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Life Cycle Analysis of a curtain wall glass assembly using high performance glazing and aluminium support system

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ABSTRACT

Curtain walls with glass infill are being extensively preferred for their aesthetic properties by the designers for contemporary building envelops in India. However it becomes necessary to consider the environmental impacts of curtain wall envelops throughout their life cycle when it comes to the selection of various types of glazing panel infils and framing materials since green buildings have become a prime necessity of time to combat global environmental challenges like climate change. The study consists of life cycle analysis of curtain wall assembly with glass panels and aluminum support system. Different glazing assemblies for high performance have been compared and analyzed for their performance based on the parameters like Solar Heat Gain Co-efficient.(SHGC), Shading Co-efficient (SC), Energy Absorption (EA), Energy Reflectance (ER), Direct Energy Transmission.(DET), U – value, Relative heat gain, Visible Light Transmittance (VLT) and thermal performance. The paper also discusses life cycle analysis of parts of curtain wall assembly viz. glass infill, aluminium frame and sealant, the discussion parameters being environmental impacts during raw material extraction and manufacturing, embodied energy, performance and maintenance, possibility of recycling and reuse, energy conservation, waste generation and other human, environmental impacts.

Keywords : *curtain wall, environmental impacts, high performance glazing, , life cycle analysis , thermal performance.*

1.INTRODUCTION

There is a rapid transformation in the envelop materials used for the buildings in India from conventional bricks, stones and concrete to contemporary glazing. Curtain wall assemblies with glazing panels are extensively preferred by architects due to their aesthetic properties and the visual connection it offers between the interiors and the exteriors. However every material used for the building construction has certain environmental impacts throughout its life cycle, from raw material extraction, processing, performance up to their disposal. Buildings account for 40% of material extraction. [1]. Hence it becomes necessary to consider these environmental impacts so as to reduce them by consciously choosing the materials in the designing of building envelops. There has been an intense research and advancement in the glazing technologies that offers an array of high performance glass infill in curtain walls. In this paper life cycle analysis of curtain wall assembly with glass panels and aluminum support system has been studied. To understand the environmental impact in the performance phase, different types of high performance glazing have been compared and analyzed based on the parameters like Solar Heat Gain Co-efficient.(SHGC), Shading Co-efficient (SC), Energy Absorption (EA), Energy Reflectance (ER), Direct Energy Transmission.(DET), U –value, Relative heat gain, Visible Light Transmittance (VLT) and thermal performance.The paper also discusses life cycle analysis of parts of curtain wall assembly viz. glass infill, aluminium frame and sealant, the discussion parameters being environmental impacts during raw material extraction and manufacturing, embodied energy, performance and maintenance, possibility of recycling and reuse, energy conservation, waste generation and other human, environmental impacts.The study will be helpful for the practitioners in taking informed decisions while designing curtain wall assemblies with selection ofmaterials viz. frame, infill and sealant so as to have minimum environmental impact for designing green buildings, at the same time to achieve desired aesthetic and functional advantages from the curtain wall envelop assemblies. It is also targeted towards the industries involved in production of glass and aluminum to look into the development and innovation of new production techniques to reduce the environmental impacts.

2. RESEARCH METHODOLOGY

The research methodology mainly included analysis of the information obtained by factory visits to the glass manufacturing units and interactions with the curtain wall design and execution agencies. Primary data has been collected from manufacturing facilities using structured questionnaires. Physical, mechanical and thermal properties of the glass types were referred from the datasheets obtained from the datasheets from manufacturers and dealers. For comparing the thermal performance Ecotectsoftware simulation method was adopted.

3. MATERIAL LIFE CYCLE ANALYSIS

Life cycle analysis is a systematic approach to understand the environmentalimpacts associated with a product throughout its entire life – from initial extraction of theraw materials through manufacturing, use, and eventual disposal or recycling. Thus , the life cycle analysis of a material is primarily be divided into four stages – 1. Raw material extraction and manufacture 2. Implementation and usage 3. Performance and maintenance in operational life and 4. Disposal.

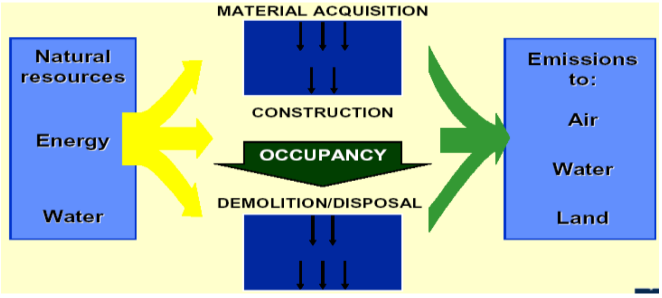


Fig 1: Life Cycle Analysis approach

4. CURTAIN WALLS WITH GLASS INFILL

Curtain wall is used as external building envelope. The assembly consists of - 1. Infill panels 2. Support system of aluminum or steel and 3. A sealant made up of urea formaldehyde or phenol formaldehyde. The aluminum frame is typically in filled with glass. Other common in fills include stone veneer, metal panels, louvers, and operable windows or vents. Glass is a unique material having properties like transparency, translucency, opacity and lightness which made it most popular and extensively used material in building industry. As the curtain wall is non-structural it can be made of a lightweight material reducing construction costs. When glass is used as the curtain wall, a great advantage is that natural light can penetrate deeper within the building. The curtain wall façade does not carry any dead load weight from the building other than its own dead load weight. A curtain wall is designed to resist air and water infiltration, sway induced by wind and seismic forces acting on the building, and its own dead load weight forces. However, parameters related to solar gain control such as thermal comfort and visual comfort are more difficult to control when using highly-glazed curtain walls. Advancement in the clear glass has been achieved to have tinted glazing, coated glazing and other energy efficient glazing so as to have a better performance in terms of reduced heat gains and glare protection. The advancement is achieved by addition of certain metals to the glass and further treatment to it. They are present in various colours like bronze, green, blue or grey.

5. LIFE CYCLE ANALYSIS OF A SINGLE CLEAR TOUGHENED GLAZING

Single clear toughened glazing is conventionally used for curtain walling. It absorbs, refract light and transmits maximum amount of light incident on its surface. It is not affected by air or water, ordinary chemicals but is affectedby alkalis. It is an excellent electrical insulator at elevated temperatures. Toughened glazing are available in many colours and are transparent. They can be blown, pressed or drawn; pieces can be welded by fusion.

5.1 RAW MATERIAL EXTRACTION AND MANUFACTURE

Primary raw materials involved in glass manufacturing are silica – 60-75% and lime – 5-12%. Soda is the secondary raw material used in the amount 12-18%. Cullet or the plant generated recycled or processed glass is used upto 37% as raw material.[2].Other raw materials with their purpose of use are explained in Table 1.

Table 1: List of raw materials with purpose in glass manufacturing.

Raw Material	Oxides/ Elements Furnished	Purpose In Glass
Sand (SiO_2) Melts 3500°F	SiO_2	Network Former - Backbone of glassy phase. Abundant material, can usually find suitable deposit near plant.
Feldspathic Sand Sandspar	SiO_2 Al_2O3	Network Former - Backbone of glassy phase.
Soda Ash (Na_2CO_3) Melts 1400°F	Na_2O	Fluxing Agent - Gives fluidity and promotes melting of glass. Expensive; only two deposits in the United States - Green River, WY, and Trona, CA.
Limestone ($CaCO_3$)	CaO	Network Modifier - Gives durability to the glassy phase. Abundant material, can usually find suitable deposits.
Dolomite ($CaO{\cdot}MgO{\cdot}2CO_2$)	CaO MgO	Network Modifier - Gives durability to the glassy phase. Abundant material, can usually find suitable deposits.
Feldspar (R_2O-$Al2O_3$-$6SiO_2$) Nepheline Syenite ($Na_2Al_2Si_2O8$) Aplite ($Ca_2Al_2Si_2O8$)	SiO2 Al_2O3 Na_2OK_2O CaO	Intermediate Formers - Al_2O_3 is a refractory material that gives durability to the glass; it also increases the viscosity and workability of the melt. Also, feldspars are additional sources of SiO_2 and fluxing agents. Feldspar - If a deposit is located near the plant, this can be a good source of Alumina. Nepheline Syenite (a blend of minerals) - Primary deposit is in Nephton, Ontario. Aplite (a blend of minerals) - Primary deposit is in Virginia.
Saltcake (Na_2SO_4) Gypsum ($CaSO_4$)	SO_3 Na_2O CaO	Fining Agent - Source of SO2 gas and Na2O or CaO.
Carbocite Carbon	C	Reducing Agent - Reacts with fining agent to form SO2 gas in flint and s in amber.
Iron Pyrite	FeS_2	Source of iron and sulfur in amber (coloring agent).
Iron Oxide Iron Scale Melite	Fe_2O_3	Source of iron in amber (coloring agent).
Iron Chromite	Cr_2O_3	Green glass coloring agent.
Cobalt Oxide	CoO	Blue glass coloring agent and decolorizing agent in flint.
Selenium	Se	Decolorizing agent in flint.
Cullet	All	Plant generated, recycled or processed. Current use in some plants is up to 50 percent in flint, 70 percent in amber, and 80 percent in green. Current average use is about 37 percent.

Source :https://archihunger.wordpress.com/tag/laminated-glass

The ingredients,silica (sand or silicon dioxide), soda ash, lime, cullets. Silica that comes from white sand or pulverized sandstone gets fused into glass at around 1600 deg celcius. The addition of cullet (bits of old or broken glass from previous manufacturing , otherwise called the waste glass) further helps in lowering the temperature that is required in order to fuse the ingredients.[3]

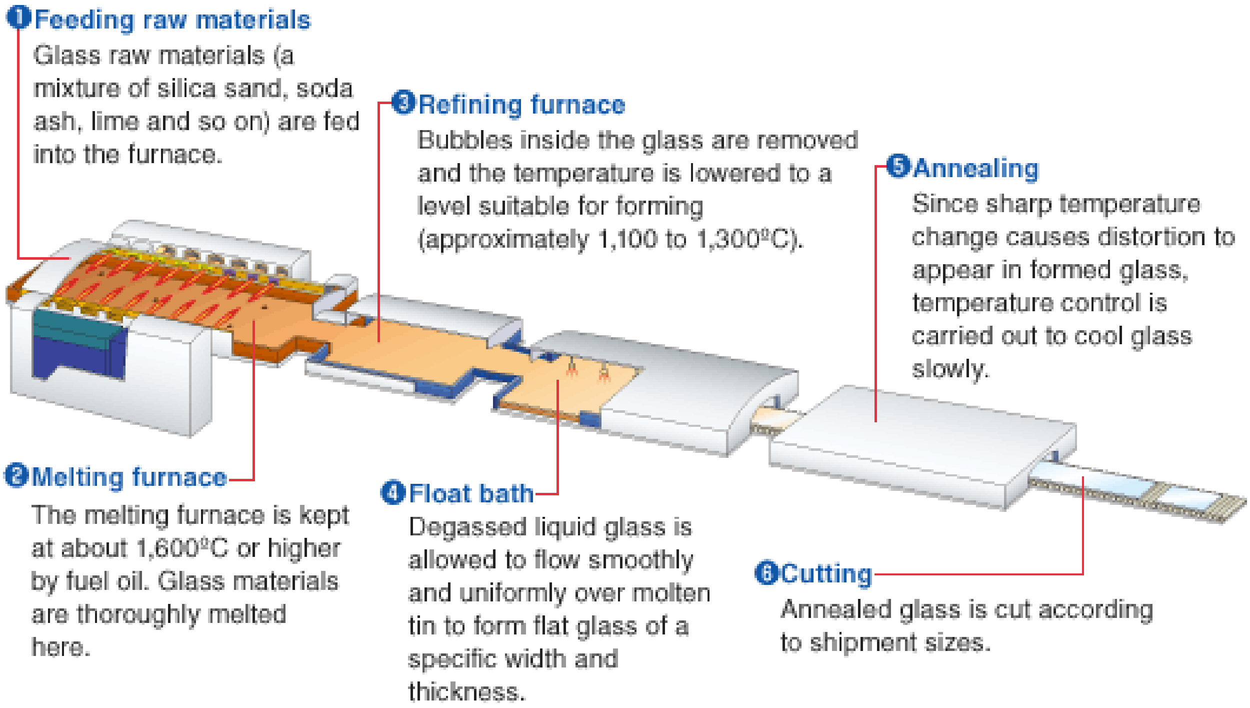


Fig 2: Manufacturing process of annealed glass

Source : https://archihunger.wordpress.com/tag/laminated-glass

Toughened or tempered glass is glass that has undergone processes of controlled thermal treatment to increase its strength.Toughened glass is made from annealed glass that has been heated to approximately 650 deg Celcius and then rapidly cooled. Due to the increased heat treatment and rapid cooling of the glass, especially between the surface and the inside of the glass, the treatment produces different physical properties. This results in compressive stress on the surface and improved bending strength of glass.

5.2 ENVIRONMENTAL IMPACT

The natural sources of primary raw materials like silica and lime are sandstone and limestone respectively are extracted by open cast mining method at both large scale and small scales. Scientific studies revealed that loss of forest cover, pollution of water, soil and air, depletion of natural flora and fauna, reduction in biodiversity, erosion of soil, instability of soil and rock masses, changes in landscape and degradation of agriculture land are some of the conspicuous environmental implications of limestone mining. Other impacts includehabitat destruction, encroachment of waste into agricultural land, destruction of buildings due tocracks, pollution of rivers , unclean rain water harvested from roofs and health related problems include inhalation of dust resulting in respiratory tract infections. [4].

All major opencast mining and stone crushing operations release particulate emissions that not only deteriorate environmental quality but also cause serious health problems in man. negative impacts especially during the crushing process such as production of dust emissions and noise pollution; on the socio-economical and biophysical environment such as the degradation of air quality by the dust emitted during the site clearing, effects of air pollution, risk of excess soil being eroded from the site where stones are manually extracted, Loss of habitat for some fauna and flora species and biodiversity reduction due to vegetation clearing neighboring the stone extraction site.[5]

Transportation of raw materials upto the manufacturing plant again results in the combustion of fuel and thus emission of carbon dioxide CO2 and carbon monoxide CO, contributing global warming and climate change.

The atmospheric emissions during the melting activities in the glass production contributes majorly towards the negative environmental impact. A glass furnace runs 24/7 and cannot be stopped and cooled down during its lifetime (15-18 years).Huge amount of natural gas or fuel oil is combusted during melting resulting in the decomposition of raw materials leading to the emission of carbon di oxide (CO2).Carbon di oxide is one of the harmful greenhouse gases1 with considerable global warming potential2. Also, Sulphur dioxide (SO2) from the fuel and/or from decomposition of sulphate in the batch materials can contribute to acidification.Nitrogen oxides (NOx) due to the high melting temperatures and in some cases due to decomposition of nitrogen compounds in the batch materials also contribute to acidification and formation of smog**.** Evaporation from the molten glass and raw materials can cause release of particlesinto the atmosphere.

Other environmental issues are water pollution, the use of non-renewable natural raw materials such as sand and minerals, production of solid waste and emission of volatile organic compounds (used in production of mirrors and coatings).

Embodied energy of toughened glass is 26.2 MJ/KG.[6]It is considerably high compared to other conventional envelop materials such as of bricks 2.5 MJ/KG, stone (imported) 6.8 MJ/KG, concrete brick, 0.97 MJ/KG, timber 2.0 MJ/KG as per the study carried by Victoria university of Wellington, architectural resource centre.

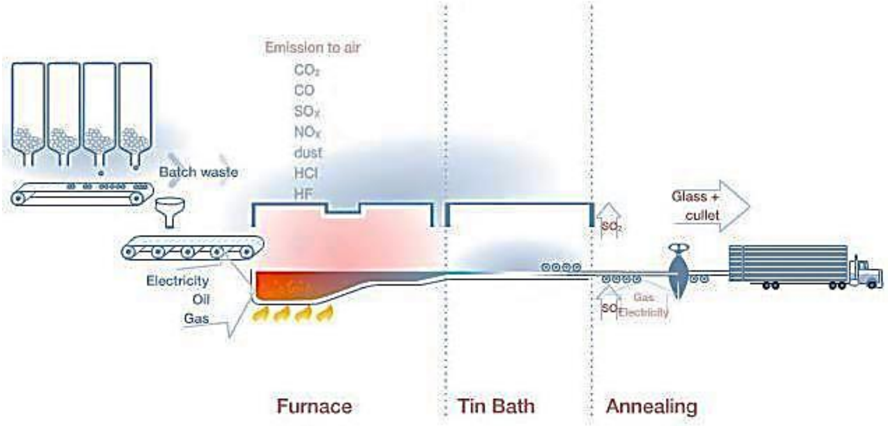


Fig 3: Emissions during glass production

[1]Gases that contribute to the greenhouse effect by absorbing infrared radiation. Carbon di oxide, methane, nitrous oxide, chlorofluorocarbons, hydro fluorocarbons are potential green house gases.

[2]Contribution of greenhouse gasses to global warming is measured by Global Warming Potential (GWP). GWP is measured in carbon dioxide equivalents.

Source : http://www.agc-glass.eu/en/sustainability/environmental-achievements/environmental-impact

5.3. COMPARATIVE ANALYSIS OF HIGH PERMORMANCE GLASS TYPES

Efficiency of glass infill in a curtain wall glazing assembly is judged considering following parameters:

a. Solar Heat Gain Co-efficient.(SHGC)
b. Shading Co-efficient (SC)
c. Energy absorption (EA)
d. Energy reflectance (ER)
e. Direct energy transmission.(DET)
f. U – value
g. Relative heat gain
h. Visible Light Transmittance (VLT)

Glasses with increased efficiency include:

1.Tinted glass
2.Coated glass –
  a. solar control coatings
  b. Low e coatings
  c. solar control + low e coatings.
3. Insulated Glazing Unit (IGU) / Double glazing.

5.3.1 SOLAR ENERGY TRANSMISSION

The above listed high performance glasses have been compared for the solar energy transmission through them. Thickness of all the glasses under consideration is 6mm.

1. TINTED GLASS / HEAT ABSORBING GLASS

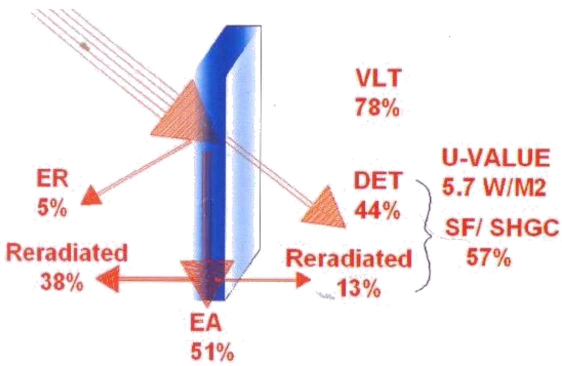


Fig 4: Heat transmission through 6mm thick green tinted glass[2]

Tinted glass, also known as heat absorbing glass,controls solar energy mainly by absorption and reflects very small amount of light, resulting in reduced heat gain and reduced transmission of daylight.It is commonly used to reduce glare from bright outdoors. The most common colours are gray, bronze, blue, green.

2. COATED GLASSES/ HEAT REFLECTING GLASSES

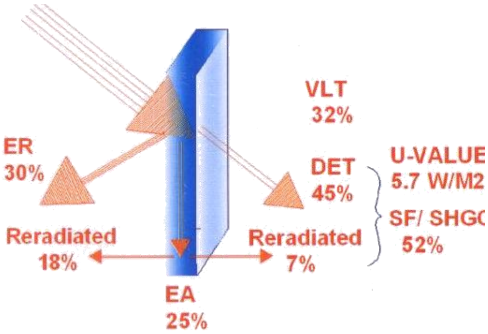


Fig 5: Heat transmission through 6mm thick reflectivecoated glass[2]

Coated glass, also known as heat reflecting glass, controls solar energy mainly by reflection. Microscopically thin vacuum-deposited metallic coatings are applied on its outer surface. Coatings can be used on clear glass to control heat and also on tinted glass to further improve its thermal performance, but with tinted glass visible light transmittance (VLT) of a reflective glazing usually declines more than the solar heat gain co-efficient (SHGC).

3.LOW E - COATED GLASSES

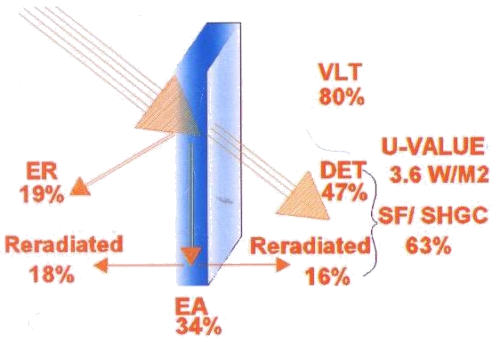
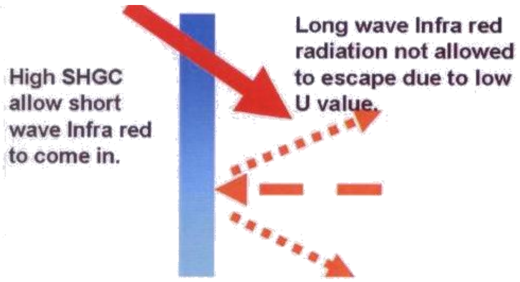


Fig 6: Heat transmission through 6mm thick low e-coated glass[2]

Coating of a glass surface with a low remittance material reflects significant amount of radiant heat, thus lowering the total heat flow through it.Reduction in this emission of heat improves insulating properties of glass i.e. reduce the U value of glass by suppressing radiated heat flow.These coatings are transparent to visible light and opaque to infrared radiation, thus allowing good amount of daylight to enter into the building at the same time restricting heat gain. Emissivity of low e glasses ranges from 0.35 to 0.04, means 65%-96% of long wave radiation is reflected back where clear glass reflects only 16%.

In Indian climatic zones like hot, warm and composite, if simple low e glass is used, higher SHGC can result in allowing short wave infra-red radiations to pass through. Hence ,to achieve solar control in climates like India, low e glasses need to be combined with a film or tint, thus giving lower U values along with low SHGC which help in reducing total heat gain.(Fig. 7)



Hence

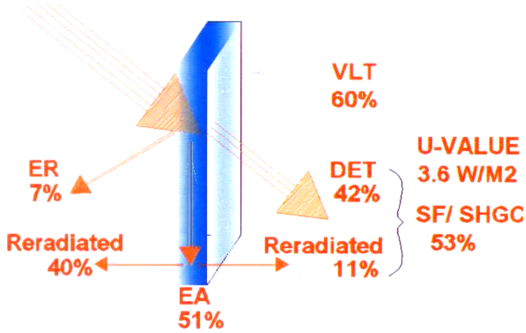


Fig 7: Heat trap effect due to simple low e- glass[2]Fig 8: Solar control low e glass[2]

4. INSULATED GLAZING UNIT (IGU), DOUBLE GLAZING

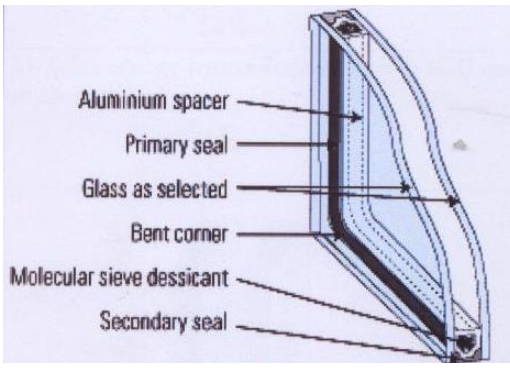
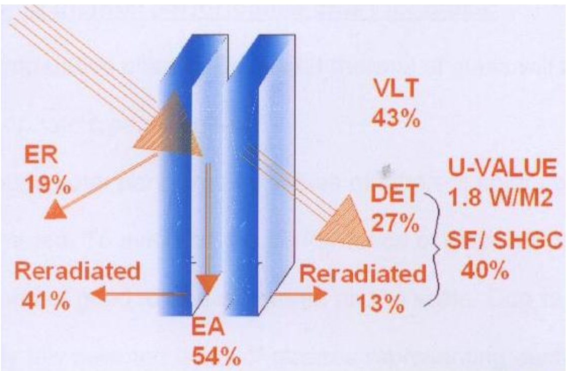


Fig 9: Composition of IGU[2]

IGU consists of 2 or more glass panes having air space or inert gas filled in between.IGU work on the principle of reducing conduction and convection heat transfer across the unit.Thermal insulation primarily depend upon the dryness of the air inside the IGU, as well as quality of hermetic seal.Many times to improve thermal performance of the glazing space between glasses is filled with inert gases like argon and krypton which can bring down U value by 0.2 to 0.3 w/sq.m.



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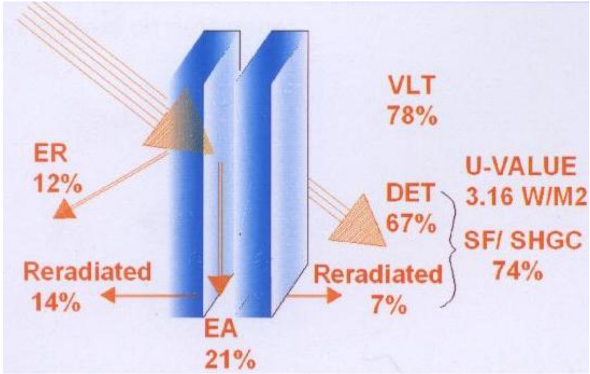


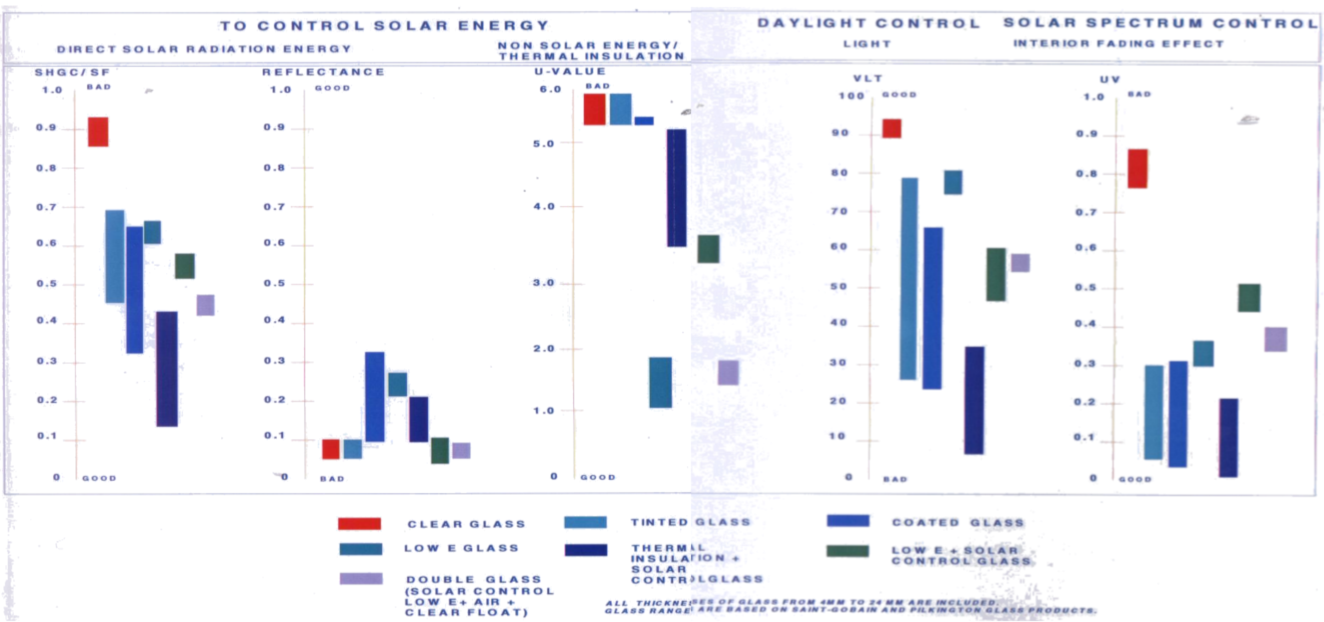


Fig 10: IGU with clear glass and 12mm air gap[2]Fig 11: Reflective outer+clear inner glass+12mm air gap[2]

IGU also mainly reduces non-solar heat gain. Hence heat trap problem may need to face in hotter climates with use of simple IGU glass. To achieve control on direct solar radiation, IGU need to be treated with tints or coats.

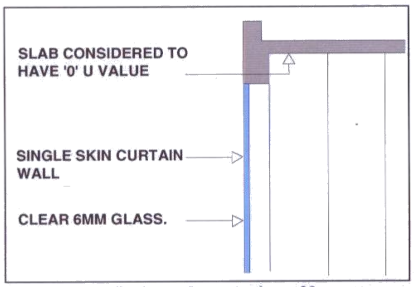
Fig 12: Comparative chart – solar and thermal performance of glass[2]

Thus solar control low-e glass and insulated glazing unit(IGU) are more efficient for controlling total heat gain as compared to other glass types.

5.4.COMPARITIVE ANALYSIS BETWEEN GLASS ENVELOPES FOR THERMAL PERFORMANCE

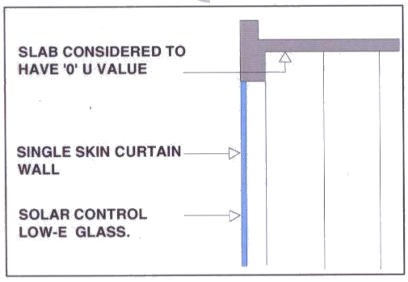
Glass envelop conditions with different types of glazings have been simulated in Ecotect software for thermal performance. The result have been compared with the base with clear glass.

BASECASE



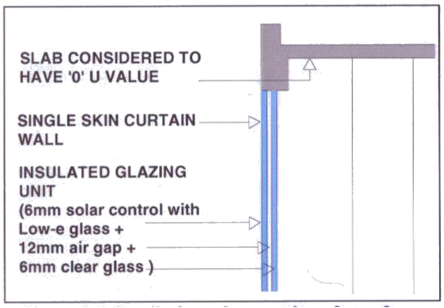
ENVELOPE	GLASS	U-FACTOR	SOLAR FACTOR	DAYLIGHT TRANSMITIVITY
SINGLE SKIN	*CLEAR 6 MM*	*5.8 W/M2degC*	*0.84*	*0.91*

CASE 1



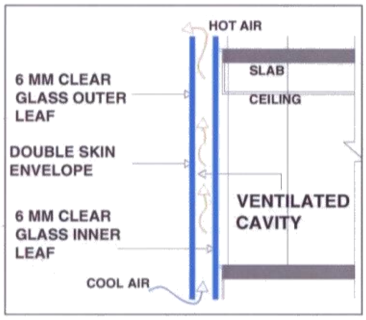
ENVELOPE	DESCRIPTION	U FACTOR W/M2DEGC	SOLAR FACTOR	DAYLIGHT TRANSMISSIVITY
SINGLE SKIN	SOLAR CONTROL + LOW-E	3.6	0.53	0.6

CASE 2



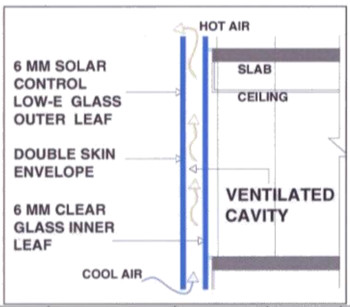
ENVELOPE	DESCRIPTION	U FACTOR W/M2DEGC	SOLAR FACTOR	DAYLIGHT TRANSMISSIVITY
SINGLE SKIN	INSULATED GLAZING UNIT	1.86	0.36	0.47

CASE 3



VELOPE	LEAF	DESCRIPTION	U FACTOR W/M2DEGC	SOLAR FACTOR	DAYLIGHT TRANSMISSIVITY
louble skin	out	clear glass 6mm	5.8	0.84	0.91
	in	clear glass 6mm	5.8	0.84	0.91
	cavity	600 mm air gap	7.4		
		total	**2.13**	**0.71**	**0.83**

CASE 4



NVELOPE	LEAF	DESCRIPTION	U FACTOR W/M2DEGC	SOLAR FACTOR	DAYLIGHT TRANSMISSIVITY
double skin	out	solar control low-e	3.6	0.53	0.6
	in	clear glass 6mm	5.8	0.84	0.91
	cavity	600 mm air gap	7.4		
		total	**1.74**	**0.45**	**0.55**

From the data of each case, it could be observed that solar control low-e glass and insulated glazing unit(IGU) are more efficient for controlling total heat gain as compared to other glass types hence can be further compared for better curtain wall envelop in terms of thermal performance.

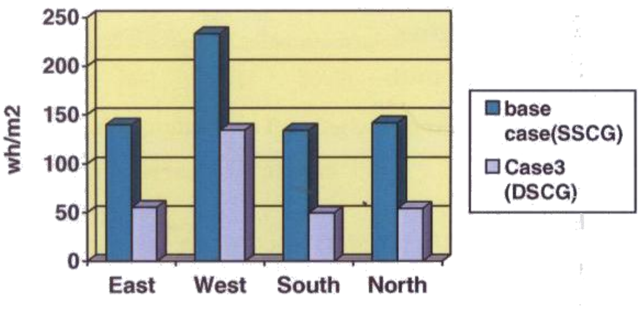


Fig. 13: Total heat gain comparison for single skin clear glass and double skin envelop in May, 3.00 p.m.

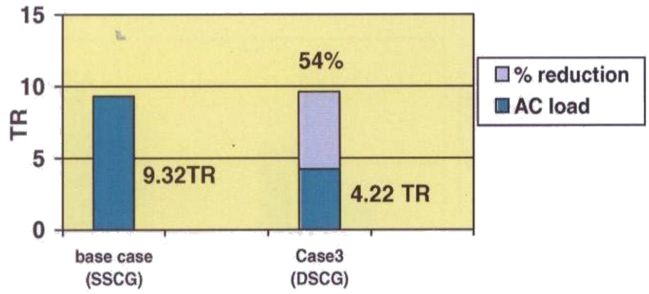


Fig. 14: A.C.loadcomparison for single skin clear glass and double skin envelop in May, 3.00 p.m.

Fig. 13 and 14 shows that Double skin envelop performs better than single skin in terms of heat gains.

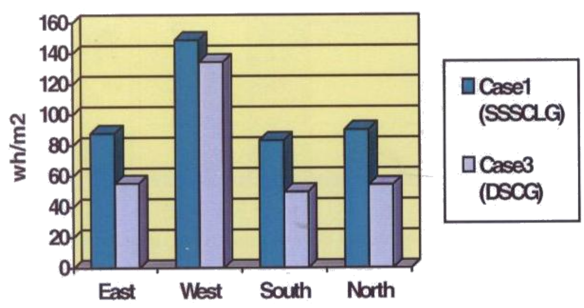


Fig. 15: Total heat gain comparison for single skin with solar control low e glass and double skin envelop in May, 3.00 p.m.

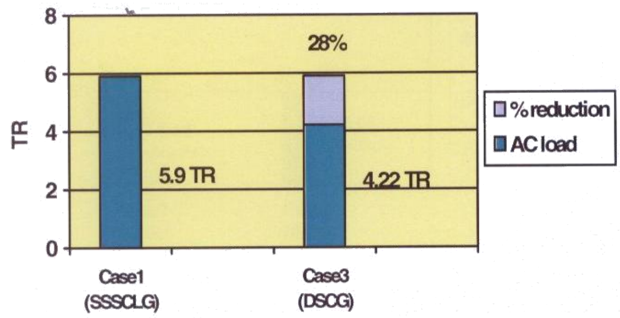


Fig. 16: A.C. loadcomparison for single skin with solar control low e glassand double skin envelop in May, 3.00 p.m.

Fig. 15 and 16 shows that Double skin envelop performs better than single skin solar control low e-glass.

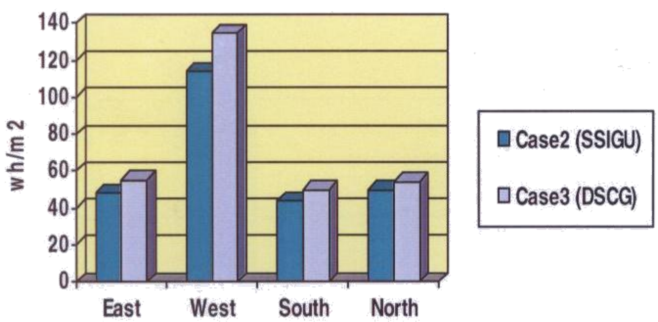


Fig. 17: Total heat gain comparison for single skin with IGU glass and double skin envelop in May, 3.00 p.m.

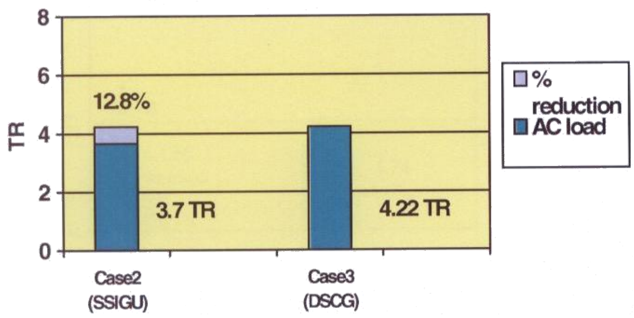


Fig. 18: A.C. loadcomparison for single skin with IGU glass and double skin envelop in May, 3.00 p.m.

Fig IGU glass performs bett

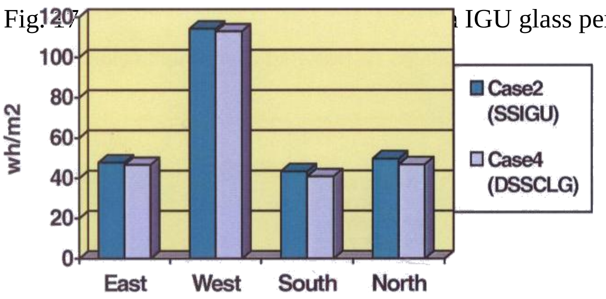


Fig. 19: Total heat gain comparison for single skin with IGU glass and double skin envelop in May, 3.00 p.m.

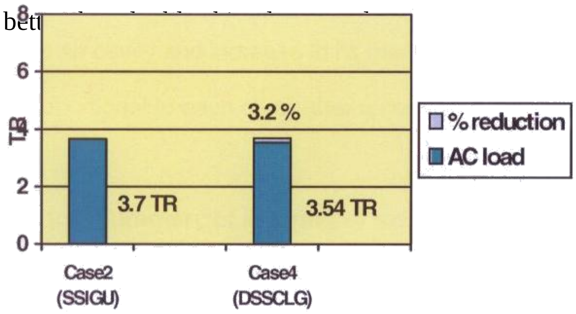


Fig. 20: A.C. loadcomparison for single skin with IGU glass and double skin envelop in May, 3.00 p.m.

Fig. 19 and 20 shows that Double skin envelop with 600mm ventilated cavity performs better than single skin composite double glass with 12mm hermetically sealed air gap.

The analysis shows that in performance phase, there is lot of scope to improve thermal performance of an envelope if designed thoughtfully.

5.5.DISPOSAL

Glass is a 100% recyclable material. Usage of recycled glass as a raw material in manufacturing process reduces the melting point of primary raw materials viz. silica and lime and soda ash. Thus it helps in reducing the furnace temperature and saves energy by reducing the requirement of fuel combustion. So inversely disposal of glass reduces negative environmental impact. However, cullet requires processing to remove non-glass contaminants and to create size uniformity. Cullet is usually color separated, crushed to a maximum size of Â¾ of an inch, and screened and vacuumed to remove contaminants.Labels, aluminum caps, and non-magnetic metal are all considered contaminants. But the process is comparatively less energy intensive.

5.6 MAINTAINANCE

Regular cleaning is needed for glazing. Exposed glazing seals and gaskets require inspection and maintenance to minimize water penetration, and to limit exposure of frame seals and insulating glass seals to wetting when used in curtain walling. It is easy to maintain.

6.LIFE CYCLE ANALYSIS OF EXTRUDED ALUMINIUM FRAME IN CURTAIN WALL ASSEMBLY

Among the widely used framing materials for curtain walling viz. aluminum, pvc, steel, alumimium is mostly preferred mainly for its lightweight. Aluminum is soft, fire-proof and heat-resistant, easy to work into new shapes, and able to conduct electricity. It reflects light and heat very effectively and it doesn't rust. Aluminium is nonmagnetic and nonsparking. It is insoluble in alcohol, though it can be soluble in water in certain forms. Aluminium has about one-third the density and stiffness of steel.

6.1 RAW MATERIAL EXTRACTION AND MANUFACTURE

Aluminium is not present in nature in its pure form as it readily reacts with oxygen to form aluminium oxide.. It needs to be extracted from its compound bauxite which is present in abundance in earth's crest. Boxcite ore is extracted from earth by open cast mining and crushed to remove impurities to leave aluminium oxide. Then by the electrical technique called electrolysis, aluminium is separated from oxygen. Once separated out, the pure aluminum is cast into blocks known as ingots, which can be worked or shaped or used as a raw material for making aluminum alloys.

6.2 ENVIRONMENTAL IMPACT

The whole process of obtaining shiny usable aluminium from the rocky bauxite by removing impurities is extremely energy intensive process. To produce 1 tonne of aluminium it requires 1.93 tonnes of alumina. The alumina in turn requires 2.9 tonnes of bauxite ore to be mined. The ratio for aluminium to bauxite ore thus becomes 1tonne of metal needs 5.6 tonnes of ore. The ore not used in the process will go to waste in the so called red mud pond. 1 tonne of alumina results in 1.2 tonnes ofred mud residue. 1 tonne of aluminium requires 14,500 kwh of energy[6]. These high levels of energy consumption in the process of aluminium manufacturing is associated with emission of carbon di oxide and methane. Both these gases are potentially harmful green house gases responsible for global warming.Embodied energy of aluminium is as high as 227MJ/KG as per the study carried by Victoria university of Wellington, architectural resource centre.[7]

Also, mining activities impact the surrounding environment negatively causing land degradation, soil erosion, air and water pollution, loss of biodiversity etc.

As per study conducted by *Rahman Azari and Yong-Woo Kim, 2012*, using aluminum in curtain wall systems causes the largest damages to the environment compared to steel, pvc and glulam timber framed curtain walls. It contributes to highest global warming potential, acidification potential (AP)[3] and eutrophication potential(EP)[4]and human toxicity[5] impacting human health[8].

6.3 PERFORMANCE AND MAINTAINANCE

Aluminium frames being lighter in weight, durable and fire-proof perform satisfactorily in curtain wall assemblies compared to other material like steel, glulam timber etc.

Aluminium frames have an extremely long life while being highly resistant to outside weather elements. Aluminium can be left in its finished condition and virtually maintenance free due to its corrosion resistant and

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3 Contribution to acidification, Acidification Potential (AP), is measured in sulfur dioxide equivalents[9]

4 , Eutrophication Potential (EP) is measured in phosphate-equivalents[9]

5 Human toxicity, which is caused by environmental and occupational exposureof humans to poisonous substances [10], is quantifiedby human toxicity potential which is a dimensionless measure of the contribution of asubstance to human toxicity.[11]

anti-rust properties. Furthermore, they are less likely to warp, rot, swell, or crack over time, thus ensuring a long product life.

When combined with energy efficient glass, aluminium frames are able to meet or exceed energy efficiency standards by providing excellent thermal and sound insulation thus easily outperforming more expensive wood and PVCcounterparts. Aluminium windows can easily achieve a significant boost in heat gain and loss through windows.

Aluminium frames provide a modern aesthetic, so is ideal for contemporary buildings at the same time they are cost effective and easy to install compared to wooden frames. They also do not require any periodical or annual expenditure on paint or polish and can simply be wiped clean with the help of a damp cloth.

When it comes to performance of curtain walls in long run there are also some disvantages with aluminium frames. Oxidation is a natural phenomenon that occurs in aluminum that can cause aluminum frames to rust over time. Aluminium frames will oxidize over a period time which appears as a white residue formation and cavity. Additionally, if suitable measures to tackle electrolysis are not taken, aluminium is also susceptible to corrosion.Aluminum is a good thermal conductor which basically means that aluminum frames may not work well in cold climates as heat will be lost through the frame. Additionally, aluminum frames also permit for condensation or even frost to form on the interior surface of the curtain wall which and can cause many performance and maintenance issues. Hence, Aluminum frames are generally painted or anodized.

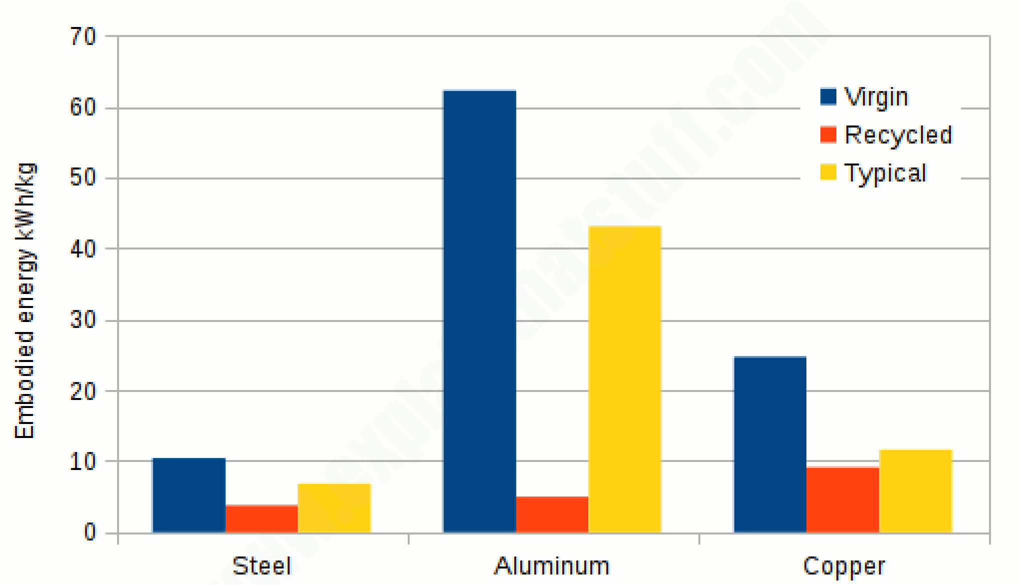
Factory applied fluoropolymer thermoset coatings have good resistance to environmental degradation and require only periodic cleaning. Anodized aluminum frames cannot be "re-anodized" in place, but can be cleaned and protected by proprietary clear coatings to improve appearance and durability.

6.4 DISPOSAL

Aluminium is an environmentally sustainable material with one of the highest recycling rates of any metal without loss of any natural quality.Aluminum ingot is used in building products. Essentially, post-consumer aluminum isrecycled back into a wide array of new products, offsetting virgin material use, via theuse of secondary (recycled) aluminum in the manufacturing process.

Recycling aluminum makes sense. The amount of energy it takes to recycle metal for reuse is a fraction of what it takes to produce virgin metal in the first place, but the difference is much greater for aluminum than for either steel or copper because it's so hard to extract and refine aluminum in the first place.(Table 2)

Table 2 : embodied energy requirements for virgin, recycled and typical metals.



Source : Inventory of carbon and energy (ICE), Department of Mechanical Engineering, University of Bath.[12]

7. SEALANTS USED IN CURTAIN WALLS

Phenol phormaldehyde and urea formaldehyde are commonly used sealants in curtain wall assemblies. Curtain walls and perimeter sealants require maintenance to maximize service life. Embodied energy of Phenol phormaldehyde is 87 MJ/KG and that of urea formaldehyde is 78 MJ/KG. Manufacturing of both these sealants is associated with environmental and health impacts due to emission of CO2, CO, VOCs, particulate formaldehyde and methanol.[13]

Perimeter sealants, properly designed and installed, have a typical service life of 10 to 15 years. Removal and replacement of perimeter sealants require meticulous surface preparation and proper detailing.

8.CONCLUSION:

From life cycle analysis of glass as a curtain wall it can be concluded that, glass has major environmental

impact during its manufacturing process due to high heat consumption and CO2 emission.These environmental impacts can be reduced using methods like electric melting and total oxygen combustion methods by reducing unwanted emissions. Also mining activities for sandstone, limestone for raw material extraction causes loss of forest cover, pollution of water, soil and air, depletion of natural flora and fauna, reduction in biodiversity, erosion of soil, instability of soil and rock masses, changes in landscape and degradation of agriculture land etc. On the other hand in performance phase curtain glass envelop if designed consciously, in a way to achieve high thermal insulation and reduced direct solar gain, proves to be very efficient in achieving energy conservation in buildings through considerable reduction in cooling loads.. Furthermore, since glass is 100% recyclable and reusable, there are no environmental impacts in its disposal.Glass nowadays offers wide choice pertaining to various parameters affecting thermal and visual performance. Regular repair and maintenance of curtain wall assembly through sealant replacement with proper detailing and protective coatings to support systems can assure longer service life span of the envelope.

Also curtain wall system with aluminum mullion makes the largest contribution to global warming pertaining to the high levels ofenergy and thus, emissions of carbon di oxide in the process of aluminum manufacturing. But aluminium is 100% recyclable with faster rate. Aluminum framing providessatisfactory performance due to lightweight, durability, easy workability, affordability and easy maintenance.So, development and adoption of less energy intensive manufacturing could be looked forward.The negative impacts caused on the surrounding environment during bauxite miningcan be minimized by adopting an effective Environmental Management Plan which includes mitigation measures for improving the eco-profile of the site area.

Thus, if a curtain glass envelop is manufactured and designed consciously by considering environmental aspects, it can prove to be an efficient building envelop from functional as well as aesthetic point of view.

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