# ENVIRONMENTAL SUSTAINABILITY
# &
# VERTICAL URBANISM

**A DISSERTATION**

*Submitted in partial fulfillment of the requirements for the award of the degree*
*of*
MASTER OF ARCHITECTURE

*By*

**KANIKA SINGH**



DEPARTMENT OF ARCHITECTURE AND PLANNING
INDIAN INSTITUTE OF TECHNOLOGY ROORKEE
ROORKEE - 247 667 (INDIA)
JUNE, 2012

# CERTIFICATE

Certified that the report entitled **"ENVIRONMENTAL SUSTAINABILITY & VERTICAL URBANISM"**, which has been submitted by **Ms. KANIKA SINGH**, for partial fulfilment of the requirement for the award of the degree of **Master of Architecture**, submitted in the Department of Architecture and Planning, Indian Institute of Technology- Roorkee, is her own work done by her under my supervision and guidance. The matter embodied in this dissertation has not been submitted by her for the award of any other degree of this or any other institute.

Date: 04/06/12

Place: Roorkee


**TINA PUJARA**

Assistant Professor
Department of Architecture and Planning
Indian Institute of Technology- Roorkee
Roorkee, Uttrakhand state, India

# CANDIDATES DECLARATION

I hereby certify that this report entitled **"ENVIRONMENTAL SUSTAINABILITY & VERTICAL URBANISM"**, which has been submitted in partial fulfilment of the requirement for the award of the degree of **Master of Architecture**, submitted in the Department of Architecture and Planning, Indian Institute of Technology- Roorkee, is an authentic record of my own work carried out during the period from July 2011 to June 2012, under the supervision and guidance of **ASSISTANT PROFESSOR TINA PUJARA** , Department of Architecture and Planning, Indian Institute of Technology, Roorkee, India.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree of this or any other institute.

Date: 04/06/12

Place: Roorkee

(KANIKA SINGH)

---

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

**TINA PUJARA**

Assistant Professor
Department of Architecture and Planning
Indian Institute of Technology- Roorkee
Roorkee, Uttarakhand state, India

## Acknowledgement

In a world ruled by diplomacy and where man has just refused to trust another person or acknowledge the support that he receives from others, I take this opportunity to thank, with all my sincerity, all those who helps me in this dissertation.

First I would like to gratefully and sincerely thank Asst. Prof Tina Pujara for her guidance, positive suggestions, understanding and patience during my post graduate studies at Indian Institute of technology, Roorkee.

I would like to thank Dr. Pushplata, HOD, Department of Architecture and Planning for her encouragement and support. I would like to thank Prof. Rita Ahuja, M. Arch. Coordinator for her help at various stages of this dissertation.

I would like to thank all the jury members for their valuable suggestions for the improvement of this dissertation.

I' m particularly indebted to my parents for inspiring me to this work.

And last but not least my gratitude goes to my friends especially Aman and Anand for their presence and support for the improvement of this dissertation.

My sincere apologies to all those who I have forgotten to mention, I hope there are none please excuse me, but your help is deeply acknowledged.

**KANIKA SINGH**

# Table of Contents

# List of Figures

# Executive Summary

India like any other country is crippled by so many problems everyday like traffic congestion, Land acquisition, population pressure etc. India accounts 2.4 % of the world's surface and accommodates 16.7 % world's population while the existing chaotic urban scenario in most Indian cities seems to make strong case in favor of going vertical, it also distinctly poses the challenge of sustainability as high rise vertical developments tends to use a far greater amount of energy than conventional buildings, these structures behave like refrigerators and pancakes by using electromechanical methods in order to achieve comfort zone, therefore the idea of going vertical is still unaccepted at some points especially when our environment is the most vital issue that has to be addressed. To develop vertical structures sustainably first we have to analyze the requirements of vertical urbanism, second we have to understand what elements we require to make these structures workas environmentally sensitive mechanism. This thesis aims to draw a sequential set of steps (design methodology) for ecological sustainable vertical urbanism, the outlines of chapters are provided below to achieve the aim-

Chapter 1- enlists the identification of problems, aims, objectives, scope and limitations of this thesis outlining a methodology in which study was conducted.

Chapter 2- points out the traces of futuristic ideal cities like "Cite de Circulation" (1924-29), "A colony in the sky" (1908) proposed by Avante Garde architects and also illustrate the problems arises in these developments due to which there ideas remains a plan on paper.

Chapter 3- analyze the concept of vertical city as a most modern trend in the development of modern cities through an example of Tokyo- Shimizu mega city Pyramid and poses it as solution for all contemporary problems like- traffic congestion, urban sprawl, destruction of nature etc. on the contrary this chapter also identifies the problems arises in vertical developments like- non availability of materials, environmental sustainability of these structures, absence of public spaces etc.

Chapters 4- focus on the environmental sustainability of vertical developments and analyze among all the building types vertical development as most unecological. This chapter also emphasized on the need of ecology in vertical developments.

Chapter 5- identify the ecoinfrastructure such as ecocells, vertical landscaping, terrace gardens, sky parks & landscaped Ramps etc. which helps in embedding nature (ecology) to sky (vertical city) to make these structure ecologically sustainable.

Chapter 6- presents two set of case-studies to demonstrate the approach of achieving environmental sustainable vertical urbanism.

Set-1 contains Solaris, Spire edge, BIDV Tower to understand the innovative techniques and ecoinfrastructure.

Set- 2 contains Tokyo Nara Tower, BATC Tower to explain sustainable vertical urbanism.

Chapter 7- explains the various design development theories proposed by ecologist architect Ken Yeang and Vidhur Bhardwaj these theories demonstrate their research to design vertical buildings and green spaces.

Chapter 8- analyze the conventional and sustainable building design methodology, this chapter also frames the existing design methodology with their advantages and disadvantages adopted by the architects based on their design processes and case studies in previous chapters.

Chapter 9- describes the methodology proposed to achieve the aim of the thesis on the basis of primary and secondary data; this was to ensure the development goes in sustainable direction throughout the process with the help of sequential steps.

Chapter 10- concludes the thesis with a review of research contribution and recommendations for designing vertical urbanism, for accommodating green spaces in vertical developments and to formulate design methodology

# Chapter 1 Introduction

## 1.1 Overview

Vertical development is evolving into different forms and styles from the very beginning, these development tries to comes out with the utopian or fantastic futuristic ideas with the help of futurist's, Avante grade architects and artists, but nature, technology, feasibility & human culture prevented them to evolve.

Today the issue with the developing world is sustainability, Infinite demanding nature of human is disturbing the ecology and environment, climate change is one of its side effects.

To meet up the growing needs we have to change our idea of development. Despite the rapid urbanization and population density, Urban Design has not been able to change itself adequately with the new solution to these contemporary problems, cities over the world are designed as two dimensional landscape plan without taking advantage of verticality.

Vertical urbanism could successfully mediate new urban environment for future urban density. It could accommodate mixed land use- Residential, Commercial, Civic parks, Green spaces, infrastructure, support system within itself at different levels. It can also help in minimizing footprints.

But from the traces of the history the vertical development takes place without thinking about technological support and environmental impact, they respond as an energy eating boxes with no green spaces & natural ventilation this may be one of the reason of that few architects, planners and urban designers are having a critical view about vertical development.

Therefore there is a need to incorporate the paradigms of environmental sustainability in vertical urbanism so that it can deal efficiently with human's demanding nature and practical urban design urge.

## 1.2 Identification of Problem

### 1.2.1 Destruction of Nature

As we sprawl across the land in order to find space to build or live, we kill a large number of species who live in these areas, when we cut a forest or remove trees actually we removing or drastically imperiling a vast array of species. Some of the species are still unknown to science and played an important role in maintaining the cycle of ecosystem.

1. Indian cities have been supposed as a major source of environmental problems. The EPA (2001) concludes that urban form and development directly affects our built and natural environment, our built practices threatened species, degrade water quality through landuse, affects ecosystem.

### 1.2.2 Aspiration for nature

"Nature is the part of original environment and its life forms that remains after the human impact. Nature is all on planet earth that has no need of us and can stand alone"[1]

Lack of green spaces leads to many environmental and psychological problems, building greener is really quite important and desirable. Human activities are degrading our nature but now it's time to conserve our resources, because earth is not able to deal up with the pace by which we are destroying. Our endless demanding nature not only harms environment but also the survival of other species on earth which in turn affect the ecosystem.

### 1.2.3 Population pressure

The populations of cities are increasing tremendously and become a burden for the existing infrastructure. Due to population pressure cities are converting into miserable and aesthetically depressing places to live, Population pressure also leads to various problems- like Land Acquisition, Deforestation, urban Sprawl, Environmental degradation.

Stabilizing population is an essential requirement for promoting sustainable growth. Some important facts which signify the importance or seriousness of the problem-

- India is the second most populous country in the world sustaining 16.7 % of the world's population
- Population of Indian states can be compared to the population of many countries-

Uttar Pradesh- 183 million; Brazil- 187 million
Maharashtra-104 million; Mexico- 104 million
Bihar- 90 million; Germany- 83 million
Tamil nadu-65 million; France- 61 million

- India accounts 2.4 % of the world's surface and accommodating 16.7 % Of the world's population.

### 1.2.4 Urban Sprawl&Land Acquisition

Urban sprawl is based on the phenomena of spreading from high density areas to low density areason the outskirts of the city.

- The urban sprawl results in the degradation of natural and landscape values.
- Higher cost ofdevelopment of public transport.
- Losing spatial order and traditional values of space.

Land acquisition leads to problems like- Forest depletion which directly affects the habitat, ecosystem, green areas and air quality, premature loss of agricultural land.

### 1.2.5 Traffic congestion

Our metro cities are facing the serious problem of traffic congestion, India's middle class is burgeining due to economic growth and rise in incomes. Delhi, Mumbai, Calcutta have 5 % of India's population but 14 % of its registered vehicles.

## 1.3 Aim& Objectives

### 1.3.1 Aim

The aim of this dissertation is to study the existing design methodology adopted for designing vertical development and formulate a new design methodology for achieving ecological sustainable vertical urbanism.

### 1.3.2 Objectives

- To understand the requirement for ecological sustainable vertical urbanism.
- To analyze the special inputs required for designing vertical urbanism.
- To identify the ecological elements required for attaining ecological sustainability in vertical urbanism.
- To study existing design methodologies adopted for achieving ecological sustainability in vertical developments.
- To formulate design methodology to show how the vertical building can be reconceived as an environmentally sensitive mechanism.

## 1.4 Scope & Limitations

To understand the requirement of vertical urbanism, use of innovative green techniques and vertical landscaping for achieving ecological sustainability in vertical development.

The study will be large based on secondary data, as no such live case studies exist.

## 1.5 Methodology

The identification of problem in this thesis called for a methodology which is quite different from conventional methodologies. In addition to literature case studies, this research involves study of ecoinfrastructure, ecological elements, vertical urbanism, conventional design methodologies and changing trend in the design methodology, a study of existing design methodology adopted by architects to design ecological vertical developments. This can be done by analyzing the primary and secondary data collected, the general work flow has been depicted in the flow chart below-

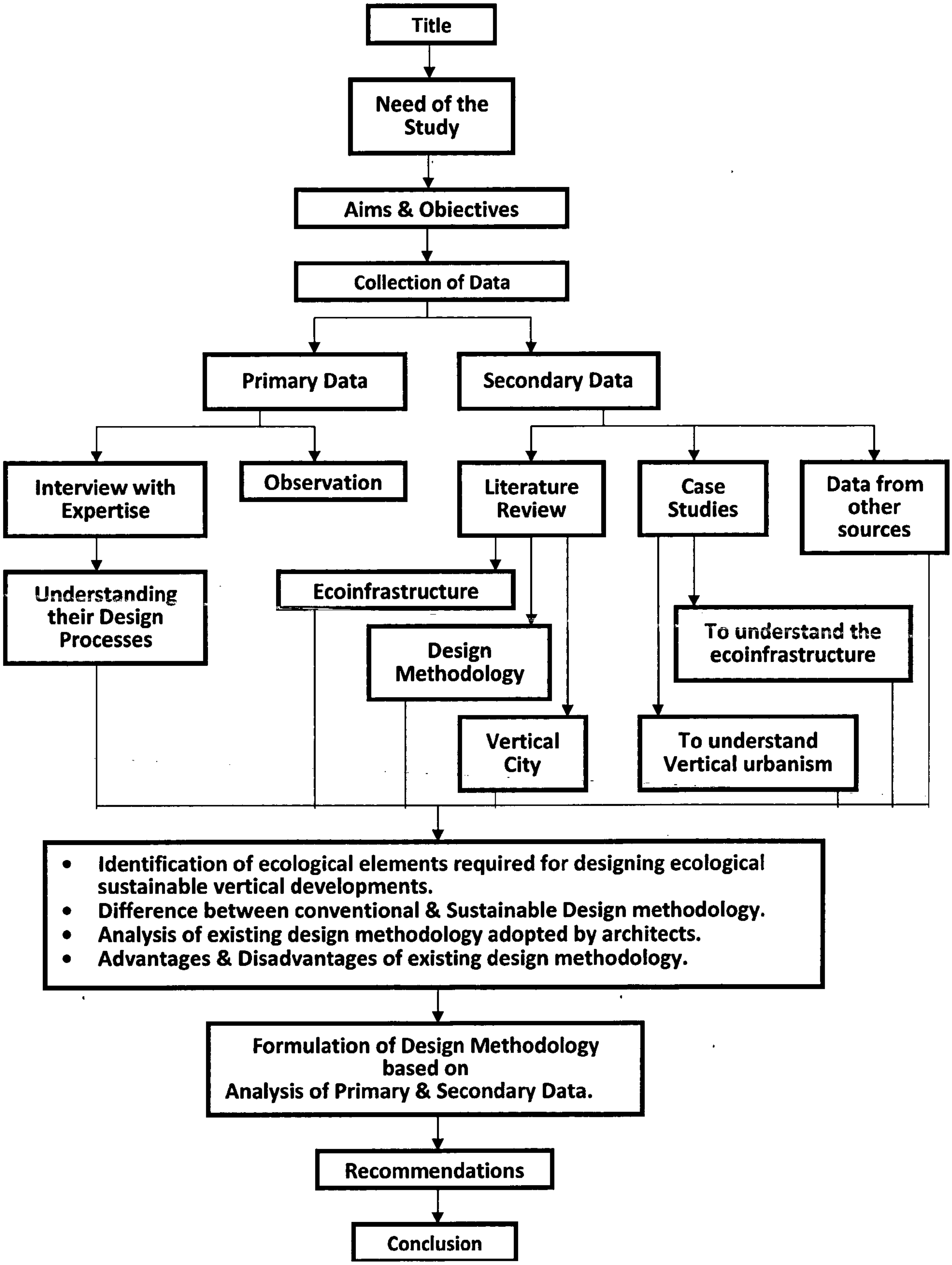



Figure 1 Methodology

# Chapter 2 Literature study

## 2.1 Futuristic Ideal Cities Traces in History (Some 'ideal cities' in the early of 20th century)

### 2.1.1 'A colony in the sky' (1908)

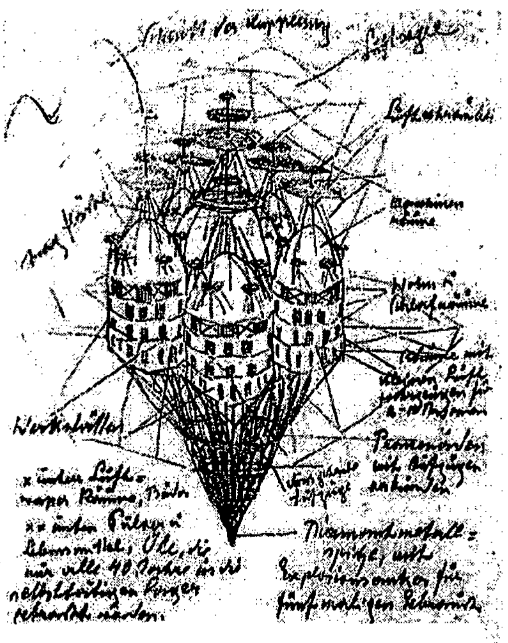


**Figure 2 'A colony in the sky 'by Wenzel-Hablik-Stiftung, 1908**

- Design is proposed by Wenzel Hablik Stiftung
- He proposed a flying settlement inspired by myth and heaven dreams, these design started an urban art movement of utopian future.
- His drawing for "Flying Settlement" depicted a cylindrical airship.
- Design consists of Workshops, bath and store rooms in the core area and the upper level contained residential spaces whereas the lower level is kept for landscaping platform for small planes.
- This movement rapidly spread over the whole western world by the artists who keep high passion on the regeneration of society system.

### 2.1.2 'Cite de Circulation'(1924-1929)

- Theo van Doesburg and Van Eastern proposed a city which is called 'Cite De Circulation' (City of Circulation).
- Cite de Circulation' (The City of Circulation) adapts the city to the problems of automobile booming.
- Became an artwork of fantasy, because of absence of correct cognizance of the relation between nature, human, and city.
- Each building has 4 pillars, access is gained in the building through pillars from ground floor.
- The space suspended between pillars is habitable space.

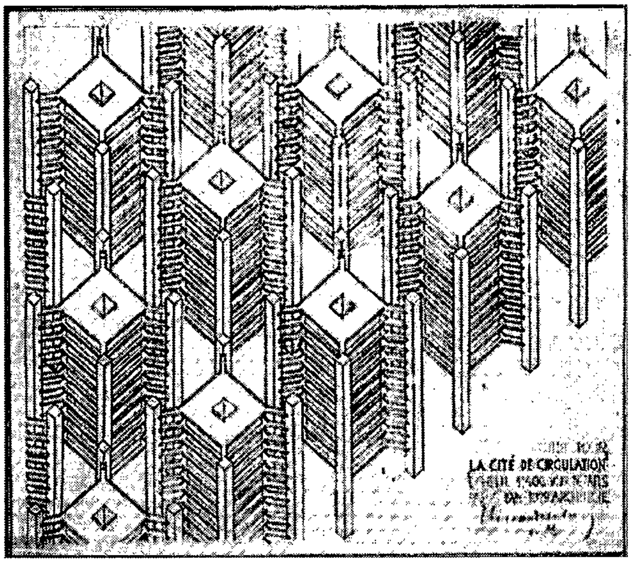



**Figure 3 'Cite de Circulation', 1924-1929**

### 2.1.3 Project of Bauhauses & 'Highrise City: perspective view of North-South STREET' (1924)

- Ludwig Hilberseimer proposed an ideal city plan for Central Berlin.
- Ground floor designed to serve automobile, pedestrian space was put vertically on the building's roof of inferior building.
- Metro would go through first level of basement, another level is used for multiple activities based on the demand.
- 5 high rises, in Stockholm's city center is nearly copy from 1924 'ideal city' strongly proves their impact.

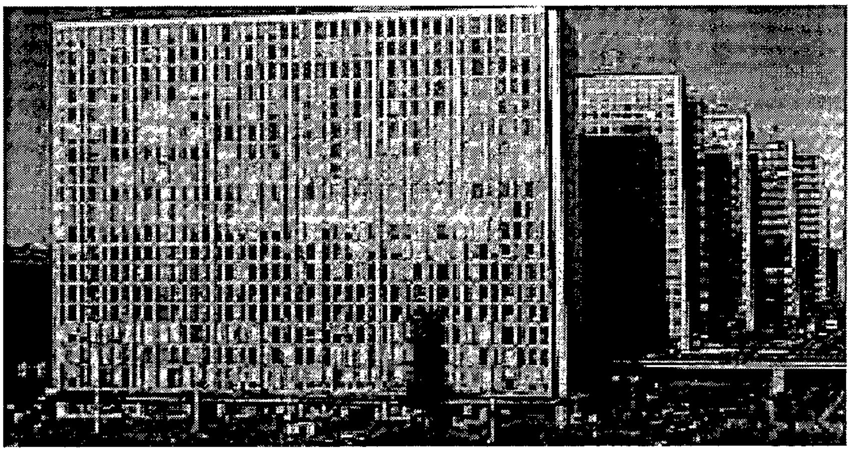


Figure 4 The 5high rise buildings in Stockholm's city

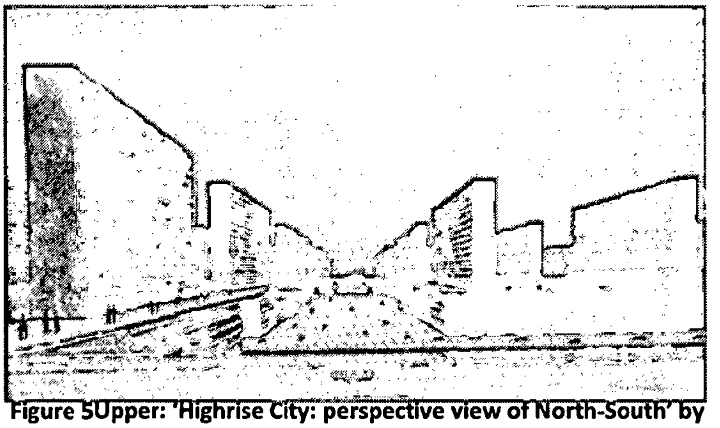
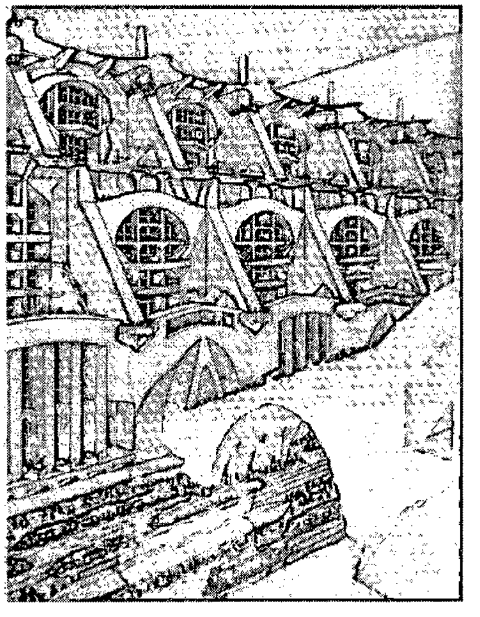


Figure 5Upper: 'Highrise City: perspective view of North-South' by Ludwig Hbergseimer, street'(1924).

### 2.1.4 Italian and Spanish 'Idea Cities'



- In 1919, Virgilio Marchi gave a 'ideal city' known as Fantastic City.
- Design is based on Latin style aesthetic due to which it looks more an artwork rather than architectural planning.
- lock the public activities and transport on the ground floor.
- Vertical spatial arrangement with multilevel pedestrian system gives a lot of design inspiration.

# Chapter 3 Vertical City

## 3.1 Solution to all contemporary problems

Despite the rapid urbanization and densification of cities and their regions, urban design has not transformed itself to respond adequately with new solution to these new conditions, cities over the world are formulated as they always were, as a spatially inefficient closed system of two dimensional practice arbitrarily composed of isolated three dimensional objects. City remains a landscape plan on paper in 2D form that extracts no advantage of vertical development

In these conditions vertical developments can prove itself a solution to meet up the need of growing population and helps in relieving our overburdening cities. Vertical development is considered as the most modern trend in the development of modern cities as prices of land increasing and availability is also less, this concept could emerge as a solution of all thrust areas of modern society.

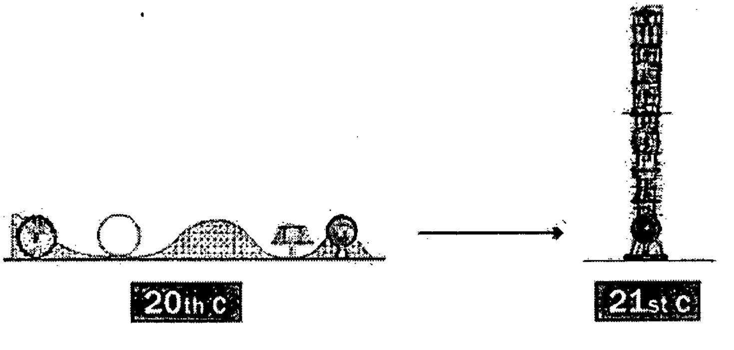
## 3.2 Vertical city

In vertical cities 'urban design' and 'vertical development' is a set of architectural design principles, by targeting towards these design principles architects & planners designed enormous habitats (hyper structures) of extremely high human density.

Vertical cities are based on the idea of vertical urbanism which says that urban design should occur in three dimensions without limiting to only ground or below ground. Public spaces and landscape should extend through the architectural objects from base to tip creating a contemporary interconnected city with all the facilities within itself.

these massive structures consist of spatial varieties at each level like Residential, Commercial, Public Spaces etc. and also helps in reducing the human impact on environment due to small footprint.

These vertical development are self-sufficient or economically self –satisfactory hyper structures, these could successfully mediate a new urban environment for future urban density.




Horizontal → Recycle → Vertical

Density + Verticality = Vertical cities (future cities)

A step towards vertical urbanism.

Vertical development can minimize the footprint of construction and create artificial interior natures and artificial infrastructural ecosystems, simultaneously providing additional public space, interior parks and public routes.

A vertical city is a city within a city, with complete residential, commercial units as well as gardens and small trams, all within the structure itself.

## 3.3 Tokyo- Shimizu Mega-City Pyramid

The Mega-City Pyramid Shimizu TRY 2004 is a proposed project to build over Tokyo Bay in Japan. Around 750,000 people would be accommodated in the proposed structure, and would be 14 times higher than the Great Pyramid at Giza. It would include 5 stacked trusses and would be 730 meters above sea level , each having similar dimensions to that of the great pyramid of Giza. lack of space is the main problem faced by Tokyo city. This structure would help to cope with such problem, the massive structure helps in accommodating 1/47th of the Greater Tokyo Area's population. The idea was rooted from the Tyrell Corporation's fictional architectural wonder, which appears in the science fiction film Blade Runner in 1982 as dual futuristic pyramidal structures.

The structure cannot be built with currently available materials because the it is so gigantic due to its weight. This megastructure would come into existence only when super-strong carbon nanotubes based lightweight materials are available in future.

### 3.3.1 Important features of mega pyramid city

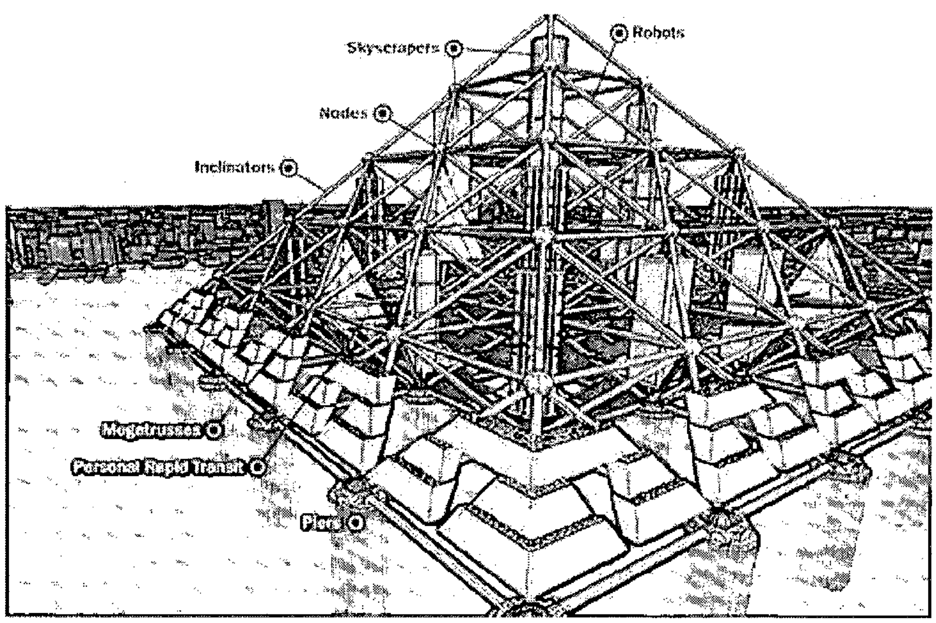



**Figure 7 Pyramid City Shimizu**

#### 3.3.1.1 Piers

Its weight could reduce by 100 times by using carbon nanotube; still it would made up of spe-cial concrete to resist extreme pressure.

#### 3.3.1.2 MEGA TRUSSES

Mega trusses are the living city's circulatory system bones consists of the critical transportation sys-tem which causes moving of thousands of people. Trusses networks are linked by aerials tunnels horizontally and diagonally of 140 Kms which meets at 55 transfer points. Trusses built of carbon nanotube, photovoltaic film coated supporting struts could produce sunlight to elec-tricity. it can also produce electricity by harnessing ocean current & even from algae pow-ered fuel cell.

#### 3.3.1.3 INCLINATOR

This pyramid would consist of inclinator rather than the normal elevator. The inclinator moves in incline way along the city.

#### 3.3.1.4 NODE

Accelerating walkway drive less pods & inclinators would be the nodes for the residents to move through the city. There would be total 55 nodes which serves as commuter transfer point & also provide structural support to the cities.

#### 3.3.1.5 SKYSCRAPERS

Skyscrapers are supported from above & below which is about 30 Storied high.

#### 3.3.1.6 ROBOTS

City would be assembly of strut & truss which would build by the help of robots.

### 3.3.2 Dimensions

Perimeter of the foundation above ground, having area of 8 square kilometers, would be 2,000 me-ters. Infrastructure is an area of around 25 square kilometers. Gross building area is about 88 square kilometers consisting of layers:

- Level 1 to 4: residential, offices, etc.
- Level 5 to 8: research, leisure, etc.

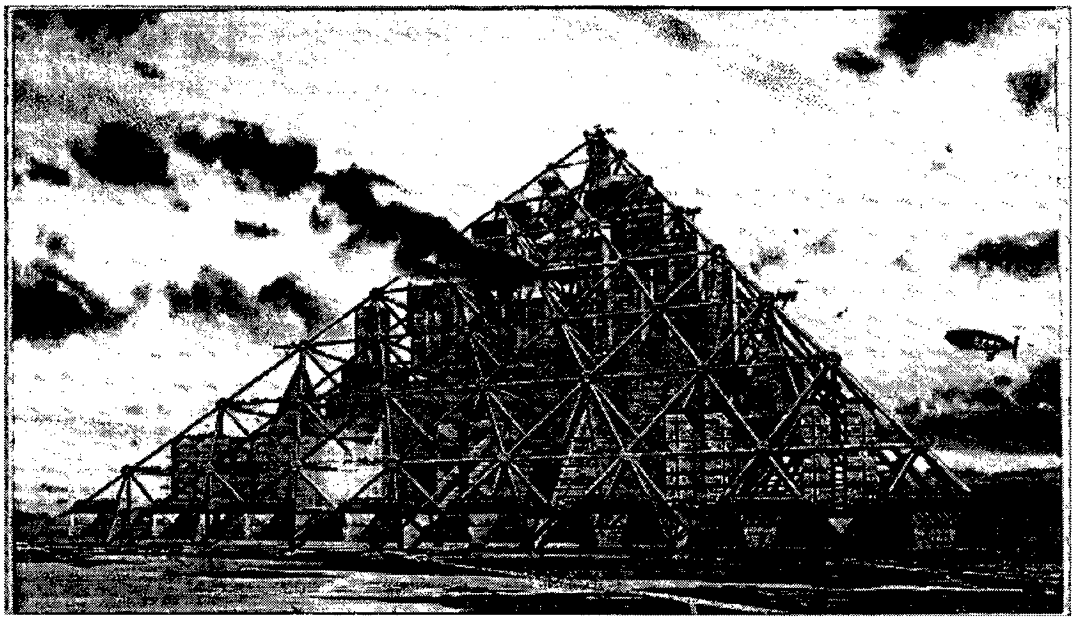


**Figure 8 Pyramid City Shimizu**

Each layer would have height of 250.5 m (pyramid is 2004 m tall for 8 layers).

204 smaller pyramids stacked in eight layers which would be composed in the pyramid structure. The size of each of the smaller pyramid would be equal to the size of the Luxor Hotel in Las Vegas.

The Pyramid city is 55 times larger and proportionally similar to the ancient Pyramid of Giza. It would consist of 55 smaller assembled pyramids in which each of the unit would be equal to the size of pyramid of Giza.

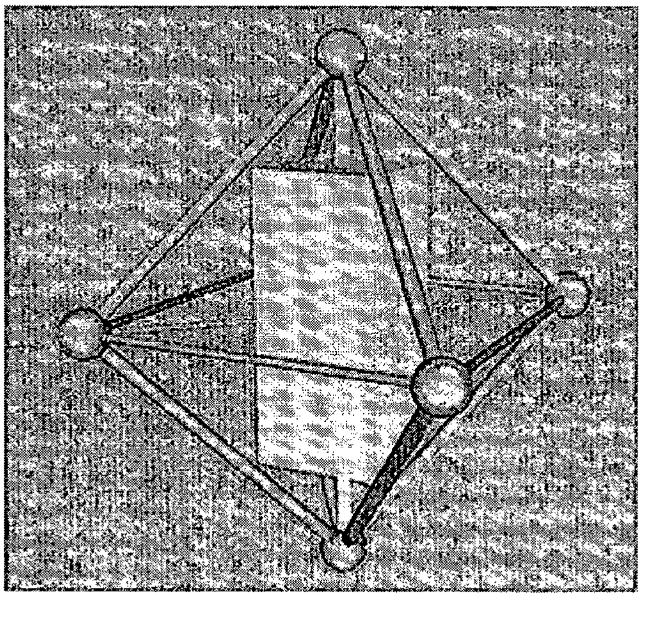
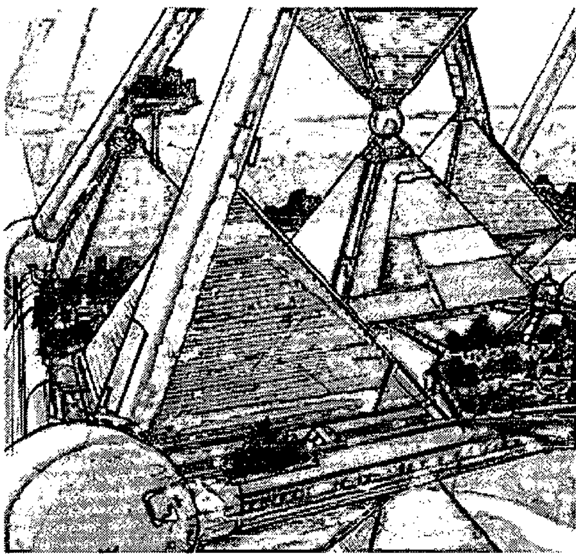
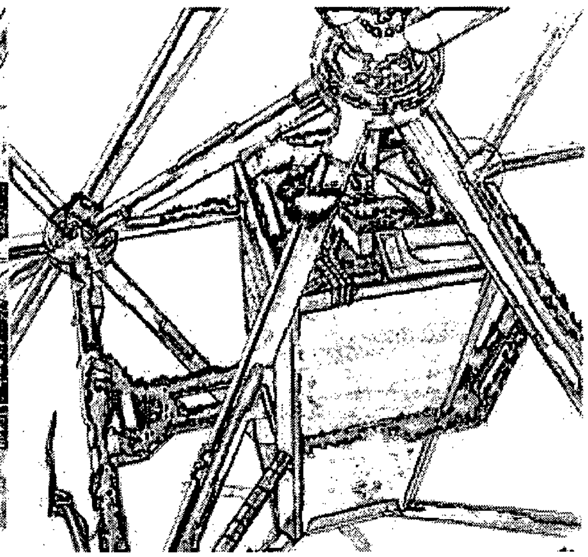


**Figure 9Flexible-space octahedral unit**

## 3.3.3 Usage

The building would consist of residential, commercial and leisure areas zones.

- For 750,000 people,50 $km^2$ will be given over to 240,000 housing units. Each of the building would have its own energy resources (wind and sun).
- For offices and commercial facilities 24 $km^2$ will be provided intended to employ 800,000 people.
- The remaining area would be used for research and leisure purposes which is 14 $km^2$.

## 3.3.4 Advantages & Disadvantages

Some advantages is that the city would move more fast, that the city will be better protected from natural calamities like tsunamis, and it also would be solution for the high-prices for land in Tokyo.

A major disadvantage in this project is that failure of one truss leads to the collapse of the whole structureand 750,000 people will crash because the structure is interconnected.

## 3.3.5 Materials & Construction Process

### 3.3.5.1 Laying Foundation

After sinking massive piers into the seabed, robot's construct the city's first layer, consisting of 25 individual pyramids.

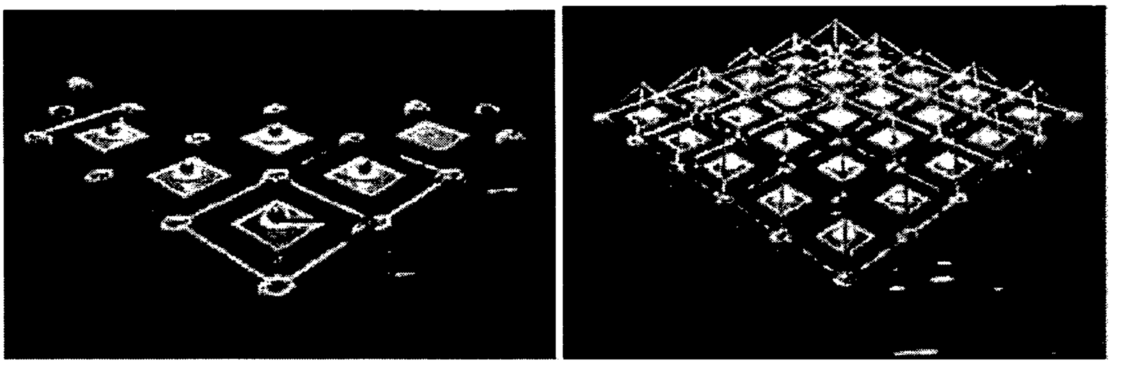
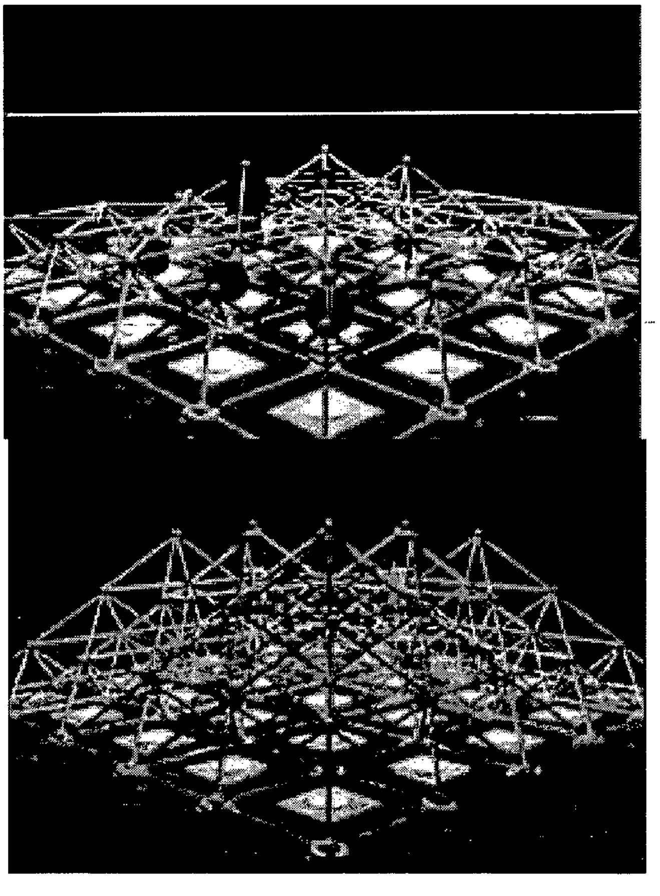


**Figure 10 Foudation Laying Concept (Vertical city Shimizu)**

#### 3.3.5.2 Construction of Upper Layers

The city's upper reaches rise in the same fashion, with the air bladders lifting the expandable mega trusses as they are inflated.

To lift the components of space frame they are using air pressure.



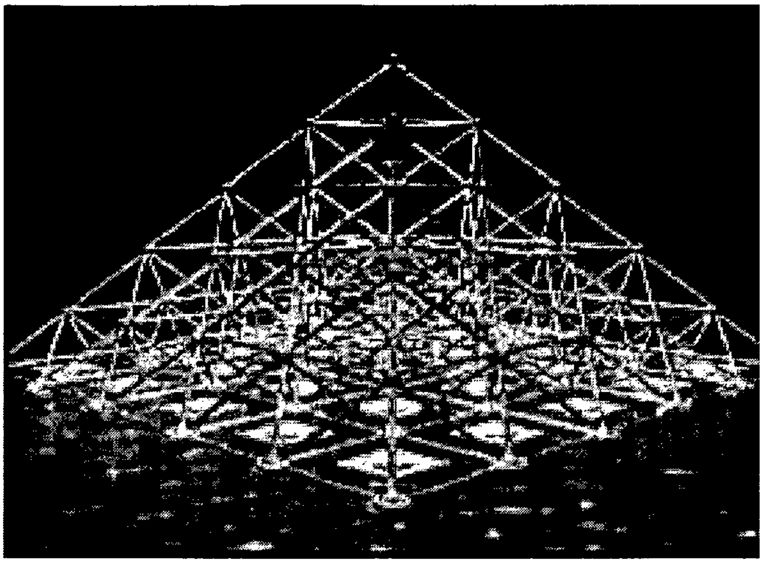


**Figure 11- Step wise Construction for the erection of Space Frame.**

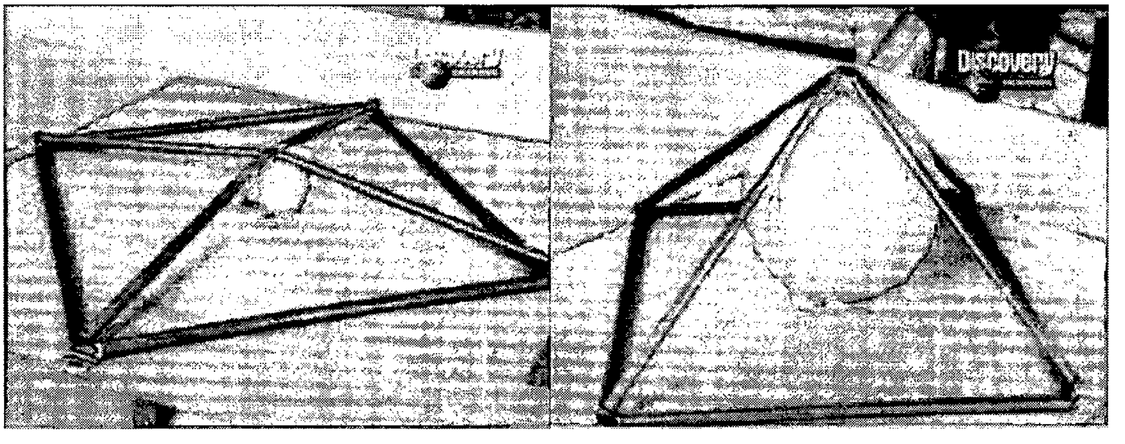



**Figure 12- Construction method for the erection of Space Frame**

### 3.3.5.3 Skyscrapers

The buildings are erected only after the city's vast exoskeleton, which also serves as its infrastructure, is completed.

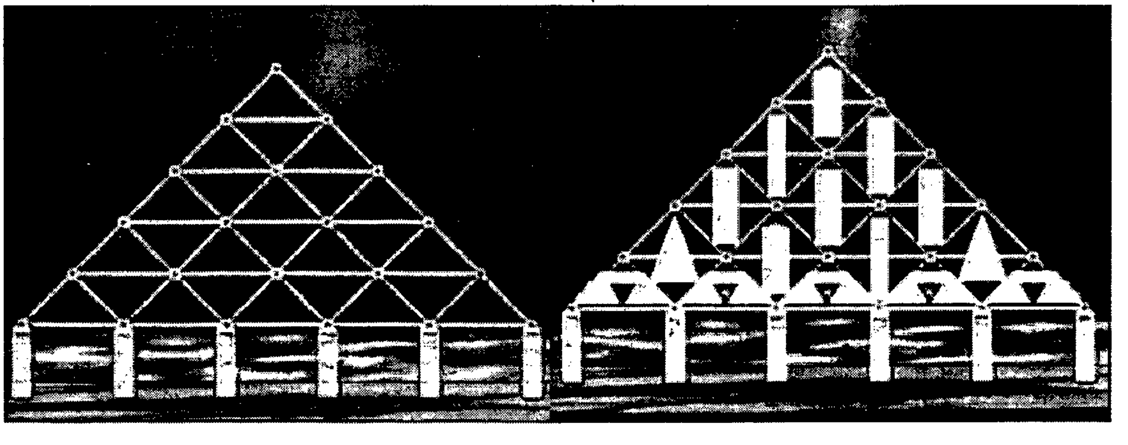


**Figure 13 Skyscrapers hung between the pyramids**

#### 3.3.5.4 Gaint Robots

Giant robots would build much of the city, including the massive pyramid's 86 miles of horizontal and diagonal aerial tunnels.

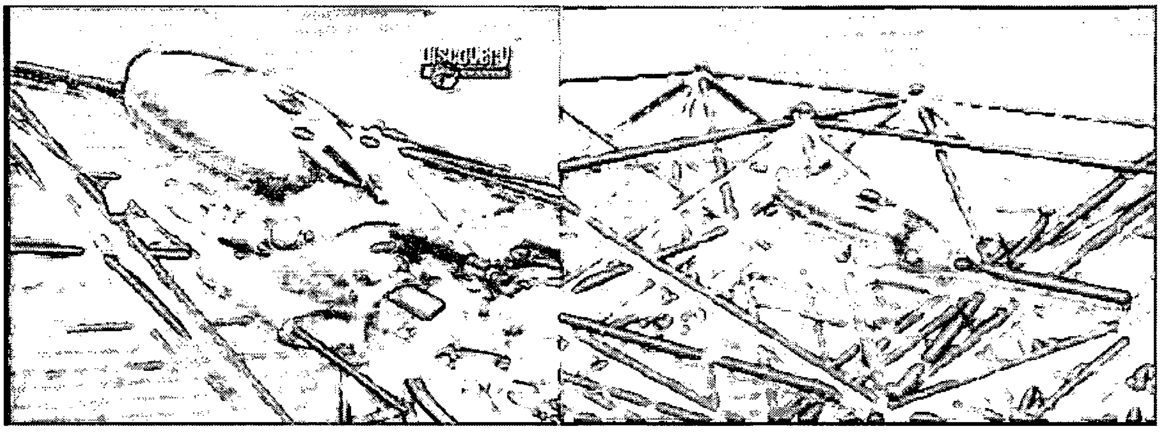


**Figure 14 Robots used for the Construction of massive trusses**

#### 3.3.5.5 Nanotubes

Neither the footing nor the frame could take load of transit system, 750,000 people; super strong materials are required for the construction. Steel reinforced with nanotubes.

Carbon nanotubes- Extremely Strong & Resilient.

Plastic & Ceramic nanotubes- super strong and light weight composites.

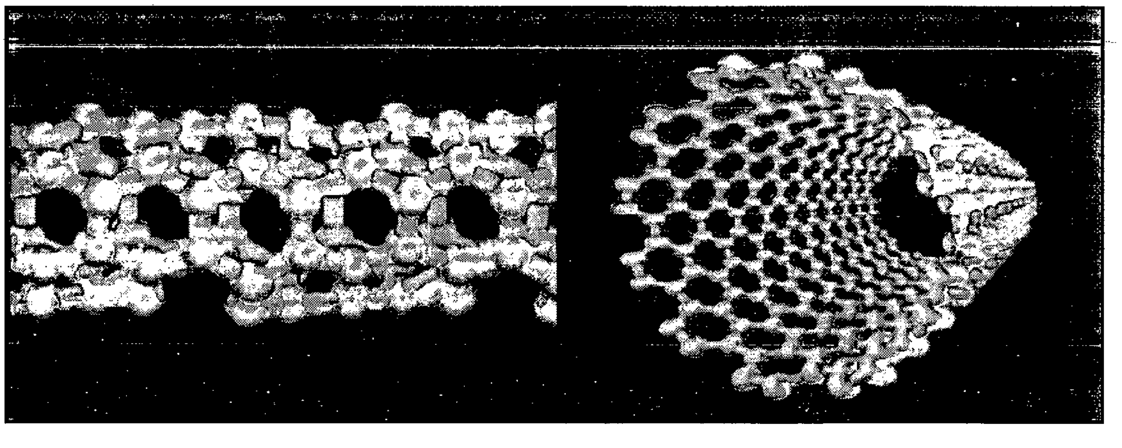


**Figure 15 Plastic & Ceramic NanotubesFigure 16 Carbon Nanotubes**

### 3.3.6 Smooth, Efficient Transportation and Distribution System

A continuous circulatory transportation system would be used to move vertically within the city that incorporates elevators in diagonal shafts (inclinators). To move laterally, residents will use motor transportation system which linearly runs inside the horizontal shafts.

People will use escalators, moving walkways or corridors to move from node to skyscraper.Elevators are used within the buildings.

For vertical conveyance, the distribution system established in the city will depend on a continuous circulatory transport system. At each node, the automatic transfer loader will place packages on a carriage or conveyor belt which automatically delivery in the horizontal direction.

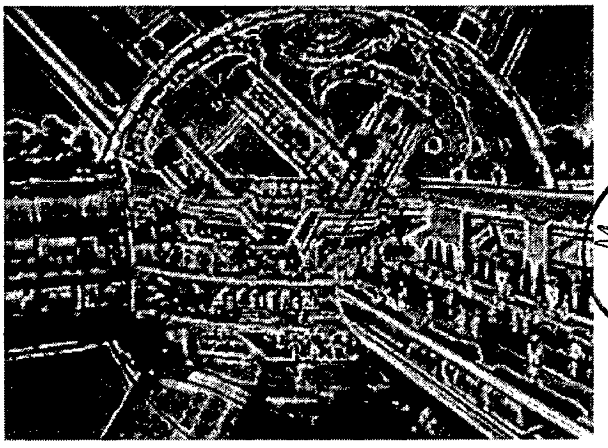




Figure 17 Tranfer Nodes

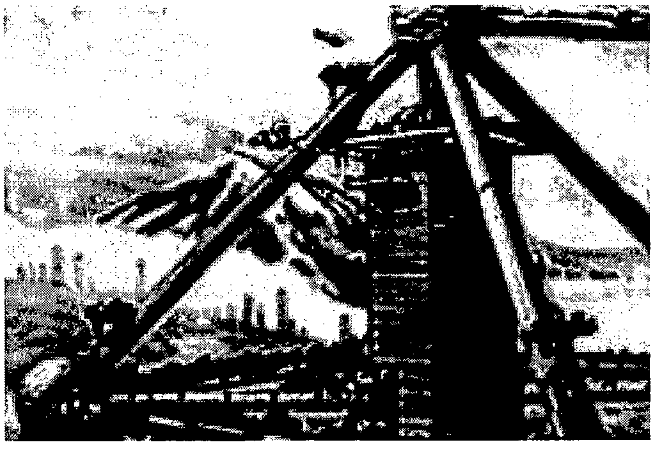


Figure 18 Mega Trusses contained Transportation System

## 3.4 Issues of Vertical Urbanism

### 3.4.1 Absence of Public Spaces- Lack of Public Spirit

Vertical urbanism gives a new definition to the urbanist's to develop our futuristic cities, but they ignored one important point during design process – public spaces, these spaces are important because these are reflectant of culture of any city these spaces gives an opportunity to come together, to mediate, to play, to rest or to experience the natural environment that surrounds them, thus allowing more liveable environment, this is essential in order for a development to be sustainable.

"Historically, the skyscraper has been a vertical extrusion of similarly inhabited floors. Implicit in the concept of tall is the omnipresence of gravity as both a structural force as well as a force to be overcome to achieve accessibility. While the horizontal space symbolizes a kind of sociable and barrier free access, vertically organized space typically presents obstacles to movement and visibility, separating activity on one floor from the next. Horizontal space is epitomized as flexibility, organisable into shade of public, semi-private and private, while a vertical extrusion of similar floor plates implies privacy and separation."

we need to outcome with some solution to deal with these multilevel spaces which creates confusion and design an effective circulation scheme or open spaces, which make the vertical development gloomy place with vertical chaos.

### 3.4.2 Non Availability of Materials

These structures are unbuilt due to non-availability of materials required to build heavy structures. The design of these giant structure is so large that it cannot be built with currently available materials, due to their weights. The design relies on the future availability of super-strong lightweight materials.

### 3.4.3 Unsustainable Vertical Urbanism

The early cities proposed by avante grade artists or futurists are having some problems, they made huge structures, without thinking about technological aspects or environmental impacts of these massive structures which means these structures would became nightmare, therefore the idea of developing a city vertically with all facilities within itself to optimize the footprint is rejected.

These unsustainable structures or ideologies of developing a city vertically without thinking about technological support and environmental impact are one of the reason of that so many architects, urban designers and planners keep a critical attitude towards vertical urbanism.

But there are some redeeming points also which boost up the idea of vertical urbanism, economical, functional compact development leads to sustainable organization of urban lifestyle.

Today the big issue is the climate change due to depletion of natural resources and forest cover, urban sprawl and population pressure, the needs of society are fulfilling by non-renewable resources "Broadly speaking, the industrial application of fossil fuels in the nineteenth century set the developing world on a path of seeing nature as a resource for consumption rather than conservation and restoration. Rapidly urbanizing cities established parks and limited natural systems within their borders as symbols of nature while broadly exploiting nature elsewhere as a source of energy."[2].

Therefore we need to incorporate ecological sustainability in vertical urbanism to propose a ideology which fulfil the practical urban design urge, a sustainable way against the destructive modernism architecture.

# Chapter 4 Environmental Sustainability

## 4.1 Introduction

Saving our environment is the need of the hour and vital subject to deal, as we are constructing vertical without even considering their energy consumption, we have to feed our fears that this millennium may be our last, we have to compel ourselves to think upon how we can design environmental sustainable vertical developments. The early cities proposed by futurists are designed without much thinking about the environmental impacts, even today in India most of our designs are energy eating boxes or cubes of glass.

At some point we all know that vertical development is not an environmental sustainable building type infact these developments are most unsustainable & unecological of all building types, they consumes energy to build, to operate and to demolish, this is regarded to understand the need of environmental sustainable vertical development.

Now other question arises from this is – if it is sustainable then why we go vertical?

The statement is responded as vertical building isa building type which hasfewer footprintsand can easily meet the growing need of our cities, urban sprawl, traffic congestion etc.

We need to moderate it's negative impacts on environment and make these structures more humane by adding ecology to the sky so that they became pleasurable to it's occupants. There might be some criteria that where these forms are justifiable like the areas where we need to meet intensive accommodation requirements , places near transportation hubs to reduce transportation energy consumption, to minimize the foot print on sensitive vegetative sites.

## 4.2 Basic Paradigms of Environmental Sustainability

- Climate sensitive architecture
- Use of ecofriendly materials
- Energy efficient design
- Use of renewable sources of energy
- Preservation of natural ecosystem
- Water resource management
- Ecological landscape design
- Solid Waste management
- Healthy indoor environment

To achieve the environmental sustainability out of 9 basic paradigms given above, in my thesis I will emphasize only on -

Ecological landscape design (incorporating ecology in vertical development)

## 4.3 Why Ecological sustainability ?

Dominance of engineering and emphasis of building performance simulations has led to ecologically advanced architecture being perceived as an issue of ecology rather than matter of ecology and other environmental concerns, so to make clarity about this misconception and incorporating ecoinfrastructure (green feature & techniques) to achieve ecological sustainable vertical development I choose ecological sustainability.

## 4.4 Ecological Sustainable Vertical Cities

Traditional vertical development acts as lifeless inorganic concrete mass and also separate the users from nature. From many surveys it is clear that in high rise developments, tenants feel lack of open spaces and disconnection from nature which leads to many psychological problems. To achieve the environmental sustainability out of 9 basic paradigms given above, In my thesis I will emphasize only on-

1)- Preservation of natural ecosystem ( Vertical landscaping )

In Vertical Urbanism sustainability of the structure can be improved with the help of ecological elements such as landscaped ramps, skycourts, sky terraces, roof gardens , stepped planters, daylit atriums etc.. All these ecological elements should be part of environmental sustainable design because these helps in reducing the temperature of building up to 2-3 degree, improve air quality, provide organic mass inside the building which also improve the health of the occupants.

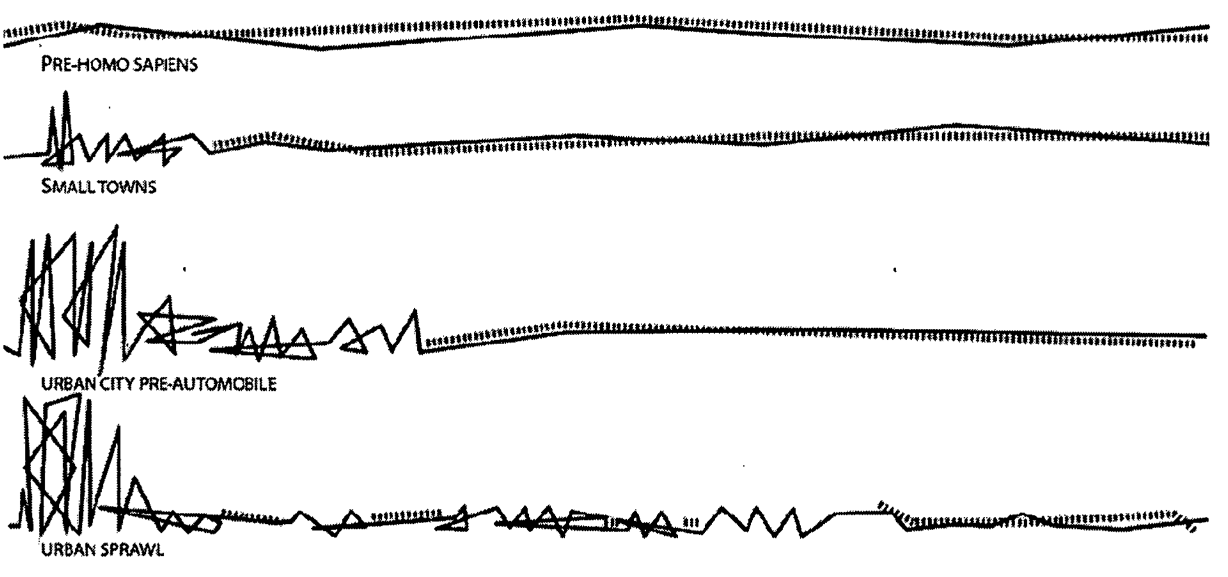



**Figure 19Evolution of Cities**

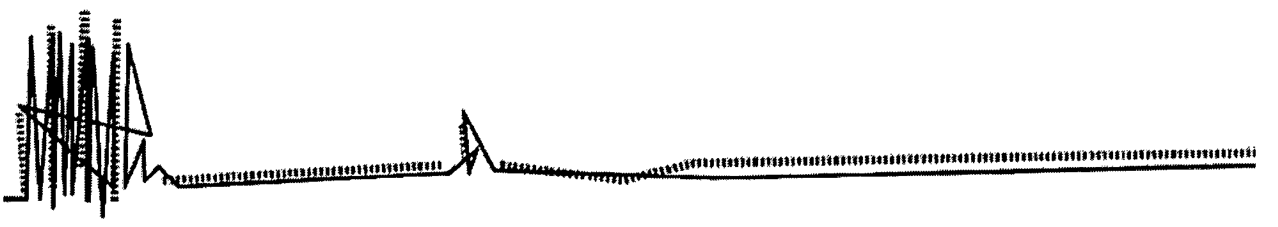



**Figure 20 Ideal city for Twentieth century**

There is a common idea of trying to put urbanism into the vertical development. The concept of hybridizing vertical and urbanism is one of the evolving types of vertical development today. However, these designs seem to still be creating private and cul-de-sac scenarios once you reach the top floors. There is also little emphasis on Environmental Issues that urban sprawl is creating. Systems such as ecological trails, use of renewable sources of energy, travel distances, street experience and healthy community connections interactions, connections to existing context must be addressed and incorporated in the design.

In the framework of vertical urbanism, vertical landscape is a key element and must be invented from the combination of skyscraper technology and landscape relationship to people, adapting and creating culture through community and self-individuality. The project must evolve through phases in time, able to change its environmental character during seasons, and changing its physical and cultural character throughout the years. Spaces are divided three-dimensionally allowing for designated public spaces and buildable spaces for businesses and residents to occupy and inhabit the spaces. The spaces and architectural style are not defined by the frame, but rather from local architects, urban designers, and landscape architects working for the clients and for the community. As the years pass, the skyscraper will evolve more, creating a community and culture within itself. 'Culture is defined as the sum total of ways of living built up by a group of human beings and transmitted from one generation to another'.

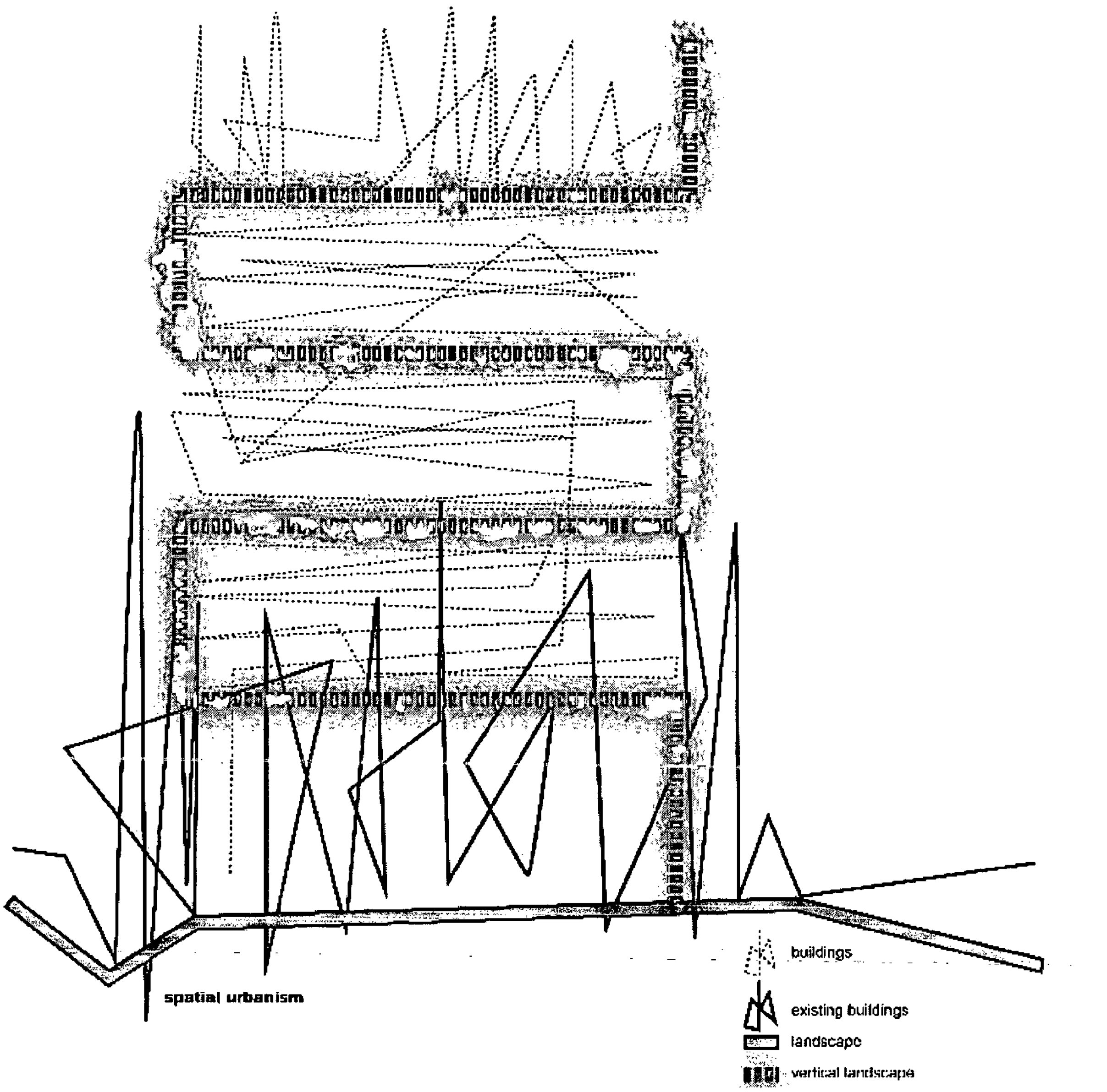



**Figure 21 Vertical frame accommodating Ecology**

In the future, we cannot bind our cities to the ground and there is no important reason why we have to. The higher spaces areour new areas for urbanization must be planned well. The idea is that cities will not be developed building by building in the ground, but rather in a spatial frame.

# Chapter 5 Ecoinfrastructure & Vertical urbanism

## 5.1 Introduction

**What sort of image conceived when you hear the word "vertical city"? To most it is lifeless, hard, concrete built mass with isolated green patches and these patches also gone away due to lack of ecoinfrastructure or proper biointegration with the built mass.**

Vertical cities can be more sustainable or enjoyable to its occupants if these structures are green in real sense. Many architects, designers, urban designers, planners and environmentalist are working together to achieve the ecological sustainability in massive structure, these would bring incalculable paybacks to the people who live in core congested areas of the city and crippled by lots of problems like- Traffic Congestion, Population pressure, unhealthy living environment, pollution etc.

Building Green concentrates on one key aspect of the greening process the use of plants on and around urban buildings (vertical city).

We need ecological approach to design vertical city appropriately, vegetation on upper levels helps in gaining against the vegetation loss beneath the built mass. Green skin can be added to the vertical cities in this way that they can create a network of continuous vegetation which links from the top of the to the roof to the basement level with the help of roof gardens, terrace gardens, sky-courts, ecocells, vegetated ramps and vertical boulevard etc.

## 5.2 Vertical Ecoinfrastructure

### 5.2.1 Infrastructure

Infrastructure is physical and organizational structure needed for the operation of a society or enterprise, or the services and facilities necessary for an economy to function.

### 5.2.2 Ecoinfrastructure

Infrastructure required to accommodate ecology in the building, it is the continuous green substructure which runs throughout a building integrating its inorganic mass with the organic content of the green ecoinfrastructure. The approach is ecomemetic of an ecosystem in nature.

The ecoinfrastructure may consist of several of the following ecological components and devices-

- Roof, terraces
- Ecocells
- Vegetated ramps
- Landscaped balconies
- Stepped planter boxes
- Wall creepers
- Landscaped walkways

- Trellis wall
- Planting at the edges- garden in the sky
- Vertical green walls
- Green sky courts atriums

**Implications-**

- Protection of native, indigenous species of vegetation.
- Provide anxiety free and natural environment to the users.
- Vegetation also helps in reducing stress, aggressiveness, and mental fatigue.
- Maintain ecological sustainability of the region.

### 5.2.2.1 Ecocells

- Ecocells is a means of integrating the inorganic mass of the built components with the organic landscaping.
- In essence it is a cell like void that is cut into the building and slicing down through all floors from uppermost to the basement. "Ecocells" are located at regular interval in the building.
- It brings natural ventilation and daylight into the inner parts of the buildings.
- The vegetated ramp brings the vegetation from the roof to floors and then to the basement.
- At the base of each 'Ecocell' are the algae sewerage treatment water tanks that convert sewerage waste into pure water.

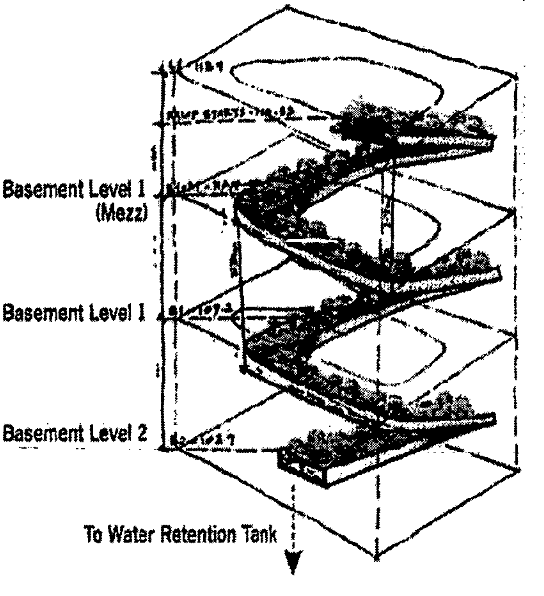



Figure 22 Concept Diagram Ecocell

- Excellent devices for the ventilation of lower levels where stale warm air rises and replaced with fresh air.

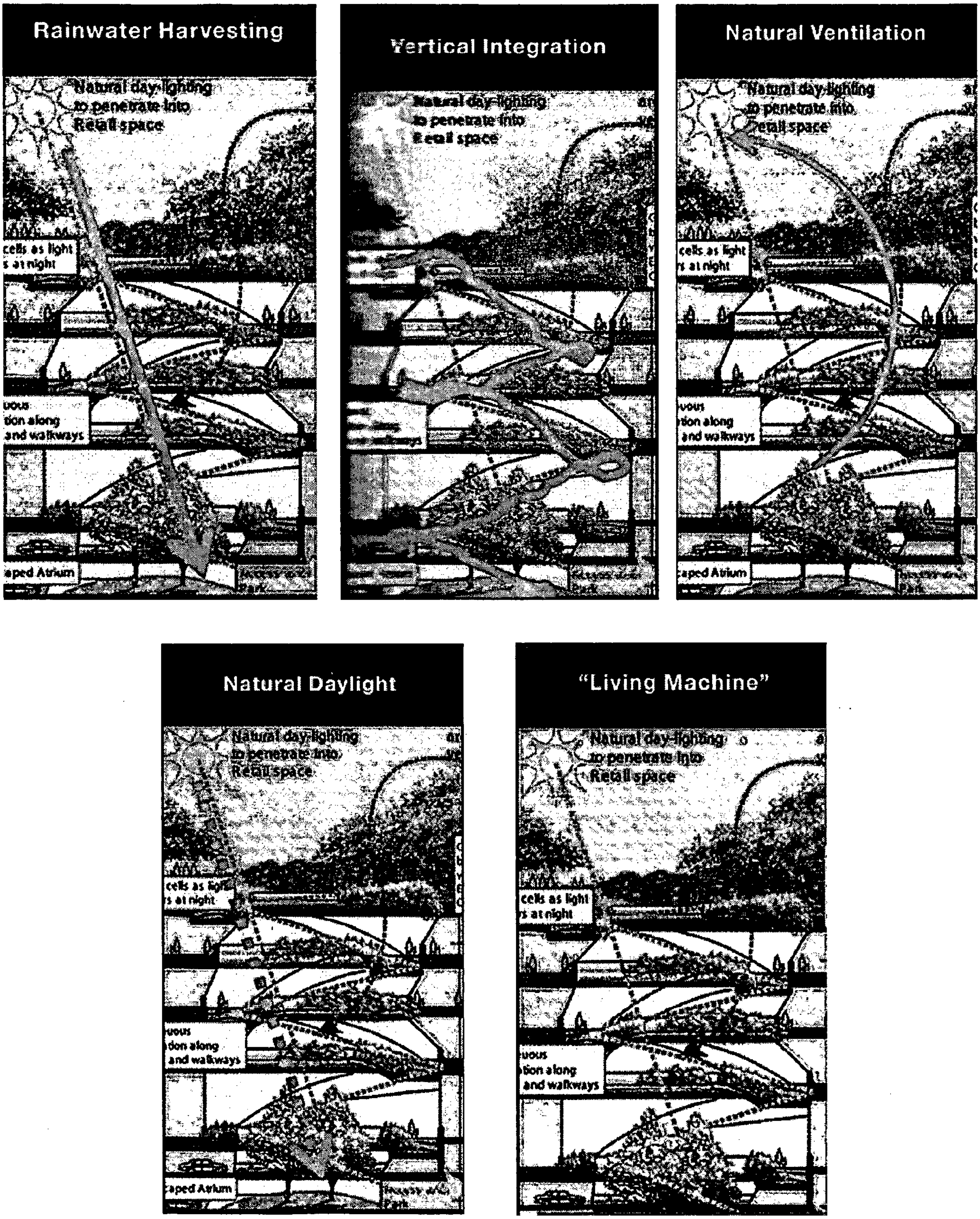



**Figure 23 Ecocell Concept Diagram**

### 5.2.2.2 Roof Gardens

Green Roofs, also known as vegetated rooftops or eco-roofs, are essentially rooftop areas that have been installed with living vegetation. There are a variety of different types of green roofs, ranging from small gardens and planters to roofs that are completely covered by sod and plants.

Lighter, thinner green roofs are known as extensive roofs, while the heavier more layered roofs are known as intensive. Green roofs can only be used on flat roofs or on roofs with gentle slopes (although some innovative techniques in Europe have grown turf on 45 degree angles). While weight is generally not an issue, as most green roof vegetation is actually lighter than a standard gravel and tar roof, consideration must still be given to soil selection and building structure to assure structural stability.

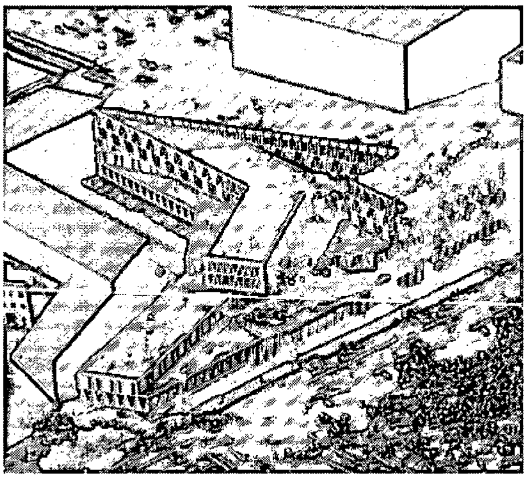


**Figure 24 Landsbanki Bank Headquarters**

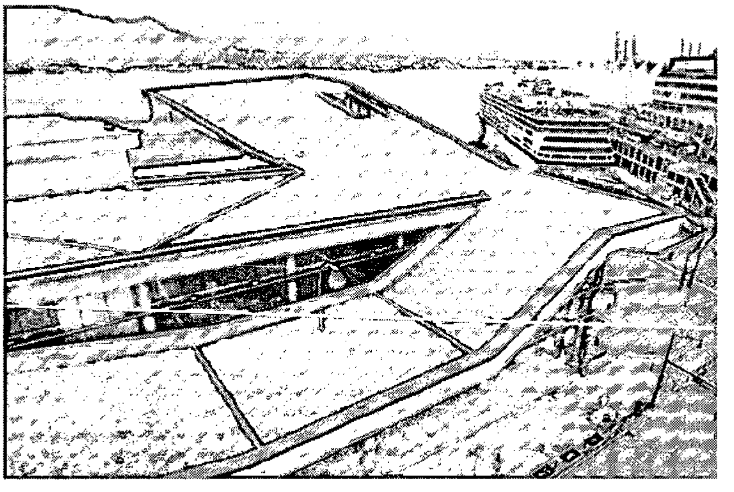


**Figure 25 Vancouver Convention Centre**

### Classification of green roofs

**Intensive green roofs**

They are generally known as roof top gardens. They are also similar to ground level parks and gardens.

They are normally accessible for recreational use and principally designed to provide amenity.

Cycads which are woody trunk with a crown of large, hard and stiff evergreen leaves are ideal for this environment.

**Simply intensive green roofs**

These are vegetated roofs with incorporation of some cycad feature with lawns or other ground cover plants.

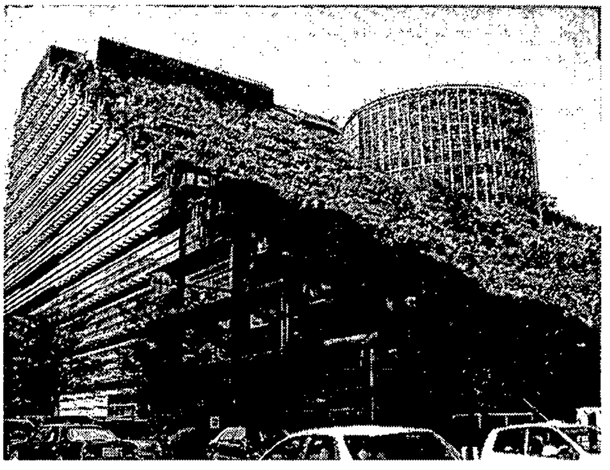


**Figure 26 Intensive Green Roof**

**Figure 31 Extensive Green Roof**

**Extensive green roofs**

These are not irrigated vegetation which require minimal maintenance and are minimally or normally consists of grass succulents and herbs.

## Benefits of green roof

**Environment**

- Storm water run-off tapering.
- Reduction of sewer overflows by runoff attenuation.
- Clearing and recycling grey water option.
- Dust particles and pollutants absorption.
- 'Urban heat island' effect reduction.
- Increase in humidity.
- It helps in noise absorption.
- It absorbs Electromagnetic radiation.
- Greenhouse gases absorption like $CO_2$and giving off oxygen.
- Use of recycled materials.

**ECOLOGY & BIODIVERSITY**

- Accommodate new wildlife habitat into the built mass .
- Through developmentit helps in replacing habitat loss.
- Providing links or stepping stones in vegetated networks.
- Often only available green space in inner urban core.

**AMENITY**

- Provide ranges for the designers.
- Uniform roofing materials and Hides grey.
- Screens all the gadgets or equipment.
- Attractive views of vegetation.
- Park system can be extended with this.
- Provides more spacious gardens.

**HEALTH**

- Contact with nature has Psychological benefits.
- It improves the air quality whichhelps in reducing lung disease.
- Helps in upgrading quality of water.

**BUILDING FABRIC**

- Protecting the built mass from harmful ultra violet radiation
- Defending the roof from any type of mechanical damage
- Reduce seasonal temperature changes in roof by creating buffer zone.
- It also helps in improving thermal insulation.

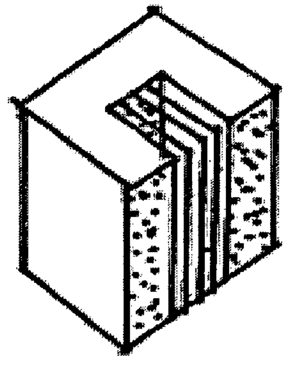
### 5.2.3 Naturally ventilated Daylight Atriums

Ken Yeang has developed his idea of tropical atrium as a space between the enclosed inside and the outside as in plaza atria.

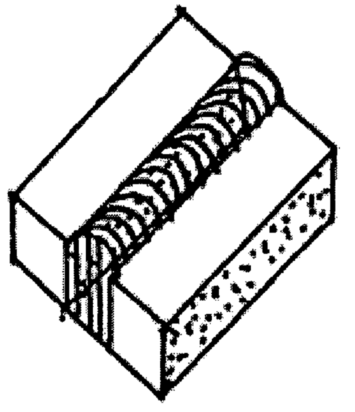
Atria can be classified into nine generic types-

1. One sided atrium
2. Two sided atrium
3. Three sided atrium
4. Four sided atrium
5. Linear atrium (generally suitable to small and single buildings as well as large complexes)
6. Bridging atrium
7. Podium atrium
8. Multiple atrium
9. Multiple vertical atrium (large & high density development)

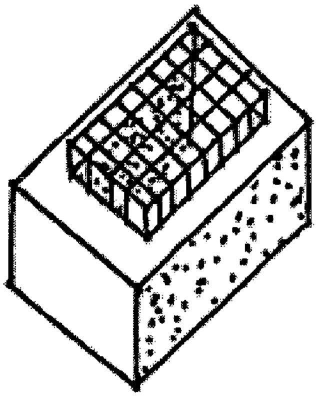
- The most common form of atrium is four sided atrium sometimes described as fully enclosed atrium with glazed roofs. These types of atrium are generally used in deep plan buildings to permit natural light into the center of the building. It functions as central organizational, circulation devices and becoming focal point of various services.
- Atrium provided space for communal activities and creative performances.
- Interior gardens and landscaping have been major elements of conventional atria.
- Atrium helps in achieving soothing conditions for its users.
- The effective use of plants and water features on the ground level will add to user comfort through natural shade and evaporative cooling.
- The interior planting design requires sensitivity to scale, proportions, texture and composition and the theme must also relate to the atrium enclosure.



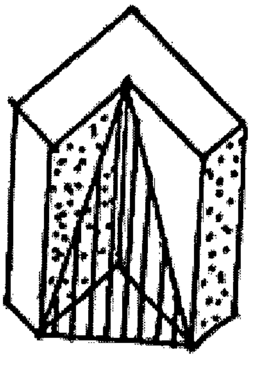
three sided



linier



four sided



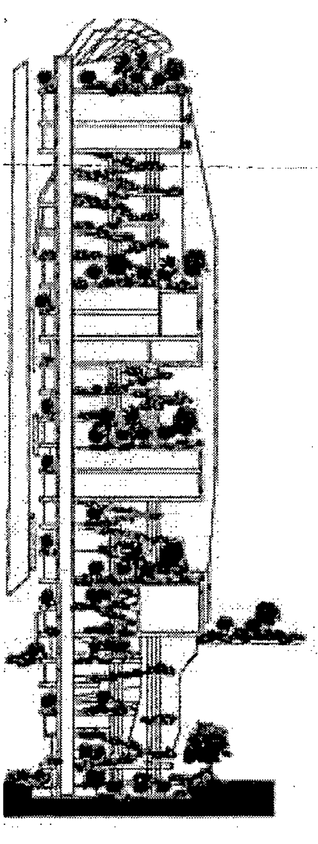
two sided

- Ken Yeang used a climate modifying device he calls "spandrelled pergolas" that filter direct sunlight in an effort to reduce solar heat gains and reduce air conditioning loads.

**Figure 27 Atrium of the University of Michigan Health Center**

- These courtyards provide pleasant green outdoor space for the occupant.

A design incorporating such an atrium space should lend itself to natural ventilation by virtue of the fact that the inclusion of the atrium will modify the building form to one that avoids deep-plan accommodation in favour of a layout with windows on inner and outer facades, allowing for good cross-ventilation. In modern architecture, atrium is a multi-storied high cut-out inside the building consist of glazed roof and windows provide open space especially in extremely vertical development.



### 5.2.4 Solar Shaft

Solar shaft is a cut through the building it may be diagonal or vertical which allows daylightand ventilation inside the building.

Vegetation can also be added to these solar shafts to enhance the internal environment of the building.

Solar shaft also provides space for landscaping inside the building .

### 5.2.5 Vertical Landscaping

Vegetation spirals up throughout the surface of the structure from the boulevard to the roof of the building with the help of various landscape elements.it accommodates various species and helps in generating a more bio diverse vertical development. Placement of vegetation at different levels and places within the tower also help in improving the microclimates of sub zones inside the building. This in turn creates greater ecosystem stability and aids in cooling the façade. Plants have been carefully selected so as not to compete with others on the site. Factors which influenced the planting collection include planting depths, light quality, maintenance level, access and orientation.Vegetation helps in maintaining microclimate of sub zones within a building at different levels of the tower. The diagram shows how organic mass is reintroduced to the urban site to counterbalance the inorganic nature of the environments.

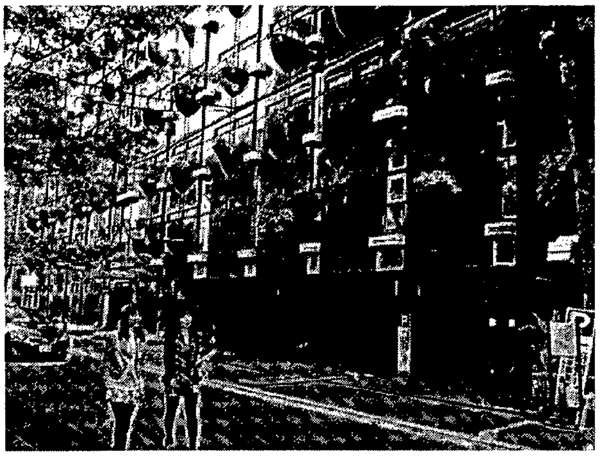


**Figure 29 Organic Building in Osaka is Clad with Plant-Filled Pockets**

**Figure 28 Green wall**

A vertical landscape is a living garden growing on walls. Vertical landscapes are designed to be modular, allowing quick vertical landscapes are installed as fully planted gardens with everything that keeps the surface lush green and covered.they used to grow aeroponic system to grow vegetation (i.e. without soil)on upper levels and also helps in reducing the dead load of soil. It can be done as integrated component of the wall.

Vertical landscaping can be done by different ways in vertical buildings.

- Green walls
- Stepped planters& zig zag planters
- Vegetated ramps
- Vertical boulevards

**Benefits of vertical landscaping**

- A Vertical Landscape enhance the aesthetic values of the facade ,it adds life to the structure and provide a healthy living environment
- Vertical Landscapes helps in saving space, allow the planting of gardens in apartments, foyers, terraces and other places where floor space is limited.
- Vertical Landscapes absorb pollutants, reduced air-conditioning requirements and reduced greenhouse gases which help in reducing carbon footprint of the structure.
- Vertical Landscapes protect the inhabitants against noise pollution and creates a buffer zone which also reduces the impact of outside temperature changes.

- It providesafe spaces for bees, butterflies and birds, it also contributes to biological diversity which helps in maintaining ecosystem.
- It helps in reducing heat island effect.

### 5.2.5.1 Green walls

Green walls help us in adding vegetation to the built mass, with the growing concern of changes in climate. Green walls have been used as a sustainable strategy for enhancing urban environment.

These helps in reducing inside temperature of a building (In Warm Climate) and improves indoor air quality. These are also known as bio walls, green trails, vertical vegetation, living walls and green facades.

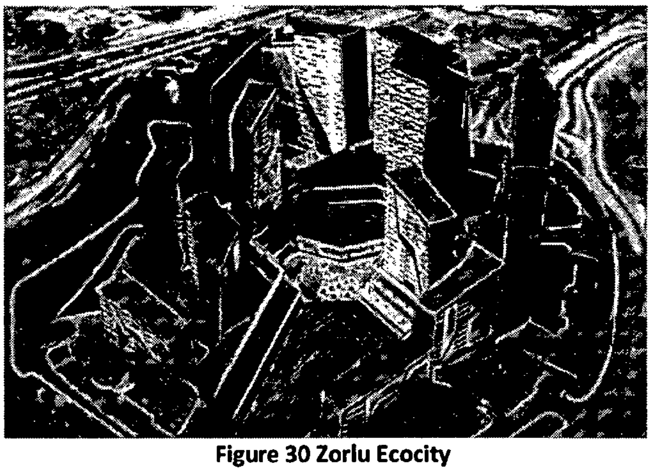


Figure 30 Zorlu Ecocity

There are different types of systems by which we can used to add vegetation to the façade. First the vegetation which grows directly on the façade of the building, second the vegetation which needs a separate structural system that can be freestanding or attached to the wall, third the vegetation which climbs on attached trellis or grown freestanding or in planters. These walls can be watered with mechanised watering system.

Figure 31 Green walls

Types of living walls-

Living walls can be internal or external to the building envelope and can be broadly classified into three systems:

Panel System: pre planted systems are used to add vegetation. These bought on site and then connect with the structural system of the built mass. Mechanical system are used to irrigate.

Felt System: felt pockets are used to grow plant this is provide with a water proof backing which is then connected to structure. The felt is kept continually moist with water that contains plant nutrients.

Container and/or Trellis System: trellis are used to climb plant which grown in container. Irrigation drip-lines are usually used in the plant containers to control watering and feeding.

Interior living Walls: can be built out of any of the above three systems. Some of these walls are specifically integrated with the building's mechanical system. Recycled and fresh air can be supplied to the building's interior through the living wall and thus the air is cleansed and humidified by the plants and growing medium.

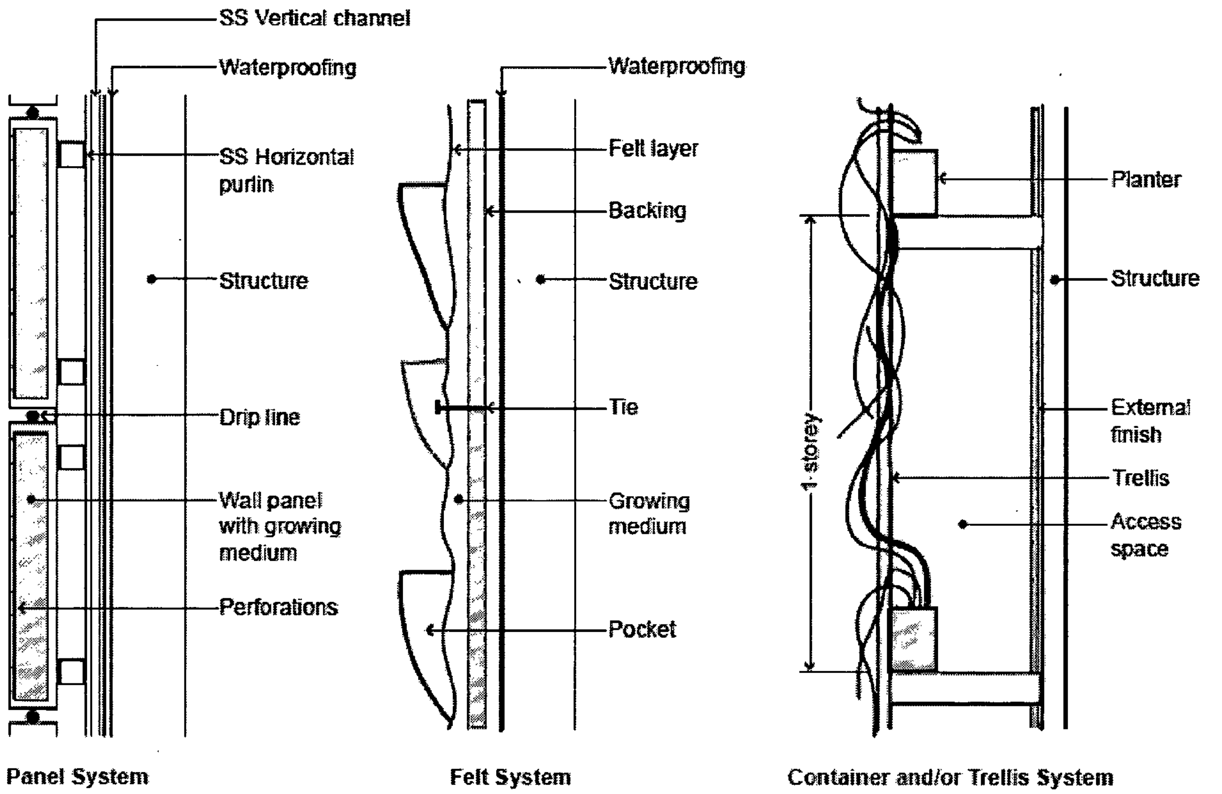



Figure 32 The Three Generic Wall System

### 5.2.5.2 Stepped Planters

Stepped planters are linked systems which are used to achieve physical continuity of vegetation in vertical development, continuous set of planters also encourage the biodiversity. "Continuous planting zones can be achieved through stepped planter boxes, these accommodates migration and interaction of species".

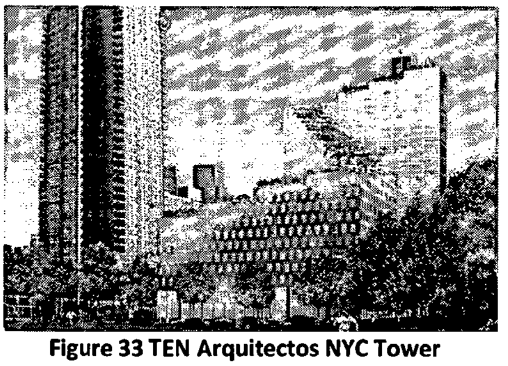


Figure 33 TEN Arquitectos NYC Tower

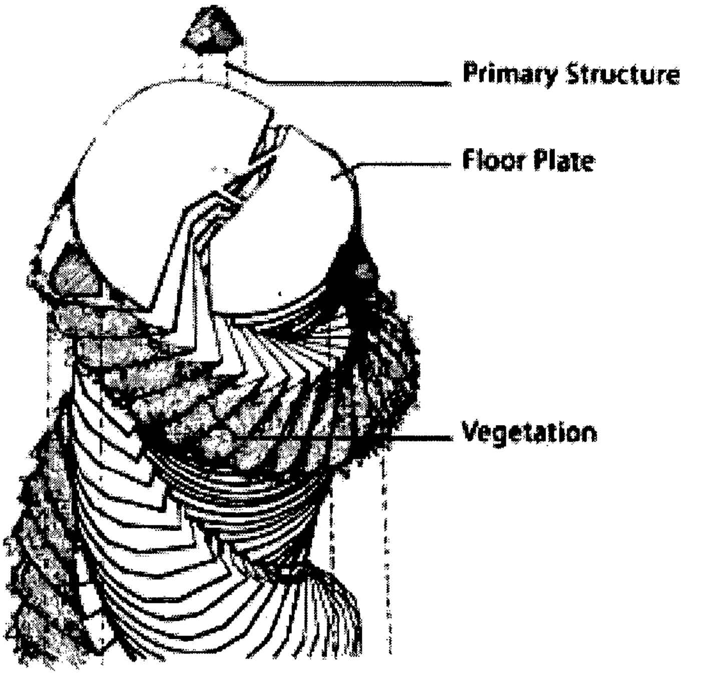
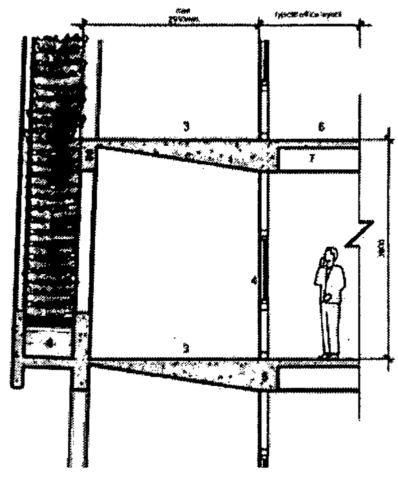



Figure 34 Stepped planters accommodating on facade

### 5.2.5.3 Vertical Boulevard



Continuous zones of vegetation that connects plants from the boulevard to the roof of the tower. Vertical boulevards are based on the concept of rising green carpet from the ground to the top of the building. This vertical landscaping rises along the wing walls of the 'vertical boulevard' that spans the entire height of the tower.

This integrated greenery further enhances the aesthetic values and the cooling effect of the sky terraces, lowering the temperature of the building and creates soothing conditions to its users; provide them opportunity to live in healthy space

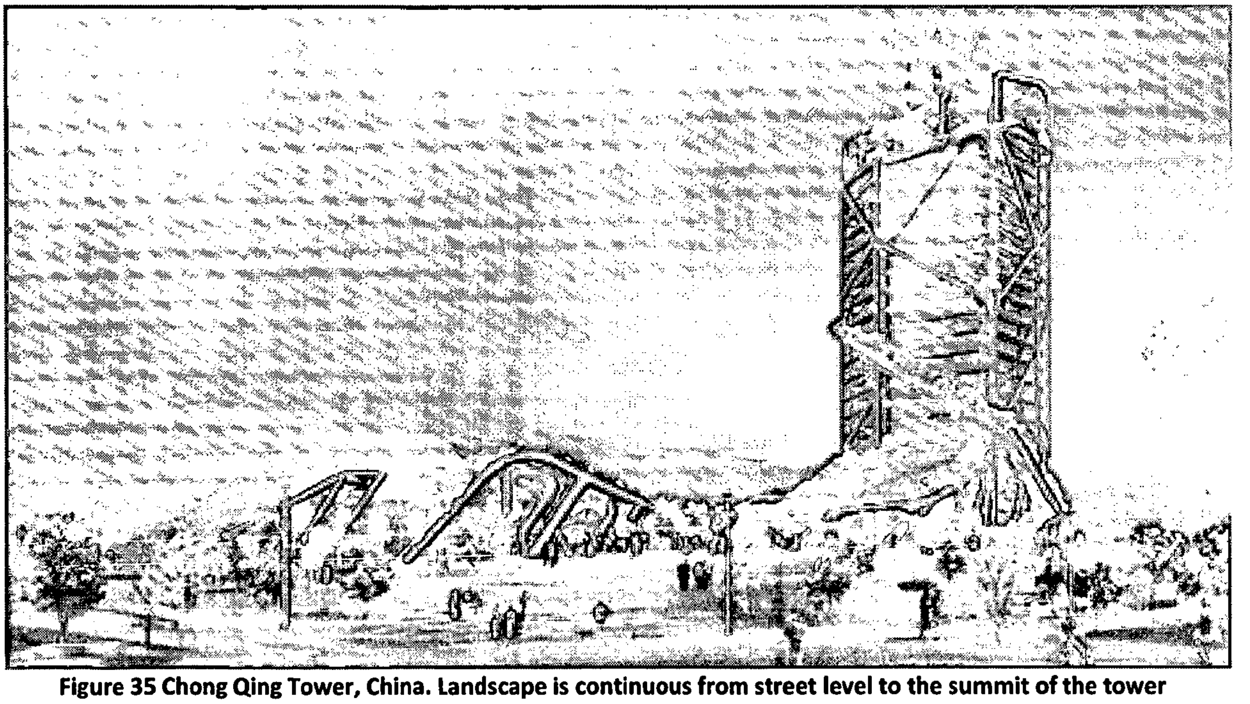


**Figure 35 Chong Qing Tower, China. Landscape is continuous from street level to the summit of the tower**

### 5.2.5.4 Vegetated Ramps

Landscape Ramps acts as an ecological armature that is Ecocells with the cascading sequence of landscaped ramps to the roof garden (Refer fig. 3). Maintenance of these ramps is achieved via a parallel pathway which allows for servicing of the continuous planters without requiring access from internal tenanted spaces.

These ramps also serve as linear park and allow fluid movement of the organisms; they enhance the biodiversity and also contribute to the overall health of these ecosystems. Large concentration of shade plants is an element of comprehensive strategy for the ambient cooling of the building façade. It helps in balancing the inherent inorganicness of the built form with a more organic mass.

## 5.2.6 Skycourts

Skycourts are the medium of adding vegetation at different levels of the building. Most of our conventional building are low rise and have a healthy relationship to land and open green spaces but this lacks in vertical developments, skycourts helps in recreating the same environment at upper levels. These are also known as "Sky Gardens"

Skycourts creates outdoor spaces at higher floors and provide a breadth taking view to its Occupants, it also help in breaking the severity of concrete mass by adding ecology and making more pleasurable to humans.
The landscaped skycourts creates a buffer zone and protect the built mass from heat, dust and lashing rain.
These are placed staggered at different levels to enhance the air flow. The transition space between inside and outside are accommodated in the form of veranda where these skycourts are placed.
These skycourts provide a get together or meeting place which is protected from sun, one can also enjoy the vegetation, open sky, mild spray, cool breezes.

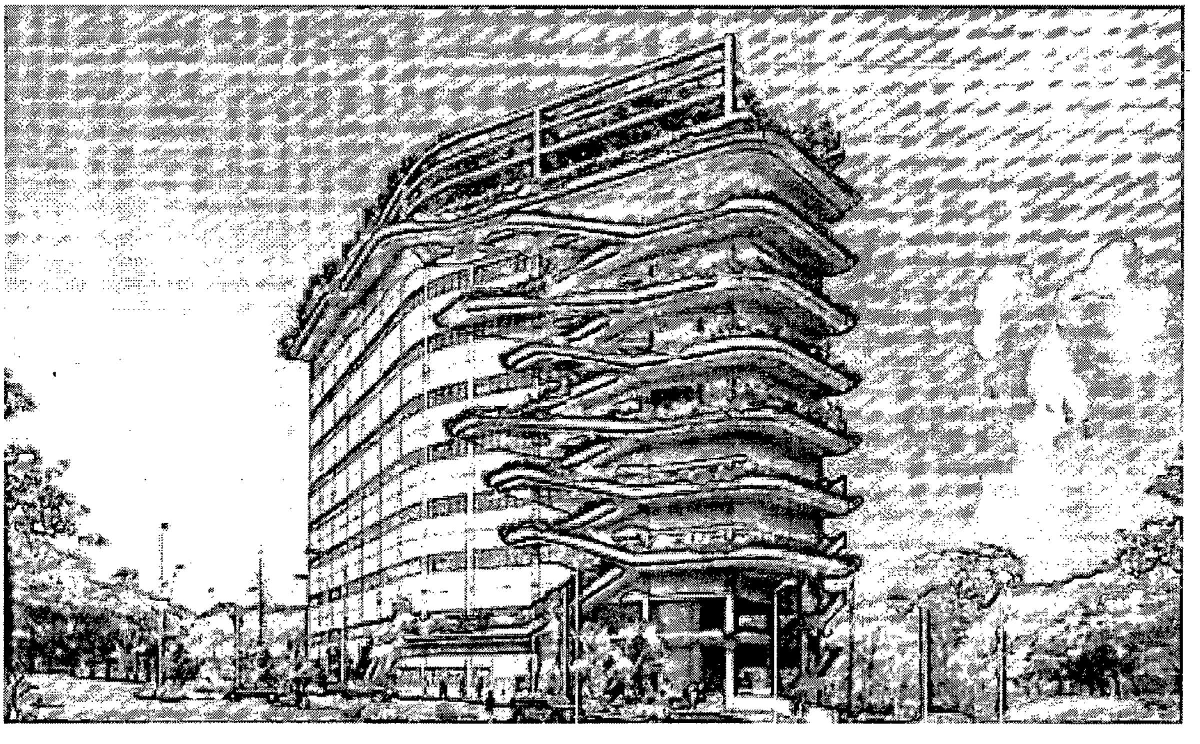


**Figure 36 Human Research Institute, Hong Kong**

The landscaped garden, acts as a buffer from the dust, heat and the lashing rain. They are staggered on different floors, which enhance the air movement between floors. The spacing between the gardens, gives each one a private uninterrupted bit of sky. The transition from the interior to the open terrace is made through a semi open veranda. The veranda is the most comfortable space from which one can enjoy the rain, only feeling the mild spray, or the cool breeze, protected from the sun.

The skycourts oases located at regular vertical intervals or according to the need and design of the tower, provide major breaks in the built volume – a form of suspended natural parks, introducing a fresh air and acting as the tower's lung, distributing via the atrial voids as essential airflow while insulated from the city beneath.

These serve as a interstitial zones between the internal areas and external areas.

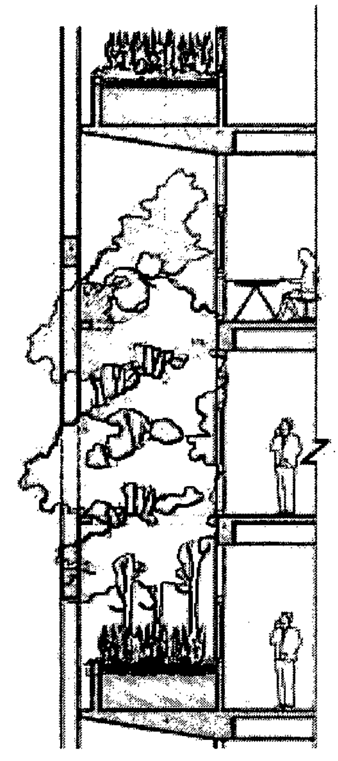


Figure 38 Park in the Sky

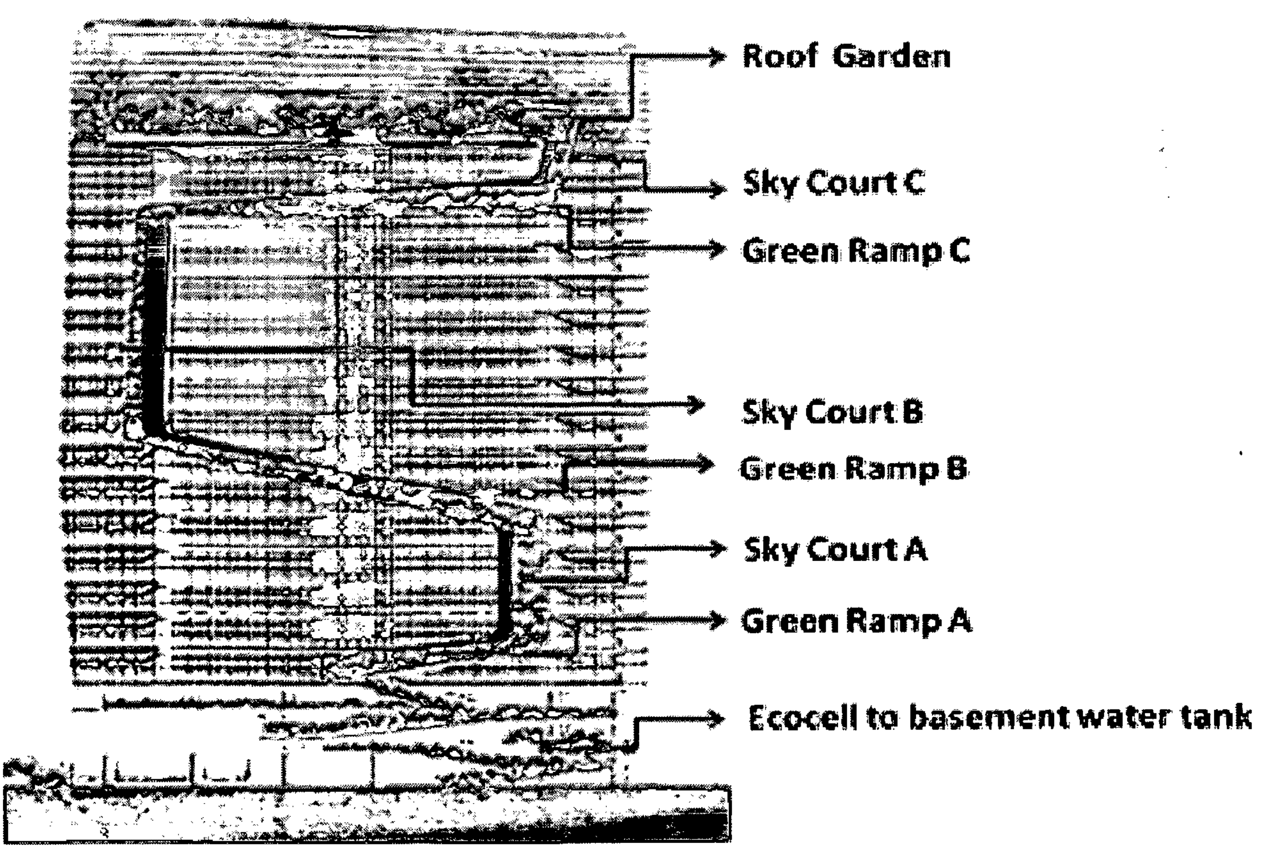



Figure 37 Sky Courts at Spire Edge

## 5.2.7 landscaped balconies and Sky terraces

Balconies and sky terraces are one of the prominent means of adding vegetation in vertical developments. These helps in linking the interior and exterior spaces.

This is the smart way of providing ecological sustainability in the vertical developments. The benefits of providing green spaces are disproportionality high in comparison with the area they required.

Landscaped balconies provide a soothing green zone to the vertical development specially where occupants do not access public or open green spaces easily.

There is a greatest scope for adding ecology in the upper levels, Now a days architects, designers incorporating vegetation in the building in the form of landscaped balconies and sky terraces.

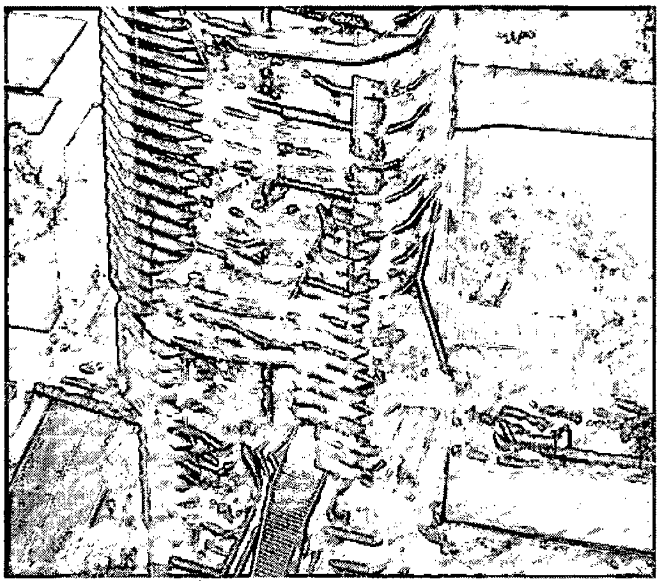


Figure 39 EDITT Tower, Singapore

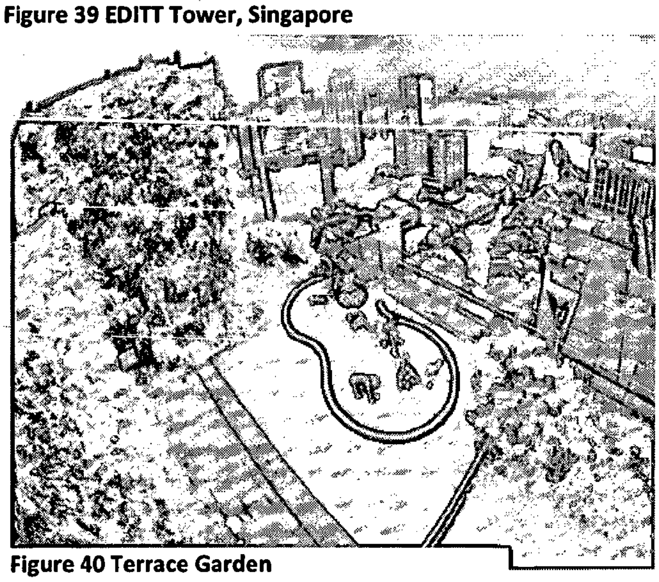


Figure 40 Terrace Garden

# Chapter 6 Case Study

## 6.1 Case study (Ecoinfrastructure)

This chapter contains two set of case studies one to understand the innovative green techniques and ecoinfrastructure for achieving ecological sustainability in vertical developments and other set explains ecological sustainable vertical urbanism which shows how urban design should occur in three dimension, public space and landscape extend through architectural objects from base to tip creating a interconnected city with all the facilities within itself.

### 6.1.1 The Spire Edge, Manesar, Gurgaon, India

#### 6.1.1.1 Basic Information

Spire edge is an office/business complex under construction in Gurgaon, India which comprises of 5 main blocks- Multitenant Block, Signature Tower, Business Suites & club, , Anchor Block and Shopping mall. The block called the Signature Tower (most commonly referred to as spire edge) is proposed by Ken Yeang which he has designed by incorporating innovative green technologies. As this vertical development is under construction the study presented here is essentially based on literature survey.

The key design features include a zone of continuous greenery that ascends from the heart of the surrounding IT park complex up to the buildings highest roof gardens. The interconnected landscape ramps provide the project with ecological diversity outdoor terraces and interactive gardens, enhance the projects creative environment.(Refer figure 6 for zone of continous greenery and figure 7 for the surroundings of the IT Complex)

The project has Large terrace gardens with vertical landscapes( green ramps), breakout spaces (skycourts), landscaped usable refuge areas, Ecocells, Rain water harvesting, Rain water gravity filtration system and high sunlit atrium entrances as ecological features to reduce down the energy demand of the building.

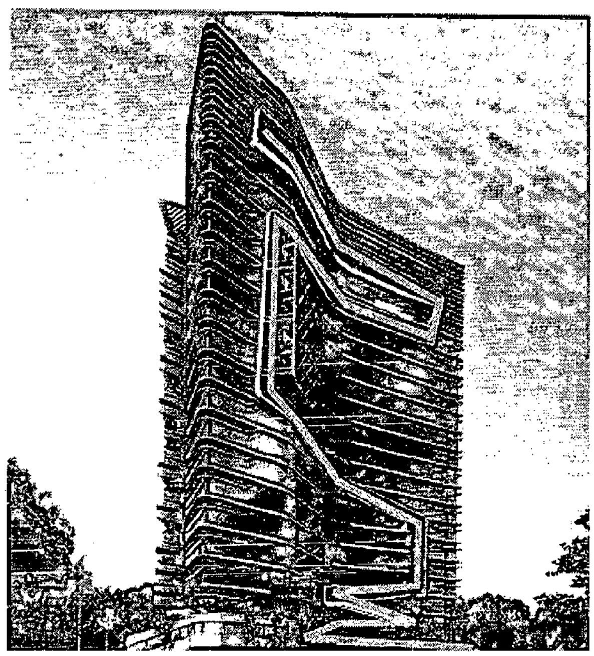


**Figure 41 Conceptual Diagram**
**Continuous ramp that carries vegetation from the base and surrounding landscape to the upper level**
**Source-Hatt, Sara, 2011. Ecoarchitecture : the work of ken Yeang. Wiley publications**

- Location- Manesar, Gurgaon, India
- Climate Zone- Subtropical
- Vegetation Zone- Subtropical Forest
- No. of Storeys- 23
- Areas
- GFA :22,559m2
- NFA :17,165m2
- Site Area- 4765 m2
- Plot Ratio- 1:4.7

## 6.1.1.2 Site Plan

North

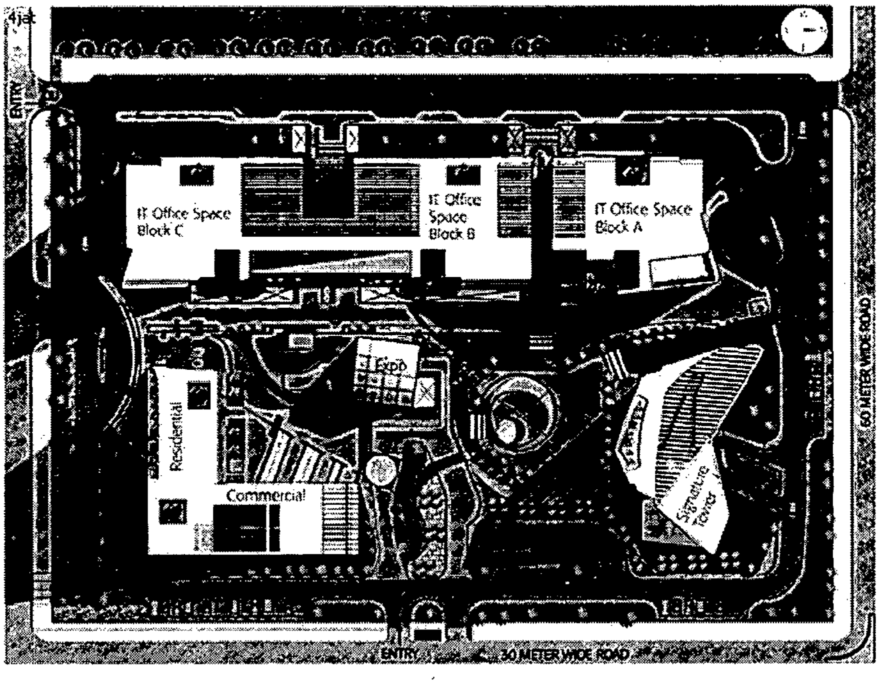



**Figure 42 Site Plan**

**[online] Available at <http://www.investors-clinic.com/show-Spire-Edge-22-2.html>[Accessed on 6 April 2012]**

## 6.1.1.3 Site Detail

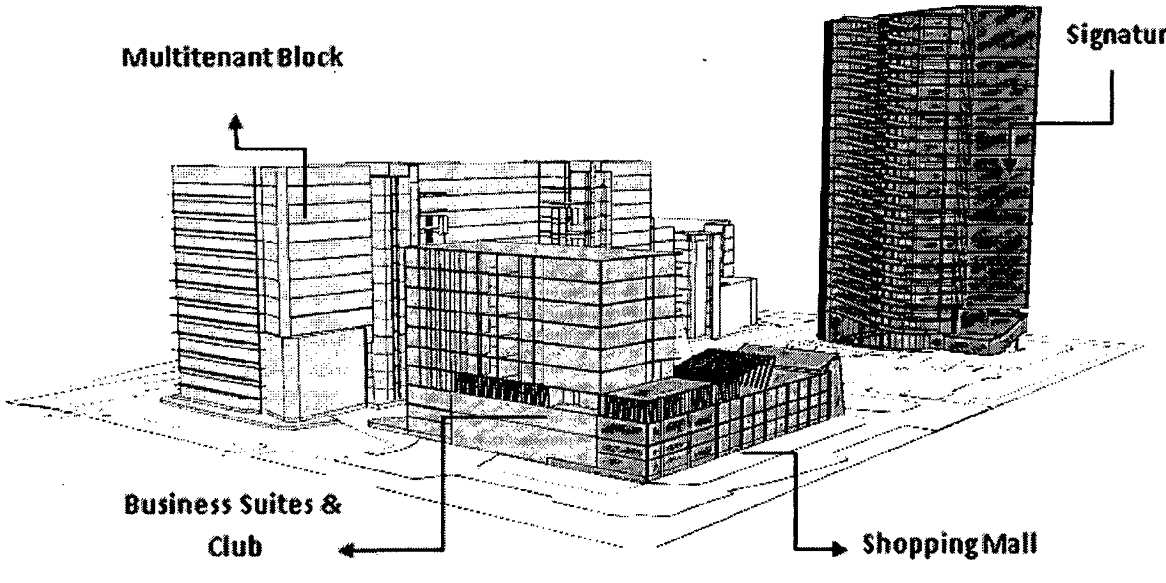



**Figure 43Three dimensional view of site**

### 6.1.1.4 Concept Diagrams for Green &Blue Ecoinfrastructure

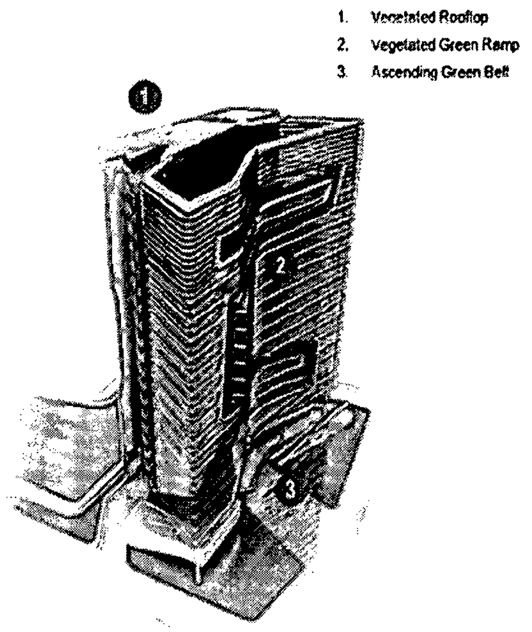



Figure 44 Green Link Concept

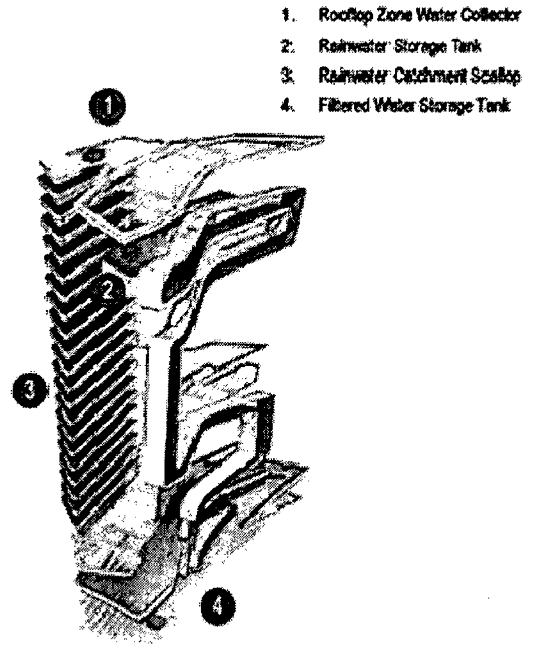
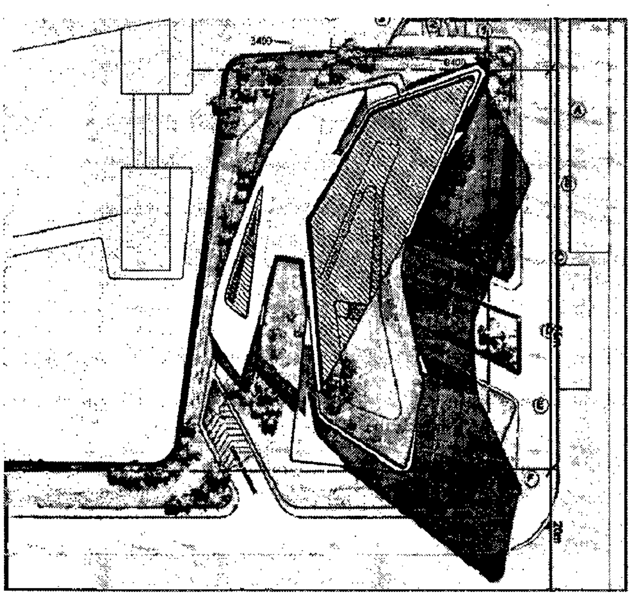



Figure 45 Water Management Diagram

### 6.1.1.5 Detailed Plans(Floor plans showing green areas)



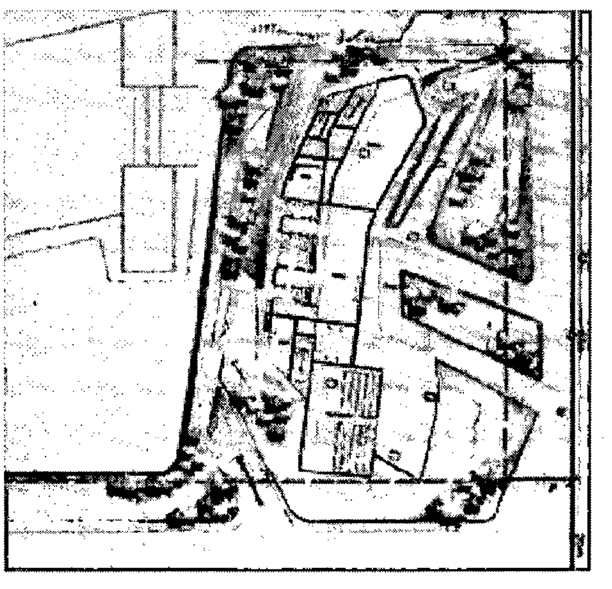
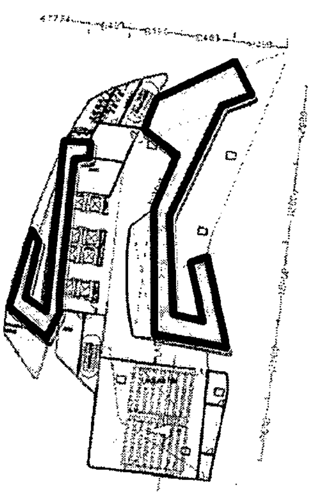


Figure 46 Site Plan;
Source- Sanjay Prakash & Associates

N



(+00 M)

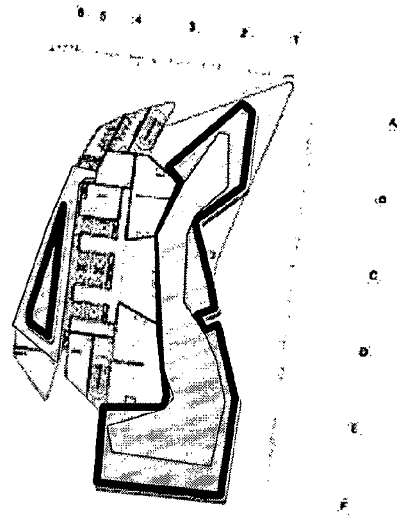
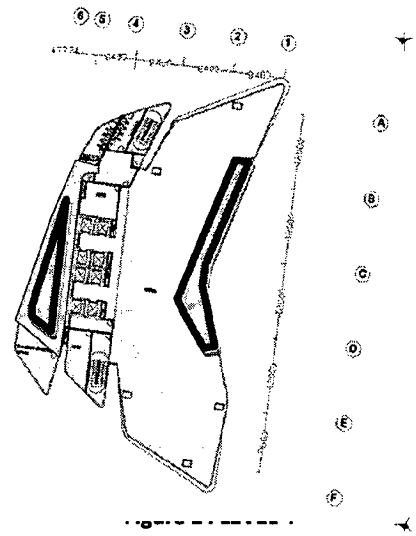
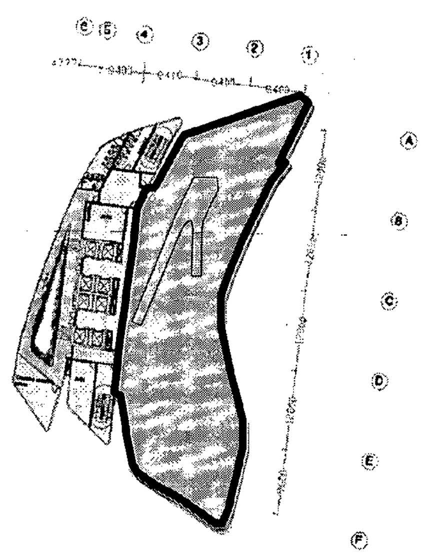


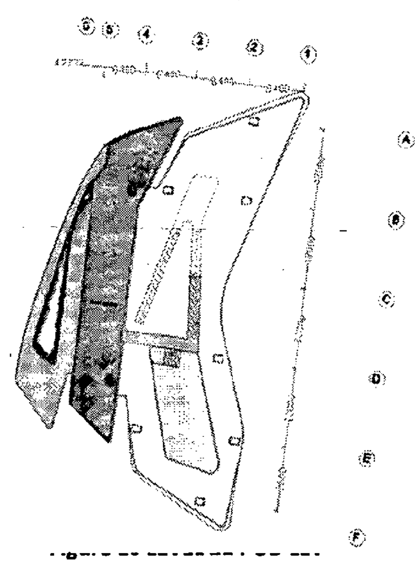
Figure 47 LEVEL 5
(+5.4 M)



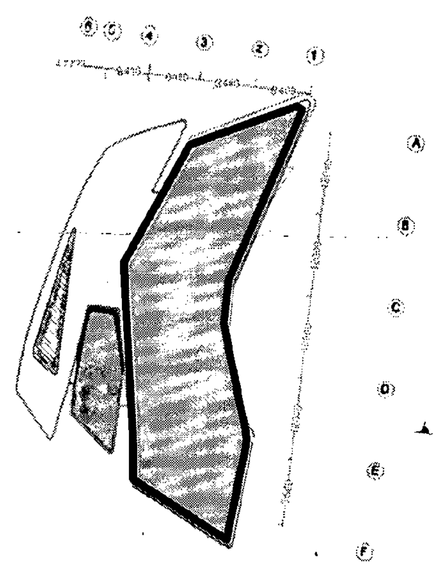
(+8.7 M)



DEN (+95 M)



EL (+100.1 M)



[illegible]

**Source- Sanjay Prakash& associates**

The noticeable green building features of the tower not only visually define the high tech style and it's organic disposition but also define it as bioclimatic vertical development. Several such technologies which helps in achieving ecological sustainability in Spire Edge, Gurgaon are discussed below-

### 6.1.1.6 Continuous green ramps-

***Green infrastructure North***

On the northern façade of the building he designed a continuous zone of planting via a series of vegetated green walls, pedestrian ramps & sky courts. Physical continuity between planting helps in encouraging species diversity (refer fig. 18). Green armature on the northern façade starts from ecocell , reaches to the podium level and continues up to roof garden by passing through Green ramp A, Skycourt A, Green ramp B, Skycourt B & Green ramp C, Skycourt C progressively. These system acts as a thermal buffer, protecting the building envelope from direct solar heat gain, create event spaces and areas for relaxation.

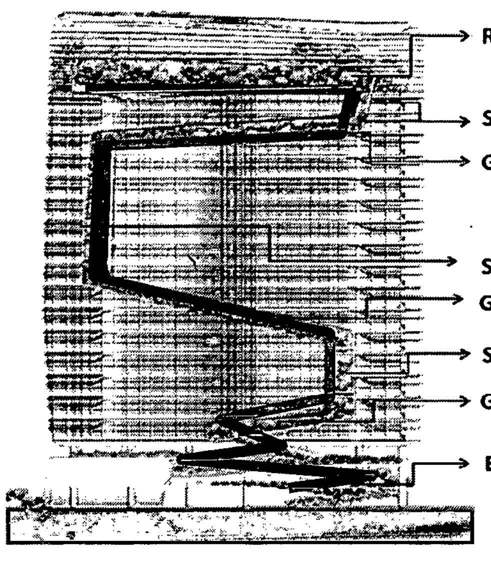



**Figure 49 Northern Elevations with Skycourts and Green Ramps**

***Green infrastructure South***

The south façade of the building features continuous landscaped ramp (from level 1 to 20) with ecocell (from basement 3 to level 1) which bring pedestrian and vegetation from the basement up to a lush green roof garden. The GFA from floor 4 to 19 is approximately 1318 $m^2$ out of which 123 $m^2$ is covered by landscape ramp. (refer fig. 19)

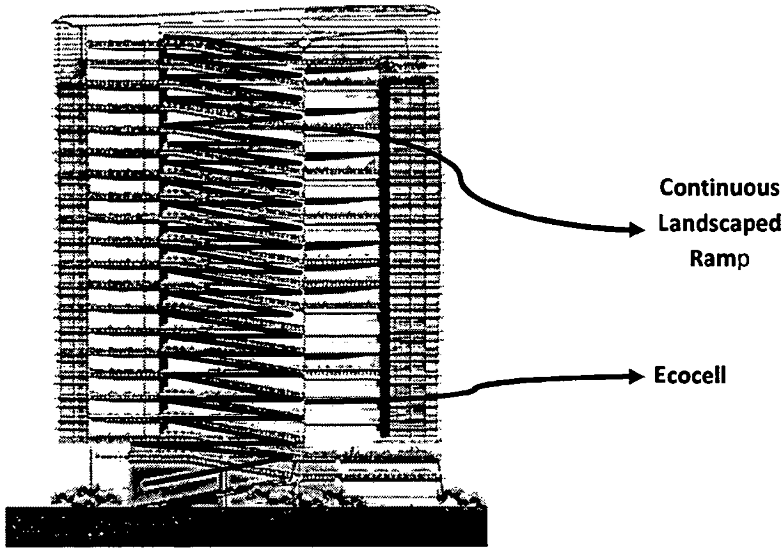



Figure 50Southern Elevation with Landscaped Ramp

### 6.1.1.7 Ecocells

There are two Eco cells located at the north(refer fig. 20)and south (refer fig. 21)of the building where the spiral ramps meet the ground. These vegetated ramps extend into the basement levels. Eco cells allow vegetation,daylight and natural ventilation to extend into the car-park levels below. The lowest level of the ecocells contains storage tanks and pump rooms that support the project's rainwater recycling system.


Figure 51 North Ecocell

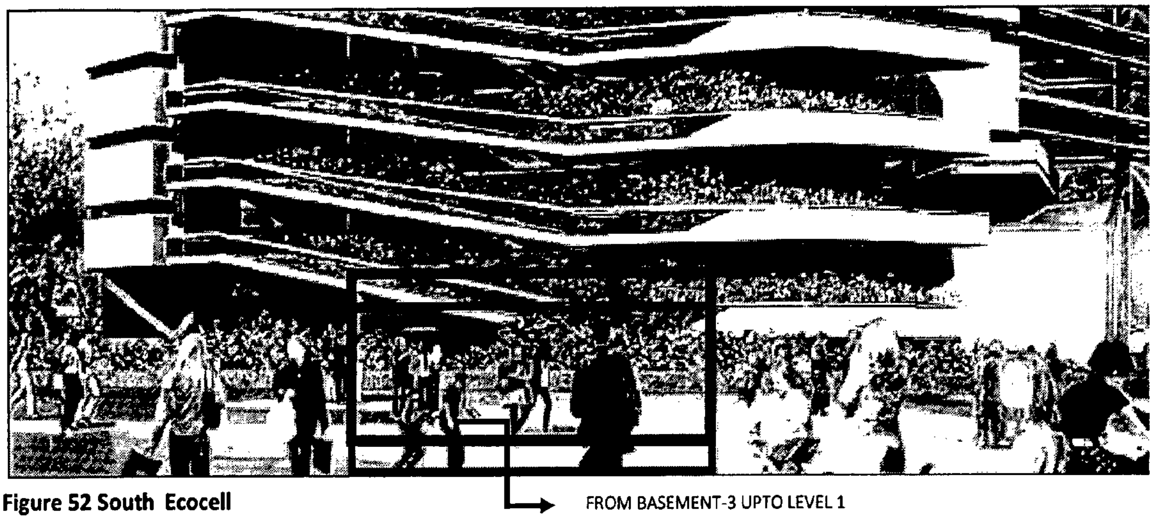



Figure 52 South Ecocell

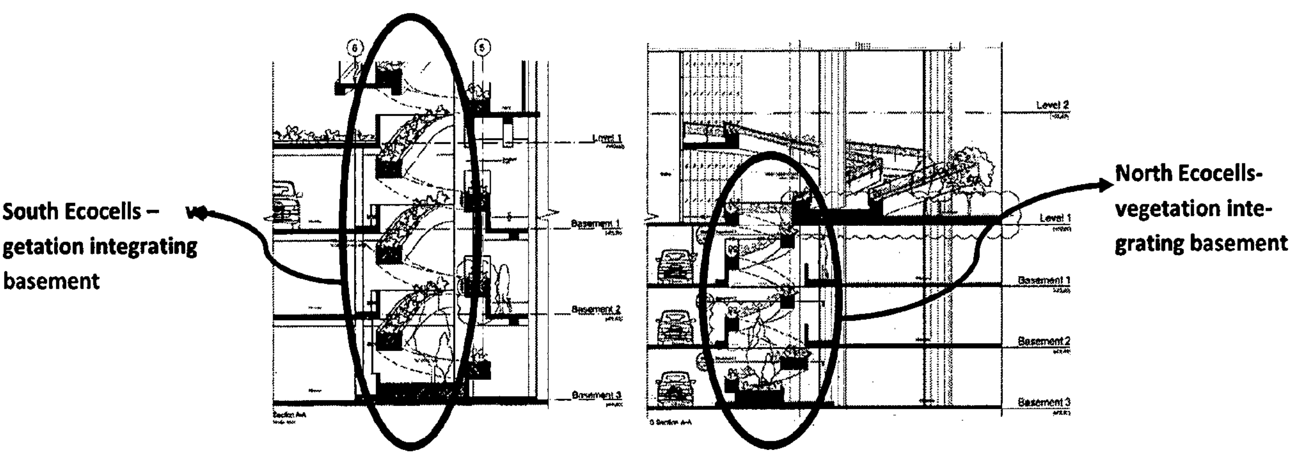



Figure 53 North and South Ecocell section

### 6.1.1.8 Roof Gardens

The building's extensive gardens allow for interaction between its occupants and nature, offering opportunities to experience the tower's external environments and to enjoy views of the adjacent IT park. The roof gardens and sky courts are further subdivided into creative meeting spaces and multi-use terraces. A series of sky courts in the north façade also provide a variety of outdoor environments for office user's creative and social interactions.

Figure 54 Roof Gardens

### 6.1.1.9 Rain Water Harvesting

The tower is designed to be as self-sufficient as possible in terms of water use. The total projected water requirement of the signature tower is estimate to be about 71 KLD after commissioning from ETP & STP. Rainwater catchment scallops are integrate throughout the facade of the building to catch rainwater, green ramps and landscaped terraces acts as filtration and collection devices, these also helps in channelling rainwater into tanks located in the basement (refer fig. 27). The harvested rainwater is then use to irrigate the building extensive landscaped areas, significantly reducing the project consumption of potable water. The building is having water backup for 28 days, rainwater harvesting tank of 1300000 litres are located in the basement.

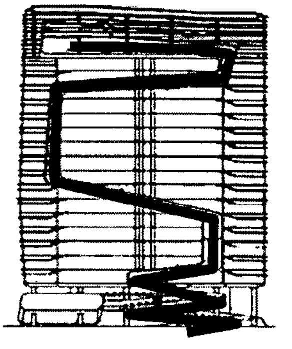


**Figure 55 Rain Water Harvesting Detail.**

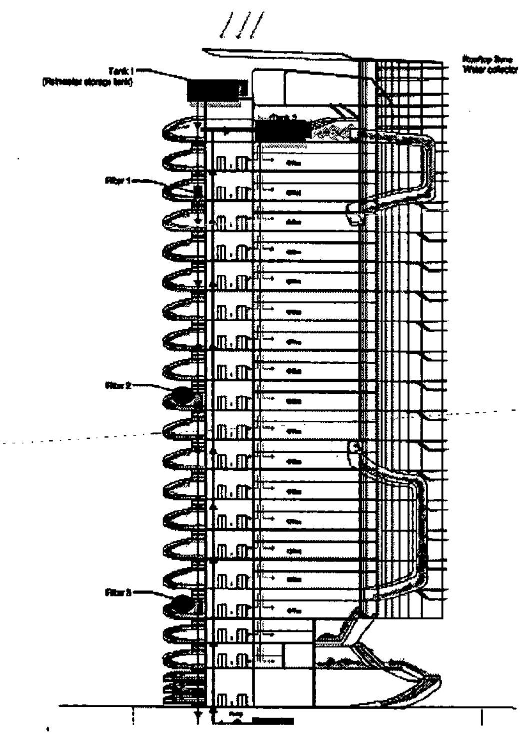


**Figure 57 Rainwater Collection & Recycling**

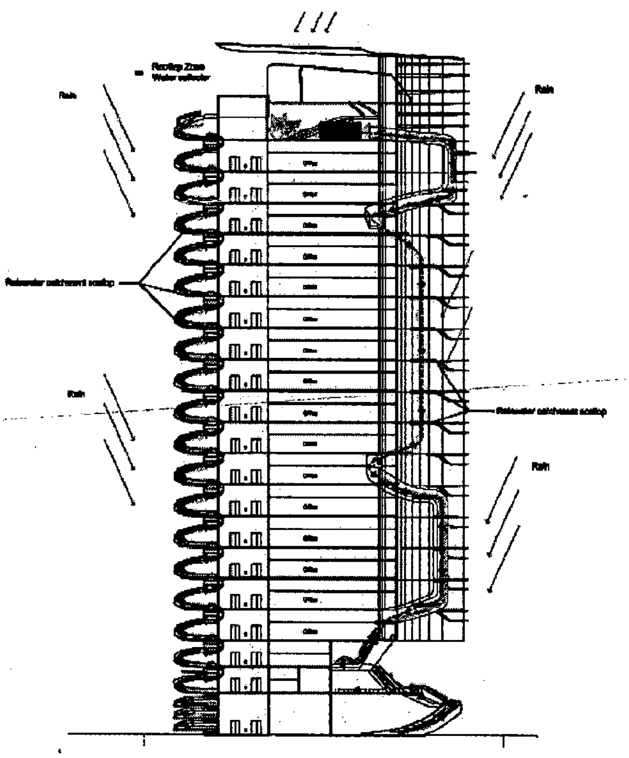


**Figure 56 Raiwater Gravity Filtration System**

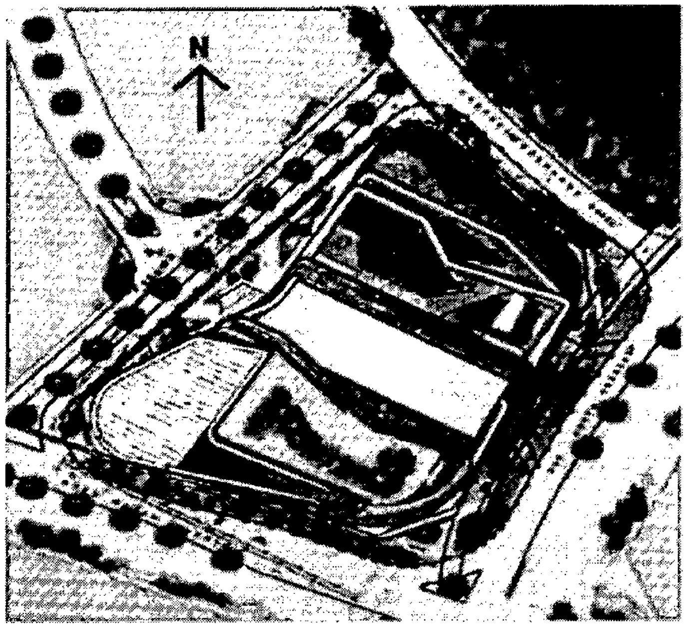
### 6.1.1.10 Rain Water Gravity Filtration System

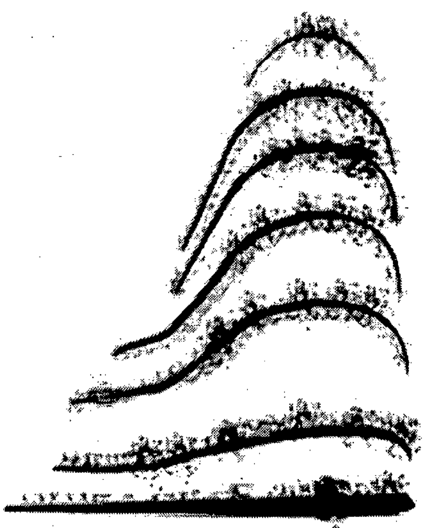
The tower is provided with three water tanks one at roof level, second in the basement level and third on the pod level (20$^{th}$ floor). Rainwater collection system is designed on the roof top, water collects on the roof and then reaches to the rainwater harvesting tank which is located in the basement by passing through three filters located at 4$^{th}$ , 12$^{th}$&,19$^{th}$ floor , filtered water is then pumped into tank 3 which exist on 20th floor, this filtered water is then used in the offices(refer fig. 28).

## 6.1.2 Solaris, Singapore

### 6.1.2.1 BasicInformation

- Building Name: Solaris
- Site: Fusionopolis [Phase 2B]
- Location: one-north Park, Singapore
- Start of Construction: Sep 2008
- Scheduled Completion: Aug 2010
- Building Height: 80 m
- Tower A: 15 Storeys + roof garden
- Tower B: 8 Storeys + roof gardens
- Total GFA: 51,274 $m^2$
- Site Area: 7,734 $m^2$
- Total Landscaped Area: 8,363 $m^2$



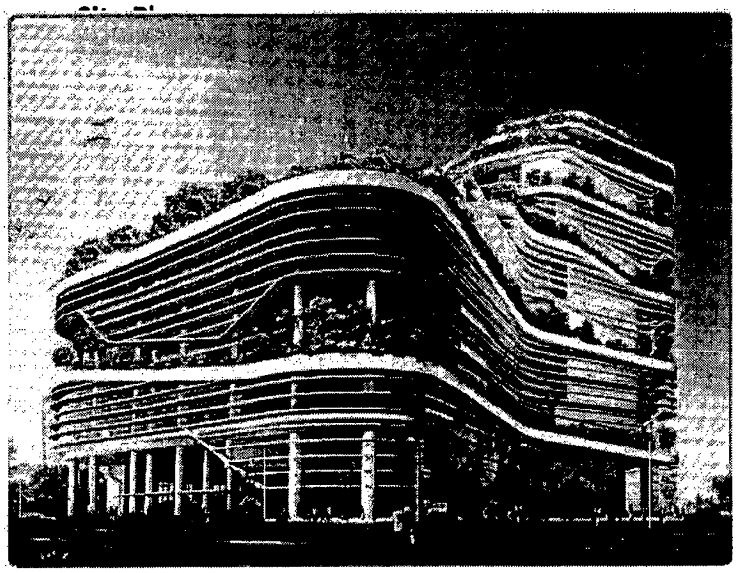
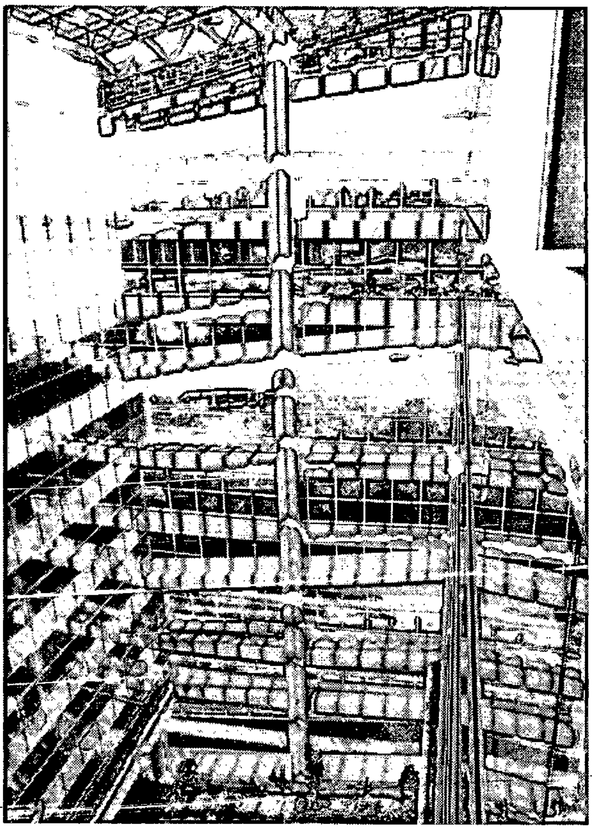


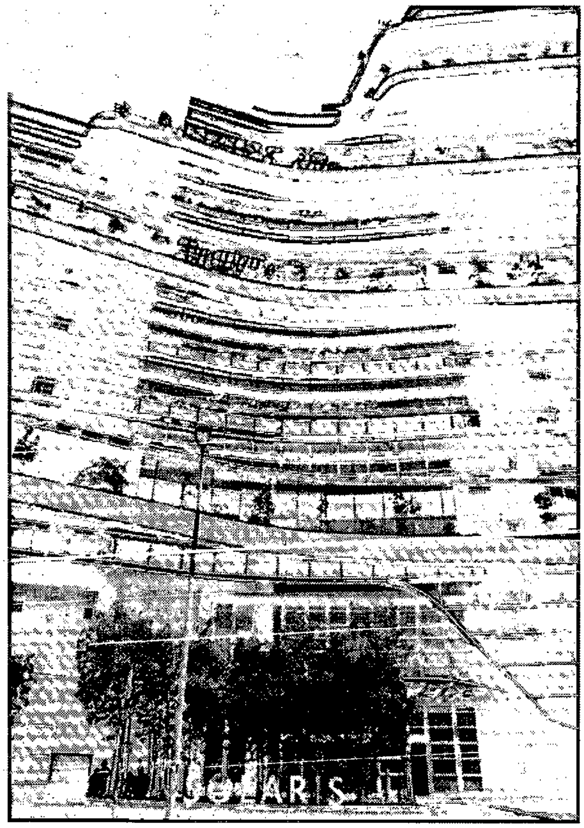
Figure 58 Concept Diagram - Solaris

### 6.1.2.2 Table of Landscaped Areas

- Atrium Planter Boxes: 304.5 m2
- Roof Gardens: 2,986 m2
- Eco-Cell: 84 m2
- Green Ramp: 4,116 m2
- Ground Level Landscaping: 488 m2
- Solar Shaft: 224 m2
- Green Walls: 165 m2
- Total Landscaped Area: 8,364 m2

- Ratio of Landscaping to Site Area: 109% Green
- Ratio of Landscaping to GFA: 18% Green
- Percentage of Total Landscape Area above Ground Level: 95%





**6.1.2.3 Key Features:**

- Estimated energy savings: 2,828,470 kWh/yr; Estimated water savings: 11,785 m3/yr; ETTV: 39.92 W/m2.
- Operable skylight louver.
- Natural ventilated Atrium with daylight design.
- Solar shaft to enhance the natural daylight to the building.
- Eco-Cell and 400m3 Rainwater Harvesting Tank.
- Extensive roof gardens and continuous vertical landscaping.

### 6.1.2.4 Continuous Perimeter Landscaped Ramp

The adjacent one-north Park at ground level and the basement is connected through uninterrupted 1.5 kilometre long ecological armature .Eco-cell with the resembling sequence of series of small water falls from rocked steps onto whichthe sequence of roof-gardens are landscaped at the building's highest levels. 3 metres minimum width of ramp has been provided. The maintenance of the spiral landscaped planters is done through the parallel pathways provided, however with no hindrance and disturbance given to the tenants at the different floors. The pathways serve as a linear park in future which stretches from the ground level to the terrace level. The ecological design concept given has the major key factor of continuous landscaped component which allows for fluid movement of plant species and organisms between all vegetated areas of the building, it helps in enhance the biodiversity and contributes to the overall health of the ecosystem.

The ramp, with its deep overhangs and large concentrations of shade plants, is also one element in a comprehensive strategy for the ambient cooling of the building facade. This eco-infrastructure provides social, interactive and creative environments for the occupants of the building's upper floors while balancing the inherent inorganicness of the built-form with a more organic mass.

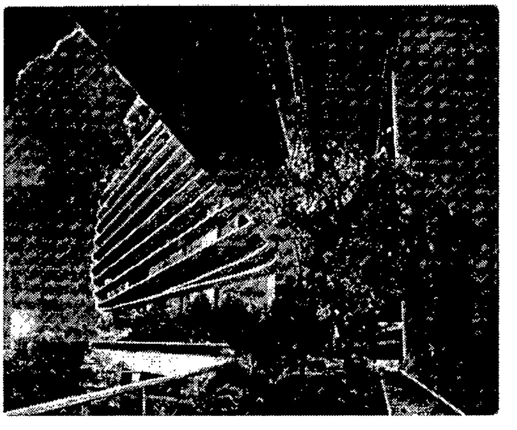


**Figure 59 Continuous landscape Ramp running throughout the facade**

### 6.1.2.5 Solar Shaft

A shaft cuts through the upper floors diagonally and provide the natural sunlight which penetrates from the glass to the sufficient interior spaces. The ceiling hung lights used in the interiors are based on a sensor which automatically reduces or increases the lux level depending upon the natural light penetrating in. Solar shaft are equipped with landscaped Terraces which bring added quality to the internal environment

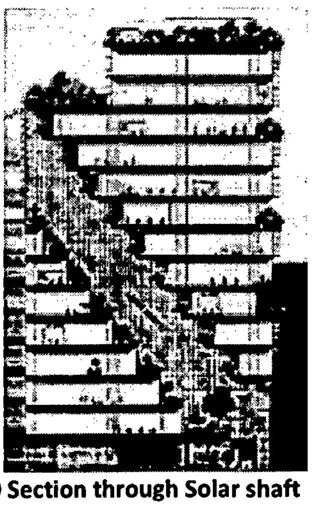


**Figure 60 Section through Solar shaft**

### 6.1.2.6 Naturally Ventilated and Day Lit Grand Atrium

To keep the fun element along with maintaining the team building and strengthening amongst the co-workers of same company, a public plaza between the two tower blocks is introduced as a space for creative performances and communal activities. Day lit atrium with operable glass louvered roof is provided to keep protected the building from the external environment, also enabling the built space fully ventilated whenever required. Naturally Ventilated and Day Lit Grand Atrium is used as mixed mode element to the building.CFD (Computational Fluid Dynamics) simulations was used to analyse thermal conditions and wind-speed within the atrium. The results CFD analyses were used to minimize the atrium facade design to improve air flow and enhance comfort levels.

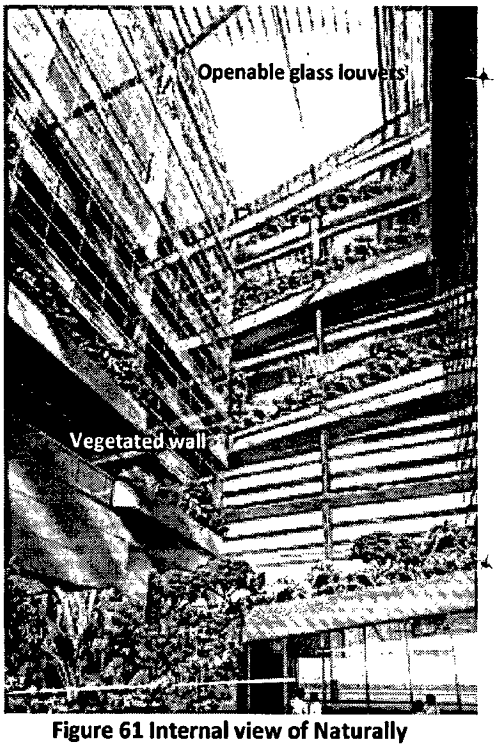
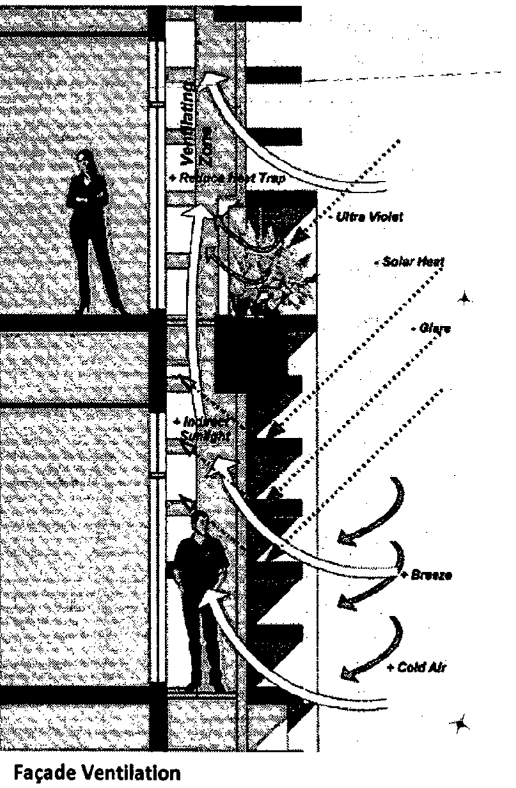



Figure 61 Internal view of Naturally ventilated Daylit Atrium

### 6.1.2.7 Extensive Sun-Shading Louvers

Sun-path is almost exactly east-west as Singapore is located at the equator. Detailed study of the sun path was done before coming to a concrete result of giving the required depth of sunshade louvers, which also double as light-shelves. Facade of the building is climate responsive and it is designed by analysing the solar path. Heat transfer across the built mass is controlled by solar shading strategy. The building is provided with low e double glazed facade which reduces the external thermal transfer value (ETTV) of 39 w/m2. To enhance the microclimates in habitable spaces sunshade louvers, deep overhangs, sky gardens are introduced. 10 km long sunshade louvers are used.

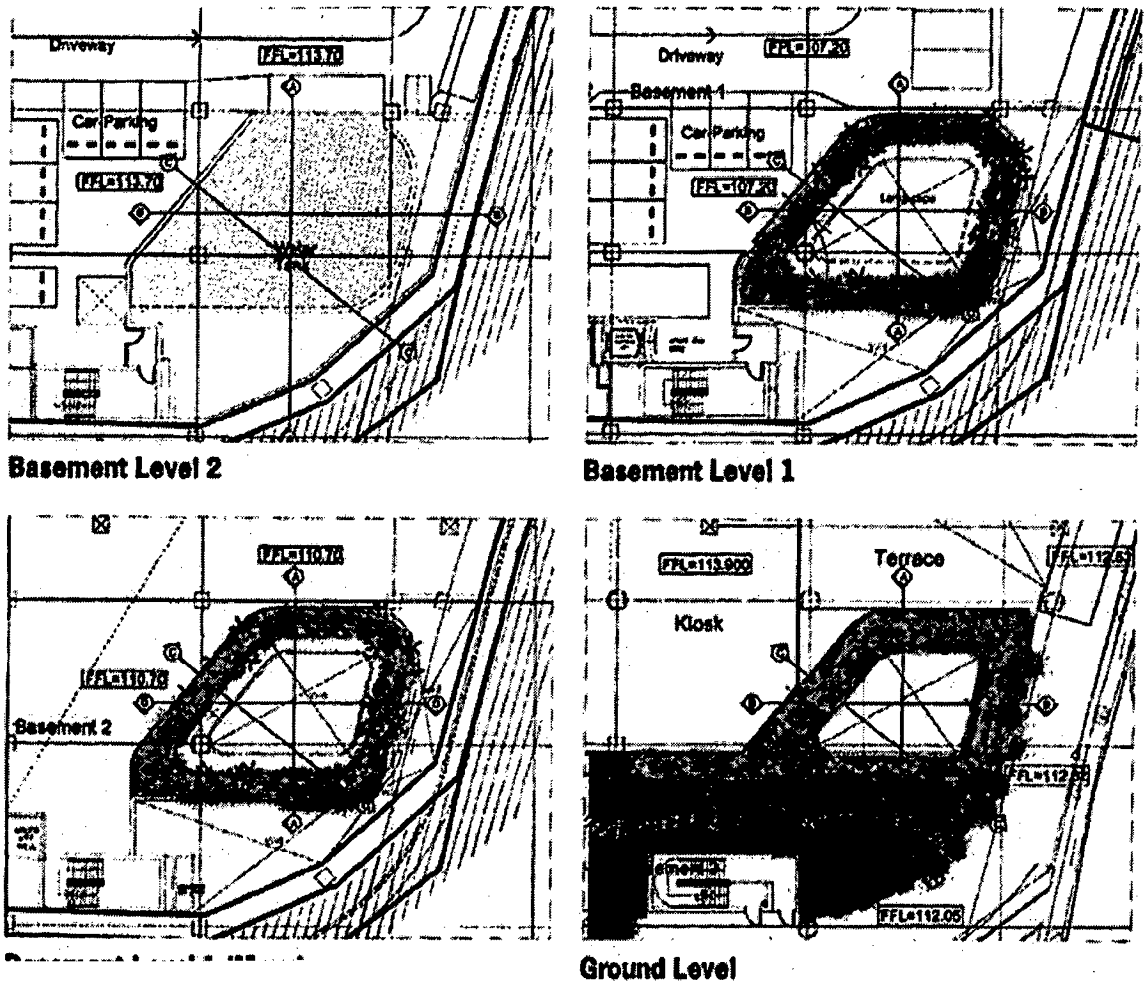



Façade Ventilation

Figure 62 Sun Shading Louvers

### 6.1.2.8 Eco-cell

Ecocells are the slots into the lower levels of the built mass where the landscapes spiral ramp meets the ground. It helps in introducing vegetation into the lifeless dark basement areas, provided day-light and natural ventilation through a cut-out. Storage tank and pump room is located at the end of the ecocell.



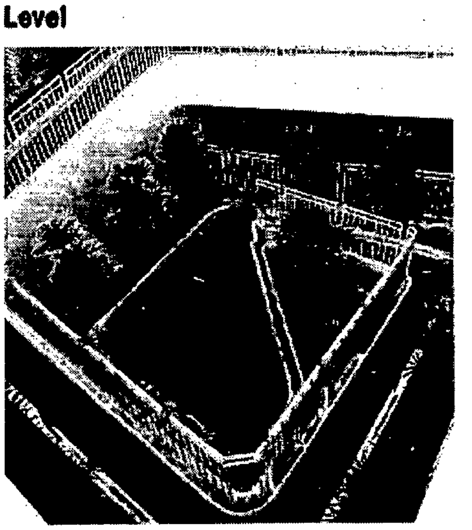



Figure 63 Ecocells at diffrent levels - Solaris

### 6.1.2.9 Roof Gardens and Corner Sky Terraces

The landscaping done in a vertical format helps in reducing the temperature around the space which is also been used as several small internal team building events for the MNC's. Occupants of the building interact with external environment through roof gardens, these also help in interacting with the nature, people can sit and enjoy the treetop views of the one north park from here. The volume of the sky garden increases generously as spiral ramps passes through the corner of the building. The green spaces provided into built mass is more than the footprint of the building on which it sits.

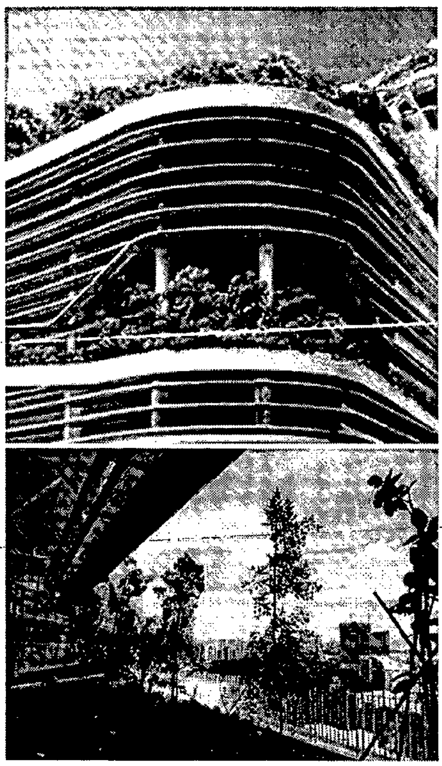


**Figure 64 Corner Sky Terrace**

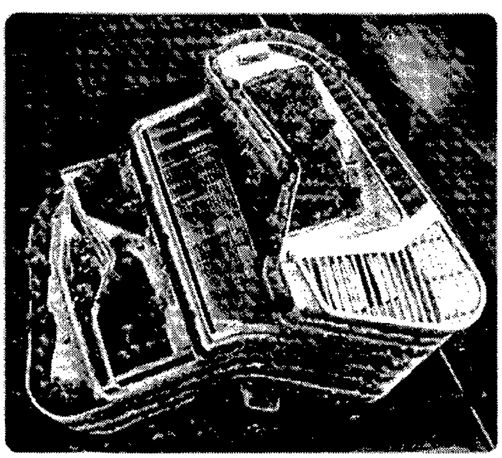


**Figure 65 View Showing Roof Gardens**

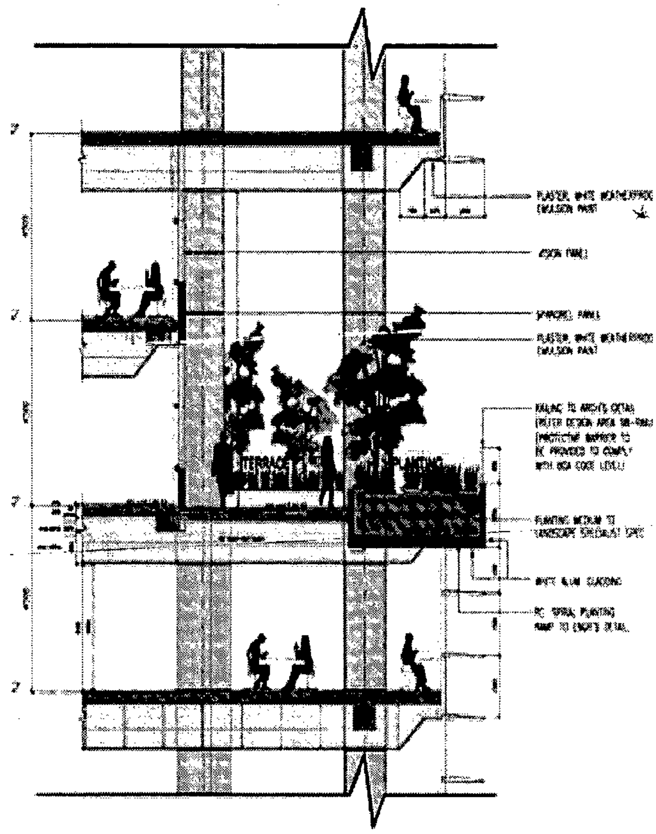
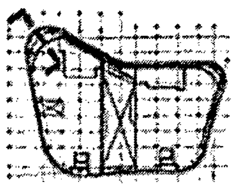


**Figure 66 Section through Roof Garden**



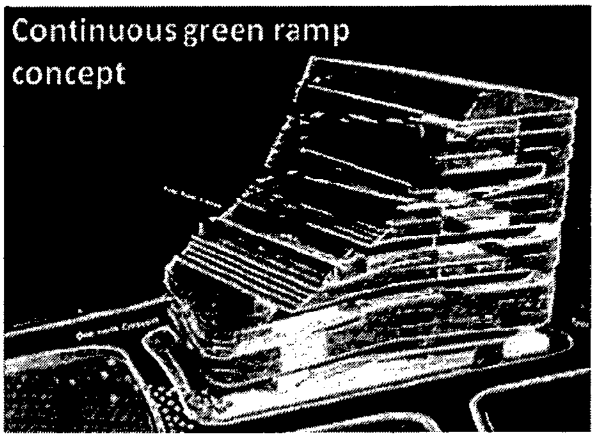
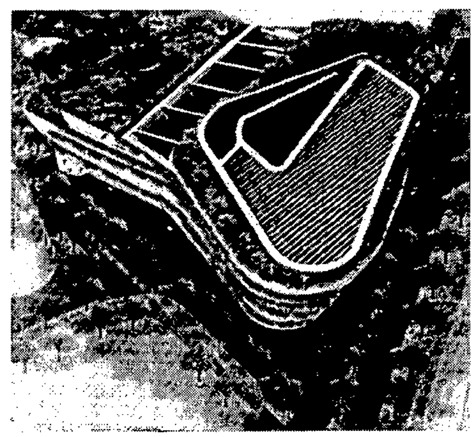



Figure 67 Conceptual Diagram for Continuous Green Ramp

### 6.1.2.10Rainwater Harvesting/Recycling



The most useful system which is provided to the building is rain water harvesting which not only harvest the landscaped done in the building in any form but also saves lot of natural rain water which comes in many further uses. Rainwater is collected through drainage downpipes which runs along the landscaped ramp and Siphonic drainage which exist on the roof of tower B. This water is then stored in the tanks located on the roof and beneath the ecocell in the basement of the building. A tank of capacity over 700 m3 stored water and allows irrigation for 5 days via recycled water between rainfalls.

### 6.1.2.11Pocket Park / Plaza

Pocket plaza not only equipped the building with place for social/ interactive event but also permitted for cross ventilation of the ground floor plaza. It links one-north park across the street with the help of ground level landscaping.

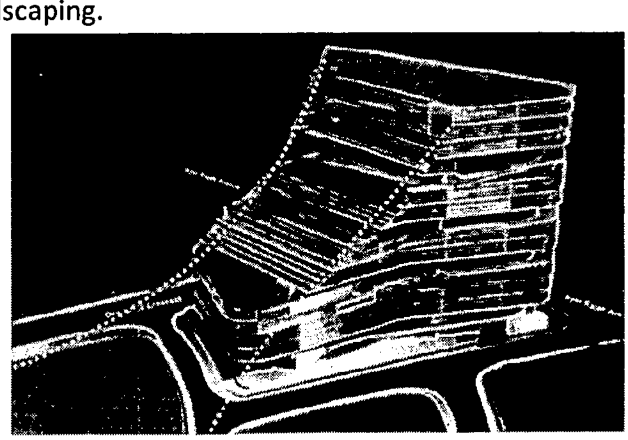


Figure 68 Rising green Carpet
(Concept-Vegetation from ground to the sky)

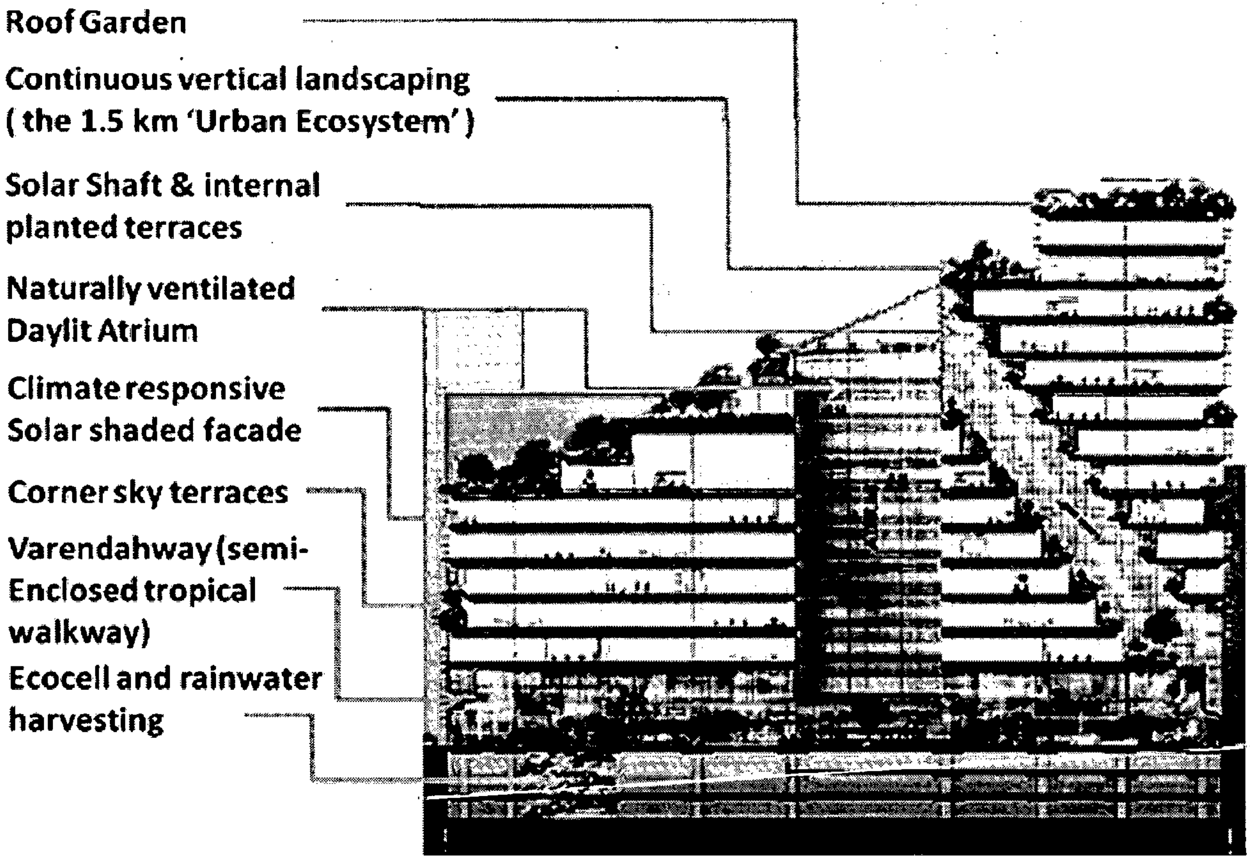
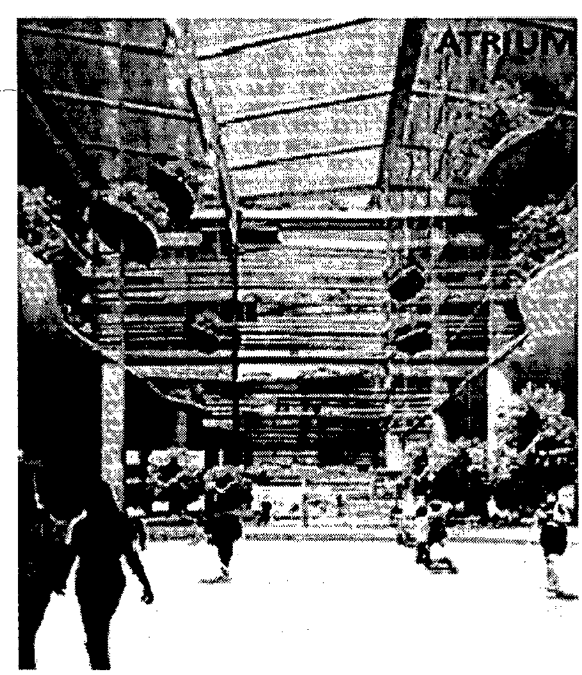
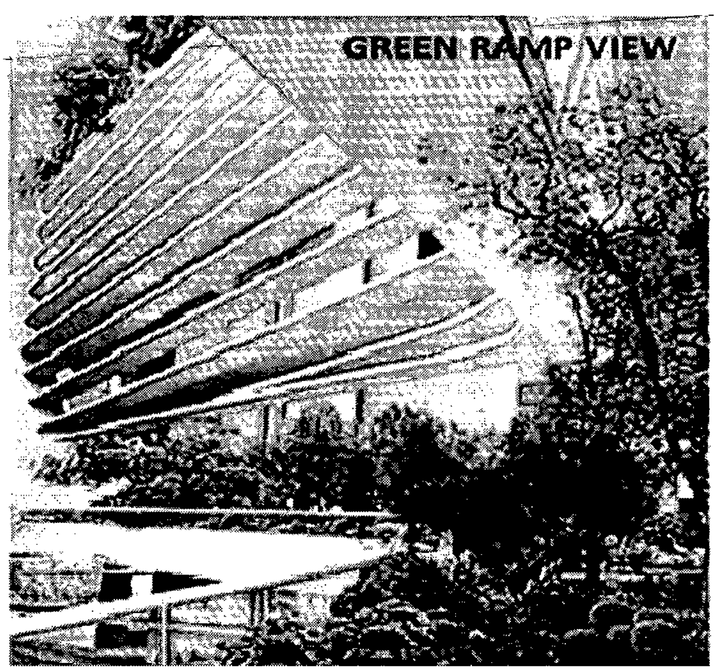



Figure 69 Sectional diagram showing passive techniques used in the design



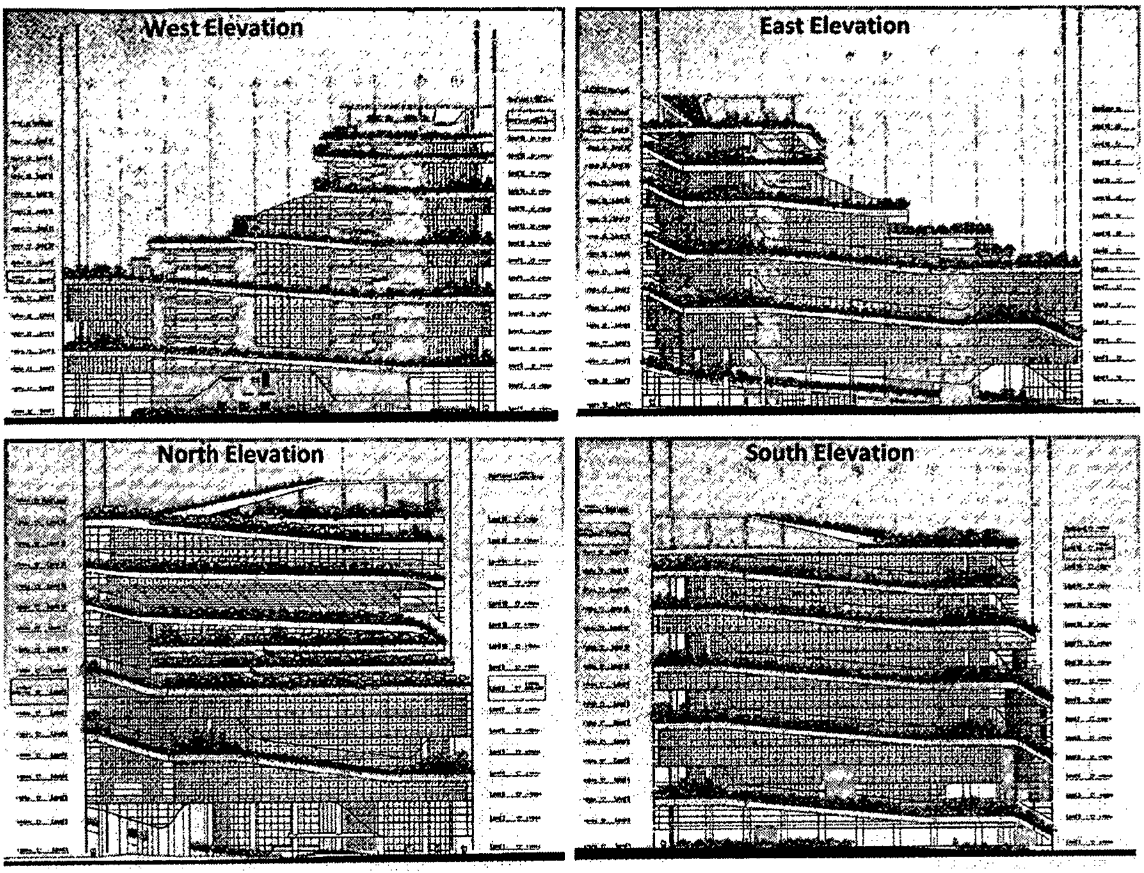



**Figure 70 Elevations Showing Green ramp**

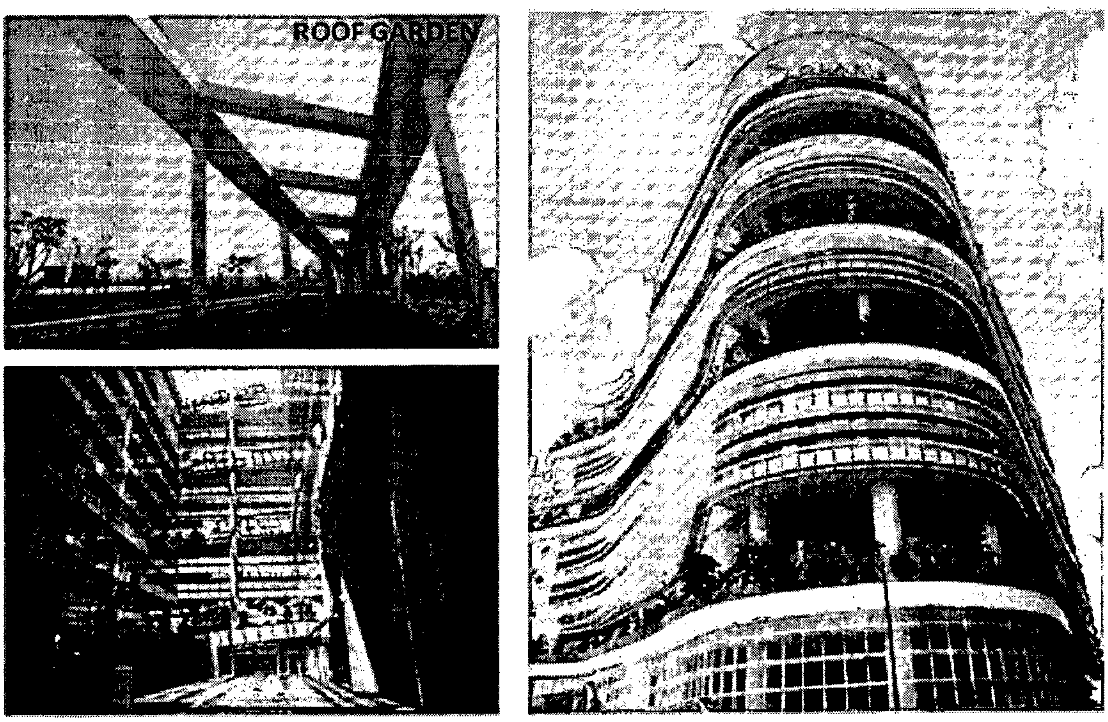



**Figure 71 Roof Gardens& Sky courts**

## 6.1.3 BIDV Tower, Vietnam

### 6.1.3.1 Basic Information

- Location-Ho Chi Minh City, Vietnam
- Climate Zone-Tropical
- Vegetation Zone-Rainforest
- No of Storeys-40
- Areas-
  GFA : 35,311 m2
  NFA :27,380m2
- Site Area-2686 m'
- Plot Ratio-1:3

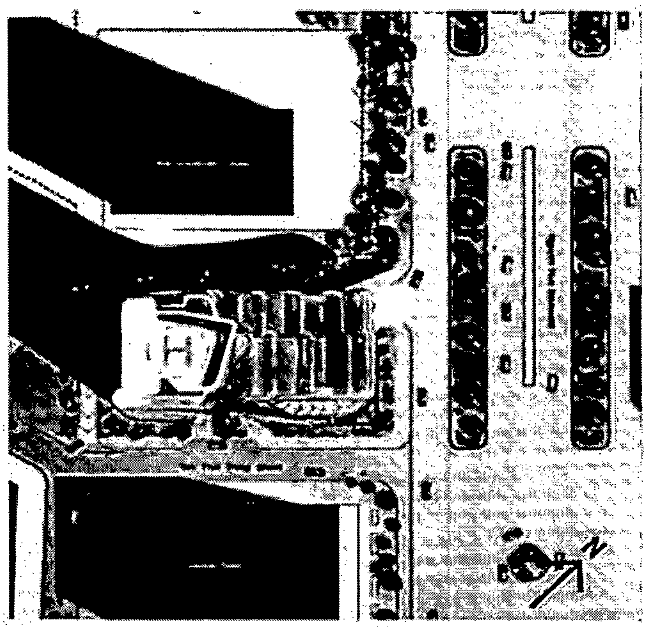
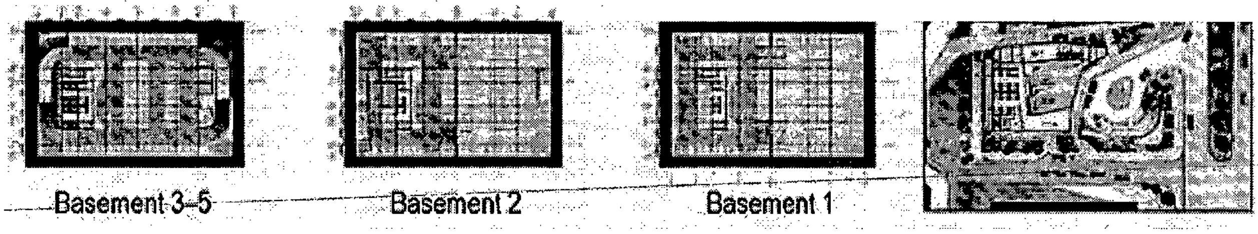
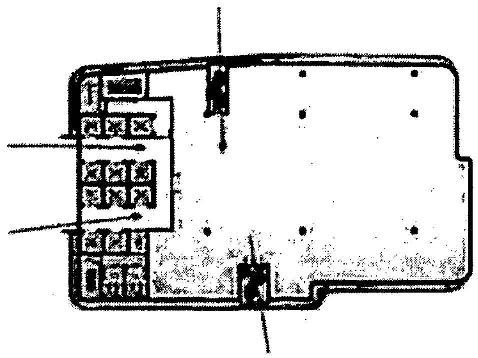
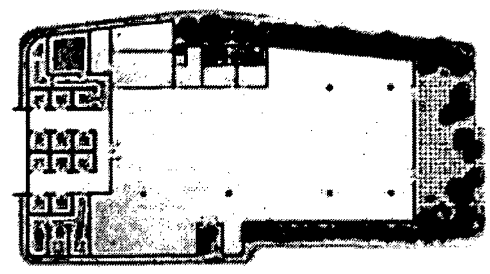


Figure 72 Site Plan - BIDV Tower

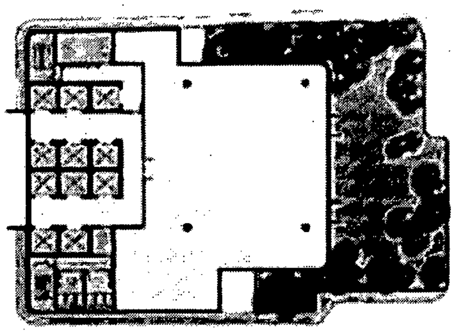



- The 40 storey BIDV Tower is composed of three different functions with integrated social spaces and landscaped areas.
- The ground floor to Level 4 are occupied by the Bank for Investment and Development of Vietnam (BIDV). Levels 5 and 6 contain international conference halls and seminar rooms. The remaining floors house leased office spaces and are topped by a roof garden with recreational areas and dining rooms,
- The primary design concept involved the social and physical integration of the boulevard into the building. Rising with the tower, the boulevard infuses each floor with greenery before descending to merge back into the city streets.
- The project's ecological features include wind funnels, Eco cells, sunshade louver's, sky courts and roof gardens.

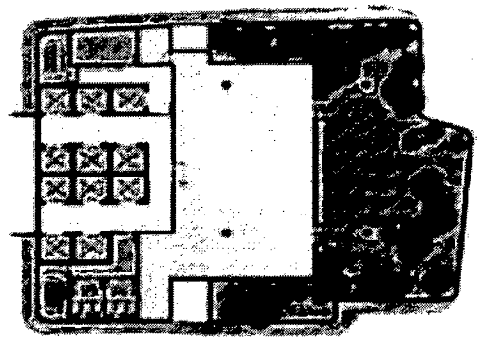




Podium Level 1



Level 6



Level 21 (Sky Lobby)

**Figure 73 Floor Plans showing Green Spaces**

Wind funnels, vertical indentations in the building's perimeter, these also helps in ensuring that all common areas of the building are ventilated naturally, They also help channel wind across upper floor plates to effectively cross ventilate office workspaces. Wind walls in the back and sides of the tower, further assist in channeling wind directly into the building.

Ecocells is a passive technique by which we can add vegetation, sunlight and fresh air into the basement levels.

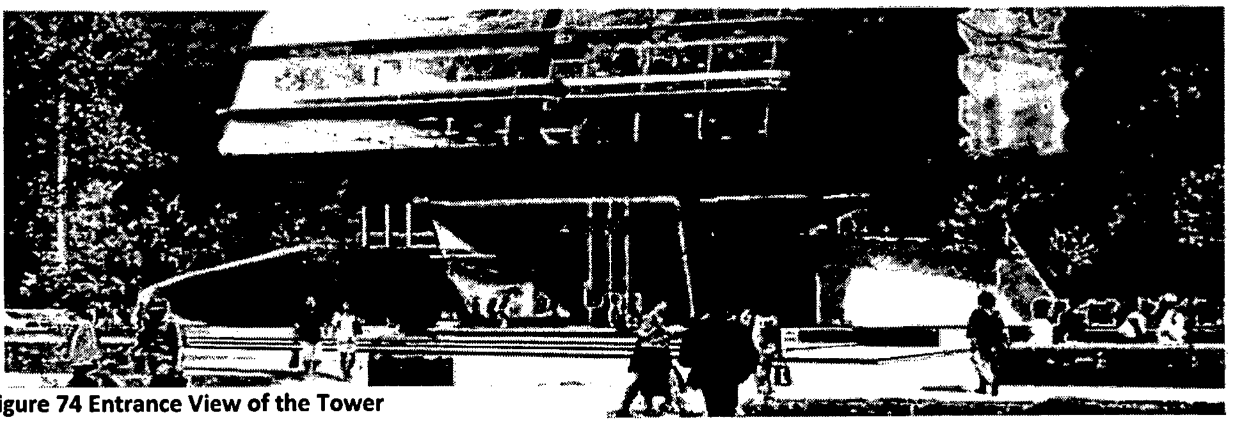


**Figure 74 Entrance View of the Tower**

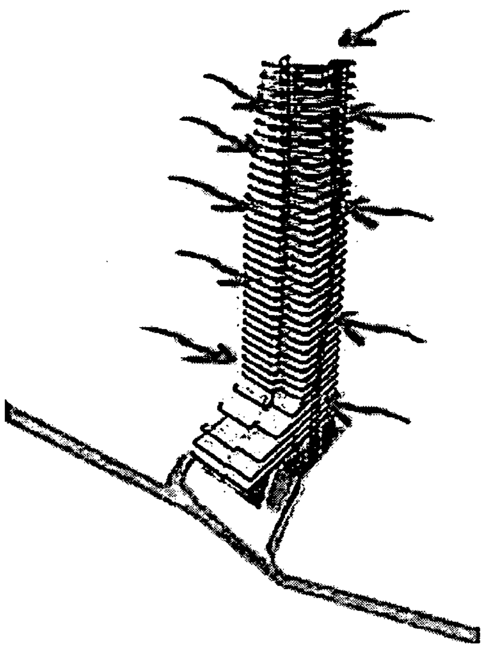


Figure 76 Naturally Ventilated Cores

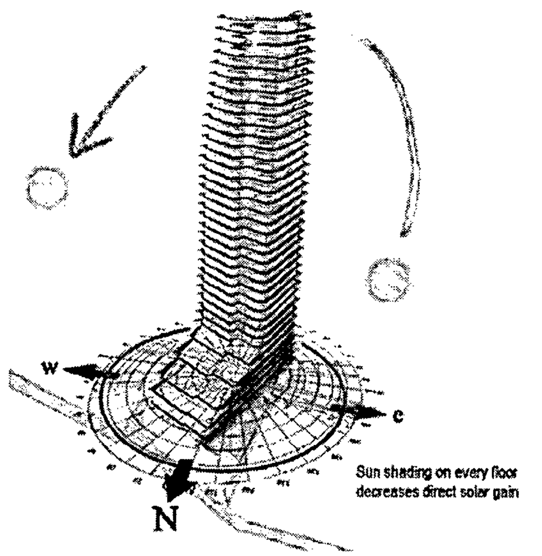



Figure 75 Sun Shading concept diagram

- Sky courts allow building occupants to enjoy greenery, and contribute to an efficient strategy for passive cooling along the building's façade.
- Greenery-filled gardens flanking the wing walls cool air as it is channeled into the building. Operable windows control the amount of fresh air passing into the workspaces.
- Should there be a power failure, these passive strategies ensure that the tower will still function comfortably. Together, these features represent a proven strategy for significantly reducing operating costs and providing a comfortable environment for the buildings occupants.

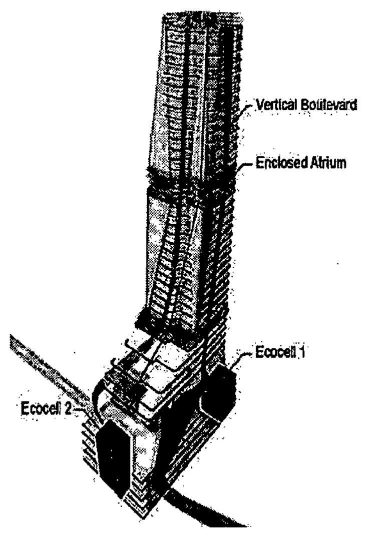
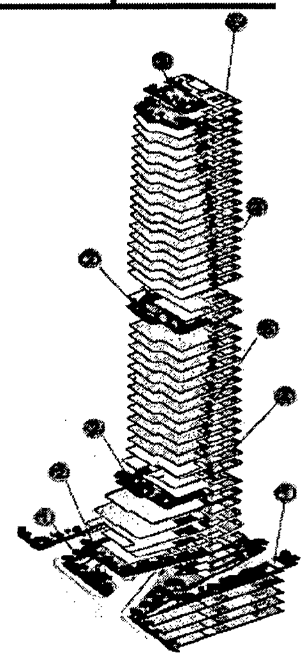



Figure 77 View showing ecological elements used in the design-BIDV Tower

### 6.1.3.2 The Vertical boulevard

Continuous zones of vegetation connect plants from the boulevard to the roof of the tower. This vertical landscaping rises along the wing walls of the 'vertical boulevard' that spans the entire height of BIDV tower. This integrated energy further enhances the cooling effect of the sky terraces, lowering the temperature of wind passing through them into adjacent workspaces.

A series of sky courts are designed to flow down the sides of the tower, With recessed balconies and full-height glazed doors opening out from adjacent offices, they act as parks in the sky' and serve as Interstitial zones between inside and outside areas, Sky courts provide occupiable areas for relaxation as well as views of greenery and plants from internal workstations Planting within the east and west façades reduces heat gain from exposure to direct sunlight and helps prevent glare from negatively



impacting on workspace productivity. Planted terraces carry soil and vegetation from existing ground- level greenery to upper levels of the Building.

- Reduces ambient air temperatures during summer.
- Reduces heat loss during winter.
- Creates healthy exterior microclimates for the buildings occupants.

### 6.1.3.3 Ecocells

Eco cells are vertical cellular voids or slots integrated into the buildings podium, located between the wound floor and the roof garden (over the podium). These voids, for example on the bottom right and top left of the building. Allow natural daylight to penetrate the full depth of the basement levels. In doing so. the ecocells serve as excellent devices for the ventilation of lower levels where stale, warm air rises and is replaced with fresh outside air.This sustainable, passive ventilation strategy requires no additional cost. In addition to enhancing natural ventilation, ecocells allow greenery to extend into the upper basement levels. Planted landscapes on the ground floor weave their way in and out of the basement levels to create seamless physical green connections. These shrubs bushes and grasses introduce biological air filters into otherwise dingy subterranean spaces.

- Allow day lighting and natural ventilation to penetrate into the building.
- Link vegetation on the roof garden to internal spaces of the building.
- A rainwater harvesting tank stores rainwater
- for reuse and recycling.

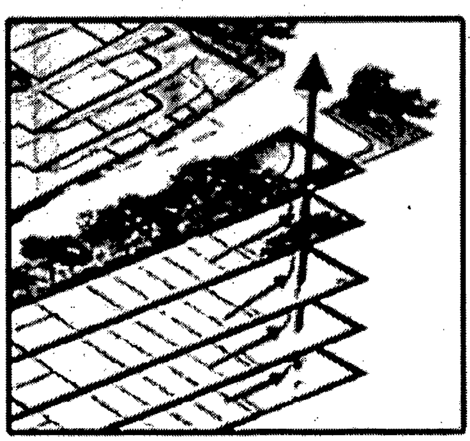


Figure 79 Car Park Ventilation System

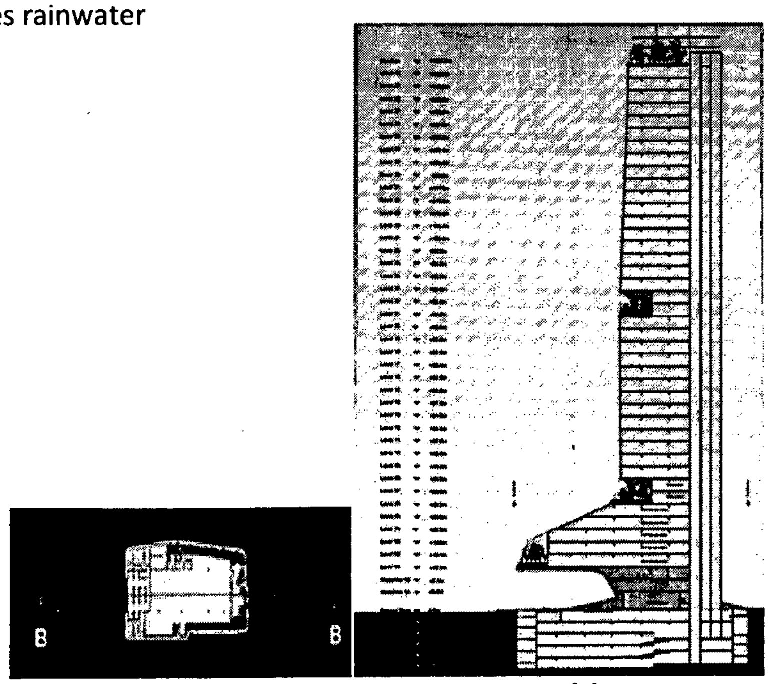



Figure 79View showing green cores of the Tower

#### 6.1.3.4 Sky Courts

- Allow interaction between nature end building occupants.
- Provide opportunities to experience the external environment and enjoy views.
- Shading for the building emergency evacuation zones.
- Areas for planting and landscaping.
- Flexible interstitial zones for future expansion.
- To provide direct experiences of the external environment on upper floors and views to outside gardens.

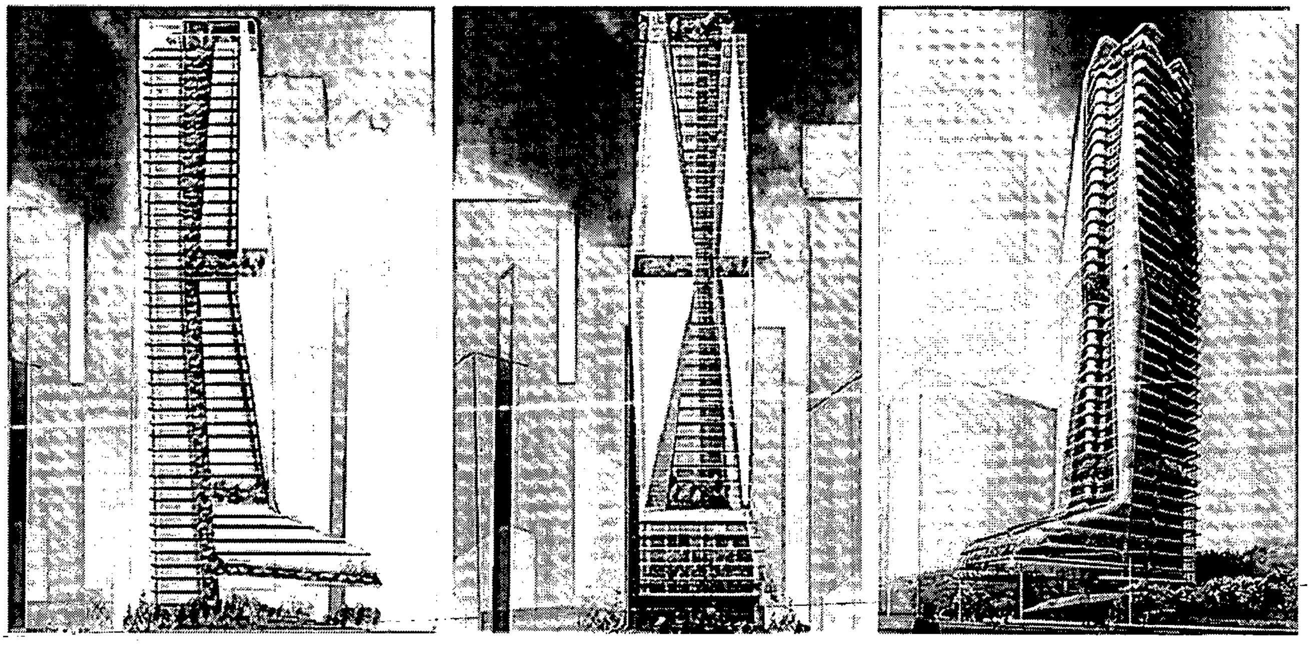


**Figure 80 Elevations showing green on the facade of the Tower**

#### 6.1.3.5 Sun Shading

- Reduces heat gain from direct sunlight, and hence the energy needed to cool the building.
- Reduces glare.

#### 6.1.3.6 Roof Garden

Vegetation on the roof helps reduce heat gain from conduction while providing a relaxing area for the community to enjoy.

#### 6.1.3.7 Wind Funnels

- Protruding walls channel wind into building core and service areas.
- Provide cross ventilation for offices.
- A sustainable natural ventilation
- Strategy with low maintenance costs.

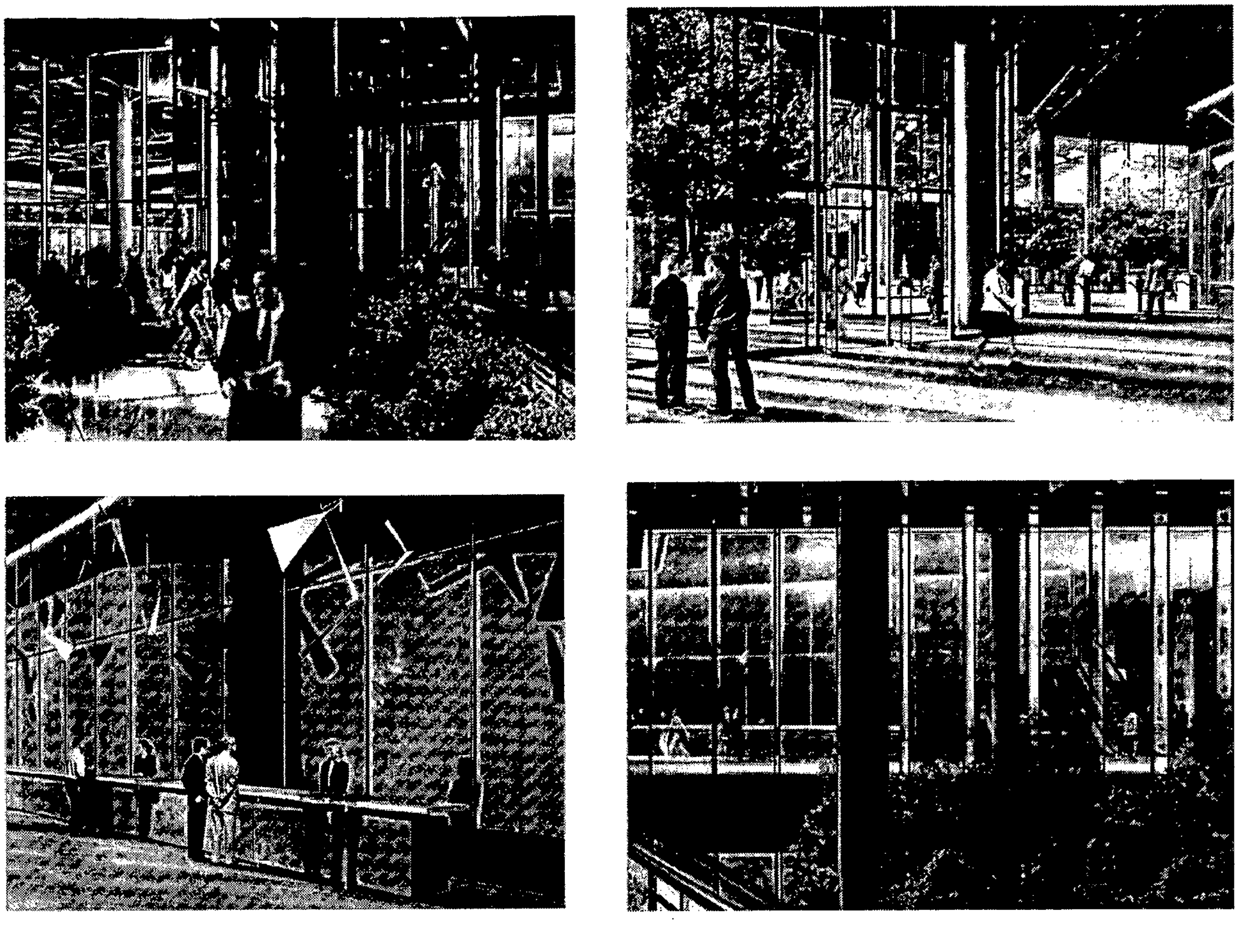


**Figure 81Internal Views of BIDV Tower**

## 6.2 Case Study (Vertical Urbanism)

### 6.2.1 TOKYO NARA TOWER

#### 6.2.1.1 Basic information

- Location- Urban site between Tokyo and Nara
- Climate Zone- Cold
- Vegetation Zone- Deciduous Forest
- No. of Storeys- 180 Storeys (approx.. 880 m)
- Areas

GFA: 448,536 $m^2$
NFA: 313,674 $m^2$

- Site Area- 22,500 m2
- Plot Ratio- 1:20

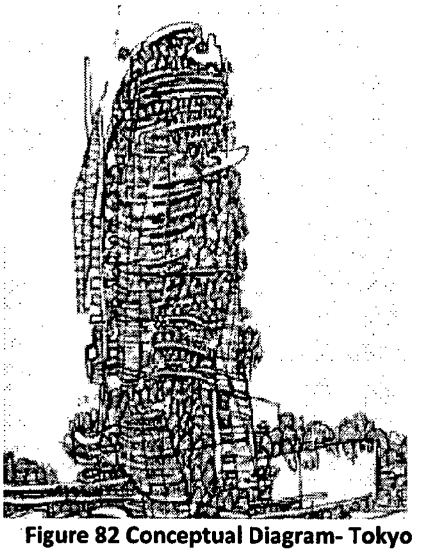


**Figure 82 Conceptual Diagram- Tokyo Nara Tower**

#### 6.2.1.2 Site plan

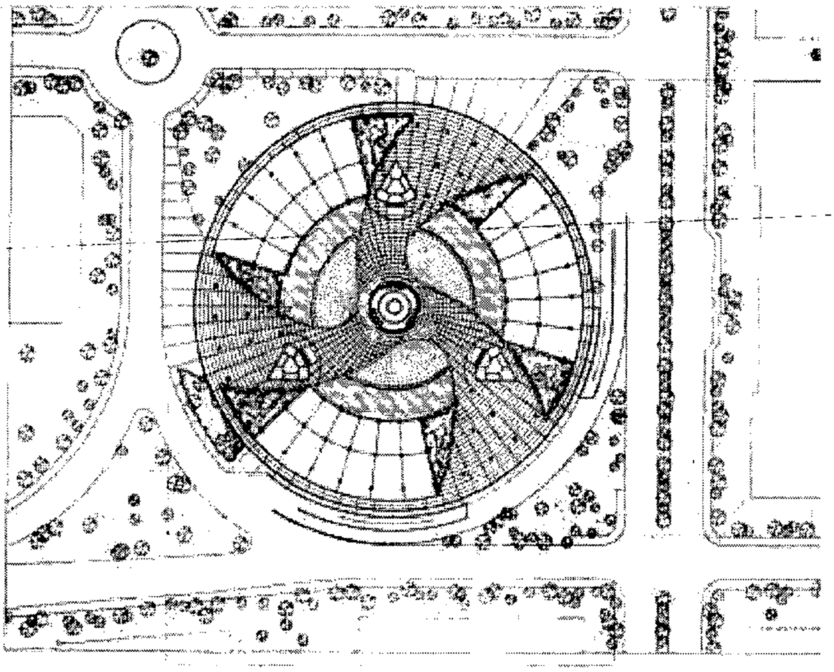
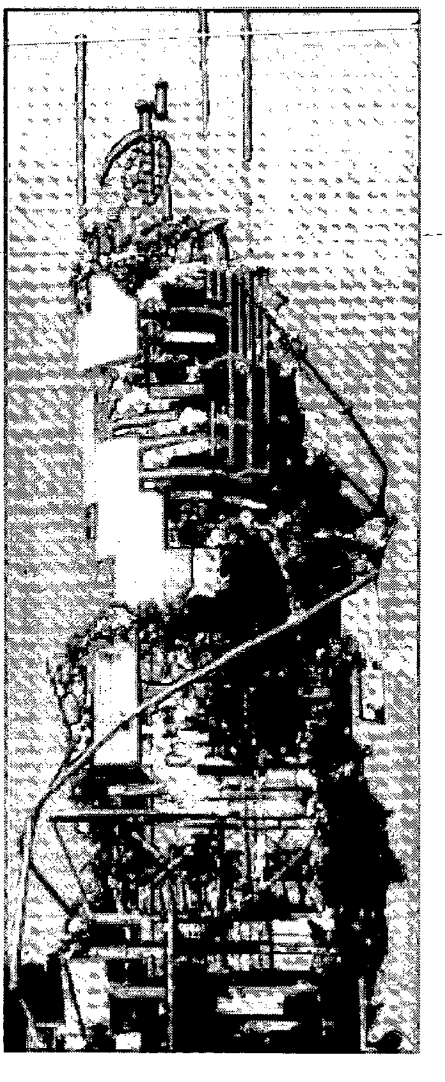


**Figure 83 Site plan**



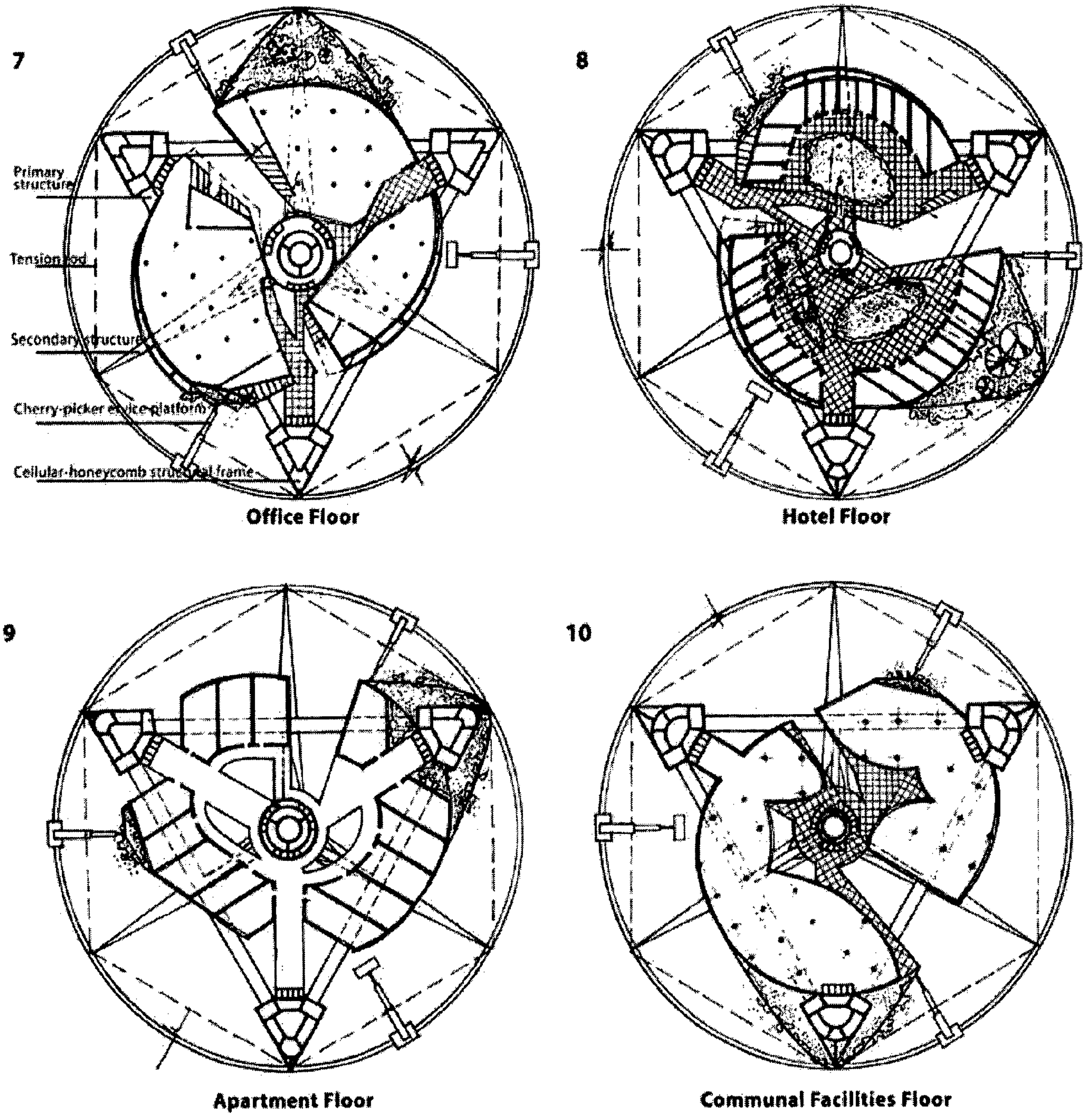


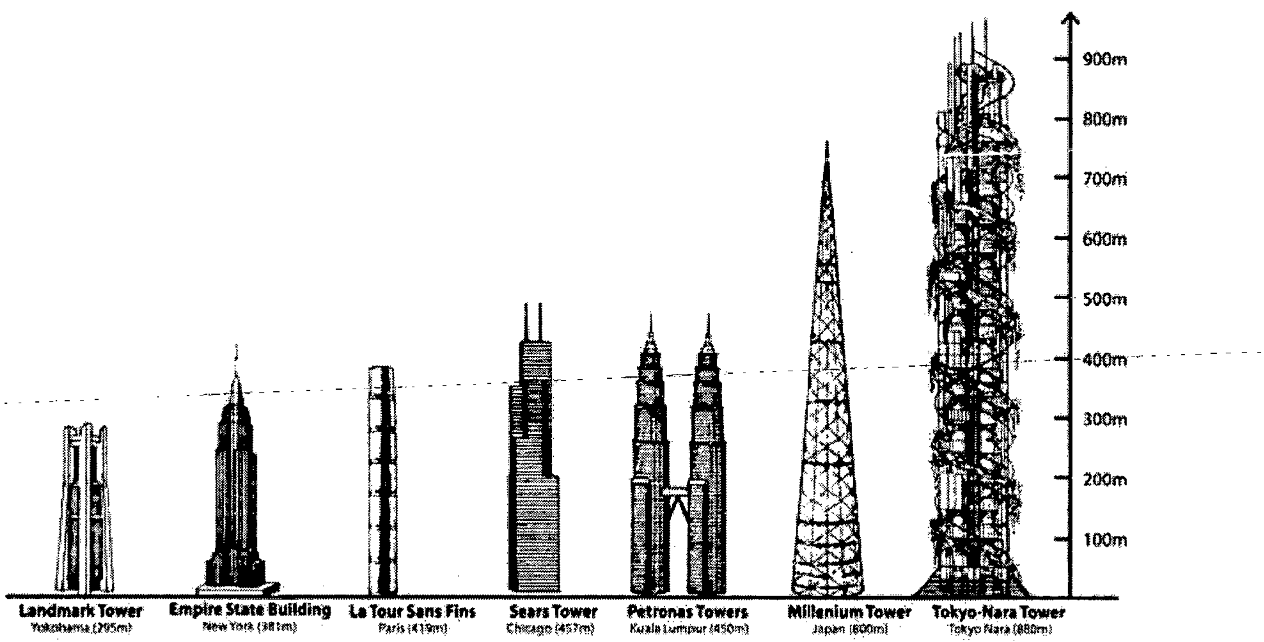

Figure 84 Floor Plans - Tokyo Nara Tower

### 6.2.1.3 Key design Feature

The tower is also described as hanging gardens of Ken Yeang-

- The tower looks like a scaly, organic skin rather a shiny, smooth corporate sheath.
- The design utilizes vertical landscaping that spirals around and throughout the tower.

- Vegetation and its careful positioning are used to cool the building as well as control air movements through strategic planting.
- The large mass planting is designed to work in tandem with the building's mechanical system supplementing their performance and reducing the energy load.
- The configuration enables daylight to penetrate into the center.
- These open terraced, vegetated spaces- which operated as the building lungs through air filtration and supply of oxygen.
- Wind flues which can be adjusted with dampers, bring fresh air deep into the building.
- The center core supports the triangular shaped floor plates which spiral up the tower, stepping up and around the core in radial fashion and leaving spaces for large atria and sky courts.




### 6.2.1.4 Cherry pickers-

The maintenance of the vertical landscaping, as well as the upkeep of external fixtures, glazing and cladding panel is ensured by specialized mechanical devices. These devices constructed in the form of multipurpose robot arms as "cherry pickers" on moveable trellises that travel along an external track that spiral and circulate the tower.

### 6.2.1.5 Radial spiral floor plates-

Floor plate creates a particular built form which allows-

- The floors to shade themselves as they spiral upwards.

- The displaced patterns to move efficiently exploit the benefits of hanging gardens; inter floor terracing, ventilation and cooling system.
- A constantly changing atrial space, articulated by terraces, internal courts and private gardens.

#### 6.2.1.6 Skycourts and green parks

Located at regular intervals the sky courts oases provide inhabitants with environmentally sound 'breaks' in the built structure.

The green park suspended high above the city would benefit from fresh air and be constantly maintained as a part of the buildings own system, they would act as lung's system, breathing life into the floors above and below via the atrial voids.

#### 6.2.1.7 Atrial spaces

The atrial spaces are the arterial routes by which floors interacts, terraces and courts looking down on each other fed by channels of through flowing air and semi communal areas. The atrial network bridged by walkways and flanked by stairwells constitute a microcosm of activity within the tower ( while open to environment) and insulated from the city.

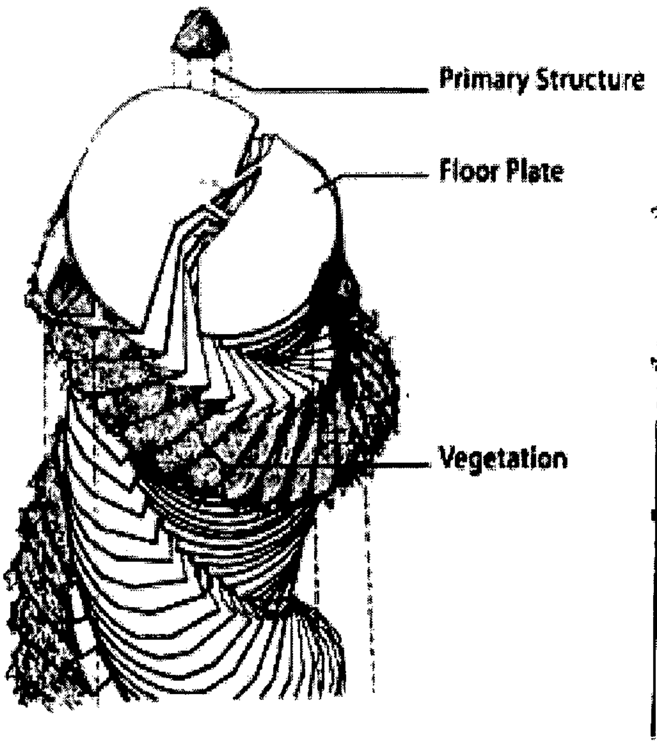



Figure 85 Stepped Planters accommodating Greenery on the facade

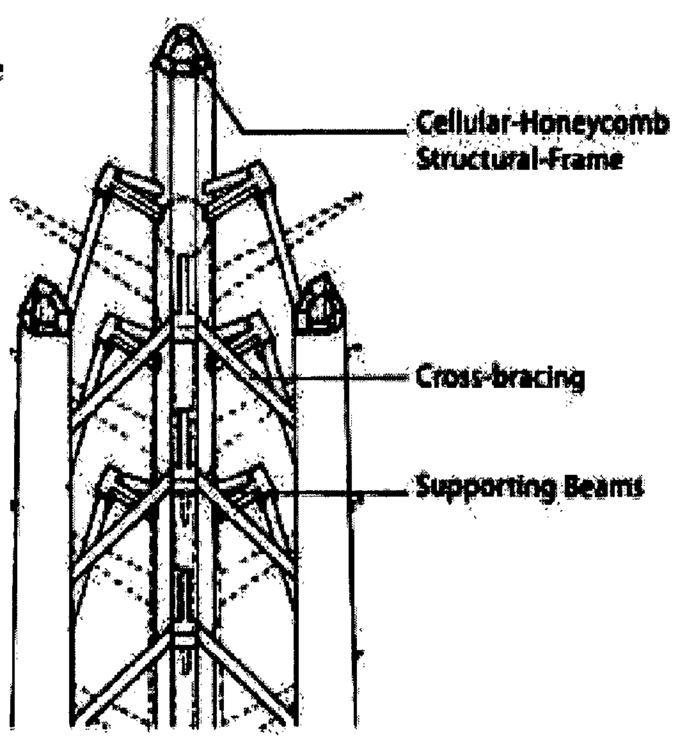



Figure 86 Structural elements used in Tokyo Nara Tower

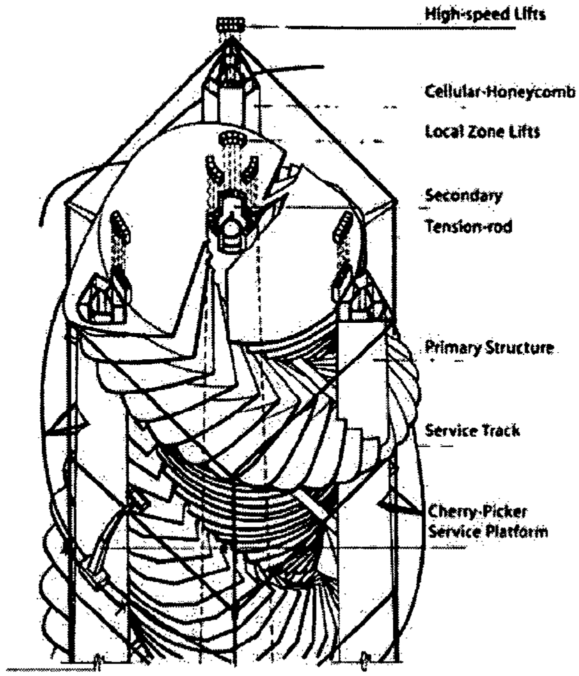
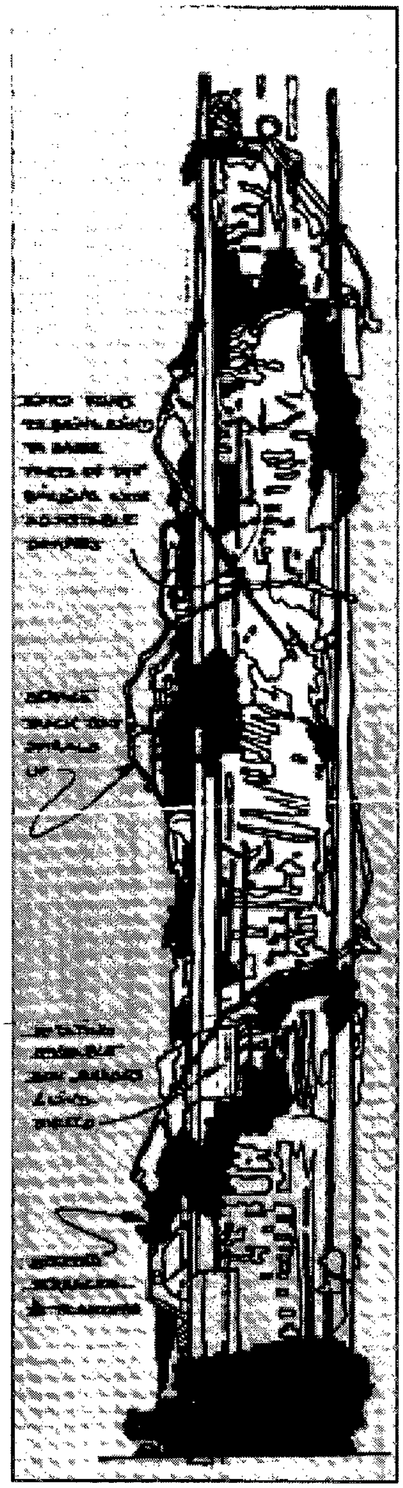



Figure 87 Floor Plates & Structure - BATC TOWER



## 6.2.2 BATC TOWER

### 6.2.2.1 Basic information

- Location- Germany
- Climate Zone- Cold
- Vegetation Zone- Alpine
- No. of Storeys-

60 storey signature tower

Five 30 storey office tower

- Areas

GFA: 708,178m$^2$

NFA: 530,669m$^2$

- Site Area- 167,286 m$^2$
- Plot Ratio- 1:4

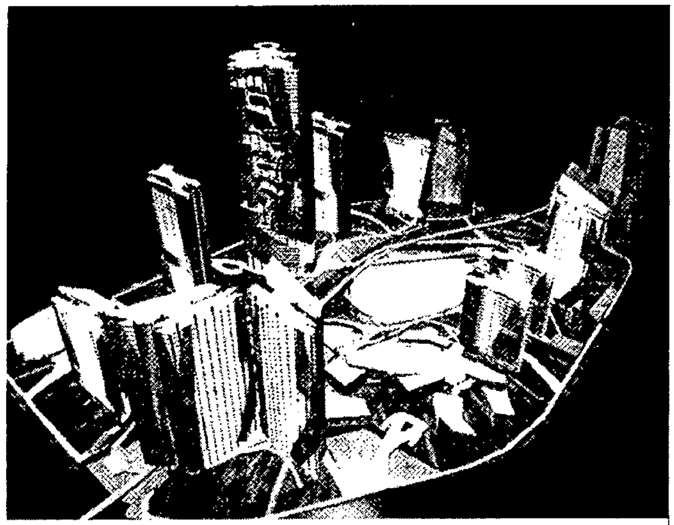


**Figure 88 Concept Diagram- BATC Tower**

### 6.2.2.2 Site plan

**Figure 90 Elevations showing green on the facade- BATC Tower**

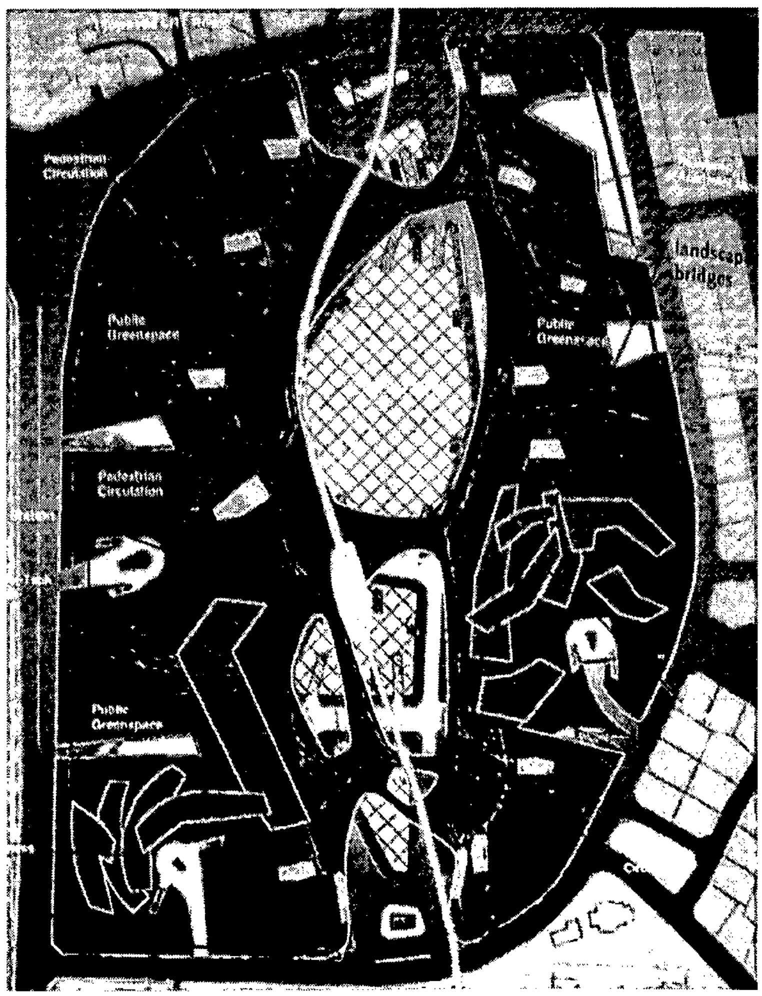



**Figure 89 Site Plan - BATC TOWER**

#### 6.2.2.3 Site detail

- High tech office park, convention & exposition centers; a multimedia and IT college, mega theme mall for retail, major outdoor public spaces with cultural uses, residential accommodation for students, post graduates and academic researchers; a four star hotel for visitors, tourist and local residents with business centers and facilities; a public park and a boulevard that runs throughout the development project.
- The central theme is that of a landscaped setting and a sheltered traffic free environment.
- The central spine of the project running north to south, is essentially surrounded by the major higher forms, that include the BATC Tower on the western side.

#### 6.2.2.4 Design features

- The scheme consist of a 47 acre landscape park within which buildings are set and serviced by a central series of public plaza, boulevard walkways and a car access routes, the LRT System is integrated into the site with a centralized station at the junction between the retail, commercial and university facilities.
- The building brings together the principles of the bioclimatic approach to the design of tall buildings and urban design developed over the previous decade by the firm
- Landscaping is applied to the entire development; the building is accessed via the landscaped ground plane of the site. Water gardens and soft landscaping enhance the pedestrian routes throughout the site.
- All areas within the site are linked by an integrated pedestrian transport system. Providing shaded car free access to all facilities within the site.
- Landscaped and terraced sky courts have been incorporated at the floors of the office towers providing building occupants the opportunity to relax in the pleasant surroundings to maintain connectivity between floors; these sky courts form a continuous vertical link, both visually and physically threading together all storey's.
- Integrated building management system control building internal conditions by monitoring the immediate (external) surroundings through a series of environment sensors located on the roof.

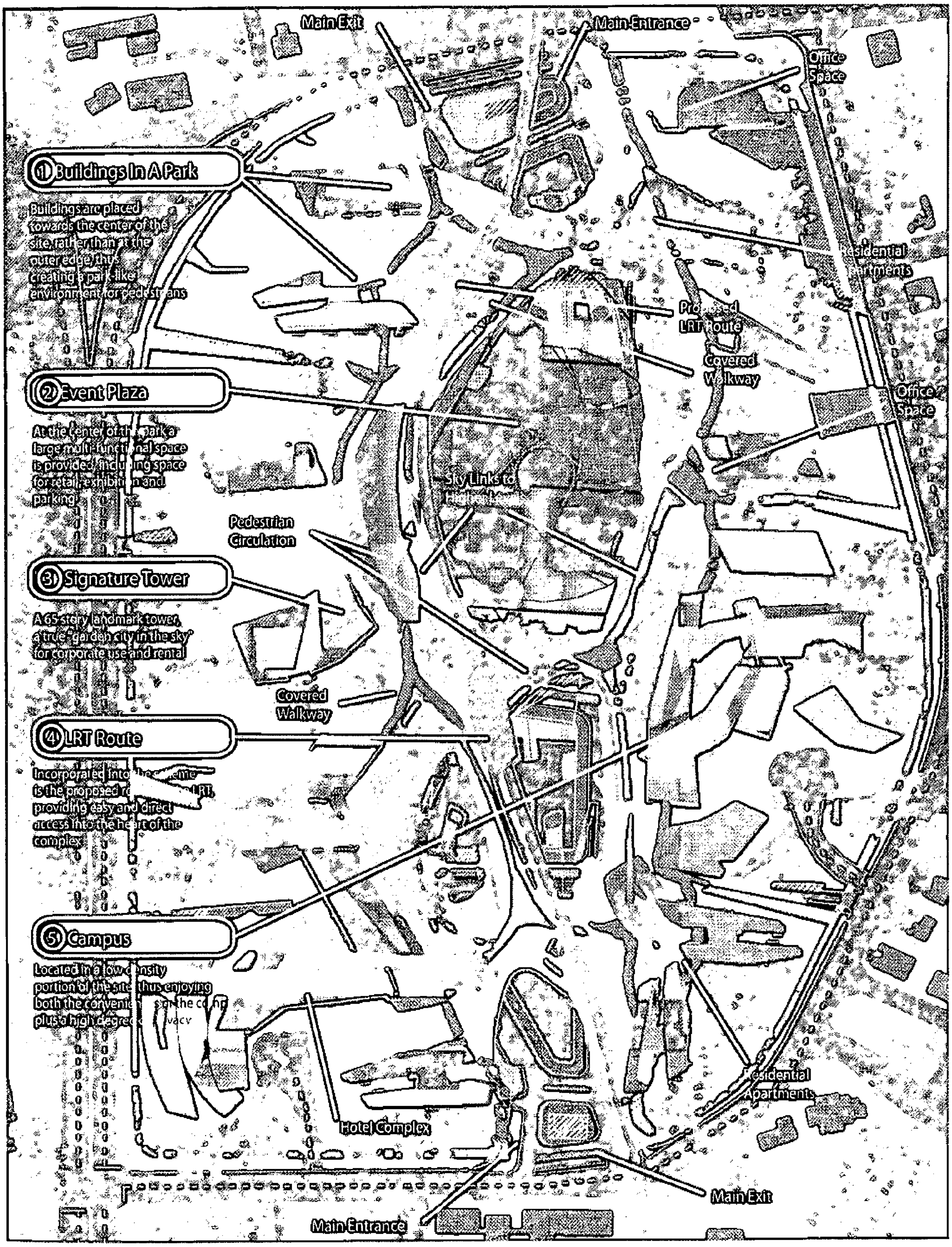



**Figure 91- Masterplan showing key features, including rapid transit line**

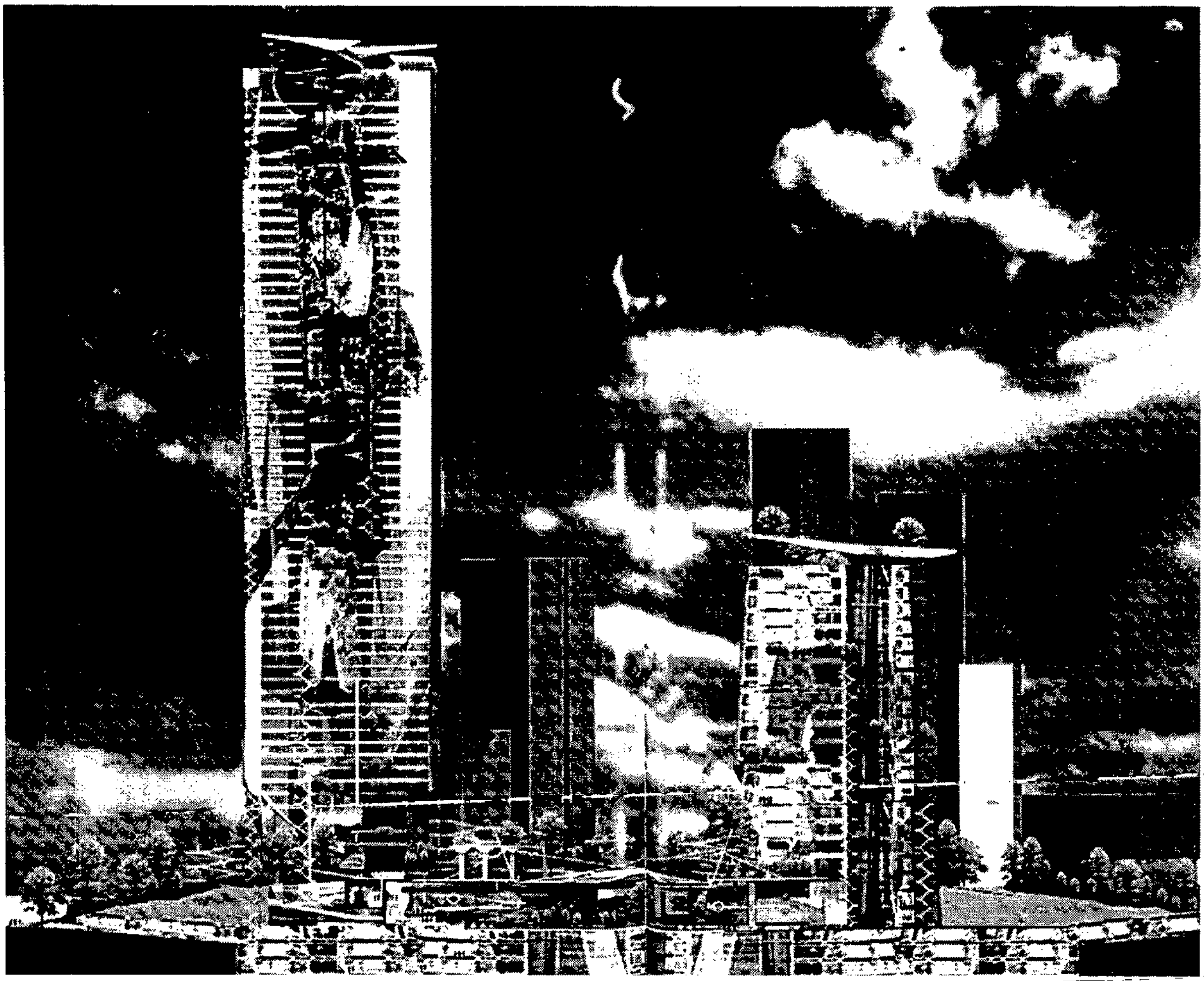


Figure 92- Site section BATC TOWER

### 6.2.2.5 Signature tower details (60 storey)

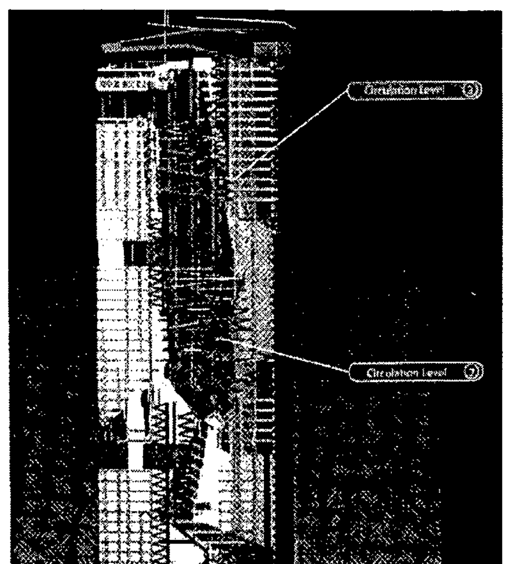



Figure 93- Multiple circulation system

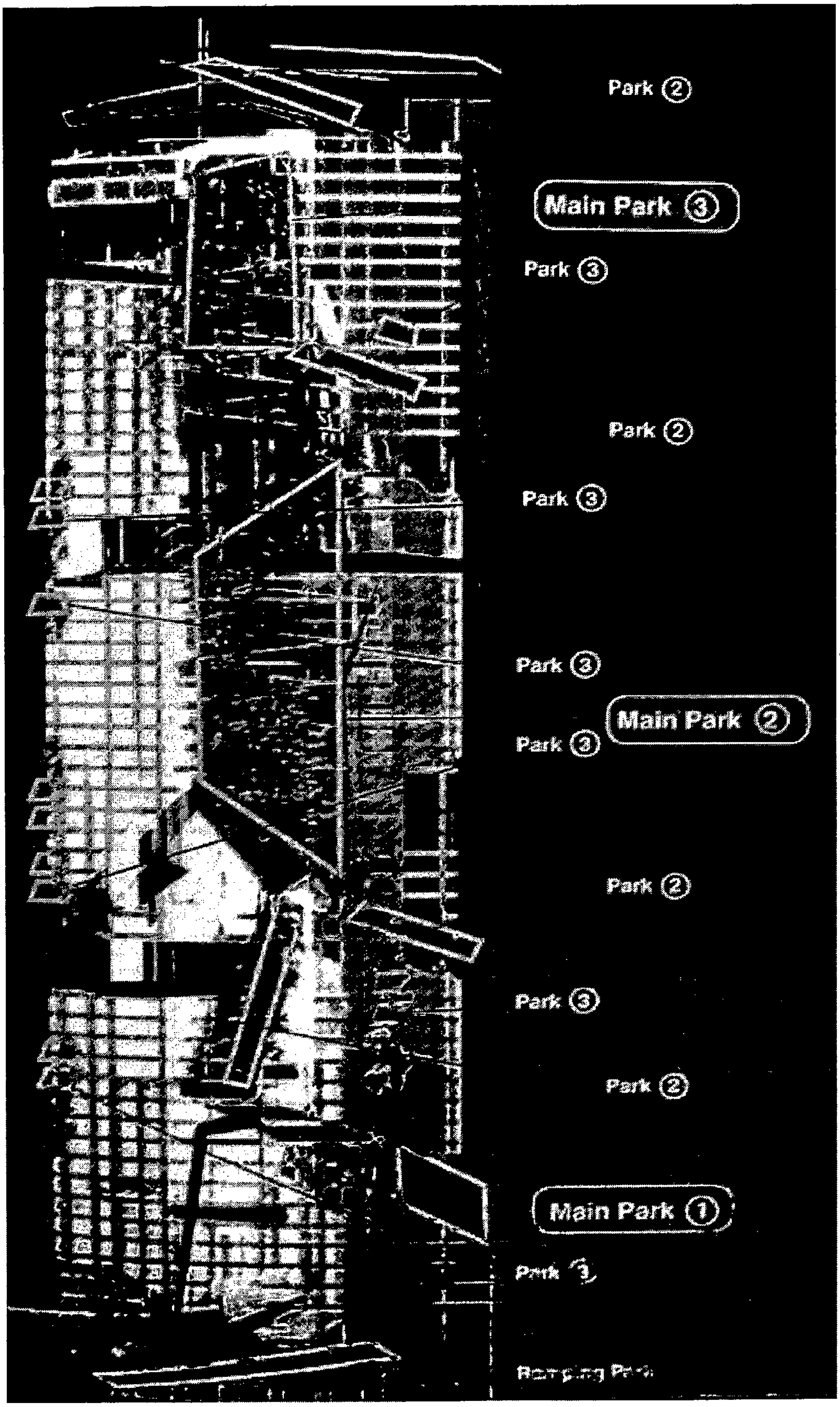



**Figure 94- Hierarchy of park systems**

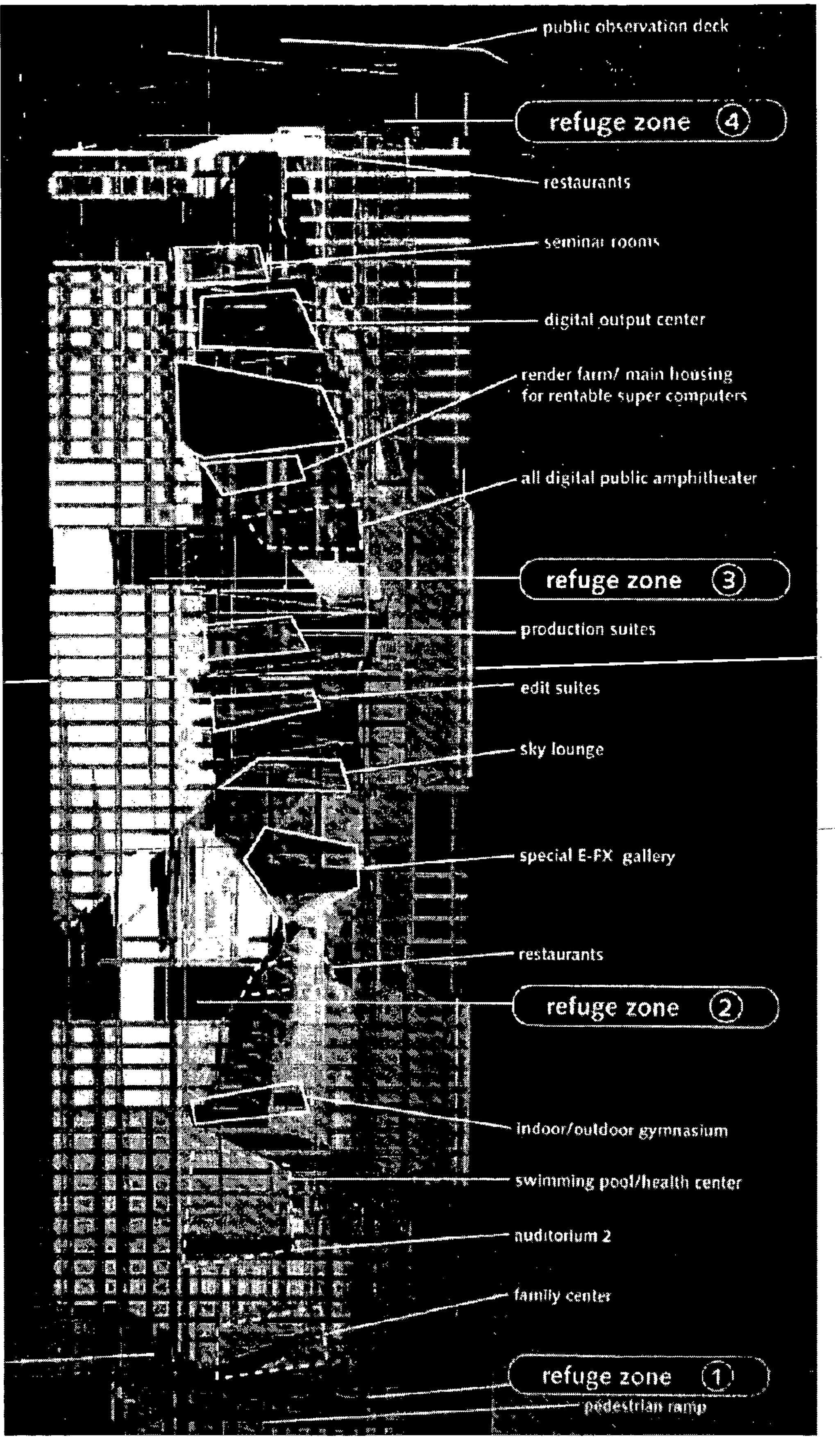



**Figure 95- Vertical building programme**

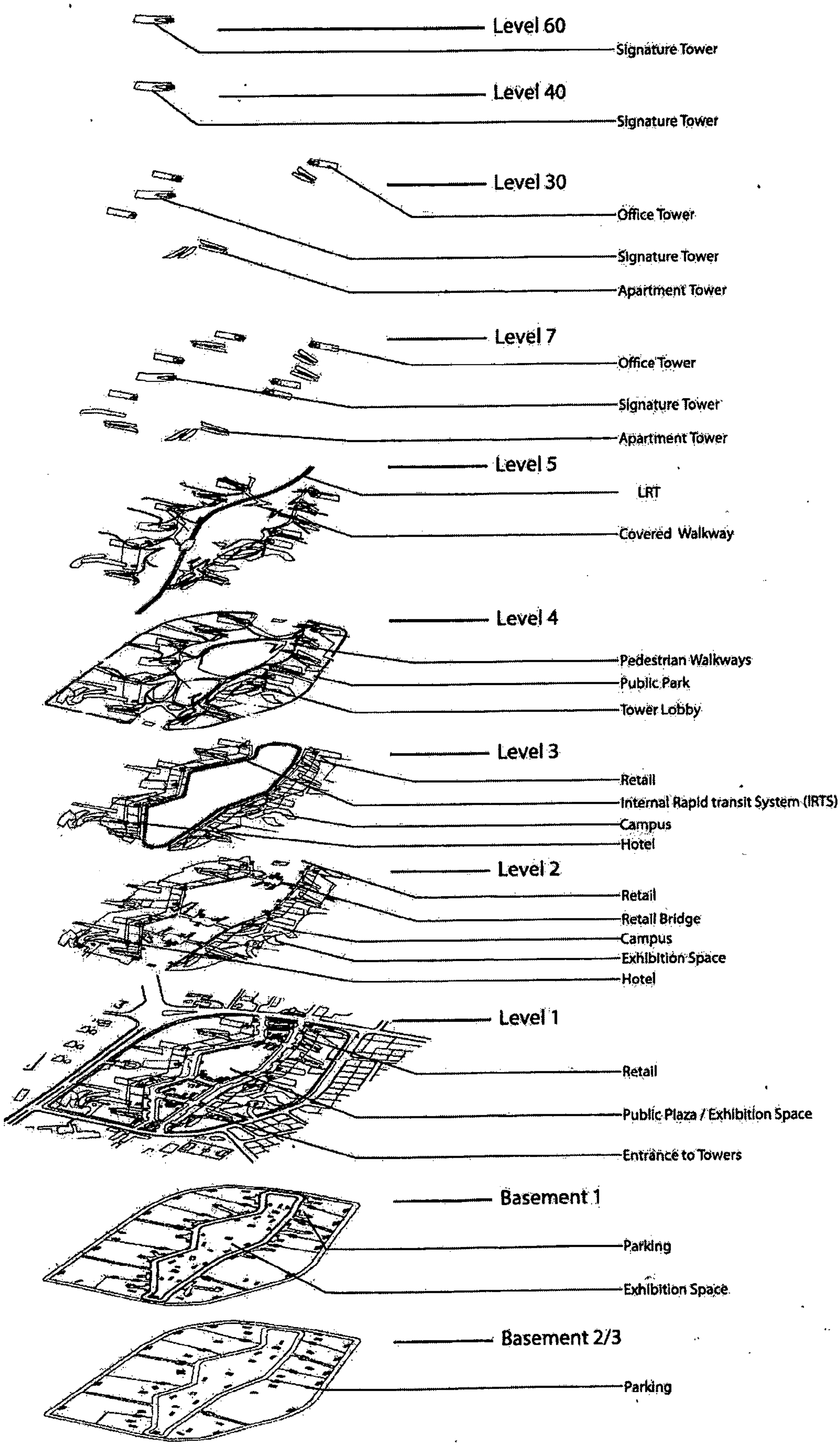



**Figure 96- Axonometric Floor Plans Diagram**

# Chapter 7 Design Development Theory

## 7.1 Ken Yeang Design Theories

### 7.1.1 Introduction

Ken yeang is an ecologist architect who had evolve many theories for designing green buildings. He is one of the leading thinker, theoretician and ecodesigner in the field of ecological sustainable vertical developments. He did his architecture at Architectural Association in London and practicing on green agenda with his doctoral programme on ecological design and planning in 1970's. in 1972 he registered professionally as architect and from that time to now he completed about dozen of high rise buildings and bioclimatic towers, a hundred of projects which involve mixed use development, hotel, retail, complexes and offices. He had done many dwellings, interior design space, ecocity, eco masterplan. He is expert in adding ecology in the vertical developments with the help of landscaped elements. He worked on many projects which go beyond the rating systems like LEED, BREEAM etc.

### 7.1.2 Theories

According to Ken Yeang ecological design concerns much more than just low energy buildings or the reduction of carbon of carbon emissions and water use; he finds it especially painful that a lifetime establishing a coherent theory can become confused with the practice of adding high gadgetry to an otherwise standard structure. To Yeang ecoarchitecture cannot be reduced to a list of techniques; it is 'totally a new way of thinking'.

Gadgets and technology like- Photovoltaic cells, Biological recycling systems, solar collectors and solar panels etc may help in reducing energy consumption of a built mass but these gadgets are not able to produce real ecodesigns, even the low energy building which is designed by taking help of gadgetries can be an ecological end product but somewhere it is merely a lifeless structure without green spaces.

| **Taxonomy of Sites** | |
|---|---|
| Ecologically mature | Pristine ecosystem |
| Ecologically immature | Partially affected |
| Mixed artificial | Landscape park |
| Mono culture | Agricultural land |
| Zero culture | Urban locality |
| Contaminated | Brownfield site |

Yeang says "The objective of Ecodesign is a benign and seamless bio integration with the environment". The word "benign" means building projects should not just minimize their impact on the biosphere but also leads to positive outcome (as against minimal impacts). They should be so integral with the biosphere, that it would barely register their presence.

| **Ecosystem Hierarchy** | **Site data Requirements** | **Design Strategy** |
|---|---|---|
| Ecologically-Mature | Complete Ecosystem Analysis and Mapping | Preserve<br>Conserve<br>Develop only on no-impact areas |
| Ecologically-Immature | Complete Ecosystem Analysis and Mapping | Preserve<br>Conserve<br>Develop only on least-impact areas |
| Ecologically-Simplified | Complete Ecosystem Analysis and Mapping | Preserve<br>Conserve<br>Increase biodiversity<br>Develop only on low-impact areas |
| Mixed-Artificial | Partial Ecosystem Analysis and Mapping | Increase biodiversity<br>Develop on low-impact areas |
| Monoculture | Partial Ecosystem Analysis and Mapping | Increase biodiversity<br>Develop in areas of non-productive potential<br>Rehabilitate ecosystem |
| Zeroculture | Mapping of remaining ecosystem components (e.g. hydrology, remaining trees, etc.) | Increase biodiversity and organic mass<br>Rehabilitate ecosystem |

### 7.1.2.1 Four Strands of Ecoinfrastructure

By the early 2000 yeang had begun to consider green design as designing "ecoinfrastructure a term which came to be considered as embracing four distinct armatures" or dimensions within the overall coherent systems. This color coded system set ecological consideration into clear categories.

**The Green ecoinfrastructure**

Green ecoinfrastructure plays a crucial role in every design and master plan. This green ecoinfrastructure consists of the chain of interconnected natural areas and open green spaces , clean air, water, biodiversity balancing etc. clearly any green ecoinfrastructure enhance the quality and function of landscape.

**The Grey ecoinfrastructure**

This consists of urban engineering infrastructure such as sewerage, roads, drain, water reticulations, telecommunications and electric power distribution system. The system used under this should be low embodied energy and carbon neutral systems as much as possible.

**The blue ecoinfrastructure**

In blue ecoinfrastructure the water cycle should be managed to close the loop, the rainfall needs to be harvested and used water to be recycled. The surface water from rain needs to be retained within the site and returned to the land for recharging of ground water. System used under this is as follows- bio swales, water efficient fixtures, retention ponds etc.

**The Red human ecoinfrastructure**

This human ecoinfrastructure comprises of human community, its built masses like- buildings, houses, hardscapes and regulatory systems (laws, regulations, ethics etc.). This comprises of social and human dimensions that is often missing in the work of many green designers.

### 7.1.2.2 Designing OoperationalSsystem's

To achieve internal comfort zone within the tall structure, we need to exploit low energy designs, Ken Yeang divides the operational systems which he used to create sustainable development into five modes-

1. Passive mode
2. Mixed mode
3. Full mode

4. Productive mode
5. Composite mode

For designing any built mass which consume low energy in comparison to convention building first we will go for passive mode if it is not able to achieve comfort zone then progressively design can be done by using full mode then productive mode and finally composite mode, selection of mode can be done according to the need of the user, site and type of building

Building can be designed by keeping in view the location and climate of the site, latitude indicates the variation in climate and season even within a given latitude there is wide variations which depends upon whether the site lies on waterfront, it's altitude above sea level or it is an inland site.

Contemporary expectations to meet comfort zone cannot be achieved by designing passive mode or mixed mode.

To achieve internal comfort zone inside the building, external sources are required as in full mode. Full mode use electromechanical system.

## Passive mode

Passive mode helps in improving internal comfort zone without using any electromechanical device Examples of passive modes strategies include appropriate facade design (solid to glazed area ratio), building configurations and orientation in relation to the local climate, suitable thermal insulation level, use of vegetation, use of natural ventilation etc.

The basic design is start with bioclimatic design or passive mode in energy sustainable buildings, passive mode is highly influenced by the openings, voids, mass, direction of the building. This is considered as first level of design after this other modes can be adopted. these designs cannot be achieved without understanding climatic conditions of the locality.

## Mixed mode& Full mode

Mixed mode is a mode in which few electromechanical systems are being used by the designers to achieve comfort zone for example includes flue atriums, ceiling fans and evaporative cooling whereas in full mode building is totally dependent upon the electromechanical devices as in many conventional buildings. This system is generally used where the occupants of the building insists for having consistent comfort condition throughout the year.

Passive mode or mixed modes can never comptete with the comfort levels of the high energy full mode conditions.

### Productive & Composite mode

The system which produces its own energy is productive mode (such as solar energy using photovoltaic systems or wind energy). Ecosystem changes solar energy into chemical energy by photosynthesis, design should be ecomimetec exhibits the properties of nature.

In productive mode hi-tech and sophisticated quality system are used because these system increase the inorganic mass and use of natural resources of the built structure.

### Composite mode

Composite of all modes like passive, mixed, full and productive is composite mode .This system can be changed according to the variations in season all around the year .

| Modes | Internal systems | Examples |
|---|---|---|
| Passive mode | No M&E systems | Native dwellings |
| Mixed mode | Partial M&E systems | Double skin facades |
| Full mode | Full M&E systems | Conventional buildings |
| Productive mode | Productive M&E systems | Photovoltaic |
| Composite mode | Composite M&E systems | Composite of the above |

## 7.1.2.3 Ken Yeang's Set of Design Strategies

Ken Yeang underpins this four part ecoinfrastructure system with a further four definitions of what green design should aspire:

### Seamless and Benign Biointegration

Green design should be considered as bio integration physical systematic and temporal. Yeang sees the work of architects as similar to the surgeons who applied an artificial prosthesis to an organic host, i.e. human body; Yeang sees the built environment as a collection of prosthesis requiring bio integration with the host organism, i.e. the ecosystems present within the biosphere. Bio integration can be done at three levels: physical, systematic and temporal.

a) **Physical**: Existent features and ecology of the environment.

b) **Systematic:** Ecosystemic and biospheric processes.

c) **Temporal:** Conservation of resources.

| INTERACTIONS | SYMBOL | DESCRIPTION |
|---|---|---|
| The external interdependencies of the designed system (it's external relations) | L22 | This refers to the totality of the ecological processes of the surrounding ecosystems, which intersect with other ecosystems within the biosphere and the totality of their earth's resources. It also includes the slow biospheric processes involved in the formation of fossil fuels and other non-renewable resources. These may influence the built environments functioning and are in turn also influenced by the built environment. These elements can be altered, depleted or added by the built environment. |
| The internal interdependencies of the designed system (it's internal relations) | L11 | This refers to the sum of the activities and actions which are associated with the built environment and its users. They include the operational functions of the built environment and directly affects the ecosystem of the location in which they takes place spatially and the ecosystem elsewhere (systematically), as well the earth's resources. These can be considered in the pattern of a lifecycle of the built environment. |
| The external/internal exchanges of energy and matter( the system's inputs) | L21 | This refers to the total input into the built environment. These consist of both the stock and the flow components of the built environment. The efforts taken to obtain these inputs from the earth's resources often result in considerable consequences to the ecosystems. |
| The internal/external exchanges of energy and matter (the system's outputs). | L12 | This refers to the total outputs of energy and matter that are discharged from the built environment into the ecosystems and to the earth. These outputs if not assimilated by the ecosystem result in environmental impairment. |

## Ecodesign as means to restoreimpairedenvironments

Ecodesign can be regarded not only as the creation of new, artificial "living" urban ecosystems or rehabilitation of existing built environments and cities, but also a strategy for restoring existing devastated ecosystems. Ecodesign must look beyond the limitations of the site and context of the locality. Where needed we should improve the ecological linkages between our designed systems not just horizontally but also vertically.

Green design involves the conservation of non-renewable and care of renewable resources to ensure that they remain sustainably available for future generations. This includes designing environments that are less dependent on non-renewable resources.

**Ecomimesis**

Green design is ecomimetec, i.e. imitating the properties of ecosystem. Yeang third design strategy is to encourage designers to imitate the properties, processes, structure, features and functions of nature leading to the idea of human built environment as an ecocyborg.

Ecodesign insists the architects to use eco or green materials and components which also facilitates in reuse, recycling and reintegration.

**Ecodesign as a self-monitoring system**

Green design monitoring and reacting to ecological interactions over the life span of built systems. This strategy includes the study of human impact and environmental devastation as well as natural disasters. It assumes a sense of ecological stewardship and an aim for environmental stability

## 7.2 Vidhur Bhardwaj Design Development Theory

### 7.2.1 Introduction

The driving force of GREEN ARCHITECTURE, Vidur Bharadwaj initiates green design and sustainable buildings in Delhi and NCR.He focused on ecological features to achieve sustainability in his building rather than designing fully electromechanical building as most of the architects done to achieve comfort zone in their design . he is designated as IGBC Chairman of delhi chapter. He also works for Hong Kong development group, he advised in relation to the "Sustainable Architecture in Urban Cities". He is the only architect in the world who designed THREE PLATINUM & FOUR GOLD rated LEED (Leadership in Energy and Environmental Design) certified Green Buildings under the USGBC (United States Green Building Council). In 2005, he was awarded by the President of India - Dr. A.P.J. Abdul Kalam for developing Wipro Technologies, Gurgaon,the world's largest environment friendly Platinum rated LEED building.

### 7.2.2 Design theories

**Design & Architecture**

Green designs comprises of landscaping green wall, terrace gardens, roof gardens, areas to plant, shades areas and use of local species .

**Conservation of Water**

Waste water from toilets and kitchen can be used for irrigation of the landscaping after treatment. Automatic fixtures which use minimal water flushing should be chosen to save water.

## Use of solar/wind energy

He used electric daylight to supplement the electricity grid power in his designs.to minimize the usage of electricity, CFL and LED lights are being used by him.

## Solar water heating

Fully programmable Solar hybrid water heating system, save at least 7.2 units/flat/day for an average of 300 days.

## Sewage &garbage processing

Physical and biological treatment systems are exploited for sewage treatment, root zone cleaning and wetland species are used for waste water treatment.

Green measures adopted by the recently constructed green buildings includes-

- Preservation and reuse of fertile top soil.
- Maximum use of natural day lighting.
- Ventilation
- roof garden to reduce heat gain impact
- water recycling for irrigation
- Air conditioning treatment of waste water.
- Use of energy efficient air conditioning systems.
- Handling of construction waste, use of materials with recycles content.
- Sealants and adhesives with low voltaic organic compound.
- Emphasize on renewable sources like sunlight (through passive solar, active solar and photo-voltaic techniques) and plants & trees (through green roofs and rain gardens) and reduction of rainwater runoff.
- Use of innovative concepts like a courtyard as a microclimate generator, a sunken courts and fins to allow maximum natural daylight entering the basement, use of grass pebbles and grass pavers light well to produce aesthetic language.
  double glaze window to reduce greenhouse effect, water harvesting, green roof.
- Terrace garden at different level to reduce the solar gain of the building.
- Channeling the direction of sunlight and wind reduce the solar gain.

# Chapter 8 Analysis of Design Methodology

## 8.1 Design Methodology

Everyone has its own way of approaching towards the final destination, in this age of technology it is difficult to work because we have thousands of option to deal with a single problem, so to deliver a reliable design we need a specific or defined set of statements or formal specifications to meet all requirements.

Design methodologies adopted in conventional buildings are mainly focuses on requirements, forms, aesthetics and function of the building. But now day's parameters are slightly shifted towards energy conservation, ecological sustainability, efficient building systems to cut down the e energy demand, renewable sources of energy etc.

### 8.1.1 Conventional Design Methodology

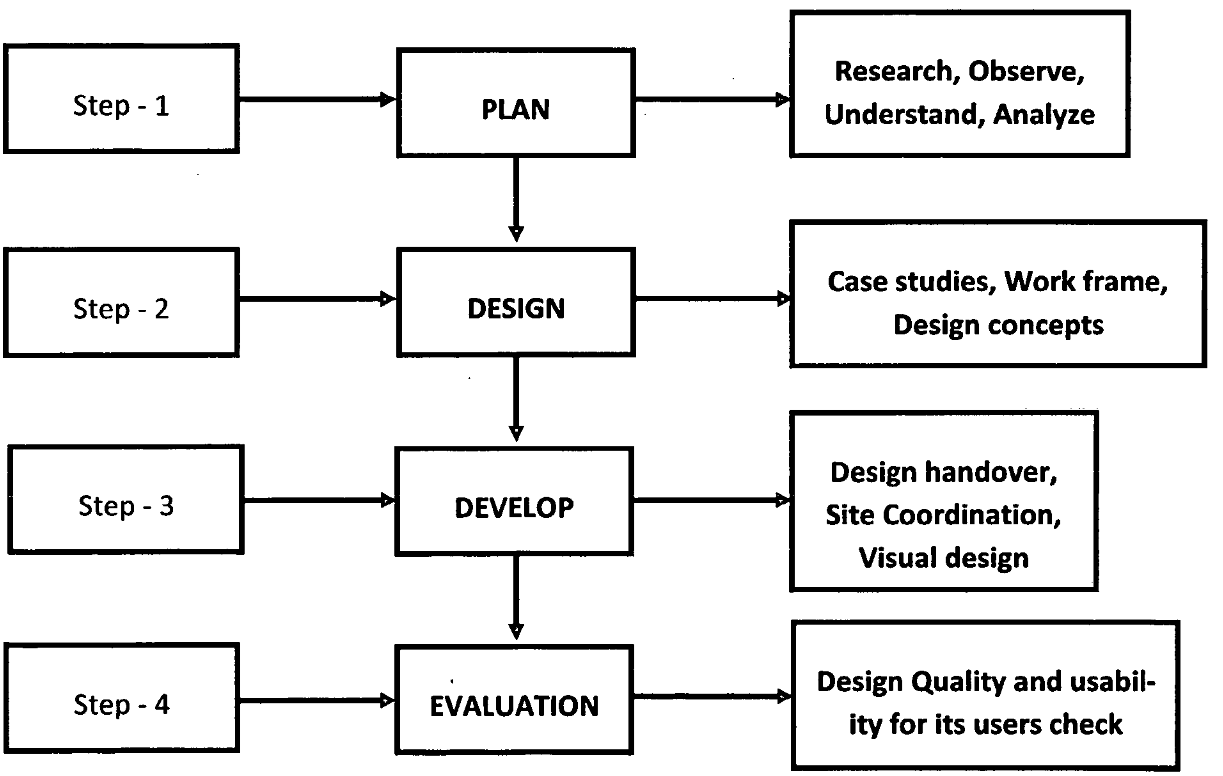



**Figure 97 Design Methodology for Conventional Building**

### 8.1.2 Sustainable Design Methodology

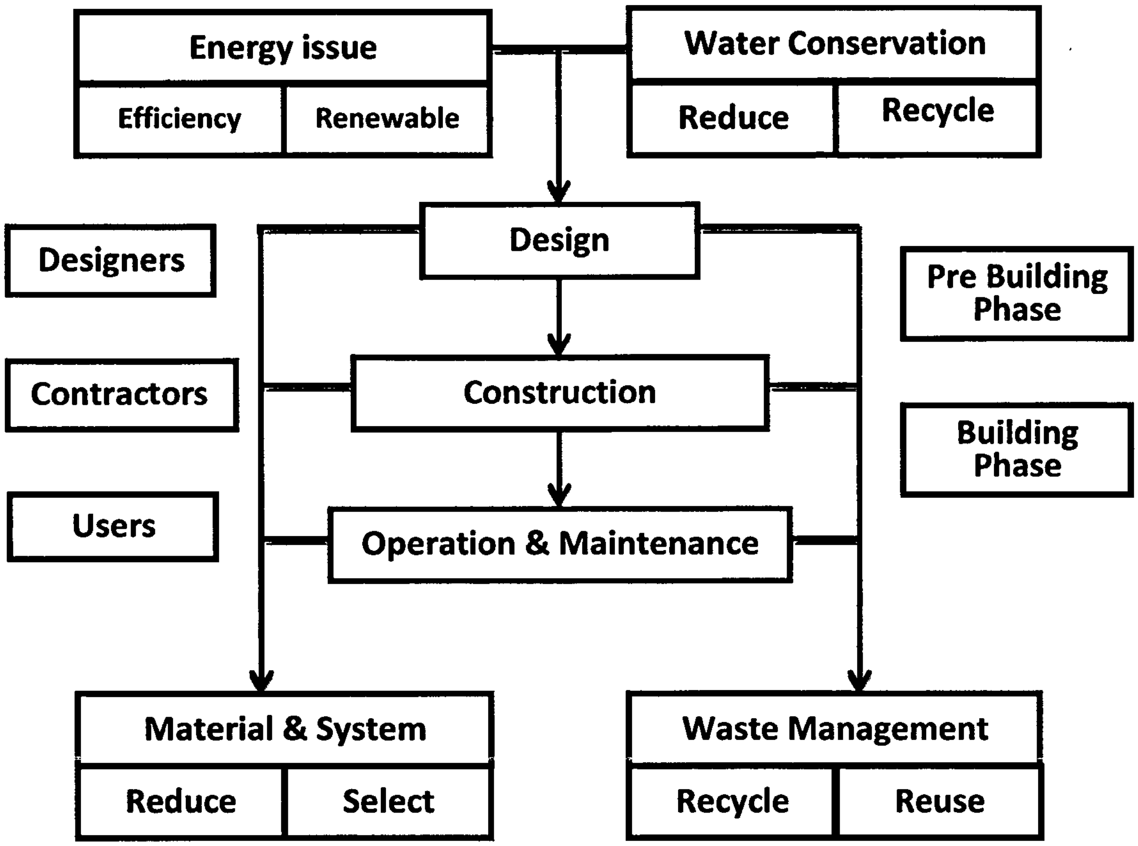



**Figure 98 Design Methodology for Sustainable Building**

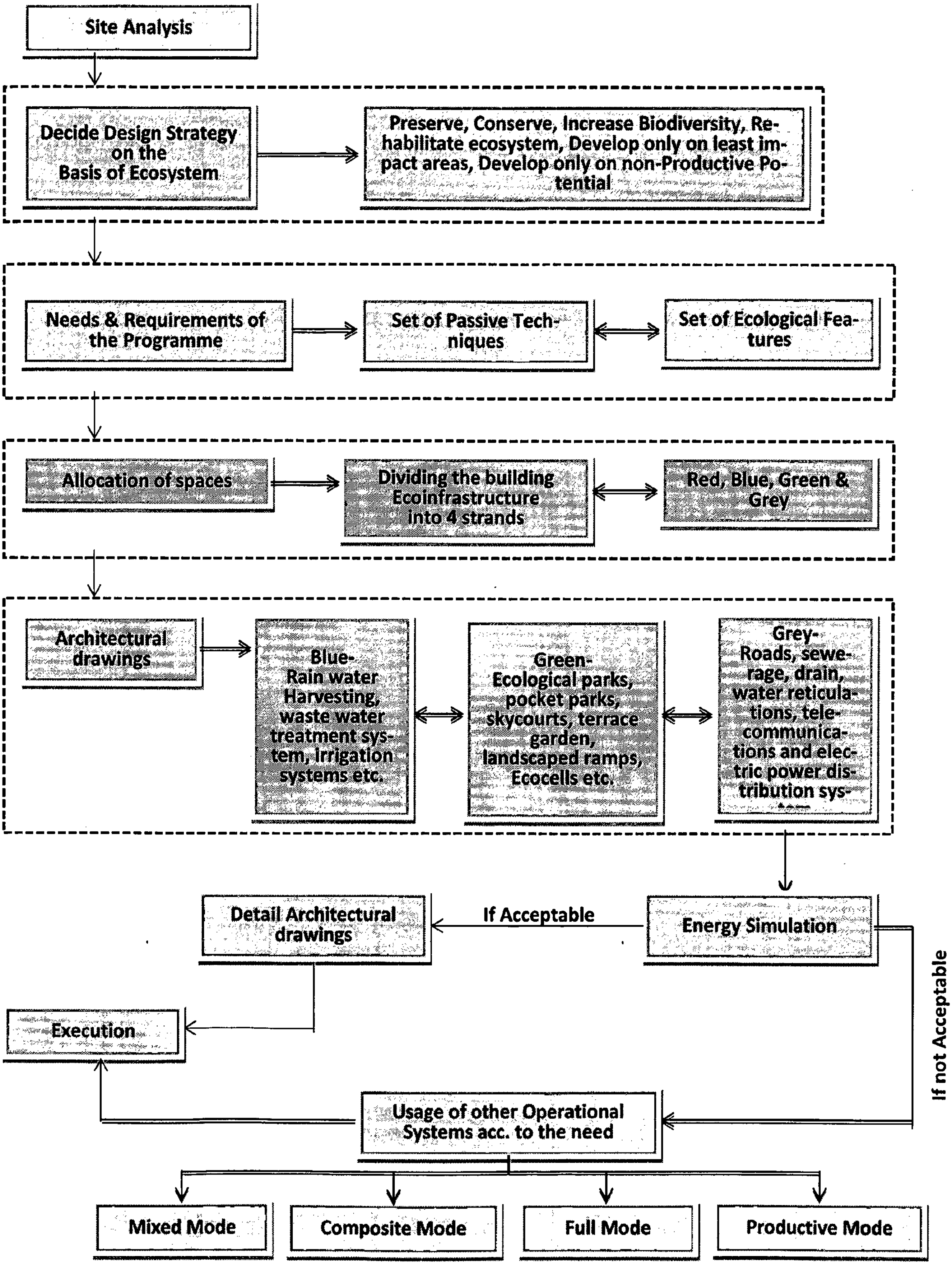
Design Methodology for sustainable buildings focused on conservation of energy and water in every phase it may be design, construction, operation or maintenance.

We studied various design processes of architects and their approach of designing a building by using active & passive techniques here in this chapter those processes are analyzed and converted into a defined methodology

## 8.2 Ken Yeang Design Methodology

According to the Ken Yeang buildingshould as an ecosystem , he developed the passive low energy design of high rise buildings using a process known as bioclimatic design. His design approaches is based on "Ecomimesis" which means designing a building that imitate the structure, properties and processes of the ecosystems.

The design features of his projects are bold and blended with nature in such a way that nature would hardly notice their presence. His methodology weaves Social, urban and ecological concerns into a single integrated system that also works as visual icon for sustainable living. This integrated system consist of vertical gardens, air purification system, irrigation system, natural ventilation, and a place of interaction and relaxation for the occupants.


Site Analysis
Decide Design Strategy on the Basis of Ecosystem
Preserve, Conserve, Increase Biodiversity, Rehabilitate ecosystem, Develop only on least impact areas, Develop only on non-Productive Potential
Needs & Requirements of the Programme
Set of Passive Techniques
Set of Ecological Features
Allocation of spaces
Dividing the building Ecoinfrastructure into 4 strands
Red, Blue, Green & Grey
Architectural drawings
Blue- Rain water Harvesting, waste water treatment system, irrigation systems etc.
Green- Ecological parks, pocket parks, skycourts, terrace garden, landscaped ramps, Ecocells etc.
Grey- Roads, sewerage, drain, water reticulations, telecommunications and electric power distribution sys-
Energy Simulation
If Acceptable
Detail Architectural drawings
If not Acceptable
Execution
Usage of other Operational Systems acc. to the need
Mixed Mode
Composite Mode
Full Mode
Productive Mode

Advantages of Ken yeang design Methodology are discussed below-

- Green Design becomes increasingly part of mainstream thinking.
- He used passive and ecological methods to achieve sustainability .
- Deep research is visible in every step of his methodology.
- He evolved new ways of adding up ecology in his building such as landscaped ramps, Sky-parks, Ecocells etc.
- He balances his master plans with organic (landscape) and inorganic mass (Built).
- His buildings have low operational cost due to the usage of renewable sources.
- Landscaping introduced by him also have positive psychological impacts on its users.
- Water is collected at different points from the site and treatment systems are used to recycle water which is further used to irrigate the huge landscaping of his buildings.

As everything has some pros and cons in the same way his design process also have some disadvantages such as-

- He applied his ecological theories mainly to the large scale buildings like high rise towers, vertical cities and masterplans etc.
- The cost of his building hikes 30-40 % due to the ecological features in comparison to the normal building construction cost due to which lower budget people are not able to use his concepts.

## 8.3 Vidhur Bhardwaj Design Methodology

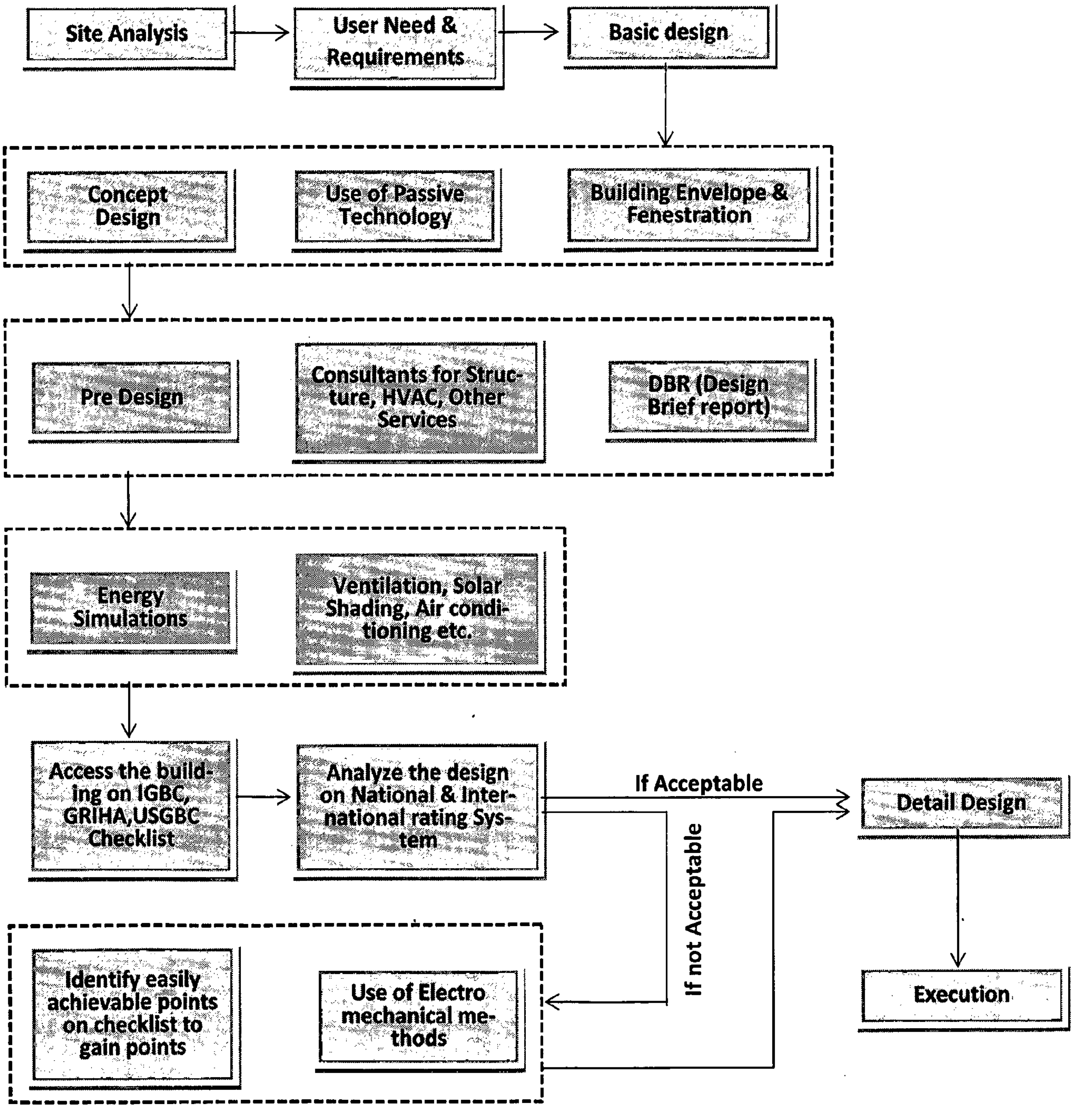
The objective of Vidhur Bhardwaj Design is to make it sustainable with the help of passive and Green techniques . He aims to achieve good points on energy rating systems like GRIHA, IGBC, USGBC while designing and constantly develops new technologies and implements the conventional practices of creating green structure,

The figure below explains Vidhur Bhardwaj Design methodology-

Designs proposed by him are primarily focused on energy optimization and building envelope, his works inspires architects and other people in construction industry to build in the lap of nature. Although his design methodology has some advantages and disadvantages which are discussed below –

- He used vernacular elements in his design like Courtyard design inspired by the traditional inward looking havelis, light wells, water bodies and vegetation inside the building.
- First he use passive techniques and work upon the building envelope to cut down the energy demand.
- Design is aimed to score good point on energy rating system.
- Use of renewable sources of energy like sunlight and wind by channeling them in required area through light well, jharokhas, jali, window etc.
- He also add ecology in his designs in the form of terrace garden, roof garden, landscaped courts, green walls etc.
- He believes that "Automation should not exist in isolation nor should it be the focal points ".
- Some disadvantages or faults of his design methodology are as follows-

- He mainly focused on technological aspects and passive techniques to achieve sustainability rather than ecology.
- Sometimes in order to chase energy assessment points his design becomes checklist.



# Chapter 9 Design methodology for Vertical Urbanism

The Proposed design programme is based on the study & analysis of design methodology adopted by the contemporary architects in order to achieve ecological sustainability in vertical urbanism. The proposed methodology tries to boost up the weak areas of the existing methodology for example- the thesis analyze the methodology and design done by Ken Yeang, he focuses on embedding ecology in vertical development in order to achieve this aim he forgets to pay attention towards the functions and spaces of the built mass, his designs are having lots of negative spaces.

To achieve ecological sustainability in any vertical development, first the design should be sustainable otherwise if the foundation is weak then there is no use of building a strong structure, so in the proposed programme after site analysis second step is the programme analysis which described in brief how vertical urbanism works and how it is similar to flat cities? This programme analysis plays significant role because it helps in designing vertical city with all its services , systems and transportation etc.

Third step comprises of requirements and zoning, in this requirements can be framed with the help of the master plan of the area where the site is located and for zoning, in flat cities we usually do zoning in two dimensions only on horizontal plane but in vertical city zoning can be done in three dimensionson horizontal as well as on vertical plane. The existing methodologies design vertical developments but without much thoughtfulness about the zoning and requirements in the initial design stages.

Prelim design can be decided in fourth stage all the ecological elements, structure, building envelope, bioclimatic design and passive design can be decide parallel for seamless bio integration, a specific size of module can also be decided in this stage according to the requirements of the design, this helps in expanding city to adapt changes and cater the society according to their needs.

This is one of the major drawback in the existing methodology that architects are designing without thinking their scope of expansion lack of this scope leads these cities towards the same conditions as we have in flat cities or even more worse then that because in case of vertical city we don't have option of sprawl.

After prelim design, evaluation takes place which can be done with the help of software's generally Ken Yeang and Vidhur Bhardwaj design buildings by using passive technique and after analysis add electromechanical device in order to achieve comfort zone but in proposed methodology design initiated with passive techniques then analysis takes place, after analysis once again passive techniques can be used rather than using electromechanical device.

At the end detailed design can be done by preparing detailed drawings for services, structure, landscaping etc.

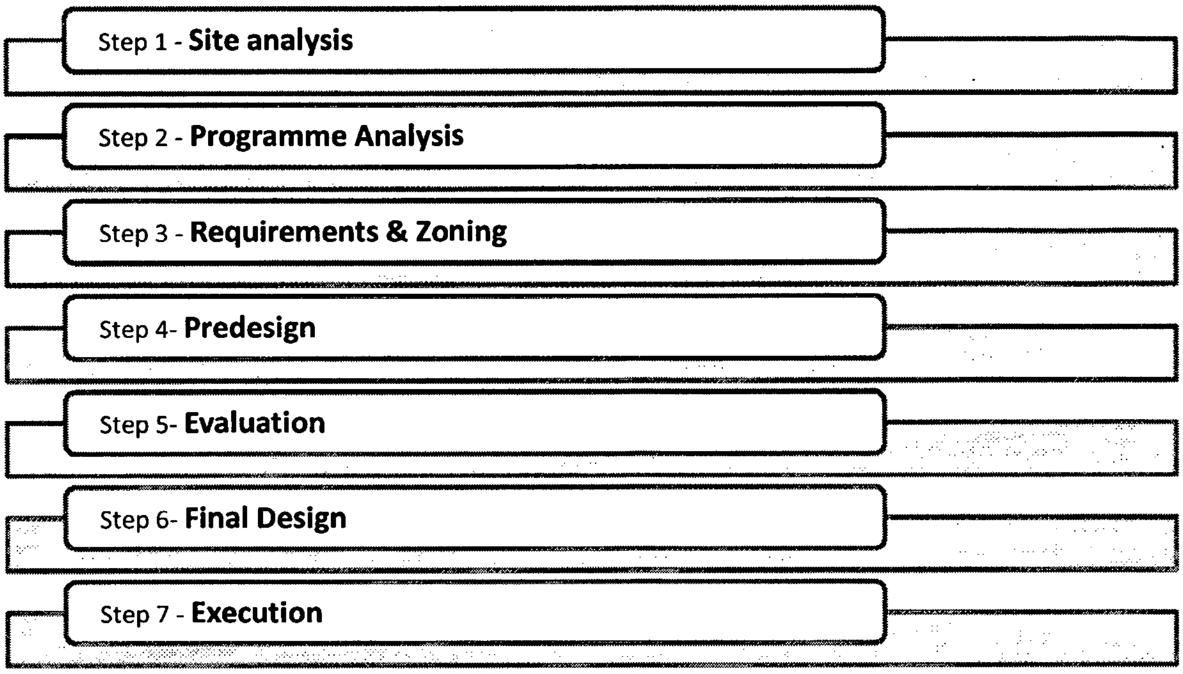



**Figure 99 Design Methodology for Ecological Vertical Urbanism**

## 9.1 Step 1- Site Analysis

**Climate**- Angles of sun at various times of the day ( also note seasonal changes in sun angles)

**Wind** - Summer and winter wind pattern throughout the site.

**Microclimate**- Area of the building or the site that is warmer or cooler due to the surrounding vegetation available on site, sun exposure.

**Rainfall**-Monthly amounts

**Topography**- Slope of the site, orientation of the sun.

**Vegetation**- Types of vegetation available on the site and irrigation methods.

**Geology**- Soil conditions, drainage for rainwater harvesting (slope of the site).

## 9.2 Step 2 Programme Analysis

### 9.2.1 Emerging Nature or deriving nature

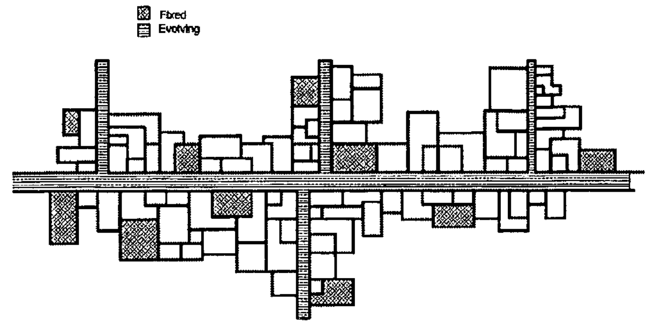



**Figure 100 For Flat City**

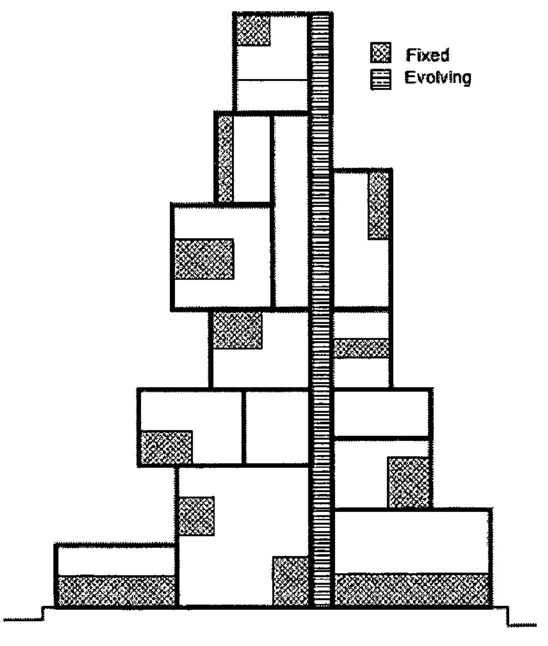



**Figure 101 For Vertical City**

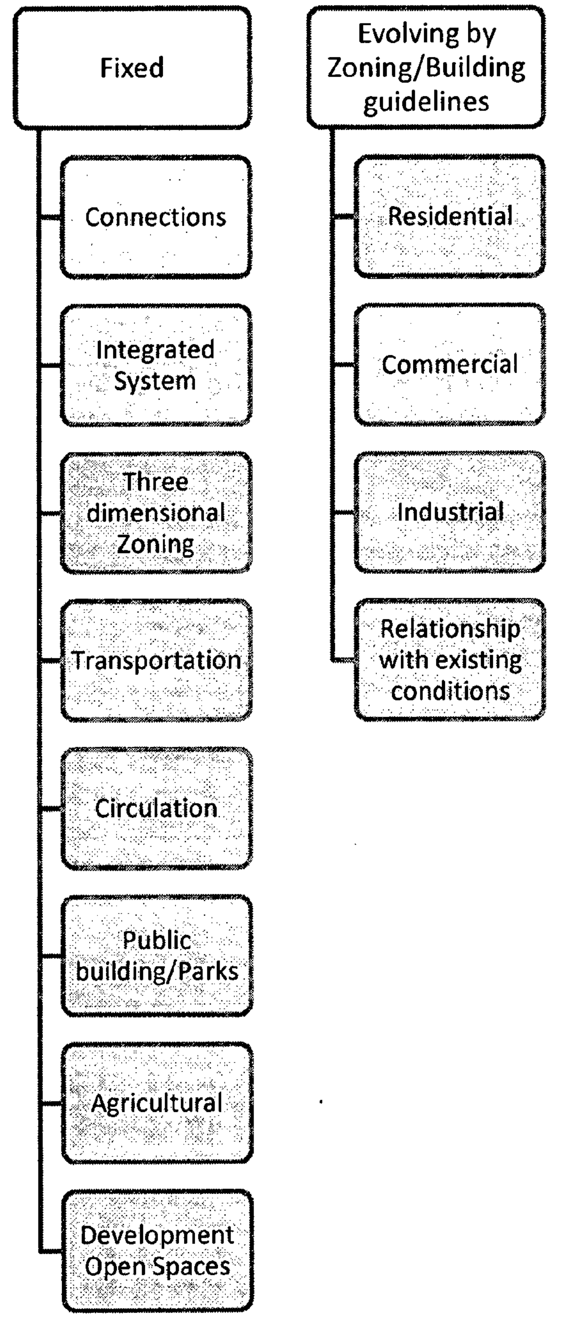



**Figure 102 Evolving & Fixed Programmes**

Before designing vertical city first we have to understand how flat city works? As in city few elements are fixed and others are evolving, the same concept is implemented in vertical city. We have set of programmes that can be change according to the need and location of the site and the another set which cannot be change are service support systems, transportation systems and public spaces. For smooth workability of a city we require an infrastructure such i.e. transportation system, electric, water, sewage system. As well as the buildings such as schools libraries, recreation and open spaces, hospitals, court etc. now out of all these the main challenge is to place transportation system vertically and how public and private spaces successfully interconnected to each other. To face these challenges we need to we need to adopt some set of rules, guidelines or a methodology for the development of ecological vertical urbanism.

## 9.2.2 Redefining the Skyscraper

Most of the vertical developments are defined in which we know our destinations it may be our work space, living space or something else but challenge is to develop it on such a large scale where we don't know our destinations so that it gives us the experience of a city to a dweller.

We have to redefine a typical skyscraper into more diverse form and make their spaces more humanized. This can be done by dividing a mega structure into different uses, and allow them to evolve or expand according to the need of the site and it's users.

## 9.2.3 From Micro to Macro

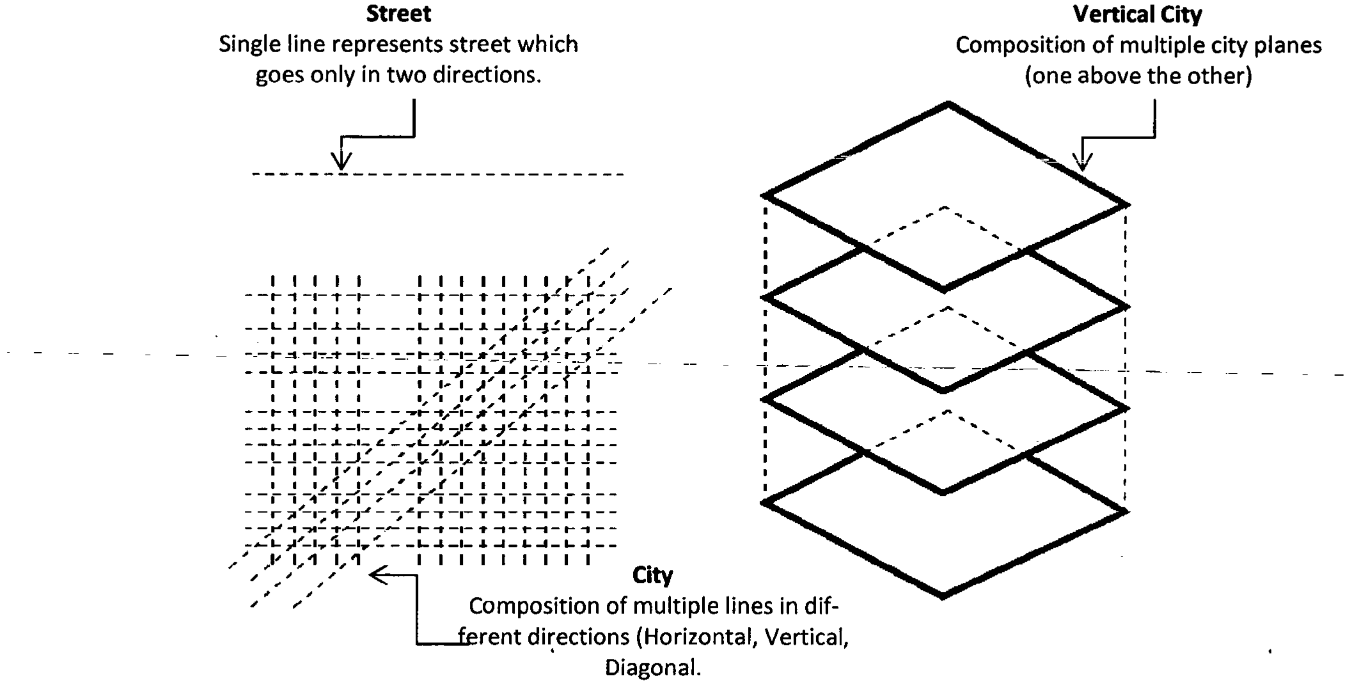



**Figure 103 Street to City to Vertical City**

By understanding the main elements of a flat city from micro level to macro level we have to reformulate the new formula which works for vertical development.

## 9.2.4 Ecology from Ground to Sky

Nature is important to us whether it may be on Ground or in Sky, ecological frame and landscaping plays same role but the only difference is ecological frames introduces greenery in vertical city and landscaping adds up life to the city.

Ecological frame is made up of wire mesh and stiff enough to take up load of the dynamic nature. A comparable study of landscaping on ground and sky is shown below-

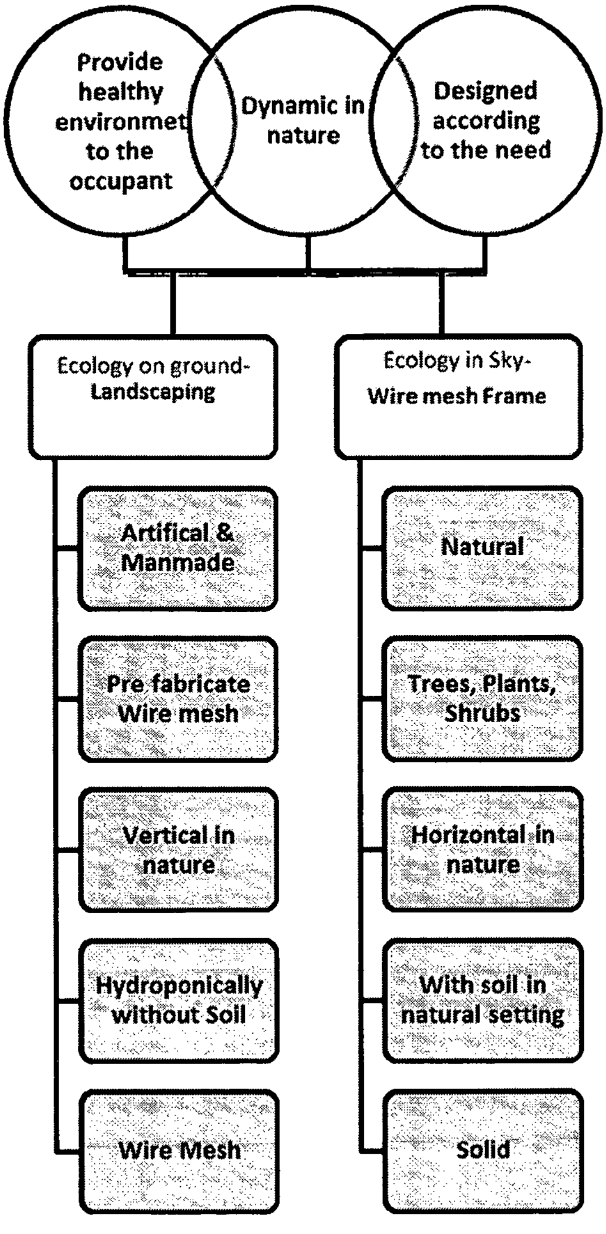



**Figure 104 Comparison between Landscaping & Wire Mesh Frame**

## 9.2.5 Behavior of spaces in city & vertical city

Because of the arrangement and vertical placement of spaces, city works in a better way. More compact development could help in dealing with the thrust of contemporary cities like traffic congestion, Destruction of nature due to sprawl. Spaces work in a better way for e.g. Residential Spaces when stack vertically could help in creating more private space, commercial and open spaces became more successful node because when you enter in an open space (Horizontal) in extremely vertical development it converts automatically into a gathering space.

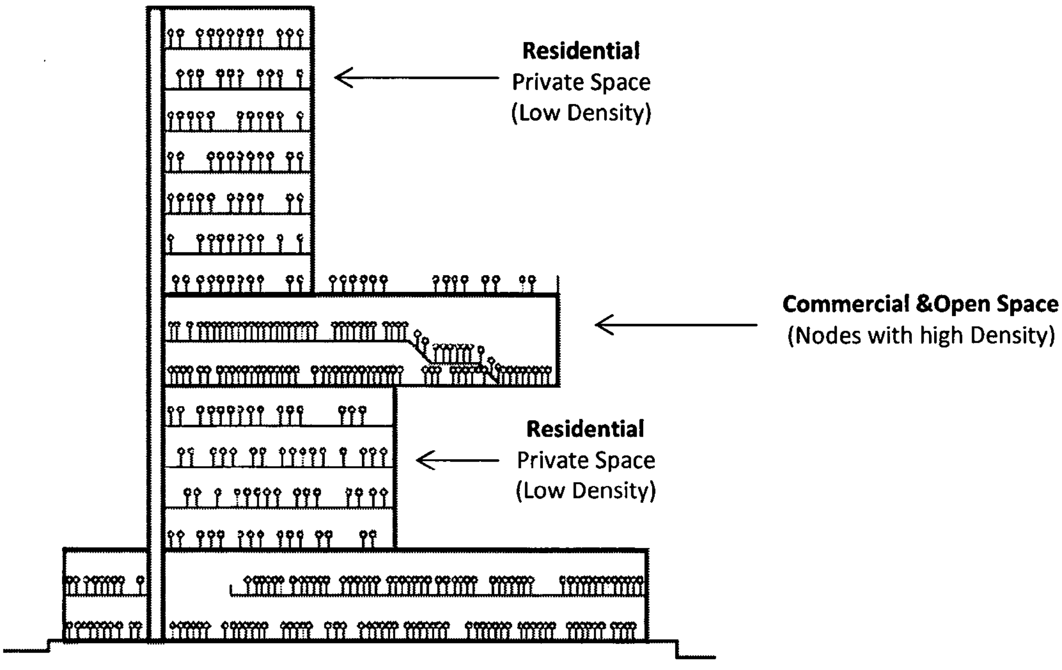



**Figure 105 Behavior of Spaces in Vertical City**

## 9.2.6 Scope for Extension

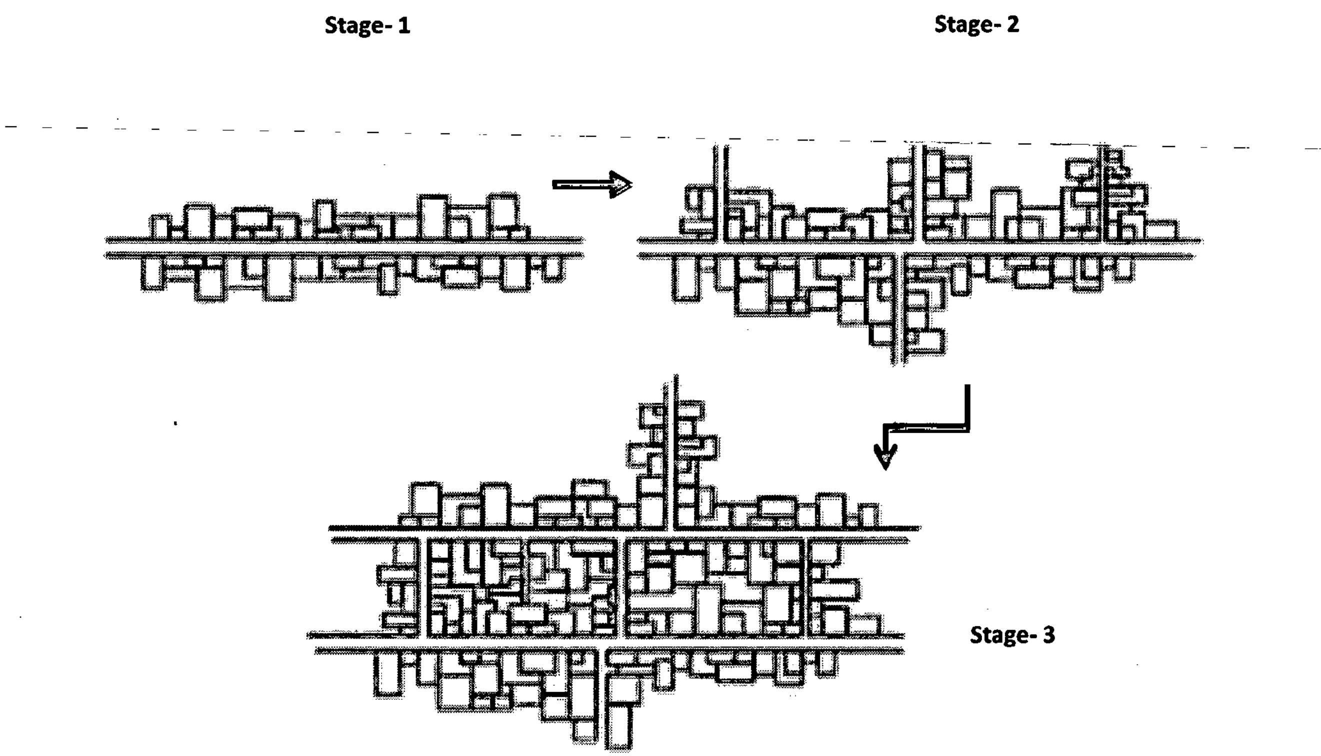



**Figure 106 Haphazard growth pattern for flat city**

For any city it is necessary that it should adapt changes with time and expand according to the need. Unplanned & Haphazard development is the main problem we are facing now days in flat cities due to urbanization and population pressure but in vertical city it is essential to sought out this problem in early stages by proper planning. These cities can be easily expanded by the means of prefabricated members. Guidelines and methodology require to ensure the balance between open & built mass.

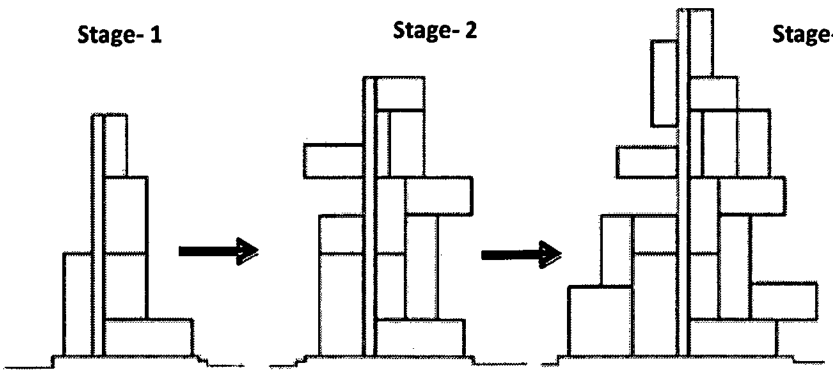



**Figure 107 Scope for Expansion in Vertical City**

## 9.2.7 Circulation & Transportation

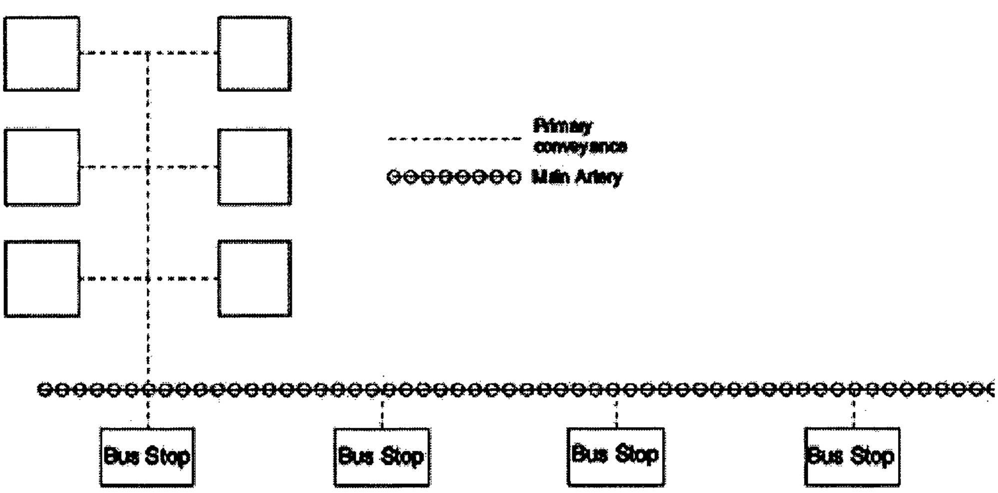



**Figure 108 Transportation system for flat city**

Transportation & circulation is an important issue specially when we are talking about vertical developments, for vertical city transportation system works same as in flat but the only thing is we have to understand it.

The other main issue while travelling vertically in elevator is that outside view is not visible due to which you are not able to know where you are and travelling in right direction or not in city, so for that elevators should be equipped monitor which will show you the right direction in which you are travelling and show all destination points.

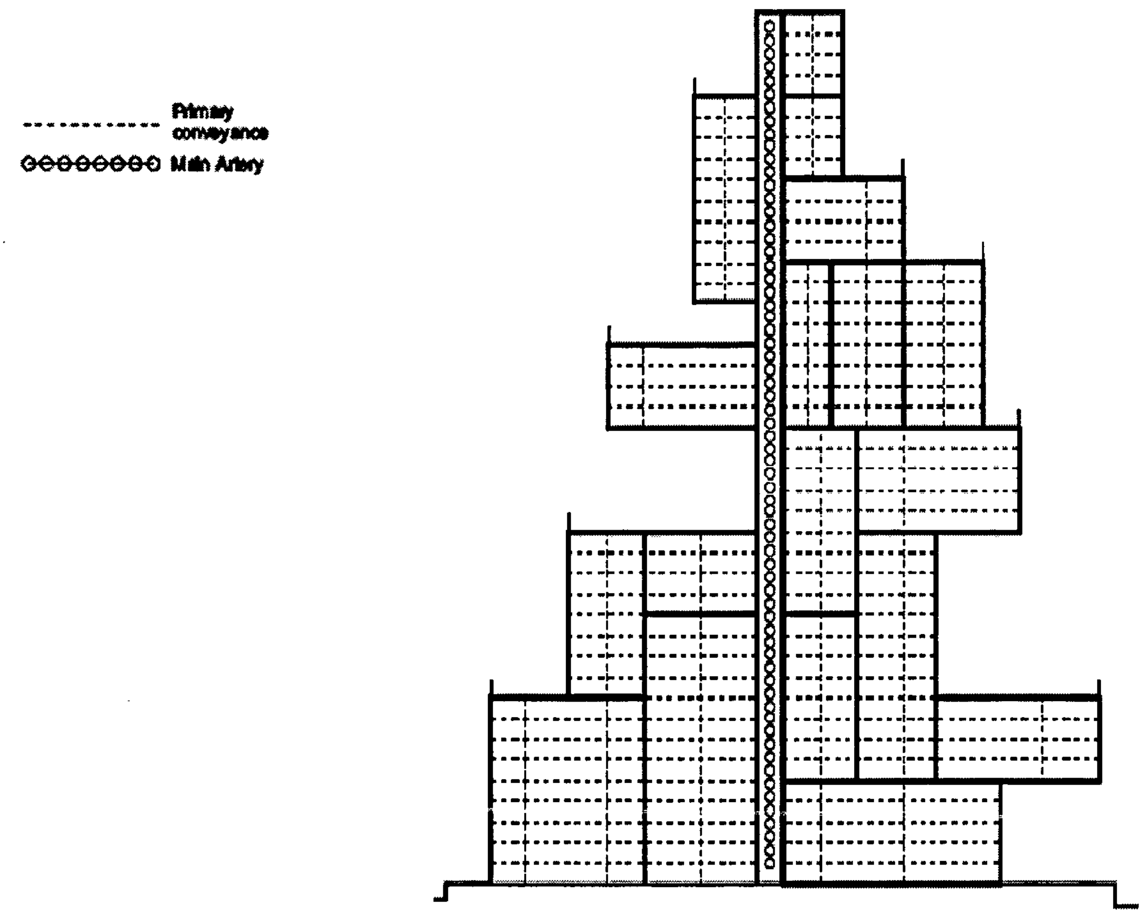



**Figure 109 Circulation & Transportation in Vertical City**

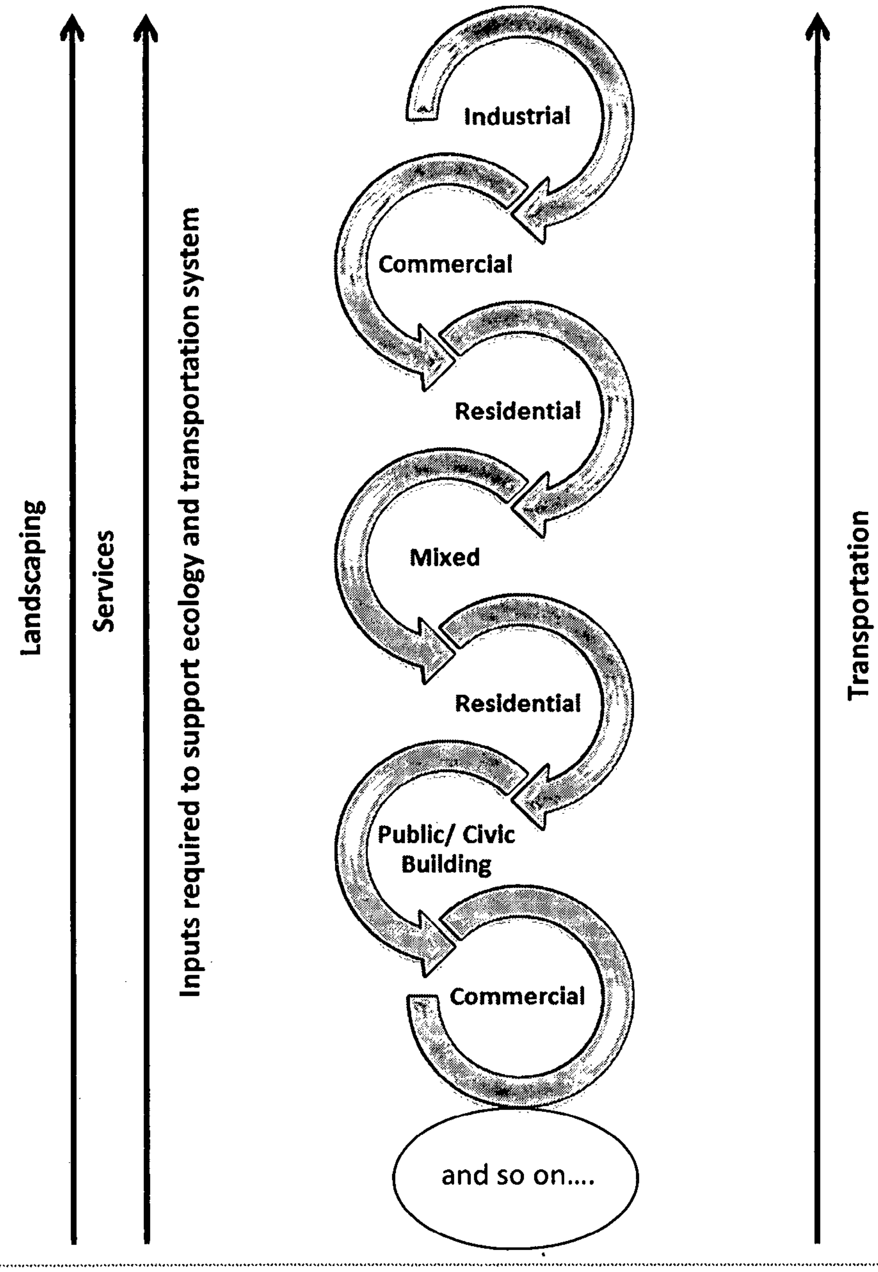
## 9.2.8 Ecological Trails & Parks

Ecological Trails, open spaces, parks are very important while designing because form of mega structure is dependent on these parameters. These areas will be the main focal point and act as a node (became hub of activity)

Parks and open green spaces are placed in such a way that these can be easily accessible by the occupants and provide a soothing recreational zone to its users. Sky Parks can act as a recreational belt that runs throughout the building, containing trees plants, these areas can be irrigated through irrigation system that recycle rain water and grey water such as- Bio filtration with trails, Root zone treatment System.

## 9.3 Step3- Requirements & Zoning

Requirements can be framed with the help of byelaws or proposed masterplan of the area for which you are designing.it may vary according to the need of the location.




#### 9.3.1.1 Recommendations

- Commercial zones are placed near public civic buildings and residential zones because these places can develop itself as a hub of activity and become a successful node easily.
- Industrial, Commercial and Mixed or public civic buildings are kept in between residential zones to maintain minimum travel distance from live space to work space and vice versa.
- Vertical city comprises of two planes- vertical plane and horizontal plane
- Vertical Plane comprises of Circulation (main artery) , Ecological Trails, Gadgetry on Façade whereas Horizontal Plane consist of Developed area, Circulation ( Primary Convince), Open Spaces, Ecological parks and landscaping.

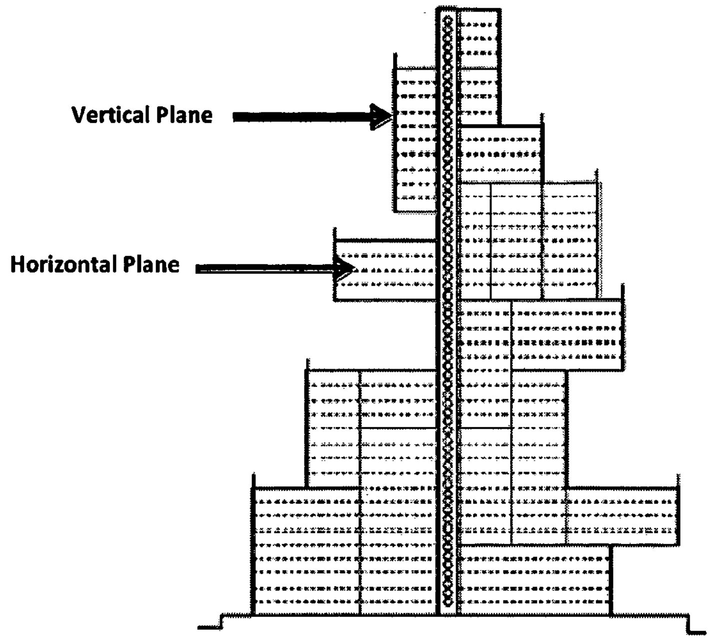
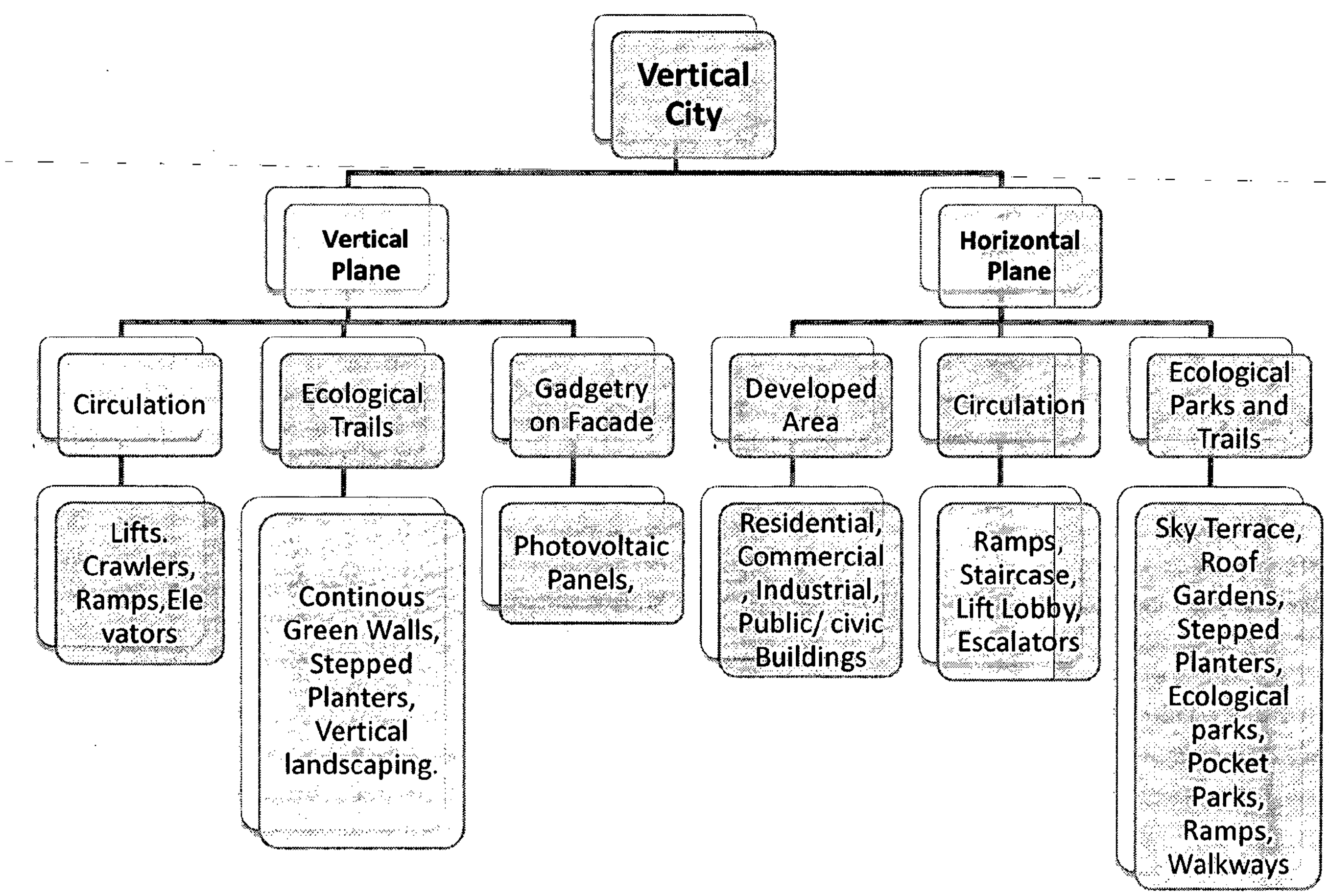



**Figure 110 Vertical city showing Horizontal & Vertical Planes**



## 9.4 Step-4-Prelim Design

### 9.4.1 Set of Ecological Features & Landscaping

Landscaping helps in altering the microclimate of a building. Vertical landscaping reduces direct sun from striking and heating up of building surfaces. It prevents reflected light carrying heat into a building from the ground or other surfaces. Landscaping creates different airflow patterns and can be used to direct or divert the wind on upper floors where wind pressure is high. Additionally, the shade created by trees and the effect of grass and shrubs reduce air temperatures adjoining the building and provide evaporative cooling. A study shows that the ambient air under a tree adjacent to the wall is about 2 °C to 2.5 °C lower than that for unshaded areas, which reduces heat gain by conduction.

Landscaping can be done according to the need of the space for e.g. Residential Spaces are equipped with play parks, landscaped Jogging tracks, open green spaces, pocket parks, balcony gardens, terrace gardens, roof gardens etc. whereas in offices corner sky parks are provided for relaxation and commercial areas with green sit out spaces, pocket plazas. Vegetation is decided according to the Climate and need of the site.

### 9.4.2 Set of Services

- Waste water management
- Water harvesting
- Ecological Trails
- Root zone system
- Bio filtration trails

### 9.4.3 Structural design

Structures are decided in prelim design stage in order to work upon the services. Determine material for structural elements and evaluate their environmental impacts and also consider embodied energy, resource management, and recycled material content.

### 9.4.4 Set of Bioclimatic Features and Passive Techniques

Court yard effect

Daylit atriums

Solar Shafts

### 9.4.5 Size of Modules

Prefab modules are used for the construction so that it can easily adapt the change and evolve according to the need of the time. A specific size of module are decided to accommodate

### 9.4.6 Building Envelope & Fenestrations

Building envelope and fenestration are the key elements which decide the heat gain and loss of the building these are the elements which helps in optimizing energy consumption of the building. The primary elements that effects the performance of a building envelope are

(a) Materials and construction techniques,
(b) Roof,
(c) Walls,
(d) Fenestration and shading, and
(e) Finishes

## 9.5 Step 5-Evaluation through softwares (Simmulation)

Various Energy software's are available to analyze the energy consumption of the building. On this stage energy intake mainly depends upon the shape of the building, orientation of the building, insulation, mass, Glazing Type, lighting Strategy, Daylight Utilization, Air change rate, window size in different façade of the building etc.

### 9.5.1 AESP System Planning

It is a softwarefor simulation of electrical power systems application for the design, modeling, and with greater stresson renewable energy sources like wind,solar, and hydro. The application estimates for modeled systems like power generation, consumption, and storage. Based on user objectives and priorities,power and cost data can be analyzed to optimize the modeled system.

### 9.5.2 Design Builder

It provides a variety of environmental performance information such as: consumption of energy, internal comfort data and HVAC component sizes. Output is known by using Energy Plus simulation engine, based on detailed sub-hourly simulation time. Many common HVAC types, buildings with naturally ventilated, day lighting control buildings, advanced solar shading strategies,dual facades, etc. can be simulated by using this software.

### 9.5.3 Overhang Design

This provides immediate, descriptive graphical feedback on the partly to which anoverhang shades a window or other opening.

### 9.5.4 Skyvision

Sky vision calculates the overall concerning sightbehavior (transmittance, reflectance,absorptance, and Solar Heat Gain Coefficient) of conventional and *tubular skylights, performance indicators of skylight/room interfaces* (well efficiency and coefficient of utilization), indoor daylight availability (daylight factor and illuminance) and daily/annual lighting energy savings. Sky Vision arranges for the shape of skylight and glazing, geometry of the indoor space (curb, well, room), layouts of skylight, lighting and shading controls, site location and sky/ground conditions. Sky Vision is being of its own kind and uses the methods based on ray-tracing and state-of-art glazing models to calculate the optical behavior of skylights andavailability of indoor daylight.

### 9.5.5 Ecotect

It is complete environmental design software which consists of 3D modeling interface with functions like extensive solar, thermal, lighting, acoustic and cost analysis. ECOTECT is the tools in which there is accuracy in performance analysis, very simple and most important it is visually responsive.

It works on the concept that addressed during the conceptual stages of design and is most effectively environmental design principles. From even the simplest sketch model,as more detailed information becomes available ,the software answers to this by providing necessary visual and analytical feedback, progressively guiding the design process. The model is completely scalable, handling simple marking models to full-scale cityscapes. Using Radiance, Energy Plus and many other tools its extensive export facilities also make final design validation much simpler.

If the consumption of energy is morethan actualthen energy consumption of a building can be analyzed through these energy simulation software's. First ecological measures and passive technology is used to improve the internal comfort zone and to reduce down the consumption we will go for electromechanical methods (technology) if it does not work to get the target.

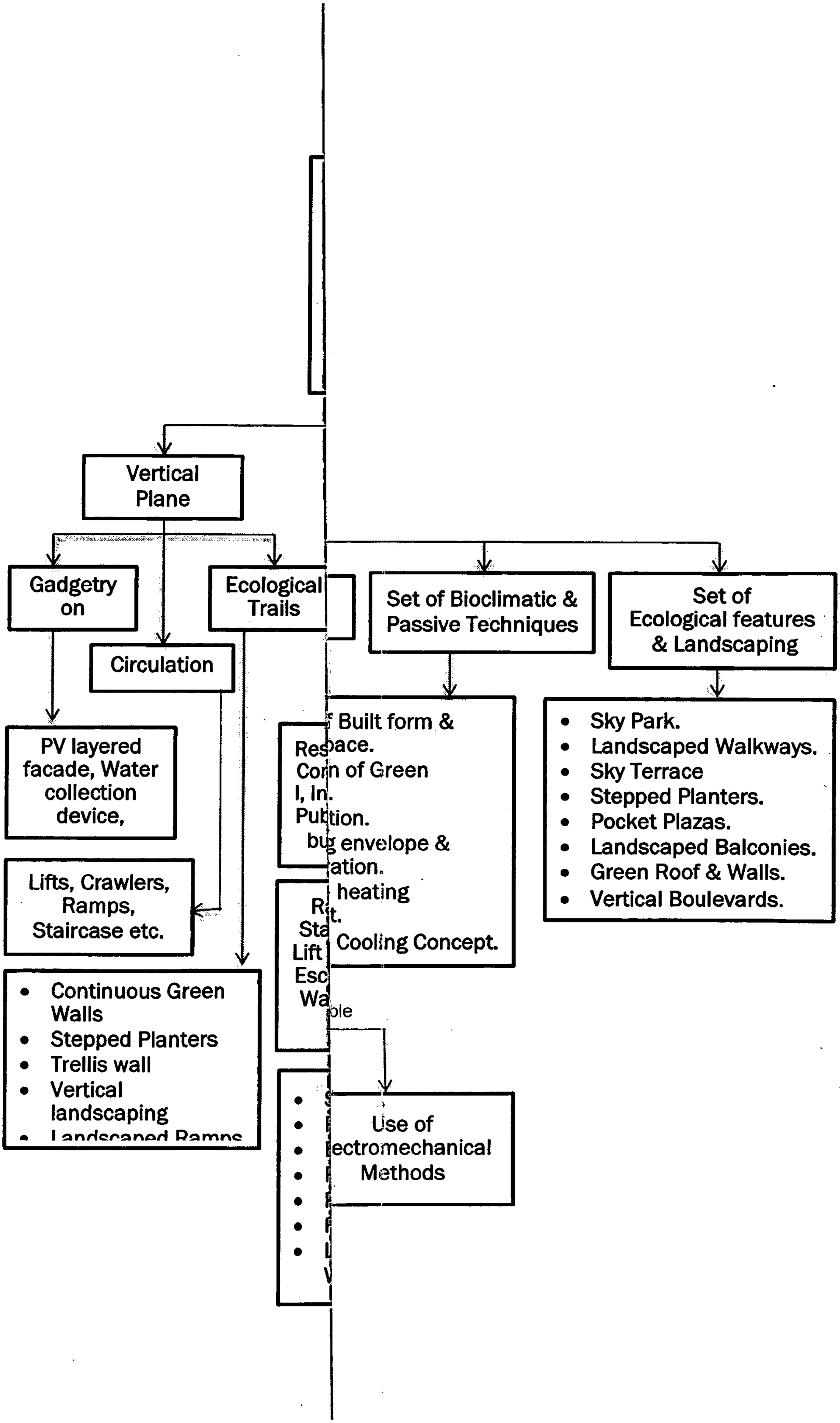
## 9.6 Step 6-Detailed Design

Detailed design focuses on all of the implementation details required for the execution of project. In this stage prelim design is converted into detailed design, technologies required after energy simulation is selected to meet the requirements of the design.

Detailed dwg. are prepared for the allocation of set of services, architectural dwg. (Size of spaces), electrical dwg., HVAC dwg. etc.

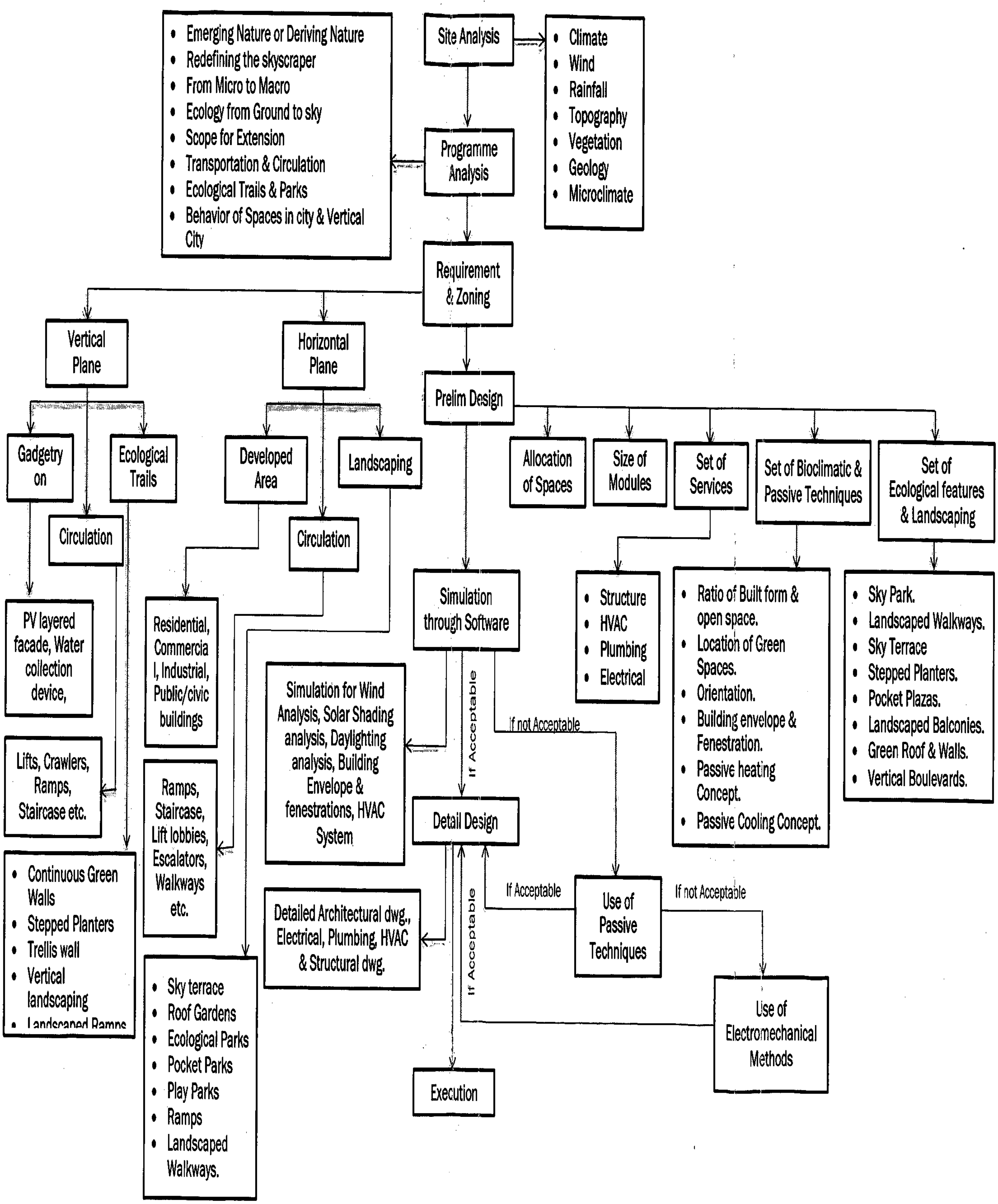
Location of ecological features and set of passive technology is decide according to the need of the design.

At the end of this stage after implementing all design details, proposed design is tested again to check its workability according to the need of the project. If it passes the test up to the satisfactory level then the detailed plans are ready format the execution and if it fails to perform then faults are rectified by revisited the previous steps. After this stage execution of plans takes place.



Vertical Plane
Gadgetry on
Circulation
Ecological Trails
Set of Bioclimatic & Passive Techniques
Set of Ecological features & Landscaping
PV layered facade, Water collection device,
Lifts, Crawlers, Ramps, Staircase etc.
Continuous Green Walls
Stepped Planters
Trellis wall
Vertical landscaping
Built form &
ace.
n of Green
tion.
envelope &
ation.
heating
Cooling Concept.
Sky Park.
Landscaped Walkways.
Sky Terrace
Stepped Planters.
Pocket Plazas.
Landscaped Balconies.
Green Roof & Walls.
Vertical Boulevards.
Use of
ectromechanical
Methods

# DESIGN METHODOLOGY FOR ECOLOGICAL SUSTAINABLE VERTICAL URBANISM



# Chapter 10 Conclusion & Recommendations -

## 10.1 Conclusion-

This report is intended to analyze the process how urbanism can evolve in three dimensions instead of two dimension plane and the environmental issues within the vertical development. The direction of research went to attain ecological sustainability in vertical developments, as a substantial potential available in nature (ecology) but the potential has to be explored to save our resources (renewable sources).The thesis aimed to use ecology and passive techniques which help designers to achieve efficiency goals which can be done with the help of methodology by using energy simulation and modeling tools.

The conclusion of this study are discussed in this chapter-

### 10.1.1 Changing forms of architectural design with time

**Low Rise Developments**

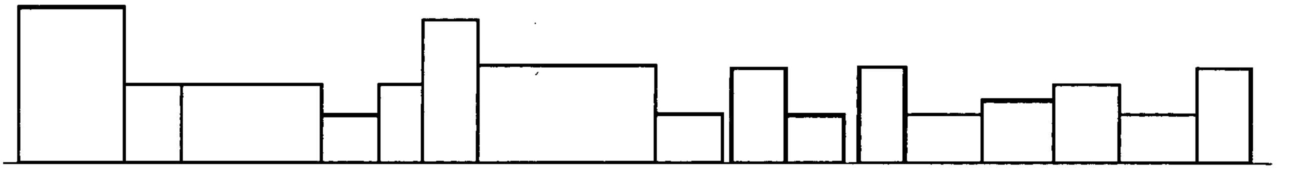


**Figure 111 Low rise developments**

The low rise developments are diverse in nature, having individual identity and more humanized but they sprawl across the land due to which increase the vehicular dependencies and also destructs the landscape & Ecology.

**High Rise Developments – Skyscrapers**

Skyscrapers are having some advantages like small footprint and dense but on the contrary they all are having similar identity & static floors, these structure are comprises of pre-defined spaces which limits the experience of the occupant.

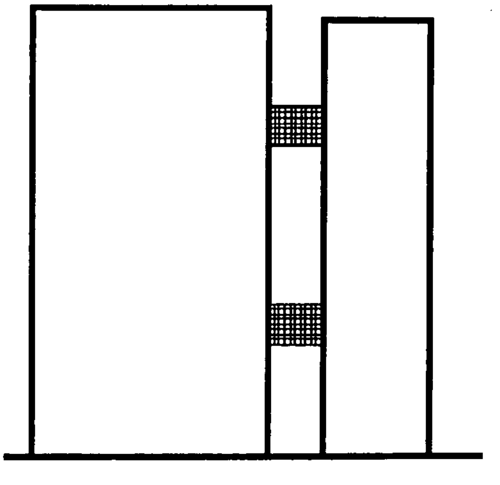


**Figure 112 High rise developments- Skyscrapers**

**Vertical Urbanism**

These structures are vertical in nature due to which they are having smaller footprints , as these structure are huge they are having dynamic floor plans which offers unlimited experience to the users and undefined space made up of modular system so that these can be expand strategically.

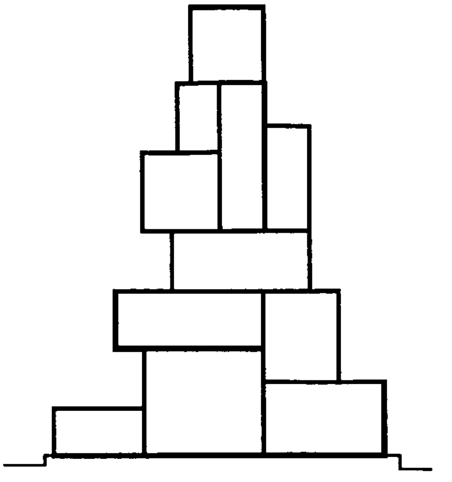
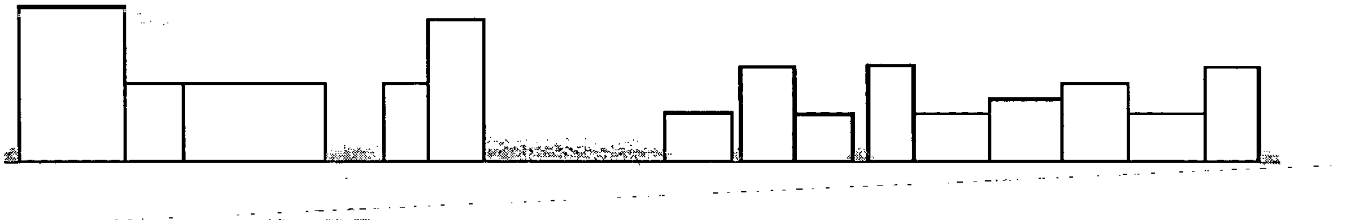


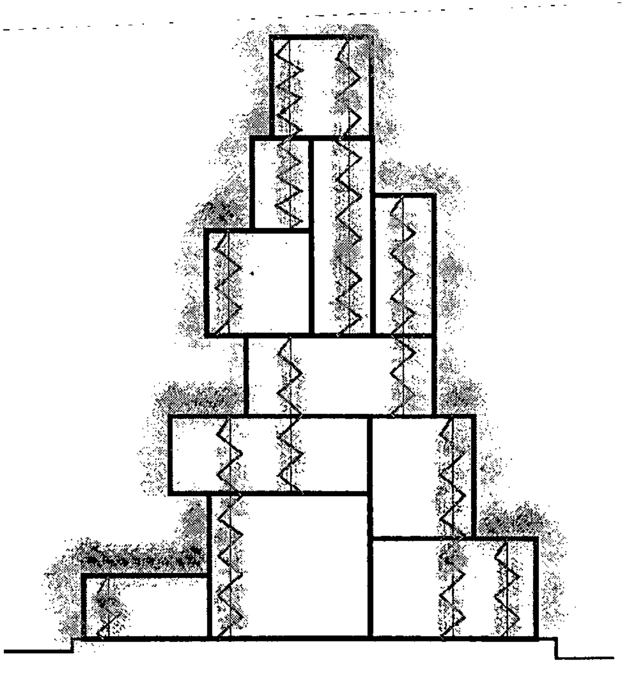
**Figure 113 Vertical City**

## 10.1.2 Ecology & Infrastructure

Cities are sprawled across the land which destroys the nature and environment, climate change is one of its side effects.

**Figure 114Urban Sprawl in City**





Vertical city accommodates ecology in the form of vertical landscaping or interior parks and ecoinfrastructure such as Bio filtration systems, rain water harvesting, which helps in reserving urban sprawl due to its compact nature gives land back to the nature to thrive in.

**Figure 115 Vertical city with green spaces**

## 10.1.3 Ecological Vertical Urbanism

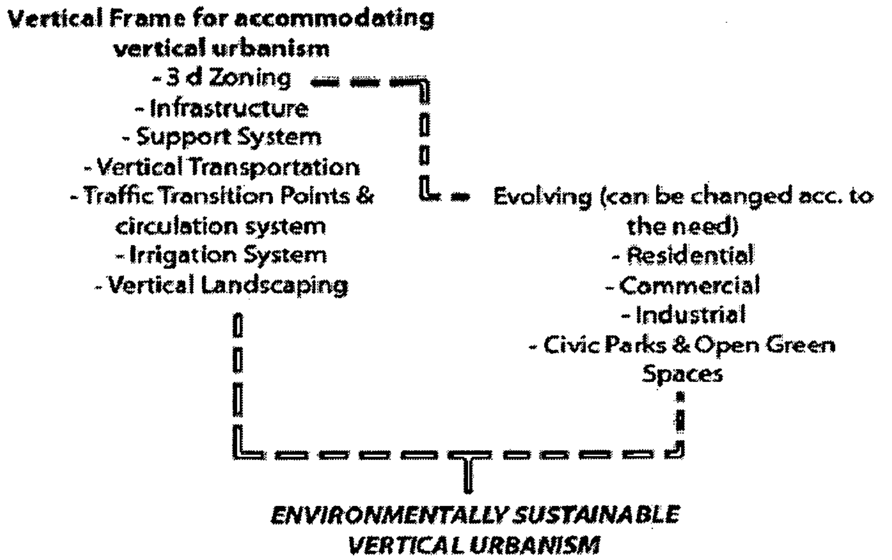



**Figure 116Conceptual Diagram for fixed & evolving Parameters of Vertical City**

Vertical city comprises of two set of elements one is fixed and other is evolving which can be change according to the need and location of the site-

**Fixed elements**- Infrastructure, Support System- electrical, plumbing etc., vertical transportation, irrigation system, vertical landscaping.

**Evolving elements**- Industrial, residential, commercial and open green spaces.

## 10.1.4 Conventional & New Design Methodology-

Design methodology adopted in conventional buildings are mainly focused on the requirements, architectural forms, aesthetic, function and structural considerations like- aspect ratio, column design, span of the living whereas existing design methodology for sustainable developments are based on the parameter which are shifted towards the energy conservation, ecological sustainability, efficient building systems to cut down the energy demand.

## 10.1.5 Steps for Design Methodology

Divide the design methodology into 7 main steps-

- Site analysis
- Programme — Research
- Requirements & Zoning
- Prelim Design — Concept
- Simulation — Analysis
- Detail Design
- Execution

## 10.2 Recommendations-

### 10.2.1 For vertical city

- Analyze the infrastructure required for vertical city.
- Allocate the masses and voids carefully.
- Design can be done in such a way so that it can expand according to the need.
- Commercial spaces are place between residential and commercial spaces so that they can become successful node.
- Connect public & private spaces.
- It should be diverse in nature.
- Decide the positions of green spaces carefully because structure is dependent on these parameters.

### 10.2.2 For achieving ecological Sustainability in vertical developments

- Various techniques used for growing vegetation can be chosen according to the climate. Orientation of the building is considered important while embedding ecology in a building because some plants needs sunlight whereas other destroys in sunlight.
- Dense trees and shrubs are provided over the surface where the striking sunlight heats the surface of the building and creates discomfort to its occupants.
- Evergreen trees are provided towards windward side to reduce the wind effects round the year.
- Roof garden introduced in structure to provide thermal insulation.
- The plantation can be done to provide interstitial zones between inside and outside.
- Skycourts and terraces are provided to break the severity of concrete block by adding ecology to the inorganic mass.
- Vertical and horizontal voids are provided inside a building which brings natural daylight and provide a space for vegetation.
- Suspended natural parks can be provided after regular intervals according to the need of the site, climate and design of the building, these parks acts as green lungs to the tower.
- The selection of plant can be done in such a way that it would not create any problem to the local ecology of the site.

- Plants species are chosen according to their requirement of water, maintenance level, planting depths, access and light quality.
- Rain water can be channelized through vertical landscaping which would also reduce the cost.
- Systems used to grow plants are chosen according to the need of the design where we are using that like for landscaped ramps we need a system with soil but for green walls we can place vegetation aeroponically in which vegetation grows without soil.

### 10.2.3 For formulation of Design Methodology

- Research, Concept, analysis, detailing and execution are the five main sequential steps for creating sustainable methodology.
- Research and Analysis is necessary at every step.
- After each step ensure that methodology is accessing in right direction.
- Verify the energy efficiency of a building after constant intervals to ensure sustainable development .

## Discussion

The thesis opens up scope for many further research areas and one of them is- what are the impacts of vertical city on surroundings, the question can be answered as vertical city may created some problems to the nearby lowrise developments, but they will definately helps in catering the alarming issues of the contemporary society.

The thesis mainly focussed on reducing the negative impacts and energy consumption of these vertical developments by adding ecology but how these developments affects the surroundings and peoples are still a question?

Few problems which has been noticed due to development of the vertical structures can be discussed as they shadowed lower floors as well as lowrise development around it. These cities also avoid wind flow in urban areas which accumulate pollutants in air, sometimes they increased air flow which creates undesirable and uncomfortable conditions to the pedestrian & visitors.

The negative side can be avoided by keeping in view the following points while designing:

- The appropriate principles and standards in height properly locate them, scale of the building, technical rules in making them, immunization, Landscaping and creating greenspaces around the vertical developments, how these towers should be expose for wind how, appropriate distance to other buildings, how to design them in terms of urban landscape must be considered to reduce the negative effects of the buildings.
- We should place these building near the transfer nodes in order to reduce energy consumed by the transportation systems.
- These could be placed by checking the availability of resources like Ground water by using GIS (Geographical Information System) which helps in reducing the energy taken by horizontal how of resources.

This is really a debatable issue whether vertical developments are desirable or undesirable to the society but it is clear that regarding to population pressure and land shortage, vertical developments cannot be avoided. The only the thing we can do is investigating the negative effects of tall structures and reviewed them or tries to find solution for them.

# Bibliography

## Books and Reports-


a) Bullivant, Lucy, 2011. Ecoskyscrapers Volume 2, Ken Yeang. Images publishing Group.

b) Hatt, Sara, 2011. Ecoarchitecture : the work of ken Yeang. Wiley publications.

c) Powell, Robert,1999. Rethinking the skyscraper:The complete architecture of Ken Yeang.Watson-Guptill

d) Richards, Ivor, 2007. Ecoskyscrapers Volume 1, Ken Yeang. Images publishing Group.

e) Richards, Ivor, 2001. T.R. Hamzah & Yeang:ecology of the sky. Images publishing Group.

f) Schaik, Leaon van, 2009. Vertical Ecoinfrastructure work of T.R. Hamzah & Yeang. Images publishing Group.

g) Vishwanath, H.R., Clarke J. N. and Tolloczko,J.J.A., Multi-purpose High Rise Towers and Tall Buildings, Taylor & Francis groups.

h) Yuen, Belinda, Foo, A.F., 1999.Sustainable cities in the 21st century. Singapore University Press.

i) Rasdi, Mohd. Tajuddin, Ahmad, Mohd. Hamdan, 2000.Design Principles for the Atrium Buildings in the Tropics . Universiti teknologi Malaysia

j) Scott Johnson, Tall Building: Imagining of the Skyscraper (Glendale, Calif: Balcony, 2008), 108.

k) Eisele,J, 1999, High Rise Manual: Typology and Design, Construction and Technology, Basel, Birkhäuser.

l) Hindrichs,D et al, 2007, Sustainable building design in tropical and subtropical regions, Beilefeld, Schuco

m) Yeang,K, 2007, Designing the Ecoskyscraper, The Structural design of Tall and Special Buildings.

## Websites-

http://landscapeandurbanism.blogspot.in/2010/05/ecological-urbanism-introduction-part-1.html

http://www.openformarchitecture.com/wp-content/uploads/pdf/verticalurbanism-en.pdf

http://www.jsk.gov.in/impactof_population_growth.asp

http://www.pewclimate.org/docUploads/EEBSummaryReportFINAL.pdf

http://www.trhamzahyeang.com/project/skyscrapers/Spire_Edge_01.html.

http://www.spireedgemanesar.com/

http://spireedge.wordpress.com/

http://www.investors-clinic.com/show-Spire-Edge-22-2.html

http://www.greenprophet.com/2009/01/jerusalem-design/

http://architexting.wordpress.com/2011/08/01/ken-yeang/

http://blog.japhethlim.com/index.php/2011/06/14/green-architecture-is-underrated-a-case-study-on-solaris-by-tr-hamzah-and-ken-yeang/

http://books.google.co.in/books?id=I8GfXB0QbjIC&pg=PA26&lpg=PA26&dq=naturally+ventilated+day-light+atriums+ken+yeang&source=bl&ots=dxy_uVdAw&sig=uGckwxeAGHOKzt7cdd_MCpnehTw&hl=en&sa=X&ei=HS1oT_jlHo6qrAfA78CNCA&ved=0CDcQ6AEwAw#v=onepage&q=naturally%20ventilated%20daylight%20atriums%20ken%20yeang&f=false

http://www.greenroofs.com/blog/tag/dr-ken-yeang/

http://www.archello.com/en/project/bio-urban-generator/137241

http://activistmagazine.com/index.php?option=content&task=view&id=129&Itemid=143

http://www.alternative-energy-news.info/technology/environment-wildlife/

http://www.bing.com/search?q=%22When%20moisture%20evaporates%20from%20plants,%20heat%20is%20consumed%22