

EMERGING ADVANCES IN CONSTRUCTION MATERIALS FOR BUILDING FACADE SYSTEMS

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Abstract— A building facade is the interface between interior and exterior, climate, user and environment, and above all, function and aesthetics. It is an important visible element of a building, affecting occupant comfort and energy efficiency. New advances in façade materials and technology create numerous opportunities to vary the height and performance of buildings across different parameters. Take ideas such as opening size, position and proportions and integrate new trends in building materials for façades to improve building performance. This paper aims to identify, investigate and understand emerging innovations in building materials and techniques currently used for facades. This paper discusses the methods of qualitative evaluation studies. Research methodology includes data collection, visual observations, and case studies of various contemporary trends in the development of façade materials.

(Key words): *Interface, comfort, energy.*

I. INTRODUCTION

The building façade is an interface between the interior and the exterior spaces, climate, user and environment and most importantly function and aesthetics. It is the vital visible element of a building and affects comfort and energy efficiency of occupants. It is a separation of exterior environment from interior environment. Two prime elements constitute a facade system:

- i. Building envelope element – It provides thermal, weather, acoustical, fire resistance for the structure.
- ii. Structural elements- They provide resistance to vertical and lateral actions exerted by the wind.

New trends in building materials and widespread innovative technologies have advanced façade cladding. The skin has evolved from a single-layer system to a multi-layered system that appears separate but is intricately connected. Advanced façades are constantly being improved and their suitability for different climate change scenarios must also be evaluated.

This paper discusses majorly about the advancements in development of façade materials adopted in contemporary practices.

II. Aim

Study the impact and solution of various façade building materials of commercial building.

III. Objectives

- To study the current construction materials used for building facades
- To compare the construction materials used for facades with respect to durability, aesthetics, maintenance etc.

IV. Scope and Limitation

- Study is restricted to various façade materials for commercial building only.
- Scope of study is for only Western Maharashtra region.

V. Research Methodology

This paper uses a qualitative research method. A systematic literature search was conducted via the Internet and secondary data through relevant journal articles, research papers and relevant scholarly literature. The basic concepts and backgrounds are investigated through identified literature observations of prominent construction materials used for building facades followed by derivation of parameters for comparative analysis.

VI. Importance of façade on human comfort:

A building facade is the interface between the exterior and interior of a building. Therefore, it has a great impact on the interface between occupants and the environment. The building's energy efficiency and indoor environmental quality, such as lighting and his HVAC power consumption. Peak loads to maintain good occupant lighting levels and thermal comfort. A high performance building façade system requires the selection and use of appropriate materials, advanced technology, excellent detailing and installation, all of which must be suitable for the situation and function.

Aesthetics, thermal comfort, quality of daylight, visual connection with the external environment, acoustic performance, energy performance, etc. This system has received a lot of attention in research and development. This offers a wide range of products and technologies for realizing high performance systems.

VII. Emerging trends in construction materials for building facades

Building Facade is the physical interface between, interior & exterior of a building is responsible for comfort of indoor environment. It blends both advances in materials technologies, and enhances with some intelligent contents interacts with the exterior environment. This paper deals with a study in new material and technologies adopted for building facades. Case studies have been conducted to learn various approaches for their use and how they have been used in contemporary practices.

Identified materials have been summarized as follows.

1. Aluminium Composite Cladding Panels

Aluminium Composite Panel or ACP is a new material that is increasingly in demand in the construction industry. This material offers builders and architects expanded possibilities in terms of diverse application possibilities. Aspects of the ACP sheet façade are as follow:



Fig 1: ACP façade used for commercial building, Pune

- A. **Durability:** ACP façade panels are weather and stain resistant and extremely durable. The panels retain their color, shape and size when exposed to sunlight and weather changes, making them ideal for all seasons. It also has a soundproof effect, allowing sounds from the outside environment to escape.
- B. **Budget:** Aluminum Composite Panel is one of the most cost-effective and economical materials on the market. Their ready availability and long service life make them the best solution for commercial operations. According to experts, ACP panels feature high-quality thermal comfort, which reduces energy consumption and, as a result, lowers your electricity bill. Available in a variety of shapes and sizes to minimize waste.
- C. **Installation:** ACP Facade Panels are easy and hassle-free to assemble.
- D. **Maintenance:**

ACP façade panels require little to no maintenance and retain their form and texture over time. A simple wipe with a cloth can remove surface dirt and dust particles.

2. Self-cleaning glass

Vehicular exhaust & industrial emissions emit Nitrogen dioxide to the cities thus causing respiratory problems & damage to buildings. Normally facades are cleaned twice a year using traditional means. These methods provide a temporary solution & building surfaces become unsightly. Frequency of Re-cleaning he increases eventually due to deteriorating effects of U V rays. Based upon type of coating used it is divided into two categories

- Hydrophobic: It cleans itself by rolling droplets
- Hydrophilic: It cleans sheeting water that carries away dirt.
- Titanium dioxide based Hydrophilic coating chemically breaks down and absorbed dirt in sunlight.

The thin layer of photo catalyst on the surface of self-cleaning glass consists of chemical compounds that accelerate chemical reactions when exposed to sunlight.

- This glass self-cleaning process is a two-step process.
- Photo catalytic stage – When exposed to light, glass breaks down organic dust particles.
- Hydrophilic phase - when rain washes loose particles from the glass.
- This improves the cleanliness of the glass and reduces maintenance costs.



Fig 2:Self-cleaning glass façade used for commercial building, Pune

Aspects:

Durability:

Self-cleaning action is apparent even in the absence of rain, and is according to the manufacturers, expected to be apparent for 25-30 years. In comparison, the user-finished do-it-yourself hydrophobic self-cleaning glazing products covered has life expectancy of 3-4 years. However applying the hydrophobic coating, its sturdiness can be increased as much as as an awful lot as 10 years.

Budget: Self-cleaning windows cost about 20% more than standard glazing. Therefore, it is worth reviewing your budget and considering the total cost of installing self-cleaning windows and other self-cleaning glass. The overall price of a self-cleaning team can be much higher than regular glazing that is regularly cleaned by a professional team.

Installation: ACP Facade Panels are easy and hassle-free to assemble.

A. Maintenance:

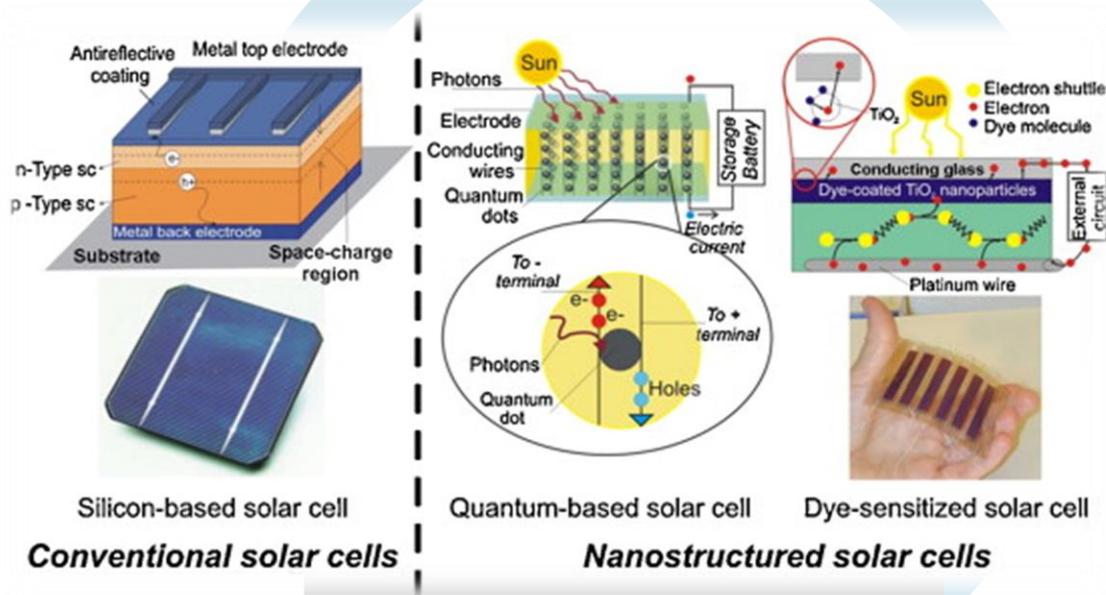
Save a good sized quantity on constructing maintenance, in particular for the glazing located at height, in regions complicated to reach (office homes, swimming pools, and many others.) or maybe situation to heavy pollution (commercial place, urban area, and many others.). The cleaning time is strongly reduced. The first-class of herbal lights, the classy and the visibility are greatly progressed for the users of the constructing or the housing. The vision is clearer within the rain because of the hydrophilic feature and discount of outside condensation. So we restriction the consumption in phrases of artificial lighting fixtures. it works on all sorts of glazing (vertical, ceiling, sloping) and on almost all styles of technical glass (tempered, laminated, double glazing, sun and thermal safety, tinted, and so on). This combination with different function lets in the patron to gain from main ecological support systems (tax credit, premium strength, and many others.). That is an actual benefit from an ecological factor of view: much less use of harmful detergents for the surroundings (supplied that the solution has no effect at the surroundings in its constitution). The price of the greater fee of a tumbler with self-cleansing function is round 15 to 25% of the original glass rate.

3. Nano materials and solar Nano technology.

Nano structuring has been used to improve the efficiency of established photovoltaic (PV) technologies. Examples include improved current collection in amorphous silicon devices, plasma enhancement in dye-sensitized solar cells, and improved light trapping in crystalline silicon. Furthermore, nanotechnology could help increase the efficiency of photo conversion by exploiting the flexible band gap of nanomaterial and by controlling the directivity and photon escape probability of photovoltaic devices. I have. Core-shell nanomaterial has recently received much attention because they integrate individual components into functional systems and exhibit enhanced physical and chemical properties (such as stability, non-toxicity, dispensability, and multifunctionality).



Fig 3 : Saint-Gobain India Private Limited, Chennai



A. Durability:

Nano based solar panels, additionally known as photovoltaic or PV panels are made to last for greater than 25 years. As with maximum technology, solar panels will naturally produce much less strength over time.

B. Budget:

Nanotechnology greatly improves manufacturing processes. This improvement leads to a reduction in the manufacturing cost of the goods. Nanotechnology is therefore expected to make files as cheap as copies. For example, a computer that can make unlimited copies of files at little or no cost.

C. Installation:

Solar panels last more than 30 years and require little maintenance. Ability to live off-grid when all the electricity generated is enough for a house/building. Can be placed virtually anywhere. From fields to buildings. Use the battery to store extra energy during the night. Solar can also be used to heat water, power homes and buildings, and power automobiles. Safer than traditional electricity. No excavation is required as the solar can be installed near or at the installation site.

D. Maintenance:

Timely and regular cleaning of solar cells and PV modules. Regular maintenance of all thermal-based components. Annual maintenance of HT side equipment. Diagnostics and testing related to photovoltaic underproduction. Circuit testing and maintenance. System check related to data acquisition, etc. Remotely or onsite detect various environmental conditions affecting the PV arrays being serviced. Evaluation of components and inverters for repair or maintenance requirements.

3. Polycarbonate panels

Polycarbonates (laptop) are a set of thermoplastic polymers containing carbonate agencies of their chemical shape used in engineering, polycarbonate is a robust, difficult cloth, and a few grades are optically clean. It is simple to machine, mould and

thermoform. Because of these homes, polycarbonate has many uses. Polycarbonate is a durable cloth. High effect resistance, but low scratch resistance for that reason, polycarbonate eyeglass lenses and polycarbonate automobile outside elements are difficult-coated. The homes of polycarbonate are corresponding to those of polymethyl methacrylate (PMMA, acrylic), but polycarbonate is stronger and might resist intense temperatures for prolonged intervals of time. Warmth-handled materials are commonly completely amorphous, quite obvious to seen mild, and feature higher mild transmission than many sorts of glass.



Fig 5: Polycarbonate panels, Pune

A. Durability:

Polycarbonate is 250 times stronger than glass and virtually unbreakable. Polycarbonate's impact resistance makes it an economical choice for protection from extreme weather conditions, flying debris, or vandalism.

B. Budget:

Polycarbonate plastics share many similar properties with acrylics. The main differences are: Higher cost, up to 25% more expensive (depending on grade) Very high impact resistance, 250 times higher than glass, 30 times higher than acrylic.

C. Installation:

Qualified installer or service technician who is familiar with solar cell components and their safety procedures. These solar panel maintenance service providers handle all of your polycarbonate plastic maintenance procedures.

D. Maintenance:

Polycarbonate Roofing Sheets require very little maintenance, but should be cleaned occasionally. Note that polycarbonate is easily scratched.

5. Stainless steel panels

Stainless-steel is an iron alloy this is evidence against rust and corrosion. It incorporates as minimum 11% chromium and might incorporate factors which include carbon, different non-metals and metals for unique perfect houses. Corrosion resistance in chrome steel is provided through chromium forming a passive movie that protects the fabric and self-renovation in the presence of oxygen. Corrosion and gloss resistance is used in many packages chrome steel can be rolled into sheets, plates, bars, wires and tubes. They'll be used as constructing substances for large homes, industrial flowers (paper mills, chemical plant life, water treatment, and many others.), storage tanks and tank cars for chemical compounds and food.

Biocleanability of stainless-steel stainless steel is superior to each aluminum and copper as biocleanability is similar to glass. Its smooth potential, energy, and corrosion resistance have encouraged the use of stainless-steel in pharmaceutical and meals processing flora.



Fig 6: Stainless steel panels building, Mumbai

A. Durability:

Stainless steel is a very strong metal and can withstand all types of impacts that cause serious damage. The metal is strong and can withstand extreme heat, sub-zero temperatures, and corrosion in alkaline solutions and chlorinated environments.

B. Budget:

Aluminum for skyscrapers with glass panels. As long as the dimensions are limited, the price advantage and design freedom are unmatched. The lighter weight of this material reduces the overall structural cost of the building.

C. Installation:

Stainless steel is a lighter material than zinc and has a finer finish. It is widely used in decorative wall coverings because of this aesthetically beneficial property. Stainless steel brings unique aesthetic benefits to any structure or building. Stainless steel is a very practical material that can be easily incorporated into any architectural façade project.

D. Maintenance:

Stainless-steel is very long lasting. The metallic plate does not alternate its appearance even after many years. That is in assessment to copper, which tarnishes over the years. Stainless steel is extraordinarily proof against corrosion because of its "self-healing" houses. Whilst the metal is scratched or starts off evolved to put on away because of abrasion, it bureaucracy an invisible layer of chromium (III) oxide (Cr_2O_3 at the periodic desk) within the presence of oxygen. This thin layer protects the underlying metallic and makes the material bright, smooth and brilliant once more.

6. Fiber-reinforced plastic panels

Fiber strengthened plastic (FRP; additionally known as fiber bolstered polymer or fiber in US English) is a composite cloth made from a fiber bolstered polymer matrix. The fibers are commonly glass (for fiberglass), carbon (for carbon fiber reinforced polymers), aramid, or basalt different fibers together with paper, wooden and asbestos had been hardly ever used. Polymers are normally thermosetting epoxies, vinyl esters, or polyester plastics, but phenol-formaldehyde resins also are used. GRP is widely used within the aerospace, car, marine and creation industries.



Fig7:Fiber-reinforced plastic panels, Commercial building ,Mumbai

Durability:

Fiber Reinforced Plastic (FRP) products withstand severe impact and scratches and provide corrosion resistance in incredibly corrosive environments such as marine environments and the oil, gas and chemical industries.

Budget:

FRP has lower installation and maintenance costs, which can lower overall life cycle costs. FRP structures can last up to 75 years with little or no maintenance, significantly reducing the overall cost of construction projects and providing long-term economies of scale.

Installation: Fiberglass strengthened Plastic (FRP) merchandise are smooth to put in as they may be reduce with wellknown hand equipment and linked with screws and clips that do not require welding. FRP merchandise do not go to pot over the years, are immune to water, and may be without difficulty cleaned with a high strain washing machine.

Maintenance:

Only 10-20% the weight of reinforced concrete decks, FRP panels are lightweight yet strong enough to withstand human traffic, vehicle traffic and high static loads.

- Easy installation. FRP is lightweight and easy to install. Combined with the Composite Advantage prefabricated option, the weight of FRP makes it one of the easiest and cheapest materials to install on site. FRP is best suited for high-traffic structures.
- A non-slip surface is safer than metal or concrete, which becomes slippery when wet. FRP can be engineered to meet almost any design parameter, including custom dimensions and specific load capacities.

7. Terracotta

Terracotta is a totally flexible material for molding. portions may be shaped each by means of the "additive" approach of including pieces of clay to a developing piece and via the "subtractive" method of carving into a solid mass with a knife or similar device. Possibly the most not unusual aggregate of those is to construct a difficult form after which get rid of elements or add extra to create detail. it's miles to take the clay that has been fashioned and mold it into the desired shape. Terracotta makes use of a far easier and quicker process to create a finished product with an awful lot decrease fabric fees. The easier responsibilities of modeling generally use a restrained range of knives and wood shaping equipment, therefore giving flexible technique. info that can't be set with stone, along with drapery and costumes, can be effortlessly made with terracotta, and curtains can from time to time be made with skinny slabs of clay, making realistic results greater effortlessly completed. Reusable mold production techniques can be used to manufacture many identical components.



Fig 8: Lattice house, commercial building, Aurangabad

A. Durability:

Terracotta is a naturally resilient material, reinforced with fire and glaze. It is fire resistant, weather resistant, unaffected by temperature fluctuations and is tolerant of salty coastal air. It is also resistant to mold, bacteria, rot and insects. Terracotta can last for over 100 years with little or no maintenance. In fact, archaeologists have found terracotta figurines and structures that are thousands of years old. There is no doubt that terracotta is a strong and durable material.

B. Budget:

Ceramic plate and ceramic tube façade construction method can achieve the purpose of speeding up construction progress and reducing construction costs. The weight of the ceramic plate of the same area is half the weight of the stone, so the construction is fast and the construction time is greatly shortened.

C. Installation:

One of the highlights is the open joint with overlap. This lets in air to flow into between the cladding and insulation, minimizing the strain differential among the inside and outside of the wall cavity. Such systems can prevent notably rain from penetrating the building envelope. in the meantime, a small quantity of permeated water is discharged from the gadget to defend the building wall structure.

D. Maintenance:

This fairing requires very little maintenance. There is no need to regularly dust the surface of this panel. A 2-3 year power wash, or even longer, can restore a building's fresh, natural look. It helps save time, effort and maintenance costs.

Energy saving

Significant energy saving can be achieved. helps prevent heat absorption into the interior. By reducing heat transfer to the building, it keeps temperatures lower and reduces energy consumption.

VIII. FINDINGS

Following are the ranking done [Out of 10] according to factors reviewed given according to study and analysis.

Facades	Ratings for material facade					
	Durability	Budget	Installation	Maintenance	Thermal comfort	Total
Aluminum Composite Cladding [ACP] Panels	7	9	7	7	7	37
Self-cleaning glass	5	7	8	8	7	35
Nano materials and solar Nano technology.	7	6	7	7	8	35
Polycarbonate panels	7	5	7	8	6	37
Stainless steel panels	9	6	8	8	6	37
Fibre-reinforced plastic panels	5	7	8	8	7	35
Terracotta	8	8	7	8	10	41

Polycarbonate panels, Stainless steel panels, Terracotta, are the advisable material for façade of commercial buildings.

IX. CONCLUSION

A excessive overall performance building façade device reduces warmness gain and loss, accordingly lowering the cooling and heating load on the constructing. This protects strength in HVAC operation and improves occupant thermal comfort.

A nicely designed and established glazing façade machine permits enough sunlight hours to go into the indoors of the constructing without growing a glazing impact. This additionally facilitates shop strength by means of decreasing the usage of artificial lighting. The glazed facade device also presents residents with an out of doors view, enhancing their best of lifestyles and work. Applying self-cleansing façade solutions to the outdoors of building façade structures can lessen the frequency of cleansing. This saves water and saves protection fees.

The fusion of hermetic systems and functional, high-overall performance cladding structures presents occupants with a degree of control, improves indoor air first-rate, reduces sick constructing syndrome, and improves occupant health. , contributes to the productivity of business building residents. On this manner thermal consolation as well as aesthetics, upkeep, and many others. may be executed the use of this building material for facades of industrial building.

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