Modern and Traditional Construction

PRIMARY STRUCTURAL ELEMENTS AND SYSTEM ENCLUSORE FOR CONSTRUCTION BASED IN SA1

MORGAN LEWIS (2005946)

Table of Contents

INTRODUCTION 2

PRIMARY STRUCTURE 2
FOUNDATION TYPE 2

STRUCTURAL ELEMENT 3

COLUMNS, WALLS, AND BEAMS 3
FLOORS 3
WIND LOADS 4

SYSTEM ENCLOSURE 5

CONCLUSION 6

REFERENCES 7

APPENDICES 9

APPENDIX 1 9

Introduction

The structural elements selected for a particular building are fundamental in establishing a secure, sufficient, and user-friendly final project. Factors such as the project's weight, height and estimated build cost can all directly influence the type of structural element that is selected. The type of foundation used coupled with appropriate structural elements and strategy will often govern the best possible enclosure for the building. The report will consider the buildings location, surroundings, and overall design to conclude on a chosen primary structure and the system enclosure best suited.

Primary Structure

There are various material choices that are available when considering the structure of the building, with concrete, steel, and timber being some of the top choices. These three materials are some of the most versatile within the construction industry and often the most frequently used as framework materials. The structure must first consider the foundation type and surrounding area to ensure all chosen factors can merge successfully.

Foundation Type

Considerations regarding the land conditions are paramount prior to choosing a foundation type. Following the borehole logs from another local site excavation the ground is established as boulder clay at depth but made ground up to 5 metres. Made ground would not support the weight of a structure of this size therefore a feasible foundation would be weight bearing piles. End bearing piles will sufficiently spread the weight of the structure, allowing the transfer of the weight across all piles at the grey mudstone level. Other pile options would not suffice, friction piles, for example are not as cost efficient and there is no evidence of subsidence or land movement to justify settlement reducing piles (Ground Engineering Ltd. , 2017). It would be recommended to use steel piles as they can directly connect to the columns of the structure for additional weight support. When opting for pile foundations there are a range of regulations and standards to be adhered to. Standards have been set by bodies such as NHBC in addition to the British Standards. Guidance can be found in Approved Document A for direct standards such as BS 8002:1994 Code of practice for earth retaining structures and BS 8004:1986 Code of practice for foundations. Correctly connecting any steel in the piles to the foundation will add to the foundations weight bearing capability. When using steel piles corrosion of the pipes can cause serious damage thus requiring a corrosion protecting coating prior to installation (The Constructor, 2022). Bearing in mind the site location for the project it is likely that the immediate surrounding area is not suitable for drilling. The potential to cause damage to other buildings is high when building in a populated area such as SA1 (Cart & Co Foundations, 2022). Using pile foundations is a great alternative solution for foundations when in a location that does not support drilling. Pile foundations are also much

more cost effective compared to drilling, the upfront cost for machinery for drilling can be expensive and would not necessarily offer an advantage in this situation (Boke, 2022).

Structural Element

Columns, Walls, and Beams

The overall design of the structure is not overly complex therefore, a few options can be considered for the structural framework. As the building is set over three floors it is important to consider the amount of weight the structural element will be required to hold. The framework must also be suitable for aesthetic of the finished design. The desired external design suggests using a form of cladding. It is important to acknowledge that the chosen structural framework must cooperate with the building's envelope. Site location and end use are also important to consider. Materials used for the structure will need to be compatible with the surroundings, this includes types of weather and its final users. Set in SA1, the final build will need to withstand moisture and be weather resistant. Both steel and concrete offer these properties, however, when factoring in overall strength of these materials steel would be the preferred option. Concrete, at normal grade does not exhibit the same specific strength as steel (CivilEngineeringTutor, 2016). To create a higher strength concrete, it would require additional cost and time for the project. A steel frame would also allow for the installation and use of metframe steel walls within the building. Metframe is a pre-panelised frame solution, brought forward by the Metsec manufacturers. These off-site manufactured frames allow for a faster build time, offer zero waste and are suitable for use with various external finishes (Voestalpine, 2022).

Using a steel framework for the structure and walls within the building offers support to the use of steel beams. Steel offers a large span, for this project it would fit well and offer the end users a large space within the building without affecting its structural durability. As noted earlier, steel also offers strength beyond that of concrete and timber. Prior to construction it is possible to pre-fabricate the required beams and columns off-site which reduces cost as well as carbon emissions (GLW Engineering & Construction Ltd , 2022). Regulations and guidance can be found within BS EN 1993, which covers requirements, basic variables, structural analysis, and design assisted by testing. When using steel as a main material throughout the sub-structure and framework it is important to follow Approved Document B, volume 2 fire regulations to ensure all aspects of the build are fireproofed appropriately.

Floors

A solid ground floor is most used for commercial buildings as they require little maintenance, and the individual layers can vary depending on client's specification. The floor will be built up from sub-base and hardcore, damp-proof membrane (DPM), insulation, a concrete bed, and screed prior to

choosing a finish such as carpets (Designing Buildings, 2021). The first floor could be a suspended solid timber floor, it would need to be secured against the external walls using some form of restraint. NHBC Standard offer guidance on joists connected to steel under section 6.4.12 (NHBC, 2022). PIR can also be installed in between the joists on the first floor for additional thermal insulation and sound damping. PIR's acoustic properties help to reduce the noise transfer between floors. All flooring will need to comply to Building Regulations Approved Document A (Welsh Government, 2010).

Roof

The drawings provided showcase a multi-level flat roof for the building. A flat roof design would be the only applicable choice to allow for the seemingly mesh/cladded overlay and only requires a slight pitch to drain water (JTC Roofing, 2022). Flat roofs are commonly used on commercial buildings for various reasons. Since commercial buildings are usually larger than domestic buildings the roofs will need to cover a larger span, offer additional structural support, and be cost effective. Flat roofs offer all these benefits as well as good versatility, durability and they require little to no maintenance (SAGE BEC, 2022). Roof installation and design must comply with Part L of the Approved Documents, this is to ensure the completed roof is thermally resistant and is insulated to achieve a maximum U-Value of 0.18 W/m^2K (BuildingRegs4Plans, 2022).

Wind Loads

Considerations for wind loads are important when building a large commercial building. Not only does the buildings size and shape influence which consideration are required but also external factors such as location, topography, and many other geographical issues. To comply with BS EN 1991-1-4 using a basic wind speed for the location and adjusting it to the required considerations calculates a q-value. This end value is a measurement of the wind strength and can influence the choice of material for the building's envelope (The Building Envelope Authority, 2014). The choice of the system enclosure can contribute to the buildings ability bear the weight of wind loads. Using a steel frame offers stability, securing the frame to the foundations it also increases strength. Further studies following BS EN 1991-1-4 states that materials, strategies, and sub-structural elements must align with the calculated q value for the site location. For best protection against heavy wind loads it is suggested that all structural elements from foundation to framework, to the roof have strong ties. It is suggested that using the high strength of these materials can reduce the stresses caused by wind loads (Extension Foundation, 2022).

System Enclosure

The final external enclosure must benefit the finished building by not only supporting the structural elements but also controlling heat and air flow. It must also offer strength and durability, all within the cost and desired aesthetic of the project (Kesik, 2016). The building seems to be a form of office or educational building, where it will be frequently used. Natural light will be important, with windows and open areas apparent throughout the drawings. This is an additional consideration when choosing a suitable system enclosure. Various types of enclosures do not offer the span required or the ability to cut through that enclosure to add window points. In addition to the other chosen structural elements such as steel frame and steel metsec internal framework it would be justifiable to use cladding externally. Although cladding does not directly contribute to the stability of a steel frame it does however hold various other benefits for this building. Wind loads are vital when considering the buildings envelope. Certain types of cladding can withstand the weight of wind loads and other weather considerations such as heavy rains and snow. Choosing the correct type of cladding will also either help or hinder the project (Timmins Engineering, 2021). Cladding not only offers good coverage, span, and durability to the design, but it also can contribute to the final aesthetic of the building. There is a variety of material choices ranging from stone, wood, and composite materials, allowing the desired protection and finish.

There are multiple types of cladding available for industrial or commercial buildings. The traditional route, with seam walls is best suited to timber frame buildings and not as easily installed with flat roofs. Composite wall cladding is also commonly used on commercial buildings, it offers load-bearing capacity but it's outer face is usually metal and does not always offer the desired aesthetic characteristic for this building. When choosing a cladding option for a structure that will be domestically used it is important to consider aesthetic properties (Jade-Aden, 2022). Rainscreen cladding is acknowledged as form of cladding that not only offers protective qualities to the building but also has good aesthetic properties. Like metsec steel framework, rainscreen cladding can be manufactured off site and assembled on site. They are lightweight and relatively easy to install. Keeping both aspects of the structural elements and exterior envelope as off-site manufacturing is cost effective. As stated by (Eltherington Architectural Solutions, 2017), rainscreen cladding offers performance related benefits such as improvements to thermal performance of the building in addition to aesthetic improvements. Any system enclosure for a building must provide protection from external factors such as weatherproofing and air and heat control on top of providing full safety for the end users. Safety regarding external system enclosures and what they should provide at a minimum can be found in BS 8414. The standard is split in two-parts, for this case study the relevant section is BS 8414-2:2015 Fire performance of external cladding systems. Test method for non-loadbearing external cladding systems fixed to and supported by the structural steel frame (Designing Buildings, 2021).

Conclusion

In conclusion, following the plans and desired drawings provided alongside the borehole logs the below construction strategies are recommended. The best foundation option would be steel assisted piles down to the grey mudstone, additional support can be provided depending on the type of steel pile used. For more weight bearing support H-piles would suffice with the ground conditions. Using steel for the foundations is beneficial when considering the framework, columns, and other structural aspects. Connections between steel are extremely strong making it an excellent option for the columns, walls, and beams. It offers the required span for the proposed project, the strength and ease of construction on and off-site. Its specific strength allows for it to hold the weight of the building and its versatility justifies the ability to create workspaces within the building. Using an internal framework such as metsec steel frames allows for ease of construction inside the project and easier connections to be built between the primary and internal structures. Metsec steel frames also work hand in hand with the proposed floor and roof. Steel's ability to bear large weights allows for the flat roof to spread its weight across the building without concern of any faults between the external and internal frame. The chosen structural elements lend themselves to the rainscreen cladding for the building's envelope. Cladding can be installed over a steel frame with ease, and assembly can be shortened if the cladding is manufactured off-site. Rainscreen cladding also supports the finished aesthetic for the project without hindering the performance of the building against external factors such as wind loads and weather.

References

Boke, 2022. *Advantages and disadvantages of rotary drilling rig construction.* [Online]
Available at: http://www.groupboke.com/ennews_show.aspx?id=388
[Accessed 7 March 2022].

BuildingRegs4Plans, 2022. *Flat Roof - Insulation.* [Online]
Available at: https://www.buildingregs4plans.co.uk/guidance_flat_roof_insulation.php
[Accessed 1 March 2022].

Cart & Co Foundations, 2022. *The Benefits of Piling & Pile Foundations.* [Online]
Available at: https://www.dartandco.co.uk/the-benefits-of-piling/
[Accessed 7 March 2022].

CivilEngineeringTutor, 2016. *Limitations of Concrete or Disadvantages of Concrete.* [Online]
Available at: https://engineeringcivil.org/articles/concrete/limitations-concrete-disadvantages-concrete-8-reasons/
[Accessed 27 February 2022].

Designing Buildings, 2021. *BS 8414 Fire performance of external cladding systems.* [Online]
Available at: https://www.designingbuildings.co.uk/wiki/BS_8414_Fire_performance_of_external_cladding_systems
[Accessed 7 March 2022].

Designing Buildings, 2021. *Types of floor.* [Online]
Available at: https://www.designingbuildings.co.uk/wiki/Types_of_floor
[Accessed 1 March 2022].

Eltherington Architectural Solutions, 2017. *Top 10: Benefits of rainscreen cladding.* [Online]
Available at: https://eltheringtonarchitectural.co.uk/news/top-10-benefits-of-rainscreen-cladding
[Accessed 3 March 2022].

Extension Foundation, 2022. *Section 5. Structures and Utilities.* [Online]
Available at: https://campus.extension.org/mod/book/view.php?id=6418&chapterid=6747
[Accessed 7 March 2022].

GLW Engineering & Construction Ltd , 2022. *The Advantages & Disadvantages Of Steel Frame Construction.* [Online]
Available at: https://blog.glwengineering.co.uk/the-advantages-disadvantages-of-steel-frame-construction
[Accessed 28 February 2022].

Ground Engineering Ltd. , 2017. *Reason why the pile foundation and bored piles should be used in construction.* [Online]
Available at: https://medium.com/@groundengineeringltd/reason-why-the-pile-foundation-and-bored-piles-should-be-used-in-construction-85c439225c81
[Accessed 27 February 2022].

Jade-Aden, 2022. *Exterior Cladding.* [Online]
Available at: https://www.jade-aden.co.uk/construction-services/exterior-cladding.html
[Accessed 3 March 2022].
JTC Roofing, 2022. *28 Types of roof designs & styles.* [Online]
Available at: https://jtcroofing.co.uk/roof-types/
[Accessed 3 March 2022].
Kesik, T. J., 2016. *Building Enclosure Design Principles And Strategies.* [Online]
Available at: https://www.wbdg.org/resources/building-enclosure-design-principles-and-strategies
[Accessed 3 March 2022].
NHBC, 2022. *NHBC Standrds 2022.* [Online]
Available at: https://nhbc-standards.co.uk/6-superstructure-excluding-roofs/6-4-timber-and-concrete-upper-floors/6-4-12-joists-connected-to-steel/
[Accessed 1 March 2022].
SAGE BEC, 2022. *The Benefits of Flat Roofing.* [Online]
Available at: https://www.sagebec.co.uk/blog/the-benefits-of-flat-roofing/
[Accessed 3 March 2022].
The Building Envelope Authority, 2014. *Guidance for wind loadings on roof and wall cladding,* Newport: MCRMA.
The Constructor, 2022. *Steel Pile Foundations – Types, Design and Connections.* [Online]
Available at: https://theconstructor.org/geotechnical/steel-pile-foundations-types-design-connections/21529/
[Accessed 3 March 2022].
Timmins Engineering, 2021. *How to clad steel frame buildings.* [Online]
Available at: https://timminsengineering.co.uk/how-to-clad-a-steel-frame-building/
[Accessed 3 March 2022].
Voestalpine, 2022. *Metframe.* [Online]
Available at: https://www.metsec.com/products/metframe/
[Accessed 28 February 2022].
Welsh Government, 2010. *Building Regulations 2010: Approved Documents A.* [Online]
Available at: https://www-ihsti-com.ezproxy.uwtsd.ac.uk/CIS/document/317109?PreviousPage=search%3ff%3dAll%26t%3dapproved%2bdocument%2bA%26sqm%3dAllTerms
[Accessed 29 December 2020].

Appendices

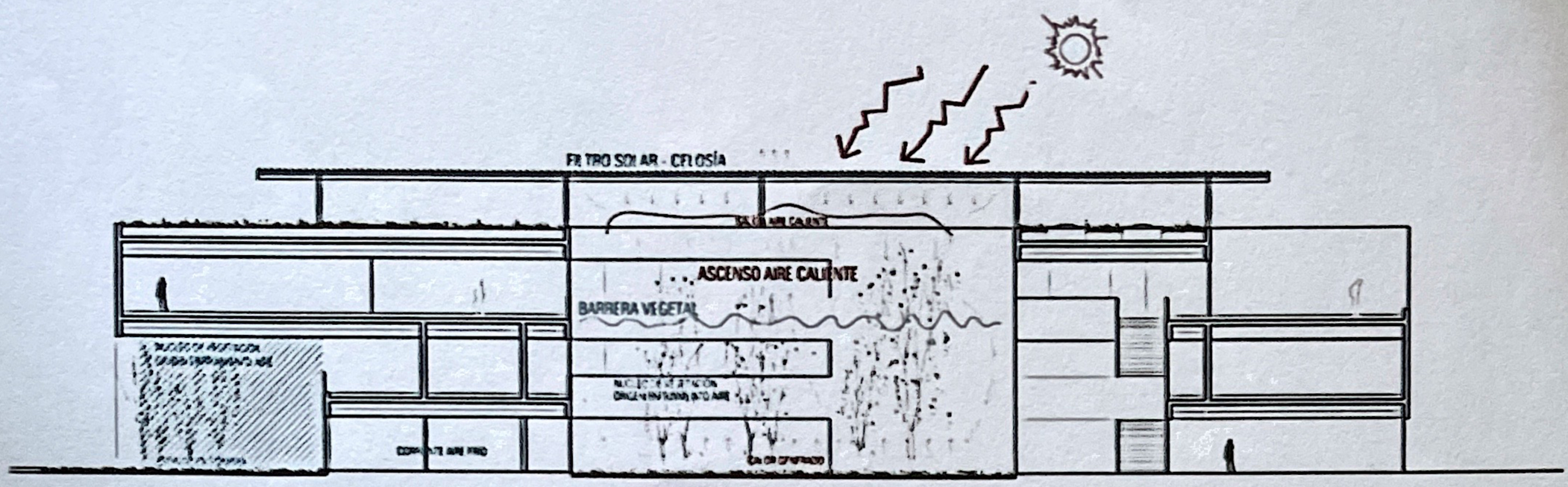
Appendix 1

Annotations of all primary structural elements.

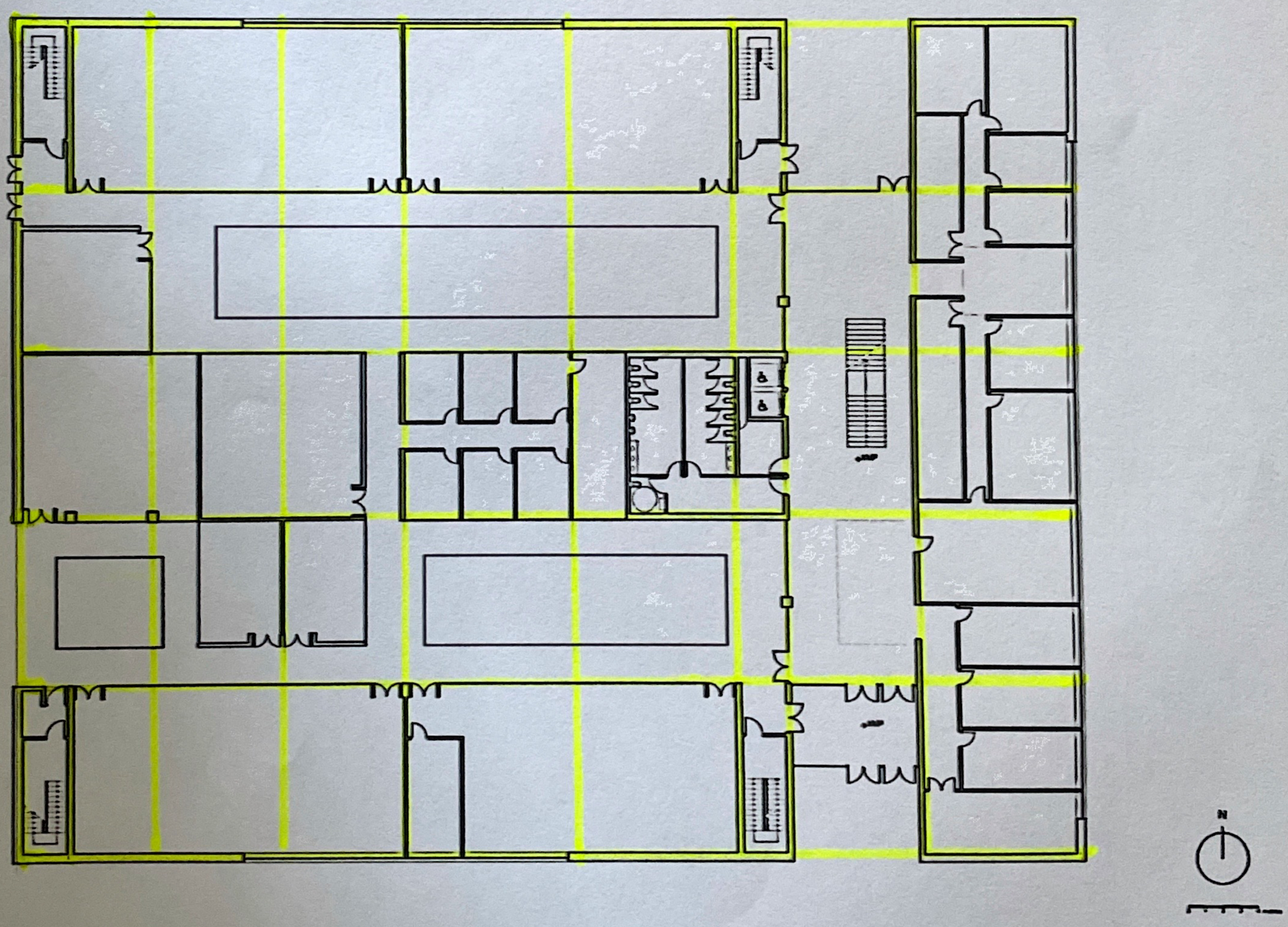
Assessment

Building case study

Offices

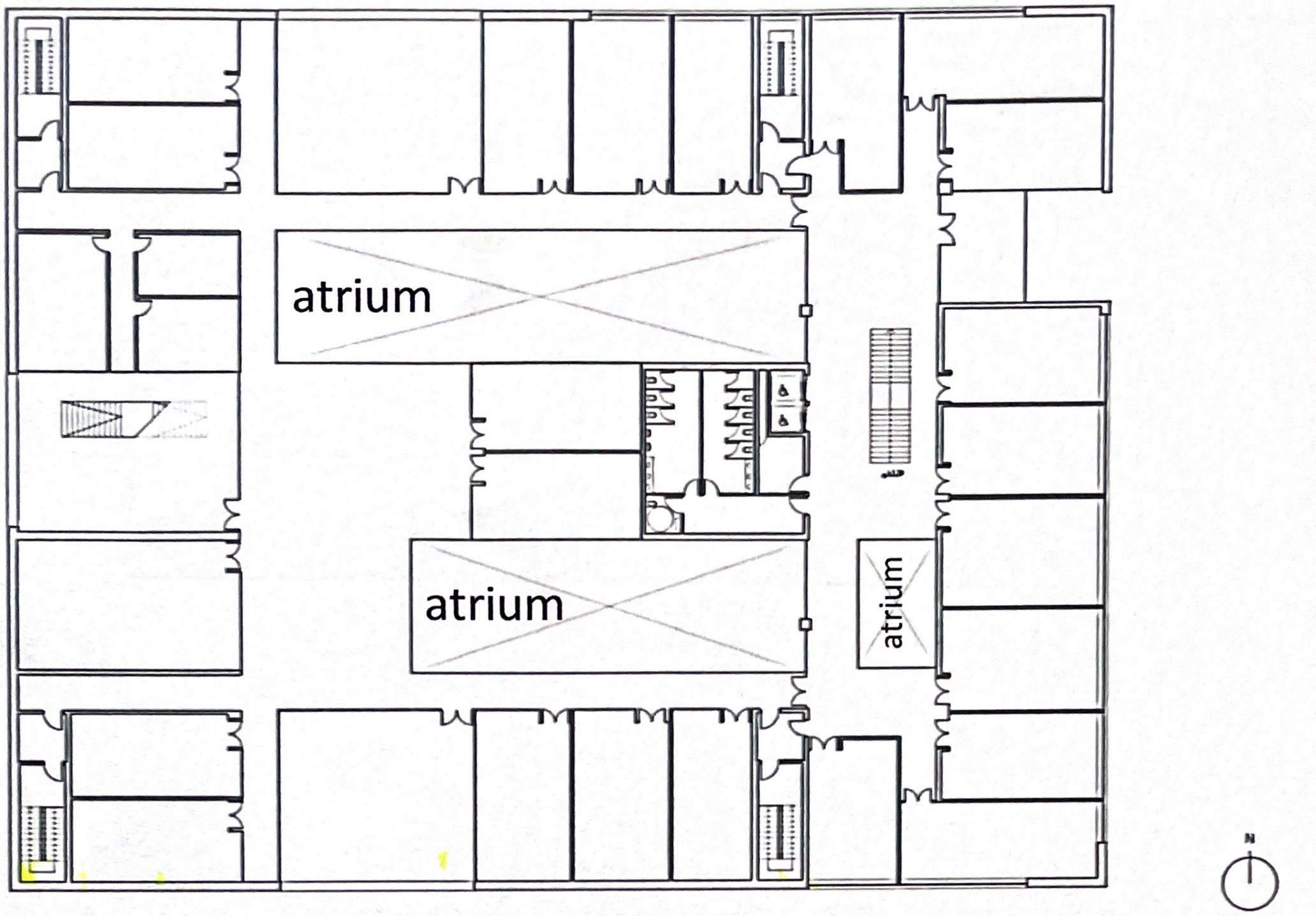


Long **Section** 1:500 approx

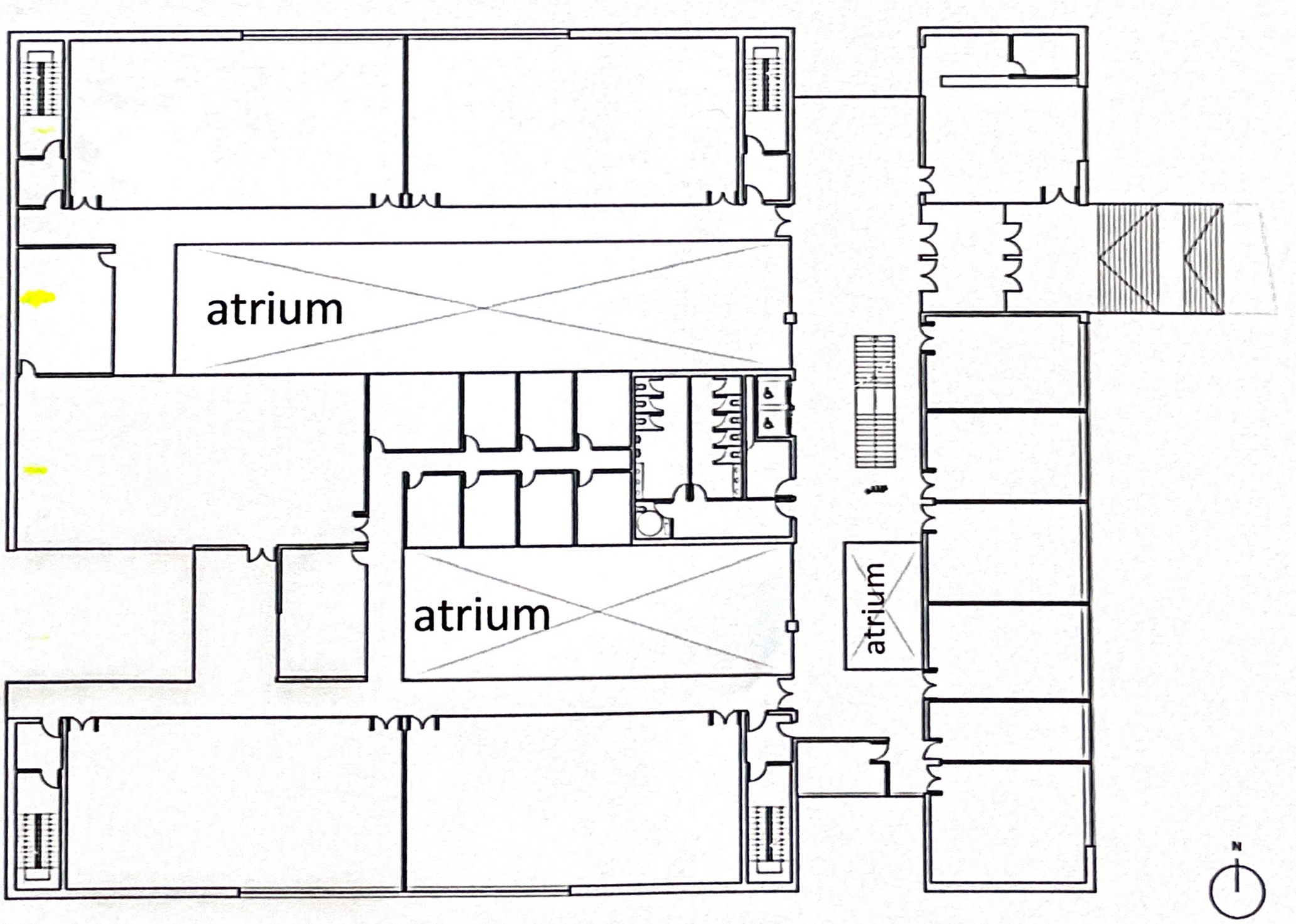


Ground Floor **Plan** 1:500 approx

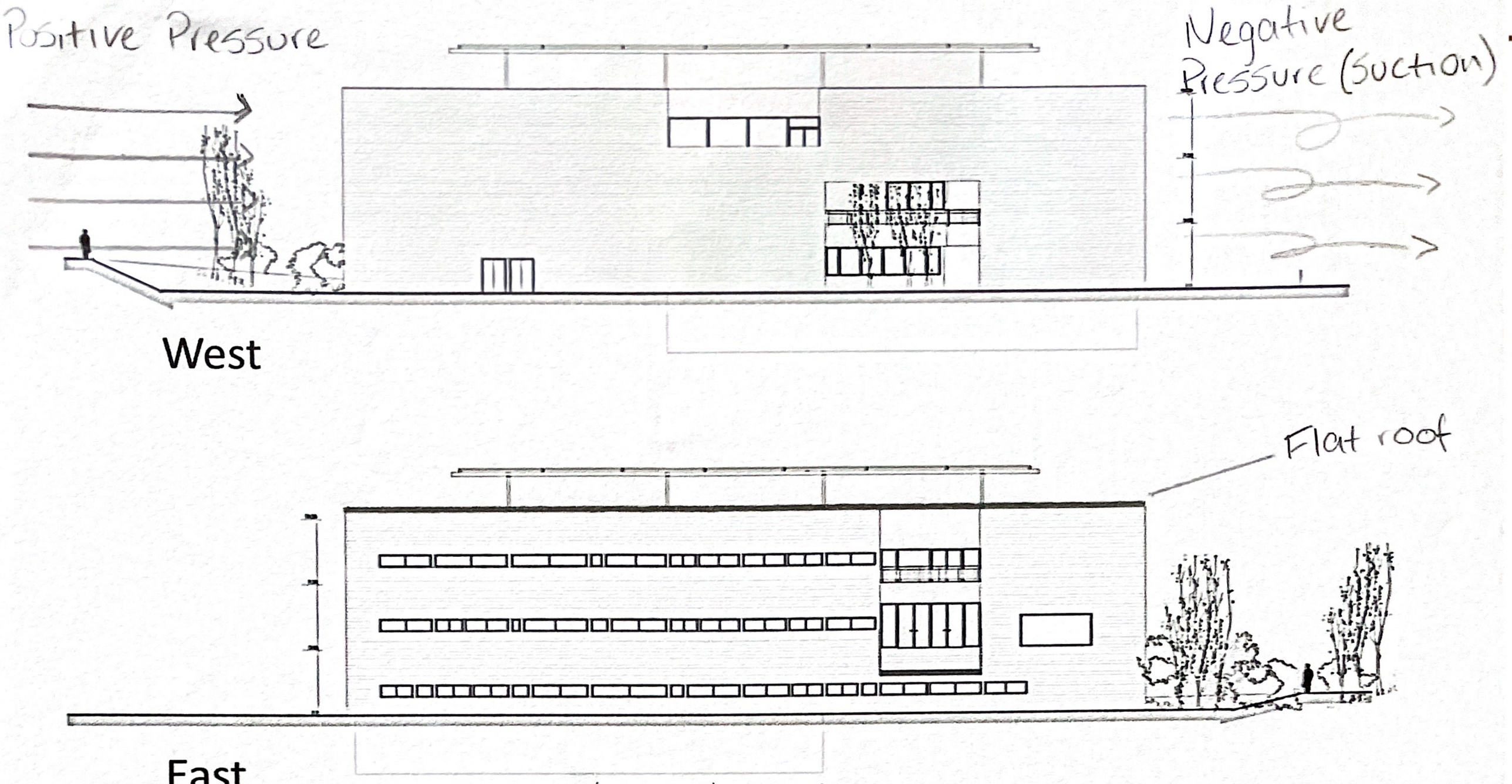
- Proposed Metsec wall framework layout



Second Floor **Plan** 1:500 approx

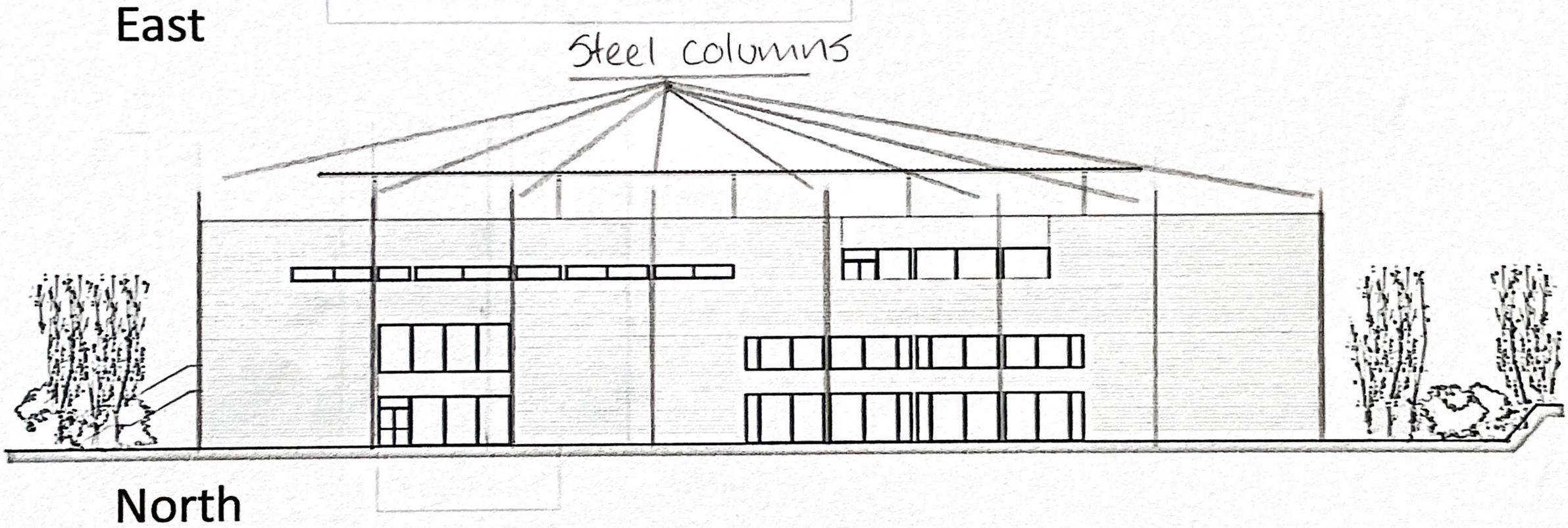


First Floor **Plan** 1:500 approx

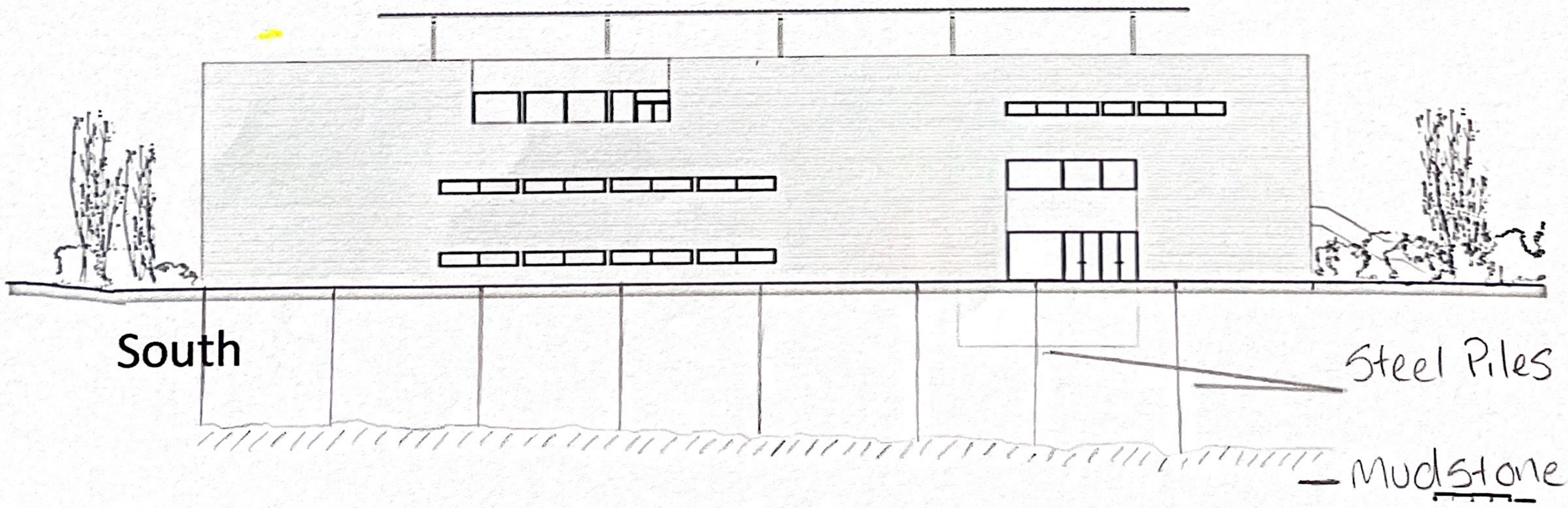


West

East



North



South

Elevations 1:500 approx

Elements of enclosure – Schematic architectural

