CARBON POSITIVE

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Abstract - Net zero carbon building (NZCB) is considered an important approach for reducing carbon emissions (CE), which may be due to the exponential rise of energy use and greenhouse gas emissions in buildings industry. Delivery of NZCB on its life cycle is considered a challenge due to its complexity and research deficiency for examining CE life cycle assessment (LCA) to reach NZCB in early design phase, especially in hot arid climates. The present proposal aims to develop an experimental methodology for NZCB in hot arid climate, with reference to the western desert region in Egypt as an experimental location due to its hot climatic characteristic, which includes the most common climate in Africa. The study was held on three models for a single floor residential unit with fixed area 110 m2, using DesignBuilder software for annual simulation and One-click LCA software for 50 years LC simulation. The effect of conventional construction materials replacement, as a passive technique, and application of solar panels, as an active technique, was examined. Simulation results indicated that there was a reduction in carbon emissions through LCA reached approximately 85% when applying both passive and active techniques on the experimental models, as well as a reduction of approximately 101% in energy consumption. Implementation and integration between passive and active systems in early design phase are evident for achieving net zero CE target in hot arid climate.

Index Terms – Net Zero Carbon Building (NZCB), Carbon Emission (CE), Life Cycle Assessment (LCA)

1.1 INTRODUCTION:

Among many construction activities in the construction industry, reinforced concrete embodied carbon is recognized as a significant source of the greenhouse gas (GHG) emissions , which is considered as a major potential for a large-scale reduction in CE . Residential sector is ranked as the second-largest electricity consumer in the world, and very few studies were conducted to standardize an approach for estimating the CE of typically used residential reinforced concrete structures over their life cycle.

Carbon footprint can be calculated with unit CO2eq/year; system boundary of a building's life cycle CE consists of two main components: operational and embodied emissions . Many researchers agreed that the operational emissions are much greater than the embodied emissions; however, other scientists revealed that the significance of embodied emissions in buildings is often underestimated in life cycle emissions analysis . The researchers applied estimation of carbon footprint per functional unit area (kg CO2eq/m2) and concluded that it can be the emissions factor.

1.2 AIM:

To explore, study and compare of carbon emissions from the construction materials (concrete, steel, etc.,). And To reduce the carbon emissions using Earth building materials (cob, rammed earth,) .

1.3 OBJECTIVE:

- To study the characteristic of cement . And How it is released.
- To do a detailed study on Earth building construction materials and techniques.

1.4 SCOPE:

- The detailed study on Earth building construction to reduce the carbon emission.
- It also helps in material selection and specification for reducing embodied carbon emission.

1.5 LIMITATION:

The study is confined to study of one or two carbon materials and compare it with earth building material.

1.6 RESEARCH QUESTION:

1. Comparison between concrete structure and earth building structure? Which is eco friendly?

2. How carbon releases from the concrete and steel structure?

1. INTRODUCTION

Among many construction activities in the construction industry, reinforced concrete embodied carbon is recognized as a significant source of the greenhouse gas (GHG) emissions [1], which is considered as a major potential for a large-scale reduction in CE [2]. Residential sector is ranked as the second-largest electricity consumer in the world, and very few studies were conducted to standardize an approach for estimating the CE of typically used residential reinforced concrete structures over their life cycle.

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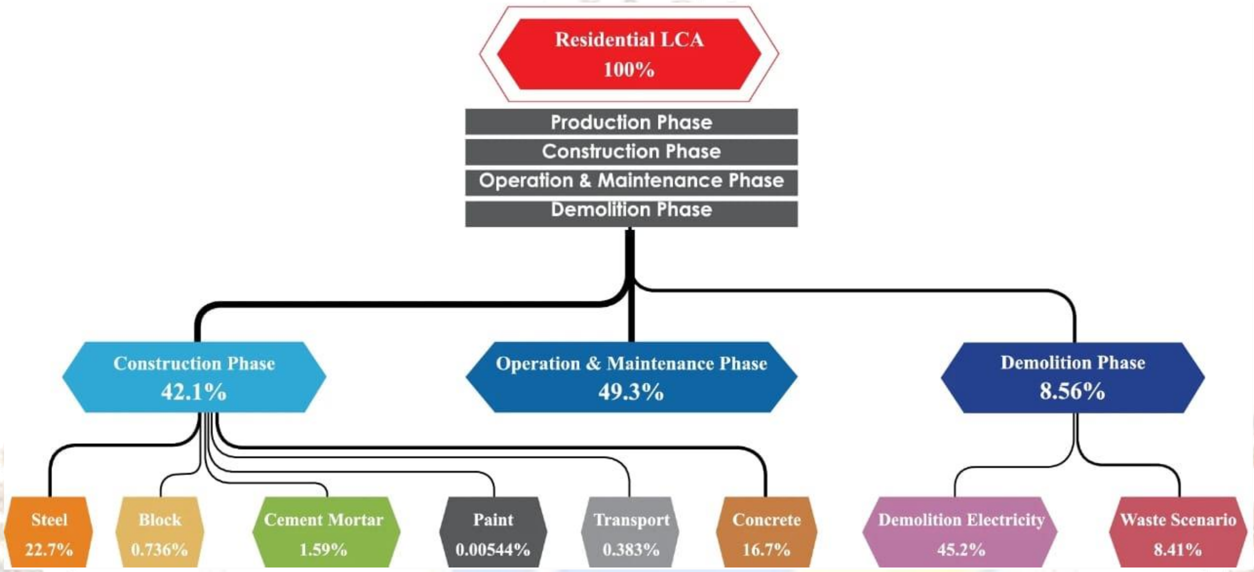


The construction phase, in addition to the operation phase, contributes the most to global warming (that can reach to 91.4%) during the residential building's life cycle with reference to a case study in China . As presented in Fig. 1, the researchers concluded that the case study emitted 42.1% of its CE during the construction phase, 49.3% during its operation and maintenance phase, and 8.56% only during the demolition phase.

2.2 EMBODIED CARBON IN MATERIALS:

Mainly construction industry in the case study region relies on conventional building materials such as concrete (plain and reinforced) and mud fired bricks. The embodied CE for reinforced concrete buildings had a range between 505.7 kg CO2e/m2 and 1050 kg CO2e/m2, which confirms its higher global warming potential (GWP) impact in reference to all other structures (concrete, masonry, steel, and wood) , with reference to Van Den Heede et al. (2012) and Zhang et AL. (2014) , who concluded a general value of embodied CE for the production of plain concrete (without steel reinforcement) with the amount of 425 kg CO2e/m3 . Referring to mud-brick as a walling material has the highest embodied energy among all conventional walling materials , Henry et al. (2014) conducted a study using BIM simulation and concluded that the mud-brick/m2 embodied CE is 228.03 k gCO2e/m2, while cement-block/m2 is 396.7 kg CO2e/m2, respectively. That means the cement-block as walling material expends at least 1.5 times more embodied energy and emits at least 1.7 times more embodied CO2 than mud-brick. Also, Kulkarni et al. (2016) concluded that the average carbon footprint of the bricks, produced in Karad clamps in India, is estimated between 162 g CO2e/kg and 195 g CO2e/kg of fired brick .

Using alternative low-emission construction materials like eco-cement can reduce the reinforced concrete embodied CE in buildings up to 31%, by using supplementary cementitious materials (SCMs) in concrete mixture . On the other hand, the previous study indicated that using 100% recycled steel scrap in reinforcement reduces the total building embodied CE by 39%, and therefore, it should be encouraged. Fernandes et al. (2019) concluded that the compacted earth blocks (CEB) had total embodied CE of about 47.5 kg CO2eq./m3 which included cradle-to-gate LCA for different walls this indicates that using CEB can contribute in a considerable reduction of potential embodied CE of 50% or more in comparison with conventional walling materials in a cradle-to-gate analysis.

2.3 STRATEGIES:

As per study for evaluation of existing NZCBs, integration of three main strategies to achieve net zero is as follows:
(1) reducing energy demand through the use of low-energy passive design measures;
(2) increasing efficiency through using energy-efficient building systems and technologies; and
(3) using RE sources like photovoltaic (PV) panels to supply the remaining energy demand and mitigate CE target .

Integration of systems and technologies, which are based on principles of sustainable site planning, energy use reduction, low-carbon construction and material selection, water use minimization, building flexibility and adaptability, had been integrated into NZCB . There is limitation in previous research for addressing NZCB outlines and challenges that face delivering NZCB which fracture our NZCBs understanding, therefore, more researches on NZCB outlines and challenges are needed.

NZCB delivery system is based on eight boundaries, which include a detailed description and role for each NZCB boundary (e.g., geographic, climatic, density, building life cycle, etc.) [16]. These boundaries are considered as an innovative approach for examining NZCBs in terms of system integration for future research and practice. Noticing that the early design phase parameters connect and integrate all NZCB boundaries, the criteria for each outline can be analyzed in the early design phase with respect for project's circumstances.

2.4 CHALLENGES:

The challenges that face NZCB delivery can be summarized in lack of understanding NZCB principles, unclear NZCB policies with conflict in NZCB management and priorities, and with underlying lack of theoretical grounds knowledge as well as NZCB boundaries. These main challenges are

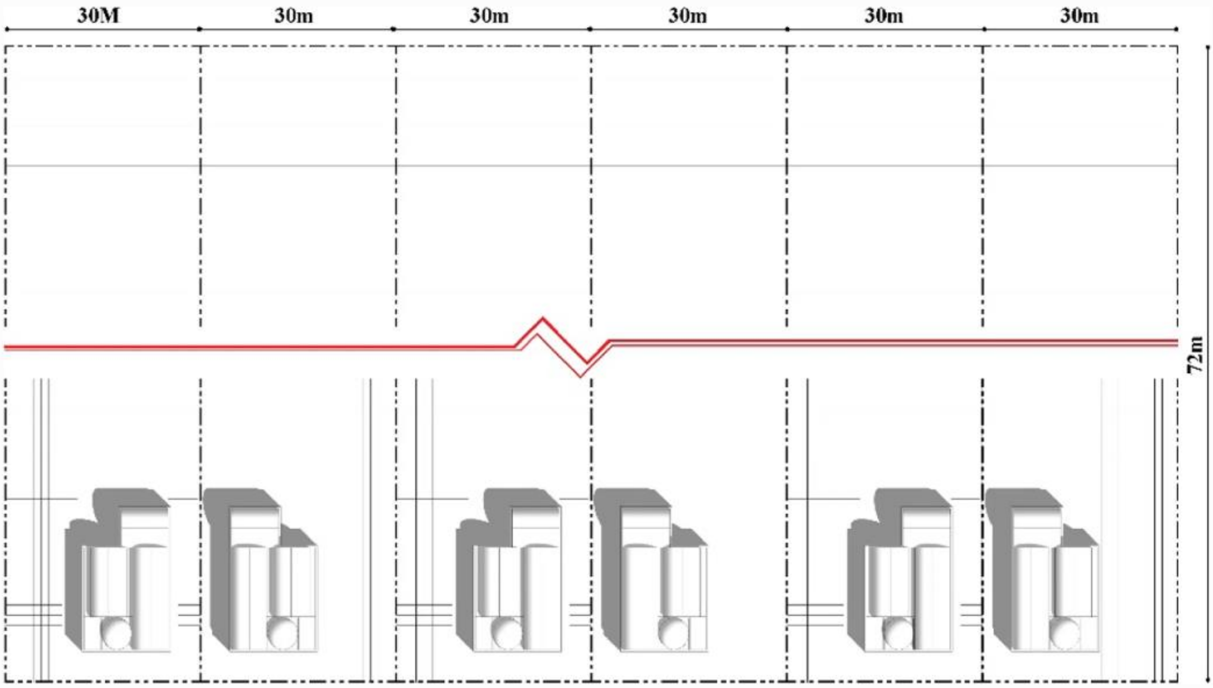
(1) designed target vs. operating target,
(2) testing and commissioning, and
(3) occupant behavior, comfort, and satisfaction.

The designed target vs. operating target can exceed 3.5–5 times initial design estimations in examined case studies which make early design phase simulation for each design parameter a necessary process. Reliability of RE generation is an essential factor for achieving net zero carbon objective and to be effective for a specific context. Finding the best combination between passive and active RE systems design strategies is also essential for achieving best CE target.

By reflecting previous literature on the case study location, the western desert is rich with climate-responsive vernacular architecture. Settlements in the Dakhlah Oasis are collected structures with a strong defensive character; constructions are bound to each other to cope with the hot arid environment. These settlements are characterized by traditional mud-brick Islamic architecture with wind catchers for natural ventilation enhancement (Fig. 2) [17]. On the other hand, the government was building housing projects governorate with the same conventional construction materials (concrete and fired bricks) with no consideration to climatic conditions

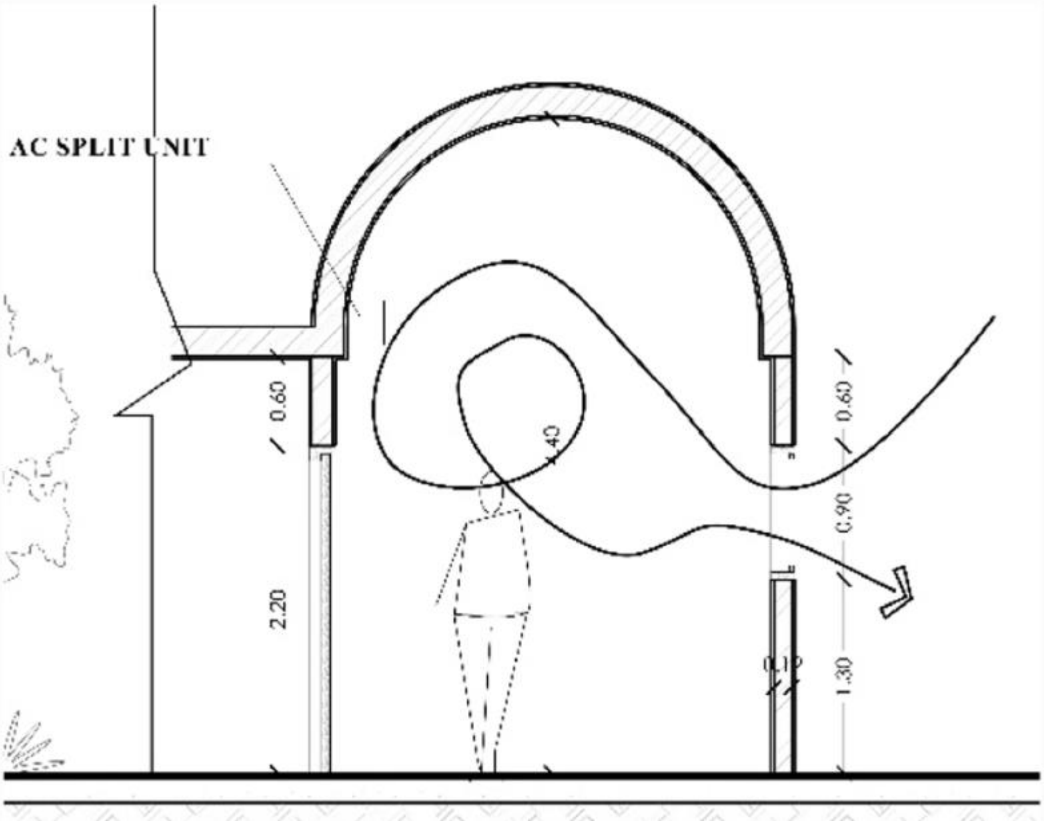
Summarizing the research's knowledge gaps for this research, limitation in conducted studies for standardizing an approach of residential structures CE estimation over their life cycle stages in hot arid climates, with no distinctive definition for NZCB in such climatic region. In addition, there is deficiency in embodied CE data for conventional and alternative construction materials in the case study region. Additionally, the absence of understanding among designers and developers results in climatic responsive design application limitations in Egypt. Addressing LCA as a tool for CE reduction in buildings in early design phase can be a valuable tool in CE mitigation . Moreover, the raise of awareness to nonprofessional users and designers to such problem has a great role in due course.

The next part of this research investigated the building's life cycle assessment based on carbon emissions (LCCO2), embodied CE for applying conventional and alternative construction materials. It was felt necessary to define the methodology towards delivery of NZCB in the western desert in Egypt through design strategies and techniques integration, which may be applicable for a governmental typology of low-rise residential buildings in a hot arid climate. The experimental yearly and LCA simulations were conducted by using DesignBuilder and One-click LCA software.



2.6 Ventilation methods and vernacular passive solutions application

The base model followed the governmental typology with partially mechanical conditioned with split units without taking into consideration any passive techniques application for natural ventilation enhancement (Fig. 8). However, the accommodates buildings with vernacular architectural style, which is responsive to hot arid climate in terms of indoor thermal environment and human comfort, using passive techniques in construction materials selection and natural ventilation enhancement (Fig. 9). The alternative model and NZCB model used natural ventilation techniques as presented in Fig. 10 without adding new masses for wind catchers for maintaining the same construction materials volume.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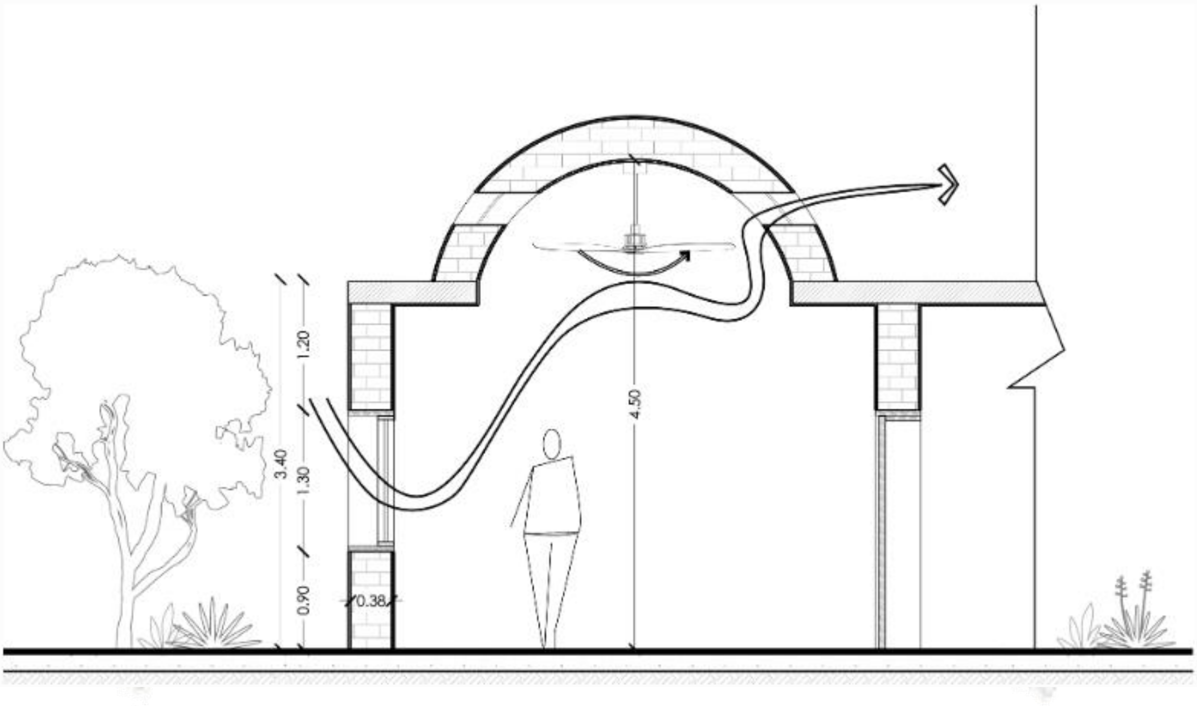
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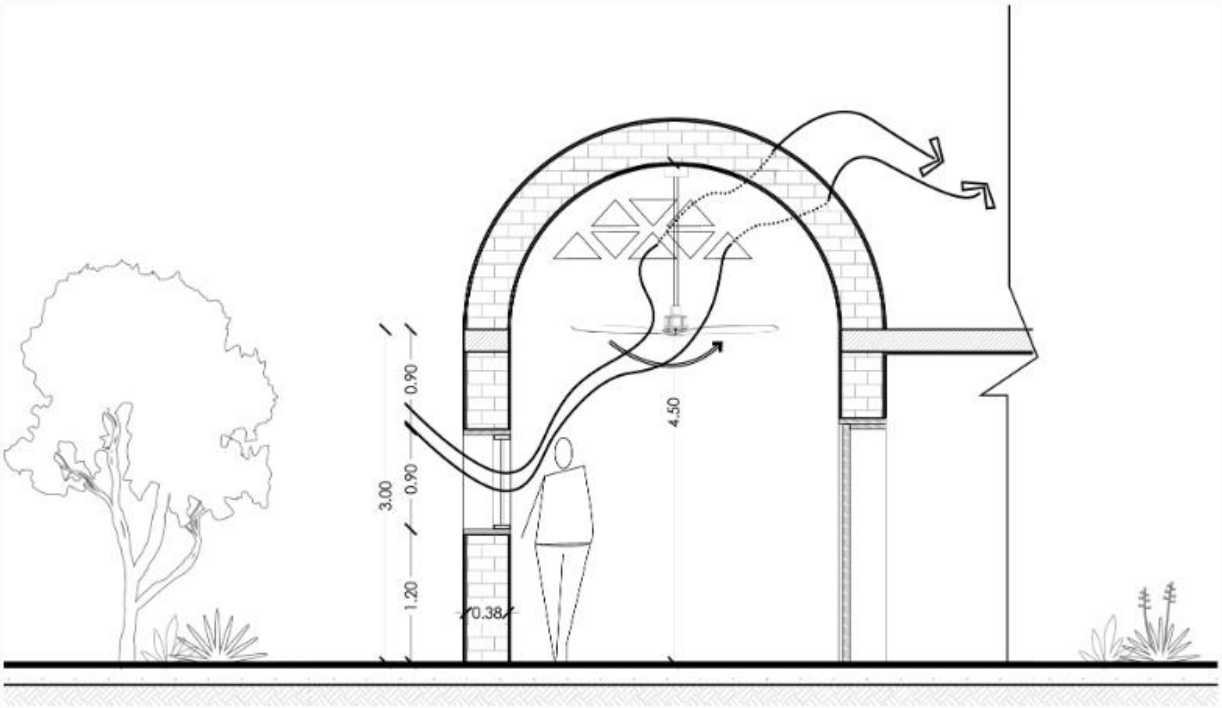
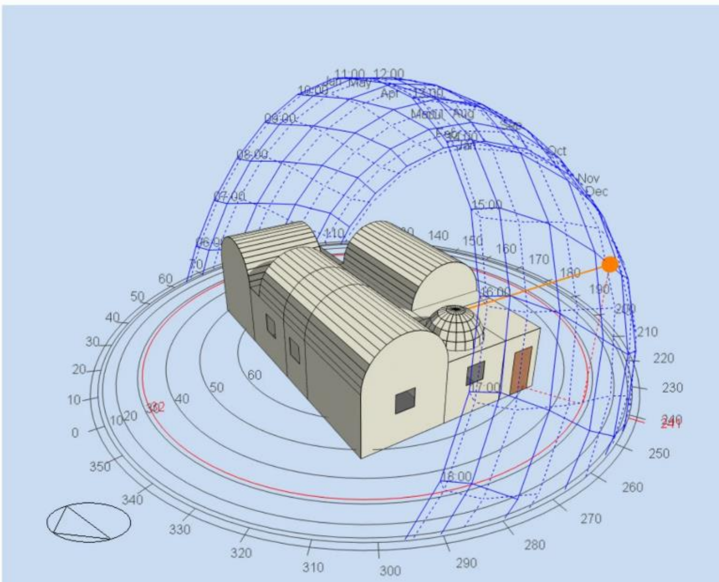


2.7 Simulation process

Three models were modeled on DesignBuilder using building block technique, and then comparable simulation for annual performance and carbon emissions took place. The first model is the base model (BM), which mimics the governmental typology for low-rise houses in western desert with its conventional construction materials and with partially air-conditioned split system. The second model is the alternative model (AM) with application of passive techniques, which are replacing conventional construction materials with alternative materials with lower embodied carbon, and natural ventilation enhancement for overcoming the AC usage. The third model is testing the selective active systems on the alternative model which is the implementation of onsite PV panels to reach net zero carbon building (NZCB).

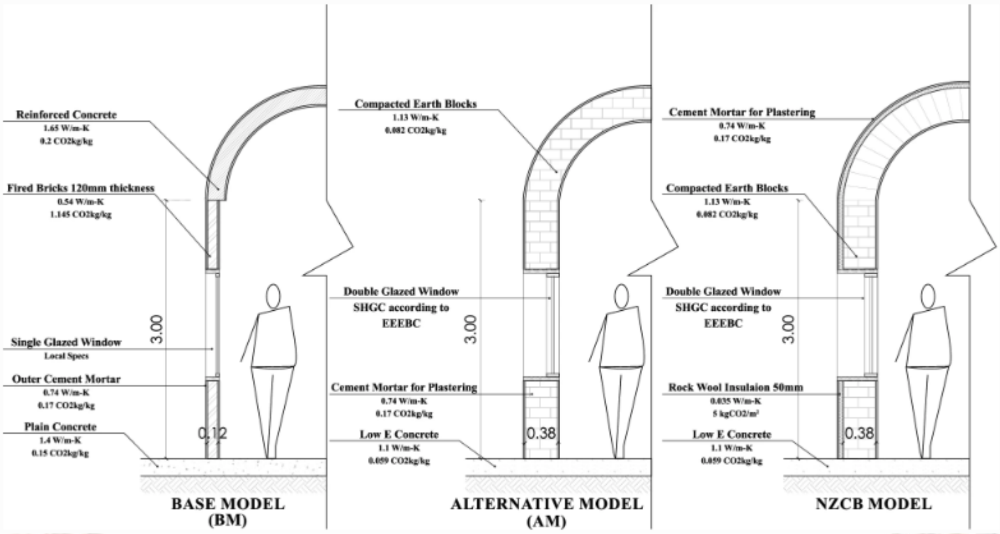


Construction materials input

Implementation of construction materials specifications for three models, as concluded from the literature review, into DesignBuilder interface took place. The conventional materials were applied as presented in Table 3 for base model (BM); walling material is fired bricks of 120 mm thickness with outer/inner cement plastering with thickness 20 mm without insulation, and the roofing system is reinforced concrete 200 mm thick with outer/inner 20 mm plastering without insulation. The openings of base model were introduced as uninsulated with single glazed of 6-mm clear glass with R-value 0.15 m2 K/W.

As for the alternative and NZCB models, alternative materials were applied as presented in Table 4 with their heat specification and embodied CE data as a passive technique. Walling and roofing materials are CEB 380 mm thick with inner/outer cement mortar for plastering with wall insulation for better thermal performance; openings were introduced as insulated 6mm double-glazed glass complied with Egyptian energy-efficient building code with R-value 0.58 m2 K/W both models had the same wall/window ratio .

Figures and illustrated the construction materials in wall sections for BM, AM, and NZCB with their thermal specifications and embodied CE, which were implemented into DesignBuilder interface.



Abbreviations

CE: Carbon emissions	***LCA:*** Life cycle assessment
GHG: Greenhouse gases	***LCCO2 :*** Life cycle assessment based carbon emissions
GWP: Global warming potential	***CEB:*** Compacted earth blocks
SCMs: Supplementary cementitious materials	***RE:*** Renewable energy
PV: Photovoltaics	***EPD:*** Environmental product declarations
BM: Base model	***AM:*** Alternative model

STEEL

3.1 INTRODUCTION:

Steel is one of the core pillars of today's society and, as one of the most important engineering and construction materials, it is present in many aspects of our lives. However, the industry now needs to cope with pressure to reduce its carbon footprint from both environmental and economic perspectives. Currently the steel industry is among the three biggest producers of carbon dioxide, with emissions being produced by a limited number of locations; steel plants are therefore a good candidate for decarbonization. While the industry must adapt to these new circumstances, it can also use them as a chance to safeguard its license to continue operating in the long term.

3.2 DECARBONIZATION:

In 2015, the global response to the threat of climate change took a step forward when 190 nations adopted the Paris Agreement. In 2019, the United Nations announced that over 60 countries—including the United Kingdom and the European Union (with the exception of Poland)—had committed to carbon neutrality by 2050, although the three principal emitters China, India, and the United States were not among that number.1 Moreover, some nations have pledged to work toward earlier dates. Together, these agreements have led to growing pressure to pursue decarbonization across all industrial sectors.

Every ton of steel produced in 2018 emitted on average 1.85 tons of carbon dioxide, equating to about 8 percent of global carbon dioxide emissions.2 Consequently, steel players across the globe, and especially in Europe, are increasingly facing a decarbonization challenge. This challenge is driven by three key developments that go beyond the Paris Agreement:

3.3 CHALLENGES:

1.***Changing customer requirements and growing demand for carbon-friendly steel products***. A trend that has already been observed in various industries, including the auto industry where manufacturers such as Volkswagen or Toyota have the ambitious aim of eliminating carbon emissions completely from their entire value chains (including their suppliers) and taking on a full life cycle perspective.

2.***Further tightening of carbon emission regulations***. This is manifested in carbon dioxide reduction targets, as well as rising carbon dioxide emission prices as outlined in the European Green Deal.

3.***Growing investor and public interest in sustainability***. For example, the Institutional Investors Group on Climate Change, a global network with 250-plus investors and over USD 30 trillion in assets under management, has raised expectations for the steel industry to safeguard its future in the face of climate change. At the same time, global investment firm BlackRock has confirmed its commitment to environmentally responsible business development and sustainable investing.

Recent studies estimate that the global steel industry may find approximately 14 percent of steel companies' potential value is at risk if they are unable to decrease their environmental impact.3 Consequently, decarbonization should be a top priority for remaining economically competitive and retaining the industry's license to operate. Moreover, long investment cycles of 10 to 15 years, multibillion financing needs, and limited supplier capacities make this issue even more relevant and lock in significant lead times for addressing the decarbonization challenge.

3.4 Technology landscape for decarbonization in steel production

Going forward, steel producers need to assess, evaluate, and decide on a technologically and economically viable way to decrease their carbon footprint.

Steel can be produced via two main processes: either using an integrated blast furnace (BF)/basic oxygen furnace (BOF) or an electric arc furnace (EAF). While integrated players produce steel from iron ore and need coal as a reductant, EAF producers use steel scrap or direct reduced iron (DRI) as their main raw material. As the predominant production method in Europe is the conventional, coal-dependent BF/BOF process, the need to assess alternative breakthrough technologies to reduce carbon dioxide emissions is high. Indeed, almost all European steel producers are currently developing decarbonization strategies and running pilot plants to assess different production technologies (Exhibit 1). These include:

BF/BOF efficiency programs. Such programs improve efficiency and/or decrease production losses in different ways, for example: 1) optimizing the BF burden mix by maximizing the iron content in raw materials to decrease the usage of coal as a reductant, 2) increasing the use of fuel injection through, for example, pulverized coal injection (PCI), natural gas, plastics, biomass, or hydrogen (as an additional reagent on top), or 3) using coke oven gas in the BF as an energy source, just to name some of the options. These processes may have the potential to decrease carbon dioxide emissions without eliminating them, but do not offer fully carbon-neutral steel production.

Biomass reductants. This process uses biomass, such as heated and dried sugar, energy cane, or pyrolyzed eucalyptus, as an alternative reductant or fuel. As such it is regionally dependent and mainly important in areas where the biomass supply is guaranteed, like in South America or Russia. In Europe, the availability of biomass is likely not enough to reduce carbon emissions on a large scale.

Carbon capture and usage. This uses emissions to create new products for the chemical industry, such as ammoniac or bioethanol. At present, carbon capture and usage remains technologically premature and yet to be proven economically.

Increase share of scrap-based EAFs. This process maximizes secondary flows and recycling by melting more scrap in EAFs. EAF producers are more environmentally friendly and flexible to the ups and downs of demand. However, shifting to EAF-based steel production requires the future supply of renewable electricity to be commercially available, as well as a sufficient supply of high-quality steel scrap. High quality scrap is necessary for the production of high-quality products, which are nowadays mainly produced through the integrated route. If high-quality scrap is not available, lower-quality scrap can be mixed with DRI to ensure a high quality EAF input.6 Increasing the share of EAF-based steel production will play a key role in decarbonizing the steel industry. However, this role will be dependent on the regional availability of high-quality scrap and could therefore be limited in regions with an inadequate supply of high-quality scrap, making other technologies a must. Increasing demand for high-quality scrap will also lead to extra cost for the EAF-based steel production.

Optimize DRI and EAF. This requires boosting usage of DRI in combination with EAF. DRI-based reduction emits less carbon dioxide than the integrated method and enables the production of high-quality products in the EAF. High-quality products require the highest quality of steel scrap; if scrap is limited, the use of DRI is necessary to guarantee specific qualities. DRI production requires cheap and readily available natural gas. Thus, regions with low natural gas prices—the Middle East or North America—are big DRI producers whereas the process is less common in Europe. Selected European steel players import Hot Briquetted Iron (HBI, a less reactive and therefore transportable form of DRI) to use either in the BF to optimize the burden mix or in the EAF where they mix it with scrap in order to increase quality.

DRI and EAF using hydrogen. This uses green hydrogen-based DRI and scrap in combination with EAFs. The process replaces fossil fuels in the DRI production stage with hydrogen produced with renewable energy. It represents a technically proven production method that enables nearly emission-free steel production. All major European steel players are currently building or already testing hydrogen-based steel production processes, either using hydrogen as a PCI replacement or using hydrogen-based direct reduction. At this point it is important to note that EAF-based steel production will not require a completely green hydrogen-based DRI supply to be able to fulfill current customer requirements and achieve carbon neutrality.

As BF/BOF efficiency programs only result in a reduction in carbon dioxide emissions, without eliminating them entirely, they cannot be a long-term solution. Biomass reductants and carbon capture and usage are either only feasible in certain regions or still in the early stages of development. The share of EAFs producing high-quality steel will increase but requires the availability of scrap and DRI. Hence, adopting an approach combining scrap, DRI, and EAF using hydrogen is currently considered the most viable option and the long-term solution to achieving carbon-neutral steel production, especially in Europe.

GREEN CONCRETE

4.1 INTRODUCTION

In this emerging world, the construction industry is at its peak with magnificent structures. The massive growth in construction industry translates into demand for building materials and concrete is one of the most significant material used in the construction. The major constituents in the production of concrete are cement, sand and aggregates. As we know every coin has two sides. Development of construction provides the luxurious facilities but also creates an adverse impact on the environment, such as CO2 emission and exploitation of natural materials.

4.2 HOW IT AFFECTS THE ENVIRONMENT.

- **CO2 emission:** According to '**Bambang Suhendro (2014)**' (Published in, Procedia Engineering), 8 to 10 % of the world's total CO2 emissions comes from manufacturing of cement and 220 kg of coal is being used to manufacturing 1 tonne of cement. The global warming gas (CO2) is released when limestone and clay are crushed and heated to high temperatures.
- **Reduction in naturally occurring materials:** Coarse aggregates are excavated from the rock mines and sand from rivers. The rate at which concrete is produced, a significant reduction in these naturally occurring materials is bound to happen.

Since last few decades, our society has become conscious of the deposit problems connected with residual products and demands. Hence government has also imposed taxes and restrictions to control it. However, restrictions are not the solution. The solution lies in finding alternatives which are green and economical. Thus, few alternatives have been explored and "**Green Concrete**" is one of them

Green concrete is a recent development in the field of sustainable construction industry. It is a revolutionary concept in the history of concrete technology. **Green concrete was first developed by Dr. WG. in Denmark in the year 1998.**

4.3 WHAT IS GREEN CONCRETE?

Green concrete is an environment centered thinking concept as far as concrete is concerned. It considers every aspect starting from raw materials to its manufacture, **concrete mix design** and ultimately the structural design, construction, and service life It is made with the use of waste material as one of its components. As per '**Mannan and Ganapathy (2004)**' (Published in, Building and Environment), use of agricultural and industrial wastes as replacement materials in the concrete have dual advantages of a better way of waste disposal and cost reduction. Also, the production process of green concrete doesn't lead to environmental destruction such as using excessive energy in its production and produces less CO2 than conventional **concrete**. Hence, the green concrete is also known as **eco-friendly concrete** or **environmentally friendly concrete**

4.4 The List of Waste Materials used in the Production of Green Concrete

01. Substitutes for the Cement:

Materials which can replace the cement content either partially or fully in the concrete manufacturing and is called substitutes for cement. Two types of alternatives are available for cement, one is usually derived from industrial waste and the second is from agricultural waste.

(a) Industrial Waste:

These materials are the byproducts you can get from the industries like power plants.

- **Ground Granulated Blast Furnace Slag (GGBS):** GGBS is a by-product which can be obtained from the blast-furnaces used to make iron.
- **Fly Ash: Fly ash** is obtained from the powdered coal burning mostly in power plants.
- **Silica Fume:** This byproduct is produced during the manufacturing of silicon metal or ferrosilicon alloys.
- **Red Mud:** Red mud is a by-product which is available during the Bayer's process of aluminium production.

(b) Agricultural Waste:

Following materials are available as a byproduct of agricultural products.

- **Rice Husk Ash:** Rice husk ash is a byproduct of agricultural waste which is generated in rice mills.
- **Coconut Husk Ash:** Coconut husk ash is obtained after burning of coconut husk in a controlled environment inside an electrical furnace at 500, 600 and 700 °C.
- **Groundnut Shell Ash:** This is obtained from the groundnut shell.
- **Sugarcane Bagasse Ash:** The fibrous residue of sugarcane after crushing and extraction of its juice is recognized as bagasse, and is reused as fuel for heat generation which leaves behind ash which is called sugarcane bagasse ash.

(c) Others:

- **Metakaolin:** Metakaolin is neither the byproduct nor the entirely natural product. It is produced by the calcinations of pure or refined kaolinite clay at a temperature between 650°C to 850°C.

02. Substitutes for Aggregates:

Materials which can be used as an alternative for natural aggregates in the production of concrete are called substitutes for aggregates. Followings are some green materials which can be used in place for same,

(a) Recycled Aggregates:

Recycled aggregates are generated from concrete demolition waste. There are two types of recycled aggregates,

Recycled Concrete Aggregates (RCA): Recycled concrete aggregates contain particles primarily originating from recycled crushed concrete.

- **Mixed Recycled Aggregates (MRA):** MRA is produced from recycled crushed masonry and includes brick, mortar, concrete, asphalt and gypsum particles etc.

03. Substitutes for Sand:

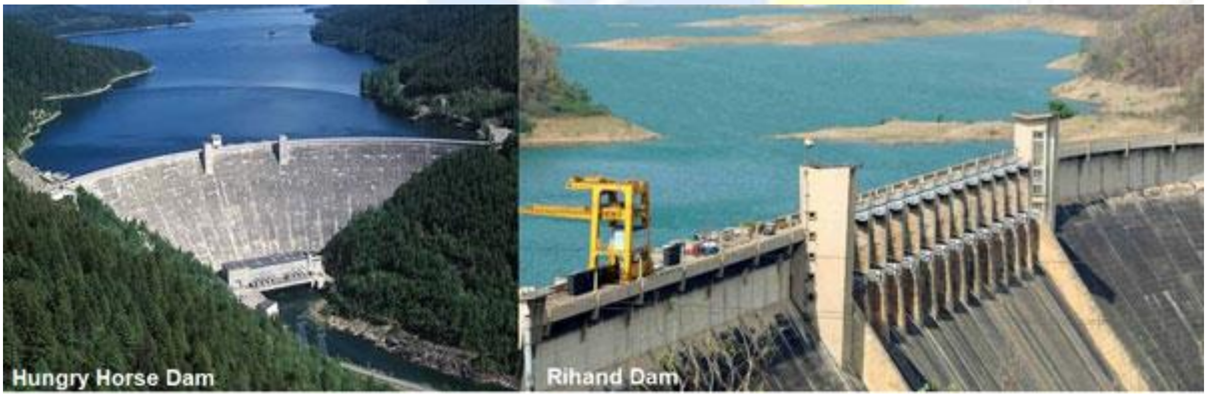
Materials which are used a partial or full replacement of natural sand are called substitutes for sand. Some eco-friendly supplements are mentioned below:

- **Manufactured Sand: Manufactured sand** is produced during crushing of stone such as hard granite stone by various crushing equipment like cone crusher, roll crusher etc. It's a better alternative to river sand for concrete construction.
- **Mining and Quarrying Waste:** Quarry dust is a byproduct of the crushing process of rock which is an intense material to use as aggregates for concreting purpose, particularly as fine aggregate.
- **Surkhi:** Surkhi is produced by grinding to powder well-burnt bricks, brick-bats or burnt clay.
- **Waste Glass:** The waste glasses are collected and crushed to the sand size. It could be used a supplementary material for natural sand as a partial replacement.
- **Sawdust:** Sawdust are loose particles or wood chippings available as byproduct from sawing of timber into standard usable sizes.

These green concrete materials are used as a partial or full replacement of the relative ingredients in concrete production. All these green concrete materials that are used as a replacement for cement are called "**Supplementary Cementitious Material**"; such as silica fume, fly ash etc. It improves both the strength as well as **the durability of concrete.**

4.5 Application of Environmentally Friendly Concrete

- Green concrete is used in the mass construction projects like bridges, dams, retaining wall etc.
- It is broadly used in building construction.
- It is also used in the road construction.



USE OF GREEN CONCRETE IN HUNGRY HORSE DAM AND RIHAND DAM

4.6 Advantages of Green Concrete

Green concrete has many advantages over conventional concrete such as:

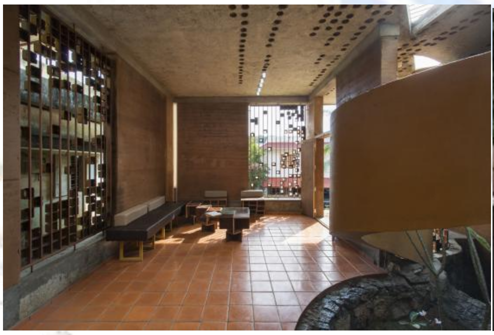
- Green concrete uses local and recycled materials like fly ash, GGBS (Ground Granulated Blast Furnace Slag, artificial aggregates etc. in the concrete.
- It reduces CO2
- Green concrete reduces environmental pollution.
- It has good thermal resistance and acid resistance.
- Green concrete reduces the consumption of **cement** overall.
- It is economical compared to ordinary concrete.
- It has better workability than conventional concrete.
- Environmentally friendly concrete helps in the disposal of industrial waste as it uses waste and recycled materials from the industries in the concrete. Like fly ash, rice husk ash etc.
- Green concrete not only helps in recycling of industrial waste, but also solve the disposal problem.
- Green concrete is suitable for mass concreting because the heat of hydration of green concrete is significantly lower than ordinary concrete. This results in a lower temperature rise in mass concreting.
- There is not much difference in the preparation of eco-friendly concrete compared to conventional concrete.

Disadvantages of Green Concrete

- The green concrete has less split tensile strength than the ordinary concrete.
- In the eco-friendly concrete, the cost of the reinforcement increases with the use of stainless steel.
- A detailed life cycle analysis of green concrete by considering different parameters is must to understand the resultant concrete properties.
- Water (which is again scarce) absorption is high compared to conventional concrete.

5. DEBRIS HOUSE BY WALLMAKERS

When a family of six approached Indian architectural practice Wallmakers for a low-cost home, the architects saw the limited budget as an opportunity to innovate and experiment rather than as a drawback. To keep costs low, recycled and natural materials were prioritized in the design of the Debris House, an approximately 2,000-square-foot dwelling that makes the most of its compact site. In addition to locally sourced materials, the environmentally sensitive home includes a rainwater harvesting and recycling system as well as passive air circulation.




Located in Pathanamthitta of Kerala in the south of India, the Debris House derives its name from the site that was peppered with the remnants of many demolished buildings, elements of which were recycled into the new construction. Although smaller towns like Pathanamthitta have increasingly looked to building homes out of glass, concrete and steel in an attempt to mirror their urban neighbors, the architects resisted those trends in hopes that their site-specific design could inspire “the towns to find their own language.

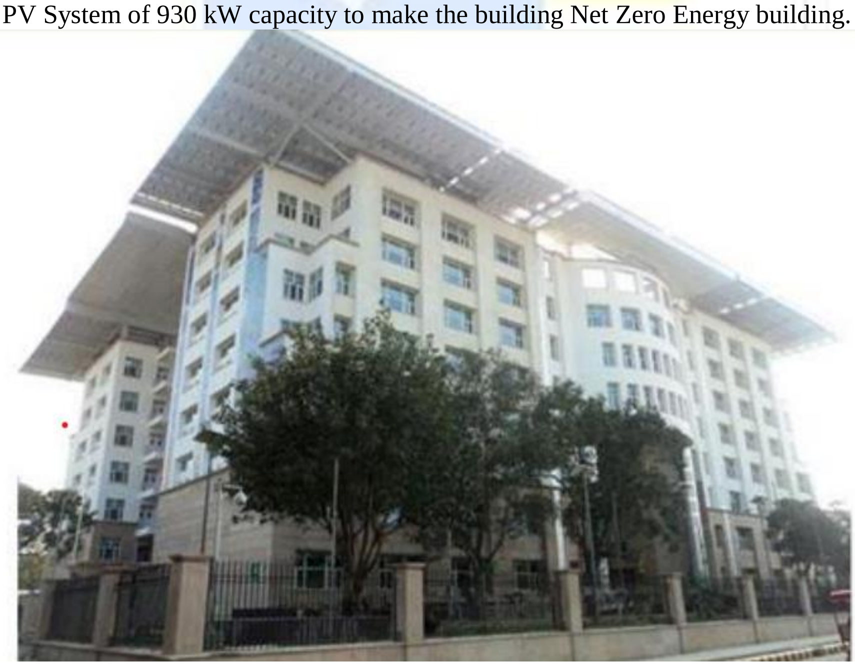

As a result, the architects built the home's rammed earth walls using soil that was excavated onsite. Recycled materials, also salvaged from the immediate area, were used to form a spiraled wall — dubbed the Debris Wall — that serves as a focal point defining the central courtyard, which allows cooling cross-winds into the home. Furniture was also built from reclaimed wood, specifically from the client's storage boxes. To protect against unwanted solar gain, the windows are protected with meter boxes sourced from a local scrapyard. The concrete roof and slab were mixed with coconut shells, thus reducing the amount of cement used

"While the house uses numerous alternate technologies, there is a certain whimsy and playfulness in its design," the architects said. "Looking at the local context, the project strikes out, humbly maintaining its commitment to the society and the environment."

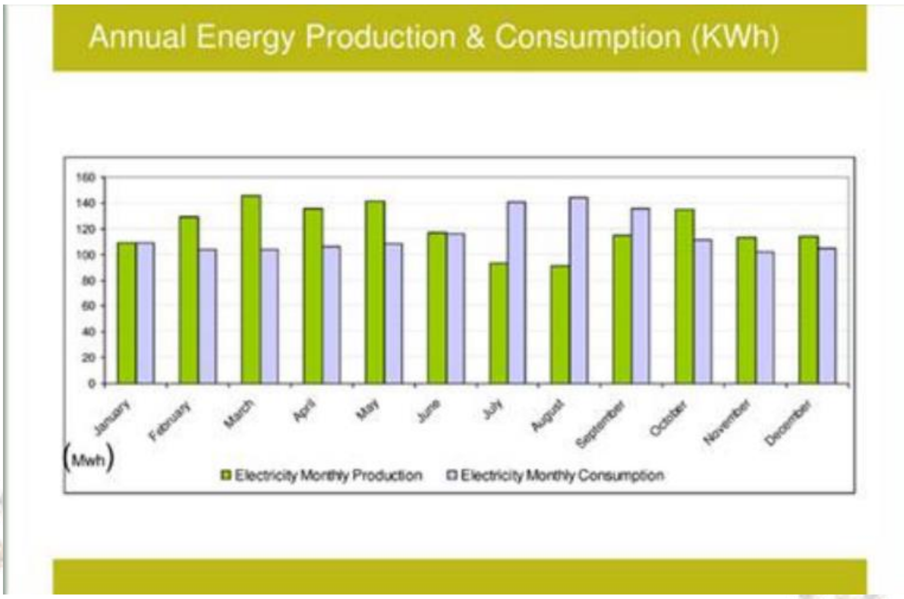
6. INDIA'S FIRST NET ZERO ENERGY BUILDING: INDIRA PARYAVARAN BHAWAN

This is a project of the ministry of environment and forests for the construction of new office buildings at Aliganj, Jor Bagh Road, New Delhi. The project has been designed to make the net-zero energy building. First in government sector targeted for both ratings of green building (5 STAR GRIHA LEED India Platinum) The building has won awards such as the Adarsh/GRIHA of MNRE for ideal illustration of Integration of Renewable Energy Technologies. This new office building has been constructed in a composite zone. This building sets revolutionary change into conventional building design. The building has been designed by CPWD by using an integrated design approach with the help of multi-disciplinary fields experts like Architect, Electric Consultant, HVAC Consultant, Plumbing Consultant, Green Building Consultant, Commissioning Authority, Landscape Consultant, Structure Consultant, and other project team members.

The project team emphasized on the energy conservation measure at every step of building design and construction for reducing energy demand by using passive design strategies by providing windows with shadings which again provide adequate natural light with that landscape to reduce ambient temperature and for outdoor greenery access with that Energy-efficient active systems. All the possible energy-efficient and conservation practices were adopted to lessen the energy load of the building and the remaining demand load was met by an onsite solar PV System of 930 kW capacity to make the building Net Zero Energy building.

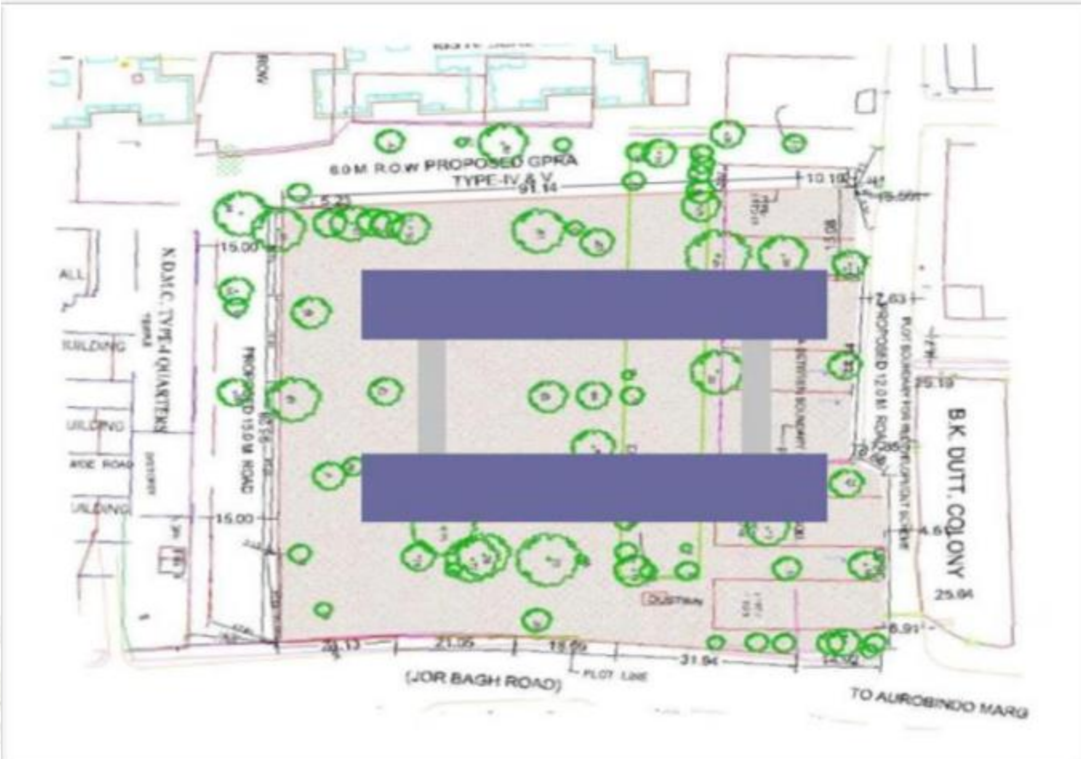


Indira Paryvaran Bhawan view



Annual energy production and consumption graph

The energy consumption of Indira Paryavaran Bhawan is 67.3% less in comparison to the GRIHA benchmark. The project adopted numerous green building concepts for occupants' wellbeing and eco-friendly approaches like water conservation and rainwater harvesting.The building orientation set in the manner that it favors optimum solar access and shading. Two blocks facingnorthsouth direction have been arranged parallelly having a linear open court in the middle. Building front is a wider setback so that it can protect tree lines for occupant’s outdoor view access.



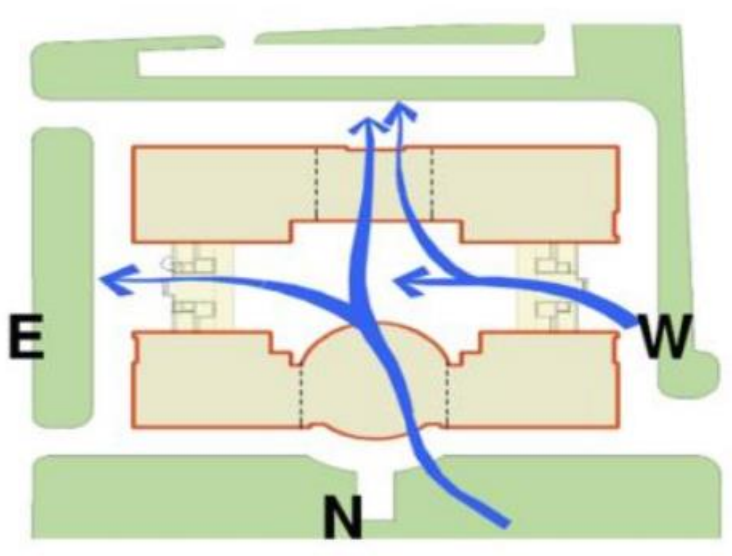
Final design view of North-South blocks orientation and courtyard

Authorities have got permission to cut 46 trees but only 19 trees were cut, and 11 trees were planted to make up for it. Native plants/trees were planted, and sprinklers and drip irrigation provided to reduce further water requirement. Local ecology was preserved as much as possible to maintain cooler microclimatic. Hard green spaces provided to elevate the greenery.

Onsite STP with FAB/MBBR technology constructed to recycle the total water amount to create zero wastewater. Water consumption has been reduced by 64% by providing water-efficient fixtures. Building top, courtyard, and edges fully covered by the Solar PV panels which gives shading and create a cooler microclimate. Onsite solar energy capacity provides sufficient energy to meet the demand capacity of the building which plays an essential role to make the building Net Zero Energy Building. This is the first govt. building in the country to achieve this landmark and one of the very few full-fledged multifunctional office buildings in the world to do so on a tight urban site.

Onsite installed Solar PV Panels

Effective ventilation provided by orientating the building N-S and by optimum integration with nature which has been obtained by separating different blocks with connecting corridors and by providing a huge central courtyard.



Effective ventilation pattern due to building design

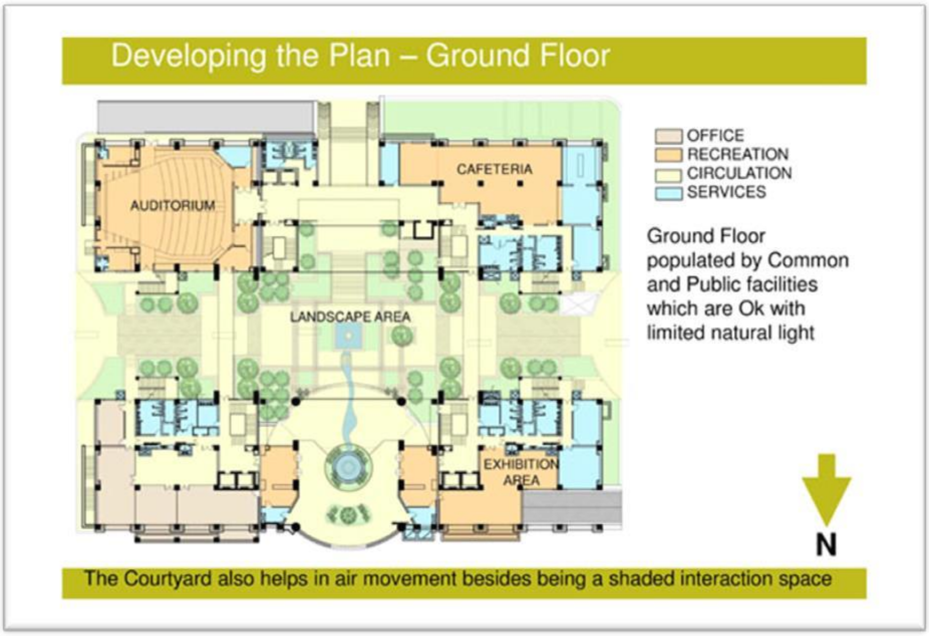
DESIGN FEATURE OF INDIRA PARYAVARAN BHAWAN:

Building design plays a vital role in the energy consumption of the building. Indira Paryavaran Bhawan was designed in three stages by using an integrated design approach. All three stages -Passive design, Active design, and Renewable Design, elaborated below which helped in achieving the net-zero energy consumption of buildings. Detailed submission guidelines can be found on the author resources Web pages. Author resource guidelines are specific to each journal, so please be sure to refer to the correct journal when seeking

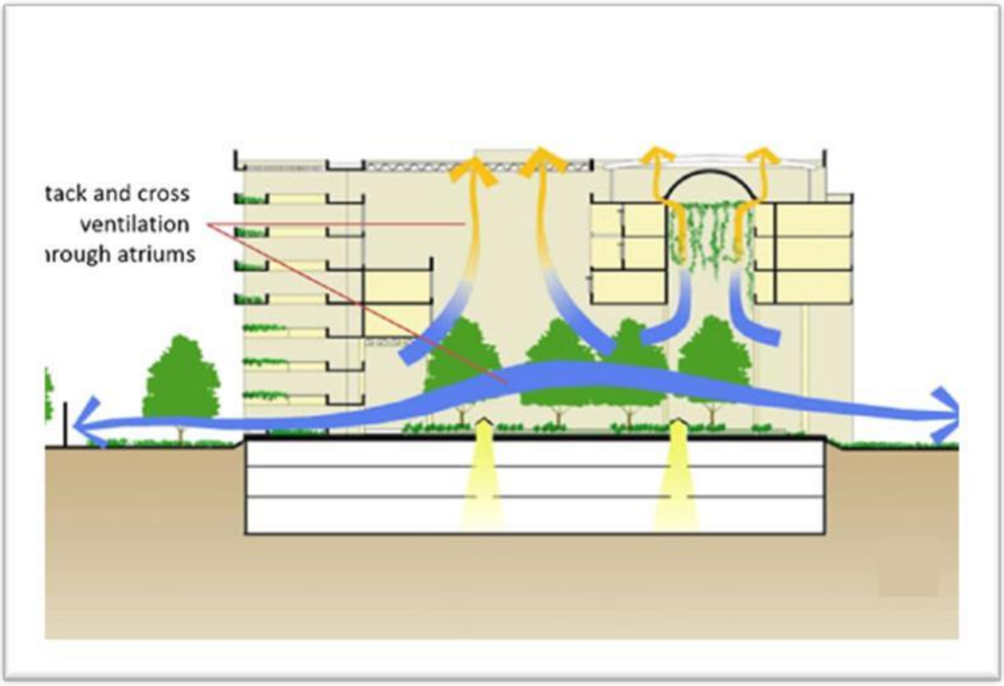
Passive Design Strategies: Passive design out-turn when a building is designed and simply works ―on its own‖. Passive design strategies based upon climate considerations attempt to control comfort by the orientation of the building envelope (plan, section) to control airflow. Apart from this Passive design strategies uses materials to control heat, optimizes the use of free solar energy, maximizes the use of free ventilation for cooling, and uses shade- it can be natural or architectural, to control heat gain. Indira Paryavaran Bhawan is in Delhi which comes under the composite zone, on this basis following passive design strategies implemented by the project team.

• **Orientation**: The building is north-south oriented, which is favorable for effective ventilation. Two separate blocks connected through corridors for optimum integration with nature and a huge central courtyard provided which again helps in better air circulation and provides skylight also. The courtyard has been provided with natural vegetation which reduces surrounding temperature, enhances air movement thus by cool air is preserved and hot air escapes easily and provides a green view. Orientation minimizes heat ingress. Window to wall ratio of the building is optimum according to the energy conservation benchmark.

• **Landscaping:** Greater than 50% area outside the building is covered with plantation especially native plants that have been planted to reduce water consumption. Circulation roads and pathways are softly paved to enable groundwater recharge



Ventilation: Courtyard in the center of the building helps in air movement as natural ventilation happens due to the stack effect. Windows and jaalis add to cross ventilation.



Daylighting: The courtyard provided with skylight which provides indoor natural sunlight. 75% of building floor space is provided with adequate daylight, consequently reducing dependence on artificial sources for lighting.

Building Envelope and Fenestration: Building Envelope Optimized, rock wool insulation used. The window uses high-efficiency low heat transmittance index double glazed glass of U-Value 0.049 W/m2K, VLT 0.59, SHGC 0.32. The hermetically sealed uPVC windows reduce incoming heat. Use of high reflectance terrace tiles (Cool roofs) or heat ingress, high strength, hardwearing

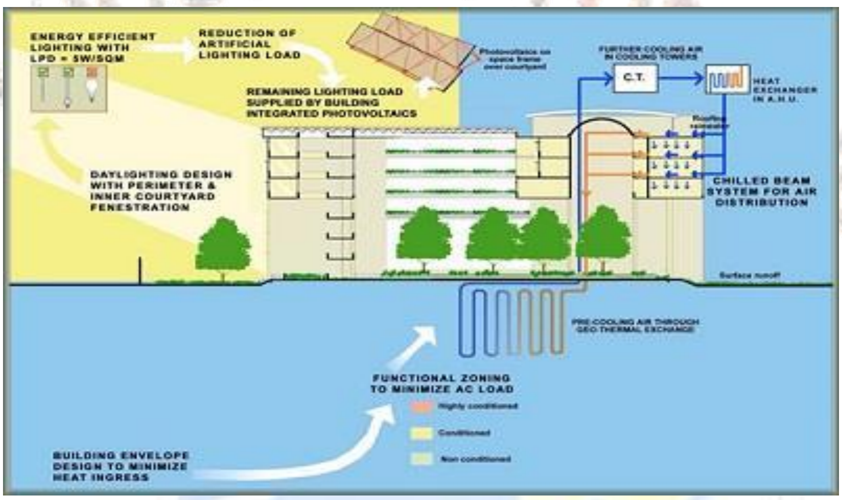
Materials and construction techniques: Building constructed with the use of low embodied energy and a recycled content-based product like AAC blocks with fly ash, fly ash-based plaster & mortar. The building has been constructed by providing local stone flooring, bamboo jute composite doors, frames, and flooring. These products are of low embodied energy. High-efficiency glass, high VLT, low SHGC & Low U-value, optimized by appropriate shading which helps in energy efficiency. Light shelves have been provided for diffused sunlight. Stone and Ferro cement jaalis used.

Active Design Strategies:

The active design uses appliances and technologies to modify the state of the building, create comfort and energy, ie. Fans, pumps, etc. This is the main part where much of the energy conservation can be done.

Lighting Design: Building provided with an energyefficient lighting system that uses a lux level sensor to optimize the operation of artificial lighting. The total lighting power density of the building is LPD = 5 W/m2 which is much more efficient than Energy Conservation Building Code benchmarks. Installed integrated photovoltaic (BIPV) provides energy to the remaining lighting load.

Optimized Energy Systems / HVAC system: Building used chilled beam system to meet 160 TR of air conditioning load. The use of a chilled beam system lessens energy use by 50 % in comparison to a conventional system by saving AHU/FCU fan power consumption by approximately 50 kW. Chilled water is supplied at 16° C and the return temperature is 20° C. This system is used from second to the sixth floor in the building. Water-cooled chillers and double skin air handling units fitted equipped with variable frequency drivers (VFD) which reduces energy consumption on variable load. Chilled water pumping system, cooling tower fans, and AHUs use VFD. All HVAC equipment controlled & monitored through an integrated building management system. Sensible & latent heat energy recovery wheel used to precool fresh supply air from toilet exhaust air. Room temperature is maintained at 26 ±1 ° C which is again a brilliant step towards energy conservation. more efficient than ECBC requirements.



The building used functional zoning to reduce air conditioning loads. With the chilled beams, drain pans are provided to drain out condensed water droplets. The overall HVAC load of the building is 40 m2/TR, which is 50%.

Geothermal Heat Exchange System: Geothermal system has been set up to meet the cooling requirement of the building which consists of 180 vertical bores to the depth of 80 meters with a minimum of 3 meters distant all over building premises. By the use of a Geothermal system, 160 TR of heat rejection is achieved without the use of a cooling tower. Each bore has an HDPE U-Loop pipe having 32mm outer diameter, connected to the condenser water pipe system in the central air conditioning plant room. Each U-loop grouted with Bentonite Slurry and one U-Loop has 0.9 TR heat rejection capacity.

Renewable Energy:

The Indira Paryavarn Bhawan met the energy demand with the green and clean energy solution, Efficient Solar PV systems. The building has a solar PV system installed in a 6000 m2 area of 930 kW capacity. The total area covered by the panel is 4650 m2 by 2844 solar panels which generate 14.3 lakh unit annually which is huge in amount.
This is the first govt. building in the country to achieve the landmark of net-zero energy building and one of the very few fullfledged multifunctional office buildings in the world to do so on a tight urban site.

7. CONCLUSION:

The construction of new buildings leads to crucial environmental issues due to the CO2 emissions produced by the use of construction materials, design and construction frames, and power consumption.The carbon impacts of cement , concrete and Steel remain complex and highly varied, as this paper demonstrates. However with climate change now starting to affect multiple regions of the world, designers, manufacturers and life cycle assessment (LCA) consultants must reduce these impacts. The analyses presented here will help them to do this. For residential we can use rammed earth and mud etc., but we cant use in High rise Building. For mass Project we can use green concrete . For example Dam, Bridge etc.,

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