CITY MANIFEST

A Manifestation of the contemporary urban condition through the use of computational architecture

Thomas Ludwich Ackermann

Submitted in partial fulfillment of the degree Magister Architecture (Prof.)

Department of Architecture in the Faculty of Engineering, Built Environment and Information Technology, University of Pretoria

Supervisor: Gary White Course coordinator: Jacques Laubscher

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Executive Summary

The theoretical focus of this study is *Meaning in Architecture.* The study does not draw from *history* or *popular culture* for meaning, but will aim to transcend Post-modern concepts by focusing on the contemporary condition and archetypal forms as a *result* of history and popular culture.

This is done through he use of fractal geometry and deals with the questions that arise regarding signification. Fractals can be considered a subdivision of the language of mathematics and will be utilised as mediation between the reality of our world and the generation of form for the purpose of design. This is explored in two analogies, Architecture and Mathematics; and Architecture and Language.

Through this process, subjectivity relating to form is removed as the design was developed in conjunction with the area in which it manifests, through the transformation of quantifiable entities into form. The programme and the process have become a *unified whole* in that mathematical concepts were utilised to design a building to house people involved with mathematics.

The aim of the design proposal is to contribute to the urban landscape of Tshwane by allowing access to facilities in which training in mathematics and computer science can be achieved and to allow individuals to come to a place of self-actualization.

The design is defined as a snapshot of the contemporary condition and therefore makes use of passive and active technologies to create a habitable environment.

It is imperative to realise that society is in a process of transition and this can be embraced by combining 'green' and 'non-green' design approaches, while working towards more energy-efficient design solutions.

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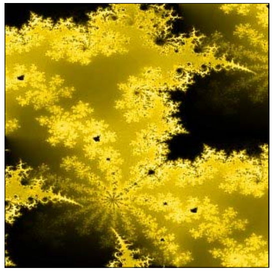

1.1 Introduction

"Architects can no longer afford to be intimidated by the puritanically moral language of Modern architecture. I like elements that are hybrid rather than 'pure'… I am for richness of meaning rather than clarity of meaning: for the implicit function as well as the explicit function…" (Venturi, 1966:22-3).

1.2 Background and context

The concept of *Meaning in Architecture* has been one of great scrutiny. Prior to the Modern movement, *meaning* was simply a matter of style, language and tradition. This was soon replaced by the Modern perception that *meaning* arose spontaneously during the design process – *meaning* became a method, rather than an interpretation of the language of Architecture. Today we realise that in order to attach and perceive *meaning* one requires a more general understanding of the world and the language of forms through which meaning is expressed (Norberg-Schulz, 2000:113).

As a result, Post-modern architecture became partly occupied with the dilemma of *meaning* (Norberg-Schulz, 2000:113). This study aligns itself with and draws from the concepts of Post-modern architecture by postulating that *meaning* can be attached through subtle and constructed references to archetypal forms.

The study will not draw from *history* or *popular culture* directly, but will aim to transcend Post-modern concepts by focusing on the contemporary condition and archetypal forms as a *result* of history and popular culture*;* and more so, by looking at quantifiable data of the current contemporary condition as a means of moving from more subjective to more objective methods of creating Architectural form.

1.3 Objective

The objective is to design a centre for the South African Mathematics Foundation (SAMF) in the city of Tshwane. The study will question the process of creating Architecture, primarily through the use of an experimental mathematical approach that is in line with the architectural programme.

1.4 Approach

Mathematics and statistics will be utilised throughout the design process and will include explorations in three-dimensional fractal-geometry as a method of generating form and arranging space.

It is widely recognised that fractals are all around us, whether in the form of clouds, trees, or the shapes of mountains and coastlines. This means that perhaps their value to us is more than mathematical whim. They have been used in explaining the spatiality of these phenomena and thus, eliminating the possibility of randomness and chaos in explaining the patterns' existence (Anton & Rorres, 1994:699; Stewart, 1995:3).

The author believes that by utilising fractals and the existing spatial organisation of the city, a design can be created that not only flows from the site and the city, but from the patterns and habitual spatial manifestations of the very species that will inhabit it, thereby attaching a deeper *meaning* to Architecture.

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2.1 Introduction

One of the most important questions that arise due to the use of fractal geometry as form generator is that of signification.

The use of statistics in generating form is open to the question: *How do statistics give meaning to the Architecture, if at all?*

The normative position will draw two analogies: Firstly, between Architecture and Mathematics; and secondly, between Architecture and Language. Thus the study will focus on three manifestations of language, namely:

- Spoken and written language;
- Architecture as language; and
- Mathematics as language.

Both spoken and written language will be referred to collectively as language, as one of the means by which ideas and concepts are communicated between humans (Preziosi, 1979:1). Architecture has the ability to allude to cultural and historical ideas through the use of symbols and can therefore be considered a language (Curl, 1999:653). Similarly, mathematics can be used to organise cognitive activities, clarify concepts and to represent certain entities and can therefore, also be considered as a language (Agostini, 1983:29).

2.2 Language

Language is defined as…

> *"…a system of communication which consists of a set of sounds and written symbols which are used by the people of a particular country for talking or writing…"* (Sinclair, 1988:439).

It is also referred to as other means of communication such as sign language, computer language and animal language. It is therefore necessary to look at Semiotics in Architecture as it aims to answer the question of *meaning* in Architecture. The question of meaning in Architecture is one that has been under intense scrutiny, especially since the 1960s when there was an in-depth interest in Architecture as a visual language and the challenges of applying the "linguistic analogy" to Architecture (Nesbitt, 1995: 110).

It is important to note that there is a clear distinction between the study of Communication theory and Semiotics. Semiotics specifically denotes the study of signification, thus the production of meaning in the relationship between the signifier and the signified.

The three different 'languages' namely, Architecture, Normal Language (as defined earlier) and Mathematics, are automatically divided into three different levels of ambiguity, while displaying enough similarity to make such an analogy viable. These levels of ambiguity are explained in Table 2-1.

Table 2-1: Levels of ambiguity within Architecture, Normal Language and Mathematics as languages

	Social contract[1]	**Ambiguity and interpretation**	**Well defined signs**
Architecture	No	Completely open and ambiguous	No
Normal language	Reasonably clear	Reasonably clear	Reasonably clear
Mathematics	Yes	No ambiguity	Yes

[1] 'Social Contract' refers to two individuals concurring on the meaning of a sign to make communication possible, for example, when referring to a 'cat' there is a set of possible meanings that can be attached to it based on the social contract between two people (Nesbitt, 1995:133).

As summarised in Table 2-1, Architecture has the ability to be very ambiguous, to the point where interpreting the sign is completely open-ended and even borders on total non-interpretation.

Normal language, on the other hand, can bridge the open-ended to the specific interpretation due to its descriptive nature, but is still ambiguous in the sense that the receiver filters language into his own understanding of words and their meaning. Lastly, mathematics is completely devoid of ambiguity and interpretation. The symbols and conventions are above the issues of mother tongue and place of origin.

It is important to realise that there are certain limitations to the two analogies between Architecture and language and secondly, between Architecture and mathematics.

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2.3 Architecture and language

This section focuses on the work of mostly Umberto Eco and his thoughts on Semiotics as a starting point for the theoretical position. This is relevant to a study of this nature in that it explores the existence of Architecture as a language, the study of language itself and the similarities between the two.

2.3.1 Why does it exist? Aspects of function and literature

In his publication *On Literature* (2002), Umberto Eco states that literature is consumed for its own sake and therefore has no clear purpose. However, Eco points out that a reductionist view like this diminishes the value of literature (Eco, 2002:2). This immediately creates a differentiation between literature and Architecture that rarely is without purpose. More than a century ago John Ruskin defined a building's function as inseparable to the point that is a duty:

> *"We require from buildings, as from men, two kinds of goodness: first, the doing of their practical duty well; then that they be graceful and pleasing in doing it; which in itself is another form of duty…"* (Ruskin, 1907).

This functionalist approach to Architecture is what Geoffrey Broadbent warns against in his 1977 article on the exploration of the possibility of meaning in Architecture through linguistic analogy (Nesbitt, 1995: 124).

A concept that pervades the study of literature and prose is the fact that literature is often compared to a musical score. The author believes that the analogy between literature and music is valid, but exploring it in this study would increase the scope to unmanageable proportions.

2.3.2 Symbolism, literature and architecture

Is architecture comparable to literature and poetics and their underlying symbolism? This question is answered by Preziosi (1979:9) when he states that…

> *"The built environment is no more an 'art', than is verbal language-except insofar as a given formation may reveal a dominance of focus upon its own signalization, precisely paralleling the 'poetic function of a linguistic art."*

In fact, Goethe states that true symbolism is when the particular represents the general *and "…*not as a dream or shadow, but as a living, instantaneous revelation of the inscrutable…" (Goethe, 1918: 314).

As discussed earlier, language has the ability to be ambiguous and it is therefore not surprising that Eco refers to a symbol in literature having the ability to be either very clear or very obscure and ambiguous (Eco, 2002: 141).

Eco further feels that there is something yet beyond the symbol that he refers to as the symbolic mode (Eco, 2002:152). He bases his definition on the writings of St. Augustine, who stated that certain biblical texts have a phrase that has a certain meaning, but could just as easily been omitted. This immediately makes the human mind question the apparent meaning and removes it from metaphorical or allegorical writing that is apparent in Post-modern Architecture.

In a similar way, certain references within the Post-modern in Architecture create questions in the observer's mind based on its triviality. The uncompleted columns of Ricardo's Bofill's *Pyramid Le Perthus* (1976) in Catalonia, as seen in Figure 2-1, serve as a prime example of this.

The building triggers the reader into questioning whether there is an alternative meaning. It is as if the almost blasé placement in the work makes one wonder if there is not some double meaning programmed into it.

It is this innocent incongruity with the work that triggers us to look for meaning (Eco, 2002:153). This pens up the door to multiple interpretations. Thereby, elements can be used to trigger double meaning as is.

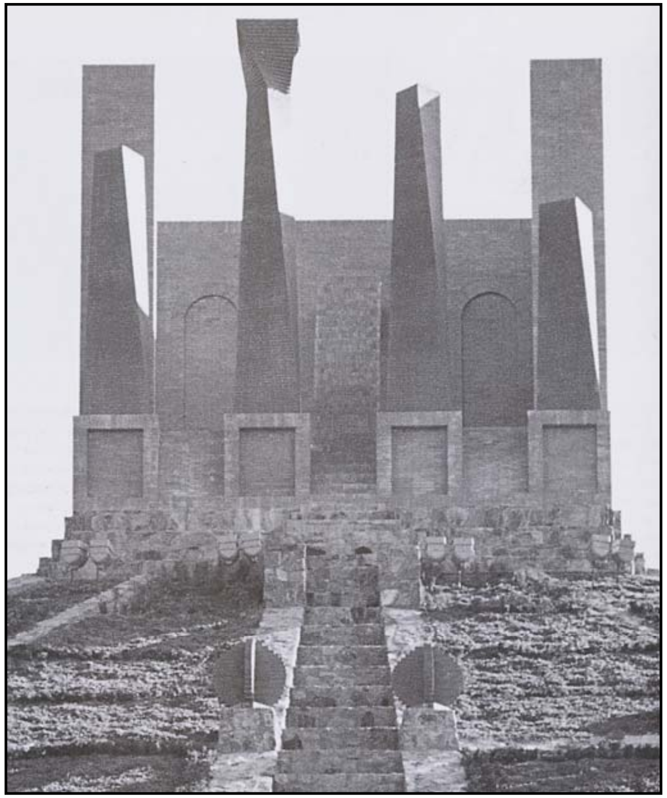

Figure 2-1: Ricardo Bofill's Pyramid Le Perthus, 1976, Catalonia *(Source: Norberg-Schulz, 2000:112)*

This incongruity in a work, literature or otherwise is not due to a lack of logic or due to frivolity. Eco states that sometimes the symbolic mode exhibits a rigid, almost paranoid logic of its own.

> *"In a more limited sense postmodern describes a design orientation that depends upon the creative manipulation of symbols and explicit references drawn from history or popular culture…"* (Doordan, 2001: 207).

In the context of this study, the conclusion is made that the symbol can be constructed from a system in its own right, which in this case, will be the symbolism of mathematical analogy and the contemporary condition. It is clear from Eco's writing that the symbolic can take center stage and represent something without boldly stipulating the obvious meaning.

This study will utilise the symbolic mode throughout, from concept to design manifestation. It will be done without forcing the user to 'understand' the symbolism. The author will rejoice even in contradictory interpretations of the symbol. The user's subjective interpretation is set both within, and as a snapshot of, the contemporary condition; and as such, is in a state of constant dynamic flux.

In an interesting way the words of Robert Venturi come to mind when he states in the opening paragraph of *Complexity and Contradiction*:

> *"Architects can no longer afford to be intimidated by the puritanically moral language of Modern architecture. I like elements that are hybrid rather than 'pure'… I am for richness of meaning rather than clarity of meaning: for the implicit function as well as the explicit function…"* (Venturi, 1966, 22-3).

Although this idea seems completely absurd in today's world, it made sense in his historical setting. He thus proposed that an argument could be solved by calculating the answer based on the logical steps in thought that it involved (Agostini, 1983:29-30).

2.4 Architecture and Mathematics

Mathematics can be defined as…

> *"The science of magnitude and number, and of all their relations…"* (Poole, 1954: 655) and *"The study of numbers, quantities or shapes."* (Sinclair, 1988: 482).

One of the beauties of mathematics is its characteristics of economy and simplicity. With the symbols of 0-9 and a decimal point, any number, no matter how big or small, can be denoted by changing the position of the symbol. There is no other symbolic system so simple or so effective (Agostini, 1983).

> *"One of the strangest relationships between mathematics and the 'real world and also its strongest, is that good mathematics, whatever its source, eventually turns out to be useful… Mathematics uses symbols, but it no more is those symbols mathematics, than music is musical notation or language is strings of letters from an alphabet…"* (Stewart, 1995:21-40).

One of the fundamental characteristics of mathematics is the fact that it is a language.

Language is there to organise cognitive activities, clarify concepts and to represent certain entities. All of the above are successfully accomplished by mathematics. It is therefore safe to say that disconnecting mathematics from the everyday language as a mental construct is artificial and absurd (Agostini, 1983:29).

Although it is true that mathematics is more apt at dealing with a certain type of problem, there is no justification for a separation in knowledge. Unlike ordinary spoken or written language, the symbols used in mathematics are unambiguous. There is thus very little, if anything, left open to interpretation in the field of Mathematical notation. It can be said that large parts of mathematical representations are completely univocal, having only one meaning or being one of voice (Agostini, 1983:30).

Gottfreid von Leibniz proposed that this meant that mathematics could be used to create a vocabulary of human thoughts that are specific enough that they could be represented symbolically. His approach is very clear when he states:

> *"All thought has universal characteristics that allow it to be reduced to abstract symbols…"* (Steele, 2001:14).

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2.5 Fractals

Fractals can be considered a subdivision of the language of mathematics and will be utilised as mediation between the reality of our world and the generation of form for the purpose of design.

A fractal is a geometrical motif that repeats itself over and over at ever smaller scale (Hersey, 2001:167). It is widely recognised that fractals are all around us, whether in the form of clouds, trees, or the shapes of mountains and coastlines.

This means that perhaps their value to us is more than mathematical coincidence. They have been used in explaining the spatiality of these phenomena and thus, eliminating the possibility of randomness and chaos in explaining the patterns' existence (Anton & Rorres, 1994:699; Stewart, 1995:3).

Upon diving into the field of mathematics and linear algebra, the definition of a fractal becomes quite different and a large amount of pre-knowledge about the field of Linear Algebra becomes necessary. It will suffice to say that it is not necessary for the author to enter upon discussion about the definition here, as it would contribute very little to the understanding of the concept.

For example, an understanding of the definition of a fractal *"…a subset of Euclidian space whose Haasdorf dimension and topological dimension are not equal…"* (Anton & Rorres, 1994: 703) seems incomprehensible if the reader has no prior experience with the concepts of Linear Algebra.

The Hungarian philosopher, Arthur Koestler, invented the word *holon* to describe something that is both a whole and an identifiable part of a larger whole. It has the same origin as *hologram* (XenoDream Software, 2008). In this sense any human settlement can be considered a holon. It is both an entity in itself and simultaneously part of a greater whole.

Central to the idea of a holon, is the fractal, which is a geometrical motif that repeats itself over and over at ever smaller scale (Hersey, 2001:167). In other words, we can think of the city as an infinite multitude of parts, or networks interwoven to the n^{th} degree. Cities, towns and villages form a self similar pattern at decreasing scales and can thus also be seen as fractals.

2.5.1 The City as Fractal

Humans have become an urbanised species, with more than half of the world's population living in urbanised environments (UNFPA, 2007). We are not unlike the Australian Compass termite, whose termitaries…

> *"…rise like tower blocks in open countryside. In this they resemble Le Corbusier's ideas for sky-scraper cities… except that the termitaries are more spaciously arranged, have lower densities of inhabitants…"* (Hersey, 2001: 75).

The question that arises at this juncture is *why* are we city dwellers, and *how* do we define ourselves as such. The following definitions have been provided as an illustration of how difficult it is to define the concept of a city, without a reference to the city itself; and with reference to the inhabitants, as opposed to the built fabric:

- City: *"A large town: an incorporated town that has had a cathedral…"* (Poole, 1954:193);
- Town: *"A farmstead or similar group of houses. A municipal or political division of a country. An urban community…"* (Poole, 1954:1165);
- Urban: *"Of or belonging to a city…"* (Poole, 1954:1217); and
- Urbane: *"Pertaining to, or influenced by a city; civilized, refined, courteous, smooth-mannered…"* (Poole, 1954: 1217).

It is clear that the even the definition is devoid of a reference to individuals. By default, the definitions above refer to built fabric as a city or a town. The reference relies on definitions of smaller cities or towns, to clarify its meaning. No direct reference is made to the fact that people dwell in cities; the closest reference is that of a community.

Less obvious examples of fractals in the literature, is that of Christopher Alexander's second pattern as described in *A Pattern Language* (1977) and illustrated in Figure 2-2.

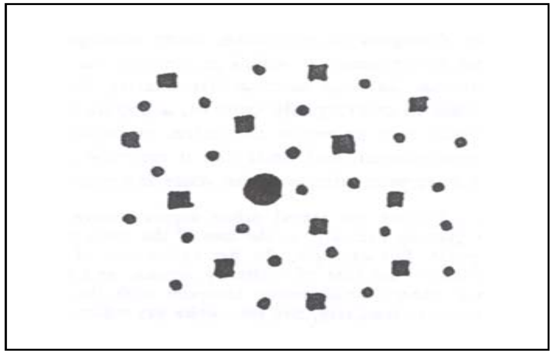

Figure 2-2: The proposed distribution of towns in A Pattern Language *(Source: Alexander, 1977:20)*

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Alexander proposes that communities should be spread out in a pattern where large towns are 250 miles apart, smaller towns of 80 miles apart and so forth, until villages are only 8 miles apart.

Another example of a fractal is that of the *Sierpinski Carpet*, as described by the Polish mathematician Waclaw Sierpinski in 1916. Figure 2-3 illustrates a pattern of bounded space in two dimensions, repeated at a smaller scale with the geometry remaining constant. It illustrates a union of eight non-overlapping repetitions of the first pattern each scaled by a third. The transformation repeats and can be extended into infinity.

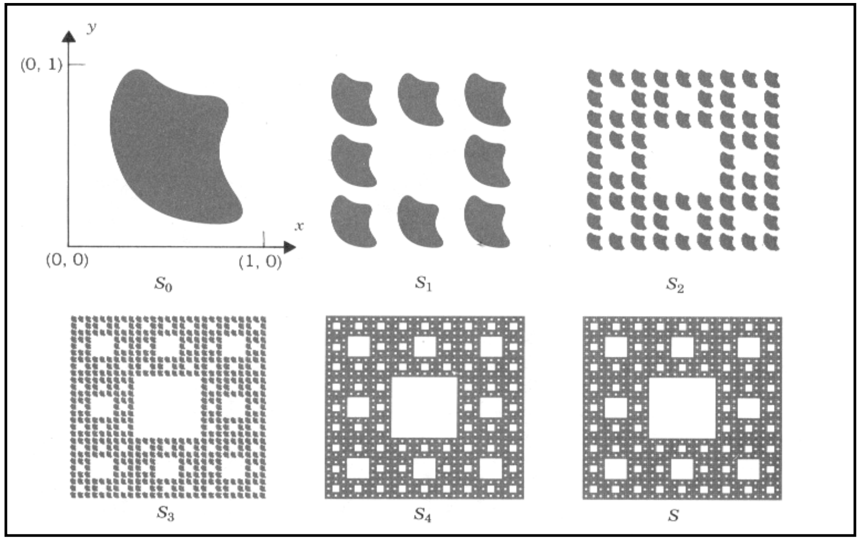


Figure 2-3: Sierpinski Carpet pattern as defined by Waclaw Sierpinski *(Source: Anton & Rorres, 1994:709)*

The similarities between Christoper Alexander's pattern (Figure 2-2) and one of the most basic examples of fractals in Linear Algebra, namely the Sierpinski Carpet.

Based on the theoretical discussion, the author is of the opinion that by utilising fractals and the existing built fabric of the city as a manifestation of human habitation, a design proposal can be created that not only flows from the site and the city, but from the patterns and habitual spatial manifestations of the very species that will inhabit it.

Doordan (2001:289) provides the following guidance:

> *"Architects have tried to provide architectural images and spatial metaphors that help people comprehend the world around them, inhabit it with some dignity, and find pleasure and stimulation in the buildings they create. This is a noble and ambitious design agenda for the architectural profession…"*

In the publication *Architecture, Language and Meaning* (1979:15), Preziosi asks the question …

> *"In what ways do built forms mark the presence of human individuals and groups, and how do made environments serve as data banks for socio-cultural information."*

Human settlement patterns and the varied ordering thereof therefore serve as a databank of information that can be utilised to explore new forms.

Socio-cultural information is usually portrayed as statistics that deal with quantified entities, for example, population sizes and literacy levels. Certain of these sets of information are generally defined at a specific time for a specific set of circumstances. It can thus be assumed that they represent some form of abstracted 'snapshot' of a given situation, time and place.

2.5.2 Where to now? Application

Even though the three concepts, namely Architecture, normal language and mathematics were treated as three different entities up to this point, it is important to understand that this study will be taking a stance that these concepts are inseparable on a theoretical, philosophical and physical level. The concept of Fractals and how they will be applied and what other applications they can be utilised in will be discussed in more detail in Chapter 6 under Methodology. It is however important to define the theoretical stance of the application at this point.

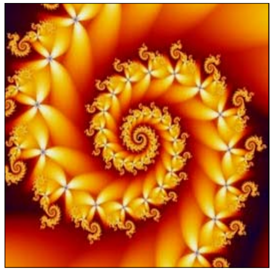
Generating architectural form, designing *genetic material* the computer can process data to create new architectural morphologies. Computational Architecture pursues various methods through which the role of the designer can shift from *space programming* to *programming space*; through the designation of software programs to generate space and form from the rule-based logic inherent in architectural programs, typologies and building codes.

Computational architecture explores the viability of mathematical computation as a method of design. It is important to note that even in this type of design process the design is not necessarily about the sudden appearance of a form, but about a combination of thoughts and processes that lead to the inception of a form. It involves the articulation of thoughts and the exploration of possibilities in the existential emergence of form.

Algorithms can be seen as a symbolic language of which the vocabulary, grammar and meaning depends on the computational power and input of the design tool.

Through this type of algorithmic transformation it allows the designer to make the attributes of the input data to visually perceptible. It is acknowledged that the limitation of this approach is that the processes themselves are arbitrary and unrelated to the site or programme. The resulting forms appear to be more a product of the translation process than of the data itself.

The author postulates that Computational architecture uses computers for their computational capability to generate forms that are an alternative to the extreme crystalline regularity of what has up to now been considered modern.



3.1 Objective

The aim of this study is to make a contribution to the urban landscape of Tshwane by allowing access to facilities in which training in mathematics and computer science can be achieved to allow individuals to come to a place of self-actualisation, in which they can express themselves and grow. Self-actualisation is not defined as a state of not lacking, but rather as an internal need for growth that is associated with the acquisition of skills and abilities (Westen, 1996: 376).

The programme further aims to address the growing problem of *Digital Divide* in undeveloped countries.

3.2 Motivation

3.2.1 The Digital Divide remedied through a Cybercafé

The *Digital Divide* refers to "the gap between those who benefit from digital technology and those who do not…" (ITU, 2001). When one talks about the *Digital divide* one immediately thinks that it refers to the accessibility of computers.

This opinion is false, in that the computer itself is only a tool and it is the inaccessibility to their benefits that constitute the *Digital Divide*. The cause of the divide can be explained by the following paragraph:

> *"The poor are ignored because market forces assume that designing solutions for them will not be profitable. The result is that even where the poor are provided access to digital technology, it is low-quality and merely 'localized' versions of products and services intended for the rich. Furthermore, the digital technologies they do have access to, such as those that lure innocent rural dwellers into vapid pop culture, could be harmful rather than beneficial."* (Digital Divide, 2009).

It is therefore important to understand that a mass distribution of computers to those who did not have access will not necessarily close the gap. South Africa finds itself in an interesting situation, where it is classified as an anomaly among undeveloped countries, because of access to most of the digital amenities of the developed world, but only recently being recognised as an industrialised nation.

Table 3-1: Internet users and population statistics for Africa *(Source: IWS, 2009)*

AFRICA REGION	Population size (2008)	Portion in world (%)	Internet users	Penetration of population (%)	User growth (2000-2008)	Users in world (%)
Total for Africa	975,330,899	14.5 %	54,171,500	5.6 %	1 100.0 %	3.4 %
Rest of World	5,734,698,171	85.5 %	1,527,400,089	26.6 %	328.5 %	96.6 %
WORLD TOTAL	6,710,029,070	100.0%	1,581,571,589	23.6 %	338.1 %	100.0 %

It is interesting to look at the amount of people that utilise the internet within South-Africa, as summarised in Table 3-1:

- At the end of 2008, there was an estimated 4.59 million South African internet users, compared to only 2.4 million in December 2000;
- Online advertisment revenues grew 27% in 2007 and 32% in 2008; and
- The number of broadband users has increased from 15 700 in 2003 to 1 058 000 in 2008.

According to South African e-Marketing specialist Dave Duarte[1]:

- Approximately 62% of South Africans with access to the internet do so from their workplace with a further 27% accessing from home, 6% from educational facilities and 3% from public Internet cafés;
- 27% of Internet access is in Johannesburg, 12% from Pretoria, 16% from Cape Town and 6% from Durban;
- The Northern Province and the Northern Cape account for a total of 1% (Burke, 2009).

South-Africa constitutes only 8.5% of Africa's access numbers, the fourth largest contributor on the continent after Egypt, Nigeria and Morocco (IWS, 2009).

[1]Dave Duarte is an online and mobile marketing specialist, based in Cape Town. He is involved with educating and inspiring people to be better marketers using technology. He also lectures in the Executive MBA programme at UCT GSB.

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It is clear that there is a large possibility for growth in South Africa with respect to internet usage, especially if one were to compare the country's statistics to that of Morocco. The Moroccan population is approximately 25% smaller than that of South Africa, but has 2.2 million more internet users than South-Africa (IWS, 2009).

This project could counter the problems associated with the lack of internet access by enabling public access on a broad scale through its facilities and siting. It is the intent to tie this in with a strong educational co-habitor that will provide training and be responsible of the internet facilities.

3.2.2 The problem of Mathematics education in South Africa

In the words of the South African Mathematics Foundation...

> *"Our country faces many challenges, the main focus being that of economic development. An accelerated economic development should be spearheaded by appropriate technological innovations and advancement. For this to happen there is general consensus that the quality of teaching and learning mathematics is central to any curriculum."* (SAMF, 2009).

One of the biggest challenges in the current education system of South Africa is the issue surrounding Mathematics education. The SAMF are of the opinion that the future prosperity of South Africa is dependent on increased numbers of mathematically qualified persons.

The two professional societies for mathematics in South Africa, the South African Mathematical Society (SAMS) and the Association for Mathematics Education of South Africa (AMESA) have combined their resources to address their common areas of operation in mathematics development and education in South Africa.

The SAMF has identified the following challenges:

- Few learners do mathematics at Further Education and Training (FET) level;
- The need for mathematical literacy;
- Poor public image of the state of mathematics;
- Shortage of appropriately equipped teachers of mathematics;
- Lack of appreciation and acknowledgement of mathematics as the basis for scientific and technological advancement; and
- The concern of stakeholders of the competency level of our learners in mathematics (SAMF, 2009).

Both these societies have been run by mathematicians or mathematics educators in their spare time. University and other tertiary educators, as well as school educators have been doing this without remuneration. With limited resources the foundation have so far been remarkably successful in their efforts, but it has now become clear that both these societies have reached a point where no further significant contribution towards a solution to the problem can be made in their current capacity (SAMF, 2009).

Through a national office situated in Pretoria, it will be possible to create awareness and have the infrastructure to extend a number of their existing initiatives and embark on new projects. It can be seen that it is a very difficult, if not impossible task to accomplish while working as a virtual office of volunteers and unpaid staff.

3.3 The client

The National Research Foundation (NRF) is the government's national agency responsible for promoting and supporting basic and applied research and innovation, The NRF provides services and grants to support research and postgraduate research training, vital to the development of South Africa. It is the NRF's vision to be a key role player in the creation of an innovative, knowledge-driven society where all citizens are empowered to contribute to a globally competitive and prosperous country (NRF, 2009).

One of the seven research themes that are outlined by the NRF is that of Science, Technology and Mathematics Education, or also called STME. According to the NRF a review of recent trends in mathematics and science, school level science and mathematics education plays an important role in societal development of a country. It is the base upon which expertise in technological development and deployment exists. The NRF states that school science and mathematics enhance the scientific literacy of citizens which empowers them to participate in decisions that affect their lives. This need for a new emphasis on mathematics and science education is recognised worldwide.

South Africa has a comprehensive science and technology policy, but there is concern that it lacks specific focus on science and mathematics education. The distressing reality is that South African students perform poorly in terms of international comparisons regarding achievements in mathematics and science. Pass rates in science and mathematics are generally poor and student enrolments at tertiary educational institutions are decreasing in science and engineering related fields.

Research has shown that schools lack adequately qualified mathematics and science educators, and that there is some indication of poor preparation during undergraduate and postgraduate training (NRF, 2009).

Funding from the NRF is mostly directed towards academic research, developing high-level human resources, and supporting national research facilities. The NRF strives is to improve research in all fields including natural sciences, engineering, and technology. By forging strategic partnerships locally and internationally, it extends the resources that researchers need to foster and expand South Africa's research capabilities and, ultimately, to improve the quality of life for all (NRF, 2009).

It is proposed for the purpose of this study that one such strategic partnership is with the SAMF and as such the client is defined as a strategic partnership between the NRF and the SAMF.

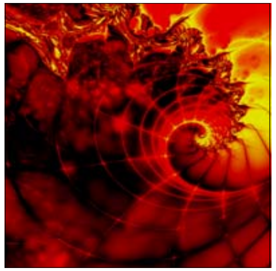
Although the main focus of the project is the flagship office of the SAMF, it is also recognised that that the cybercafé would need to be sublet to a competent tenant. It is suggested that a partnership is embarked upon by the SAMF and an existing franchise that may be interested in such a high profile project due to its purpose and also proximity to the Gautrain station.

3.4 Areas allocated

After making contact with the American Mathematical Society (AMS) as a model of how the SAMF could operate in the future, a Schedule of Areas was developed.

Table 3-2: Schedule of areas

Basement -2	Basement -1		Ground Floor		First Floor		Second Floor	
Lift	Lift		Lift		Lift		Lift	
Stairs	Stairs		Stairs		Stairs		Stairs	
Fire Escape	Fire Escape		Fire Escape		Fire Escape		Fire Escape	
			Water Storage		Water Storage		Water Storage	
Access Roads	Access Roads		Access Roads					
Parking	Parking		Parking					
	Disabled Parking		Disabled Parking					
	Deliviries Parking							
	Miscellaneous Store Room	16.10 m^2	**SAMF**		**SAMF**		**SAMF**	
	Sanitary Store Room	10.20 m^2	Ablution	32.89 m^2	Ablution	25.97 m^2	Ablution	25.97 m^2
	HV & LV Room	12.30 m^2	Ablution for Disabled Persons	3.50 m^2	Sound Lobby	5.38 m^2	Library	38.79 m^2
	HVAC Plant room	12.30 m^2	Reception	5.75 m^2	Auditorium	73.46 m^2	Audio Visual cubicles	44.60 m^2
	Security Office	11.70 m^2	Waiting Area	24.70 m^2	Exhibition Space	46.58 m^2	Pause Areas	14.38 m^2
			Facilities-Manager Office	10.29 m^2	Lecture Rooms	102.47 m^2	Staff Board Room	36.36 m^2
			Store-Room	2.26 m^2	Computer lab	71.85 m^2	Staff Kitchen	8.32 m^2
			Book Shop	41.83 m^2	Pause Area	14.89 m^2	Server & Patch Room	7.39 m^2
			Store Room for Bookshop	2.90 m^2	Balcony	9.60 m^2	Offices-Open Plan	80.93 m^2
			Cyber Café		Balcony	13.70 m^2	Offices-Private	4.93 m^2
			Reception	5.20 m^2	Balcony	15.16 m^2	Balcony	9.60 m^2
			Seating Area's	41.35 m^2			Balcony	13.70 m^2
			Server & Patch Room	11.14 m^2			Balcony	15.16 m^2
			Equipment Store	3.18 m^2				
			Kitchen & Scullery Area	24.12 m^2				



4.1 Introduction

The precedents will be dealt with at levels of importance. There will be a focus on theoretical and conceptual precedents as it is the approach that needs to be justified.

It is necessary to look at theoretical and conceptual precedents for two reasons:

- To inform the concept and look at other similar approaches in Architecture and other fields; and
- To illustrate that the concept is an existing way of exploring space in Architecture.

4.2 Möbius House

Architect:	UNStudio
Date Completed:	1998
Location:	Amsterdam
Total area:	300 square meters
Program:	Residential House and SOHO

In 1993, Ben van Berkel was commissioned by a young couple to design a house that would be acknowledged as a reference for the renovation of the architectural language.

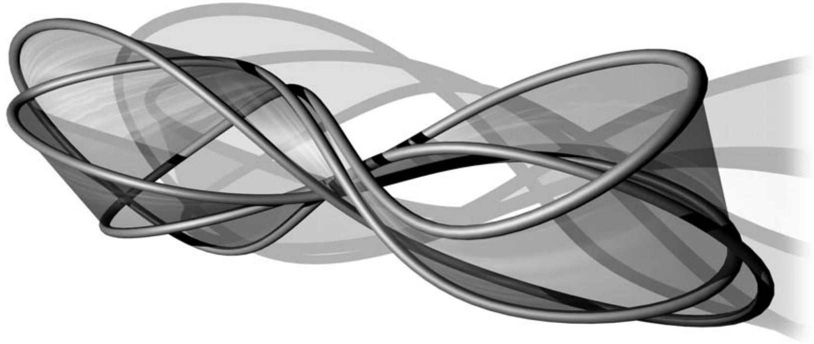


Figure 4-1: Möbius strip
(Source: Stories of Houses, 2003)

Completion of the design took the architect six years, creating a house based on the studies of a 19th-century German mathematician, August Ferdinand Möbius (1790-1868).

The design was developed around the principle that the new architectural language should be a direct consequence of their new way of life. The idea of two people moving along their own routes, but sharing certain moments - possibly also reversing roles at certain points - was elaborated into the built object.

By giving the Möbius band (Figure 4-1) a spatial quality, the architect has designed a house that integrates the programme seamlessly, both in terms of circulation and structure. Movement through this concrete loop traces the pattern of one's daily activities.

Arranged in three levels, the loop includes two studies (one on either side of the house), three bedrooms, a meeting room and kitchen, storage and living room and a greenhouse on the top, all intertwined during a complex voyage in time.

With its low and elongated outlines, the house provides a link between the different features of its surroundings. By stretching the building's form in an extreme way and through an extensive use of glass walls, the house is able to incorporate aspects of the landscape. From inside the house, it is as if the inhabitant is taking a walk in the countryside.

Figure 4-2

The perception of movement is reinforced by the changing positions of the two main materials used for the house, glass and concrete, which overlap each other and switch places. As the loop turns inside out, the exterior concrete shell becomes interior furniture such as tables and

Figure 4-3

Figure 4-4

Figure 4-5

The contortions and twists in the house go beyond the mathematical diagram. They refer to a movement that has moulded a new way of life as a consequence of using electronic devices at work. The architect has managed to give an additional meaning to the diagram of the Möbius band, where its new symbolic value characterised by blurred limits between working and living that corresponds to the clients' way of life.

Figure 4-6

The concept that generated the Möbius House did not expire with it being built. Instead, it became further developed in the architect's mind and explored in at least two other projects of UNStudio. The other projects being the Living Tomorrow Pavilion in Amsterdam and the Mercedes-Benz Museum in Stuttgart .

(Paraphrased from: EMAP Architecture, 1999; Stories of Houses, 2003; UN Studio)

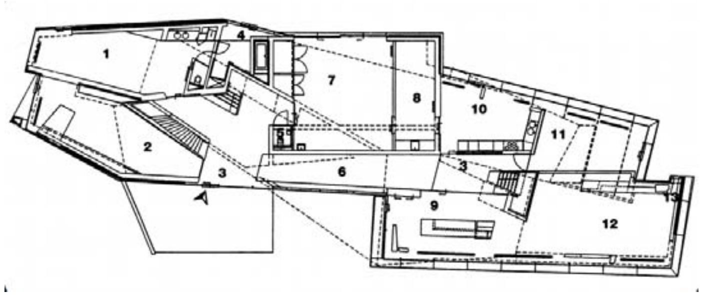


Figure 4-7

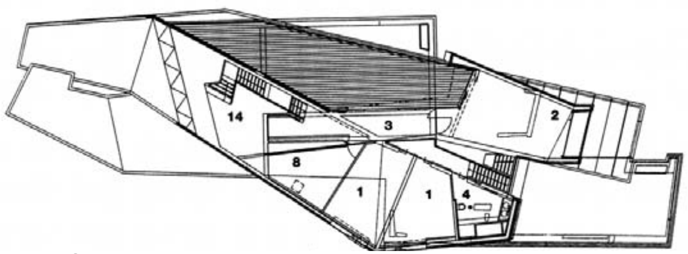


Figure 4-8

Figure 4-10

Figure 4-11

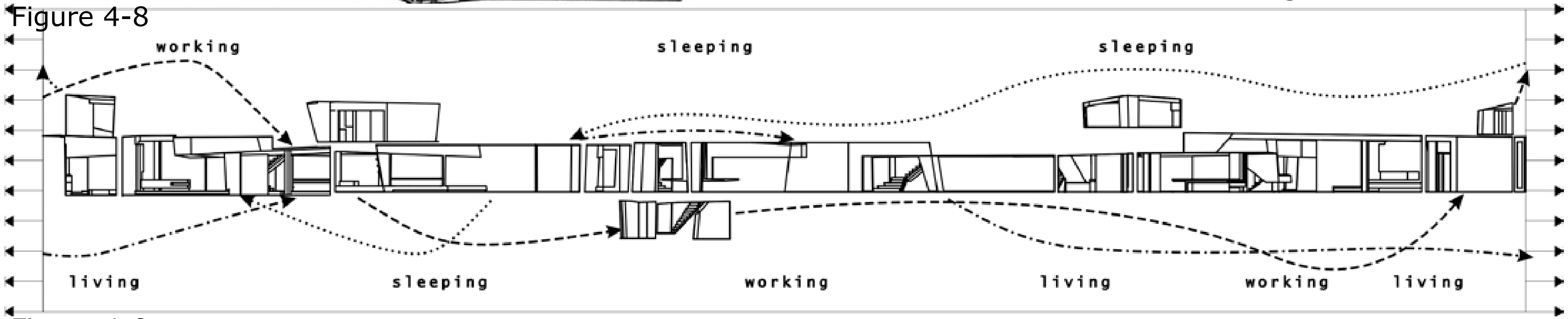


Figure 4-9

4.3 Living Tomorrow Pavilion

Architect:	UNStudio in collaboration with Living Tomorrow, Brussels
Date Completed:	2003
Location:	Amsterdam
Total area:	3,500 square meters
Program:	Future oriented living- and working prototype, temporary building

Figure 4-12

According to UNStudio the design models that they used integrate several elements, instead of providing the designer with just one paradigm. Thus it does not simply state 'surface' or 'fold', but it instrumentalises possible concepts such as these that they incorporate the real ingredients of a built work of architecture.

The design model is prototypical, can evolve and can be implemented in various situations and projects. The design model condenses complexity: everything has to be already in it, including routing, construction, budget, programme, as well as its own driving principle, a direction, something that the designer points at. The Living Tomorrow Pavilion is a combination of a laboratory, an exhibition space and an auditorium. It is a temporary building where a variety of businesses can demonstrate their innovative technology and research for future buildings.

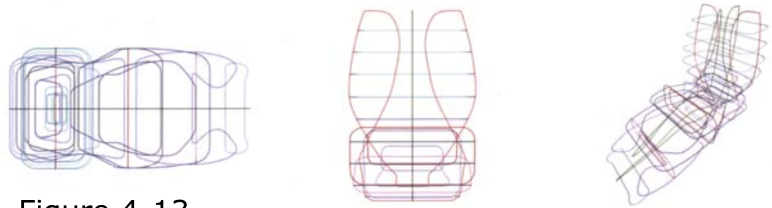


Figure 4-13

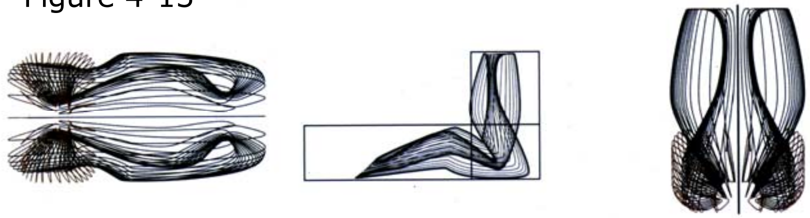


Figure 4-14

Visitors can get exposed to and acquainted with the products and services. The metal clad, curved shape derives from the concept that the vertical and horizontal parts of the building form one continuing inside-out-turned shape.

This is linked once again to a three dimensional exploration of the Möbius Strip where the vertical and horizontal were combined in a fluid whole.

Figure 4-15

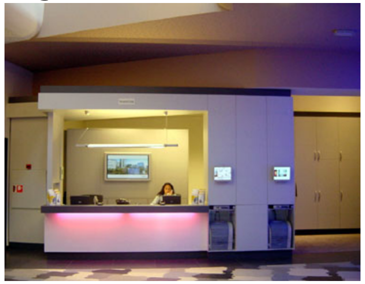


Figure 4-16

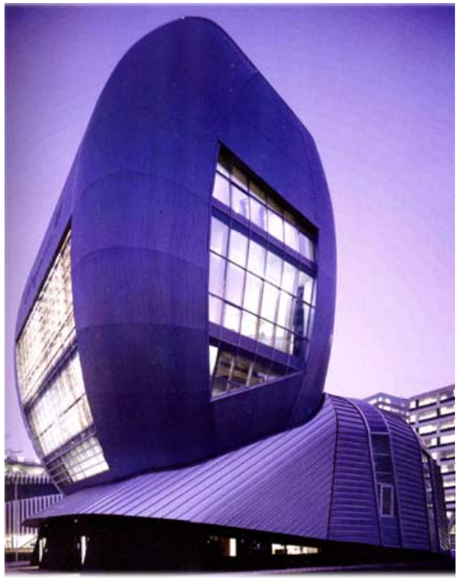


Figure 4-17

These integrated volumes form the basis for the spatial structure of the interior. All materials used are recyclable or have a low environmental impact.

The entrance, auditorium, event hall, exhibition room, administration and kitchen are located on the ground floor. On the four levels above, more exhibition rooms, a small restaurant and other secondary facilities are situated.

Figure 4-18

(Paraphrased from: Arcspace, 2004; Krajewski, 2009; UN Studio, 2003; Bahamon, 2005)

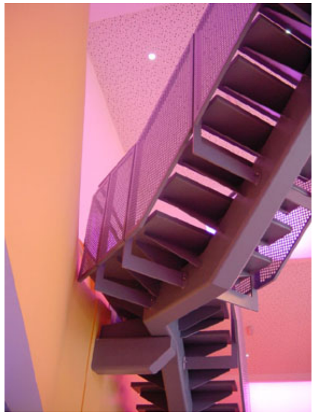


Figure 4-19

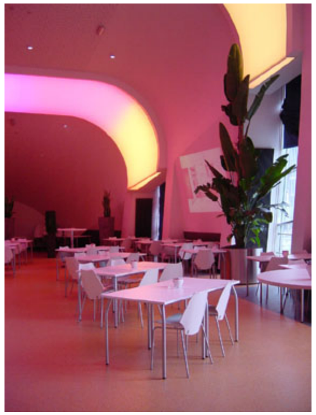


Figure 4-20

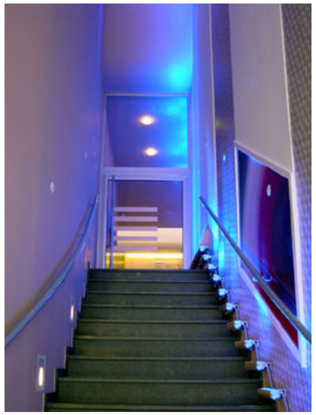


Figure 4-21

Figure 4-22

Figure 4-23

4.4 Beachness

Architect:	NOX, Lars Spuybroek
Date Completed:	Research project for a beach hotel and boulevard (1997) in.
Location:	Noordwijk, the Netherlands
Total area:	Undetermined
Program:	Hotel and Promenade development.

Nox has been developing the possibilities of an interactive architectural territory for a number of years and one of their focus areas is the development of certain architectural logic to adapt architecture to the evolution in human perceptions.

More than mere adaptation, however, it attempts to synthesise existing and emerging technologies. The most recent projects touch on the notion of a cognitive architecture achieving a reactive "expert system" which mutates according to needs and functions as they arise.

Figure 4-24

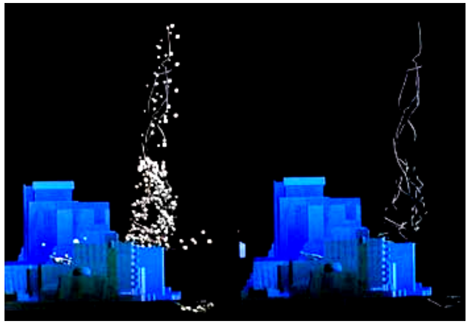


Figure 4-25

Figure 4-26

Figure 4-27

By using a sort of genetic engineering, where architecture has been crossbred with other media, they have been able to generate a supple architecture that has nestled itself in the transitional area of two worlds: one being that of biological organisms and the other, electronic and modern technologies

According to Lars Spuybroek (Principal architect of Nox) we are experiencing an extreme liquidising of the

Figure 4-28

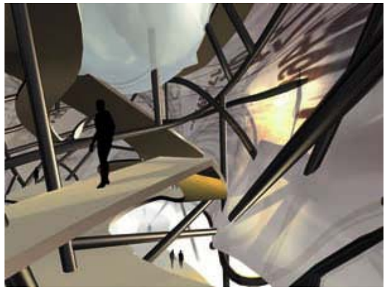


Figure 4-29

Figure 4-30

world, of our language, of our gender and of our bodies. We are witness to a situation where everything becomes mediated, where all matter and space are fused with their representations in media, where all form is blended with information.

In “Beachness” the firm started with quantified diagrams of various phenomenon that were translated into conceptual diagrams in a software environment that was then animated with the quantified data. This resembles the sand of the beach and bubbles being drawn up in a spiral (Steele, 2002: 142).

In the architects’ words "Beachness" is defined as a certain state of mobility, because the beach should be primarily conceived as a place in which everything is in a state of flux. A beach is a loose architecture of light materials, wood, fabric and sand which is used for a highway when wet and for a bed or a chair when it is soft. Everything is mobile and moveable: furniture, bodies, fabric, sand and cars.

The flux of the project is expressed in a two-part design, namely the boulevard and the New Palace Hotel. Both parts are linked in terms of content and are based on two characteristics of soft matter: *plasticity* and *memory*.

On the one hand, this implies the capability to move and to transform. On the other hand, the possibility to "imprint" multiple traces, for instance imprints in the sand, the browning of the skin from the sun, brands projected on the fabric, the intent of the project is to ‘remember’ these and to let these interact with the movements of the visitors.

In its most basic explanation the area of Noordwijk is a road next to the coastline. In the Netherlands there is an interesting phenomenon that the coast is generally the countryside and the cities in the interior are much larger and more developed. The coastline consists of small coastal towns that are under threat from the ocean. For this reason the coastline is almost always undeveloped and unimpressively static. The idea is to lay down asphalt over a part of the beach so that the distinction between behaviour on the beach and the road melts into an exciting new intermediate form.

This will then be the available parking along the boulevard and in the vicinity, which will eliminate the problems surrounding parking. The problem is not that there are cars that are stationary, but that it is considered as parking, as in the Netherlands pedestrians are considered more important than cars.

Because cars and pedestrians are mixed at street level, the car will be forced to act as pedestrian. This dynamic mix of cars - moving and stationary - pedestrians, cyclists and the like, creates an active surface, upon which NOX proposes to place moving structures of steel and canvas that have ‘thought’ and move in the wind.

The structures can host restaurants hidden from the elements. On these structures videos will be projected at night. The area will be dotted with thin lampposts that bend in the wind some of these even "walking" into the sea.

Instead of people passively lying and staring into the horizon, the horizon is wrapped around a building. The hotel has no sea view and the reason for this is that the concept of the hotel is based on the idea that people are the horizon and not the view. The expectation that it will attract a lot of attention is based on the fact that the tower is not only five times as high as that of Pisa, but also twice as skew.

A steel structure wrapped with translucent fabric, the spiral tower with a large plinth and tapers to an elegant 140m high pinnacle. The intent for the user’s perception inside the hotel is that of a Floating Tank (the kind where you float on salt water, with diffuse light, hints of sound on the ears, transporting you very far away).

The rooms are also all equipped with such a tank. They are not on the perimeter edge of the building, but a few meters behind it and very irregularly placed. The 'cavity' is the traffic and the sound of the wind will be electronically enhanced in this corridor.

As night falls and the sun finally sets, the building remains in vivid view as six cameras film the sunset while the sun "travels" through other time zones. These images are then broadcast at the Palace Hotel all through the night via the Internet. Thus, for example, at twelve at night you will be watching the sunset from New York.

(Paraphrased from: Vividvormgeving, 2009; Arcspace, 2004; Spuybroek L., 1999; NOX, 2003)

5.1 Introduction

The City of Tshwane was chosen as the setting for the new centre of the SAMF.

This chapter provides a description of the factors that influence the development of the design proposal on a macro-, meso- and micro-scale. It is the intent to align the design proposal with the spatial development frameworks of the City of Tswhane, while at the same time, presenting the urban dweller with a snapshot of the contemporary urban condition as manifested through the design process.

5.2 Macro-scale analysis

Factors that influence the design on a macro-scale generally refer to natural environmental aspects, such as geographical setting, topography, climate and biological factors.

Due to the anthropogenic nature of the urban environment, these factors do not necessarily persist on the project site, but should be taken into consideration in an attempt to integrate the city into the surrounding natural landscape.

5.2.1 Climate

The City of Tshwane falls within the summer rainfall region of South Africa and is characterised by intense thunderstorms in the afternoon, often accompanied by hail. The climate is warm and moderate, with a mean daily sunshine factor of 8.7 hours per day (Bolwheki, 2002:4).

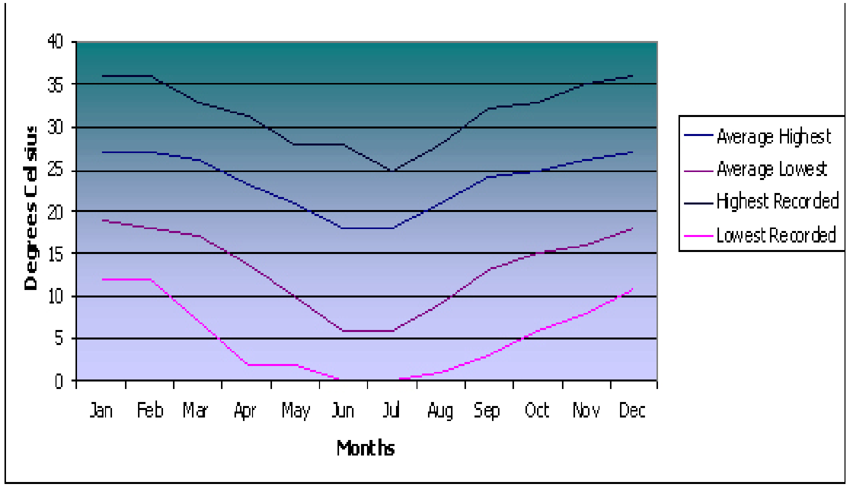


Figure 5-1: Average Air Temperatures for Pretoria (*Source: Adapted from Weather SA, 2003)*

The climate makes the city an ideal location to live and work, as well as a popular tourist destination (CTMM, 2007).

Table 5-1: Climate of City of Tswhane, 1961 – 1990 *(Source: Weather SA, 2003)*

Month	Temperature (° C)				Precipitation (mm)		
	Highest Re-corded	Average daily maxi-mum	Average daily mini-mum	Lowest re-corded	Average monthly	Average number of days with >1mm	Highest 24- hour rainfall
January	36	29	18	8	136	14	160
February	36	28	17	11	75	11	95
March	35	27	16	6	82	10	84
April	33	24	12	3	51	7	72
May	29	22	8	-1	13	3	40
June	25	19	5	-6	7	1	32
July	26	20	5	-4	3	1	18
August	31	22	8	-1	6	2	15
September	34	26	12	2	22	3	43
October	36	27	14	4	71	9	108
November	36	27	16	7	98	12	67
December	35	28	17	7	110	15	50
Year	**36**	**25**	**12**	**-6**	**674**	**87**	**160**

As seen in Table 5-1, maximum daily air temperatures range from 19°C in June to 29°C in January. The average annual rainfall is 674mm and the wettest month of the year is January with an average monthly total rainfall of 136mm. During winter months, less than 17mm rainfall occurs (Weather SA, 2003). The dominant wind direction is from the northeast, with an average wind speed of 2m/s. The strongest winds occur during September to December as can be seen in Figure 5-2.

5.2.2 Topography

The City of Tswhane is situated on the central Highveld plateau of South Africa at an average altitude of 1 500m above sea level. The topography can be described as rolling hills with scattered rocky outcrops and quartzitic ridges, intersected by small streams and rivers.

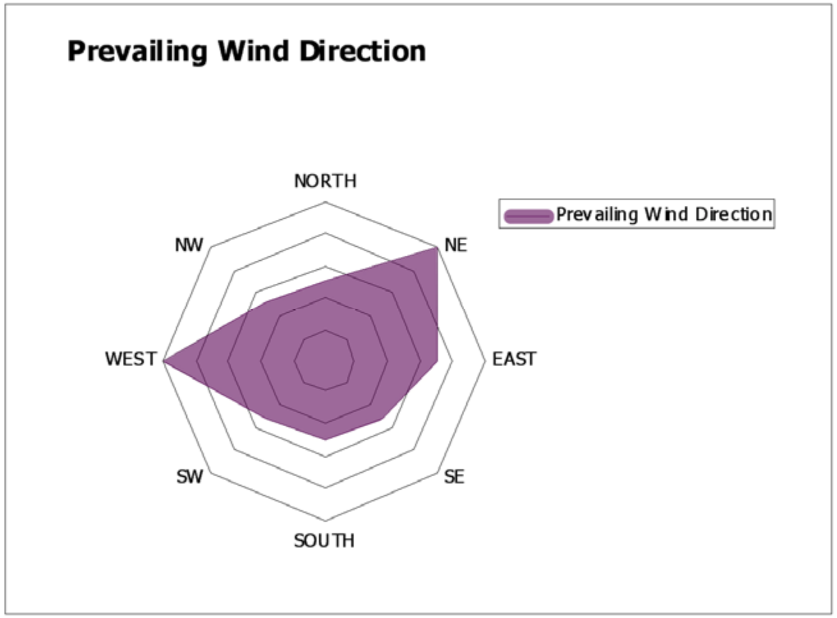


Figure 5-2; Prevailing Wind Direction *(Source: Adapted from Weather SA, 2003)*

On a regional scale, the City of Tshwane lies within a shallow valley that is framed by quartzitic ridges to the south and the Magaliesberg Mountains to the north. The valley topography is of special significance in that it has directly resulted in the development of a limited number of access routes leading from the north and south of the city. The project site is situated directly north of Fountains Valley, which is a regional topographical low-lying area and therefore, one of the limited and most important access points to the city.

5.2.3 Geology

The City of Tshwane is underlain by four major geological units, including:

- Basement granite/gneiss;
- Witwatersrand Supergroup;
- Malmani Dolomites; and
- Pretoria Group.

The southern part of the City of Tshwane consists of dolomite and chert which are prone to the formation of sinkholes and dolines. More specifically, the dolomites in the Fountains Valley area are a strategic groundwater resource for domestic water supply to the city (WRC, 1995).

5.2.4 Surface hydrology

The most prominent surface water feature in the City of Tshwane is the Apies River, which flows approximately 400m to the east of the project site. The Apies River forms part of the greater Crocodile River Catchment which drains large parts of northern Gauteng and the Mpumalanga Province.

As the Apies River enters the City of Tshwane, stormwater is added to the natural river flow and the river is largely canalised. Due to runoff from the street network, the water quality in the Apies River canal is generally of poor quality (Bolwheki, 2002:4-7).

5.2.5 Biomes

Due to the lower temperatures within the winter months, tree species in the City of Tshwane are restricted to kloofs and rocky areas, which are sheltered from the frost. These areas are therefore dominated by herbaceous species and grassland vegetation as the most important ecological drivers within both these biomes are fire, frost and grazing (CTMM, 2007).

The city further contains exceptional natural features within its boundaries, including ridges, wetlands, a meteoritic crater and ecologically sensitive areas. Only 27% of the municipal area is built-up, leaving 73% in some form of open space (CTMM, 2006).

5.2.6 Protected and sensitive areas

There are several protected and sensitive areas in the City of Tswhane, of which the Groenkloof Nature Reserve, Fountains Valley Park, Salvokop, Burgers Park and Magnolia Dell are all located within a 5km radius of the project site. As mentioned earlier, Salvokop is a prominent quartzite ridge situated only 1km to the southeast of the project site. Salvokop used to be a lookout post for hunters during the Stone Age and Iron Age (Bruwer *et al*., 2003).

Salvokop is currently home to Freedom Park, which was designed as monument to commemorate the lives of men and women who sacrificed their lives during the struggle for a democratic South Africa (Freedom Park, 2009).

The vision of the park is…

> *"To provide a pioneering and empowering heritage destination in order to mobilise for reconciliation and nation building in our country; to reflect upon our past, improving our present and building our future as a united nation; and to contribute continentally and internationally to the formation of better human understanding among nations and peoples…"* (Freedom Park, 2009).

5.3 Meso-scale analysis

The vision and mission of the City of Tswhane Metropolitan Council (CTMM) is…

> *"To be the leading international African Capital City of excellence that empowers the community to prosper in a safe and healthy environment,"* and *"To enhance quality of life of all people in the City of Tshwane through a developmental system of local government and the rendering of efficient, effective affordable services."* (CTMM, 2007).

In order to realise their vision and mission, the metropolitan council defined the following objectives as part of the *City of Tshwane Metropolitan Spatial Development Framework* (MSDF):

- To achieve shared and accelerated growth;
- To determine the City's contribution towards the Provincial economic growth target of 8% economic growth;
- To reduce unemployment by 50% by the year 2014;
- To create and environment that will ensure a more balanced and equitable sharing of benefits of economic growth between the first and second economies; and
- To address gender focused issues in the economy by dealing with the inequalities and mainstreaming women, youth and the disabled (CTMM, 2005a).

In recent years a number of developmental frameworks have been developed for the City of Tshwane. The two frameworks that have received the most attention are the Salvokop and Re Kgabisa inner city frameworks within which the new Gautrain Rapid Rail Link (GRRL) will be situated.

5.3.1 Re Kgabisa Framework

One of the key frameworks within which the design proposal will be developed is the Re Kgabisa framework which focuses on the upliftment of existing government buildings along the Paul Kruger and Church Street spines. The proposed site for the new SAMS centre is located at the end of the Paul Kruger spine and therefore, an important beacon in the urban landscape.

Although the Re Kgabisa SDF focuses on the development and rejuvenation of government buildings in the inner city, other objectives include:

- Incorporate cultural and heritage sites;
- Integrate with municipal initiatives, e.g. Mandela Corridor; housing, transport planning and open space developments; and
- Allow for flexibility, possible expansion to include other government entities and multilaterals.

This design proposal will be done in line with the cultural and heritage objectives of the Re Kgabisa SDF and simultaneously, become an integral part of an existing transport and educational hub.

5.3.2 Salvokop Framework

Although the design proposal is not situated directly in the Salvokop area, the Salvokop SDF focuses on the area directly to the southwest of the site. The framework therefore has a great influence on the development of the site itself and in addition, aligns itself with the objectives of the city-scale framework. The site therefore becomes both an extension of and a catalyst for certain elements within the Salvokop SDF.

Some examples that are part of the broad scale proposal that are deemed to be imperative to the site in question are:

- The Creation of a unique re-development area that builds on the assets of the Inner City and contributes to the progressive revitalisation of the area;
- Focusing, within the establishment of a mixed-use area, on heritage tourism, festival retail, commercial, housing and recreation activity to establish a new living cultural precinct for the Inner City;
- Creating a core exemplary heritage and environ mental conservation area that provides a tourism and educational attraction to the area supporting the location of Freedom Park and the National Leg acy Site; and
- Creating a new civic cultural and tourism spine that links the Central City system, Museum Park the Pretoria Station and through the re-developed Salvokop Village to Freedom Park (GAPP/MMA, 2003).

As can be seen from the broad outlines of the framework, there is a distinct intention to establish a cultural and educational area that will stimulate tourism development and act as a feeding ground for revitalization of the city. It is also the intent of the Salvokop SDF to revitalise the area on the northern side of the railway line around the Pretora Station and strong emphasis is given to the Paul Kruger arterial line.

It is important to note that the Apies River is currently the subject of redevelopment planning and a consortium of designers has been appointed to investigate the proposed upgrading of this spine. The following initiatives are of relevance:

- Apies River Open Design Framework;
- Rainbow Junction; and
- Apies River Development Corridor (Bruwer *et al.*, 2003).

5.4 Micro-scale analysis

5.4.1 Site selection

25°45'31.01"S
28°11'28.67"E

The choice of the site for the design proposal was influenced by a number of factors, of which the most important was the architectural programme and its contextual significance. The site therefore had a few prerequisites that are listed as:

- Distinct urban characteristics;
- Easily accessible by pedestrians and motor vehicles;
- High degree of visibility;
- Reclamation of ‘lost’ space.

A decision was made to make use of an *underutilised* site in the area of the future Gautrain station in Pretoria (Figure 5-3, Figure 5-4 and Figure 5-5).

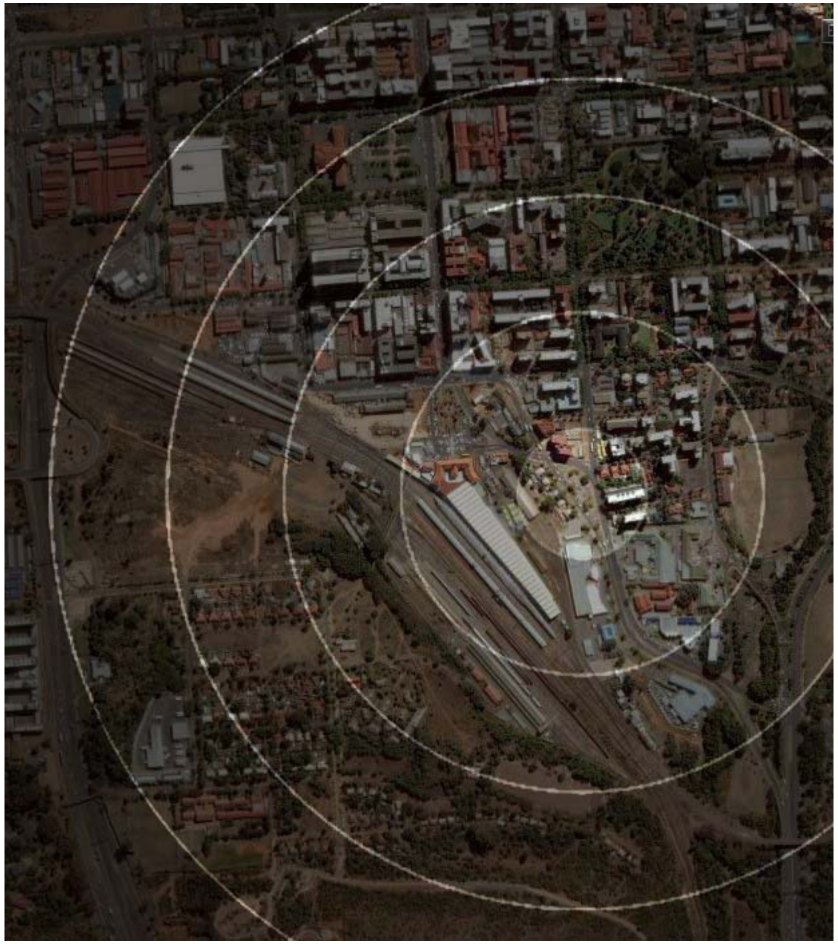


Figure 5-3: Site location *(Source: CTGIS,2009)*

Figure 5-4: Aerial view of site *(Source: Railways Africa, 2009)*

In the *City of Tshwane Densification and Compaction Strategy* (CTMM, 2005b), reference is made to a few enemies of densification, of which at least four will be directly addressed by this project namely:

- Shortage of functional and attractive communal open space and recreational facilities in strategic areas to support higher density housing;
- Inefficient use of valuable land by large parking areas around commercial developments;
- Pedestrian unfriendly nodal areas; and
- A lack of emphasis on redevelopment and regeneration, with a strong emphasis on Greenfield developments.

The City of Tshwane also stated in its Integrated Transport Plan, 2004-2009 (CTMM, 2008) that…

> *"….the GAUTRAIN will have a major impact on the demarcated destinations in Tshwane (i.e. Centurion Station, Pretoria Station and Hatfield Station) in terms of future development of these areas. To ensure the viability of these stations, the areas around the stations will have to comprise a specific land use mix … at a specific intensity and density with a strong focus on pedestrians and inter-modal transfer facilities. They will also have to comply with specific urban design requirements."* (CTMM, 2008:4-15).

Figure 5-6: View from Northwest *(Source: Own Image)*

Figure 5-7: View from East *(Source: Own Image)*

Figure 5-8: View from South *(Source: Own Image)*

Figure 5-5: Overview of the site *(Source: CTGIS, 2009)*

It is clear that The City of Tshwane will be greatly transformed by the Gautrain and will trigger a whole range of development and renewal through its implementation. This has been one of the key considerations in the choice of a site for the design proposal. The proximity to the Gautrain station is of great significance.

5.4.2 Land tenure

Currently the site consists of four stands that would need to be consolidated. Three of the sites are currently owned by the Metropolitan Council of the City of Tshwane, and the fourth is owned by the Muslim Educational Trust (see Table 5-2 and Figure 5-6).

5.4.3 Palimpsest and Architectural Character

The Paul Kruger Street Spine Development Framework (2001) identified the precinct surrounding the Pretoria Station as a very important node in the city. This is mainly due to the station's landmark and in particular, the imposing visibility of the main station building at the southern end of Paul Kruger Street. The asthetic importance of the station precinct at the end of the Paul Kruger spine is of especial significance (Bruwer *et al*., 2003).

The palimpsest and architectural character of the site will be described with reference to the station precinct and the areas immediately surrounding the precinct.

Table 5-2: Ownership of the land in question *(Source: Compiled from WinDeed)*

Stand no.	**Address**	**Area**	**Owner**	**Purchase date**	**Purchase price**	**Registration date**
2275	562 Andries Street	907 m^2	Pretoria Municipality	Unknown	Unknown	1973/10/08
2276	48 Railway Street	760 m^2	Pretoria Municipality	Unknown	Unknown	1974/01/15
2282	52 Railway Street	858 m^2	Pretoria Municipality	Unknown	Unknown	1976/12/09
43	N/A	1288 m^2	Muslim Educational Institute Trust	2003/10/07	R900 000	Unknown

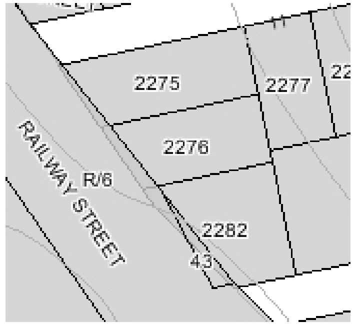


Figure 5-9: Stand numbers *(Source: CTGIS, 2009)*

5.4.4 Pretoria Station Precinct

The Station building is the well-known Herbert Baker designed design, which was completed in 1912. The building was partly gutted by fire in 2002 but has since been restored. To the West of the main building is the former station for "non-whites" and according to Bruwer *et al*., "…a near forgotten relic from the days of apartheid," (2003:14). The station precinct, shown in Figure 5-7) further consists of the sheds and annexes to the main building and the landscaped open space between the main building and Scheiding Street. The building was never afforded permanent protection status under the former National Monuments Act, 1969 and is not a provincial heritage site in terms of the National Heritage Resources Act, No. 25 of 1999 (NHRA).

In the days of the former Transvaal Republic, the Pretoria Station was the point of connection of the capital city with the gold mining industry of Johannesburg. In addition, it was the only station in the interior of the country from where Lourenço Marques (now Maputo) in Mozambique could be reached.

Figure 5-10: Pretoria Station Precinct *(Source: Own Image)*

Located in the area surrounding the station is a mixture of apartment blocks, office, retail as well as residential dwellings of which many date back to the days of the 'old' or historic Pretoria. Many of these buildings are older than 60 years and thus protected under the NHRA.

5.4.5 Berea Park

Continued expansion of the railway operation resulted in the construction of houses for railway employees in the area east of the station. This also led to the development of a recreational facility for white railway employees of the former Central South African Railways (CSAR). The area became known as Berea Club or Berea Park, as it is currently known. The Club used to be frequented by white railway employees and public service officials who lived in apartment buildings in Sunnyside and the suburbs of Arcadia and Muckleneuk.

The buildings of Berea Club date from 1906 to 1927 and are thus considered a national heritage in terms of the NHRA. In fact, the Berea precinct is currently the oldest recreational facility of its kind in the City of Tswhane. Unfortunately, the facilities are no longer in use and the former club grounds are in a state of neglect.

5.4.6 Muckleneuk and Lukasrand

To the east of the Station lie the suburbs of Muckleneuk and Lukasrand. The area is well defined by its topography, location and street grid. The residential character of the area has been maintained since it was laid out before the turn of the 19th century. In fact, Muckleneuk is currently one of the three Jacaranda routes in Pretoria. Also to the near east is the UNISA Sunnyside Campus. Following the Second Anglo-Boer War (1899-1902) the site was used for the former Pretoria Normaal College. Most of these buildings dating from 1910 to 1965 have been taken over and extensively renovated by UNISA (Bruwer *et al*., 2003).

5.4.7 Salvokop

Salvokop was established by the Nederlandsche Zuid-Afrikaansche Spoorweg-Maatschappij (NZASM) in 1892 as a permanent railway village for employees. During the past 110 years, Salvokop developed as a typical semi-isolated, self-contained railway township.

The architecture of Salvokop is significant in that it displays a range of architectural styles dating back to the 1980s. Every ten years, another architectural style was adopted by the various railway administrations.

5.4.8 Summary

Important historical buildings in the vicinity of the project site include the old mill building in Andries Street and the Berea Park recreational facility. As stated earlier, the Berea Park recreational facility could again become an integrated part of the Pretoria Railway Station precinct. Other important buildings within the area include Victoria Hotel (formerly the Hollandia Hotel), the Belgrave Hotel (1929), the historical coach washing shed, the Audit building 1928, as well as the railway-associated houses previously known as Du Preez's Hoek (Bruwer *et al*., 2003).

5.5.Proposed urban framework

The proposed urban framework is not only a combination of the Salvokop and Re Kgabise SDFs, but also an extension thereof.

Some of the challenges facing this area of Tshwane are:

- Uncontrolled development;
- Rapid growth and change;
- Congested circulation;
- Uneven accessibility;
- Unbalanced use of facilities;
- Restricted choice of residence typologies;
- Unstable pattern of activity;
- High running cost of the City as a whole;
- A visually characterless and confused landscape;
- Alternative land uses disturb the residential character of established residential areas;
- Decline and negative changes are taking place in the character and function of the Inner City;
- Little or no night-time activity, leading to unsafe areas;
- Under-utilisation of space; and
- Low variety in density.

Some of the strengths of the area include:

- An established Inner City and suburbs;
- A radial road system with arterials converging on the Inner City;
- Nodal development along the arterials;
- Rapidly growing areas on the periphery;
- An open space system comprising of space that can become parks and existing watercourses ridges etc;
- Established Infrastructure;
- Proximity to the inner city and other nodes and modal interchanges;

- Good views of the city-scape;
- Cosmopolitan demography; and
- Ample recreational facilities.

5.5.1 Objectives

In view of the above mentioned challenges and strengths, the objectives of the proposed urban framework are to:

- Make efficient use of land;
- Discourage urban sprawl;
- Promote the extension of the already efficient transport system;
- Enhance environmental protection;
- Manage open spaces effectively;
- Make efficient use of urban and regional facilities, including bulk infrastructure;
- Reduce existing infrastructure and service disparities;
- Encourage affordable growth of local economies;
- Improve the quality of the urban environment; and
- Establish safe and secure living and working environments.

5.5.2 Preliminary design guidelines

In order to achieve the objectives of the proposed framework, the following design guidelines have been formulated:

- Variation in the alignment of roofs;
- Variation of façade treatment in order to promote diversity and individuality, as well as to eliminate monotony;
- Screen walls are to be staggered or otherwise articulated;
- Hard landscaping should be restricted to vehicle parking and access zones, essential pedestrian pathways and private patios so as to reduce storm water runoff;
- Paved areas must not hamper the efficient management of storm water;
- A minimum of one tree for three open parking bays to be planted;
- Car parking facilities should not dominate the development or street frontage;
- Landscaping should not detract from lines of vision and hiding places should not be created;

- Compatibility of densities is a key consideration in restructuring the city and in the urban design of local areas;
- Transitional zones can be established where appropriate, so that there are gradual increases and decreases in density;
- Variation in scale through height difference is encouraged;
- Street frontage should suit the efficient use of the site, the residential amenity and the character of the precinct;
- The placing of individual buildings should avoid long rectangular footprints, while utilising setbacks, preferably not positioning buildings at right angles to the street boundary;
- Layouts should respond positively to site features, e.g. topography, drainage, vegetation. Good lighting, visibility and surveillance with perimeter lighting on the street frontage are encouraged. Lighting of common spaces such as the perimeter, pathways, and entrance halls are imperative;
- The placement of windows on the façade of buildings to allow for surveillance from the building onto the street and other public spaces is strongly advisable;
- Spaces around buildings should be designed to relate to the built form, so that the land owner can take ownership of the space;
- Pedestrian paths, particularly along mobility spines and roads and along public transport routes, should be articulated;
- Specific provision need to be made for pedestrian routes in strategic areas, particular from residential areas to nodes, amenities and public transport points. These paths must include clear signage, street lightning, managed vegetation and pedestrian crossings;
- Property enclosures, if really deemed necessary, should be permeable to allow for visual surveillance onto and from the street;
- The access must be in line with mobility policy requirements and the access way must be sited so that cars entering the development will not hinder the vehicle movement in the public streets surrounding it; and
- Residential developments along mobility spines and roads should have a strong edge with the road. Perimeter block courtyard buildings as well as linear buildings along the street edge would be appropriate.

5.5.3 Continuation of Urban Fabric

One of the problems with the area in question is that it does not integrate very well with the rest of the city. It is therefore the intent to integrate the area surrounding the Pretoria Station with the urban fabric by densification around the site of the new Gautrain Station, shown in Figure 5-8. The Berea Park sports facility will also be re-evaluated as a residential or commercial entity. In fact, the Heritage Impact Assessment for the new Pretoria Gautrain Station states that;

> *"From the viewpoint of historic context, the Berea Park recreational facility should again become an integrated part of the Pretoria Railway Station precinct and its heritage importance."*
> (Bruwer *et al.*, 2003:30).

It is also deemed necessary to continue densification into the Salvokop Precinct, as the new vehicle and pedestrian bridges that are planned will enable better integration into the city as a whole. The continuation of urban fabric is illustrated in Figure 5-9.

5.5.4 Districts

It is envisaged that the area should be conceptually divided into three districts.

To the West are the station and all its amenities with a proposed foyer building as an 'entrance' from Salvokop. In the area directly to the west of this to the South of Burgers Park there is a proposed Hotel and Public facilities area.

On the western side there is a designated precinct for residential, retail and office developments that tie in with the UNISA Sunnyside campus as part of an educational precinct. It is also proposed that an iconic gateway building is placed at the southern entry point into Pretoria. The locations of the proposed districts are shown in Figure 5-10.

Figure 5-11: Rendering of the new Gautrain Station in Pretoria *(Source: Africa Railways, 2009)*

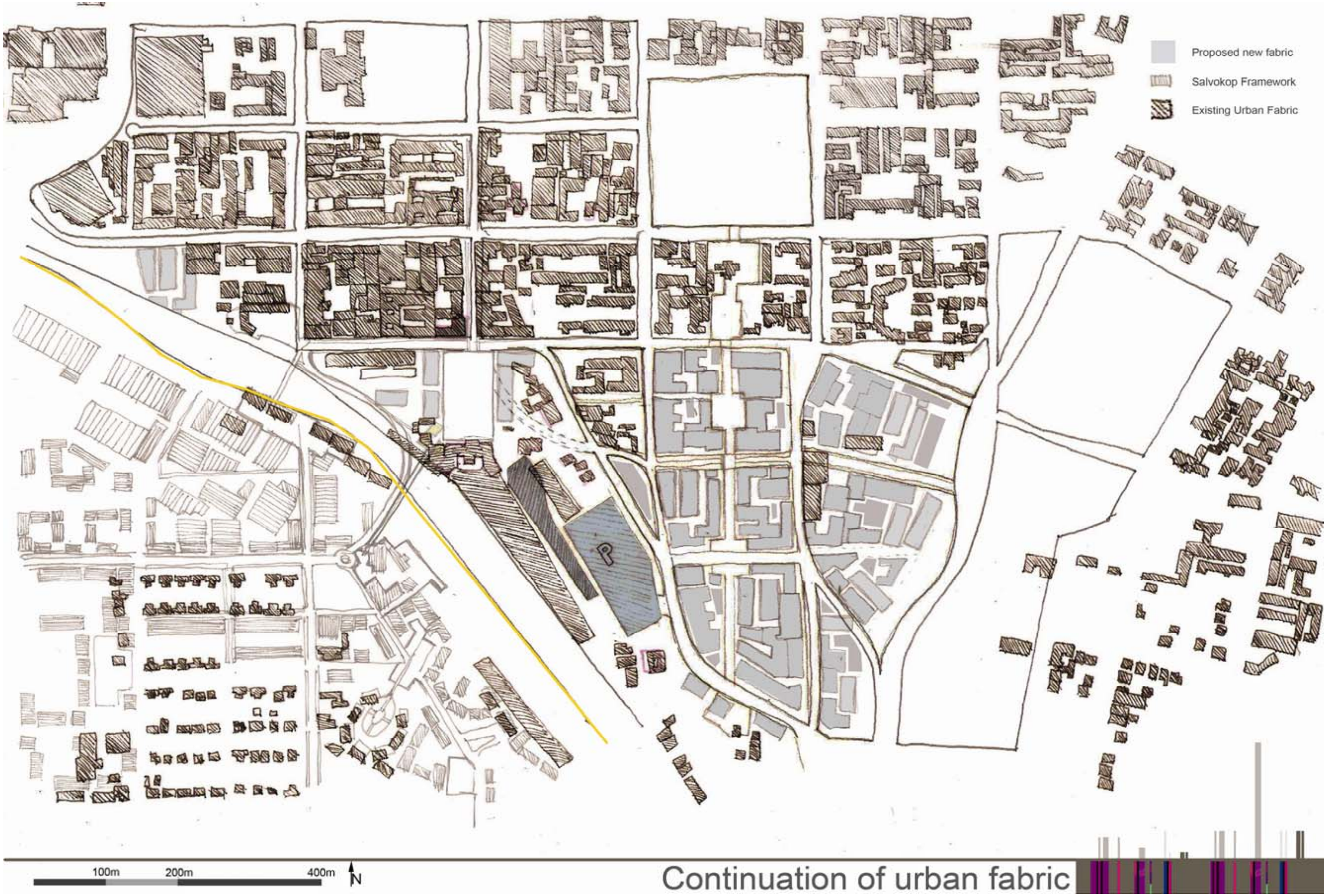


Figure 5-12: Continuation of urban fabric *(Source: Own Image)*

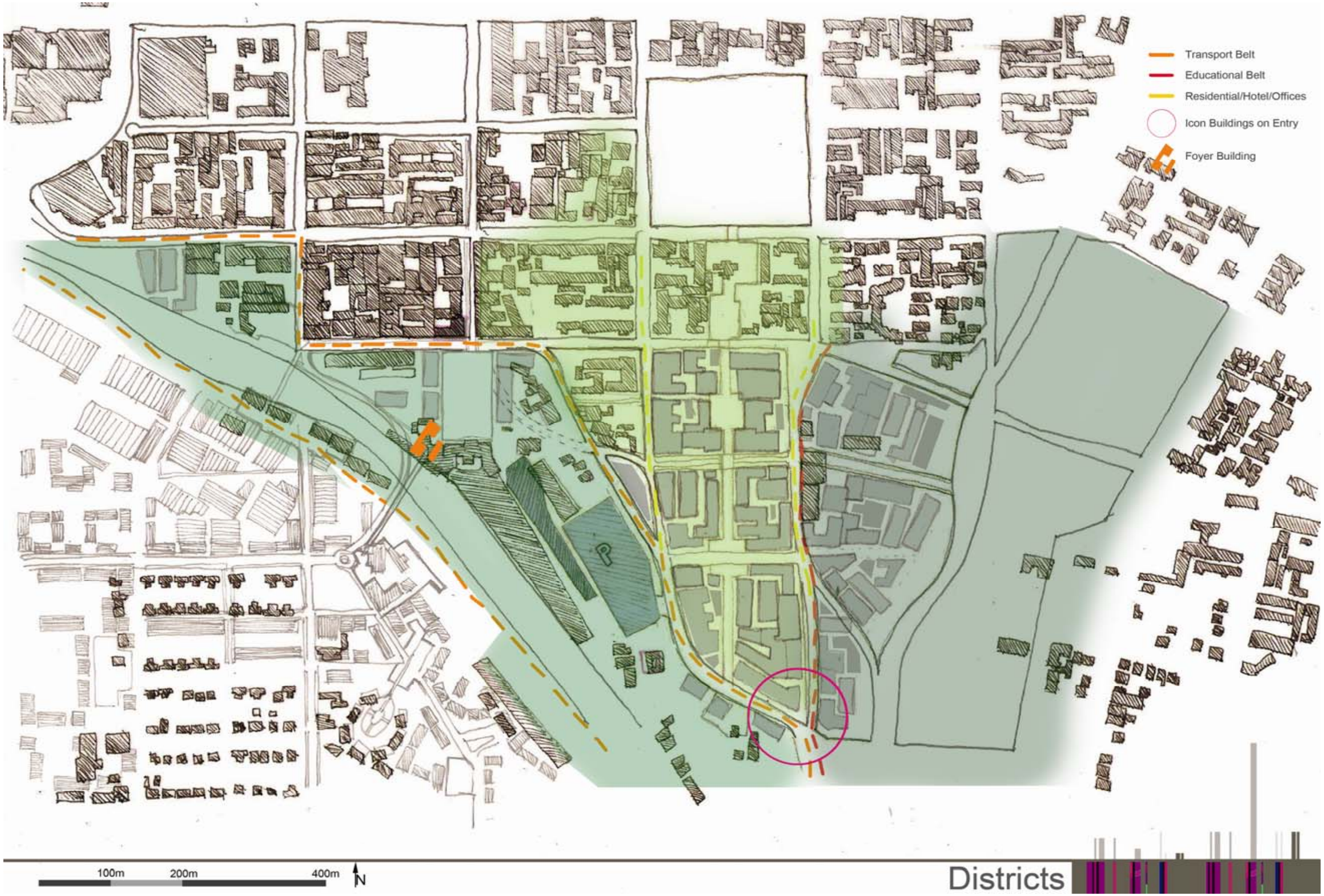


Figure 5-13: Districts *(Source: Own Image)*

5.5.5 Public open Space

An important part of the proposed design framework is its focus on public open space as a part of future developments. A green belt is proposed from Burgers Park to the South terminating close to the Pretoria Station, as shown in Figure 5-11.

Another noteworthy aspect is intensive intervention along Scheiding Street to enable pedestrian traffic from the UNISA Sunnyside Campus to the Pretoria Station. The pedestrian link to Salvokop is of paramount importance.

It is also suggested that a green open space be provided at the new Gautrain Station as their proposals do not make provision for such spaces.

Lastly, it is important to re-establish the square to the North of the Station as an urban green space. It is deemed necessary to define the square better through the use of perimeter buildings and densification.

5.5.6 Links

As stated earlier, important frameworks that were considered included the Paul Kruger Spine framework. This axis needs to be strengthened intensively.

It is suggested that in the future the link between the UNISA Sunnyside Campus and the Pretoria Station will become increasingly important.

It is also important to establish a link through Burgers Park to the south. It is also envisaged that the link to Salvokop will become increasingly important as it forms the threshold to Freedom Park from the station (see Figure 5-12).

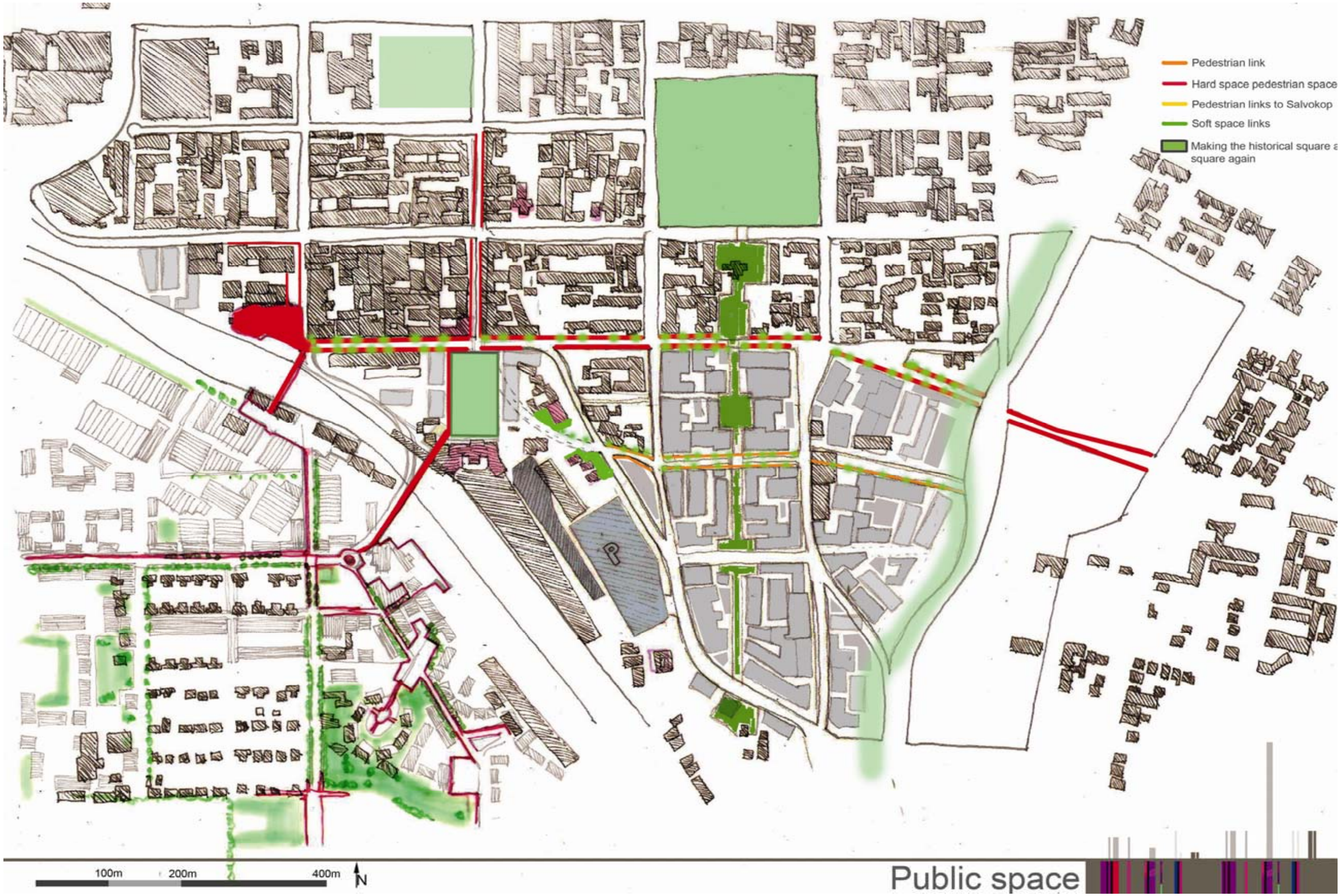


Figure 5-14: Public space *(Source: Own Image)*

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

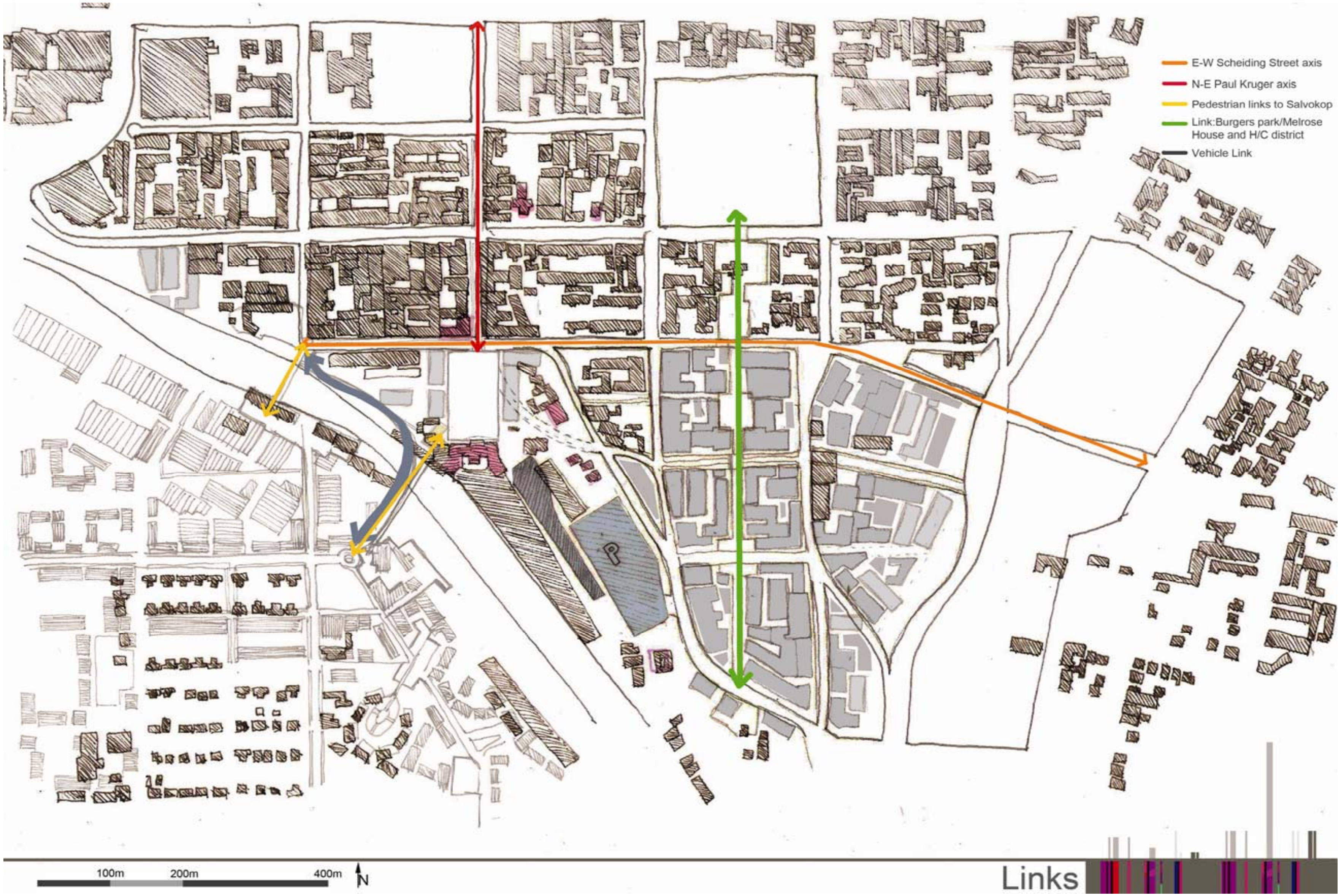


Figure 5-15: Links *(Source: Own Image)*

5.5.7 Circulation

The most important adaptation to the existing circulation in the area is that of the closure of the extension of Tulleken Road. The author is of the opinion that this road no longer serves any purpose as it was originally developed when the Nelson Mandela corridor was under construction. The removal of this road re-integrates the site to the north of the station and restores it as a pedestrian-friendly legible entity.

The proposed ring road flow of traffic is a slight adaptation to what was proposed by the Gautrain development (see Figure 5-13). It is the opinion that the secondary ring-road should be utilised only for drop-off and pick-up and should not be of such significance that it segregates the existing Pretoria Station building from the public space to the north.

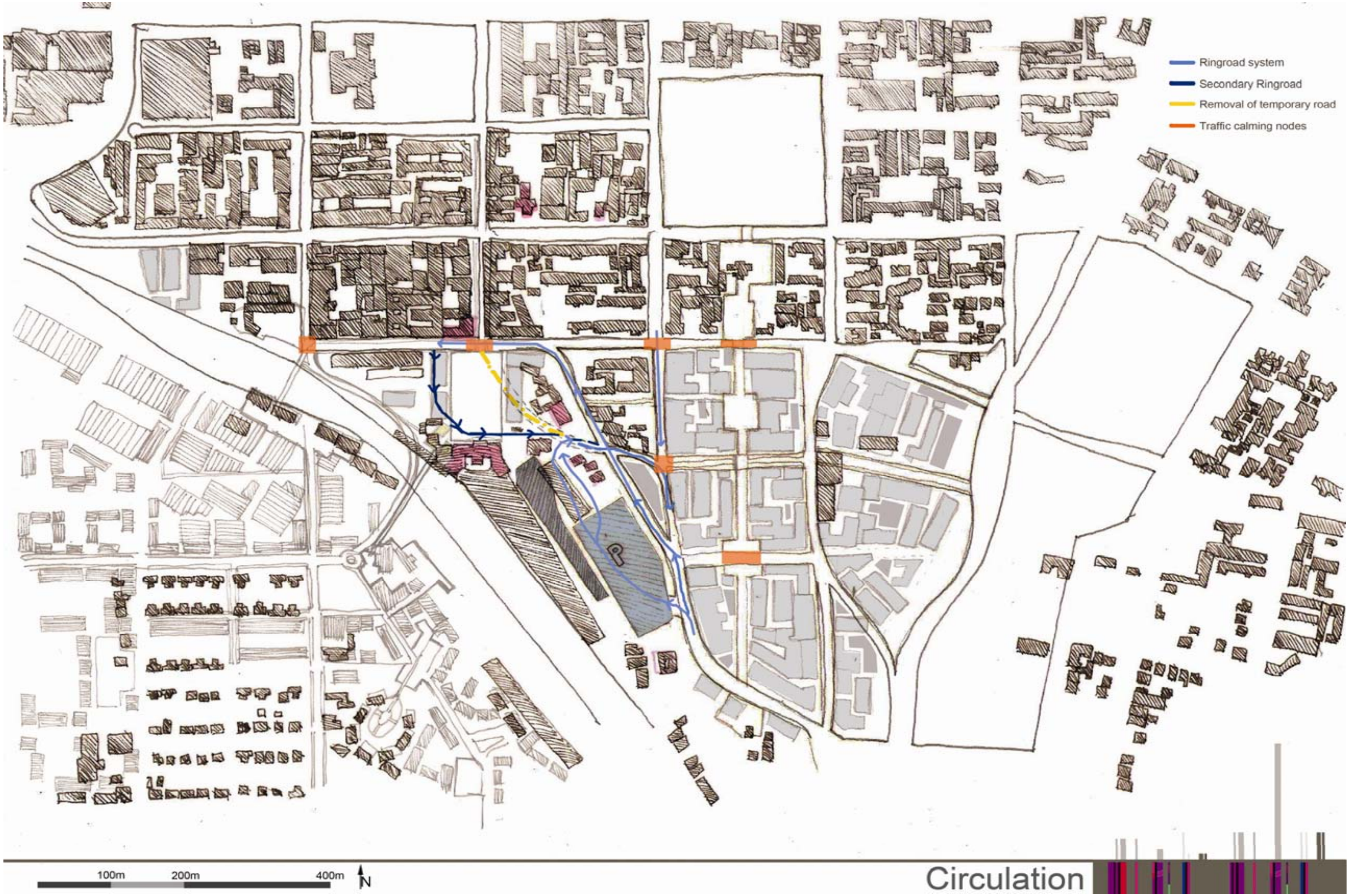
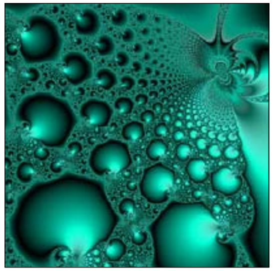


Figure 5-16: Circulation *(Source: Own Image)*



6.1 Assigning symbols

As stated earlier the most important question that arise due to the use of fractal geometry as form generator is that of signification.

Once again it is open to the question: *How does statistics give meaning to the Architecture, if at all?*

The Process of assigning symbols to the given statistical data was influenced largely by the ideas of Faber Birren (1900-1988) who on his turn drew upon the Work of Johannes Itten (1888-1967). For the purposes of assigning a specific shape and color to a statistical entity, a simplified summary compiled from the work of Birren was utilised (Dreyfuss ,1972 :233-246).

In this summary, 12 colors are directly related to 12 shapes and then through looking at different cultural, mythological and psychological associations are then linked to Symbolism, Folklore, Emotion, Cultural convention and even symbols and colors used in Technical Documentation.

As such the summary provided useful palette from which shapes were assigned to statistics.

The Challenge of this process was to find a link between a statistic and a two dimensional geometrical shape, but then also to interpret that shape into a three dimensional form that can be utilised as a Fractal Generator. Table 6-1 serves as a summary of the Statistics through to the assignment of a shape from the library of the software utilized, called Xenodream™. It is important to note at this point that as an objective exercise shapes were assigned to all data and objectively transformed by their respective quantities as inputs into Xenodream™

Table 6-1: Summary of the assignment of shapes

Statistics	Association	Color Association	Xenodream associated shape
Population group	Hexagon	Green	Quartz Prism
Gender by age	Disk/ Spiral	None	Disk
Highest education levels	Circle	Blue	Sphere
Labour force	Trapesium	Black	Square Disk
Language	Halfsphere	White	Bowl
Mode of travel	Maze/Spiral	None	Spiral spring
Dwelling type	Hexagon	Green	Hexagon
Source of energy for lighting	Triangle UPRIGHT	Yellow	Triangular Prism up
Water	Triangle DOWN	Yellow(Blue)	Triangle Prism down
Annual household income	Diamond	Brown	Octahedron

6.2 Discussion of each shape

The following text will serve as a discussion on how each shape was assigned to a statistical parameter.

6.2.1 Population group

It was decided that the associations of fertility, prosperity and life as outlined in the aforementioned summary of Faber Birren, were strong driving forces in all population groups and thus the decision was taken to assign the Hexagon to this statistic (Dreyfuss, 1972:235). It was interpreted three dimensionally as a Quartz Prism due to its Hexagonal Shape.

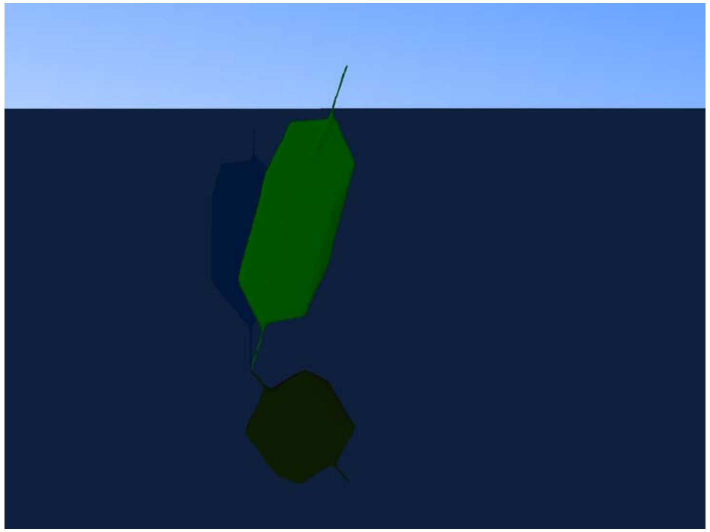


Figure 6-1: Hexagon - Population group *(Source: Own Image)*

6.2.2 *Gender by age*

According to Fontana (1994), the circle or spiral is associated with masculinity and femininity, while simultaneously signifying a journey. The circle has long been a symbol of completeness and union of opposites (male and female), while also being an analogy for the circular nature of life (Fontana, 1994:97; Jung, 1964:280).

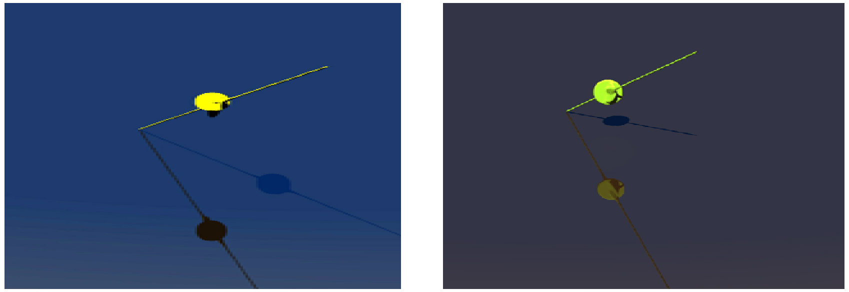


Figure 6-2: Circular Disc - Male and female *(Source: Own Image)*

6.2.3 Education levels

The circle and the color blue have also been associated with the realization of obligations and higher education (Dreyfuss, 1972:243). As early as Plato, the human psyche and the endeavour to understand was associated with the circle (Jung, 1964). This was interpreted as a Sphere for the purposes of generating a model.

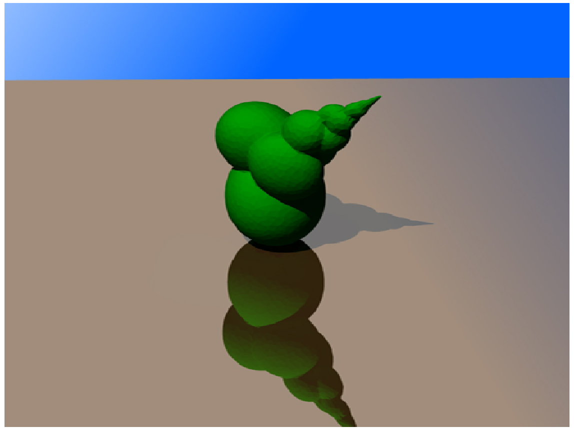


Figure 6-3:
Sphere
Education levels
(Source: Own Image)

6.2.4 Labour force

The colour black and the shape of a Trapezium have varied interpretations, ranging from positive to frightful. It is also associated with honesty, dignity and humility, which are all strongly associated with what is called the working class (Dreyfuss, 1972:245-6). The trapezium also can be interpreted as a square seen in perspective and thus a square disk was chosen as the model generator.

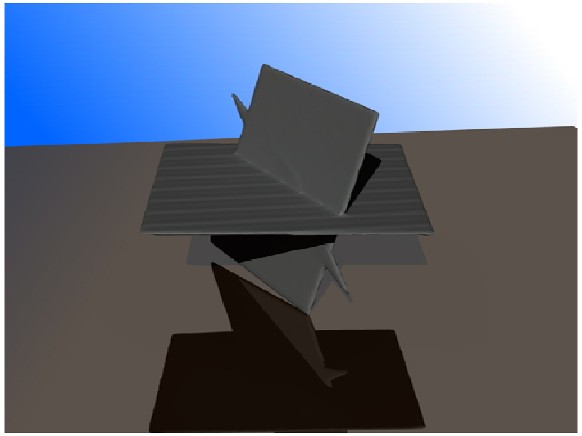


Figure 6-4:
Square disk
Labour force
(Source: Own Image)

6.2.5 Language

White is greatly associated with light and clarity, also colour used in academics to denote Arts and Letters. It is therefore associated with clarification and explaining and thus with language (Dreyfuss, 1972:245). White is associated with the shape of a semi-circle and as such was represented by a half-sphere.

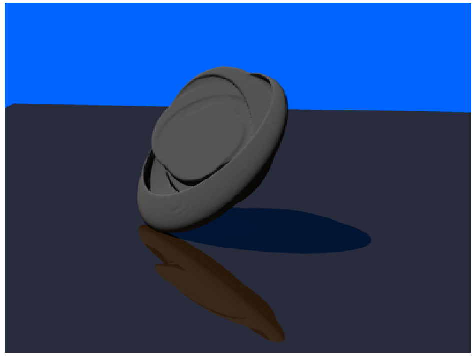


Figure 6-5: Half sphere - Language *(Source: Own Image)*

6.2.6 Mode of travel

The idea of a Journey has for very long been associated with the flow of energy and movement (Fontana, 1994:75). It was therefore decided to utilise a coil or a spring as a three-dimensional form generator to represent transport and movement patterns.

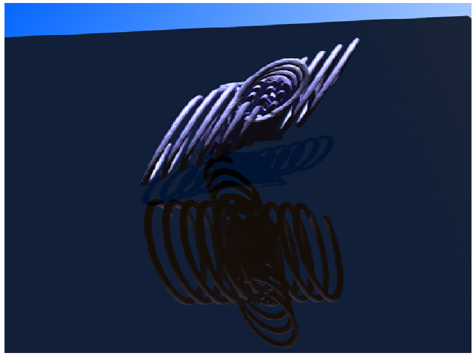


Figure 6-6: Coil - Mode of travel *(Source: Own Image)*

6.2.7 Dwelling type

The colour green and its associated form of a hexagon also signify fertility, prosperity and civility, or in other words a good citizen that subjects himself to social customs and etiquette of the bourgeois (Dreyfuss, 1972:241). It is therefore a symbol of neighbourliness and as thus can be interpreted as symbolic of the human dwelling. A hexagon was thus utilised to symbolise the dwelling type.

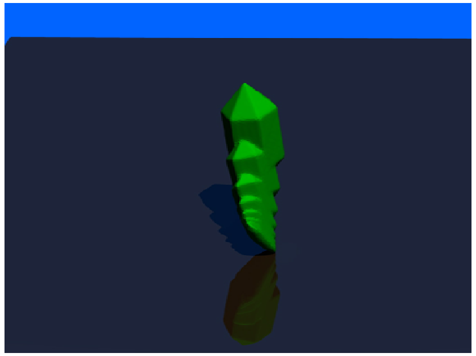


Figure 6-7: Hexagon - Dwelling type *(Source: Own Image)*

6.2.8 Source of energy

Since time in remembrance the upright triangle has been a symbol for fire, one of mans most important and earliest sources of energy, it was therefore decided that a three-dimensional triangular prism in its upright position should be used as a symbol for energy (Dreyfuss, 1972:86).

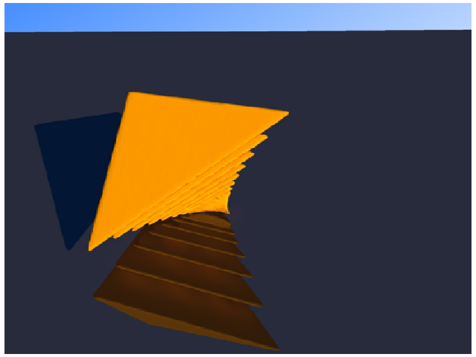


Figure 6-8: Prism - Source of energy *(Source: Own Image)*

6.2.9 Water source

Similar to Energy the symbol for water is also an ancient one, and is an upside down triangle. The choice was thus made to utilise an upside down prism to create the model for the water source statistics (Dreyfuss, 1972:86).

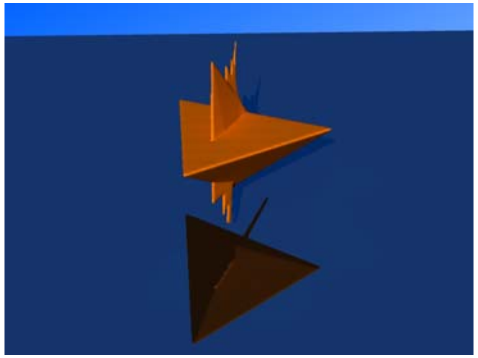


Figure 6-9: Upside down prism - Water source *(Source: Own Image)*

6.2.10 Annual household income

Brown and its associated shape of a diamond have the associations of Earth and abundance, and also barrenness or poverty, associated with it. It is also a symbol of parsimony and shrewdness with money (Dreyfuss, 1972:236-244). It was therefore utilised as a symbol for the income per family in the area under study. An octahedron was assigned to the statistic as it represents a diamond from all sides.

Figure 6-10: Octahedron - Annual household income *(Source: Own Image)*

6.2.11 Closing Remarks

After these shapes were assigned the models were generated in Xenodream™ by using their respective quantifiable data as inputs into the software. Thus far in the process there was a distinct shying away from the subjectivity of the designer although a certain amount of poetic license was taken with the interpretation of the symbolic representation of the statistics.

6.3 The Shapes as Fractals

As stated above the different values of each statistic were fed into Xenodream™ as rotation angles of the fractal. A decision was taken to be as objective as possible during this process, in other words, to define rules that are strictly followed without question. This was done based on the fact that the software only has six quantifiable inputs that can be fed in objectively namely a skew distortion in the X,Y, and Z axis and a rotation in the X,Y, and Z axis.

The rules are:

- If there are less than six partitions they are fed in the order that they occur; and
- If there are more than six partitions, the six highest are fed in.

It was observed that the smaller partitions had very little effect on the model and are therefore deemed insignificantly small.

6.4 Utilising the models as a form vocabulary

The subsequent use of these models as a form vocabulary has proven to be one of the largest challenges of this study. After the possibility of utilising the models as a single combined entity that is reworked into architecture proved unsuccessful, a decision was taken to explore each of the models separately in plan and section, but not excluding the possibility of three-dimensional experimentation. The combination of these three explorations proved to be highly successful in generating plan section and elevation while still giving high priority to spatial experience.

It is important to state that although all statistics were developed into models without bias, there came a point in the design process where the objectivity no longer as pure as it had been and the designer had to *regain control* of the design. In the same way that any coherent text does not try and give equal importance and significance to all the words of a particular language, certain pieces of the vocabulary were used directly, certain other with greater subtlety, and yet another with only a hint of reference.

It is also important to note that these entities were primarily evaluated on a formal level and secondarily at the level of their supposed meaning.

This was done because the authors believes that the meaning had already been encapsulated in the form itself and is therefore of lesser importance at this point in the process.

The process was not exclusively done in digital media as it is the opinion of the author that it is important to understand the process through both digital modeling and drawing.

6.4.1 Process

As described earlier, initially the models were combined into a single model as a starting point. This model can be seen in Figure 6-11. The model was however deemed too complicated and incoherent to be an expression of the architectural intent.

It was therefore decided to embark on a process of analysing the models in section and plan to unlock the spatial characteristics thereof.

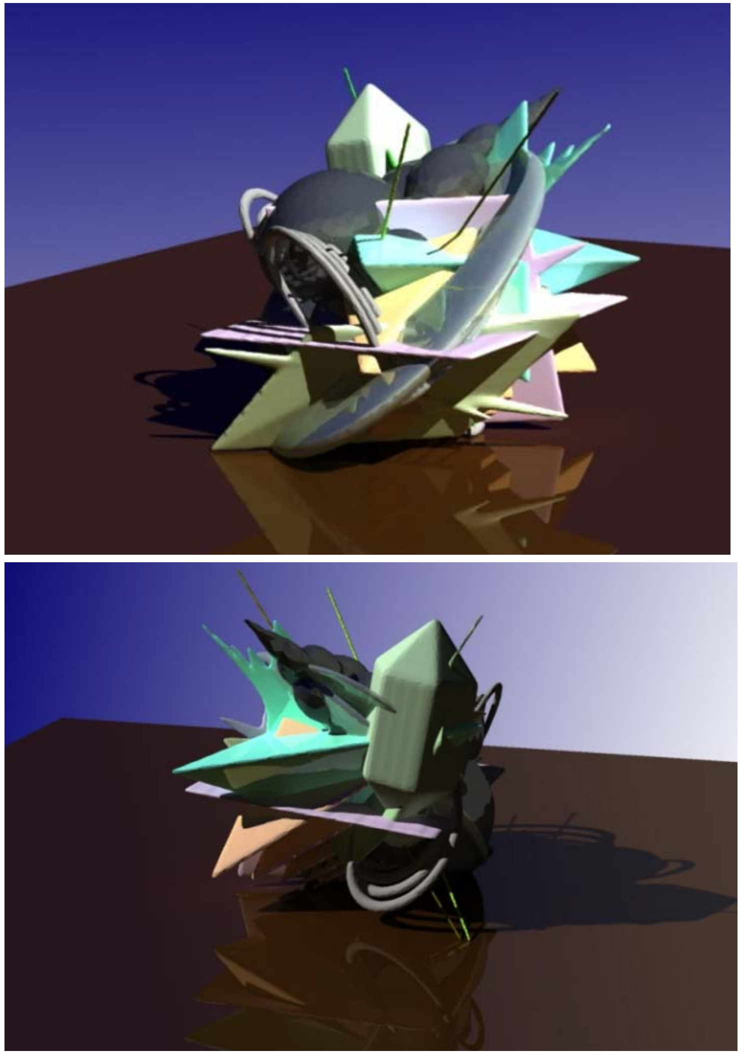
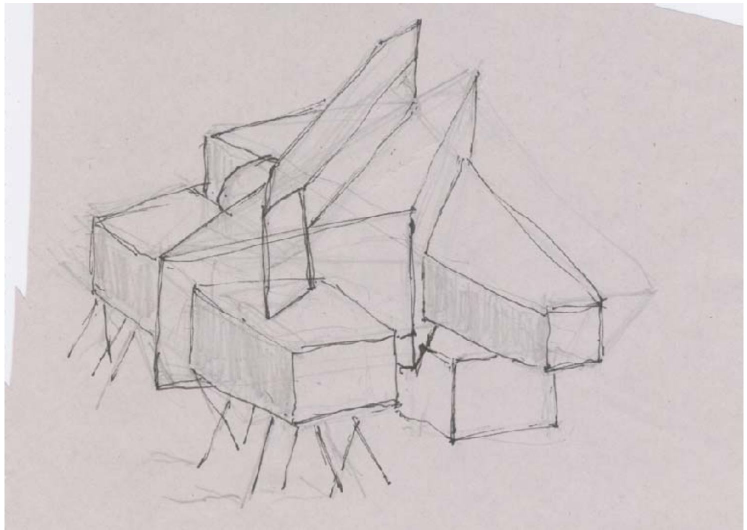


Figure 6-11: Combined Xenodream™ model
(Source: Own Image)

The designer had to move away from a purely objective design approach to a more integrated analysis of form that take the site, climate, area required and the existing built fabric into account. It was the intent to capture the spatial and other qualities of the models into a design that had a strong identity but drew on the combination of different forms, rather than trying to be monolithic and iconic. The intent was to carry the idea of combining different shapes through to the final design without trying to hybridise them into simpler forms.

By analysing the models in section and plan the vocabulary of forms not only included the eleven models but also one hundred and ninety seven line diagrams of sections and plans. With these two hundred and eight 'letters' the designer had to be very selective to combine without repeating unnecessarily, while still trying to create form that is interesting and true to the original concept both physically and theoretically.

The design development is exhibited in Figures 6-12 to 6-14.



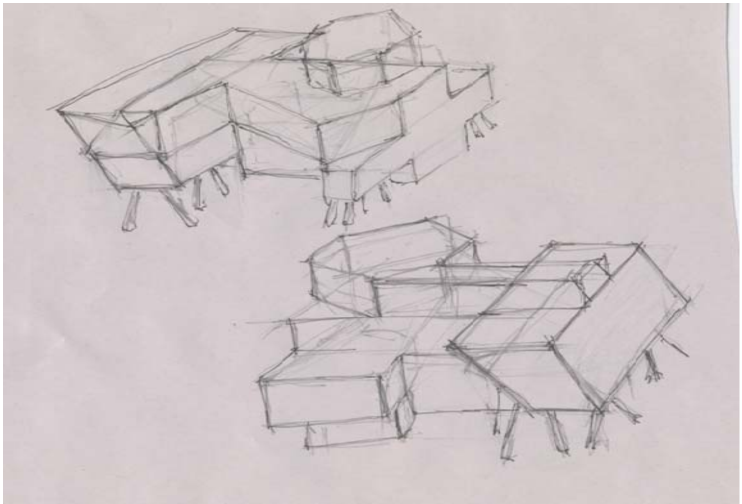


Figure 6-12: Design development (1)
(Source: Own Image)

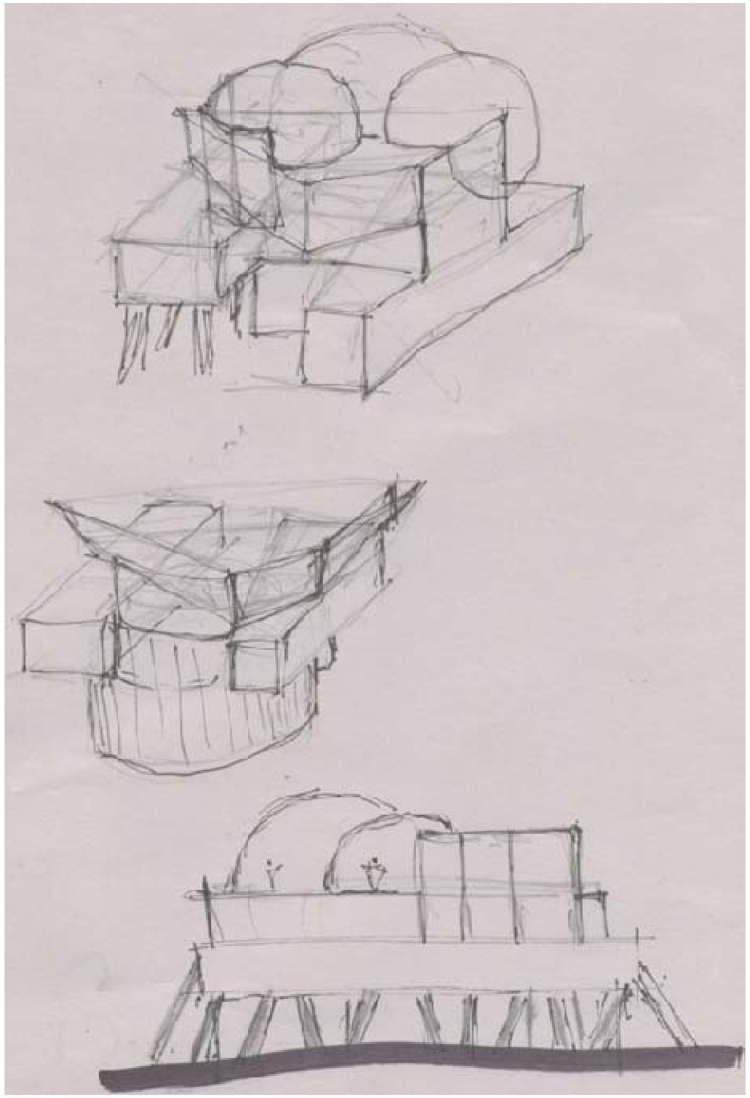


Figure 6-13: Design development (2)
(Source: Own Image)

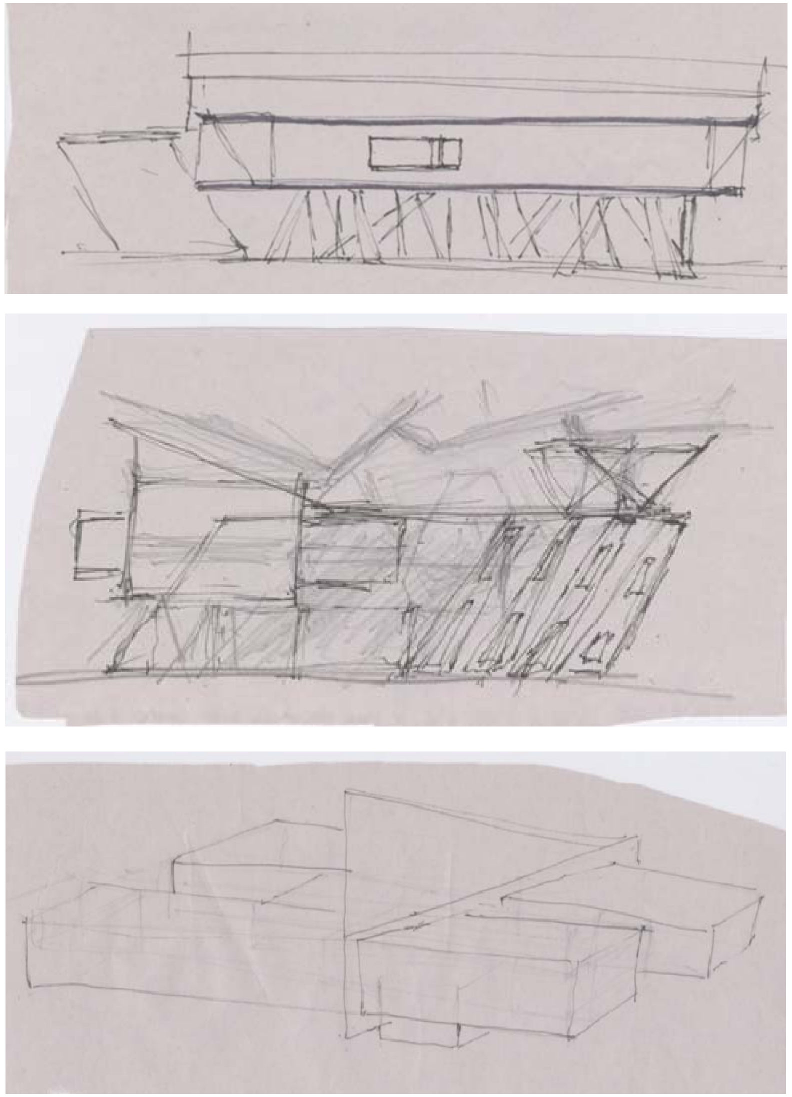


Figure 6-14: Design development (3)
(Source: Own Image)

As stated earlier the form vocabulary that was created was utilised to create form. Here are some of the 'words' that were used in deriving plan.

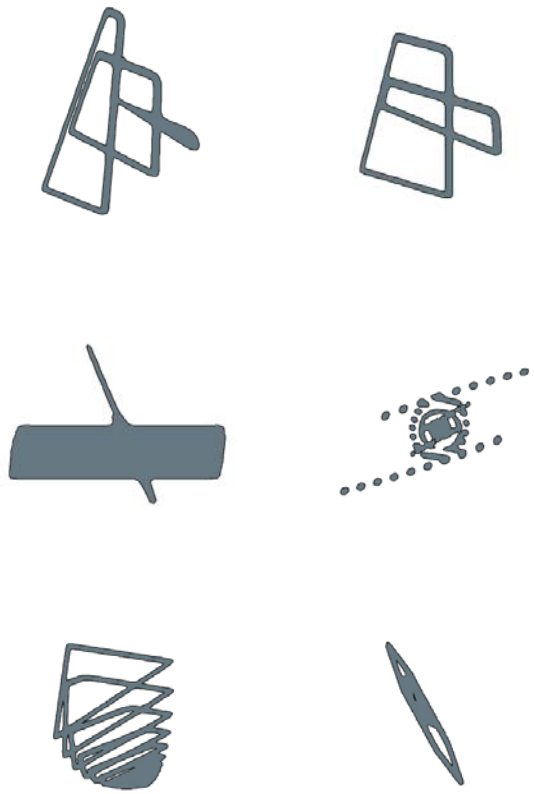


Figure 6-15: 'Words' utilized for plan generation
(Source: Own Image)

The 'words' were combined into sentences through sketching and 3D modeling into a ground, first and second floor. In certain instances the geometry was rotated or mirrored but the original aspect ratio was always maintained. It is important to note that the internal structure was maintained through the design procces. It would negate the original premise of this thesis if the internal geometry of the fractal was destroyed. In certain instances minor adjustments had to be made but always trying to remain true to the original concept

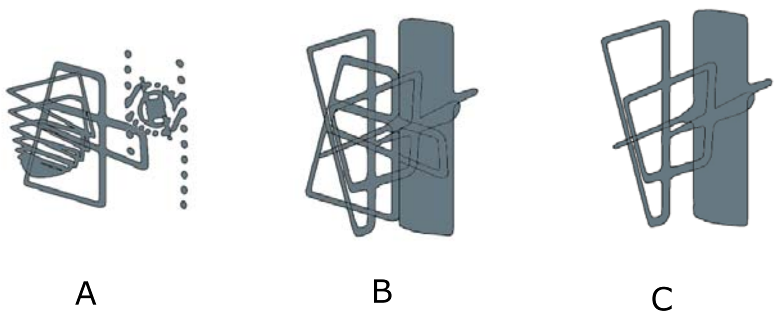


Figure 6-16: A Ground Floor
B First Floor
C Second Floor

(Source: Own Image)

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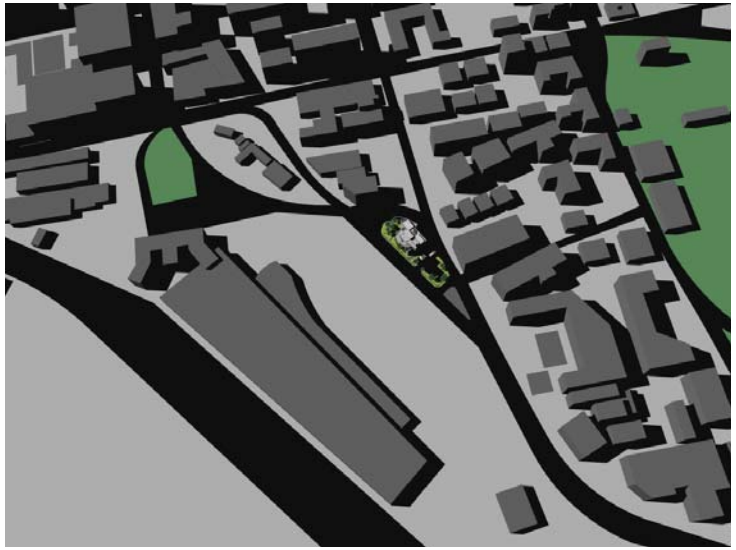


Figure 6-17: Greater Context
(Source: Own Image)

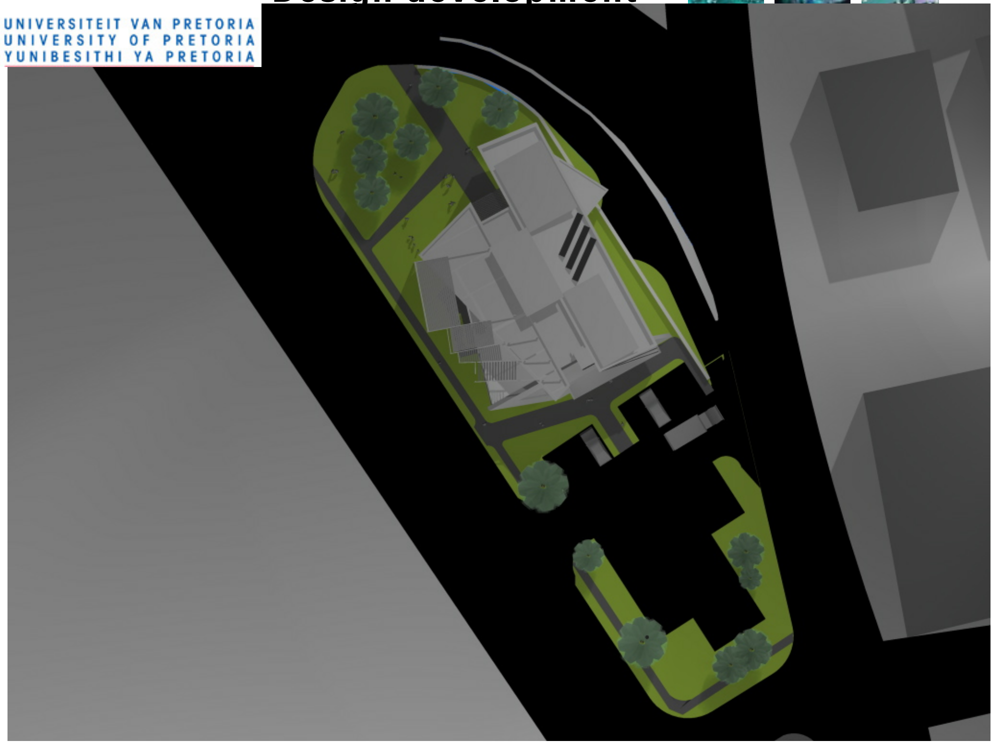


Figure 6-18: Site

Figure 6-19: North Eastern Perspective
(Source: Own Image)

Figure 6-20:View From Gautrain Station
(Source: Own Image)

Figure 6-21:North Western Perspective
(Source: Own Image)

Figure 6-22: Southern Perspective
(Source: Own Image)

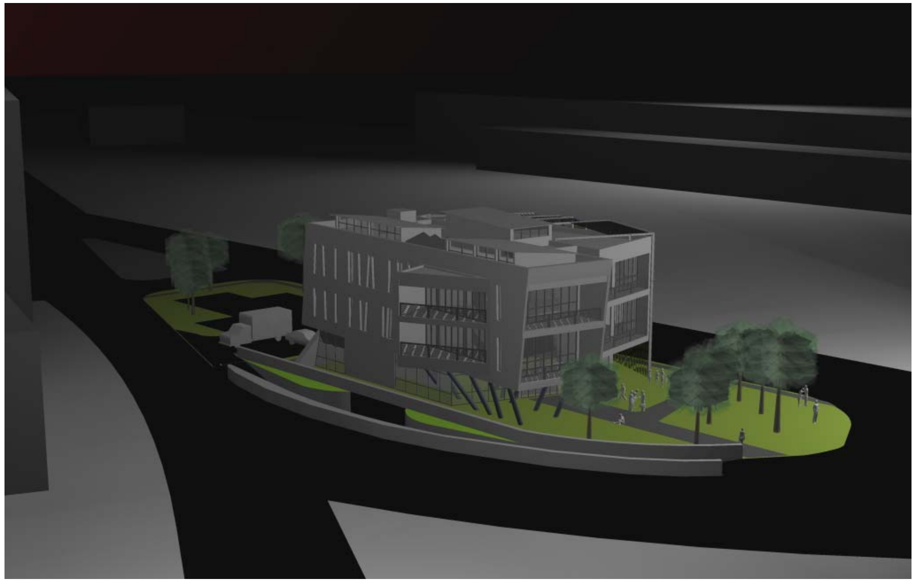
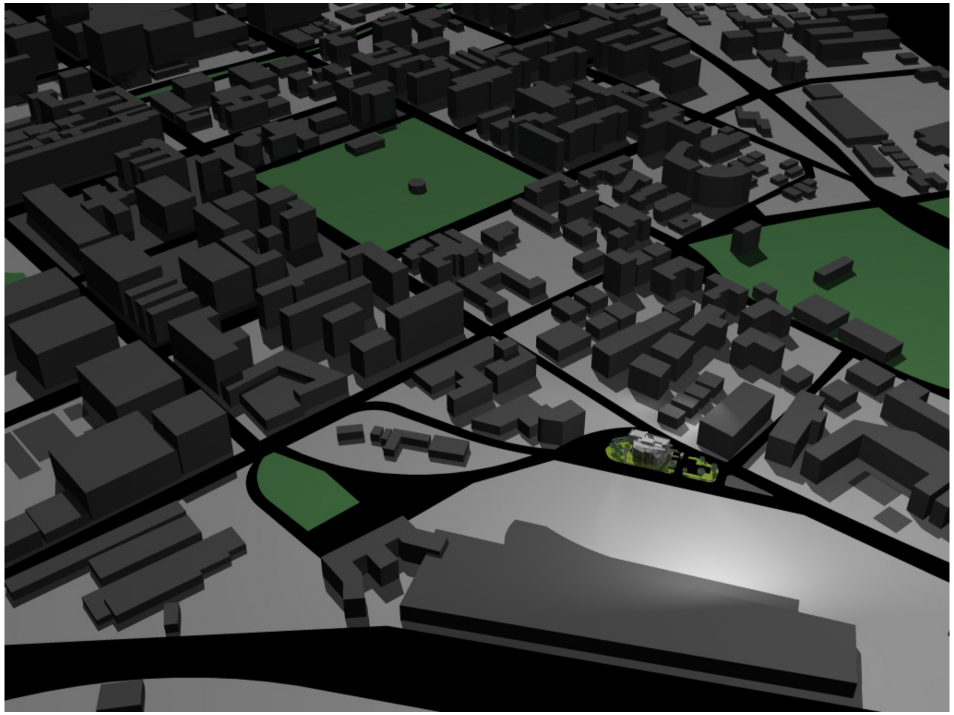


Figure 6-23: North Eastern perspective with Gautrain Station in the Background
(Source: Own Image)

Figure 6-24:View of the Context from South –



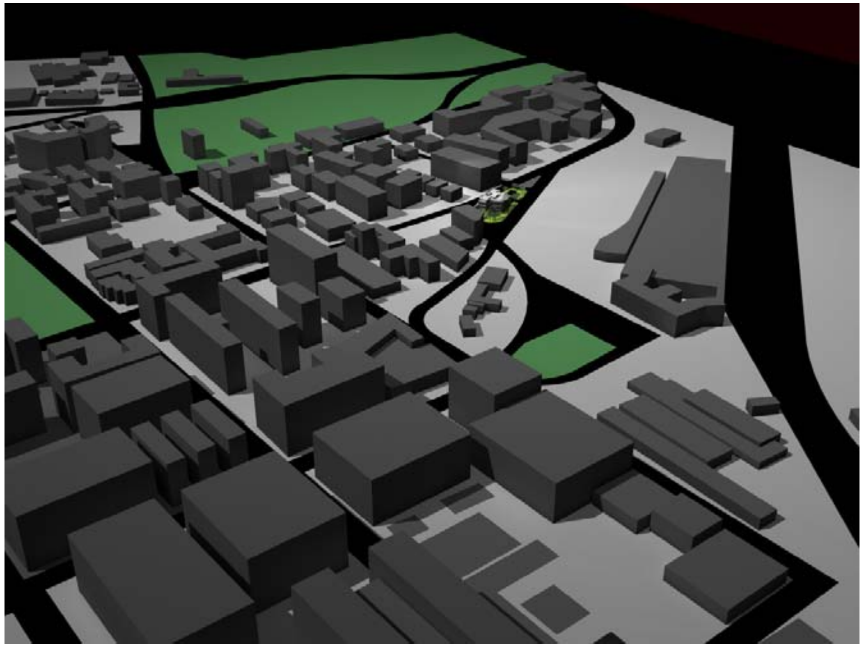


Figure 6-25:North Western Perspective
(Source: Own Image)

Figure 6-27: North Eastern perspective with Gautrain Station in the Background
(Source: Own Image)

Figure 6-26: South-Eastern Perspective
(Source: Own Image)

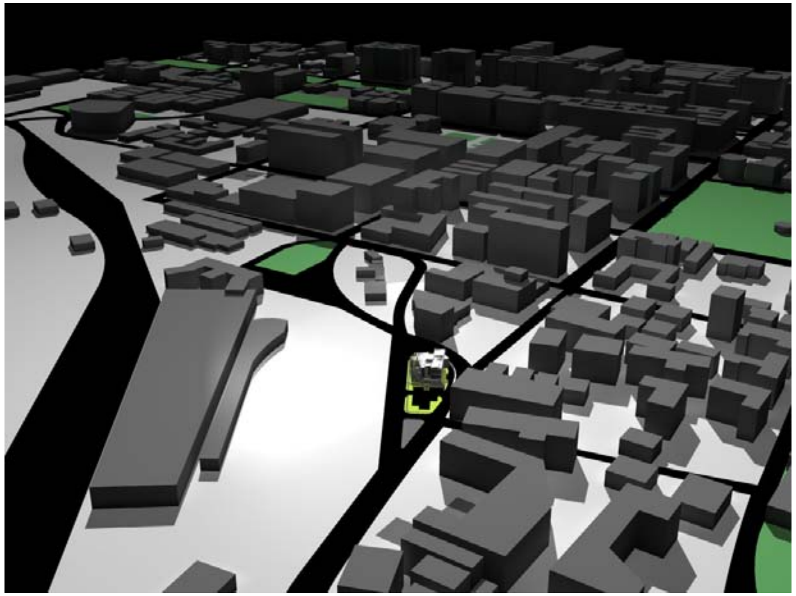


Figure 6-28: Eastern Perspective *(Source: Own Image)*

Figure 6-29: Public Space on Northern Side
(Source: Own Image)

6.5 Conclusion

Through the process as described above, a large amount of subjectivity relating to form was removed. The design was developed in conjunction with the area in which it manifests, through the transformation of quantifiable entities into form. The programme and the process have become a *unified whole* in that mathematical concepts were utilised to design a building to house people involved with mathematics.

7.1 Introduction

One of the primary functions from a technical point of view is that the design should function as a hybridisation of systems rather than trying to be completely self sustaining.

The reasons for this approach are elaborated upon in the closing of this section. It will suffice to say that it was the author's intent to recognise existing infrastructure, while simultaneously trying to alleviate the dependency on these systems.

7.2 Water storage

The approach to water storage on site attempts to alleviate the dependency on a Municipal connection rather than trying to be totally self-dependent. As such, all the water closets make use of stored rainwater in the months that water is available. This water can also be utilised for irrigation purposes.

The water from the entire roof structure is transferred to the western side of the building where the 'external' service core is situated.

All the ablution facilities have been allocated to this side of the structure to ease the utilisation of rain water.

It is envisaged that water storage tanks on an elevated platform will be hidden from view with expanded metal mesh. They will be elevated to such a height that no pumping is needed to fill the water closet cisterns as they continuously empty. On both the first and second floor the size of the water tank is 5 500ℓ and on the ground floor two storage tanks with a capacity of 5 500ℓ each are situated. There is also a 5 500ℓ tank in the basement for HVAC purposes (which will be discussed in the following section). The total water retention capacity for the building is thus 27 500ℓ.

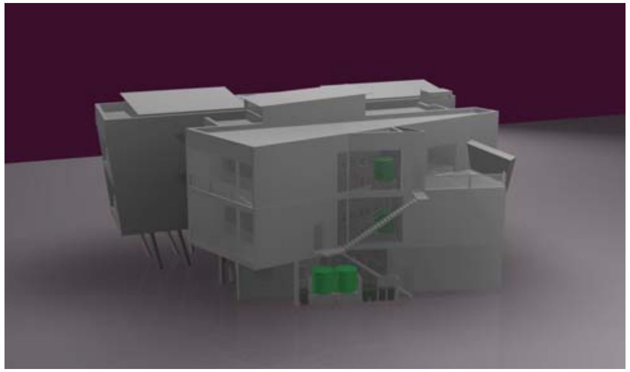


Figure 7-1: Water Storage Tanks
(Source: Own Image)

Table 7-1: Rain water harvest calculations

Month	Precipitation (mm)	Area (m^2)	Total acquired (ℓ)	Left from previous month	Used in toilets per month	Used on irrigation per month	Used for HVAC system	Surplus or deficit	Amount lost as runoff
January	136	77 071.20	77 071	27 500	26 700	9 000	924	27 500	40 447
February	75	42 502.50	42 503	27 500	26 700	9 000	924	27 500	5 879
March	82	46 469.40	46 469	27 500	26 700	9 000	924	27 500	9 845
April	51	28 901.70	28 902	27 500	26 700	12 000	924	16 778	0
May	13	7 367.10	7 367	16 778	26 700	0	924	-3 479	0
June	7	3 966.90	3 967	0	26 700	0	924	-23 657	0
July	3	1 700.10	1 700	0	26 700	0	924	-25 924	0
August	6	3 400.20	3 400	0	26 700	0	924	-24 224	0
September	22	12 467.40	12 467	0	26 700	12 000	924	-27 157	0
October	71	40 235.70	40 236	0	26 700	9 000	924	3 612	0
November	98	55 536.60	55 537	3 612	26 700	9 000	924	22 524	0
December	110	62 337.00	62 337	22 524	26 700	9 000	924	27 500	20 737
Total	674	NA	NA	NA	320 400	78 000	11 088	N/A	76 908

Table 7-1 presents a calculation of the amount of water that can be retained and shows the months in which no potable water will be wasted through water closets, irrigation or HVAC usage.

It is shown that for at least seven months of the year the building will be self sufficient regarding the usage of water in the water closets, irrigation and HVAC.

7.2.1 Assumptions regarding the calculations

The calculation of the amount of water required as a result of water closets assumed that at maximum occupation, each occupant uses the toilet at least once while in the building. Calculated according to SANS 0400 it resulted in a maximum occupation of 264 persons, as shown in Table 7-2. The dual flush cisterns flush at either 3ℓ or 6ℓ giving an average of 4.5ℓ per flush.

It was also assumed that the fact that the SAMF will only occasionally utilise the building over weekends and therefore the total weekly usage will be between 70-75%. Thus

$$264 \times 4.5L \times 0.75 = 891L$$

This over a month (30 days) works out to approximately 27 600ℓ.

The irrigation calculation assumed that each square metre would require 1ℓ of water per day. It was also assumed that in the rainy season the irrigation requirements would be half this number as the soil would receive natural precipitation. If there is ±600m² of landscaped area the calculation becomes.

$$600m^2 \times 30days \times 0.5L = 9000L$$

The monthly requirement is thus 9 000ℓ except for the dryer months where the natural precipitation is under 70mm, where 12 000ℓ was utilised. It was decided not to irrigate the landscape over the height of winter, May June and July, as water is scarce and it would contradict the environmentally sensitive approach of the building.

The HVAC water requirements are discussed later under mechanical ventilation. For the purposes of this table it 88ℓ per day was used.

The HVAC system will rarely be used for the auditorium over weekends and occasionally in the week therefore an average of 21 working days is considered a liberal estimate of usage. It is also important to note that for the purposes of this calculation the assumption was made that 50% of the water will be recycled in the HVAC unit which would decrease the usage further.

$$88L \times 21days \times 0.5 = 924L$$

The HVAC requirements are thus 924ℓ per month. It is interesting to note is that with the installation of a further two 5 500ℓ tanks at a later stage, the deficit can be negated and the building can become completely self sufficient regarding water closet usage irrigation and HVAC requirements.

It is foreseen that this could be done in one of the basement levels with solar powered submersible pumps to move the water higher as the need arises.

Although 50ℓ geysers are provided on each level they operate in conjunction with a solar water heater on the Western Roof. The intent is to have them activate only if the temperature is below 50° Celsius.

7.3 Ventilation

As stated above, one of the primary functions from a technical point of view is that the building should function as a hybridisation of systems rather than trying to be completely self-sustaining.

As such there is both a system of natural ventilation and an HVAC system employed in the design. The exterior shape of the building, although generated from the fractal geometry as discussed in Chapter 6, was still utilised in such a way that natural ventilation remained possible. The design deliberately tries to move away from utilising a HVAC system, however it was deemed necessary for the 73.6m² auditorium and the server room of 6.3m².

7.3.1 Mechanical HVAC system

The 90 seater auditorium is the only venue that cannot be serviced with natural ventilation as it is completely windowless. The Auditorium is situated directly one storey above the plant room, in Basement -1. This design decision was made to simplify the installation while creating enough distance from the air intake to reduce noise ingress. Calculations regarding the air flow requirements are as follows.

Figure 7-2: HVAC-System Ducting
(Source: Own Image)

According to the SABS 0400 the amount of air required per person in public hall of this nature is 3.5ℓ per second per person. For an auditorium of this size (90 persons) this translates to 90 x 3.5ℓ = 315ℓ per second per person, or then 0.315m^3/s.

In the following formula:

$$V = \frac{N.v}{3600}$$

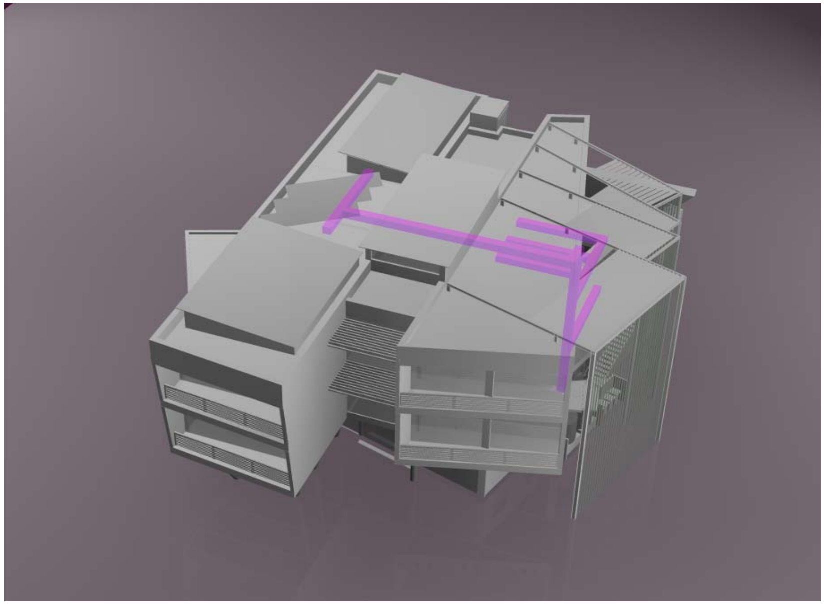


Figure 7-3: HVAC-System Ducting
(Source: Own Image)

Where V= Rate of airflow in m^3/s ($0.315m^3/s$)
N= Amount of air changes per hour
v= Volume of the room ($294.4m^3$)

$$0.315m^3 = \frac{N.(294.4\,m^3)}{3600}$$

N equates to 3.8 air changes per hour. An air change of between 1 and 10 is within limits.

The real question however is the sizing of the duct. As the auditorium will be used mostly for presentations that involve spoken word it is important to ensure that the air change is still acceptable but that the air speed in the duct is slow enough that it does not contribute significantly to noise level in the auditorium.

For this

$$V = (0{,}6).A.v$$

Where V = Required rate of air flow (0.6 is an efficiency factor due to friction in the duct)
A = Area of the duct (m²)
v = Required air speed

The air speed (v) can vary between 2m/s and 7m/s, but an increase in air-speed also increases the noise level due to friction. It is therefore decided that the air-speed should be 2m/s to ensure that fresh cool air quietly drops out of the ceiling duct without causing a disturbing hum. Consequently,

$$0.315m^3s^{-1} = (0{,}6).A.(2)$$

If A equals 0.2625 m² in the form of a square duct of L²=0.2625m², then L equals 510mm. This can be easily accommodated in the ceiling void of the auditorium.

A decision was taken to op for a Pulsed Power water treatment HVAC system to cool down the 80m² that is made up by the Auditorium on the second floor and the Patch and Server Room on the Third floor. This decision was taken as the Stored Rainwater could be utilised in the HVAC system and the Pulsed Power performs better pertaining to maintenance issues.

With this system in place it would require 1.1 litre per day per square metre if the system runs for 12hours per day for 5 days per week. For the total 80m² it would thus require 88ℓ of water per day. It is however foreseen that the auditorium will not be in constant use and therefore the usage will be much lower. It is also deemed unlikely that the HVAC system will be run for cooling purposes in the auditorium in the winter months. In all probability it will be run only to ventilate.

Another question that arises is the energy usage of the HVAC system. It is possible to calculate that to cool the 80m² of floor area would require a 5.27 kWh system. This translates to between a 1.55kW - 1.8kW unit. It is important to note that the efficiency of an HVAC system increases the longer it is left on.

For explanation purposes this means that the 1.550kW system will be running at full output for an actual 3.4 hours per 12 hours. Of course it is running at a lower output for a longer period.

The cooling capacity of this unit at its maximum power output of 1.8kW would translate into a 4.6°Celsius drop in temperature per hour. The following calculation serves as an explanation.

$$q = 1250.V.(T_0 - T_i)$$

Where q = Power output in Watt
1250 = Volumetric heat capacity of air
V = Rate of airflow (calculated earlier as $0.315m^3$)
T_0 = Outside temperature (in Kelvin)
T_i = Inside temperature (in Kelvin)

Thus

$$1800W = 1250.(0.315M^3).(T_0 - T_i)$$

$(T_0 - T_i)$= 4.6° Kelvin (or Celsius)

If the unit is run for one hour at 1800W, it means that it reduces the air temperature by 4.6°C per hour.

If one correlates this with the average daily maximum temperature in Pretoria (Table 5-1) and were to assume that the temperature inside the auditorium is equal to the outside temperature, it would take the cooling unit less than an hour to bring the temperature down to levels that are acceptable for human comfort even on a hot day (20°-24°C).

The hybrid intention mentioned earlier means that it is important to limit dependency on the Eskom grid but that it is still available as a source of energy. As stated earlier, a 5.27kWh unit will be sufficient. Most commercially available Photovoltaic units can deliver 170W/m². This means that with 12m² correctly placed Photovoltaic units over 2kW can be produced. With only 5 hours of sunshine (the average for Pretoria is 9 hours per day for 300 days of the year), 10kWh can be stored.

This can run the unit for almost 5 hours at maximum output capacity. The battery units that store this energy require ±0.5m²/kW (therefore 5m²) and will be housed in the LV room in Basement-1. The Photovoltaic Panels are installed North-Facing, on the Eastern wing as indicted on the roof plan, the intention is to be as inconspicuous as possible.

It is important to note that although the building has mechanical ventilation, *it is not* dependant on the municipal electricity supply for this. It is thus utilising existing HVAC technology where it is necessary without compromising sustainability.

7.3.2 Natural ventilation

It was decided to utilise natural ventilation in the rest of the building. This means that each floor functions on its own as a natural ventilation system, but they also connect together to form a system of natural ventilation to cool the building.It is therefore important to read Figure 7-4 to 7-9 as a whole and not as individual sketches. One aspect that enables the natural ventilation feasibility is generated from the 'air-scoop' or wing -wall that is situated on the eastern side of the building. The prevailing wind direction is thus utilised to generate enough air changes in the building's top two floors.

Wing walls are vertical solid panels placed alongside of windows attached to the wall on the windward side of the building (OSE, 2009). Casement windows offer better airflow and because awning type windows need to be fully opened or air will be directed to ceiling. It is also important to note that this 'scoop' feeds fresh air directly into the two venues that will have the highest occupation in the entire building besides the occasionally occupied, mechanically ventilated, Auditorium.

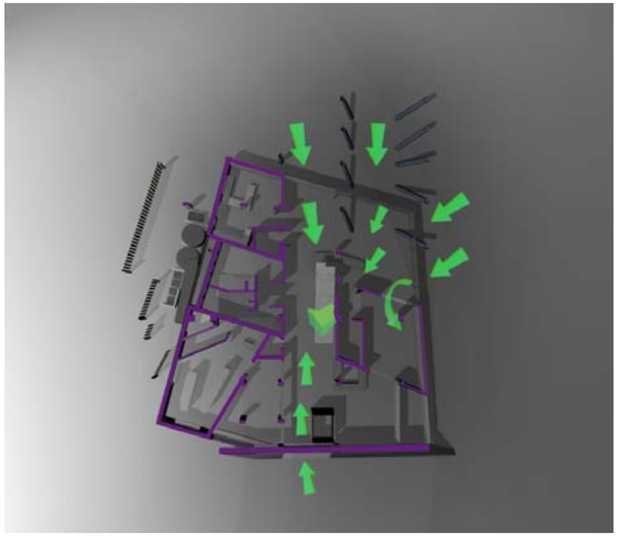


Figure 7-4: Airflow on the Ground Floor
(Source: Own Image)

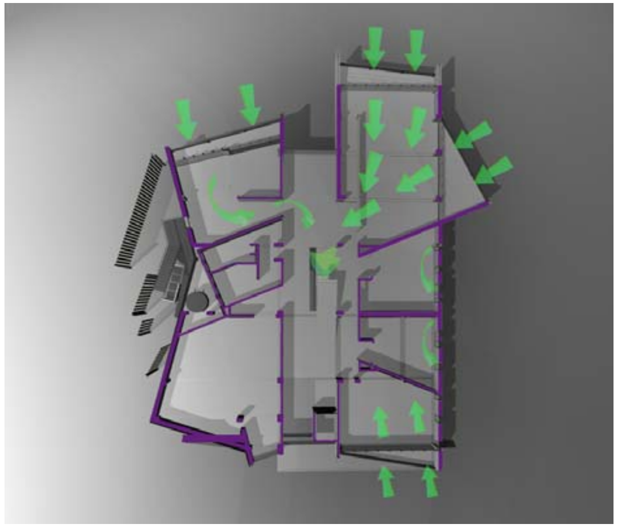


Figure 7-5: Airflow on the First Floor
(Source: Own Image)

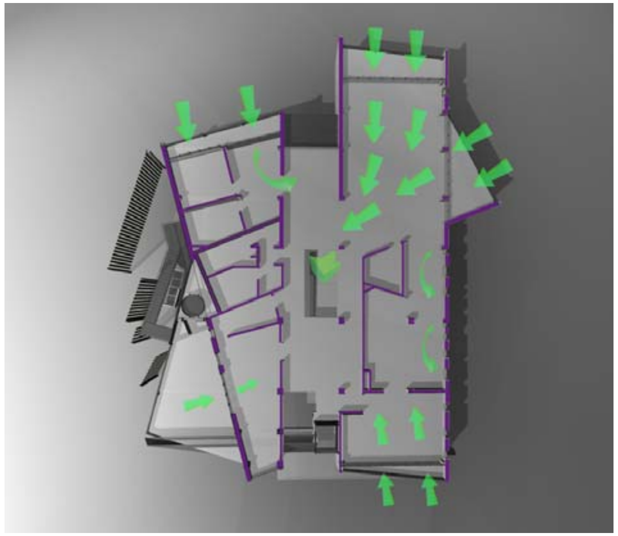


Figure 7-6: Airflow on the Second Floor
(Source: Own Image)

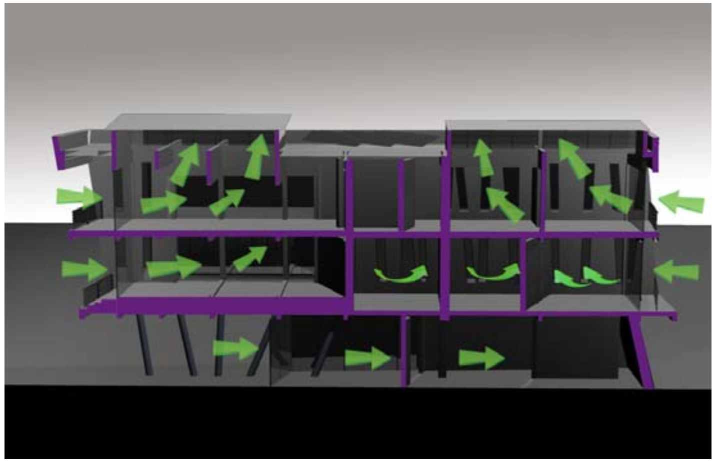


Figure 7-8: Airflow on the Western side through the clerestory windows
(Source: Own Image)

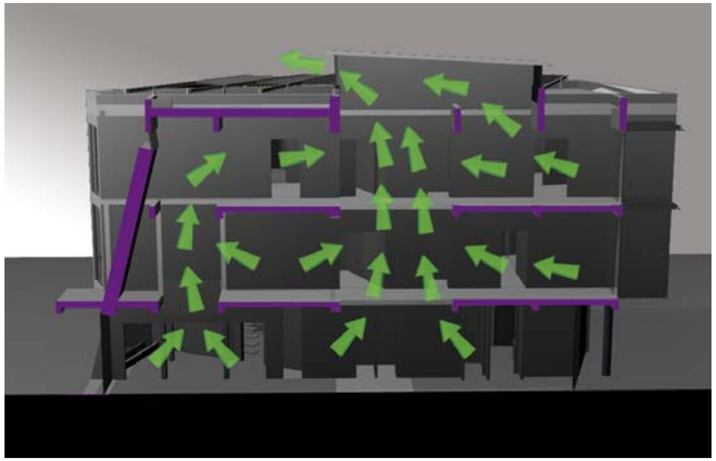


Figure 7-7: Airflow on Eastern Side between the three floors to the clerestory windows
(Source: Own Image)

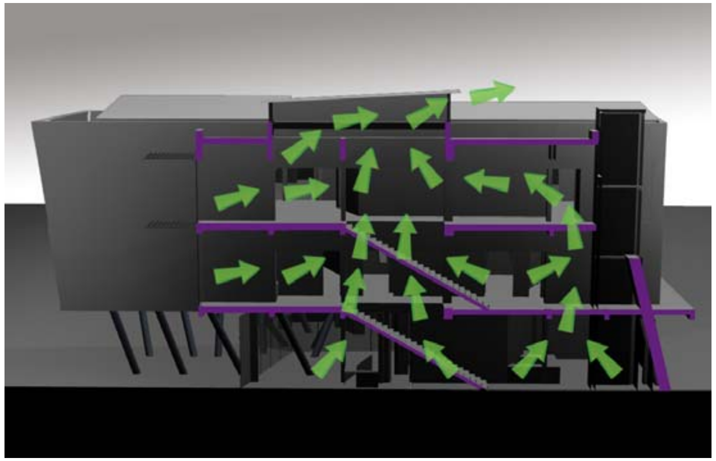


Figure 7-9: Airflow in the Central core between the three floors to the clerestory windows
(Source: Own Image)

The rest of the venues on the Eastern side are supplied with more than one window placed along the eastern wall. These are deeply recessed casement windows, as they create better airflow but need to be cognoscente of rainwater. They allow for natural ventilation that can be controlled individually in each venue. They form a cross ventilation into the central core by having openable windows next to the door. Although this compromises privacy and could create internal noise pollution, these aspects are deemed negligible in the light of the benefit of the natural cross ventilation. In the case where it is preferred to have only windows open on the Eastern façade the room one can have two widely spaced windows open instead of one window as this would increase airflow and is a natural way of controlling the amount of airflow (Level, 2009).

Single-sided, single-opening natural ventilation is effective to a depth of approximately two times the ceiling height. This implies a maximum room depth of approximately 8m, for a 4m ceiling height with a window approximately 1.8m high (Schultz, 2009).

The separate high and low openings that are used means that warm air leaves through the upper vent in the passage induces inflow through window on the Eastern side. In this situation, if the vertical separation between the openings is approximately 1.5m, ventilation is effective for 2.5 times the ceiling height although in some instances the depth could be up to 4 times as deep. This gives a maximum room depth of 12m to 16m for this scenario.

The spaces on the north-western side that require ventilation are the Exhibition space and the Private offices. These are supplied with high stacking doors that can be opened to varying openings as ventilation is required.

Although the climate of Pretoria could be considered quite temperate as winter and summer average temperature only differ by 10°C, an important aspect to incorporate into the design of a passive ventilation system is the differing design requirements between summer and winter seasons. Summer airflow requirements will be more than for winter, dictating varying openable areas in the building's skin between the extremes of these two seasons. In addition, there is an accelerated stack effect in the colder months due to the indoor and outdoor temperature differential.

Controlling passive ventilation can be manual, automatic, or a combination of the two. Based on the fact that not all the venues are occupied all the time and the design of the building that manual control would be sufficient.

A strategy to automate the clerestory windows located up high in the central core would work well while the other openings are controlled by hand. Clerestory window automation will be linked to interior temperature sensors and will thus optimise airflow. As commissioning is integral to the successful operation of any building, it is very important that natural ventilation adds to the relevance of commissioning. It is therefore highly recommended that the commissioning agent and Facilities Manager become part of the design process and the service contract be extended long past the initial occupancy to enable fine-tuning and calibration.

7.4 Shading

With regards to shading there are four important shading applications in the design.

On the Northern side care was taken to ensure that the overhangs exclude direct sunlight from spring to autumn only allowing direct sunlight with its associated heat gain in the winter months see figure 7-14 to 7-17. The respective solstice angles are 87° in summer and 40° in winter. Secondly on the northern windows that allow light into the central core shading has been provided with repurposed concrete palisade fencing. This shading is structured in such a way that the shading becomes progressively more in the summer and less in the winter (See figure 7-10 4 7-11)

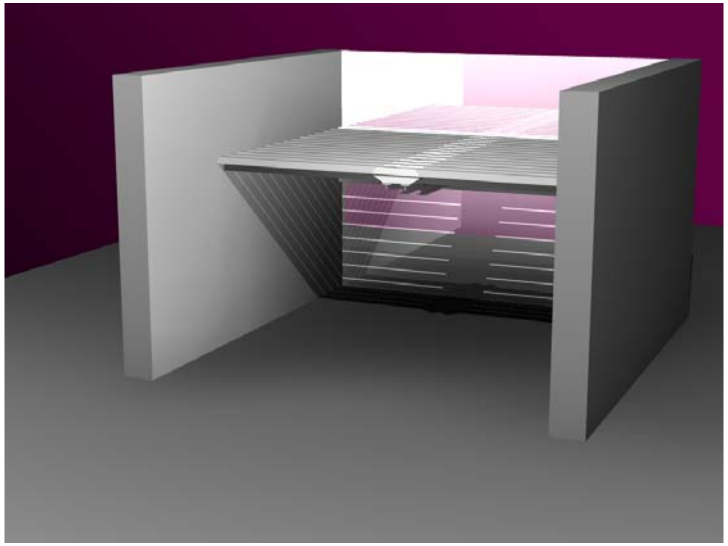


Figure 7-10: Repurposed Concrete palisades used as shading (winter) *(Source: Own Image)*

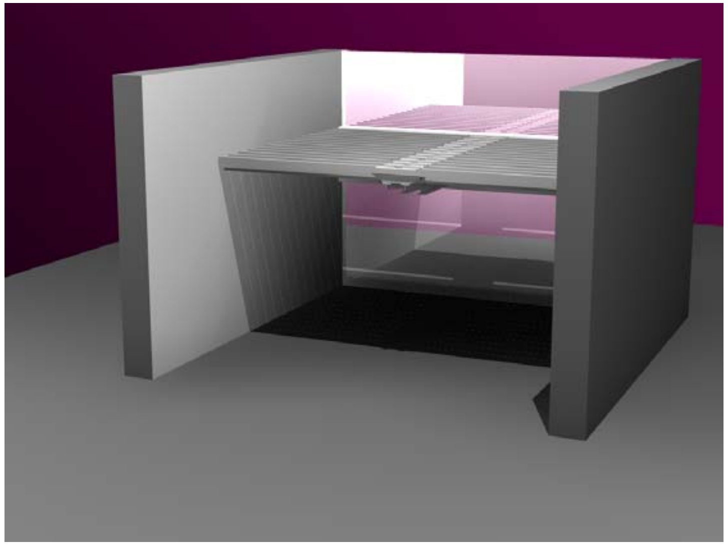


Figure 7-11: Repurposed Concrete palisades used as shading (summer) *(Source: Own Image)*

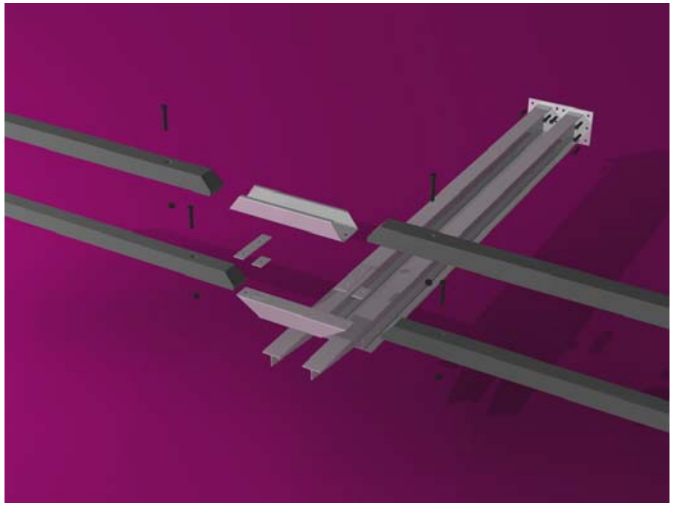


Figure 7-12: Detail of fixing of shading device
(Source: Own Image)

This was done by using the exact location of the design to calculate the spacing of the concrete palisade blocks in such away that they block out the sun in the height of summer while allowing direct sunlight in between them in winter.

Thirdly, it was deemed necessary to avoid solar heat gain on the western façade. As this façade faces directly toward the Gautrain station it was important that it is aesthetically pleasing, interesting but still effective shading.

Although there are no windows that receive direct sunlight on this façade it was still important to create effective shading. The form of the shading was developed from one of the fractals as discussed in Chapter 6.

It was decided to go for a dynamic shading device in the form of plant material and more specifically, *Rhoicissus tomentosa*.

Figure 7-13: Rhoicissus tomentosa
(Source: Sheat, 1984)

Figure 7-14: Winter noon solstice sunlight penetration on the Eastern Wing *(Source: Own Image)*

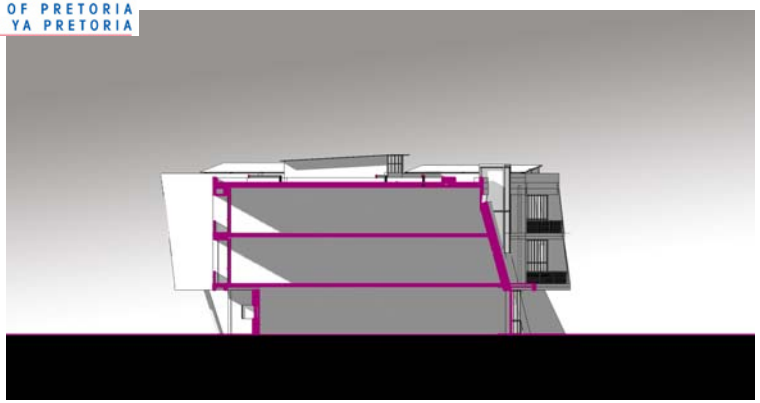


Figure 7-16: Winter noon solstice sunlight penetration on the Western Wing *(Source: Own Image)*

Figure 7-15: Summer noon solstice sunlight penetration on the Eastern Wing *(Source: Own Image)*

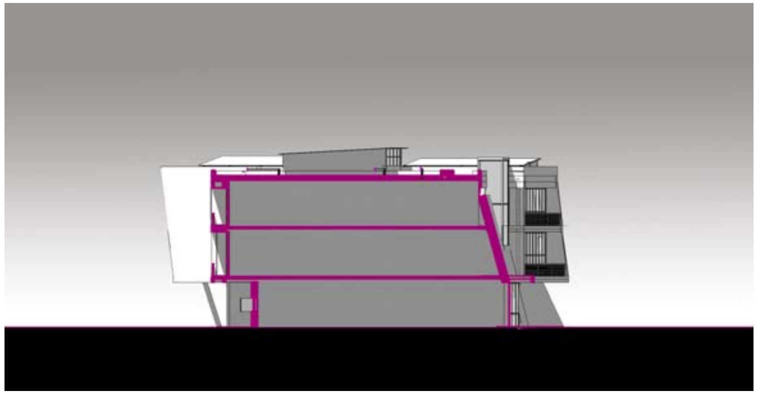


Figure 7-17: Summer noon solstice sunlight penetration on the Western Wing *(Source: Own Image)*

This Species is endemic to South Africa and can easily grow to more than 12m high with proper care (Sheat, 1984:186).

This plant with is large green leaves grows quickly and easily, and will create a green façade that is aesthetically pleasing and iconic while delivering the necessary shading to the western façade. All things considered, the shading devices work together with the passive ventilation and cavity walls to create a design that will function well thermally. It is the intent that the shading serves to enhance that passive cooling proposal and also lighten the load on the mechanical ventilation in the Auditorium.

Table 7-2: Parking and Sanitary requirements (accordi

Area Classification according to SANS	Area Specification	Required parking for that Area	Actual Area	Required Parking Spaces	Occupant Amount
A 1 Restaurant	Kitchen	2/100m	26.8	1.0	27.0
	Seating Area	10/100m	100.0	10.0	64.0
A 2 Theatre	Auditorium	1/4 Seats	71.0	23.0	90.0
A3 Places of tuition	Lecture Rooms 1	1 per 10 pupils+1 attendant	54.0	6.0	11.0
A3 Places of tuition	Lecture Room 2	1 per 10 pupils+1 attendant	54.0	6.0	11.0
A3 Places of tuition	Lecture Room 3	1 per 10 pupils+1 attendant	21.0	3.0	4.0
A3 Places of tuition	Lecture Room 4	1 per 10 pupils+1 attendant	41.0	5.0	8.0
A3 Places of tuition	Lecture Room 5	1 per 10 pupils+1 attendant	47.0	6.0	9.0
Total			**217.0**		**43.0**
C 1 Exhibtion Space	Exhibition Space	2/100 m	60.0	1.0	6.0
C2 Library		use same as lecture rooms	40.6	5.0	2.0
F2 Small Shop		1 6/ 100 m	44.5	3.0	4.0
G 1 Offices	3rd Level	4/100m	172.6	10.0	12.0
Total Parking Required				79.0	
Total Parking Provided				86.0	
Total Occupants					248
Total Sanitary appliances required					
Total Sanitary appliances required Ground					
Total Sanitary appliances required First					
Total Sanitary appliances required Second					
Total Required					
Provided					

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	Required Toilets	Required Urinals	Required Basins	Required Toilets	Required Basins
	0.0	0.0	0.0	0.0	0.0
	1.0	2.0	2.0	3.0	2.0
	1.0	1.0	1.0	2.0	1.0
	1.0	2.0	2.0	2.0	1.0
	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0
	1.0	1.0	1.0	2.0	1.0
	1.0	2.0	2.0	3.0	2.0
	2.0	3.0	3.0	4.0	2.0
	1.0	1.0	1.0	2.0	1.0
	4.0	**2.0**	**6.0**	**9.0**	**5.0**
	6.0	**6.0**	**6.0**	**9.0**	**6.0**

7.5 Parking and Sanitary Fitting calculations

In Table 7-2, the number of parking bays and sanitary appliances that are required are calculated. In each case, the room type and its occupancy classification is shown with the relevant calculations that are strictly based upon the SANS 0400. In the instances where it is shown that a specific occupancy class has 0 requirements for sanitary appliances it is because it has been combined with another occupancy class on the same floor by adding the amount of occupants.

This can only be done in instances where the occupancy requirement is measured against the same table in the SANS 0400. In the case of the Restaurant, occupancy class A1, the staff and visitors are measured against two different tables and thus the more liberal of the two was applied to make sure that they comply.

It can be seen that the design complies in all instances with the amount of parking bays required and sanitary fittings.

7.6 SBAT Rating

As part of the Technical investigation an analysis was done to determine a rating of the sustainability of the building. The system that was utilised for this purpose is the SBAT (Sustainable Building Assessment Tool) developed by Jeremy Gibberd from the CSIR.

The tool's purpose is to provide an assessment tool that was developed within the context of a developing country for developing countries. The assessment criteria is therefore strongly related to the circumstances in South Africa.

It contains sets of objectives, divided into Economic, Environmental and Social that are measured against the extent to which these objectives are reached. This provides an easy to understand but effective measure of the level sustainability. Below are the different categories and their sub-sets that are evaluated in the SBAT tool:

Economic:

- Local Economy Input
- Efficiency of Usage
- Adaptability & Flexibility
- Ongoing Costs
- Capital Outlay Costs

Environmental:

- Water Usage
- Energy Usage
- Waste Management
- Site Management
- Materials & Components

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Social:

- Occupant Comfort
- Inclusive Environments
- Access to Facilities
- Participation & Control
- Education
- Health & Safety

To the right is the Pie Chart Summary generated by the SBAT tool for this design and the final scores attained. The rating is interpreted in the following manner.

Between 0 and 1	Very Poor
Between 1 and 2	Poor
Between 2 and 3	Average
Between 3 and 4	Good
Between 4 and 5	Excellent

Although the design scores average in three categories namely: Waste, Site and Materials and Components, it does perform excellent in the Energy management sub-set of the same category.

The main reasons why the building has scored so low in the three sub-sets mentioned is due to the lack of organic and sewerage waste handling on the site, the large landscaped lawn on the north that requires maintenance,

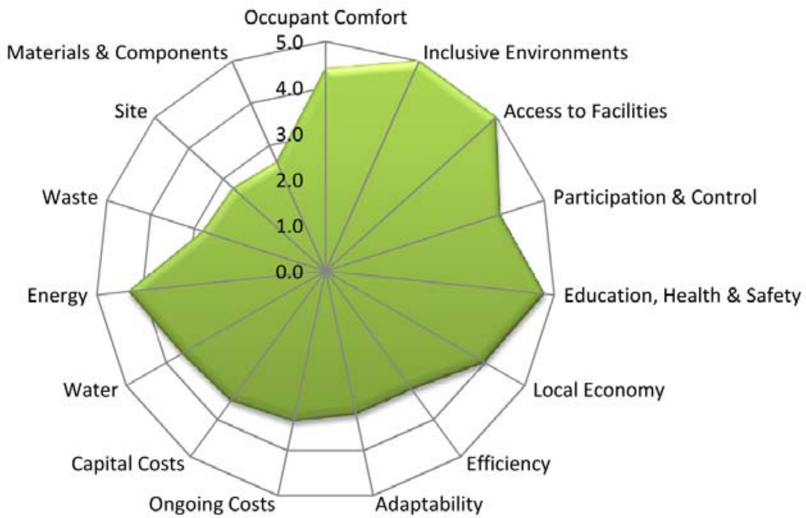


Figure 7-18: SBAT Rating *(Source: SBAT Spreadsheet)*
Final Scores: Social 4.6, Economic 3.5 and Environmental 3.2

and the fact the very little of the building material is repurposed or form organic sources. The fact that it is a loose standing very urban site has contributed to these low scores and the positive impact it will make to the area as a whole could be said to negate these average scores.

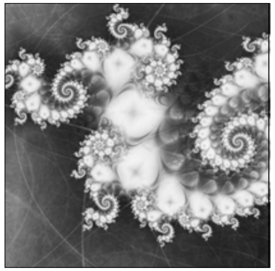
Notwithstanding these lower scores the design scores a *Good* (average of 3.8). An important fact is that the assessment reflects the intended positive social impact as outlined in Section 3.1. The design scores 4.6 out of 5 in this category.

7.7 Conclusion

The author is of the opinion that part of the design being defined as a snapshot of the contemporary condition is the way that passive and active technologies are applied in the building. It is therefore important to note that we find ourselves as humans at a very interesting point in our history where we know that the way we build needs to change but we have become very dependant on the ways of the past.

This design seeks to recognise this fact and combine passive systems that are seen as environmentally friendly with stereotypical existing technology as a way to move forward. Hopefully in the future we can move to new and innovative construction methods that will allow us carbon neutral construction.

What the author thus proposes is that we realise that we are in a process of transition and embrace that, by combining 'green' and 'non-green' design approaches while working towards more energy-efficient design solutions.



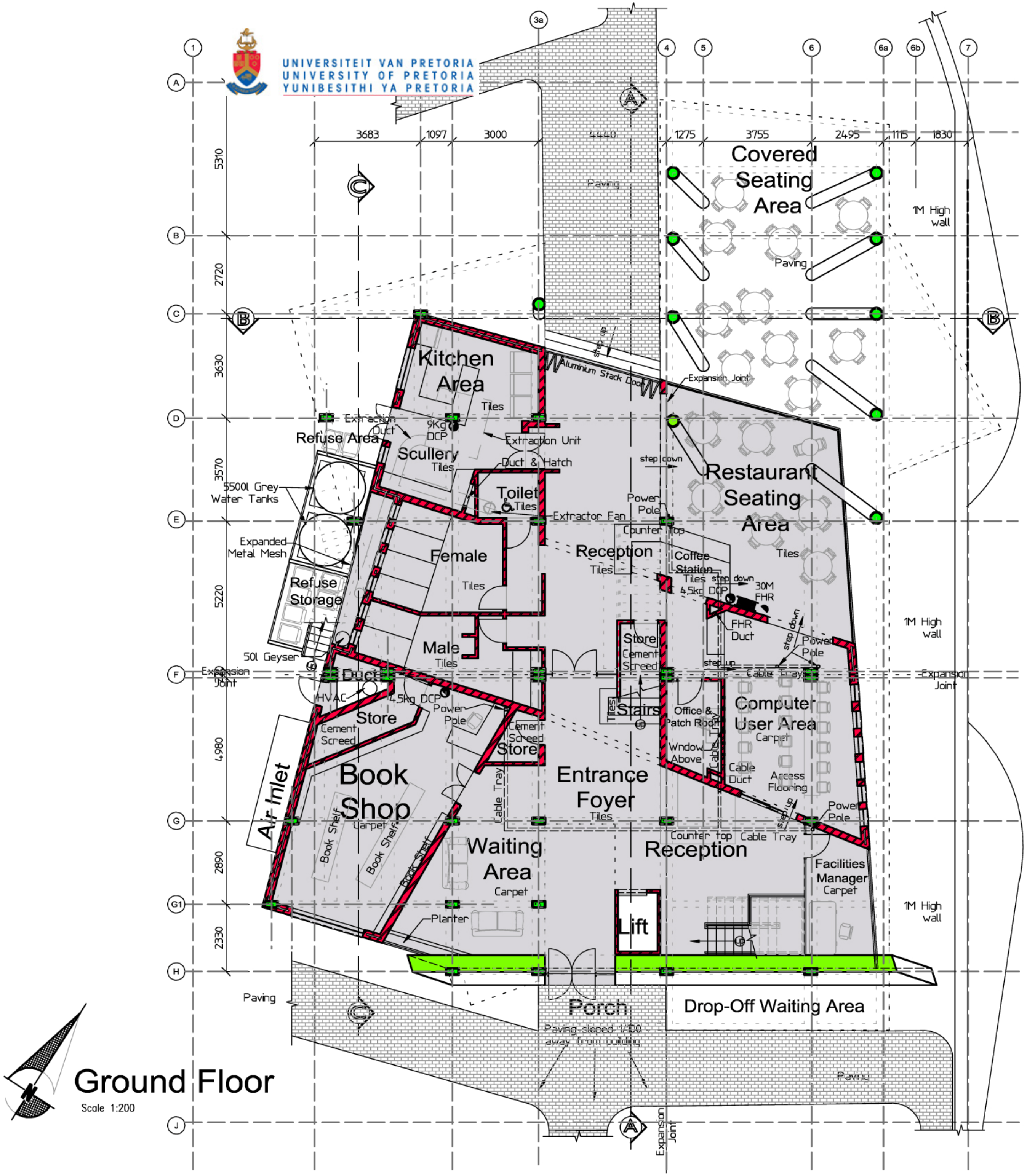
8.1 Introduction

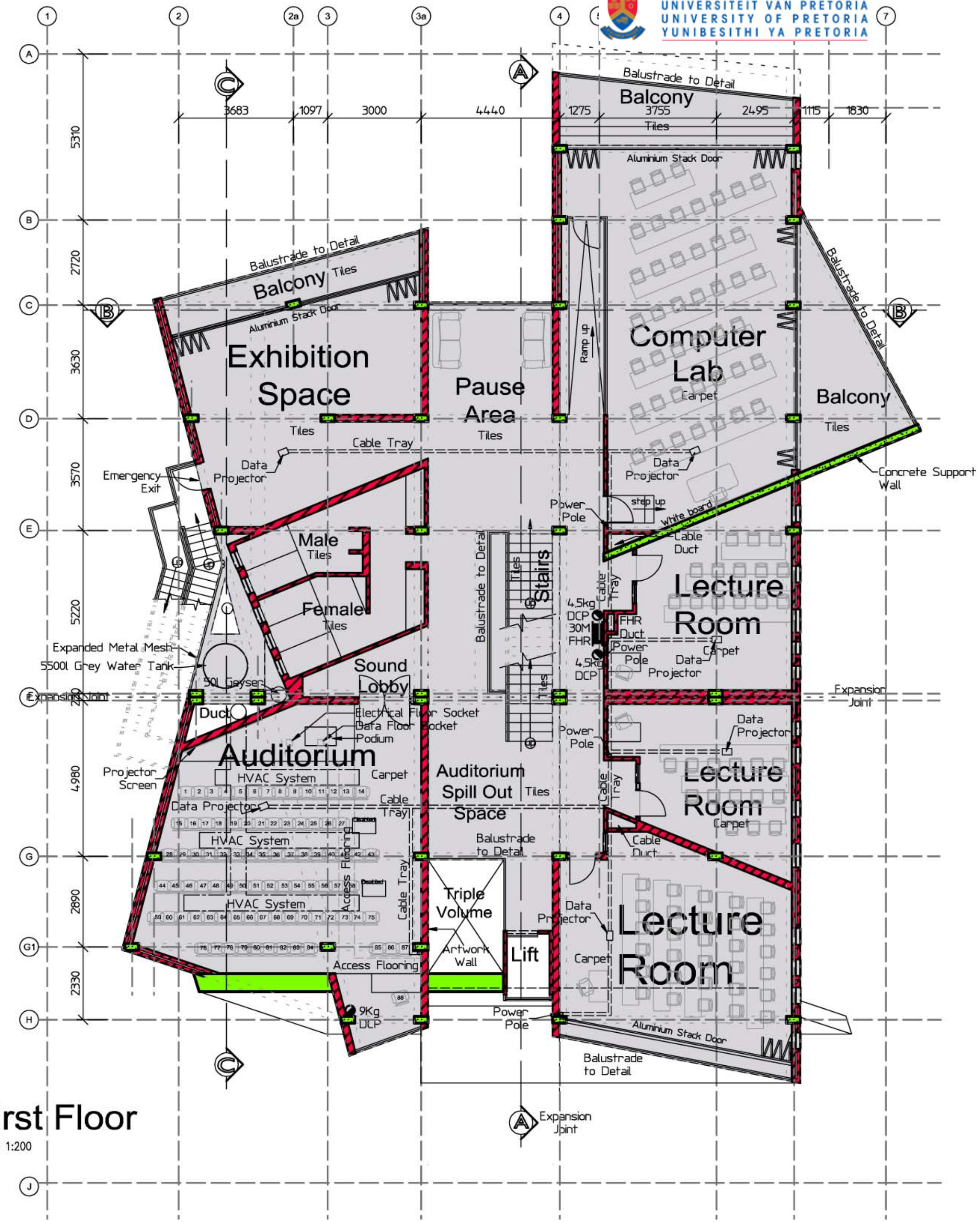
This chapter contains a simplified version of the technical documentation. The simplification is to enable legibility and scale.

It is believed that the technical documentation should be read in conjunction with the other chapters, especially Chapter 2 and Chapter 7.

The intent of the documentation is to show intent rather than complete working drawings.

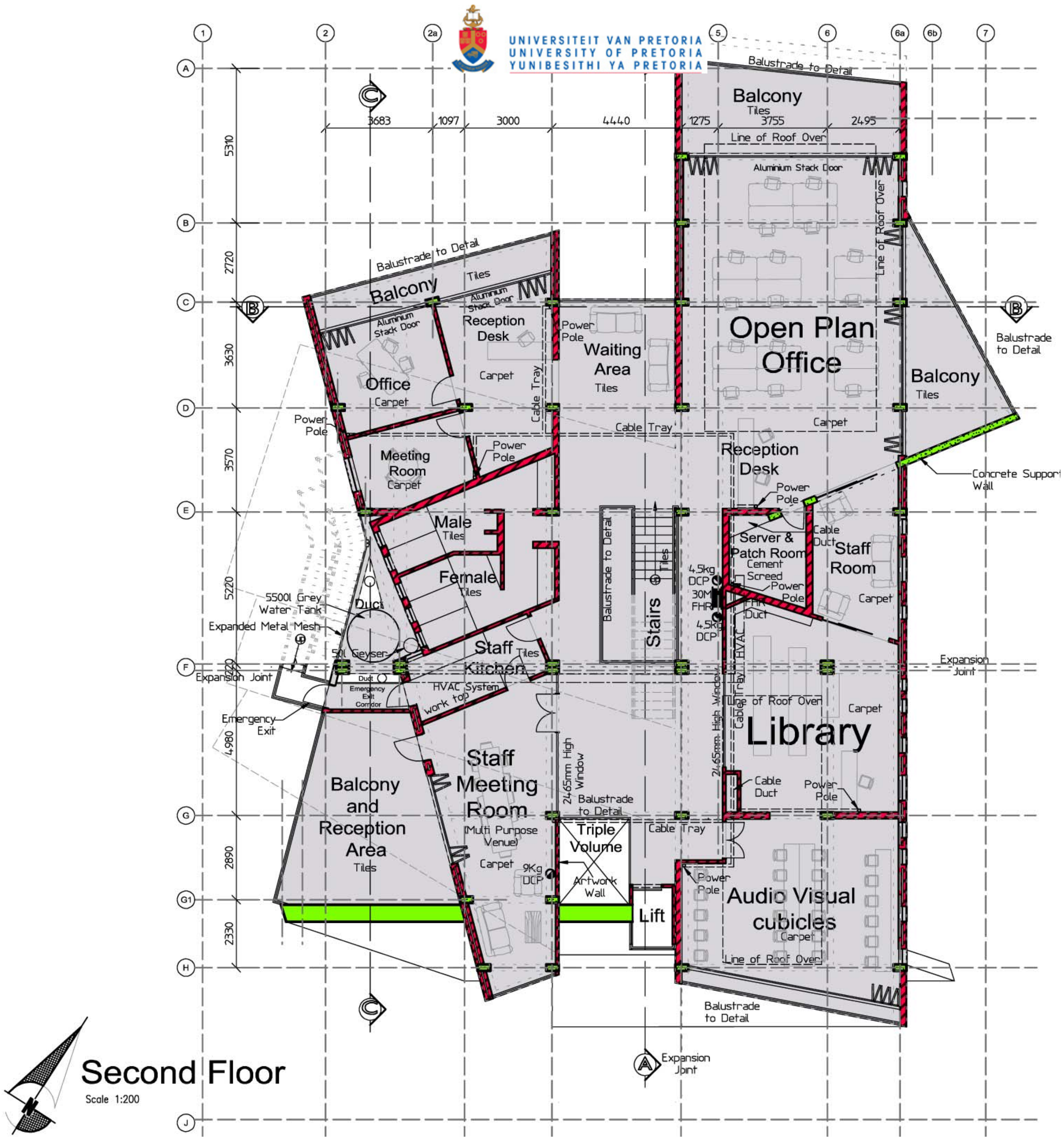
8.2 Documentation





First Floor

Scale 1:200



Second Floor

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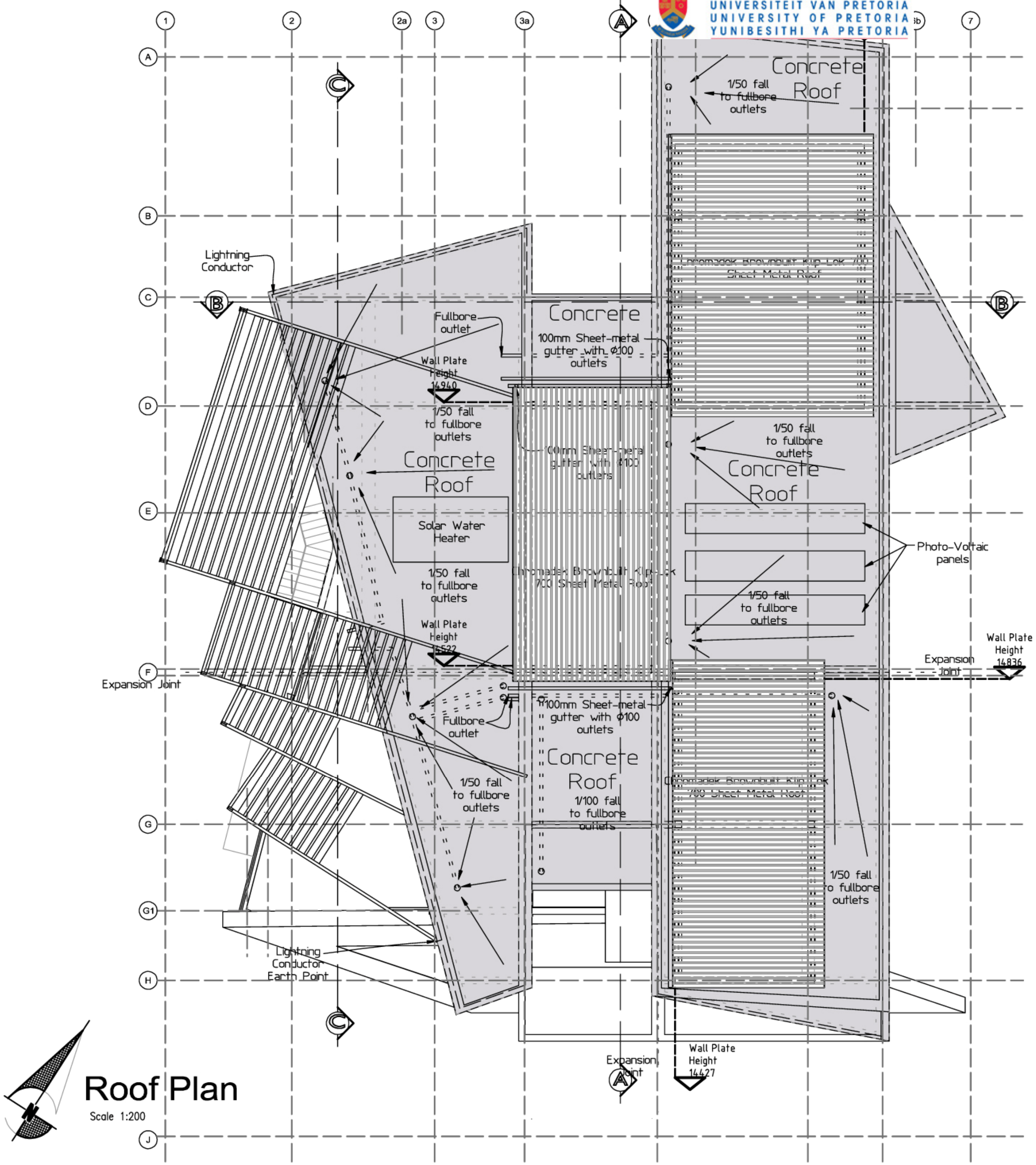
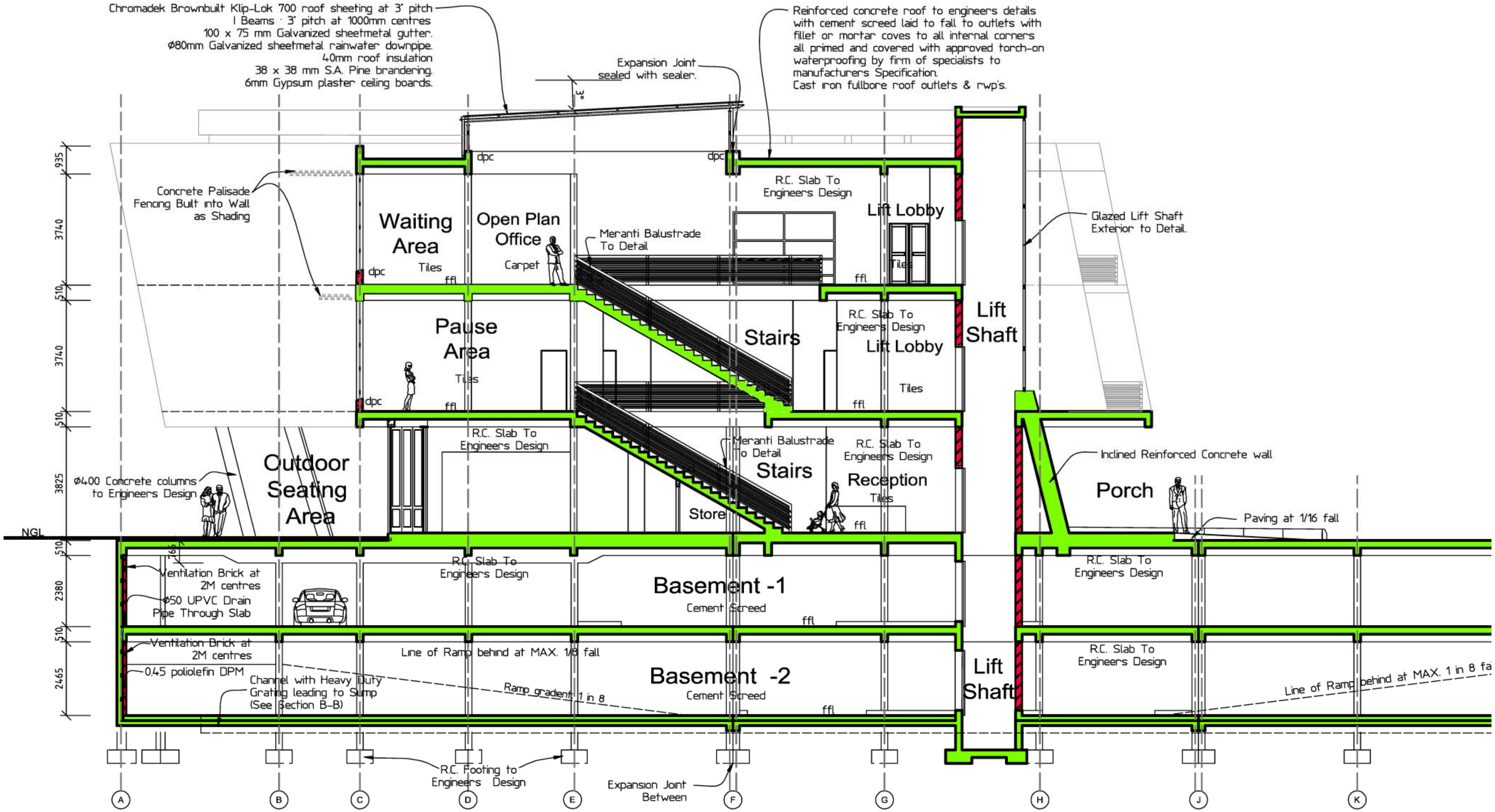


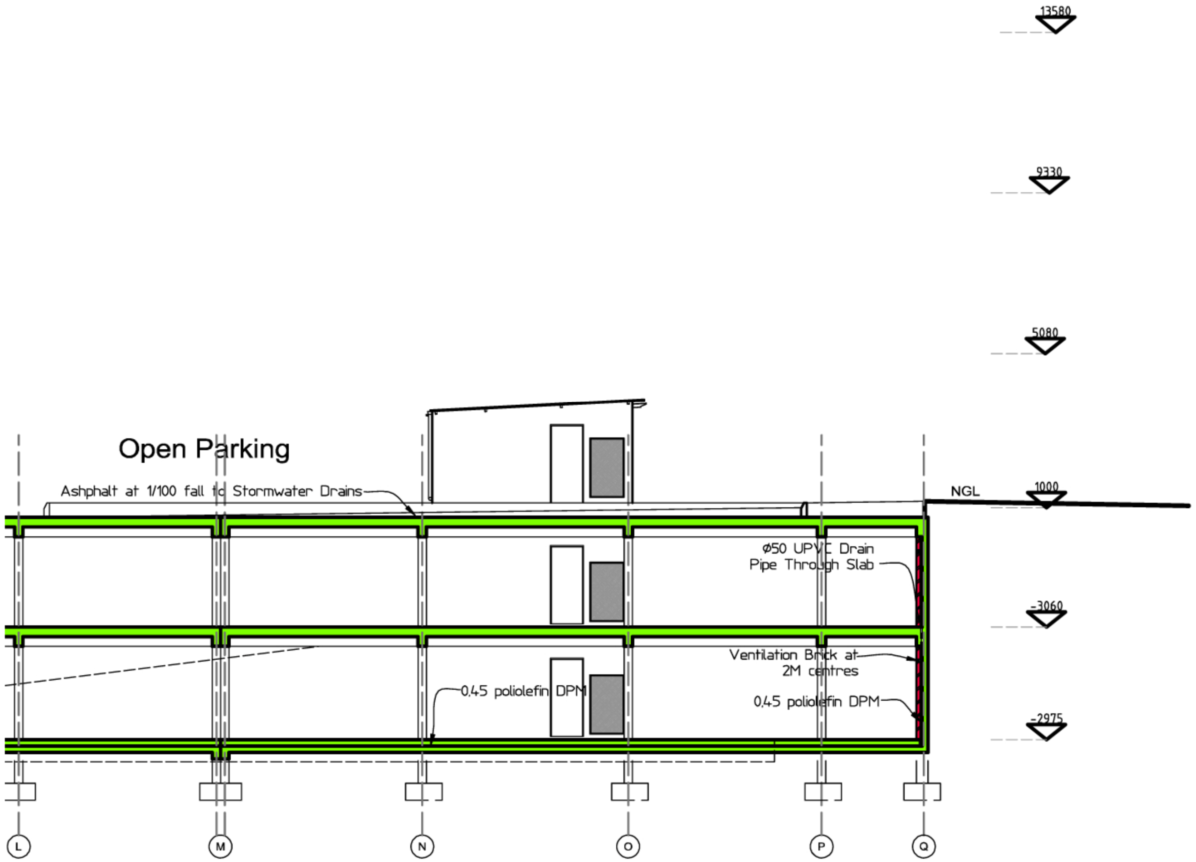
Roof Plan

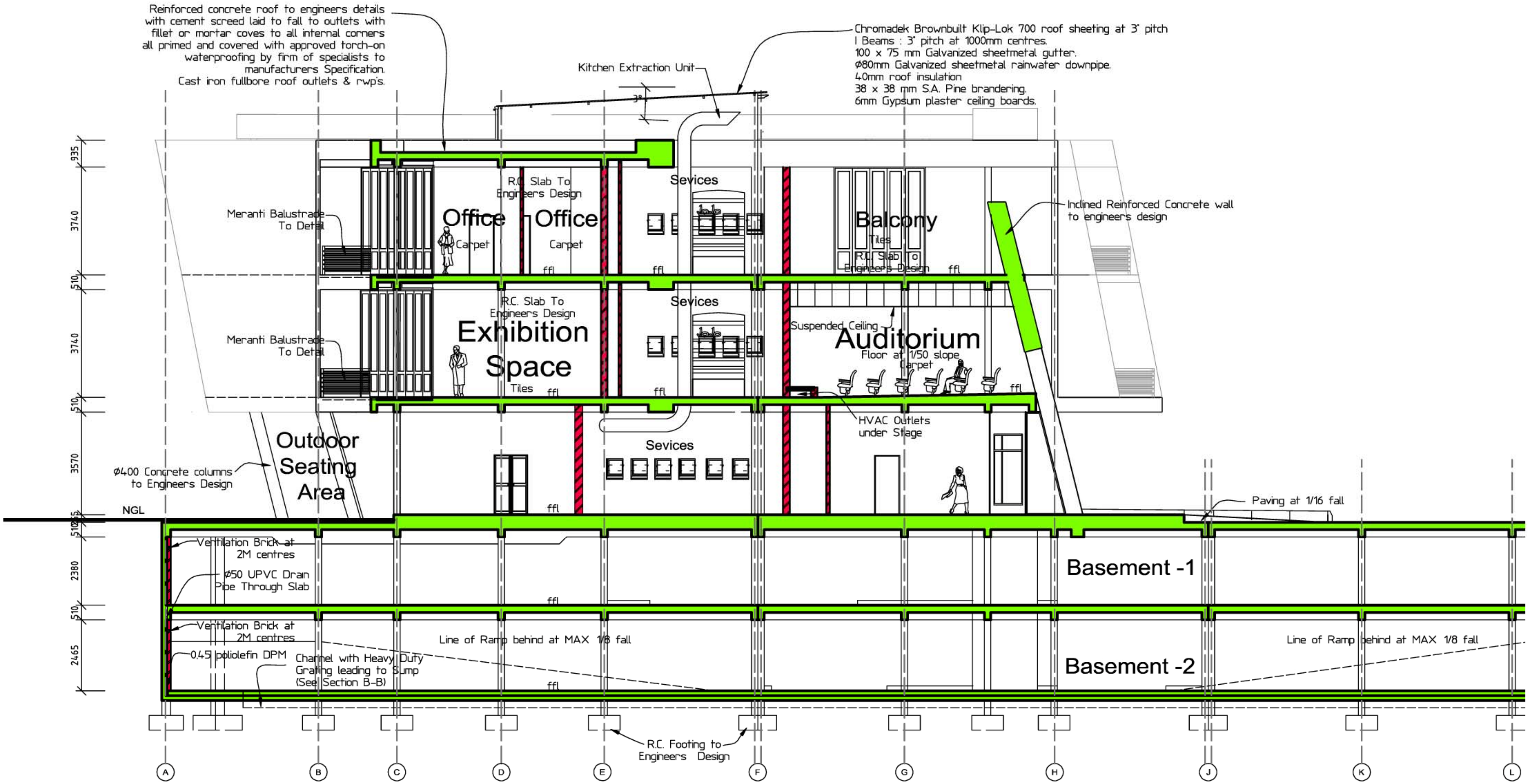
Scale 1:200



Section A-A

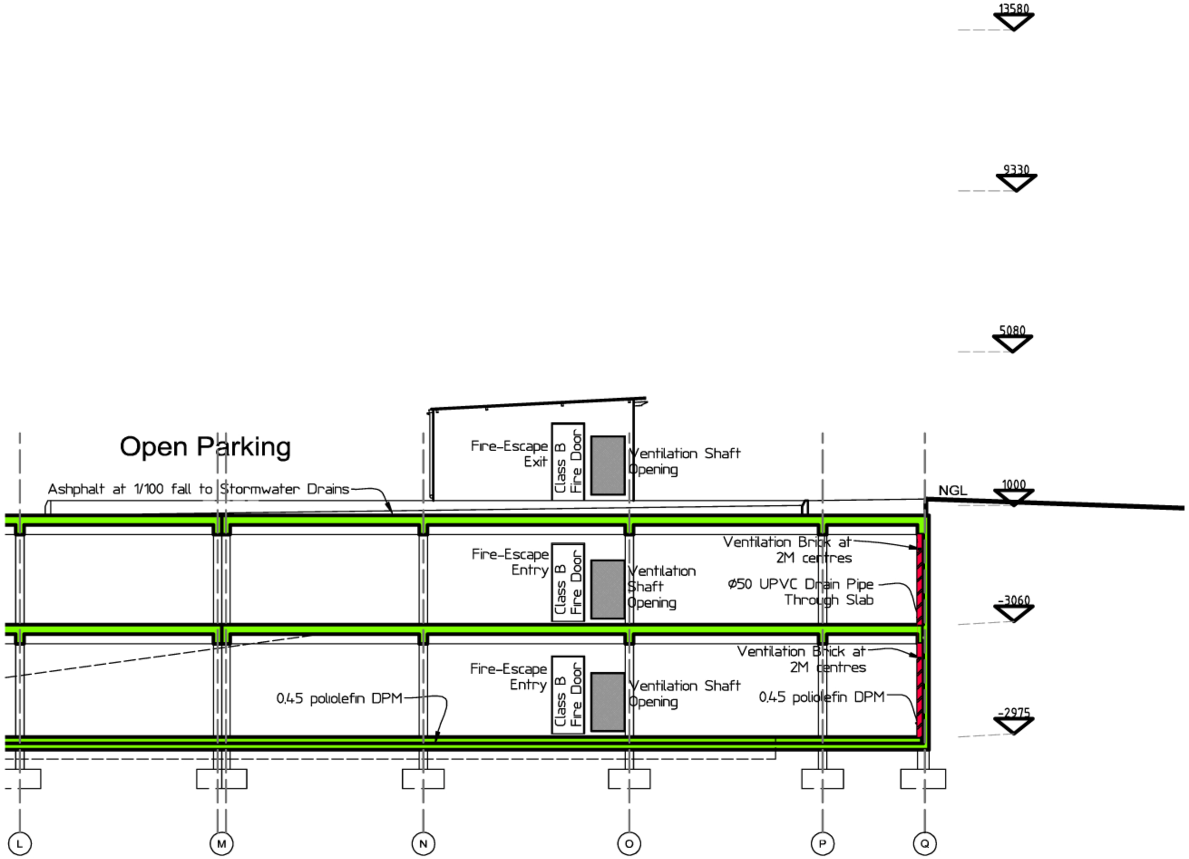
Scale 1:200

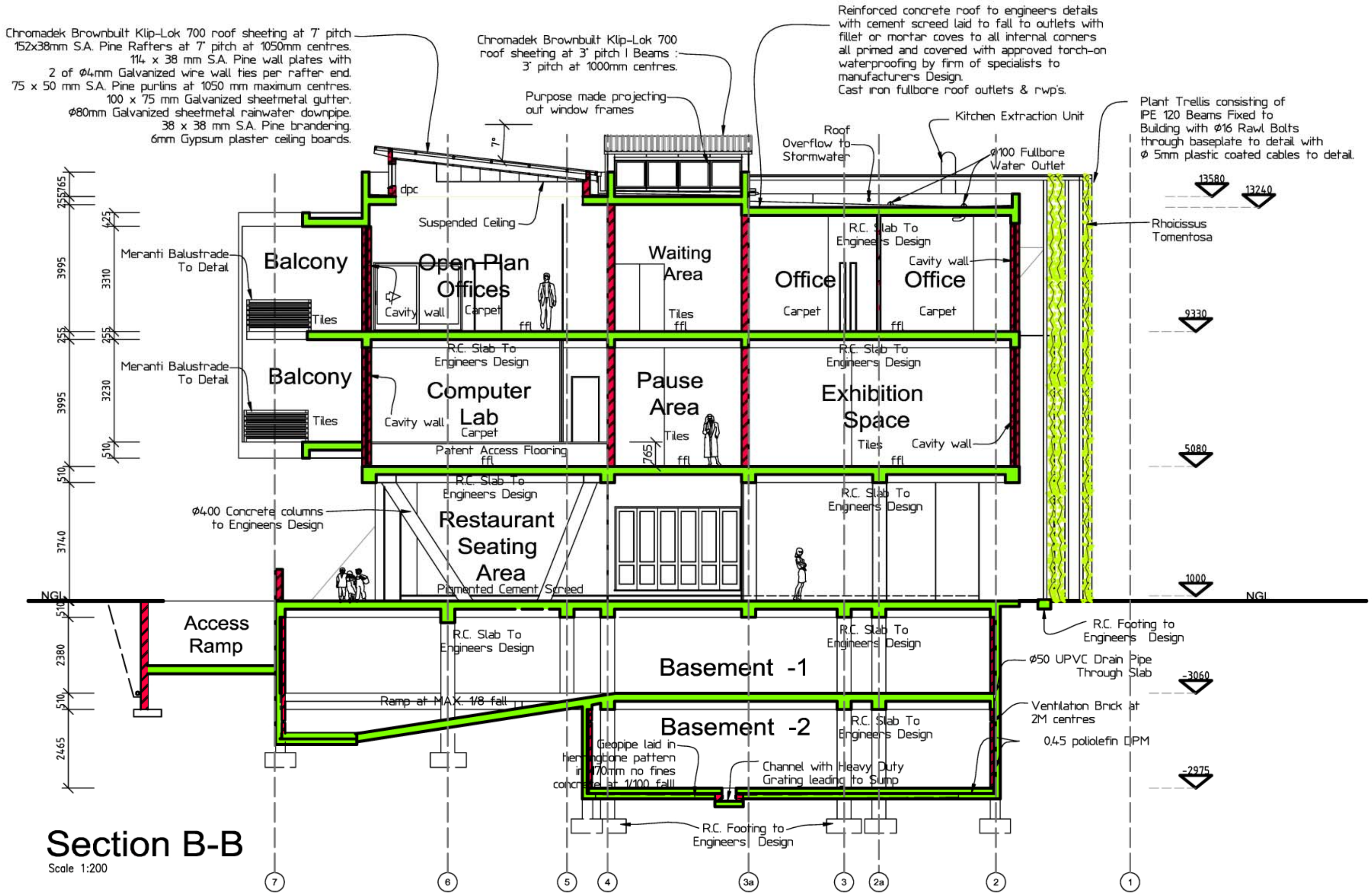

13580
9330
5080
Open Parking
Ashphalt at 1/100 fall to Stormwater Drains
NGL
1000
ø50 UPVC Drain
Pipe Through Slab
-3060
Ventilation Brick at
2M centres
0,45 poliolefin DPM
0,45 poliolefin DPM
-2975
L
M
N
O
P
Q



Section C-C

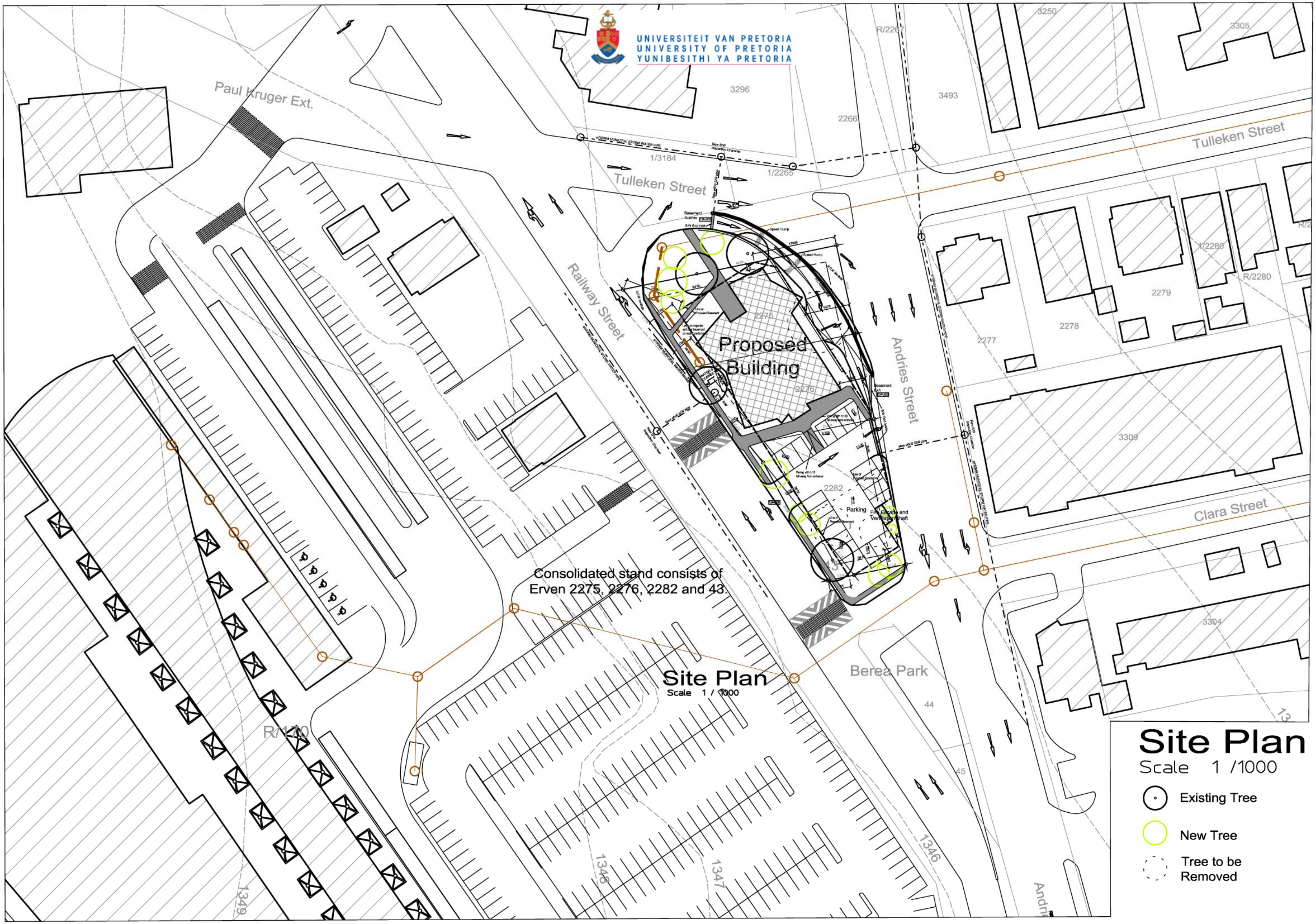
Scale 1:200


13580
9330
5080
Open Parking
Ashphalt at 1/100 fall to Stormwater Drains
Fire-Escape Exit
Class B Fire Door
Ventilation Shaft Opening
NGL
1000
Fire-Escape Entry
Ventilation Brick at 2M centres
Ventilation Shaft Opening
Ø50 UPVC Drain Pipe Through Slab
-3060
0.45 poliolefin DPM
-2975
L
M
N
O
P
Q



Section B-B

Scale 1:200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Paul Kruger Ext.
Tulleken Street
Tulleken Street
Railway Street
Andries Street
Clara Street
Berea Park
Proposed Building
Parking
Consolidated stand consists of Erven 2275, 2276, 2282 and 43.
Site Plan
Scale 1 / 1000
3296
3493
2266
3250
3305
1/3184
1/2265
2279
2278
2277
3309
3304
2282
R/170
1346
1347
1348
1349
44
45
Site Plan
Scale 1 /1000
Existing Tree
New Tree
Tree to be Removed

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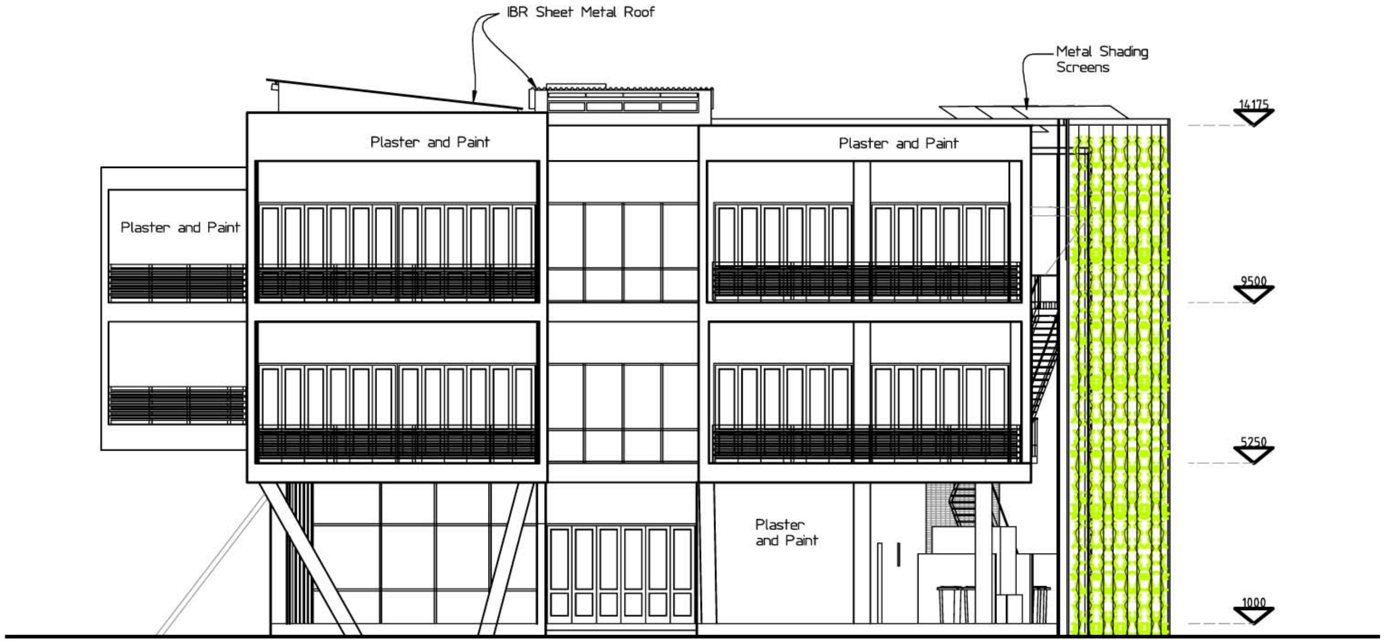
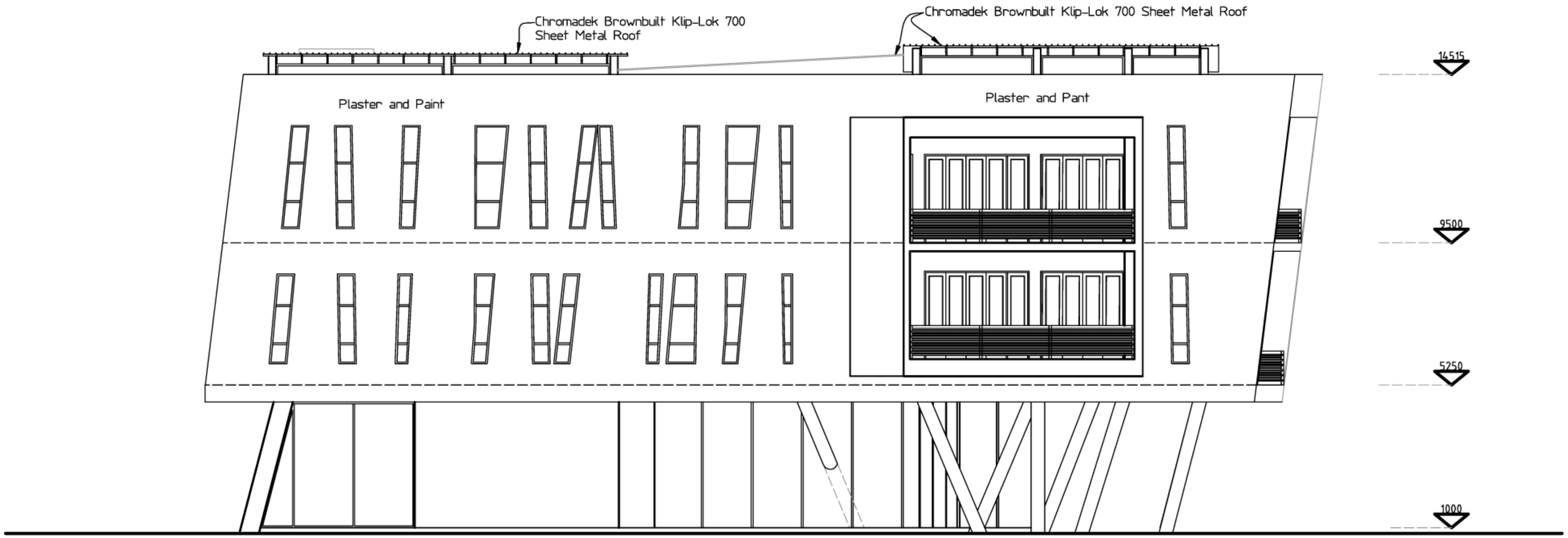


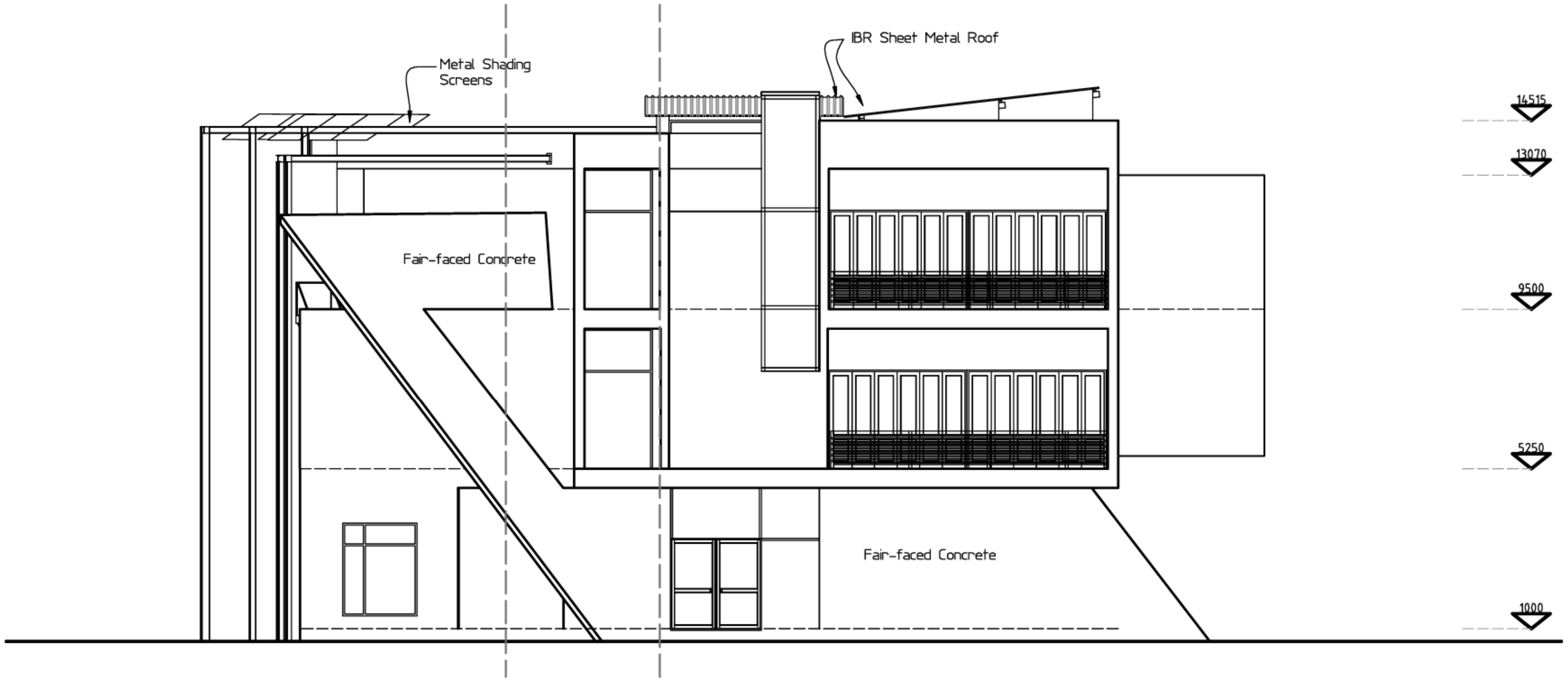
North Elevation

Scale 1:200



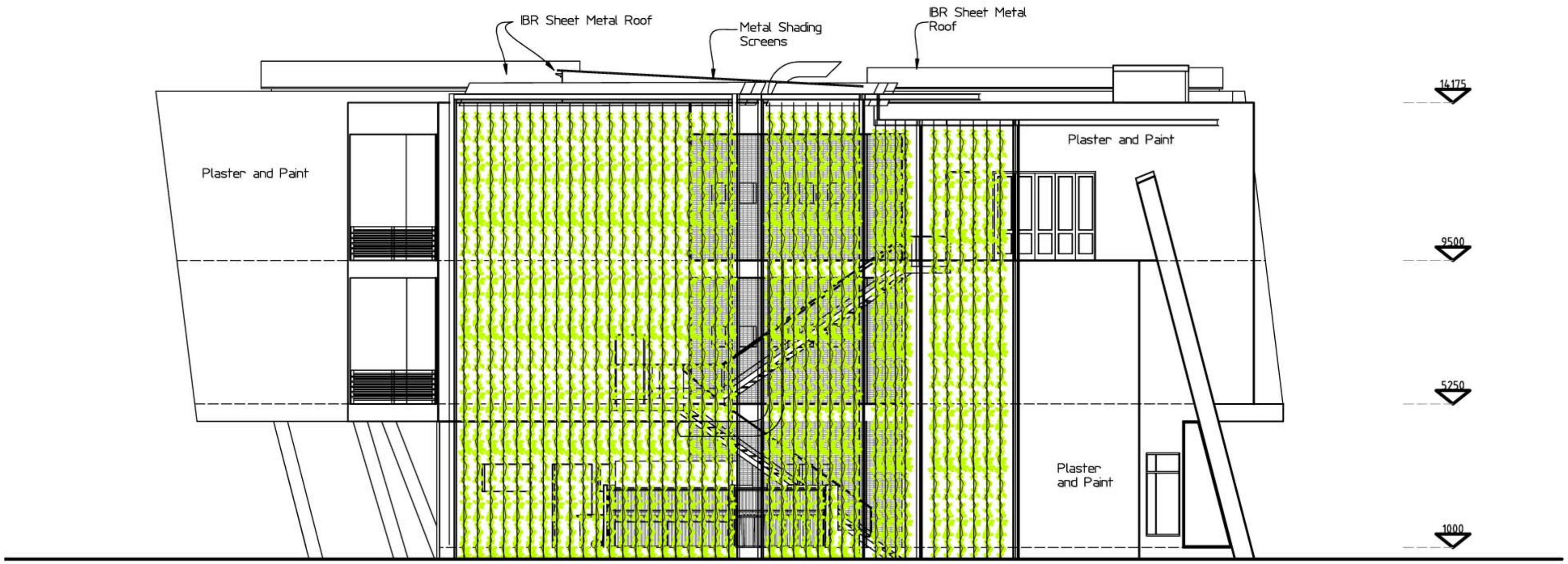
East Elevation

Scale 1:200



South Elevation

Scale 1:200



West Elevation

Scale 1:200

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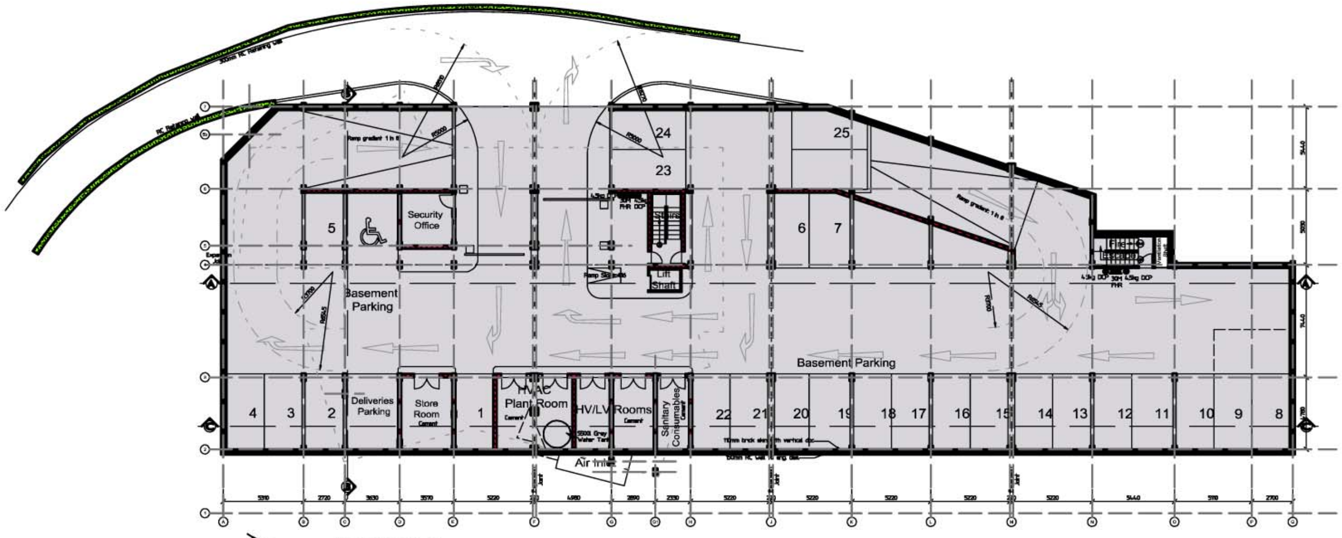
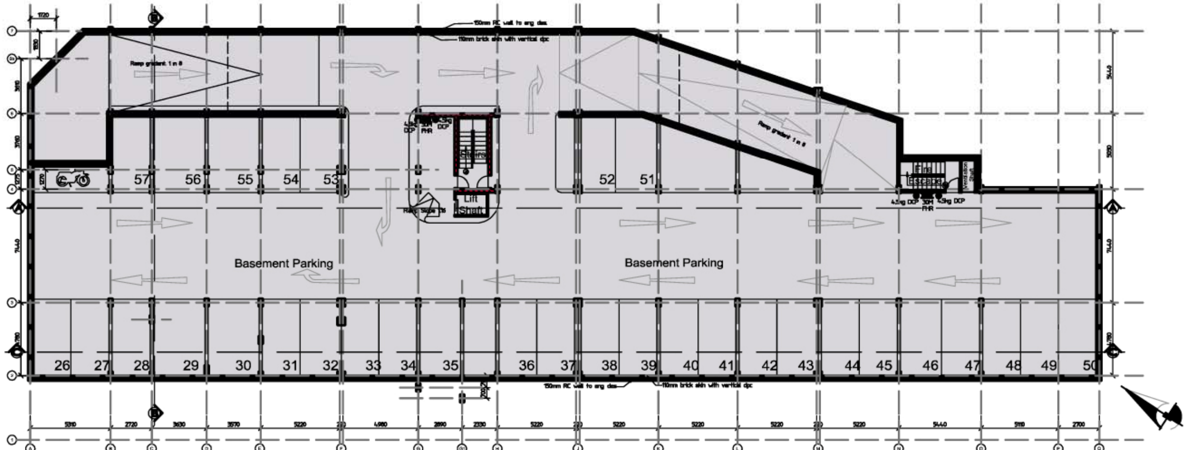


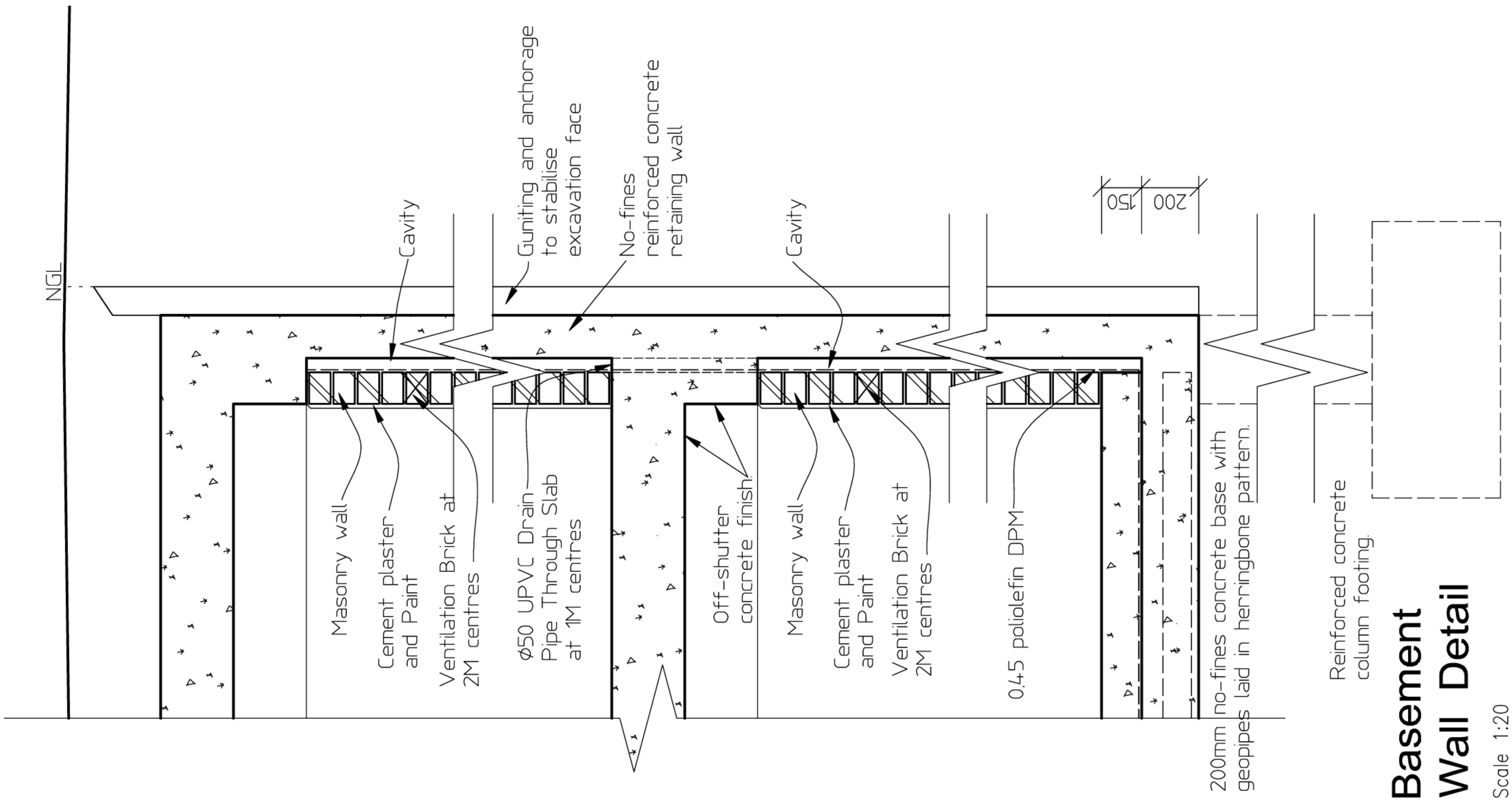
Basement -1

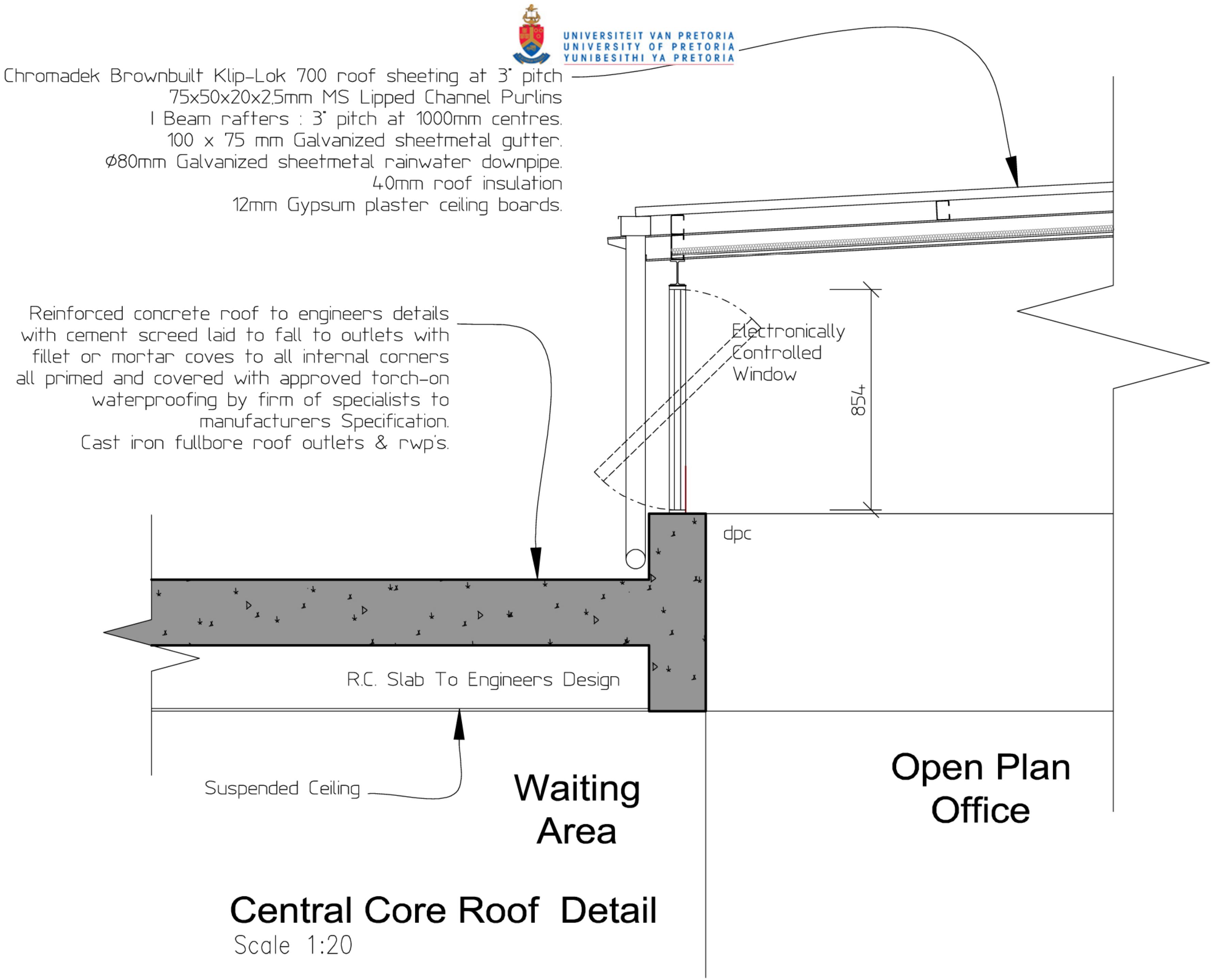


Basement -2

Fire Escape (Ground Floor)

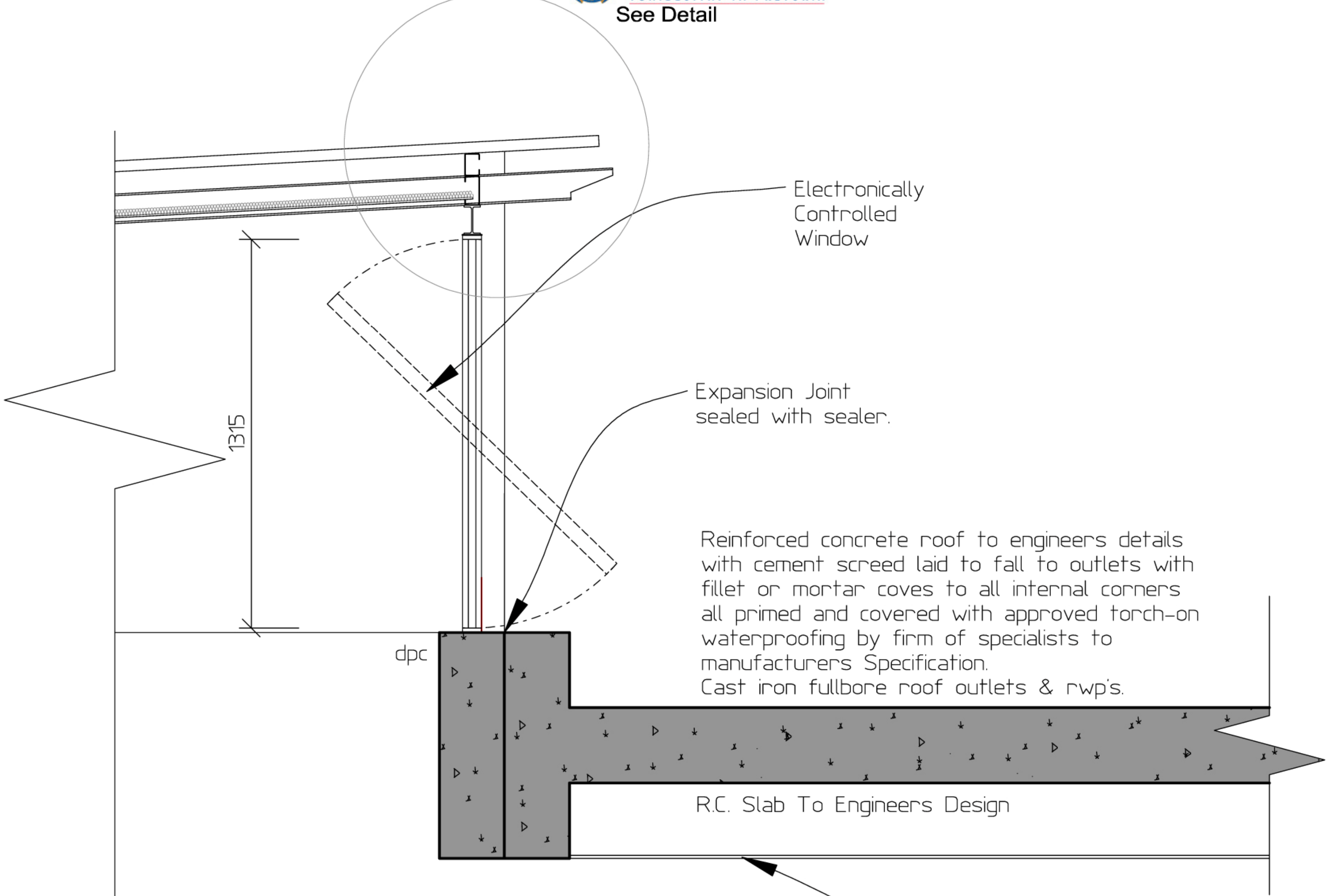
Scale 1:200


NGL
Cavity
Guniting and anchorage to stabilise excavation face
No-fines reinforced concrete retaining wall
Cavity
150
200
Masonry wall
Cement plaster and Paint
Ventilation Brick at 2M centres
Ø50 UPVC Drain Pipe Through Slab at 1M centres
Off-shutter concrete finish.
Masonry wall
Cement plaster and Paint
Ventilation Brick at 2M centres
0.45 poliolefin DPM
200mm no-fines concrete base with geopipes laid in herringbone pattern.
Reinforced concrete column footing.
Basement Wall Detail
Scale 1:20



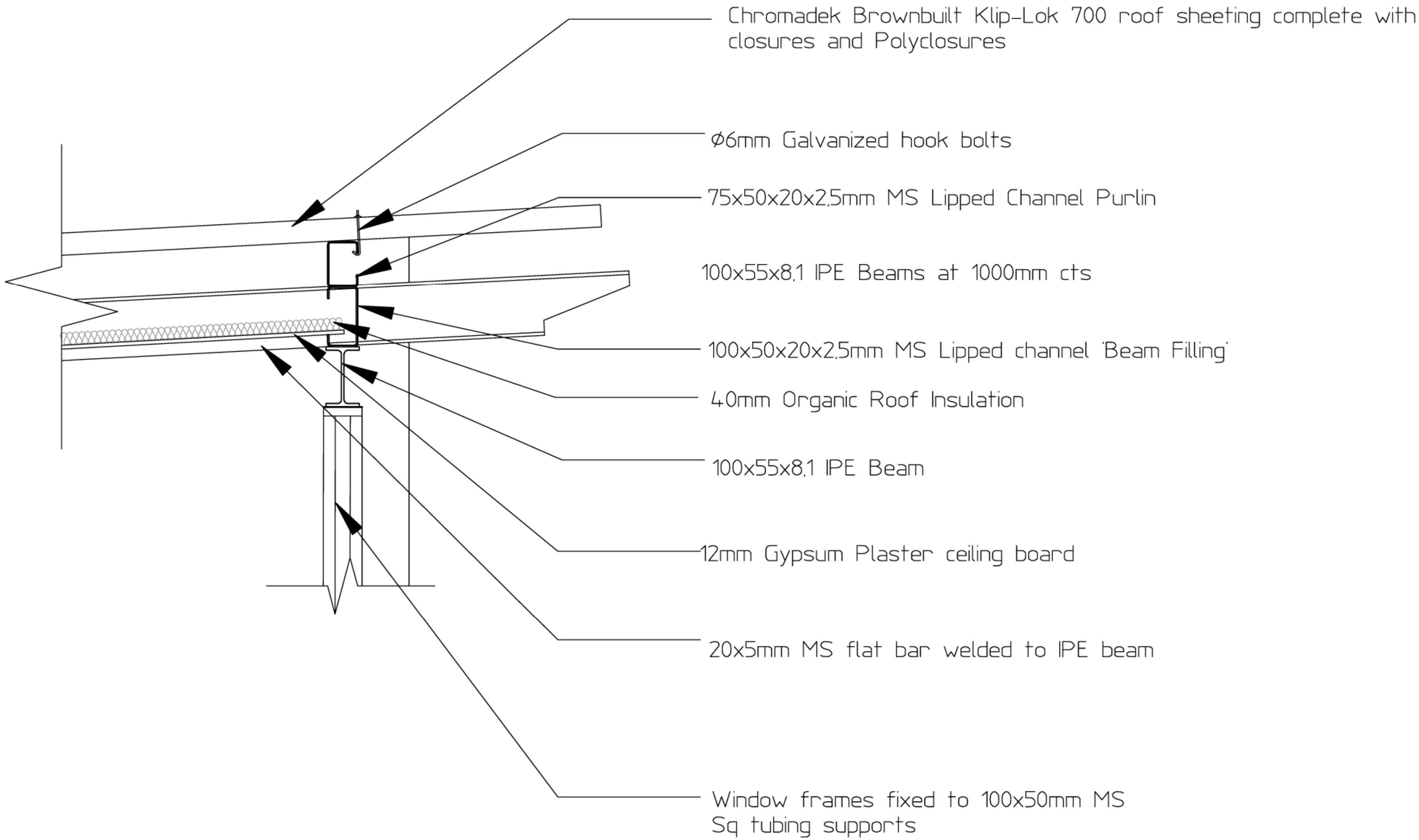
Central Core Roof Detail

Scale 1:20



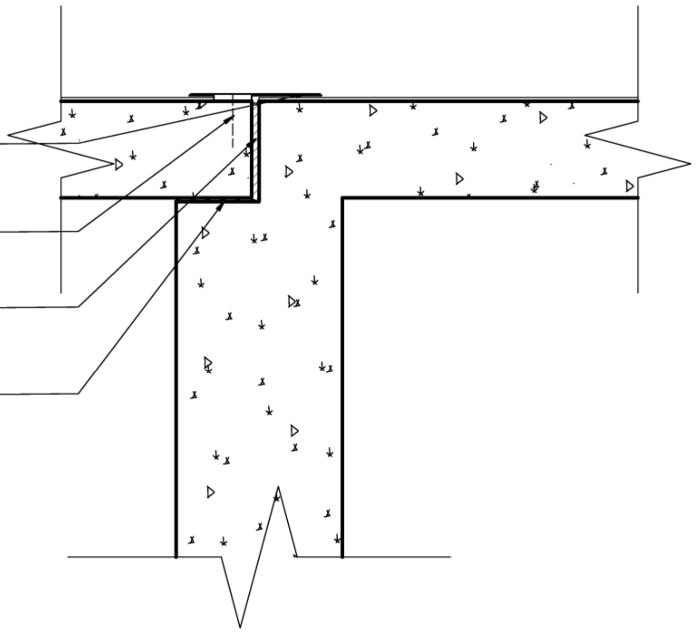
Central Core Roof Detail

Scale 1:20



Roof Detail (Central Core)

Scale 1 : 10



Expansion Joint Detail

Scale 1:20

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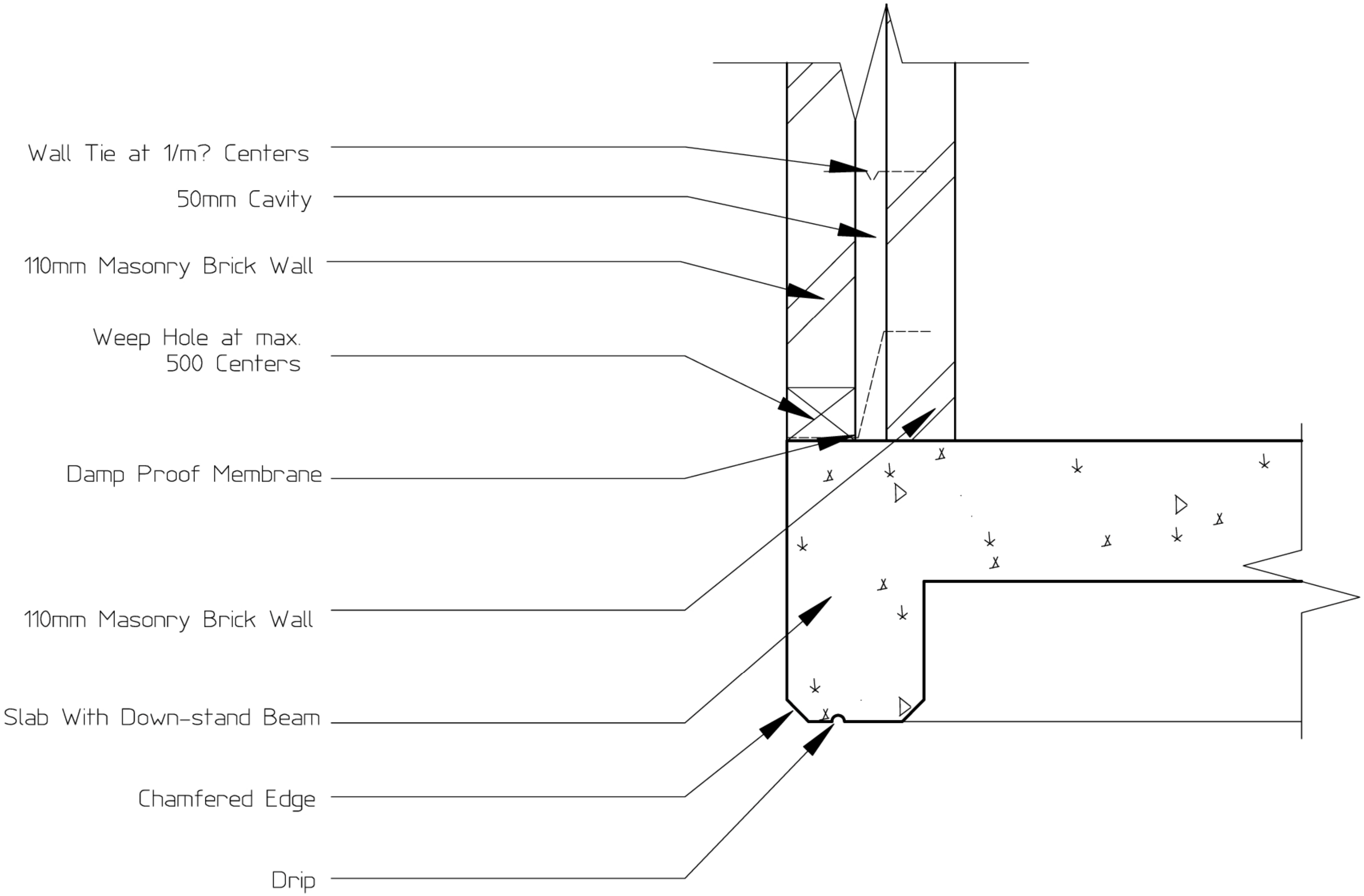
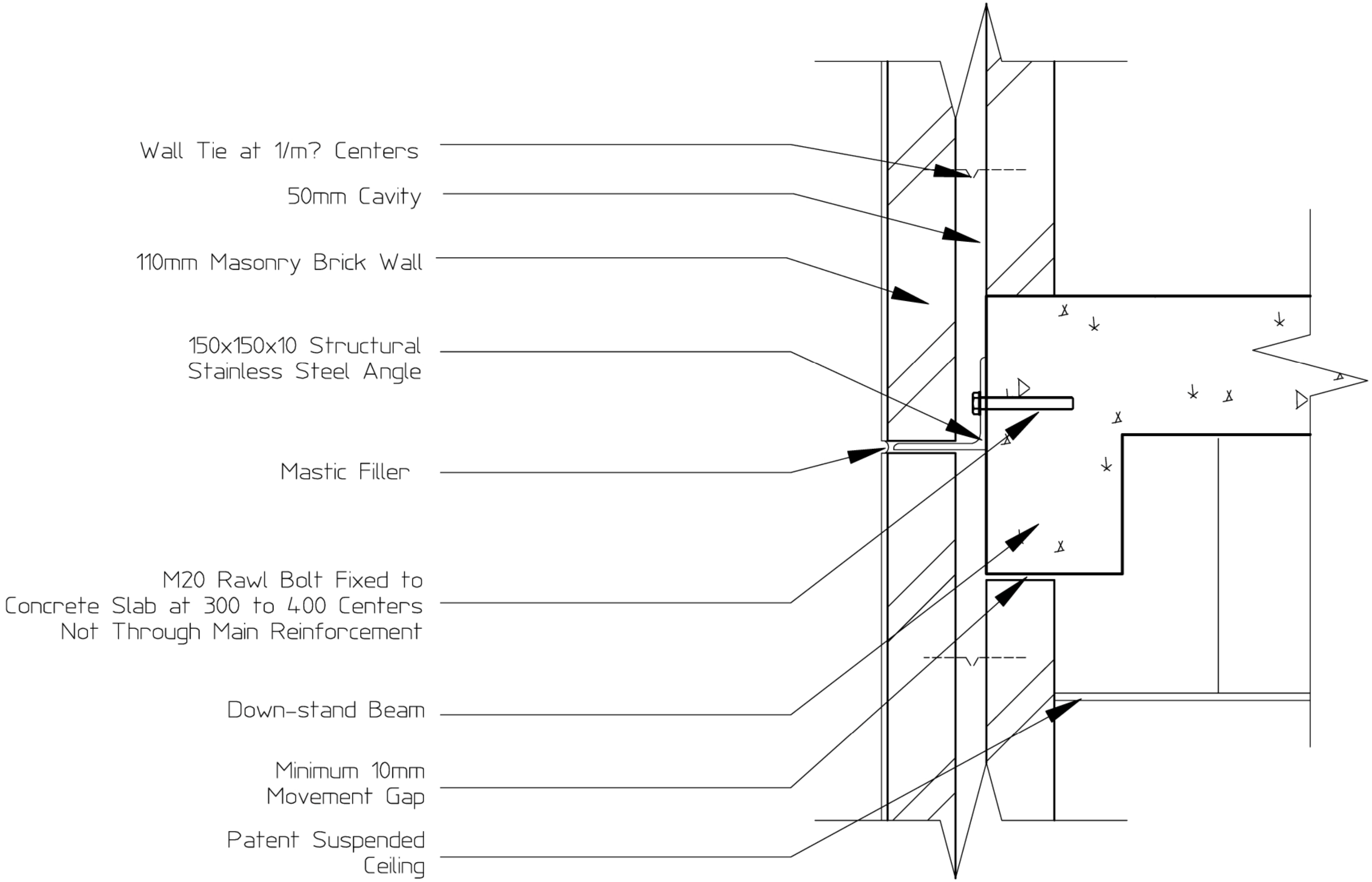


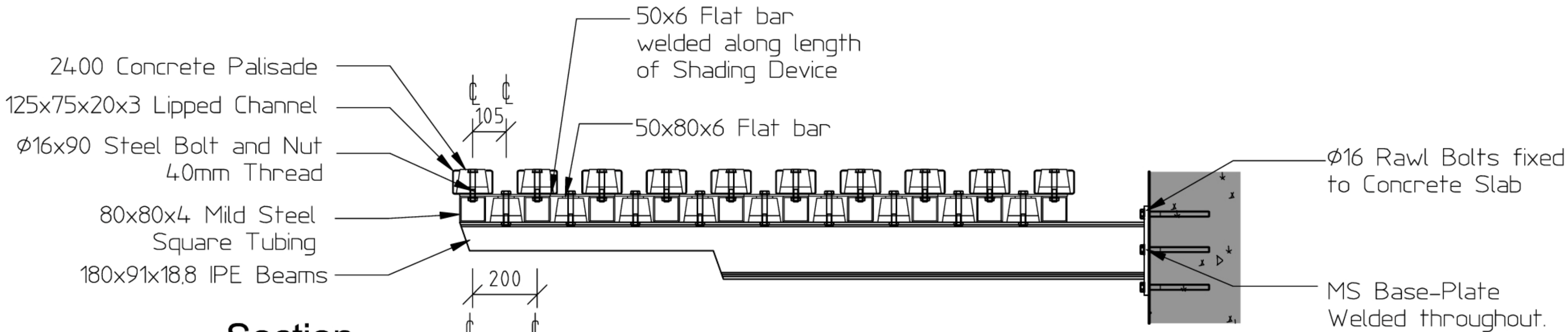
First Floor Slab Overhang Detail

Scale 1 : 10

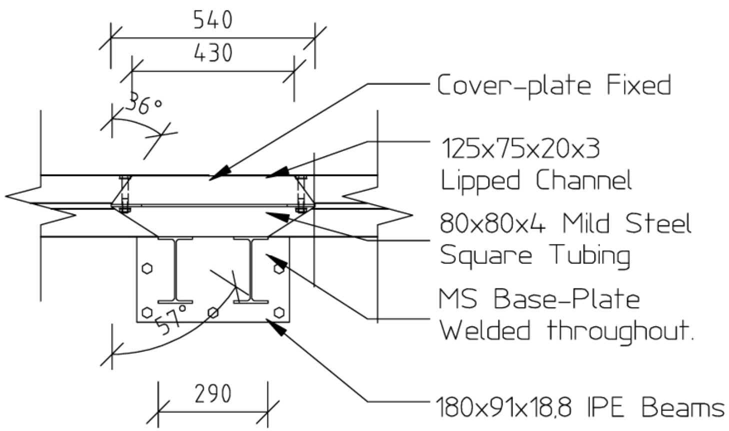


Second Floor Slab Detail

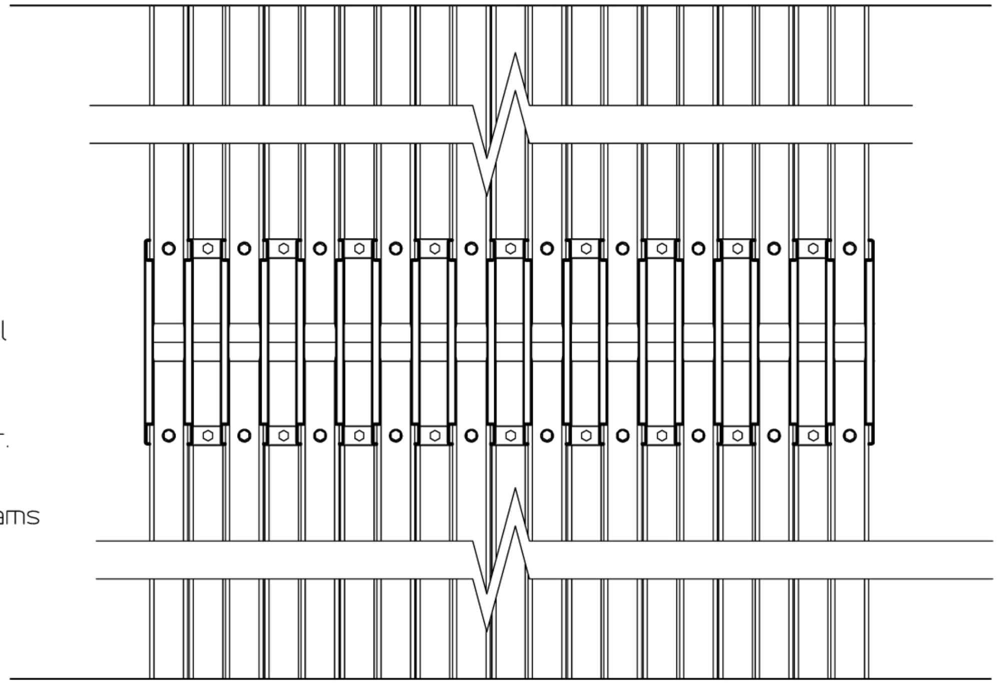
Scale 1 : 10



Section



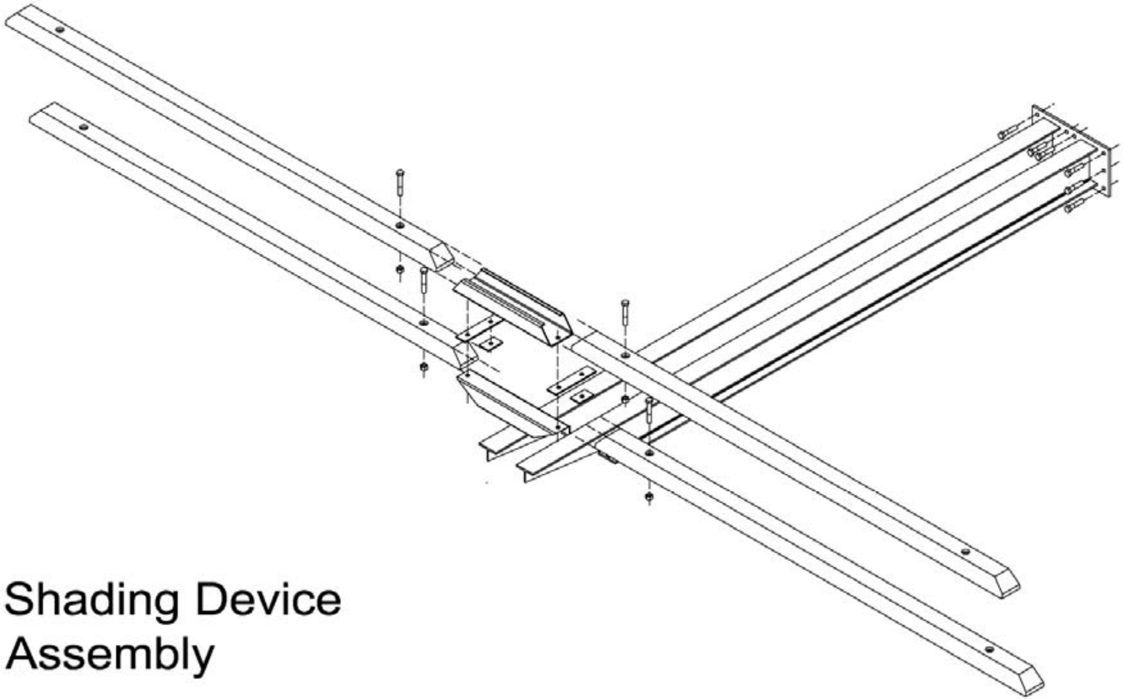
Elevation



Plan

Shading Device Detail

Scale 1:20



Shading Device
Assembly

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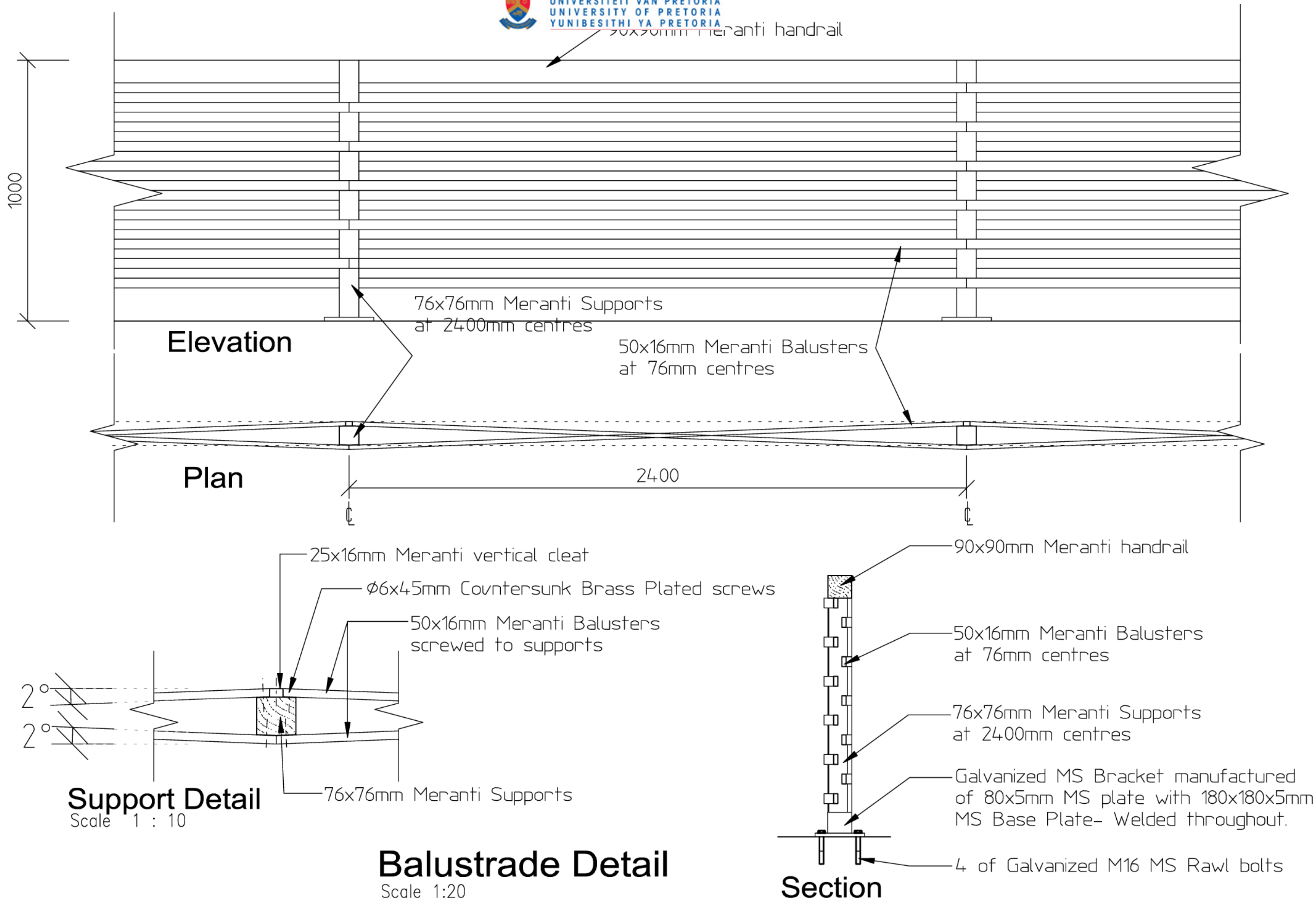
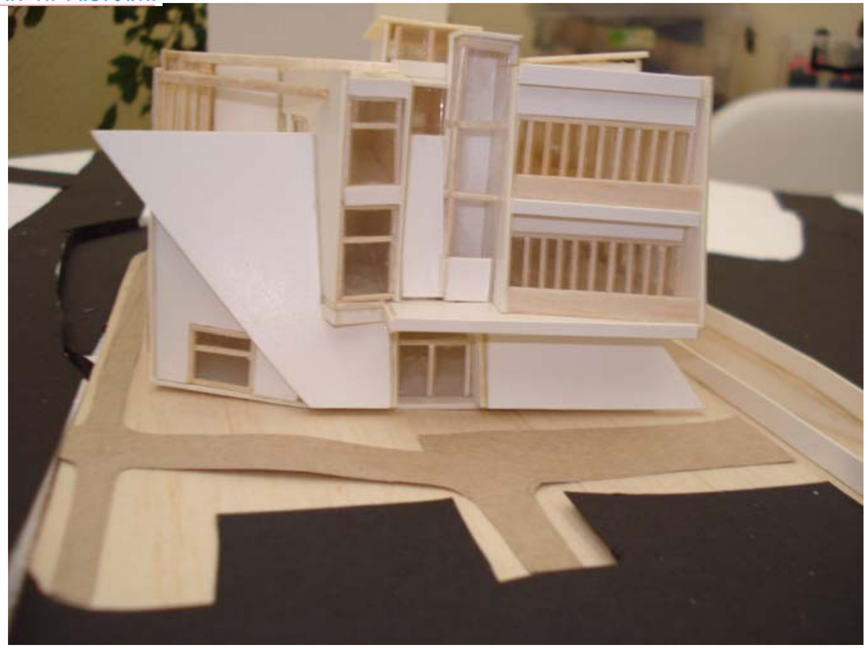
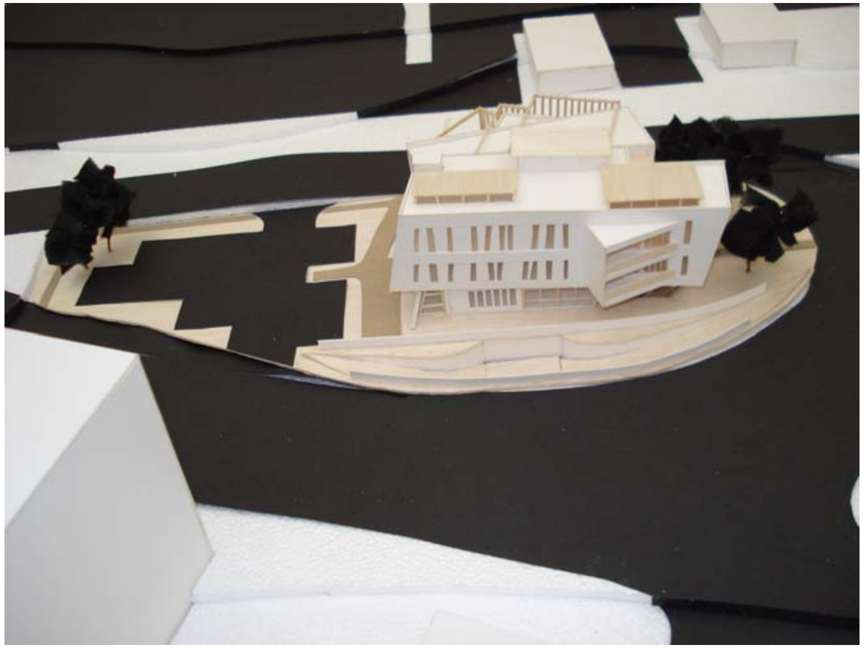


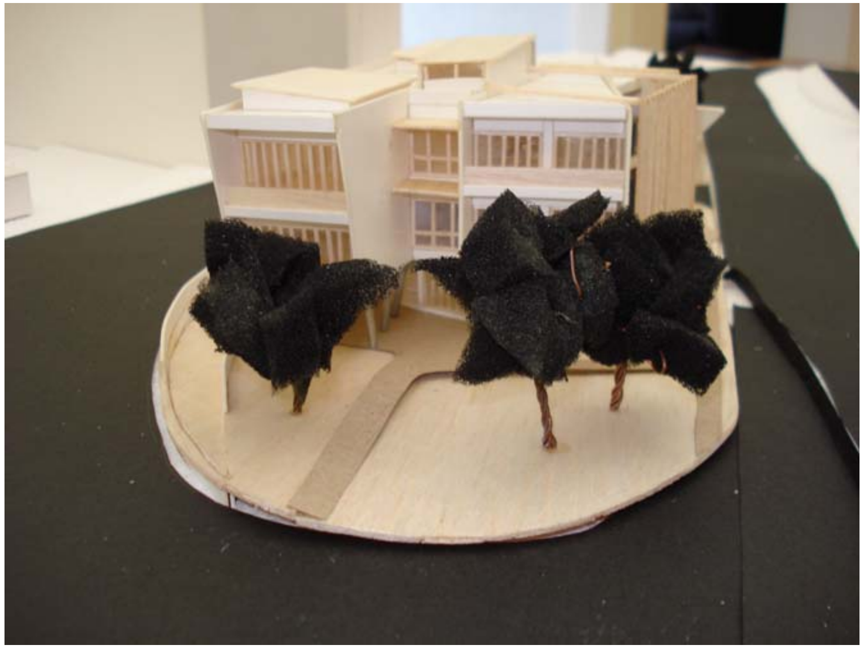
Balustrade Detail
Scale 1:20

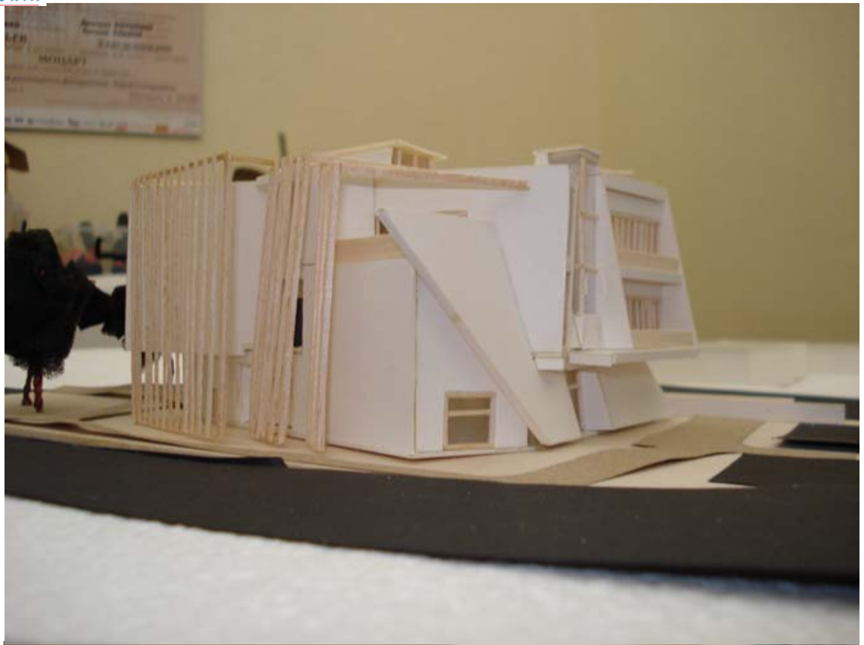
1. Model

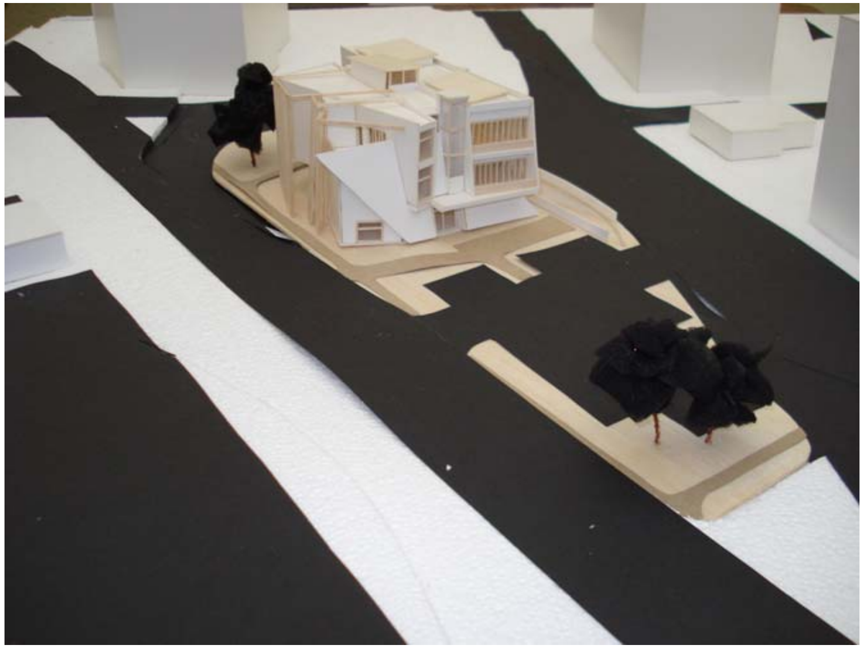
This serves as a documentation of the model that was built as part of the submission.

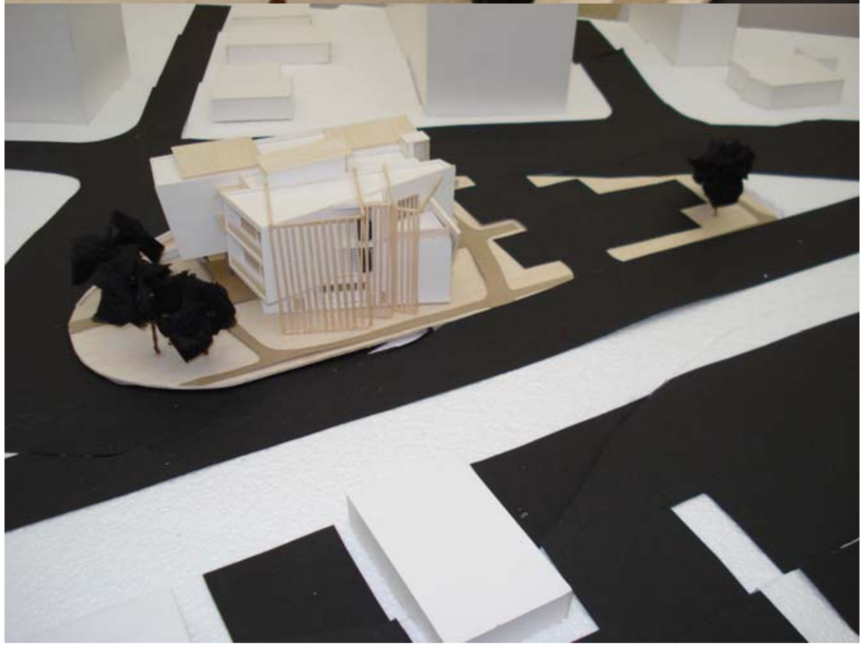


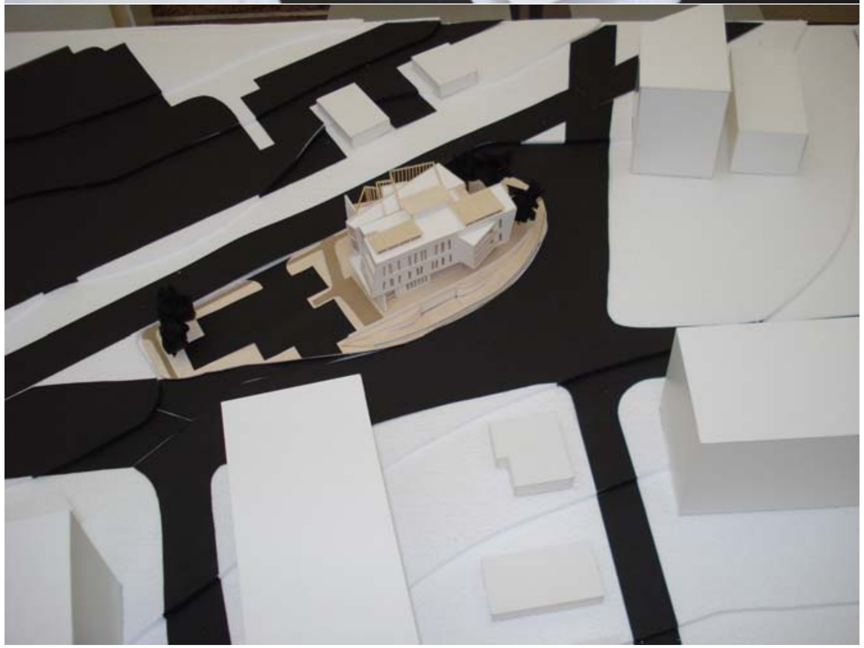












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