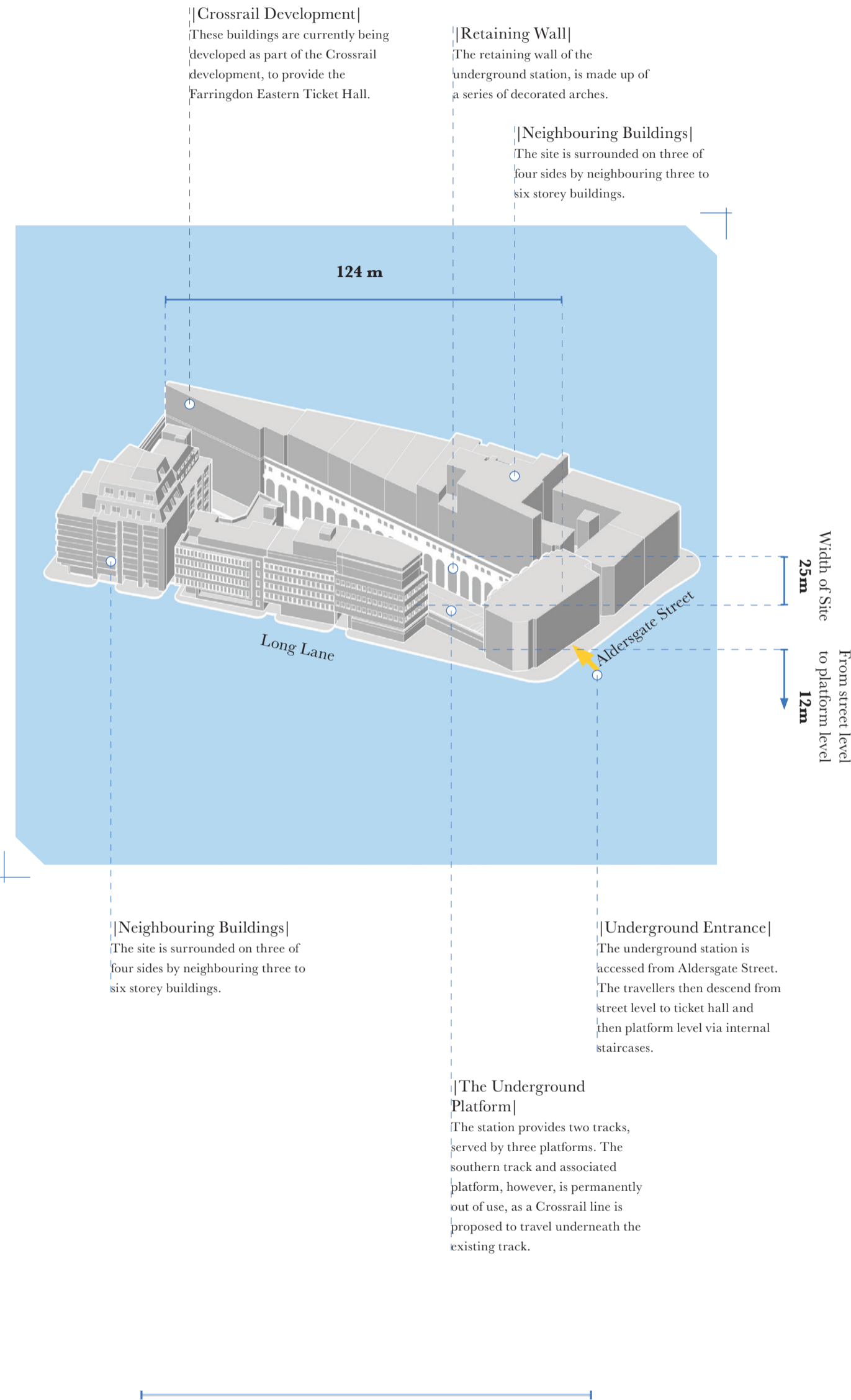


| The Site: Overview |

Site Specifics

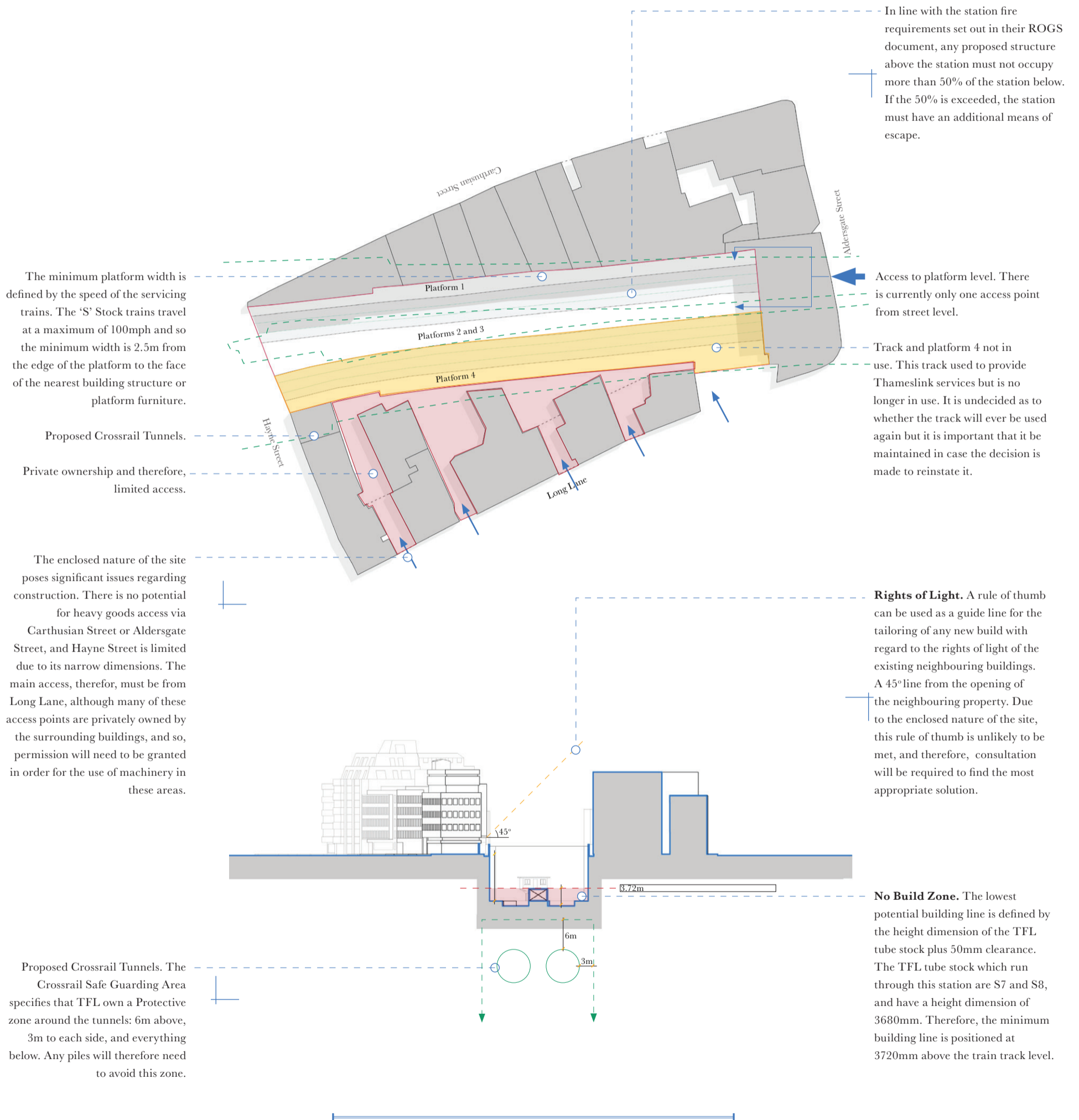


## | Site Context: Constraints |

### Exploring the Implications of Building Above an Underground Station and Within an Enclosed Site

The site is defined as the air rights spaces above the Barbican Underground Station.

Therefore, there are several implications due to the necessity for the continuing use of a live station. The following diagram sets out those implications, and the impacts that they may then have of the proposed development.



# | The Programme |

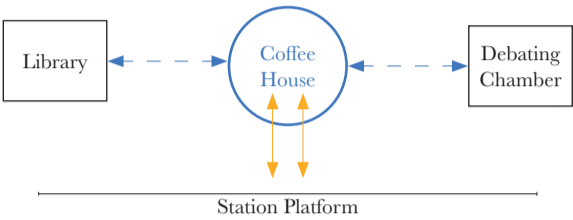
## Spaces within the Political Enclave

In order to achieve the atmosphere of a political hub, a wide range of programmatic uses were chosen, so as to create a diverse range of environments within the building.

The uses are documented below.

### Coffee House

The coffee house provides the core of the building, being the most democratic of all the spaces conceived within the political hub. It is to be equidistant from the library and the debating chamber, so as to show an equality between the two forms of political engagement. It is to have a strong connection to the station below, and encourage an atmosphere of debate and discussion.



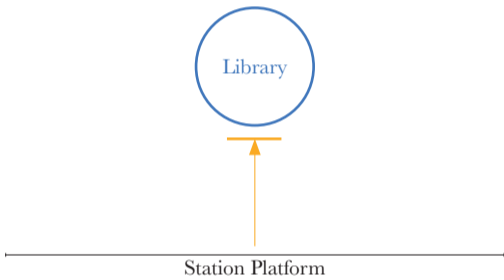
### Debating Chamber

The debating chamber provides a space for formal debate, offering the opportunity for political leaders and activists to come to the building to speak and discuss ideas. It is essential that this space is strongly connected to the station below acoustically, so as to harness the atmosphere of debate.



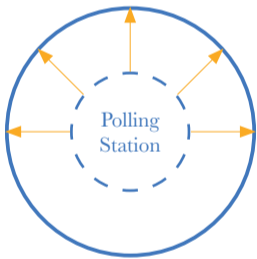
### Political Main and Youth Library

The library will provide a space where ideas can be attained in either a private or group setting. These ideas can then be transferred through the building and down onto the station below. The library is to be positioned at the opposing end of the site to the debating chamber, so that a sonic contrast is created between the spaces, and as far away from station noise as possible.



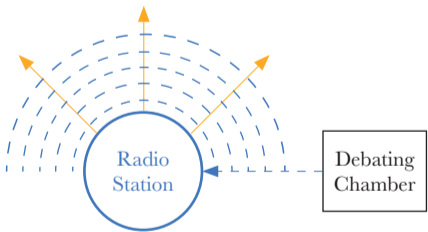
### Polling Station

The polling station will only be activated during election periods. At all other times it will provide an additional coffee house, situated within a reverberation chamber. The space will therefore acoustically transform periodically, so as to provide a space for both loud and quiet contemplation of opinions dependant on the circumstance.



### Radio Station

The radio station will function in contrast to the debating chamber, broadcasting information gathered within the more secluded areas of the debating chamber complex, for example the dressing rooms and debating prep rooms, so as to encourage a feeling of total sonic transparency within the building, and creating a presence which exceeds its boundaries.



## | Site Strategy |

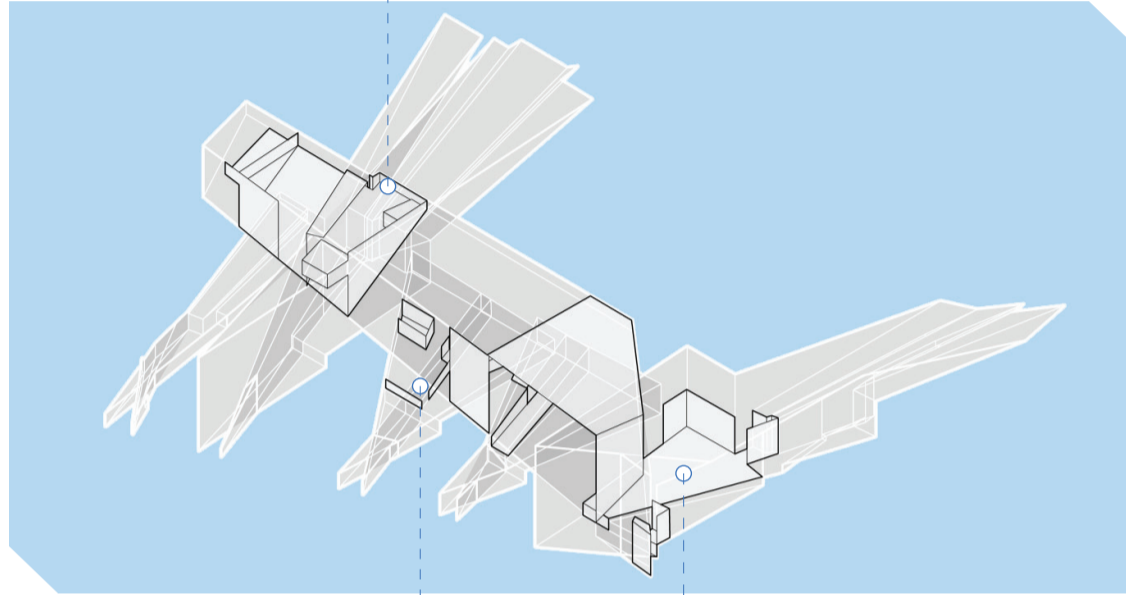
### The Fragmented View Planes

Within the geometry specified by the view planes, fragments were highlighted, using a system of coding, based on the intended use, acoustic atmospheres and required privacy of the intended spaces.

These fragmented planes were later used to begin to generate the overall building form.

#### **The Library**

The most fragmented planes were selected from this area, because the space should be a private, acoustically insulated place.

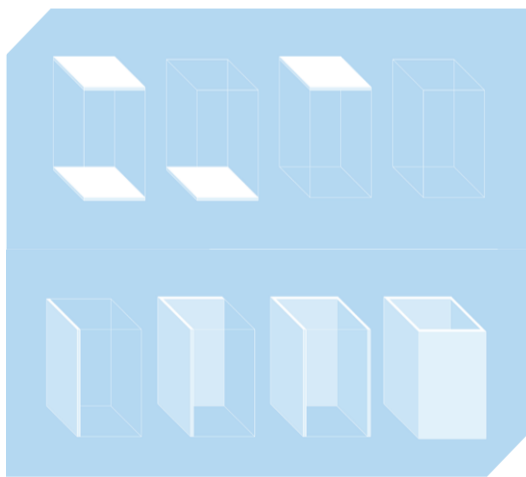


#### **The Coffee Shop**

The fewest fragmented planes were selected from this area, because the space was intended to be a public space where conversation and discussion are freely encouraged, both within the space and with the platform below.

#### **The Debating Chamber**

The planes selected in this area were chosen to express that the space, whilst encouraging discussion and interaction with the platform below, must be more controlled, in terms of acoustic egress. It is a half way point between the coffee shop and the library.

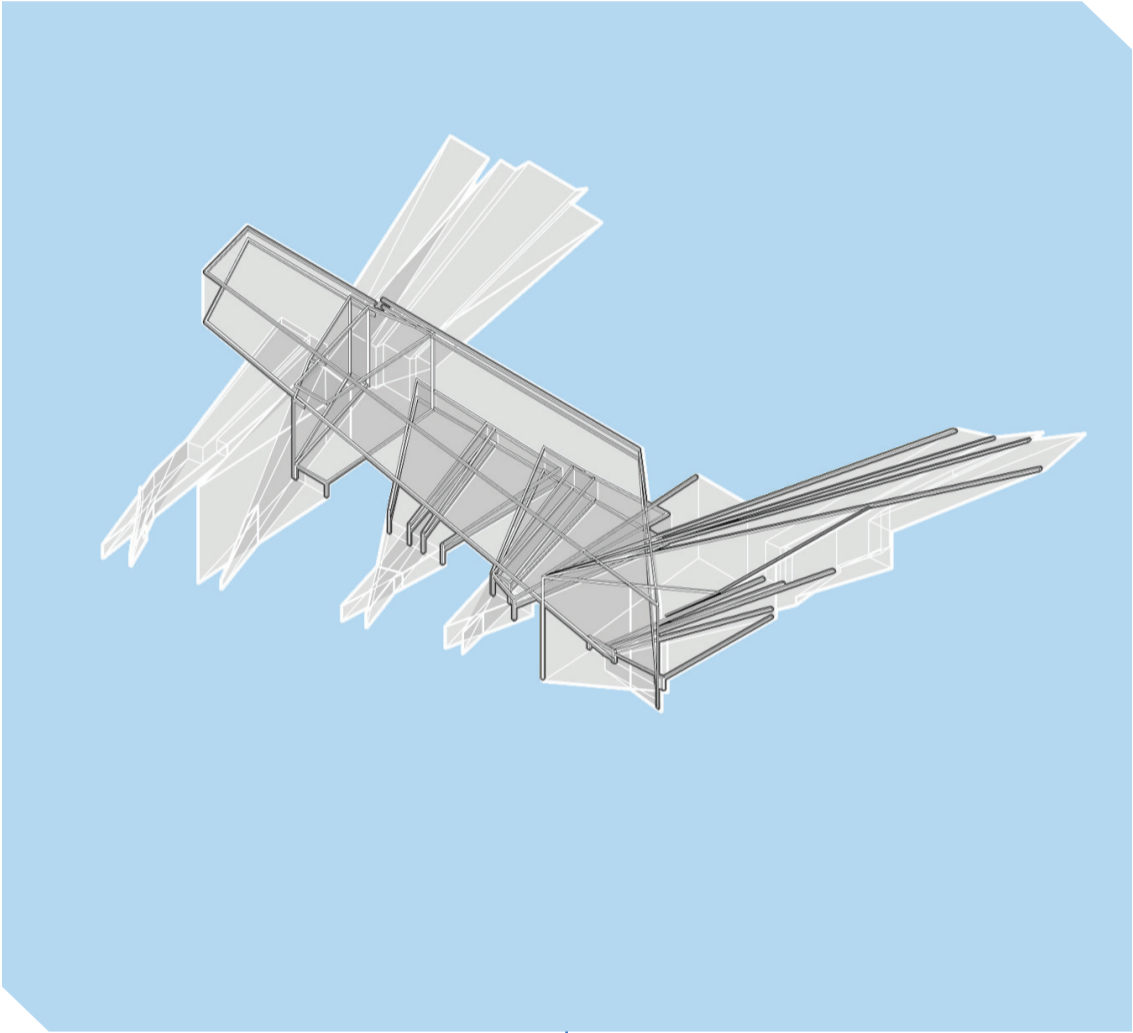


| Structural Strategy |

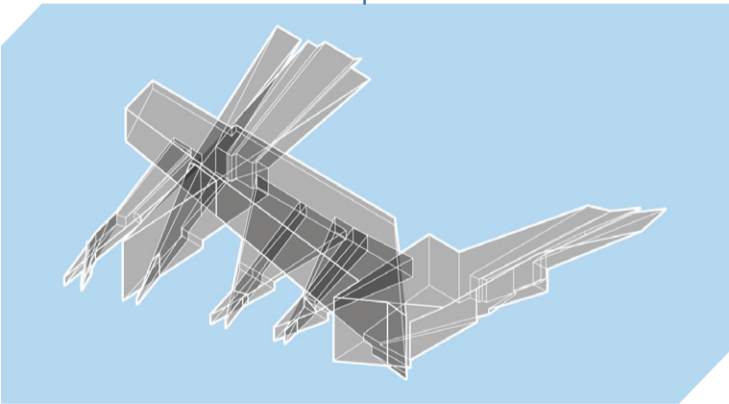
Deriving a Structure from the Sight Lines

The sight lines have been used to develop a basic structural strategy. Because the building form has been defined by the sight lines, the structure, derived from the vertices of the sight lines, will cut through the majority of spaces.

The structural elements shown here, however, do cut through some spaces at inappropriate levels, restricting circulation, and not providing the extent of the structure needed to support the proposed building. Therefore, this strategy has been adapted in order to be more appropriate.



Conceptual Structural System



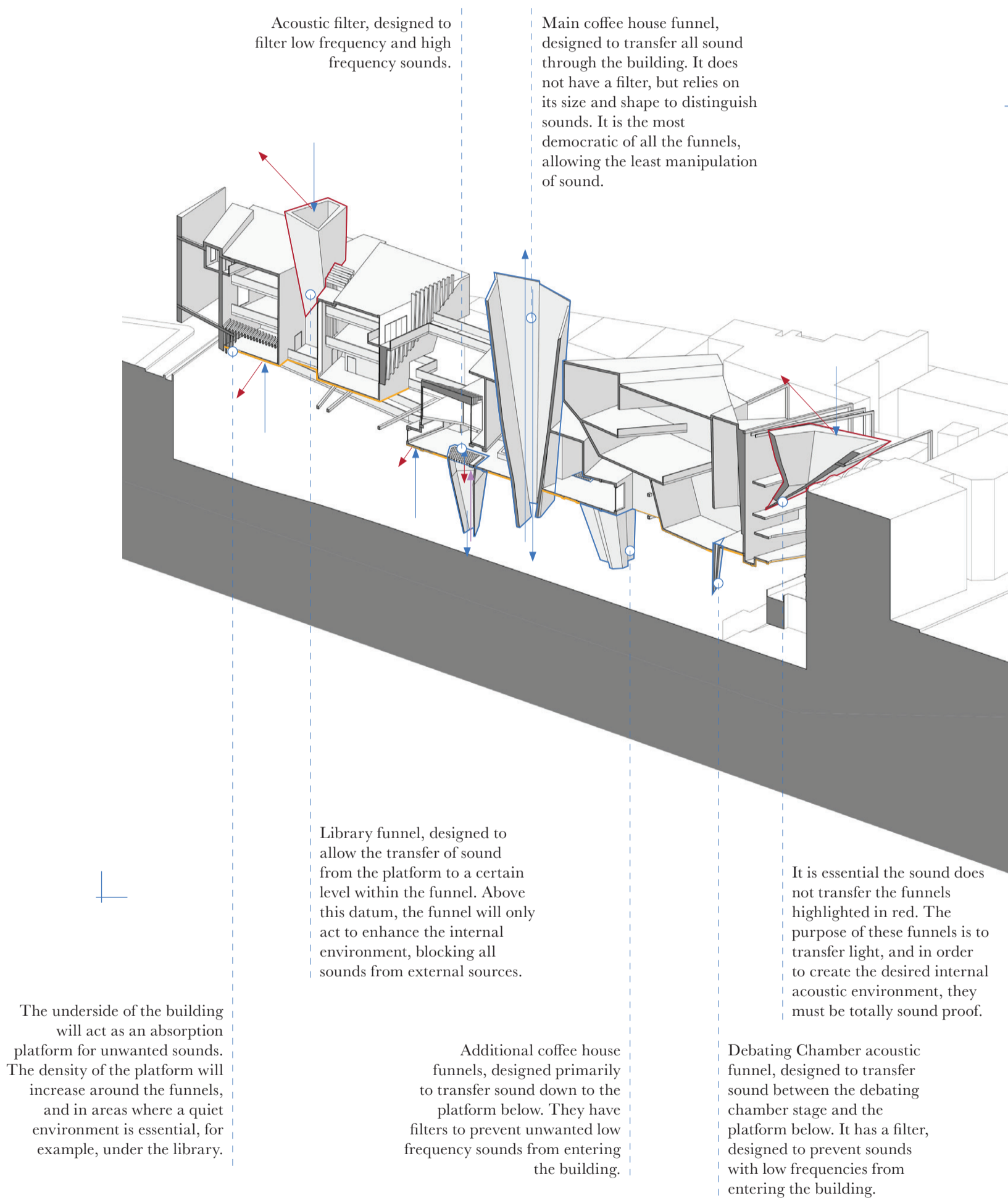
Sight Lines from Long Lane

## | Acoustic Strategy |

### Overview

One of the key considerations for the building proposal is the transfer of sound from the platform into the building and visa versa. The funnels provide the main strategy for this transfer of sound.

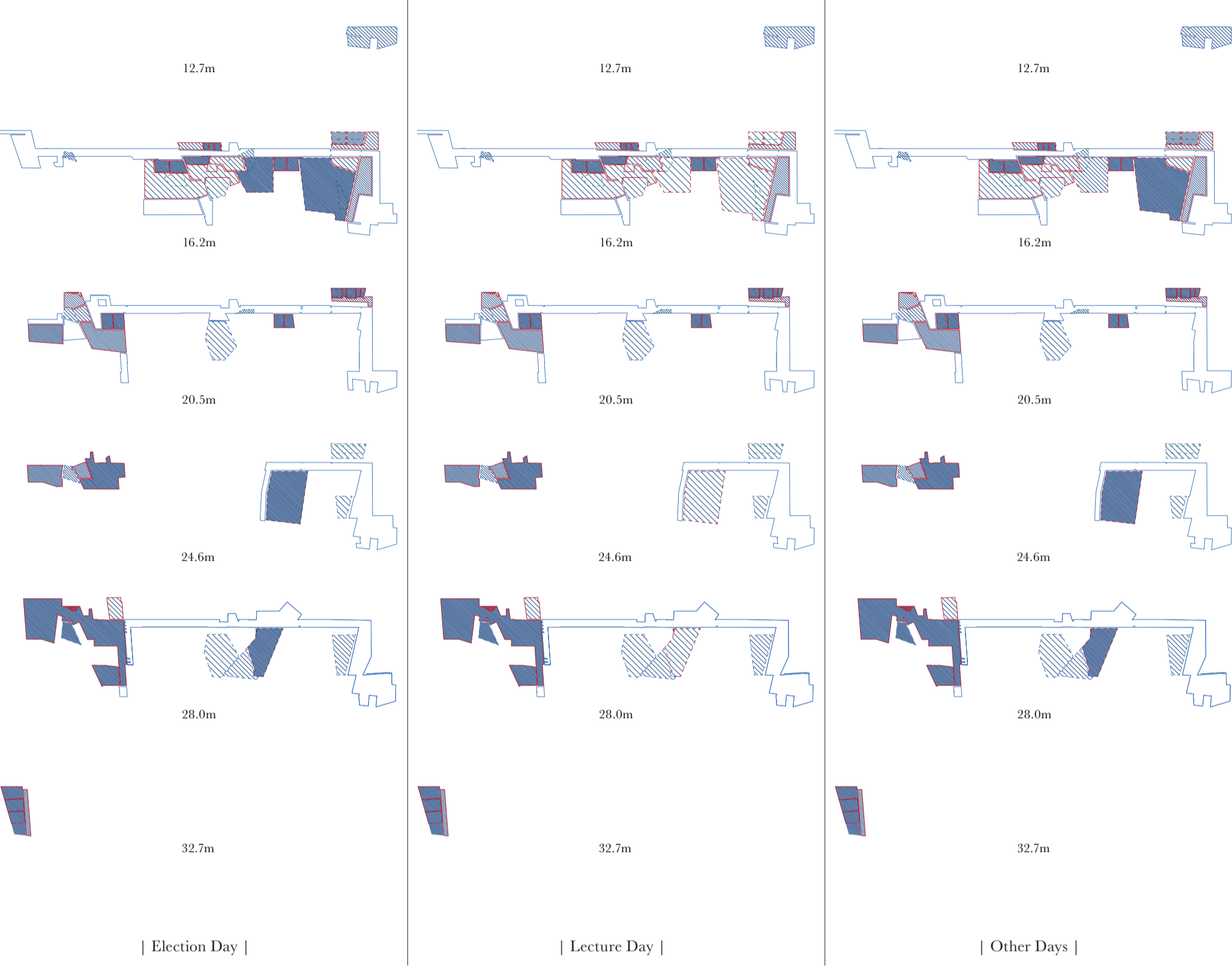
Additionally, the underside of the building will be treated as a sound absorption platform to absorb any unwanted sound, creating an additional barrier to the internal environment, and improving the environment of the station below.



| Acoustic Strategy |

Strategic Plans: Volume

The diagrams on the following pages document the intended sound environments within the building, using a diagrammatic language to denote volume, clarity, echo and leakage.

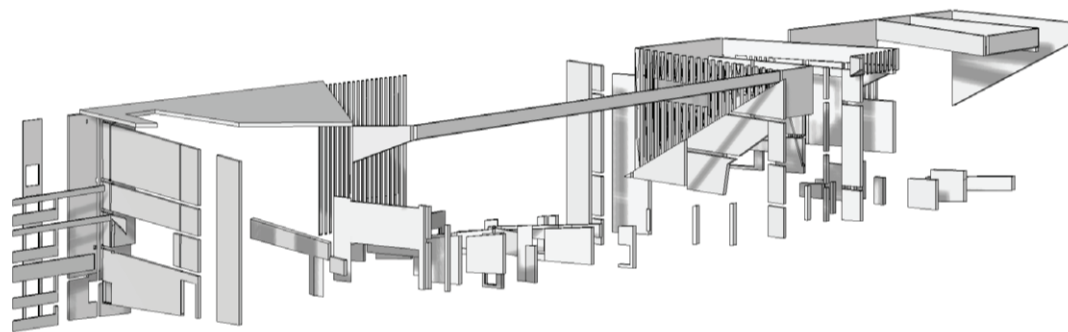
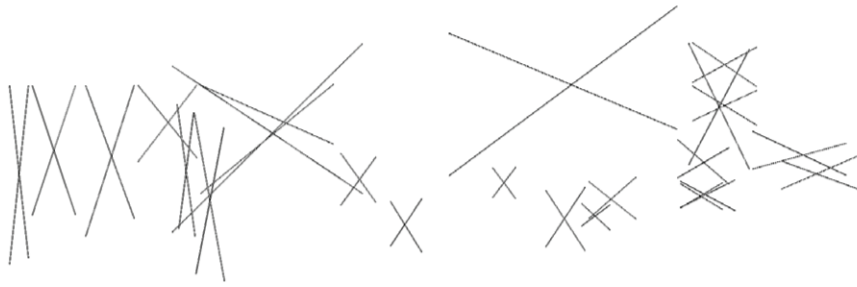


Funnel below  
Funnel  
External Space  
Fluctuating Internal Space  
Static Internal Space

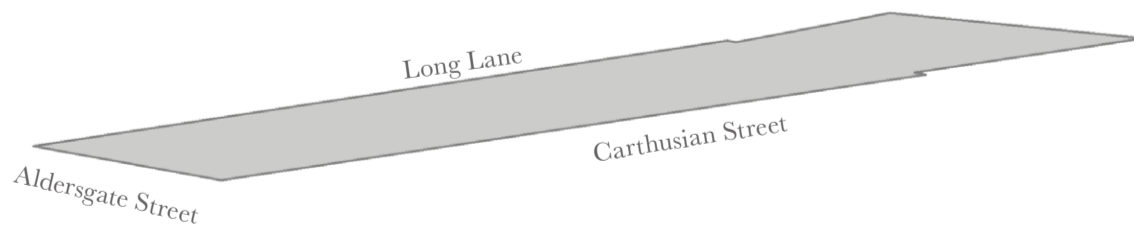
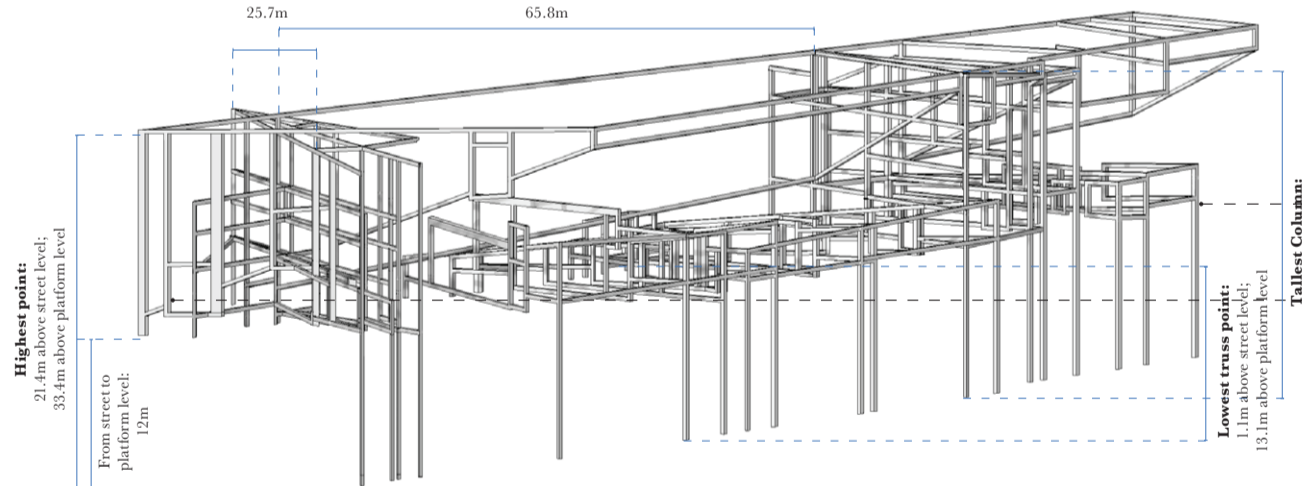
Loud Quiet

## | Structural Systems |

### The Overall Scheme

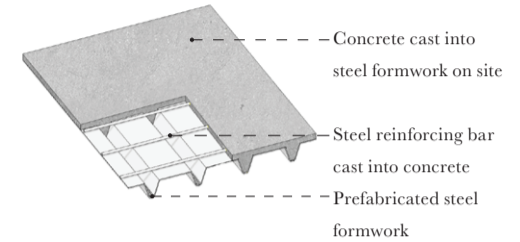


Longest Transverse Span: 25.7m  
Longest Longitudinal Span: 65.8m



#### 4: The Composite Concrete Plates

The composite concrete plates provide a slender light weight solution for the floor plates.



#### 3: The Steel Bracing Cables [Secondary Structure]

The cables provide bracing to the steel frames where light or views are required and a solid bracing element would not be appropriate.

#### 2: The Solid Bracing Elements [Secondary Structure]

The solid bracing elements are flat planes inserted into the main steel frame to provide bracing and, in addition, provide some of the dividing walls. They are made up of refined concrete, concrete clad in timber or concrete clad in timber. They can be prefabricated to reduce on site construction.

#### 1: The Main Frame [Primary Structure]

The main frame is made up of two parts:

##### 1a: The Transverse Frames

These bespoke truss systems span the short length of the site.

##### 1b: The Longitudinal Frame

This large frame runs the long distance of the site, and is propped primarily by the transverse frames.

#### 0: The Footprint of the Site

# | Structural Systems |

## Transverse Truss 06

Transverse truss 06 provides the truss systems to support the library. It extends over the four main levels of the building. Alongside Truss 01, it is the tallest transverse frame within the buildings

The solid bracing elements within this truss are slightly more complex than in the previous trusses, encompassing a rain screen as well as the solid elements. Solid elements also extend past the frame, providing, essentially, a large base at street level.

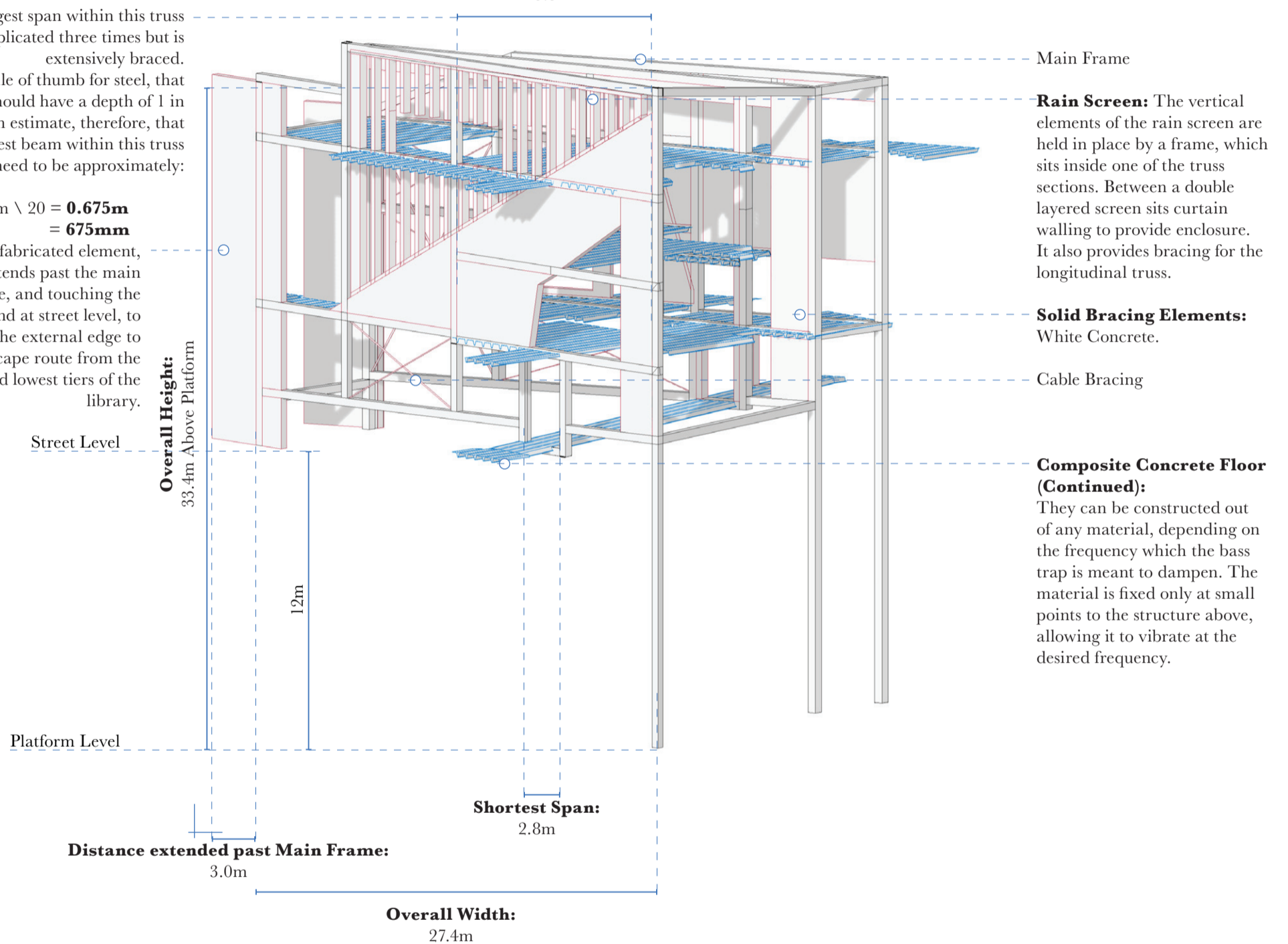
The main frame is made up of three trusses, all braced at the front and rear by longitudinal beams. The three trusses originate from two points at the front and extend at different angles to the rear of the site.

**Longest Span:**  
13.5m

The longest span within this truss is replicated three times but is extensively braced. Using a rule of thumb for steel, that structure should have a depth of 1 in 20, we can estimate, therefore, that the deepest beam within this truss will need to be approximately:

$$13.5\text{m} \div 20 = \mathbf{0.675\text{m}} \\ = \mathbf{675\text{mm}}$$

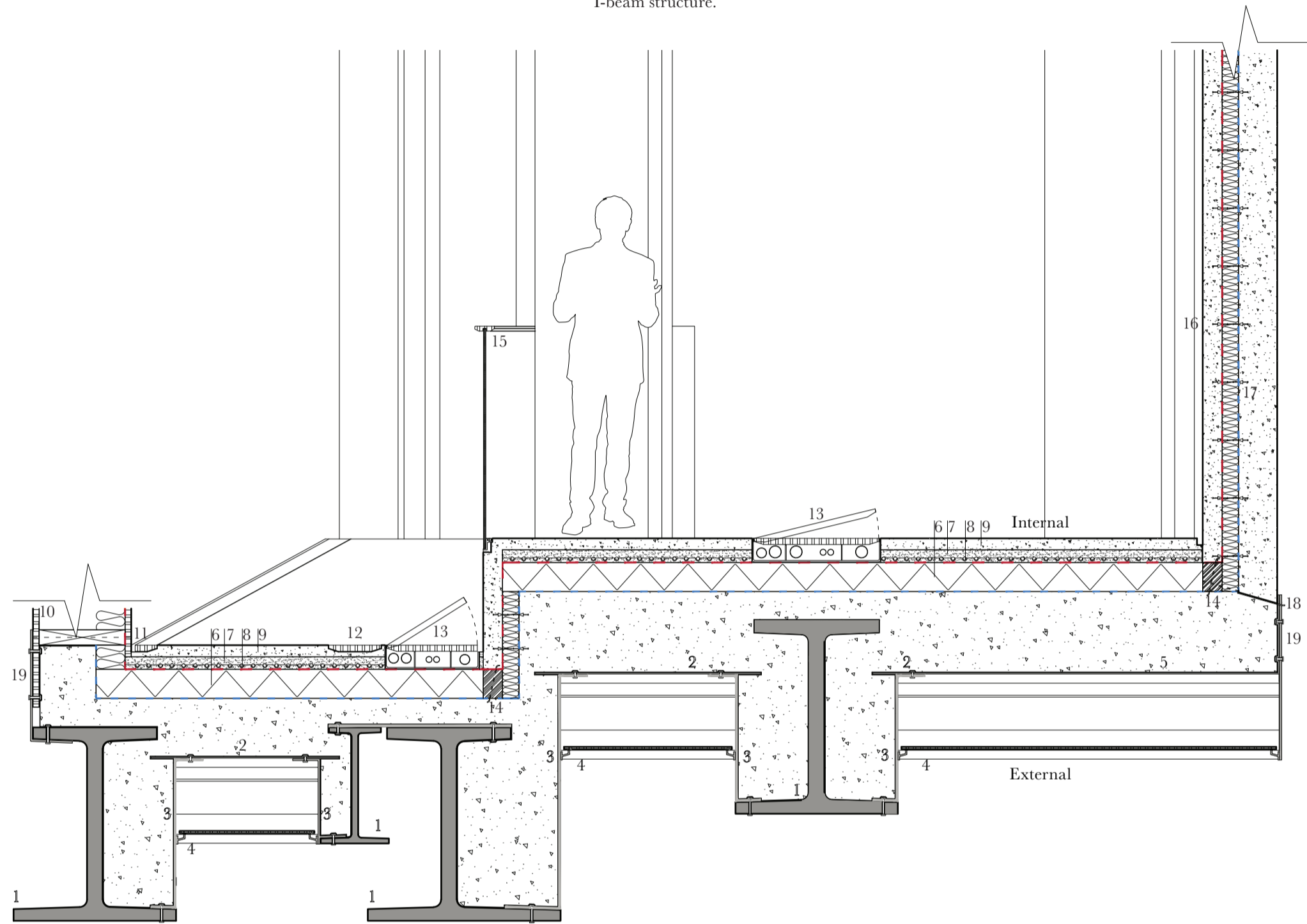
Solid pre fabricated element, which extends past the main frame, and touching the ground at street level, to provide the external edge to the fire escape route from the highest and lowest tiers of the library.



| Structural Systems |

Composite Floor Deck Detail  
1:25 @A3

Detail cutting through the internal debating chamber lobby space, to show the integration of the composite flooring deck, timber and double skin concrete walls and the steel I-beam structure.



1. Steel I-beam, sized based on load and length
2. Trapezoidal profiled steel deck
3. Steel decking end plate, bolted to steel I-beam and profiled steel deck
4. Bass trap (See Bass Trap Detail)
5. In-situ reinforced concrete, cast into profiled steel deck (minimum depth 150mm)
6. 150mm polyisocyanurate rigid insulation
7. 65mm screed
8. Underfloor heating
9. 60mm In-situ fair faced concrete
10. Timber wall, with 150mm soft insulation
11. Shadow gap
12. Timber cast into concrete, in line with steel I-beams to express structure within the building
13. Timber, hinged to concrete, in line with I-beams, concealing services access
14. Thermally insulated, load bearing block work, structurally connecting concrete elements across the thermal barrier
15. Glass and timber handrail
16. Fair faced, double skin concrete wall
17. Concrete wall tie
18. Weep hole to allow drainage of condensation from insulation
19. Steel end plate

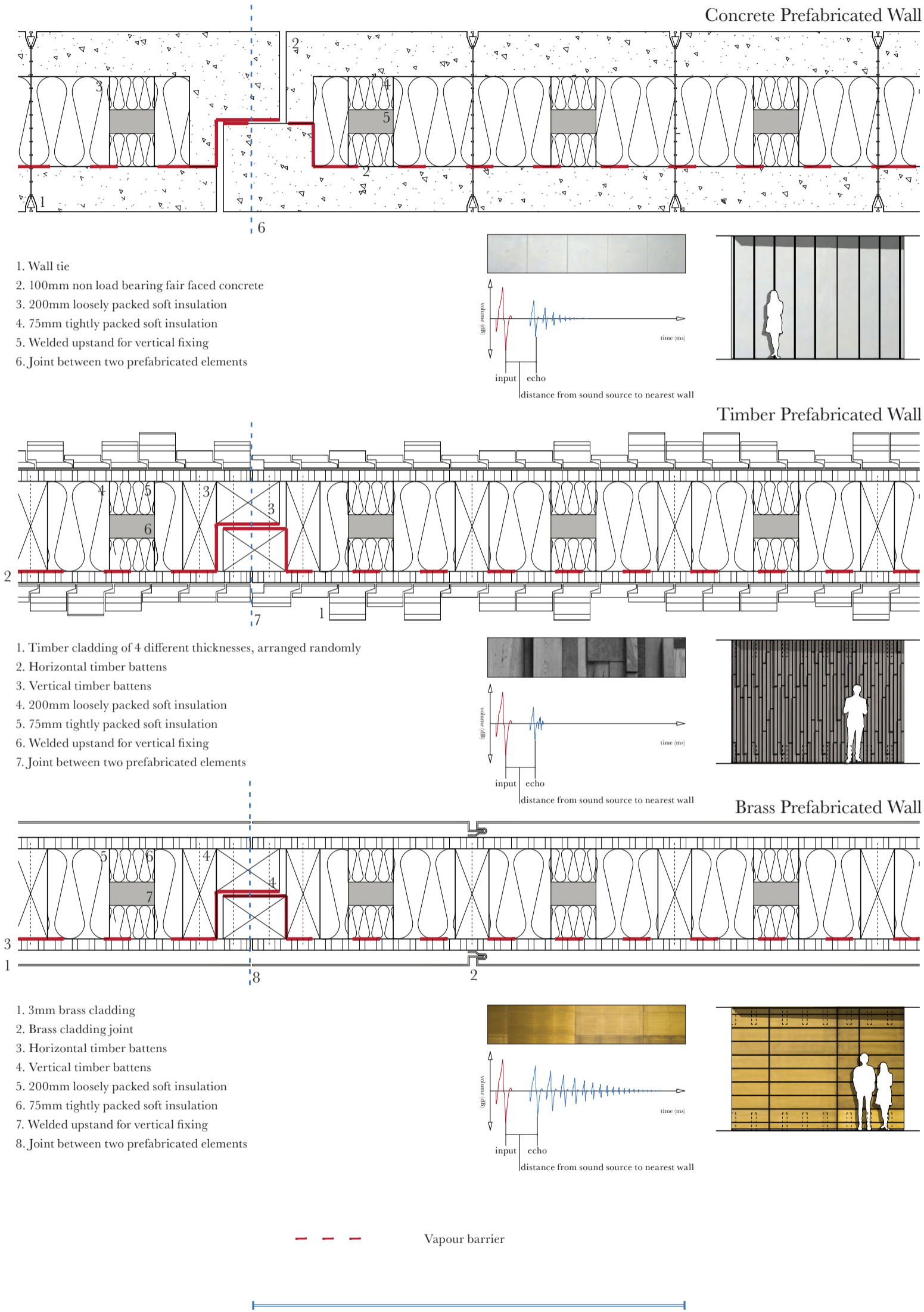
--- Vapour barrier  
--- Waterproof membrane

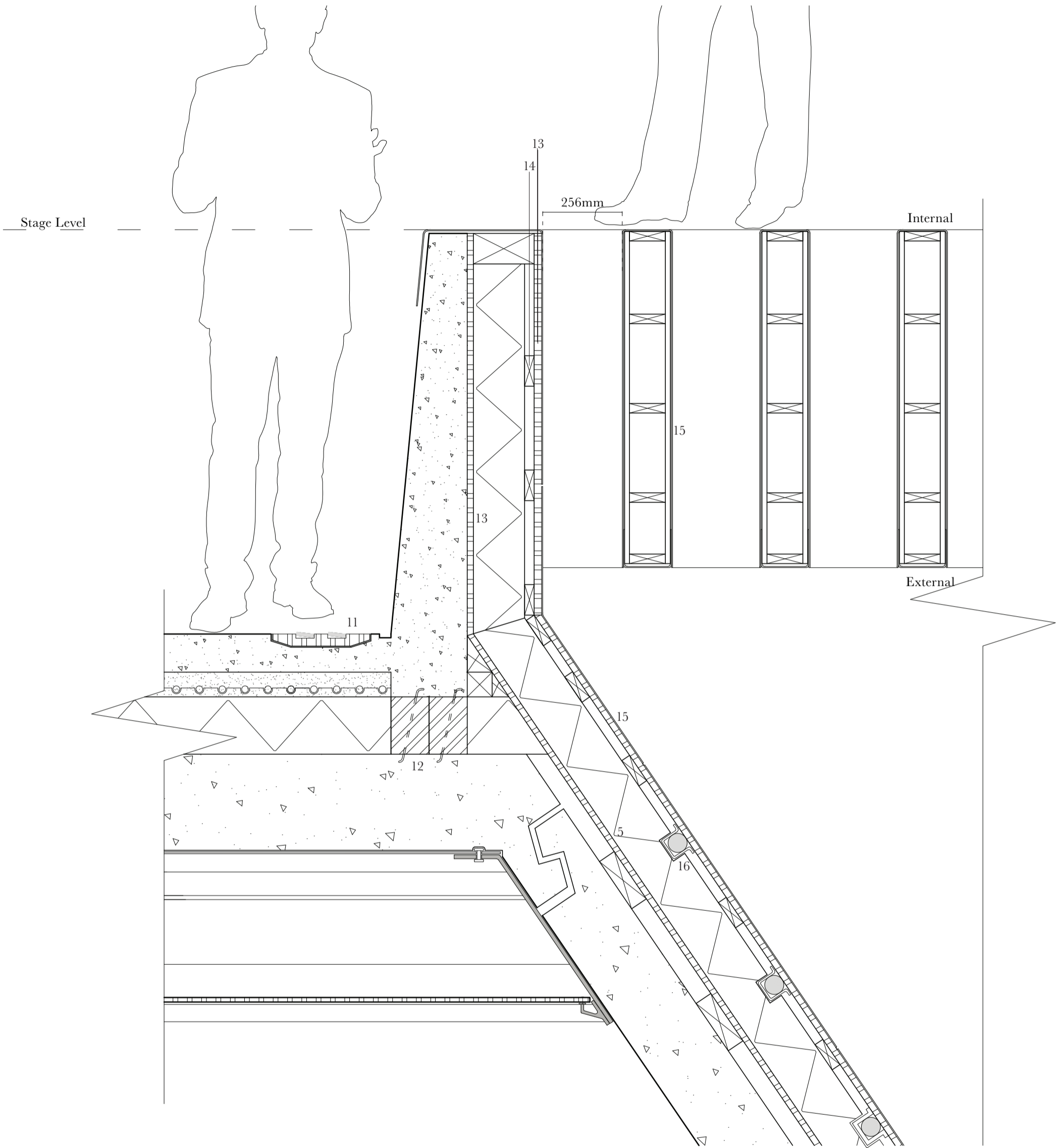


| Prefabrication |

The Solid Bracing Elements: Construction  
1:10 @A3

The following drawings and diagrams show the prefabricated elements of the design: how they would be constructed, their materiality, how they might look and how they would be likely to respond to sound, in terms of echo, volume and scatter.





### Timber Cladding

The timber cladding has been designed to create a diffuse scatter effect. The exact form of these walls will need to be extensively tested to ensure that the desired effect is achieved.

### Acoustic Baffles

Designed to be different sizes and thicknesses to prevent a diffraction grating effect. They are designed to absorb sounds when they reach the top of the auditorium, to prevent reflections which may distort the acoustic environment.

### Plenum

Attenuators used to reduce extent to which external noise enters the building through the plenum.

### Cavity Walls

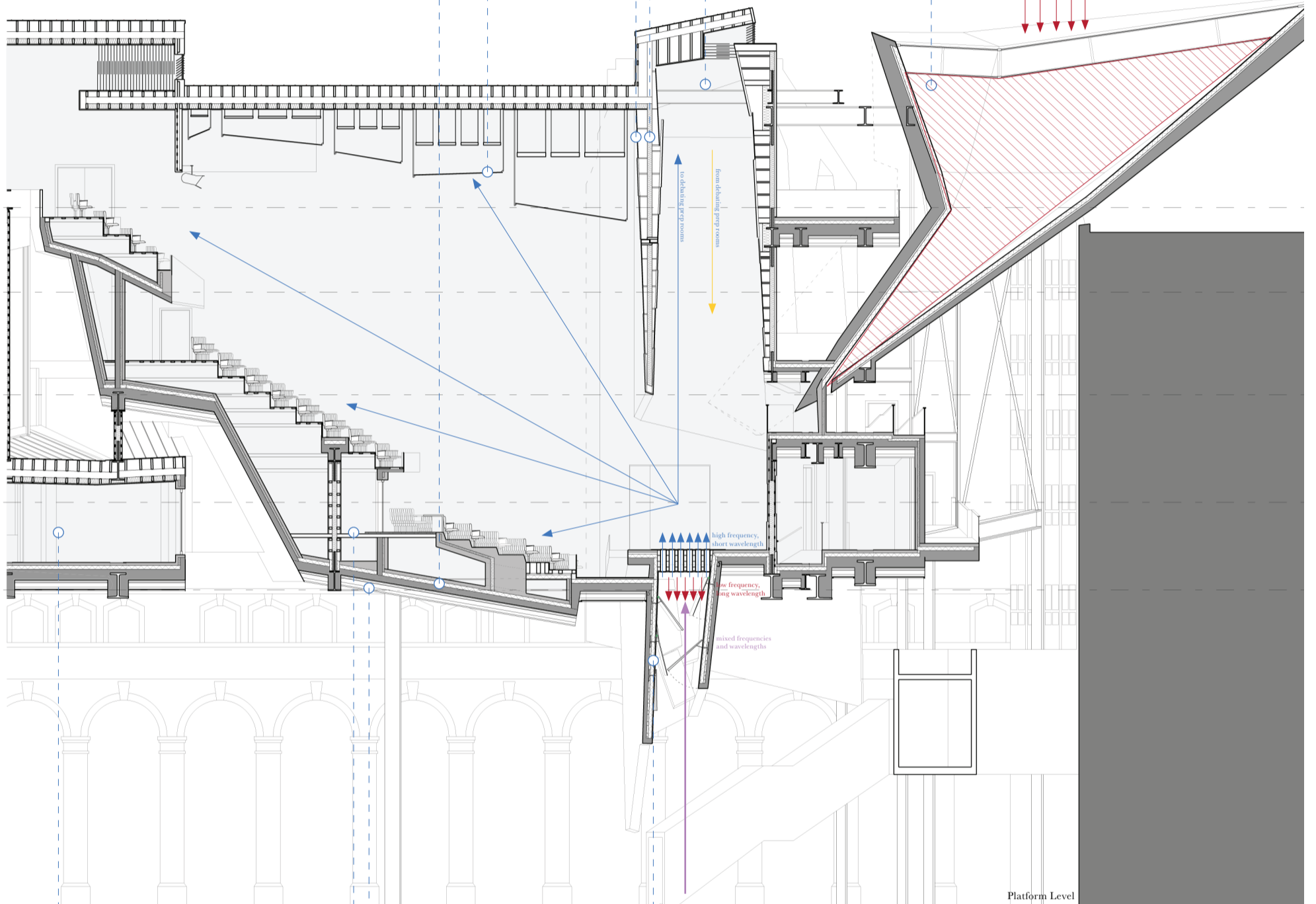
These walls have been designed to work like bass traps, tuned to resonate at frequencies undesirable within the debating chamber. This tuning can be done by changing the thickness and shape of the panels on the facing edge of the wall.

### Debating Chamber/ Debating Prep Funnel

This funnel transfers sound between internal spaces and then down to the platform. It transfer sound primarily between the debating prep rooms and the stage, so that audience members can gather in the auditorium before the debate begins and hear as the speakers prepare their arguments. This is intended to formalise the concept of sonic transparency, whereby the building users are at all times aware of the acoustic activity within other parts of the building.

### Debating Chamber Light Funnel

The primary function of this funnel is to transfer light. It is essential that it does not transfer external noise into the debating chamber, and so a large cavity double glazing system has been designed to prevent the transmission of sound.



### Coffee House Reverberation Chamber

It is proposed that this space be a temporary reverberation chamber, changeable based on the spaces current use.

### Base Traps

Located on the underside of the building to resonate at and absorb the unwanted sounds create in the underground station.

### Plant Room

Heavily insulated shared walls to reduce leakage of unwanted sound.

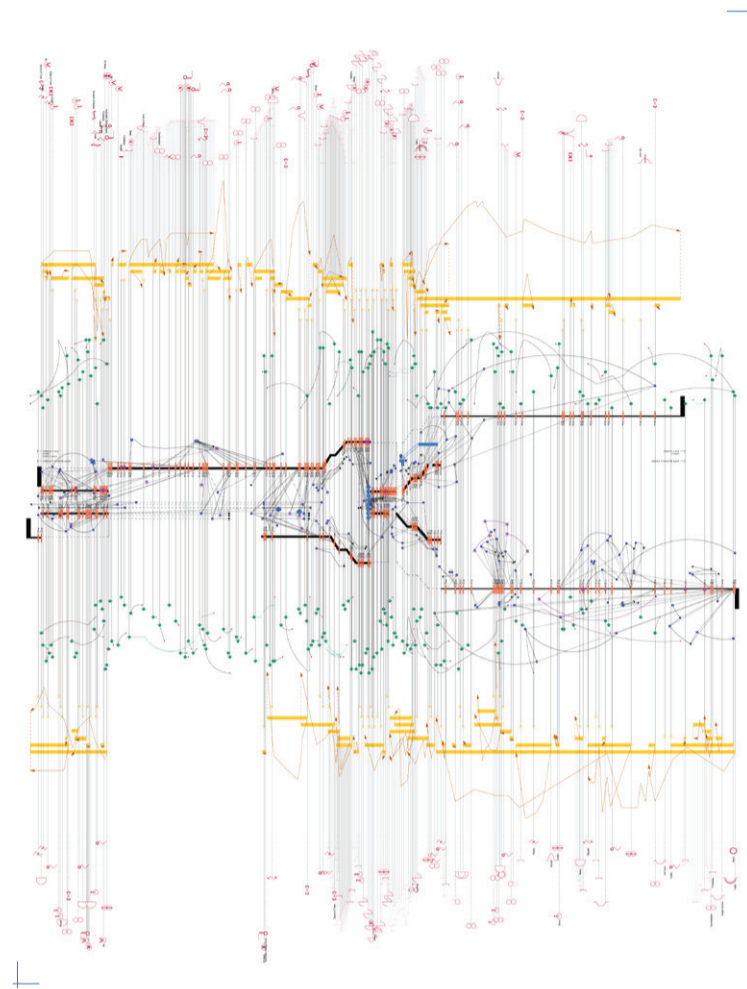
### Stage Funnel

This funnel transfers sound between the platform and the stage of the debating chamber. At its top (stage level), it has a filter, with openings size to the wavelength of human speech, so as to filter out any larger wavelengths (lower frequencies). The internal face of the funnel is lined with brass, to highlight its purpose to the users of the platform below, and to better transfer heat (see Heating Overview). The internal configuration of the funnel can be changed using articulated plates, which can be manipulated dependent on the desired clarity and volume of the sound.

## | Site Sound Analysis |

### Evaluating the Site's Acoustic Environment

The project began with an investigation into the site's acoustic environment through the medium of video recording. The audio of these videos was then drawn conceptually, measuring the site through time and sound.



Having understood the acoustics of the site conceptually, it was important to better understand the logistics of the environment technically, in order to design a building which responds and interacts with these sounds.

The original recordings were imported into a sound analysis software, which formatted the sound into a visual representation, describing the volume in decibels and the frequency in hertz through a series of graphs. Through these graphs, it has been possible to read the frequencies of selected sounds, identified on the site. The results of these readings is documented on the following pages.

| Acoustic Testing |

Methodology

This section looks at how physical testing can be used to examine the functionality of the acoustic funnels proposed in the design of the political enclave. Through the experimentation, it is anticipated that the form, size and details of the funnels can become more informed. The purpose of the funnels is to create a dialogue between the people within the building and the people on the station platform below, opening up a conversation about politics to everybody, rather than retaining the debate within the building. In order to do this, the funnels will need to filter the sounds of conversation from other noises created within the underground station context, creating clarity and audibility within the building.

The physical tests will concentrate on three key design principles:

1. The Filters

Through previous investigation, testing the frequency of several sounds identified as the sounds of the underground, it has become clear that each of the aforementioned sounds have distinct frequencies, and therefore, wavelengths in millimetres. These can then be translated into opening sizes within the filter element, in order to allow the transfer of the sounds of human speech, and block the other sounds, in particular, the sound of the underground trains themselves. This element will therefore be tested to ensure that the opening size is correct.

2. The Internal Configuration of the Funnels

Currently, the internal surface of the funnels matches the external face. This section will look to test how the configuration of the internal form affects the resultant sound; whether the sound becomes more or less distorted or amplified, dependant on the number of internal vertices. It is proposed that these internal surfaces are clad in brass, a highly resonant and reflective material. Unfortunately, it is not possible to test this element, as it would require the

scaling of the material, which is near impossible. Instead, a hard-soft principle has been adopted, as recommended in consultation with an acoustician, where a hard surface is used to replicate proposed hard surfaces, and more porous materials can be used to test soft materials.

3. The Length of the Funnels

The length of the funnel will determine the amount of end reflection which occurs and the opportunity for echo, and therefore, resultant volume.

These elements will be tested on one funnel, namely the debating chamber stage funnel, in the hope that the data gathered through this experiment can then be extrapolated and applied to the other funnels which are being analysed within this document. It is worth noting that each of the funnels requires a different acoustic environment, as set out in the Acoustic Strategy, in Section One of this document. Therefore, the results of the experiments will not be simply copied between the funnels, but analysed for correlation and applied in whichever form is appropriate.

There are several elements of the experiment which will need to be controlled in order to achieve non-biased results.

These include:

- ⊕ The overall opening size at the top of the funnel
- ⊕ The volume at which the sound enters the funnel
- ⊕ The distance of the sound source from the top of the funnel
- ⊕ The apparatus used to record the resultant sound
- ⊕ The audio file used as the source sound
- ⊕ The materiality and density of the elements being tested against one another
- ⊕ The acoustic qualities in the space within which the tests are being carried out
- ⊕ The funnels must be sealed completely, apart from the opening at the top and the opening at the bottom.

The following pages set out the practical method by which the experiments will be undertaken, and document the experiment itself, before analysing the results for correlation.

The following diagrams set out the components and their configurations to undertake the three experiments, with the goal of achieving three or four sets of resultant data from each.

In order to remain within the range of human hearing, each of the funnels has been scaled at 1:10. This means that the sound will also need to be scaled at 1:10, meaning that frequencies, such as that of human speech, which has been measured at between 631Hz and 1967Hz, will fall within the range of 6310Hz and 19670Hz.

Note: The very highest sounds may not be audible as the fall at the upper range of the human hearing spectrum, but the majority of human speech falls below this bracket.

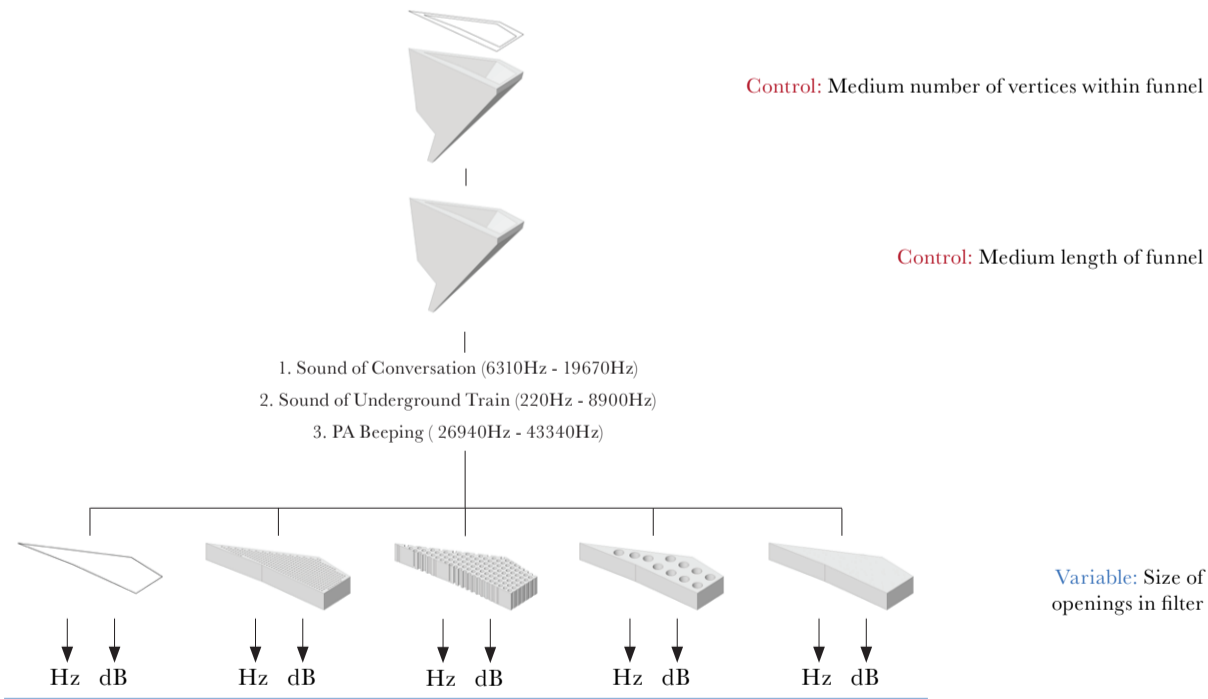
For each set of components, the same recording, made at the Barbican Tube Station, will be played, encompassing three key sounds: The sound of human speech, the sound of the underground trains and the sound of the PA Beeping.

Two results will then be recorded for each configuration: The resultant frequency (Hz) and the resultant volume (dB).

In addition, each test will be undertaken three times, in order to highlight any anomalous results that might occur.

The tests will be undertaken in the same room, on the same day, and the components and testing equipment will meet the requirements set out on the previous page.

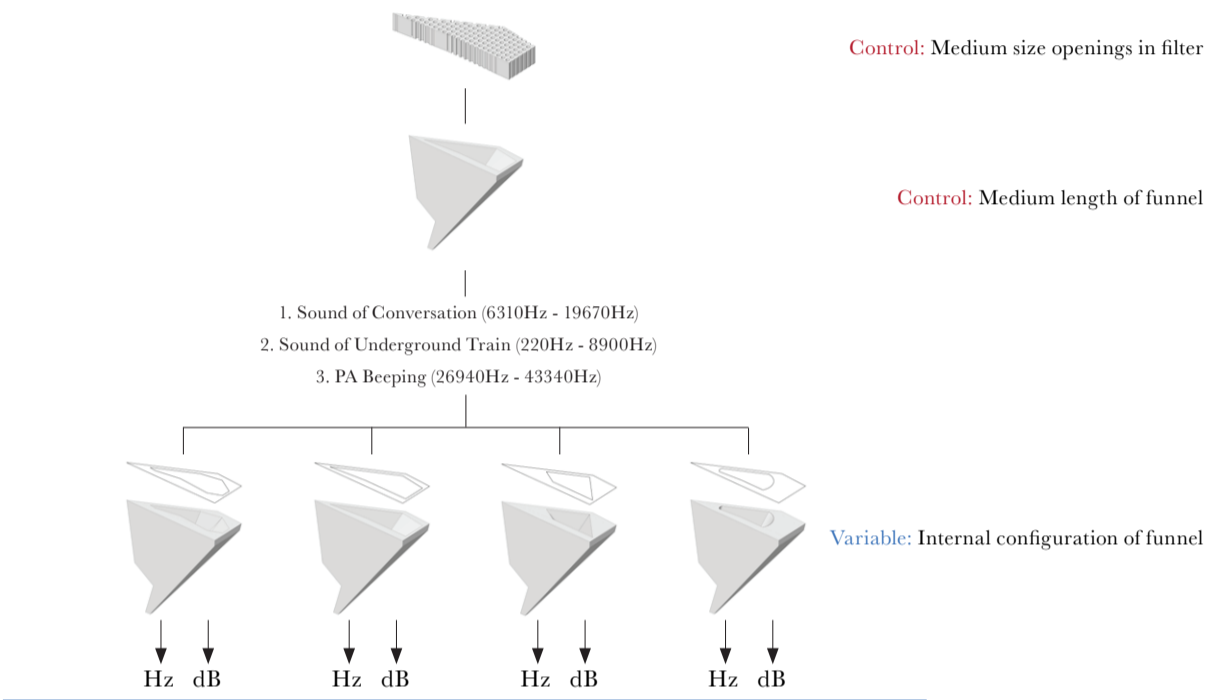
Test One: The Filters



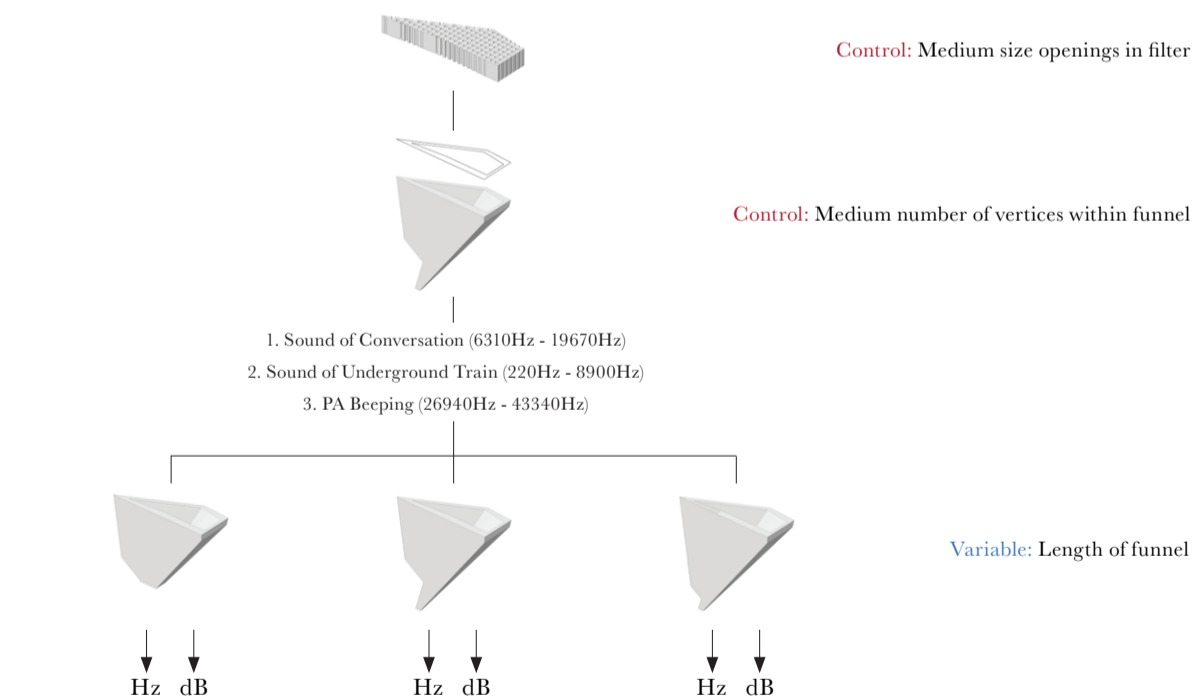
| Acoustic Testing |

Methodology

Test Two: The Internal Configuration of the Funnels



Test Three: The Length of the Funnels



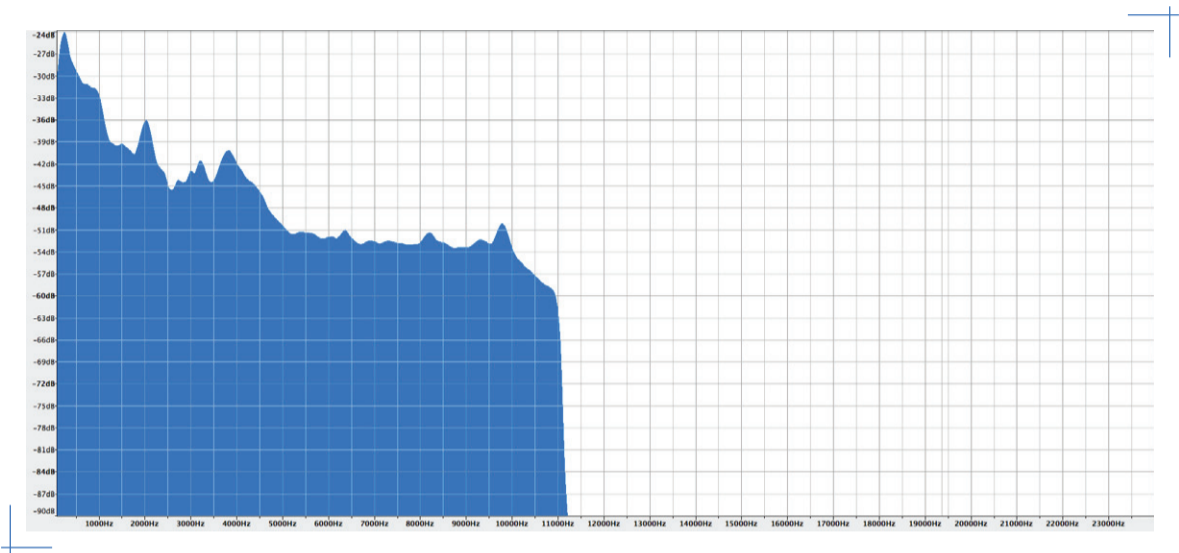
# | Acoustic Testing |

## Scaling Sound

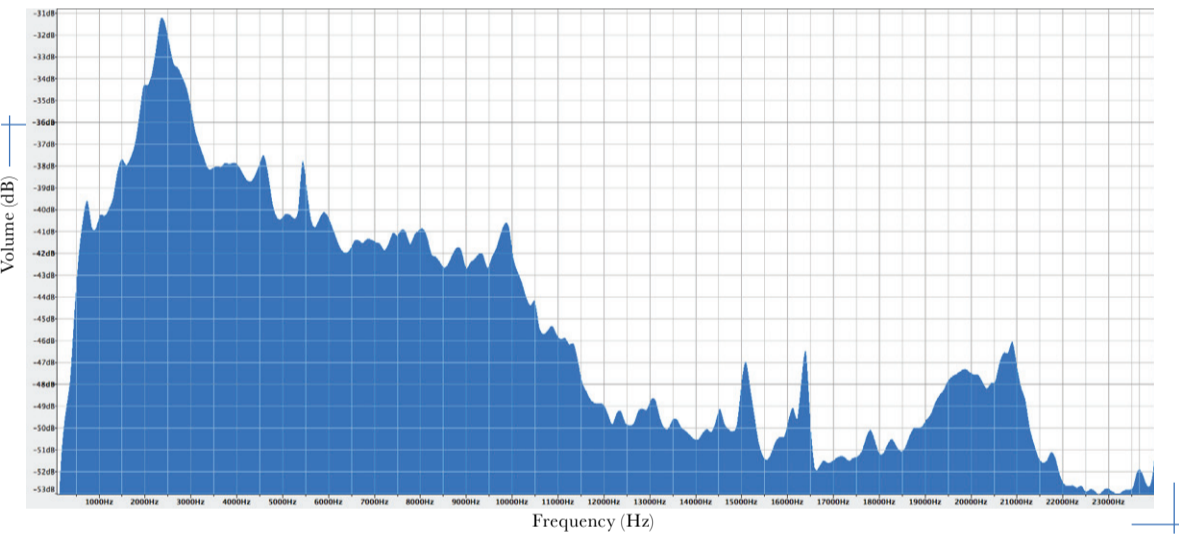
Because the funnel components have been made at a scale of 1 to 10, the sound used to test them must also be scaled at the same ratio.

This was done using Audacity, a sound editing software, where by the wavelength was scale to a tenth of its original size, meaning that the frequency, since frequency is an inverse of the wavelength, is multiplied by 10.

The images below show how the sound graph changed, with the y axis showing volume in decibels (dB) and the x axis showing frequency (Hz).



Sound File: As Recorded



Sound File: Scaled at 1:10

When scaled, the range of frequencies increases, showing a greater number of high frequency sounds. The increase in range, and the remainder of a great deal of low frequency sound is perhaps because of some these sounds, which were inaudible in the As Recorded file, having been scaled, became recognisable.

The volumes, however, have remained the same. This was to be expected because no editing has been done to the dB readings, and there is no link between frequency and volume.

It is worth noting that the high frequency sounds, ie those of conversation, tend to be much quieter than those of the lower frequency sounds, therefore, creating an additional obstacle to hearing speech over train noise within the building.

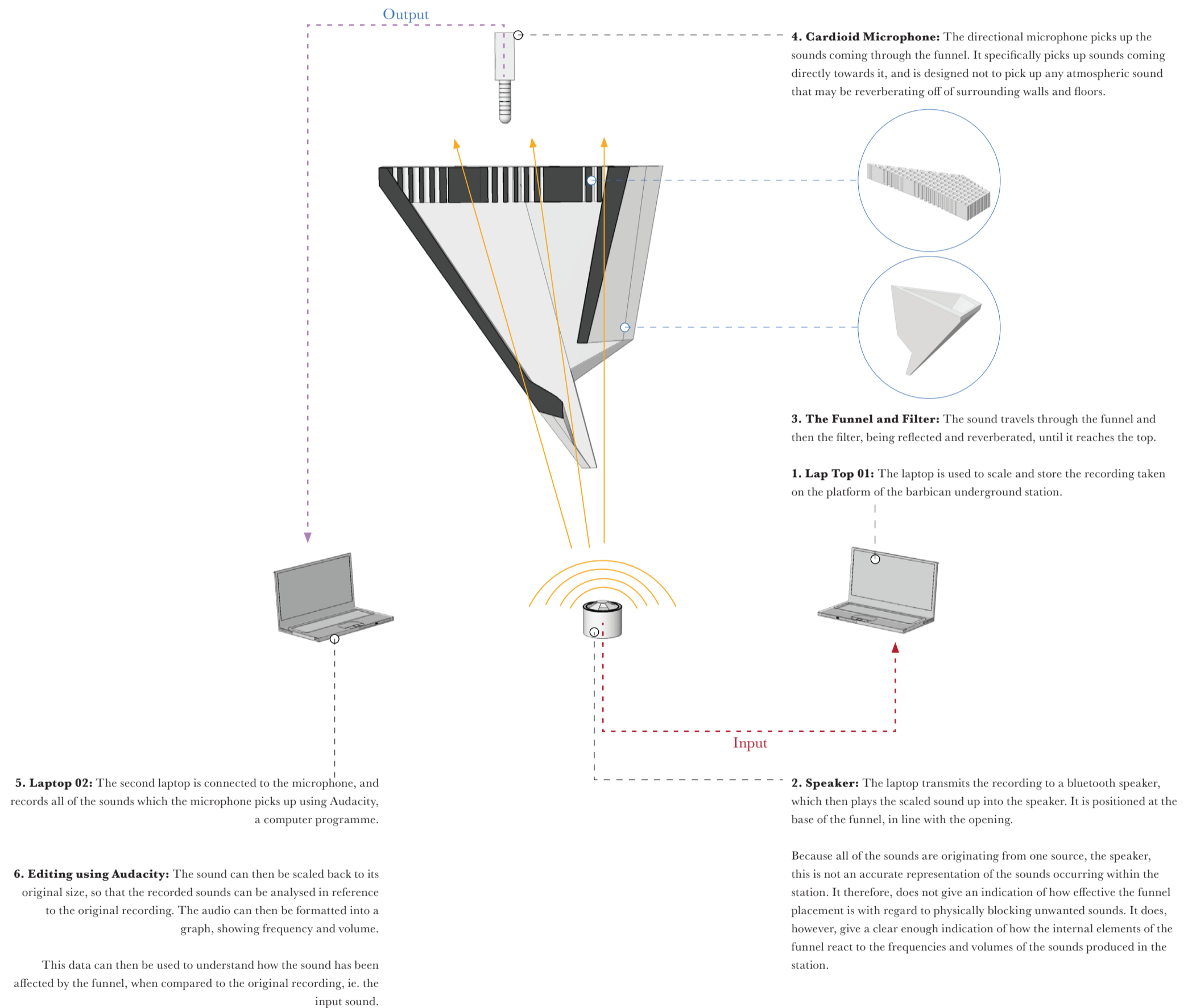
# | Acoustic Testing |

## Setting up the Experiments

In order to obtain the most accurate results possible, it is important to engineer the most controlled environment possible, reducing the number of variables which may screw or affect the results.

Therefore, the experiments will all be carried out in the same room, on the same day, using the same equipment and recorded in the same way.

The diagram below documents the system that will be used to carry out the experiments.



## | Acoustic Testing |

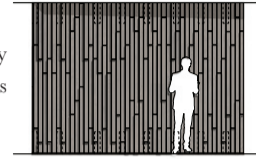
## Summary Sections

The section below shows the debating chamber funnel system. The funnel highlighted in red is the funnel chosen for the physical testing and computer simulations. The section shows the design as it stood before any acoustic testing was undertaken.

The proposed amendments, informed by the acoustic research and testing, have been marked on.

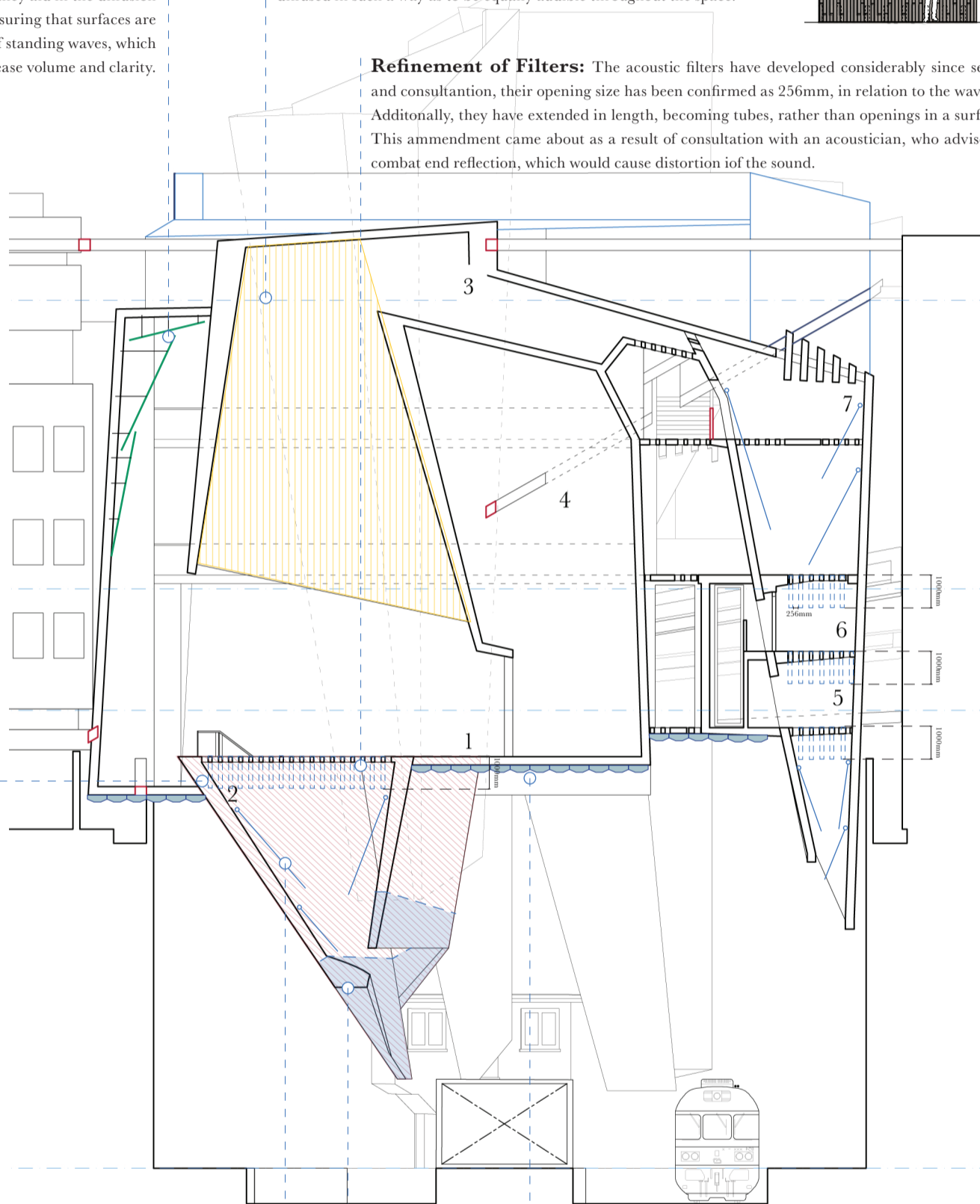
**Articulated Cladding/ Cavity Walls:** Designed to make the space more easily due post construction. The panels can be tested before the are fixed, to ensure that they aid in the diffusion of sound around the auditorium space. By ensuring that surfaces are divergent (as opposed to parrallel) the risk of standing waves, which significantly decrease volume and clarity.

**Timber Cladding:** To scatter sound. This will need to be physically tested at 1:1 to ensure that the desired effect is achieved, ie. that sound is diffused in such a way as to be equally audible throughout the space.



**Refinement of Filters:** The acoustic filters have developed considerably since section 1. Through testing and consultation, their opening size has been confirmed as 256mm, in relation to the wavelength of human speech. Additionally, they have extended in length, becoming tubes, rather than openings in a surface, as initially proposed. This ammendment came about as a result of consultation with an acoustician, who advised the change in order to combat end reflection, which would cause distortion iof the sound.

Tested Funnel



**Articulated Plates:** Following the internal configuration experiments, it was made clear that the internal form of the funnel will greatly affect the resultant sound at the top. In order to allow for tuning and user interaction and customization, articulated plates, fixed onto piano hinges have been introduced to allow for incremental adjustments in form, so that the user can apply the most appropriate system for any given event or circumstance.

**Bass Traps:** Bass traps have been introduced along the underside of the building in varying densities dependant on the use above, or their proximity to a funnel. They will provide an improved station environment and create an additional barrier to low frequency sound emerging from the station.

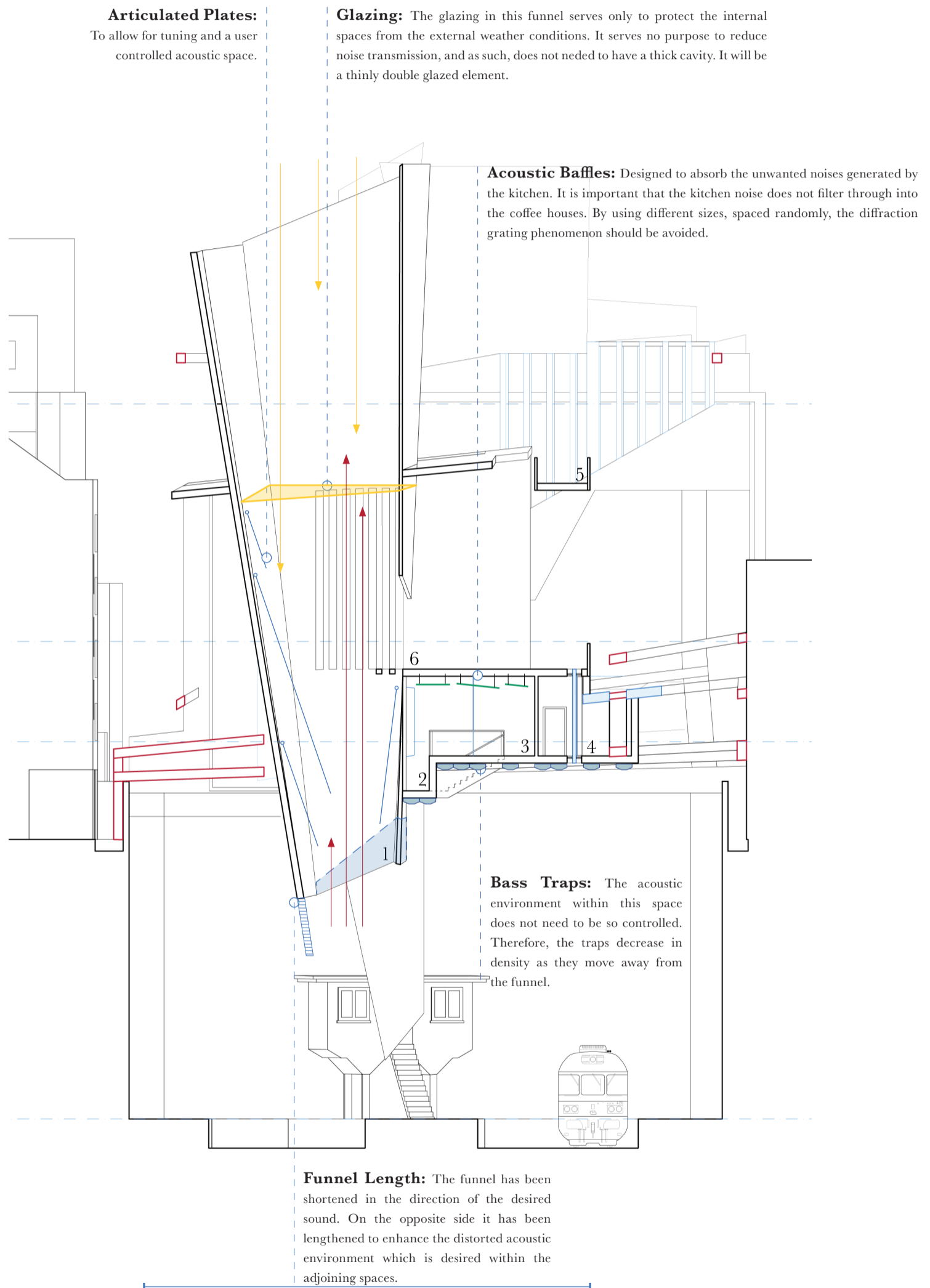
**Shortening of Funnel:** Following the length testing, it is apparent that the funnels will be more efficient if they are a little shorter. Approximately 1m has been removed from the platform end of the funnel.

## | Acoustic Testing |

### Summary Sections

Although the funnels on the following pages were not tested, the principles learnt from the experiments can be applied to them.

The section below shows the funnel which intersects the coffee houses and servery, supplying light and sound.



## | Acoustic Testing |

### Summary Sections

As before, the principles learnt through the acoustic testing can be applied to this funnel.

The section below shows the library light and sound funnel. The two functions of the funnel are intended to operate separately, ie. no sound should filter through to the light transferring region of the funnel. However, light can transfer through the sound section.

