for proposed soil vent pipes, stub stacks and floor gullies as identified by the Public Health Engineer and Pool Specialist.
- To provide points of connection for proposed roof water downpipes as identified by the Architect.
- To provide drainage of hardstanding areas as identified by the Landscape Architect.
- To provide a means of controlling the rate of discharge of surface water run-off from the development, along with the appropriate storage, to prevent undue rush of flooding on or off site.

9.4.2 The design of the new drainage works is undertaken in accordance with:

- BS EN 752:2008 Drain and sewer systems outside buildings.
- Sewers for Adoption 7th Edition.
- Building Regulations Part H (Drainage and waste disposal).
- Kent County Council –The Soakaway Design Guide (July 2000)

9.5 Existing Drainage

9.5.1 As the site is currently a greenfield site it is not anticipated that there will be any below ground drainage on the site.

9.5.2 An asset map will be requested from Southern Water to ascertain the location of the nearest public foul and/or surface water sewer to the site. Following a review of planning applications for neighbouring lands on the Dover District Council Planning Portal, there appears to be a 225mm diameter foul sewer running in Honeywood Parkway with a 150mm foul spur adjacent to the proposed site, by the roundabout. According to Southern Water records this sewer is approximately 4.27m deep at an invert of 116.72m.

9.5.3 There is no record of a surface water sewer in the area.

9.5.4 A topographical survey should be carried out on the site, this will indicate if there are any ground features that suggest there is ditches/drains crossing/serving the site.

9.6 Proposed Foul Water Drainage

9.6.1 Relevant applications to Southern Water should be made as required, including pre-development enquiries and connection applications.

9.6.2 Access throughout the new drainage system will be provided through the use of manholes or rodding eyes at branch connections and changes in direction to allow the system to be properly maintained and for blockages to be removed.

9.6.3 Given the depth of public foul sewer it would be assumed that the foul water could drain by gravity to the public network. This will be dependent on the site layout and topography.

9.6.4 As swimming pools are proposed in the leisure centre it will be necessary to discuss the impacts of a trade effluent license with Southern Water. Having previously carried out discussions with statutory bodies for similar projects it is likely that the rate of discharge will need to be restricted and therefore a holding tank for the backwash water will be required. The volume and rates will be determined following discussions with the pool specialist and Southern Water.

9.6.5 The British Water Code of Practice for Flows and Loads will be used to calculate the proposed foul run-off. The anticipated foul sewerage flows will be determined for the proposed development when occupational values are available. Typically, for a sports centre, a foul loading rate of 50 litres per head per day would be used.

9.7 Proposed Surface Water Drainage

9.7.1 The strategy for the design of the surface water system will consider the hierarchical approach laid down within Part H of the Building Regulations, which requires the run-off from any new development to consider the following in order of preference:

- store rainwater for later use.
- use infiltration techniques, such as porous surfaces in non-clay areas.
- attenuate rainwater in ponds and open water features for gradual release.
- attenuate rainwater by storing in tanks or sealed water features for gradual release.
- discharge to watercourse.
- discharge rainwater to surface water sewer/drain.
- discharge rainwater to the combined sewer.

9.7.2 Given the geology of the site, it is anticipated that the surface water drainage will infiltrate to ground via soakaways or similar systems.

9.7.3 Given a large car park is proposed to serves the development a petrol interceptor will be required to treat the surface water runoff from this area. The use of permeable paving within the car park will eliminate the requirement for a petrol interceptor. This will be subject to agreement with the Environment Agency.

9.7.4 Relevant applications to the Environment Agency and the Lead Local Flood Authority (LLFA); Kent District Council; should be made, as required, including completing the council's SuDS pro-forma as part of the major development planning application.

9.7.5 The Greenfield runoff rate for the site was estimated to be 1.08 l/s. This was calculated using the IH 124 Greenfield runoff method. Based on the site location an SAAR and SPR value of 800 and 0.15 were used, respectively.

9.7.6 Calculations will be carried out for various storm return periods, as required by the SuDS proforma. These calculation will determine the volume of attenuation storage required for the development in order to prevent flooding.

9.7.7 The scheme will also incorporate sustainable urban drainage systems, where practicable. Refer to section 9.8 for details.

9.8 SuDS Proposals

9.8.1 In accordance with best practice requirements Sustainable urban Drainage Systems (SuDS) proposals are being considered for the development in order that the completed development run-off characteristics mimic the existing Greenfield as closely as possible, or to the rate agreed with relevant LLFA.

9.8.2 A concept known as SuDS Management train (also known as the treatment train) is shown on Figure 9.3. Drainage techniques similar to the way natural catchments function can be used to alter the flow and quality characteristics of the flow. This is achieved at different stages:

- Source Control: Managing the site could increase the quality (by minimising the use of de-icing products and garden chemicals, keeping paved areas clean to reduce first-flush pollution) and quantity problems (by reducing the paved areas).
- Site Control: Water should be returned to the natural drainage system as near to the source as possible.
- Regional Control: For large public areas storage could be shared between a number of sites.

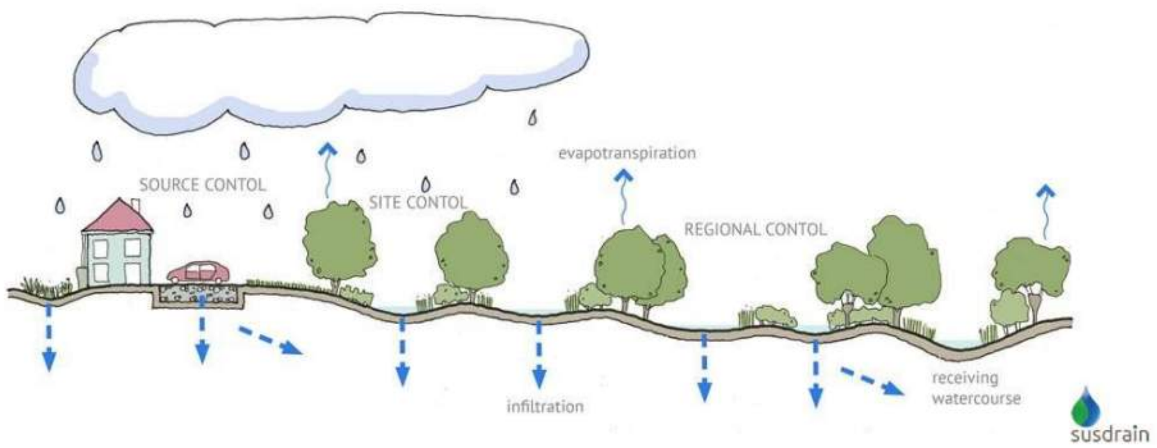


Figure 9.3 - SuDS Management Train

9.8.3 There are many SuDS technologies available to improve the quality and decrease the quantity of the storm water run-off from a development. The measures proposed for the site were selected to suit the particular circumstances of the development.

9.8.4 Table 9.1 details the SuDS measures that will be considered for the proposed development

	Proposed	Comment
Filter Drains	✓	Infiltration testing to be undertaken to confirm suitability
Swales	✓	Infiltration testing to be undertaken to confirm suitability
Infiltration Basins	✓	Infiltration testing to be undertaken to confirm suitability
Soakaways	✓	Infiltration testing to be undertaken to confirm suitability
Ponds	✓	To be investigated further ,although space may be an issue
Retention / Detention Basins	✓	To be investigated further ,although space may be an issue
Wetlands	X	Insufficient space on site
Trees	✓	To be investigated further
Pervious Surfaces	✓	Infiltration testing to undertaken to confirm suitability
Attenuation Tank	✓	Site conditions indicate feasiblity
Brown/Green Roofs	✓	To be investigated further
Rainwater Harvesting	✓	To be investigated further

Table 9.1 – SuDS Measures Proposed

9.8.5 Once the proposed layout, geological and hydrological information and proposed runoff rates have been finalised the SuDS features will be fully assessed and a detailed drainage design will be developed. Further details of SuDS measures are listed below.

9.8.6 **Green Roofs** comprise a multi-layered system that covers the roof of the building with vegetation cover/landscaping over a drainage layer. They are designed to intercept and retain precipitation, reducing the volume of runoff and attenuating peak flows.

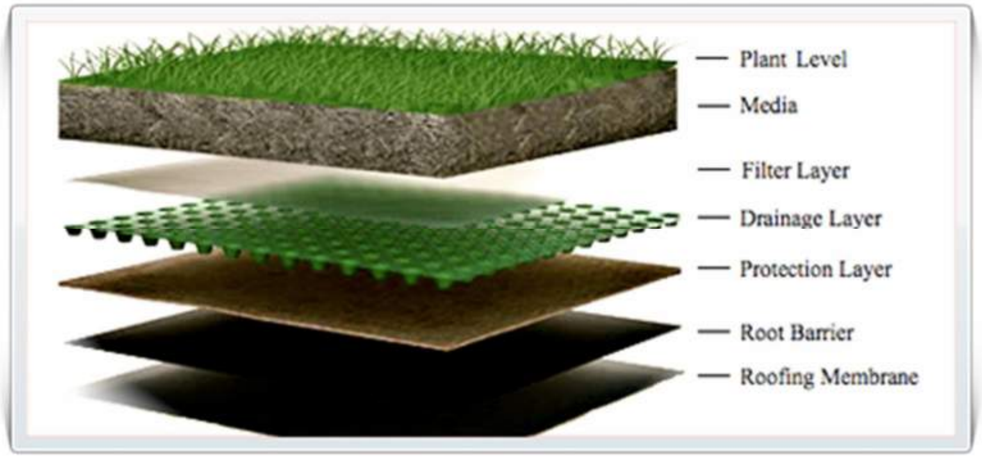


Figure 9.4 – Typical Green Roof Build Up

9.8.7 **Rainwater harvesting** stores rainwater from roofs, which can then be reused to serve the development toilets and landscaping. These systems can reduce the rates and volumes of surface water runoff from the site.

Figure 9.5 – Indicative Rainwater Harvesting Layout

9.8.8 **Pervious surfaces** provide a surface suitable for pedestrian and/or vehicular traffic, while allowing rainwater to infiltrate through the surface and into underlying layers. The water can be temporarily stored before infiltration to the ground, reused, or discharged to a watercourse or other drainage system. Surfaces with an aggregate sub-base can provide good water quality treatment.

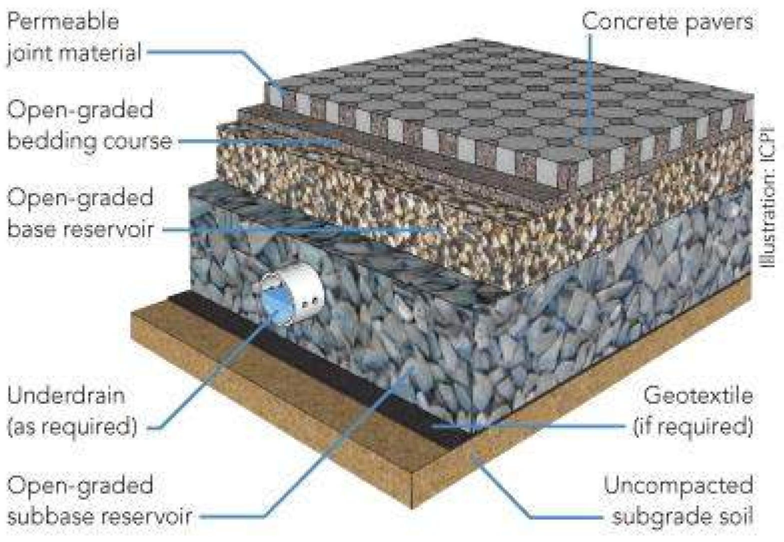


Figure 9.6 – Typical Pervious Paving Build Up

9.8.9 **Detention basins** are surface storage basins or facilities that provide flow control through attenuation of stormwater runoff. They also facilitate some settling of particulate pollutants. Detention basins are normally dry and, in certain situations, the land may also function as a recreational facility. However, basins can also be mixed, including both a permanently wet area for wildlife or treatment of the runoff and an area that is usually dry to cater for flood attenuation.

9.8.10 **Retention ponds** can provide both stormwater attenuation and treatment. Runoff from each rain event is detained and treated in the pool. The retention time promotes pollutant removal through sedimentation and the opportunity for biological uptake mechanisms to reduce nutrient concentrations.

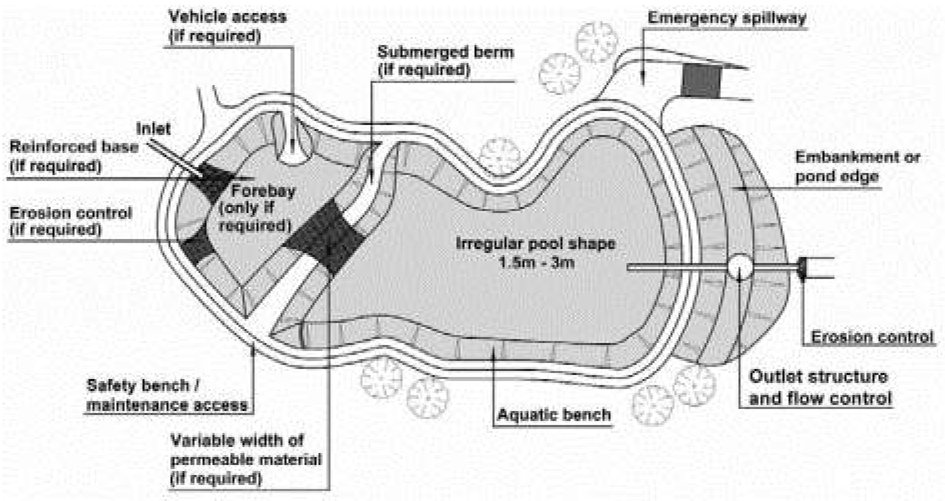


Figure 9.7 – Example of a Retention Pond / Detention Basin

9.8.11 **Soakaways** are square or circular excavations either filled with rubble or lined with brickwork, pre-cast concrete or polyethylene rings/perforated storage structures surrounded by granular backfill. Soakaways provide stormwater attenuation, stormwater treatment and groundwater recharge.

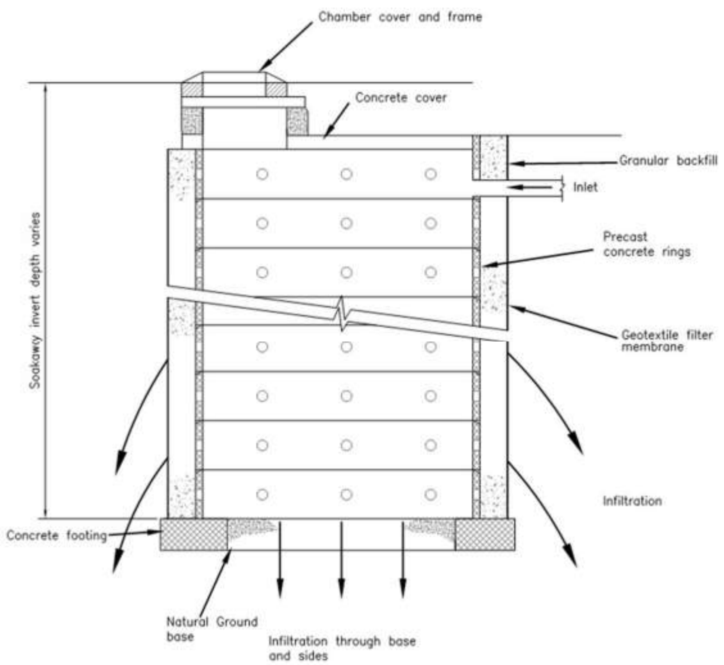


Figure 9.8 – Typical Soakaway Layout

9.8.12 **Infiltration basins** are vegetated depressions designed to store runoff on the surface and infiltrate it gradually into the ground. They are dry except in periods of heavy rainfall.

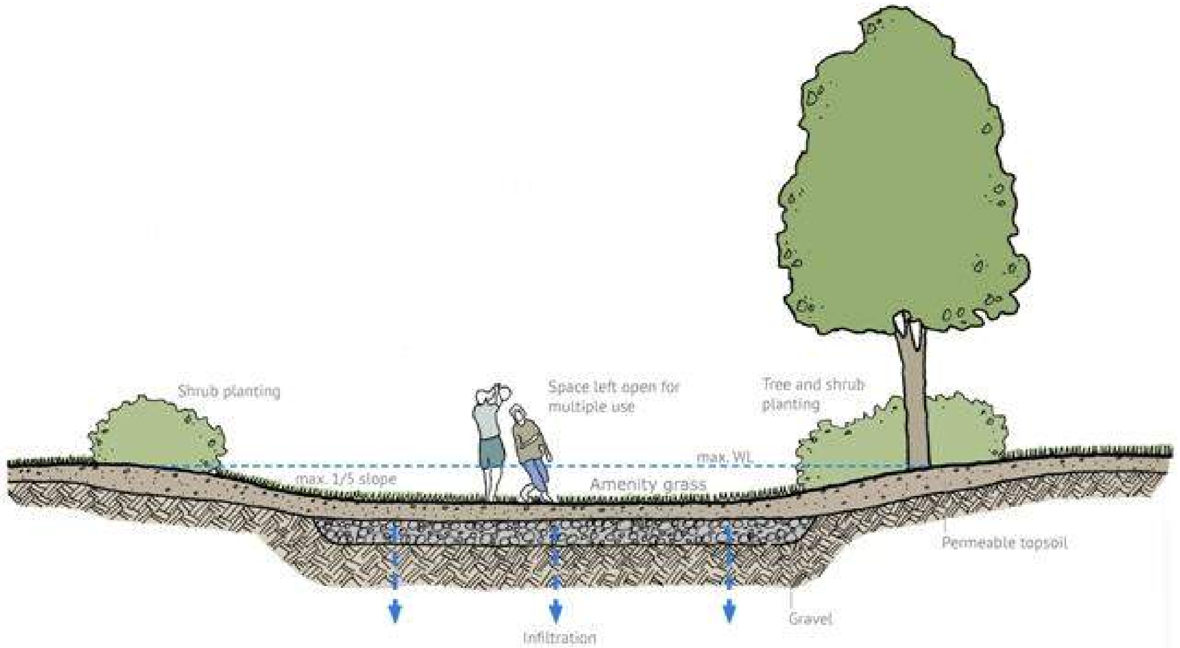


Figure 9.9 – Typical Infiltration Basin Layout

9.8.13 **Swales** are shallow, broad and vegetated channels designed to store and/or convey runoff and remove pollutants. They are designed to promote infiltration where soil and groundwater conditions allow. Check dams and berms also can be installed across the flow path of a swale in order to promote settling and infiltration.

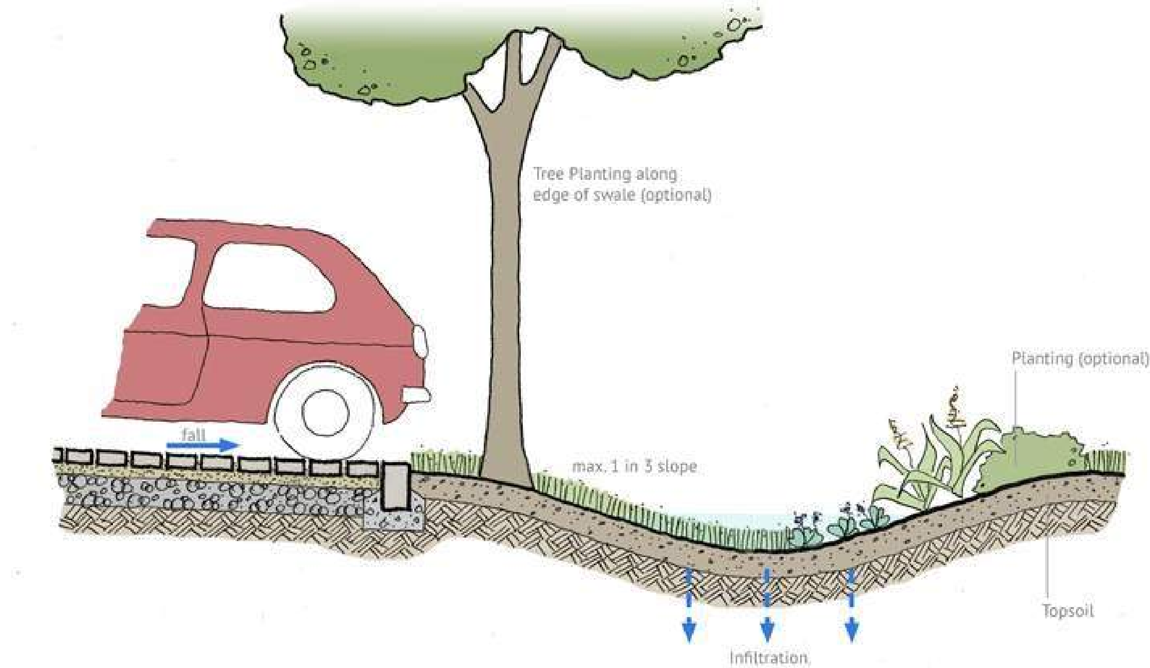


Figure 9.10– Example of a Swale

9.8.14 A **filter strip** is a gravel filled trench, generally with a perforated pipe at the base. Runoff flows slowly through the granular material, trapping sediments and providing attenuation. Flow is then directed to a perforated pipe, which conveys run-off either back into the sewerage network or into a waterbody.

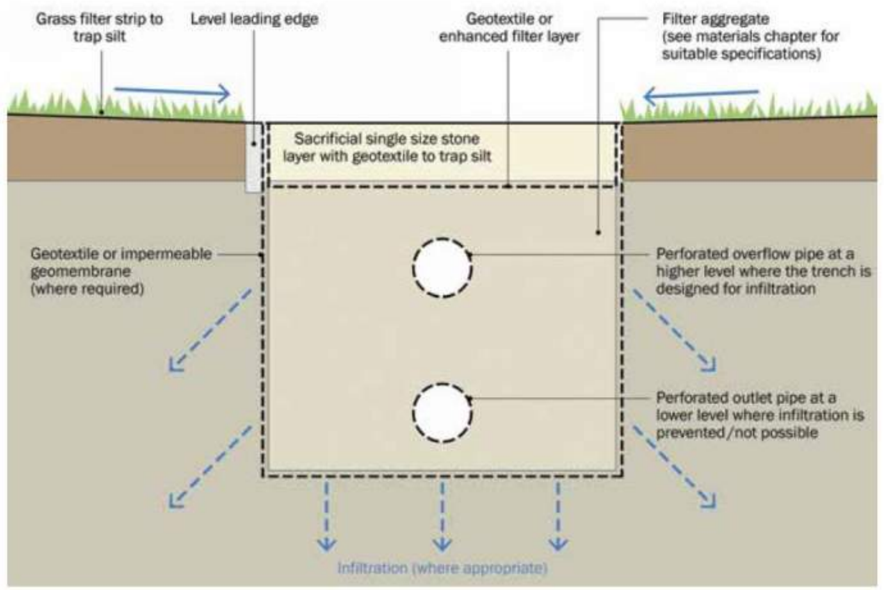


Figure 9.11 – Typical Filter Strip Build Up

10 SUSTAINABILITY

10.1 General

10.1.1 Sustainability is a key feature in the design processes that Engenuiti undertakes. As an industry we use a significant amount of the Earth's natural resources and by default this means we can significantly reduce our resource and energy demands in the projects we design.

10.1.2 For this project a number of sustainability considerations have been included in the design and a number more should be considered in the future. In particular the use of solid timber in lieu of structural steel and either block work or cold formed steel secondary backing systems should be explored.

10.1.3 Concrete will be proposed in which the cement content could be reduced by using cement replacements such as pulverised fuel ash or ground granulated blast furnace slag to form a more sustainable mix. The decision to use concrete has been based on sound engineering principles and hence reducing the impact of using a large quantity is the most sustainable option. Where exposed concrete is to be used, careful selection of additives should be made to ensure that colour consistency is not degraded to the point where the finish is left unacceptable and requires painting.

10.2 Concrete

10.2.1 The global cement industry accounts for around 5% of global CO_2 emissions (source: World Business Council for Sustainable Development). The construction and demolition of buildings accounts for around 120 million tonnes of waste material in the UK, about half the national total waste.

10.2.2 There are significant opportunities for concrete construction to reduce its environmental impact through the specification and construction processes.

10.3 Conservation of Natural Resources

10.3.1 Although global supplies of the raw materials used to make cement, and aggregates used in concrete are not in short supply, their extraction can cause damage to their local environment. It is generally more sustainable to make use of a waste product in lieu of extracting more raw material: it has the double benefit of conserving natural resources for use by future generations and reducing the problem of disposal of unwanted materials.

10.3.2 Cement replacements – GGBS and PFA cannot replace 100% of the OPC used in cement as they rely on the hydration products from the lime to 'kick start' their own hydration reactions. However, 30 - 50% replacement is very common and will have limited effects on the concrete. Replacement rates of 80% are possible in certain circumstances. This has the potential to save a large amount of reserves of lime and clay, the raw materials used to make OPC.

10.3.3 Recycled aggregates – as the material that makes up the largest proportion of concrete by mass, the use of recycled coarse aggregates have a significant effect on reducing the mass of raw material used to make cement. The use of recycled fine aggregates is also possible and beneficial for similar regions.

10.3.4 Water – concrete manufacturers with a well developed environmental management systems should be recycling much of their water, as a great deal can be wasted in batching plants, through washing out machinery and lorries. Simple procedures minimise the use of water, with obvious benefits, especially in dry climates where it is a resource in short supply.

10.3.5 Formwork – by increasing the number of times formwork panels can be reused, the volume of material required on a project will be greatly reduced.

10.3.6 Release agents – there are many different types of release agents for use on formwork systems, made from different raw materials. Those that are derived from vegetable oil or other biodegradable sources, rather than petroleum based materials are preferable from a sustainability point of view, as they are made from readily renewable materials. They may cost more per litre, but the coverage rate of the petroleum based versions should be checked: often they require more coats, so the cost per m^2 of formwork is similar and the labour cost may be more.

10.4 Embodied Energy and Embodied CO_2

10.4.1 Although the cement industry has been making significant steps to improve efficiency and so reduce its CO_2 emissions, it will always be a major emitter as the chemical reaction involved in the manufacture of OPC produces CO_2 as a waste product. The drive to reduce the carbon footprint of industrial processes has resulted in significant interest in using cement replacement materials in concrete to reduce its carbon footprint.

10.4.2 Measuring the embodied CO_2 of raw materials is not a simple process, and depends very much on the boundary conditions and methodologies that are applied.

10.4.3 However, Table 10.1 shows data that can be used to make 'order of magnitude' comparisons. WRAP (Waste Reduction Action Programme) is private company in the UK which works in partnership with organisations to reduce waste and increase recycling.

	Embodied Energy MJ / tonne	**Embodied CO_2 Kg CO_2 / tonne**
OPC	4770	800
GGBS	436	100
PFA	12	1

Table 10.1 - Embodied energy and CO_2 data (WRAP carbon calculator)

10.4.4 It can be seen that significant savings can be made by replacing OPC with replacements. An early estimate of the volume of concrete to be used in the project is around 9500m^3. Assuming a typical mix that contains around 16% of cementitious materials by mass, and the use of a blended cement of 50% OPC, 50% replacement material, the CO_2 saving on the project will be approximately 1000 tonnes or 1500 tonnes, depending on whether GGBS or PFA are used.

10.4.5 It is not thought that the use of recycled aggregates offers a saving in embodied energy or CO_2 due to the significant processing that it must undergo in order to be used in most circumstances (transport from its original location, crushing if necessary, washing, grading etc.).

10.5 Use of Thermal Mass in Building Cooling Strategies

10.5.1 Internal temperature control is typically a large source of energy consumption and CO_2 emissions of buildings.

10.5.2 Concrete framed buildings can be used to reduce this energy demand by acting as a 'heat sink' during the day when the building is heated by internal activity and sunlight. It can then release this heat during the night time, provided it is adequately ventilated by a supply of fresh air to which it can transfer its stored heat. The overall effect is to reduce the peak temperatures within the building and introduce a time lag between the peak external and internal temperatures, reducing the load on ventilation systems working to maintain a comfortable temperature for the people inside.

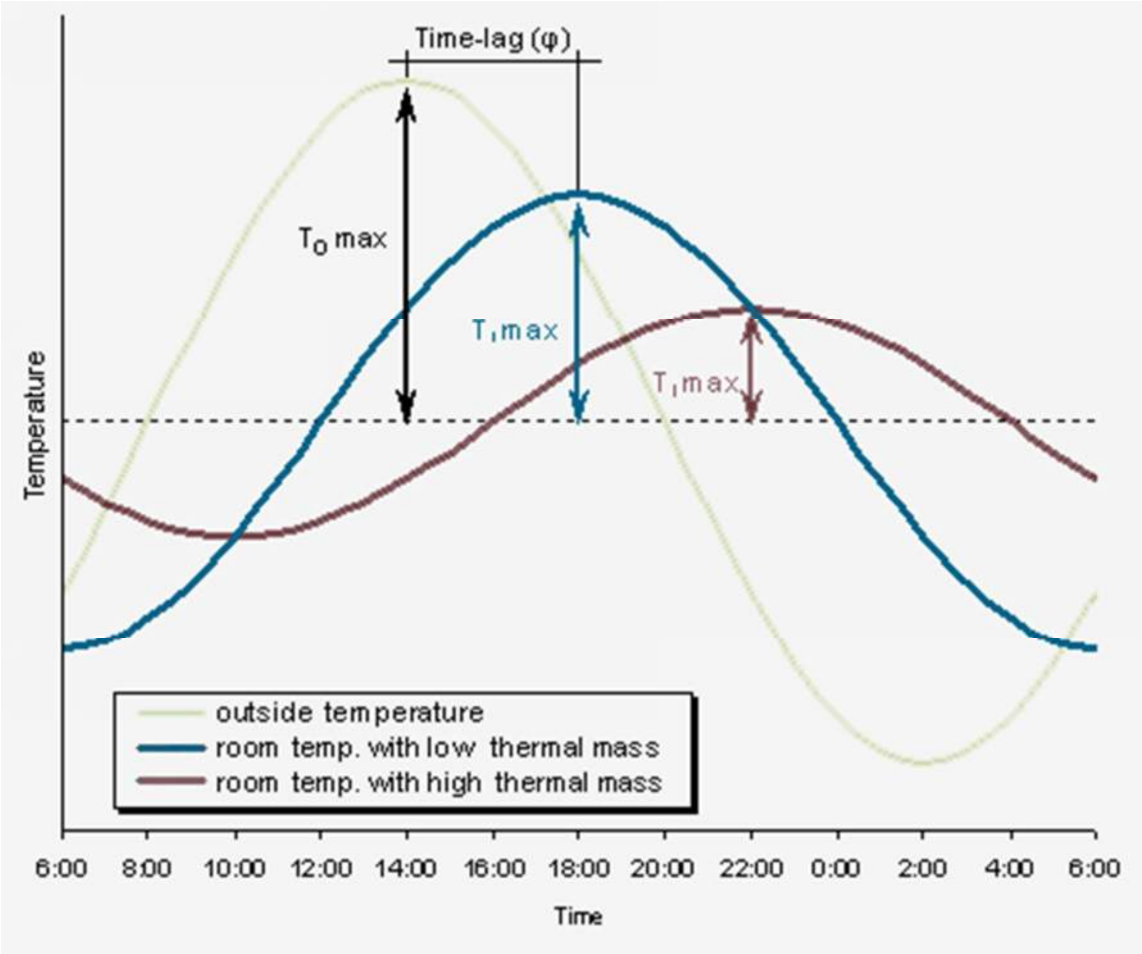


Figure 10.1 - Effect of high thermal mass on the internal temperature of a typical building (European High Quality Low Energy Buildings (EULEB) project)

10.6 Transport of Materials

10.6.1 The movement of heavy materials across long distances can account for large amounts of energy and CO_2 emissions. Table 10.2 gives approximate values for emissions per mile of various modes of transport.

	CO_2 emissions / passenger-mile
Typical large car	0.4 kg
Train	0.1 kg
Plane	0.25 kg

Table 10.2 - Embodied CO_2 emissions for transport modes (Transport Direct)

10.7 Socio-Economic Factors

10.7.1 Some materials used in construction can be certified under a 'chain of custody' scheme, provided the supplier can demonstrate they source responsibly and have an environmental management system in place that restricts the environmental impact of their product. The FSC & PEFC certification systems that applies to all timber used in construction, including plywood formwork panels, is one such scheme that is now standard practice in the UK. 'Eco-reinforcement' is another example, introduced very recently, that will apply to steel reinforcement used in concrete structures: having the eco-reinforcement certification will verify the product is made from 100% recycled steel.

10.7.2 There are strong sustainability arguments for using local labour resources wherever possible. Construction is a major source of employment and it is thought this project will provide work to a large number of local people. Offering training to local people will increase their capacity to contribute to their local economy.

11 FURTHER STUDIES & INVESTIGATIONS REQUIRED

11.1 Further Surveys & Investigations Required

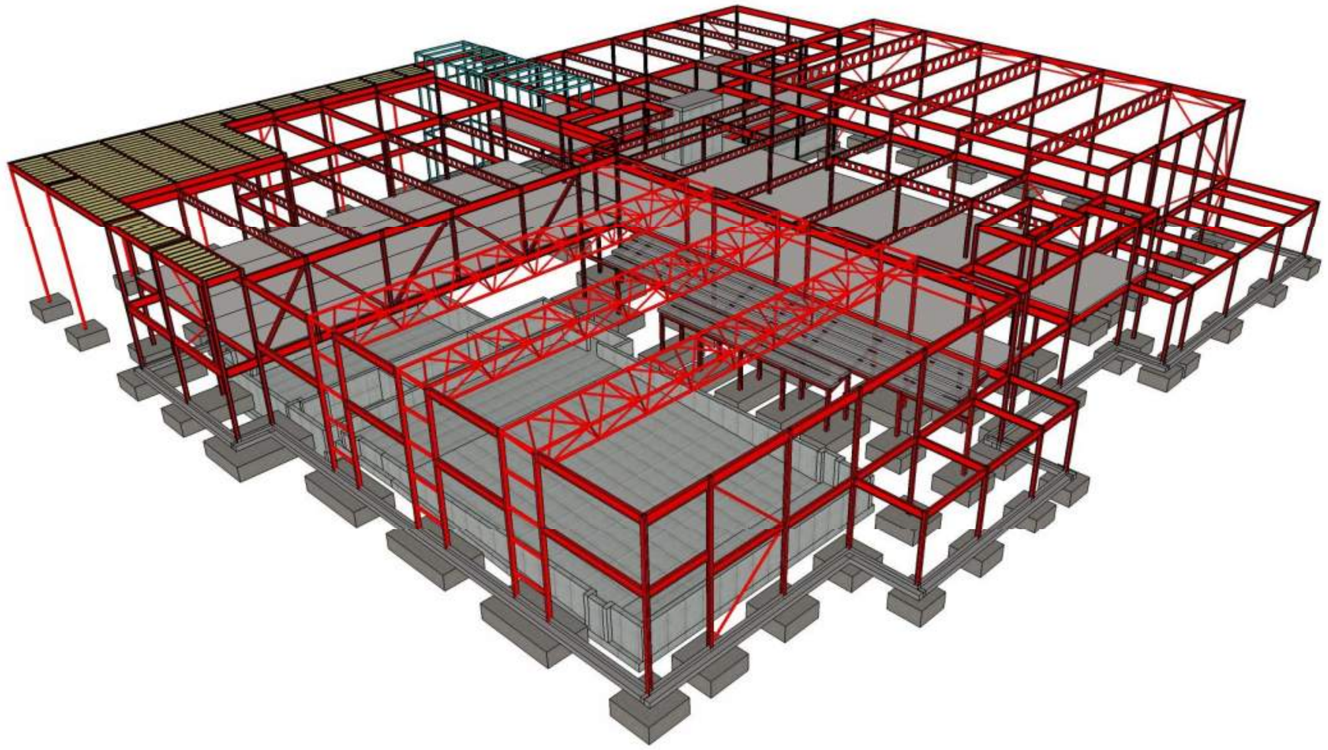
11.1.1 The following surveys and investigations are required in order to support the next phase of design:

Survey	Reason / scope	Proposed Timescale
Topographic Survey	To establish site levels and boundaries.	ASAP
Geotechnical Site Investigation	To establish geotechnical design parameters, ground conditions etc.	ASAP
UXO Desk Study	To establish site risk.	ASAP

Table 11.1 - Additional Surveys and Investigations Recommended

APPENDIX A

STRUCTURAL & CIVIL ENGINEERING DESIGN CRITERIA & MATERIALS engenuiti



DOVER LEISURE CENTRE

STRUCTURAL & CIVIL ENGINEERING DESIGN CRITERIA & MATERIALS

for

GT3 Architects

17th June 2016

634-S-REP-002
Rev 0

Engenuiti
2 Maltings Place
Tower Bridge Road
London, SE1 3JB

STRUCTURAL & CIVIL ENGINEERING DESIGN CRITERIA & MATERIALS

CONTENTS

Revision History

Rev	Date	Purpose/Status	Document Ref.	Comments
00	17th June 2016	Draft	634-S-REP-002	Issued for Information

Prepared by:

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Reviewed & Approved by:

Paul Grimes
Director

1 INTRODUCTION

1.1 General

1.1.1 Engenuiti has been appointed by GT3 Architects Limited to provide structural & civil engineering design services for the proposed new Dover Leisure Centre.

1.1.2 The purpose of this Structural & Civil Engineering Design Criteria & Materials report is to describe the structural and civil engineering design criteria of the proposed development and provide outline material specifications to enable GT3 Architects to finalise the design parameters for the project.

1.1.3 This report has been produced for the exclusive use of GT3 Architects Limited and should not be used in whole or in part by any third parties without the express permission of Engenuiti in writing. This report should not be relied upon exclusively for decision-making purposes and should be read in conjunction with other documents and drawings produced by the design team.

1.2 Proposed Development

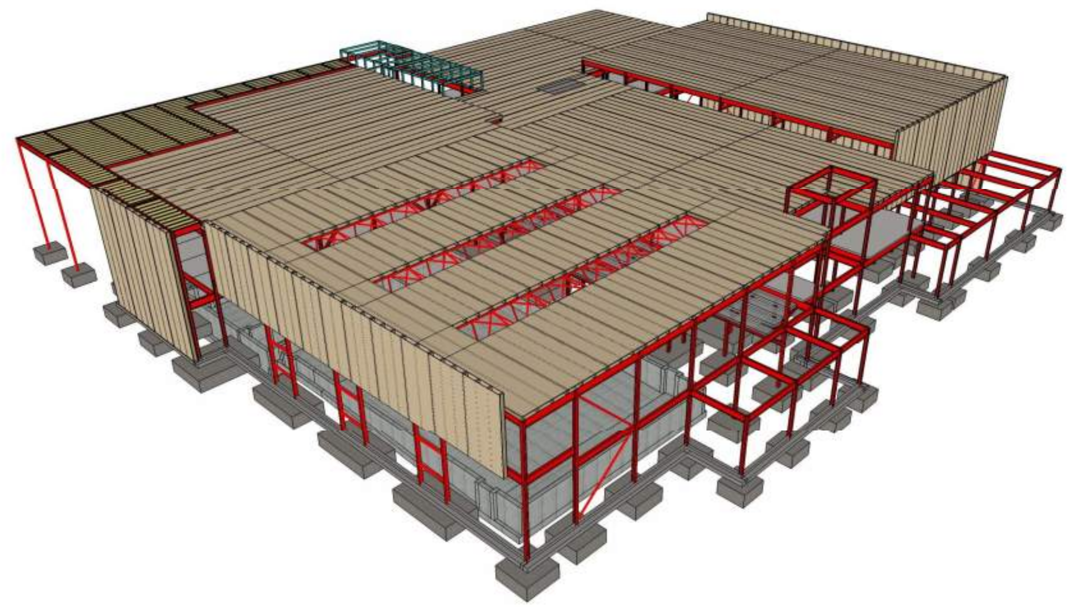
1.2.1 The proposed leisure centre is located in Whitfield, Dover. The site postcode is CT16 3FH. The site location is south of Honeywood Parkway and east of The Glenmore Centre.

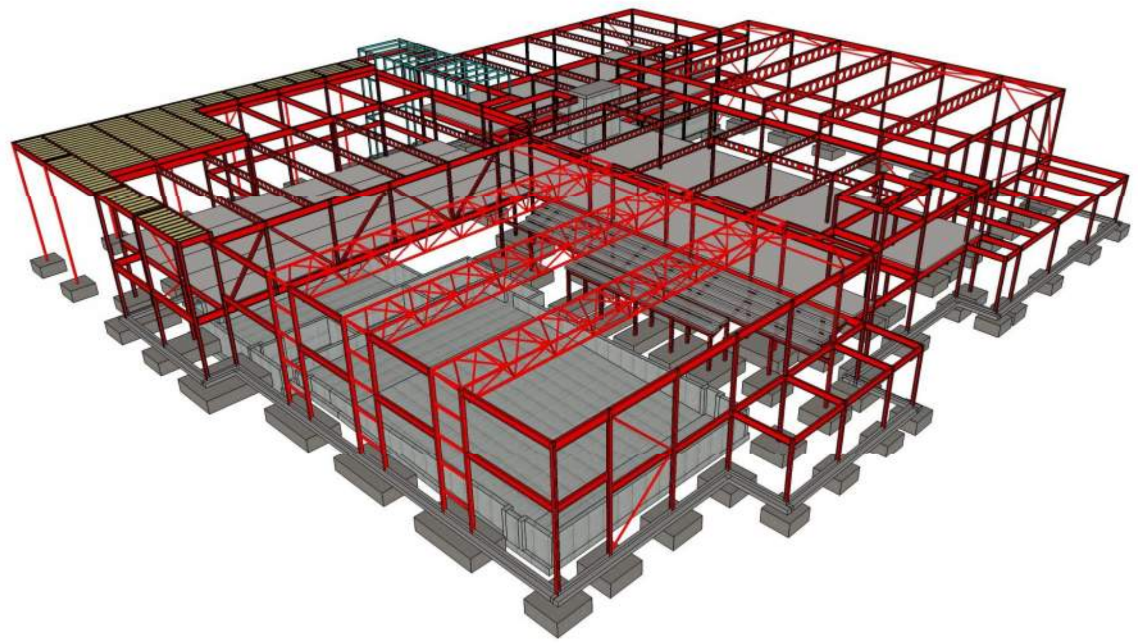
1.2.2 The site is currently a greenfield location bounded by Honeywood Parkway and a spur road to the east of the site.

1.2.3 The proposed leisure centre is a new build facility. The new facility will be designed around the following accommodation mix:

- 8 lane 25m pool
- Learner pool with moveable floor
- Wet changing village
- Activity zone around a new café space
- 4 court sports hall with associated changing
- Treatment rooms
- Gymnasium
- 2 large dance studios
- Spinning studio.

1.2.4 At this stage this Design Criteria & Materials report is based around a structural solution of steel frame with long span cell beam roof, shallow RC foundations and in situ RC swimming pool. The document will be developed as the design evolves.





2 DESIGN CODES

2.1 Design Codes

Eurocode Ref	Eurocode	National Annex
BS EN 1990:2002+A1:2005	Eurocode - Basis of structural design	NA to BS EN 1990:2002 (UK National Annex for Eurocode 0 – Basis of structural design)
BS EN 1991-1-1:2002	Eurocode 1: Actions on structures – Part 1-1: General actions – Densities, self-weight, imposed loads for buildings	NA to BS EN 1991-1-1:2002 (UK National Annex to Eurocode 1: Actions on structures – Part 1-1: General actions – Densities, ...)
BS EN 1991-1-2:2002	Eurocode 1: Actions on structures – Part 1-2: General actions – Actions on structures exposed to fire	NA to BS EN 1991-1-2:2002 (UK National Annex to Eurocode 1: Actions on structures – Part 1-2: General actions – Actions on structures exposed to fire
BS EN 1991-1-3:2003	Eurocode 1: Actions on structures – Part 1-3: General actions – Snow Loads	NA to BS EN 1991-1-3:2003 (UK National Annex to Eurocode 1: Actions on structures – Part 1-3: General actions – Snow Loads)
BS EN 1991-1-4:2005	Eurocode 1: Actions on structures – Part 1-4: General actions – Wind actions	
BS EN 1991-1-5:2003	Eurocode 1: Actions on structures – Part 1.5: General actions – Thermal actions)	NA to BS EN 1991-1-5:2003 (UK National Annex to Eurocode 1: Actions on structures – Part 1.5: General actions – Thermal actions)
BS EN 1991-1-7:2006	Eurocode 1: Actions on structures – Part 1-7: General actions – Accidental actions	
BS EN 1992-1-1:2004	Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings	NA to BS EN 1992-1-1:2004 (UK National Annex to Eurocode 2: Design of concrete structures – Part 1-1: General rules and rules for buildings) (+A1:2009)
BS EN 1992-1-2:2004	Eurocode 2: Design of concrete structures – Part 1-2: General rules – Structural fire design	NA to BS EN 1992-1-2:2004 (Uk National Annex to Eurocode 2: Design of concrete structures – Part 1-2: General rules – Structural fire design)
BS EN 197-1:2000+A1:2004+A3:2007	Cement – Part 1: Composition, specifications and conformity criteria for common cements	
BS EN 934-2:2009	Admixtures for concrete, mortar and grout Part 2: Concrete admixtures – Definitions, requirements, conformity, marking and labelling	n/a
BS EN 206-1:2000+A1:2004+A2:2005	Concrete – Part 1: Specification, performance, production and conformity	BS 8500-1:2006 BS 8500-2:2006

Eurocode Ref	Eurocode	National Annex
BS 8102:2009	Code of practice for protection of below ground structures against water from the ground	
BS 8500-1:2006	Concrete – Complementary British Standard to BS EN 206-1 – Part 1: Method of specifying and guidance for the specifier	
BS 8500-2:2006	Concrete – Complementary British Standard to BS EN 206-1 – Part 2: Specification for constituent materials and concrete	
BRE Special Digest 1:2005 Third Edition	Concrete in aggressive ground	n/a
BS EN 1993-1-1:2005	Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings	NA to BS EN 1993-1-1:2005 (UK National Annex to Eurocode 3: Design of steel structures Part 1-1: General rules and rules for buildings) (2008)
BS EN 1993-1-3:2006	Eurocode 3: Design of steel structures – Part 1-3: Cold-formed thin gauge members and sheeting	
BS EN 1993-1-5:2006	Eurocode 3: Design of steel structures – Part 1-5: Plated structural elements	
BS EN 1993-1-8:2005	Eurocode 3: Design of steel structures – Part 1-8: Design of joints	NA to BS EN 1993-1-8:2005 (UK National Annex to Eurocode 3: Design of steel structures Part 1-8: Design of joints) (2008)
BS EN 1994-1-1:2004	Eurocode 4: Design of composite steel and concrete structures – Part 1-1: General rules and rules for buildings	NA to BS EN 1994-1-1:2004 (UK National Annex to Eurocode 4: Design of composite steel and concrete structures – Part 1-1: General rules and rules for buildings) (2008)
BS EN 1995-1-1	Eurocode 5: Design of timber structures – Part 1-1: General – Common rules and rules for buildings	
BS EN 1995-1-2	Eurocode 5: Design of timber structures – Part 1-2: General – Structural fire design	
BS EN 1996-1-1:2005	Eurocode 6 - Design of masonry structures – Part 1-1: General rules for reinforced and unreinforced masonry structures	NA to BS EN 1996-1-1:2005 (UK National Annex to Eurocode 6 - Design of masonry structures – Part 1-1: General rules for reinforced and unreinforced masonry structures) (2007)
BS EN 1997-1:2004	Eurocode 7: Geotechnical design – Part 1: General rules	NA to BS EN 1997-1:2004 (UK National Annex to Eurocode 7: Geotechnical design – Part 1: General rules)
BS EN 1997-2:2007	Eurocode 7: Geotechnical design – Part 2: Ground investigation and testing	

3 GEOTECHNICAL DESIGN PARAMETERS

The following values have been taken from the ??? SI Report (TBC).

- SI included TBC
- Site Profile TBC
- The British Geological Survey (BGS) online map indicates that the sites bedrock geology is Margate Chalk Member. The sites superficial deposits are of Clay with flints formation, consisting of clay, silt sand and gravel.
- Concrete sulphate class Ds-1 and AC-1 required? TBC. Ground contamination TBC.
- Ground gases TBC

4 LOAD ACTIONS & COMBINATIONS

4.1 Ultimate Limit States (BS EN 1990:2002, Section 6.4)

Combinations of actions for persistent or transient design situations (BS EN 1990:2002, Cl. 6.4.3.2, Eq. 6.10):

$$\sum_{j\geq1}\gamma_{G,j}G_{k,j}+\gamma_P P+\gamma_{Q,1}Q_{k,1}+\sum_{i\geq1}\gamma_{Q,i}\psi_{0,i}Q_{k,i}$$

Combinations of actions for accidental design situations (BS EN 1990:2002, Cl. 6.4.3.3, Eq. 6.11a/b):

$$\sum_{j\geq1}G_{k,j}+P+A_d+(\psi_{1,1} or \psi_{2,1})Q_{k,1}+\sum_{i\geq1}\psi_{2,i}Q_{k,i}$$

4.2 Serviceability Limit States (BS EN 1990:2002, Section 6.5)

Characteristic combination used for irreversible limit states (BS EN 1990:2002, Cl. 6.5.3, Eq. 6.14a/b):

$$\sum_{j\geq1}G_{k,j}+P+Q_{k,1}+\sum_{i\geq1}\psi_{0,i}Q_{k,i}$$

Frequent combination used for reversible limit states (BS EN 1990:2002, Cl. 6.5.3, Eq. 6.15a/b)(i.e., temperature loads):

$$\sum_{j\geq1}G_{k,j}+P+\psi_{1,1}Q_{k,1}+\sum_{i\geq1}\psi_{2,i}Q_{k,i}$$

Quasi-permanent combination used for long-term effects and the appearance of the structure (BS EN 1990:2002, Cl. 6.5.3, Eq. 6.16a/b) (i.e., long-term deflections [for reinforced concrete floor framing] which include creep and shrinkage effects):

$$\sum_{j\geq1}G_{k,j}+P+\sum_{i\geq1}\psi_{2,i}Q_{k,i}$$

where:

$G_{k,j}$ = characteristic value of permanent action j (i.e., self-weight or superimposed dead load)
P = value of a prestressing action
A_d = design value of accidental action
A_{Ed} = E in load combinations below = design value of seismic action = $\gamma_I A_{Ek}$ where A_{Ek} is characteristic value of seismic action
$Q_{k,1}$ = characteristic value of leading variable action 1 (e.g., Live, Wind, Temperature, etc.)
$Q_{k,i}$ = value of accompanying variable action i

$\gamma_{G,j}$ = partial factor for permanent action j
$\gamma_{Q,1}$ = partial factor for leading variable action 1
$\gamma_{Q,i}$ = partial factor for accompanying variable action i

Ψ_0 = factor for combination value of a variable action
Ψ_1 = factor for frequent value of a variable action
Ψ_2 = factor for quasi-permanent value of a variable action

4.3 Partial Factors for ULS design situations

Per the UK NA to BS EN 1990:2002 Tables NA.A1.1, NA.A1.2 (B) (same as A1.2 (B)) and NA.A1.2 (C) (same as A1.2 (C)), the following factors will be applied:

Action	Ψ_0	Ψ_1	Ψ_2
Imposed loads in buildings			
Category A: domestic, residential areas	0.7	0.5	0.3
Category B: office areas	0.7	0.5	0.3
Category C: congregation areas	0.7	0.7	0.6
Category E: storage areas	1.0	0.9	0.8
Category F: traffic area ≤ 30kN veh wt	0.7	0.7	0.6
Category G traffic area >30kN veh wt ≤160	0.7	0.5	0.3
Category H: roofs	0.7	-	-
Snow alt <1000m	0.5	0.2	0
Wind loads on buildings	0.5	0.2	-
Temperature (non-fire) in buildings	0.6	0.5	-

For the design of structural members not involving geotechnical actions (Set B):

Permanent actions (unfavourable), $\gamma_{Gj,sup}$=1.35
Permanent actions (favourable), $\gamma_{Gj,inf}$=1.00
Partial factor for leading variable action, $\gamma_{Q,1}$ = 1.50 (where unfavourable, 0 where favourable)
Partial factor for accompanying variable action, $\gamma_{Q,i}$ = 1.50 (where unfavourable, 0 where favourable)

For the design of structural members involving geotechnical actions and resistance of the ground (both Set B and Set C in separate calculations, the most unfavourable):

Set B as above.
Set C:
Permanent actions (unfavourable), $\gamma_{Gj,sup}$=1.00
Permanent actions (favourable), $\gamma_{Gj,inf}$=1.00
Partial factor for leading variable action, $\gamma_{Q,1}$ = 1.30
Partial factor for accompanying variable action, $\gamma_{Q,i}$ = 1.30

4.4 Design Combinations

Ultimate Limit States (BS EN 1990:2002, Section 6.4) using partial factors for ULS design situations to the UK National Annex:

1.35D
1.35D+1.5L
1.35D+1.5T
1.35D+1.5L+0.9T
1.35D+1.5T+1.05L
1.35D+1.5W
0.9D+1.5W
1.35D+1.5L+0.75W
1.35D+1.5W+1.05L
1.35D+1.5W+1.05L+0.9T
1.35D+1.5L+0.75W+0.9T
1.35D+1.5T+1.05L+0.75W

Note: where L is a storage load and is not the leading variable 1.35L should be used in lieu of 1.05L

Serviceability Limit States (BS EN 1990:2002, Section 6.5) using partial factors for SLS design situations (UK National Annex):

1.0D
1.0D+1.0L
1.0D+1.0T
1.0D+1.0L+0.6T
1.0D+1.0T+0.7L
1.0D+1.0W
1.0D+1.0L+0.5W
1.0D+1.0W+0.7L
1.0D+1.0W+0.7L+0.6T
1.0D+1.0L+0.75W+0.9T
1.0D+1.0T+0.7L+0.5W
0.9D+1.0W

Note: where L is a storage load and is not the leading variable 0.9L should be used in lieu of 0.7L

Where D = dead load, L = live load (roof, floor or storage), W = wind load ($+W_x$, $-W_x$, $+W_y$, $-W_y$), T = temperature load.

Note: clause 3.3.2 of BS EN 1991-1-1:2002 states that imposed loads on roofs (L) need not be applied in combination with wind actions (W)

5 PERMANENT ACTIONS

The following values have been assumed for the purposes of this design and will need to be confirmed by the Architect before moving to the next stage of design. In the absence of detailed loading design criteria, the loads are based on experience on similar projects.

Tag	Description	Area	Uniform Load	Point Load
-	*Self-weight of structure*	*All*	*as calc.*	-
	GROUND FLOOR			
G1	*Ground Bearing RC Slab – as calc.* *75mm Screed – 1.50* *Floor Finishes – 0.20* *Water - depth x 10kN/m^3*	*Swimming Pool*	*1.70kN/m^2 + water load*	-
G2	*Ground Bearing RC Slab – as calc.* *125mm Screed – 3.00* *Floor Finishes – 0.20* *Floor Services (U/F Heating System) – 0.10*	*General Ground Floor, High Screed Levels*	*3.30 kN/m^2*	-
G3	*Ground Bearing RC Slab – as calc.* *Sprung Timber/Studio Floor System – 1.00*	*Sports Hall/Studio, Ground Floor*	*1.00 kN/m^2*	-
G4	*Ground Bearing RC Slab – as calc.* *75mm Screed – 1.50* *Floor Finishes – 0.20*	*General Ground Floor*	*1.70 kN/m^2*	-
	FIRST FLOOR			
G5	*130mm SMDTR60 0.9 Gauge Deck – as calc.* *Max 25mm Screed – 0.5* *Floor Finishes – 0.20* *Ceiling & Services – 0.30*	*Typical First Floor*	*1.00 kN/m^2*	-
G6	*130mm SMDTR60 0.9 Gauge Deck – as calc.* *Sprung Floor System – 0.75* *Ceiling & Services – 0.30*	*First Floor Studio*	*1.05kN/m^2*	-
G7	*130mm SMDTR60 0.9 Gauge Deck – as calc.* *125mm Screed – 2.50* *Floor Finishes – 0.20* *Ceiling & Services – 0.30*	*Typical First Floor, High Screed Levels*	*3.00 Kn/m^2*	-
	ROOF (Metal deck weight included where it is not part of a composite slab system)			
G8	*Steel Deck (Tata D100 0.9mm Gauge) – 0.15* *Roof Finishes – 0.15* *Ceiling & Services – 0.20*	*Typical Flat Steel Roof*	*0.50 kN/m^2*	-
G9	*130mm SMDTR60 0.9 Gauge Deck – as calc.* *Concrete Pavers – 1.50* *Roof Finishes – 0.15* *Ceiling & Services – 0.25*	*Roof Plant*	*1.90 kN/m^2*	-
G10	*PV Allowance – 0.20* *Deck(Tata Steel D159 1.25mm Gauge) – 0.20* *200mm Insulation – 0.050* *50mm Acoustic Insulation – 0.050* *Standing Seam External Roof– 0.050* *Services – 0.10*	*Sports Roof with PV Panels*	*0.65 kN/m^2*	-
G11	*PV Allowance – 0.20* *Deck(Tata Alu D159 1.5mm Gauge) – 0.10* *200mm Insulation – 0.050* *50mm Acoustic Insulation – 0.050* *Standing Seam External Roof – 0.050* *Services – 0.10* *Timber Soffit Panels – 0.15*	*Swimming Roof with PV Panels & Timber Soffit*	*0.70 kN/m^2*	-

6 VARIABLE ACTIONS

The following values have been assumed for the purposes of this design and will need to be confirmed by the Architect before moving to the next stage of design. In the absence of detailed loading design criteria, the loads are based on experience on similar projects.

Tag	Area	Uniform Load	Point Load
Q1	*Ground Floor Plant*	*10.0 kN/m^2*	*9.00 kN*
Q2	*Sports Hall, Gymnasia, Studios & Roof Plant*	*5.0 kN/m^2*	*4.50 kN*
Q3	*Typical Floor*	*3.0 + 1.0 kN/m^2*	*4.50 kN to Corridors, 2.70 kN otherwise*
Q4	*Typical Flat Steel Roof*	*0.60 kN/m^2*	-
Q5	*Sports & Swimming Hall Roofs*	*0.40 kN/m^2*	-
Q6	*Swimming Pool Surrounds*	*4.0kN/m^2*	*4.50 kN*

Notes: 1. Categories per NA to BS EN 1991-1-1:2002.

7 WIND LOADING & SNOW LOADING

7.1 Wind Loading & Snow Loading

The following values have been assumed for wind loading.

Parameter	Value	Reference
v_{bmap}	21.5m/s TBC	BS EN 1991-1-4 UK NA (Figure NA.1)
c_{alt}	1.12	BS EN 1991-1-4 UK NA (NA.2.5, A = 120m)
c_{prob} (60 years)	1.01	
q_b (worst case based on c_{dir}=1.0)	0.360 kN/m^2	BS EN 1991-1-4 (Figure A.NA.2)
q_p **(Westerly wind direction)** (at max building height)	0.860 kN/m^2	BS EN 1991-1-4 (Figure A.NA.2)

The following values have been assumed for snow loading:

Area	Value	Reference
Zone number	3	BS EN 1991-1-3 UK NA (Figure NA.1)
Typical Roof (Pitch 0-30^o, un-drifted)	0.43 kN/m^2	BS EN 1991-1-3 Table 5.2 (μ_1 = 0.8)

8 PARAPETS / HANDRAILS LOADING

8.1 Parapets/Handrails Loading

Feature	Line Load	Reference
All parapets, balustrades balconies: Category A (ii) (conservative loading, for robustness of structure)	0.74 kN/m^2	BS EN 1991-1-1 UK NA (Table NA.8)

9 STABILITY & ROBUSTNESS

9.1 Stability Overview

TBC

9.2 Robustness

In accordance with Building Regulations Approved Document A – A3 Disproportionate collapse:
Building Class: Section 5 - Table 11: The structure is defined as a **consequence class 1 structure**.
Detailing of the building will be undertaken as per a consequence class 2B building.

9.3 Design Tie Forces

Parameter	Value	Reference
CLT panel – CLT panel and CLT panel – RC ground floor structure, Horizontal tie force (applied as shear along panel length or across panel length)	Internal Ties - $F_{t,hor,int,d}$ = max{15 or 0.8(g_k + q_k)sL} (kN) Perimeter Ties - $F_{t,hor,per,d}$ = max{7.5 or 0.4(g_k + q_k)sL} (kN)	Structural Timber Association – 5. Structural Timber Engineering Bulletin: *Timber frame structure – platform frame construction (part 3)*, Table 3

10 PARAPETS / HANDRAILS LOADING

10.1 Deflection Limits

The following deflection criteria have been assumed in the design:

Area	Limit
Vertical Deflection: Typical Floors (beams and slabs) Typical Roof (Tiled)	Lesser of: Span/250 under total loading Span/360 post-construction movement 20mm post-construction movement for areas with partitions
Vertical Deflection: Flat Roof	Lesser of: Span/150 under total loading Span/250 post-construction movement 20mm post-construction movement for areas with partitions
Horizontal Deflection Glazed/Stone Clad/Rendered Walls	Height or Span/500 (or 14mm if less)
Horizontal Sway/Storey Structural Frames	Height/300 (per storey)

Notes: SLS deflections assessed under characteristic dead and imposed loads in accordance with BS EN1990.

11 FLOOR VIBRATION

11.1 Vibration Criteria

Floor vibration to be evaluated per, Floor Vibrations Due to Human Activity in conjunction with the Steel Construction Institute (SCI) P354 'Design of Floors for Vibration'

For Steelwork
General Areas
Typical floors and corridors are designed for an element frequency limit of 5Hz and a combined system frequency limit of 4Hz.

Studio & Party Room
Studios and the Party Room are designed for an element frequency limit of 8Hz and a combined system frequency limit of 8.4Hz.

12 FIRE RESISTANCE

12.1 Fire Resistance

The following fire resistance periods have been assumed in design based on the architect's specifications. TBC by Fire Engineer.

Area	Minimum fire period of resistance
Floors	60mins
Roofs	30mins
Beams/Columns/Walls supporting roof only	30mins
Beams/columns/walls supporting floors	60mins

The strategy for the design of structural elements for the given minimum fire period of resistances is summarised below.

Element	Value	Method	Alternative
Roofs	R(30), EI(0)	Inherent in CLT floor panel	N/A
Beams/Columns/Walls supporting roof only	R(30), EI(0)	Inherent in CLT/Glulam member	All fire protection provided by plasterboard finishes

Notes:

1. It is assumed that all steel structures, where supporting fire rated floors or roofs, are to be fire protected by fire board protection or intumescent paint.
2. It is assumed that plasterboard finishes do not generally contribute to fire resistance of timber elements.
3. All CLT panels are designed for fire on one side only. Should protection be required on both sides this should be established by the architect who should design and specify additional boarding or other protection.

13 TEMPERATURE & HUMIDITY EFFECTS

13.1 Fire Resistance

The effect of temperature and humidity will have an influence on the structural elements. When considering these effects it should be noted that the external temperature will not in all cases directly influence structural elements and the sheltering and insulating of elements should be considered.

The effects of differential thermal movement should also be considered not just for elements with different thermal coefficients but also for similar elements partially insulated by varying amounts to temperature change effects.

Temperature ranges
The following temperature ranges should be considered:
- Internal elements: 5°C to 25°C
- External elements: -10°C to 40°C
- Plant rooms: -10°C to 40°C

In the absence of further information 3/4 of this temperature range should be considered for free expansion and contraction of elements.

14 MOVEMENT & TOLERNACES

14.1 Movement & Tolerances

This section outlines the movements and tolerances of the structural elements of the development that could reasonably be expected during the frame life. This section should be used by the Architect, MEP, Main and Trade Contractors to understand the initial fit and behaviour under loading of the primary structural elements such as beams, columns, decking, floor plates and load bearing walls.

Some of the materials that make up the structural elements such as steel, concrete and other metals have properties that are well understood and established over a narrow range. The interaction of the structure with elements such as floor finishes, cladding and internal partitions, that, although not designed to stiffen structural elements, may never the less stiffen in an unpredictable and unreliable manner the span of slabs and beams etc or the sway of columns and walls.

Connections of elements is another area where unpredictable effects may take place and elements tend not to behave elastically in these locations causing discontinuities across the connection which should be considered for interfacing elements. Indeed many simply supported beams and slabs are deliberately designed to rotate at end connections and this effect should be noted for interfacing beams.

The net results of all the above effects is that although limits can be established for the range of movement of structure under applied loads, the actual deflection or movement is not predictable and may vary from place to place in the structure even for similar elements under similar load conditions. Consideration should be given to the effects if deflection etc did not happen to one element but happened to another.

14.2 Construction Tolerances

The following should be considered. The sources of tolerance include:
- Setting out, Erection, Fabrication manufacture
- Movement joints in cladding where noted on GA and sections, typically +/- 25mm.

15 CONCRETE

The concrete grades used for design are listed in below:

Concrete Grade Section
> Grade 32/40 ~ Composite Metal Decks (fcu =25 N/mm2) - All concrete metal decks
> Grade RC40 / GEN3 ~ C32/40 (fcu = 40 N/mm2) - All foundations, retaining walls, ground beams and ground bearing slabs

Concrete Material Properties:
Material Property Grade C32/40
Young's Modulus, E = 33.35 kN/mm2
Poisson's Ratio, v = 0.2
Co-efficient of thermal expansion, 1.0 x 10 −5 per oK
Shear Modulus, G = 13.9 kN/mm2

16 STEEL

The design, details, fabrication and erection of structural steelwork shall be in accordance with BS EN 1993-1-1: 2005: Eurocode 3: Design of steel structures. Structural steel shall be Grade S355 unless noted otherwise (UNO).

Form	Material	Tolerances
Universal Beams and Columns	BS EN 10025	BS EN 10034
Joists		BS EN 10024
Channels		BS EN 10279
Angles		BS EN 10056-2
Rolled Tees		
Plates		BS EN 10029
Flats		BS EN 10029
Hollow sections (hot finished), Typ., U.N.O.	BS EN 10210-1 For weathering steels: BS 7668	BS EN 10210-2
Hollow sections (cold formed)	BS EN 10219-1	BS EN 10219-2
Galvanised open sections and strip	BS EN 10147	BS 2989
Ordinary bolt assemblies	Property classes 8.8: Full-threaded bolts to BS EN ISO 4017 (s/s BS 3692) Part-threaded bolts to BS EN 4014	Bolts: BS EN ISO 4018 or 4016 (s/s BS 4190) Nuts: BS EN ISO 4034
	BS 4395	
Holding down (foundation) bolt assemblies	Bolts to BS 7419 Nuts to BS EN ISO 4032 Washers to BS EN 7091	
Welding consumables	BS EN 756:2004 BS EN ISO 14171:2010 tbc BS EN 760:1996 BS EN ISO 2560: BS EN ISO 14341: BS EN ISO 17632: BS 639 BS 2901-1 BS 4165:1984 BS 7084	
Shear studs (headed)	BS EN ISO 13918 min f_y=350 N/mm^2	
Profiled steel sheeting for composite slabs	BS EN 1993-1-3, Sections 3.1 and 3.2 Steel per BS EN 10025 Cold-formed steel sheet per BS EN 10149-2 or -3 Galvanised steel sheet per BS EN 10326 Nominal thickness t=0.70mm	

16.1 Steel Properties

Density:	7,850 kg/m^3
Young's Modulus:	E = 210,000 MPa
Poisson's Ratio:	υ = 0.30
Coefficient of linear expansion:	α_T = 12x10^{-6}/°C (per BS EN 1991-1-5:2003 Table C.1)

16.2 Welding Electrodes

Consumables for use in metal arc welding shall comply with BS EN 756 (or BS EN ISO 14171 tbc), BS EN 760, BS EN ISO 2560, BS EN ISO 14341, or BS EN ISO 17632 as appropriate. These standards will be added to those in QCS 2007 Section 16 Part 5 (Welding).

Consumables used for completing welding of steels to BS EN 10025-5 shall have a weather resistance at least equivalent to the parent metal.

17 TIMBER

1. All structural timber will be service class 1 (inside insulation and vapour barrier), including the pool area where specific climate control is to be provided (by others).
2. CLT to be TBC
3. Glulam frame members are specified as TBC

18 SWIMMING POOL CONSTRUCTION

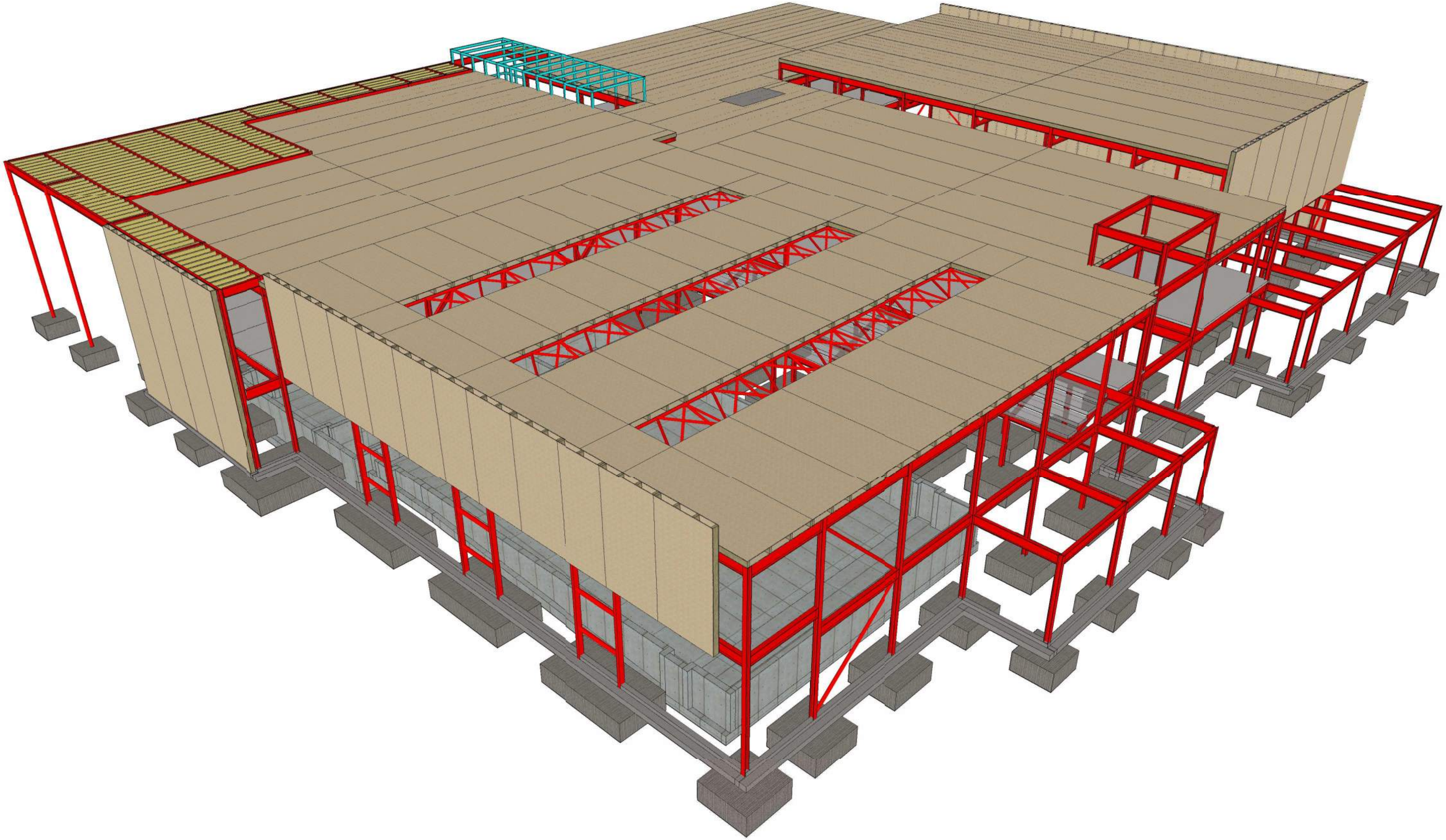
TBC

19 DRAINAGE & HARDSTANDING

TBC

APPENDIX B

STRUCTURAL ENGINEERING SKETCHES



NOTES

1. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS NOTED OTHERWISE

REVISION / DESCRIPTION	DRAWN	CHECKED	DATE
P1 PRELIMINARY ISSUE	PG	PG	17/06/16
FIRST ISSUE			

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PROJECT TITLE: DOVER LEISURE CENTRE

DRAWING TITLE: 3D VISUAL SHEET 1

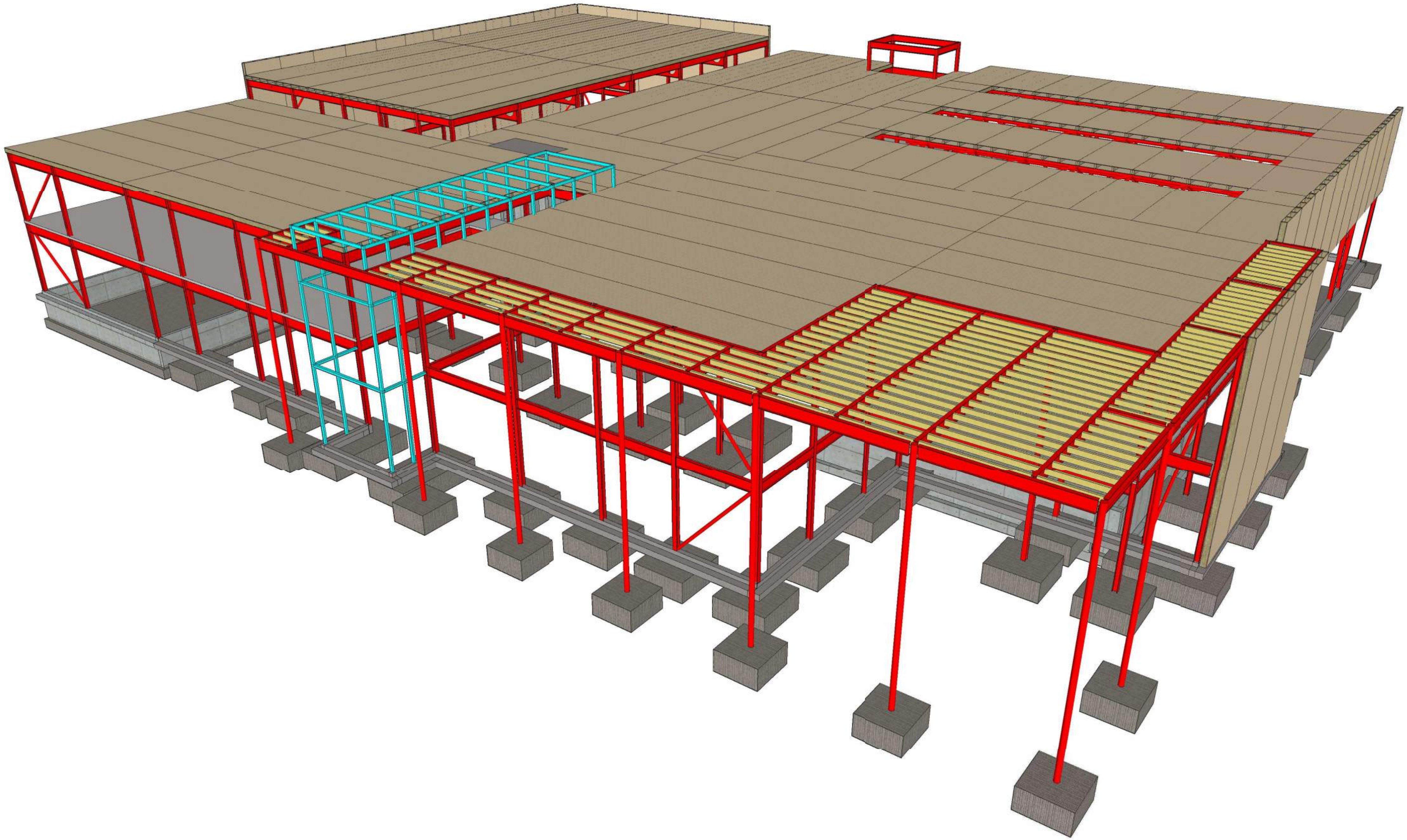
SCALE: NTS

DATE: 17.06.16

PROJECT NUMBER: 634

DRAWING No: 634-SK-S-005

REVISION: P1



NOTES

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DRAWING TITLE: 3D VISUAL SHEET 2

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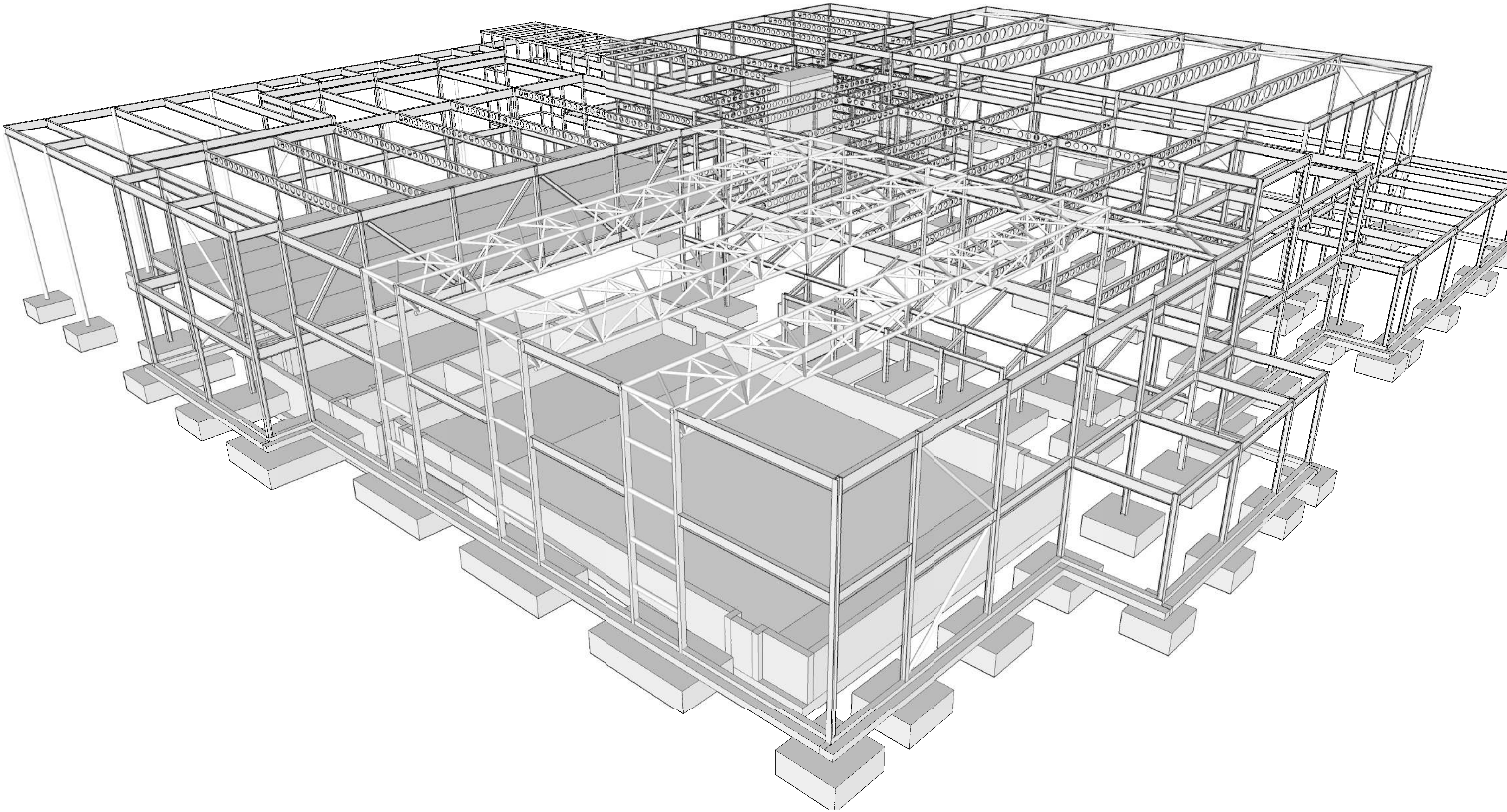

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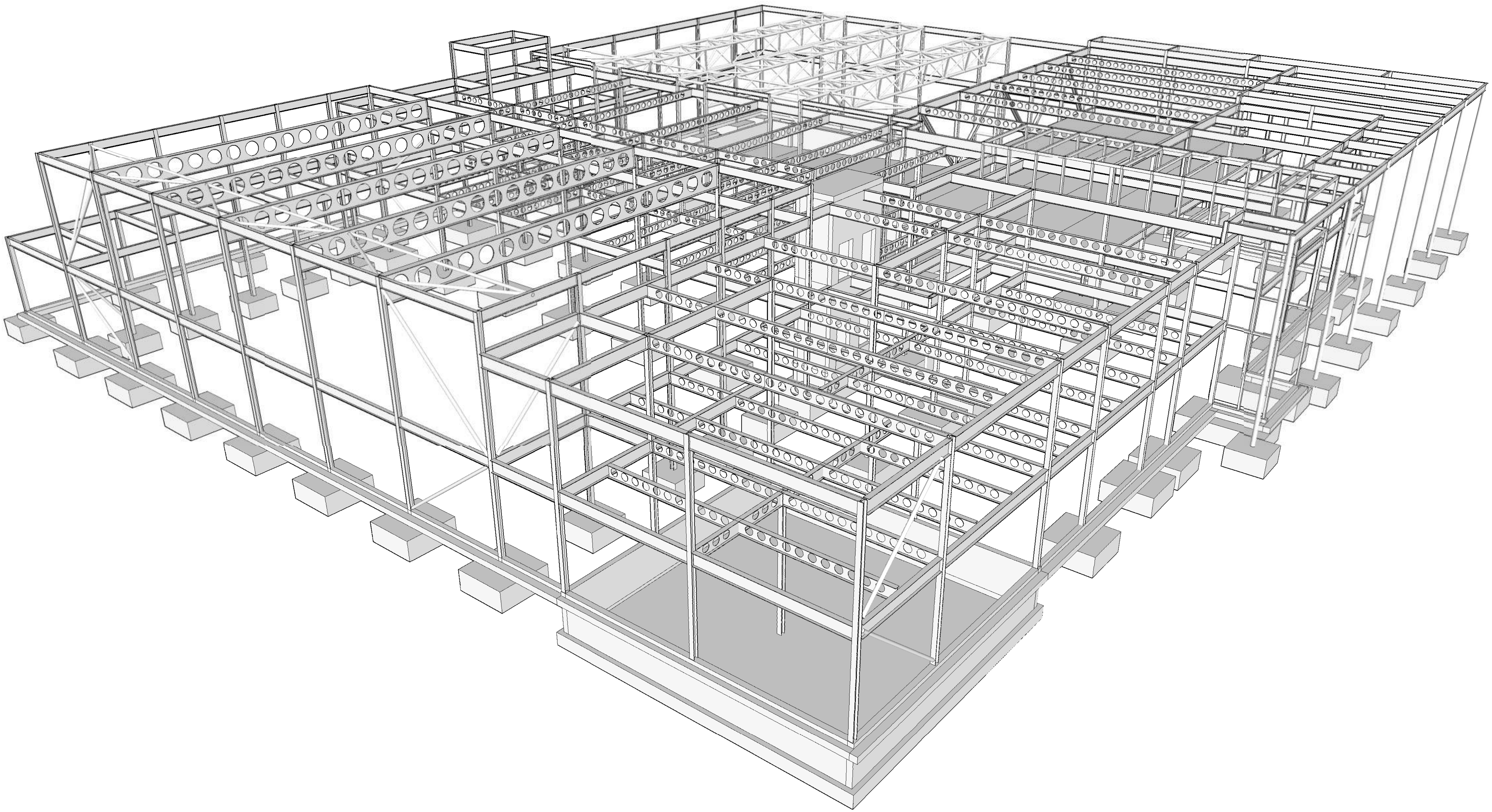

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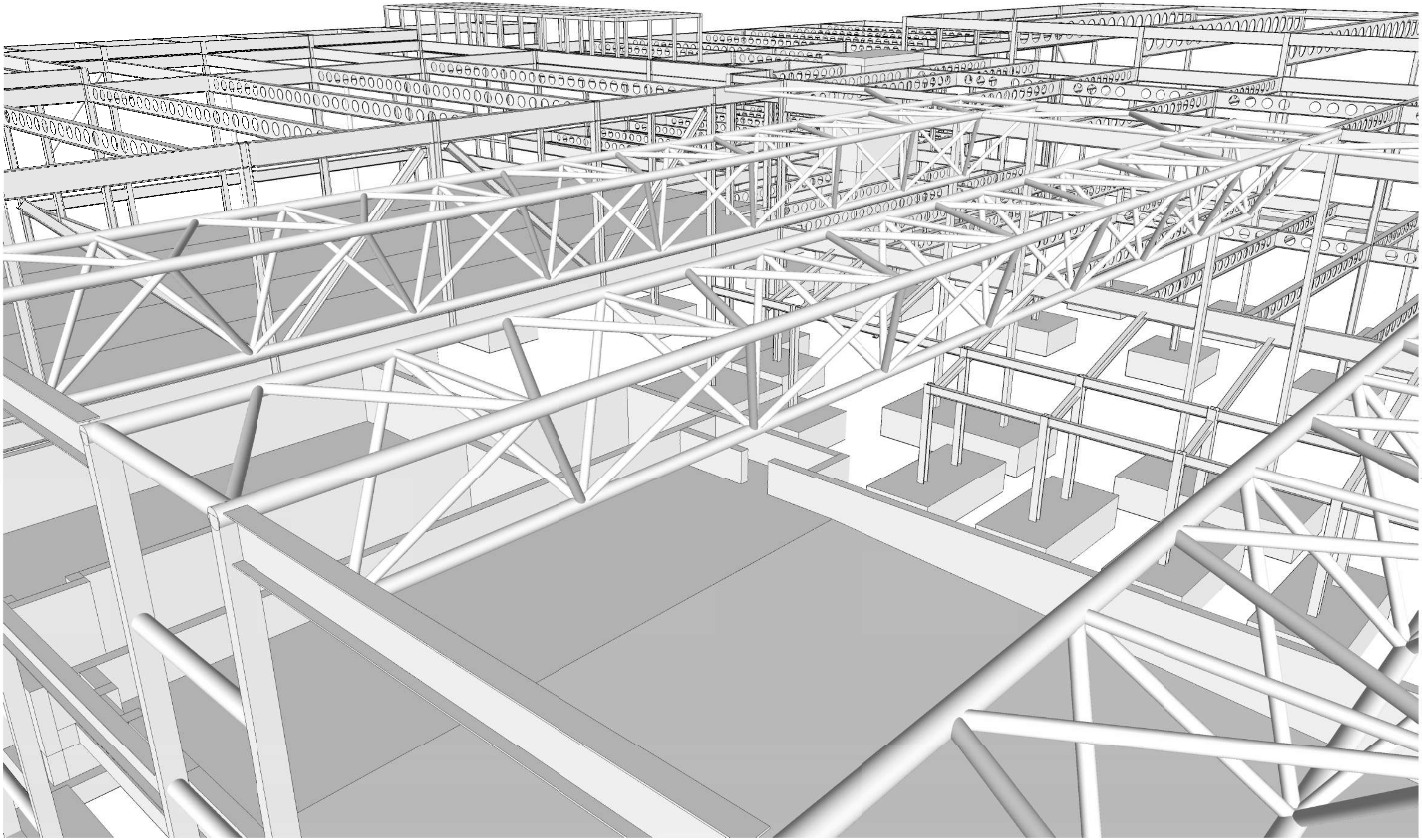

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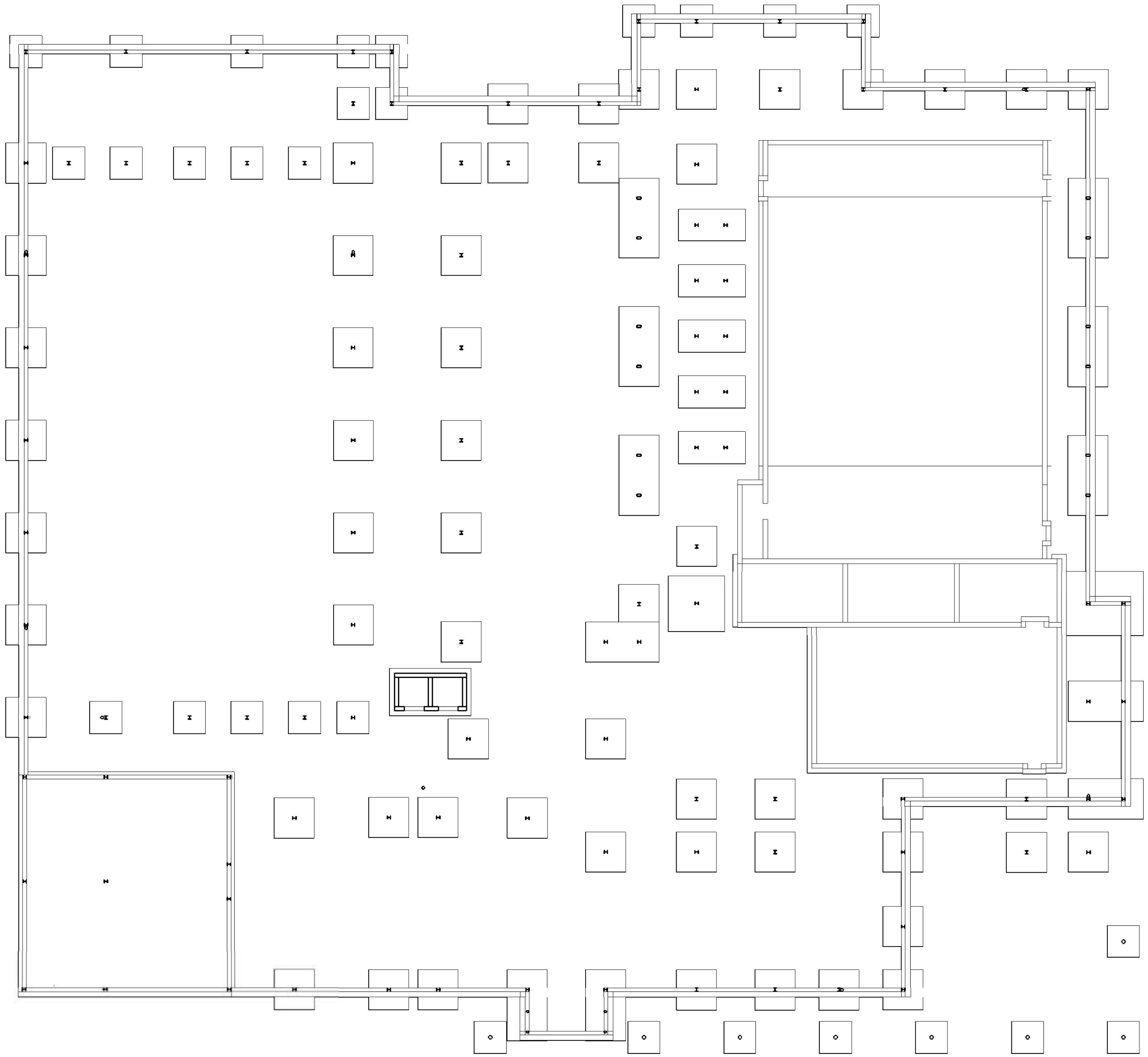

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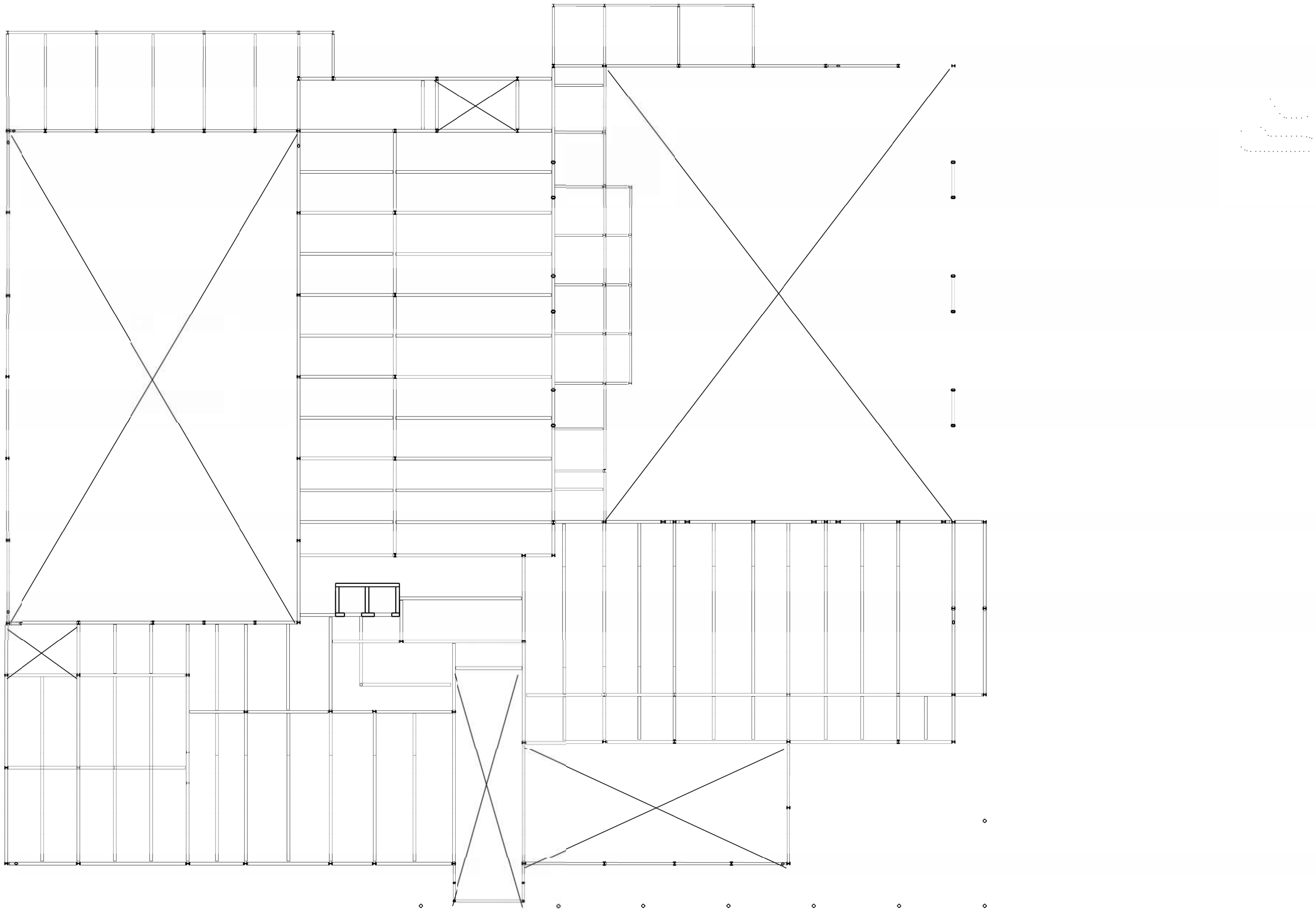

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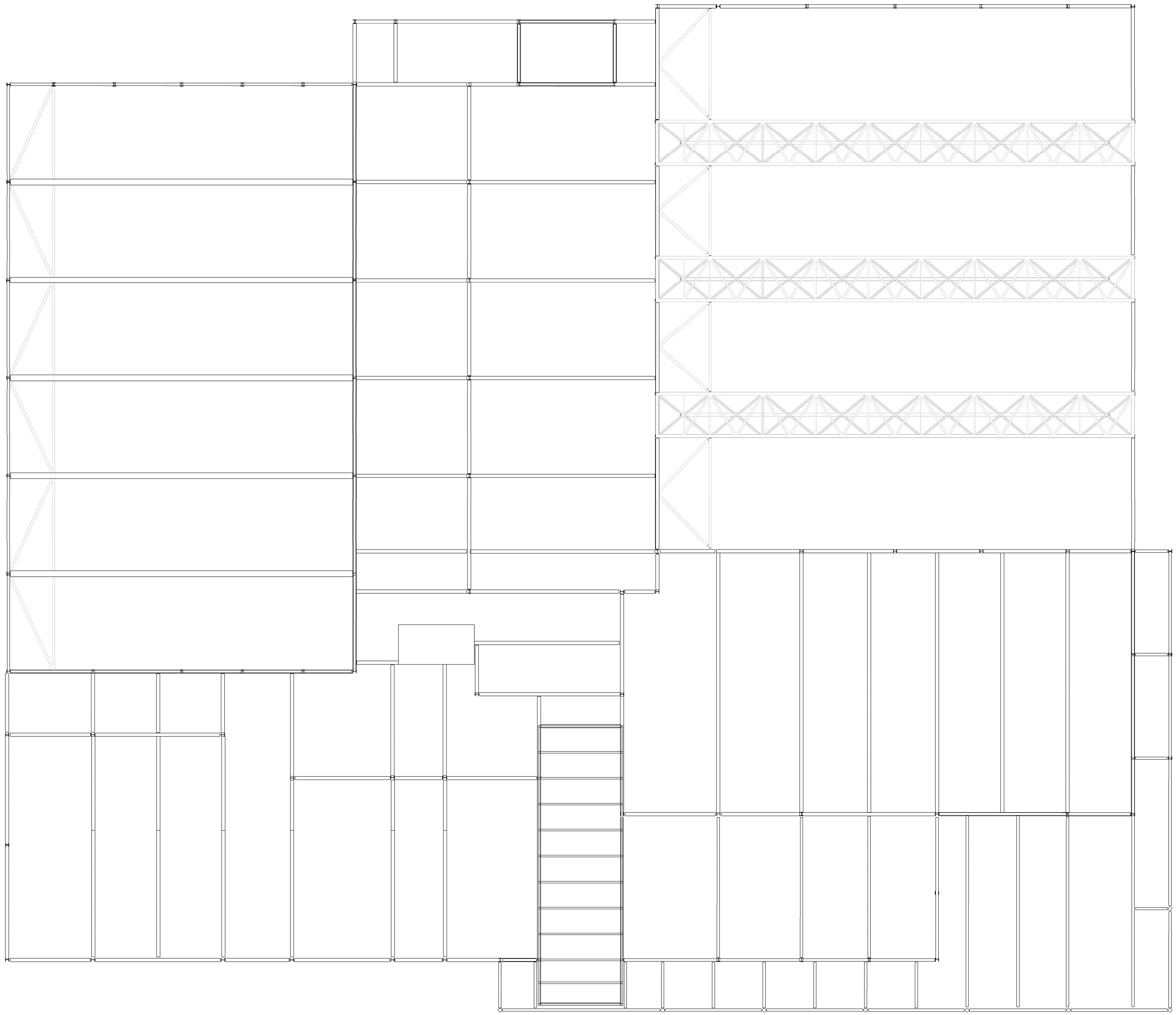

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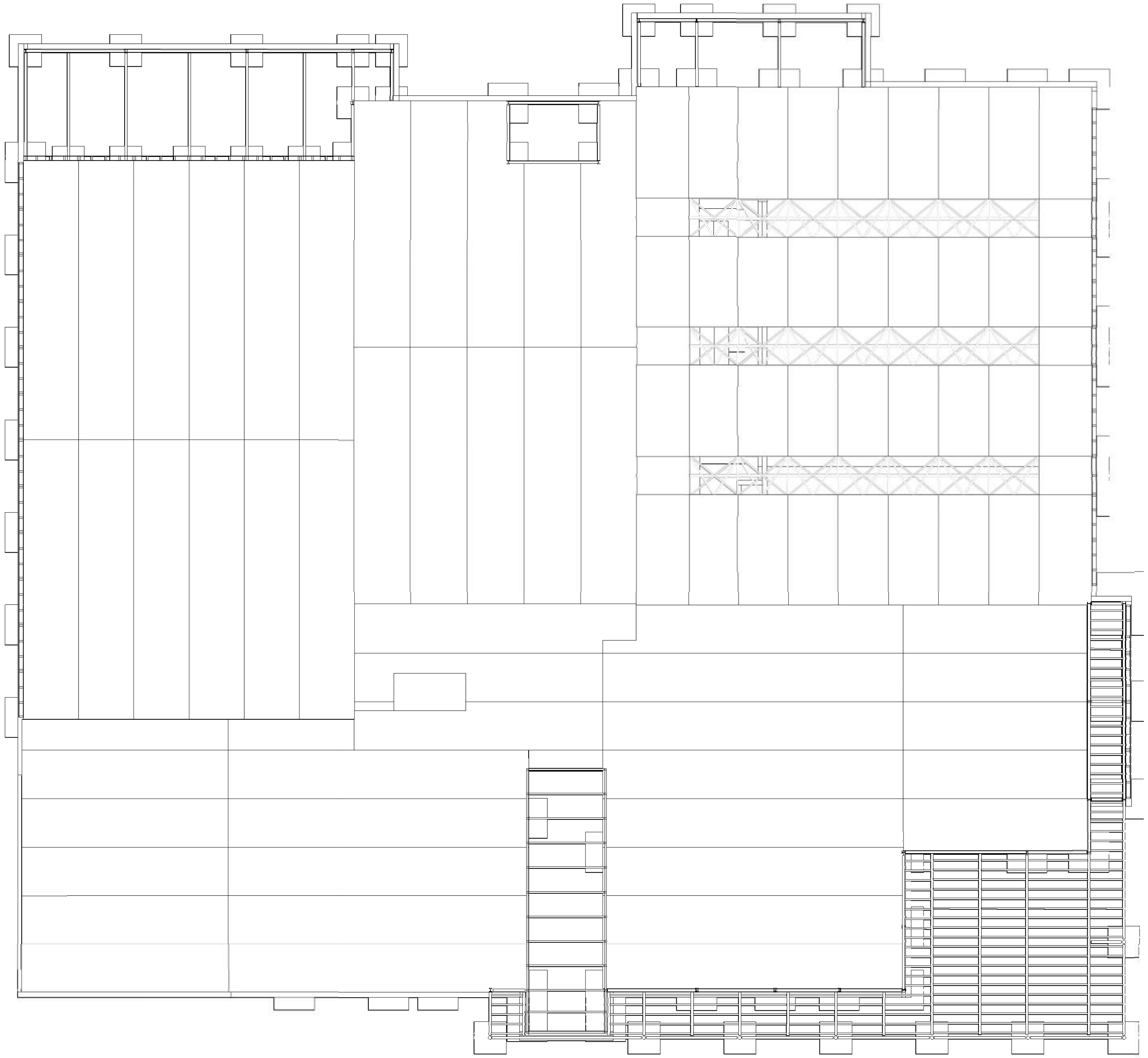

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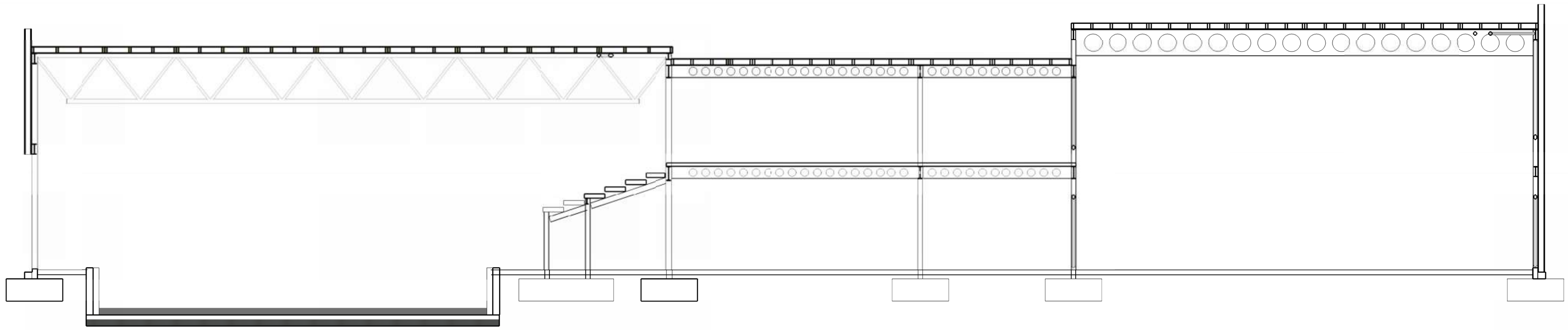

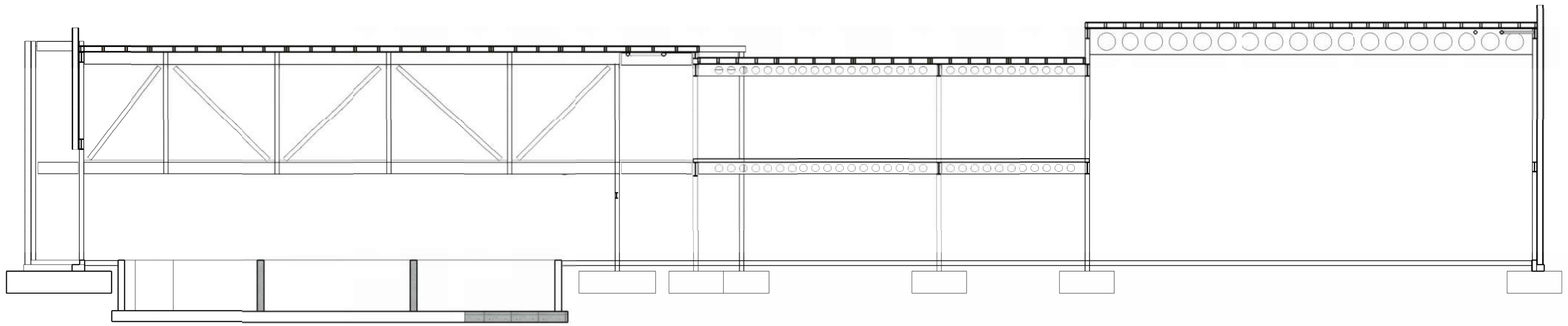

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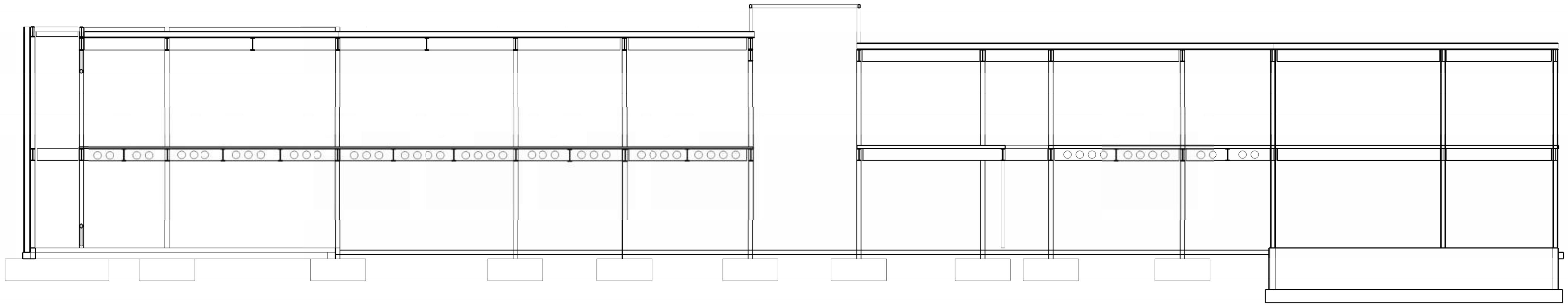

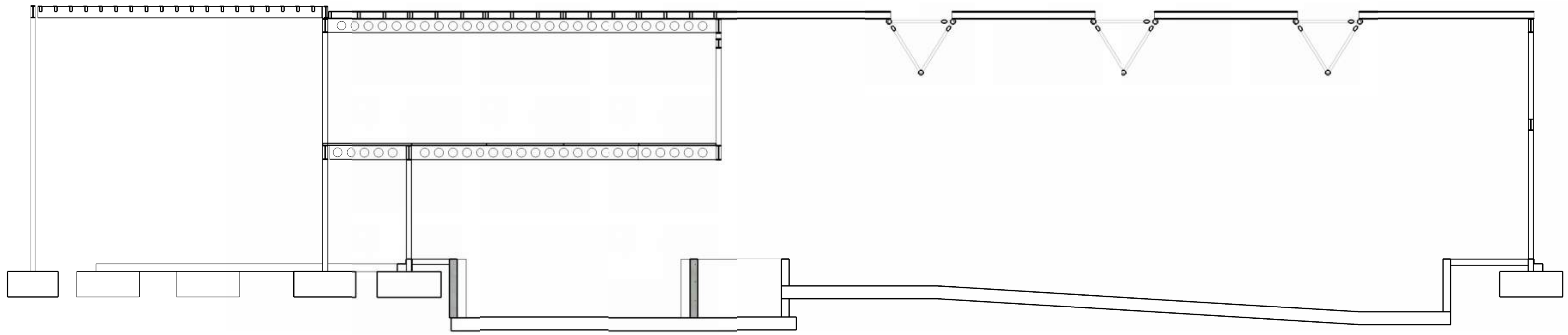

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DRAWING No	634-SK-S-201
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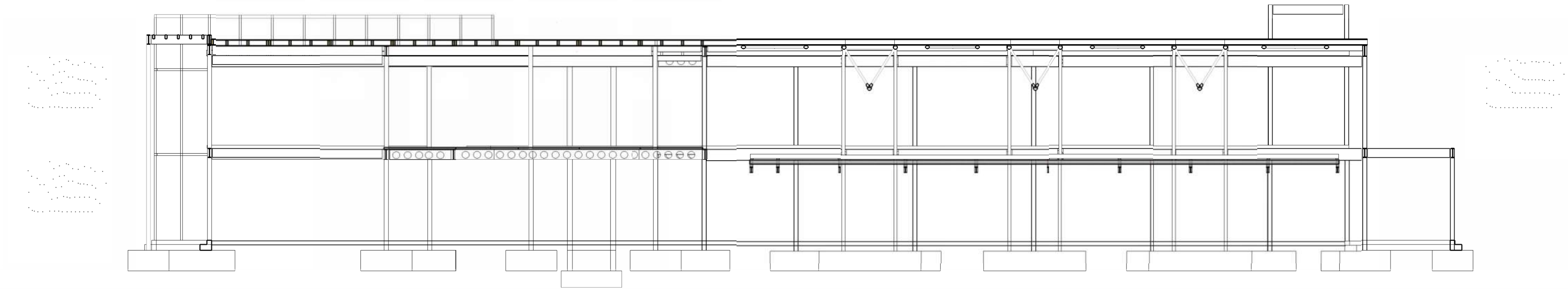

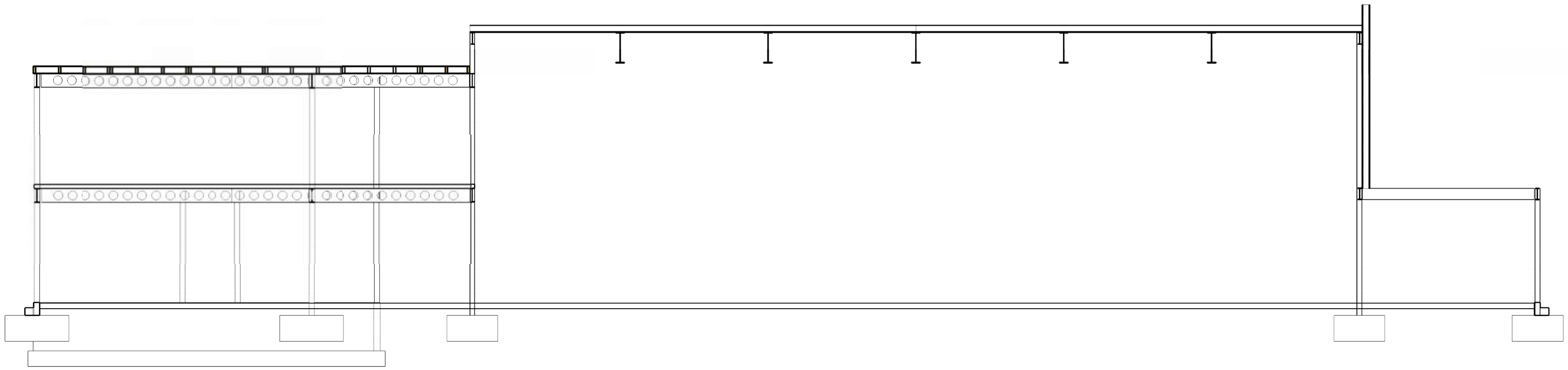

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DRAWING TITLE
BUILDING SECTION 5 & 6

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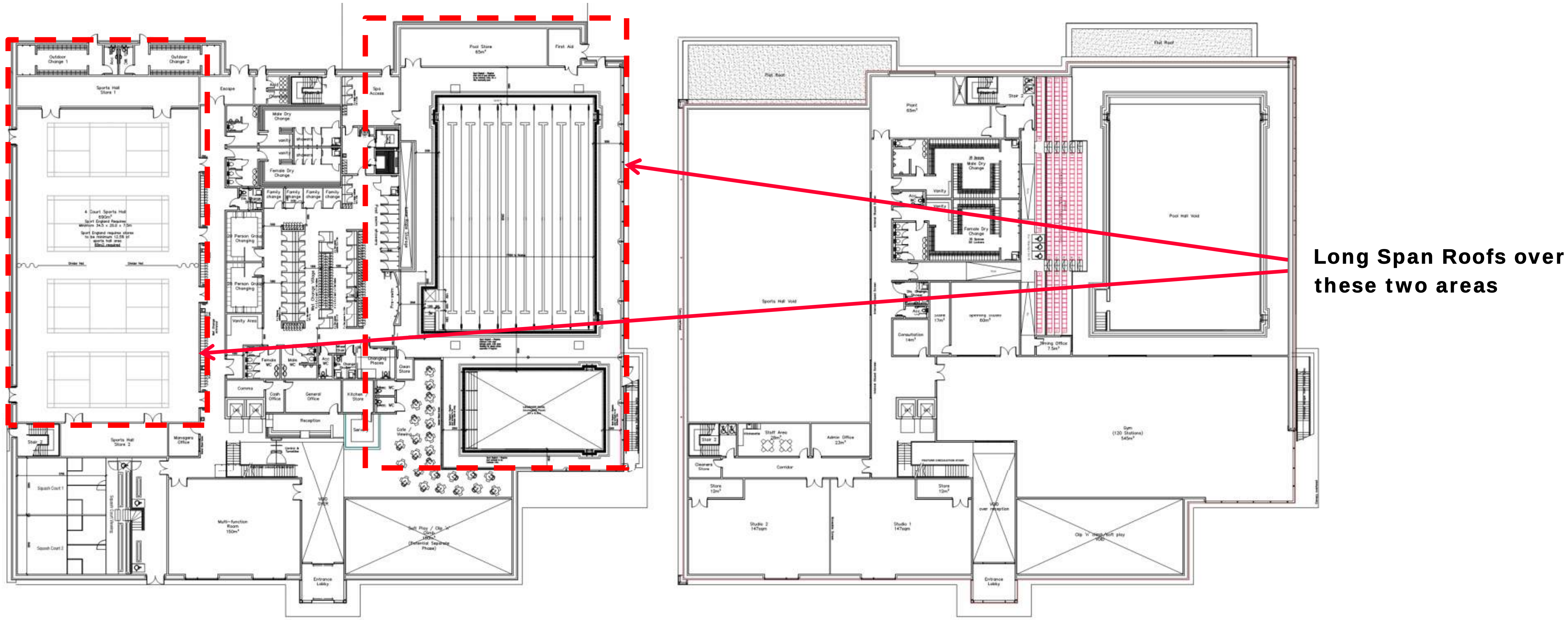
APPENDIX C

LONG SPAN ROOF STUDIES

Long Span Roof Studies

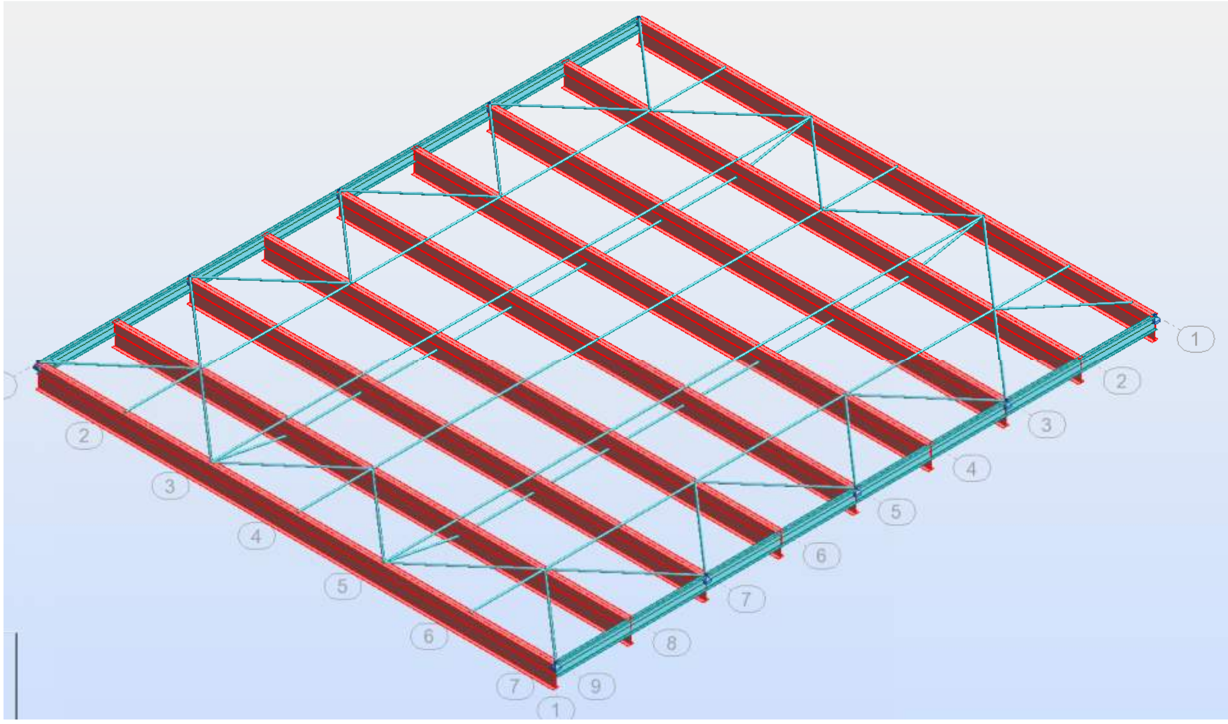
Introduction

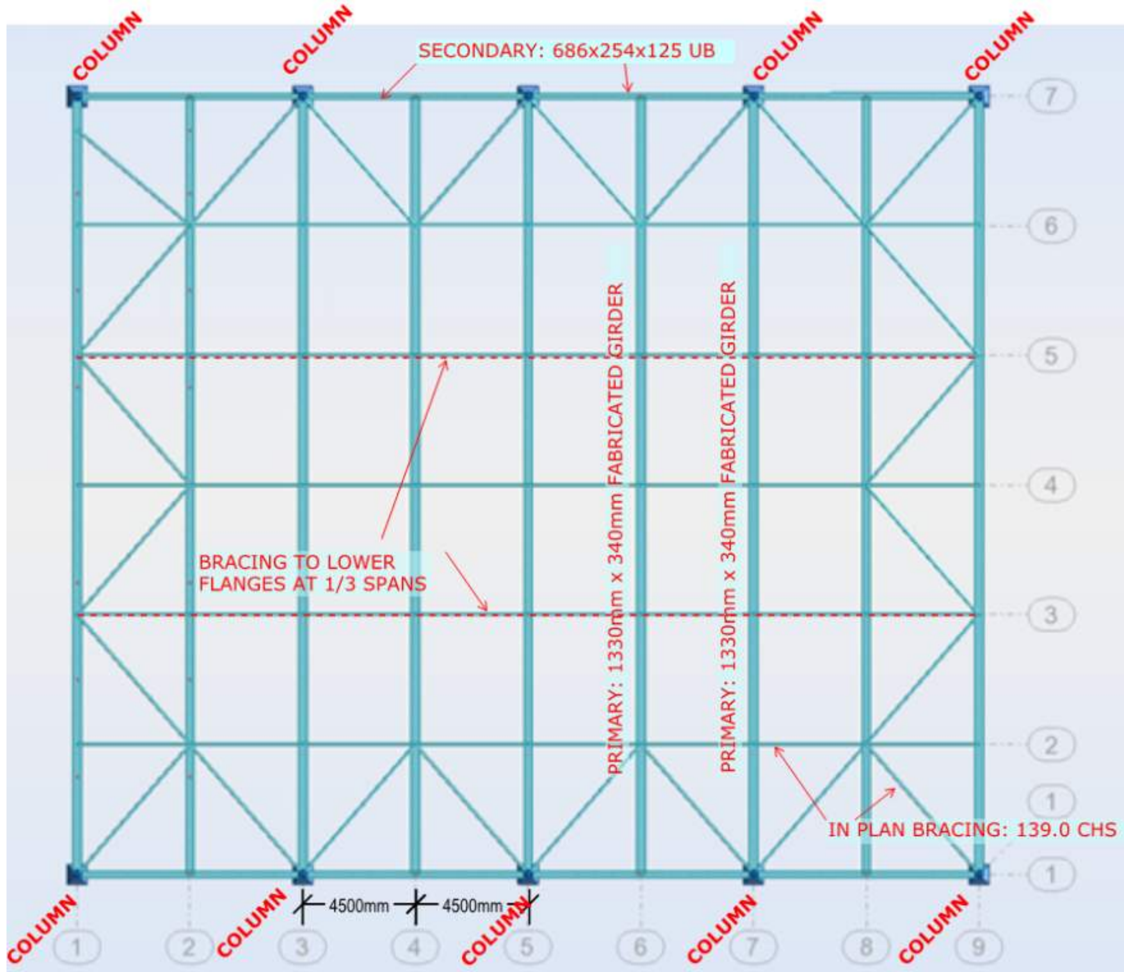


- This study aims to explore possible structural arrangements to the long-span roofs over the swimming pool and sports hall.
- This report explores the various options for roof beam arrangements, suitable roof decks and columns grids. The combinations of these parameters presented are not an exhaustive list – there are many more permutations.
- Alternative arrangements could be developed with column/beam spacings and roof decks varied.
- The study is based on the roof over the swimming pool (the larger of the two roofs) and thus can also be applied to the sports hall
- Five roof variants (A-E) of primary beam options are presented, each combined with a suitable column grid and roof deck option.
- Various column grids are considered along the main facades, with columns either at 7.2m or 9.0m centres.
- Long span beams are considered at both 7.2m and 4.5m spacings.
- Timber and trussed roofs have been proposed with CLT roofs which are heavier than steel versions and thus increase overall roof weight.
- Estimated quantities and weights for the whole roof (excluding columns) are given for initial guidance. Further studies would be required to refine these estimates and chose final configurations.
- To limit the potential for wind flutter, a limit of 2Hz has been placed on the natural frequency of long-span roofs. This is an onerous requirement and further refinement of this area would aim to lighten the roof and allow slightly shallower structural zones.
- Use of pre-cambering is not considered at this stage.
- Beams/Trusses have been designed to be stable during construction.

Long Span Roof Studies

Variant A – Fabricated Steel Girder





BEAM SPAN: 31.0m

COLUMN SPACING: 9.0m

PRIMARY BEAM SPACING: 4.5m

PROPOSED ROOF SLAB: METAL DECK ON PURLINS (ELEMENT LENGTH: 9m – DOUBLE SPAN)

DESIGN CRITERIA

LOADING

SW	AS CALCULATED
Gk (SID)	DECK (0.35), FINISHES (0.25), SERVICES (0.25): 0.85 kN/m^2
Qk (ROOF)	0.60 kN/m^2
Qk (SNOW)	0.60 kN/m^2
Qk (WIND)	+0.20/-0.75 kN/m^2

SERVICABILITY LIMITS

DEFLECTION (TOTAL):	SPAN/150
DEFLECTION (POST CONSTRUCTION):	SPAN/250
VIBRATION (WIND):	2Hz MIN

MATERIAL QUANTITIES

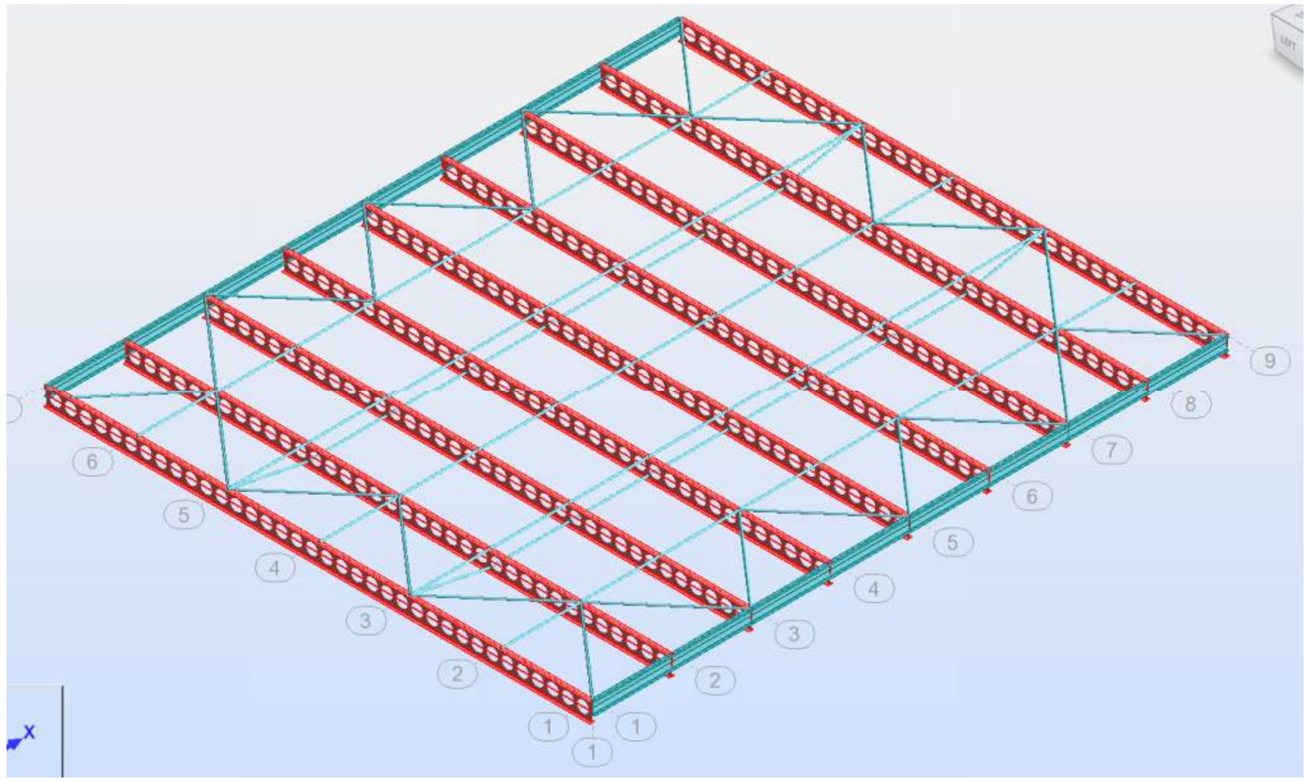
Steelwork – primary/secondary beams:	71 Tonnes
Steelwork – In plane bracing:	4.5 Tonnes
(Purlins and Roof Deck additional)	
Miscellaneous Steelwork/Connections:	Allow 20% additional tonnage

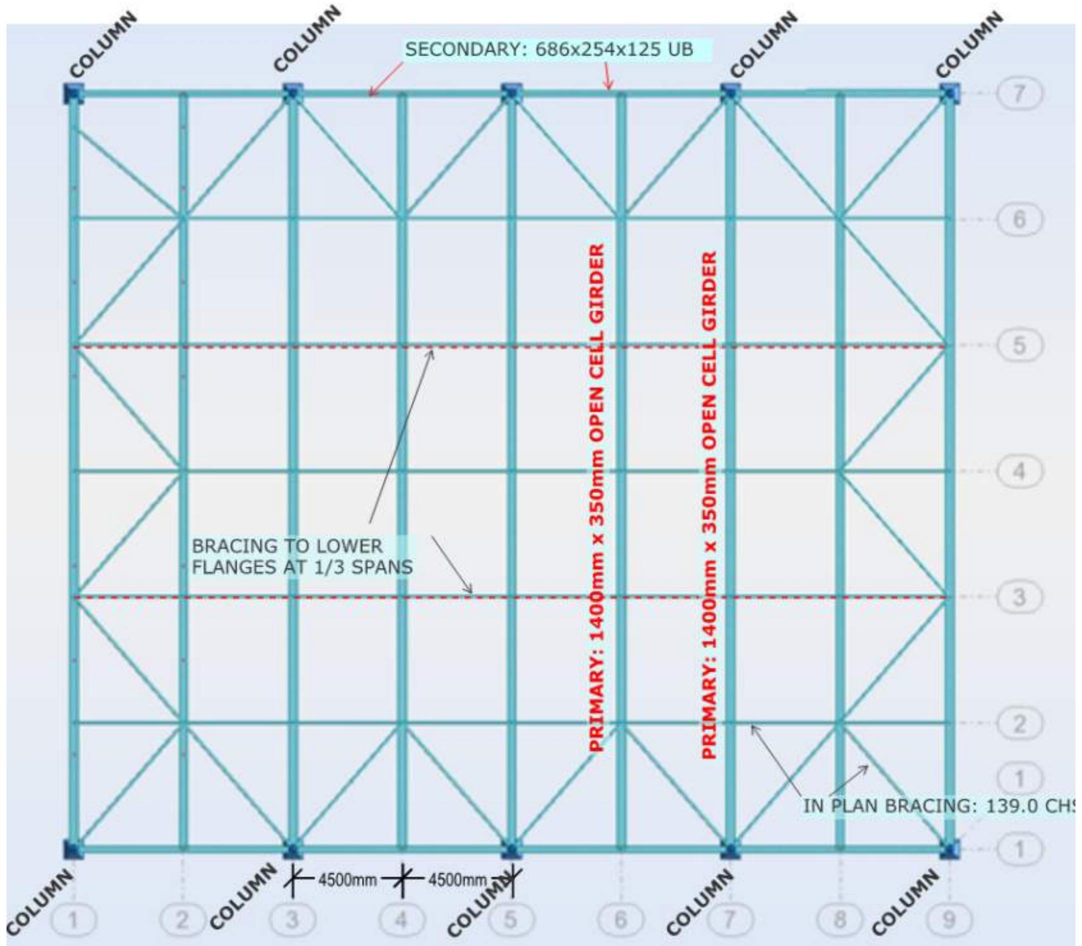
NOTES

- Primary Beams brought to site in three sections (splices at 1/3 points). Assembled on ground and lifted into place
- Diagonal bracing installed as roof erected
- Services zone beneath beams

Long Span Roof Studies

Variant B – Fabricated Steel Beams + Open Cells





BEAM SPAN: 31.0m

COLUMN SPACING: 9.0m

PRIMARY BEAM SPACING: 4.5m

PROPOSED ROOF SLAB: METAL DECK ON PURLINS
(ELEMENT LENGTH: 9m – DOUBLE SPAN)

DESIGN CRITERIA

LOADING

SW	AS CALCULATED
Gk (SID)	DECK (0.35), FINISHES (0.25), SERVICES (0.25): 0.85 kN/m^2
Qk (ROOF)	0.60 kN/m^2
Qk (SNOW)	0.60 kN/m^2
Qk (WIND)	+0.20/-0.75 kN/m^2

SERVICABILITY LIMITS

DEFLECTION (TOTAL):	SPAN/150
DEFLECTION (POST CONSTRUCTION):	SPAN/250
VIBRATION (WIND):	2Hz MIN

MATERIAL QUANTITIES

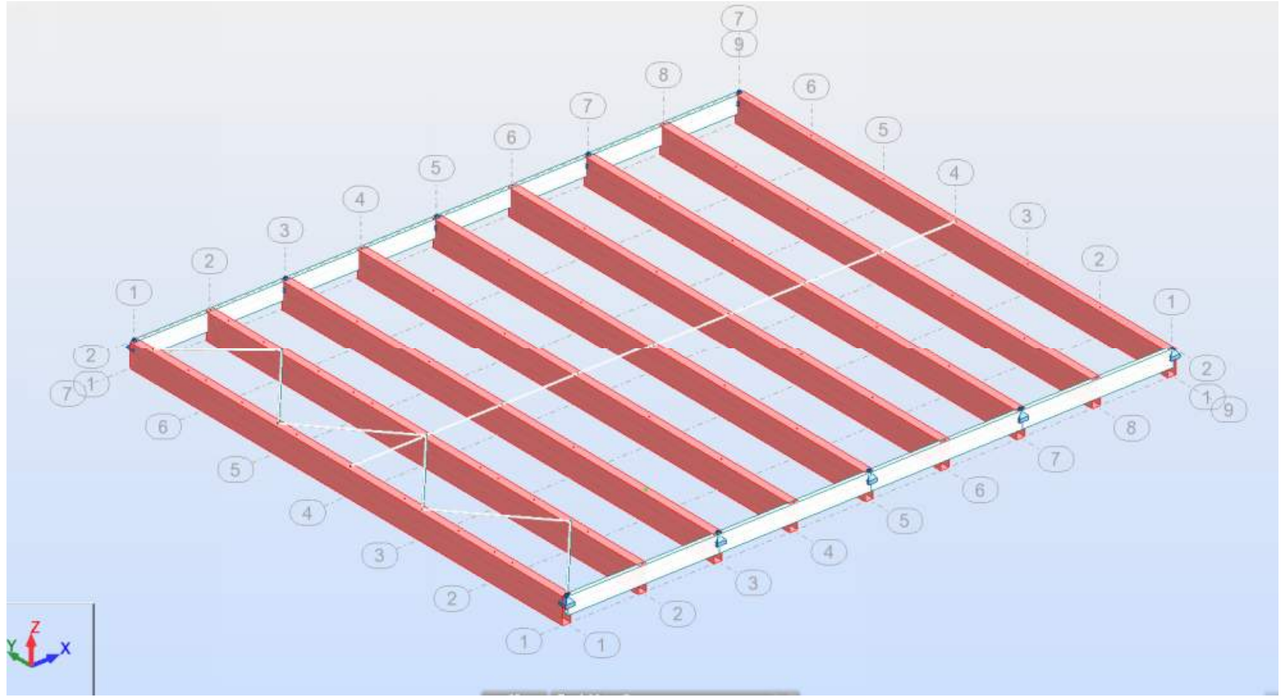
Steelwork – primary/secondary beams:	63 Tonnes
Steelwork – In plane bracing:	4.5 Tonnes
(Purlins and Roof Deck additional)	
Miscellaneous Steelwork/Connections:	Allow 20% additional tonnage

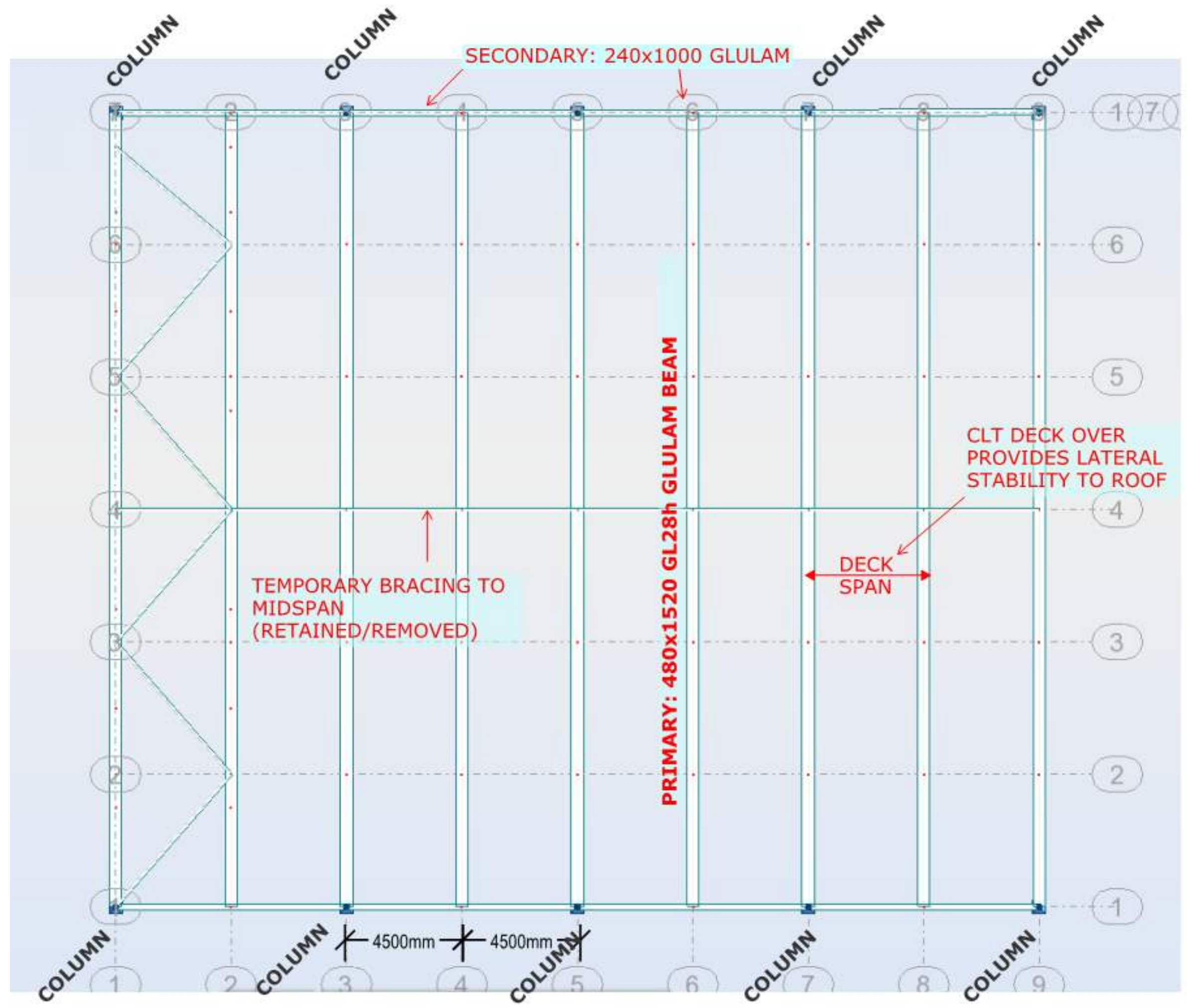
NOTES

- Primary Beams brought to site in three sections (splices at 1/3 points). Assembled on ground and lifted into place
- Diagonal bracing installed as roof erected
- Open cells (750mm) allows services to pass through

Long Span Roof Studies

Variant C – Solid Glulam Beams





BEAM SPAN:	31.0m
COLUMN SPACING:	9.0m
PRIMARY BEAM SPACING:	4.5m
PROPOSED ROOF SLAB:	100mm 3-Layer CLT Deck
	(ELEMENT LENGTH: 9.0m – DOUBLE SPAN)

DESIGN CRITERIA

<u>LOADING</u>

SW	AS CALCULATED
Gk (SID)	DECK (0.50), FINISHES (0.25), SERVICES (0.25): 1.00 kN/m^2
Qk (ROOF)	0.60 kN/m^2
Qk (SNOW)	0.60 kN/m^2
Qk (WIND)	+0.20/-0.75 kN/m^2

<u>SERVICABILITY LIMITS</u>

DEFLECTION (TOTAL):	SPAN/150
DEFLECTION (POST CONSTRUCTION):	SPAN/250
VIBRATION (WIND):	2Hz MIN

MATERIAL QUANTITIES

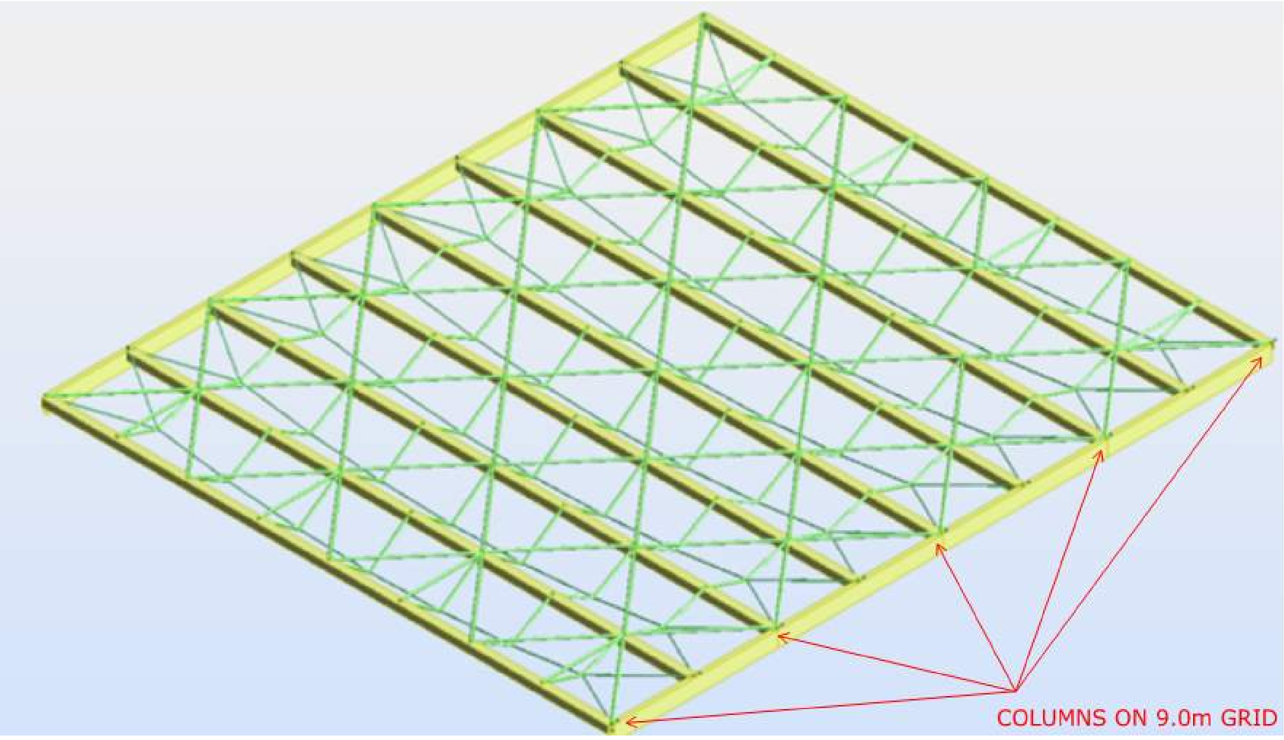
Glulam Primary/Secondary Beams	99 Tonnes
CLT Roof Deck	50 Tonnes
Temporary in-plane bracing	2 Tonnes
Miscellaneous Steelwork/Connections:	Allow 10 Tonnes

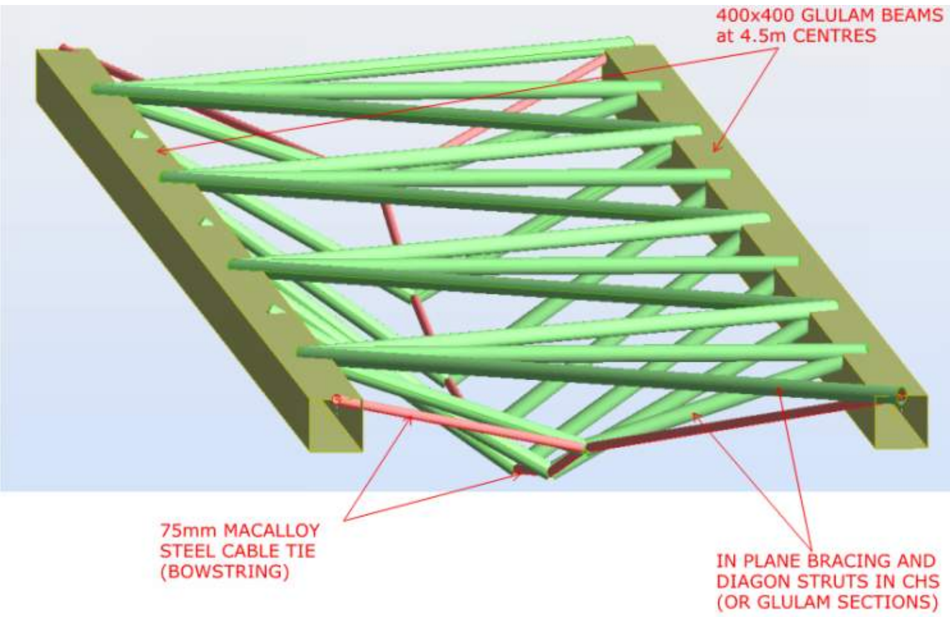
NOTES

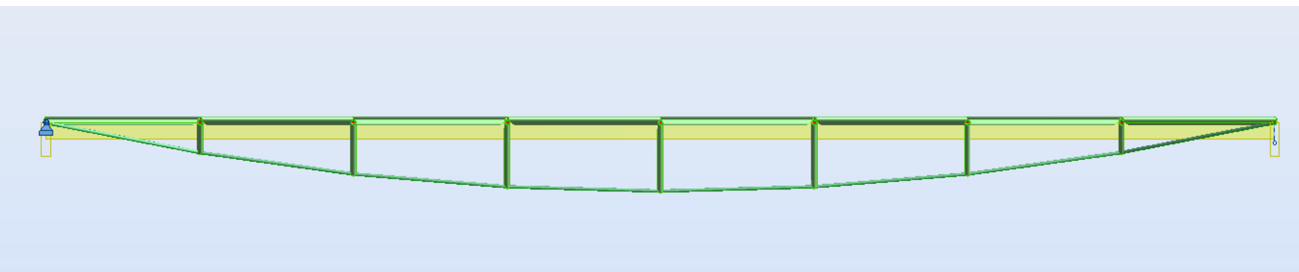
- Primary Beams brought to site in three sections (splices at 1/3 points) with steel plates and bolts. Connection plates/bolts to be high grade stainless steel.
- Diagonal bracing installed as roof erected for temporary lateral restraint – may be removed after installation when CLT deck provides roof diaphragm action
- System could be coupled with Glulam Columns and CLT walls in sports hall as a viable alternative to steel columns and masonry infill

Long Span Roof Studies

Variant D – 3D Hybrid Bowstring Truss







BEAM SPAN:	31.0m
COLUMN SPACING:	9.0m
PRIMARY BEAM SPACING:	4.5m
PROPOSED ROOF SLAB:	140mm 3-Layer CLT Deck
	(ELEMENT LENGTH: 9.0m – DOUBLE SPAN)

DESIGN CRITERIA

LOADING

SW	AS CALCULATED
Gk (SID)	DECK (0.75), FINISHES (0.25), SERVICES (0.25): 1.25 kN/m^2
Qk (ROOF)	0.60 kN/m^2
Qk (SNOW)	0.60 kN/m^2
Qk (WIND)	+0.20/-0.75 kN/m^2

SERVICABILITY LIMITS

DEFLECTION (TOTAL):	SPAN/150
DEFLECTION (POST CONSTRUCTION):	SPAN/250
VIBRATION (WIND):	2Hz MIN

MATERIAL QUANTITIES

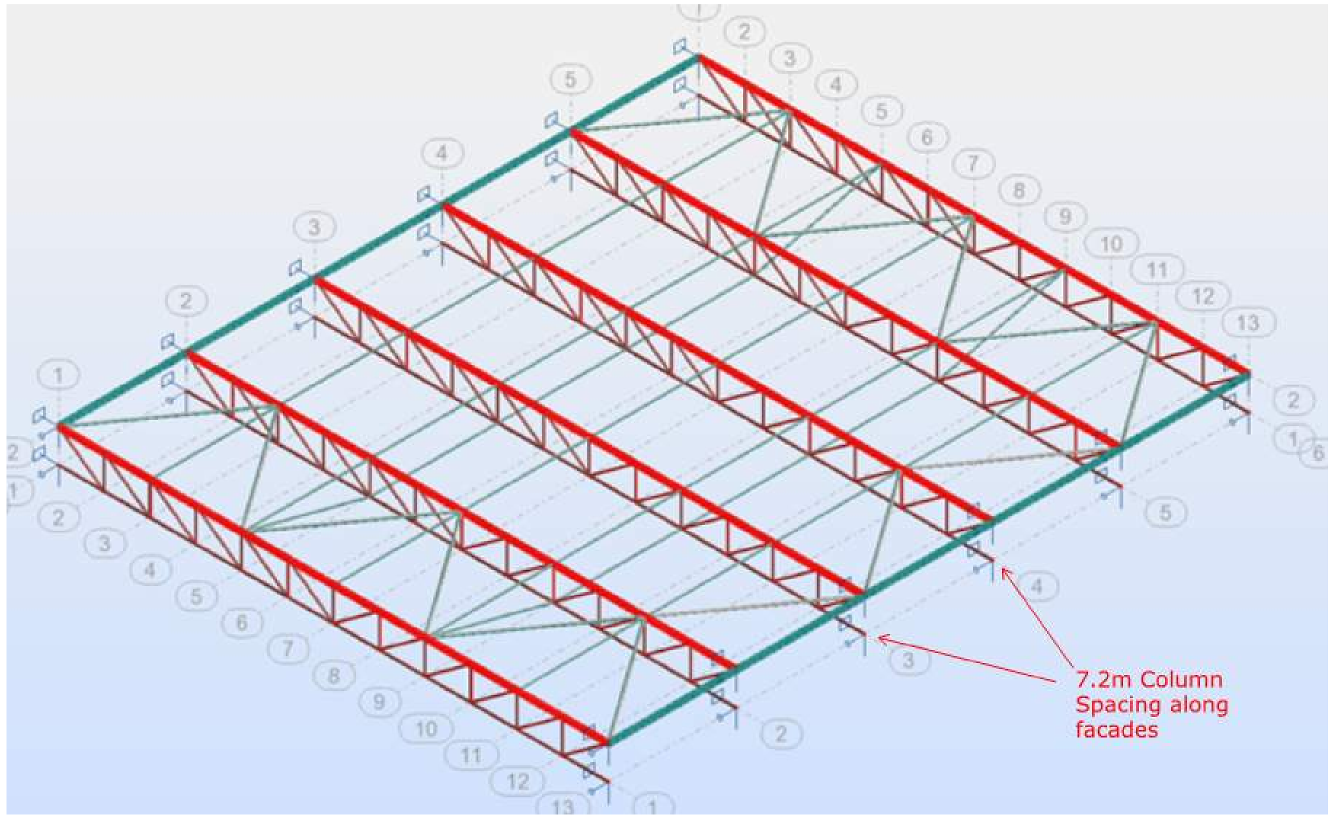
Glulam Primary/Secondary Beams	29 Tonnes
Steel Bowstring/Struts/Bracing	25 Tonnes
CLT Roof Deck	72 Tonnes
Miscellaneous Steelwork/Connections:	Allow 5 Tonnes

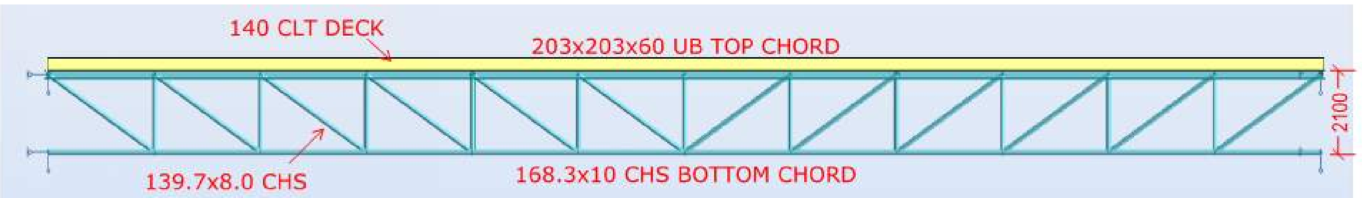
NOTES

- Thick CLT Deck required to restrain lightweight cable truss against load reversal from wind suction
- System could be coupled with Glulam Columns and CLT walls in sports hall as a viable alternative to steel columns and masonry infill

Long Span Roof Studies

Variant E – Steel Truss (Pratt)





BEAM SPAN:	31.0m
COLUMN SPACING:	7.2m
PRIMARY BEAM SPACING:	**7.2m**
PROPOSED ROOF SLAB:	140mm 5-Layer CLT Deck
	(ELEMENT LENGTH: 14.4m – DOUBLE SPAN)

DESIGN CRITERIA

LOADING

SW	AS CALCULATED
Gk (SID)	CLT DECK (0.75), FINISHES (0.25), SERVICES (0.25): 1.25 kN/m^2
Qk (ROOF)	0.60 kN/m^2
Qk (SNOW)	0.60 kN/m^2
Qk (WIND)	+0.20/-0.75 kN/m^2

SERVICABILITY LIMITS

DEFLECTION (TOTAL):	SPAN/150
DEFLECTION (POST CONSTRUCTION):	SPAN/250
VIBRATION (WIND):	2Hz MIN

MATERIAL QUANTITIES

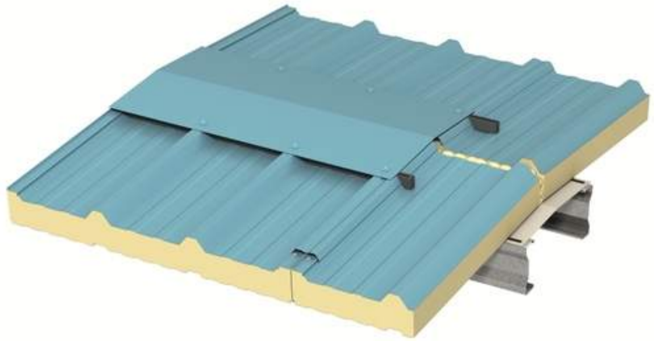
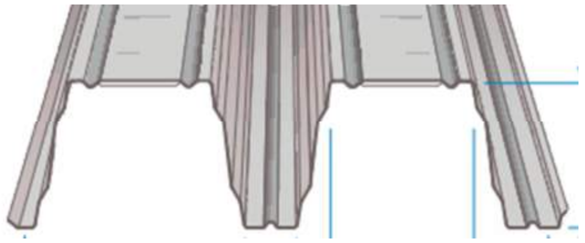
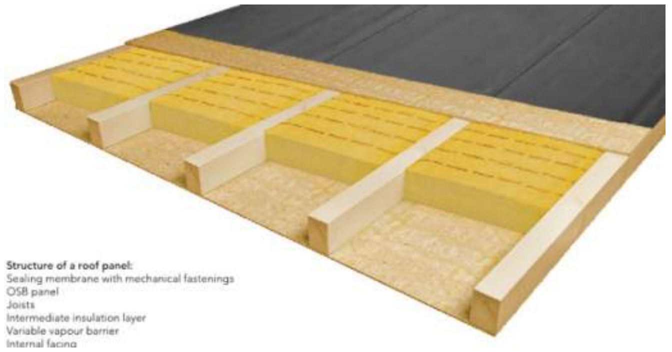
Steelwork – primary/secondary beams:	28 Tonnes
Steelwork – In plane bracing:	5.0 Tonnes
CLT Roof Deck	72 Tonnes
Miscellaneous Steelwork/Connections:	Allow 20% additional tonnage

NOTES

- Overall Depth of Truss: 2100mm
- Trusses brought to site in three sections (splices at 1/3 points). Assembled on ground and lifted into place
- Diagonal bracing installed as roof erected
- Use of CLT roof would allow some in-plane bracing to be removed after installation.
- CLT decks on shorter span areas offer good plant area platforms

Long Span Roof Studies

Roof Deck Options

Roof Deck		Typical Spans Achievable	Weight	Notes
COMPOSITE METAL DECK ON PURLINS		Roof Decks: Upto 3.0m Purlins: Upto 7.5m (400mm purlins)	Deck: 20 kg/m^2 Purlins: 15 kg/m^2	Roof deck thickness dependant on U-Value required. Typical decks are 100-200mm thick. Special versions available to support plant loads
SINGLE PLY LONG-SPAN METAL DECK		8.5m	Deck: 10-20 kg/m^2 Finishes: 20 kg/m^2 allowance	Build-up of finishes over liner typically includes insulation and single ply weatherproof membraine Special versions available to support plant loads
CROSS LAMINATED TIMBER (CLT) PANEL		7.5m	45-72 kg/m^2	Typical deck thicknesses 100-160mm depending on span Typically able to support moderate plant loads without special measures
TIMBER CASSETTE		7.5m	40 – 65 kg/m^2	Typical Deck Thicknesses 200-400mm Not generally suited for supporting plant loads