"CASE STUDY ON GREEN HOME: A SUSTAINABLE & INNOVATIVE APPROACH"

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ABSTRACT: Today, the world is shifting rapidly toward the green features and materials for the construction activity. The ongoing construction procedure in the recent trend has tilted toward the sustainability concept. The Global warming, Green House gases and increasing population is producing the negative impact on the environment. The different groups like Middle Income Group is continuously increasing in developing countries like India which requires deep research. Most of the population comes under the middle income group in India and they requires a habitat for their living. In India, the current status of the lower MIG section is getting degrading and the govt. policies are not creating any difference toward producing the home to the people with the concept of the sustainability. The house which is constructed by them is not that much efficient and effective in minimizing the energy and water consumption that would cost a lot more in long term.
Indian Green Building Council (IGBC) has provided the smart criteria which can be fulfil by implementing the small changes over the conventional materials and technologies which would produce a drastic makeover onto the conventional building. Home constructed by using these criteria would produce low emission of Green House gases and low construction waste which would saves the construction cost.
This paper would provide the best and efficient methods to save the money right before the construction start and till the building survive. In order to fulfilling the need of green home to the middle income group, the implementation of the IGBC's Criteria, the virgin materials and the locally available materials would make a solid start toward the conservation of the environment by reducing the utilization of energy, water and processed materials. This would also help in minimizing the Global Warming and Green House gas and low Carbon footprint which is continuously increasing into the environment.

KEYWORD: IGBC Criteria, Global Warming, Green House gas, Middle Income Group, Sustainability principles, locally available materials, Population, Rating system.

I. INTRODUCTION

In today's world, construction procedure in developing countries like India has been in full pace. With the development and enhancement in construction procedure, the utilization of materials and equipment is rapidly increasingly day by day. The technologies and materials which are used these days tremendously affect the environment and putting the world's population is in danger. Growing Human activity has increased the concern for sustainability even more in recent times. Sustainability in real estate context is not only limited to energy conservation, but also includes resource usage, impact on the neighbouring environment and working conditions for tenants (Roy and Gupta, 2008). Among the other production and manufacturing sectors, building and construction sectors occupies the first place as the largest contributor to pollution and natural resource consumption (Levine et. al., 2007; Plank, 2008). We would have to start thinking about the sustainable materials and procedures which would help us to conserve the natural resource for the further coming generation in order to provide green and sustainable work.

In India, achieving the sustainable goals is very difficult. People more than 30% are living in slums are not capable to afford house. Peoples who comes under the LIG and MIG section are not capable to build a green featured house on its own. They would have to live in a passive or conventional building which produce ample amount of carbon footprints. In order to raise the living standard of LIG and MIG section and provide a green home with sustainable at a affordable price, we have to take some initiative and innovation point to be considered.

Thinking of green goals with sustainable materials or development at some point would help to live a long and prosperous life in a cheerful world. A concept of 5R's (reduce, reuse, recycle, replace and refine) will help to extend the sustainability criteria for building to accomplish the Green Homes.

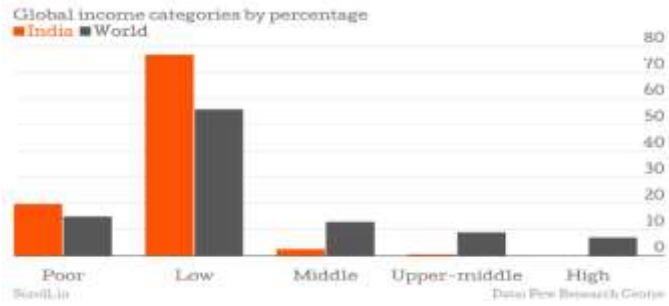

Fig. 1 Global Income Percentage

As per the National Council of Applied Economic Research, India's recent middle class population is 267 million in 2016. It is further estimated that the middle class household is likely to increase twice about 115 million than the population in 2016.

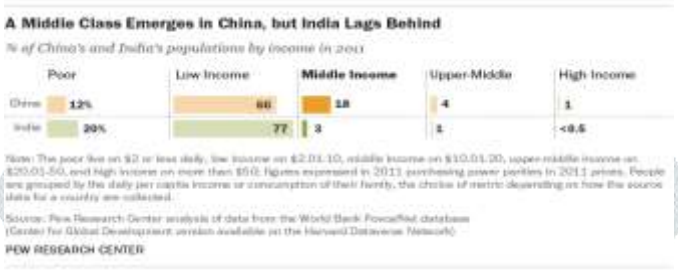

Fig. 2 Condition of MIG in China vs India

The Emergences of Middle income group and Low income group has not been carried out significantly as the population of the India are searching for suitable and appropriate housing. In the searching for the housing, the people are likely to live in the small and inappropriate house.

II. IGBC'S GREEN HOME

Since, GRIHA promotes soil conservation/ top soil laying stabilization/ hard landscaping & boundary protection, site operation and maintenance while LEED India promotes minimum energy performance or optimize ozone depletions. LEED India also promotes reduced heat island effects, thermal insulation of building. LEED India promotes water monitoring, water consumption, building reuse & reuse of structure. LEED also promotes local or regional materials while GRIHA promotes min. waste management, storage and disposal. GRIHA also promotes utilization of Fly Ash in building structure.

As the GRIHA rating is especially made for India in accord ance with the topographical and climatic conditions. The GRIHA rating is only applicable for the area more than 2500sq.m^2. GRIHA rating system and certification is made for the newly construct building. Hence the regional or local materials is not encourage to use in construction. GRIHA rating certification cannot be achieved for the old or renovated building. This has split the Indian developers down the middle as the two green rating agencies hardsell the advantages of their respective building certification methods. Since, the LEED rating is used by the different countries all over the world (108 countries). Hence the LEED is international rating system as it takes hypothetical cases because of different topographical and climatic condition prevailing in the different countries. Though the different firms and agencies like USGBC (United States Green Building Council) in USA and IGBC (Indian Green Building Council) in India has modified the LEED criteria accordance with the prevailing topographical and climatic conditions. IGBC has modified LEED criteria for the old home, new home and renovated home. Although the GRIHA criteria are partially different from the LEED criteria but they offers different aspect & outline for the advancement of the building and structure.

IGBC has built up the Green Homes Core Committee to give centre around private division. The advisory group incorporates developers, engineers, mortgage holders, modelers, specialists, specialists on building science, makers and industry agents. The diverse experience and callings of the advisory group individuals acquires an all encompassing perspectives in the method for improvement of the rating framework.
The IGBC has provided the rating for the GREEN HOME rating system for the old and new house for any built up area. They don't have the limit for the criteria to put on the different built up areas.

III. CASE STUDY AT BHOPAL (M.I.G DUPLEX BY BDA)

3.1 Conventional House - The conventional house that is constructed by Bhopal development Authority (BDA) for the middle income group people as the house are constructed with the conventional methods. The calculated estimated quantity of material

and costing as per Scheduled of Rates (SOR) 2014 MPPWD. The estimation of the superstructure of the conventional building is carried out only. In the calculated part not considering the sub-structure of the conventional building.

Fig. 3 Conventional house

TOTAL ESTIMATED COST FOR SUPERSTRUCTURE EXCEPT PLINTH AS PER SOR 2014 MPPWD

1. Brickwork with cement mortar (1:4) - 1,92,384
2. Plain Cement Concrete (M20) - 1,24,288
3. Reinforced Cement Concrete (M20) - 20,764
4. Cement mortar (1:4) - 41,370
5. Door Frame and door - 45,000
6. Window Frame and windows - 30,000

TOTAL ESTIMATED COST FOR SUPER STRUCTURE - ₹ 4,53,806

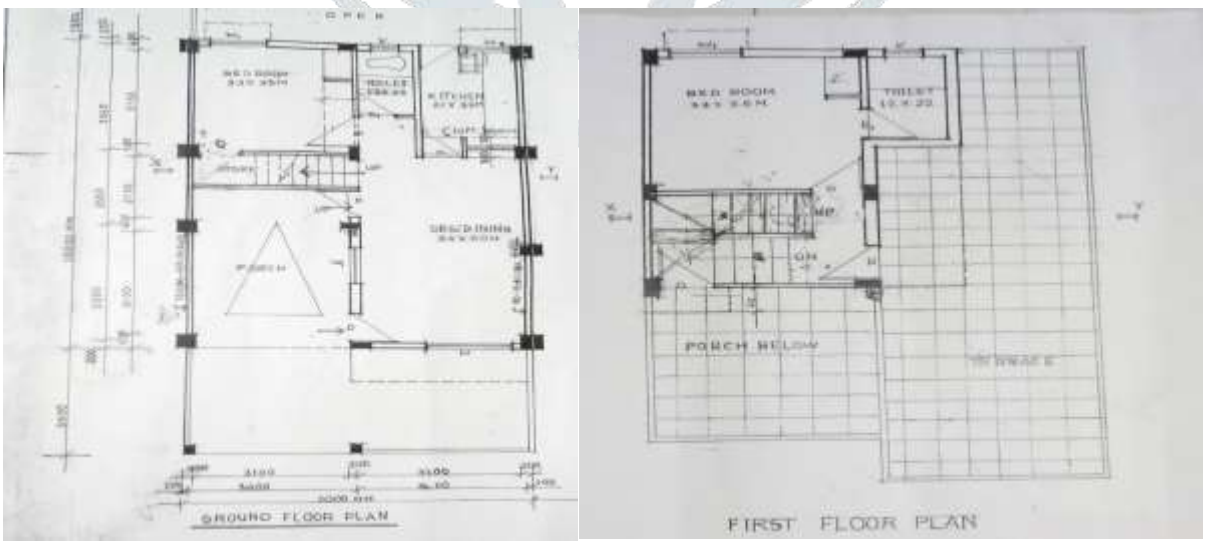

Fig. 4 Ground & First Floor Plan

3.2 Green Home - Green home are the habitat for the individuals or householder with the concept of sustainability and R's concept outsourcing the nature's benefits to the house and reducing the adverse effects on the environment. Green Home in place of

conventional house irrespective of the constructed area, floor area ratio and carpet area. The conventional materials are replaced by the green materials for the green home of the same constructed area and floor area ratio.

Constructed Area – 69 sq.m.
Floor Area – 93 sq.m.
Floor Area Ratio – 0.885

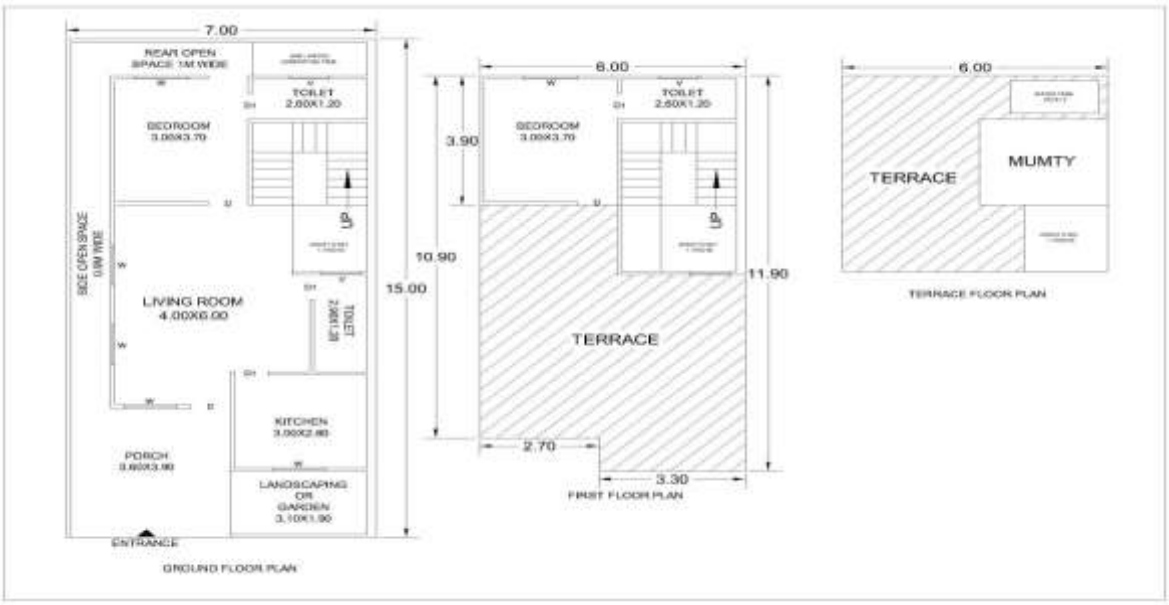

Fig. 5 Green Home Planning

3.3 Cost Comparison

3.3.1 Superstructure cost of Conventional House

Table 1

CONVENTIONAL HOUSE					
S.No.	**Particulars**	**Quantity**	**Units**	**Rate**	**Total**
1	**BRICKS**	**8640**	**nos.**	**3**	**25920**
2	**CEMENT**	**222**	**Bags**	**330**	**73260**
3	**SAND**	**20.022**	**cu.m.**	**900**	**18019.8**
4	**AGGREGATES**	**10.869**	**cu.m.**	**800**	**8695.2**
5	**MARBLE**	**980.915**	**sq.ft.**	**140**	**137328.1**
6	**TEAKWOOD**	**80**	**cu ft.**	**1400**	**112000**
7	**REINFORCEMENT**	**8.284**	**tonne**	**30000**	**248520**
TOTAL COSTS					**623750**

3.3.2 Superstructure cost of Green Home

Table 2

GREEN HOME					
S.No.	**Particulars**	**Quantity**	**Units**	**Rate**	**Total**
1	**CSEB BLOCK**	**14000**	**nos.**	**3**	**42000**
2	**CEMENT**	**250**	**Bags**	**330**	**82500**
3	**SAND**	**18.369**	**cu.m.**	**900**	**16532.1**
4	**AGGREGATES**	**15.96**	**cu.m.**	**800**	**12768**
5	**KOTA TILES**	**940.765**	**sq.ft.**	**15**	**14111.48**
6	**PINEWOOD**	**80**	**cu ft.**	**350**	**28000**
7	**REINFORCEMENT**	**5.0829**	**tonne**	**33000**	**167736**
8	**GREEN ROOFTOP**				**150000**
	TOTAL COST				**513650**

3.4 Materials used while building the Green Homes

- Compressed Stabilized Mud Blocks(CSEB) in place of Conventional Bricks
- Pinewood in place of Conventional Teakwood
- Filler Slab in place of Concrete Slab
- No Inner Plaster
- Kota Tiles in place of Marble
- Green Rooftop above the Slab
- LED in place of CFL

3.5 Green Home features on the accountability of the sustainability principles

- **Materials and Resources**

- **Compressed Stabilized Mud Block** – It is very cost effective, eco-friendly and simple blocks can be constructed on site by the use of excavated soil and locally available materials. It also reduce the energy consumption. It does requires 70% less energy to burn as compared to conventional burnt bricks. But it requires less skilled labors for making mud blocks. Though it is bigger in shape and size, as it requires less in numbers. It is very economical about 10-20% when compared to brick masonry. The net benefits in term of labor per block for manufacturing is Rs 1.70 as compared to Rs 1.50 for the conventional bricks as it requires less in numbers. It will save the transportation cost. So in the broad scenario, with the utilization of the mud block constructed on site, the overall cost requires for wall will reduced by 10-20% as a whole.

- **Clay tiles & Simple Kota tiles** – Clay tiles and Simple Kota tiles are used in place of marble as it provides the cooling effects inside the house and it is very cheap materials used for the flooring. They are $1/10^{th}$ times cheaper than the marbles.

- **Pinewood pressing cases (Recycled Materials)** – All the windows, staircase, kitchen cabinets, books rack can be made from disposed of pinewood pressing cases and recycled woods from the demolished building. These items can be again used with the coating of linseed oils. The cost of these items will be $1/20^{th}$ of the cost of teakwood.

- **Linseed oil and Turpentine oil –** Linseed oil and Turpentine oil is used as a plastering work for the outer and inner walls. It will work as a water proofer and fill up the small pores in the exposed wall sides. It will drastically improves the dampness of the walls.

➢ **Water Efficiency:** By the construction of the rainwater harvesting system, the overall consumption of the water can be reduced a lot. A system can be made to collect the water coming from the washbasin, kitchen sinks, bathroom and washing machines and again reused in gardening and cleaning of cycles and cars. The water coming from the first floor bathroom can be used in the ground floor flushing commodes by installing the tank just outside the bathroom wall. All the Grey water coming from the different sources is also utilized by construction the grey water conservation system. By this systems, this house can make a self-sufficient water house. Somehow it will minimizes the use of municipal water by 20-30%.

Fig. 6 Grey Water Conservation tank

➢ **Indoor Environment Quality:** With the proper ventilation and lightening through the skylight and glass windows helped to retain the indoor environment pleasing and harness the natural beauty. Introducing a Skylight will help to give the proper lightening to the inner side of the house. The house which has open spaces from three side will have the full ventilation and lightening and from the fourth side, we have incorporated the skylight will means full lightening throughout the day. This will save the electricity bill by 40%.

Fig. 7 Open Space

- **Green Rooftop** - It reduces the energy costs by absorbing the heat in place of attracting it and provided the natural insulation for the house. An extreme and extensive green rooftop can minimizes the summer heat consumptions by 75%. Green roof diminishes the production of associated air pollution and green gas emission with lowering down the use of the AC demands. It also help in minimizing the Effects of Urban Heat Island, a condition in which the environment traps and absorb heat. It would increase the cost of the building by 15%.

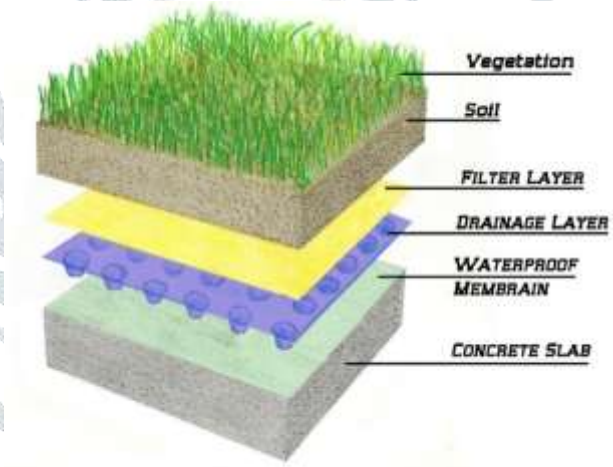

Fig. 8 Green Rooftop

- **Solar Rooftop** – It will provide the shade to the roof and does help in minimizing the inner temperature of the house. It will consequently help in reducing the power consumption of the building.

➢ **Energy and Atmosphere:** Having the proper ventilation and lightening inside the house, the utilization of the electricity has been reduced to minimal during daylights. Installation of solar lantern in the house would be the best alternative to UPS during breakdown. Use of LED's in place of CFL would provide minimal bill of electricity. For the cooling effects inside the house, use of Clay tiles and Simple Kota tile appreciable. These tiles provide the cooling and cost less as compared to the marble. They will provide the great textures and gestures to the appearance.

➢ **Homeowner Awareness:** The owner and occupants of this home should be aware toward conserving the natural resources minimizing the wastage & usage and tries to incorporating toward green features in order to live the life into a sustainable and green environment.

- **Site Selection and Planning:** Site should have a proper topography and vegetation as it should not be constructed by destructing the existing natural resources. Planning of the home should be ascertain with the proper ventilation and day lightings.

IV. IGBC Criteria Accomplished Using Green Features and Materials

- **Site Selection and Planning**
  - Credit 1- "Basic House-hold Amenities(1 point)"
  - Credit 2 –"Natural Topography or Vegetation(2 points)"
  - Credit 4 – "Heat Island Effect, Roof(4 points)"
  - Credit 8 – "Basic Facilities for Construction Workforce(1 points)"

- **Water Efficiency**
  - Credit 1 – "Landscape Design(2 points)"
  - Credit 3 – "Rainwater Harvesting, Roof & Non-Roof(4 points)"
  - Credit 4 – "Waste Water Treatment and Reuse(4 points)"

- **Energy Efficiency**
  - Credit 2 – "On-site Renewable Energy(6 points)"
  - Credit 4 – "Energy Saving Measures in Other Appliances & Equipment(2 points)"

- **Materials & Resources**
  - Credit 2 – "Handling of Construction Waste Materials(1 point)"
  - Credit 3 – "Reuse of Salvaged Materials(2 points)"
  - Credit 4 – "Materials with Recycled Content(2 points)"
  - Credit 5 – "Local Materials(2 points)"

- **Indoor Environmental Quantity**
  - Credit 1 – "Enhanced Daylighting(4 points")
  - Credit 2 – "Enhanced Fresh Air Ventilation(2 points)"
  - Credit 4 – "Low VOC Materials, Paints & Adhesives(2 points)"
  - Credit 6 – "Cross Ventilation(4 points)"

By implementing the above the features and materials, these criteria can fulfill which can make it Green Homes. Around 38-44 points required to get the certification of IGBC's Green Homes. By achieving the certification and with the minimum implementation of these features, the conventional building can be make or convert into Green Homes.

V. RESULTS AND DISCUSSION

From the recent studies, we conclude the following points are as follows:

- The overall construction cost of conventional house was ₹ 623750 and cost of construction of Green home was 513650 that would costs 21.4% less capita.

- The Energy consumption and Water Consumption get reduced considerably by 10% with the adoption of the Green Home features.

- Adaptability of R's concept (reduce, reuse, recycle, reinvent and reduce) will intend to conserve the depletion the natural resources and to reduce the materials cost by 10%.
- The Indoor environment and temperature has reduced by 3-5 degree celcius by proper ventilation, lightening and green rooftop.
- Evolution of Green House Gases gets minimized by minimizing the utilization of Cement in the construction process.
- With the incorporation of good lightening and cross ventilation, the use of air conditioner during daytime get reduced which would help in minimizing the Global Warming and saves the energy consumptions.
- Use of virgin material (pinewood, linseed oil, stabilized mud blocks) helps in reducing the adverse impact on the environment and saves the economy.
- The Groundwater level and sources gets less depleted with the introduction of rainwater and greywater harvesting system. The impact on the municipality for the water delivering to the house get effectively reduced with introduction of the rainwater harvesting system.
- Use of green features and virgin materials would intend the less bad impact on the green and healthy environment. Health and Well Being gets improved by living with the green environment and virgin materials.

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