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Critical Review, Analysis & Suggestions for Transforming Existing Building into Green Building.

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Abstract: The term "Green Building" is not just applicable to products, but also to the construction strategies, building design, orientation, landscaping, building operations, maintenance etc. Lesser the negative impact of a building on human health and environment, the greener it is. In present study, Transformation of an existing building (School building) to green building is taken into account considering the aspects of landscaping, architecture, energy, water, waste-water, materials and lifestyle along with cost considerations, so that the occupant's well-being, environmental performance and economic returns are improved. The overall consumption of energy, water, waste-water & solid waste generated has been determined and the energy and water that will be saved after the additional inputs (like ground water recharging system, rain water storage tank, landscape design, vermi-composting, use of renewable energy and use of passive architectural design strategies etc.) to improve the efficiency of the building is worked out. The study concentrates on the tangible and non-tangible, beneficial outcomes once the building is converted to "green building". Various measures are proposed to impart the green performance to the building. Measures already adopted for incorporating green building features during construction are also discussed.
Keywords: Green Building, SVA-GRIHA, Heat Island Effect, Indoor Air Quality, Rain Water Harvesting, Landscaping, SHGC, Wastewater Recycling, LPD, day-light factor, PPC, Embodied Energy, VOC, Carbon Footprint, Green Lifestyle, Daylight Factor.

I. INTRODUCTION

A green building is one which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building. Green or sustainable Building is a designing concept that reduces the environmental impact of buildings through innovative land use and construction strategies. A Green Building incorporates the use of clean, renewable energy and efficient use of natural resources and recycled or recyclable materials to provide healthy indoor and outdoor environment. The green building trend has increased rapidly worldwide in recent decades. The idea of green rating of buildings has taken roots in India also. This is in line with the global trend in which the rating tools sets benchmarks for green measures for construction and operation of buildings to make them sustainable and to reduce their negative impacts on environment. Based on the magnitude of green measures adopted, points are awarded to a building (as per GRIHA or SVA-GRIHA) and, after appropriate weighting; a total score is ascribed to determine the rating of the building. This helps to convey the range of application of green measures in building construction.

II. NECESSITY OF GREEN BUILDING

Due to tremendous growth in industrial sector and advancement in technology, the use of energy has been increasing all over the world, causing an irreversible damage to the global environment. This will cause an undesirable impact on the quality of life of the future generations. As per Indian Green Building Council (IGBC) Report, at present, conventional buildings contribute as much as one-third of total global greenhouse gas (GHG) emissions. The building sector contributes up to 35%-40% of global annual greenhouse gas emissions and consumes up to 40% of all energy. One of the main culprits of GHG is carbon dioxide, which is implicated to contribute up to 47% of all global emissions in world. India's position is 144th (1.4 metric ton) in carbon emission rating in the world. Due to rapid increase of new infrastructural developments in transitional economies of developing countries, and the insufficient and improper use of existing buildings universally, it is an imperative of the construction industry to develop sustainable building technologies. If no necessary steps are taken soon, greenhouse gas emissions from buildings are likely to become more than double in the next two decades. The flow chart for root cause of environmental pollution due to conventional buildings is shown in below (Fig. 1.1). It shows that energy consumption is the main reason for greenhouse gas emission from

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buildings. Green building (GB) is a key architectural concept of the 21st Century and it is the technique of constructing or transforming structures to become environmentally conscientious, sustainable and resource-efficient throughout their life cycle. The GB are capable to have efficient water use, energy-efficient and eco-friendly environment, use of renewable energy and recycled/recyclable materials, effectual use of landscapes, effective control and building management systems and enhanced indoor quality for good health and comfort of the residents as compare to conventional building. The concept of green building (Fig.1.2) not only favors human health, but also safeguards earth from harmful and poisonous effects, fulfilling the accountability of the concept of sustainable development.

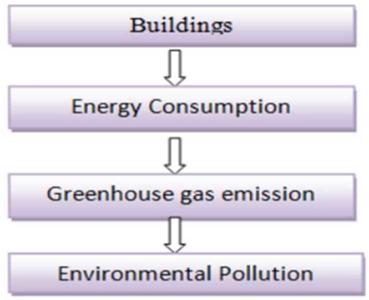

Fig. 1.1 Root cause of pollution

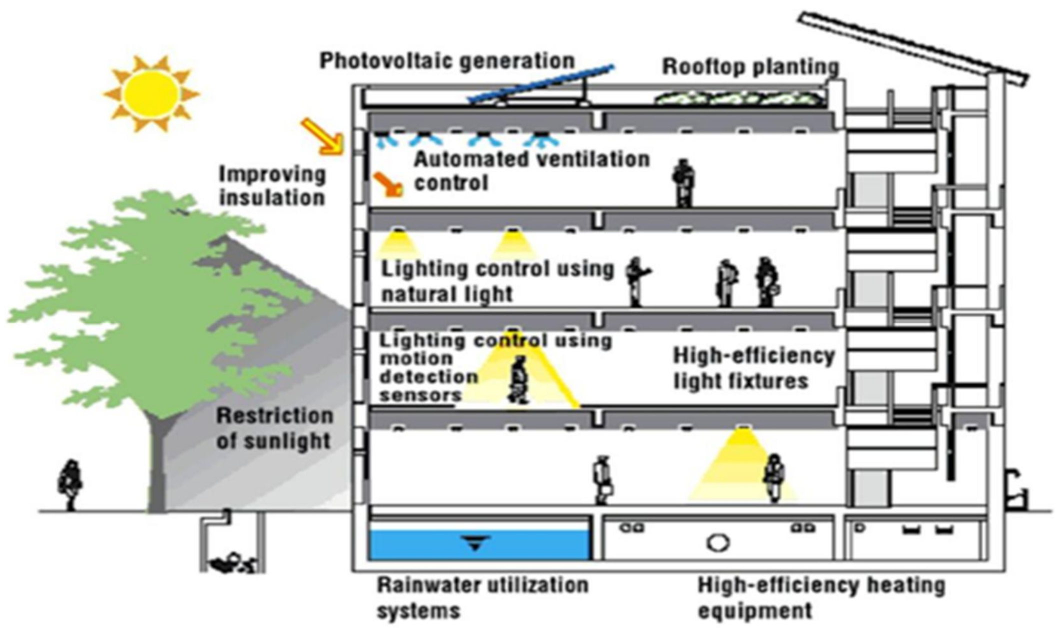

Fig. 1.2 Conceptual drawing of green building.

III. WHAT MAKES A BUILDING GREEN?

National Building Code (NBC) provides the guidelines on energy consumption for green buildings in India. According to NBC green buildings save water (36%-40%), save energy (30%-40%) and save material (25%- 40%) compared to conventional buildings. The specific features of sustainable buildings are as follows:

1) Site selection with full respect to ecology of the area, existing environment and use of local materials.
2) Minimum consumption of energy by the building.
3) Minimum use of fresh water from external sources.
4) Maximum use of non-toxic, recycled and renewable material.
5) Integrated Building Management System for control, monitoring, measurement and verification.
6) Innovation in design and construction technique.
7) Secured power infrastructure.
8) Highest indoor air quality without affecting the energy consumption.

IV. METHODOLOGY FOR MAKING GREEN BUILDINGS.

Methodology adopted for making green building is grouped in some domains, which are mentioned below.

A. *Sustainable Site*

It refers to a site that would have the least environmental threat during construction stage. It shall have access to basic amenities like water, transport; market, hospitals, electricity etc. It also optimizes the use of on-site storm water management and provision for ground water recharge.

B. *Water Efficiency*

The main goal here is to increase the effective use of water within the building, thereby reducing the amount of fresh water needed for various operations. Some methods which can be adopted for this includes, efficient landscaping techniques, use of innovative wastewater management technology, Reuse of rain water such as Rainwater Harvesting, Recycling of Wastewater using STP, waterless urinals, low pressure fixtures & innovative technique etc.

C. *Energy Efficiency*

It involves the installation of various methods of on-site renewable energy production to reduce the overall energy consumption of the building and other means of energy generation using green power (solar, wind etc.). The optimization of building orientation, shape, design, interior colors and finishes, is done to maximize the use of natural day lighting. This reduces the dependence on artificial lighting. Window frames, sashes and curtain wall system are so designed to optimize energy performance. Use of Bureau of Energy Efficiency (BEE) rated electrical equipment's is also encouraged. Use of CFC-free refrigerants (Freon, etc.) in Air conditioners (AC) and refrigerators shall be practiced. Renewable sources of energy such as solar, wind, geothermal etc. are recommended to reduce the electricity load at peak hours.

D. *Material Selection*

Emphasis shall be given to maximize the use of recycled content materials, re-usable, renewable, sustainably managed and bio-based materials. Ways shall be identified to use high recycled content materials which ranges from blended concrete using fly ash, slag, recycled concrete aggregate or other admixtures to structural steel, ceiling and floor tiles, carpeting, carpet padding etc. Bio-based materials and finishes made from agricultural waste and by-products including straw, wheat, barley, soy, sunflower shells, peanut shells etc. shall be used. Reuse of household waste in the form of biogas is also a feature of this aspect.

E. *Indoor Environment Quality*

In order to enhance the health of the occupants, buildings should be constructed with materials having low VOC-emissions. Building is designed to maximize the use of natural light for all occupants. Bio-degradable and environment friendly cleaning agents are recommended to be used, (which do not release harmful agents and residue). There should be a provision for cross ventilation and enhanced ventilation system. By considering all above aspects a green building can be designed and constructed. The conceptual planning & drawing for green building is shown in Fig. 1.2

V. SIGNIFICANCE & IMPORTANCE OF STUDY.

Our country is witnessing a boom in the construction sector and in the real estate development. The construction sector contributes 11% (INR. 2491 Billion, year 2015) of India's GDP and is growing at about 9%, as against the world average of 5.5%(as per the Ministry of New and Renewable Energy, Government of India).This has led to a rapid rise in energy demand in urban areas. Urban areas have emerged as one of the biggest source of Green House Gas (GHG) emissions. Buildings alone contributes around 40% of total GHG emissions.

As per latest UN report, worldwide 1 million people are moving to urban areas each week. It is estimated that around 2/3rd of the world population will be living in cities by 2050. Due to this a tremendous shift in energy resources in urban areas is likely to take place. Therefore the conversion of existing building to green building can be helpful in reducing the thrust on energy resources and carbon footprints.

The aim of this study is to undermine the myth that existing non-rated building cannot be economically transformed into green building. A school building constructed during year 2015 is taken as a case study.

VI. DETAILS OF CASE STUDY

A. Location & Identification of Building

1) *Name*: SANSKAR PUBLIC SCHOOL
2) *Location*: Naugaon, Gwalior (13 KM from heart of Gwalior i.e., Maharaja Bada)
3) *School Coordinates*: latitude 26.1218° N, longitude 78.1279° E
4) *Climatic Zone:* Composite
5) *Site Area:* 4026 m^2
6) *Total Built-up Area:* 2400 m^2 approx.
7) *Occupancy hours:* 07-09 hours
8) *School working days:* 240day /yr. (Considering vacations, & weekly holidays)
9) *Renewable energy installed on site:* 6.5 kW (solar panel)
10) *Building type:* Institutional (None Air-Conditioned)
11) *Building Orientation:* North- East
12) *Water Supply dependency:* Municipal water supply, & Bore-Well

B. Critical Observation

The school building has been observed critically on the basis of various criteria proposed by national rating system, BEE & ECBC. Observations are categorized into 5 different sub-groups & various recommendations are also proposed to improve the green performance of building; thereby increasing its rating (SVA-GRIHA) after its implementation.

1) *Landscape Design:* At present there is no provision for parking, check post, landscape area and peripheral zone for plantation in the building premise. At centre place of building Courtyard is provided consisting of hard paved which causes increase in surrounding temperature due to absorption of solar energy. Building is exposed directly to sunlight in all directions, as there is no plantation provided at site. Only one mature tree (Neem) exists in school premises and also no pergolas are provided for shade.
2) *Architecture & Energy:* Simple projections of 600mm up to full width of the window is provided. No plantation is provided on southern or S/W facades to protect direct sun rays to enter into building through ventilators, windows. No provision of louvers, baffles, use of creepers, screenings/ shading shutters is used in building. Lightening fixtures such as 60W Incandescent lamps, 40W tube light, 15W CFL for illumination is provided in the classes, library, halls and staff-rooms. Ordinary glasses are fixed in windows and in ventilator panels. No thermal treatment on the roof is provided in school building. Flush doors without door closer are used. A 6.5KW capacity solar panel is installed on the roof of school building but solar water heater is not installed.
3) *Water & Waste:* Waste water generated in school is directly discharged into municipal sewer. There is no provision of reuse & recycling of waste-water. No sewage treatment plant is provided to use generated waste-water for gardening/flushing/lawn watering. Water efficient fixtures in building and in landscape are not provided. There is no provision of storing/harvesting rain water as no rain water storage tank is provided in school. Colored dustbins are provided for waste collection but no guidelines are specified for segregation of waste for generating resources.
4) *Materials:* PPC has been used in all types of masonry related work during construction of school. Fly- ash bricks are used for brick masonry work. Flush doors (low energy) made up of wooden waste are also used. Such types of doors are made up of waste wooden materials and agricultural waste. All almirah, wardrobes, storage spaces, student's bench and chairs are also made up of block boards, fiber boards and particle board (MDF, HDF) on steel frame. Simple IT flooring (Plain Cement Concrete) in 1:2:4 PCC with neuro finish using PPC cement and locally available coarse and sand aggregate is used in flooring of class-rooms. Interior wall surfaces of class-rooms are white washed. No oil bound paints and putty is used. No false ceiling is provided in any space. Minimum use of oil paints is practiced. All paints used in interior surfaces are low-VOC and lead free.
5) *Lifestyle:* In the case study it is found that following services are located within the radius of 500 m. of the school building which may reduce the excessive use of private vehicles. These services are General store, Stationary store, Grocery store, Milk, dairy products store, Photocopy, printing store, Electronics/ electrical appliances store, Fast food, bakery products, sweets store, Clinic and Medical store.

VII. RECOMMENDATIONS / SUGGESTIONS FOR TRANSFORMATION EXISTING BUILDING INTO GREEN BUILDING.

A. Landscape Design

It is proposed to demarcate periphery zone (2m inside boundary wall) and plant native trees (like Bel, Neem, Semal, Palash etc.). Provision of dense vegetation cover towards western and southern facades of building to moderate microclimate and to protect it directly from sunlight is also suggested (see fig. 1.3). Plantation of native trees like (Ashok, Mitha Neem, Avla, Sisam etc.) is also suggested to plant towards southern façade of building to moderate the micro climate. It is proposed to convert hard paved courtyard into soft paved courtyard by growing native grasses and provide a water storage tank cum platform of size (12.0mX4.0mX1.5m) to store rain water from roof of passage/corridor. This soft paved area will absorbs solar heat energy and will help in maintaining low building temperature. Parking area and check post area is proposed to be covered (i.e. hard paved area under shade) with the help of bamboos, pergolas climbers and partially with solar photovoltaic panels.

B. Architecture & Energy

It is proposed to use desert coolers and fans instead of air-conditioners. Provide one 48" (1200mm) ceiling fan for each 18 sq. m working floor area. It is also proposed to shift toilets, store rooms etc., from north direction to western façade to acts as buffer zone & provision of false ceiling in air conditioned rooms is also recommended. Provide Horizontal inclines (40cm wide at an angle of 30 degree), on south façade on exterior surface of windows. This will cut-off the entry of direct sunrays through windows from southern direction. Vertical inclines are also suggested to be provided on windows facing western direction. This will prevent the entry of direct sun rays from west. Dense trees (deciduous) are proposed to be planted along the southern wall of school at center to center space of (4-5) m and at (4-5) m distance from southern facing wall. This will screen off the direct sunrays to fall on the southern wall during summer causing excessive heating but at the same time during winter sun rays will be permitted to keep space warm. Replacement of all incandescent/ballasts/CFLs with suitable LED (9W-12W) lamps is also recommended. It is suggested to use luminaire of BEE 5 star rating. As per the study more than 60% of heat energy enters from ceiling, therefore provision of thermal treatment of roof by using Mud-phuska /Thermacol sheet/inverted earthen pot etc., is proposed to restrict heating of space. It is also suggested to provide heat reflecting paints on the exterior walls to reflect solar heat thereby to reduce temperature. Use of door closers on door facing outside can also be helpful in preventing heat to enter inside the building. A solar water heater of 100Lpd is also proposed to meet the daily hot water demand of school (i.e., in laboratory etc.).

C. Water & Waste

Low flush toilets cisterns with a capacity of 3.0 liters of water per flush (in place of presently provided 6-7 liters per flush) are proposed. It is also recommended to use ground vegetation covers such as Asparagus sprengeri, which is succulent; Pandanus dwarf, which is xerophytic; and Bougainvillea, which is a climber. Use the sprinklers irrigation in landscape area which have the water application efficiency more than 70%. Reduce the lawn area and plant more trees that require less water. Water-efficient urinals equipped with sensors and solenoid control valves are proposed be installed in toilets. The roof top harvesting can be used for the collection of rain water (18 no. of water recharging points are suggested) for ground water recharge and roof of passage area is proposed to be used to collect rain water for subsequent storage in water tank (three days water demand). Provide gravel filter in ground water recharge system to remove the unwanted materials like leaves, gravels, organic and inorganic substances. A STP of 10KLD is also proposed so that treated waste-water can be used for gardening, lawn watering, road cleaning, flushing etc. At least 40%-50% reduction in daily fresh water demand can be made possible, if above mentioned measures are adopted. Solid waste generated from the building proposed to be properly segregated. Recyclable, reusable materials like paper, plastic, metals etc., are proposed to be sorted out for selling it to authorized vendors. Organic Waste along with agriculture waste is suggested to be used for vermi-composting. This will provide improved quality of vermi-compost (manure) for utilizing it in lawn and garden. Burning of waste shall be strictly banned. Through the above strategy almost 100% waste can be transformed into resource.

D. Materials

The building is already constructed during 2015. As per the above critical observation it is revealed that low energy materials are already used in flooring, furniture, doors and windows. The interior walls are also painted with low energy paints like white wash and dry distempers. The paints used are also lead free and low-VOC. Spaces provided with air-conditioners like computer center, principal office and other few spaces are proposed to be provided with false ceiling for enhancing thermal performance & reducing

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space for air conditioner. It is also suggested that low energy materials like asbestos cement, panel or similar other type of low energy materials shall be used for false ceiling.

E. Lifestyle

For working service staff, it is proposed to have a separate rest room with attached toilet at the ground floor. These rest rooms are proposed to be provided with a desert cooler and ceiling fan for comfort. Creation of environmental awareness through potential efforts in the building itself such as showcasing energy efficient building systems and technologies, materials used in building, proper labelling or documenting their respective energy performance or savings, can also be done. Adoption of innovative strategies such as labelling the water fixtures for the water source (for example, 'this tap uses rainwater harvested from the roof', recycled waste-water is used for watering in lawns. Also demonstrate different spaces using recycled waste water from sewage treatment plant with proper documentation. Landscape area shall be labelled with name, medicinal value etc., for native species or aromatic herbs, to raise awareness towards low-maintenance and low water-consuming native species as compared to high-maintenance exotic species.

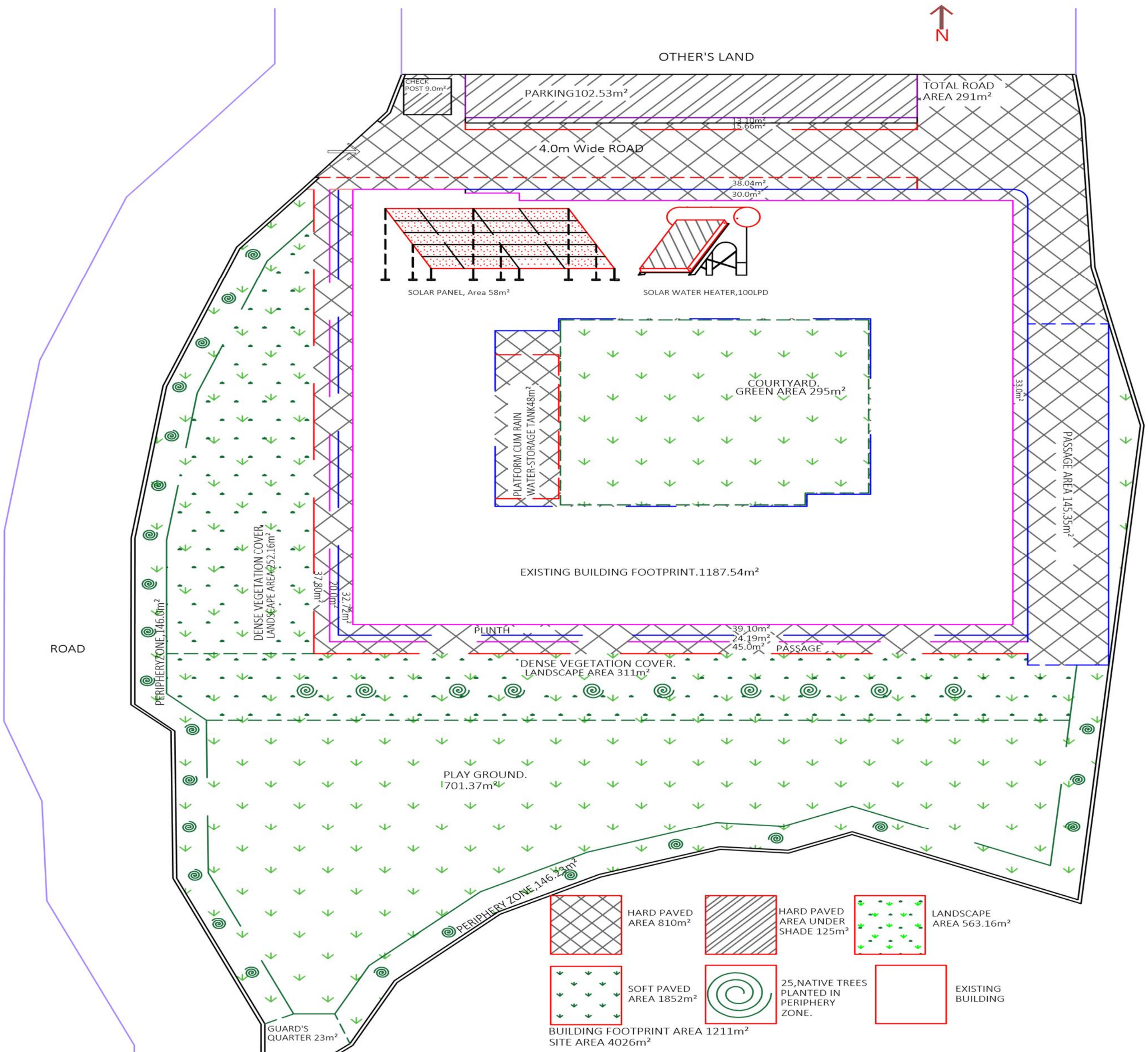

Fig. 1.3 Modified Plan of Existing Building after Transformation into Green Building showing some Green Building Features

VIII. CALCULATIONS.

A. *Percentage reduction of exposed hard paved surface on site to reduce Urban Heat Island Effect (UHIE)*

Total site area of the existing school …………………………… 4026 m^2
Area covered by the building footprint …………...……….. 1211 m^2
Total area under garden/landscape ……………………………. 563 m^2
Calculate the total paved area on site by using the following formula:

- Total paved area = Site area – (building footprint + landscape area)………….EQ---1
- Soft paved area + hard paved area under shade > 50% Total paved area…..EQ—2

Total paved area on site ……………………………………………..2252 m^2 (eq.1)
Soft paved area on site ………………………………………………1852 m^2
Hard paved area under shade ……………………………………125 m^2
As per eq.--2 (1852+125) > 50% of 2252 …………..OK
Total 87% of the paved on site is either soft paved/shaded by trees to reduce the urban heat Island effect.

B. *Calculation of Waste-Water Generated in School*

Daily water requirement per person= 45L/head (as per BIS code)
No. of persons (including student & working staff) =500
Total water requirement =500X45= 22500 lpd (litres per day) or 22.5 m^3/d
For flushing =15 litres per head is required.
Total water required for flushing =15X500 =7500 lpd or 7.5 m^3/d
Water requirement for lawn/gardening = 0.5 cm/day (0.4-0.6cm/day or 3-4cm/week)
Area of garden/lawn =563 m^2.
Per day water required for gardening = (563 m^2 X 0.5)/100 =2.8 m^3
Total recycled water can be used for flushing & gardening (2.8+7.5) =**10.3 m^3.**
Total water required for all purpose = 22.5+2.8=25.3 m^3.
It is proposed to provide at least 10KLD sewage treatment plant (using MBBR technique). Treated sewage can be recycled and may be used for flushing, gardening & floor washing.

C. *Percentage of water conserved through rain water harvesting*

It is suggested to use roof area of passage for storing the rain water into underground water-tank (constructed in courtyard) to partially meet the school water demand, its calculations are as follows:

The total area of roof of passage provided in school =160 sq. m
Annual rainfall in Gwalior city is assumes to be 0.70 m or 70cm
Runoff coefficient is taken as 0.65
Volume of water storage tank = (160 X 0.70 X 0.65) = 72.8 cum
Provide a water storage tank in the courtyard having dimensions of Length=12.0, Width=4.0 Height=1.5m. This water storage tank will be able to meet the complete water requirement for 3days (daily water requirement of school is 22.5cum) and may also serve as storage for fire-fighting.

D. *Payback Period of Installed Solar Panels*

The payback period of solar panel installed in school building, A 6.5KW capacity solar panels are installed on the roof of school building.

1) The cost of 1KW (On Grid) solar panel in India = ₹ 70,000
2) Net cost of 6.5 KW capacity solar panels installed = ₹ 70,000 X 6.5 = ₹ 4,55,000
3) Sunny day's available in a year (assume max. 45 rainy & 45 fog days) = (365-90) = 275 sunny days
4) Effective energy generation in these 275 sunny days from (9AM to 6PM) =9hrs.
5) Per day energy generation = 6.5 X 9= 58.5 KW/day
6) Cost of energy generated = 58.5 X 8 = ₹ 468/day
7) Per year energy generation = 275 X 58.5 = 16087 unit
8) Cost of energy generated per year = 16087 X 8 = ₹ 1,28,700

9) No. of years required to recover installation cost(payback period)
= cost of investment/annual net earning
= ₹ 4, 55,000/₹ 1, 28,700 = 3.5 years or (42 months)

Note:

a) During off hours of the school (holidays, early morning, late evening) energy generated can be sold through GRID and the amount earned is not considered.
b) The hike of electricity charges are also not considered.
c) Non tangible advantages like reduce carbon footprints, conservation of resources, and heat reduction through ceiling are also not considered.

IX. CONCLUSIONS

The green building experiences in India are challenging due to additional cost and lack of awareness. Country lacks in technological demonstration and knowledge dissipation. This case study of school building concludes that there is sufficient scope to transform an existing building into green building without introducing major changes and alterations. As per calculation it is revealed that the transformed school building will be compatible to 4 star SVA-GRIHA rating. There exists several parameters and strategies for improvements. A skilful, judicious and optimum choice of strategies or combination of strategies may prove economical, feasible and economically viable to convert existing buildings to moderately or moderately high Green rated building. Present study also concludes that in some cases payback period of technological input is as small as 3.5 years (if the suggestions are implemented in true sense). This case study may also acts as a demonstration project to encourage others to convert their old existing buildings into energy efficient green building. Such type of demonstration projects may provide a great leap towards energy conservation and environmental protection in future with regard to building and infrastructure projects.

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