ETS5 DESIGN THESIS

HYBRID TYPOLOGIES: CIVIC AND RESIDENTIAL RE-USE OF THE STEEL PORTAL FRAME

Muhittin Can Binan - Diploma 14

Contents

1. INTRODUCTION

ETS Statement

The ETS project will focus and deal with the practicalities and technical aspects of adapting part of an existing warehouse/logistics cluster into being used under a new residential and civic programme, and explore strategies of overcoming expected issues around insulation, heating and structural manipulations that aim to transform and reprogram the site. The project will do so while maintaining fragments -or large chunks- of its industrial character and set an example within the context and testing the feasability and best ways of converting underused shed/warehouse structures into becoming a provocative new civic space.

Definitions

Civic Programme:

The set of functions and activities within a building or urban space that serve the public or community at large. Civic programs typically include facilities and spaces designed for government administration, public services, cultural events, community gatherings, and recreational activities.

Definitions

Re-use:

The practice of repurposing existing buildings or structures for new uses or functions, rather than demolishing them and constructing new ones. It involves adapting and renovating buildings to meet contemporary needs while preserving their historical, cultural, or architectural significance. Re-use promotes sustainability by reducing waste, conserving resources, and maintaining the character and integrity of the built environment. It often involves creative design solutions to adapt older structures to modern requirements while retaining their inherent value and charm.

Definitions

Retrofit:

The process of upgrading existing buildings by adding new technologies or features to enhance functionality, efficiency, or compliance with current standards. Architectural retrofitting often involves improvements such as updating heating, ventilation, and air conditioning systems, enhancing insulation, and installing energy-efficient windows. This approach aims to extend the building's life, reduce environmental impact, and adapt structures to new uses or improved safety regulations, all while maintaining the original architectural integrity.

Definitions

Sustainability (Architecture):

The practice of designing and constructing buildings in a manner that utilizes resources efficiently, minimizes environmental impact, and reduces energy consumption. Sustainable architecture focuses on maximizing the use of sustainable materials, enhancing energy efficiency, and incorporating renewable energy sources. It aims to create spaces that are environmentally responsible and resource-efficient throughout a building's life-cycle: from siting to design, construction, operation, maintenance, renovation, and demolition. This appro-ach seeks to promote occupant health and productivity, reduce waste and pollution, and harmonize with the natural environment.

Definitions

Thermal Efficiency:

A measure of the performance of a system that converts heat into work or energy output. It is calculated by dividing the energy output of the system by the heat input, often expressed as a percentage. In practical terms, thermal efficiency indicates how well a system such as an engine, furnace, or boiler utilizes the heat provided to perform work or produce heat, minimizing energy losses as much as possible. High thermal efficiency means that a greater proportion of the heat energy is effectively used for its intended purpose, reducing energy waste and improving overall system performance.

Thermal Transmittance (U-Value):

The measure of the rate of heat transfer through a material or an assembly of materials (like a window or wall). The U-value is expressed in watts per square meter per degree Celsius ($W/m^2 \cdot °C$). It indicates how well a building element conducts heat; lower U-values signify better insulation properties and higher thermal resistance. This metric is crucial in the building and construction industry for assessing the energy efficiency of structures, influencing decisions on materials and methods to optimize thermal performance and comply with building regulations.

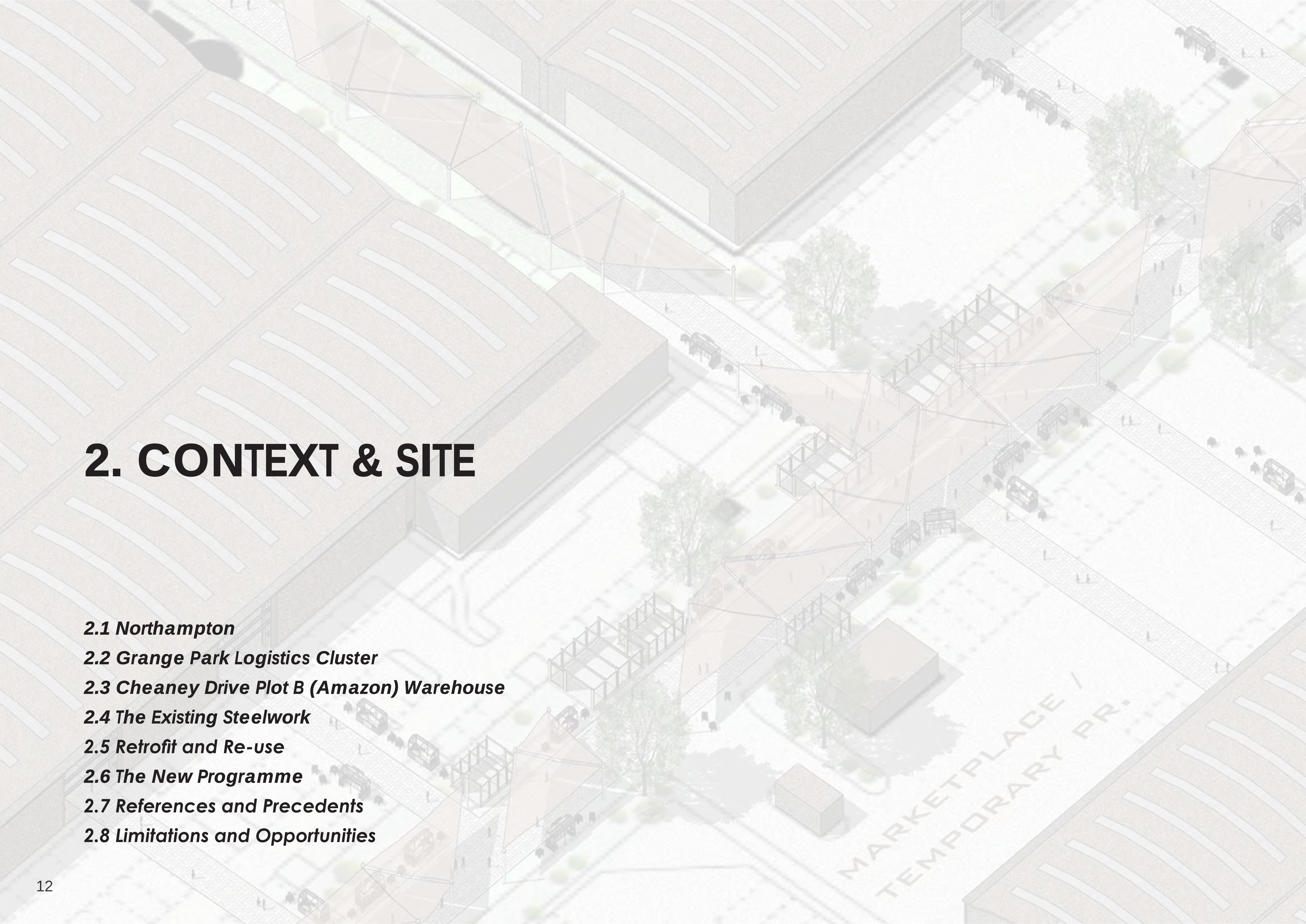
Definitions

Logistics:

The process of planning, implementing, and controlling the efficient and effective flow of goods, services, and information from the point of origin to the point of consumption. This field encompasses the management of various facets such as transportation, warehousing, inventory management, material handling, and order fulfillment, as well as the associated information systems required to coordinate these activities. Logistics aims to meet customer demands and enhance the efficiency of operations in the supply chain, often involving coordination across multiple companies and geographic boundaries.

Urban:

Pertaining to or characteristic of a city or town. The term "urban" describes environments that are densely populated and highly developed, typically featuring extensive infrastructure such as roads, utilities, housing, and buildings. Urban areas are centers of economic, administrative, and cultural activities, often differentiated from rural areas by their higher population density, diverse social dynamics, and concentrated services and facilities.



2. CONTEXT & SITE

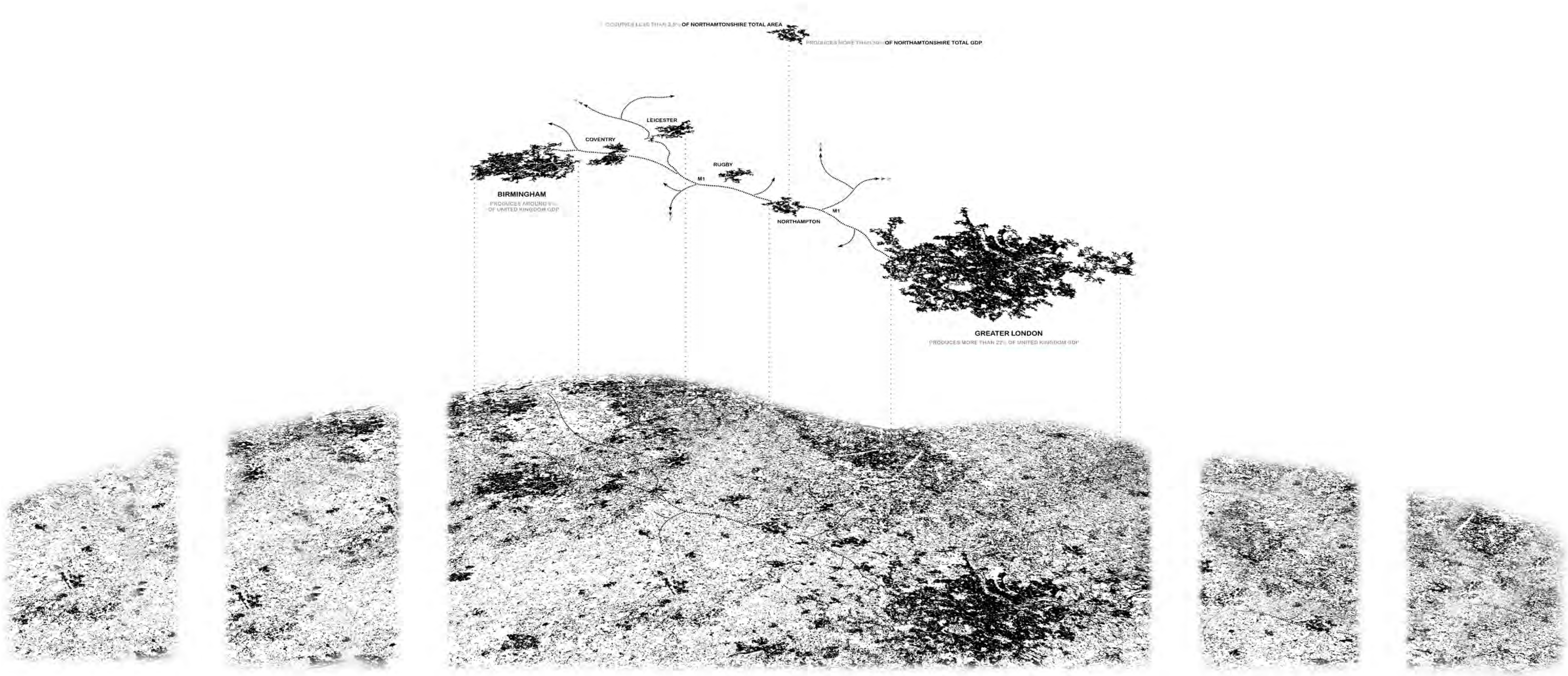
2.1 - Northampton

Within broader context

Northamptonshire, located in central England, contributes to the UK economy through diverse sectors:

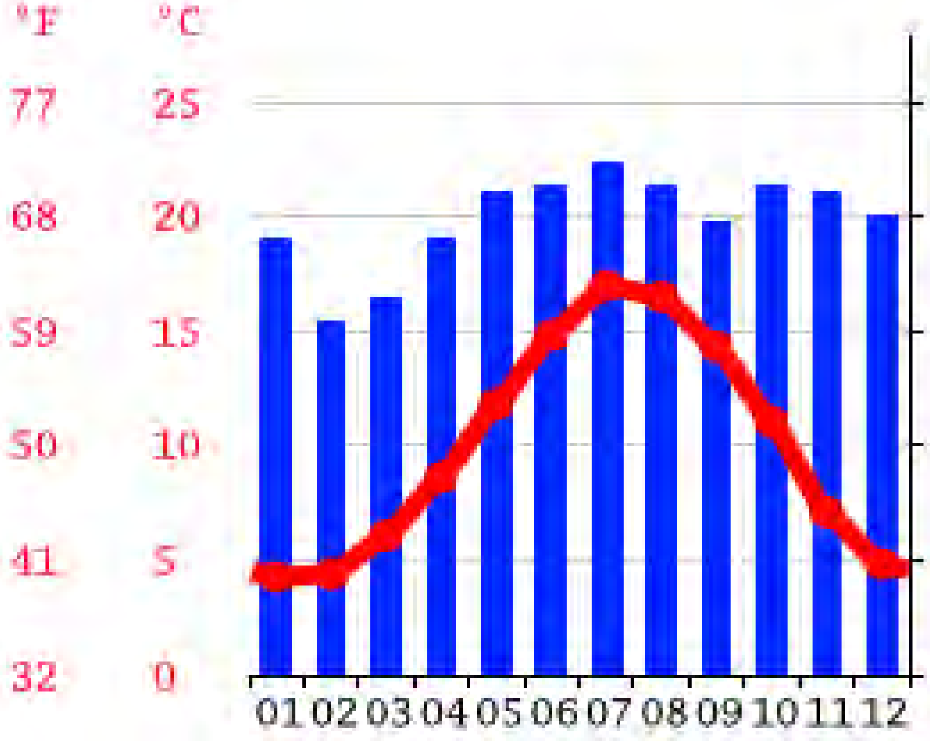
- *Advanced Manufacturing and Engineering: Known for precision engineering, hosting companies like Cosworth and Siemens.*
- *Agriculture: Significant farmland supports the agricultural industry, contributing to food production and supply chains.*
- *Services Sector: Growing industries including finance, education, healthcare, and tourism, with historic towns attracting visitors.*

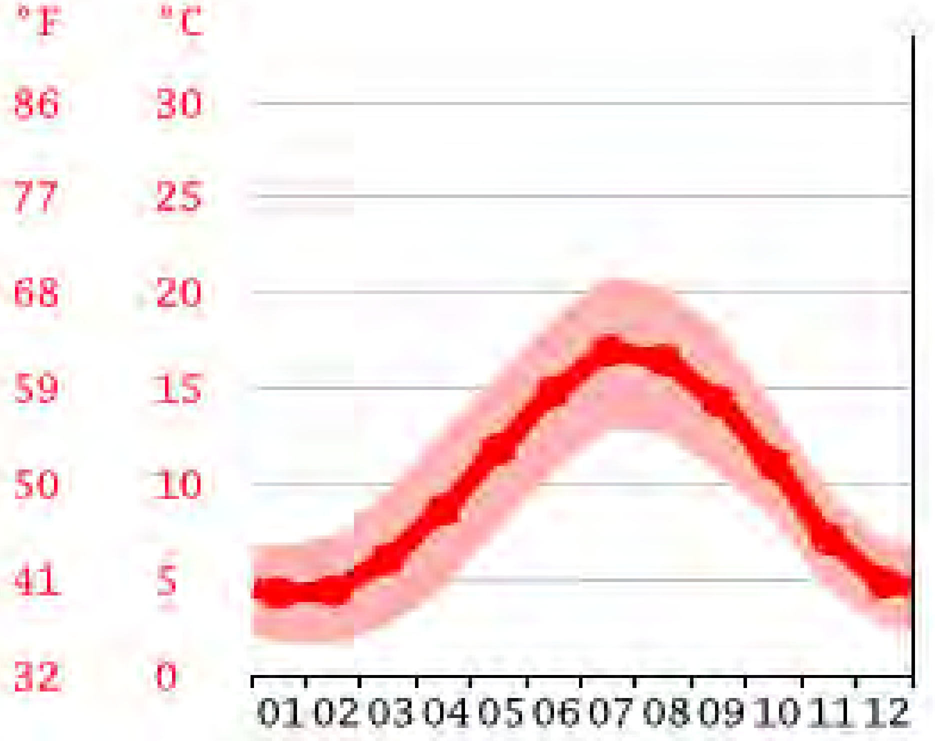
- Logistics and Distribution: Strategic location with the East Midlands Airport and M1 motorway, making it a hub for transportation and distribution.



2.1 - Northampton

Climate Analysis



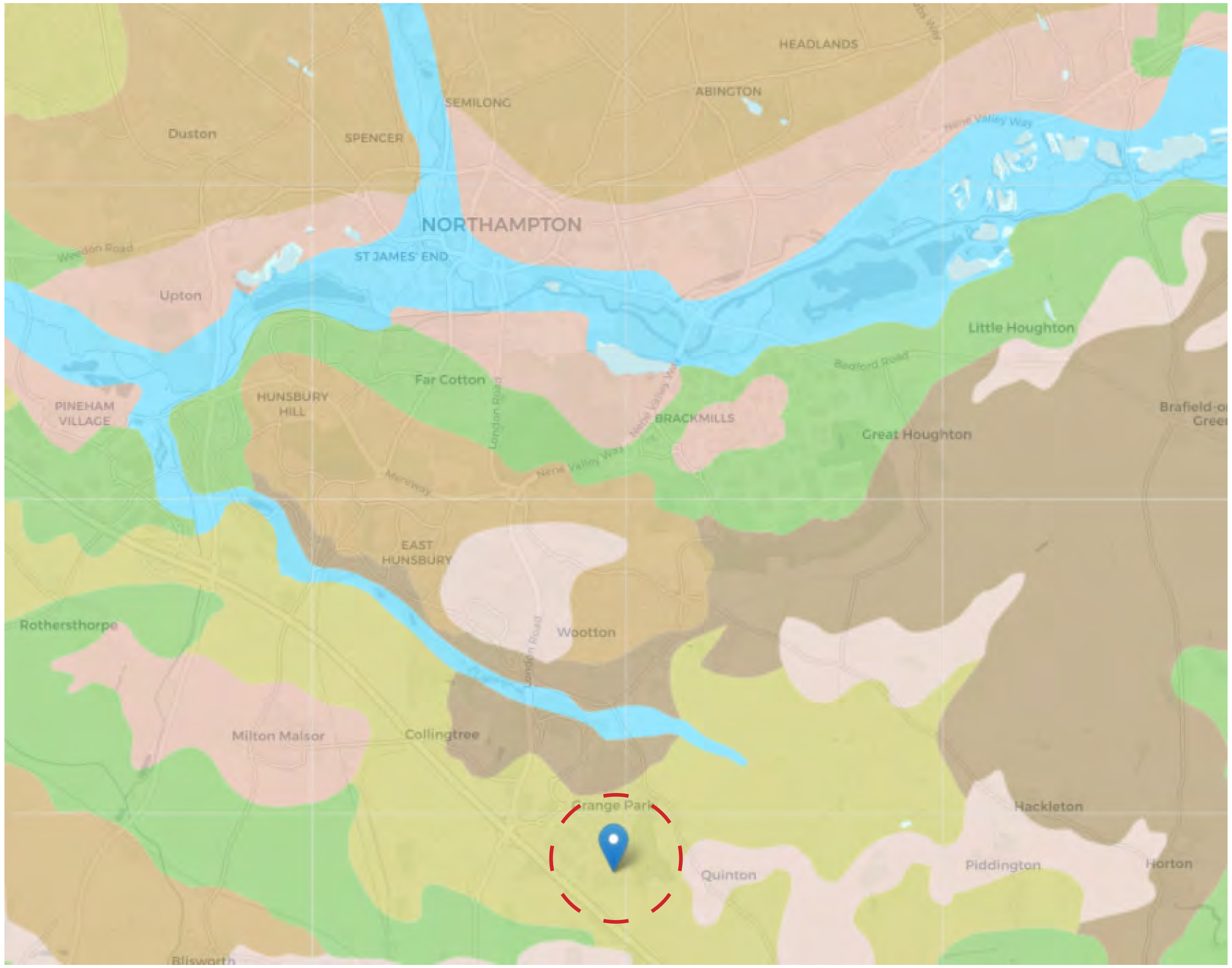


Northampton, located in the United Kingdom, experiences a temperate maritime climate, typical of much of the British Isles. This results in relatively mild temperatures throughout the year, with cooler winters and warmer summers. The average annual temperature hovers around 10°C. Precipitation is distributed fairly evenly across the months, with wetter conditions generally occurring during autumn and winter. Northampton does not often experience extreme weather, although occasional bouts of heavier rain or unexpected cold snaps can occur, influenced by Atlantic weather systems. This climate contributes to lush green landscapes in the surrounding countryside, but also necessitates preparedness for varied weather conditions.

**Graphs from Climate-data.org*

2.1 - Northampton

Soil Type Analysis



Location of Project Site (Grange Park)

*Graph and data from from https://www.landis.org.uk/soilscapes/

2.1 - Northampton

Soil Type Analysis

Looking at the soil type of Northampton in general and the specific site of the project, it is immediatly noticeable that Grange Park, the recently urbanising part of Northampton falls within coverage of a different type of soil.

Accoring to data from LandIS, it is “Lime-rich loamy and clayey with impeded drainage” - a highly fertile type of soil, normally best for agriculture, however due to Northampton’s strategic location within major hubs, This probably means that logistics investments in the area (especially around M1) still yield more return than conventional means of agriculture.

Soilscape 9:

Lime-rich loamy and clayey soils with impeded drainage

Texture:
Clayey, some loamy

Coverage:
England: 5.3%,**Wales:** 0.0%,**England & Wales:**4.5%

Drainage:
Slightly impeded drainage

Fertility:
High

Landcover:
Arable some grassland

Habitats:
Base-rich pastures and classic chalky boulder clay ancient woodlands; some wetter areas and lime-rich flush vegetation

Carbon:
Low

Drains to:
Stream network

**Graph and data from from https://www.landis.org.uk/soilscapes/*

2.2 - Grange Park

Site Plan

2.2 - Grange Park

Site Plan

LOGISTICS *INFRASTRUCTURE* *RESIDENTIAL* *AGRICULTURE*

2.2 - Grange Park

Areas of each warehouse

The focus site in Grange Park, that is built around Cheaney Drive was first developed in 2000s by Northampton Logistics Ltd. with only two warehouses and continued to function until 2009 when Yusen Logistics, a Japanese Logistics company bought the site and developed it further into its current state. The way the company operates is that they develop potential sites of value and then lease it to various companies. They do not specifically manage day-to-day logistics operations.

Leased to: CombiSafe
8.500 sq meters

Leased to: JohnLewis
17.000 sq meters

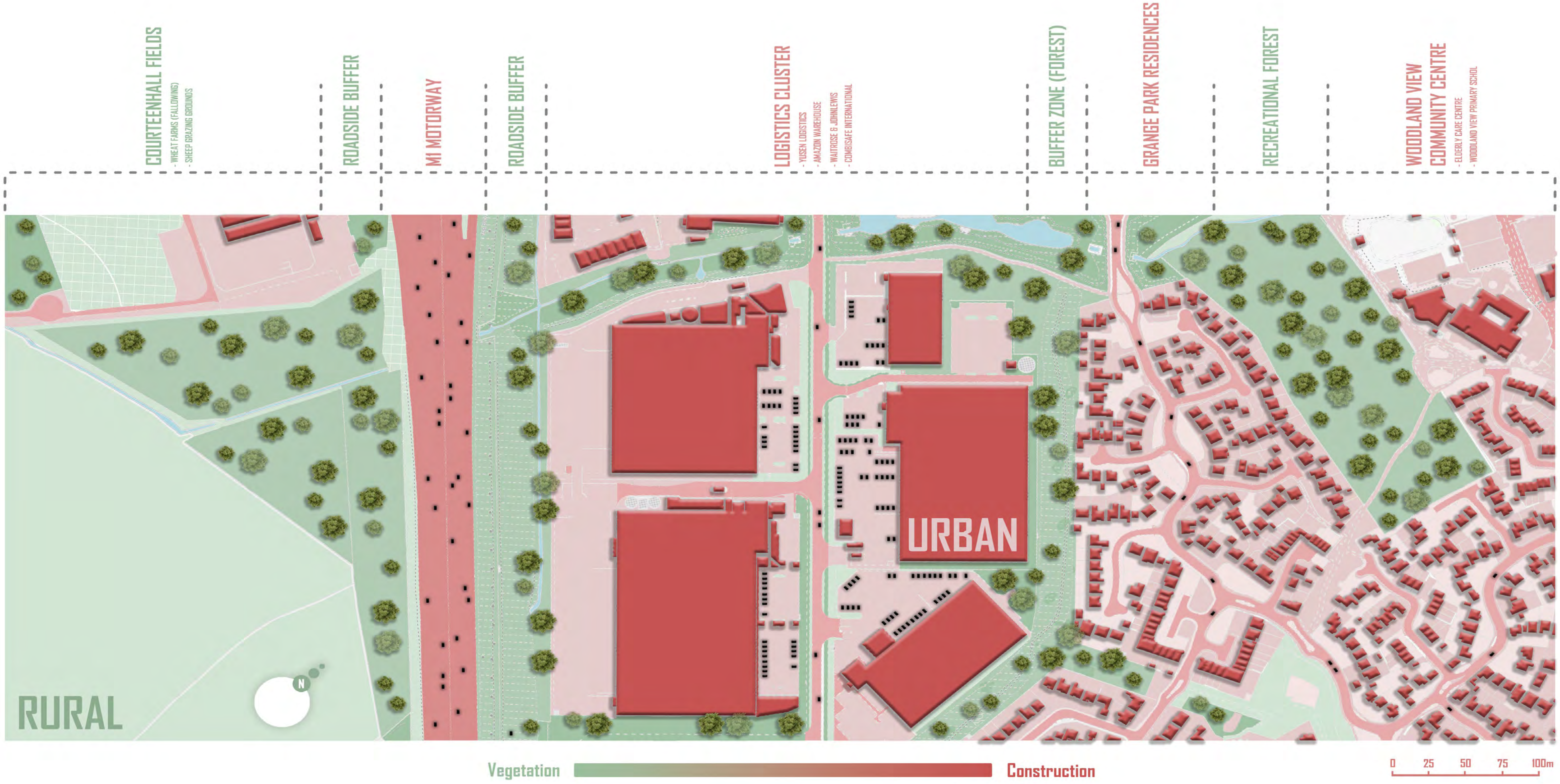
Leased to: MySteps
14.000 sq meters

Leased to: Amazon UK
18.500 sq meters

Leased to: Amazon UK
14.000 sq meters

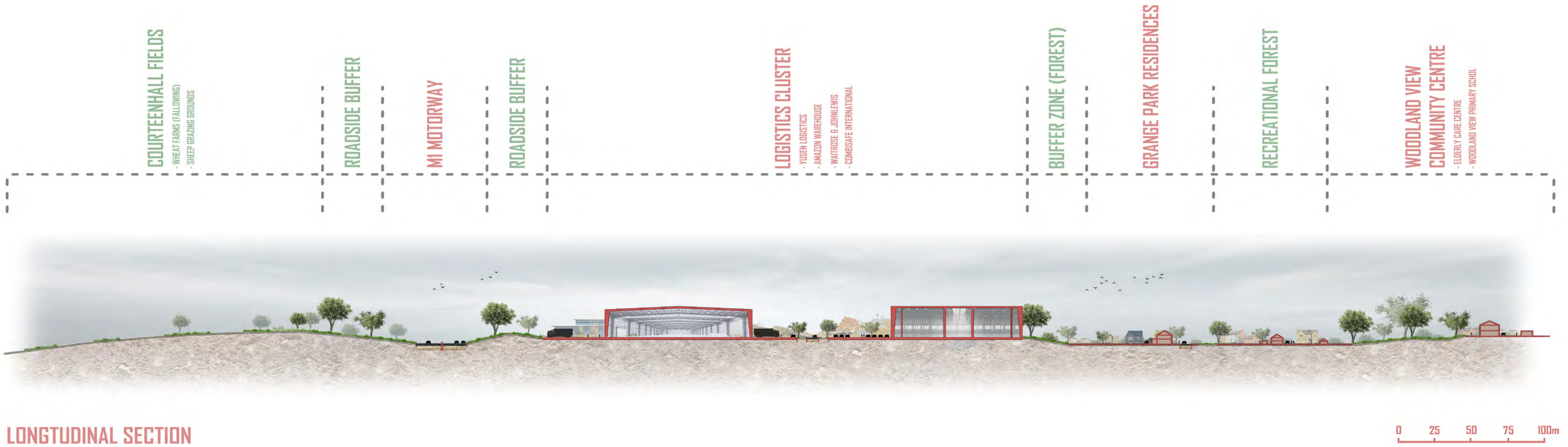
2.2 - Grange Park

Focused strip - Logistics cluster sandwiched between farmlands and housing developments



2.2 - Grange Park

Longtidunal Section

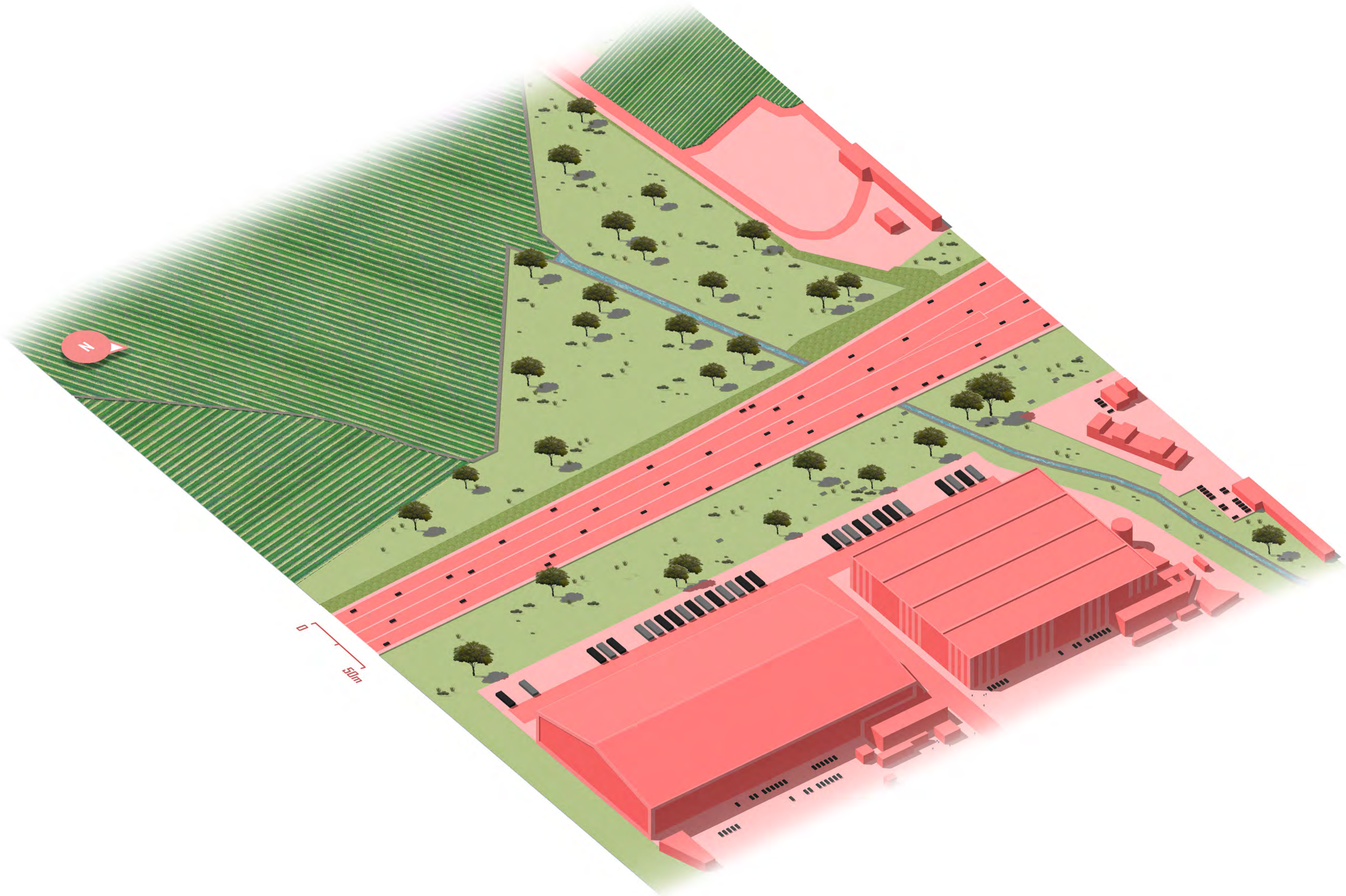


The logistics cluster dominates the skyline with its towering warehouses and infrastructure designed to facilitate the movement and storage of goods. These structures often rise prominently, their sheer size and scale reflecting the pivotal role of logistics in modern commerce. Giant distribution centers, container yards, and transportation hubs form a dynamic landscape, symbolizing the interconnectedness of global supply chains. Against the horizon, the silhouette of logistics facilities underscores the engine of trade and commerce, shaping the modern urban landscape with its efficiency and scale.

2.2 - Grange Park

Axonometric diagram of the relation between the JohnLewis Warehouse, buffer zone and the neighboring residential area.

2.2 - Grange Park



Axonometric diagram of the strip encompassing (left to right) farmlands - M1 motorway - buffer zone, warehouses(Amazon and Yusen Logistics)

2.2 - Grange Park

August 1985 - Low quality image however observable that there is no development in the general area.

June 2004 - Earliest possible aerial imagery of the site, after its purchase by Yusen Logistics

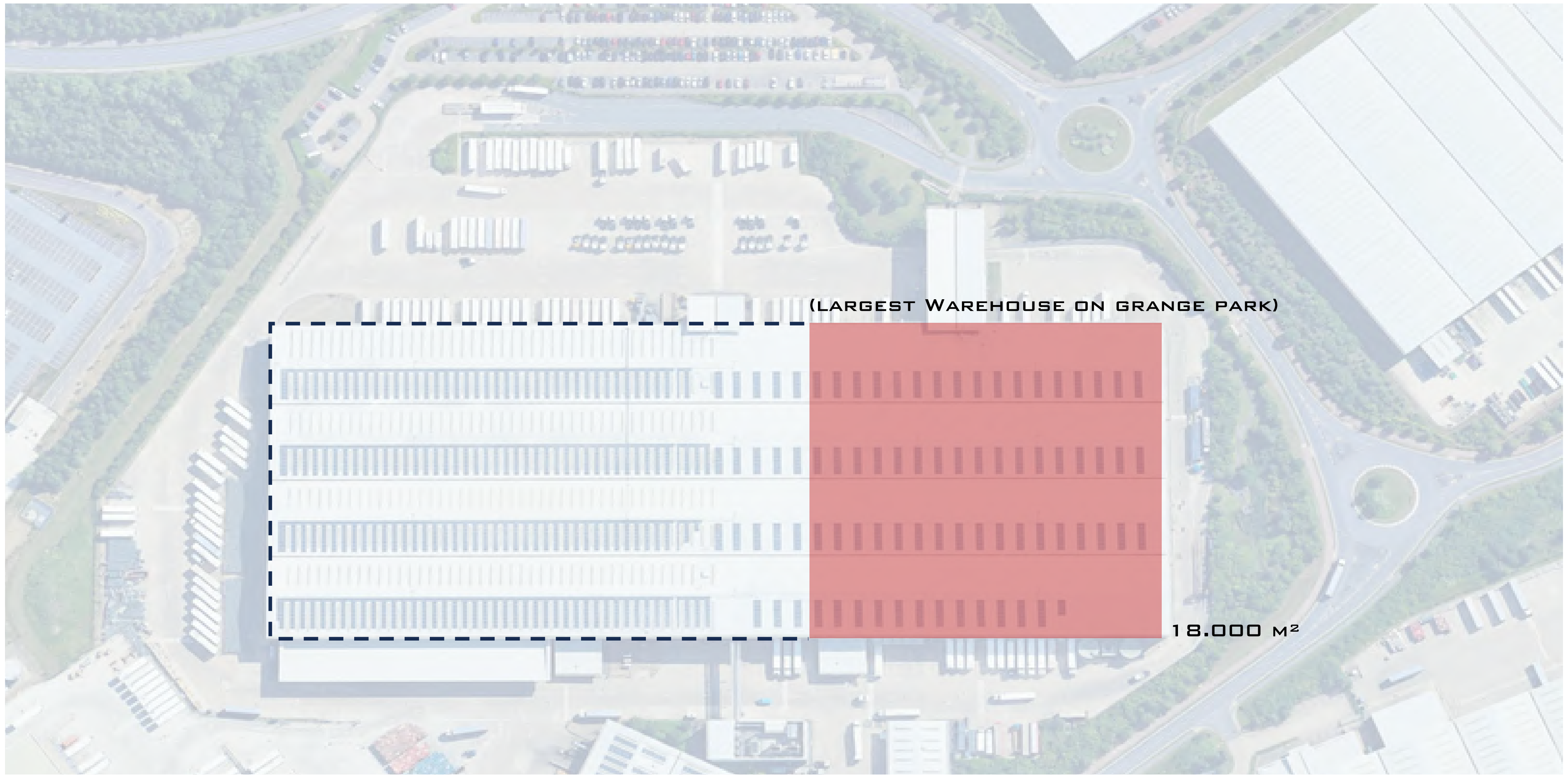
January 2009 - The addition of the last structure, making the site the same as it is today.

March 2024 - Current imagery. Notice additional warehouses being built to the north and ground being cleared to the west for more development.

2.2 - Grange Park

Future of Grange Park Cluster

Size comparison of the Largest Warehouse in Grange Park to the newer logistics development further outside of Northampton but still next to M1, signalling the inevitable future insufficiency replacement of Grange Park Cluster



As the city of Northampton is growing, we can notice how the urban tissue has now started to wrap around the former peripheral logistics cluster.

Through a basic understanding of market dynamics this means the land value around logistics cluster is rising (better connection to city centre, good infrastructure, nearby residential area and amenities) and therefore in the near future the potential profit of redeveloping the logistics cluster will become increasingly feasible in terms of return on investment for a developer. This historically results in the purchase of underused / obsolete industrial areas and their subsequent development into private residential or commercial zones.

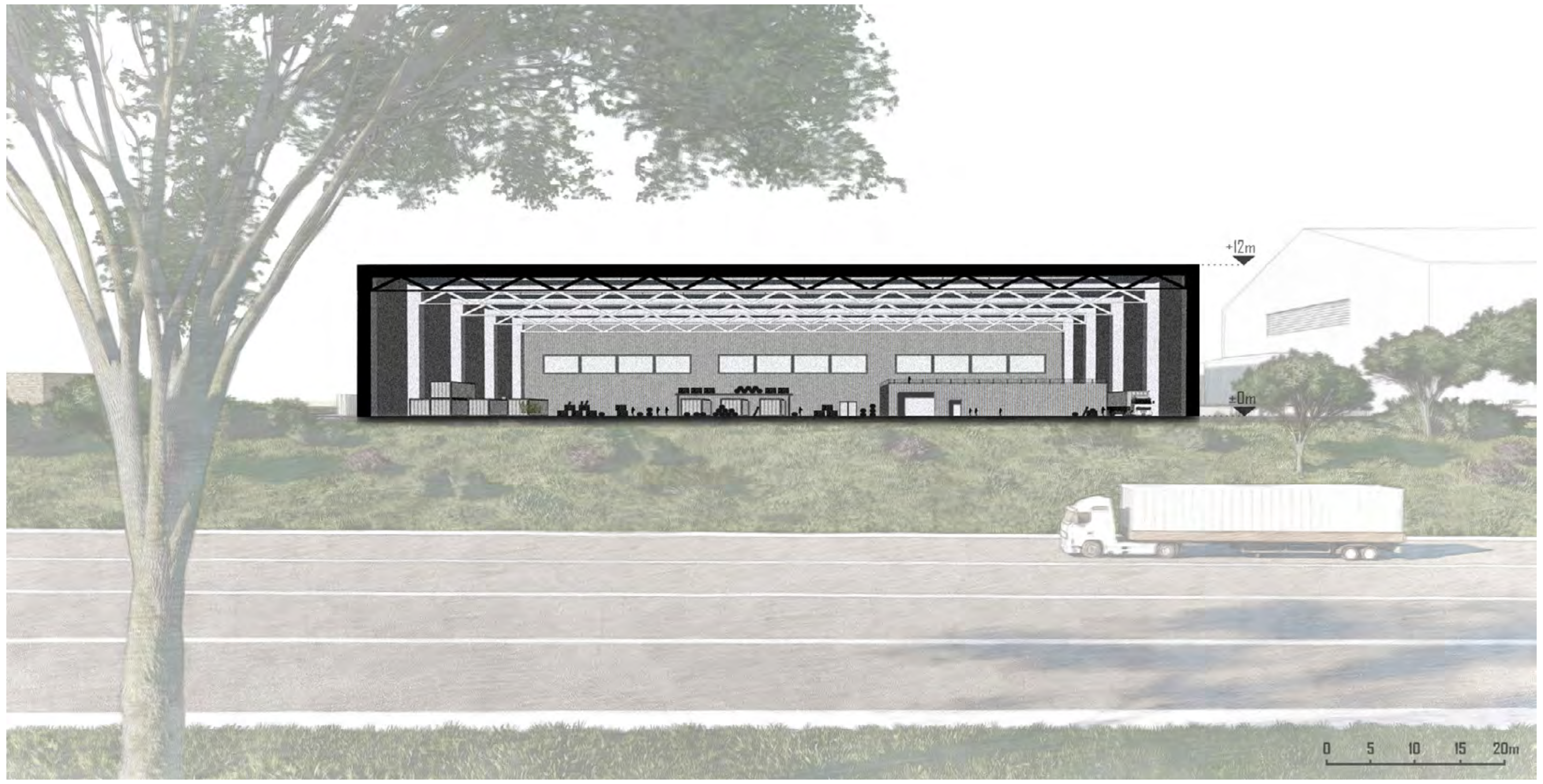
Although Grange Park has not yet become fully encroached and its function and current mode of operation is still yet to become seriously out-competed by other modes generating revenue, the project argues that if not now, in the near future the site will inevitably experience this scenario. This is where the design project comes in and seizes the opportunity to make a statement.

(“Statement” detailed further at the end of Chapter 2)

2.3 - Cheaney Drive Plot B (Amazon Warehouse)

View towards the warehouse from the opposite site of M1

Earlier studio exercise prior to site visit.



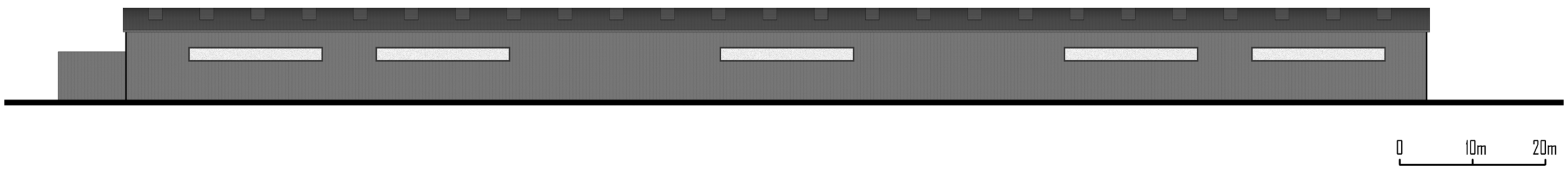
Section through the warehouse from the opposite site of M1

Earlier studio exercise of an imagined interior prior to site visit,
hence the structure is largely fictional and wrong.
(the rafters span the wrong direction)

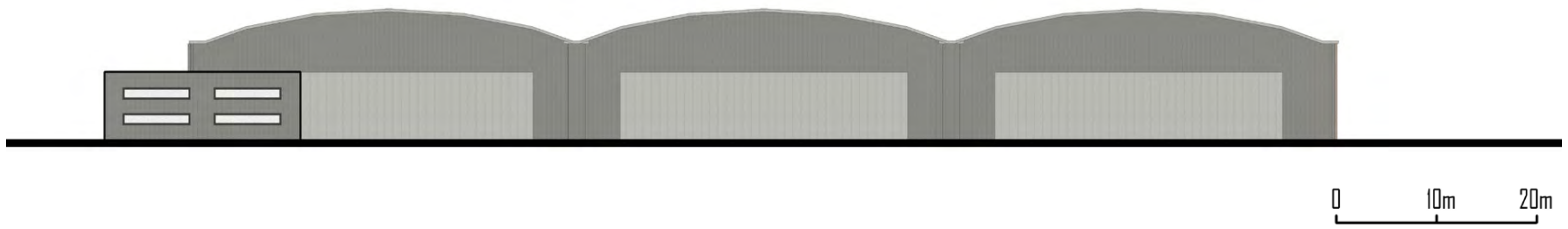
2.3 - Cheaney Drive Plot B (Amazon Warehouse)

WEST ELEVATION

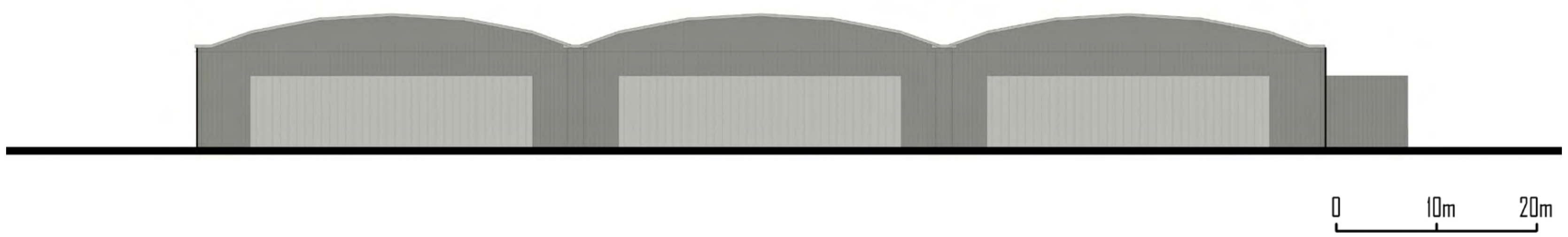
EAST ELEVATION



NORTH ELEVATION



SOUTH ELEVATION



KEY DIMENSIONS

Warehouse Width ≈ 110m

Warehouse Lenght ≈ 178m

Height - minimum 8.5m, maximum 11.5m

(due to curved roof)

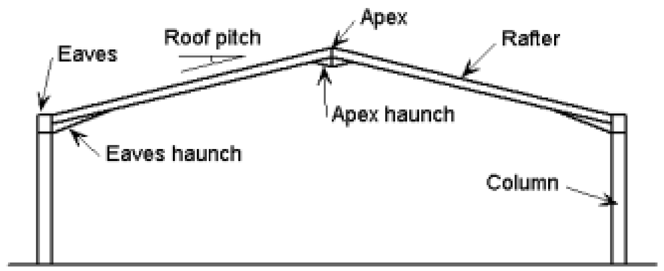
Total Floor area ≈ 18,500 m²

2.4 - The Existing Steelwork

The specific building the project will focus on is the largest inside the logistics cluster currently in use by Amazon, which is a ***multi-gable building with three clear spans of curved rafters.***

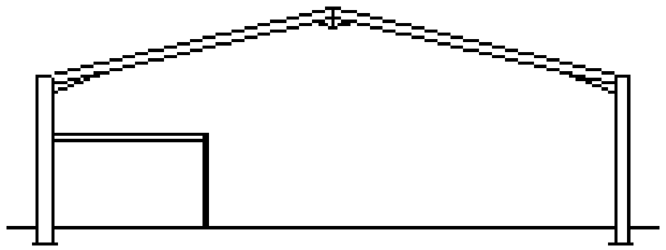
2.4 - The Existing Steelwork

Types of Portal Frames



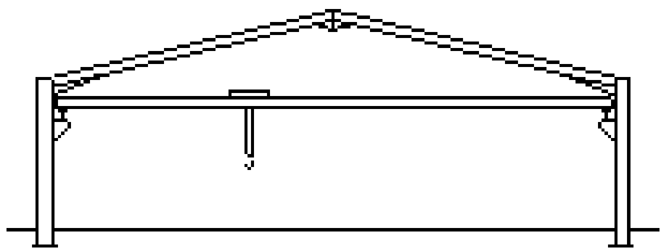
Pitched roof symmetric portal frame:

Generally fabricated from UB sections with a substantial eaves haunch section, which may be cut from a rolled section or fabricated from plate. 25 to 35 m are the most efficient spans.



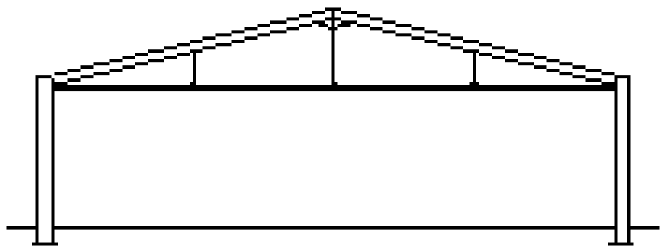
Portal frame with internal mezzanine floor:

Office accommodation is often provided within a portal frame structure using a partial width mezzanine floor. The assessment of frame stability must include the effect of the mezzanine; guidance is given in SCI P292.*



Crane portal frame with column brackets:

Where a travelling crane of relatively low capacity (up to say 20 tonnes) is required, brackets can be fixed to the columns to support the crane rails. Use of a tie member or rigid column bases may be necessary to reduce the eaves deflection.



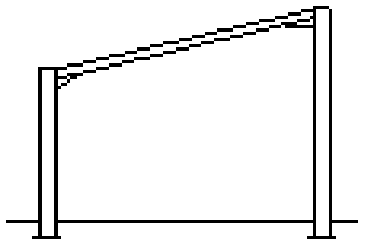
Tied portal frame:

In a tied portal frame the horizontal movement of the eaves and the bending moments in the columns and rafters are reduced. A tie may be useful to limit spread in a crane-supporting structure.

**In-plane Stability of Portal Frames to BS 5950-1:2000, In-plane Stability of Portal Frames,* Charles King, Steel Construction Institute

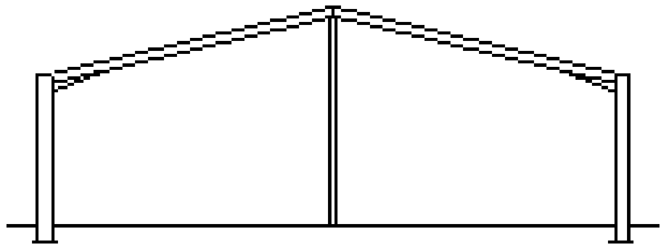
2.4 - The Existing Steelwork

Types of Portal Frames



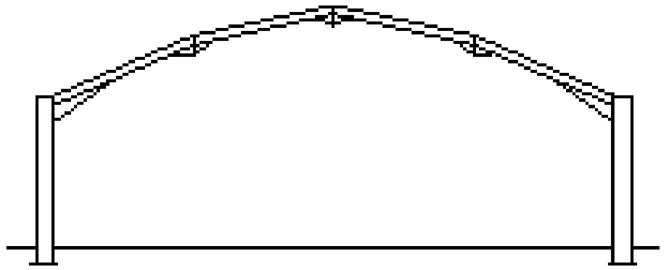
Mono-pitch portal frame:

A mono pitch portal frame is usually chosen for small spans or because of its proximity to other buildings. It is a simple variation of the pitched roof portal frame, and tends to be used for smaller buildings (up to 15 m span).



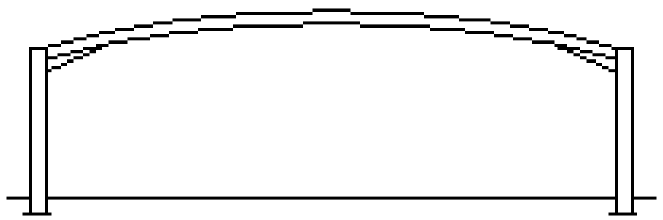
Propped portal frame:

Where the span of a portal frame is large and there is no requirement to provide a clear span, a propped portal frame can be used to reduce the rafter size and also the horizontal shear at the foundations.



Mansard portal frame:

A mansard portal frame may be used where a large clear height at mid-span is required but the eaves height of the building has to be minimised.



Curved rafter portal frame:

Portal frames may be constructed using curved rafters, mainly for architectural reasons. Because of transport limitations rafters longer than 20 m may require splices, which should be carefully detailed for architectural reasons. The curved member is often modelled for analysis as a series of straight elements. Guidance on the stability of curved rafters in portal frames is given in SCI P281.*

**Design of Curved Steel,* David Brown and Charles King, Steel Construction Institute

2.4 - The Existing Steelwork

***Advantages** of steel portal frame construction*

Durability and Strength: *Steel is highly durable and possesses excellent strength-to-weight ratios, making it ideal for creating large spans and complex shapes like curved rafters. This strength allows the building to withstand heavy loads, severe weather conditions, and environmental stressors.*

Aesthetic Flexibility: *Curved rafters can create visually striking structures that offer architectural distinctiveness. This can enhance the building's appeal in commercial or public spaces that benefit from unique aesthetics.*

Clear Spans: *The use of steel allows for large clear spans without the need for intermediate columns, maximizing the usable interior space. This is particularly beneficial for warehouses, sports facilities, and other applications where unobstructed space is crucial.*

Design Versatility: *Steel is adaptable in terms of modifications and expansions. Additional floors or extensions can be more easily integrated than with some other construction materials.*

Speed of Construction: *Steel structures can be prefabricated, which significantly speeds up construction time compared to traditional concrete construction. Prefabrication also reduces onsite labor needs and can decrease overall project costs.*

2.4 - The Existing Steelwork

***Disadvantages** of steel portal frame construction*

***Cost:** Initial costs can be high due to the price of steel and the complexity involved in designing and constructing with curved elements and clear spans. Specialized design expertise and manufacturing processes for curved rafters add to the expense.*

***Thermal Conductivity:** Steel conducts heat more efficiently than many other building materials, which can lead to higher energy costs for heating and cooling unless properly insulated. This can also contribute to a less stable indoor environment in extreme weather conditions.*

***Corrosion:** Depending on the environmental conditions, steel can be susceptible to corrosion over time unless properly treated or maintained. Coastal areas or places with high humidity require additional protective measures, such as galvanization or regular maintenance.*

***Acoustic Issues:** Steel buildings can sometimes suffer from poor acoustics, especially in large, clear-span areas. Sound can echo, which may require additional investments in acoustic treatments to ensure comfort and usability.*

***Foundation Requirements:** The substantial weight of a steel structure, especially one with large spans and heavy loads, typically requires a strong foundation, which can increase construction costs and complexity.*

2.4 - The Existing Steelwork

Three Essential Layers of the Steel Portal Frame Warehouse

PRIMARY STEEL FRAME

(consisting of columns, rafters and bracing)

The example shown is a portal frame, however, it is equally applicable to other types of structural frames.

SECONDARY STEELWORK

(consisting of side rails and purlins for the walls and the roof respectively)

- Support the cladding

- Transferring load from the cladding to the primary steel frame

- To restrain the primary steel frame members

ROOF AND WALL CLADDING

(Separating the enclosed space from the external environment)

- Transferring load to the secondary steelwork

- Restraining the secondary steelwork

- Providing thermal insulation

- Providing acoustic insulation

- Preventing fire spread

- Providing an airtight envelope

- Providing ventilation to a building (ventilated or unventilated roofs and walls).

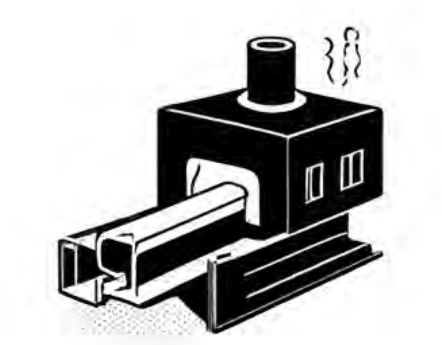
2.4 - The Existing Steelwork

Three Essential Layers of the Steel Portal Frame Warehouse

Material Preparation

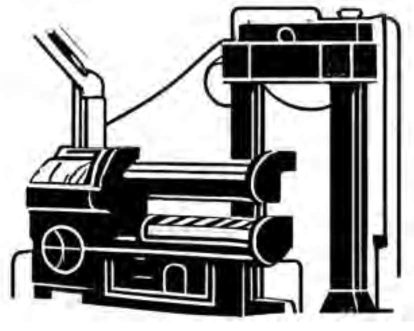
Raw steel is prepared and inspected to ensure quality before processing.

Heating



The steel is heated to a specific temperature to make it malleable.

Rolling



The heated steel is passed through a series of rollers to form the flanges and web of the H-profile.

Welding

The flanges are welded to the web to form the basic H-shape.

Cooling & Straightening

The newly formed H-profile is cooled at a cont-rolled rate to avoid warping and the column is straightened to correct any deviations from the desired specifications.

Drilling & Cutting

The column is cut to the specified length, and holes are drilled into the flanges for bolting purposes.

Surface Treatment

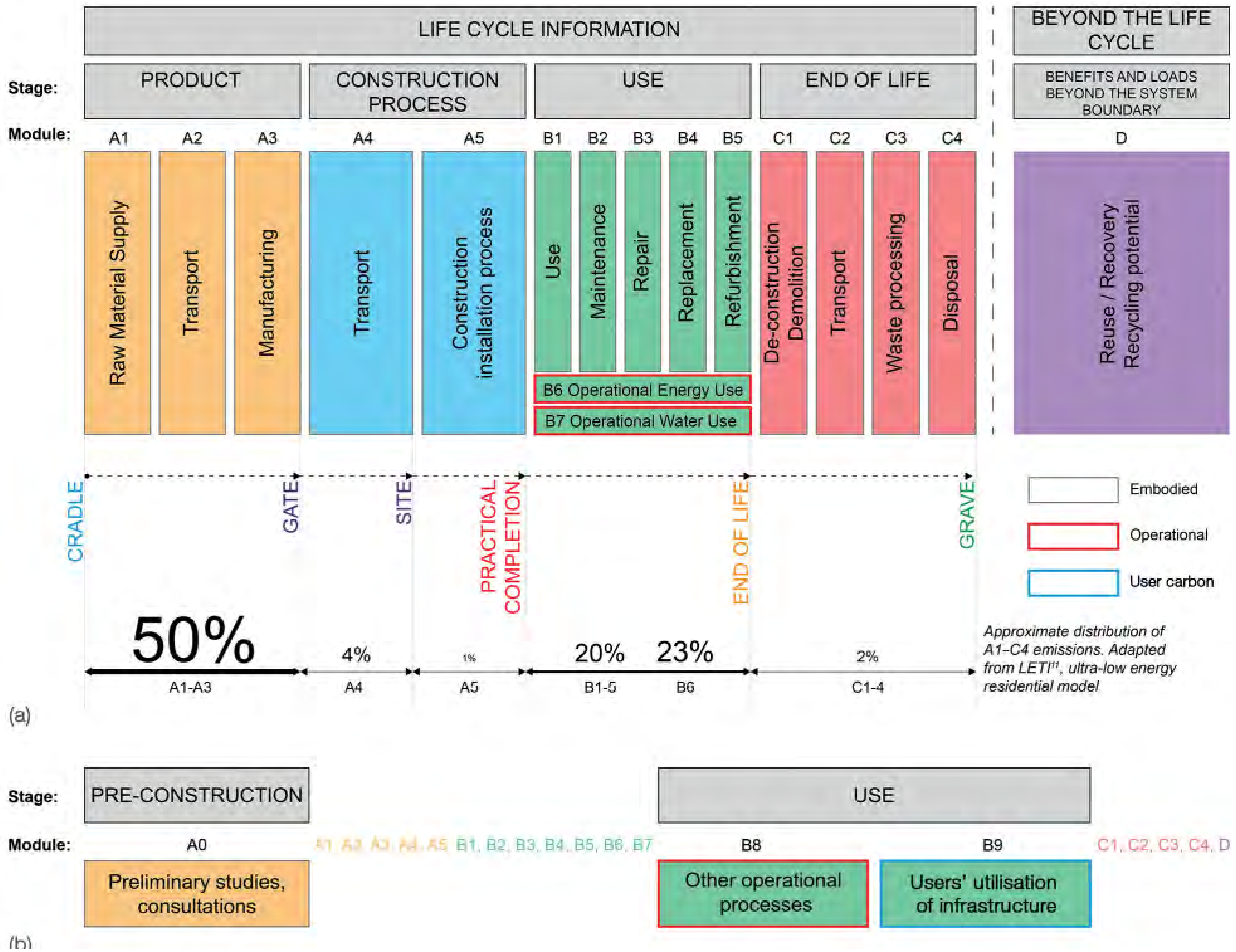
The column is treated for corrosion resistance, typically through galvanizing or painting.

Quality Control

Each column undergoes a series of quality control tests, including dimensional checks and strength tests - Approved columns are packed and shipped to the site or customer.

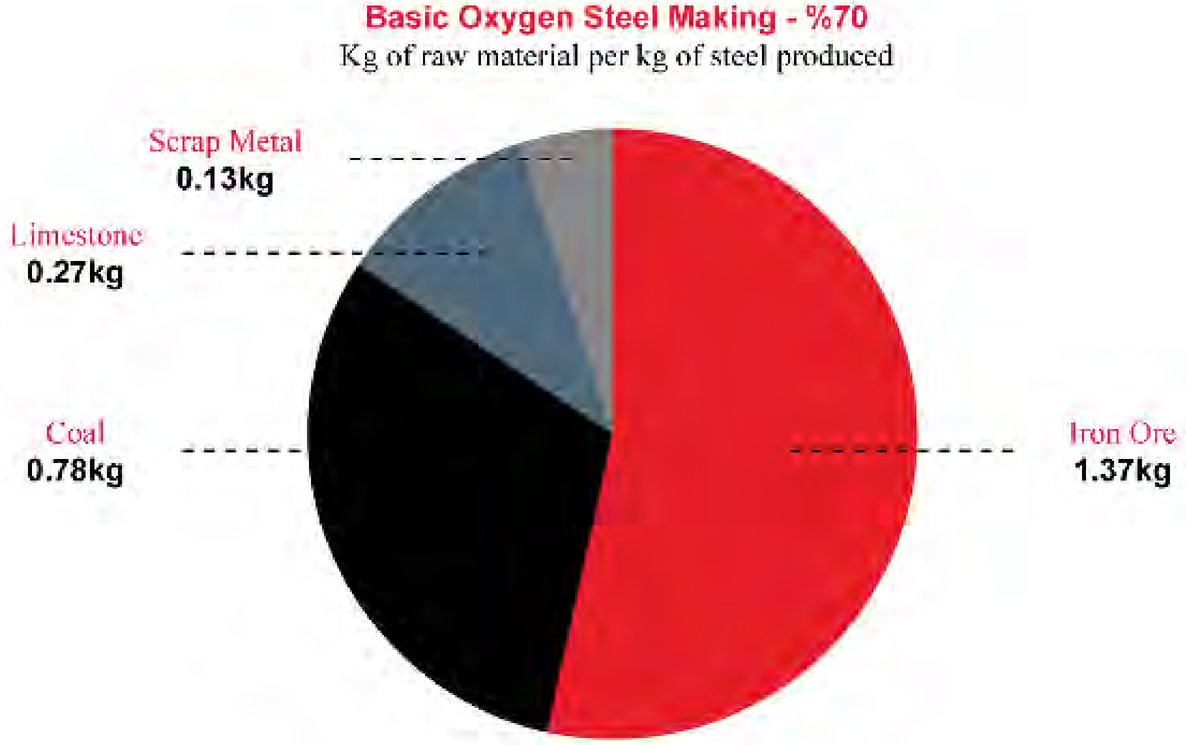
2.4 - The Existing Steelwork

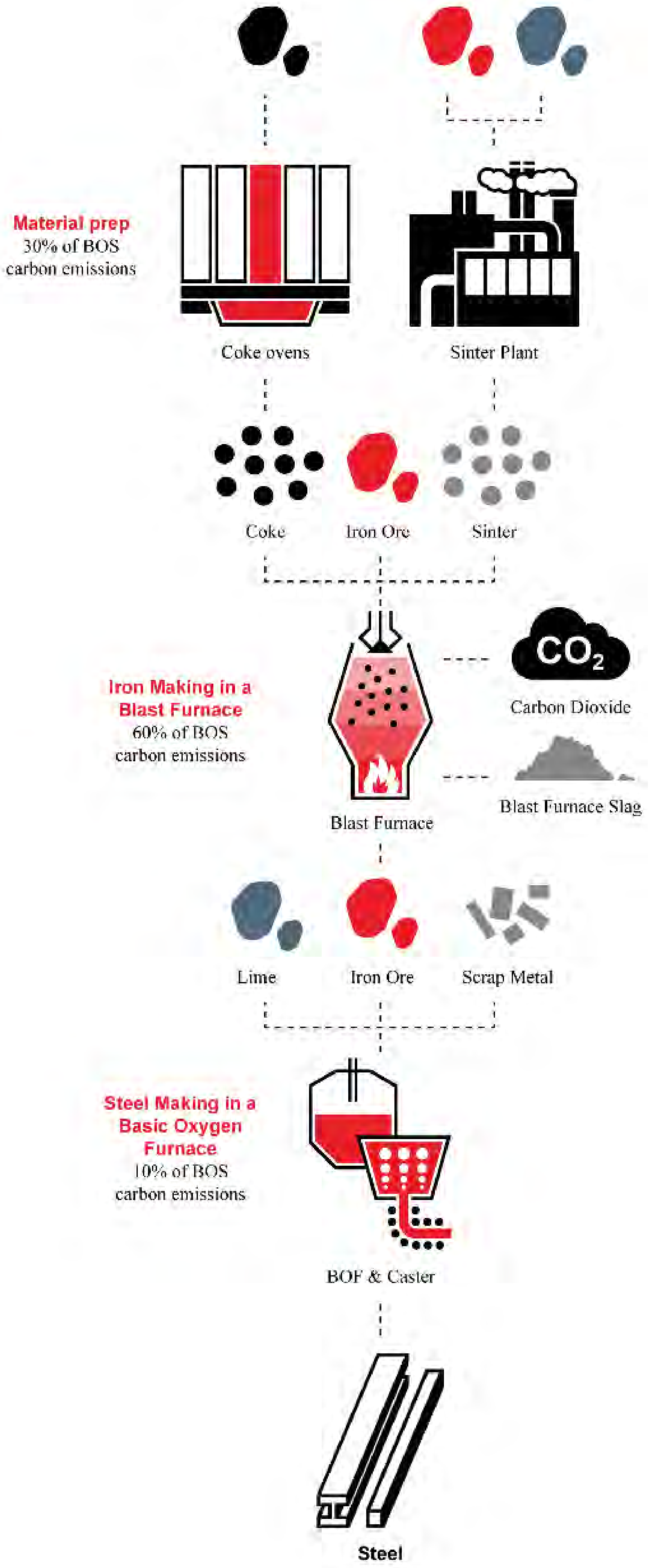
BS EN 15978 - Life cycle stages



2.4 - The Existing Steelwork

Basic Oxygen Steelmaking - from "ARUP Embodied Carbon Steel"

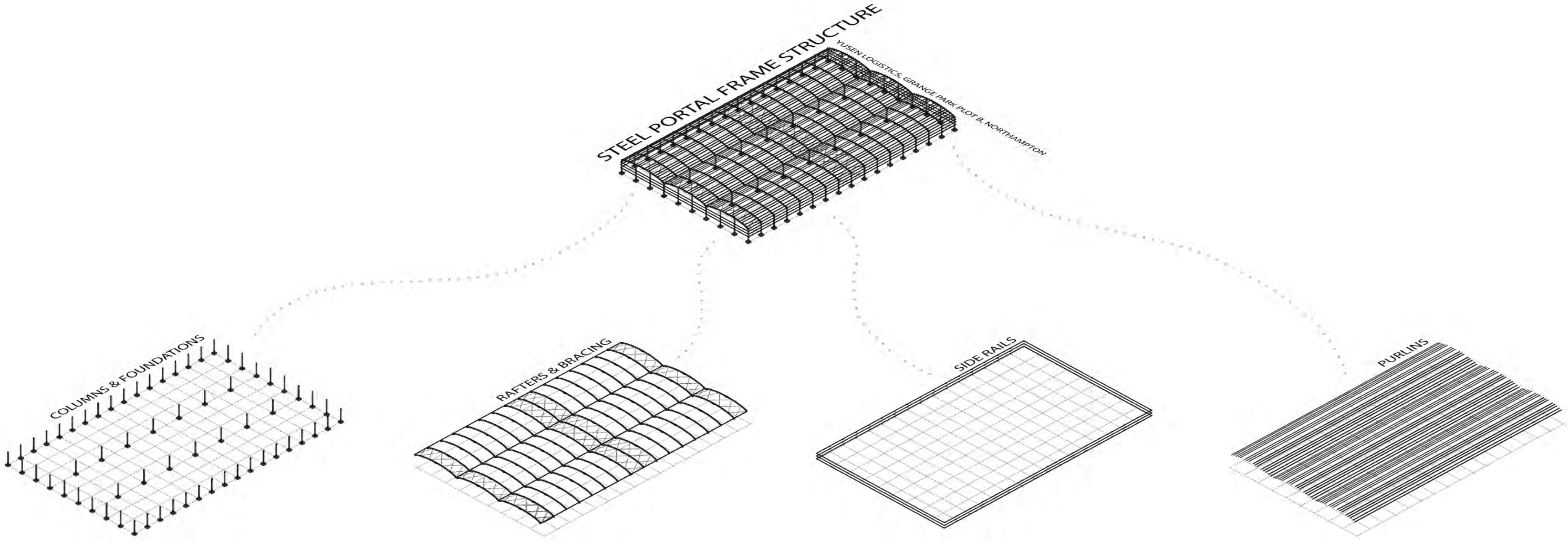


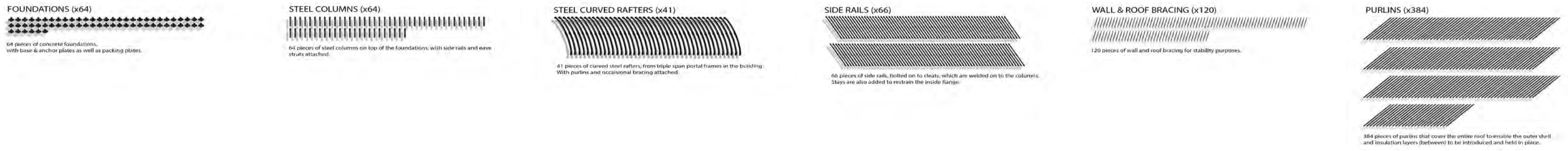


The calculations on embodied carbon of steel in the following chapters in this design thesis will be based on the "Basic Oxygen Steel Making" process detailed here, which is ow approximately around 70% of global steel is produced. The remaining 30% of global steel production uses Electric Arc Furnace - EAF in short, which is predominantly used for producing steel products from recycled steel elements.

2.4 - The Existing Steelwork

Primary and Secondary Steelwork





Elements that come together to form the primary and secondary steelwork of the Amazon warehouse in focus

2.4 - The Existing Steelwork

Embodied carbon calculations associated with the production of steel elements

FOUNDATIONS (x64)

64 pieces of concrete foundations,
with base & anchor plates as well as packing plates.

0.9-1.0 kg CO^2 emitted per kg of concrete (with ~14% cement). For clarity purposes we will use the typical **value of 1.0 kg CO^2 per kg.**

Volume of concrete block ≈ approx 5m³

Typical density of concrete: 2400 kg/m³

Total weight of concrete foundation
= 2.4 tonnes per 1m³
2.4 x 5 = 12

Emissions per founcation
= **12 tonnes CO^2 per each foundation**

Total emissions for all foundations
12 x 64 = **approx. 768 tonnes CO^2**

STEEL COLUMNS (x64)

64 pieces of steel columns on top of the foundations, with side rails and eave struts attached.

We will assume the mid point of typical values (1.8-2.3) for steel, and **assume 2.0 kg emissions CO^2 per kg of steel.**

Weight of one H-profile column of 850 cm
= 520.55 kg ≈ 520 kg

Emissions per column
= 520 x 2.0 = 1040
= **1.04 tonnes CO^2 per each column**

Total emissions for all vertical steel columns
1.04 x 64 ≈ **approx. 66,5 tonnes CO^2**

STEEL CURVED RAFTERS (x41)

41 pieces of curved steel rafters. from triple span portal frames in the building.
With purlins and occaisional bracing attached.

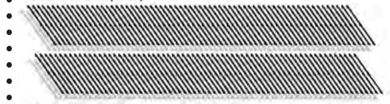
We will assume the mid point of typical values (1.8-2.3) for steel, and **assume 2.0 kg emissions CO^2 per kg of steel.**

Weight of one curved rafter spanning 3600 cm
≈ 2080 kg

Emissions per rafter
= 2080 x 2.0 = 4160 k
= **4.16 tonnes CO^2 per each column**

Total emissions for all steel rafters
4.16 x 41 ≈ **approx. 170,56 tonnes CO^2**

SIDE RAILS (x66)



66 pieces of side rails, bolted on to cleats, which are welded on to the columns.
Stays are also added to restrain the inside flange.

We will assume the mid point of typical values (1.8-2.3) for steel, and **assume 2.0 kg emissions CO^2 per kg of steel.**

Weight of one side rail with a lenght of 1600 cm
≈ 978 kg

Emissions per side rail
= 978 x 2.0 = 1956
= **1.95 tonnes CO^2 per each column**

Total emissions for all side rails
1.95 x 66 ≈ **approx. 128,7 tonnes CO^2**

WALL & ROOF BRACING (x120)

120 pieces of wall and roof bracing for stability purposes.

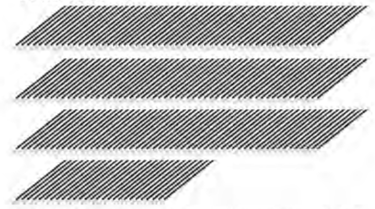
We will assume the mid point of typical values (1.8-2.3) for steel, and **assume 2.0 kg emissions CO^2 per kg of steel.**

Weight of one bracing element of 1000cm
≈ 130 kg

Emissions per bracing
= 130 x 2.0 = 260
= **0.26 tonnes CO^2 per each bracing**

Total emissions for bracing elements
0.26 x 120 ≈ **approx. 31,2 tonnes CO^2**

PURLINS (x384)



384 pieces of purlins that cover the entire roof to enable the outer shell and insulation layers (between) to be introduced and held in place.

We will assume the mid point of typical values (1.8-2.3) for steel, and **assume 2.0 kg emissions CO^2 per kg of steel.**

Weight of one purlin with a lenght of 1600 cm
≈ 978 kg

Emissions per purlin
= 978 x 2.0 = 1956
= **1.95 tonnes CO^2 per each column**

Total emissions for all purlins
1.95 x 384 ≈ **approx. 748,8 tonnes CO^2**

CO^2 emissions from concrete foundation: ***768 tonnes CO^2***

CO^2 emissions from steelwork: ***66,5 + 170,56 + 128,7 + 31,2 + 748,8 = 1145,76 tonnes CO^2***

Total CO^2 emissions: 1913,76 tonnes CO^2

2.5 - Retrofit and Re-use

The value and importance in re-use of steel construction warehouses and obsolete industrial space in general

A steel construction multi-gable building with curved rafters offers a compelling mix of durability, aesthetic appeal, and flexibility, making it suitable for a range of uses that benefit from large, unobstructed spaces. However, considerations around cost, environmental conditions, and specific use-cases need to be carefully evaluated to ensure that the advantages outweigh the disadvantages in any given project scenario. In any case, demonstrable through their widespread use in logistics & warehouse programs, they perform well for such scenarios.

Importantly, Steel is primarily produced through the integrated steelmaking process, which involves the use of coal as a reducing agent in blast furnaces. This process releases carbon dioxide (CO2) as a byproduct, contributing to greenhouse gas emissions which were calculated and comparatively analysed in this chapter. The transportation of raw materials to the steel mill and the finished steel to construction sites also adds to the carbon footprint, however as per LETI design guide and the document BS EN 15978 - "Life cycle stages", transportation of goods accounts for around 5-6% of emissions compared to the 50% during production, therefore the design thesis did not calculate emissions from transportation but rather deemed the manufacturing emissions to be proportionately substantial enough to reach conclusions.

As our cities grow towards their peripheries, the analysis strongly enables the argument towards the re-use and retrofitting of these massive steel structures which offer large, structurally sound, weatherproofed (and potentially well-insulated) spaces. The fact that the production of steel building elements contribute heavily to greenhouse gas emissions is the very reason we should try to fit in more than one single programme/use within such a structures lifespan.

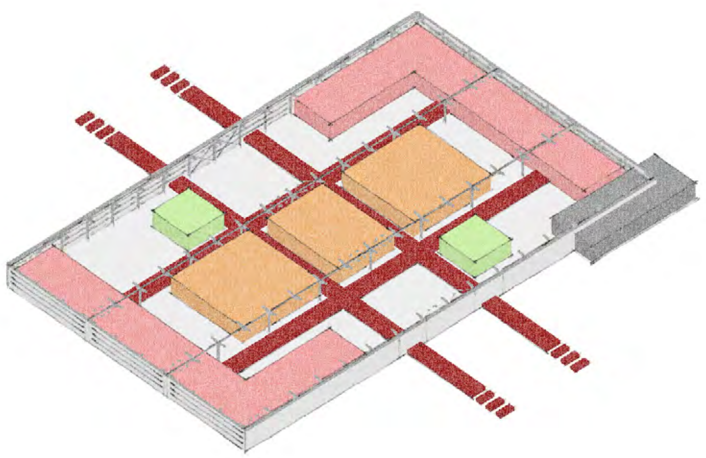
2.6 - The New Programme

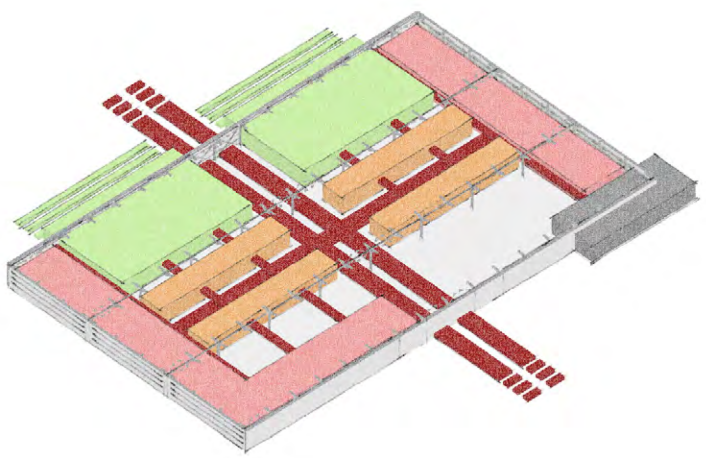
Planned new functions of the site

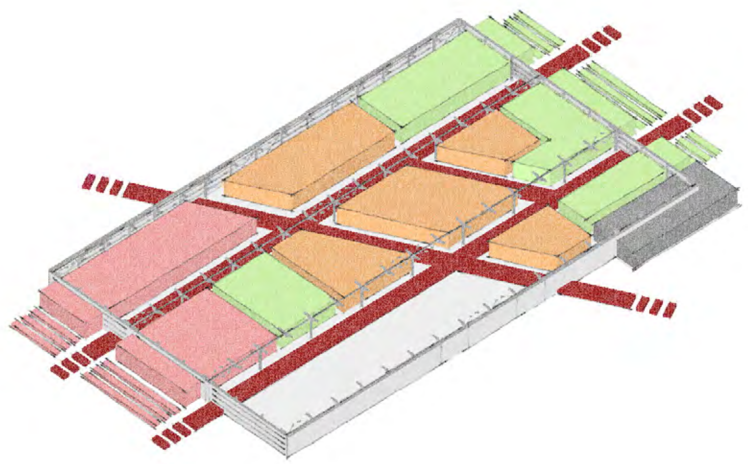
The planned new function of the site, is essentially to enable a new civic centre which also acts as a council outreach (meaning there will be programme associated with council offices, meeting rooms and community spaces). However more importantly the wider aim of the project is to bring "a piece of a city" within this massive warehouse complex, with a focus on civic & public programmes like libraries, exhibition centres and flexible-programmed open spaces.

As the site is situated right next to the main road leading from M1 to Northampton Centre, the project makes the argument that it is important to make such a gesture at the "entrance" of northampton. Making reference to Jeremy Dixon's Northamptonshire County hall competition entry and his remarks about the "importance and power of a unique landmark in the countryside". The project aims to give northampton a provacative and iconic new civic centre.

The contemporary, "new" landmark -unlike a pyramid in the countryside- being a retrofitted former industrial site sends a purposeful message as the a new "icon" for a city and sets a positive example, becoming a precedent regarding environmental/sustainability strategies for future developments.







2.7 - References & Precedents

Sesc Pompéia Factory

São Paulo Brazil

Sesc Pompeia factory

Architects: Lina Bo Bardi

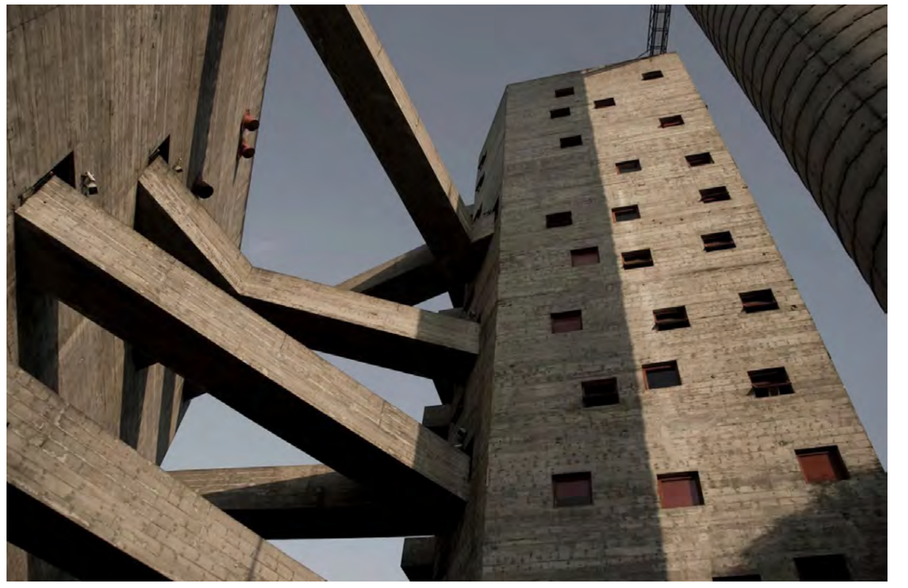
Project Year: 1977 – 1986

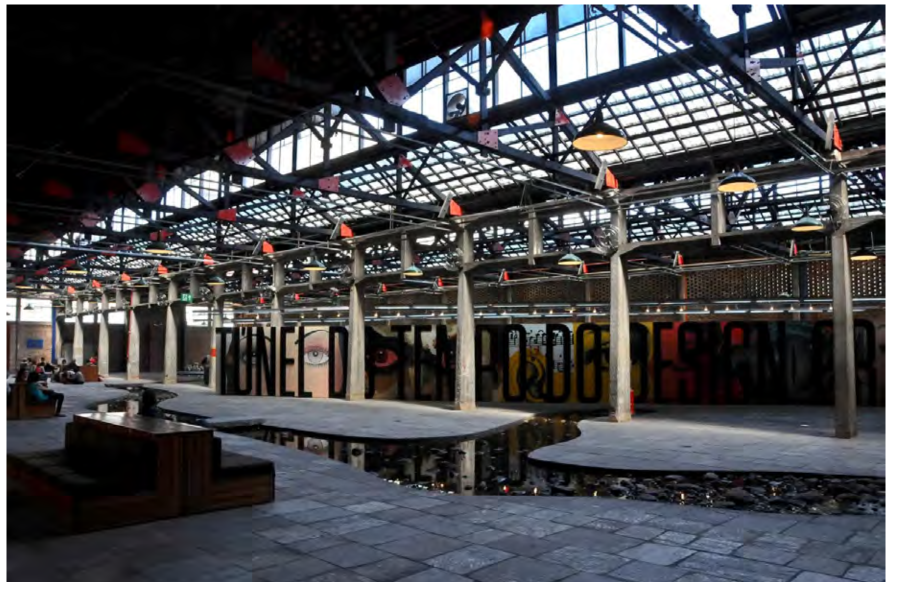
Topics: Concrete, Adaptative Reuse, Sports Centers

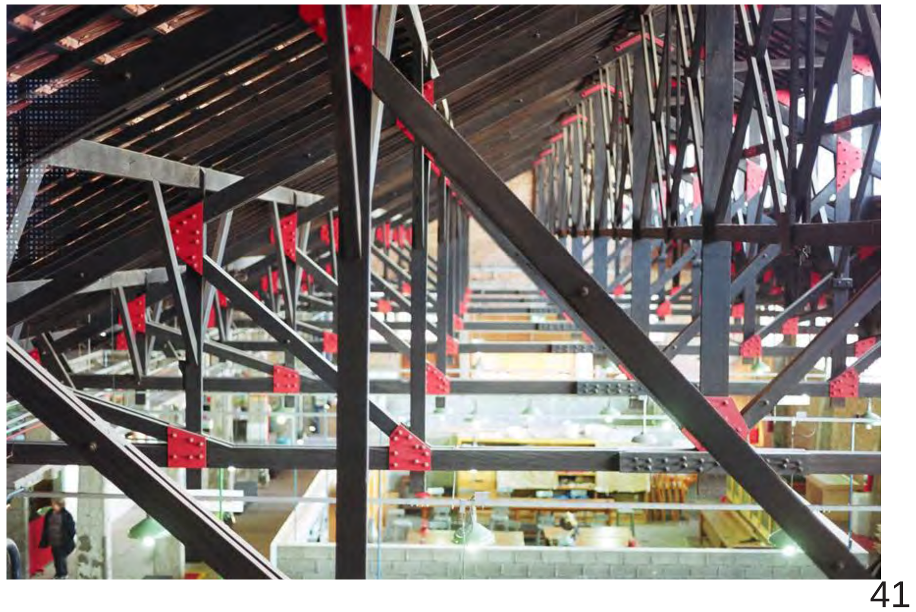
A landmark example of adaptive reuse project

‘Architecture and architectural freedom are above all a social issue that must be seen from inside a political structure, not from outside it.’
– Lina Bo Bardi

Key approach:
Bon Bardi’s design approach was centred around emphasizing the building’s structural components. Inspired by a socially utopian concept, the building reflects modernism’s ultimate goals by exposing the factory’s original concrete and brick.







2.7 - References & Precedents

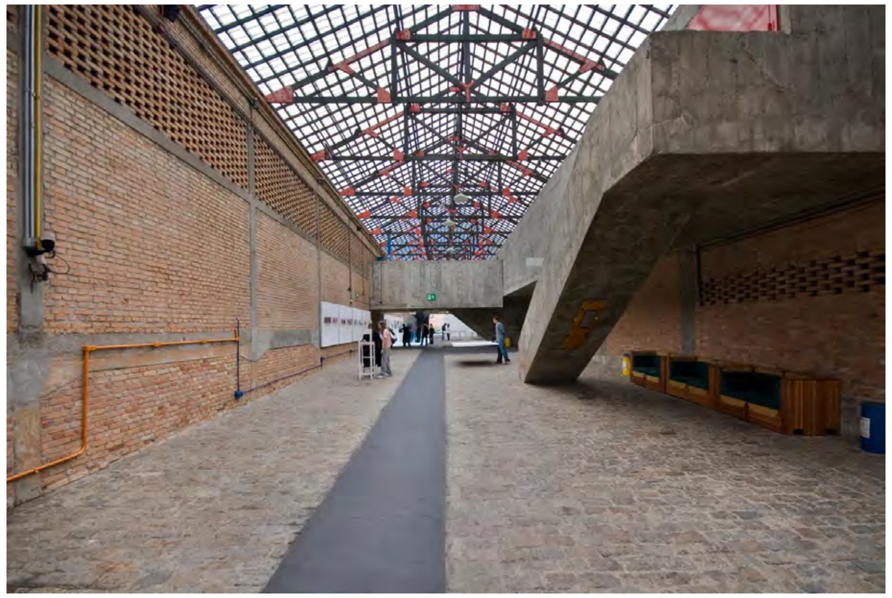
Key characteristics of the building:

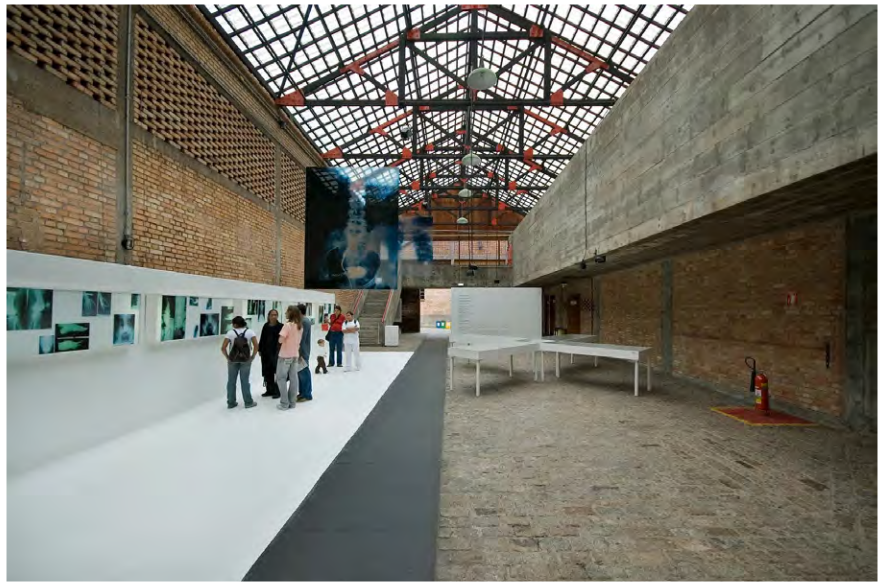
Adaptive reuse and industrial aesthetic:
The design approach embodies the adaptive use concept. An existing industrial structure was transformed into a vibrant cultural space.

-exposed concrete walls
-structural tectonics
-a postmodern remix of colonial-style components

Integration with surroundings:
Thanks to the buildings low-profile design and facade with colourful ceramic tiles, it reflects cultural richness of Brazil.

Human-Centric Design and Community Engagement:
At the core of the design philosophy,lies a human centric approach, encouraging social interaction, with adaptable spaces for exhibitions, performances and gatherings. Inspired by Lina Bo Bard's vision, the building creates a vibrant hub for cultural engagement.





2.7 - References & Precedents

2.7 - References & Precedents

Gare Maritime

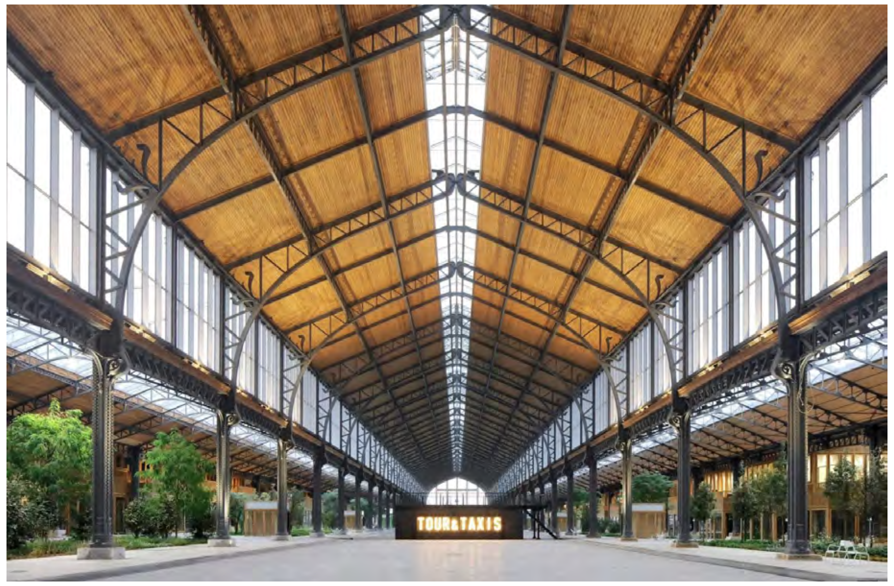
Belgium/ Brussels

Architects: Bureau Bouwtechniek, Neutelings Riedijk Architects

Built: 2020

Topics: Timber, Sustainability, Mixed-used development

Sustainability: BREEAM outstanding



'a city where it never rains'

Key approach:
Design centers on sustainability, adaptability, and integration with its surroundings. The building is preserving the industrial heritage of the site while creating a modern, functional space.

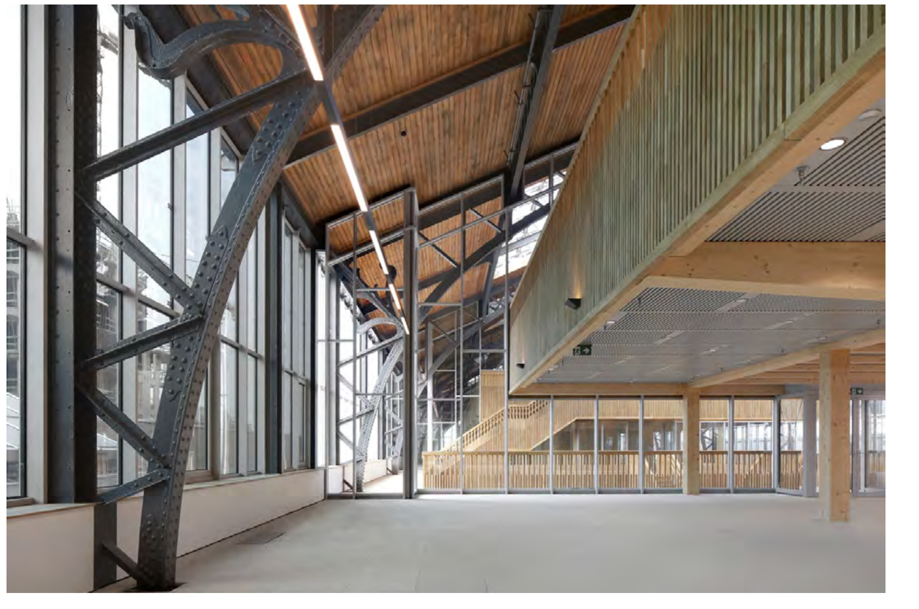
Design focus:
The 20th-century railway station, which is formed of three main and four smaller halls, has been renovated to accommodate the new programme of offices, retail stores, and public places for relaxation. Through the addition of twelve new pavilions, a new structure of boulevards and street, gardens and squares are created, which represents the metropolitian setting.

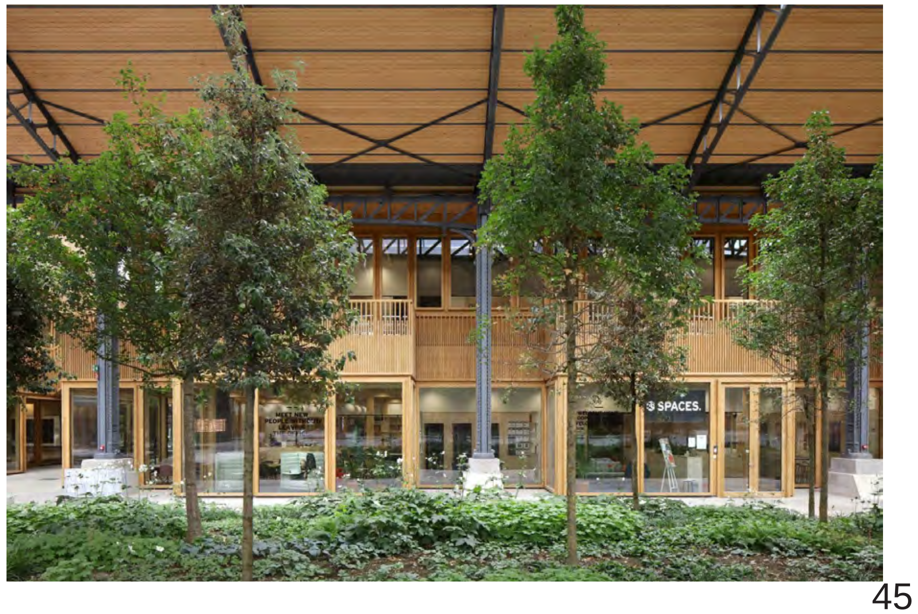
2.7 - References & Precedents

Key characteristics of the building:

State-of-the-art in sustainability:
The building is completely energy neutral and fossil free. Wide-ranging environmental initiatives, like the utilisation of geothermal energy and rainwater reuse, have been put into place. Gare Maritime makes a significant contribution to the Tour & Taxis location's and Brussels' Kanaalzone's sustainable development.

Europe's largest CLT project:
Thanks to the use of Cross Laminated Timber (CLT) in the construction of new pavilions, the amount of cement has been reduced significantly. At a later time, the panels can be readily removed from the modular CLT structures and used for other purposes.
The decision to use wood had a positive impact on the construction process as well. The dry construction technology and prefabrication allowed for a significantly shorter construction period.

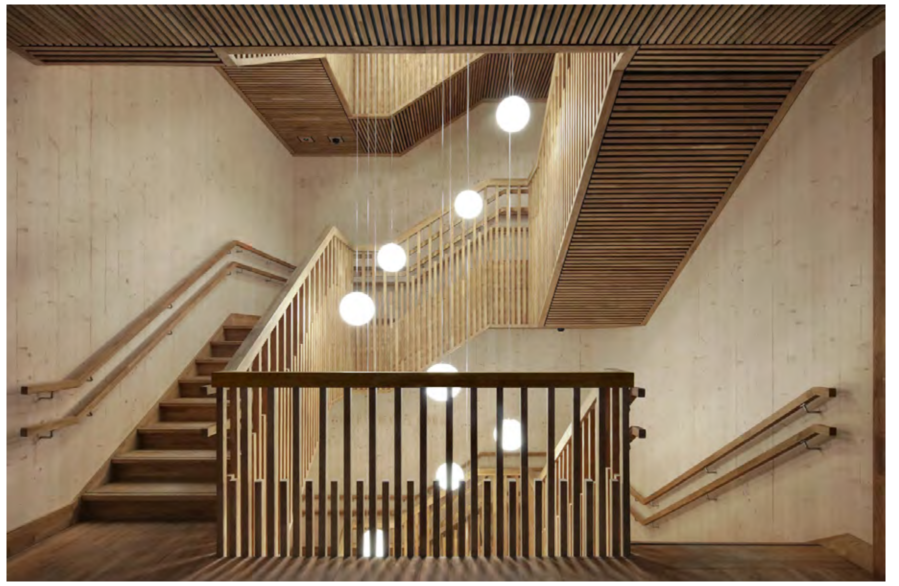




2.7 - References & Precedents

Modular Flexibility:
The building's layout facilitates easy reconfiguration to accommodate different functions,.This flexibility enhances the building's longevity, ensuring it can adapt to changing needs and uses over time.
The use of modular construction techniques enables efficient assembly and disassembly, further contributing to the building's sustainability and resilience.

Adaptive reuse:
Rather than demolishing the former railway station, the architects transformed it into a modern, multi-functional space while preserving its industrial heritage. This design philosophy reflects a commitment to sustainable development by repurposing existing structures rather than constructing new ones, thus reducing environmental impact and conserving resources.



2.7 - References & Precedents

Urban Outfitters Corporate Campus

Philadelphia, USA

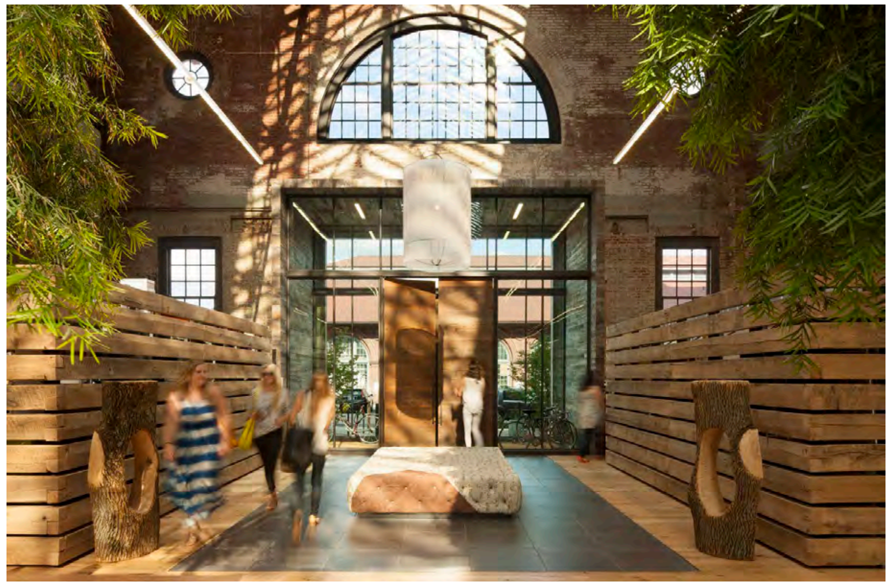
Architects: MSR Design (Meyer, Scherer & Rockcastle, Ltd.)

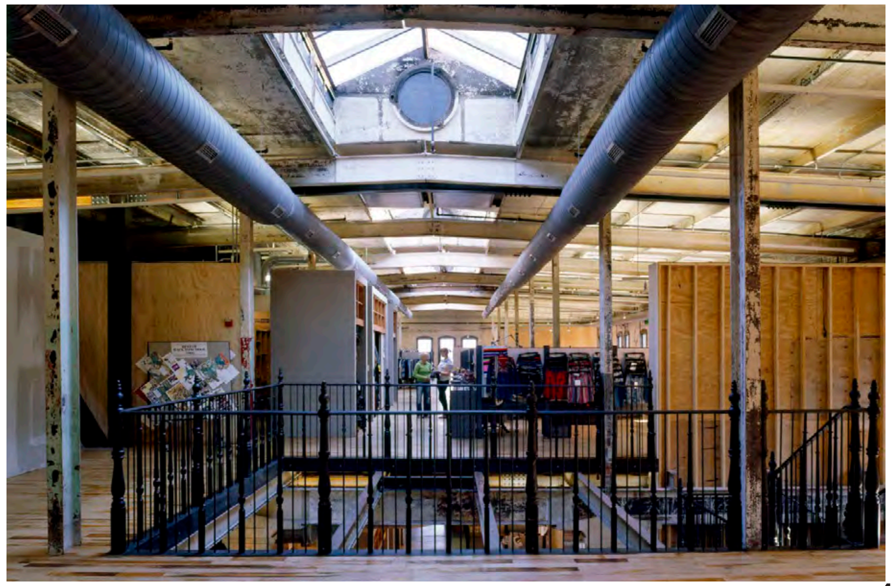
Built: 2006

Topics: Industial materials, Reuse, Functionality

Transformation of former industrious building complex into a creative workplace. Client's aim was to bring the staff that were spread across six different buildings througout downtown Philadelphia.

Design focus:
The design centres on leveraging the factory's inherent features—such as its industrial materials, spacious interiors, and natural light—to transition its primary function from production to fostering creativity. By combining art, culture, economy, and environmental considerations, the space undergoes a transformation from a publicly-oriented production site to a privately-focused hub for creativity.





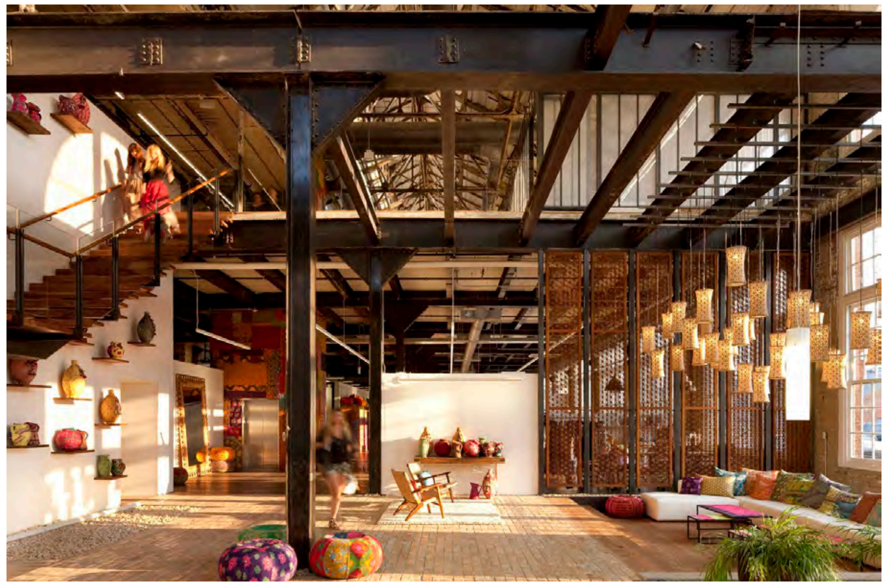
2.7 - References & Precedents

Key characteristics of the building:

Layering old and new:
The new corporate campus now houses new creative spaces while honouring the distinctive remnants of 125 years of shipbuilding and the history of the Navy Yard

Construction process:
Instead of erasing the signs of aging completely, the architects opted to preserve the rough aesthetic by sealing the weathered paint and salvaging rugged timbers for stairways. They even sandblasted the steel beams to achieve a rusted appearance before sealing them for durability.
ltimately, the objective was to honor the entire history of the buildings rather than conforming them to the standards of a specific era.

Industrial materiality and reuse:
"This is a great example of a reuse project. The new design brings out the best of the old and highlights the historic features in ways that might have been less successful with a more traditional response. The tension between old and new, tactile and smooth, light and dark, indoor and out, all of this while holding in character with the corporate image—genius."
—National AIA Honor Awards Jury



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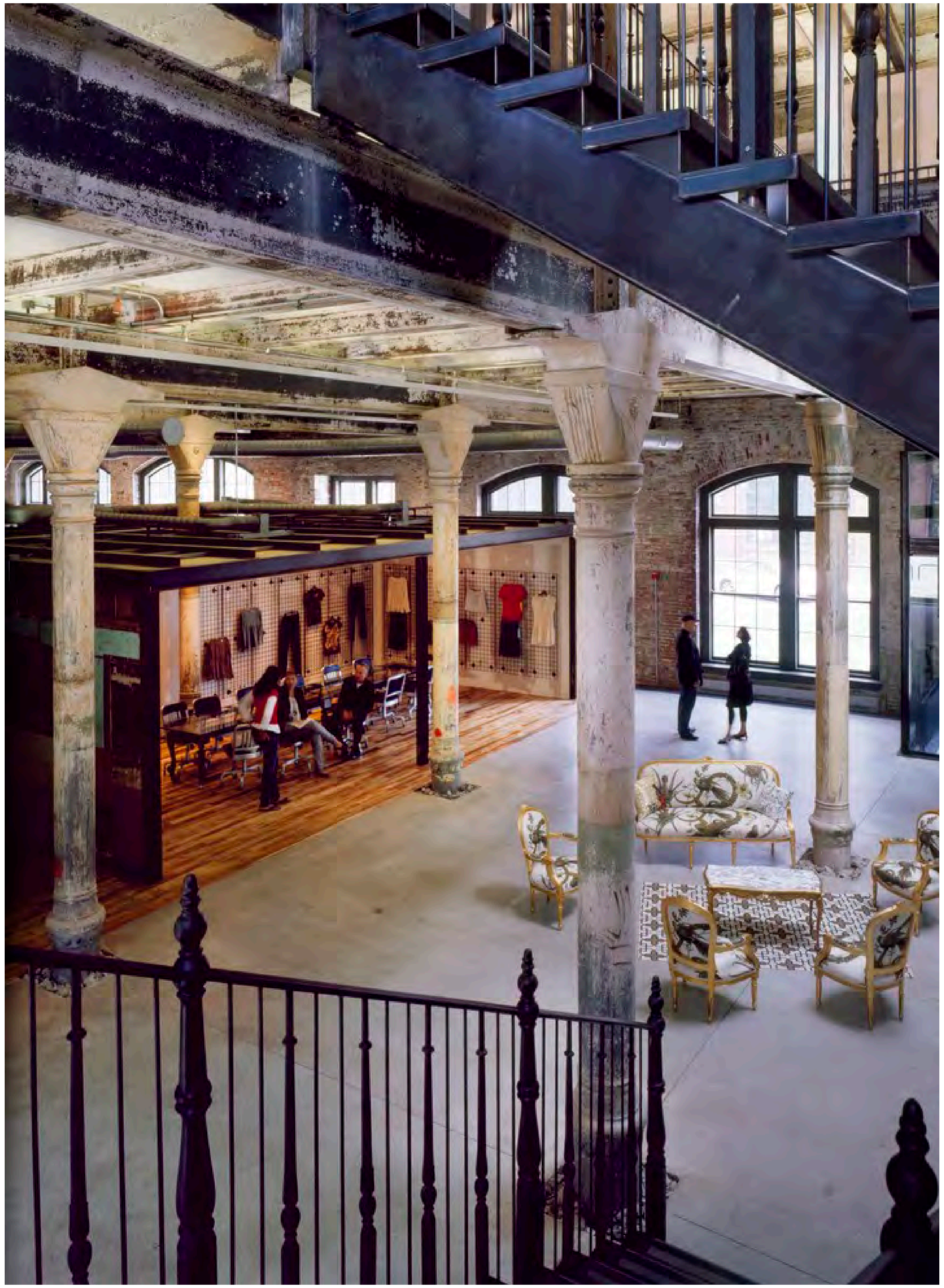


2.7 - References & Precedents

Tate Modern

London, UK

Architects: Herzog & de Meuron

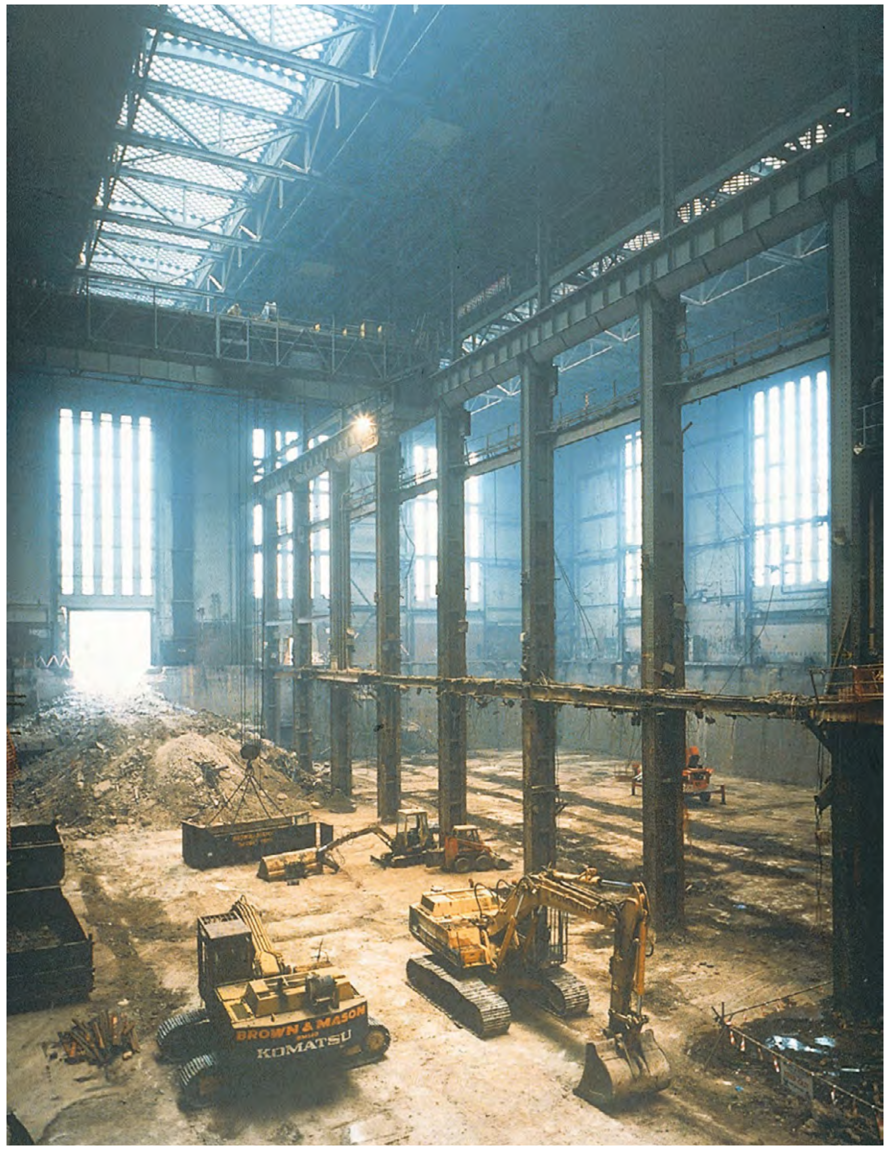
Competition: 1994-1995

Project: 1995-1997

Realization: 1998-2000

Topics: Urban, Light, Versality

Sustainability: BREEAM 'Very Good'



Key approach:

Design focuses on repurposing London's former Bankside Power Station, which remained unoccupied from 1981 until 2000, into a dynamic cultural institution. By leveraging industrial elements and steel structures to craft adaptable gallery spaces that accommodate various contemporary artworks...

2.7 - References & Precedents

Key characteristics of the building:

Utilitarian Design:

The exposed steel beams, brickwork and bare concrete surfaces are examples of the building's industrial character. This design concept, which represents an integration of historical and contemporary architectural forms, celebrates the building's industrial background while creating a visually striking juxtaposition with the contemporary artworks displayed within.

Sustainability & Lighting:

In the light of Tate's requirements to take a 'leading role in sustainability', H&dM, together with the consultants, implemented various measures that led the building to achieve a BREEAM 'Very Good' rating under the BREEAM Bespoke 2006 scheme. One of the considerations was to target lighting installations that used at least 20% less energy than those typically found in galleries.

2.7 - References & Precedents

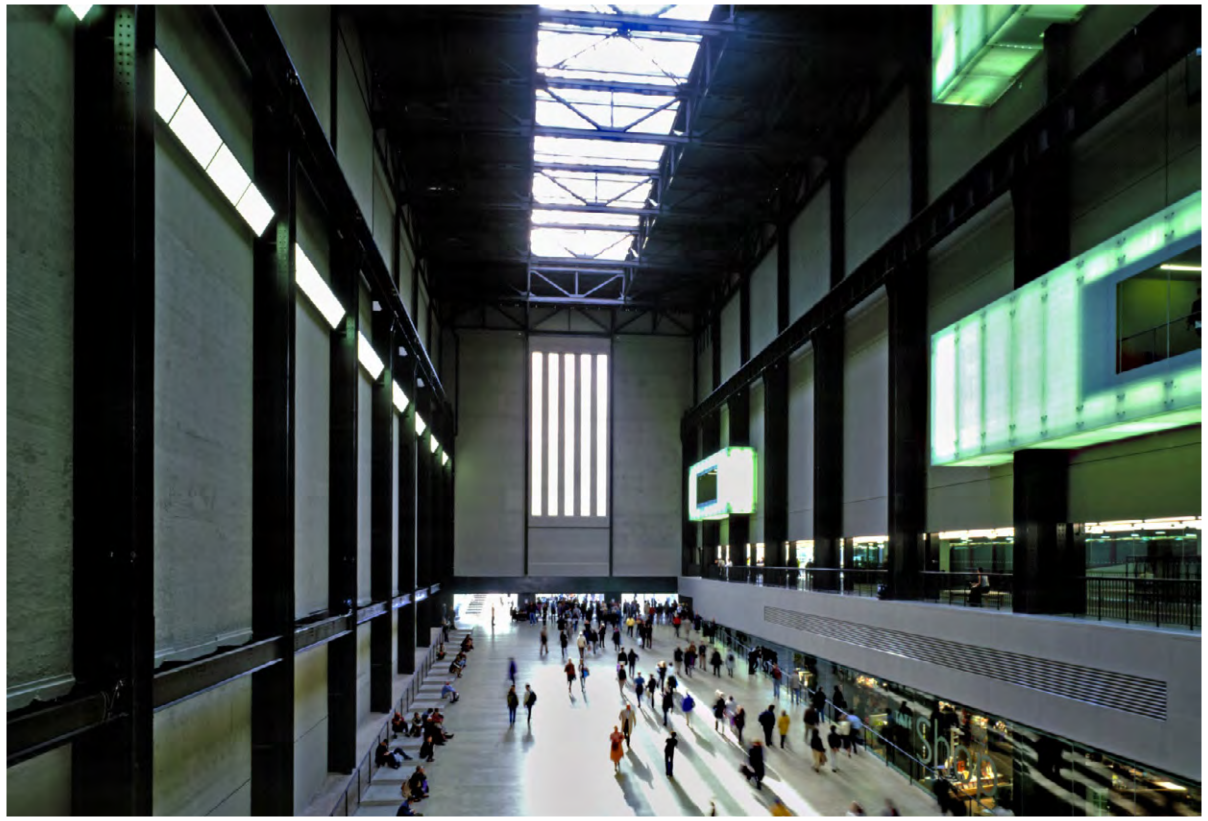
Flexibility and Versatility:

Tate Modern prioritises flexibility and versatility in its design, with spacious galleries and adaptable exhibition spaces that can accommodate a wide range of contemporary artworks and artistic installations. This design philosophy promotes experimentation and innovation in curatorial practices while providing visitors with diverse and engaging experiences.

Adaptive reuse:

This design philosophy reflects a commitment to preserving industrial heritage while repurposing existing structures for contemporary cultural use, demonstrating sustainability and respect for historical context.

2.7 - References & Precedents



2.7 - References & Precedents

Conclusion and Remarks on Reference & Precedent Study

Across these reference projects, several common themes emerge that resonate deeply with the core characteristics of the project. These themes simply revolve around adaptive reuse methods, emphasis on sustainability, integration of natural elements, and community engagement.

Emphasis on preserving the building while revitalizing the urban environment is evidently part of these considerations throughout the design, which can be seen as a prevalent aspect in the examples.

For instance, the Sesc Pompeia factory stands as a prime example of repurposing industrial structures to create vibrant, community-centric spaces.

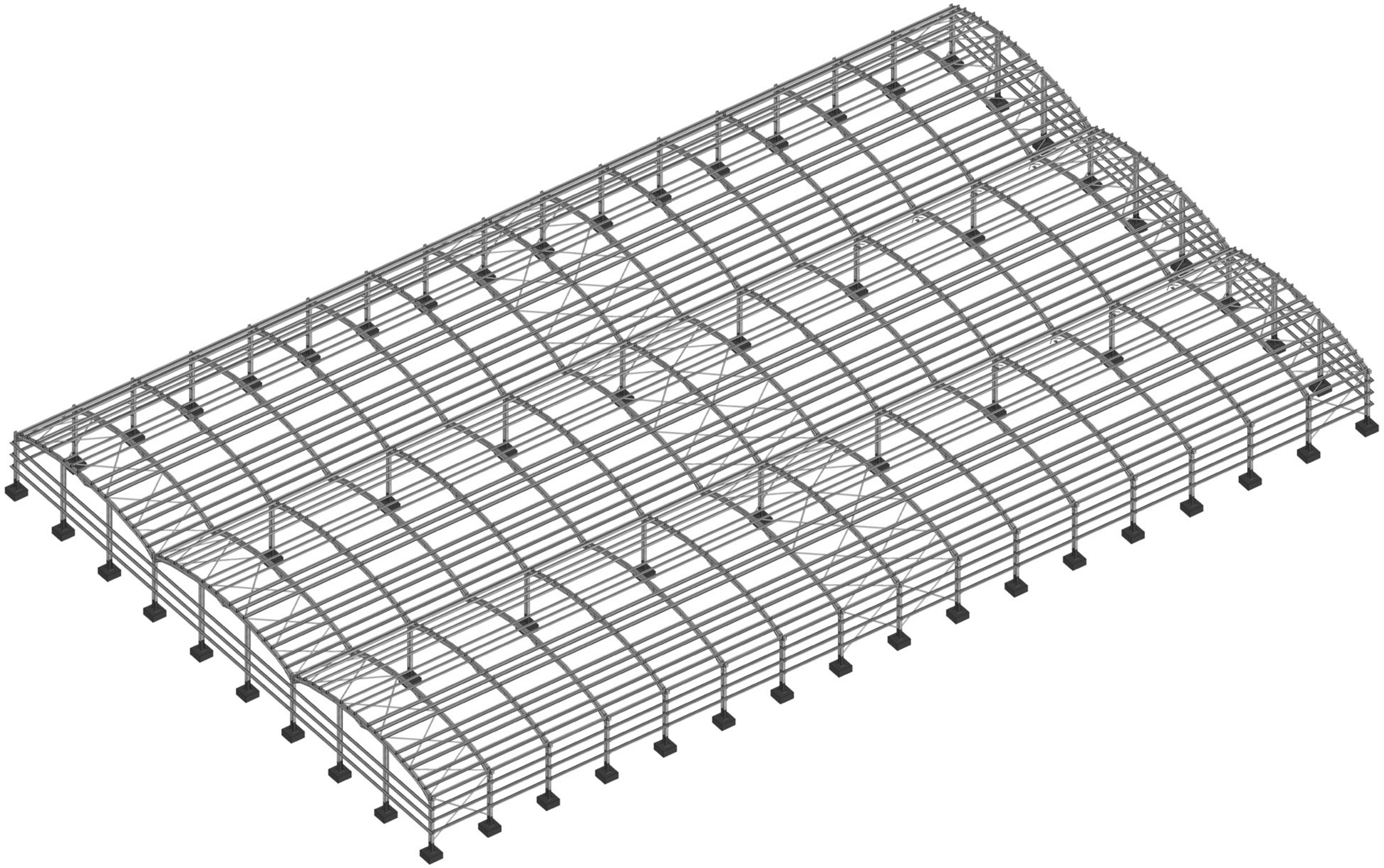
As a notion that aligns with the project's emphasis on optimizing space utilization and environmental performance, the Tate Modern demonstrates the possibility of integrating functional efficiency with artistic quality, from creative lighting solutions to adaptable, flexible spaces.

Another prioritized topic throughout the project is to carefully consider adaptable construction methods. CLT's modular and prefabricated nature allows for flexible assembly, making it adaptable to various design needs and construction scenarios, which places it among the materials that align seamlessly with the project objectives. In this regard, Gare Maritime offers valuable lessons for optimizing the layout of interior spaces with a similar motif.

Overall, the lessons learned from the reference projects can be summarized as: Steel has the potential to create versatile and adaptable spaces while ensuring structural efficiency and integrity. Aesthetic appeal and structural modernization are achievable through steel construction in creating wide-span spaces supportive of modern commercial environments. What is found common as well as beneficial in the example projects are innovative architectural design concepts, whether through their unique aesthetic expressions, functional layouts, or creative spatial arrangements.

2.8 - Limitations & Opportunities

the crucial, replacable and expendable elements

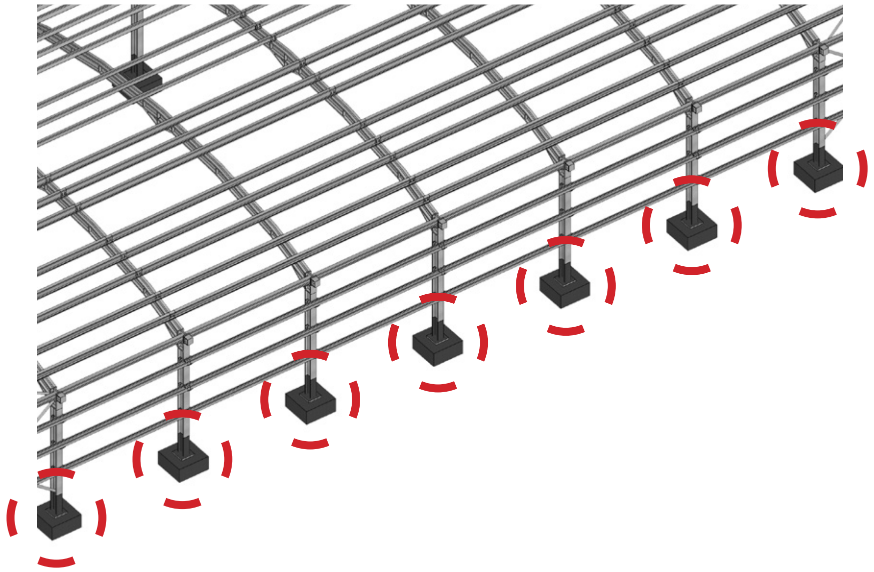


Adapting an existing portal frame warehouse for a new purpose presents several design challenges. While the rectangular form initially appears rigid, the structure's large spans and 8-9 meter clear heights pose opportunities for innovative redesign. To breathe new life into the former industrial space, the integration of atriums and lightwells towards the inner core becomes essential. These elements not only enhance aesthetics but also address the need for natural light penetration, creating a more inviting and functional environment. By strategically introducing openings within the structure, we can infuse the space with daylight, fostering a rejuvenated atmosphere while preserving the warehouse's original aesthetic and structural integrity.

2.8 - Limitations & Opportunities

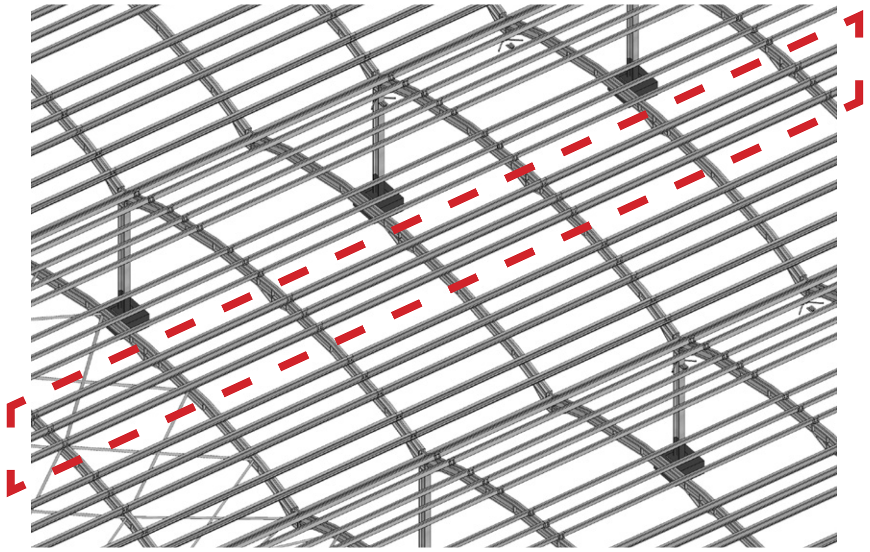
the crucial, replacable and expendable elements

Foundations



The most important element contributing towards the structural integrity of the overall building. Each foundation is ***individually critical.*** *It is therefore better to refrain from engagement and stay clear, unless the act is part of a major design gesture or a key statement. However due to the already excessively large volume of space, it is highly unlikely that any levels will exist below ground. The nature of these foundations also eliminates any potential of underground parking under the structure.*

Purlins & Side Rails

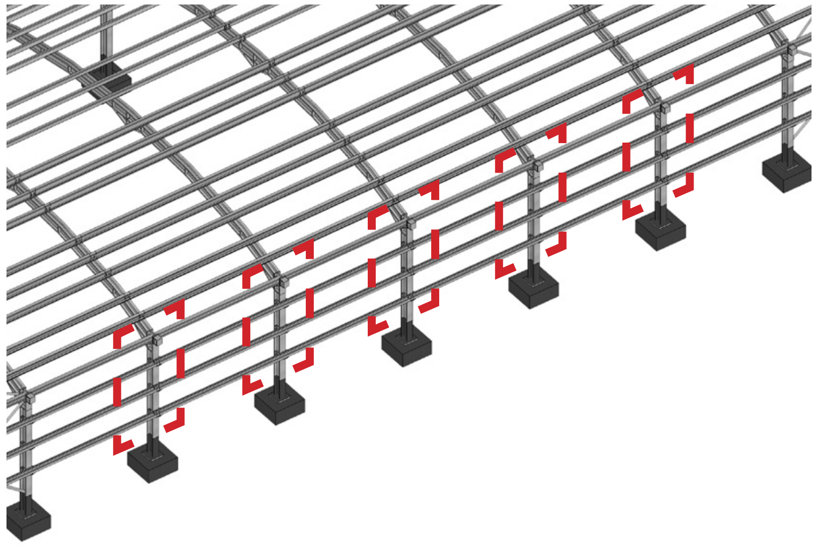


Important for the attachment of the outer skin of the building, as well as to provide stability. However each individual purlin is not as critical as a foundation and can be operated on. The statement about the need for atriums and openings for light could be achieved as long as a square/rectangular frame can transfer the load and cover for the lack of horizontal purlins in a designated area.

2.8 - Limitations & Opportunities

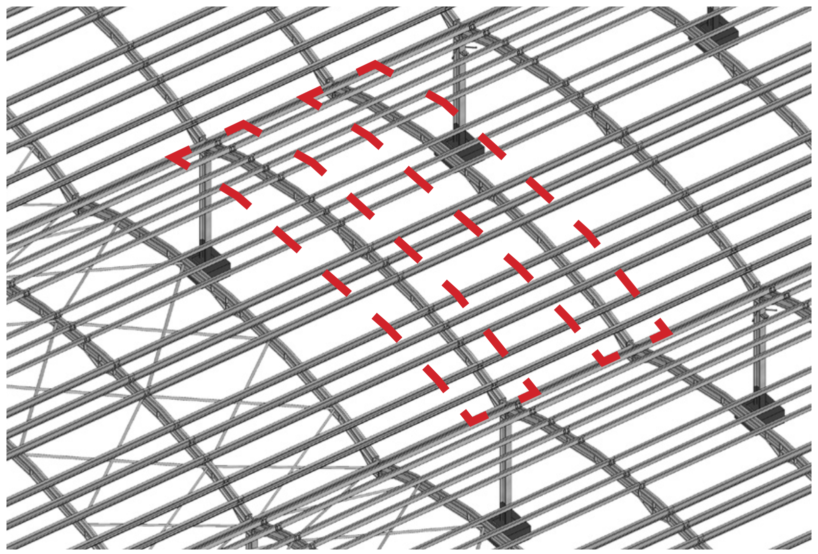
the crucial, replacable and expendable elements

Columns



Similarly one of the most important elements like the foundation. In essence equally critical as the foundations. Part of the primary steelwork and by extension critical for structures stability and load transfer.

Rafters



Steel rafters in a portal frame structure are essential components that primarily serve to support the roof. They span across the width of the building, transferring loads from the roof to the columns, thus enabling large, column-free spaces which are ideal for warehouses, factories, and retail spa-ces. These rafters also enhance the structural stability and durability of the building, resisting various environmental stresses such as wind and snow loads, ensuring long-term integrity of the structure.

2.8 - Limitations & Opportunities

Openings, Atriums and Generous Ceiling Heights

While it is generally advisable to avoid major interventions on the primary steelwork of a portal frame structure to maintain structural integrity, there can be creative solutions to diversify the industrial aesthetic and meet specific architectural needs. Introducing a steel frame that integrates seamlessly between the cut sections of purlins and rafters can be a viable intervention. This method allows for the incorporation of outdoor openings or atriums, providing a necessary "pause" in the repetitive industrial atmosphere without compromising the overall stability and functionality of the structure. Such targeted modifications can effectively enhance both the utility and aesthetic appeal of the building.

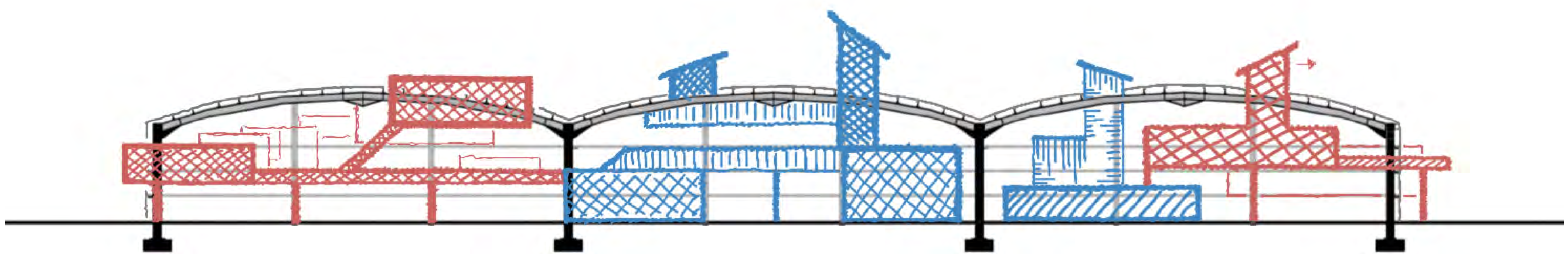


Image - one of earlier conceptual sketches about "populating" the interior of the warehouse

Another key opportunity to recognise in this context are the ceiling heights of the spaces. The height of each column is approximately 8.5 meters, which can possibly accomodate three seperate levels, however as this is a n adaptive re-use approach it is not sensible to have a generic "developer mindset" of creating and making use of every bit of potential floor space for program. The very fact that the construction of the skeleton being done beforehand enables this intervention to spread comfortably in a "relaxed" manner, celebrating and highlighting the fact that the visitor is inside a retrofitted warehouse amongst the uncensored repetition of portal frames.

3. STRUCTURE

3.1 Openings & Atriums

3.2 Excess Material

3.3 EAF Process - Recycling Steel

3.4 Conclusion & Remarks

3.1 - Openings & Atriums

Enabling different modes of circulation, access and recrational space

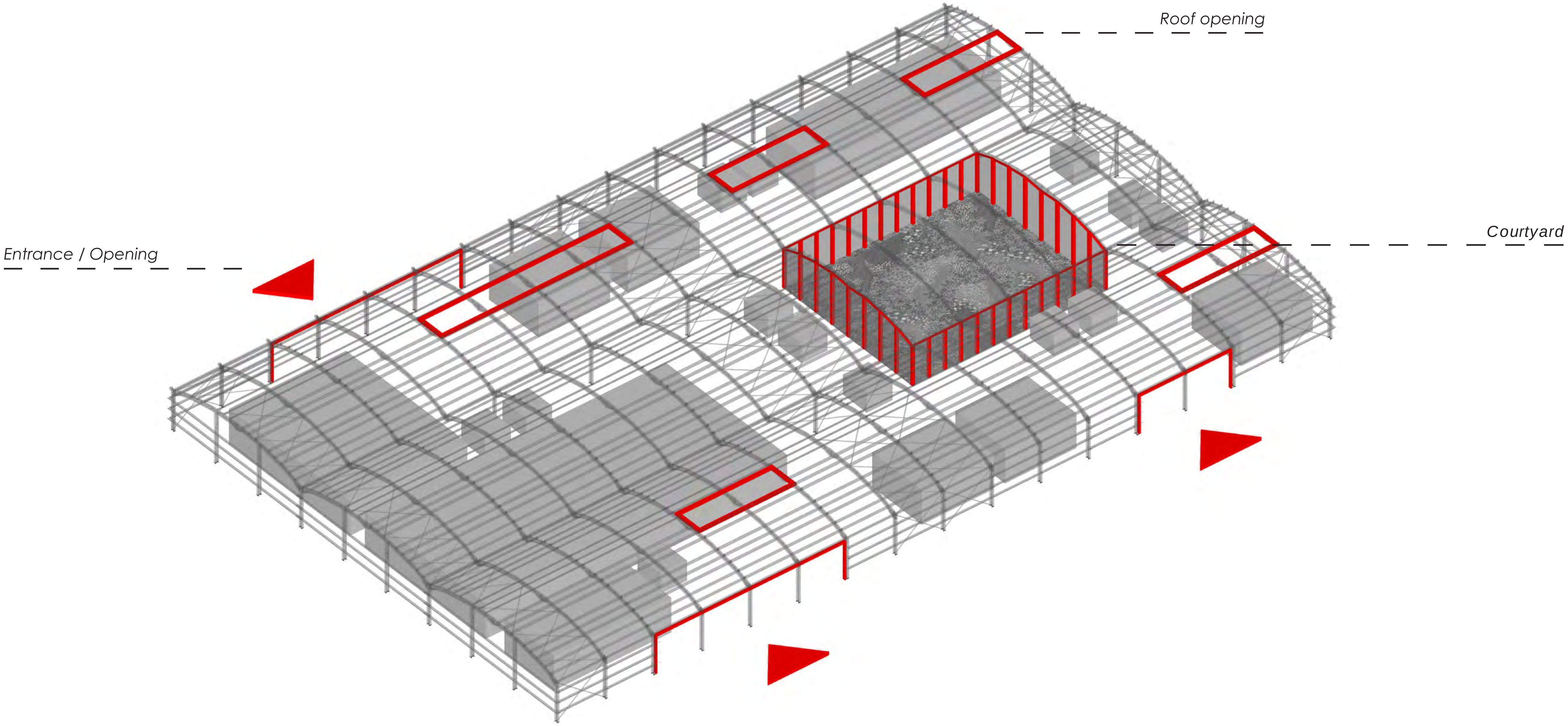


Image - iagram showing the base concept of the retrofit goals; red highlights tentative new openings for entry, lightwells, and a courtyard.

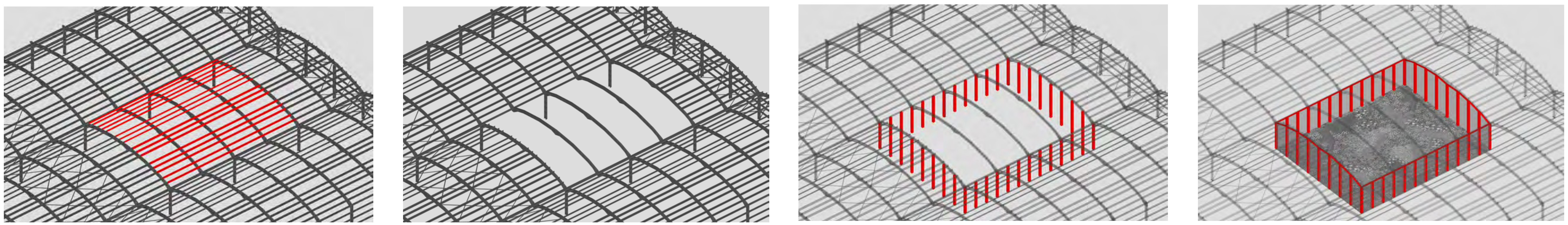
3.1 - Openings & Atriums

Enabling different modes of circulation, access and recrational space

Looking into creating an inner courtyard space within the building, the process making such an incision creating such a space involves two steps;

1. Cutting and unbolting the cladding (sandwiched panels) which are attached to the secondary steelwork - the roof purlins

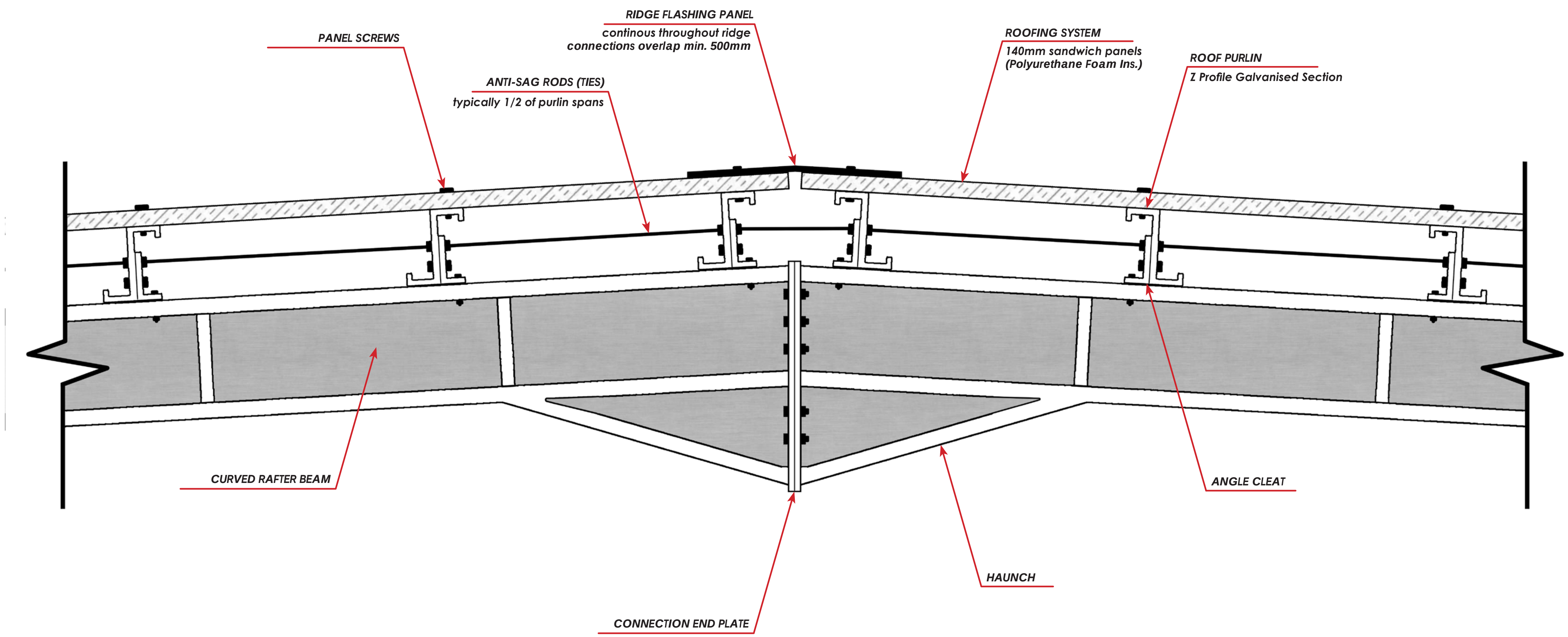
2. Removing the purlins themselves from the specific area (44x36m), which are bolted on to the cleats welded on to the curved rafters.



Images - Diagrams on the sequences of removing purlins and creating an inner courtyard of 36x44m

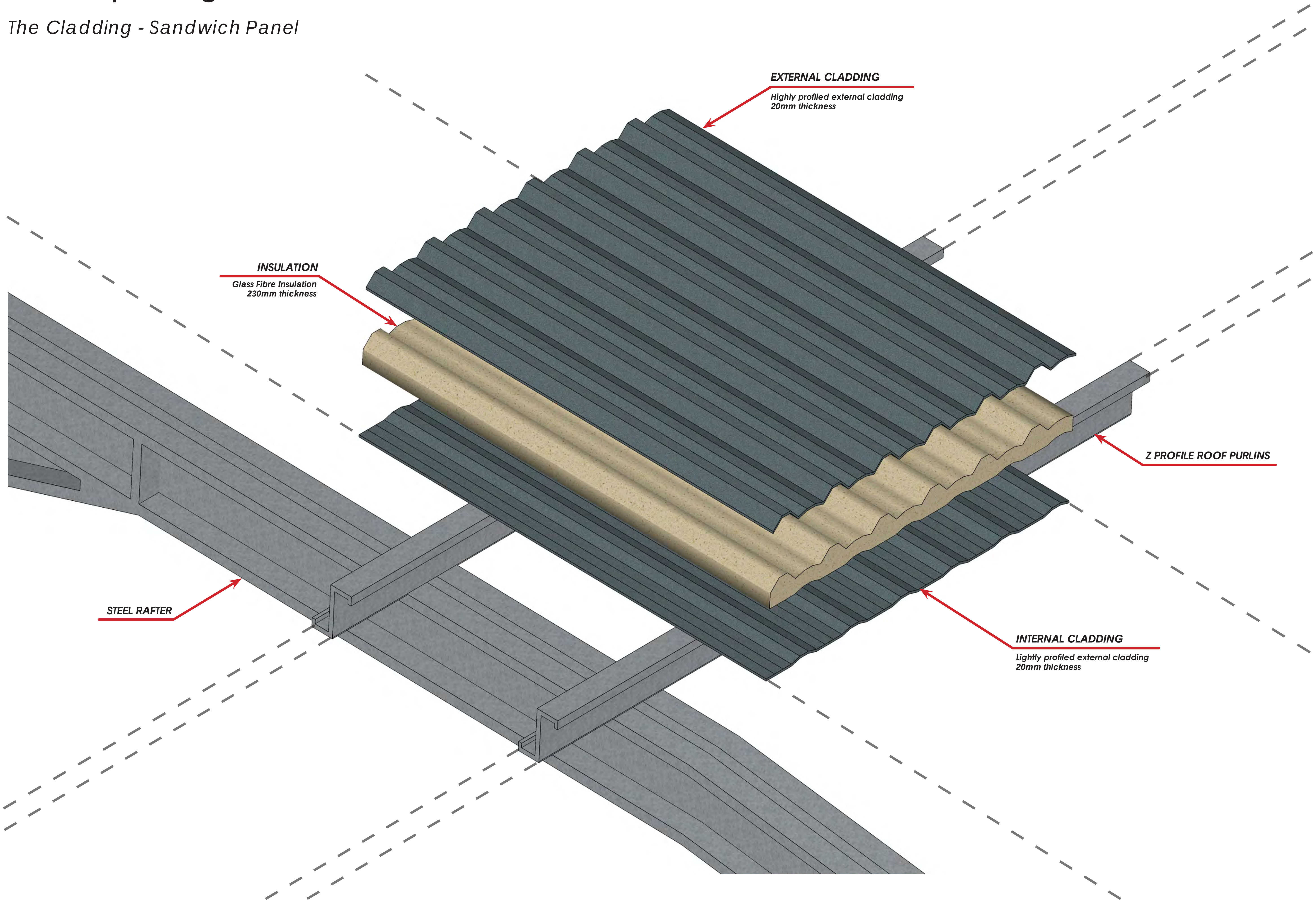
3.1 - Openings & Atriums

Opening up a courtyard - Roof Ridge Detail Drawing

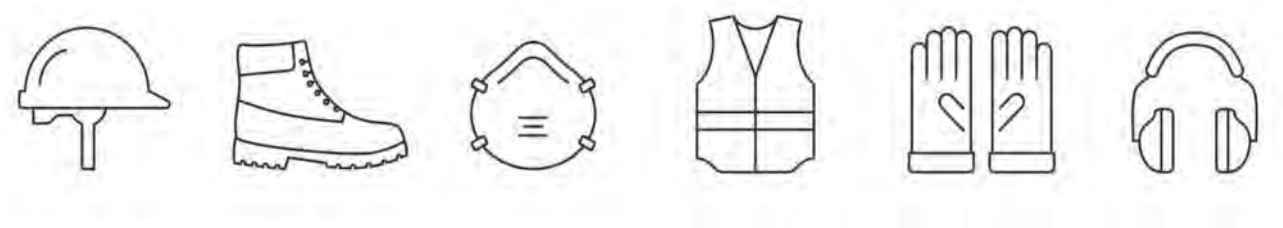


3.1 - Openings & Atriums

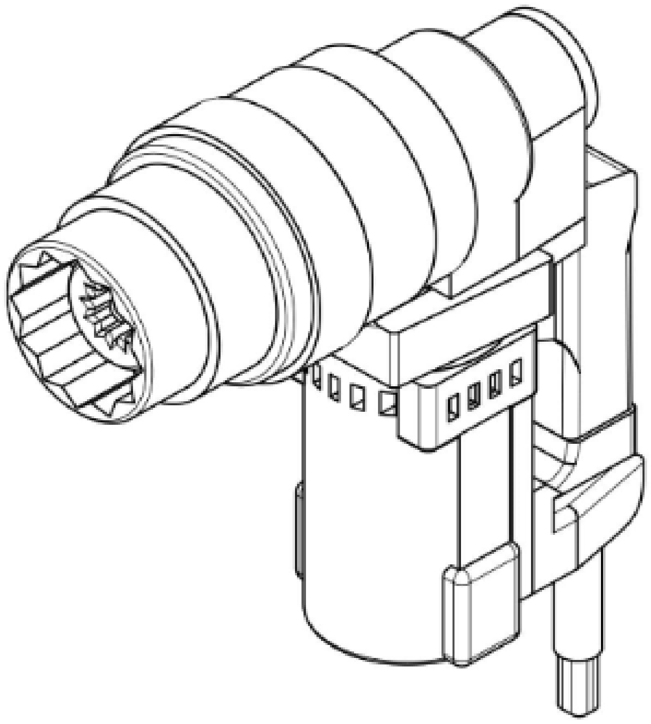
The Cladding - Sandwich Panel



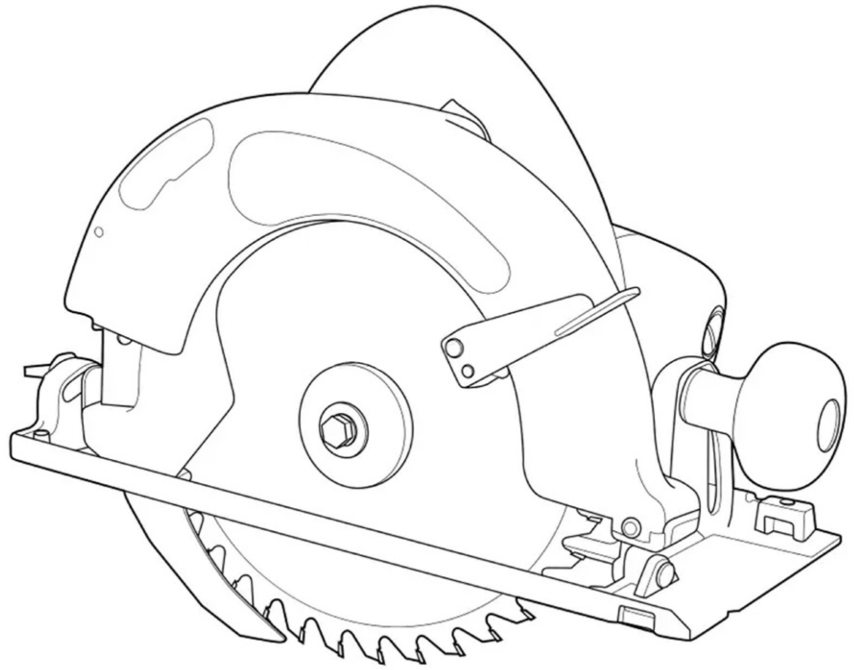
Tools Required



Personal Protective Equipment



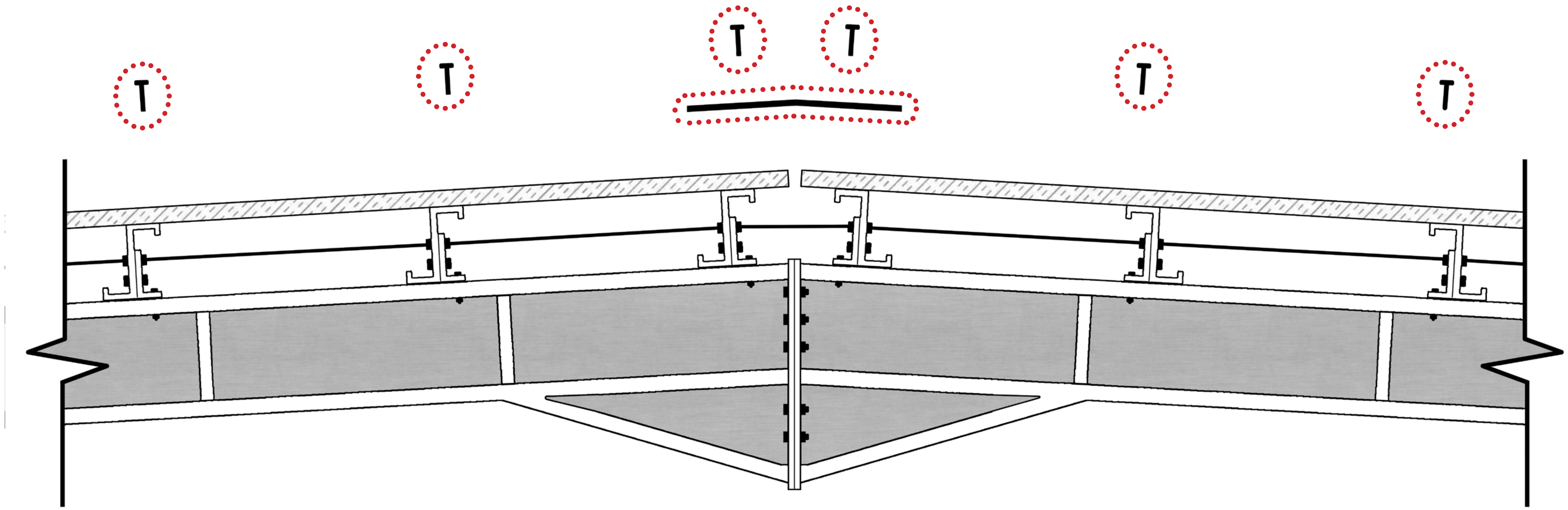
Electric Shead Wrench
For removal of bolts
that holds the roof system and purlins in place



Circular Saw
For cutting the flashing panel
that spans horizontally across the roof

3.1 - Openings & Atriums

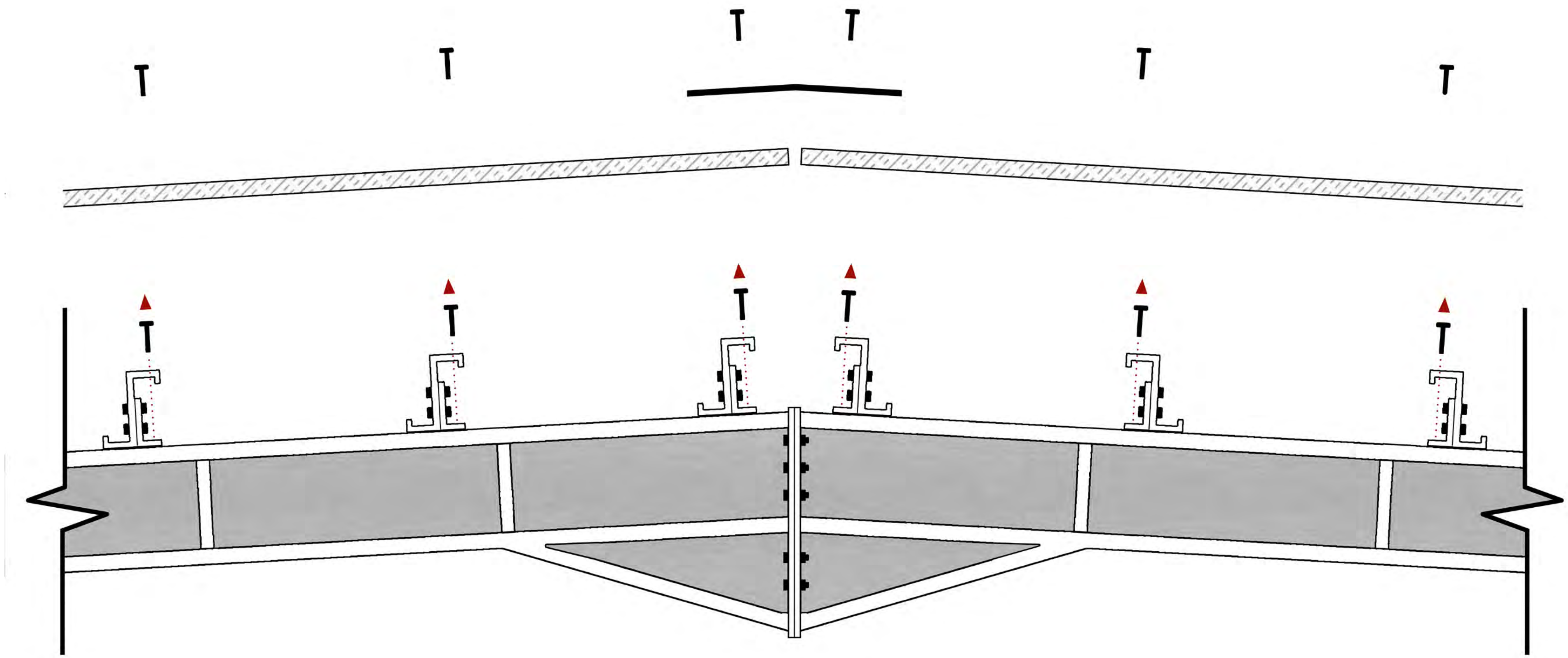
Removal Process - Step 1



After cutting the flashing panel at the required lenght which is 44m, the flashing panel and sandwich panels (effectively the entire roofing system) are unbolted from the Z profile roof purlins.

3.1 - Openings & Atriums

Removal Process - Step 2

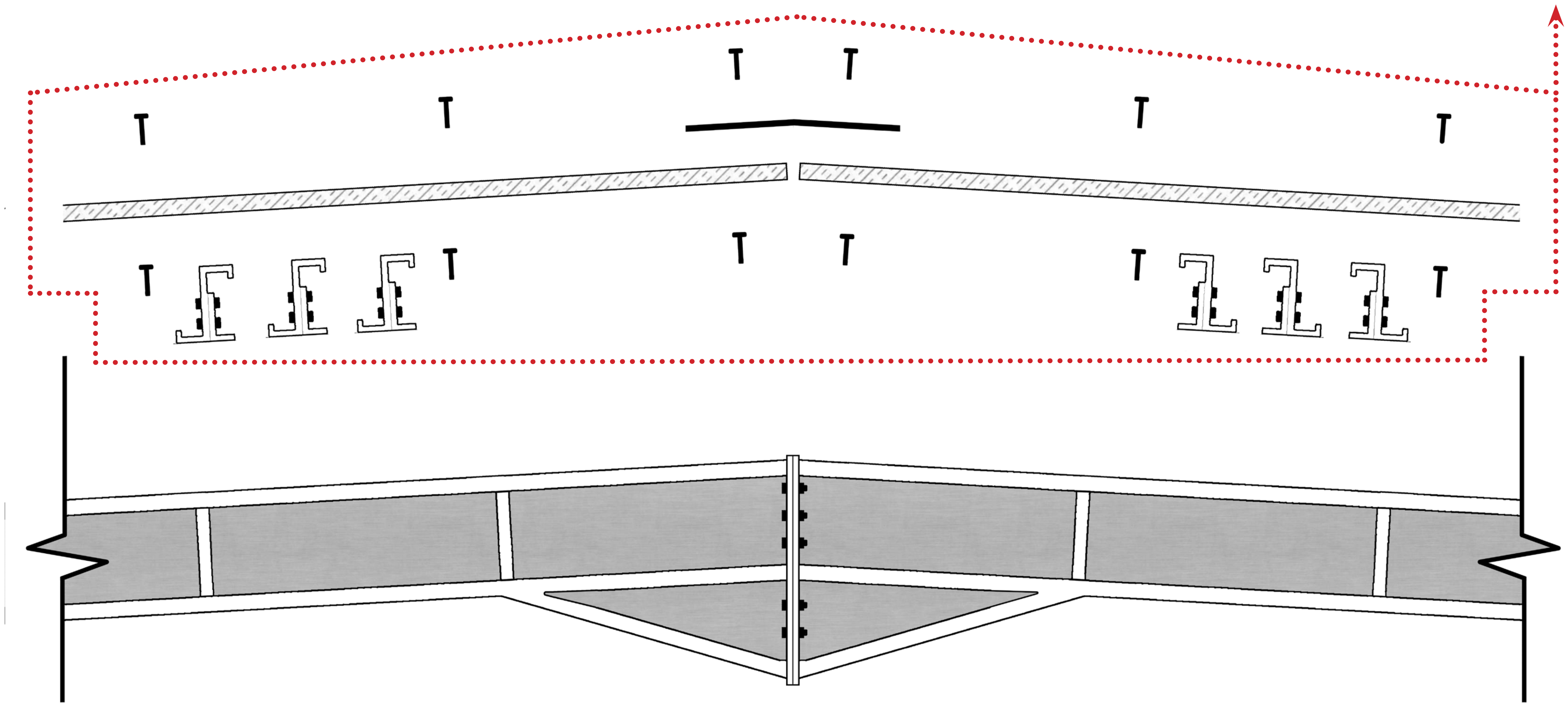


The purlins which are bolted on to cleats attached to the rafters -on both their ends- are removed. The cleats are removed along with the purlins, as they won't serve a purpose anymore.

3.1 - Openings & Atriums

Removal Process - Step 3

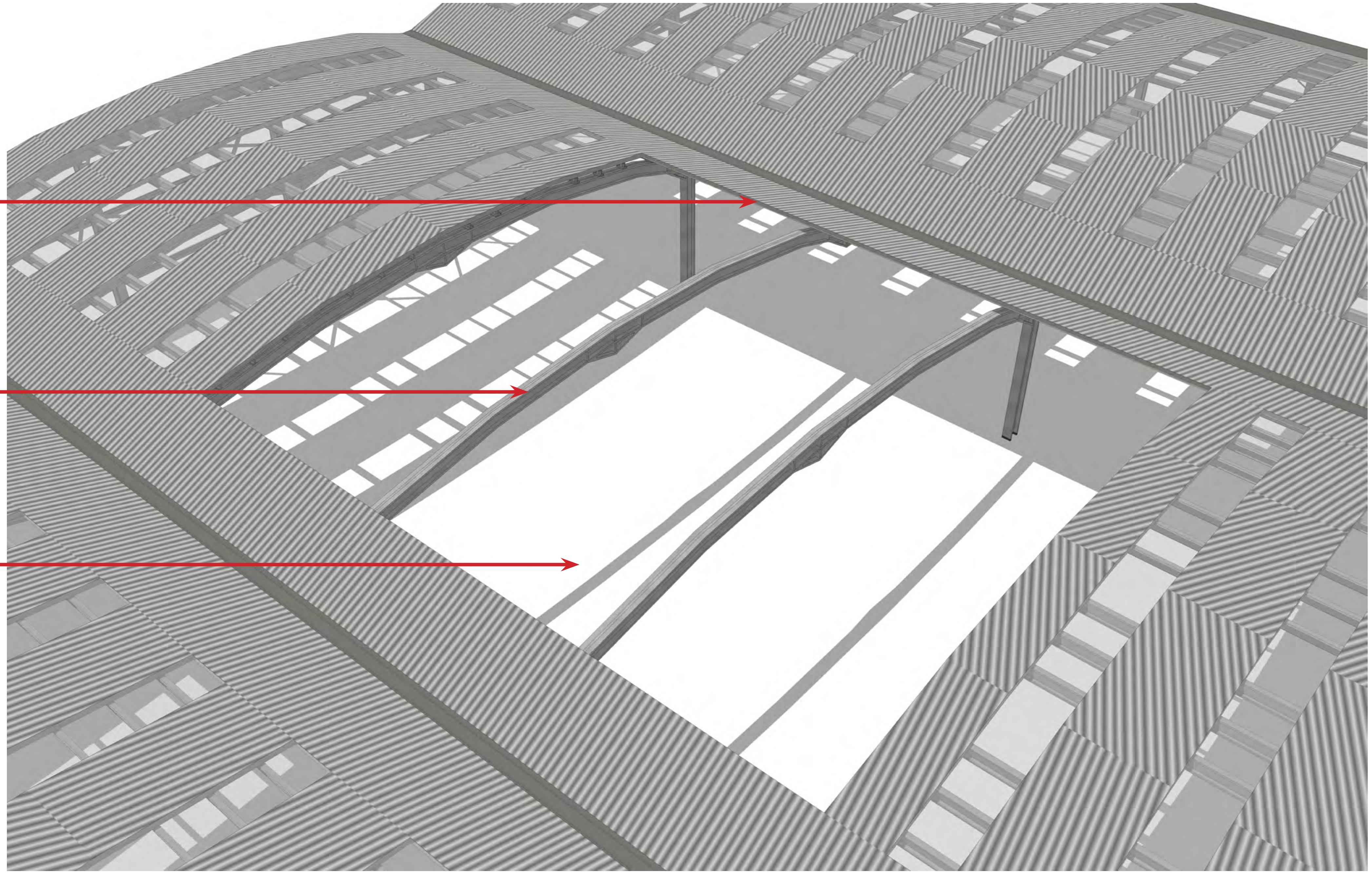
REMOVED IN TOTAL:
Curved sandwich panels (600x1800cm) - ***8 panels***
Part of Flashing Panel - ***44m of flashing panel***
Screws & Washers - 12x3 = ***36 total screws***
Roof Purlins (each 2250cm long) - 16x2 = ***32 purlins***
Cleats based on the number of Purlins = ***64 cleats***



Removal of all parts, <u>keeping detailed inventory</u> for later uses of the removed material within the site.

3.1 - Openings & Atriums

Constructing the Courtyard



Cut & Exposed sandwich panels

Curved Rafters

Space to be used as the recreational garden

The following interventions will have two goals:

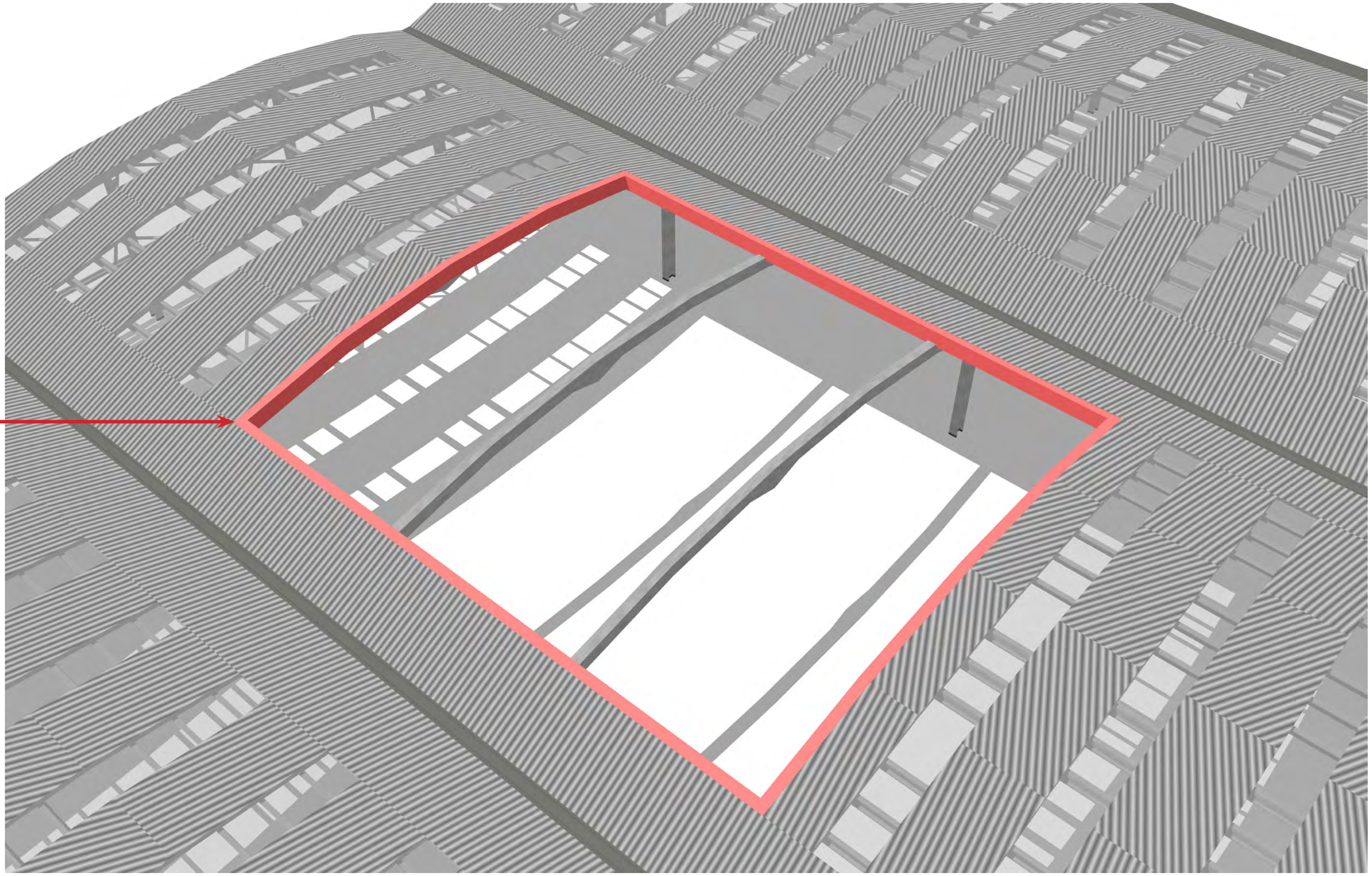
1. Weatherproofing the exposed sandwich panels & secondary steelwork

2. Constructing the inner faces of the courtyard without adding substantial load to the existing primary steelwork

3.1 - Openings & Atriums

Constructing the Courtyard

Compression Frame

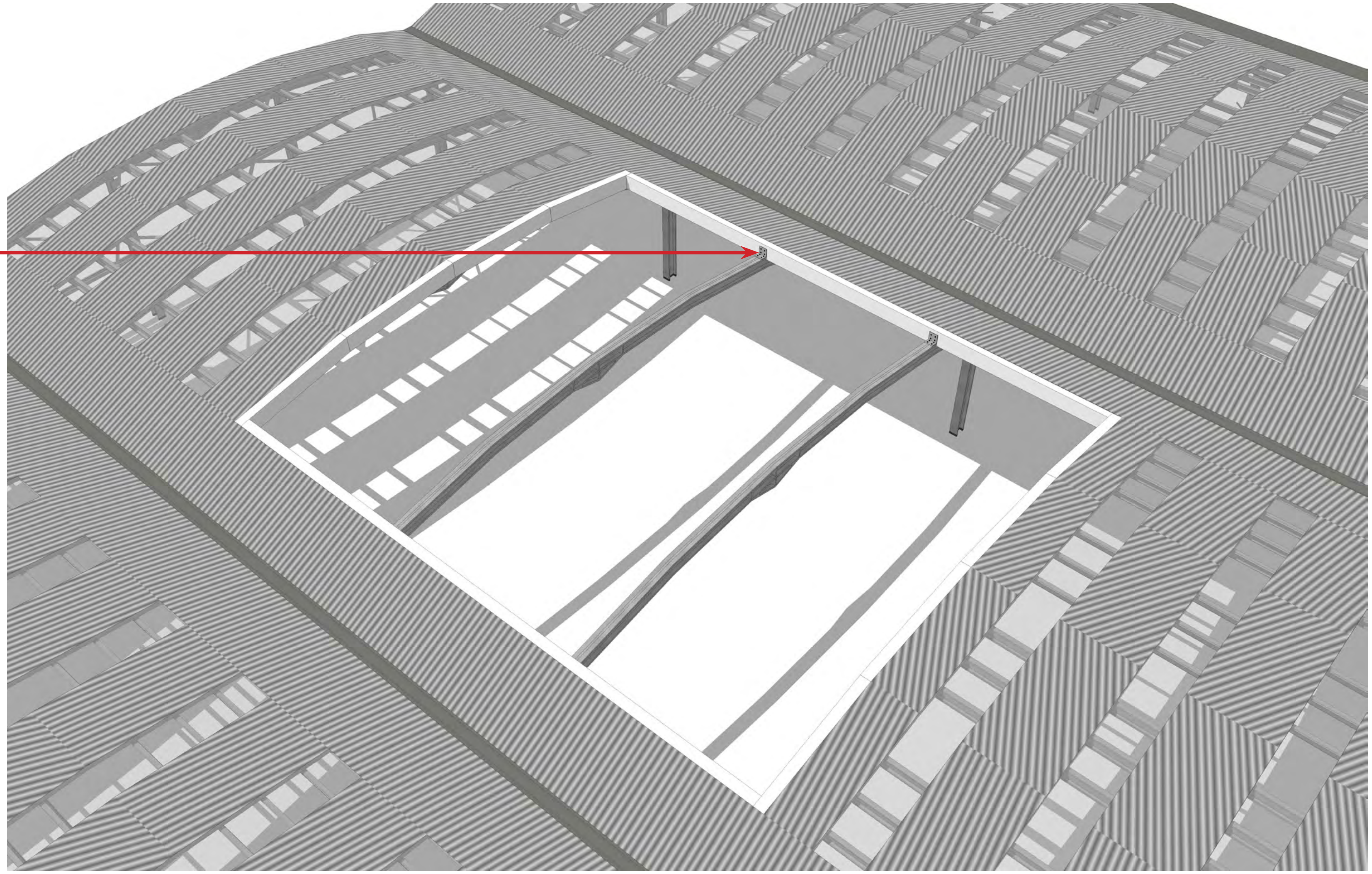


- A 50mm thick frame is fitted inside the cut-through section of the roof, fitting between the exposed sections of the roof.

3.1 - Openings & Atriums

Constructing the Courtyard

Cleats connecting the frame and rafters

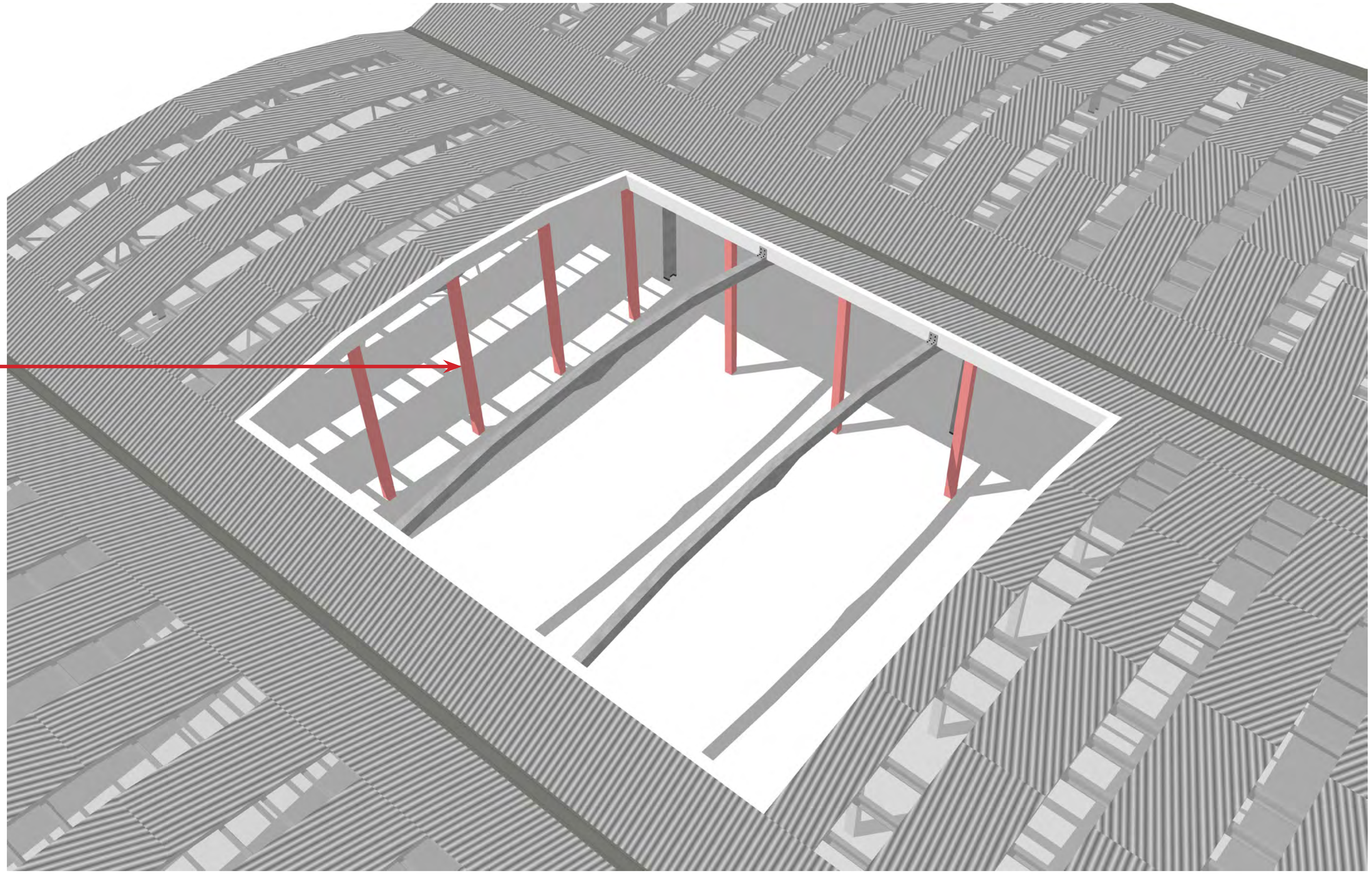


- The Frame rests on the rafters and bolted on to them for stability, however the frame will be held up primarily through its own columns, to avoid adding load on to the primary steelwork.

3.1 - Openings & Atriums

Constructing the Courtyard

Colums holding the frame up

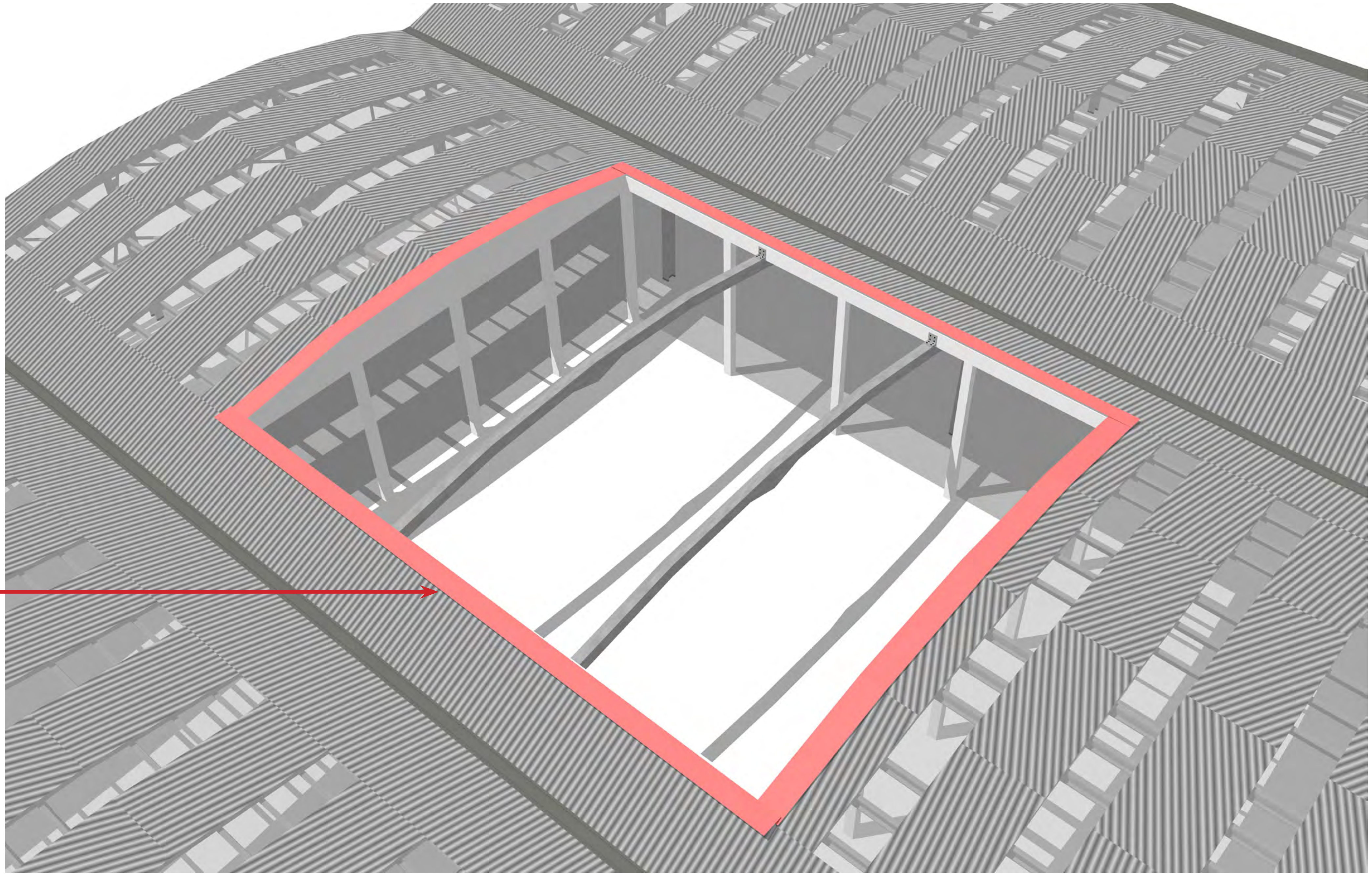


- The loadbearing columns are incorporated in order to hold up the weight of the frame around the removed section.

3.1 - Openings & Atriums

Constructing the Courtyard

Flashings covering over the frame and sandwich panels (minimum 500mm)



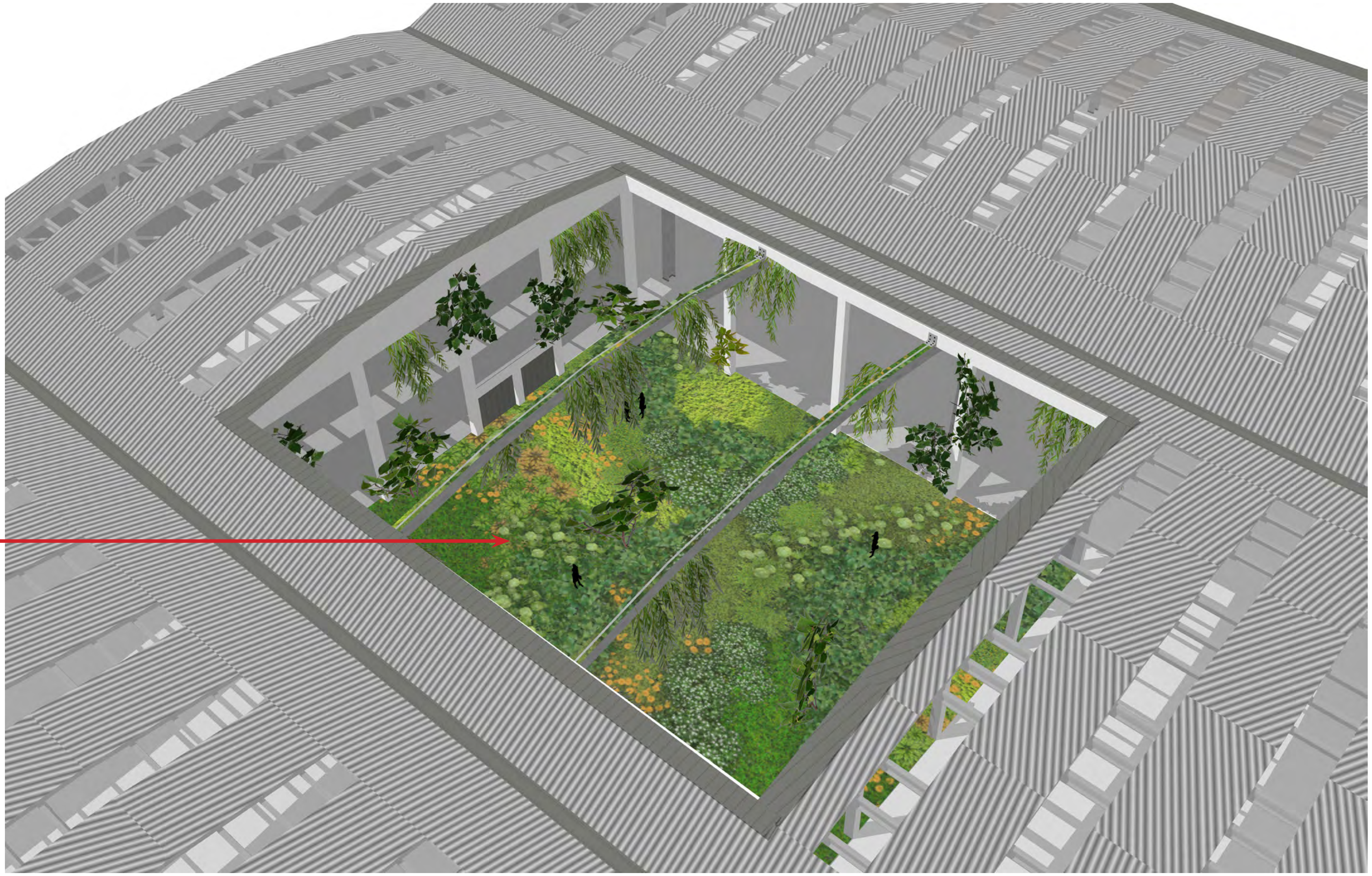
- Flashings are introduced on top and fixed through bolts onto the frame and panels to cover and help weatherproof the newly sliced section.

- Glass panels are fitted between the columns, as the courtyard is also designed to provide more daylighting to central parts of the structure and to form an aesthetic of permeability within the former warehouse atmosphere

3.1 - Openings & Atriums

Constructing the Courtyard

Landscaping & Planting



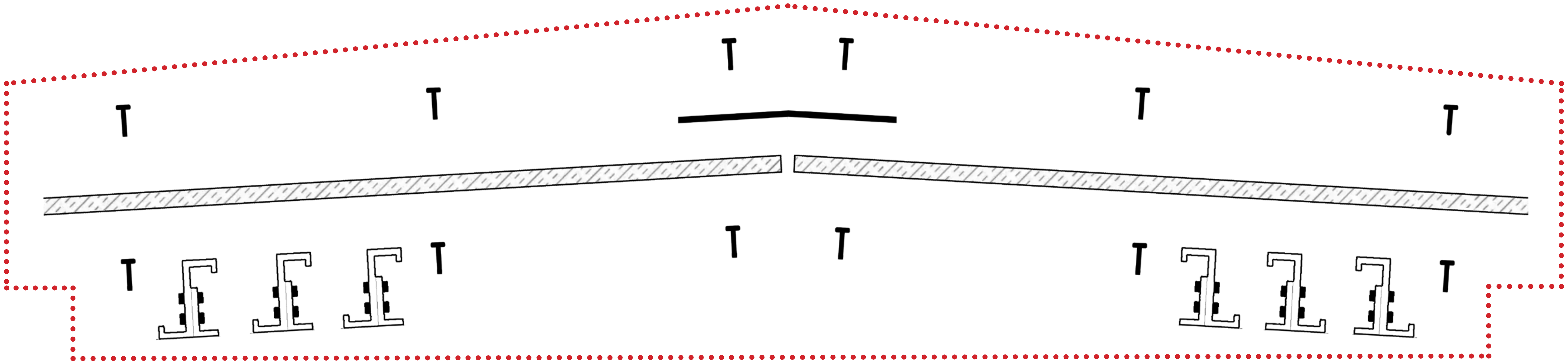
- The Rafters are intentionally left within the space, making formal reference to the other existing rafters within the structure while being uniquely in dialogue with its new surroundings and program, which in many aspects reflects the core values and spirit of this project.

3.1 - Openings & Atriums

Image / Render of the Courtyard - From earlier concept images of the interiors

3.2 - Removed & Excess Material

Potential futures for the cladding & steelwork removed



(X3)

REMOVED IN TOTAL:
Curved sandwich panels (600x1800cm) - ***8 panels***
Part of Flashing Panel - ***44m of flashing panel***
Screws & Washers - 12x3 = ***36 total screws***
Roof Purlins (each 2250cm long) - 16x2 = ***32 purlins***
Cleats based on the number of Purlins = ***64 cleats***

3 POTENTIAL FUTURES

1. RECYCLED WITHIN SITE
(best option)

2. SCRAPPED AND SENT TO EAF PROCESS
(acceptable)

3. DISPOSAL WITHOUT REGARD
(waste)

3.3 - EAF (Electric Arc Furnace) Process - Reusing Steel

The acceptable option - EAF

A furnace that heats material using an electric arc is known as an electric arc furnace (EAF).

The Electric Arc Furnace (EAF) process stands as a pivotal method for recycling unused steel materials.

This process involves a series of steps:

- first sorting to categorise steel according to its type and condition,

- then melting the steel scrap in the EAF to transform it into molten form,

- through chemical analysis verify composition,

- purification to get rid of contaminants, moulding into solid forms,

- and lastly, fabrification into structural components.

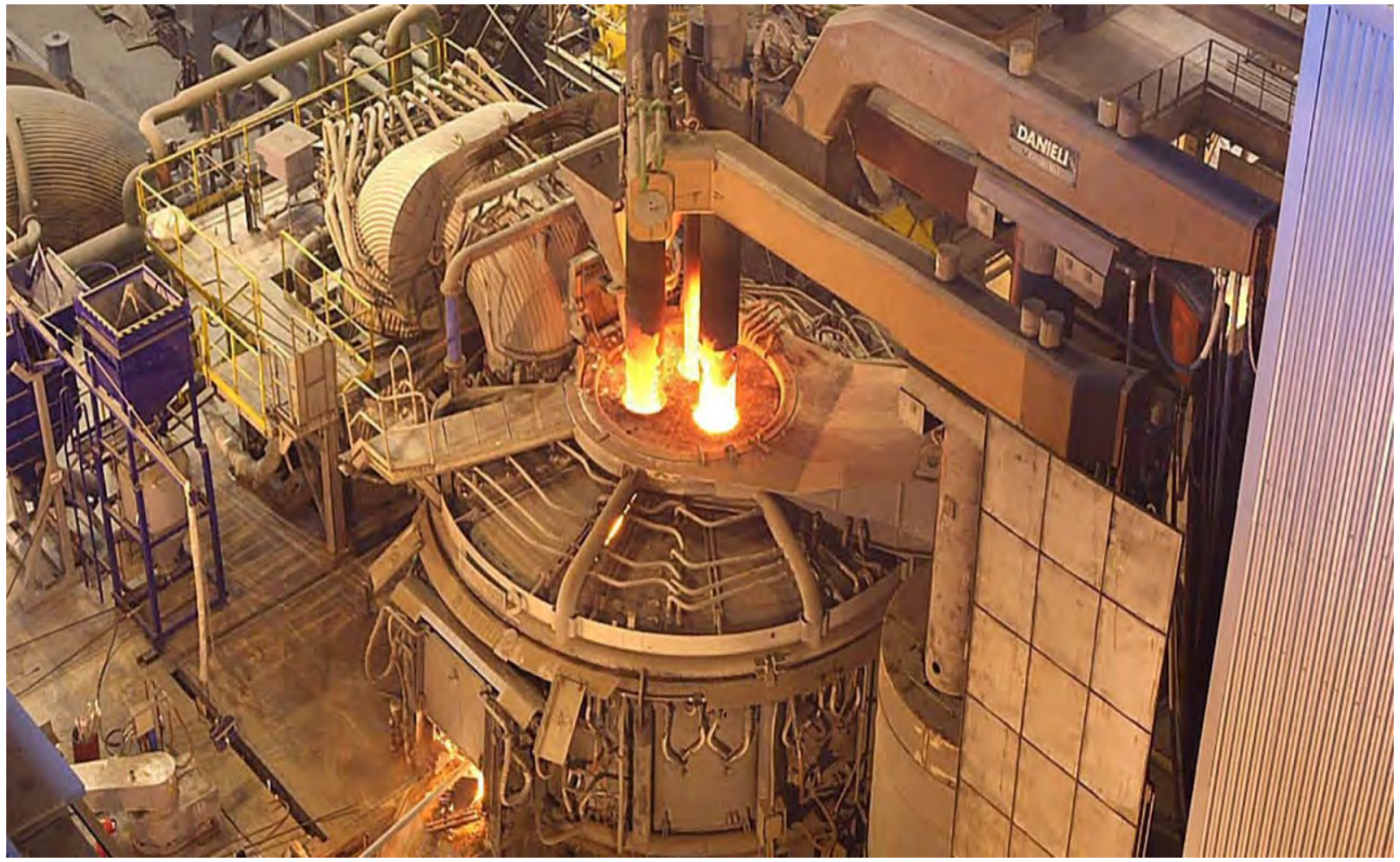
By utilizing the EAF method, scrap steel is transformed into high-quality building materials. This process fosters sustainability by minimizing environmental impact and preserving resources. It also aligns with the principles of the circular economy by promoting the reuse and recycling of resources. Consequently, contributing to a more efficient and environmentally conscious approach to material reuse and resource management.

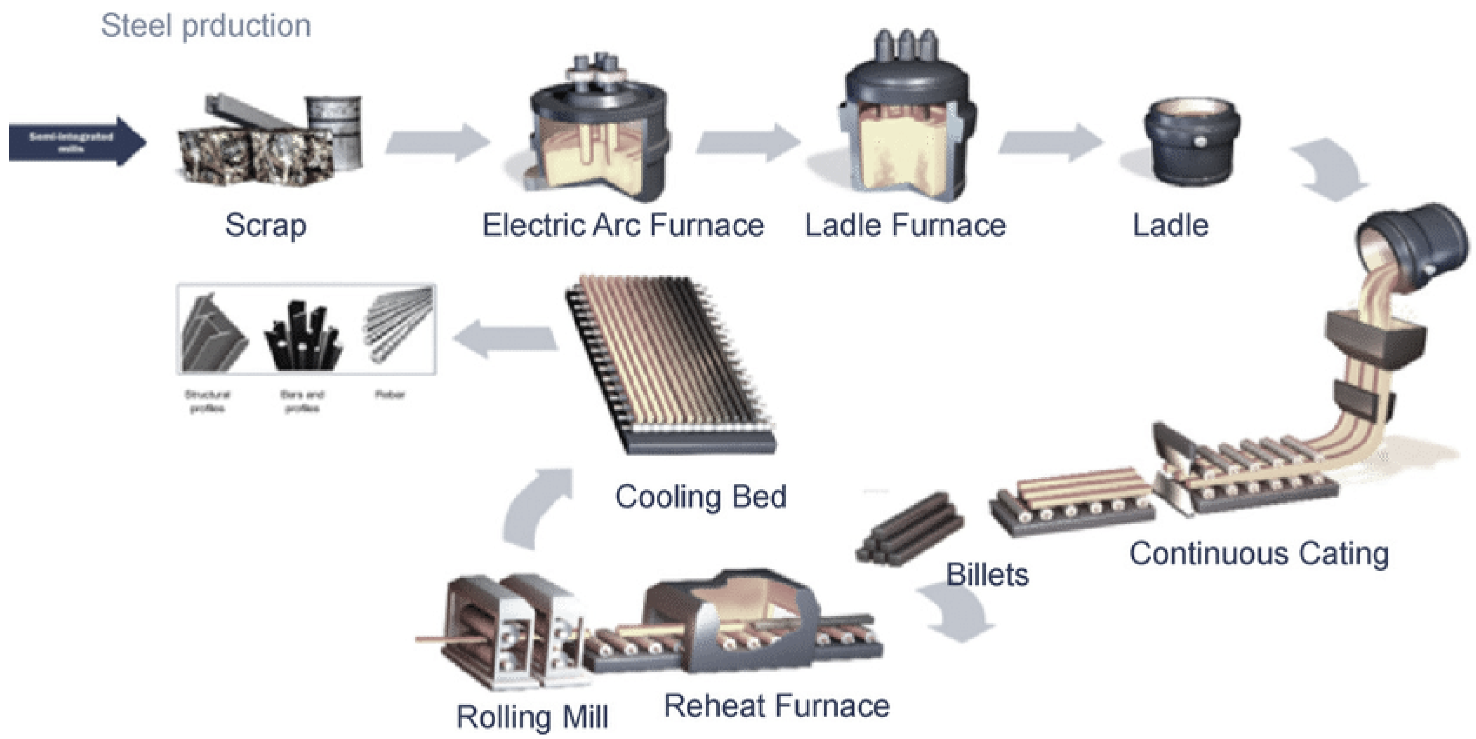
3.3 - EAF (Electric Arc Furnace) Process - Reusing Steel

The acceptable option - EAF

Advantages and Disadvantages of the process:

The EAF process offers several advantages including cost efficiency through the recycling of steel scrap, reduced environmental impact by minimizing the need for new raw materials, and flexibility in design due to the availability of recycled steel. However it also comes with some drawbacks, including the possibility of reduced structural integrity as compared to the manufacturing of new steel, the need for more energy to melt scrap steel, and the demand for strict quality controls to ensure that the recycled steel meets industry standards.





3.4 - Conclusion & Remarks

The best option - Reuse within site

Although relevant progress in the field of design within the production timeframe of ETS thesis haven't been made, The ETS project recognises that the best way of dealing with the material (The excess steelworks and other intermediary material) in hand would be to convert them into being perhaps smaller, site specific interventions to contribute further into the idea of a circular economy that is continously demonstrated at all levels of the new development.

A few of these could include:

1 - Pavillions situated around the recreational spaces of the former warehouse complex constructed through Z profile and excess sandwich panels.

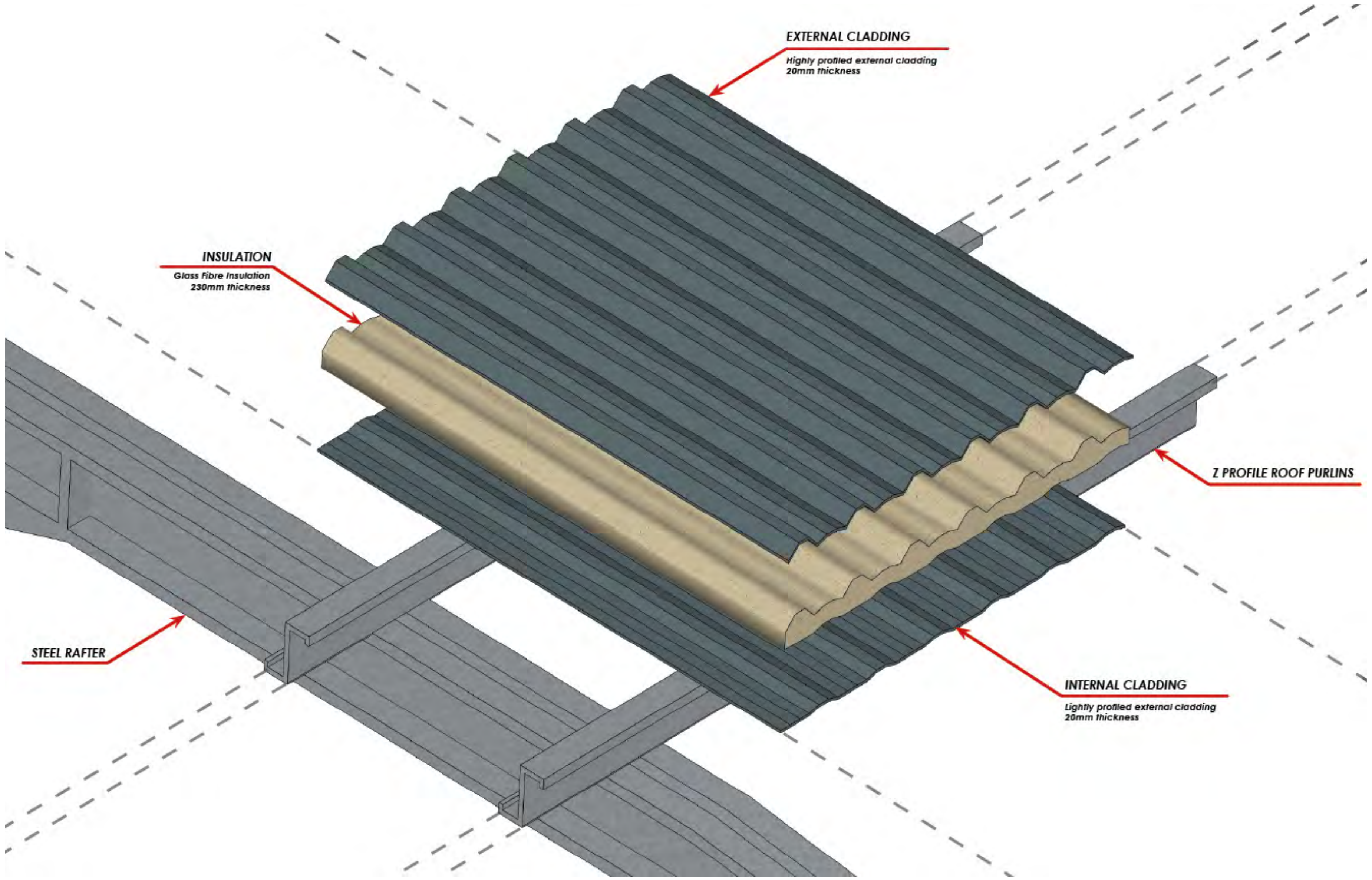
2 - Purposefully designed outdoor furniture that uses pieces of excess material

3 - Materials used as part of landscaping & decoration

4. CLIMATIC ZONES & THERMAL STRATEGY

4.1 - Existing Climatic Conditions

The existing insulation & heating conditions



As explored in the previous chapter, the building is cladded with ***<u>140mm thick sandwich panels with polyurethane foam as insulation inbetween the weather sheet and the liner sheet.</u>***

4.1 - Existing Climatic Conditions

The existing insulation & heating conditions

During winter and cold months, such warehouses typically operate at temperatures around above 5°C in order to ensure no damages come to goods from freezing. Although the insulation is somewhat adequate, the massive interior space and surface area of the warehouse, along with thermal bridging from being attached secondary steelwork (brackets) makes this space extremely costly to heat to a sustainable level, therefore such large volumes are usually just best for storage use, as they are built to be.

Most of the time this largely depends on the heating systems being used and how effective they are, however even though the sandwich panels are not too bad in terms of their u-values, the sheer amount of space simply prevents keeping this space at -for example- around 20°C for 180 days a year extremely costly.

4.1 - Existing Climatic Conditions

Calculating the energy and costs

The following calculations will be based on the unlikely event that an operator will attempt to keep the entire building at an average of around 16-20°C during the cold months of the year (assuming 180 days).

What we need to estimate the cost of heating a space:

1. Temperature Difference

2. U-Value of the Walls

3. Wall Area

4. Heating Season Lenght

5. Energy Cost

6. Heating Efficiency

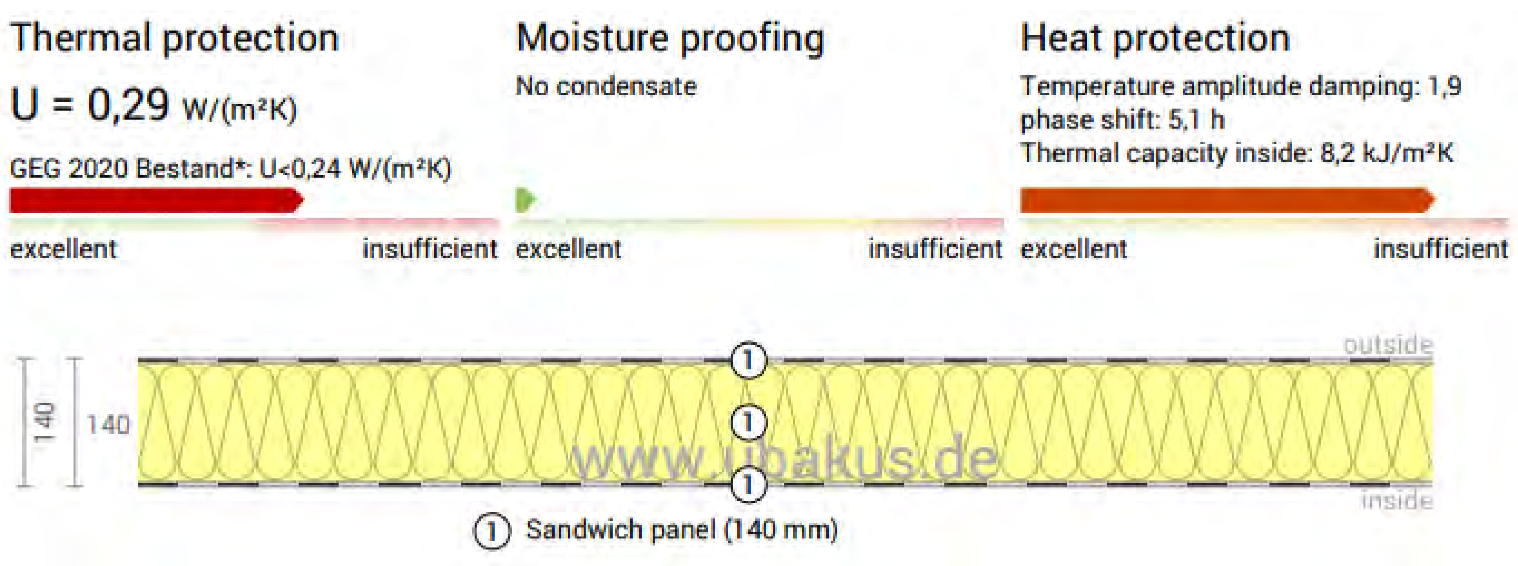
There will be calculations and analysis of two scenarios:

1. Existing Mineral Wool Filled Sandwich Panels

2. Alternative Polyurethane Foam Filled Sandwich Panels

4.1 - Existing Climatic Conditions

U-Value of Sandwich Panels with Mineral Wool Insulation (Existing)



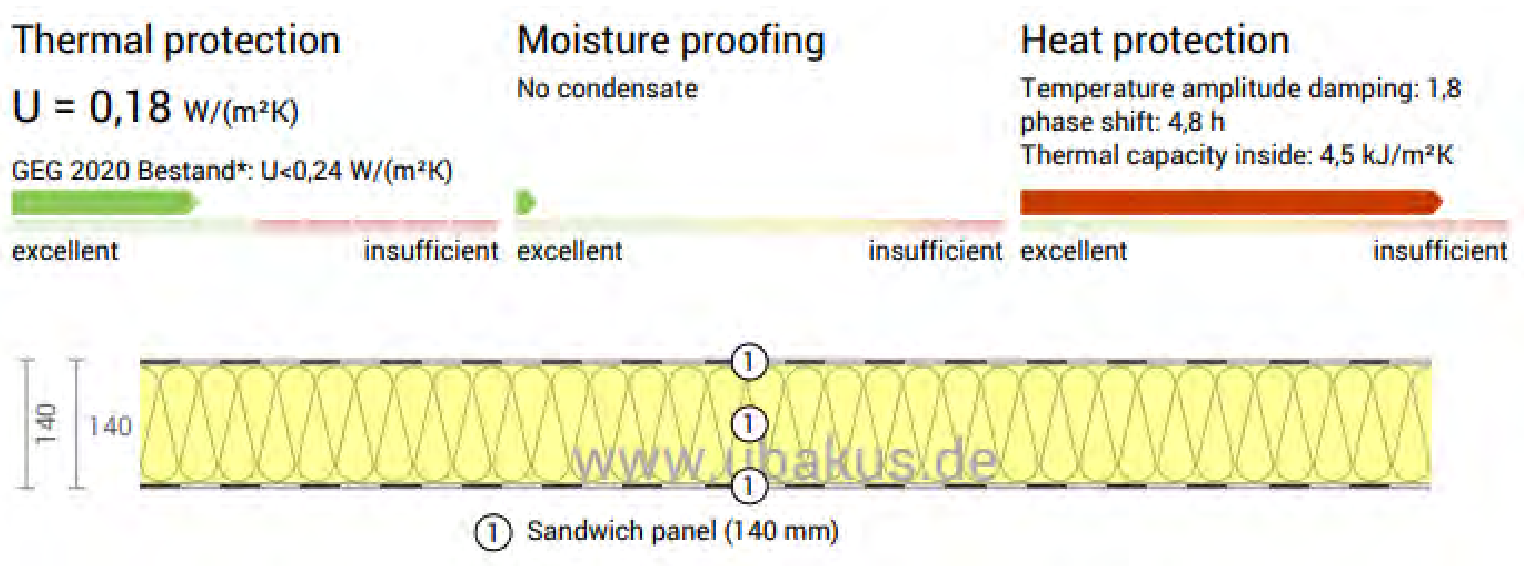
The Thermal Protection (U-value) of the sandwich panel sits at around 0.29 W/(m²K)

It is very far off from LETI Climate Emergency Design Guide (0.10-0.12 for roofs and 0.2 higher for walls) and as it stands is not a feasible insulating option, especially at this thickness.

One key aspect that immediatly stands out is the Heat protection levels, which means the material is highly flammable on the inside and also as steel is a material that gains heat very quickly. This is one of the reasons why standard traditional sandwich panels are not ideal for residential uses, but are rather more ideal for such scenarios where even during an even of fire, the ste-el structure of the building will not suffer critical damage under elevated temperature levels for prolonged periods of time.

4.1 - Existing Climatic Conditions

U-Value of Sandwich Panels with Polyurethane Foam Insulation (Alternative)



The Thermal Protection (U-value) of the sandwich panel sits at around 0.18 W/(m²K)

It does not meet the requirement of LETI Climate Emergency Design Guide* for commercial buildings (0.10-0.12 for roofs), however it is not -by more conventional standards- an inefficent insulation choice.

Although a little bit less flammable, the material analysis shows that the heat protection values are still highly insufficient just like the previous material.

4.1 - Existing Climatic Conditions

Calculating the energy and costs - Existing Condition (Mineral Foam)

Surface Area: 45,496 m²

Heat Loss Per Hour Formula: $\text{Heat Loss} = U \times \text{Area} \times \Delta T$

Calculation:

$$\text{Heat Loss per Hour} = 0.29 \times 45,496 \times 13 = 171,859.16\,\text{Watts}$$

Conversion to kWh

$$\text{Heat Loss per Hour in kWh} = \frac{171,859.16}{1000} = 171.859\,\text{kWh}$$

Daily and Annual Energy Requirement:

$$\text{Daily Energy Requirement in kWh} = 171.859 \times 24 = 4,124.616\,\text{kWh}$$

$$\text{Annual Energy Requirement} = \frac{4,124.616 \times 180}{0.95} = 782,018.652\,\text{kWh}$$

Annual Heating Cost:

$$\text{Annual Cost} = 782,018.652 \times 0.25 = £195,504.663$$

Space heating demand per m² - ***39.94 kWh/m²***

KEY VALUES

ΔT = 13°C *(let's assume the average outside temperature is 7°C)*

U-Value *for exterior cladding = 0.29 W/(m²K)*

Surface Area *= 2(lw+lh+wh) = 45,496 m²*
(we are neglecting any windows for this demonstration, and
assuming the building fully covered with panels)

Heating Season Lenght: *180 days*

Heating system *with an energy efficent rating (ErP) of A - (95%)*

Cost *per kWh = 26p for Large Businesses in the UK as of 2024*

4.1 - Existing Climatic Conditions

Calculating the energy and costs - Alternative Condition (Polyurethane Foam)

Surface Area: 45,496 m²

Heat Loss Per Hour Formula: $\text{Heat Loss} = U \times \text{Area} \times \Delta T$

Calculation:

$$\text{Heat Loss per Hour} = 0.18 \times 45,496 \times 13 = 106,349.04\,\text{Watts}$$

Conversion to kWh

$$\text{Heat Loss per Hour in kWh} = \frac{106,349.04}{1000} = 106.349\,\text{kWh}$$

Daily and Annual Energy Requirement:

$$\text{Daily Energy Requirement in kWh} = 106.349 \times 24 = 2,552.376\,\text{kWh}$$

$$\text{Annual Energy Requirement} = \frac{2,552.376 \times 180}{0.95} = 484,115.752\,\text{kWh}$$

Annual Heating Cost:

$$\text{Annual Cost} = 484,115.752 \times 0.25 = \pounds 121,028.938$$

*Space heating demand per m² - **24.73 kWh/m²***

KEY VALUES

ΔT = 13°C *(let's assume the average outside temperature is 7°C)*

U-Value *for exterior cladding = 0.18 W/(m²K)*

Surface Area = 2(lw+lh+wh) = 45,496 m²
(we are neglecting any windows for this demonstration, and
assuming the building fully covered with panels)

Heating Season Lenght: *180 days*

Heating system *with an energy efficent rating (ErP) of A - (95%)*

Cost *per kWh = 26p for Large Businesses in the UK as of 2024*

4.1 - Existing Climatic Conditions

Reflecting on Calculations & Moving Forward

Even if we are to consider the "better alternative" option as basis of our argument about the feasibility of keeping this space heated, the conclusion is regardless of how good or better the insulation can be.

Looking at the Annual Energy costs, which is ***£121,028***

As well as the "space heating demand" - which is ***24.73 kWh/m²***
(LETI Climate Emergency Design Guidelines state large commercial businesses should aim for below 15 kWh/m²)

We can say that keeping the entirety of the interior space is both financially and environmentally unsustainable and therefore not viable. The current buildup of the building and contemporary heating systems (assuming even around 100% efficiency) combined are not enough for efficent and sustainable heating of the entire volume by any means.

Rather than attempting to come up with a series of counter-proposals against the existing cladding system and make tests on other more optimal buildups/scenarios to reach better results

The design thesis will explore a different way of bringing sustainable thermal comfort into this massive enclosed space.

4.2 - Climatic Zones Strategy

The Third Option

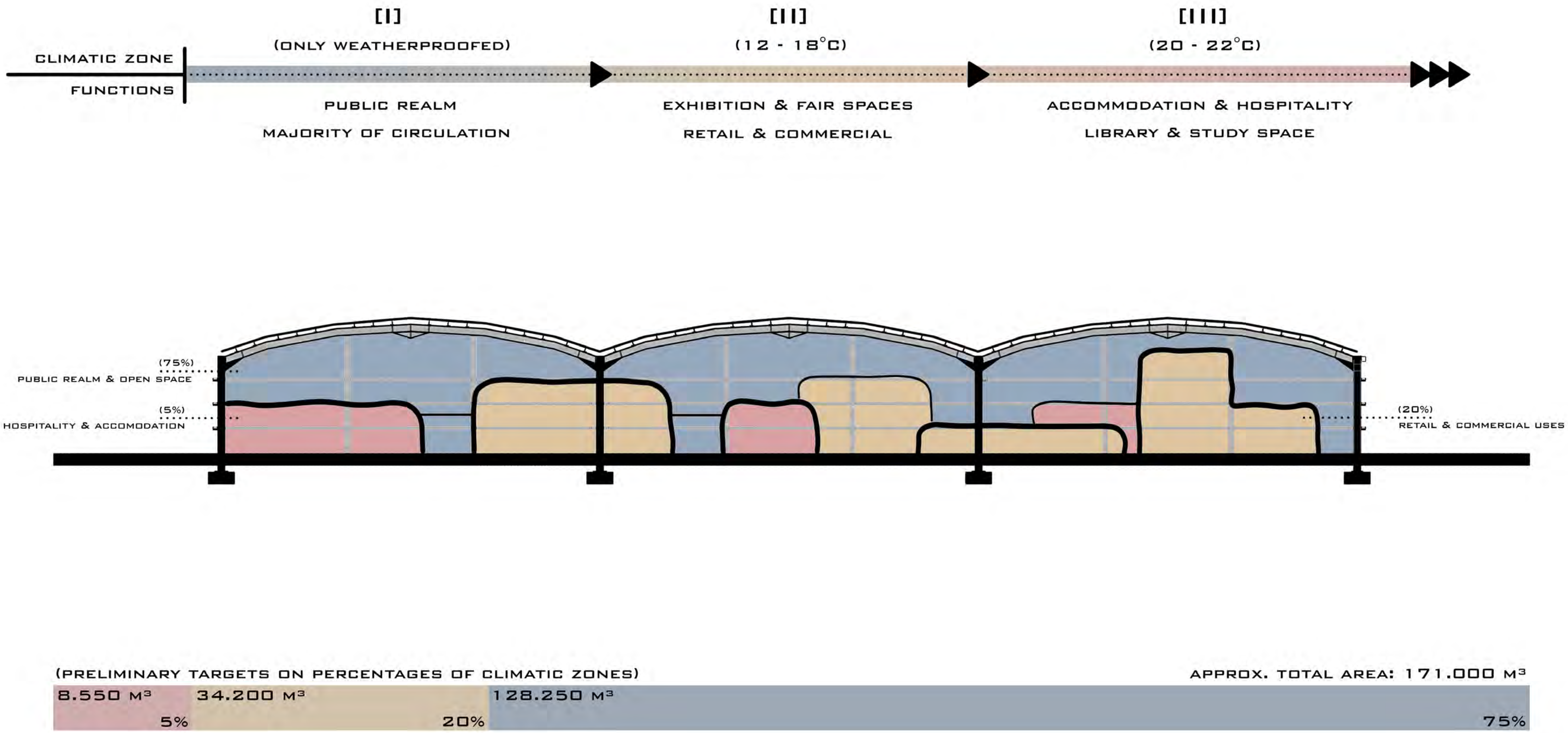


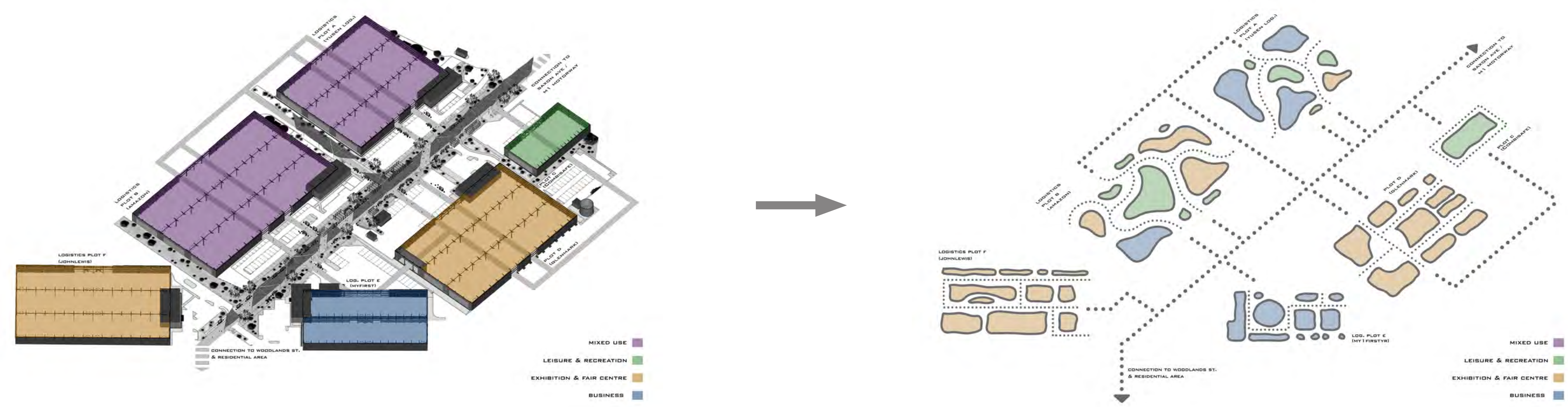
Image - Diagrammatic concept plate explaining the basic principles and preliminary targets of the environmental strategy

4.2 - Climatic Zones Strategy

Dividing the space into more manageable sections

By utilizing different climatic zones within the space, such as designated areas with controlled temperatures and humidity levels, energy consumption can be optimized, thereby reducing overall environmental impact.

This approach means that the project essentially becomes ***"a series of buildings within a building"***



It enables the potential to design something that is environmentally and financially sustainable as opposed to suggesting the building be completely re-clad with 300mm thick sandwich panels.

This multi-faceted approach not only improves environmental performance but also enriches the experiential aspect, making the warehouse shed a vibrant and engaging space for occupants and visitors.

4.3 - Proposed Build-up & Analysis

Insulation of the buildings within the weatherproofed shell

Sustainable and well insulated build-ups are possible for the sheltered and structurally standalone buildings on the inside of this
warehouse shell.

Referring back to the reference & precedent study in chapter 2.7 (especially the Gare Maritime), ***CLT (cross-laminated timber) stands out as an ideal material for the main framework of the interior structures***, due to following reasons;

- Design Choice: *Ideal aesthetic contrast both on the level of texture and colour. To highlight and form a juxtaposition on the level of material to create a stark contrast between the “existing” and “new”. (i.e granular timber vs the shiny steel)*

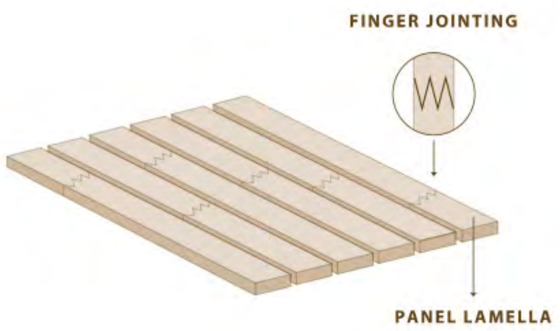
- Environmental Impact: *CLT is known to be an environmentally friendly material, with low carbon costs associated with its production.*
(Steel typically emits around 1.4 kg CO_2 per each kg, while CLT has a negative carbon emission value)

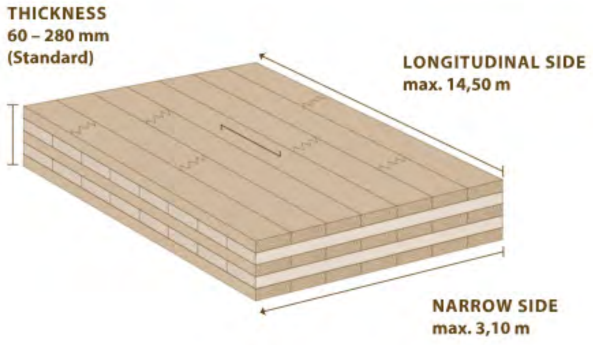
- Sheltered/Weatherproofed Exterior Conditions: *Unlike being in a scenario where we would have to ensure the ideal weathertightness of our buildups, the nature of being inside the warehouse shell enables the CLT to be exposed without further cladding.*

4.3 - Proposed Build-up & Analysis

Buildup Option - CLT with Natural Fibre Insulation

The suggested wall build-up for the interior buildings will involve a CLT structural frame walls insulated with a 200mm STEICO Therm Dry* Insulation Board.





128mm CLT Cross Laminated Timber

200mm STEICO Therm Dry* Insulation Board

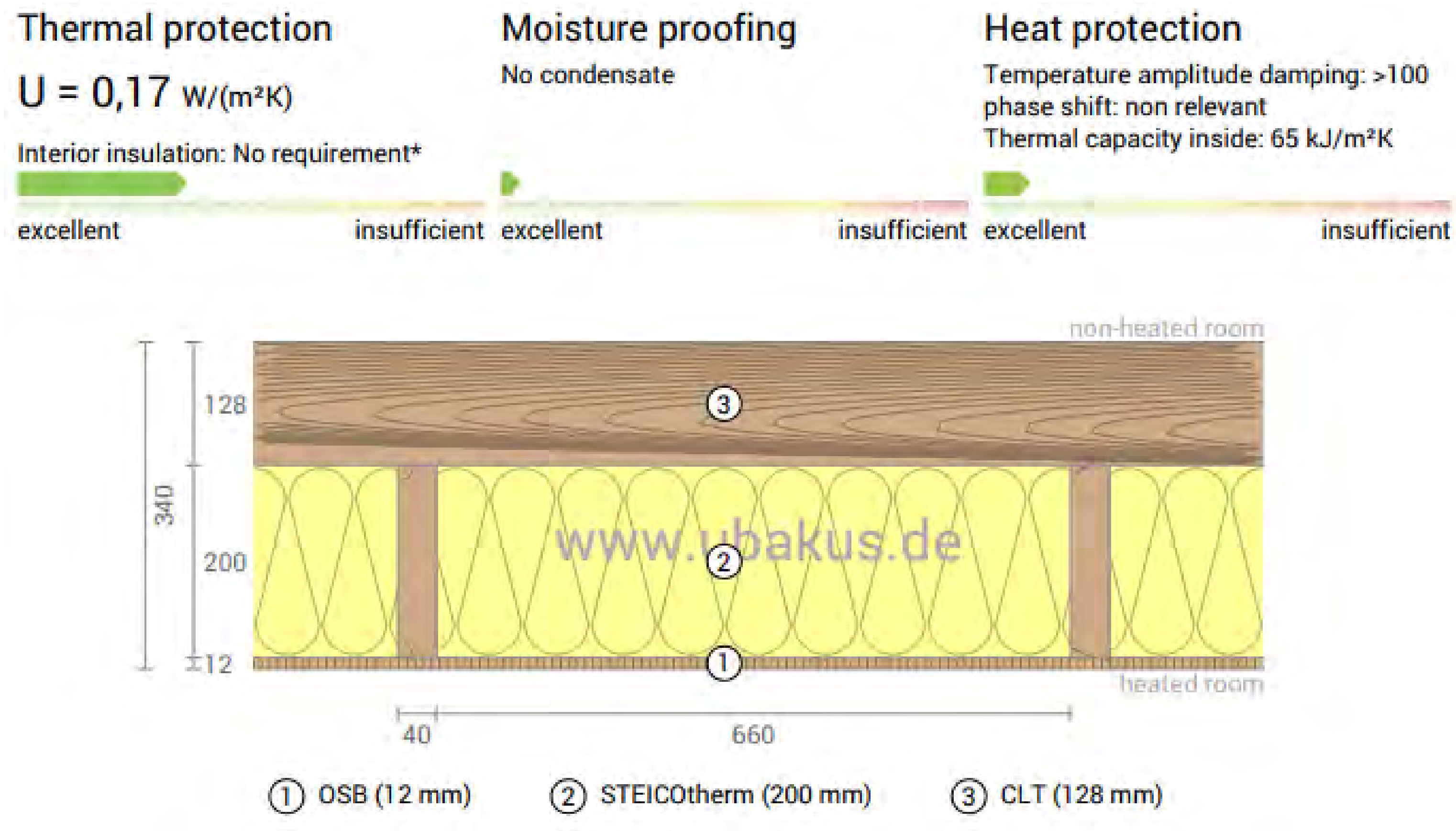
4.3 - Proposed Build-up & Analysis

Buildup Option - CLT with Natural Fibre Insulation

The Thermal Protection (U-value) of a 128mm CLT wall with a 200mm thick Natural Fibre Insulation is <u>0.17 W/(m²K)</u>

The maximum suggested U-Value for walls are 0.15 m²K according to LETI Climate Emergency Design Guide.

This buildup is currently not meeting the specific standards, it is a succesful enough alternative in terms of environmental impact to sandwich panels which use polyurethane and steel as its core materials.



Environmental Analysis - Steel Sandwich Panels

Heat loss: 9 kWh per m² and heating season

Amount of heat that escapes through one square meter of this component during the heating period. Please note: Due to internal and solar gains, the heating demand is lower than the heat loss.

Primary energy (non renewable): 157 kWh/m²

Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

Green house gas potential: 34 kg CO_2 Äqv./m²

Quantity of released greenhouse gases in the production of building materials used ("cradle to gate").

Environmental Analysis - CLT with Natural Fibre Insulation

Heat loss: 13 kWh per m² and heating season

Amount of heat that escapes through one square meter of this component during the heating period. Please note: Due to internal and solar gains, the heating demand is lower than the heat loss.

Primary energy (non renewable): >133 kWh/m²

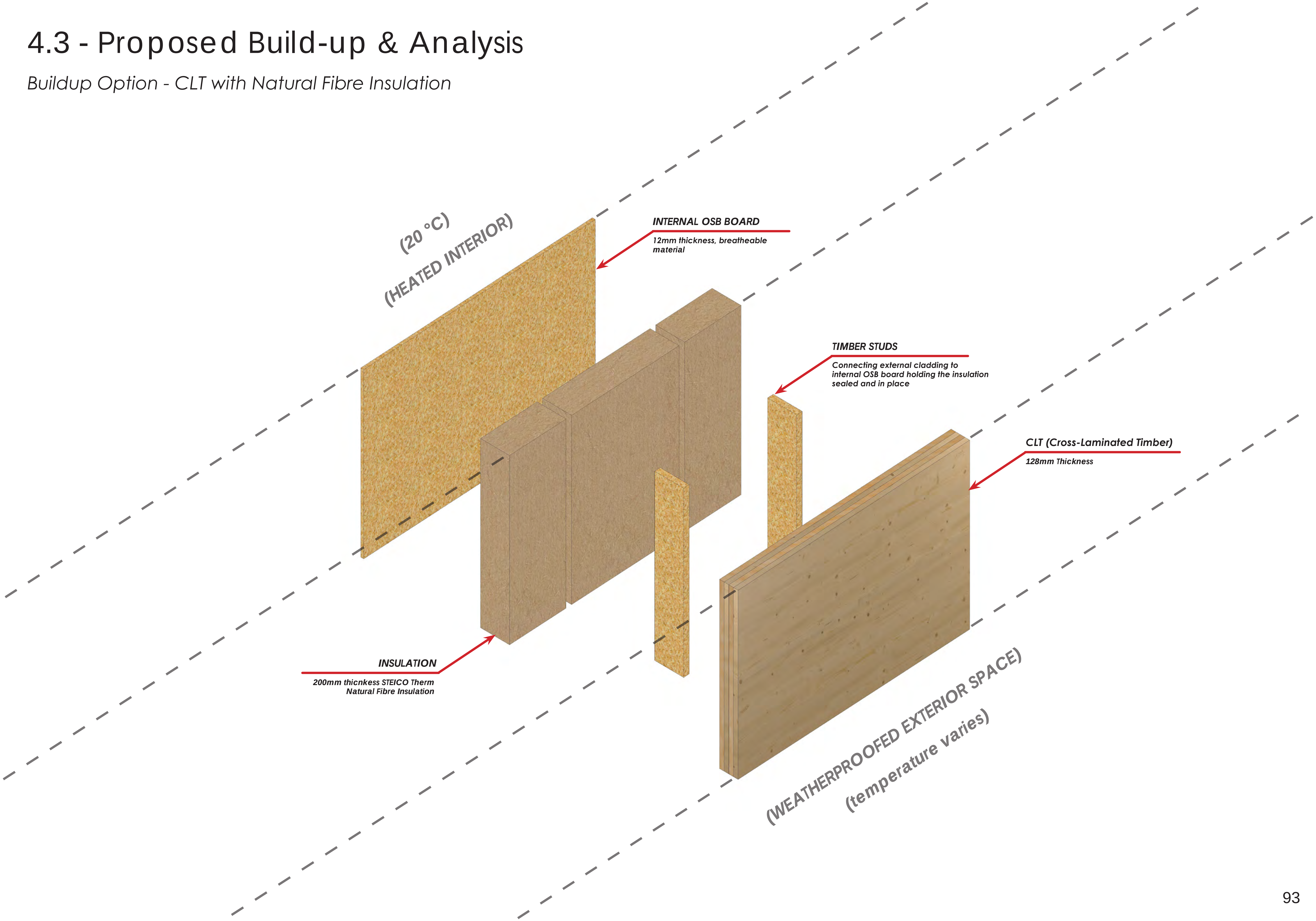
Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

Green house gas potential: -44 (?) kg CO_2 Äqv./m²

For the production of the building materials used, more greenhouse gases were withdrawn from the atmosphere than emitted.

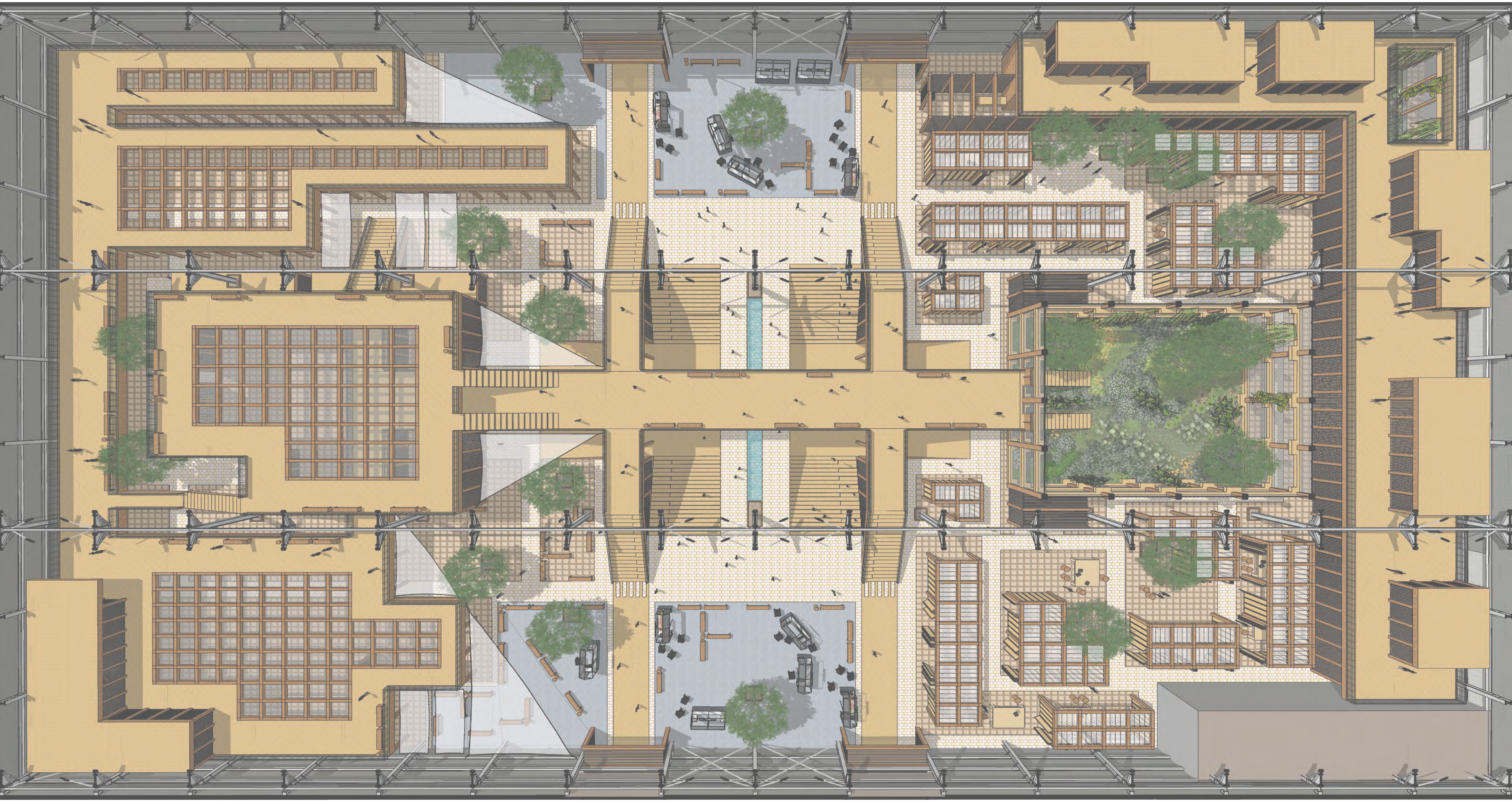
4.3 - Proposed Build-up & Analysis

Buildup Option - CLT with Natural Fibre Insulation



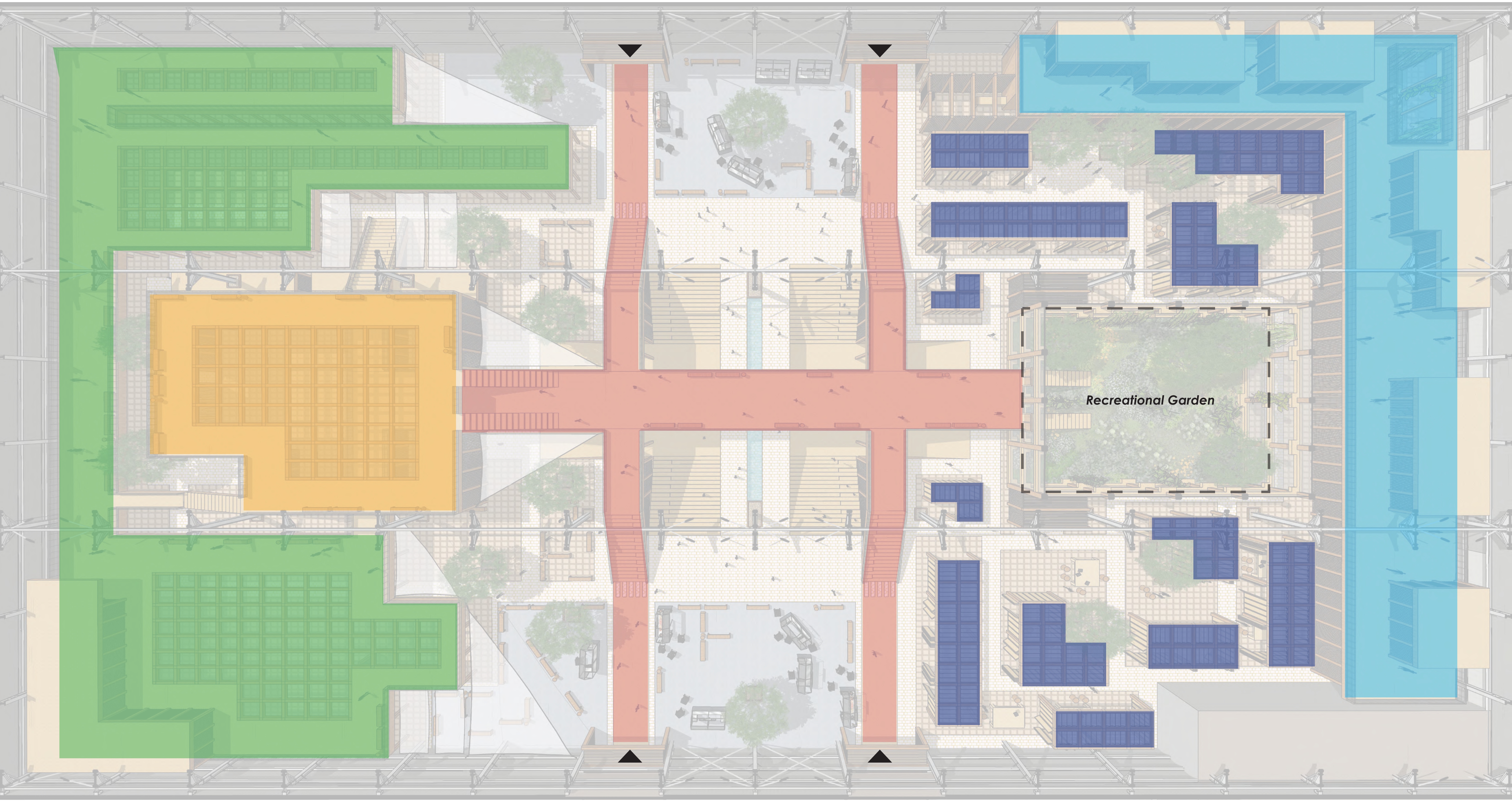
4.4 - Heated Zones & Calculations

Key Programmes and Interior of the weatherproofed space based on latest design



4.4 - Heated Zones & Calculations

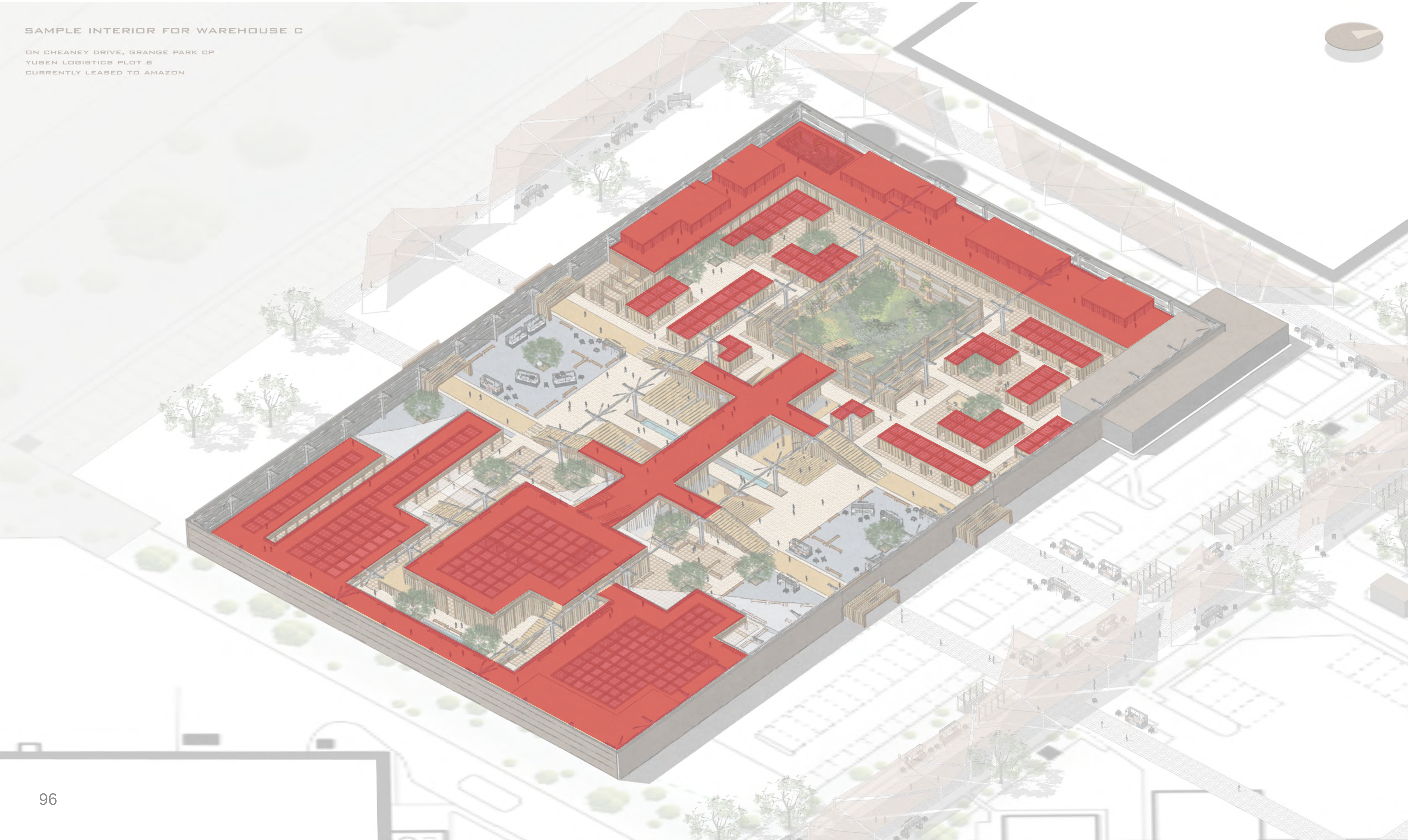
Key Programmes and Interior of the weatherproofed space based on latest design



Exhibition & Gallery Space
Library & Study Space
Circulation (above) Council Offices & Rooms (below)
Marketplace & Bookable Spaces
Private Office Space

4.4 - Heated Zones & Calculations

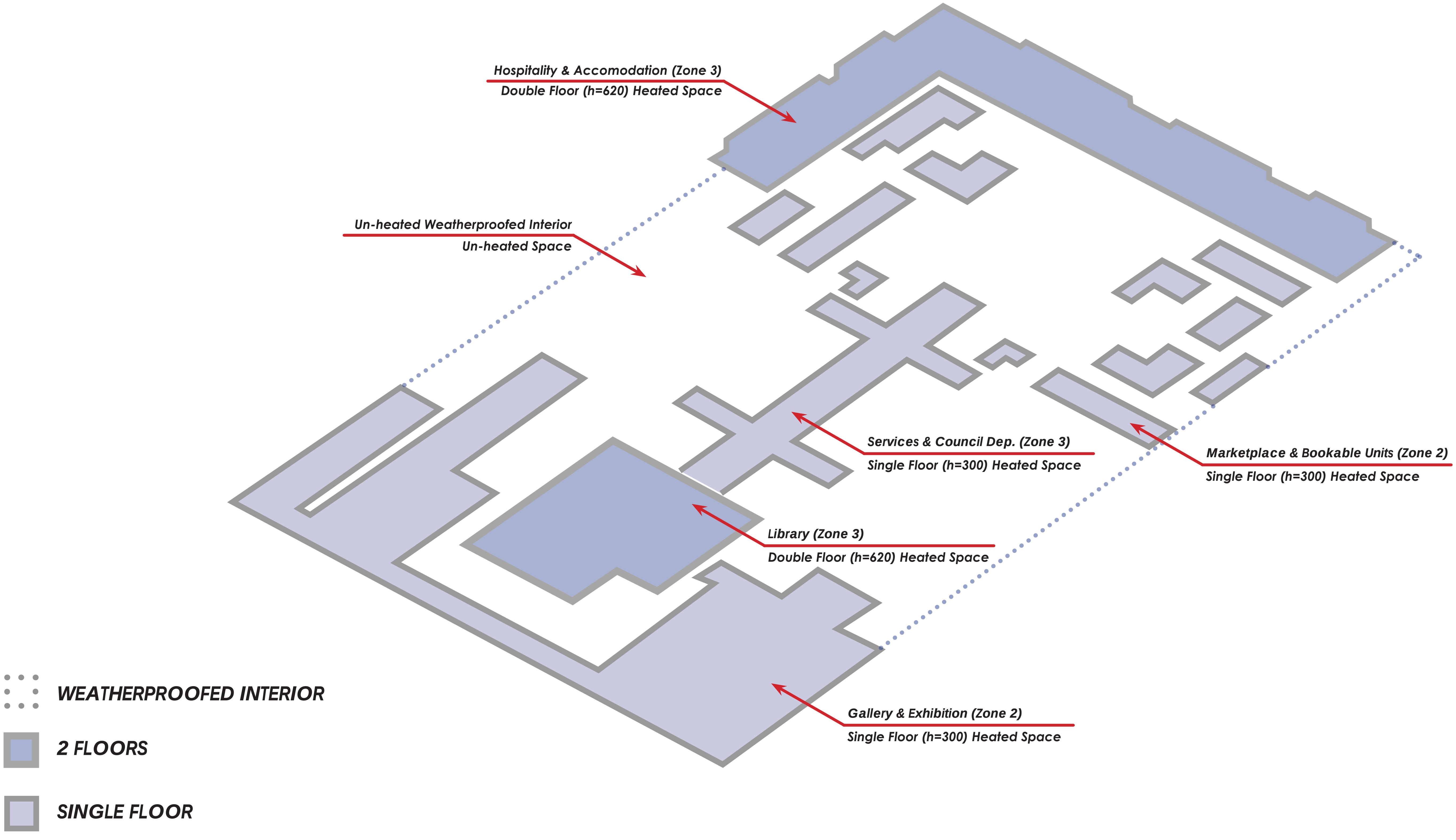
Proposed Volumes and Arrangements of Areas to be Heated - Based on the current design scheme



4.4 - Heated Zones & Calculations

Proposed Volumes and Arrangements of Areas to be Heated - Based on the current design scheme

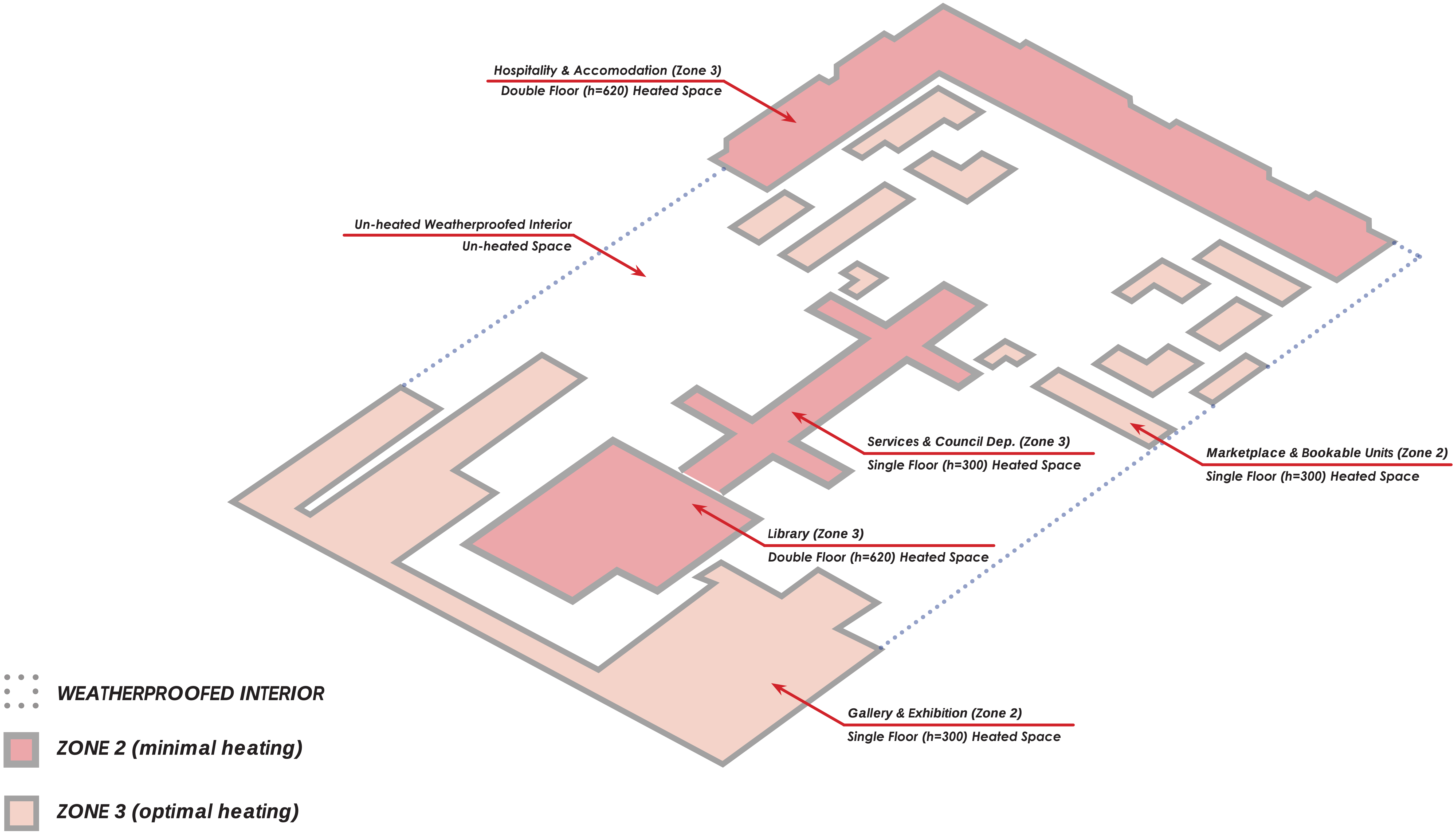
(Highlighted Floor count)



4.4 - Heated Zones & Calculations

Proposed Volumes and Arrangements of Areas to be Heated - Based on the current design scheme

(Highlighted Climatic Zones)



4.4 - Heated Zones & Calculations

Calculating the Volumes, Zones and their Energy consumption

Climatic Zone 3 (Target Temperature of 20 °C)

Library (two floors)	Council Offices & Rooms	Hospitality & Accomodation
$1002\ m^2 \times 2 = 2004\ m^2$	$721\ m^2 \times 3.2m = \underline{2307\ m^3}$	$1974\ m^2 \times 2 = 3948\ m^2$
$2004\ m^2 \times 3.2\ m = \underline{6412\ m^3}$		$3948\ m^2 \times 3{,}2\ m = \underline{12633\ m^3}$

Climatic Zone 2 (Target Temperature of 15 °C)

Marketplace & Bookable Units	Gallery & Exhibition Spaces
$1455\ m^2 \times 3.2m = \underline{4656\ m^3}$	$2889\ m^2 \times 3.2m = \underline{9244\ m^3}$

Total Volume of Warehouse: 214.170 m³

Total Volume of Area to be heated: 35.252 m³

We can see that only around 16% of total interior volume will require heating - based on the "climatic zones strategy".

(Volume itself is not a value enough by itself to calculate heat loss, but simply useful to compare the amount of enclosed space in this context. The following chapter will be making calculationg based on the exposed surface areas)

4.4 - Heated Zones & Calculations

Calculating the Volumes, Zones and their Energy consumption

The following pages will delve into further detailed analysis based on surface area data to calculate heat loss (based on the U-Values of the proposed CLT & Natural Fibre buildups detailed previously) and energy consumption -and associated costs- of these spaces under their specific conditions, depending on their "climatic zone" designations (which effects ΔT).

4.4 - Heated Zones & Calculations

Calculating the Volumes, Zones and their Energy consumption

(CLIMATIC ZONES 3)

Library & Study Space

Heat Loss Calculation:

Heat Loss = U×A×ΔT

= 0.17W/(m²\.K) × 2921.9m² ×13°C

= 6457.399W

Conversion to kWh:

$$\frac{6457.399\,\mathrm{W}}{1000} = 6.4574\,\mathrm{kWh}$$

Daily Energy Requirement:

$$6.4574\,\mathrm{kWh/hour} \times 24\,\mathrm{hours/day} = 154.98\,\mathrm{kWh/day}$$

Annual Energy Requirement:

$$\frac{154.98\,\mathrm{kWh/day} \times 180\,\mathrm{days}}{0.95\,\mathrm{efficiency}} = 29,364.17\,\mathrm{kWh/year}$$

Annual Heating Cost:

$$\mathrm{Annual\ Heating\ Cost} = 29,364.17\,\mathrm{kWh} \times £0.25/\mathrm{kWh}$$

$$= £7,341.04$$

Council Offices & Rooms

Heat Loss Calculation:

Heat Loss = U×A×ΔT

= 0.17W/(m²\.K) × 1785.56m² ×13°C

= 3946.088W

Conversion to kWh:

$$\frac{3946.088\,\mathrm{W}}{1000} = 3.9461\,\mathrm{kWh}$$

Daily Energy Requirement:

$$3.9461\,\mathrm{kWh/hour} \times 24\,\mathrm{hours/day} = 94.706\,\mathrm{kWh/day}$$

Annual Energy Requirement:

$$\frac{94.706\,\mathrm{kWh/day} \times 180\,\mathrm{days}}{0.95\,\mathrm{efficiency}} = 17,944.31\,\mathrm{kWh/year}$$

Annual Heating Cost:

$$\mathrm{Annual\ Heating\ Cost} = 17,944.31\,\mathrm{kWh} \times £0.25/\mathrm{kW}$$

$$= £4486.08$$

Hospitality & Accomodation

Heat Loss Calculation:

Heat Loss = U×A×ΔT

= 0.17W/(m²\.K) × 8699.87m² ×13°C

= 19226.713W

Conversion to kWh:

$$\frac{19226.713\,\mathrm{W}}{1000} = 19.227\,\mathrm{kWh}$$

Daily Energy Requirement:

$$19.227\,\mathrm{kWh/hour} \times 24\,\mathrm{hours/day} = 461.44\,\mathrm{kWh/day}$$

Annual Energy Requirement:

$$\frac{461.44\,\mathrm{kWh/day} \times 180\,\mathrm{days}}{0.95\,\mathrm{efficiency}} = 87,431.95\,\mathrm{kWh/year}$$

Annual Heating Cost:

$$\mathrm{Annual\ Heating\ Cost} = 87,431.95\,\mathrm{kWh} \times £0.25/\mathrm{kWh}$$

$$= £21,857.74$$

4.4 - Heated Zones & Calculations

Calculating the Volumes, Zones and their Energy consumption

(CLIMATIC ZONES 2)

Marketplace & Bookable Units

Heat Loss Calculation:

Heat Loss = U×A×ΔT

= 0.17W/(m²\.K) × 3398 m² × 8°C

= 4621.28W

Conversion to kWh:

$$\frac{4621.28\,\mathrm{W}}{1000} = 4.621\,\mathrm{kWh}$$

Daily Energy Requirement:

$$4.621\,\mathrm{kWh/hour} \times 24\,\mathrm{hours/day} = 110.91\,\mathrm{kWh/day}$$

Annual Energy Requirement:

$$\frac{110.91\,\mathrm{kWh/day} \times 180\,\mathrm{days}}{0.95\,\mathrm{efficiency}} = 21,014.66\,\mathrm{kWh/year}$$

Annual Heating Cost:

$$\mathrm{Annual\ Heating\ Cost} = 21,014.66\,\mathrm{kWh} \times £0.25/\mathrm{kWh} = £5,253.67$$

Gallery & Exhibition Spaces

Heat Loss Calculation:

Heat Loss = U×A×ΔT

= 0.17W/(m²\.K) × 6465.46² × 8°C

= 8793.03W

Conversion to kWh:

$$\frac{8793.03\,\mathrm{W}}{1000} = 8.793\,\mathrm{kWh}$$

Daily Energy Requirement:

$$8.793\,\mathrm{kWh/hour} \times 24\,\mathrm{hours/day} = 211.03\,\mathrm{kWh/day}$$

Annual Energy Requirement:

$$\frac{211.03\,\mathrm{kWh/day} \times 180\,\mathrm{days}}{0.95\,\mathrm{efficiency}} = 39,985.13\,\mathrm{kWh/year}$$

Annual Heating Cost:

$$\mathrm{Annual\ Heating\ Cost} = 39,985.13\,\mathrm{kWh} \times £0.25/\mathrm{kWh} = £9,996.28$$

4.4 - Heated Zones & Calculations

Calculating the Volumes, Zones and their Energy consumption

(SUMMARY)

EARLIER CALCULATION BASED ON HEATING THE ENTIRETY OF STRUCTURE:
(with steel sandwich panels with polyurethane foam insulation build-up)

Annual Energy Requirement: 484,115 kWh
Associated Costs: £121,028

CLIMATIC ZONES STRATEGY MODEL CALCULATIONS:
(with natural fibre insulated CLT wall build-up)

Annual Energy Requirement: 195.738 kWh
Associated Costs: £48.933

4.5 - Conclusion

Analysis and Conclusion on the effectiveness of Climatic Zones Strategy

To conclude, following detailed analysis and calculations, it is demonstrably clear that;

(based on calculations and summaries on part 4.3 and part 4.1)

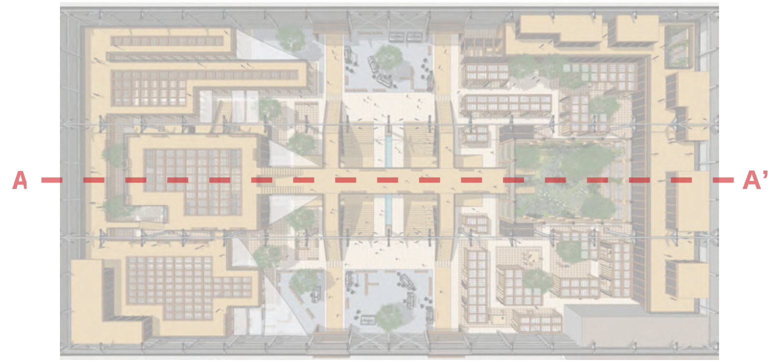
<u>The “Climatic Zones Strategy” is is highly beneficial in terms of energy consumption and costs associated.</u>

The act of assigning individual heating targets for certain environments with different programmatic needs -especially in such contexts where large open spaces are involved- is proved to be highly effective. Circulation and other intermediary spaces for the most parts have also been specifically left “outside” of heating zones, which also was a main contribution towards lowering the energy usage.

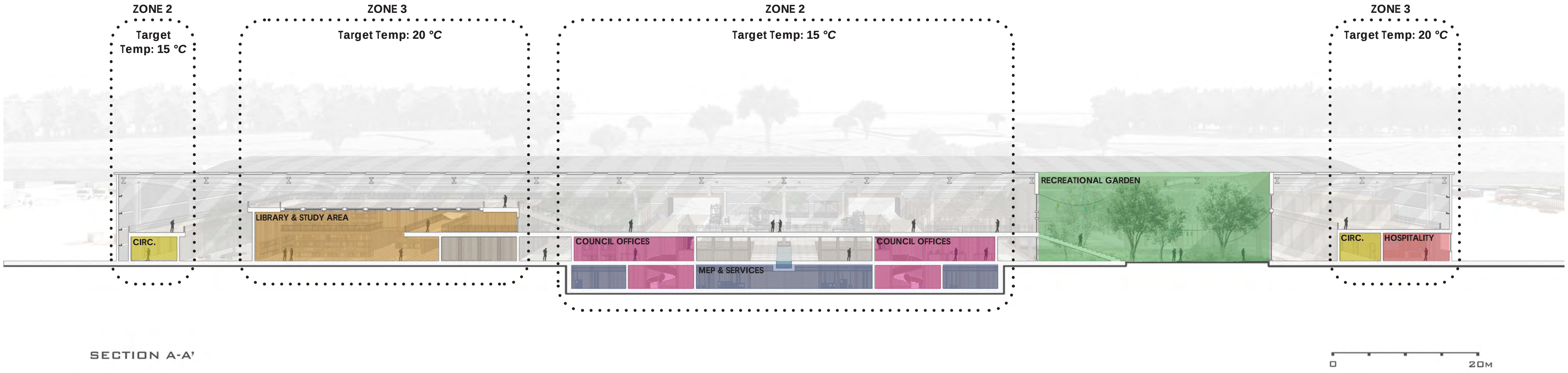
It is also a major factor to keep in mind (although not further empirically explored in this thesis) that the environmental impact of using a CLT and Natural Fibre buildup compared to Steel and Polyurethane Foam buildup is a much more sustainable choice, with regards to the carbon emissions associated with the production of said material.

4.5 - Conclusion

Summative Images - Section & Highlights

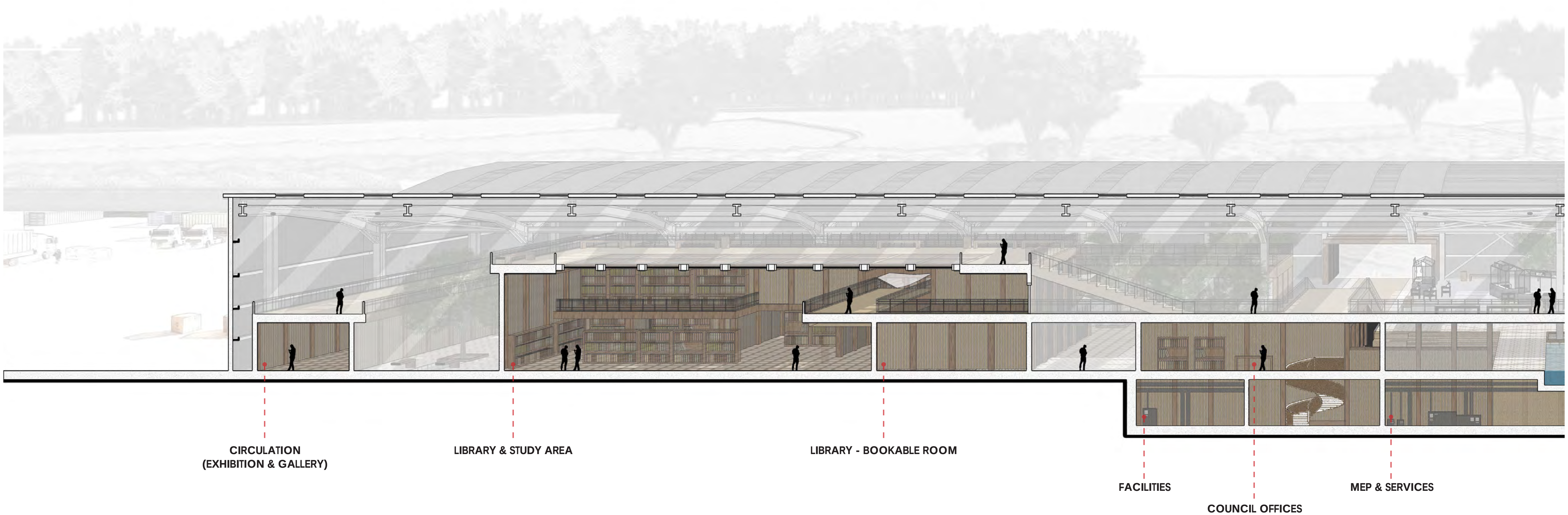


Longtidunal section through the warehouse

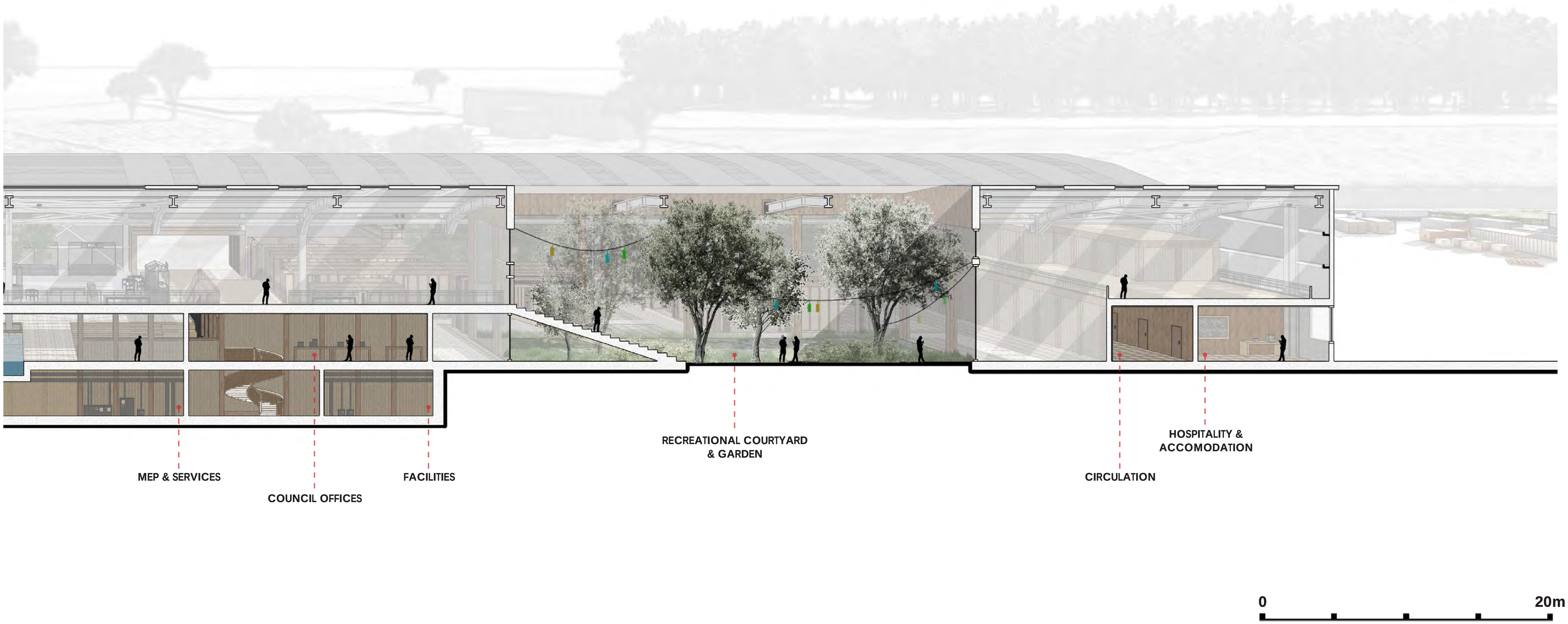


4.5 - Conclusion

Summative Images - Section & Highlights



SECTION A-A'


MEP & SERVICES
COUNCIL OFFICES
FACILITIES
RECREATIONAL COURTYARD
& GARDEN
CIRCULATION
HOSPITALITY &
ACCOMODATION
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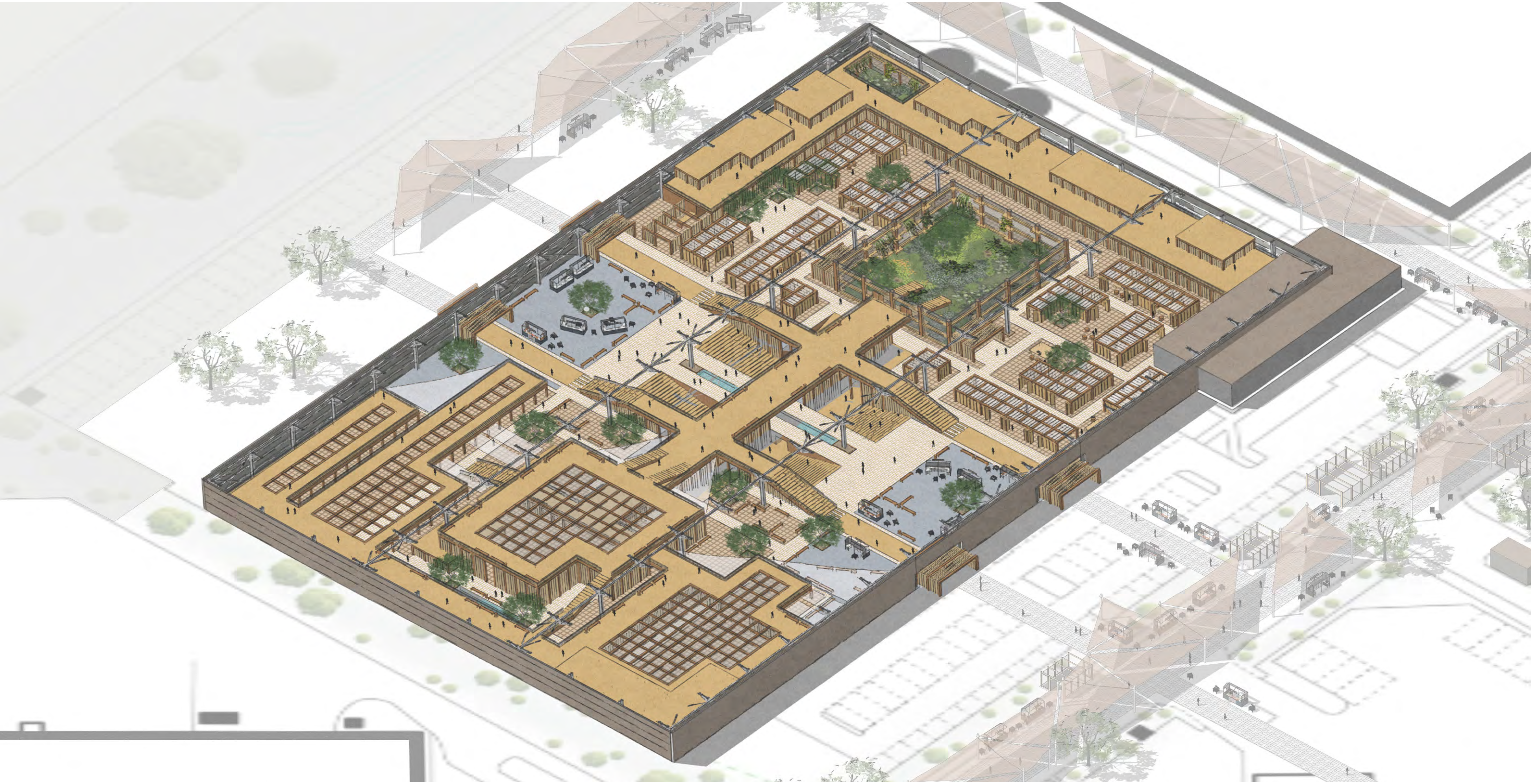
4.5 - Conclusion

Summative Images - Axonometric View



5. CONCLUSIONS

5.1 - Future Potential Directions for the Project

Moving forward, the project can explore into the potentials within the broader site - the former logistics complex and test out different densities and approaches that could perhaps challenge the currently proposed design scheme.

As mentioned in the chapter about the associated benefits of re-using the excess/removed material back on the site, the project should also keep on maintaining an inventory of the parts and sections removed from the steelwork to then think about potential better uses for the materials before resorting to scrapping them for recycling.

Additionally, specifically regarding the climatic zones strategy, there can be future chapters exploring heating systems, exploring options and innovative contemporary ways of heating solutions (for example transpired solar walls one other energy efficent heating) which could put forward different levels of thermal efficiency which would be another controllable parameter to work with, as the existing calculations simply assumed the efficiency to be around 95-100%

5.2 - Conclusion and Reflections

The ETS Design Thesis initially focused on the structural aspects and explored the qualities and potentials of Steel construcion, what it consists of, how it is manufactured, assembled, disassembled, recycled, and how it could be operated on. The report then moved on to evaluate the thermal performance of the existing building and proposed a climatic zones strategy which was backed by and proved through quantified evidence and comparisons.

In essence, the thesis sets an example - going through initial explorations of a potential retrofit project of a portal frame structure which can always be taken further and expanded on in the future.

The Design Thesis focused on the contemporary reality that in a world overpopulated by "new-builds", the future potential role of the architect should involve being an agent for the re-use and retrofit of existing buildings.

The role of the average architect has been in a steady decline in face of the larger demands and realities of the industry, however the increasing emphasis on the re-use of "obsolete" or "underused" buildings present opportunities for us architects to step in and purposefully provide solutions in face of highly context-driven unique challenges as we are trained to do so.

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