The city as a continuous Quarry

Methods of reuse as means of embodied carbon retention

Acknowledgments

My upmost appreciation and gratitude to my loved ones and those who have supported me through my academic journey through the ups and downs of what was one of the hardest challenges in my life so far.

To all the lecturers and staff of Architecture TUD i would like to thank them as withoput there support and imput through the years this all would not be possible.

Content

Jamie Proctor

Abstract

The environmental impact of the construction and demolition industry is enormous; therefore, the processing of architectural debris and the existing building stock has become the priority for the design of sustainable buildings and cities. At present, more focus is put on how to reduce the carbon emission of buildings during the design, construction, and operational stages of an architectural construction however less consideration has been paid to the quantifying of the continued use and retaining of a structure embodied carbon post end-of-life stage in the form of its Demolition material waste. Currently it is commonly practice for structures to be deemed unfit for use before their constituent materials have reached their designed end of life stage due to many factors ranging from ground conditions to poor upkeep and changes in society (1) Because of this A structure's embodied carbon energy can be seen to have been released earlier than designed, resulting in the wasted potential of its constituent embodied carbon. This demolition material to conserve its embodied carbon potential should be fed back into the material flow of the city converting the city and its contained sites of demolition into stores of embodied energy in urban quarries (2). Considering the scale of the current climate crises requires that the materials held in these sites be reclaimed to actively retain as much of their original value as possible. Through this process of reclamation via urban mining principles of circular economy can be applied.

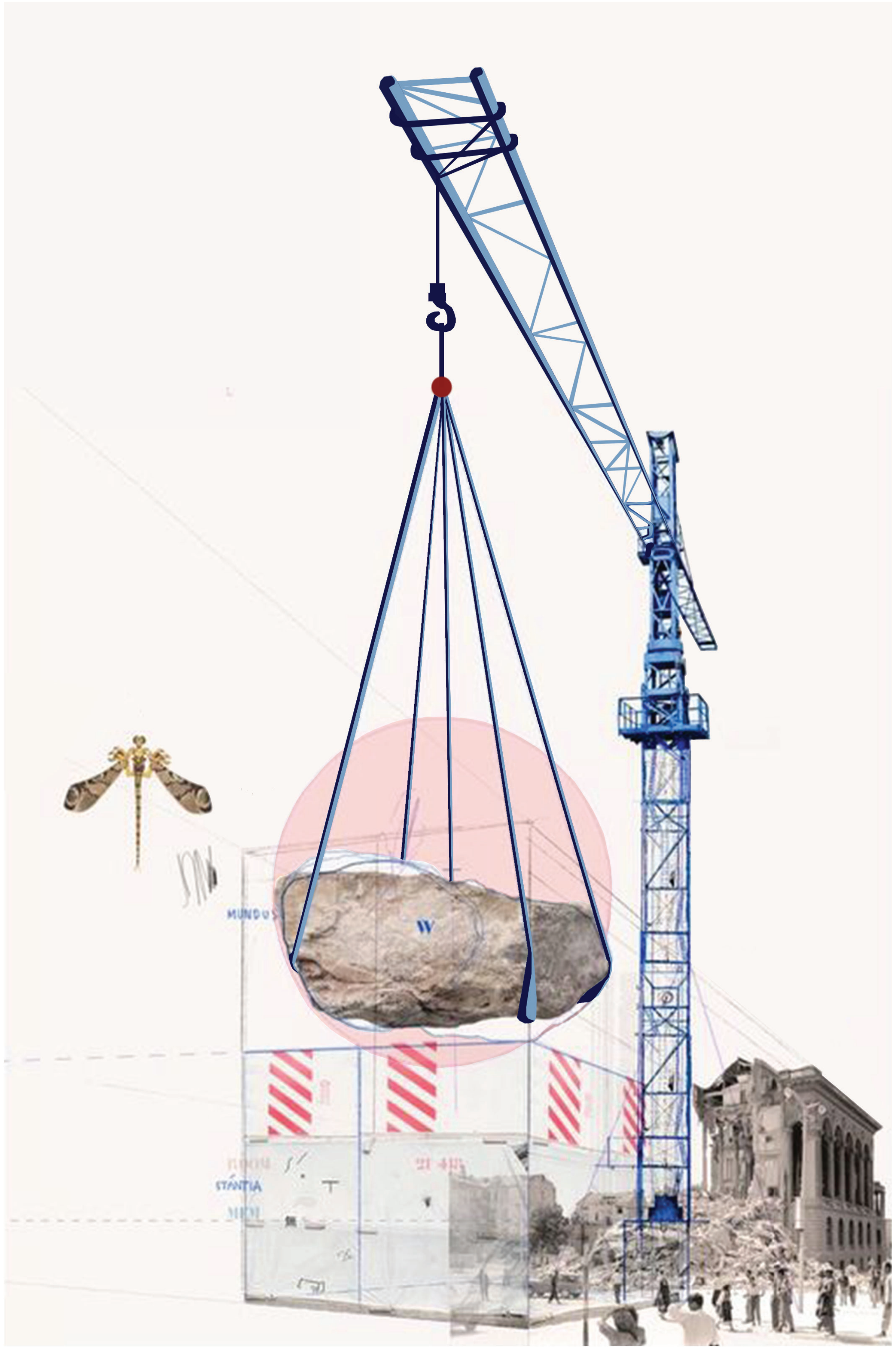


Fig 1 Architectural Quarrying

Introduction

At current, the earth is on track for unprecedented global climate change and global warming driven by increased human economic activity worldwide with the current environmental models estimating an increase in temperature of around 1.5 degrees Celius with the next few decades(3) a leading cause of contributor to this escalating environmental situation is the construction industry as a whole producing half of all solid waste generated annually with construction sectors contributing to 23% of air pollution from processing, 50% of total climate change and accounts for 50% of landfill wastes generated worldwide .(4) in Dublin annually 1.2 million tons of CDW is produced annually with the designed life span of the average modern structure valued at 75 years or above on average but as a result to changing trends are demolished and replaced before reaching end of life stage maturity in Favour of more efficient and denser architectural programs (5) .The rate at which structures are demolished is set to rise each year with an increasing population requiring greater densities of housing in the greater Dublin area already under strain from the existing housing crisis (5)At current trends of urban expansion, the future city is predicted to inevitably create a proportional increase in CDW to its expansion further straining the local region's ability to absorb the additional CDW. While urban construction is set to increase the existing building stock will additionally be reaching the limits of its designed life span.

Fig 2 Disposable city

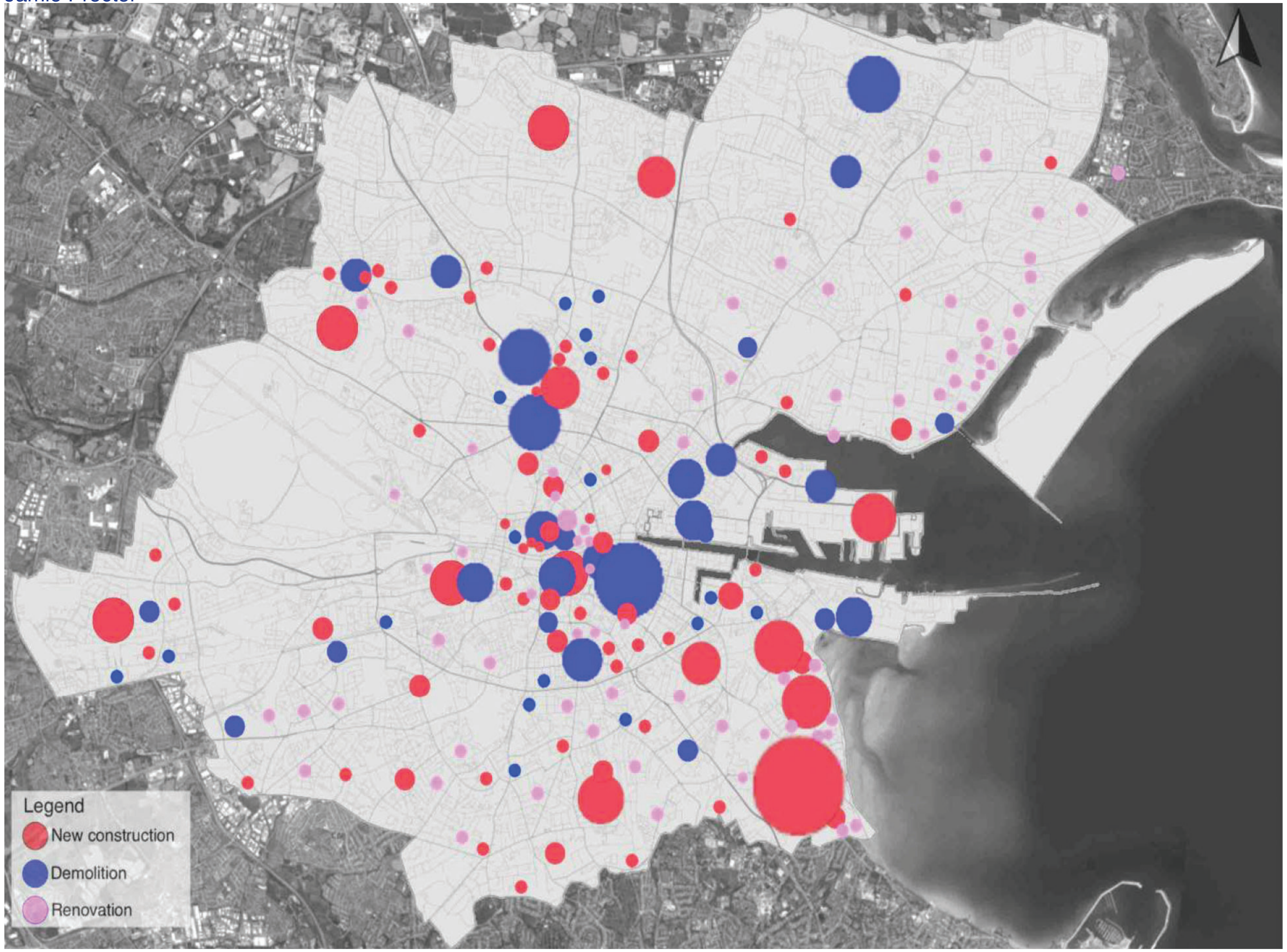


Fig 3 Planned construction, demolition, and renovation projects Dublin 2022

Scope

As the severity of the climate crises is set to worsen the need to reduce the levels of new material entering the built environment and the need to retain existing embodied carbon energy in the city becomes crucial. The emphasis on the reuse of existing materials in a manner that holds as much of the materials original embodied carbon as possible. Two approaches emerge in retaining the embodied carbon of Construction and demolition waste (CDW) materiality. The first processes the material through transformation to create a transformed product. At each step, there are manufacturing, transportation, and labor costs, which take time, energy, effort, emissions and have an additional environmental impact. Hence each production step, from extraction to manufacturing and assembly, adds carbon value to a construction product. The second process maintains as much value as possible from the reclaimed CDW materials, for as long as possible through reuse and upcycling without extensive progress. Through these processes materials removed from their respective sites through means of either 'urban mining' or total demolition site excavation of CDW materials post demolition will be fed back into the material flow of the city in one

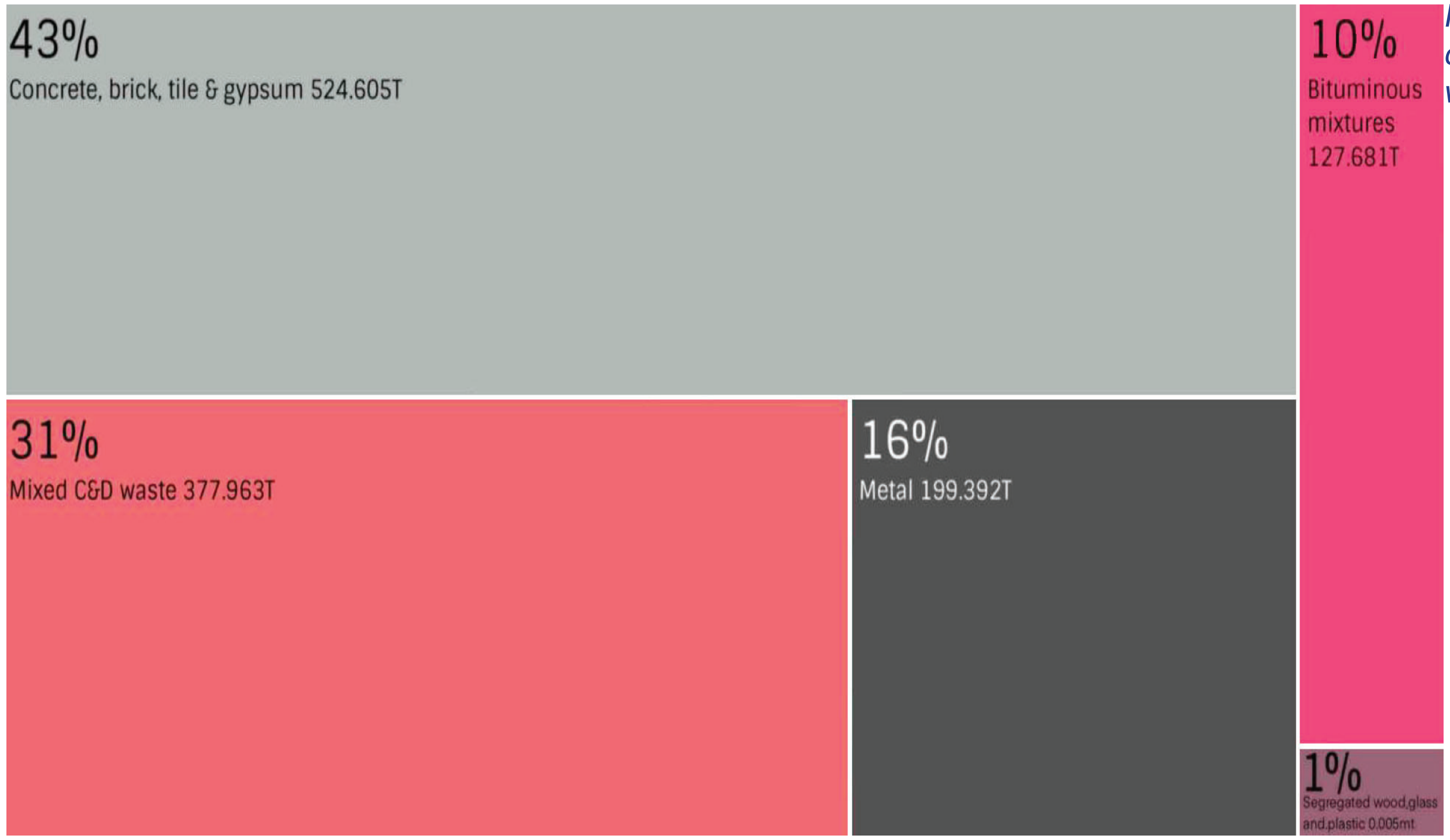


Fig 4 Removed construction waste 2019

Methodology

To clarify the research case qualitative bibliographical research was conducted, together with the study of CDW recycling and upcycling techniques. Using current material reuse practices an investigation into the life cycle of materials post end of life stage through a circular economic system was conducted, comparing current recycling and upcycling processes and their ability to conserve the respective embodied carbon and respective value of

Current approach on the built environment(recycling)

According to the European Commission: “The circular economy is emerging as an alternative to the linear economy construction, use, disposal in which raw materials remain in use for as long as possible, their maximum value is extracted during use, while, at the end of their life, these products shall be recovered and reused” (6) Recycling is today considered to be the most Enviromental conscious method of tackling the flow CDW leaving the construction industry today. In relation to the processing of material post end of life cycle it is transformative in nature, via mechanical, chemical or thermal processing. converting input material into reformed products (fig 2.2). in terms of development, it is relatively a new development where building materials were traditionally organic in nature. Due to intensive processing required to transform the material into reformed products ready for use, recycling has become energy intensive. Recycling requires multiple stages of carbon level generation from the transportation of the material its which in most cases is a processing plant located away from population centers and the processing of the material itself with additional embodied carbon being added to the material in the for of additives vital to the transformation process. Additionallay through the act of conservation of embodied carbon of the material itself pollutants are inevitably produced as a result (7). As a result, the process of recycling materials post-end –of-life to conserve embodied carbon is flawed. In efficiency and processing, the most effective recycling method requires the least input, creating the least amount of additional embodied carbon and pollutant byproducts.

Through current legislation in Europe it is required that construction and demolition waste be recycled for reuse through the implementation of what is the first stages of a circular system to the flow of construction materials created by European the construction industry dictating that ‘by 2020, the preparing for re-use, recycling and other material recovery, including backfilling operations using waste to substitute other materials, of non-hazardous construction and demolition waste shall be increased to a minimum of 70 % by weight’(8). Currently Ireland exceeds this target with a rate of 97% recovery of CDW (9) for the purposes listed where much of that percentage being made up of soil and rock backfilling operations. With reuse targets for material recycling are set to increase to 60% by 2030.

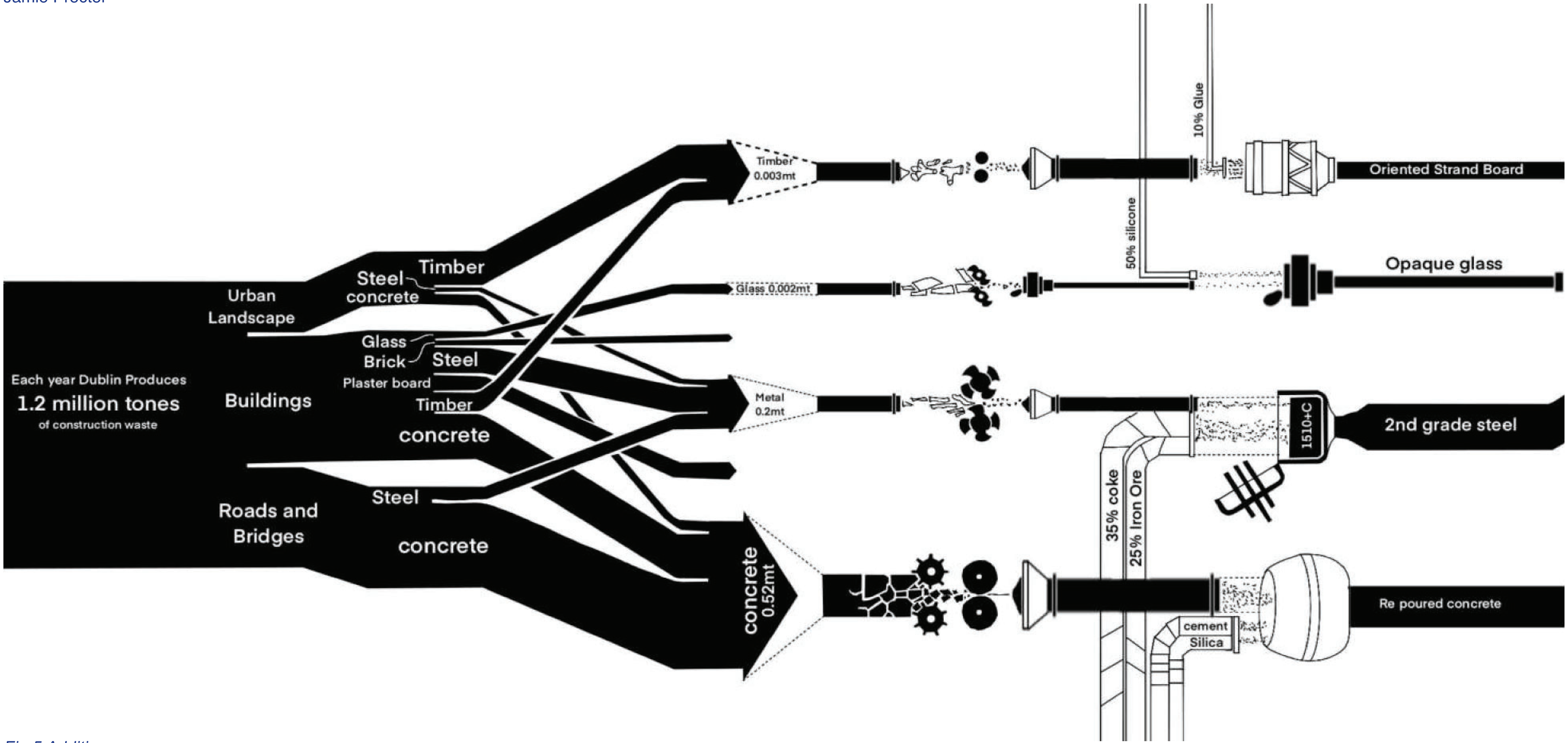


Fig 5 Additive Recycling

Recycling techniques

Annually Dublin produces 1.2 million tons of CDW (10) excluding soil and rock debris. the Processing of materials post end of life stage vary from category to category with the major elements recycled consisting of concrete, steel, glass, timber.

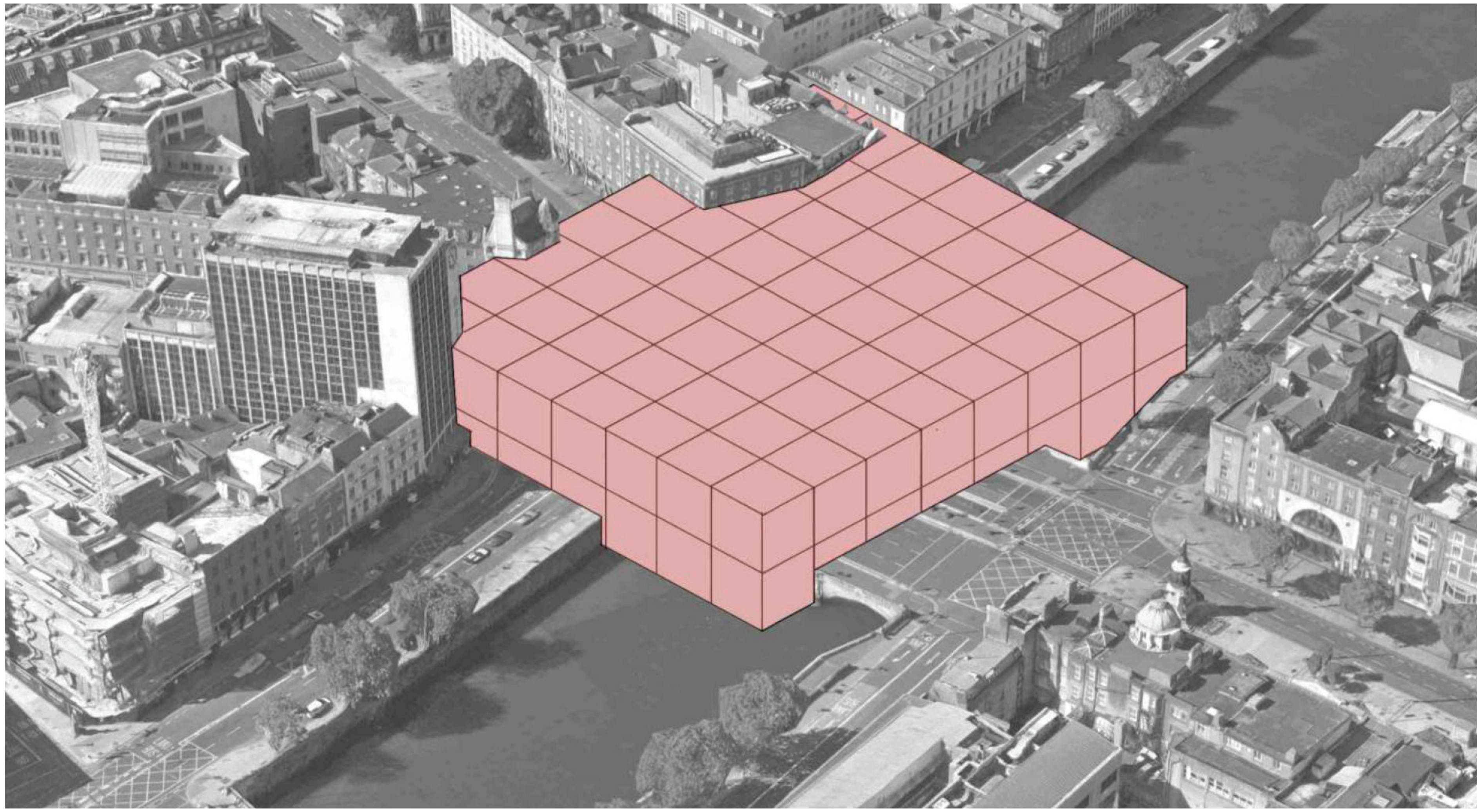


Fig 6 Additive Annual Dublin concrete waste as a single form at 524,605 tones

Conservation of embodied carbon through upcycling reuse and change of function

Unlike recycling, most reclaimed material is downcycled through destructive methods, meaning the material loss of value is primarily used outside the architectural sector. Whereas upcycling is the preservation of an object's embodied value and embodied carbon potential. This value can be summarized in the steps taken to bring raw materials from the point of extraction, their subsequent refining into units of value, assembled into components and the final assembly of the object. Every step along the supply chain requires natural resources, energy, labor, and time. Transportation, and every step creating a total sum of embodied carbon. Every product has embodied energy, embodied impacts, embodied potential.
Seen as a recent development in modern architecture and the built environment, upcycling is as ancient as human society. In relation to the built environment, it relates to the re-use of architectural parts. In the current setting it can be utilized as a means of waste exploitation turning low-value materials into higher-value materials through noninvasive means where it can simply be a simple change of function that brings additional value.

Concrete

Concrete forms the bulk of modern-day Irish constrution material with an annual 524,605tones (10) entering the end-of-life stage in its life cycle from Dublin alone but retains much of its value even while in its demolished form but also has one of the highest levels of embodied carbon in the industry as a whole with 0.92 kg CO2e and accounts for about 7% of global carbon emissions (11). Once transported to the designated processing plant its constituent materials must be separated as modern concrete is a mixture of physical additive consisting of mortar paste, gypsum, Trace plastics, metals and woods. More commonly of chemical additives are added to enhance its physical properties but reduce its recyclability into higher grades of recycled material for reuse as a since unwanted and potentially hazardous composites should not be recycled into new products as a result, concrete is commonly downcycled into an inferior product via mechanical crushing/shredding to form shredded or pebbled concrete aggregate or infill material in infrastructural projects such as road construction. Additional challenges come in the form of percentage tolerances of allowable concrete aggregate in reported concrete in order to meet specific mechanical performance requirements (12) Through recycling it can be found that concrete is subject to a loss in potential embodied carbon because of its material value degradation with additional carbon value added to its transformed state.

Part 2

Prototype

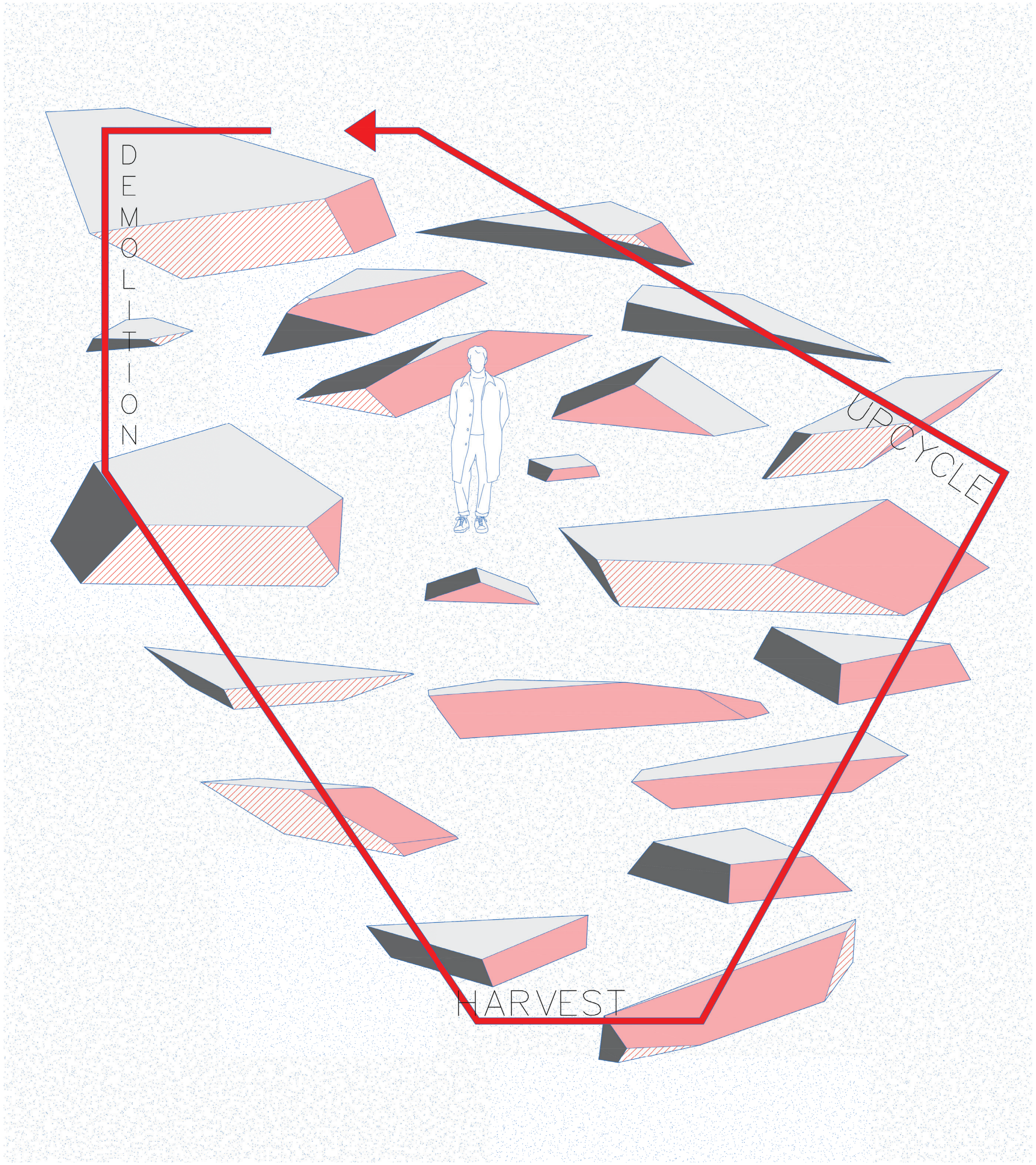
To investigate the viability of the thesis topic of material reuse through change of function and reclemation a prototype was created to test the

process in the field

This stage of the investigation focuses on the exploration of maximizing embodied carbon reclamation of CDW by means of a combination of both methods of material reuse by architectural means.

To demostrate this process a derilict site was chosen to allow for the best utilisation of its embodied materials.

Fig 7 Material Cycle



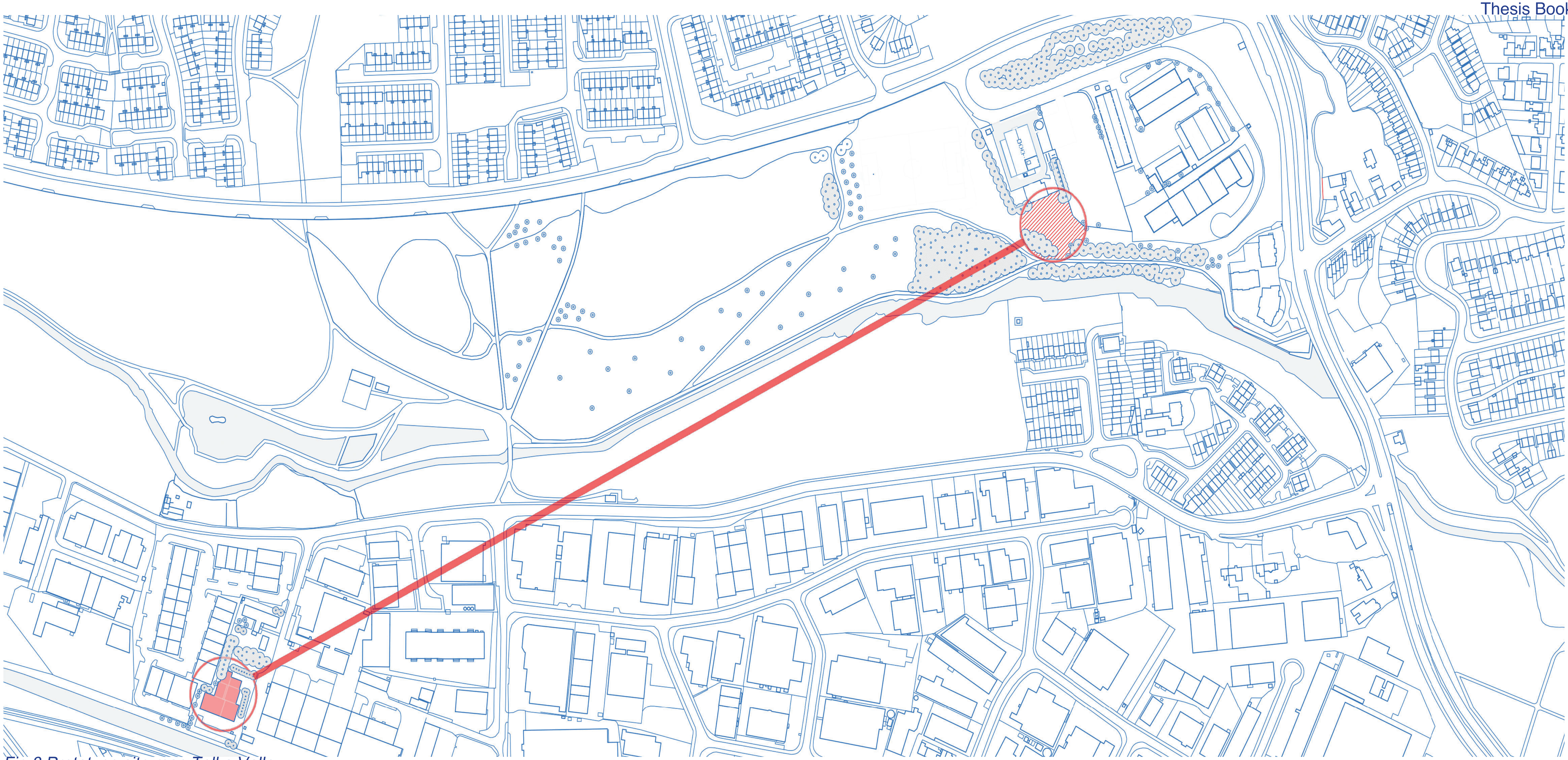


Fig 8 Prototype site map Tolka Valley

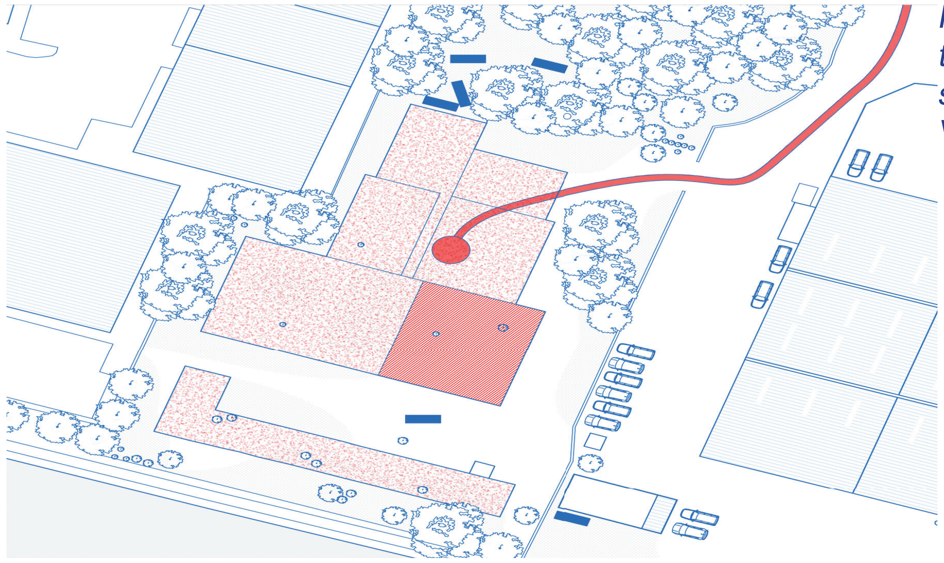


Fig 9 Prototype Material site map Tolka Valley

The chosen site situated within tolka valley north of inner city dublin consists of a series of abandoned foundation slabs left unused since the 2008 economic crisis. As a change of use of the site would require that the slab be repoured to fit a change of use the existing slab would be unfortunalty be sent to landfill.

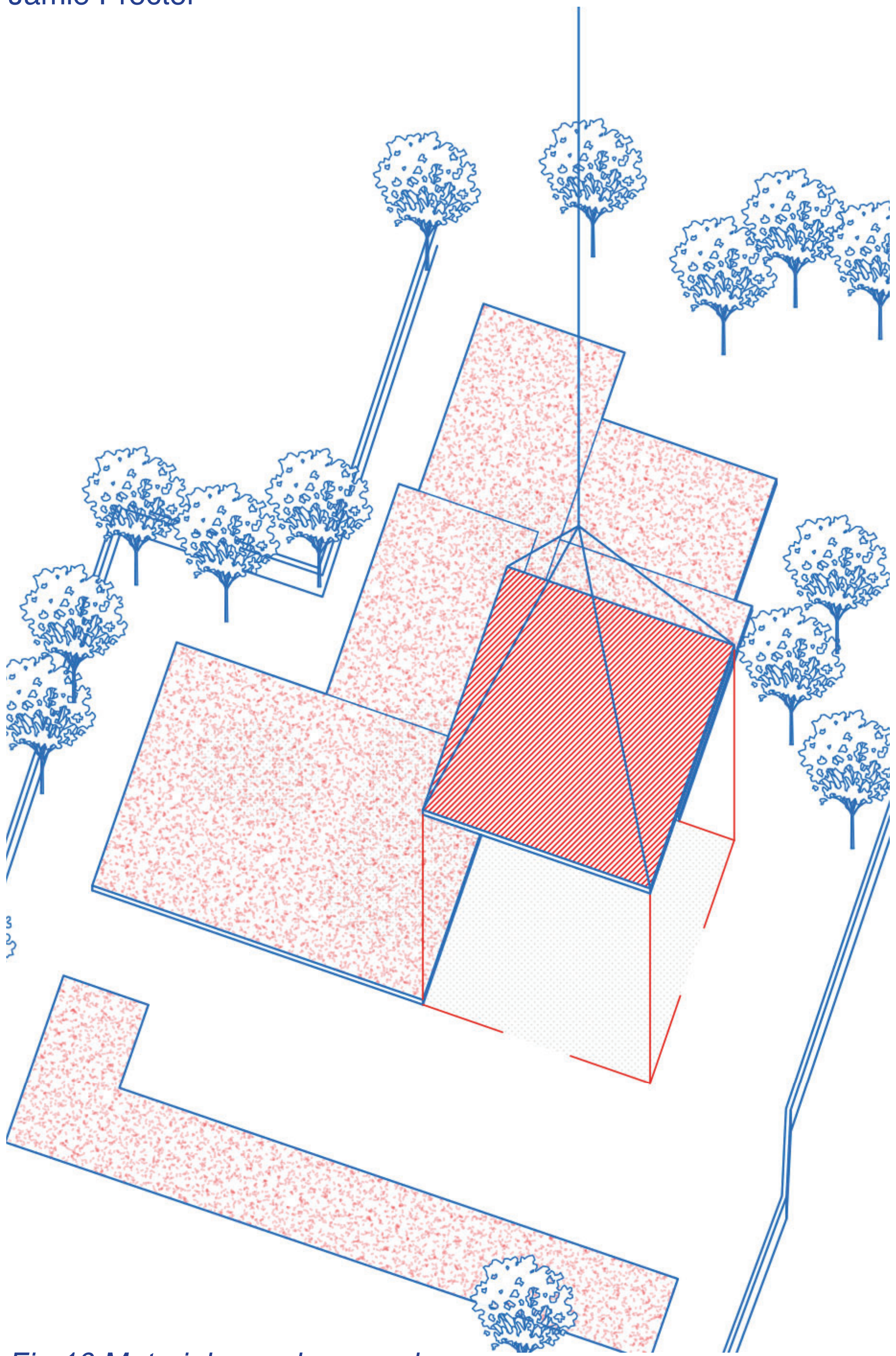


Fig 10 Material sample remval

In its current form the foundation slab may only serve a limited number of functions to rectify this the embodied materials must be freed through change of form. This is also to allow the floor slab to act as a test case for the potential utilisation of concrete rubble as well as pristine structural units. From the demolition of the floor slab we then gain our sample set of materials.

This sample set will then be utilised to created the prototype.

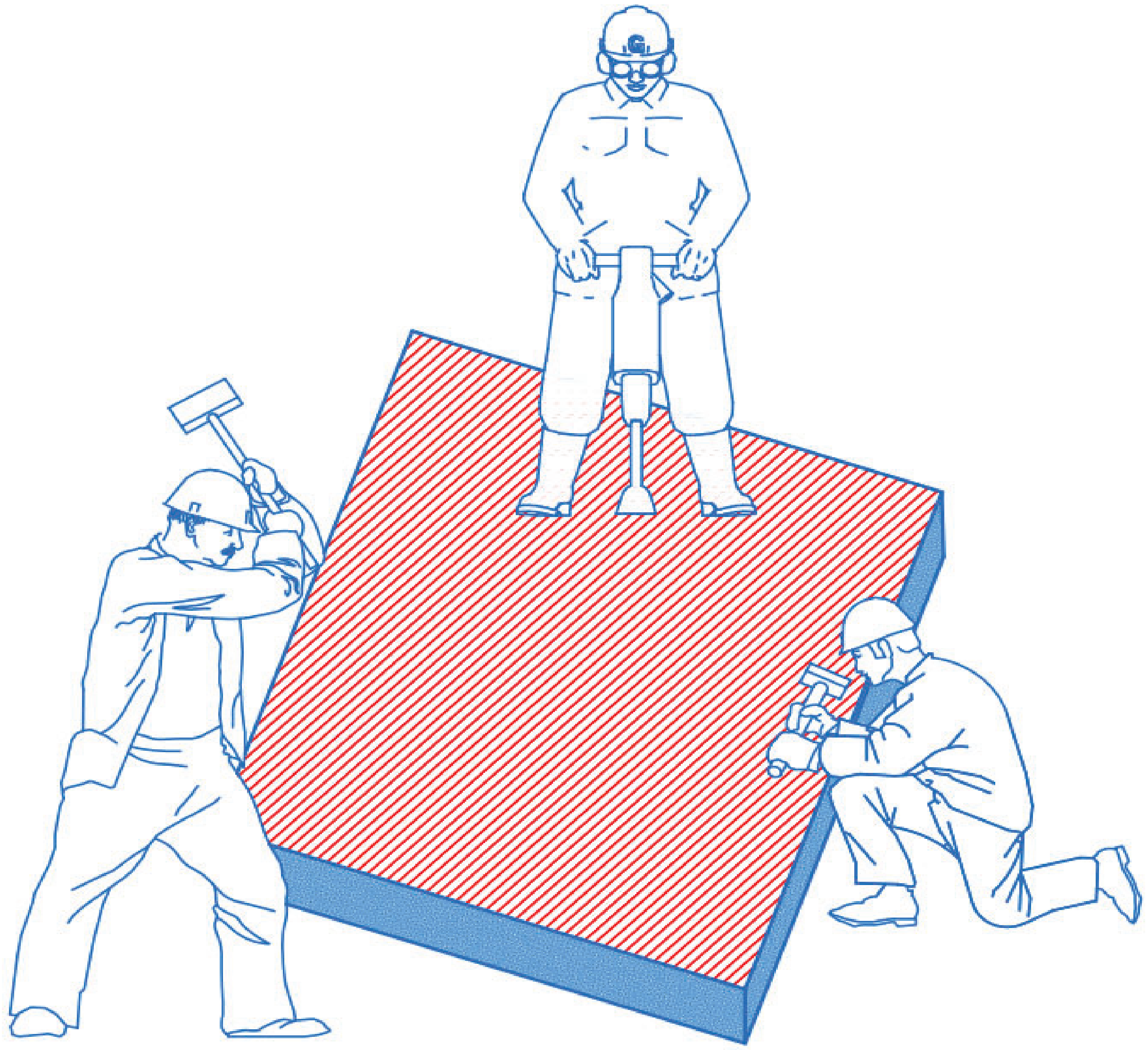


Fig 11 Material Rubble sample creation

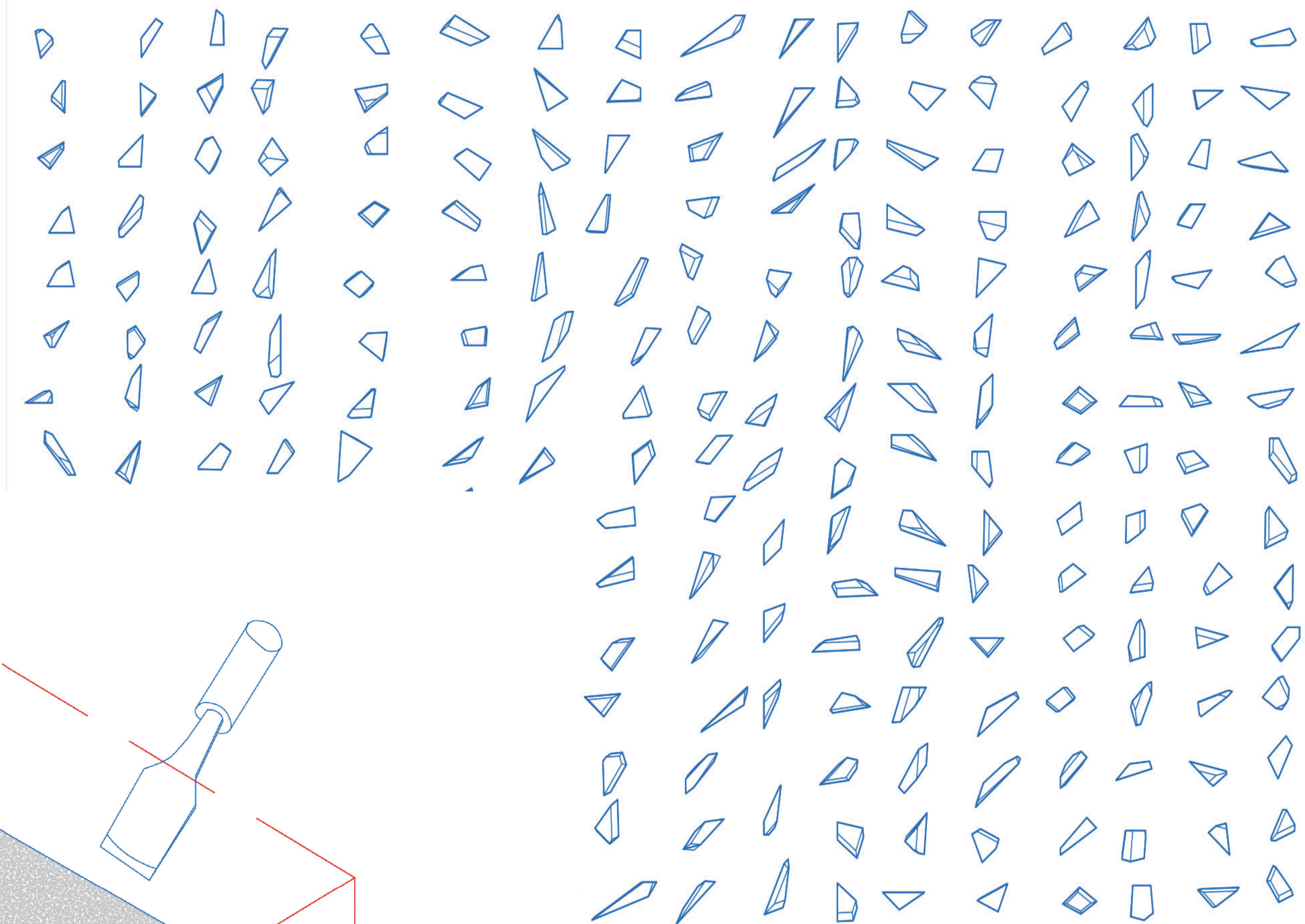


Fig 13 Rubble Sample Set

To fully realise the potential of the supplied materials the show structure was designed in a manner in which it can be structurally sound while performing a role as both wall and roof.

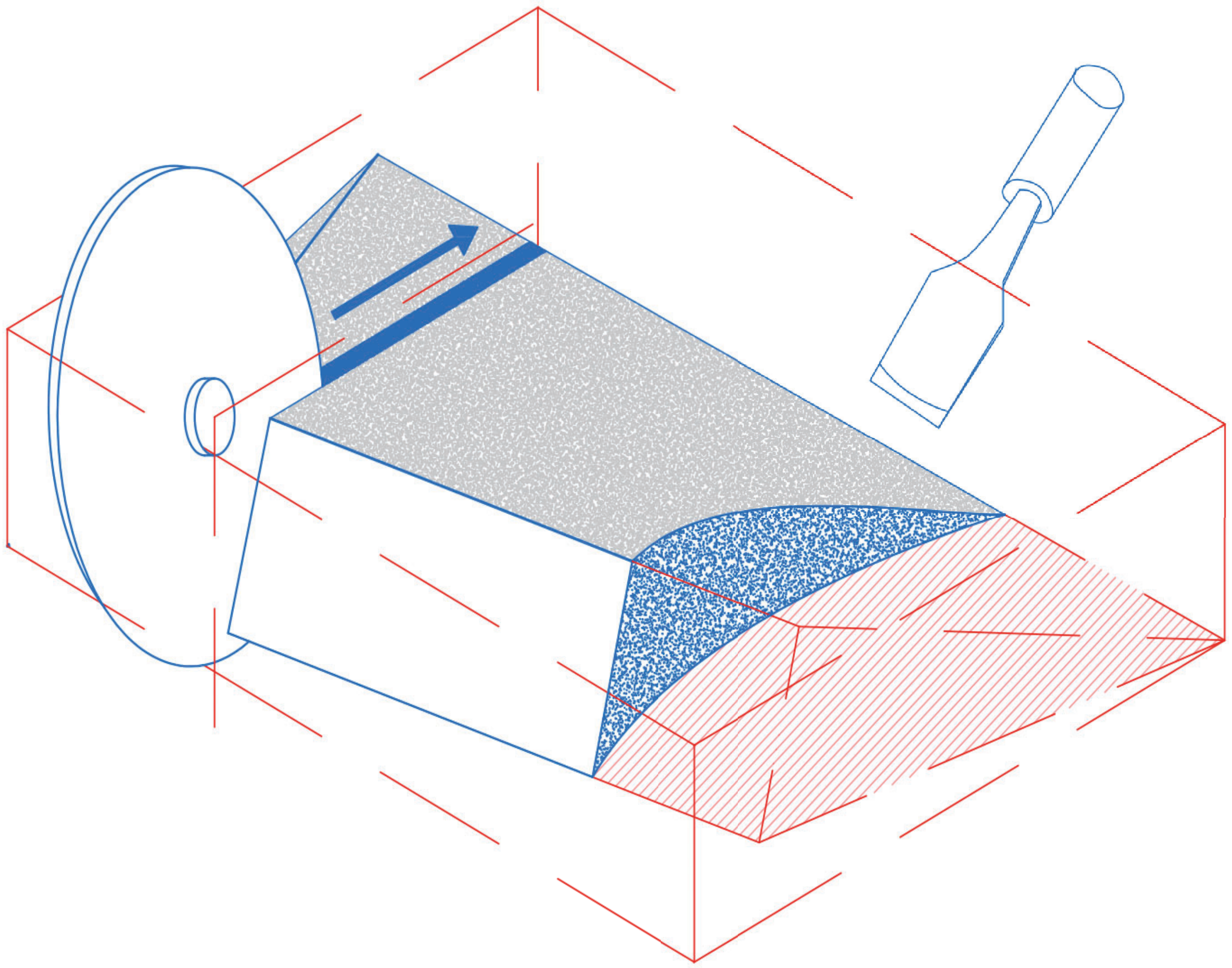


Fig 12 Machining the rubble

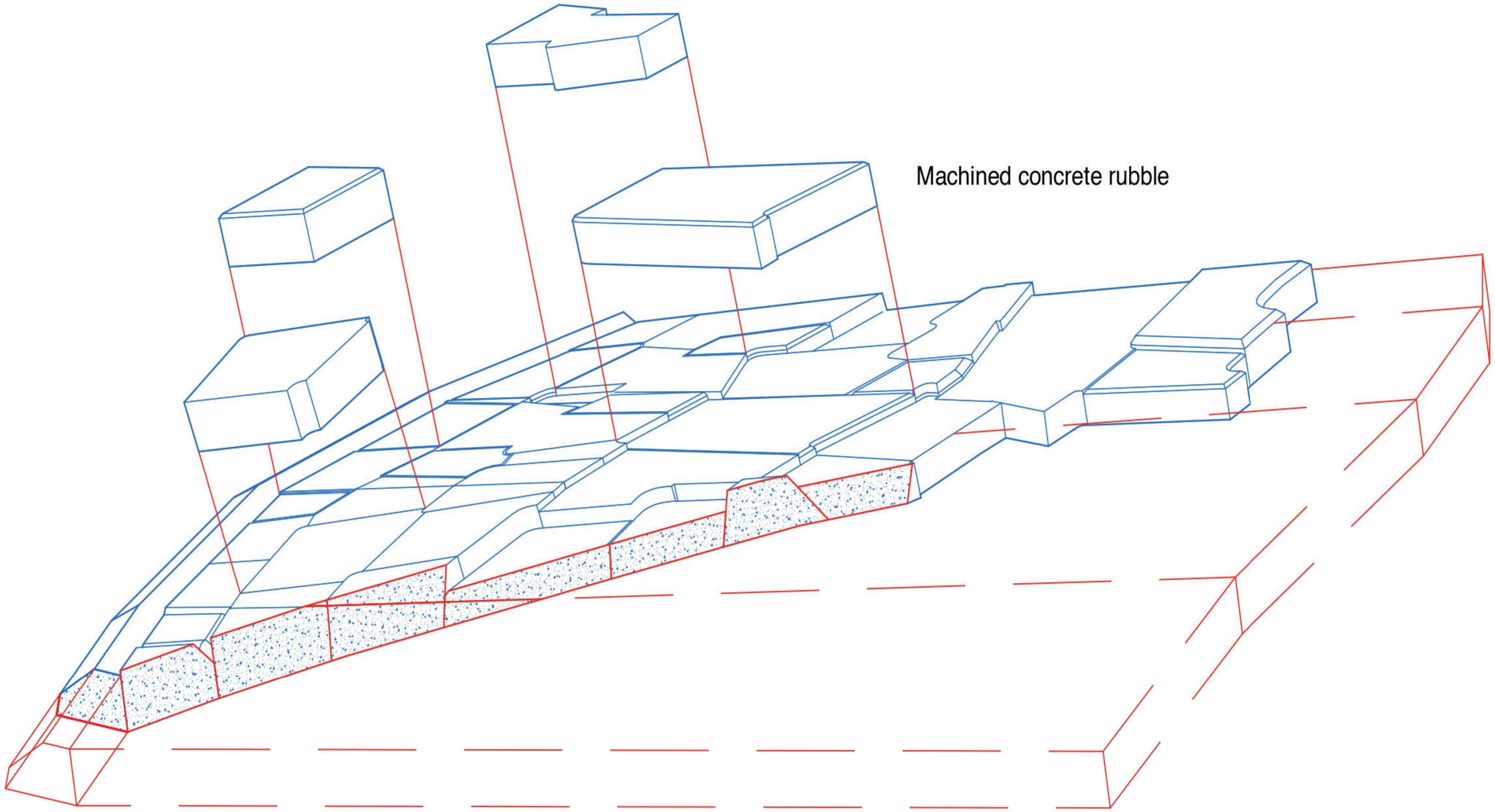
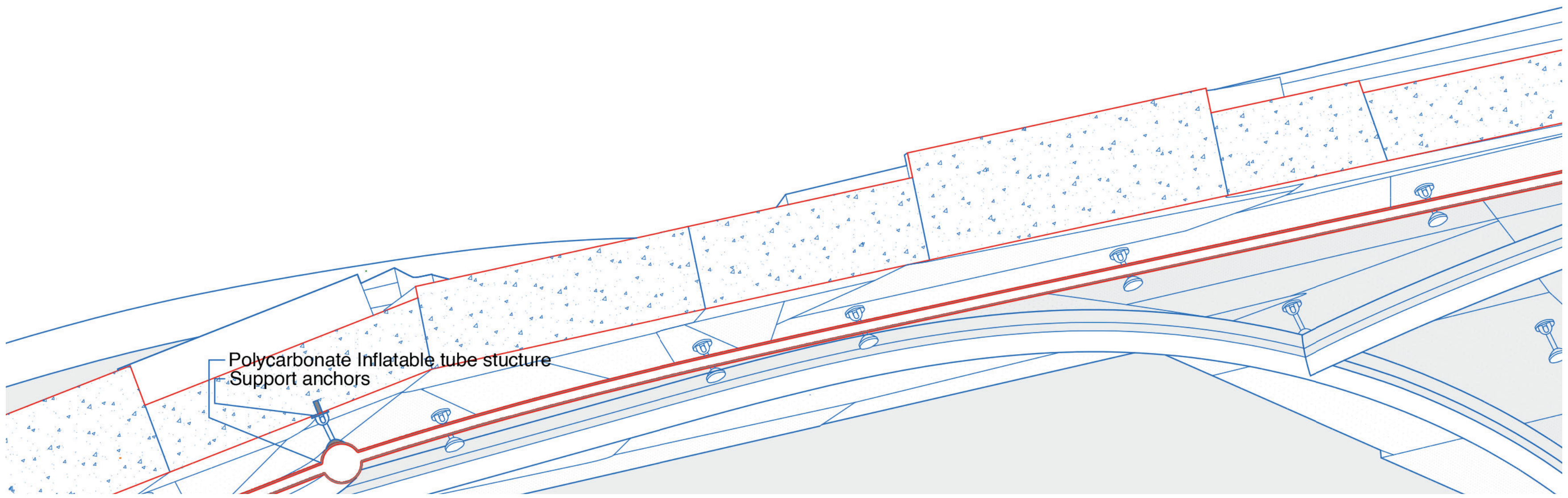


Fig 14 Rubble assembly

Fig 16 Section detail



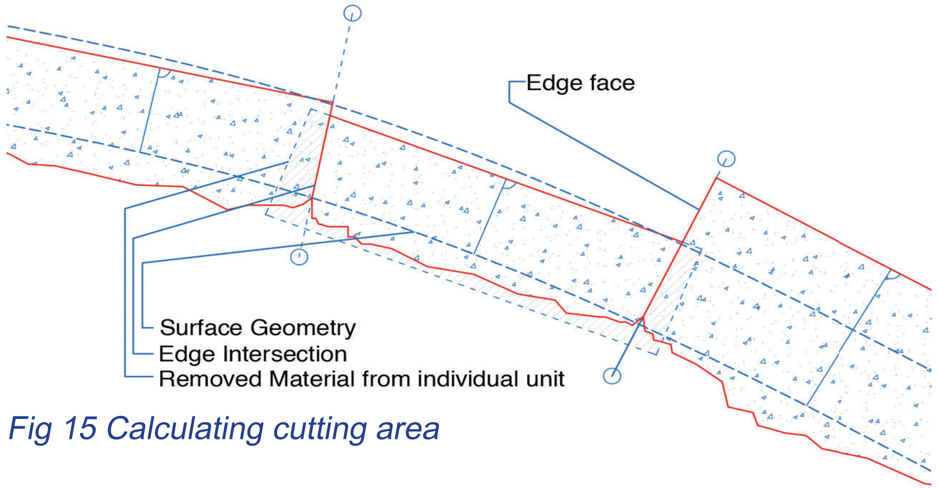


Fig 15 Calculating cutting area

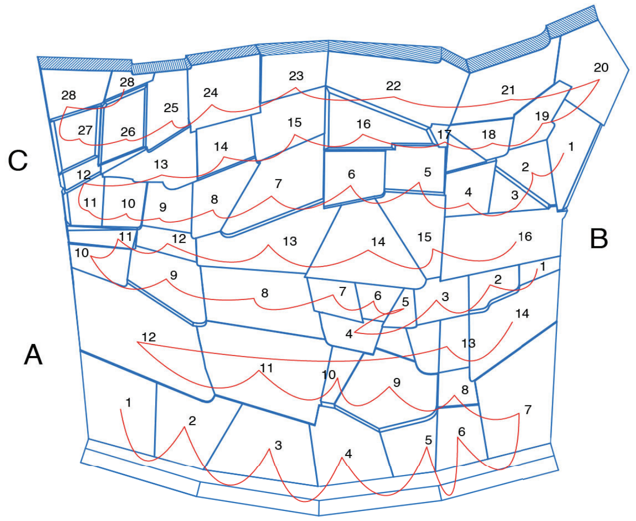


Fig 17 Cyclopean Masonry building order

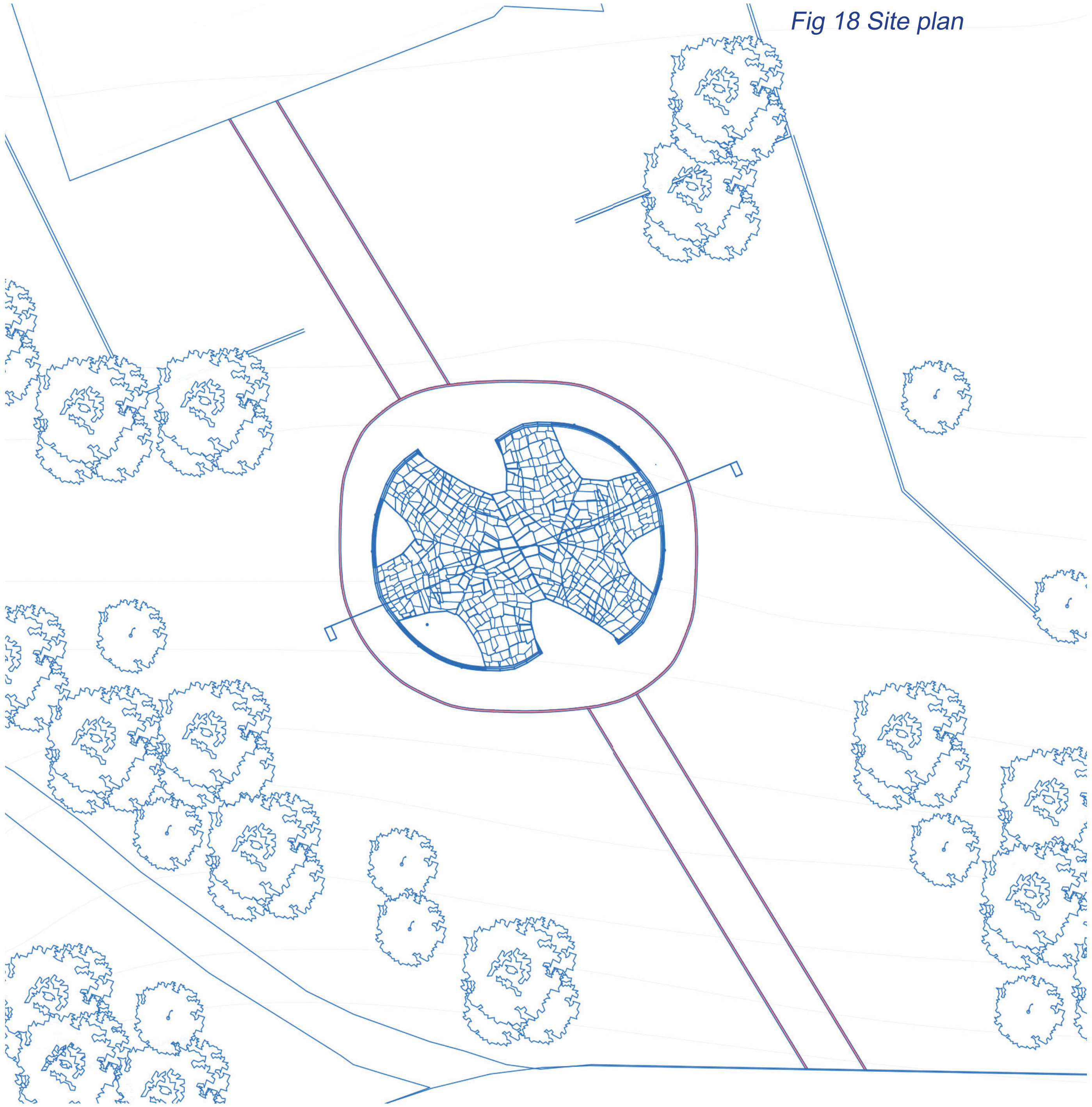


Fig 18 Site plan

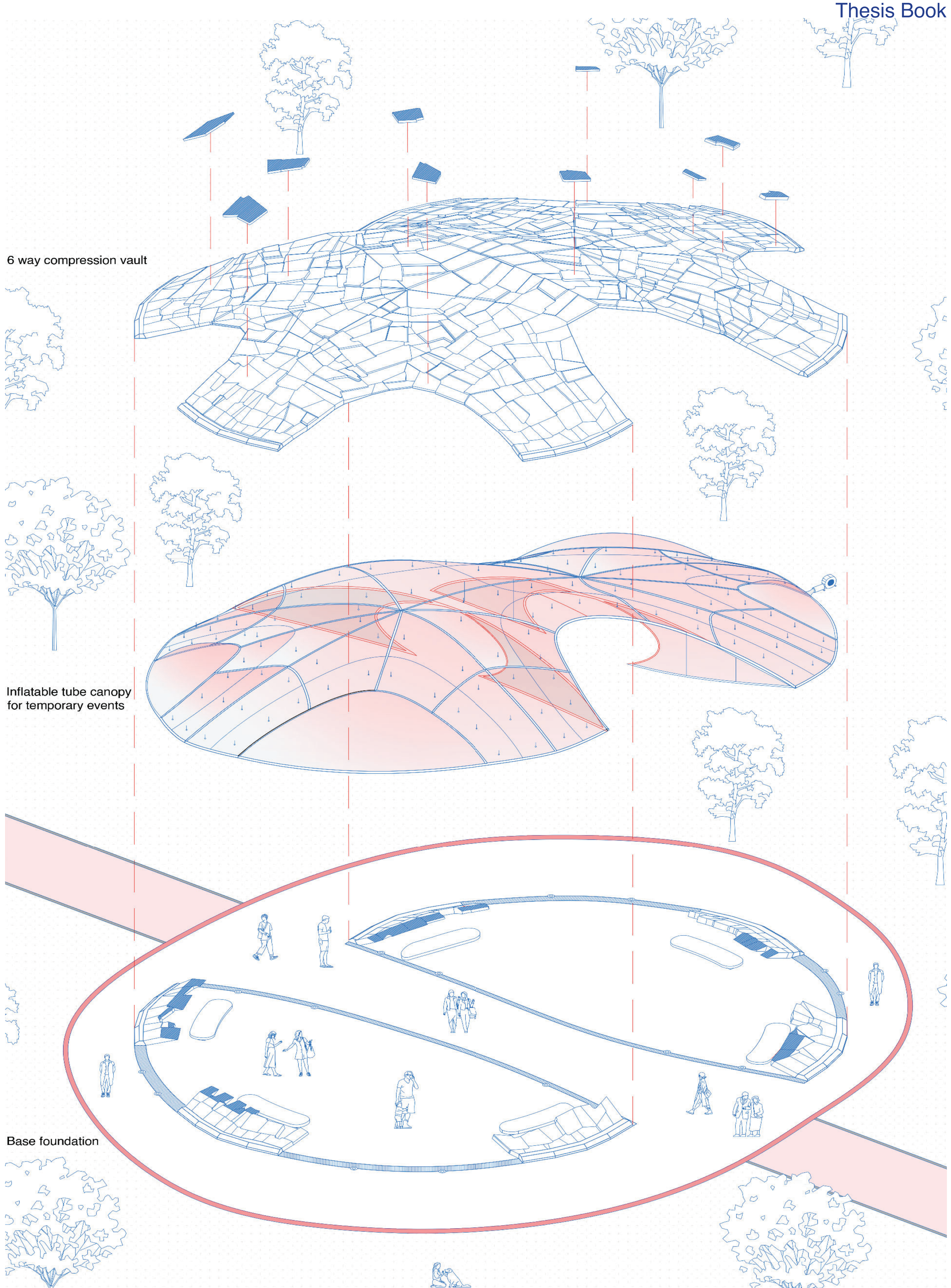


Fig 19 Exploded view

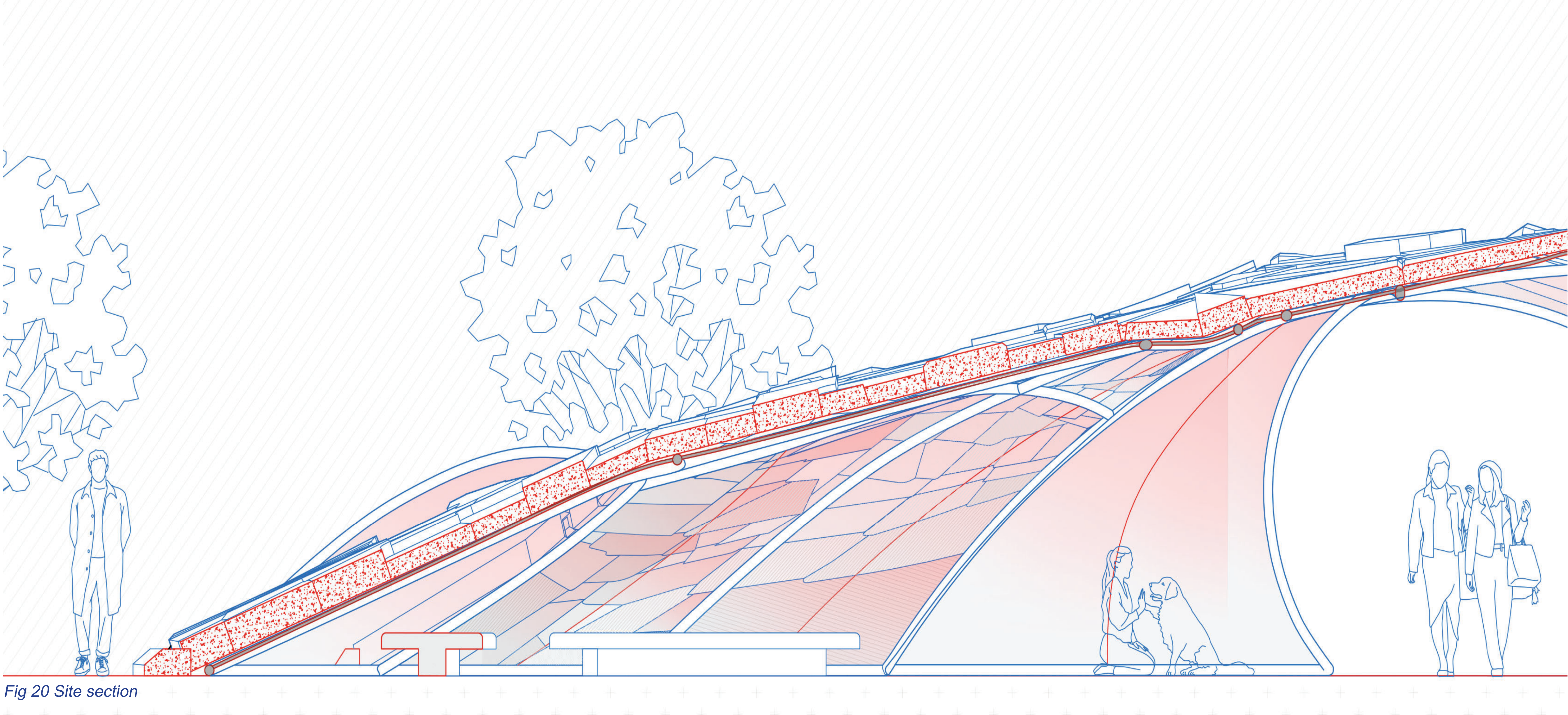
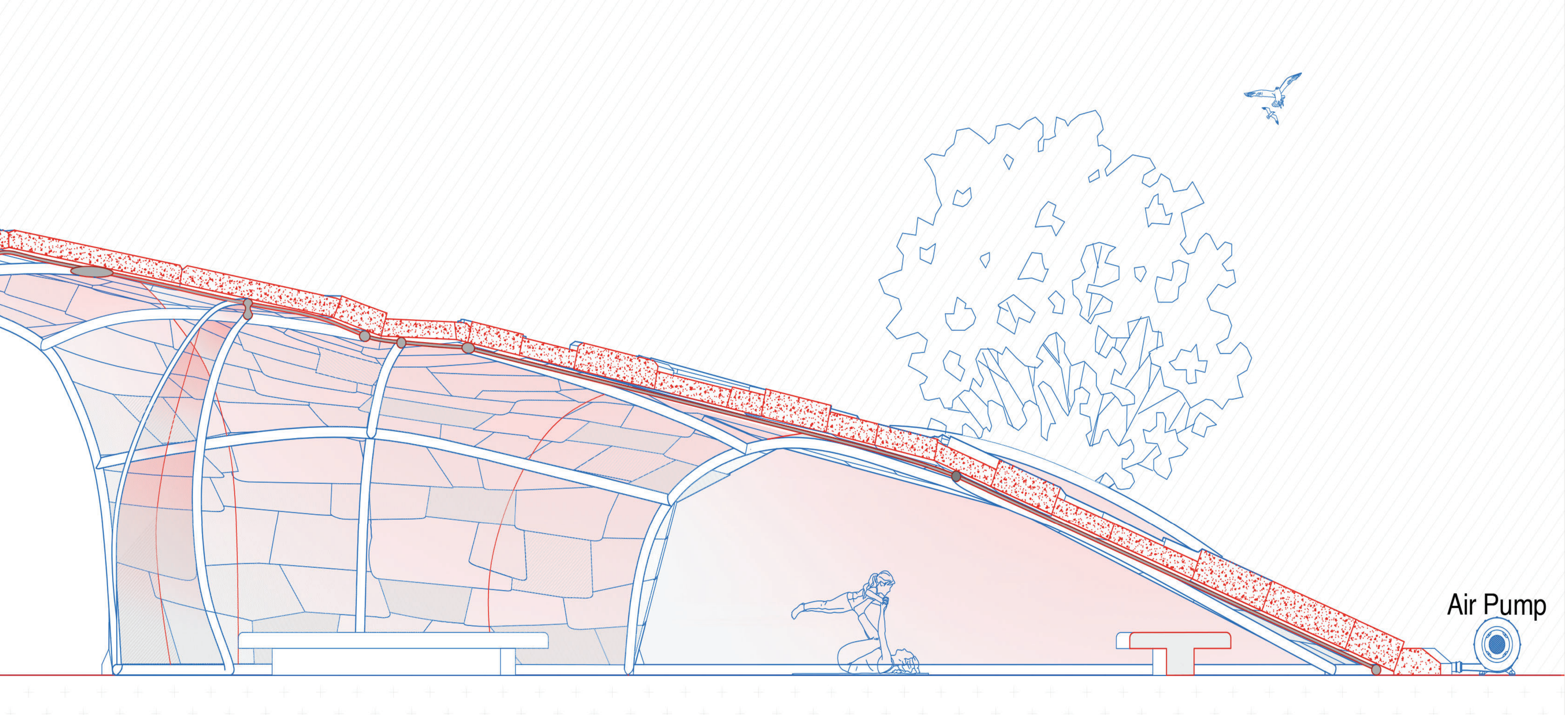


Fig 20 Site section

Inspired by iron age passage tombs the form allows for the supplied materials to perform multiple roles where its original purpose was just that of a floor slab


Air Pump

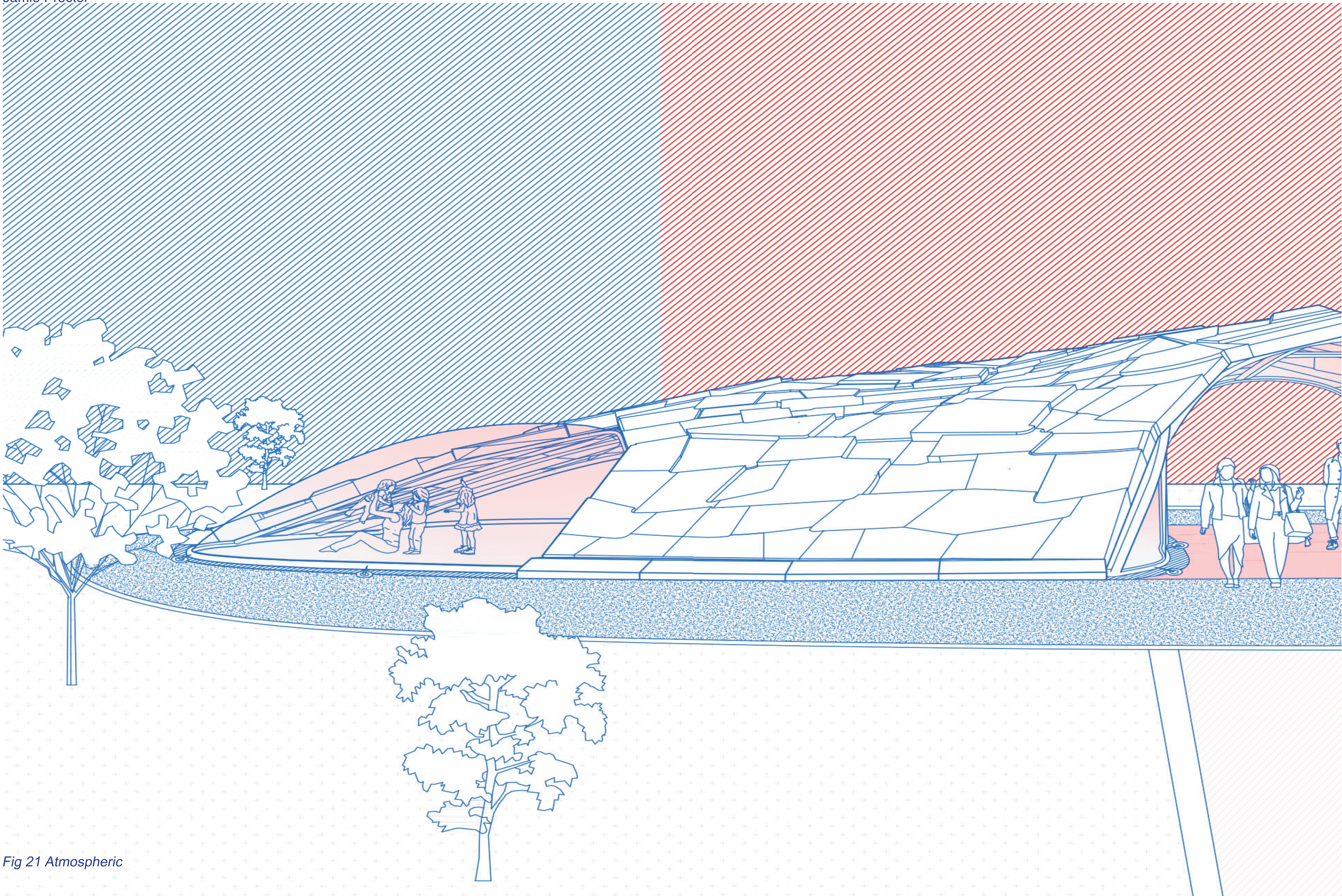
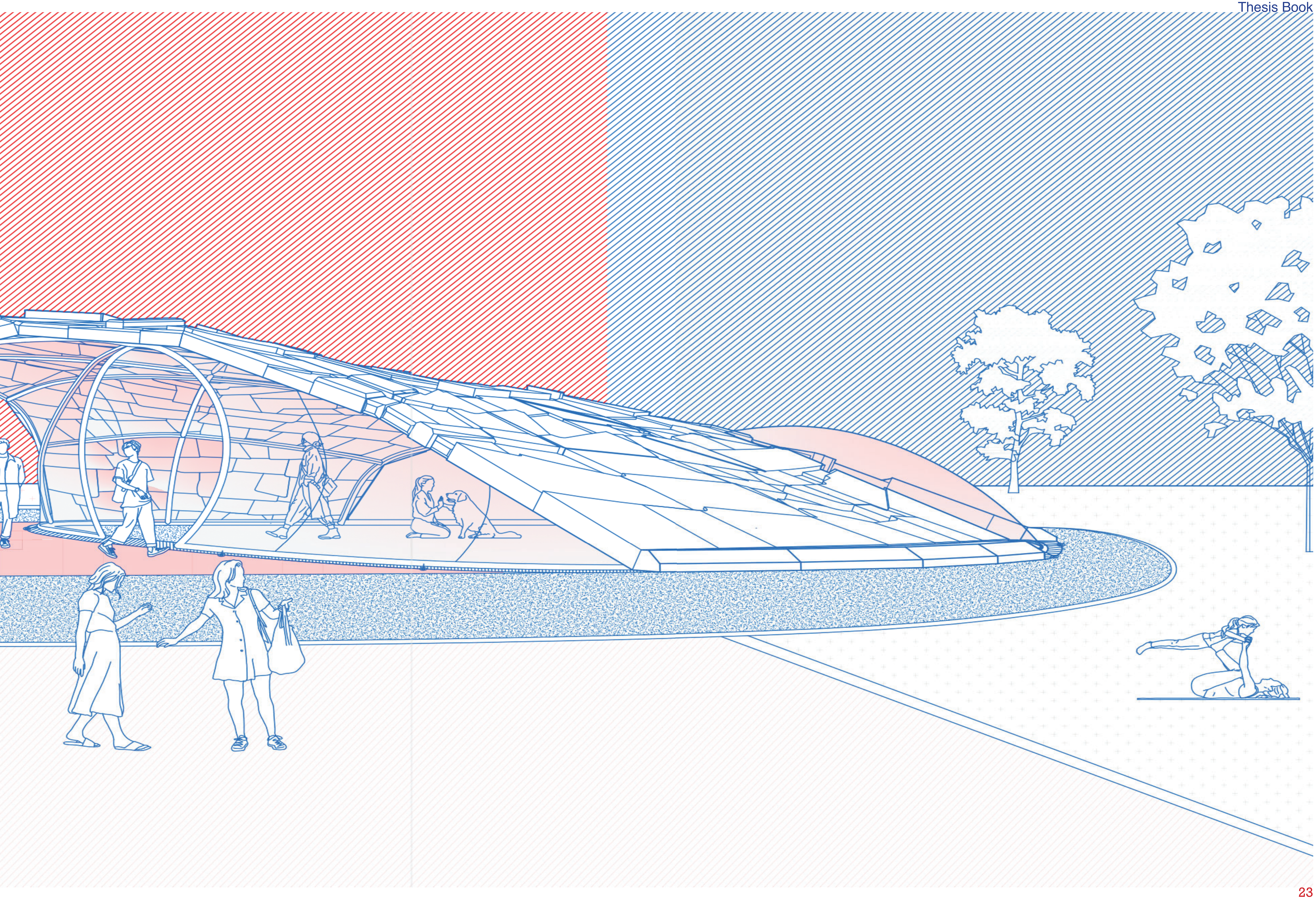


Fig 21 Atmospheric



Part 3

The Quarry

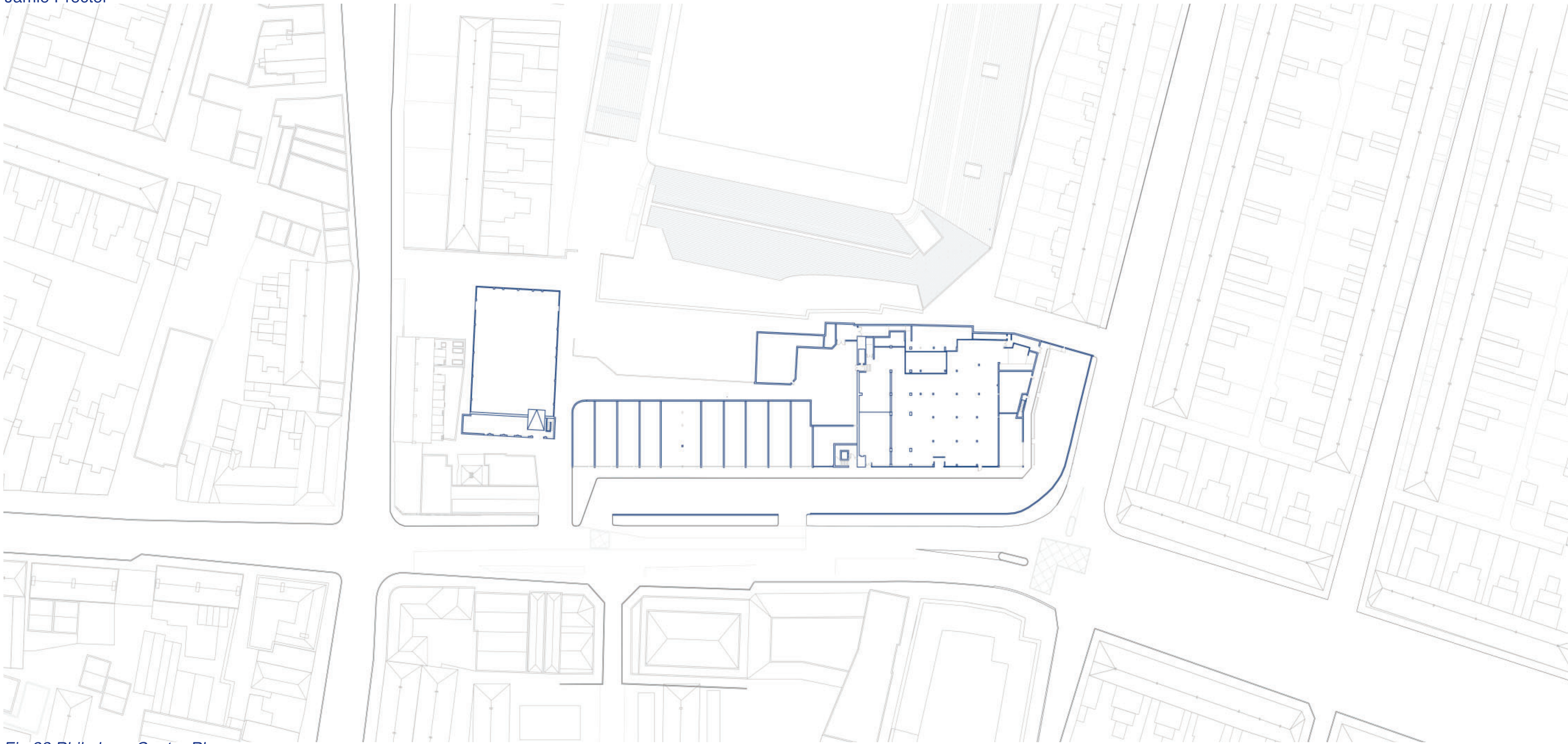


Fig 22 Phibsboro Centre Plan

Fig 23 Phibsboro Centre Photography

The Quarry

To realize my chosen thesis topic where the city is viewed as a continuous quarry where each architectural expression can be seen as a store of materiality alongside the embodied carbon that materiality wealth may embody.

To investigate the architectural expression of such a ethos the chosen site required that it be ripe for harvest metaphorically where its embodied architectural expression has reached the end of its life cycle.

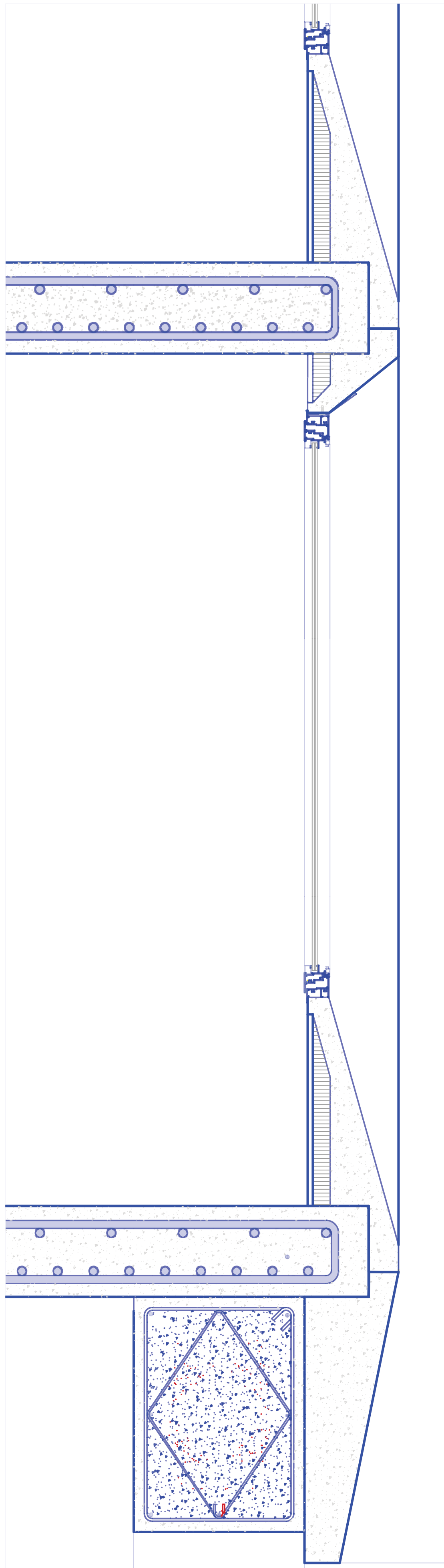


Fig 24 Existing Wall detail

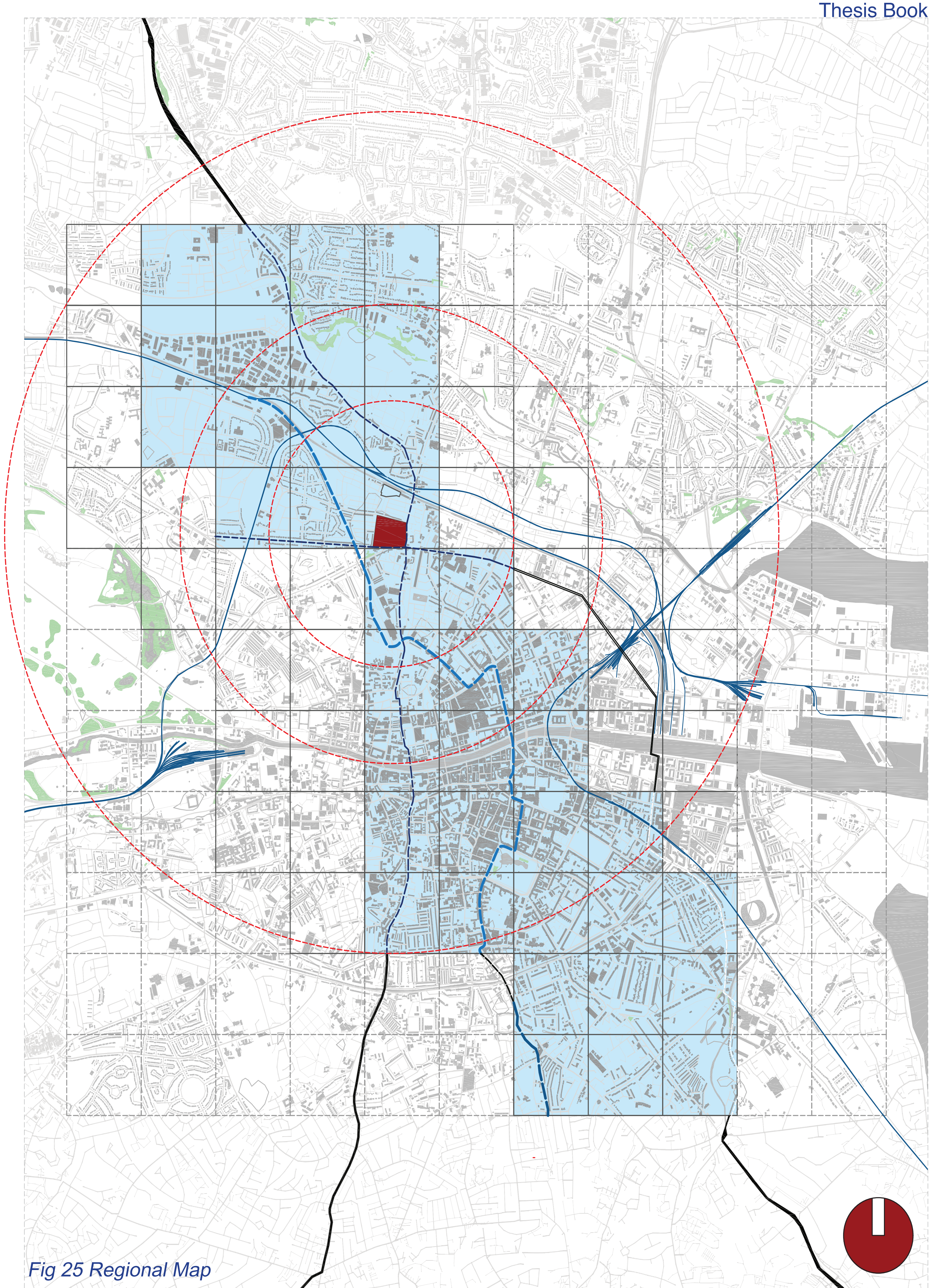


Fig 25 Regional Map

Site

Phibsboro Centre was found to meet the requirements needed to be optImal for material reclamation and up-cycling. Being marked for demolition sometime in the year 2024/25 to make way for newer developments where its embodied materiality would be marked for landfill.

What makes the centre perfect for reuse is its construction. Consisting of mostly precast units the materiality and its structural units are ripe for reuse and adjustment where they may be recombined and structurally changed so that they may serve new functions while preserving its material value and embodied carbon value.

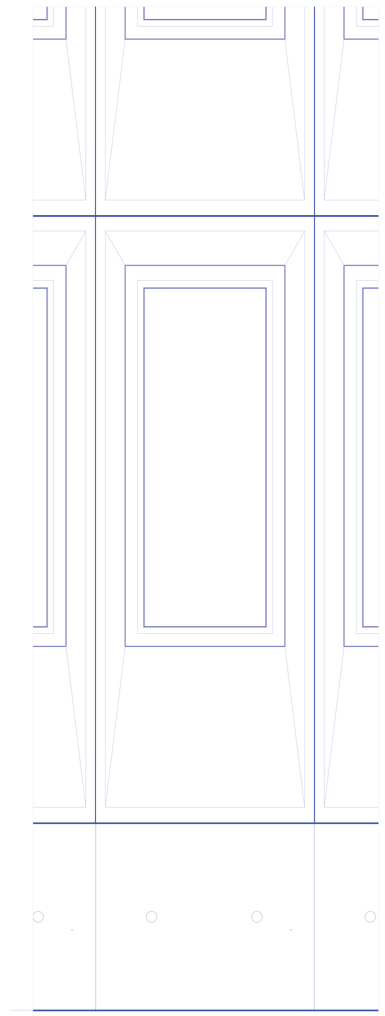


Fig 26 Exiting facade elevation

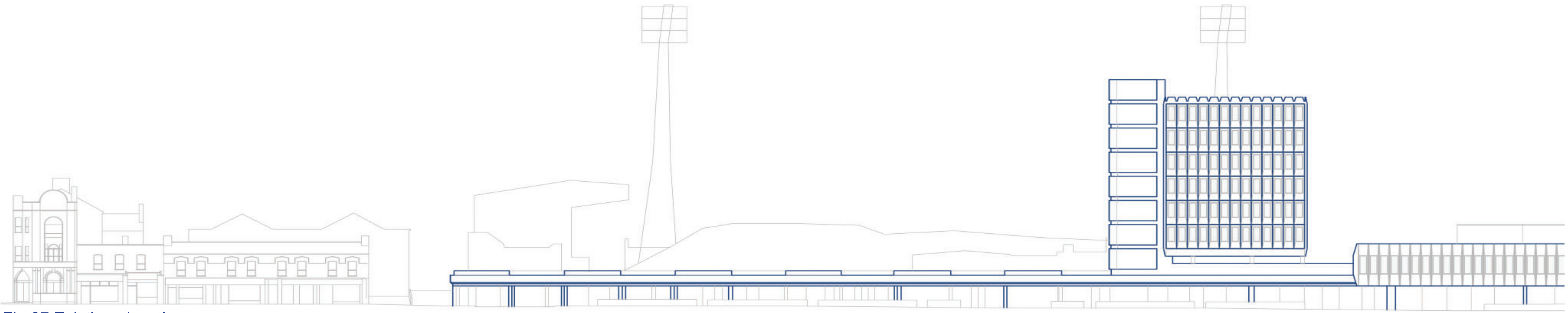


Fig 27 Existing elevation

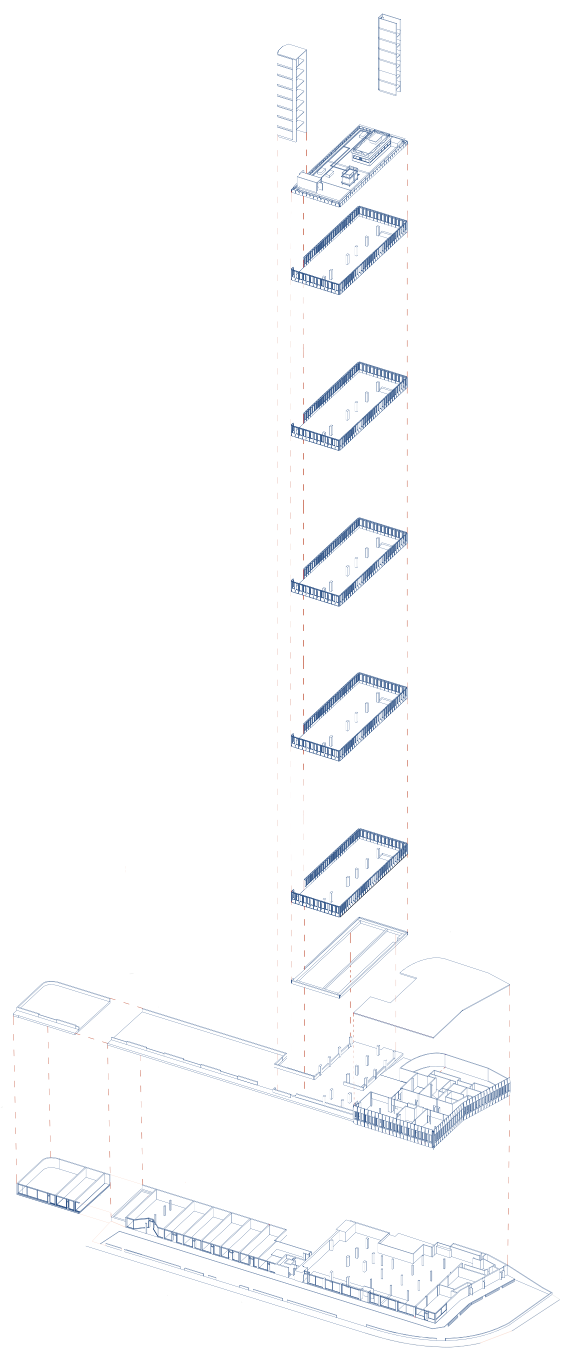


Fig 28 Exploded view

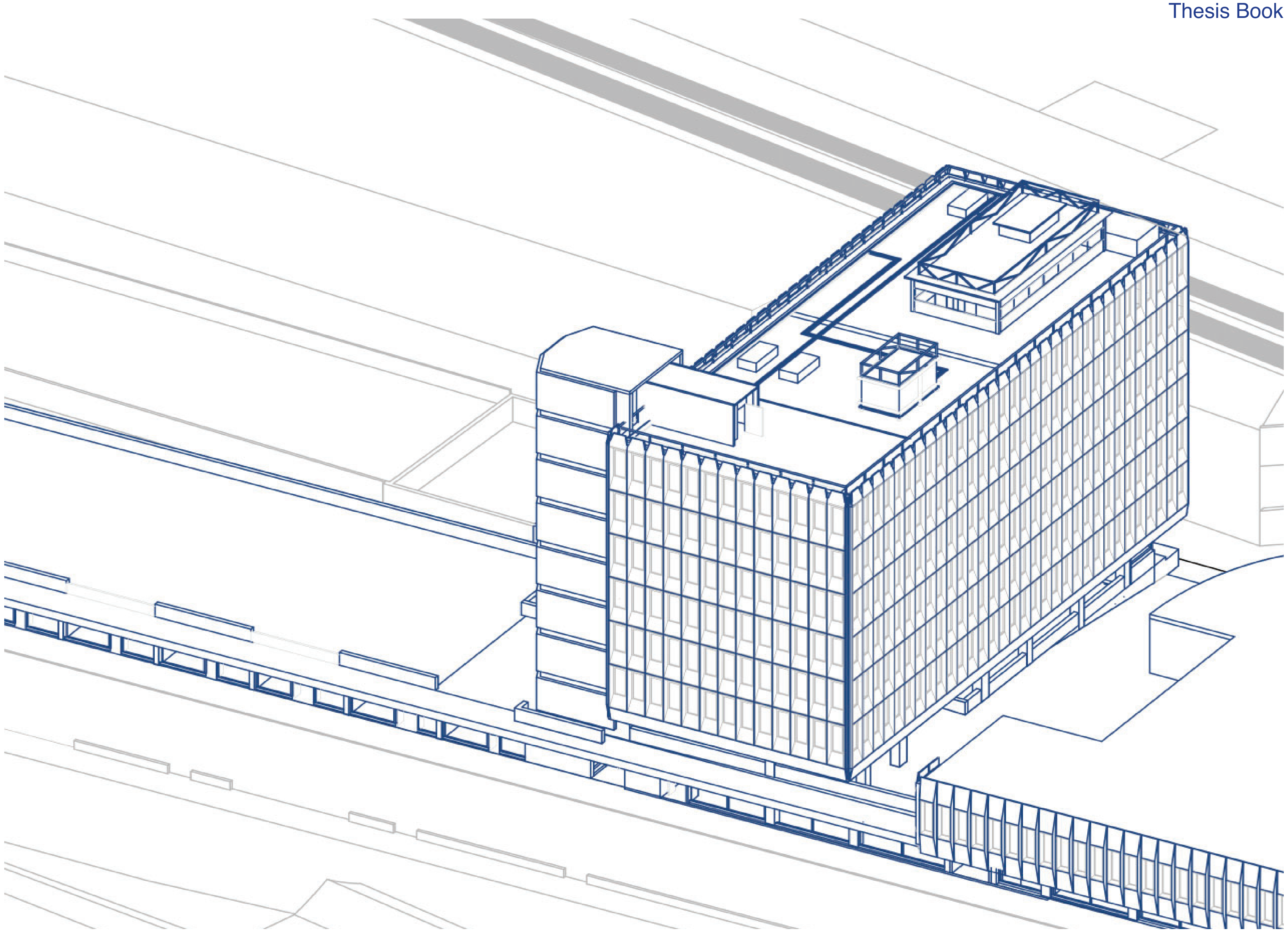


Fig 30 Existing Axonametric view

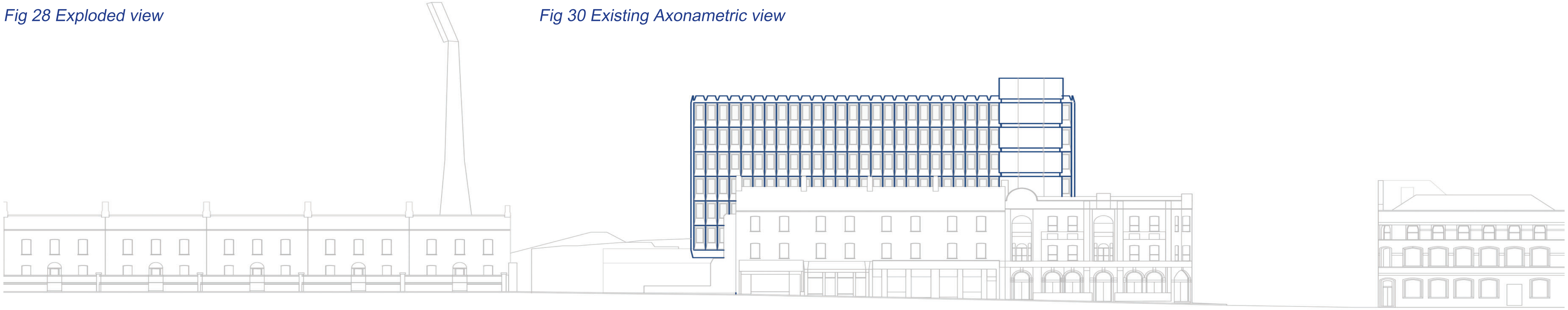


Fig 29 Existing Side elevation

Part 4

DEVELOP-
SCHEME1

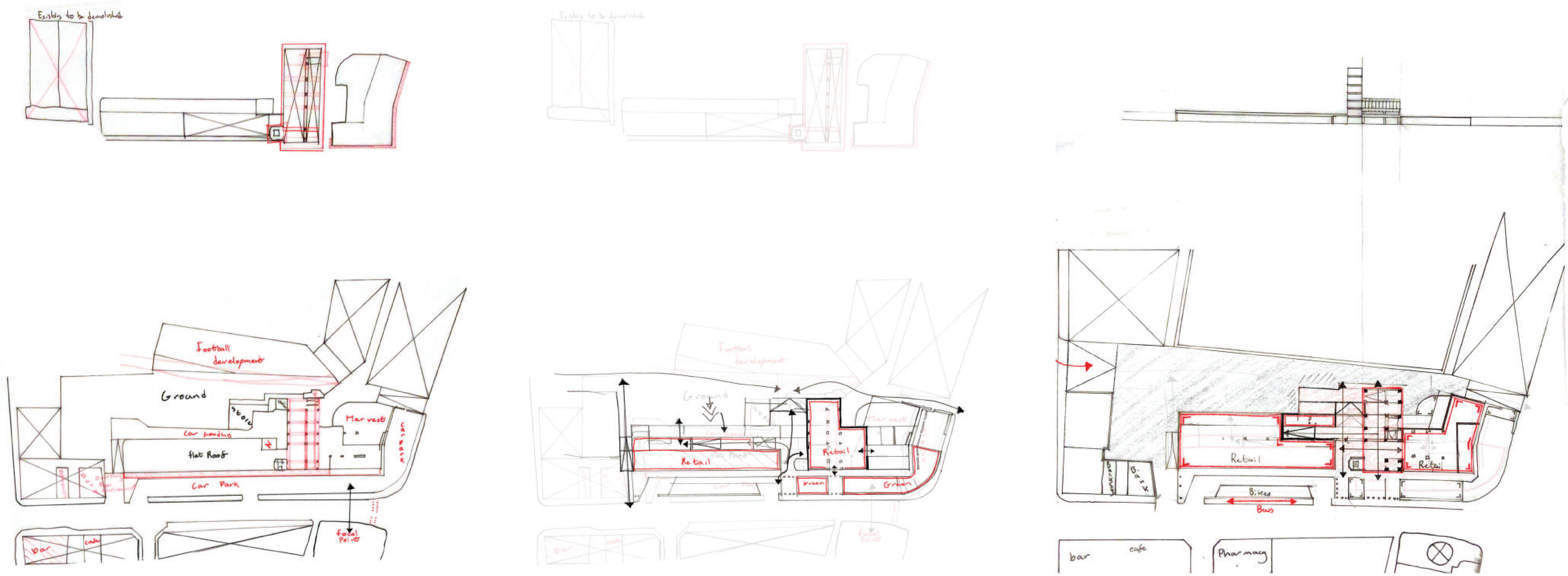


Fig 31 Site analysis

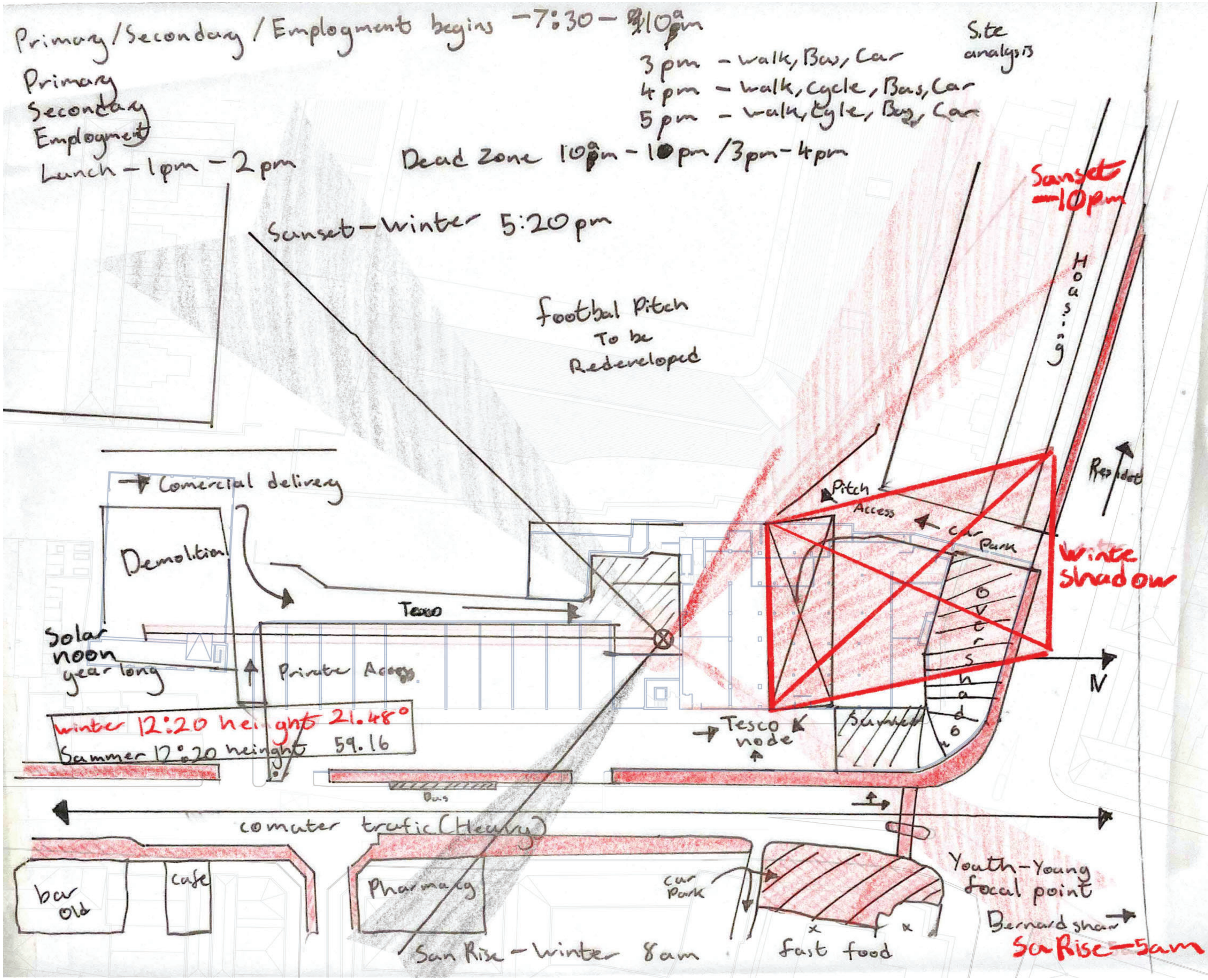


Fig 32 Site analysis
Shadow study

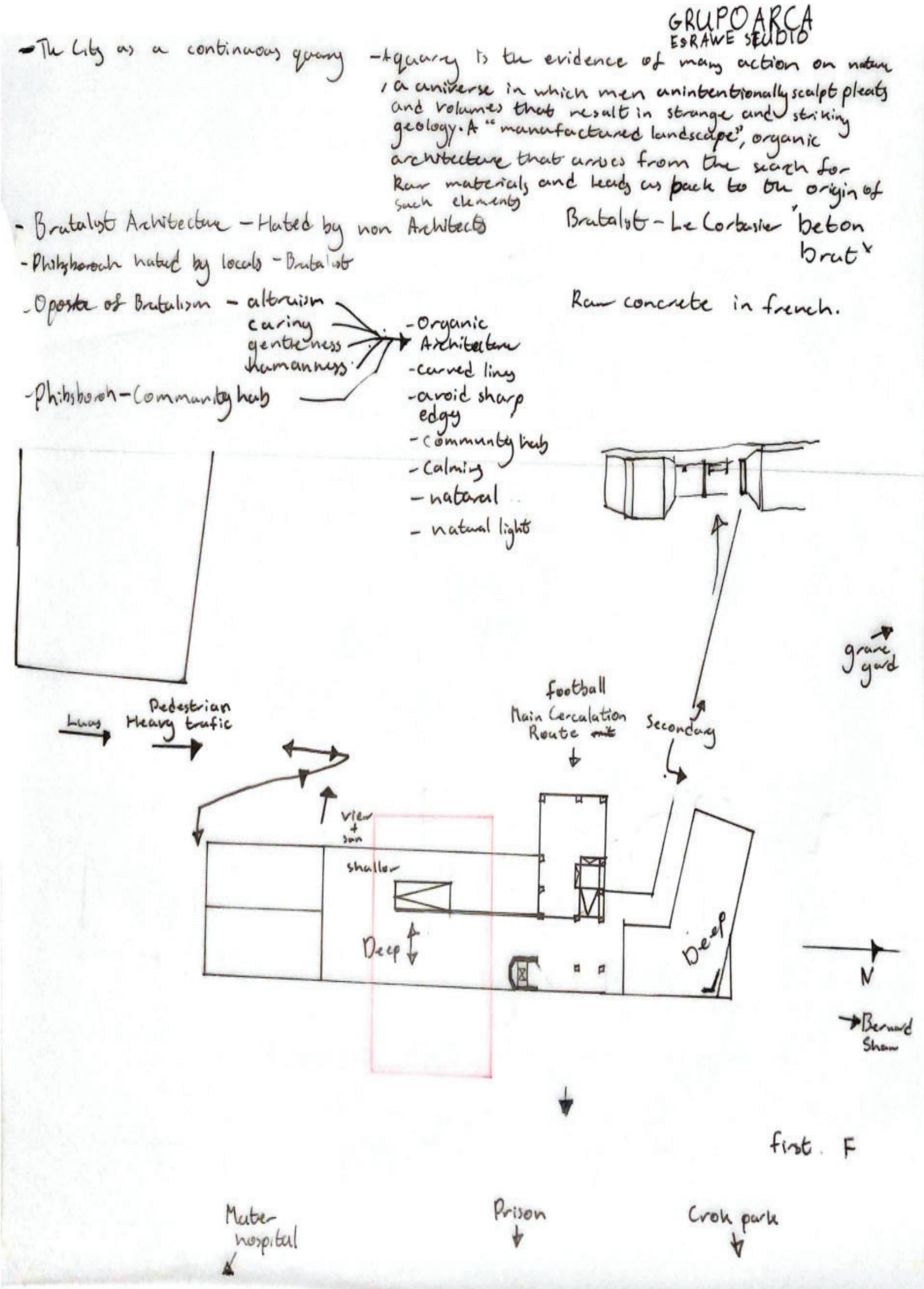
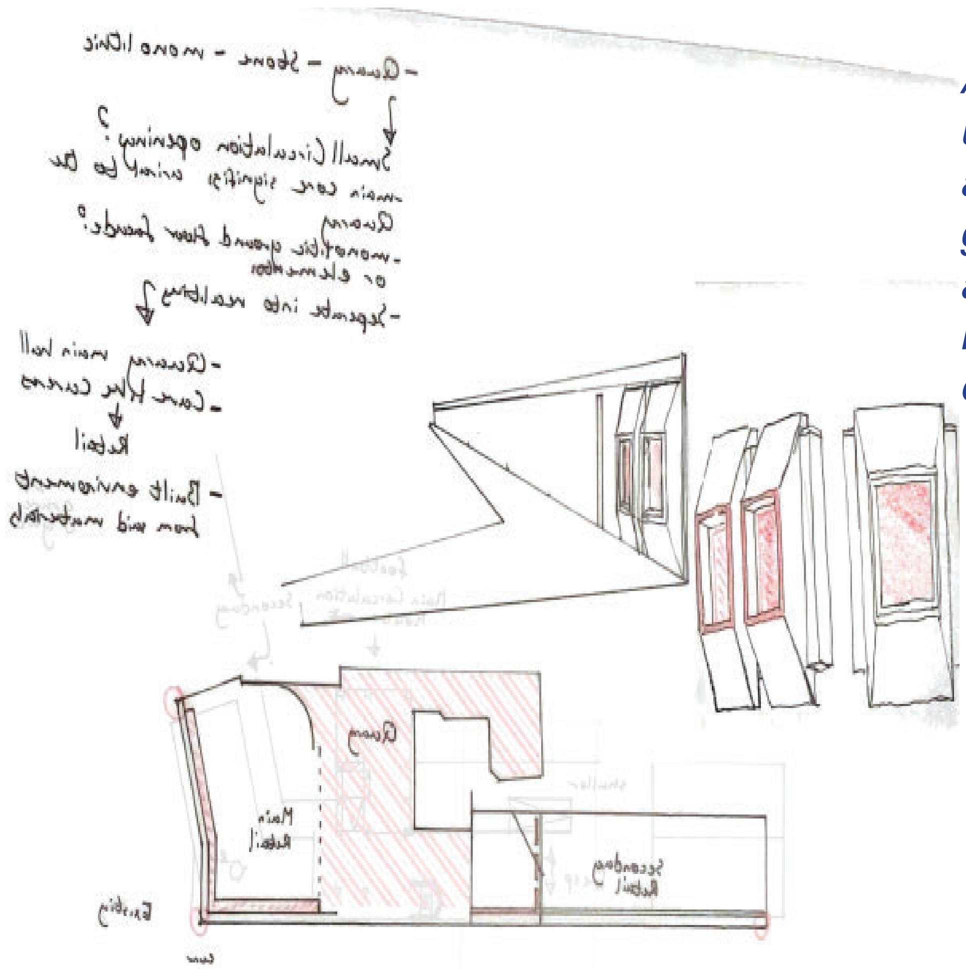
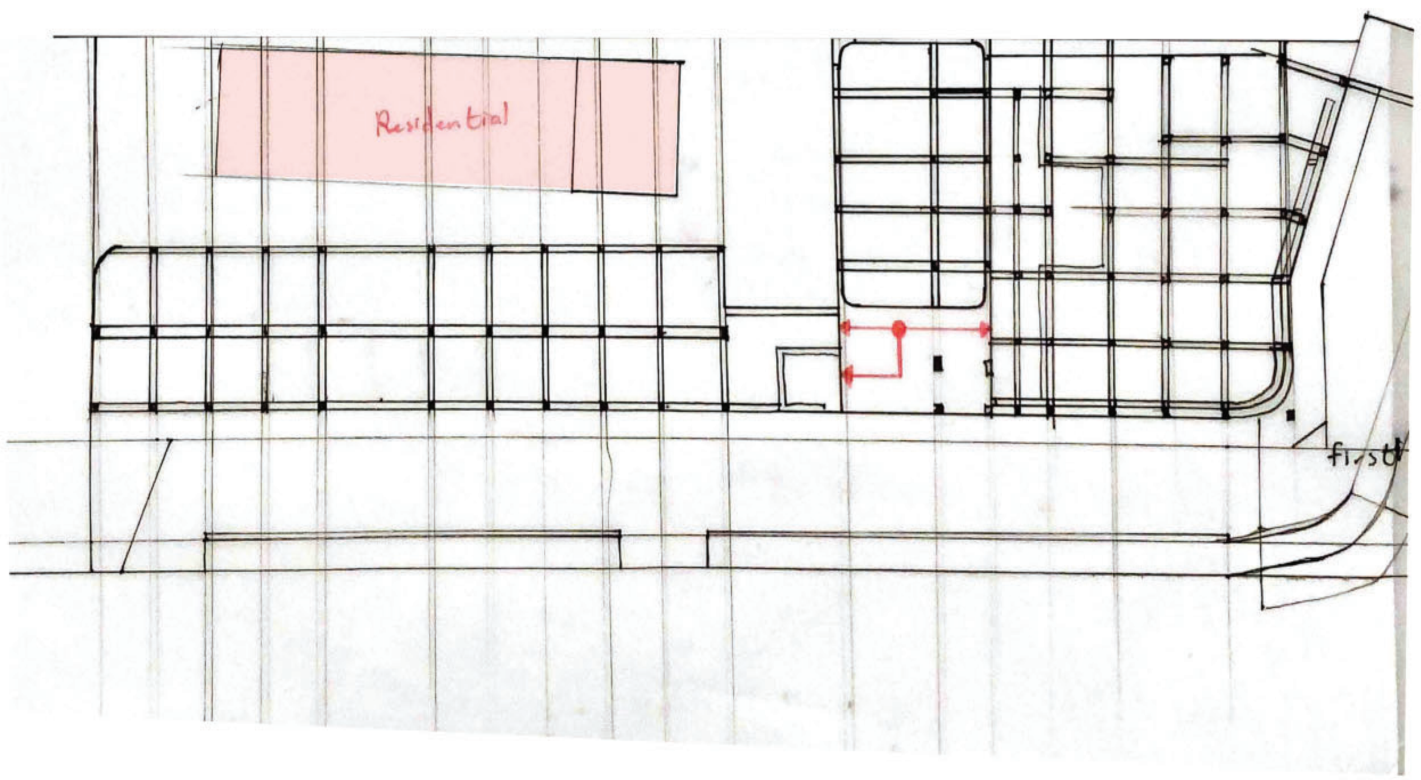


Fig 33 Site analysis



The city as a continuous quarry

A quarry is evidence of mans action on nature, a universe in which men unitentionally sculpt pleats and volumes that result in strange and striking geology .A “manufactured landscape”, organic architecture that arives from the search for raw materials and leads us back to the origin of such elements



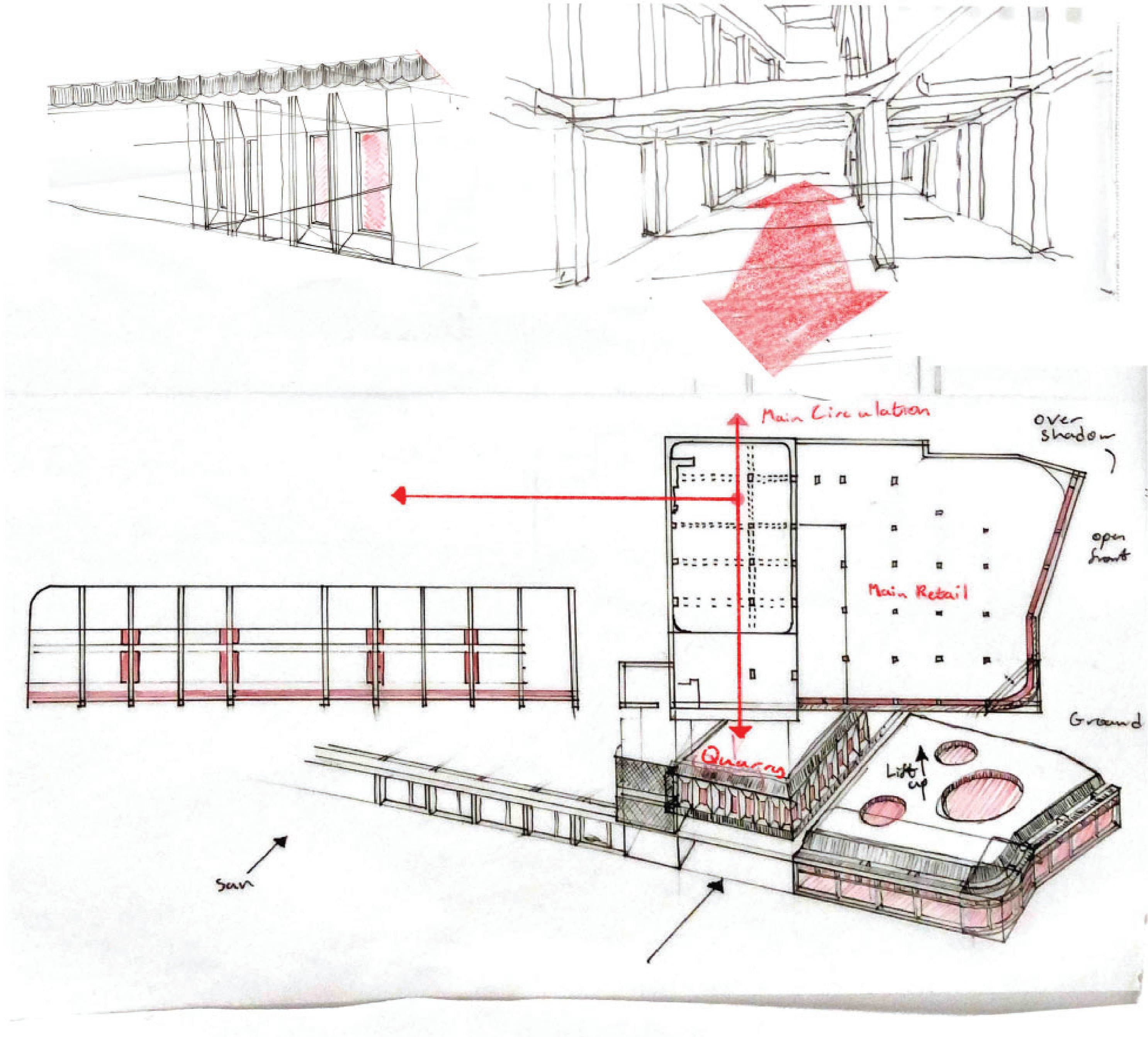


Fig 33 Intervention development

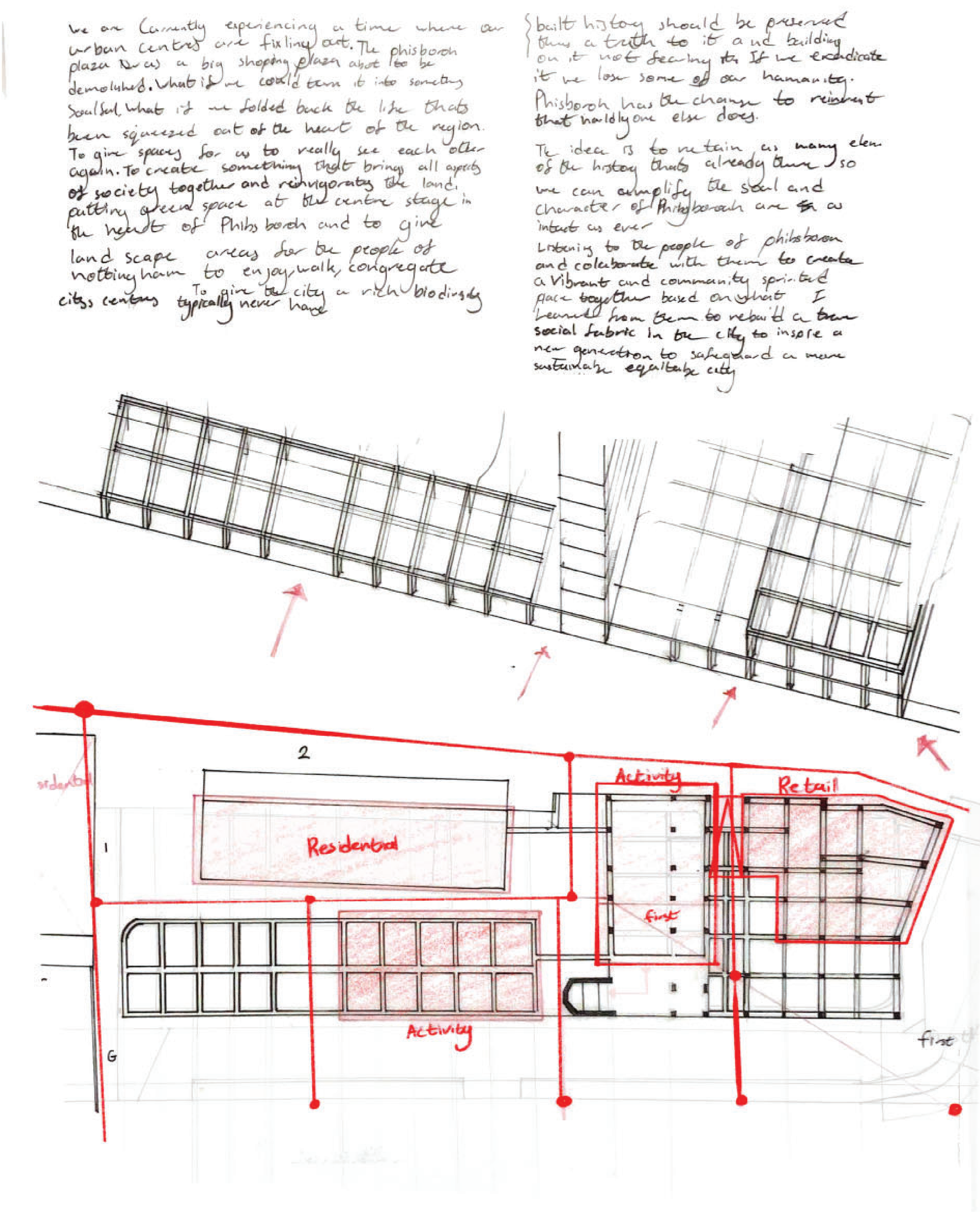


Fig 34 Circulation study

We are currently experiencing a time where our urban centres are fizling out.The Phibsboro plaza was a prime example of this. Currently slated for demolision what if we could turn it into something new and meanigful, what if we folded the life back thats been lost from our urban centres back into the centre of our communities. To give space for us to really see each other again. To create something that brings all aspects of society together and reinvigorates the land, creating green landscapes at the centre stage in the heart of phibsboro and to give landscape areas to the people of dublin for the enjoyment of the greater community to live,walk, and meet. To give the city a rich biodiversity city centres typically never have.

Built history should be preserved where theres a truth to it and building on it not fearing it.If we eradicate it we have lost a key part of the cultural heritage of the region. Phibsboro has the chance to reinvent itself a possibility mny failing population centres today do not have.

The idea is to retain as many elements of the architectural history as possible so that they may be amplified through reuse. Preserving the soul and character of phibsboro.

Listening to the people of the area and colaborating with them to create a vibrant and community spirited place together based on what i learned from them. To rebuild a true social fabric in the city to inspife and foster new generations while supporting the existing ones and to safeguard a more sustainable equitable city.

By changing the use of the existing already demed unfit for use we chance upom the opertunity of change of use from shopping plaza to civic space fostering community interaction with the building. Through material reclemation the plaza is transformed into a rich techtonic enviroment. Via reuse of extracted materiality new program may be introduced alowingfor the full utilisation of a structures embodied carbon through reuse. allows for the site specific needs to be confronted in line with enviromental responsibilities.

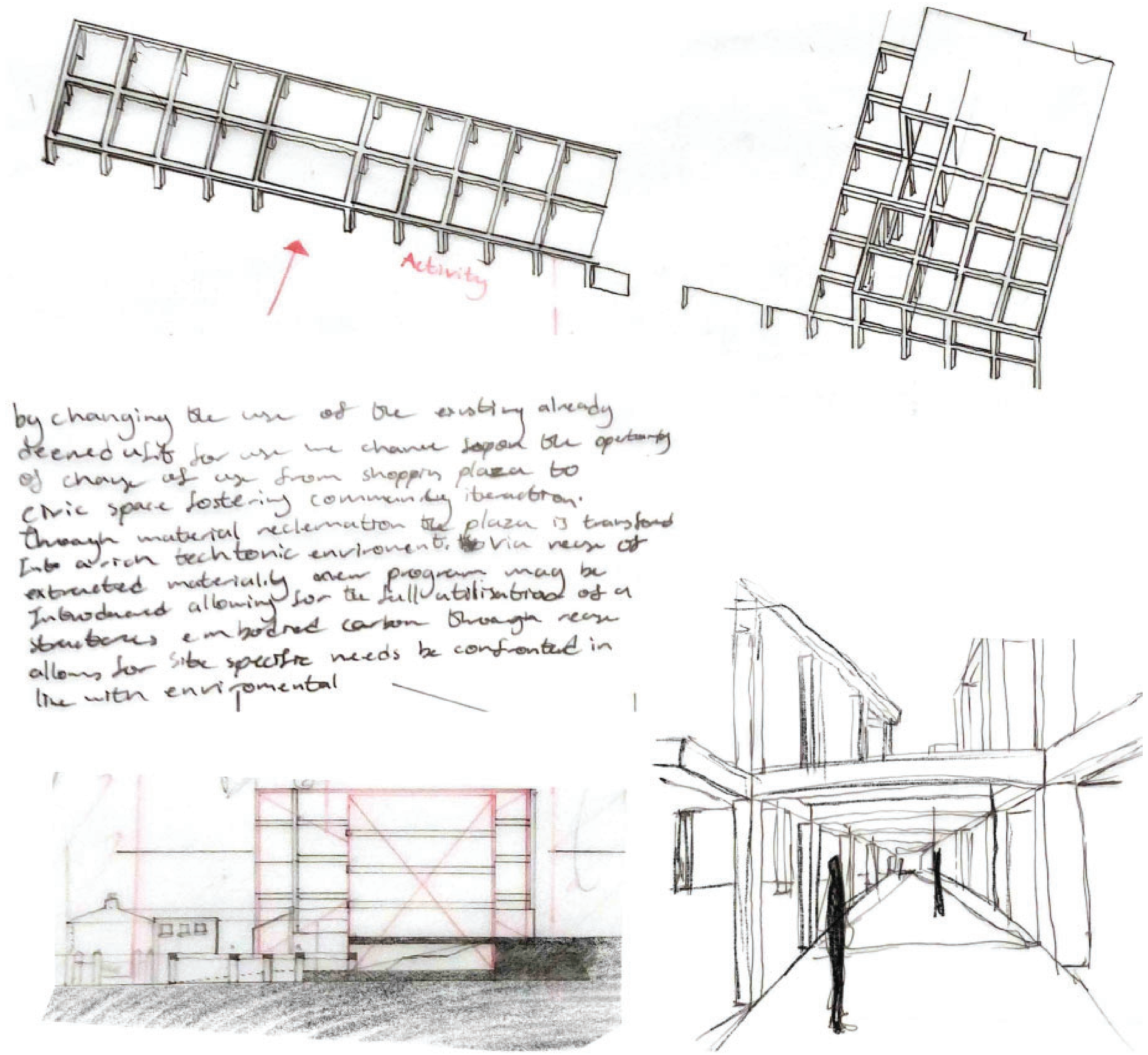


Fig 35 Concept development

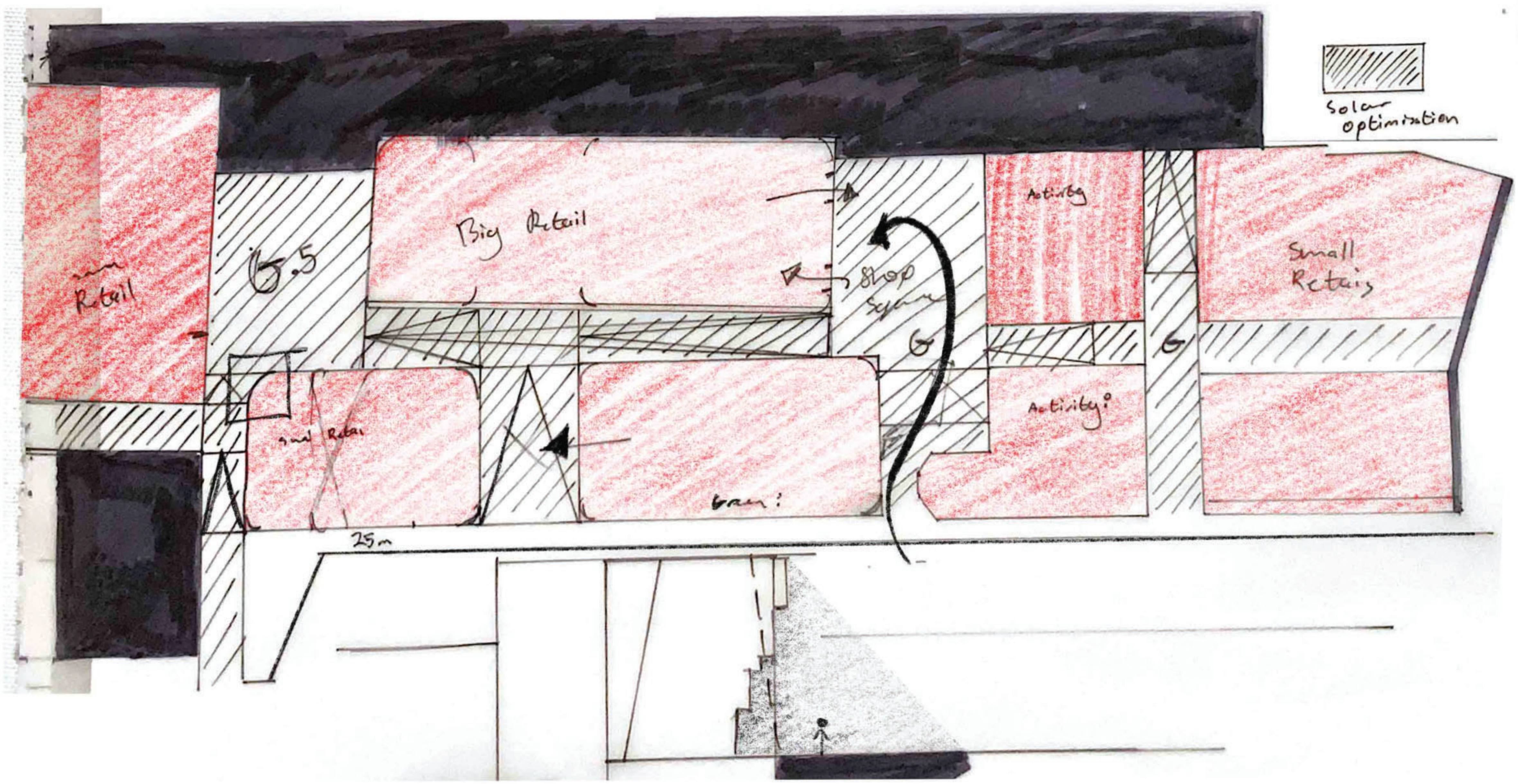


Fig 36 Concept development

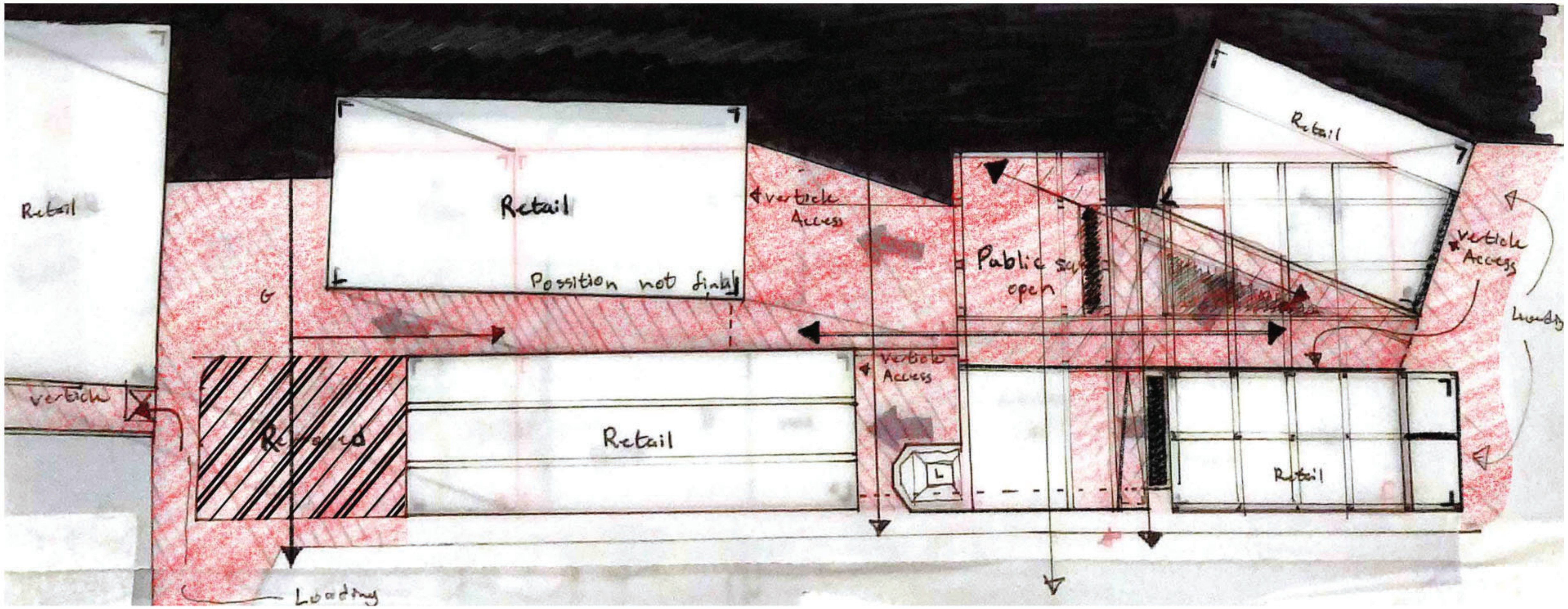


Fig 37 Concept development site optimization

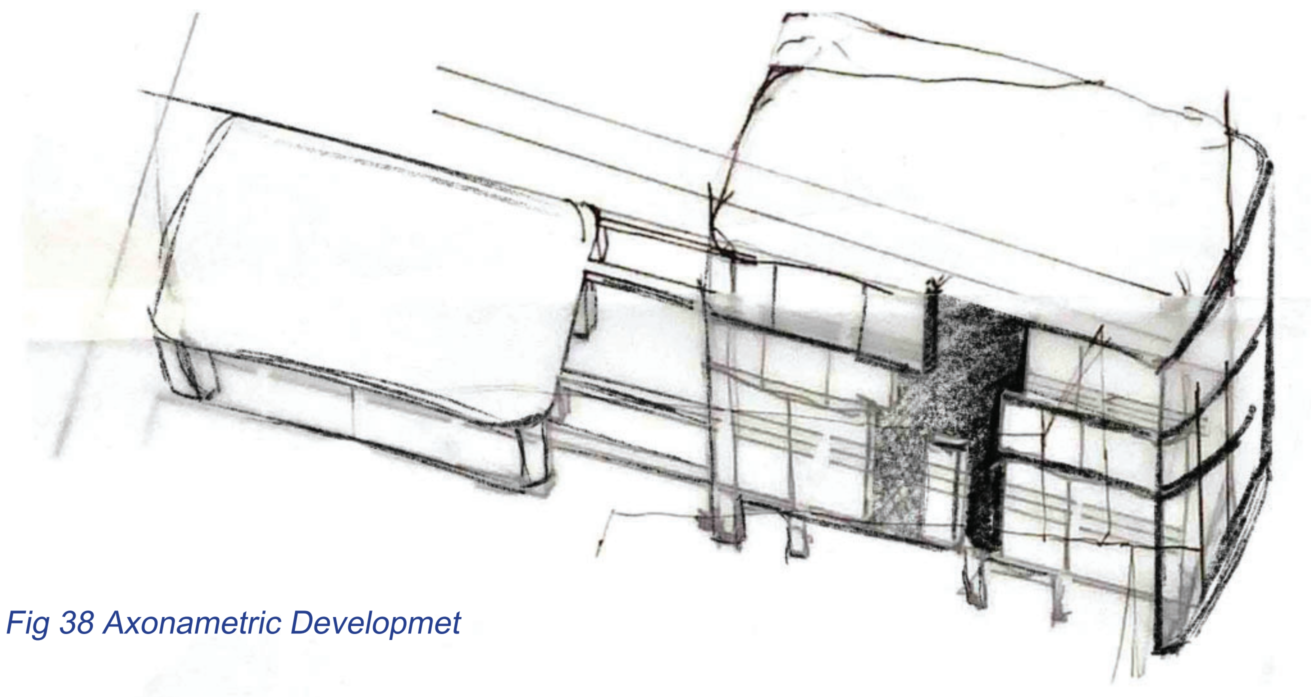


Fig 38 Axonametric Developmet

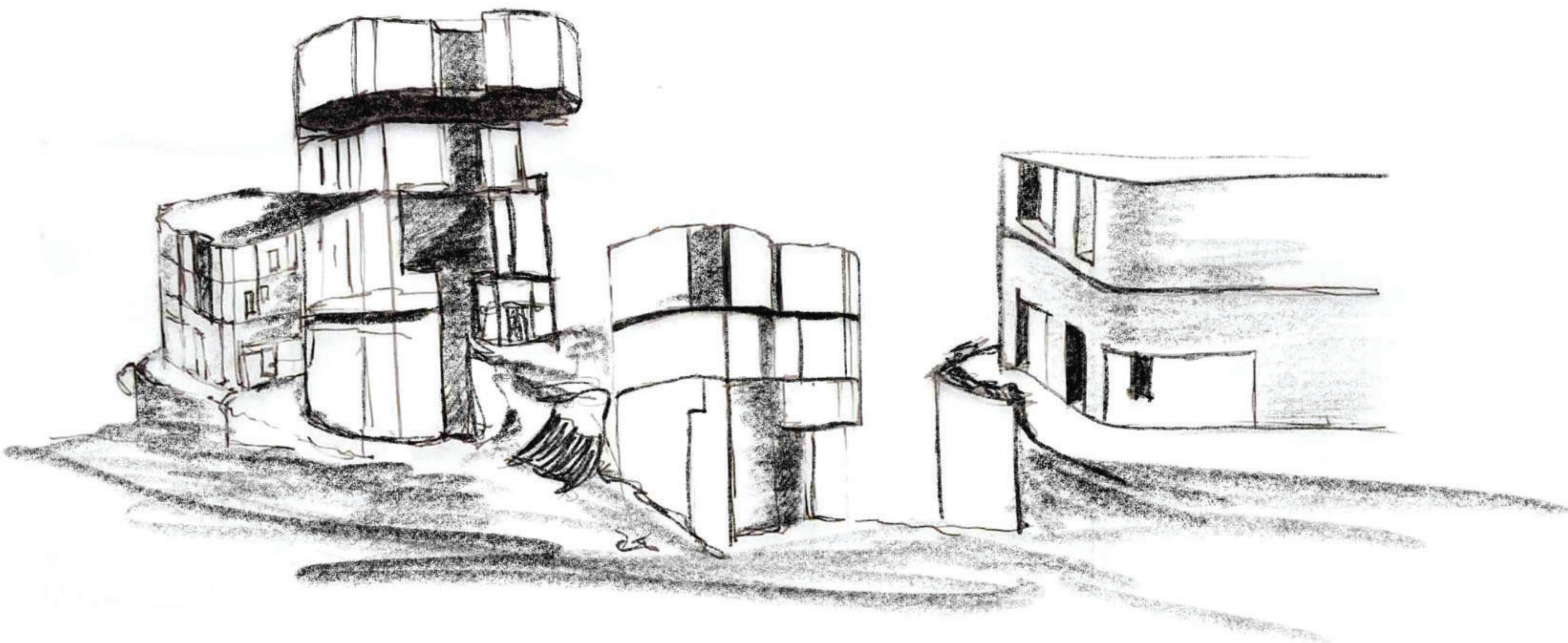


Fig 39 Concept sketch

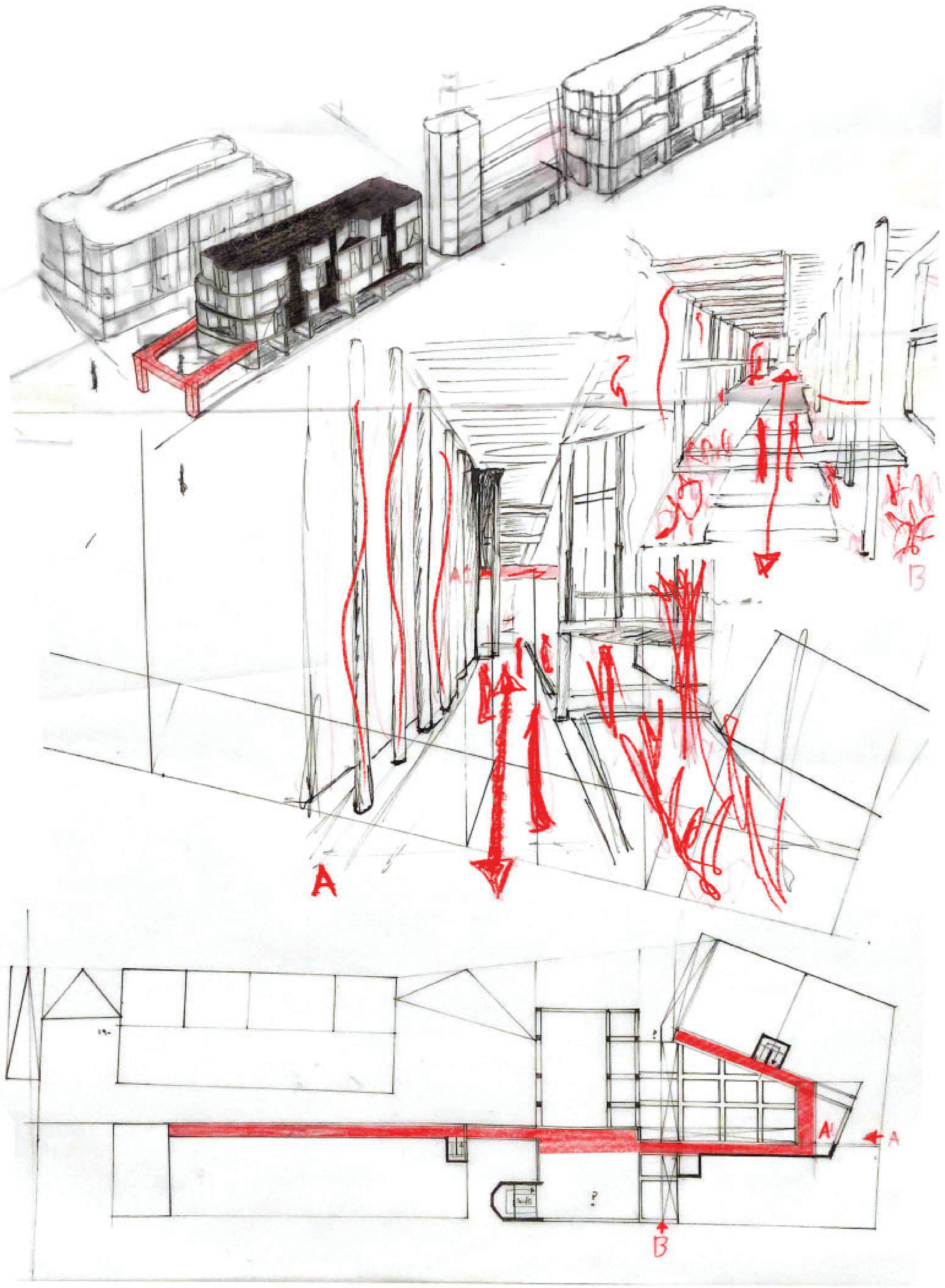


Fig 40 Site walk through

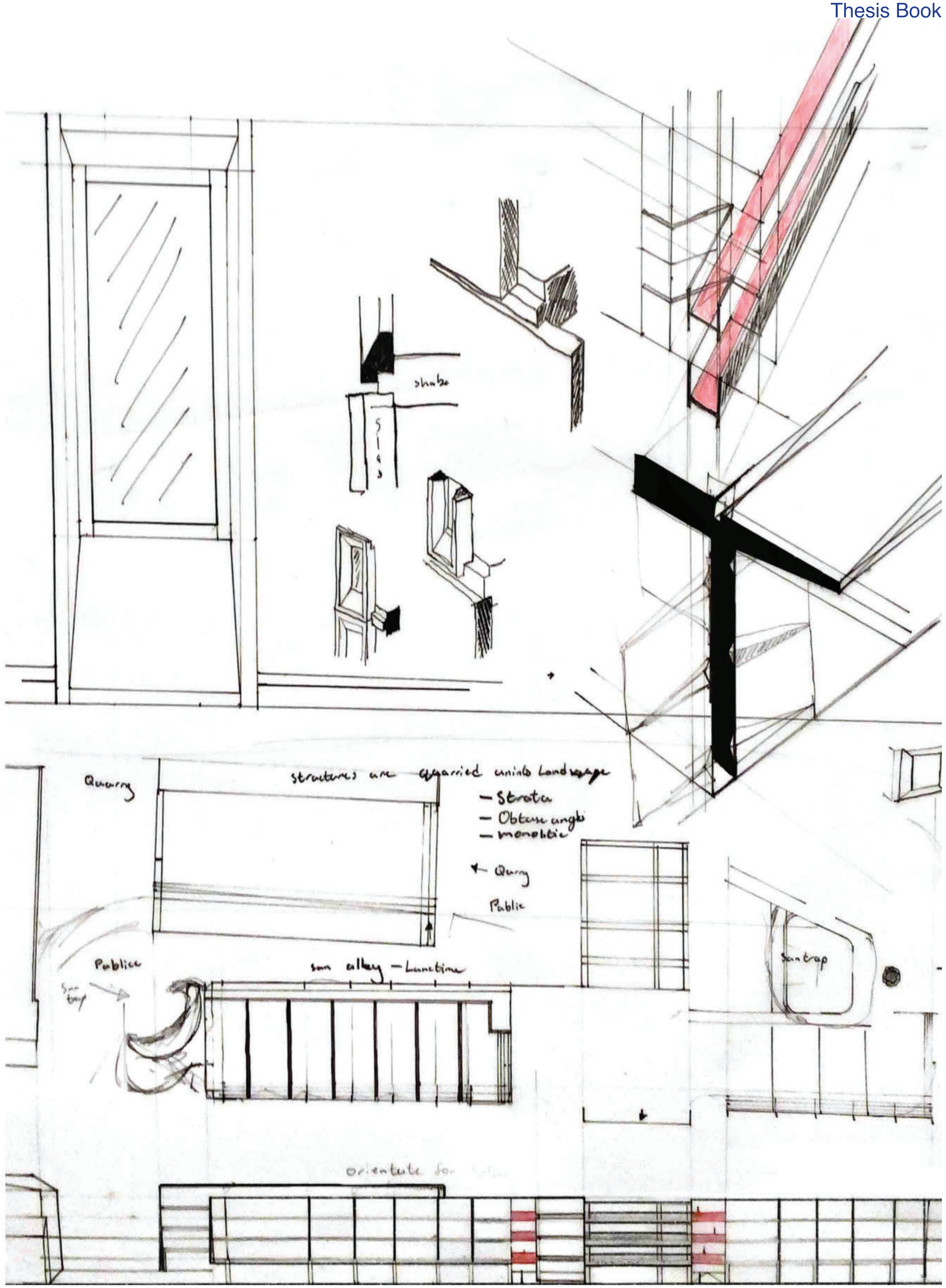


Fig 41 Material reassembly development

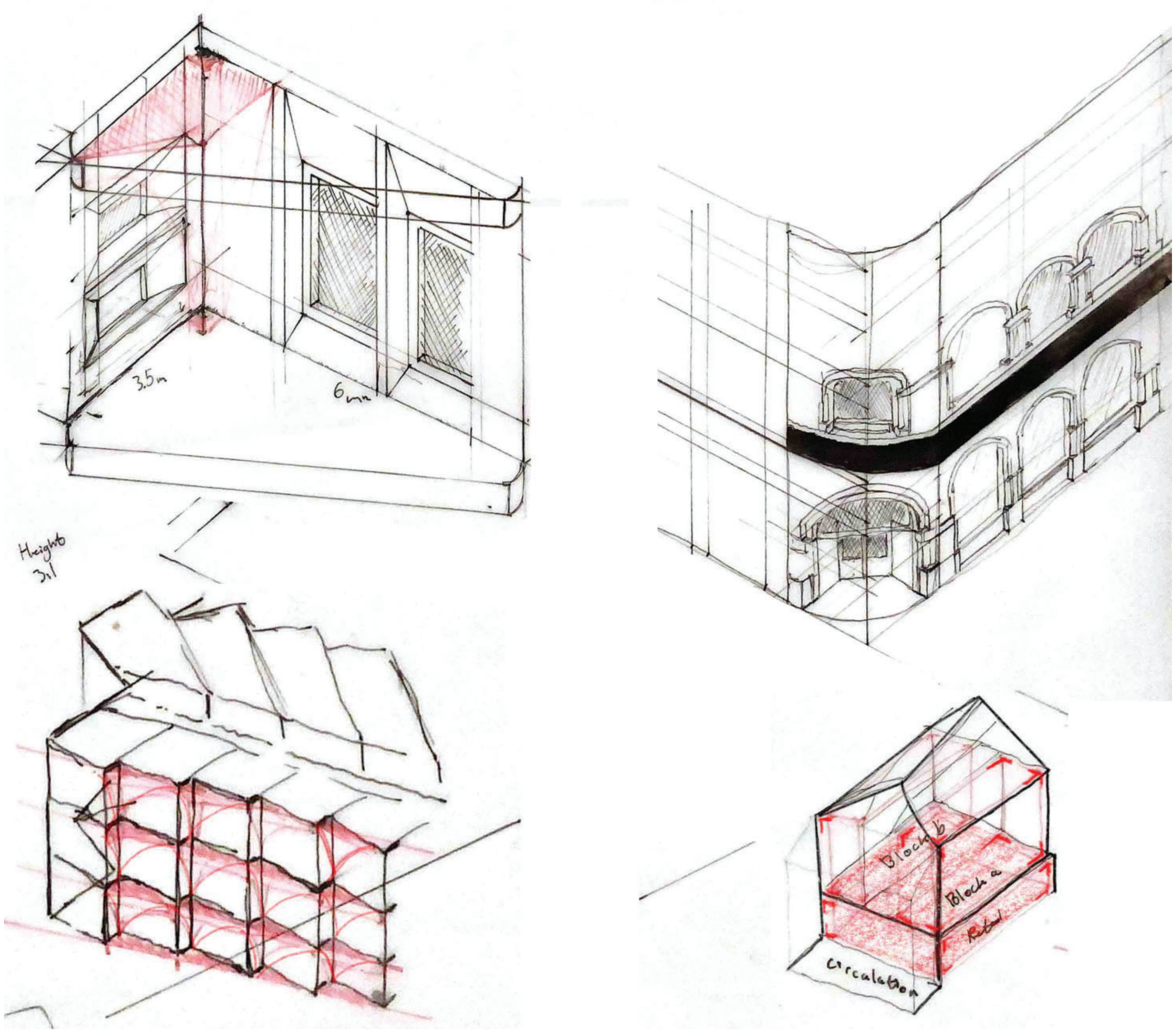


Fig 42 Material reassembly
3d study

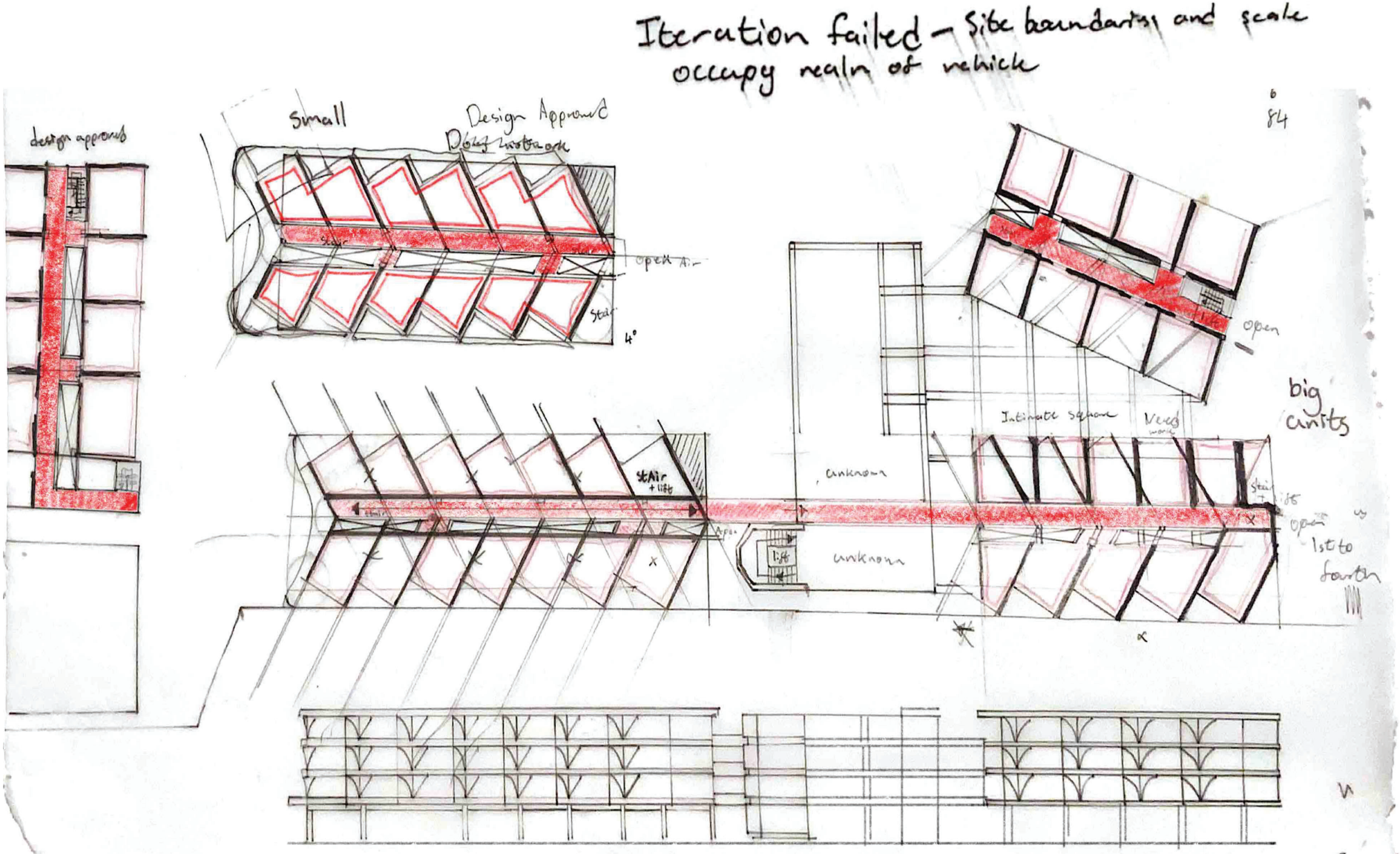


Fig 43 Scheme 1 developed site- Iteration failure

Part 4

DEVELOP-
SCHEME2

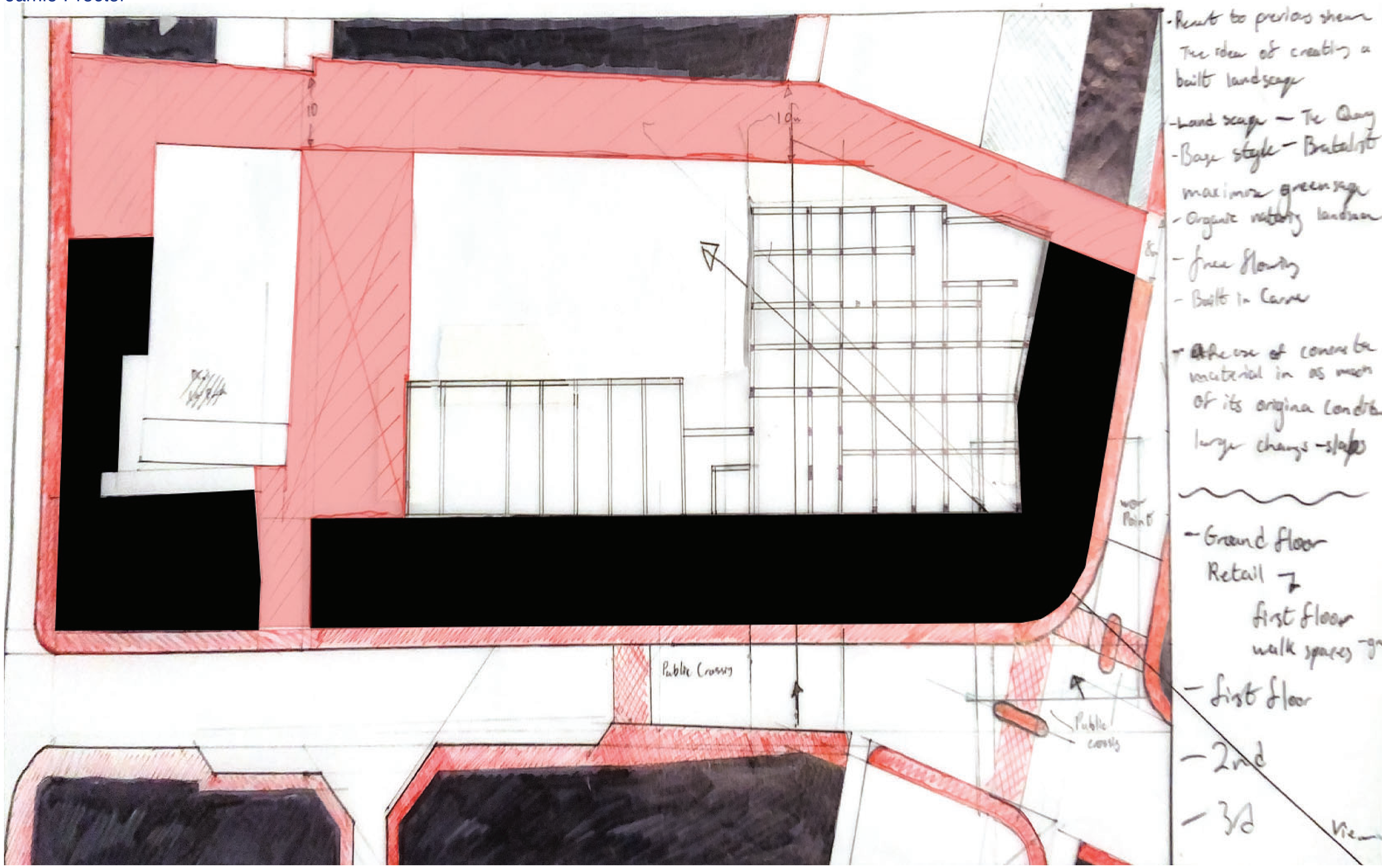


Fig 44 Scheme 2 development

Scheme 2

Moving on from the previous scheme where the program set to utilise the entirity of the existing buildings floor area.This scheme moves on from that where to make the point of focusing on comunity interaction. To incourage interaction the floor area of public spaces is massively increased to the point where the entirety of scheme 1‘s floor area in now set to be used as the public realm where it is sheltered from the realm of the car by the development itself. To further this the site is now moved to the exterior carpark as so to maximise the space utilised by people and not set aside for the storage of cars where in the future individual car ownership is suspect at most.

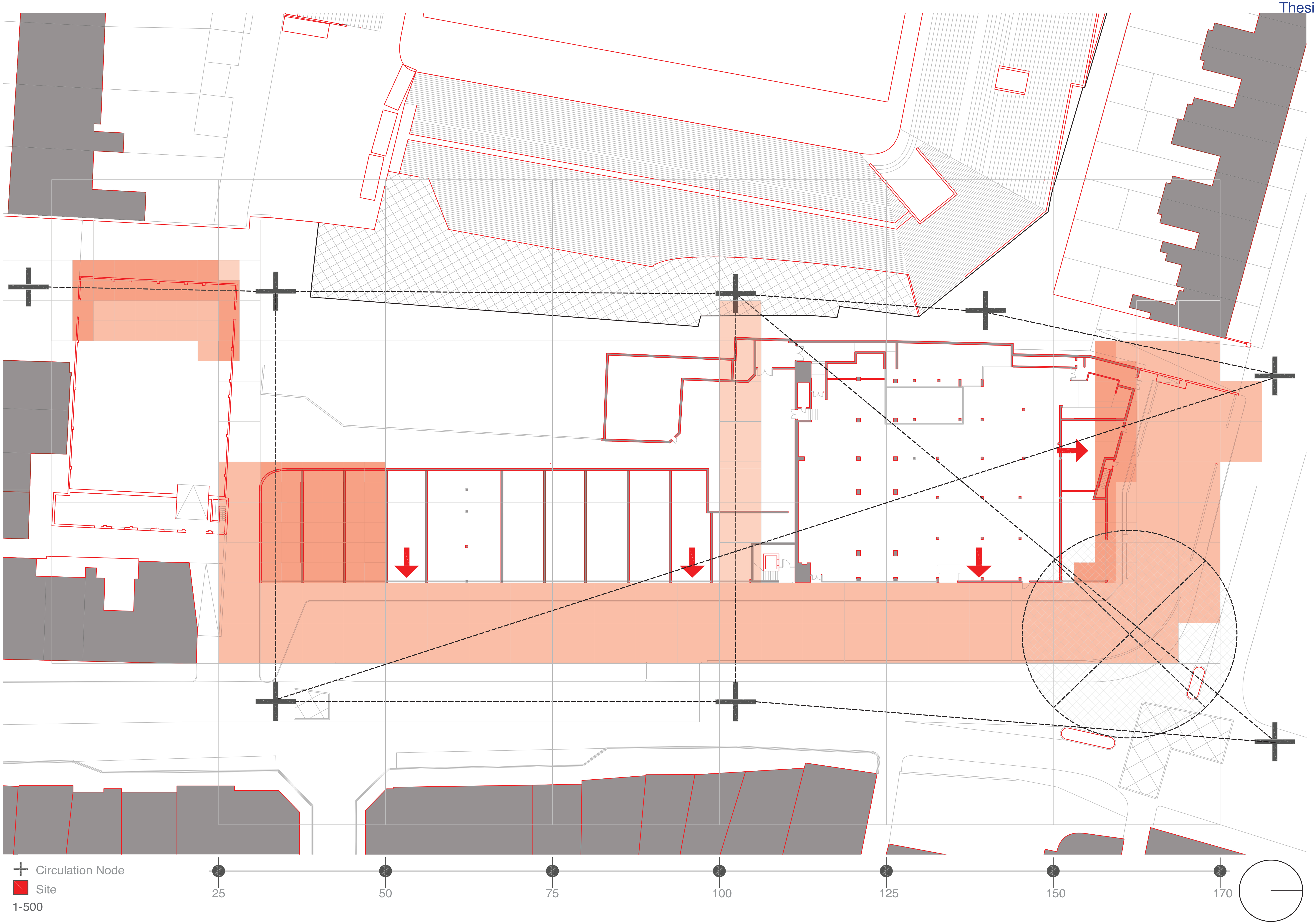


Fig 45 Site circulation and movemnet

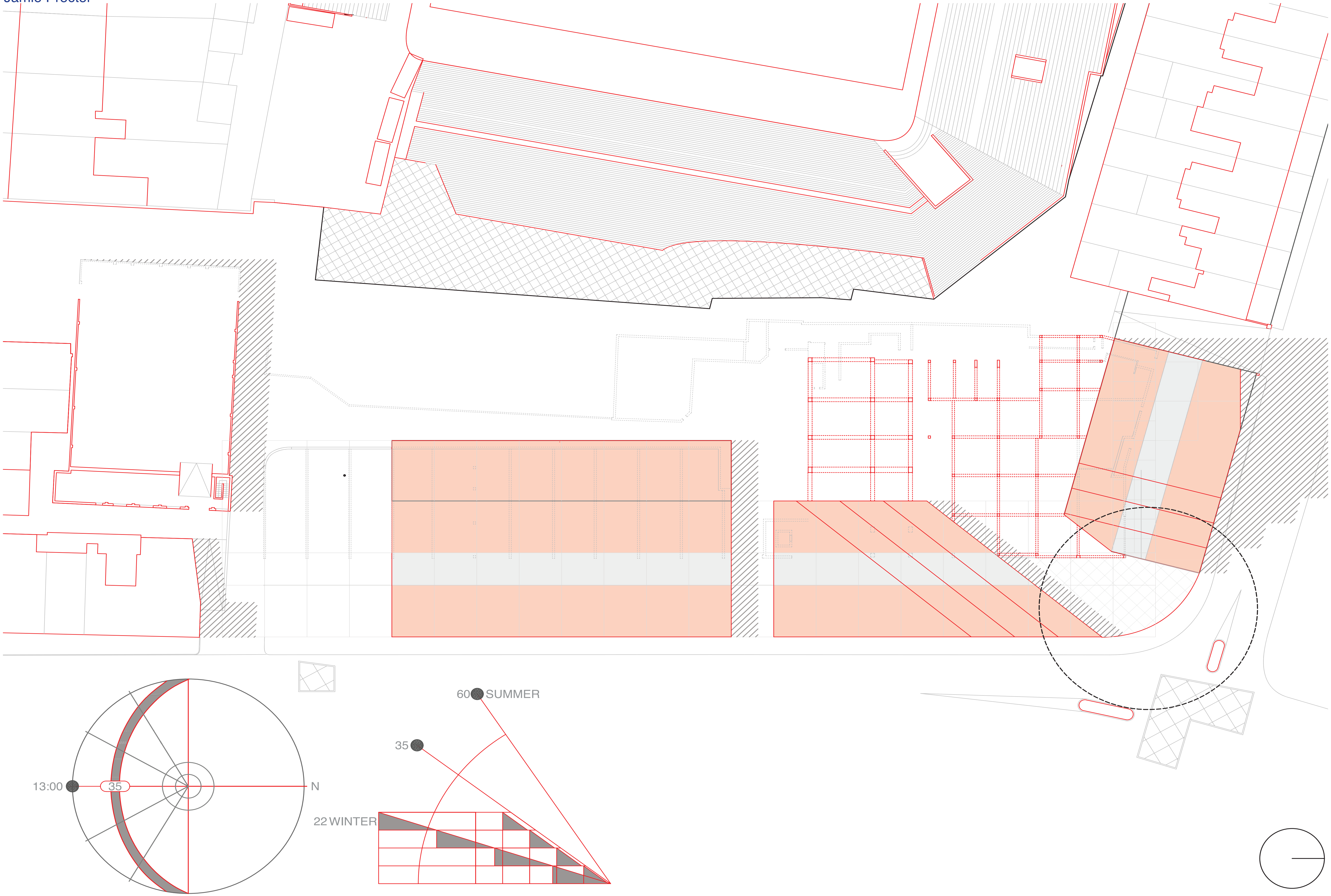


Fig 46 Shadow study

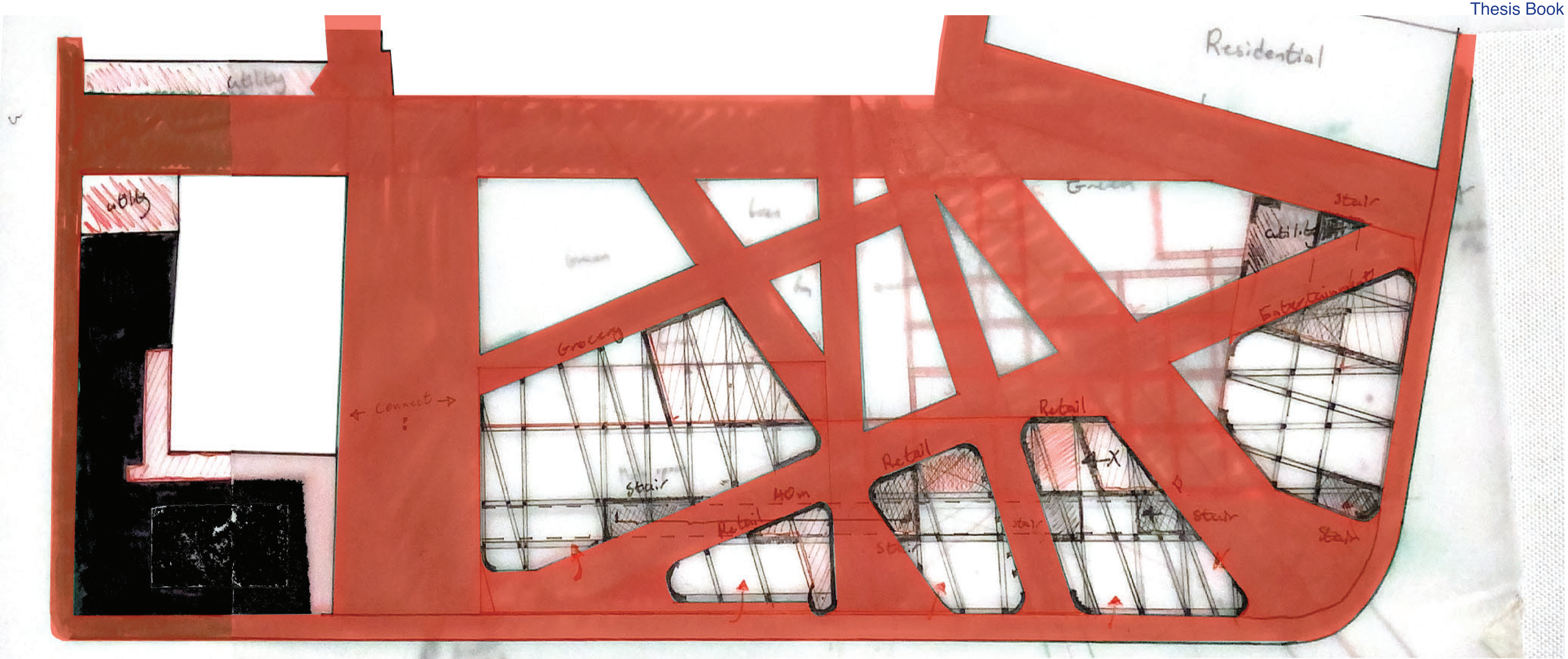
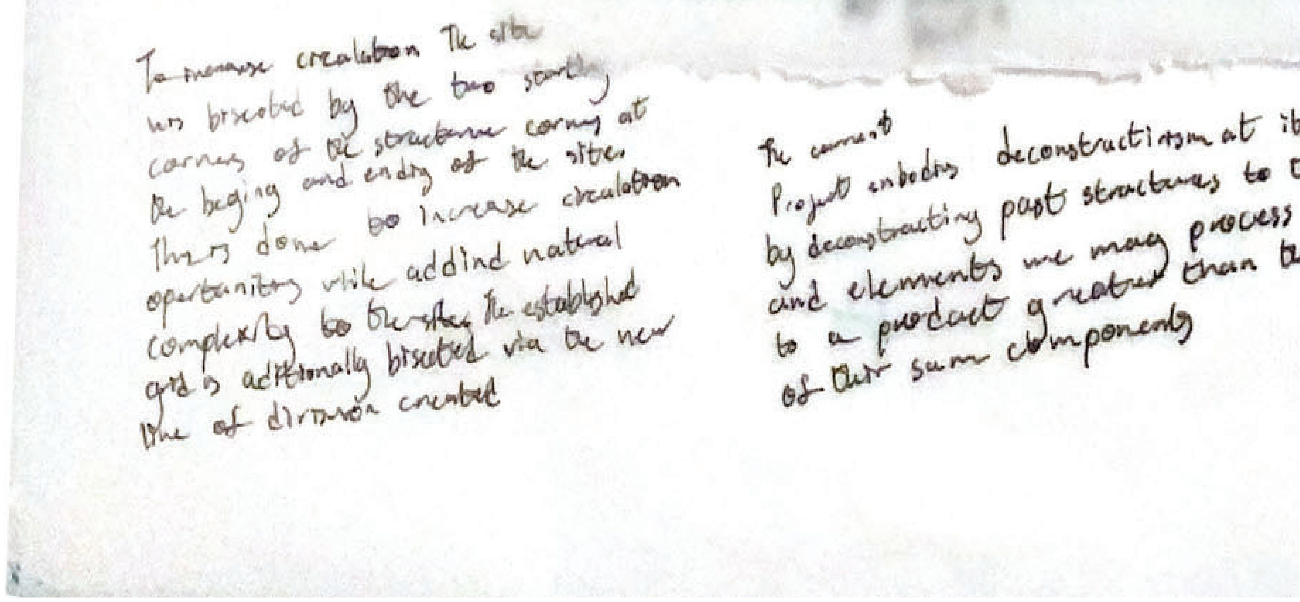


Fig 47 Site development

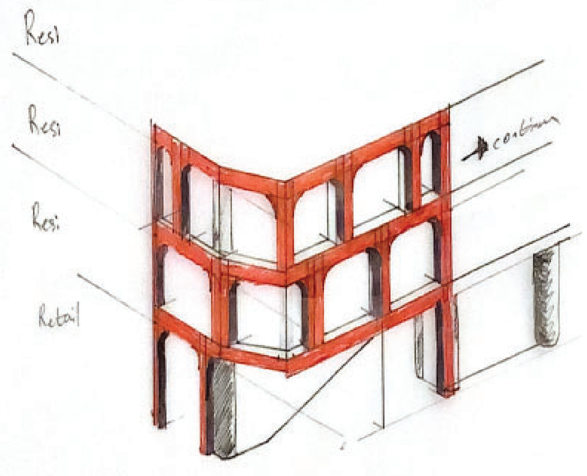


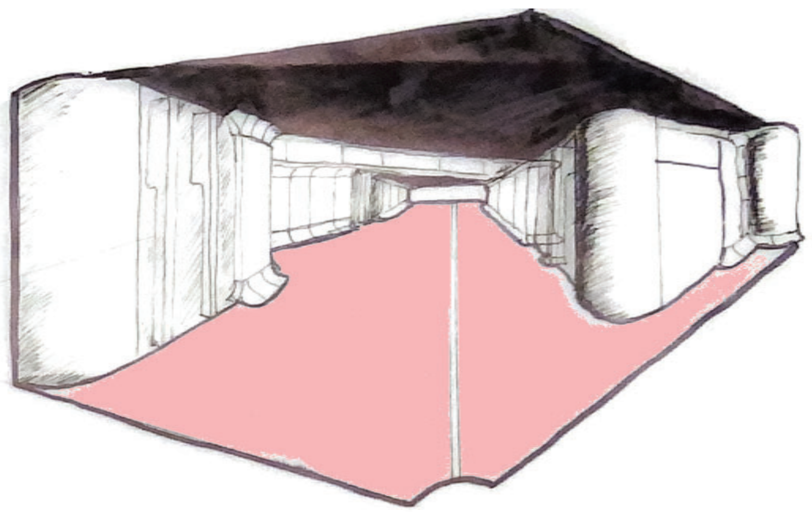
To increase circulation the site was bisected by two starting at corners of the site. This is done to increase circulationopertunities while adding natural complexity to the site. The established grid is additionally bisected via the new line of divisions created.

The current project embodies deconstructivism at its core by deconstructing past structures

Conclusion

On further development the scheme was found to not meet the requirements required under the ethos of the design thesis as going further would require the use of external sources of material bodies.





Part 4

DEVELOP-
SCHEME3

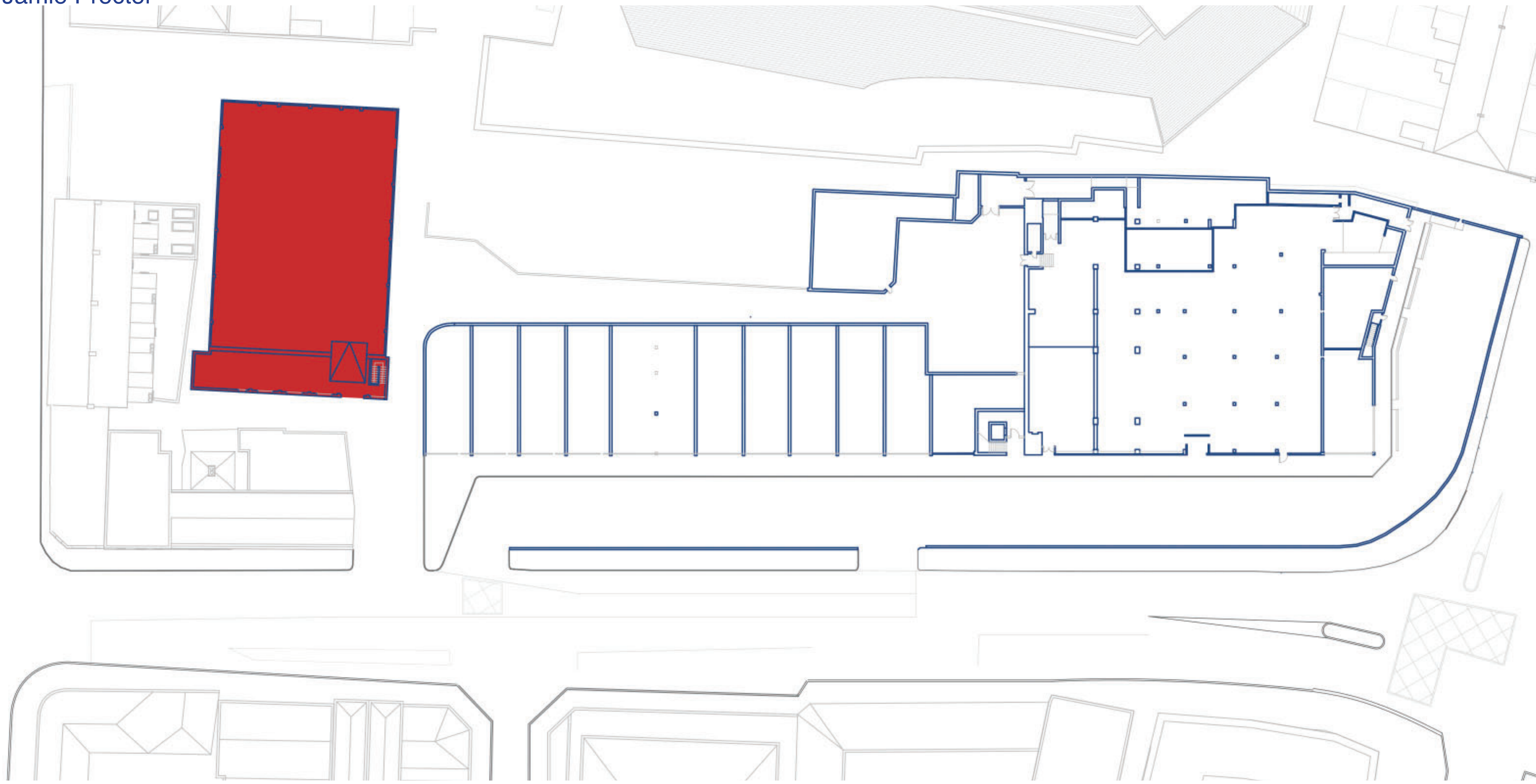


Fig 48 Site location

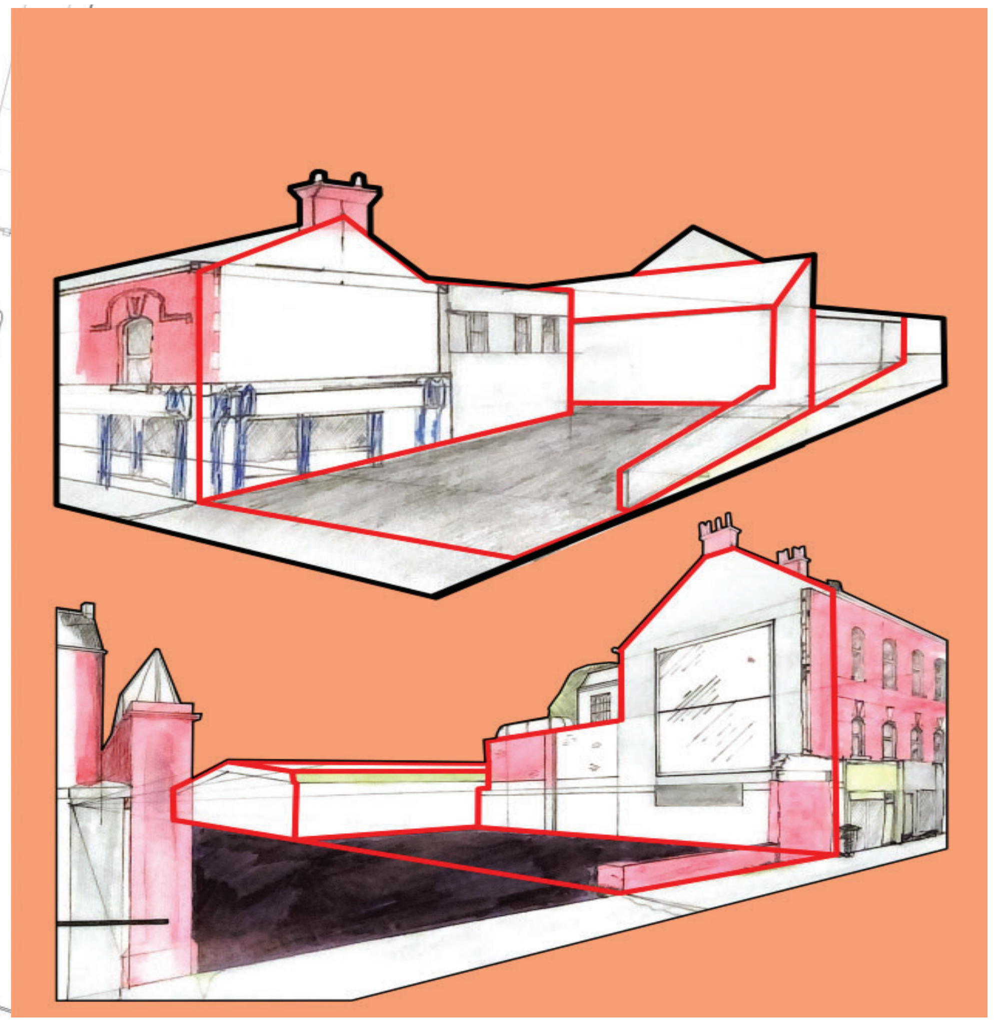


Fig 49 Site entrance

Intervention

The intervention for the development scheme 3 was the creation of a mixed use plaza that comprising of mixed residential units with retail spaces on the ground floor to encourage community development. From the removal of the program on site marked in red which is already set for demolition the scemes aim is to create a structural block comprising of the exsisting fabric on the main street and then backed by the proposed intervention on the rear. Once compleated with the addition of residential passage ways into the program it is hoped that neighbour to neighbour interaction may take place while using the shared access ways in and out of the intervention.

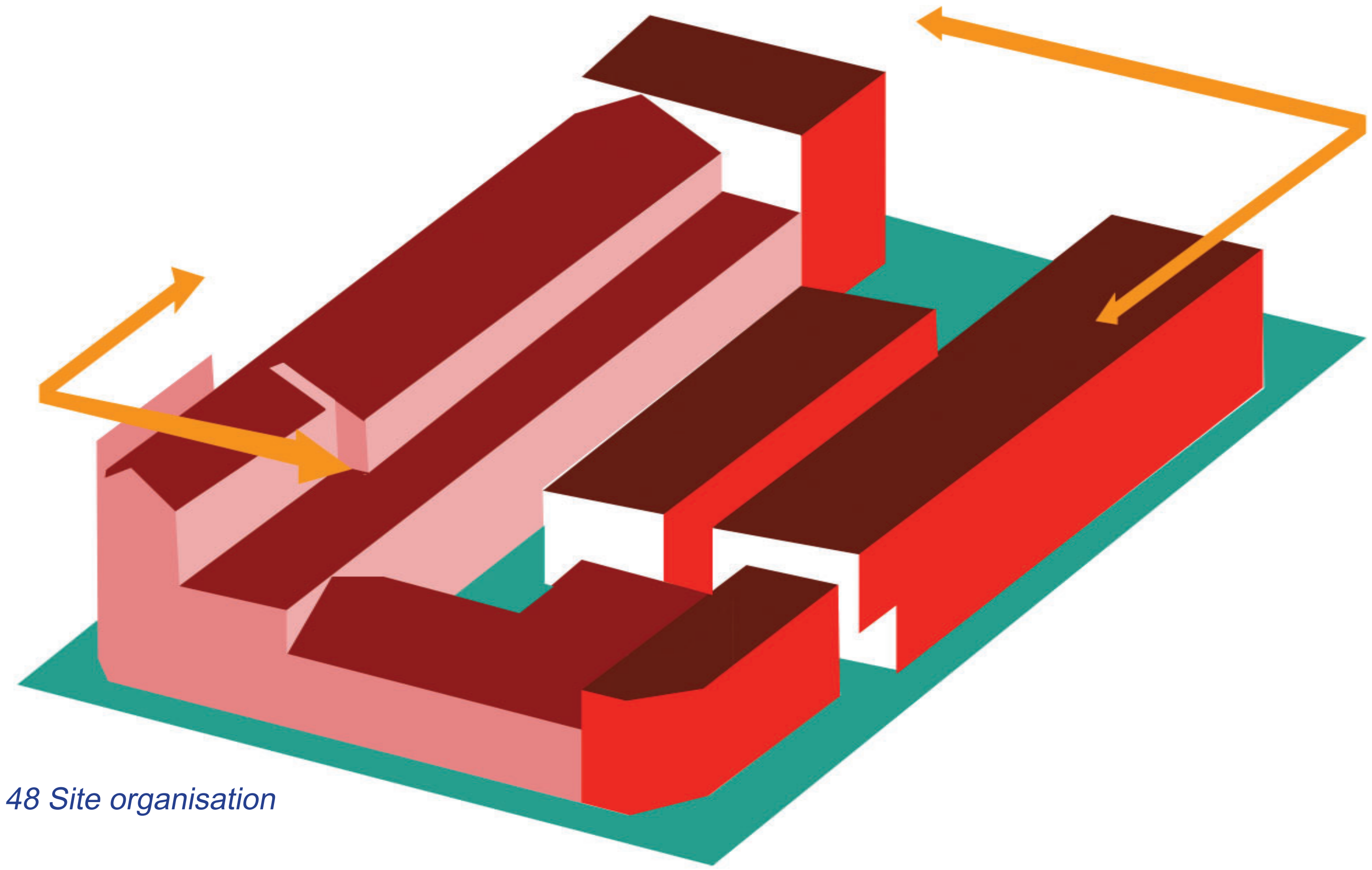


Fig 48 Site organisation

RE-USE

From experience gained through the development of the prototype project previously shown i began the process of creating a scheme and process for the use and reuse of the material body found within the phisboro shopping plaza.

Through the development of the previous design schemes this ethos of material reuse was tested. The most effective method for material reclemation from the existing structure was through a process called hydro demolition

Hydro demolition is a concrete removal technique that uses high preasure water and abrasive material contained within to remove deteriorated and sound concrete as well as a multitude of other solid materials. This process was chosen as it creates a ideal boding surface for new mateial and other coating aplications while also being harmless to any metal reinforcement found within a concrete member. Its speed and efficiency was also a deciding factor.

Once the process of reclemation had been decided to next was decision was the method of how to utilise the reclaimed material.

For the constituating floor slabs the process was simple.The existing floor slab is cut using hydro demolition removing the concrete in set locations and at a specific width to allow for sufficent metal reinforcement to be exposed so as to allow for new concrete material to have sufficient metal reinforcent to bond too. To allow for stronger bonds the exposed reinforcement will aditionally bew bent to allow for individual cut slabs edges to be woven into one another.

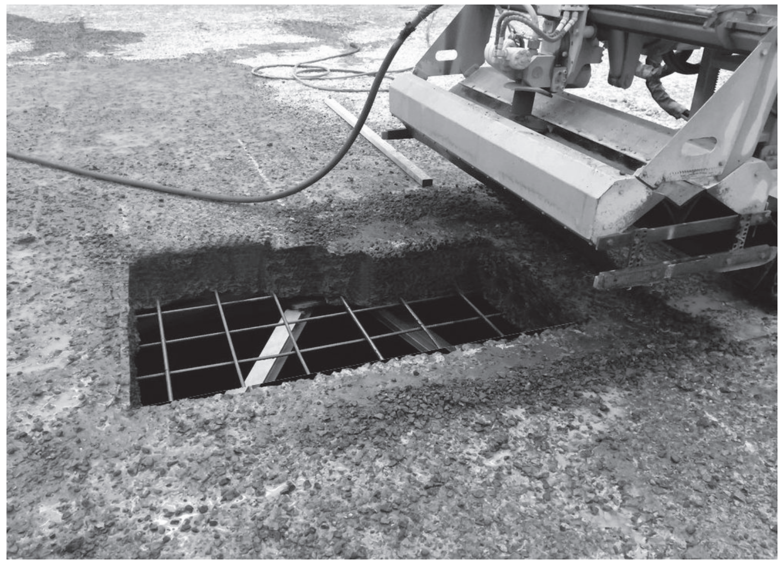


Fig 50 Hydro demolition cut through slab

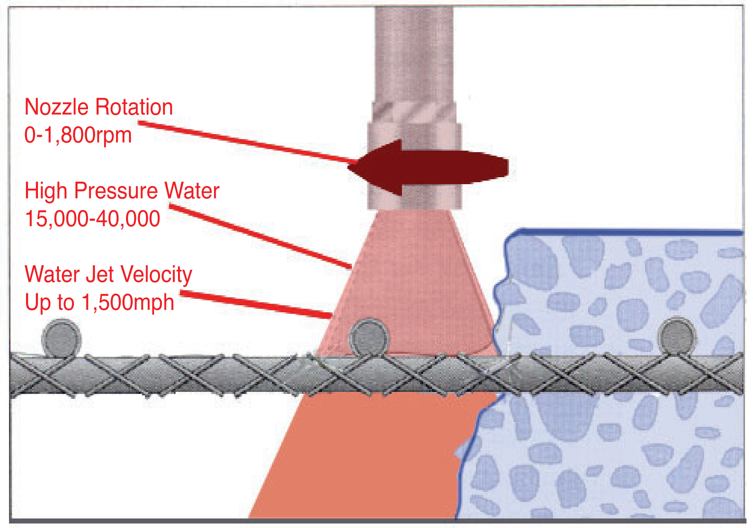


Fig 51 Hydro demolition cut through slab

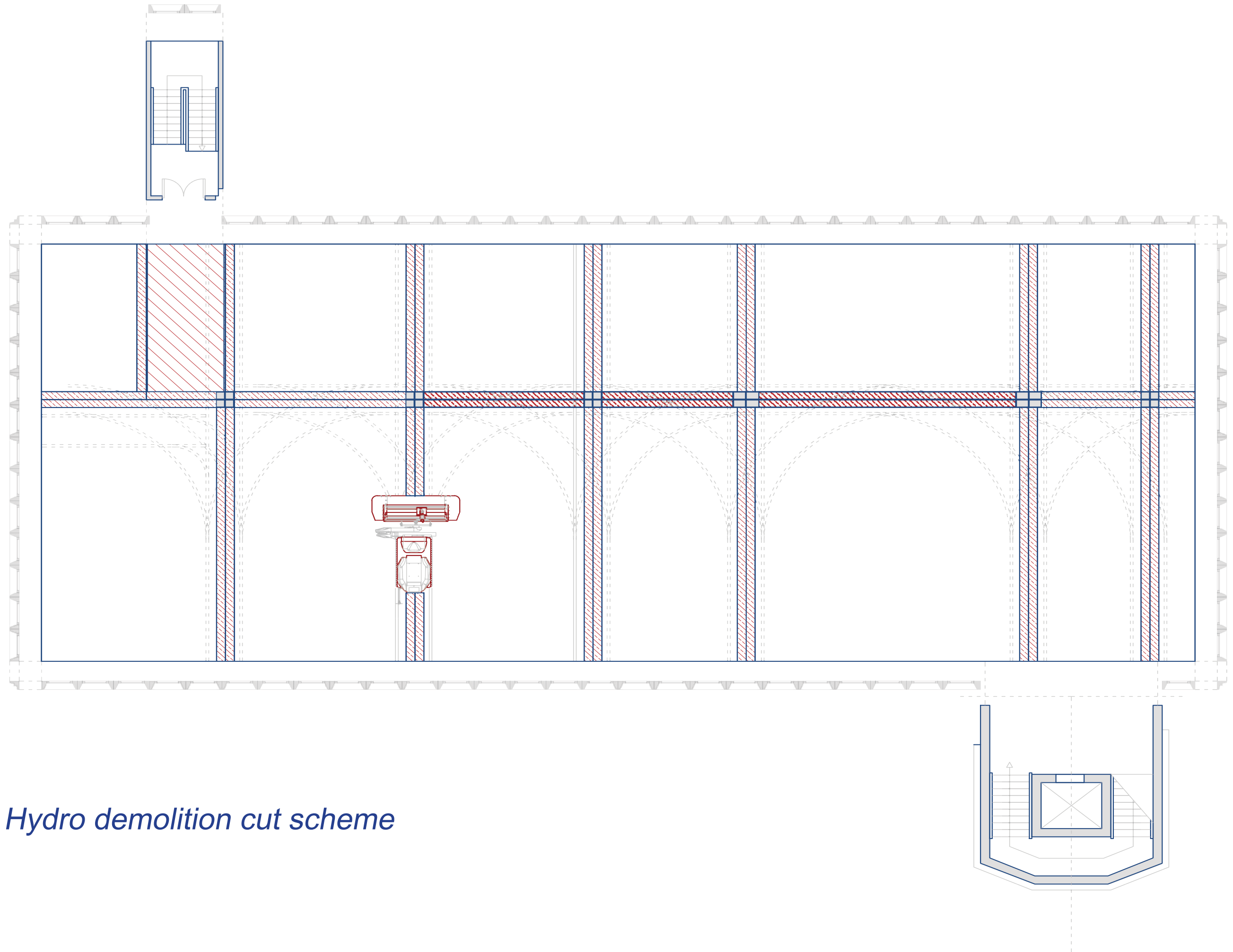


Fig 52 Hydro demolition cut scheme

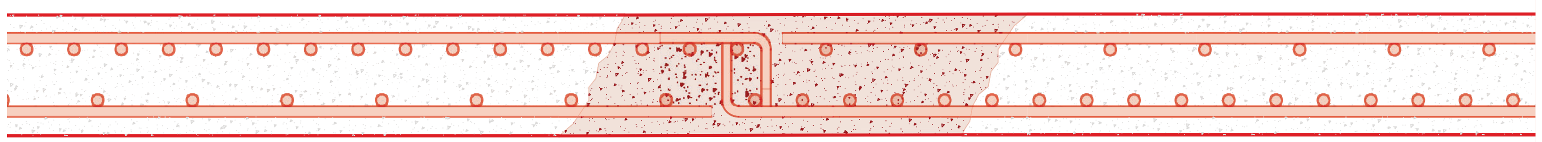


Fig 53 Floor slab connection detail

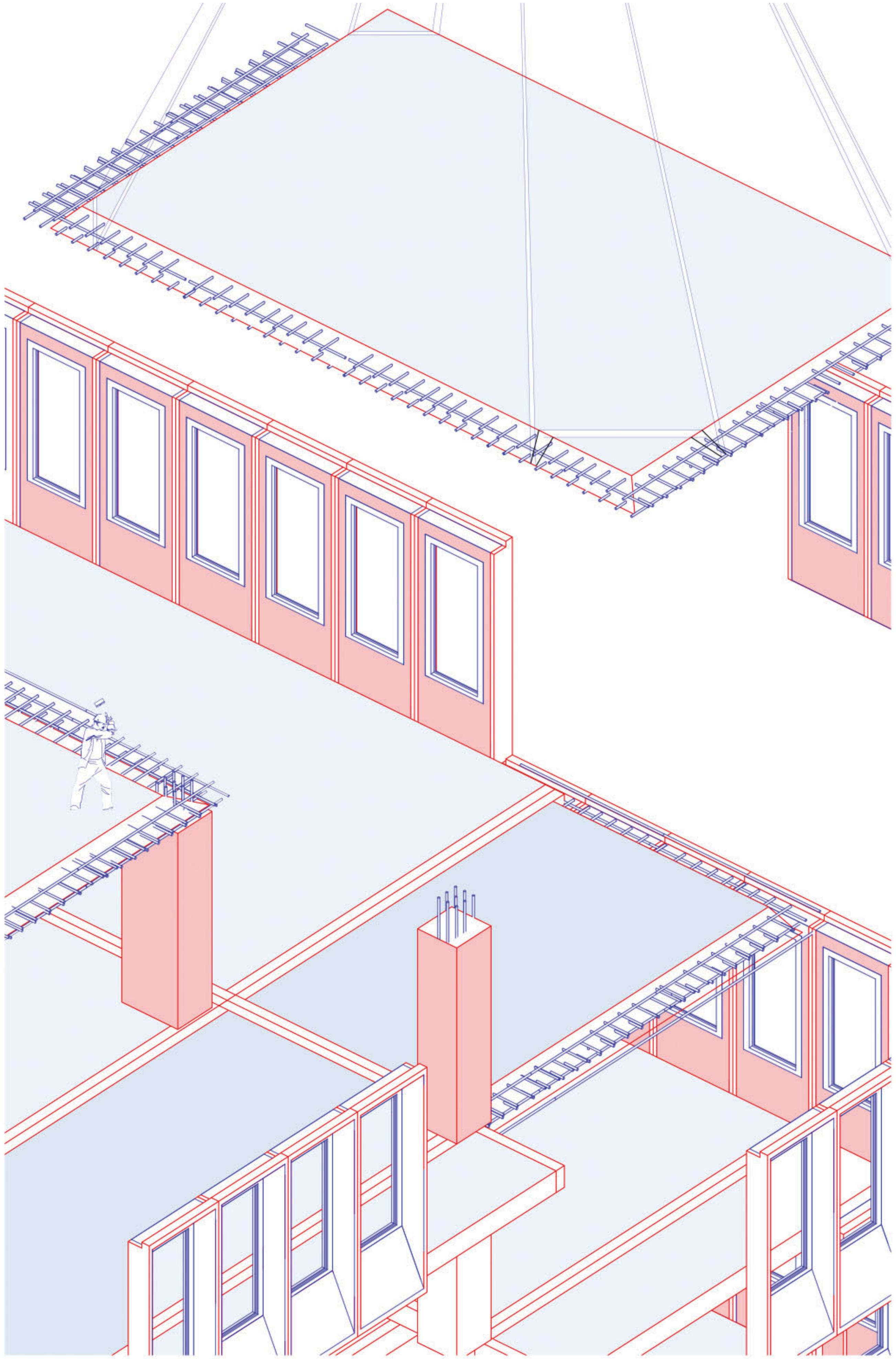


Fig 54 Material reclemation in progress

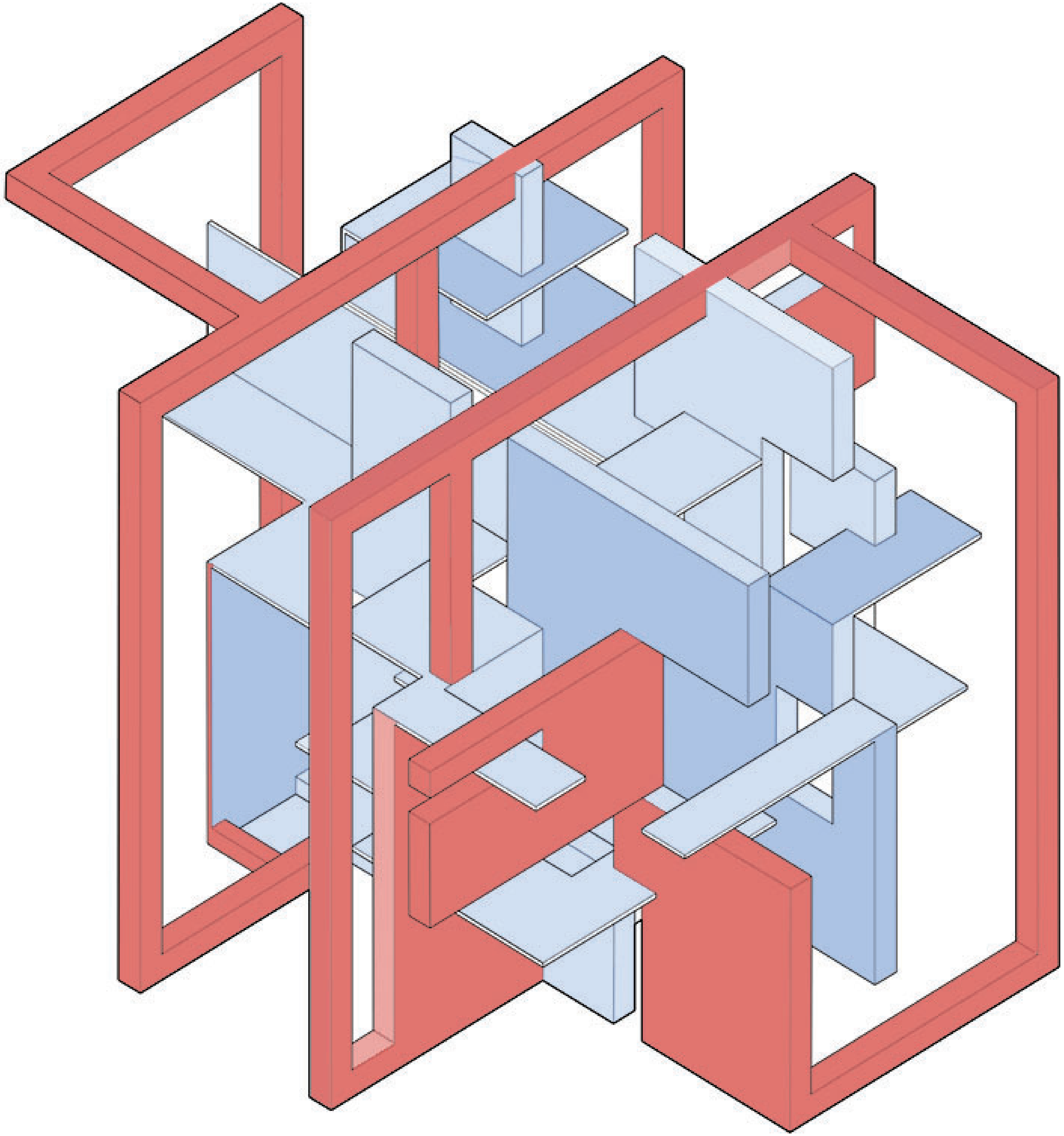


Fig 55 Concrete joinery concept

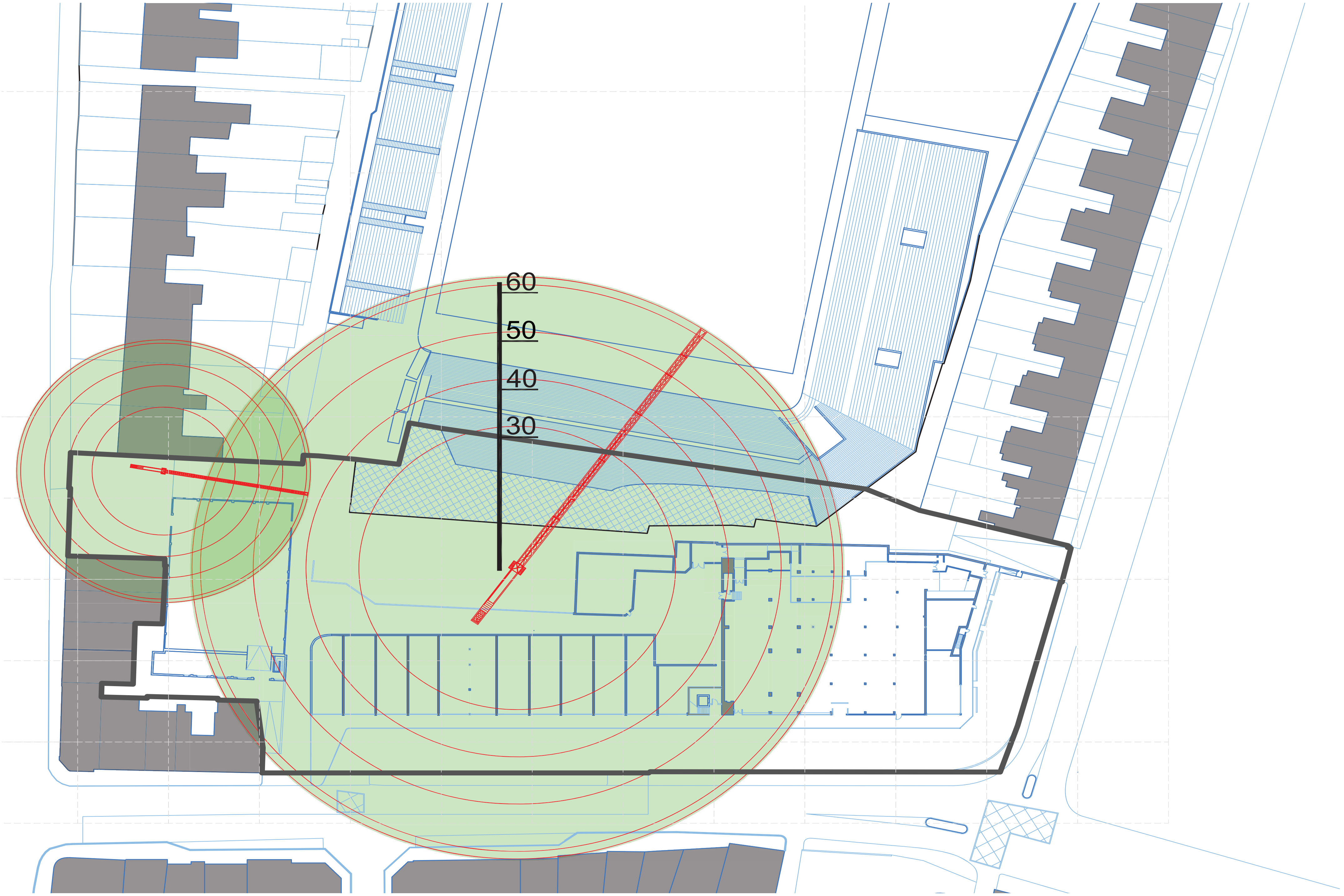


Fig 56 Crane layout

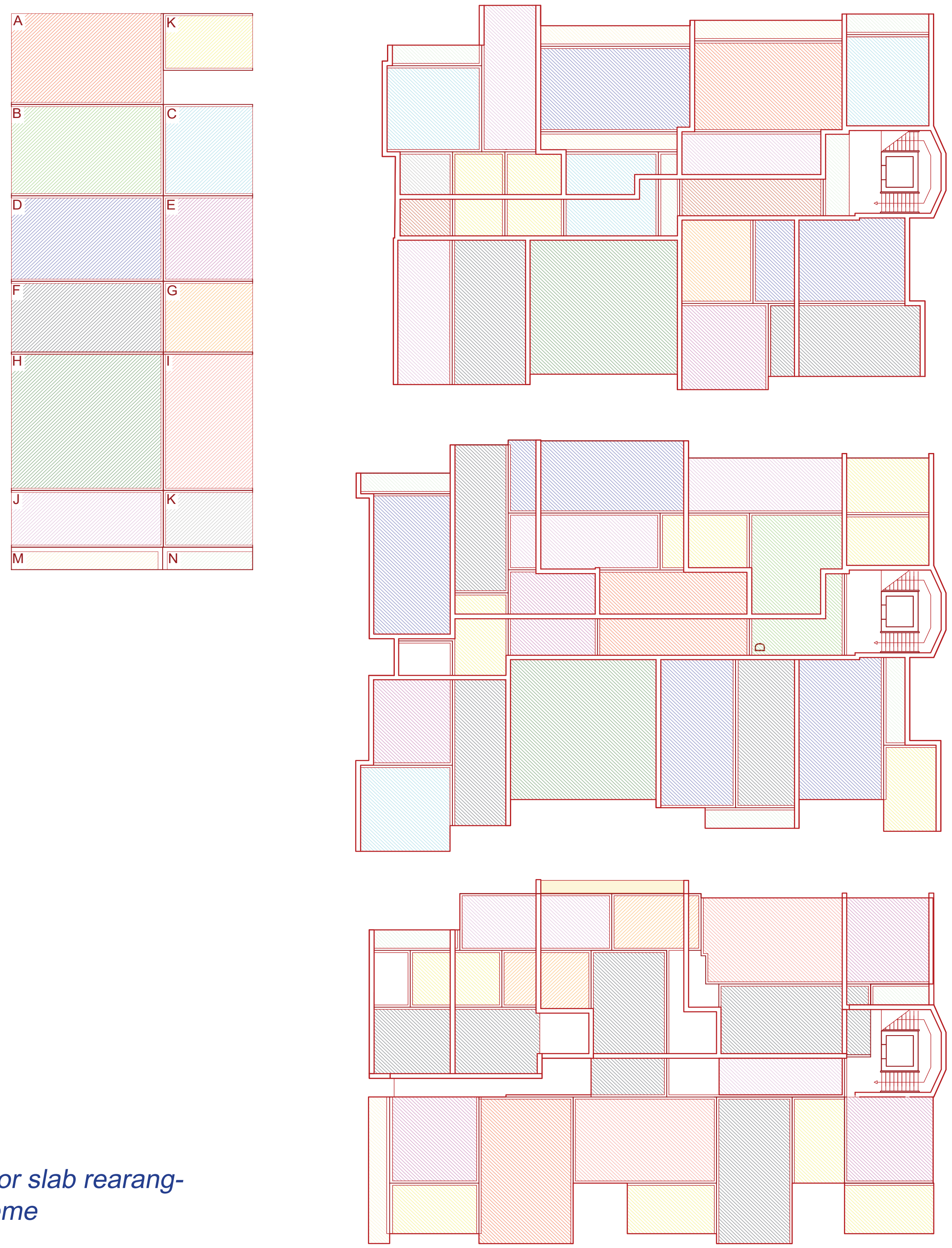


*Fig 57 Floor slab rearrang-
ment scheme*

Fig 58 Floor slab Developmet Ground Floor

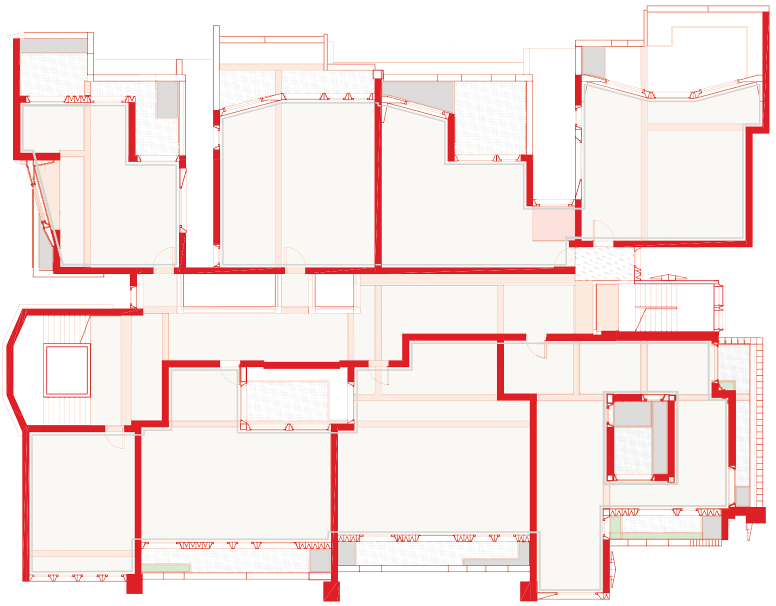


Fig 58 First Floor

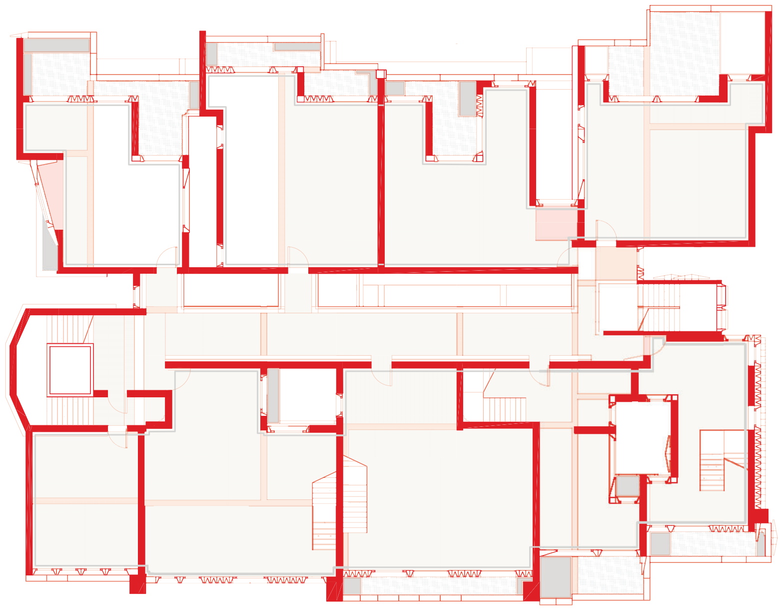


Fig 59 Second Floor

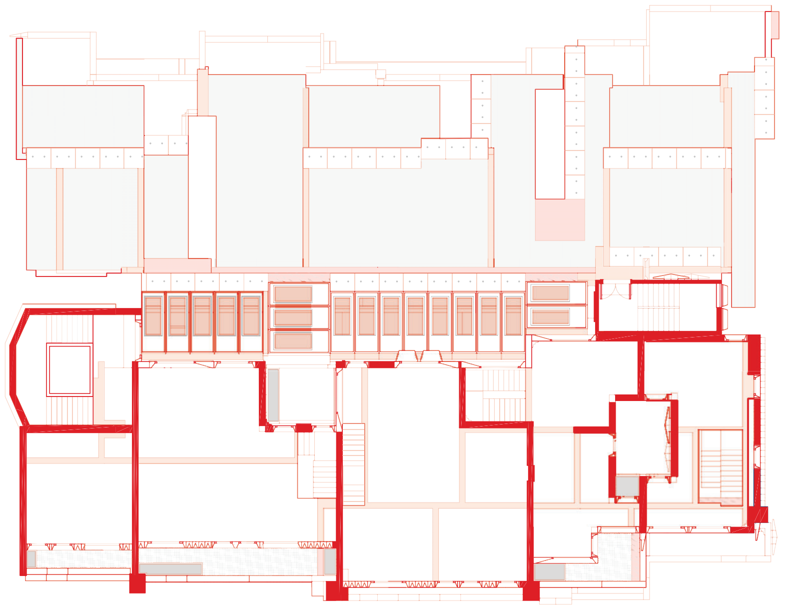


Fig 60 Third Floor

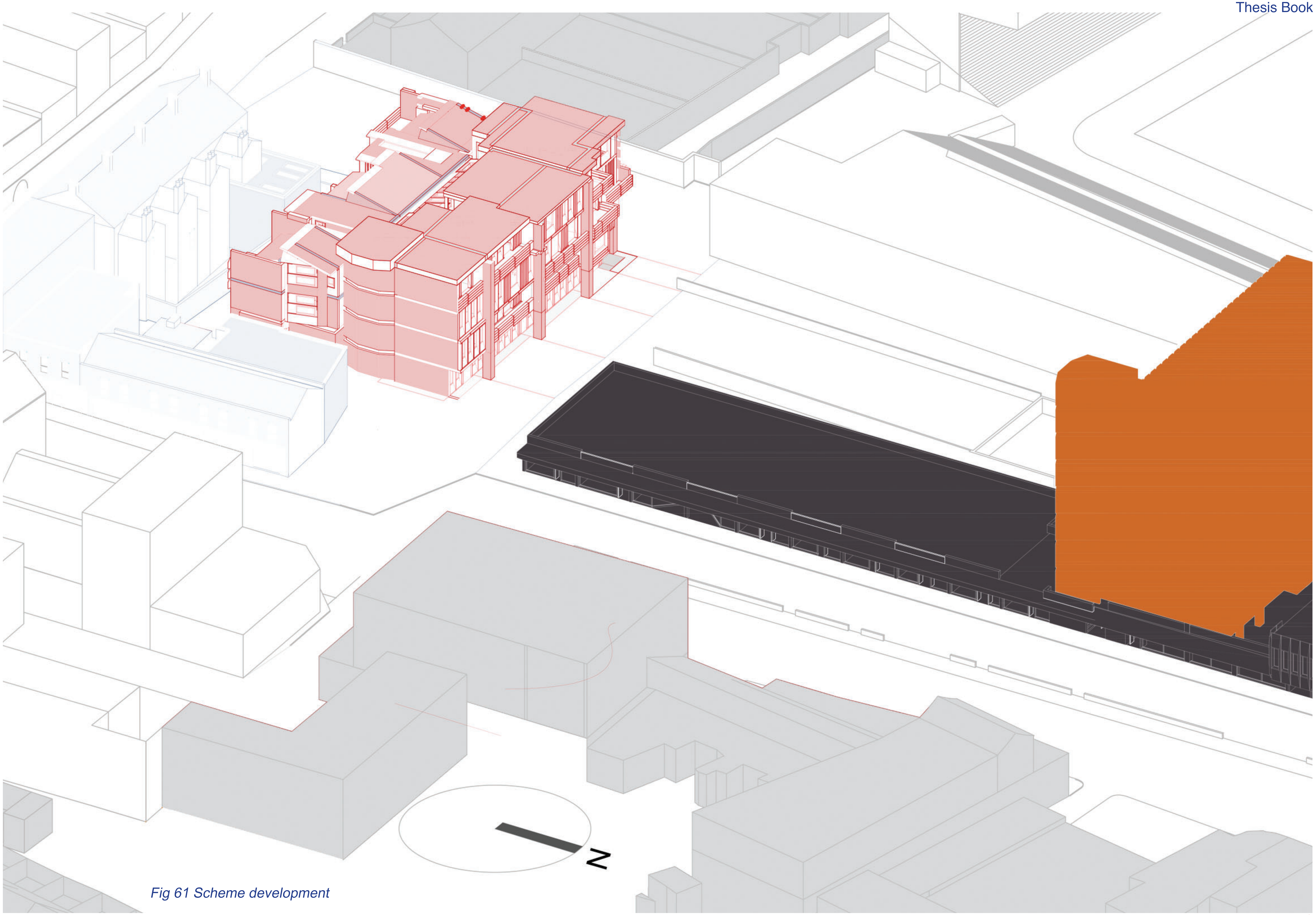


Fig 61 Scheme development

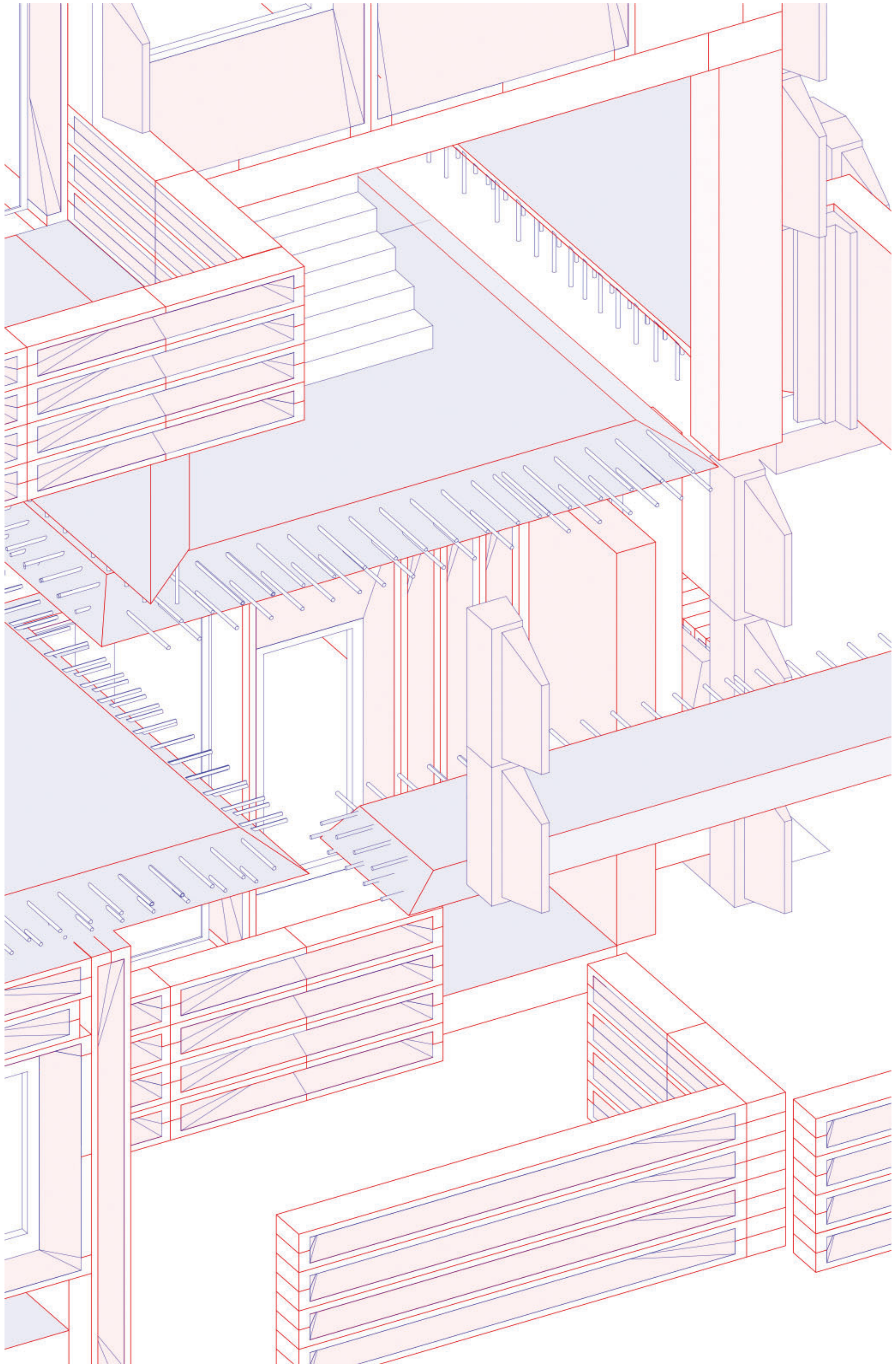


Fig 54 B Material reclemation in progress

Part 5

Final Design

Fig 62 South face render

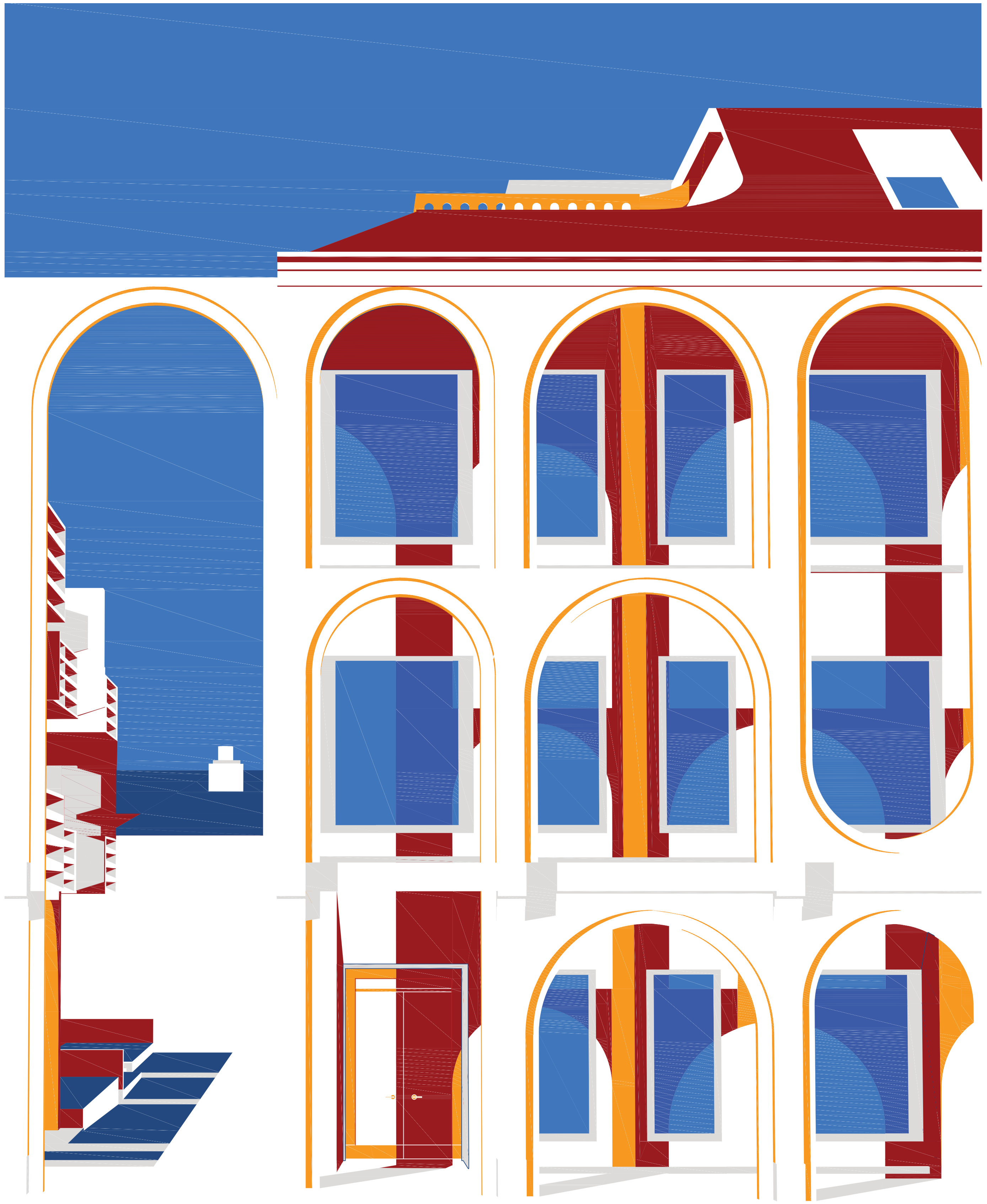


Fig 63 West face render

Fig 64 North View Axo

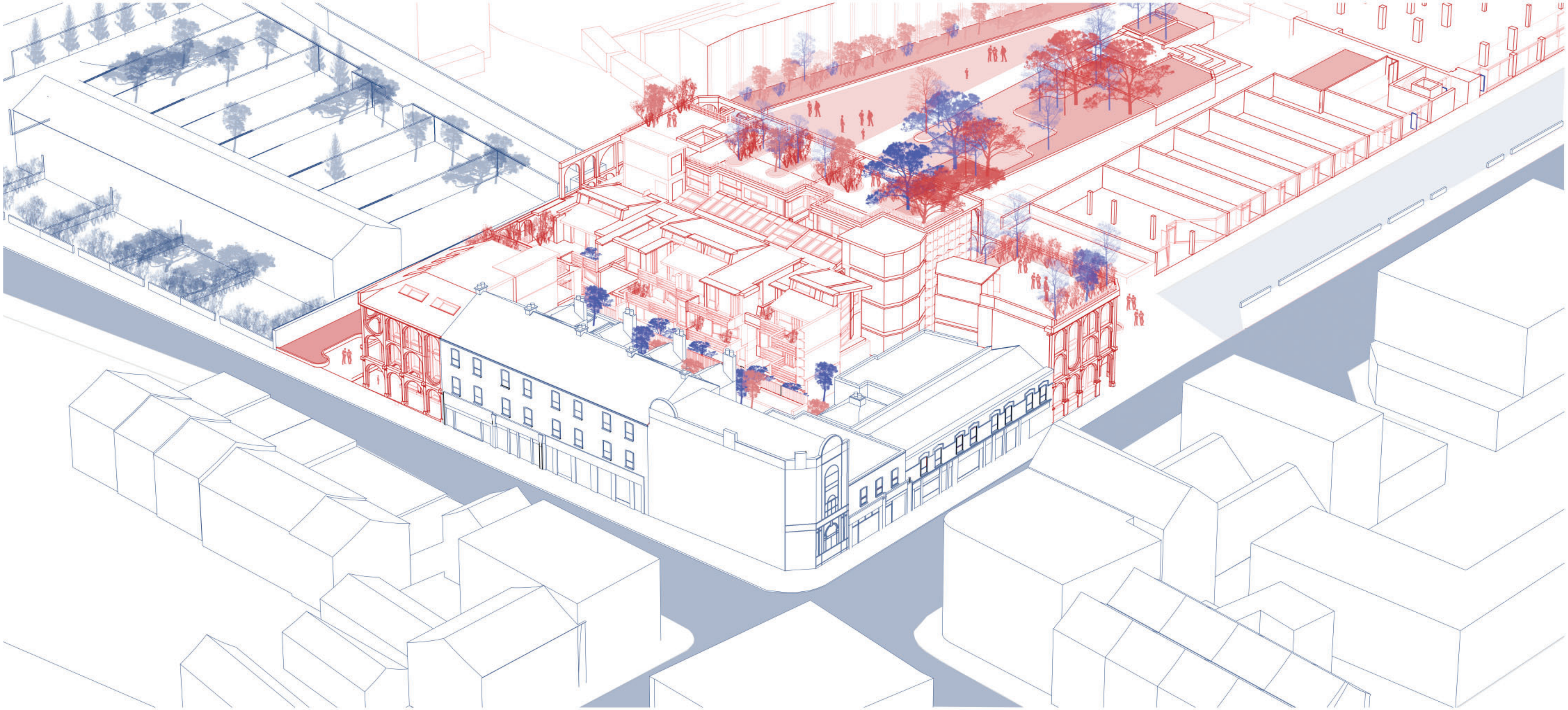


Fig 65 SouthView Axo

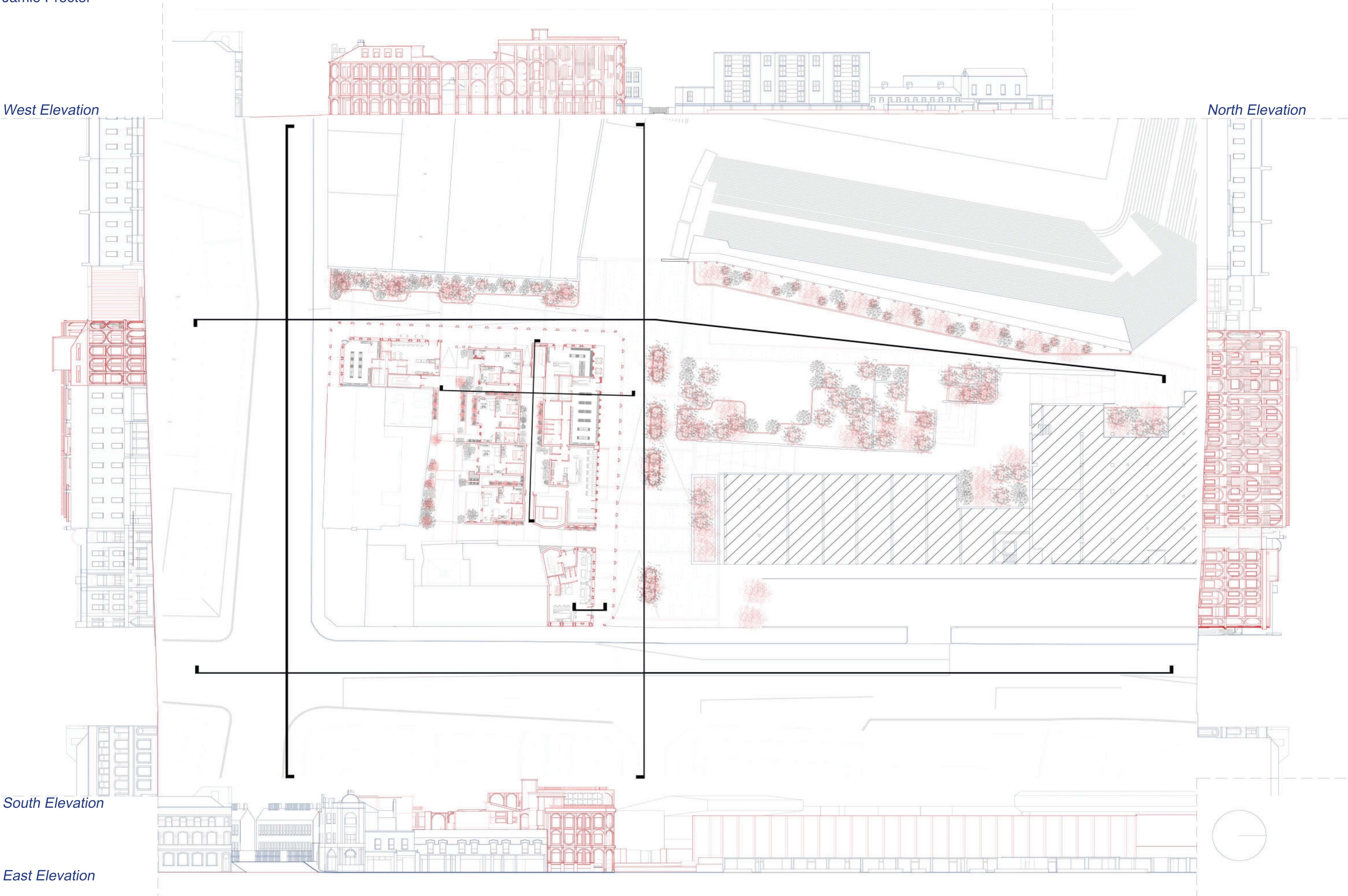


Fig 66 Site plan and elvations

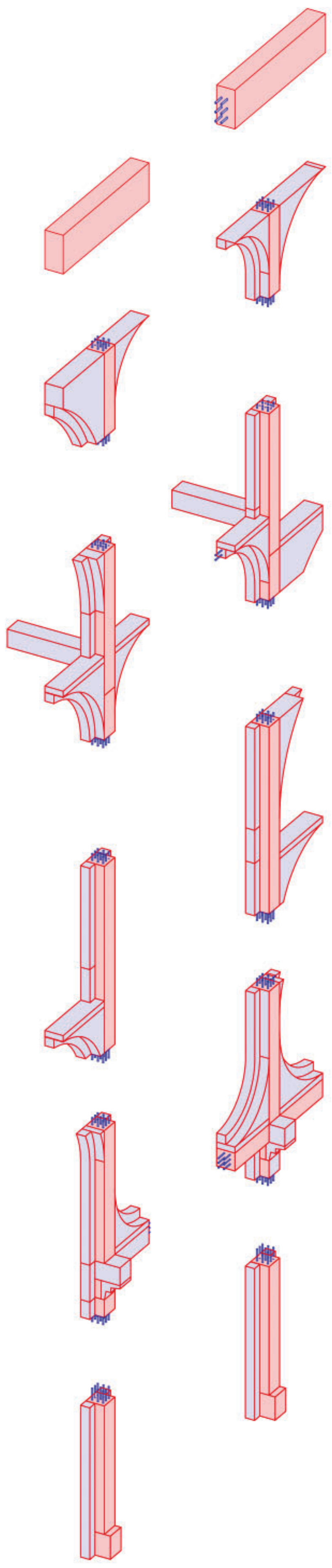
Fig 67 Ground floor

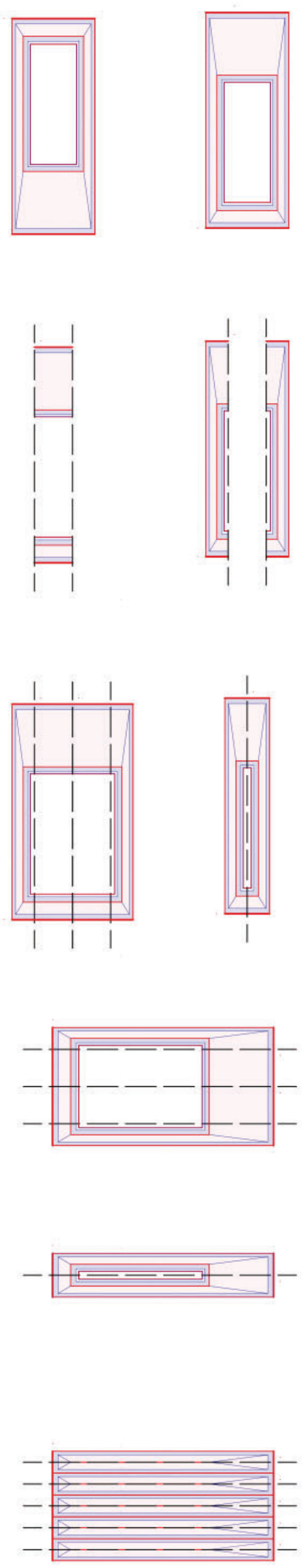
Fig 68 First floor

Fig 69 Second floor

Fig 70 Third floor

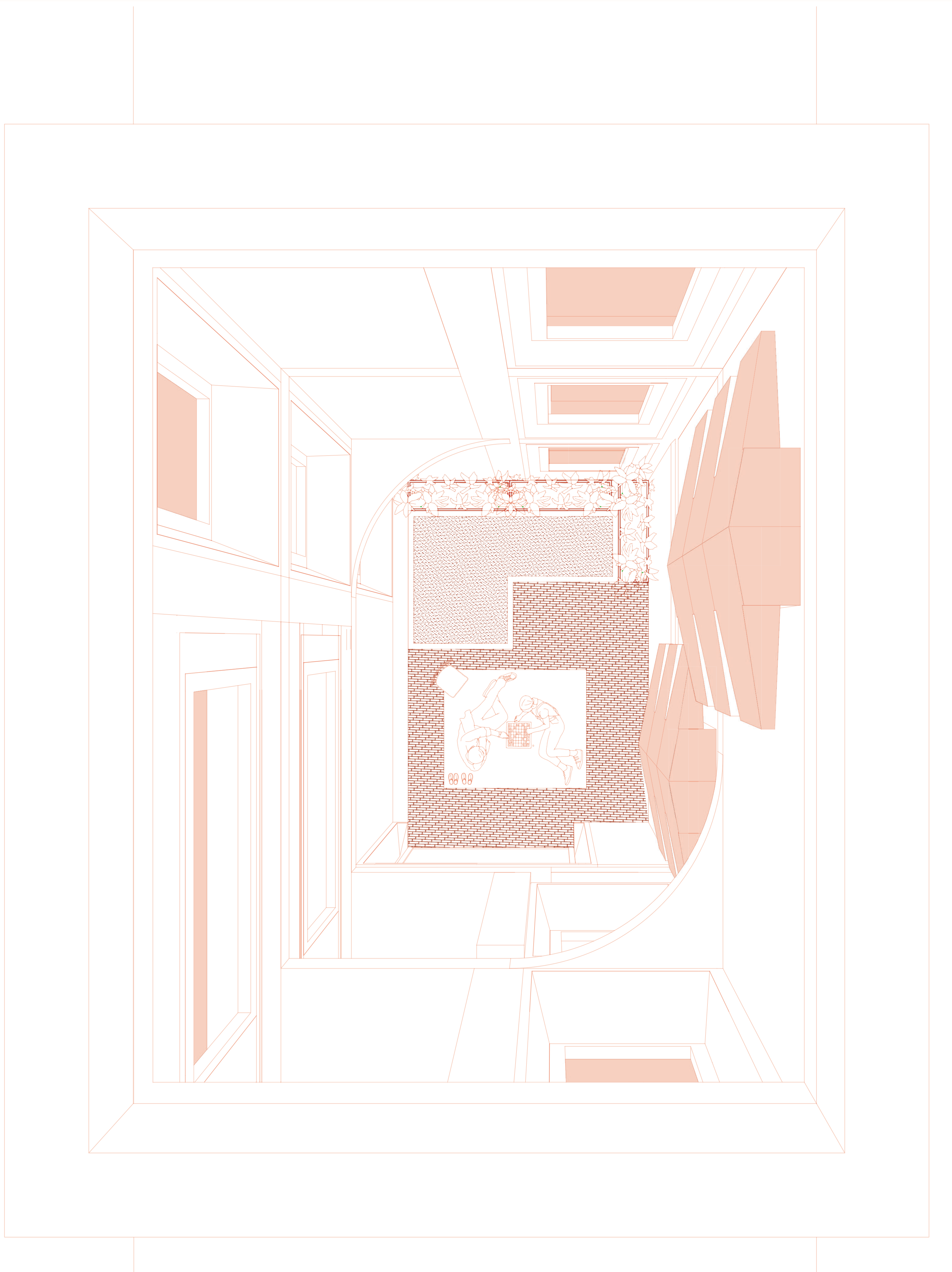
Fig 71 Fourth floor





Arch Concstruction,

Existing facade reuse and upcycling



Lightwell

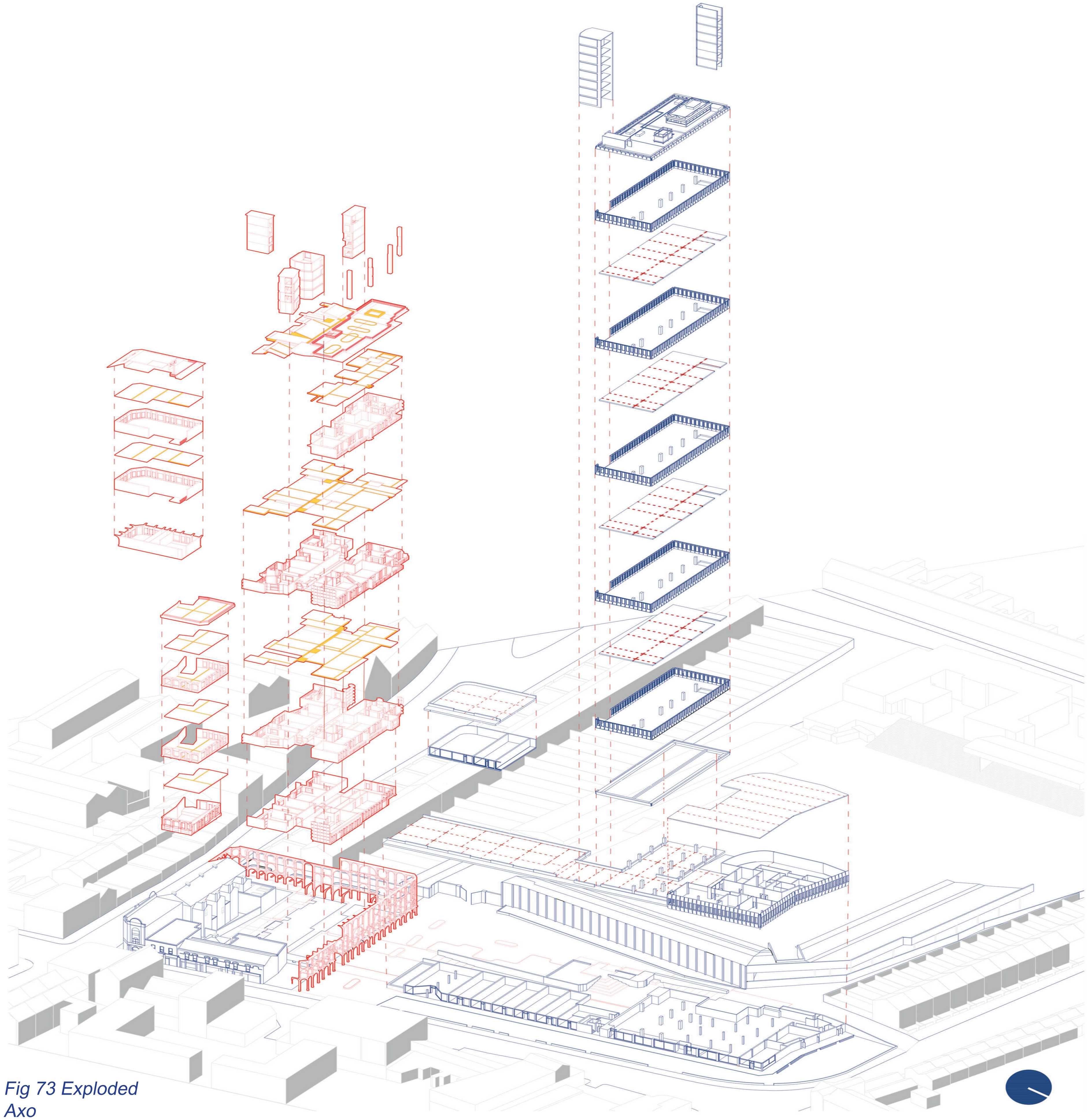
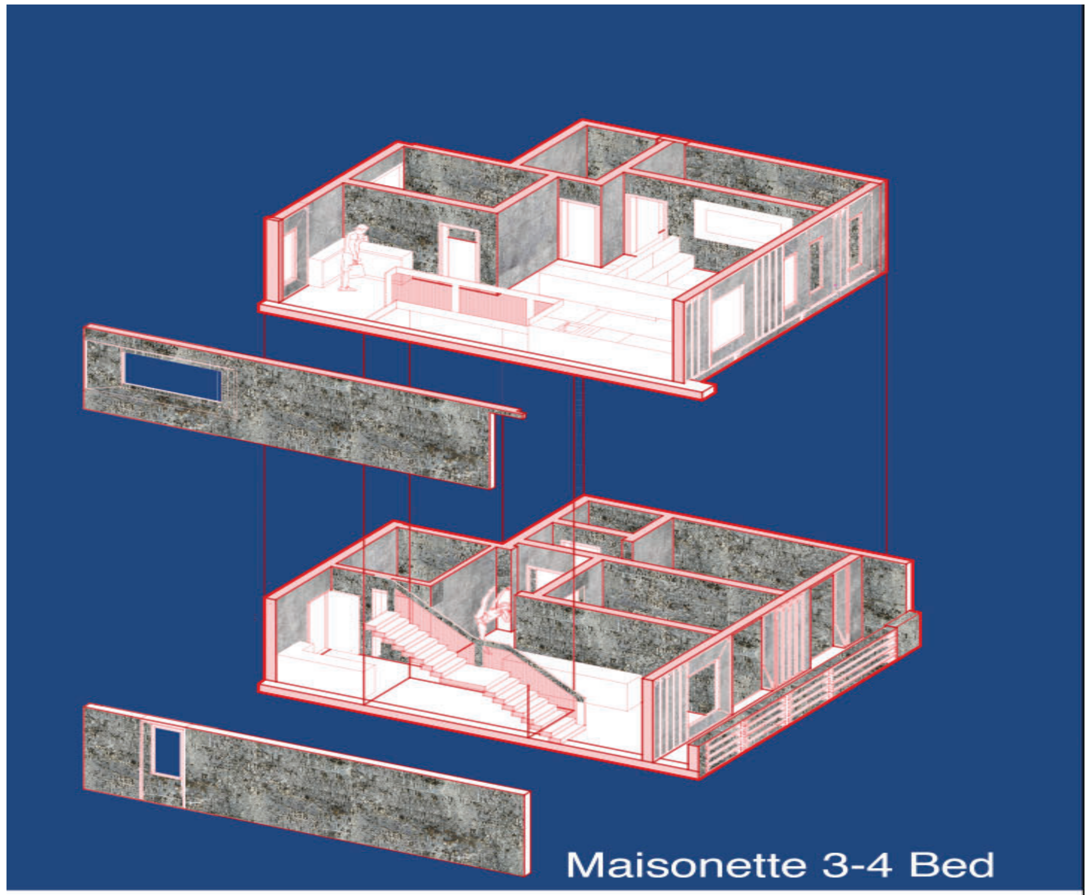
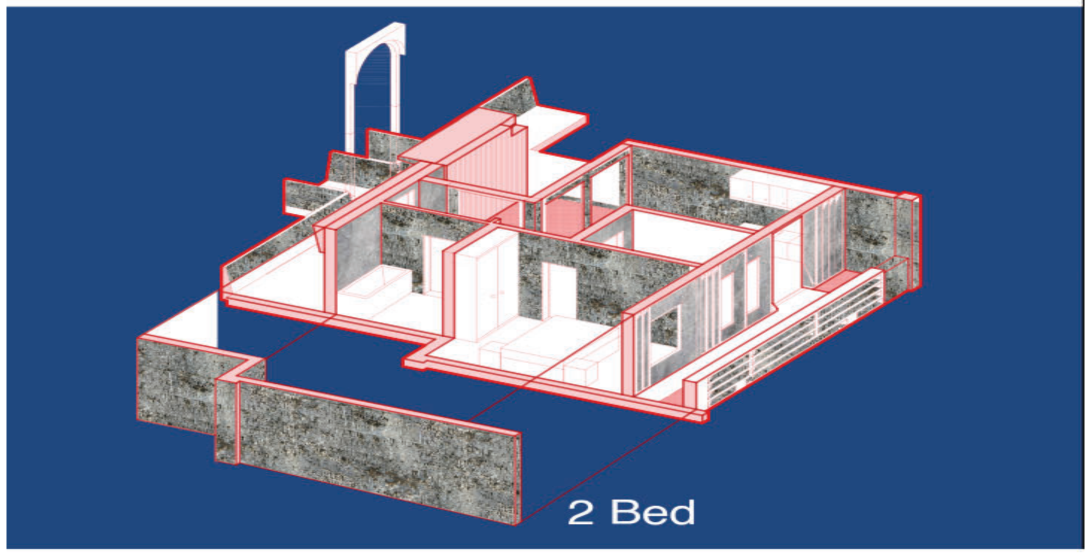
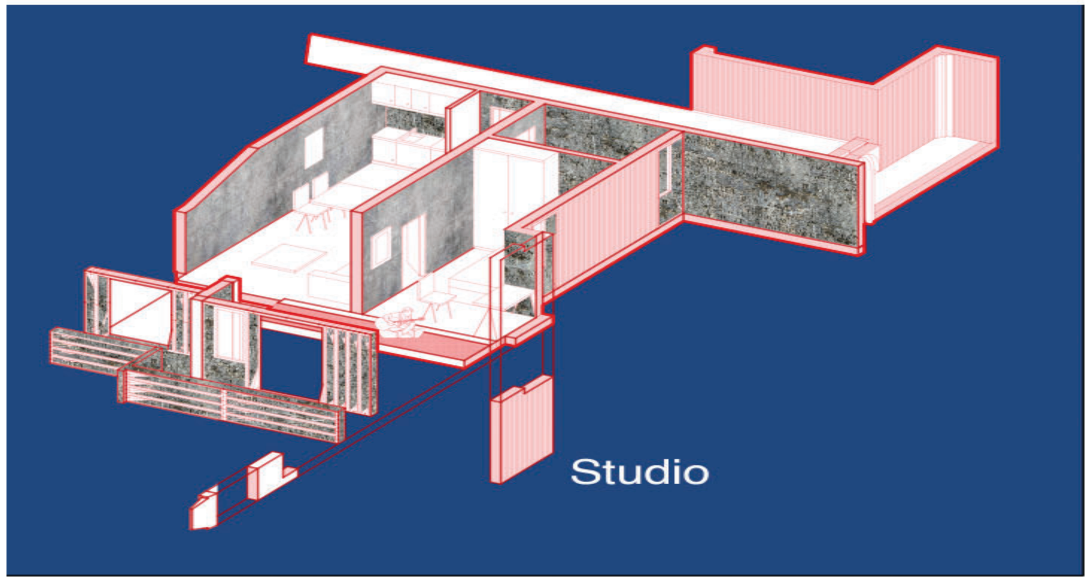


Fig 73 Exploded Axo

Fig 74 Dwelling Type







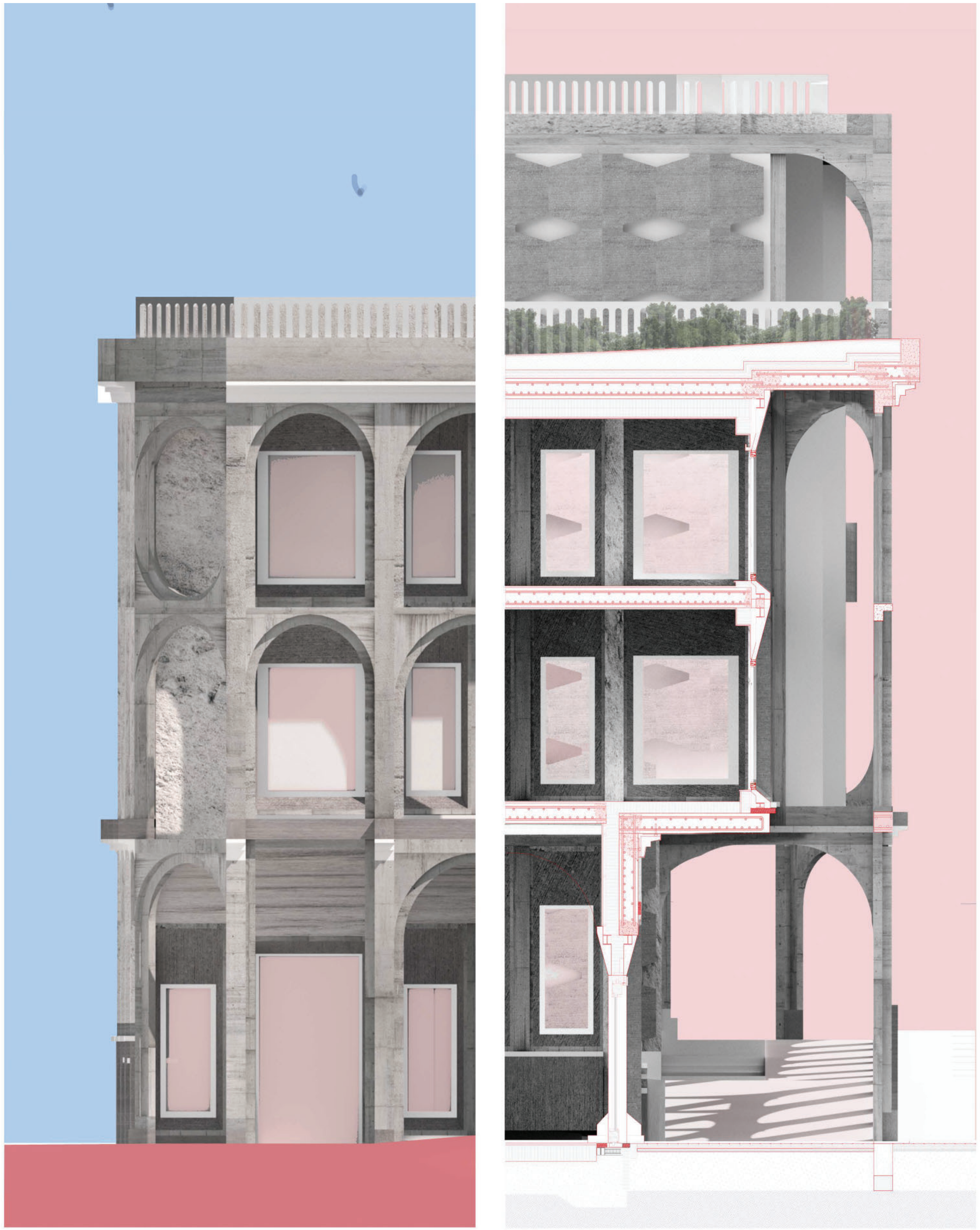


Fig 75 1-20 Section and Elevation

Fig 76 Long Section


Night
Late Night Pharmacy
1-3 Bed Apartments and Maisonettes
Roof Garden Access and outdoor garden

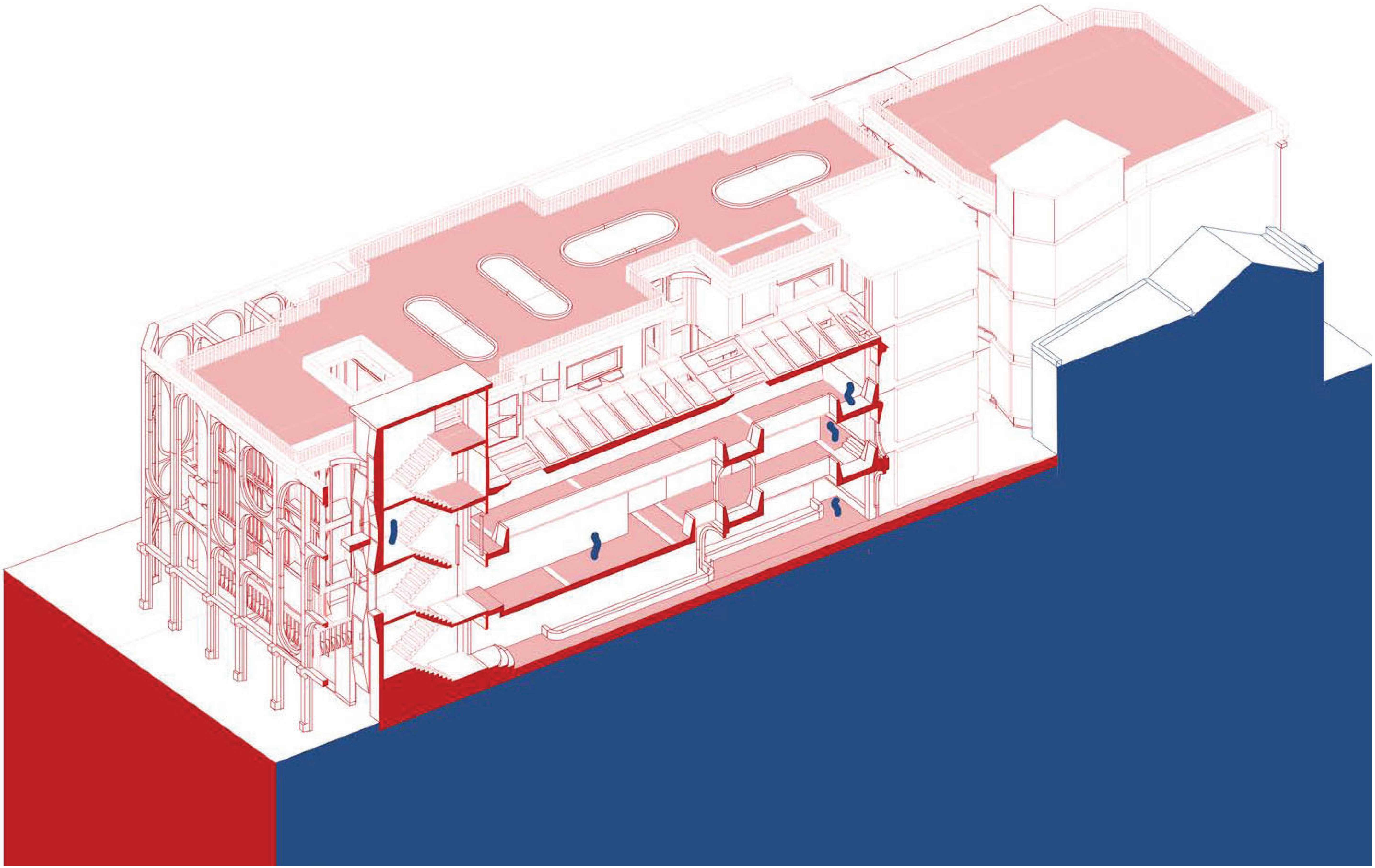


Fig 77 Axo section

Fig 78 Section

Conclusions

Though upcycling techniques, though more costly in nature as it functions on an individual unit scale rather than blanket conversion under current practices in recycling. The underlying theory is of more environmental merit as it demonstrates that the construction of a new building is temporary and not a permanent condition. A construction and that of the built environment can be seen in base terms as a storage of materials and its stored embodied carbon and its potential combined to serve an immediate need and condition where once its purpose is complete said stored embodied materials of a structure may be reutilized to fulfill a greater purpose. Additionally, through upcycling, the embodied value of a material is retained, allowing for more dynamic reuse potential. This process of upcycling can be applied to existing embodied material stock as well as current CDW as a means of a more efficient method of resource reclamation as upcycling functions on an in-situ basis without the need for pre-existing infrastructure to transform designated material present in recycling processes.

This paper will have hopefully demostrated the need to challange existing practices in the reuse of materials in the architectural realm and identified a method of adaptive reuse and upcycling for architectural expression while also taking note of site based architectural expression.

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Figures