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ENERGY RETROFITTING TO REDUCE ENERGY CONSUMPTION OF RESIDENTIAL BUILDING

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ABSTRACT:

The well known countries are facing adverse energy catastrophe that directly affects their economic condition. Day by day there is also boost in carbon emission which needs to reduce as early as possible. Retrofitting is one of the solutions to overcome this problem. Retrofitting of already constructed building aids to lessen the energy consumption as it uses energy efficient materials and techniques. This paper involves the study and analysis of energy consumption of existing base building and retrofitted building. The results illustrate that yearly huge amount of energy can be saved by doing slight amendment in base building. The various advanced methods for retrofitting are explained to guide the tenants of other existing base buildings so that they can move towards energy saving practices.

KEYWORDS: Energy Consumption, Retrofitting, Carbon Emission, Advanced Methods etc.

INTRODUCTION:

Nowadays, most of the buildings are designed by considering the basis of sustainability. But before introducing the concept of sustainability, huge portion of the building was already built. These buildings were designed by considering traditional approach which consumes lots of energy and resources. Moreover, these buildings emit huge amount of carbon which is a serious problem for an environment. This carbon emission poses threat to environment for greater extent. To reduce carbon emission there is a need to look forward towards new advanced construction technique which benefits in all aspect. There are various techniques such as green building, low carbon building, zero carbon building etc. for reducing carbon emission. All these techniques aim to reduce carbon which is emitted from residential building. But these techniques are suitable for newly proposed building. What about the carbon emission from existing building or already constructed building? The solution for this is to dive towards Energy retrofitting concept.

Retrofitting is the process in which modification takes place after manufacturing. Bringing this concept to building, this means that making changes to the systems inside the building or even the structure itself at some point after its initial construction and occupation. Energy retrofitting technique helps to reduce energy transfer and carbon emission to greater extent. With energy efficient retrofitting, buildings are able to obtain comfort conditions by minimum energy.

ENERGY RETROFITTING:

The various ways of energy retrofitting are as follows:

1. Improving the thermal insulating material properties of building envelope.
2. Improving performance using natural cooling and heating sources.
3. Improving the lighting system (using energy-saving lamps and natural lighting)
4. Using renewable resources
5. Raise awareness of energy conservation and encourage energy conserving behaviors.

IMPROVING THE THERMAL INSULATING MATERIAL PROPERTIES OF BUILDING ENVELOPE:

1. SMART MATERIALS:

Retrofitting includes use of smart materials in large amount. According the Encyclopedia of Chemical Technology smart materials and structures are “those objects that has capability to sense the environmental events, process that sensory information, and then operate on the environment”. These smart materials have designed with active property changing and energy-exchanging features that respond to external stimuli and materials. [v]

2. EFFECTS OF THE SMART GLASSES IN INTERIORS:

Using the smart glasses in the interiors of building is a part of sustainable building as well as retrofitting. These smart glasses are used for blocking ultra violet lights entering on the ceiling windows. When common window is used it allows sunlight to enter in directly which causes glare and results in use of curtains to block the direct light entry. These electro chromic glasses provide light and heat control as well as prevent from glare. They also lead to cancel use of curtains as normal glass does.

When normal or ordinary glasses are used, during summer season direct heat enter inside the room and increase heat inside the interiors which causes the use of cooling machines for longer period. But smart glasses decrease transmissions of light and cools down the interiors by saving 80% of energy. 95% of ultra violet light is also reduced in entering the interiors. As a result of this interior wall, fabric and flooring fading is reduced. The opacity can be controlled depending upon the materials used in the structure of the glass. Hence, the amount of light entering inside the interiors can be controlled. Smart glass can be preferred for aesthetical concerns. The different interior space and shade qualities can be observed when the smart glass contains the property of transparent or translucent. This glass also has ability to absorb the interior air and gets them into nano filters which are placed inside the glass. [vi]

3. ADD ON INSULATION ON WALL AND ROOF:

To reduce heat entry inside the building, there is need to use insulating material onto the wall and roof. Energy retrofitting uses chaina mosaic or light colored tiles, high reflecting material on top of the roof and walls.

IMPROVING PERFORMANCE USING NATURAL COOLING AND HEATING SOURCES:

1. SHADING:

Window should be fully shaded in order to receive maximum comfort. other shading devices which sufficiently shade the south-facing elevation from the summer sun; south elevation overhangs should be horizontal while east and west elevations usually require both horizontal and vertical overhangs. [viii]

2. COOL ROOF:

A Cool roof is a roof that has an ability of high solar reflectance and high thermal emittance. Solar reflectance is the ability to reflect the visible, infrared and ultraviolet rays coming from the sun which reduces heat transfer to the building. Thermal emittance is the ability to release a large proportion of absorbed, non-reflected solar energy. Cool roof is used to handle global warming which is based on solar radiation management principle where materials that are used reflect solar energy as well as emit solar radiations for cooling planet. Over 90% of the roof in the world consists of dark color which leads to increase temperature around 90 degrees F in summer season. Cool roof provides lots of advantages over ordinary roof. [viii]

3. WIND TOWERS:

The basic purpose of wind towers is to provide cooling in hot and dry climates. The tower is placed at higher elevations to catch the wind and direct it to living space. The tower may have one opening facing the wind or may have different openings depending upon direction & flow of wind. The tower has airflow passages through which wind enters inside and consists of different areas. These systems are used mainly to provide natural ventilation and cooling. [x]

4. STACK EFFECT:

Thermal buoyancy effect or wind causes air to move inside the structure with high pressure. Thermal buoyancy effect is generated due to the warmer air present in the surrounding. Because warmer air is having lower density than surrounding air(cooler air). Warmer air tries to go up as cooler air enters through the bottom. The stack consists of opening at top and bottom. As cooler air enters in through lower opening, the warmer air tries to displace through top opening. This leads to cooling of surface area. [x]

5. EVAPORATIVE COOLING:

To maintain or lower inside temperature of building, Evaporative Cooling method is used. When there is contact between air and water, rate of evaporation increases. When water bodies such as fountains, ponds etc are located inside or nearby building then they help in reduction of air temperature.

6. EARTH AIR TUNNEL SYSTEM:

Earth air tunnel system is the most practical system which reduces temperature of building with greater extent. This system is more viable when soil contains adequate water. Earth air tunnel system approximately reduces 60% of energy consumption as air conditioning systems that are used in building. [x]

7. TREES OR VEGETATION:

Planting trees and vegetation in the surrounding areas proves to be good option in cooling the building temperature. Mostly deciduous trees are good to plant. They provide natural breeze in summer and sunlight in winter as their leaves fall in winter. These trees should be plant on west and south west orientation of the building. When trees are plant in such a way that cool breeze enters inside the building through a channel or windows then natural air conditioning can be achieved.

IMPROVING THE LIGHTING SYSTEM:

Nearly 15% of Indian total energy consumption is done by lighting system. If huge amount of natural light enters inside the building then less amount of lighting system is required and hence energy consumption reduces.

1. INTERNAL FINISHES FOR DAY LIGHTING:

If reflectance of the internal surface is higher then there is better daylight distribution. Moreover full height partitions should be minimized so that access amount of natural light and ventilation can be observed. Shading must be provided to windows to get maximum comfort.

2. ENERGY AUDITS:

Energy audits must be carried out for replacing existing equipments with efficient features. This may include things like replacing florescent bulb with LED bulb etc. The energy saving device that includes lighting equipments with greater lumen output and lessen heat output, electronic ballasts or other efficient devices etc. must be used.

USING RENEWABLE RESOURCES:

1. SOLAR PHOTOVOLTAIC DEVICES:

Solar Photovoltaic devices help in converting sunlight into electricity using solar cells. They can produce energy up to kilowatts. These devices are used in multiple applications such as calculators, buildings, communications, satellites, watches etc.

2. SOLAR WATER HEATING SYSTEM:

The most economic and attractive application of solar energy is solar water heater which is used by most of the populations. The solar water heater uses solar energy and utilizes it for heating water. This hot water is useful for bathing, washing, cleaning etc at homes. The solar water heater having capacity of 100 lit per day is enough for 4 to 5 members which can save up to 1500 units of electricity per year. This pays back the cost of water heater in 3 to 4 years depending upon the utilization of hot water and electricity tariff. Rest of the lifespan, the hot water will be available free of cost of use.

CASE STUDY:

Retrofitting of already existing building is done by using energy efficient material in order to reduce energy consumption. This study involves analysis of energy consumption pattern of an existing residential building in Kolhapur and its Retrofitting. The results suggest that significant amount of energy can be saved by making slight modifications in the building using energy efficient material available in the market. The cost of retrofitting can be recovered within a few years. The findings of this study also serve as a guide for owners/tenants of other existing residential & commercial buildings on how to move towards sustainable practices and gain enormous amount of energy savings.

BASE LINE BUILDING:

Base line building is the building which has no any GHG emission reduction strategies or no any low carbon emission construction technology or any low carbon emission construction materials.

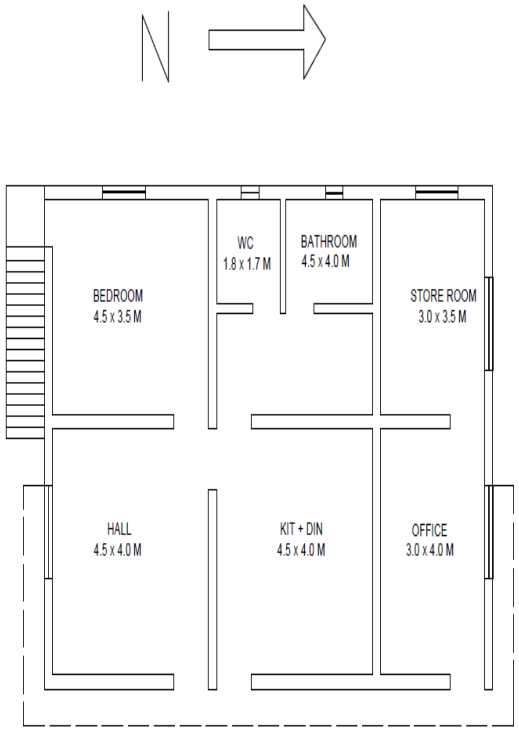

Fig. No.1. Plan for Baseline building (Ground Floor)

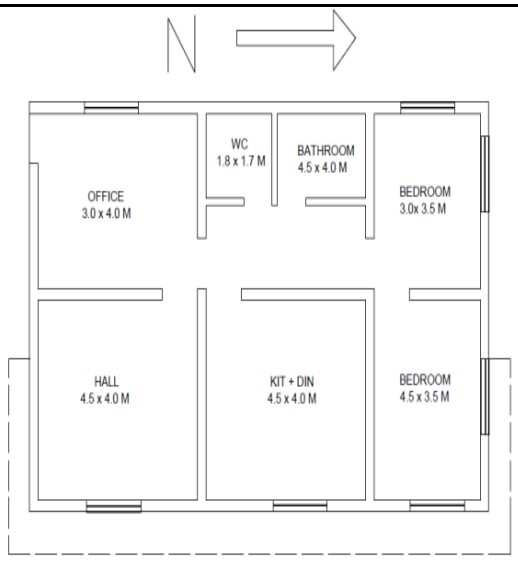

Fig. No.2. Plan for Baseline building (First Floor)

The plan of residential building including retrofitting activity is as follows:

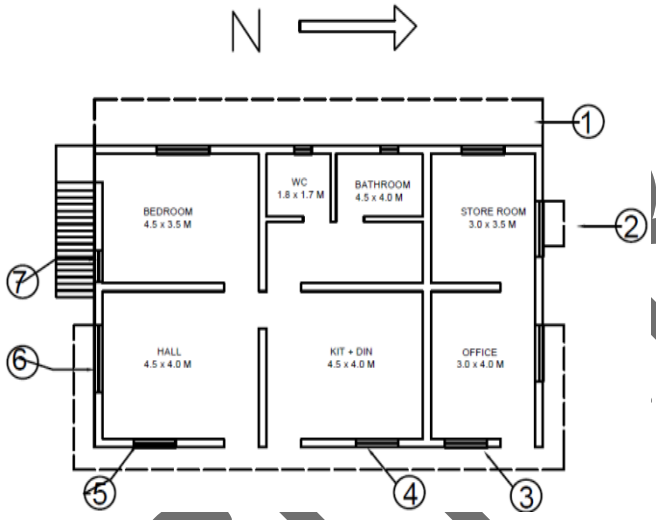

Fig. No.3. Plan for Retrofitted building (Ground Floor)

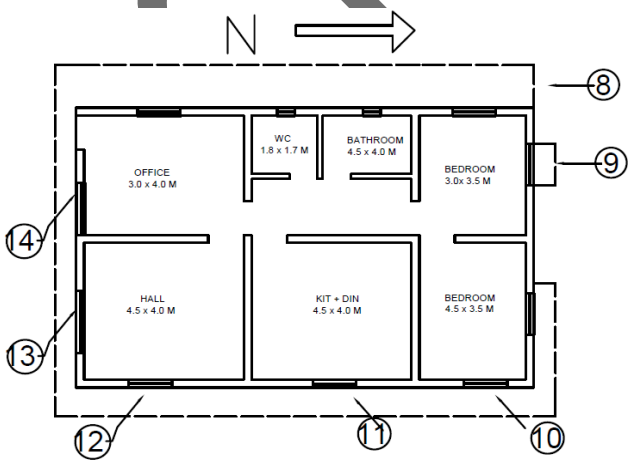

Fig. No.4. Plan for Retrofitted building (First Floor)

SOUTH SIDE:

Base building does not contain window opening on south side. Due to this, there is lack of lighting and ventilation in the rooms. Hence, more lighting and cooling devices are required. The notification numbers in diagram are 6,7,12,13. The applicable retrofitting techniques are shading system, stack effect & provision of window openings.

At the site location, the direction of wind during day time is towards North and during night is towards south. There is need to provide large size windows towards south side in order to achieve cooling. Also there is need to provide shading towards south side to avoid direct solar radiations and heating of the room.

NORTH SIDE:

Base building does not contain window opening on North side. Hence, more lighting and cooling devices are required. The notification numbers in diagram are 2,9. The retrofitting techniques that are applicable are shading system, stack effect, provision of window.

EAST SIDE:

Base building does not contain window opening in East side. Again there is requirement of cooling devices. The notification numbers in the diagram are 3,4,5,10,11. The validation of technique helps to improve lighting as well as early morning refreshment of kitchens. But the low sun angle on East is difficult to shade in summer. Hence vertical shading system is more effective and the size of windows should not be large.

WEST SIDE:

Base building does not contain shading to window opening on West side. Due to this, intense sunrays directly enter into room at an evening. The notification numbers in the diagram are 1,8. The Retrofitting technique used here is shading system. West side provides intense exposure to sunrays during evening hours. Hence there is a need to provide shading to the window to get the comfort.

Side	Existing Base condition	Problems created by base building	Retrofitting technique	Retrofitting technique notification nos. in diagram	Validation of Retrofitting technique
South side	Base building does not contain window opening & shading system on south side	Lack of lighting and ventilation in the rooms. Hence, more lighting and cooling devices are required.	shading system, stack effect & provision of window openings	6,7,12,13	Direction of wind during day time is towards North and during night is towards south, large size windows towards south side in order to achieve cooling
North side	Base building does not contain window opening & shading system on North side.	lack of lighting and ventilation in the rooms. Hence, more lighting and cooling devices are required.	shading system, stack effect, provision of window	2,9	Minimum radiation on north side so provide the large window than the previous (existing) window, for the excellent day lighting
East side	Base building does not contain window opening in East side	Lack of lighting and ventilation in the rooms.	provision of window openings with vertical shading system	3,4,5,10,11.	helps to improve lighting as well as early morning refreshment of kitchens
West side	Base building does not contain shading to window opening on West side	intense sunrays directly enter into room at an evening	provision of shading system	1,8.	West side provides intense exposure to sunrays during evening hours. Hence there is a need to provide shading to the window to get the comfort.

COMPARATIVE STUDY FOR BASELINE & PROPOSED RETROFITTED BUILDING:

The comparative study is made with respect to orientation, shading, cooling and day lighting and is given below in tables:

ORIENTATION:

Site/Orientation Check List					
Sr. No.	Category	Sub-Category	Base Building	Retrofitted Building	Modification/Remark
01	Orientation				
		Natural Breezes	Not sufficient, require cooling devices.	Use of passive cooling methods	Natural cooling can be achieved, reduction in AC and Fan is possible
		Existing Trees or Vegetation Considered in Design	No availability of trees on existing	Planting trees on west and south west orientation of building	Natural cooling can be achieved Reduction in

			building	provides natural shade and wind control	AC and Fan is possible
02	Exterior Spaces	Located or Shaded from Direct Sun	Building comes in contact with intense sun rays	Glazed south-facing wall, Planting trees on west and south west.	Natural cooling can be achieved Reduction in AC and Fan is possible

SHADING:

Shading Check List					
Sr. No.	Category	Sub-Category	Base Building	Retrofitted Building	Modification/Remark
01	Adequate Shading of Facades/Glazing	a) South	South side directly come in contact with Sunrays	Provide shading by using chajjas, and planting trees	Natural cooling can be achieved Reduction in AC and Fan is possible
		b) West	At evening West side directly come in contact with Sunrays	Planting trees on west side of building	Natural cooling can be achieved Reduction in AC and Fan is possible

COOLING:

Cooling Check List					
Sr. No	Category	Sub-Category	Base Building	Retrofitted Building	Modification/Remark
01	Orientation	Openings	Openings were improper lack of light and ventilation.	The position of some of the Openings will be changed.	Natural cooling can be achieved Reduction in AC and Fan is possible
		Insulation	Ordinary type of material which absorb more unnecessary heat	Insulating material like smart glass	Cooling and Day lighting causes reduction in fan and Bulb
02	Ventilation	Natural Breezes of Site Considered with Air Flow Diagram	The air flow aspect was not consider	Provide Stack effect, change the position of windows	Natural cooling can be achieved Reduction in AC and Fan is possible
		Exhaust Vents/Windows	Lack of ventilation	Provision of cooling tower	Natural cooling can be achieved Reduction in AC and Fan is possible

DAY LIGHTING:

Day lighting Check List					
Sr. No.	Category	Sub-Category	Base Building	Retrofitted Building	Modification/Remark
01	Direct Sun Shaded but Not Daylight	-	Directly sunrays enter into rooms	Shading of roofs-It helps to reduce indirect solar radiation	Cooling and Day lighting causes reduction in fan and Bulb
02	Windows	Windows on Multiple Walls	Provide windows were at improper Orientation	Provide at proper Orientation	Cooling and Day lighting causes reduction in fan and Bulb
03	Reflected/Filtered Lighting	Light Shelf	opening for light was not sufficient	Provide opening for light	Cooling and Day lighting causes reduction in fan and Bulb

COMPARATIVE STUDY:

The energy consumption of base building and retrofitted building is computed with respect to cooling, lighting and heating. The base building energy consumption is 3988 KW/year for cooling, 1084 KW/year for lighting and 2190 KW/year for heating. The energy consumption for retrofitted building is 571 KW/year for cooling, 501 KW/year for lighting and nearly 0 KW/year for heating. This is zero because instead of electric energy we are using solar energy devices such as solar water heater. For Lightning, instead of electric energy we are using solar lamps for particular condition such as outdoor lightning, fluorescent and CFL bulbs are replaced by led light which is having low energy consumption than CFL. The day lightning is improved by providing smart glass window system. Cooling natural ventilation is provided by stack effect, cooling tower, or tunnel system and proper orientation of windows. Due to this the utilization of cooling devices such as AC, FAN etc. is reduced and hence leads to reduction in energy consumption. From the above study it is observe that energy consumption can be reduced by using advanced retrofitting techniques and which helps to reduce carbon emission.

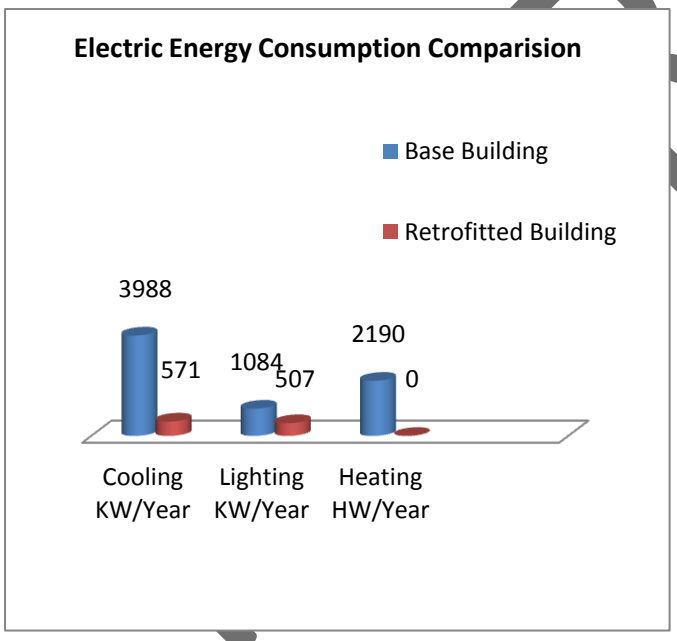

Fig. No.5. Electric Energy Consumption Comparison

CONCLUSION:

Considering the need and importance of higher destiny of our country, study of Retrofitting building to guard our "mother Earth" has end up an importance in present situation. The appropriate selection of site and building orientation performs a vital position in deriving maximum blessings from assets like solar, wind and so on. The advanced energy retrofitting construction techniques, strategies and eco-friendly smart material enable construction to become more strengthen & eco pleasant additionally to lessen carbon emission related to construction. In energy retrofitting, right choice of construction materials plays a significant function to discount the energy consumption and additionally carbon emission also. Energy efficient systems like LED, renewable energy systems like wind turbines, sun PV systems, sun water heating systems allows to reduce energy intake & carbon emission through building. It is important to amend present building bye laws and developments manage rules. Hence, amendment of building to reduce energy consumption and carbon emission is nothing but retrofitting of building.

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