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Design of Green Township for Sustainable Development and Energy Conservation

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Abstract - *The escalating population, urbanization, industrialization and pollution levels have caused serious damage to the environment thus the objective of this research is to bring nature back to its long lost glory. The contribution of the construction industry and the energy production industry is huge in this pollution. The time has come for us to rethink and bring about a change.*

The research presents a sustainable green and energy efficient township in Khopoli which gives more to the environment than take from it. The town planning incorporates various residential, commercial, educational, medical, agricultural and recreational amenities in a walk to destination concept within a 1.5 km radius. All the structures are structurally robust and architecturally marvelous and intellectually appealing and follow LEED and TERI guidelines.

The 2D planning, 3D modeling, structural analysis and design analysis are done using AutoCAD, Autodesk Revit, STAAD Pro and Design Builder Software respectively. The use of solar and other sustainable power sources powers the town. The inclusion of grey water recycling system, efficient water, sewage and garbage treatment methods, ergonomic road design, Bio-mimicry conceptualization, feasibility prioritization are the key highlights of the research.

Key Words: Green Township Planning, Environmental Protection, Energy Conservation, Bio- Mimicry

1. INTRODUCTION

Nature is the only thing that can sustain in this world. Nature sustains itself and anything that is left in her womb. None of the artificial-human made developments or structures will survive or sustain if it does not follow the rules of nature.

The construction industry and buildings themselves contribute to 35% of all the emissions and energy usage which have put the fauna and flora of the entire planet at risk of great deterioration. Green buildings and sustainable development ensure the wellbeing of all aspects of the environment.

We are civil engineers, the nation builders, bringing in change for an entire civilization with the help of Green and sustainable township. We need to promote the concept of 'man with nature' rather than 'man and nature' and restore the mystical link between nature and our habitats which was cut off due to urbanization. Each and every structure in the township is designed so as to create eco-friendly habitat for a sustainable future.

1.1 Objectives

1) To use AutoCAD software for depicting two-dimensional floor plans and column and beam layout plans.

2) Using Autodesk Revit for designing and planning aspects with render three-dimensional models of all the building components

3) To use STAAD Pro Software for the structural analysis of one of the structures.

4) Design Builder software for building performance analysis, energy efficiency calculations for residential villa and apartment.

5) To use solar and other sustainable power sources in the project for the improvement of sustainable energy efficiency.

2. METHODOLOGY

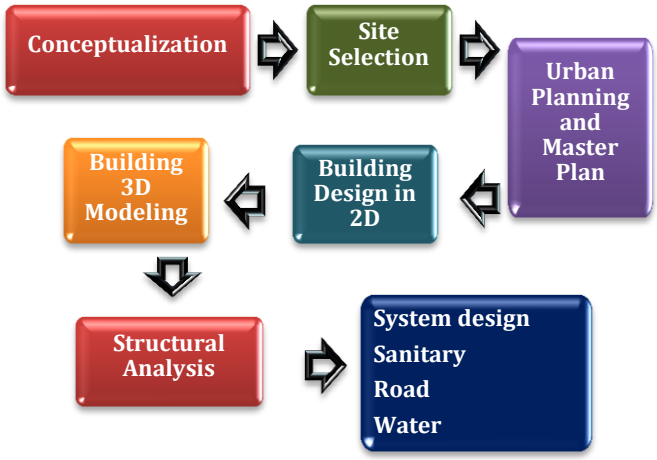

Chart -1: Methodology

2.1 Site Profile

We considered a site adjoining the Mumbai-Pune highway in Khopoli. Khopoli is a city in the Khalapur taluka of Raigad district, in the Indian state of Maharashtra, at the base of the Sahyadri Mountains. The site profile is as mentioned in Table 1.

Table -1: Site Profile

Parameter	Description
Location	Khopoli, Ratnagiri, Maharashtra India
Coordinate	18.7939° N, 73.3346° E
Altitude	67.00 m
Latitude	16.98°
Longitude	73.33°
Area	Rectangular plot of 1.153Km^2
Climate	Tropical monsoon with extremely heavy rainfall from June to September.
Major River	Patalganga
Soil type	Laterite soils and hard Basalt rock

2.2 Population Forecasting

Table -2: Population Forecasting Data

Year	Population	Increase	Incremental	Incremental (%)
1991	49000	-	-	
2001	63020	14020	-	22.24
2011	108648	45628	31608	41.99

x = 14020+45628/2 = **29824**

y = **31608**

METHOD 1: ARITHMATIC METHOD

Pn = Po + nx

P2021 = 108648 + (1 x 29824) = **138472**

P2031 = 138472 + (1 x 29824) = **168296**

P2041 = 168296 + (1 x 29824) = **198120**

METHOD 2: INCREAMENTAL INCREASE METHOD

Pn = Po + nx + n(n+1)/2 y

P2021 = 36107 + (1 x 29824) +1(1+1/2) x 31608 = **170080**

P2031 = 36107+ (2 x 29824) +2(2+1)/2 x 31608= **263120**

P2041= 36107+ (3 x 3(3+29824) +3(3+1)/2 x 31608= **387768**

Average population the from result of arithmetic method and incremental increase method is given below

2021 population is **154276**

2031 population is **215708**

2041 population is **292944**

After calculating population forecasting, we decided to plan the township for a minimum of 10,000 people.

2.3 Water Demand

Water demand for the township was calculated on the basis of population, to estimate the supply of long-term requirements. Waste water generated from the communities can be considered as a resource for recycling, recharging and creating water balance for the township.

Table -3: Water Demand

Average daily water demand	(per capita average consumption in l/p/d) =250 x 10000 lit/day	25 MLD
Maximum day demand	=180/100 x 25 MLD	45 MLD
Maximum hourly demand	=270/100* Average daily water demand (Assuming 270% of annual average demand)	67.5 MLD
Fire water demand	By American Insurance Association's formula: Q (L/min) =4637 √P (1-0.01 √P) Using population in thousands as equal to P=10 thousand (i.e., 10,000)	14199.78 Lit/min =14199.78 x 60 x 24/1000000 =20.44 MLD
Total water demand	Maximum day demand+ Fire water demand=45+20.44	**67.44 MLD**

2.4 Electric Power Demand

The following standards have been adopted for the estimation of power requirement for the planning area.

Domestic Demand

1. 1.5 KW per household for EWS/LIG
2. 3.0 KW per household for MIG
3. 4.0 KW per household for HIG

Commercial and Industrial Demand

1. 1.5 KW per Shop
2. 10 KW per Service

Industrial Unit Social Facilities and Public Utilities Demand

1. Public Facilities – 50 KW per 7500 persons
2. Public Utilities – 120 KW 7500 persons

Table -4: Power requirement in Residential Areas

Sr. No.	Household	No of houses	Power requirement in MW
1	LIG	480	0.72
2	MIG	960	2.07
3	HIG	20	0.08
	Total	1460	2.87

Table -5: Power requirement in commercial areas

Sr. No.	Shops and service industries	Unit per 1000 persons	Power requirement in MW
1	Shops	20	1
2	Service industry	2	10
	Total	22	11

Table -6: Power requirement in public amenities and facility

Sr. No.	Facility	KW per facility	Power requirement in MW
1	Social	50	2.6
2	Public Utility	120	6.2
	Total	170	8.84

To satisfy this demand, we have constructed solar power plant on wide-open spaces, constructing a solar farm, which produces a significant amount of electricity.

2.5 Master Plan

The northern part of the township is dedicated to residential purposes. The hospital is located in the central part for easy accessibility. The central part has a grey water recycling canal and the center and the southern part for commercial purposes.

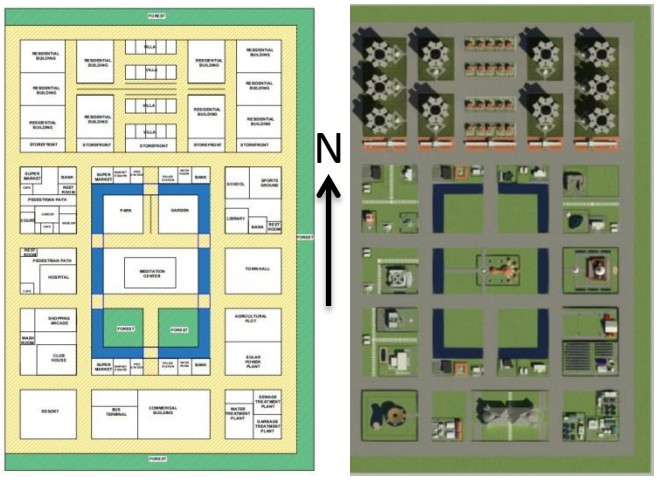

Fig -1: Master Plan of Township

2.6 Components of Township

Fig -2: Components of Township

2.7 Transportation

Transport network is the backbone of growing cities. Around the proposed plan where adequate land has been reserved for circulation, integration of public transport and parking.

Following parameters have been taken into consideration while planning transport system

1. Walk: Developing neighbourhoods that promote walking by providing neighbourhood facilities and public transport at walk able distance

2. Cycle: Promoting and encouraging non-motorized transport system by providing cycle-specific lanes and reducing emissions.

3. Connections: Creating networks of streets and roads, proposing roads in loops to provide a choice of mobility.

For road planning, we have considered a one-way, two-lane road of 8 m on either sides of the median. The median is converted into an emergency lane especially for vehicles like ambulance, fire brigade, police van, etc. to prevent any delays in their workflow. This emergency lane is provided with shading with solar panels to generate electricity. On either side of this 6m wide emergency way a 2 meter wide green patch is provided. Busses are known to stop at continual distances and create traffic congestion to avoid this separate 4 meter wide bus lane is provided. A special bicycle lane is provided on the peripherals of the road along with a pedestrian path and a 1 m wide green patch. To avoid accidents due to road crossing for the bus terminal, we are proving special skywalks. The bus stop lane is adjacent to the pedestrian path. The entire width of the road is 52m.

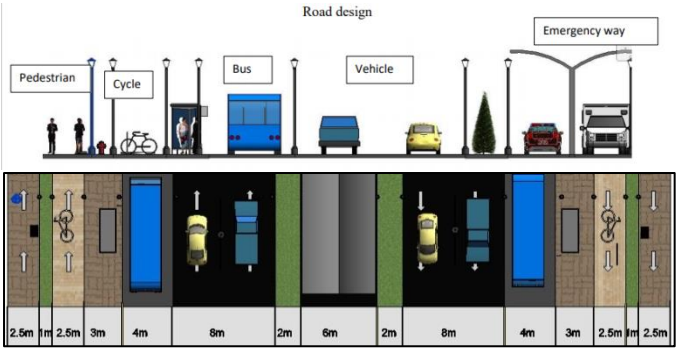

Fig -3: Road Design

3. REVIT 3D MODELS

Autodesk Revit is BIM software that enables the user to model 3D models of buildings and efficiently model the interiors and landscaping aspects along with structural detailing.

3.1 Residential Buildings

For housing facilities, we have planned for three types which are based on income groups these are LIG, MIG and HIG. The total number of flats in the LIG is 940 and in MIG is 640 and HIG comprises of 20 villas.

Fig -4: Villa and Residential Building

3.2 Commercial Buildings

For the economic development we have planned commercial spaces like two office buildings, four banks, three super market, two market squares and a shopping arcade.

Fig -5: commercial office building

Fig -6: Bank and Super Market

Fig -7: Market Square and Shopping Arcade

3.3 Educational Facilities

Educational institutes comprises of a school, library and museum one unit each.

Fig -8: School and Library

Fig -9: Museum

3.4 Healthcare

For health care we have provided a hospital which is centrally located.

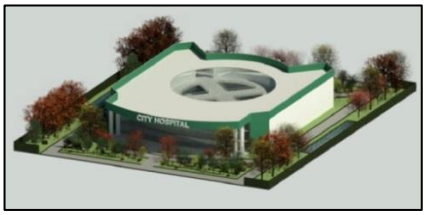

Fig -10: Hospital

3.5 Government Institutional Buildings

For government institutional buildings we have designed a town hall and a court and along with that three units of fire station and police station each.

Fig -11: Town Hall and Court

Fig -12: Fire Station and Police Station

3.6 Recreational Buildings

The recreational spaces include three cafes and a single unit of club house, resort and wellness center each.

Fig -13: Café and Club House

Fig -14: Resort and Wellness Center

3.7 Public Amenities

The central part of the township serves as an open space inclusive of lush green trees and joggers Park. This area will not only act as a recreational area but also as the lungs of the township. Along with this, we have designed eco-public washrooms and a bus terminal.

Fig -15: Central Park, Public Washroom and Bus Terminal

4. REVIT SOLAR ANALYSIS

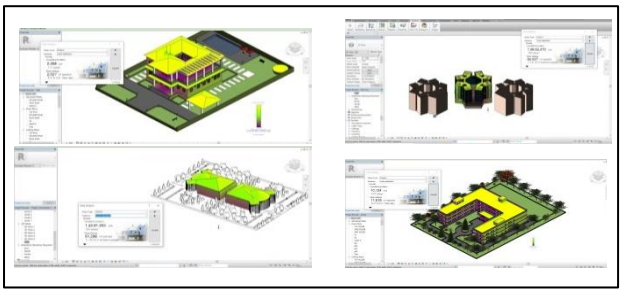

Fig -16: Solar Analysis Results: Villa, Apartment, School and Office

5. STRUCTURAL ANALYSIS

The G+13 storey residential building structure is capable to sustain all loads including earthquake and wind loads acting on it. Slab, beam, column, rectangular footing and staircase are designed with IS 456-2000 using limit state method. We have taken one box of building which consists of two flats because our building is symmetrical in shape and to make analysis easier to understand. The one box which we have chosen here is an apartment, which is a G + 13 storey with a base area of about 246.11 square meter with a total height of 55.5 m and floor to floor clear height of 3.70 m for all floors. For the part of drafting floor plans, AUTO CAD is used for center line of column beam layout plan which had imported in STAAD pro and further design and load analysis is done.

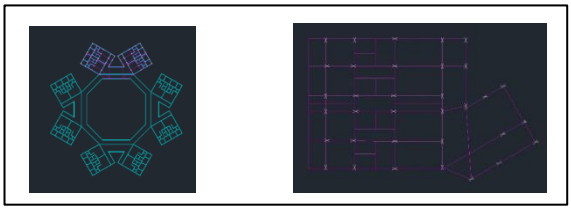

Fig -17: DXF file of AutoCAD with center line and column

Table -7: Dead Load

Sr.No.	Items	Weight
1	Self-weight factor	1
2	Slab load including floor finishing	4.75 KN/m^2
3	Wall load (300 mm thickness)	15.66 KN/m^2
4	Wall load (135 mm thickness)	7 KN/m^2

Table -8: Live Load

Sr.No.	Items	Weight
1	Live load (flat area)	2 KN/m^2
2	Live load (balcony +corridor +terrace +service floor area)	3 KN/m^2

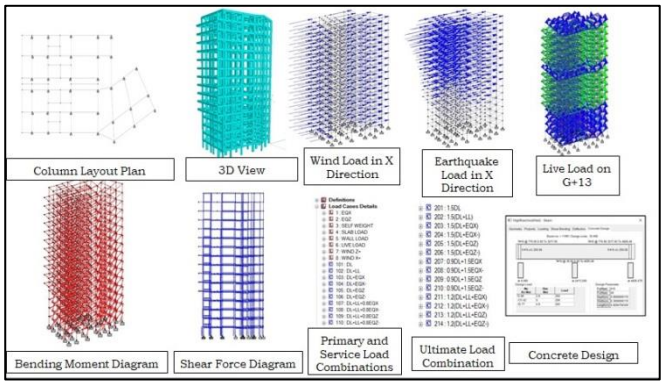

Fig -18: STAAD Pro Results

6. DESIGN ANALYSIS

Design Builder software uses the Energy Plus dynamic simulation engine to generate environmental performance data such as: energy consumption, carbon emissions, comfort conditions, daylight illuminance, maximum summertime temperatures and HVAC component sizes.

Table -9: General Information

		Apartment	Villa
Architectural space data	Total Building area	2708.78 m^2	246.80 m^2
	Atrium space area	1141.80 m^2	20 m^2
	Gross Roof Area	1141.80 m^2	284.98 m^2
Mechanical system data	Heating system	Floor heating, Floor Type Fan coil	
	Fuel of Heating system	Electricity	
	Cooling system	Fan coil and Natural Ventilation	
	Fuel of Cooling system	Electricity	

In design builder, after putting input data regarding construction, opening, HVAC and lighting system in the model, each zone of a building is created separately to find efficient results of energy consumption. “ASHRAE 62.1 Ventilation for acceptable Indoor Air Quality standard”, “ASHRAE-55 Thermal Environmental Conditions for Human Occupancy” and “ASHRAE 90.1 2007- Energy Standard for Buildings except Low-Rise Residential Buildings” were defined among zones in the program. Natural ventilation of the building helps to reduce the required energy and surrounding temperature through

atrium. Even blocks of the apartment adjacent to each other help in sun shading.

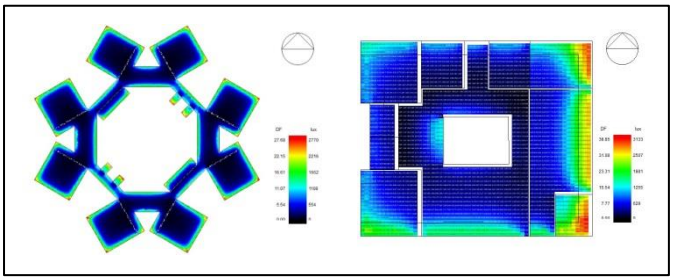

Fig -19: Illuminance Result: Residential Building and Villa

Table -10: Illuminance result according to LEED

Description	Apartment	Villa
Total area (m^2)	2776.6	225.7
Total area meeting requirements (m^2)	2401.1	212.2
% area meeting requirements	86.5	94.0
LEED NC 2.2 Credit EQ 8.1 Status	**PASS**	**PASS**

Table -11: Thermal Properties of materials used in apartment in design builder

Wall	Brickwork Outer	105.00 mm	U values
	Air Gap	25 mm	0.825 W/M^2-k
	Phenolic Foam	25 mm	
	Concrete Block [Heavyweight]	100.00 mm	
	Plaster [lightweight]	13 mm	
Pitched roof	Board Insulation [Glass Fiber board]	95.60 mm	0.358 W/M^2-k
	Metal deck	10.00 mm	
facades	Guardian Green Float glass	3.2 mm	1.940 W/M^2-k
	Air Gap	12 mm	
	Generic clear glass	6 mm	

Table -12: Energy Use Intensity -Electricity (LEED Summary)

Description	Apartment	Villa
	Electricity [kWh/m^2]	Electricity [kWh/m^2]
Interior Lighting (All)	304.44	18.49
Space Heating	0.00	0.00
Space Cooling	1017.39	56.64
Fans (All)	128.29	7.08
Receptacle Equipment	104.39	104.39
Miscellaneous (All)	186.60	186.60
Subtotal	186.60	186.60

7. CONCLUSIONS

As a solution for the survival of humanity in an ecologically literate manner we have designed and proposed a plan for sustainable township. To create self-sustaining township, we have added various substantial facilities which do not harm the environment like the solar power plant, rain water harvesting system, previous concrete pavements and urban farming. By building a sustainable township, we are creating better livelihoods, increasing economic growth, improving social inclusion and promoting the decoupling of living standards from smart environmental resource use, uplifted projection of local materials and manpower and protecting regional ecosystems.

We conclude by saying that our sustainable township is an embodiment of a sustainable future that entrails in developing the physical, mental, emotional and meta-physical lifestyle of its citizens' by prioritizing environmental and economic stability.

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