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Evaluating the effectiveness of Retrofitting an Existing Hospitality Building

Ar.Sasidharan J
Aggham Design Studio, Chennai

Abstract:- Buildings play a major role in being a distinct feature of a city's heritage and skyline. The building also needs to be maintained as they consume a lot of energy and resources. Upgrading an existing building supports the owners in maintaining occupancy changes. Hence Green retrofitting is now gaining its control over the environment. With the known fact that Sustainability is our future and existing buildings which are in higher number gains more popularity in retrofitting, it is informative to know the upcoming advancement of where the world is headed to. Also, the world cannot reach the peak of sustainability, if energy efficient measures are applied only in upcoming buildings as existing buildings are more in numbers than, to-be constructed buildings.

The major focus of this study is to gain knowledge on how retrofitting works in an existing building and how effective it is when compared with newly constructed building that has energy efficient measures implemented. The study's first phase is to understand the concept of green retrofitting, study the strategies that are being developed and practiced across the globe, process and methodologies involved in retrofitting. These factors are then analyzed well through means of case studies and the inferences are listed. The second phase, deals with selection of an existing building of one typology - Hospitality, with no sustainable measures undertaken till now. Then the primary retrofit options are applied and values are calculated to achieve the optimization value. The thesis seeks to prove how economical, viable and environmentally friendly a retrofitting building could be.

Keywords:- *Buildings, Green retrofitting, sustainability, Existing buildings.*

I. INTRODUCTION

The future is headed towards sustainability, Green, Energy Efficiency and other efficiency strategies. These ideas and methods which are in recent trend can be easily applied for upcoming buildings but questions the performance of the existing buildings. Hence in order to provide a solution for the existing buildings, retrofitting can be suggested. Retrofitting an older building is actually an up gradation to help improve environmental performance, reduce and recycle the water and energy and also increase the indoor air quality and the comfort to the building. The intent is to maintain these buildings over time.

Retrofitting an existing building can sometimes become cost effective than that of a new building. As mentioned earlier the existing buildings, uses large amount of energy for heating and cooling. So it is essential to implement retrofit measures to the existing buildings in order to decrease the consumption of the energy and the cost which is caused due to the heating, cooling and lightings in buildings.

Knowing sustainability as our future and as existing buildings is in higher number, more popularity is attained towards retrofitting. Historic blackouts across India during July 2012 exposed the sternness towards India's crisis on energy. Since the country undergoes rapid urbanization and racing to keep up the demand for commercial properties like hotels, malls, offices and high-rise residential housing. Integrating efficiency measures in an existing and a new building will help in reduced use of energy and save the cost in order to face the threat on the changing climatic conditions.

The ultimate goal of the study is to bring out the differences created in terms of cost, energy performance, and optimization of a building by green retrofitting. A comparative study between a conventional building and a retrofitted building is done to get more clear idea of the goal. The inferences are made out of the extensive study and analysis done. The conclusion of the study would be drafting recommendations for the best use of retrofitting in buildings.

II. LITERATURE STUDY

Buildings use about 50% of all the energy produced in our planet during operation for heating, cooling, and lighting, during building construction (Izzet Yüksek, 2017). The consumption of energy uses approximately 80% of GHG emissions which take place during the operational phase of buildings, especially when the energy is used for HVAC, lighting and other equipments (Vassiliki Drosou, november 2018).The major issue that kindles of the need of sustainability is change in the climate and the need to reduce greenhouse gas emissions.

Since there is a concern over an environmental issues where the non-renewable resources are reduced, lessening in the emission of wastes and the pollutants. There few sustainable measures which can be adapted to many buildings such as optimising the site, re use of environmentally friendly materials and water for landscaping, maintaining practices with the equipment to reduce the consumption of energy in order to provide a sustainable environment (Luís Bragança, 2010).

There are many tools in the construction market to evaluate the sustainability and are also in current practices. Some of them are **GRIHA** (Green Rating for Integrated Habitat Assessment) India, **BREEM** (Building Research Establishment Environmental Assessment Method) UK, **LEED** (Leadership in Energy and Environmental Design) USA (Arukala, 2018). There are six main phases for achieving energy efficiency retrofits in existing buildings. These phases help to identify in what level of the energy survey is needed for the specific site and the building.

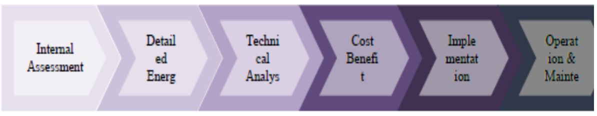

Fig 1:- Retrofitting existing buildings

Internal Assessment: Before starting any analysis of energy parameters or level of audit, it is important to perform a preliminary phase of energy use analysis to determine current energy consumption of a building and cost effectiveness with regard to other similar buildings (roadmap for incorporating energy efficiency retrofits in existing buildings, 2013).

The Energy Performance Index or EPI is defined as the ratio to the annual energy used to the overall built up area. This ratio gives the energy usage of a building. The assessment of the EPI calculation involves the following steps given below.

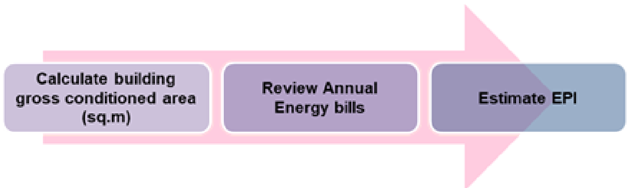

Fig 2:- EPI Estimation

There are few steps involved in Assessment phase, where the overall area of the building is considered. Utility bill for a year is collected and the EPI is calculated. The calculated EPI is compared to the related characteristics with respective climatic zones. In India as an example, EPI could also be compared to BEE (Bureau of Energy Efficiency) indices for existing building (roadmap for incorporating energy efficiency retrofits in existing buildings, 2013).

The second phase is conducting energy survey in existing buildings. For an existing building energy mapping or plotting is done to determine their energy consumption. And by collecting the required information of the energy and the equipment details, the estimated energy is segregated. A through survey would provide sufficient information about all the energy systems which helps to generate the suggestions for the building retrofit measures.

Hence to determine the baseline, a survey on energy and the operating conditions of the building details are obtained. Once the data is collected, the building consumption is analyzed and formulated.

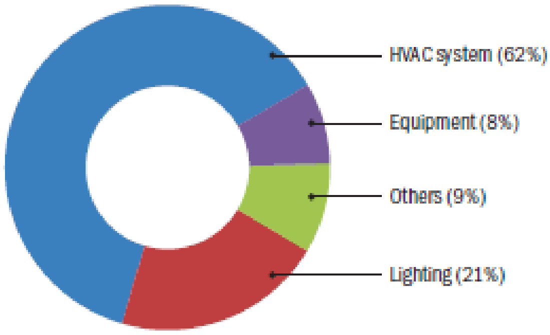

Fig 3:- Building energy mapping

According to the building operations, the minimum energy requirements are listed. The data required for energy evaluation are:

- A plan of the site layout
- A plan of the Building envelope
- Airflow rates and the schedules of mechanical equipment and their capacities
- Lighting and the Electrical schedules
- Fixture details and the Lighting control diagram
- Detailed specifications on the equipment
- Systems which are connected to the BMS

During the initial phase of the energy survey, the cost and the efficiency of a building is analyzed by evaluating the energy bills. The collection of data aids to identify if the cost reduction can done just by saving energy efficient measures. The energy consumed and the demand analysis is done as a technical analysis from the data which is collected from the survey. A series of parameters are then listed and suggested for the electrical fixtures and the products which can be implemented by the energy simulation analysis of the building. By this effective information can be obtained of which can be incorporated. By the retrofit options available in the market, a detailed formulation plan is carried out and the results are assessed and the analysis of it working is studied through the software. From the results of the software, retrofitting strategies are suggested (roadmap for incorporating energy efficiency retrofits in existing buildings, 2013)

After the retrofitting is finalized by the cost benefit analysis, the building should then be initiated for the same. The implementation will be seamless with proper finance and planning and assigning sufficient timeline for the execution. Energy audits and visualizing the current operating conditions are done during the implementation. The data collection and analysis is also done in this phase.

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III. CASE STUDY

The strategies can be broadly classified into active and passive strategies. Active strategies includes use of solar panels for electrical and thermal systems, active ventilation and cooling technologies – use of energy efficient HVAC, electrical and lighting systems etc. Passive strategies include solar and passive control, cooling. All these measures are based on climatic conditions. In this study, three case studies (In India) have been analyzed with retrofitting measures. They are INFOSYS CAMPUS (Chennai), GODREJ BHAVAN (Mumbai) and ITC SHERATON (Delhi).

In the first case study (Infosys office campus), existing data for analysis has been procured. The energy efficient measures were suggested since 2008 and the retrofitting program has covered up all the necessary measures during 2017 – 2018. A table is plotted in comparison of the energy usage between the year 2007-2008 and after retrofit during 2013-2014.

Description	2007-2008	2013-2014	Change
Building energy	200kWh/sqm per yr	85kWh/sqm per yr	57% lower
Lighting	1.2 W/sqft	0.45W/sqft	62% lower
AC capacity	350sqft per TR	550sqft per TR	36% lower
Electrical	6.5W/sqft	3.25w/SQFT	50% lower

Table 1:- Comparison of before and after retrofit

Other efficiency measures are also taken like, Addition of heat exchanger; Electrical water heaters to be replaced by the solar water heaters enhanced with heat pumps, RO plants (water for chillers) and so on. At the end of the analyses it is found that the retrofitting has a reduction in the target of 7MX power, which is 50% reduction in the electricity usage per employee which can be achievable by FY2018.

The second case study, **GODREJ BHAVAN, MUMBAI (India)** demonstrates that the retrofits are energy saving and profitable.

➢ *Building basic information*

The building is an Office space which is constructed during 1972, located in Fort Southern Mumbai. The Gross area of the building is about 3826 square meters, with Air conditioned area about 2192 square meters and Non Air conditioned area about 1634 square meters. The building is a six storey building with two basements and a roof top terrace. It experiences Hot and humid climate and is owned by Godrej and Boyce. The retrofitting is self-financed and completed during 2010. The project team is Godrej‘s Green Building consultancy service and Ingersoll Rand. The retrofitting of the building amounted to Rs.53, 84,000 and the payback period for the same is 4.7years.

The energy retrofit costing has tabulated as follows.

Energy efficient measures and audit	Cost (Rs)
HVAC – system replacement	5,000,000
Water-flow meters	24,000
Energy metering system	52,000
Auto blow down controller at the cooling tower	29,000
High reflectance paint for the terrace surface	62,000
Energy audit	45,000
Lights with energy efficient tube lights	172,000
Total cost of the energy efficiency measures installed	**5,384,000**

Table 2:- Energy Retrofit costs

The third case study is ITC Sheraton, Five star hotel, opened on 31st December 2000 is located in New Delhi. It consists of 220 rooms with Executive suite, Deluxe and Presidential suites. It also has the Multicusine restaurant with a banquet hall, a swimming pool, shopping arcade, board room and a lounge bar. The floor area of the building is about 9850 square meters. The building is studied in detail, analyzed and energy saving measured are implemented.

	2008-2009		2009-2010	
	LY	TY	LY	TY
Energy Cost	5.15 Crore	4.65 Crore	4.65Crore	4.43Crore
Savings in Lacs	50 Lacs		22Lacs	

Table 3:- Comparison of Energy and cost savings

After implementation it can be noted that the amount of savings done in the year 2008-2009 is 9.7% and year 2009-2010 is 4.73%. Average savings in two years is approximately 15%.

IV. COMPARITIVE STUDY

This section comprises of comparative study against various retrofitting elements of the case studies discussed above.

Retrofitting elements	Infosys Campus	Godrej Bhavan	ITC Sheraton
Building envelop	• Fenestration that lets • natural light • Envelope sealing avoids leakage of heat inside building • White roofs	• Insulation materials • Double glazing windows • Cool roofs	• Insulation materials • Double glazing windows • Cool roofs
HVAC	• Heat exchangers • Piping routing optimization • Chilled plant room retrofits • Auto tube cleansing system	• Efficient HVAC systems • Duct sealing • Natural ventilation • System balancing (fans adjust airflow)	• Efficient HVAC systems • Double skin, AHU, VFDs • Auto balancing values • Energy efficient chiller
Lighting	• Efficient light bulbs (LED) • Automatic lighting shut-off • Occupancy sensors	• LED lights • Automatic lighting shut-off • Occupancy sensors • Master lighting control	• Use of LEDs • Automatic lighting shut-off • Occupancy sensors • Exit lights - LED
Electrical	• New system of 1200 kVA (25% reduction) • UPS energy consumption (32% reduction)	• Motor efficiency • Transformer efficiency • Electric metering & monitoring • PDS	• Heat recovery wheel • Digital thermostat • Optimization in power distribution
Others	• Solar water heaters, heat pumps • PV cells • BMS • RO plants	• Solar water heating • Equipment efficiency • Heat traps • Piping insulation	• IR washbasin, sensor taps • Double flushing system • Waste convertor

Table 4:- Comparative chart between the case studies

A. *Inference from case study:*

Above case studies determines the actual cost savings with reduced energy consumption in an existing buildings. The retrofitting helps save the operating costs, reduces the electricity usage, enhances the occupants comfort and improvises the building systems. The conclusion from the case studies is

- ➢ Godrej‘s corporate assurance to the sustainability helped the project‘s efficiency goals. Cost savings and High efficiency are the achievement of the project.
- ➢ The retrofitting in Godrej Bhavan determines cost effective opportunities and low hanging energy. By the installation of the updated HVAC systems, BMS (Building Management Systems) and up gradation of lighting proves efficient energy savings with improved air quality and easy maintenance.

The building has also incorporated in energy management systems in training its occupants by suggesting measures in building operations to enhance energy savings.

V. FIELD STUDY

Retrofit elements in an existing building are analyzed for different typologies.

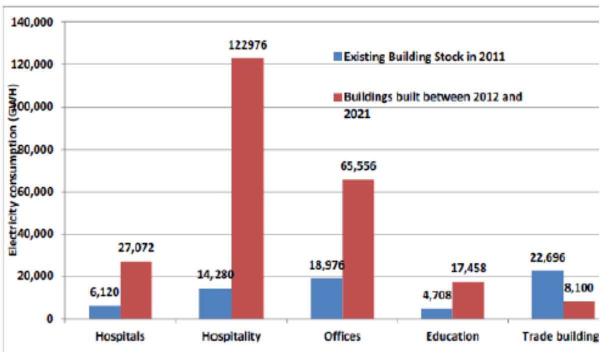

Fig 4:- Energy consumption growth rate in Indian commercial buildings

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While other buildings operate for 12 hours a day, hospitality buildings function 24 hours a day. Also, the energy consumption growth rate in commercial buildings shows that hospitality building shows a stark growth than the other typologies.

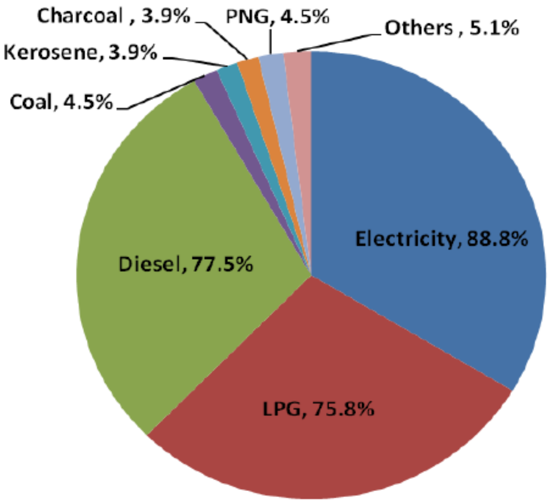

Fig 5:- Energy consumed in hospitality sector

The reasons to select hospitality building (that needs energy efficiency measures) are listed below:

- ➢ Load factor
- ➢ Wide energy consumption
- ➢ Statistics (that shows energy exploited by this sector)
- ➢ To compare an existing building with a newly developed sustainable building
- ➢ Live proposal – where the retrofit elements can be applied and analyzed, study the consequences and draw inferences.

The hospitality building selected for the study is, Germanus Hotel, Madurai, Tamil Nadu. It is a Business class hotel with good services and approachable hospitality. This location of the hotel serves as the better destination for the travellers around the city. It also serves as grandeur with cozy rooms and spectacular amenities.

Building data:
Location – Kaalavasal, Madurai
Typology – Hospitality
Architect – Ar.Y.R.Raamnath
Floors - G + 6, one basement
Orientation – East facing
Area - 5640 sq.m

Internal assessment for the study is done by EPI.The unit for EPI is kWh/ sq.m /year. Data for electricity consumption for all the months in a year are collected; the power consumption and the costing are also tabulated.

Electricity consumption				**Occupancy (85 rooms)**
S.no	Month	Kwh	Cost	
1	January	92880	743040	
2	February	98760	790080	75%
3	March	101120	808960	
4	April	99920	799360	
5	May	94240	753920	
6	June	94600	756800	60%
7	July	94550	756400	
8	August	99400	795200	
9	September	98280	786240	
10	October	94560	756480	45%
11	November	89720	717760	
12	December	77920	623360	
Total		**1135950**	**9087600**	

Table 5:- Electricity consumption of a year

$$EPI = \frac{\text{Total power consumption (kwh)}}{\text{Total area of the building (sq.m)}}$$

$$= \frac{11,35,950}{5,640}$$

$$= \mathbf{201.40\ kWh\ /sq.m/year}$$

Lighting & HVAC:
HVAC Load = 6,24772.5 kwh/yr
Lighting Load = 238549.5 kwh/yr

$$EPI = \frac{\text{HVAC LOAD + Lighting load (kwh)}}{\text{Total air conditioned area(sq.m)}}$$

$$= \frac{624772.5 + 238549.5}{2315.17}$$

EPI = 372.89 kWh/sq.m/year

A. Lighting calculation:
Lighting efficacy – CFL:
Wattage = 8
Lumens = 425
Lighting efficacy = lumen / watt = 425/ 8 = 53.1
Lighting efficacy – LED
Wattage = 4
Lumens = 350
Lighting efficacy = 350/ 4 = 87.5

B. HVAC calculation:

Used Water based Chiller unit
Rating of chiller (TR) = 75 +75 TR
No. of Chilled Water Pumps = 3 (7.5,7.5,15 HP)
No. of Condenser water pumps = 2 (20,10 HP)
Cooling Tower = 200TR
Compressor (2 nos) = 80HP each
(1HP = 0.7457 KW) = 119.31KWH
KW/TON = Measurement of Compressor / TR
=119.31/150
KW/TON = 0.8
=3.516 / 0.8
COP = 4.3 (*higher the COP, higher the efficiency*)

The building not only gains heat from many sources but also from the machines, but also from other equipment. The sum of the total amount of heat by all of the sources is called as Heat load (Heat gain) of the building which is expressed as Kw (kilowatts).

Cooling load Estimation

1. Heat gain through walls

= U value × Area of the wall or ceiling × CLTD correct
CLTD correct = CLTD + LM + (25.5 – Ti) + (To,m – 29.4)
where CLTD - Cooling Load Temperature Difference
LM - Latitude correction factor for the month
Ti - Indoor design temperature
To,m - Outdoor mean temperature = (T max + T min)/2
where T max - Maximum outdoor temperature
T min - Minimum outdoor temperature
Cooling load – wall
Brick Wall
U- VALUE = 1 / R
R = thickness of material (d)/
Thermal Conductivity (k)
Corr. CLTD = CLTD + LM + (corr.*tr) + (corr.tm)*
where
tr = inside temperature and
tm = mean outdoor temperature
Corr. CLTD = 33 + 9 + (-2)+9
Corr. CLTD =49 F(9.4 degree C)
Inside temperature = 84.9F (28.3 C)
Outside temperature = 101.3 F(38.5 C)
Daily range = daily max temp – min temp
= 16.4 F (38.5 – 28.3)
Heat gain through walls
= U value × Area of the wall × CLTD correct = 0.351 x 114 x 49 = 1960.68 Btu/hr

Heat gain through walls = 574.62 W

The cooling loads and wattage for the following are also calculated similarly to get total watts and total tons.

S.no	Cooling load	Wattage
1	Heat gain through Exterior Wall	574.62
2	Heat gain through Glass	1560.19
3	Glass by conduction	301.75
4	Heat gain through partition walls	48.69
5	Heat gain through ceiling and floor	61.05
6	Sensible Lighting load	44.93
7	People - sensible	169.86
	- Latent	167.05
8	Equipment	217
9	Infiltration - Sensible	160
	-Latent	230.45
10	Ventilation -Sensible	627
	-Latent	453
	Total Watt	**4615.59**
	Total Tons	**1.312**

Table 6:- Cooling loads and Wattage

C. Building Envelope:

➢ *Heat gain through walls*

= U value × Area of the wall × CLTD correct
= 0.068 x 114 x 49
= 379.848 Btu/hr
Heat gain through walls = 111.32 W
Insulation – EPS/ albedo paint finish

➢ *Lighting (interior)*

= 3.41 x q x Fu x Fs x CLF
Sensible cooling load = 3.41 x 24 x 0.71 x 1.30 x 0.87 = 65.71 btu/hr
Sensible cooling load of Lighting = 19.26 W

➢ *Heat gain through window*

= SGHF × Area of the window × SC × CLF x SGHC
= 241 x 45 x 0.32 x 0.8 x 0.28
= 777.36 Btu/hr
Heat gain through window = 227.82 W
LOW-E GLASS – KNT140 PLANILUX

➢ *Heat gain through window by conduction*

= U - Value × Area of the window × CLTD
= 14 + (-2)+6
Corr. CLTD = 18F
= 0.316 x 45 x 18
= 255.96 Btu/hr
Heat gain through window = 75.01 W

➢ *Reduce Heat gain through Roof*

- Trussed _Solar panel, which act as a shade for terrace
- Reduce the terrace building envelope
- Terrace landscape reduce the heat gain through roof
- Thermal shield tiles reduce 85% of the heat gain on surface.

D. Solar Power:
Hot water requirement = 20liters / person
Total hot water requirement = 3400 liters
Boiler system = 20 liters/day
Power = 2kw
6 hours per day run (morning and evening)
Total energy consumption = 4380kwh
Total Diesel consumption = 7300Litrs

VI. RESULTS AND ANALYSIS STUDY

From analysis and calculations, the values are compared against the existing conditions and the percentage of savings in cost and energy are given in following tables.

S.no	Area	Existing watt	Retrofit watt	Savings	Efficiency (%)
1	Bedrooms	10256	3669	6587	64.23
2	Reception	928	498	430	46.34
3	Conference	2412	1512	900	37.31
4	Restaurants	1966	752	1214	61.75
5	corridor/lift lobby	1240	685	555	44.76
TOTAL		**16802**	**7116**	**9686**	**57.65**

Table 7:- Savings and Efficiency % - Lighting

Description	Existing chiller system	Water cooled centrifugal chiller system	savings	Efficiency
KW/TR	0.8	0.35	0.45	**56.45%** Total energy load = 228855kwh Due to building envelope and reduction in heat gain can reduce the load up to 205969.5 kwh Total efficiency of HVAC **65.16%**
TR	150	149.3	-	
KW	120	52.25	67.75	
Annual operating days	365	365	-	
Operating hours/day	12	12	-	
Total annual Kwh	525600	228855	296745	
Power cost(Rs/Unit)	8	8	-	
Annual operating cost(Rs)	4204800	18,30,840	2373960	

Table 8:- Savings and Efficiency % - HVAC

VII. CONCLUSION

The cost analysis and operation and maintenance costs are calculated. These values are then compared with ITC Chola (case study – newly built with energy efficient measures incorporated) to understand how energy and cost can be optimized in existing vs. newly built.

	Existing	**Saving**	**cost/yr (Rs)**	**cost/ month (Rs)**	**Capital (Rs)**	**Payback period**
Lighting	238549.5	137523.7	1100190.29	91682.52	2,50,000	3 months
HVAC	624772.5	352684	2821472.61	235122.7	41,00,000	18 months
Solar Panel	Load (Kwh)	4380	35040	39505.17	9,60,000	25 months
	Diesel (ltr)	7300	439022			
		Total	**474062**			

Existing load(kwh)	**Cost (Rs)**	**Retrofit load (kwh)**	**Cost (Rs)**	**Savings (kwh)**	**Cost (Rs)**
1135950	9087600	641362.15	5130897	494587.9	3956702.8
43.53 %					

Table 9:- cost analysis of hotel Germanus – existing condition, savings done, capital cost and payback period.

Green retrofitting has many strategies. Retrofit may or may not be included in a new building. But for an existing convention building to become a self-sustaining or sustainable, then retrofitting should be considered. The selected case studies also falls into this category – 10-15 years old building being taken into the consideration of retrofitting, studies and the inferences are drawn. Similarly, the field study is also 15 year old building and analyzed on the perspective of green retrofitting. By comparing ITC Chola-new building and Hotel Germanus-existing building it is clear that optimization in newly built and retrofitted buildings are 82% and 73.45% respectively. The latter are done by applying basic green retrofitting strategies. The difference between both is 8.55%, which is a remarkable result for a retrofitted building done using basic strategies.

The study on ITC Chola-new building had more active strategies than passive strategies. But all new buildings need not focus only on active measures. But for an existing building to be retrofitted, active strategies are employed at higher rates. Passive measures may or may not be implemented. All these decisions are primarily based on need, typology, and comfort of the occupants. But better option for existing building to be retrofitted is to rely on active measures.

The positive effective of retrofitting is that we can foresee the outcomes during analysis. On research we can provide the best option that is suitable for the building‘s condition and its usage. Proper awareness and education about the retrofitting measures will enhance the betterment of the environment.

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