

Aluminium Composite Panel as a Facade Material

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Abstract- The purpose of the study is to understand every aspect of aluminium composite panels in terms of manufacturing, life cycle, sustainability, properties, its usage in construction of buildings. The study also describes the experiments which are performed to understand the usage of aluminium composite panels with other building material i.e. marble sheets.

Keywords — aluminium composite panels, facade, elevation, cladding

I. INTRODUCTION

Aluminium Composite Panels are sandwiched panels which have layers of aluminium sheets with the polyethylene core. It is used in the exterior as well as in the interior of the buildings. The main purpose of this cladding is to enhance any dead wall or to provide aesthetics to the elevation of the building. Aluminium composite panels are available in different colours, different sizes and different shapes. Aluminium composite panels can be utilized in every type of building. Hence, mainly used in commercial complexes and corporate buildings. Aluminium composite panels are available in various types; there are matte finish, plain finish, wooden finish, marble finish and many more. These panels are used in different requirements. Aluminium composite panels are also used with other building materials such as glass. There are many building which have aesthetic facades in which aluminium composite panels are used with glass. The iconic building Burj Al Arab in Dubai also has cladding of aluminium composite panel with combination with glass in its elevation.

II. WHAT IS ALUMINIUM AND ALUMINIUM COMPOSITE PANEL

A. ALUMINIUM- Aluminium is a silvery-white metal; it is the 13th element in the periodic table. It is the most commonly used metal on Earth and also makes up more than 8% of the Earth's core layer. It also ranks third most common chemical element found on our planet after oxygen and silicon. Aluminium is not found in pure state in the environment it always combine with other elements to form alloys. Most commonly found is aluminium sulphate.

Another aluminium ore, bauxite, is also utilized as the primary raw material in aluminium production. It is a clay mineral comprising different

mixtures of aluminium hydroxide mixed with iron, silicon, titanium, sulphur, gallium, chromium, vanadium oxides, as well as sulphuric calcium, iron and magnesium carbonates. Due to the texture and colour of bauxite hundreds of years ago aluminium was often considered as the silver which is obtained from the aluminium. On the average 4-5 tonnes of bauxite are required to produce 1 tonne of aluminium.

B. ALUMINIUM COMPOSITE PANELS-

Aluminium composite panels are prefabricated panels which consist of two aluminium sheet with 3mm of polyethylene core. The thickness of aluminium sheets are 0.5mm therefore total thickness of the panel comes out to be 4mm which varies accordingly. The exterior panel of the aluminium panel i.e. aluminium sheet is coated with PVDF.

The standard sizes used for aluminium composite panels are 3mm, 4mm and 6mm, depending upon the thicknesses for polyethylene and aluminium sheets available. Aluminium composite panels are mainly used in facades of the buildings. They are used externally as well as internally in a building.

III. HISTORY OF ALUMINIUM AND ALUMINIUM COMPOSITE PANELS

A. HISTORY OF ALUMINIUM- Aluminium is a very new metal in human applications which was extracted in the year 1854 for the very first time. Later in 1886, the precious metal was used commercially. The first application of aluminium in buildings was done in 1898, when the dome of San Gioacchino's church in Rome was covered in aluminium sheets. Back in 1931, Empire State Building in New York was the first building to use aluminium components as stunning art decor.

B. HISTORY OF ALUMINIUM COMPOSITE PANEL- For the first time in 1969, aluminium composite panels were introduced by the company ALUSINGEN as a joint invention with BASF. Alusingen was bought by Alusuisse which was then acquired by the giant multinational company ALCAN in 2000(today Rio Tinto). Alusingen patented the process of Alucobond for 20 years which was between 1971 and 1991. Upon the expiry of the patent several players like ALCOA (brand reynobond), ETEM (brand etalbond), MITSUBISHI

(brand alpolic) entered in the field. This is the reason why the product became more commercialized as well as economically more efficient.

Along with curtain wall and glass Aluminium Composite Panel materials have dominated the façade industry and now there are many modern cities which are entirely built with only and only these materials.



Figure 1: one of the first projects with aluminium composite panels

IV. LIFE CYCLE OF ALUMINIUM COMPOSITE PANEL

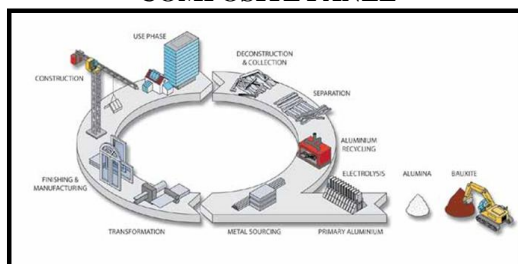


Figure 1: life cycle of aluminium composite panels

A. METAL SOURCING-As the energy is required for recycling the aluminium about 5% of it is needed for primary productions, the ecological benefits of metal can be observed. Bauxite, the ore from which primary aluminium is produced, originates mainly from Australia, Brazil, west Bengal and West Indies and other tropical and subtropical regions also. Primary aluminium is obtained from the electrolysis of alumina (oxide of aluminium) which is extracted from bauxite.

B. TRANSFORMATION- Aluminium flat products are mostly obtained from rolling process that turns the aluminium into various thicknesses. The process begins with hot rolling process, passing the block back and forth through a reducing roller. And the final rolling is done through cold rolling process, in which the thickness of the sheet is reduced to 0.15mm to 0.007mm. These sheets can then be used for making cladding panels and many more.

C. FINISHING - Aluminium is one of the metals that can be left into its natural state without finishing.

So it gets naturally oxidize when exposed to air and a thin layer of oxide then fully protects the aluminium foil form further oxidation.

Anodizing is an electrochemical process to reinforce the natural oxide film on aluminium surface. It provides a silvery matt surface finish and coloured metallic surface can also be obtained by sealing metallic dyes into the anodized layer.

Composite panels constitute an important application of coil-coated sheets, i.e. a sandwich of two aluminium sheets bonded in a polyethylene core. **D. USE PHASE-**aluminium is highly utilized in buildings for the reason of low maintenance and energy efficiency.

Aluminium composite panel is mainly used in exterior as well as interior of the building. It is also used in corporate identity designs.

- Exterior use (as façade treatment)- IT parks, shopping malls, any commercial and office, residential building, renovation of old building
- Interior use- ceiling, false half ceiling, wardrobes, table tops, doors, internal wall coverings, kitchens, partition walls
- Corporate-signage, outdoor display, totems, stall designs, billboards, canopies, kiosks, fascia, wall advertising panels, indoor display pillars, column

E. RECYCLING-aluminium scrap can be repeatedly recycled without any loss of value or properties. The energy required is a mere fraction of that is needed for primary production, often as little as 5%. Many a times aluminium is found in combination with other materials such as plastics and steels which are required to be separated from aluminium before being molten, shredded followed by eddy currents and sink float separation.

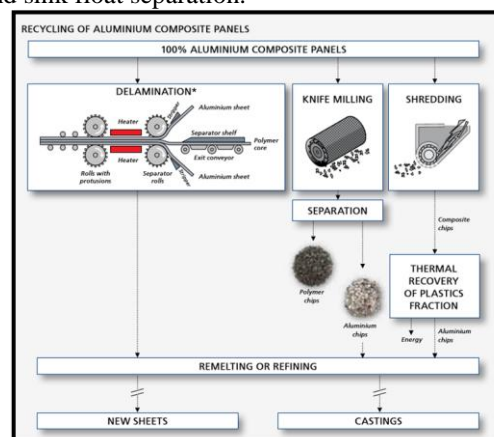


Figure 2: recycling of aluminium composite panels

V. COMPOSITION OF ALUMINIUM COMPOSITE PANEL

Aluminium composite panels consist of skins of aluminium sheets, which are coated with PVDF paint, bonded to a polyethylene core.

There are mainly three technologies for processing of these panels- coextrusion, lamination with pre made adhesive films and extrusion lamination.

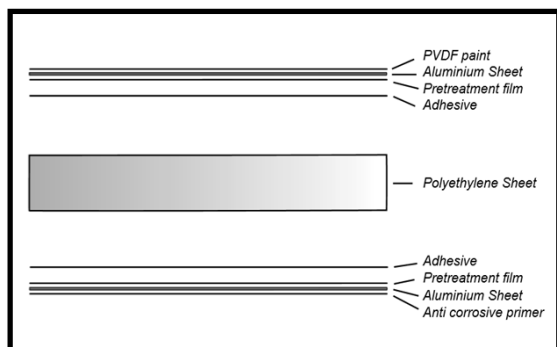


Figure 3: Composition of aluminium composite panels

VI. CHARACTERISTICS OF ALUMINIUM COMPOSITE PANELS

- Aluminium panel alloy offers increased corrosion resistance and advantages in processing
- The super polyester lacquer guarantees ideal printing properties, for screens as well as digital printing
- The black PE core with UV blocker increases UV resistance.
- Despite of its light weight, aluminium composite panel offers high rigidity and perfect flatness, also within thin sheets.
- Provides excellent exterior stability within a large range of temperatures from -50 to +80°C

VII. PROPERTIES OF ALUMINIUM COMPOSITE PANELS

A. PHYSICAL PROPERTIES

item	unit	thickness			standard
		mM	mm	mm	
density	g/cm ³	.52	.37	.22	
weight	Kg/m ²	.55	.48	.34	
Thermal expansion(-20-600)	10-6/0c	2	4	5	ASTM D696
Thermal conductivity (appearance)	w/m.k		.15-0.1		ASTM C518
Temperature of thermal deformation	0C		13		ASTM D648
Acoustic deformation	dB	4	6	7	ASTM E413

Figure 4 : Physical Properties

B. MECHANICAL PROPERTIES

item	unit	thickness			standard
		3mm	4mm	6mm	
Tensile strength	Mpa	45.8	48.0	8.2	ASTM D638
Yield strength	Mpa	43.4	44.2	0.4	ASTM D638
Extension rate	%	12	14	7	ASTM D638
Transverse modules	X104Mpa	3.2	4.2	.8	ASTM D638
Impact resistant(maximum loading)	kg	1320	1670	120	ASTM D732

Figure 5 : Mechanical properties

VIII. SUSTAINABLE FEATURES OF ALUMINIUM COMPOSITE PANELS

Aluminium is a sustainable material as it is 100% recyclable, without any loss of quality. It has high durability. Aluminium Composite Panel which are used in the building has energy saving systems, air tightness, solar heating and photovoltaics.

IX. ADVANTAGES AND DISADVANTAGES

A. ADVANTAGES OF ALUMINIUM COMPOSITE PANELS-

- Excellent mechanical properties at light weight
- Weathering and chemical resistance
- Rigid and flat yet highly formable
- Significant noise and thermal insulation
- Cost effective
- Non-toxic and environment friendly
- Durable exterior coating performance
- Easily and quickly processed
- Least maintenance required

B. DISADVANTAGES OF ALUMINIUM COMPOSITE PANELS

- Prone to dent especially during harsh weather
- Waterproofing is necessary for aluminium composite panel

X. EXECUTION, INSTALLATION AND MAINTENANCE OF ALUMINIUM COMPOSITE PANEL

A. EXECUTION-

1) FIXING-

1. Adhesive and double sided tape.
2. Prefabricated cassettes fastened with rivets, bolts, screws.
3. Curtain wall type facades and shop front system.

2) PREPARATION-(cassette method)-

1. All cladding panels should be factory fabricated and assembled to the highest standard of workmanship and supervision.

2. Panels should be fabricated into cassettes complete with aluminium sub frame.
3. All mitred joints should be sealed with approved sealant.
4. Finished cassettes should be delivered to the site complete with components marking for easy identification and assembly.

3) FIXING OF CASSETTES-

1. Fasteners including concealed screws, nuts, bolts, and other items are required for connection of panel should be non magnetic stainless steel.
2. Rivets used for fastening the sub frames should be of aluminium, large flange head type with stainless steel mandrel.
3. All other fixing materials should be of aluminium or stainless steel.

4) **DRAINAGE-** Drainage system should be incorporated into external façade system. All water collected by the drainage system should be discharged at ground level in a controlled manner.

5). **EXPANSION AND CONTRACTION-** Any temperature change due to climatic conditions shall not cause harmful buckling, opening the joints, undue stress on fastening and anchor, noise of any kind or other defects.

B. INSTALLATION-

1. Defective panels including warped, bowed, dent, abraded and broken members must not be installed.
2. Any cutting, trimming, welding or brazing which would cause damage to finish, decrease the strengths or result in visual imperfection or failure in performance should not be executed during installation.
3. Supporting brackets should be designed to provide three-dimensional adjustments and accurate location of wall component.
4. All joints should be of specified widths. No two adjacent or perpendicular joints should have difference in width of more than 2.5 mm. Tolerance between adjacent panels across any joints should not exceed 1.5 mm locally.

C. MAINTENANCE-

The cleaning of the panels should be done at least once in a year. Warm water with detergent and a soft cleaning cloth, cleaning liquid with temperature higher than 40⁰ C must be used. All the cleaning agents must have a pH value between 5 and 8.

XI. PROCESSING TECHNIQUES OF ALUMINIUM COMPOSITE PANEL

A. **Sawing and Cutting-** Aluminium composite panel can be sheared easily by using a carbide tip saw. Also guillotine shears can be used. However, shearing by using guillotine shears

may cause a slight tilt at an approximate angle of 1° - 1, 5°, in the shearing process at the point of shear.

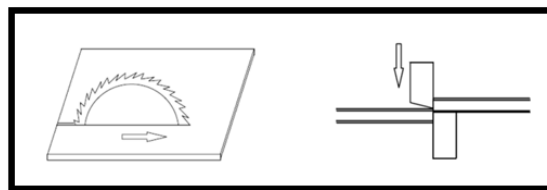


Figure 6: Shearing with saw and guillotine shears

B. **JOINTING-** First the tip should be chosen according to the folding type of jointing gaps to be opened by using the machinery. Polyethylene filling material should be left at a thickness of 0.3 mm at the point of jointing opened. 0.5 mm and thicker polyethylene cannot be folded easily. On the other hand 0.1mm and thinner polyethylene causes fracturing of aluminium, and no polyethylene at the jointing point causes the aluminium to break at the first impact.

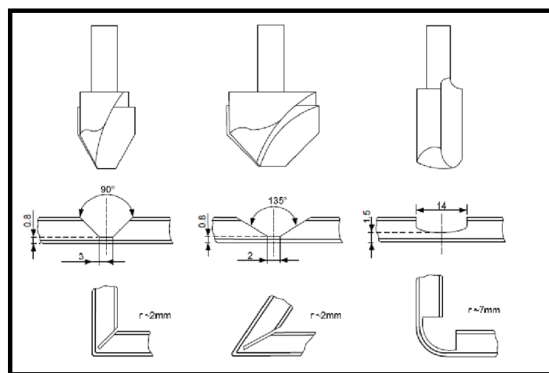


Figure 7: jointing angles

C. **BENDING PROCESS UNDER PRESSURE-** Aluminium Composite Panels can be easily bent and shaped by single roll press machine. Bending angle is determined by the mould width, roll radius, stroke force and stroke distance. Front opening of the mould must be smooth and in a specific radius.

The two ends of shaping mould must not be sharp cornered but rather rounded at a specific radius. Besides a soft buffer material can be placed to prevent crushing. The ideal mould width is calculated using the formula below. Bending radius is 40-55 mm with press and 200-300 mm with three roller machine.

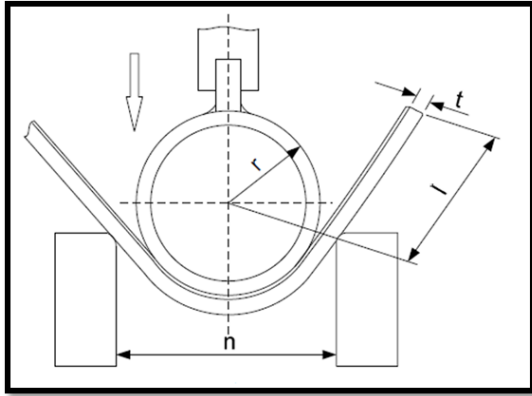


Figure 8: Press bending under pressure

D. WIND LOAD CALCULATIONS

Wind force on m^2 can be calculated if speed of wind is defined.

$$P_w = k \cdot q$$

k: Aerodynamic factor (between 1,2 and 1,6 according to height)

$$q = v^2 / 16$$

v: Speed of Wind (m/sec)

P_w : Wind Force (kg/m^2)

XII. ALUMINIUM COMPOSITE PANEL IMPROVES THE ENERGY PERFORMANCE OF BUILDING

A. ENERGY SAVING DURING THE HEATING SEASON- Aluminium ventilated cladding systems protect the outer side of insulation materials against rain, which would cause their heat-saving properties to deteriorate. Furthermore, the air gap serves as an additional retainer of warmth; ventilated façade systems make it possible to prevent considerable loss of energy.

B. ENERGY SAVING DURING THE COOLING SEASON- ventilated aluminium cladding partially reflect solar radiation and ensure natural ventilation, which reduces the amount of heat that buildings in hot weather.

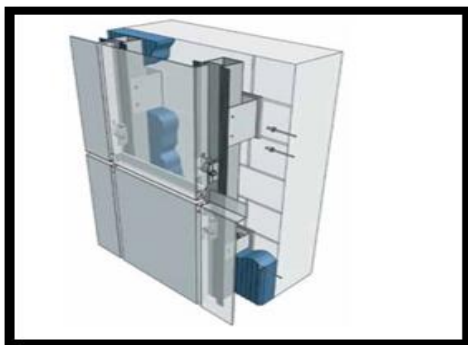


Figure 9: Ventiladed aluminium cladding

XIII. BUILDINGS CLADDED WITH ALUMINIUM COMPOSITE PANELS

A. BURJ-AL-ARAB- Dubai is well known for its distinctly extravagant architecture. The construction of the hotel started in 1990. The Burj Al Arab hotel is designed by WS ATKINS AND PARTNERS. Completed in 1999, the stunning five star hotel stands on an artificial island constructed 280m offshore.

Using custom white aluminium composite ALPOLIC panels, coated in LUMIFLON FEVE RESIN, salt and wind have had no effect on the exterior ACM.

Lumiflon feve paint resin is commonly used on bridges, boats and airplanes it creates a strong exterior coating on ALPOLIC panels. Additionally, acrylic glass is used on the exterior to withstand the water pressure.

The hotel's façade features a material called DYNEON, which is a two layered fabric covering over 160000 square feet of the structure's exterior. At night, the white fabric is illuminated with multicoloured lights, drawing further attention to the hotel's sleek design.



Figure 10: Burj-Al-Arab, Dubai

XIV. EXPERIMENTATION

Aluminium composite panels can be combined with various other materials such as glass etc. As aluminium is a light weighted material it can easily be combined with light weighted materials. The shape of aluminium can be easily changed as it can be bended easily.

The experiment done with the aluminium composite panels is to combine it with the material which is not as light as aluminium and is a very hard material i.e. marble stone sheet.

Marble stone sheets are very hard i.e. they cannot be converted into other shapes. As compared to aluminium composite it is very heavy.

The minimum thickness of the marble sheet is 30mm.

Marble sheets can be used with aluminium composite panels by following ways-

- By using tray method, marble sheets can be converted into the same shape as aluminium composite panels using in tray method.
- By achieving the required thickness of the sheet i.e. 4mm, marble sheets can be joined aluminium composite panels with the help of rivets.
- The material required for the façade treatment is-
Aluminium pipe 25×38mm
MS angle 19×19×1.5mm
Marble sheets 1200×1200×30mm
ACP sheets 1200×1200×4mm
Rivets
- The process-
 - The aluminium pipes are joined to walls with the help of MS angles with rivets.
 - Aluminium composite panels and marble sheets are connected to the aluminium pipe with the help of MS angles by riveting.
 - ACP sheets and marbles sheets are converted into C shape sheets.
 - ACP sheets are converted by making small cuts at the point of fold. Marble stone sheets are converted by making a 100 mm groove into the sheet.
 - And the sheets are connected to the pipe from both sides of the pipe.
 - ACP sheet and marbles stone are applied one after the other to the whole wall.

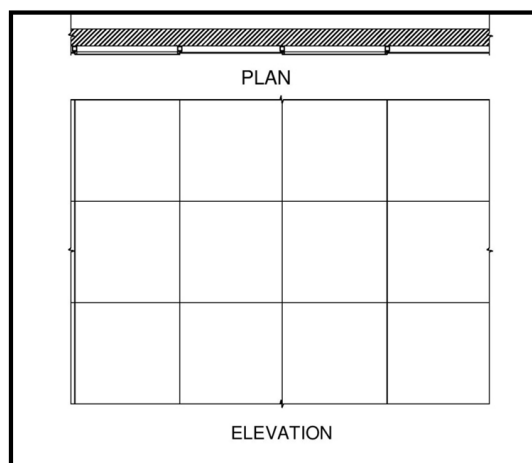


Figure 11: plan and elevation

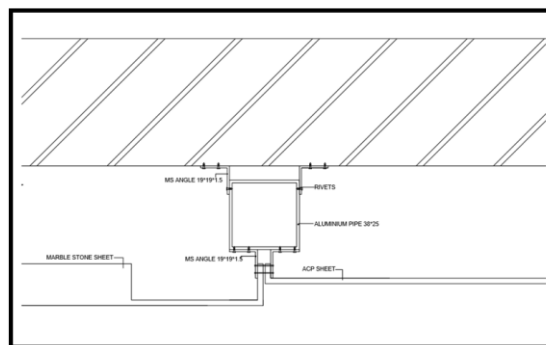


Figure 12: joinery detail

XV. CONCLUSIONS

The above study includes all aspects of aluminium composite panels which can be installed to any building façade to enhance the aesthetical appearance of the elevation of any building. Aluminium composite panels are most suitable material for the treatment of the facades of the building as it is light weighted, easy to maintain and does not increase the dead load of the building and increases the beauty of the facades as well.

Aluminium composite panels can be installed to any types of building and is very easy to install it in the facades of the elevation. It is used in the exterior as well as the interior of the building.

Aluminium composite panels are also used for the renovation of many buildings. It is very cheap material and is very economical therefore; its installation does not depend upon the scale of the building.

Aluminium composite panels can be installed in any shape as it is a flexible material.

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