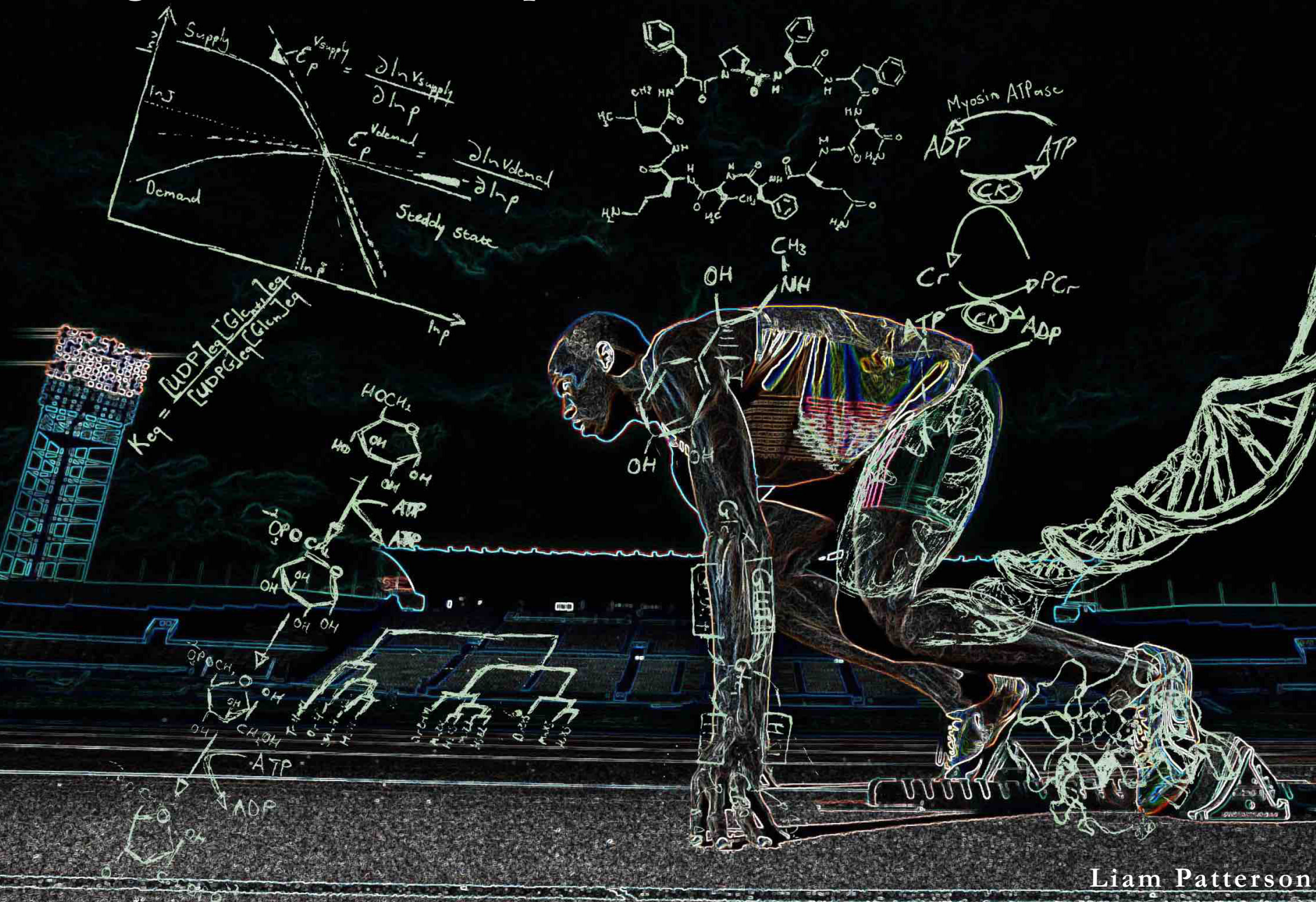


Mechanical Fluidity

High Performance Sports Academic Research Centre



Declaration

I, Liam Patterson (student number - 459671) am a student registered for the course ARPL 7003 in the year 2017. I hereby declare the following:

I am aware that plagiarism is wrong. I confirm that the work submitted for assessment for the above course is my own unaided work except where I have stated explicitly otherwise. I have followed the required conventions in referencing thoughts, ideas, and visual materials of others. I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my unaided work or that I have failed to acknowledge the source of the ideas or words in my own work.

Liam Patterson

09 October 2017

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To Ludwig Hansen. Thank you for your weekly guidance and wisdom. Your supervision was a richly rewarding experience.

To my peers, who always were a source of motivation and support.

To my friends, who are waiting to catch up on all the drinks I've missed over the course of the year. Looking forward to catching them up. ;)

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Glossary

Actin - a protein which forms (together with myosin) the contractile filaments of muscle cells, and is also involved in motion in other types of cell.

Anatomical - relating to bodily structure.

Biomimicry - the design and production of materials, structures, and systems that are modeled on biological entities and processes.

Eddy - a circular movement of water causing a small whirlpool

Hydrodynamic - the branch of science concerned with forces acting on or exerted by fluids (especially liquids).

Osteon - A central canal and the concentric osseous lamellae encircling it, occurring in compact bone. Also called haversian system.

Myosin - a fibrous protein which forms (together with actin) the contractile filaments of muscle cells and is also involved in motion in other types of cell.

Polyurethane - a synthetic resin in which the polymer units are linked by urethane groups, used chiefly as constituents of paints, varnishes, adhesives, and foams.

Retarding - delay or hold back in terms of progress or development.

moving object, or process from its regular or normal state or path, caused by an outside influence.

Trabeculae - each of a series or group of partitions formed by bands or columns of connective tissue, especially a plate of the calcareous tissue forming cancellous bone.

Transducer - a device that converts variations in a physical quantity, such as pressure or brightness, into an electrical signal, or vice versa

Perturbation - a deviation of a system,

Abstract

The Wits High Performance Academic Sports Research Centre will be located on Wits educational campus Johannesburg. Its aims are to act as a centre for teaching, learning, research development as well as giving back to the community.

The centre will host a variety of users including students, staff, lectures, researchers local and international as well as high performance athletes. Doctors and patients from the Nelson Mandela children's hospital will also have access to some of the facilities and equipment to help with medical treatment.

The Sydney Brenner research institute and the Wits Sports clinic who have their facilities next to the site will also interact and have a symbiotic relationship with the Performance centre sharing their knowledge and expertise. As their expertise lie in the human body and cellular research and would be a small adaptation to researching sports research still focusing on a cellular level, however now looking at factors that could affect sports performance.

The aim is for the centre to be internationally recognized putting Wits in the spotlight of the sports research. This combination and in depth facility in sports research does not exist as one entity in any facility across the world. There are universities in the states

which are starting to make the connection between scientific sports research and performance. This centre will be purely a research and assessment centre and will not be a training centre, Its concept is to have athletes coming in from all over the world, stay for two weeks and take the knowledge they acquired and apply it to their training in their home city.

The centre will host international exhibitions and conferences on sports research. Income from these events will help offset operating costs and alleviate pressure from the funding sponsors. Along with these functions the centre will house permanent staff who do testing assessments on athletes as well as house a Restaurant and accommodation for traveling athletes and researchers which will provide a more constant flow of income. The centre will be heavily teaching based with lectures taking place within the centre as well as students being actively involved as the centre is part of Wits University.

It is important to understand that the Centre is not a training facility for athletes. Athletes are examined on multiple levels over the course of a few days. Their results are analysed and recommendations are made to how they can increase their performance.

The public will have access to the Performance Centre and it is designed in a way that the public can view the athletes being assessed without invading their privacy.

It is important to understand the diverse uses of this centre along with all who shall use it.

Diverse user list

- Doctors and therapists
- Researchers
- Patients/children
- Athletes
- Academic Staff
- Admin staff
- Students
- Foreign visitors and athletes
- The Public

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Chapter 1

Transitional Space

Understanding the theory and design motives of architectural space

Structure

Introduction- Introduce the idea of connecting spaces

Timeless Architecture -Creating architecture that is still relevant many years on

Procedural and substantive theory - Types of design processes.

Fundamental layout patterns - Fixed-feature space, semi-fixed-feature space and informal space.

Transitional space between functions - Dealing with the space between functions

Ability and disability - Disability and afterthought.

Public and Private - Public and private interaction.

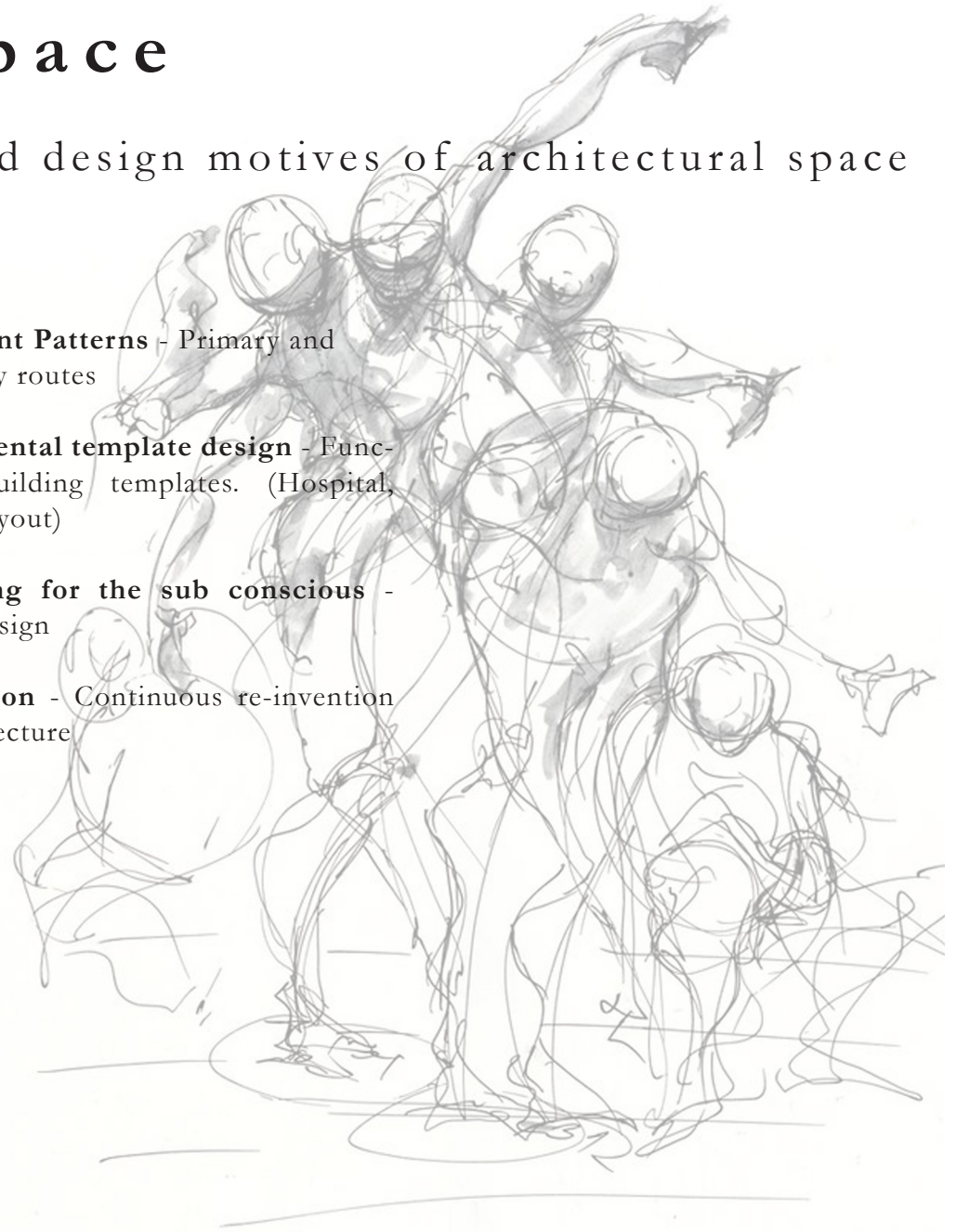
Balance - Balance within design

Movement Patterns - Primary and secondary routes

Fundamental template design - Functional building templates. (Hospital, church layout)

Designing for the sub conscious - Subtle design

Conclusion - Continuous re-invention of architecture



Introduction

New buildings are designed and built all the time. They are driven by aesthetics, needs and functions. Buildings are mostly designed independently but how often are the connections between different buildings considered, be it separate or overlapping functions? Although these spaces are often on the edges of the building they may be overlooked or have a low importance value. The spaces between buildings are not seen to have the same value or opportunity to spaces on a public edge. These spaces are sometimes lost opportunity as it can serve many functions. The space can be green urban space offering relief from the building structure as well as an open transitional space. In order to understand the edge space we must understand the manipulative grip architecture has on us and us on it. The purpose of the space should be defined, does it act as a barrier separating spaces or a node joining spaces? Spaces can be a bridge joining or continuing the space as a result from an extension, or to architecturally link old spaces with new spaces as we develop. The space is an interaction area and will set the mood of the people within it, even if just passing by. Architecture may be seen as physical forms yet it affects us on so many different intellectual and emotional levels. In order to understand the edge space we must understand the manipulative grip architecture has on us and us on it.

Timeless Architecture

The human population lives constantly adapting ourselves to change (Lang, 1987). We can look at the effect the mobile phone has had over the years and how it constantly evolves with society, right there ready for the next step. "If we stagnate, we perish. But if we create for the future out of the present we have made the necessary adjustment, have changed our environment and have a new viewpoint of life." (Fry 1961) Designers are also looking to evolve and develop architecture for the future. This can lead to problematic architecture being described as "wicked". (Rittel 1971) Wicked is when the nature of the future is seldom defined and therefore we run the risk of designing unsuccessful architecture. This is more prominent in some fields of architecture than others such as environmental design.

As architects we are encouraged to take design risks, when we do get it right and produce world renowned pieces of architecture as when we take risk it generally means pushing the boundaries of architecture in one form or another. We cannot play it safe as it is impossible to test all solutions nor is there a golden formula for design. Thus architecture is subjective to a large degree, it is highly unlikely that you will satisfy everybody with a

complex building or open space design. We cannot attend to all requirements of a building equally as well, hence there will always be a portion of unhappy users. (Lang, 1987)

When dealing with a design proposal, especially linked space and building edges, one must understand the current use of the space in order to design the new space successfully. We understand the architecture from two main points of theory, procedural theory and substantive theory. (Lang, 1987)

Lang understands architecture is a push and pull relationship between parties. It is a balancing act to keep all sides happy. The reality is this can be very difficult at times especially when one area is really trying to push their idea on the architectural space to promote their side. The importance of what Lang has said is to make sure we do consider how architecture affects all parties and not just the primary benefactor or client.

Procedural and substantive theory

Procedural theory is the knowledge about process of analysis, creation and evaluation. This includes all your design strategies and methodology that are common practice in architecture. This is where architects look at the use of space and with that knowledge design the altered or new space to best fit their intention. Architects do look at typical mapping and site analysis of the space, looking at how the space is currently used, by who is used by as well as its connection to the site and surroundings. All this logging of pre design information helps the architect design more successful spaces and lowers the risk of designing bad space when designing for the future. Often two key elements of procedural theory are forgotten or not taken too seriously in design, especially at connection nodes is interview and observation. Although these are basic ways of acquiring information they can be incredibly insightful. Questions to the users such as how does the space currently work for you? What do you use the space for? How much time do you spend in the space?

Basic questions can help you identify the current state of success of the space as well as its needs going forward in design. Observation is another method of obtaining information but allows you understand it from an unobtrusive perspective where you can observe

movement patterns, volume flow and other factors with the user being unaware and your results natural.

A test was done on queuing behavior with different layouts of the ropes for the queues.

Although the researchers were able to identify which layouts caused more aggression and irritation of people in the queues and which configurations were better for them to remain calm. (Patterson 1974) (Lang, 1987)

Substantive theory is explanations and descriptions of the physical nature of the built environment. It is looking at the buildings material and structure and how these are integrated into the design.

One of the most important factors of treating linking spaces is evaluating the present environment. One can identify the existing facilities and decide to use them or alter them in a way that the existing facilities meet the new design requirements. The manner in which activities are carried out could also be changed to ensure the existing facilities meet there needs. Designs are sometimes successful spaces on paper but not successful in real life. It may not always be obvious to people how a space should be used.

If the present environment does not have the characteristics that will cater for the behavioural program and/or aesthetic value of the user, then one of the following must be done to rectify the problem. Either the intended function of the space must be addressed and changed to fit within the space at hand, or one must specify how the physical built environment should be altered to fit the spaces function.

Fundamental layout patterns

According to Edward T. Hall from Lang's *Creating Architectural Theory* (Lang, 1987) there are three fundamental types of layout patterns, fixed-feature space, semi-fixed-feature space and informal space. Fixed feature space is your heavy space that is not easily altered such as walls, floors, windows and fittings. Semi-fixed items would be furniture that can be moved around. In some traditional Japanese homes and new modular homes the walls are movable to create alternate spaces for different functions. This trend is mostly is small confined spaces where one cannot have separate rooms but is instead able to adapt a room and transform it into another to meet the desired function. These ideas of formalized space can be tested in transitional and connective spaces where its function continually change to make the spaces successful. The spaces that can be easily changed to allow for different activities is known as flexibility. Adaptability is when the existing space serves more than one function. This is more important for large buildings such as stadiums as the running cost of these stadiums can be quite high and sometimes normal scheduled sporting events do not meet the financial requirements. Stadiums are then used for other functions such as concerts and public speeches to generate more income to pay for the cost of the stadium. It is also seen as an opportunity for concerts and gather-

ings as the infrastructure is already in place and can be executed easily and be more cost effective. On a smaller scale the main restrictions to adaptability is the location of fixed features such as windows and doors as these cannot be moved.

On a greater scale when designers design for the future the same principles apply as to designing small additions, based on prediction, explanation and organization forming a fairly homogeneous model. (Choi & Trotter, 2008) Cities are designed with an organizational clarity, categorized by function as well as movement. Buildings are designed in the same regard and room spaces within buildings should be seen under the same principles just within a smaller environment. These different scales of design can be seen as a set of Russian nesting dolls as they all fit into one another and follow the same design principle. As movement within a city complex is considered linking block to block, the internal spaces are the same as movement patterns within them link the spaces to one another.

Transitional space between functions

Although these design principles are put in place the one aspect that the designer has the least control over is the end user. Often in connective or transitional spaces there are user conflicts, especially when the transitional

space is between two different functions. The issues are around favoritism to one program compared to the other within the space or lack of attention to user needs or occasionally more social problems such as unwelcome people in the space, such as drug users and homeless people. Conflict can be seen as a positive in some instances such as diverse groups competing for open space as it creates necessary tensions between freedom and control. (Carr & Francis, 1992) User conflicts, according to studies, are most likely a result of lack of concern for context regarding the users and how context effects their program as well as public access and privatization. (Chidister 1986)

The type of user may differ in the spaces and thus conflict arises as it is nearly impossible to design for all user types. An example of type contrasts are old and young, different ethnic groups as well as people in different economic tiers. Studies by investigated by Francis have shown that women require more specialized needs in spaces, typically open spaces as they tend to require a greater sense of comfort and security. Women tend to also not like spaces that may seem uninviting as they fear safety is a threat. (Francis, 2003)

Ability and disability

Ability and disability access is always an issue in all aspects of architecture. Although by law there is disabled access, but often it is obvious it was an afterthought. The access does not fit into the overall design smoothly, with long roundabout routes for the disabled. The minimum requirements by law are met, but the design may not meet the need requirement of the disabled user. Ironically the result of this is segregation instead of inclusion. (Francis, 2003) This is an aspect where in my design I have catered for three different user groups with some overlaps. It is important that I do not favour one in my design and the others are seemingly squished in. My building is essentially three buildings in one, however it is important to see the building as one with these different spaces linked in a logical non biased manner.

Public and Private

Public and private space cause major conflict surrounding the argument if spaces should be private or public, mainly referring to your outside and connection spaces. Public support for creating open public spaces is on the decrease, whereas there is an increase in the private sector creating open spaces, but limiting the space to its users only as they wish to keep control of the space and monitor risks of vandalization and safety. If the open space is next to a building on a public

street is it right to privatize the open space to just the users of the building? The overall context of the buildings location along with the demographic of people using the space should be considered. Building edges in the city should always remain public especially if there in some greenery as it is a break from the concrete jungle we live in and shall be appreciated by all.

Balance

Architects always face a dilemma of balance when it comes to any design space. Time and budget constraints are two fundamental reasons the user's needs are not fully addressed. Some architects are weak at community outreach to inspire and guide user visioning and participation. Architects can be very focused on just getting the job at hand done within schedule and on budget. Clients are mostly sensitive to the community and encourage architects to engage with them to better understand the project at hand as well as to include the community. Other clients need convincing that time spent engaging with the public and addressing their user needs can lead to a better functional design as well as can lower the cost by saving money later on in the project. (Francis, 2003)

Professional architects such as Randy Hes-

ter, Tom Fox and Susan Goltsman (Francis, 2003) have done studies and proven that though it may take extra time to address the user's needs and conflicts early in the design process, it will save money later on in the project by avoiding project delays and minimizing the risk of redesign further along into the project. It is therefore highly important the client and architect has a strong understanding profession relationship. Especially with complicated projects where problems are sure to arise throughout the build. This professional understanding will help maintain a smooth build as well as keep all parties happy and promote a successful project.

Movement Patterns

An important aspect from a design perspective is movement patterns. Patterns represent and determine the main traffic flow, volumes as well as how buildings connect to one another functionally and to all parts of the site. Simplify the form to have an understanding of the movement and its consequences. Movement patterns are not always seen as basic elements of design composition or made of shapes which is the norm for a building and its parts. In master planning the pattern is the key feature created by the use of shapes and forms, it can also be the main driver of the design. Plans are concerned with transition spaces, connection spaces, and the relationship between spaces, movement flow and the manner in which these are ordered to in regards to the pattern. (Billings, 1993)

Larger plans result in simplified dominant patterns as only the main important routes are shown with all the smaller corridors just connecting into the main simple pattern. It is the same concept as main roads and side streets. The design principle is to design the main simple route leading to the important program parts. The smaller routes are designed in later on in the design process. The designer should understand the pattern and have an understanding of the implications of the use of any pattern in terms of the way it can be related to the building forms

and shapes as well as it's ability to cope with change within all parts of the building, including edges and external connection points to its surroundings.

The image below shows different movement patterns in cities around the world. Notice when one zooms out a pattern will start to

emerge with some cities more noticeable than others. As the city sprawls the pattern is extended along the edges allowing the pattern to grow and the city cover a larger footprint.

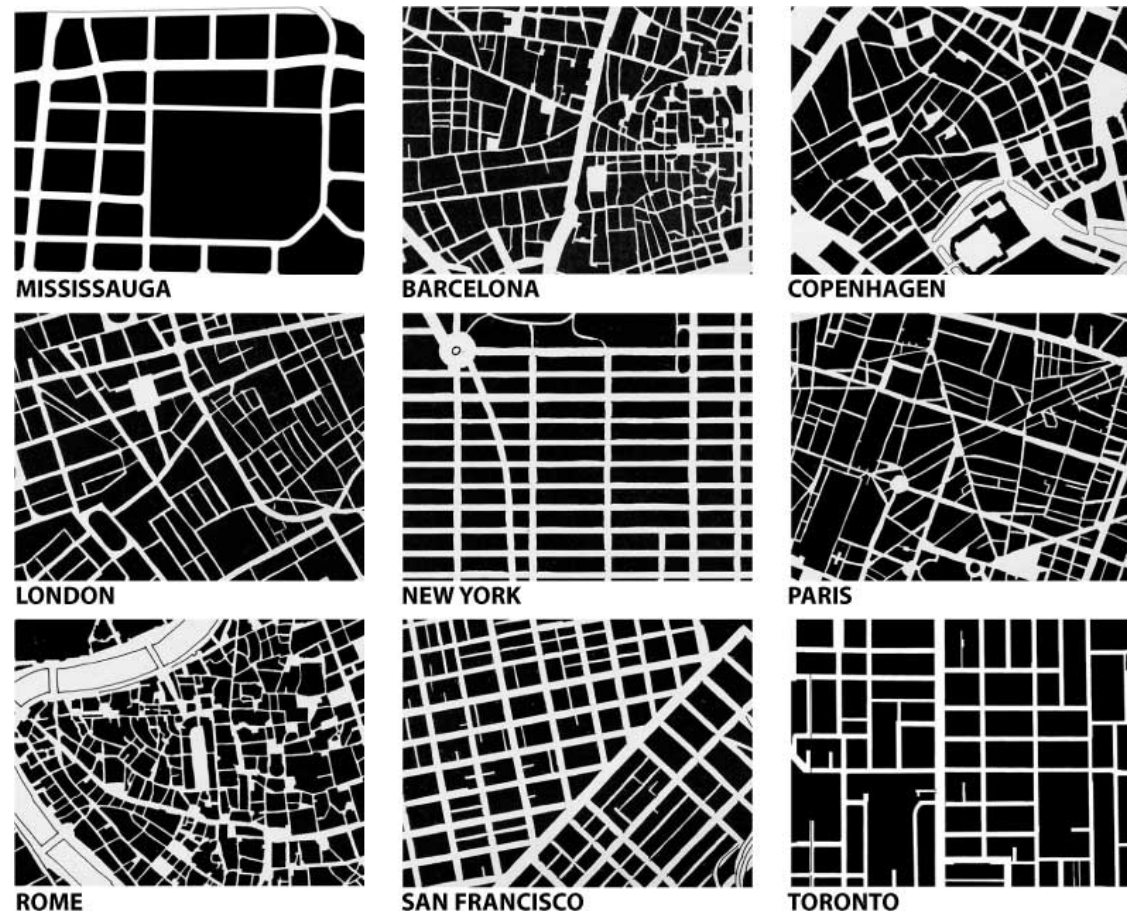


Fig 1.1- City planning

Fundamental template design

Building types can have templates of a movement pattern design. As religious structures or Christian church buildings can have a cross shape and have a central space at its centre. This design form is based on a cruciform.

Most Christian Churches conform to this generic layout. It has become a religious symbol throughout the ages and is designed around the service practices of a church service.

Legend

1. Narthex.
2. Façade towers.
3. Nave.
4. Aisles.
5. Transept.
6. Crossing.
7. Altar.
8. Apse.
9. Ambulatory.
10. Radiating chapels.

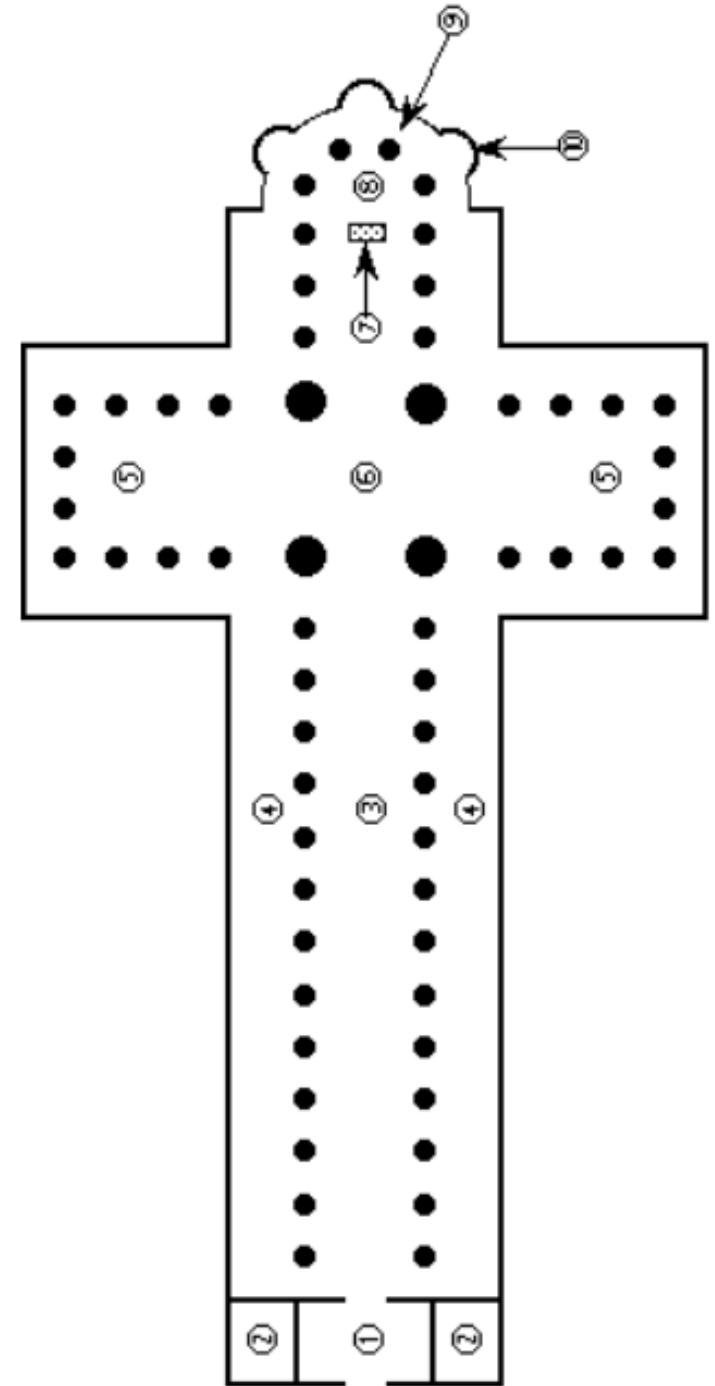


Fig 1.2- Christian Church

Hospital and large institutional buildings generally employ a design movement shape of two main parallel or perpendicular movement patterns. As shown in the adjacent figure. As the corridors move away from each other they require recognition of the need to provide a way of connecting each to the same common functions. This is done by adding return routes (secondary routes) and courtyards. As these main corridors grow if extended, more returns are added to allow for this extension, allowing the building to expand with need.

A maximum expansion can be determined by understanding the ultimate design of the hospital and understanding all factors such as available doctors and number of patients in the surrounding area as well as the buildings proximity to other surrounding hospitals. Site also determines the buildings movement pattern as site entries and exits have to be considered. One also needs to understand the surrounding environment of the site and how we interact and/if we connect to them. The site will determine ideal private and public entry points.

The plan of the hospital clearly shows a repetitive design pattern with the option to continue extending the hospital.

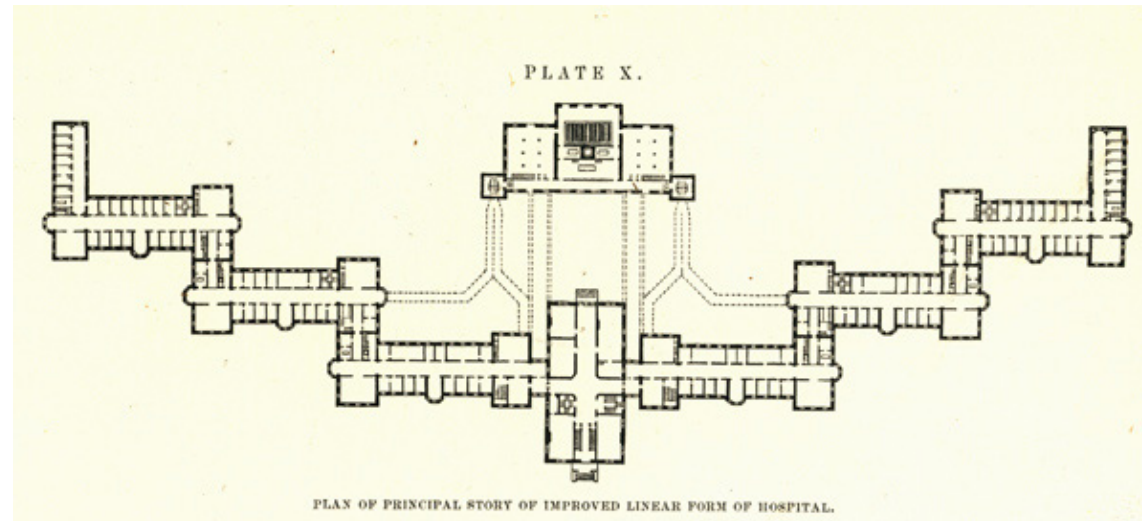


Fig 1.3- Hospital layout

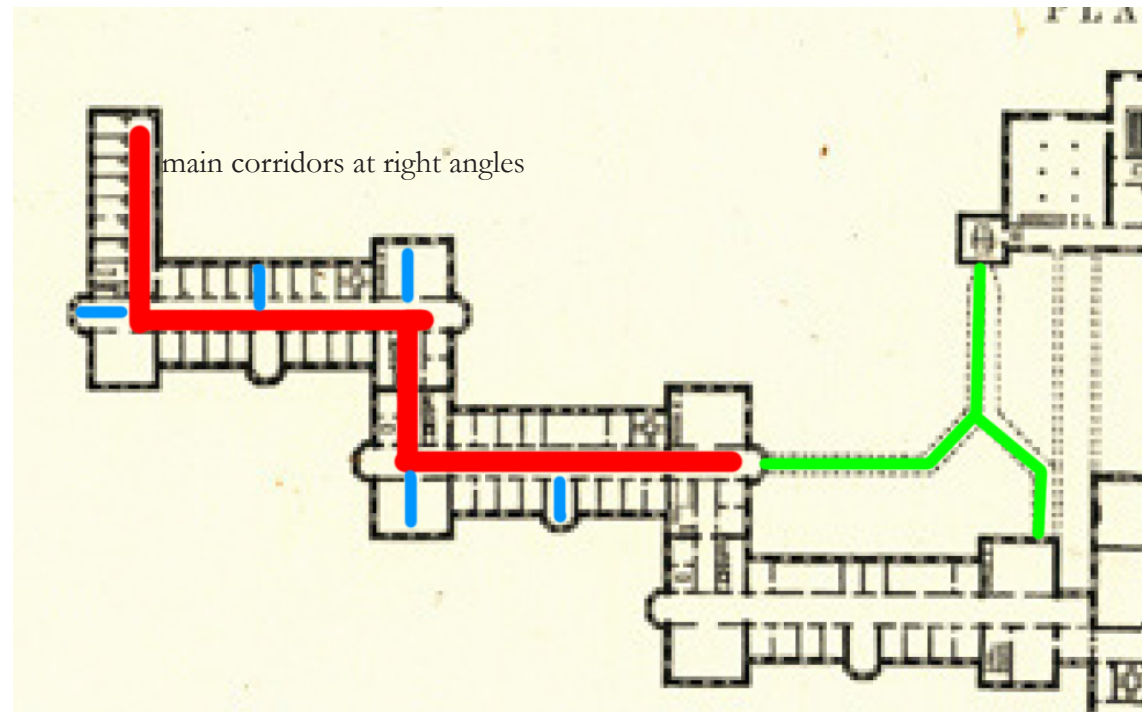


Fig 1.3- Hospital layout movement pattern

Designing for the sub conscious Conclusion

The analysis of space has led to new theorizations of the similarity and interaction of different levels of interaction and experience. (Crysler, 2003) Space is designed in a way to portray rules and instructions to our subconscious. Architects need to design spaces in a language that the general user who is not an architect or designer can understand. This is done successfully when the user does not question the space with any uncertainty as the spaces function and program comes naturally to the user.

The user will also feel safe in this space as the moment there is any doubt by the user they will begin to question the space. Designers use precedent studies as a base to work on their designs but are open minded and are subject to continual change in their assumptions, languages, methodologies object of analysis and users. (Crysler, 2003) With each individual project there will be holes or opportunities which stem from the site or other unique characteristics of the project at hand. New ideas will continue to arise in architecture due to the creative profession it is as well as advancement in other fields such as technology and the shifts in need of the user.

In architecture, change is the only constant. Architecture and design will never be a straight forward process. The amount of factors known and unknown as well as the continual shift in user need and advances in technologies. Architecture has for centuries and will for centuries to come remain creative and boundary pushing. Adaptability is architecture's biggest strength and weakness, we will always adapt to change but some trials and experimentation of new designs will not be successful. Individual spaces will always be reinvented on how they should be designed depending on the users need at the time or the estimated user needs and requirements of the future. According to Billings change can be viewed as an environmental adaption, as the cycle of genesis and decay, as a description of change in society, and as a social evolution. (Billings, 1993)

Adaptability is even more important at this moment in time with the current economic state. New buildings can be too costly to be built. Older buildings which are adaptable are the better solution. Adaptability is becoming more and more important with architects as they design today. A building may be built today but its function may change in the future, a building which can adapt to that change will remain and become successful. The same principle applied to spaces within and around a building. Although adaptability is the key, due to individual personalities and users of space one will never be able to please everyone in its space all the time. That is the beauty of architecture, the reason architecture and space will continue to be redefined and tweaked is because architecture will develop with the human race as we developed and change needs and functions over time.

Chapter 2

Bio Mechanics In Sport

Skeletal muscle system, resistive and propulsive forces

Structure

Introduction - Introducing why I have researched skeletal muscles.

Mechanical Properties And Performance In Skeletal Muscles - Understanding the link between skeletal muscles and mechanical forces.

Five Basic Muscle Mechanical Considerations

The Force- Velocity Relationship - maximum force occurs at a low velocity

The Force-Length Relationship - Understanding cross bridges in a sarcomere (the inner workings of a muscle)

The Power- Velocity Relationship - An insight in gear ratio's

The Endurance Time-Stress Relationship - Decrease in muscle performance due to fatigue

Selected History-Dependant Properties - Previous theories and the role of stretching in muscle performance



Introduction

As my thesis design project is a high performance academic sports research facility, there needs to be an understanding of what research and testing occurs. I have chosen to research skeletal muscle systems to give the reader an understanding of the research and science behind the human body.

The muscle system is explained in a basic manner to give a non medical reader an understanding. In this chapter we highlight the complexities and inner working of muscles. It shows how, like in architecture the mechanics and success of the muscles begins from a cellular level. There are calculations which reveal how to get the best performance out of a muscle depending on the type of performance requirement. We can relate this medical understanding of muscle research to the architectural field. We as architects do not just draw building plans. We begin by doing research on the required functions and performance requirements of the building. Applying this knowledge leads to a better functioning and more successful building.

Mechanical Properties And Performance In Skeletal Muscles

The mechanical properties of skeletal mus-

cle determine its performance. Skeletal muscle properties can be measured through the use of mechanics, force, length, velocity, work and power (W.Herzog). This implies that the human body is a machine and in order to function at peak performance all these aspects need to work together in the right ratios. Power can produce speed but many muscles move during a physical action pivoting at joints. As joints are crossed by many muscles an athlete's performance depends on the property of many muscles and the coordination between one another. This can be compared to gears and the importance of gear ratios and alignment as if the gears are not in ratio or alignment, there will be increased friction and possibly buckling amongst the gears and therefore not functioning at optimum performance. Although in the human body coordination is an issue of motor control and not pure mechanics as our movements in sport are voluntary.

“Despite the well-accepted relationship between the mechanical properties of skeletal muscle and performance in many sports, there is a sparsity of muscle mechanics research in sports (W.Herzog). The practical application of physical training geared at improving performance through mechanical properties of muscles is rarely considered with an exception of strength training. The

following factors might be responsible.

- Mechanical properties of muscles are mostly non-linear, making mathematical calculations somewhat inaccurate.
- Currently it is almost impossible to determine the properties of individual in vivo and non-invasively.
- In vivo- (of processes) performed or taking place in a living organism.
- The time dependence of mechanical properties (e.g. increasing fatigue) are poorly understood.

Architectural link

We can identify that the success of muscles is influenced by many factors depending on the action required by the muscles. A successful building space has the same requirements. An example would be a hospital which would require wider passages to allow gurneys and wheelchairs along with people walking to all move through the space efficiently. If the passages are too narrow a patient on a gurney might not make it to an operating room in a timely manner if there is an emergency, which could result in death as it took too long to get to the operating room.

Five Basic Muscle Mechanical Considerations

The Force- Velocity Relationship

The force velocity relationship is the observation that contraction velocity and muscle force are inversely related. In shortening (concentric) muscle actions, where contraction velocity is high, muscle force must be low. Where muscle force is high, contraction velocity must be low. A simplified understanding is a weightlifter doing a bench press. He can do high velocity reps with a low weight but the force would be low as the energy required to move a light weight is low. Whereas a heavy weight being bench pressed will have a lower velocity but a much higher force.

The shape of the force velocity relationship graph depends on the muscles distribution of fiber types. There are slow-twitch muscle fibers and fast twitch muscle fibers. The force per sectional area is about the same when these fiber types are compared. The maximum speed of shortening differs by a factor of roughly 2. Therefore for a given speed of shortening, fast-twitch fibers can exert more force. This understanding explains why athletes with more fast-twitch fibers perform better in activities which require high speeds of movement combined with high force requirements such as sprinting and throwing.

$$F = \frac{F_o b - av}{b + v}$$

F -maximal force of a muscle at optimal length
 F_o -maximal isometric force at optimal length
 v -speed of shortening
 a and b are constants

(Fenn& Marsh 1935; Hill 1938)

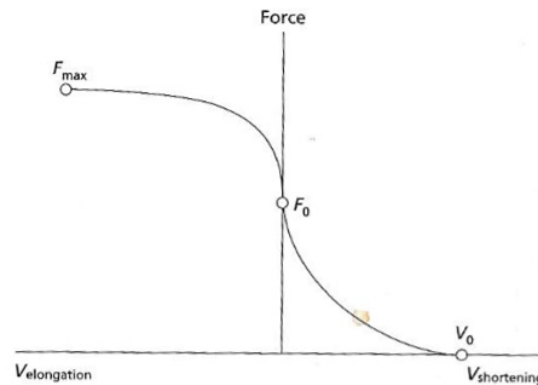


Fig 2.1- Schematic force-velocity relationship for shortening and lengthening muscle

Architectural link

We now understand there are fast and slow-twitch muscle fibers, which perform better at different tasks. We can relate these fibers to material properties in architecture. My outdoor gearing facade system needs gears which will last while being exposed to the elements, their movement will be slow and therefore not generate large amounts of heat due to friction. We look at the performance requirements and compare that to the material expectations and find the best material for the job.

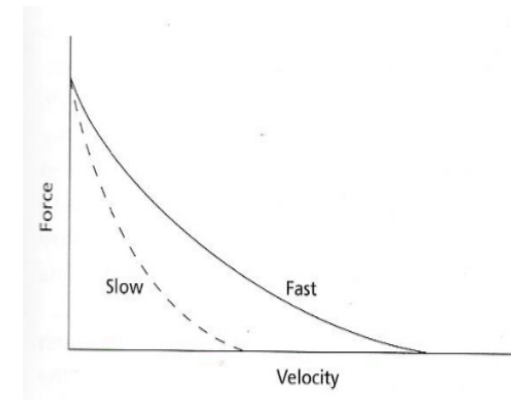


Fig 2.2- Force-velocity relationship for shortening contractions of a slow-twitch and a fast-twitch muscle fiber

The Force-Length Relationship

The force-length relationship of skeletal muscles relates the maximum force to length through understanding sarcomeres which make up muscles. Isometric tension, which is created in skeletal muscle is a function of the magnitude of overlap between actin and myosin filaments. The force generated by a muscle depends on the total number of cross-bridges attached (Gordon et al.1966).

A practical example of this is clenching your fist as hard as you can. First flex your wrist and try make a fist.

Now make a fist with your wrist in a neutral position.

Finally fully extend your wrist which lengthens the muscle and then make a fist.

You will find your strongest fist was when your wrist was in the neutral position where there were the most connections under tension.

The humans muscle systems the length of the muscle can be related to the angle or angles of the joint or joints the muscle is crossing. There is therefore an optimal angle or length for which muscle force will be at maximum. This knowledge of this length or angle is a huge factor in sports such as cycling as the geometry of the bike determines over which range the force-length relationship in your leg muscles work (Yoshihuku & Herzog 1990).

Whole muscle-tendon complex

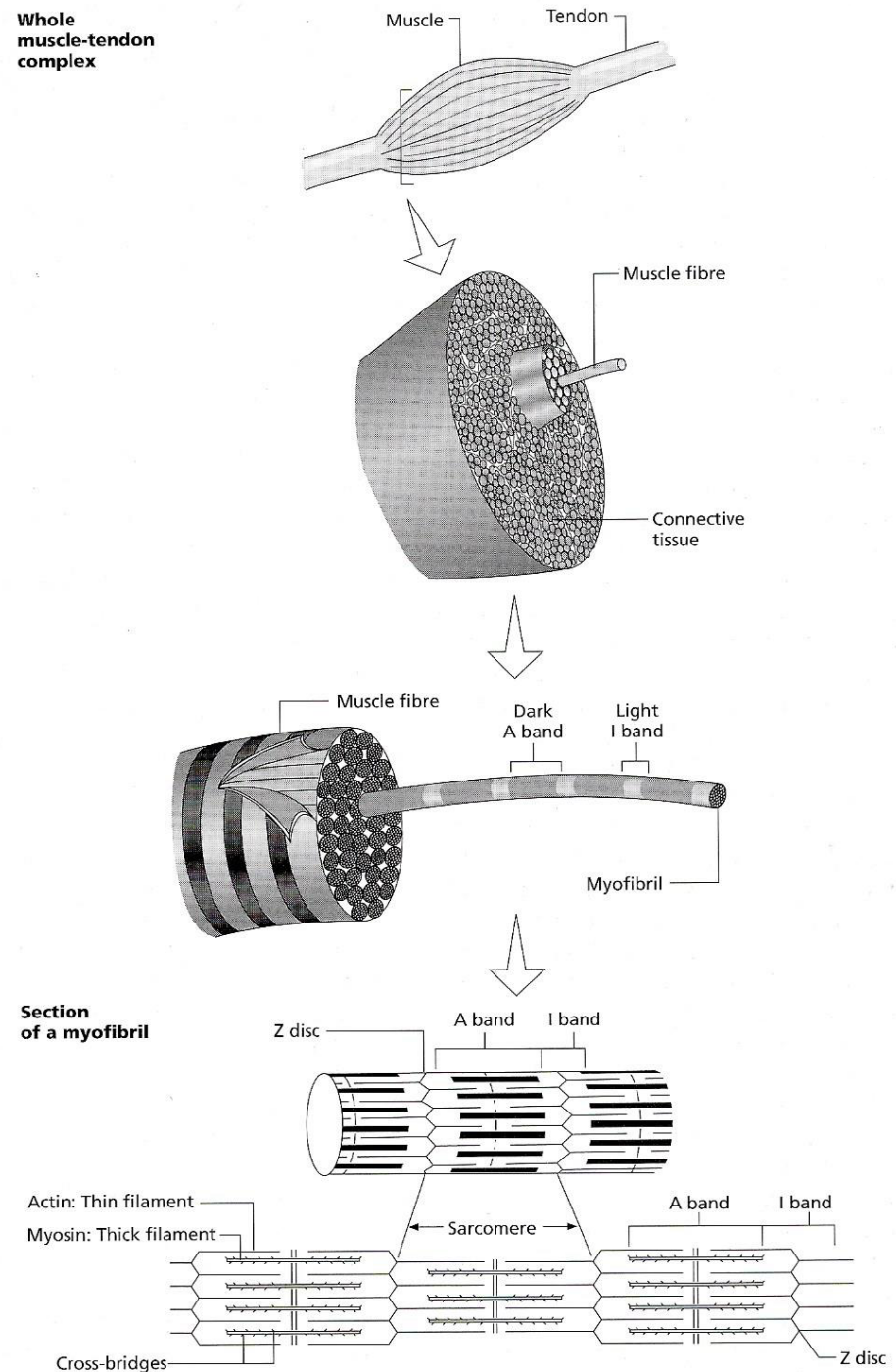


Fig 2.3- Organization of a skeletal muscle

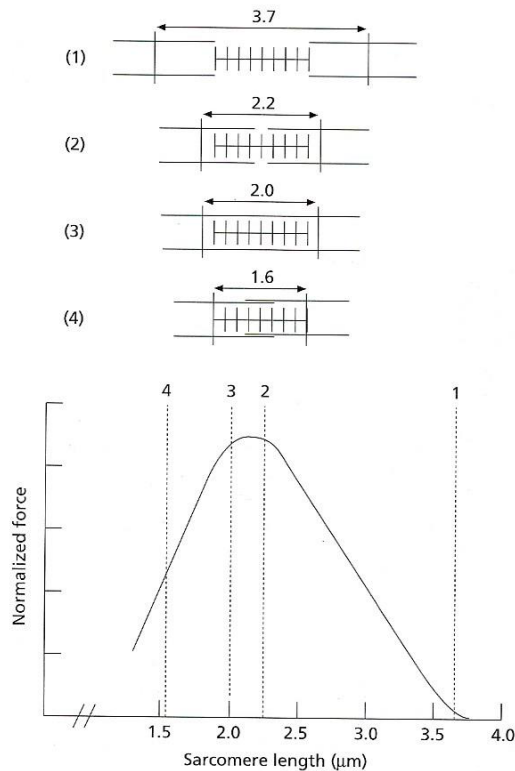


Fig 2.4- The isometric force-length properties of the sarcomere of frog skeletal muscle.

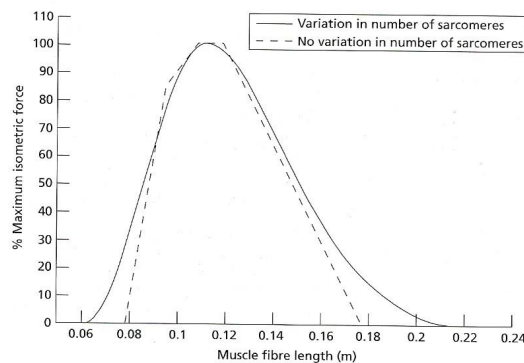


Fig 2.5- The isometric force-length properties of a muscle composed of 1000 myofibrils with a mean of 41 800 sarcomeres making up each myofibril and a standard deviation of 5300.(Meijer et al 1998)

Architectural link

We now have a basic understanding of how a muscle works and how to obtain its maximum force output. The force generated is dependent on the amount of cross-bridges in the sarcomere, which happens at a microscopic level. Yet its strength performance is evident at a human scale.

Successful spatial architectural building design follows the same principle. Here we can look at edge space leading into a public space such as an auditorium. A large auditorium requires multiple entry points with adequate space to allow for a timely entry and exit from the space for people. It also requires adequate toilet facilities to accommodate the large amount of people. The design of the air conditioning and ducting must be of a standard to accommodate the large numbers. If one of these aspects are not designed for, the space can come across as mildly successful. The room holds the large crowd, but entry and exit is slow, the room is hot and stuffy as the air conditioning system cannot handle the numbers.

It can then be said that a successful space is not surface deep but reliant on many smaller factors which work together to create a good quality space.

The Power- Velocity Relationship

The power- velocity relationship can be derived directly from the formula. $P=F.v$
Power output of a muscle reaches a peak at a speed of roughly 30% of the maximum speed of shortening (Lutz & Rome 1993).

In cycling, movement speed can be determined by the rider. If the rider were to ride at a constant speed of 45km/h he can use different gear ratios to travel at 45km/h. A lower gear would require a higher cadence and a higher gear would require less cadence but more power. It can therefore be deduced that the gear ratios cyclist use could be a decisive factor in the success of a cyclist.

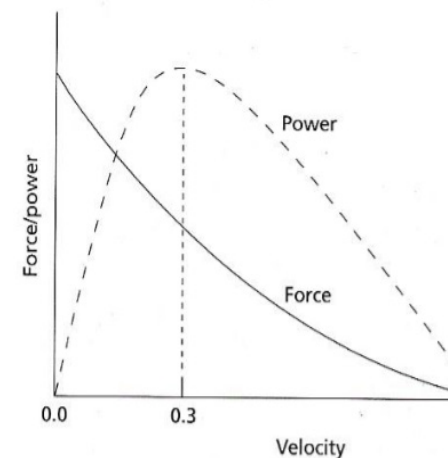


Fig 2.6- Force-velocity and corresponding power-velocity relationship for shortening muscle

The Endurance Time-Stress Relationship

This is where we look at the affect fatigue has on the skeletal muscle. Fatigue is when the muscle is no longer able to maintain a required force. Fatigue sets in faster when muscles exert greater forces. Maximal force can only be held for a few seconds. A small force can be maintained by a very long period of time by the muscle. (Fig 2.7)

Notice here that slow-twitch muscle fibers can maintain a constant amount of stress for a longer period of time compared to fast-twitch fibers. A conclusion can be made that athletes with predominately slow-twitch fibers will performs better in more endurance and lower force requirements sports such as long distance running. The fast-twitch athletes will be better at the high explosive energy, high intensity short time activities such as sprinting and weightlifting.

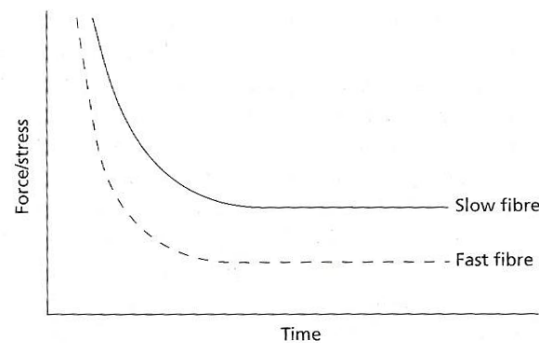


Fig 2.7- Schematic force/stress-time relationship for a fast-twitch and a slow-twitch fiber

Architectural link.

The objective of this research is to get a greater understanding of the science of measuring performance in athletes. Like a cyclist can choose and alter the gear ratio and remain at 45km/h, architects must also be adaptive in their designs. Spaces should be designed to be adaptive especially in this industry of hightec equipment with which the constant evolution of technology, machinery and research methods. A world class research facility will always be at the forefront of development within this research space. The architecture of the building should mimic the cutting edge research within the design of the building.

Understanding the human body at more than just a glance allowed me to really understand and appreciate the body, giving me a better understanding of the science and research that would happen within the building.

Selected History-Dependant Properties

History dependent properties of skeletal muscles refer to the ability to produce force and have for the majority been ignored in muscle mechanics even though they have been experimentally observed over the last 50 years (e.g. Abbott & Aubert 1952; Marechal & Plaghki 1979; Edman & Tsuchiya 1996; Herzog & Leonard 1997). These properties

are dynamic and differ from the static properties of muscles previously described.

Focusing on the force enhancement following muscle stretching and force depreciation following muscle shortening.

Force depreciation

This property has been accepted for many years (Abbott & Aubert 1952). The mechanism causing force depreciation is not understood (Marechal & Plaghki 1979; Herzog 1998). Currently to date there has only been one study on human skeletal muscles (Lee et al 1999).

Force enhancement

Refers to muscle strength increasing following muscle elongation (stretching). This has only been observed artificially on non-human muscles (Abbott & Aubert 1952; Edman & Tsuchiya 1996). Even though there is no study on human muscles many athletes believes stretching prior to an action is beneficial and adds strength to the muscle.

Chapter 3

Dynamics of Swimming, Biokinetics, Human Factor Engineering

An investigation of resistive and propulsive forces in swimming. Understanding Biokinetics and Human Factor engineering

Structure

Introduction - Introduction to dynamics of swimming

Resistive forces - Pressure forces, friction forces

The Forces At Play - Air resistance, friction, pressure forces

Passive resistance - Forces when gliding in water

Decreasing Frictional Resistance - Methods to decrease boundary layer

Pressure Resistance (Head On Resistance) - Streamline forces

Angle Of Attack - Optimal angle of applied force

Measuring Methods

The MAD System - Measures propulsion in freestyle

Velocity Perturbation Method - Measure drag in all strokes

Propulsive Forces In Swimming - Maximize the pulling power of swimmers

Biokinetics in sport
What is biokinetics

Human-factor engineering and ergonomics
HFE explained

Velocity Perturbation Method Recap with HFE

Linking swimming testing methods with human factor engineering

Introduction

In this chapter we will look at the dynamics of swimming. The focus will be on forces, both resistive and propulsive. It will incorporate knowledge of the muscular system and will be integrated into the understanding of the swimming dynamics. The chapter will give us an understanding on how to improve swimmers technique by analyzing the forces, angles and streamlining of a swimmers stroke from a scientific mathematical view.

Methods of measuring drag and forces will also be investigated. This is important as there is an assessment pool within my building and understanding the systems to be put in place will be required to design into building.

Resistive Forces

When a swimmer moves through water he/she will have a retarding force known as resistance or drag. There are two force types applied on swimmers.

- Pressure forces; Perpendicular to frontal area.
- Friction forces; Act along the body surface.

Hydrodynamic resistance (HDR) may be divided into two categories.

1. *Passive Resistance*; resistance experienced when a swimmer glides in the water.
2. *Active Resistance*; experienced by a swimmer during swimming. (Incorporates passive resistance) (Clarys 1978; Kolmogorov & Duplisheva 1992).

The Forces At Play

- Air resistance. (recovering arms) (Minimal as small amount of body is out of the water, also the density of air is significantly less than water.)
- Friction between body and water
- Pressure resistance; Eddy formations in body's wake. Wave making resistance.

Passive Resistance

Swimmers experience passive resistance only when gliding through the water. This would be imminent after a dive or wall turn. It would also act between breaststroke and butterfly strokes. Therefore the technique of the swimmer is of the most importance as the swimmer needs to be as streamlined as possible to produce the least amount of resistance. The passive resistance or drag can be measured by towing a swimmer through water or exposing the swimmer to water flow in a swimming flume.

$$F_{DP} = 1/2 C_{DP} P V^2 S_M$$

P = water density

V = speed of water flow

S_M = the area of the middle section

C_{DP} = drag coefficient

Reynolds Number (Re)

In fluid mechanics Reynolds number tells us if the flow of water around the swimmers body is streamlined (laminar flow) or turbulent and therefore determines the magnitude of the hydrodynamic resistance.

Laminar flow: water travels smoothly without disturbances. The velocity and pressure of the flow will remain constant. Laminar flow occurs when the moving body is streamlined and/or moving at a low velocity through the water. Laminar flow can be depicted as multiple horizontal parallel layers moving over the body. When velocity is increased eddy's form due to greater resistance and pressure until the pattern flow is disturbed and the water is now turbulent.

Turbulent flow: Turbulence or turbulent flow is a flow regime in fluid dynamics characterized by chaotic changes in pressure and flow velocity.

Turbulence also arises within boundary layers around the moving solid body.

Boundary layer: A thin layer of liquid in contact with the body surface. The fluid in the

layer is subjective to frictional forces, different velocities exist across the boundary layer from zero to a maximum. The layer is thinner at the leading edge of the body and thickens towards the trailing edge.

According to Clary (1979) competitive swimmers have a Reynolds number within the range of 2×10^5 - 2.5×10^6 which would make the boundary later turbulent and the resistance greater.

Decreasing Frictional Resistance

Frictional resistance (skin resistance) is in the boundary layer which sticks to and travels at the same speed of the swimmer. If a swimmer is dragging a greater frictional resistance (a greater boundary layer), the swimmers resistance will be increased.

Smoothness of the body can reduce the frictional resistance. This is the reason swimmers shave their bodies as to create a smoother contact surface with the water. It is still debatable if shaving has a measurable performance impact on the swimmer. Sharp and Costill (1989) found that the swimmers who shaved showed less energy expenditure and faster swimming. The argument is this improved swimming times could also simply be a psychological effect.

Buoyant polyurethane suits were worn by professional swimmers in mid 2000's and world records tumbled. The suits were banned in 2010 as it was proven that the suits

could give up to an 8% reduction in drag (Barrow, 2012).

The buoyancy is a big factor as the air resistance is about 780 times less than the water resistance, the more buoyant you are, the less of you is in the water, therefore less drag (Barrow, 2012).

Pressure Resistance (Head On Resistance)

Pressure resistance is the result of hydrodynamic processes occurring at the front and rear of a moving body. The water pressure is less at the back of the body than the front as the boundary layers move relative to the body.

When a streamlined swimmer moves through water at a slow velocity, the boundary layers pass smoothly over the trailing surface and very little eddy formation takes place. As a swimmer increases in velocity in the water, the boundary layer around the skin becomes thinner. Thus the effect of skin friction becomes less important, and the growing pressure gradient becomes more important. More eddy formation occurs and begin to occur closer to the front of the body. At maximum velocity the swimmer would appear to be completely surrounded by eddy's (white water).

Fast swimming sea mammals and fish have a streamlined anatomical form. The body of a human compared to a dolphin with the same length to width ratio experiences much greater hydrodynamic resistance at the same speed. The reason being some of our extremities decrease our streamline. These are the head, shoulders, buttocks and knees etc. (Clarys 1978).

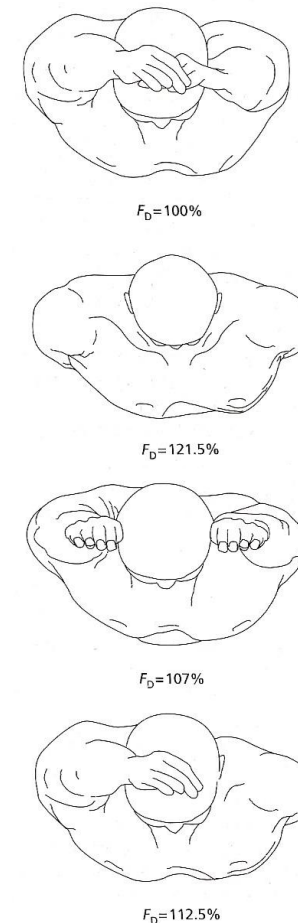


Fig 3.1- Impact of body form upon hydrodynamic resistance during underwater towing. (the magnitude of total resistance in glide position.) (Adapted from Bulgakova & Makarenko 1996.)

Angle Of Attack

An important factor for competitive swimming, is the magnitude of the angle of their strokes. For freestyle the angle is quite constant during a stroke. Butterfly and breaststroke have multiple varying angled movements in each completed stroke. An angle of attack between 0° and 5° the HDR increases by 15%. With an angle of 18° there is a 50% increase (Onoprienko 1968). In butterfly and breaststroke there will always be a varying angle due to the nature of the stroke. It is however in the swimmers best interest to minimize the up and down movement, minimizing the hydrodynamic resistance forces. This will also help to increase the maximal and average inter-cycle swimming velocity.

Total Hydrodynamic resistance

$$F_{\text{total}} = F_{\text{friction}} + F_{\text{wave-making}} + F_{\text{form}}$$

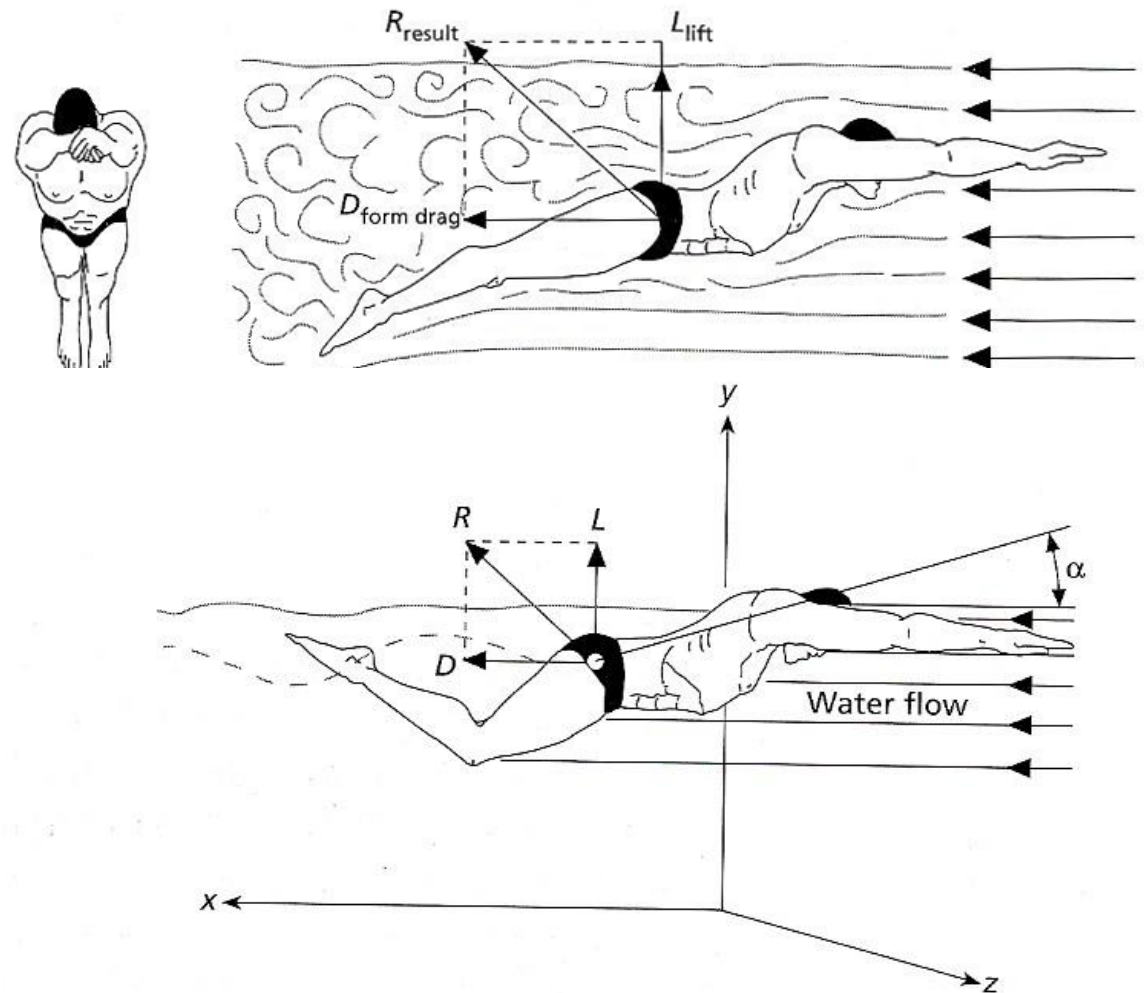


Fig 3.2- The origins of normal (lift) and frontal (drag) components of resultant hydrodynamic resistance (R) due to the angle of attack (X) induced by: (a) underwater torque and (b) deviation of the body from horizontal alignment. D, drag; L lift; R, resultant resistance; α angle of attack

Architectural link

Although the forces described in this chapter may be in more detail for an architects requirements. I found through understanding the more detail components and forces associated with swimming, the architect becomes more invested and has a better understanding of space requirements.

We understand a swimmer needs a pool to swim in. However technology today has gone far beyond a simple swimming pool. Devices which measure drag and propulsion forces are now implemented. Every aspect of a swimmer is now isolated and tested. The detail to which athletes are now studied is extreme. Although as an architect we do not need to comprehend such details, I did go into more detail to prove to the reader that these are real life considerations. It also emphasizes the level of professionalism and detail this Performance Centre will achieve.

The detail expressed was on the research side and was to emphasize the fact that the proposed performance centre is a research testing facility and not a training facility. Going into detail on the forces evolved in swimming may help the reader to comprehend this idea of an assessment facility and not a training centre.

No pure research centres exist in South Africa. There is the (HPC) High Performance Centre in Pretoria as well as (SAS) Stellenbosch Academy of Sport in the Western Cape. These facilities are more involved with training methods and have no link to performance on a cellular level.

Including the type of research and assessments that will occur at my facility will help the reader see my vision and understand the functions of the building. There is no building currently that links medicine, research, academics, sports excellence and community upliftment in the manner which i have approached this thesis.

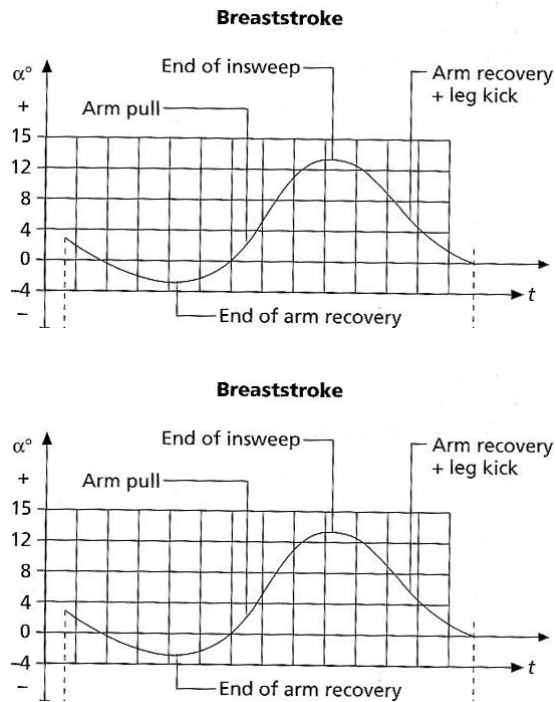
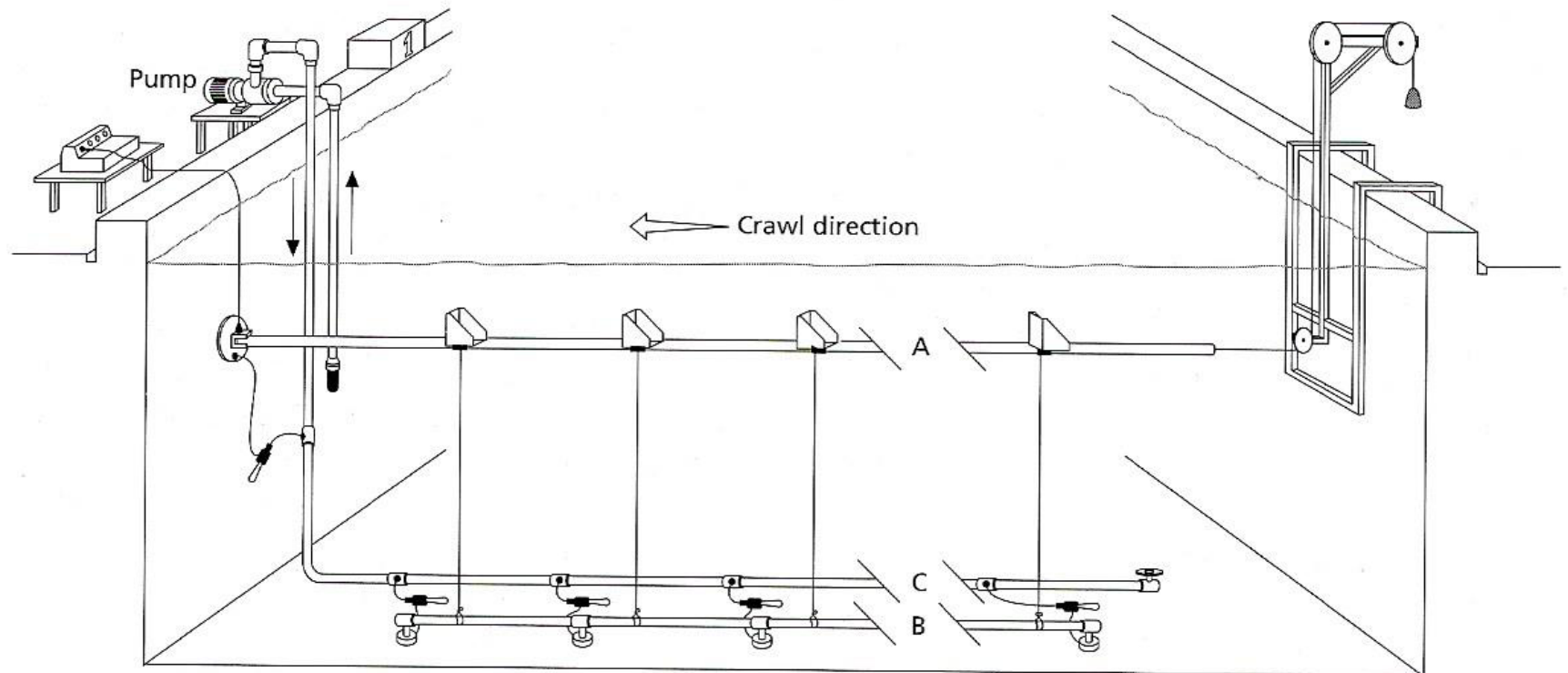


Fig 3.3- Intra-cyclic change of the angle of attack in (a) breaststroke and (b) butterfly stroke. α , angle of attack; t , time; T , time of swim cycle. (Bulgakova & Makarenko 1996; adapted from Haljand et al. 1986.)

Measuring Methods

The MAD System

The MAD (Measuring Active Drag) system (Toussaint et al. 1988, 1990) This method measures propulsion in freestyle only. The swimmer pushes off against grips, which are attached to a tube 0.8m below the surface. The tube is connected to a force transducer.



Velocity Perturbation Method

This method involves changing the maximum swimming velocity by adding drag which the swimmer tows. Swimmers swim at full speed with and without the drag weight over 25m. The hydrodynamic body (drag weight) is placed between 3.5-4.5 body lengths behind the swimmer where the water will no longer be turbulent. This is known as the Kolmogorov & Duplisheva method. This method can measure drag in all strokes where the MAD method can only measure freestyle.

The affects and understanding of resistance is only one part of the understanding of swimming dynamics. Another important understanding must be propulsive forces in swimming.

Architectural link

This basic understanding of these systems is required by the architect as they will be used within the pool space in the Performance Centre. This machinery also has spatial requirement which the architect must account for. The understanding of the hightec mechanics is also a source of inspiration to design the building with a strong link to the activities it supports.

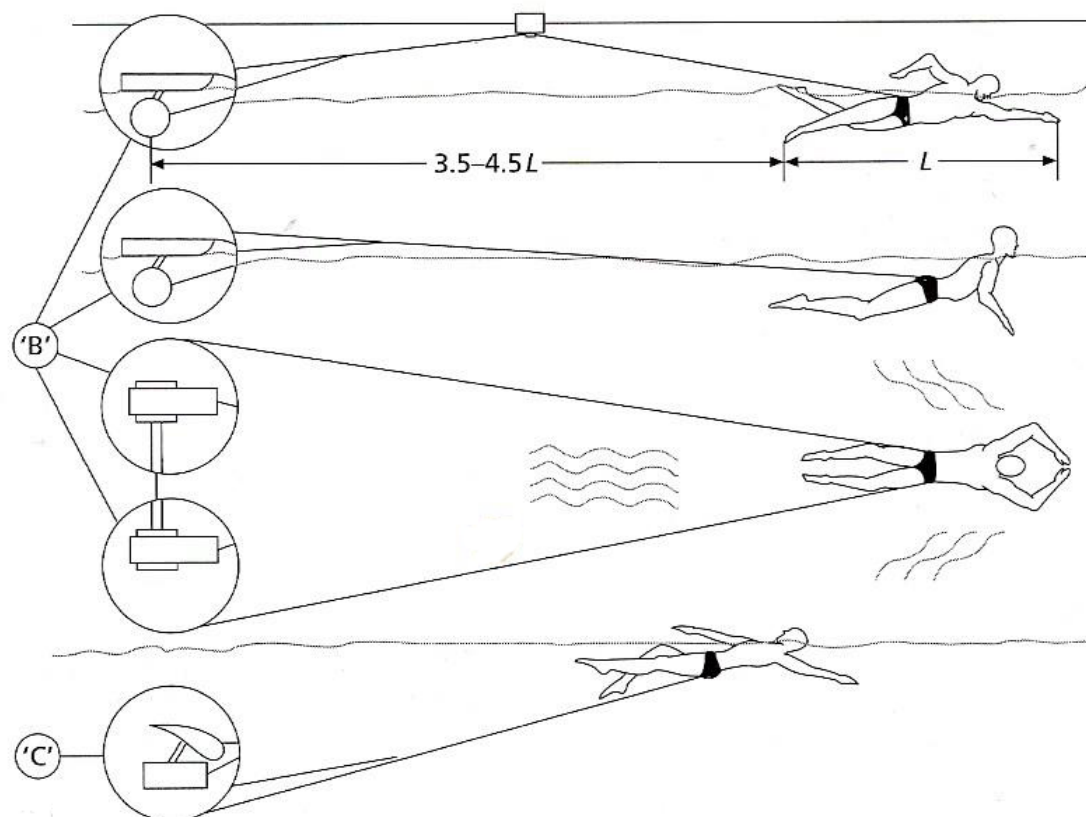


Fig 3.5- The velocity perturbation method. (a) Structure of the hydrodynamic body the swimmer pulls. 1. carrying body (foamplast); 2. waterline; 3. hole for water; 4. knifeposts; 5. fixing hook for ropes; 6. hydrodynamic cylinder (made of light metal); (b) attachment of an additional hydrodynamic body; (B and C) to the swimmers body; L, body length. (Reprinted from Kolmogorov & Duplisheva (1992), pp. 311-318.)

Propulsive Forces In Swimming

A swimmers velocity is also dependent on the total pulling force created by the moving segments of the swimmer (arms and legs). The pulling force of the swimmer constantly changes within the stroke and the recovery action which is constantly repeated. An example is a swimmer swimming butterfly, as the swimmers hands enter the water and pull there is a pulling force, the swimmer pulls his/her arms back until he/she needs to pull them out the water and back to the front and repeat the process. There is no pulling power in the arms as the swimmer swings them back to start a new stroke.

To maximize the pulling power swimmers must pull in the direction vector closest to the swimmers direction which is forward.

As discussed earlier we also look at the bending angle of the swimmers arms as they pull to maximize strength output. A slightly bent arm pull will create an average of 20% more force than a straight arm pull (Butovich & Chudovsky 1968; Vorontsov 1981) (Zatsiorsky, 2000) This bending implies that more muscle can deliver work in the joint while swimming as explained in an earlier chapter regarding muscle strength.

In freestyle it is proven that the maximum force of a stroke is when the arm is at 90° to the body in line the middle of the body (Zatsiorsky, 2000). This is known as the theory of the straight 'oar-like' arm pull (OLP). The OLP theory also notes that the swimmer should maintain maximum surface area of the propelling segments and constantly increase the velocity of the pulling action until recovery action in the stroke begins, then repeat.

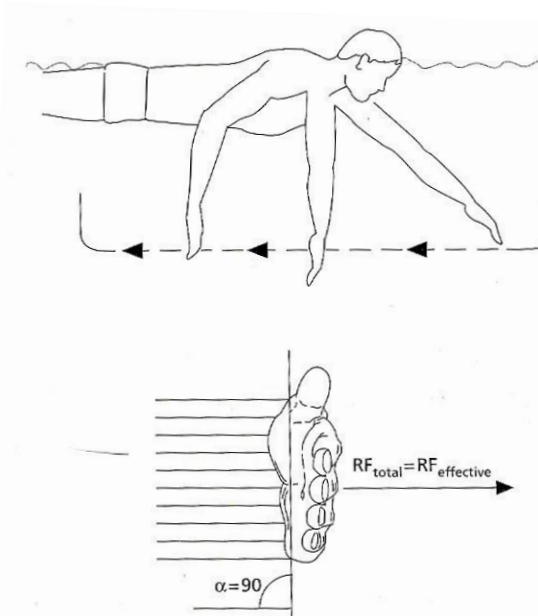


Fig 3.6- (a) Oar-like pull (side view). (b) Contribution of frontal drag force (RF_{total}) on the hand into RF (Resistance force).

Conservation Of Mechanical Energy While Swimming Is Also An Important Factor.

Conserving of efficient kinetic energy is achieved in the following ways.

- Rigid fixation in joints under pulling action.
- Tension in muscles doing the work to create a rigid body frame.
- Relaxation of non-active muscles.
- Streamlining- Use the kinetic energy of the recovery action to increase forward momentum.

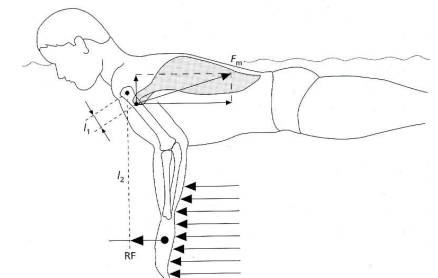


Fig 3.7- The formation of the muscle drought torque and RF torque during arm pull.

Biokinetics in sport

“Biokinetics is the profession concerned with health promotion, the maintenance of physical abilities and final phase rehabilitation, by means of scientifically-based physical activity program prescription.” (Sports Science Institute of South Africa, 2015)

Biokinetics has two major sides. The first being performance improvement and the second being injury rehabilitation.

The SSISA (Sports Science Institute of South Africa.) is the leading board of biokinetics in South Africa, and has a relationship with UCT. They offer assistance to the ordinary person who just wants to improve their health, all the way to the professional athletes. As my Performance centre is aimed at the use of professional athletes we shall focus our attention in that department.

Since 1995, the Sports Science Institute of SA's High Performance Centre has provided scientific and medical testing, monitoring and the direct application of the results of a high quality applied research program for athletes in many sporting codes of all abilities. (Sports Science Institute of South Africa, 2015)

Teams and individuals can select a range of services according to their needs. These services include:

- Physiological assessments using world-class expertise and equipment. In this way scientific, individualized training programs can be designed and prescribed.
- Fatigue and performance management using our unique web based Athlete Monitoring and Assessment System (AMAS).
- Sports Team Consulting.
- High intensity strength and conditioning classes.

The SSISA have developed the AMAS system. (Athlete Monitoring and Assessment System) It is an online system which tracks and monitors athletes in a variety of different ways. Some of these include.

- Total recovery
- Rate of average fatigue
- Symptoms to illness
- Training loads

Other tests include

- Muscular strength
- Explosive power
- Evaluation of mobility and stability

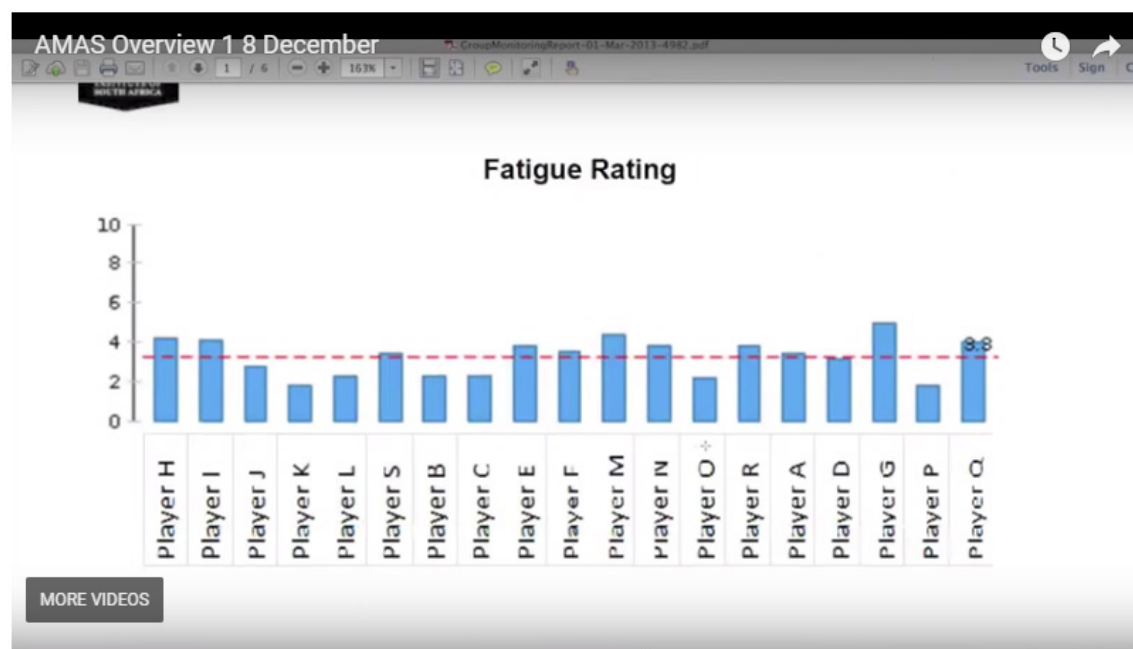


Fig 3.8- Fatigue rating

Each athlete is given an individual profile and report. The system compares the athletes details to the normative data of the sport and age group of the athlete. Teams are also tested and the results of all the athletes in he team can be compared to one another.

The system is backed by well known sports scientist Tim Noakes. He believes through constant testing and monitoring athletes are able to reach their performance peak at the desired time. An example would be a swimmer who peaks when the Olympics come around.

It is physically impossible for an athlete to be in top form all the time. The body will suffer from fatigue and will need to recover. The AMAS system guides athletes on how to control their peak performance and reach it at the desired time.

Although this information and research will be incorporated into my Performance centre. An additional layer of science of the internal workings of the human body will be looked at. This includes DNA, minerals within the body, the amount of fast and slow twitch muscle fibers in the athletes body, as well as more information on a cellular level. This knowledge combined with the AMAS system will furthermore promote the improvement of an athletes performance.



Group Testing Report

Testing Date: 2013-07-19
Team: Rapid Rangers

		Group Average
*Anthropometrics	Body Fat Percentage (Borzek Equation)	17.40
	Derived Lean Body Mass	86.10
	Height (cm)	177.80
	Weight (Kg)	104.50
Aerobic Capacity	Running 2.4km Time Trial - Time Minutes	9.50
	Running 2.4km Time Trial - Time Seconds	17.00
	Yo Yo Test Level - Intermittent Recovery Test Level 1	16.40
Explosive Power	Vertical Jump	56.80
Muscle Endurance	Dynamic Core Test Result (out of 180)	0.00
	Maximum Pull Ups - Underarm	10.40
Muscle Strength	1RM Bench Press	120.00
Speed and Agility	10m - Speed And Agility - Static Starts	1.80
	40m - Speed And Agility - Static Starts	5.60

Fig 3.9- AMAS test report



Fig 3.10- Prof Tim Noakes

Human-factor engineering and ergonomics

Human-factors engineering, also called ergonomics or human engineering, science dealing with the application of information on physical and psychological characteristics to the design of devices and systems for human use. (Pike, 2017)

It is about designing something with the end user in mind. It is the entire process of the design from start to implementation and its success is based on the users success.

Medical examples of human factor engineering are.

- Anesthesiology
Design of alarms, monitors and safety systems
- Emergency medicine
Design decision-making tools and monitoring
- Surgery
Design of hand tools and visualization tools.

The human factors are most important when designing. “Human factors and ergonomics are also known as comfort design, functional design, and systems, is the practice of designing products, systems, or processes to take

proper account of the interaction between them and the people who use them.”(Chapanis 2018)

In todays society human factor engineers go by different names such as bio-engineers.

The data and core principles of human factor engineering are concerned with human performance, training, behavior, the design and development of man-machine systems and systems-related biological or medical research. (Pike, 2017)

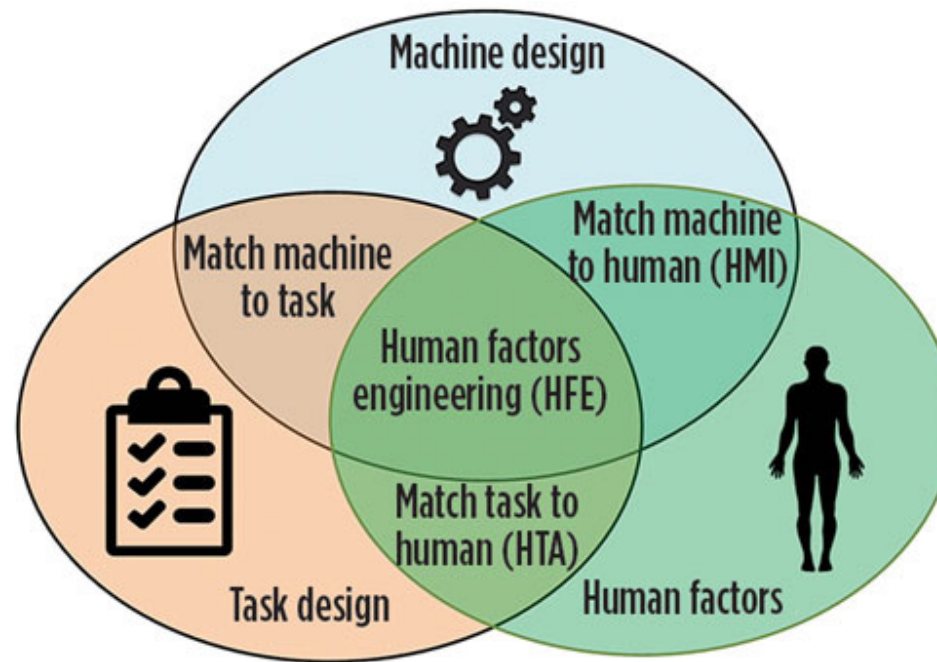


Fig 3.11- HFE venn diagram

It is a wide scope as the engineering at hand is normally focused on solving a specific task on hand.

The above diagram shows the different factors and considerations of HFE and additional factor that is not listed in the bubbles would be cost. A successful product or service must still be affordable

Velocity Perturbation Method Recap with HFE

Looking back at the Velocity Perturbation Method we looked at earlier in the chapter. We can make the connection from this device to what Human factor Engineering is.

The purpose of the device is to improve human performance in the swimming pool by analyzing the swimmers drag and propulsion forces.

This data can then be analysed and the swimmer can make adjustments to their techniques and the results can be measured again. This process can be repeated over and over again until the swimmer finds their optimal performance in terms of their swimming stroke. This is where they will exert the least amount of energy and produce the least amount of drag and maximum propulsion.

As architects we understand and also design through human factor engineering as we are designing spaces for people which must be ergonomically correct. In such specialized and complicated buildings it is more critical to understand the users needs and requirements so we can unload the information and turn it into working plans which will also compliment the needs to the end user and client.

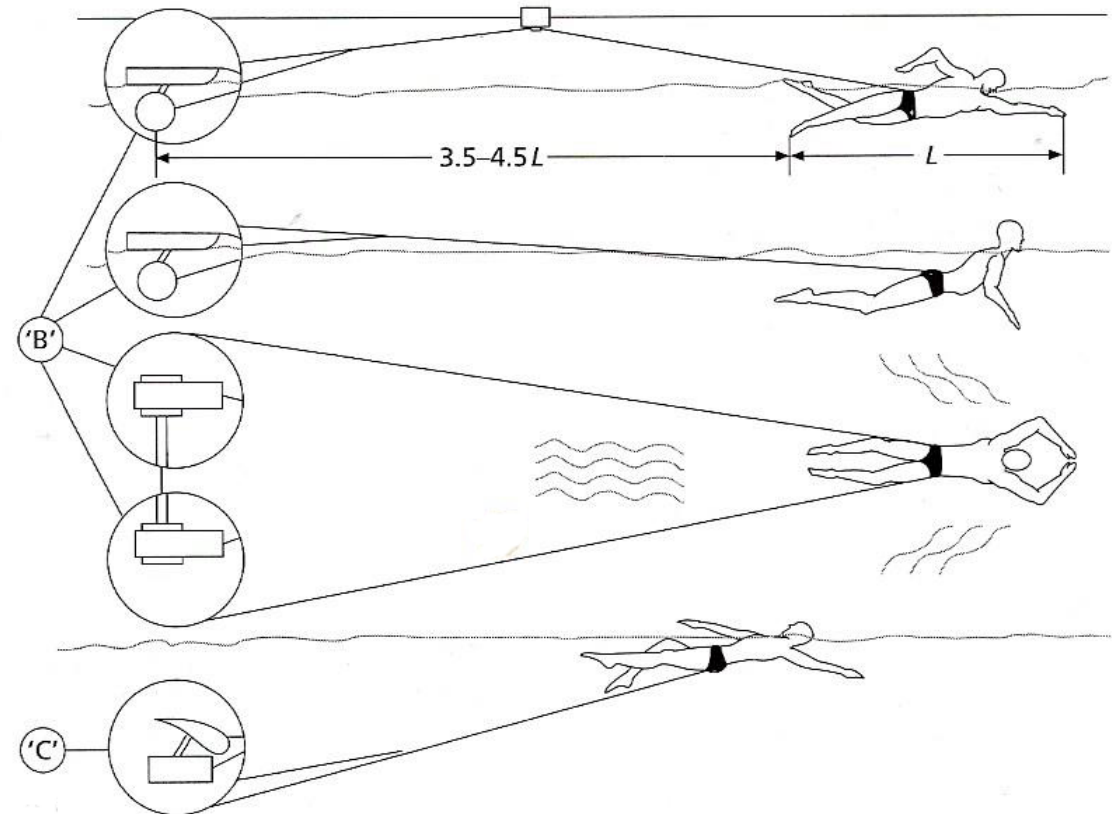


Fig 3.5- The velocity perturbation method. (a) Structure of the hydrodynamic body the swimmer pulls. 1. carrying body (foamplast); 2. waterline; 3. hole for water; 4. knifeposts; 5. fixing hook for ropes; 6. hydrodynamic cylinder (made of light metal); (b) attachment of an additional hydrodynamic body; (B and C) to the swimmers body; L, body length. (Reprinted from Kolmogorov & Duplisheva (1992), pp. 311-318.)

Chapter 4

The Laboratory

Safety & research

Structure

Introduction - Understanding the laboratory

Laboratory safety - Understanding the required safety measures in laboratories

General Information - Molecular biology, biochemistry, genetics

Generic Lab Layouts - General layouts

Research Rooms - Required rooms in a research laboratory



Introduction

My building not only analyses athletes physically but also analyses them on a cellular level. Therefore a laboratory facility is required. As laboratories have such strict safety standards and facility requirements it is crucial to understand the workings of the space.

It is highly important to understand the specific space requirements for the research department in my building and the spacial requirement that come with it to allow for successful planning.

Laboratory safety

All laboratory research programs most important factor is safety. It is a requirement to protect personnel as well as the external environment from products, organisms, effluents or hazardous substances that may be emitted as a result from the research laboratories activities.

With the implementation of strict laws and regulations regarding laboratories, serious accidents caused by research laboratories are now rare (White, 1988). Academic institutions in the past were where the majority of accidents took place. With more and more universities now doing research which involves radiation, carcinogens, and bio-technology they have developed high safety standards.

A laboratory director.

Most laboratories have a director who manages the safety program. The director's job is to ensure the smooth running of the laboratory in all aspects. The director will assign responsibilities to other staff members and manage the implementation of these responsibilities. The success of the safety program will be based overall on the cooperation of the entire staff and a common goal for the standard of the facility. The size and functions of the research laboratory will determine the size of the staff.

Chemical safety

Chemicals occur in many varieties and under certain circumstances, virtually all chemicals

can be hazardous. The researches involved are normally aware of the risks but may overlook some safety aspects. The surrounding conditions of the laboratory is very important and may require certain ventilation, safety hoods, incinerators and showers. A researcher may need to be sterilized and wear a laboratory suit before handling chemicals.

Bio Safety

Microbiological and biomedical laboratories have special safety requirement in a laboratory. Knowledge, techniques, and equipment to prevent accidents are required. As indigenous and exotic infectious agents continue to evolve, so must the safety precautions with it.

Summary Of Recommended Biosafety Levels For Infectious Agents

Biosafety level	Practices and techniques	Safety equipment	Facilities
1	Standard micro-biological practices	None, open bench operations	Basic
2	Level 1 practices. + Lab coats, decontamination of all infectious wastes, limited access, protective gloves, and biohazardous warning signs.	Partial containment equipment. Class I or II biological safety cabinet.	Basic
3	Level 2 practices. + special lab clothing, controlled access	Partial containment equipment used for all manipulations of infectious material.	Containment
4	Level 3 practices. +entrance through changing room, shower on exit, all waste decontaminated on exit of facility.	Maximum containment equipment. (Class III biological safety cabinet), Full body positive-pressure suit for all activities.	Maximum containment

Fig 4.1- (Richardson, J.H., and Barkley, W.E., eds. Biosafety in Microbiological and Biomedical Laboratories. Centres for Disease Control and National Institutes of Health, USPHS, 1984).

General Information



Molecular Biology

The branch of biology that deals with the structure and function of the macromolecules (e.g. proteins and nucleic acids) essential to life.

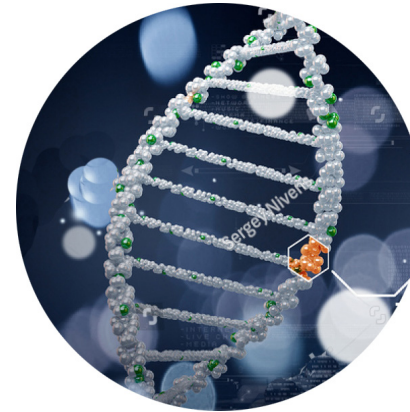
Fig 4.2



Biochemistry

The branch of science that explores the chemical processes within and related to living organisms. It is a laboratory based science that brings together biology and chemistry. By using chemical knowledge and techniques, biochemists can understand and solve biological problems.

Fig 4.3



Genetics

The study of genes, genetic variation, and heredity in living organisms. It is generally considered a field of biology, but intersects frequently with many other life sciences and is strongly linked with the study of information systems. E.g. Redcap

Fig 4.4

Research Rooms

	Room+Size	Description	Requirements	
	General work lab 60-100m ²	General laboratory space	10 research work benches; chemical store; equipment store; fume hood; fr+fz; autoclave; chemical spill kit, Personal Protective Equipment (PPE - e.g. gloves, coats, etc), wash basin.	
	Tissue culture lab 15m ²	Laboratory for cell growth and experimentation	Co2 incubator, Biological Safety Cabinet (BSC), work bench + microscope + computer, sink, shelf storage	
	Pre PCR lab 15m ²	Preparation of cells for tests - add reagents to cell sample which results in the DNA strand 'growing'	Work bench, reagent storage, fr+fz, lamina flow hood, centrifuge	
	PCR lab 15m ²	Where you perform the reaction in the PCR machine to amplify the DNA	Work bench, reagent storage, fr+fz, PCR machines	
	Post PCR lab 20m ²	DNA is suspended in a gel and tested	Work bench, reagent storage, fr+fz, gel running apparatus	
	Bio Imaging room 20m ²	Room to view results	Work bench, computers and viewing equipment	
	Biobank room 50-100m ²	Storage facility for bio samples	CO2 freezers for storage. PC for filing system.	
	Imaging room 50m ²	Place to view samples and test results	Work desks/benches, imaging equipment	
	Dark room 15m ²		No windows	
	Genomics lab 50m ²	Concerned with the structure, function, evolution, and mapping of genomes	Same as Tissue Culture Lab	
	Proteomics lab 50m ²	Study of proteins and their functions	Same as 'Tissue Culture Lab'	
	FACS (Fluorescence Associated Cell Sorter) 50m ²	Fluorescent 'markers' are put into cell sample to attach only to certain 'contaminated' cells; this mixture then undergoes a process in a machine, and then they come out one-by-one so that the marked/contaminated cells can be counted to aid with the diagnosis	Connected darkroom. Work benches, Biological Safety Cabinet (BSC)	
	Preparation room 80m ²	General laboratory space	Research work benches, chemical store; equipment store; fume hood; fr+fz; autoclave; chemical spill kit, PPE, wash basin.	
	Cold room 10m ²	Kept at 4°C	Connected to back up power	
	Equipment storage room varies	Store research equipment	Locked to protect equipment	

Additional Notes	Ideal Room connections	Key
Lab can be circulation space	    	
Positive pressure and solid brick walls on all sides		  
Positive pressure	  	
Positive pressure	  	
Negative pressure	   	
Can be combined with 'Post PCR Lab', dependent on equipment	 	
Automatic opening doors. Sterile connections to reduce contamination		
Can include dark room		
Can be within imaging room		
Positive pressure and solid brick walls on all sides. Can connect directly to Biobank. Room	 	 
Positive pressure and solid brick walls on all sides. Can connect directly to Biobank. Room	 	 
Controlled temperature is important		 
		 
		
		

Fig 4.5- Research rooms table

Note

This table lists all the rooms associated with a research centre, it also lists their requirements, both spacial and safety. The table has been set up in a way for the architect to design the most successful building. The key allows the architect to group the rooms by spacial requirements, (water) or by procedural functional requirements. (Ideal rooms which should be located in close proximity due to function).

This table was created by myself through information from Ludwig Hansen architects as well as Visiting the labs in Charlotte maxeke hospital.

The table is all the rooms listed that will be required in my design and helped as a layout template in order to get the most practical and efficient design layout.

Key

-  Wet room
-  Sterile room
-  No sunlight

Chapter 5

Site Location & Mapping

The site

Structure

Site Location

Green space

Building Typologies

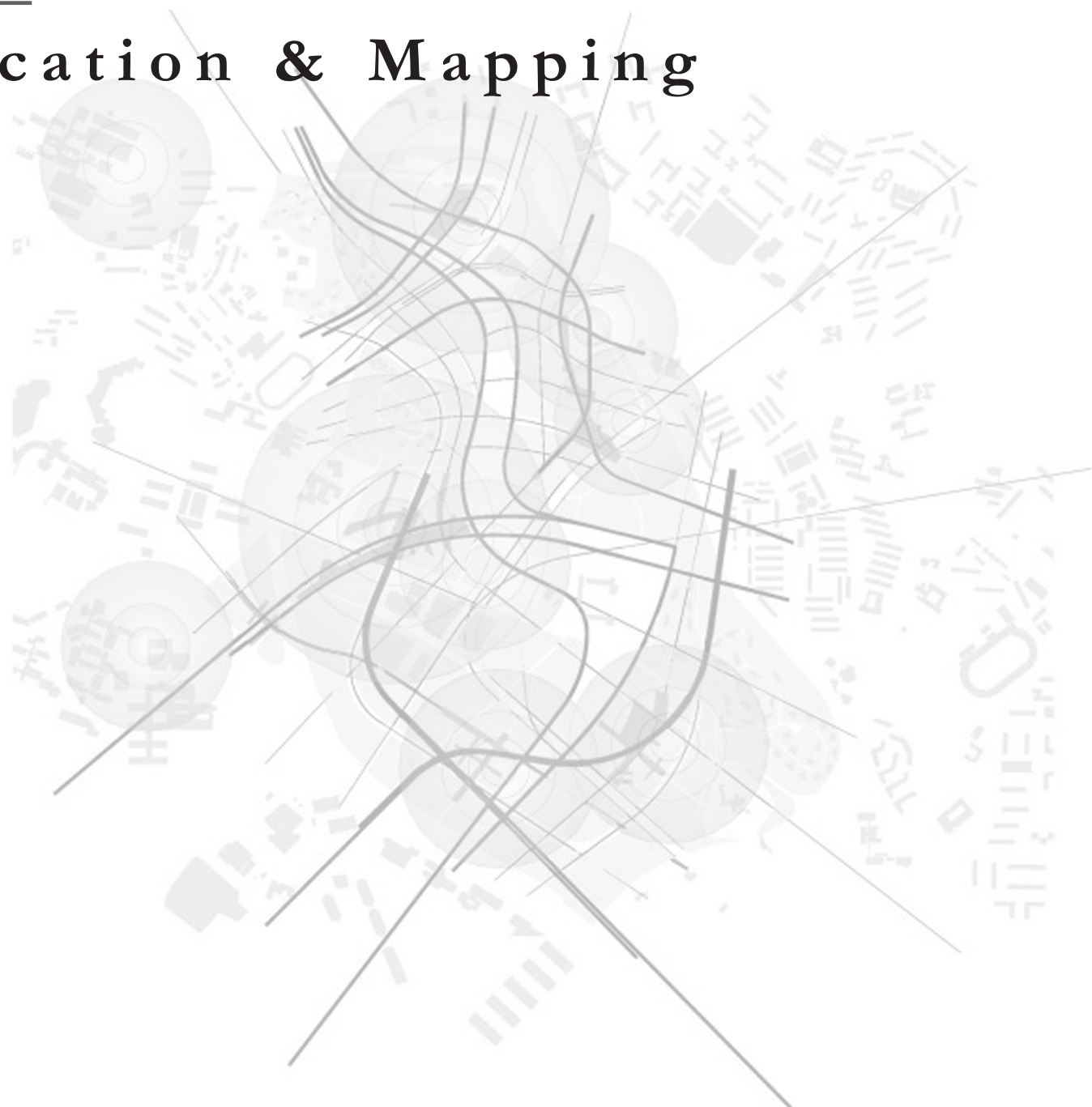
Movement

Adjacent Buildings

Medical Corridor

Transport Systems

Site Surroundings



Site Location

The Centre will be located in Johannesburg, Gauteng, South Africa's most densely populated province. Johannesburg is both the economic and transportation hub for the entire SADC (Southern African Development Community) region, and therefore the most logical and central location for it to meet its mandate of serving the region's population. The selected site is on the Wits College of Education campus in Parktown adjacent to the Wits Medical School and in between the Nelson Mandela Children's Hospital and The Wits sports clinic. The Wits Sydney Brenner Research institute is directly across the road from the site.

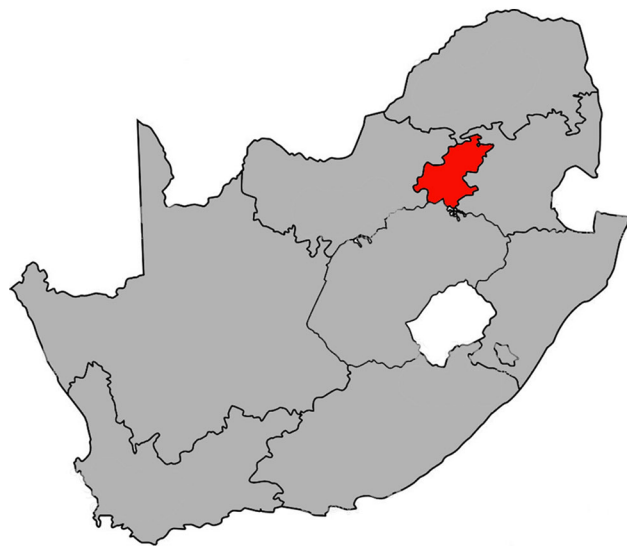
This site was chosen for the following factors
Reasonable zone and site restrictions

- Ease of student access
- Proximity to symbiotic facilities
- Availability of existing infrastructure. (cost saving)

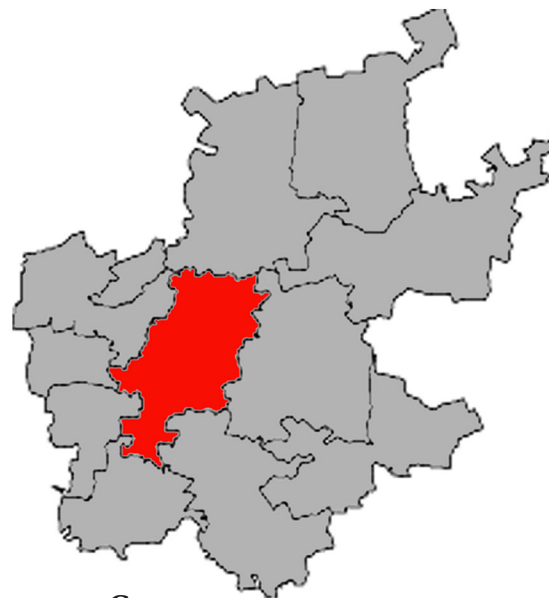
Statements that motivate the above mentioned are listed below.

- Can make use of existing facilities such as swimming pool and fields.
- Next to the children's hospital for easy access
- On campus for students to have access to the facility
- Next to the current Wits sports centre
- Across the road from the Sydney Brenner research centre
- Along the Wits medical corridor
- Available existing parking within the university and Children's hospital
- Site currently old tennis court and therefore no building need to be torn down.

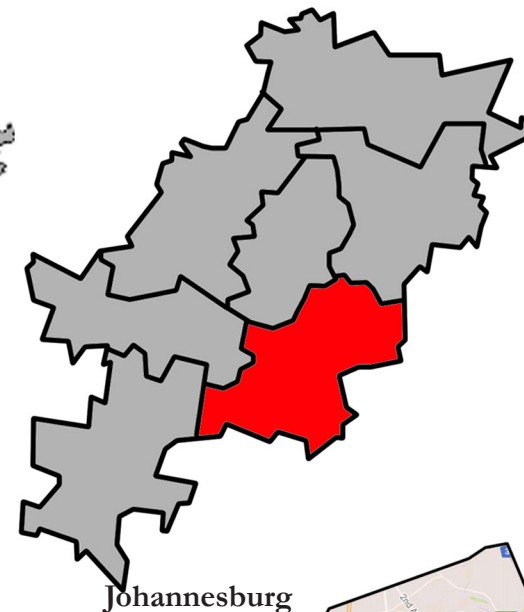
Site Location



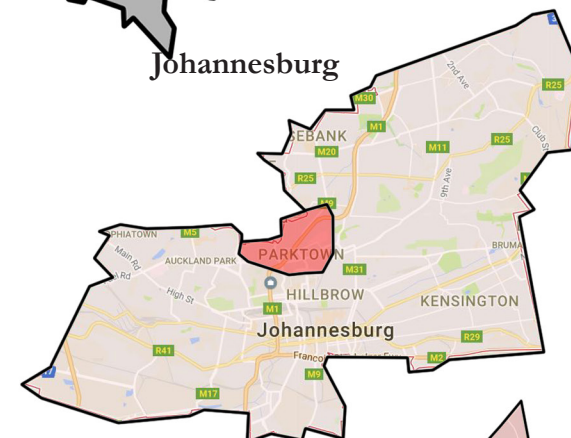
South Africa



Gauteng



Johannesburg



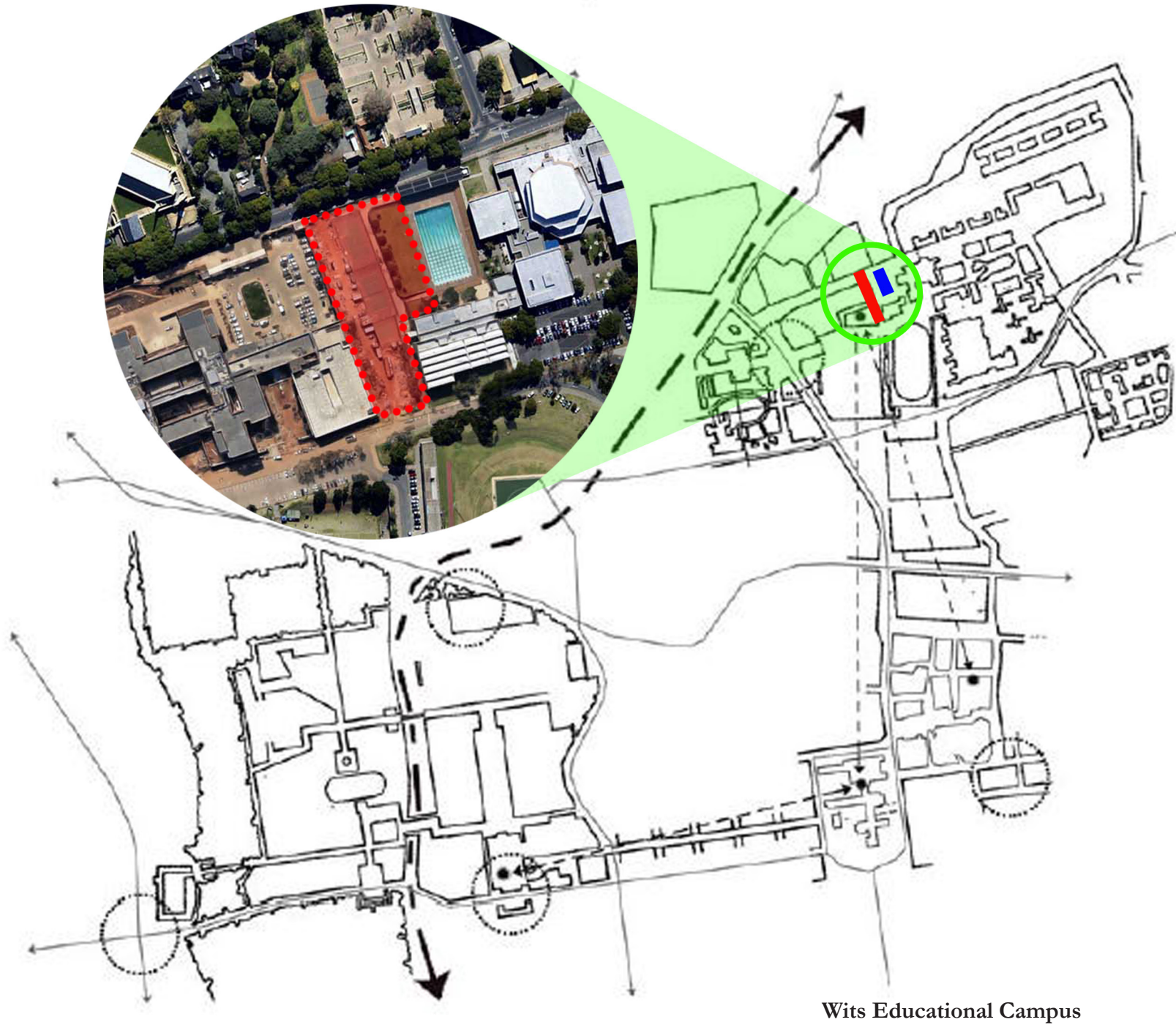
Parktown



Wits Educational Campus

*“Education is the most powerful weapon
which you can use to change the world.”*

Nelson Mandela 23 April 2013



Wits Educational Campus

Fig 5.2- Wits educational campus sketch

Green Space



Scale 1:12500



Wits

sport space

Site

Building Typologies

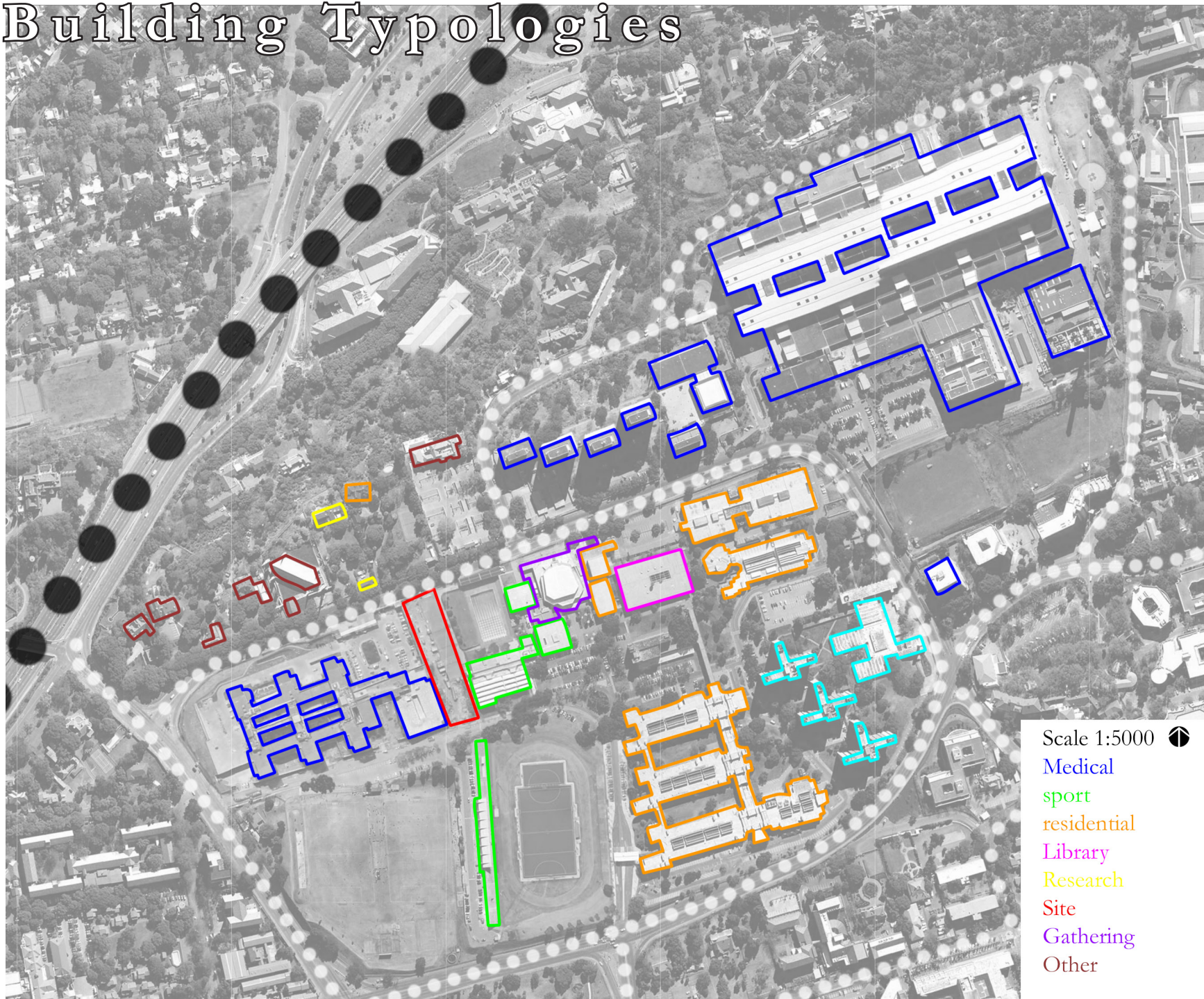


Fig 5.4- Building Typologies

Movement

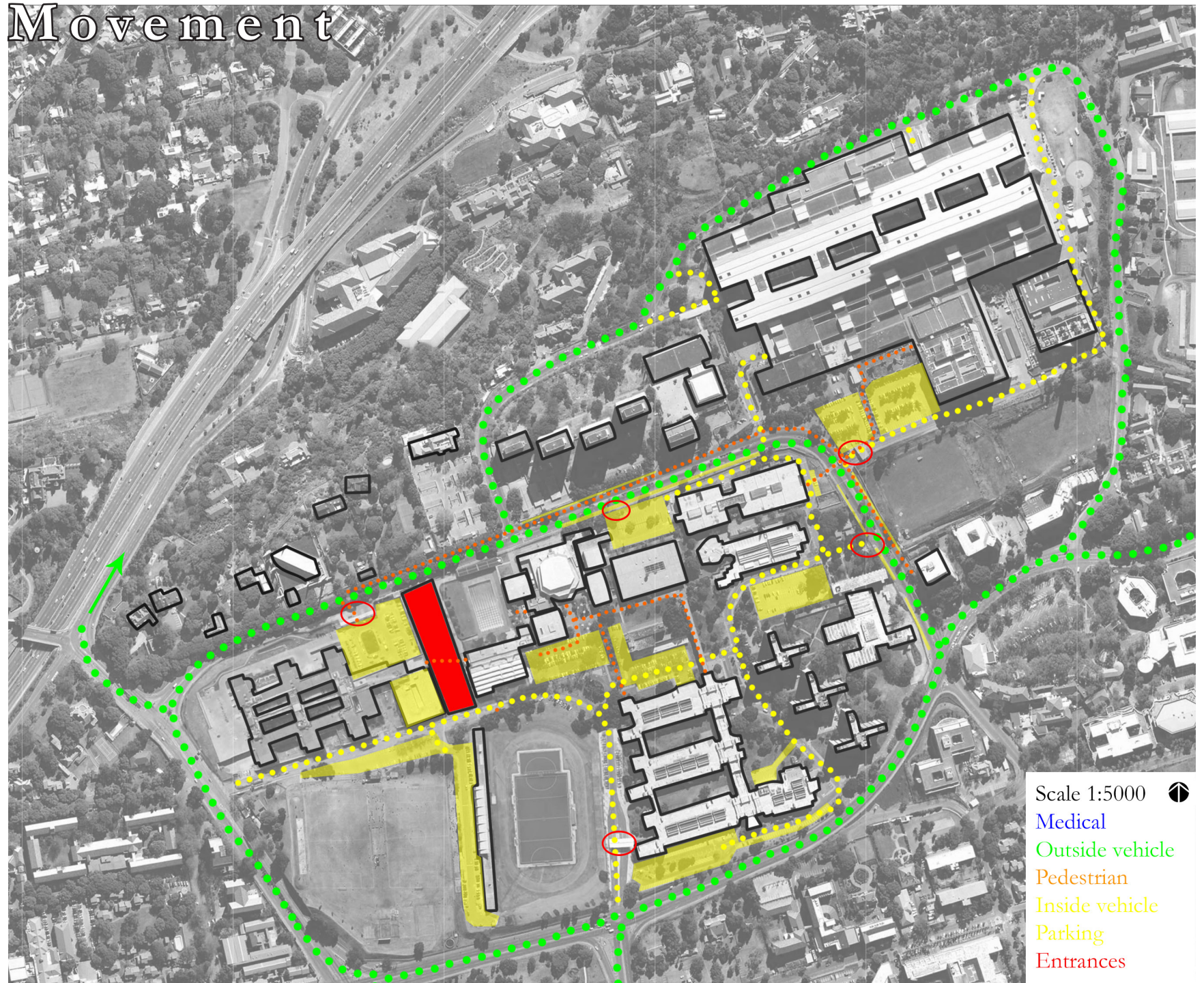
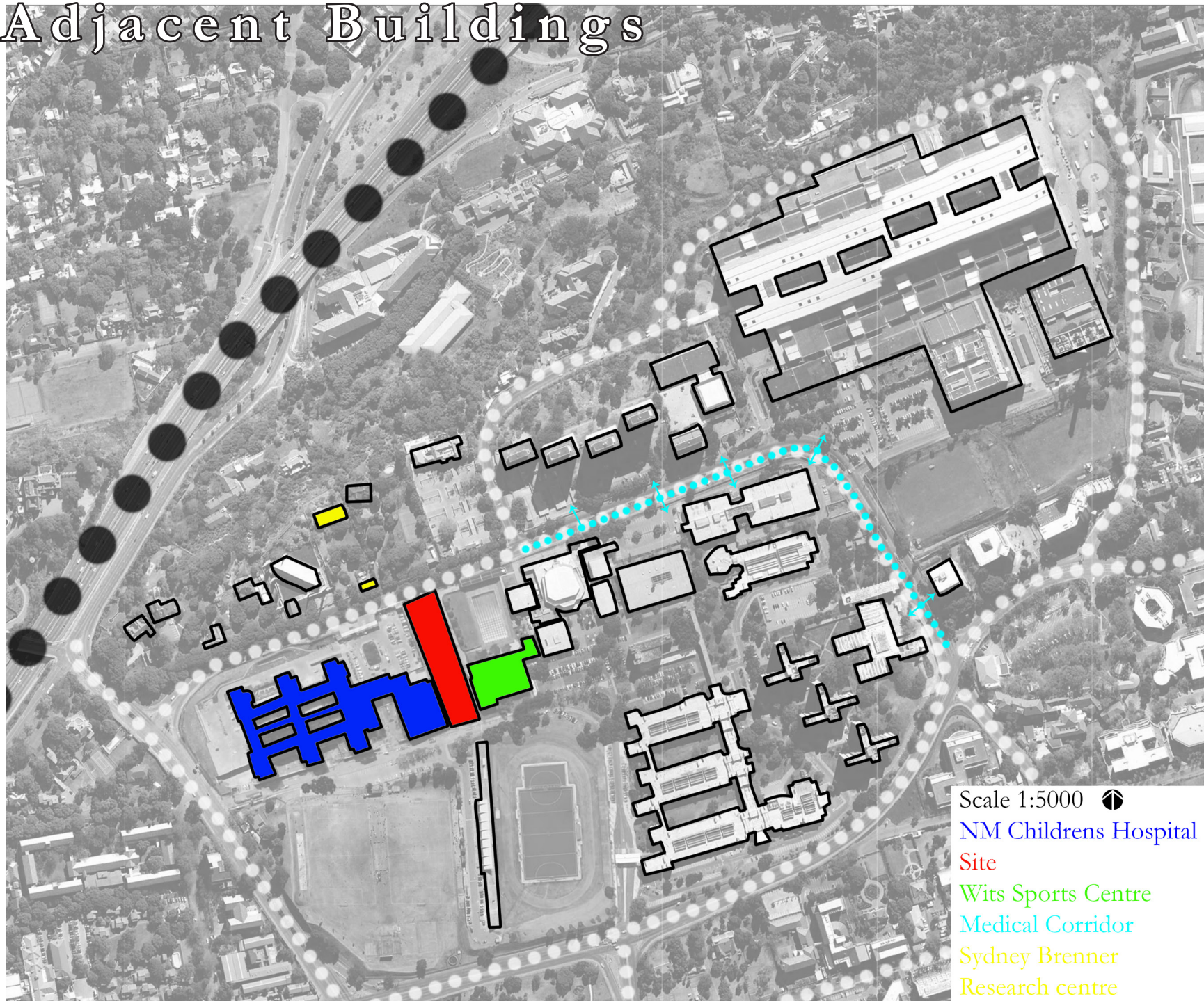


Fig 5.5- Movement

Adjacent Buildings



Scale 1:5000



NM Childrens Hospital

Site

Wits Sports Centre

Medical Corridor

Sydney Brenner

Research centre

Fig 5.6- Adjacent Buildings

Medical Corridor



Transport Systems

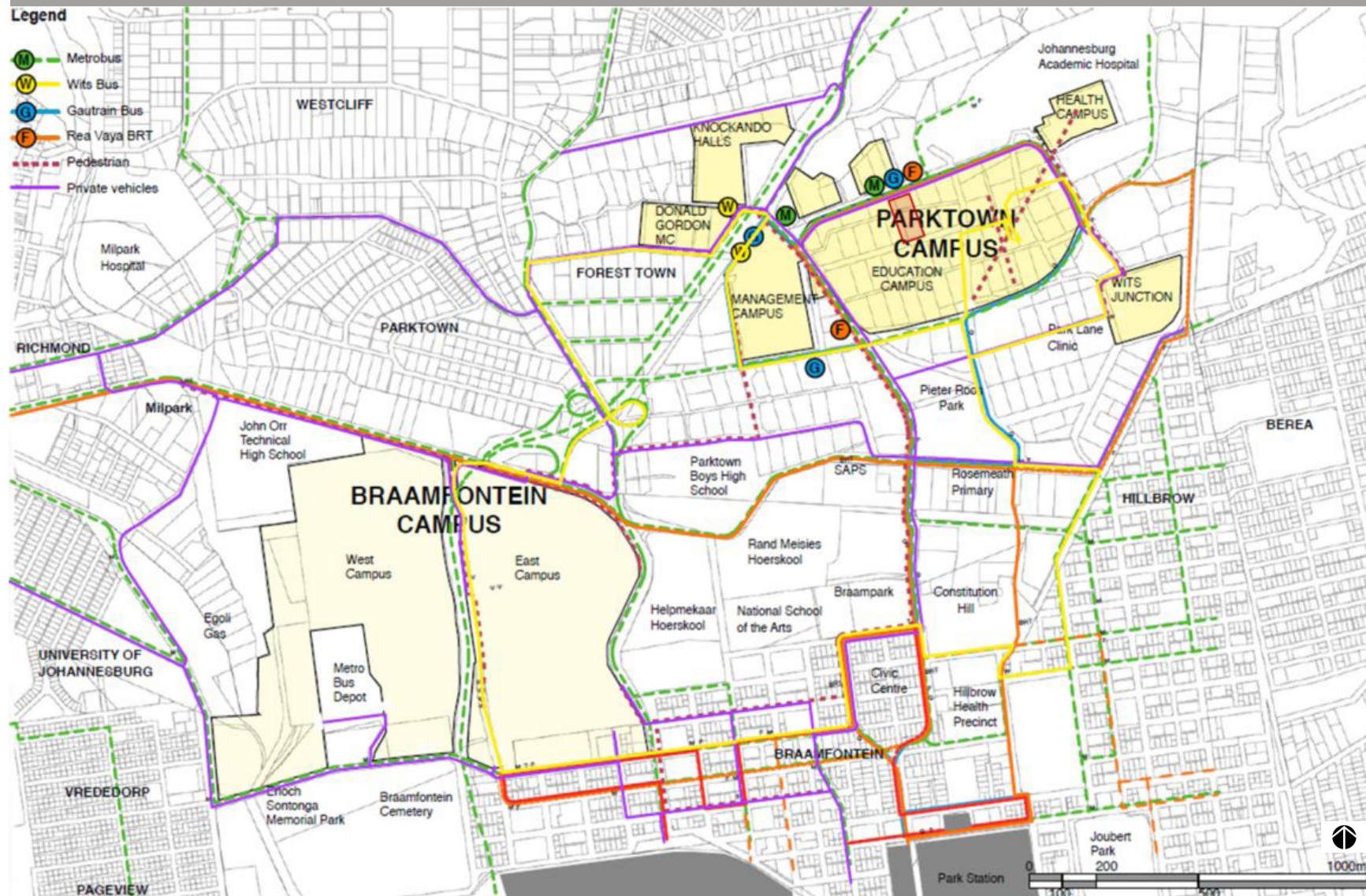
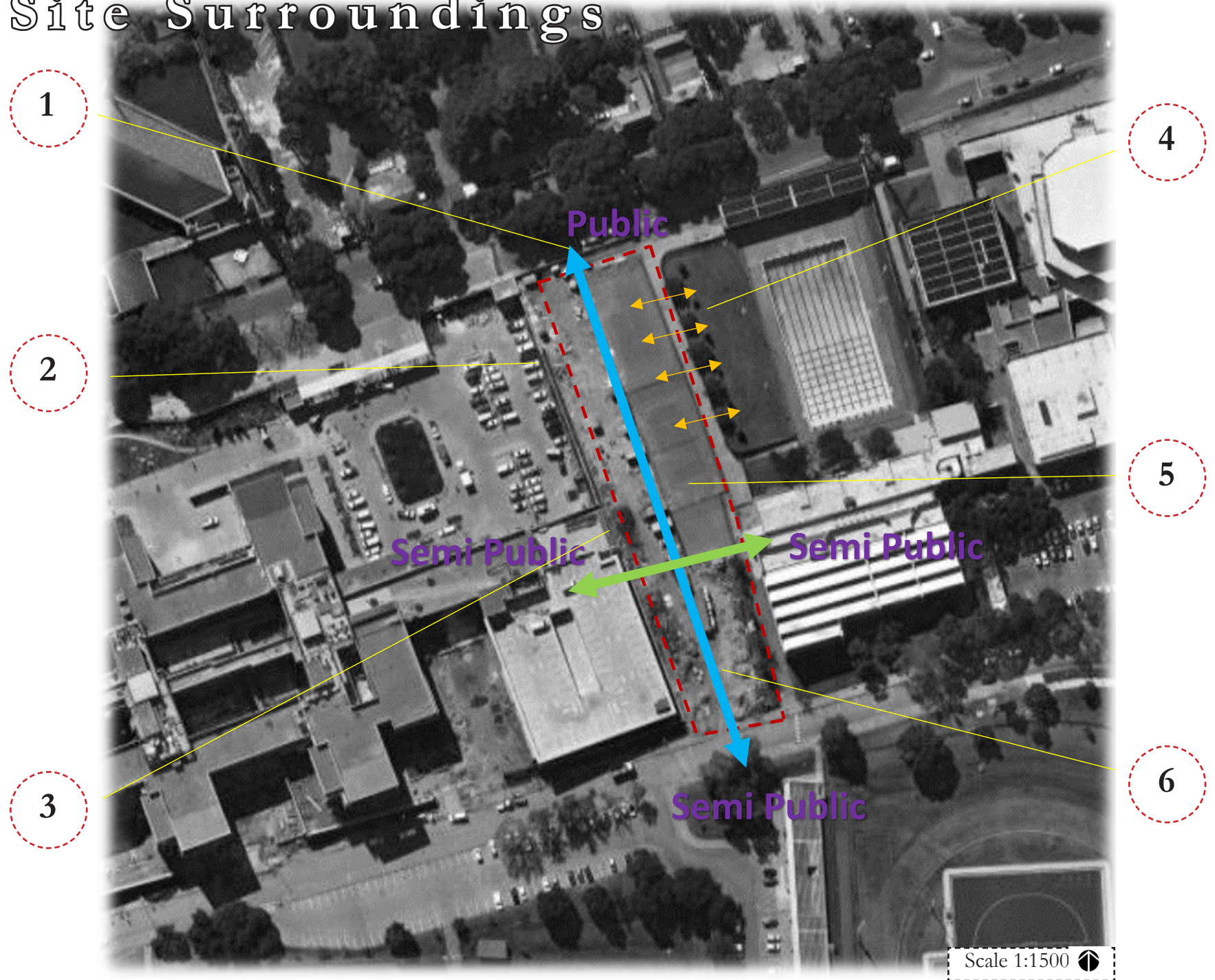


Fig 5.8- Transport Systems

Site Surroundings





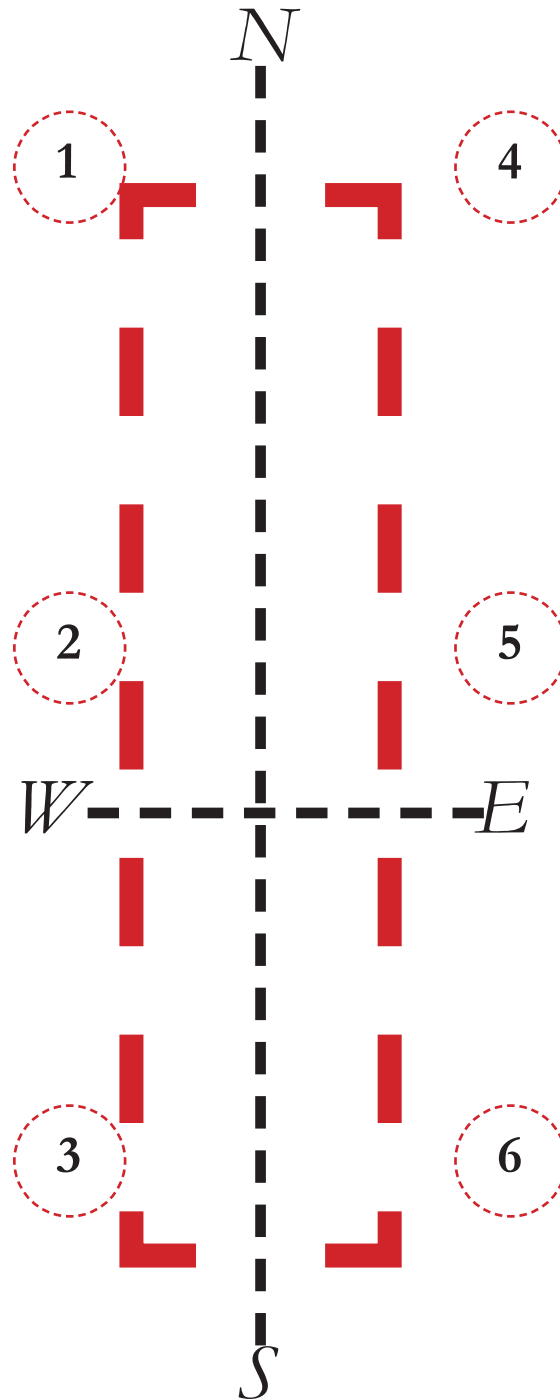
South Gate entry onto Jubilee road



NMCH parking



Site entry into NMCH



Wits pool



South site perspective



South entry from within Wits

Fig 5.10- Site Surroundings



Fig 5.11- Jubilee street view





Fig 5.12- North site view



Fig 5.13- Site panoramic



Chapter 6

Precedent Studies

Relevant buildings

Structure

Art Stable

Chicken Point Cabin

High Performance Centre (HPC)

Goldring Centre for High Performance

Wits Sports Centre

Sydney Brenner Institute of Molecular
Bioscience

Nelson Mandela Children's Hospital
(NMCH)

Centre For Environmental and Life Sci-
ences (CELS)



Art Stable

Tom Kundig

This lake cabin was built for a family in Northern Idaho. In the summer the temperatures very high. The solution was to make a 9x6m door opening to allow a breeze sweeping off the lake into the cabin.

My real interest in this projects was the mechanics of the door system. Particularly the minimal force required to move a large door opening.

Tom Kundig specializes in moving architecture and has applied moving facades on both a residential and commercial scale as seen in Art Stable.

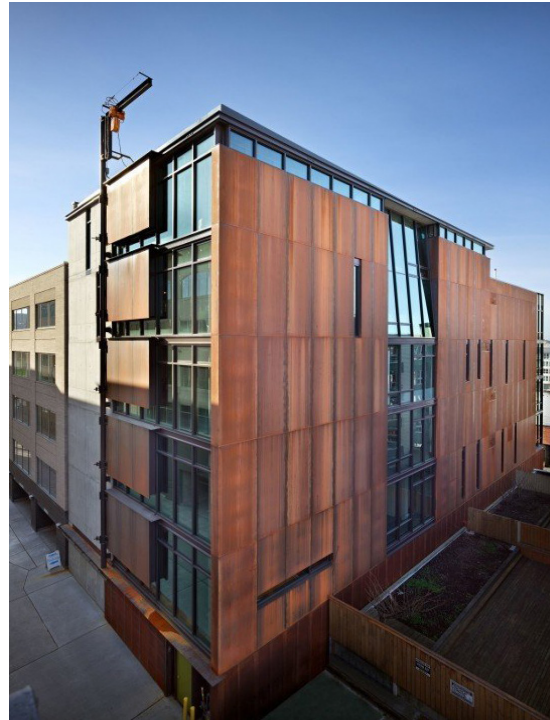


Fig 6.1- Art Stable closed facade

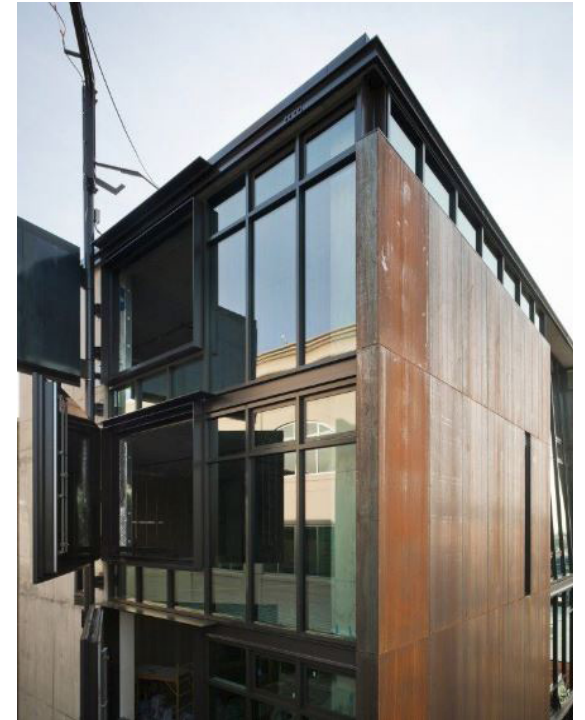


Fig 6.2- Art Stable Open facade



Fig 6.3- Art Stable Joint detail



Fig 6.4- Art Stable turning detail

Chicken Point Cabin

Tom Kundig



Fig 6.5 - Chicken Point Cabin interior



Fig 6.6- Chicken Point Cabin exterior

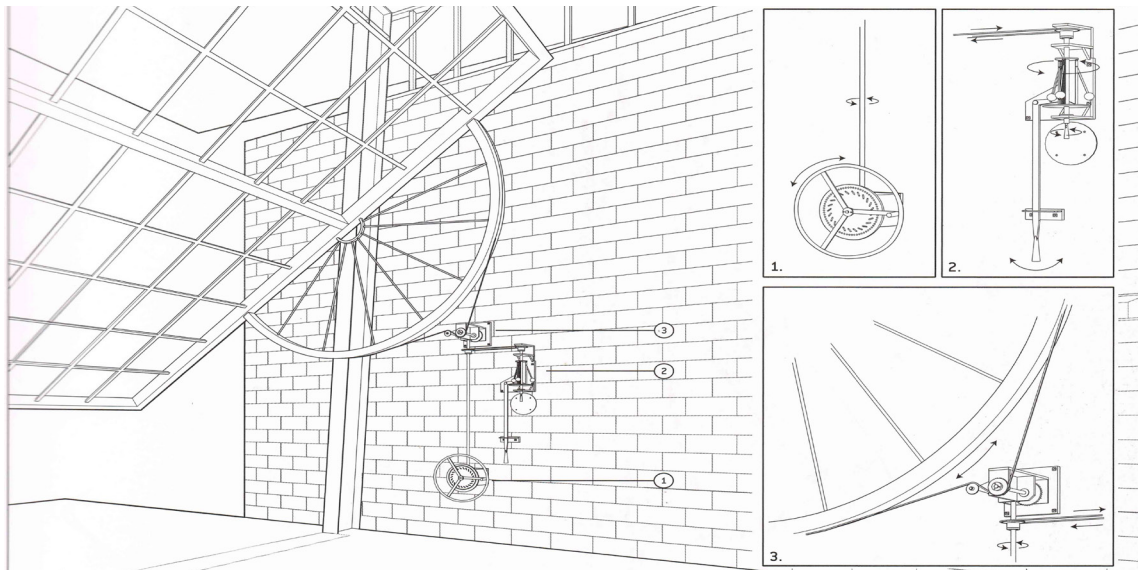


Fig 6.7- Chicken Point Cabin mechanism detail



Fig 6.8- Chicken Point Cabin mechanism

High Performance Centre (HPC) Pretoria

Don Albert Architects, Pretoria University

The High Performance Centre (HPC) in Pretoria is South Africa's lead Performance training centre. Athletes such as Cameron vd Burgh, SA Breaststroke swimmer and former world record holder.

Many athletes use this facility as a training facility. The centre does not receive much attention from traveling athletes as was anticipated. The hotel located on the second floor has closed. The floor is now being re-purposed.

While the centre has similar attributes to my Wits high performance centre it is more focused on the training aspect of high performance athletes. Where the Wits Centres focus lies more on the research and assessment side.

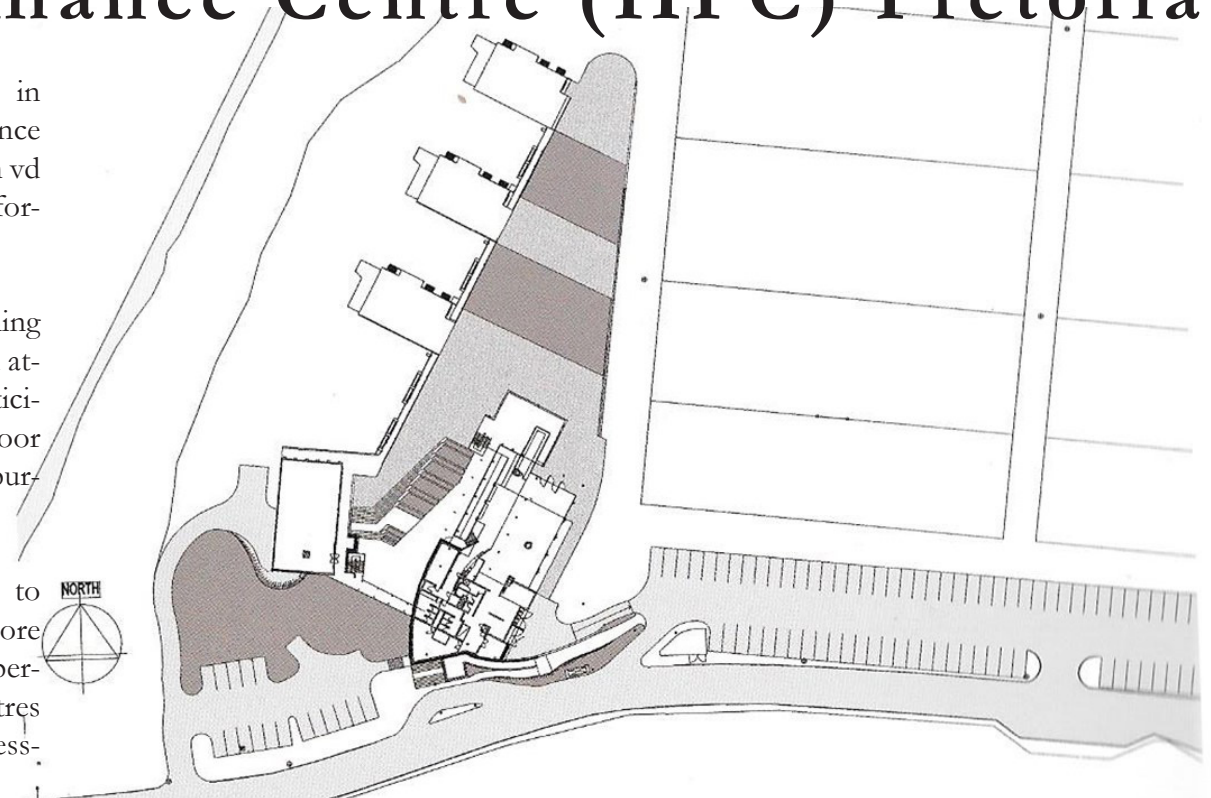


Fig 6.9- HPC Site Plan



Fig 6.10- HPC perspective

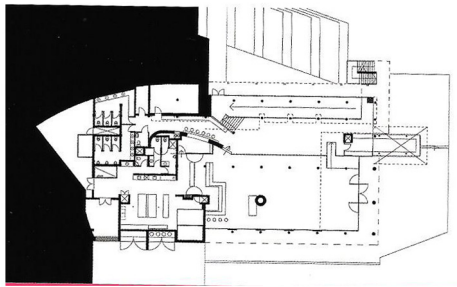


Fig 6.11- Dining Level - Lower Ground

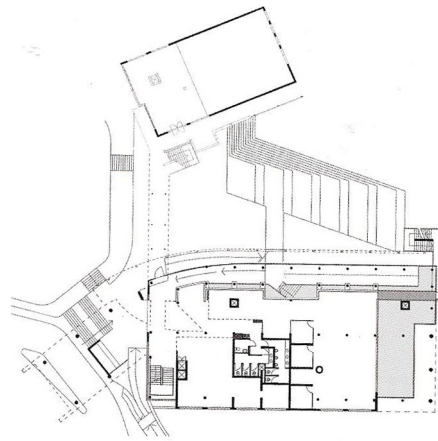


Fig 6.12- Medical Level - Ground

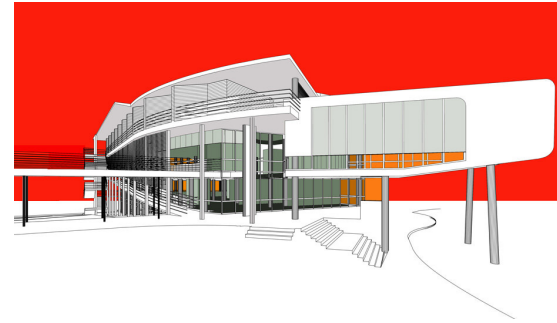


Fig 6.16- HPC render perspective

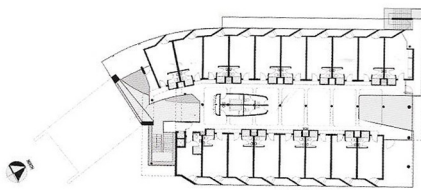


Fig 6.13- Hotel Level - 2nd Floor

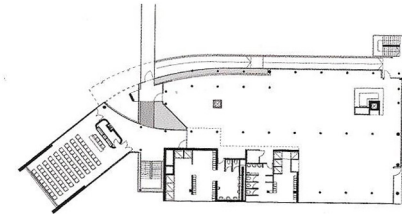


Fig 6.14- Gym Level - 1st Floor



Fig 6.17- HPC render perspective



Fig 6.15- HPC entrance



Fig 6.18- HPC render perspective

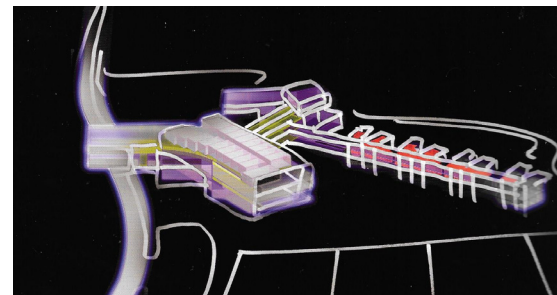


Fig 6.19- HPC concept sketch

Goldring Centre for High Performance

Patkau Architects, Toronto University Canada

The Goldring Centre has been designed to welcome everyone from the university and local community who is interested in physical activity and sport - from students, faculty and staff looking for a great place to work out. As well as international-level student-athletes coming to train, practice and compete.

The Goldring Centre is also used for academic programs, children's programs and camps.

Student and community groups can rent space within the facility for special events.

The 4th floor is dedicated to labs and clinics all focusing on the following.

- Biomechanics & Sport Medicine Lab
- Muscular skeletal health, fitness and performance
- Biomechanics
- Quantitative and qualitative analysis of human movement
- Extreme Human Physiology Lab
- Mechanisms of pathophysiology in chronic disease
- Mechanisms of physiological adaptation to exercise in extreme environments
- Physiological impact of physical activity
- Child and youth

The research program is the aspect of this building which coincides with my thesis the most, The facilities are too extreme and accommodate full time training where the Wits Performance Centre does not.

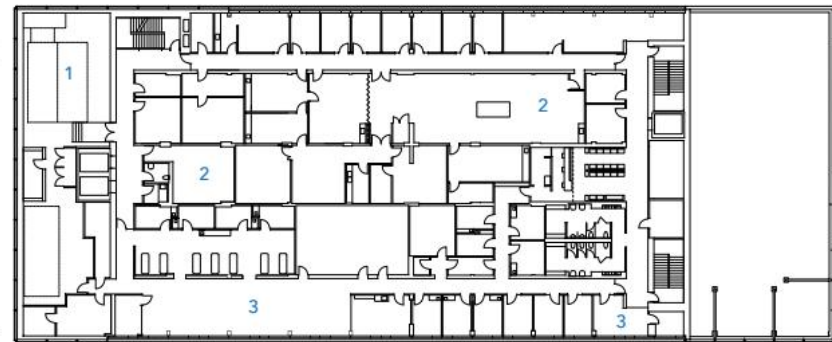


Fig 6.20- 4th Floor- Labs & Clinic

1. Mechanical
2. Sports Research land
3. Sports Medicine Clinic

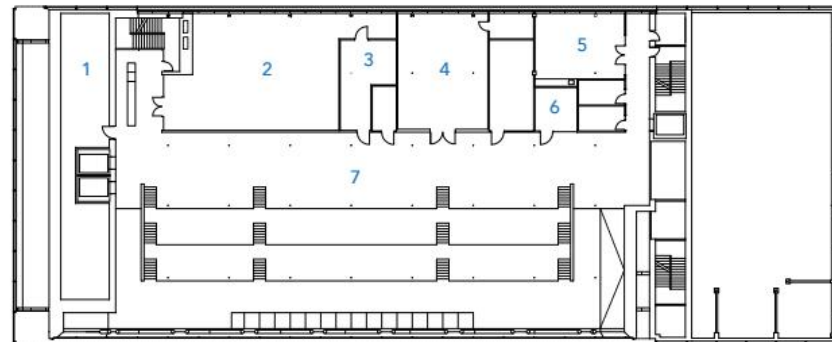


Fig 6.21- 3rd Floor - Strength & Conditioning

1. Mechanical
2. Exercise Studio
3. Storage
4. Weightlifting
5. Multipurpose
6. Office
7. Strength & Conditioning

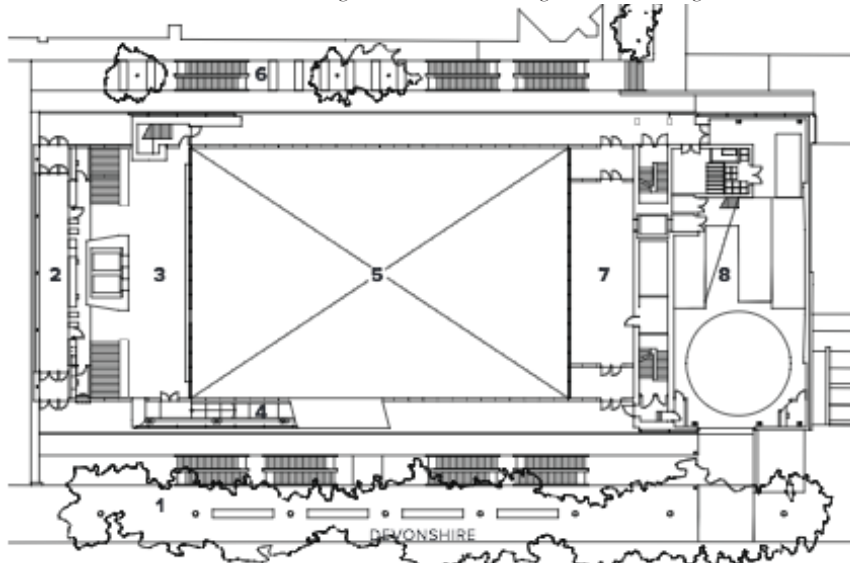


Fig 6.22- Ground Floor

1. Entrance
2. Lobby
3. Lounge
4. Stepped Ramp
5. Open to Field
6. Student Lane-way
7. North Lobby
8. Common Service Bay



Fig 6.23- Goldring Centre exterior perspective



Fig 6.24- Goldring Centre interior perspective



Fig 6.25- Goldring Centre rendered perspective



Fig 6.26- Goldring Centre rendered perspective

WITS Sports centre

TC Architects, Wits Educational campus

Facilities

- Pool
- Rehab gym
- Indoor court
- Rugby Gym
- Hockey fields
- Running Track

Issues

- No flow or organization
- Function is unclear

Needs

- Better flow of patient care
- Upgraded facilities.

Currently the Wits sports centre is a private company which works with the university. The Sports centre currently employs the following (one person per title) Biokineticist, Physiotherapist, Dietitian, Podiatrist, Optometrist.

The centre currently has private treatment for the following conditions. Cardiac disease, High blood pressure, Diabetes, Vascular conditions, Back and neck conditions, Arthritis, Mild neurological impairments.

The Sports centre also manages and monitors the Wits rugby teams health. The rugby team also uses the existing postgraduate gym for strength and conditioning.

The Wits sports centre will be integrated into the High performance Centre and share amenities creating a symbiotic relationship.

Interviewed Staff

Estelle Watson -Sports Medicine Professor

Demitri Constantinou-Adjunct Professor



Fig 6.27- Wits Sports Centre pool entrance



Fig 6.28- Wits Sports Centre perspective



Fig 6.29- Wits Sports Centre hockey field

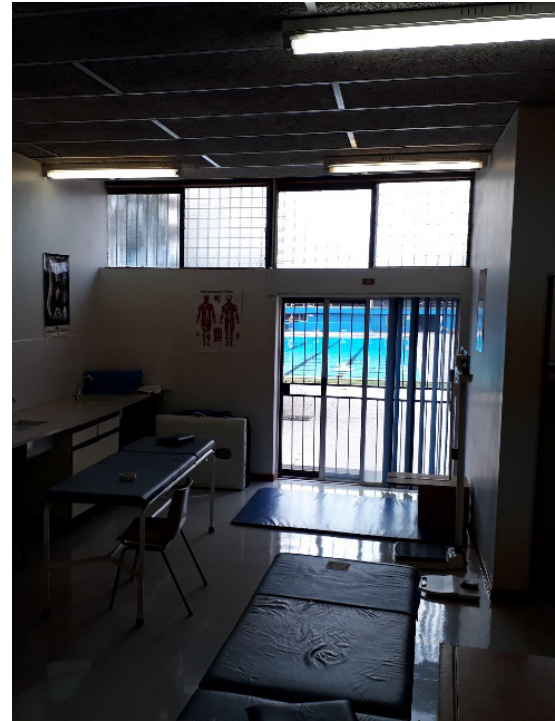


Fig 6.30- Wits Sports Centre biokineticist room



Fig 6.31- Wits Sports Centre site entrance



Fig 6.32- Wits Sports Centre interior perspective



Fig 6.33- Wits Sports Centre gym room

Sydney Brenner Institute of Molecular Biosciences

Herbert Baker, Parktown

In 2014 moved to 9 Jubilee road into a converted heritage home.

Molecular bioscience research
Wits Bioinformatics.

(SBIMB) is a growing multi-disciplinary research institute dedicated to investigating the molecular and genomic aetiology of diseases among African populations.

Biomedical, molecular and genomic research on the African continent.

Conduction innovative research addressing health issues and excel as a centre for learning. Currently the 5 main research areas that the Institute focuses in, those being evolutionary, population and biomedical research. Several projects cut across research areas and promote new research in other areas.

The Institute said their research is geared and the subject matter is driven by funding. An interest in high performance athletes will be possible with the funding from the High Performance Centre

Bio Bank- Accredited for the storing of DNA. The Sydney Brenner currently has a small bio bank storage facility on the property with was previously staff facilities. It is very small and therefore not a pleasant working environment to be in.

A proposal for a new building and location

was done in 2011 for the Institute. Currently due to lack of funding and other interests of more importance to Wits university there has been no traction on this development.

The Role of the Sydney Brenner Institute will be further discussed in the design development chapter.

The Institute also houses Redcap Biomedical informatics.

REDCap is a tool that allows you to create research databases, capture and manage your data and export directly to a stats program of your choice.

Universities and institutions all over the world have signed up to Redcaps database including prestigious universities Oxford and Yale.

Interviewed staff

Michelle Ramsay-Director and research chair

Jocelyn Gayenga-Microbiology

Irma Mare- HD Biomedical Informatics Officer & REDCap Administrator



Fig 6.34- Sydney Brenner Institute perspective



Fig 6.35- Sydney Brenner Institute Biobank



Fig 6.36- Logo



Fig 6.37- World locations

Genomic- personal medicine, DNA that determines how we look and function

Epigenetics-the study of changes in organisms caused by modification of gene expression rather than alteration of the genetic code itself

**Bioinformatics
and
Computational
biology**

Nelson Mandela Children's Hospital

John Cooper Architects, GAPP Architects, Parktown Johannesburg

The NMCH is a public and private referral hospital. They are sent children from both private and public hospitals. These children receive the same level of care and treatment. The hospital has seven departments. The hospital has only just completed its building stage. The hospital is opening in phases with currently on Oncology operating as of 30th August 2017. The hospital is a teaching hospital with WITS medical students doing their service in this hospital.

The hospital was inspired by Nelson Mandela and aims to continue his legacy of love and care for children.

I shall speak more about the role of the hospital in my design development section as the building neighbors my site. It shares parking as well as direct access onto my Performance Centre.



Fig 6.38- NMCH perspective

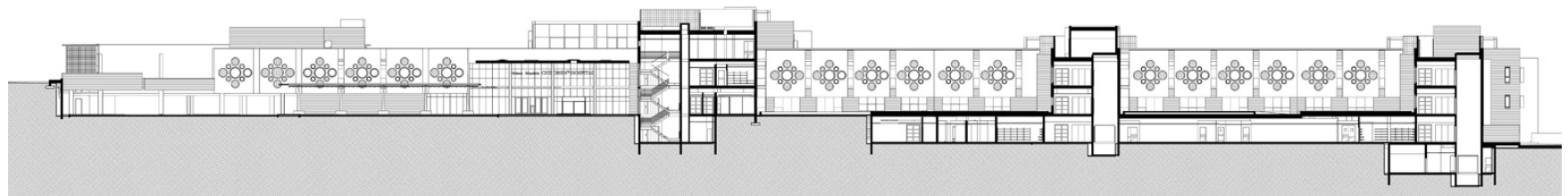


Fig 6.39- NMCH section



Fig 6.40- NMCH Site Entrance

Our Centres of Excellence



Fig 6.41- NMCH

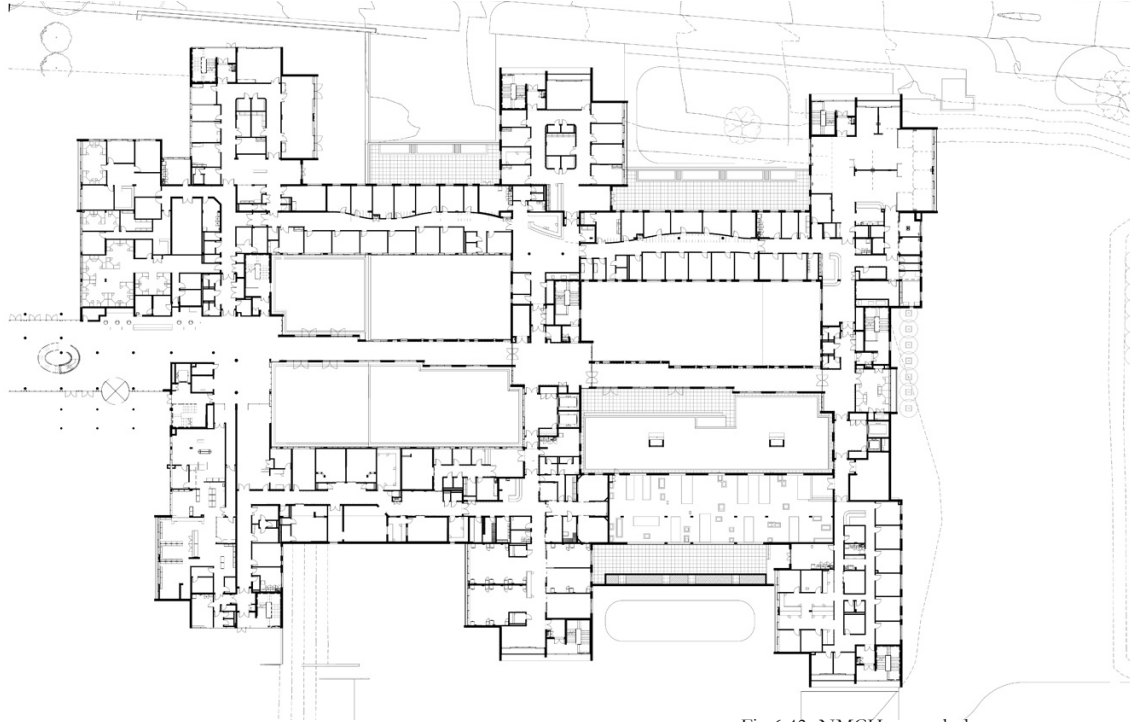


Fig 6.43- NMCH general plan



Fig 6.42- NMCH interior entrance perspective



Fig 6.44- NMCH exterior perspective

Center for Environmental and Life Sciences (CELS)

SLAM Architects, Monte Clair State University



Fig 6.45- Environmental laboratory

Monte Clair State University's CELS centre consists of two main laboratory levels, It is a cutting edge facility and a leader in its field of research. Although the research subject matter differs from my research centre. However the laboratory layout and sizing is still very relevant and gives a professional understanding a laboratory design layout.

Geodynamics Laboratory - Study of the earths surface

Remediation Laboratory - Study of the quality of soil.

Earth Systems Laboratory - Study of environmental changes due to human activities.

Pharmaceutical Incubator Laboratory - Study of a variety of diseases, with flexibility to respond to emerging clinical needs.



Fig 6.46- Life Science Laboratory

Biodiversity / Ecology Laboratory -

Aimed at highlighting the importance, protection, and status of biodiversity and ecology in terrestrial, freshwater, and marine ecosystems. This research is mainly on water, soil, rock and plant matter at a cellular level.

Natural Products Laboratory -

Focused on studying the properties of compounds that occur naturally in various plants and organisms such as green tea, algae, and others, using approaches from microbiology, virology, biochemistry, and chemistry.

Medicinal Chemistry Laboratory -

Particular medicinal compounds used in treating disease. Studies include how enzymes speed up chemical reactions in the human body, focusing on those enzymes that are important targets of pharmaceutical inhibitors (drugs).

Chapter 7

Design Brief

Buildings function

Structure

Project Definition

Project Brief

Vision

Mind Maps

Research Flow Chart

Goals

Benefits

Research And Academic

Summary Chart



Project Definition

The High performance centre will serve multiple purposes that will have a clear and definite long-term impact on the provision of specialist sports research and conditioning. The creation of the centre will attract and retain high quality staff in the medical and sporting field, many of which are currently in short supply in Southern Africa. The Centre will also enhance the South Africa's image and identity to attract referrals and serve the needs of athletes from around the world.

Project Brief

The Centre will function and excel in four disciplines. The first being high performance sport assessments and testing where elite athletes will come to the centre from around the globe. They will undergo testing analyzing their bodies and technique. They may have strength and endurance testing, stroke analysis for swimming, breathing analysis with oxygen input and output results. Athletes may want to see how their body reacts simulated different climate conditions as they may be traveling to a destination around the globe with different climate conditions. The Centre is there to maximize an athletes potential where he/she can take the knowledge gained and apply it to their training. Athletes may also come to the centre for an assessment on recovery post an injury in order to heal in the fastest time and best manner.

The second discipline of the Centre is research which will go hand in hand with the assessments and testing. Research may be done on Asthma for example as Olympic gold medalist South African swimmer Cameron Van der Berg suffers from Asthma. All research will be processed through the Sydney Brenner Institute of Biological Research and will be uploaded on Redcap a data sharing database with over 250 institutions members including the most prestigious universities in the world such as Harvard and Oxford.

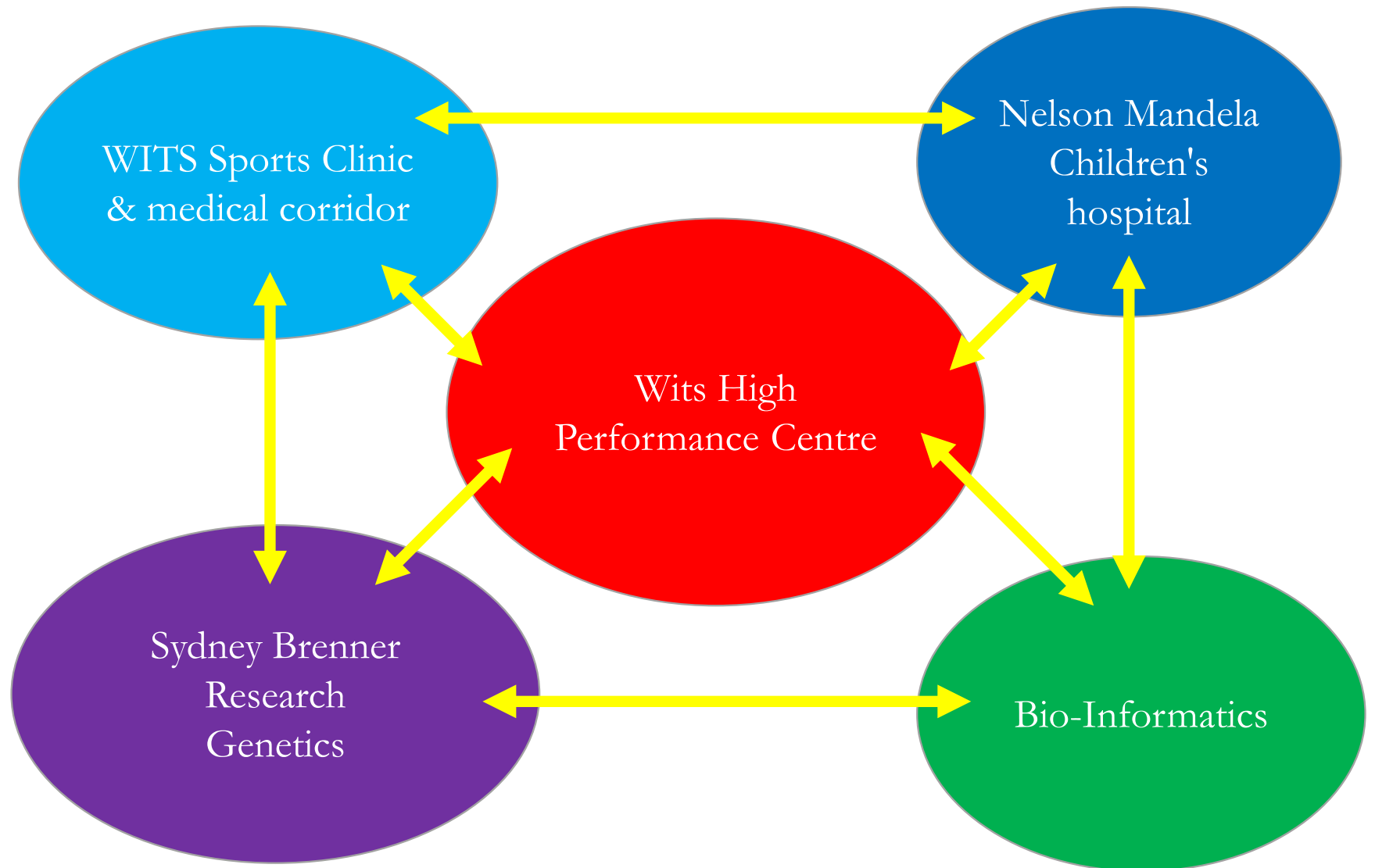
The third discipline is education as the Centre is on Wits campus. Postgraduate students will be interning as well as students doing their PHD through the institution. All specialists who choose to work at the facility will take students under their wing and be mentors to them in so excelling the stand of education.

The fourth discipline is Outreach where the centre gives back to the community and surroundings. The Nelson Mandela Children's hospital is directly next to the site and the Performance centres facilities will be available to use if required by the hospital staff. The Profound sportsman and woman who come to the centre will be encouraged to visit the children's hospital or have children coming to the centre as a chance to meet their hero putting a smile on the children's face who are in the hospital.

Vision

The Wits High Performance Academic Research Sports Centre will provide cutting-edge sports analysis through clinical and medical research within the centre by sharing skills and expertise with like-minded facilities worldwide. The Performance centre will be a world-class, high-tech facility with advanced know-how in an environment suited for professionals and learning students.

Connection Mind Map



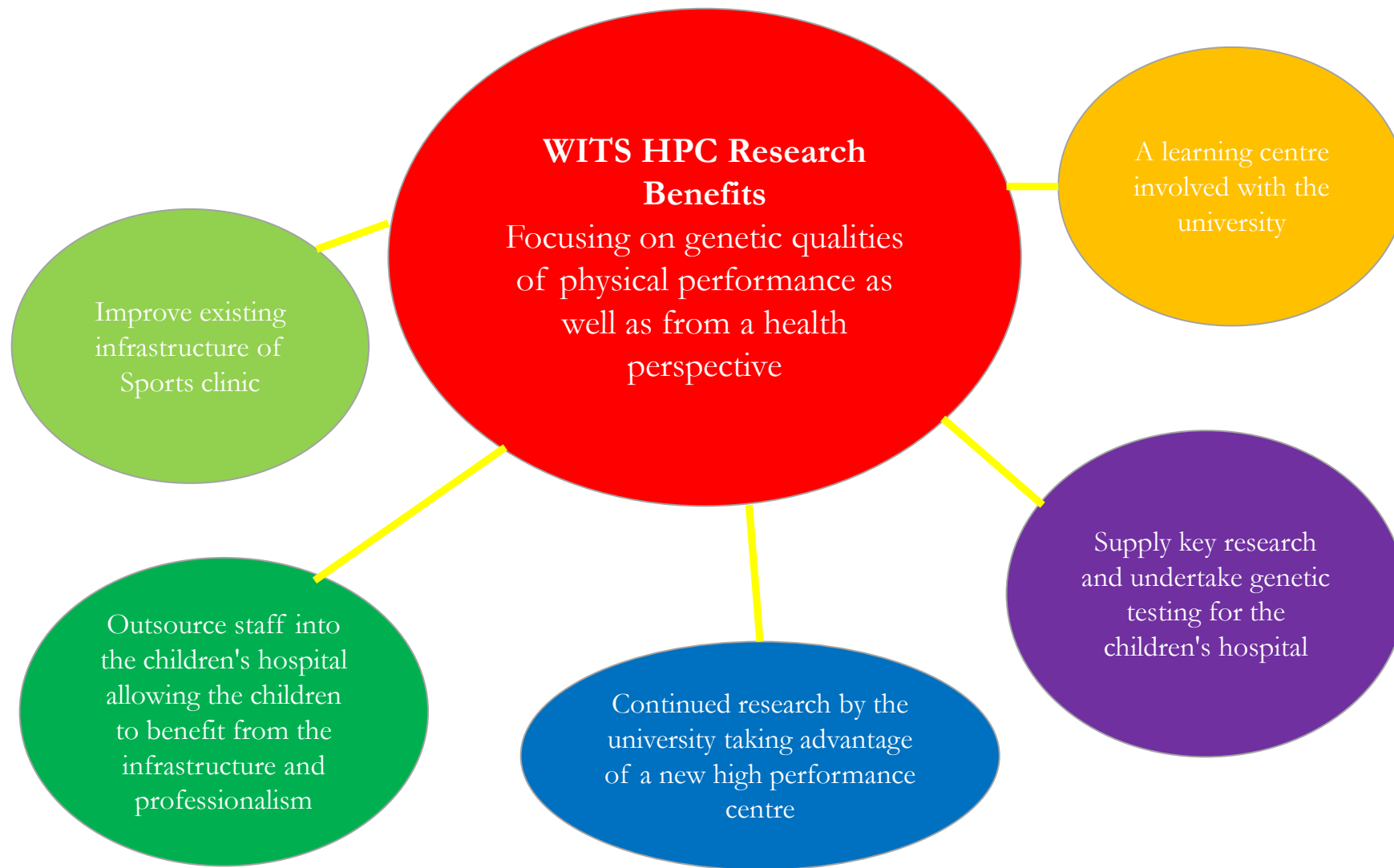
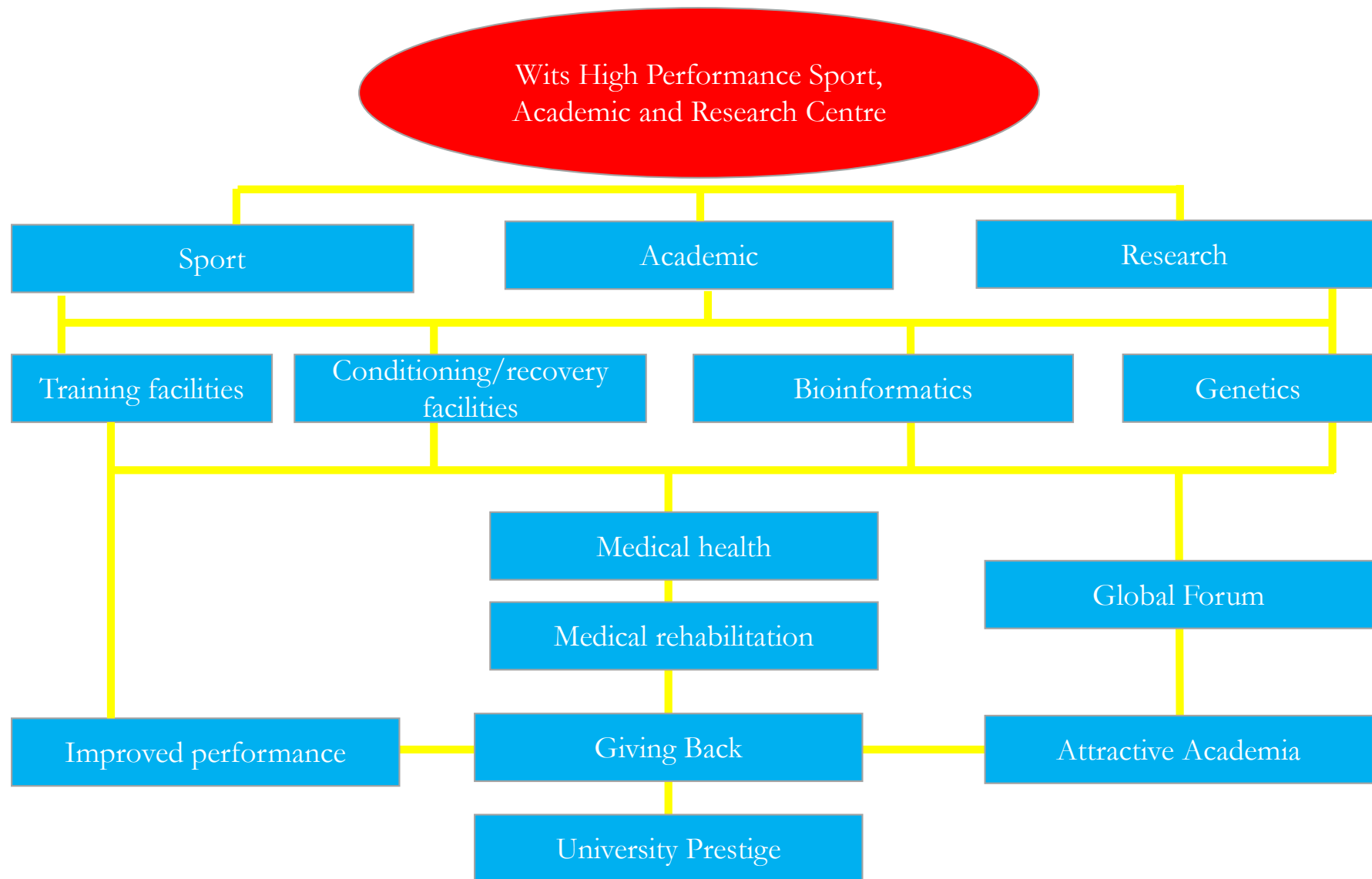


Fig 7.2- Research Mind Map

Research Flow Chart



Goals

Research and teaching

- Locating the Centre on an academic institution to assist in attracting staff and sharing resources.
- Ensuring that the main research programs are closely linked to the clinical specialties.
- Ensuring that the Centre is a hub for specialist skills development in medical, sport research and allied fields.

Staff

Training and provision of qualified staff in required field.

Benefits

The clients will benefit in the following manner:

- The Centre will be a dedicated high performance research facility
- Specialized qualified staff and support staff
- Excellent professional level of care

The academics will benefit in the following manner:

- There will be a centralized location for sport research sub specialties
- There will be interdisciplinary and collabora-

tive clinical excellence

- The facility will attract and retain high quality staff in medical, sporting, and allied disciplines
- Post graduate clinical training for students both full time and on rotation from other academic medical centres
- The facility will support high quality medical education to create the medical surgical sub-specialty practitioners of the future
- The facility will generate opportunities for medical and sporting clinical research

The health and sports sector will benefit in the following manner:

- International interest and involvement will be attracted
- Efficient operational practices
- Additional production of qualified medical professionals
- Raising the standard of the Wits University education

Benefits to investors

Most importantly, this project offers the opportunity to both donors and sponsors to play an integral part in the Wits High Performance Academic Sports Research Centre lasting legacy and to significantly impact the

sports research system in South Africa as well as around the world. An investment in the centre helps the broader community and will also enhance the potential investors' community and business image. There has already been a significant investment in this project with a wide array of experts and consultants having been brought on board to ensure not only the feasibility of the project but also the sustainability of the High Performance Centre into the future.

Research and academic

The Wits High Performance Academic Sports Research Centre will be integrated into the platform of teaching and research of the University of the Witwatersrand. The Sydney Brenner Institute of Molecular Bioscience is across the road and facilities for research within the Centre include a full time director of research as well as areas designated for research activities. A research protocol will be developed, to identify all clinical focus areas to be addressed.

The home for research is in the university, and as the facility is based on the grounds of a university with an open door to the Sydney Brenner research centre, this contributes to the demographic positioning for this as a Centre of high performance.

Summary Chart

High Performance Academic Research Sports Centre



Chapter 8

Business Plan

Implementation into the real world

Structure

Company Structure

Leadership & Decision-Making

Feasibility Study and Findings

Fundraising & Marketing

Financial Management

Capital Funding

Sponsor Objectives

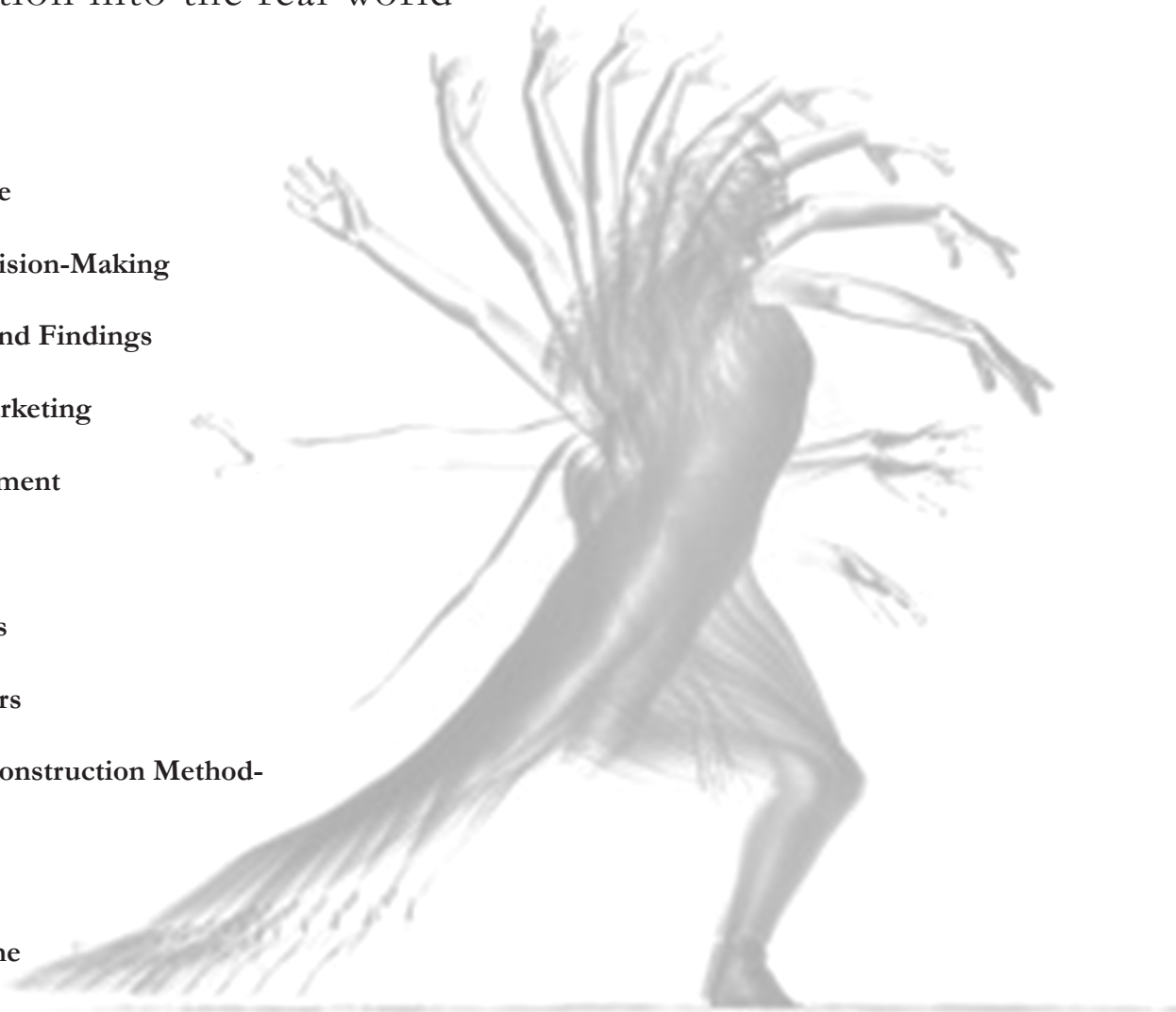
Key Success Factors

Contracting and Construction Methodology

Project Costs

Operational Income

Operational Expenses



Company Structure

The structure of the Wits High Performance centre will be a NPO as the main aims of the centre are to promote physical excellence as well as provide advances in research and give back to the less privileged. Wits shall own the building and set up the trust as the initiator and custodian of the

Project, with an Asset Company (AssetCo) and Operating Company (OpCo) set up as not-for-profit organizations that will manage the assets and operations respectively. The Asset Company will be run by the university within its portfolio of buildings and land. The Non-Profit Company will be formed under Section 21 of the Companies Act 78. Of 2008.

Some of South Africa's most prominent and influential clinical, philanthropic and Business leaders sit on the board as politicians have strong connections in government and a sports representative such as Ryk Neethling (Olympic Gold medalist) has sporting connections around the world and is also advantages for advertising. The Nelson Mandela Children's Hospital, Sydney Brenner Research Institute, Wits medical and Wits sports clinic all get a seat on the board as they are direct beneficiaries of the building and will also be using the building.

Leadership & Decision-Making

All-important decisions will be made by the board. The CEO and CFO will make all the day to day running decisions with employed managers and staff members below them. This is because they are the only members on the board who work for the company full-time. Even though the centre is an NPO it was important to have a full time CEO and CFO as the company needs to be run efficiently and there are large volumes of cash flow within the business.

Feasibility Study and Findings

Representatives of the Performance Centre, visited both local and international similar centres to identify the successful components that could be relevant to a high performance academic sports research centre in South Africa. Locally the HPC in Pretoria was looked at as well as SAS (Stellenbosch Academy of Sport). Internationally the Goldring Centre for High Performance at Toronto University, Canada was reviewed at amongst others. The feasibility study also showed the suitability of the High Performance Centre in its location (Wits Educational Campus) due to the surround facilities which would hugely benefit from the Centre, as the Centre would benefit from the surrounding facilities creating a symbiotic relationship.

Fundraising & Marketing

The success of the project relies heavily on the ability to raise funds as well as market the project. A fundraising Consultant will work on behalf of the NPO to help attract funds for the development to the Centre. The consultant shall work hand in hand with a The Creative Council, an expert marketing company based in Johannesburg. Marketing will be in constant need even once the centre is complete and operational as to continue to attract world renowned athletes and build the brand and continue to raise the standard of the Performance Centre, making it remain a world leader in high sports performance and research.

Financial Management

Investec shall manage the investment portfolio of the Performance Centre, investing the profits of the Centre. Investec will also supply bridging debt finance to the centre if needed. Investec have shown great interest in the Centre as they see it will fit in very well with some of their other ventures such as the Investec brand is heavily associated with test cricket.

Capital Funding

The Capex component is expected to be raised primarily through sponsor funding, with the Wits High Performance Centre board working to secure funding from a broad range of both local and international institutional and private sources. The Capital funding requirements of this NPO will be structured in the following manner. Wits will pay 20% of the capex as they are the owners of the centre and also owned the land and therefore there was no land acquisition cost. 20% will be funded the prime sponsor Bidvest which include a structured contract of the naming of the sports centre. (Bidvest Wits High Performance Academic Research Sports Centre) as well as other benefits. 10% will come from the national

lotto as the Centre is seen as an academic institute which will benefit South Africa. 30% will come from secondary sponsors, corporate companies who want to associate their brand with the centre as well as also receive benefits. Marketing and advertising utilizing sports persons of global statue is a key role in getting these large corporate sponsors. The final 20% will come from an international company as a strategic move to help market the centre internationally and get more exposure. Any shortfall in the Capex requirement from donor funding will be covered through bridging debt finance obtained from development finance institutions (DFI). Investec has already been approached and has indicated their appetite for the project.

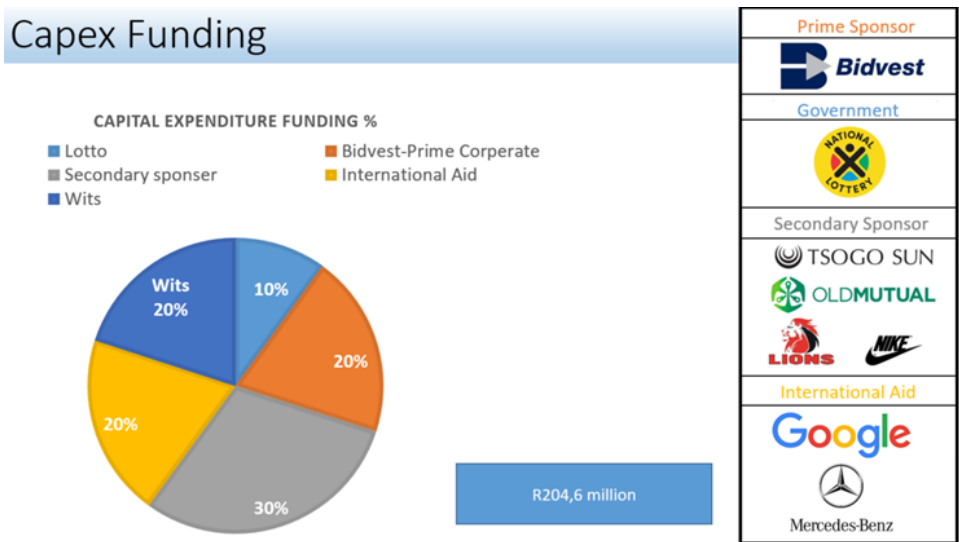


Fig 8.1- Capex Pie Chart

Sponsor Objectives

It is Important that sponsors that support the High Performance centre receive due recognition, that such recognition is consistent with the level of giving, is applied equitably and within the framework of the Centres capabilities.

The further objectives of sponsors are.

- Cultivate lasting relationships with existing sponsors and to encourage them to achieve higher levels of giving
- Attract new sponsors and act as a legitimate incentive and reward to attract and retain sponsors
- Ensure that the broad principles of fairness and consistency prevail in exercising sponsor recognition
- Ensure that all actions and decisions concerning sponsor recognition occur within a framework of the Centre.

Sponsor Recognition Methods

- Granting naming rights
- Allocating a special awards for large sponsorships.
- Granting an Award for gifts-in-kind or donations specifically towards training and research
- Membership Pin and branded jacket, shirt, etc.
- VIP invitation to special annual events
- Inclusion on the Centres' newsletter mailing list
- Providing website linkage to the Centres' website
- Providing tax benefits as prescribed by law
- Plaques, Murals, Media exposure
- Name included on donor board

Key Success Factors

- Academic support from Wits University and other institutions
- Commitment, support and operational funding from sponsors
- Land allocation from Wits University
- Donor funding for capital building and equipment
- Debt funding for any shortfall in capital required for building and equipment
- Iconic sports persons support

Procuring an operator that will take responsibility for ensuring:

- Specialists commitment and availability
- Support staff commitment and availability
- Efficient operational control
- Renewal and maintenance of assets
- A supportive and mutually beneficial work environment for International academic support and affiliations as well as Academic research and publication

Contracting and Construction Methodology

Negotiated tender with group 5 as they have the capabilities of upholding the building standard of a specialized building in the medical sector. Group 5 just completed the Nelson Mandela Children's hospital costing R1 billion for phase 1 (238 bed facility) giving the High performance Centres board conference in group 5s ability to deliver a successful project both on time and up to standard. An independent QS will be appointed by Wits to also do accurate costing to compare with the amount quoted by group 5.

The contract will be a managed contract where the client shall appoint an independent project manager who shall co-ordinate the project. This contract is chosen due to the complicated nature of the project. It allows for the large amount of specialist consultants needed to inform the project. This contract also allows for a better management of costs. The Managed contract will be taken out the JBCC.

The project will be a single phase project. However it may allow for additional development in the future as to what further requirements the building needs to meet. A portion of the monthly profits will be put aside for such developments.

The construction method of the building will be steel and concrete with brick infill with large e-coated glass to give the building a modern architectural design and feel. The main contractor group 5 would also be apportioned a fee to hire a construction-training consultant, to improve the skills of the participatory members of the community, to reach a level of quality workmanship for

the required brief. The skills training would be performed in advance of the proposed building program; so that participators are prepared at the time that their skills would be incorporated. The structure and complicated construction will be done by group 5 with their own trained workers. The project manager would be required to ensure that the objectives of the brief are adhered to, in terms of set money



Fig 8.2- Flow Chart

Projected Project Cost						
	Quantity	Singular Area	Total	Cost per m²	Total Cost	Section Cost
Administration						
Standard Executive offices	3	20	60	R14 000,00	R840 000,00	
Standard Open plan office	1	100	100	R12 000,00	R1 200 000,00	
Prestigious Board Room	1	30	30	R14 000,00	R420 000,00	
Security Office	1	20	20	R11 000,00	R220 000,00	
			210			R2 680 000,00
Performance Rooms						
Medical Research Labs	4	150	600	R22 000,00	R13 200 000,00	
Consultant Offices	4	20	80	R15 000,00	R1 200 000,00	
Indoor 25m Pool + Resistance Pool	1	600	600	R40 000,00	R24 000 000,00	
Observation Rooms	4	50	200	R12 000,00	R2 400 000,00	
Assessment Rooms	4	100	400	R12 000,00	R4 800 000,00	
			1880			R45 600 000,00
Retail						
Restaurant	1	400	400	R160 000,00	R64 000 000,00	
			400			R64 000 000,00
Public Amenities						
Entrance Foyer	1	150	150	R15 000,00	R2 250 000,00	
Reception	1	20	20	R10 000,00	R200 000,00	
Library	1	150	150	R15 000,00	R2 250 000,00	
Auditorium	1	300	300	R35 000,00	R10 500 000,00	
			620			R15 200 000,00
Service Amenities						
Bathrooms	5	30	150	R6 000,00	R900 000,00	
Change Rooms	2	50	100	R6 000,00	R600 000,00	
HT Room	1	20	20	R2 000,00	R40 000,00	
LT Room	1	20	20	R2 000,00	R40 000,00	
Generator Room	1	20	20	R2 000,00	R40 000,00	
Storage	3	40	120	R2 000,00	R240 000,00	
General Circulation	1	300	300	R16 000,00	R4 800 000,00	
			730			R6 660 000,00
Parking						
Staff Parking	0			Use existing Wits parking		
Public Parking	0			Use Existing Nelson Mandela Children's Hospital Parking		
						R0,00
Total building cost						R128140000,00
Total property/land cost:						R0,00
Professional Fees Cost						R5 541 246,92
Total holding cost:						R185681246.9

Fig 8.3- Projected costs table

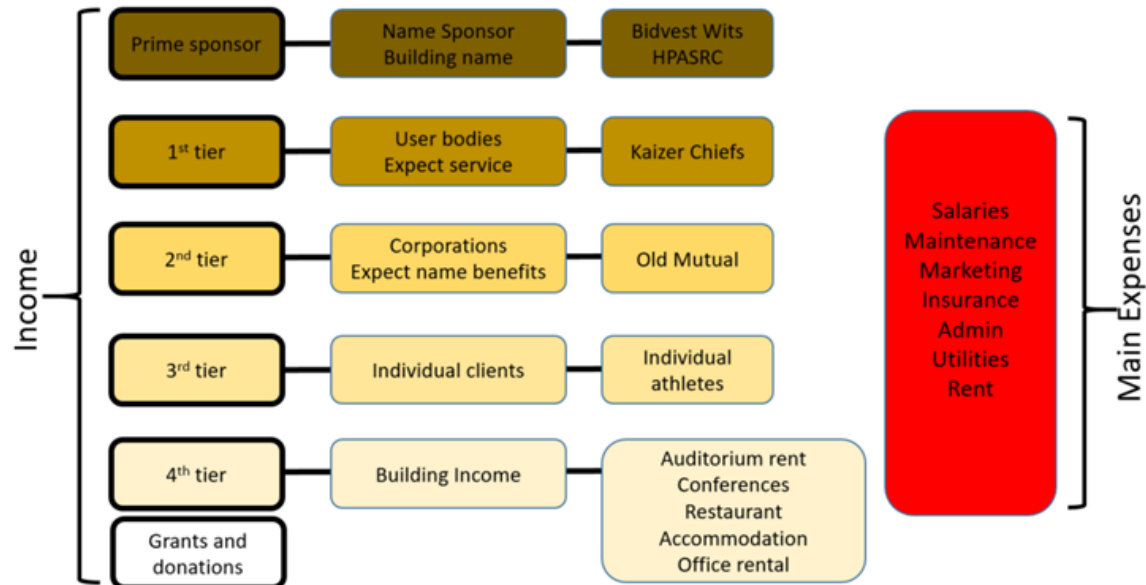


Fig 8.4- Income Chart

Operational Income		
Source	Monthly Income	Annual Income
Prime Sponsor	R200 000,00	R2 400 000,00
1st Tier (User Bodies)	R1 000 000,00	R12 000 000,00
2nd Tier (Corporations sponsor)	R200 000,00	R2 400 000,00
3rd Tier (Individual Clients)	R150 000,00	R1 800 000,00
4th tier (Building Income)		
Auditorium Rent	R15 000,00	R180 000,00
Restaurant	R450 000,00	R5 400 000,00
Specialists Rent	R25 000,00	R300 000,00
Specialists Commission	R30 000,00	R360 000,00
Accommodation	R100 000,00	R1 200 000,00
Conferences	R50 000,00	R600 000,00
5th Tier(Grants and Donations)	R200 000,00	R2 400 000,00
Total Income	R2 420 000,00	R29 040 000,00

Fig 8.5- Operational Income Table

Projected Operation Costs				
Salaried Staff				
	Quantity	Salary per month	Total Fee Per Annum	Section Cost
Administration				
CEO	1	R200 000,00	R2 400 000,00	
CFO	1	R140 000,00	R1 680 000,00	
Managing Director	1	R120 000,00	R1 440 000,00	
Marketing Director	1	R90 000,00	R1 080 000,00	
Auditor	1	R50 000,00	R600 000,00	
Secretary	1	R12 000,00	R144 000,00	
Researchers	5	R20 000,00	R1 200 000,00	
Subtotal	11			R8 544 000,00
Public Amenities				
Receptionist	1	R16 000,00	R192 000,00	
Librarian	1	R22 000,00	R264 000,00	
Subtotal	2			R456 000,00
Service Amenities				
Cleaners	3	R7 000,00	R252 000,00	
Maintenance manager	1	R25 000,00	R300 000,00	
Landscaping services	1	R15 000,00	R180 000,00	
Subtotal	5			R732 000,00
Building Overheads				
		Per Month	Annual Fee	
Electricity		R60 000,00	R720 000,00	
Insurance		R100 000,00	R1 200 000,00	
Water		R30 000,00	R360 000,00	
Telecommunications		R30 000,00	R360 000,00	
Marketing		R100 000,00	R1 200 000,00	
Restaurant		R250 000,00	R3 000 000,00	
Other general maintenance		R40 000,00	R480 000,00	
Subtotal		R610 000,00		R7 320 000,00
Total Salary Costs	Per month:	R811 000,00	Per Annum:	R9 732 000,00
Total Building Overheads Cost	Per month:	R610 000,00	Per Annum:	R7 320 000,00
Total Building Operational Cost	Per month:	R1 421 000,00	Per Annum:	R17 052 000,00

Chapter 9

Conceptual Development

Implementation into the real world

Structure

Concept

Biomimicry

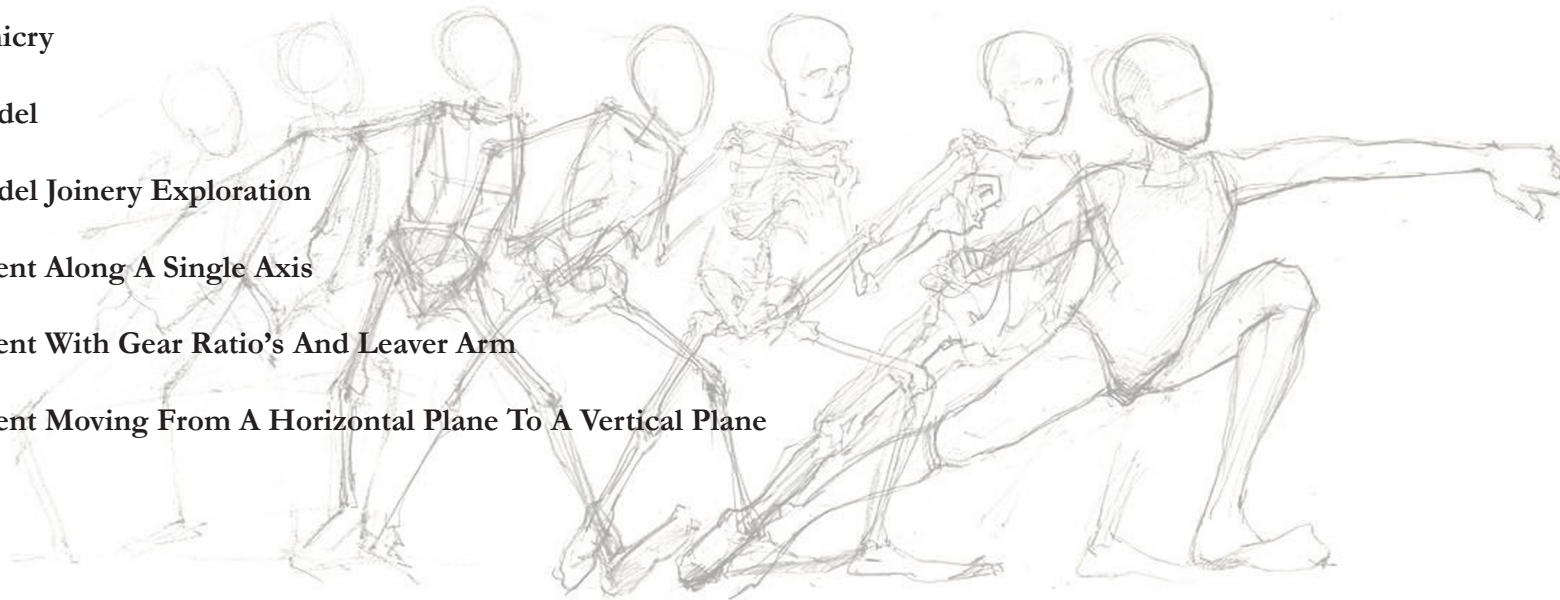
Site Model

Site Model Joinery Exploration

Movement Along A Single Axis

Movement With Gear Ratio's And Leaver Arm

Movement Moving From A Horizontal Plane To A Vertical Plane



Concept

The program and function of my building was driven by my site selection. Through research of the functions and attributes of my building program common themes began to appear. I was always drawn to the human body as a reference point as my Centre promotes high performance in athletes.

I zoomed in on the human body and started to understand and appreciate the body at a cellular level. Understanding the forces and architectural make up of muscles which determine force output was fascinating.

Our bodies are organic but when we look with more detail and understand how muscles and bones work, we find mechanical systems. Bone density, muscle fiber density, joints connections, are just a few aspects of the human body which can be explained using quantifiable mechanics.

We look at prosthetics, a mechanical representation of human body components. My exploration with gears gave me a better understanding of the mechanics and how they work.

Through this understanding i came to realize I had always viewed the relationship between man and machine backwards.

The human body is the most advanced out the two. We are now only using methods like biomimicry to advance structural design. This is when we imitate nature and apply it to creates new materials or methods of construction and structural designs.

The human body is not just singular components but a 200 000 year old reworked biological machine. All the components in our body work together to create perfection. Our bones are the skeletal structure and our muscles are the moving parts and our skin is the facade of this machine.

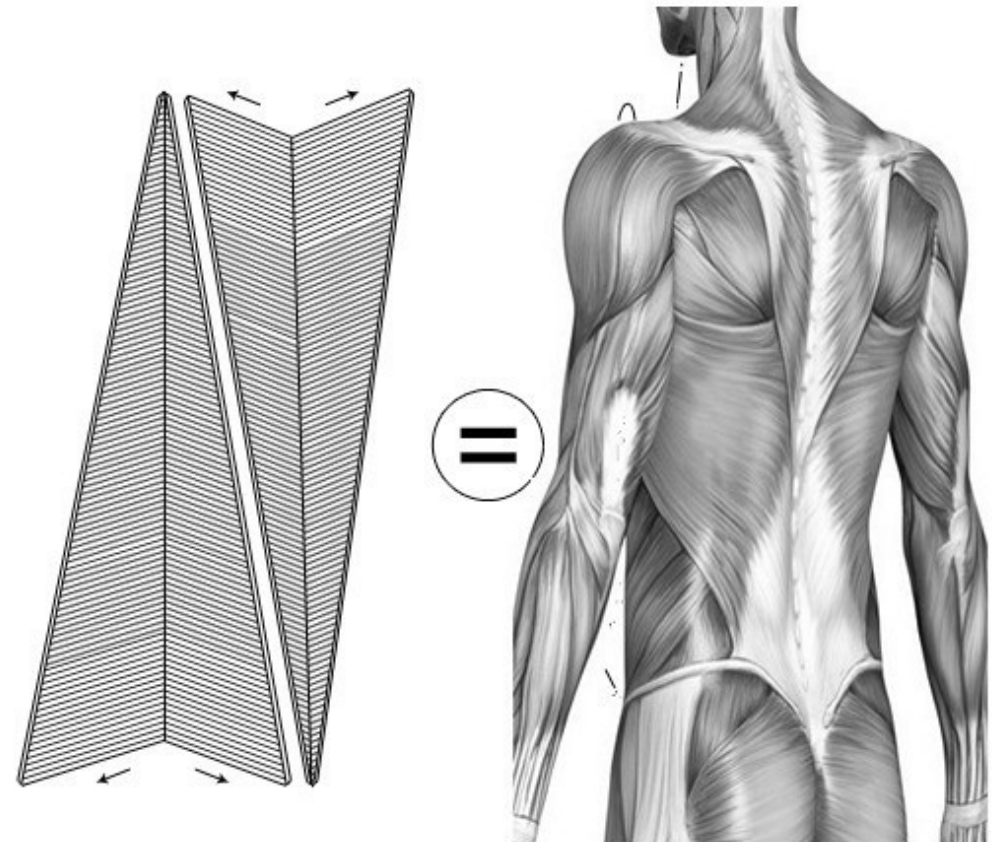


Fig 9.1- Muscle Structure

Mechanical ideas from the natural

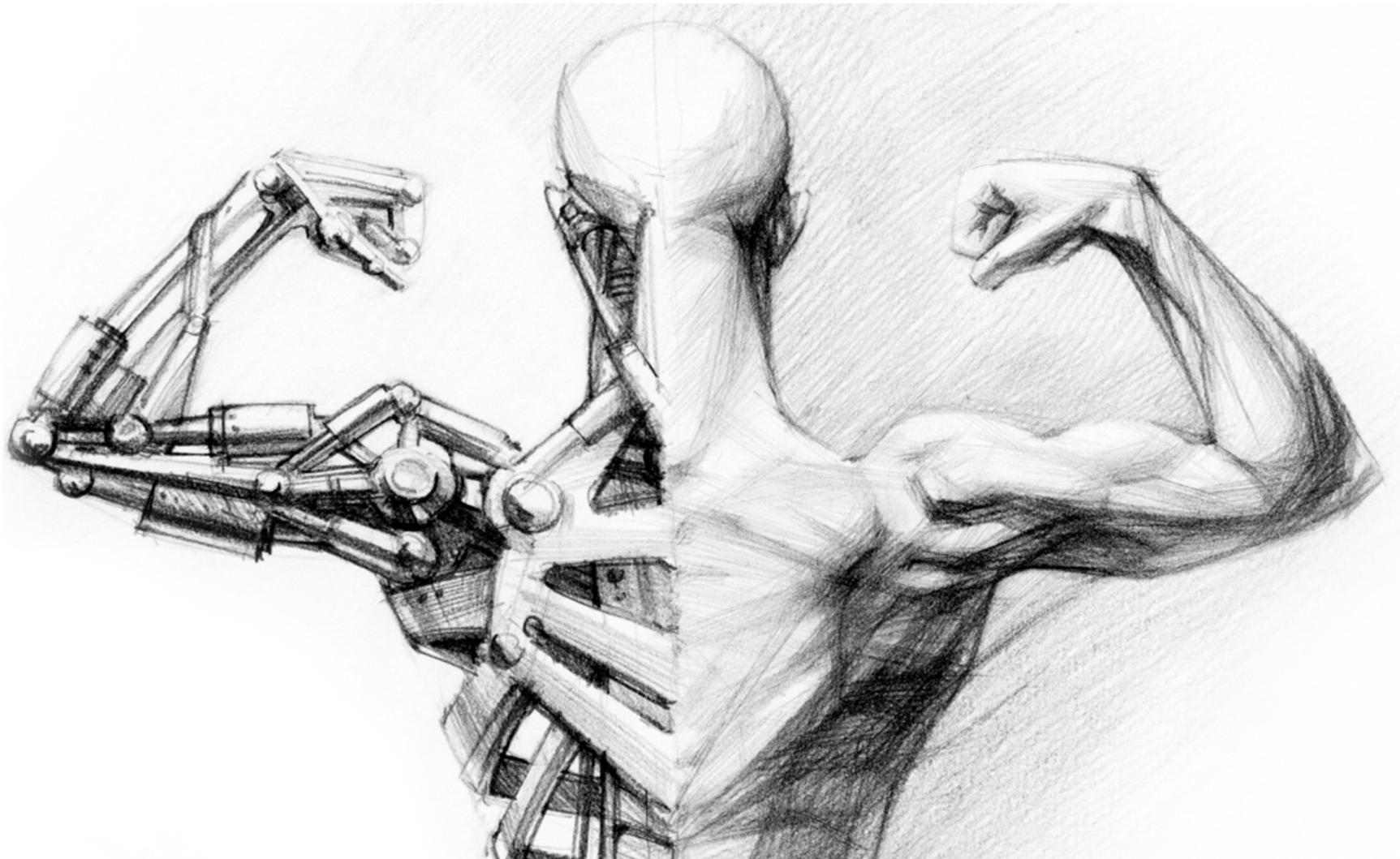


Fig 9.2- Mechanical and Natural

Biomimicry

Biomimicry is the imitation of systems and elements found in nature, and applied for the purpose of solving complex human problems. Quick examples being ultra-strong synthetic spider silks, adhesives modeled after gecko feet, and wind-turbine blades that mimic whale fins.

According to Niewiarowski a biologist at the University of Akron Biological systems solve problems very differently to engineered systems. Engineered solutions can be crude and additive, relying on using more materials or energy. The natural world relies on unique geometry and material properties. (Mortice 2016)

There are Three levels of biomimicry
The organism level
Behavior level
Ecosystem level

Biomimicry in Architecture

Organism level

On this level architecture looks to the organism itself, we then apply its form and/or function to a building.

Norman Foster's Gherkin Tower (2003) has a hexagonal skin inspired by the Venus Flower Basket Sponge. This sponge sits in an underwater environment with strong water currents and its lattice-like exoskeleton and round shape help disperse those stresses on the organism. (Ehsaan 2010)



Fig 9.33- Gherkin Tower

Behavior level

On this level, the building mimics how the organism interacts with its environment to build a structure that can also fit in without resistance in its surrounding environment.

The Eastgate Centre in Harare, Zimbabwe designed by architect Mick Pearce in conjunction with engineers at Arup Associates is a large office and shopping complex. To minimize potential costs of regulating the building's inner temperature Pearce looked to the self-cooling mounds of African termites. The building has no air-conditioning or heating but regulates its temperature with a passive cooling system inspired by the self-cooling mounds of African termites. The structure however, does not have to look like a termite mound to function like one and instead aesthetically draws from indigenous Zimbabwean masonry. (Doan, 2012)

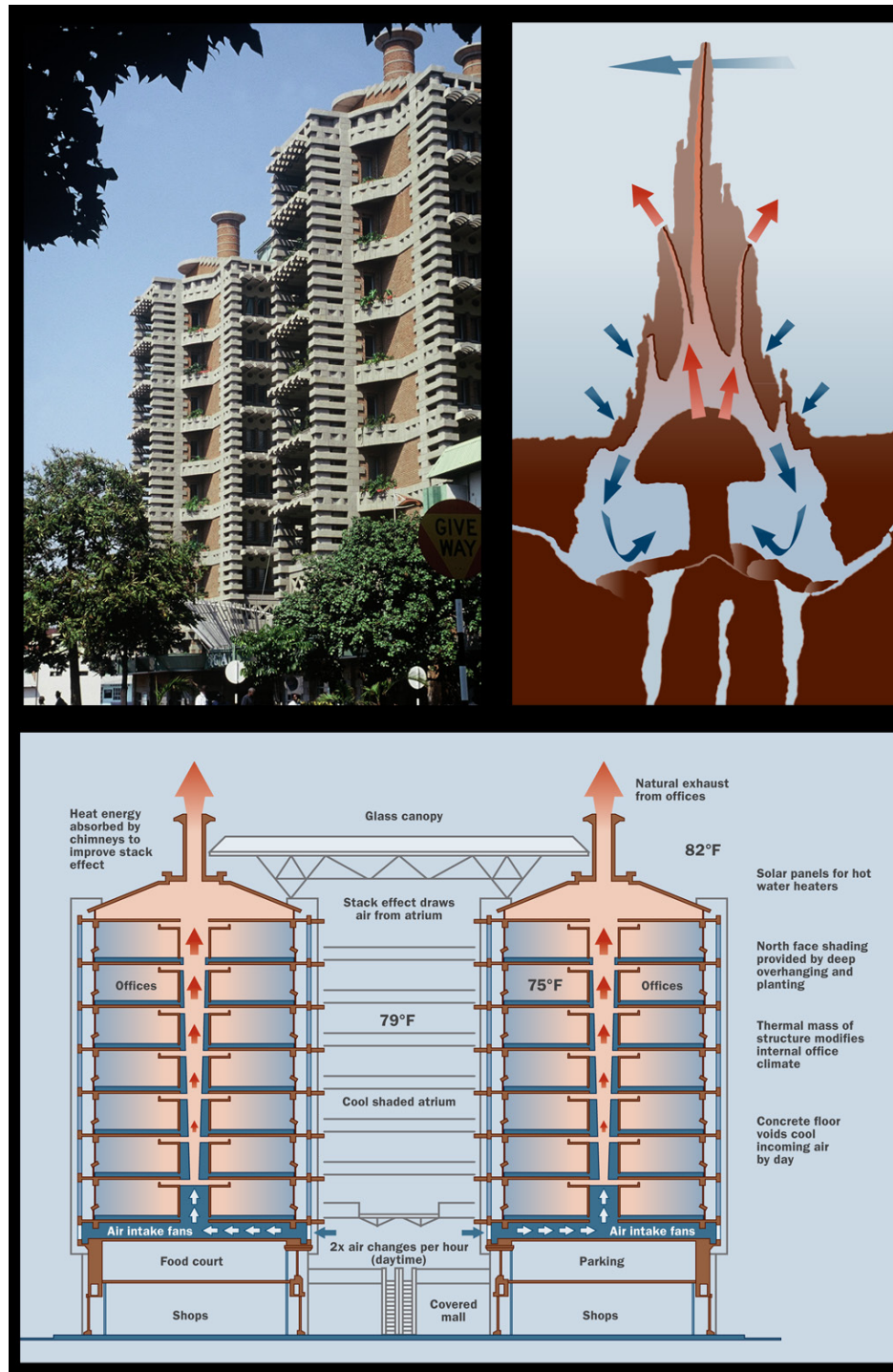


Fig 9.34- The Eastgate Centre

Ecosystem level

This level involves mimicking of how the environments many components work together and tends to be on the urban scale or a larger project with multiple elements rather than a solitary structure. The system will work like a flow chart, with each part benefiting from the part before it.

The Cardboard to Caviar Project founded by Graham Wiles in Wakefield, UK is a cyclical closed-loop system using waste as a nutrient. Restaurants are paid for their scrap cardboard, it is then shred, and sells it to equestrian centers for horse bedding. Then the soiled bedding is bought and put into a composting system, which produces worms. The worms are fed to roe fish, which produce caviar, which is sold back to the restaurants. This idea of waste for one as a nutrient for another has the potential to be translated to whole cities. (Bradley, n.d.)

Essentially like the circle of life using biomimicry at a ecosystem level can benefit each party involved, having only a positive impact.

In nature there are countless examples as nature requires ecosystems and animals and plants depend on each other to keep the balance and continue with life. It is us humans who disrupt the ecosystems and cause problems.

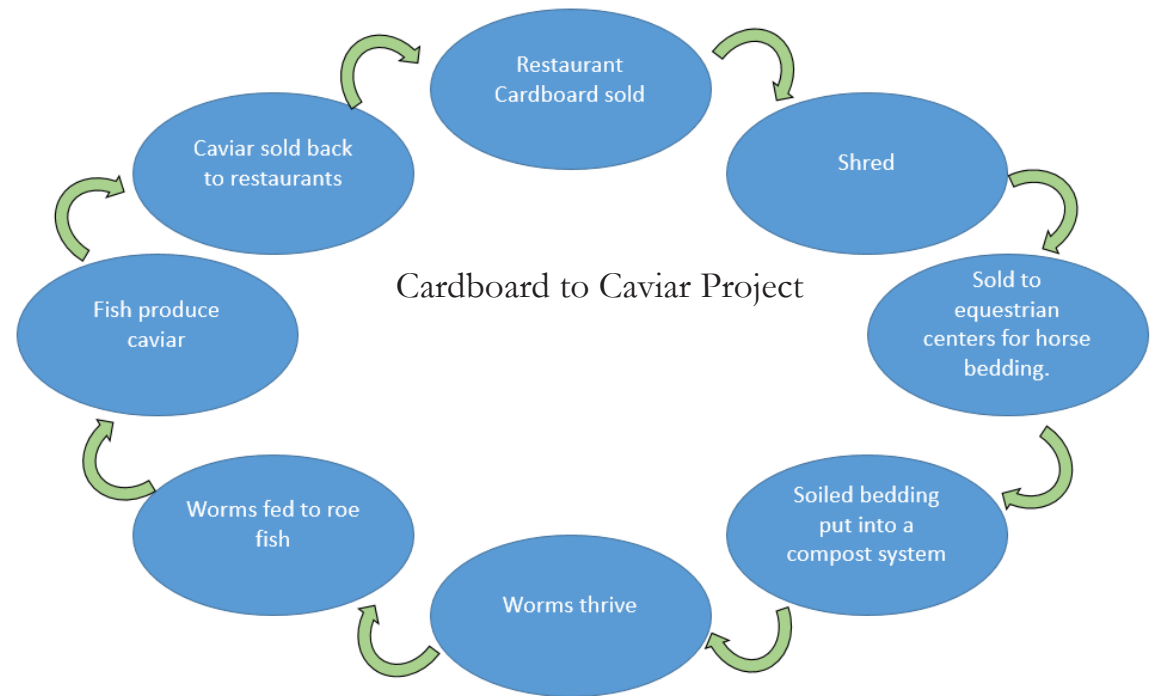


Fig 9.35- Cardboard to caviar flow diagram

BioMASON

BioMASON is a company in North Carolina which aims to reduce carbon emissions in masonry manufacturing. They grow bricks in a kiln-free greenhouse environment. They are creating “biological cement” says CEO Ginger Krieg Dosier.

The process is using bacteria that alters the PH balance of surrounding aggregate material, this allows calcium carbonate to grow and bind the material together with minimal carbon emissions.

The principle was taken from how microorganisms create coral reefs. The cost of the bricks are close to the cost of normal bricks, but much better for the environment.

(Mortice, 2011)



Fig 9.36- BioMason Brick

“If you trap biomimicry in design or engineering as though any one field owns it,” says Niewiarowski, “you poison its potential.”
(Mortice, 2011)

Biomimicry in the body

The large image is a magnified image of a human femur bone. It shows the bone is not solid but a network micro structure with a lattice structure.

It is comprised in this way to minimize weight yet maximize strength. This is also the reasons why birds bones are hollow, They need to be light as to be able to fly. Taking off requires rapid flapping of the wings and solid boned wings would not allow for a rapid flapping motion. Bone strength is lost as it is hollow. However the birds wings purpose are to fly and are not designed to sustain impact forces.

Graded Concrete

A patented new concrete structure. This concrete was designed through biomimicry from the trabeculae and osteon components of the bone. Beam stress is never uniform along the beam length yet we still design beams with the same profile along its entire length.

The graded concrete has large cavities where low stresses occur and smaller cavities where the stresses become greater. This allows for concrete slabs to have a dead weight of 50% of a normal slab. It also allows for walls to be built from concrete which has thermal regulation properties replacing an addition layer of Styrofoam. (Werner Sobek, 2012)

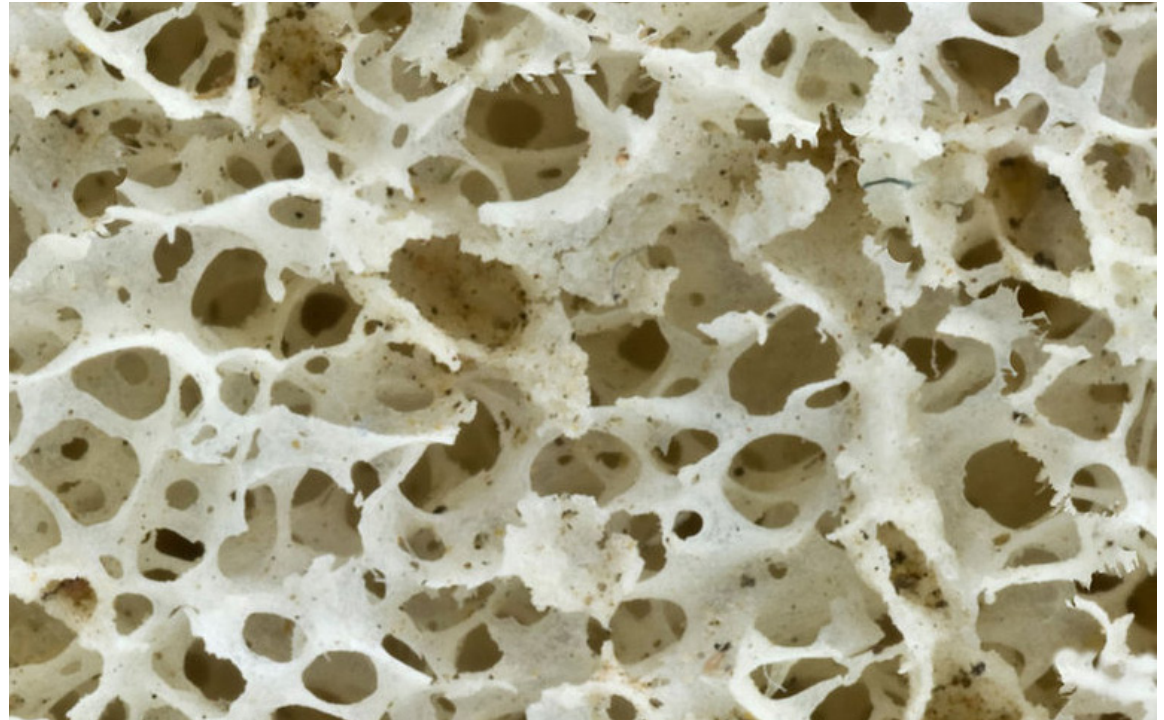


Fig 9.3- Micro-structure

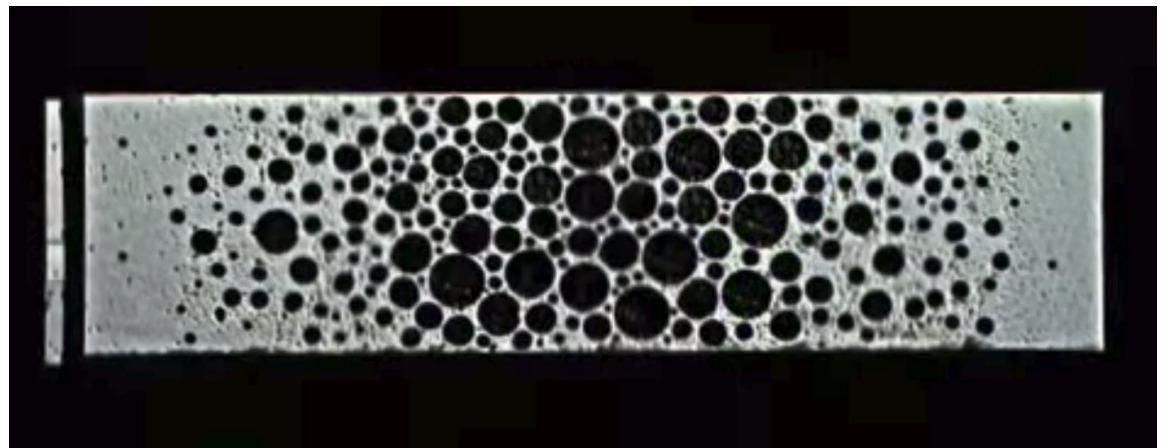


Fig 9.4- Graded Bone



Fig 9.5- Themer bone

Here is a femur bone which we can analyze in a structural manner.

1. Cylinder-like thick walls. (Solid bone).
2. Trabeculae of spongy bone. Acts as a stabilizer to the solid bone. This is where stresses are less which allows for larger openings in the lattice structure. This is in regions of low stress.
3. Osteon of compact bone transfers and evenly distributes the loads applied on the bone. Hence the geometric pattern configuration of the osteon seen in images. This is in regions of high stress.

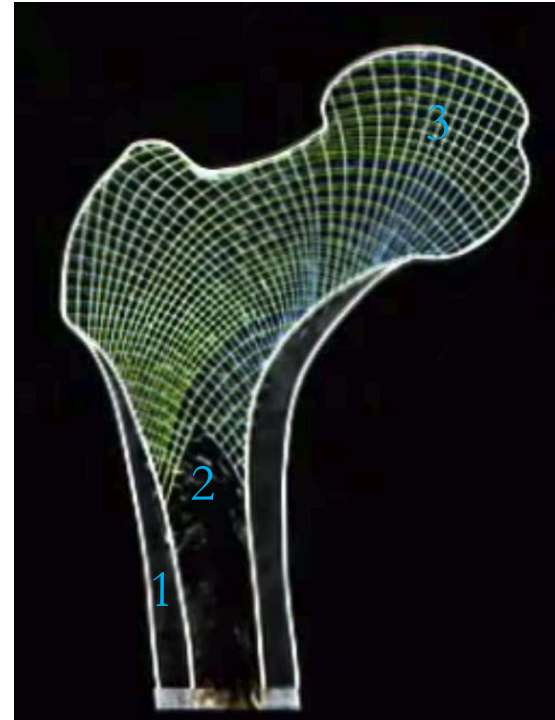


Fig 9.6- Themer bone

Werner Sobek is a German architect and structural engineer who specializes in lightweight structural design. He is at the forefront of using biomimicry in architecture and has achieved architectural feats through his innovative way of thinking.

Like Sobek I too am using the bone structure and characteristics to inform and shape my design of my high performance centre.

Compact Bone & Spongy (Cancellous Bone)

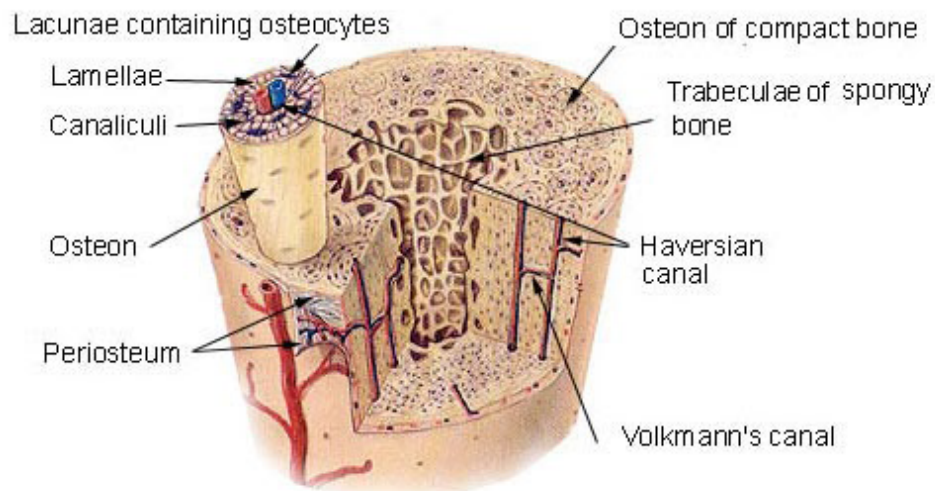


Fig 9.7- Bone Detail

Site Model

Due to the nature of my thesis my site context i required to show was very large with my model being 1450mm x 780mm. This size model would be unpractical to have as one piece and nearly impossible to transport. The model would therefore be split into two. The model will be constructed using MDF board. If I just caked the layers of the MDF, the model would become extremely heavy (+- 160kg) as well as very costly in material. My site model would therefore be made hollow making the model about 75% lighter and cheaper to build.

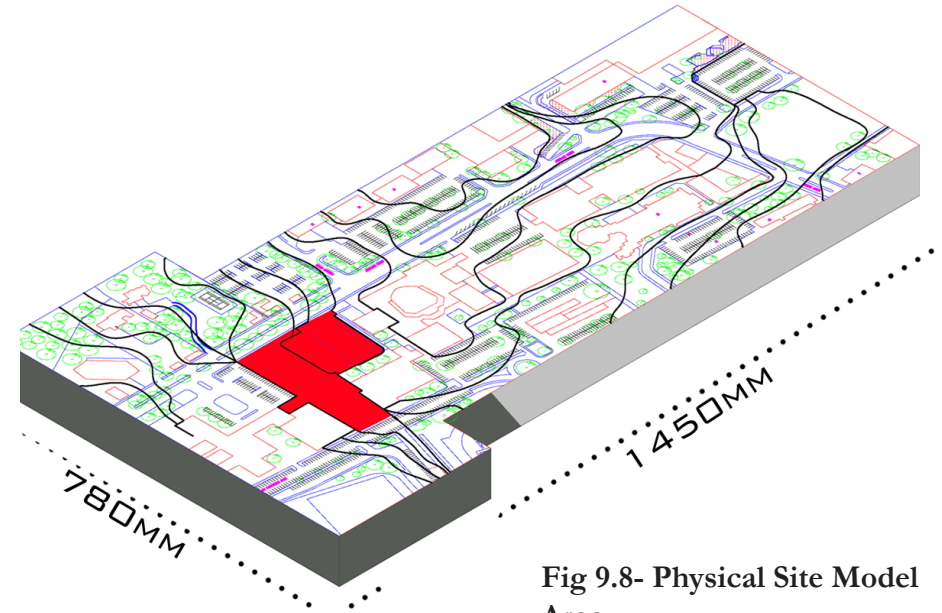


Fig 9.8- Physical Site Model Area

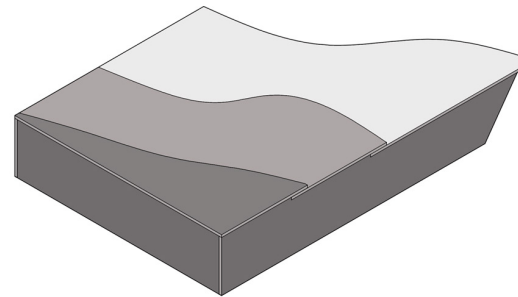


Fig 9.9- Layers
Showing the contour steps

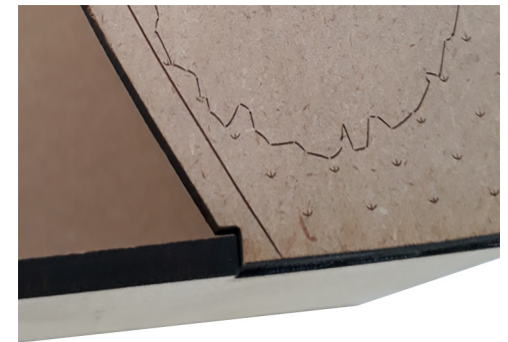


Fig9.10- Edge Joint Detail.
Straight edge joint along sides to ensure a good joint.

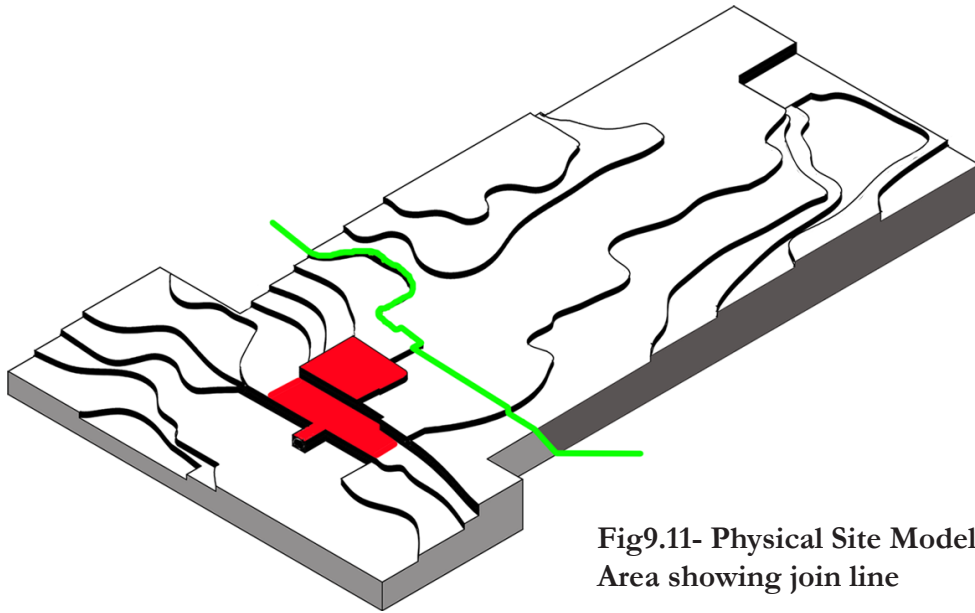


Fig9.11- Physical Site Model
Area showing join line



Fig9.12- Physical Site Model in
progress

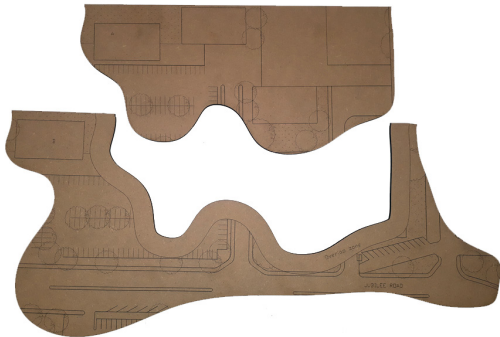


Fig 9.13- Overlap Zone
An overlap of 2cm to allow for a strong
joint and save material

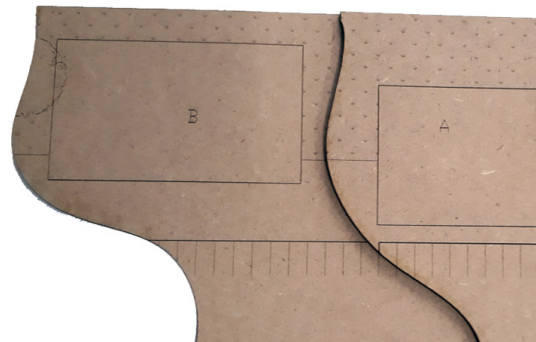


Fig 9.14- Layer Labeling
Label layers prior to lazercut to allow for
quick assembly



Fig 9.15- Same height joint
Where two pieces of a model meet and
there is no contour overlap, a building could
act as a pin between the two contours as
shown in prototype C

Site Model Joinery Exploration

Fig 9.16- Prototype A

Rectangle base and sides

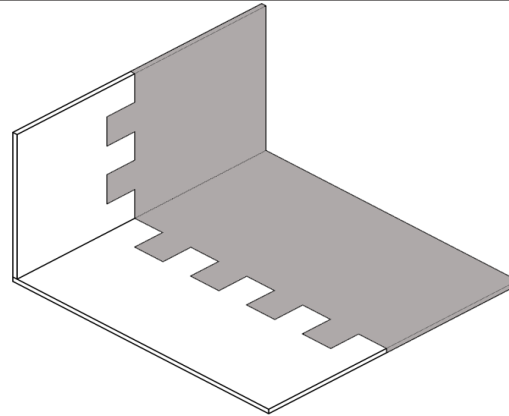


Fig 9.17- Prototype B

Rectangle base and slanted sides

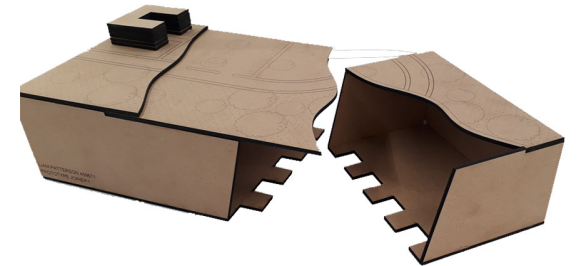
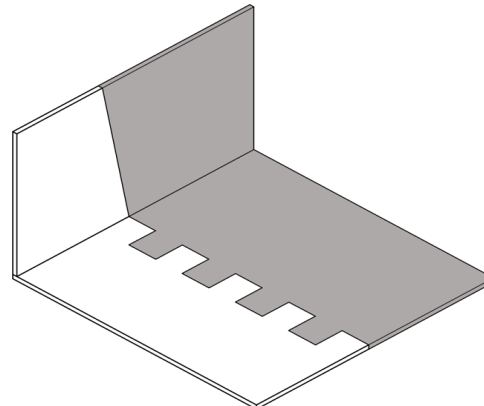
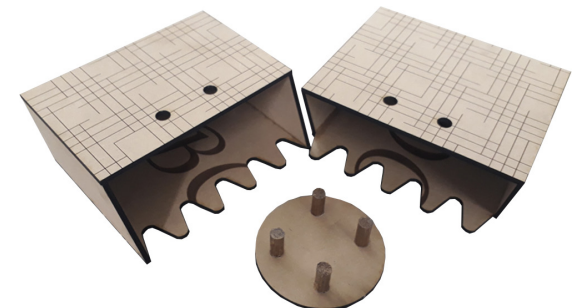
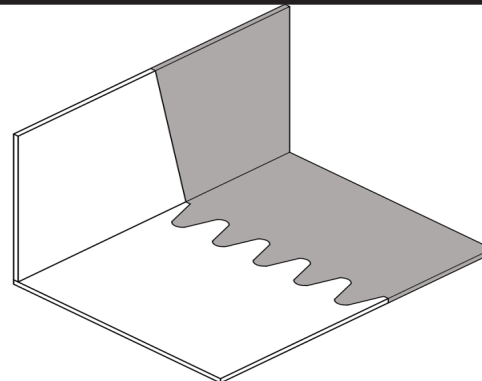
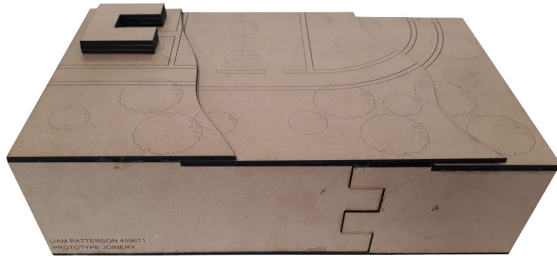


Fig 9.18- Prototype C

Wave base and slant side

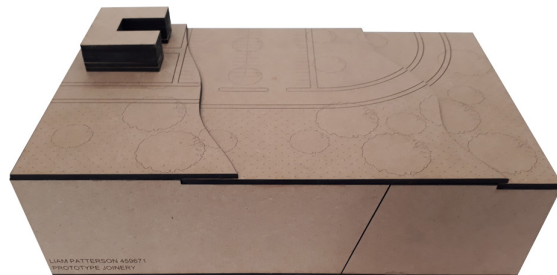


I designed a series of small scale prototypes of how my site would join together. Focusing on the type of join as well as the stepped layering of the contours



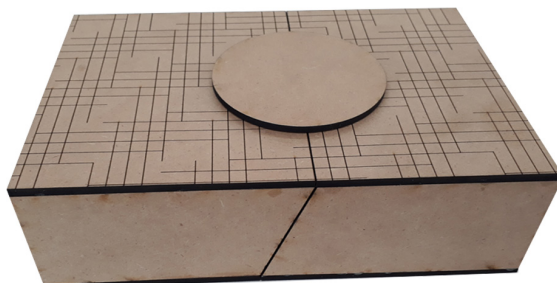
Cons

Difficult to line up both base and sides to side in. On a large model will be very challenging



Cons

Base still needs to be lined up exactly to slide in.



Pros

Base now slides easily as rounded triangle pointers guide into each other

Types of joints

Testing different types of joints for my model to fit together easily and successfully.

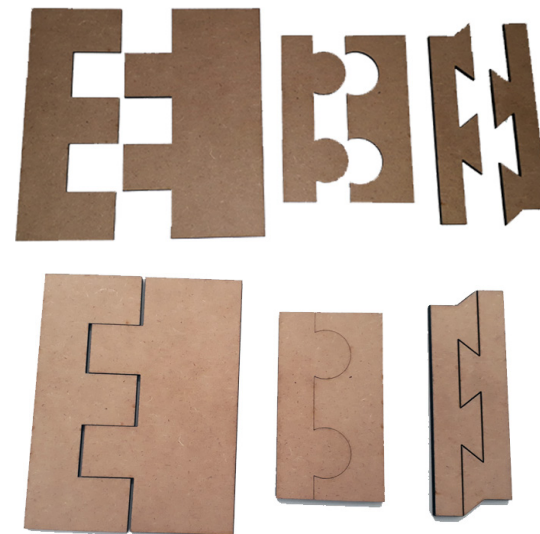


Fig 9.19- Types of Joints

Rack And Pinion

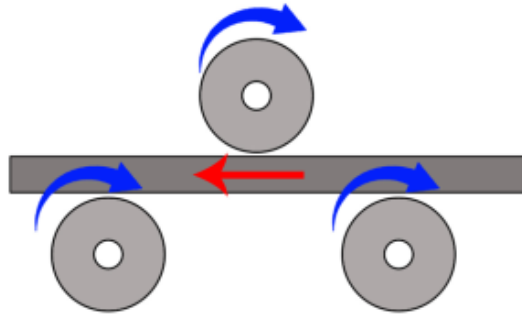


Fig 9.20- Rack and pinion

Rack and pinion

Converts rotational motion into linear motion.

This mechanical movement has been used in the bio-medical industry in human bodies and prosthetics. It allows for bending and straighting as depicted (Shin, 2009).

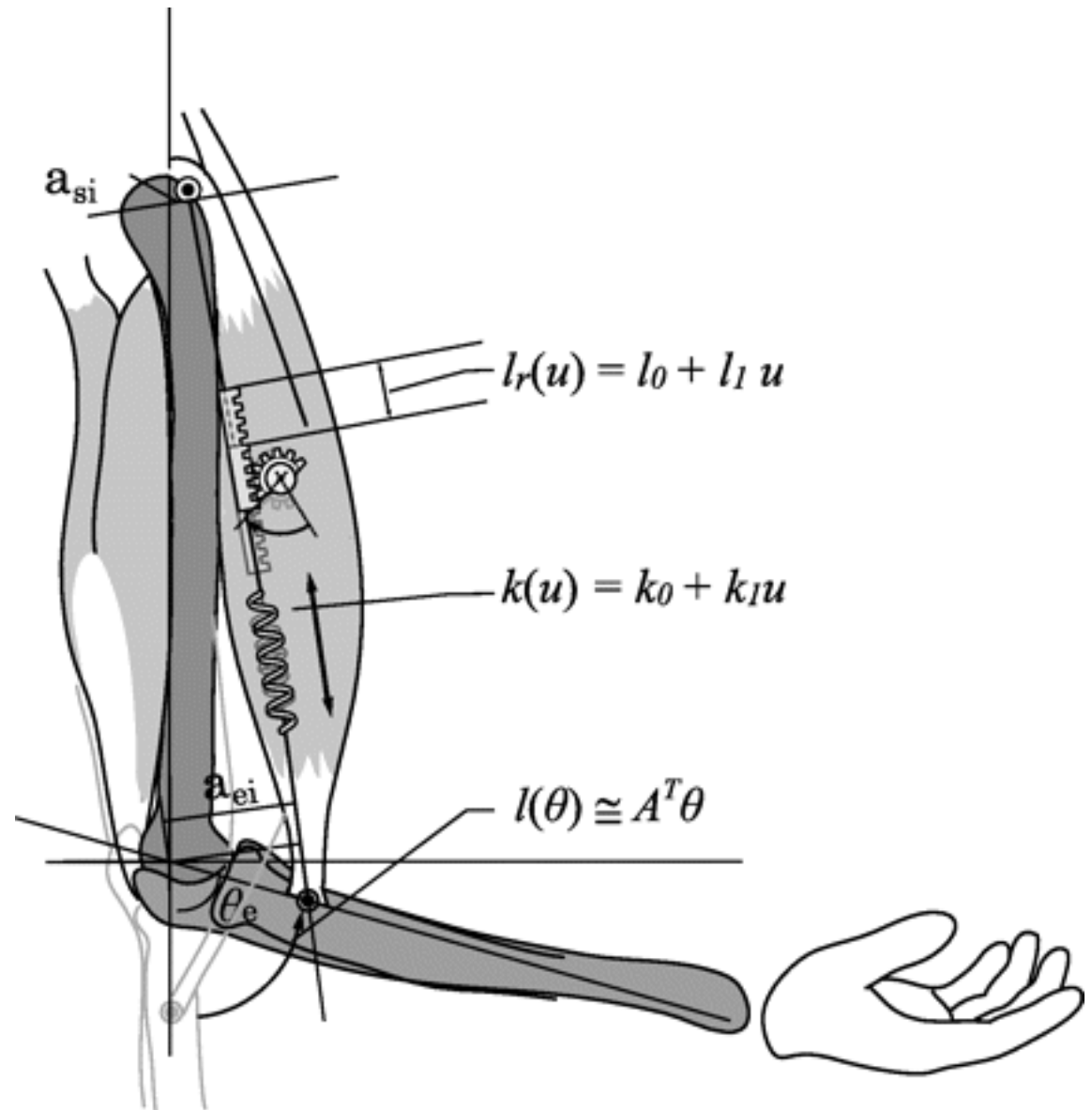


Fig 9.21- Mykin model and changes in limb position

Lazercut moving model of exploration

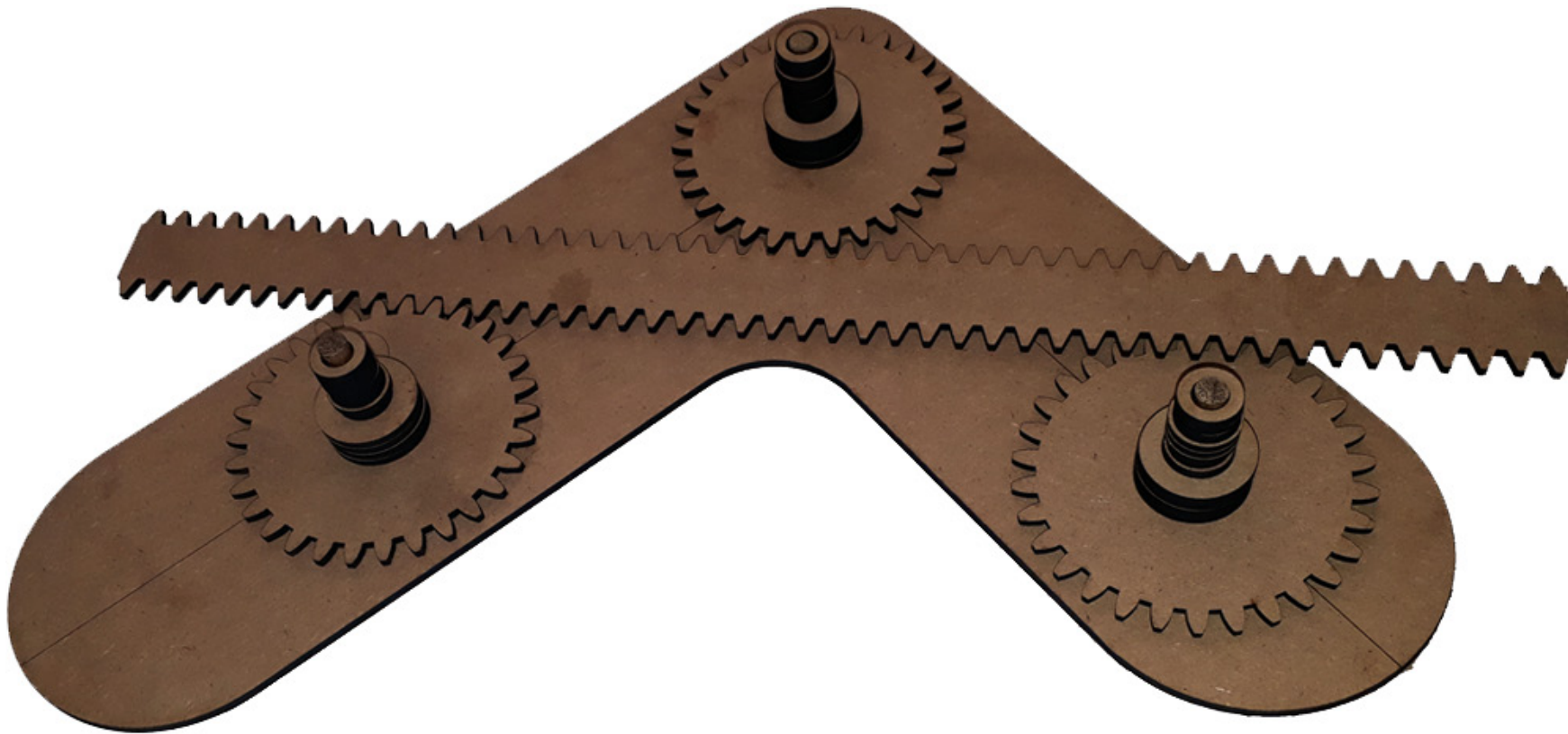


Fig 9.22- Lazercut moving model of exploration

Movement With Gear Ratio's And Leaver Arm

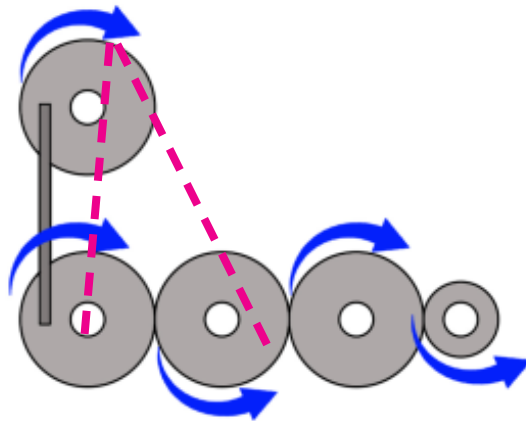


Fig 9.23- Gears and leavers

A form of this mechanical movement was adapted by scientists to aid people in walking. The inventors of the “exoskeleton” device said that it boosts the performance of the calf muscles and the Achilles tendon by absorbing small amounts of energy when the foot hits the ground, releasing it again when the foot is lifted through the air. I explored this motion of movement and combined it with the general principles of gears.

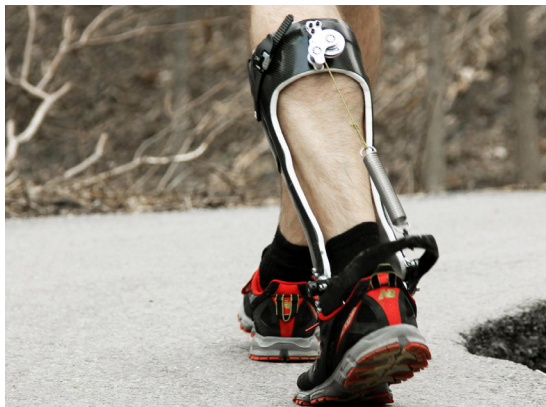
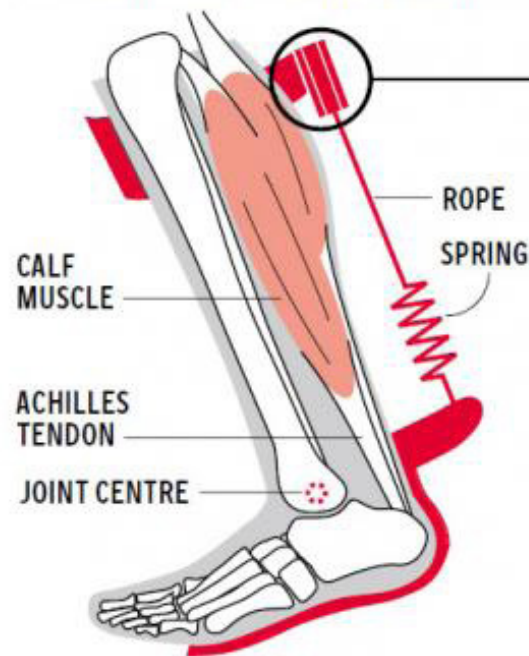


Fig 9.24- Exoskeleton

A SPRING IN YOUR STEP HOW THE MECHANISM WORKS

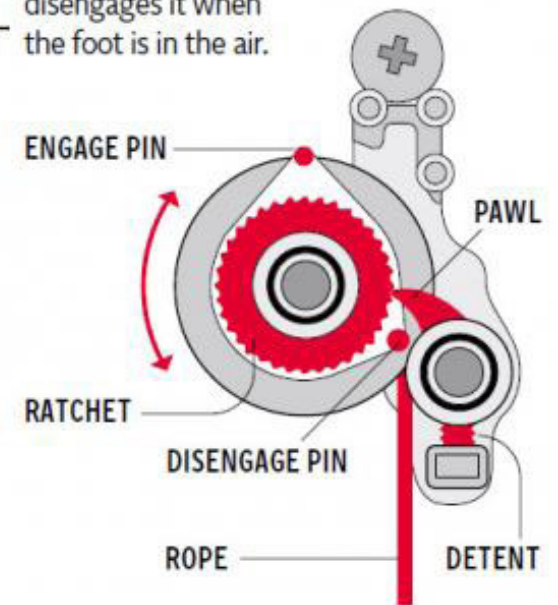
THE UNPOWERED EXOSKELETON

The exoskeleton is attached to the lower leg and foot and hinged at the ankle. A clutch and spring act in parallel with the calf muscles and Achilles tendon.



THE PASSIVE CLUTCH

The clutch mechanism has no electronics, but instead uses a ratchet and pawl that mechanically engage the spring when the foot is on the ground and disengages it when the foot is in the air.



WALKING MECHANICS

1 Heel touches ground and clutch immediately engages



2 As knee moves forward, with foot still on ground, the spring is stretched



3 Toe leaves the ground and clutch is disengaged, releasing energy stored in the spring



Fig 9.25- Exoskeleton

Lazercut moving model of exploration

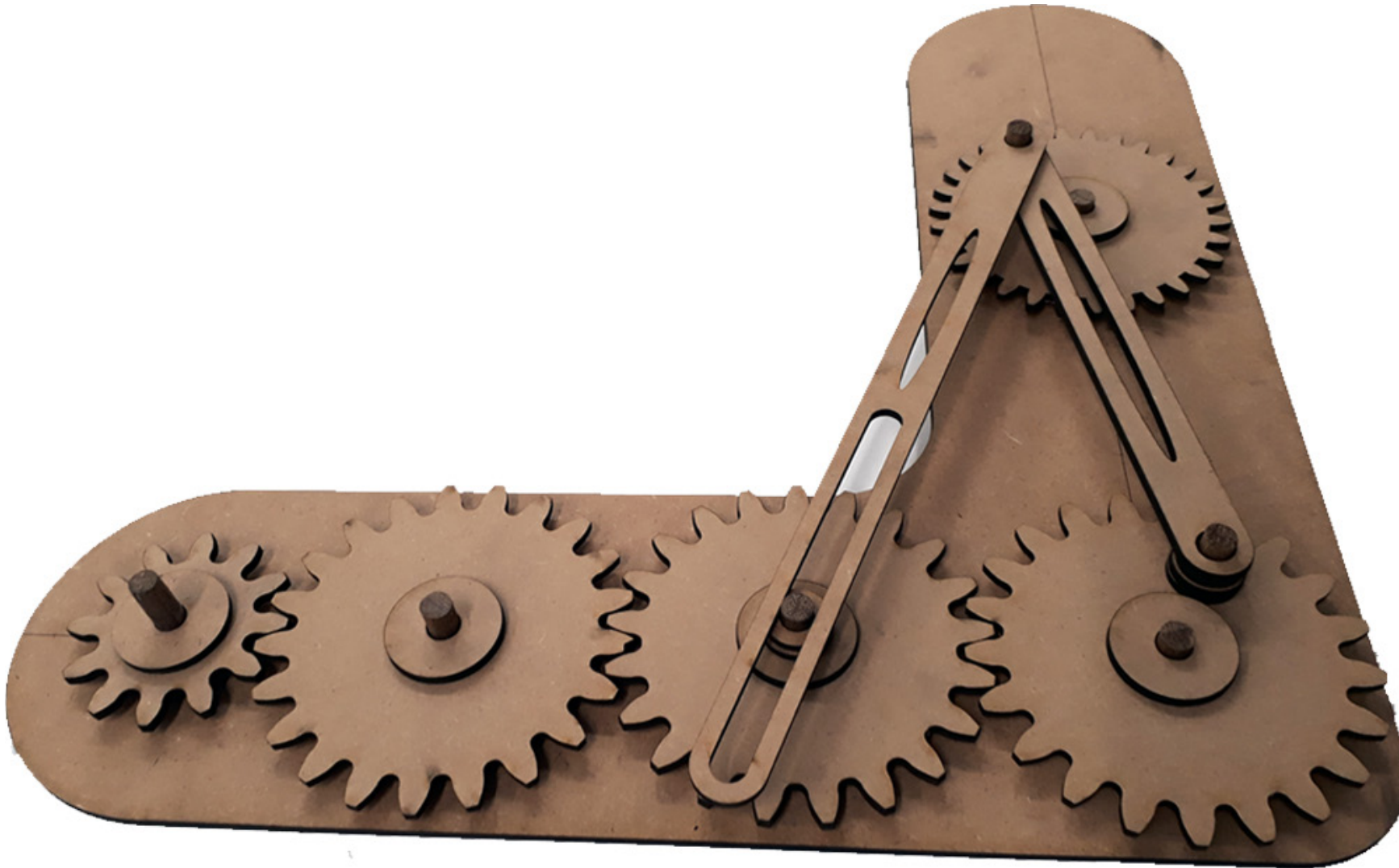


Fig 9.26- Lazercut moving model of exploration

Movement Moving From A Horizontal Plane To A Vertical Plane

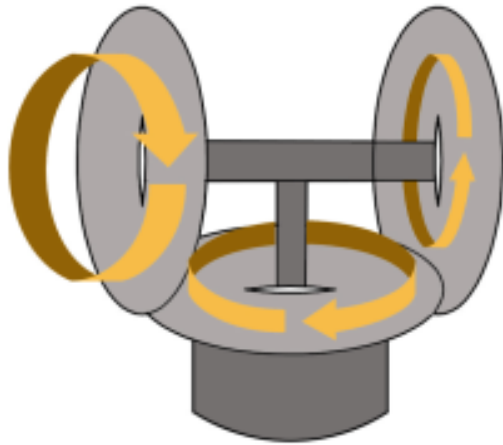


Fig 9.27- Movement plane shift



Fig 9.28- Straight bevel gearbox



Fig 9.29- Spiral bevel gearbox

After the explorations shown previously I wanted to investigate forces in two dimensions. I wanted to not work in a flat plane but change the axis of the movement from a horizontal to vertical force. I found that this system is how most gear boxes in motor vehicles work.

There are two main systems, a bevel gear and a worm gear.

Through this exploration I acquired a better knowledge of forces and how to manipulate the direction of force.. I shall apply these principles moving forward in my design development chapter.

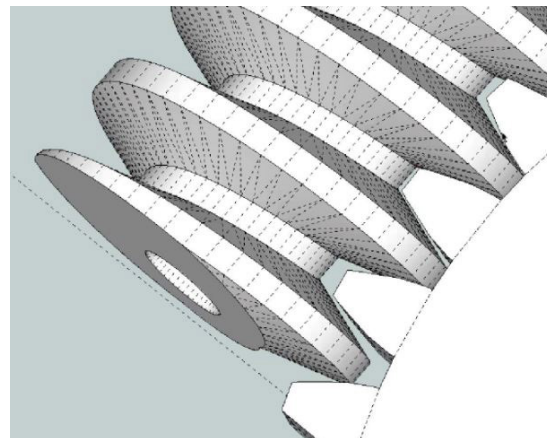


Fig 9.30- Worm drive detail



Fig 9.31- Worm drive

Lazercut moving model of exploration



Fig 9.32- Lazercut moving model of exploration

Chapter 10

Design Development

Design Process

Structure

Initial Concept model

Programmatic planning

Beginnings Of A Form

Review 2

Provisional Design

Facades

Site Plan

Plans

Elevations

Sections

Perspective

Moving Forward



Initial Concept Model

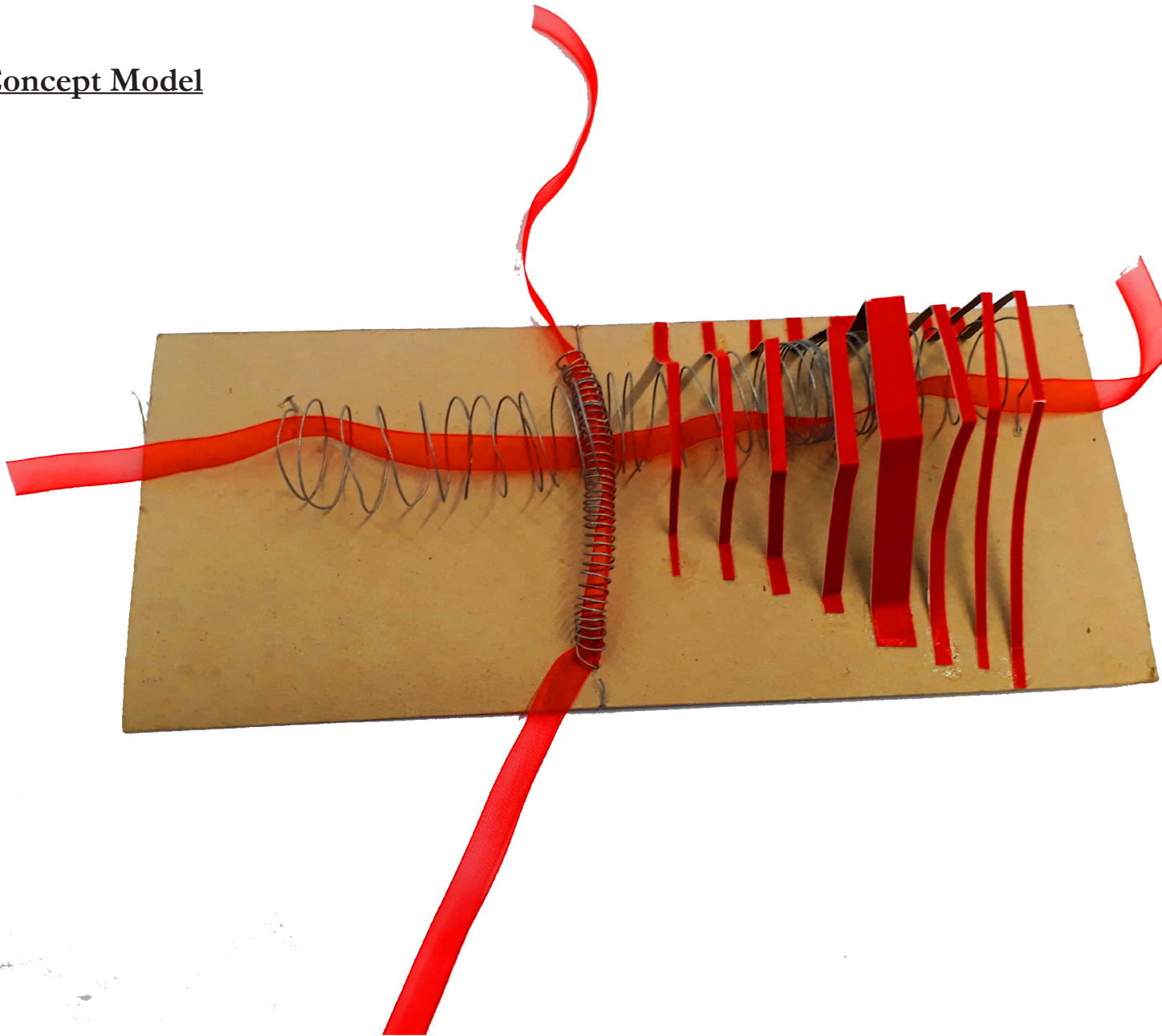


Fig 10.1- Initial concept model

Programmatic Planing

When it came to start the design process I had a basic understanding of the program of my building. I had analysed my site and understood the how I wanted to approach it.

I wanted to keep the north/south and east/west movement flows. The main foyer and circulation space will happen where these routes meet. All the other spaces would happen off these main routes like multiple off-ramps on a highway.

The analogy behind this was to link all four existing buildings to mine. Those buildings being the NMCH, Wits sports clinic, Sydney Brenner Institute and an entry from within Wits main campus. The idea was to have the building site within the site design around the two main movement patterns.

Plan Of Attack

Keeping the two movement routes as main attributes to design, I began my design with a programmatic layout design.

I had listed the program and sizes of each space and represented it spatially on the site.

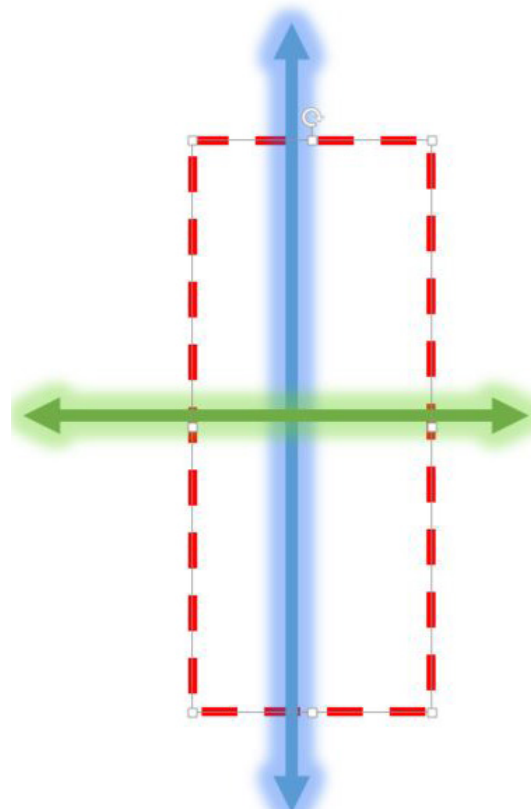


Fig 10.2- Main movement

Successes

The success I achieved through this exercise was the understanding of the scale of my building.

Lessons

Although a programmatic plan can be helpful, it became a controlling factor within my design. I found myself conforming to very rigid box spaces. I found that the two access routes was also not enough of a concept to inform a comprehensive design.

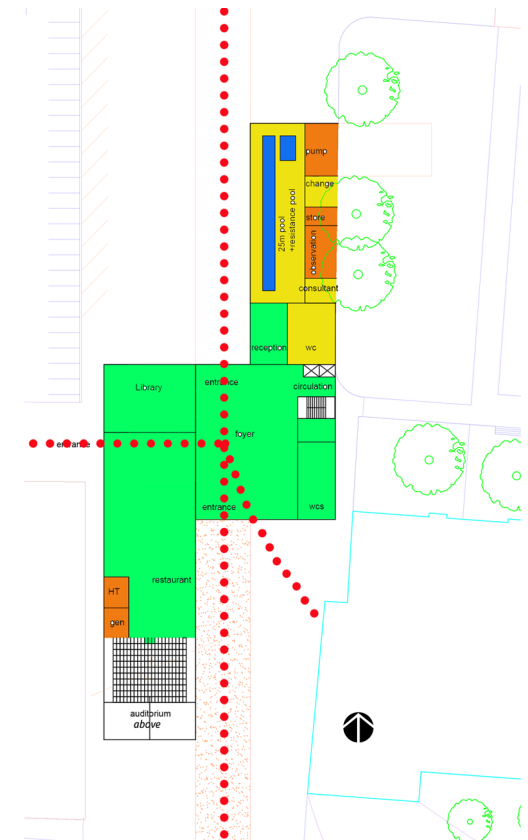


Fig 10.3- Ground floor plan 1:1000

Key

- Public
- Semi Private
- Private

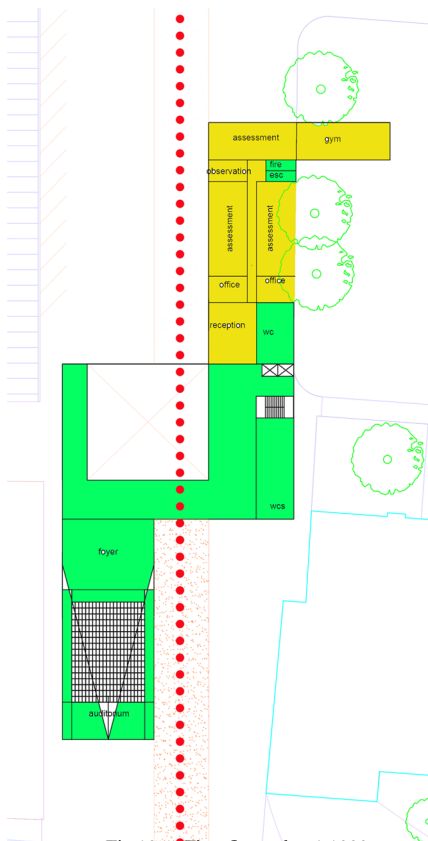


Fig 10.4- First floor plan 1:1000

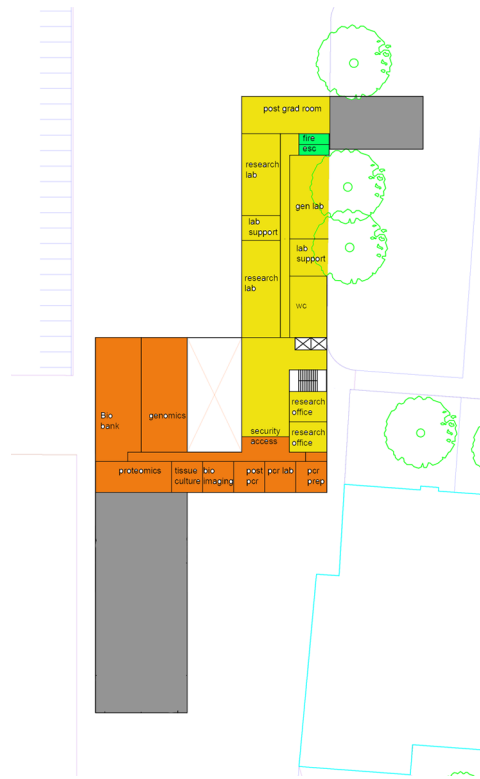


Fig 10.5- Second floor plan 1:1000

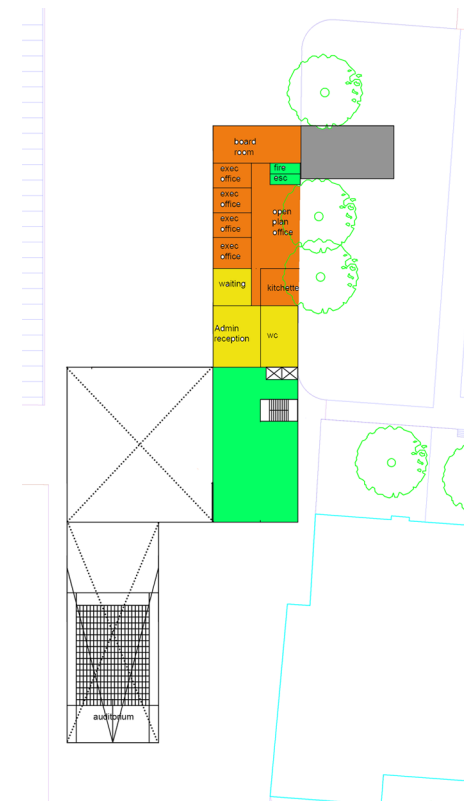


Fig 10.6- Third floor plan 1:1000

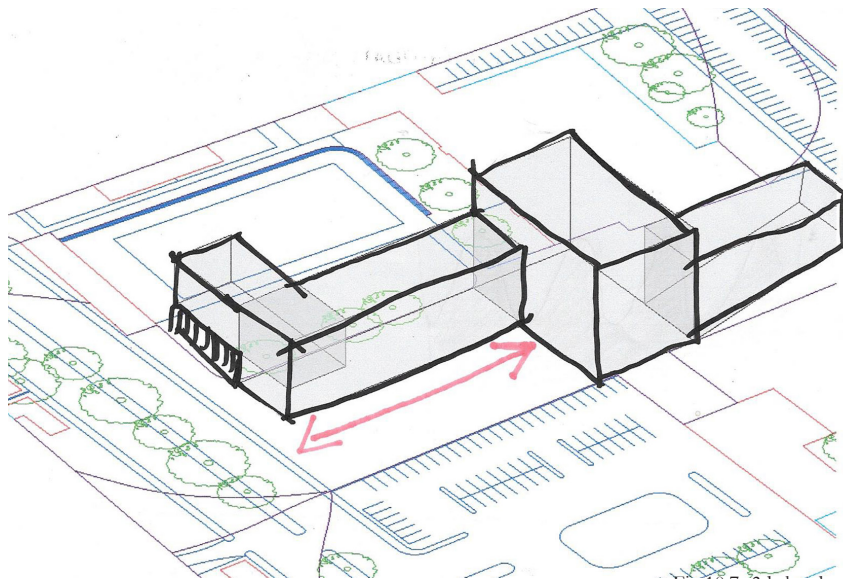


Fig 10.7- 3d sketch

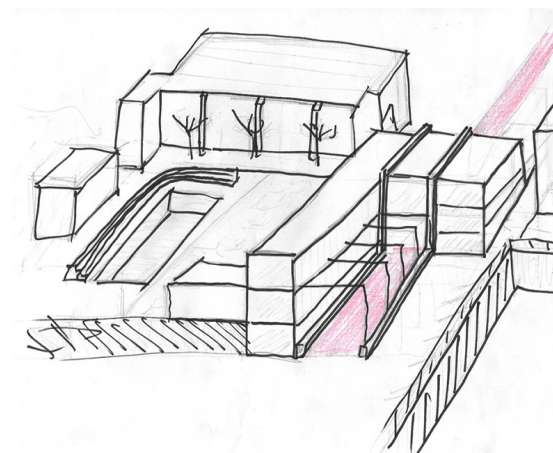


Fig 10.8- 3d sketch

Beginnings Of A Form

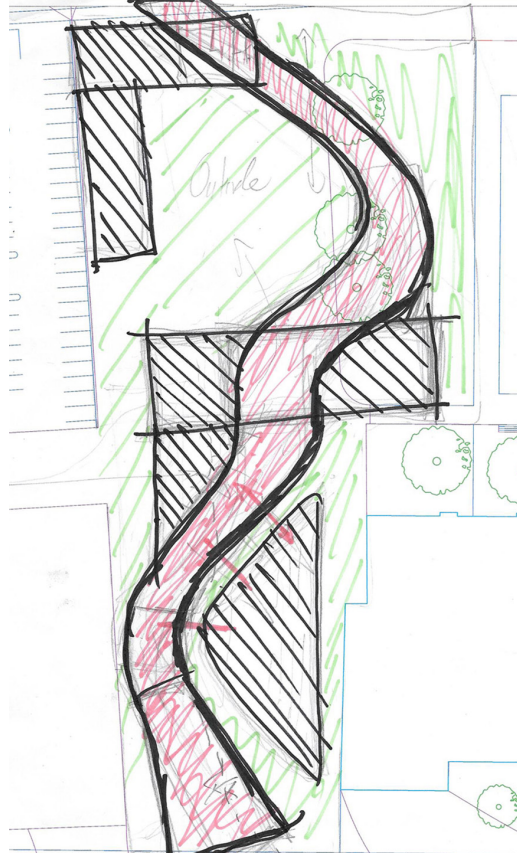


Fig 10.9- Sketch

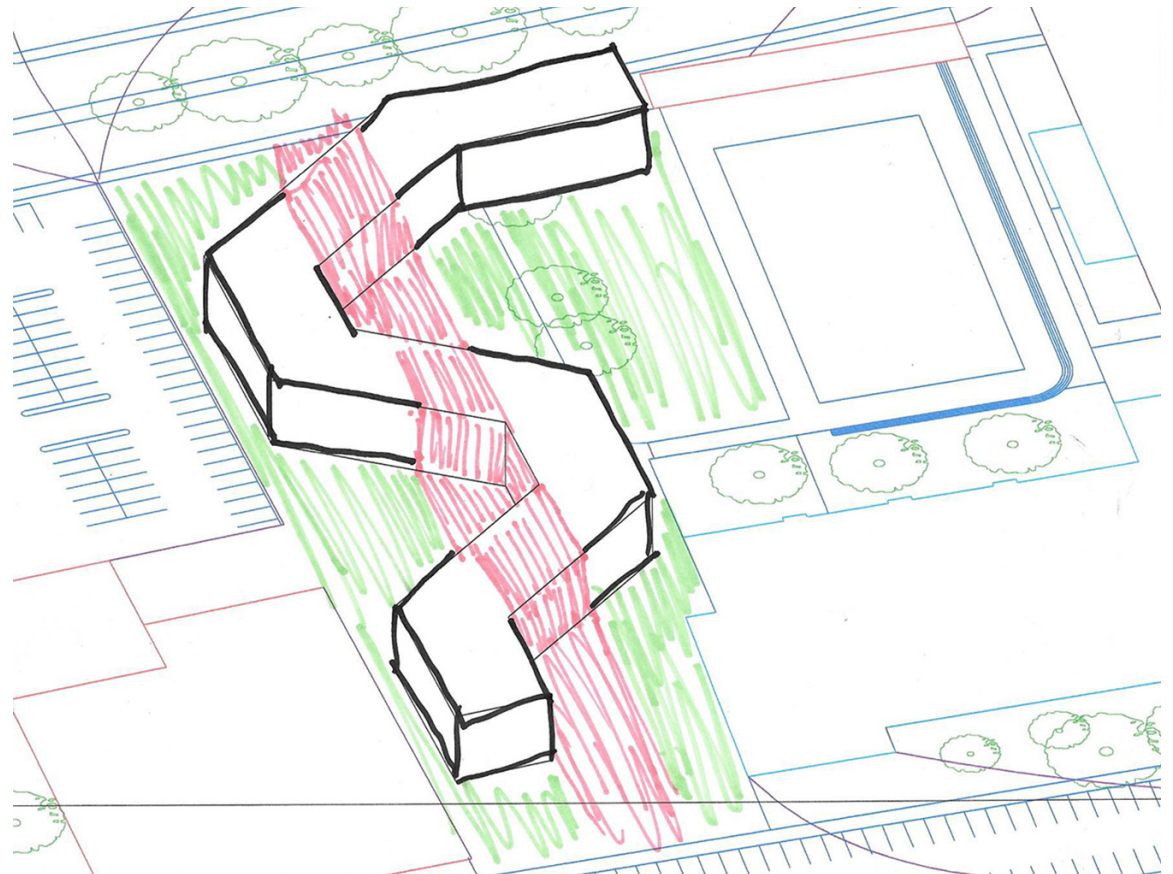


Fig 10.10- Sketch

Stepping back from the bounds that programmatic design gave me, I continued to work and explore form. The access routes were still an intricate part of my design process. Continuing with the transitional space I spoke about in chapter one, I began to implement these aspects into my design.

The access paths still ran across the site however the path was no longer restricted to in or out of the building. The routes would meander through the site transitioning through nodes spaces. The goal was to design building and landscape simultaneously.

My ideas for design were beginning to become more informed by the research topics I was investigating. In these designs I was influenced by transitional and linkage spaces, which I researched in chapter one.

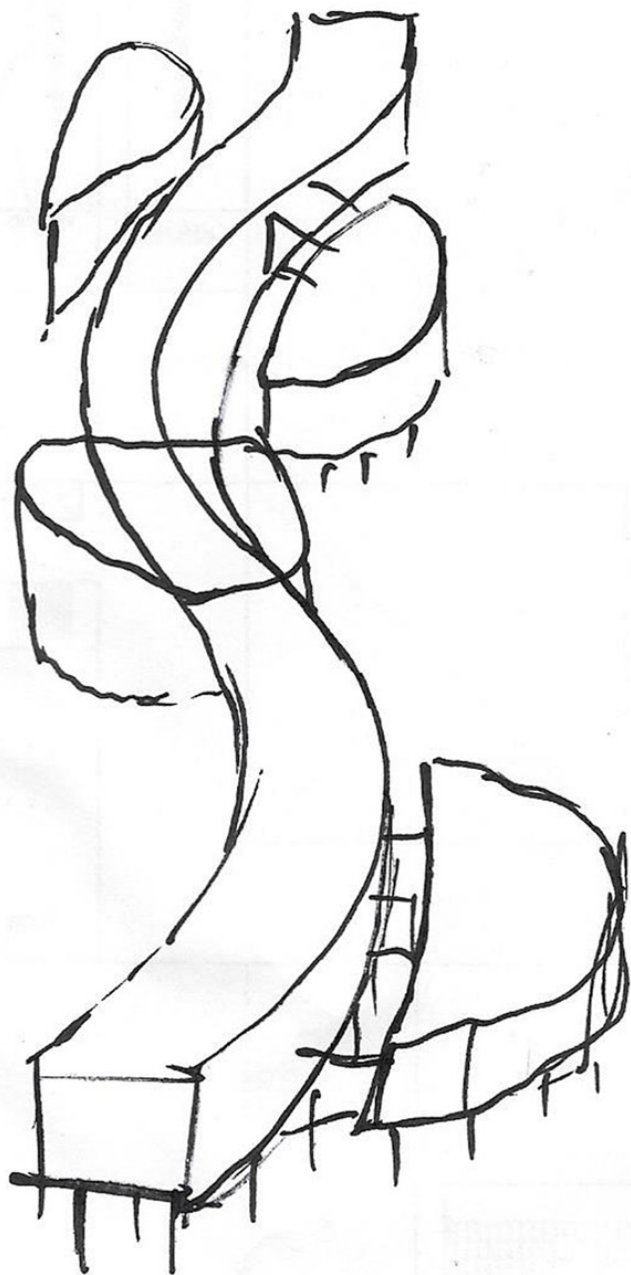


Fig 10.11- Sketch

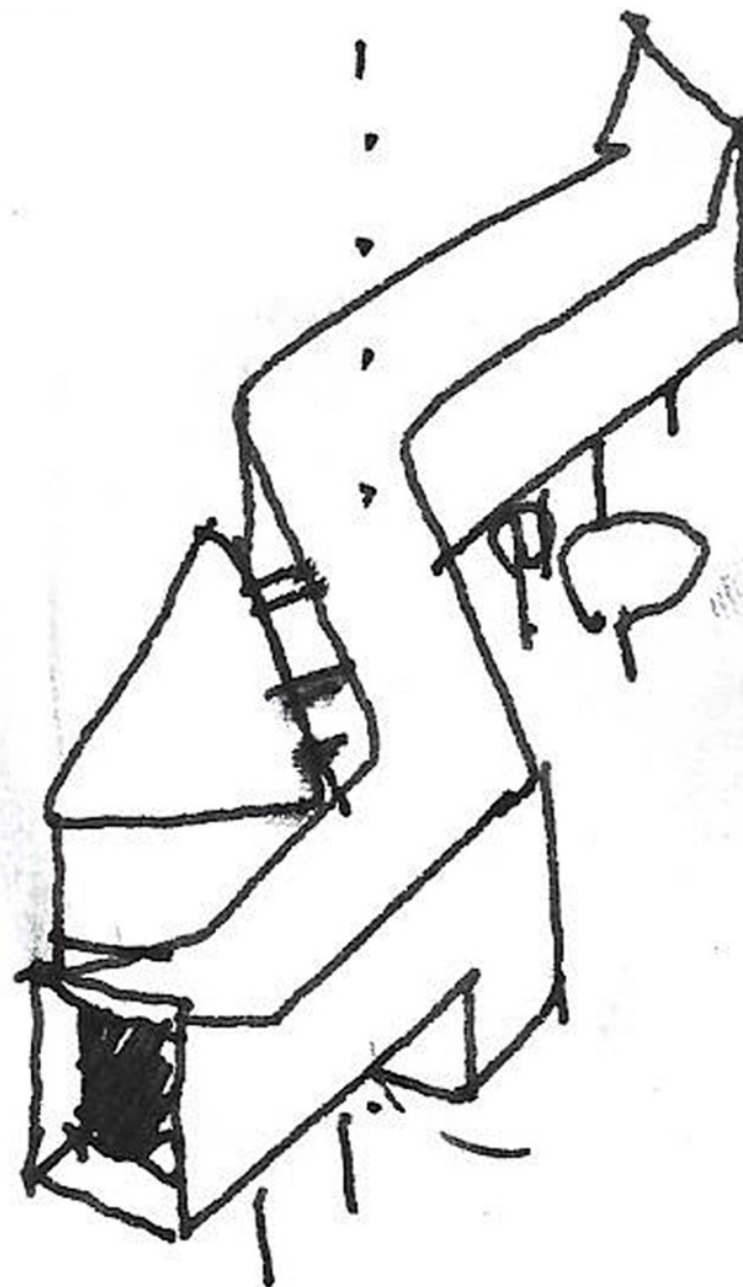


Fig 10.12- Sketch

Review 2

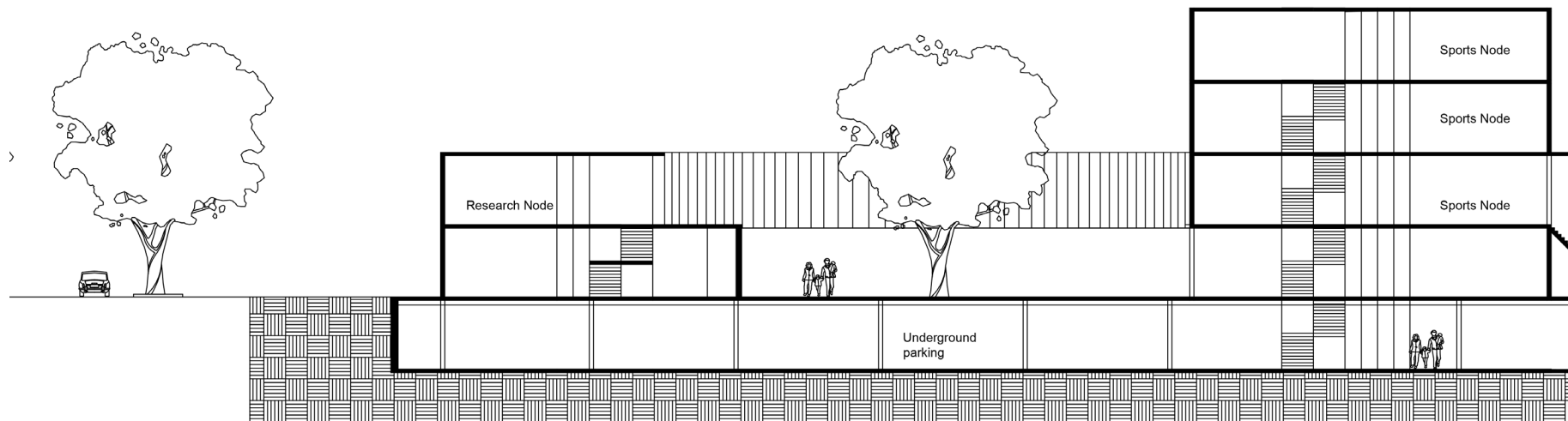
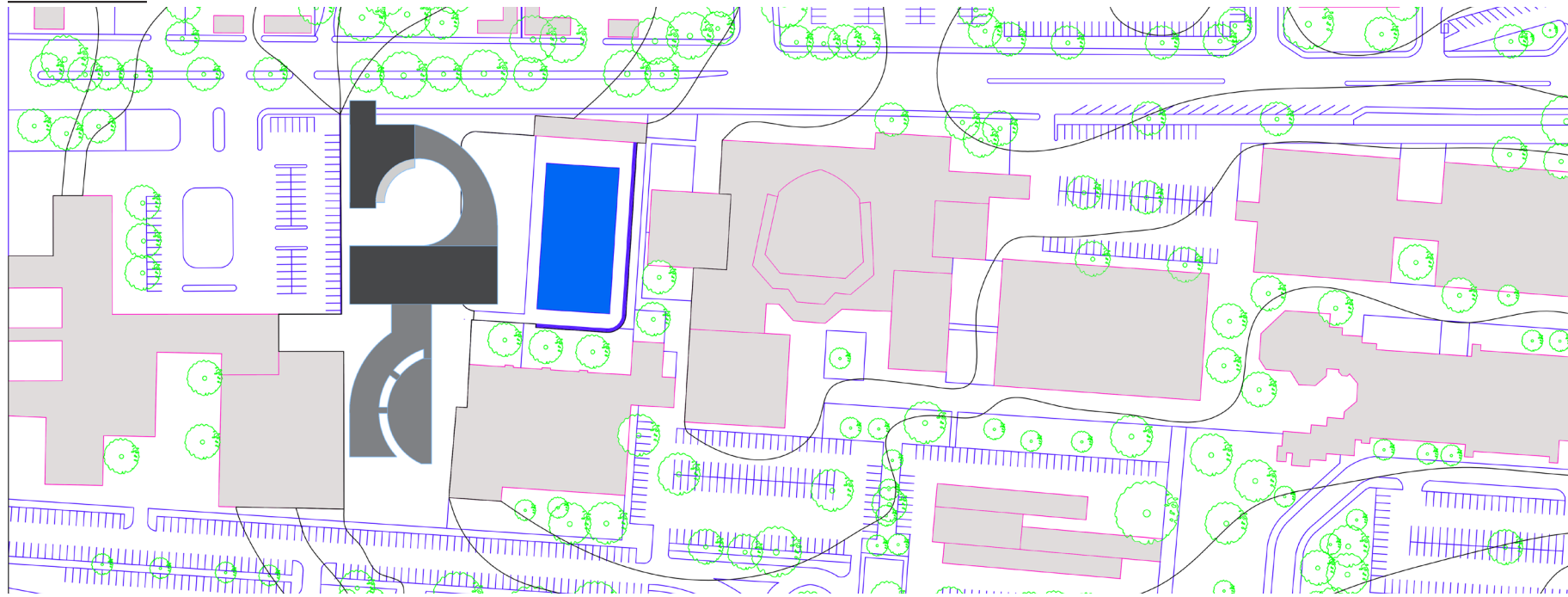




Fig 10.13- Site plan 1:21700

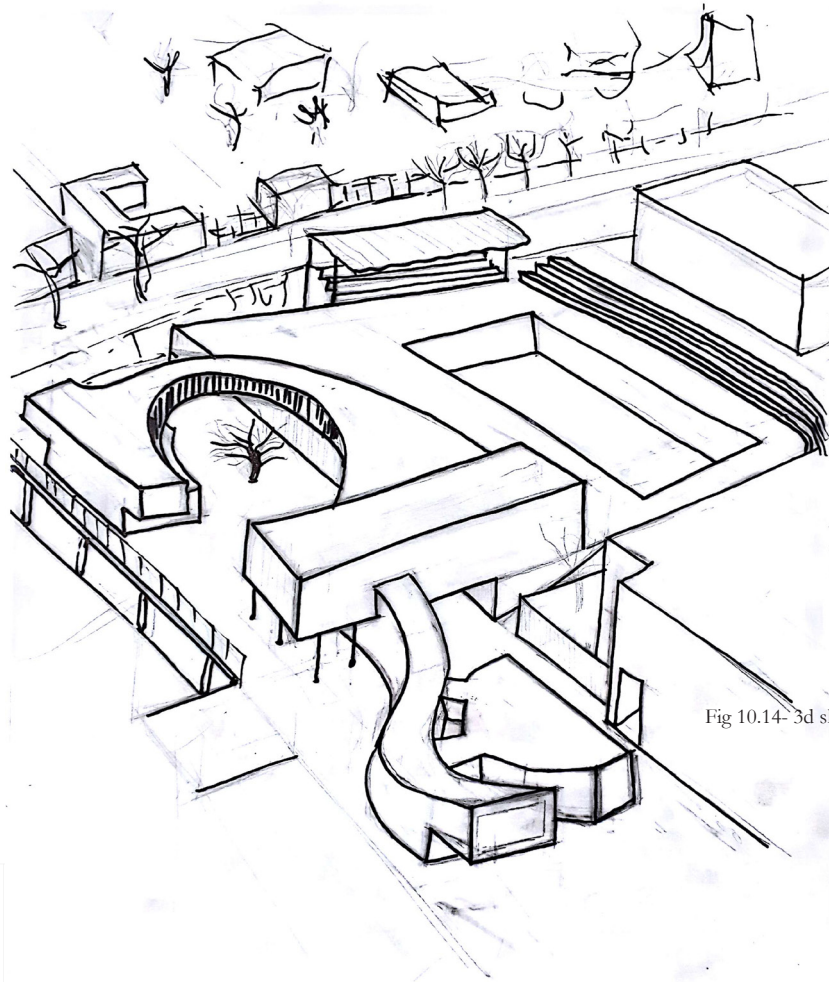


Fig 10.14- 3d sketch

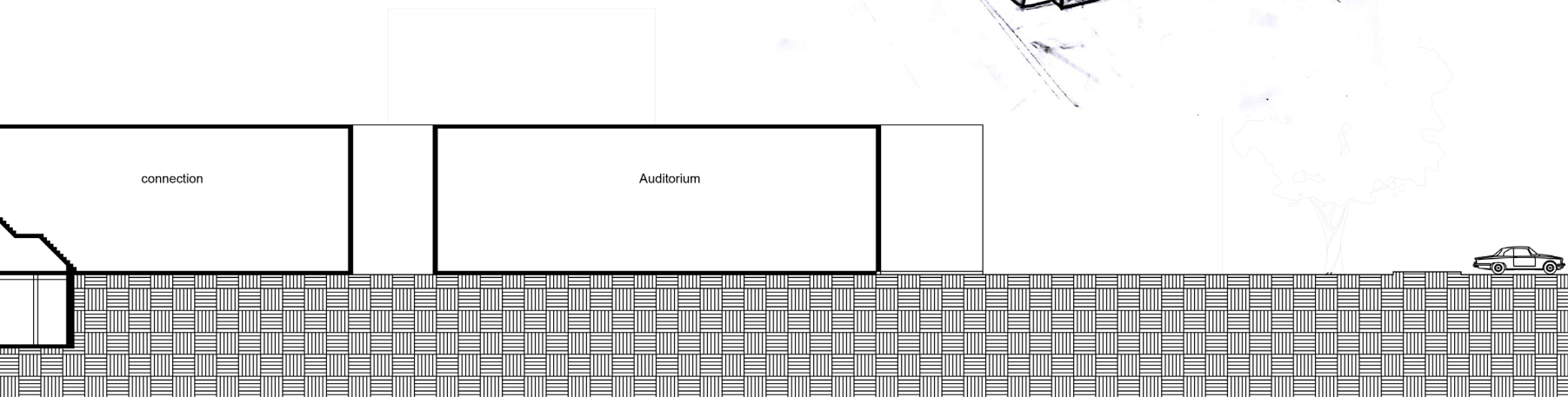


Fig 10.15- Section 1:200

Review 2

The concept of review 2 was based on thresholds and linking spaces. The overall form was inspired by the figure 8 movement pattern of force between two interlocking gears. This Form was unsuccessful as it did not fit well in the site. I also felt

that I was not evolved with the project enough. Most of my research was about the human body. How it works and its bio-mechanical make up. I moved away from this form and continued to re-search the human body in relation to my thesis.

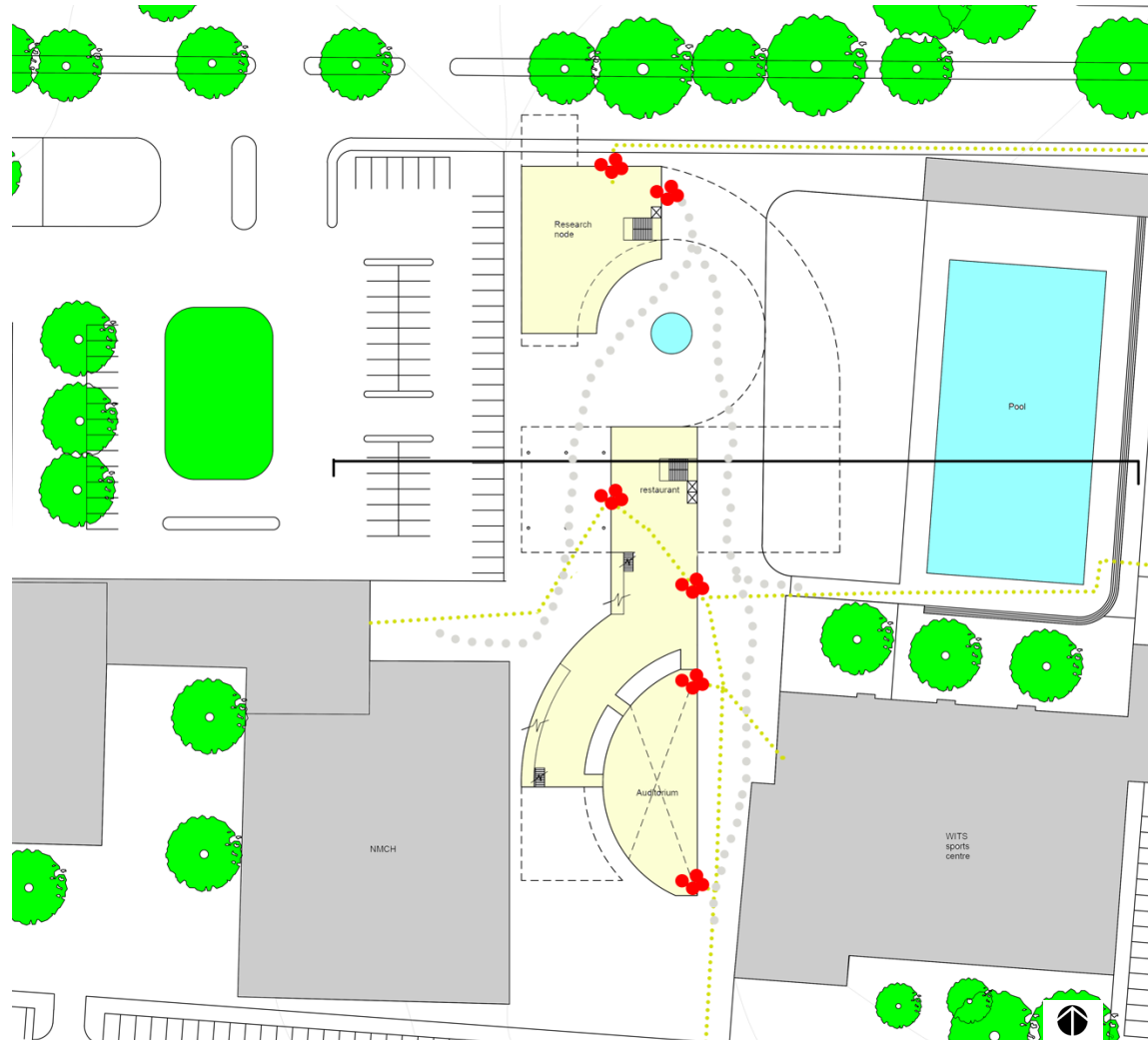


Fig 10.17- Ground floor plan 1:1250

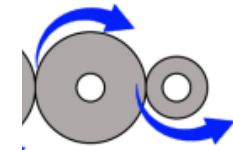


Fig 10.16- Gear diagram

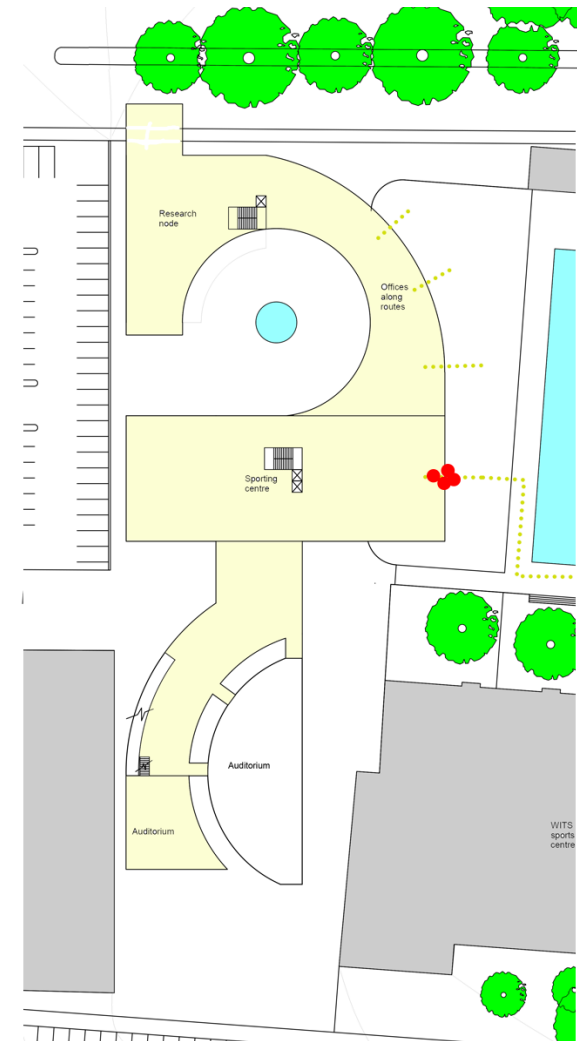


Fig 10.18- First floor plan 1:1250

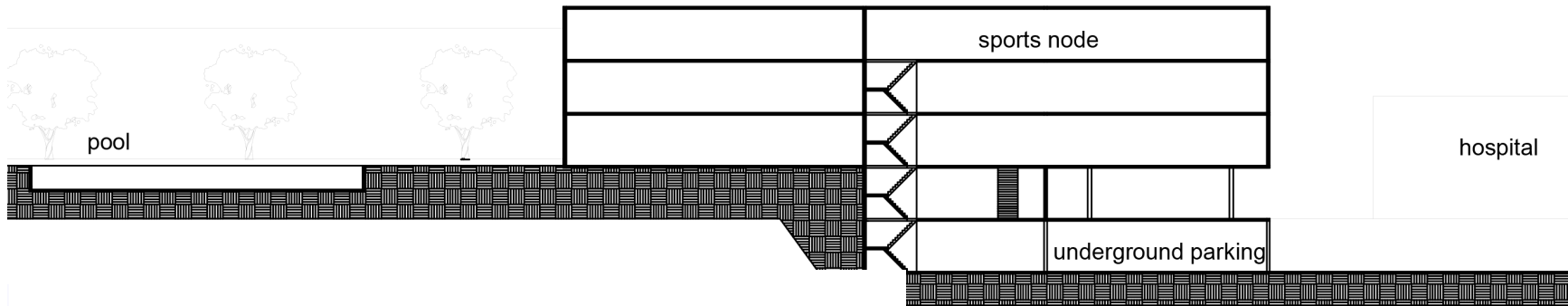


Fig 10.21- Section 1:600

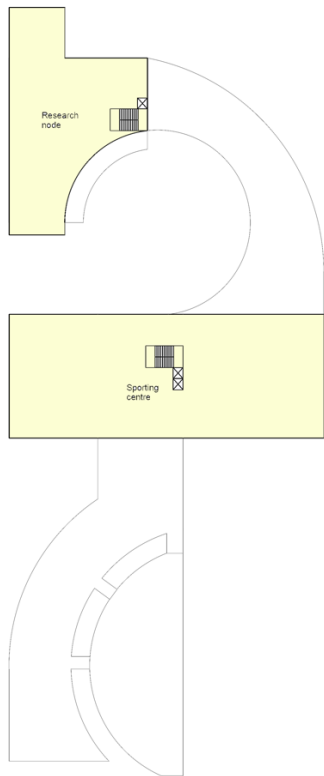


Fig 10.19- Second floor plan 1:1250

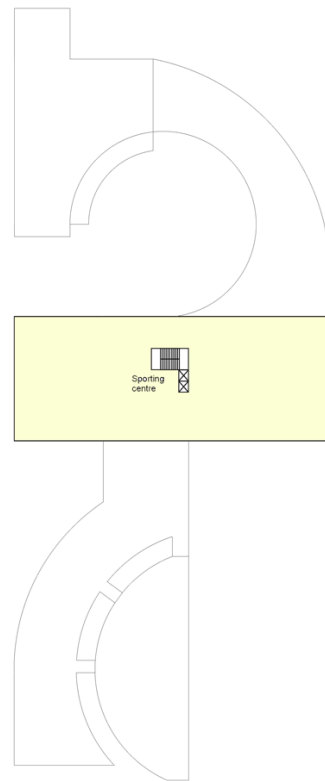


Fig 10.20- Third floor plan 1:1250

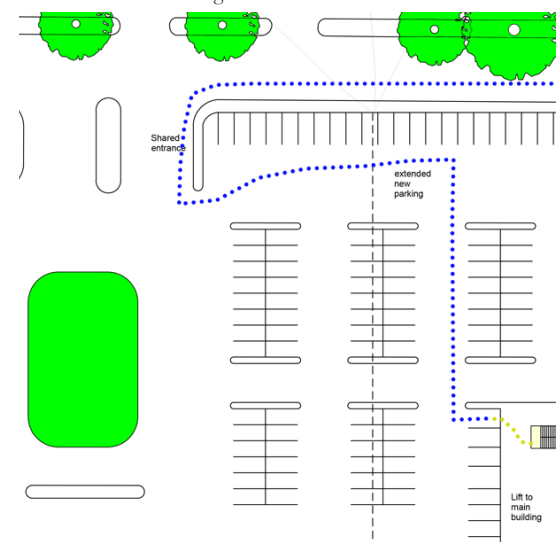


Fig 10.22- Underground plan 1:1250

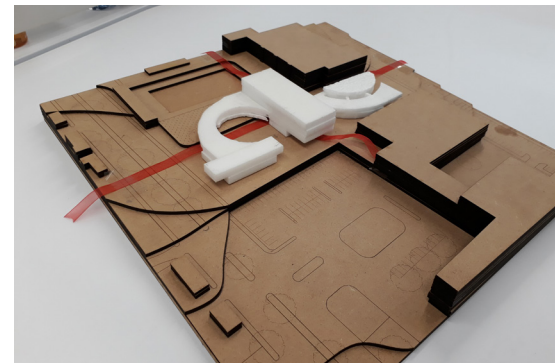


Fig 10.23- Concept model

Provisional Design

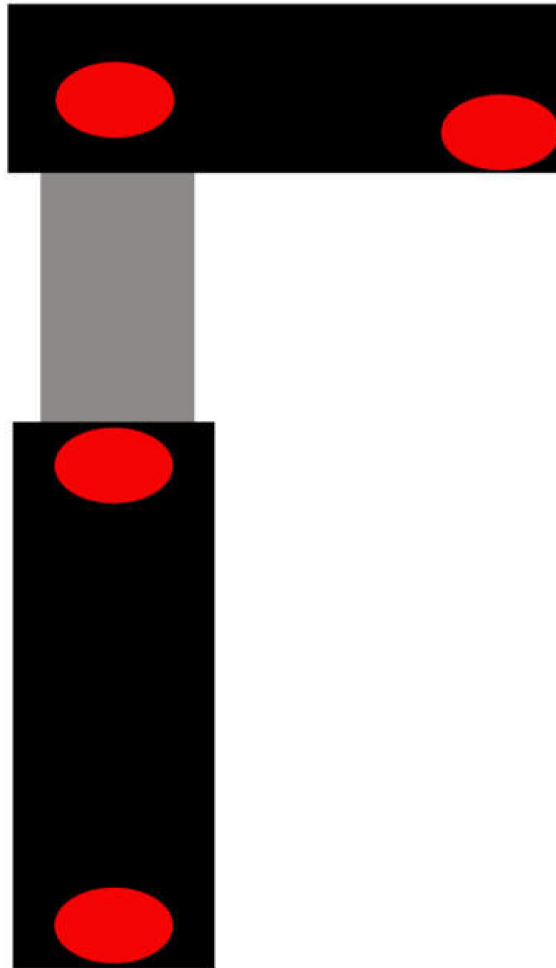


Fig 10.24- footprint

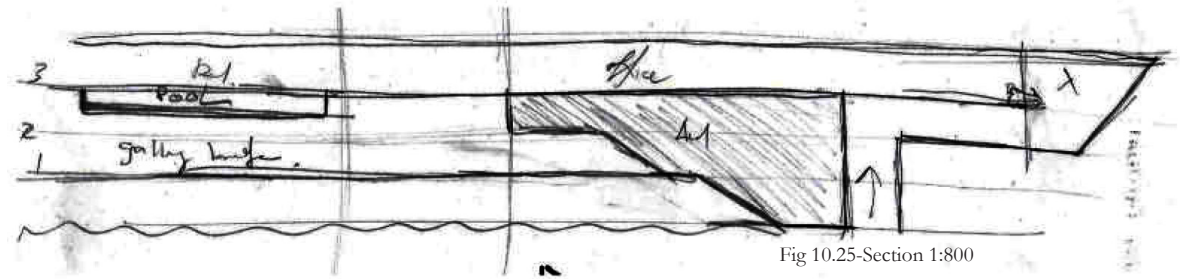


Fig 10.25-Section 1:800

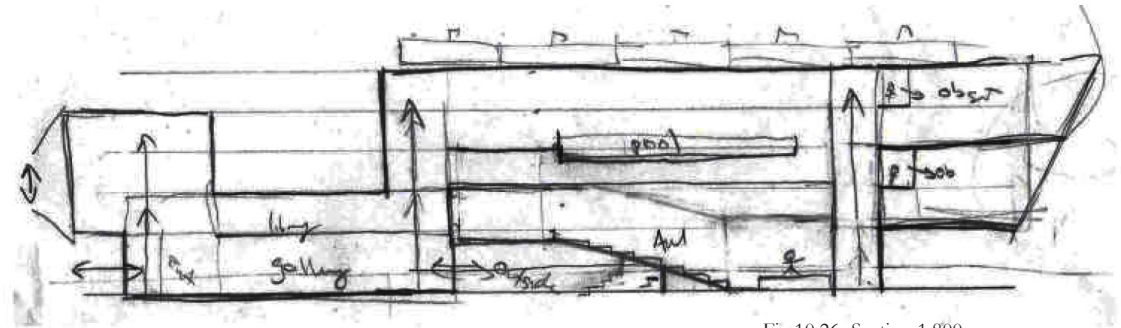


Fig 10.26- Section 1:800

My current concept is not a new idea. It still incorporates all that has come before it. I am still aware of the original movement paths I focused on in the early stages of my design.

I am aware of connection spaces and have designed my building essentially in three categories. One, a research facility; Two, a sports assessment centre; Three, a public interactive building. All these components feed off each other in the design, however they do not interfere with each other.

The long form of the building was molded by the site. I felt the rectangle site should be

complimented or strongly challenged. I felt with my ideas of movement through the site it would be best to work with it.

The initial planning of the building was done so the public could move through the building and observe the high performance athletes assessments. The public would observe the athletes assessments but would not be able to engage and disturb them. This idea was from my investigation of thresholds and in what manner to deal with them. More attributes of the human body have been incorporated into my building and is a constant theme.

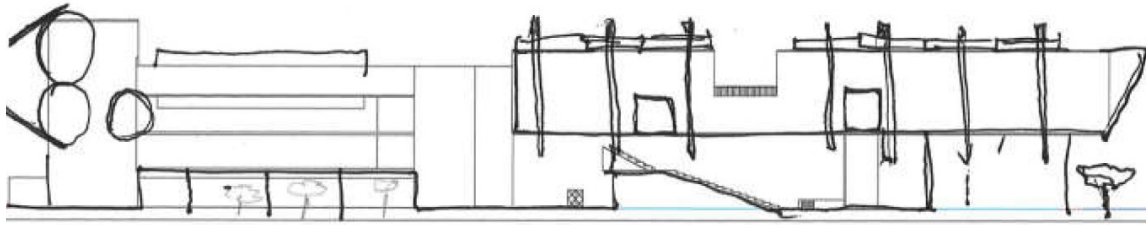


Fig 10.27- West elevation 1:800

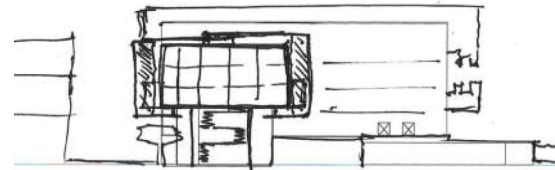


Fig 10.28- South Elevation 1:800

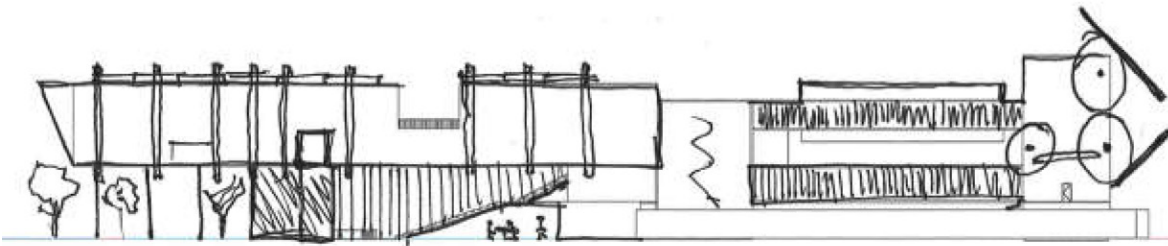


Fig 10.29- East elevation 1:800

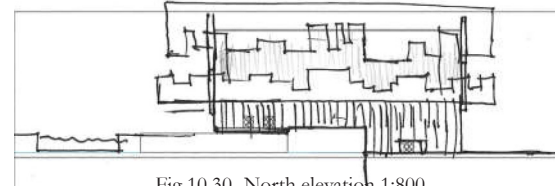


Fig 10.30- North elevation 1:800

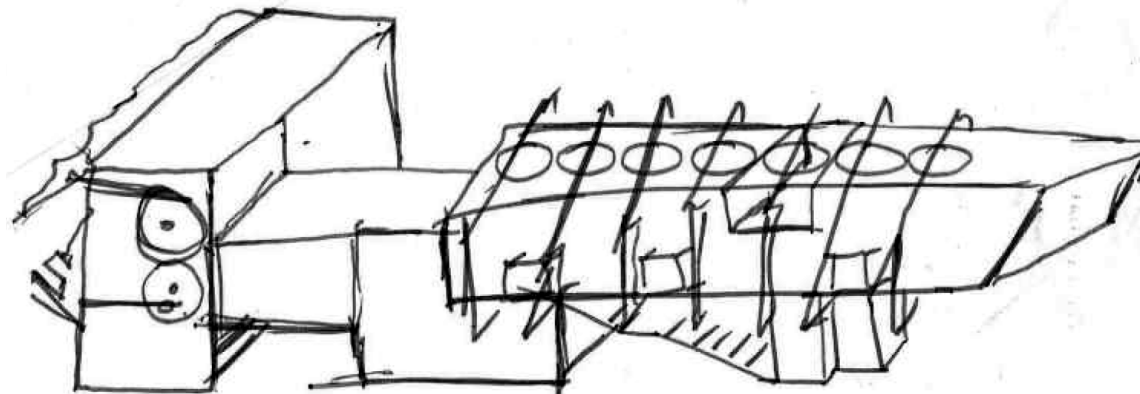


Fig 10.31- 3d sketch

Facades

Through my exploration of gears and their mechanics I thought of a facade system I could implement to deal with the east west orientation of my building. I invented my own moving facade shading system for the east west sun.

The system is symbolic of a human rib cage and acts as a protector to the inner organs of the building.

The gears rotate causing the rods to move back and fourth. The facade will come alive and be symbolic of the activity within the building causing the ribs to expand and contract, as if the building were breathing.

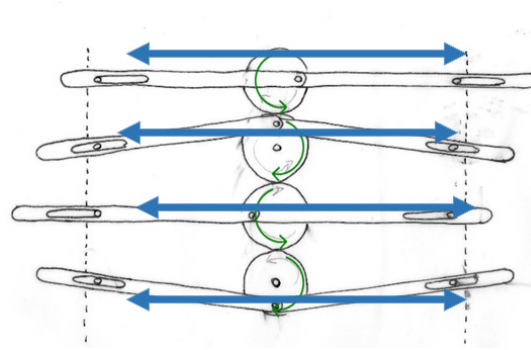


Fig 10.32- Facade detail

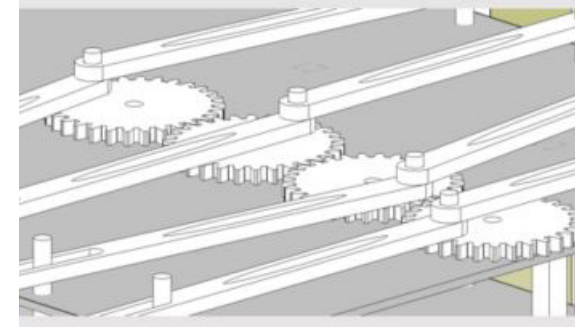


Fig 10.33- Facade detail

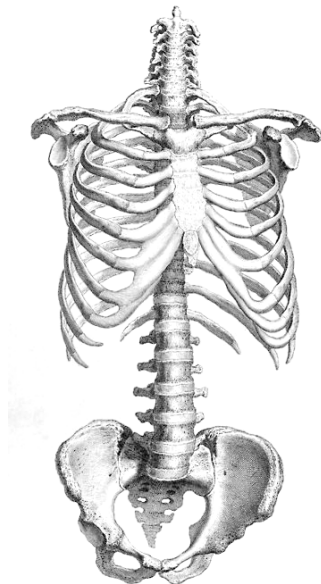


Fig 10.34- Skeleton sketch

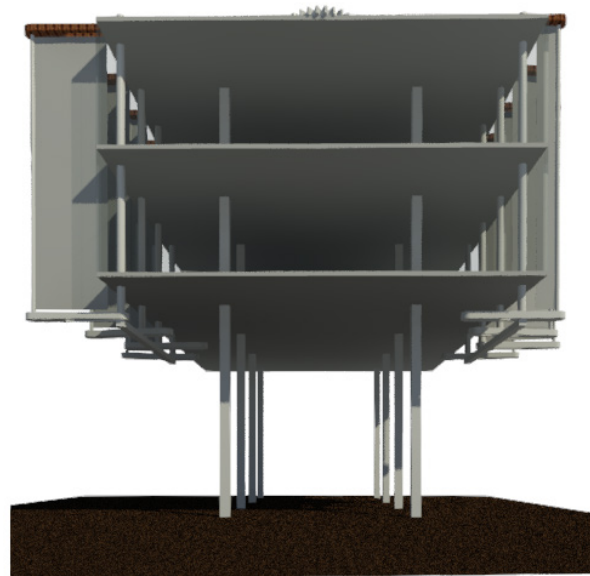


Fig 10.35- Facade detail

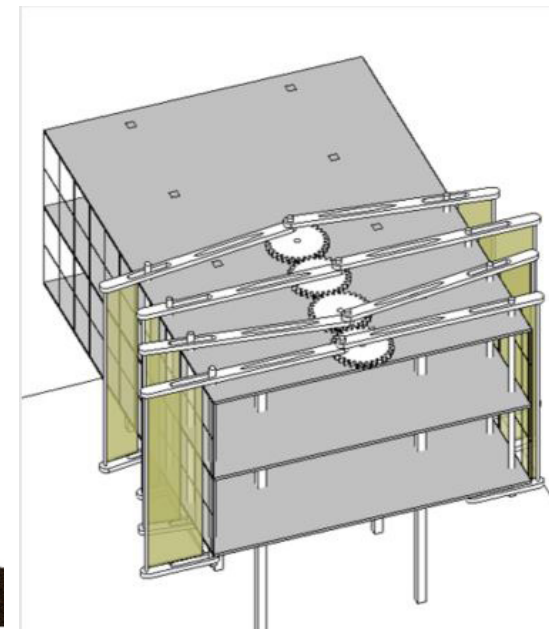


Fig 10.36- Facade detail

A system for the north facade which also has its own inventive use of gears. The facade is designed to open and close depending when the labs require no natural light. The idea stems from the teeth like connections i explored creating my site model.

This facade system was abandoned as it was adding too much detail to an already busy building. The north facade was also passages leading into the labs as some lab rooms had a requirement of no sunlight.

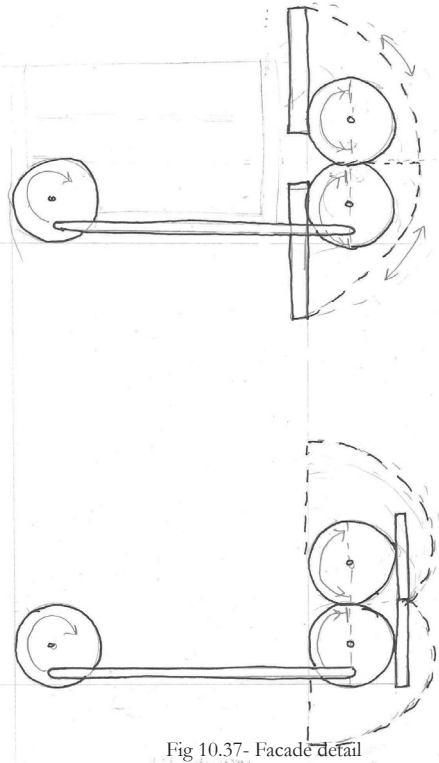


Fig 10.37- Facade detail

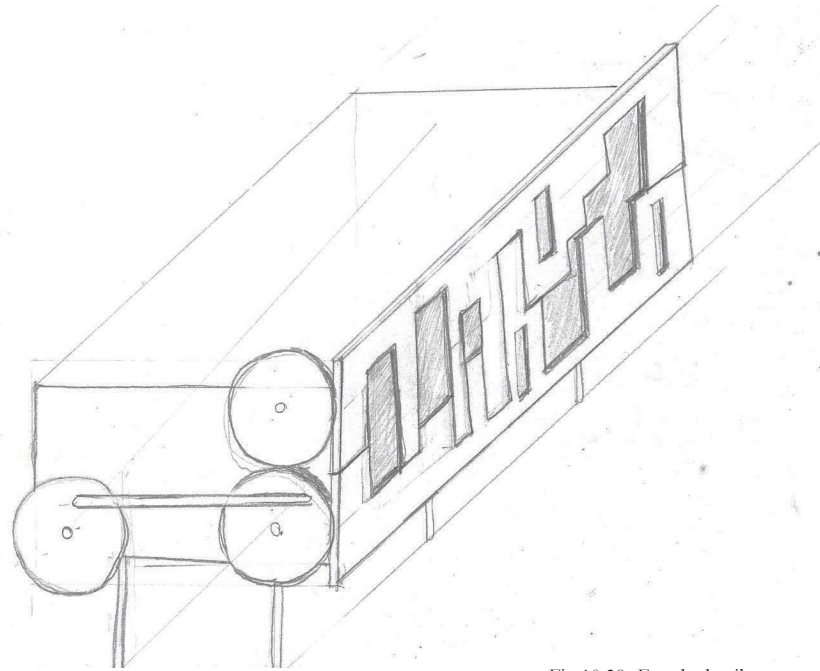


Fig 10.38- Facade detail

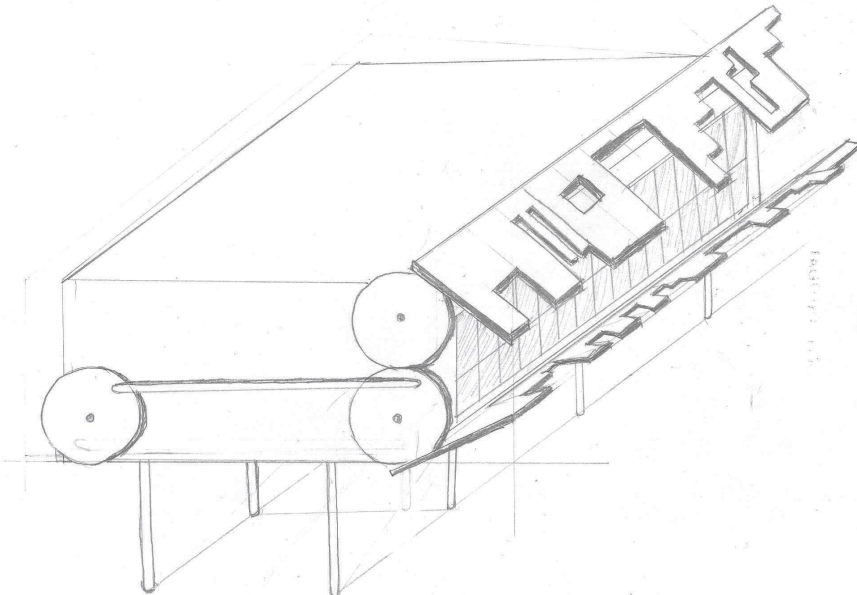


Fig 10.39- Facade detail

Site Plan



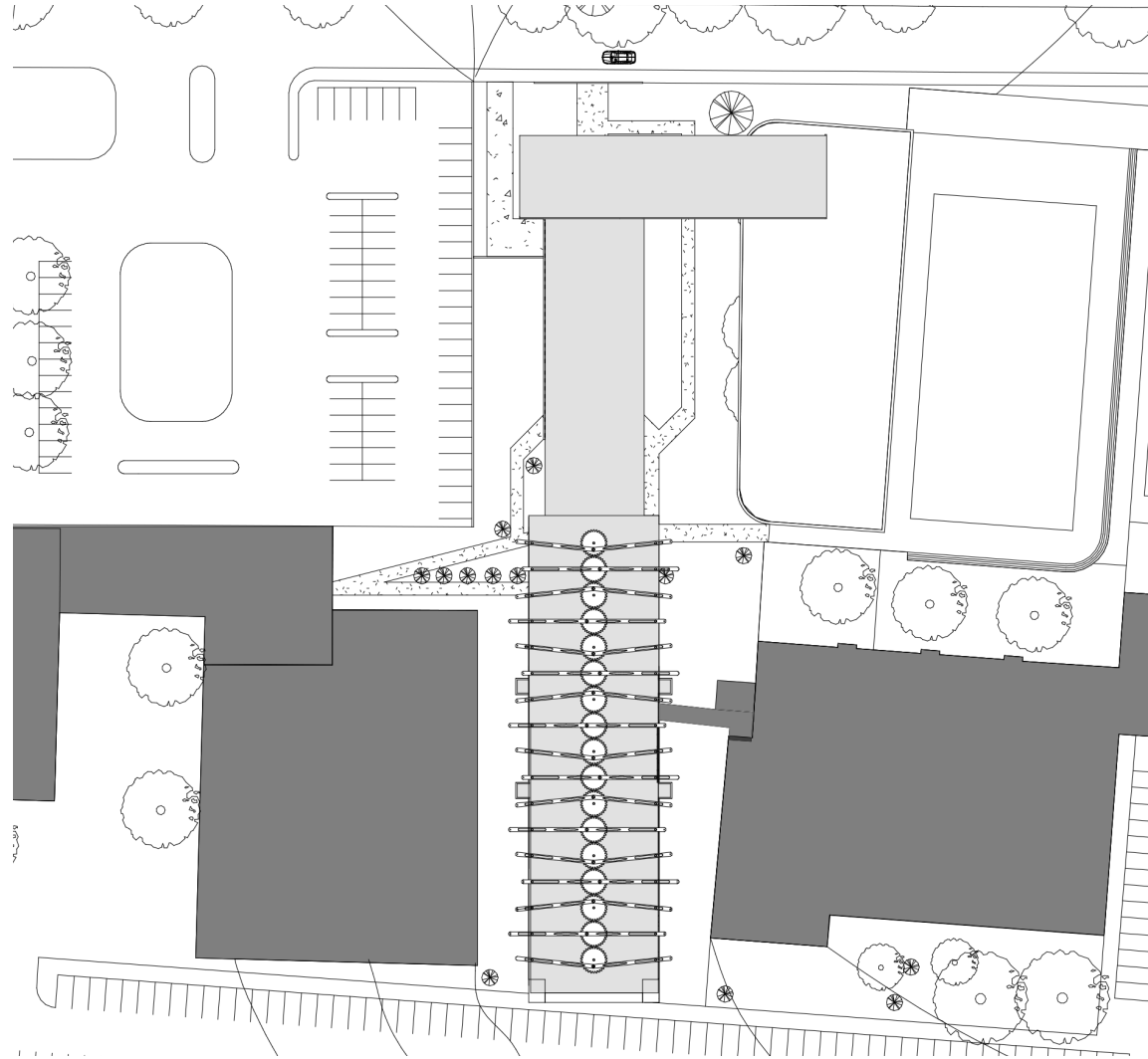


Fig 10.41- Site plan 1:1000



Plans

	Labs
	Admin/teaching
	Sports
	BOH
	Vertical circulation
	WC
	Public
	Semi public

The pathways moving through the site are rigid in form. Possibly a more natural pathway flow would be better suited to the project.



Fig 10.42- Footpath sketch 1:2650



Fig 10.43- Ground floor plan 1:650



Fig 10.44- First floor plan 1:650

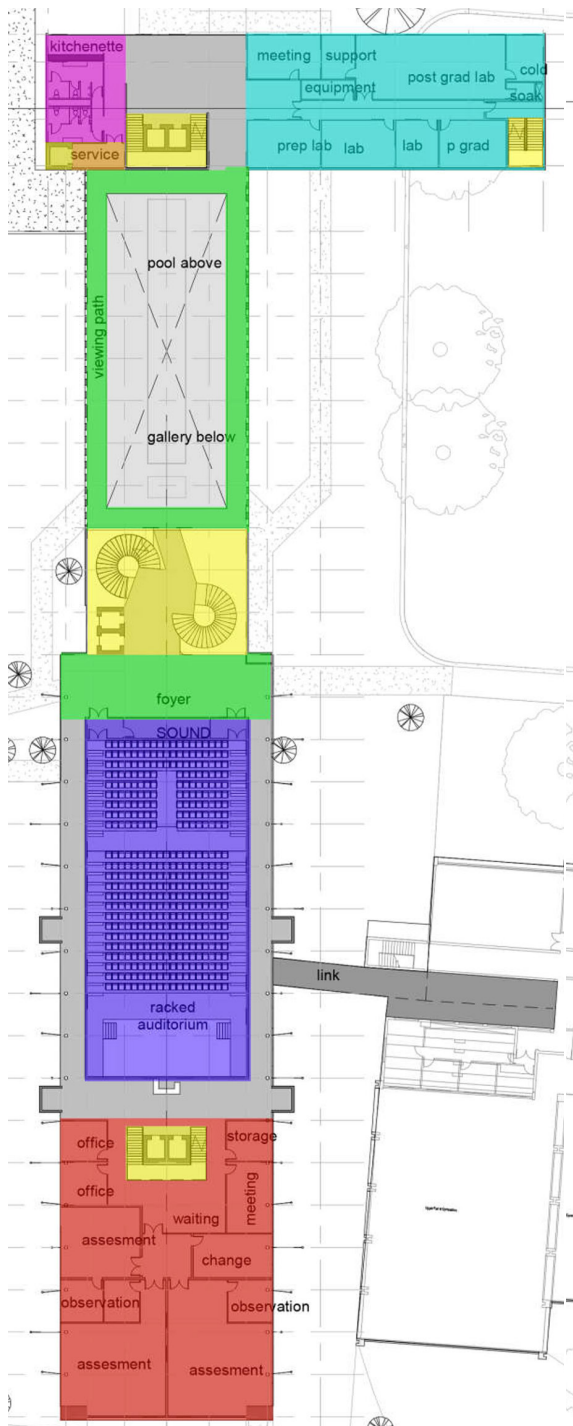


Fig 10.45- Second floor plan 1:650



Fig 10.46- Third floor plan 1:650



Fig 10.47- Fourth floor plan 1:650



Elevations

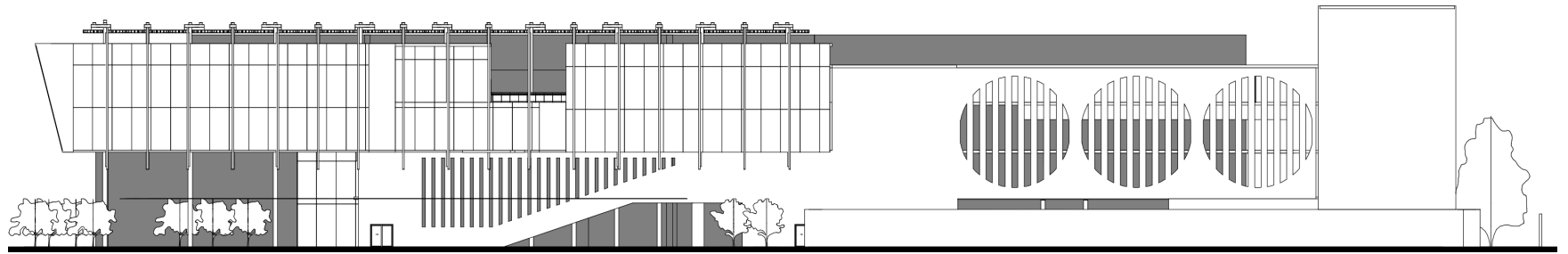
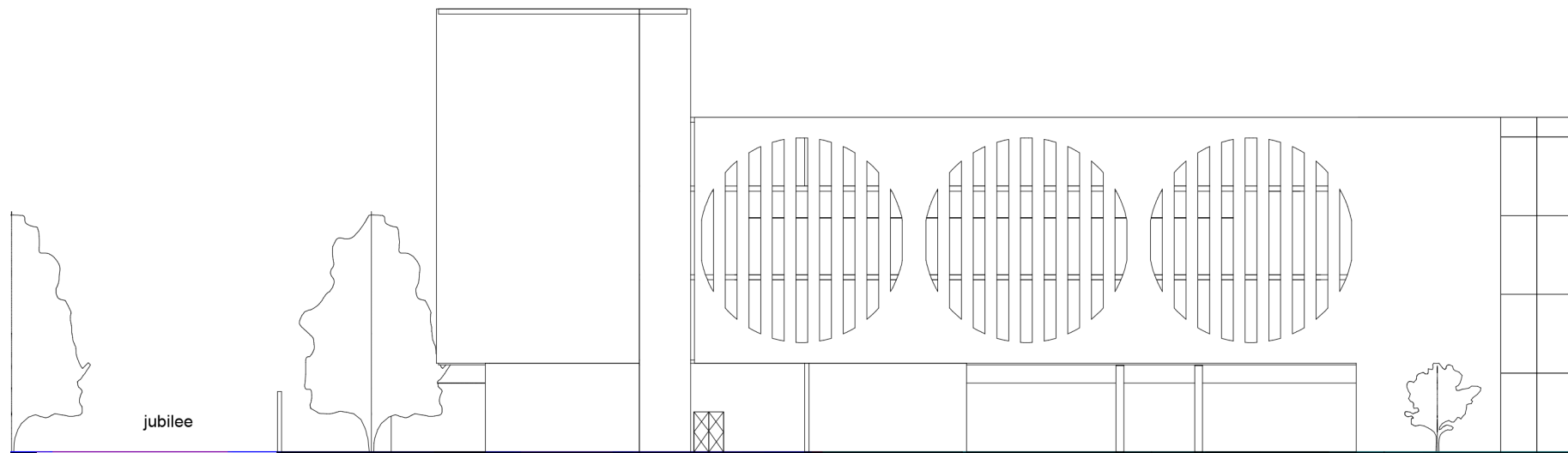


Fig 10.48- East elevation 1:600



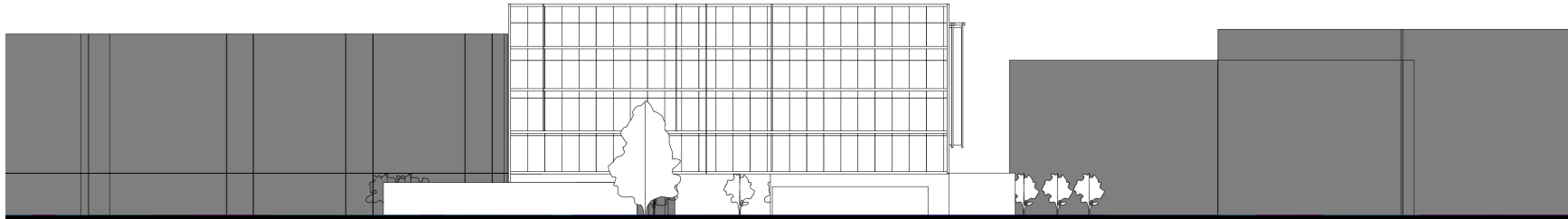


Fig 10.49- North elevation 1:600

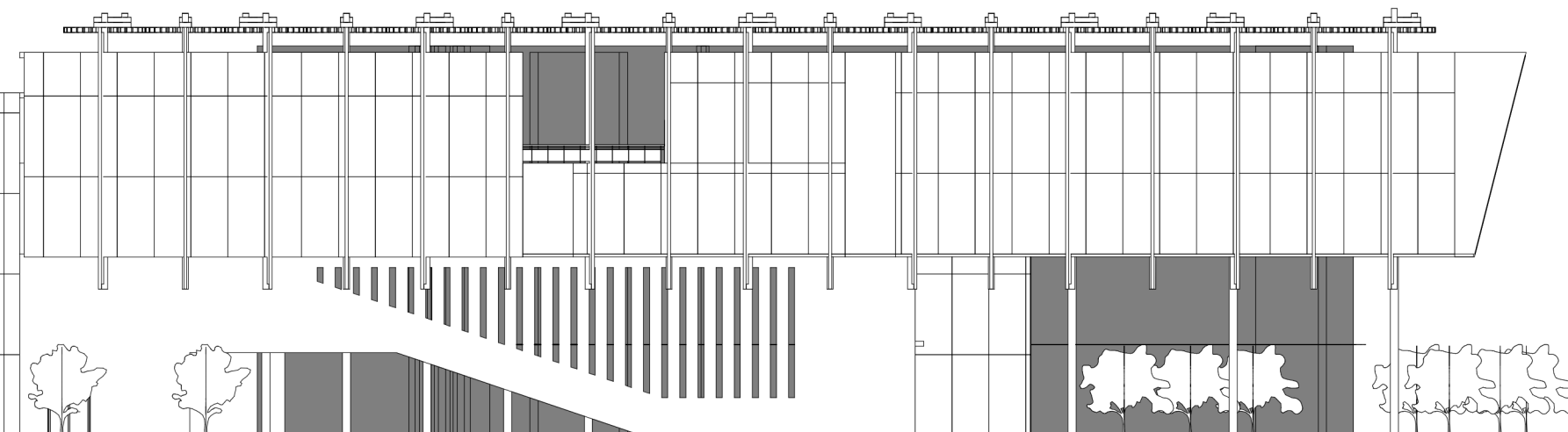
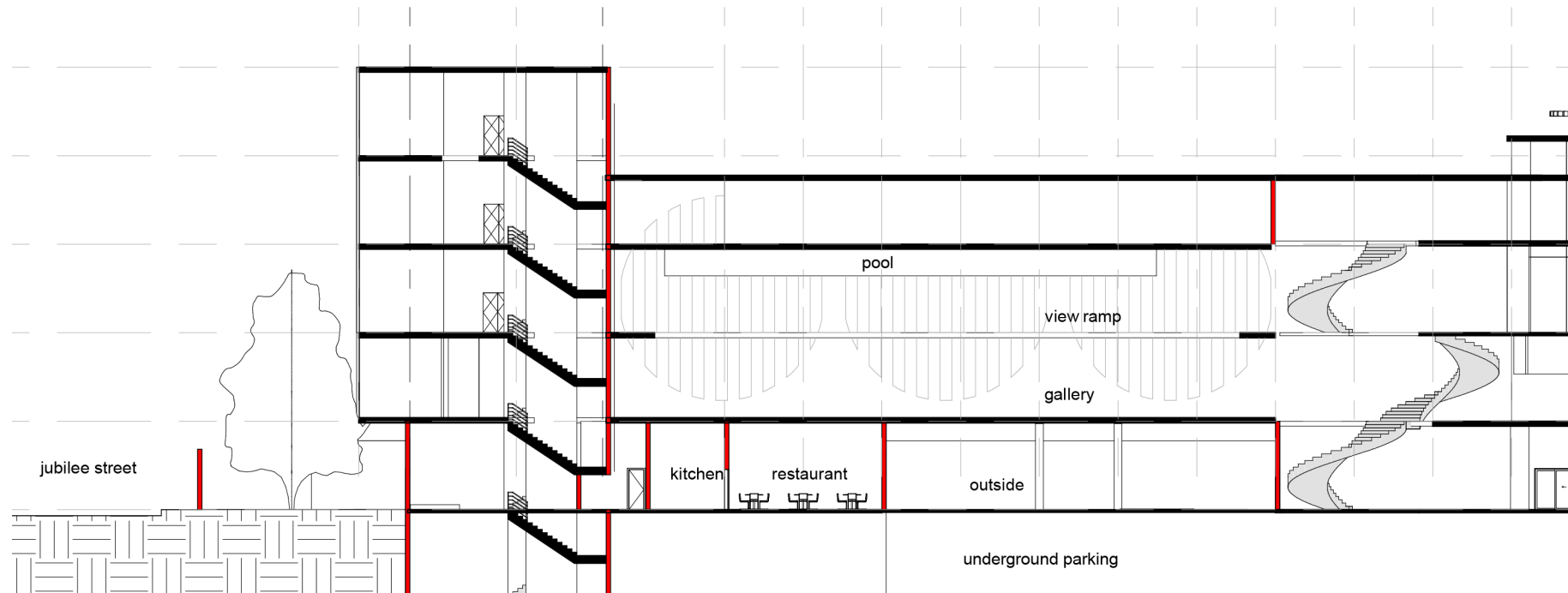


Fig 10.50- West elevation 1: 350

Sections



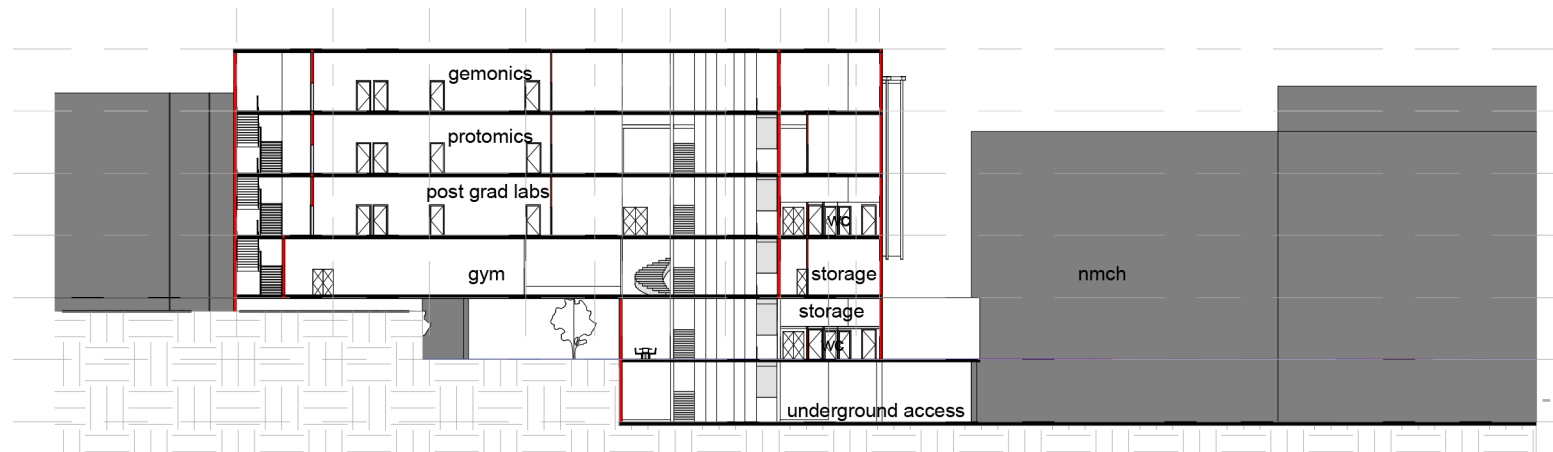


Fig 10.51- Section B-B 1:500

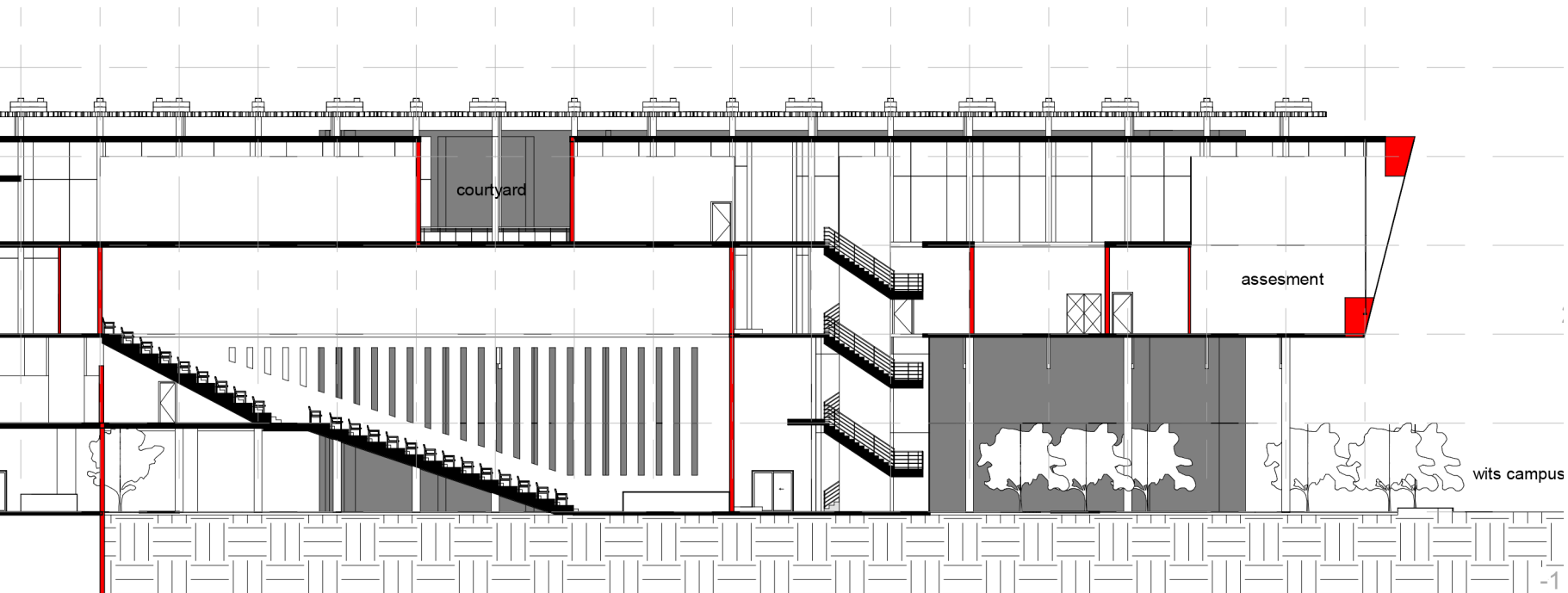


Fig 10.52- Section A-A 1:350



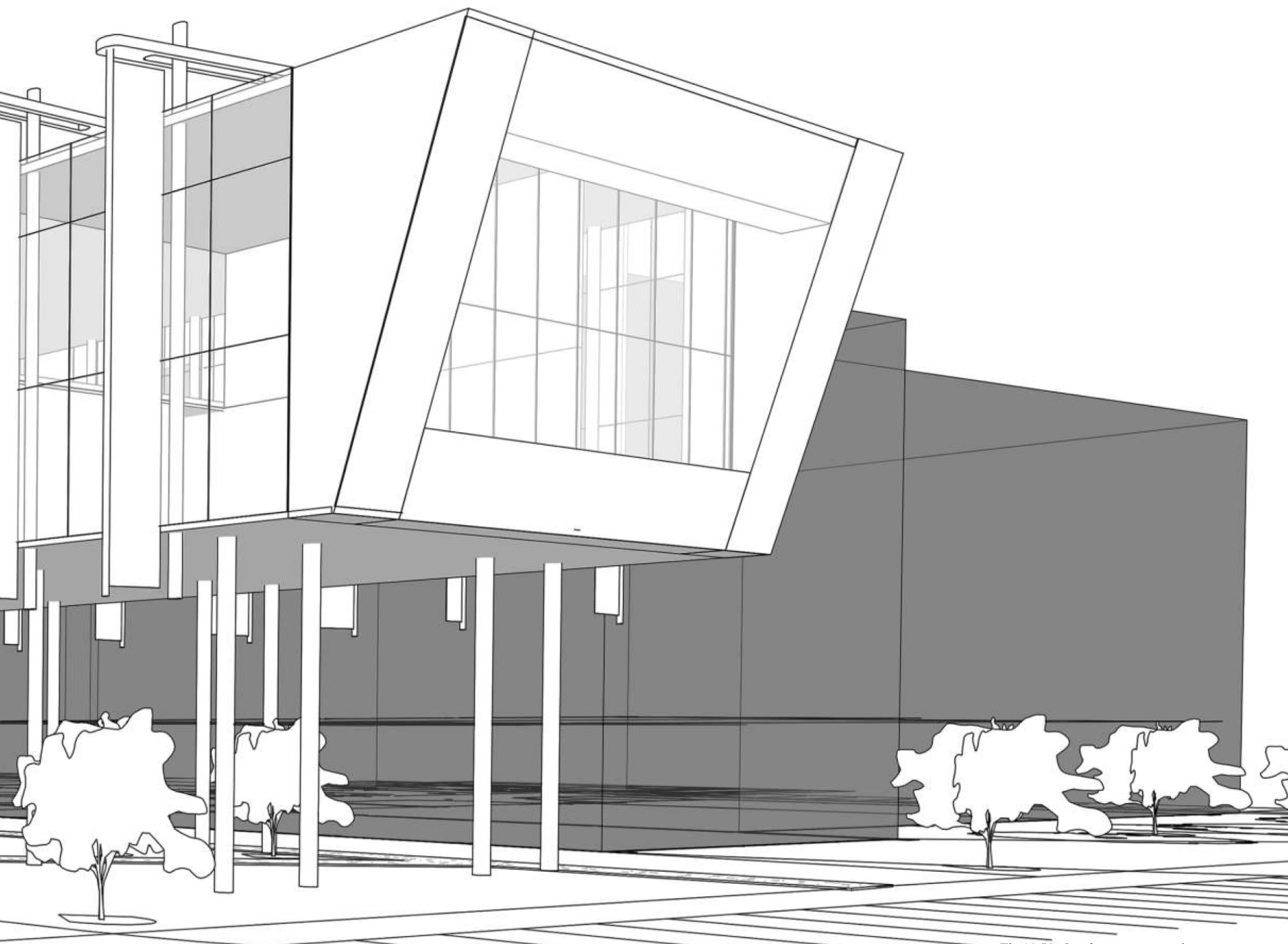


Fig 10.53- South west perspective

Moving Forward

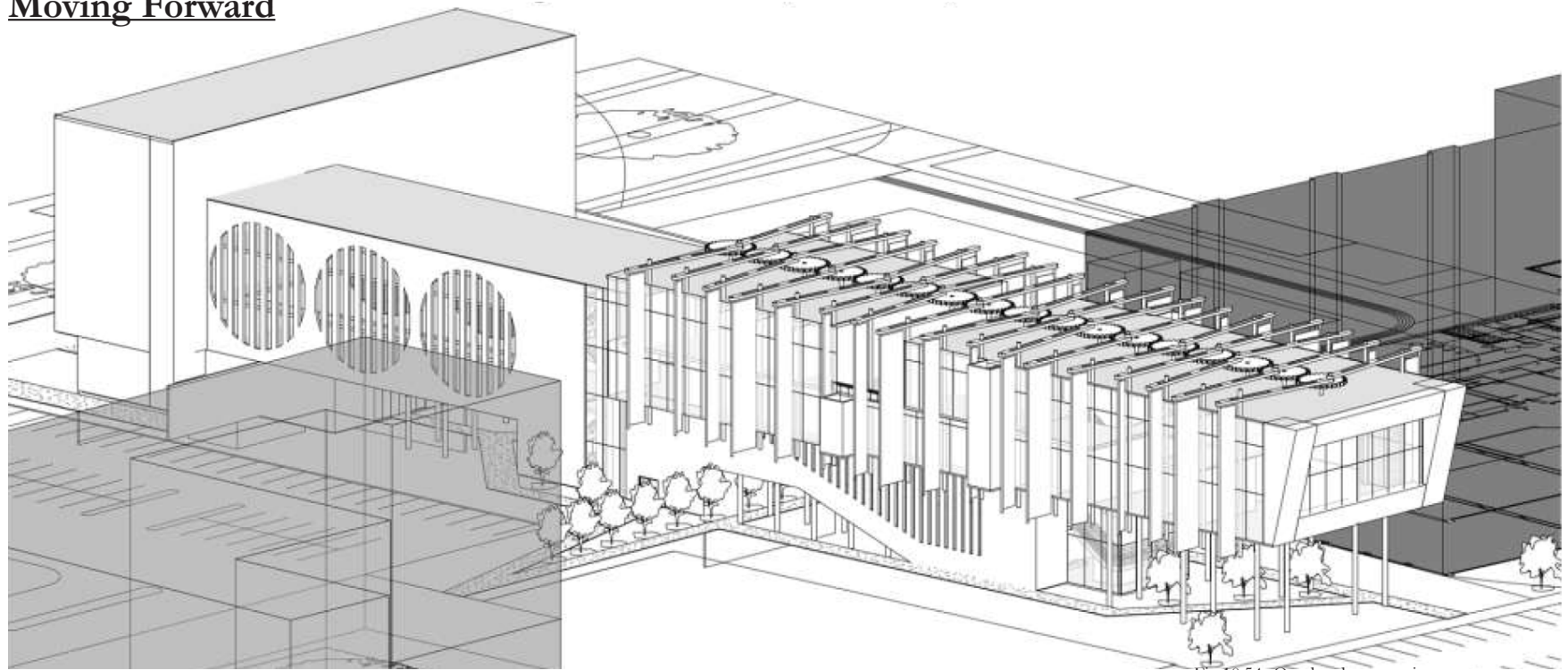


Fig 10.54- Overhead perspective

East west facade system

The facade system is great as a concept, however it is still lacking refinement and a connection to the building. The gears on the roof are not visible to people on the ground. The facade does not engage with the building and its spaces. My solution is to move some of the gears to be within the building. The internal spaces will then engage with the systems and a greater sense of movement will also occur. The high performance centre celebrates movement, bringing moving components into the building will help connect the

facade to the building and concept.

Planing

Although the basic planning works, the spaces created are not dynamic and need more designing. The spaces should evoke movement and also express my concepts.

The auditorium for example is a visible space. It has not been designed yet to feel like an auditorium and be a successful space.

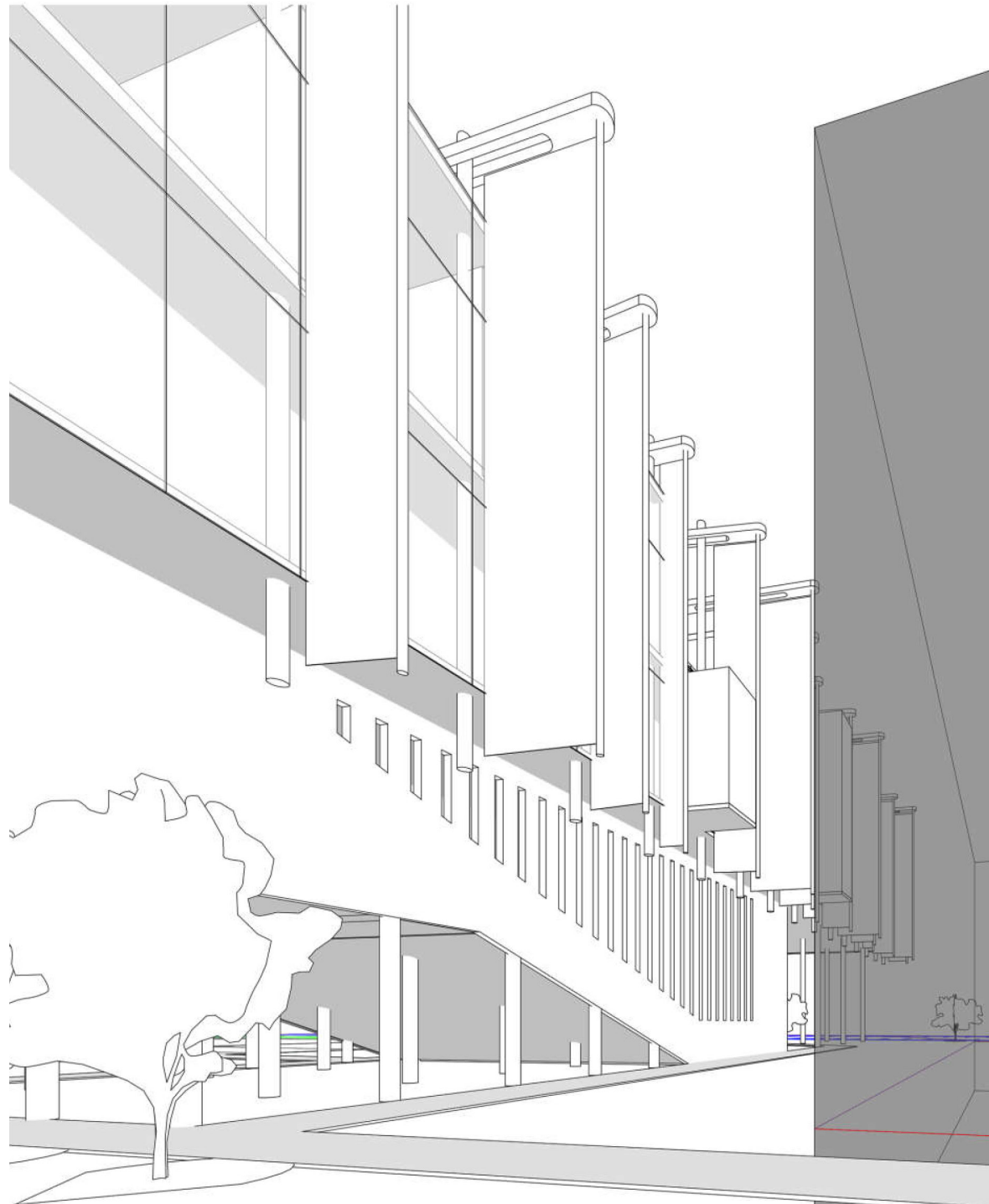


Fig 10.55- Louver perspective

Chapter 11

Final Design

Final Drawings

Structure

Site Plan

Plans

Elevations

Sections

Perspectives

Facade detail

Conclusion



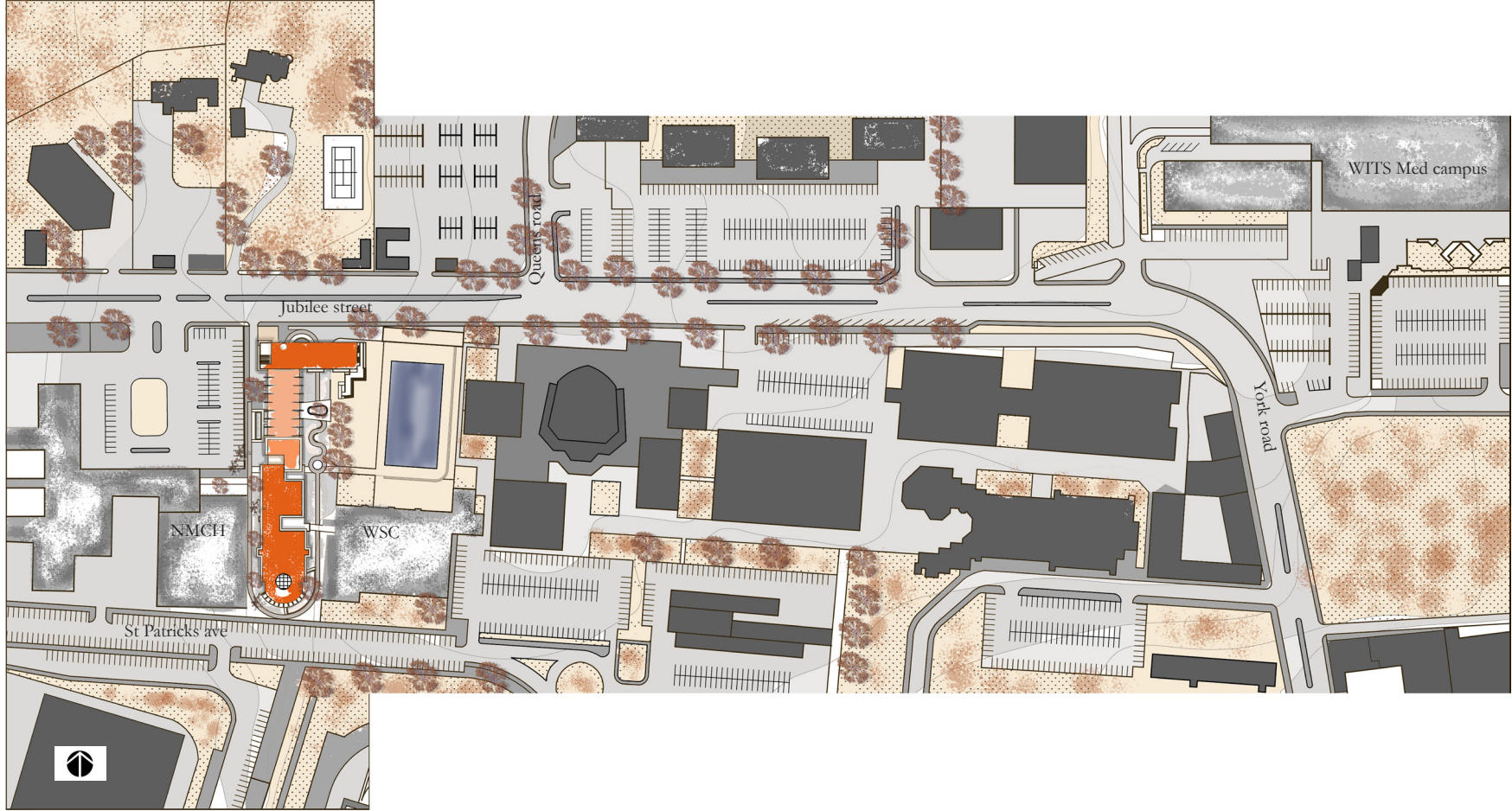


Fig 11.1- Site Plan 1:4000

The surroundings on the site was a play on structured and natural with the west side paths being obstructed and the east being natural and free.

Although the building is one building. It is essentially divided into three wings which naturally cross into each other as you move through the building. The North end being office and research labs. The central space being mostly your public areas and the south side of the building mostly for the assessments of athletes.

These different parts of the building almost become merged as my intension was to allow the public to view the athletes being tested but not interfere, thus privacy and professionalism are still achieved.

The gear system which sat on the roof is now incorporated into the gallery and pool area creating actual movement in the building.

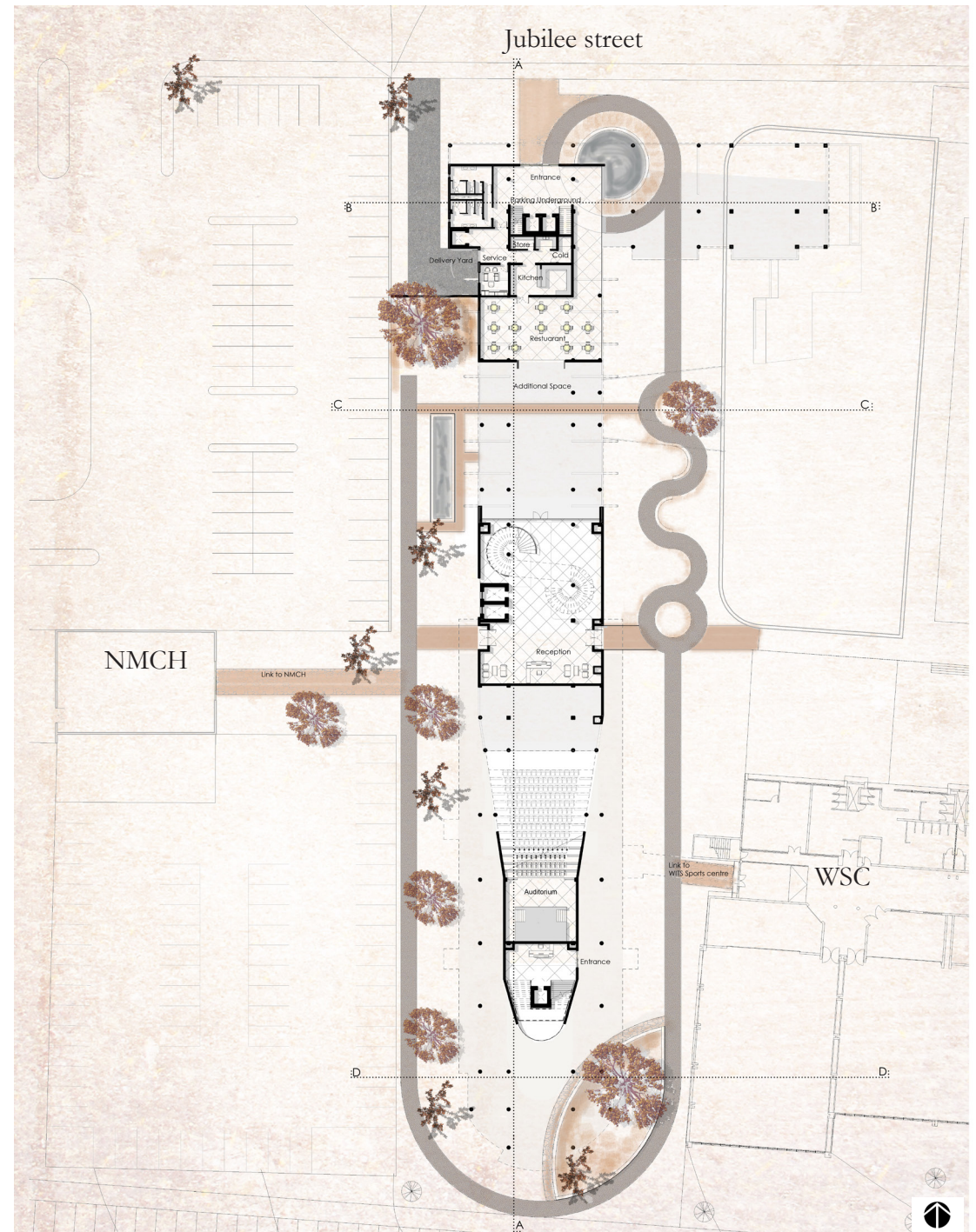


Fig 11.2- Ground floor plan 1:750

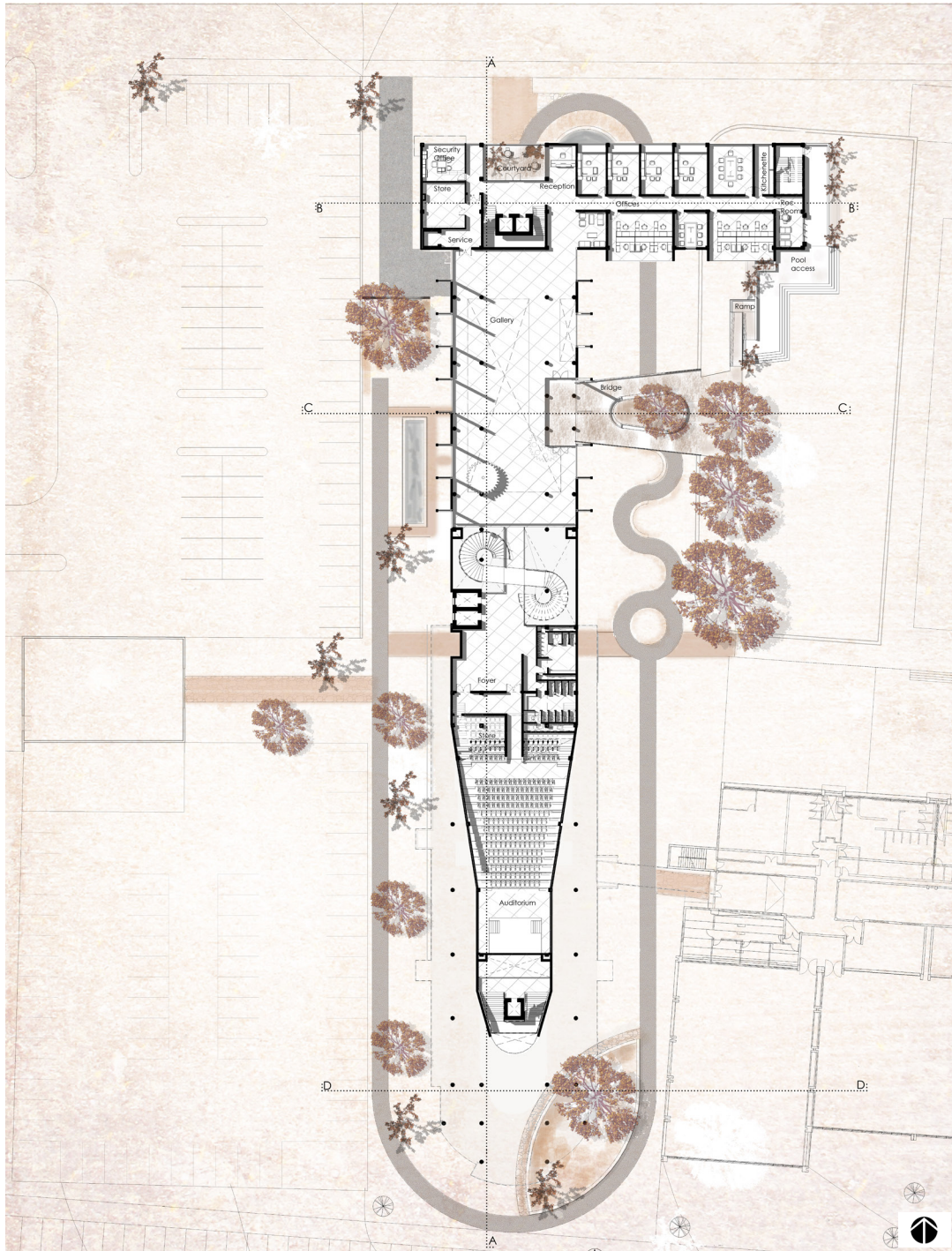


Fig 11.3- First floor plan 1:750

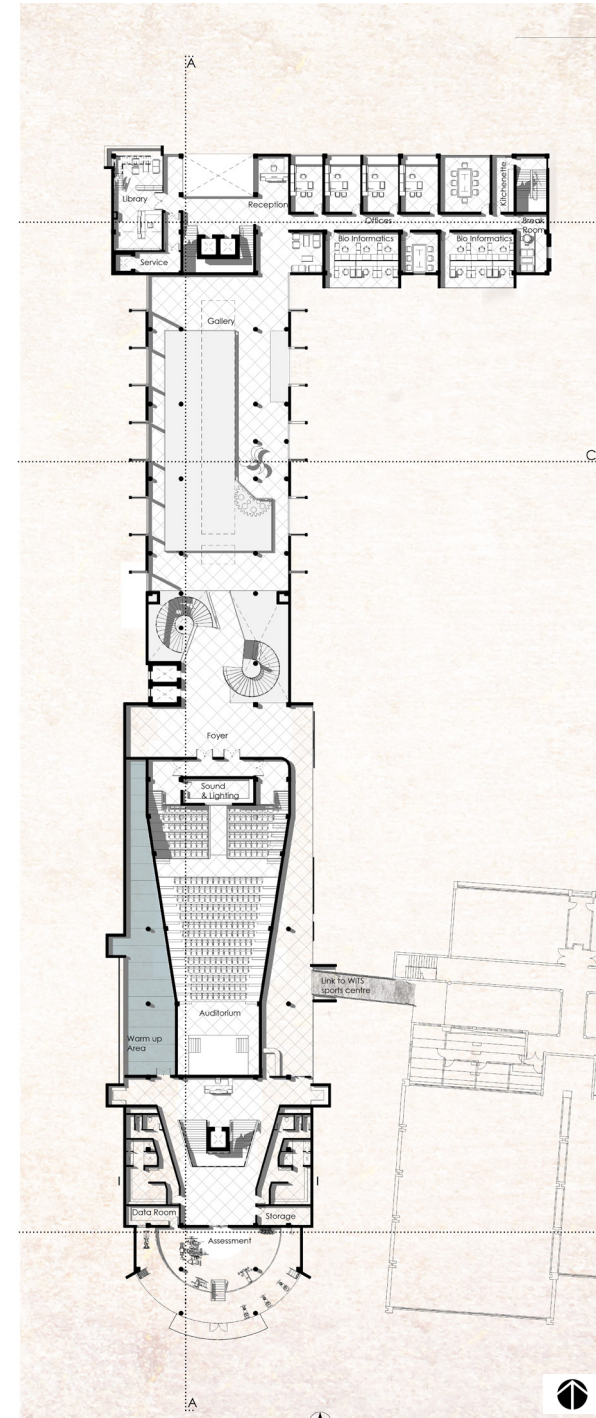


Fig 11.4- Second floor plan 1:750

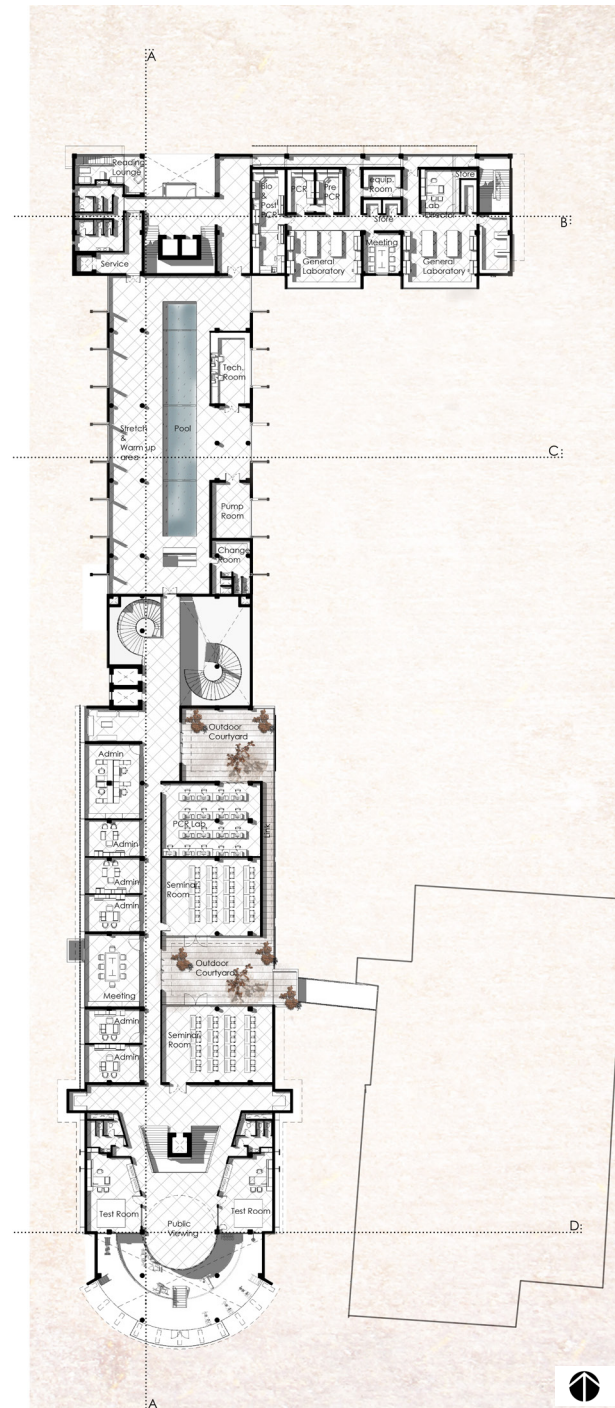


Fig 11.5-Third floor plan 1:750

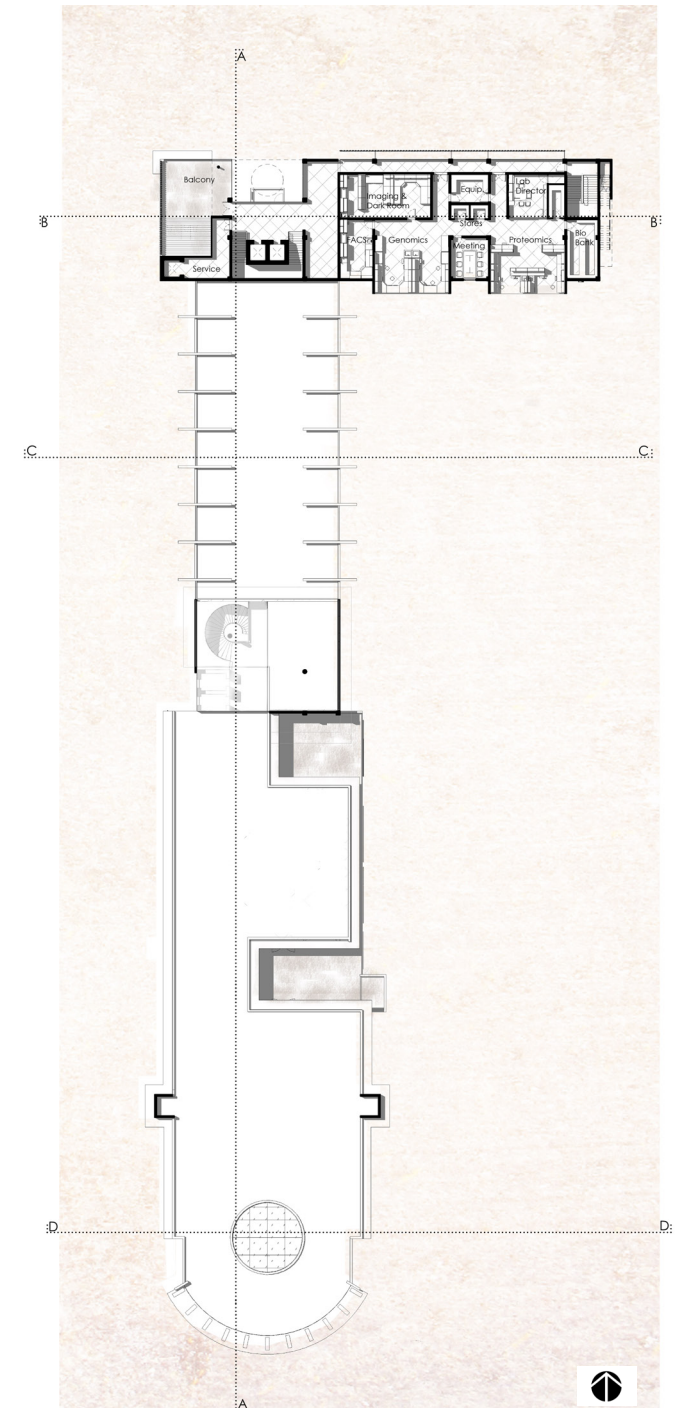


Fig 11.6- Fourth floor plan 1:750

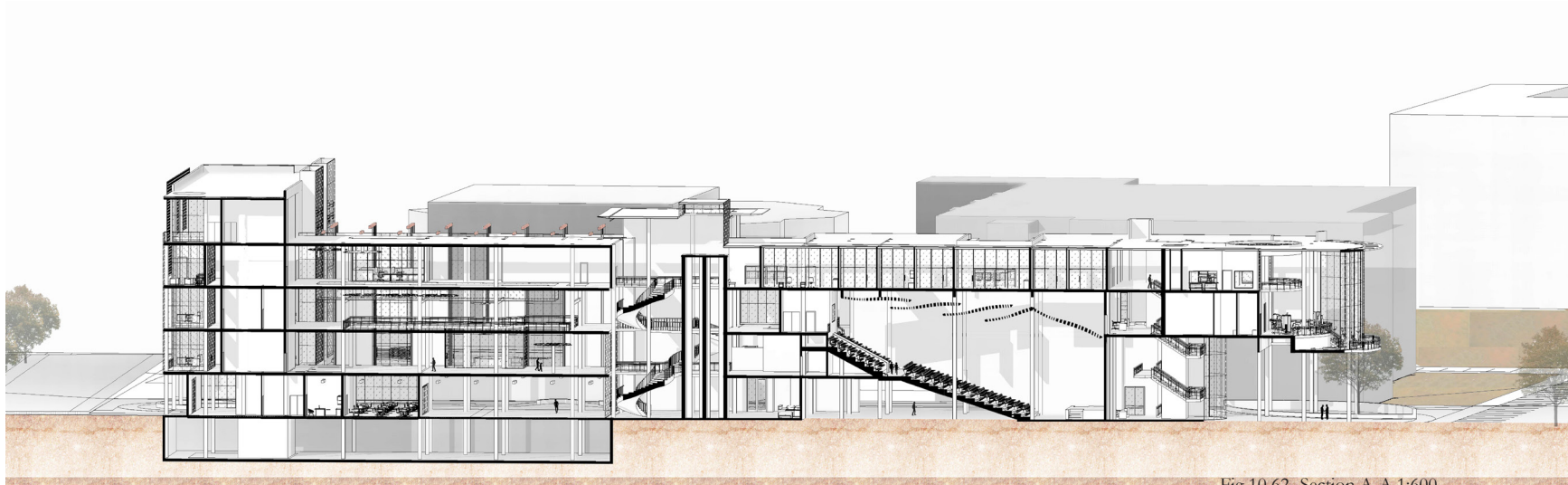


Fig 10.62- Section A-A 1:600

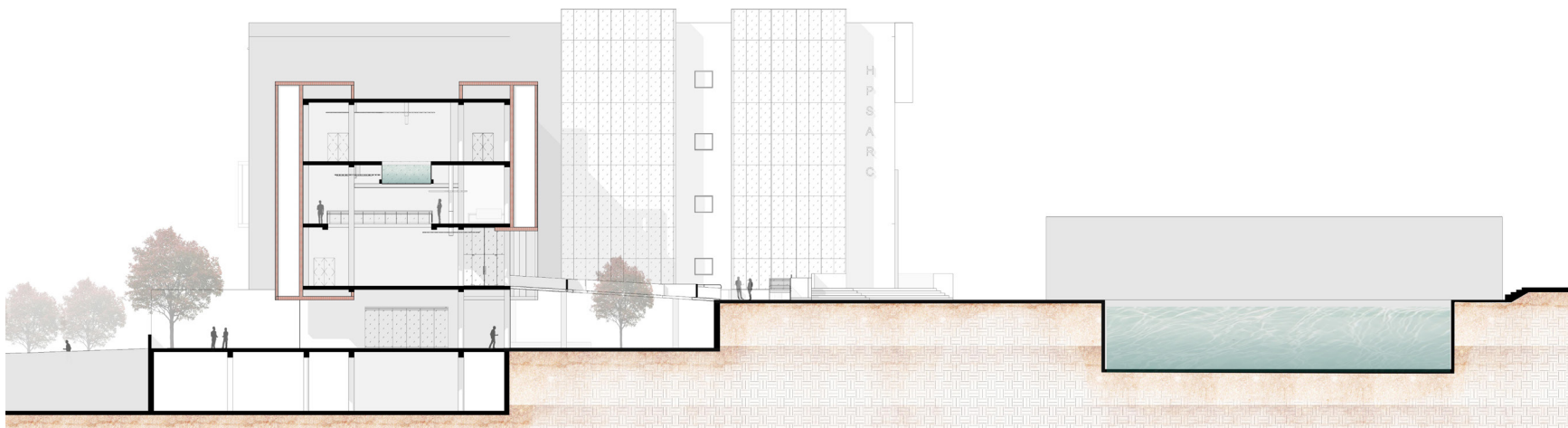


Fig 11.7- Section C-C 1:500



Fig 11.8- Section B-B 1:500

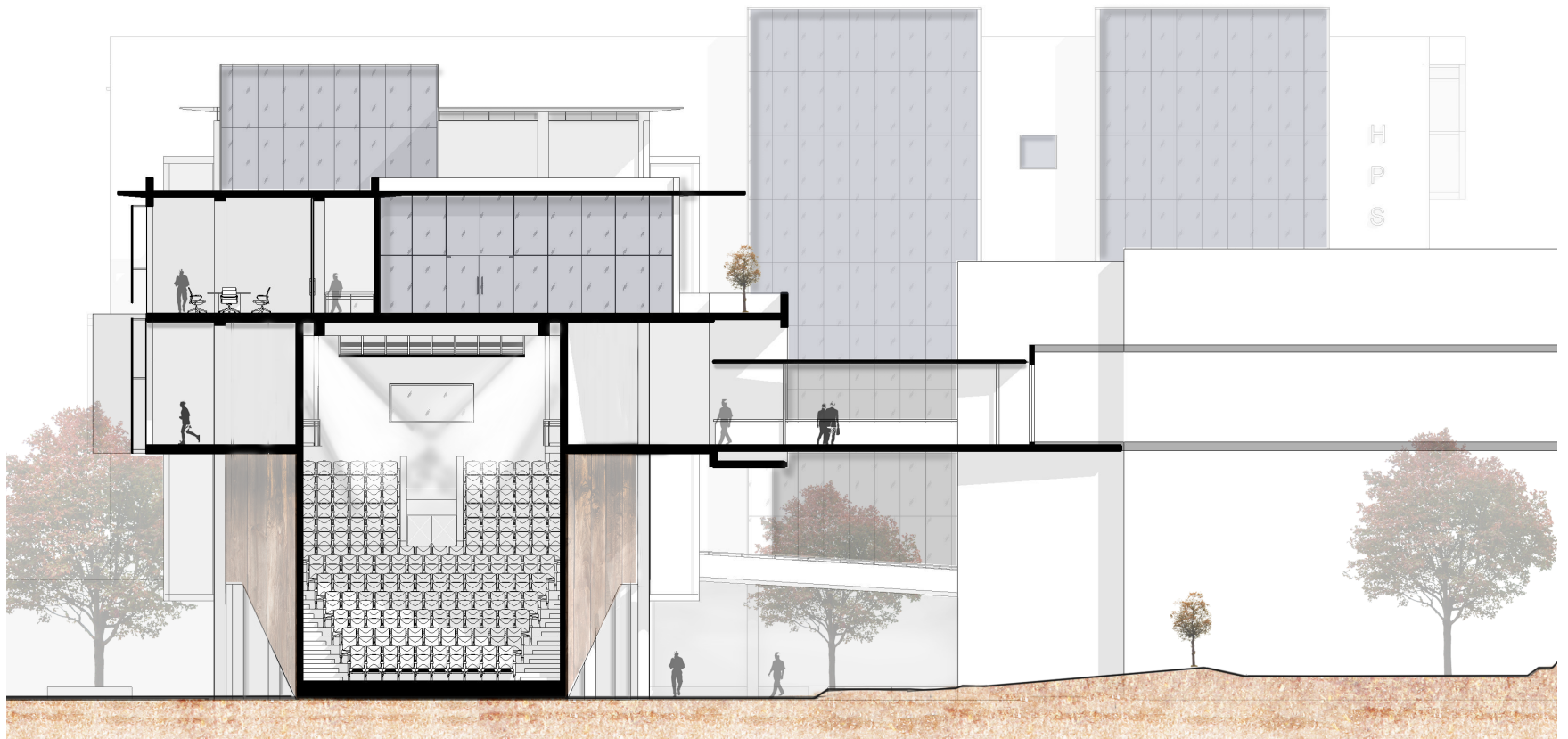


Fig 11.9- Section D-D 1:250

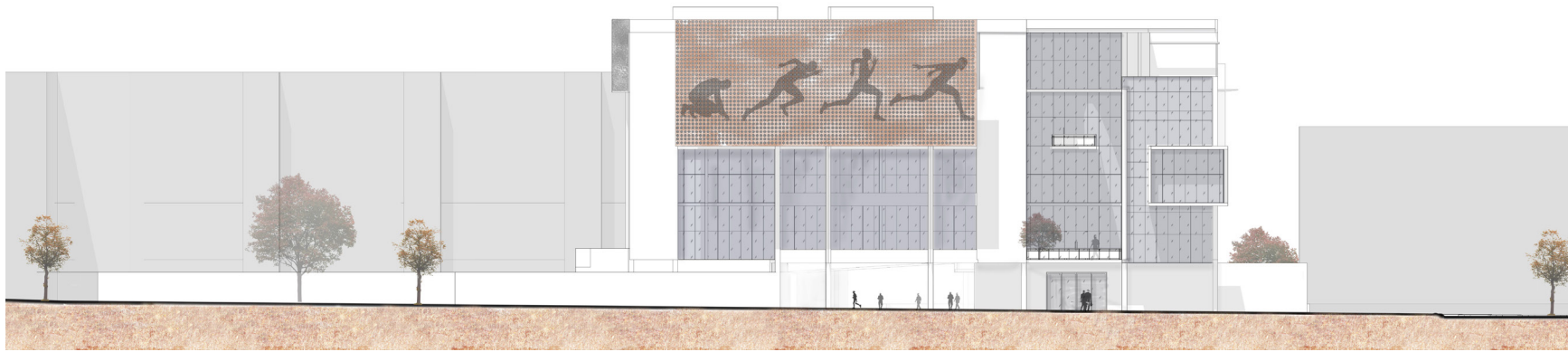


Fig 11.10- North elevation 1:500



Fig 11.12- South elevation 1:500

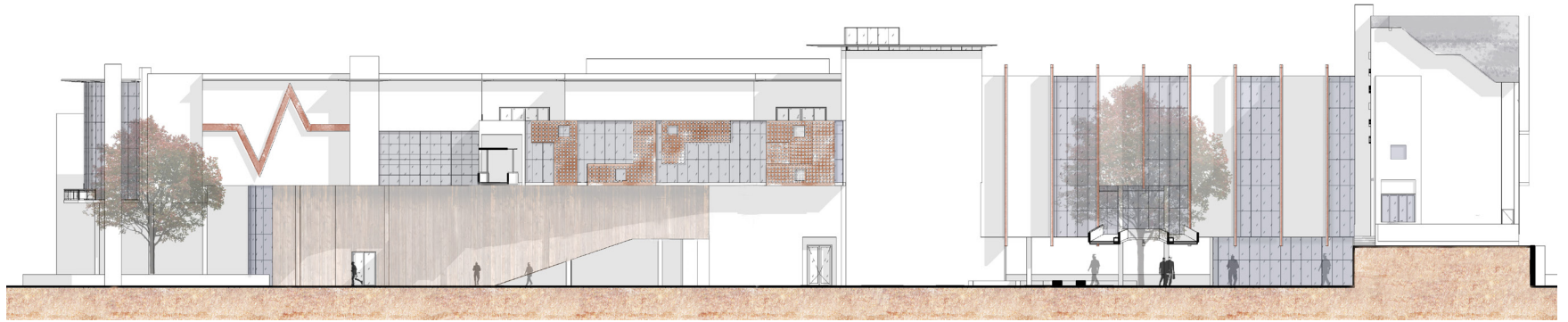


Fig 11.13- Stepped east elevation 1:650

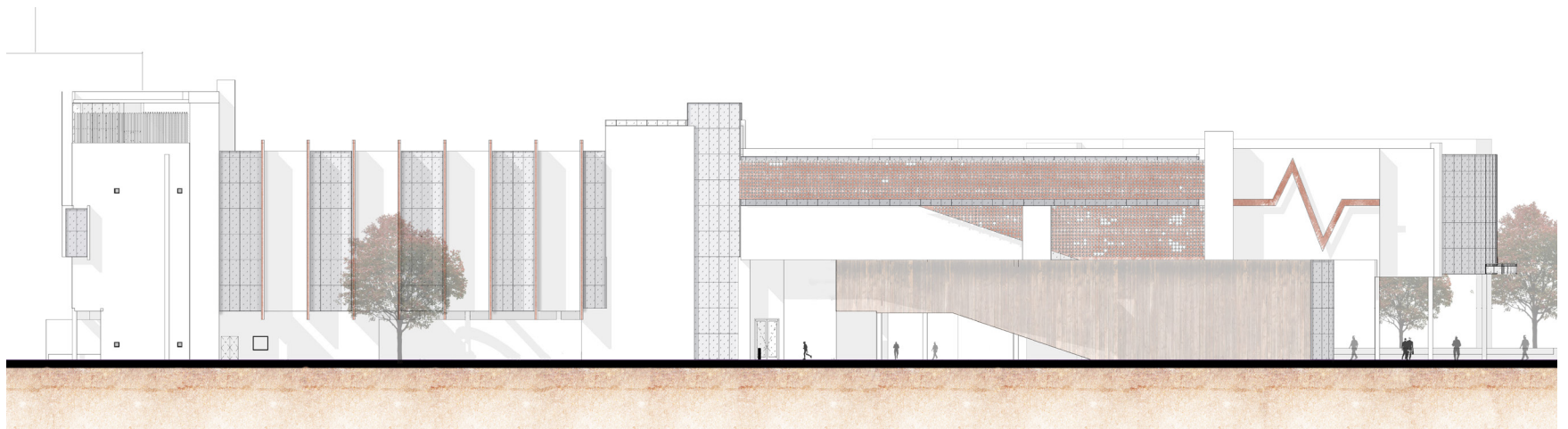


Fig 11.14- West elevation 1:650

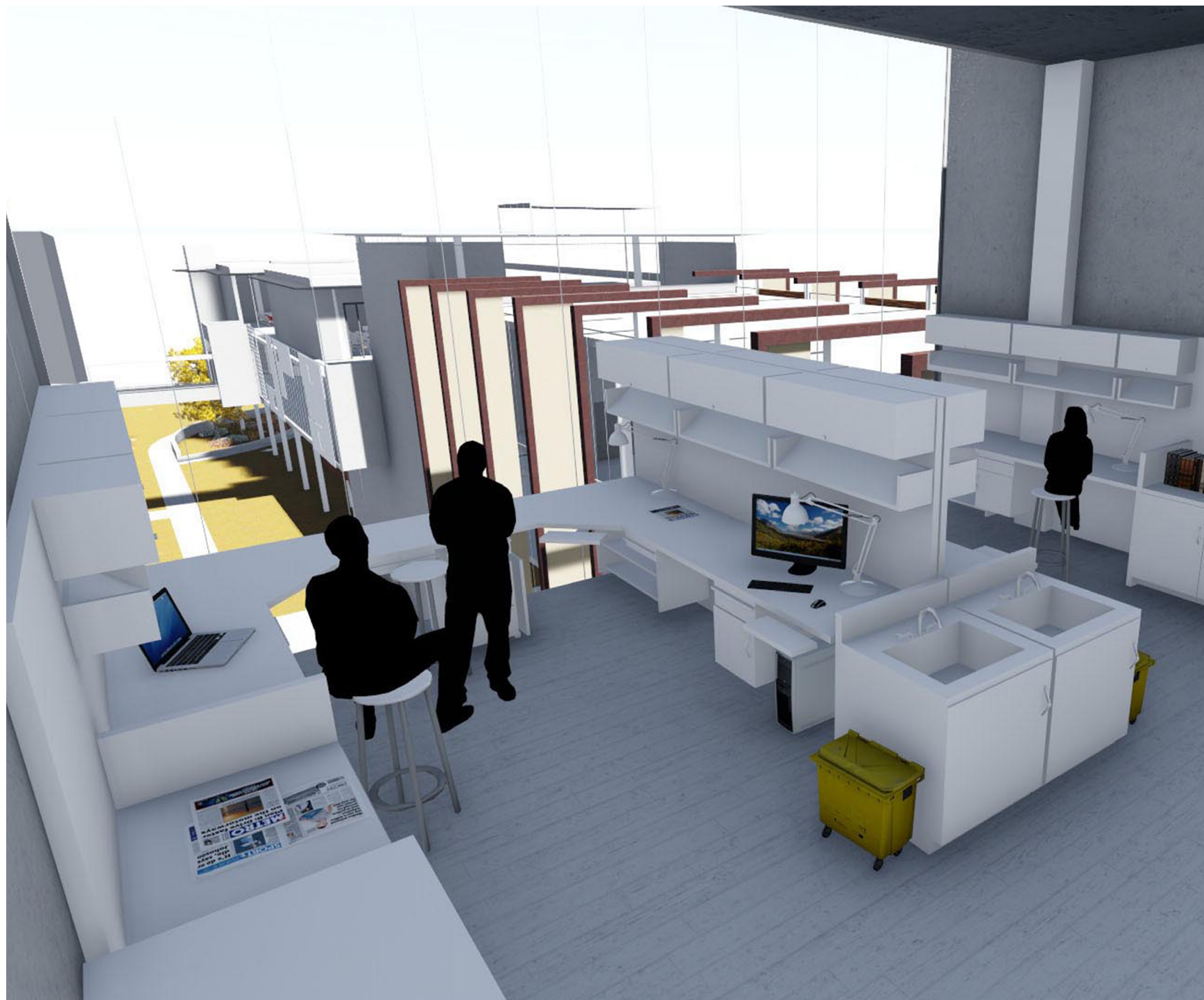


Fig 11.15- North perspective





Fig 11.17- Gallery perspective



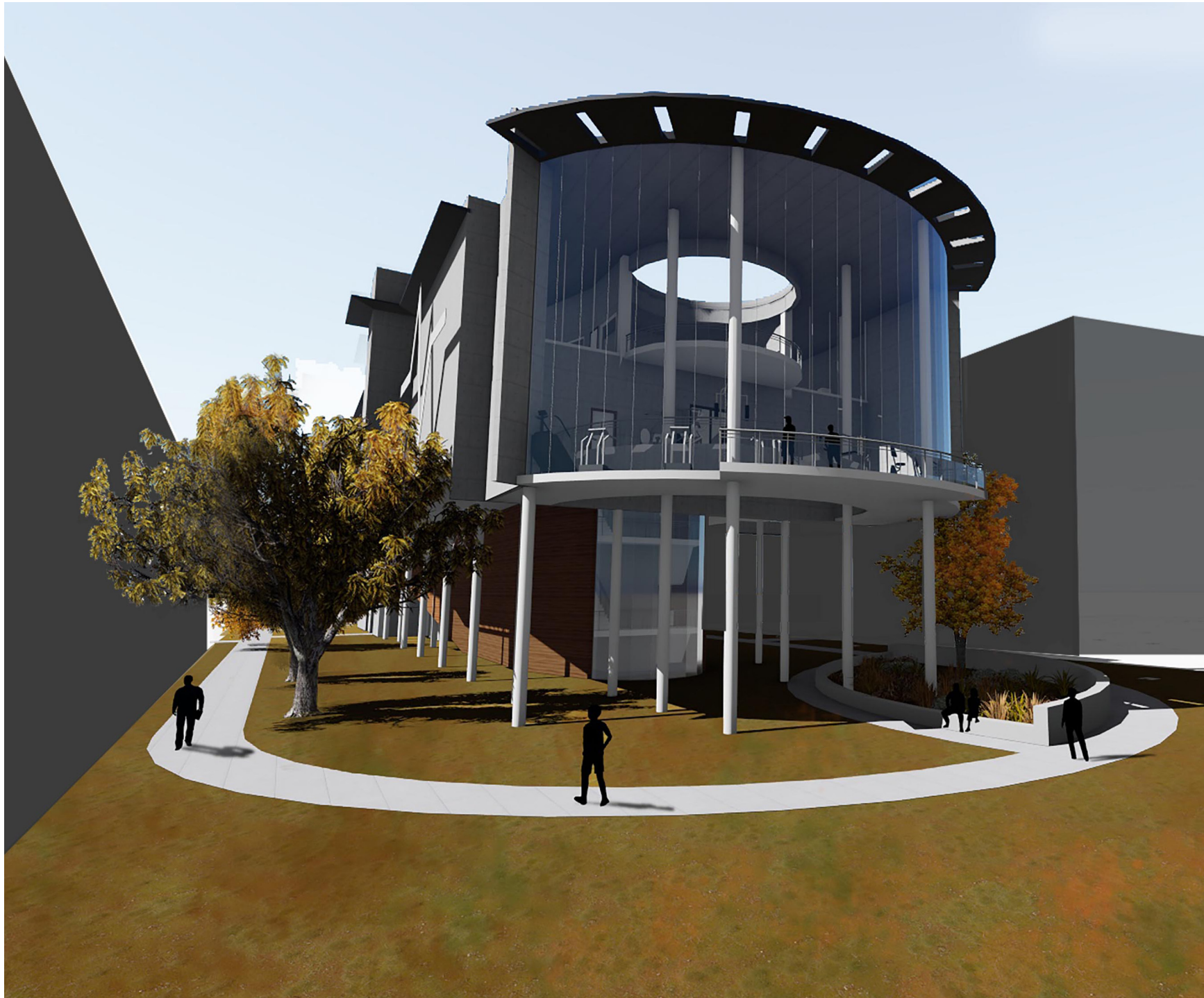
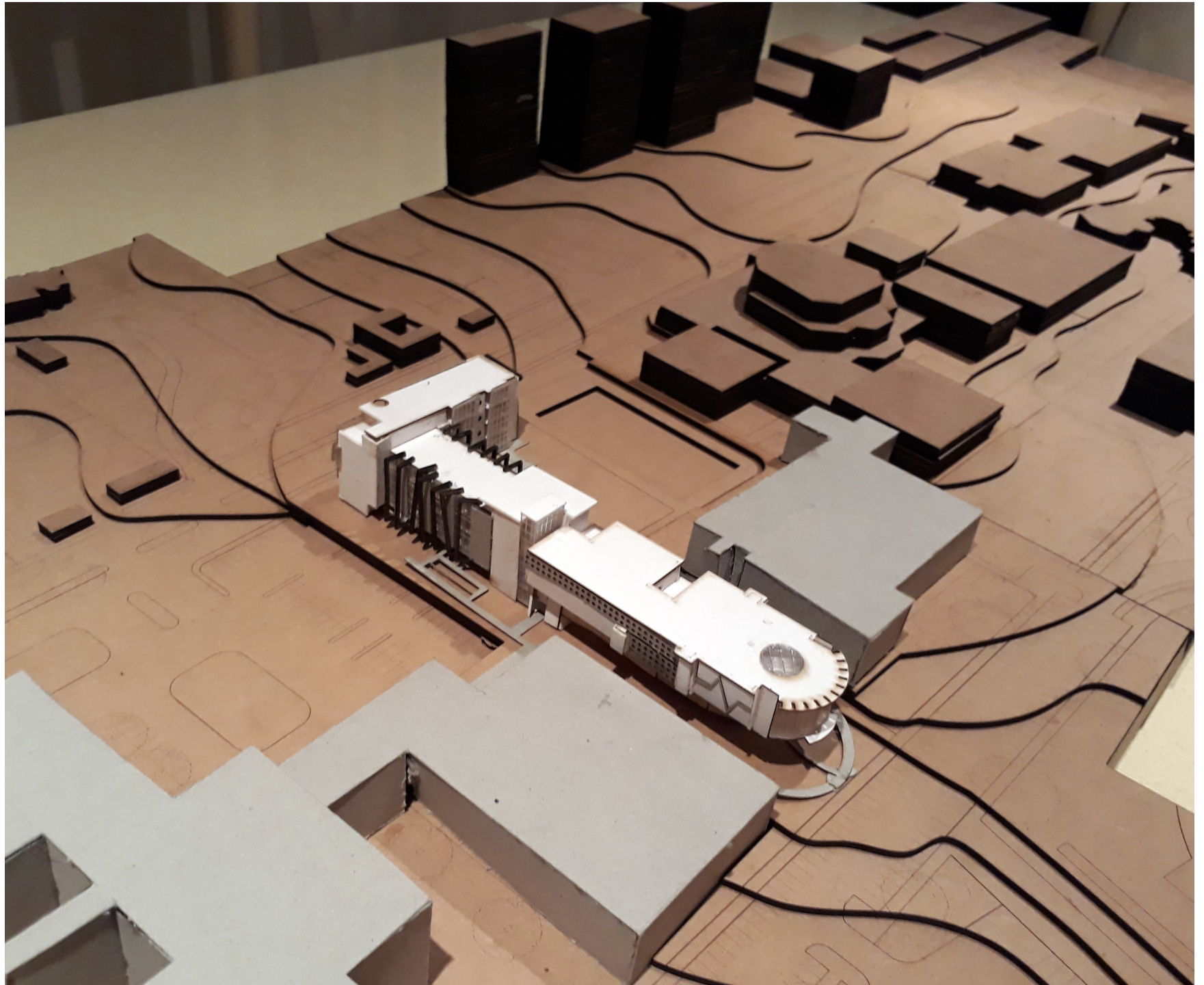


Fig 11.19- South perspective



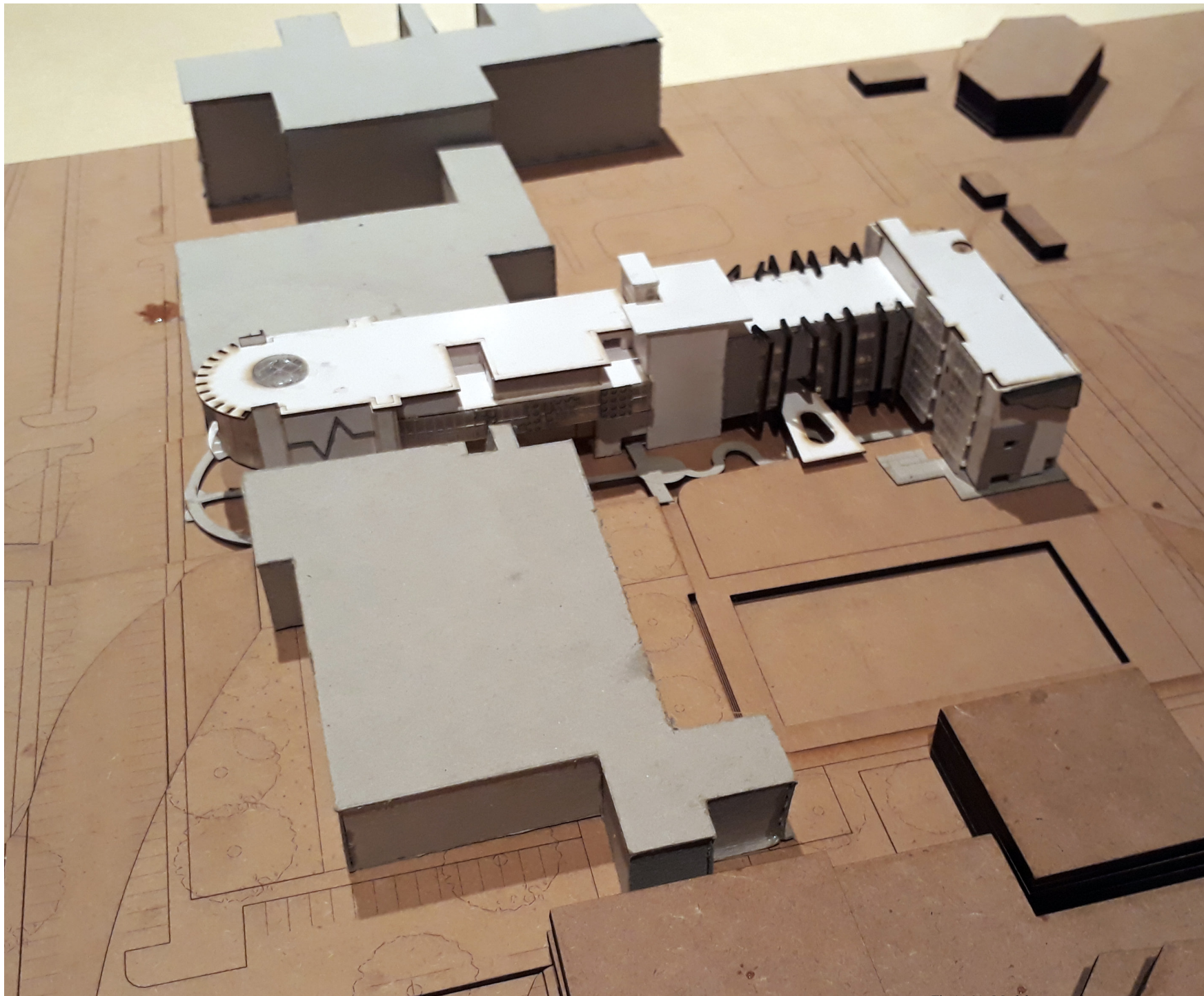


Fig 11.21- Model perspective

Facade detail



Fig 11.22- Louver perspective

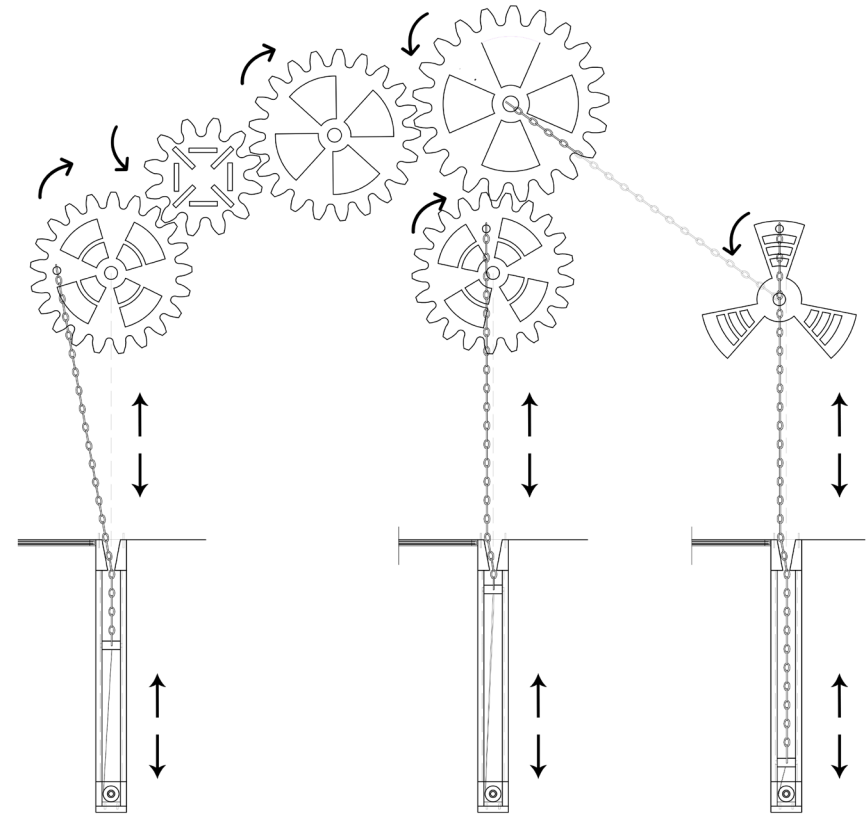


Fig 11.23- Gear detail

The facade system worked through a system of gears with cabling connected to the louvers on the outside of the building. All the gears are connected and as they turn the louvers would unroll and roll back up continuously. The visual effect was similar to that of a caterpillars legs while it walked forward.

The louvers would roll out in a similar fashion to that of a roller blind, with the roll being hidden in the exterior part of the frame. The system was on the west and east of the build-

ing around the gallery and pool area. As a shading device it was not successful as the constant moving would allow light into the spaces. Also over time the actual mechanics and because it is a moving system can cause maintenance issues.

If the project were to be taken further alternate solutions should be looked at as a shading device or system.

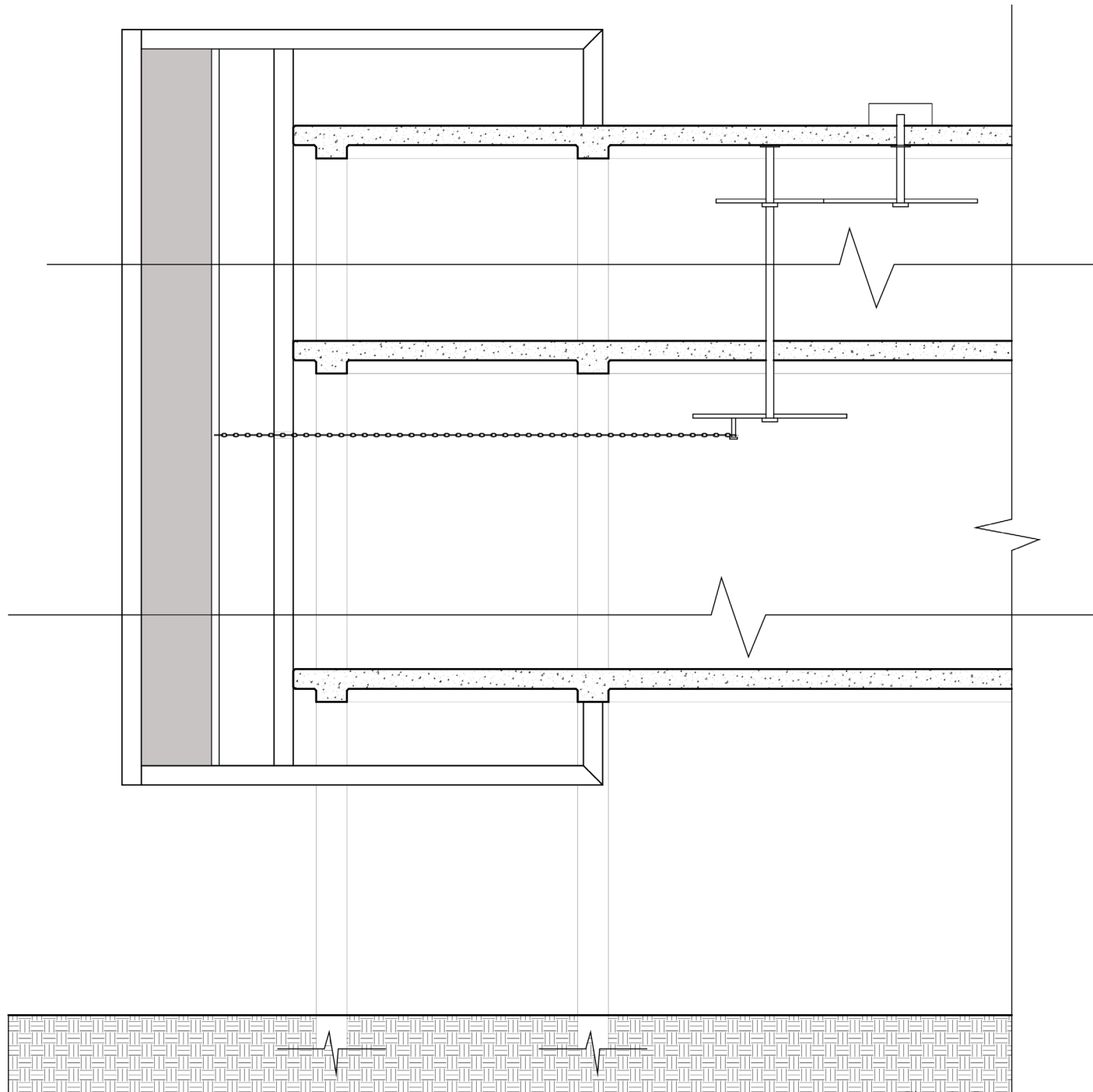


Fig 11.24- Louver system section

Conclusion

Upon completion of the project I was able to look at the project as a whole and identify its strengths and weaknesses.

If this project were to be worked on again there are some areas that I would really rework and address.

The overall feel of the building was surrounded by movement. Incorporated by the moving gears as well as the activities viewed in the building.

The way how the public could move through the building and see the athletes without invading or interrupting them was successful. The large physical moving aspects such as the gears however were not.

The gears were very heavy on the architecture of the building and although expressed movement it was slow and medieval like architecture.

The building is a new High Performance Sports Academic Research Centre, Its appearance should compliment that. The physical design of the building should have been pushed more to extreme advances in technology, using cutting edge technologies and systems.

Within my project I looked at biomimicry, and biomimicry in architecture. I only barely dipped into it however. As part of my amendments of my thesis, I went back and researched more on biomimicry in architecture. Post research I see there was a much greater opportunity in incorporating bio mimicry into my project rather than the Victorian gear system.

Biomimicry is cutting edge and as it is based on nature it can easily compliment movement within the structure.

It would have also been a great and strong connection between the natural world and technology with was a constant comparison throughout my thesis.

Chapter 12

Appendix

Structure

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