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Tall Office Building Form to Attend Sustainability

Authors

Ar. Priya V.Gupta(Raut)[1], Ar. Anjali V.Narad[2]

[1]Assistant Professor, Ar.Priya V. Gupta, Radhikatai pandav Institute of Architecture, Nagpur,Maharashtra,India
Email: *priyaaguptaa7@gmail.com*

[2]AssistantPprofessor, Ar.Anjali V. Narad, Radhikatai pandav Institute of Architecture, Nagpur,Maharashtra,India
Email: *abhasme3@gmail.com ,ar.anjali616@gmail.com*

Abstract

From the early history, we can visualize that there is continuous development in urban areas. Development not only city settlements but rather in individual buildings along with innovative technologies from pyramids of Egypt to Eiffel tower to till date. Slowly and gradually, people were migrating from villages to town areas with the demand of more employment which directly escalate the need of land for to perform work and to live. Global warming, energy and water shortage, urban sprawl, air pollution, overflowing landfills, disease, and global conflict will be the legacy of the twenty-first century. Rapid development is overtaking and transforming villages, towns, cities and metropolises in the world. Social& economic transformation is producing new aspiration in the society. Development of world is mainly driven by economy. The city continued dynamism it given its business required ideal surrounding in which to operate. The time has come to pause a little, to think about long term development objectives rather than speeding blindly into a state of exhaustion unless we move quickly towards the notion and implementation of sustainability it will be tough to survive and need the ways to come out of it. This paper will discuss –How sustainability will be achieved through tall office building and analysis of convenient forms for tall building.

Index Terms: *sustainable development, organizing sustainability, tall building, building form,*

1. Introduction

To preserve, to procure & to conserve.....Is the aim of today's generation. One can feel the sudden exploration in population, directly affecting and rapidly consuming huge amount of natural resources majorly land, energy & water. With the advancement of people the need for living style, food and shelter has triggered to the greater extent.

As shelter is the base requirement of a human being from ancient time. People developed, evolved and change with the social, political& economical conditions. Development depends on economical conditions, the development of Indian economy is vital but it should not be our only consideration. Strong effort is needed to establish equilibrium between prosperity, people & our own environment. Building a society, merely not for today, but for our children & for the future generation. A positive approach should be there towards sustainability. "As every action has equal & opposite reaction".....

Our today's action takes accounts of their economic, social & environmental consequences. City growth sustains for longer time, if commerce being given required ideal surrounding. Land is being engaged by larger footprints of building rapidly. A sustainable approach towards tall offices building will give maximum privilege to the growth of city. An attempt has been taken to study tall buildings and its suitable form in the urban context of sustainable development. All buildings, high-rise and low-rise deep plan, could be more sustainable in terms of their design, the construction and operation process, mainly their form which leaves the impact on the community as a great image.

2. Organizing sustainability

2.1 Sustainability and its impact on urban form

The word *sustain* means to "maintain". Sustainability demands judicious and efficient use of resources to satisfy the needs of present generation without compromising the need of future generation as defined internationally. Future depends on what we do in present. *Sustainability* creates and maintains conditions under which humans and nature can exist in productive harmony fulfilling the social, economical and environmental requirements as the three pillars.[2005 World Summit on Social Development.]

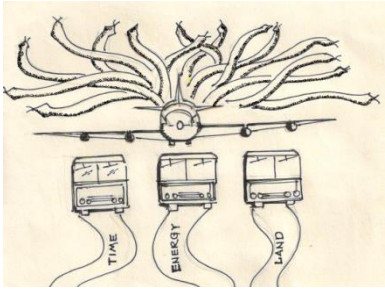


Fig -1: **Modern Hydra**

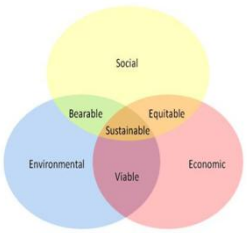


Fig -2: Sustainable Development

2.2 Components for sustainable development

Sustainable development focuses on following major vision simultaneously at a single moment

- Use of natural resources
- To preserve & protect the environmental envelop
- Fulfilment of needs of everyone forwarding the social progress
- Maintenaining the equilibrium between economic growth and employment.

Currently, almost half of the world is urban when 20 years ago it was only one-third. By 2030, it is expected that about 60% of the world's population will be urban. Accommodating such a large population in cities will be a colossal challenge. In such cases, high-rise development is almost certain to be part of the solution.

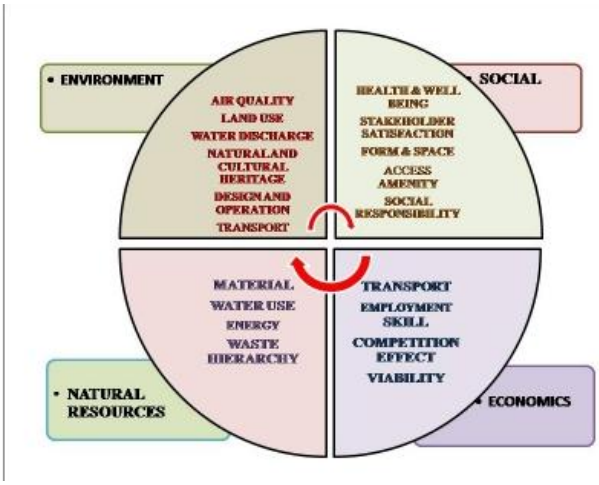


Fig -3: Sustainability Factors

Economic considerations are vital with any form of development. Construction industries are on of the major player for the economical development of country/place. When we see the both face of coin we find that, this industry generate employment to greater extent, on the other side it booms up the land cost. Main factor of sustainability is the location of a building which will directly make a impact on cost of material, cost of labour and the transportation which will directly raise up the building cost, location building also ease of access and desirability of area. Densities often have to be reduced with new developments, increasing the land take and impacting on the economics. Preservation of resources determines the economic activities of the nation hence, promote economic growth. Economical sustainability is not merely think about present but continues generation of revenue for future.

Group of people together forms a community which further develop in social circle to develop social sustainable which is a need of healthy and livable community.

Good quality of life is a result of good quality of surrounding. Therefore it becomes mandatory to reduce negative impact on environment. It is not simply about reducing the amount of waste you produce or using less energy, but is concerned with developing processes that will lead to businesses becoming completely sustainable in the future.

According to the theorist it is said that 20 years ago only 1/3rd of population was residing at urban areas. But scenario changes for present and for tomorrow almost 65% of the population will be urban giving a greater angle of challenge with the raise of no. of population within the specified land availability. In such circumstances, vertical development is the only solution so that horizontal acquiring can be restricted to some extent. There are several issues which needs to be deal while urbanisation.

2.3 Consequences of sustainable urban areas

- Land cost
- Availability of land
- Infrastructure
- Construction and maintenance cost

Land cost and Availability of land

Land prices recently have been significant drivers for development in many cities seeking to re-populate their urban centers with residential-recreational complexes inserted in the predominantly commercial-retail Central Business Districts (CBD) to minimize the use of land. To minimize the impact on land use, the only way to expand is upwards. There is hardly any choice other than to build tall because geographic boundaries limit horizontal growth.

Building up means less building out: an equivalent square metreage of space can be accommodated on a smaller area of land. This allows more land to be used for public realm, conservation and environmental purposes. When developments expand vertically, public space, agricultural lands, and wildlife remain untouched. Tall buildings maximize building area with a minimum physical footprint.

Le Corbusier advocated the high-density city mainly for the purpose of increasing access to nature

Infrastructure

Zoning is an important adjunct of any town planning. The main principle of use of zoning is to divide the city into different sections or zones, and utilizing of each of the zone to the right purpose and in correct location with respect to other

so as to avoid the encroachment of one zone upon another adjoining it. Business or commercial areas are also separately located with their garages and service stations at a distance from the residential areas. As such the residential areas are free from noise, bustle of the road traffic. Commercial zone consists of market, ware-houses, godowns, business offices, banks. This should be located near the centres of traffic preferably the city centre. By taking the optimal advantages of available infrastructure can lead to smart growth of city rather than expanding outwards into the suburb has resulted in descending in travel time, energy consumption as well as CO2 emission. In order to fulfill this vision, it is necessary to put on emphasis on multistory development which further proceeds to clustering of tall building with the easement of better of transport energy in less timeframe and providing an approach to environment sustainability, one can able to layer wise with the arrangement of number of working spaces or business segments spreaded randomly can be single cater of land with several floor plate which ultimately give rise to tall office building

Construction and maintenance cost

Cost of maintenance can be well taken care by energy consumption in the form of material used, ventilation, light and transportation. Buildings should be designed for energy efficiency with the use of passive energy efficiency design features. The building should have proper orientation to gain required amount of solar radiation and heat. Large openings should be provided to get the maximum natural light.

The need to install lifts in tall buildings will increase energy demands, but the day lighting potential is better than in low-rise deep plan buildings. All buildings in the modern world use energy, and modern culture emphasizes the electronic age. The architectural, engineering and construction industries are also advocating e-construction. If a building is then to be truly sustainable that energy should be generated on site tapping into natural energy sources. A tall building can take advantage of renewable energy sources in the same way that a low-rise structure can, but the choice of source might be different.

3. Nature & Architecture

Nature is an always inspirational force in the field of architecture. There are several Architects who got inspired for their creative structure. Among them, well known F.L.Wright who said that "*Nature is my manifestation of God and I am inspired by it. I follow in building the principle which nature has used in its domain*." Another famous Architect , Antino Gaudi said "*Anything created by human being is already existing in great book of nature."*

In a very simple we can understand the conceptual relationship between Nature and Architecture.

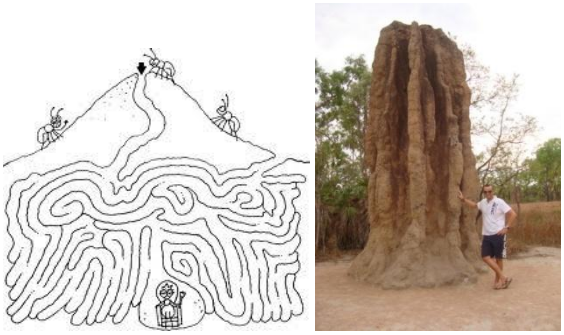


Fig -4: Ant hill (high-rise in nature)

3.1 Tall –tall building

Nature is giving is an examples to understand the meaning of Tall for their shelter. There are many such micro-organisms which are responsible for the creation of tall structure in nature.

The word *TALL* defined height and it is used to compare height of an object or living things with the height of other living thing or objects. Tall word related to building is yet to be set in proper context. Wherever the building is exceeding its average height with surrounding average elevation it is called as tall at that moment for that particular place. It is a relative term to urban context. It may vary from country to country with its larger footprints and massive appearance.

Tall buildings are often regarded as being greater than 20 storey. However, a tall building is really defined with respect to the height of the surrounding buildings. If the majority of the buildings in a city are 3 or 4 storey, then a 12 storey building would be considered tall. In locations such as New York or Hong Kong, a tall building is 40 plus storey high. Four main drivers behind the current boom in tall building construction,

- To gain max revenue from a piece of land.
- To create or set as an example for powerful icon.
- Innovative designs for tall buildings.
- To create dense concentrated cities for more sustainable ways of life.

The symbolic value of a tall building is very powerful in a urban landscape. To architects and the public, the form of a tall building is primary concern. In the development of tall buildings, the overall building form should be one of the major elements that impacts building aesthetics and behavior. However, architecturally, structurally and aesthetically, it is a complex task to develop an optimal form for tall buildings which is climate responsive and which contributes to sustainability.

Historically, the development of the tall building has been dependent on technological advancements.

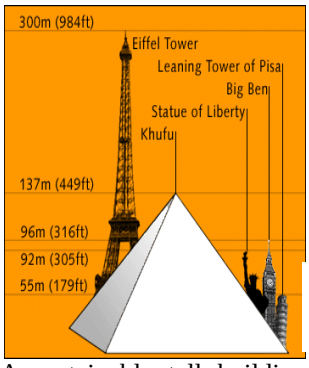


Fig -5: development of tall building from history

A sustainable tall building is one which emits free from pollution to air, land and water, and can be economically occupied throughout its design life, which contributing positively to the local community. It was observed that not only in nature but in the history of Architecture from the early civilization importance and need of tall building was felt and were in existence.

3.1 Advantages of tall building construction

Material:- use of environmentally friendly materials in facades can reduce impact

Repetitive design:- repetitive floor plans can offer major savings in terms of materials and services

Land- intake:- tall buildings acquire less land and allows more spaces for public use & develops healthy recreational environment.

Minimum Footprint:- use of min footprint leads to the gift of more land for public open space, agriculture and for wild life

Floor planning:- use of narrow floor area or depth of floor should be such that it use maximum natural light and ventilation deducting the cost and energy of electrical use

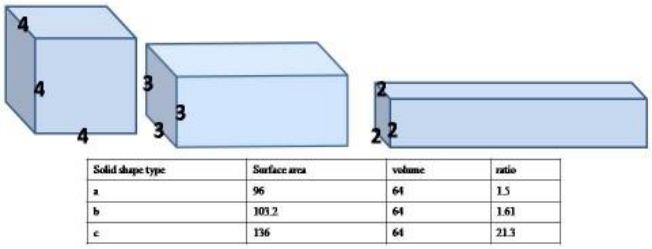
Technology: tall building provided the major advancement in the new engineering and technology for construction.

3.2 Planning and design consideration of tall building

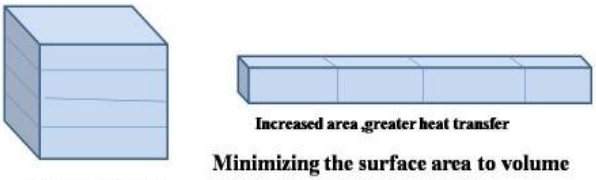
A large quantum of office space is required to have everyone under one roof, and this often means tall buildings in key urban areas which provides expanding and contracting can easily accommodate a degree of flexibility for tenants.
The various considerations for planning and designing the tall building are as follows:

3.2.1 Building form / surface to volume ratio

The volume of space inside a building that needs to be heated or cooled and its relationship with the area of the envelope enclosing the volume affect the thermal performance of the building. This parameter, known as the S/V (surface to volume) ratio, is determined by the building form. For any given building volume, the more compact the shape, the less wasteful it is in gaining/ losing heat. Hence in hot and dry regions and cold climates, buildings are compact in form with a low S/V ratio to reduce heat gain and losses, respectively. Also, the building form determines the airflow pattern around the building, directly affecting its ventilation. The depth of a building also determines the requirements for artificial lighting- greater the depth, higher the need for artificial lighting.



Solid shape type	Surface area	volume	ratio
a	96	64	1.5
b	103.2	64	1.61
c	136	64	21.3



Increased area ,greater heat transfer

Minimal surface area reduces heat transfer

Minimizing the surface area to volume ratio minimizes heat transfer

Fig -6:-Building form & surface to volume ratio

3.2.2 Building envelope and fenestration

Building envelope and its components are key determinants of the amount of heat gain and loss and the wind that enters inside.
The primary elements affecting the performance of building envelope are

- Materials and construction techniques
- Roof
- Wall
- Finishes

A. Materials and construction techniques

- Material with low embodied energy
- Thermal insulation

B. Roof

Roof receives significant solar radiation. The roof is prime source of energy loss in a building in addition to the façade. As such, a 50-story building of 10 apartments per floor has one roof and 500 single-family homes each having the same floor area of an apartment have 500 roofs. Clearly, energy loss from 500 roofs is greater than that from one roof.

C. Walls (façade)

Walls are the major part of the building envelope and receive large amount of solar radiation. Appropriate thermal insulation and air cavities in wall reduce heat transmission into the building. Façade is a important fabric of the building which needs to tackled. Hence **Double-skin facades** are a design strategy increasingly used in medium and high-rise buildings in temperate climates to facilitate natural ventilation, and thus,

potentially reduce operational energy requirements. Double skin facades offer several advantages. They can act as buffer zones between internal and external conditions. **Photovoltaic** (PV) is an advanced and practical solution for the sustainable supply of energy in buildings. PV cells convert light into electrical energy. It is not a new concept but has recently been developed as a viable "building integrated" PV system.

3.2.3 Other miscellaneous

Building Services and Design Issues

Sufficient capacity in the public utilities services of power (electricity, oil and gas), water and sewerage is a pre-requisite for sustainable development of tall buildings, where resource input and waste output are extremely high and concentrated. Building services have to provide a comfortable working environment in the building for several thousand people.

- Vertical transportation
- Electric Lighting and Daylight
- Telecommunications
- Fire safety
- Water and waste water

3.3 Building form

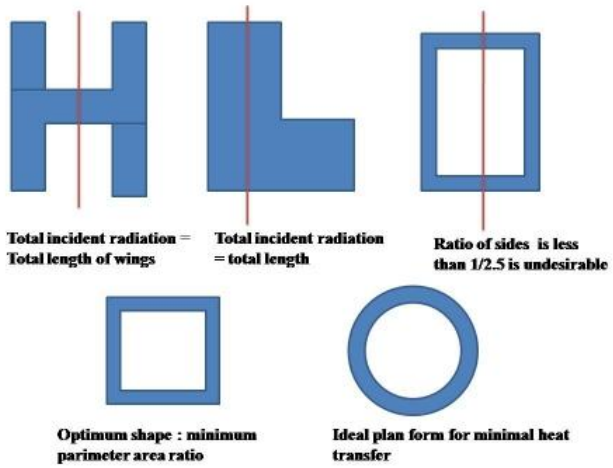


Fig -7: Various types of Building Forms

The exterior shape and texture of large buildings make up the views that people see of the City, and here form plays a vital role. Building form plays the major role in development of tall building which establishes an impact on both aesthetics and behavior. However, architecturally, structurally and aesthetically, it is a complex task to develop an optimal form for tall buildings due to the interrelations of large numbers of components.

The plan form of a building affects the air flow around and through it. It could either add or hinder the perimeter to area ratio of the building is important indicator of heat loss and heat gain. As stated earlier, physical obstacles in the path of airflow create pressure differences. This causes a new airflow pattern. Air tends to flow from high pressure to low pressure areas. Knowing the direction of air movement, the plan form can be determined also as to create high pressure areas to low pressure areas would cause effective natural ventilation. in the case of radiative gain or losses, the perimeter is a crucial factor. However, it goes without saying that a large building would have a greater perimeter than a very small building. To be able to make a real comparison we need to consider the perimeter to area ratio and not just the perimeter. A large perimeter to area (P/A) ratio means that a small area is being bounded by a large perimeter. A small P/A ratio means that the same area would be bound by a much smaller perimeter. A greater the P/A ratio the greater the radiative heat gain during the day and the greater the heat loss at night. Similarly, smaller the P/A ratio, the lesser will the heat gain be during the day and the lesser the loss at night. Thus the P/A ratio is an important factor in controlling heat gain and loss.

Curvilinear form is aerodynamically shape "to confuse the wind" minimizing the negative effect of the wind action on curvilinear form

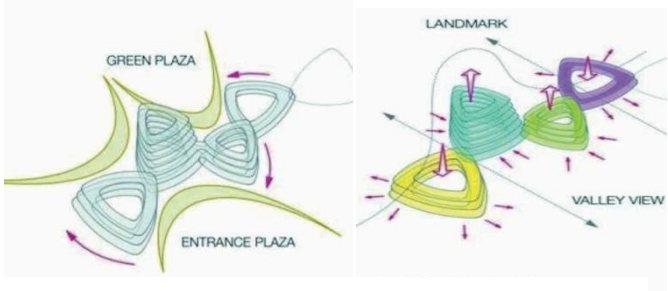


Fig -8: Air response in curvilinear form

3.4 Building Shape and the Effects of Wind

The shape and profile of a tall building determines its performance in wind. Aerodynamic modifications of the building form in conjunction with structural optimization are effective design approaches for reducing wind-induced vibrations in tall slender buildings, which are subjected to across-the-wind motion caused by vortex shedding. In this phenomenon, wind hits a building's façade swirling around adjacent faces revolving in the form of vortices. The principal approach to aerodynamic modification is to "confuse" the wind.

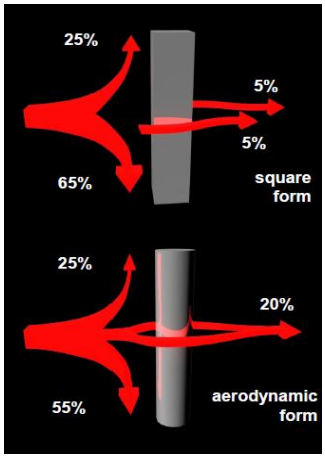


Fig -9:Building form and wind flow

Tall buildings as a built form consume more material and energy resources in their construction, operation, and demolition than the low-rise or mid-rise buildings. By themselves they consume an enormous amount of energy, but

have the potential to consume less energy than low-rise complexes since they have many energy-effective attributes such as agglomeration, savings in auto fuel and travel time, and reduction in losses in power lines, *etc*. Also, power in tall buildings can be served with a shorter length of distribution lines, and hence decreased power losses, than in low-rise complexes, when identical total space served is considered. However, pumping water to higher floors and operating the elevators consume additional energy in tall buildings.

Natural elements being harnessed to improve the sustainability of new buildings

- Free heating
- Free cooling
- Day-lighting
- Rainwater collection
- Solar power
- Wind power
- Orientation on Plan: Daylight and Passive Solar Gain
- Material used

Building Shape and the Effects of Wind

4. Case Study

Buildings such as the Swiss Reinsurance Building in London, the Menara Mesiniaga Tower in Malaysia, Norman Foster's Commerzbank in Frankfurt, Germany are few examples that represent a new generation of sustainable Tall buildings that are challenging conventional Tall building practices and incorporate a powerful visual expression with smart building systems. Tall buildings conceived as "vertical garden cities" can use urban space and resources more efficiently and, at the same time, create more user-friendly and habitable buildings. Consequently, future sustainable tall buildings will need to be even more energy-efficient and functionally diverse with emphasis on multi-functional tall buildings that consolidate living, working, retail, and leisure spaces into a single building.

Fig -10: **The Swiss Reinsurance Headquarters Sectional elevation**

5.1 The Swiss Reinsurance Headquarters

The Swiss Reinsurance Headquarters building, constructed in 2004 in London, Foster and Partners developed innovative technological, urban planning, and ecological design concepts. The steel spiral "dia grid" structure creates an aerodynamic form that provides the lowest resistance to wind. The shape of the building also diminishes demands on the load-bearing structure ,as well as the danger of strong downward winds in the area around the building.

Swiss Re Tower has a circular plan that widens as it rises from the ground and then tapers toward its apex. This form responds to the specific demands of the small site and reduces its apparent bulk as compared to a conventional rectangular mass of equivalent floor area.

The aerodynamic form of the tower encourages wind to flow around its face, minimizing wind loads on the structure and cladding, and enables the use of a more efficient structure. Natural air movement around the building generates substantial pressure differences across its face, which can be used to facilitate natural ventilation within the building.

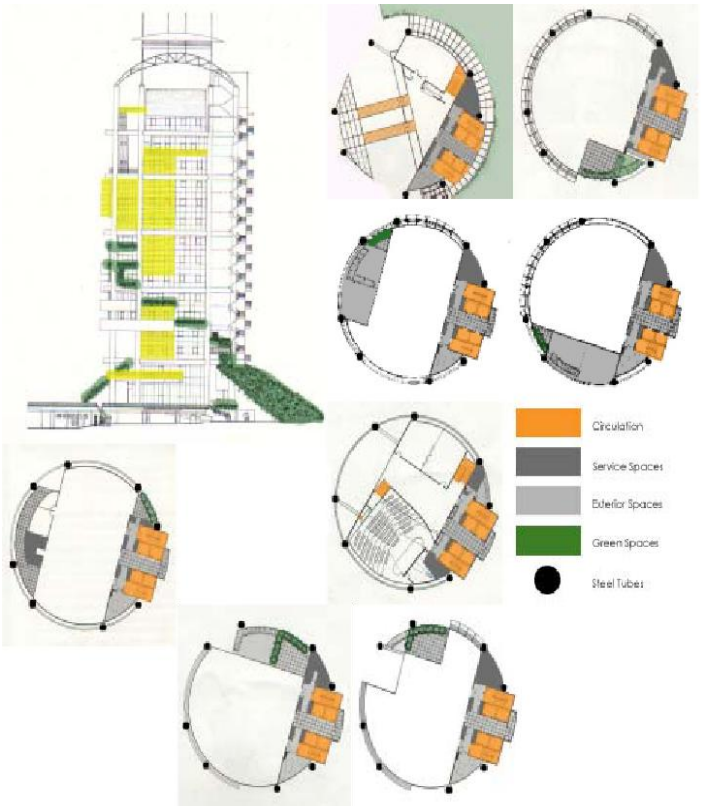


Fig -11:**The Menare Mesiniaga**

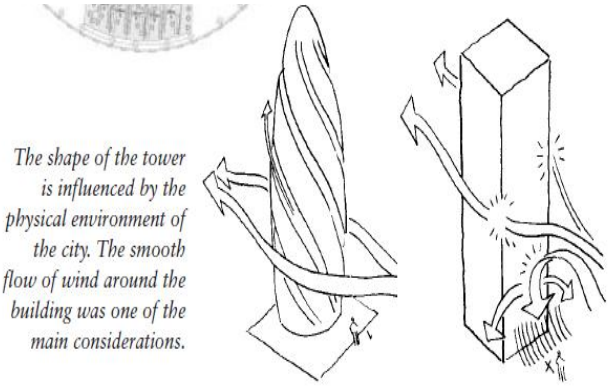


Fig -12: The Swiss Reinsurance Headquarters- Smooth flow of wind

5.2 The Menara Mesiniaga

The Menara Mesiniaga in Subang, Malaysia, designed by T.R. Hamzah and Yeang in 1992, presents an early model building for the physical translation of ecological principles into high-rise architecture .

Fig -13: The Menare Mesiniaga

The fifteen-story tower expresses its technological innovationson its exterior and uses as little energy as possible in the production and running of the building. Instead of a continuous facade, the building opens and closes in sections arranged in stages around the tower.

The interior and exterior structure of the tower is planned around climatic considerations and its orientation toward the daily path of the sun. The massive core of the building, with elevator shafts and staircases, faces east and screens off the penetrating heat up to midday Deep incisions and suspended aluminum sunscreens on the south facade ward off the direct rays of the noon and afternoon sun into the interior. Most of the office space faces west and north.

Around the base of the tower lies a semicircular, steeply sloping garden, which continues into the building itself in the form of spiral terraces planted with grass. This visibly brings the natural environment into the architecture.

5.3 Commerzbank: Frankfurt, Germany

Norman Foster's Commerzbank in Frankfurt,

Foster creates a piece that not only meets those requirements, but defines space not scene before in tall building design. Winter gardens allow vast amounts of light deep within the building and provide pleasant views to those working deeper within the building.

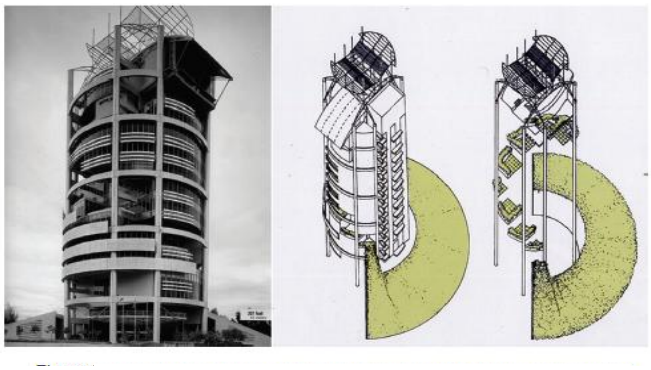


Fig -14: Details Of The Menara Mesiniaga

Plan Development

First of all, the typical building layout includes a centralized core area for circulation, mechanical, and other basic building needs. To achieve this, the core functions were pushed to the outer corners of the building to make way for the atrium space.

Architectural Intent

Although Norman Foster's Commerzbank design was the tallest building in Europe at the time of its completion, its height was an after-thought to the true intentions driving its creation. Commerzbank is a social, economic, and ecological statement in architecture. Foster considered the lives of theusers, clients, and neighbors of the building when formulating his design. Fosters social, economic, and ecological goals often overlapped. Foster could have designed a cheaper building than what Commerzbank is today, but he asked his clients to consider additional investments to realize long-term gains. The buildings program enhances its users lives and because of this increases their productivity. The ecologically friendly design lessens the energy costs required to maintain the building over time. Even the decision to build in the urban core of Frankfurt rather than on cheaper land in the suburbs, continued the growth of Frankfurts development and contributed to the strength of the city as a whole.

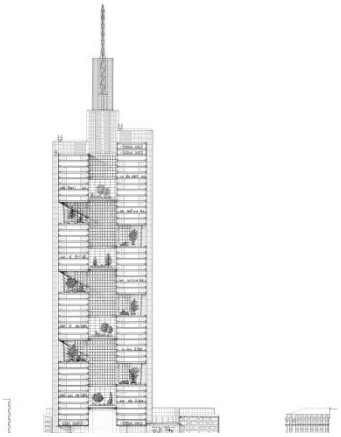


Fig -15: sectional detail of Commerzbank: Frankfurt, Germany

Structure

The structure of Norman Fosters Commerzbank Headquarters is essentially a perforated tube in the shape of an equilateral triangle. The structural components work together to form this shape and to resist both gravitational and lateral forces.

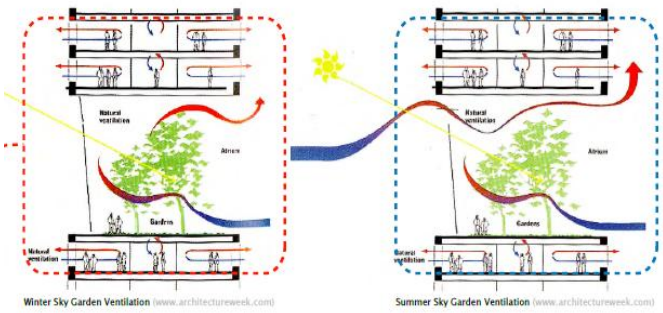


Fig -16: sectional detail of Commerzbank: Frankfurt, Germany

Environmental Response

Considered to be the world's first ecological office tower, Commerzbank Headquarters relies heavily on passive strategies to create a pleasant work environment for its occupants. These strategies include a triangular (doughnut) floorplan, 'sky' gardens, and a full-height atrium that allows for every office in the tower to have operable windows for views, natural ventilation, and daylight. The four-storey 'sky' gardens (which spiral up the sides of the tower) provide fresh air and allow for passive solar gain, while the central atrium space acts like a natural ventilation chimney for the inward-facing offices. Despite the effectiveness of passive systems in Frankfurt's temperate climate zone, Foster recognizes the potential for technical (active) systems to maximize the buildings efficiency. A computer controlled building management system decides whether passive or active systems are most appropriate for use at a given time and adjusts openings and shading devices accordingly. Commerzbank tower also uses water, instead of air, to condition the building, which saves a tremendous amount of energy over the life of the building.

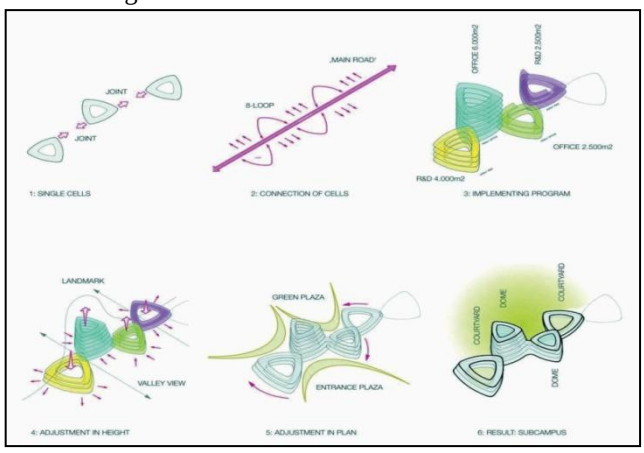


Fig -17: planning details of Commerzbank: Frankfurt, Germany

CONCLUSIONS

- Tall office building plays major role in the economy generation for a city for a country with minimum foot print.
- Energy efficiency has become the core issue for the acceptance of any design solution that advocates long-term economy.
- The application of green technologies in tall buildings can accelerate our march towards sustainability.
- Curvilinear forms are best suited form for climatic consideration.

REFERENCES

1) Council on Tall Buildings and Urban Habitat, (1995) Architecture of tall buildings. New York: McGraw-Hill Inc Hyeong-ill Kim, (2004) Space efficiency in mixed-use high-rise building. Illinois Institute of Technology
2) Kamon Jirapong, (2002) Discovering architecture within seashell. Illinois Institute of Technology
3) Nianquan Zhang, (2001) A computer-based environment for preliminary structural design, design collaboration and design automation of tall buildings. Hong Kong University
4) Alison Crompton, Ant Wilson, Sustainable Tall Buildings- Fact or Fiction?, Faber Munsell Ltd.
5) Environmental Applications of Nanotechnology, Science, Technology and Society, the university of texas @austin
6) Brundtland Report "Our Common Future" World Commission on Environment and Development. 1987.
7) . "Building a Better Quality of Life" A strategy for more sustainable construction April 2000, HMSO.
8) "Tall Buildings and Sustainability"- Economic Development Office, Corporation ofLondon, March 2002.
9) Energy efficient buildings by Mili Mujumdar.
10) Stratagies for integrated design of sustainable tall buildings by Mir M.Ali,Paul J.armstrong(university ofillionois)

BIOGRAPHIES

Ar.Priya Gupta is currently the Assistant professor In Radhikatai Pandav Institute Of Architecture,Nagpur,India. Before joining the college she has been worked as Assistant professor in HCET & HCATP Jabalpur for over five years. contributed her experience in civil as well as architecture. She did her masters in architecture education from Nagpur, she is an active researcher and has published a paper in architectural magazine.Her interest areas include experiment & explore in the field of Architecture education.. In addition, she has also enthusiastically contributed to the relevant professional institutions and the community.
Contact Details: Mob:-8087061296, Email: priyaaguptaa7@gmail.com

Ar.Anjali V.Narad is currently the Assistant professor In Radhikatai Pandav Institute Of Architecture, Nagpur, India. Before joining the college she has been worked as Assistant professor In **K.I.T.S Ramtek** for over three years. Her experience in the construction industry, especially as a interior designer. she is an active researcher and has published a number of research papers in national & international conferences. Her current research interests includes, sustainable & green development in the field of Architecture. In number of research papers in national & international conferences. Her current research interests includes, sustainable & green development in the field of Architecture. In addition, she has also enthusiastically contributed to the relevant professional institutions and the community.

Contact Details: Mob:-09595484232**, Email:**abhasme3@gmail.com,ar.anjali616@gmail.com