EVOLUTIONARY TECHNOLOGY AND ITS' INFLUENCE ON THE STRUCTURAL INTEGRITY OF ARCHITECTURAL DESIGN

A Proposed Science Research Centre for Durban

By

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DECLARATION

I hereby declare that this dissertation is my own unaided work carried out by the author and that all citations, references and ideas have been acknowledged accordingly. All images within this document are by the author unless otherwise accredited. This dissertation is towards the submission to the School of Built Environment and Development Studies, University of KwaZulu-Natal in partial fulfillment of the requirements for the degree of Master of Architecture. This dissertation has not been submitted previously for any degree or assessment at any other educational facility.

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DEDICATION

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ABSTRACT

The evolution of technology has influenced the lives of man through the discoveries made and infrastructure created. It has allowed man to build shelter and survive. These strategies have been adapted by man and have informed him of future possibilities. In an evolving world, were every aspect of life can be adapted, man's comprehension of daily life changes to fit in with these adaptations. How then has this ever changing status been understood and recorded and for what purpose?

The industrial revolution proves to be the milestone of technology's biggest step forward by increased supply and manufacturing processes. It also injected the world with the potential for mass production in aiding rebuilding after the destruction of the World Wars. The focus was directed to solutions for recovering from the losses due to wars. This may appear to benefit man but the sensitivity and connection from society was lost when mechanization came to the forefront. All sense of self was removed from design.

This technological impact is evident in the evolution of architectural design. A separation between design and technology has occurred, where the urgency for instant results meant the shift of importance from holistic design to repetitive production.

Man's curiosity and intelligence has been the strength behind technology, thereby allowing it to evolve. This evolution impacts man, and conversely man impacts technology. In a world created by man, for man, man is the main instigator. This creation is evident throughout the world in the makings of man, one aspect of which is architectural design.

The focus of this dissertation is on structural technology and its influence on design, specifically exploring the basis of structure as an ever changing system and how this impact on man's perception as well as the effect structural technology has on architectural design.

Architecture describes realms of change; it is influenced by its context, its people and the time of its existence. Through the background and literature review these changes can be seen as well as the influence that materials have had on mans perception. With this in mind this document explores the realms within which technology has influenced design and impacted on man.

Theories and concepts are used as the tools for explaining the relationships and components of technology in the lives of man and architecture. Actor-Network theory summarizes structural technology as a network where man and technology co-exist. Here the acknowledgment of singular aspects is required to create a whole system. Conviviality is a theory derived by Ivan Illich which further reiterates what kind of tools technology has formed. It is used to uncover the flexibility of evolutionary technology, the possibilities of structure and the means in which technology has been limiting. This connection draws from the actor network theory being interpreted as a network that strives to become the tools of conviviality with flexible use and adaptive functions. Finally the concept of Bio mimicry is derived from the theory of Post Modern Ecology introducing the sustainable approach to futuristic design with regard to structure. Biomimicry is a concept that shows how advances in structural technology can incorporate design in its language, can learn from the complexities of nature and bring the sensitivity that man craves to relate to architecture.

By using these concepts and theories, the literature review outlines the issues of self and human need. It will further explore the contextual response and materiality of built design as this forms part of the language of architecture. This establishes an understanding of what makes structural technology in architecture a mechanized system and how this impacts on the lives of man.

It is found that sensitivity in architecture is lost when the ability of technology overwhelms design or conversely, when it is completely lost in a blanket of facades. This is comprehended through precedent and case studies using the theories and key elements from the literature review against them in order to understand how existing architecture has incorporated these aspects or failed to do so. The intention of the document is to explore how design is a reflection of technology and how they may co-exist with deference and relevance.

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PART ONE

PART ONE

BACKGROUND RESEARCH ON ISSUES

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

The period of 1880 to 1920 saw the formation of strong, independent nations across the world- mainly the US, Great Britain, France, Germany and Japan. These leading nations encouraged the scientific advancement and facilitated industrial development at a rapid pace that ultimately aided in the First World War (1914- 1918) by implementing fast tracked manufacture and processes for housing and rebuilding of ruined cities. In the aftermath, technology played a vital role for redevelopment and overcoming the world's loss (Sebastyen, 2003). The combination of human intelligence and mechanization contributed to the industrial revolution after the great World Wars. New developments and infrastructure had to be erected to replace the built landscape that had been destroyed in the path of the war. Thus, the swift nature of this process introduced the period of the industrial revolution. This method of increasing the product and quickening the process meant that man and the collaboration with machines were the new techniques for optimal outcomes.

By introducing mechanized technology, the need for mans 'first hand approach' is no longer required as machines will do the work. Man can now sit in an office, delegating work and cheering on development without actually being there. Ivan Illich describes that increase in the power of machines meant the decrease of mankind's roles in society to be that of mere consumers, driven as slaves to the technology that they had created (Illich, 1973). The divorce of direct interaction removes the element of responsibility whilst rendering man obsolete and disconnecting man from social interaction. The component of sensitivity that man adds to the built environment is replaced with hi-tech, mystifying creations. On the one hand structural technology is an opportunity for new creations and flexible buildings in terms of function. On the other, the removal of sensitivity and obsession with mechanization forms isolated, exclusive buildings. These networks of technology and design are divorced, creating space for function and removing the aspect of the actual living inhabitants.

> *"The straight line –as we know-the shortest route between two points. In other words it has only one concern-not the most gentle, most lively, but the shortest route. Machines make dead straight lines"* (Day, 1999:88).

Christopher Day (1999) compares machines to insensitive, dead objects that are here for the purpose of function alone. Their purpose is for a specific task, with no interaction or consideration to man, creating design without "soul".

This lack of social connection between man, nature and technology, will produce individuals and networks that are absent of the element of 'self'. Christopher Alexander (2005) explains the 'I' that is felt but not recognized in buildings and other artifacts. Alexander says that these buildings are the products of passionate designers whose essence resonates in their creations. In technology, this passion is lost thus the hardness of machinery and mechanisms become the focus. This element of self should be present in technologically advanced design to spur on an unexplainable pleasure, sense of nostalgia and create excitement in human interaction with the built environment. Similarly Ivan Illich's concept of Conviviality (2004) reiterates man's relationship with machine. He states that tools for conviviality should express the user rather than make the user its slave.

The industrial revolution produced the expansion of elaborate systems in technology for energy creation, energy reduction and transportation, further divorcing man from responsibility and interaction with each other. They have buried their intelligence in the science of technology and treated architecture as a means to create an everlasting structure, neglecting the actual quality of design and the effect of the built environment on the human mind.

There is a need for the combination of natural and human systems which supply ecological knowledge and create a connection between man and technology. In order to achieve this outcome of integration, the design of spaces need be more complex than physical assimilation. The implementation of technology requires detailed attention from the onset in the actual process in order to create a sensitive design that responds to man and his environment.

1.2 DEFINITION OF THE PROBLEM

The increasing focus on hi-tech networks removes the need for human interaction, as technological advances have aided ease of communication. Hi-tech design creates vessels for production however divorces man from the connections with each other. It is understood that technology is an important, vast and permanent development in the evolution of man. The relationship between man and sensitive architecture is recognized as a missing link to modern day living which needs to be restored and valued as equally as technology. Lack of sensitivity within architectural design removes the life vitalities of man when weighed against structural technology's exclusivity. Technology, design and man are currently disconnected although they require one another to fully function.

1.2.1 Aims

The main aim of this dissertation is to uncover the social effects that evolutionary technology has on man. In doing so, understand the benefits of evolutionary technology and implications they have on man and architecture.

1.2.2 Objectives

The Objectives of this study are:

- To investigate the affects that evolving technology has had on human behaviour and social interaction.
- To examine the advances of structural technology from the industrial revolution to present day, for the purpose of understanding how such technological developments have influenced the lives of man.
- To critically assess how structural technology in architecture has impacted on man, through precedent and case studies.

1.3 SETTING OUT THE SCOPE

1.3.1 Delimitation of Research Problem

This research study will investigate the relationship between man, architecture and structural technology. It will further examine the progress and development of technology, sensitive to man, in order to provide better social interaction within the built environment. As an architectural dissertation, the technological advancements discussed will be in the field of architecture. It will not explain all advances in technological science, but rather the affect of architectural technology on man.

1.3.2 Definition of Terms

- ***Actor Network Theory (ANT):*** The theory derived by Bruno Latour, Michel Callen and John Law defining the relationships between things and concepts.
- ***Architectural Design***: The complex or cautiously considered composition or structure of something.
- ***Biomimicry***: The design of materials, structures and systems that are based on or representations of biological elements and methods.
- ***Environment:*** The natural surrounding more precisely a geographical area which is affected by human doings. Overall composition within which a user functions.
- ***Conviviality:*** The quality of friendliness and being lively. The term used by Ivan Illich in his theory "Tools of Conviviality", describing the warmth and soul of an inanimate structure.
- ***Evolutionary Technology:*** The gradual progression or development of knowledge or mechanical arts and applied sciences in the field of architecture based on structure.
- ***Influence:*** To have an effect on the character, advances or behaviour on another aspect.
- ***Man***: Human being considered collectively, the Human race.
- ***Structure Integrity***: The unified and sound composition of a constructed object or building.

1.3.3 Stating the Assumptions

It is assumed that structural technology has evolved over the years and that man is responsible for its growth. It is also assumed by extracting the features of mans sensitivity and merging this with technology through principles of Biomimicry, that man will form a better relationship with his social and environmental context.

1.3.4 Hypothesis

Structural technology has grown through the years in the attempt to better the lives of human beings. However, the vast increase in machinery and tools have removed man from the environment and alienated people from one another. It also created exclusive architecture that is removed from the sensitivity that man requires as a life essential. By integrating sensitivity and the structural technology used in the creation of architectural design in forming a joint system, man can relate and benefit from both. This combined approach to design will incorporate technology that encourages interaction with man and form a design language that expresses structural technology through the design instead of a separate element. The influence therefore of evolutionary technology, specializing in structure, can transform from an isolated component into an integral part of design.

1.3.5 Key Questions

Primary research question:

- How has the advancement of structural technology impacted on man's experience of the built environment?

Secondary questions:

- What are the psychological aspects that evolutionary technology has on human beings and how does this influence the perception of architecture?
- Why should structurally based technology be sensitive to man?

1.4 CONCEPTS AND THEORIES

The following concepts and theories are used to expand on the issues that reflect the reason of how evolutionary technology has impacted man and its influence on the structural integrity of design in architecture.

1.4.1 Conviviality

Ivan Illich an Austrian philosopher created the concept called Conviviality. He speaks of the tools needed by man, insisting man needs convivial tools rather than machines (Hamdi, 2004). In the area of technology tools should be the expression of the one using them instead of being the slave to them. He also speaks of flexibility in use, relating to technology as an evolutionary element.

"I choose the term conviviality to designate the opposite of industrial productivity. I intend it to mean autonomous and creative intercourse among persons, and intercourse of persons with their environment" (Illich, 1973:11).

He states that in a society the needs of man cannot be fully satisfied by the quantity of industrial productivity. He uses the word convivial in response to the sterile, selective nature of mass fabrication of industrialization.

1.4.2 Actor –Network Theory

Actor-Network Theory was introduced by Bruno Latour, Michel Callen and sociologist John Law through science and technology studies intended to encourage the role of non-humans or machines in the social lives of humans. Abbreviated as ANT, this theory can be associated in the scientific field inclusive of sociological studies. Research has drawn upon the possibility that ANT acts as a guild or instrument rather than a theory, to assist researchers to remain sensitive when discovering and examining complex issues. This would provide the receivers of the research with comprehensible information instead of obscure science.

> *"There is semiotic relationality (it's a network whose elements define and shape one another), heterogeneity (there are different kinds of actors, human and otherwise), and materiality (stuff is there a-plenty, not just 'the social'). There is an insistence on process and its precariousness (all elements need to play their part moment by moment or it all comes unstuck)"* (Law, 2007:7).

ANT developed as a methodology and it explains the relations between things (materials) and concepts (semiotic). Often referred to as material semiotics, the Actor Network Theory relates to the manner in which connections assemble, forming a description instead of a foundation based idea.

It is a method explaining how the elements of a system come together from a perspective of its entirety. The arrangement of how these components hang together forms the whole system. In the example of science, the term 'actor' is the elements or technologies and the ideas or the people whom are responsible for these ideas. These relationships between actors require a constant interaction for the network to emerge. The 'network' is the system encompassing this arrangement which may be called science.

In the context of architecture, ANT is the link between intelligence and the humans who create the technology. In the complexity of modern technology, the self and sensitivity is removed or completely absent (Alexander, 2008). This description of advancements in design technological systems encourage that enthusiasm be introduced and celebrated through the science of non-human artifacts.

1.4.3 Post Modern Ecology

Integral design, as discussed by Sim Van Der Dyn and Sterling Bunnel, Post Modern Ecology is the application of lessons learned from biological natural systems that directly influence the built environment and the people within it. Still in its primary years, this relatively recent theory can be further divided into Bio mimicry and Eco-tecture (environmentally sustainable architecture) (Jencks, 1997).

Biomimicry is aimed at solving challenges through the imitation, adaption and inspiration for nature (Yahya, 2006). Models of nature optimize productivity with the minimal use of energy and material consumption. Yahya states that this silent production, together with visually appealing presence is one to reckon with and is the prime example for man to try to emulate.

1.4.3.1 Biomimicry

Originating from the Greek words "bios" and "memisis" which mean life and imitate respectively the idea of Biomimicry it just as the definition sounds. It is a form of developing form (structural or otherwise) from mimicking natural form in the attempt to solve human problems. It is an innovation inspired by nature, through observing how the natural world works; humans have developed and perfected the art that nature has provided. Mankind has learned many things from observing other species, adopting and adapting their behaviours for their needs.

1.5 RESEARCH METHODS AND MATERIALS

1.5.1 Research Design

The research conducted for this dissertation is aimed at developing the theoretical framework for understanding mans relationship with technology and identify ways in which man can incorporate sensitivity into the advancements in technology towards the betterment of the built environment. The character of this research resulted in a qualitative process when doing data collection and analysis thereof. The relevance of this section to the proposal will be to explore the methods in which useful information will be collected in order to provide a guide, to inform and answer key questions.

1.5.2 Research Methods

The informative process of the proposal will include both primary and secondary data. Primary data will include the use of three case studies uncovering the firsthand approach to this issue of technology in relation to man and its influence on architecture. This data will be evaluated against a list of practical research methods to form a base which will in turn inform the research and design process.

The secondary research will explore the aspect on a broader scale with the use of a literature review. This will include consulting media resources, journals, and articles for valid information used to assist in the understanding and unraveling of the key questions. It will include research covering man, technology and architecture, and attempt to find the connections of all three vital aspects.

1.5.3 Primary Methods – Interviews and Case Studies

Case studies will be conducted on facilities that are examples of forward thinking design and advanced technology integration which display a vast input from human development in the field of structural technology. It will also study facilities where sustainable technology has a hand in development and compare the two types. The cross examination of these examples will uncover certain conditions and characteristics which will create a foundation of sound knowledge aimed at outlining information relevant to the research problem. The three Case studies will provide an enhanced understanding of how these facilities affect the users and the incorporation of technology evolution in the design.

Interviews with people directly interacting and designing the spaces will be conducted including the architects and engineers reflecting the professional perspective of technology and design relationship and its impact on man. An analysis of these facilities from a personal perspective will be argued and discussed.

The research methods will include:

- Interviews to be carried out with professionals in the field of design and structural advancements. These will include architects and engineers who will provide personal standpoint. This will assist in enlightening the topic of 'creators' and 'actors' as stated in the actor-network theory to the purpose of connected design and structural technology. Questionnaires which will assist in obtaining the opinions of focused group interviews were structural technology has affected these professionals in their practice if in any way. It will clarify the relationship humans and technologies have as well as their current perspective and involvement of the architects and engineers as a team towards the structural integration of a project. It will feed the theories chosen previously and discover if these have been implemented or ignored, in turn reflecting on the effect of the design on man.

- Participant Observation on site of case studies that have utilized significantly advanced technology in their approach. These would include buildings in their context, which have shown development with regard to structural technological thinking in design and construction. Other features that will be examined are response to site, materiality, integration and sensitivity to users all of which will be tested against the concepts and theories.

1.5.4 Secondary Methods – Literature Review and Precedent Studies

This will explore the aspect of technology and man on a broader scale with the use of a literature review and precedent studies. This will include consulting media resources, journals, and articles for valid information used to assist in the understanding and unraveling of the key questions. It will consist of a review of concepts and theories that will be in the format of a comprehensive literature review and relevant precedent studies to relate the concepts and theories to examples.

1.5.5 Research Materials

Professional interviews will focus on technology and their professional perspectives of structural technology being an evolutionary tool. The questions are aimed at functional space and integration with design, process, manufacture and reliability of technology. This will highlight the technology present, the options for flexibility and it will aim to extract the user preference, while understanding the process undergone to ensure that technology is a required component in architecture.

The process of absorbing and reinterpreting these interviewed persons will highlight the commonalities as well as differing aspects that surround structurally based architectural design. Each interpretation may differ according to the opinion of the person involved. The questionnaire will utilize questions from a user orientated perspective to better understand the required needs for the outcome.

Some interviews will be carried out with the professional team of a case study thus giving an in depth analysis of the conceptual drivers for such technical buildings, the systems put in place for manufacture and processes carried out and the construction phase before the building materialized.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

The relationship between man, technology and architecture is multifaceted. It dates back to the early lives of man, in need of shelter and survival, carried through the years, evolving and adapting with time. This chapter will set out the understanding of how architecture has been influenced by technology, and the effects this has had on man. The research will uncover associations of these concepts and theories that interlink the subject of man, technology and architecture. They will be carried through via three parts including:

Structural Technology through the years: This section focuses on technology and its relationship with architecture. Using Ivan Illich's concept, technology and materials are compared to the stages of architecture as the "Tools" of Conviviality. It establishes the history and development of advanced technology and materials in the human world and sets the stage for further derivatives that technology has influenced. One of these is architecture.

Paradigm of Industrial Revolution, Man and the Machine: This portion of the research discusses the relationship between man, technology and architecture. This section will also reveal the positives and negatives between these relationships. The key factors here are tested against Actor Network Theory, as it explores the interrelationship between the three actors, namely: Man, Technology and Architecture. It will bring to surface conflicts and opportunities and explore the future of all. It will explain the needs of man to experience life in its value rather than a plain existence.

The Relationship between Technology and Architectural Design: This section explores the ways that architecture and technology can integrate one another, inclusive of sensitive technology for the future of designing for man. It explores possibilities of recent technological developments and the way in with it has shaped design. Of these is Biomimicry, a more current design concept that involves structure in relation to natural systems. This is one technique were structure is the design, evident that man has to interpret the complexity of technology in nature and mimic it with available materials.

2.2 STRUCTURAL TECHNOLOGY THROUGH THE YEARS

2.2.1 History of Material Technology through the Architectural Eras

The history of technology begins at the onset of the industrial revolution as this is the start of a new shift in developments and mass production of architectural materials and design. This was the first influx of immense achievements in relation to the time in which these architectural revelations were made. It was in part response to the upheaval of the destruction that war had caused and it used structural technology as a tool for aiding in the reconstruction of fallen cities. This catalyst initiated architectural design to create faster means and more efficient methods for built form. The periods that followed always responded to its' history, and grew with the intention to achieve design unique to the next period.

Industrialized countries began building steel railways in the 1830's. Steel proved to be versatile and robust as a new material to utilize it created interest in material design for architects (Sebastyen, 2003). Steel and reinforced concrete became the closest competitors as these materials vied for first choice as the newest building fabric. Art Nouveau was the first response to the progression and mass production of industrialized technology. "The aim was to recapture the spirit of earlier craftsmanship" (Sebastyen 2003:3).

Figure 1. Sagrada Familia (Pedersen and Täljsten, 2007:12)

Technology as the natural organic form can be found in the Sagrada Familia by Antonio Gaudi. (Refer to Figure 1) The church's design is described as the eccentric extreme of Art Nouveau; however the intention from Gaudi was his interpretation of organic architecture expressing his love for nature. In the historic times of 1884, the language of Art Nouveau defied the industrial development transforming structural architecture that was churned out without relevance previously, into unique creations of fluidity and organic form. The adornment of natural features translated into structure was a feat as it contrasted with the rigidity and repetition that industrial style expressed.

Modernist Architecture

In the 1920's after the First World War in 1918, were architects opted to design minimalist architecture free of decoration and unnecessary detail (Sebastyen 2003). Modernism was the break away from décor and display, focusing on the bare essential for functional design. The first modernist architecture movement was the Bauhaus, by Walter Gropius. Bauhaus meant functional design which was aesthetically pleasing however resulted in machine-like appearance for mass production rather than luxury or sensitivity. Modernist architecture was influenced by the ability to mass produce materials, in this means the influence came from industrial materials that were manufactured in abundance.

The move replaced the assumption of buildings pulled by gravity to those that defied gravity. The classic period by distinction was determined by the materials they were built with; this limited the structures to strength of their joints (Wilson, 1983). Modernism allowed structure to distribute the stresses throughout, relieving the system and enabling lighter materials. The combination of columns, vaults and arches transformed into a modern engineered space with structure being the only divisions. This freed up space internally, with minimalist built form separations and spaces that flowed from one to another.

Following suit was the notable works of Le Corbusier in the villa Savoye. The then technology of cantilevering floors of circular columns resulted in the ability to use strip windows. Described as plasticity in shape and movement Villa Savoye was the example of technology of modernism, minimalist, functional and sleek. This approach was derived from pure form, using the structure of the building to shape it.

Le Corbusier (1929, cited in Sebastyen, 2003) states that a house is a machine for living in, conveyed by the development of the Villa Savoye using Le Corbusier's Five Points of a New Architecture. Pilotis included the wall supports be replaced with a reinforced concrete column grid (Le Corbusier, 1923). This first principle formed the basis for the aesthetic structure as the loads would be transferred on these columns. The second principle was a roof garden, which allowed for an extra level of usable area at the roof top. It also meant the concrete flat roof would be maintained and protected. The third principle determined the usage of space on the ground floor. By freeing up the space with only structural columns, the absence of structural walls meant continuous area for uninhibited usage. The fourth principle Le Corbusier calls the free design of Façade. Due to the grid forming the structure the facades are free of function, enabling the facades to behave independently from the grid. This freedom provides a separate exterior with the ability to be shaped completely on its own. The horizontal window forms the last of the five principles, allowing the façade to be cut for entire lengths. Rooms can be naturally lit, with equal amounts of light and the opportunity for more views (Refer to Figure 2).

Figure 2. Villa Savoye by Le Corbusier, a representation of minimalist modern architecture (Source: Foster, 1983:126)

In 1929 Germany fell under dictatorship of the Nazi regime and modernist architecture was perceived as obscene and detested and the Bauhaus school shut down. This led many members of the modernist movement to immigrate to the United States, continuing their passion for modern architecture in the country and influencing design for up to 25 years.

In the 1930's the great boom in design was found in the United States of America. Chicago saw major architectural breakthroughs with the first skyscrapers whose developments had started 25 years earlier (Sebastyen, 2003). The Empire State building in New York was symbolic of this technological advancement in steel, reaching a height of 381 meters, at 12 storeys high. Europe was in that same time period creating domes and great spans of reinforced concrete and steel. The use of roof membrane s was the key for these advances in large areas of open space. It was an idea adopted from nature and adapted to suit the behaviour of structural components steel and concrete. This enabled huge spans with no support beneath, providing flexible functional space for larger buildings.

International style

The Nazi were defeated in Germany at the end of the Second World War, and yet again the need for infrastructure was optimal (Sebastyen, 2003). The United States built strength in politics and economy. Reconstruction meant requirements or housing, transportation and industry, creating opportunity for architects.

Although the mass production was the answer for quick housing schemes in Europe, it resulted in repetitive, large structured shells. It was called "Industrialized Architecture". Fast and robust technology in buildings like Le Havre, in France resulted in reinforced concrete panelled housing. On one hand this large scale production provided the homes for millions, forming multi storey buildings for vertical living (Sebastyen, 2003). Apartments were being churned out at a good rate however they became repetitive, featureless and socially disengaging. The advance in technology again comes in conflict with the lives of man. It removed man from the ground level activities, and the social connection with each other.

> *"Nor did the prefabrication of family houses, applying the experience of shipbuilding, car manufacturing and plastic industries, bring any general relief to housing shortage"* (Sebastyen, 2003:5).

People relate to images they recognize. The design of industrial structures is meant for just that. In the necessity for housing brought about technology influenced architecture insensitive to man. Sebastyan (2003) states that the destroyed cities in Europe recovered through large scale developments however here to the result were characterless. All the advances in technological tools didn't help the actual character of peoples need and the housing shortage was replaced with monotonous duplication.

Figure 3. Cathedral at Brasilia by Oscar Niemeyer
(Source: http://www.homesthetics.net/cathedral-of-brasilia-by-oscar-niemeyer)

In search for inspirational architecture, the most identifiable source was in the design of the new city capital cathedral at Brasilia by Oscar Niemeyer and Lucio Costa. The style adapted for the town planning motivated architects around the globe to redefine a character to architecture (Sebastyen, 2003). Technology took another giant step in process when prefabrication and methods of assembly were introduced. An example of this was Richard Buckminster Fuller's 1950 invention of geodesic dome.

Mies van de Rohe was a founder of International Style, a term used to describe architecture of skyscrapers like that of the Seagram building in New York (Sebastyen, 2003). Technology had transformed columns into a cage, or grid like structure and carried the loads of the entire building on these few members. Similar to the concept of the Dom-in-o house by Le Corbusier, the loads from each storey are transferred along the slab to the points where those columns directed them downward. This freed up space internally and kept significant structure below each other, concentrated in a single space, allowing for open space on each floor, and the external skin would flow, uninterrupted creating the sleek curtain wall façade.

Post Modernism

> *"The increased variety and complexity of functions within and around buildings called for new structural and architectural solutions"* (Sebastyan, 2003:8).

Local and global design has adopted trends from the one other, leading to the challenge of multi-functional abilities of architecture. Design needs to satisfy the first function, that is functionality, and the following aspects are flexibility and environmental harmony (Sebastyen, 2003). As evolution of structural technology occurs, architects themselves evolve. These designers of space and structure go through change themselves which is often reflected in their buildings. Their character is arguably what the language of each of their design portrays. It is the "self" that Christopher Alexander (2008) expresses that gives life to design, and encourages architects to incorporate their enthusiasm into a built structure.

Post Modernism sees what can be described as "Contemporary Architecture". In the past the vision of architects responded to their past experience of architecture. Function based design is no longer the only purpose for architecture. Previously technology enabled architecture to respond to functions by encasing a space, or opening up a space. The structure that created that space influences the functionality of the space. Architecture that worked together with functional space meant that flexibility and opportunities for changes might be required. This is what happened once the need for multifunctional architecture was required.

Charles Jencks states "the main motivation for Post Modern architecture is obviously the social failure of modern architecture" (Jencks, 1996 cited in Sebastyan, 2003). Jane Jacobs (1961) argued that architecture in the modern period created cities that lacked the equality of life for man as a response to Le Corbusier's rationale that architecture was a machine to live in. Although the Post Modern era solved the problem for housing and industrialized developments, the absence of sensitive design was a result thereof. Human beings are a species that require the natural environment as much as any other natural being. Having a social characteristic, humans are interactive species that thrive and prosper through physical and verbal connections to each other and the habitat they live in. This learning and sharing process is the means through which humans build their sense of belonging and grow to respect their environment and each other.

Disconnecting from the natural environment as structural technology often did, challenged the sense of place and impacted negatively on human well-being.

Late Post Modernism included design approaches that tested the ability of structure to incorporate the natural environment. Examples of these are Metabolic and Organic architecture. Metabolic architecture used design as an artistic device, symbolically representing an idea or object. Architect Jorn Utzon together with Peter Rice of Arup Ove created the metaphoric design of the Sydney Opera House, Australia (Figure 4). This representation of an object in the built form sensitized that material and scale of the design. Often Metabolic buildings are large and imposing, therefore the environmental setting completes the image and gives it substance and sensitivity once placed in context.

Organic architecture took this symbolism further by using nature specifically as its influence. Frank Lloyd Wright was in the forefront for nature inspired architecture as seen in the Falling Water (Figure 5). Although it did not appear as a free form, the conceptual thinking drew from the natural setting and developed that theme to create flowing space and textured aesthetics. Organic design explored the fluidity of nature and incorporated this into architectural structure. This approach is the predecessor of Biomimicry in its' ability to incorporate nature and the natural environment into the structural integrity of design.

Figure 4. Sydney Opera House-Metaphoric Architecture (Source: http://www.inaresort.com/sydney-opera-house/sydney-opera-house-australia-hd-desktop-wallpaper-high/)

Figure 5. "Falling Water", Kaufmann House depicting organic architecture in design concept. (Source: http://community.artofmanliness.com/group/architectsandarchitecture/forum/topics/frank-lloyd-wright?xg_source=activity)

2.2.2 Sustainability and the factors that influence materials

> *"There is a new area that greatly affects architectural design: aspects of the environment, ecology and sustainability"* (Sebastyen, 2003:33).

The impact of technological advances on building materials affected that natural resources and the environment. Sourcing, fabricating and transporting these materials required huge amounts of energy. This vital resource is precious, to the wellbeing and balance of human life. Apart from pre-construction energy consumption, certain materials emit large amounts of $C0^2$ once built and exposed to the natural elements. Water absorption and reduction cause materials to act in specific ways, altering the structure ever so slightly but have a great effect on the energy balance.

Shanghai Armoury Tower is a prototype for responsive high-rise buildings at 36 stories high (Kenneth Yeang, 1999). It attempted to merge the internal and external environment in a symbiotic relationship, changing the usual parasitic nature of technology. The name "armoury" comes from the Chinese military kit. The metallic screens resemble armour and the solar top panel represents a helmet. Symbolic of the Chinese heritage and the use of materiality in the structure Ken Yeang introduced convivial tools in the design. The structural system speaks of integration with design and through sustainable responses created an ANT that was cohesive.

Climatically Shanghai experiences close to extreme conditions. The drastic change in seasonal climates requires a system that adapts and provides a comfortable, habitable interior environment. Ken uses a heat exchanger however instead of a mechanical ventilation system he utilizes an atrium through the entire building. The arrangement of the tower was designed for passive effective ventilation. The central atrium is linked to sky courts, which act as oasis intervals. Together this acts as thermal chimney encouraging cross ventilation, functioning with the assistance of the Venturi's effect (Refer to Figure 6). His interpretation of design and structure co-exist, forming spaces and volumes specifically to suite the weather conditions in this area.

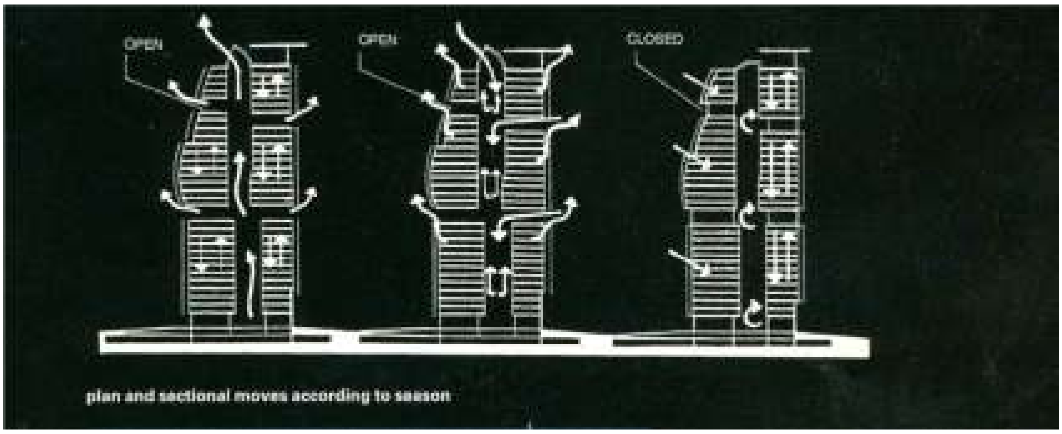

Figure 6. Section drawings through the atrium and sky courts of the Shanghai Armoury Towers indicating seasonal air movements (Yeang ,1999)

Sustainability urges architecture to be most optimal, by optimizing materials (Wilson, 1983), and effective structural techniques that least impact on the natural ground. Here too, the environment forms part of the vital context that architecture needs to respond too, with least amount of disturbance.

Material choice depends on the purpose intended and the context (Foster, 1983). Factors that need to be taken into account when selecting materials should be determined as follows:

Availability: It can be said that the availability of a material influenced the time of its use, in the example of medieval England were the use of oak was extensive so much so that it led to a stylized architecture in time for timber frames.

Cost and Labour: Pre-industrial Revolution, labour was in abundance and cheap. Now the cost of preparing materials of more than replacing them as the cost of labour has risen. This has further influenced the architectural character because the material shave been developed to be more durable in order to prevent maintenance and replacement.

Geography: Climate conditions dictate the construction method. New York is a rock based city where as Los Angeles is prone to earthquakes. In comparison to tropical climates the building techniques are very different and influence the material choice and the construction method, giving rise to the form of that building.

Structure and Physical properties: Originally the materials of stone and brick limited architecture to mass rectilinear design due to the properties of the materials having great weight and no flexibility. The solid would form an enclosed structure and connections to other spaces or to the exterior was limited or completely lost as all the structural forms where mainly walls or columns used as structure. This hindered the chance for cohesive flowing spaces.

With the introduction of steel and timber frame structures transparency became a possibility. The use of light and fixed grids with infill allowed for more opportunistic design and open space inside buildings. This revelation of natural daylight as an element within that building and free flowing spaces gave the flexibility for change and adaptive uses in one building. Similarly concrete and reinforced concrete meant structure could be molded and shaped to suite the purpose of the design rather than the design following the constraints of its materials. Architecture evolved from a rigid mass technique to a plastic form or even organic opportunities.

2.2.3 Advances in Structural Materials

Timber

Timber used as one of the first building materials was only restricted to the direction of the grain and length of the member, this natural organic material is high in strength to weight ratio (Sebastyen, 2003). Materials used in architecture had previously come direct from nature. Timber is the purist form of nature used even today, giving a completely unique quality to design. Nature provides materials in many ways, as glass is created from sand and heat, and metals or other resources are extracted from the very earth we live.

The beginning of acceptance of timber as a material began post World Wars I and II in building for financial organisations (Foster, 1983). Timber has been part of the construction process for many years, as it is vital for shuttering, scaffolding supports, and various temporary fixings. As a technological structure the material has the opportunity to be prefabricated and transported with ease due to its lightness in weight. Other benefits of timber are the off cuts can be used to make boards or insulation, a sustainable material when compared to concrete

Foster (1983) explains the historical methods of timber construction as *solid timber construction* were the stacking of timber formed the structural walls as seen in Russia forming the enclosed cabins in much colder climatic areas. *Half-timber constructions* was the support and infill method with the timber forming the frame structure, *mast or stave work* was a combination of solid and half timber construction forming and *post and beam* mainly evident in Chinese and Japanese architecture.

Traditionally China and Japan utilised timber, as it served as an ideal surface for carvings and screens into the structural elements. The distinctive roof shape in China is due to the space between the timber roof beams. Modern methods used stressed timber specifically for the intended use such as frames, trusses and beams. These structures soon were treated and exposed as a true material for aesthetic reasons apart from its structural integrity. Modern application of timber changed from a laborious traditional material into a technically evolutionary one when used in conjunction with steel and metal (Foster 1983).

> *"Timber made a significant contribution here as a result of development in jointing techniques using metal connectors and glue. With metal plates, rings and bolts to join timbers, the strength of the joint increases greatly in tension and shear"*(Foster 1983:76).

This made it possible for timber use in larger buildings, greater spans and higher volumes. The previous restrictions on framework and stacking were lifted, reintroducing a natural material into modern architecture. In the most recent works of timber as structure, CLT (cross laminated timber) has allowed timber to work in compression enduring heights of high rise buildings. As seen in the Pompidou Metz, timber is stressed, curved and laminated to form fluid shapes of structure (Figure 7). It is the main frame system exposed internally for its adaptability, texture and evolutionary flexibility.

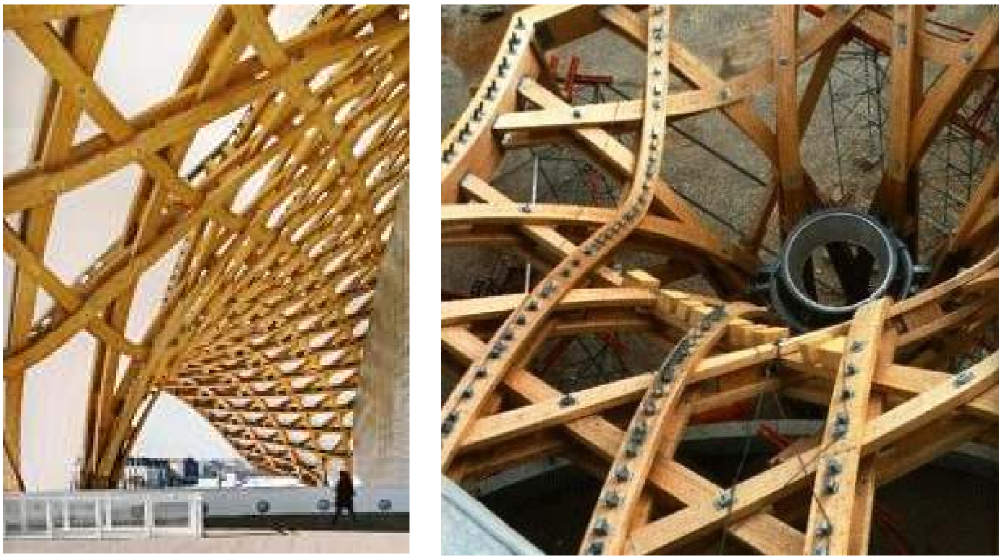

Figure 7. Pompidou in Metz built of laminated timber forming a hexagonal support system. (Schittich, 2010:1045,1044)

Stone and Brick

Stone originated in the period of the Pyramids in Egypt, Stonehenge in England and later the aqueduct systems in Rome and the Parthenon at Athens, Greece. The material was sourced from the earth and in some cases rock was carved out as part of the original point of discovery, temples and tombs built into the rock. Post World War I and II, stone was one of the strongest materials that presented importance for buildings of politics and worship. The period of Art Nouvaeu took on the material for the use in churches and schools or educational facilities (Foster, 1983). Currently stone is used as cladding or as features on buildings rather than the structural support. As technology has evolved so have the systems, hence lighter and more flexible materials are employed.

Egyptians are noted as the firsts for sun drying mud and straw to make bricks, which is the first manufactured material made by man for construction (Foster, 1983). Brickwork relies on mass, the coming together of many blocks to form the cohesive load bearing structure. Over time builders realised that brick could create openings in the form of arches and the vaults. This gave the material more prominence and features than the system of a solid structure wall.

Brick was introduced in late medieval England, having similar load bearing properties as stone. In China and India brick played a role in the tradition of the countries architecture. The Great Wall of China was predominantly stone, although the additions of arches are made of brick (Foster, 1983). The bondage systems in brick allowed for visual and structural opportunities of change (Figure 8). But the main system of load bearing masses restricted heights. Modern applications of brick seen by Frank Lloyd Wright as the old material could transform in the presence of the contextual time frame. In that period of the Modern Movement the material was used to create sheer elevations, taking advantage of the uniform structure.

Figure 8. Great Wall of China, the only man made structure that is visible from the moon.(Source: http://famouswonders.com/the-great-wall-of-china)

Iron and Steel

Materials played the role for new creations in structural design. The discovery of iron and steel enabled the opportunity for larger space, taller structures and complex form. The first recorded steel frame skyscraper is the Home Insurance Building in Chicago built in 1885(Sebastyen, 2003). Upon demolition it was found that steel was used as the key structural component in the building. The first metals to be used were wrought and cast iron. The Chrysler building was the first construction of surface metal.

The realization was that steel allowed high rise buildings to maintain a rigid form and reach higher heights. The Eiffel Tower was meant to be a temporary exhibit, however still stands at 300m, taller than any man made structure at the time in 1889 (Foster, 1983). Here the use of steel was displayed in an elaborate way, showing flexibility and strength as a material alone. Steel was taken a step further with it being used in the presence of another material as reinforcing for strengthening concrete. What was previously seen as an engineering feat became an example of artistic steel made of lattices and spatial ratios in structural technology.

The modern movement employed steel and concrete to be fully exposed as individual structural materials. There was to be no covering the steel in concrete as this went against the visual and theoretical characteristics of Modern Architecture (Foster, 1983). The Barcelona Pavilion and the Farnsworth House true indication of this, using the slender steel columns and clean unclothed materials to depict true nature of structural technology (Refer to Figure 9-10).

Figure 9. Farnsworth House by Mies van de Rohe expresses ordered structure. The entire framework is steel, in filled with glass.(Foster:118)

Figure 10. Barcelona Pavilion in true Modernist architecture.(Source: http://www.cumbu.com/barcelona-pavilion-building-by-mies-van-der-rohe)

Sebastyen explains Frank O Gehry's opinion on how steel is a material of "this" time. Its free-form flexibility allows for a sculptural structure that is almost impossible with other materials.

Concrete

Concrete alone is 2000 years old, however reinforced concrete is the more durable and featured material in architecture (Foster, 1983). Performance of concrete completely transformed with the insertion of steel rods, wire or mesh. The material was now monolithic and continuous, allowing for larger spans and more plasticity, as well as slenderer sections.

Le Corbusier's Dom-Ino house, in 1914, explained the capabilities of reinforced concrete, freeing the structure of loads on internal supports (Figure 12). Le Corbusier's creation thereafter in Modernist architecture utilized concrete as the material of choice, embodying the molding ability of it.

Figure 11. 1936, the monument in Como by Cataneo showcasing the structural integrity of reinforced concrete. (Foster, 1983:127)

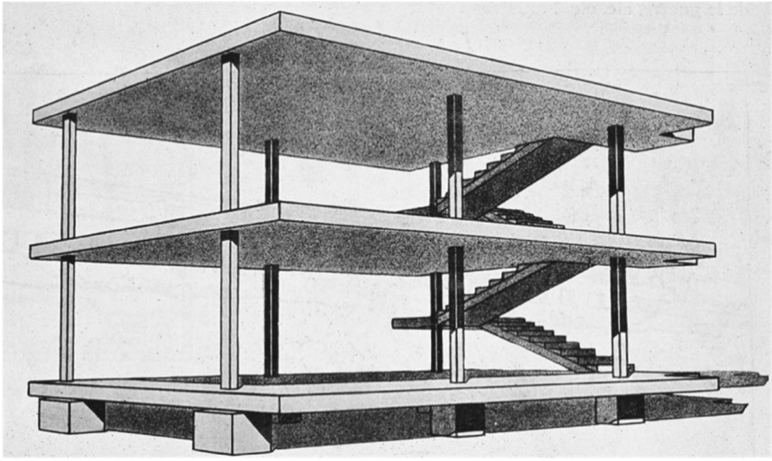

Figure 12. Dom-Ino House by Le Corbusier (Source: http://mlehman.wordpress.ncsu.edu/2012/11/12/8/)

Glass

Glass can be characterised as a traditional material, however due to its expense the use of glass was restrictive in the 19th century. The combination of Sand, Soda and lime infused by heat created the transparent material.

The Crystal Palace (Figure 13) had the advantage of iron, using precast frames that were quickly assembled on site. The building was meant to be a temporary structure; however the impact of new combinations and integration of materials for that time that it remained permanent and planted its place in history. The building resembled a massive green house, with a vaulted glass roof.

From being an infill material for openings and top lights in churches and cathedrals, glass evolved to continuous ribbons and curtain walls.

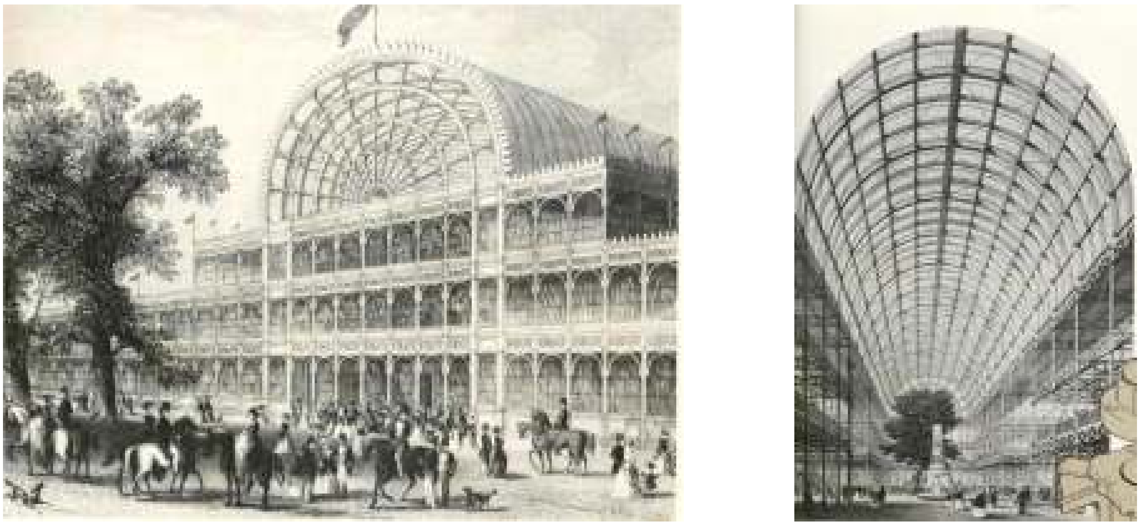

Figure 13. Crystal Palace(Foster, 1983:201,113)

As the advances in production and manufacture, glass could be produced in large sheets. Also, the development of cable and steel frames, sealants and devices for fixing glass meant the material could be used in new innovative means. The term “structural glass” comes later in the evolution of structural materials referring to tempered and toughened glass.

Modern application of glass came hand in hand with steel yet again. The two materials were opposites in physical properties but complimented each other due to this. Glass became the alternative to bricks and concrete, allowing visual connections because of its transparency.

High rise buildings currently are infamous for the use of glass. The double skinned system is more for aesthetics and climate control that structure. However the greatest outcome of the evolution of glass is the use of other materials in order to form a composite.

2.2.4 Informers of Structural Technology

In her paper, *The Structure's Architecture* (2008), Adrianna Guisasola states that in the opportunity and complexity of contemporary architecture, “architects must incorporate the various scientific and technological advances and synchronize them in a creative, imaginative and pure manner through economics, sociology, aesthetics, engineering, planning and design.” She addresses the response of architecture to its context, with close attention to topography and landscape. For architecture to be incorporated into the environment, the activities of that environment must be considered.

Guisasola explains that each architectural design must take into account the context as this affects the architectural response. This setting being the components that directly relate to the building. Amongst these aspects are natural and physical facets as well as the cultural, social and economic features. Of these, the focus will be the natural and physical as this aspect depends on that structure of architecture to withstand natural disasters and it places the design in a physical setting for it to respond too. Guisasola states that architecture intends to provide solutions for these occurrences while attempting to integrate a sustainable approach to the specific environment (Guisasola, 2008). This provides the opportunity for structure to form part of the language of the design while offering support physically. In this way structure becomes the architecture, not an additional support system.

2.3 PARADIGM OF INDUSTRIAL REVOLUTION, MAN AND THE MACHINE

2.3.1 The Role of Technology in the lives of Man

> *"The most significant impression one receives from the industrial town is that it made the most of what it had between the means and technology available"* (Hough, 1995:12).

In early civilization in development of cities, the limitation to resources like water and cattle restricted the area of that city. With time and technological changes likes expanded, however the initial framework for designs of these cities meant that a great part of it was for walking, as vehicles were limited.

Wilson explains the paradigm of structural architecture and its impact on mans psyche. Man has mastered the art of building, however has failed to understand the art of the built environment. *"Architecture combines external form and internal space, structure and material into one essence"* (Wilson, 1983:7). It is easy to bring together parts that form a building, however that self known as "I" (Alexander, 2005) or "soul" (Day, 1999) is the key spirit of architecture. Technology has no real meaning if it abandons all sensitivity to man and the environment.

Architecture is an art as much as an industry. This "art" Sebastyen (2003) says is influenced by the art of sculpting. In the classical period architecture was limited to the materials available, making the structure a sculpture of material elements (Wilson, 1983) rather than a science. Modern engineering in architecture redefines it and is more likely influenced by technological structure as a current interpretation on design. This may be as the design now is faced with the technological impact made in modern design. Similarly in his analysis of evolution systems and man's approach to modern living, Pearson (1994) mentions interrelationships using self-sufficiency and creative diversity rather than isolation.

Architecturally, evolution relates to man and technology in the natural environment. Advances in technology were only possible due to humans drive to prosper and better living standards. This creates an environment that impacts on the human psyche (Weinstock, 2010). Man is linked to nature through evolution and cultural history. Natural environments have been altered by the introduction of built form, and further shaped by technological advances and developments created by man itself. As the natural and built environment of man evolves so will man's psychological and sociological integrity.

Debora Scatena questions the approach man had adopted when dealing with climatic challenges. She states that the developments that man has made have altered the relationship with nature. She questions if technology will create a new balance or bridge the gap between man and nature. Heidegger's (cited in Scatena, 2011: 12) opinion of technology is that it will lead people to the truth. His belief implies technology has the potential to develop a new framework were man and nature can create that interrelationship that is lacking. Explained further, it is acknowledged that technology is a means of benefitting man by creating opportunity for better performance, reaching areas that are untouchable by man, discovering new means and methods, new sources of energy.

Toffler (1970) explains once people experience an abrupt collision with the future of technology, they will fear the radical change and struggle psychologically to keep up with it. On the one hand technological change is for mans improvement and appreciation of science. It uses the knowledge of man and produces it to serve man. On the other hand change is happening faster than mans capability to comprehend it, therefore evolutionary technology will affect mans response, hindering man further instead of empowering him.

Sensitivity of architecture is the aspect where design becomes a sense of place for the user. When interviewed on his opinion of sensitive architecture Hugh Fraser (refer to Appendix II) explains that technology should in fact be the 'Tool" to create architecture. The outcome still needs to be sensitive to the users (man) and the context (environment). He states the relationship should be symbiotic. In some ways, nothing has changed, architects are providing a built environment for humans (and animals) and the targets haven't changed only the vehicle. Technology must serve our ultimate target responsibly.

In comparison Malcolm Macleod (Refer to Appendix III) disagrees that technology needs to be sensitive to man. The reason technology exists is to be the crutch for design to materialise. He states it should not be the saviour of design as that would mean architecture is treated as individual systems of exclusive design and only later is technology applied almost to save it. Technology shouldn't be used to repair a bad design but rather it should afford new building types specifically in relation to structure.

> *"It takes more than putting building materials together to create architecture. No one can explain exactly what that more is, except that architecture has a spirit and a building has not"* (Wilson, 1983:7).

The time of responsive building and material retrieval has changed. Mans acknowledgement of materials from the earth, and responsibility to that environment once they remove those materials is lost in the machinery and urgency to create buildings without understanding the consequences.

2.3.2 Structure's role in the Perception of Space

Wilson (1983) states that man can easily distinguish scale and proportion relating himself to that space or opening. The size of windows required for people to look through or openings to walk through, man uses his body a tools to measure against even if he does not intentionally to so. The act of comparison helps man understand and reflects the comfort level in a particular space or against a particular structure. In complete contrast, the size of a rocket cannot be measured by the human eye, as this reaches beyond our ability to compare ourselves to it. The surfaces are smooth and uninterrupted leaving no segments of ratio, or allowance for comprehending height.

This explains the overwhelming emotions and perplexity man feels in front of structures he cannot understand or relate too.

A space is determined by the structure defining it and the experience of that space is felt by mans movement in that space (Wilson, 1983). Since man is created to move, the spaces created by structure are related to man and movement. Man requires space to view things, to hear sounds, to feel the change in air movement. Space is a part of a living world, and this is due to the structure that forms the space, therefore space and structures are undividable.

Space is perceived by man as a judgment of distance, by the play of light and shadow and by the perspective of lines to help interpret distance. This directly relates to technological structure as it is responsible for forming that space, as well as the being the elements that are compared for man to distinguish the space. Apart from created space, man embodies his own personal space (Wilson, 1983). The interactions of these two spaces are what make a whole space memorable. Similar spaces in different areas give a sense of nostalgia and man can relate to them accordingly. Technological structure of architecture must therefore be selected with this in mind as it not only has the ability for a support system for a building but it is also responsible for the spatial significance it represents.

The human being can perceive an object while standing; seven times his height (Wilson, 1983). Afterward he would need to move to completely comprehend the structure and space. Therefore greater heights and distances are harder to understand and more difficult to relate. The meaning of a space and structure becomes more meaningful if it is concentrated and humanly sensitive.

Divisions in space enables the human mind distinguish the punctuation of space and in so doing understand the space (Wilson, 1983). This sense of repetition is compared to machine quality which is deadening to man's receptivity.

Technological structure can be compared against the same principles of the human body. Apart from psychological affects, structure can relate to man through the physical aspects of geometry (Wilson, 1983). The human being is a complex system of structure that keeps one intact. The height and weight of bones and matter all form part of a structural system to support that body as an entirety**.** Similarly the size and materials of structure is a system in itself.

> *"The limits of buildings that obey physical law is critically important. These laws demonstrate the bond between materials and structural principles. They determine the limits of architectural structure and the space it encloses"* (Wilson, 1983:22).

From this man's sense of structure, scale, and space can be derived. Materials cannot be doubled or tripled without some impact on its strength. The material itself becomes too heavy or unstable to support itself hence the sense of ratio and structure system in place. For every structure to perform at its best, it is required to be at the most appropriate scale.

Wilson describes the term "counter culture" or "communes" as members developing new technological systems in architectural design. They break the mould, reinterpreting human values when dealing with technology and architecture. Their use of hi-tech materials and systems experiment is not focused on only the appearance and proficiency of structure; it mainly intends to affirm a new approach in life and sensitivity into buildings. The buildings are quality of architecture, housing spirit and true conviction that can be compared to the rationale of the self or "I" that Alexander describes (2005), Ivan Illich's "Tools of Conviviality"(1973), as well as Day's (1999) "soul".

2.3.3 Life Essentials of man

Robert L Thayer Jr (1994) analyses the relationship between what he calls the three facets of human evolution. These include *Means for living, Context of life and Motives for living*. He illustrates how the relationships are an interrelation between philosophical, contextual and technological aspects that lead and involve one another. They depend on each other, and have direct effects on one another. It can be said that although it is in the perspective of man, it is also the view of architecture (Refer to Figure 14).

- *Means for living* are the tools of survival= Technology.

  Technology forms the 'tools' as they are the drivers that have allowed man to progress. Mans ability to create better living conditions required mechanisms, techniques and evolving methods to improve life. Technology being the instrument for man's progression is described as such.

- *Context for Life* is the land, the environment that this technology impacts on structurally = Environment.

  The environment natural is the place where man has developed. From the initial historic accomplishments, to the current architectural designs, the surface on which all this was possible is the environment. It is the stage that life has been played out on and the constant in the subject of change.

- *Motives for living* are man's psychological experience, and feeling of belonging = Quality of Life

  Man's requirements for living have changed from survival to fulfillment**.** The mere need for shelter is the basic need, however man too has evolved. Man now requires 5 levels of needs as explained by Maslow's Hierarchy of Needs (Wilson, 1983). As societies evolve, their needs become more complex and they require more specialized means to fulfill life including psychological, emotional and social stimulation (Refer to Figure 15).

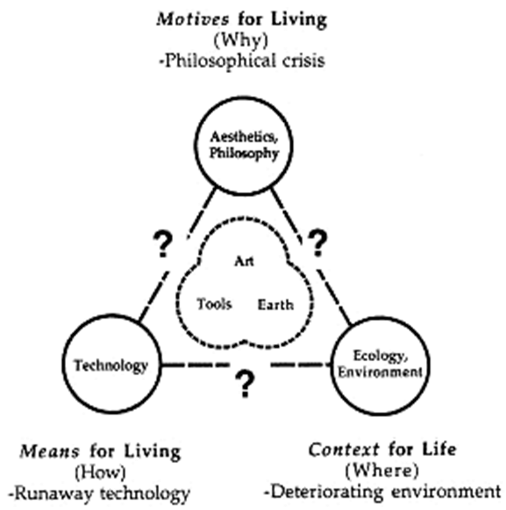

Figure 14. The "Life Essentials" triangle for man. (Thayer, 1994:31)

Figure 15. Maslow's Hierarchy of Needs(Source: http://www.mindtools.com/media/Maslow2.GIF)

Man and architecture are composites of the same doing. As previously mentioned, the actor-network theory can be applied to this instance. The actors are the relevant facets that make up the network. Technology, environment and quality of life are present in architecture not only survival of man but experience life. As ANT is explained the same divisions and relations are drawn. For a sensitive design in technology and architecture the context and the purpose need to form part of the whole system.

> *"Whether Mumford is correct and we have a way out of technical determinism or whether we are evolutionarily locked into technology as a way of life, the landscape we now inhabit betrays the emigration of technology and nature away from one another, and away from the center of our collective being"* (Thayer, 1994:31).

Granted this triangular relationship did not exist at the dawn of man, however as civilizations evolved using technologies to create systems and so did the triangle relationship come into being (Thayer, 1994). It can be said therefore that some of the ancient fetes of technology like Stonehenge, encompass these three driving elements. As time has passed, technology has dominated as the driving force, resulting in the manmade mechanical landscapes we live in today.

Wilson (1983) described humans are beings of movement, discovering that people are social creatures. Their need for socialization provides a positive atmosphere where people are drawn to gather and interact and comprehend space. The spaces that structure forms therefore require this meaning of space, an allowance of comfort for people to interrelate with each other and the structures surrounding them.

> *"Most of the time we don't notice our surroundings and then they can work upon us without any conscious resistance on our part. As these surroundings are mostly built environment, architecture can significantly affect us"* (Day, 1999:4).

Day (1999) explains the relationship between man and the environment. The environment being the complete built existence and natural surroundings of man. Although mans perception may only concentrate completely on one sense at a time (Wilson, 1983) the other senses are present, absorbing and reflecting in the human mind. Although it may appear insignificant, the context of structure, that the environment is in, affects the structure, the spaces, and the users.

"The city's where people live and non-urban regions beyond the city where nature lives" (Hough, 1995: 10).

The perception for many years is that humanity and the environment are separate entities. This perception has a profound effect of how people have thought of themselves, either as superior beings or absent of natural instinct. By controlling design, engineering and natural environment, the effect is also felt as controlling human behaviour.

Wilson (1983) examines mans perception of space, concluding it to be memory and that sense of nostalgia when in a similar space, surrounded by similar structures. In the bolder experiments of technological structure, spaces are being redefined, unfamiliar to mans bank of memories and initially create the sense of unease or perceptual shock. However using these recent techniques and materials in ways not familiar with man creates the interest to keep changing and gradually the new will become the current and inevitably the past.

2.4 THE RELATIONSHIP BETWEEN TECHNOLOGY AND ARCHITECTURAL DESIGN

2.4.1 Architecture as a Structural System/Art

The factors that affect technological change on building and structure in architecture are function, structure, components and equipment (Sebastyen, 2003). The function of a building greatly influences the structure of it. Residential and industrial architecture have two distinctive differences, each arranged around and accommodating the function of that space. This determines the structural system from the onset of the design, suggesting that function definitely plays a role in shaping the building and the structure required for best accommodating that function.

"The form of a structure should correspond to the type of a structure and that the function of a building should harmonize the structure from" (Sebastyen, 2003:51).

Historically this already existed. It translates the structure from a system of technologically based support into a design system that forms a composition of aesthetics and arrangement, an integrated language of engineering and architecture.

"In modern and post modern architecture the use of steel and reinforced concrete made it easy to design structures whose form did not really correspond to the type of the structure. The principle of harmony and structure was in fact undermined by this development" (Sebastyen, 2003:51).

Mega buildings, atria and elevators created a whole new dynamic in the technological structure and criteria for architecture. These aspects further determine the choice of materials and structural framework due to the size, the volumes and mechanical shafts that need to be incorporated.

Earlier construction was based on trial and error, when practicality of building required it. Over time construction became more experimental, using science for calculations and materials tested to the maximum of their ability. Technological advances allowed the science of structure to evolve, giving opportunity for new material and composite materials to form new systems to design. Technology and architecture has evolved as explained through the history of architectural realms and history of materials. By comparing them an explanation may be given for a clearer perception of how architecture can change from a static object to a dynamic system.

Sebastyen (2003) states many of these progressions affect the appearance of buildings. Apart from material properties the manufacturing and construction processes for those materials have also evolved.

Effects of technology on Architecture (Sebastyen, 2003):

1. *Process effects: Relating to the design directly*
   The instruments of conceptual design in architecture are the software and computer technology that allow architecture the freedom to be creative.
2. *Modern Construction: Structure of the design.*
   The process and development in architecture that dictate construction of materials. This includes prefabrication, mechanization and industrialization.
3. *New Technological activities: Flexibility of design*
   Using these 'tools' to create multi-functionality of the buildings

Malcolm Macleod (Refer to Appendix III), states architecture is lost if structure is the afterthought. He explains the expression of technology and structure may change, the language however should be similar in the execution of design and technology. Architecture cannot be divorced from structure. It is the entirety that distributes that validity of each constituent forming a whole.

Michael Foster (1983) explains that architecture depends on abstract parameters that determine its character. These include "context, time, function, and style" all related to "availability and suitability of materials, climate and ecology" (Foster, 1983:8). All these reflect on the design, and analyzing this in later years can identify the time frame of the building.

Since the onset of industrialization the lifespan of buildings are much longer than previously because the approach of architects is for flexible adaptive design.

> *"There can be no solution without a problem, no problem without constraints and no constraints without need"* (Foster, 1983:9).

The task for technology to evolve begins with the requirement for a better solution. This is an ongoing process, and recognized so when compared to ANT, the network encompasses the needs of actors, the solution of technology evolving to suite this need. Structural technology as a solution to a given need succumbs to constraints, physical, contextual, and materials.

> *"To be successful, a design must encourage new and unexpected uses as well as having its roots in the original proposal" (*Foster, 1983:9).

Technology can be basic where the function is fixed and does not allow for change or technology can be intricately different, resulting in opportunistic adaptable tasks that one "technology" can do.

Idealistically architecture and engineering combined will form the optimized opportunity for structure and space (Wilson, 1983). In the coming together of these elements the resultant responds to human sensibility. The structure, and space that structure creates, should reflect ambiguity and diversity in order for man to be intrigued. There should be an unlimited interpretation of that space; with no restrictions as these very restrictions are the tools that control human behaviour and loss of self.

2.4.2 Structure as an incentive for renewal.

Christopher Day explains the interconnection between past, present and future. Technology strives to be cutting edge and modern, pushing the boundaries in structural design. He states that each present is relevant to the time, expressing the intention for that time. Instances were technology is futuristic; it is in fact inspired by the future, and compared to the past to give it the status of "futuristic".

> *"For the present, however future-inspired, is built upon the past...Neither past nor future mean anything on its own. Future grows out of, is fed by, past; and past is always inspired by future"* (Day, 1999:16).

Christopher Day believes that architecture is always related to either or all in order to exist. It would have had to have learned from the past or strive for a futuristic design for it to be present. Forrest Wilson (1983) acknowledges that new buildings are formed and technologies advance to create these structures. However in comparison, he claims these lack sensibility of past precedents. Man is more inclined to trust what they perceive, and that perception is based on robust, visual and solid structure. New technological structures that defy gravity and transparency, slenderness and joints of these structures may appear unbelievably weak although the strength is much more.

In the interview with Malcolm Macleod (Refer to Appendix III), he states that seamlessness must occur in the planning and design and aesthetic. It must be as one because if not it becomes divorced and lacks credibility. In the instance of the Shanghai Bank, the building embraces the structural technology and uses this as the aesthetic. Here there is an overtly recognition of structure, and excessively used to push the boundary of the norm in design.

The Shanghai Bank in Hong Kong by Norman Foster appears as a technologically driven resolution. However examination of the culture of the society of the location, it is certain that Foster has captured the tradition of the society in his approach. This has been illustrated in the strong structural representation of the building, abstracted from traditional Chinese architecture in which the structural supports are emphasised. By the same principle structure now has the ability to not only mimic but symbolise and translate traditional form, shifting design from an adornment feature into a structurally integral component (Refer to Figures 16 and 17).

Figure 16. Shanghai Bank by Norman Foster (http://thewondrous.com/hong-kong-photos-10-superb-skyscrapers-of-hong-kong/)

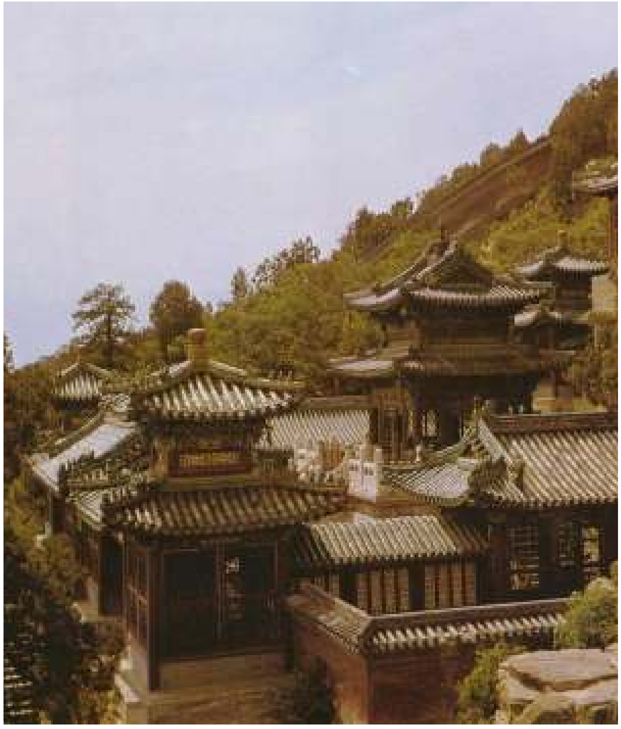

Figure 17. The Summer Palace complex, with emphasis on the roof structures as Chinese tradition. (Foster, 1973:63)

2.4.3 Biomimicry as a design of structure

Biomimicry is a relatively recent concept derived from the theory of Post Modern Ecology. It is a discipline that examines nature's physical structure, nature's processes and the systematic aspects then imitates them (Tsui, 1999). The inspiration for innovative design comes from nature, trying to best interpret what nature has perfected. The science of nature and the complexities within natural systems that man has unraveled through the years serves as the background for design principles in architectural design. The aspect specifically that proves to be an opportunity for technological evolution is the structure of nature. Mimicking the mere appearance or form creates the literal translation of nature, where as the structural integrity of nature is an alternate source of fresh and complex properties architecture can learn from.

Biology Design Spiral (Refer to Figure 18) is a design methodology incorporating Life's Principles into a measure of nature (Benyus, 1997). This assists in designing sustainably through Biomimicry using a spiral to the best interpret "process", as this shows an ongoing cycle and as life's principles are evaluated, another challenge arises. Each step in the spiral equates to a mimicking process, of form, function and the ecosystem of nature. These answers are compared against life's principles in the attempt to best create a design of adapting, learning and evolving.

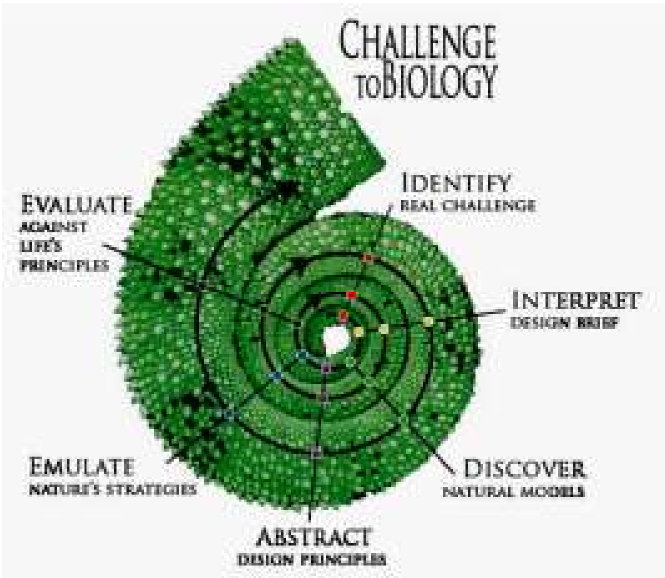

Figure 18. The Design Spiral (Source: http://biomimetic-architecture.com/what-is-biomimicry/)

Although a methodology, the Biology Design Spiral extracts the vital elements that Biomimicry attempts to do. Apart from the physical form, the deeper lying principles of materials, processes and functions for design require to work together for the most fruitful outcome of cohesive design sensitive to man. Technology translating nature into physical form and livable space adds another layer to design approach of form follows function. The "tools" here are Biomimic design that extracts the aspects of nature that are most conducive to sensitive response.

Itsuko Hasegawa is a founding member of the Metabolist Group, who views human activities and technology as an extension of natural systems (Jencks, 1997). Many of her works resemble natural systems, both living such as organic forms and non-living, in the instance of crystalline formations. She states that history of the past is involved with natural systems on every level, considering the landscape, available materials and climate forming part of earth's ecosystem.

"I believe any new building must make up for the topography and space that is altered because of its introduction and help create a new natural system in the place of the one that used to be there"(Jencks, 1997:113).

She explains that as animals exist so do humans, who are ultimately creations of natural systems and as the skill of architecture is practiced so are many other skills, hence these too are natural. Since it is discovered and produced by man then architecture is a natural construction and should be responsive to the ecosystem as any form of matter would be. "...buildings as well as human beings are born of natural systems, receive their image from natural systems and return to a more profound form of life through depth and destruction" (Jencks, 1997: 114). Everything has a lifespan and therefore all of it should contribute to the natural cycle of life.

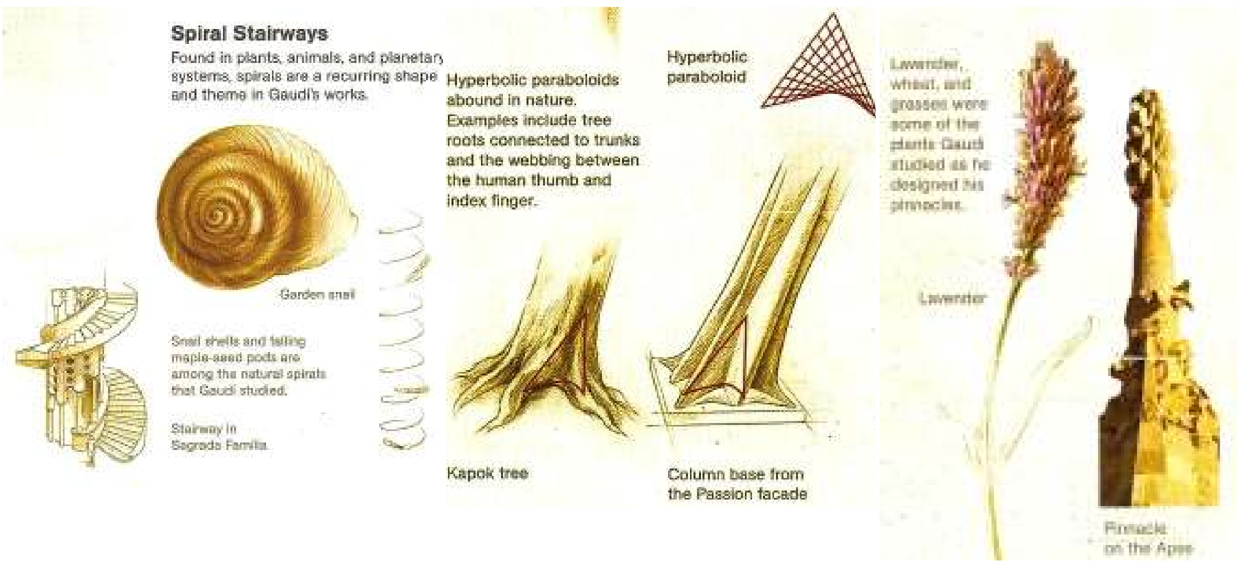

Figure 19. Elements in the Sagrada Familia based on natural structure(Yarnall, 2010: Part 2)

Antonio Gaudi is known for architectural structures based on nature and its forms (Yarnall, 2010). The Church in Barcelona, Spain is evidence of him using structural and ornamental design derived from nature with the most advanced technical integration of the time. It reflects the nature and ingenuity to translate into architecture. There are many literal translations however majority are technologically sound. Gaudi had designed the structure and ornamentation, many of which were related to aspects of nature and specifically, nature related to Barcelona (Refer to Figure 19).

His use of a spiral stair in the Sagrada Familia proved successful after studying the natural occurrence of such a shape in snail shells and the movement of maple seed pods. This repetitive circular shape meant smaller footprint verses height. Large structural columns are based on trees, from the root (bottom) to the canopy (top). Using the aspect of hyperbolic parabloids and the webbing in between found in nature, like that of fingers, the base meets the column similar to roots of a tree connected to the trunk. The column assumes the appearance of the Kapok tree.

Comparatively, Calatrava's desires are derived from nature (Hart and Barraneche, 2000); the structures and movement of animals, framework of skeletons, lightness and intricacy of feathers, shellfish exoskeletons and the intriguing techniques of natural beings.

Santiago Calatrava's design clearly shows his influence from nature (Hart and Barraneche, 2000: 133). He produces buildings that mimic the elements of nature that can move. Often the buildings or parts thereof are moveable, taking design a step further in structural design. The dynamic shape and ever changing form of the building is intriguing in this instance of a non-living built structure to perform, however Calatrava achieves this, giving life to an arguable inanimate form. The concept of Biomimicry translates the movement of an eye into the structural essence of the building.

> *"There are principles in nature that are appropriate for buildings: the optimal use of materials and the capacity of organisms to change shape grow and move"* (Hart and Barraneche, 2000: 133).

Hart and Barraneche agree with adapting dynamics of technological structure as well the movements in nature, pushing the structure to become more than a support system.

Orient train Station is described as a modern take on the Gothic arches on which glass and steel pyramidal canopies are mounted. The columns do also resemble trees, with treetop canopies casting a web of shadow and light (Davey, 1998: 34). Beauty of nature inspires many forms of design, the strongest of which is the mechanical composition of nature. (Pedersen and Täljsten, 2007) This structural aspect is a complex system that baffles the human mind. However in stances where it is dissected and understood, it may be employed in architecture as a technological structure based on nature. This facet of Biomimicry removes the much debated visual depiction and focuses rather on the structure and the precision of nature (Refer to Figure 20-21).

Figure 20. Orient Station (Davey, 1998: 35)

Figure 21. Stuttgart Airport based on the tree branch support system. (Pedersen and Täljsten, 2007:8)

Calatrava designs with nature as a tool, drawing aspects that inform design and produce an alternate connection to becoming sensitive to nature (Slessor, 1995:38). His interpretation of design is combining the "how" and "what" of architecture. Man relates to visual connections first, it is taken for granted what we see is what we know. In the same way the "how" is not necessarily understood or portrayed. This means of structure or support in architecture could easily relate to the mechanics of any machine or even nature. The underlying system that is lost due to mans naiveté. In bringing forth the "how" and integrating with the "what" Calatrava aims to create architecture that contains the secret of life, more poetic than static architecture(Refer to Figure 22).

Figure 22. Milwaukee Art Museum winged structure mimicking that of a bird in flight (Source: www.engagdet.com)

> *"Sometimes naturally occurring geometries become not an invitation to unlock the rules behind their formation, but a direct formal inspiration for a project"* (Actar, 2006: 66).

The perception of an element of nature can be changed to the extent that it becomes the concept, form and structure of a building apart from an inspirational object. The composition of that natural substance is taken a step future and the structure explored as an essence of nature.

Biomimicry captures nature through structure as the design and form. The language carries through as a simple yet complex element. In Post Modern Ecology the focus is to respect and be responsive to the environment. Soap bubbles are inspiration for a form and façade for the National Swimming Centre in Beijing, called the "Water Cube". It is because of the materials present today that engineering allowed for this mimic of nature. Through Biomimicry the "water cube" resembles that lightness of the natural element water and utilizes this in the conceptual reference also seen in the function of the building.

Adhir Imrith, of Arup (Refer to Appendix IV), explains the use of ETFE membrane in the Beijing Swimming Pool. It is an opaque material based on plastic that is ductile and flexible and water resistant. The use in the Water Cube it forms the membranes of pocketed air creating bubbles. It has the ability to disintegrate rather than melt when on fire, therefore argued as safe for the indoor pool. With the adaptability of the material and the flexibility of the clients the water cube is an excellent example of structure as design. The influence also comes from Biomimicry, particularly in structural integrity. The air filled pocked resemble the chaotic arrangement of soap bubbles, forming hexagonal intersections and light aesthetic. The etfe membrane adopts this and creates an infill of insulation, transparency, shelter, and complex aesthetic of form. Although appearing haphazard and random the air pockets (bubbles) are individually filled and specifically placed with steel frames for each. In the entirety, the building forms a light silhouette with texture and creativity of adaption to multifunctional materials (Refer to Figures 23and 24).

Figure 23. National Swimming center (Source: www.asknature.org**)**

Figure 24. Intention of the structural integrity of façade+ structure+ space (ACTAR 2006: 83)

Malcolm Macleod (Refer to Appendix III) explains the consideration of design when dealing with structure. The success of structure and design is in the expression of both. "Beauty of structure is the way of making a building" (Macleod, 2013) Looking toward a new way of integration is really looking at a new way of doing the same. With reference to Biomimicry, structure is considered on a micro scale. A leaf appears to be a small, simple object however the technological system of structure and materials in that minute scale challenge the human perception. Man then looks at this fascination of structure, were biological systems defied what we call common sense. Acknowledgement of these natural complexities and adaption of them in the world of architecture will recreate the systems of nature that work fluidly, were design and structure is one.

2.5 CONCLUSION

The examination of the sequence through architectural history clarifies post World War as well as man's relationship with technology and the need for construction after the destruction of war. In the most recent years after the wars, redevelopment and housing were the key drivers for buildings, however as the industry grew so did the needs of man. Technological change enabled the onset of industrial revolution, a major milestone and possibly the beginning of technologies recognition by man.

Throughout the years man's needs to be inclusive in architecture played an absent role. The starkness of Modernism extracted the bare minimum from structure, and the decor of Art Nouvaeu added adornment to bulk up and camouflage structure. Both responded to space differing outcomes. One would remove all un-necessity while the other would clothe and embellish with extra features. The free flowing space of one would contrast with the distinctive spaces of the other. Similarly, Post Modern architecture and the styles that follow challenge the architect and the recreate a language of space. In this way man's relationship in space would be completely altered if he were to sample each and every "style".

Materials of technology are the tools for which design and man have evolved in the field of architecture. Convivial tools are explained as the means to create and better the lives of man. Materials have given man the opportunity to do so, changing and adapting to suite availability and context. The new developments and methods of these materials enable alternate ways of experiencing the material. Technology of structural materials has gone to the extent of providing structure that becomes the form.

Evolutionary technology is explained as the gradual change and development of structure. In the discussion on materials as the tools for architectural integrity, it is evident that it truly has evolved. Stone is almost insignificant, as the properties not as versatile and flexible materials like steel and reinforced concrete. In the time of their prominence they served well and created structures beyond their years. Factors used to construct structurally challenging buildings in active landscapes were spatial richness, different shape patterns, formal connection with the surrounding area, and fluency of spaces and exploitation of natural recourses.

Evolutionary technology should take this opportunity to make certain that materials and design can integrate sensitivity through responsibility. This means of connection and relativity to both the function and the environmental response will create a sustainable approach for design. Biomimic design gives architecture the option to be inspired by nature. The 'self' and 'I' that are lost can be introduced through natural integration. This angle of incorporating nature is a method rather than an aesthetic, which creates space surrounded by structure that has drawn its essence fro nature. That sensitivity that nature encapsulates comes through in the structural design instead of as an infill or afterthought. This in turn affects the spaces, transferring that energy of self onto man. This forms a complete cycle of man, technology and architecture as individuals who form a whole.

CHAPTER 3: PRECEDENT STUDIES

3.1 INTRODUCTION

The following chapter will investigate two precedents studies which will illustrate the issues discussed in the Literature Review based on the concepts and theories. This assists testing against the technologic and design of buildings that have been previously built. It explores the extensive use of materials as structural elements while incorporating the theory based conceptual vision into the technological design integrity.

The following criteria were used in the study of these precedents:

- Structure + Design Integration

Architectural design will be examined as the main conceptual drivers for the building and its' combination with structure. Based on the structural technology of the building, the question is if and how this was adapted into the design of the scheme. What were the client's brief and how the representation of conceptual thinking was translated into a structural form?

- Contextual + Environmental Responses

Site location and natural environments form the defining factor for a buildings structural system. It determines the structural methods and requires the design to respond or ignore what is present on site. This will help determine how the technology has played the role being sustainable and if the environment has been considered in the design integration.

- Material Palette and textures

Technological advances have influenced the use of materials, in the attempt extract the maximum potential of a material. With the use of recent materials in new ways or considerably older materials in new ways makes for an adapted design. Similarly texture is related to materials, with spaces and forms created with structure and the texture of that structure becomes of importance as it influences the feeling of a space.

- Ecological Responses + Sustainability

Differing from environmental responses, ecological responses address the actual nature within the context. As discussed, the 'Life Essentials' of man require natural environments, with substance and natural elements. Sustaining nature as part of these 'hi-tech' buildings can sensitize and connect what structural technology may have removed.

3.2 POMPIDOU CENTRE, Paris, France

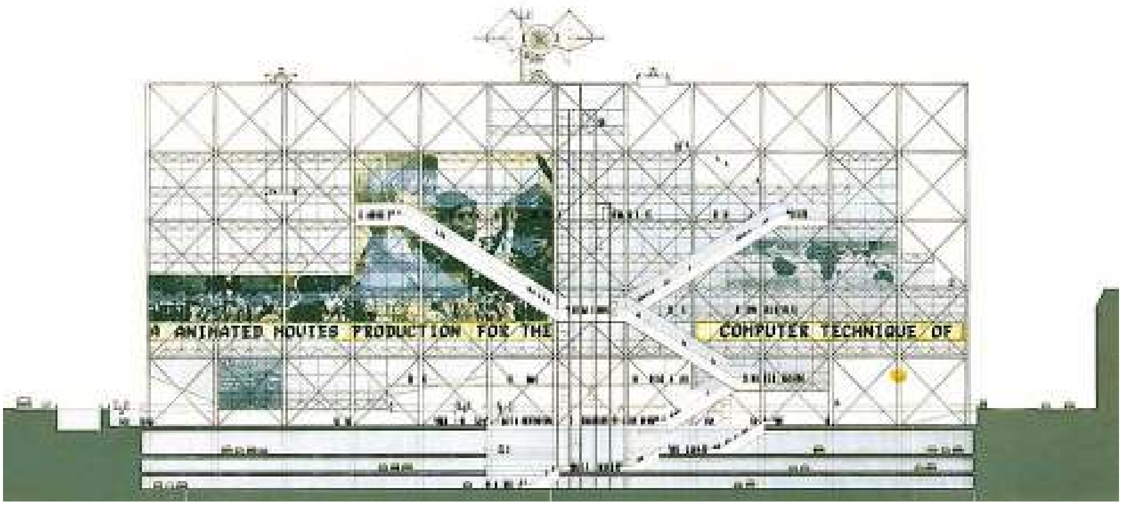

Figure 25. The competition drawing entry. (www.richardrogers.co.uk)

George Pompidou, the president of France in 1969 commissioned a competition for a design that would house the collection of art of France that would be stationed in Paris and was awarded to Piano + Rogers, a collaboration of Renzo Piano and Richard Rogers including structural engineers Ove Arup (Kucharek, 2007). (Refer to Figure 25).

Rogers's intention for the Centre was based on the 1960's design characteristics of membrane and makeup, flexibility, technology, movement and anti-monumentalism. Having a steel cross braced super structure, with the services towards the outside the internal space was freed up. It put a spin on the concept of transparency and technological expression, created the interest the city required to be revitalized as stated in the competition brief.

Structure + Design Integration

The Centre works as a shed, with the exoskeleton being the main structural form and support. Completely exposed systems for services and ducting were brightly coloured to accentuate the functions and identify the purpose, which often is hidden behind duct walls, screens or within ceilings. It literally turned the building inside out, exposing the mechanical and structural systems for better understanding and to open up the inside space. This meant a greater internal footprint for display space and flexible functioning.

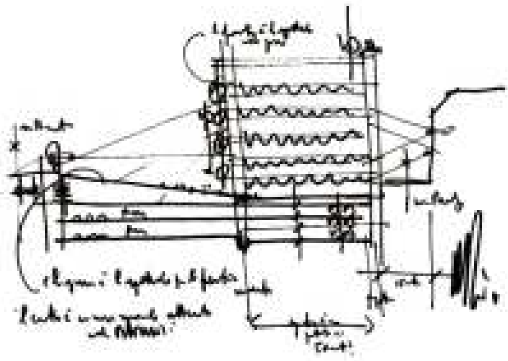

Figure 26. Conceptual sketch by Richard Rogers of the initial proposal of the Pompidou Centre (www.richardrogers.co.uk)

> *"Using state of the art engineering principles and technology, the centre was conceived as a flexible structure, an arts complex designed to accommodate change as functional requirements and technology evolved"* (Kucharek, 2007:37) .

The choice for Renzo Piano's and Richard Rogers work was due to the revolutionized version of what a museum is. The museums at the time were decreed as a privileged opportunity for the wealthy and powerful. This however, broke the mould, and introduced the underbelly of design. It brought forth the crux of a building and showcased all aspects, as would the Centre, which was to become a public space encouraging social and cultural integration.

The steel superstructure would be the fixed exoskeleton, with the walls and floor inserted as moveable elements. The intention was for flexibility of space, and thus these elements could be removed and replaced. The superstructure was made up of thirteen bays, six levels and made of 16,000 tons of steel with concrete floors (Refer to Figure 27).

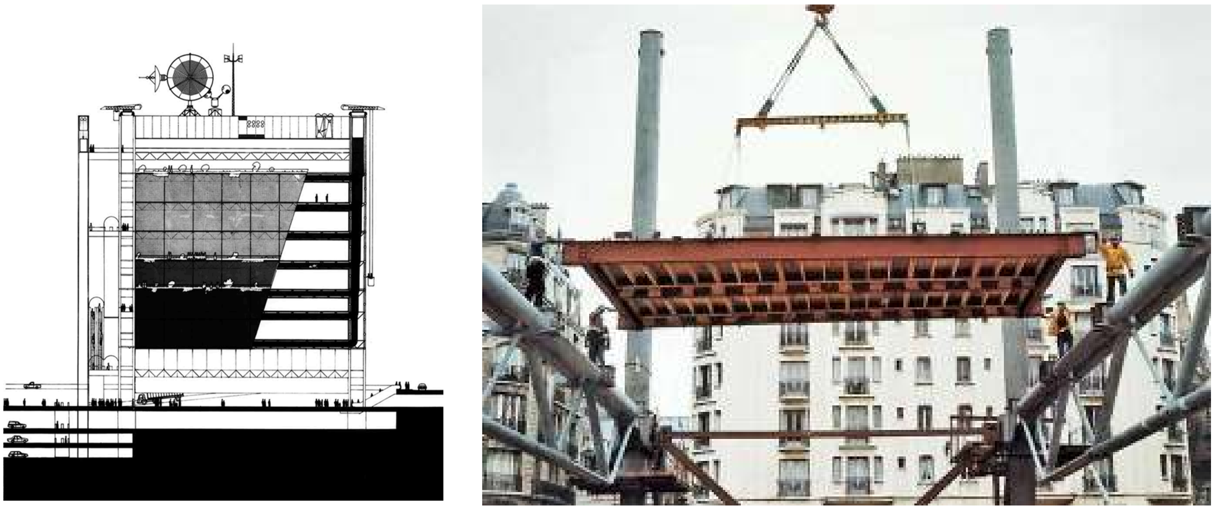

Figure 27. Transverse section of the Pompidou Centre and on site construction of the floor section being carried by crane. (www.richardrogers.co.uk)

A member of Arup Ove, structural engineer Peter Rice (1994, cited in Sebastyen, 2003) states the importance and essentiality of engineers as makers of architectural design. Although design is theoretically the responsibility of the architect, the engineers form part of the design team for the translation of design into built form. Peter Rice suggested the technological concept for the exterior faces. He developed a system of steel structures that consisted on hollow 800mm columns that supported cast steel rocker beams, known as Gerberettes (Refer to Figure 28). These were cast and constructed of site and transported in trucks to site during the night. The side facades were cross braced with steel cables.

Figure 28. Gerberettes transported and fitted on site. (www.richardrogers.co.uk)

Plattner cited in Cruiskshank's article (1997) states that it was Renzo Piano's dedication to maintain and possibly increase the clarity at street level. The centre's activities could be extended outside the building into streets and the building surrounds having a positive impact on the street life. In the Centre the design for internal walls meant they must hang from the main steel structure as an alternative to the norm of rising from the floor. This is due to the truss support system for the floors.

As a museum space the requirement was high volumes and plenty of natural light in the offices and library. The steel frame structure allowed great amounts of glass to be the only element that separated the outside from the inside. This openness is felt throughout the building with views of the city from every floor. Enclosure vs. openness is a constant play, from the open piazza to the enclosed escalator and opening again to each level (Figure 29). Once inside the structural frame, although an enclosed space the height and width creates openness internally.

Figure 29. High volumes supported by steel trusses systems enable large panels of glazing and natural light. (Cruiskshank,1997:62)

Designed as a flexible space and building; the Centre intended to house the newest technologies of the time (which was 1977). However the discussion and irony of that concept is that technology has since evolved. In truth the technology structure and elements of free space, exoskeletons, and steel was beyond the years for the construction of the building. Now however it falls short. The building requires changes with regard to new fire regulations and the introduction of newer technologies. The refurbishment began in 1997 with Richard Rogers and Renzo Piano having full control over the external facades to upgrade. Internally the changes were made to suit those functions, destroying the open space, once flexible to become fixed areas.

"The design of the Centre Pompidou was all about flexibility but is it possible to preserve a permanent image of change?" (Cruiskshank, 1997:63)

The fire hazard meant that the transparency of the building would be lost. The glazing wouldn't contain the blaze in case of fire. It would be removing the concept of transparency only if it were to be built up with masonry (which was suggested as fire proofing).

Contextual + Environmental Responses

"It was designed to bring the city and its cultural machine together, and its shallow curve; discreetly directing the masses down towards the building's entrance was a masterstroke" (Kucharek, 2007:40).

The design of Pompidou's piazza was so that it sloped toward the building. It faced the huge façade of the caterpillar climbing up the building. The slope was subtle, and allowed the public to sit, and even lay on the surface. This space became vital to the design and the surrounding.

Richard Rogers explains (Kucharek, 2007) when designing the Centre, that is the only entrant that incorporated a piazza. The open space outside the building was vital in terms of gathering space, as the existing market, Les Halles, had no a public space.

The main circulation for the public was the "caterpillar" escalator that rose against the side of the frame exoskeleton. This exposed the circulation structure, while serving as a platform for the public to view the city of Paris from that height.

Material Palette and textures

"Transparency was one of the original big ideas of the design-along with flexible and open floor areas, honestly exposed structure and services, and the expression of the nature of the different building materials" (Cruiskshank, 1997:61).

The compact concept of transparency almost contradicts the use of bright colours. However this is better explained, as the word transparency could mean being honest to the function, without clothing the truth. This is what architects Rogers and Piano tried doing when dressing the building in the structure. And being transparent with truth to systems that hold the building together.

The intention was for all the systems are colour coded; this would identify individual pipes and elements while creating the contrast of bright colours (Cruiskshank, 1997). This added to the visual concept of hi-tech as the main systems highlighted would reflect their function. This gave the public a better understanding of the services and movement structures as well as a further layer of focus on the technological integrity of the design (Refer to Figure 30).

Figure 30. Differing systems each coloured accordingly. (Cruiskshank, 1997:61&59)

Analysis

Actor Network Theory implemented in the Pompidou Centre would explain the technological challenge and product of the “scientists” creating it. The result is a building that expresses the strengths of the centre, so distinctively that it becomes the design. The technological systems are the art from the outside, while the interior is left for display art. The function of the building did influence the concept, by freeing up the space. The same space created by structure.

The concept of Tools of Conviviality, describes the warmth or emotion that architecture can bring to the users instead of mechanized exclusive structures. Pompidou brought people closer and provided that space for translation and transition

3.3 BIRDS NEST STADIUM, Beijing, China

Figure 31. Birds Nest (www.architonic.com)

Herzog & de Meuron, China Architectural Design & Research Group (CADG) and Arup Sport (specializing in Sport Architecture) worked across continental boundaries for the combined effort of design, structural technology, contextual integration and an iconic concept for China.

Beijing, China was elected to host the Olympic Games 2008, requiring a stadium to seat 100 000 for the 2008 Beijing Olympics, a monument that showcased Beijing as a destination city and the adaptability for the stadium to be used in the following years with a lifespan of structure lasting 100 years. It required a retractable roof for the rack to be undercover but the stadium would also play soccer games making natural light vital.

Beijing's Olympic Green (Figure 32) positioned the proposed stadium to the east of city's axis. The intention was to position symbolically important structures along this axis. The stadium was shifted to the east in symbolism of the people utilizing the space directly on the axis, thus making them the most important (Brown, 2009). For Beijing, the orientation and situation of these national monuments meant the heart of the city would be exposed and visited therefore the design of the stadium would require the same dedication and design symbolism as the entire precinct. Contextually this set the tone for a symbolic design with huge structural responsibility that would reflect Beijing's culture.

Figure 32. Locality plan of the Nest stadium within the Beijing Olympic Green (Brown, 2009:5)

Structure + Design Integration

Arup explains that the brief was altered to a 91 000 seated stadium and the complications and cost of the retractable roof cut the budget by $110 million from the initial $500 million. This was the initial inspiration for the design, as the retractable roof system was hidden between the "nest" like structure. The criss-crossing of the members camouflaged the mechanisms for the roof, and filled the space between the members.

Later the same concept of the nest remained, however the need to house the retractable roof fell away. The bowl was made of 6 separate units with 200mm V movement joints between catering for seismic movement.

> *"The elliptical form of the bowl, the depth of its structure, the acoustic reflectivity of its envelope, and a special lining below the ethyltetrafluoroethylene roof membranes, all give the stadium an outstanding acoustic quality"(*Brown, 2009:11) .

The shape of the bowl was significant to the Chinese culture, symbolizing the special bowl the Chinese eat from. The architects took that concept further by incorporating it into the structure of a stadium and optimized the visual lines of spectators and maximized the acoustic value to create the sporting atmosphere heard clearly. In this way, the structure and design integration forms an expressive development concept.

The outer façade was the second part of the stadium. It was based on the one of the ceramic works of China, the local crackle-glazed pottery (Figure 34). The crossing members would meet at junctions and create a net effect (Refer to Figure 33). It would demand architectural, engineering and construction collaboration and precise measuring for the complex design. Once presented the concept was welcomed, however named the "Bird's Nest" (Brown, 2009).

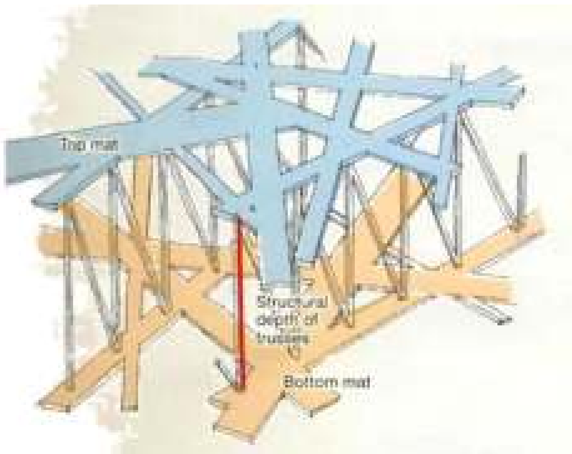

Figure 33. Initial concept sketch design for the roof (Brown, 2009:4)

Figure 34. Crackle-glazed pottery used as the ceramic influence for the design (Source:http://www.aliexpress.com)

The façade and roof structure forms one whole structure made of steel that envelopes the bowl of the stadium but never impacts on it. An ETFE membrane (Figure 35) is stretched between the steel frameworks, covering the top of the "nest". The complex crossing of steel structures makes it difficult to differentiate the primary and secondary members of the frameworks. It creates a network of structure that is the design, and the intricacy and layering form the design aesthetics for the "Bird's Nest".

Figure 35. ETFE membrane between steelwork. (Brown, 2009:11)

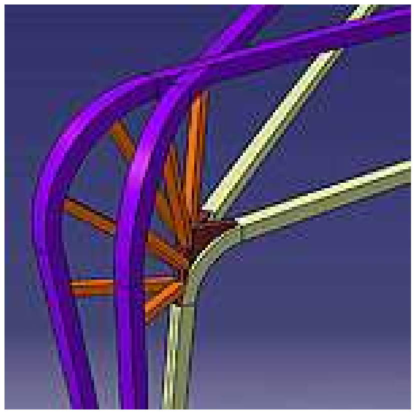

Figure 36. Structure members at the main curve connection point. (Source: http://beijingbirdsnest.wordpress.com)

Extract from the Arup Engineering Section (Brown, 2009:16).

Centerline Geometry definition: Most of the geometry can be assigned to three categories:

- *Primary: This comprised the space truss lines and main structural system.*
- *Secondary: This was used to break up the panel size created by the main structural system to facilitate the cladding system Panels.*
- *Stairs: The access stairs to the top tier of the bowl were integrated into the walls supporting that roof structure.*

Although appearing as a chaotic mesh of steel the underlying logic of the structure would need to transfer the loads from the roof to the horizontal members. The result was to derive a system of successive layers, superimposed for the "Nest".

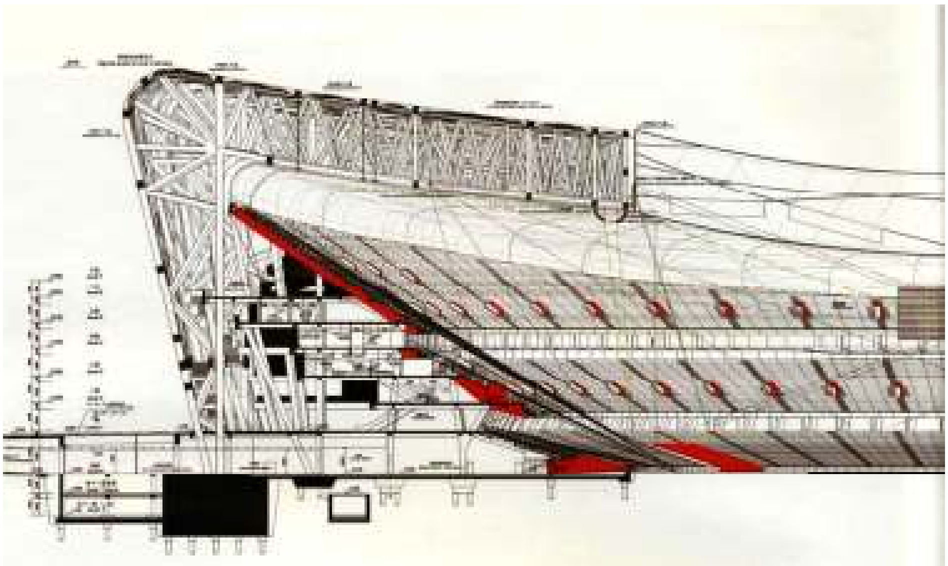

Figure 37. North-South Section through bowl and "Nest" structure. (Brown, 2009:12)

Contextual + Environmental Responses

The city of Beijing is situated close to a seismically active environment, deemed one of the most active on earth. The stadium was built in two separate parts. The bowl that housed the seating and the exterior shell was built 50 feet away from the bowl.

The close proximity to the seismically active site required the stadium design of heating, ventilation and air-conditioning (HVAC) infrastructure to be based on a piping system for encasing and least disruption. It also meant the members could be flexible and be removed and replaced in necessary.

Material Palette and textures

> *"The steel structure is painted light grey, contrasting with the red-painted external concrete wall of the bowl, which is clearly visible through the façade. This creates a variety of impressive effects, particularly when lit at night"* (Brown, 2009: 14).

The entire façade of the Bird's Nest was left unclad; visually expressing the material and creating an element of notify able function. The staircases which also form part of the matrix of steel network were left open adding to the complexity and allowing visitors to view all aspects of the structure. "Weaving past each other and offering clear views into every passing zone, they ensure the visitors have an unusual degree of interaction with the building" (Brown, 2009:14). For a dramatic approach the choice of raw materials exposed and truth in the infrastructure cam be seen as brutalism or honesty. In the case of the Bird's Nest Stadium, the structure is the design.

Ecological Responses + Sustainability

The piping systems beneath the field are responsible for capturing the heat and cold for redistribution in the stadium. The heat is harvested and used in the thermal systems for acquiring a comfortable temperature during the colder times. Similarly those cooler nights capture that cold, and circulate cooler air in warmer times.

Figure 38. Solid and void effect by the roof membrane and the solid appearance of the steel framework. (Brown, 2009:36)

Analysis

Beijing Stadium used the function as an added aspect of the shaping tool for the bowl, and the external "nest" as the cover image. Implementing a complex structural technique in comparison to the most economic and simple is evident in both precedents. The limit for technology surpasses the norm of simplistic design, and the expression of the true materials is an added value to structural integrity of design in architecture.

The Beijing Stadium is a destination structure; its intricacy of technological design has intrigued the mind on how it works structurally as the appearance is chaos and complexity. Although Biomimicry is not directly evident the stadium does appeal to people as the translation of a "nest", a natural home for birds.

3.4 CONCLUSION

Both precedents discussed are international therefore give a broad overview of what structural technology is capable of in the global context. In these particular examples of technological structure the times of construction are decades apart. Upon comparison the Pompidou Centre proved being an exceptionally advanced building for its time. The conceptual design, structural support system and function checked the box against the theories. In the long term however, as any building maintenance and public traffic within the building require changes. In the team effort from the professionals involved the architects and engineers formed an interrelated system with the vision of the Centre in mind. The Beijing "nest" Stadium too had a large design team that worked together from the beginning of the project in order to create a holistic design both conceptually significant and structurally sound.

Contextually the Pompidou was in a well built area; however the stadium was in a more complex location. The possibility of natural disaster of seismic movement was a major factor to contend with for the Beijing Stadium and dictated the structural system that would have been implemented. Since context is a factor that greatly influences technical structure, the response in both cases took into account structural stability.

When tested against the Actor Network Theory, the cohesiveness and integration of structure design in both examples as well as the interaction opportunity for man was definitely explored. The scale of both examples asks for large structures with high volumes and wide spans. This is the true test for technology as the materials are pushed to the maximum capabilities. The techniques used by Arup are aided by computer design software (Refer to Appendix IV), and this added geometric opportunities to create design out of structural technology.

CHAPTER 4: CASE STUDIES

4.1 INTRODUCTION

The selected Case studies will form the part of empirical research in order to examine and evaluate existing facilities that include the key issues that were discussed earlier. The chosen Case studies are due to their relevance to the topic and are strong examples of built structure using technology in the design process. They will provide information from the observers, architects and engineers point of view (Refer to Appendices), demonstrating the system put in place for modern technology in recent architecture.

The case studies were assessed by first hand observation, physically walking the site and experiencing the building as a user would. Comments and opinions where provided from the persons whom facilitated the building, as well as the architects and engineers.

The following criteria were used in the study of these Cases:

- Structure + Design Integration

Architectural design will be examined as the main conceptual drivers for the building and its' combination with structure. Based on the structural technology of the building, the question is if and how this was adapted into the design of the scheme. What were the client's brief and how the representation of conceptual thinking was translated into a structural form?

- Contextual + Environmental Responses

Site location and natural environments form the defining factor for a buildings structural system. It determines the structural methods and requires the design to respond or ignore what is present on site. This will help determine how the technology has played the role being sustainable and if the environment has been considered in the design integration.

- Material Palette and textures

Technological advances have influenced the use of materials, in the attempt extract the maximum potential of a material. With the use of recent materials in new ways or considerably older materials in new ways makes for an adapted design. Similarly texture is related to materials, with spaces and forms created with structure and the texture of that structure becomes of importance as it influences the feeling of a space.

- Ecological Responses + Sustainability

Differing from environmental responses, ecological responses address the actual nature within the context. As discussed, the 'Life Essentials' of man require natural environments, with substance and natural elements. Sustaining nature as part of these 'hi-tech' buildings can sensitize and connect what structural technology may have removed.

4.2 NEDBANK, Ridgeside, Umhlanga, South Africa

Figure 39. Nedbank Ridgeside western entrance(by author)

Nedbank is known for setting the benchmark in green building design. They have incorporated the responsibility to the earth as they're pledge to be sensitive to the environment. Amongst the few buildings in Durban, Kwa-Zulu Natal, the Nedbank Ridgeside (Figure 39) has been the most recent addition. GBCSA awarded it a Four (4) Star Certified Rating- Office Design v1 Rating. This building was chosen as a Case study as it was completed in 2010, a recent and recognized green star achievement for Durban. It is situated on the ridge of the Umhlanga coastline; to the east it overlooks the M4 highway and the grand hotels of Umhlanga's coastline. The Coastlands hotel and surrounds are to the west while the northern border runs parallel to the road. The Nedbank building is situated within an office park, as this is the language of the area. However it is along a busy roadway between the N2 and the M4 giving it recognition by its positioning.

Structure + Design Integration

Designed by DHK Architects, the Nedbank Ridgeside is described as contemporary in its style. The most prominent structural element is the V-shaped steel circular columns on the east side of the building. Two sets of three V-columns support three office levels above. Visually this contributes to the design image, showing off the structural integrity of the columns at the front of the building. This however is not present throughout the building. The structure is seen internally only in the foyer area, whereas in the offices it is lost. The covered entrance portrays a high volume with a single circular column supporting the corner. The impact of the height versus the strong line of the cantilever with the recessed glazing celebrates the space. The structure stands proud and is focus as the entrance into the building. In the basement, the concrete rounded grid columns can be seen between bays of parking.

Contextual + Ecological Responses

Apart from the basement parking utilizing the steep site to allow for natural ventilation on two sides, the building does not respond to its context. Views form the main driving force, and this means glazing in large amounts facing east and north, a challenge when taking into account the suns movement in Durban. Although green star rated, the building received zero for Land Use and Ecology in the allocation of points. Due to the functionality of the building, the activities need to be controlled within the building. This however should not restrict the building from following the natural ground, or incorporating the site in a more respectful manner. The office entrance area id completely covered in cobble paving. This may be deemed sensitive, as no vehicles are allowed here, however the entire space is flattened. Apart from some young trees and planters, there is no modulation, or integration with what the site might have looked like before.

Material Palette and textures

Reinforced concrete forms majority of the structure and can be seen on the outside as well. In keeping with true materials the building comes across as a strong, rigid form with glass infill. On the exterior planes of off shutter concrete punctured with slivers of glazing makes for a contrast. The concrete mixes were substituted with 30% fly ash instead of Portland cement.

The abundance of glass softens the appearance however it is questionable on the northern side of the building. Interiorly, the use of timber assists in softening the sleek lines of glass and steel and concrete.

All reinforced steel used was CISCO steel, ensuring that 96% of the overall steel was recycled. Colours are kept neutral with white, concretes natural colour, and the glazing tinted a slight dark shade.

Throughout the building vegetation is positioned. In the foyer tall potted plants humanize the scale of the overwhelming triple volume. The colour green is the accent colour in this building, in keeping with the theme colour for Nedbank and introducing images of trees and forests in the office spaces. The boardrooms are enclosed with semi transparent glazing, also floor to ceiling images of vegetation.

Ecological Responses + Sustainability

The pond at the lowest level of the building collects all rainwater from the hard surfaces, including the paved areas and the rooves. This is held in the pond before being filtered and cleaned by pumps in the basement level. This water is cooled for the ventilation system, and reused in the toilets for flushing and watering indoor vegetation.

The hi-technology adopted in the building shows how a seemingly ordinary design can respond to the environment. Apart from design, the building has tried to integrate modern simple means for sustainable living. The use of paper is in great quantities in the offices and separated bins are situated in all pause areas and levels for the clear differentiation of waste. Once separated, they are taken down to the recycle refuse area in the basement for bulk separation and temporary storage.

Analysis

In Nedbank Ridgeside, technology is explored in the functioning of the building. The high-tech building reads as a contemporary form. It is the technology that keeps it running that has been adapted for a sustainable low maintenance outcome. The use of natural systems as a source for efficient water usage is an opportunity in many Durban buildings.

The relation to the theories discussed does not come through in this building. Although the technology is 'hi-tech', it is more for the maintenance rather than structure that make this building an icon. The frontal image of the V-shaped columns only in fact supports one storey. This use of structure as an aesthetic image instead of functional technology questions the motives of the design. Conviviality as a concept can be ruled out as the structure is completely absent from the design. As the theory of Post Modern Ecology, the building touches strongly on the sustainability that is required in current architecture. Finally when tested against Actor Network Theory it may be said that it does fulfill that needs for a composite that works together in function rather than structure.

4.3 INDONSA UNILEVER, River Horse Valley, Durban, South Africa

Figure 40. Unilever Foods Factory and Distribution centre, River Horse Valley (http://www.skyscrapercity.com)

River Horse Valley is a developing business estate located between Durban city and up market suburb of Umhlanga in Kwa Zulu Natal. This estate together with the eThekwini Municipality plans to grow the potential for a greater business area just outside the city. Within this developing district is the Unilever plant for savory dry food production. Its' intention was to create a landmark as well as an international pointer. Opened in 2011, the building is worth R670 million and named Indonsa, meaning “Morning Star” in isiZulu. Called the largest private scheme in Durban since the 2010 Soccer World Cup, the Unilever building sets the standard as a first for a green manufacturing plant in South Africa. Located in a growing hub, the Unilever building mimics the key intention of River Horse Valley of creating employment, enhancing manufacturing investments, increasing production and developing a framework for similar products, thus creating demand and capacity in one area.

The chairman of the brand stated that Unilever is striving for a sustainable vision in the field of plant production. This sustainability pushes the boundary of building typology, and incorporates the systems in place for production of the product. It means the company addresses accountability, honesty and honorable responsibility of both the workers and the business to the environment.

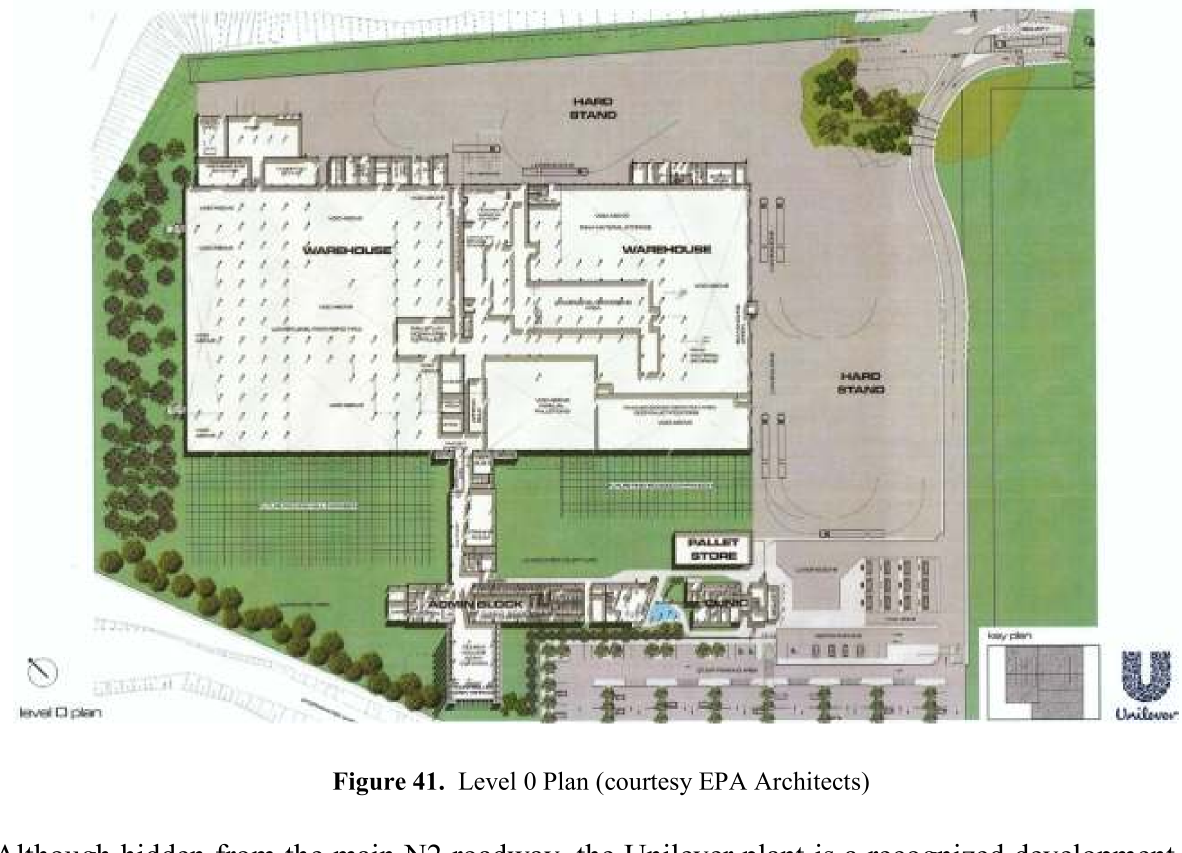

Figure 41. Level 0 Plan (courtesy EPA Architects)

Although hidden from the main N2 roadway, the Unilever plant is a recognized development in the precinct of River Horse Valley. The project is large, covering 22 000 square meters on a 78

000 square meter plot of land. It proves for growth and expansion, enabling a later phase to become the largest savory dry food plant in the world.

Structure + Design Integration

Elphick Proome Architects, a Durban based architecture firm designed and managed the Unilever building. The plant takes on its distinct form derived from the major production machinery-the conveyor belts (Refer to Figure 42). Described as a formal metaphor in an abstract manner, the building adjusts its scale in parts to suit the functions within the building (Refer to Appendix I). This can be explained as a version of the phrase "form follows function", were the form in this instance follows functionality of space and the actual function of conveyor production lines.

Figure 42. Curved reinforced concrete external structure depicting conveyor belts from the factory(Courtesy EPA Architects)

Figure 43. Steel columns and steel frame with structural glass at the entrance (by Author)

Unilever's brief specified an exciting and stimulating environment for the employees. The offices are the focus for dynamism allowing for a lively space to connect and interact. Externally the client requested a building that would respond to its urban fabric by integrating within the area however being distinctly memorable in its appearance.

The entire building speaks a similar language having the concept running through the two parts. The main integration of design and technology would have to be the roof structure (Refer to

Appendix I). Almost a ripple effect, the choice of material influenced the shape, as aluminium sheeting allows for flexibility. This shape called for a greater function that could utilize the roof to harvest rainwater. Thus the technology is almost always considered when a design decision is proposed. The best outcome would mean a fully functional and sustainable building, utilizing all resources available.

Contextual + Environmental Responses

The one challenge that added character to the design was the existing wetland on the site. This was retained and created into an island and buffer just after the gatehouse. In the vast hard surface area of roadways and parking lots, the wetland acts as an oasis (Refer to Figure 44).

Figure 44. Wetland maintained(courtesy EPA Architects)

The one substantial issue is the 100 year flood line, which the site falls into. This meant the site was reclaimed and major earthworks had to take place to raise the platform. It was the last site left on the road. By shaping the platform a berm was created for protection in the event of high rainfall to avoid flooding (Refer to Appendix I).

Material Palette and textures

In keeping with a select palette, the Unilever building strand proud of the site using identifiable materials that curve and bend creating the effect of a conveyor belt. By adapting the materials to suit the concept and creating space and light, the materials were both relevant structurally and aesthetically. The warehouse required lightweight materials for the high volumes. This meant almost a cladding to the frame structures, while acting as a rainwater harvesting mechanism. The choice of aluminium sheeting, insulated for the controlled internal spaces for dry food manufacture. Main choices in the warehouse were due to durability and structural integrity (Refer to Appendix I).

The admin part of the building used the more flexible approach of concrete, still in keeping with concept for the form. The entire building sits on a face brick plinth, minimizing the impact of the footprint on the ground.

The abundance of glazing used is questionable, however this is mainly found in the admin area. The large overhangs allow for deep set glazing. Although open able the windows are never really opened due to the air conditioning system (Figure 45).

Figure 45. Double volume canteen surrounded by 3 sides of glazing. (by Author)

Were the warehouse sections is corrugated and darker, the admin building is lighter coloured and smooth in comparison. The language of form and fluidity still runs parallel, but the function of each is distinctly seen even from the outside. This is the design intention by the architects, for recognition of separate entities that merge. The actor network theory has the very same concept, were as here it is seen in layers. The material palette is greatly influenced by structure. The structure is the integrity of the design as this is influenced by the concept. The concept is the conveyor belt which is in fact the major mechanism responsible for the function of the building, which is dry food production. In all the building reads as one network, the actors are the individual entities that overlap and influence each other in forming the entire network.

Ecological Responses + Sustainability

Although more relevant in the process of the production of products than the building, the Unilever brand aims to create the sustainably-sourced products.

Rain water from the roof of the building is channeled into a tank with the capacity of 1.5 million liters. The 22 000 square meter rooftop supplies abundant rainwater to be treated in this tank and merged with recycled water. 70% of all water used in the production phases is recovered through this process. Captured condensate dispensed from the air conditioning is used in cleaning toilets while reverse osmosis management recycle the processed and shower dispensed water.

Analysis

The Unilever in River Horse Valley also takes advantage of the rainwater abundance. They have managed to channel the entire roof surface area worth of rain water to be reused.

The idea was to use the machinery in the production plant as inspiration for the form of the building. EPA found this would be an interesting play in the design aesthetics, while a fluid shape was derived. In this way the form of the building becomes a visual embodiment of the function within the building and use the structure as the main representation of this. The incorporation of technical structure with design is the first expression of technology used as a tool for convivial design. The system works together, each playing its role in the concept of functional translation and unifying space through the arrangement of such structure as Actor Network Theory explains.

4.4 NORTON ROSE, 15 Alice Lane Towers, Sandton, South Africa

Figure 46. Norton Rose, 15 Alice Lane Towers (courtesy Paragon Architects)

15 Alice Lane Towers (Figure 46) is situated in the central business district of Sandton, Johannesburg. Alice Lane is home to many large scale buildings, each with individual recognition and design strategy. However, in recent years the architectural initiative is to incorporate green status in developments. The Norton Rose Towers was before this time as construction began in April 2008. Architects on the project were Paragon Architects, an acclaimed architectural firm that push the envelope in design creativity and challenge the structural normality. Often described as a “dancing” tower, the Norton Rose Towers have indeed introduced dynamism in South African high rise office buildings. The building serves as offices, majority of which is for Deney Reitz legal firm.

Structure + Design Integration

The towers consist of 6 levels of parking below ground level and rises the most of 18 floors above. The offices are split into two towers, the northern with 15 and southern towers with 18 levels. Hillary Erasmus explains the challenges and solutions the project faced (Erasmus, 2009). The towers each have two sides that curve, however these are asymmetrical, requiring each floor slab to have a different shutter in length. The solution is the use of leaning shutter boxes, unitized façade panels enabling a smooth finish.

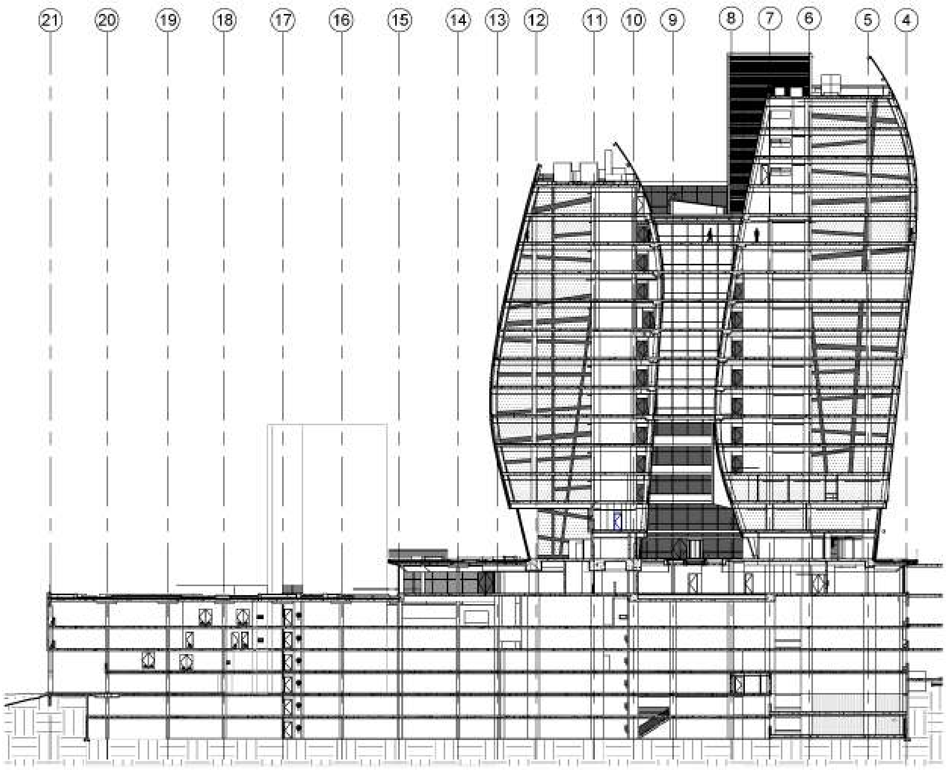

Figure 47. Drawing section of Norton Rose, 15 Alice Lane Towers indicating 6 levels of parking, the atrium and towers. (courtesy Paragon Architects)

The curve mentioned is not a faceted one; the intention is for a smooth, single curve of each side (Refer to Figure 47). The paneling of the glazing was done in unison resulting in a connected interface of each row of glazing. The towers required 10 sides on the building to be addressed; this is inclusive of the atrium sides. This was limited to the cranes vertical movement, and would mean more time delays. The solution lay in the movement of scaffolding after hours, this prevented working time to be infringed upon.

The intention was to create a roof garden on the top of the atrium space. The solution fell with testing the water proofing before the scaffolding was removed. This meant that in case of leaks it would be rectified instantaneously.

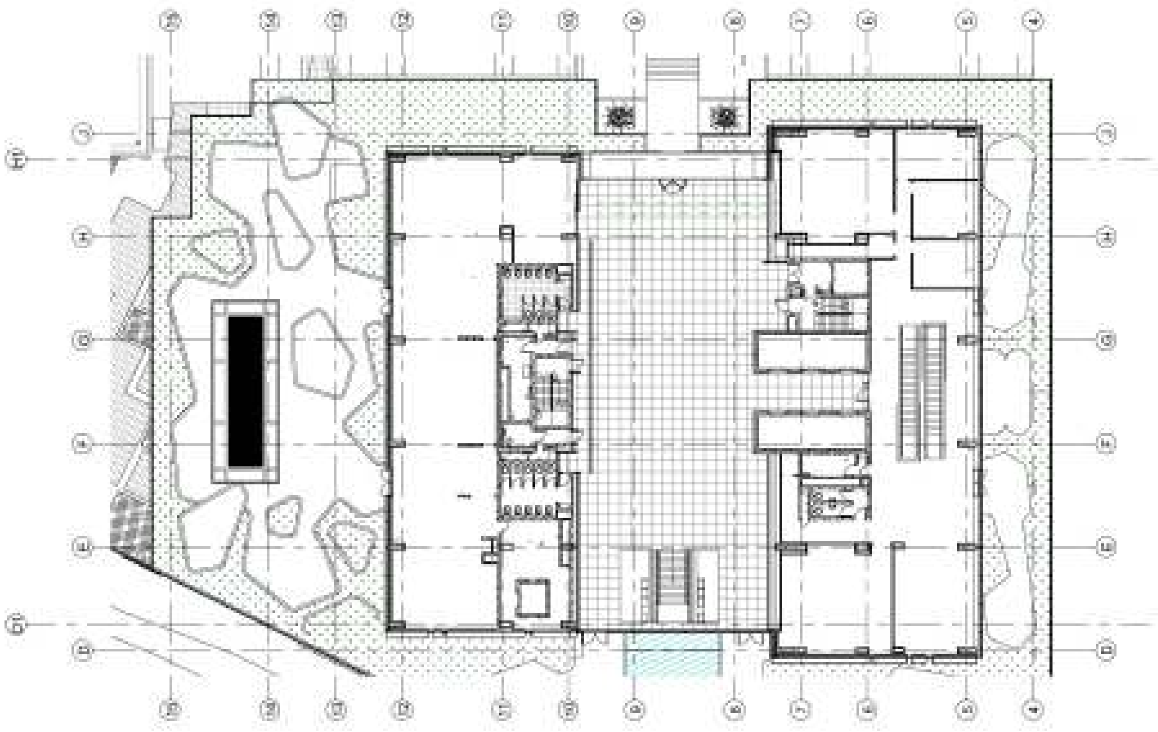

Figure 48. Upper Ground Level with grassed terraces and water fountain on the, atrium space between the towers with lift lobby on the south tower and staircase on the north joint by the bridge above (courtesy Paragon Architects)

Contextual + Ecological Responses

All buildings in the area have a different language. There are no distinct design criteria, however similar to many developing business districts in SA, the contemporary style comes through. This also however means that the competition for recognition is evident.

Contextually the building is set in a business district with tight areas and boundaries. The attempt in the Norton Rose was to set back the building and create a parking at the front of the building. By drawing back the line of building, it appears clear and can be fully viewed. The shapes of the "dancing" curves are distinct from human scale, ass the building rises quite height with only the sky in the background.

Figure 49. Exterior view of the parking level in comparison to the Norton Rose Towers.

(courtesy Paragon Architects)

As mentioned earlier, the building offices sit on a 6 storey parking. Contextually the footprint is of the parking level, with a maximized footprint. Norton Rose reintroduced the ecological aspect by dedicating pockets of greenery around the building and on the roof. There are grassed and planted terraces on the Lower ground level, as well as the Upper ground. In fact the surrounds of the upper ground outside the offices and atrium is grassed. There are doors that lead onto these areas for staff and the public to experience. The parking also has green paneled walls (Refer to Figure 49).

The exterior elevations of the parking required a similar language as the main building and it responded with a pattern of solid void, similar to the Norton Rose glass panels. Here the use of steel grating, allows for creepers to grow, in contrast to the lighter coloured panels and the void space for ventilation into the parking. The purpose of the creepers on the screens enables a visual appeal of bright green, a textural difference and it functions as a filter for the fumes in the parking.

Internally, the building functions as a unit. The atrium is the main light source and the high volume allows natural daylight inside, and the opportunity for views outward. In this way indirect light enters the offices, providing four side of natural light in the floors.

Material Palette + Textures

The main structure is reinforced concrete for the grid frame of the building. The circular columns on the curve edge where angled and cast in place, held by collars once the shuttering was removed. The materials in this Norton Rose Towers played an integral part of the design. Paragon Architect Hugh Fraser stated that the relationship between aesthetics and technology should be symbiotic, as they form part of the other. (Refer to Appendix)

Glazing panels cover majority of the external facades, except for the aluminium boxes on the east and west ends. The glazing is described by Andrew Butcher (Erasmus, 2009) as deconstructed office block. This is created visually in the glazing panels being of different opacity. A pattern is created with grey, white mad black panels, in a random arrangement (Refer to Figure 50). It is however situated such that each level has the open able windows.

Figure 50. Patterned glazing on the south elevation. (courtesy Paragon Architects)

Aluminium blocks with inset glass creates the effect of slashed surfaces on the west and east façade. This was deliberately done to prevent the harsh morning and afternoon light from flooding the offices.

As mentioned earlier, the introduction of vegetation and grass on the terraces and the roof account for the loss of land with the large footprint of the building. One more textural element is water introduced through water fountains outside the building. This plays on the reflective quality of the entire building but in contrast is soft. The glazing is rigid and fixed were as the water flows in the entrance in an enclosed fountain. At the back of the building the atrium opens up to the angled fountain with rock like shards and flowing water (Figure 51).

Figure 51. Water fountain on the west terrace. (courtesy Marjorie Blom)

Analysis

Norton Rose, 15 Alice Lane Towers is practically a futuristic design with regard to structure. The appearance of the building suggests it 'moves' redefining how structure is seen as a stagnant, rigid form. This reinterpretation or transformation of technical structure into a design driver is what proves to be a tool for Conviviality. Once understood as a component for change in perception and space, ANT can immediately be included in the test against the theories. The building connects on a structural level, with architecture and technology forming the holistic creation. The critism however must be the lack of structural exposure. The techniques show that the building is a modern, current and technically challenging design however the structure is lost in the mass of glazing. There are no spaces that people can enjoy on the upper floors that connect to the outside, leaving the building an introverted, exclusive and disconnected space.

The attempt at sustainable management comes through with rainwater used in the landscaped surfaces. The only levels that have connections to nature are the ground and roof garden that are planted areas. This introduction of planting, although minimal, is a welcomed textural and visual beneficent for the users. It allows for the one of the 'life essentials' of contextual environments, encouraging people to obtain a break from the technical envelop that they work within.

4.5 CONCLUSION

The intention was to identify the aspects discussed in the literature review and theories within the chosen case studies. However similar or different the building types the focus was on the interrelationship of structural technology with design. The approach of design would depend on the architects, while the structural integrity would depend on the combination of the architects and engineers. Each study differed due to the teams involved; however all drew the same comment, that design must include technology initially for the scheme to succeed. The architects all felt that integration was a definite necessity as it relied on architectural knowledge of how the structure would work and be built even upon conception.

Structurally the buildings are situated in relatively safe environmental conditioned areas. One of the aspects discussed in the literature review was the influence of the environment on the structural technology of architecture. The need for structural technology to be responsive to the possible natural systems is not as relevant as it may be internationally. South Africa experiences great amounts of rainfall, so if any response it would be to this environmental element. Unlike cities that have earth quakes, or tornados, or snow, it is seldom if ever found in the sites of these case studies. Even so, the Unilever building is situated in a flood plain area. This was catered for by raising the site, and creating a berm in case of a water level rise. The building itself did not incorporate any technological structures for responding to the possibility of a flood.

In the Unilever building the team of Engineers and Architects worked closely, consulting each other for the fragile nature of the project. The warehouse section was almost entirely structural. This succeeded in visual language as the rest of the building, as an extension of the same, but reading as different function. The Norton Rose Towers does this in a similar way, with acknowledging that the parking would be maximized using the footprint of the site, while the towers raised high in the sky. The language here, although external and merely a façade clothing, ties into the same patterned expression. The functions, the planning and orientation are completely different, but the entire building reads as a variation of the same. The Nedbank building in complete contrast appears separate, with the building reading as offices and the parking separated. The attempt here was with applying similar materials.

Through the Case studies, it can be said that architecture is attempting to incorporate structure as a sculptural design. The understanding of components within a system, and that system to be subject to an evolving technology, these building have shown such basis when tested against Actor Network Theory. The examples compared to Conviviality on a lesser level, as the structural technology in Nedbank and Norton Rose Towers were lost in building. Unilever prepared the ‘tools’ as the design and structured the form and spaces with the technology never lost.

CHAPTER 5: ANALYSIS AND RECOMMENDATIONS

5.1 INTRODUCTION

The research was set out to understand the relationships between technology, man, and architecture through the analysis of primary and secondary data. The theoretical framework in Chapter 1 outlined theories (Actor Network Theory, Conviviality, and Post Modern Ecology) what would be used as tools for investigating the research problem. It was applied to the issues of Materials, Sustainability, Man's needs, Sensitivity and Connection to Nature, discussed in the Literature review, forming key elements that would feed back into answering the key questions.

In the findings of the research, it is the composition of materials and methods of technology that play the biggest roles in structural design. It has influenced the makings of historic architecture and pushes the boundaries for future design with ground breaking new material properties. The insight of man's intelligence has allowed for materials to adapt and join with other materials, with the intention for more intriguing design technology. Man is an extension of nature and an evolution thereof, which has the gift of knowledge and learning skills. For thousands of years this strategy of survival and progression has developed from primarily a space to merely inhabit into a sense of place. Through day to day activities they may encounter an environment that will affect their experience of space and influence their perception, in turn causing them to evolve according to their reaction to that environment. The intention is for this building to be an expression of that evolution of technology, man and architecture.

Evolutionary technology has proven to optimize its structural capabilities and physical properties if conjoined with another material. Therefore composite materials and structures are the main elements that impact a space to create space. With a composite material the possibilities are endless, reflecting on tools of conviviality as the structural ties that connect and form the whole design. This provides more opportunity in structure of architectural design than any material by itself.

Structural systems are related to man's perception of space. Physical structure forms spaces, and mans movement through those spaces influence his experience of it. Therefore it is fitting for technological structures of architecture to encompass a simplicity and complexity at the same time. Simplicity is the network in place but complexity through the execution. In this way, technology would have evolved further merely by material choice in that "new" composition. Similarly, it was discussed that man best relates to a space when comparison of structure within the space allows man to experience it psychologically. The idea is to take that simple, repetitious machine like structure and transform it into a multifaceted system.

The overall intention of this research was to identify the ways that technology and design can be unified to encompass a sensitive architecture that responds to man and the environment. By creating technically based architecture, man's intelligence is used as a tool for convivial living. This sensitive design will reintroduce connection and social stability that man thrives to prosper and interact, fulfilling the need for man to belong and comprehend space within a natural environment.

5.2 CONCLUSION

The study was set out to explore how structural technology has affected man and architecture. Secondary questions focused on how the aspects of structural technology that have evolved and how to introduce sensitivity that it lacks when subjected to man and the environment. The research breaks these into three essential sections and follows through by testing these theories and aspects against precedents and case studies.

Structural Technology through the Years outlines the gradual change in structural support systems, and its relation to materials, architectural styles, and in turn the impact of man on the adaptations in both. Distinguishing the most expressive buildings of each era gives the over view of how far architectural design has come, and the evolutionary modifications that were made. Exploring the materials themselves gives a greater detail of how technology adapted. Mans intelligence introduced new ideas and machines that formed composite materials, a great fete in architecture. This pushed materials to the maximum potential and allowed for opportunity of complex architectural solutions instead of the safe route. It touches on sustainability as the materials are the tools for building and eventually the components of architecture.

The following section of the Literature Review focuses on *Man and the Machine*. It takes the perspective of man in the space of structural technology. It finds life's needs the essentials of man to live rather than merely survive. It is understood that technology is an important element as it is responsible for mans survival strategies, however it realizes that this technology needs to be connected to the environmental image. That environment is in fact the natural element that is the sensitivity that man craves when confronted with technological complexity. Man can be described as an extension of nature; however man is the originator of technology. The problem with technology is the lack of sensitivity and self, which is found in nature. The relationship between nature and technology directly influences the social relations in the built environment.

The senses form the largest part of how man experiences space and the positive and negative impacts that space may have. It is clarified that space is formed by structure, and that structure dictates the way man reacts in that space. "In the absence of aesthetic nourishment, the emotional part of the human being is left to seek fulfillment by indulgence."(Day, 1999:4) Christopher Day believes that visual appreciation is the first emotion that impacts man. In the absence of such emotion, the need for completion and realization is present. In searching for that fulfillment man looks to other means of accomplishing it. He describes it as indulgence, a pleasure that can be felt, touched, smelt or tasted. Wilson (1983) explained that architecture requires all the senses, and if compared to Day (1999) then surely this "indulgence" can come from the rest of the building if vision where blindfolded. The textures in materiality, the confines and release in spaces forms by the structure and the connections between these spaces are tools for creating an interrelated design.

The last part of the Literature Review explores *The Relationship between Technology and Architecture*. The understanding of this section was architecture is subject to context, time, function, and style. All these factors are linked directly to technology. As one progresses so does the other, making the relationship between Technology and Architecture inseparable. As technology has evolved, its impact on architecture has proved mans capability to excel in production, manufacture and material opportunity. For design to be architecture the integration of technology is essential. It is taken further by delving into a recent concept of Biomimicry, a technologically challenging concept of combining nature's techniques with manmade materials. Humans have tried to develop and assume the qualities of nature, mimicking their optimal strengths and forming architecture through an alternate approach. The necessity to tie back to nature through concepts, languages, structure, form making, theories or materials has become a strong connection that requires an already existing link between man and the natural environment. By using Biomimicry as a technological solution, research is tested with the association with nature in the structural sense.

Precedent studies follow with looking to these key aspects of functionality, context, sustainability, structure and materiality as the tools to test against them. This together with the Concepts and theories form the framework for discussing how architectural projects had been carried out and the end result. In both Precedents discussed the outcome proved to have fulfilled majority of that aspects, although differing in context and function the response to the site with regard to structure and the housing of the functions within the building did indeed impact of the technological structure as discussed before.

In a similar method Case Studies carried out with local buildings allowed insight into the thinking in South Africa. The Nedbank building lacked the criteria to test against as the structure was lost, and the claim of technology was in fact the services and maintenance rather than structural support. It did however cover the aspect of sustainability to a great extent, in the choice of materials and the reusable natural elements such as rainwater. The Unilever building did offer more insight into the Actor Network Theory with its cohesiveness and Conviviality through structure based from inception. Drawing from the function and conceptual connection with structure the building provided more opportunity for technological information. The materials and the techniques were relatively new. The Norton Rose building provided the aesthetic indulgence that man craves. Technically the building pushed the boundary in terms of use of materials and structural techniques. The structure although is not visually effective from the exterior, encourages the mind to look further to understand the spaces. The building is very form based and therefore cannot be a true reflection of structure. It covers the main elements, and uses huge amounts of glazing. In all the Case studies showed the negatives and positives that can be learnt from for the ideal building to be designed later.

Interviews with Professional architects and engineers gave an insight into the realm of architecture in reality. The main questions focused on the integration or lack thereof of technological structure design. In all, the interviewees agreed that architecture is not possible on the consultation of one. The structural part of architecture must come through in the design or the building will lose integrity. The languages can be similar and should as the user deserves to acknowledge all parts of architecture. They also reiterated that man has indeed come a long way in technology, so this should be taken advantage off. As further research into the technology of structure the topic of computer science had to be discussed. Both architects and engineers mentioned the great possibilities computer software enables. An argument of architects and engineers with regard to structural technology blurs the lines of responsibility. Through discussions and interviews however, the views of each are always in acknowledgment of the other profession. Both architects and engineers agree that technologically challenging architecture is not possible without the input from the design influence of architects and the structural opportunities that engineers provide. Computer software design technology could be a new era of design. So radically has the structural technology shifted, that the outcomes are completely redefined, pushing architectural structural technology into a design incorporating aesthetic form and defining space.

Finally in conclusion it can be said that architecture is the ideal tool to bridge the gap between technology and man. Surely that connection it present, but the responses from both sides are affected when not treated with sensitivity. In response to the problem statement of disconnection of man as structural technology evolves, it would require for technology to use its resources for the opportunity for sensitive design. Nature and the natural environment is a historic phenomenon that man has survived alongside, and learnt from for centuries. In this similar situation, the loss of connection between technology and man can use advances of materials in architecture as the tools for convivial design. Bio mimicry is concept derived for the inspiration for nature. It is one of the conceptual initiatives that encourage sustainability, responsibility, integration and substance in structure. Evolutionary technology can take its' influence from nature, creating a hi-tech design that is sensitive to man and reconnect to the loss of conviviality.

5.3 SITE CRITERIA AND DESIGN GUIDLINES

The criteria that are discussed will aid in developing a technologically influenced design for the proposed *Science Research Centre for Durban, South Africa.* The criteria for the accommodation of such a space will involve the analysis of these users and specific functions that will take place in order to achieve the specific requirements. These guidelines are based on the theoretical framework undertaken and will therefore reflect the structural and contextual criteria of the proposed facility.

Site Selection Criteria for a Science Research Centre for Durban would include proximity to a natural resource. Located near or in an element of interest that is challenging for the complexity of a structural technological solution. This in turn forms the criteria for what kind of technological route the building would take. Natural elements would also provide the opportunity for the chosen science to be close to a natural source. The setting will also set the tone for the design intention, as discussed that technology will be the focus structurally, the sensitivity will be drawn from the natural environmental setting. Equally as important would be a contoured area, as this allows for split levels and integration with the environment. The functions of the centre are likely to relate to ground level activities and projects. The intention of a Science Research Centre as a public building would require relatively easy accessibility, as well as visual connections for maximum exposure. Structurally the design would be inspired by nature in either the methodology or the physical properties. The building would require large spans in the attempt to showcase the best technologically structural solution. The scale of the building should challenge such technologies. The choice and use of materials would need to be current, enabling the building to respond to the context, housing the function efficiently and produce a complex structure with simple systems.

Criteria for accommodation would include spaces related to the function of Science Research Centre. From the discussions, and approach of technological structure as the influence, the spaces created will require the structure to form part of it. This would include materiality, and the composition of materials. This proved as the best solution when dealt through the years on flexible and current materials. It also shows the evolution of technology through resemblance of materials and the length of change and adaption it has gone through. The sensitivity, self, soul that lacks in mechanized repetitive buildings would inspire to create the opposite in this case. The Centre would house unique spaces reflecting its function, and connected to the context as well as a designed structure true to the user.

In recent times local and global design has adopted trends from one other, leading to the challenge of multi-functional abilities of architecture. Design needs to satisfy the first function, that is functionality, and the following aspects are flexibility and environmental harmony.

Architecturally, the life spans of buildings have changed from ancient periods of creating everlasting, to current design for the here and now. This must be taken into consideration as the impact of technology on architectural structure can influence the future of design. Similarly, structure should be designed with the intention for change and adaptations. Frameworks instead of solid buildings allow for the infill to alter. New functions can be introduced once the occupants leave, enabling flexibility of space. Instead of rebuilding and majorly adding to the energy consumption, structure should be reused, recycled, all in keeping with sustainable responsibility.

The key drivers for technologically based design will influence the response to context, the functionality of the spaces and the incorporation of structure in aesthetic form. The intention for these guidelines is to create a responsive and sensitive hi-tech design for the proposed Science Research Centre while forming architecture with structural integrity.

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APPENDICES

I. FOCUS GROUP INTERVIEW: UNILEVER BUILDING, RIVER HORSE VALLEY

My research requires an in depth understanding of Cases studies chosen. For this the option of a focus group enabled the chance for main questions to be answered in the presence of the major professionals involved in the project. This focus group allowed for comparisons and opinions from both sides of the team. The choice of engineers and architects meant the building could be explained from both ends. It exposed the positives and negatives while describing the relationship between the structure and the design which is the focus of my dissertation.

Elphick Proome Architects		
Date:	09th April 2013	
Name:	Anand Govender	Mark Govindasami
Profession:	Architect (SACAP no. 7846)	Architect (SACAP no. 7180))
Years of Experience:	6	8
Sutherland Consulting Engineers		
Date:	09th April 2013	
Name:	Ian	
Profession:	Engineer	
Years of Experience:	17	

1. What was the client's brief and how was it met?

The client (Unilever) approached the Engineering firm first, who then appointed EPA for the design concept. Unilever's driving concept was the "agile workspace environment", explained as three sections for this to be achieved, consisting off; "Staff focus, Connect and Vitality *spaces". With this in mind EPA would need to create spaces within the building to promote the key concept.*

Although divided into an office/admin area and a warehouse, the building was connected and once employees entered they would stay inside the building until their shift ended. Due to cleanliness requirements, when dealing with food products and processes, they could not come into contact with bacteria, or even natural elements. This meant no courtyards, indoor-outdoor interaction was permitted.

Unilever handed over the manufacturing process flowchart, explaining the system in place for dry food production and storage. This included all the schedules of accommodation and heights of machinery for the warehouse section of the building. Using the existing Unilever production plant in Pietermaritzburg, EPA consulted the clients regularly to come to a unanimous decision for the design and function.

2. What was the design intention for the Unilever, River Horse Valley building?

The idea was to use the machinery in the production plant as inspiration for the form of the building. The entire building represents conveyor belts, an integral part of the production for Unilever. EPA found this would be an interesting play in the design aesthetics, while a fluid shape was derived. In this way the form of the building becomes a visual embodiment of the function within the building.

3. Where there any environmental issues in this area that needed to be considered?

The one substantial issue is the 100 year flood line, which the site falls into. This meant the site was reclaimed and major earthworks had to take place to raise the platform. It was the last site left on the road. By shaping the platform a berm was created for protection in the event of high rainfall to avoid flooding.

4. **How does this design respond to the context of the site?**

Due to the function of the building, acknowledging it is an introverted building. The employees are not meant to be outside the building once they begin work and access to the public is limited if they are even allowed. Apart from this, the building also meant one level planning for the use *of delivery vehicles and the production plant area. Given that the platform was already created before being sold EPA's design approach was simplified with a level piece of land.*

The one challenge that added character to the design was the existing wetland on the site. This was retained and created into an island and buffer just after the gatehouse. In the vast hard surface area of roadways and parking lots, the wetland acts as an oasis.

5. **What involvement did the Engineers have, if any in the design stages?**

The engineers had to be on board from the beginning as the warehouse plant structure required specifications only they would provide. The warehouse section of the building is the most influenced by technological structure due to the height variations required for the machinery, the roof trusses became the design intervention shaping exterior while providing a huge span internally. Here the design was formed around the function of the space. The language of the smaller portion (the offices and canteen area) used the concept of conveyor belts. The warehouse couldn't use the same material thus the engineer formed a means of translating the same language by using other materials more suitable. The trusses acted as a lattice built as a unit of horizontal and vertical members, expressing the shape and maintaining a balanced design.

Engineers had to be involved as well because of costing; they were able to estimate an amount for the choice of structural system and materials which directly affected the budget.

6. **How has the Unilever building integrated technology into its form/design language?**

The entire building speaks a similar language having the concept running through the two parts. The main integration of design and technology would have to be the roof structure. Almost a ripple effect, the choice of material influenced the shape, as aluminium sheeting allows for flexibility. This shape called for a greater function that could utilize the roof to harvest rainwater. Thus the technology is almost always considered when a design decision is proposed. The best outcome would mean a fully functional and sustainable building, utilizing all resources available.

The office part of the building, although made of concrete, was also designed to capture rainwater. Thus the entire buildings footprint is recovered in usable surface area.

7. **What materials did you use to best portray the building and why?**

From the design team side, there was a select palette. This included glass, concrete, face brick and metal sheeting. Further choices were made due to durability; like the aluminium sheeting for the warehouse, the hot dipped galvanised trusses and the fibre glass panels used for neat termination of the building. The patterns and Unilever logo on the warehouse was all in fibre glass, an extremely durable and aesthetically pleasing choice. In essence no "new" materials in the technical side were introduced. This does not mean however that the expanse of use is limited.

The entire building sits on a face brick plinth. This is both a design and technical choice as the building appears to flat slightly off the ground with the shadow line intentionally created were the walls meet the plinth. Technically, this choice was for cleaning purposes and simplifying the point where the building touches the ground.

In the office area, the reception is greeted with a cantilevered concrete slab. This is supported by steel columns, which appear random. Being a design decision for aesthetic purposes, the columns are in fact also structural due to material choice, and the arrangement acts as cross bracing support system.

8. **In hindsight, would you implement any changes to the building?**

NO. Although this was a high pressure project the outcome was one that the architects, engineer and client were satisfied with. Unilever proposed a specific brief and this was fulfilled from the side of the design team and engineering.

9. **How has the building responded with regard to orientation?**

The warehouse calls for a fully sealed space however the roof was designed as a pluvial system, with part of the warehouse receiving natural daylight through clear sheeting. The office area is enveloped in concrete as the roof wraps down, exposing two sides of each win. This is glazed and catered for depending on the orientation. The west faces are protected with wings angled to shield the glass from the strong afternoon Durban sun. The north facades are more solid with horizontal cantilevered sun protection devices. The south optimises the use of south natural daylight with an abundance of glazing.

10. What is your opinion of structure based design?

*The reality is that people want to know what their money is being invested in. If structure is implemented in the initial stages of a design, it will not only benefit the design with solid credibility but it will inform an economic decision***.**

11. How has structural technology evolved since your involvement with it?

With regard to materials, there isn't a great advancement in technology. Sure new products are available, but the main structural systems in place call for specific materials, for example- grid structures mean columns, either reinforced concrete or steel. The greatest advancement would be the computer technology. The use of the latest software allows architects and engineers the opportunity to utilize these "same" materials but adapt new ways of adapting it. This informs innovative thinking for the vast possibilities structure can become.

It also enables cost estimates, which as a business relies on numbers for the client to get a better understanding. It can analyse the breakdown of where the cost lies most and least, while preparing 3d images for better understanding of space to someone who does not read drawings well.

12. Do you believe advances in technology have benefitted architecture and man?

Again the use of computers is a great benefit to man. Revit and other 3d software programs enable detailing at a minute degree thus creating opportunity for new ideas in technological structure. It allows calculations of spans and strengths. So although the formula stays the same the context may differ and this software creates the chance for "advances" in technology.

Thank You

II. INTERVIEW QUESTIONNAIRE: PROFESSIONAL ARCHITECT

Paragon Architects (Johannesburg)	
Date:	16^{th} April 2013
Name:	Hugh Fraser
Profession:	Architect
Years of Experience:	25 years

1. **What involvement do the Engineers have in the design stage of a project? Should they be involved?**

In contemporary architecture it is critical that not only engineers but also other building professionals, e.g. Green Consultants. Buildings are currently so technical that one cannot design without their content and input. That includes all engineering input, electrical, mechanical, and structural.

2. **In the projects you've worked with, how has technology of structure been integrated its form/design language (if in any way)?**

Our practice depends heavily on Revit so all our fellow consultants must use it too, to facilities the relationship between all the services and structures. Technology changes from project to project. Financial services companies are obviously different to industrial. Our latest project Alexander Forbes required large open floor plates to accommodate staff, so the slabs and columns structures become important. Atria were introduced to bring in natural daylight. The bridges linking the spaces were important and the structural integrity was critical. The glass used in the glazing becomes very important too. Eight glass types were used in the project.

3. **Do you believe technology can be sensitive to man? Should it be?**

Yes. Human comfort, performance, sustainability and responsibility all come before technology. Technology is the slave, not the master.

4. **How has technology (structure) influenced your method of design?**

Energy, cost, value engineering. Structure is considered from the outset particularly when starting with parking.

5. **Should design be considered when dealing with structural engineering? If yes, why?**

Design is very important; however the departure point has changed. Design is not about how a building 'looks'. A building is not a picture. Buildings now look how they must perform, so the concept of design has changed from being a graphic to a response.

6. **How would you describe the evolution of technology in architecture?**

Technology itself changes all the time. It is becoming more 'virtual' and architecture must respond in the same ways. Hot seating, virtual offices, data storage have all influenced architectural design.

7. **When technology vs. aesthetics, can there be a balanced language? If yes, how do you think this may be achieved?**

   Yes, this relationship should be symbiotic. In some ways, nothing has changed, we providing a built environment for humans (and animals) and the targets haven't changed only the vehicle. Technology must serve our ultimate target responsibly.

8. **What are your thoughts on Bio mimicry as a design concept (where man learns from nature)?**

There are some valid lessons to be learnt but as usual there is a lot of bullshit that needs to be cleared out of the way. The practices need to be general rather than some glib marketing tool.

9. **Do you have any further comments?**

No

Thank You

III. INTERVIEW QUESTIONNAIRE: PROFESSIONAL ARCHITECT

Charles Taylor Architect cc (Durban)	
Date:	10th April 2013
Name:	Malcolm Macleod
Profession:	Architect
Years of Experience:	19

1. **What involvement do the Engineers have in the design stage of a project? Should they be involved?**

At the outset of a project very little involvement is required from the Engineers. Whatever the vision of the design, the end product must be kept in mind. This can only be in relation to years of experience as an architect. The more years being in the field of architecture and the more involvement in projects determines the attitude that architects have when designing. These years of experience serve as the reference when designing, allowing the architect to always take into account the engineering challenges that may occur. Architecture without engineering is not architecture. For there to be a balance, these two elements must be married as architecture is an assembly of structure and aesthetics.

2. **In the projects you've worked with, how has technology of structure been integrated its form/design language (if in any way)?**

Seamlessness must occur in the planning and design and aesthetic. It must be as one because if not it becomes divorced and lacks credibility. In the instance of the Shanghai Bank, the building embraces the structural technology and uses this as the aesthetic. Here there is an overtly recognition of structure, and excessively used to push the boundary of the norm in design. By attempting to find a balance is always best, were the machine aesthetic isn't the focus but rather a fluid, seamless idea in detail and execution.

3. **Do you believe technology can be sensitive to man? Should it be?**

No, only because it needn't be sensitive. The reason technology exists is to be the crutch for design to materialise. Is shouldn't be the saviour of design as that would mean architecture is treated as individual systems of exclusive design and only later is technology applied almost to save it. Technology shouldn't be used to repair a bad design but rather it should afford new building types specifically in relation to structure. The only problem with technology being an elaborate design in itself is the expense. For it to be effectively deployed it requires to used on mass, however in that case the people who actually need it cannot benefit from it, as their group is too small(e.g., housing schemes).

4. **How has technology (structure) influenced your method of design?**

Always. It must allow you to push the boundaries as a designer and thinker. It must "look at the adaptive possibilities of conventional systems". One shouldn't limit the possibilities of keeping design safe. Often it means a simple solution but it is solved in a way not seen before. One should always challenge the client and the brief as technology is only limiting when you don't put yourself in the mind space of what could be.

5. **Should design be considered when dealing with structural engineering? If yes, why?**

Yes. The success of structure and design is in the expression of both. "Beauty is structure is the way of making a building." Looking toward a new way of integration is really looking at a new way of doing the same. With reference to Biomimicry, structure is considered on a micro scale. A leaf appears to be a small, simple object however the technological system of structure and materials in that minute scale challenge the human perception. Man then looks at this fascination of structure, were biological systems defied what we call common sense. As designers must pay attention to these natural complexities and adapt them in the world of architecture with available materials to recreate the systems of nature that work fluidly, were design and structure is one.

6. **How would you describe the evolution of technology in architecture?**

"I don't think it has changed much. Depending on situations however materiality remains the same. Buildings are still held up the way they used to be." The question is rather what are the components of structure that have evolved? As mentioned before, the only limiting factor with regard to technological structure is expense.

7. **When technology vs. aesthetics, can there be a balanced language? If yes, how do you think this may be achieved?**

Yes. Depending on the desired outcome, the expression of technology and structure may change. The language should however be similar in the execution of design and technology. Architecture cannot be divorced from structure. What makes it architecture? It is the entirety that distributes that validity of each constituent forming a whole. Then the language will be similar if t is integrated.

In this day and age, the use of computers is vital to the outcome of a building. Then everything is "virtually" possible. And once it is likely to be imagined what then holds back the possibility of it materialising?

8. **Do you have any further comments?**

Where do ethics fall when all things are possible? The imagined approach is that there are a set of rules, or key aspects that determine the criteria for smart design. Then this list once inspected leads to another set of rules that need to be adhered to when designing. Taking into account that technology and design are integrated from the beginning. However is this the only way? Is this the correct way?

In the contrary, is it wrong to design first and allow technology to "catch up"? This would mean the design will be conceptualised and the technology to make it possible will need to evolve to accomplish it. In this way technology is adapting and changing and evolving, which may be considered a positive, even though it wasn't considered as a design trait at the beginning.

Thank You

IV. INTERVIEW QUESTIONNAIRE: PROFESSIONAL ENGINEER

My research requires an in depth understanding of professional opinions in the field of architecture and structural design. For this the option of an interview enabled the chance for main questions to be answered in the presence of the major professionals involved in current structural technology. This interview allowed for comparisons and opinions on the key aspects of my dissertation. The choice of engineers helps explain the complications and details of structural technology as the major element of architecture. It exposed the positives and negatives while describing the relationship between the structure and the design which is the focus of my dissertation.

ARUP (Durban)	
Date:	08 May 2013
Name:	Adhir Imrith
Profession:	Senior Structural Engineer
Years of Experience:	6

1. **What involvement do you have as Engineers in the design stage of a project?**

As project managers or engineers the involvement begins as different stages, depending on the contractual agreement. Some require the beginning stage of design including the inception and conceptual stages followed by scheme, design development, construction and closing. It's more the architect's role for design development; however the engineer should make the architect aware of the design technologies of the materials.

2. **In the projects you've worked with, how has technology of structure been integrated its form/design language (if in any way)?**

Added in design- complex geometries-parametric modelling is used to optimise geometries.
Software performance-would not be possible for complex problems as 20 or 30 years ago. Structural logic through computer software aided programmes.

3. **What is your opinion of the manner in which structural technology has been treated previously? (neglected/afterthought)**

- *Resistance to accept new technologies by architects and clients. No one wants to take the initiative because of their fear of the unknown. As engineers we have a professional indemnity and a responsibility.*
- *Forward thinking clients (globalised) push the boundaries.*
- *That technique or technology needs to build its credibility before it actually gets employed as a new system.*

4. **How has structural technology evolved since your involvement with it?**

Visual and cost. Engineering is an applied science therefore it's only limited by the tools. Now days there are less and less of an excuse for creative design. The architects can bring forth their vision. Manufacturing methods are quicker and materials can be pushed to their design limits. E.g. steel processes quality contracts.

- *Evolution of materials has enabled the strength to weight ratio to tighter (e.g. revolutionary carbon fibre). The repercussions of this are now what are the limitations of materials? By adapting the weights of materials one is achieving efficiency and economy.*
- *Reinforced concrete which was previously limited due to the slenderness ratio were the concrete worked in tension and metal rods worked in compression, although a revolution as the time now has been adapted further. Ultra high performance concrete is a fibre reinforced concrete. It gets the most of plasticity of concrete and the metal fibres enable the material to be ductile or elastic giving the material a bending capacity.*
- *Waterproofing too is a "new" tool in construction with the spray on waterproofing. It is colourless and texture-less forming a chemical barrier when combined with concrete instead as a physical barrier as used before. This however has barely been accepted as the contractors and engineers alike are baffled with the non visual waterproofing they are used too. As mentioned before this unknown is hard to accept when new materials are introduced.*

5. **How do you think man has learned or adapted their thinking from structural technology when designing?**

Developed in IT and software(more feasible as to before, it determines costs indicating what is uneconomical and determines if something will actually work structurally. Designs can be safely executed through computer simulation and the ability for it to stand and function will be determined. This has become mainstream allowing computer software with the knowledge from engineers to investigate and aid in the design of a project.

6. **Can a space affect man's response? How do you think this is achieved?**

Yes. Lack of mans connection rather the architect aid in achieving their vision.

7. **Do you believe advances in technology have benefitted architecture and man?**

Yes and No.

Yes. It has made architects more demanding and no longer accepts excuses because engineers have the skill to design (applied science) and can add value. Technology and software makes the design process simpler and quicker enabling collaboration between client, architect and engineer.

No. The communication is lost as the lack of coherency due to advances in technology. The client can use a software programme to design their own building, without the theory that an architect has researched for the functionality and feeling of the space. Technology then becomes a tool of separation rather than collaboration.

8. **When technology vs. aesthetics, can there be a balanced language (aesthetically + conceptually)? If yes, how do you think this may be achieved?**

Yes. Technology and aesthetics can be achieved now, unlike before. Now the possibility of building geometrics has allowed the chance for technology and aesthetics to be an integrated component.

9. **What would you say determines the choice of materials?**

It is driven by cost and economic feasibility. Due to the architectural requirements in South Africa concrete id a cheaper option as the climate in SA will corrode the structural steel if chosen. The protection against corrosion is an expensive option. Also in SA the cost of labour is cheaper, therefore although prefabricated materials are quicker, the cheaper labour costs make a building more economic to use labour induced materials. In Europe for example, it's the opposite, and labour in construction is a high paying job, here prefabrication is the better *solution. Prefabrication enables speed in the construction. Labour requirements limit the architect to do what is known, sticking to something safe and familiar.*

10. How does the context of the building/ site inform the structure?

Usually the engineers influence on material type is followed through from the architects or clients brief. In the case however were the architect or client is way off in choice of material (e.g. function or durability) then the engineer can suggest a better suited material.

In the instance of rural schools, materials are gathered from the natural surroundings, or in close proximity to the school.

In the case of a live construction, e.g. a mall being extended while still in use by the public provides a difficult contextual arrangement. The use of construction vehicles, materials, workers, machinery etc will endanger the public. Here the materials for the both support and ability to be erected quickly influences the choice of materials. In this case the structure dictates the design, and commands the existing structures to be adaptable (e.g. strengthening of columns or walls for heavier loads).

11. What would you suggest as the best/most sensitive approach when designing a hi-tech project?

The role of choice of materials and choice of construction using the Pompidou as a reference, it was a purely structural response. The use of steel and the construction method of exposing the technical aspects of the museum added the element of people understanding the structure. This brought what I believe to bring the users closer to the design. In a similar means, certain material brings forward different emotions. Timber is a warmer material that steel. The colour and texture of timber creates another layer of meaning apart from a material choice.

12. What are your impressions of Biomimicry-adapted structural design?

ETFE membrane is used by Arup in the Beijing 'Nest" Stadium and more extensively in the Water Cube indoor pool. It is an opaque material based ob plastic that is ductile and flexible and water resistant. The use in the Water Cube it forms the membranes of pocketed air creating bubbles. It has the ability to disintegrate rather than melt when on fire, therefore argued as safe for the indoor pool. With the adaptability of the material and the flexibility of the clients the water cube is an excellent example of structure as design. The influence also comes from

Biomimicry, particularly in structural integrity. The air filled pocked resemble the chaotic arrangement of soap bubbles, forming hexagonal intersections and light aesthetic. The etfe membrane adopts this and creates an infill of insulation, transparency, shelter, and complex aesthetic of form. Although appearing haphazard and random the air pockets (bubbles) are individually filled and specifically placed with steel frames for each. In the entirety, the building forms a light silhouette with texture and creativity of adaption to multifunctional materials.

13. Do you have any further comments?

Parametric modeling in engineering is an intelligent 3d modeling tool that provides opportunity to play and adapt structure. It allows for an input of variables that can be adjusted and calculate instantaneously. It adjusts parameters for the best solution and the architects and clients can apply fixed variables while the others will adapt accordingly depending on the materials. In this way the opportunities for materials and geometrics are pushed to the design for front. This is then the technology for architects and engineers.

Thank You

PART TWO

DESIGN REPORT

Contents

CHAPTER 1: INTRODUCTION

1.1 Background

The period of 1880 to 1920 saw the formation of strong, independent nations across the world that encourage scientific advancement and facilitated industrial development by implementing fast track manufacture and processes for housing and rebuilding of ruined cities. In the aftermath of the world wars, technology played a vital role in redevelopment and overcoming the damage wreaked by the war loss (Sebastyen, 2003).

This method of increasing the product and quickening the process meant that man and machine were the new techniques for optimal outcomes. The evolution of technology has assisted and encouraged learning of technology for the benefit of the human race. The socio-technical relationship is formed between humans and the advances in design. The problem with technology is the lack of sensitivity and 'self'. On one hand the progress that is evident is intended to improve the lives of man. However on the other hand, this process for such technology has divorced man from direct interaction between the environment and other socials needs of interaction.

Ivan Illich describes that increase in power of machines meant the decrease of mankind's roles in society to be that of mere consumers, driven as slaves to technology that they had created (Illich, 1973). The lack of social connection between nature and man, and nature and technology will produce individuals and networks that are absent of 'self' and sensitivity (Alexander, 2005). The divorce of direct interaction between man and the environment removes the element of responsibility whilst rendering man obsolete and disconnection man from social interaction. The component of sensitivity that man adds to the built environment is replaced with hi-tech creations. The networks of technology and design are divorced, creating space for function and removing the aspect of the actual living inhabitants.

CHAPTER 2: THE CLIENT

2.1. The Notional Client

The research thus far indicates that the most suitable client for the proposed development would be a partnership between the University Of KwaZulu-Natal School Of Engineering and the Council for Scientific and Industrial Research (CSIR).

The University of KwaZulu-Natal School of Engineering

The University Of KwaZulu-Natal School Of Engineering is a subdivision of the College of Agriculture, Engineering and Science at UKZN offering five disciplines of science to tertiary education students. These include: Agriculture Engineering, Chemical Engineering, Civil Engineering, Electrical, Electronic and Computer Engineering, Land Surveying and Mechanical Engineering.

The differentiation between these are greater established once the first year of the basic four year degree has been completed. This is largely due to the fact that students have no exposure to the variances in science that can be perused at the University.

The University has understood this issue and has provided a solution. The 'University Intense Tuition for Engineers' (UNITE) program hosted by the school serves as a bridge course for students of secondary education facilities that might be interested in further studies into science. Currently the program is run from within the facilities held by the School of Engineering. However, in order to expand the reach of the program to a larger audience, the University requires a facility dedicated to this function.

At present, the School of Engineering is currently very fragmented. The disciplines are hosted in facilities that are spread across the university campus that rarely relate to each other. Thus the university would also like to utilize this new facility as a headquarters for the School of Engineering. The aim of introducing a headquarters facility would be to provide a space for the staff, visitors and students to interact in, encouraging the cross pollination of information across the various disciplines of the school. This will enhance the spirit of learning in the institution, the standard and quality of work, and the spirit of the students whilst solidifying the identity of the school to the university campus.

The Council for Scientific and Industrial Research (CSIR)

CSIR is a South African multidisciplinary research, development and implantation organization with the South African Parliament as a key shareholder. The main aim of the organization is to understand the impact of development of research, technological innovation, and the ways in which industrial and scientific development can improve the value of life and promote environmental sustainability. The organization aims to improve the countries' competitiveness on an international basis as well as creating new technological ventures and opportunities for the future science, and contributing to the economic growth of the country.

The Partnership

The partnership between The University of KwaZulu-Natal School of Engineering and the Council for Scientific and Industrial Research is one that has been existence for years. Students are offered internships from CSIR after completing their degrees thus providing the first stepping stones in their careers in science. Allowing CSIR and students from the University to engage at an earlier stage in their education can prove to be beneficial to both the students and CSIR. CSIR will be be able to grow students of a high skill level that will contribute positively to their business. At the same time CSIR will aid in producing graduates from the University of Greater Quality.

2.2. The Clients Requirements

The design should aim to:

- Increase the interest and enrollment of the youth intending to pursue tertiary level education into Engineering Sciences.
- Provide a platform to assist in clarifying and showcasing the differences between the disciplines of Engineering on offer at the University.
- Enhance skills training and create a specialized environment to boost learning at the university.
- Provide a resourceful and accessible space for students to research, practice, display and their work
- Provide a platform to accommodate lecturers, staff and students as one composite body in one facility.
- Host conferences and allow for orientation into the disciplines of engineering.
- Improve education results at secondary level and tertiary institutions.
- Link the UNITE building as a sister to the Research Centre, accounting for passionate students who cannot enter into the first year university course.

2.3. The Users and function of the Building

The main purpose of the centre is to provide a platform for the cross pollination of knowledge not only for those currently enrolled in the tertiary institution, but for all people that express an interest in the sciences. Thus the centre should accommodate a variety of spaces that enhances this and cater to users across a broad spectrum. Thus the centre will incorporate ancillary functions such as an outreach program, and in-house education program, workshops and seminars, as well as continuous exhibitions. Spaces such as seminar rooms must be flexible in their application of the learning process. The spaces should allow for flexibility in the arrangement of furniture and encourage the interaction between users across various levels. Furthermore, the spaces should vary in size to cater for a variety of functions.

The secondary aim of the centre is to provide a head quarters for the University Of KwaZulu-Natal School Of Engineering and assist in the formation of the identity of the school on the university campus.

2.4. Detailed Brief

- The centre must acknowledge the environment in which it is located.
- The centre should accommodate office spaces for the Council for Scientific and Industrial Research. This is in order to facilitate a consistent flow of interaction and information between the organization and the University Of KwaZulu-Natal School Of Engineering. By situating offices within the facility, awareness is created for the organization and an air of easy access to the resource is created for the general public and students, thus enhancing communication and interaction.
- The centre should provide a composition of spaces of a relaxed, informal and flexible nature with the main aim being to encourage the cross pollination of knowledge. The design should create an atmosphere that is nonthreatening to the curious individual. In order to achieve this, consideration should be placed in to the detail design of the center. For example, the connection between spaces should be informal and casual as to encourage the friendly environment whilst fostering interaction. By creating an open, accessible environment, users of the space are allowed to discover the spaces freely. Hence it is important that the detail design of the centre investigates the concept of blurred boundaries between spaces and between functions.
- The design should always consider the end user and maintain an appropriate human scale.
- Flexibility of spaces is meant to enhance the longevity and use of spaces. However, it is not necessary a quality that applies to all spaces.

2.5. Schedule of Accommodation

Space	Square m	Description
	Transparent Tower	
Lobby/entrance	200	**Pause entrance area surrounding reception + information**
Reception	100	**Receptionist station**
Information	100	**Information station about the centre and related areas in the close vicinity**
Conference Centre/cinema(40x30)	1000	**Large unobstructed area for functions**
Restaurant	500	**In house restaurant that caters to the public, and visitors to the center.**
Canteen	300	**Staff canteen with garden**
	Public Wing	
Four themed exhibition galleries	1000	**Areas for showcasing the works from the science divisions**
Media Library	1000	**Library housing books, research spaces, computer lan, media room for smaller**
Science store	350	**Shop accessible to public, selling books and artifacts from the science centre**
Discovery Room	500	**Area allocated for future sciences**
Ablutions for public + visitors	200	**Toilet facilities**

Educational Wing

Parking	2000	**Parking facilities for staff and visitors on site**
Electrical, Electronic and Computer Science		**Specialized areas for the purpose of design and construction in the mechanical and electrical field of engineering**
Workshops	500	**Sound room** **Solar panels on roof space** **Computer rooms with diff trainers** **Storage for components(quite small)**
Labs	300	**High voltage machine lab-Metal balls with jumping electricity**
Storage	100	**Space for excess or currently unused materials**
Chemical Science		**Specialized areas for the purpose experiments for the chemical field of engineering.** **Sealed area, no natural ventilation, temp controlled, but encourage natural light**
Workshops	500	**Distillation tubes(2/3 levels)-master flow rates**
Laboratories	500	**Temp, light controlled.** **Sensitive to pressure differences(buffer door between)**
Storage	100	**Space for excess or currently unused materials**
Civil Science		**Specialized areas for the purpose of design and construction in the civil field of engineering**
Workshops	500	
Storage	100	**Space for excess or currently unused materials**

Mechanical Science		**Specialized areas for the purpose experiments for the mechanical field of engineering.**
Workshops	500	**Space for construction of mechanicals**
Storage	100	**Space for excess or currently unused materials**
Cloakroomsx4	150	**Pause areas for staff and visiting scholars**
Ablutions for subdivisionsx4	200	**Toilet facilities**
Offices	250	**Facilities manager +staff to be accommodated**
CSIR offices	250	**Liaisons with CSIR and persons interacting through the company to the centre**
Accommodation	1500	**Short term accommodation facilities for speakers and scientists visiting the centre**

		Other
Rooftop Garden, terraces and courtyards	1000	**Relaxation space for staff and visitors, views into the tree canopy**
'Forrest' Walkways	500	**Elevated pathways through the trees around the building linking the different science disciplines**
Total		

		Services and specified areas
Ducts-gases from store to **chem.** labs Ducts- waste runoffs to the		**Colour coded piping for specific gases to the dry laboratories. (helium, oxygen, nitrogen, o air, hydrogen, compressed air)**

collection point Extractor ducts Air-conditioning ducts for labs Hazardous waste storage in basement Secured Gas storage in basement	**Removing chemical air from the laboratories**

CHAPTER 3: SITE SELECTION AND ANALYSIS

3.1. Introduction

So far, the research conducted has been leading towards a resolution of the problem statement in the built environment. Thus far the research has covered a multitude of issues that are pertinent to the design of the centre. However, before the research takes the form of built proposal, the dissertation must analyze the built environment on the principles derived from the literature review and case studies in order to arrive at the best suited location for such a facility.

3.2. Issues Derived From the Research

3.2.1. Man and the Machine

- Explores the interrelationship between the three main actors: Man, Technology and Architecture.
- It brings to surface conflicts and opportunities and explore the future of all.
- Discusses the needs of man to experience life in its value rather than a plain existence.

3.2.2. The Relationship between Technology and Architectural Design

- Explores the ways that architecture and technology can integrate one another, inclusive of sensitive technology for the future of designing for man.
- Biomimicry, a more current design concept that involves structure in relation to natural systems.

3.3. Site Selection Criteria

A list of criteria was derived in order to assess each of the selected sites thoroughly. This process is important to arrive at the best possible site for the intentions of the centre to be carried through successfully.

1. Proximity to nature

The site should be close to a natural element for the centre to interact with and conduct research. (Water bodies, dense vegetation etc.)

2. Natural setting

Nature within the surrounding area as the sensitivity will be drawn from the natural environmental setting.

3. Ease of accessibility

The requirement for easy accessibility as well as visual connection (sight lines) and physical connections to existing or future proposed areas of interest or relation to the proposed building.

4. Large site area

Large site area as large spans may be used in the attempt to showcase the best technologically structural solution.

5. Evolving physical environment

Intention for a complex structure with simple systems requires changing or evolving physical environmental setting. (Residing tides, changing levels, changing temperatures).

6. Relation to the city

Requires a site closely related to the city of Durban, but removed enough for experimental freedom and space, still being responsive and sensitive to the environment.

3.4. Selected Sites

3.4.1. Blue Lagoon

Site 1. Plan view of the water's edge in relation to the green edge along the riverside(Source: www.googleearth.com)

Positives:

- Existing man made dam, river and vegetation.
- Sandy soil, water level at a constant change, slightly sloped site.
- Water bodies that fluctuate with the tides. Exposure to the mangroves across the river
- Located at the entrance of the city. Can be seen from the M4 highway, with accessibility of existing off ramps available.
- Transport routes already established. Allocated as a Public area still developing under municipal upgrade.
- sufficient room for a large scale public building

Negatives:

- Existing public space.
- River needs to be considered not to be imposed on or damaged
- Not located within the city proper
- Existing parking may not be sufficient, space for new parking.

3.4.2. Botanic Gardens

Site 2. Botanical garden in plan showing the extensive vegetation and pond on site. (Source: www.googleearth.com)

Positives:

- Existing man made pond.
- Trees are the main natural features with abundance of birds and animals for research
- Located just outside the CBD.
- Accessibility is relatively easy

Negatives:

- Existing public space that is utilized as a Park.
- Animals living in the pond and park will have their habitat altered
- Not as frequently visited by the public except as a destination site
- Existing parking will not be sufficient; space for new parking is limited.
- Vegetation is too dense for the proposed scale of a large Public building.
- Static natural elements in comparison to moving bodies of water.
- Unable to be seen from surrounding areas due to dense vegetation

3.4.3. University of KwaZulu-Natal, Howard College Campus

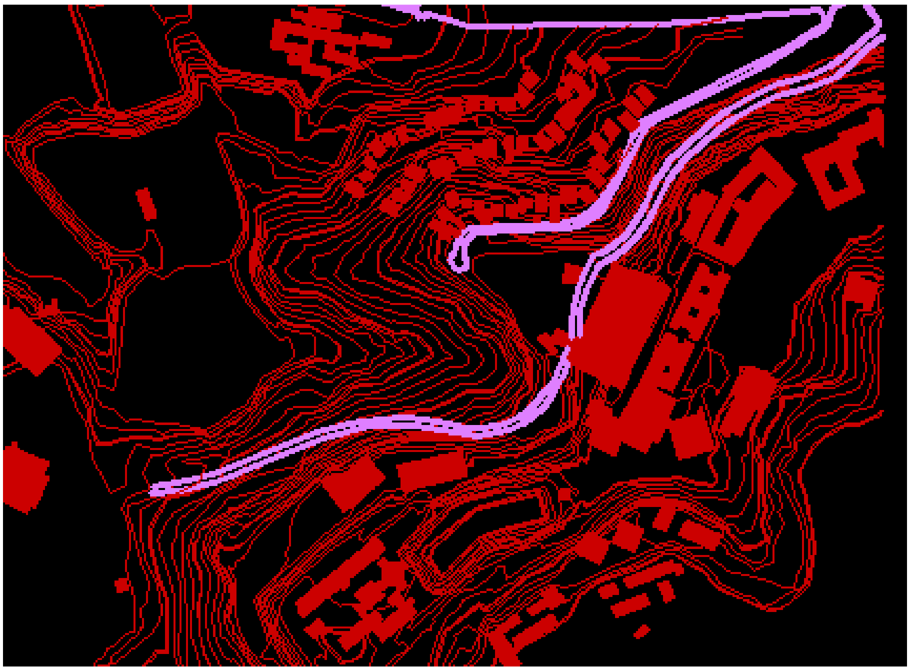
Site 3. Site indicating dense vegatation and extremely steep contours falling towards the sports fields. (Source: www.googleearth.com)

Positives:

- Typography of the site is challengingly steep
- Vegetation is in abundance, with flat crowns and large trees for maximum shaded areas
- Located within the UKZN campus, which is walking distance to surrounding engineering and science facilities in and outside the University.
- Accessibility to the site is off one of the main existing roads into the campus
- Existing parking (Shepstone Building) provides parking for over 600 cars.
- Located on the outskirts of the campus which allows for public and students to access.
- The site overlooks a dense vegetated space, and sports field increasing exposure from the road down below.

Negatives:

- The site is extremely steep for access, association with other buildings and access
- The vegetation may hinder the location of the building or opportunities for larger footprints.
- Orientation of the site as existing looks mainly to the west.



Site 3. Figure ground drawing with contours highlighting the valley created naturally and water course probablity. (By author)

3.5. The Chosen Site

University of KwaZulu-Natal, Howard College Campus

The three potential sites were evaluated against the site selection criteria and awarded scores for strength in each category that was stipulated as important for selection. The importance for the criteria and the evaluation process is to ensure that the facility is located in the best possible location in order to serve the intended clientele well.

The results of the assessment reveal that the strongest and best site is the University of KwaZulu-Natal Howard College Campus site. The location of the proposed centre here will ensure a continuous awareness about the centre and encourage the cross pollination of knowledge.

Figure 1. Locality Map of the University of Kwa-Zulu Natal showing the chosen site location for the proposed Research Science Centre (Google earth)

3.6. Site Analysis

3.6.1. The Campus Masterplan

Further research was conducted in to the selected site to understand the relation to the rest of the university campus. The intention of the centre is to create a space that responds to the surroundings and contributes to the campus as a whole.

The figure ground image below indicates the chosen site amongst the plan of the university campus. The site has been marked as a vacant site that hosted natural vegetation. The close relation to other major university buildings and the existing science building makes it highly appropriate to host the proposed centre.

Figure 2. Figure Ground diagram indicating the site in relation to existing buildings and the impact it will have as the base of science in the greater outskirts of the campus (Courtesy of UKZN-Howard College Guide)

The figure ground analysis illustrates that the site is amongst a densely designed residential area. However, the urban fabric of the immediate vicinity of the site is sparse. Hence the site has a high level of visual prominence from all directions and an ease of accessibility.

3.6.2. Zoning Analysis

Figure 3. The diagram above indicates the facilities in the immediate vacinity of the proposed site

As indicated above, the site is conveniently located amongst the existing buildings belonging to the School of Engineering, as well as other major buildings such as the Dennis Shepstone building. Thus the proposed facility will be able to easily create relationships with its environment whilst serving as an anchor for the School of Engineer.

3.6.3. The Site Network

The map below examines the relation of the proposed site to the major zones of the university. As indicate below, two distinct zones of groups of buildings exist in the campus layout. The first node is the ‘Science Zone’ consisting of the existing sciences buildings belonging to the School of Engineering. The second zone is the ‘Historical Zone’ that houses some of the campuses oldest buildings which houses faculties such as law and social science. The examination of these two zones in relation to each other reveals that there is an overlap which occurs directly in front of the proposed site, creating anode that is still to be addressed by the urban scheme of the university. The overlap zone indicates that the proposed site is also in the middle of the campus layout, thus making it equally accessible from all directions.

The map below indicates that the proposed site is conveniently nestled amongst the major pedestrian and vehicular routes. The site is directly accessible by vehicles by the use of Shepstone Road. Major pedestrian traffic occurs along the primary road, 75^{th} Anniversary, as the main entrance gate to the campus is situated along this route. The pedestrian traffic filters easily from this route through the pedestrianised campus thus access to the proposed centre by foot will be easy.

The red dots on the map below indicate major collection points of people on the university. The proposed site I located closely to these collection points, thus awareness of the facility will be easily created.

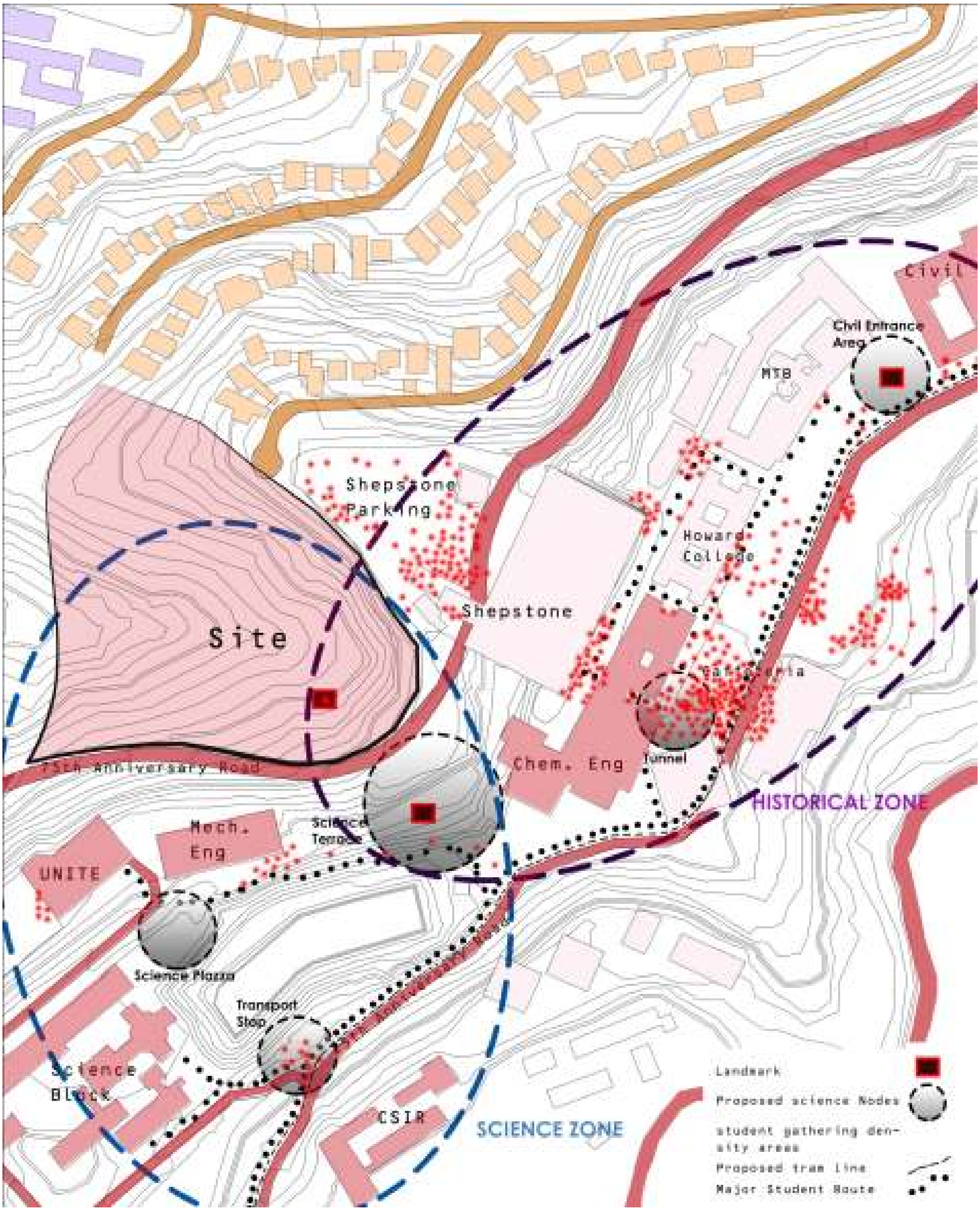


Figure 4. Site Network indicating two zones that interlink, creating a central overlapping area that is ideal in terms of location, proximity, access and privacy within the UKZN campus layout. (By author)

CHAPTER 4: DESIGN GENERATORS

4.1. Conceptual Framework

4.1.1. Conviviality

Ivan Illich as Austrian philosopher created the concept called Conviviality. He speaks of the tools needed by an, insisting man needs convivial tools rather than machines (Hamdi, 2004). In the area of technology, tools should be the expression of the one using them rather than being the slave to them. He also speaks of flexibility in use, relating to technology as an evolutionary element.

4.1.2. Actor- Network Theory

Actor-Network theory was introduced by Bruno Latour, Michel Callen and sociologist John Law through science and technology studies intended to encourage the role of non-humans or machines in the social lives of humans. ANT developed as a methodology and it explains the relations between things (materials) and concepts (semiotic). Often referred to as material semiotics, the Actor-Network Theory relates to the manner in which connections assemble, forming a description instead of a foundation based idea.

4.1.3. Biomimicry

Bio mimicry originated from the Greek word 'bios' and 'memisis' it is a form of developing form (structural or otherwise) from mimicking natural form in the attempt to solve human problems. It is an innovation inspired by nature, through observing how the natural world works; humans have developed and perfected the art that nature has provided. Mankind has learned many things from observing other species, adopting and adapting their behaviours for their needs.

4.2. Theoretical Framework

4.2.1. Structural technology through the years

This focuses on technology and its relationship with architecture. Using Illich's concept, technology and materials are compared to the stages of architecture as the 'tools' of Conviviality. It establishes the history and development of advanced technology and materials in the human world and sets the stage for further derivatives that technology has influenced. One of these is architecture.

4.2.2. Man and the Machine

This portion of the research investigated the relationship between man, technology and architecture. This section will also reveal the positives and negatives between these relationships. The key factors here are tested against Actor-Network Theory, as it explores the interrelationship between the three actors, namely: Man, Technology and Architecture. It will bring to surface conflicts and opportunities and explore the future of all. It will explain the needs of man to experience life in its value rather than a plain existence.

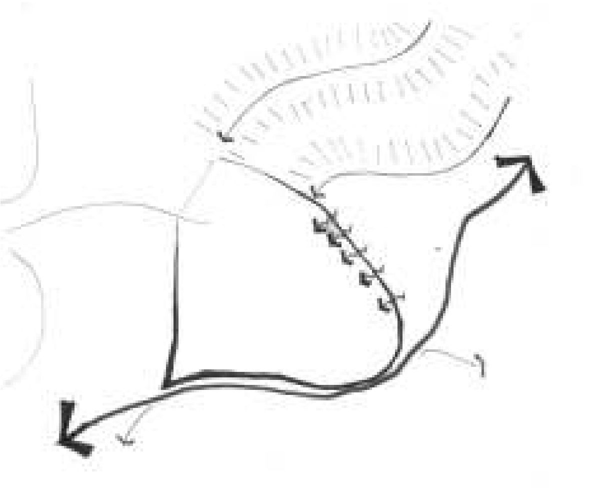
4.2.3. The Relationship between Technology and Architectural Design

This section explores the ways that architecture and technology can integrate one another, inclusive of sensitive technology for the future of designing for man. It explores the possibilities of recent technological developments and the way in which it has shaped design. Of these is Bio mimicry, a more current design concept that involves structure in relation to natural systems. This is a technique were structure is the design, and has to interpret the complexity of technology in nature and mimic it with available materials.

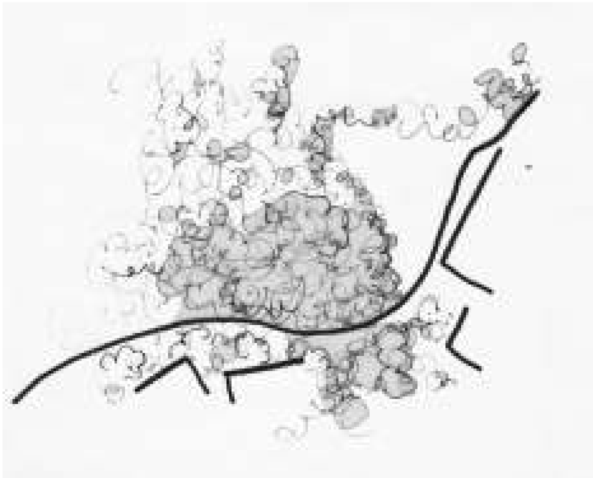
CHAPTER 5: DESIGN CONCEPT

5.1 Design Generators

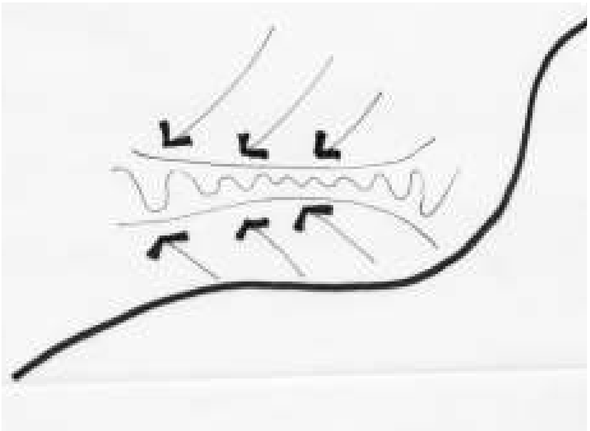
The design generators form the foundation of the design concept of the facility that directly informed the spatial relations and form of the building.



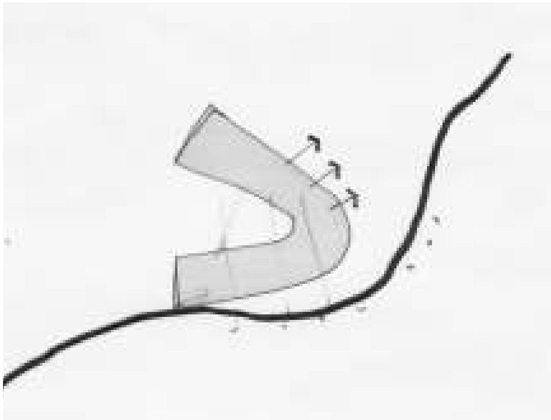
Existing movement routes and access from Shepstone parking



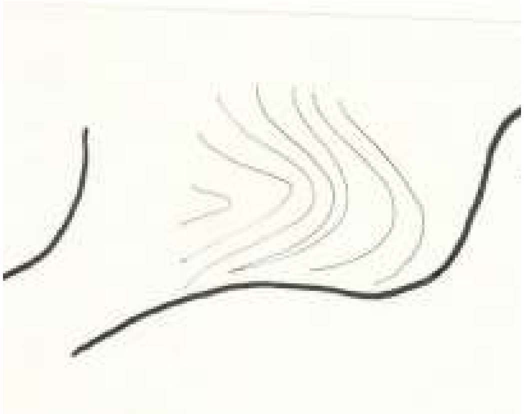
Hard vs Soft edges-Vegetation and buildings



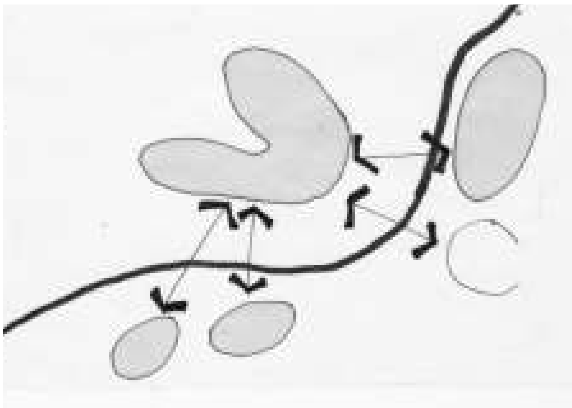
Water flow- avoid building within this area-to influence lighter weight structure on natural drainage routes



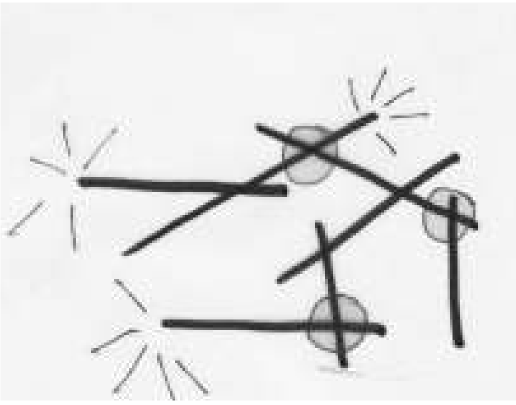
Derived design form with relation to context, site typography and access.



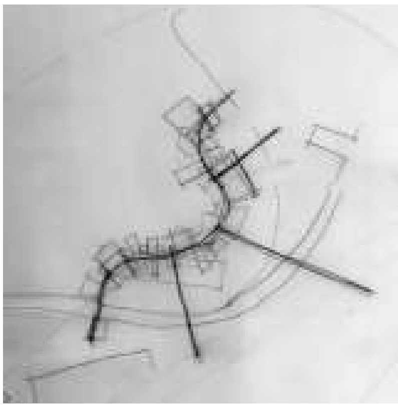
Contours drawing the eye downward, also indicating the steep fall of the site



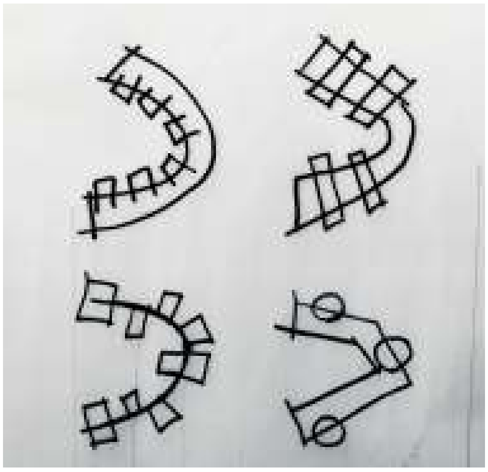
Immediate surrounding buildings that will be associated both physically and visually to the proposed building



Crewating links and connections with the building an doutward into the site



Design generation of “links” or “bridges” to the adjacent buildings and pathways



Exploration of shapes and means to spread outward with smaller boxes and link back into the “main” structure

Figure 5. Conceptual drivers that influenced the design orientation, access and response to contextual existing buildings. (By author)

CHAPTER 6: CONCEPTUAL PLANNING

6.1 Massing

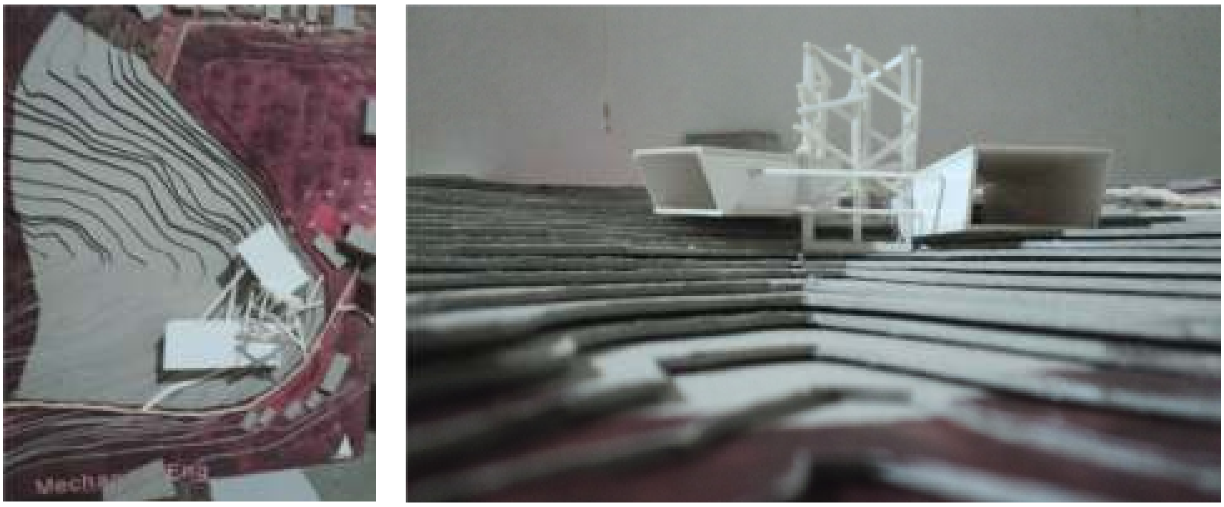


Figure 6. Massing model conveying the concept of a transparent, light weight centre “heart” with flanked by two “wings” running the line of the contours on the highest part of the steep sight

The conceptual design followed through from influences of the site and contextual issues, creating the basis for a single building circulation however fragmented specialised portions. Due to the functionality of the engineering and special needs for specific sciences the location of these would be separated and orientated to best suite the space.

6.2 Planning

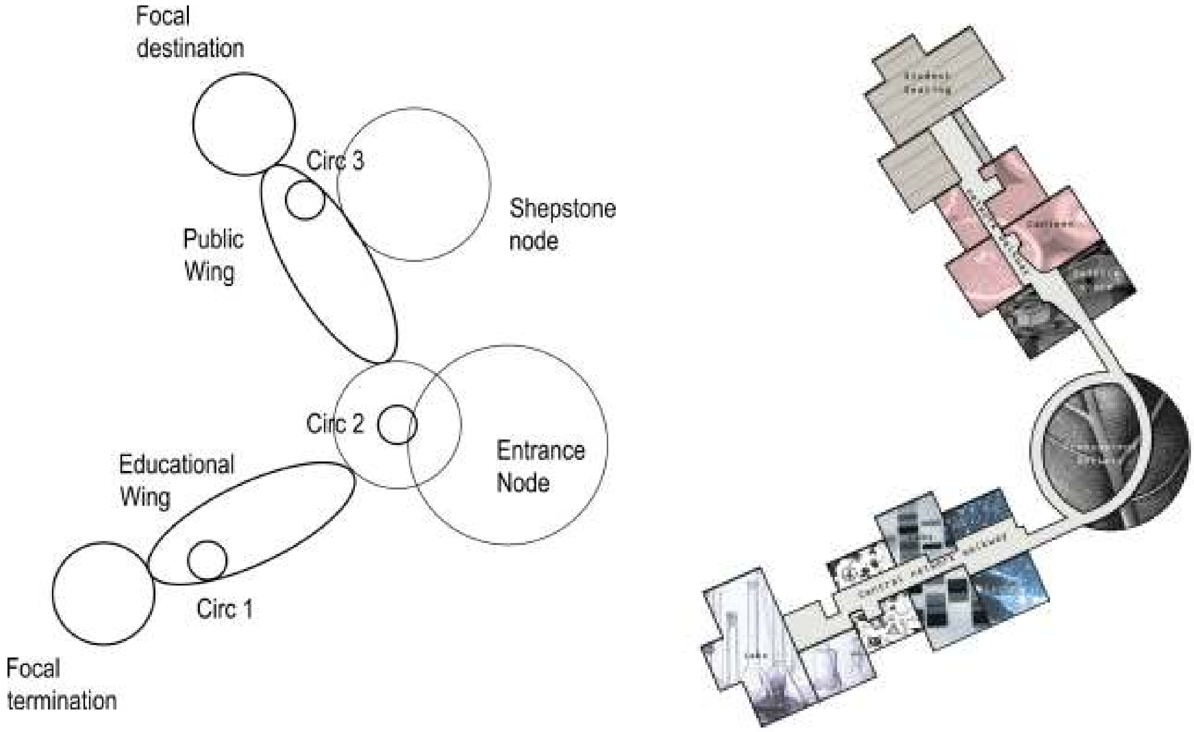
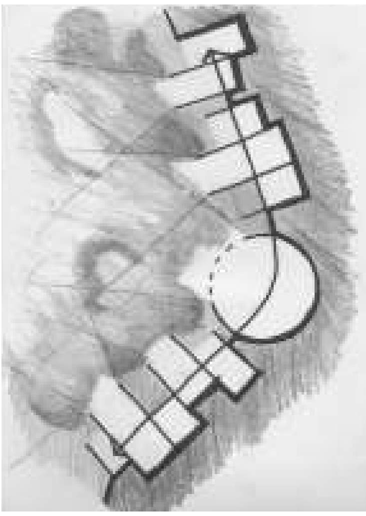


Figure 7. Conceptual ideas of plan vs movement. The nodes create points of interest along the length of each spine with vertical circulation in central areas for easy accessibility. The main node is the entrance. (By Author)

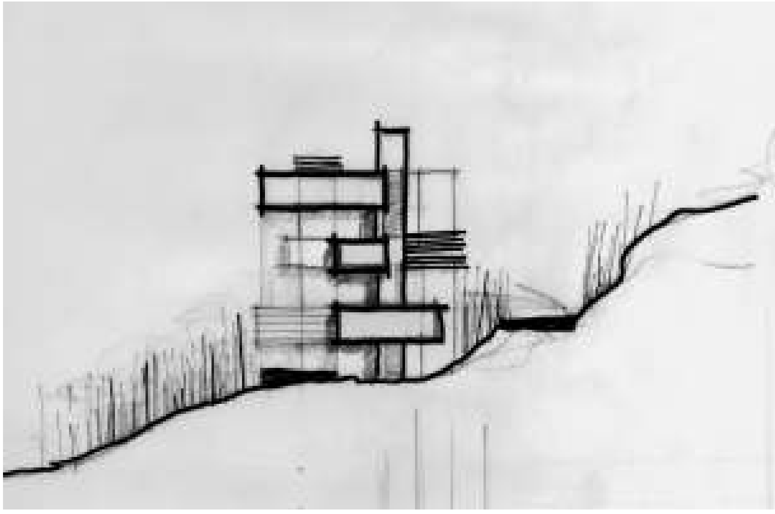
The laboratories were allocated at the lowest level for easier access to gases and easy extraction of waste, including hazardous waste. The orientation was mainly south with greater screening methods taken in cases were labs were north or west facing. Fenestrations were minimised and screens would shade the computer lans.

Workshops and studios that utilised heavy duty machinery areas were also located neared to the basement, for easy access into and out of the way. The noise would be minimised and masked by the vegetation from the levels above.

More public spaces were located on the ground level with the main core being the gallery entrance. This formed the heart of the building, drawing people to the knuckle, centre point and dispersing them to the desired destination within the building. The U-shaped design meant the directions would need to be very strong and end in a celebrated space. Each floor explored science, through books or food or research or showcasing galleries. The idea was to excite ones senses of the presence of science with the backdrop of nature. The two "spines" run the length of the building terminating in a point of either exceptional views of the valley or a gathering space.



Sketch showing the knuckle of the building with the two wings and directional arrows for fluid movement through



Sketch indicating the site in section with a main circulation "spine" and boxes of lighter proportion cantilevering off it.

Figure 8.Conceptual massing and planning with the building on site creating an embedded structure that emerges from the ground (By Author)

The design moved forward as a structural celebration of the site and a counter balance of solid-void space. The interiors would be tighter directionalised movement routes that were dictated by the spaces that punctured the "spines". Structurally the Science Research Centre consisted of a core shear wall that served as the spines. The pods or boxes attached to them pierced the shear wall and clipped on in some places acting at branches to this immense tree that grew from the steep site.

The theories of conviviality through nature, design, science and space are in experiential unison. The "heart" acts as the beacon and its transparency draws views through the building into the vast vegetation beyond the science centre. It overlooks the green canopies and acts as the pause area before the specialised zones inside the building. The boxes reduce as the building rises and they stagger to form a gradual break into the sky. The same effect assists in creating rooftop spaces for gardens and balconies, utilising the maximum area vertically while overlooking the treetops and valley below.

The link to Shepstone is strengthened through restaurants and the research library, activating the edge that interfaces with the parking lot on ground level. By drawing in students from the other faculties the Science Research Centre aims to educate and intrigue on the aspect of science.

The building is spread and narrow, clinging to the circumference of the site almost hidden in the vegetation, while dictating its presence at the top. It’s the balance of nature that meets science through an architecturally structural employment of camouflage and mimicry.

Figure 9. Model of the Proposed Science Research Centre (By Author)

CONVIVALITY > TOOLS VS THE MACHINE

TECHNOLOGY AS AN EVOLUTIONARY ELEMENT

ACTOR - NETWORK > ASSEMBLY OF THINGS AND CONCEPTS >
CONNECTIONS > NARRATIVES

BIOMIMICRY > NATURAL SOLUTIONS TO HUMAN PROBLEMS >
INNOVATION INSPIRED BY NATURE

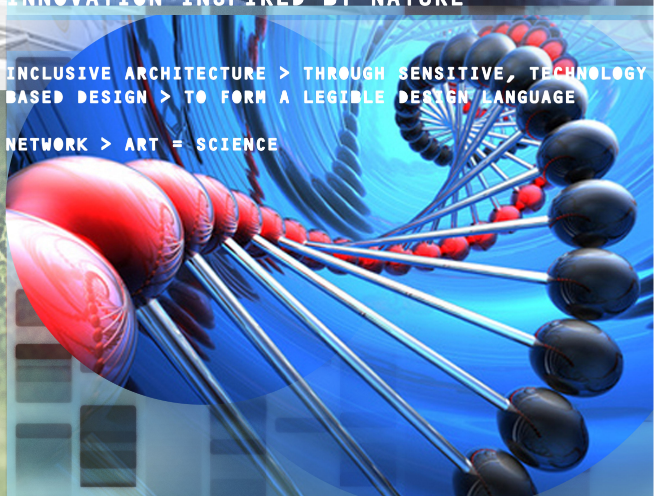
INCLUSIVE ARCHITECTURE > THROUGH SENSITIVE, TECHNOLOGY
BASED DESIGN > TO FORM A LEGIBLE DESIGN LANGUAGE

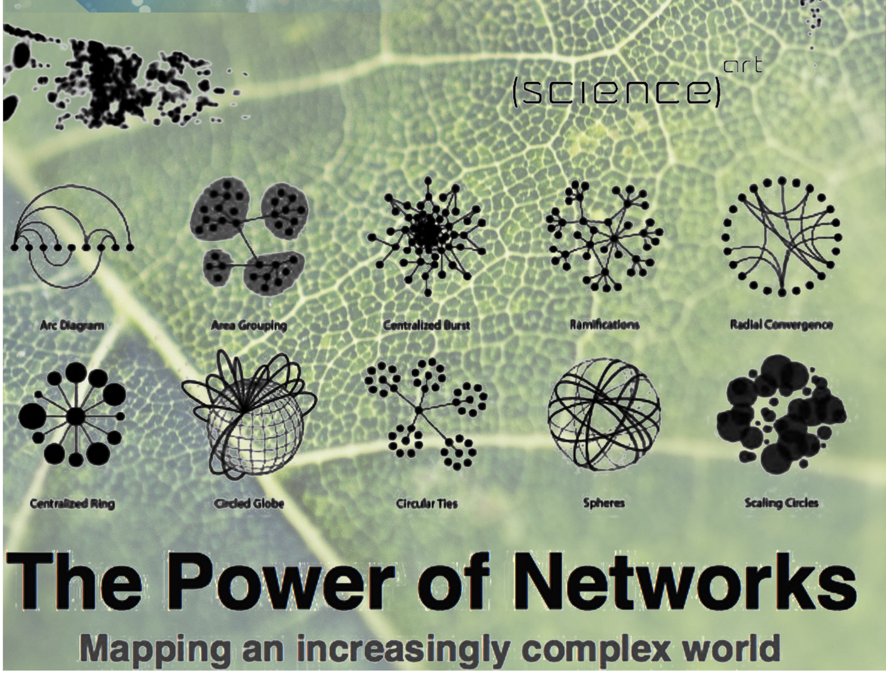
NETWORK > ART <-> SCIENCE

BIOMIMICRY > NATURAL SOLUTIONS TO HUMAN PROBLEMS >
INNOVATION INSPIRED BY NATURE

INCLUSIVE ARCHITECTURE > THROUGH SENSITIVE, TECHNOLOGY
BASED DESIGN > TO FORM A LEGIBLE DESIGN LANGUAGE

NETWORK > ART = SCIENCE





The Power of Networks

radial connections > centred focus > arched branc

>INTEGRATION
>STRUCTURE
>ORGANISATION

Background

The period of 1880 to 1920 saw the formation of strong, independent nations across the world that encouraged scientific advancement and facilitated industrial development by implementing fast-track manufacture and processes for housing and rebuilding of ruined cities. In the aftermath of the world wars, technology played a vital role in redevelopment and overcoming the damage wreaked by the war loss (Sebastyen, 2003).

This method of increasing the product and quickening the process meant that man and machine were the new techniques for optimal outcomes. The evolution of technology has assisted and encouraged learning of technology for the benefit of the human race. The socio-technical relationship is formed between humans and the advances in design. The problem with technology is the lack of sensitivity and 'self'. On one hand the progress that is evident is intended to improve the lives of man, however on the other, this process for such technology has divorced man from the direct interaction between the environment and other social needs of interaction.

Ivan Illich describes that increase in the power of machines meant the decrease of mankind's roles in society to be that of mere consumers, driven as slaves to the technology that they had created (Illich, 1973). The lack of social connection between nature and man and nature and technology, will produce individuals and networks that are absent of 'self 'and sensitivity (Alexander: 2005). The divorce of direct interaction between man and man and the environment removes the element of responsibility whilst rendering man obsolete and disconnecting man from social interaction. The component of sensitivity that man adds to the built environment is replaced with hi-tech creations. The networks of technology and design are divorced, creating space for function and removing the aspect of the actual living inhabitants.

Aims

The main aim of this dissertation is to uncover the social effects that evolutionary technology has on man. In doing so, understand the benefits of evolutionary technology and implications they have on man and architecture.

Objectives

- To investigate the affects that evolving technology has had on human behaviour and social interaction.
- To examine the advances of structural technology from the industrial revolution to present day, for the purpose of understanding how such technological developments have influenced the lives of man.
- To critically assess how structural technology in architecture has impacted on man, through precedent and case studies.

Hypothesis

Structural technology has grown through the years in the attempt to better the lives of human beings. However, the vast increase in machinery and tools have removed man from the environment and alienated people from one another. It also created exclusive architecture that is removed from the sensitivity that man requires as a life essential. By integrating sensitivity and the structural technology used in the creation of architectural design in forming a joint system, man can relate and benefit from both. This combined approach to design will incorporate technology that encourages interaction with man and form a design language that expresses structural technology through the design instead of a separate element. The influence therefore of evolutionary technology, specializing in structure, can transform from an isolated component into an integral part of design.

Conceptual Framework

Conviviality

Ivan Illich an Austrian philosopher created the concept called Conviviality. He speaks of the tools needed by man, insisting man needs convivial tools rather than machines (Hamdi, 2004). In the area of technology tools should be the expression of the one using them instead of being the slave to them. He also speaks of flexibility in use, relating to technology as an evolutionary element.

Actor –Network Theory

Actor-Network Theory was introduced by Bruno Latour, Michel Callen and sociologist John Law through science and technology studies intended to encourage the role of non-humans or machines in the social lives of humans. ANT developed as a methodology and it explains the relations between things (materials) and concepts (semiotic). Often referred to as material semiotics, the Actor Network Theory relates to the manner in which connections assemble, forming a description instead of a foundation based idea.

Biomimicry

Originating from the Greek words "bios" and "memisis" it is a form of developing form (structural or otherwise) from mimicking natural form in the attempt to solve human problems. It is an innovation inspired by nature, through observing how the natural world works; humans have developed and perfected the art that nature has provided. Mankind has learned many things from observing other species, adopting and adapting their behaviours for their needs.

Theoretical Framework

Structural Technology through the years

This section focuses on technology and its relationship with architecture. Using Ivan Illich's concept, technology and materials are compared to the stages of architecture as the "Tools" of Conviviality. It establishes the history and development of advanced technology and materials in the human world and sets the stage for further derivatives that technology has influenced. One of these is architecture.

Man and the Machine

This portion of the research discusses the relationship between man, technology and architecture. This section will also reveal the positives and negatives between these relationships. The key factors here are tested against Actor Network Theory, as it explores the interrelationship between the three actors, namely: Man, Technology and Architecture. It will bring to surface conflicts and opportunities and explore the future of all. It will explain the needs of man to experience life in its value rather than a plain existence.

The Relationship between Technology and Architectural Design

This section explores the ways that architecture and technology can integrate one another, inclusive of sensitive technology for the future of designing for man. It explores possibilities of recent technological developments and the way in with it has shaped design. Of these is Biomimicry, a more current design concept that involves structure in relation to natural systems. This is a technique were structure is the design, and has to interpret the complexity of technology in nature and mimic it with available materials.

Precedent Study

MUSEE QUAI BRANLY MUSEUM

_Paris, France

Musée Quai Branly, dedicated to indigenous art of Africa creating a 420,000-square foot partial treehouse, raised on pilotis and curved to follow the river.

A strange property, located along the Seine, in Paris (France), the Quai Branly Museum, designed by Architect Jean Nouvel, consists of three buildings, each with a distinct identity: the museum proper, the administration building, with its façade full of plants, and the property devoted to the management of the collections and library.

The building appears to be a wild, disorganized jumble of colorful boxes. To add to the sense of confusion, a glass wall blurs the boundary between the outer streetscape and the inner garden.

This is a museum built around a specific collection, where everything is designed to evoke an emotional response to the primary object, to protect it from light, but also to capture that rare ray of light indispensable to make it vibrate and awaken its spirituality.It is a place that is unique and strange, poetic and unsettling.

Its architecture must challenge our current Western creative expressions. Away, then, with the structures, mechanical systems, with curtain walls, with emergency staircases, parapets, false ceilings, projectors, pedestals, showcases. If their functions must be retained, they must disappear from our view and our consciousness, vanish before the sacred objects so we may enter into communion with them.

What is solid seems to disappear, giving the impression that the museum is a simple façade-less shelter in the middle of a wood. When dematerialization encounters the expression of signs, it becomes selective; here illusion cradles the work of art.

EVOLUTIONARY TECHNOLOGY AND ITS INFLUENCE ON THE STRUCTURAL INTEGRITY OF ARCHITECTURAL DESIGN

BACKGROUND + PRECEDENT STUDIES

Science Research Centre

Shoroma Dindial

Precedent Studies

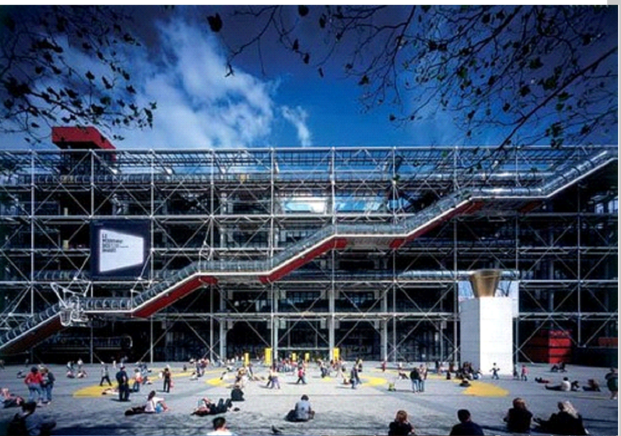
POMPIDOU CENTRE_Paris, France

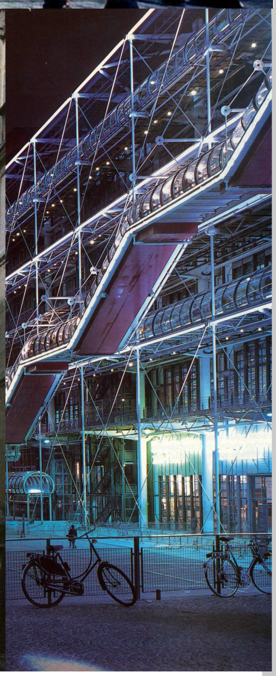
Renzo Piano and Richard Rogers designed the Centre in France, as a museum for collections of art. The concept based on the 1960's design characteristics of membrane and makeup, flexibility, technology, movement and anti-monumentalism.

The steel superstructure would be the fixed exoskeleton, with the walls and floor inserted as moveable elements. The intention was for flexibility of space, and thus these elements could be removed and replaced.

Actor Network Theory implemented in the Pompidou Centre would explain the technological challenge and product of the "scientists" creating it. The result is a building that expresses the strengths of the centre, so distinctively that it becomes the design. The technological systems are the art from the outside, while the interior is left for display art. The function of the building did influence the concept, by freeing up the space. The same space created by structure.

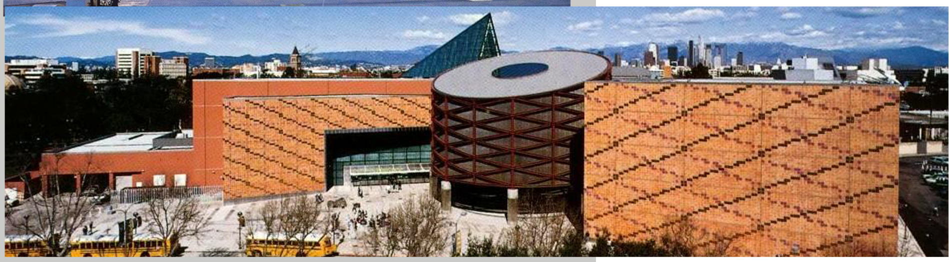
The concept of Tools of Conviviality, describes the warmth or emotion that architecture can bring to the users instead of mechanized exclusive structures. Pompidou brought people closer and provided that space for translation and transition.

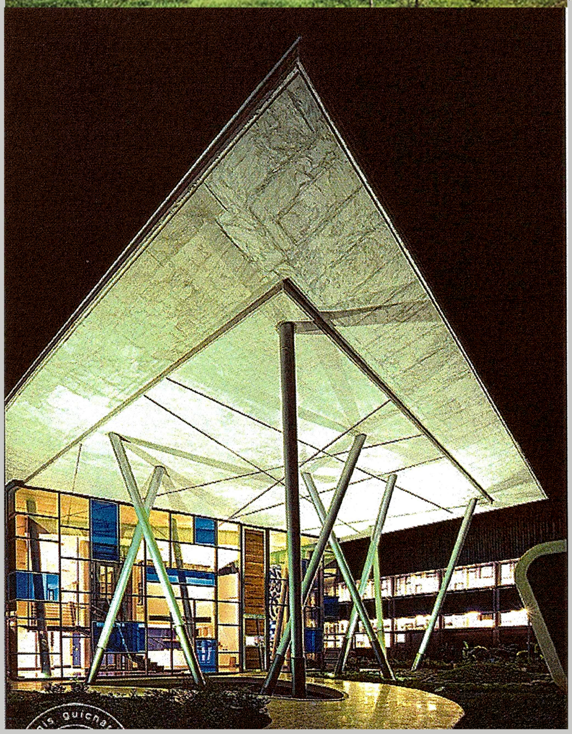




CALIFORNIA SCIENCE CENTRE
_Los Angeles, California

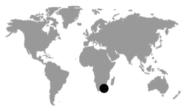
The open-air drum of the central rotunda is 100 feet in diameter and 88 feet high. Its exoskeleton is clad in panels of perforated stainless steel. Ramps attached to the inside of the rotunda provide upper floor
connections between the theater and the exhibition space.
The main aim for the building was to create a collection space for students and kids to gater, readying them for the inside of the centre. The architects extracted distinct programmatic peices, pulling out, most natably, a three-story open-air rotundaas both building symbol and giant front porch.
The rotunda forms the pourous buffer between exhibition and theater, which compensates for the hieght of seven stories.
Main spaces in the centre are the Pavilion, IMAX theatre, atrium, conference center, world of life
exhibitions, Previews for future
exhibitions.
The use of high volumes enable grand experiments and exhibitions throughout the centre. In addition the skylights are positioned to focus light into these spaces making them icelebrated nodes in the buildings form.





Case Study

UNILEVER_River Horse Valley, Durban



The idea was to use the machinery in the production plant as inspiration for the form of the building. EPA found this would be an interesting play in the design aesthetics, while a fluid shape was derived. In this way the form of the building becomes a visual
embodiment of the function within the building and use the structure as the main representation of this.

The incorporation of technical structure with design is the first expression of technology used as a tool for convivial design. The system works together, each playing its role in the concept of functional translation and unifying space through the
arrangement of such structure as Actor Network Theory explains
separate components coming together to form a systematic network and resposibility.

Client

The client will consist of a Joint Venture between School of Engineering, University of Kwa-Zulu Natal and Council for Scientific and Industrial Research (CSIR).

The School of Engineering, a subdivision of the College of Agriculture, Engineering and Science at UKZN, house five disciplines of science. These include: Agriculture
Engineering, Chemical Engineering, Civil Engineering, Electrical, Electronic and Computer
Engineering, Land Surveying and Mechanical Engineering. The differentiation between these are greater established passed the first year of the four year degree. The school therefore requires a space that can introduce the Sciences to scholars prior to entering tertiary learning. The University Intense Tuition for Engineers (UNITE) program forms part of the school, as a bridge course into the university.

CSIR is a South African multidisciplinary research, development and implantation
organization with the South African Parliament as a shareholder. Its main aim is the impact of development of research, technological innovation, industrial and scientific
development to improve the value of life. It aims to improve the countries'
competitiveness on an international basis as well as creating new technological ventures and opportunities for the future science.
CSIR transfer the knowledge explored through technology and skilled persons.

Qualified students completing their degrees at UKZN are currently serving their
internships at CSIR, providing the first stepping stone to the career of Science and
Industry. The opportunity for this merger at an earlier stage will enable students and scholars the vision that Science has for the evolving world of technology.

UKZN:
Increase the interest of students into Engineering Sciences
Clarify the differences between the disciplines of Engineering at the University
Enhance skills training and create a specialized environment for learning at varsity
Provide a resourceful and accessible space for students to research, practice, display and their work
Accommodate speakers and staff
Host conferences and allow for orientation into the disciplines of engineering
Improve results at secondary level and tertiary institutions
Link the UNITE building as a sister to the Research Centre, accounting for passionate students who cannot enter into the first year course

CSIR:
Impact through information and education transfer
Improve and expand the knowledge of science
Improve the quality of life
Contribute to economic growth
Promote environmental sustainability
Create jobs for the South African public
Achieve a higher rate of skilled persons in the science field

UNIVERSITY OF KWAZULU-NATAL

CSIR
our future through science

Site Criteria

Proximity to a Natural element for the centre to interact with and research. (Water bodies, dense vegetation etc.)

Located near or in an area of interest that is challenging for the complexity of a structurally technological solution. (Soil conditions, sloped land, water surfaces, changing tides, cliff face)

Nature within the surrounding area as the sensitivity will be drawn from the natural environmental setting.

Requirement for easy accessibility, as well as visual connection(sight lines) and physical connections (to existing or future proposed areas of interest or relation).

Large site area as large spans may be used in the attempt to showcase the best technologically structural solution.

Intention for a complex structure with simple systems requires changing or evolving physical environmental setting. (residing tides, changing levels, changing temperatures)

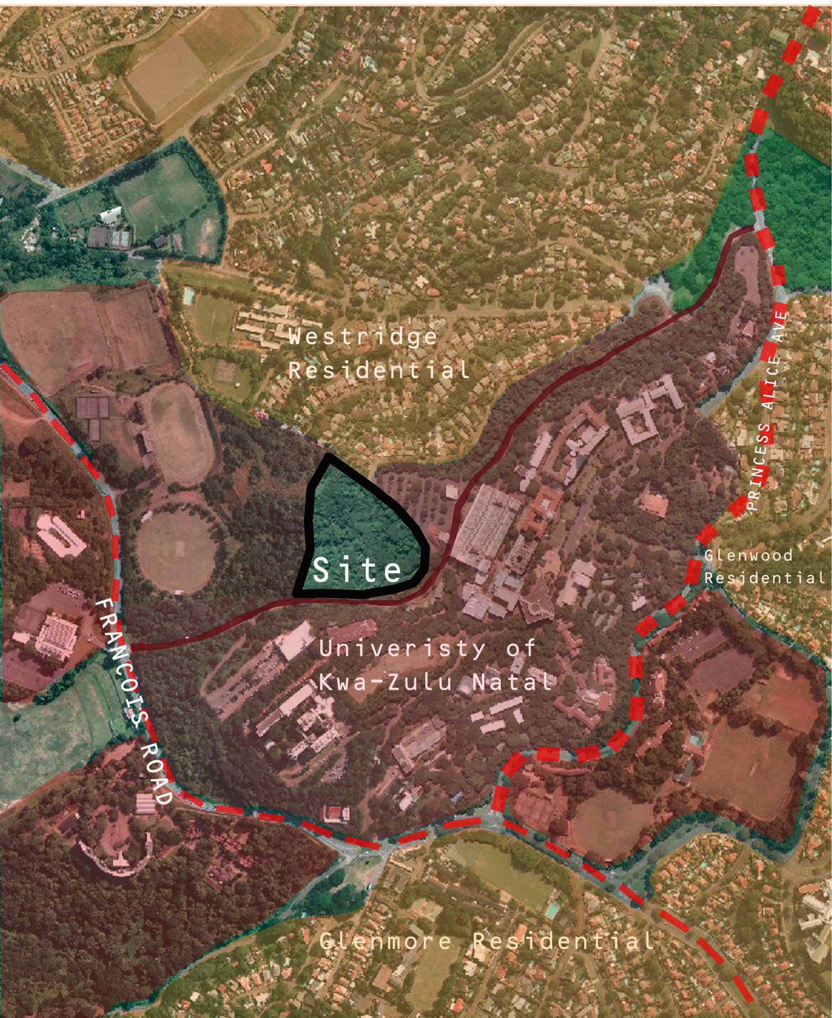
Requires a site closely related to the city of Durban, but removed enough for experimental freedom and space, still being responsive and sensitive to the environment.

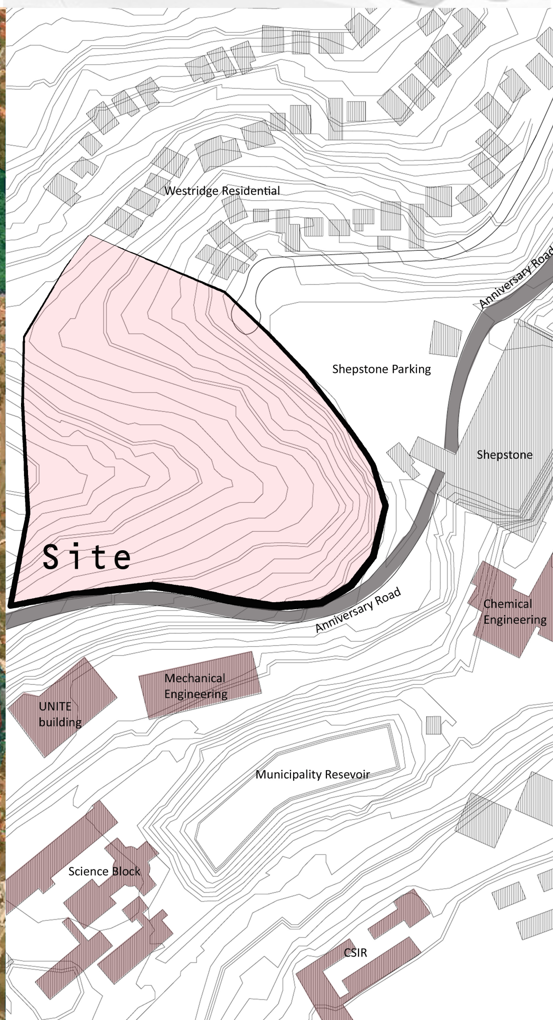
Durban_South Africa

Schedule of Accommodation

Transparent Tower		
Lobby/entrance	200	Pause entrance area surrounding reception + information
Reception	100	Receptionist station
Information	100	Information station about the centre and related areas in the close vicinity
Conference Centre/cinema(40x30)	1000	Large unobstructed area for functions
Restaurant	500	In house restaurant that caters to the public, and visitors to the center.
Canteen	300	Staff canteen with garden
Public Wing		
Four themed exhibition galleries	1000	Areas for showcasing the works from the science divisions
Media Library	1000	Library housing books, research spaces, computer lan, media room for smaller
Science store	350	Shop accessible to public, selling books and artifacts from the science centre
Discovery Room	500	Area allocated for future sciences
Ablutions for public + visitors	200	Toilet facilities
Educational Wing		
Parking	1000	Parking facilities for staff and visitors on site
Electrical, Electronic and Computer Science		Specialized areas for the purpose of design and construction in the mechanical and electrical field of engineering
Workshops	500	Sound room. Solar panels on roof space. Computer rooms with diff trainers
Labs	300	High voltage machine lab-Metal balls with jumping electricity
Storage	100	Storage for components(quite small). Space for excess or currently unused material
Chemical Science		Specialized areas for the purpose experiments for the chemical field of engineering. Sealed area, no natural ventilation, temp controlled, but encourage natural light
Workshops	500	Distillation tubes(2/3 levels)-master flow rates. Temp, light controlled. Sensitive to pressure differences(buffer door between)
Laboratories	500	
Storage	100	Space for excess or currently unused materials
Civil Science		Specialized areas for the purpose of design and construction in the civil field of engineering
Workshops	500	
Storage	100	Space for excess or currently unused materials
Mechanical Science		Specialized areas for the purpose experiments for the mechanical field of engineering.
Workshops	500	Space for construction of mechanicals
Storage	100	Space for excess or currently unused materials
Cloakroomsx4	150	Pause areas for staff and visiting scholars
Ablutions for subdivisionsx4	200	Toilet facilities
Offices	250	Facilities manager +staff to be accommodated
CSIR offices	250	Liaisons with CSIR and persons interacting through the company to the centre
Accommodation	1500	Short term accommodation facilities for speakers and scientists visiting the centre
Other		
Roof Garden, terraces, courtyards	1000	Relaxation space for staff and visitors, views into the tree canopy
'Forrest' Walkways	500	Elevated pathways through the trees around the building linking the different science disciplines
Total	13 050	
Services and specified areas		
Ducts-gases from store to chem. labs		Colour coded piping for specific gases to the dry laboratories. (helium, oxygen, nitrogen, air, hydrogen, compressed air)
Ducts- waste runoffs to the collection point		
Extractor ducts		Removing chemical air from the laboratories
Air-conditioning ducts for labs		
Hazardous waste storage in basement		
Secured Gas storage in basement		

Site Selection





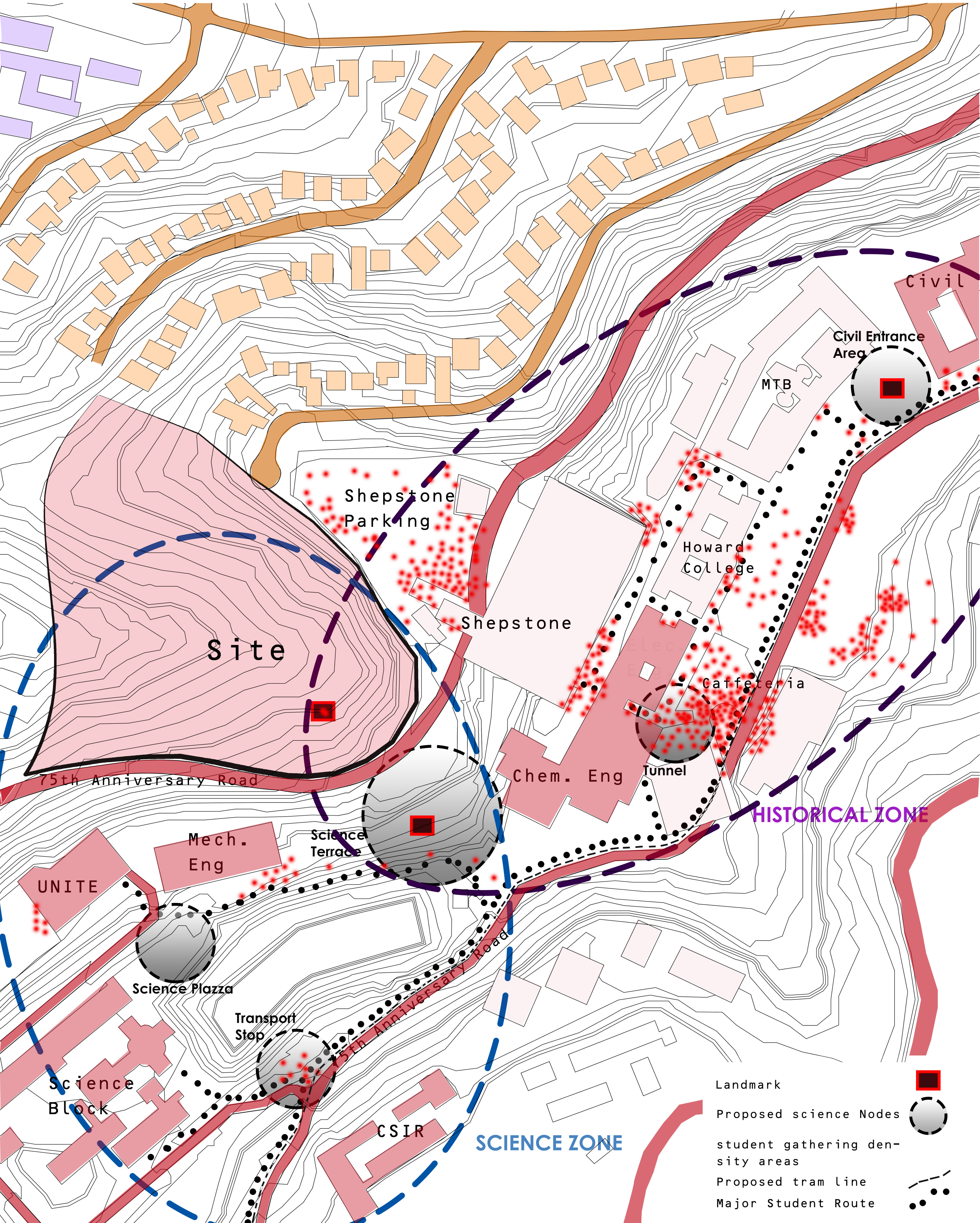
EVOLUTIONARY TECHNOLOGY AND ITS INFLUENCE ON THE STRUCTURAL INTEGRITY OF ARCHITECTURAL DESIGN

CLIENT + SITE

Science Research Centre

Shoroma Dindial

Locality Map 1:1000



EVOLUTIONARY TECHNOLOGY AND ITS INFLUENCE ON THE STRUCTURAL INTEGRITY OF ARCHITECTURAL DESIGN

SITE CONTEXT

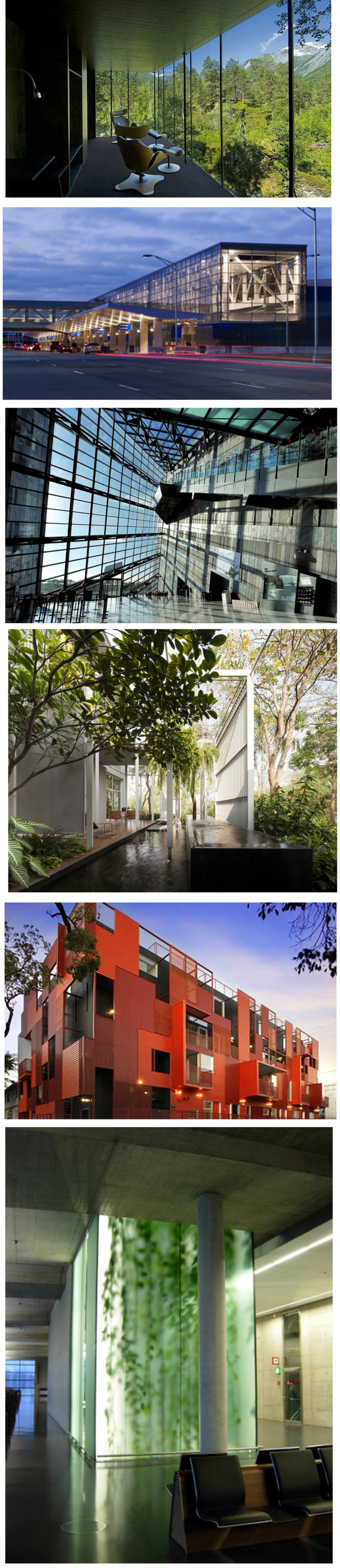
Science Research Centre

Shoroma Dindial

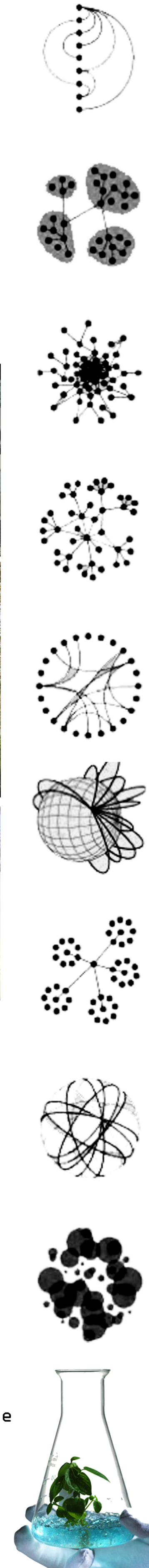
NETWORKS

ENGAGING

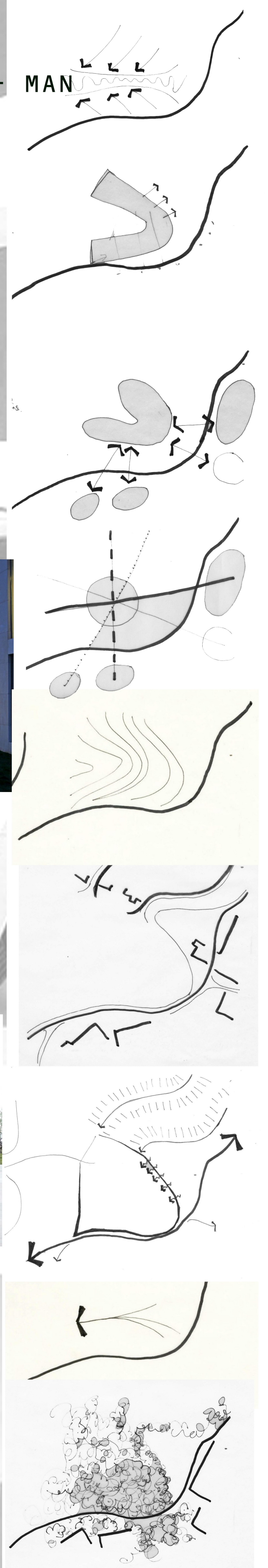
SCIENCE + TECHNOLOGY + NATURE + MAN



Where Science meets nature



The sites characteristics and response as the influence for sensitive design. Form, Function and flexibility



Conceptual Development

Using Actor Network Theory as the basis for conceptual framework, the design follows a similar aspect of connectivity and structure.
NETWORKS is a derivitive of science, featured in every discipline and used as a tool in thl field of engineering.

It focuses the design on:
Collection of spaces, sciences, functions, structures, systems etc.
It is the coming together of elements that feed design integrity, linking to ANT.
A Network creates the opportunity for the UKZN campus to work as a system or complex, forming sets of connections.
The site in relation to networks will act as the subtrate for the building to attach and form a spread our "network" encouraging movement, subdivision, selective science functions and relations to the natural setting.

EVOLUTIONARY TECHNOLOGY AND ITS INFLUENCE ON THE STRUCTURAL INTEGRITY OF ARCHITECTURAL DESIGN

CONCEPT

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Shoroma Dindial

SITE PLAN 1:1000

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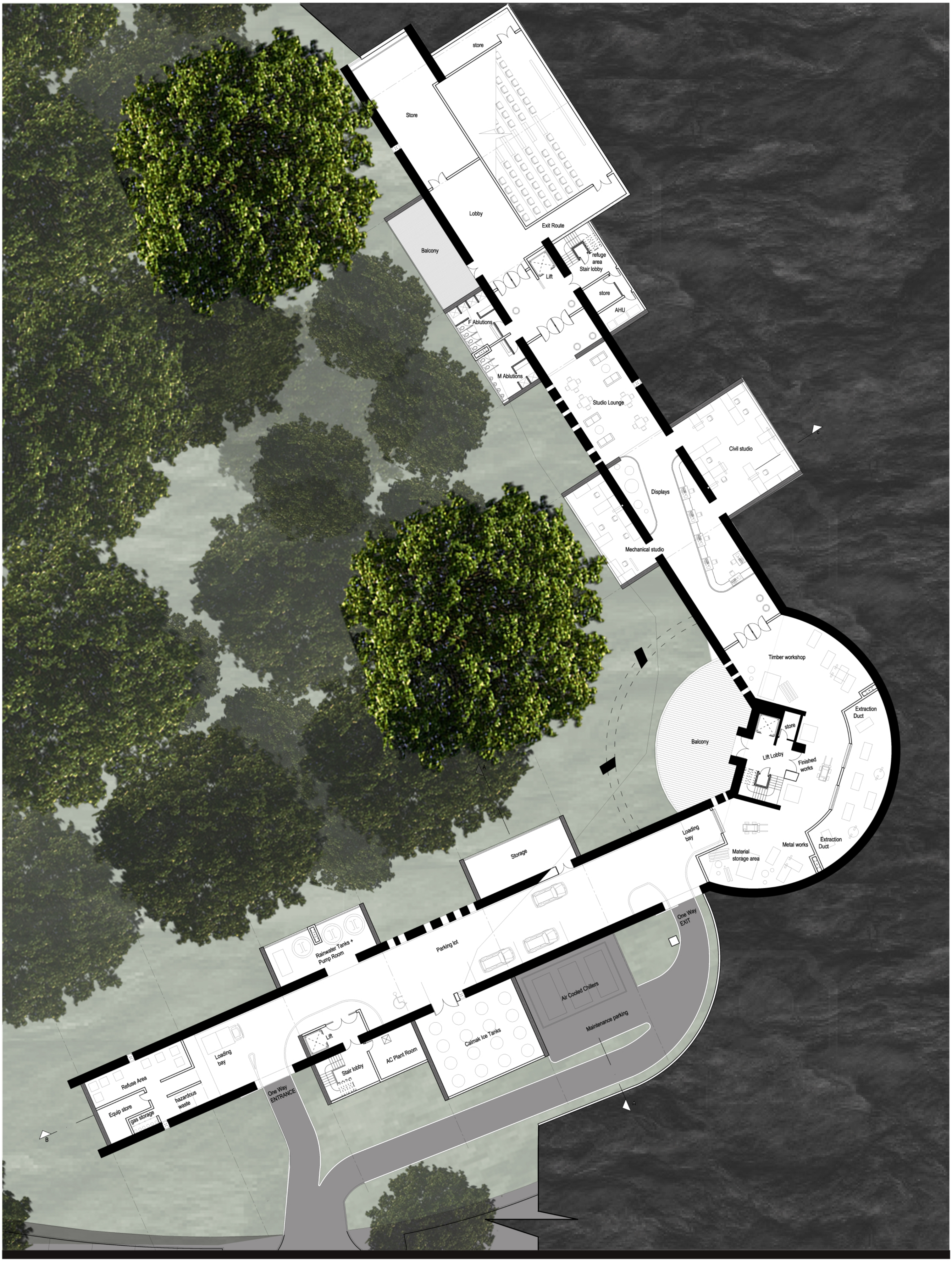
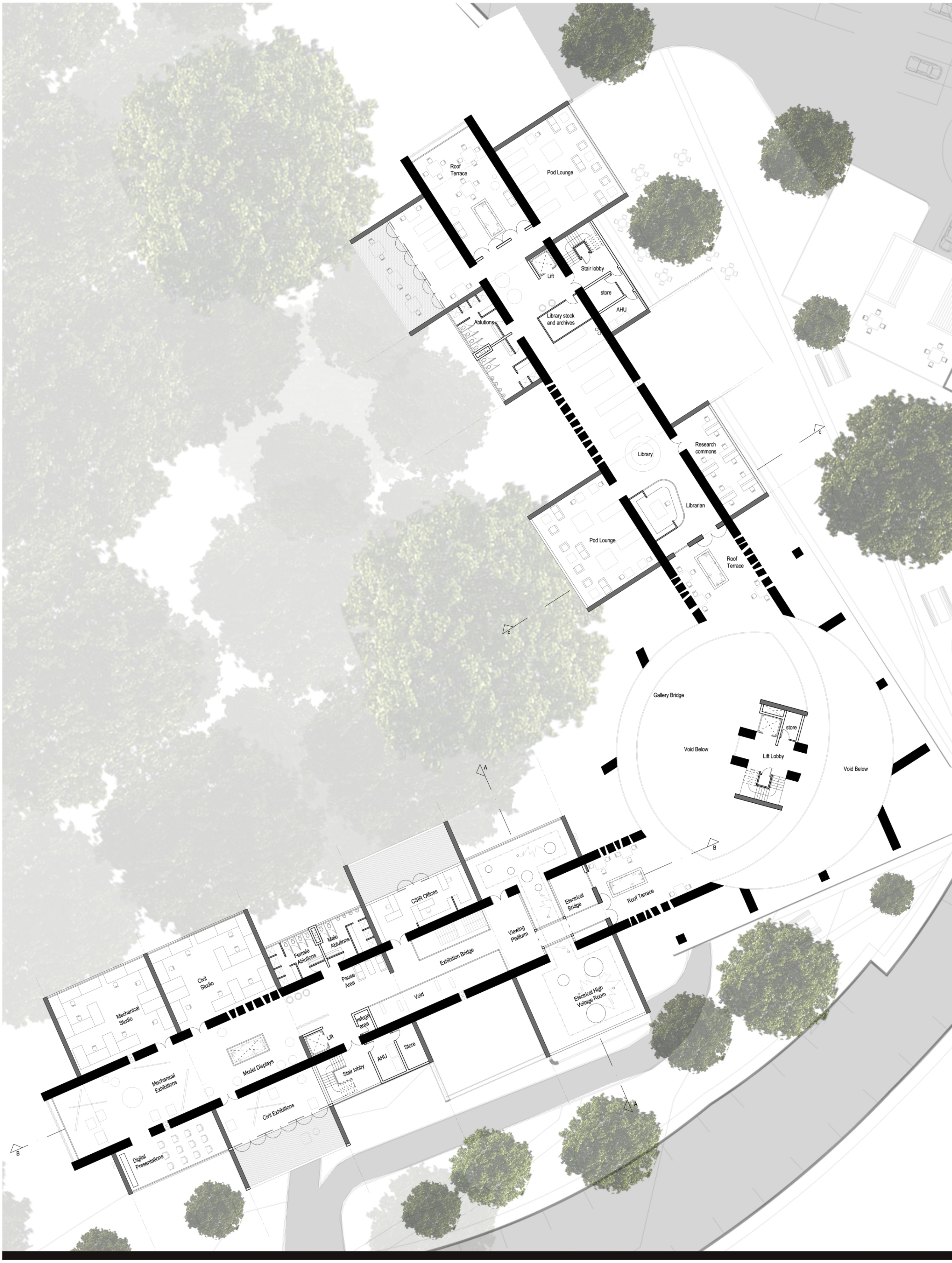


LEVEL -02_SCALE 1:200

Science Research Centre

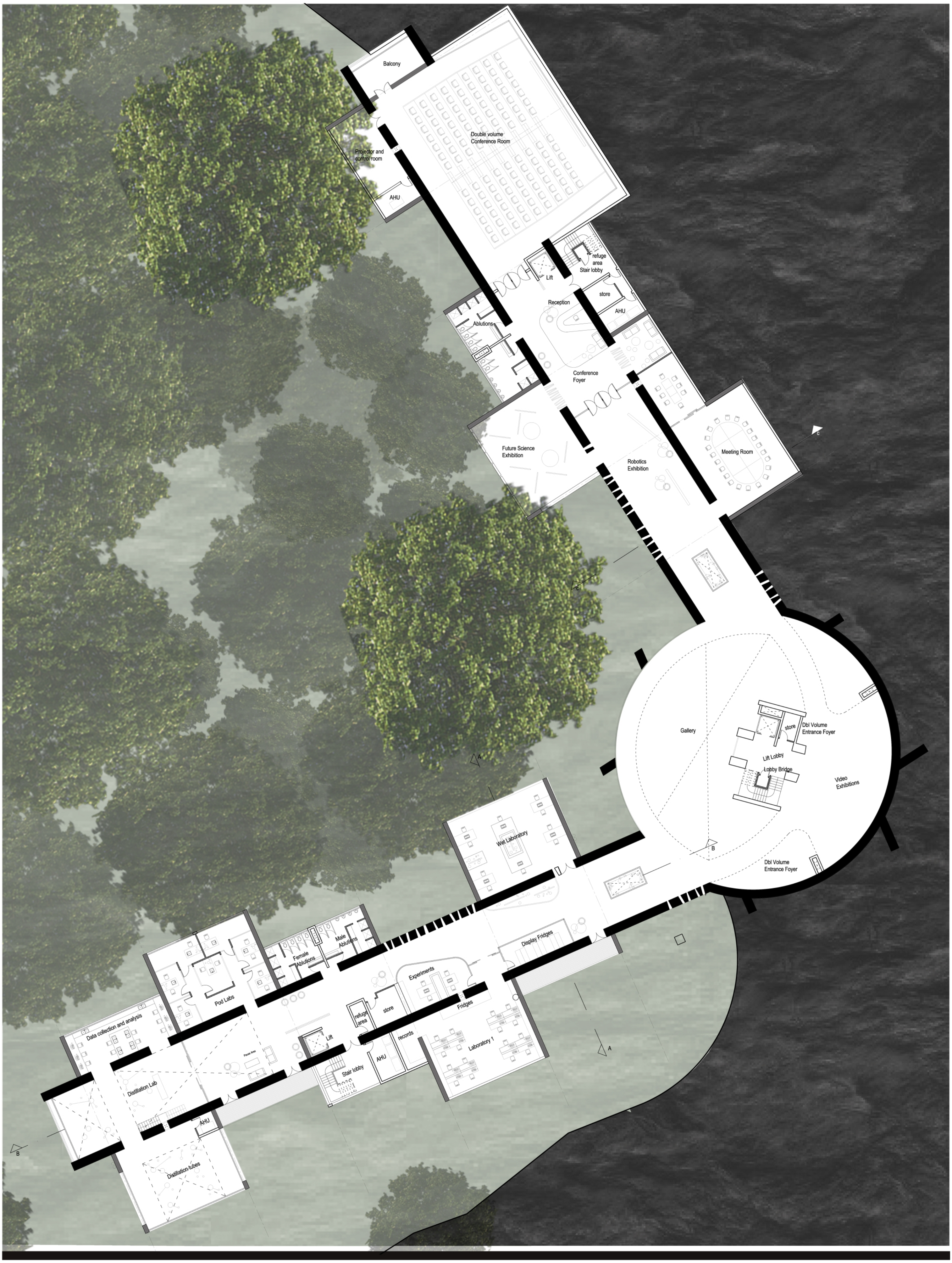


LEVEL 1_SCALE 1:200

Science Research Centre

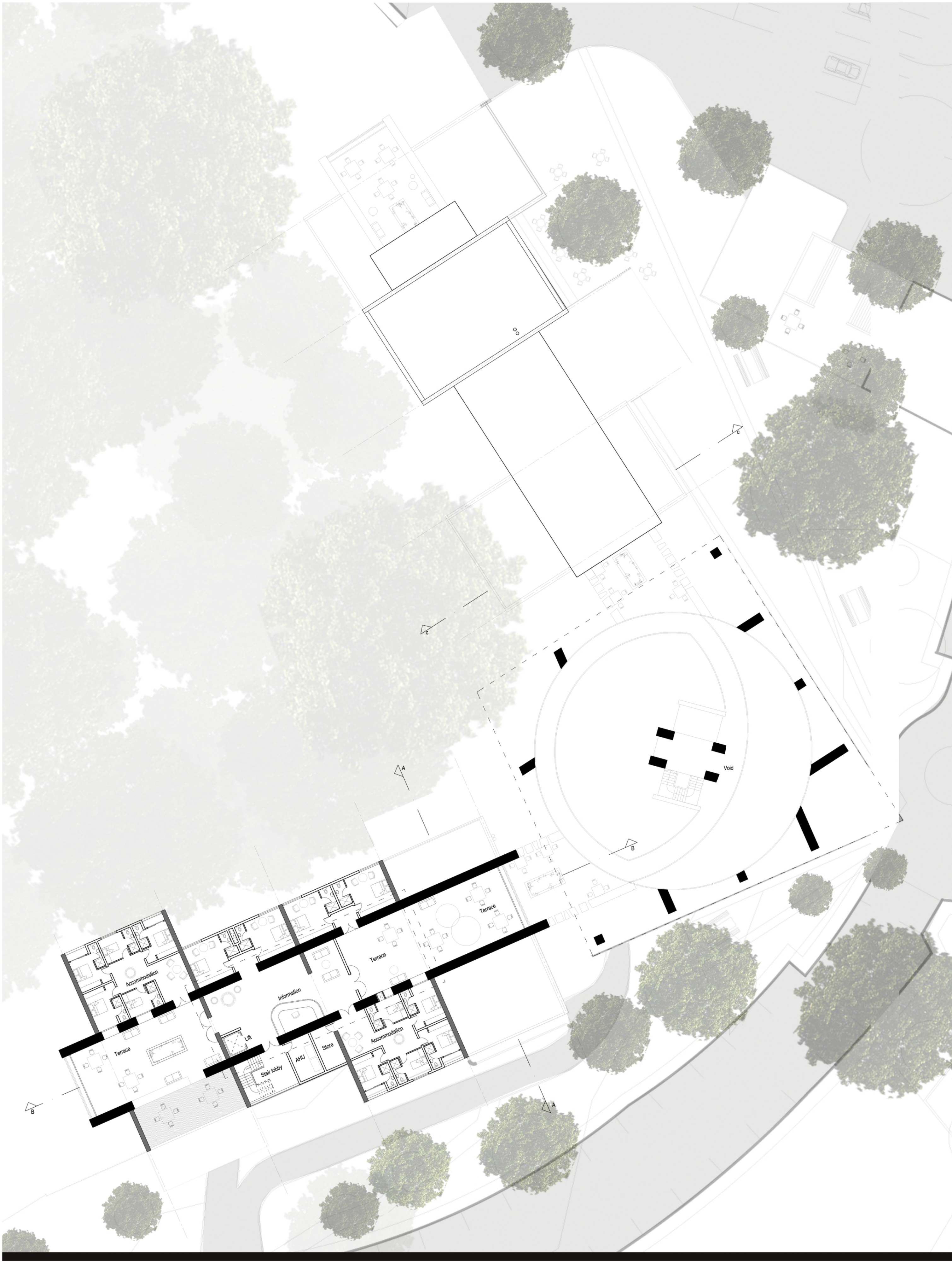
GROUND LEVEL_0 1:200

Science Research Centre



LEVEL -01_SCALE 1:200

Science Research Centre



LEVEL 02_SCALE 1:200

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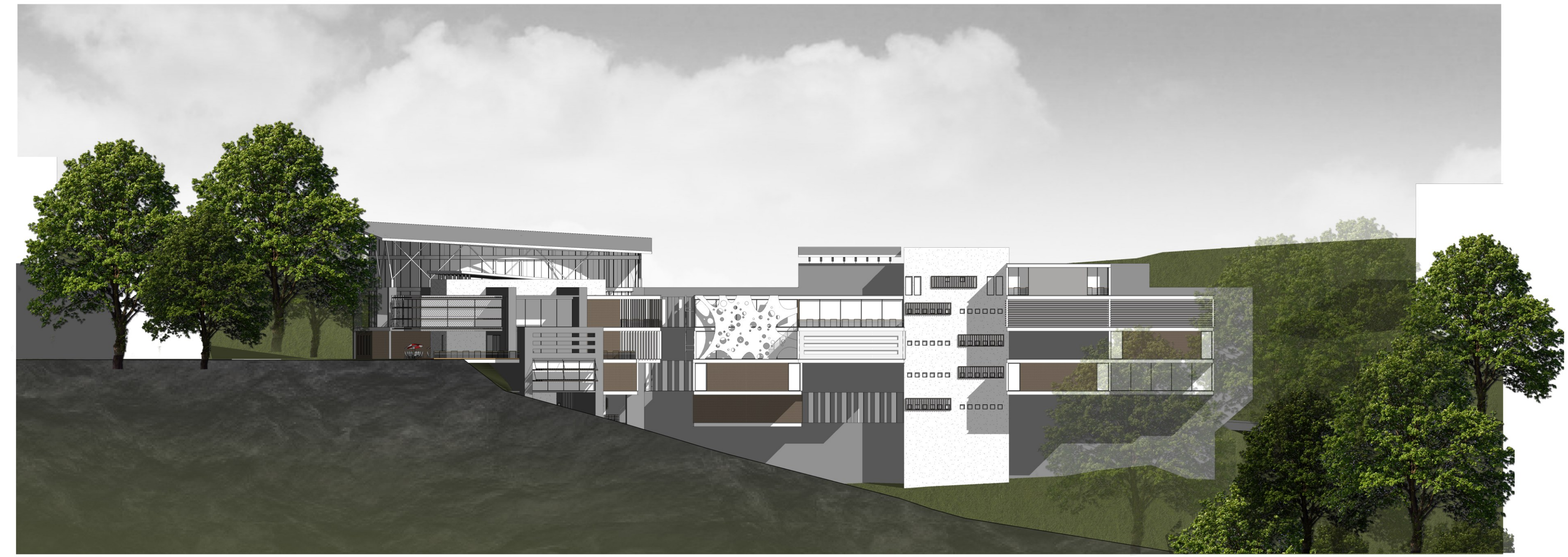


NORTH WEST ELEVATION 1:200

Science Research Centre

NORTH EAST ELEVATION 1:200

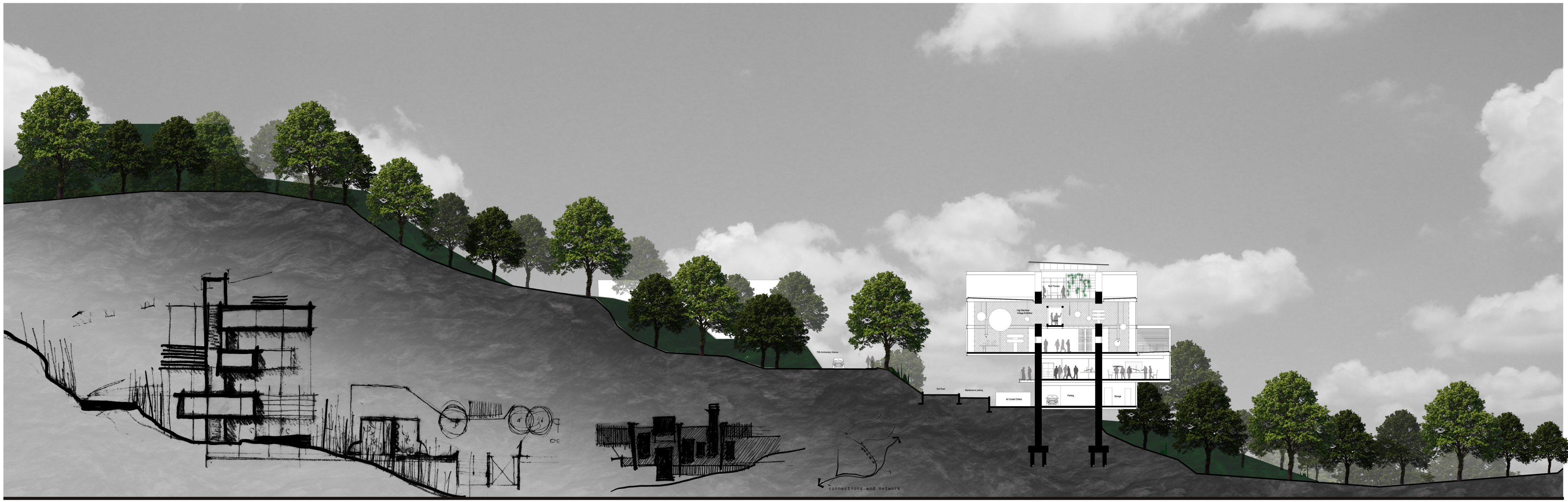
Science Research Centre

SOUTH WEST ELEVATION 1:200

Science Research Centre

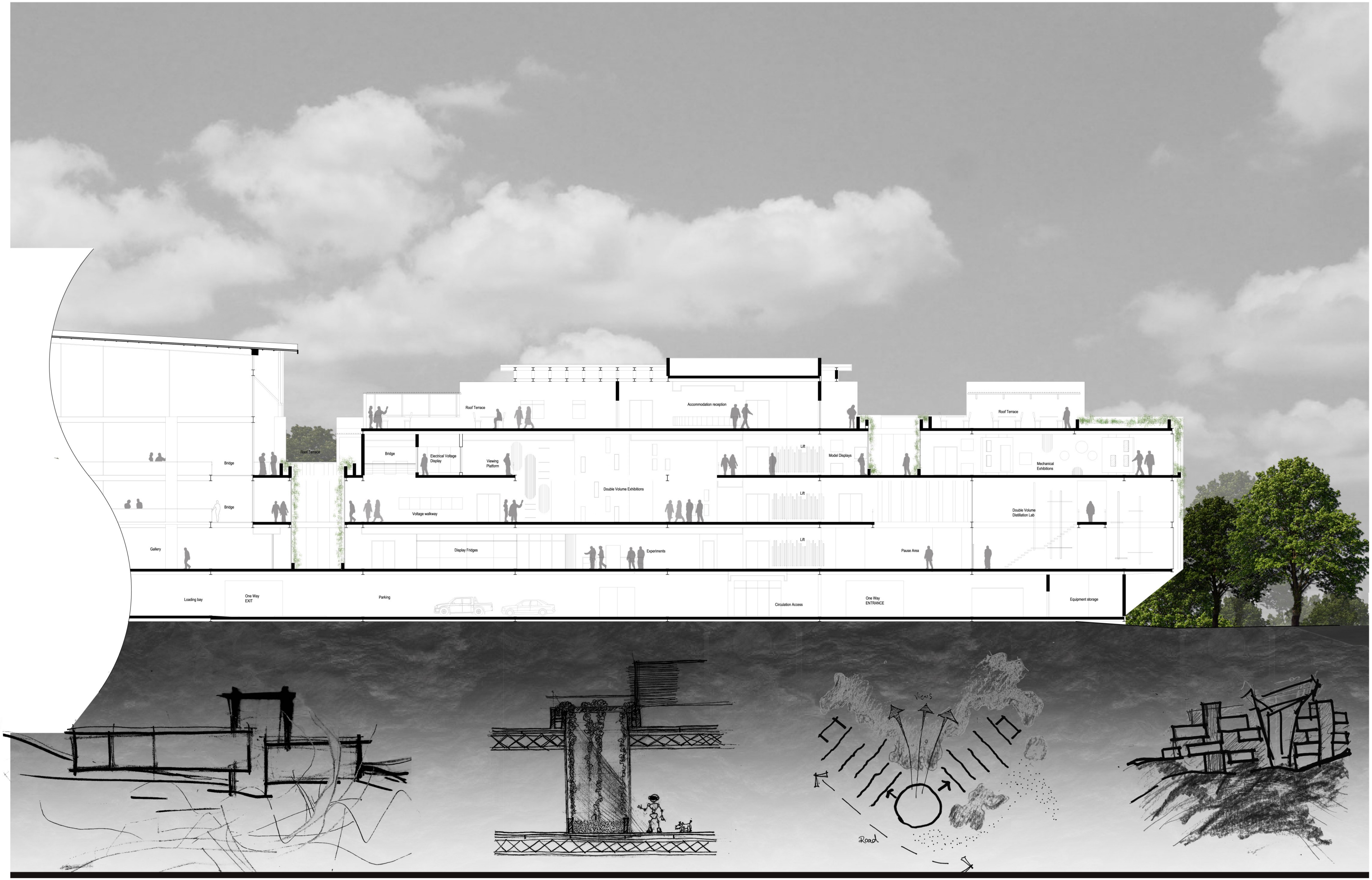
SOUTH EAST ELEVATION 1:200

Science Research Centre



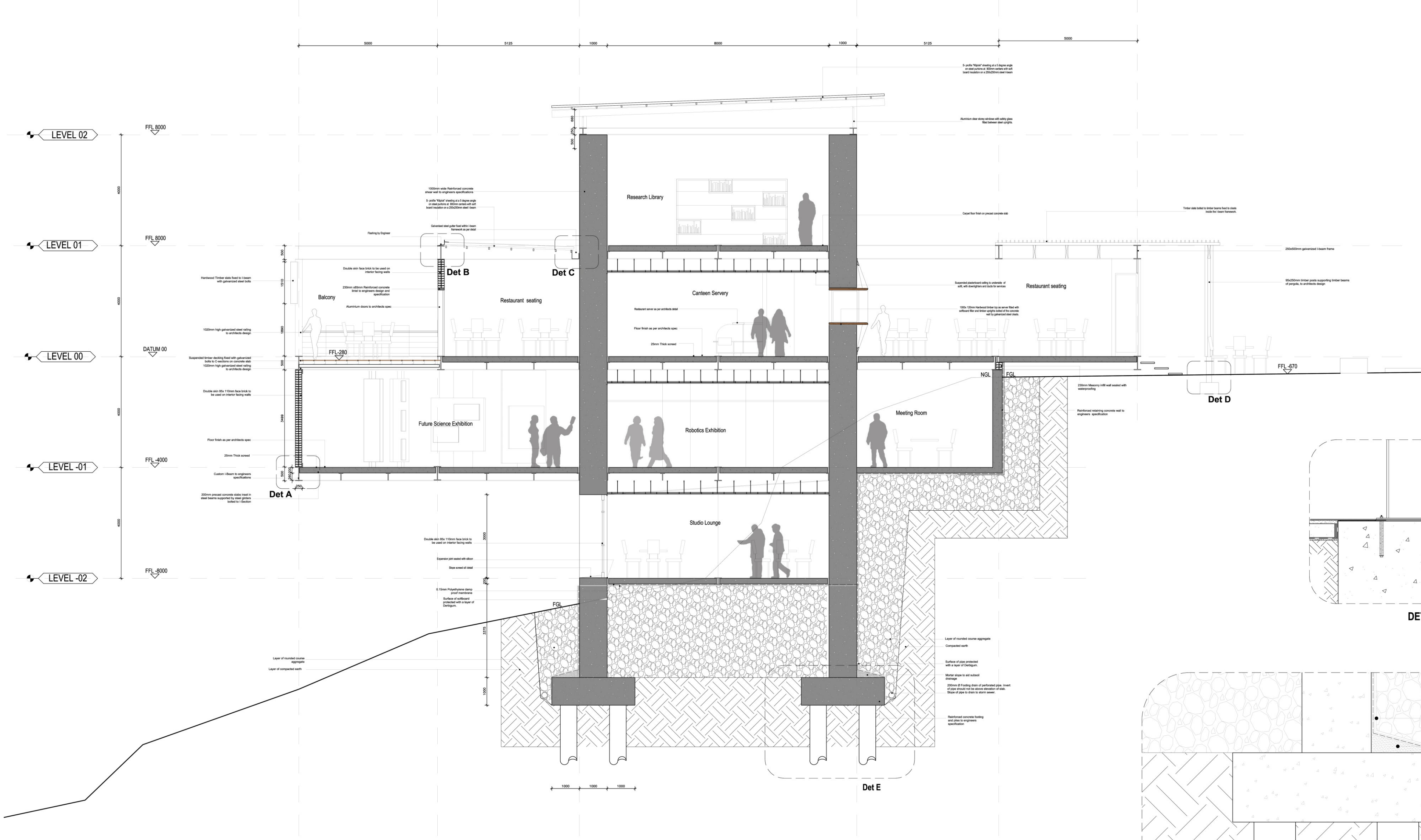
SECTION A 1:100

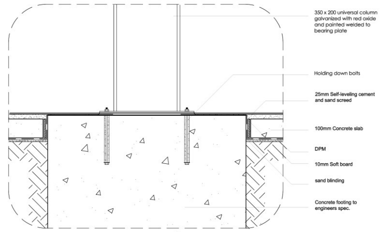
Science Research Centre



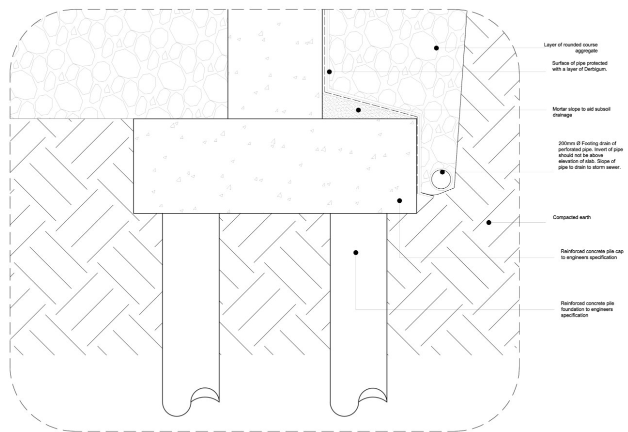
SECTION B_SCALE 1:100

Science Research Centre

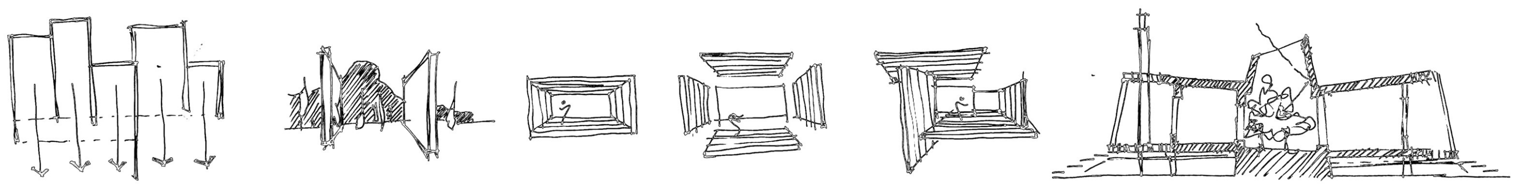


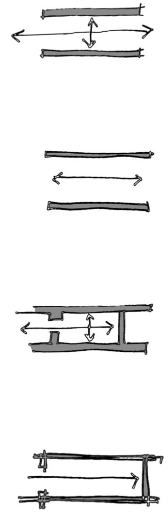


DET D Scale 1:10



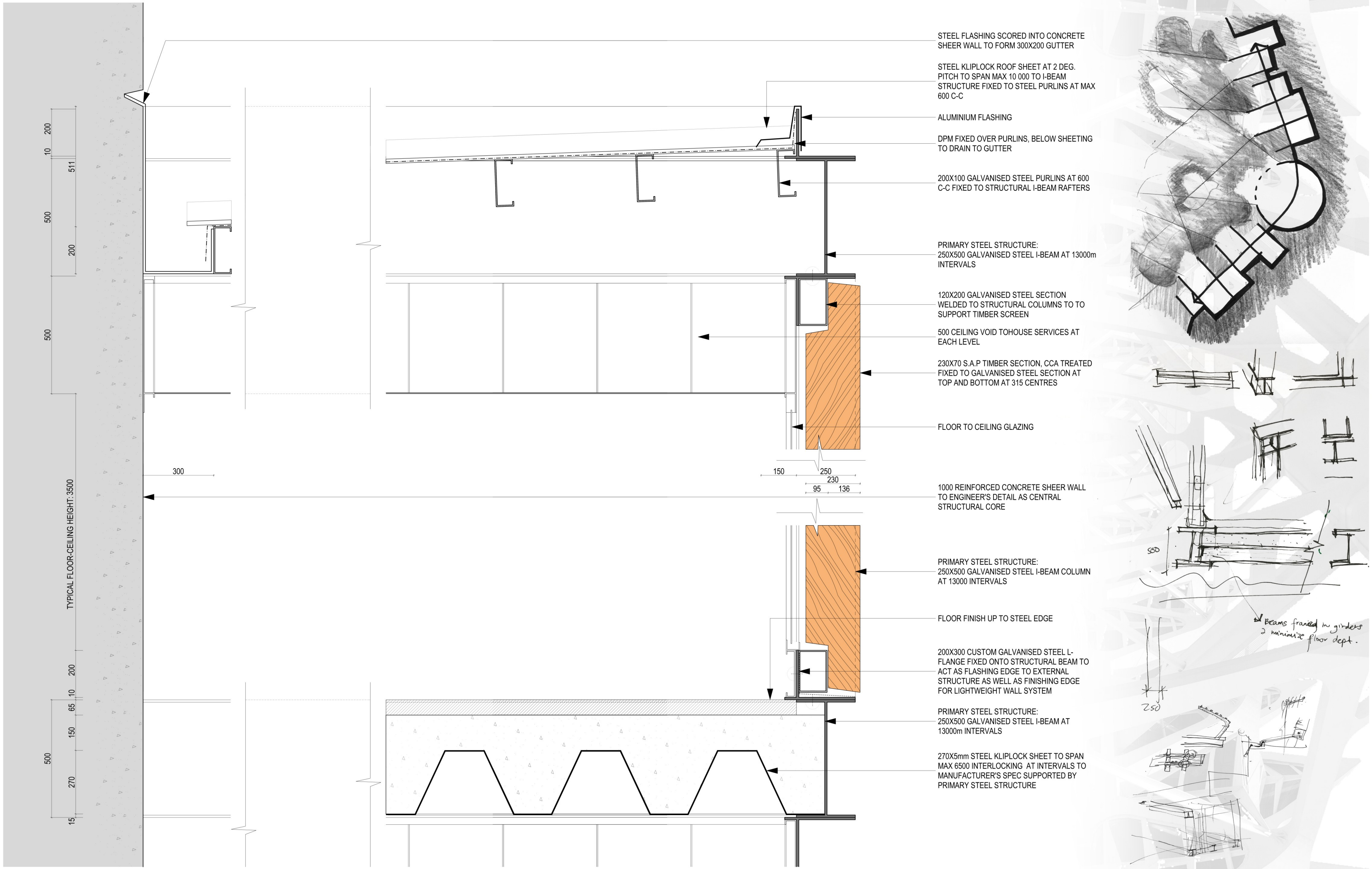
Det E Scale 1:25





SECTION C_SCALE 1:50

Science Research Centre



TYPICAL POD DETAIL 1:5

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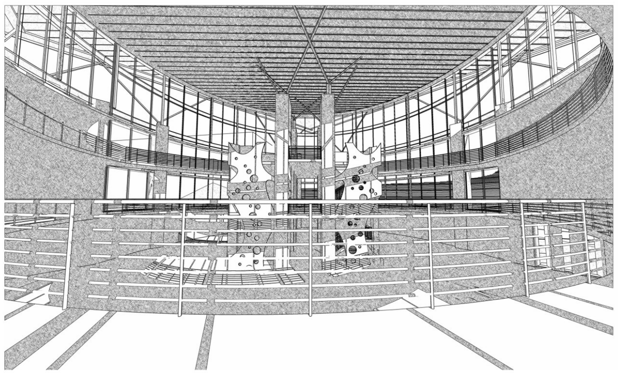
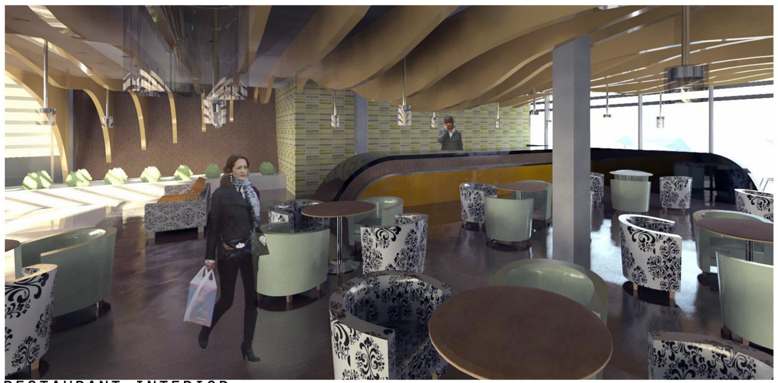


ATRIUM AS AN EXPERIENTIAL SPACE



RESTAURANT INTERIOR

ARTIST IMPRESSIONS

Science Research Centre

ARTIST IMPRESSIONS

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