Comparison of Windows made with different type of Materials-A case study
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ABSTRACT

Windows are one of the important components of building for ventilation. Windows are of various type depending up on materials, purpose and opening types. Wooden windows are traditional type and used widely. They are easily available and made in various sizes and shapes. Aluminum power coated windows are light weight and fabricated as per requirements. It is available in all sizes and types. Cost of aluminum window depends upon the section size and thickness used for the window. Aluminum window are not energy efficient and not sound resistance but it is light weight, low cost, rustproof, and required less maintains and painting. Aluminum windows are commonly recommended for building where high degree of elegance is required. UPVC windows are the un plasticized polyvinyl chloride. Now a day’s UPVC windows are becoming more popularly used because of high energy efficient, excellent appearance and smooth surface. But they are costly as compare to wooden and aluminum and they are not that flexible in design and execution. A case study was also done to see the suitability and economy of all these three types of windows and it was found that the aluminum window was best suited for construction, as it has low cost, easily available & can demolded in any shape & size. Also it has high degree of elegance and good appearance when powder coated.

Key words: Powder coated Aluminium windows, UPVC windows, Wooden windows, methacrylates, compounding, weatherability

1. Introduction

Windows are generally provided to give light & ventilation to interior parts of building. When windows are provided for the purpose of light only, as in case of storage room, show rooms etc. they may be fixed so that they cannot be opened. But when windows are provided for light & ventilation, some or all the portion of window must be open. This can be achieved by providing suitable height at top, bottom or sides. Size of window depends on the dimensions of the room, direction and speed of the wind, obstruction to light by neighboring buildings and trees, dry bulb temperature, relative humidity, climatic conditions of the region, etc.

2. Wooden windows

2.1 Introduction

Wood is an organic material, a natural composite of cellulose fibers (which are strong in tension) embedded in a matrix of lignin which resists compression. People have used wood for millennium for many purposes, primarily as a fuel or as a construction material for making houses, tools, weapons, furniture, packaging, artworks, and paper. Wood is a natural readily available material. Wood is divided into two groups, softwoods and hardwoods.
depending on the type of tree from which it came. Hardwoods come from deciduous trees – that is tree that lose their leaves every autumn. Coniferous trees that stay green all year round is the source of softwoods. In general hardwoods as the name suggest are harder and heavier than softwoods, there are exceptions though.

2.2 Quality

(Reference: Code No. IS : 883-1981 (Revised))

2.2.1 First class wood

- Well-seasoned.
- Uniform color.
- Free from cracks, dead knots, shakes, sapwood, etc. No individual hard and sound knot is more than six sq. cm in size and the aggregate area of all such knots should not exceed one percent of the area of the piece.
- Close-grained, having not less than two growth rings per cm width in cross-section.
- In case of deodar, the wood is reasonably straight-grained and has four growth rings per cm width in cross-section.

2.2.2 Second class wood

- Well-seasoned.
- Free from cracks, dead knots, shakes, sapwood, etc.
- No individual hard and sound knot is more than 15 sq. cm in size and the aggregate area of all such knots should not exceed two percent of the area of the piece
- Fairly close-grained, having not less than two growth rings per cm width in cross-section.
- In deodar, traces of sapwood may be allowed. Fairly uniform colour and reasonably straight grains at the rate of three growth rings per cm width in cross-section should be present.

2.2.3 Naturally occurring characteristics

- Knots, checks, cracks, splits and shakes
- Slope/steepness of grain
- Closeness of grain
- Moisture content
- Sapwood
Table 1: Following are some market rates of timber available in market

<table>
<thead>
<tr>
<th>Sr No.</th>
<th>Type of Wood / Timber</th>
<th>Rate per Cubic Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Siliguri sal</td>
<td>Rs. 650/- to 700/-</td>
</tr>
<tr>
<td>2</td>
<td>Malaysia sal</td>
<td>Rs. 600/- to 650/-</td>
</tr>
<tr>
<td>3</td>
<td>1st class teak</td>
<td>Rs. 1800/- to 2000/-</td>
</tr>
<tr>
<td>4</td>
<td>2nd class teak</td>
<td>Rs. 1200/- to 1500/-</td>
</tr>
<tr>
<td>5</td>
<td>Gamari</td>
<td>Rs. 650/- to 700/-</td>
</tr>
</tbody>
</table>

Table 2: Rate analysis for 1.5 m x 0.9m teak wood window with two fully panel shutter of 40mm thick

<table>
<thead>
<tr>
<th>SL No</th>
<th>Particular</th>
<th>NO.</th>
<th>Length</th>
<th>Breadth</th>
<th>Thickness</th>
<th>Qty</th>
<th>RATE</th>
<th>Unit</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Teak wood in window frame</td>
<td>1</td>
<td>4.8</td>
<td>0.1</td>
<td>0.075</td>
<td>0.036</td>
<td>44143.34</td>
<td>cum</td>
<td>1589.16</td>
</tr>
<tr>
<td></td>
<td>Fully panned double shutter (40mm)</td>
<td>1</td>
<td>1.374</td>
<td>0.774</td>
<td>1.06</td>
<td>1.06</td>
<td>1883</td>
<td>sqm</td>
<td>2002.53</td>
</tr>
<tr>
<td></td>
<td>Butt hinges</td>
<td>4</td>
<td>4</td>
<td></td>
<td>30</td>
<td>Each</td>
<td>120</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Handle 10cm</td>
<td>2</td>
<td>2</td>
<td></td>
<td>45</td>
<td>Each</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tower bolt 25cm (top)</td>
<td>2</td>
<td>2</td>
<td></td>
<td>20</td>
<td>Each</td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tower bolt 10cm (bottom)</td>
<td>2</td>
<td>2</td>
<td></td>
<td>20</td>
<td>Each</td>
<td>40</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## 3. Powder coated aluminum windows

### 3.1 Introduction

Aluminum is now widely used as the first choice for the construction of Aluminum Doors & Windows, Ventilators and Front Wall Glazing at all major construction sites such as Hotels, Offices, Complexes, Auditoriums, Hospitals, Show rooms etc. Aluminum Ladders are widely used for domestic as well as in industrial purposes and is also used for various outdoor services such as street light, multistoried buildings, industrial sheds, loco sheds and auditorium’s maintenance.

### 3.2 Specification

<table>
<thead>
<tr>
<th>Hook s</th>
<th>2</th>
<th>15</th>
<th>Each</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hold fast (6&quot;0)</td>
<td>4</td>
<td>20</td>
<td>Each</td>
<td>80</td>
</tr>
</tbody>
</table>

Total material cost (A) = Rs 3991.69

### B Labour

<table>
<thead>
<tr>
<th>Labour</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpenter</td>
<td>1.75</td>
<td>1.75</td>
<td>250</td>
<td>Each</td>
</tr>
<tr>
<td>Helper</td>
<td>0.5</td>
<td>0.5</td>
<td>150</td>
<td>Each</td>
</tr>
</tbody>
</table>

Total labour cost (B) = Rs 512.5

### C Sudries or contingency and T.& P. etc

1% of total (A + B) = Rs 45.04

### D Profit and overhead

10% of the total (A + B + C) = Rs 454.92

Grand Total = Rs 5004.15
3.2.1 Codes and Standards

The codes and standards generally applicable to the work of this section are listed herein under:

- IS: 733 Wrought aluminum and aluminum alloy bars, rods and sections (for general engineering purpose).
- IS: 1285 Wrought aluminum and aluminum alloy extruded round tube and hollow sections (for general engineering purpose).
- IS: 1362 Dimension for screw thread for general purpose.
- IS: 1761 transparent sheet glass for glazing and framing purposes.
- IS: 1948 Aluminum doors, window and ventilators.
- IS: 1949 Aluminum windows for industrial buildings.
- IS: 7088 Recommended practice for anodizing aluminum and its alloys.

3.3 Materials

Aluminum alloy used in the manufacture of extruded door and window sections shall correspond to IS designation HE9-WP of IS: 733. Aluminum alloy hollow section and coupling sections used shall conform to IS designation HV9-WP of IS: 1285. They shall conform to dimensions shown in Fig. 5 to IS: 1948 unless otherwise specified in the drawings. Screw threads of machine screws used in the manufacture of aluminum doors, window and ventilators shall conform to IS: 1362. Other threads may be used if permitted by the Engineer.

3.4 Fabrication

3.4.1 Frames

Frames of aluminum doors and windows shall be of profile and dimensions as shown in the drawings. Frames shall be square and flat, the corners of the frames being fabricated to a true right angle. Both the fixed and opening frames shall be fabricated out of sections which have been cut of length, mitered and welded at the corners. Where hollow sections are used with welded joints, argon-arc welding or flash-butt welding shall be employed (gas welding or blazing shall not be done). Sub-dividing bars of units shall be tenoned and reverted into the frame. Fabricate aluminum frames to allow for clearances and shim spacing around perimeter of assemblies to enable installation into prepared openings. Provide anchorage devices to securely and solidly attach the frame assembly in place. Accurately and rigidly fit together joints and corners, match components ensuring continuity of line and design. Ensure joints and connections are flush, hair-line and weather-proof. Provide drain routes and outlets to exterior for moisture entering joints and connections occurring within the frame construction.

3.4.2 Shutters

Shutter thickness and dimensions of vertical stiles, head and sill shall be as shown in the drawings. Unless otherwise specified, the hinges shall be of anodized aluminum alloy and
shall normally be of projecting type. Slot shall be cut in the fixed frame and the hinges inserted inside and may be riveted to the frame. The fins for hinges shall be of stainless steel of non magnetic type of aluminum alloy HR-30 anodized and shall be sealed with oil, wax of lanolin.

3.4.3 Fittings

Handles, peg stays, tower bolts, locking device, hinges and pivots, floor springs, automatic door operators shall be of the design and make approved by the Engineer. Door leaf shall be equipped with adjustable mechanism located in top rail near lock style that will provide for minor clear adjustments after installation. Snap of (Clip on) anodized /powder coated aluminum beadings and glazing clips shall be provided as per design and size approved by the Engineer.

3.4.4 Finish

After fabrication, any fabrication oil, scratches and tool marks shall be removed leaving the surface free from discoloration, blemishes and defects. Aluminum surfaces shall first be given a medium matte finish by caustic soda etching or by mechanical methods. All aluminum glazing shall be anodized conforming to IS: 7088 to the light fast shade approved by the Engineer. A thick layer of clean transparent lacquer based on methacrylates or cellulose butyrate shall be applied to all aluminum glazing to protect the surface during installation. The lacquer coating shall be removed after the installation is completed. The unit assemblies shall be anodized/powder coated finish. Anodizing shall be minimum 15 microns thick of mat texture, non-directional and non-specular. Anodized surfaces shall be suitably protected during transportation, storage and erection. Powder coating if specified shall be not less than 50 Micron.

3.4.5 Receiving and stacking

Fabricated aluminum frames and members shall be individually wrapped and delivered at site in crates. The contractors shall receive and unload the same at site with utmost care. The crates shall be opened and the materials carefully examined by the Engineer to detect any damage. Damaged materials shall be immediately removed from the site. Materials found to be acceptable on inspections shall be repacked in crates and stored safely in a vertical position above ground in a dry area. During the unpacking and repacking operations the contractor shall take all precautions to ensure that the protective coating of the fabricated materials is not damaged at all.

3.4.6 Glazing

The glass panes shall be of the type and thickness specified in the item. Their sizes shall be as shown in the drawings. The glass panes shall be of quality and make approved by the Engineer. They shall have properly squared corners and straight edges. Damaged or defective glass shall be replaced with new glass at no additional cost. Each piece of glass shall be delivered with factory labels intact, indicating glass type, quality and thickness. Labels shall not be removed until installation has been accepted. Glazing gasket channels and beads of P.V.C. or rubber must be furnished by the door and window manufacturer to fit their frames.
Setting block shall be of neoprene of rubber width and high enough to provide minimum edges clearance for glass. Protect glass from breakages immediately upon installation by applying suitable warning markings.

3.4.7 Weather proofing

Frame at door perimeter shall be fitted with non-porous polymeric weather stripping and door bottom shall have an adjustable elastomeric weather-strip. Weather strips shall not bind or prevent door from closing easily and tightly with weather tight contact between metal. Alternatively gaps between frames and supports as well as any gap in the various sections shall be raked out as directed and filled with mastic cement of approved make and colour to ensure complete water tightness. The mastic cement shall be of such colour and composition so that it would not stain the supports and shall receive paint without bleeding. Moreover, it shall not sag or run and shall not set hard or dry out under any weather conditions.

3.4.8 Final clearing

Protective coating and warning markings shall remain undisturbed until final acceptance. Immediately prior to final inspection, temporary protective covering or coating shall be removed and surfaces shall be washed with a suitable thinner and left in a finished condition having approved uniform appearance and free from all marks and blemishes.

3.4.9 Advantages

1. Air tightness : A well designated aluminum window is perfectly airtight and sealed for dust and rain water, when closed
2. Appearance : The finished aluminum is generally smooth , having bright finish which is highly amenable to further finishing as demanded by application
3. Ease in fabrication and assembly : As aluminum is comparatively soft and ductile metal, the fabrication of window can easily carried out
4. Handling and transportation cost : As aluminum window are very light , the handling and trans portion cost is very low
5. High corrosion resistance : The aluminum window has excellent corrosion resistance and it can resist weathering condition very well
6. High reflectivity : It does not absorb radiant heat and low absorption helps in maintaining the surrounding area cool during summer and warm in winter
7. High scrape value : The scrap value of aluminum window is very high and as it hardly deteriorates , it enjoy high

3.4.10 Disadvantages

1. Aluminum window will oxidate.
2. This oxidation appears as white residue and pitting
3. Aluminum can corrode quickly if suitable precautions against electrolysis are not taken
4. Welding of Aluminum requires specialized equipment and training compared to standard welding of steel
4. UPVC windows

4.1 Introduction

PVC (Polyvinyl Chloride Vinyl) is one of the three major thermoplastics- Polypropylene (PP), Polyethylene (PE) and PVC being manufactured and used across the globe. Globally, around 60% (~21 million metric tons) of PVC finds its way into infrastructure in the form of Water/SWR/ Plumbing/Drainage Pipes, Window & Door Profiles, Pre-fab Housing, Portal Cabins, False Ceilings, Wires & Cables, Floorings, Sidings & Claddings, Dockings, Fencing, Cable Trays & Channels, etc. thereby earning the sobriquet of “Infrastructure Plastic”. To make PVC useful for various applications, additives such as thermal stabilizers, lubricants, processing aids, colorants, UV stabilizers, Plasticizers, fillers, etc. are added to it before processing to ensure good mechanical properties and weatherability. Due to this process, called “Compounding”, PVC becomes a highly versatile plastic making its processing possible for the rigidest of products (unplasticised PVC, i.e. UPVC) to the softest (FPVC)

4.2 Why UPVC Windows?

UPVC Windows are widely used across the globe, from the deserts of Arizona to the coldest parts of Scandinavia/Russia, from the hot environs of Gulf to the tropics of Malaysia, Thailand as well as very extensively in China, S. Korea, Taiwan, and many more Geographies. In fact Europe and North America predominantly use only UPVC Windows in their residential constructions, for both new and replacement. This is due to their good aesthetics, durability, noise proofness, low maintenance requirement, best air & water tightness, and their ability to provide excellent thermal insulation, thereby helping save air-conditioning power costs in homes, offices and commercial centers. UPVC Windows come with a very high-quality surface finish, soft-contoured profiles and a variety of styles to meet the needs of the most demanding architects, designers and users. The environmental benefit of using UPVC Windows instead of wood and metal windows is phenomenal. Due to their ability to conserve energy throughout their life-time (from raw-material stage to in-use stage), UPVC Windows are recognized as Green Windows thereby scoring over traditional wood and metal windows. UPVC Windows are the best fit for all weather conditions prevalent across India - from salty humid corrosive air of coastal areas to sub-zero temperatures of Ladakh to heavy rains of Cherrapunji to the hot dust storms of Central India to the cyclonic gale winds of Orissa coast to the extremely hot deserts of Thar in Rajasthan.

4.3 Advantages

- Do not allow rains to come in due to their double gasketting and water drainage design - Ideal for rainy and coastal locations
- Do not let outside heat in (and vice-versa in cold climate) thereby providing inhabitant comfort & saving heating/cooling energy to the extent of 20-25% due to insulating multi-chambered profile and air-tight sealing design
- Provide Sound & Dust insulation , reducing noise to the extent of 20-30 decibels thereby providing user comfort – Ideal for Schools, Colleges, Canteens & Messes, Hospitals , Community Centers, etc
• Do not Rust, Corrode, Rot or Swell, are Termite proof, need no Painting
• Design flexibility and versatility - Any shape, form and size can be made; can be customized Stylish, elegant and aesthetically pleasing - Available in a choice of colours, printed patterns, laminates and colour-coordinated grilles (white is the best suited colour for Indian weather conditions)

4.4 Disadvantage

• Replacement cost is high.
• The process that is required to make UPVCs is highly toxic and this in turn leads to toxic by-products.
• Problem related to UPVC windows disposal at the end of their useful life.
• UPVC windows discolor by the action of weather, so periodic painting is required
• Very bad weather or severe extremes of weather can cause cracking, expanding or warping to your double glazing.

4.5 Sizes available

It is available all sizes from 300mm to 2400mm as per requirements.

5. Case study

Name of Project – Resident Colony, RC-4,
Near IIM, Rau, Agra Bombay road,
Indore, MP.
Type of Project - Residential Apartment, GF+5.

5.1 Introduction

Aluminium powder coated windows were used for a residential building G+5 floor at various locations, such as kitchen, bed rooms, hall and ventilators for toilets blocks. The aluminum sliding window were made up of Z section of various sizes, 1500mm X1200mm – three track, 1200mm X1200mm two tracks, 1100mm X 1000 mm – two tracks and ventilator glazed of size 700mm X 900mm. The glazed windows were having the float glass thickness of 5mm with aluminum frame. All frames were fixed with 50 mm long screws to the wall. The rates for glazed window was Rs 180/- per sqft for two tracks and 205/- per sqft for three tracks windows and Rs 155/- per sqft for ventilators. The properties and rates were then compared with wooden windows and UPVC windows and the same is mentioned below.
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Properties of window</th>
<th>UPVC window</th>
<th>Aluminium window</th>
<th>Wooden window</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Energy Consumption</td>
<td>Low Embodied energy, Low energy consumption during extrusion</td>
<td>Low Energy consumption similar to PVC</td>
<td>High Embodied energy, 7.5 times high energy consumption during extrusion</td>
</tr>
<tr>
<td>2</td>
<td>Convenience in Installation</td>
<td>Easy</td>
<td>Fair</td>
<td>Fair</td>
</tr>
<tr>
<td>3</td>
<td>Usage</td>
<td>Never</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Does heat or cold transmit through the material</td>
<td>Only if kept dry</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Is it cool all year?</td>
<td>Only if kept dry</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>6</td>
<td>Will it require painting or other maintainace</td>
<td>Yes- if scratched</td>
<td>Yes- if scratched</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Will scratches show as a different colour under the paint</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Does soap and water cleaning make material look new again</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>Aesthetics</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>10</td>
<td>Waste Disposal</td>
<td>Up to 99% after separation from Hardware and reinforcement</td>
<td>Recycling difficult as profiles are treated with paint, silicon and various protection coatings</td>
<td>Separation of aluminum and plastic parts difficult</td>
</tr>
<tr>
<td>11</td>
<td>Life Time</td>
<td>50-100 years. PVC windows are in market since 50 years</td>
<td>Have to be painted &amp; maintained</td>
<td>40 Years with adequate surface coatings</td>
</tr>
<tr>
<td>12</td>
<td>Cost Per sqft</td>
<td>Rs. 500/- to 700/- for fixed and Rs 800 to 900 for sliding</td>
<td>Rs 150/- to 300/- per sqft as per no. of track, size and thickness and type(sliding or fixed window) of aluminum section.</td>
<td>Rs. 300 – 400/- sq.ft.</td>
</tr>
</tbody>
</table>
6. Conclusion

The aluminum window is best suited for construction, as it has low cost, easily available & can de molded in any shape & size. Also it has high degree of elegance and good appearance when powder coated. It is light in weight & having high scrap value as compared to wooden and UPVC windows

7. References


