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A Research Paper on Retrofitting of Institutional Building into Green Building in Construction

Mr. Fulsoundar Akshay Bhagwan[1], Prof. R. A. Binayake[2]

[1]PG Student, Department of Civil Engineering, JSPM's Imperial College of Engineering& Research Wagholi, Pune, India.

[2]Assistant professor, Department of Civil Engineering, JSPM's Imperial College of Engineering& Research Wagholi, Pune, India.

Abstract- *Retrofitting can be defined as changing, modifying certain parts, aspects of a structure with new or better parts which will prove to be beneficial for the user of the building & building itself. In a similar sense, Green Retrofit can be done by changing certain parts of building that damage the environment and changing it with sustainable alternatives which will increase the life of the building and reduce the life-cycle cost of the same. This can also be achieved by undertaking many practices which not only enable conservation the natural resources but also enable us to enhance the environment and contribute towards adopting & encouraging sustainable construction practices.*

Keywords: Green retrofit, environment, conservation, natural resources. Etc.

INTRODUCTION

Green Buildings will benefit greatly, both directly and indirectly. The main physical benefits are reduction in water consumption and energy consumption starting from the first day of ownership. Power efficiency would vary from 20 to 30% and water conservation from 30 to 50%. The impalpable advantages of green innovative buildings include better air quality, wonderful sunshine, health & comfort of tenants, safety benefits and the preservation of country's limited resources. Other advantages of retrofitting existing buildings include; long-term cost savings through minimizing power and water usage through integrating new technology, facilities or machinery; enhancing the height of comfort in buildings by upgrading the façade and interior to increase end-user performance & efficiency by illuminating indoor thermal comfort; depressed greenhouse discharge and improving the water use in structures; Future-proof constructions, which ensures that the structure will be used and can sustain for several years as it is fitted with modern automation; and maintaining the cultural and tradition value of prevailing structures by updating the outdoor and interior architecture of buildings to meet present requirements and plan depending on the requirements of end customers.

OBJECTIVES

1. To understand important aspect of retrofitting through study done on research papers.
2. To study planning required for green retrofitting.
3. To analyse cost effectiveness of green retrofitting of institutional building.
4. To apply the concept and parameters of green retrofitting which are found suitable and feasible.

LITERATURE REVIEW

Mohd. Ahmed & Mohd Abul Hasan et al., (2018) stated the comparison between the world green building rating systems and presents an insight into green building rating systems aspects and motives. To qualify the building green or sustainable, the developed and developing countries have their own rating systems and certification methods.

Stefano Cascone (2018) states that to improve the energy performance of existing buildings, the retrofit with green roof is an effective solution. This study through active thermal simulation estimates the extent of energy savings originating by the use of two different types of green roofs applied on the flat roof of a multi-storey residential building.

Alok Thacker and Deepa Joshi (2018) carried out green audit in existing educational complex and provided suggestions for green retrofitting using LEED rating system. Cost analysis has been carried out for application of proposed measures for the green retrofitting measures. The repayment time of the investments has been evaluated.

Nushrat and Saad Bin (2017) stated the economic and social benefit of green building. Aspects of green building were studied and SWOT analysis was done. In financial analysis, the total economic cost and non-monetary cost are calculated. The excess cost for construction of green building was calculated. It is theoretically possible to calculate the relative benefits of green building.

Muhammad Khairi et al., (2017) stated the importance of retrofitting the existing building to green building to reduce the dependency on constructing new buildings. They discussed the application, benefits and disadvantages of retrofitting an existing building. Retrofitting is one of the most environmentally friendly and effective solutions to improve the energy performance of building.

Binoy and Sharadindu (2017) stated the sustainable development implies fulfilling the needs of the present without negotiating the ability of the future needs. They studied the amount of electricity generated by renewable energy. This paper suggests us the various alternatives by which we can retrofit the existing buildings considering cost parameters.

DATA COLLECTION AND ANALYSIS

Case study details

- Chosen Case Study: School Building
- Area: Jambe, Hinjewadi, Pune
- Developer: Kolte Patil Developers
- Township Name: Life Republic Township
- Architect: Space Designers Syndicate
- School Name: ANISHA GLOBAL
- School Playground: 18322.39SQM
- School Area: 19441.71SQM
- No. of Classrooms: 44

Selection of Feasible Parameters:

Selection of parameters is one of the important tasks after thoroughly studying all the general parameters. Out of all the parameters studied, we able to find most feasible parameters for our study.

1. Photovoltaic Solar Panels 2. Energy efficient windows 3. Light Emitting Diodes

4. Brushless Direct current Fans

Fig 1 School Building

Analysis of Existing Data:

From electrical consumption data given in electricity bill we came to conclusion that average per month billing cycle cost Rs.90, 231.00 and the average units consumed is 7646.7 units

Total energy consumed (Tube lights, CFL lightings, fans and other miscellaneous sources, with super built up area amenities) = 7646.70 kWh

Cost of 1 unit = 11.80 INR, 11.80 x 7646.7 **= 90231.06 Rs. - (Monthly Electricity Bill)**

Table no. 1 Total consumption of Energy

mptio n	**ıber s**	**Powe r W**	**Consumptio n W per hour**	**kW**	**Duratio n Hrs.**	**Total Consumptio n kWh**
Fan	168	28	4704	4.704	7	88.15
Lighting	90+116	40+45	3600+5220	3.6+5.22	7	61.74
aneou s	-	-	15000	15.00	7	105.00
Total consumption in kWh per day						**254.89**
Total consumption in kWh per month						**7646.7**

- **Brushless DC (BLDC) Fans**

BLDC fans save up to 60% of the energy used by standard fans, with larger sweep widths, better air delivery and rotation per second available.

Table no. 2 Energy Consumption by Regular Fans

	Numbers	Fan type	Wattage W	Usage Duration Hrs.	Wattage consumption per day Wh	Consumption in kWh
G. Floor	62	Regular	75	7	32550	32.5
Floor 2	58	Regular	75	7	30450	30.45
Floor 1	48	Regular	75	7	25200	25.20
Total consumption in a day kWh						**88.15 kWh**

Table no. 3 Energy Consumption by BLDC Fans

	Numbers	Fan type	Wattage W	Usage Duration Hrs.	Wattage consumption per day Wh	Consumption in kWh
G. Floor	62	BLDC	30	7	13020	13.02
Floor 2	58	BLDC	30	7	12180	12.18
Floor 1	48	BLDC	30	7	10080	10.08
Total consumption in a day kWh						**35.28 kWh**

Table no. 4 Energy Reduction

	Wattage	Hourly Electricity Consumption	Daily Electricity Consumption	Yearly Electricity Consumption	Yearly Costs (assuming Rs 6 per unit)
Regular Fans	75 Watts	0.075 units	1.125 units	410.625 units	Rs. 2463.75
BLDC Fans	30 Watts	0.030 units	0.45 units	164.25 units	Rs. 985.5

Energy saving per day kWh after retrofitting 88.15 – 35.28 = 52.87 kWh

Cost Saving just by using BLDC Fan= 52.87 × 30 × 11.8 = 18,715.28 Rs.

- **LED Lighting :**

The light-emitting diode (LED) is actually one of today's most energy-efficient and rapidly growing automation of lighting. Compared to other forms of lighting, quality LED light bulbs are long-lasting, more resistant, and provide equal or better light quality.

Less heat is emitted by LEDs. In contrast, as heat, incandescent bulbs release 90% of their power and CFLs release about 80% of their energy as heat.

Table no.5 Total Number of CFL

Fixtures	Ground Floor	1st Floor	2nd Floor
Wall light points	18	17	18
Ceiling light points	22	20	21

Table no.6 Cost Comparison of CFL and LED lighting

Items	Quantity & Power	Price
CFL bulb power	No. 116 / 45 w	Rs. 250 each
Total CFL lights	5220 w power	**29,000.00**
LED bulb power	No. 116 / 12 w	Rs. 100 each
Total LED bulb	1392 w power	**Rs. 11,600.00**
Equivalent LED Lights	No. 90 / 25 w	**Rs. 500 each**
Total LED Tube-light	2250 w	**40,000.00**

Energy savings before retrofitting = 8.820 kW

After retrofitting = 3.642 kW So, = 8.820 – 3.642 = 5.18 kW

Assuming the daily use of bulbs is 7 hours, Therefore 7 x 5.18 = 36.26 kWh energy saved per day

Cost Incurred= 51,600 INR.

Capital Cost saving achieved by Selecting LED instead of CFL 29,000 – 11,600 = **17,400.00 INR**

Electricity Cost Saving per month just by using LED Lights = 36.26 × 30 × 11.8 = 12,836.00 Rs

- **Photovoltaic Panels**

  Study of the energy and costs saved after the planned improvements have been implemented:

  Total energy consumed, after new lighting Fixtures (LED Tube lights, LED lightings, BLDC fans and other miscellaneous sources, with super built up area amenities) = 4974.00 kWh per month

  Cost of 1 unit = 11.80 ₹, 11.80 x 4974.00 **= ₹ 58693.20 - (New Monthly Electricity Bill)**

  On Grid Solar PV system:

  On grid panels are to be used having power generation capacity of 15 kW,

  Number of hours power generated per month = 6 hrs.

  (Sun hours are 5.5 but we have assumed 6)

  Cost reduction:

  Approximate power production by 15 kW panel systems is 9000 units, considering efficiency factor as 0.7

  Total units produced per month = 6300 units

  Therefore, 6300 units' of energy can be harnessed by solar PV system per month

  The building can be made self-sufficient if we go by calculations, but as we are using On- Grid system, we don't have energy storage, so we will be dependent on Main power grid for high load consumption and weather contingencies.

  Remaining solar energy = (6300 – 4974) kWh = 1326 kWh per month

  For Sale purpose

  Whereas, 1 kWh = 5.5 ₹ - **(For sales to main grid)**

  (50% of purchase rate)

  Total Cost of energy sold by solar power = 5.5 × 1326 kWh = **7293.00 Rs**

  Total cost saved/month = **58693.20 ₹ - (100% saving)**

  Extra Gain due to sales to main power grid = **7293.00 ₹ / month Profit annually = 87,516.00 ₹**

Total solar system price = 7, 50,000.00 ₹

Payback period of Solar gird system through profits only (we have not taken the savings on billing cycle into consideration) **= 8 years 6 months**

- **WATER CONSERVANTION**

Institutes use a significant amount of water every day and need water in washrooms, drinking water faucets, locker rooms, cafeteria, classrooms, and outdoor playgrounds and for lawns and for their heating and cooling systems.

In the washrooms, we will add low flow rate fixtures and a terrace rainwater harvesting setup. Water would thus be largely preserved, thereby leading to the conversion of institutional buildings to green buildings.

Table no. 7 Water Requirement for boys

Fixture	Ex. Flow rate	Duration	Usage Lit.	No. of usage/boy/day	Usage/boy/day (lit)	Total usage of school
WC (LPF)	6	1 flush	6	1	6	4566
Urinals (LPF)	4	1 flush	4	2	8	6088
WHB Taps (LPM)	6	15 sec	1.5	4	6	4566
HF (LPM)	6	15 sec	1.5	1	1.5	1141.5

- **Low Flow Rate Fixtures :** Water consumption calculation percentage comparison

No of teachers	
Male	18
Female	27

Janitor service	
Male	8
Female	5

No. of Students	
Boys	801
Girls	801

Total Males	787
Total Females	793

95% attendance Boys	761
95 % attendance Girls	761

Table no. 8 Water Requirement for Girls

Fixture	Ex. Flow rate	Duration	Usage Lit.	No. of usage/boy/day	Usage/boy/day (lit)	Total usage of school
WC (LPF)	6	1 flush	6	1	6	4566
Urinals	4	1 flush	4	2	8	6088

(LPF)						
WHB Taps (LPM)	6	15 sec	1.5	4	6	4566
HF (LPM)	6	15 sec	1.5	1	1.5	1141.5

Table no. 9 Water Usage after Retrofitting

3 Star Flow rate	Usage Lit.	Usage/boy/day (lit)	Total usage
4	4	4	3044
1	1	2	1522
3	0.75	3	2283
2	0.68	0.68	517.48

3 Star Flow rate	Usage Lit.	Usage/girl/day (lit)	Total usage
4	4	4	761
2	2	4	3044
3	0.75	3	2283
2	0.68	1.36	1034.96

Table no. 10 Water Savings in %

Total water consumption of boys/day (litres)	16361.5	Liters
Total water usage After RTF	7366.48	Liters
Water Saving	**8995.02**	**54%**

Total water consumption of Girls/day (litres)	14839.5	Liters
Total water usage After RTF	7122.96	Liters
Water Saving	**7716.54**	**52%**

Similarly,		after RTF	
Water Consumption for Teachers/janitors (Male)	572	260	l/d
Water Consumption for Teachers/janitors (Female)	640	305	l/d
Total water consumption per day (Male)		16933.5	l/d
Per capita/day		21.51652	l/d
Total water Consumption per day (Female)		15479.5	l/d
Per capita/day		19.52018	l/d

Per capita Saving Male	**11 l/d**
Per capita Saving Female	**10 l/d**

Summary		
Water consumption Before	**32413**	l/d
Water consumption After	**15054.44**	l/d
Percentage Saving	**53.55431**	% l/d

- **Rain Water Harvesting**

  Rainfall Data of Last 5 Years (2014-2018)

  2014 = 1007.3 mm, 2015 = 803.9 mm, 2016 = 1214.9 mm, 2017 = 997 mm

  2018 = 1066.5 mm

AVERAGE RAINFALL = 1017.92 mm

Per month average calculation till now = 763 mm

Step 1: average rainfall in Pune = **1017.92 mm**

Step 2: surface area of roof: **832 sq.m**

Step 3: runoff coefficient according to type of roof

Roof type: concrete roof (flat slab), Runoff coefficient: **0.70**

Total harvestable rainwater in a year: **1017.92*832*0.70 = 592836 litres**

Total: 763*832*0.70= 444371 litres

Cost of Rainwater Harvesting:

Capacity of Existing Underground water Tank: **1, 23,135 liters**

Estimated Rainfall harvest: **4 lakh liters** approximately in entire year

Material required storing the harvested water and using it accordingly and save it from time to time.

Table no. 11 Cost of Rainwater Harvesting

Name/ Description	Quantity	Cost/Unit(Rs)	Amount (Rs)
Syntax/Plasto watertank (10,000 liters)	4	6/lit	2,40,000
90 mm PVC downpipe (20feet pipe)	11	400	4400
Rainwater Filter	4	3850	15,400
PVC Elbow	12	76-80	1000
PVC Elbow with Door	4	100	400
PVC Pipe Coupling	10	20	200
Miscellaneous			1600
Total			2,63,000

- **Low U Factor - UPVC Double Panel Windows**

In the winter it is warm, Energy cost savings, & Cool in the summer, Safety, Less condensation, less noise.

Fig : Double Glazed Windows

Cost: 400Rs/Sq. ft. (W=3.2X2.4 W1=2.2X1.2)

Table no. 12 Double Glazed Window Calculations

No. of Windows	Sizes = Area	Total	Total Cost
W=68	3.2X2.4 =7.68	7.68X68 =522.24 Sq.ft	2,08,896 /-
W1=4	2.2X1.2 =2.64	2.64X4 =10.56 Sq.ft	4,224 /-
		Total	2,13,120 /-

RESULT:

		Energy Efficiency		
Sr. No	Parameters	Before Retrofit (kWh)/Month	After Retrofit (kWh)/Month	Saving/Profit (Rupees)
1.	Energy Consumed	7464.70	4974.00	58693.20/Month
2.	BLDC Fans	88.15	35.28	18715.28/ Month
3.	LED Fixtures	61.74	36.26	12836.00/Month
4.	Photovoltaic Panels	0.00	6300.00	7293.00/Month

		Water Efficiency		
Sr. No	Parameters	Before Retrofit Liters/Day	After Retrofit Liters/Month	Saving/Profit (Liters)
1.	Low Flow Fixtures	32413.00	15054.40	17358.6
2.	Rain Water Harvesting	0.00	444371.00	444371.00

CONCLUSION:

The data & cost benefit analysis is done in the project clearly states that around

Rs. 1, 00,000/- can be saved every year if we implement the green retrofit methods stated above in the project. Also, the life of the building will increase with the increase in the building efficiency. This green retrofit can be implemented in every re-development project & it will make huge profits to the owner with a payback period of solar panel system is 8.5 years. Environmental benefits of green buildings are well recognized. The report is talking about green building economic benefits.

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