UNDERGROUND ARCHITECTURE

Connections Between Ground-Level Public Space and Below-Ground Buildings

AIMEE WRIGHT

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A thesis submitted in partial fulfilment of the requirements for the degree of

Master of Architecture (Professional)

at the

School Of Architecture

of

Victoria University of Wellington

February 2012

Abstract

The main objective of this research is to develop an underground space framework which establishes design solutions to underpin the successful design of underground buildings. The poorly conceived nature of contemporary underground space often means it has little, or no contribution to its above-ground environment, as it neglects the significant relationship between the ground plane, and above and below-ground space. As a result of this omission towards its above-ground environment, urban design theory and practice have neglected the subject of underground space, where it is presented typically as ancillary spaces, of a highly fragmented nature.

This problem is addressed through a literature review, establishing the treatment of underground space within urban design literature, a taxonomy analysis of the physical form of 90 contemporary underground buildings, and a discussion of the five archetypes of underground space. Developed from the findings of each of these research sections, an underground space framework is established. The framework is divided into six guideline categories with which each focusing on a major design issue relevant to underground space. The presentation of each guideline briefly states the issue, its objective, and then suggests various solutions for implementing the specific objective. The guidelines are intended to be flexible, where they are selected, developed and applied with regard to the underground buildings unique site and programme characteristics.

The design case study, an extension of Wellingtons Museum of City and Sea located at Post Office Square, demonstrates how these guidelines can be used, through selecting, developing and then applying, suitable guidelines in response to its specific site and programme requirements.

In total, the research suggests that the underground space framework can underpin the successful design of underground space through establishing strong physical connections between below ground and above ground public space. This can be achieved through blurring the boundaries between above and below -ground space, revealing historical underground elements above ground, and considering the underground as a viable option to resolving specific urban design issues present above ground.

Acknowledgements

Firstly I would like to thank Victoria University of Wellington staff, in particular my supervisor, Chris McDonald, for his guidance, suggestions, and support during this research.

I would also like to thank my class mates for always being there to bounce ideas and concepts when needed. In particular to those that were there for our constant tea breaks and couch session which always provided a much needed break.

Finally I would like to acknowledge my wider friends and family, but in particular my parents, Ian and Barb, whose constant support and encouragement not only throughout this research but throughout my five years of study, has been greatly appreciated.

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CHAPTER ONE | INTRODUCTION

1.1 CONTEXT OF RESEARCH

Building underground provides new insight on all aspects of architecture and urban design. It presents new opportunities not typically available in conventional above-ground buildings to contribute to its above-ground environment. Considered only suitable for highly complex sites and programmes by architects and urban planners prior to the 1970s, underground space have in fact been built for a wide variety of reasons (Carmody & Sterling, 1993, p.3). Not limited by its above-ground location, underground space has become an ever present building type in contemporary architecture. Exceeding beyond its preliminary function as a way to reform cramped and overcrowded urban environments, underground space is frequently being used for more conventional building programmes. However, these conventional programmes situated underground often neglect their relationship to the above-ground plane. Therefore, the highly internalised nature of contemporary underground architecture sees it have little or no contribution to its above-ground environment.

Although it cannot be suggested that underground space represents the optimal solution for buildings, it can be considered as a suitable alternative when considering complex sites, programmes and building functions, making underground space a viable alternative to conventional above-ground buildings.

As more spaces consider this underground alternative, a better understanding of the particular design issues frequent to underground spaces is highlighted. One of the most significant design issues is the importance of the ground plane, and the underground spaces relationship to it. In the urban environment the ground level is the fundamental level for activity. However, with underground space there is a need to establish connections between above and below-ground environments to ensure that underground space can contribute positively to its above-ground environment, sustaining life at both levels.

1.2 PROBLEM STATEMENT

The poorly conceived nature of underground space often has little or no contribution to its above- ground environment, as it neglects the significant relationship between the ground plane, and above and below-ground space. As a result of this omission towards its above-ground environment urban design theory and practice has neglected the subject of underground space. However, careful and effective planning can ensure that underground space establishes a strong connection to its above-ground environment. This planning should be a precursor to the development of underground space, providing a framework for improving connections between above and below-ground space and making positive contributions to the public domain, consequently creating quality above and below-ground environments.

1.3 RESEARCH AIM

The aim of this research is to investigate how underground buildings can activate their above-ground public realm by critically analysing the physical relationship between above and below-ground. From analsying the physical relationship between above and below-ground, this research develops an underground space framework which establishes design strategies to underpin the successful design of underground buildings. The research also establishes a vocabulary, both verbally and visually, for discussing and describing underground space and the particular physical forms it can take.

This research yields new and improved strategies for connecting underground space with its above-ground public space. It is hoped that this knowledge will extend current urban design theory and practice with regard to underground space.

1.4 RESEARCH APPROACH

The research is divided into eight chapters. Chapter Two underpins the project through a literature review. It provides a critical review of existing theories relevant to underground space and its relationship to its above-ground public space. It critically analyses the treatment of underground space within urban design literature, establishing an apparent omission towards underground space. It continues by discussing some of the significant issues that arise from underground space with respect to the principles of quality of public space, from which a basic set of principles basic set of principles which can be used to mitigate the effects of such issues are established.

Chapter Three expands on the principles of successful underground space established in Chapter Two to identify the particular physical forms and spatial structures that underground buildings must take to achieve these principles. Therefore Chapter Three presents a complete taxonomy analysis of the physical structure of 90 underground buildings. It initially analyses each example with respect to five key physical attributes which express the possible connections between above and below-ground, these being, Depth, Aperture, Ground Plane Manipulation, Spatial Structure and Geometry. These attributes and the variations within them are weighted and subsequently used to rank the examples according to their degree of connection between above and below-ground. As a result of this ranking system, the 15 strongest and 15 weakest examples are identified, and further diagrammatic analysis is then carried out with respect to the principles of creating successful underground space established in the Chapter Two Literature Review. This chapter also begins to establish a vocabulary for discussing underground space. This vocabulary is used further within the research to discuss and describe the underground space framework and the design case study.

Chapter Four discusses the image of the underground. It identifies five underground archetypes which contain the original essence of the underground, these being, Caves and Caverns, Dungeons and Cellars, Bunkers, Grottoes and the Crypotporticus. It discusses the physical form and the associated meanings of each archetype, specifically focusing on their unique historical notions.

Chapter Five presents the underground space framework, a set of design guidelines which underpin the successful design of underground buildings. The presentation of each underground space guideline briefly states the issue, its objective, and then suggests various solutions for implementing the specific objective. Alongside each objective is an accompanying diagram, illustrating these various solutions. The guidelines are divided into seven categories with each focusing on a major design issue relevant to underground space. These categories include, Building Exterior, Building Entrance, Interior Configuration, Vertical Circulation, Natural Light, Sight Lines, and Spatial Image.

Chapter Six acts as a pre-design stage to the design case study chapter through outlining the site context and programme requirements. It discusses and analyses the site - Post Office Square and the public programme, an extension to the Wellington City to Sea Museum. It also presents the site specific framework, a set of principles derived from the urban analysis which the design case study must address.

Chapter Seven presents the design case study. It demonstrates how underground design guidelines can be selected, developed and applied in response to the site specific framework and programme requirements identified in the pre-design chapter, to aid the successful design of the extension of the Wellington Museum of City and Sea located at Post Office Square. It discusses how these principles have influenced the design decision and how they been developed to express the underground nature of the building.

Chapter Eight, discussion and conclusion, presents the findings from the research. It discusses how the research has met the intention of developing an underground space framework which underpins the successful design of underground buildings by establishing strong connections between above and below-ground space. It also discusses areas of future research in order to develop the framework further.

CHAPTER TWO | LITERATURE REVIEW

2.0 INTRODUCTION

This chapter provides a critical review of existing theories relevant to underground space and its relationship to its above ground public space. It critically analyses the treatment of underground space within urban design literature, establishing an apparent omission towards underground space. It also discusses the some of the significant issues that arise from underground space with respect to the principles of quality public space. From this understanding a basic set of principles, which can be used to mitigate the effects of such issues, are established.

This chapter is divided into five sections. Section one establishes the role of public space within urban design, focusing closely on the principles in creating quality public spaces. Section two is concerned with the treatment of underground space within urban design literature, presenting a brief overview of the areas and forms of underground space discussed in urban design texts. Section three is concerned with specific literature on underground space, establishing how some of the most significant negative effects of underground space oppose the principles established in ensuring quality public spaces. In response to these negative effects the fourth section presents a brief set of principles that ensure the successful creation of underground space. The fifth and final section discusses the analysis from this chapter, drawing together the previous sections findings, as well as discussing the apparent gap of knowledge in regard to underground space within urban design literature.

2.1 PUBLIC SPACE WITHIN URBAN DESIGN

Urban Design:

The key notion of urban design is that of "making places for people" (Carmona, 2010, p.7). This wide and inclusive meaning sees it encompass varying principles and definitions with regard to desirable physical and social form. However, it is the one key notion of people and places that is consistently present throughout each theoretical basis of architectural knowledge. Although the definition of urban design changes when applied to unique environments and settings, for the purpose of grounding it within this thesis, the most inclusive and perhaps the most complete definition has been chosen. Explored in By Design: Urban Design in the Planning System: Towards Better Practice, urban design is:

> *"The way places work and matter such as community safety, as well as how they look. It concerns the connection between people and places, movement and urban form, nature and built fabric, and the processes for ensuring successful villages, towns, and cities." (CABE, DETR, 2000, p.8)*

Successful urban design is essential in producing quality, attractive spaces that stimulate the lives of its inhabitants, encouraging them to work, live, and relax. However, many theoretical texts place emphasis on the product rather than the process, highlighting a significant jump in theory to practice and then to setting. Therefore principles established in creating successful spaces must be approached with flexibility, allowing them to be adapted to their unique setting.

Public Space:

One of the fundamental elements within urban design, and therefore the city, is public space. Public space is concerned with the physical and social structure of places, paralleling key notions of people and places explored by urban design. Within many significant urban design texts, public space is defined as

the publicly owned spaces between buildings (Gehl, 1996) (Tranick, 1986). However, as Ali Madanipour states in *Whose Public Space* it is also readily concerned with accessibility, where "it is space concerning the people as a whole, open to all, accessible to or shared by all members of the community, provided by the public authorities for the use of people in general" (2010, p.23).

Although a clear definition of public space has been established what remains unclear is a concise set of principles which guide the design of quality public spaces. Although each key urban design text presents a series of guidelines to encourage better public space design, each establishes a different degree of guidance regarding desirable physical and spatial form.

The Quality of Public Space:

The quality of public space is concerned with the detailing of the space itself, its surrounding buildings, and the interface between the two (English Partnerships, 2000). This detailing occurs at varying scales from the board and macro to the detailed and micro, creating a rich overlay of consideration in forming quality public space. The space itself includes broad elements such as squares, streets, parks and public buildings while detailed elements include vegetation, texture, lighting and street furniture. The surrounding buildings include elements such as elevations, setbacks, heights while specific detailed elements include materials, colours and textures. The interface addresses the relationship between the two, created through elements such as windows, doors, steps and fences.

The success of public spaces and how they are perceived by people is determined by the consideration of detail, as it is where identity and quality are shaped (English Partnerships, 2000). Taken from a wide range of noted urban design texts, the principles focus primarily on the detailing of the space itself as this section encompasses the most significant principles of quality outdoor public space. Together the texts cover five important categories and state that quality space must (Carmona, 2010) (English Partnerships, 2000) (Lynch, 1960) (Shaftoe, 2008):

Enclosure:

- Create a strong sense of enclosure through articulating distinct boundaries and edges of the space to create a definitive shape that creates a sense of threshold between inside and outside.
- Create a balance between enclosure and complete enclosure, to ensure that other significant elements such as permeability and connectivity can still occur.

Activities:

- Design outdoor public space to support and facilitate a range of activities so as to attract people to work, live and play in that area.
- Concentrate activity around main access routes and focal points to ensure that a wide dispersal of activities does not occur.

Movement:

- Integrate public space with pedestrian networks and routes by creating strong access ways and well connected routes between the public space and its surrounding environment.

Legibility:

- Create pedestrian access routes that are easily distinguishable from other elements of the public space to enhance legibility and way finding around the space.
- Create a series of landmarks, pathways and focal points within the space to increase legibility.
- Enhance existing views significant to the public space, while also create new ones to enhance legibility and way finding.
- Ensure the public space has a sense of place by creating a distinct atmosphere and character so that it is not only easily recognisable, but also strengthens local identity.

2.2 TREATMENT OF UNDERGROUND SPACE WITHIN URBAN DESIGN LITERATURE

Literature on underground space within urban design is relatively scarce. When underground space is mentioned, it is often fragmented and discussed as individual spaces which are seen as ancillary spaces to larger buildings or urban design situations. This suggests that there is a gap in knowledge where underground space does not go beyond these somewhat elementary attributes. Instead the fragmented and pragmatic treatment of the underground limits the potential for it to actively contribute to current urban design literature and practice.

One of the most notable elements of underground space discussed within urban design literature is the use of underpasses (Figure 2.0), where they conflict with the basic principles of urban design. They are often viewed as a negative response to the segregation between vehicular traffic and pedestrians, confining each to a separate system of routes (Gehl, Cities for People, 2010) (Shaftoe, 2008). The use of underpasses as a response to this problem, as noted by Gehl "conflicts with the basic premise for good pedestrian landscapes" (Gehl, Cities for People, 2010, p.132), allowing vehicular traffic to become the primary mode while "subjecting pedestrians to stairs either side of the crossing" (Gehl, Cities for People, 2010, p.131). Bentley continues this negative perspective with regard to the physical form and lack of visibility. Two integral factors concerning the strong aversion by pedestrians toward the underground, where "pedestrians are expected to follow ill-defined paths, sometimes underground, sordid and alienating, threaded tortuously up and down through the gaps between vehicular roads" (Bentley, 1985, p.43). However, it is Gehl that best summarises the opinion toward underpasses stating that they "belong to a certain time and certain philosophy" (Gehl, Cities for People, 2010, p.132). It is this dated philosophy that consequently has led to the abandonment of many underpasses in cities today.

Figure 2.0: *Typical Pedestrian Underpass. (Source: Bayshore Underpass, 2008)*

Another specific element of underground space discussed within urban design literature is the use of sunken plazas (Figure 2.1), where they are perceived to fragment the continuity of the street and its surrounding public space. Carmona attributes the physical and social properties of the sunken plaza to the reason why they can easily become 'residual' spaces. He refers to their physical structure as "cracks in

the urban form, often left underdeveloped, underused and deteriorate therefore disrupting the continuity of space" (Carmona, 2010, p.11). The abrupt differentiation between the ground plane and activity plane significantly alters the social structure, where a division between social worlds is created be it purposefully or accidentally (Carmona, 2010). Shaftone applies the same notion to the examples of Sergels Torg Plaza, noting that no matter what aesthetic improvements are made, it is its "fundamental design as a sunken, hard space surrounded by traffic which means it will never be fully convivial" (Shaftoe, 2008, p.50). Gehl best summarises the opinion toward sunken plazas by implicitly stating that "open space should never be sunk...sunken plazas are dead spaces" (2010, p.99).

Underground transit systems (Figure 2.2) are another significant element discussed within urban design texts, where they act as invisible roots that connect the city together, yet they are significantly disconnected from the city which they serve. Kevin Lynch, in the *Image of the City* refers to transit systems as being detached from the life of the city above, as their function is purely for horizontal transportation connection and acts independently from the city above. It is the entrance; the only vertical element which has the potential to create any connection between the two worlds. Although these entrances may be placed in "strategic nodes in the city, they are related along invisible conceptual linkages" (Lynch, 1960, p.57). Therefore the vast underground transit systems are entirely concealed, where the only possible connection between the above and below-ground worlds is established by the often poorly conceived entrances of the transit system.

Figure 2.1: *Sunken Urban Plaza. (Source: The McGraw Hill Building, 1996)*

In Jan Gehl's *Cities for People*, the importance of the ground plane as the principle zone for exchange is discussed. Although the underground is not specifically referred, its importance is undermined by the ground plane being established as the only "exchange zone between human and city" (Gehl, 2010). It is this zone where interior and exterior activity combines, that creates a quality city at eye level, and is an important principle of urban design. Architectural elements that defy this principle, such as stairs and upper and lower levels are also assessed to reinforce this notion. Although looking down and viewing something at a lower level allows you to have a greater perceptive, it also means that "participation and

interaction are still physically and psychologically difficult" (Gehl, 1996, p.99). The same psychological challenge is also faced when ascending or descending to such levels as they represent physical obstacles and are therefore often avoided by pedestrians. This omission toward activities occurring at levels other than the ground plane has given the ground plane unprecedented power, where it is considered the only level that can provide quality human conditions.

Privatisation of public life is another key feature noted within urban design texts, where public spaces are created within private buildings. Although not specifically based on underground space, the same notions are highly relevant as the internalised nature of underground space means that its space, if public can be severely disconnected from its surroundings. Examples of this, as stated by Gehl include shopping arcades, underground street systems, and large indoor squares (Gehl, 1996). These spaces will always result in a "dispersal of people and effective closing in of people and activities, emptying the public spaces of human beings and interesting attractions" (Gehl, 1996, p.127), therefore highlighting an important aspect of the underground. That is, underground space if at all effective can drain life from the 'real' public domain at ground level. Through the privatisation of public space the connection to the street is lost, resulting in an environment that is depopulated, unsafe, neglected and discarded.

Figure 2.2: *Underground Transit System. (Source: Paris Metro, 2011)*

2.3 UNDERGROUND SPACE AND ITS RELATIONSHIP TO THE GROUND PLANE

The concealed nature of underground space means that many significant issues arise with regard to its relationship to its ground plane. Some of the most significant issues are that underground space often lacks a building image, lacks boundaries and edges, and lacks legibility. These issues are significant in the fact that are important principles in creating quality public space, as public space must create a strong sense of enclosure to create a sense of threshold between inside and outside, must articulate distinct boundaries and edges to create a definitive shape and its space and access points must be easily legible. Therefore it is apparent that the issues that arise from underground space contrast with the principles of

quality public space.

One of the most profound issues facing underground space, and therefore its inhabitants, are the implications associated with lack of building image. Unlike conventional buildings, underground space has no perceivable mass and therefore has no building image. As explained by Camody and Sterling, the omission of this critical visual cue means that underground space is "less recognisable as objects or specific places" (1983, p.41), where they use Kevin Lynch's Image of the City to explain the importance of the environmental image. Lynch suggests that the building image is a two way process between "the observer and his or her environment" (1960, p.6), where the observer has a "need for identity and structural in the perceptual world" (1960, p.10). When the environment fulfils these crucial visual cues the inhabitant has a sense of emotional security, highlighting the importance of a definable image and a perceivable exterior form in ensuring successful underground space.

Another issue which arises from lack of building image is the lack of definitive edges which therefore creates a profound loss of sense of space at ground level. Sense of space is attributed to distinct boundaries and perceivable edges that "limit the visual field and define individual space" (Gehl, Cities for People, 2010, p.75), however underground space conceals these important boundaries, relying on the sometimes ambiguous edges of the surrounding built environment, such as roads, footpaths and landscape elements to create spatial enclosure and define the limit of the building, and its associated above-ground spaces. As Gehl states, "edges make a vital contribution to a spatial experience and to the awareness of individual space as a place" (Gehl, Cities for People, 2010, p.75). Therefore without any definable edges of the underground building visible from the ground plane the above-ground space can easily become shapeless and inconceivable.

Another significant issue with regard to underground space is the lack of legibility and therefore lack of orientation. Carmody and Sterling refer to legibility as the "use of visual cues to help maintain orientation, distinguish boundaries and determine the function of a building" (1983, p.175), however, the unique setting of the underground prevents these important visual cues. Therefore the traditional elements of

legibility, such as, activity nodes, landmarks and systems of paths become scarce, and when applied are often blurred and unrecognisable (Bentley, 1985). Through the omission of these orientation elements, underground space becomes difficult to comprehend, circulation and way finding is obscured, and spaces and their associated activities become illegible. This lack of visual legibility means that inhabitants are unable to determine the buildings image and consequently "must take extra effort to get their bearings" (von Meijenfeldt & Geluk, 2003, p.168). It is this search for orientation and legibility that can provoke anxiety, making the building uncomfortable to inhabit, attributing to a negative perception of underground space.

2.4 PRINCIPLES OF SUCCESSFUL UNDERGROUND SPACE

The discussion presented in the previous section demonstrates the conflicting nature between underground space and the quality of public space. It highlights the fact that traditional urban design principles cannot merely be applied to underground space in order to mitigate the significant problems which arise from concealed buildings. Instead underground space must be approached in a different manner in order to mitigate these negative effects. There must be a degree of balance between the principles of quality public space and principles of underground space in order to ensure successful spaces both above and below-ground, otherwise "insurmountable problems could occur if ignored in design" (von Meijenfeldt & Geluk, 2003, p. 168).

Therefore a unique set of principles to ensure the successful creation of underground space is needed. Discussed in Underground Space Design and Underground Building Design Commercial and Institutional Structure, a set of basic guidelines and objectives have been developed in response to the issues that arise from underground space. These guidelines are categorised into Exterior Design, Entrance design, Layout and Spatial Orientation, Interior Design Elements and Systems, Lighting and Life safety representing a wide range of criteria. However, it is the first three categories, that being, Exterior Design, Entrance design, Layout and Spatial Orientation that are predominant in developing principles that are applicable

to both above and below-ground space.

Together the two texts state that successful underground buildings must (Carmody & Sterling, 1993) (Carmody, Sterling, & Underground Space Center, 1983):

Exterior Design:

- Create a distinct overall image through articulating the building boundaries and exposing architecture elements to clarify the buildings location and extent.
- Where possible, create functional connections between interior activity and ground plane activity.
- Provide visual connections between interior and exterior environments.

Layout and Spatial Orientation:

- Create an interior layout that is legible, yet also creates a stimulating indoor environment.
- Arrange spaces and building circulation to create a distinct image within the building and to enhance the feeling of spaciousness.
- Provide natural light wherever possible.

Entrance Design:

- Provide clear, legible entrances that can be recognised from a distance along major paths of approach.
- Provide gradual transitions between levels, especially from the ground plane to the first underground level.

2.5 DISCUSSION

The reviewed literature establishes the apparent contrast between quality public space and successful underground space. Additionally, the principles in creating quality public space identify four major categories that must be achieved to ensure successful public space. These are:

- Enclosure
- Activity
- Movement
- Legibility

However, the issues that arise from underground space contrast these basic public space principles. These are:

- Lack of Building Image
- Lack of Definitive Edges
- Lack of Legibility

This contrast is acknowledged by literature on underground space where the implications and limitations of such issues are discussed with respect not only to the buildings image, but to a wider set of factors such as its inhabitants and ground plane. This acknowledgement on a broader scale identifies the significant influence that underground space can have on its above-ground public space.

Another important finding was the treatment of underground space within urban design literature, where its rather pragmatic elements were presented in a highly fragmented nature. There was no knowledge, that if the building, in its entirety was completely concealed underground. This highly limited view on

the underground limits the potential for it to positively contribute to current urban design, consequently presenting a gap in knowledge and practice with regard to underground buildings.

One of the most significant findings in this chapter was the establishment of underground space principles in response to the negative issues that arise from such space. However, these broad set of principles do not differ significantly from the aims of above-ground buildings and can therefore only be considered preliminary. What also remains unclear is how these principles can be achieved. Although they establish a clear design framework they do not establish the physical forms that underground space must take to successfully achieve these principles. This provides a clear opportunity for further research in this area to develop these principles with respect to the physical form of underground buildings.

CHAPTER THREE | TAXONOMY ANALYSIS

3.0 INTRODUCTION

Chapter Two presented a discussion of the relevant ideas and principles in which underground architecture can successfully contribute to its above-ground public space. It focused primarily on the principles of creating successful underground space but failed to establish the particular physical forms and spatial structures that partly contribute to the successful nature of these principles. Therefore this chapter analyses the physical structure of contemporary underground buildings with respect to a set of specific physical attributes that best demonstrate the range of possible connections between above and below-ground space.

This chapter is divided into six sections. The first section presents the taxonomy analysis, its limitations, sources and how each example is graphically analysed. The second section presents a set of five physical attributes which are weighted, and subsequently used to rank given examples according to the degree of connection established between above and below-ground spaces. The third section presents the results from this ranking, focusing on examples that demonstrate the strongest and weakest connections between above and below-ground. Additionally, in this section it is shown that this taxonomy analysis creates new terminology which can be used to analyse the design case study. The fourth section presents further diagrammatic analysis of the 15 strongest and weakest examples with respect to the principles of creating successful underground space established in the second chapters Literature Review. The fifth section compares the diagrammatic analysis of the strongest and weakest examples. The six and final section discusses the results from this chapter.

3.1 TAXONOMY ANALYSIS

To assist the understanding of the theoretical ideas established within the literature review, the first section of this chapter presents a complete taxonomy analysis of the physical structure of 90 contemporary underground buildings. Each example has been described in respect to a set of specific physical attributes that best establish the range of connections that exist between above and below-ground space. These five physical attributes are; Depth, Aperture, Ground Plane Manipulation, Spatial Structure and Geometry, which together convey a precise image of the forms that existing underground buildings can take. As a result of this taxonomy analysis, attributes that have the ability to create a strong relationship between above and below-ground will be established, therefore identifying which of the 90 examples present the strongest and weakest connections between above and below-ground. By distinguishing both the strongest and weakest examples, comparative analysis can occur, identifying the most promising strategies for establishing strong connections between above and below-ground environments.

Limitations:

This taxonomy analysis of both built and proposed underground buildings focuses on the specific physical attributes of underground space. They are intended to convey essential physical characteristics within the selected examples, and are therefore independent of the buildings programme or specific site or project feature such as age of construction or design rationale. The survey of examples is limited to contemporary underground buildings and projects in order to retain an emphasis on present and future design and construction. The age of buildings spans a range of 42 years, including buildings from 1969 to the present day. A few examples, although highly relevant to this analysis have been omitted due to insufficient material for an accurate and complete analysis. The attributes allow for the categorisation of the majority of examples, however, some examples were difficult to classify. With these latter examples additional rigor was taken to ensure the correct categorisation.

Sources:

Although this analysis is not exhaustive, the examples do present a diverse range of current underground architecture forms. The examples used in this taxonomy analysis have been drawn from a wide range of sources. These sources include literature on underground space, such as *Underground Space Design*, *Underground Building Design : Commercial and Institutional Structures* and *Below Ground Level : Creating New Spaces for Contemporary Architecture,* all of which are used within the literature review. Other sources include all examples of underground, or partially underground, buildings noted in the journal of *Architecture and Urbanism* within the last 10 years, and examples noted on the architectural website *ArchDaily*.

Graphical Presentation:

Each example is presented and analysed in vertical section as this architectural drawing convention most accurately portrays the overall physical structure of the building and its relationship to the ground plane. Whether the example has been analysed in longitudinal or transverse section depends on which drawing most accurately represents the connections between above and below-ground the clearest. Alongside each building example are graphic interpretations of the five specific attributes assigned by the taxonomy analysis to that specific example, providing an understanding of how each example fits within the overall taxonomy study. For the sake of clarity throughout this classification system, typical building elements have been simplified to only be represented by a line weight. The section of each building is presented at a scale that most accurately presents the examples physical form, therefore there is a variation of scale within the taxonomy analysis.

3.2 WEIGHTING CRITERIA

This section establishes the individual importance of each of the five physical attributes, and its associated variants within the taxonomy analysis. These attributes and variants, identified through the analysis of the 90 examples, express the range of possible forms and combinations that underground buildings could take. So far, the analysis has been neutral as to value, and it hasn't attempted to assess the degree or effectiveness of connection. In order to identify the buildings that demonstrate the strongest and weakest connections between above and below-ground, both levels within the taxonomy analysis, the attributes and their associated variants, have been given a weighting, with a higher weighting meaning a stronger connection between above and below-ground.

The weighting system for each of the attributes has been derived from the 'Principles of Successful Underground Space' established in Chapter Two, where each principles is linked with the attribute which most accurately manifests its aim into a physical form. The weighting of the each attribute, and its associated principle, is then determined by the degree of applicability to create connections between the buildings ground plane and the buildings physical form, therefore above and below-ground. From this, three weightings have been established, with the strongest attributes having the highest weighting.

The two physical attributes of Depth and Aperture have been given the highest weighting as they provide a mutual basis for both the ground plane and the physical form of the building. As these attributes have the strongest ability to establish the connections between above and below-ground they have been given the highest weighting of three. The attribute of Ground Plane Manipulation has been given a moderate weighting as it is concerned primarily with the ground plane, yet still takes into account the building. As this attribute has a moderate ability to establish connections between above and below-ground, it has been given a medium weighting of two. The two remaining attributes, Spatial Structure and Geometry have been given the lowest weighting as they focus squarely on the building itself, and are therefore largely independent from the ground plane. As these two attributes have the weakest ability to establish connections between above and below-ground, they have been given the lowest weighting of one.

Each of the variants that exist within these five physical attributes has also been given a weighting. This weighting system, like the attribute weighting, is also determined by the degree of ability to create connections between above and below-ground, where they are ranked from strongest to weakest, with the former variant having the highest weighting. As each attribute does not carry the same number of variants a maximum weighting for the strongest variant within all attributes has been established as to not give attributes with a greater number of variants a higher weighting, ensuring an even weighting throughout the taxonomy analysis. As the greatest number of variants within an attribute is six, the maximum weighting for the strongest variant within an attribute is also six. To establish the weighting of the other variants this maximum is divided by the number of variants within each attribute establishing the numerical difference between each variant. This difference is intended to act a constant value between variants within an attribute to establish their weighting, therefore ensuring an even weighting throughout all variants.

To establish the variants overall weighting within the taxonomy analysis, the variants weighting is then multiplied by the weighting given to its associated attribute, assigning it a final weighting (Figure 3.0). This weighting system allows each category and attribute to be systematically ranked against one another, allowing the buildings which present the strongest and weakest connections between above and below-ground to be identified.

ATTRIBUTE					
Variant 1	Variant 2	Variant 3	Variant 4	Variant 5	Variant 6
10	20	30	40	50	60
(Multiplied by Attribute Weighting)					
Total Variant Weighting	Total Variant Weighting	Total Variant Weighting	Total Variant Weighting	Total Variant Weighting	Total Variant Weighting

Figure 3.0: *Structure of Weighted Attribute and Variant Table.*

Depth:

The category of Depth (Figure 3.1) establishes the location of the building in relation to the ground plane, where it is the amount of visible building that is the characteristic element.

Its associated principle established in Chapter Two aims to 'create a distinct overall image through articulating the buildings boundaries and exposing elements to clarify the buildings location'. As it is concerned with both the ground plane and the building, it has a strong ability to establish connections between above and below-ground, and therefore has the highest weighting of three.

From the examples used within the taxonomy analysis, four variants were identified. These being- from weakest to strongest - *Completely Submerged, Submerged, Partially Submerged,* and *Earth Covered.*

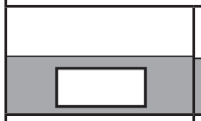
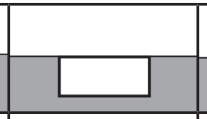
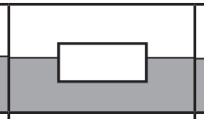
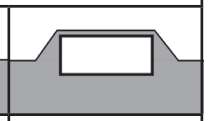
DEPTH			
			
Completely Submerged	Submerged	Partially Submerged	Earth Covered
1.5	3	4.5	6
(x3)			
4.5	9	13.5	18

Fig 3.1: *Weighted Depth Table.*

Aperture:

The category of Aperture (Figure 3.2) demonstrates the various openings in which natural light enters underground space. In underground environments, the role of natural light and aperture is significantly heightened as together they can shape the interior layout of the building, create and control unique atmospheres within the building, and also establish a physical and perceivable relationship between above and below-ground.

Its associated principles established in Chapter Two aims to 'provide natural light wherever possible' as well as 'provide visual connections between interior and exterior environments'. As it is concerned with both the ground plane and the building, it has a strong ability to establish connections between above and below-ground, and therefore has the highest weighting of three.

From the examples used within the taxonomy analysis, six variants were identified. These being - from weakest to strongest - *None, Inverted, Open, Flat, Stepped,* and *Projected.*

APERTURE					
					
None	Inverted	Open	Flat	Stepped	Projected
1	2	3	4	5	6
(x3)					
3	6	9	12	15	18

Figure 3.2: *Weighted Aperture Table.*

Ground Plane Manipulation:

The category of Ground Plane Manipulation (Figure 3.3) demonstrates the variation of intersections, cuts and extensions of the area above the underground building. These manipulations determine the overall shape, size, and appearance of this area.

Its associated principle established in Chapter Two aims to 'provide gradual transitions between levels, especially from the ground plane to the first underground level'. As it is concerned primarily with the ground plane, it has the ability to establish a moderate connection between above and below-ground and has therefore been given the weighting of two.

From the examples used within the taxonomy analysis, six variants were identified. These being - from weakest to strongest – *Open Cavity, Open Cavern, Open Sloped Cavity, Covered Cavity, Covered Cavern,* and *Covered Sloped Cavity.*

GROUND PLANE MANIPULATION					
					
Open Cavity	Open Cavern	Open Sloped Caviy	Covered Cavity	Covered Cavern	Covered Sloped Cavity
1	2	3	4	5	6
(x2)					
2	4	6	8	10	12

Figure 3.3: *Weighted Ground Plane Manipulation Table.*

Spatial Structure:

The attribute of Spatial Structure (Figure 3.4) demonstrates the division of the internalised spaces within the geometry of the building.

Its associated principle established in Chapter Two aims to 'arrange spaces and building circulation to create a distinct image within the building and to ensure the feeling of spaciousness'. As it is concerned primarily with the building, this category has a weak ability to establish connections between above and below-ground, and therefore has been given the lowest weighting of one.

From the examples used within the taxonomy analysis, five variants were identified. These being - from weakest to strongest – *Combined, Cellular, Layered, Unified,* and *Atrium.*

SPATIAL STRUCTURE				
Combined	Cellular	Layered	Unified	Atrium
1.2	2.4	3.6	4.8	6
(x1)				
1.2	2.4	3.6	4.8	6

Figure 3.4: *Weighted Spatial Structure Table.*

Geometry:

The category of Geometry (Figure 3.5) is perhaps the most easily defined of all the variants. It demonstrates variations within the overall shape of the building. Although the Geometry of underground buildings is strongly influenced by the structural implications of building underground, considering strong water and ground pressures, this attribute primarily takes into account the overall form of the buildings shell.

Its associated principle established in Chapter Two aims to 'create a form and interior layout that is legible'. As it is concerned primarily with the building, this category has a weak ability to establish connections between above and below-ground, and therefore has been given the lowest weighting of one.

From the examples used within the taxonomy analysis, three variants were identified. These being- from weakest to strongest – *Centered, Linear,* and *Composite.*

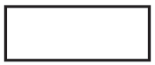
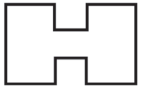
GEOMETRY		
		
Centered	Linear	Composite
2	4	6
(x1)		
2	4	6

Figure 3.5: *Weighted Geometry Table.*

Below is a selection of twelve of the 90 examples, demonstrating the way in which the physical form of the buildings have been analysed (Figure 3.6 to Figure 3.17). Refer to Appendix B for the complete taxonomy analysis of all 90 examples.

Chicago Children's Museum

Figure 3.6: *Chicago Children's Museum Taxonomy Analysis* *1:500*

Fovam ter Station

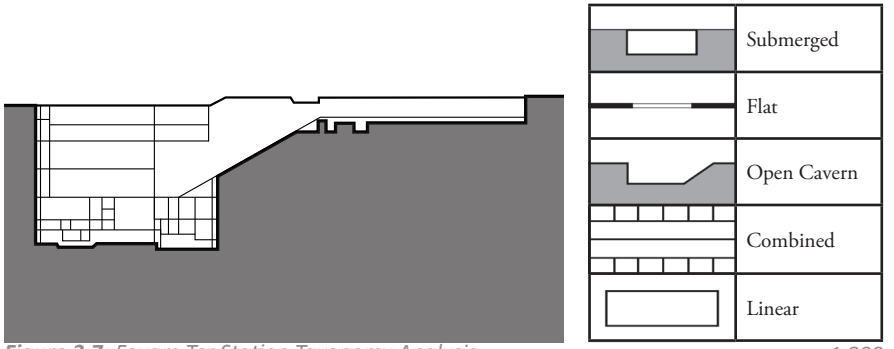


Figure 3.7: *Fovam Ter Station Taxonomy Analysis* *1:800*

Chichu Art Museum

Figure 3.8: *Chichu Art Museum Taxonomy Analysis* *1:800*

Holocaust History Museum at Yad Vashem

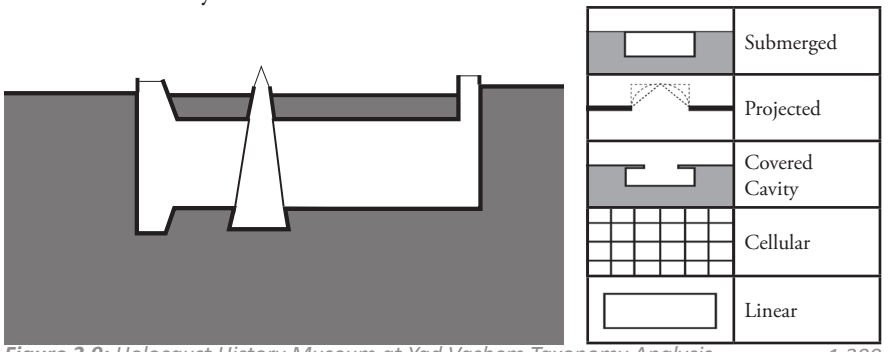


Figure 3.9: *Holocaust History Museum at Yad Vashem Taxonomy Analysis* *1:300*

Jubliee Line, Canary Wharf

Figure 3.10: *Jubilee Line Taxonomy Analysis* *1:800*

National Museum of History and Art

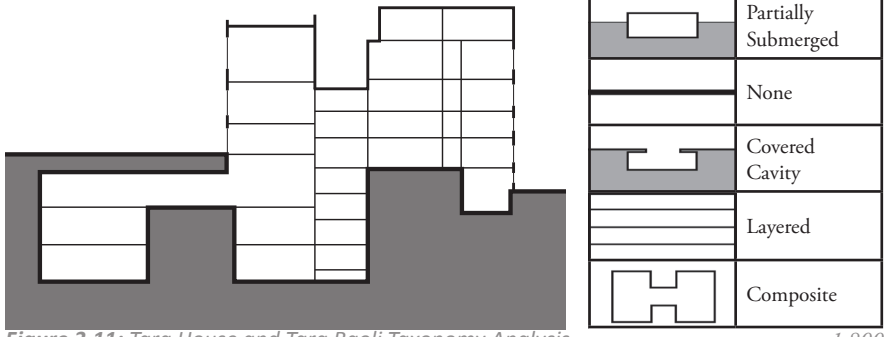


Figure 3.11: *Tara House and Tara Baoli Taxonomy Analysis* *1:800*

Nordpark Cable Railway

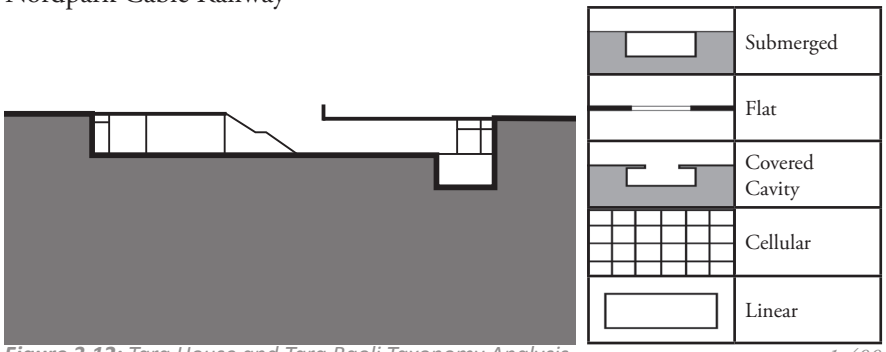


Figure 3.12: *Tara House and Tara Baoli Taxonomy Analysis* *1:400*

Saxton Federal Library

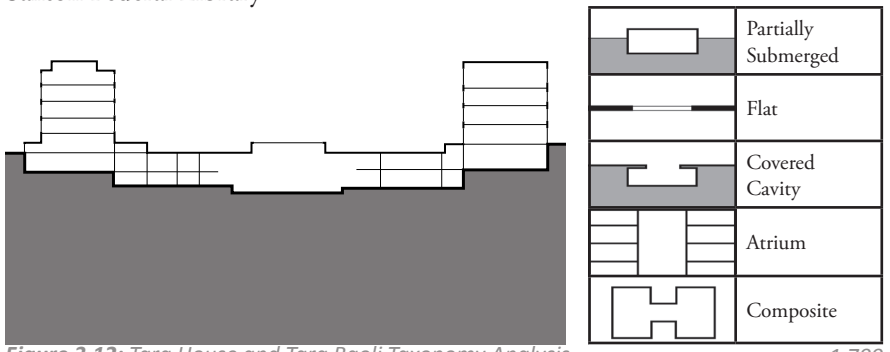


Figure 3.12: *Tara House and Tara Baoli Taxonomy Analysis* *1:700*

Tara House and Tara Baoli

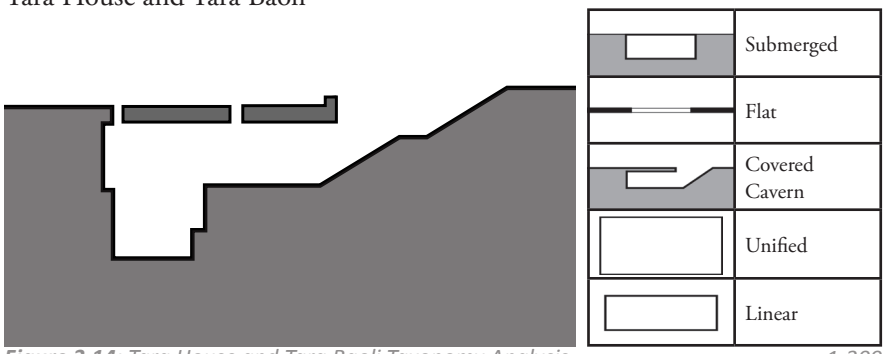


Figure 3.14: *Tara House and Tara Baoli Taxonomy Analysis* *1:300*

University of Michigan Law Library

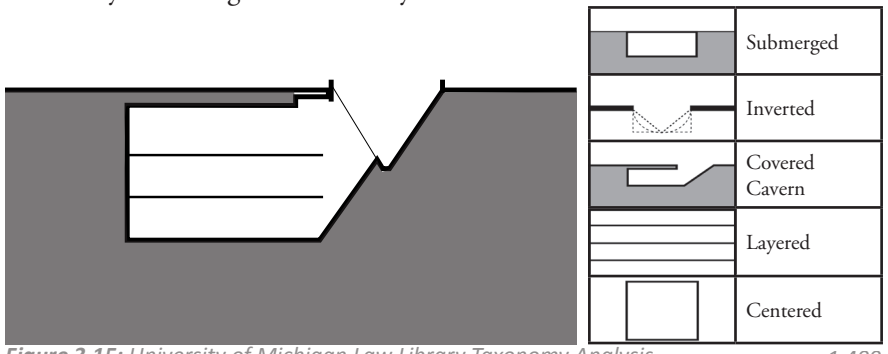


Figure 3.15: *University of Michigan Law Library Taxonomy Analysis* *1:400*

Walker Community Library

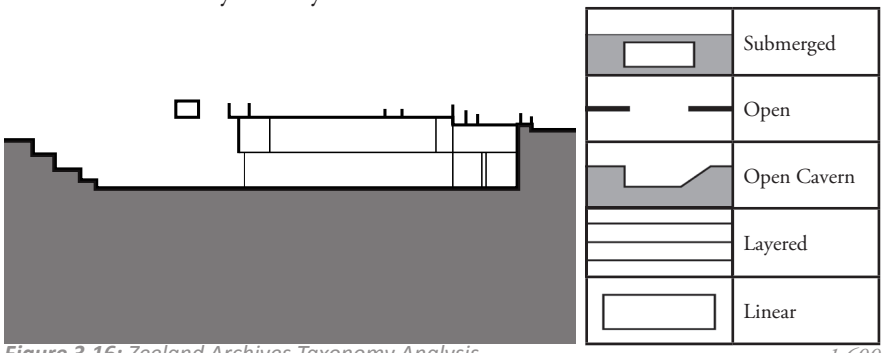


Figure 3.16: *Zeeland Archives Taxonomy Analysis* *1:600*

Zeeland Archives

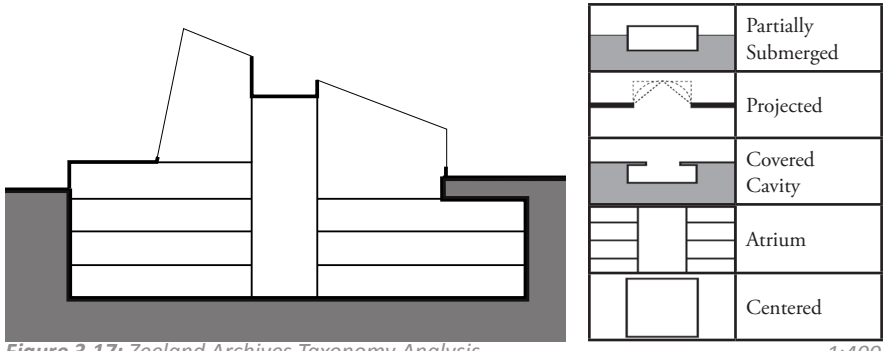


Figure 3.17: *Zeeland Archives Taxonomy Analysis* *1:400*

Weighted Taxonomy Analysis

	DEPTH				APERTURE						GROUND PLANE MANIPULATION						SPATIAL STRUCTURE					GEOMETRY			
	COMPLETELY UNDERGROUND	SUBMERGED	PARTIALLY SUBMERGED	EARTH COVERED	NONE	INVERTED	OPEN	FLAT	STEPPED	PROJECTED	OPEN CAVITY	OPEN CAVERN	OPEN SLOPED CAVITY	COVERED CAVITY	COVERED CAVERN	COVERED SLOPED CAVITY	COMBINED	CELLULAR	LAYERED	UNIFIED	ATRIUM	CENTERED	LINEAR	COMPOSITE	
BUILDING	**4.5**	**9**	**13.5**	**18**	**3**	**6**	**9**	**12**	**15**	**18**	**2**	**4**	**6**	**8**	**10**	**12**	**1.2**	**2.4**	**3.6**	**4.8**	**6**	**1.2**	**2.4**	**3.6**	**TOTAL**
Terraset and Terra Centre Elementary Schools				■						■				■						■			■		50.4
Lucille Halsell Conservatory				■						■				■						■			■		50.4
Qumran Winery				■					■						■		■			■					50.2
Prado Museum			■						■			■								■				■	50.1
Kimbell Museum			■							■					■					■				■	49.1
Museum of Judenplatz			■							■				■							■			■	49.1
Museum Heldenberg		■						■						■			■			■					47.1
Almere Masterplan				■			■									■				■				■	46.6
Williamson Hall, University of Minnesota			■						■					■							■			■	46.1
Mutual of Omahia Headquarters Addition			■							■			■							■				■	45.1
Civil and Mineral Engineering Building			■						■			■						■			■			■	44.5
California State Office Building				■				■						■						■			■		44.4
Invisible House			■							■		■					■			■					44.3
New Cantina Antinori at Bargino			■						■						■							■			43.7
M9 Memorial			■				■					■					■			■					42.6
Therme Vals			■					■							■				■				■		41.9
Vancouver Concert Hall Extension		■						■							■		■				■				41.8
Shibuya Project			■							■	■							■	■						41.5
Shopping Centre				■			■							■						■			■		41.4
Holocaust History Museum at Yad Vashem		■								■				■						■			■		41.4
Concert Hall Under the Parade		■								■				■					■					■	40.6
Temppeliaukio Church			■							■	■						■		■						40.3
National Museum of History and Art	■		■											■							■			■	40.1
Blue Ridge Elementary School			■						■			■								■				■	40.1
Mauritshuis		■						■						■			■				■				39.8
Benetton Communication Research Center		■								■		■					■			■					39.8
Leon Municipal Funerary Services		■								■		■					■			■					39.8
Yates Fieldhouse		■						■							■		■			■					39.8
Tara House and Tara Baoli		■						■							■		■			■					39.8
Zeeland Archives			■							■	■								■					■	39.1
Le Carrousel Du Louvre		■								■			■							■		■			38.2
Museumplein			■							■				■						■				■	37.8
Bell Lloc Cellars	■							■								■	■			■					37.3
Saxton Federal Library			■					■						■				■			■				37.1
Faculty of Theatre and Dance Artez		■						■						■				■	■						37
Brussels Meeting Centre			■					■			■										■			■	37
Holaday Circuits			■						■		■									■			■		36.9
Les Halles		■								■	■									■				■	36.6
Langen Foundation/ Hombroich			■					■			■						■			■					36.3
Moscone Convention Centre			■					■			■						■			■					36.3
Chichu Art Museum		■								■	■										■	■			36.2
Jubliee Line - Canary Wharf		■								■	■						■		■						35.8
Museum		■								■	■									■			■		35.8
Museum of the Holocaust			■						■		■									■		■			35.7
Research and Multimedia Centre		■					■								■					■				■	35.6

Figure 3.18: *Weighted Taxonomy Analysis Table.*

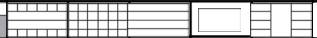
	DEPTH				APERTURE						GROUND PLANE MANIPULATION						SPATIAL STRUCTURE					GEOMETRY			
																									
	COMPLETELY UNDERGROUND	SUBMERGED	PARTIALLY SUBMERGED	EARTH COVERED	NONE	INVERTED	OPEN	FLAT	STEPPED	PROJECTED	OPEN CAVITY	OPEN CAVERN	OPEN SLOPED CAVITY	COVERED CAVITY	COVERED CAVERN	COVERED SLOPED CAVITY	COMBINED	CELLULAR	LAYERED	UNIFIED	ATRIUM	CENTERED	LINEAR	COMPOSITE	
BUILDING	**4.5**	**9**	**13.5**	**18**	**3**	**6**	**9**	**12**	**15**	**18**	**2**	**4**	**6**	**8**	**10**	**12**	**1.2**	**2.4**	**3.6**	**4.8**	**6**	**1.2**	**2.4**	**3.6**	**TOTAL**
Nordpark Cable Railway		■						■						■						■			■		**35.4**
Guggenheim Museum in Rio De Janerio		■								■	■									■			■		**35.4**
Phoenix Museum of History				■			■							■						■				■	**35.3**
Councils Chamber		■					■									■				■		■			**35.2**
Walker Community Library		■					■					■								■				■	**34.8**
Museum of Modern Art Tower		■						■						■					■					■	**34.6**
Capodichino Underground Station		■								■	■								■					■	**34.6**
Andalucia's Museum of Memory			■				■				■							■		■					**34.5**
Extension of the Zaragoza Museum of Fine Arts			■		■									■							■			■	**34.1**
Kunstmuseum Extension			■		■									■							■			■	**34.1**
Embassy of the Czech Republic		■					■					■								■			■		**34.1**
Joe and Rika Mansueto Library		■								■	■						■		■						**33.8**
Le Van Tam Underground Car Park		■					■							■						■				■	**33.6**
Nathan Marsh Pusey Library		■					■							■						■				■	**33.6**
Chicago Childrens Museum		■							■		■									■				■	**33.6**
Veranda Car Park			■				■				■							■	■						**32.5**
Museum of WWII in Gdańsk		■					■							■						■			■		**32.4**
Florence TAV Station		■								■	■								■			■			**32.2**
Museum for the Royal Collection			■				■				■									■				■	**32.1**
Basel Burghof			■				■				■										■	■			**31.7**
Kolner Philharmonie			■		■						■			■							■	■			**31.7**
Ewha Campus Centre		■					■							■					■					■	**31.6**
Plaza Mayor		■			■											■				■				■	**31.6**
Honpukuji Water Temple			■				■				■									■			■		**30.9**
Villa Vals	■						■								■				■				■		**30.9**
V&A Boiler House Yard		■						■			■									■				■	**30.6**
University of Michigan Law Library		■				■									■				■					■	**30.6**
Fovarn ter Station		■						■				■								■		■			**30.2**
Glass Temple		■					■				■							■		■					**30**
Garden of Fine Art		■					■					■								■				■	**29.7**
National September 11th Memorial and Museum		■					■							■			■			■					**29.6**
Beelden Aan Zee Museum		■						■			■									■			■		**29.4**
Nydalen Metro Station	■				■									■						■			■		**28.9**
Westminster - Jubilee Line		■						■			■								■					■	**28.6**
Rijksmuseum Museum			■				■				■										■			■	**28.4**
Friedrichstrasse			■			■					■									■		■			**26.7**
Memorial to the Murdered Jews of Europe		■					■				■									■			■		**26.4**
The Dok		■			■									■						■		■			**25.2**
Arnhem Carpark		■				■					■									■				■	**24.6**
Plaza Del Torico	■				■									■			■			■					**24.3**
Souterrain		■			■								■							■		■			**23.2**
Museum of WWII		■				■					■									■		■			**22.2**
Villa Hoogerheide			■				■				■									■			■		**21.9**
Itakeskus Swimming Pool	■				■										■					■		■			**20.7**
Samuel Beckett Theatre	■				■									■			■		■						**20.3**

Figure 3.19: *Weighted Taxonomy Analysis Table.*

3.3 TAXONOMY ANALYSIS RESULTS

As there is no present system to classify underground space, this taxonomy analysis presents a scheme with which the physical form of 90 underground buildings are analysed. The results form a first-order analysis, presenting a fundamental understanding of the forms of underground architecture, from which to initially categorize the examples. These initial results can then be further developed and refined by a more comprehensive and in-depth analysis which considers more than just the building physical form.

One of the most important aspects of the taxonomy analysis is that it provides a basis to understand the physical forms that underground spaces currently take, and develops an associated terminology. This terminology can be used to describe any of the various forms of underground space. It is comprehensive enough to describe the 90 examples within the taxonomy analysis in regard to their individual formation, yet broad enough to describe existent underground buildings not used within the analysis. Additionally, new underground building forms can be described by the taxonomy analysis, which could include new combinations of variants not previously analysed above. The development of this terminology, together with the earlier design principles, allow for a more detailed design brief to be developed, than which would otherwise be the case for underground space. Together they can also be applied throughout the design case study to describe the building, and evaluate its final outcome.

Initial analysis of the 90 examples identified individual variants which were represented the most and least common within the examples. Variants represented the most within the 90 examples in the taxonomy analysis are:

- *Depth: Submerged*
- *Aperture: Projected*
- *Ground Plane Manipulation: Open Cavity*

- *Geometry: Linear*
- *Spatial Structure: Layered*

Variants represented the least within the 90 examples in the taxonomy analysis are:

- *Depth: Completely Submerged*
- *Aperture: Inverted*
- *Ground Plane Manipulation: Covered Sloped Cavity*
- *Geometry: Composite*
- *Spatial Structure: Atrium*

This initial analysis highlights that variants given a higher weighting, as they are considered to the have the strongest connection between above and below-ground, are not necessarily the most frequent within the analysis.

The use of the weighted attribute and variant system also allowed the examples to be ranked with respect to their strength in establishing physical connections between above and below-ground. Through selecting the examples with the highest and lowest rankings, buildings that expressed the strongest and weakest connections between above and below-ground were identified. To ensure an accurate and sufficient representation of the data a third of the examples (i.e. 30 out of 90) were chosen for more in-depth diagrammatic analysis. Specifically the 15 highest and 15 lowest examples were chosen. Selecting examples from the opposite ends of the gradient system allows for comparative analysis and highlights how the physical structure of the buildings can influence other important connections that can exist between above and below-ground.

The strongest examples used for diagrammatic analysis include (from the strongest first):

- *Terraset and Terra Centre Elementary School*
- *Lucille Halsell Conservatory*
- *Qumran Winery*
- *Prado Museum*
- *Kimbell Museum*
- *Museum of Judenplatz*
- *Museum Heldenberg*
- *Almere Masterplan*
- *Williamson Hall, University of Minnesota*
- *Mutual of Omahia Headquarters Addition*
- *Civil and Mineral Engineering Building*
- *California State Office Building*
- *Invisible House*
- *New Cantina Antinori at Bargino*
- *M9 Memorial*

The weakest examples used for diagrammatic analysis include (from the weakest first):

- *Samuel Beckett Theatre*
- *Itakeskus Swimming Pool*
- *Villa Hoogerheide*
- *Museum of WWII*
- *Souterrain*
- *Plaza Del Torico*
- *Arnhem Car Park*
- *The Dok*
- *Memorial to the Murdered Jews of Europe*
- *Friedrichstrasse*
- *Rijksmuseum*
- *Westminster - Jubilee Line*
- *Nydalen Metro Station*
- *Beelden Aan Zee Museum*
- *National September 11th Memorial and Museum*

Initial analysis of the 15 highest and lowest buildings identified the variants used the most within the examples. For the highest examples these were (Figure 3.20):

- *Depth: Partially Submerged*
- *Aperture: Projected*
- *Ground Plane Manipulation: Covered Cavity*
- *Spatial Structure: Unified*
- *Geometry: Linear*

	DEPTH				APERTURE						GROUND PLANE MANIPULATION						SPATIAL STRUCTURE					GEOMETRY		
BUILDING	COMPLETLEY UNDERGROUND	SUBMERGED	PARTIALLY SUBMERGED	EARTH COVERED	NONE	INVERTED	OPEN	FLAT	STEPPED	PROJECTED	OPEN CAVITY	OPEN CAVERN	OPEN SLOPED CAVITY	COVERED CAVITY	COVERED CAVERN	COVERED SLOPED CAVITY	COMBINED	CELLULAR	LAYERED	UNIFIED	ATRIUM	CENTERED	LINEAR	COMPOSITE
Terraset and Terra Centre Elementary Schools				■						■				■						■			■	
Lucille Halsell Conservatory				■						■				■						■			■	
Qumran Winery				■					■						■		■			■				
Prado Museum			■						■			■								■			■	
Kimbell Museum			■							■					■					■			■	
Museum of Judenplatz			■							■				■							■			■
Museum Heldenberg		■						■						■			■			■				
Almere Masterplan				■			■									■				■				■
Williamson Hall, University of Minnesota			■						■					■							■			■
Mutual of Omahia Headquarters Addition			■							■			■							■				■
Civil and Mineral Engineering Building			■						■			■						■			■			
California State Office Building				■				■						■						■			■	
Invisible House			■							■		■					■			■				
New Cantina Antinori at Bargino			■						■						■					■		■		
M9 Memorial			■				■					■					■			■				
TOTAL	0	1	9	5	0	0	2	2	5	6	0	4	1	6	3	1	4	1	0	12	3	1	5	4

Fig 3.20: *Attributes Used the Most Within the 15 Strongest Examples.*

For the lowest examples these were (Figure 3.21):

- *Depth: Submerged*
- *Aperture: No Aperture*
- *Ground Plane Manipulation: Open Cavity*
- *Spatial Structure: Unified*
- *Geometry: Linear*

	DEPTH				APERTURE						GROUND PLANE MANIPULATION						SPATIAL STRUCTURE					GEOMETRY		
BUILDING	COMPLETLEY UNDERGROUND	SUBMERGED	PARTIALLY SUBMERGED	EARTH COVERED	NONE	INVERTED	OPEN	FLAT	STEPPED	PROJECTED	OPEN CAVITY	OPEN CAVERN	OPEN SLOPED CAVITY	COVERED CAVITY	COVERED CAVERN	COVERED SLOPED CAVITY	COMBINED	CELLULAR	LAYERED	UNIFIED	ATRIUM	CENTERED	LINEAR	COMPOSITE
Samuel Beckett Theatre	■				■									■			■		■					
Itakeskus Swimming Pool	■				■										■					■		■		
Villa Hoogerheide			■				■				■									■			■	
Museum of WWII		■				■					■									■		■		
Souterrain		■			■								■							■			■	
Plaza Del Torico	■				■									■			■			■				
Arnhem Carpark		■				■					■									■				■
The Dok		■			■									■						■		■		
Memorial to the Murdered Jews of Europe		■					■				■									■			■	
Friedrichstrasse			■			■					■									■		■		
Rijksmuseum Museum			■				■				■										■			■
Westminster - Jubilee Line		■						■			■								■					■
Nydalen Metro Station	■				■									■						■			■	
Beelden Aan Zee Museum		■						■			■									■			■	
National September 11th Memorial and Museum		■					■							■			■			■				
TOTAL	4	8	3	0	6	3	4	2	0	0	8	0	1	5	1	0	3	0	2	12	1	4	5	3

Fig 3.21: *Attributes Used the Most Within the 15 Weakest Examples.*

From this analysis it is apparent that the higher ranked examples (those which have the strongest physical connection between above and below-ground), have variants which are visible above-ground as well as below-ground. This is represented by their use of *Partially Submerged Depth, Projected Aperture and Covered Cavity* variants. The lowest ranked buildings (those which have the least physical connection between above and below-ground) do not have visible above-ground variants; instead the variants are only visible within the building. This is seen by their *Submerged Depth* and *No Aperture*, consequently making the buildings have a highly internalised nature. Although the lower examples have an *Open Cavity Ground Plane Manipulation*, which allows the building to have a physical connection to the above-ground, any connection is impaired due to their Depth and Aperture attributes.

The only similar variant within the highest and lowest examples is the *Linear Geometry* nature of the building. Although it could be said that this geometry allows for a larger surface area of the building to create physical connections between above and below-ground, the Geometry of the building is irrelevant unless the Depth and Ground Plane Manipulation establish physical connections themselves. Within the highest examples the *Linear Spatial Structure* of the building becomes relevant because it's *Partially Submerged Depth* and *Covered Cavity Ground Plane Manipulation* allows it to be experienced from ground level. Therefore it can be suggested that any Geometry is irrelevant unless its Depth and Ground Plane Manipulation allow it to be experienced from the ground level. This idea can also be extended further with regard to Spatial Structure, where the Spatial Structure of the building becomes irrelevant unless the Depth allows for a physical connection between above and below-ground. Therefore the *Layered* nature of the highest examples is supported by the *Partially Submerged Depth*, establishing a connection between above and below-ground, where as the *Unified* nature of the lowest examples is irrelevant as the *Submerged Depth* allows for no possible physical connection.

These results highlight the obvious hierarchy between attributes, where Depth is a significant attribute in establishing physical connections between above and below-ground, reinforcing the weighted system used for the taxonomy analysis. Geometry and Spatial Structure are the least significant attributes, as they

are only able to establish physical connections if the Depth of the buildings allows, that is only if the Depth it *Partially Submerged* or *Earth Covered*. However, the attributes of Aperture and Ground Plane Manipulation are significant because they are not confined by Depth as they have the ability to manipulate themselves to create connections above-ground, even if the Depth is *Completely Submerged* or *Submerged*.

Comparative analysis of the frequency of variants used within the 90 examples with respect to the frequency of variants used within the strongest and weakest 15 examples, highlights that variants given the highest weighting are not necessarily used the most within the strongest examples. Therefore it is apparent that it is not the individual variant, but the combination of variants, that are critical in establishing physical connections between above and below-ground. This means that variants with weaker connections can be combined with a series of variants with a moderate connection, to create an underground building that establishes strong physical connections between above and below-ground.

3.4 DIAGRAMMATIC ANALYSIS

This taxonomy analysis closely analyses the examples with respect to their physical form, investigating how this physical form can establish connections between above and below-ground. However, as this analysis is independent from a wider set of factors, for instance, the buildings programme or specific site or project features, it does not present a comprehensive understanding of how underground buildings can successfully contribute to their above-ground context. Therefore the 15 strongest and 15 weakest examples identified within the taxonomy analysis have been selected to be analysed further against a wider set of criteria in order to present a critical understanding of how these examples contribute to their above-ground context. Similar to that of the initial taxonomy analysis, the examples are further analysed in vertical section, as again this most accurately represents the building and its relationship to the ground plane.

The criteria for diagrammatic analysis has been derived from the 'Principles of Successful Underground Space' established in Chapter Two. These analytical criteria include:

1. Interior and Exterior Relationship: Where possible, create functional connections between interior and exterior activity.

2. Concealed and Exposed Elements: Create a distinct overall image through articulating the building boundaries and exposing architecture elements to clarify the buildings location and extent.

3. Natural Light: Provide natural light whenever possible.

4. Sight Lines: Provide visual connections between interior and exterior environments.

5. Access and Circulation: Provide clear, legible entrances that can be recognised from a distance along major paths of approach as well as create a form and interior layout that is legible, yet also creates a stimulating indoor environment.

Below is the Diagrammatic Analysis of the 15 strongest examples (Figure 3.22 to Figure 3.37). Refer to Appendix C for the 15 weakest examples.

Diagram Key

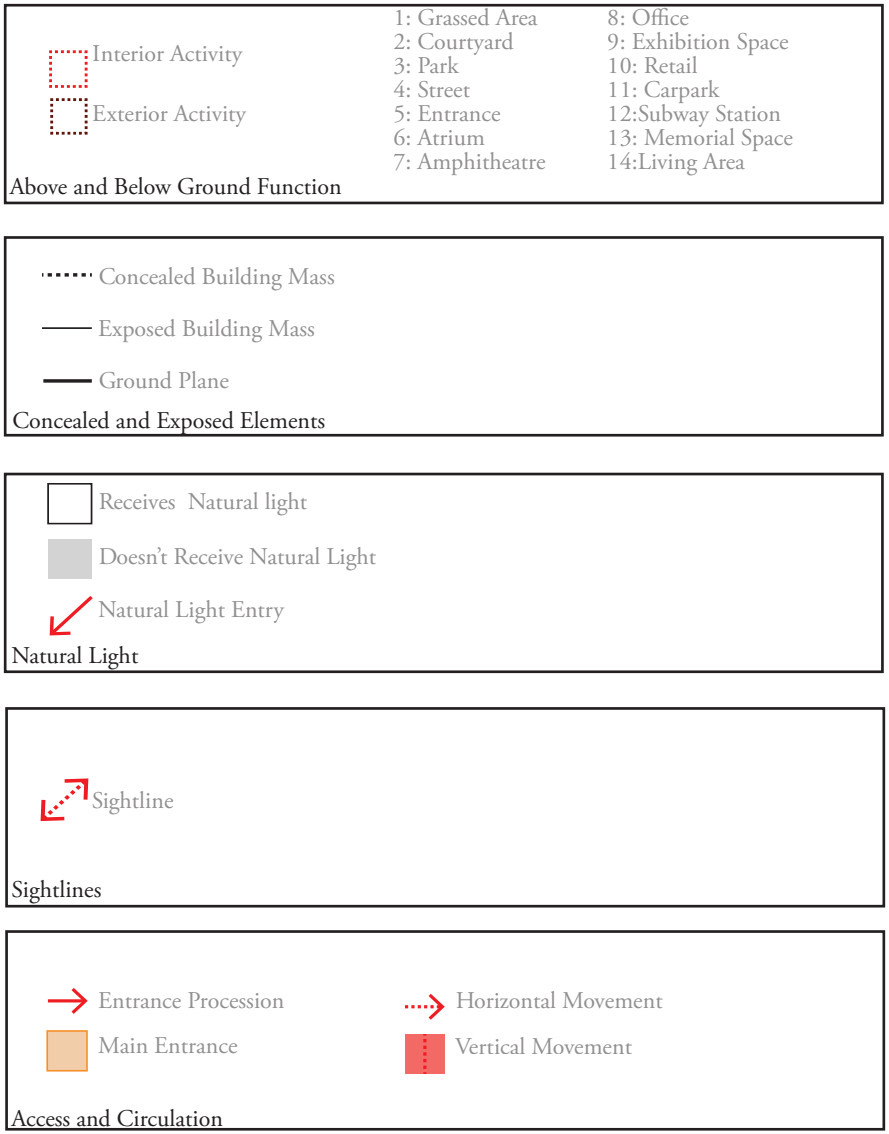


Figure 3.22: *Diagrammatic Analysis Key*

Terraset and Terra Elemantary School

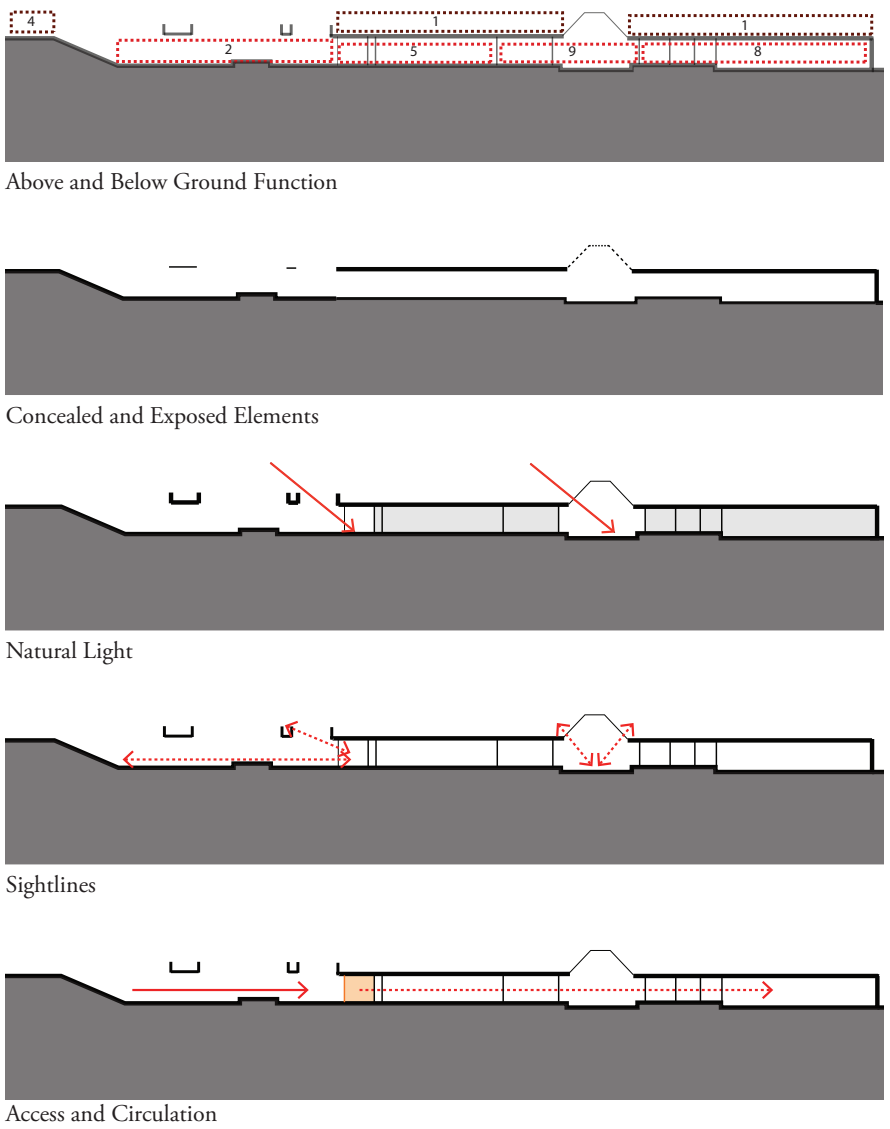
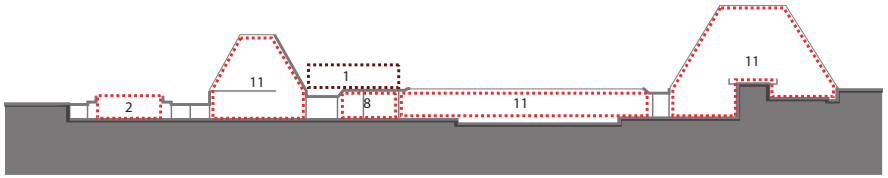
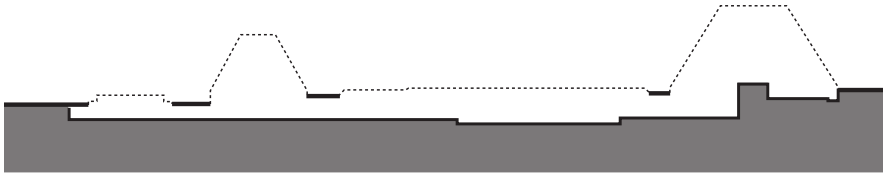


Figure 3.23: *Terraset and Terra Elementary School Diagrammatic Analysis* *1:600*

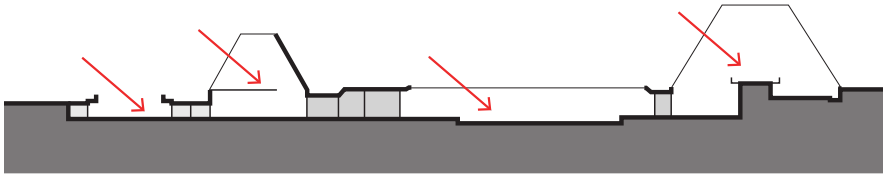
Lucille Halsell Conservatory



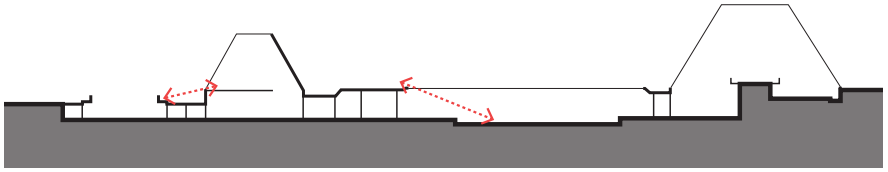
Above and Below Ground Function



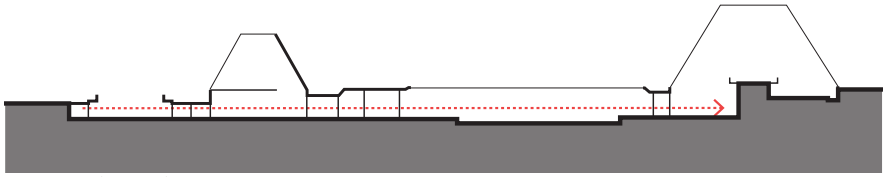
Concealed and Exposed Elements



Natural Light



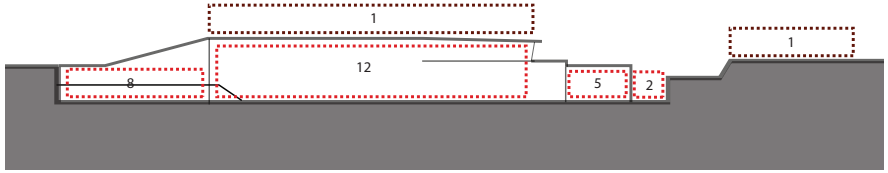
Sightlines



Access and Circulation

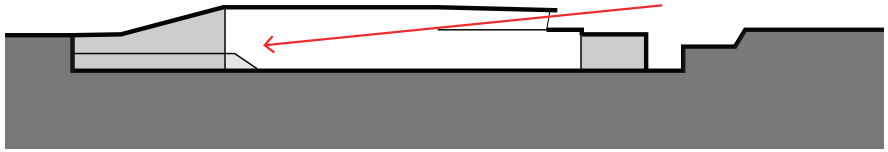
Figure 3.24: *Lucille Halsell Conservatory Diagrammatic Analysis* *1:600*

Qumran Winery



Above and Below Ground Function

Concealed and Exposed Elements



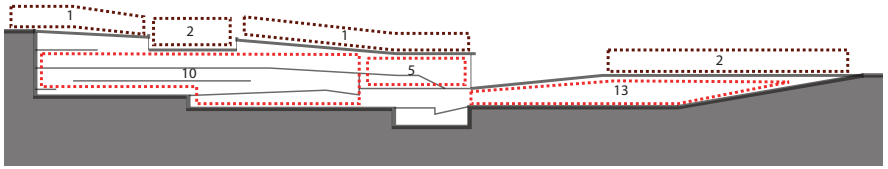
Natural Light

Sightlines

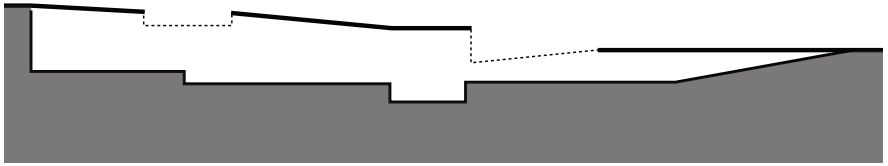
Access and Circulation

Figure 3.25: *Qumran Winery Diagrammatic Analysis* *1:500*

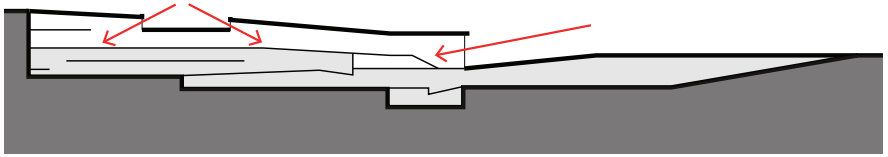
Prado Museum



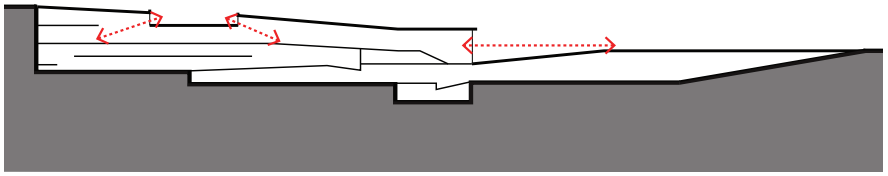
Above and Below Ground Function



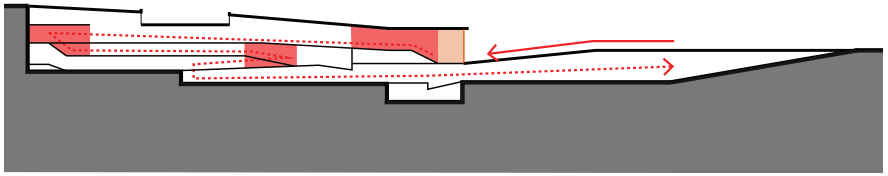
Concealed and Exposed Elements



Natural Light



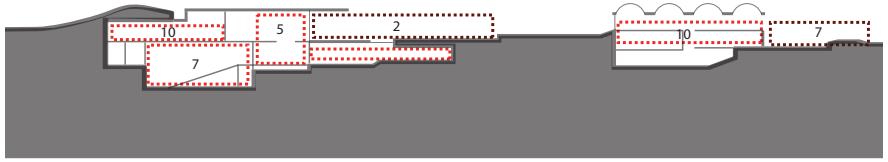
Sightlines



Access and Circulation

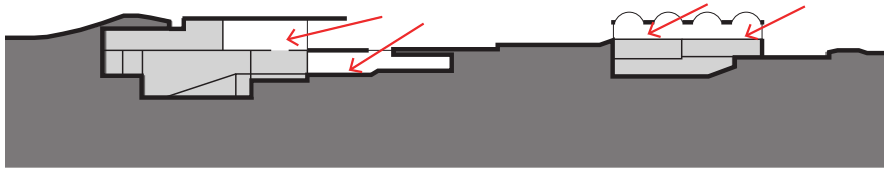
Figure 3.26: *Prado Museum Diagrammatic Analysis* *1:800*

Kimbell Museum

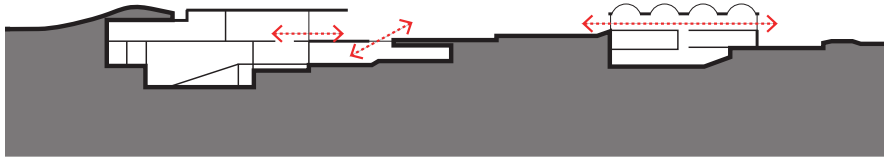


Above and Below Ground Function

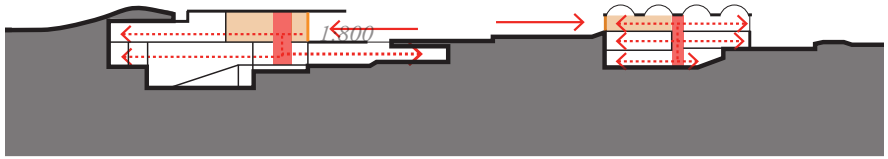
Concealed and Exposed Elements



Natural Light



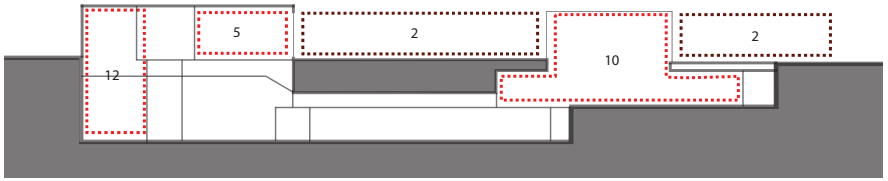
Sightlines



Access and Circulation

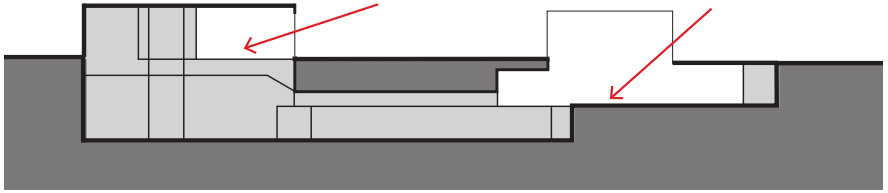
Figure 3.27: *Kimbell Museum Diagrammatic Analysis* *1:800*

Museum of Judenplatz

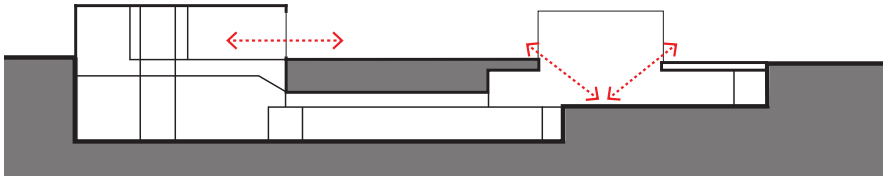


Above and Below Ground Function

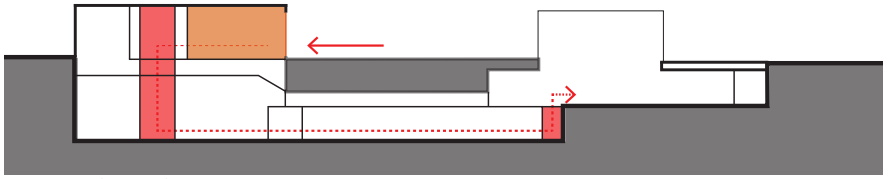
Concealed and Exposed Elements



Natural Light



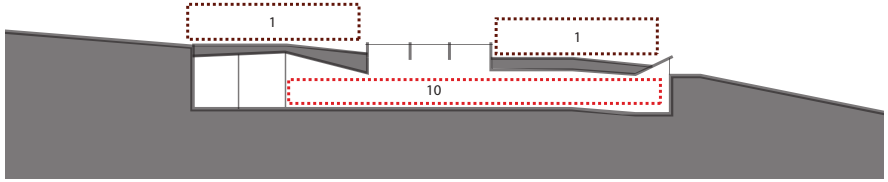
Sightlines



Access and Circulation

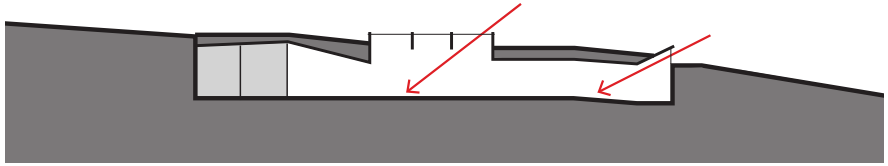
Figure 3.28: *Museum of Judenplatz Diagrammatic Analysis* *1:500*

Museum Heldenburg

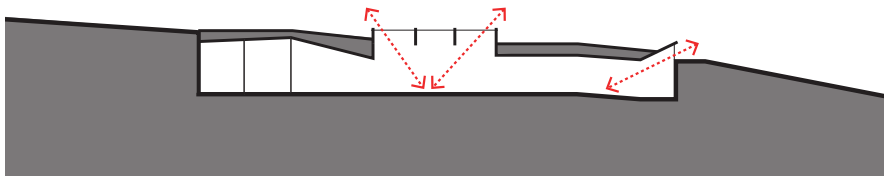


Above and Below Ground Function

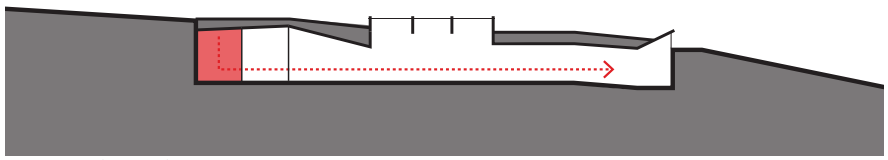
Concealed and Exposed Elements



Natural Light



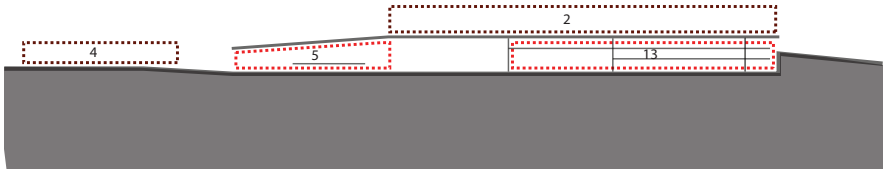
Sightlines



Access and Circulation

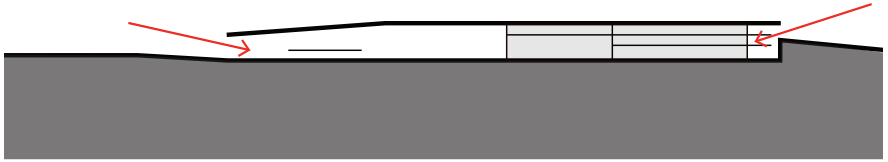
Figure 3.29: *Museum of Heldenberg Diagrammatic Analysis* *1:300*

Amere Masterplan



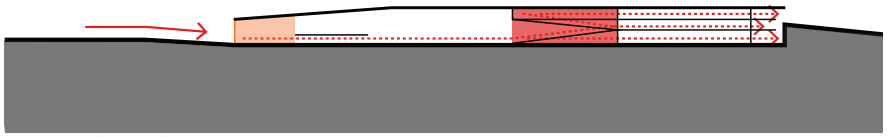
Above and Below Ground Function

Concealed and Exposed Elements



Natural Light

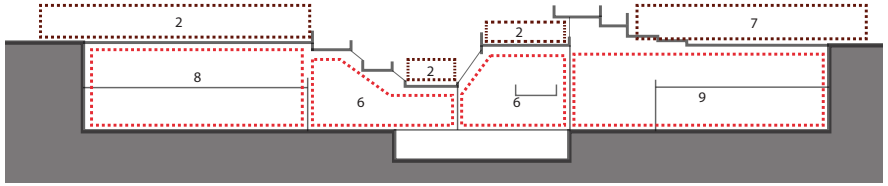
Sightlines



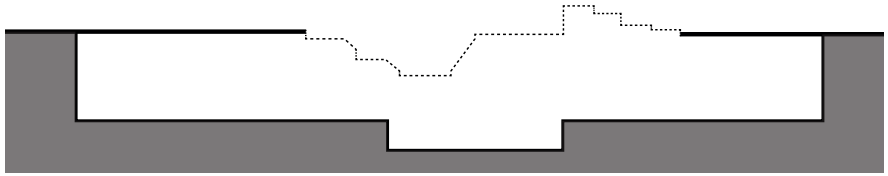
Access and Circulation

Figure 3.30: *Almere Masterplan Diagrammatic Analysis* *1:1000*

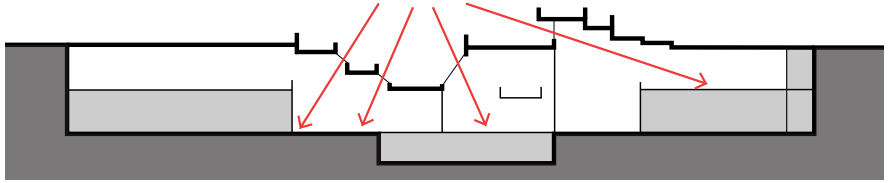
Williamson Hall



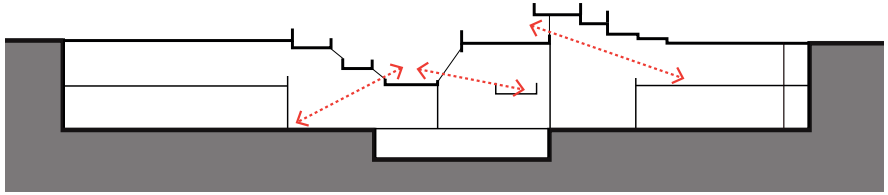
Above and Below Ground Function



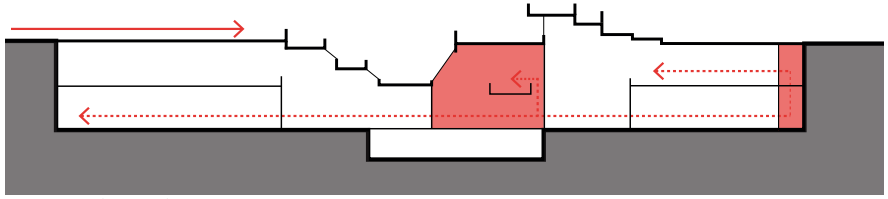
Concealed and Exposed Elements



Natural Light



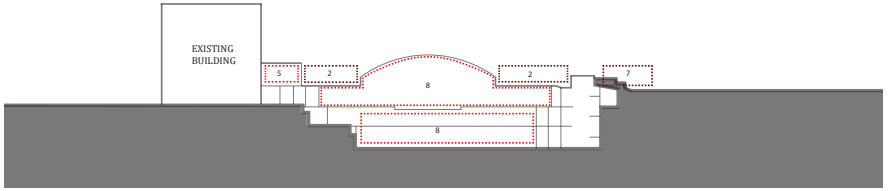
Sightlines



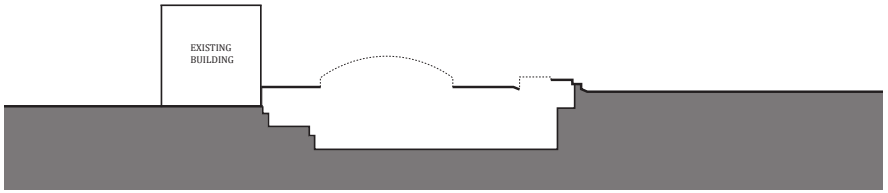
Access and Circulation

Figure 3.31*: Williamson Hall Diagrammatic Analysis* *1:600*

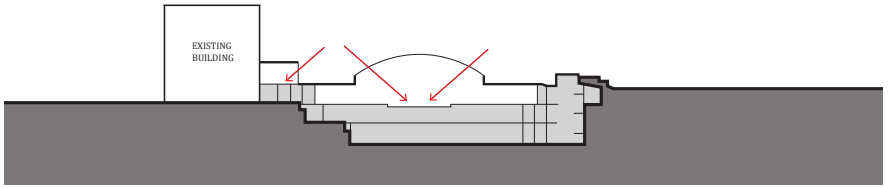
Mutual Of Omahia Headquarters Addition



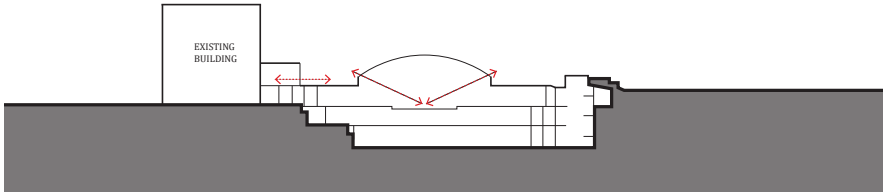
Above and Below Ground Function



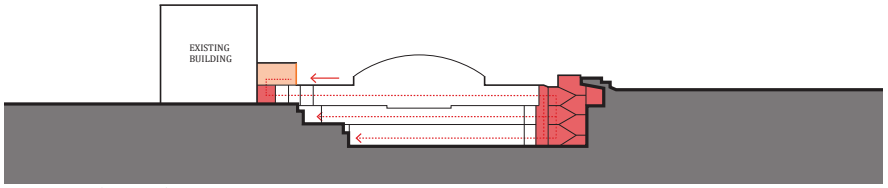
Concealed and Exposed Elements



Natural Light



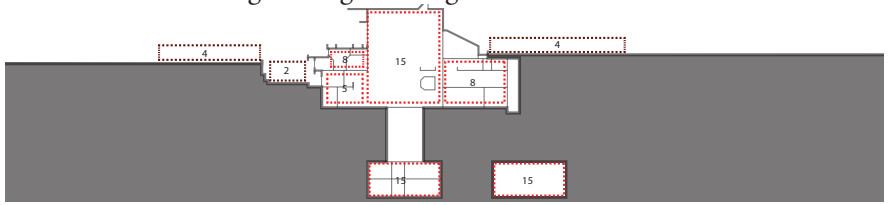
Sightlines



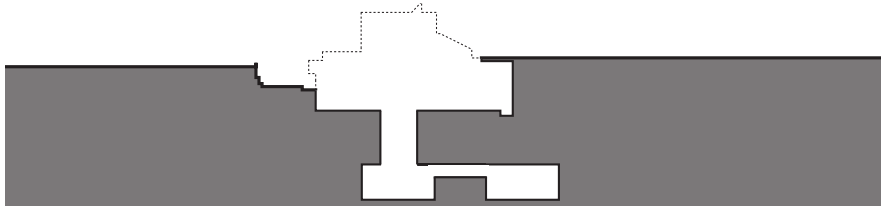
Access and Circulation

Figure 3.32: *Mutual of Omahia Headquarters Addition Diagrammatic Analysis* *1:600*

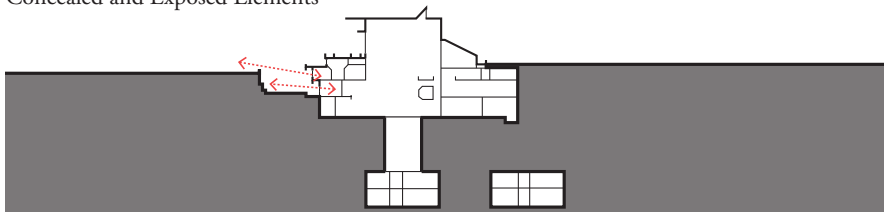
Civil and Mineral Engineering Building



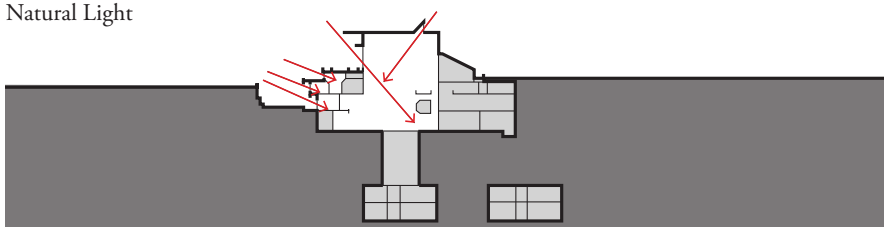
Above and Below Ground Function



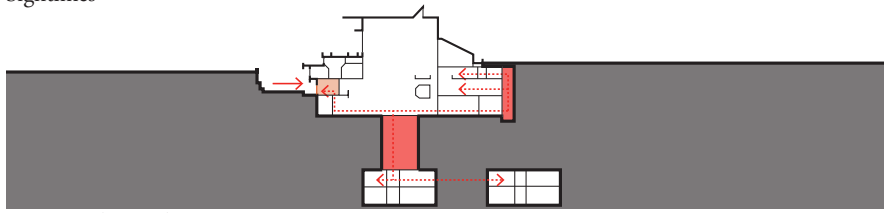
Concealed and Exposed Elements



Natural Light



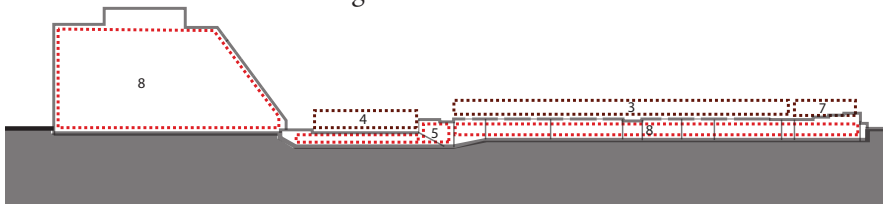
Sightlines



Access and Circulation

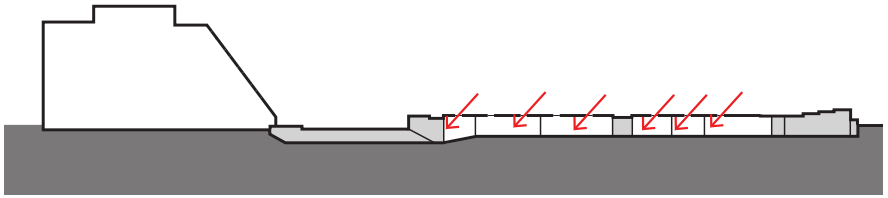
Figure 3.33: *Civil and Minerl Engineering Building Diagrammatic Analysis* *1:700*

California State Office Building

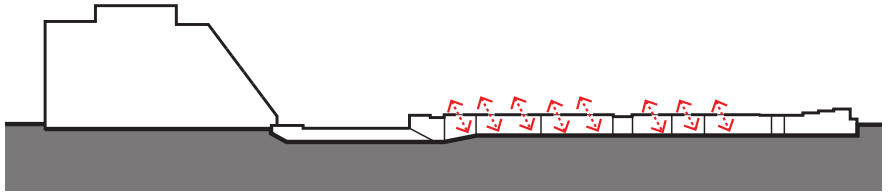


Above and Below Ground Function

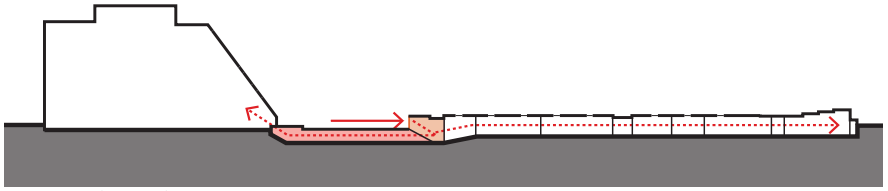
Concealed and Exposed Elements



Natural Light



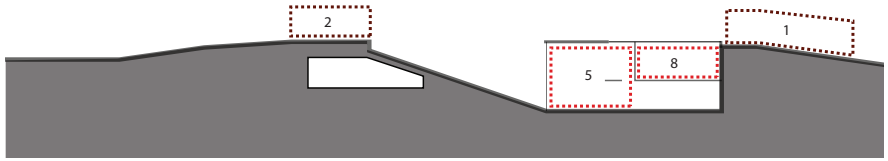
Sightlines



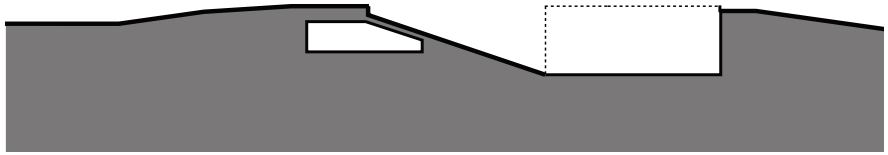
Access and Circulation

Figure 3.34: *California State Office Building Diagrammatic Analysis* *1:800*

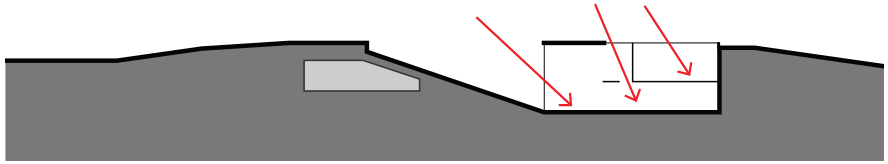
Invisible House



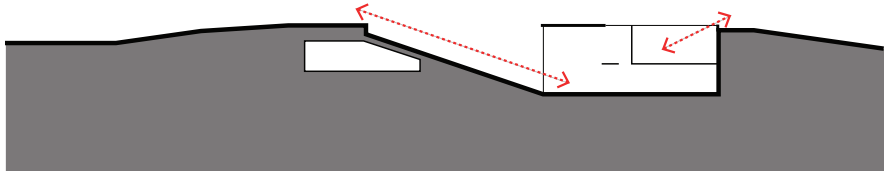
Above and Below Ground Function



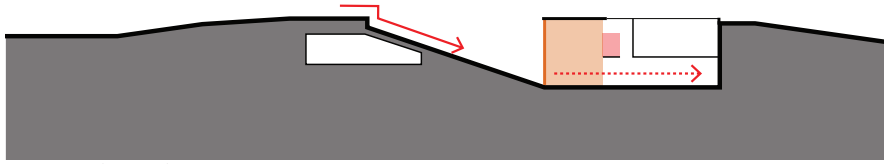
Concealed and Exposed Elements



Natural Light



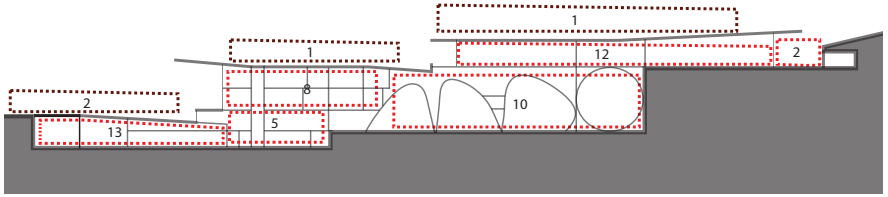
Sightlines



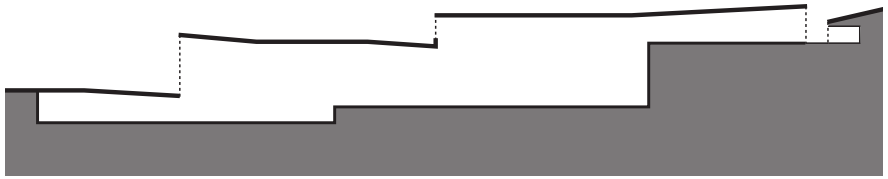
Access and Circulation

Figure 3.35: *Invisible House Diagrammatic Analysis* *1:400*

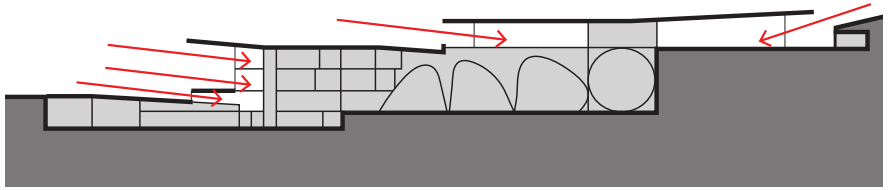
New Cantina Antinori At Bargino



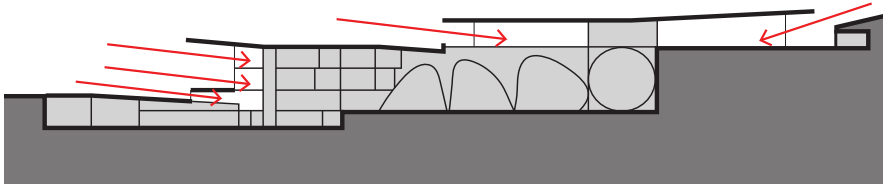
Above and Below Ground Function



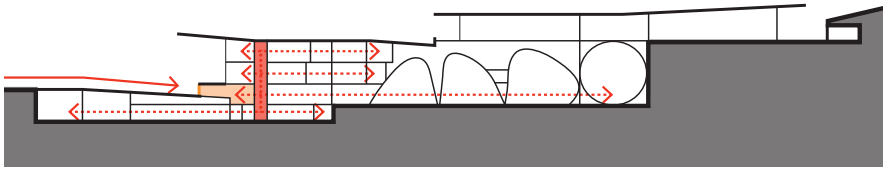
Concealed and Exposed Elements



Natural Light



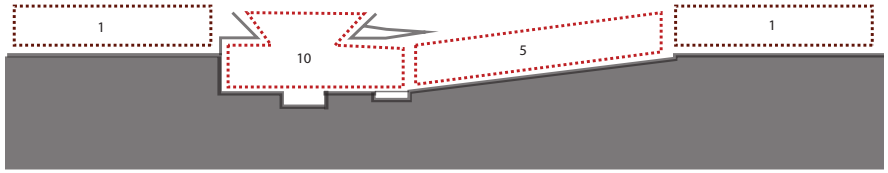
Sightlines



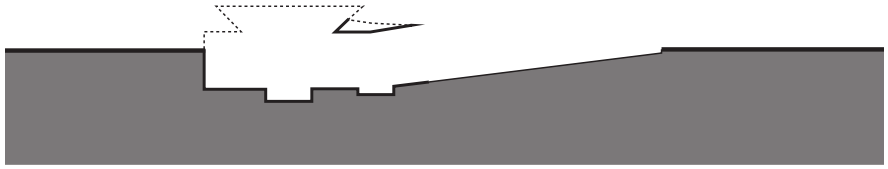
Access and Circulation

Figure 3.36: *New Cantina Antinori at Bargino Diagrammatic Analysis* *1:900*

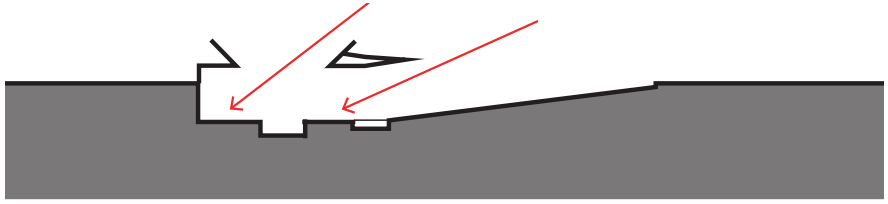
M9 Memorial



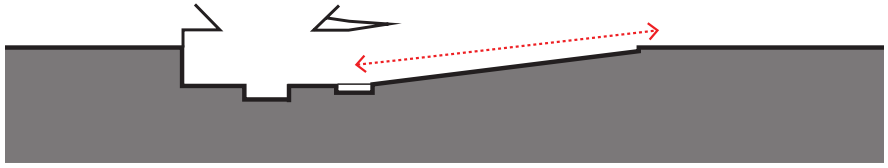
Above and Below Ground Function



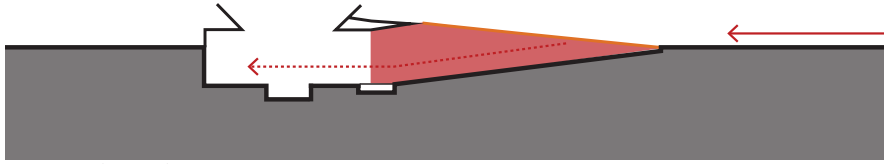
Concealed and Exposed Elements



Natural Light



Sightlines



Access and Circulation

Figure 3.37: *M9 Memorial Diagrammatic Analysis* *1:400*

3.5 RESULTS FROM DIAGRAMMATIC ANALYSIS

Above and Below-Ground Function:

This diagrammatic analysis investigates the functional relationship between the building's interior and exterior environments. Through analysing various types of spaces and their associated activities both internally and externally, the functional relationship between above and below-ground is established.

Buildings which have no habitable exterior ground plane can be described as having the weakest functional relationship between above and below-ground. Key examples of this include Itakeskus Swimming Pool, Samuel Beckett Theatre, and Friedrichstrasse, where they are either situated at a *Completely Submerged Depth*, or their form projects significantly beyond the ground plane, appearing as a conventional building (Figure 3.38). Both of these building depths represent an extreme detachment from the ground plane, making the ground plane uninhabitable and therefore disregarding any functional connection between above and below-ground spaces.

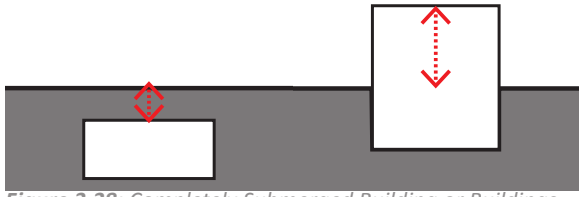


Figure 3.38: *Completely Submerged Building or Buildings that Project too far Beyond the Ground Plane are Extremely Detached from their Ground plane.*

Many of the buildings from the 15 strongest examples demonstrate a close relationship between their above and below-ground functions, attributed through their use of *Partially Submerged* or *Earth Covered* building depths (Figure 3.39). Examples which best demonstrate this include Williamson Hall, Prado Museum, and Terraset and Terra Centre Elementary School, where the exterior environment offers a diverse range of spaces, such as amphitheatres and courtyards, which can be used by the buildings inhabitants and general public. This diverse range of spaces, both above and below -ground creates a stimulating environment, ensuring that activity is sustained at both levels, while simultaneously expanding the public realm.

Figure 3.39: *Partially Submerged and Earth Covered Building Depths have a Close Relationship to their Ground Plane.*

However, examples such as Arnhem Car Park and The Dok, both of which are car parks, extend their programme above-ground. These examples see the above-ground space become lost space through the concreted ground surface. Although these examples present a continuous programme throughout, they disregard the significance of the above-ground space, and therefore create an undesirable ground plane

environment.

Some of the examples expand on their functional relationship between above and below-ground through creating an above-ground plane environment which is not only functional to the below- ground programme, but it also responds to its surrounding urban fabric. This is achieved by providing public amenities, infrastructure and transportation networks, both above and below-ground, and integrating them seamlessly into the buildings surrounding environment. Key examples of this include California State Office Building and Almere Masterplan, where underground pedestrian networks extend underneath major boulevards and connect to surrounding buildings.

Concealed and Exposed Elements:

This diagrammatic analysis investigates the degree of exposure the underground building has above-ground by analysing the types of spaces that are situated above-ground.

Figure 3.40: *Completely Submerged and Submerged Buildings have no Presence Above-Ground*

Buildings with the greatest degree of concealment are those solely from the weakest 15 examples, where their depths are either *Completely Submerged* or *Submerged*; in either case the buildings form is entirely concealed underground (Figure 3.40). Key examples of *Completely Submerged* buildings are Itakeskus Swimming Pool and Samuel Beckett Theatre, where the entrance is the only exposed building element. Key examples of *Submerged* buildings include Arnhem Car Park, Plaza Del Torico and The Dok. In these examples, the expansive flat roofs are the only exposed building element; however they ultimately become indistinguishable from their surrounding context as they align with the ground plane. Therefore, these examples lack visibility cues, where the location and extent of the building is unknown, as its boundaries are either obscured or completely hidden. Consequently the buildings lack an identity and furthermore often rely on a small portion of the building, usually its poorly conceived entrance to project such a valuable image.

Buildings with the greatest degree of exposure above-ground are those solely from the strongest examples, where their depths are either *Partially Submerged* or *Earth Covered*, allowing the image of the building to be determined above-ground (Figure 3.41). Key examples of this include the *Partially Submerged* Civil and Mineral Engineering Building and Kimbell Museum, and the *Earth Covered* Museum Heldenberg and Lucille Halsell Conservatory, where the depth of these examples allows the building to have at least a vestigial presence above-ground. Although this vestigial presence does not mean that every one of the buildings boundaries is articulated, it does at least allow for some indication of the buildings location and extent above-ground increasing building legibility and allowing the buildings' image to be experience from the ground plane.

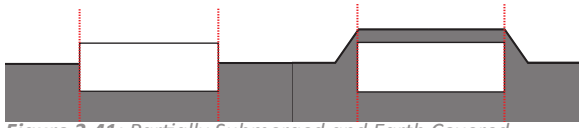


Figure 3.41: *Partially Submerged and Earth Covered Depths Allow the Building to have a Presence Above-Ground.*

Natural Light:

This diagrammatic analysis investigates how natural light enters and filters through the interior of the building. It analyses the degree to which natural light provides legibility, and how it facilitates activities within the building.

Buildings with the least amount of natural light are found within the 15 weakest examples as they either discard natural light entirely, or have the ability to receive natural light but do not do so. Key examples which have no aperture and therefore discard natural light entirely include Plaza Del Torico, The Dok, Souterrain, Itakeskus Swimming Pool, and Samuel Beckett Theatre. The depths of these building are either *Completely Submerged* or *Submerged* (Figure 3.42), highlighting the directly proportionate relationship between natural light and depth, where the deeper the building, the less likely it is to have an aperture and receive natural light.

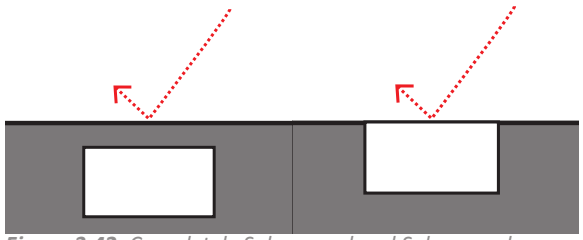


Figure 3.42: *Completely Submerged and Submerged Buildings do not have Apertures and therefore do not Receive Natural Light.*

Examples which have the ability to receive natural light, but do not harness potential light include Souterrain, Plaza Del Torico and The Dok. Although the *Submerged Depth* of the building easily permits

the interior to receive natural light through vertical apertures, any placement of apertures are significantly restricted by the activity of the above-ground environment, and therefore it has been easier to disregard them entirely.

Within these two categories natural light is displaced, making artificial light the main source of illumination. Therefore the buildings often lack visual stimulation or any possible connection to the exterior environment. The artificially lit building creates no hierarchy between spaces, seeing them become easily indistinguishable from one another where legibility and orientation is lost.

Buildings with the most amount of natural light are found within 15 strongest examples. However, it is the examples which manipulate light to create a sense of hierarchy within the building, thus increasing legibility and orientation, which maximise the potential use of natural light. Examples which best exemplify this include, Williamson Hall, Kimbell Museum, M9 Memorial, and the Civil and Mineral Engineering Building. These examples integrate vertical and lateral light through *Projected* and *Stepped Apertures*, allowing a uniform illumination within the building, thus reducing the sense of being underground (Figure 3.43).

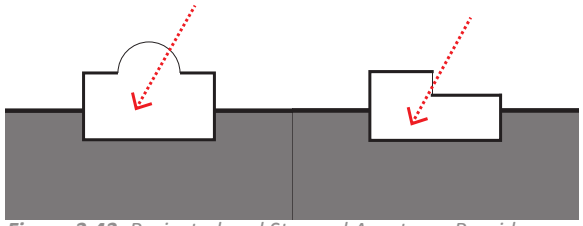


Figure 3.43: *Projected and Stepped Apertures Provide Uniform Lateral and Vertical Illumination.*

These examples use natural light as an implicit connection to the exterior environment while simultaneously creating stimulating interior environments. This connection allows subtle changes in the weather to directly influence the building's interior atmosphere, creating an ever changing dynamic interior.

Sight Lines:

This diagrammatic analysis investigates the visual connections between exterior and interior elements of the building. It establishes the views, both into and from within, the building, analysing their depth and extent.

The buildings with the least amount of sightlines are those found within weakest 15 examples. Key examples include, Itakeskus Swimming Pool, Samuel Beckett Theatre, and Plaza Del Torico, highlighting the same relationship identified in the natural light section, where deeper the building is sited the less likely it is to have apertures, and therefore the less likely it is to establish sightlines between above and below-ground. As these examples are *Completely Submerged*, the only sightlines that exist are horizontal between the entrance and its immediate exterior (Figure 3.44). With only one sightline between interior and exterior environments these buildings are significantly detached from their ground plane activity and are consequently seen as highly internalised. Therefore, the building's interior environments lack any visual stimulation and neglect any possible visual reference, making orientation and way finding difficult.

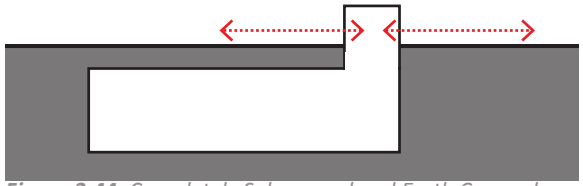


Figure 3.44: *Completely Submerged and Earth Covered Buildings Rely on their Entrance to Create Sightlines Between Interior and Exterior Environments.*

The buildings with the greatest number of sightlines are found within the 15 strongest examples, where they are either *Partially Submerged* or *Earth Covered (Figure 3.45)*. Key examples include Prado Museum, Williamson Hall Library, and The Civil and Mineral Engineering Building, where sightlines have been manipulated to ensure pronounced visible connections between their interior and exterior environments. Sightlines often extend to significant areas of interior activity, allowing the buildings identity to be experienced above-ground. These spaces consist of atriums, entrance or significant exhibition or memorial space. These sightlines allow the building to be experienced from above- ground, gaining an insight into the building without having to enter it.

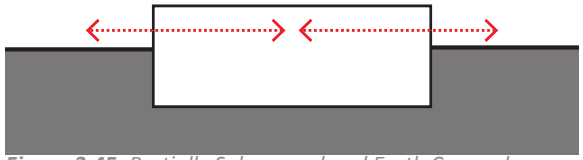


Figure 3.45: *Partially Submerged and Earth Covered Buildings have Pronounced Visual Connections Between Interior and Exterior Environments.*

Furthermore, buildings such as Williamson Hall Library, Kimbell Museum, and Cantina Antinori at Bargino, reduce the sense of confinement and descent within the deeper level of the building by creating expansive views which penetrate through the interior of the building and extend to the exterior environment (Figure 3.46). These sightlines not only enhance the feeling of spaciousness by increasing interior permeability but also strengthen orientation and way finding at deeper levels within the building through using interior and exterior building elements as landmarks.

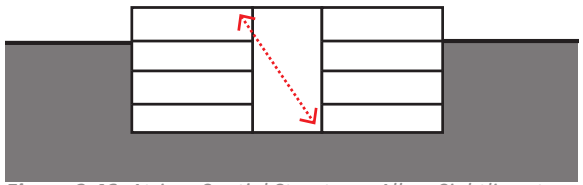


Figure 3.46: *Atrium Spatial Structures Allow Sightlines to Penetrate Deep within the Building.*

Access and Circulation:

This diagrammatic analysis investigates the means of horizontal and vertical movement within the building examples. Through analysing the location of access points, the means of decent and patterns of circulation, the degree of legibility and ease of movement of each example are established.

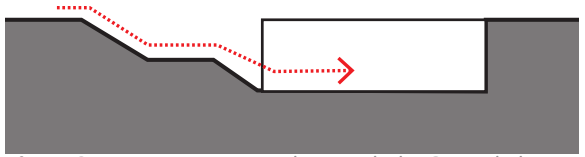


Figure 3.47: *Entrance Located Beneath the Ground Plane.*

Within the examples, there are three distinct patterns of access. The first being where the entrance is located beneath the ground plane and access is by means of terracing or more frequently a ramp, ensuring a gradual transition between levels (Figure 3.47). As the entrance is approached horizontally, similar to the conventional buildings, the sense entering an underground space is significantly reduced. This access type is best demonstrated by examples which either have a *Covered Sloped Cavity* or *Opened Sloped Cavity*, or a *Covered Cavern* or *Open Cavern Ground Plane Manipulation*. Key examples include M9 Memorial, Civil and Mineral Engineering Building, and Terraset and Terra Centre Elementary School. As the majority of descent occurs externally, a subtle transition zone between above and below-ground spaces is created.

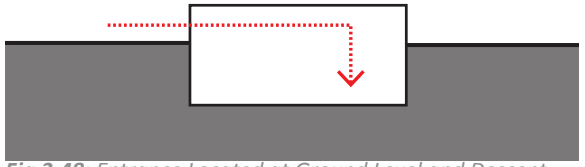


Fig 3.48: *Entrance Located at Ground Level and Descent Occurring within the Building.*

The second entrance pattern, and perhaps the most prevalent within the examples, sees the entrance located at ground level and descent occurring within the building (Figure 3.48). This access type is best demonstrated by examples which have an *Open Cavity Ground Plane Manipulation*, such as The Museum of Judenplatz, Plaza Del Torico, Mutual of Omahia Headquarters Addition and Rijksmuseum. The location of the entrance at ground level allows the building to project its identity and orientation as one approaches the building, reducing the sense of the transition between interior and exterior. However, this prolonged approach often followed by rapid descent located immediately adjacent the entrance, imparts a profound sense of descent.

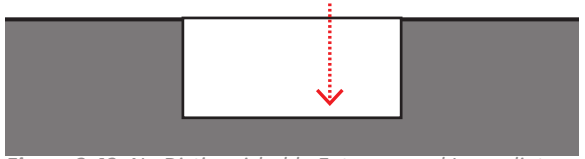


Figure 3.49: *No Distinguishable Entrance and Immediate Descent*

The last type of entrance involves the most abrupt form of descent, where the building has no distinguishable entrance at ground level (Figure 3.49). This access type is best demonstrated by examples which have a *Covered Cavity Ground Plane Manipulation* such as Arnhem Car Park, Souterrain, The Dok, Memorial for the Murdered Jews, and Plaza Del Torico. These examples all found within the weakest examples, have

entrances located below the ground level where access is through means of an opening in the ground. This type of entrance has the least distinction at ground level, often concealing the identity of the building as well as confusing its location and orientation.

One of the most prevalent circulation types found within the both the strongest and weakest examples involves a distinct separation between horizontal and vertical movement (Figure 3.50). This is best exemplified by buildings with a *Layered Spatial Structure*, such as Almere Masterplan, Souterrain, Nydalen Station, The Dok and Westminster Metro Station, all of which have transportation based programmes. This structure allows movement to be controlled through definitive nodes of vertical movement located around the perimeter of the building, with horizontal movement running longitudinally throughout the building. Although this circulation pattern allows large numbers of people to move efficiently within the building, it does sometimes make descent mundane and ordinary.

Figure 3.50: *Distinct Horizontal and Vertical Movement*

Conversely, buildings with an *Atrium* or *Combined Spatial Structure*, such as The Civil and Mineral Engineering Building and New Cantina Antinori at Bargino, found within the strongest examples, demonstrate an integrated approach towards circulation and interior configuration. The majority of horizontal and vertical movement within the building is situated near, or located within, significant areas of internal activity, creating a primary node of movement (Figure 3.51). This primary node creates a zone of distinct character as it is easily distinguishable from other interior environments, subsequently enhancing orientation and way finding within the building. Without separating areas of horizontal and vertical movement, a focus of activity can be created within the node, seeing circulation movements become diverse, while also providing visual stimulation and extended views inside the building.

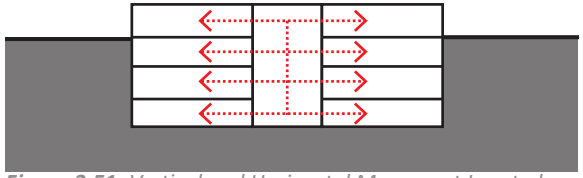


Figure 3.51: *Vertical and Horizontal Movement Located Near Significant Areas of Internal Activity.*

Further examples which clearly reinforce this integrated approach, yet expand on its basic premise are Prado Museum and Rijksmuseum. Through manipulating their *Layered Spatial Structure* within the building, simultaneous horizontal and vertical movement occur throughout the entirety of the building (Figure 3.52). Subtle inclines and declines in the angled floor planes integrate circulation with interior spaces, therefore allowing for free flowing circulation instead of defined movement paths, while simultaneously

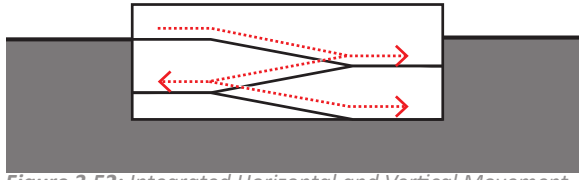


Figure 3.52: *Integrated Horizontal and Vertical Movement.*

creating subtle transitions between levels. This elevated degree of integration through the building distorts the distinction between vertical and horizontal movement, therefore the inhabitant has a less profound, often unnoticeable sense of descending into the underground. However, this approach can often lead to a loss of orientation seeing the building become a labyrinth in which natural way finding is significantly impaired.

3.6 DISCUSSION

This chapter analysed the physical structure of 90 contemporary underground buildings with respect to a set of specific attributes that best demonstrate the range of possible connections between above and below-ground space. From the analysis of the 15 strongest and weakest examples initial guidelines established in chapter one are developed and refined, while further guidelines are established. These include:

- Building Exterior
- Building Entrance
- Interior Configuration
- Vertical Circulation
- Natural Light
- Sight Lines

The comparative analysis of the 15 strongest and weakest examples identified the most promising strategies for establishing the above guidlines.

The further guidelines focus primarily on the physical structure of the building, but also acknowledging a wider set of factors which are applicable only to the building's unique site, programme and design rationale. They reflect many of the issues and problems frequent within underground buildings established in the literature review, and begin to establish the ways in which the physical structure of the building can resolve such issues.

Another significant aspect of this chapter is the development of terminology used to describe the various physical forms of underground space. This terminology can be used to discuss the physical form which the underground building must take to achieve the guidelines, allowing for a more detailed underground space framework to be developed. Together they can also be applied throughout the design case study to

describe the building, and evaluate its final outcome.

However, what these guidelines do not consider is how the physical characteristics of underground space can determine the image of the underground, the important atmosphere and mystical and emotional qualities which are unique to the underground. Therefore the next chapter aims to discuss how these features can be achieved.

CHAPTER FOUR | UNDERGROUND ARCHETYPES

4.0 INTRODUCTION

Chapter Two and Three presented a discussion of the relevant principles in which underground architecture can successfully contribute to its above-ground public realm and the physical structures that can be used to achieve these principles. The latter focused primarily on the physical attributes of the buildings but failed to express the unique qualities and spatial experiences of the underground. Therefore this chapter presents a more holistic, experienced based analysis of underground space with regard to the meaning and association of the archetypes of underground space- it is these archetypes that contain the original essence of underground space.

This chapter is divided into three sections. The first section presents the image of the underground, establishing various factors which influence our perception of the underground. It also introduces the five identified archetypes; Caves and Caverns, Dungeons and Cellars, Bunkers, Grottoes and the Cryptoporticus. The Second section discusses the physical form and associated meanings of each of the archetypes, specifically focusing on their unique historical notions. The third and final section synthesizes the results from this chapter.

4.1 THE IMAGE OF THE UNDERGROUND

People feel a certain aversion towards descending into the underground as it provokes negative associations of cramped and dark conditions. These connotations may stem from previous experiences or as Von Meijenfeldt and Geluk explain “they can be culturally determined, connected with language and language use, or even traceable back to the subconscious” (2003, p. 168), seeing them become a result of a wider set of hidden factors.

In addition to this attitude, the inhabitant’s feelings, opinions and ideas all play a significant role in forming images of underground spaces. The underground therefore holds the potential of a myriad of experiences, as Sack identifies in his explorative writing, Messages from the Bowels of Earth, “where else can one find reality and myth, banality and mystery, refuge and menace as close to each other as under the earth?” (1993, p.9) . For there is nowhere else that such powerful moods can be held.

However, it is the rich history of underground structures that these images originate from, seeing underground archetypes, the original forms from which all other underground forms are derived from, contain the true essence of the image of the underground.

Within the literature and built forms of underground structures, seven different archetypes were identified. These archetypes appear sufficiently in underground literature to be idenitifed as disitnct ideas about underground space. However, through further reading and analysis it became apparent that some archetypes contain the same physical structures and essences, with no real distinguishable difference. Therefore these archetypes were paired together and treated as a single archetype, developing a set of five different archetypes. These are:

1. Caves and Caverns

2. Dungeons and Cellars

3. Bunkers
4. Grottoes
5. Crypotporticus

These archetypes not only explore the myriad of notions associated with the underground, but how the physical structure of each individual archetype forms this unique image, and how this image affects us psychologically. The first three archetypes; Caves, Dungeons and Cellars, Bunkers and Grottoes were often encompassed in darkness and shadow, air was stale, conditions were humid and there was an ever-present fear of entrapment from collapse. Therefore these spaces are situated around notions of incarceration, death, burial and entrapment. The remaining two archetypes; the Grotto and Crypotporticus are paradox in nature from the first three. These archetypes exploit the earth's natural features to create practical spaces which evoke notions of romanticism and sanctuary through offering refuge and safety.

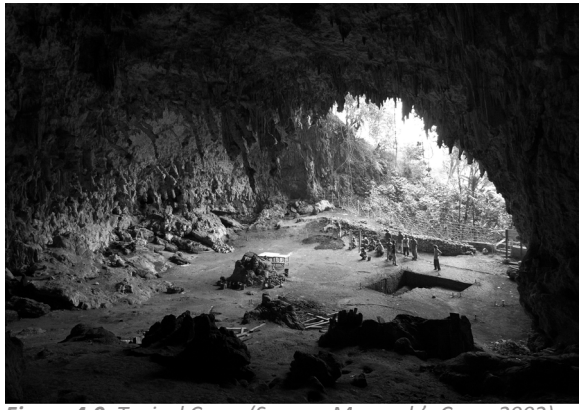


Figure 4.0: *Typical Cave. (Source: Monarch's Cave, 2002)*

4.2 CAVES AND CAVERNS

Caves are perhaps the most basic of underground structures. Their simple construction of merely a carving hollowed into the earth sees it as an ill-defined form (Figure 4.0) ; however it does have certain properties. As noted by Betsky, they consist of "a restricted opening, a sequence of open spaces and an indefinable or unstable relationship between ground, walls and ceilings" (Betsky, 2002, p.58). However, it is the rich connotations associated with such a primitive structure that truly captures the unique essence of the Cave.

Caves, the earliest habitations of man, contain the origins of human kind. Man used them as temporary shelters, while they migrated with the seasons. Yet it wasn't until the discovery of fire that the true potential of the Cave was fully exploited, as it provided shelter for cooking. The enclosure also offered a feeling of protection, where the strength of the structure and the single point of entry allowed the

inhabitant to rest peacefully without fear from attack. It is these primitive inhabitations that are the basis of the rich connotations associated with the cave.

The Cave can be associated with "preterhuman existence-with rites of birth and death" (Miller, 1982, p.11), seeing it as a place of return. The burrowing into the land is a reminder of the womb, a place that is confined, warm and concealed in darkness, a place that offers feelings of security, safety and protection to its inhabitant. In paradox the most central notion of the Cave is that it is associated with danger. Its jagged rock interior shrouded in permanent darkness and shadow makes it difficult to understand, "provoking a feeling of mystery and fear of the unknown" (Carmody & Sterling, Underground Space Design, 1993, p.138). Its physical "existence as a void always seems tenuous" (Betsky, 2002, p.58), so when its physical form and symbolic meaning combine, an extremely powerful image of the cave is created, an image that one cannot simply forget.

Alongside these physical feelings, the Cave and more importantly its enveloped darkness present a metaphor for knowledge. In Plato's Allegory of the Cave, the Cave is a prison, in which matter and understanding are concealed in shadow. The Cave becomes both the "organiser and constraint of human functions, an active agency in the formation of experience and morality in a goal to reach utopia" (Plummer, 1987, p.24). Utopia is therefore considered to be when one is exposed to the natural light and has the ability to see, "for seeing is linked to knowing and knowing is linked to power" (Plummer, 1987, p.21). Here the Caves physical structure does not come into question. Instead its characteristic of complete darkness and permanent shadow in stark contrast to its illuminated exterior are the formation of the Cave as a place for uneducated, primitive human beings, possibly diminishing some of the associations as the cave as a home and place of refuge.

4.3 DUNGEONS AND CELLARS

Dungeons and Cellars developed in the Middle Ages were often cages constructed within the subterranean portions of fortresses, castles or public buildings. Many of these submerged Dungeons (Figure 4.1) connected to a series of passageways that acted as a vast hidden underground network, connecting the main elements of the castle together. Dungeons and Cellars were often crude structures that were not initially built to house criminals (Johnston, A Brief History of Prison Architecture, 1973). Instead they were used for storage of perishable goods, where the earth's constant temperature was utilised to create cool rooms. With the advent of many of these storage rooms converted to house prisoners, dungeons often lacked humane living conditions. Spaces were often too confined and prisoners were unable to stand upright, and were deprived of natural light, fresh air and sanitary facilities.

Figure 4.1: *Dungeon. (Source: Old Exchange Dungeons, 2005)*

It was not until the 12th Century that specifically designed Dungeons appeared, however the horrific conditions associated with the Dungeon and Cellar remained. They were not designed to be healthy or aid the rehabilitation of the prisoners; instead they were "barely sufficient to sustain the lives of the inmates" (Johnston, Forms of Constraint: A History of Prison Architecture, 2000, p. 5). These Dungeons consisted of two chambers, one below the other. The lower chamber was the smaller and the darker of the two. Access was via a trapdoor in the ceiling that opened into the chamber above. This chamber was slightly larger and had an aperture that allowed a small amount of natural light to partially illuminate the interior. Confinement to the lower pit was used for prisoners in lieu of the death penalty, while the above chamber was used for minor offenders (Johnston, Forms of Constraint: A History of Prison Architecture, 2000).

The conditions within Dungeons and Cellars, along with histories of torture and torment, consequently saw them gain a sinister and disturbing reputation, leaving permanent marks on our memories. It is in these underground spaces that "darkness prevails both day and night" (Bachelard, 1994, p.19), exaggerating the inhabitants fears and letting their imagination run free with terrifying thoughts. The inhabitant experiences "buried madness" (Bachelard, 1994, p.20) knowing that "the walls of the Cellar are buried walls, that they are walls with a single casing, walls that have the entire earth behind them"

(Bachelard, 1994, p.20), creating a dramatic and volatile situation. Movies, novels and tales have adopted these connotations of the Dungeon and further exploited them, transforming them into a symbol of the terrifying and the sadistic. They become places from "where the living dead operate" (Von Meijenfeldt & Geluk, 2003, p.14), you only have to look as far as Dracula and Frankenstein to know that Dungeons and Cellars "appeal to the imaginations that create thrillers and horror stories" (Von Meijenfeldt & Geluk, 2003, p.14).

4.4 BUNKERS

The Bunker (Figure 4.2) , designed to protect its inhabitant's from incoming bombs, flying shrapnel and other attacks was extensively used in World War I and World War II. Its 'aerostatic' form was purely concerned with survival; it provided "shelter for man in a crucial period, the place where he buries himself to subsist" (Virilio, 1994, p.46). Its characteristics, a monolith shell constructed from heavily fortified concrete walls with only a narrow slit for the observer to spot the enemy were all adopted to ensure survival. It was partially submerged into the landscape allowing the earth to conceal the main portion of the structure while offering a sense of stability and assurance. The camouflage potential of the Bunker "nestles in the uninterrupted expanse of the landscape and disappears from our perception" (Virilio, 1994, p.44), the structure becomes linked to the surrounding earth providing the inhabitant with a sense of fortification and concealment. Yet the Bunker is also a physical manifestation of "our own power over death, the power of our mode of destruction, of the industry of war" (Virilio, 1994, p.46), for it is the actions of human kind that have created the need for such a pivotal structure.

Figure 4.2: *Bunker. (Source: Pointe du Hoc, 2011)*

The powerful notions of War, and therefore the Bunker also reversed the associated connotations of light and shadow, for being in the path of light means that you could be seen and exposed to possible attack. It was not until you were concealed in shadow that you were protected and sheltered. However, shadow only protects the inhabitant to a certain degree. It only acts as a partial screen, for you were only screened from

what you could not see, yet allowing sounds, feelings and images of the war raging outside to still affect the inhabitant taking refuge inside the Bunker.

4.5 GROTTOES

The Romantic Movement emerged during the second half of the 18th century as a reaction to the industrial revolution. It saw a noticeable increase in primitive constructions that were not meant just for living, but for reconnecting the enlightened, wealthy classes to something they had a lost; "a civilisation of nature, or their own bodies" (Betsky, 2002, p.58) . The Grotto (Figure 4.3)was a predominant type within these constructions. It was designed to integrate into its natural surroundings, becoming an embellishment in many parks and public places, where its form was dictated by the natural arrangement of the surrounding earth and rocks. However, it is not the form that sets the Grotto apart from other cavernous structures, it is the fact that it pays homage to the qualities of water. It seeks to create and manipulate this precious element through displaying, recycling and worshipping it (Miller, 1982). It is this individual focus on the essence of nature that establishes the grotto as a place of sanctuary in both a functional and spiritual sense.

Figure 4.3: *Grotto. (Source: Jeita, 2010)*

Functionally, the Grotto provided an escape from the harsh rays of the summer sun. Exploiting the earth's natural insulation to maintain lower temperatures along with the cooling affect from flowing water collected from the surrounding landscape, a shady retreat was created. This constant cool temperature of the Grotto and the subtleness of illumination and shadow entering from above allowed for the inhabitant to partake in "delight, mediation, rest, and relaxation" (Sullivan, Subterranean Rooms, 2002, p.11), as nature provided the backdrop for many sociable activities. Spiritually the Grotto, where light prevails darkness, was an imitation of the natural world, where its elusive world of shells and water had strong connections to classical imagery (Miller, 1982). Together, the Grotto as a place of sanctuary was used for restoring and renewing the senses, it became a place to "escape from the world of reality, from the rules and artifices and constrictions of society" (Miller, 1982, p.10). This withdrawal from reality into a fantasy

world was seen as a unity between man and nature, but also had feelings of danger, concealment, and the "illicit that legitimised the hidden pleasures of the upper class" (Betsky, 2002, p. 58), reinforcing the notions driving the Romantic Movement.

4.6 CRYPTOPORTICUS

The Cryptoporticus (Figure 4.4) is a long, narrow, subterranean corridor that's function is to connect and provide access between individual villas on a site. Its depth utilizes the earth's natural cooling features while offering protection from the direct summer sun, providing a comfortable environment for circulation. Developed by the Romans purely for function purposes, it was a completely submerged underground space, often built as a network of corridors, mainly used by the family and their servants to move around the villa (Sullivan, Subterranean Rooms, 2002). However, its full potential was not fully harnessed until the Renaissance period, where it became subterranean and high vaulted ceilings, along with clerestory openings, were incorporated. These simple features created a microclimate through the stimulation of air movement (Sullivan, 2002), while also allowing natural light to subtly illuminate the interior, and provide views to the gardens above.

Figure 4.4: *Cryptoporticus. (Source: Neros History,2009)*

The comfortable environment that was created saw the Cryptoporticus become "more than just a mere passage way, but discrete living places in their own right". (Sullivan, 2002, p. 34). The original concepts of earth and exposed rock walls and ceiling, were now adorned by marble mosaics and paintings, transforming the Cryptoporticus into a gallery displaying the talents of the wealthy.

4.7 DISCUSSION

This literature underlines the significant role of underground archetypes in the projection of the images and associations of underground space. It established that the characteristics of the underground allow all elements of design of space to be manipulated, actively informing and controlling the inhabitant's perception of the underground. Many of the archetypes manipulate these elements in a way which creates a profound sense of being underground. Therefore it can be said that they are severely detached from their ground plane, having little physical connection to their above-ground environments. Although these archetypes may not actively contribute to their above-ground plane, they are by no means considered less important in forming the guide lines of the underground space framework. Instead these archetypes can be used to inform the expressive spatial experiences of the underground, an aspect that the previous two chapters have not previously analysed. Therefore this chapter ensures that the underground design principles embody the unique sense of the underground as well as establishing strong connections to its above-ground public space.

CHAPTER FIVE | UNDERGROUND SPACE FRAMEWORK

5.0 INTRODUCTION

This chapter presents an underground framework containing a set of design guidlines which underpin the successful design of underground buildings. Developed from the findings of the literature review, taxonomy analysis, and archetypes discussion these guidelines aid the successful design of underground buildings by suggesting a comprehensive menu of solutions for implementing these guidelines.

This chapter is divided into three sections. The first section introduces how the underground space guidelines have been developed, the way in which they are organised, and the role they play in the final underground design. The second section presents the guidelines and their associated categories, stating the issues with underground space, the objectives that arise from such issues, and the way in which these objectives can be achieved. The third and final section presents the conclusions from this chapter, highlighting an obvious contrast between guidelines which respond to the issues that arise from underground space, and the spatial image guidelines which express the unique nature of being underground.

5.1 DEVELOPMENT OF GUIDELINES

The underground space guidelines presented in this chapter have been developed from the preceding chapters. They incorporate findings from:

- The 'Principles of Successful Underground Space' established in Chapter Two's literature review.
- Taxonomy Analysis of the physical structure of 90 contemporary underground buildings.
- The five archetypes of underground architecture.

The guidelines have been developed as a response to the general issues that arise from underground space as discussed within the preceding chapters. They have been developed to identify a range of objectives for underground space and suggests possible solutions in which the design can address these objectives. Therefore, the solutions to these objectives are less specific, providing room for a certain degree of development in response to the building's unique identity.

Guideline Presentation Outline:

The underground space framework is divided into seven categories, with each focusing on a major design issue relevant to underground space. The first six categories were developed from the findings of chapter twos literature review and chapter threes taxonomy analysis. These categories include:

- Building Exterior
- Building Entrance
- Interior Configuration

- Vertical Circulation
- Natural Light
- Sight Lines

The last category was developed from the findings of chapter fours underground archetypes. This category is:

- Spatial Image

However, it is important to note that the last category of Spatial Image is profoundly different from the previous categories as instead of being developed from the issues relevant to underground space, it has been developed from the five archetypes, all of which are detached from the ground plane, and as a result have a profound sense of being underground. Therefore these guidelines present a set of strategies which can be used to express and enhance the sense of being underground.

The sequence of these categories is, to some degree, based on the scale of the design decision they relate to, starting at a macro scale where they include the relationship between the building and its surrounding context, and then progressing to smaller scales where the detail of individual spaces are considered.

The presentation of each underground space guideline briefly states the issue, its objective, and then suggests various solutions for implementing the specific objective. Alongside each objective is an accompanying diagram, illustrating these various solutions (Figure 5.0).

Issue	Objective	Solution	Diagram
Describes the unique underground issue.	Describes what the building must aim to do to mitigate the underground issue.	Describes the physical form the building must take to achieve the objective.	Illustrates the physical form the building must take to achieve the objective.

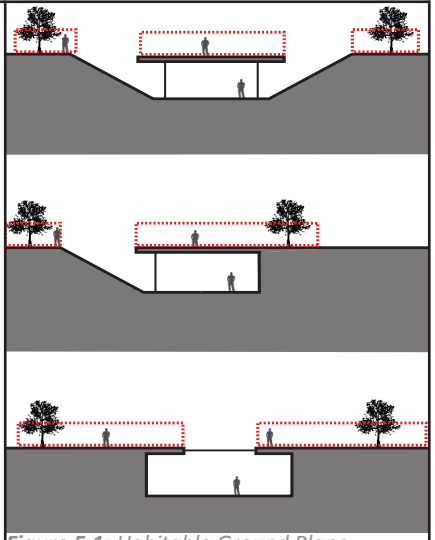
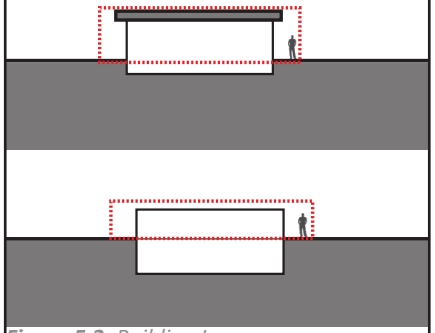
Figure 5.0: *Structure of the Underground Framework.*

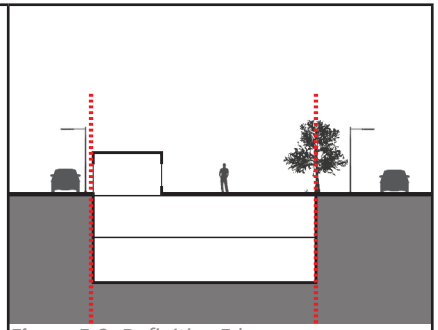
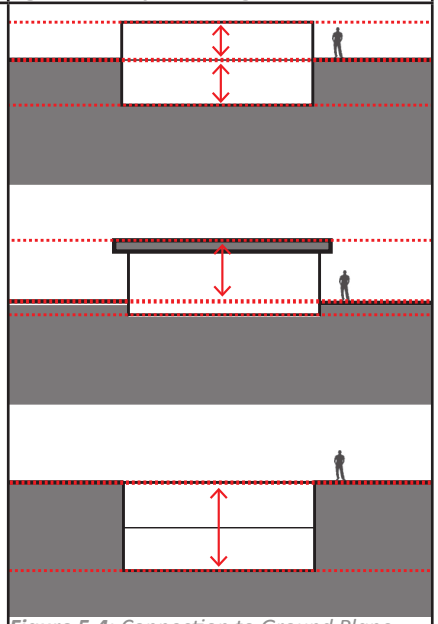
Role:

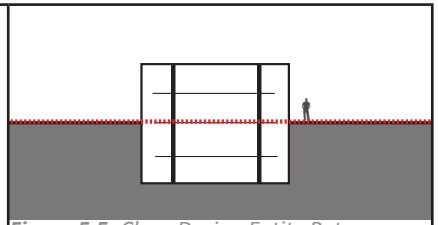
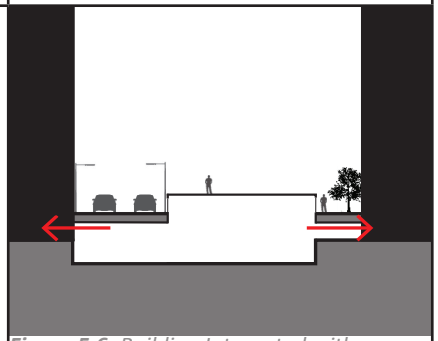
The role of this framework is intended to act as an aid in the development and design of underground space by focusing specifically on creating successful physical connections between above and below ground. The guidelines are not intended to be definitive, but are considered to be broad in order to offer a certain degree of flexibility. This flexibility allows the guidelines to be selected, adapted, and then applied in response to the specific requirements of their site and programme.

5.2 GUIDELINES

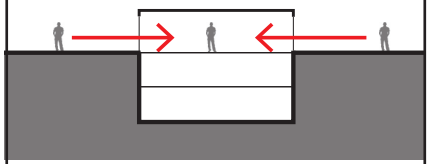
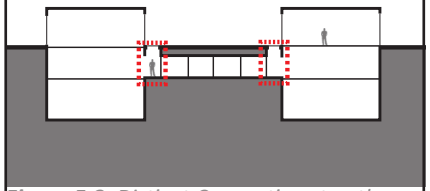
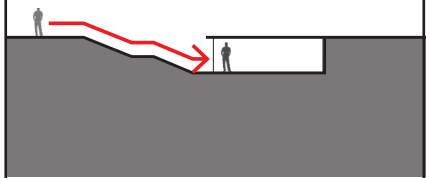
Exterior Building:

Issue	Objective	Solution	Diagram
No habitable ground plane.	Ensure the building has an inhabitable ground plane or roof so that a diverse range of activities can occur, sustaining life at ground level.	Use a covered Ground Plane Manipulation that creates flat open space at ground level. This can be achieved through a *Covered Cavity, Covered Cavern,* or *Covered Sloped Cavity.*	 **Figure 5.1:** *Habitable Ground Plane.*
Lack of building image.	Articulate the buildings mass and expose architectural elements so that the building is easily recognisable at ground level.	Use a depth that exposes the building mass above-ground, making it distinct from the ground plane. This can be achieved through either a *Partially Submerged* or *Earth Covered Depth.*	 **Figure 5.2:** *Building Image.*

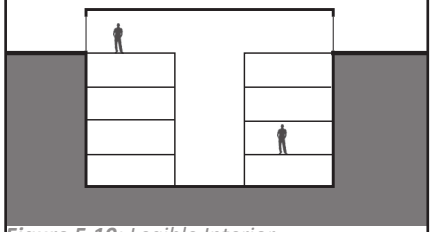
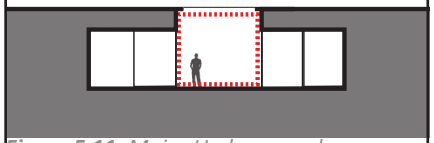
Lack of definitive edges.	Articulate the buildings boundaries and edges above-ground, to create an above-ground space which is distinct from its surroundings. Use these edges to also create a sense of spatial enclosure and to suggest sense of scale and shape of the underground building.	Allude to the limit of the buildings by exposing the edges of its mass above-ground by using a *Partially Submerged* or *Earth Covered Depth.* Use landscape elements which align with the building edges to define the above-ground space.	 **Figure 5.3:** *Definitive Edges*
Physical detachment from the ground plane.	Ensure that underground is not significantly detached from the ground plane i.e., that it is not too deep underground, nor does it project too far past the ground plane so that it appears as a conventional building.	Use a Depth which allows the building to have a physical connection to the ground plane, such as a *Submerged, Partially Submerged,* or *Earth Covered* building.	 **Figure 5.4:** *Connection to Ground Plane.*

Architecturally distinct spaces above and below-ground.	Create a close design entity between above and below-ground space to ensure that the two levels are not completely distinct from one another.	Continue significant elements situated underground above-ground, such as columns, walls and details.	 ***Figure 5.5:*** *Close Design Entity Between Above and Below-Ground.*
Building distinct from urban fabric.	Integrate the building both above and below-ground with its surrounding urban fabric.	Create an underground network of spaces by connecting the underground building to the basements of important buildings that surround it. Create above-ground space that can be accessed by the public and enhance life at ground level.	 ***Figure 5.6:*** *Building Integrated with surrounding urban fabric.*

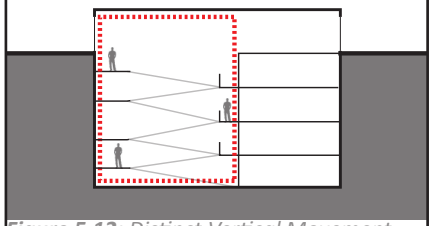
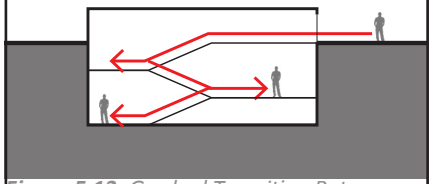
Building Entrance:

Issue	Objective	Solution	Diagram
Poorly conceived entrances.	Abrupt transitions between ground plane and underground space	Situate entrances at ground level, often within above-ground structures, so that descent only occurs once having entered the building.	 *Figure 5.7: Clearly Articulated Entrances.*
Poorly conceived connections to surrounding buildings.	When connecting to surrounding buildings create distinct connections and entrances that enhance the transition between buildings.	Create a clear transition space between buildings that is distinct from its surroundings. This can be achieved through apertures which illuminate the space or by a change in Spatial Structure and building Geometry.	 *Figure 5.8: Distinct Connections to other Underground Buildings.*
Abrupt transitions between ground plane and underground space.	When the entrance is located beneath the ground plane, ensure the access is by means of gradual descent.	Use a *Sloped Ground Plane Manipulation* to create a gradual transition between above and below-ground. This can be achieved through an *Open Cavern, Open Sloped Cavity, Covered Cavern* or a *Covered Sloped Cavity.*	 *Figure 5.9: Gradual Transition between the Ground Plane and Underground Building.*

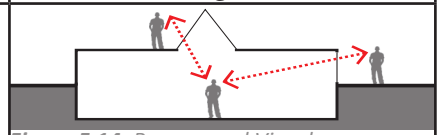
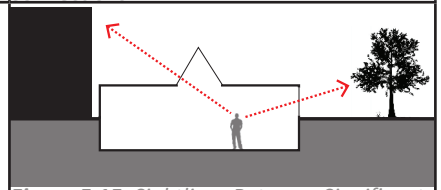
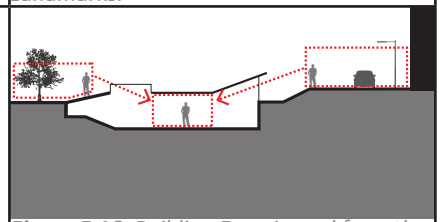
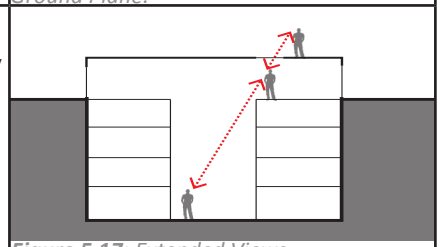
Interior Configuration:

Issue	Objective	Solution	Diagram
Lack of legibility.	Create an interior layout that is legible and enhances orientation and way finding within the building.	Create a central underground space by using an *Atrium Spatial Structure*. Treat legibility similar to above-ground public space where a system of paths, zones and activities nodes increase orientation within the building and create a distinct image as you pass through the spaces.	 ***Figure 5.10:*** *Legible Interior*
No distinct primary circulation.	Create major thoroughfares in underground buildings to increase orientation.	Treat these thoroughfares as public streets, where they appear wider and higher than other underground areas to increase distinction, and provide areas for social interaction.	 ***Figure 5.11:*** *Major Underground Thoroughfares.*

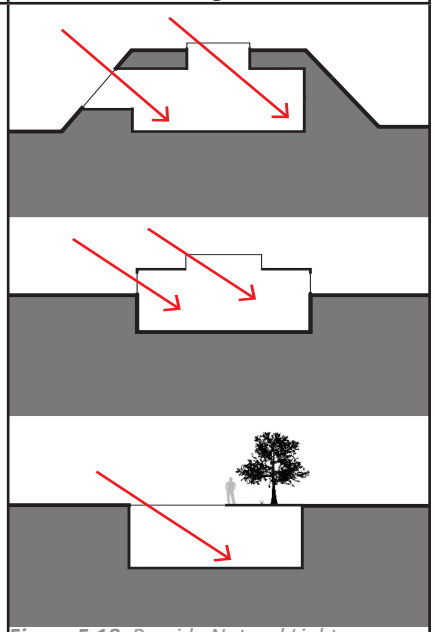
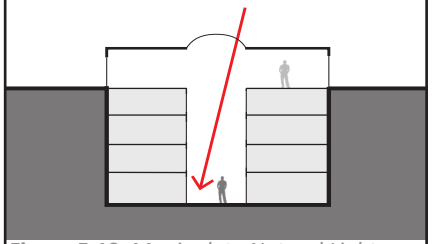
Vertical Circulation:

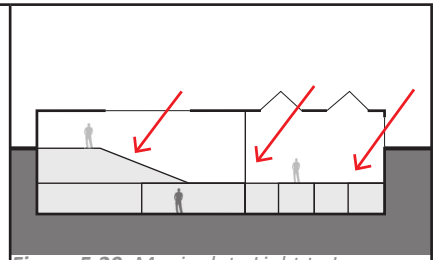
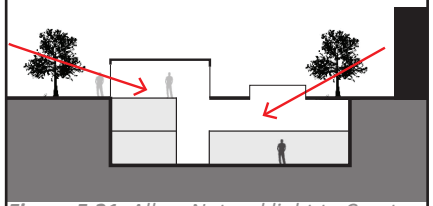
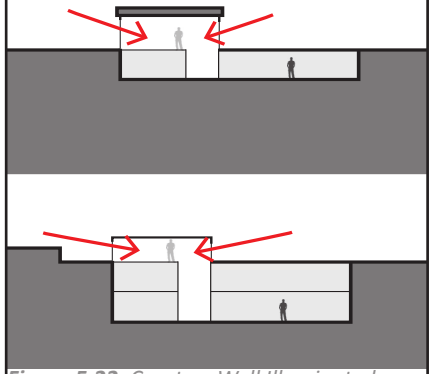
Issue	Objective	Solution	Diagram
Lack of vertical orientation.	Create distinct zones where primary vertical movement between upper and lower levels occur, to enhance orientation within the building.	Place primary nodes of vertical movement (such as stairs, ramps and escalators) near significant areas of activity, most often this is around the main entrance or in large multi- storey spaces that use an *Atrium Spatial Structure.*	 ***Figure 5.12:*** *Distinct Vertical Movement Zones.*
Abrupt transitions between levels.	Provide gradual transitions between levels.	Use a Spatial Structure that can be developed to provide both horizontal and vertical movement. Use a *Layered Spatial Structure* where floors can be manipulated to provide a gradual slope between levels.	 ***Figure 5.13:*** *Gradual Transition Between Levels*

Sightlines:

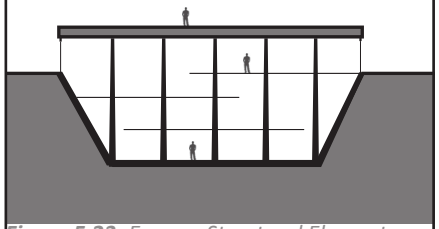
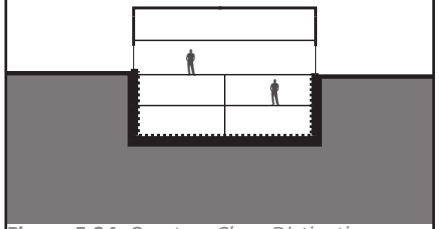
Issue	Objective	Solution	Diagram
Lack of visual connections.	Provide pronounced visual sightlines between above and below ground environments.	Use Apertures which are either *Stepped* or *Projected* to create distinct sightlines.	 ***Figure 5.14:*** *Pronounced Visual Connections*
Lack of orientation.	Create sightlines between significant interior spaces and important exterior landmarks to increase orientation within the building,	Use Apertures which are either *Stepped* or *Projected* to create distinct sightlines but orientate them towards significant exterior elements.	 ***Figure 5.15:*** *Sightlines Between Significant Interior Spaces and Important Exterior Landmarks.*
Lack of building permeability.	Allow the interior of the building to be experienced from its exterior ground plane by manipulating sightlines so that they extend to important interior spaces within the building.	Use *Open, Stepped* or *Projected Apertures* and situate them near significant areas of interior and exterior activity.	 ***Figure 5.16:*** *Building Experienced from the Ground Plane.*
Lack of extensive views.	Create extended views that penetrate through significant areas of the building to enhance orientation and confinement within deeper levels of the building.	Use a Spatial Structure that creates permeability within the building, such as a *Layered, Unified or Atrium Spatial Structure.* Extend these views further by making them visible from the building's exterior.	 ***Figure 5.17:*** *Extended Views.*

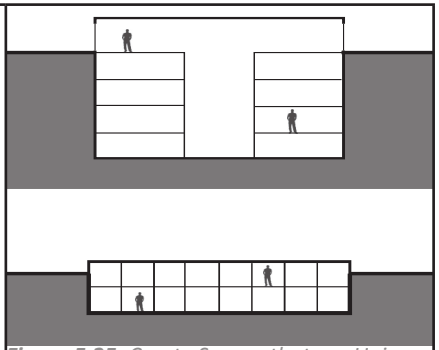
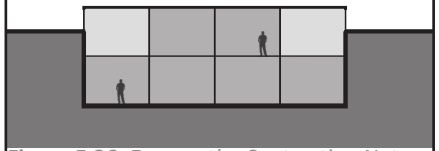
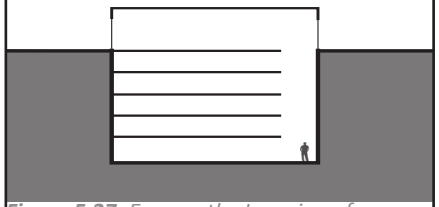
Natural Light:

Issue	Objective	Solution	Diagram
Lack of natural light.	Provide natural light wherever possible.	Use a *Submerged, Partially Submerged* or *Earth Covered Depth* to introduce natural light from ground level or above, maximising illumination. Use *Projected* or *Stepped Apertures* where above-ground activity allows. If above-ground space is restricted use a *Flat Aperture* as it offers the least disturbance at ground level.	 ***Figure 5.18:*** *Provide Natural Light wherever Possible.*
Natural light only received by levels closest to the ground plane.	Manipulate the extent of natural light so that illuminates deeper levels within the building.	Use an Aperture that captures the most light and a Spatial Structure that allows light to extend to the deeper levels within the building. This can be achieved through *Projected* or *Stepped Apertures* used with an *Atrium Spatial Structure*.	 ***Figure 5.19:*** *Manipulate Natural Light so that it Extends Deep within the Building.*

Lack of orientation and spatial hierarchy.	Manipulate natural light to increase orientation and to create a sense of spatial hierarchy.	Ensure that interior areas of significant activities and primary circulation routes use an Aperture so that they receive natural light. This can be achieved through an *Open, Flat, Inverted, Stepped* or *Projected Aperture.*	 **Figure 5.20:** *Manipulate Light to Increase Orientation and Spatial Hierarchy.*
Lack of stimulation.	Allow natural light to create a stimulating and dynamic interior environment by allowing the above-ground environment to influence the underground spaces atmosphere.	Use Apertures of a significant size so that the above-ground environment, such as people, weather and buildings influence the degree of natural light entering the underground space.	 **Figure 5.21:** *Allow Natural light to Create a Stimulating Interior Environment.*
Exterior to interior transition.	Reduce the transition from above-ground to below-ground by creating an entrance which is well illuminated.	Ensure that the entrance receives natural light by situating it at a *Partially Submerged* or *Earth Covered Depth,* and using an *Open, Flat, Stepped* or *Projected Aperture.*	 **Figure 5.22:** *Create a Well Illuminated Entrance.*

Spatial Image:

Issue	Objective	Solution	Diagram
Underground spaces require more vertical structure to support gravity loads.	Express the structural elements in a way which increases the sense of being underground and the forces that the building is withstanding.	Express the movement of gravity loads by tapering columns at the end closest to the ground. To express the nature of retaining earth use slopped exterior walls. Treat primary structure with the most importance by arranging interior spaces around such elements.	 ***Figure 5.23:*** *Express Structural Elements.*
Distinction between exterior and interior walls.	Create a clear distinction between exterior structural walls which are retaining earth and interior walls that create the Spatial Structure of the building.	Express the structural implications of underground retaining walls by exposing them in their true form, revealing their rawness. Expose the textured surface of the reinforced concrete; expose tie backs and structural ribs and any possible waterproofing.	 ***Figure 5.24:*** *Create a Clear Distinction Between Interior and Exterior Walls.*

Monotony of space.	Manipulate interior spaces to create spaces which are unique to the activities which occur in them.	To create areas with feelings of spaciousness use a unified or atrium spatial structure. To create spaces which have a profound sense of being underground situate buildings at a *Completely Submerged* or a *Submerged Depth* and use a *Cellular Spatial Structure* to increase confinement.	 ***Figure 5.25:*** *Create Spaces that are Unique to their Function.*
Clear distinction between inside and outside, light and dark.	Express the contrasting nature of illumination between above and below-ground to create a sense of being underground.	Use small Apertures sparingly so that some interior spaces have little illumination, enhancing the contrast with the exterior environment.	 ***Figure 5.26:*** *Express the Contrasting Nature of Illumination Between Above and Below-Ground.*
Layers of underground space.	Express the layering of elements within the building to enhance the feeling of being underground.	Express layering within the building through exposing horizontal building elements, such as floors and roofs and horizontal structural beams which retain the weight of the earth.	 ***Figure 5.27:*** *Express the Layering of Underground Space.*

5.3 DISCUSSION

The guidelines established in this chapter synthesize together the findings of the previous chapters to develop a framework which aids the design of successful underground buildings that establish strong connections between above below-ground. The guidelines focus mainly on the issues relevant to underground space and its relationship to the ground plane, and therefore are proposed as a set of guidelines which can be applied to a conventional building. However, what distinguishes these guidelines from conventional guidelines is the physical form which achieves them.

One of the most significant categories is Spatial Image, a category developed from the five underground archetypes, of which all express the unique nature of being underground, and therefore have little consideration to their above-ground environment. This category differs significantly from the categories developed from the taxonomy analysis; Building Exterior, Building Entrance, Interior Configuration, Vertical Configuration, Natural Light and Sightlines, which carefully consider the physical relationship between the underground building and its ground plane. The different considerations of underground space highlight the contrasting nature between categories. Therefore guidelines and objectives must be used and developed judiciously to ensure that the unique nature of the underground is retained, while simultaneously responding to the issues that arise from underground space.

The design case study will demonstrate how this balance can be achieved by selecting, developing, and then applying specific guidelines to meet the particular requirements of the site and programme.

CHAPTER SIX | SITE AND PROGRAMME ANALYSIS

6.0 INTRODUCTION

This chapter acts as a pre-design stage to the design case study, describing the site context and programme requirements. It is divided into five sections, with the first section introducing the chosen site. The second section presents the programme, an extension to the Wellington Museum of City and Sea. It discusses and analyses the rich history of the building and museum, and establishes the project brief along with the basic programmatic requirements of a museum. The third section presents the urban analysis of the site, Post Office Square, on both a macro and micro level, identifying the sites strengths and weaknesses. The fourth section presents the site specific framework, a set of principles derived from the urban analysis which the design case study must address. The fifth and final section summarises the findings of this chapter.

6.1 SITE ANALYSIS

The site chosen for the design case study is Post Office Square located in Wellington. The site was chosen as it:

- Exists currently as an underdeveloped open public space (Figure 6.0).
- Has the ability to re-establish the significant city to sea pedestrian link from Lambton Quay to Queens Wharf which is currently severed by the vehicle dominated Jervois Quay (Figure 6.1).
- Has the ability to create an underground network between the significant buildings that surround it. These being the Hotel Intercontinental, TSB Arena, Wellington of Museum City and Sea and The New Zealand Academy of Fine Arts.
- Is located in close proximity to both the city centre and waterfront pedestrian activity (Figure 6.2).

These specific site characteristics increase the feasibility of building underground, as it allows the design case study to respond to the urban design issues facing Post Office Square, and contribute to redeveloping it into a more successful open public space.

Figure 6.0: *Post Office Square*

Figure 6.1: *Looking from Post Office Square to Queens Wharf*

Figure 6.2: *Figure Ground Study.* *1:5000*

Description of Post Office Square:

Post Office Square (Figure 6.5) is essentially defined by roads that surround each side of its triangular shape, while the area itself is defined by the buildings which surround it. Much of Post Office Square is open space, with only a small kiosk, known as the Clarrie Gibbons building located in the centre (Figure 6.3). Some of the issues that affect the site at a macro scale include:

- There are no distinct boundaries between the open public space and the surrounding streets.
- As it is a highly conspicuous public space it is not exactly peaceful.
- The site is highly exposed to passing traffic on Jervois Quay.
- Only the short side of the square is activated by passing foot traffic moving from the city to the sea.
- The main period of activity occurs in the morning, with people preferring to walk the extra distance to the waterfront during their lunch break or after work (Figure 6.4).

These significant urban design issues means the space itself is largely under-utilised with it having no real identity.

Figure 6.3: *Clarrie Gibbons Building.*

Figure 6.4: *Food kiosks at Post Office Square.*

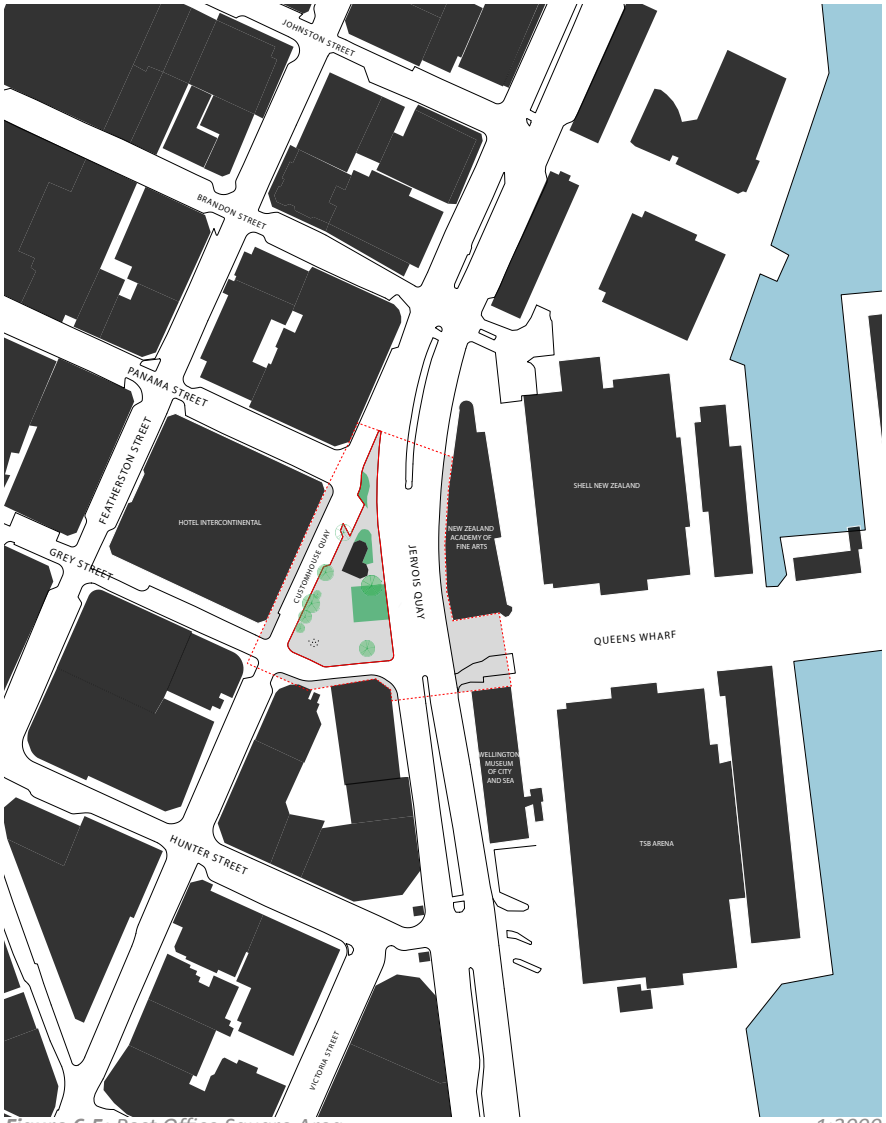


Figure 6.5: *Post Office Square Area.* *1:3000*

History of Post Office Square:

For over 100 years Post Office Square has been a significant open public space in Wellington. Located at the entrance of Queens Wharf and surrounded by important harbour board and commercial buildings, Post Office Square has been closely associated with the establishment of Wellington's historic waterfront (Wellington City Council, 2006). Its name comes from the former General Post Office building which was located across the road, at the site where the Hotel Intercontinental and IBM Tower now are sited (Figure 6.6).

The unique triangular formation of the space developed during the 1857-1863 reclamations of the waterfront, where the reclamation of land met the base of Queens Wharf. This reclamation of land not only formed Post Office Square but developed space for what is now known as Jervois Quay, as well as the land of the surrounding buildings, including the Bond Store and Harbour Board Offices (Figure 6.7).

Since its formation the site has only undergone only minor changes. A statue of Queen Victoria stood on the site for a short time during the years of 1906-1912 but was removed to give way to a new tram shelter, which is now known as the Clarrie Gibbons Diary. Although the surrounding buildings and landscape may have significantly changed, Post Office Square has 'maintained its basic configuration and essential characteristics' (Wellington City Council, 2006, p.14), seeing it still largely recognisable as the place it was 100 years ago (Figure 6.8). It is this unmodified status that sees Post Office Square have a high heritage value (Wellington City Council, 2006) as well as being a significant open space to many of Wellington's citizens.

Figure 6.6: *Post Office Square with the General Post Office Building to the left. 1940. (Source: Transpressnz, 1940)*

Figure 6.7: *Post Office Square located at the Intersection of Jervois Quay and Custom-house Quay. 1940. (Source: National Library NZ, 1940)*

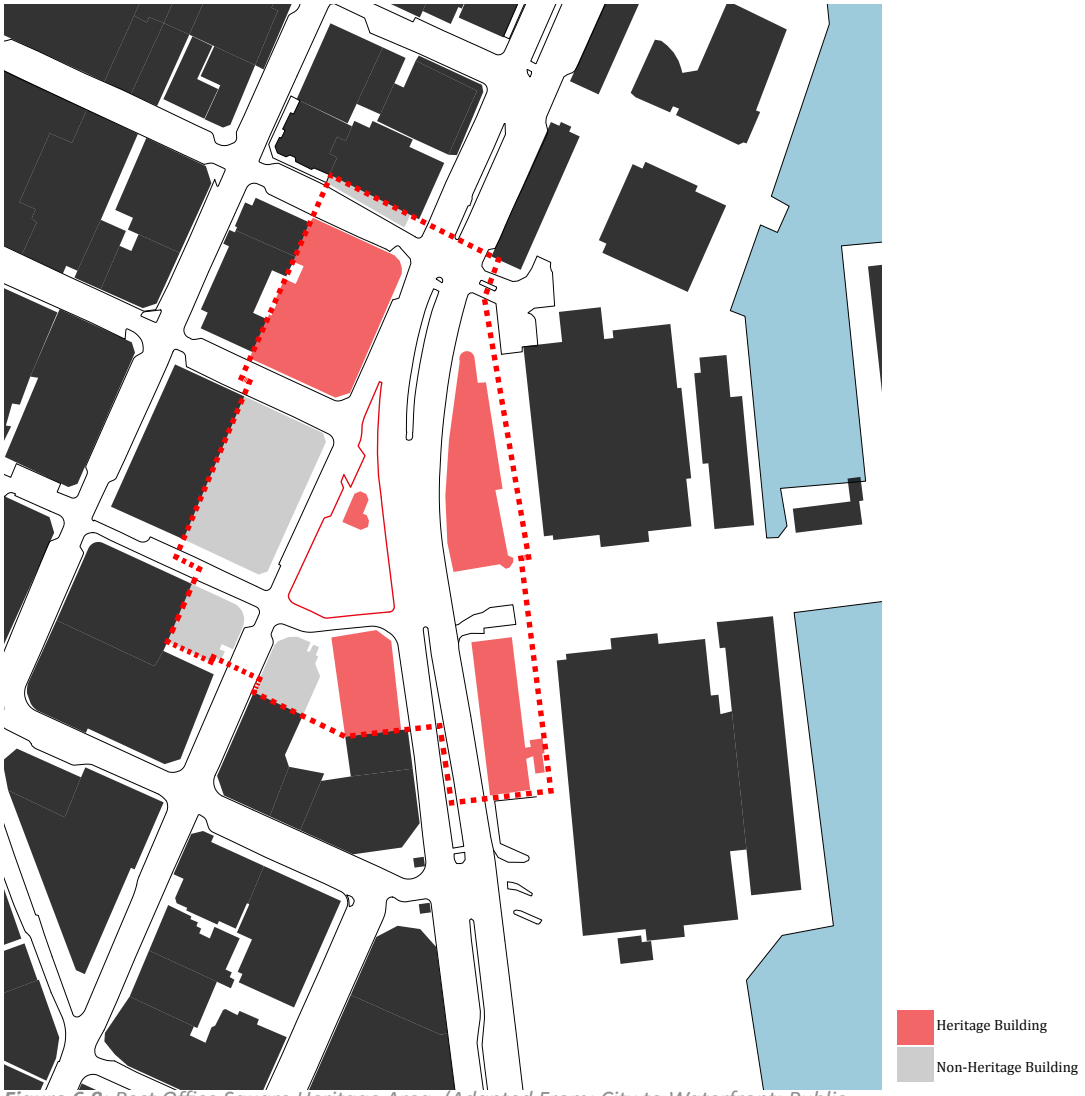


Figure 6.8: *Post Office Square Heritage Area. (Adapted From: City to Waterfront: Public Spaces and Public Life Study, 2004).*

1:5000

Reclamation of Land

1852-1876 Reclamations:

The first major Wellington Harbour reclamations (Figure 6.11) began in 1852 where brick sea walls, which run almost parallel to the original shoreline, reclaimed a significant portion of land now known as Wellington's Central Business District. During this period, Queens Wharf, the first deep-water wharf and pivot area of Wellingtons' export and import industry was also constructed (Figure 6.9). It is this reclamation that began to shape the distinct triangular shape of Post Office Square.

Figure 6.9: *Queens Wharf looking towards Post Office Square. 1863. (Source: Carter Observatory Archives, 1863)*

1886-1893 Reclamations:

Major reclamations south of Queens Wharf took place in 1886, reclaiming land now known as Te Aro (Figure 6.12). At the beginning of this period the outer "T" of Queens Wharf was expanded, allowing for more space for ships to birth (Figure 6.10). The 1893 reclamation of the inner Queens Wharf "T" completed the construction of Post Office Square land, while the 1889 reclamations created space for the surrounding Bond Store and Harbour Board buildings.

1901-1970 Reclamations:

Reclamations from 1901 onwards were the last in this area of the waterfront, shaping it to its current day formation (Figure 6.13). The once prosperous, but then under-utilised Queens Wharf was shortened during the 1967 reclamation of the middle "T", instead creating space for public building developments, such as the Event Centre, which sought to draw the public to the waterfront.

Figure 6.10: *Ships moored at Queens Wharf. 1887. (Source: Wellington City Archive, 1887)*

1852-1876 Reclamations

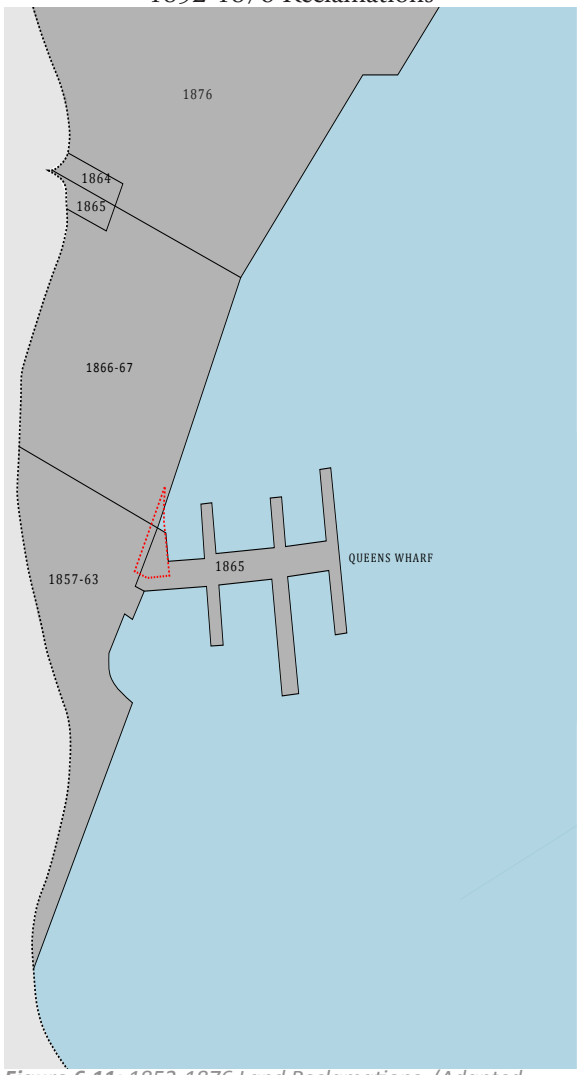


Figure 6.11: *1852-1876 Land Reclamations. (Adapted From: Fresh About the Cook Strait, 1984)*

1:6000

1886-1893 Reclamations

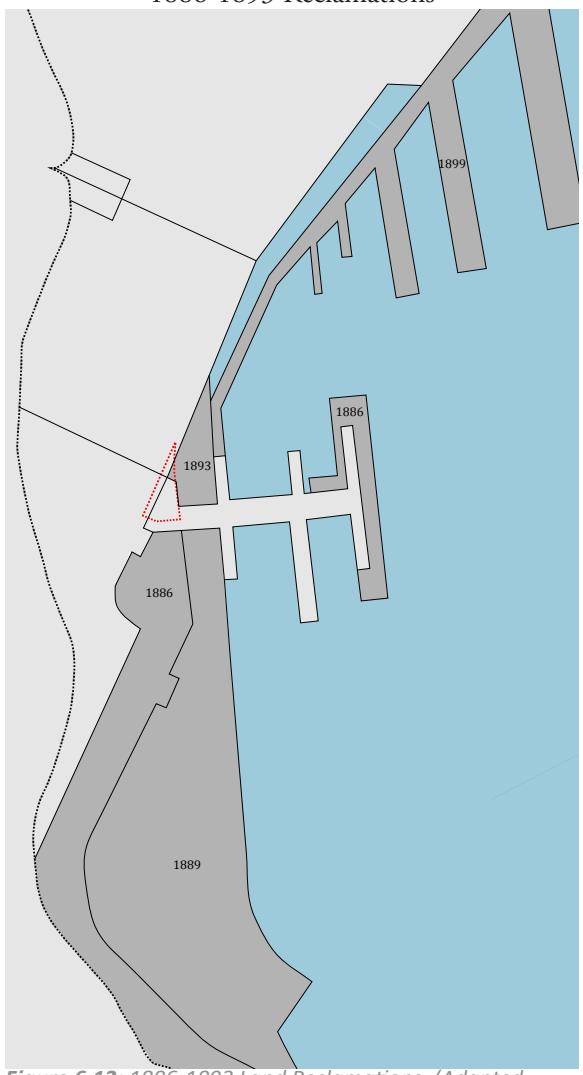


Figure 6.12: *1886-1893 Land Reclamations. (Adapted From: Fresh About the Cook Strait, 1984)*

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1901-1970 Reclamations

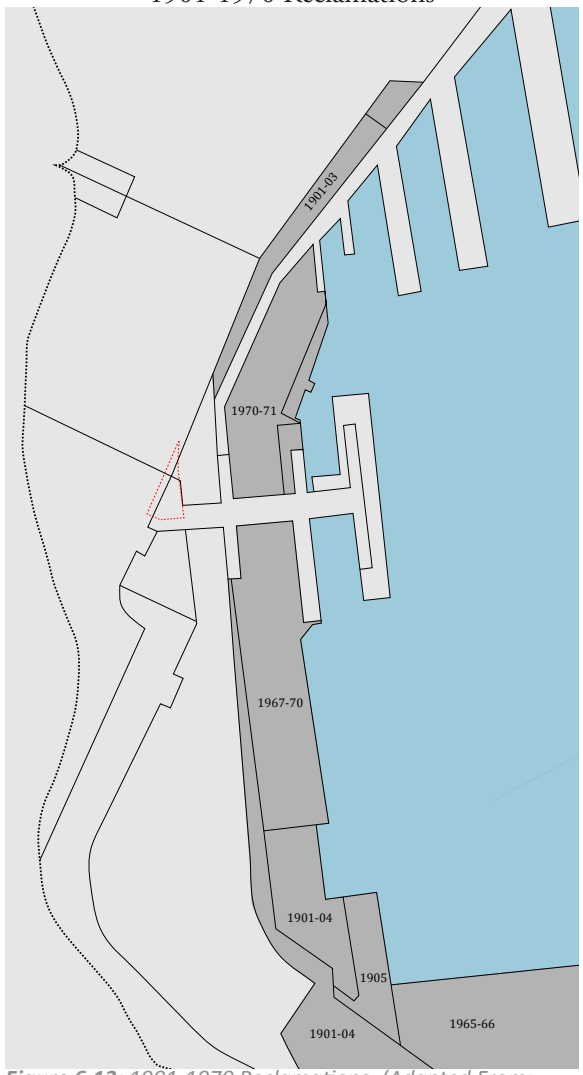

Figure 6.13: *1901-1970 Reclamations. (Adapted From: Fresh About the Cook Strait, 1984)*

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Wharf Structure:

As Post Office Square is located at the convergence point of where the reclaimed land of Wellington City met Queens Wharf, there is a significant amount of historic structure underneath the site (Figure 6.14). Two brick sea walls, constructed for the reclamation of land in 1863 and 1889 run vertically along the outer edges of Post Office Square, while three lines of timber piles constructed in 1862 and 1878, which form the structure of Queens Wharf Harbour run horizontally through the site, with pile intervals of 3 metres.

Figure 6.14: *Wellington Harbour Wharf Structure. (Adapted From: Fresh About the Cook Strait, 1984)*

1:5000

Wellington 2040:

Released in June 2011 by Wellington City Council, the Wellington 2040 project focuses on the development of Wellington over the next 30 years. It presents a vision to build on Wellingtons 'existing strengths – such as its natural beauty, vibrancy, compactness, close-knit communities and great people – while raising the bar higher'. A significant part of the plan identifies triangular spaces within the city as important green spaces, one of which spaces is Post Office Square.

Triangular spaces are a reminder of the history of the city, as they are created through the intersection of the structured city grid with the shoreline. Not only do they represent how the city has changed over time but they also create pedestrian friendly spaces that offer wide views, multiple access points, and enhance legibility around the city.

Wellington 2040 plan outlines drivers towards creating Post Office Square as a more successful open public space (Figure 6.15). The drivers seek to 'improve connections to the waterfront and other civic spaces, create more quality cultural and performance spaces, and revitalise parts of the city (Wellington City Council, 2011, p.129). These drivers include:

- Improving the physical connection between waterfront and CBD.
- Enhancing sightlines from Post Office Square to Queens Wharf.
- Redeveloping the existing kiosk building to make it more sheltered.
- Creating a more defined and enclosed public space by creating a buffer zone between the site and traffic intensive Jervois Quay.

1. Unified design of street furniture, including, street lights, bollards, bins, post box, telephone box, signage.
2. Incorporate cafe in renovated historic building including the addition of contemporary canopy structure.
3. Remove free standing kiosk (obstructs sight lines).
4. Remove raised planter beds, extend paving to street edge.
5. Extend paving to Grey Street as share way.
6. Paved Jervois Quay crossing.
7. Unify tree planting to Post Office Square including new trees to line Jervois Quay.

Figure 6.15: *Wellington 2040 Proposed Plan. (Source: Wellington 2040, 2011)*

City to Sea Urban Section:

Queens Wharf Harbour once has a seamless connection to the shore, creating a fluid connection from city to sea. However, with the construction of the TSB Arena a partially submerged basement was constructed a the base of Queens Wharf creating a subtle incline from Post Office Square to the top of the Queens Wharf public plaza Figure 6.16 and Figure 6.17). This incline, although subtle, further disconnects the city to the sea. Possible site lines are obstructed and the transition from the city to the sea, or vice versa, is made more apparent through the sense of inclining and declining as you move across the space.

Figure 6.16: *Section cut.* *1:5000*

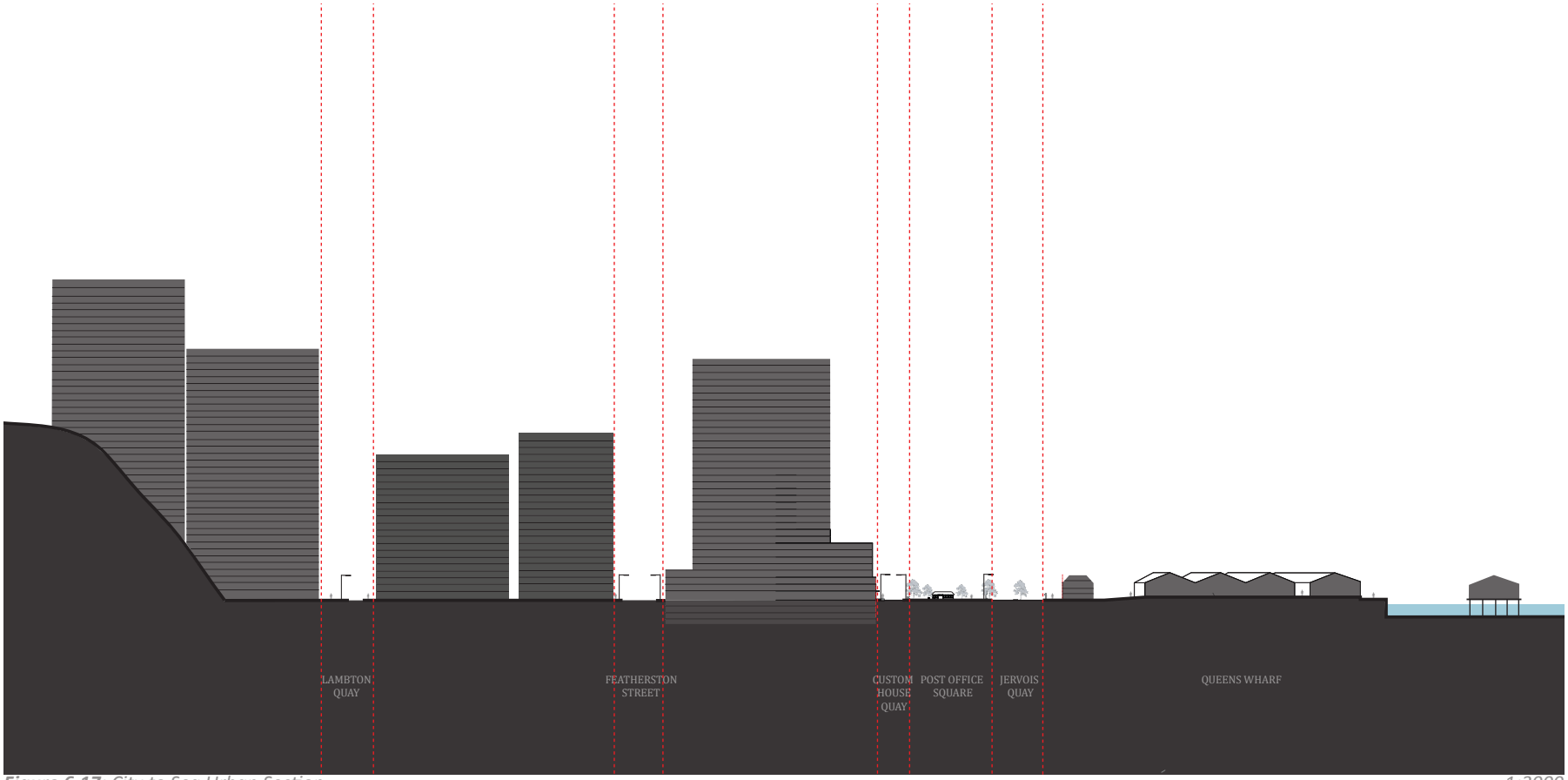


Figure 6.17: *City to Sea Urban Section.* *1:3000*

6.2 URBAN ANALYSIS

Pedestrian Movement:

As identified by the site analysis (Figure 6.21) the majority of pedestrian movement from city to sea occurs along Grey Street, from Lambton Quay to Queens Wharf and through Civic Square, from Willis Street to the Lagoon. The City to Sea Bridge maintains this large pedestrian movement across Civic Square through an elevated crossing, connecting the Main pedestrian routes with the recreational route that exists along the waterfront. The pedestrian route along Grey Street (Figure 6.18) however, is severed by Jervois Quay, disconnecting the significant city to sea pedestrian connection. It is important to note that although the side streets between Lambton Quay and Jervois Quay have low volumes of pedestrian traffic they are still seen as important city-to-waterfront connectors.

Figure 6.18: *Grey Street*

Figure 6.19: *Jervois Quay*

Road Hierarchy:

As identified by the site analysis (Figure 6.22) the high vehicle flow along Jervois Quay creates a distinct separation between Wellingtons Central Business District and the waterfront. It is this six lane vehicle orientated Quay (Figure 6.19) that severs connections from the city to the sea.

Public Space:

Post Office Square, Illiot green and Civic Square are all key open spaces adjacent to the Waterfront but directly disconnected by Jervois Quay (Figure 6.23). Each open space provides areas for different activities, with Post Office Square (Figure 6.20) being primarily a hard space utilised the most during the morning.

Figure 6.20: *Post Office Square Open Space*

Pedestrian Movement

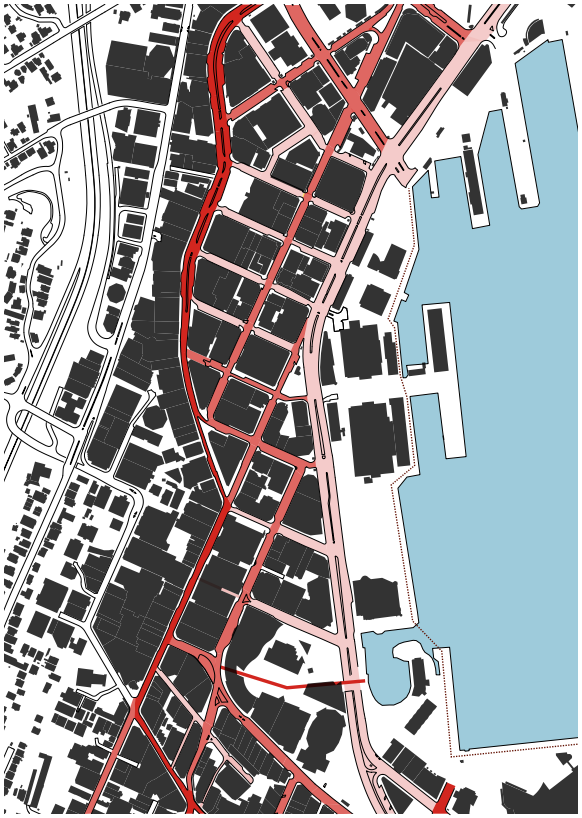


Figure 6.21: *Pedestrian Movement (Adapted From: City to Waterfront: Public Spaces and Public Life Study, 2004).*

1:6000

Vehicle Movement

Figure 6.22: *Vehicle Movement (Adapted From: City to Waterfront: Public Spaces and Public Life Study, 2004).*

1:6000

Public Space

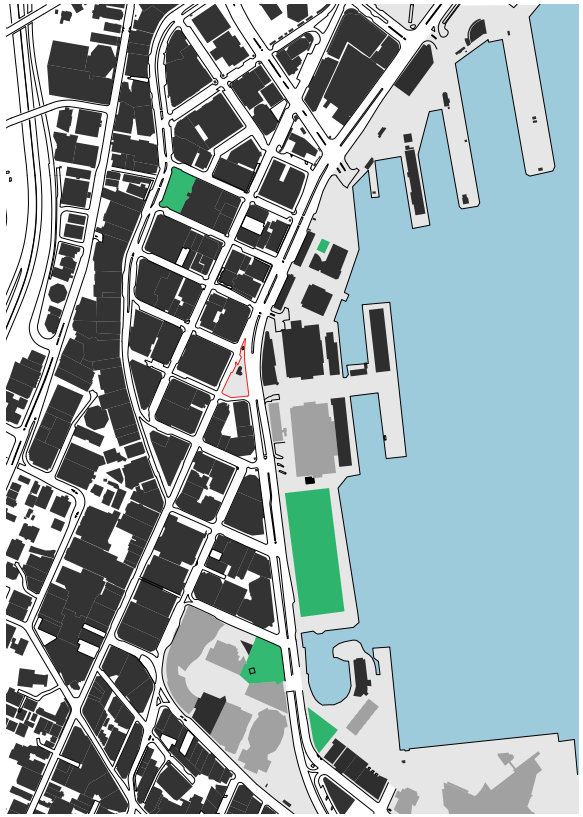


Figure 6.23: *Public Spaces.*

1:6000

Current City to Waterfront Pedestrian Access Routes:

The most significant pedestrian crossing from city to sea is the elevated crossing known as the City to Sea Bridge located at the most southern end of Jervois Quay (Figure 6.27). Although another elevated crossing is located nearby it is not as nearly as successful. All other crossings are located at ground level (Figure 6.24) and are interrupted by the vehicle oriented Jervois Quay making pedestrian movement second over vehicles and seeing no significant crossing located at the northern end of Jervois Quay.

Figure 6.24: *Jervois Quay Pedestrian Crossing*

Historic View Shafts:

The two view shafts significant to Post Office Square are located along Panama Street and Grey Street (Figure 6.28). Both view shafts are elevated significantly above Lambton Quay, and therefore can only be experienced looking down from the Terrace or taller buildings.

The focal points of Panama Street View Shaft (Figure 6.25) are the Old Harbour Board Building, the inner harbour and at a distance Oriental Bay. The focal elements of Grey Streets View Shaft (Figure 6.26) are the Wellington Harbour Board offices the inner harbour and at a distance Oriental Bay.

One of the issues that arise from these view shafts are that they are often tapered, with their wider end at the waterfront. This means they do not conform exactly to the geometry of the street grid, and tend to produce wider than street widths, open spaces along the waterfront.

Figure 6.25: *Panama Street View Shaft. (Adapted From: Central Area Urban Design Guide, 2006)*

Figure 6.26: *Grey Street View Shaft. (Adapted From: Central Area Urban Design Guide, 2006)*

City to Sea Pedestrian Crossings

Elevated Pedestrian Crossing

Level Pedestrian Crossing

Figure 6.27: *City to Sea Pedestrian Connections.*

1:6000

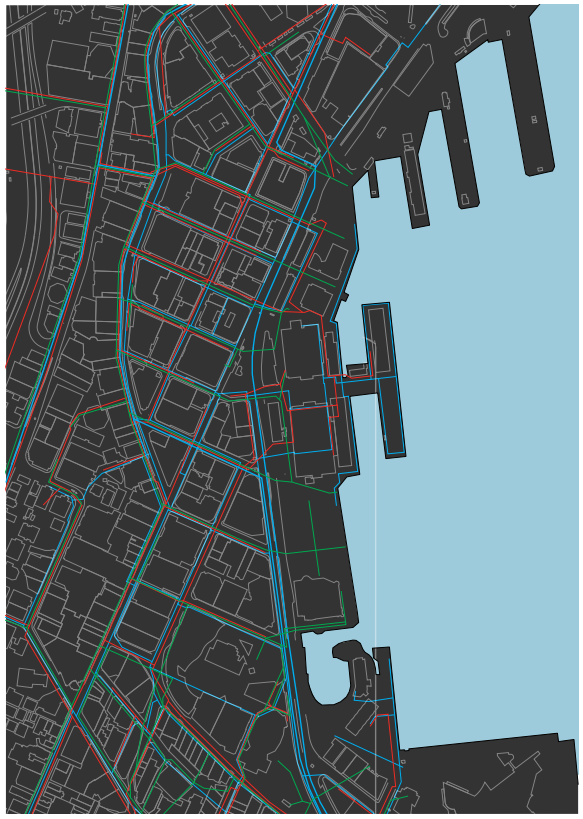
View Shafts

View Shaft

Figure 6.28: *View Shafts. (Adapted From: Central Area Urban Design Guide, 2006)*

1:6000

Underground Pipe Network



Water Network Pipes

Stormwater Network Pipes

Sewer Network Pipes

Building Footprints

Figure 6.29: *Underground Pipe Network. (Adapted From: Wellington City Council Web Map: Drainage Information,2011)*

1:6000

6.3 PROGRAMME ANALYSIS

The design case study called for a public programme to ensure activity that sustained the vitality of both the above and below ground environment however, with respect to the sites size and location, the feasibility of a large public programme was dismissed. However, with Wellington's Museum of City and Sea (Figure 6.30) located across the road and requiring more exhibition and storage space the programme proposes itself as an extension to this significant museum.

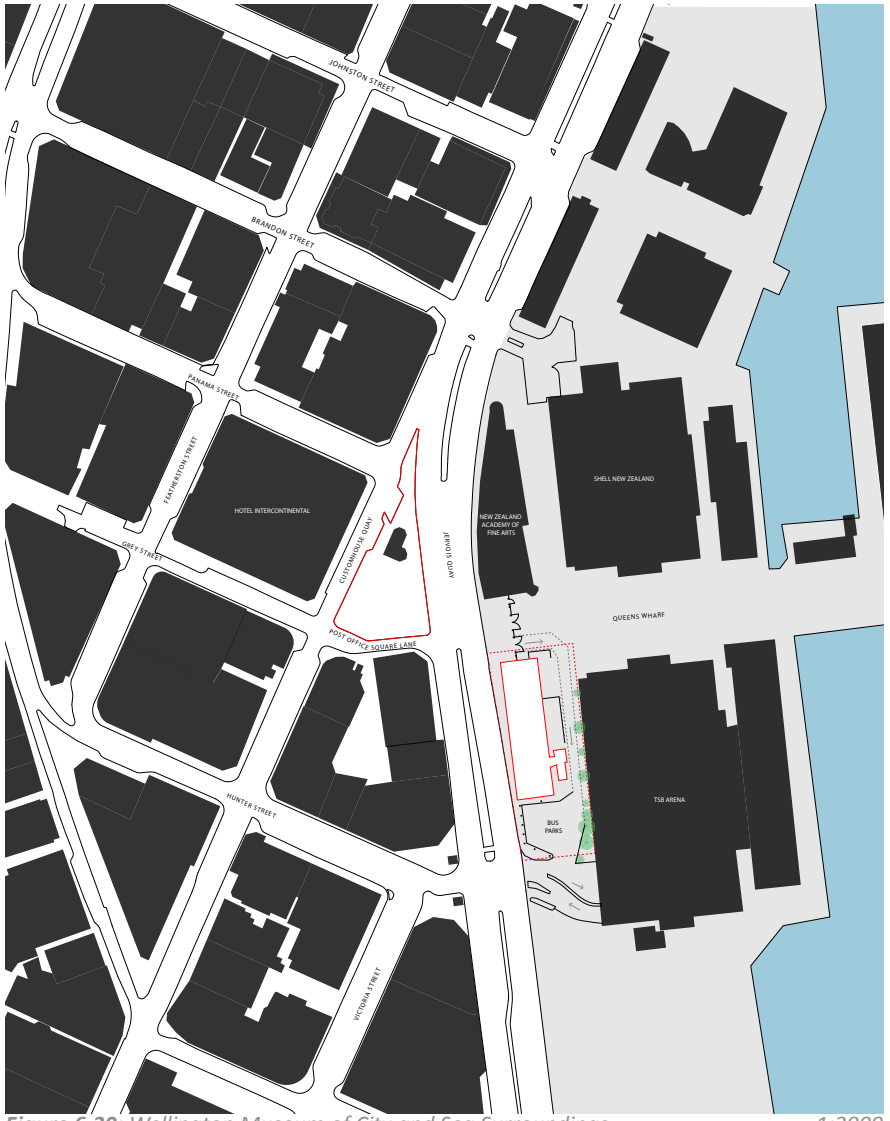


Figure 6.30: *Wellington Museum of City and Sea Surroundings.* *.1:3000*

History of the Bond Store:

The Wellington City and Sea museum , formerly known as the Bond Store is the second oldest building on the Wellington Waterfront. Designed by the architect Frederick de Jersey Clere and constructed in 1892 for the Wellington Harbour Board, the new head quarters contained offices and a large bonded warehouse. Situated at the entrance of one of Wellington's most prosperous wharfs of the time, Queens Wharf, the building became an icon, demonstrating the ever increasing importance of the shipping industry to the vitality of Wellington. Within it, the warehouse stored 'goods that required payment before they were released to the importer' (Morrow, 2000, p.4) while the board rooms and offices 'formulated and administered policies which shaped the character of the harbour and city' (Morrow, 2000, p.4).

As the method of shipping and handling cargo changed in the mid 1960's, the Bond Store and Wellington's inner harbour were no longer the centre of

shipping activity. Slowly offices became empty and by the 1970's the building was completely abandoned. At this juncture the Harbour Board decided to convert the warehouse portion of the building into a small museum, housing artefacts collected during the thriving shipping years. In 1972 the museum officially became The Wellington Harbour Board Maritime Museum, developing a strong presence within Wellington during its 20 years.

History of the Museum of Wellington City and Sea:

The opening of New Zealand's National Museum Te Papa on Wellington's waterfront saw a rise in civic pride, establishing the capital as a culturally unique and distinctive city. Therefore it was serendipitous and timely to expand the Wellington Harbour Museum to one that also displayed the cultural and social pride of the Wellington region. The Wellington based firm, Athfield Architects, were commissioned to restore and museum back to its former building. After undergoing extensive earthquake strengthening and conservation, The Museum of Wellington City and Sea was officially opened in 1999.

The Museum of Wellington City and Sea (Figure 6.31) strives to 'preserve, present and promote' (Morrow, 2000, p.31) Wellingtons' heritage and future, seeing the Bond Store as the perfect setting. The rich history of the Bond Store and the city combine to create a detailed account of Wellington City. Through following the buildings ever evolving context over its lifetime an 'insight into the trends and transitions, cultural and commercial developments which forged and defined the capital' (Morrow, 2000, p.4) is offered. The

Figure 6.31: *Exterior of the Bond Store.*

Figure 6.32: *Historic Bond Store Entrance.*

building and its programme therefore not only tell of the story between city and building but also the 'story between maritime and social history, between geography and commerce, the imperatives of profit and the needs of people (Morrow, 2000, p.32)'.

Figure 6.33: *Wellington Museum of City and Sea Entrance.*

Figure 6.34: *Wellington Museum of City and Sea Exhibition Space. (Source: Wellington Museum of City and Sea, 2009).*

Current Programme:

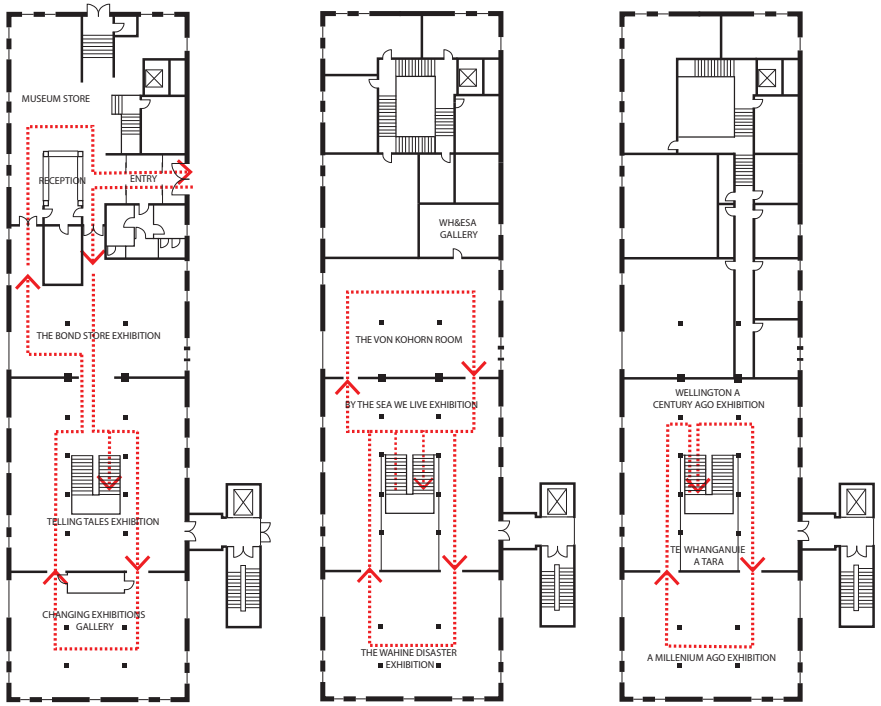
The Museum of Wellington City and Sea exhibition spaces are currently split across three levels (Figure 6.35), each level telling a unique story about Wellington. The first floor exhibits Wellington 20th century history, exploring its significance as a city today. The second floor exhibits Wellington's maritime history, telling the story of Wellington's close connection to the harbour. The third floor exhibits Wellington's early history, documenting how Wellington has changed since its foundation from early Maori and European settlement. A large screen extends between these floors (Figure 6.34), screening films about early Wellington. Offices for staff, curators, Museum Wellington staff and public and private meeting and function rooms are located on the upper two levels, while the ground level houses the museum shop, entrance, reception and service entrance.

Figure 6.35: *Wellington Museum of City and Sea Interior Spaces.* *1:400*

Museum Circulation:

This layout of the museum (Figure 6.36) sees visitors recall the history of Wellington as they circulate through the exhibition spaces, where each level speaks of important events that have shaped Wellington. Visitors are first presented with Wellington as it is today, and by ascending through the three levels of the buildings interactive exhibits, various forms of media, whether it is visual, audio or interaction, reveal the history of Wellington.

The circulation through the museum spaces occurs as a loop on each floor where the main staircase acts as the both the beginning and end of that loop, increasing orientation within the building. This sees circulation through the building act as a timeline, where each ascent goes travels back in time, revealing Wellington's earlier history.



Ground Floor
Wellington's 20th Century

First Floor
Wellington's Maritime History

Second Floor
Wellington's Early History

Figure 6.36: *Wellington Museum of City and Sea Current Circulation Path.* *1:400*

Museum Visibility:

The museum currently suffers from a lack of visibility (Figure 6.37) as the entrance to the museum is located along the Eastern side of the building and not from the Northern 'front' door of the Bond Store. Although the building itself is highly visible, it is offers few views into the interior, meaning the museum programme is largely visually inaccessible.

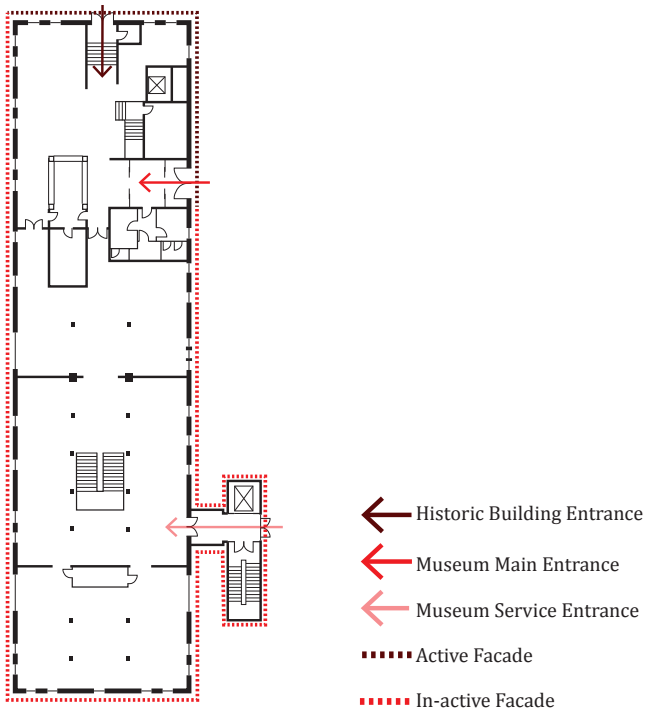


Figure 6.37: *Wellington Museum of City and Sea Exterior Facade Activity.* *1:400*

Programme Requirements:

Currently the museum suffers from a lack of exhibition and storage space as it is strictly bound by the historic building it is housed in, and therefore cannot expand on its current site. Much of Wellington's history is archived or in stored off site as the museum does not have the appropriate facilities or spaces to store and exhibit such significant historic material. This lack of exhibition and storage space means that much of Wellington's historic material is not accessible to the public, limiting public knowledge of Wellington's rich history. The design brief of the museum extension seeks to provide this necessary exhibition and storage space all on one site, so to act as a central building of Wellington's history.

The extension design brief recognises the interactive nature of the existing museum and seeks to display the diverse range of archived material, ranging from old movies, historic photos, and old Harbour Board records in their various forms. Therefore the exhibition spaces become tailored in response to the type of media they are displaying, allowing previous archived information to become accessible to the public.

Aim of the Programme Extension:

- Increase museum visibility from Queens Wharf.
- Provide exhibition space that is tailored specifically to the material it is displaying.
- Provide storage, archival and workshop space to allow for the curation of exhibits on site.
- Provide diverse spaces which can be used for non-related museum use, such as function rooms and meeting rooms which can be hired.
- Ensure the museum is supported by other amenities such as cafes and shops to increase activity.
- Continue and enhance the interactive nature of the existing museum.

Design Brief:	**Approximate Size:**
Exhibition Spaces:	
▪ Photography Exhibition Space	200m^2
▪ Public Library	150m^2
▪ Flexible Exhibition Space	100m^2
▪ Plimmers Ark Exhibition Space	200m^2
▪ Flexible Meeting Rooms/ Function Rooms	80m^2
Curator Spaces:	
▪ Curator Workshop	150m^2
▪ Dark Room/ Photography Studio	25m^2
▪ Storage Room	250m^2
▪ Goods Lift	6m^2
Staff Spaces:	
▪ Staff Offices	60m^2
▪ Staff Breakout Area	40m^2
▪ Staff Toilets	25m^2

Amenities:

- Cafe 40 m^2
- Museum Shop 30 m^2
- Retail Shops 25 m^2 Each
- Toilets 50 m^2
- Disabled Toilets 10 m^2

6.4 SITE SPECIFIC FRAMEWORK

As Post Office Square is currently an under-utilised site which lacks some of the basic urban design principles in ensuring successful public spaces, it is important that the design case study address these issues and seeks to rectify them. Through macro and micro site analysis, as well as acknowledging the Wellington 2040 vision for Post Office Square, the following site specific framework has been established.

Pedestrian Movement

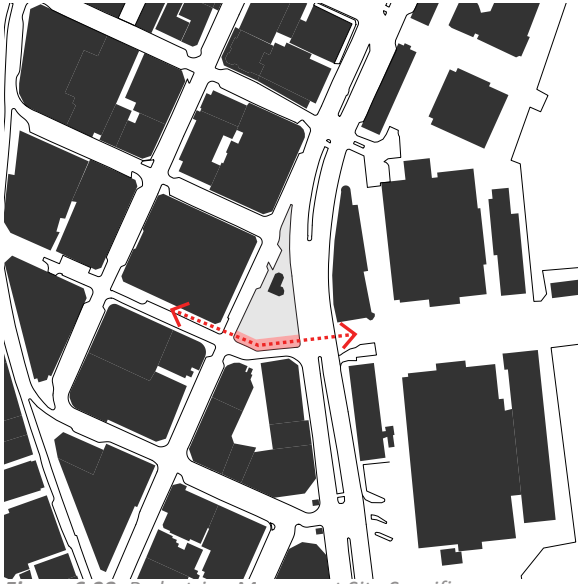


Figure 6.38: *Pedestrian Movement Site Specific Framework.*

Retain and improve the current city to sea pedestrian movement path on the southern end of the site by defining the procession towards Queens Wharf to ensure a continuous link along Grey Street to the harbour.

Vehicle Movement

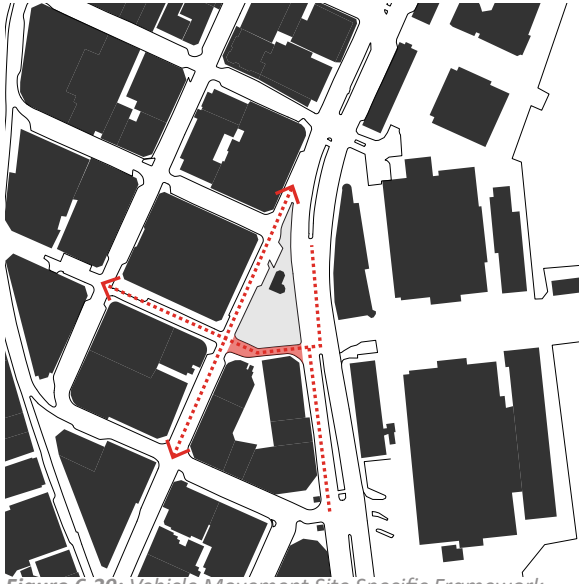


Figure 6.39: *Vehicle Movement Site Specific Framework.*

Retain existing vehicle movement along the southern end of the site to retain wider traffic circulation patterns around the site, but develop this lane into a shared space between pedestrians and vehicle to minimise the impact of vehicle movement along this edge of the site.

Entrance Node

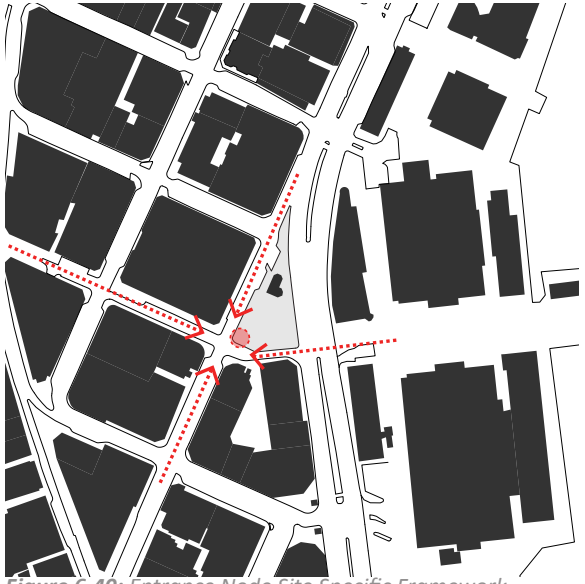


Figure 6.40: *Entrance Node Site Specific Framework.*

Locate the entrance node as the convergence point of the surrounding streets to enhance activity along the major pedestrian movement channel, ensuring easy access to the underground building.

Building Alignment

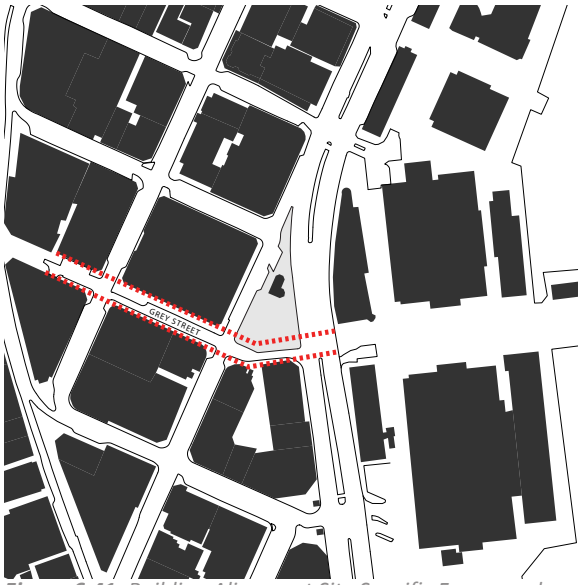


Figure 6.41: Building Alignment Site Specific Framework.

Ensure the building frontage aligns with Grey Street to create a continuous connection to the adjoining street yet maintain the historic bend in the site that signifies where the city street grid and waterfront grid met.

Site Access

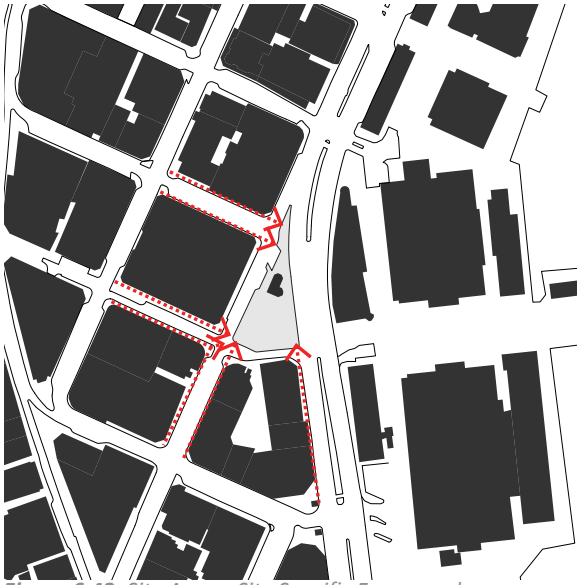


Figure 6.42: Site Access Site Specific Framework.

Retain the current pedestrian access along the western and southern edges of the site to ensure easy access from surrounding footpaths to the open public space.

View Shafts

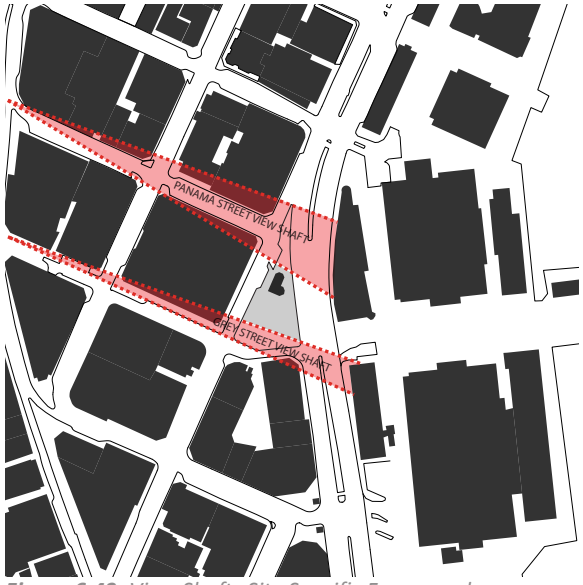


Figure 6.43: View Shafts Site Specific Framework.

Ensure the building does not significantly impact or alter the Grey Street or Panama Street historic view shafts that run from Lambton Quay to the waterfront.

Definition of Space

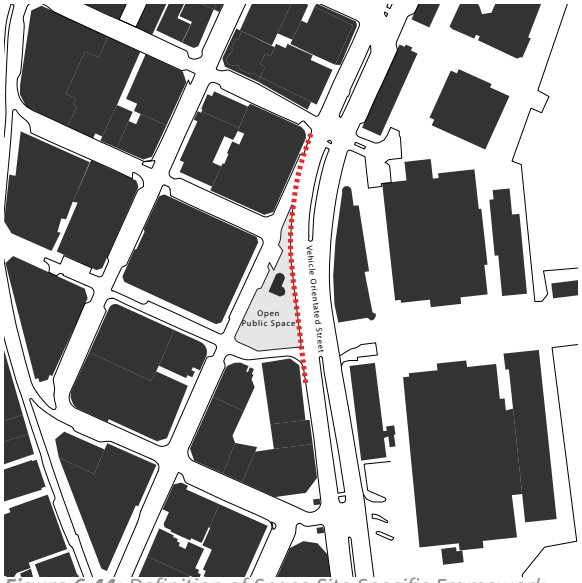


Figure 6.44: *Definition of Space Site Specific Framework.*

Create a clear distinction between the open public space and Jervois Quay to see it act as a buffer zone or threshold in order to create public space that is sheltered from the adjacent vehicle movement.

Underground Pedestrian Network

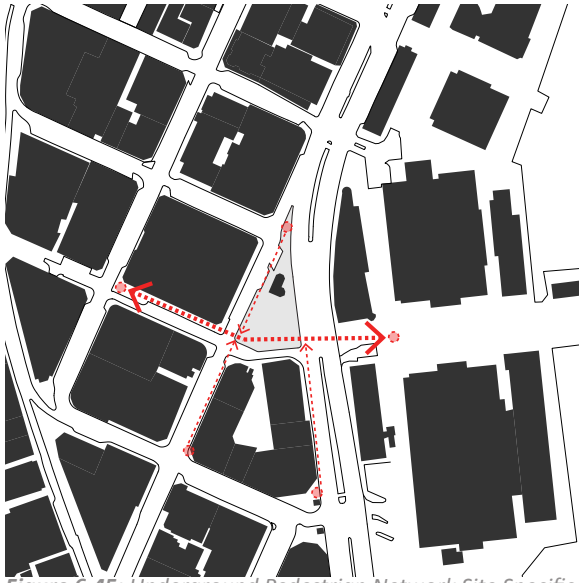


Figure 6.45: *Underground Pedestrian Network Site Specific Framework.*

Ensure the primary underground movement runs from city to the sea, bridging the gap created by Jervois Quay. Secondary movement routes linking northern and southern routes should also connect to this underground pedestrian network.

Connection between Existing and New

Figure 6.46: *Connection between Existing and New Site Specific Framework.*

Ensure the connection between existing museum and extension is visible as to increase the visual presence of the Museum on the waterfront, yet create a connection that is respectful of the Category One Historic Bond Store Building.
Ensure a direct pedestrian connection between this combined waterfront entrance and the Post Office Square entrance.

6.5 SUMMARY

This chapter presented an analysis of the site, Post Office Square, and the programme, and extension of Wellington's Museum of City and Sea. The programme analysis identified that the museum suffers from a lack of exhibition and storage space as it is strictly bound by the building it is housed in, and therefore cannot expand in its current configuration. Through macro and micro urban analysis of Post Office Square a site specific framework was developed. From this site specific framework, appropriate underground space guidelines will be selected and applied, developing the initial formation of the site specific design framework which seeks to resolve the current urban design issues of Post Office Square.

CHAPTER SEVEN | DESIGN CASE STUDY

7.0 INTRODUCTION

This chapter presents the design case study, demonstrating how the underground space framework established in chapter five can be developed and applied to aid the successful creation of underground buildings through creating strong connections between above and below-ground environments. As well as demonstrating the underground framework the design case study also acts as a base to test and refine the framework. The design consists of two sets of elements, firstly the space components which respond to the issues in the site specific design framework and secondly the major design generators which are responses to the underground design guidelines.

The chapter is divided into five sections. The first section establishes the role of design within this thesis. The second section discusses role of the site specific framework, established in chapter six, within the design case study. The third section discusses the space components of the design case study with respect to the issues identified in the site specific framework in chapter six. The fourth section addresses the main design generators within the building with response to the underground design guidelines. It is important to note that the concepts of the building have been divided into three discrete sections for clarity purposes, where within the building many of the ideas are integrated and the design is determined by the way the concepts interact. The chapter concludes with the design discussion and evaluation of the design case study.

7.1 ROLE OF DESIGN

The role of this design case study is to demonstrate how the guidelines presented in the underground space framework can be applied. These guidelines were developed from the relationship between above and below-ground space identified in the previous chapters. The guidelines underpin the successful design of underground space through creating strong connections between above and below-ground environments.

The design case study selects appropriate guidelines in response to the site specific framework established in chapter four, including the site and programme analysis. The guidelines are then developed and applied to meet the specific requirements of the site and programme. The design case study also allows the guidelines to be evaluated, refined and in some cases augmented with new guidelines.

The guidelines chosen for the design case study are site specific. Each unique site and programme will require different guidelines to be selected, and will require guidelines to be interpreted differently.

7.2 SITE SPECIFIC DESIGN FRAMEWORK

This section discusses the underground space guidelines selected in response to the site specific framework identified in the previous chapter and identifies key design responses. The table below identifies the site specific objective and its selected underground design guideline, developing the initial formation of the site specific design framework.

	Site Specific Framework	Site Specific Objective	Selected Underground Design Guideline
1.	Pedestrian and vehicle movement	Retain and improve the current city to sea pedestrian and vehicle movement path on the southern end of the site.	Articulate the buildings boundaries and edges above-ground, to create an above-ground space which is distinct from its surroundings.
2.	View Shaft	Ensure the building does not significantly impact or alter the Grey Street or Panama Street historic view shafts that run from Lambton Quay to the waterfront.	Articulate the buildings boundaries and edges above-ground, to create an above-ground space which is distinct from its surroundings.
3.	Building Alignment	Ensure the building frontage aligns with Grey Street to create a continuous connection to the adjoining street yet maintain the historic bend in the site.	Articulate the buildings mass and expose architectural elements so that the building is easily recognisable at ground level.
4.	Entrance node	Locate the entrance node as the convergence point of the surrounding streets to enhance activity along the major pedestrian movement channel.	Create distinguishable entrances at ground level as to enhance the image of the building and to ease the transition into it.
5.	Site Access	Retain the current pedestrian access along the western and southern edges of the site to ensure easy access from surrounding footpaths to the open public space.	Ensure the building has an inhabitable ground plane or roof so that a diverse range of activities can occur, sustaining life at this level.

6.	Definition of Space	Create a clear distinction between the open public space and Jervois Quay to see it act as a buffer zone or threshold.	Articulate the buildings boundaries and edges above-ground, to create a sense of spatial enclosure at ground level while also suggesting a sense of scale and shape of the underground building
7.	Underground Pedestrian Network	Ensure the primary underground movement runs from city to the sea, bridging the gap created by Jervois Quay. Secondary movement routes linking northern and southern routes should also connect to this underground pedestrian network.	Integrate the building both above and below-ground with its surrounding urban fabric.
8.	Connection between Extension and Existing Museum	Ensure the connection between existing museum and extension is visible as to increase the visual presence of the Museum on the waterfront.	When connecting to surrounding buildings create distinct connections and entrances that enhance the transition between underground buildings.
9.	Retail Frontage	Ensure retail frontage faces the main pedestrian channel; to not only create a continuation of Grey Street but to also ensure activity both within the building and along the street.	Articulate the buildings mass so that the building is easily recognisable at ground level.

A series of cardboard models (Figure 7.0 and Figure 7.1) were initially created to explore the architectural response to the Site Specific Design Framework. These models explored the various options of manipulating the ground plane to generate the building mass. Slices along significant edges of the site, such as Post Office Square Lane, Customhouse Quay and Panama Street View Shafts were created, and the ground plane was either extruded or pushed in response to the aim of the guidelines.

These models established the initial formation of the building, but were further developed in response to the interior programme (Figure 7.2 and Figure 7.3). From this early testing and through further development, the exterior form of the building emerged as a manipulation of the ground plane, where numerous extrusions and depressions in response to the site, create a formation that blurs the boundaries between interior and exterior, above and below-ground space.

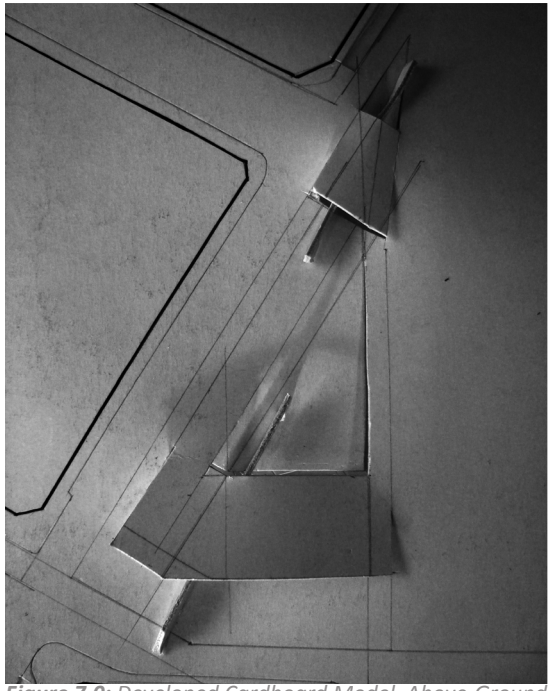


Figure 7.0: *Developed Cardboard Model, Above-Ground.*

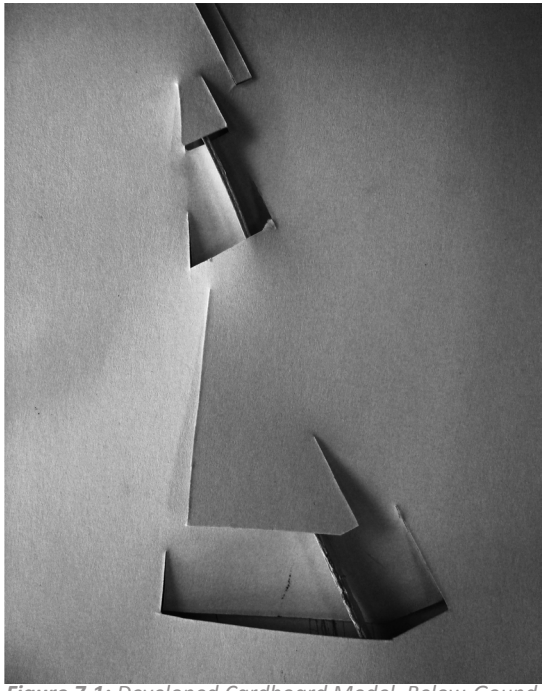


Figure 7.1: *Developed Cardboard Model, Below-Gound.*

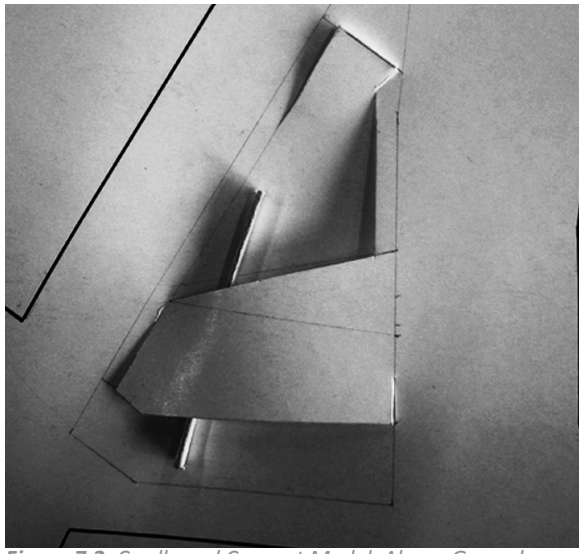


Figure 7.2: *Cardboard Concept Model, Above-Ground.*

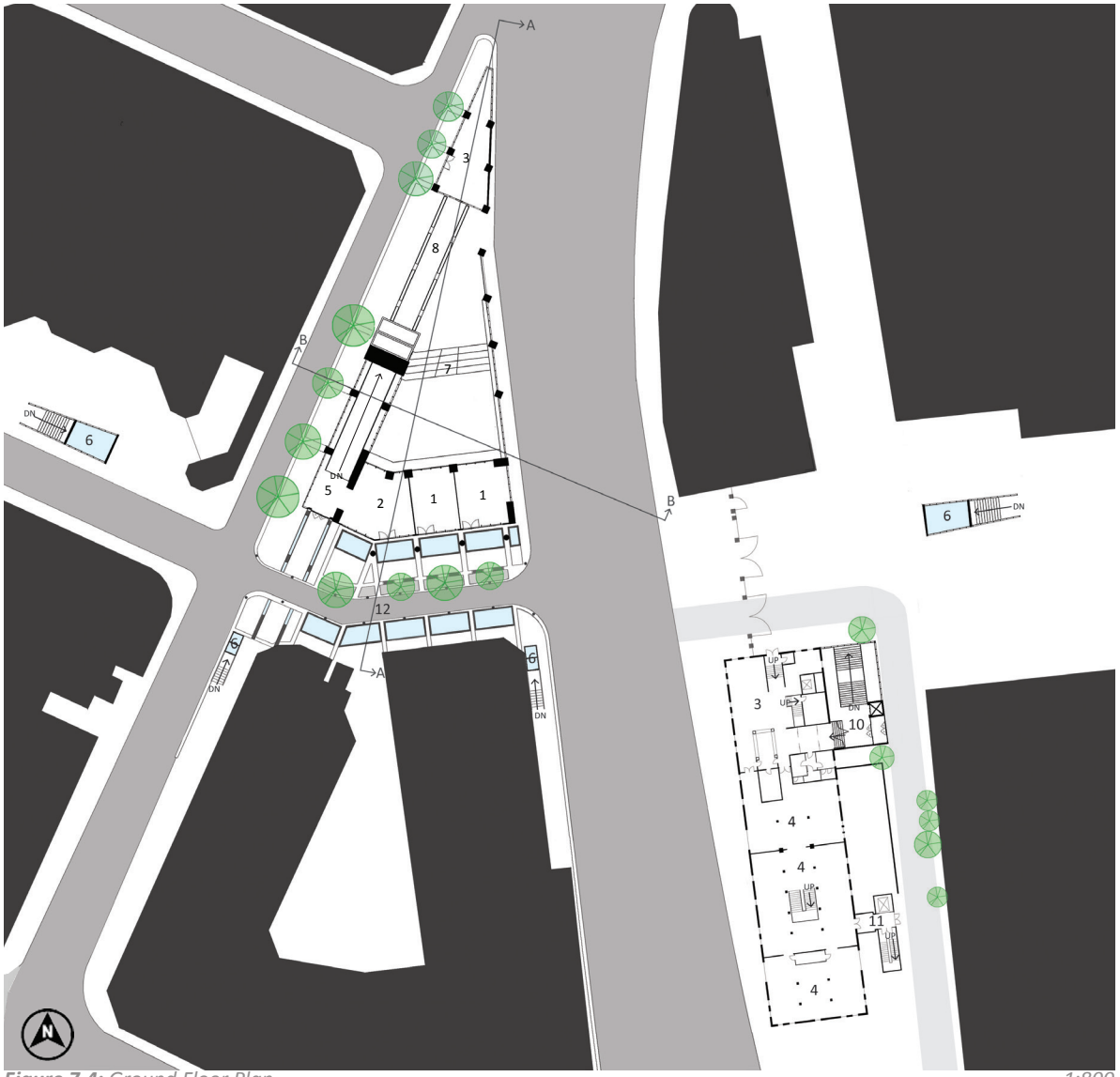
Figure 7.3: *Cardboard Concept Model, Below-Ground.*

7.3 SPATIAL COMPONENTS

Having established how the site specific objectives can be achieved, the following discusses the space components of the design case study. The overall form of the building developed in response to the site specific design framework can be divided into the following six spatial components:

- Grey Street Corridor
- Museum Image
- Museum Entrance
- Stepped Plaza
- Under-Quay Pedestrian Link
- Museum Connection

Many of the Site Specific Objectives can be achieved by the same Underground Design Guidelines and therefore exist within more than one section.



1. Retail
2. Museum gift shop
3. Cafe
4. Exhibition space
5. Entrance to Museum and underground pedestrian link
6. Secondary entrance to Museum and underground pedestrian link
7. Sunken amphitheatre
8. Exterior cafe area
9. Terracing
10. Combined Museum connection
11. Service entrance
12. Shared pedestrian and vehicle space

Figure 7.4: *Ground Floor Plan.* *1:800*

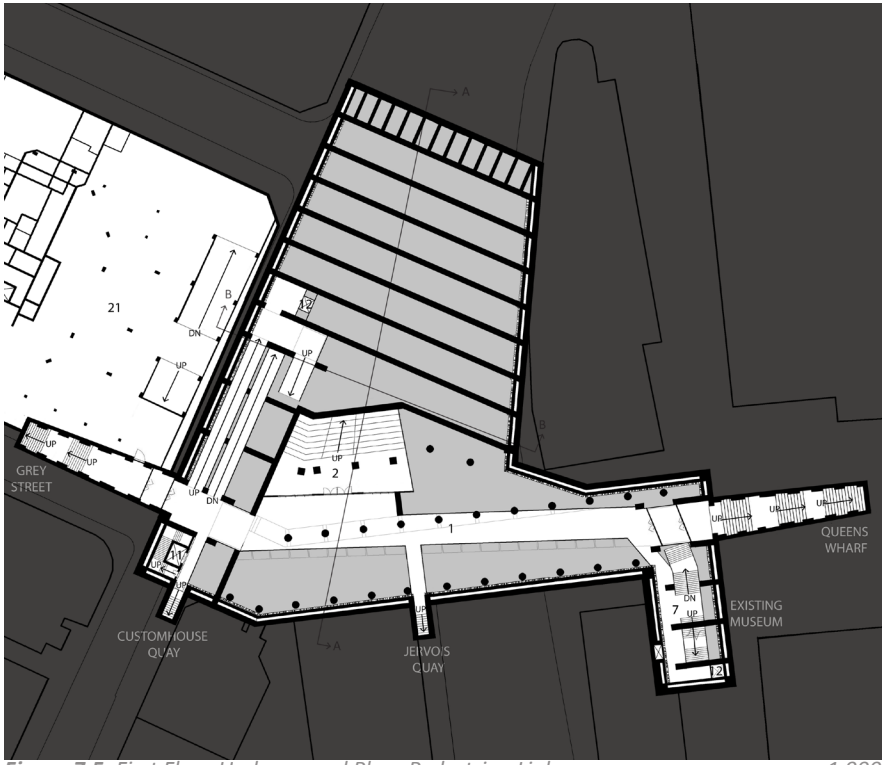


Figure 7.5: *First Floor Underground Plan- Pedestrian Link* *1:900*

1. Pedestrian Link
2. Exterior Auditorium
3. Museum Entrance
4. Public Meeting Rooms
5. Library Exhibition Space
6. Historic Wharf Pile Exhibition Space

Figure 7.6: *Second Floor Underground Plan - Exhibition Spaces* *1:900*

7. Connection to Existing Museum
8. Photography Exhibition
9. Plimmers Ark Exhibition
10. Visual Exhibition Space
11. Goods/Staff Lift
12. Museum Lift

Figure 7.7: *Third Floor Underground Plan- Exhibition and Curator Spaces* *1:900*

13. Staff Workroom
14. Staff Meeting Room
15. Staff Break Room
16. Dark Room
17. Storage Space
18. Staff Toilets

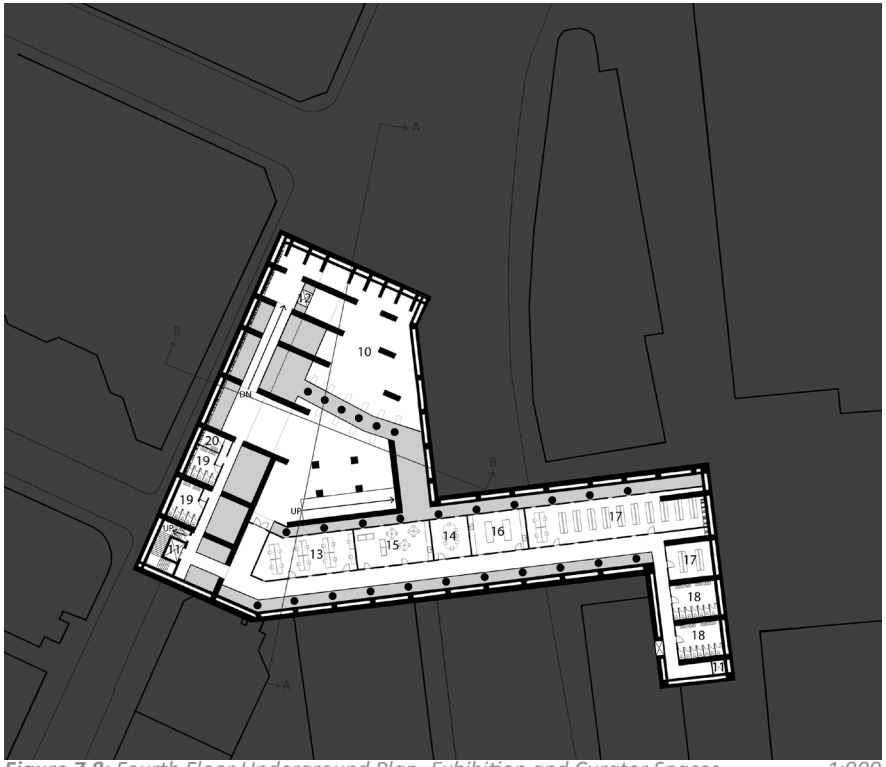
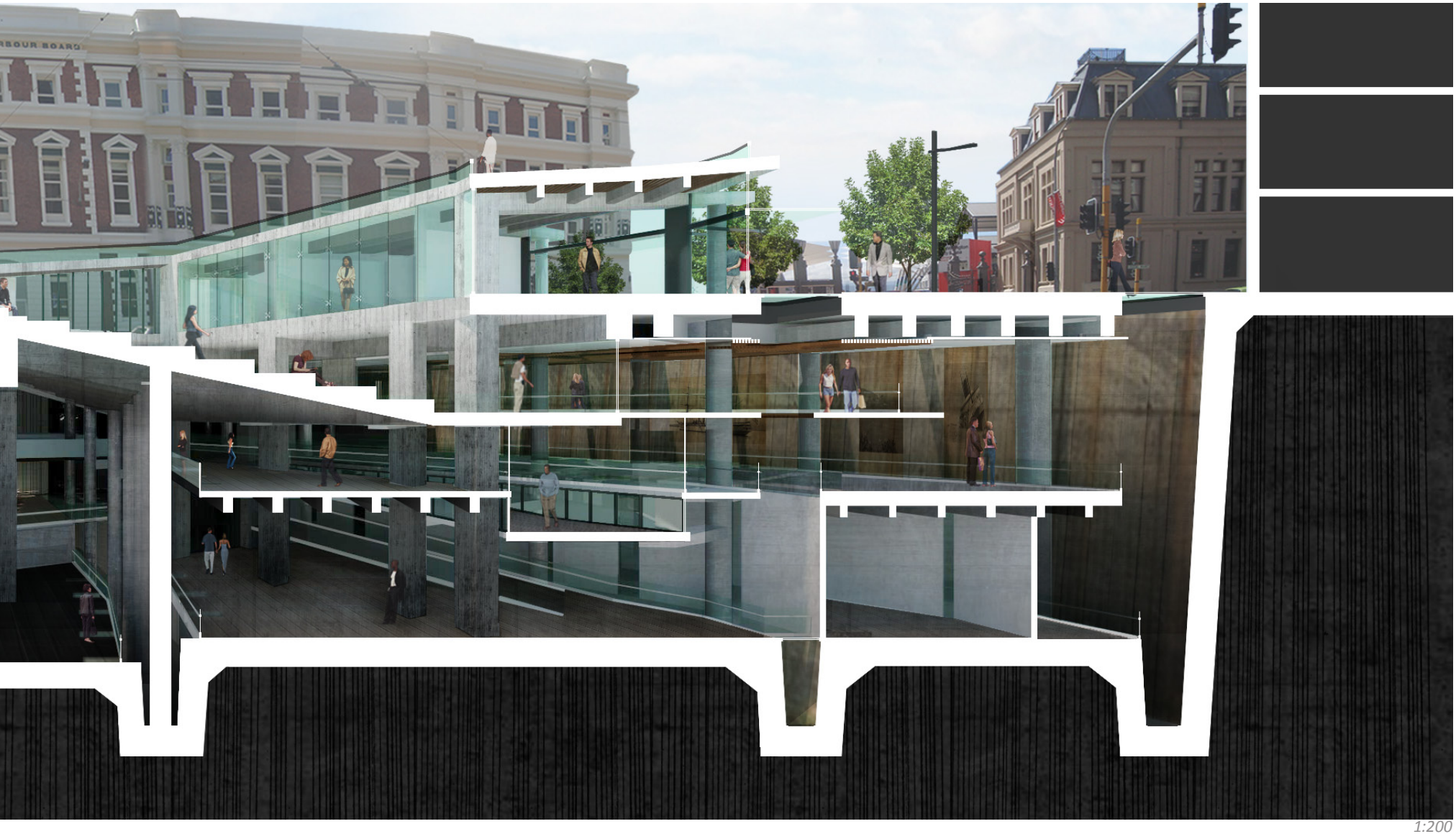


Figure 7.8: *Fourth Floor Underground Plan- Exhibition and Curator Spaces* *1:900*

19. Toilets
20. Disabled Toilets
21. Carpark

Figure 7.9: *Section A-A: Longitudinal Section through Exhibition Spaces*



1:200

Grey Street Corridor: (1: Pedestrian and Vehicle Movement)

The portion of Grey Street adjacent to Post Office Square has been developed into a shared pedestrian and vehicle space (Figure 7.6). The bend in the lane, defined on either side by its surrounding buildings, represents where Queens Wharf used to define the shoreline. Through preserving and defining this bend the historic procession towards Queens Wharf is clearly articulated above-ground.

The development retains the current one-way vehicle movement but develops into a shared movement space (Figure 7.4). However, pedestrian only footpaths, defined by planting and seating are situated along the buildings edge creating an active edge. The pedestrian only footpaths are further defined by *Flat Apertures* which are flush with the ground plane. These flat apertures create sight lines into the exhibition spaces below, allowing the general public above to see into the museum's exhibition spaces below.

Figure 7.10: *Grey Street Shared Vehicle and Pedestrian Space.*

Museum Image (2: View Shaft, 3: Building Alignment, 9: Retail Frontage)

The depressions and extrusions of the ground plane define important site elements while ensuring accessible interior and exterior spaces where appropriate (Figure 7.5). The most pronounced extrusion, located at the southern end of the site applies an *Earth Covered Depth*. The use of an *Earth Covered Depth* allows the building mass to delineate the historical bend in the site, defining the procession towards Queens Wharf.

The main entrance to the underground pedestrian link and museum spaces, as well as three retail spaces, one of which being the museum gift shop, are located at this end of the site. By aligning the *Earth Covered* building mass with Grey Street and locating retail spaces along this edge, an active edge is created while also ensuring that the building mass has little intrusion on the Grey Street view shaft.

The northern most tip of the site, like the Southern building mass, uses an *Earth Covered Depth*. This ground plane extrusion aligns with the Panama Street view shaft, where its one story building height and

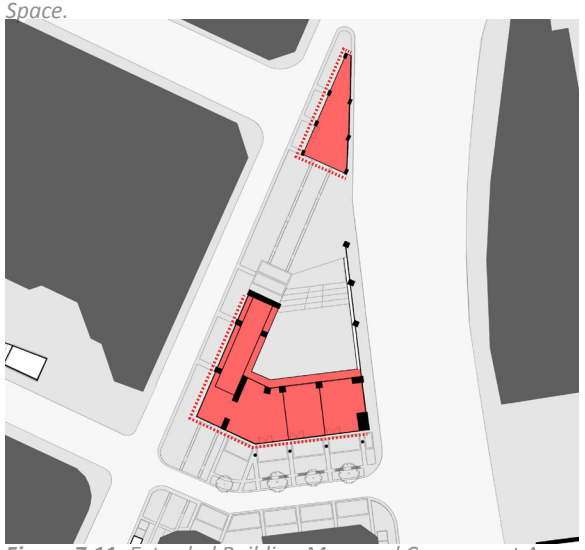


Figure 7.11: *Extruded Building Mass and Consequent Active Edges.*

Figure 7.12: *Grey Street View.*

green roof have little intrusion on the existing view shaft. Located at this point is a small cafe which opens up onto the ground level public space and Customhouse Quay.

The use of an *Earth Covered Depth* at the most Northern and Southern ends of Post Office Square clearly defines the extent of the above-ground public space, while simultaneously defining the extent of the underground space.

Museum Entrance: (4: Entrance Node)

The Site Specific Framework identified that the museums main entrance node should be located on the most active corner of Post Office Square, this being the South Western Corner (Figure 7.7). The elevated ground plane manipulation of the entrance is the most pronounced, allowing it to be easily identified. By locating the entrance at an *Earth Covered Depth* the building is entered horizontally, allowing decent to occur once inside the building. Glazing along the entire entrance and retail edges not only creates a visible connection between interior and exterior environments but also gives the ground manipulation a sense of elegance and lightness, an aspect successfully achieved in the initial cardboard models.

Stepped Plaza: (5: Site Access, 6: Definition of Space)

The building creates an inhabitable ground plane through using a *Covered Sloped Cavity Ground Plane Manipulation,* where the depressed sloped ground plane forms a terraced courtyard that descends into the museums interior (Figure 7.9). This terracing creates a gradual descent from the public ground plane to the *Submerged* underground pedestrian connection and museum spaces. The opening created between the difference of the ground plane and the pushed terrace allows *Stepped Apertures* to be used, establishing sightlines between interior and exterior spaces. These sightlines allow the general public to view the

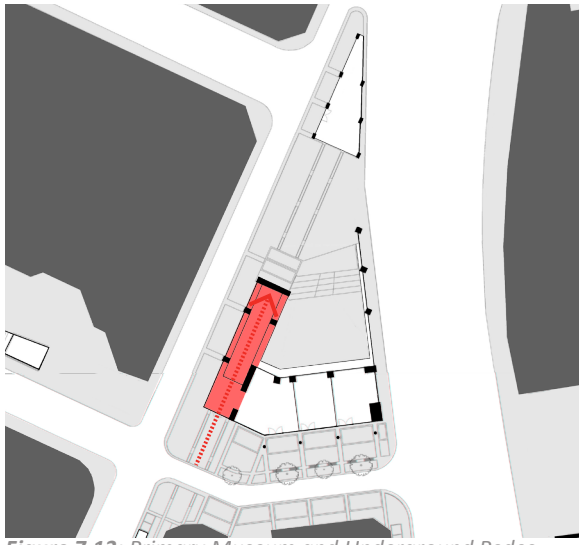


Figure 7.13: *Primary Museum and Underground Pedestrian link Entrance.*

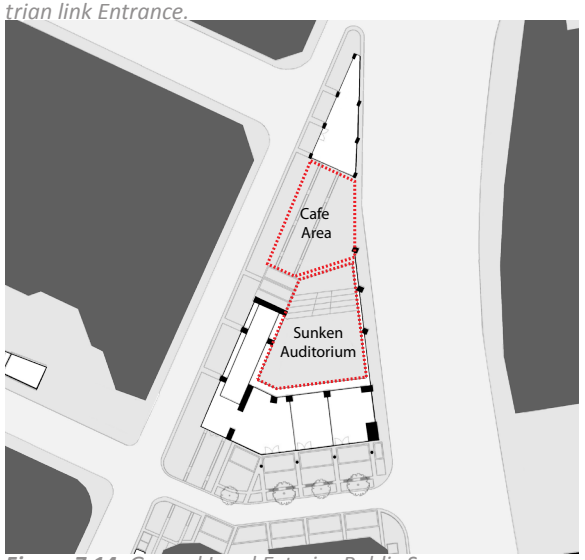


Figure 7.14: *Ground Level Exterior Public Space.*

Figure 7.15: *Exterior Sunken Auditorium.*

exhibition spaces from the exterior terrace without having to physically enter the building.

The Site Specific Framework identified that the building should retain current pedestrian access along the Western and Southern edges of the site to ensure accessible public space, while also creating a clear distinction between open public space and Jervois Quay (Figure 7.8). The depressions and extrusions of the *Covered Sloped Cavity Ground Plane Manipulation* converge at ground level. This ground level space, which is mostly used as exterior Cafe space, creates a level connection to Customhouse Quay allowing the public space to be easily accessible. At ground level people can ascend up the gradual sides of the *Earth Covered Ground Plane* to the grassed public roof, or descend through the terracing to the underground pedestrian connection (Figure 7.10). The use of a gradual transition between ground level and the extruded ground plane creates a distinct edge between the public space and Jervois Quay. This distinct edge acts as a buffer zone along the Eastern edge of the site creating a sheltered public space.

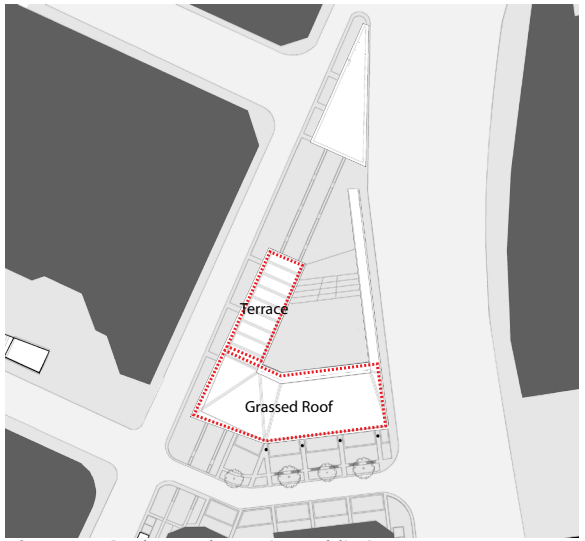


Figure 7.16: *Elevated Exterior Public Space.*

Under-Quay Pedestrian Link: (7: Underground Pedestrian Network)

The Site Specific Framework identified a need to re-establish the pedestrian route across Jervois Quay, re-connecting the significant Grey Street city to sea link (Figure 7.11). The pedestrian link is *Submerged* underneath Jervois Quay to ensure no disruption to the existing vehicle network, nor any interference with ground level public space. By locating the pedestrian network at this level, it limits pedestrian descent to only one level below-ground, making it more accessible and allowing a gradual transition between levels. This depth also allows the pedestrian network to have a physically close connection to ground plane, ensuring that pedestrians are not significantly detached from the above-ground environment.

The primary entrance to the pedestrian link is located at Post Office Square, where it is accessed through the same entrance as the extension of the museum, by means of a gradual descending ramp (Figure 7.12). Sharing the same primary entrance node allows pedestrians and museum inhabitants to enter the building

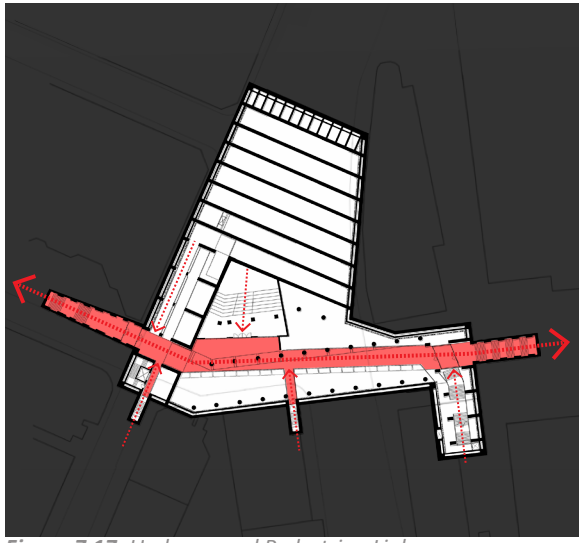


Figure 7.17: *Underground Pedestrian Link.*

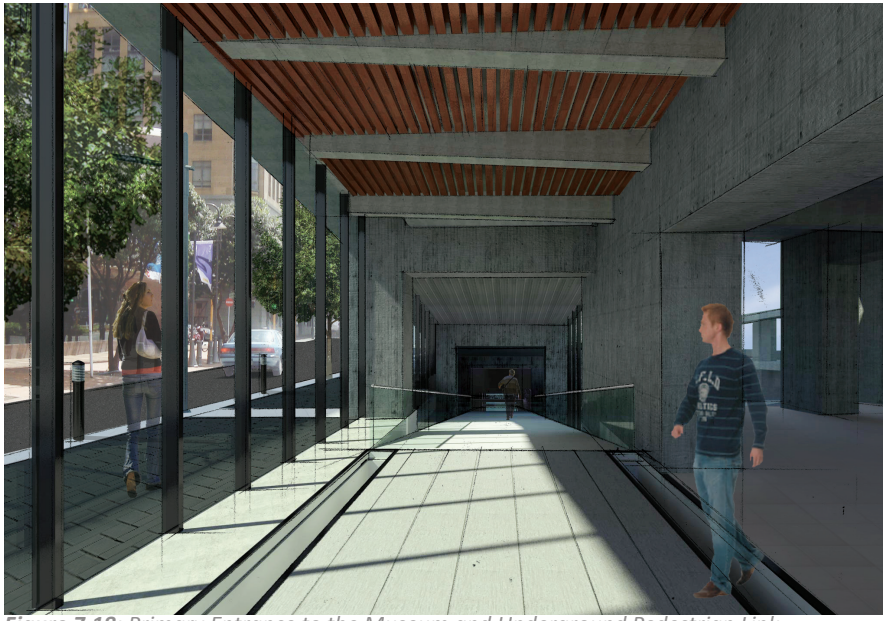


Figure 7.18: *Primary Entrance to the Museum and Underground Pedestrian Link.*

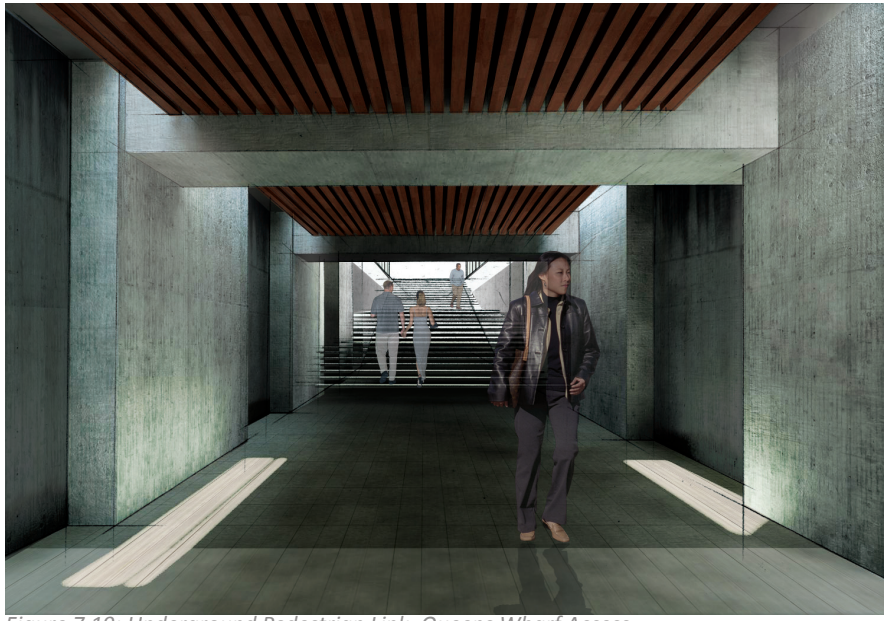


Figure 7.19: Underground Pedestrian Link- Queens Wharf Access.

together, highlighting the integration of the two programmes. It is not until they have descended to the first level underground that they diverge from one another.

The main pedestrian link exits at Queens Wharf (Figure 7.13). At this point pedestrians can either ascend up the stairs to the existing museum entrance or continue and connect to the basement of the TSB Arena or ascend up to the above-ground courtyard of Queens Wharf.

Secondary entrances to the underground pedestrian network, accessible by means of stairs, create a more abrupt transition from ground level to the pedestrian link. These covered entrances are located along Grey Street (Figure 7.16), and the southern ends of Customhouse Quay and Jervois Quay. The location of these access points allows pedestrians approaching the site from directions other than Grey Street or Queens Wharf to easily access the underground pedestrian spaces.

For security reasons, all underground access points can be shut off when the museum is closed, preventing people from entering the pedestrian link from street level after museum hours.

The pedestrian link way is described in terms of entrances and exits purely to ensure clarity when discussed. However, it is intended that pedestrians enter and exit the underground pedestrian link from multiple access points (Figure 7.14).

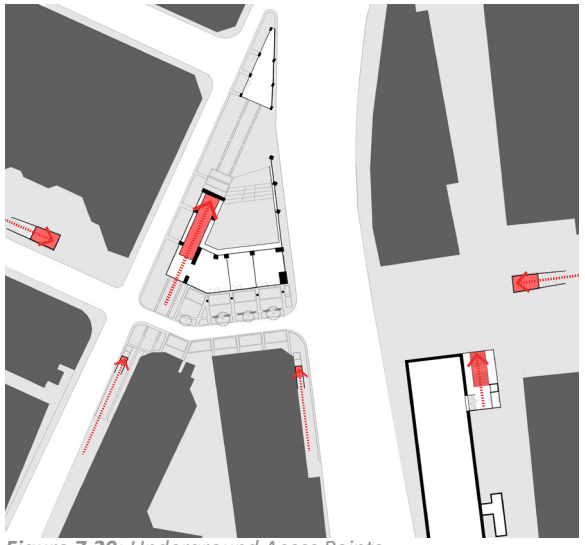


Figure 7.20: *Underground Acess Points.*

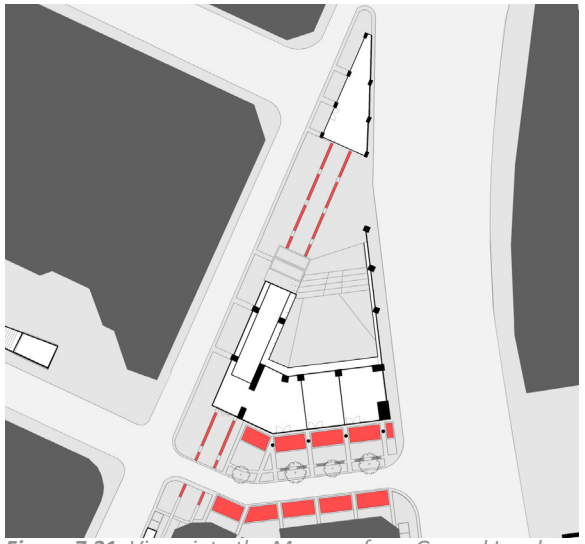


Figure 7.21: *Views into the Museum from Ground Level.*

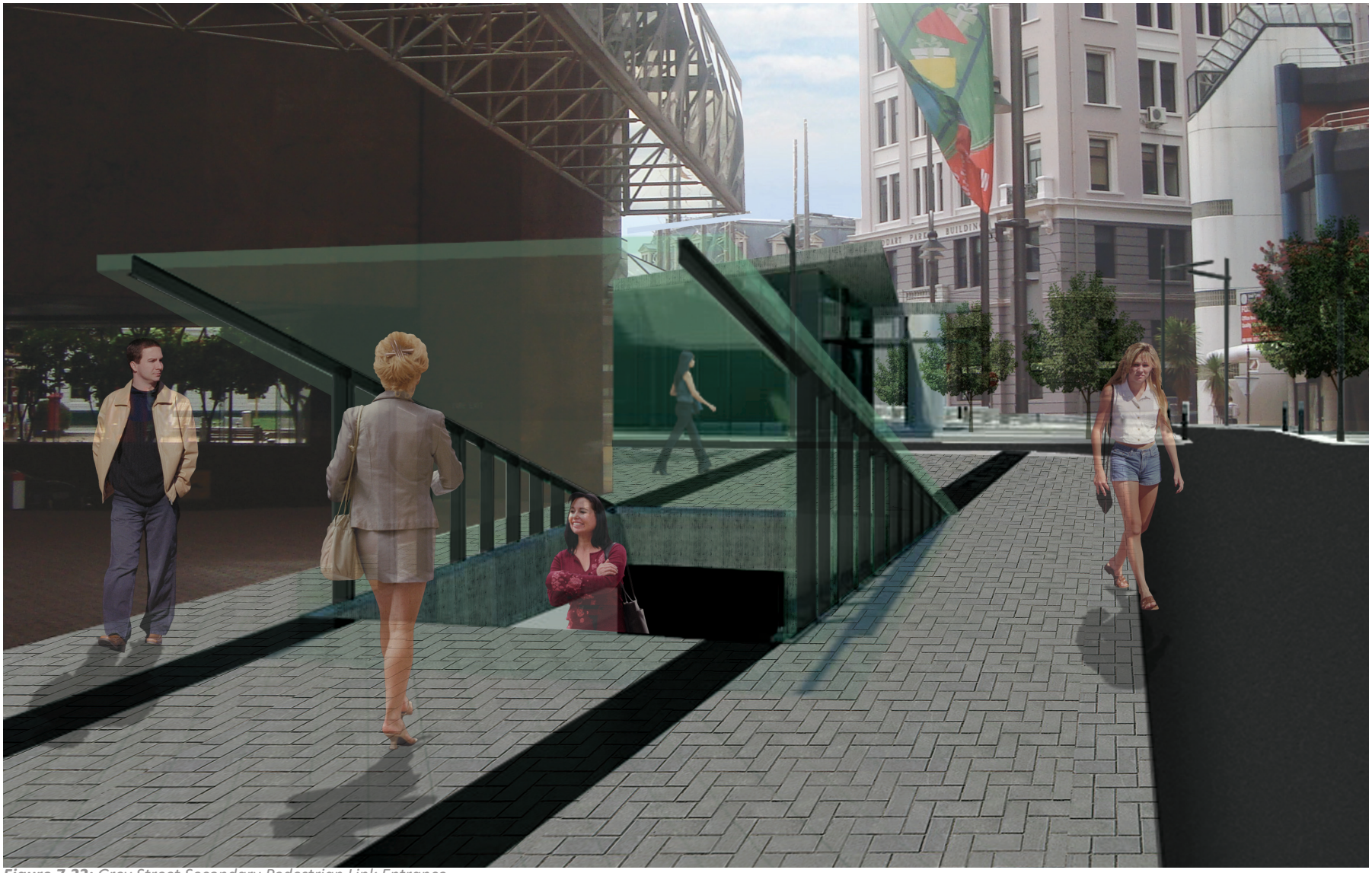


Figure 7.22: *Grey Street Secondary Pedestrian Link Entrance.*

Museums Connection: (8: Connection between Extension and Existing Museum)

Initially the connection between the museums was located underneath the current Museum of City and Sea to ensure a seamless connection between museum spaces. However, placing the connection underneath the Bond Store could have severely compromised the structure of the foundations supporting the Category One Historical Building. It would have also meant that the extension did not address the significant issue of the museums lack of visibility. Therefore the connection between the existing museum and its extension is situated at ground level, creating a new combined entrance on the Northern Eastern corner of the Bond Store. This combined entrance not only creates an obvious entrance node, but also creates a distinct transition between the two buildings, clearly articulating the original and new areas of the museum.

At the combined entrance, inhabitants can either enter the existing museum (Figure 7.17) or descend by stairs or lift into the underground museum spaces (Figure 7.18). The combined entrance is intended to be the primary entrance for the Bond Store Museum, while only a secondary entrance for the Post Office Square extension.

The combined entrance is mostly glass, respecting the significance of the Category One Historic Building by allowing it to be visible from the exterior (Figure 7.19). Through locating the combined entrance above-ground and on the exterior of the current museum, it has little impact on its historic facade and existing interior configuration, while simultaneously increasing the visual permeability of the museum from Queens Wharf.

Figure 7.23: *Ground Level Museum Connection.*

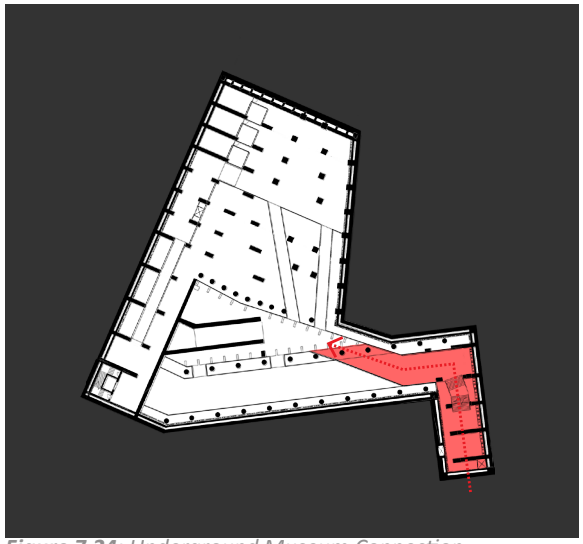


Figure 7.24: *Underground Museum Connection.*

Figure 7.25: *New Combined Entrance- Bond Store.*

7.3 MAJOR DESIGN GENERATORS

As well as the site specific framework the design case study also constitutes a set of major design generators which are responses to the underground design guidelines. These major design generators have been developed by the designer and are therefore independent of the site specific design framework. It is important to note that the major design generators, although independent from the site specific framework, develop and apply relevant underground space guidelines where possible to underpin the successful nature of these design elements.

Along with these guidelines some the design elements also abstract and apply the unique essence of relevant underground archetypes, manipulating the buildings spatial image to express the distinctive characteristics of being underground. The following section discusses the individual design generators, their associated underground space design guidelines and applied archetypes, as well as their significant interaction with other design elements. The buildings eight major design generators are:

- Historic Sea Wall Void
- Historic Wharf Piles
- Integration of Pedestrian Link
- Underground Atrium
- Museum Circulation
- Three Exhibition Levels
- Distinct Exterior Walls
- Structural Expression

Although presented individually, much of the design is determined by how these elements interact.

The extension of the Museum of Wellington City and Sea seeks to display Wellingtons Maritime History, focusing especially on the significant reclamations that have developed Wellington's harbour to how it is today. The design case study expands on the interactive nature of the existing museum through seeking to utilise the rich history of the site through revealing and framing the historic waterfront structure which exists underground to forge a dynamic relationship between the museum and its site. From this a seamless connection between architecture and exhibition space is created, where the building reveals the historic waterfront structure and integrates it into the building and its exhibition spaces.

Historic Seawall Voids:

Two historic seawall voids run longitudinally through the building, following the 1863 and 1889 brick seawalls (Figure 7.26) which reclaimed a significant portion of land. Initially the design of the voids within the building explored the concept of framing the historic seawall structure, as it is believed that the historic seawall still remains underneath the site today. This would have allowed inhabitants to physically interact with the historic wharf. However, for feasibility purposes this idea was discarded as it would have required a significant amount of conservation, where the seawall would have initially been removed, the building structure built, then the seawall placed back to its original position. Having also been underground for such prolonged period of time meant that the condition of the seawall would have not been known.

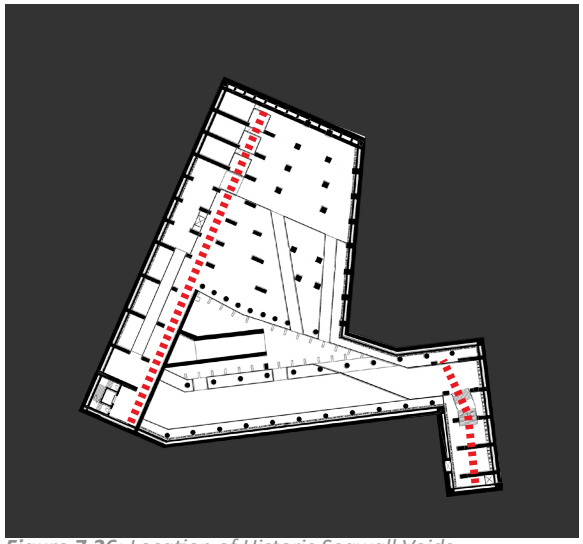


Figure 7.26: *Location of Historic Seawall Voids.*

Therefore the position of the historical seawalls has been replaced by expansive voids, inverting the notion of the seawalls structural ability by using naturally illuminated voids. These voids only gesture towards the significance of the space. It is not until the inhabitant circulates through the building and recounts the development of the waterfront that their significance is revealed.

The qualities of the underground archetype, the Cryptoporticus have been abstracted, developed and applied to the two historic seawalls (Figure 7.27). The two seawall voids are formed by the subtraction of mass cut from the thick ribbed concrete walls. These cuts, similar in proportion to the seawall create deep voids through the museums interior, rendering them visible from any floor. The voids are illuminated by two parallel *Flat Apertures* that run the entire length of the voids, allowing natural light to illuminate the void from above. An apparent gradient of illumination is created by only introducing natural light from above. This illumination gradient enhances the sense of being underground as deeper levels with the building receive less natural light.

The location of the seawall voids on the outer edges of the museum means they act as apparent thresholds, distinguishing between the museum exhibition spaces and its access points. Therefore the historic seawall voids can only be experienced when passing through it. Pedestrians using the underground link pass

Figure 7.27: *Historic Seawall Void.*

through the seawall thresholds at the start and end of the link, signifying their movement underground and their brief journey through the museum. Museum inhabitants pass through the threshold on entering the museum, and every time they descend a level deeper within the museum. As the historic seawall voids are visible from all areas within the building they act as underground landmarks, increasing orientation and way finding, a highly important element within deeper levels underground.

Historic Wharf Piles:

Three rows of historic wharf piles run horizontally through the building, following the 1862 and 1878 Queens Wharf structure (Figure 7.29). These historical piles are represented by structural steel columns located in the same place as the historical wharf piers. These 1000mm diameter steel columns, placed at three meter centres form a significant part of the buildings structure, where they support the above-ground activity on Grey Street while also defining the historic procession towards the waterfront within the interior of the underground museum (Figure 7.30).

Flat Apertures located between the columns allow natural light to illuminate the historic columns, further highlighting their significance. These apertures are flush with the ground plane meaning they have little intrusion on the above-ground activity of Grey Street, allowing people to walk over them while simultaneously allowing significant amounts of natural light to enter the museum spaces below. The use of *Flat Apertures* also means that above-ground activities influence the degree of natural light entering the spaces below, creating a dynamic interior environment which is directly affected by above-ground activity.

Four of the structural columns have been extruded above-ground (Figure 7.28) to support the extruded ground plane which forms the above-ground portion of the building. Appearing as normal structural columns above-ground it is not until inhabitants circulate through the museums interior and recount the development of the waterfront that their significance is revealed.

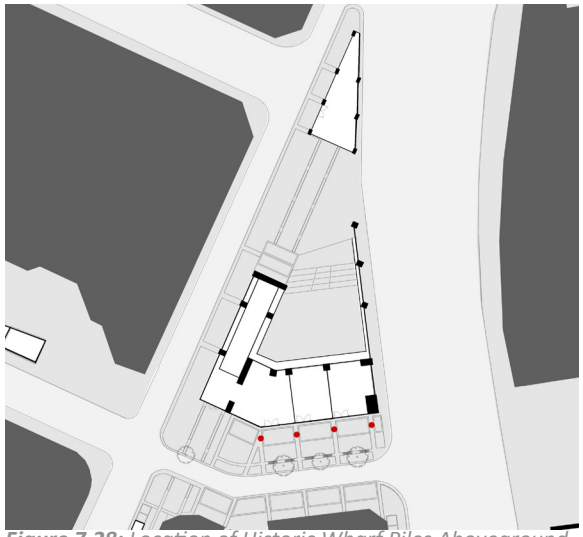


Figure 7.28: *Location of Historic Wharf Piles Aboveground.*

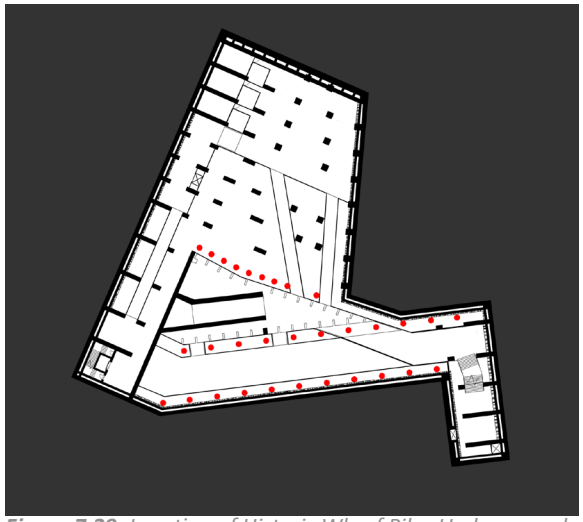


Figure 7.29: *Location of Historic Wharf Piles Underground.*

Figure 7.30: *Second Exhibition Space-Historic Wharf Pile Exhibition Space.*

The circular shape of the steel columns is a stark contrast to the exposed concrete angular walls which much of the design aesthetic of the underground building follows. This contrast in shape and material highlights the significance of these columns, making them easily distinguishable from the surrounding building elements. As these elements are easily identifiable, and can be seen from every level within the building, they act as an interior landmark increasing orientation and way finding within the building.

Pedestrian Link Way Integration:

The extension of the museum creates a public pedestrian walkway, extending from Post Office Square, beneath Jervois Quay to Queens Wharf. The link way is integrated with the museums programme to ensure that it acts more than just an underground tunnel, but through incorporating it with one of Wellington's iconic museums, it becomes a civic entity (Figure 7.32).

From the interior, the pedestrian link way is seen as a raised platform above the exhibition spaces, allowing pedestrians to look down into the exhibition spaces as they pass through the building. The pedestrian link way is uncovered, where only a glass balustrade and its elevated height above the exhibition spaces define it from the museum. This allows pedestrians to truly experience the museum without having to enter it (Figure 7.31). Through integrating the pedestrian link and museum, an interdependent relationship is formed, where each programme relies on the activity of the other to create a stimulating interior environment.

The two historic seawall voids cut through the pedestrian connection at the ends of the link way, acting as thresholds which define the process above the museum's exhibition spaces. These voids heighten the pedestrians movement through the museum, defining their experience of the museum as they proceed across the link way.

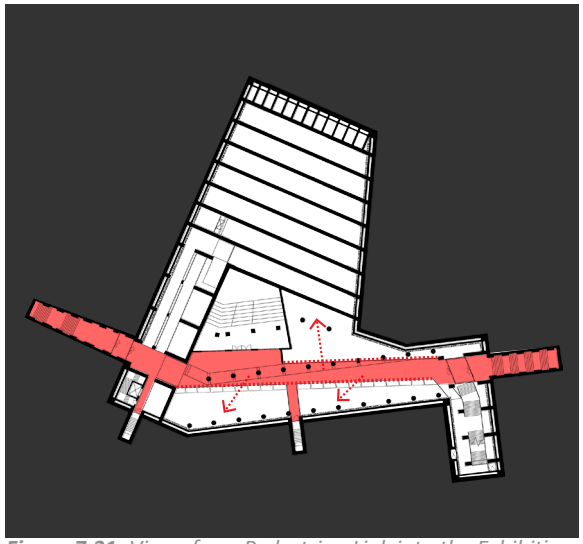


Figure 7.31: *Views from Pedestrian Link into the Exhibition Spaces Below.*

Figure 7.32: *Underground Pedestrian Link.*

Underground Atrium:

The interior configuration of the museum is principally arranged around an *Atrium Spatial Structure*, where various exhibition spaces surround the central exhibition space situated at the lowest level within the building (Figure 7.33). This spatial structure allows sightlines to extend to the deeper spaces of the building as well as creating sightlines to adjacent floors increasing orientation within the building. As the central atrium space is visible from every level, it acts as landmark within the building, further enhancing orientation and way finding (Figure 7.34).

Situated beneath the public terrace the central atrium space is illuminated by *Stepped Apertures* created through the depression of the ground plane. The use of an *Atrium Spatial Structure* allows natural light to extend to the deeper levels within the museum, providing all exhibition spaces with a degree of natural illumination.

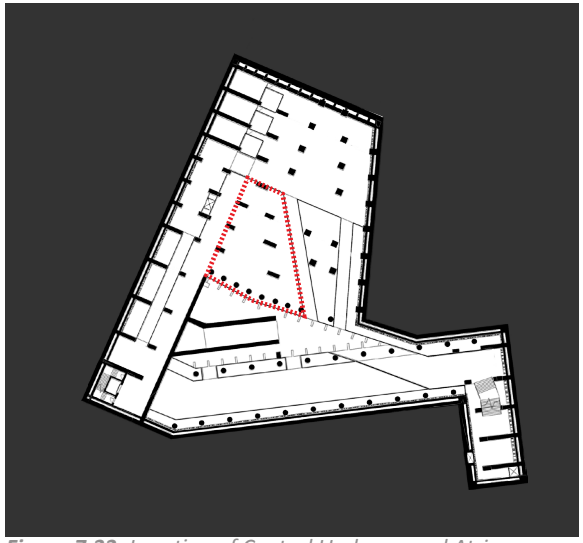


Figure 7.33: *Location of Central Underground Atrium Space.*

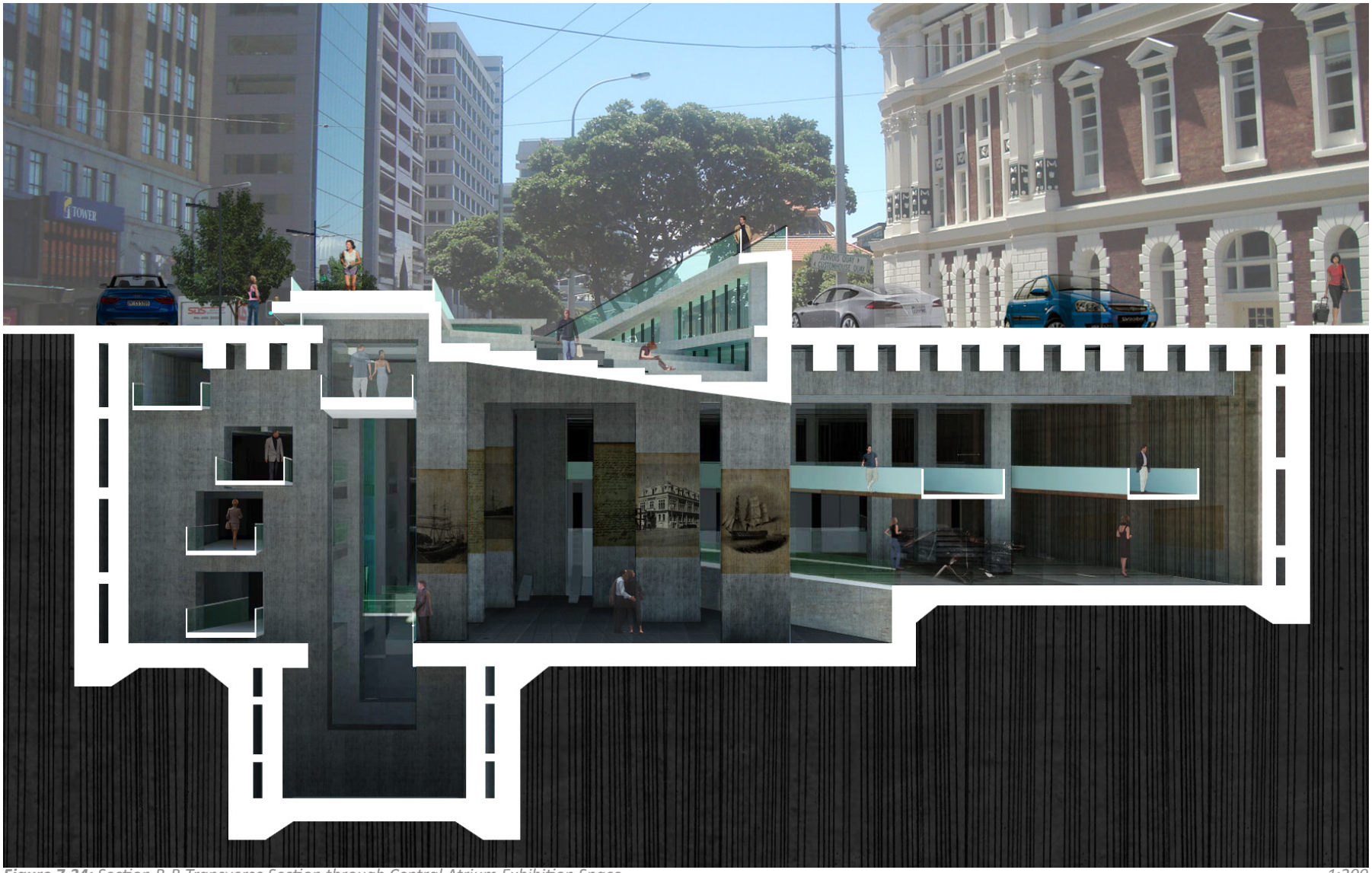


Figure 7.34: *Section B-B Transverse Section through Central Atrium Exhibition Space.* *1:200*

Museum Circulation:

Primary circulation through the building occurs as loop through the exhibition spaces, emulating the same circulation pattern as the existing museum (Figure 7.35). This type of circulation allows inhabitants to experience the building as a timeline, revealing the history of Wellington as they circulated through the building.

The *Atrium Spatial Structure* of the museum has been carefully manipulated so that primary circulation provides simultaneous horizontal and vertical movement. Subtle declines in the angled levels of the building integrate interior circulation with the exhibition spaces, allowing for free flowing circulation within the building. This subtle manipulation of the levels means that inhabitants slowly descend as they move throughout the building. This descent is intended to be gradual so that inhabitants are unaware of their significant movement into deeper levels of the building. It is not until the inhabitant reaches the lowest exhibition space and is able to see the exhibition spaces above, that the true descent of their journey is realised.

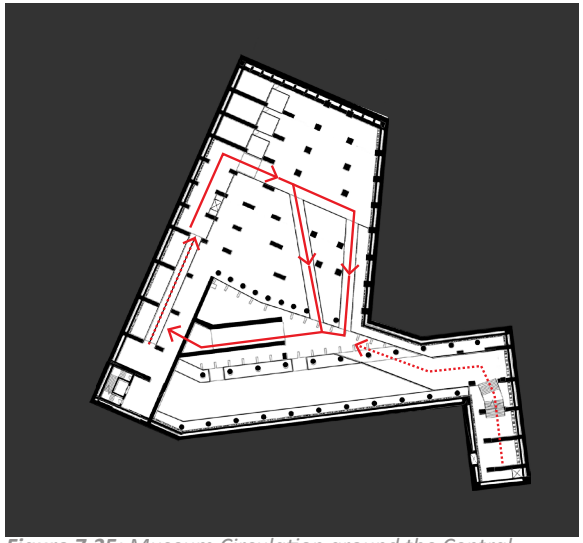


Figure 7.35: *Museum Circulation around the Central Atrium Space.*

Figure 7.36: *Channels Cut into the Exterior Walls.*

Figure 7.37: *Entrance Ramp through the Eggcrate Walls.*

Three Exhibition Levels:

Although the spaces within the museum are staggered in height, three distinct exhibition levels arranged around the central atrium space exist within the building. The first level of the museum is connected by a ramp which extends from the pedestrian bridge above to the museum entrance below. From here visitors pass through the Historic Seawall Void to the first exhibition space. The Historic Seawall Void acts as a threshold, signifying the inhabitants crossing from the public pedestrian area into the museum. The first exhibition space (Figure 7.38) acts as an interactive library, displaying historical civic documents from Wellingtons Harbour Board. Three multipurpose rooms also open onto this exhibition space. These rooms are intended to be used for a diverse range of activities such as staff meetings or a quiet area where the public can view historical documents more closely.

From this exhibition space inhabitants descend down one of either two bridges, across the exhibition space below, to the node at which the extension of the museum and link to the existing museum converge. From here inhabitants enter the Historic Wharf Pile Exhibition Space, where photographs and artefacts retell the various reclamations of Wellington harbour. It is this exhibition space where inhabitants reveal the significant placing of the structural columns.

Inhabitants continue by passing through the Historical Seawall Void again and descending to the second level where they enter the third exhibition space displaying the remnants of Plimmers Ark (Figure 7.39). Also located at this level are the staff and curator spaces. The staff areas include a large office space, two meeting rooms, and a break out area and staff toilets. The curator spaces consist of a large workshop, storage space and darkroom. Located at this level is a curator lift and stairs to the existing museums exhibitions spaces and goods entrance. This link is only accessible by staff to ensure the safe movement of exhibition pieces between museums.

Inhabitants then pass through the Historic Seawall Void and descend to the third level. Here visitors pass through the Photography Exhibition Space, which displays biographies of significant Wellingtonians, and

Figure 7.38: *First Exhibition Space - Interactive Library.*

arrive at the Central Exhibition Space. This experience of entering the main exhibition space is heightened by the Photography Exhibition Space before it, where the qualities of the underground the archetype the cave have been applied. Here inhabitants pass through a narrow and constricted tunnel, defined by angled walls and slopping floors excavated from the building's interior structure. Linear fissures of light penetrate through the sloped wall into the dark photographic space, signaling the importance of the exhibition space beyond. It is not until visitors complete the movement through the Photography Exhibition Space and exit that they are also able to step out into the full height Central Exhibition Space and see the spaces above, revealing true descent of their journey.

It is here in the Central Exhibition Space where visitors are able to take the time to reflect on the historical development of Wellington as well as the journey which they have just taken (Figure 7.45). Large images are projected onto structural concrete walls which surround the space. These images recap the significant history revealed through the journey through the museum.

From this lowest exhibition space inhabitants can enter one of two lifts which take them back to the museums entrance, where they can either exit through the main entry onto Post Office Square or continue along the pedestrian path to Queens Wharf.

Figure 7.39: *Third Exhibition Space - Plimmers Ark.*

Distinct Exterior Walls:

As Post Office Square is situated on reclaimed land it has a high water table, therefore in order to ensure the building does not float and remains submerged the buildings' weight must be heavier than the amount of water displaced. The museums interior aims to express this required weight, as well as the structure needed to resist the pressure from the surrounding earth. Museum inhabitants are therefore not only exposed to Wellingtons history but are also able to experience and understand the significant amount of structure needed for underground space, heightening their experience underground.

The qualities of water established in the underground archetype, the grotto have been abstracted, developed and applied to the underground exterior walls. As waterproofing is a frequent issue within underground space, especially on sites with a high water table the underground exterior walls have been designed to allow moisture to seep through them (Figure 7.40). These two meter thick concrete walls have tiny penetrations in which moisture from the earth behind is able to seep through. The moisture then runs down the vertical channels cut into the inside of the wall and into the historic sea wall voids and historic wharf pile channels, where it is then pumped out. Backup pumps and generators are also used to maintain the amount of moisture entering the building, ensuring that the museums interior environment is climatically controlled for the display of artefacts.

These underground exterior walls are angled in order to resist the forces being applied from the earth behind (Figure 7.41). These exterior walls are the only non vertical walls within the building, establishing a coding between interior and exterior walls. These identifiable exterior walls create a sense of fortification and strength in the museums interior, further expressing the sense of being underground (Figure 7.42). This design feature not only deals with the significant issues of waterproofing but also distinguishes between exterior and interior walls, enhancing legibility within the building.

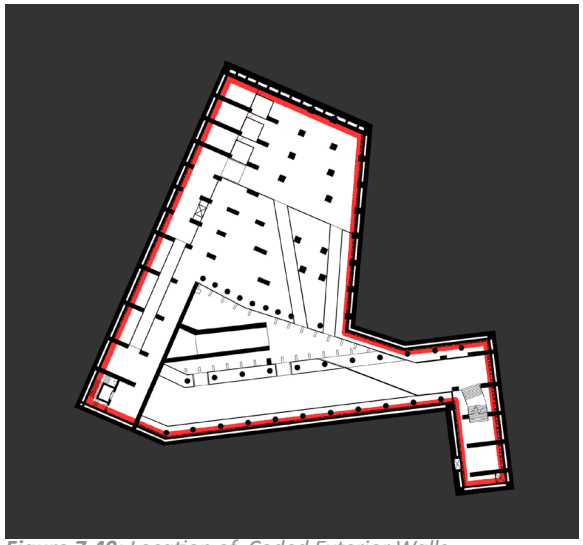


Figure 7.40: *Location of Coded Exterior Walls.*

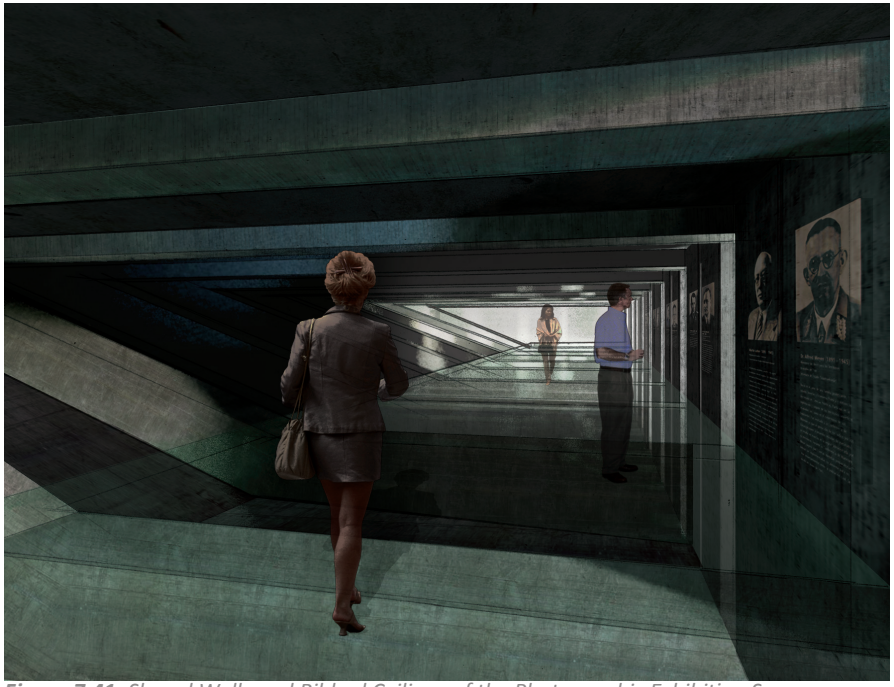


Figure 7.41: *Sloped Walls and Ribbed Ceilings of the Photographic Exhibition Space.*

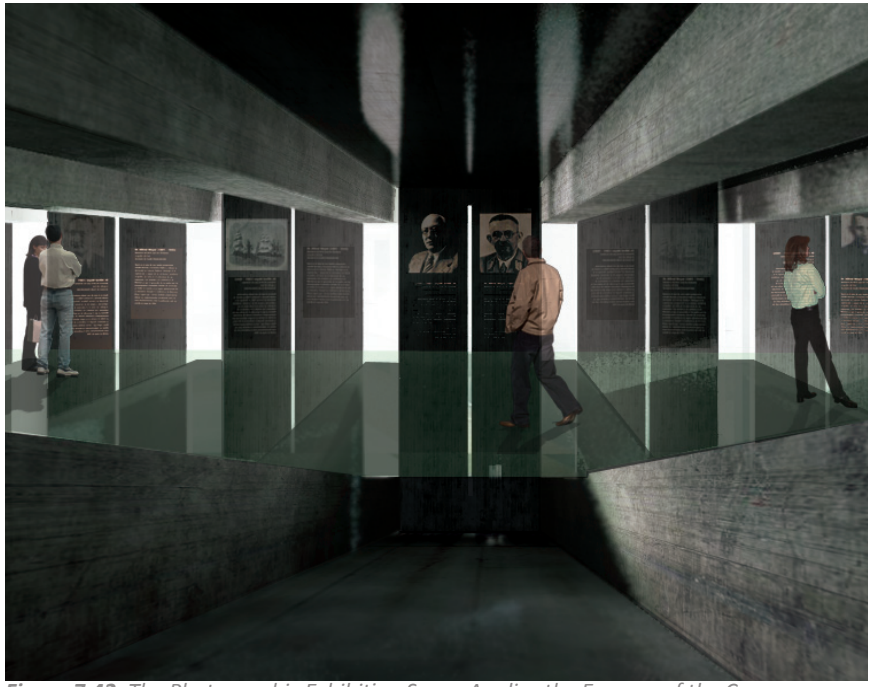


Figure 7.42: *The Photographic Exhibition Space Applies the Essence of the Cave.*

Structural Expression:

The gravity loads on the underground museum, in places, are far greater than conventional above-ground buildings. These loads become even greater beneath the streets where not only the road, but several meters of road substrate are supported. Gravity loads from the above-ground environment are expressed through the significant amount of vertical structure within the building. Two meter thick and six meter long reinforced concrete walls, situated five meters a part line the west side of the museum (Figure 7.43). Located underneath Customhouse Quay they support the weight from the road above as well as providing a significant amount of weight within the building. The walls also divide the large museum interior into smaller spaces, housing many of the museums amenities, such as the meeting rooms and bathrooms.

Large columns situated underneath Post Office Square lane and Jervois Quay also resist gravity loads from the above-ground road. These columns are differentiated from the Historic Wharf Piles which rely on their close spacing, rather than great mass for strength (Figure 7.44). Tapered at the top, the columns highlight the importance of the structural elements within the building, expressing the significant weight resisted from the above-ground environment.

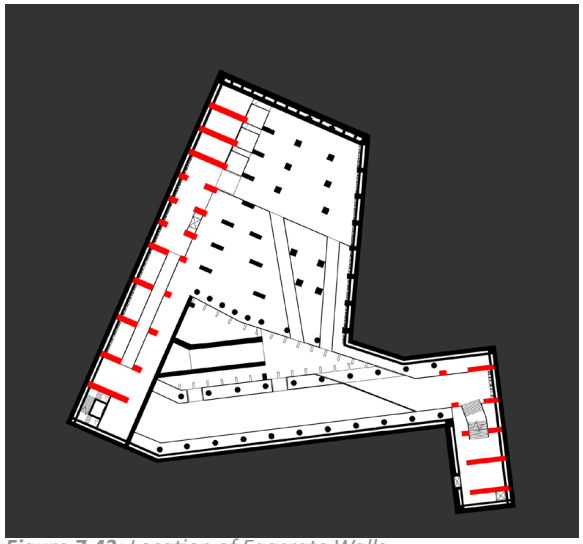


Figure 7.43: *Location of Eggcrate Walls.*

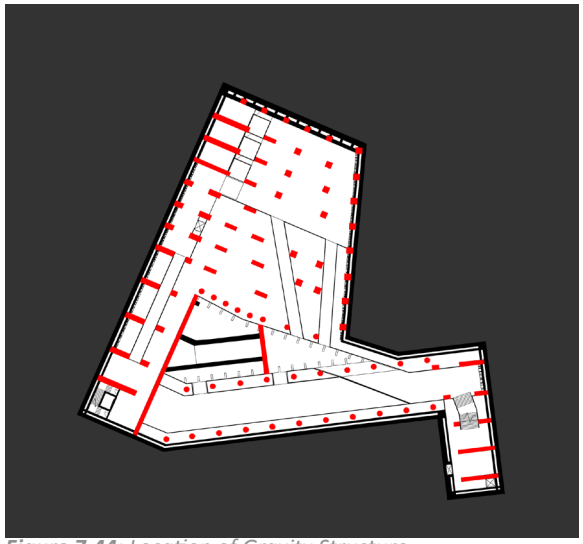


Figure 7.44: *Location of Gravity Structure.*

Figure 7.45: *Main Exhibition Space - Visual Exhibition.*

7.5 DESIGN DISCUSSION AND EVALUATION

The final design evolved in two distinct ways. Firstly through selecting and developing appropriate Underground Space Design Guidelines in response to the Specific Site Framework in order to create the Site Specific Design Framework. Secondly, it evolved through the main design building elements, which have been developed by the designer and apply relevant Underground Space Design Guidelines where possible. The application of these guidelines throughout the design case study allows existing guidelines to be altered and refined, while new guidelines to be identified.

The design case study highlighted the somewhat conventional nature of the Underground Space Design Guidelines. As the categories within the guidelines have developed in response to the issues that arise from underground space they focus closely on the above-ground portion of the building, and its relationship to the ground plane, while somewhat negating the underground portion of the building. Therefore, these guidelines produce distinctive external architecture but relatively conventional internal architecture. Only the spaces deeper within the building and less accessible to the public appear distinctively underground as the guideline category of Spatial Image and the essence of the underground archetypes can only be applied to completely underground areas, therefore enhancing the sense of being underground in such areas.

As the design case study only applies the underground Spatial Image and essence of the underground to individual design elements, only certain spaces have a profound sense of being underground, while many other spaces appear as conventional above-ground space. This creates a somewhat conflicting spatial image within the building, where the building loses its distinct underground appeal. This highlights the importance of developing and applying the Spatial Image and underground archetypes throughout the building to ensure that a distinct underground sense is created.

Historic underground features became an important theme in the design, providing additional connections between above-ground and below-ground spaces. The design case demonstrates a further way of responding, to both the underground and above-ground environment, by revealing significant

underground elements. Although this notion is unique to Post Office Square, and therefore may not be applicable to all underground spaces, it does identify a new and highly important guideline. This being that underground space should not only address the historical surface of a site but should also reveal the historical underground significance to enhance connections between above-ground and below-ground spaces.

As the design case study replaces the historical underground elements with expansive voids and structural columns the significance of the underground is somewhat reduced. From above-ground inhabitants can only view down into a dark expansive void and cannot directly see the structural columns. It is not until they enter the building that they are aware of the significance of these elements. Therefore, ideally to enhance above-ground and below-ground connections the original historical elements should be revealed and remain in their original form so that they are also easily recognisable from above-ground.

Initially the underground pedestrian link was significantly detached from the museums interior spaces, where it was completely enclosed and situated at the deepest level underground. This allowed the museum exhibition spaces to have a closer relationship with the ground plane. However, by situating the pedestrian link way deeper underground, access required a large degree of descent and the link way differed little from normal underpasses which are often ill-defined and conditions are inadequate. Therefore the pedestrian link way was integrated into the museums programme and situated closer to the ground plane, while significant exhibition spaces were moved to deeper levels within the building. This design development establishes a new underground space guideline, that being the importance of spatial hierarchy, where more significant and frequently used spaces should be located closer to the ground plane. In the design case study this space is the most public space within the building. This notion relates back to the earlier observation that a strong sense of being underground is most likely to be achieved at deeper levels underground.

The design case study sought to enhance the physical connection between above and below-ground by blurring the boundaries and edges which defined the interior and exterior programmes of the building, while articulating important site edges. This was done as some principles within the underground

space framework identified the need for clearly articulated edges to ensure the underground building had a presence above-ground, however this creates clear boundaries between above and below-ground environments, highlighting a potential conflict between original guidelines. Through extrusions and pushes of the ground plane in response to site, various depths and ground plane manipulations were integrated obscuring the boundaries between exterior public space and interior museum space and therefore above and below-ground. Therefore through this judicious design, particular edges of the building significant to the site have been clearly articulated above-ground, while edges which define the exterior public space and internal museum programme have been blurred, allowing both objectives to be met. This demonstrates that underground buildings do not have to articulate every edge, but only edges significant to the above-ground space.

It was initially intended that the pedestrian link and museum would be accessed by means of a ramp to create a gradual descent from the above-ground environment. However, the significant length of the ramp would have seen a large proportion of Grey Street and Queens Wharf dedicated to vertical circulation, interrupting ground level activity. Therefore all the entrances are accessed by means of stairs, except the main entrance which is located within the main volume of the building and is therefore able to be manipulated. Although this is considered less desirable as it creates abrupt transitions between levels, ramps were not applicable on the streets as the location and dimensions as well as the edge conditions were severely constrained. However, the same constraints do exist to the same extend for the ramp within the building. This identifies that gradual transitions between levels at all access points cannot always be achieved and therefore should at least be applied to primary access points.

The purpose of the design case study was to provide a test to whether the underground space framework could aid in the successful nature of underground buildings by establishing strong physical connections between above and below-ground. The design case study demonstrates that the guidelines are flexible enough to be developed and adapted to the unique requirements of site and programme, while simultaneously being specific enough to ensure the successful creation of underground space.

CHAPTER EIGHT | DISCUSSION AND CONCLUSION

8.0 DISCUSSION

This chapter draws together the findings of the previous chapters of research to present the discussions and conclusions. Each of the preceding chapters has dealt with a distinct part of research; this chapter draws together those findings in response to the research aim.

The main intention of this research was to develop an underground space framework which underpins the successful design of underground buildings. The poorly conceived nature of contemporary underground space often means it has little to no contribution to its above ground environment, as it neglects the significant relationship it has to the ground plane. As a result of this omission towards its above-ground environment, urban design theory treats the underground as space only worthy for ancillary functions, where there is no acknowledgment of entirely underground buildings. Therefore this research examined the physical connections between above and below space, identifying a series of issues from which the underground space framework has been developed from.

An inherent tension between underground space and urban design is present throughout this research. Three key elements which drive this tension were identified. Firstly the principles of creating quality public space contrast the issues common to underground space. Secondly, contemporary underground spaces are significantly detached from their ground plane and therefore do not contribute to their above ground environment. Thirdly, current underground spaces are seen as undesirable urban spaces. Together these three elements highlight the inherent tension between underground space and urban design, driving the gap in underground space knowledge.

Contrasting Underground and Urban Design Principles:

The research identified that the issues frequent to underground space such as lack of building image, lack of definitive edges and lack of legibility, contrast with the basic principles of creating quality public space such as enclosure, activity, movement, legibility. This contrasting nature between urban design and underground space is continued through to the Underground Space Design Framework, where the categories of Building Exterior, Building Entrance, Interior Configuration, Vertical Circulation, Natural Light and Sightlines Lines have been developed in response to the issues creates above-ground from underground architecture. As these categories address basic urban design principles they create underground spaces which differ little from their above-ground environment. These somewhat conventional categories contrast significantly from the category of Spatial Image which has been developed from the underground archetypes and therefore possess a profound sense of being underground.

The design case study continues this apparent contrast where many of the spaces within the museum, especially those closest to the ground plane, do not have a profound sense of being underground, as they attempt to respond to the above-ground environment and therefore appear as relatively conventional above-ground space. Therefore, the design case study demonstrates that the guidelines, as applied, produce distinctive external architecture but relatively conventional internal architecture. Although this conventional internal architecture is considered more desirable urban space it negates the unique sense of being underground, reinforcing the inherent contrast throughout the research.

This inherent contrast throughout the underground space design framework and the design case study highlights the importance of integrating the two distinctive sets of categories. This integration ensures that the unique nature of underground space is expressed while simultaneously ensuring that underground space is considered desirable, and that underground issues apparent from the ground plane are addressed and resolved. Therefore, although the guidelines appear conventional, what makes them unique to underground space is the physical form which the building must take to achieve them.

Avoiding Detachment from the Ground Plane:

The research also identified that current underground space is significantly detached from its ground plane, and therefore does not actively contribute to its above ground environment. Therefore, for underground space to be considered successful and contribute to its above ground environment it must establish strong physical connections between above and below ground environments.

The design case study demonstrates that the underground space design guidelines establish the physical form which the building must take to create these necessary connections. However, the design case study also goes beyond these elementary underground space design guidelines, and establishes physical connections that are unique to the building and its site. Such design moves include the blurring of the ground plane, allowing internal and external spaces to be integrated, and by revealing the rich underground history of the site. These design outcomes demonstrate that buildings must go beyond the guidelines and establish strong physical connections between above and below ground space through specific and carefully considered design moves unique to the building.

Combating the Assumption that Underground Space Detracts from the Public Domain:

Underground buildings can also successfully contribute to their above ground environments by resolving specific urban design issues present above ground. This research identified that urban design literature does not typically favour the underground as a viable solution to site specific problems, where underground urban space such as underpasses and sunken plazas are considered as ancillary, undesirable spaces and are therefore unsuccessful. However, the design case study integrated the pedestrian underpass into the museum programme, allowing pedestrians to view the exhibition spaces without having to physically enter the museum. This demonstrates that ancillary spaces can be carefully integrated with the building programme, creating a dependant relationship between the two to ensure that underground space is seen

as a desirable urban response. Underground space should therefore be considered as a viable option in resolving possible above ground urban design issues, where if successfully achieved, can contribute to its above ground environment.

Underground Space Vocabulary:

The research also identified that currently there is no established terminology to identify and describe the various forms of which underground space can take. However, from the taxonomy analysis in which 90 examples were analysed with respect to their physical from, five key physical attributes which make up underground space were identified. These being: Depth, Aperture, Ground Plane manipulation, Spatial Structure and Geometry. Within each of these attributes, variants were established. Together these attributes and variants form a set of terminology to describe the physical forms of underground space. The taxonomy analysis demonstrates how the terminology is specific enough to describe the existing forms of underground architecture while the design case study demonstrates how it can be used to describe new underground forms.

Overarching Design Approach:

This research ultimately demonstrates that the underground space framework can underpin the successful design of underground space through establishing strong physical connections between below-ground and above-ground public space. However, for these strong connections to be achieved:

- Appropriate guidelines should be selected in response to the buildings unique programme and site.
- Selected guidelines should then be developed and applied in a way which contributes to the above ground environment and the underground programme.

- The relationship between the various categories within the guidelines should be carefully considered so that the unique nature of underground space is expressed while simultaneously ensuring that underground issues apparent from the ground plane are addressed and resolved.
- The building must not only follow the underground space design framework, but must also use specific design moves to establish strong physical connections between above and below ground environments.
- Underground ancillary functions must be integrated with other underground programmes to be considered successful.
- Guidelines should seek to resolve specific urban design issues relevant to the site.

8.1 LIMITATIONS AND FUTURE RESEARCH

One of the obstacles facing the guidelines is the difficult negotiation between the buildings architectural concept and the prescriptive guidelines. There must be a necessary compromise between the two to ensure that the architectural concept in inherent throughout the design while ensuring that the guidelines still aid the successful design of underground space. This compromise may establish a hierarchy, where the effectiveness of the guidelines is reduced in order to ensure that the architectural concept is effective, or vice versa. Future research could therefore address this degree of compromise, establishing the various ways in which the guidelines can be manipulated and integrated with design elements, while remaining effective.

The design case study demonstrates how the guidelines can be selected and applied in response to a museum programme. The specific interior environment needed in museums means that they can be considered internalised where natural light and exposure must be limited. As a result of this, the guidelines used in the design case study may not necessarily demonstrate the way in which the guidelines can be developed

to create the strongest possible connections between above and below-ground. Future research could therefore address how the guidelines could be selected, developed and applied to a less internalised public programme, one that requires a stronger connection to its surrounding environment to be considered successful. Alternatively future research could also address how the guidelines could be developed for private programmes, such as schools and office buildings.

Although the design case study demonstrates that it was appropriate to build underground on Post Office Square, it would be essential to carry out a feasibility study of underground space for each unique site and programme to determine whether underground space is necessarily the best solution.

8.3 RESEARCH CONCLUSION

Despite these limitations, the design case study still demonstrates how these guidelines can be used to underpin the successful design of underground buildings by creating strong connections between above and below-ground. Following further research it would be hoped that the successful nature of underground space would establish the underground as a viable building type for various programmes, while being seen to actively contribute to it above ground environment.

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APPENDIX

Appendix A: Taxonomy Catalogue

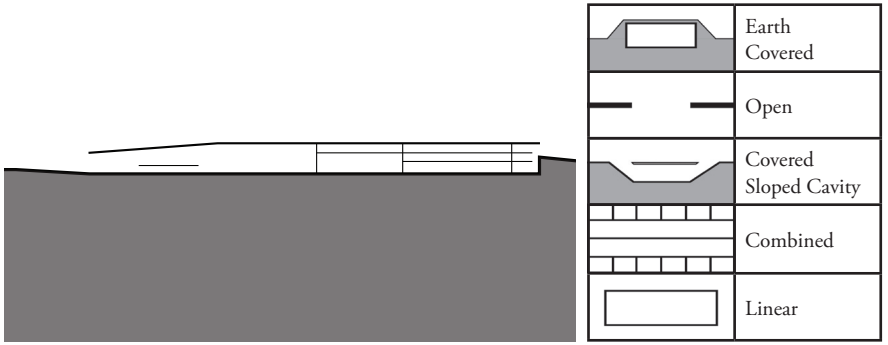
BUILDING	ARCHITECT	CITY	COUNTRY	YEAR	PROGRAMME	STATUS
Almere Masterplan	OMA	Almere	The Netherlands	2007	Masterplan	Under Construction
Andalucia's Museum of Memory	The MA: Alberto Campo Baeza	Granada	Spain	2008	Museum	Complete
Arnhem Carpark	UN Studio	Arnhem	The Netherlands	2002	Carpark	Complete
Basel Burghof	OMA	Basel	Switzerland	2009	Museum	Competition
Beelden Aan Zee Museum	Wim Quist	Harteveldstraat	The Netherlands	1993	Museum	Under Construction
Bell Lloc Cellars	RGR Aranda Pigem Vilalta Architects	Bell Lloc	Spain	?	Cellar	Proposal
Benetton Communication Research Center	Tadao Ando	Treviso	Italy	2000	Offices	Complete
Blue Ridge Elementary School	Walker McGough Foltz Lyerla	Washington	USA	1982	Education	Complete
Brussels Meeting Centre	A2RC Architects	Brussels	Belgium	2009	Square	Proposal
California State Office Building	The Bentham Group	California	USA	?	Office	Complete
Capodichino Underground Station	Rogers Stirk Harbour + Partners	Naples	Italy	2006	Transportation	Proposal
Chicago Childrens Museum	Krveck & Sexton Architects	Chicago	USA	2011	Museum	Proposal
Chichu Art Museum	Tadao Ando	Naoshima	Japan	2004	Museum	Complete
Civil and Mineral Engineering Building	BRW Architects	Minnesota	USA	1983	Education	Complete
Concert Hall Under the Parade	A Becker	Den Bosch	The Netherlands	?	Arts	Proposal
Councils Chamber	Stéphane Bigoni and Antoine Mortemard	Brest	France	2011	Chambers	Proposal
Embassy of the Czech Republic	Your Building Here	Washington DC	USA	2009	Embassy	Proposal
Ewha Campus Centre	Dominique Perrault	Seoul	Korea	2004	Museum	?
Extension of the Zaragoza Museum of Fine Arts	OMA	Zaragoza	Spain	2006	Museum	Competition
Faculty of Theatre and Dance Artez	Gerrit Rietveld	Arnhem	The Netherlands	1958	Arts	Complete
Florence TAV Station	Foster and Partners	Florence	Italy	2003	Transporation	Under Construction
Fovam ter Station	Spora Architects	Chicago	USA	2010	Transporation	Complete
Friedrichstrasse	Jean Nouvel Paris	Berlin	Germany	1996	Retail/Offices	Complete
Garden of Fine Art	Tadao Ando	Kyoto	Japan	1994	Museum	Complete
Glass Temple	Takashi Yamaguchi and Associates	Kyoto	Japan	1998	Temple	Complete
Guggenheim Museum in Rio De Janeiro	Jean Novel	Rio De Janerio	Brazil	2002	Museum	?
Holaday Circuits	BRW Architects	Minnesota	USA	1981	Retail	Complete

BUILDING	ARCHITECT	CITY	COUNTRY	YEAR	PROGRAMME	STATUS
Holocaust History Museum at Yad Vashem	Moshe Safdie	Jersualem	Israel	2005	Museum	?
Hompukuji Water Temple	Tadao Ando	Awajishima	Japan	1991	Temple	Complete
Invisible House	Tadao Ando	Milan	Italy	1999	House	Complete
Itakeskus Swimming Pool	Hyuamaki Karhunen Parkinen Archtiects	Helsinki	Finland	1993	Recreation	Complete
Joe and Rika Mansueto Library	Helmut Jahn	Chicago	USA	2011	Library	Proposal
Jubliee Line, Canary Wharf	Foster and Partners	London	England	1998	Transporation	Complete
Kimbell Museum	Renzo Piano	Texas	USA	2008	Museum	Proposal
Kolner Philharmonie	Peter Brushmann, Godfri	Cologne	Germany	1986	Arts	Complete
Kunstmuseum Extension	Christ & Gantenbein	Lucerne	Switzerland	2010	Museum	Competition
Langen Foundation/ Hombroich	Tadao Ando	Neuss	Germany	2004	Gallery	Complete
Le Carrousel Du Louvre	I.M Pei Duval	Paris	France	1992	Museum	Complete
Le Van Tam Underground Car Park	?	HCM City	Vietnam	2006	Carpark	Proposal
Leon Municipal Funerary Services	BAAS	Leon	Spain	2000	Office	Complete
Les Halles	OMA	Paris	France	2003	Retail	Proposal
Lucille Halsell Conservatory	Emilio Ambasz	Texas	USA	1980	Conservatory	Complete
M9 Memorial	Gonzalo Mardones Viviani	Santiago	Spain	2011	Memorial	Competition
Mauritshuis	Hans van Heeswijk Architects	The Hague	The Netherlands	2010	Museum	Proposal
Memorial to the Murdered Jews of Europe	Peter Eisenman	Berlin	Germany	2005	Memorial	Complete
Moscone Convention Centre	Hellmuth, Obata & Kassabaum	San Fransico	USA	?	Retail/Offices	Complete
Museum	Alessandro Console, Giudutta Benedetti, Alessio Cancellieri	?	?	?	Museum	Proposal
Museum for the Royal Collection	Zaha Hadid	Madrid	Spain	1999	Museum	Complete
Museum Heldenberg	Peter Ebner & Franziska	Heldenberg	Austria	2005	Museum	Complete
Museum of Judenplatz	Jabornegg and Palffy	Vienna	Austria	2000	Museum	Complete
Museum of Modern Art Tower	Peter Ebner	Salzburg	Austria	2001	Museum	Complete
Museum of the Holocaust	Belzburg Architects	Los Angeles	USA	2010	Museum	Complete
Museum of WWII	ARHIS	Gdańsk	Poland	2011	Museum	Competition

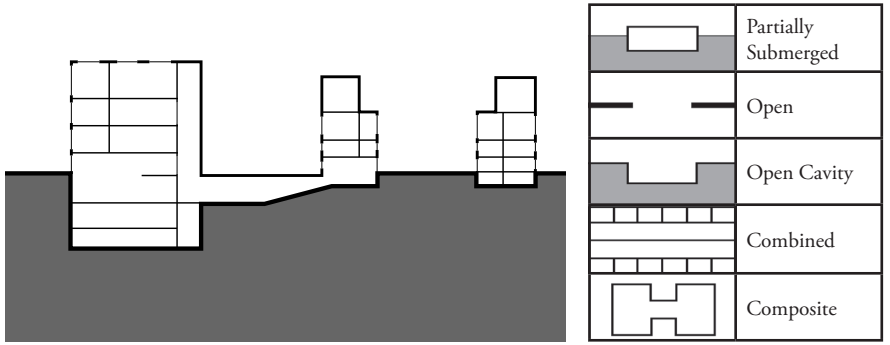
BUILDING	ARCHITECT	CITY	COUNTRY	YEAR	PRO-GRAMME	STATUS
Museum of WWII in Gdańsk	Brochet Lajus Pueyo	Gdańsk	Poland	2011	Museum	Competition
Museumplein, Van Gogh Museum	Kisho Kurokawa, Greiner	Amsterdam	The Netherlands	1998	Museum	Complete
Mutual of Omahia Headquarters Addition	Leo A Daly Company	Omaha	USA	1979	Offices/ Retail	Complete
Nathan Marsh Pusey Library	High Stubbins and Associates	Cambridge	USA	1976	Library	Complete
National Museum of History and Art	Christian Bauer and Associates	Luxembourg	Luxembourg	2002	Museum	Complete
National September 11th Memorial and Museum	Michael Arad/Handel Architects LLP	New York City	USA	2004	Memorial	Under Construction
New Cantina Antinori at Bargino	Archea Associati	Florence	Italy	2008	?	Proposal
Nordpark Cable Railway	Zaha Hadid and Patrick Schumacher	Innsbruck	Austria	2007	Transporation	Complete
Nydalen Metro Station	Kristin Jarmund	Oslo	Norway	2004	Transporation	?
Phoenix Museum of History	Emilio Ambasz	Phoenix	Arizona	1989	Museum	Complete
Plaza Del Torico	Fermin Vazquez	Teruel	Spain	2007	Plaza	?
Plaza Mayor	Emilio Ambasz	Salamanca	Spain	1982	Plaza	Proposal
Prado Museum	S33 Architecture and Urbanism	Madrid	Spain	1995	Museum	Proposal
Qumran Winery	Konkrit Blu Arquitectura	Peñafiel	Spain	2010	Winery	Proposal
Research and Multimedia Centre	Massimiliano Fuksas	Vicenza	Italy	2004	Offices	?
Rijksmuseum Museum	Cruz and Orti	Amsterdam	The Netherlands	2007	Museum	Complete
Samuel Beckett Theatre Project	Norman Foster	London	England	1978	Arts	Competition
Saxton federal Library	Orten & Orten	Dresden	Germany	2002	Library	Complete
Shibuya Project	Tadao Ando	Tokyo	Japan	1987	Retail	Proposal
Shopping Centre	Emilio Ambasz	Holland	The Netherlands	?	Retail	Proposal
Souterrain	OMA	The Hague	The Netherlands	2004	Transporation	Complete
Tara House and Tara Baoli	Studio Mumbai	Alibag	India	2005	Recreation	Complete
Temppeliaukio Church	Timo and Tuomo Suomalainen	Helsinki	Finland	1969	Church	Complete
Terraset and Terra Centre Elementary Schools	Douglas N. Carter	Virginia	USA	?	Education	Complete
The Dok	Zuidas Company	Amsterdam	The Netherlands	2008	Transportation	Proposal
Therme Vals	Peter Zumthor	Vals	Switzerland	1996	Recreation	Complete
University of Michigan Law Library	Gunnar Birkits & Assoicates	Michigan	USA	1981	Education	Complete
V&A Boiler House Yard	OMA	London	England	2010	Plaza	Competition

BUILDING	ARCHITECT	CITY	COUNTRY	YEAR	PRO-GRAMME	STATUS
Vancouver Concert Hall Extension	Bing Thom Architects	Vancouver	Canada	2011	Arts	Proposal
Veranda Car Park	Paul de Ruiter	Rotterdam	The Netherlands	2009	Carpark	Complete
Villa Hoogerheide	Jo Crepain, Antwerp	HoogerHeide	The Netherlands	1999	House	Complete
Villa Vals	Search & CMA	Vals	Switzerland	2009	House	Complete
Walker Community Library	BRW Architects	Minnesota	USA	1981	Library	Complete
Westminster - Jubilee Line	Michael Hopkins Partners	London	England	1999	Transportation	Complete
Williamson Hall, University of Minnesota	BRW Architects	Minnesota	USA	1977	Education	Complete
Yates Fieldhouse	Daniel F. Tully Associates	Washington DC	USA	?	House	Complete
Zeeland Archives	Bentham Crouwel Architect	Middelburg	The Netherlands	1999	Archives	Complete

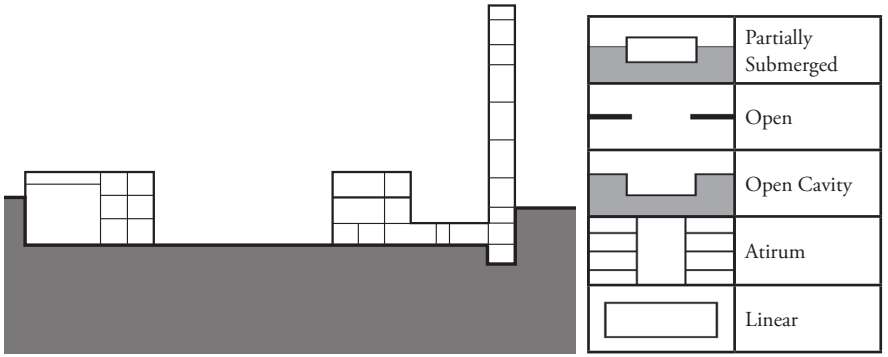
Appendix B: Taxonomy Analysis



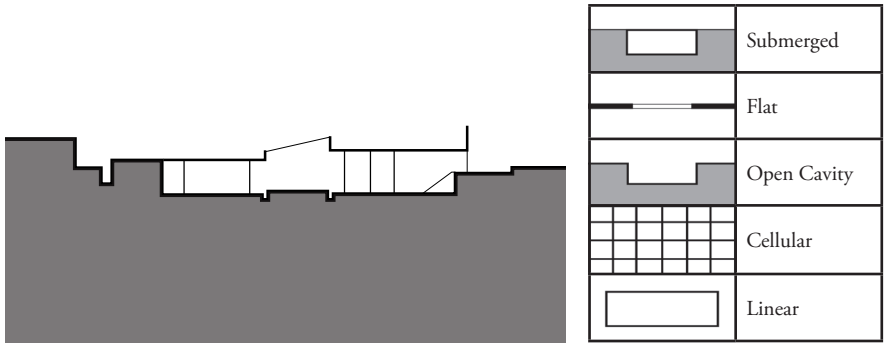
Almere Masterplan *1:1500*



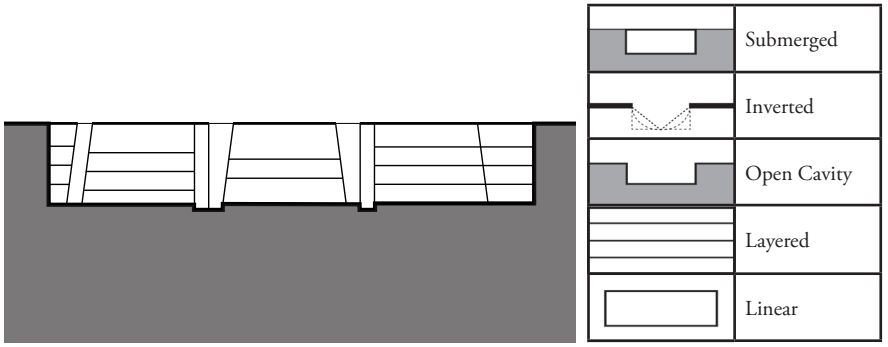
Basel Burghof *1:600*



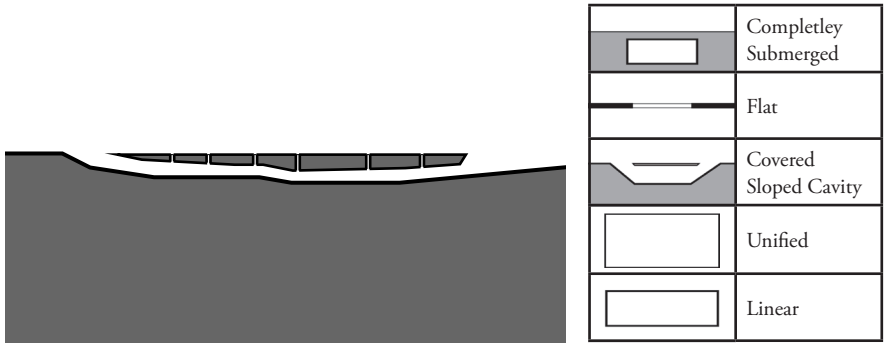
Andalucia's Museum of Memory *1:600*



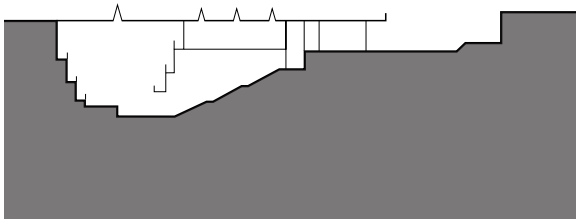
Beelden Aan Zee Museum *1:400*

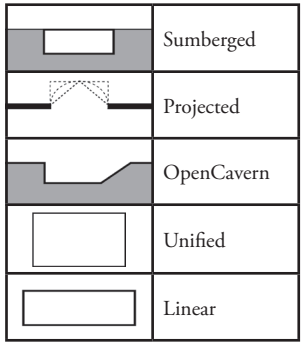


Arnhem Carpark *1:1000*



Bell Lloc Cellars *1:400*





Benetton Communication Research Centre

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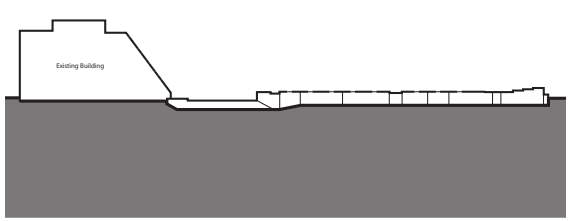
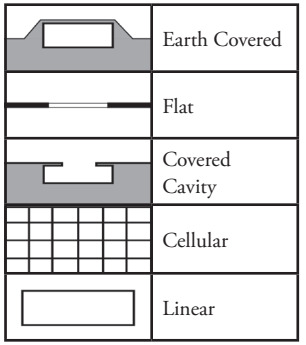
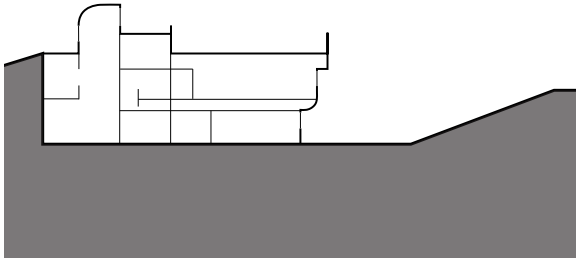
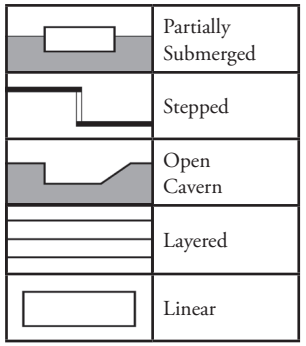




California State Office Building

1:1000





Blue Ridge Elementary School

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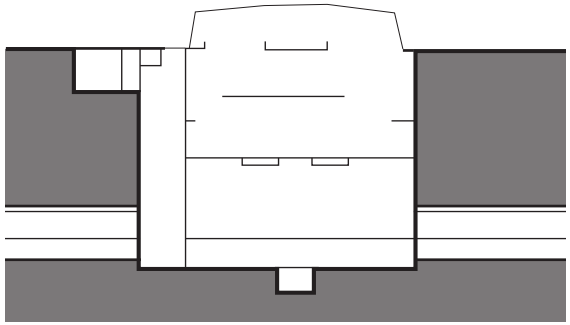

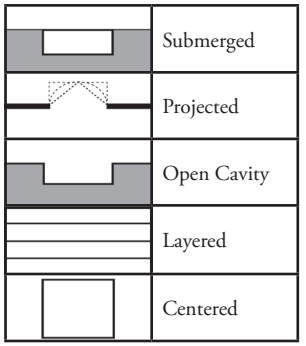

Capodichino Underground Station

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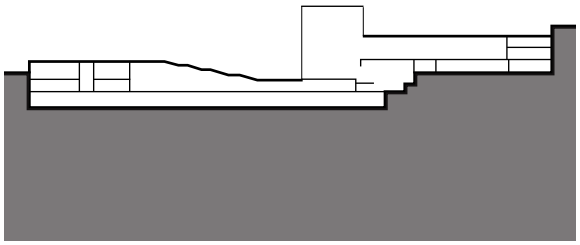

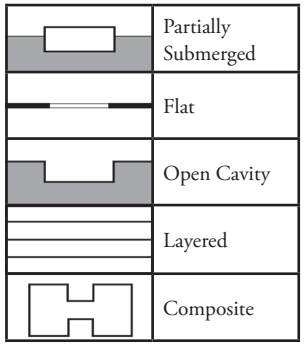

Brussels Meeting Centre

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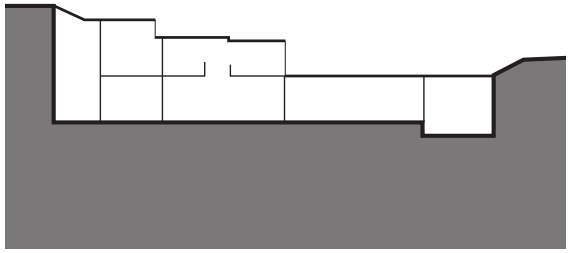

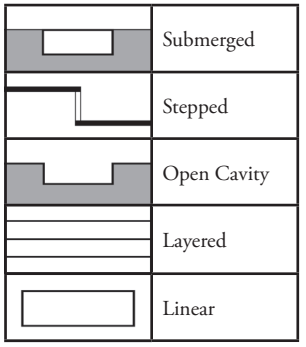

Chicago Childrens Museum

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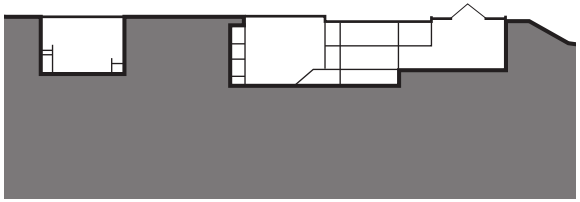

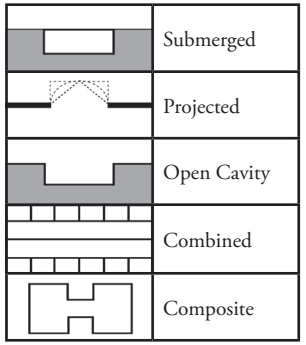

Chichu Art Museum

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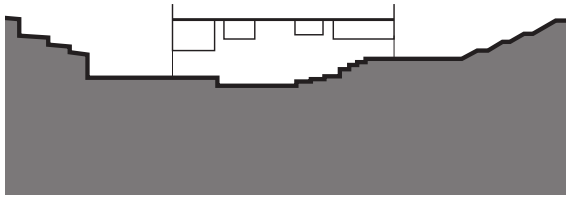

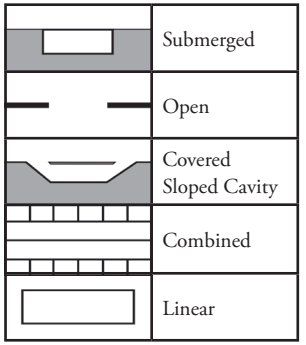

Councils Chamber

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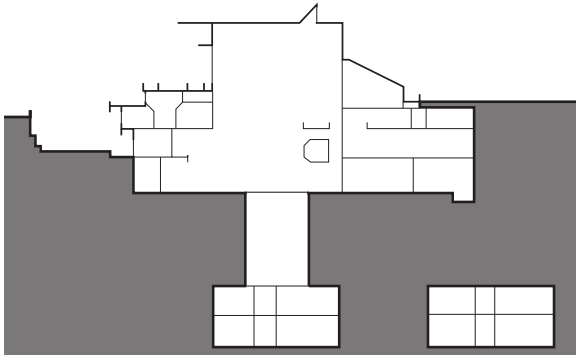

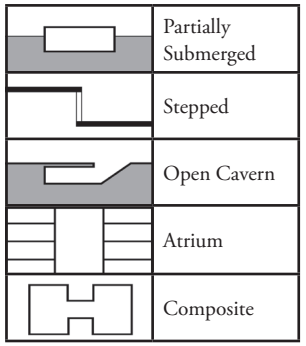

Civil and Mineral Engineering

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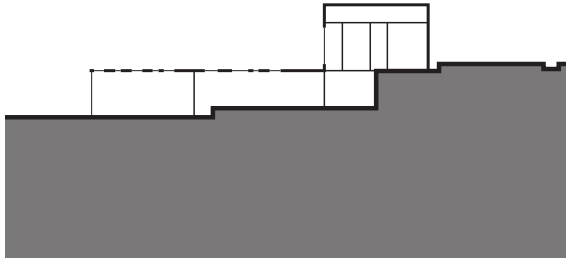

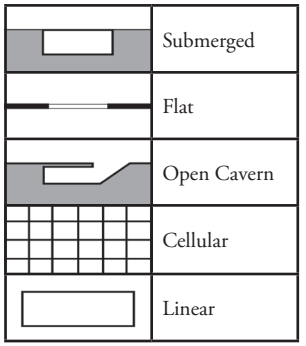

Embassy of the Czech Republic

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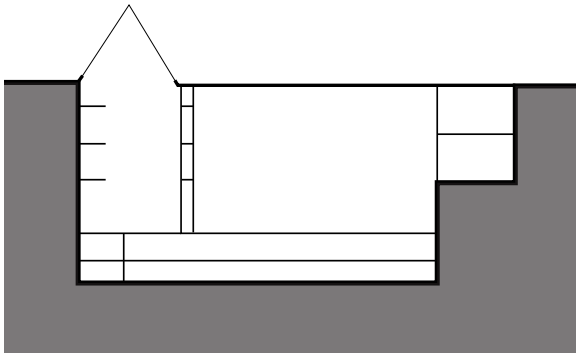

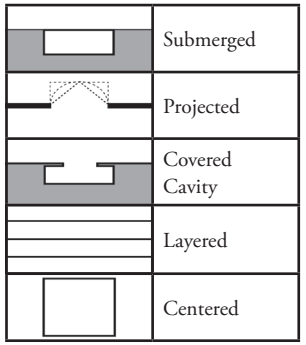

Concert Hall Under the Parade

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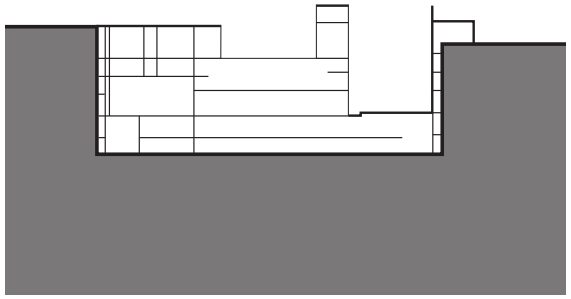

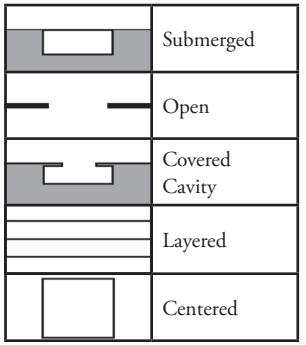

Ewha Campus Centre

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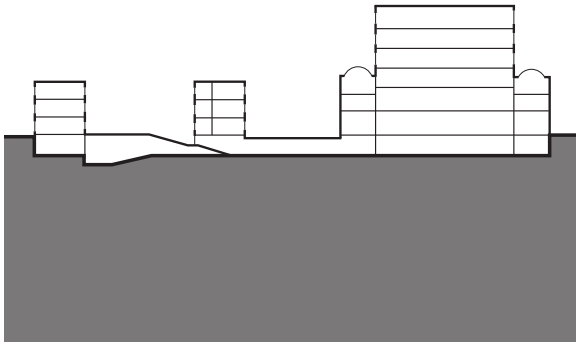

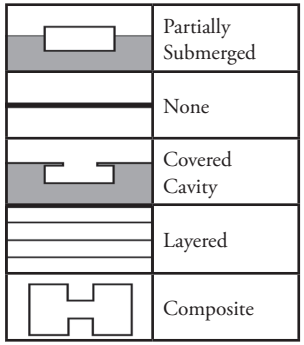

Extension of the Zaragoza Museum

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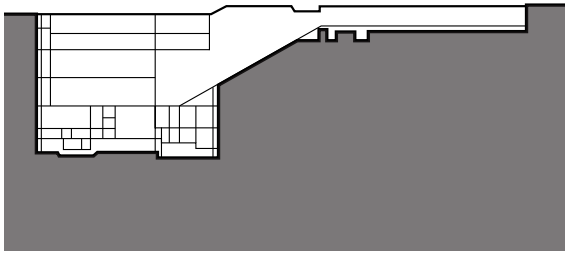
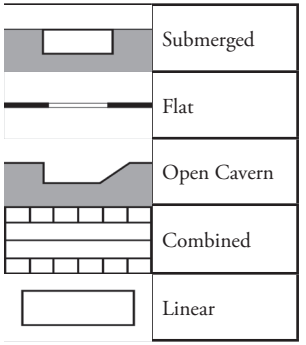
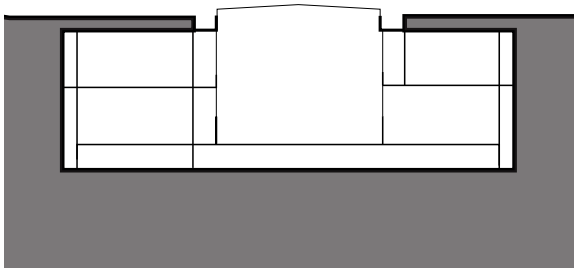
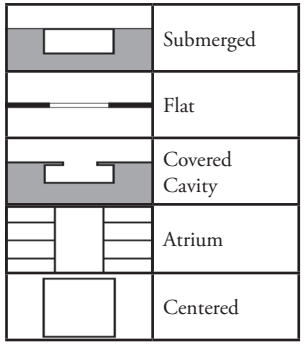




Fovam ter Station

1:800





Faculty of Theatre and Dance Artez

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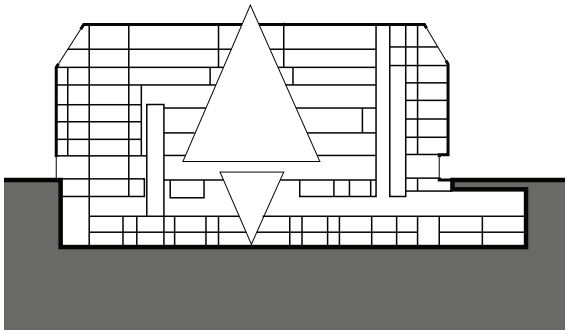
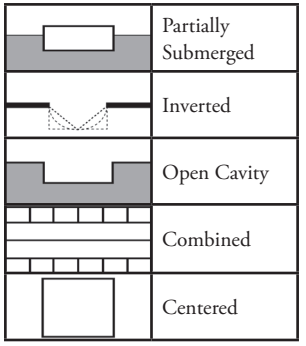
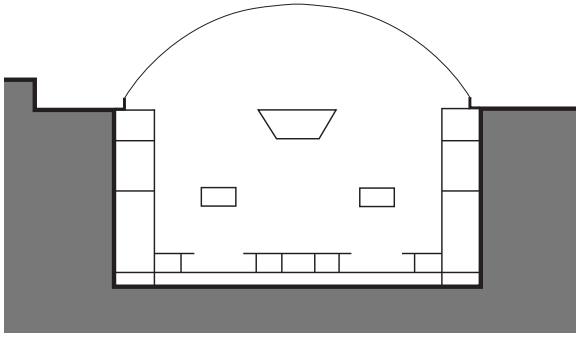
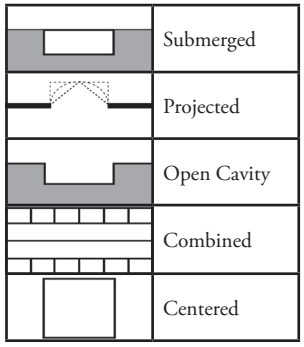




Friedrichstrasse

1:600





Florence TAV Station

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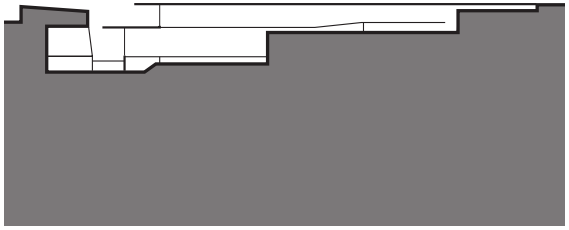
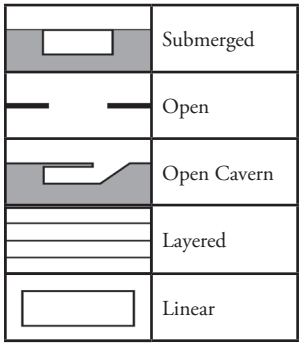
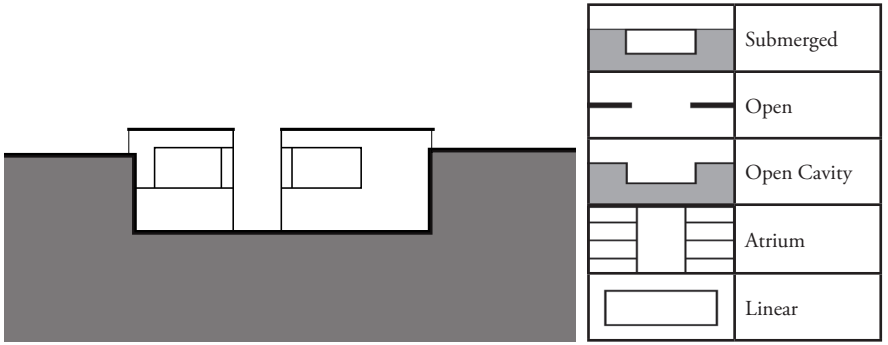




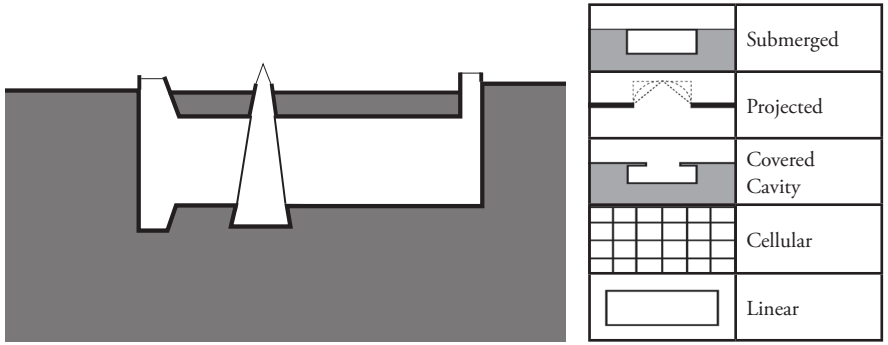
Garden of Fine Art

1:600



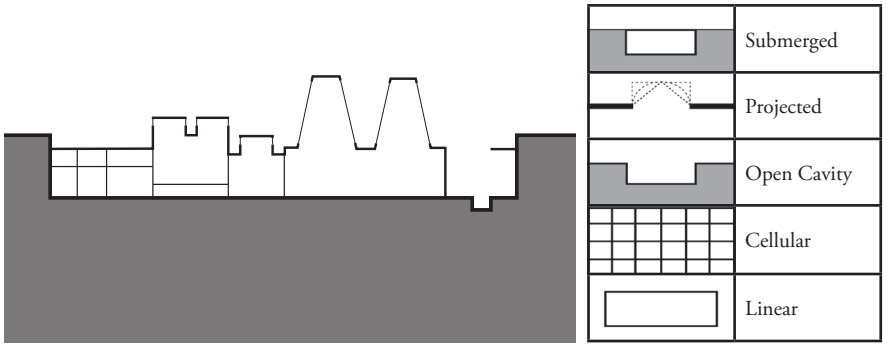
Glass Temple

1:300



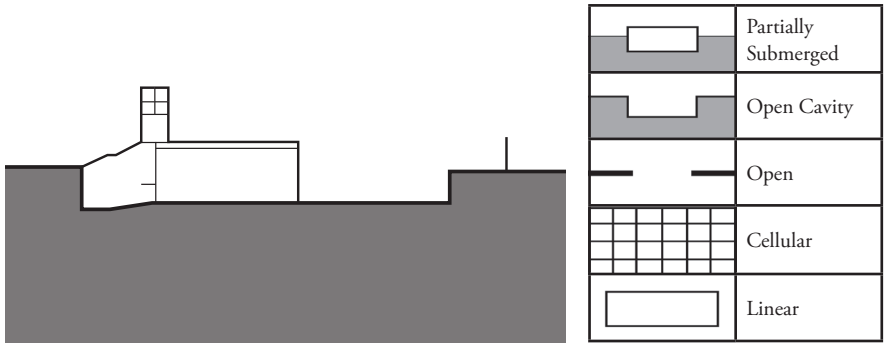
Holocaust History Museum at Yad Vashem

1:400



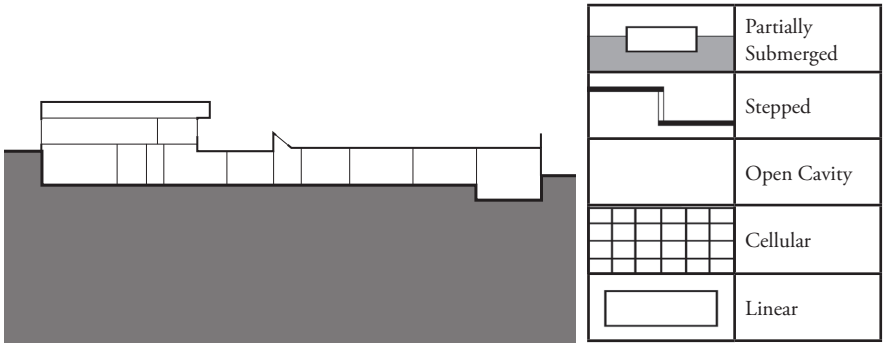
Guggenheim Museum in Rio De Janeiro

1:800



Hompukuji Water Temple

1:500



Holaday Circuits

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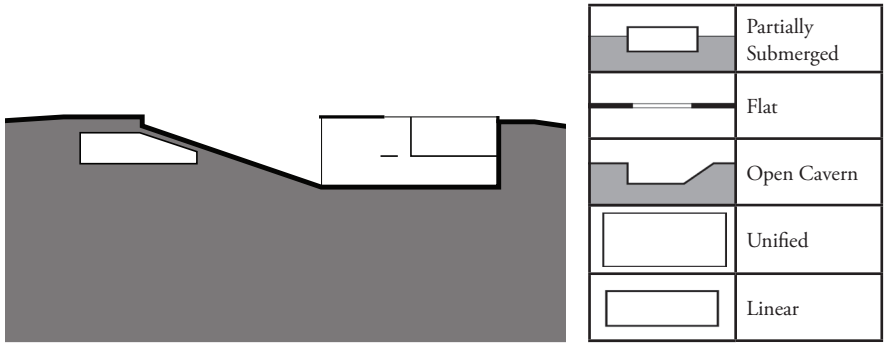
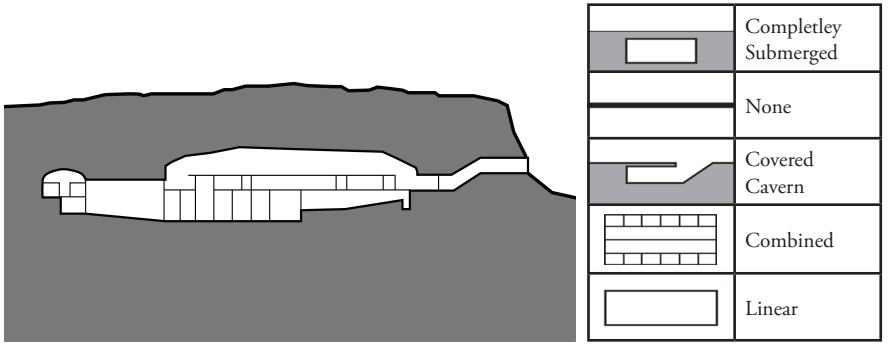


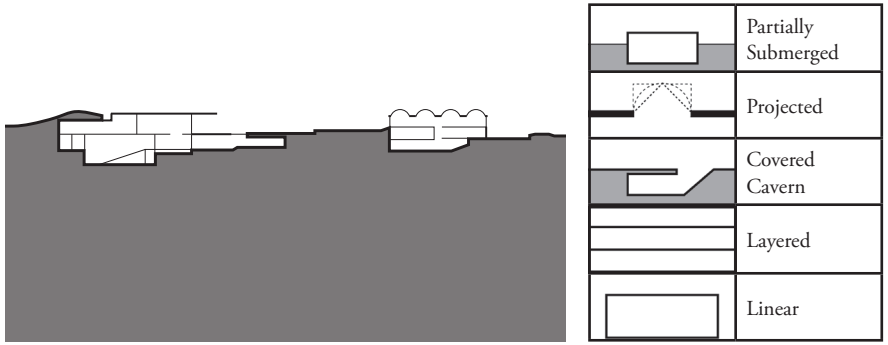
Invisible House

1:400



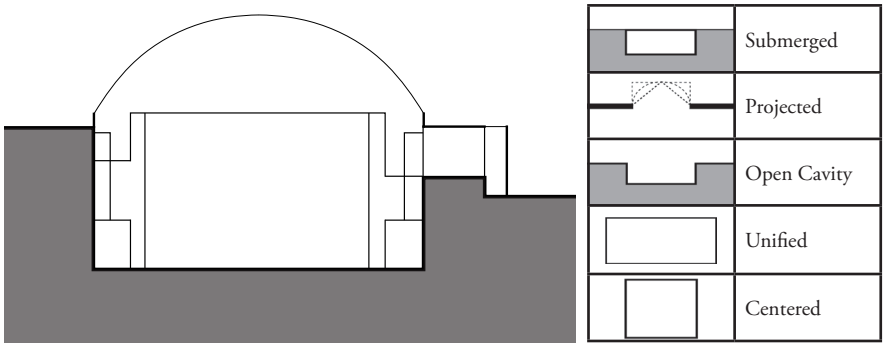
Itakeskus Swimming Pool

1:800



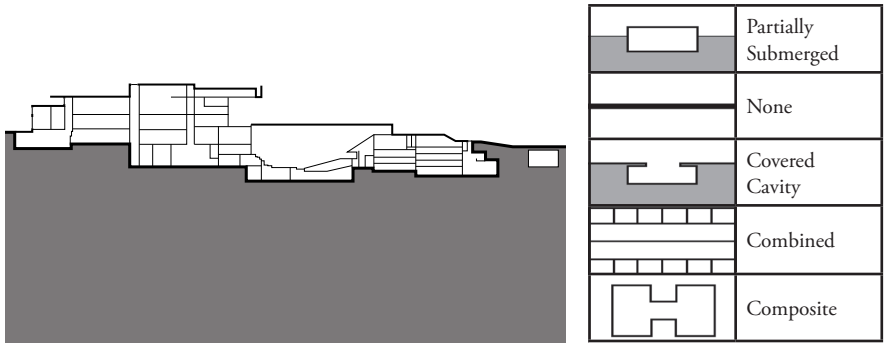
Kimbell Museum

1:800



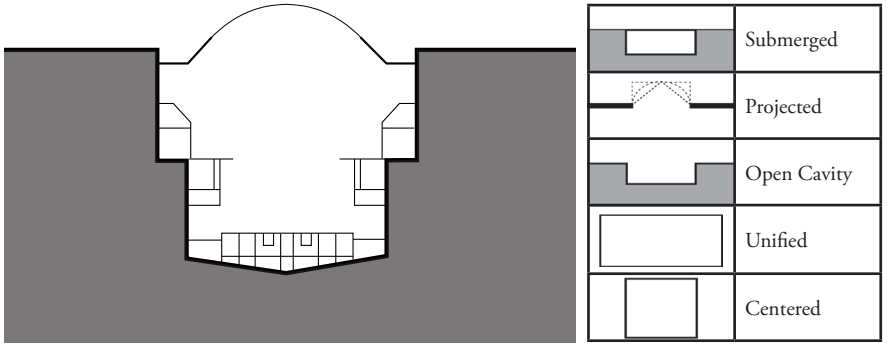
Joe and Rika Mansueto Library

1:600



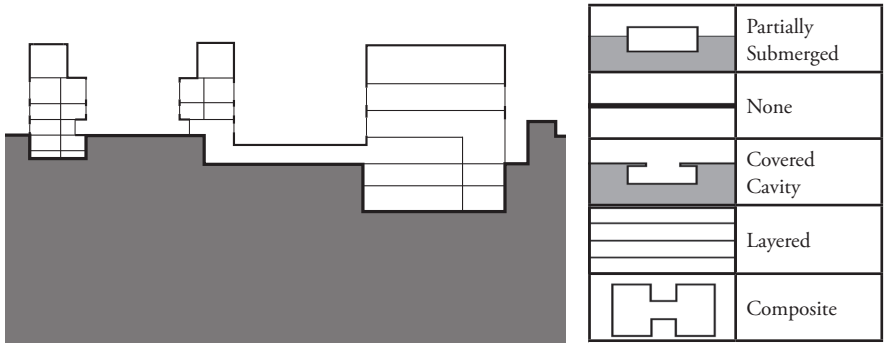
Kolner Philharmonie

1:1000



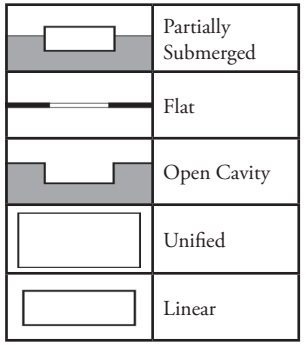
Jubliee Line, Canary Wharf

1:600



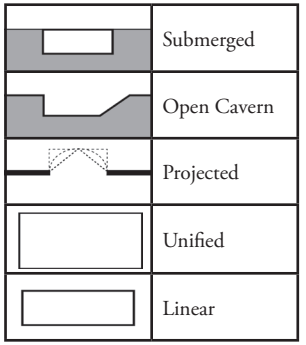
Kunstmuseum Extension

1:600



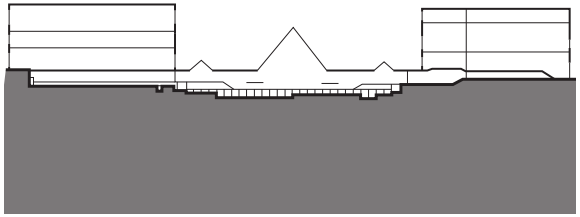
Langen Foundation/ Hombroich

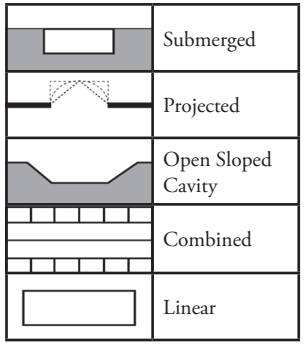
1:400



Leon Municipal Funerary Services

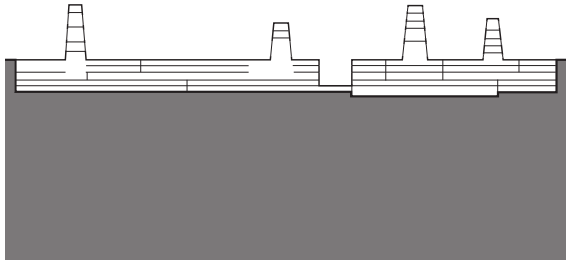
1:600

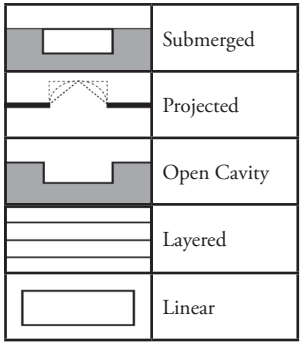




Le Carrousel Du Louvre

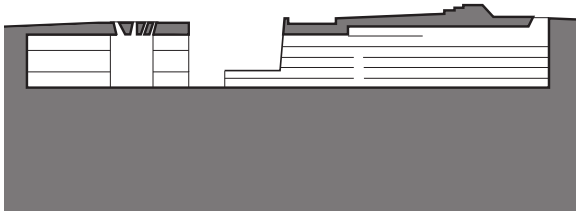
1:1200

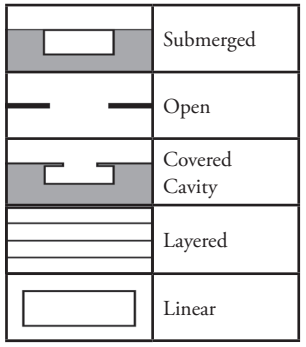




Les Halles

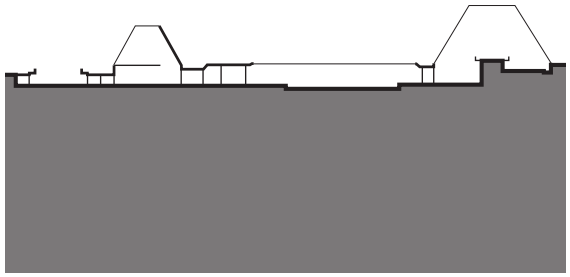
1:800

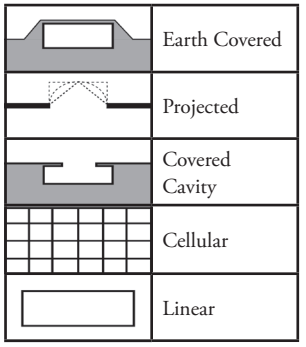




Le Van Tam Underground Car Park

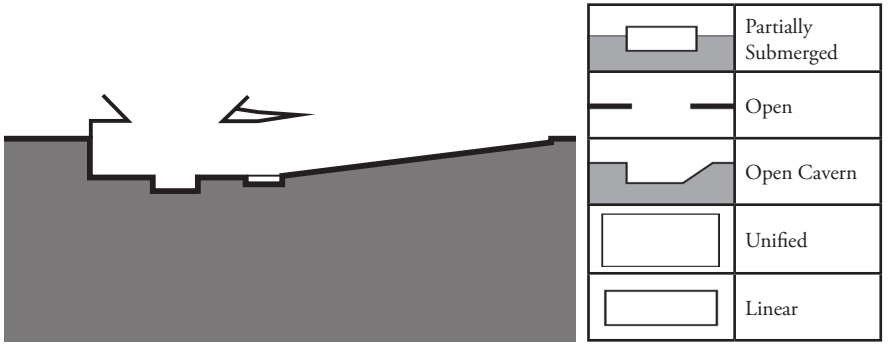
1:800





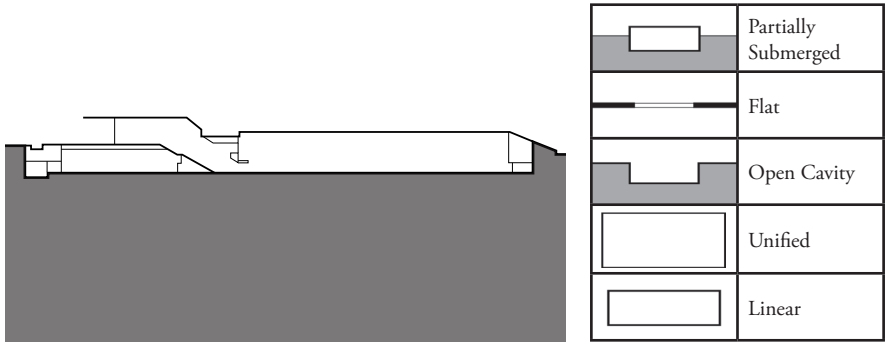
Lucille Halsell Conservatory

1:600



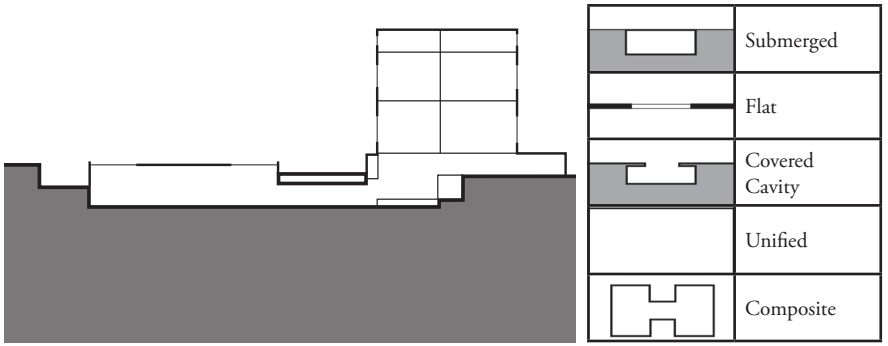
M9 Memorial

1:400



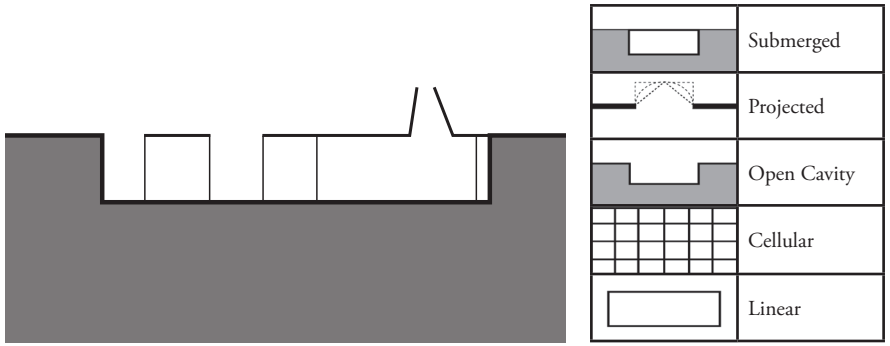
Moscone Convention Centre

1:600



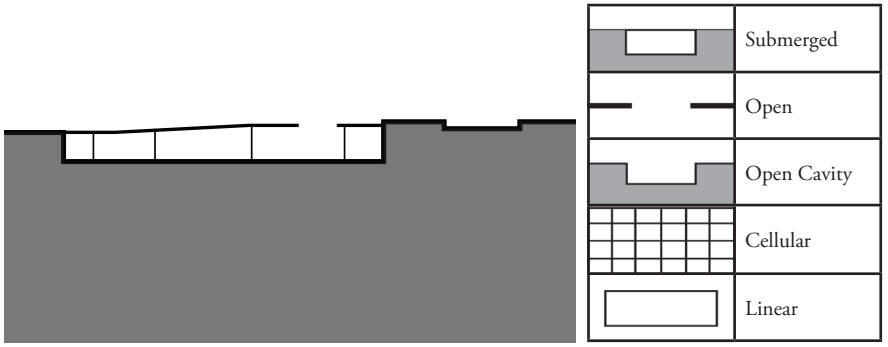
Mauritshuis

1:800



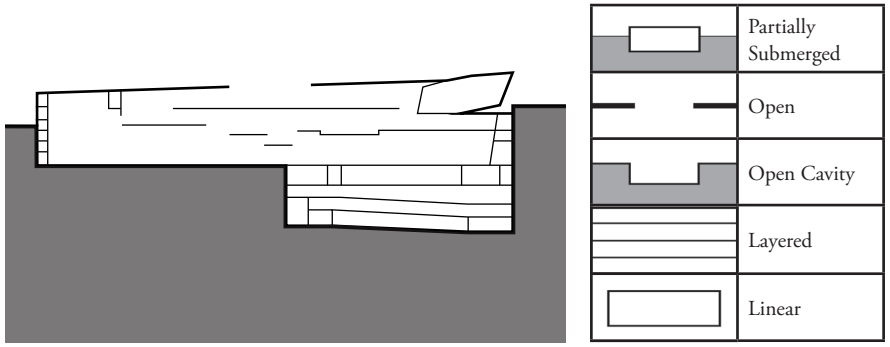
Museum

1:400



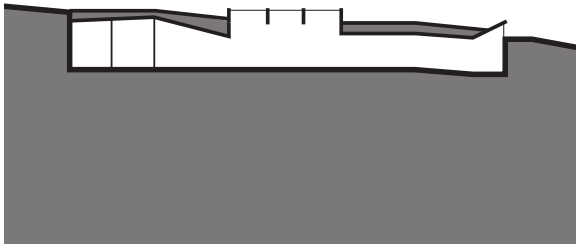
Memorial to the Murdered Jews of Europe

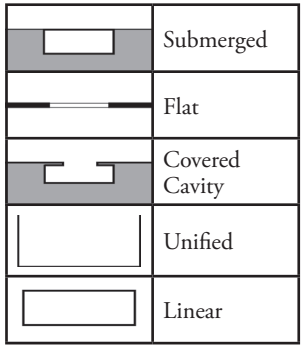
1:400



Museum for the Royal Collection

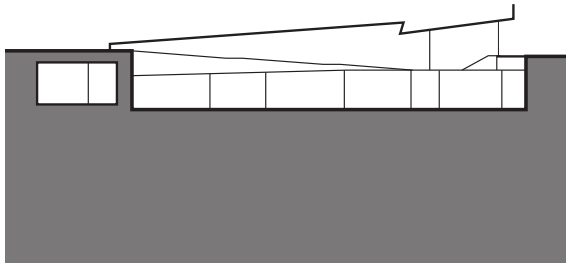
1:800

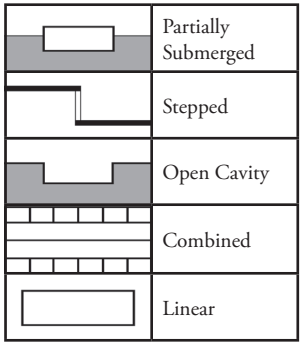




Museum Heldenberg

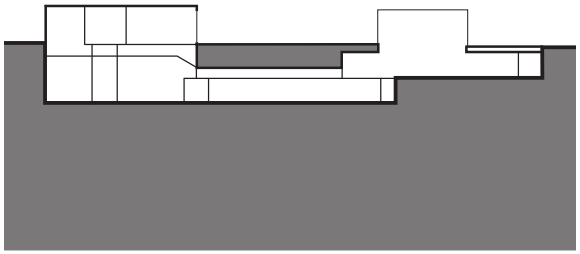
1:600

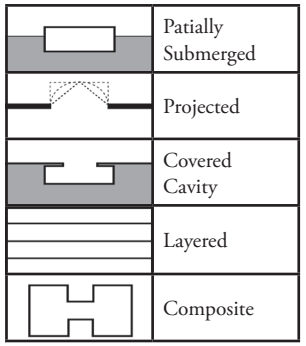




Museum of the Holocaust

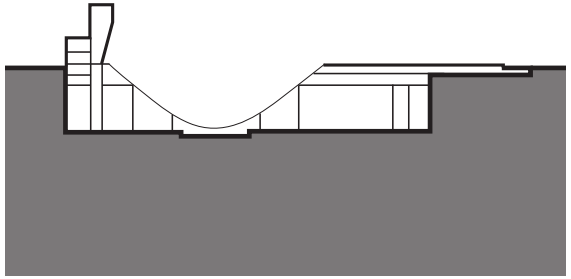
1:700

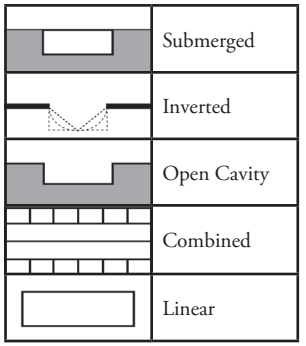




Museum of Judenplatz

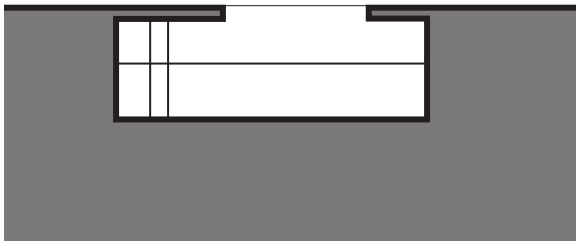
1:700

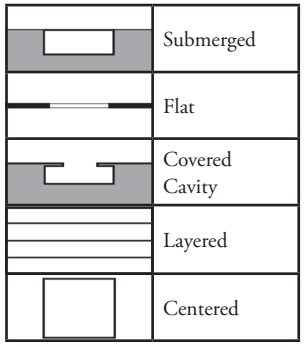




Museum of WWII

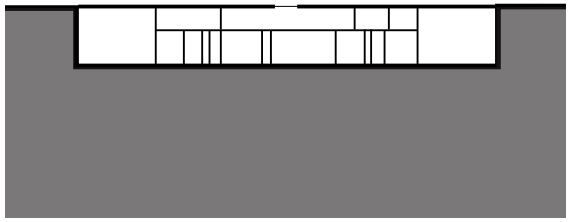
1:700

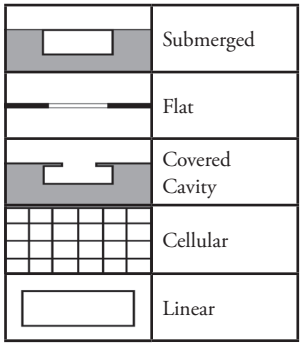




Museum of Modern Art Tower

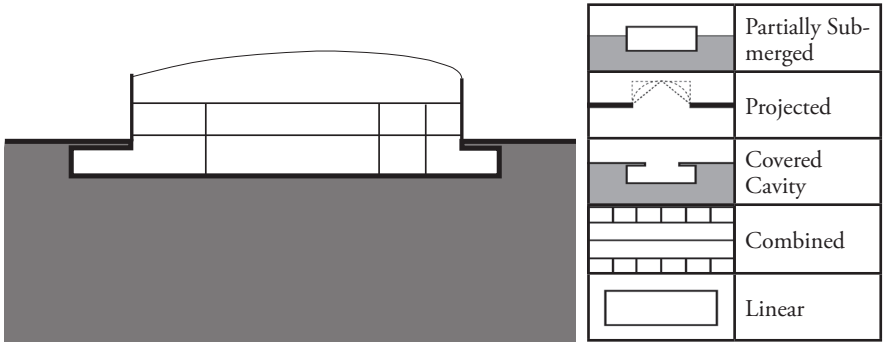
1:400



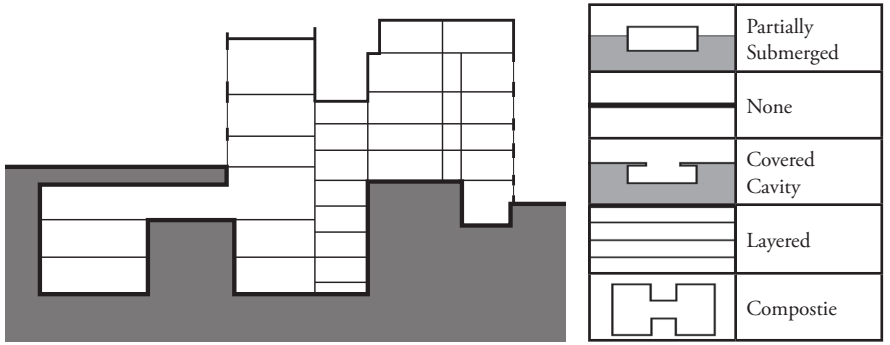


Museum of WWII in Gdańsk

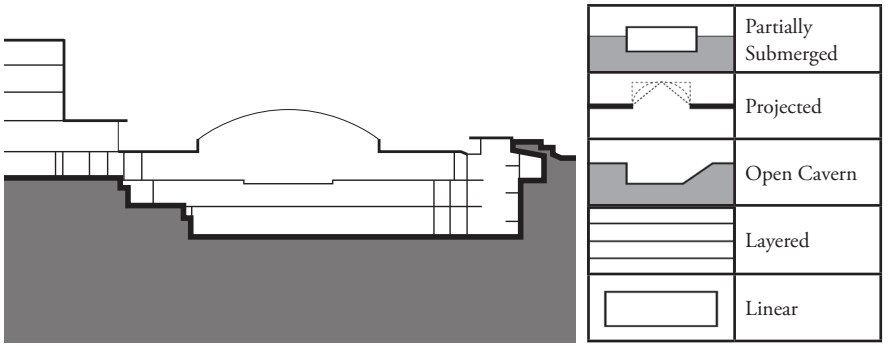
1:500



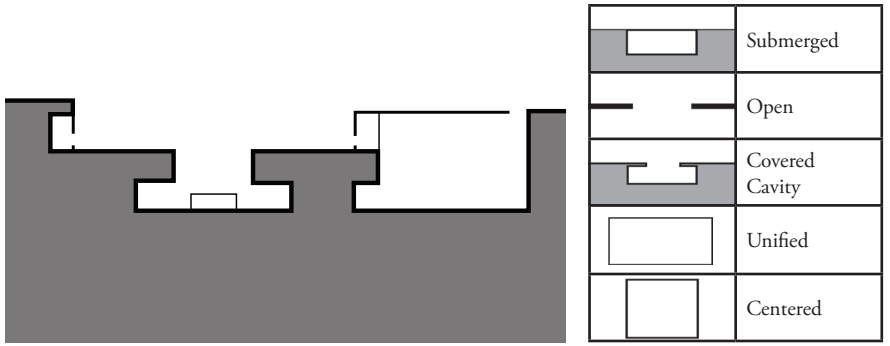
Museumplein *1:700*



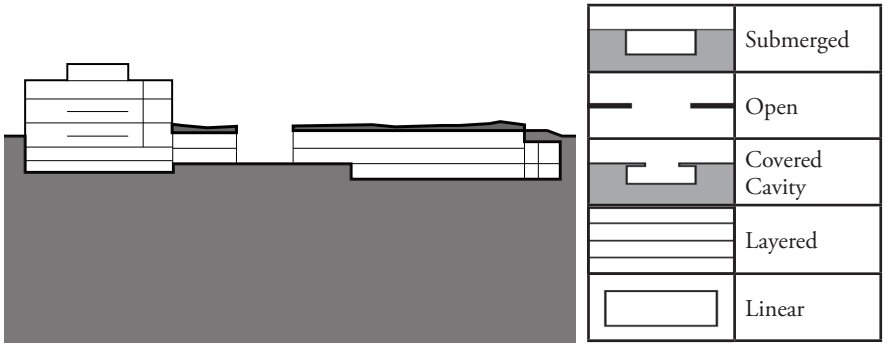
National Museum of History and Art *1:800*



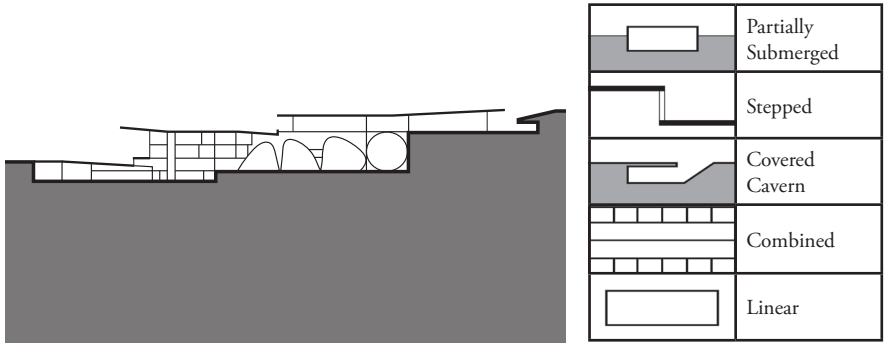
Mutual of Omahia Headquarters Addition *1:600*



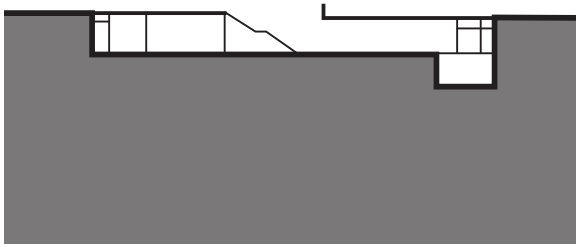
National September 11th Memorial and Museum *1:500*

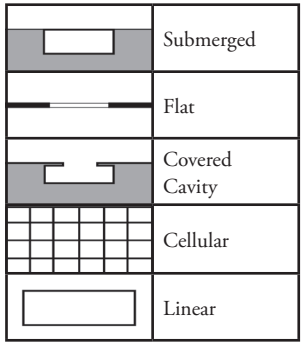


Nathan Marsh Pusey Library *1:900*



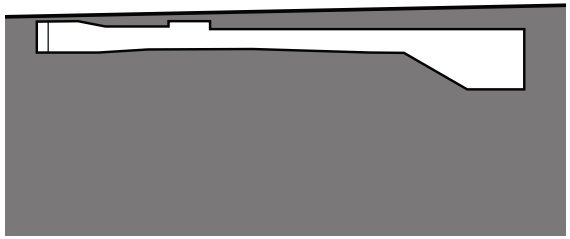
New Cantina Antinori at Bargino *1:1000*

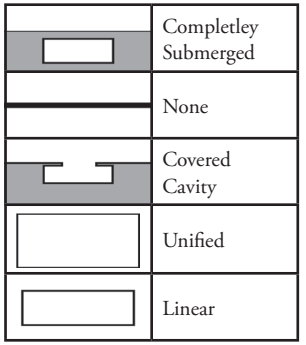




Nordpark Cable Railway

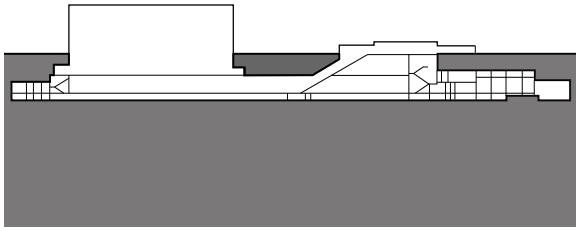
1:400

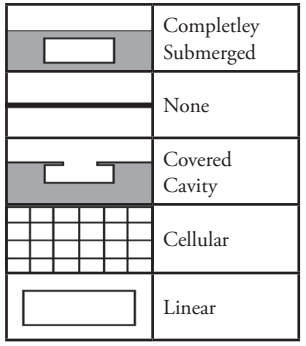




Plaza Del Torico

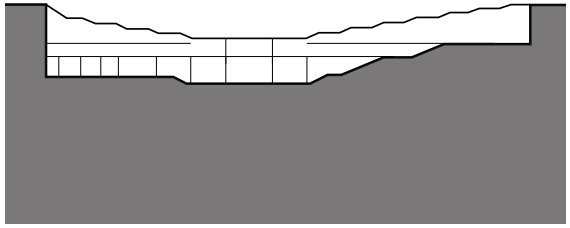
1:500

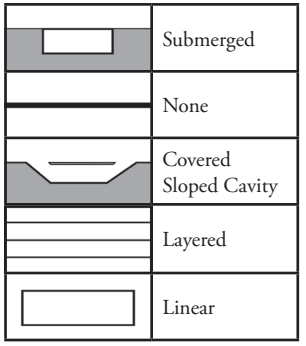




Nydalen Metro Station

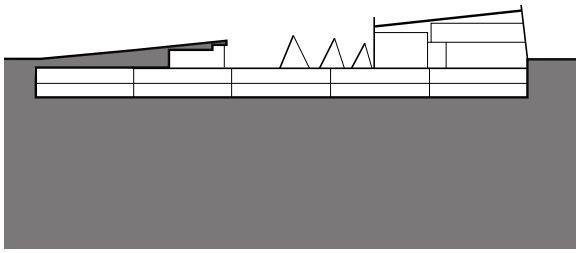
1:1000

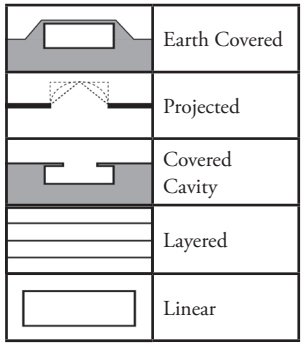




Plaza Mayor

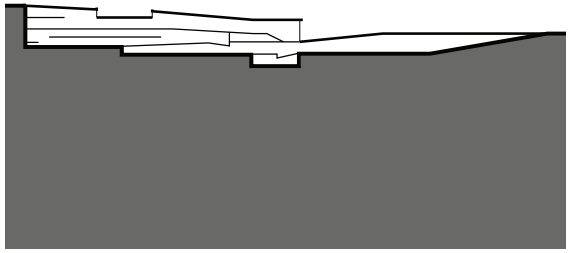
1:700

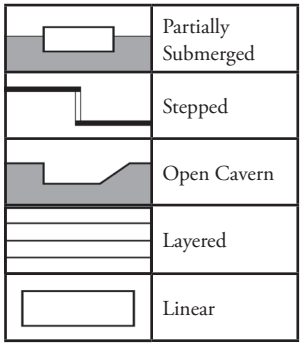




Phoenix Museum of History

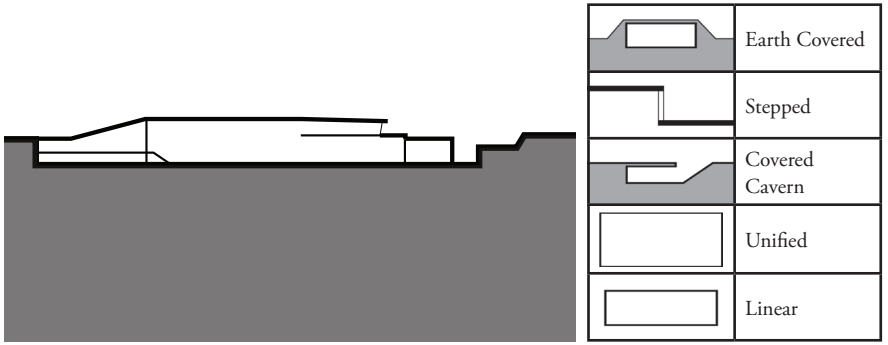
1:800



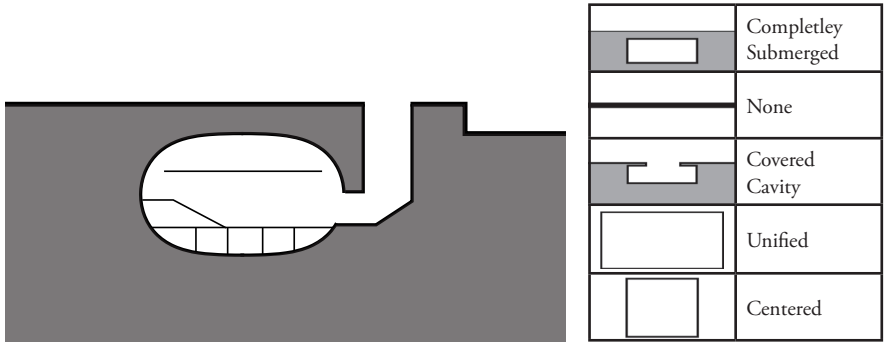


Prado Museum

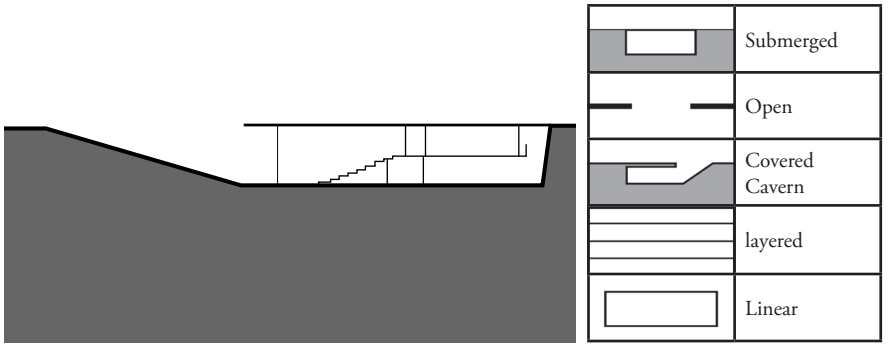
1:1200



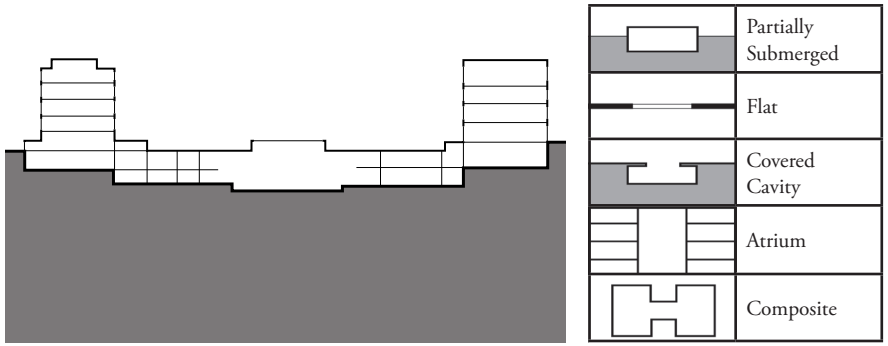
Qumran Winery *1:400*



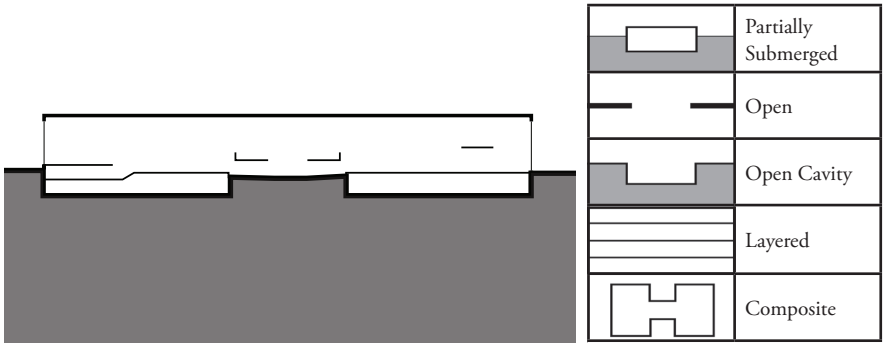
Samuel Beckett Theatre Project *1:600*



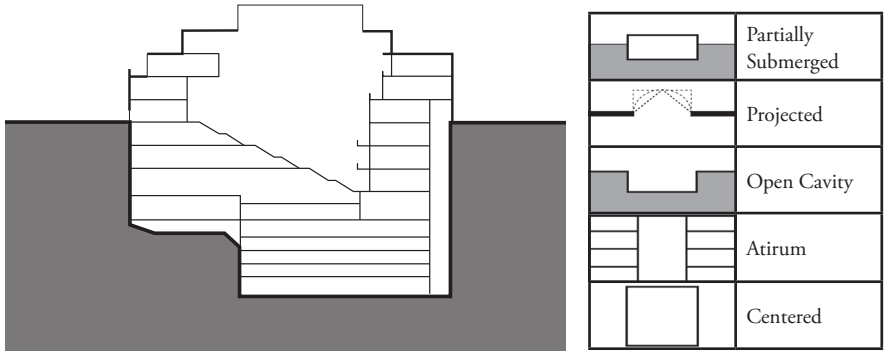
Research and Multimedia Centre *1:400*



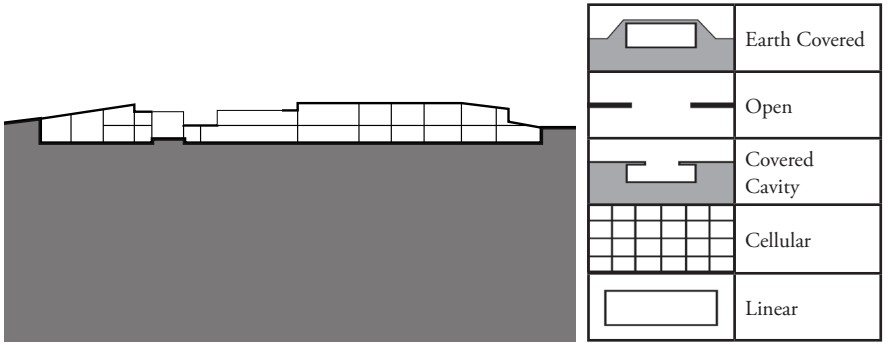
Saxton Federal Library *1:700*



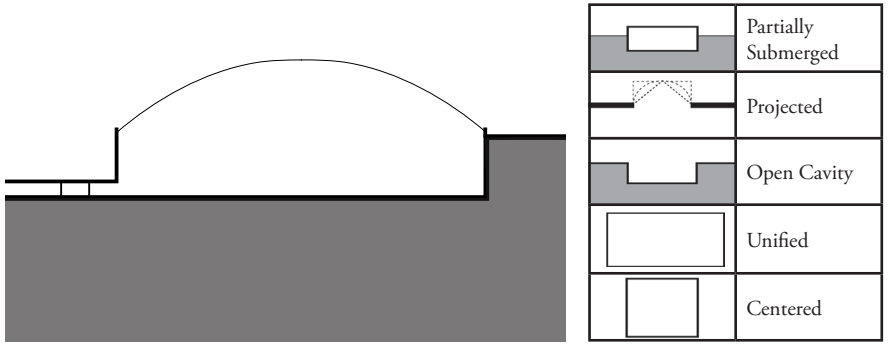
Rijksmuseum Museum *1:600*



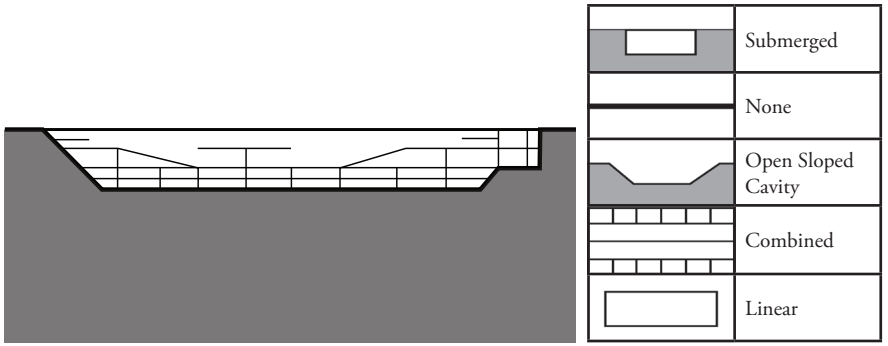
Shibuya Project *1:800*



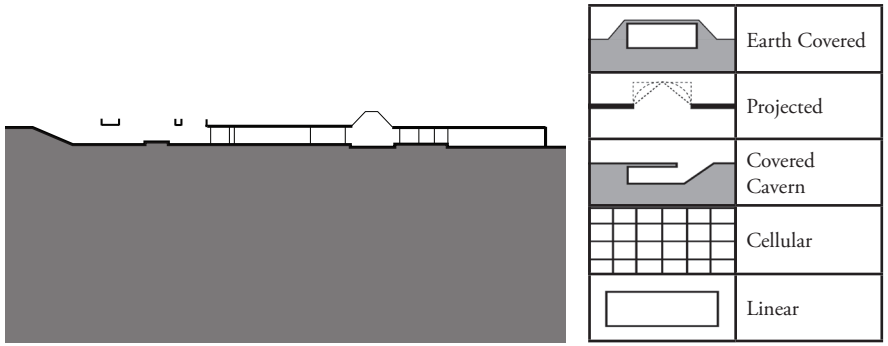
Shopping Centre *1:800*



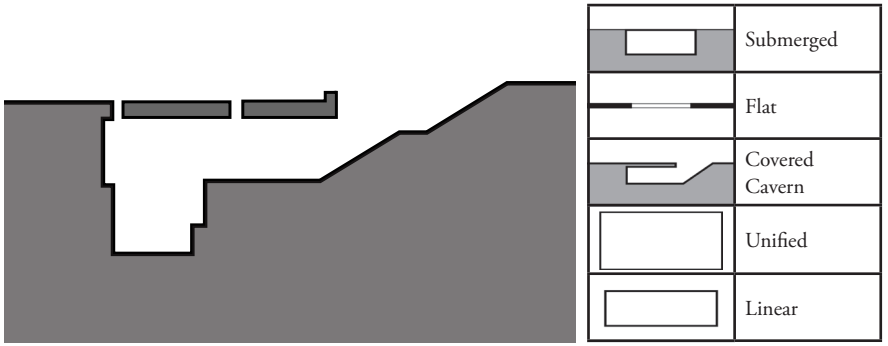
Temppeliaukio Church *1:500*



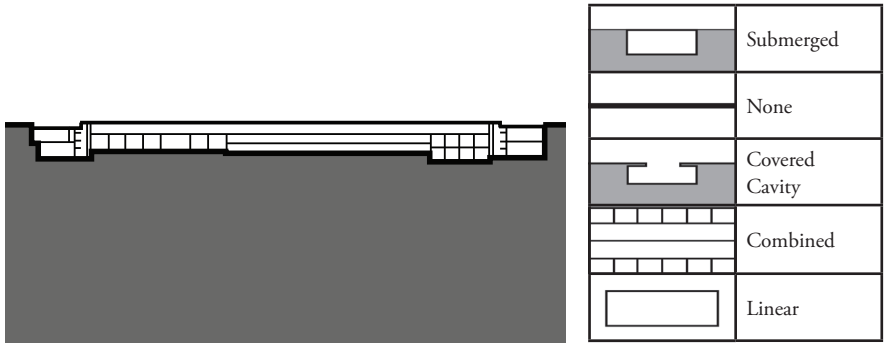
Souterrain *1:800*



Terraset and Terra Centre Elementary Schools *1:600*



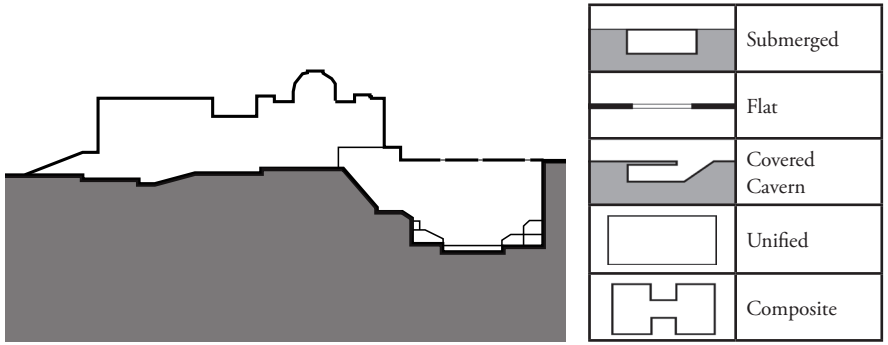
Tara House and Tara Baoli *1:400*



The Dok *1:800*

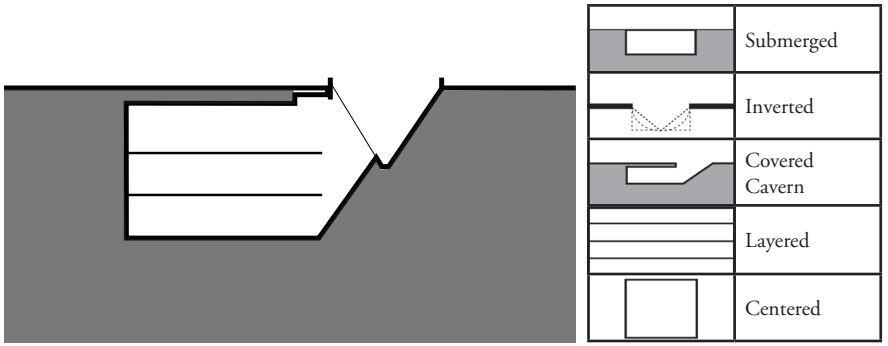
Therme Vals

1:400



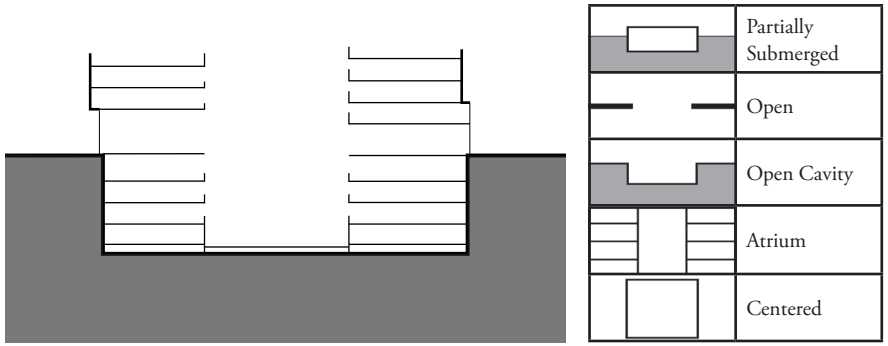
Vancouver Concert Hall Extension

1:800



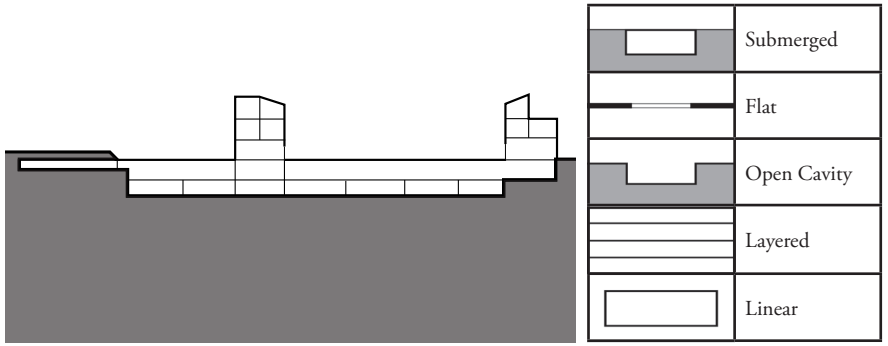
University of Michigan Law Library

1:400



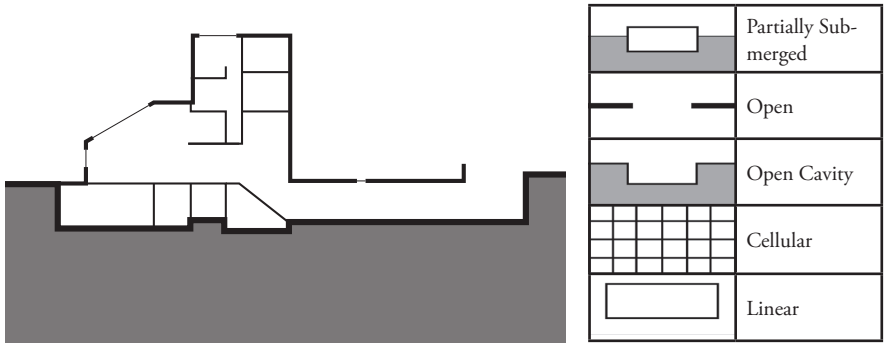
Veranda Car Park

1:600



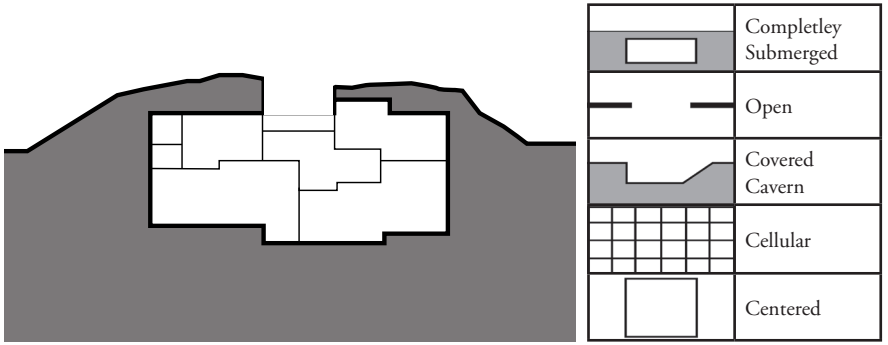
V&A Boiler House Yard

1:500



Villa Hoogerheide

1:400



Villa Vals

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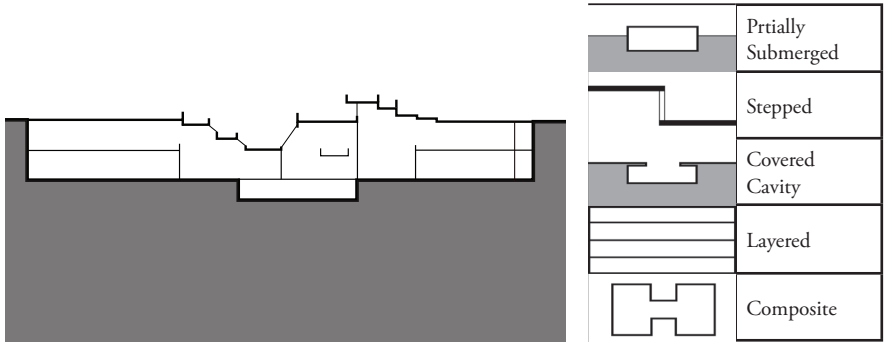
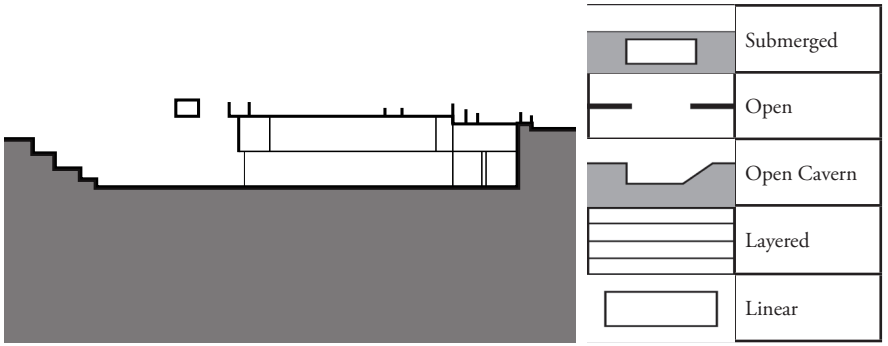


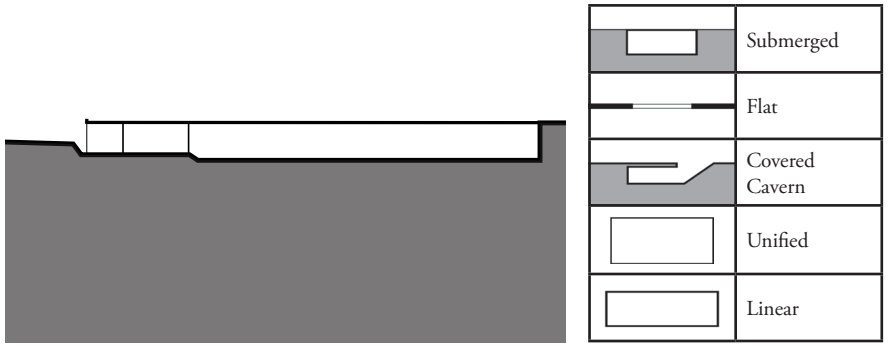
Williamson Hall, University of Minnesota

1:600



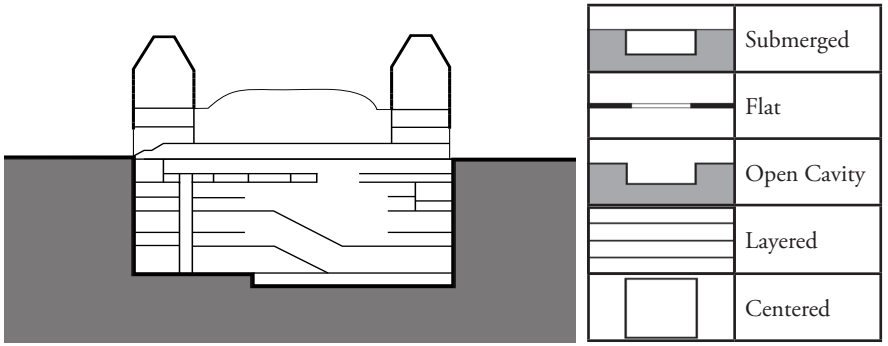
Walker Community Library

1:600



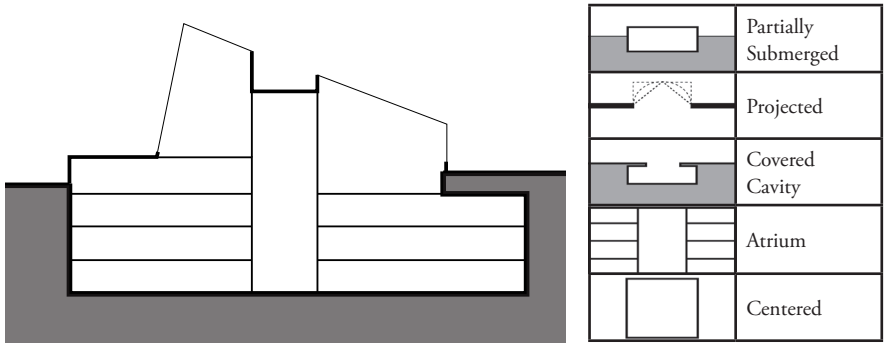
Yates Fieldhouse

1:600



Westminster - Jubilee Line

1:1000



Zeeland Archives

1:400

Appendix C: Diagrammatic Analysis

Diagram Key

Interior Activity

Exterior Activity

1: Grassed Area
2: Courtyard
3: Park
4: Street
5: Entrance
6: Atrium
7: Amphitheatre
8: Office
9: Exhibition Space
10: Retail
11: Carpark
12:Subway Station
13: Memorial Space
14:Living Area

Above and Below Ground Function

Concealed Building Mass

Exposed Building Mass

Ground Plane

Concealed and Exposed Elements

Receives Natural light

Doesn't Receive Natural Light

Natural Light Entry

Natural Light

Sightline

Sightlines

Entrance Procession

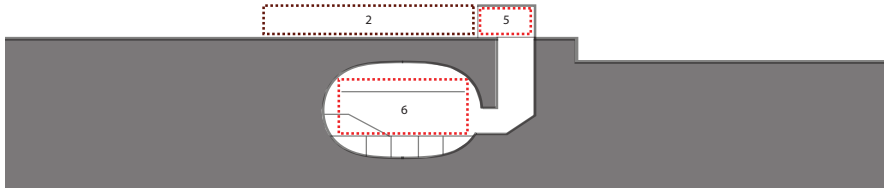
Main Entrance

Horizontal Movement

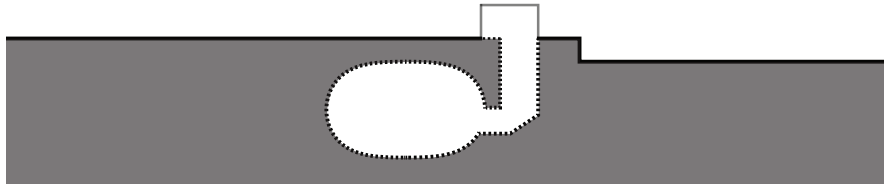
Vertical Movement

Access and Circulation

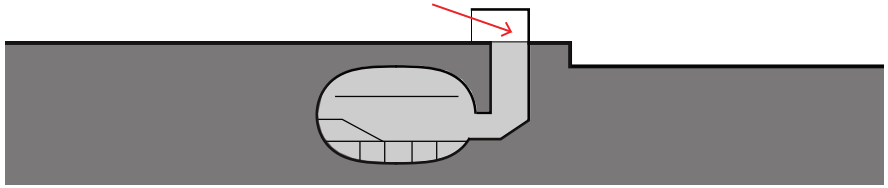
Samuel Beckett Theatre



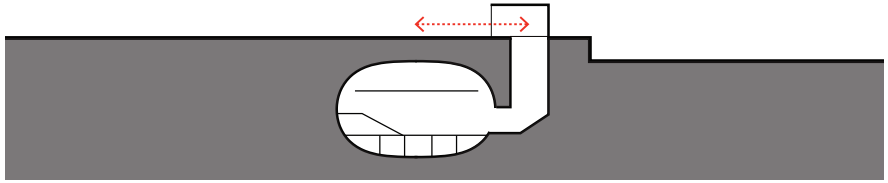
Above and Below Ground Function



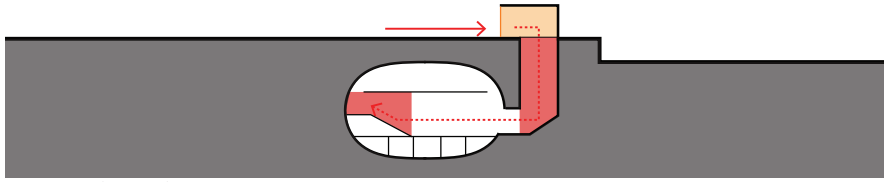
Concealed and Exposed Elements



Natural Light



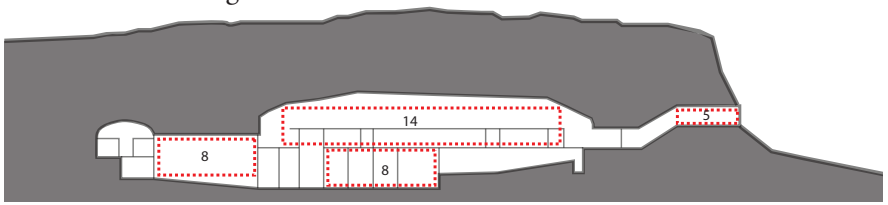
Sightlines



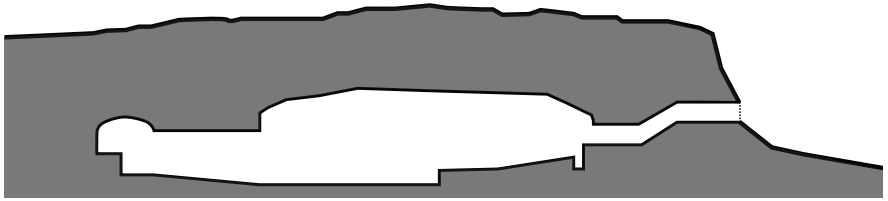
Access and Circulation

1:500

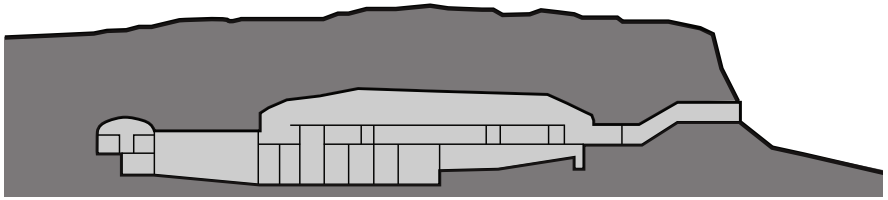
Itakeskus Swimming Pool



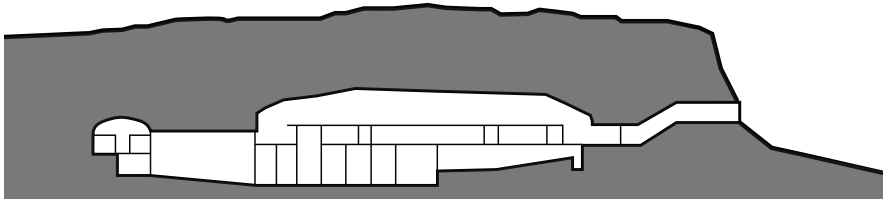
Above and Below Ground Function



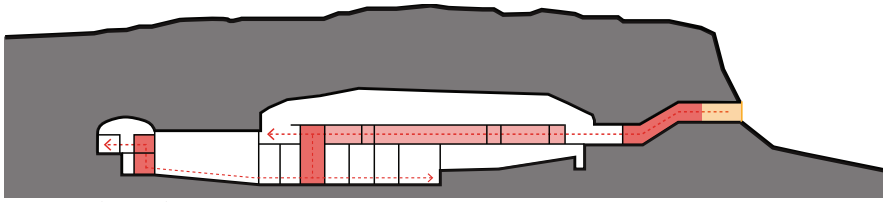
Concealed and Exposed Elements



Natural Light



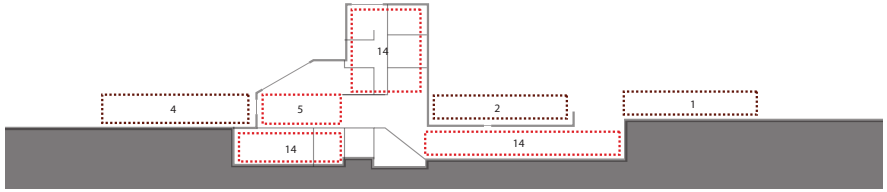
Sightlines



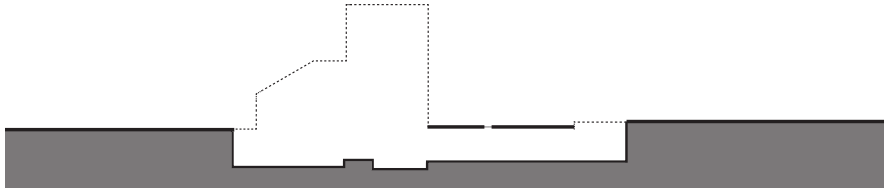
Access and Circulation

1:500

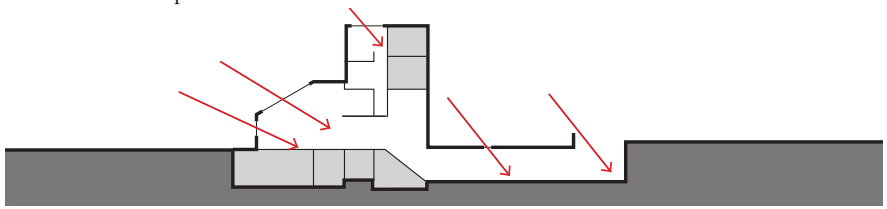
Villa Hoogerhide



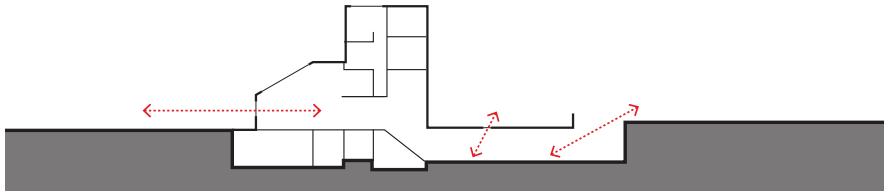
Above and Below Ground Function



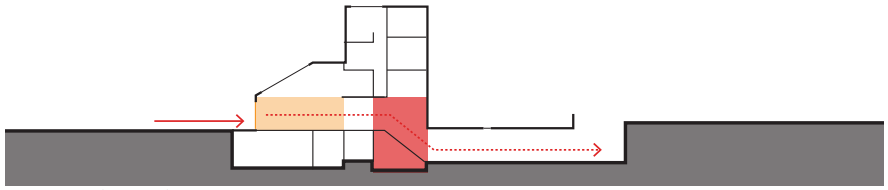
Concealed and Exposed Elements



Natural Light



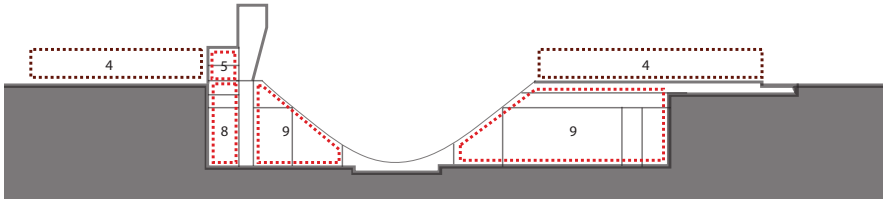
Sightlines



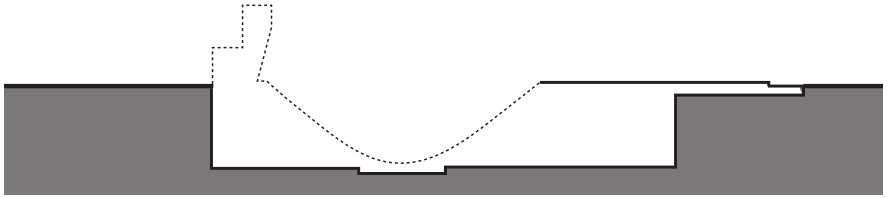
Access and Circulation

1:400

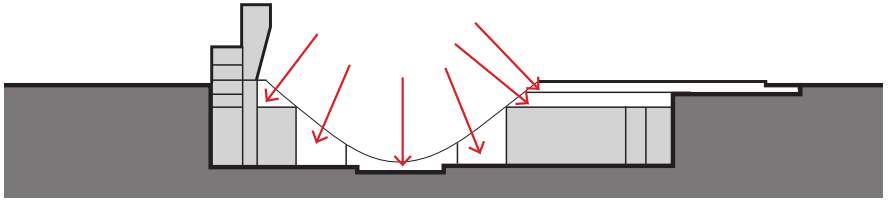
Museum of WWII



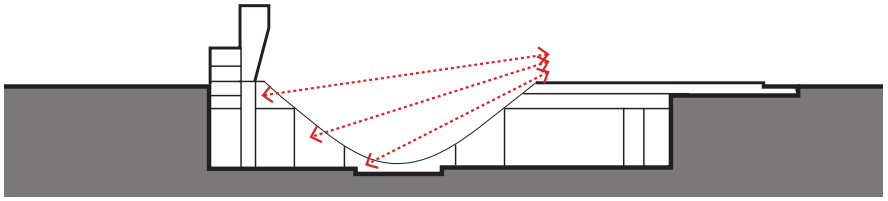
Above and Below Ground Function



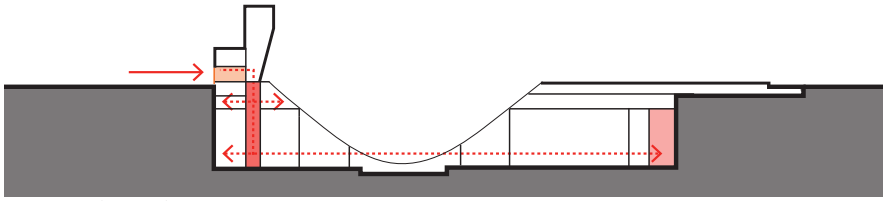
Concealed and Exposed Elements



Natural Light



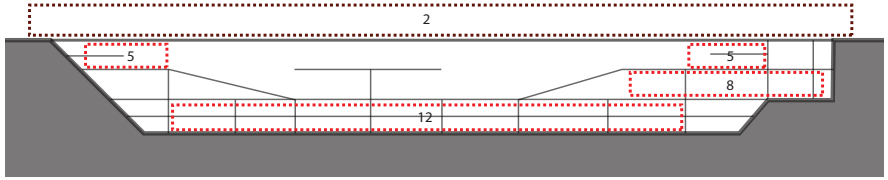
Sightlines



Access and Circulation

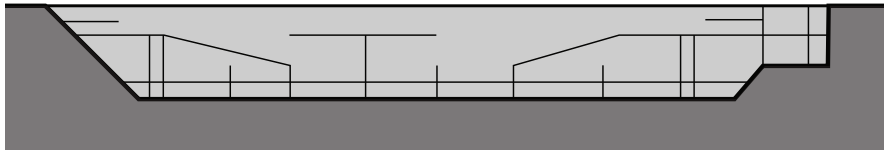
1:500

Souterrain



Above and Below Ground Function

Concealed and Exposed Elements



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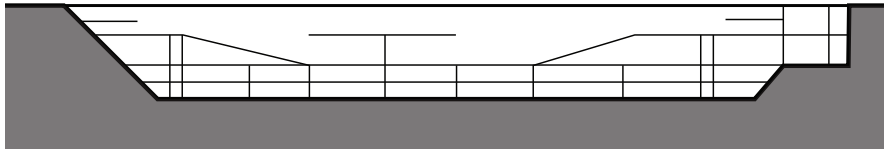
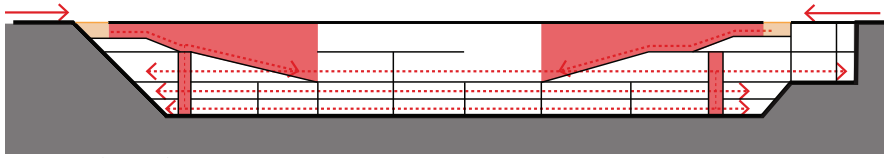


Sightlines



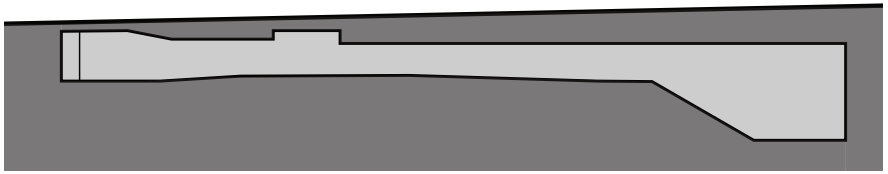
Access and Circulation

1:800

Plaza Del Torico

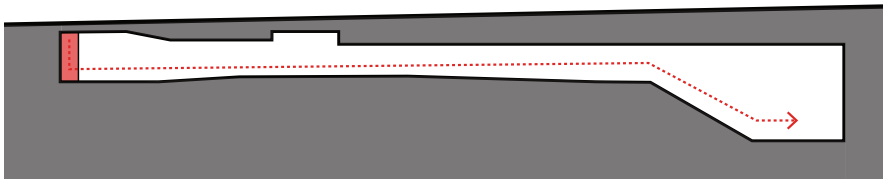
Above and Below Ground Function

Concealed and Exposed Elements



Natural Light

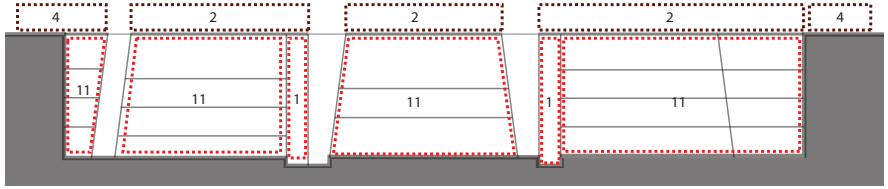
Sightlines



Access and Circulation

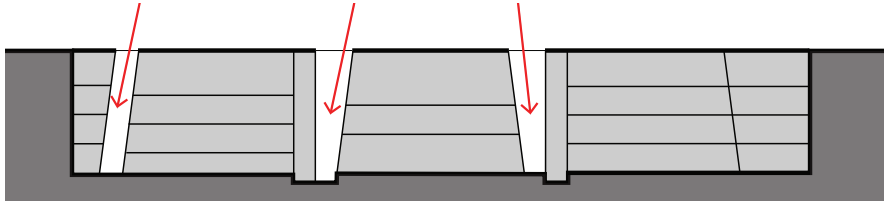
1:500

Arnhem Carpark

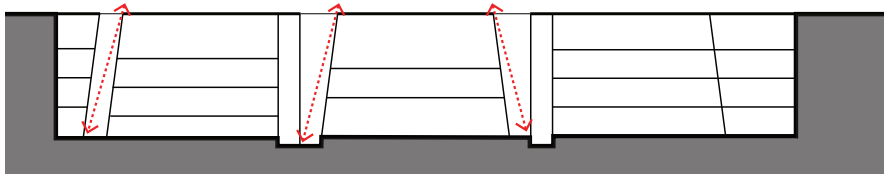


Above and Below Ground Function

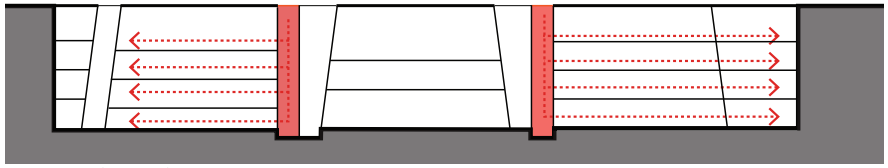
Concealed and Exposed Elements



Natural Light



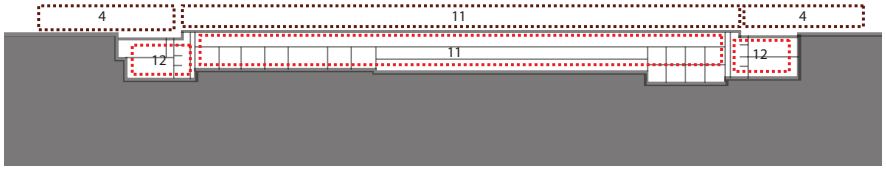
Sightlines



Access and Circulation

1:600

The Dok

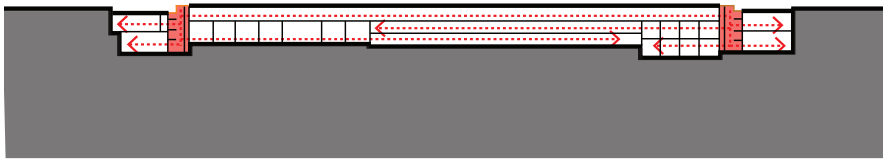


Above and Below Ground Function

Concealed and Exposed Elements

Natural Light

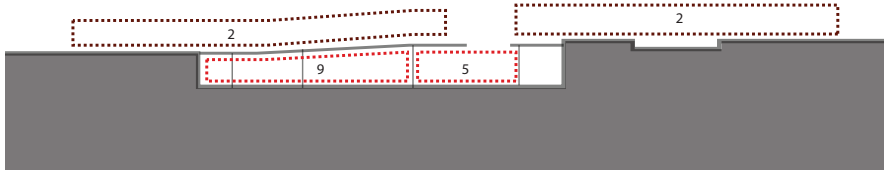
Sightlines



Access and Circulation

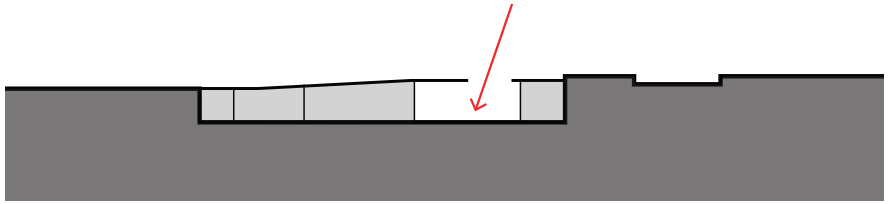
1: 700

Memorial to the Murdered Jews of Europe

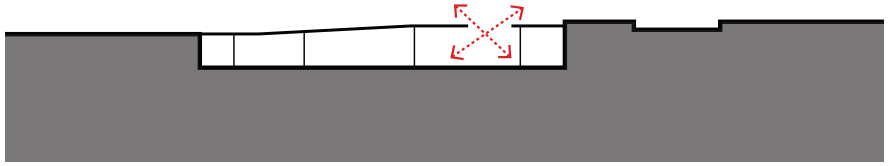


Above and Below Ground Function

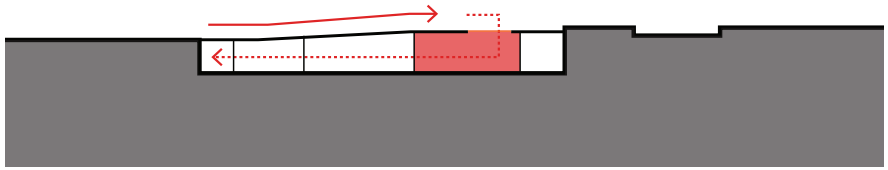
Concealed and Exposed Elements



Natural Light



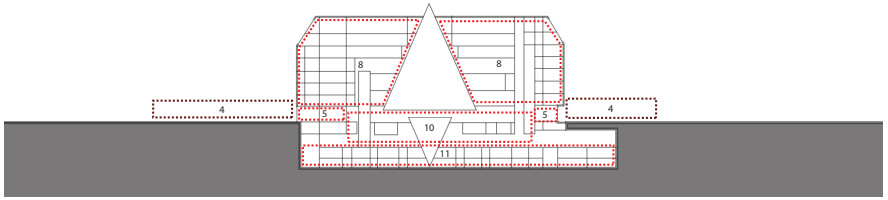
Sightlines



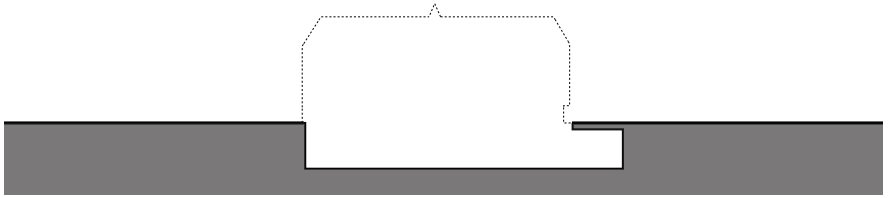
Access and Circulation

1: 300

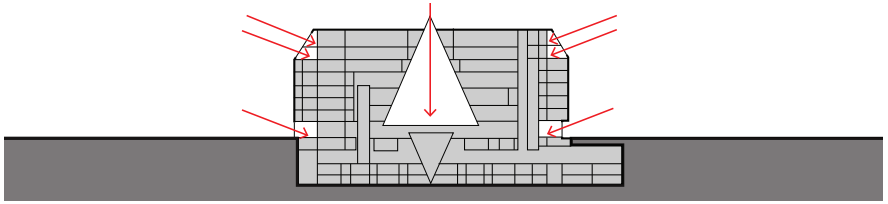
Friedrichstrasse



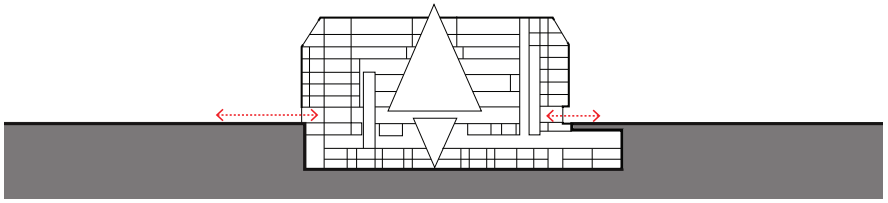
Above and Below Ground Function



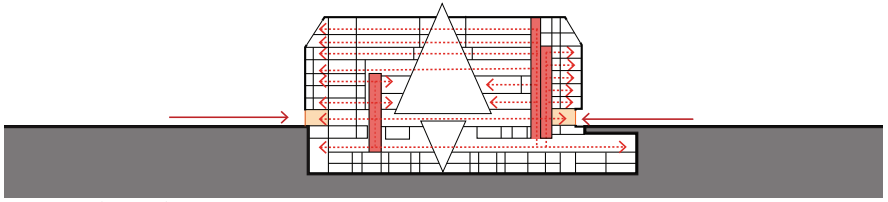
Concealed and Exposed Elements



Natural Light



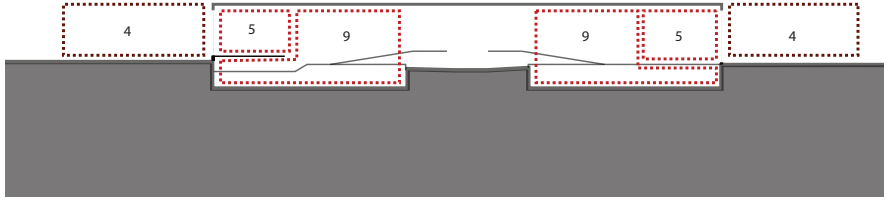
Sightlines



Access and Circulation

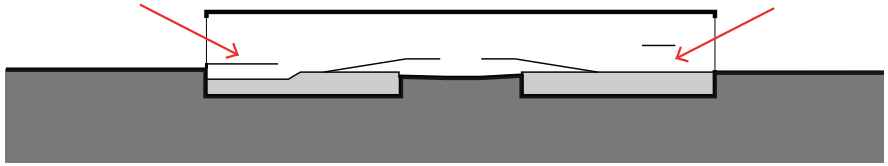
1: 500

Rijkmuseum

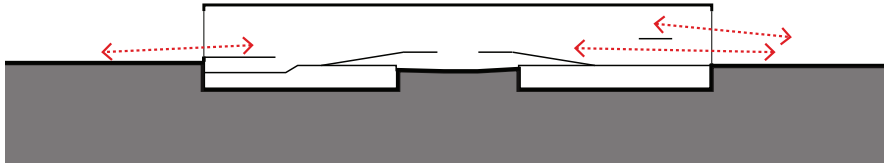


Above and Below Ground Function

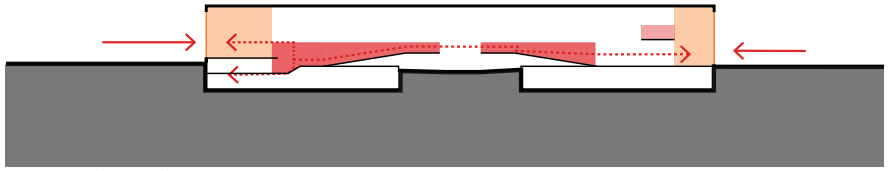
Concealed and Exposed Elements



Natural Light



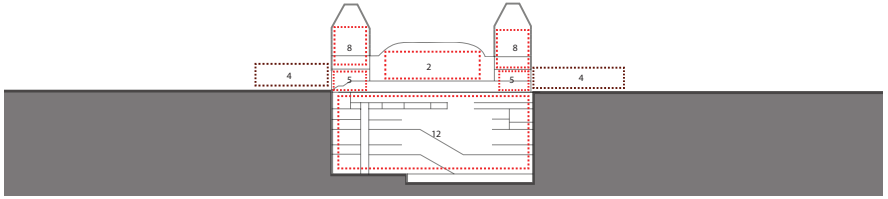
Sightlines



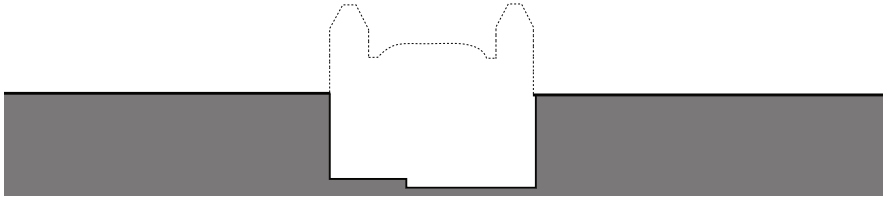
Access and Circulation

1: 500

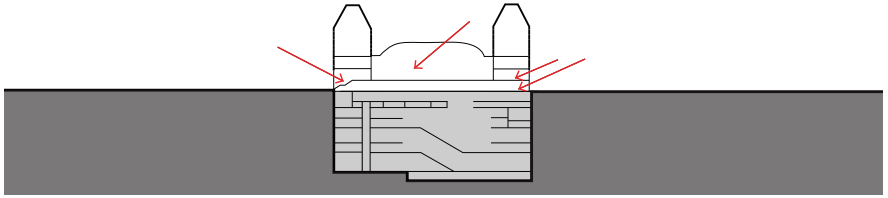
Westminster- Jubilee Line



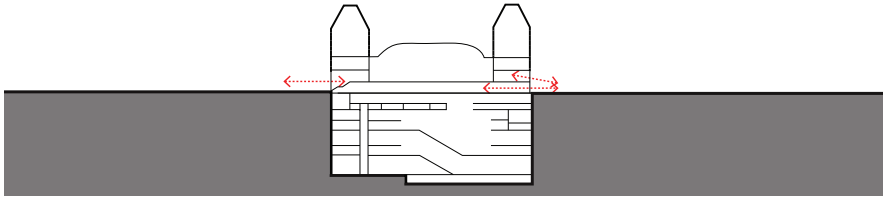
Above and Below Ground Function



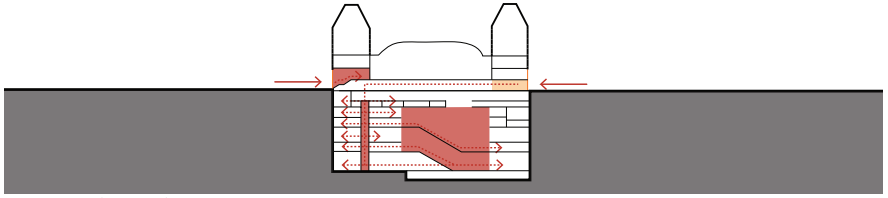
Concealed and Exposed Elements



Natural Light



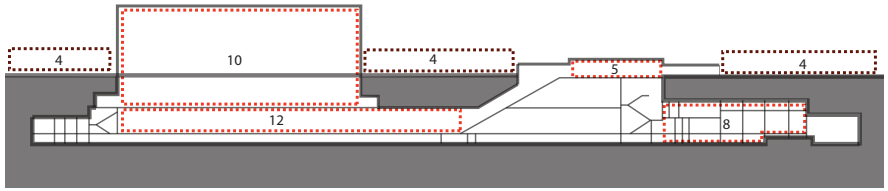
Sightlines



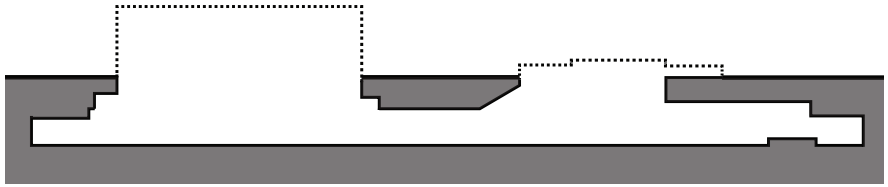
Access and Circulation

1: 700

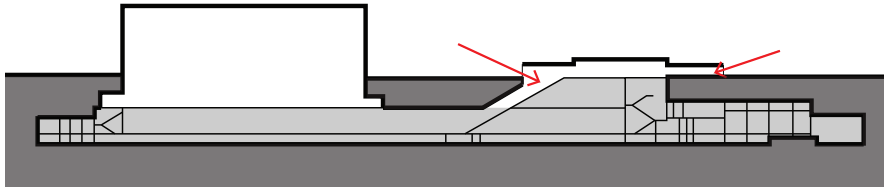
Nydalen Metro Station



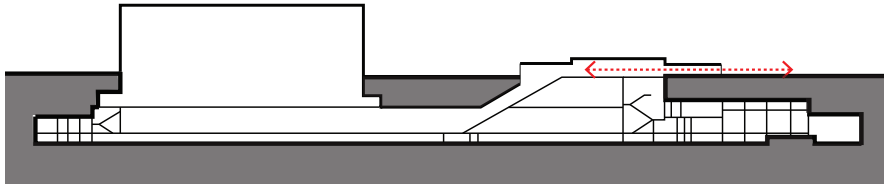
Above and Below Ground Function



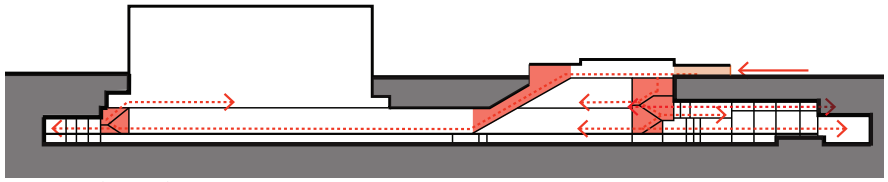
Concealed and Exposed Elements



Natural Light



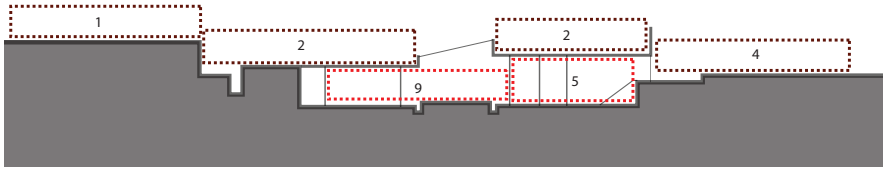
Sightlines



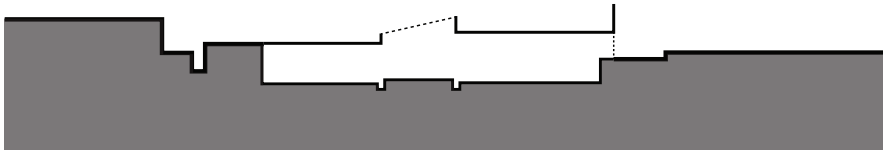
Access and Circulation

1: 800

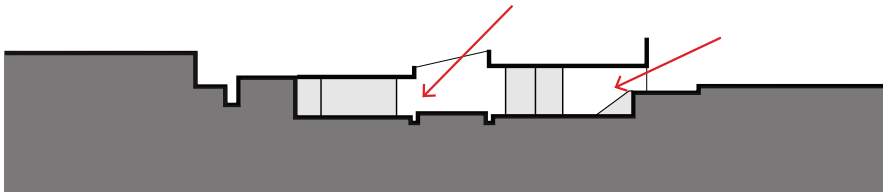
Beelden Aan Zee Museum



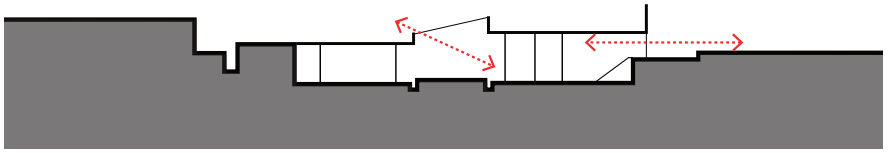
Above and Below Ground Function



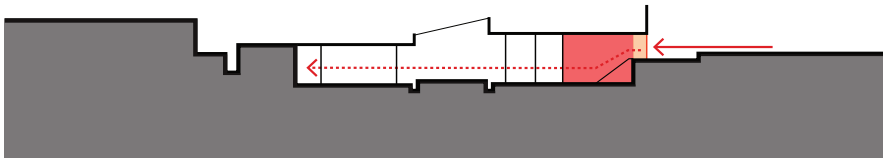
Concealed and Exposed Elements



Natural Light



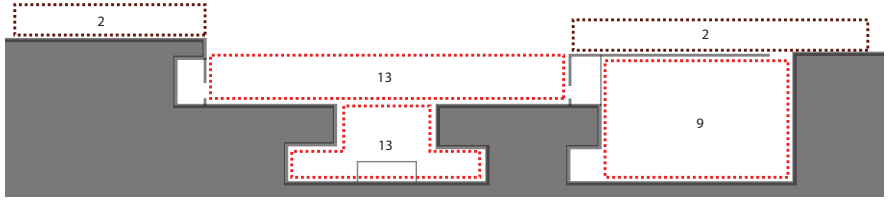
Sightlines



Access and Circulation

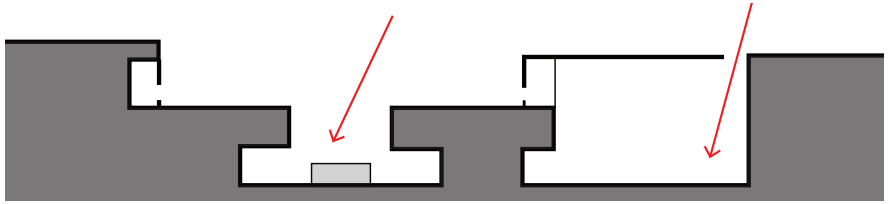
1: 400

National September 11th Memorial

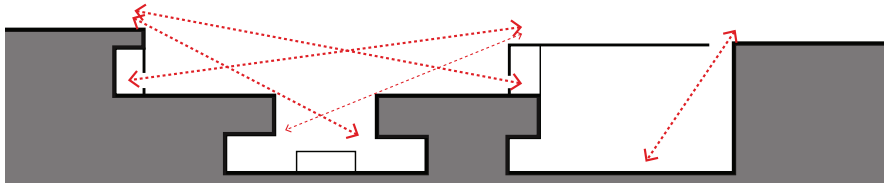


Above and Below Ground Function

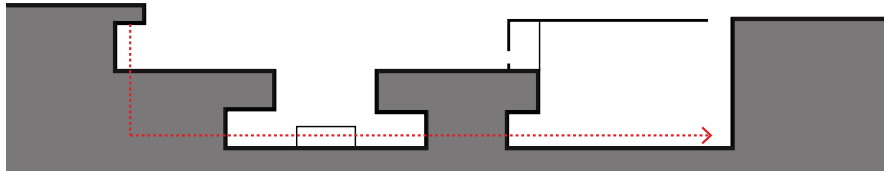
Concealed and Exposed Elements



Natural Light



Sightlines



Access and Circulation

1: 400