"Planning, Designing and Analysis of Net-Zero Residential Building with BIM Integration".

Dr. A.R. PATIL,
Head of Civil Department, JSPM's RSCOE, Pune, Maharashtra, India-411033

SOORAJ NAIR
Student of B.E. JSPM's RSCOE, Pune, Maharashtra, India-411033

NIHAL SHINDE
Student of B.E. JSPM's RSCOE, Pune Maharashtra, India-411033

SIDDHANT PAWAR
Student of B.E. JSPM's RSCOE, Pune Maharashtra, India-411033

---***---

Abstract - *Due to the ever-increasing population and the subsequent need for urbanization, there is an excessive load on natural resources to compensate for the energy requirements. In the construction domain, this requirement is quite high. This has led to the evolution of the Net-Zero Energy concept that can relieve the energy requirements of these buildings in the future. Sustainable development and sustainable engineering are the need of the hour given that the cost-benefit ratio is in the green. In this project, a a residential building has been planned and designed with the Net-Zero concepts in mind which later is analyzed with respect to a conventional residential building for parameters such as active energy loads, availability of materials, and cost-benefit ratio. The Net-Zero Energy Building (NZEB) is designed to be operated by solar energy along with the energy from grid under the clause that the excess can be given back to the grid. Thus far, findings indicated that though the project has a high initial investment it proves to have a better cost-benefit ratio as compared to a conventional building. NZEB could become a sustainable way of constructing buildings and infrastructure which promises a greener and brighter futurefor Earth and people alike.*

***Key Words*: AutoCAD, SketchUp, Lumion, Google Earth Pro, Solar Energy, Sustainable Development, Net Zero Energy Building**

1. INTRODUCTION

Acceleration of Urbanization and consequently the need and consumption of energy is ever-increasing. In Maharashtra, since 2009, the consumption has increased from 1054.1 KWh to 1317.7 KWh which growing at an average annual rate of 3.88%. And the MSEB is unable to fulfill the requirements of the public and industrial sectors. With multiple factors affecting the energy industry such as shortage of coal reserves, movement for turning to Green fuel, increasing global warming and so on, it is important to bring in new building technologies which can utilize renewable energy resources.

So, to define a design workflow of said project we have chosen a land for its development. We have named that Project SNS Complex, which is located at Kasarasai, Pune, India. (Refer **Figure 1: Project SNS Complex Location**)

The global position of the site is at about 18°38'N 73°39'E. The site is about 7.4131 acres located on the outskirts of the town of Kasarsai and Chandkhed. This project is initiated for planning, designing and analyzing a Net-Zero Building capable of using the available renewable energy resources using multiple BIM software integration. To determine the Design workflow of the Project we have considered a G+ 1 residential building incorporating provision for using the available renewable resources such as solar energy.

Figure 1: Project SNS Complex Location

1.1 Key Objectives

The Objectives of this Project are listed below:

- Design a commercial building and landscapewith Net Zero Energy concept
- To eliminate the requirement of Active Energyof a building
- Comparing the designed NEB building withconventional building.

1.2 Project Scope

We will prepare consultancy services for the planning, concept and preliminary design, detailed engineering, and preparation of construction drawings for the following utilities by using multiplesoftware integrations:

- Functional Planning of G+1 Residential Building
- Design of Solar Panels
- Comparison of Room Temperature betweenNZERB and Conventional Building
- Comparison of Energy Consumption betweenNZERB and Conventional Building
- Conceptual Modelling

This report is the Assessment Report for the 7.4131 acres G+1 Residential Building in the outskirts of Kasarsai and Chandkhed Village.

2. Methodology

As we were defining a design workflow of proposed building using multiple software Integration, we have split the design workflow into different steps asfollows:

- Detail Topographical Study of the site by using

QGIS and **Google Earth Pro** Software.

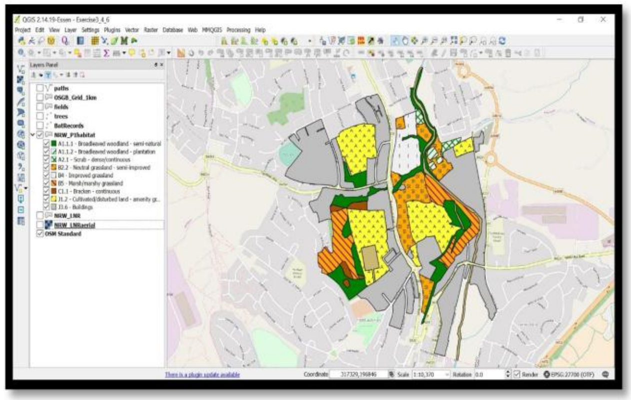

Figure 2: QGIS Reference

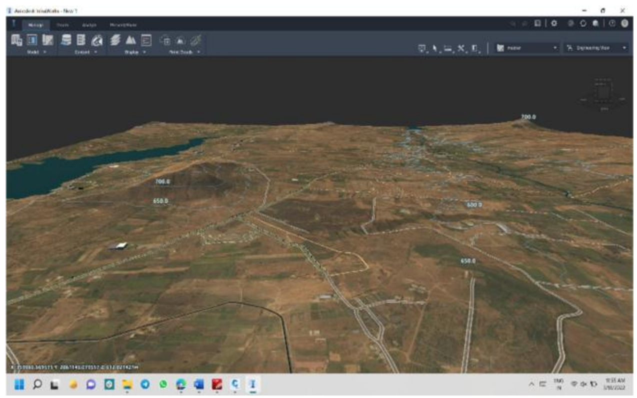

Figure 3: Infraworks Model

- Preparation of Master Plan for the Area by using **AutoCAD** and **SketchUp Pro** software**.** Also to plan and design proposed NZEB Building.

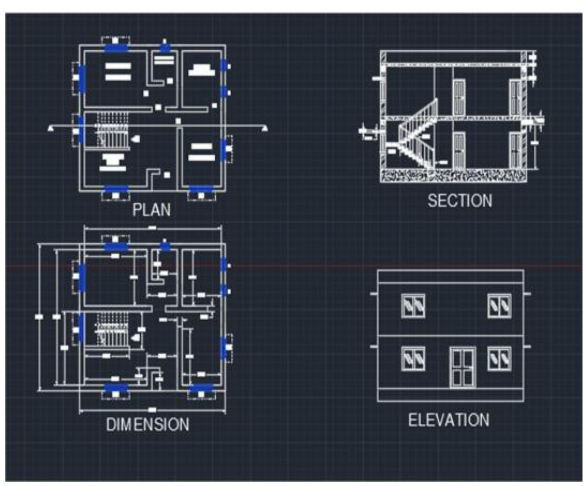

Figure 4: Master Plan

- Site Preparation & Site Grading using **Civil 3D** software.

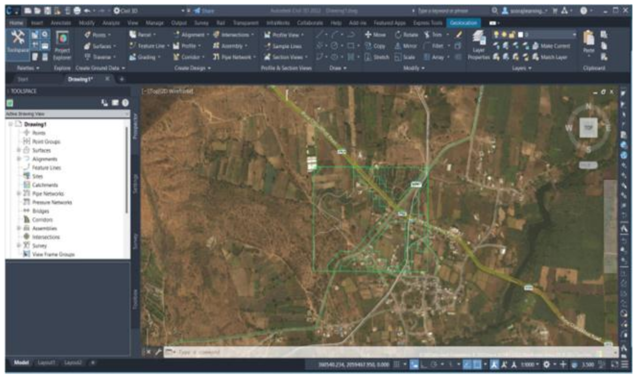

Figure 5: Optimization of Site Location

- Conceptual Modeling/3D Visualization of Entire Project using **Infraworks-360**, **Twin motion,** and **Lumion 10** software.

Figure 6: 3D Modeling using Infraworks, Lumion &Twinmotion.

- Comparison of the NZEB Building with other Conventional Building

3. Expected Outcome

- To design a NZEB building capable for being self- sustainable.
- To provide consultancy services for the planning, concept and preliminary design, detailed engineering for the following utilities:
- Functional Planning of G+1 Residential Building
- Design of Solar Panels
- Comparison of Room Temperature betweenNZERB and Conventional Building
- Comparison of Energy Consumption betweenNZERB and Conventional Building
- Conceptual Modeling
- Comparative study of Conventional Building and NZEBusing various parameters.

Various design codes/standards were referred to for thedesign of the residential building structure.

- The codes for the design of buildings and structures,IS 875:1987 -1,2

- Design loads for buildings and structures (Dead load,Imposed load), IS 456:2000 Design co-efficient
- Limit state design method used for slab and footing, IS 2572-1963(R 1997)
- Design of Hollow bricks, IS 1905:1987
- Structural use of Unreinforced Masonry, SP 20:1991 Handbook of Masonry Design and Construction

A residential building zone is considered wherein buildings shall be permitted for the following purposes and accessory uses:

(1) Place of entertainment and recreational uses.

(2) Business and Professional office

(3) Services uses like hair cutting saloons, tailoring shops,beauty parlors, laundry, and dry cleaning shops, etc.

(4) Restaurants, hotels, and eating houses.

(5) Boarding houses, social and welfare institutions.

(6) Clinics, public utilities, and buildings.

(7) Parking lots.

(8) Public recreational uses.

(9) Meat, fish, vegetable & fruits markets.(10)Wholesale & retail shops

(11) Wholesale storage yards.

(12) Weigh bridge & other uses incidental to the main use.

In so far as the determination of the sufficiency of all aspects of structural designs, building services, plumbing, fire protection, construction practice, and safety are concerned the specifications, standards, and code of practices recommended in the National Building Code of India, shall be fully confirmed to any breach thereof shall be deemed to be a breach of the requirements under these rules. Every multi-storied development erected shall be provided with (i) Lifts as prescribed in National Building Code; (ii) a standby electric generator of adequate capacity for running a lift and water pump, and a room to accommodate the generator; (iii) a room of not less than 6 meters by 4.5 meters in area with a minimum headroom of

3 meters to accommodate electric transformer in the ground floor; and (iv) at least one-meter room of size 2.4 meters by 2.4 meters for every 10 consumers or three- floor whichever is less. The meter room shall be provided on the ground floor.

All buildings in their design and construction shall be such as to contribute to and ensure individually and collectively the safety of life from fire, smoke, fumes, and also panic arising from these or similar other causes. In a building of such size, arrangement, or occupancy that a fire may not itself provide adequate warning to occupants automatic fire detecting and alarming facilities shall be provided where necessary to warn occupants of the existence of fires, so that they may escape, or to facilitate the orderly conduct of fire exit drills. Fire protecting and extinguishing system shall conform to accepted standards and shall be installed in accordance with good practice as recommended in the National Building Code of India, and for the satisfaction of the Director of Fire Services by obtaining a no-objection certificate from him .

The applicant shall deposit a sum at the rate of Rs.100 per square meter of floor area as a refundable non-interest earning security and earnest deposit.

The deposit shall be refunded on completion of development as per the approved plan as certified by CMDA, if not, it would be forfeited.

The complete project is planning and design in nature and the methodology followed is as follows:

1. Selection of Site where Renewable energy is available:

The village Kasarsai is located in Mulshi Tahsil of Pune District in the State of Maharashtra in India. The weather is hot and humid for most of theyear. The hottest part of the year is late March to early May with a clear sky most of the year. Hencesolar energy is available abundantly on the site to be harnessed.

2. Study the Climate conditions of the Area:

The village lies to the north of the thermal equator. The weather is hot and humid for most ofthe year, with a maximum temperature of around 33-40°C.

3. Alignment of the Building to Utilize maximum amount of Renewable Resources:

The building is designed to be elongated East- West and oriented with South-facing windows to harvest solar energy.

4. Planning and Design of Proposed NZEB Building

5. Comparison of the NZEB Building with other conventional buildings.

The Solar energy is harnessed using solar panels. The workings of these panels are as follows:

The solar panel converts sunlight into DC power or electricity to charge the battery.

i. This DC electricity (charge) is controlled via a solar regulator which ensures the battery is charged properly and not damaged and that power is not lost/(discharged).

ii. DC appliances can then be powered directly from the battery.

iii. AC appliances need a power inverter to convert the DC electricity into 220 Volt AC power.

Rate Analysis for the NZEB Project is as follows:

1. NZEB Building
    - NZEB Construction Total Cost =1,013,057.00
    - Solar Panel and Assembly Total Cost =142600.00
    - Total Cost for Overall Project =1155657.00
2. Conventional Building
    - Overall Cost = 1013057.00
    - Over 5 years tenure Costs inculcatedthrough energy consumption=179436.2
    - Total cost = 1192493.00

Here the overall initial cost of the NZERB building is higher; in the long run it is able to save a considerableamount of money in terms of reducing electricity consumption.

3. CONCLUSIONS

In this project we have completed the complete planning, designing of an NZEB Residential Building and analysis with respect to a Conventional Building. The planning, Designing, and Analysis was done using multiple BIM software.

The comparison between the NZEB and Conventional Building was done using parameters such as Active Load calculations, Temperature, and overall efficiency over 5 years. It was observed that even though the initial cost for the NZEB was higher, it had better efficiency and higher energy savings over a longer period of time. The energy- saving was able to compensate for the high initial cost over the period of time. It shows that by using renewable energy as an alternative we can save money over a longer period of time as well as make sure that there is no negative environmental effect. This is a very effective and efficient method of sustainable engineering.

The NZEB is designed to produce its own energy, so it can save a huge amount of energy required to sustain it. The use of local and sustainable materials makes these kinds of buildings environmentally friendly and reduces various environmental hazards.

ACKNOWLEDGEMENT

I would like to express my sincere gratitude to several individuals and organizations for supporting me throughout my Graduate study.

My profound gratitude goes to my wonderful supervisor, Dr. Ajit Patil for his invaluable support, patience, time, and guidance in seeing me to the completion of this research work.

His enthusiasm, patience, insightful comments, helpful information, practical advice, and unceasing ideas that have helped me tremendously at all times in my research and writing of this thesis

I also extend gratitude and appreciation to my lecturers in the Civil Engineering department who have taught me at one point or the other.

I also wish to acknowledge the great support and advice of Mrs. Nilima Pote, my lecturer for Architectural Planning & Design of Buildings at JSPM's Rajarshi Shahu College of Engineering.

My appreciation also goes to Mr. Raj Bhosale for his on- the-spot advice during my research work.

REFERENCES

[1] Definition and Design of Zero Energy Buildings : Yuehong Lu, Xiao-Ping Zhang, Zhijia Huang, Jinli Lu, and Changlong Wang

[2] Zero Energy Buildings: A Critical Look at theDefinition. P. Torcellini, S. Pless, and M. Deru, D. Crawley

[3] Zero Energy Building project in the University ofTokyo Prof. Tomonari YASHIRO and Prof. Ryozo Ooka

[4] Zero Energy Buildings Hyojung Lee, Suresh Gurung, Tony Brick.

[5] Sustainable and Integrated Urban Planning and Governance in Metropolitan and Medium-Sized Cities Eduardo Medeiros and Arno van der Zwet

[6] BIM use in the construction process Mariapaola Vozzola, Gregorio Cangialosi, MassimilianoLo Turco

[7] The impact of urbanization on nature dose andthe implications for human health Daniel T.C. Coxa,b, Danielle F. Shanahanc,d , Hannah L. Hudsona , Richard A. Fullerc , Kevin J. Gastona

[8] Analysis and Design of a Residential Building Harsitha M N, Binod Kumar Das,Rajiv Kumar Chaudhary,Saurabh Singh,Shivam Shivhare

[9] GIS Based 4D Model Development for Planningand Scheduling of a Construction Project Gopal M. Naik, Aditya M., and Suma B. Naik