INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 3 - V7I3-2212)
Available online at: https://www.ijariit.com

Analysis and applications of transparent wood in existing commercial building reducing electrical load

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ABSTRACT

Electricity is one of major energy consumption in any commercial building. There are many ways to consume energy. One of the ways is by using building material. Plywood and furniture industry is growing day by day in India from last few years. The wood which is itself made transparent and stronger. The tiny fibres that form the walls of channels are what makes wood so robust. These channels, being the backbone structure of wood. The approach of using transparent wood could slash energy costs by reducing there need for artificial lighting inside buildings. The transparent wood has more strength and better insulating properties than glass and other materials. It also has better biodegradability than ordinary plastic, and is shatter-proof as well. This material reduces a building net energy consumption not only by reducing the need for artificial lighting but also by generating electricity. These results are analysed by simulating this material in a building. Comparing other materials with these materials, is beneficial in many aspects.

Keywords— *Wood, Transparent Wood, Glass, Energy, Cost*

1. INTRODUCTION

Most of the electricity is consumed in commercial building as per the analysis. The average number of kilowatt hours per square foot for a commercial building is approximately 22.5. Wood acts as lockbox for carbon dioxide. Wood on the other hand, is highly insulating but it's not transparent usually. Wood consumption is less than wood production in India. As deforesting is not good for environment, this material can be even made from left over wood.

Transparent wood, It is lighter than concrete and steel, more biodegradable than plastic and able to withstand 10 times more stress than normal wood. The optically transparent wood is a type of wood in which the lignin, a component of the cell wall of wood, is being removed chemically. It has a greater potential to be used in architectural projects. This material can be suggested in low-cost lightweight structures. The composite is not only transparent it is also stronger and durable than other materials. The current material used in constructions are polycarbonate and glass, which is already transparent. This transparent material is usually used for transmitting light, but glass has a little disadvantage like brittleness and shattering type of failure and polycarbonate is not resistant to scratches. It can store heat by absorbing and it will be crystal clear and when it cools down, it will release heat and turns opaque. The process of making transparent wood does not cost much. We get the product by treating with many chemicals, still it is biodegradable material. The researchers suggest that it could be used for both windows and roofs. It has several usages, as load bearing walls, as solar cells and then as heat storage. By applying this material on a glazed building will create a great change in energy consumption of the building. This analysis is done by simulating this material using U- value and R-value in commercial building in Chennai.

3. PROCESS OF MAKING TRANSPARENT WOOD

Step 1: Delignification process - wood is immersed in sodium chloride and sodium hypochloride solution up to 100 deg Celsius for 12 hours
Step 2: Boiling hydrogen peroxide
Step 3: Lignin is removed and turned white to increase transparency it is immersed in resin epoxy (poly methyl methacrylate) under 85 deg celcius and in vacuum for 12 hours
Step 4: It will remove lignin and fill the polymer.

4. MAJOR PROPERTIES OF TRANSPARENT WOOD

4.1 Strength – Transparent wood

It can withstand 10 times more and strain 4 times more than wood
It will transmit 85% light it means haziness can trap some light. It can store heat by absorbing and it will be crystal clear and when it cools down it will release heat and turns opaque.
It has lower thermal conductivity and better impact strength , also it is lower dense than glass.

4.2 Heat storage – Transparent Wood

Transparent wood can be used as an encapsulating material for preventing the leakage of the phase change material. Wood has an ideal structure since it has Nano porosity. The wood generally absorbs heat when the temperature is more than 30 degrees Celsius, and will release the heat once it starts cooling down.

4.3 Mechanical properties – Transparent wood

The tensile strength of transparent wood increases with an increase in wood/cellulose volume fraction. Transparent wood does not shatter in an unfavourable way. It has outstanding toughness.

4.4 Solar cell – Transparent Wood

When photons hit the layers of silicon, electrons pass through the junction between the positive and negative layers, generating electric current.

5. LIVE STUDY FOR ANALYSING THE ENERGY CONSUMPTION OF THE BUILDING

5.1 Project Description

- NAME - Ticel Bio park
- LOCATION - Tharamani Chennai
- TOTAL FLOOR AREA - 6.5 lakhs sq.feet
- FLOOR AREA – 54,166 sq.feet
- NO. OF FLOORS- 3 Basement , G+12 floors
- NO. OF BLOCKS – 2 block
- OCCUPANCY LOAD – 30,000 Sq.ft (150 sq.ft/person)
- LOAD OF BUILDING – Live load = 500 kg/sq.m
    - Dead load = 250 kg/sq.m

5.2 Justification

This building is partially covered by Aluminum composite panels and Glass. They have used double glazing and a curtain wall to reduce heat load. The cost of this installation rate is too high. Which is 14,000rs per sq.m as per the given data.

The temperature of this building should be comparatively low (compared with IT parks) inside.

Approximately 23 – 24 degree Celsius in canteen and work stations and 21 – 23 degree in Research development Area.
To Reduce the Electricity Bill and Save Heat loads and use Heat energy.

5.3 Temperature

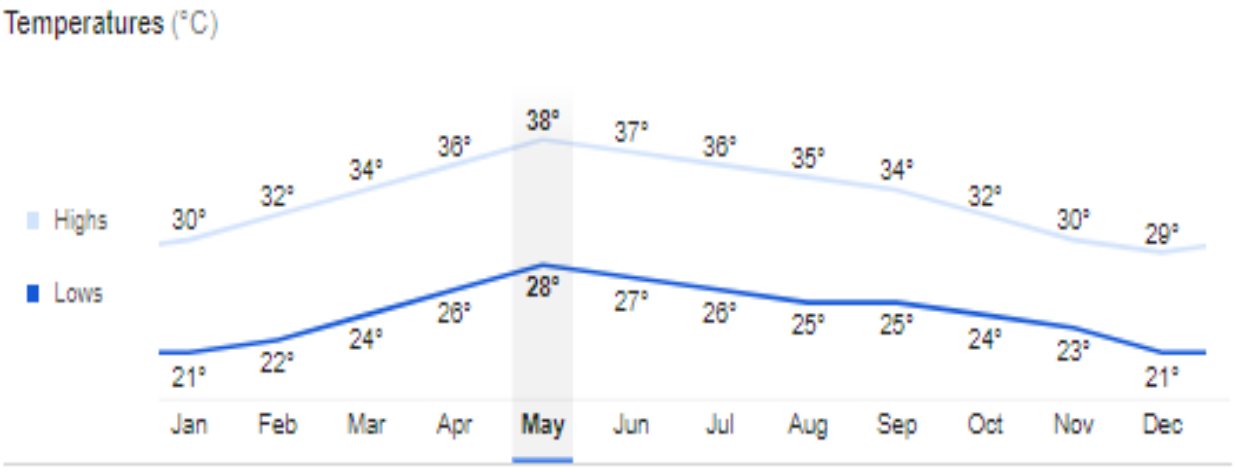


Fig 1. Temperature analysis of tharamani site

5.4 Daylight

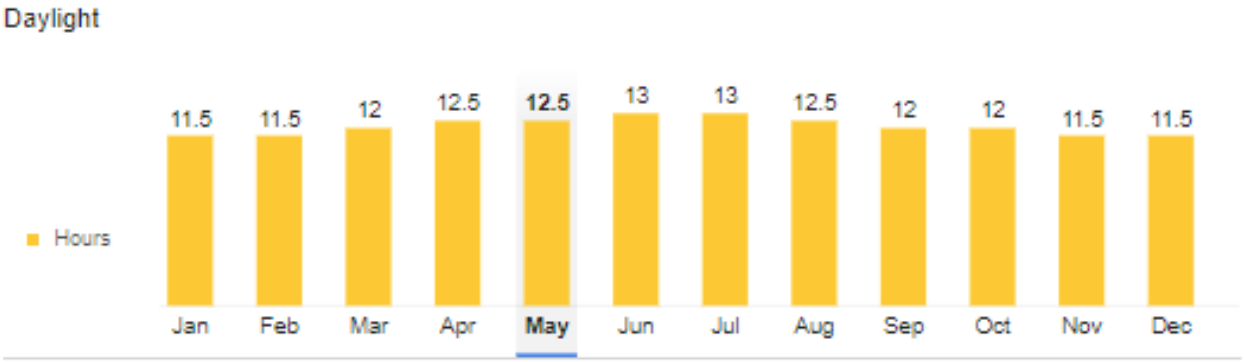


Fig 2. Day light analysis of tharamani site

6. LIVE STUDY DATA

These are the given data in live study:

6.1 HVAC – Heating, Ventilation, Air conditioning

They used Centralized air conditioning. 1.0 tonne Air conditioning covers approx. 100sqft floor area.

Table 1. HVAC details

DESCRIPTION	TONS OF REFRIGERATION
CHILLER PLANT	1200 TR
NO. OF AHU UNITS	16 AHU UNITS/ FLOOR
COOLING TOWER	NOT USED

They used Air cooled chiller plant which is located in terrace.

6.2 STP AND ETP

Table 2. STP details

DESCRIPTION	KLD
STP – Sewage Treatment Plant	200 KLD
ETP – Effluent Treatment Plant	50 KLD

They use sequential batch reactor as their STP

Table 3. Details of BIO park

DESCRIPTION	VALUES
Size	1.5 m x 1.1 m
Tensile strength	190 MPa
Thickness	12.52 mm
Compressive strength	230 MPa
Area coverage of glass	2 lakh sq. feet
Area coverage of aluminum	63,000 sq feet
Overall electricity bill in a month	84,00,000 to 1,20,00,000 (84 lakhs to 1 crore)

7. ELECTRICAL LOAD REDUCTION ANALYSIS

To reduce the electricity bill:
(i) By Heat load
(ii) By Solar cells

7.1 Simulation Analysis

(NOTE- The total area denoted is area covered by double glazing on East and South side of the building which is 76,862 sq.ft.)
These data are taken by simulations and calculated.

1. AREA COVERED BY GLASS ON EAST AND SOUTH SIDE = 6380 SQ.FT / FLOOR
2. TOTAL AREA = 76862 SQ.FT
3. MONTHLY CONSUMPTION = 13,44,000 UNITS
4. HVAC CONSUMPTION = 7,55,000 UNITS
5. COST OF 1 SQ.FT (SOLAR PANEL) = 587 RS
6. COST OF 1 SQ.FT (TRANSPARENT WOOD) = 367 RS

7.2 Energy Analysis

Hereby , the costing of using solar panels and transparent wood perovskite and existing cost of electricity bill and its savings and production.
The existing charges are given and for a roof top solar panel 80 – 100 sq.ft per 1 KW panel is required. By using Transparent wood perovskite solar cells can be used which is more energy efficient than solar panels. The analysis is below –

Table 4. Cost analysis using Solar and Transparent wood

EXISTING CHARGES	SOLAR PANEL (SILLICON)	TRANSPARENT WOOD (PEROVSKITE)
Per year production = **1,61,28000** Units Of Electricity	Per year production = **10,46,438** Units Of Electricity	Per year production = **12,13,860** Units Of Electricity
Per month production = **13,44,000** Units Of Electricity	Per month production = **87,203** Units Of Electricity	Per month production = **1,01,155.48** Units Of Electricity
Per unit cost = **6.35 INR**	Per unit cost = **6.35 INR**	Per unit cost = **6.35 INR**
Total cost = per year production x per unit cost	**Total cost = per year production x per unit cost**	**Total cost = per year production x per unit cost**
1,61,28000 x 6.35 = **102412800 (10.2 crores)**	1,046,438 x 6.35 = **66,44,868 (66. 4 lakhs)**	**1,213,860** x 6.35 = **77,08,011 (77.08 lakhs)**
The total expenses spent is 10.2 crores	It will save upto 66 lakhs in one year.	**This will even save more than 10 lakhs compared with solar panels in one year.**

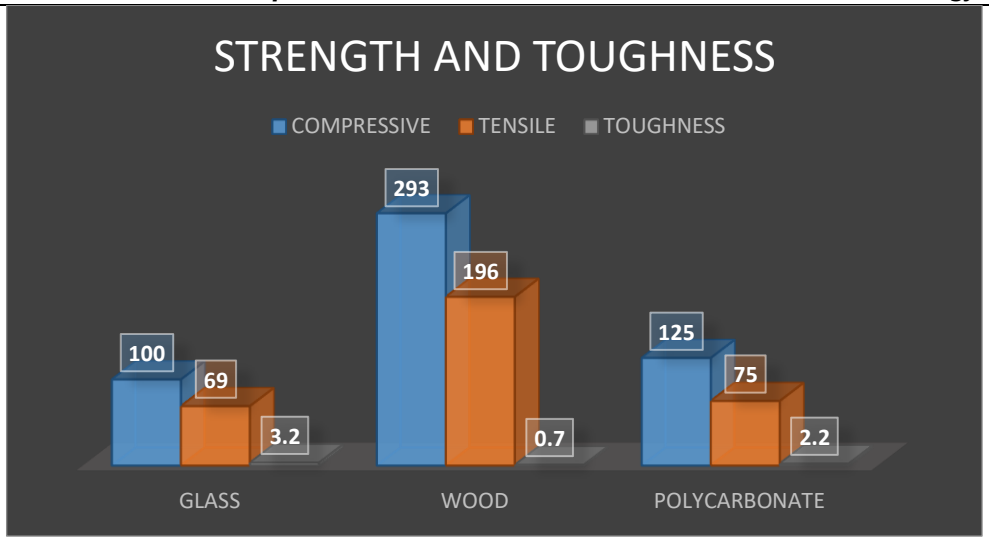
This transparent wood using perovskite will save even 16 % more of energies and it will reduce electricity cost and energy gets saved.
38% percent of one month electricity bill is saved through –
(i) By Heat load – 25% of electricity cost is reduced (12,00,000 inr)
(ii) By Solar cells –13% of electricity cost is getting saved (6,43,334 inr)
So by summing up both the cost we get = 18,42,334 inr i.e.

Total savings per month = 25% of electricity cost + 13 % of electricity cost
Total amount of electricity of HVAC = 12,00,000 + 6,43,334 X 100 = **38.38%**
48,00,000

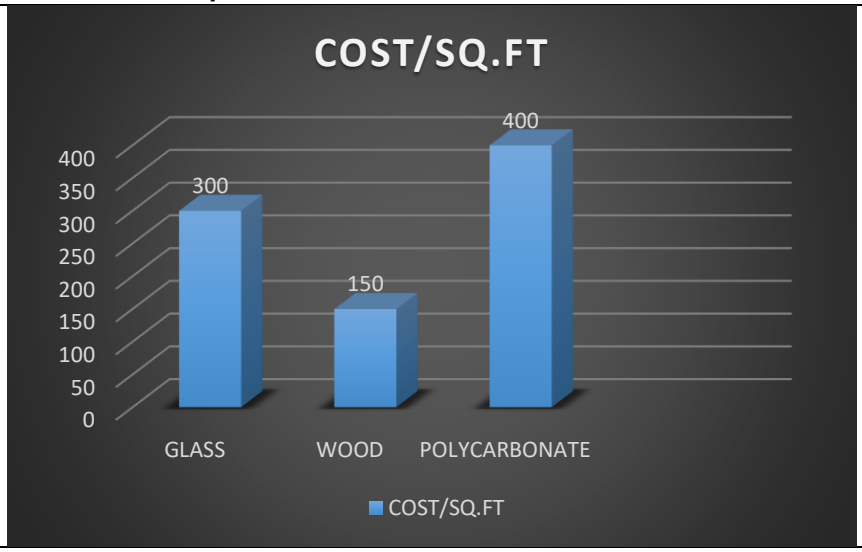
7. COMPARITIVE ANALYSIS OF EACH MATERIAL

Table 5. Comparative analysis of glass , Transparent wood and polycarbonate

	GLASS	TRANSPARENT WOOD	POLYCARBONATE
Basic Introduction	It is transparent, colorless, or colored glass, with uniform thickness and homogenous mass. Has high light transmission, double glazing.	*Transparent wood composites* are novel wood materials which have up to 90% transparency and some higher mechanical properties than wood itself. These materials are significantly more biodegradable than glass and plastics.	Polycarbonates (PC) are a group of thermoplastic polymers containing carbonate groups in their chemical structures. Polycarbonates used in engineering are strong, tough materials, and some grades are optically transparent. They are easily worked, molded,and thermof ormed.
• Sizes	5100mmx300mm max 300mm x 300mm min	600mm x 600 mm	6000mm x 2100mm max 400mm x 400 mm min
• Thermal conductivity	0.8 W/mK	0.15 to 0.3 W/mK	0.19–0.22 W/(m·K)
• Strength	Brittle at times	Very stronger	Very strong
• Compressive strength	100 MPa	293 MPa	125 MPa
• Tensile strength	69 MPa	196 MPa	75 MPa
• Toughness	3.2 MPa.m1/2	0.7 MPa.m1/2 (30 times stronger than glass)	2.2 MPa.m1/2 (10 times stronger than glasss)



• Thickness	3mm,6mm,8mm,12mm,16 mm	1.5mm to 5mm	4mm,6mm,10mm,16mm
SAFETY	yes	yes	yes
USES	Sound reduction UV reduction Impact resistance Durable	Glazing system Solar cells Load bearing walls	Electronic components Construction materials Data storage Automotive, aircraft, and security components
ADVANTAGES	Toughened glass is extremely tough and hard. These glasses reduce the risk of injury and damage in care of disaster or calamity. It is a very lightweight glass which reduces the load of building Ravishing variations of toughened glass provide a very rich and elegant look to the buildings It facilitates natural light into the homes and buildings while providing a soothing sensation	High transmittance of 90% and a high optical haze of 95%. Potential for energy efficiency and operational savings in the building industry are very promising. Its combination of structural and functional performance for load-bearing structures that combine optical, heat-shielding, or magnetic functionalities. Lower thermal conductivity and better impact strength	Fire-resistant Vandal-proof Hardwearing Insulating Lightweight Easy to machine
DISADVANTAGES	Re-sizing, re-cutting and re-working on a toughened glass is not possible The glass will break completely if its edges are damaged The waviness on its surface creates problems in making thin film solar cell	Transparent Wood is; the epoxy isn't environmental friendly.	Sensitive to scratches Can expand
COST	150 to 350 rs / sq.ft	4 USD 300 rs / panel Approximately. i.e. 150rs / sq.feet	292 to 400 rs / sq.ft



9. CONCLUSION

The Payback period for solar panel is 6.6 years and then by using Transparent wood (perovskite cells) 3.6 years of payback period. Approximately 40% of global CO_2 emissions are emitted from electricity generation through the combustion of fossil fuels to generate heat needed to power steam turbines. Burning these fuels results in the production of carbon dioxide (CO_2)—the primary heat-trapping, "greenhouse gas" responsible for global warming.

Solar energy, as the name suggests, derives energy from the sun. Any form of energy that utilizes the sun produces clean energy and it does not produce any kind of emissions. So, when you install solar panels on your home, you are ensuring that your home is powered by a clean source of energy. If you install a solar panel that provides 5KW of energy then in one lifespan you will reduce carbon emissions equivalent to planting approximately 21, 000 square feet of trees. By using Perovskite cells in it can save 32,788 trees added because they produce very low carbon emissions.

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