



.:TRILLIUM GROUP

SIMPLY SUSTAINABLE DESIGN SOLUTIONS

Team Members.:
Paula Damasceno
Irelis Pimentel
Nwaram-Billi Ugbo

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- Air barriers and sealants
- Attachment systems & Fire safety
- Rain penetration & Moisture control
- System Joints & Connections
- External architectural finishes & durability
- Internal options, finishes & connections to partition walls

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SIMPLY SUSTAINABLE DESIGN SOLUTIONS

FACADE CLADDING RESEARCH ASSIGNMENT

GLASS FIBER REINFORCED CONCRETE (GFRC) PANELS
PHOTOVOLTAIC (PV) FAÇADE PANELING SYSTEMS

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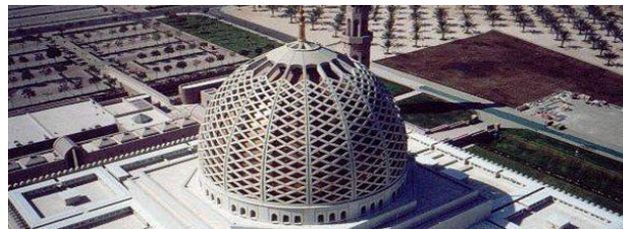
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GFRC PANELING SYSTEM OVERVIEW

- Glass fiber reinforced concrete also known as GFRC is comprised of Portland cement, acrylic co polymer, fine aggregate, water, additives and glass fibers.
- The high strength glass fiber is embedded within a cementitious matrix, wherein both the fibers and the cement maintain their physical and material integrity while the union of these two components creates new desired properties.
- Within the GFRC composite, the fibers act as the principal load carrying members and the cementitious matrix keeps the fibers in the desired position. Fibers add flexural, tensile, and impact strength and the resulting material allows the production of strong yet light weight products that may be applied in architectural and civil engineering projects.
- GFRC is mainly applied on building exteriors, or as architectural precast concrete. The properties of a GFRC paneling system is dependent on the method of production, mix design and the type and content of the alkali resistant glass fibre.



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GFRC PANELING SYSTEM

OVERVIEW

- First introduced in Russia in the 1940's GFRC gained popularity in the UK in the 1970's as it became more widely available
- GFRC ranges in price from \$2.50 to \$3.00 per square foot for ¾" thick material and from \$3.50 to \$3.75 per square foot for 1" thick material.
- GFRC can accommodate a variety of artistic embellishments including acid staining, dying, integral pigmentation, decorative aggregates, veining, etc. GFC can be polished, etched, sandblasted or stenciled. GFRC presents a world of creative options for 2D and 3-dimensional concrete elements.



Alkali resistant Fibres



Adding fibres to concrete mix

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GFRC PANELING SYSTEM

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LiTraCon ("light transmitting concrete") is a translucent concrete building material made of fine concrete embedded with 5% by weight of optical glass fibers. It was developed in 2001 by Hungarian architect Aron Losonczy working with scientists at the Technical University of Budapest.

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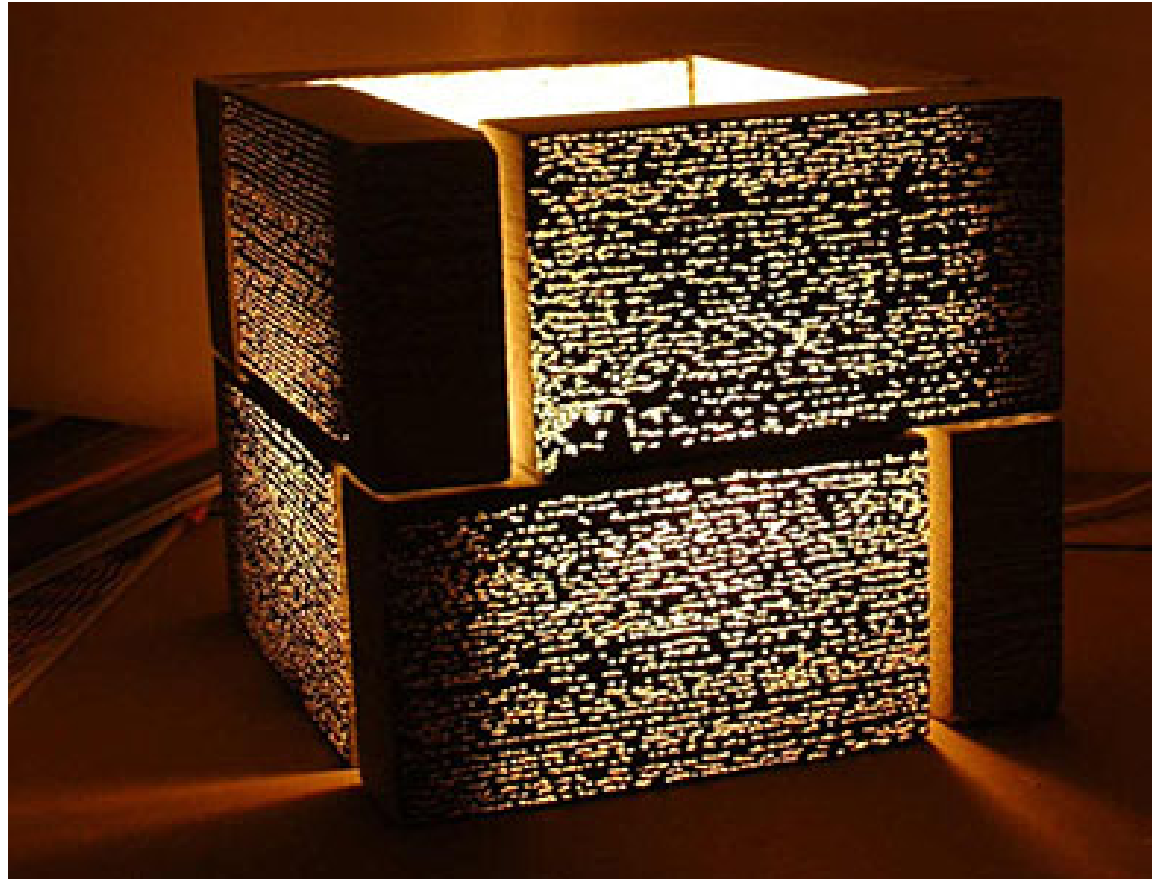
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LiTraCon

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GFRC PANELING SYSTEM OVERVIEW



Spray-up GFRC Fibers



Formtique, from London-based Formsquare, is a line of concrete panels and surfaces made from glass-fiber-reinforced concrete

Benefits of GFRC

- Design freedom and Flexibility
- Highly Durable
- Requires very little maintenance
- Installation is relatively quick and often cost effective
- Weather resistant & Fire resistant
- Energy efficient
- Economical

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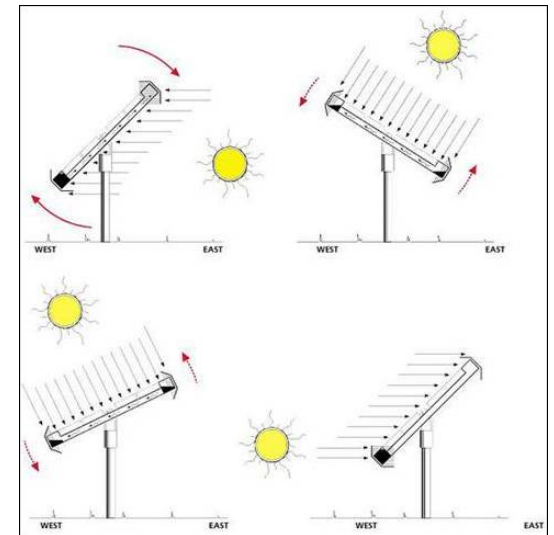
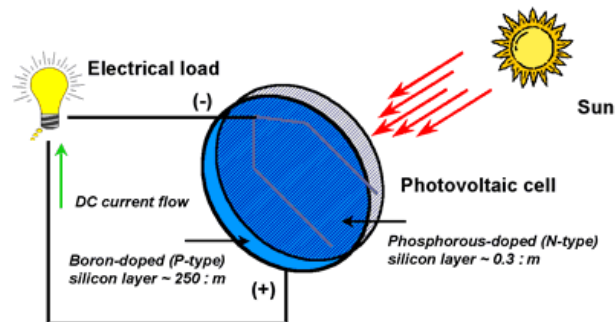
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- Photovoltaic Facades are comprised of Photovoltaic panels.
- Photovoltaics have steadily increased in popularity as a means of generating electrical power through the conversion of solar radiation into direct current electricity by using semiconductors.
- The photovoltaic effect is the creation of voltage or electric current as sunlight is incident upon a material surface.
- Photovoltaic arrays are often associated with buildings in what is often known as BIPV or Building-integrated Photovoltaics. Typically, an array is incorporated into the roof or walls of a new building or more commonly is retrofitted into existing buildings.



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GFRC PANELLING SYSTEM

Air barriers and sealants

- Typ. max. sizes of GFRC panels for simple transport and handling may range from 8' x 14' to 12' x 24'
- Joints between GFRC panels are typically filled with silicone sealant.
- Sealants have several advantages, on darker panels they may create continuity and color uniformity.
- Sealants also reduce water and vapor permeability to the panel and facilitate the removal of road dirt, hand and footprints, welding fumes or airborne contaminants deposited on the panel during transportation, handling or installation.

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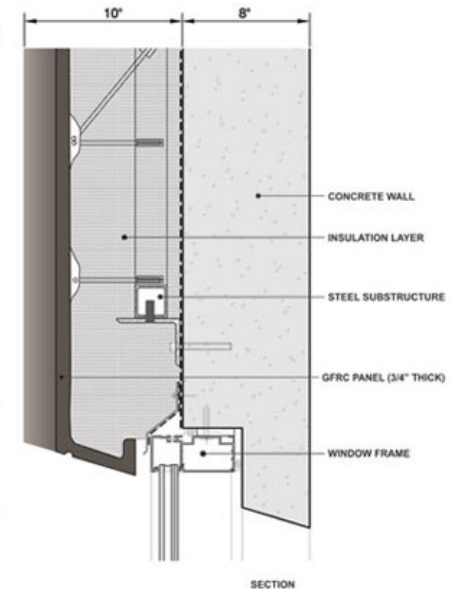
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GFRC PANELLING SYSTEM

Attachment systems & Fire safety

- GFRC is comprised of mineral components that are non-combustible and therefore offer a flame spread of 0. These non combustible panels can achieve a 2-hour fire rating with UL listed assemblies.
- Thermal insulation may be incorporated either as a lining against the interior face of a panel, or as a core between two GFRC layers.
- GFRC Panels may be attached to a metal stud frame with the use of 'flex anchors'. These rods allow for minor movements between the GFRC face of the cladding and the steel frame.



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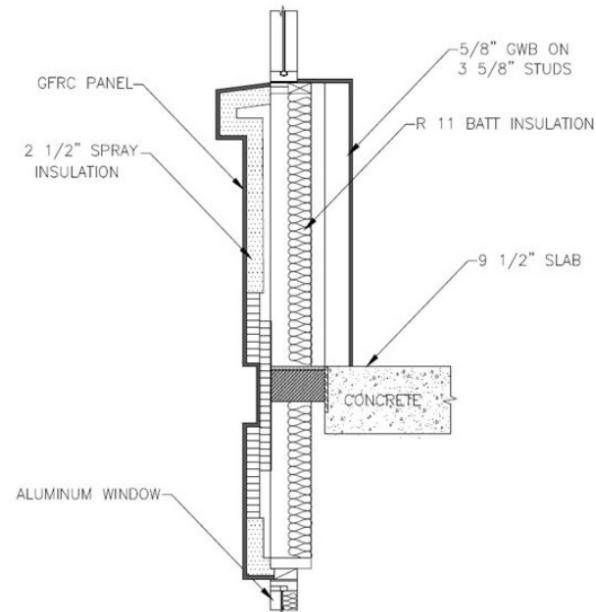
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GFRP PANELLING SYSTEM

Attachment systems & Fire safety

- Thermal insulation may be incorporated either as a lining against the interior face of a panel, or as a core between two GFRP layers.



GFRP WALL SECTION

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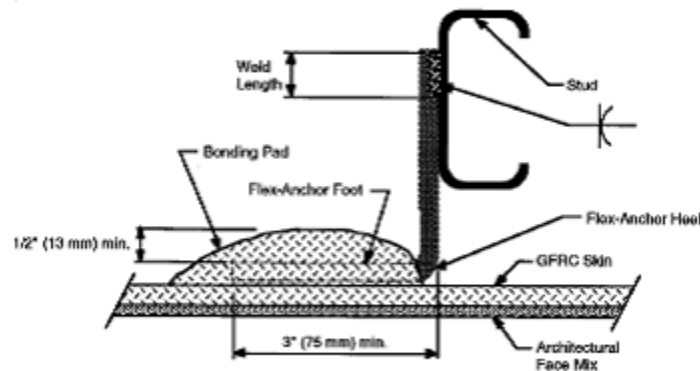
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This system consists of GFRC skin supported by light gauge, cold-formed steel studs.

The flex anchor design concept can be used to support dead loads of the façade.

Flex rods also neutralize wind loads, seismic loads, by resisting skin bending stresses.

- The connection is designed to accommodate thermal expansion in order that no buckling, opening of sealed joints, excessive stresses in panel components or other detrimental effects may occur. Panels may be attached to a metal stud frame with the use of 'flex anchors'. These rods allow for minor movements between the GFRC face of the cladding and the steel frame.
- Additionally, this system offsets any initial drying and shrinkage loads and moisture movements due to change of ambient conditions.

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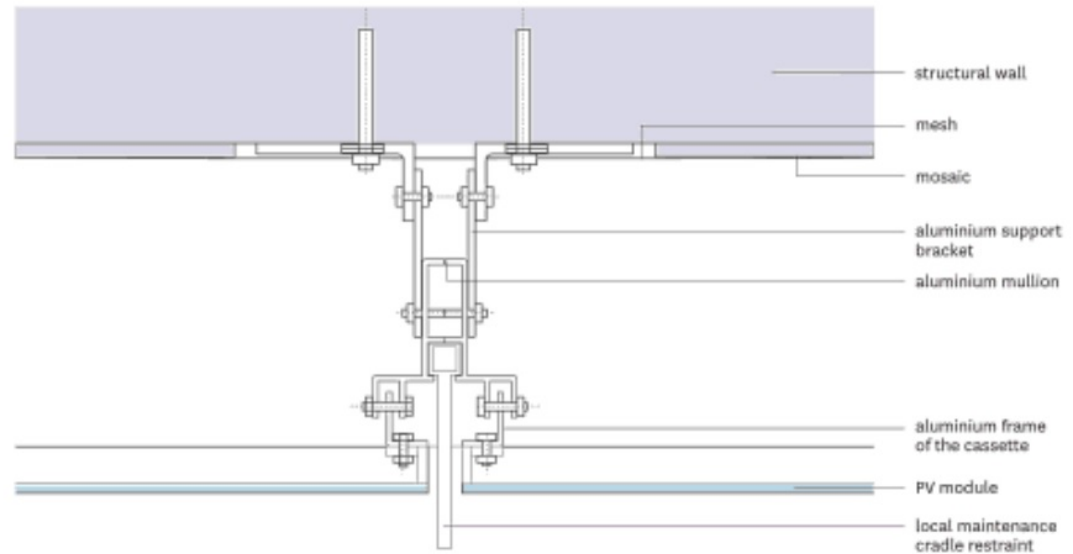
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PV FAÇADE PANELING SYSTEMS

Rain penetration & Moisture control

- Rainscreen systems represent the best opportunity for PV integration in a building.
- The rainscreen is typ. Dimensioned against the floor heights and the window spacing, the resulting grid then dictates the dimensions of the panels.
- There are two variations of the rainscreen system
 - The drained and back ventilated rainscreen
 - The pressure equalized rainscreen



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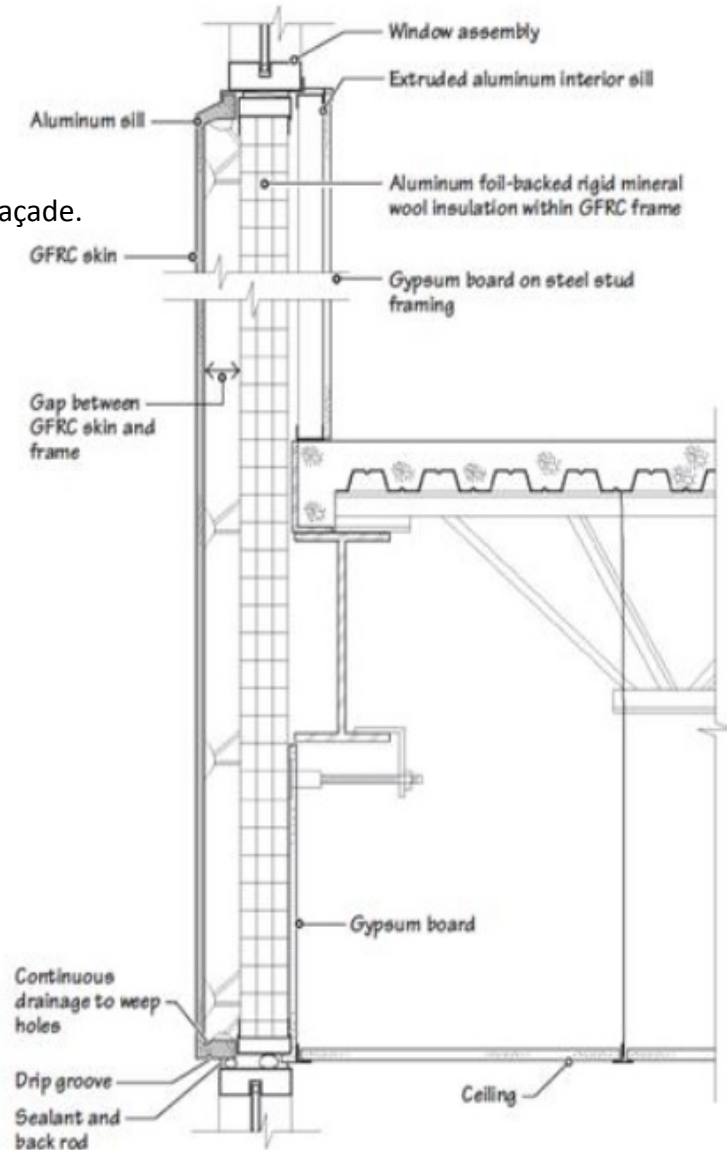
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Rain penetration & Moisture control

- An effective moisture control system for GFRC panels would incorporate some form of water drainage behind the façade.
- Condensation of water vapor between the GFRC and framing is prevented by introducing a ventilation system at the joints.
- Finally, a sealant may be used at the joints to deter water from adversely affecting the system.



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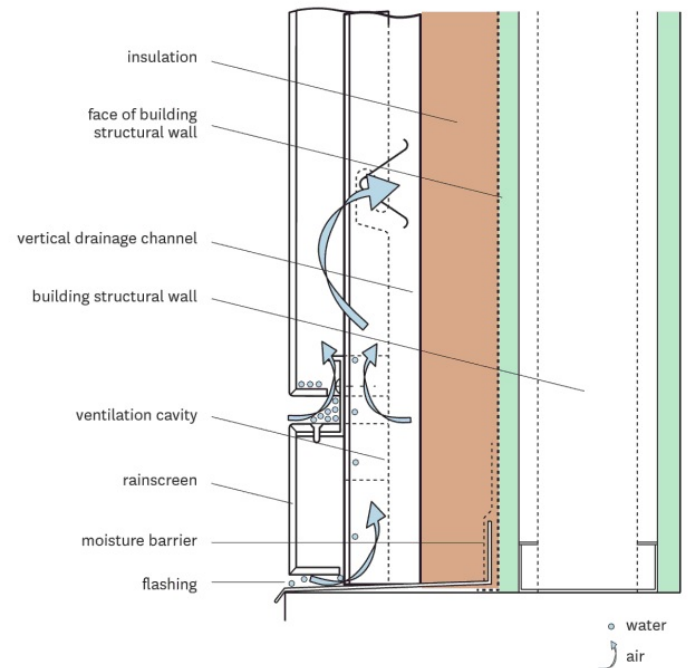
PV FAÇADE PANELING SYSTEMS

Rain penetration & Moisture control

- The difference between the two types of rainscreen systems = the amount of water allowed within each cavity.

Drained and back ventilated Rainscreen

- Within this system, no attempt is made to prevent the introduction of water through joints and relatively large quantities of rain penetrate the joints and run down the reverse side of the cladding panels. The water is allowed to drain and evaporate from the cavity.



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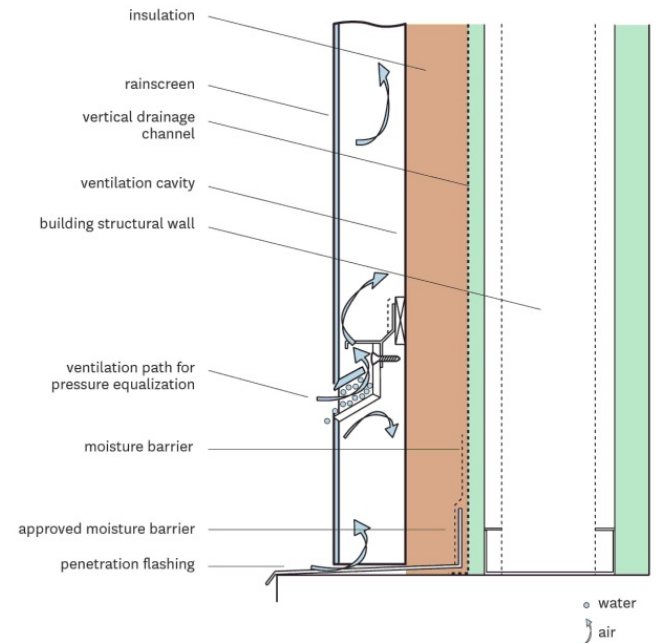
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Rain penetration & Moisture control

Pressure-equalized Rainscreen

- Within this system, water penetration is controlled by the use of baffles, compartments, drips, upstands, barriers and opening sizes in the assembly in order to equalize the pressure in the cavity with the external pressure. The result of this equalization is a reduction in the force of rain, dispersion of moisture. As in the drained and back system, positive drainage and ventilation is provided to remove water



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Rain penetration & Moisture control

- Both rainscreen systems are constructed using light weight metal panels (usually coated aluminum).
- Panels are then fixed to the primary structure using bolts, studs or specially designed cladding rails, or using a 'hook-on' system. (which would required additional mechanical fixings to lock the panels in place and prevent them from coming loose due to 'uplift')

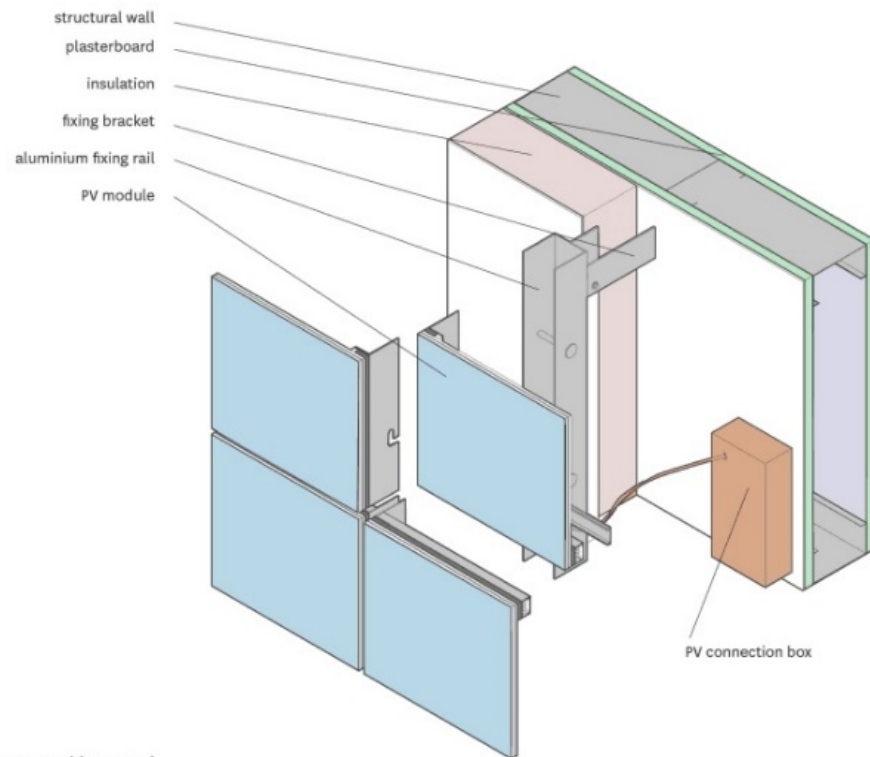


Fig. 6.4 Detail of a rainscreen panel integrated with a PV module showing electrical connections.

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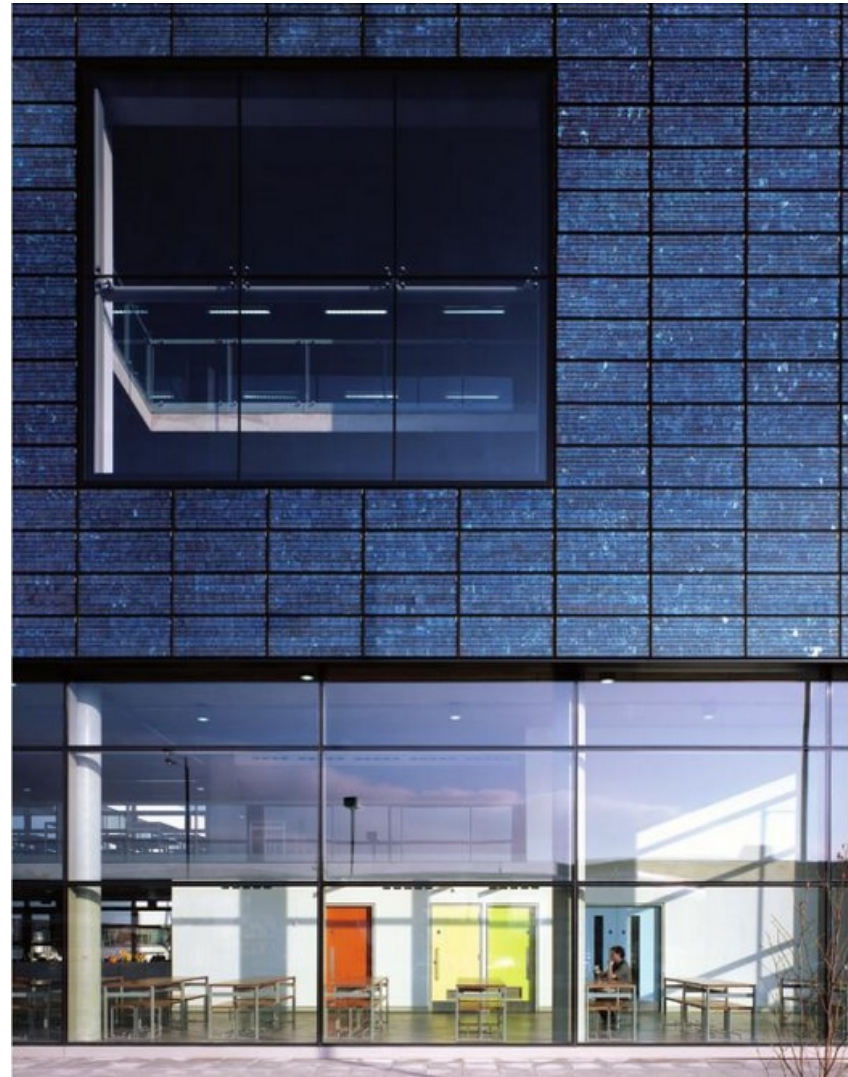
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Rain penetration & Moisture control

- The South façade of the building is clad in a monolithic array of solar PV modules.
- A total of 482 80W polycrystalline modules are used in the cladding design.

BIPV rainscreen on Manchester College of Arts & Technology. Manchester, England
Walker Simpson Architects



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GFRC PANELLING SYSTEM

System joints & Connections

- The overarching need that must be addressed within a GFRC panel system is the ability to adequately accommodate vertical and horizontal differential movements between the panels and concrete frame which may result in failure or cracking of the panels.
- This differential movement may be caused by extensive shrinkage or ‘creep’ and thermal expansion/contraction of the panels, relative to the concrete frame.
- For systems with a walled structure behind the GFRC panel, the walls are framed, sheathed and a water barrier is installed before the GFRC wall panels are erected.
- For metal framed wall cladding systems, the structural framing of the building is erected before the GFRC cladding is erected..
- GFRC Panels may be attached to a metal stud frame with the use of ‘flex anchors’. These rods allow for minor movements between the GFRC face of the cladding and the steel frame.
- On larger panels where the GFRC serves as the aesthetic face, the steel stud backup adds rigidity. At the construction site, steel frames are welded/bolted into place. The stud cavity may be used for insulation or to accommodate electrical wiring. Flex anchors are designed to flex and allow the GFRC skin to expand/contract independent of the light gauge steel frame,, to avoid cracking.

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External architectural finishes & durability

- GFRC can accommodate a variety of artistic embellishments including acid staining, dying, integral pigmentation, decorative aggregates, veining, etc. GFC can be polished, etched, sandblasted or stenciled. GFRC presents a world of creative options for 2D and 3-dimensional concrete elements.
- GFRC allows designers a wide range of freedom, from sweeping curves to intricate reliefs. The thin shell of GFRC allows for deep sections to be used for projecting cornices or window surrounds w/o impacting the structural integrity.



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GFRC PANELLING SYSTEM

Internal options, finishes & connections to partition walls

- In the implementation of detailed reliefs on interior partitions, GFRC may enable the designer to explore in greater depth, color or historical depictions as in the grand mosque in Abu Dhabi .



Sheik Zayed, Grand Mosque interior Abu Dhabi

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Paula Damasceno

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Fire Resistance

- Non-combustible
- Made of minerals (cement, aggregates, glass fibers and, in some cases mineral pigments and special polymers,) will not easily burn. *When exposed to a flame, the concrete functions as a thermal regulator protecting the materials from the heat.*

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How much does GFRP cost?



- GFRP panels are often costed by the square foot (\$/SF), on either an "FOB Job Site" (Materials only), or an "Installed" cost basis (Materials and Installation)
- The Material cost of GFRP panels will depend on a number of factors, including the project size, the size and complexity of the panels, and the repetition of different skin profile forms.
- The Installation cost of GFRP panels will vary based on the average panel size, accessibility to building connection points, building site location (NYC is more expensive than Dallas), and availability and type of cranes required.
- For a typical sand/cement GFRP panel with moderate profiling and good accessibility, we would estimate a material cost of \$30-\$35 per square foot, and an installation cost ranging from \$6 to \$15 per square foot.

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Environmental implications and sustainability

- There is no worry about this sort of material having environmental issues as GFRC is an inorganic material as well as there not being a health risk.
- The aspects of GFRC which make it a green material include its composition of natural materials such as sand, and other aggregates. Also, the inclusion of recycled content gives the design team to specify this material and garner LEED points for their projects.



Vivo City Happa Shelter - GRC Top Panel

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PHOTOVOLTAIC (PV) FAÇADE PANELING SYSTEMS



Thermal performance

- The thermal performance of insulating glazing depends mainly on the solar energy transmittance through the glazing and the reflectance of the glazing. Reflective coatings help to minimize interior solar heat gain by reflecting solar energy.
- Glass and glazing choices are instrumental to the curtain wall's thermal performance. Single glazing has poor thermal performance and is suitable only where interior and exterior temperatures do not vary substantially. If the curtain wall system comprises single-pane, non-insulating glass panels, a fair amount of heat loss/gain may take place through the curtain wall.

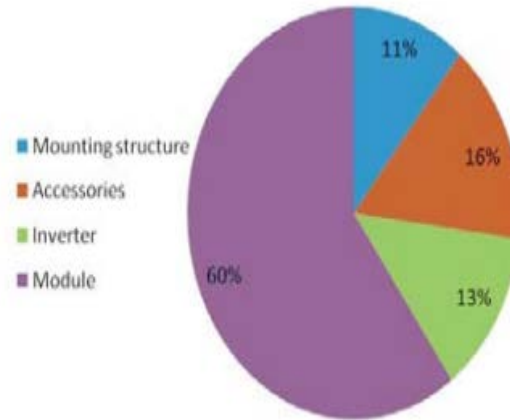
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How much will a PV system cost ?

- Costs and returns will be project specific and will largely depend on the way the building is used.
- a general rule of thumb for calculating the cost of a PV system is \$3.50 per installed watt. A 5,000 watt (5 kW) PV system costs approximately \$17,500 initially. Currently, the federal government offers a 30 percent tax credit (you have to file income tax to qualify), lowering your out-of-pocket expenses to \$12,250.



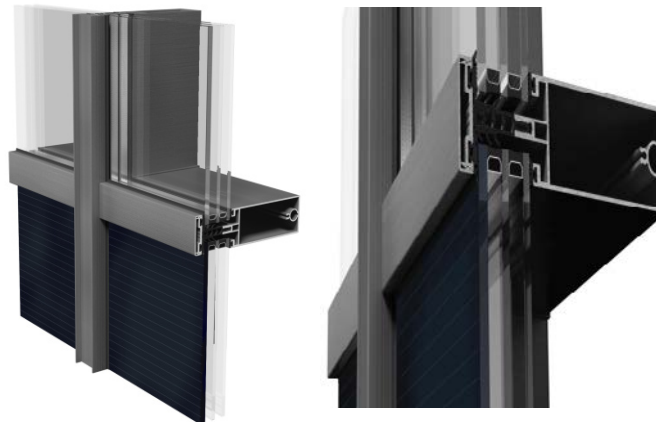
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Installation

- Installing photovoltaic panels on the roof uses available space on flat roofs. Additional modules can be added to the principal at any time. The system has special fixing accessories anti-burglar and a stable foundation and heavy concrete structure providing stability on the underlay of the roof.
- For assembly and installation of panels on flat surfaces of land use that is modular mounting panel is divided into modules which need contain 1 or 2 solar panels. You can then add other modules to existing ones. Installation is quick and easy mounting systems and due to pre-drill or preformed profiles and anti-theft system contains special sections.

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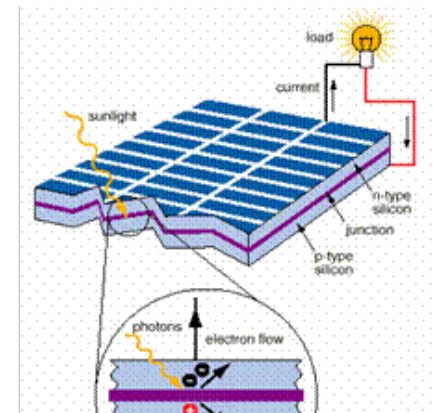
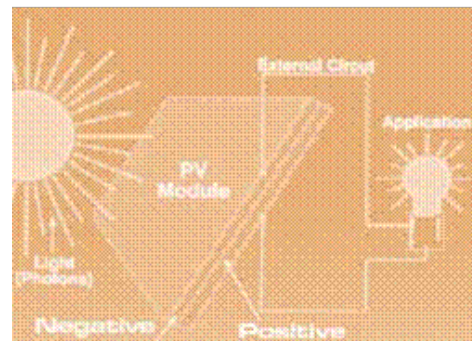
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Environmental implications and sustainability

- Photovoltaic (PV) systems provide green, renewable power by exploiting solar energy. We can use photovoltaic (PV) panels as an alternative energy source in place of electricity generated from conventional fossil fuels. Consequently, the more we use PV panels (or other renewable energy technologies) to cover for our energy needs, the more we help reduce our impact to the environment by reducing CO2 emissions into the atmosphere.



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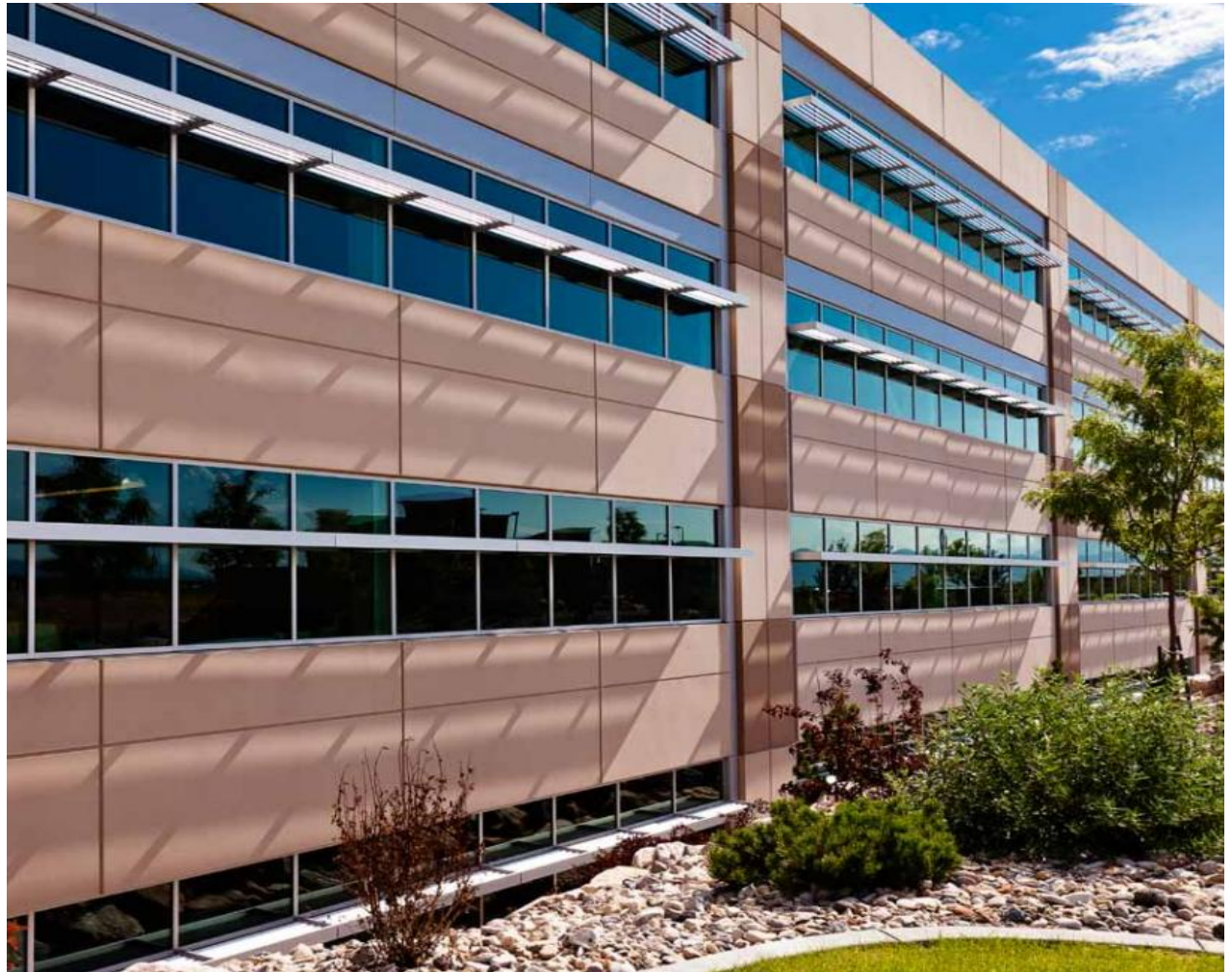
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Mountain America Credit Union Headquarters Annex

Mountain America Credit Union Headquarters Annex had decided to turn the once retail center at Jordan Landing into their new headquarters. Where architect Don Mahoney of EMA Architects LLC envisioned it as a GFRC building.

It's a 106,000 square foot headquarter in which was completed in 2002 and contained 20,780 square feet of GFRC panels. The GFRC allowed the architects the ability to play with color. Which allowed them too express a contemporary aspect that would not be able to be achieved with masonry. The color that they choose was a warm sand tone and a salmon orange color. GFRC are a thin shell panel skin with an integral steel frame. The panels are erected to the steel or concrete building frame and form the building ski. It is extremely durable ,freeze resistant and light weight . The 15-20 PFS weight of the GFRC also reduces the lateral forces due to earthquakes loads on the supporting structure.

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PV FAÇADE PANELING SYSTEMS

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GFRC vs. Curtain Wall

65% Lighter

Lower Shipping Cost

Better Insulation

Better Fireproofing

Can be cut on Site

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GFRC vs. Precast Concrete

GFRC doesn't require steel reinforcing

GFRC provides tensile strength / also gives toughness

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GFRC vs.	EIFS Panels
Advantage: Easier to install	Disadvantage: if not properly installed an sealed water can seep into building
Advantage: rapid Installations	Disadvantage: Delays project schedule that can impact cost
Advantage: Can be prefabricated	Disadvantage: Not Prefabricated
Advantage: quick easy labor	Disadvantage: labor is Intensive
Disadvantage: is slightly more expensive	Advantage: Lower initial cost
Weighs about the same	Weighs about the same

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4 Times Square NY Office Building

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4 Times Square NY Office Building

The tallest skyscraper built in New York City in the 1990s, this 48-story office tower at Broadway and 42nd Street is a somewhat unusual but impressive way to demonstrate green technologies. Kiss + Cathcart, Architects, are the designers for the building which is composed of thin-film BIPV system. The PV system was design to function as an integral part of the tower's curtain wall. This dual use makes it one of the most economical solar arrays ever installed in an urban area. As the first major commercial application of BIPV in the United States, 4 Times Square started the way to large-scale production of solar electricity at the point of greatest use. The south and east facades of the 37th through the 43rd floor were designated as the sites for the photovoltaic skin. BIPV was incorporated into the design after the tower's general appearance had already been decided upon, so the installation was made to harmonize with the established design concept.

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Photovoltaic (PV)

Advantage:

provide green renewable power by exploiting solar energy

operate autonomous without any noise generation and no moving mechanical parts

the cost is lowering due to high demand

Disadvantage:

they have a limited efficiency level compared to other energy sources

PV produces direct electric current that which must be converted to alternating current

it only delivers in direct sunlight and doesn't not store excess amounts of produced energy for later on

low voltage in PV electric current may lead to increase waste of electricity

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Sources

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