The Symbiotic Relationship between Man, Nature and Architecture: towards the design of an Environmental Education Centre

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A dissertation submitted to the School of Architecture, Housing and Planning – University of KwaZulu-Natal, Howard College Campus, in partial fulfilment towards the degree of Master of Architecture.

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DECLARATION:

Submitted in fulfilment of the
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South Africa.

I declare that this dissertation is my own unaided work. All citations, references and borrowed ideas have been duly acknowledged. I confirm that an external editor was not used and that my Supervisor was informed of the identity and details of my editor. It is being submitted for the degree of MArch in the Faculty of Humanities, Development and Social Sciences, University of KwaZulu-Natal, South Africa. None of the present work has been submitted previously for any degree or examination in any other university.

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Student name & surname

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Date

DEDICATION:

This work is dedicated to my supportive family and the wonderful people who surround me. Firstly, thank you, Mom and Dad for supporting me throughout my life. You are both such inspirations and I am so grateful to have you as my parents. Thank you to Zandi and Sean for motivating me and to Oma and Opa for all your love and 'Sunday night' dinners. And finally, a special thank you to Oros. You have encouraged me throughout this journey and I am so lucky to have you in my life. I am truly grateful to you all, without all of your love and support I would not be where I am today.

ABSTRACT:

The primary objective of this dissertation is to attain a design brief for an Environmental Education Centre which encourages a harmonious and symbiotic relationship between man and nature. This will be achieved by establishing an environmentally appropriate, climatically and contextually responsive architecture, specific to Durban. The building will ultimately function as a tool for education and aims to rekindle society's appreciation for nature while building humanity's sense of environmental awareness through education, exhibition and demonstration.

The facility shall be placed near an ecologically rich zone so that the building can serve as a gateway to generate controlled activity to the area. In this respect the building will solve problems associated with disconnection and lost space while enhancing environmental awareness to the area.

The applied research will result in an architecture which is appropriate to an environmentally sensitive site as it will operate as part of the ecosystem and will respond to climatic and contextual parameters. This will be achieved by examining suitable literature and theories, the investigation of appropriate case and precedent studies and interviews conducted with associated professionals and architects. The result of this research will generate an architecture which is environmentally responsible and socially and economically sustainable.

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INTRODUCTION:

Global warming is possibly the most serious issue which is currently confronting the planet, with the effects of climate change being environmentally, financially and socially detrimental. The majority of international scientists agree that global warming is a consequence of anthropogenic factors and has become a planetary emergency (Gore, 2006: 10). Contemporary society has become unaware of their destructive existence and has forgotten that nature is the source of human kinds' survival. In this regard environmental issues are associated with the disconnection between man and nature making it apparent that there is a need for architecture to function as a vehicle in connecting man and nature. (Walker: 2007).

This research dissertation investigates various architectural movements throughout history to determine how architectural parameters either separate or link man and nature. This analysis aims to determine an architecture, which is environmentally responsible and responsive (specifically to Durban's climate and context) and encourages a symbiotic relationship between society and the environment. The research will further guide the author to make informed decisions regarding the design brief and appropriate functioning of the building.

Furthermore, it is apparent that there is a lack of disseminated knowledge concerning environmental issues, which if implemented would begin to mitigate irresponsible behaviour (MacKay: 2009). The built intervention aims to solve this problem by allowing for the transfer of knowledge within an education centre. In this respect it is vital to produce a design which is didactic in nature to demonstrate innovative, sustainable design solutions and to function as a tool for education. An Environmental Education Centre will therefore cater for learners from the surrounding schools and educational institutions, professional, as well as the interested general public and tourists. Furthermore, the building will accommodate researchers, educators and administrative staff from Ezemvelo KZN Wildlife who are involved in environmental education, specifically mangrove forest ecology and conservation.

An education centre would additionally generate controlled activity to an area which is lost or forgotten, particularly along the uMgeni River. In this regard the facility will act as a gateway to the environmentally valuable site, that aims to increase awareness of this threatened 'biodiversity hotspot', augment responsible conservation while enhancing the area's ecological value. The renewed interaction between man and nature will promote awareness and appreciation amongst society.

The applied research will include theories pertaining to interconnectivity, bioclimatic design, regionalism, architectural expression and planted corridors. Other sources of research will be interviews with associated professionals, case studies and precedent studies which will ensure that the building will respond to its climatic and contextual parameters as well as fulfil its accommodation requirements.

CHAPTER 1

RESEARCH BACKGROUND AND RESEARCH METHODOLOGY

1.1) Research Background

1.1.1) Introduction

This dissertation seeks to determine an appropriate, responsible architecture for an Environmental Education Centre on an environmentally sensitive site. The research background will focus on fundamental questions which will aid in examining the research topic. The hypothesis and research problem will be stated and the path which the research will take shall be established.

1.1.2) Hypothesis

Global environmental issues, such as global warming and climate change, have become a planetary emergency and are expected to devastate humanity, in environmental, social and economic terms. In this regard, there is a need to promote environmental awareness and education to produce a society that is informed regarding environmental issues and solutions so that responsible action can be executed (Sassi, 2006: 2) (Gore, 2006: 10).

This research document aims to investigate how environmental architecture has connected or separated man from the environment, either by responding to or ignoring the natural parameters, namely climate and surroundings. Ultimately, the built intervention will transpire from research discussed within this dissertation and will result in an appropriate, responsive and environmentally sensitive architecture, specifically to Durban's coastal region. The building shall become a vehicle to promote environmental awareness through education, exhibition and demonstration. The facility will be placed in close proximity to an environmentally rich site, allowing the visitor to interact directly with the surrounding nature for palpable and practical education.

1.1.3) Research Problem

> "An Armageddon is approaching at the beginning of the third millennium. But it is not the cosmic war and fiery collapse of mankind foretold in sacred scripture. It is the wreckage of the planet by an exuberantly plentiful and ingenious humanity." (Cited by Wilson: 2002 in Sassi: 2006, 3)

Man-induced activity has contributed to the environmental crises which are jeopardising the survival of many species, including mankind. Activities such as deforestation, habitat destruction and resource depletion have led to environmental degradation and changes in climate, which is detrimental to society and the environment (Sassi: 2006, 2). Furthermore, the construction and the operating of buildings contribute to two thirds of carbon dioxide production, which significantly increases global warming. This highlights the importance of environmentally responsible buildings and the individual's responsibility towards reducing global climatic issues (Day: 2004, 57). Scientists and environmentalists have warned against a human attitude that separates itself from its environment. This disconnection has resulted in a predominantly unaware and irresponsible society, which can be associated with the increase in global warming and climate change (Walker: 2007).

The Umgeni River estuary is a distinct example of one of Durban's many unique natural environments. This zone is characterised by mangrove forests which the South African National Biodiversity Institute (SANBI) has regrettably classified as being critically endangered. This is due to increased pollution in estuaries which has negatively affected the biodiversity of the area (eThekwini Municipality: 2007, 22). Furthermore, the Umgeni River's banks, especially the northern banks, have become forgotten, polluted and dangerous places. This is due to the current disconnection between the community and the environment resulting in a lack of activity and sense of ownership.

In this regard, it is clear that controlled activity should be implemented to improve awareness of this particular ecologically valuable area. This can be achieved by introducing an Environmental Education Centre that functions as an architecturally sensitive gateway to the environment and encourages the community to "get to know their estuary" (Delta Environmental Centre: no date). In this respect people will possess a greater appreciation and understanding for their natural surroundings.

1.1.4) Aims and Objectives

The primary aim of this research dissertation is to determine a symbiotic relationship between society and the environment by establishing an appropriate and responsive architecture, specific to Durban's unique climate and context. The research shall investigate this connection and will identify how architecture can enhance the natural environment rather than degrade it. The built intervention will be didactic in nature, thereby operating as a tool to demonstrate methods of sustainability while promoting environmental awareness through palpable and practical education, exhibition and demonstration. Additionally, the study will explore the fundamental requirements of an education centre, such as planning, architectural expressions, the implementation of green technologies and environmental comfort. Consequently, it is vital to determine a design brief which minimises environmental degradation, is sensitive to the surrounding ecology and responds to Durban's climate while providing a comfortable, healthy environment for occupants and visitor to reconnect with nature along the Umgeni River.

1.1.5) Research Questions

1.1.5.1) Main Questions

The main questions needing to be addressed when designing an Environmental Education Centre will pertain to designing an educational facility in an environmentally appropriate manner, which aids in providing a symbiotic relationship between man and nature.

Firstly, it is important to determine how architecture can operate as part of an interrelated ecosystem and minimise environmental degradation / while enhancing the environment. In this respect it is imperative to investigate how buildings respond to their climate and surroundings and in this regard how does the building serve to connect or separate man and nature? Furthermore, it is vital to question how a building can be designed to operate as a tool for education to promote environmental awareness.

1.1.5.2) Subsidiary Questions

Subsidiary questions will be raised within this research document to inform the brief for an Environmental Education Centre. These include questions concerning social, economic and environmental aspects as well as site selection requirements.

Questions relating to social aspects include information regarding the users of the building and the local community. Will the learners from adjacent schools, tertiary institutes or professionals in the associated field utilise the educational component? What are the functions which need to be incorporated within the building? And what are the viable sizes of the facilities within the building? What is needed for the building to become a vehicle for environmental education? And as the facility will attract tourists, how can the facility generate incomes for the local traders in the area?

Questions pertaining to economic aspects involve who the client or organisational body will be for the Environmental Education Centre? Does the client have existing facilities which need to be relocated or housed in the Environmental Awareness Centre? Will the facility be funded by the client or be reliant on the visitors?

In terms of environmental aspects, the questions which will be raised are how can the building be environmentally conscious in terms of materials, energy, water and waste? What are the architectural expressions, which are suitable for an environmentally sensitive building which will be sited near an ecologically important area? How will the building respond appropriately to Durban's specific climate and context? Which green strategies are appropriate for an Environmental Education Centre? And how can they be demonstrated in an educational manner?

In regards to the site selection, which is the best site choice for a design which will generate ecological awareness? Will the site be able to house all the relevant functions of an Environmental Education Centre without ruining the integrity of the flora and fauna? What are the micro and macro characteristics of the site and are they suitable for an Environmental Education Centre?

1.2) Research Methodology

1.2.1) Introduction

The research gathered within this document will generate a design brief for an Environmental Education Centre along the Umgeni River, which establishes a symbiotic relationship between man and nature. The research methods and approach for this dissertation will be outlined within this section in terms of primary and secondary research.

1.2.2) Study Area

Durban is situated in between the Cape's temperate and Mozambique's tropical habitats. In this regard Durban falls into a biogeographic transition zone which is a biologically rich and diverse area (eThekwini Municipality: 2007, 20). A biologically diverse area is important as it provides environmental services and goods ensuring the constant 'balance of nature'. In this respect it is imperative to conserve and maintain Durban's biodiversity through the conservation and maintenance of 'biodiversity hotspots'. Biodiversity hotspots can be defined as species rich zones which are under threat. An example of an important hotspot is the uMgeni River estuary. Despite industrial development and canalisation upstream, the uMgeni River estuary has been noted to contain the largest area of mangrove habitat in the eThekwini Municipal area and is rated as the third most important estuary for water birds in Kwa-Zulu Natal (eThekwini Municipality: 2007, 29). In this respect it is vital to recognise the ecological significance of this zone.

The specialised conditions of estuarine ecologies are very significant to natural eco-systems as it is the ideal feeding ground and nursery for aquatic species (Collins: 2007). Furthermore, estuaries are chief indicators of the river's ecological well-being. This is due to the nature of macrobenthos and microbenthos, occupying the substrate of the river bed, which when studied exposes the history of the river and the present state of the water quality (MacKay: 2009).

uMgeni River estuary is bordered by the Blue Lagoon Recreation area to the South and the Beachwood Mangroves Nature Reserve to the North. Blue Lagoon, is zoned as an active eventing zone and is not environmentally established, being described as the "ecological sacrificial lamb" of the uMgeni River (Nicci Deadrichs: 2010). Whereas the Northern bank (Beachwood Mangroves Nature Reserve) exhibits ecological value. Unfortunately this environment is under threat but can be recovered and repaired by the promotion of an environmentally aware society

1.2.3) Research Plan

The research conducted within this dissertation consists of primary and secondary data collection and analysis. Primary research includes first-hand investigation through case studies and interviews, while secondary research includes data assembled by means of a thorough literary study to investigate existing buildings in terms of theoretical principles. This document is largely theoretical in nature and in this regard the research focuses mainly on qualitative rather than quantitative data collection. Qualitative research relates to human experiences and interpretations rather than the numerically and statistically concerned quantitative data collection. Conclusions will be obtained from the literature review, precedent study, case study and interviews which will enable the author to gain a coherent/ comprehensible stance regarding environmental architectural responses and to achieve an appropriate design brief.

1.2.4) Primary research

Primary research is essentially data assembled by the author and encompasses case studies and interviews. The case studies will be discussed in terms of Interconnectivity, regional architecture, design requirements for education facilities and architectural expression of sustainability. These principles will be examined and demonstrated by buildings such as the Kirstenbosch Gardens Visitors Centre, Issy Benjamin's Las Vegas apartment block, uShaka Sea World Education Centre and the BP Head office in Cape Town. These buildings have been chosen for various reasons and shall conclude in an appropriate design brief for an Education Centre which works in harmony with the surrounding environment.

Interviews will be conducted by the author with selected professionals in the environmental and scientific field. Informal interviews with Fiona MacKay (Senior Scientist of the Oceanographic Research Institute) and Heidi Kilian (Course Co-ordinator at the Sea World Education Centre) will be performed to gain a clearer understanding of the environmental aspects, specifically pertaining to mangrove forests and estuaries as well as the efficient functioning of educational facilities. In terms of realising an appropriate brief for the client and to establish an ecologically sound perspective of the site, Ian Porter, the manager of the ecotourism division from Ezemvelo KZN Wildlife and Nicci Deadrichs, the Environmental director from Future Works will be interviewed. Issues concerning case studies will be resolved by interviewing users of the buildings such as Andrew Jacobs, the communications officer at Kirstenbosch Gardens and Juilian Roman, the site co-ordinator at the BP building.

1.2.5) Secondary Research

Secondary Research comprises of information gathered from secondary sources such as books, journals, unpublished dissertations and the internet. Secondary data encompasses a literature review and precedent studies. The literature review will be a detailed literary study of prominent architecture throughout history which has employed architectural parameters to respond to nature; consequently the analysis will determine how architecture aids in linking or disjointing/separating man and nature. Furthermore the literature review will evaluate the shift in mans' perceptions towards the environment and subsequent global environmental degradation. In this respect the literature review will guide the author to establish an environmentally responsive and responsible architecture.

Precedent studies include international existing and proposed buildings. The analysis will incorporate issues such as interconnectivity, bioclimatic design and regional architecture in terms of appropriate architectural expression, choice of materials, built form, spatial organisation and sustainable devices. The investigate buildings comprise of are the Hockerton Housing Project, Piney Lakes Environment Centre, Pocono Environmental Education Centre, Council Housing 2 (CH_2), Tjibaou Cultural Centre*,* Ken Yeang's master plan for Nottingham University and Glenn Murcutt's numerous houses and the Bowali Visitor Information Centre. This will ensure that the proposed Environmental Education Centre is truly interconnected with the ecosystem, function as a suitable tool for education as well as assists in breaking down the barriers between learner and nature. Additionally this study will accomplish an efficient and appropriate design brief and accommodation schedule.

1.3) Conclusions

The information which will be assembled and analysed will guide the author to generate appropriate architectural requirements and an efficient design brief for an Environmental Education Centre for the uMgeni River. It is vital to logically examine primary and secondary sources so that conclusions and recommendations can be derived within each chapter. In this regard, the data analysed for this dissertation has been rationally separated into a literature review, precedent studies, case studies and interviews.

CHAPTER 2
THEORETICAL FRAMEWORK

2.1 Introduction

Mankind's survival on Earth depends on the fundamental recognition that human beings are part of an intricate web, whereby everything, including man-made organisms and nature are related. Societies must acknowledge the full degree of their interconnectedness with the natural world and in this regard must take responsibility for their considerable impact and degradation towards nature (Crowe: 1995, 24). This is clear in the 'chaos theory', whereby everything is related and any small initial change can cause a chain reaction which may lead to larger affects across the world (Pearson: 1994, 150). This theory is relevant when considering architecture's relationship with the natural world. Designers often forget that structures, transitory or permanent, affect the environment in its entirety, and will eventually affect man's survival on Earth. *The ultimate requirement of this thesis is to produce an architecture which functions in harmony with its related, interconnected systems.* This is not simply a sentimental aspiration, but has become an essential necessity to ensure mankind's survival. (Stannard: 2004)

For a building to fully harmonise with nature and become responsive in terms of climate and context, one must analyse theories of interconnectivity, such as the 'Philosophy of Symbiosis' and 'biomimicry', as well as 'bioclimatic design' and 'regionalism'. These theories, in essence, address constituents of natural parameters in terms of climate and environmental surroundings (Wines: 2000, 57). These theories, which will be analysed within this chapter and will form rudimental elements of comparison within the literature review. The literature review will be discussed in terms of architectural parameters (materials, built form, spatial organisation and devices) which respond to or are affected by the parameters of nature.

Furthermore, it is relevant to analyse how society can be made aware of man and nature's fundamental relationship through architectural expression. In this respect it is vital to examine organic architecture and environmental control systems, both of which form an architectural vocabulary which emphasises a symbiotic relationship between man and nature (Pearson: 2001, 40). The urban design theory which will be discussed is the principle of ecological corridors and focuses on 'greening' the city while improving biodiversity (Yeang: 1996, 102).

2.2 Interconnectivity

Modern society is preoccupied with industrialisation and dominance over nature, propelling humanity on a path towards extinction. This is due to their inability to live a sustainable existence (Stannard: 2004). Many theorists have claimed that a shift in the way mankind perceives their connection with the natural environment is the key to a harmonious existence on Earth. In this respect, it is crucial to appreciate that all organisms, natural or man-made, are interconnected in the same regard as ecosystems. The connection between society and nature is tremendously significant in terms of social, economic and environmental factors. The concept of disconnected, sealed, air-conditioned buildings are rejected by environmentally concerned designers on the basis of consequential health problems such as Sick Building Syndrome as well as the rapid depletion of resources. Most energy consumption is fossil fuel generated, which has a "huge price in terms of ecological damage" (Day: 2004, 58). The reckless use of energy has a direct consequence on the increasing levels of climate change and global warming. These environmental crises have been associated with the current disconnection between man and the natural world (Walker: 2007). Mankind has produced an unsustainable way of life, due to their disconnected lifestyle which results in a society that has become increasingly unaware of mans impact on nature. Al Gore urges people to become reconnected with nature and to learn about the state of the environment so that an informed and inspired society can take action towards combating global warming (Gore, 2006: 319).

> "We need to regain our sense of the natural world as sacred... In our working world, we are no longer present to the natural world in any manner". (Berry cited in Jensen: 2002)

The 'Philosophy of Symbiosis' respects this concept and supports the notion of interconnectivity (Kurokawa: 1994, 41). There is an advanced current of thought that is emerging around the world and is changing society's perception of life on Earth and the concept of what it is to be human. Kisho Kurokawa, the Japanese architect and theorist identified this change as the 'Philosophy of Symbiosis'. Kurokawa advocates that this is the key word for the Twenty-first Century and is prevalent in all facets of life, such as business, science, art and culture, philosophy, architecture and urban design (Kurokawa:

2000, 6). The Philosophy of Symbiosis is concerned with the intimate organism-organism interaction, which is not one of domination of the stronger element over the weaker, but rather an endeavour to determine common rules, without removing the variance between the elements. This theory has its roots in traditional Japanese culture, Buddhism and biology (Kurokawa: 1994, 41). Traditional Japanese people encouraged the theory of 'Zen' and believed that the whole universe is a system of interrelated parts. They perceived a state of Zen to be an important psychological symbiosis and to be purely part of nature. The Japanese architects of the time translated this concept in the expression of an integral connection between inside and outside, thereby utilising thin membrane-like walls, which allowed for "architecture to converse with nature" (Wines: 2000, 57). The Buddhist beliefs have much to offer contemporary society as they view nature as being fundamental to life. The Buddhist concept of 'Non-Duality of Life and its Environment' (*e-sho-funi*) indicates that life and nature are two separate entities but are dual in their chief constituent. The concept of 'Origination in Dependence' (*engi*) suggests that an organism does not survive and induce independently but relies on relations with other entities (Kurokawa: 1994, 41). These notions recognise that the environment is part of a balanced system, denoting that environmental damage is interconnected with individual destruction; incidentally they believed that environmental conservation is vital for prosperous life on Earth (Yamomoto: 2006, 176).

Kurokawa foresaw a shift from the "Age of Machine" (Modern Age), which represented homogenisation and dualism to the "Age of Life", which signifies pluralism and diversity. Architecture during the "Age of Machine" was concerned with progression and humanism, denoting that human beings were regarded as being more valuable than other animals, plants and living organisms. This resulted in environmental degradation which was considered to be unavoidable in the quest for economic and technical development and growth, which was required to support society and its perpetual cities (Kurokawa: 1994, 8).

> "During the Age of the Machine, Western culture spread across and dominated the world, producing a homogeneous world. In contrast, the new age will treasure the distinct cultures of minority peoples and aim for the symbiosis of distinct cultures."
> (Kurokawa: 1994, 21)

In this regard architecture has transformed from an International style towards an Intercultural style which aims for symbiosis of the universal and the regional. Architecture of the "Age of Life" encourages a diverse environment allowing for a richer existence. This architecture reflects the Buddhist concept of 'the impermanence of all things' and the Japanese belief that shelter must merge with nature and favours continuity with the natural surroundings (Kurokawa: 1994, 92). Borrowing landscapes is a traditional Japanese method for achieving symbiosis with nature, and was essentially the act of incorporating surrounding nature and views into one's personal space (fig. 2.2.1). This technique ultimately reminds the inhabitant to be concerned with the landscape (Kurokawa: 1994, 95) (Kurokawa: 2000, 6).

Fig. 2.2.1- Photograph of the Shugaku-in Imperial Villa, in Kyoto is a famous example of the technique of borrowing landscapes as it uses elements such as mountains which are 10km away in the gardens composition

(Source- Kurokawa: 1991, 117)

It is evident that the 'Philosophy of Symbiosis' is concerned with the concept of interconnectivity pertaining to architecture and nature. This theory clarifies the importance of nurturing the environment for man's survival and expresses this through architectural elements. These include merging internal and external spaces through transparent or translucent materials, framed views of 'borrowed scenery' and the concept that all structures are transient.

The theory of biomimicry acknowledges that man and nature are connected and responds to this by allowing architecture to function as a part of natural systems. Biomimicry is the "conscious emulation of life's genius" (Benyus: 2002, 2) as well as the design discipline that seeks sustainable solutions by imitating natures time tested patterns and strategies. Biomimics are inventors and scientists who have analysed nature's paramount accomplishments and have adapted them for human use. The fundamental belief of Biomimics is that organisms, out of necessity, have already solved many of the problems which man is currently undertaking, such as energy, green chemistry and climate control (Benyus: 2009). For millennia, nature has perfected structures and mechanisms that are more efficient, use less energy and omit less harmful waste than modern technology.

Benyus stated that: “failures are fossils, and what surrounds us is the secret to our survival” (Benyus: 2002, 3). This emphasises the need to work with and learn from nature’s achievements so as to become more accepted on the Earth. This new approach of respectfully mimicking nature’s mechanics is distinctly novel in a modern society which is accustomed to dominating over or ‘improving’ nature.

Ken Yeang claims that designers must study and imitate nature to achieve bio-integration between man’s built environment and the natural environment. He states that “nature without humans exists in stasis” (Yeang: 2007, 21). And to achieve this similar state in human built environment man must design systems to function like ecosystems. Ecosystems have no waste as everything is recycled within. In this regard all emissions which a building produces must be reused and recycled within, and when it is emitted it is regenerated benignly into the natural environment. An ecosystem also uses non-renewable energy sources and materials efficiently.

> “More than enhancing ecological linkages, we must biologically integrate the inorganic aspects and processes of our built environment with the landscape so that they mutually become ecosystemic. This is the creation of human-made ecosystems compatible with the ecosystems in nature. By doing so we enhance human-made ecosystems’ ability to sustain life in the biosphere.” (Yeang: 2007, 23)

The concept of biomimicry demonstrates that when inorganic elements operate as nature does it will result in the ultimate symbiotic instrument. This is relevant as it is necessary to use principles from nature as clues to designing appropriate and responsive architecture. In this regard, designers can replicate nature’s methods of harnessing energy, recycling and emitting waste products, to produce a building which functions as part of a connected ecosystem. (Benyus: 2002, 3) (McDonough: 2002, 30)

The concept of “oneness with nature” is expressed in the ‘Philosophy of Symbiosis’ and is implied in the study of biomimicry. The aforementioned theories express the necessity of society's shift towards a more symbiotic relationship with the environment as it is seen as humanity's only means of salvation (Wines: 2000, 57). In this regard, it is vital that man appreciates the concept of interconnectivity and designs with this concept in mind. Further examples, which demonstrate interconnectivity, will be discussed within the literature review and precedent study.

2.3 Bioclimatic Design

Since the onset of civilisation, humans have constructed ecologically suitable shelters to protect themselves from the elements while modifying the internal climate to improve comfort levels. Regrettably, during recent years, specifically the industrial revolution, architecture has evolved to respond to economic and social criteria, while ignoring climatic factors. In this regard climate dependant form has been rejected by most designers, especially during the modern movement (see literature review in chapter 3) (Hyde: 2008, 8). However, the current "Environmental Age" promoted sustainability, making it evident that it is imperative to obtain a symbiotic relationship between living organisms, buildings and the climate, which is the intention of bioclimatic design.

> "the greatest lesson is the fundamental principle that architecture is at its best when it is working with not against nature. That the severance of the historical symbiosis with climate was achieved at a cost to both architecture and nature."
> (Olgyay cited in Hawkes: 2002, 6)

Bioclimatic principles form the cornerstone of sustainable design and is concerned with improving the health and comfort of the occupant of a building, while enhancing the ecological value of a site (Hyde: 2008, 21). Man's energy, health and comfort are largely dependent on his/her environment. The human body reacts physically and psychologically to reach biological equilibrium, known as the 'comfort zone', so that minimal energy is expended to adjust him/her to the environment. A balanced shelter plays a vital role in reaching this 'comfort zone', which modifies the natural environment to satisfy physiological needs. In this regard the primary intention of a bioclimatic building is to react to the climate and environment by absorbing, filtering or repelling environmental elements depending on their positive or negative effects on human comfort (Olgyay: 1963, 14).

Research maintains that bioclimatic buildings use five to six times less energy than conventional buildings over their lifetime (Jones: 1998, 45 cited in Hyde: 2008, 24). This is realised through the manipulation of the building's microclimate, form and fabric to achieve thermal comfort rather than through the utilisation of mechanical equipment, such as air-conditioning, which incurs large environmental penalties (Hyde: 2008, 24). Bioclimatic design endorses the use of passive design features such as orientation, fabric and form of a building which are suitable for the specific climate of the region. Active systems are also employed, such as photovoltaic panels, mechanical ventilation and evaporative coolers. Air-conditioning is also viewed as an active system utilised to reach the comfort zone, but it should be noted that this alternative is a huge burden on energy supply and exacerbates climate change.

For architecture to fully connect with the environment it must respond to all the parameters of nature, particularly climatic and contextual. *Climatic parameters involve airflow, relative humidity, air temperature, radiation and precipitation* (Hyde: 2008, 301). Once these elements have been analysed and evaluated they will function as determinants of the area's regional characteristics. Accordingly, to achieve regional architecture and improve human comfort and health within the building the above climatic elements must be responded to (Olgyay: 1963, 15). The architectural solutions to these climatic factors will be utilised as comparative measures within the literature review. This will demonstrate the level of symbiosis between architecture and nature for each architectural trend throughout the ages (Vernacular, Modern and Environmental movements), which will essentially reflect man's perception towards nature.

Victor Olgyay, a seminal figure amongst environmentalists and designers, acknowledged the significance of designing buildings to relate to climatology and biology (Olgyay: 1963 cited in Hawkes: 2002, 4). Olgyay noted that human thermal comfort depended on how the building responded to the climate specific to the region. Consequently, Olyay was one of the first to propose the potential of an architecture of regionalism (Hawkes: 2002, 5). Olgay is credited with establishing a bioclimatic chart, that begins to express zones of human comfort in relation to ambient air temperature, humidity, mean radiant temperature, wind speed, solar radiation and evaporative cooling (fig. 2.3.1). The chart functions as a tool to show the designer which strategies to use (such as orientation, shading and form) so that the occupant may reach thermal comfort and to produce a climate responsive building (Turner: 2003, 2). The work of Olgyay suggests that the climate must be analytically investigated, which proceeds through a series of steps to result in a climate responsive and regional design (Hyde: 2000, 17). These steps consist firstly of climate investigation through gathering information on seasonal and daily climatic data, secondly, the utilisation of bioclimatic charts and thirdly, climate modification strategies through architectural solutions (fig. 2.3.2).

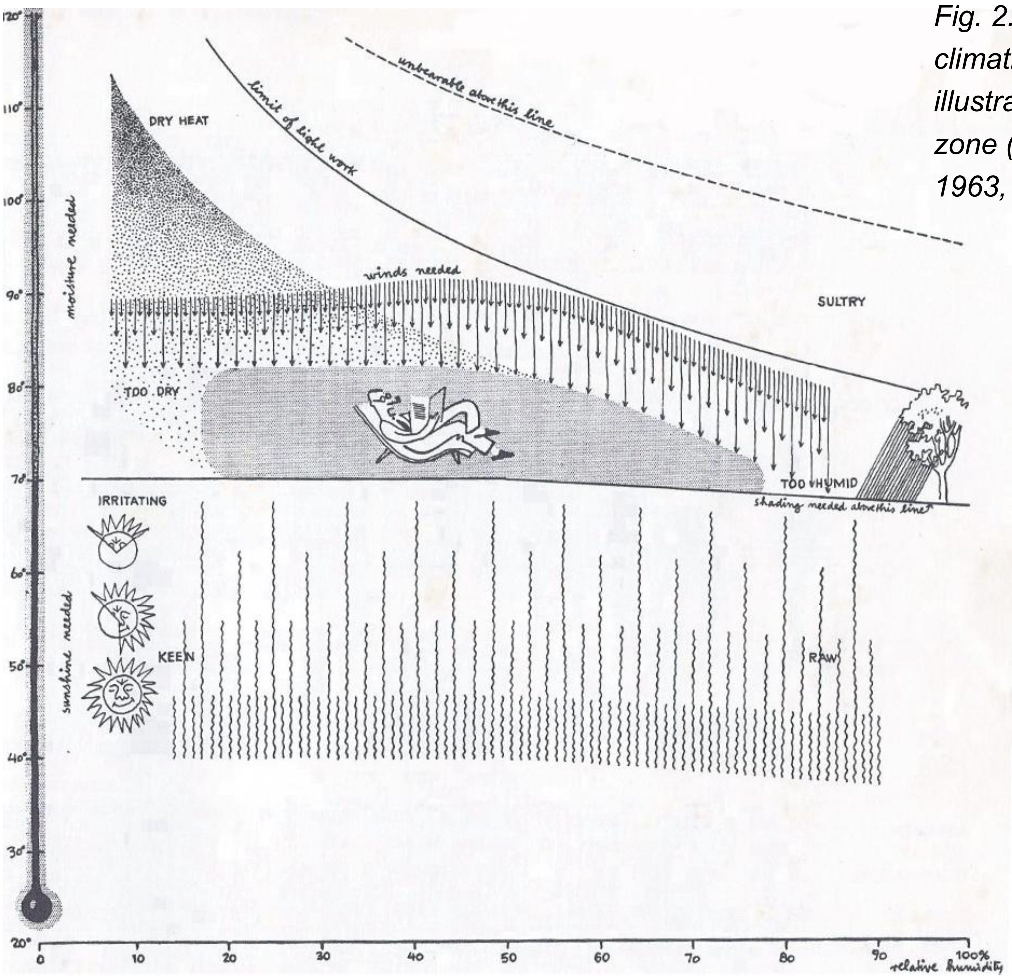


Fig. 2.3.1- Schematic Bio-climatic Chart by Olgayay illustrating the comfort zone (Source- Olgyay: 1963, 23)

The first step, climate investigation, is evident in the table (fig. 2.3.3) and pertains to Durban on a regional or macroscale. It is clear that Durban possesses a subtropical climate with hot and moist summers and mild, dry winters. This data can be plotted onto a bioclimatic chart to identify passive cooling strategies to ensure comfort within the building (this will be done within the design report).

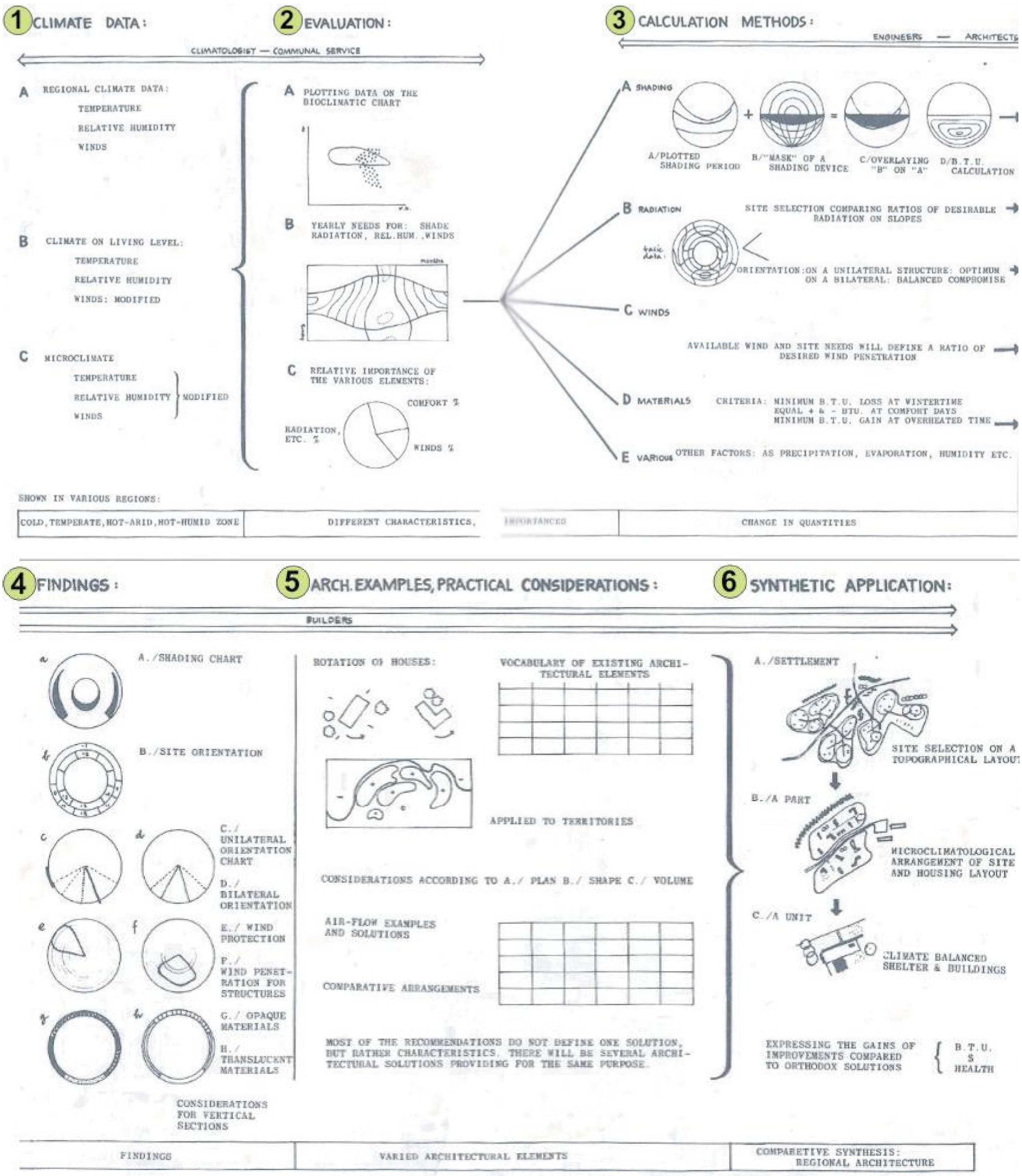


Fig. 2.3.2- Diagram illustrating the steps necessary to determine architectural solutions which respond to the climate (Source- Olgyay: 1963, 12)

	DURBAN
Durban Co-ordinates: 29°58'07"S 30°56'52"E Climate: Subtropical	
CLIMATIC PARAMETERS	
airflow	Prominent NE and SW wind direction and 10 knots speed
relative humidity	73%-83% average: 78%
air temperature	11ºC-28ºC average: 19.5ºC
radiation	6.4 hours of sunshine per day
precipitation	1003mm per annum

Fig. 2.3.3- Table of used to investigate Durban's climate (Step 1) (Source- weatherreports.com: 2010)

The suggested typology set for a subtropical climate in the southern hemisphere is a narrow plan stretching along an east-west axis, orientating the building towards the North and the building should be orientated to capture the prevailing winds. A significant method to maintaining a comfortable internal climate is to protect the building from solar gain by providing sufficient overhangs to the northern facade to exclude summer sun radiation but allow for winter sun penetration as well as sun shading and insulation on the western and eastern side of the building (Hyde: 2008, 232). Additionally it is important to provide a thermal mass to the southern side of the building to allow it to act as a cooling mass as well as incorporate lightweight materials which allows air movement. These principles will ensure a comfortable internal climate through the utilisation of passive design methods.

Architects using bioclimatic design principles mitigate the destructive burden which buildings have on the environment. The aim of this theory is to create an internally comfortable environment by relying on natural climatic cycles rather than artificial mechanical support which uses surplus amounts of energy and produces sealed buildings. The architectural outcome of bioclimatic design is a balanced shelter, at harmony with the natural cycles and functions as a mechanism which shifts depending on the climate to ensure that the comfort zone is reached. It is evident that to achieve a balanced shelter regional climate must be investigated and then responded to by architectural elements. These architectural elements will be exhibited within the literature review and precedent studies.

2.4 Regional Architecture

Regional architecture is regarded as the "architecture of place" (Hyde: 2000, 8), as the form and character is determined by the culture, climate and region specific to the locality. The ancients recognised that regional adaptation was a crucial principle of architecture, which is evident in Vitruvius's writings in De Architecture:

> "For the style of buildings ought manifestly to be different in Egypt and Spain, in Pontus and Rome, and in countries and regions of various characters. For in one part the earth is oppressed by the sun in its course; in another part the earth is far removed from it; in another it is affected by it at a moderate distance" (Vitruvius, De Architecture, Book VI 1934 cited in Olgyay: 1963, 4).

Unfortunately numerous developing countries have been affected by industrialisation and globalisation. This has caused the problems of lack of identity and loss of historical linkages in their architecture, and in essence has resulted in the rejection of climatic dependant forms (Hyde: 2000, 8).

Regionalist architecture incorporates principles of 'spirit of the place' or genius loci to produce a locally contextual and relevant architecture (Yeang: 1987, 13). Architects have the responsibility to create a meaningful place and design for 'dwelling' to occur, which is the word Norberg-Schulz utilises to indicate the true man-place relationship. This can be achieved by giving man an existential foothold over their place by applying theories of genius loci which involves the analysis and understanding of a place's spirit and character so that one can orientate and identify themselves within a space (Norberg-Schulz: 1980, 5). Genius loci is a Roman concept, which the ancients recognised as the "opposite man has to come to terms with, to be able to dwell" (Norberg-Schulz: 1980, 16). They believed that every independent being has its genius (guardian spirit) which determines its character or essence. To wholly understand the concept of genius loci one must analyse the basic relationship between man and his or her existential space. Existential space comprises of "space" and "character" in accordance with the fundamental psychic functions "orientation" and "identification" and is thus not merely a geographical location (Norberg-Schulz: 1980, 5). Norberg-Schulz has interpreted and has been inspired by Heidegger's philosophy on dwelling (from "Poetry, Language, Thought", New York, 1971). He sees existential space and dwelling as being synonymous and in essence is the purpose of architecture.

> Norberg-Schulz claims that man only dwells when: "he can orientate himself within and identify himself with an environment, or, in short, when he experiences the environment as meaningful. Dwelling therefore implies something more than 'shelter'. It implies that the spaces where life occurs are 'places', in the true sense of the word. A place is a space that has character. Since ancient times the genius loci, or 'spirit of place' has been recognized as the concrete reality man has to face and come to terms with in his daily life" (Norberg-Schulz: 1980, 5).

For man to have an existential foothold over a place, the designer must relate the built environment to the psychic functions of 'identification' and 'orientation'. Identification occurs through symbolisation, whereby man translates a meaningful experience or character of the place into another medium such as a building. This is performed so as to enhance the natural character and concretise man's world. Orientation on the other hand depends on a 'good environmental image' which can be attained by using urban design theories by Kevin Lynch. These consist of 'nodes', 'paths', 'edges', 'landmarks' and 'districts' which offers man a sense of "emotional security" (Norberg-Schulz: 1980, 19). Lynch is also preoccupied with the 'character' and 'meaning' of places as he claims that they protect man from getting 'lost' and provide "imageability" (Lynch: 1960, 2). The modern environment evokes a sense of 'loss of place' due to the deficient relationship with the natural world or 'Earth and sky' (Norburg-Schulz: 1980, 190). Norburg-Schulz claims that most modern buildings "exist in a 'nowhere'" which makes human orientation and identification difficult. Lynch claims that poor imageibilty is the cause of this and results in emotional anxiety (Norburg-Schulz: 1980, 190).

Once a place's meaning is captured and gathered the designer may create a 'meaningful' place which obtains a certain sense of character and identity. In this regard the special cultural or environmental place may be celebrated and enhanced as people will have a greater sense of genius loci or a sense of place, allowing them to enjoy the place for its truly valuable qualities. In the case of this thesis the site will be ecologically significant and thus engaging with the places genius loci will contribute to the conservation of the fauna and flora and the ultimate awareness of nature's importance. (Regional architecture and genius loci will be further analysed within the literature review, precedent studies and case studies.)

2.5 Architectural Expression

Architectural expression, in terms of material, form and massing, can be used to communicate the building's intention through symbolism or stylistic expression to create an emotional effect. In the case of this thesis the architectural expression aims to facilitate the connection between man and nature. In this regard it is pertinent to analyse the theories behind organic architecture as well as architectural expression through environmental control systems. The principles relating to Organic architecture is centred around a “significant empathy and bond with nature: designs which are not a conquest of nature but a symbiotic embrace” (Toy: 1993). The theories are concerned with representing the connection to nature as well as repairing the natural balance within the ecosystems which ensures man’s survival on Earth. It was established as a combination of respect towards nature and a celebration of nature’s beauty and harmony, due to nature’s systems, forms and flows being the fundamental and recurring influence (Pearson: 2001, 3). Organic architecture has been described as a “harmonious art” which emphasises that this type of architecture relies on emotion, like art does, to command a response (Toy: 1993). And in this sense organic architecture expresses accentuated curved forms, as seen in Rudolf Steiner’s first (1913-1919) and second (1924-1928) Goetheanums, Dornach, Switzerland (fig 2.5.1) (fig 2.5.2) or emphasised geometries evident in Frank Lloyd Wright’s Falling water (fig 2.5.3). Rudolf Steiner, who is said to be one of the founders of organic architecture, is infamous for his use of colour and sculptural forms which he believed to represent the interrelationship between humanity, nature and the cosmos. Steiner designs represented his anthroposphic architectural theories and Goethe’s studies of biological morphology, which he expressed through unique ornamentation, sculptural form, stained glass and murals. He did not merely imitate natural forms but rather his designs reflected the feelings and impulses experienced through colour and organic form. Steiner utilised tinged coloured glass to artistically make the walls transparent giving the impression that the whole universe is connected with the internal space (fig 2.5.4) (Pearson: 2001, 40)

Fig. 2.5.1- The sculptural form of the first Goetheanum (Source- absoluteastronomy.com 2010)

Fig. 2.5.2- The second Geotheanum expressing Steiner’s use of concrete to create organic forms reminiscent of organisms found in nature (Source- Architecture Week 2009)

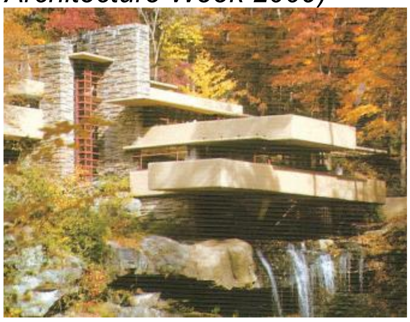


Fig. 2.5.3- Photograph of Falling Water depicting Wright’s use of horizontal and vertical lines to connect the building with the landscape (Source- Glancey: 2000, 162)

Fig. 2.5.4- Photograph of the interior of the second Goetheanum depicting the light from the tinted glass and painted ceiling (Source- absoluteastronomy.com 2010)

Frank Lloyd Wright, on the other hand, used symbolism to represent the man-nature relationship. This is evident in many of his buildings whereby he utilised concrete cantilevers to imitate the way trees support their canopies of branches. Examples of this are visible in George D Sturges Residence, 1939 (fig 2.5.5) and the Administration Building for the Johnson Wax Co, 1939 (fig 2.5.6). The Administration Building contains unique, tapering lily-pad columns which are arboreal in nature. Furthermore, to reiterate the connection between inside and outside, the ceiling is made up of glass tubing which emits diffused light giving the impression of working inside a forest. (Costantino: 1991: 67)

Fig. 2.5.5- Photograph of the George D. Sturges Residence which symbolically resembles the formation of a tree (Source- Costantino: 1991, 66)

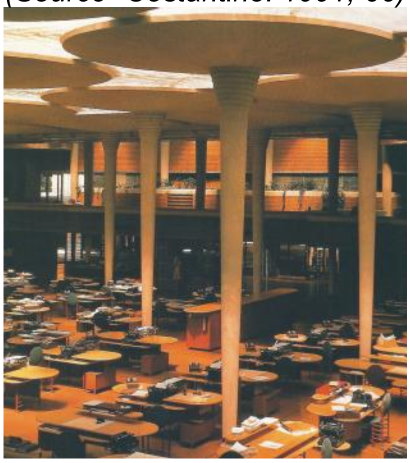


Fig. 2.5.6- Photograph of the Administration Building for Johnson Wax Co. depicting the lily-pad columns and glass ceiling emitting natural light (Source- Costantino: 1991,71)

The fact that many different forms can result from adhering to the principles of organic architecture makes it evident that it moves vaguely from definite style to unspecified concept. In this regard Sidney K. Robinson states that:

> "For some, organic is curved, organic is asymmetrical, organic is natural materials, organic is individualistic, organic is holistic, organic is not mechanical, organic is good." (Robinson: 1993, 1)

Organic architecture was epitomised in traditional structures, where the Neolithic architect utilised local materials and simple form and structures to provide shelter from the elements. Pearson stated that Ancient Egyptian and Greek civilisations studied the geometries of nature and the human body which they incorporated within their temples and shrines and is depicted by Vitruvius's homo quadrates and Le Corbusier's Modular Man (fig 2.5.7). This was achieved by using circles, eclipses, triangle and rectangles which functioned to promote harmony between themselves and the spirits of the Earth and cosmos (fig 2.5.8) (Pearson: 2001, 30). This is depicted by the Golden Section, also known as the divine proportion and distinguishes perfect proportions found in nature. This implies that the utilisation of this principle will link architecture with the environment.

Organic architecture, as a style, re-emerged as a response against modernists expressionist architecture, an example of which, is Ville Savoye which emphasised function and attempted to cater for specific needs rather than imitate nature (Pearson: 2001, 30). This is confirmed in Le Corbusier's famous phrase "a machine for living" (Menin: 2003, 124).

Organic architecture promotes penetrable and reversible spaces as well as the integration of the external world, whereby energies can flow from the interior to the exterior. The building must be able to adapt to changing necessities and seasons and in this respect work with metamorphosis, the process of growth and change (Branzi: 2004) (Pearson: 2001, 3).

A further approach to emphasise an environmentally integrated building is the architectural expression of environmental control systems. These systems, such as ventilation and cooling strategies, permit the building to become a part of interrelated ecosystems while allowing the internal climate to be comfortable without the use of energy sapping air-conditioning or heating. The exploitation of these design elements is vital for the building to function as a vehicle for environmental education and awareness. (See BP building in Case Studies, Chapter 5)

In regard with this specific design dissertation, it is relevant for the architectural expression to communicate its connection with the natural cycles. This expression, whether it is organic or environmental control devices, will emphasise the fact that the building functions as a part of nature. In this respect, the built intervention will operate as a tool to educate society regarding architectural solutions for environmental issues.

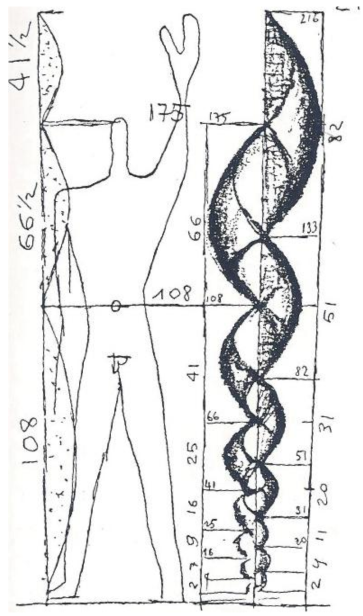


Fig. 2.5.7- Diagram of the Modular Man which is essentially a scale of dimensions which enables man to build with the help of mathematics and is based on systems of proportion in regards to man's height (Source- Le Corbusier: 1960, 159)

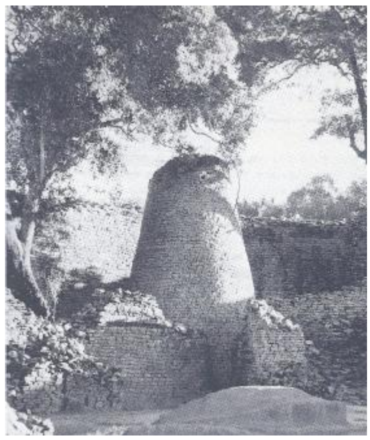


Fig. 2.5.8- The Great Zimbabwe Ruins expresses 'rootedness' to the landscape due to its curved forms and natural, locally available materials (Source- Denyer: 1978, 29)

2.6 Ecological corridors

Richard Register, a world renowned and respected theorist in ecological design and planning observes that cities are the largest of mankind's creations and therefore play a significant role in creating a sustainable existence (Aberley, 1994: 62). In this sense it is necessary to improve the relationship and provide linkages between man and nature within the urban realm. The high inorganic concentration of a building generally incurs a large footprint, which impacts on the location's ecosystem (Yeang: 1996, 102). The naturally absorbent ground cover is often removed during construction and subsequently resurfaced with impervious materials. This hinders any future re-vegetation or arable use as well as prevents the infiltration of rain-fall to return into the groundwater and destroys natural drainage routes. This has long term affects on the locality's hydrological regime which consequently disturbs other ecological factors of the area (Richards: 2001, 9). This facet of environmental planning makes it evident that any built intervention affects all aspects of the ecosystem given its attributes of interconnection. In this regard it is necessary to consider the site as part of a holistic urban layout. The designer must, therefore at the onset of the design process, avoid large areas of impervious surfaces and bear in mind the concept of green 'fingers'. These strips are also identified as ecological corridors which are biologically significant zones running through the city and incorporating the site. These linked linear patches of vegetation function to maintain and improve the biodiversity of the locality by permitting the migration of flora and fauna (Richards: 2001, 9). Biodiversity, is essentially the term used to define the variability among living organisms which are interconnected within an ecosystem and provide genetic wealth within each species. Durban is in a very unique bioregional position where certain climates and species overlap, resulting in rich biodiversity (fig 2.6.1) (eThekwini Municipality: 2007, 21). In this regard, Durban's rich biodiversity must be conserved and enhanced, which can be achieved through proper and appropriate design.

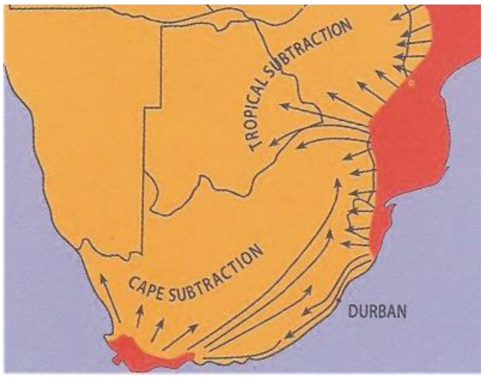


Fig. 2.6.1- Map of Southern Africa showing Cape and tropical sub-traction zones (Source- eThekwini Municipality 2007: 20)

Ken Yeang believes that where possible these organic linkages must be further integrated into the built form through vertical or horizontal landscaping. This will provide new ecological habitats and increase the organic mass in the built environment which is beneficial to the microclimate and macroclimate as it produces more oxygen, absorbs carbon dioxide and reduces overall urban heat-island effects. Yeang has put schemes into place for repairing ruptured ecological corridors, such as ‘landscaped bridges’ and ‘landscaped underpasses’. These are basically vegetated platforms which extent over inorganic zones, such as tarred roads or paved areas, and provide an ecological extension which links green zones. This concept positively contributes to the biodiversity of the locality and in this regard recognises that manmade structures can instigate ecological improvement rather than degradation, through appropriate interventions (Richards: 2001, 10). Consequently, it is crucial to analyse the site in terms of slope, drainage, existing topography and ecological features which will be integrated with the new built form.

An example of a landscaped bridge can be seen at Mile End Park in London, which was severed by a busy road (fig 2.6.2) (fig 2.6.3). The green zones were successfully linked by a 25m planted bridge, which illustrates how to form a fully connected network of ecosystems. The bridge was designed to include retail facilities allowing a source of income to maintain the park. This design element brought life to a neglected environment and has proven to be environmentally, socially and economically sustainable. (Sassi: 2006, 40)

Fig. 2.6.2- Photograph taken from the road of the planted bridge linking Mile-End park and illustrating other facilities such as shops under the bridge which is a source of income (Source- Sassi: 2006, 41)

Fig. 2.6.3- Photograph taken from the planted bridge of Mile-End park (Source- Sassi: 2006, 41)

2.7 Conclusions

The magnitude of interconnectivity must be recognised and translated into an architectural response to achieve a truly sustainable existence with the environment. The 'Philosophy of Symbiosis' acknowledges the importance of interconnectivity of all things and merges biological concepts of organism-organism interactions with traditional theories. This concept conveys the importance of environmental conservation which is believed to be fundamental for a prosperous life. In this sense architecture is regarded as being something which is transient and beneficial to nature. This study guides environmentally conscious architects to consider methods of breaking down barriers between the internal and external environments as well as utilising natural elements in a celebratory manner as a component of architecture. These architectural aspects aid in building society's appreciation for the natural world as the connection between man and nature is enhanced.

Biomimicry expresses the relevance of using nature as an indicator to produce a superior and efficient design. Biomimics maintain that architects can gain knowledge from nature in terms of climate control, energy harnessing and waste recycling, which nature has spent millennia mastering. Yeang claims that man's inorganic products, such as buildings need to become ecosystemic, in their functioning and construction. In this regard, architecture may become part of nature's ecosystems so that it is ecologically beneficial rather than detrimental.

As this dissertation's eventual aim is to produce an architecture which responds to nature's parameters, including climate and context, it was essential to investigate bioclimatic design and regionalism. Furthermore, the environmental issues which global society is confronted with makes it clear that bioclimatic design is exceedingly relevant to architects. Bioclimatic buildings utilise passive or active architectural solutions to respond to climatic determinates. This results in an inorganic structure which is responsible and conservative in terms of resource consumption. This is due to the fact that the occupants within these buildings occupy a certain level of comfort through the thermal capacity of materials which have been specified, the external skin of the building as well as orientation and ventilation systems.

It is evident that a climatic investigation must be performed to sincerely respond to the locality's climate. In this regard, Durban's regional climate has been tabulated and will assist in determining architectural solutions for the final design of this thesis.

The study of regionalism is vital in terms of producing a contextually responsive and responsible design. To achieve regional architecture, the genius loci of the place must be identified and celebrated. In regard with this specific dissertation topic, the locality boasts ecological importance and therefore the architecture must convey this message. This will allow society to observe the place while augmenting a sense of conservation.

Architectural expression essentially communicates the buildings intension. In this regard the architectural expression of this design dissertation will convey man and nature's symbiotic relationship and the fact that the building will be a tool for environmental education. This can be achieved via organic form, materials and massing as well as the showcase of environmental control systems such as ventilation stacks, fans or shading devices.

Ecological corridors or 'green fingers' are an important urban design tool, which improves levels of biodiversity as well as beautifies the city. In regard with this dissertation, Durban exhibits many green zones however they are not efficiently linked. This can be resolved by introducing landscaped bridges or underpasses into the urban design framework. This urban design theory will ultimately enhance ecological value to the locality and consecutively will be beneficial to the microclimate of the site.

The aforementioned theories assist in providing an architecture which is environmentally beneficial and benign allowing for a symbiotic relationship between society and the environment. Subsequently, the theories which have been discussed outline the parameters of nature. These theories can be used as comparable measures for further study within the literature review, precedent and case studies and will result in a design which demonstrates and truly understand these principles.

CHAPTER 3

LITERATURE REVIEW:

THE CONNECTION BETWEEN MAN AND NATURE THROUGHOUT THE TRADITIONAL, MODERN AND ENVIRONMENTAL ARCHITECTURAL MOVEMENTS

3.1) Introduction

The relationship between architecture and society has changed radically since the turn of the Twentieth Century. Architecture was once governed by natural forces, which man recognised as being intrinsic to their ultimate survival. However this connection was severed during the Technocratic Era when architecture began to reflect society's preoccupation with the "Age of Industry and Technology". At present there is a noticeable need to shift course in response to the contemporary "Age of Information and Ecology" (Wines: 2000, 8). This chapter will explore one of the most pressing and complex issues which modern man is currently confronting: how to produce a human habitat which acquires a symbiotic relationship and works in harmony with the natural world. This concern must be addressed by contemporary society so as to guarantee humankind's survival on Earth.

In exploring the above, mankind's perception of their natural surroundings and the manner in which they have expressed the relationship between built interventions and nature will be analysed. Focus will be placed on how architecture has been utilised to function as a vehicle in connecting or separating the inhabitant and the natural world throughout history. For this reason this literature review will investigate the Vernacular, Modern and Environmental Movements. This analysis will be structured in a manner which allows one to compare how architectural parameters; namely materials, built form, spatial organisation, and devices; have responded to or affected the natural parameters; specifically in regards to the climate which includes temperature, precipitation, humidity and airflow as well as context (which have been discussed within the theoretical framework). This will result in the knowledge of how to design a structure which responds to the surrounding environment and modifies the internal conditions allowing for comfortable healthy spaces, without the use of mechanical interventions. Environmentally conscious architecture can 'mend' problems which have occurred during the Modern Movement by reconnecting the built form to the immediate landscape, climate and culture.

Vernacular shelters epitomised environmentally connected architecture, due to early man's perception of nature as part of an inter-related, living ecological system. They recognised this as being intrinsic to their survival and thus worshiped and respected nature's workings

(Crowther: 1992, 6). Regrettably, this perception changed and man's once harmonious relationship with nature was irreparably damaged during the Industrial Era, when Modern Architecture was at its pinnacle. Modern society perceived nature to be an abundant resource, which could be utilised for man's benefit. This was at a time when most architects were strongly influenced by the International Style and were creating mass produced "wasteful dead boxes" (Wells: 1981, 28) which incorporated little contextual and climatic responses. The Modern movement initiated a descent towards the disconnection and the ultimate disrespect amongst modern society and the surrounding nature. Unfortunately this rupture between mankind and their environment has led to global climatic crises, contributing to global warming. As a result of mankind's damaging actions which impact on planet Earth, there is a dire need for a shift of attitude, a new need to reinvent the way mankind lives, functions and interacts with nature (Firsing: 2007, 49). Society is now confronted with solutions in an era known as the Environmental Movement.

The starting point of an inquisition such as this would unquestionably refer to the origins of human's attempts at producing permanent settlements. Mankind has inherited the concept of urban habitation and human imprints imposed on the landscape from the prehistoric world of Neolithic man.

> "It is from this time in human history, that the imprint of man was beginning to emerge in the landscape of nature, and its most characteristic expression- its artifice expressed in the medium of geometry- revealed a dauntless species out to colonise the earth." (Crowe: 1995, preface)

3.2) Traditional Architecture and the Environment

> "Vernacular buildings may be interpreted in one case as an almost direct analogue of the climate of the place in which they are built." (Amos Rapoport cited in Hawkes: 2002, 21)

Early traditional structures, built by empirical architects, are particularly relevant when considering today's current global environmental crises since they can inform the contemporary designer of many essential environmental design principles (Crowe: 1995, 8). This investigation will seek to determine how Neolithic man perceived and responded to the natural forces and how they achieved a man-nature symbiotic relationship. This in essence will exemplify bioclimatic design resulting in regional architecture that is specific to place, thus strengthening theories of genius loci. In this respect, the study will also determine how vernacular structures have utilised architectural parameters; namely materials, built form, spatial organisation and specific devices; to modify internal climate so as to produce comfortable conditions. It is relevant to concentrate on tropical vernacular architecture, as the ultimate purpose of this research is to design a building which is specific to Durban's subtropical climate. Accordingly, examples which express climate modification will be discussed, specifically the structures which have been shaped by tropical climatic determinants, such as the stilt houses of the fishing villages from the eastern coast of African, as well as from east Asia. The Dogon tribes' dwellings also express examples of climate modification and in this regard, will reiterate the importance of bioclimatic design which has allowed the architecture to be specific to its place and region (Denyer: 1978,24).

The vernacular people's existence was attuned to the natural world. The early societies perceived themselves as being a link in a "great chain of being" (Crowe: 1995, 35) whereas modern mans' attitude towards nature is one of opposition and domination. The vernacular domiciles reflect the traditional architects innate sense of harmony with nature as the structures are "of and with nature" (Crowther: 1992, 6) and their methods of construction and technologies bare little intrusion on the environment.

The Indigenous people believed in the interconnectedness of all things, suggesting that "everything affects everything else" (Oppenheimer: 1995, 10). In this regard respecting nature and its power was intrinsic and vital for their existence. This is reflected in their cultures, traditions and architecture. Many dwellings and religious buildings were aligned with the heavens or orientated towards significant topographical features such as sacred places or natural landmarks. In this regard the structures were "integrated with the order of the infinitely larger world outside them" (Crowe: 1995, 30) and connecting the inhabitants to the natural world. Consequently, vernacular dwellings epitomise the philosophy of symbiosis and in many ways are interrelated to the ecosystem.

‘Primitive’ domiciles articulate the environmental wisdom of its designers, which can be seen in its response to its surrounding conditions, circumstances and influences, resulting in a built form which is climatically and contextually attuned to its specific region (Turan: 1990,8). Vernacular buildings are customarily constructed by using traditional technologies to meet specific needs, including human comfort and social values. For cultures in different climatic regions around the world, this design response will vary for instance.

One of the first forms of shelter was a temporary dwelling used by nomadic hunter gatherers (fig.3.2.1), which was, along with the domestication of migratory animals the first realisation that “humans could manipulate nature in a permanent way to their advantage” (Crowe: 1995, 29). When man passed into the Neolithic age of agriculture and settlements, the wandering hunter-gatherer converted to a permanent way of living in fixed dwellings.

Fig. 3.2.1- illustration of a nomadic hut from North Africa (Source- Lauber: 2005, 25)

> “Such events led the way to the creation of permanent settlements and the development of architecture, an invention that would become the archetype for myriad means to circumvent the unpredictability of nature “(Crowe: 1995, 21).

Fixed dwellings permitted the designers to obtain a certain amount of control over their immediate environment, through the decisive rearrangement of natural materials to suit their specific needs. In this sense vernacular built forms and settlements can be identified as a “new nature” (Crowe: 1995, 30). The domiciles, which will be discussed, reveal the indigenous people’s need to “transpose the system of the universe onto the built form” as the roof metaphorically represents the sky, the smoke hole as the sun, the walls as the boundary of the cosmos and the floor represents the earth. Thus further reiterating the strong link between man and nature (Crowe: 1995, 30).

Each domicile was evolved and perfected through traditional processes entailing trial and error, being refined over time by necessity and being passed down through the generations.

Slight and gradual modifications were made to the designs and structure, to suit the social or climatic changes in the region.

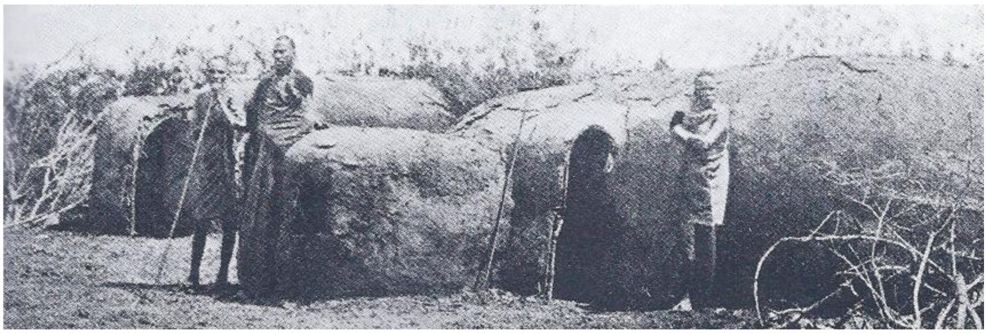
> "In this respect these domiciles are like living organisms, able through the ingenuity of their occupants to incrementally adapt to their environment so long as they remain essentially as they were from beginning, delicately and inextricably connected to the natural world around them." (Crowe: 1995, 38)

In this regard the dwellings may be seen as extremely evolved examples of essential shelter. The domicile's direct, intricate, and sensitive relationships with their surrounding environment functions as a relentless reminder to those who live in them that there must always be a "consummate resonance between what they build and nature" (Crowe: 1995, 38). More than the basic requirements of shelter, the dwellings represent man-made order constructed in response to a substantial and immediate world of nature (Crowe: 1995, 38).

Vernacular dwellings are built to serve a number of various functions, including fundamental shelter and security, as well as to provide acceptable living conditions in relation to the region's climate. Vernacular architecture mastered the art of modifying the internal climate of a dwelling by utilising local and appropriate materials, taxonomy of forms and specific techniques or elements which contribute to the micro-climate of the dwelling. Traditional architecture responds to specific environmental determinants depending on the geographic location and climatic factors of an area. This provides the built form with a sense of regional expression. (Oliver: 2003, 130)

Locally available materials were selected from the surrounding environment for their thermal performance and climatic suitability. Generally, natural materials which are used for 'mass construction' such as earth or clay, are utilised in dry, hot climates. The mud brick walls, in this regard, are slow to transmit heat during hot days (interior remains cool) whilst act as a heat source during cold nights (interior warms up at night) (Kahn: 2000, 8-18). In the dry arid climates, massive clay construction is the most ecologically sensible way of producing

Fig. 3.2.2- Photograph of the Masia's mud shelter (Source- Denyer: 1978, 105)



comfortable internal spaces. Examples of this can be seen in the mud 'barracks' of the Masai people from East Africa (fig. 3.2.2), which share similar properties to the rammed earth dwellings of the Dogon people from West Africa and Morocco in North Africa (fig. 3.2.3) (Lauber: 2005, 66-68). The lesson which must be gained from the analysis of these mud brick vernacular dwellings is that a comfortable internal temperature was achieved by passive means, without the consumption of fossil fuels or the expenditure of energy, which many modern technologies require (Oliver: 2003, 130). Vernacular architects created, what Crowe called, "low-energy societies", which utilised passive design elements to provide high levels of comfort for the inhabitant (Crowe: 1995, 35). Obviously the principles which are advantageous in arid regions are not suitable for tropical regions, where the temperature and humidity are high during both the day and night. In this context the materials used in the regions would be light weight timber frames with infill panels, usually of wattle and daub or bamboo, which all possess properties of low heat absorption and retention and allow for ventilation (fig.3.2.4).

Fig. 3.2.3- Photograph of the Dogon mud shelter (Source- Denyer: 1978, 24)

Fig. 3.2.4- photograph of bamboo construction illustrating the quality of lighting and ventilation (Source- Lauber: 2005, 47)

Bamboo is recognised to be an ecological building material given its ability to grow quickly and is used frequently in tropical regions as they are readily available and have a low thermal capacity (Denyer: 1978, 97). This is also due to the fact that the most common method of construction in the tropics is the lightweight rod structure, which utilises local hardwood timber, such as bamboo. This is evident in the Palace of Bandjoun, Cameroon, where materials and construction methods have been used to create a cool, well ventilated internal environment (fig. 3.2.5). In this hot and humid climate ventilation and protection from solar radiation is imperative. This has been achieved by utilising a 'house-within-a-house' plan, which is essentially the layering of skins. In this instance the palace's outer skin is made up of lightweight bamboo canes with mat walls, that forms a buffer or 'brise-soleils' allowing for ventilation and filtered, indirect light. This skin is protected from precipitation by large overhangs, supported by loggia which runs around the building. The main internal space is enclosed by solid clay walls, which act as cool sinks, as the high thermal mass of the clay is protected against solar radiation by the lightweight 'veranda' space (fig. 3.2.6). This type of construction has provided a model for the veranda style colonial buildings of the 19th Century (Lauber: 2005, 46).

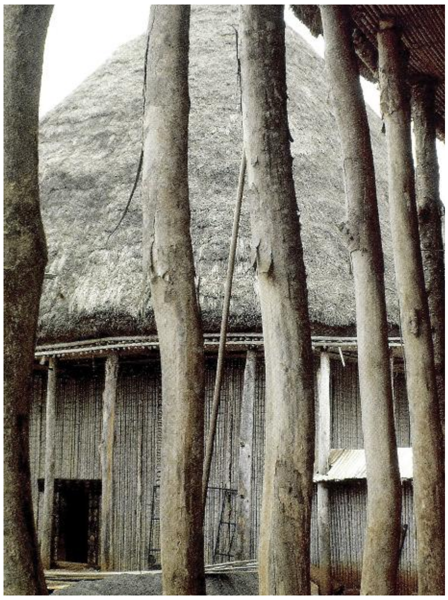


Fig. 3.2.5- Photograph of The Palace of Bandjoun, illustrating the use of bamboo (Source- Lauber: 2005, 48)

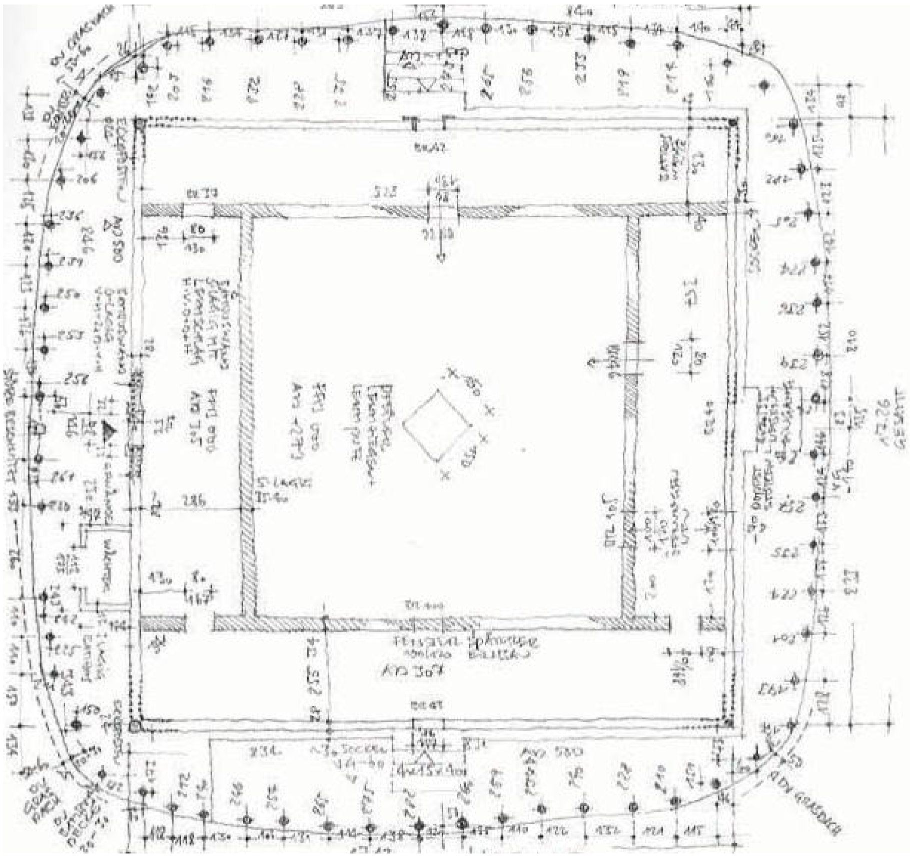


Fig. 3.2.6- Plan of the Palace of Bandjoun, illustrating the '3 skin' construction (Source- Lauber: 2005, 47)

Stilt-houses in a fishing village on Lake Ganvie, Benin, on the eastern boarder of Togo, illustrates that plant materials such as bamboo cane, grass mats and palm-leafs can provide a comfortable internal environment. This is due to the lightweight qualities of the thatched and reeded finishes which were used throughout to improve the 'breathing' capabilities of their structures (fig.3.2.7) (Lauber: 2005, 52). Oliver sums up their dwellings as follows:

> "The houses of the Ganvie are admirably adapted to provide the best possible comfort conditions from available materials, which are all obtained from the trees and grass in the region" (Oliver: 1976, 43).

Fig. 3.2.7- Photograph of the use of light weight materials by the Ganvie people (Source- Oliver: 1976, 43)

The built form also contributes to climatological performances. For example the built form allows for climatic modification of the Dogon people's shelters to provide comfort. The Dogon people used the 'reduit' principle, whereby internal core living spaces are protected by buffer zones, such as storerooms and grain store (fig.3.2.8). In this manner the traditional core houses echo the termites nest (Lauber: 2005, 66).

Fig. 3.2.8- Sketch of the Dogon's method of 'core living' (Source- Lauber: 2005, 68)

However, South East Asia possesses a very difficult climate as it has a very high level of humidity and high temperatures, both day and night. This has been dealt with by altering the building form to make it climatically responsive. The climatic adaptation includes positioning the structure onto stilts thereby raising the living space and augmenting ventilation, as at ground level the breezes are often restricted by the low bush growth. The large thatched overhangs provide protection from the heavy rains as well as from the solar radiation. Ventilation is obviously vital for the comfort of the inhabitants as it negates the effects of the high humidity levels (Olgyay: 1963, 10). In this regard the structure was permeable due to its open plan and woven mat external skin. As the structure is raised, air can pass underneath and cool the material as well as permeate through the timber flooring. The unique roof structure, which is steeply pitched with large decorative vents at the top, permits warm air and smoke to rise up and out of the plaited vents (fig. 3.2.9). The response to this difficult climate is 'openness' and 'lightness', which has become the architectural mode of expression (Lauber: 2005, 57). The climatic adaptations have very similar characteristics to the architecture of the Ganvie people as their response was also to raise the buildings on stilts, to increase airflow and improve evaporative cooling (fig. 3.2.10). This conveys 'parallelism' as both societies responded to similar climatic determinants. (Prof. Adebayo: 2008).

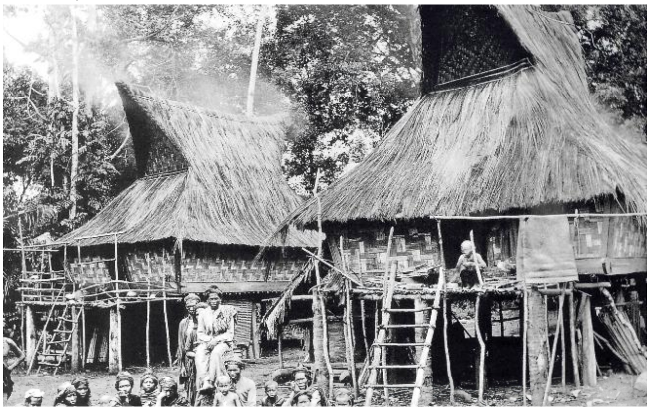


Fig. 3.2.9- Photograph illustrating the climatic response of the South East Asian houses (Source- Lauber: 2005, 57)

Fig. 3.2.10- Photograph of the Ganvie people's dwelling expressing 'parallelism' (Source- Lauber: 2005, 40)

Regarding Spatial organisation, houses which are located in arid regions are generally stacked several stories high, which permit a small site area with a highly dense and vertically compact settlement which is suitable for steep terrain. This is climatically advantageous as the well shaded narrow lanes and squares create cool and comfortable gathering and working spaces. The winding routes also form barriers from sand and dust that is carried by the wind (Lauber: 2005, 6-66). These qualities are evident in the Dogon villages, which cling to the Bandiagara escarpment and comprise of closed building forms with few openings (Denyer: 1978, 67) (fig. 3.2.11).

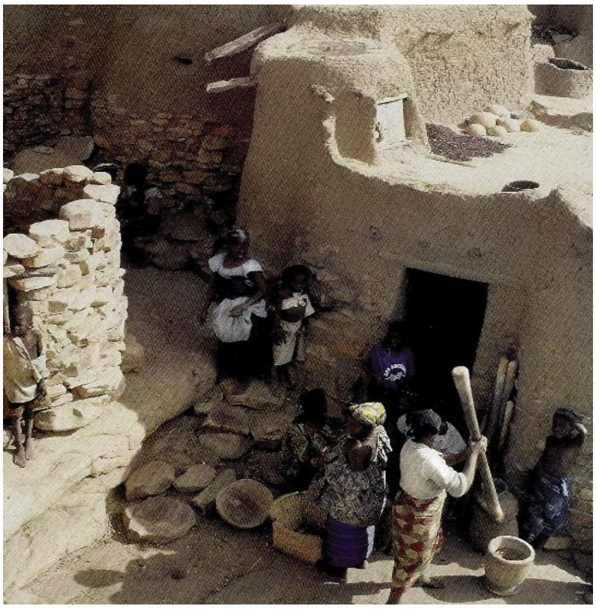


Fig. 3.2.11- Photograph expressing the Dogon people's spatial organisation and shaded streets (Source- Lauber: 2005, 65)

Fig. 3.2.12- Photograph expressing the Ganvie people's dependency on their canoes which resulted in organic planning (Source- Lauber: 2005, 53)

On the other hand, the Ganvie people responded to their surroundings in a very different manner due to the fact that the tropics are climatically hot and humid and the environment is waterlogged and overgrown. As a result their houses were built entirely on stilts over the water and were accessible by dug-out canoes which were 'parked' beneath the houses (fig. 3.2.12). The houses always had access to an external platform or veranda, where most of the daytime activity occurred and which supported outdoor living (fig. 3.2.13). Verandas were often utilised as climate modification tools in vernacular architecture and were widespread throughout the world. These spaces were mostly covered and raised to facilitate shading and breezes where social interaction through outdoor activity, working and sleeping could occur. Verandas were often shared by more than one family which encouraged communal living and functioned similarly to a courtyard (Oliver: 1976, 43). Consequently the Ganvie people's shelters demonstrate how comfort can be reached in a hot and humid region through passive cooling and ventilation solutions that do not utilise energy from fossil fuels. (Oliver: 1976, 43) and (Bridge: 2007, 91).

Fig. 3.2.13- Photograph of a veranda which the Ganvie people use a mulitfunctional space (Source- Oliver: 1976, 132)

Courtyard houses are distributed throughout the world and encompass slight regional variations. Courtyards are associated mainly with Arabic or Islamic buildings in North Africa, however they are also located in regions such as India and the Middle East (Bridge: 2007, 71). Courtyards were developed as a response to social and climatic factors. Socially, courtyards provided a sense of community where gatherings could occur, often for religious reasons (fig. 3.2.14). The space also offered women protection and security, specifically in Arab regions (Oliver: 2003, 136). As a climatic response courtyards varied depending if the region possessed a hot and dry or hot and humid climate. Courtyards in drier regions tend to function as a cool sink for the adjacent rooms. In this respect the design solutions include compact form and materials with high thermal mass for radiant cooling (Hawkes: 2008, 328). It was common in hot arid regions to find small, compact courtyards, known as 'sky wells' that restricted the infiltration of solar radiation and induced ventilation (Bridge: 2007, 71). In humid regions, where ventilation is essential for cooling, courtyards are used to operate as air funnels (fig. 3.2.15) (fig. 3.2.16). The upwind flow of the air funnel promotes cross-ventilation, creating different pressure fields, which

Fig. 3.2.14- Photograph of a courtyard at Hausa Palace, Nigeria used for social gatherings (Source- Denyer: 1978, 177)

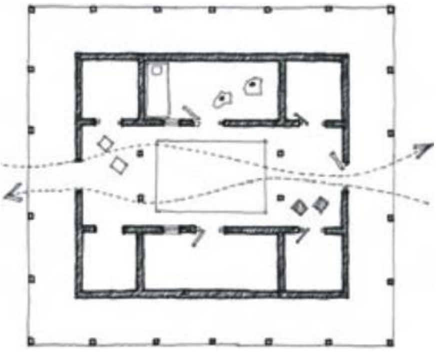


Fig. 3.2.15- Plan of a typical courtyard dwelling in Sri Lanka illustrating how an air funnel would work (Source- Hyde: 2008, 328)

basically causes the 'Venturi' effect and assists in the stack effect due to thermal buoyancy of the air. This removes warm air from the courtyard which provides passive ventilation and cooling (fig. 3.2.17) (Hyde: 2008, 328).

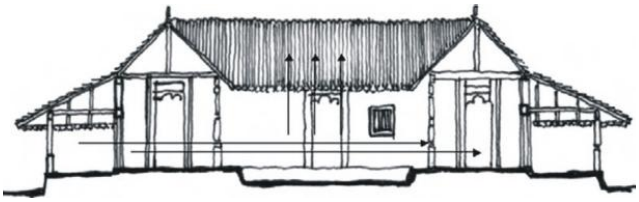


Fig. 3.2.16- Section of a courtyard house in a tropical region which utilises principles of an air funnel for passive ventilation and cooling (Source- Hyde: 2008, 328)

Fig. 3.2.17- Section illustrating how air pressure facilitates the stack affect (Source- Hyde: 2008, 330)

In Southern Nigeria, the Benin house's courtyard possesses an impluvium, an ingenious method of drainage and water collection. Impluvia are drained via gutters constructed by stems of paw-paw trees, which rot leaving a drainpipe. This water was collected and stored for drinking purposes. Additionally Impluvia provide a sense of being part of the natural cycles given the fact that rainwater levels are visible (fig. 3.2.18) (Denyer: 1978, 84). It is evident after studying the spatial organisation that social interaction usually occurs outdoors, be it in courtyards, on the narrow shaded streets or verandas as it is much cooler due to shaded spaces and breezes. In this respect, it is essential to provide an outdoor gathering space for comfortable socialising. This also allows for further physical connection between man and nature.

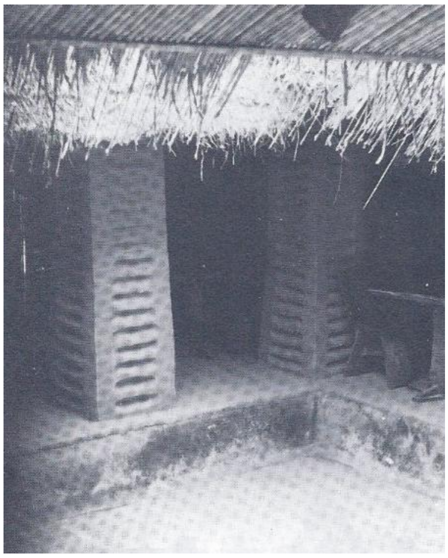


Fig. 3.2.18- Photograph of the Benin house's (Nigeria) courtyard possesses an impluvium (Source- Denyer: 1978, 84)

In addition to materials, built form and spatial organisation, vernacular architecture also used devices to modify internal climate. This is evident in the use of decorated screens called a *shamashil* or *ursi* in hot desert zones. The screens are geometric lattices which function to filter cool air into the building while preventing direct sunlight and glare into the space therefore maintaining a cool and comfortable internal climate. In Saudi Arabia, rowshin box-frames are utilised, which are projected beyond the walls creating a cool and ventilated gap between the skin of the wall and the screen where sleeping can occur (fig. 3.2.19). These provide similar climatic solutions to a courtyard (Oliver: 2003, 135). One of the most ingenious and widely-used climate modifiers is the wind-scoop (fig. 3.2.20). This method of ventilation and cooling is used from North Africa to Pakistan, generally in regions which experience an arid climate, but can be utilised in tropical regions where ventilation is imperative for providing comfort. The wind-scoops collect breezes above roof level and diffuse them into the living spaces. Wind-scoops adopt various forms depending on the region and culture. Wind-scoops in Hyderabad are constructed of stretched fabric over a cruciform frame which can be closed or opened depending on the inhabitants needs. Badgir (wind catches) of Iran, Iraq and the Gulf of the States is a more sophisticated structure and was used in Mosques and houses of the wealthier members of society. The Badgir is essentially a tower with a row of vents which catch the prevailing wind and direct it down the shaft. Often the air which is pulled into the dwelling is warmer than the air in the house. In this regard water vessels or moist straw is placed by the openings of the shaft to enhance cooling. (Oliver: 2003, 136)

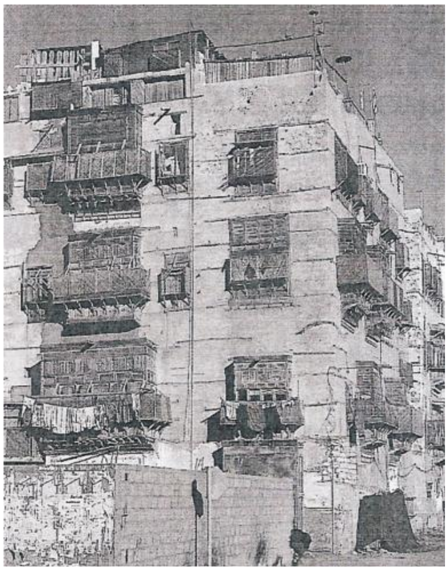


Fig. 3.2.19- photograph of the row-shin box frames (source- Oliver: 2003, 138)

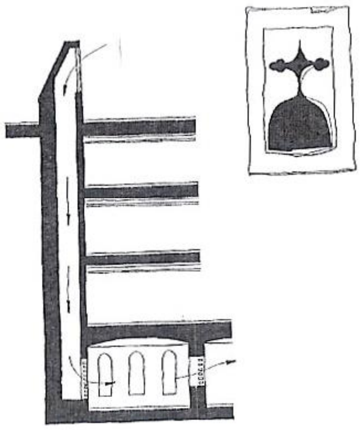


Fig. 3.2.20- A general illustration of the a Badgir (wind-scoop) (source- Oliver: 2003, 141)

Climates are generally stable to a certain extent and follow diurnal and seasonal variations. But often extreme climatic variations are experienced whereby temporary add-ons are needed to ensure the comfort of the occupants. This demonstrates the advantages of the nomadic non-permanent structure, which may seem architecturally rudimentary but are very effective in terms of climatic control. This is due to the temporary structures ability to "exploit the prevailing conditions to the greatest advantage" (Oliver: 2000, 133). The flexibility of the structure is also relevant as the walls can be raised or closed and openings can be made depending on the wind, rain or solar needs. This traditional design principle makes it evident that contemporary architecture should not only respond to its climate in a fixed 'passive' manner but should also be able to transform with the external conditions of the environment causing it to become a "climatic machine" (Fromonot, 2003: 50).

The fact that vernacular architects recognised prevailing climatic conditions to be a major design determinant, as well as the fact that the occupants respected interconnectivity with nature allowed for vernacular dwellings to effortlessly integrate themselves with their environments. In the context of society's need to 'regain man's sense of the natural world', the review of the origins of permanent shelter conceived by the vernacular architect was essential. The indigenous dwellings were paradigms of environmentally responsive and regional architecture as they were perfectly adapted to their climate and well attuned to their context (Oliver: 2003, 130).

The 'primitive' principle that architecture was "part of nature" ultimately produced a "low energy society" (Crowe: 1995, 35 and 32). This is due to the use of passive design and climate modification methods to ensure comfortable and healthy living spaces. Vernacular architecture revealed many intrinsic indications for designing appropriate environmentally sensitive architecture which responded directly to the specific region's climate; namely solar radiation, humidity, temperature and air movement as well as contextual parameters.

Vernacular cultures chose materials for their availability and climatic responsiveness regarding thermal capacity in terms of their ability to function as heat or cold store and to permit air movement, depending on the locality's climate. In hot and dry climates vernacular architects often utilised earth or stone as materials. This is evident in the shelters of the Dogon or Masai people. Whereas, lightweight materials were used in humid regions, such as timber and grasses to allow ventilation and due to the materials low thermal capacity.

This was apparent in the Ganvie people's dwellings found in Togo and the shelters particular to the tropical regions of South East Asia. The Palace of Bandjoun, Cameroon, represents an ingenious climatic response, whereby both timber and clay materials were used. The timber loggia offered an outer skin which sheltered the thick clay walls, which consequently remained cool and therefore functioned as a cool sink.

The built form of vernacular buildings also differed greatly from region to region, thus representing design responses to climatic determinants. The Dogon people from dry hot regions utilised the 'reduit' principle with few external openings and compact form to keep the internal core cool. However, the built form found in tropical regions utilised large overhangs and screens to prevent solar gain and protection from heavy rain. The shelters were often placed on stilts and had steeply pitched roofs with vents to augment ventilation and provide healthy comfortable internal climates.

Spatial organisation played an additional role in responding to the regions climate. Clustered settlements, found in arid regions, provided narrow shaded streets, where comfortable gathering can occur, whereas widely spread settlements allowed for natural ventilation. Courtyards and verandas were utilised to modify internal climate as they both promoted passive ventilation and cooling. Additional devices such as various types of screening and wind scoops were utilised in desert zones to produce comfortable internal conditions.

3.3) Modern Movement and the Environment

> "As we have progressively perfected our world, it has moved us farther from the nature that once served as the paradigm for its creation" (Crowe: 1995, preface).

The development of technically advanced societies, ever expanding cities and an environmentally unaware population has resulted in a society which became completely disconnected from nature. Ancient wisdom kept society linked with nature; for instance early man believed that repercussions would be felt if man impacted negatively on the natural environment. Regrettably, the notion that nature is interconnected with the man-made environment has faltered, predominantly due to modern society's domination over the natural world and it's greedy exploitation of the planet's natural resources (Connors: 2007). The increasing fissure between modern man and the natural environment has been responsible for the current environmental degradation and global crises.

> "The big rupture came in during the 19th Century with the steam engine, fossil fuel age and the industrial revolution... Nature was converted into a resource which was seen as eternally abundant." (Nathan Gardels cited in Connors: 2007)

In the early 1900's, the connection between man and nature was irreparably ruptured by the commencement of the modern movement. Modern architects rejected classical and traditional teachings and knowledge, which had been tried and tested for generations, and adopted design principles which disengaged and dominated the environment. The modern movement focused on a purging of tradition so as to emphasis the notion of a "society reinventing itself" (Crowe: 1995, 152). The prevailing intention of the modern movement was to purify the man-made world of its alleged 'clutter' by eliminating all elements which could not be associated with steam, electricity and mass production (Heynen: 1999, 73). Architecture of the time became a celebration of the pure, simplified and functional nature of the Modern Industrialised world (Crowe: 1995, 152). Architect, Theo Crosby described the Modern Movement as "an attempt to adjust architecture to new technologies" where methods of mass production were utilised to quickly construct affordable buildings. This was essential during the post-war building boom, when there was an extreme shortage of housing, but unfortunately resulted in an unavoidable lack of flair and originality which had been prevalent in classical architecture. Mass production permitted buildings to exhibit an unprecedented scale and could be ‘plugged-into’ its context, and in this respect rejecting theories on rootedness (Knevitt: 1985, 12). In 1980 Herman Bahr became aware that society needed to experience change in the form of ‘emptiness’. Bahr “advocated a new beginning, based upon the rejection of the old” thus embracing the sense of innovation, which was ubiquitous of that era (Heynen: 1999, 73). Crosby believed that predominant underlying key elements of the modern movement, such as “man is at the centre, bigger is better, history is bunk and the city is evil”, guaranteed the further depredation of the urban environment (Knevitt: 1985, 14). Cities were carved up to accommodate large roads to allow for universal mobility and the development of skyscrapers because ‘bigger was seen as being better’ (Knevitt: 1985, 14).

Buildings became ‘look alike’ and cities lost their character and scale (Wells: 1981, 5). Rationalisation and simplification of form resulted in what Frank Lloyd Wright called “coffins for living” (Wells: 1981, 28) which had little connection with the surroundings and were environmentally destructive. Classical principles were abandoned and precedent in any form avoided. This resulted in “rootless theories of proportion and scale, of composition and form” (Wells: 1981, 44), which set the scene for modernity’s demise (Heynen: 1999, 12). In Martin Heidegger’s lecture titled ‘Buildings, Dwelling, Thinking’ he stated that Modern Architecture resulted in social problems such as “homelessness” and a society which no longer knew how to ‘dwell’ (Heynen: 1999, 15). Many critics of the Modern Movement believed that the functional, modern buildings which swept the Western World at the beginning of the 1920’s were empty and meaningless shells (Theodor Adorno cited in Heynen: 1999, 16).

> “Modern individuals experience themselves as ‘rootless’: they are not in harmony with themselves and they lack the self-evident frame of reference of norms and forms that one has in society where tradition prevails.” (Heynen: 1999, 27)

Norburg-Schultz considered these social problems to be caused by the functionalist architecture of the time and the fact that the modern movement, specifically the international style, evaded the fundamental task of architecture. This consisted of making the genius loci of the site visible and emphasising the relationship between man and place. Norburg-Schultz saw these problems as being of a temporary nature (Heynen: 1999, 19). Christopher Alexander regarded modernity as a: "sort of temporary aberration, as though humanity had gone off course and had to be persuaded to cast aside this heresy and base itself once more on a holistic world view. In most cultures up to about 1600, he argues, a world view prevailed by which man and the universe were seen as more or less interrelated and inseparable. Modernity, perhaps unwisely, departed from that idea." (Christopher Alexander cited in Heynen: 1999, 20)

> "The Industrial Revolution ushered in man's ability to manufacture all his material needs and to control his environment. The achievement of such aims, however, cannot be made without cost; the cost, which we are heirs to, has been that the twentieth-century man, far from exercising total mastery over industry and technology, has had to succumb to control by technology itself." (Knevitt, C. 1985, 11)

In the late 18th Century the Industrial Revolution made a great impact on the building industry. The Industrial Revolution allowed for new technologies and materials, such as glass, cast iron and steel, which were utilised to construct structures of unimaginable size and form. Architects and engineers were employed to build tunnels, bridges and highways to cater for the increasing amount of public infrastructure, as well as privately owned vehicles, which ultimately resulted in urban sprawl and disjointed cities (Hawkes: 2002, 63).

The Industrial Revolution and subsequent technological advancements allowed for the construction and use of buildings which were taller than four story walk-ups, resulting in the development of skyscrapers. Modern, glass and steel skyscrapers generally rejected notions of bioclimatic design and regionalism. An example of this is Mies van der Rohe and Philip Johnsons' Seagam Building (1958) in New York City (fig.3.3.1). The electrical elevator made it possible for skyscrapers to be accepted by the public and also led to sealed internal environments (Knevitt: 1985, 57). Other technical advancements were vital for the development of skyscrapers, such as electric lighting which made it possible to use the building after daylight hours and allowed for efficient use of deeper floor plans. In this regard inhibiting natural daylight to enter the building and wasting large amounts of electricity. Skyscrapers had to become sealed, controlled environments mostly due to the problems caused by air entering at the entrance level which turned the lift and ventilation shafts into "vertical wind tunnels" (Knevitt: 1985, 57). Therefore revolving doors were used to create a 'sealed building' with little air movement and ventilation, consequently, resulting in the need for air conditioning. Christopher Day labelled theses structures as "Energy-expensive sickness incubators" (Day: 2004, 49). As the buildings became taller, the construction methods altered from load bearing brickwork to lighter steel frameworks and glass so as to reduce the load on the frame and foundations. The loss of mass resulted in loss of thermal capacity and accordingly there was a need for artificial heating and cooling (Knevitt: 1985, 60). Consequentially, the occupants of the buildings became disconnected and unaware of their disastrous effect on the natural environment, while exploiting non-renewable resources.

Fig. 3.3.1- photograph of the Seagram building (Source- http://www.skyscraper.org: 2004)

The international style was a major architectural style of the 1920s-1930s. The term usually referred to the buildings and architects before World War II during the influential years of Modernism. Phillip Johnson and Russell Hitchcock identified characteristics which were common in Modernism throughout the world, which included a radical simplification of form, a rejection of ornament, an adoption of glass, honest expression of construction, acceptance of industrialised mass production and the representation of the machine aesthetic. The International Style could be applied anywhere in the world and in this respect exasperated issues of rootless, uncontextual and unclimatically responsive architecture. Architects of the Modern Movement rejected any notion of national or regional identity, which resulted in row after row of unoriginal glass boxes which needed to be artificially heated and cooled. This wasted large amounts of energy, separated man from nature and resulted in unhealthy and uncomfortable living and working conditions (Wells: 1981, 28). Furthermore, Norburg-Schulz believed that the modern environment expressed symptoms of loss of place:

"Lost is the settlement as a place in nature, lost are the urban foci as places for common living, lost is the building as a meaningful sub-place where man may simultaneously experience individuality and belonging. Lost is also the relationship to earth and sky. Most modern buildings exist in a "nowhere"; they are not related to a landscape and are not to a coherent, urban whole, but live their abstract life in a kind of mathematical-technological space which hardly distinguishes between up and down." (Norburg-Schulz: 1980, 190)

Le Corbusier, One of the prominent leaders in the Modern Movement, coined the phrase "machines for living" (Happauf: 2005, 142) was known as a classical functionalist. He designed buildings by following the strict rules of the International Style (especially in his early works) which resulted in white-washed, geometric, simple and stark architecture. Le Corbusier, like Aalto, knew the benefits of uniting man and nature. He believed that this could be achieved through architecture by following mathematical laws seen in the human body and nature, which he emphasised by developing of the Modular scale (fig. 3.3.2). The Ville Savoye (1929-31) (fig 3.3.3) is a prime example of the use of the Modular, which conveys rational form, geometry and order, which Le Corbusier believes is found in nature and in this regard connected the natural world and inhabitants. The house was built for mass production and Le Corbusier believed that it is a "machine for living" which, like a product of natural selection, would work as effectively as possible (Menin: 2003, 124). Critics have compared the house to an "unearthly machine" which is poised on its pilotis, ready for lift-off. The machine-like symbolism is further evident in the strip windows that give the impression that the environment is being

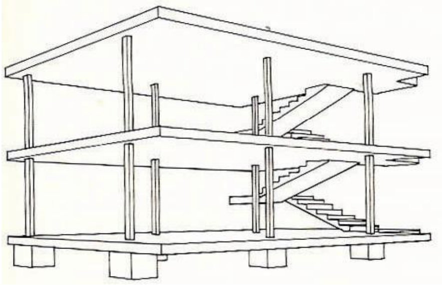


Fig. 3.3.2- an illustration of Le Corbusier's 'Dom-ino' paradigm expressed his preoccupation with the modular and mass production using steel and concrete (Source-Knevitt: 1985, 153)

Fig. 3.3.3- a photograph of Ville Savoye illustrating Le Corbusier's use of rationalised form (Source- Glancey: 2000, 182)

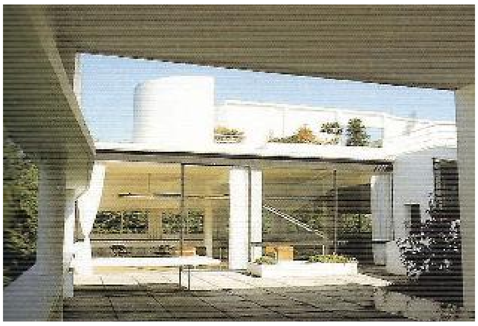


Fig. 3.3.4- a photograph of the Ville Savoye's roof garden and predominant use of glass (Source- Menin: 2003, 125)

viewed from a fast moving car or alternatively, from First World War protective bunkers (Farmer: 1996, 118).

In the Ville Savoye (1929-31), nature was introduced in a more cerebral manner, “through games and allusions” as Le Corbusier depended heavily on geometry to conjure nature. This is apparent in his use of roof gardens, glass which facilitates the blurring of boundaries, concrete which he felt was a natural material and framed views of natural landscapes (fig. 3.3.4) (Menin: 2003, 141). However, the Chapel of Notre-Dame-du-Haut at Ronchamp (1954) connected man and nature in a more direct way. This is clear by the use of organic form, the crab shell-like roof and the symbolic representation of the female body (fig. 3.3.5). Furthermore, Le Corbusier celebrated water, which was seen to be symbolically linked with The Virgin Mary. He achieved this by designing gargoyles, which were shaped like abstracted breasts and the rainwater was stored in a womb-like form cistern. The external wall of the church protrudes at the point of the cistern, which is reminiscent of a woman’s pregnant stomach. Rough plaster is used on the walls which can be likened to the skin of a woman (Menin: 2003, 107) (fig. 3.3.6). Le Corbusier designed the church to function as a sundial marking time and the rhythms of nature, therefore causing the man-made structure to become part of the natural environment. The Chapel at Ronchamp is a move away from Le Corbusier’s infamous machine aesthetic to a more site-specific response. He perceived the genius loci as developing from the site’s overwhelming historical legacy as a place of worship. In this case Le Corbusier used symbolism to reflect the ‘meaning’ of the place by incorporating the image of a nuns cap in the roof of the design.

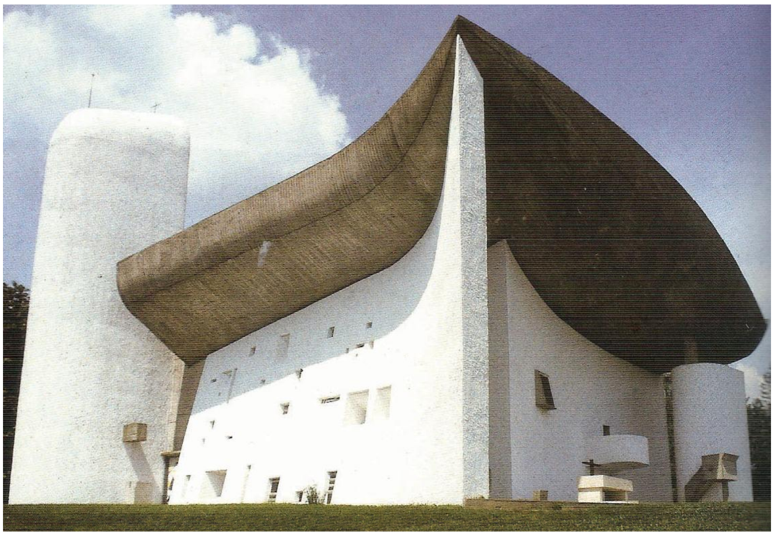


Fig. 3.3.5- Photograph of the Chapel at Ronchamp, expressing Le Corbusier’s use of organic form and textures (Source- Menin: 2003, 44)

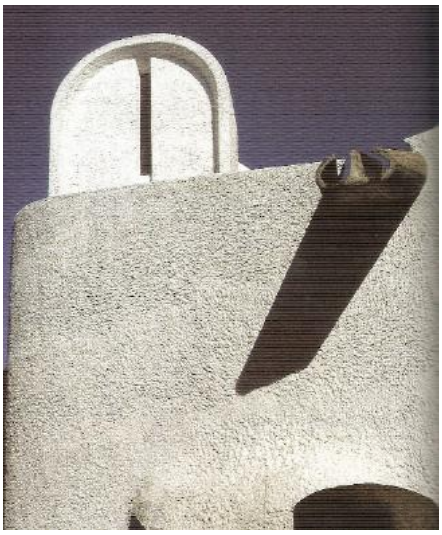


Fig. 3.3.6- Photograph of the textured plaster and reference to the female body (Source- Menin: 2003, 50)

> “The great turning point, however, came with the church of Ronchamp. Here the psychological dimensions of architecture return with full force... In fact the building has become a true centre of meaning and a ‘gathering force’, as Vincent Scully said with fine intuitive understanding.” (Norburg-Schulz: 1980, 197)

This ‘transnational’ style which Le Corbusier employed in his pioneering designs was met with disparagement and was viewed as an architecture “without boarders” (Happauf: 2005, 44) as the design solutions were unconcerned with climate, location and site. This notion was criticised by many as it generally resulted in stark, sterile and inhumane architecture, which expressed little cultural or regional identity. In the late 1930’s and early 1940’s, Alvar Aalto, an influential Finnish architect, began to withdraw from the inhumane, disconnected nature of the International Style. He saw that the thin-walled, glass buildings with flat concrete roofs was inappropriate for Finland’s climate and therefore began using traditional methods and materials, making him a ‘nationalistic’ architect (Farmer: 1996, 123). He acted as a protector against mechanisation which he believed would “strangle the individual and organically harmonious life” (Menin: 2003, 2). Aalto assumed a significant role in influencing architects who were conscious of the importance of connecting man and nature and formed a pivotal point during the Modern Movement. Therefore it is essential to study Aalto’s architectural theories and designs within this literature review which focuses on the connection between man and the environment.

> Alvar Aalto believed that: “the purpose of a building is to act as an instrument that collects all the positive influences in nature for man’s benefit, while sheltering him from the unfavourable influences that appear in nature. For this reason he drew light, sun and greenery into the heart of the interior space.” (Menin: 2003, 3)

Aalto used symbolism to draw nature indoors by incorporating organic forms and natural materials. He believed that nature is a “lasting symbol of freedom” (Menin: 2003, 78) and therefore should make up the basis of architecture. It was for this reason that Aalto experimented with wood, which had been used in Nordic vernacular architecture for its hepatic warmth (fig. 3.3.7). Aalto recognised the connotation between the use of wood as a material and its sentient characteristics, flexibility and closeness to nature. This can be seen as a reaction towards the popular materials used during the Modern Movement, such as steel and concrete, which he believed restricted mankind (Menin: 2003, 78). The symbolic use and practical utilisation of wood as a material can be seen in Vuoksenniska church (1957) (fig. 3.3.8). Aalto created the feeling of being subsumed by "pseudo-natural form", with the tree-like mullions, the timber ceiling which assisted in acoustic functions and the symbolic reminiscence of light penetrating through trees. Aalto designed the windows so that they are all uniquely sized and placed, giving the natural light a sense of materiality (fig. 3.3.9). "In this way Aalto may be said to imitate the a-geometric form of the trees in order to recall the form and quality of light penetrating deep forests from above" (Menin: 2003, 114).

Fig. 3.3.7 Photograph of traditional Nordic architecture expressing the use of timber (Source- Weston: 1995, 89)

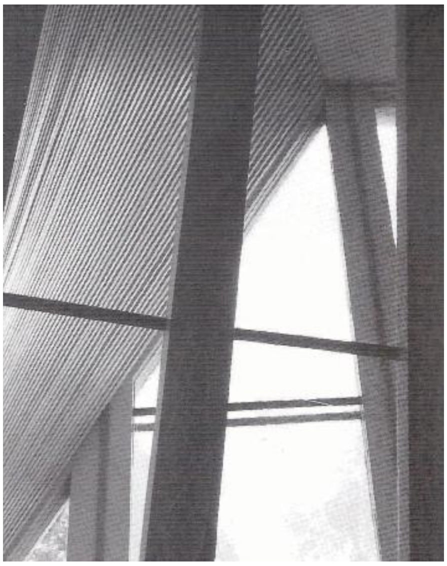


Fig. 3.3.8- Photograph of the interior of Vuoksenniska Church (Source- Menin: 2003, 123)

The use of timber and sunlight as a material is also clear in Villa Mairea (1937-9) (fig. 3.3.10). This is visible at the entrance where the vertical timber members cast shadows, giving the impression that one is entering a forest (fig. 3.3.11). Structural steel columns are scattered in pairs at regular intervals and are bound in rattan along the staircase, which reflects the image of silver birch trees (fig. 3.3.12). This was originally inspired by Japanese bamboo screens (Weston: 1995, 93). The modern age has been emphasised with large windows and nautical handrails, which is juxtaposed with the quality of a forest due to its timber structural members, bleached beech floors and pine ceilings (fig. 3.3.13). This has produced a "sophisticated primitive intimacy; a reinterpretation of a traditional home for the forest" (Farmer: 1996, 129).

Fig. 3.3.9- Photograph of the irregular windows of the Vuoksenniska Church (Source- Weston: 1995, 125)

Fig. 3.3.10- Photograph of the Villa Mairea (Source- Glancey: 2000, 186)

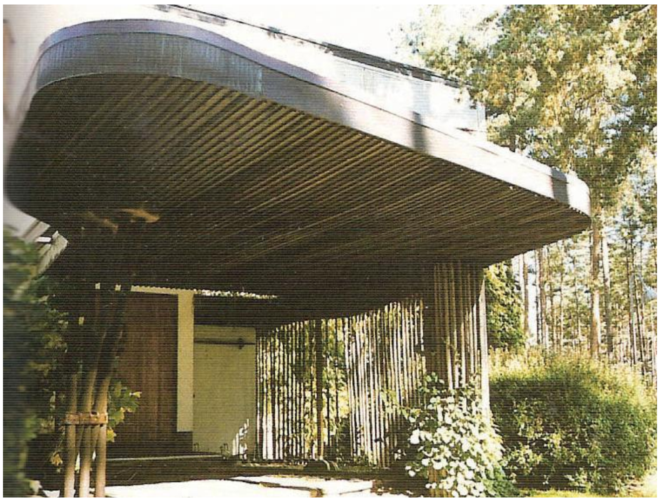


Fig. 3.3.11- Photograph of Villa Mairea's entrance illustrating the use of vertical timber echoing the forest which surrounds the house (Source- Menin: 2003, 123)

Fig. 3.3.12- Photograph of the Villa Mairea's staircase which emphasises the vertical timber see in Nordic forest (Source- Weston: 1995, 92)

Fig. 3.3.13- Photograph of the entrance hall at Villa Mairea's depicting the internal finishes' sentient characteristics (Source- Weston: 1995, 96)

Aalto instinctively knew that living and working spaces which associated with nature produced psychological and material health (Menin: 2003, 63). He therefore found it necessary to blur the boundaries between buildings and the environment and believed that the "outside should inhabit the interior of the buildings" (Menin: 2003, 72). Aalto achieved this by manipulating he built form by incorporating courtyard spaces. He studied these building forms in the vernacular Pompeian houses which possessed an atrium garden (fig. 3.3.14). Aalto believed that these atrium houses functioned as a mechanism for uniting intimate rooms with the open sky and incorporating the outside environment (Menin: 2003, 69). This characteristic is evident in Aalto's experimental house, Muuratsalo (1953) (fig. 3.3.15 and fig. 3.3.16). The courtyard plan allowed for the house to become climatically responsive, as depending on the season, the house became either “extraverted or introverted”. The courtyard, which encompassed a sunken fire-pit, allowed for certain degrees of interaction between nature and man, depending on the season (fig. 3.3.17). The courtyard, as mentioned by in Ranulph Glanville essays on Finnish Vernacular farmhouses (fig. 3.3.7), is the architectural element which is “key to the “Finnishness” of Finnish architecture.

> “The courtyard acted as a sensitive screen between inside warmth and outside cold, a place of transition, a defensible space, like the vernacular stockyard, enclosed by the huts and fence.” (Menin: 2003, 97)

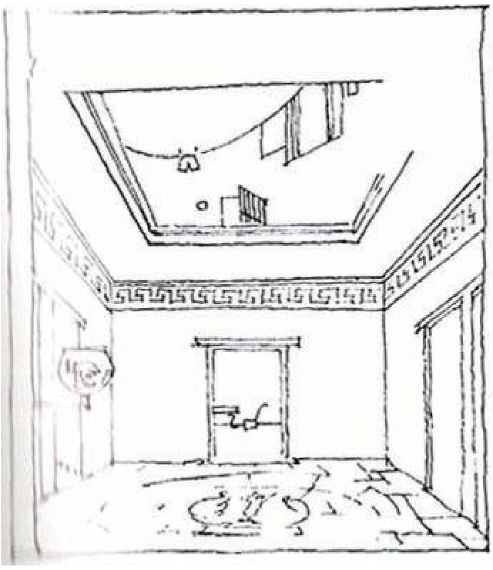


Fig. 3.3.14- sketch of the vernacular Pompeian house illustrating a private space which is open to the sky (Source- Menin: 2003, 69)

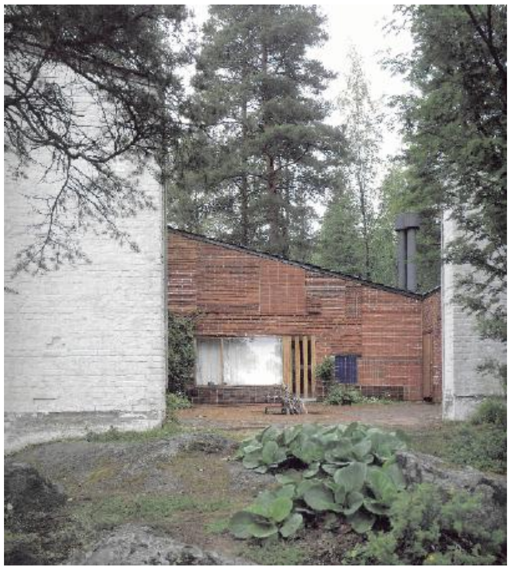


Fig. 3.3.15- a photograph of the courtyard at Muuratsalo, expressing the simple form coupled with rich textures (Source- Weston: 1995, 118)

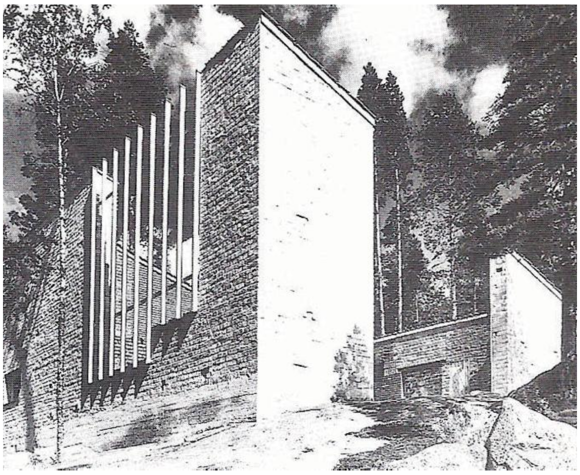


Fig. 3.3.16- an external view of the courtyard at muuratsalo, where Aalto has incorporated the vertical timber elements to echo the forest (Source- Menin: 2003, 98)

Fig. 3.3.17- an internal view of the courtyard at Muuratsalo, illustrating the sunken fire-pit (Source- Weston: 1995, 119)

Unlike many architects during the Modern Movement, Aalto embraced historical knowledge and was highly influenced by ancient Greek architecture, which he considered to be in total harmony with its surroundings (Menin: 2003, 11). This was because of their expression of perfect proportion, which acted as a link to the human body and elements in nature, which he expressed with the organic line and flexible standardisation (Menin: 2003, 145). He also felt that there was a need to "encouraged vegetative growth to engulf their human interventions in the environment" which resulted in the expression of a historical relic which looks as if it grew from the earth (Menin: 2003, 30). This is clear in the housing design for Sunila Pulp Mill (fig. 3.3.18). Aalto also held a great respect for vernacular forms, which he knew responded to the region's climate and surroundings.

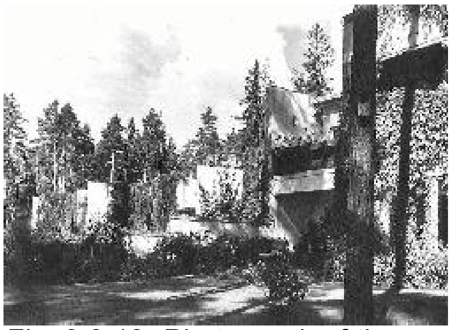


Fig. 3.3.18- Photograph of the Sunila Pulp Mill showing the engulfing quality of the vegetation (Source- Weston: 1995, 76)

Fig. 3.3.19- Photograph of the Nordic landscape which Aalto expresses in the built form of many of his designs (Source- Weston: 1995, 112)

Aalto's nationalistic architecture can be considered as concretising the genius loci of Finland (Weston: 1995, 132). Aalto captured Finland's natural characteristics which are unique to the region and in this regard he enabled identification to occur through symbolic and meaningful architecture. Aalto had an intimate connection with Finland and knew the importance of studying the landscape and prior to designing. The archetypical image of Finland is of the glaciated landscape that includes forests and lakes (fig. 3.3.19). Aalto identified these unique elements and represented them in serpentine lines; which is evident in the Finnish Pavilion (fig. 3.3.20) and the built form of Villa Mairea. And also by incorporating the concept of 'forest space' to represent the genius loci of the place. He evoked the image of the forest through symbolism by

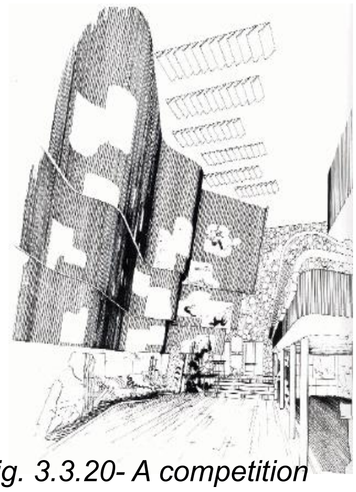


Fig. 3.3.20- A competition perspective which Aalto sketched illustrating his use of the 'serpantine' line and 'forest' space concept and therefore reiterating the theory of genius loci (Source- Weston: 1995, 108)

incorporating regular, vertical ‘tree-columns’, which can be seen in the staircase, entrance and external timber cladding of Villa Mairea. Aalto complimented the ‘forest space’ by replicating the ‘Nordic light’ within his designs, which is observed as being dappled through trees. This is evident in the windows of Vuokkenseniska Church (fig. 3.3.9) (Weston: 1995, 122)

Another architect who celebrated the ‘organic’ philosophy is Frank Lloyd Wright (1867-1959), the renowned American architect. He did not mimic European architectural trends, like many other American architects, but was rather inspired by nature and traditional architecture, which resulted in an individual style. Frank Lloyd Wright believed that a good design had the ability to make people more aware and respectful of their context and the natural environment (Farmer: 1996, 127). He was once quoted in saying: “Study nature, love nature, stay close to nature. It will never fail you”, which expresses the importance which the environment played in his ideologies and the perpetual need to live in harmony with the natural world (Gina: 2006, 322). This can be seen in his famous buildings, Falling Water (1934) (fig. 3.3.21) and Taliesin West (1937) (fig. 3.3.22), which were buildings of the industrial age and are “fully of the present in form, yet resonant of the ways of the past in the materials that give their forms substance” (Farmer: 1996, 128).

Fig. 3.3.21- a photograph of Falling water expressing how the building is perched over the river and dominates the environment (Source- Costantino: 1991, 68)

Fig. 3.3.22- a photograph of House Taliesin showing the strong qualities of genius loci and ‘growing from the earth’ (Source- http:// www. highereducation.org: 2000)

Frank Lloyd Wright connected the inhabitants of Falling Water with their natural surroundings by utilising natural stone and glass, which interconnects the waterfall and the woods with the interior and he also consciously used horizontal lines which expressed contact with the earth. His concept for this house was to transform the landscape into a backdrop but also displayed an overwhelming sense of domination over the natural environment. This is due to its positioning over the waterfall, which "shows who is boss" as well as allowing the occupant to appreciate what is being 'bossed' (Farmer: 1996, 129).

Unlike Falling Water, House Taliesin expresses a sense of integration with the natural surroundings as it has been designed to blend into its desert context (fig. 3.3.22). It has been stated that the house is "tucked down for survival in its harsh desert climate" (Farmer: 1996, 129) and seems to have naturally grown from the earth. This is mostly due to its use of natural materials such as stone walling, which peters out to join the natural landscape, as well as gives the impression of a historical Gothic Cathedral. Wright has additionally used exposed timber trusses, which forms a tree-like image or reflects a primitive hut (fig. 3.3.23 and fig. 3.3.24).

Fig. 3.3.23- a photograph of House Taliesin expressing its horizontal lines and use of natural form and materials which gives the impression that it is integrated into the the environment (Source- Colvin: 2009)

Fig. 3.3.24- a photograph of House Taliesin's tree like quality due to the use of expressive timber (Source- Architecture Week: 2009)

The Modern Movement rejected traditional teachings, and in doing so initiated the fracture in man and nature's relationship. Consequently modern man is left with buildings which are 'rootless' and are able to be plugged into any context with no acknowledgment for the climate or genius loci of the site. This has resulted in unhealthy and uncomfortable buildings which are mechanically run, augmenting the use of air-conditioning and heating. In this regard these modern structures fuel the climate crises, whilst producing a society which is unaware of their actions and responsibility to the environment. However, architects such as Le Corbusier, Aalto and Wright have played instrumental roles in drawing attention to environmentally conscious architecture. They were largely inspired by their respective regions vernacular architecture, surrounding nature and climate. Accordingly, they created buildings which are bioclimatic in nature, regionally responsive and have a strong sense of genius loci. Much can be learnt from these architects especially when regarding the relationship between man and nature.

Various materials were utilised by the aforementioned architects to connect man and nature. Le Corbusier believed that concrete was a natural material which he could manipulate into organic forms, which is evident in his later works. Aalto, on the other hand, incorporated timber into his designs as a structural and decorative element for its hepatic warmth, sentient characteristics and ability to link man and nature. Furthermore, Aalto employed timber to symbolise the concept of 'forest space' and to replicate 'Nordic light', which he adopted to represent Finland's genius loci. In regards to Frank Lloyd Wright, he applied stone and concrete to achieve organic form, which enabled him to express architecture which seems to have grown from nature itself. Le Corbusier, Aalto and Wright represented organic built form within their architecture to communicate the intrinsic man-nature relationship. For instance Le Corbusier expressed the female body in Ronchamp chapel, Aalto used his notorious 'serpentine line' and Wright explored cantilevers to represent tree-like structures. In this respect the architects utilised built form to celebrate the genius loci of the localities of the specific buildings. In regards to spatial organisation Aalto utilised courtyards as a bioclimatic architectural response, which he saw in vernacular architecture inspiring him to design truly nationalistic architecture.

3.4) Environmental movement

The Environmental Movement became popular in the 1960's and 1970's as a reaction to the environmental crises which were being experienced by society and predicted by scientists. Edward O. Wilson stated that the planet is under pressure due to human induced factors and that man is contributing to the "environmental crisis which is threatening the survival of many species, including the human species" (Edward O. Wilson cited Sassi: 2006, 2). There is widespread agreement among climate scientists worldwide that climate change has been caused by anthropogenic activity, mainly through the burning of fossil-based energy. Thus illustrating the dire consequences of humankind's actions and the need for man's ability to react responsibly to counteract them (Smith: 2006, 1). The technical and medical advancements of the industrial revolution resulted in a population boom, thus increasing activity. This developed an increase in energy, water and food requirements, human induced global warming, climate change and resource depletion, to name a few. These problems were then amplified by man's disconnection with nature, which is evident in Kenny Ausubel's statement that: "there is a fundamental illusion that we are separate from nature, but we are part of nature, we are nature" (Connors: 2007). This essential miss-understanding has caused havoc across the world.

The built form and cities make up a large and long lasting part man's footprint on the planet. Architecture is among the more enduring objects which society has casually produced, having significant affects on the environment, that far outlive their creator (Stannard: 2004, 1). Statistics show that the operation and construction of buildings are the biggest single indirect sources of carbon emissions, accounting for more than 50 per cent of total emissions. Fortunately, "it is the built environment which is the sector that can most easily accommodate fairly rapid change without pain" (Smith: 2004, 53). Presenting architects with the power to positively intervene and to generate a shift in modern culture's consumptive path towards a more holistic, responsible and sensitive attitude (Stannard: 2004, 1). The environmental movement has encouraged architects to investigate alternative approaches to design and to address aspects of sustainable, green and environmentally conscious architecture. This led to a search for an architectural style which was appropriate for the age. "Buildings reflected the psychological groundswell in society caused by the new knowledge" (Farmer: 1996, 51) and in this regard architecture indicates the change in man's perspective towards nature. Man is currently being faced with the scientific facts and physical evidence of their disastrous effects on the earth. Accordingly, it should become unavoidable to commit to the utilisation of renewable energy sources and bioclimatic architectural design so as to "avert the apocalyptic prospect of catastrophic climate change" (Smith: 2006, 1).

When considering a definition for environmentally conscious architecture it is important to recognise the Native American adage, "We do not inherent the land from our ancestors, we borrow it from future generations" (Zeiher, 1996: 42). Environmental architect, Susan Maxman believes that if society is governed by this attitude and realises the fragile balance of life on earth, it will result in beneficial consequences. Environmentally conscious architects are concerned with designing built interventions which are contextually and climatically responsive. Consequently, they utilise strategies and technologies, such as passive cooling and ventilation, alternative energy, water conservation and appropriate materials.

> "Buildings are the mediator between man and nature; the designer is the artistic intermediary charged with creating a responsive, responsible architecture" (Stannard: 2004, 1)

Architects are liable, not only to design comfortable, healthy, appropriate spaces for inhabitants but must also express respect towards the immediate and global environment. Contemporary architects must create a symbiotic relationship between the planet and man and must realise that "man's existence within the earth's fragile ecosystems (of which we are a part) calls for sensitive, responsive, appropriate design" (Stannard: 2004, 5).

2.5) Conclusions

The intension of this chapter was to establish an architectural solution to produce a symbiotic relationship between man and nature and which works in harmony with natural ecosystems. In this regard, it was relevant to analyse society's perception of nature and the manner in which they responded to the environment through architectural parameters. This was investigated by reviewing architectural movements throughout history to discover when and why mankind became disjointed from the environment.

It is clear that the symbiotic relationship, which was prevalent in vernacular architecture, was ruptured by the Modern Movement's preoccupation with technical advancements and rejection of tradition. There is much which contemporary environmental architects can gain from studying vernacular architecture. Indigenous architecture was unobtrusive, sustainable and evolved out of nature itself, linked man with the environment and became an integral part of the cycle of life. The inhabitants became a part of nature and evolved to respect and praise its powers, knowing full well that their very existence depended on their relationship with the environment (Crowe: 1995, 32). This lead to an architecture which responded to climatic and regional determinants in terms of utilising suitable local materials, taxonomy of the built form, spatial organisation, cooling or heating strategies and elements such as shading devices, verandas or courtyards. Consequently generating a "low energy society" (Crowe: 1995, 35). This high level of connection and respect for the natural environment faltered as 'modern' man's fixation on the industrialised world lead to the mutilation of the natural environment. However, architects such as Le Corbusier, Aalto and Wright had pivotal responsibilities in mending this ruptured connection. This was achieved through the use of natural materials, appropriate building form and spatial organisation, such as courtyards as seen in many of Aalto's buildings, aid in creating site specific and regional architecture. It is also clear that symbolism allowed architecture to connect man and nature by celebrating the genius loci of the site. It is thus apparent, after analysing the modern movement, that the fragile symbiotic relationship between man and nature can either be relinquished or promoted through appropriate architecture. Architects have the ability to create a shift in society's attitude, towards a reconnection between man and the environment, resulting in a higher level of respect and knowledge of nature, thereby promoting environmental awareness and conservation. All architects have a creative responsibility to provide society with not only comfortable, healthy spaces but also to protect and enhance aspects of the environment. Ultimately, architects need to be concerned with altering the current architectural style, to produce contextual and climatically responsive and responsible architecture (Stannard: 2004). Subsequently, it is relevant to examine how contemporary environmental architects have started to repair the problems associated with the Modern Movement. It is important to analyse their design strategies, in terms of bioclimatic design and regionalism, in order to become inspired by their theories and work. This will be further discussed within the precedent study (chapter 4). The study of these works express that the means for a solution to the environmental crisis does exist and that there is no excuse to design buildings which aggravate the environmental crisis.

CHAPTER 4
PRECEDENT STUDY

4.1 Introduction

The study of existing or proposed buildings will ensure that the resulting design of this dissertation will convey a symbiotic relationship between man and nature. This can be realised through the examination of interconnectivity, bioclimatic design and regional architecture in terms of appropriate architectural expression, choice of materials, built form, spatial organisation and sustainable devices. The information gleaned within this chapter will aid in permitting the ultimate design to function as a suitable tool for education and eco-tourism as well as assisting in breaking down the barriers between learner and nature. The buildings which will be discussed within this chapter are the Hockerton Housing Project, Piney Lakes Environment Centre, Pocono Environmental Education Centre, Council Housing 2 (CH_2), Tjibaou Cultural Centre, Ken Yeang's master plan for Nottingham University and Glenn Murcutt's numerous houses and the Bowali Visitor Information Centre.

4.2 Interconnectivity

It is relevant to analyse systems and buildings, which assist in an autonomous existence so as to ultimately determine a facility which functions as part of an intricate ecological web. William McDonough believes that buildings should be designed like trees by using design principles which are inspired by nature's laws. These laws include nutrient cycling and photosynthesis which can be architecturally interpreted as water collection, waste management and utilisation of solar energy. (McDonough: 2002)

> "But what if buildings were alive? What if our homes and workplaces were like trees, living organisms participating productively in their surroundings? Imagine a building, enmeshed in the landscape that harvests the energy of the sun, sequesters carbon and makes oxygen. Imagine on-site wetlands and botanical gardens recovering nutrients from circulating water. Fresh air, flowering plants, and daylight everywhere. Beauty and comfort for every inhabitant. A roof covered in soil and sedum to absorb the falling rain. Birds nesting and feeding in the building's verdant footprint. In short, a life-support system in harmony with energy flows, human souls, and other living things." (McDonough: 2002)

The section regarding interconnectivity will analyse specific buildings in terms of water storage and purification, waste management and energy expenditure. The buildings which are concerned with water storage and cleansing are the Hockerton Housing Project and Piney Lakes Environment Centre. Piney Lakes Environment Centre is further discussed under waste management, which includes information on Pocono Environmental Centre. Examples of how to harness renewable energy is evident in the Piney Lakes Environment Centre, Hockerton Housing Project and CH_2.

4.2.1 Water

Water, the most important source for survival, is generally recognised as a mains service and can be divided into three principle systems. Firstly, potable water which is supplied to buildings in pipes. Secondly, waste water which is taken away in sewer and thirdly, rainwater which is not usually collected and is taken away via storm water drains (Hyde: 2008, 380). In most countries, including South Africa, clean potable water is being used for all building-related uses, which put a large strain on the diminishing resource. This can be rectified by minimising municipal water consumption, collecting rainwater and recycling grey water. These systems are clear in Piney Lakes Environment Centre and the Hockerton Housing Project (Hyde: 2008, 380).

The Piney Lakes Environment Centre in Melville, West Australia (fig. 4.2.1 and fig. 4.2.2) depicts systems of rainwater collection and waterless toilets which minimises water consumption. The facility was perceived as a model for an autonomous education building and demonstrates to the visitors how technologies aid in producing a building which is independent from mains electricity, water and waste connections (Sassi: 2006: 280). Rainwater is collected from the roof and stored in a 60 000 litre tank and then pumped to header tanks by a process of a solar powered pump (fig. 4.2.3). In these smaller tanks the water goes through a purification process whereby it is filtered and disinfected with UV lights making it possible to use for all purposes; however

Fig. 4.2.1- Areal view of Piney Lakes Environmental Centre (Source- City of Melville: no date, melvillecity.com.au)

it must be boiled before drinking. The building minimises water use by up to 80% by installing two types of waterless toilets and urinals and avoids connection with the sewer system (City of Melville: no date). The most interesting system is the hybrid toilet system which provides primary and secondary treatment in two chambers as it functions as a mechanically operated package sewage treatment unit and a septic tank (fig. 4.2.4). The untreated waste from toilets, sinks and basins enter into biological treatment tanks where decomposition through anaerobic bacterial action occurs. In a similar manner to septic tank, the non-digested matter settles at the bottom of the tank forming a layer of sludge which must be removed every 4-7 years when the holding capacity of the tank has been reached (Sassi: 2006, 280). The tank is ventilated by a photovoltaic operated fan to prevent odours. As more waste enters the first chamber, water is pushed into the second chamber which consists of a maze of plastic pipes with a layer of biofilm on the surface. This degrades the organic matter resulting in an effluent which is clean enough to be discharged to the ground or a holding tank. The two chambers or tanks are located in the basement in the Piney Lakes Environment Centre, but it can also be partially sunk underground. (Sassi: 2006, 280)

Fig. 4.2.2- World map illustrating location of Melville, Australia (Source- By Author)

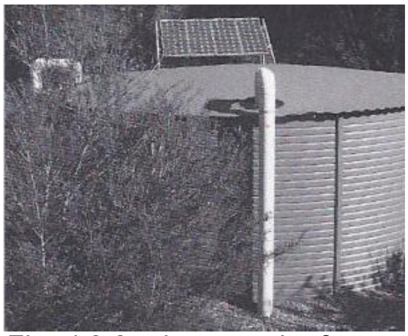


Fig. 4.2.3- photograph of a 60 000 litre rainwater tank at Piney Lakes Environmental Centre (Source- Sassi: 2006, 280)

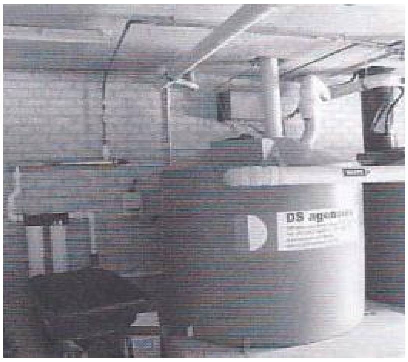


Fig. 4.2.4- photograph of tanks in basement for hybrid toilets (Source- Sassi: 2006, 281)

As per the concept of sustainable cities it is important to reduce the use of mains drains and sewers by introducing onsite treatment systems (also known as green water systems), so as to inhibit the occurrence of sewage and storm water pollution incidents (Hyde: 2008, 380). The Hockerton Housing Project, Hockerton, Southwell, UK (fig. 4.2.5 and fig. 4.2.6), collects water and treats all wastewater on site with the combined use of septic tanks and reed beds. The housing development utilises three effective systems so that self-sufficiency is acquired. Two systems have been put into place for water collection for non-potable and another system for potable water. Water for non-potable use (bathing, laundry and flushing low flush toilets) is collected throughout the site, from access roads and other hard surfaces as well as from fields. This water is carried through trough-like swales (which may not be suitable for urban areas) to a sump (fig. 4.2.7). The water is then pumped into a reservoir (holding 150 cubic meters of water and is 25m long and 2m deep) which is then passed through a sand filter and gravity fed to the houses (fig. 4.2.8). Potable water is essentially treated rainwater which is collected from the roofs and directed via copper pipes to a 16-cubic meter tank. Small particles are removed by passing the water through a 5mm string filter and the dissolved chemicals are removed by using a carbon filter. Before the water is transferred to drinking water taps in the house the bacteria and viruses are killed by using an ultraviolet light treatment. (Sassi: 2006, 278)

Fig. 4.2.5- areal photograph of Hockerton Housing Project (Source- Energy Saving Trust: 2003)

Fig. 4.2.6- World map illustrating location of Southwell, UK (Source- By Author)

Fig. 4.2.7- photograph of swale with 6kW wind turbine behind (Source- Energy Saving Trust: 2003)

Fig. 4.2.8- photograph of the 25mx2m deep reservoir (Source: Sassi: 2006, 278)

Reed beds facilitate water disposal as all wastewater, including black water (sewage) and grey water is transferred from the houses on site to a communal septic tank for a five to ten day period (fig. 4.2.9). In the septic tank the solids are separated through settlement and the relatively clean liquid is passed through a reed bed treatment area. This process usually takes three months. The treated water then passes from the treatment area into the main lake through a gabion wall, made up of 30-60mm limestone blocks and is therefore filtered even further. The cleaning process occurs due to the reeds supply of oxygen to the bacteria living in their roots which digest the pathogens in the effluent, which moves slowly passed. This reed bed system cleans the water to a similar standard of the water cleaned by a typical mechanical treatment plant and in terms of the Hockerton development; the water has met European Union bathing quality standards. These reed beds are not only beneficial in water disposal but also create attractive and healthy environments. (Sassi: 2006, 278) (fig. 4.2.10).

Fig. 4.2.9- photograph of the reed bed in the lake at Hockerton Housing project (Source- Energy Saving Trust: 2003)

Fig. 4.2.10- photograph of the Lake with various plants and animals and enjoyed by the occupants (Source- Sassi: 2006, 278)

4.2.2 Waste management

Population growth has caused an increase in the amount of waste being produced and being dumped in landfill site or being incinerated, both of which are detrimental to the environment (Sassi: 2006, 188). Waste minimisation can be divided into two parts. Firstly, waste management of the facility, which constitutes the sorting of waste into various bins on site which can then be recycled. Recycling of waste such as glass, metal, paper and plastic will help to alleviate environmental problems and is necessary in assuring a secure future. Peter Smith reiterates this by stating that “we are slowly moving to a position where there will be no such thing as waste, merely transformation” (Smith: 2006, 203).

And secondly, minimising construction and demolition waste. Both of these principles are evident in Pocono Environmental Education Centre, Pennsylvania which is situated within a national park (fig. 4.2.11 and fig. 4.2.12) (Moskow: 2008, 53).

Fig. 4.2.11- photograph of the Pocono Environment Education Centre's east elevation (Source- Moskow: 2008, cover)

Fig. 4.2.12- World map illustrating location of Pennsylvania, USA (Source- By Author)

This building was completed in 2005 and was designed by Bohlin Cywinski Jackson Architects and is currently occupied by 8 staff members with 250 visitors per week. This building serves to provide a gathering space, conference centre and public hall for the community and environmental groups in the area (fig. 4.2.13). The project is highly interactive and outwardly expresses principles of green architecture making it a relevant teaching tool for visitors and staff. One of the most apparent teaching opportunities is the building's north recycled-tire clad wall (fig. 4.2.14 and fig. 4.2.15). This was designed to serve as a visible example of environmental design, specifically waste management (Moskow: 2008, 59).

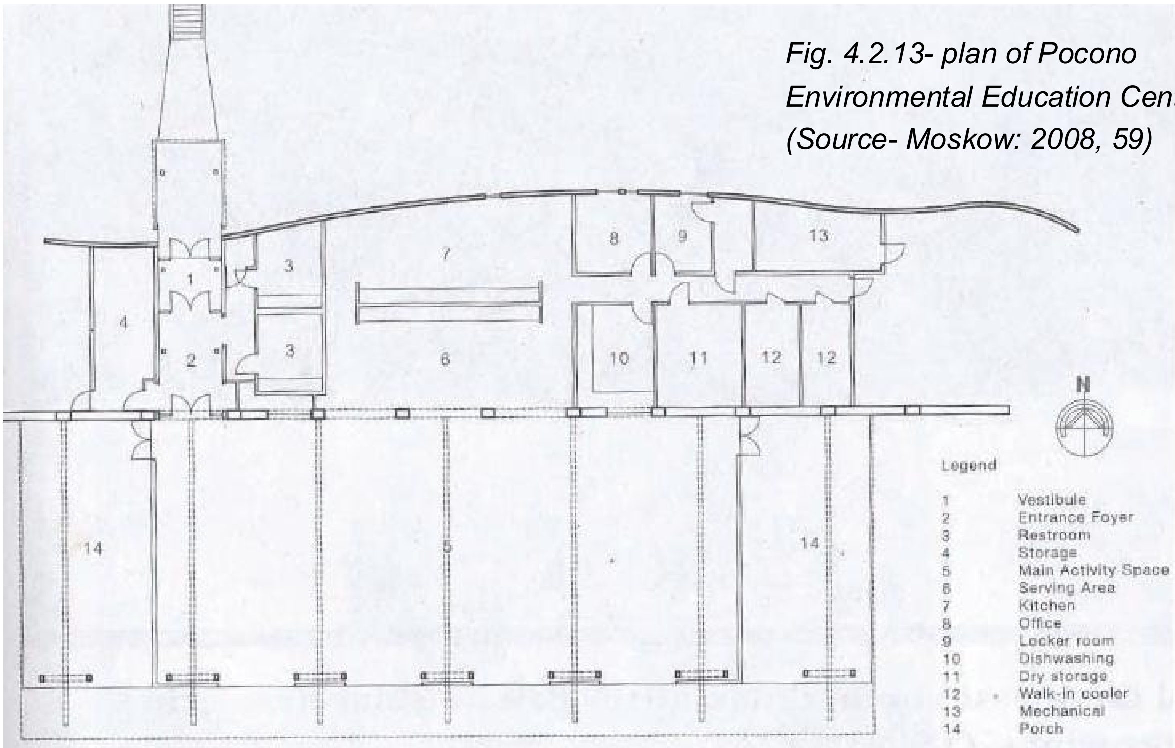


Fig. 4.2.13- plan of Pocono Environmental Education Centre (Source- Moskow: 2008, 59)

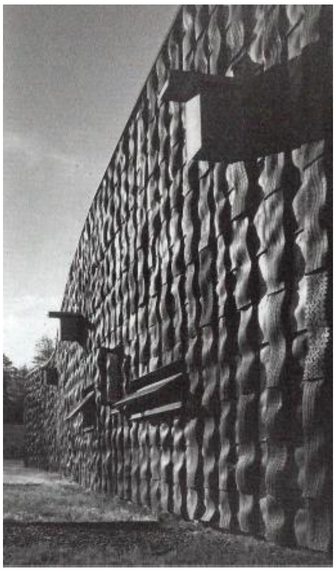


Fig. 4.2.14- Detailed photograph of the tireclad wall at the entrance of Pocono Education Centre (Source- Moskow: 2008, 61)

Fig. 4.2.15- Photograph of view when approaching the centre illustrating the striking tireclad wall (Source- American Institute of Architects: 2008)

The architects intensively researched all of the materials and chose them for their durability, low environmental impact, energy efficiency, low maintenance and long life span. This is evident in the use of exposed concrete floor slab and structural frame, face brick, wood structural system, and tire clad north wall all of which will not require any refinishing throughout the life of the building. Recycled building materials consist of reused items, refurbished materials and reconstituted materials. The use of recycled materials allows for closed-cycle systems which William McDonough calls Cradle-Cradle as opposed to Cradle-Grave (McDonough: 2002, 30). The recycled materials which have been specified are recycled wood-plastic composite lumber which substitutes preservative-treated wood and is made up of recycled plastic trash bags and waste wood fibres and can be used for decking, door and window frames, and exterior moldings; fly ash which replaces up to 30% of the cement in concrete and is a waste product of coal combustion; recycled rubber flooring in the lobby; recycled content porcelain tiles in the kitchen and serving area. The concept of recycling has been followed through into the structural system which has the ability to be disassembled for reuse or be recycled (American Institute of Architects: 2008). The structural system consists of the frame which is constructed from Douglas fir glue-laminated timber beam and columns, steel trusses, wood stud bearing wall and in-situ concrete slab; the floor which utilises thermal mass for climate control is of in-situ concrete slab with integral colour and the roof which is insulated plywood panels with Douglas fir finish. Other than the recycled-tire clad wall, education through architecture is further provided by the etched images of nature in the block wall which offers opportunities for scavenger hunts to find animal tracks, leaf patterns and local wildlife (Moskow: 2008, 59).

The etchings were made by the children during the construction process and therefore give them a sense of ownership. The users are made aware of the natural forces and energy conservation as manual devices such as manually operated light switches and window ventilators on the east, west and south walls of the building are used rather than automated mechanical systems. In this manner the users make direct energy conscious decisions (Moskow: 2008, 56).

The designers from Eco-tect Architects responsible for Piney lake Environment Centre, have selected recycled and natural materials to demonstrate solutions to sustainable design problems and to reduce the embodied energy of the building (Sassi: 2006, 91). They have specified recycled light poles which are used load bearing posts and timber which is reused or sourced from sustainable production forestry. The walling aids in thermal mass as it is made up of 300mm thick rammed earth (limestone) walls. Clay-based materials such as this are highly hygroscopic and are therefore beneficial in terms of maintaining relative humidity due to the materials ability to absorb or release moisture (Sassi: 2006, 111). These provide an introduction to environmentally conscious building techniques (Sassi: 2006, 91).

4.2.3 Energy expenditure

Buildings which are environmentally sensitive must include a possible "net zero energy" concept. This may be achieved by reducing energy expenditure and by harnessing renewable energy that is available on site. Harnessing renewable energy assists in alleviating pollution and the nuances associated with coal fire power plants, which generates most of South Africa's power (Roos & Noir: 2005). The sun is the principal source of renewable energy as it directly offers solar energy as well as generates the climate making it possible to draw energy from wind, waves and tides (Smith: 2001, 42).

> "A sustainable energy system is probably the single most important milestone in our efforts to create a sustainable future… Decarbonisation of the energy system is task number one." (Oystein Dahle, Chairman of the Worldwatch Institute cited in Smith: 2001, 26).

Fig. 4.2.16- Photograph of the NW corner of the CH_2 building (Source- City of Melville: no date, melvillecity.com.au)

Fig. 4.2.17- World map illustrating the location of Melbourne, Australia (Source- By Author)

Buildings that exhibit energy saving principles are Council Housing 2 (CH_2), the Hockerton Housing development and the Piney lake environment centre. Council Housing 2 (CH_2) was designed by the City of Melbourne and DesignInc in 2005 (fig. 4.2.16 and fig. 4.2.17). The building is powered by renewable resources and is Australia's first Green Star rated building to be awarded 6 Stars which carries an "international leadership" status. CH_2 energy harvesting can be divided into two categories; harvesting from squander and harvesting from nature. In terms of harvesting from squander the architects have designed the building on the basis of an energy-efficient lighting scheme, whereby the local task lighting above individual workspaces have adjustable controls to suit the occupancy trend and time of use. This has achieved a 25 per cent lighting energy cost reduction in general office areas (City of Melbourne: 2006, 8). An additional tool to reduce improve energy efficiency is enhance natural day lighting to substitute artificial lighting and is beneficial in terms of reducing internal heat gain, energy squander and increased occupant satisfaction and wellbeing. This has been accomplished as the architects introduced light shelves to reflect indirect light deep within the floor plan (fig. 4.2.18). CH_2 harvests energy from the wind by introducing six wind turbines on the top of solar stacks on the north side of the building (fig. 4.2.19 and fig. 4.2.20). These turbines were designed to aid night purge air flow through the building, enhancing ventilation and to operate as electricity generators during the day. The solar hot water system uses solar energy to heat the hot water supply for the basins and nine showers, which are used to encourage people to cycle to work. The hot water requirement for CH_2 is 2000 liters per day, 75 per cent of which is reached by the 48m^2 panels and is supplemented by the gas boiler, both of which are located on the roof. CH_2 has 23 solar photovoltaic panels (26m^2 photovoltaic cells) located on the roof and generates 3.5kW of electricity, which is estimated to produce enough power to move the western timber shutters. To improve the efficiency of solar energy, it has been suggested that solar concentrator systems are introduced (City of Melbourne: 2006, 14). A tri-generation system which produces power, heating and cooling is located in the roof plant room. A gas-fired micro-turbine is used to generate 60 kW of electricity, catering for 30 per cent of the buildings electricity requirements (City of Melbourne: 2006, 14). The CH_2 design team incorporated an absorption chiller into the system which recycles the waste heat produced in the energy generation process for cooling.

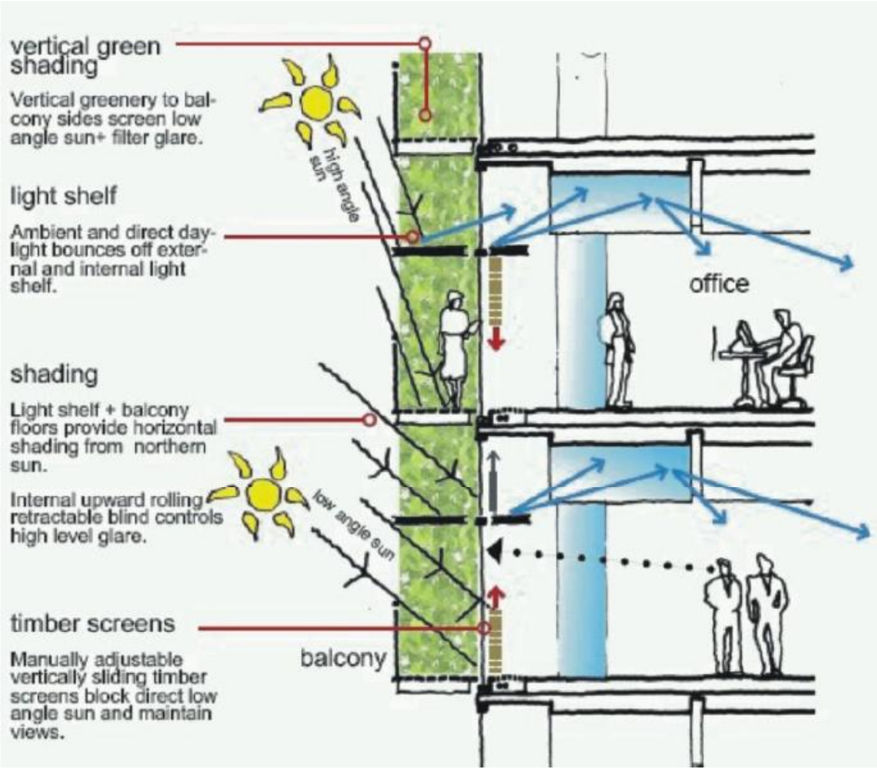


Fig. 4.2.18- Diagram of the north facade's external skin illustrating the control of light due to light shelves, shading devices and screening (Source- City of Melville: no date, melvillecity.com.au)

Fig. 4.2.19- North elevation depicting the darkly painted ventilation stacks (Source- City of Melville: no date, melvillecity.com.au)

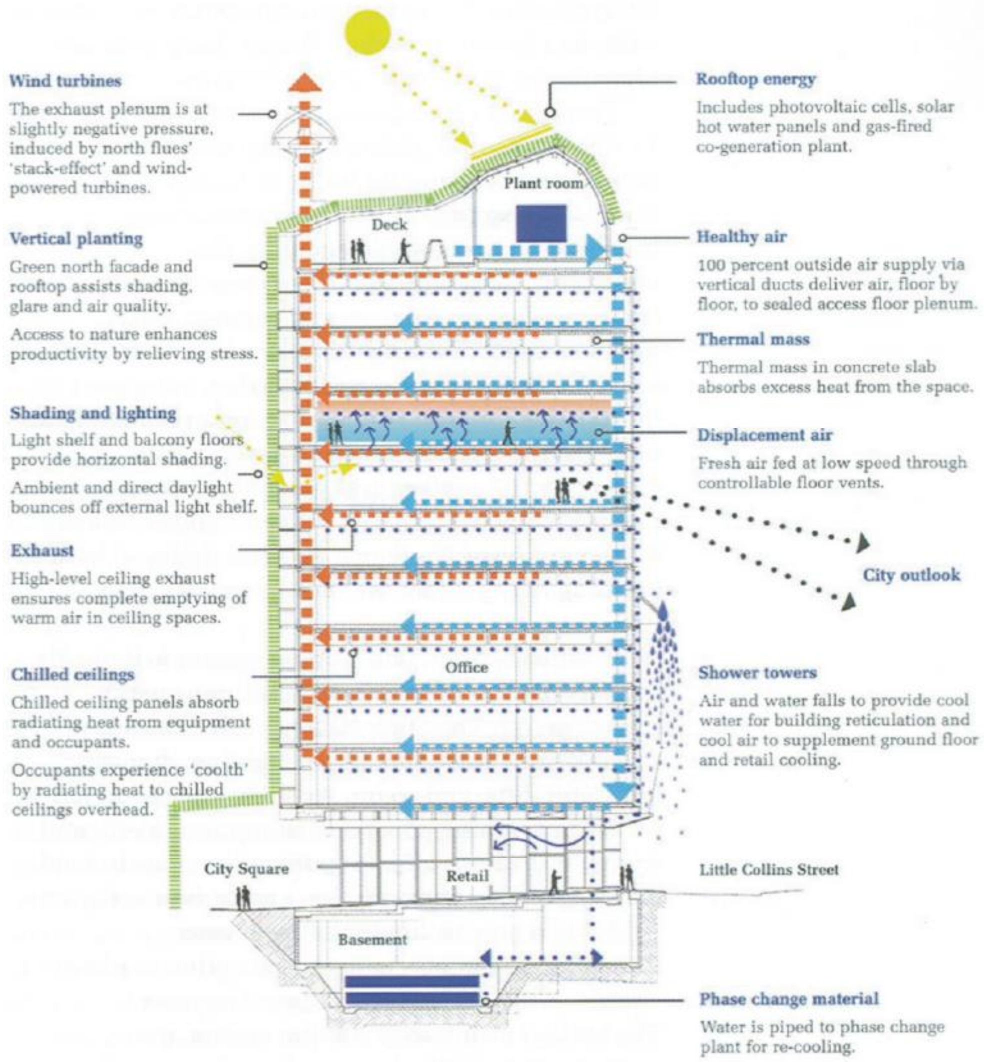


Fig. 4.2.20- Diagramatic section cooling methods, ventilation paths and renewable energy sources (Source- City of Melville: no date, melvillecity.com.au)

Additionally, renewable energy harvesting is apparent at the Hockerton Housing development, which aims to be CO_2 neutral and therefore relies on renewable sources of energy, including both wind and solar, resulting in a successful experiment low-energy design. Firstly, to achieve this, the development aimed to minimise energy requirements by utilising means of passive design in terms of thermal mass, well insulated and air tight construction and taking advantage of passive solar energy through south facing conservatories. In this regard, the houses used 20,500 kWh per year, equivalent to 4,000 kWh per house and around 11 kWh per house per day (Energy Saving Trust: 2003, 6). The power supply to supplement this is sourced from a 26m high, 6 kW wind turbine (fig. 4.2.7) and a 7,6 kW photovoltaic array (fig. 4.2.21). In 2005 the development introduced another wind turbine which, when used in addition to the existing systems, will guarantee 20,000 kWhr of energy produced on site per year. These systems are connected to the grid permitting the surplus electricity to be exported and when need be electricity can be imported. (Sassi: 2006, 247)

In the case of Piney Lakes Environmental Centre, the education building utilises a system known as the Remote Area Power Supply (RAPS) given its isolated location. The RAPS is capable of supplying an output of 12kW of 'clean' power by using renewable energy, which has caused a reduction of up to 8 tonnes of greenhouse gas emissions per year. The key components to the RAPS are a 5 kW wind turbine which is positioned near the main car park and converts kinetic energy from the wind into electric energy which directly charges the batteries (fig. 4.2.22); photovoltaic (PV) arrays with the potential solar power output of 6.5 kW due to the photovoltaic array which consists of 55x100 Watt PV modules mounted in a frame located at the front of the centre and a further 10 modules positioned on an automatic solar tracking array on the Technology Tower (Sassi: 2006, 91) (fig. 4.2.23 and fig. 2.2.24); the 12 kW interactive inverter, located in the Energy Room and along with the generator can provide up to 22 kW of power if required and the 120 Volt DC battery bank (Sassi: 2006, 91). Energy demand has been minimised within the building by installing low energy light fittings with movement control sensors (located in the kitchen, storerooms and bathrooms) as well as introducing solar powered outdoor lighting. Another method to lower the energy demand is the use of solar hot water heating systems. (City of Melville: no date) (Sassi: 2006, 91)

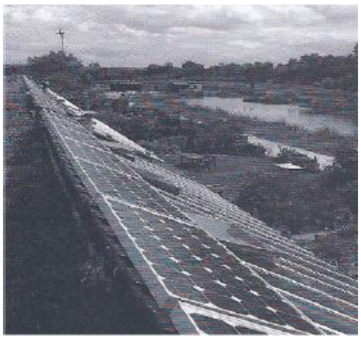


Fig. 4.2.21- Photograph of the 7,6 kW photovoltaic array (Source- Sassi: 2006, 45)

Fig. 4.2.22- Photograph of the 5 kW wind turbine (Source- Sassi: 2006, 91)

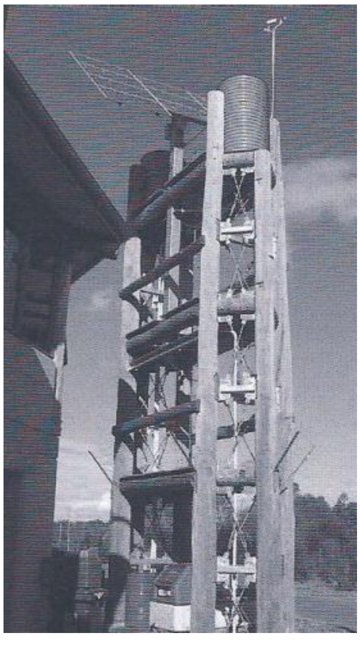


Fig. 4.2.23- Photograph of the Technology Tower (Source- Sassi: 2006, 281)

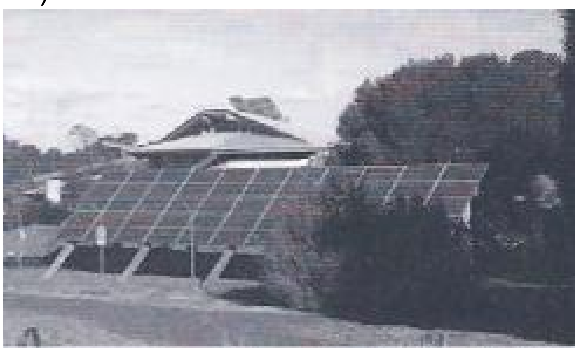


Fig. 4.2.24- Photograph of the 6.5 kW photovoltaic array mounted on a frame, positioned in a visible location as a tool for education (Source- Sassi: 2006, 91)

Various examples of buildings incorporating autonomous qualities and functioning in harmony with the natural systems have been discussed. Evidently, it is essential to minimise water consumption, waste production and energy expenditure through the discussed systems. Water can be conserved by collecting rainwater in large storage tanks, utilising grey water and by introducing waterless toilets which have been observed at Piney Lakes Environment Centre. In addition, it is significant to improve systems of water disposal which was achieved at Hockerton housing development. This system was successful given its duality, as it functionally cleans the water as well as beatifies the environment. Waste minimisation and management is apparent at Piney Lakes Environmental Centre and Pocono Environmental Education Centre due to the recycled materials that were specified. These materials are used as visual tools for educating the visitors on waste management. In the case of energy expenditure CH2, Hockerton Housing development and Piney Lakes Environmental Centre demonstrated that when designing autonomous buildings the primary step is to reduce energy consumption by utilising methods of passive design, such as the thermal capacity of materials, orientation, natural light and ventilation. It is then necessary to harvest natural renewable resources to produce ‘clean’ power. Durban’s coastal position consequently allows for high levels of annual wind speed but lower levels of sunshine. In this regard it is recommended that a combination of solar power and wind turbines are used in a building on the east coast. It is important to have a bidirectional inverter and battery storage system so that excess power can be sent back to the grid or if need be power can be imported from the grid. (Brown: 2009, 31)

The aforementioned buildings, specifically Piney Lakes Environmental Centre and Pocono Environmental Education Centre operate as teaching tools for environmental education and awareness. These buildings noticeably exhibit systems and environmental solutions through architecture. For instance the systems are very interactive, in terms of manual operation, presenting the leaner with the ability to make environmentally mindful decisions as well as intensifying their perception of the rhythms of natural cycles. Another visual tool for educating through architecture is the prominent weather station and technology tower at Piney Lakes Education Centre, used to demonstrate the importance of harnessing renewable resources such as rainwater and solar power.

4.3 Bioclimatic design

It is vital to analyse buildings that exhibit principles of bioclimatic design when intending to design a thermally comfortable and healthy internal environmental. These buildings essentially respond and react to the local climate by means of passive design and environmental control systems, preventing the need for artificial heating or cooling and rejecting the concept of sealed buildings. Elements of bioclimatic design are clear in Pocono Environmental Education Centre, Tjibaou Cultural Centre, Ken Yeang's master plan for the University of Nottingham Malaysia campus, Council Housing 2 (CH_2) and the architecture of Glenn Murcutt. It is necessary to undertake a process of climate investigation of the locality for each building to clearly understand the reasoning for the architectural responses and solutions. This investigation will ultimately generate a building that functions as an appropriate climate responsive instrument.

Pocono Environmental Education Centre, which is situated in Pennsylvania, USA (fig. 4.3.1). The building utilises passive solar cooling and ventilation to provide a comfortable internal climate for its users (fig. 4.3.2). The building has been designed to maximise the natural light during the winter months as the sunlight floods the south (in the northern hemisphere) facing main activity space (fig. 4.3.3 and fig. 4.3.4). This allows the concrete slab to heat up serving as a heat sink to store solar energy (this principle may be used in a hot climate where the thermal mass functions as a cold store). The light-coloured roof aids in minimising the heat island effect and lowers cooling bills because of the large overhangs and the east and west porches which protect the building from the direct summer sun (fig. 4.3.5) (American Institute of Architects: 2008). The roof is sloped permitting the promotion of natural airflow as the warm stale air rises and is expelled through the manually operated high level

	Pocono Environmental Education Centre
Location	Pennsylvania, USA
Co-ordinates	41.21°N 74.86°W
Climate	Cool-humid
Average Rainfall	1104.3mm / annum
Average Temperature	2°C-15°C

Fig. 4.3.1- Weather table of Pennsylvania, USA (Source- weatherreports.com: 2010)

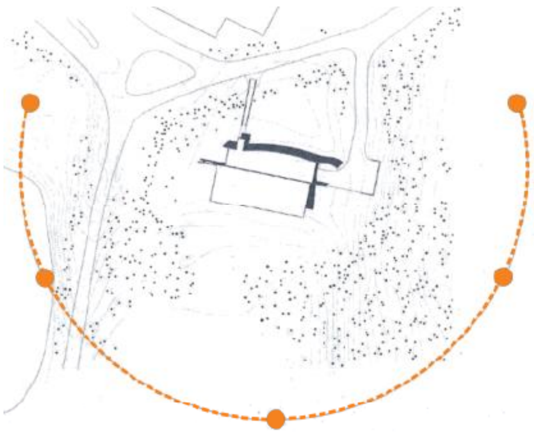


Fig. 4.3.2- Site plan showing the solar path (Source- Moskow: 2008, 58)

windows. Furthermore, the Venturi effect augments natural ventilation as the wind moves over the roof creating a suction (Moskow: 2008, 60).

Fig. 4.3.3- Photograph of the multi-use activity space (Source- American Institute of Architects: 2008)

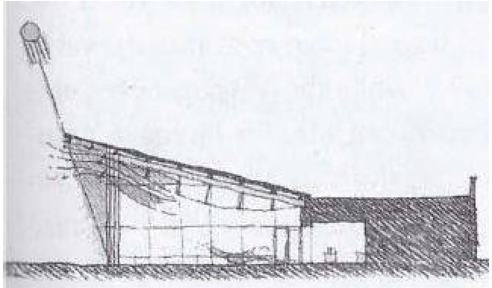


Fig. 4.3.4- Transverse sectional sketch looking west (Source- Moskow: 2008, 95)

Fig. 4.3.5- Photograph of the west elevation illustrating large protective overhangs (Source- American Institute of Architects: 2008)

Tjibaou Cultural Centre (1992-1998) designed by Renzo Piano in Noumea, New Caledonia in the Western Pacific, where the climate is tropical (fig. 4.3.6, fig. 4.3.7 and fig. 4.3.8). The facility celebrates and preserves the culture and wisdom of the local Kanak culture (Hawkes: 2002, 96). Piano aimed to reflect the Kanakis appreciation for a harmonious life with the earth, wind and sky and their response to the climate. This is evident in the pavilions, or what Piano has named ‘cases’, ability to create a comfortable internal environment through the use of bioclimatic principles. The need for passive cooling was recognised and therefore the wind direction and solar orientation dictated the design of the centre. In this regard the facade was not merely designed for its aesthetically pleasing and historically sentimental qualities but rather as a functional passive system. The form of the cases function as wind scoops while the facade is fundamentally a double skin where an airspace is created between the timber slats and the glass encased galleries, which permits airflow known as the 'stack effect' (fig. 4.3.9) (Buchanan: 2000, 93). During the day hot air rises through this gap and is replaced by air cooled by the lagoon or sea. The Iroko timber slats were designed to have altering sized gaps between to control wind movement. For example there are relatively wide gaps at the bottom of the cases so that wind can pass through horizontally. Whereas midway up the facade the spaces decrease, trapping the air to form a chimney where the air is forced to rise between the two skins. And at the top the slats are even more widely spaced augmenting the Venturi effect, sucking air upwards and aiding in ventilating the building. It has been stated that the wind 'sings' as it blows through the timber slats making the building's interaction with nature audible and almost palpable (Buchanan: 2000, 97). The amount of airflow is controlled by louvers at the base of the perimeter wall as well as on the opposite side of the building (McInstry: 1998, 30). This is clear in the diagrams illustrating the air movement in any condition and consequently the building is continuously working to find a balance with the natural forces (fig. 4.3.10 and fig. 4.3.11) (McInstry: 1998: 30).

	Tjibaou Cultural Centre
Location	Noumea, New Caledonia in the Western Pacific
Co-ordinates	21. 30 S 165. 30 E
Climate	Tropical
Average Rainfall	1083 mm / annum
Average Temperature	22.7°C

Fig. 4.3.6- Weather table of New Caledonia (Source- Climatetemp info: 2009)

Fig. 4.3.7- World map illustrating the location of Noumea, New Caledonia (Source- By Author)

Fig. 4.3.8- Photograph of the SE elevation taken from the lagoon side (Source- McInstry: 1998, 34)

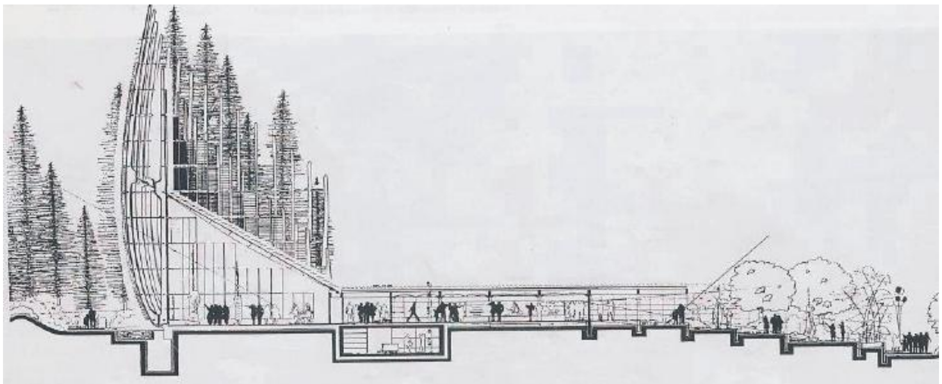


Fig. 4.3.9- East West section through case and gallery illustrating double skin construction, cross ventilation and surrounding norfolk pine trees (Source- McInstry: 1998, 32)

Shading is another method in keeping the building comfortable and is a result of large overhangs, landscaping the pathways and louvers. Double roof construction has been used in the building to reduce the extensive heat experienced in New Caledonia. This is achieved by forming an air gap between the two aluminium panels of the sloping roof so that air movement cools the materials and functions as an additional layer of insulation (4.3.12) (Buchanan: 2000, 110).

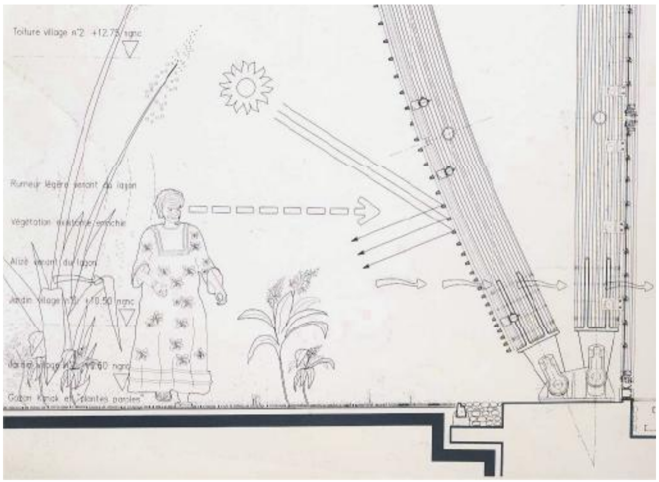


Fig. 4.3.11- Illustration of the cases external skin which has louvers to augment airflow (Source- Buchanan: 2000, 110)

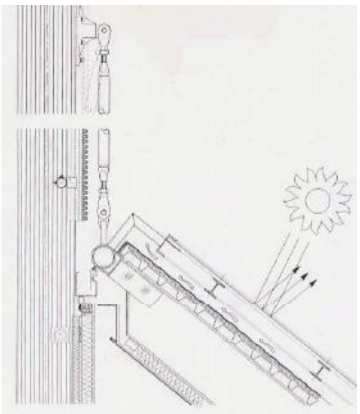


Fig. 4.3.12- Sectional diagram of the upper edge of the roof illustrating double roof construction and louvers which expel stale air (Source- Buchanan: 2000, 110)

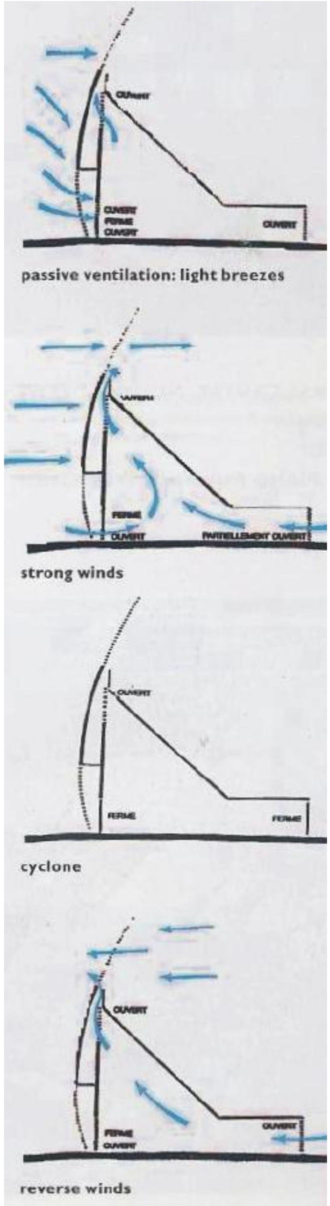


Fig. 4.3.10- Diagrams illustrating air movement through the cases during passive breezes, strong winds, cyclones or wind coming from the north west (Source- McInstry: 1998, 35)

Numerous bioclimatic principles can be observed in Ken Yeang's architecture. Yeang is a prominent environmental architect who believes in counteracting ecological imbalances between the high concentration of inorganic materials of a building with the natural flora and fauna of the untouched site. In this regard he became the ambassador of vertical landscaping which allows his unique skyscrapers to counteract the inorganic materials, while the plants provide many benefits such as the absorption of carbon dioxide, carbon monoxide and noises and smells of the city. The plants also help to soften the hard architectural surfaces (Yeang: 1996, 102). Yeang believes that the external walls of a bioclimatic building should be regarded as a 'sieve' rather than a sealed skin. The walls need to function as a permeable membrane with adjustable openings which filter air movement and sunlight. To enhance natural cross ventilation, which is an effective substitute for air conditioning, Yeang claims that the best arrangement for openings in on both leeward and windward sides of the building. Other arrangements can be seen in Brown and DeKay's diagrams of permeable buildings (4.3.13).

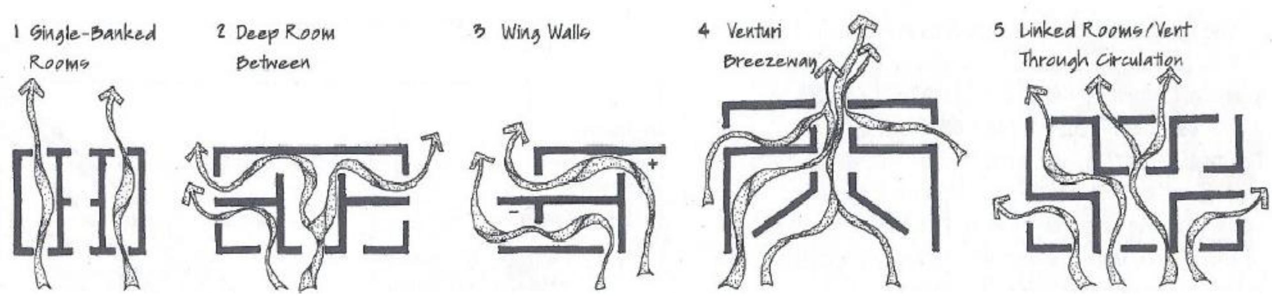


Fig. 4.3.13- Diagram illustrating air flow with various internal wall positioning (Source- Brown: 2001, 147)

The master plan of the University of Nottingham, Malaysia Campus illustrates Yeang's objective to create an ecological design which provides a protected and comfortable outdoor environment while enhancing the natural environment (4.3.14 and 4.3.15) (Richards: 2001, 43). Yeang's aim is to minimise the use of off-site infrastructure by responding to the tropical climate of Malaysia so as to prevent the need for surplus amounts of energy for cooling. He has achieved this by implementing principles of bioclimatic design. For instance he has incorporated systems to improve cross ventilation which allows for cool, comfortable conditions within a hot and humid environment. This is evident in the public 'event plaza' in the centre of the development, which is enclosed by a repeated portal frame structure covered by a lightweight membrane allowing for comfortable, shaded outdoor gathering (4.3.16 and 4.3.17). This system combines a wind scoop, air funnel and extractor fans (which mechanically assist in airflow when the wind levels are low) making up the Wind-tower which induces air movement from the valley. Yeang has taken advantage of the buildings configuration by employing 'wind walls' that channel the air towards the Wind-tower (4.3.18). The Pedestrian Promenades, that link the academic and the residential blocks function in a similar manner to the Wind-tower, providing a cool pedestrianised boulevard (4.3.19). The academic buildings also rely on natural ventilation to create cool working environments. This has been achieved by designing the buildings like 'landscaped courtyard pavilions' on pilotes which improve air circulation through the courtyard spaces. (Richards: 2001, 41)

Fig. 4.3.14- World map illustrating the location of Malaysia (Source- By Author)

	The master plan of the University of Nottingham, Malaysia Campus
Location	Malaysia
Co-ordinates	101.40 E 2.57 N
Climate	Tropical
Average Rainfall	2409 mm / annum
Average Temperature	27.5 °C

Fig. 4.3.15- Weather table of Malaysia (Source- Climatetemp info: 2009)

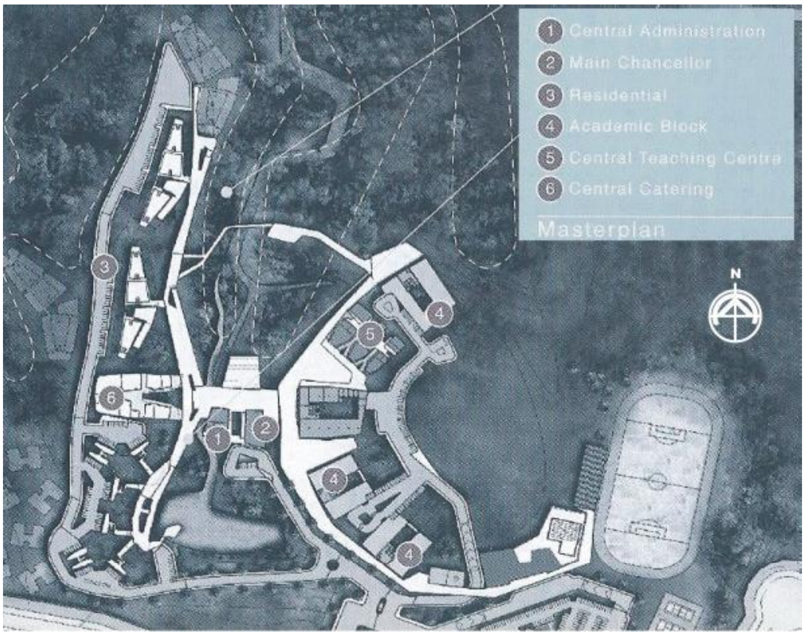


Fig. 4.3.16- Master plan of the campus (Source- Richards: 2004, 36)

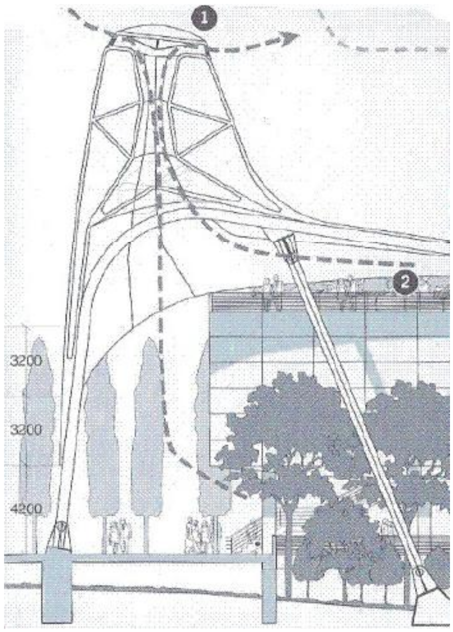


Fig. 4.3.17- Diagrammatic section through the wind tower (Source- Richards: 2004, 45)

Fig. 4.3.18- A 3D perspective of the university depicting wind walls which channel air towards the wind tower (Source- Richards: 2004, 38)

Fig. 4.3.19- A 3D perspective of the pedestrian promenade's portal frame system (Source- Richards: 2004, 43)

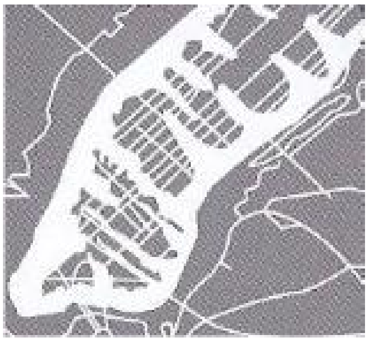


Fig. 4.3.20- A site diagram illustrating the green fingers to enhance biodiversity (Source- Richards: 2004, 44)

Yeang has also designed the building to minimally intrude on the landscape, for example the residential block follows the existing site contours to reduce earthworks. This project illustrates Yeang's theories on green corridors which is clear in the 'ecological belt' running through the campus allowing for improved biodiversity and the restoration and maintenance of indigenous vegetation (4.3.20). The University of Nottingham, Malaysia campus is an environmentally conscious building due to its responses to the natural forces of the site, resulting in a building featuring sun shading, cross ventilation and rain water collection. (Richards: 2001, 35)

The CH_2 office building, which is located in Melbourne, Australia (4.3.21) includes cooling systems involving radiant cooling, thermal mass and night purging, chilled ceiling panels and Phase Change Material (PMC) and shower towers. CH_2's comfortable temperature of 21°C -23°C is reached primarily due to radiant cooling rather than ventilating the space with chilled air. Radiant cooling is based on the principle of radiative heat exchange, whereby body heat is radiated to

	Council Housing 2 (CH_2)
Location	Melbourne, Australia
Co-ordinates	37° 49'S 142° 30'E
Climate	moderate oceanic climate with very inconsistent weather throughout the day
Average Rainfall	146mm / annum
Average Temperature	11°C-19.5°C

Fig. 4.3.21- Weather table of Melbourne, Australia (Source- Climatetemp info: 2009)

cooler surfaces (4.3.22). This is found to be the most effective form of modifying thermal sensation of the human body (Giovani: 1974 cited in City of Melbourne: 2006, 9). The cooler surfaces consist of the exposed concrete ceilings and chilled ceiling panels. The chilled ceiling panels are cooled by water which is supplied by three large tanks in the basement that contain frozen phase change material (PCM) balls. The chilled water circulates around the building, returning to the tanks 2°C-3°C warmer, where the PCM balls absorb the heat and in this regard they function as thermal storage batteries. Water was selected rather than air for space cooling as water has a higher heat capacity and in this respect reduces energy consumption for cooling transfer (City of Melbourne: 2006, 9). The heat which is accumulated in the water during the day is dissipated through two cooling towers on the roof to the cooler night air and then the cool water is re-circulated back to the phase change plant. During summer this process may occur during the day. A similar process is used to cool down the thermal mass of the concrete structure which is called night purging and occurs when the windows open automatically when the external temperature is cooler than the concrete (4.3.23). The cool night air removes the heat from the structure by cross ventilation and is then drawn up and expelled through exhaust air shafts on the northern side of the building, which utilises the stack effect and are assisted by roof-mounted wind-driven turbines. The process of night purging is controlled by a computerised building automated system (BAS) utilising information collected from temperature sensors and a weather station on the roof. This system directs the windows to open at the coolest time of

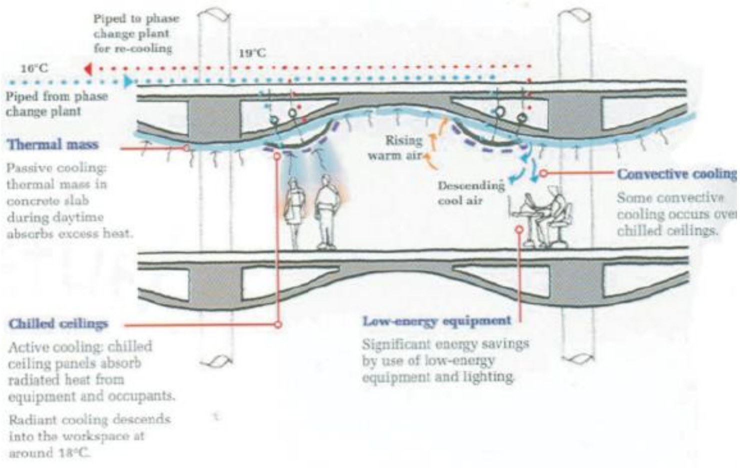


Fig. 4.3.22- Illustration depicting radiant cooling (Source- City of Melville: no date, melvillecity.com.au)

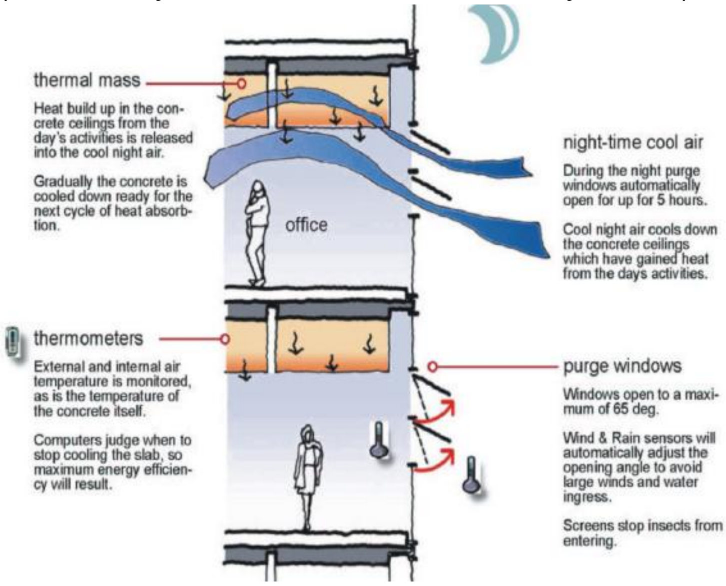


Fig. 4.3.23- Illustration depicting night purging (Source- City of Melville: no date, melvillecity.com.au)

the night which is usually between 2am and 6am. Shower towers that are 1,4m in diameter located on the south side of the building extract outside air approximately 14m above street level. The air is cooled as it falls within the tower by evaporation from the shower of the water. The cool air is supplied to the retail spaces on the ground floor and the cool water is supplied to the phase change material tanks (4.2.20).

The ventilation systems used are mechanically driven during the day and naturally driven at night. During the day air is drawn from roof level into ducts on the southern side of the building. Depending on the air temperature the air is either cooled by the absorption chiller or heated using waste heat recovered from the gas-fired cogeneration system. The air is then injected into the building via a sealed access floor plenum into the room at floor level at a low velocity providing staff with a fresh air supply and ensures the removal of stale warm air (4.3.24). This provides ventilation air used for the displacement ventilation system which is a key element for cooling and maintaining thermal comfort. Due to conduction the ventilation air heats up and rises to the void in the curved ceiling where there are exhaust-air shafts. The stale air is then ducted horizontally to join the exhaust air shafts on the northern side of the building. These shafts have been painted a dark colour to encourage the absorption of solar energy and resulting in a stack effect. This system improves the air quality of the buildings internal environment creating a healthy work place.

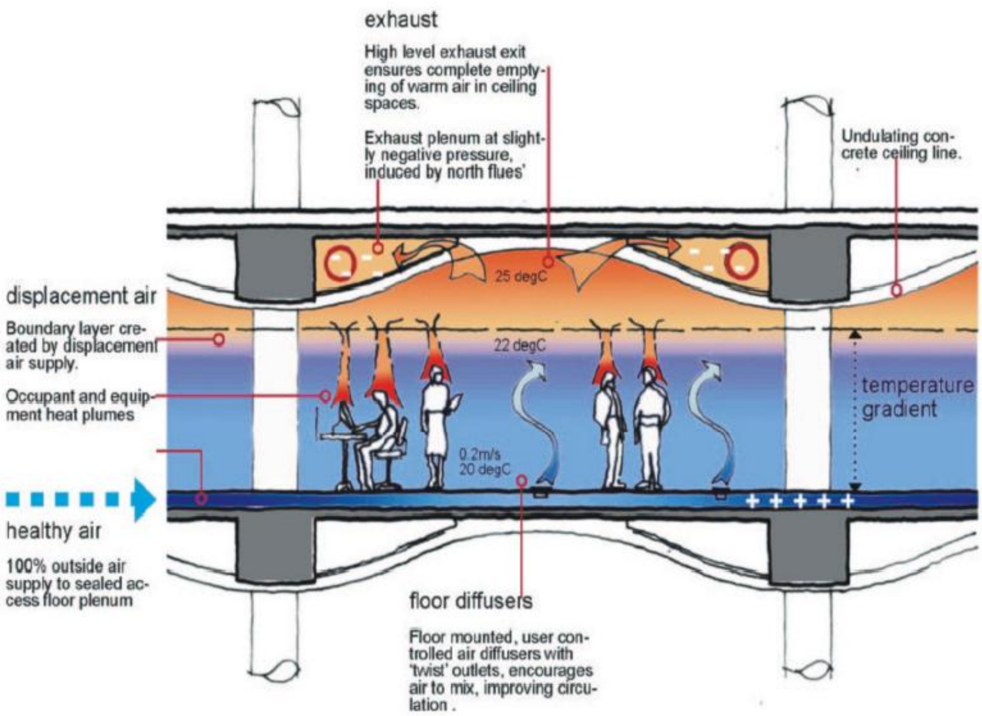


Fig. 4.3.24- Illustration depicting air displacement as a method of cooling (Source- City of Melville: no date, melvillecity.com.au)

Glenn Murcutt, the renowned Australian architect and winner of numerous awards including the Pritzker prize in 2002, has become well known for his environmentally conscious and autochthonous architecture. He was highly influenced by the great Modernists, Mies Van Der Rohe for his use of rational forms and Alvar Aalto's application of natural materials, integration with the natural landscape and nationalistic architecture. However, Murcutt's most noteworthy inspiration came from the Australian climate and natural landscape, which he has learnt to understand and intuitively respond towards, making him a truly nationalistic architect.

> "The buildings that Glenn Murcutt has made in Australia in the last 30 years are one of the most convincing demonstrations of the way in which the demands of climate and environment can be translated into architecture of the utmost eloquence." (Hawkes: 2002, 80)

Murcutt's aim is to "work with nature, but also to do as nature does, not by imitating its forms but by adopting the same logic" (Fromonot: 2003, 50). He designs his buildings "like simple mechanisms" which the occupants can fine tune depending on altering moods and climate. Thus allowing the building to be environmentally permeable and become part of the workings and the natural flows of the climate. Murcutt has achieved this by applying principles of bioclimatic design in terms of introducing architectural elements (spatial organisation, built form and environmental control systems) that respond to the basics of organic life (water, air and sunlight) to provide comfortable, environmentally conscious houses. In regards to spatial organisation, Murcutt positioned his houses for optimal orientation to capitalise on the movement and angle of the sun, inhibiting direct sunlight in summer and permitting it in winter (4.3.25). His buildings are arranged on site to capture the prevailing winds, and in this regard the built form is usually long and narrow to allow for cross ventilation. The built form responds to sunlight in terms of overhangs to prevent solar gain, and often incorporates verandas, skylights, moveable screens and louvers.

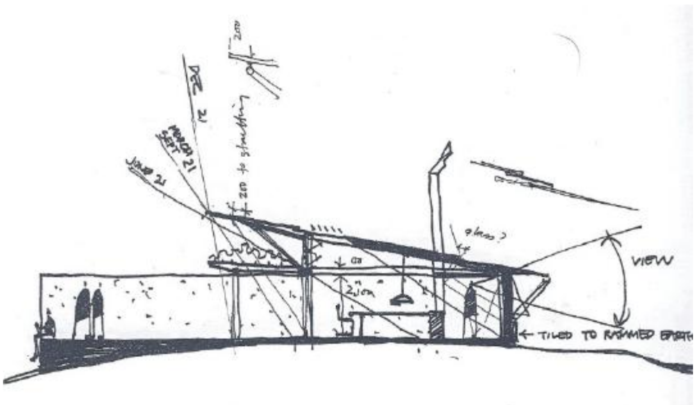


Fig. 4.3.25- sketch by Murcutt of the Simpson-Lee house illustrating environmental elements (Source-Fromonot: 2003, 204)

Ventilation systems have become an iconic part of Murcutt's architecture such as extractors, rotary turbine vents, and cowls atop chimney stacks as well as slatted screens which allow for the building to breathe (fig. 4.3.26). Murcutt utilises a 'triple skin' building envelope which allows the building to 'breath' and filter required levels of illumination (fig. 4.3.27). The above elements clearly adhere to his concept of producing a 'climatic machine' (Fromonot: 2003, 42).

Fig. 4.3.26- Photograph of Marika-Alderton House illustrating cross ventilation techniques and rotary turbine vents (Source- Fromonot: 2003, 219)

Fig. 4.3.27- Photograph of Simpson-Lee House illustrating triple skin wall construction and the materiality of sunlight (Source- Fromonot: 2003, 212)

Murcutt incorporates nature into his designs to create a sense that nature is "visible, legible and palpable, to make their presence felt in the very stuff of the building" (Fromonot: 2003, 47). Murcutt exaggerates environmental control devices such as rainwater downpipes, rainwater storage tanks and rotary turbine vents to illustrate that his buildings operate as part of the climatic systems. This allows the viewer or occupant to gage the power of natural forces and realise how architecture can function in harmony to create a comfortable internal environment without the use of artificial cooling or heating. This is evident in Simpson-Lee house's celebration of water (fig. 4.3.28) and sunlight (fig. 4.3.27) as well as in the exaggerated rainwater downpipes of Magney House (fig. 4.3.29).

Fig. 4.3.28- Photograph of Simpson-Lee House illustrating the incorporation of water within the design (Source- Fromonot: 2003, 209)

Fig. 4.3.29- Photograph of the exaggerated rainwater downpipes at House Magney (Source- Fromonot: 2003, 153)

Subsequently, it is clear that the level of comfort felt within buildings in the tropics or subtropical regions depend predominantly on controlled solar heat gain and successful ventilation. This has been revealed in the aforementioned building's choice of materials, built form, spatial organisation, shading devises and wind interactions around the building's facade (Hyde: 2008, 232). In this respect it is important to perform a climatic investigation prior to beginning the design process so as to passively respond to air movement, sunlight and precipitation. Ventilation is paramount in this study, given the fact that most of the buildings discussed are situated in hot or humid regions. Natural ventilation was achieved by means of double or triple skin construction, the Venturi effect and vent stacks. Controlled solar heat gain is additionally vital for a comfortable building and can be accomplished through shading devices and overhangs which prevent solar heat gain during summer while allowing light to penetrate into the building during winter. Furthermore, the thermal capacity can be utilised to modify the internal climate through radiant cooling which was clear in Pocono Environmental Education Centre and CH_2. This technique permitted the structure of the building to operate as a heat or cold store which, by conduction keeps the occupants comfortable. Bioclimatic buildings are specific to their place and locality and in this regard augment the concept of regional architecture.

4.4 Regional architecture

Architecture which is truly nationalistic is determined by local culture, climate and region. Regional buildings reflect and respond to their surroundings giving a 'sense of place' or genius loci through symbolism and identification (Norburg-Schulz: 1980, 190). The subsequent buildings, Tjibaou Cultural Centre and Bowali Visitor Information Centre display examples of regional architecture. This section will determine whether they have successfully grasped the genius loci of the place through elements of regionalism.

When designing the Tjibaou Cultural Centre Renzo Piano replicated the concept of a village cluster, which is evident in the 'three villages' specifically the Interpretation Centre, Resource Centre and Youth Centre (fig. 4.4.1). The cases are arranged in groups along the gentle axis of the peninsula and reveal the cultures spatial theories in terms of hierarchy of spaces. The distinctive form of the cases are reinterpretations of the vernacular conical architecture of the South Pacific and also echo the tall, stiff characteristic of the Norfolk

Island pines, which articulate the skyline of the island (fig. 4.4.2 and fig.4.4.3) (McInstry: 1998, 30). The regional identity is further enhanced as Piano has designed the building to allow for the interaction between the visitor and the indigenous tropical landscape. He has achieved this by creating a journey along a central pathway where the visitor is exposed to views of the landscape and is allowed to break away from the path and physically experience the environment through outdoor auditoriums and display zones. By fully understanding the Kanak's culture, history and environment, Piano has been able to produce a built intervention which expresses gratitude for the past and respect to the genius loci. The cases are perceptibly organic in regards to their materials and form. The woven Iroko timber skin imitates the thatched palm roofs of the Kanak people as well as the form of the Norfolk pine trees. The cases also give the impression that they are "combing the sky, seemingly bowed by the prevailing wind" and consequently appear to have been fashioned by the surrounding forces of nature (Buchanan: 2000, 101).

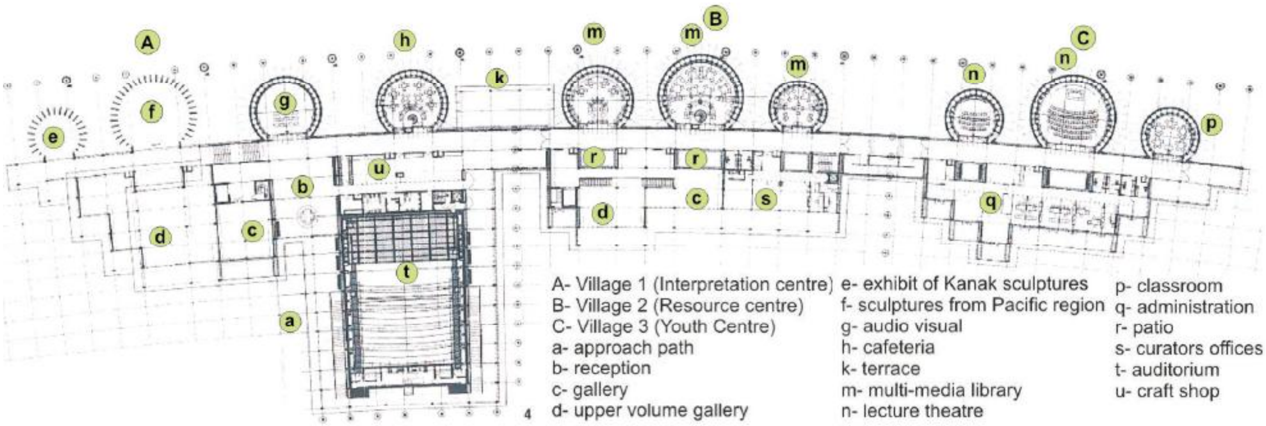


Fig. 4.4.1- Plan of the Tjibaou Cultural Centre (Source- Buchanan: 2000, 91)

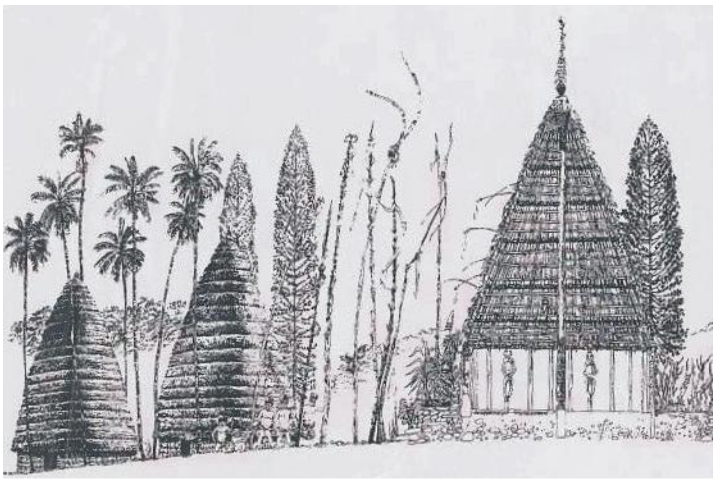


Fig. 4.4.2- Sketch by Piano of traditional huts (Source- McInstry: 1998, 35)

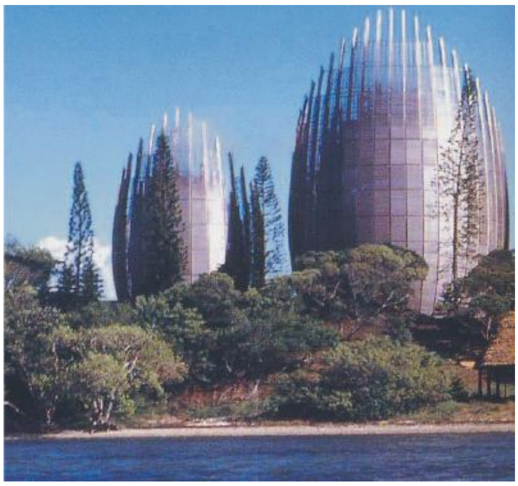


Fig. 4.4.3- Photograph of cases that reflect the Norfolk trees (Source- Buchanan: 2000, 86)

The Nationalistic architect, Glenn Murcutt was inspired by early aboriginal's shelter and traditional Australian woolsheds and barns, which he feels is "appropriate to place" (Fromonot: 2003, 32) (fig. 4.4.4 and fig. 4.4.5). This is due to their response to the restraints and possibilities of the Australian landscape, which is accomplished in a direct, logical and beautiful manner. Murcutt emulates this in many of his designs, such as Marie Short House (fig. 4.4.6) and the Marika-Alderton House, which illustrates truly regional architecture. Murcutt was influenced by the Aboriginal's pragmatic synthesis with the landscape and followed one of their proverbs: "one must touch the earth lightly" (Fromonot: 2003, 39). He understood that this was architecturally and environmentally beneficial that it would create a "temporary relationship between architecture and landscape, founded on respect and tact" (Fromonot: 2003, 39). Murcutt's response was to raise his buildings onto stilts, which improved ventilation and reduced human's environmental impact, while creating a transient presence rather than an attempt to dominate over nature (Fromonot: 2003, 40) (fig. 4.4.7).

Fig. 4.4.4- Photograph of a bakery dating back to 1870 which shows similarlities to many of Murcutt's designs (Source- Fromonot: 2003, 34)

Fig. 4.4.5- Photograph of a barn from Murcutts collection (Source- Fromonot: 2003, 32)

Fig. 4.4.6- Photograph of Marie-Short House (Source- Fromonot: 2003, 102)

Fig. 4.4.7- Ball-Eastaway House on stilts (Source- Fromonot: 2003, 137)

Murcutt designed the Bowali Visitor Information Centre in association with Troppo Architects in 1992-1994. The museum and visitors centre is located in the Kakadu National Park, Northern Territory, Australia, and aims to explain the park's natural and cultural qualities to the visitors (fig. 4.4.8). Murcutt's communication with the local Aborigines helped to develop a culturally rooted concept in terms of 'bush' materials (such as rammed earth, rocks, timber and anthills) and local rituals and perceptions pertaining to the place. Cultural symbolism inspired the architects to design the access ramp in a tangential manner rather than head-on, due to the late Big Bill Neidje's (leading elder of the Gagudji clan) recommendation as to how sacred sites in the region are approached and used (fig. 4.4.9 and fig. 4.4.10). Murcutt was further influenced by the tropical climate and the horizontally spread characteristics of the place. He manifested these factors in the building's single storey sprawled form, natural materials, use of timber slatted screens and permeable structure (fig. 4.4.11 and fig. 4.4.12). In this manner the Bowali Visitor Information Centre truly represents regionalist architecture.

Fig. 4.4.8- World map illustrating the location of Kakadu, Australia (Source- By Author)

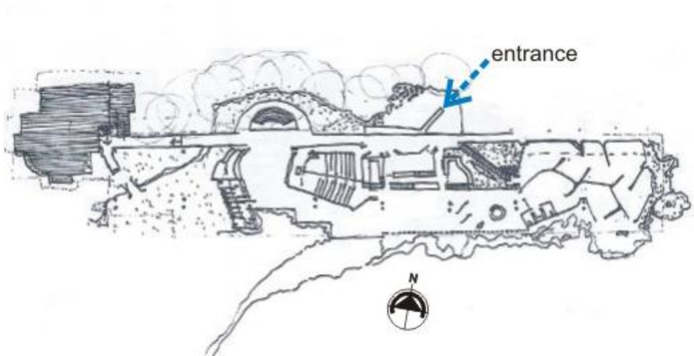


Fig. 4.4.9- Concept plan of Bowali Visitor's Centre illustrating the diagonal entrance (Source- Fromonot: 2003, 234)

Fig. 4.4.10- Concept sketch of the off axis entrance and lofty roof of Bowali Visitor's Centre (Source- Fromonot: 2003, 204)

Fig. 4.4.11- Aerial view of the complex (Source- Fromonot: 2003, 235)

Fig. 4.4.12- Photograph of the cave-like ceiling form and timber screen which filters sunlight and breezes (Source- Fromonot: 2003, 238)

Two core principles were adopted for the design; the presence of water which Murcutt claims allows the visitor to "immediately translate the season" (Fromonot: 2003, 234) as well as connects the visitor with the natural cycles of the place. The second principle is to allow natural ventilation, which is a major theme throughout Murcutt's architecture and resulted in an open pavilion built typology (fig. 4.4.13). The architects created large volumes over the 'observation veranda' by using plywood ceilings beneath the upturned roofs which symbolically evoke caves found in the Kakadu National Park and commemorate the sense of protection which they offer in the expansive landscape (fig. 4.4.12).

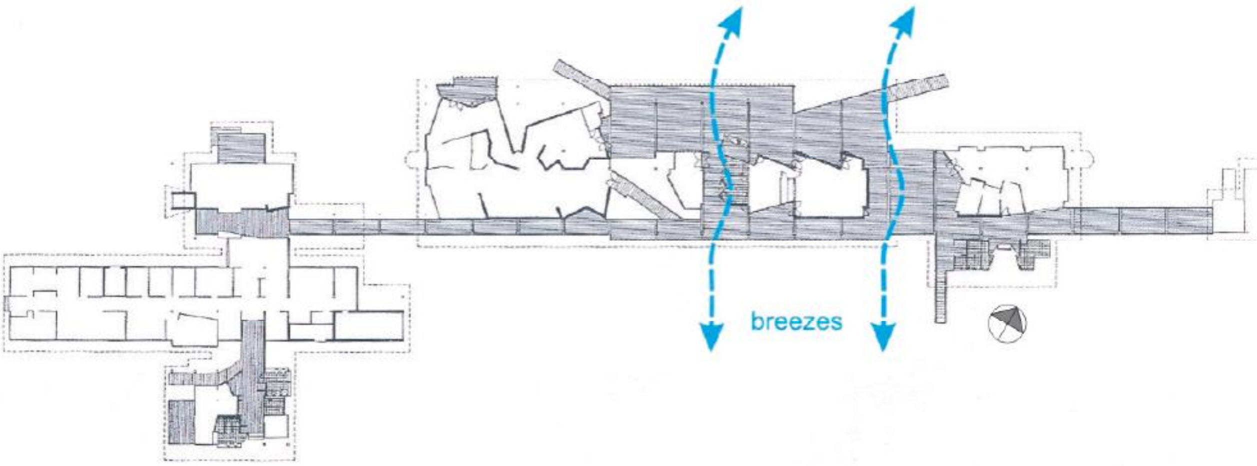


Fig. 4.4.13- Plan of the Bowali Visitor's Centre's 'pavilion' typology permitting air movement (Source- Fromonot: 2003, 241)

Fig. 4.4.14- Photograph of House Ball-Eastaway's verandah illustrating Murcutt's concept of feathering, giving the impression that the architecture is merging onto the natural surroundings (Source- Fromonot: 2003, 50)

Murcutt reiterated his beliefs that nature and architecture should be connected with the use of symbolism, whereby he encompasses a type of dematerialisation, which he calls 'feathering'. He usually accomplishes this at the point of interaction between the man made structure and the surroundings, such as the veranda. An example of this can be seen in Ball-Eastaway House (fig. 4.4.14) (Fromonot: 2003, 50). He also draws upon materials to allow the building become part of nature. He has achieved this in the Marie-Short House, whereby "the landscape starts to consume it" or the house "takes on the landscape" as Murcutt uses timbers with grey varnish which weathers resulting in a natural texture and colour (fig. 4.4.6). (Clark: 2009)

Regional architecture was successfully accomplished in both Piano's Tjibaou Cultural Centre and Murcutt's Bowali Visitor Information Centre. These nationalist architects truly comprehended and appreciated the cultural heritage of the localities, as they sentimentally replicated traditional concepts within the contemporary buildings as well as respond to the locality's climate and surroundings. The built forms echo and celebrate the surrounding landscape, whether it is the verticality of trees in the case of the Tjibaou Cultural Centre or the horizontality of the outback reflected in Bowali Visitor Information Centre. The natural forces are revealed through the architecture of these buildings as they respond to the local climate in terms of solar shading or visual ventilation techniques, giving the impression that the buildings were determined by climatic factors. Murcutt encourages the concept of making the presence of nature felt within architecture and thus chooses to exploit natural resources such as sunlight by introducing solar screens or water where he uses water features, rainwater storage tanks and exaggerated rainwater downpipes. All of the aforementioned qualities aid in generating unique buildings which celebrate and enhance their genius loci. In this respect the architects have accountably producing special, identifiable places for the occupants.

4.5 Conclusions

The purpose of this secondary investigation was to guide the design process of an Environmental Education Centre on the Umgeni River. This chapter was significant in indicating how contemporary architects have addressed issues such as interconnectivity, bioclimatic design and regionalism to produce environmentally conscious buildings. This study aimed to generate a design proposal which is an autonomous built intervention that respects natural systems, becomes part of the intricate ecological web and employs renewable energy rather than coal-fire power which is prevalent in South Africa.

Interconnectivity was expressed in the Hockerton Housing Project, Piney Lakes Environment Centre, Pocono Environmental Education Centre, and Council Housing 2 (CH_2). It is clear that reduced dependency on municipal electricity and water supply is crucial. Rainwater collection and storage as well as the use of grey water are vital for an autonomous design. Furthermore it is relevant to purify waste (black and grey water) to reduce pressure on the main drains. In terms of materials it is relevant to specify recycled materials to reduce waste as well as use natural materials such as earth blocks which can be part of the 'Cradle to Cradle' concept. A truly interconnected building clearly must prohibit the use of coal-fire power and preferably employ energy through renewable sources such as kinetic and solar energy.

Methods of artificial cooling and heating, which are energy consuming, are mitigated due to principles of bioclimatic design through climate modification systems and devises. These principles were studied in Pocono Environmental Education Centre, Tjibaou Cultural Centre, Ken Yeang's master plan for the University of Nottingham Malaysia campus, Council Housing 2 (CH_2) and the architecture of Glenn Murcutt. It is apparent that this concept required a clear understanding of the locality's climate to in environmentally responsible buildings that harmonise with the climate. It is vital to respond to the climatic elements such as ventilation, solar heat gain and precipitation. This was achieved through passive design principles, such as orientation, thermal capacity of materials or ventilation and cooling systems. Most architects, discussed above, expressed climatic responses by exaggerating environmental control systems, such as Murcutt's celebrated rainwater downpipes and incorporation on nature.

The concept of regional architecture, which was analysed in Tjibaou Cultural Centre and the Bowali Visitor Information Centre, aimed in generating buildings that are culturally and climatically relevant and specific to their locality. This was achieved through symbolism and identification. Evidently, it is crucial to examine the locality's traditional culture and defining or distinguishing factors and through symbolism exaggerate these points. In this regard the genius loci was captured and celebrated producing a unique and distinctive place.

When designing an Environmental Education Centre it is vital to produce interactive and legible architecture. This was studied in Piney Lakes Environmental Centre and Pocono Education Centre. Factors which were ascertained within this research are for example, emphasised recycled materials which were a visual tool of waste management, an imprinted 'scavenger-hunt' wall which educated and entertained learners, manual systems so that the learners became conscious of energy choices and visual reference to renewable energy systems in the form of technology towers which created awareness. This chapter was vital for indicating a brief and accommodation for the Environmental Education Centre proposed for the Umgeni River.

CHAPTER 5
CASE STUDY

5.1 Introduction

This chapter comprises of primary research in the form of case studies. The gathered information will indicate methods of designing appropriate educational facilities and depict how architects have dealt with expressing environmental design to the public. This information will also reveal accommodation requirements, architectural elements which are specific to Durban's locality and climate resulting in regional architecture as well as sustainable devices utilised for energy harnessing. In this respect this analysis has been separated into subdivisions; Interconnectivity, regional architecture, education centres and architectural expression of sustainability. Interconnectivity with nature will be exhibited by Kirstenbosch Gardens Visitors Centre where techniques of blending the building into the landscape and designing the building as a gateway rather than a destination will be investigated. Elements of regional architecture specific to Durban are illustrated in Issy Benjamin's work, whereby the apartment block, Las Vegas will be studied to determine true regional architecture in Durban. The study of education facilities, specifically uShaka Sea World Education Centre will indicate an appropriate schedule of accommodation. Architectural expression of sustainability is important when designing a building which aims to demonstrate environmental solutions and therefore the BP Head office will be investigated.

5.2 Interconnectivity

There is merit in studying the Kirstenbosch Gardens Visitors' Centre located in Cape Town (fig. 5.2.1) (fig. 5.2.2) given its close proximity and interaction with the ecologically sensitive zone of the botanical gardens (fig. 5.2.3). In this respect it is vital to analyse how the architects at GAPP dealt with blending the building into the landscape and designing the building as a gateway rather than a destination.

Fig. 5.2.1- Photograph of Kirstenbosch Visitors' Centre taken from the parking lot (eastern corner) with Table Moutain in the back ground (Source- C.S: 2000, 46)

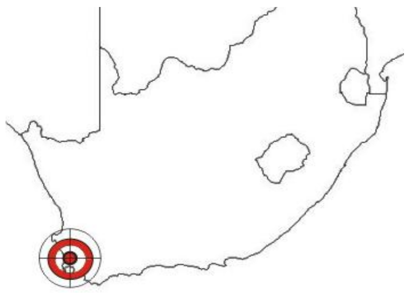


Fig. 5.2.2- Map of South Africa locating Cape Town (Source- By Author)

Kirstenbosch Gardens aims to create awareness and conserve the unique natural environment of the botanical gardens as well as popularise the educative and research activities (fig. 5.2.4) (Lewis: 1996). The brief for the Visitors' Centre consists of an Entrance Pavilion, which includes information kiosks, an audiovisual room which can accommodate 20 people, public phones and public toilets. The complex also boasts a large, multi-functional conference room, which caters for 450 people and can be divided into three parts for exhibition purposes (fig. 5.2.5) (fig. 5.2.6) (fig. 5.2.7). There is a fully equipped kitchen with stove and bin area as well as chair storage room attached to the conference facility. In addition there is a book store and curio shop in the Visitors' Centre which together with the sales of entry tickets, provides funding for the Kirstenbosch Gardens. The main amphitheatre space in the centre of the complex functions to host public space making, while introducing the visitors to the external environment (fig. 5.2.8) (fig. 5.2.9) (Jacobs: 2009). The natural element, water, is celebrated in this outdoor amphitheatre space as there is a water feature which channels the precious source around the perimeter of the courtyard depicting its importance (fig. 5.2.10). The audibility of the water serves to soothe the visitors as

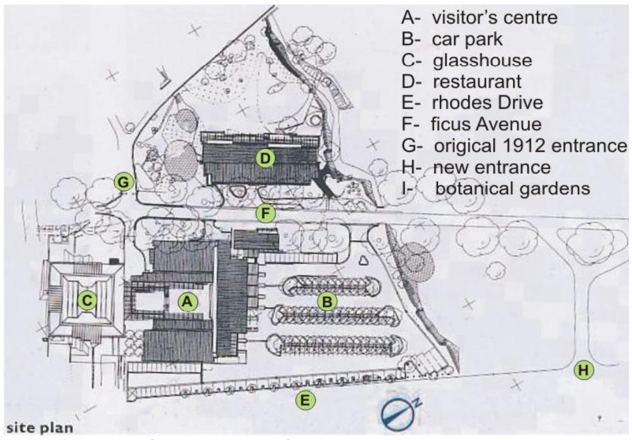


Fig. 5.2.3- Site plan of Kirstenbosch Visitors' Centre illustrating it's placement in regards with the botanical gardens and restaurant (Source- C.S: 2000, 46)

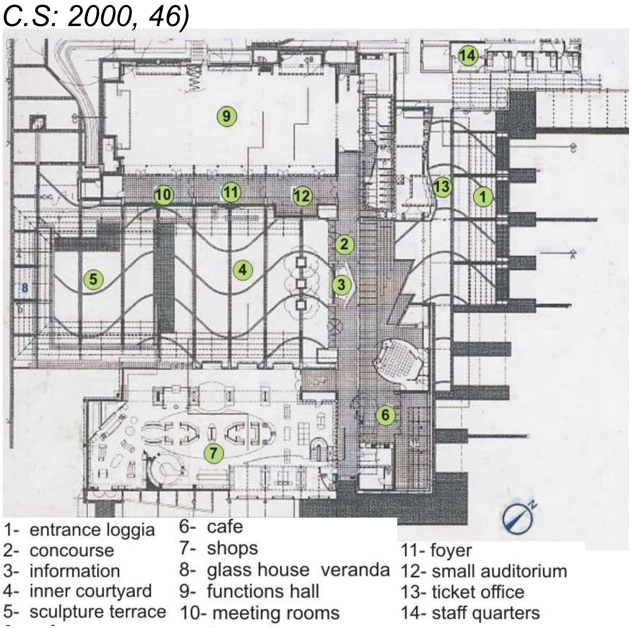


Fig. 5.2.4- Plan of the Visitors' Centre (Source- C.S: 2000, 48)

Fig. 5.2.5- Photograph of the multifunctional room illustrating the dividing screens, making the room flexible and the large windows, which connect the interior with the natural environment (Source- By Author)

well as mitigate the noise of traffic from the busy adjacent road (C.S: 2000). The central courtyard possesses a hospitable quality due to the human scale of the planted screens and timber pergolas (fig. 5.2.11).

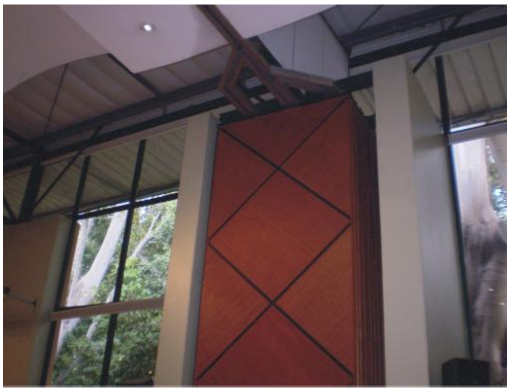


Fig. 5.2.6- Photograph dividing screens (Source- By Author)

Fig. 5.2.7- Photograph of the multifunctional room divided into three parts for an exhibition (Source- SANBI: 2009

Fig. 5.2.8- Photograph of the sculptural display in the amphitheatre with mountains in the background (Source- By Author)

Fig. 5.2.9- Photograph of the amphitheatre (Source- By Author)

Fig. 5.2.10- Photograph of the water feature at the edge of the amphitheatre, thus incorporating natural elements into architecture (Source- By Author)

Fig. 5.2.11- Photograph of the water feature and planted pergolas which make the visitor aware of the natural cycles of the environment (Source- C.S: 2000, 47)

It is important that the architects made an effort to blend the building into the landscape as the main focus should be the botanical gardens and not the building. The architects achieved this by applying the design philosophy of placing the bulk of the building into the slope of the site so that the roof followed the profile of the landscape and therefore maintaining the views of the mountains and gardens. GAPP Architects designed a stepped amphitheatre at the heart of the complex which is flanked by the existing glass conservatory and single storey wings consisting of information counters, offices and a conference centre. The double storey wing on the south-eastern edge comprises of a curio and book shop on the upper floor while offices and storage are located on the lower floor, and serves to negotiate the slopping site (fig. 5.2.12) (fig. 5.2.13).

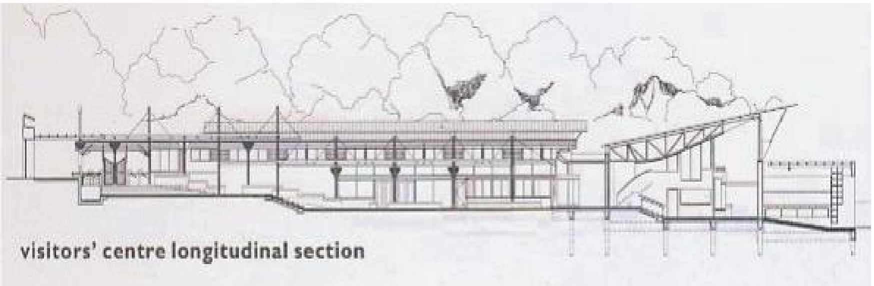


Fig. 5.2.12- longitudinal section through the Visitors' Centre illustrating how the building hugs the landscape (Source- C.S: 2000, 48)

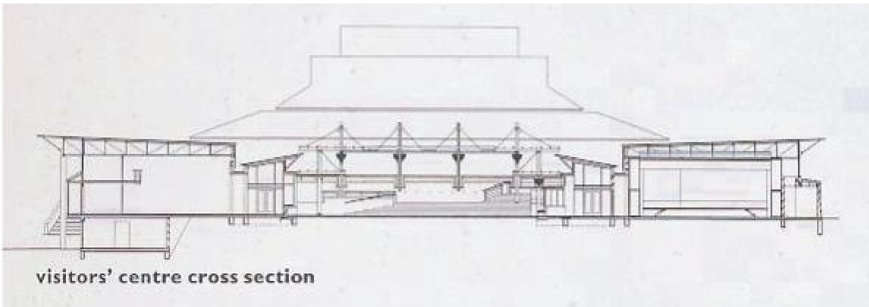


Fig. 5.2.13- cross section through the Visitors' Centre depicting the courtyard space and the way in which the double storey negotiates the slope of the site (Source- C.S: 2000, 48)

The built form has been designed to reflect the natural surroundings. This is clear in the roof structure which is lightweight corrugated iron with arboreal timber supports, echoing the formation of the ficus trees outside. The reiteration of a tree-like formation is also evident in the timber fan trusses supporting the roof at the Kirstenbosch Restaurant (Silver Tree Restaurant) and in a sense brings the outside into the building (fig. 5.2.14). The concept of planted screens also assist in integrating the building with the environment and can be seen at the grand vine covered loggia and the planted pergola fronting the conservatory (fig. 5.2.15) (fig. 5.2.11). The incorporation of plants into the building lends itself to being a visible part of the natural cycles and climate as the plants change colour or blossom depending on the season. The choice of materials also promotes integration with nature as the finish of the walls, which are of local stone, have been plastered the colour of the soil, giving the sense that the building is rooted to the site. (SANBI: 2009)

Fig. 5.2.14- Photograph of the arboreal timber supports at the Silver Tree Restaurant (Source- By Author)

Fig. 5.2.15- Photograph of the grand vine covered loggia (Source- By Author)

The architects designed the Kirstenbosch Gardens Visitors' Centre as a gateway rather than a destination. The entrance pavilion is of a civic scale, which GAPP architects claims has allowed the building to become a grandiose gateway to the garden (fig. 5.2.16) (fig. 5.2.15) (Lewis: 1996). The use of substantially tall columns and double storey elevation is effective as it is perceptibly the main entrance to the gardens, however it is also overpowering given its lack of human scale.

Fig. 5.2.16- Photograph of the grandiose entrance which is very overpowering as it is not to human scale (Source- By Author)

A clear and legible organisation of the building complex is paramount in the Visitors' Centre as it allows the visitor to easily read the space and orientate themselves while on their journey to the gardens (Lewis: 1996). This unfortunately was not achieved as the visitor feels lost when reaching the open amphitheatre space. This could possibly be due to the fact that there was a lack of visual markers and clear visual lines. For example the turnstiles to the gardens are not visible and have been located off axis from the entrance.

This prevents the visitor from being easily guided towards their destination. To achieve a legible complex, a clear route towards the destination should have been set out or the visitor should be given a glimpse or direct view of their destination when he or she reaches the entrance pavilion.

The architecture of Kirstenbosch Gardens Visitors' Centre advises methods of blurring boundaries between the visitor and nature by permitting the building to sit unobtrusively in the landscape, which prevents the obstruction of views to the garden and mountain. The architects have used symbolism to incorporate nature into the building in terms of arboreal supports which echo the formation of surrounding trees. Planted timber pergolas and water features further assist in including nature into the built form and operates to provide awareness of the natural cycles of climate and seasons. The architects designed the building to function as a gateway into the gardens and in this regard it was necessary to create vistas which exaggerate and celebrate the experience of being in an ecologically sensitive zone. The gateway into the building is overpowering which created a contrast between nature and man-made structures, allowing the visitor to recognise the vulnerability of the natural landscape. Unfortunately this negates the image of an environmentally sensitive building. Furthermore, it is vital that a public building has a strong sense of legibility which was not well achieved in this design due to the lack of visual routes and views towards the destination.

5.3 Regional architecture

To reflect regionalism it is important to respond toward and celebrate the locality's unique climate, context and culture. uShaka Marine World is an example of an unsuccessful attempt towards regional architecture while the work of Issy Benjamin provides an indication into Durban's regional architecture. This will be studied in terms of providing solutions to Durban's subtropical climate in terms of sun shading devices and reflect principles of bioclimatic design.

The architecture of uShaka Marine World, designed by Boogertman Kriege with Architects Collaborative, negates the principles of regionalism as it is a patronising imitation of Zulu vernacular architecture and culture (fig. 5.3.1). Durban's local climate, geography and context have been ignored by the architects which is especially evident in the SAAMBR facilities as the buildings are entirely sealed prohibiting any architectural response to the natural forces. This fact illustrates that the architects disregarded the client's brief which was to provide a 'green' building reflecting the organisation's responsibility to conserve nature and impart environmental knowledge. Instead, the architectural vocabulary of this development is one of false ethnic forms and materials, ultimately communicating a theme park appearance which is completely air-conditioned.

Fig. 5.3.1- Photograph illustrating the pseudo vernacular forms which are prominent at uShaka (Source- By Author)

It is necessary to study the South African Architect, Isaac (Issy) Benjamin due to his rich, vibrant and ultimately regional architecture. This case study will review the manner in which he was able to draw upon certain qualities unique to Durban (fig. 5.3.2) and express them through architectural vocabulary to provide regional expression.

Fig. 5.3.2- Map of South Africa locating Durban (Source- By Author)

Issy Benjamin began practicing architecture in the 1950's when the Brazilian regional architect Oscar Niemeyer and the Modern Movement were influential. Benjamin was inspired by the way Niemeyer transformed Le Corbusier's strict purist ideals into a lighter more lyrical style. Niemeyer became infamous for introducing a sensuous local architectural expression where he adjusted the vocabulary of the International Style to represent Brazil's tropical climate. Benjamin emulated Niemeyer's sensitivity towards the site's conditions, local climate and culture in search of a truly nationalistic architecture. In this regard, Benjamin became a recognised regional architect in Durban as his architecture reflected and responded to Durban's context and subtropical climate. He accomplished this by permitting his designs to be site specific, culturally reflective and climatically responsive in terms of shading and ventilation. (Butler: 1981)

The building which reflects these regional qualities is the Las Vegas Apartment block (fig. 5.3.3), built in 1957 along Durban's beachfront. Benjamin depicted his sense of context through the curved front elevation which reflects the edge of the sea as well as echoes Niemeyer's admiration for organic architecture (fig. 5.3.4). Issy Benjamin celebrated his beloved city's vibrant culture through bright colours and textures, such as the juxtaposed use of stone work, concrete and brick. (fig. 5.3.5) (Benjamin: 1997)

Fig. 5.3.3- Photograph of Las Vegas apartment block taken from the boulevard (Source- Benjamin & Crofton: 1958, 36)

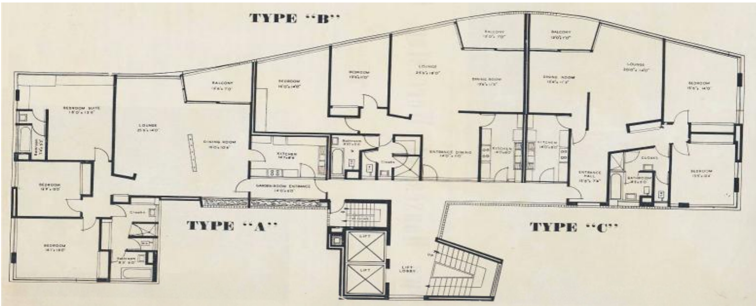


Fig. 5.3.4- Plan illustrating the curved front elevation (Source- Benjamin & Crofton: 1958, 41)

Fig. 5.3.5- Photograph of Benjamin's use of stone to create texture (Source- Benjamin & Crofton: 1958, 38)

Benjamin explored architectural solutions to respond to Durban's subtropical climate resulting in a building distinct to its locality and in this respect expressed his nationalistic style. This was achieved as Benjamin responded to the prevalent sunlight by introducing perforated screens, which posses the dual function of shading and ventilation (fig. 5.3.6) (fig. 5.3.7). These vertical screens are reminiscent of brisole, a Brazilian solution to providing thermal comfort. In a sense, the building conveys parallelism given Durban and Brazil's similar climatic determinants and architectural solutions. Perforated concrete slabs are also evident in this building and can be seen from the ground floor which give the impression of lightness as well as provides strong, distinct organic shadows which shift with the sun giving the building a 'sundial' quality (fig. 5.3.7) (fig. 5.3.8). Additional shadows are cast by the zigzagged railings augmenting the contrast between light and dark. Shadows are a significant element in Benjamin's buildings as they are used to exaggerate the importance and materiality of the sunlight to give the building a tropical atmosphere. (Benjamin & Crofton: 1958)

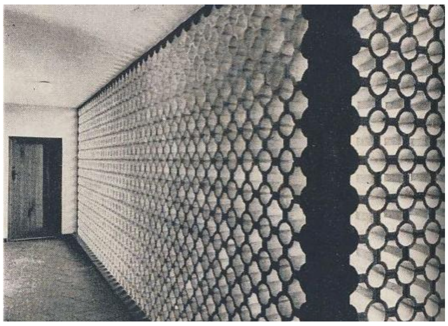


Fig. 5.3.6- Brisole evident on the rear elevation for ventilation and shading (Source- Benjamin & Crofton: 1958, 38)

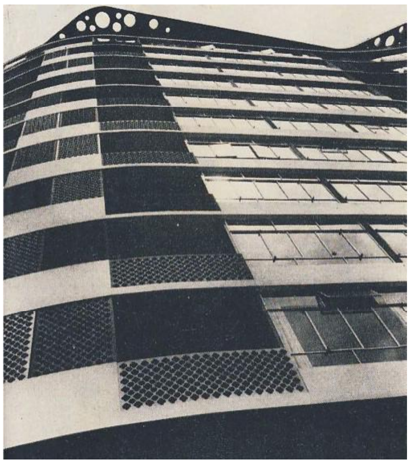


Fig. 5.3.7- Photograph of the perforated screens and concrete slabs giving the impression of 'lightness' (Source- Benjamin & Crofton: 1958, 39)


Fig. 5.3.8- Photograph of the penthouse's balcony depicting the unique shadows which are cast by the perforated slabs and railings (which have subsequently been replaced) (Source- Benjamin & Crofton: 1958, 38)

Benjamin extracted Durban's distinct characteristics and reflected them in his architecture, resulting in truly regional work. He exposed Durban's coastal positioning, culture and subtropical climate by creating a unique tropical atmosphere. Benjamin achieved this by celebrating sunlight through the introduction of perforated screens and slabs to create strong, exaggerated shadows. In this sense, it is important to conclude that regional architecture can be executed by defining and expressing distinct qualities to the place. And in Durban's case regional architecture can be achieved through the exaggeration of shadows so as to celebrate Durban's comfortable and pleasant climate.

5.4 Education Centre

uShaka Sea World Education Centre was selected as a case study as it is relevant in terms of determining accommodation of an educational facility. The Sea World Education Centre is a division of the South African Association for Marine Biological Research (SAAMBR) which also consists of the Oceanographic Research Institute (ORI) and the uShaka Sea World (fig. 5.4.1) (fig. 5.4.2). The Education Centre aims to encourage awareness and appreciation of the marine environment by utilising live exhibits of the aquarium as well as promoting sustainable use of the marine environment (uShaka Sea World: no date). In this regard, hands-on-learning is endorsed as the curriculum includes practical activities within the experimental laboratory. The overall architectural brief required by SAAMBR was a 'green' building which demonstrated their responsibility to the environment. This case study, in addition to determining an appropriate brief, will investigate if this has been achieved.

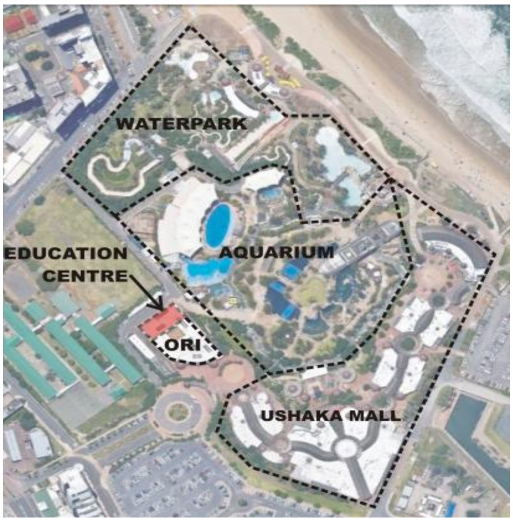


Fig. 5.4.1- Map of uShaka development (Source- By Author)

The Education Centre is needed to interpret and disseminate the knowledge gained at ORI to the public and specifically the learners from schools. Unfortunately the educational facility presents artificial exhibitions, for instance the man-made aquarium and the fact that all the marine specimens have been plucked from their natural settings. This prevents the learners from ascertaining a realistic view of the natural contexts and ecosystems of which the specimens are a part of. There are also barriers formed between the learner and the natural environment due to the 'sealed' quality of the building as the classrooms and conference room do not have any windows and are closed off from the very subject matter which is being explored, the natural environment. Most of the uShaka Marine World development, including ORI and the Education Centre have inoperable windows, meaning that the whole development is ventilated and cooled via air-conditioning systems. This is obviously needed in some of the laboratory facilities such as the microscope laboratory and fume room, but it is undesirable to utilise artificial ventilation and cooling throughout the whole of uShaka Marine World. This type of architecture may contribute to sick building syndrome, expends copious amounts of energy and omits heat which exacerbates the heat island effect of cities (MacKay: 2009). As a result, the architects for uShaka Marine World development have abandoned SAAMBR's requirement for the building to outwardly express environmental responsibility.

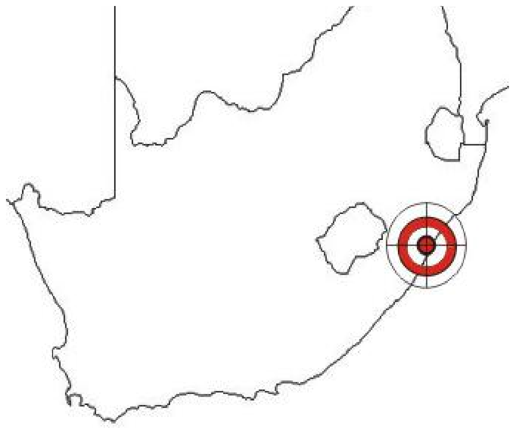


Fig. 5.4.2- Map of South Africa locating Durban (Source- By Author)

The Education Centre accommodates up to 400 learners per day and can manage six school buses at any given time. The Education Centre consists of a conference facility, one large classroom (with a dividing screen to make two smaller rooms), an experimental laboratory and staff facilities (fig. 5.4.3).

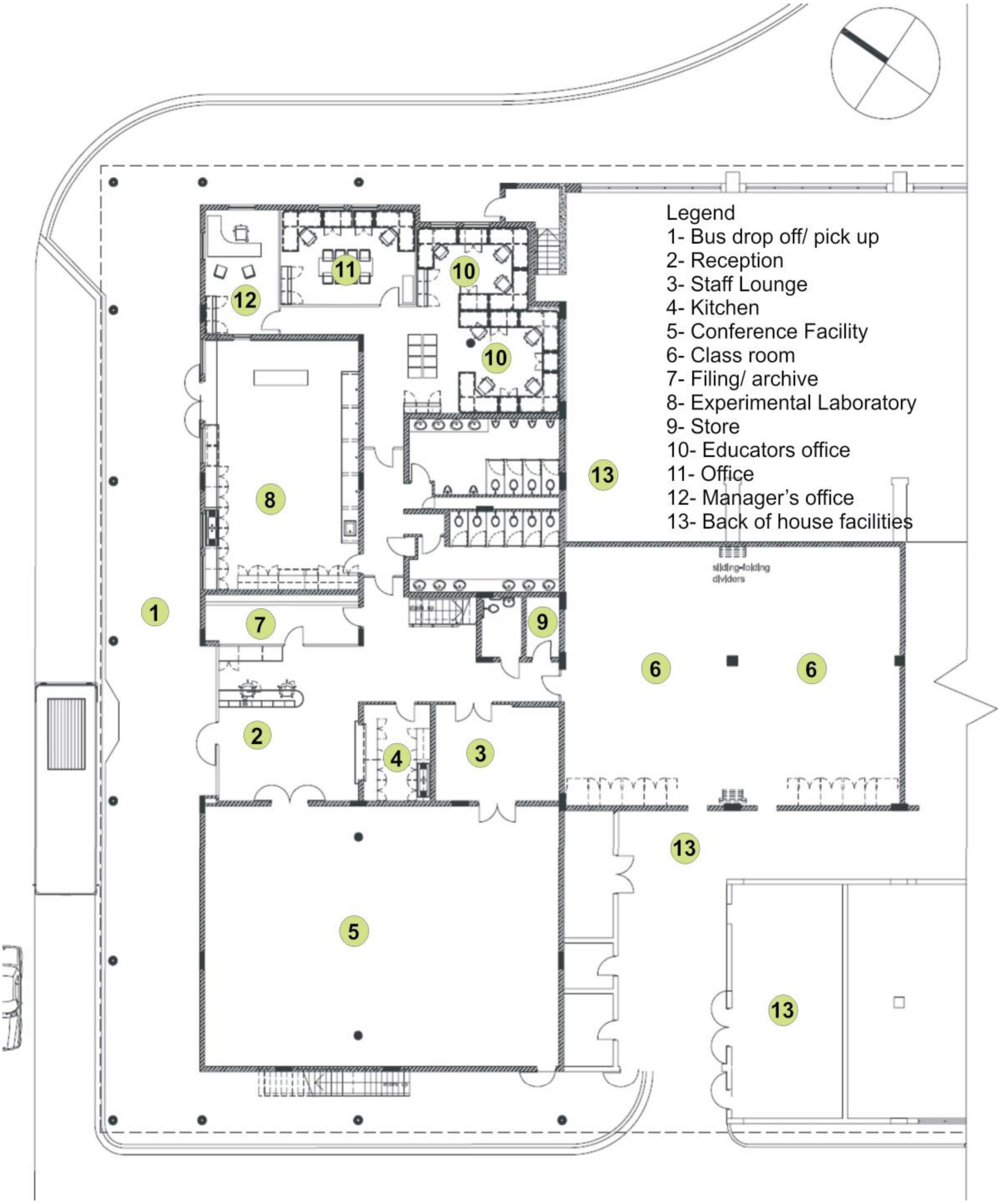


Fig. 5.4.3- Plan of uShaka Education Centre (Source- Bellingan: 2008, 57)

It is imperative to have a clear understanding of the learners' progression through the Centre as this ultimately allows for a legible and functional design proposal. Firstly, the learners (in groups of 15-60 children) arrive by bus and sit on benches on the covered 'waiting veranda' (fig. 5.4.4) while their teachers go inside to the reception (fig. 5.4.5). This becomes impractical when it is windy and turns chaotic when there is more than one group of learners waiting at a time. In this regard Kilian expressed that a large sheltered waiting space with a form of entertainment is necessary for an Education Centre. The learners are then greeted by one of the educators and asked to leave their bags on the floor in the foyer, which is inconvenient and unsafe, making it apparent that there is a great need for lockers or storage space for the children's belongings. The learners are then either led into the multi-purpose conference room, the classroom (fig. 5.4.6) or taken on a tour of the aquarium. The conference room may accommodate approximately 150 people and is available to learners from schools or universities, the staff of the entire uShaka development as well as independent businesses for conferences. This space is formally set out in a lecture room fashion and requires a white board, television, projector and screen. The kitchen lies adjacent to the conference room and opens onto the foyer where tea or snacks may be served (fig. 5.4.7). Kilian suggested that a dedicated catering kitchen with an oven is needed to assist in providing a functional and efficient conference facility (Kilian: 2009). The Classrooms can cater for up to 50 people per room and work well in terms of an interactive and flexible space due to the dividing screen, movable furniture and the storage for additional chairs (fig. 5.4.8). The rooms have technically advanced equipment such as a smart board which is used for presentation purposes and in this respect

Fig. 5.4.4- Photograph of the 'waiting veranda' with benches and recycling bins (Source- By Author)

Fig. 5.4.5- Photograph of the reception area (Source- By Author)

Fig. 5.4.6- Photograph of the classrooms illustrating the use of a white board, projector and a smart board (Source- By Author)

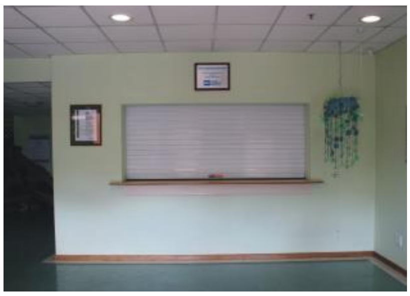


Fig. 5.4.7- Photograph of the kitchen counter which opens to the foyer and is used for functions. The students also place their bags on this floor (Source- By Author)

there is a need to be able to black out the room. A design criticism is that the entrance does not serve both classrooms when the dividing screen is closed, which is a major source of disruption for both the learners and the educators. The experimental laboratory allows the learners to put their recently acquired knowledge into practice as they are allowed to investigate specimens under microscopes and in tanks in a hands-on manner (fig. 5.4.8) (fig. 5.4.9). It is vital for this 'wet' laboratory to have storage and display cases as well as a projector, a white board and smart board. The experimental laboratory has a capacity for 30 learners however Kilian claims that it is preferable to cater for up 60 learners at a time so that classes do not need to be divided in half. The education centre has outgrown its staff facilities as the number of permanent and non permanent staff members have increased since 2006. There is a great need for a staffroom with a kitchenette which can accommodate up to 30 staff members at a time, because at the moment the employees have to eat their lunch at their desks which is unrealistic and inefficient (fig. 5.4.10) (fig. 5.4.11). Furthermore the centre does not have a separate staff ablution facilities or a staff meeting room which is an essential element in terms of management.

Fig. 5.4.8- Photograph of the experimental laboratory illustrating the need for shelving and exhibition cases as well as storage which is below the sinks (Source- By Author)

Fig. 5.4.9- Photograph of the sinks in the experimental laboratory showing the need for water resistant finishes (Source- By Author)

Fig. 5.4.10- Photograph of the open plan offices used by the directors of the Education Centre

(Source- By Author)

Fig. 5.4.11- Photograph of the notice board which is essential for the staff (Source- By Author)

The research component of the uShaka development (Oceanographic Research Institute or ORI) consists of offices for 25-30 scientists and administration staff, a fully equipped library and laboratories. Like the Education Centre, ORI has outgrown their facility and require expansion. In this regard, it may be suggested that ORI expand to the current uShaka Education Centre which will be moved to the new proposed Environmental Education Centre on the Umgeni River. The new proposed centre is only a short bus or people-mover trip away from the existing uShaka Education Centre, which can still function as a satellite facility where groups of learners can assemble for visits to the aquarium, utilising the Conference room for workshops or lectures.

SAAMBR required a 'green' brief to demonstrate their responsibility to the environment and ecological awareness. Unfortunately this was not realised by the architects as the building expressed no connection with nature and denied any response to the climate. This resulted in a sealed, air-conditioned building which is very disconnected from the subject matter which is to be taught, the environment. This case study was beneficial in determining an appropriate brief and understanding the operating of an education centre. Recommendations which were attained are to provide: a covered waiting area for the learners where they can be entertained; lockers for the learners' belongings; a sick room; a dedicated catering kitchen adjacent to the conference room; a suitably sized staffroom for 30 staff members; a larger experimental laboratory for 60 learners and appropriately flexible classrooms with an efficient method of division.

5.5 Architectural expression of sustainability

The new BP Head Office (fig. 5.5.1) (fig. 5.5.2) is intended to demonstrate BP's commitment to providing sustainable and innovative environmental leadership as well as providing a comfortable and safe working environment for their employees. Furthermore the building clearly has to express green architecture while minimising environmental impact. It is necessary to examine this building given its architectural expression of 'green' principles which is a vital element to BP's design brief. To explore this aspect it is relevant to find out how the building represents sustainable architecture to the public in terms of its architectural vocabulary. This encompasses the buildings envelope, ventilation strategies, cooling devices and employment of renewable resources. In this sense, the BP building called for a Resource Efficient Design (RED) brief which addresses energy and water harnessing and consumption, local and recycled materials and recycling of construction waste (Roos & Noir: 2005). This case study will investigate if this RED brief was genuinely achieved or if the ultimate design goal was for expression purposes only.

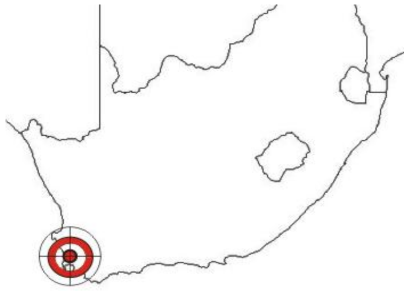


Fig. 5.5.1- Map of South Africa locating Cape Town (Source- By Author)

Fig. 5.5.2- Photograph of the PV panels at the entrance to the BP Head Offices (Source- By Author)

Fig. 5.5.3- Photograph of the SE elevation depicting the recessed windows created by the ventilation stacks (Source- By Author)

KrugerRoos architects aimed to realise a RED brief firstly by designing a climatically responsive building envelope so as to provide a comfortable working environment, thus reducing the excessive use of energy for artificial cooling, heating or lighting. Secondly, by focusing on harnessing renewable resources, in terms of energy and water, to alleviate the building's reliance on coal fuel and municipal water supply. And thirdly, by sourcing recycled internal materials wherever possible. (Roman: 2009)

The first factor that the architects dealt with to produce a RED brief was to design a climatically responsive building envelope and natural ventilation. This is paramount in providing thermal comfort for the employees. The building's envelope assists in maintaining a constant indoor temperature in Cape Town's variable climate by utilising insulation and shading. Insulation is provided on the roof as well as the envelope's cavity wall construction. Solar shading is attained by implementing double glazed windows that are recessed due to a series of ventilation stacks at the edges of the building which extract stale air (fig. 5.5.3). Light shelves offer the dual function of reflecting indirect light deep into the open plan floor plate as well as providing the necessary amount of shading or entry of sunlight depending on the season (fig. 5.5.4) (fig. 5.5.5) (fig. 5.5.6) (Roos & Noir: 2005).

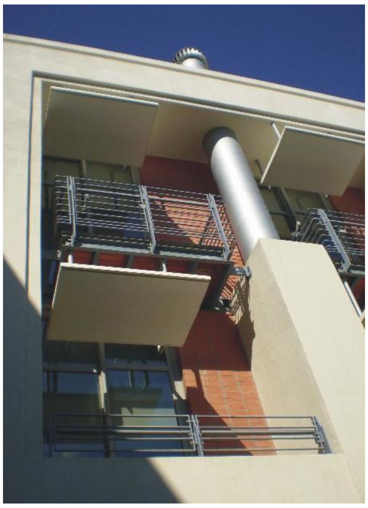


Fig. 5.5.4- Photograph of the light shelves and ventilation stacks (Source- By Author)

Fig. 5.5.5- Photograph of the BP Head Office illustrating its relationship with the surroundings and the recessed windows with light shelves (Source- Le Roux & Du Toit: 2005, 60)

Fig. 5.5.6- Site plan and ground floor plan of the BP Head Office illustrating its relationship with the surrounding gardens (Source- Le Roux & Du Toit: 2005, 63)

Methods of ventilating the building can be attributed to the ventilation stacks on the outer edge of the building and the lanterns running along the main circulation route, both of which expel stale air or smoke in the case of fire (fig. 5.5.7). The noticeable series of ventilation stacks, which, due to the sheer number, give the impression of being able to entirely ventilate the office block, have been supplemented by air-conditioning and in this regard function more as a display to represent an environmentally sustainable building to the public. The lanterns also distribute natural light into the core of the building, where a row of mahogany trees grow, giving the impression that the employees are provided with cleansed air as well as incorporating elements of nature into the building (fig. 5.5.8). These lanterns additionally provide an aesthetically pleasing fifth elevation (the roof) which is enhanced by the photovoltaic panel, overseen by adjacent buildings. Unfortunately the windows are fixed, preventing natural ventilation, due to the use of air-conditioning used to regulate temperature (Roman: 2009). The design

Fig. 5.5.7- Photograph taken on the roof of the PV panels and the lanterns which have louvers (Source- By Author)

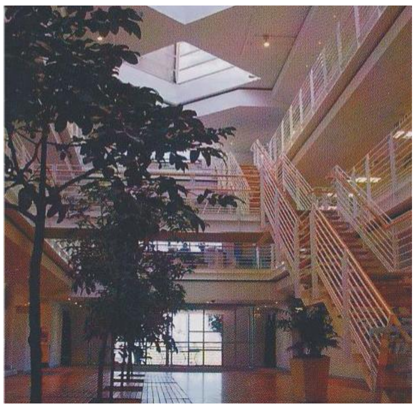


Fig. 5.5.8- Photograph of the 'mahogany forest' and lanterns which allow natural light deep within the building (Source- Roos & Noir: 2005, 39)

team investigated many methods of controlling the internal temperature so as to prevent the use of air-conditioning but were unable to attain a suitable solution to the location's Mediterranean climate. Kruger Roos Architects investigated methods of rock storage, sea cooling and the use of phase change materials but they were either unsuitable for the climate or uneconomical for South Africa.

Fig. 5.5.9- Photograph taken from the roof of the PV panels (Source- By Author)

The second factor KrugerRoos architects employed to achieve a RED brief was the reduction of over-consumption of the municipal's power and water supply and the harnessing of renewable sources. The architects attempted to accomplish this by introducing thermal solar panels, that heat water for the gym's showers and the kitchen as well as 400 photovoltaic panels which generate 10% of the building's electricity (fig. 5.5.9) (Roos & Noir: 2005). The harnessing of energy is obviously lacking and has not reached its full potential as the PV panels should clearly be used in combination with wind turbines which, in such a windy city, would supply a much larger amount of energy. In terms of municipal water consumption the BP building only uses 25% of that of a conventional building. This is suitably accomplished by utilising recovered rainwater and grey water from showers and wash-hand basins. The grey water is sand-filtered and stored in a 1350 m^3 grey water tank and used for flushing toilets and irrigating the landscaping (Roos & Noir: 2005).

Fig. 5.5.10- Photograph of the wall hanging made from recycled materials (Source- By Author)

Thirdly, recycled, low maintenance, durable and local materials had to be specified by KrugerRoos architects to attain a RED brief. This is evident in the 100% recycled carpets, the wall hanging made from recycled materials by ladies in Khayelitsha (fig. 5.5.10) and the rosegum timber flooring located from a sustainable Zimbabwean plantation. Unfortunately these are the only materials which indicate a RED brief and it is clear that many other opportunities have been overlooked. A worthy point is that the building instils a recycling ethic in terms of placing recycling bins (for paper, glass, metal, plastic and organic or wet materials) in gathering areas and near individual work spaces. (Koblitz: 2009)

The above analysis proves that the architects have only partially achieved a RED brief. Due to the fact that the primary cooling method is air-conditioning which is not resource efficient and renewable energy harnessing was not effectively accomplished, however this could be rectified by the introduction of wind turbines. Furthermore, recycled materials were sparingly specified. In essence, the BP building advices the public that it is environmentally responsible and that it harnesses energy from natural sources while negating over consumption. This unfortunately is propaganda as the building has been designed to possess control systems that function as accessories rather than operate the building. This is evident in the buildings lack of energy harnessing when the opportunity is clearly available in terms of wind energy. In spite of this, the building is still very relevant for the investigation of this thesis topic given its need to provide a sustainable architectural expression.

5.6 Conclusions

The main purpose of studying and experiencing the aforementioned buildings was to establish principles of interconnectivity and regional architecture as well as to determine appropriate design requirements for an educational centre and expression of sustainability through architecture. Kirstenbosch Gardens Visitors' Centre assisted in guiding the author in terms of designing a building which breaks down barriers between man and nature by providing views of the natural environment, utilising symbolism; such as arboreal truss supports and incorporating natural cycles, evident in the planted pergolas and water features. Furthermore, this building made it clear that it is imperative to construct a legible building that leads the visitors to their destination and functions as a gateway that celebrates the botanical gardens rather than overpowering it.

It is relevant to analyse Issy Benjamin's work when determining principles of regional architecture as he identified Durban's unique culture, climate and context and celebrated them within this architecture. Benjamin achieved this by incorporating perforated concrete slabs and screens, reminiscent of brisole into his buildings. In this respect Benjamin utilised exaggerated shadows to give sunlight materiality and therefore celebrated Durban's tropical, coastal qualities which represented the place's genius loci.

Architecture can be utilised as a tool for education in a direct manner, in terms of its building typology and function, evident in an educational facility. Alternatively, architecture can provide education in a demonstrative approach by exhibiting sustainable technologies such as photovoltaic panels or ventilation stacks to the public so as to gain environmental awareness. The uShaka Sea World Education Centre provides knowledge in a direct manner due to its functioning. Numerous lessons can be ascertained from studying this building in terms of establishing an appropriate design brief. The education centre demonstrated that it is necessary to provide flexible classrooms, an experimental laboratory which can accommodate at least 60 learners at a time and a conference facility which has a dedicated catering kitchen. It is also important to design a safe and entertaining waiting space which is covered and protected from unfavourable weather conditions as well as a sick room and locker facilities for the learners' belongings. In regards to the staff, it is essential to supply a staff meeting room, staff ablutions and a dedicated staff room and kitchenette for 30 employees. This education centre has also made it abundantly clear that it is important to provide practical education and exhibitions which are part of their natural settings and ecosystems. This is essential for learners and society in general to gain environmental responsibility and awareness. In this respect it is vital to create a built intervention which is connected to the natural environment as opposed to a sealed building prohibits natural ventilation and views to the exterior.

The BP Head Office on the other hand provides environmental solutions through architectural vocabulary and expression and in this respect is didactic in nature. The building is efficient in terms of providing natural lighting and water conservation but unfortunately lacks in terms of ventilation and energy harnessing. In this regard, the building essentially uses control systems as accessories which communicate to the public that the building is environmentally conscious, but after investigating further, it becomes apparent that this is not the case.

This chapter provided suitable knowledge to ascertain an appropriate and efficient Environmental Education Centre which will begin to break down barriers between humanity and nature, celebrate the unique regional qualities of Durban and will be beneficial to the surrounding ecology. Furthermore, the building will essentially become a vehicle for environmental education, directly in terms of function and didactically in terms of architectural expression.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

Architecture, one of man's most permanent interventions, reflects the prevalent "psychological groundswell" (Stannard: 2004, 53) in society. In this respect it was significant to investigate how man's perception towards nature has shaped their architecture. Architects possess the ability to connect man and nature through environmentally sensitive buildings and by providing a shift in mans perception through environmental awareness and didactic architecture.

There is an apparent fracture which has formed between man and nature's relationship (which has been established in the literature review) resulting in catastrophic environmental issues. In this regard the need to promote environmental awareness and reconnect society with their 'source of life' has become evident. Consequently, the primary aim of this dissertation is to establish an architecture which encourages a symbiotic relationship between humanity and the environment, so that society becomes equipped to combat environmental issues which they are currently being confronted by. This has been achieved by investigating literature and theories which facilitate a symbiotic relationship, while generating design requirements for a building which functions in harmony with interrelated ecosystems. The knowledge which has been gained throughout this dissertation can be divided into sections, namely, interconnectivity, bioclimatic design, regional architecture and architecture as a tool for education.

6.2 Interconnectivity

It is imperative to promote a shift in society's perception from a detached ideology to one which is aware of nature's interrelated attributes. The research within this document indicated that a shift in society is the means to humanity's salvation (Wines: 2000, 57). Vernacular shelters epitomised interrelated architecture, due to their use of locally available materials, climatic determined form and appropriate spatial organisation, however the modern movement instigated the trend towards sealed, disconnected buildings. Architecture has the ability to create interconnected buildings through its function, use of architectural vocabulary and expression. In this respect, the apparent function which would ultimately promote the connection between man and nature is an Environmental Education Centre, where recent scientific knowledge would be disseminated to learners, professionals and the general public. Since analysing literature and other buildings which boast principles of interconnectivity, it has become clear that the architectural vocabulary and expression of a truly connected building must physically and metaphorically merge into the natural landscape. In this regard the building should physically merge with nature as the materials should integrate benignly with nature and the built form should be permeable uniting the interior and exterior through the use of membrane-like walls, verandas and 'borrowed landscape'. Additionally, the building should function like an ecosystem whereby all waste is recycled within; rainwater is collected, stored and purified; materials form part of the cradle-cradle cycle and energy is harnessed from renewable resources (these principles are summarised within the precedent study). The building may metaphorically reflect nature's significance through symbolism which can be achieved through architectural expression such as organic architecture. This is evident in the use of curved forms imitating organisms or geometric, arboreal structures which represent trees. Nature's rhythms and cycles can also be incorporated into the building in terms of water features, planted pergolas and trees in the building which allows the visitor to understand and appreciate natural and climatic changes

6.3 Bioclimatic design

Architecture must respond to the fundamental parameters of climate to truly attain a symbiotic relationship with the natural world. Buildings which incorporate principles of bioclimatic design mitigate the need for artificial cooling or heating as well as prohibit the concept of sealed buildings. In this regard a bioclimatic building consumes less energy and initiates healthy, comfortable internal environments, which are in harmony with climatic changes. It is apparent that regional climatic conditions as well as the microclimate of the site must be investigated to achieve a balanced shelter through architectural solutions. In this regard it is important for architectural elements such as materials, built form, spatial organisation and devices to be determined by the climate.

The research within this document has presented the author with tools to design a responsive, comfortable and balanced building specific to Durban's subtropical climate. Vernacular architecture has intimated design solutions to modify internal climates so that the comfort zone is reached. This may be achieved by exploiting the thermal capacity of materials. Knowledge which has been acquired is the ability for adobe, concrete or similar materials to function as cold stores (or a heat store depending on positioning and solar gain) to provide coolth via radiant cooling. For this method to work appropriately for Durban's climate, it should be combined with shading devices and permeable materials to induce ventilation. Built forms differ from region to region depending on the prevalent climate. In a subtropical zone, such as Durban, the built form is used to augment ventilation and prevent solar heat gain in summer. This can be accomplished by raising the building onto stilts, using large overhangs to prevent penetration of solar radiation and utilising a steeply pitched roof with vents to expel stale air. In terms of spatial organisation, cooling can be provided by inducing ventilation through correct orientation and the use of courtyards and verandas. These design elements encourage airflow due to different pressure fields (Venturi effect) and the stack effect. Furthermore, climate control devices are exploited to modify the internal climate, these include screening, ventilation ducts or stacks, fans, wind walls, chilled ceiling panels, phase change material (PCM), shower towers and night purging. When combined appropriately, the aforementioned architectural elements will result in a building which reaches the 'comfort zone' and additionally, will express environmentally responsible design. Furthermore, these architectural solutions vary depending on the prevalent climatic conditions of the area and in this regard aid in providing regional architecture.

6.4 Regional architecture

Architects have the responsibility to create special, meaningful places and not merely spaces. This may be accomplished by identifying and celebrating the locality's genius loci and unique characteristics through architecture. Pioneering architects such as Aalto, Murcutt and Benjamin understood how to design nationalistic architecture. Aalto utilised his infamous serpentine line, forest space and Nordic light to capture Finland's regional characteristics, while Murcutt acquired clues from Australian vernacular architecture and the climate. Izzy Benjamin articulated Durban's tropical atmosphere by incorporating vibrant colours, brisole and perforated concrete slabs which produced distinctive shadows. In this respect it can be concluded that the genius loci of Durban can be summarised as vibrant culture, tropical atmosphere and coastal context. These regional characteristics can be expressed by giving sunlight a sense of materiality through the exaggeration of shadows, which will emphasise Durban's tropical atmosphere and celebrate the notion of a pleasant climate.

6.5 Architecture as a tool for education

Architecture has the capability to impart knowledge either through its typology (education centre) or through its expression and built form. Research, executed within this dissertation, has permitted the author to design a didactic building, which will encourage environmental awareness. It is apparent that for an educational facility to function appropriately, it must be legible and interactive for the users so that they are made aware of energy conscious decisions and their individual affect on the environment. In terms of architectural expression, demonstrative environmental control systems can be incorporated within the building such as technology towers, PV panels and rainwater storage or expression of recycled materials, which teachers people about waste management. This would express the building's aim which is to educate society on methods of sustainability so that they become more aware of the solutions to the environmental issues. This aspect can be emphasised through symbolism or organic expression of the built form illustrating that architecture has the ability to merge with the natural environment in a benign manner.

6.6 Conclusion

The research within this document was concerned with how man's perception towards the environment affected architecture. In this respect architectural parameters were investigated in terms of how they responded to and affected parameters of nature. The parameters of nature were investigated within the following divisions; interconnectivity, bioclimatic design, regional architecture so as to establish a form of architecture which reconnects man and nature.

Ultimately the research which has been executed will guide the author to design a proposed Environmental Education Centre which aims to reconnect humanity and nature through a symbiotic relationship while benefiting the ecology along the specified zone, namely the uMgeni River. Furthermore, the facility will encourage an environmentally aware and responsible society through education, exhibition and demonstration.

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ABBREVIATIONS

Abbreviations

CH2-	Council Housing 2
ORI-	Oceanographic Research Institute
PCM-	Phase change material
PV-	Photovoltaic