Composite Materials in Building and Construction Applications

Presented at:
ACMA's CORROSION, MINING, INFRASTRUCTURE & ARCHITECTURE CONFERENCE
May 15, 2013 - Denver, CO

Course Description

Composites have been used extensively in industries such as marine and transportation for more than 50 years. Yet in some industries composites are just now becoming a primary material of choice.

The use of composites in the building industry is growing rapidly.

Traditional benefits offered by composites are being recognized and utilized to address design limitations and can be used to reduce life cycle environmental and cost impacts.

Learning Objectives

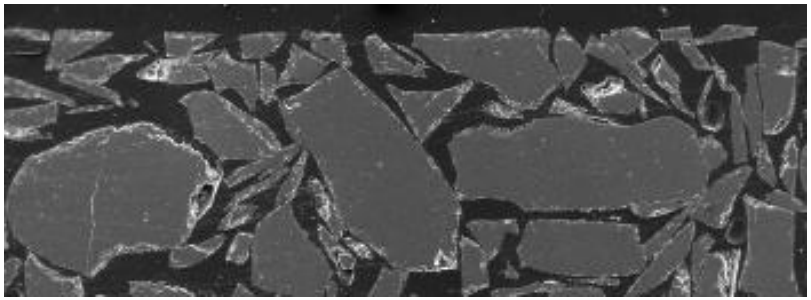
- **Define 'Composite Materials'** and learn the history of composites in multiple industries and the factors that led the growth of composites in these industries.
- **Identify the design and performance attributes** of composites used in other industries that are applicable to the building / construction market.
- **Review case studies** that demonstrate how the inherent attributes of composites such as low weight, durability and low thermal conductivity, result in environmental and cost effective material options.
- **Explore web based education tools** that offer case studies on the use of composites in construction and allow users to connect with composite fabricators that specialize in design, fabrication and installation of composite building materials.

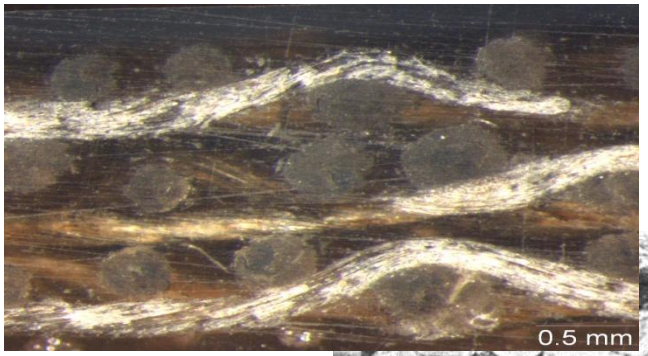
What is a Composite?

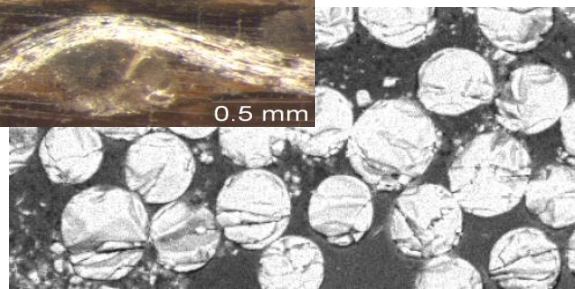
Composite

An engineered combination of materials that result in a finished material with better overall properties than the starting constituents.

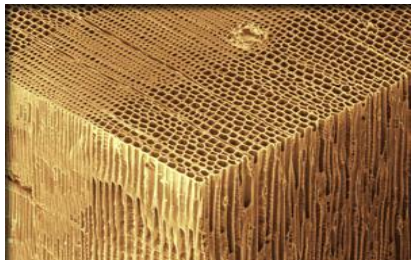
At a microscopic level, the constituent materials remain distinct within the finished structure.







“Traditional” Composites



Wood is a natural composite of cellulose fibers in a lignin matrix.

Engineered wood is wood fibers, strands or veneers bound using adhesives.

Concrete is a composite of aggregate, cement, additives and water.

Disc brake pads are composites of hard ceramic particles embedded in soft metal.

Polymer Matrix Composites

Polymer Matrix Composites

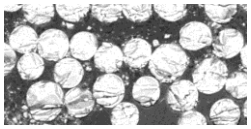
A composite made from a polymer and a reinforcing and/or particulate material

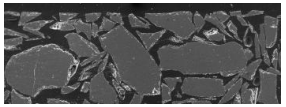
The polymer binds the reinforcement & particulate together.

Reinforcement material
- Glass fibers
- Natural fibers
- Carbon fibers

Particulate material
- Sand, talc and other fillers
- Color chips
- Recycled glass

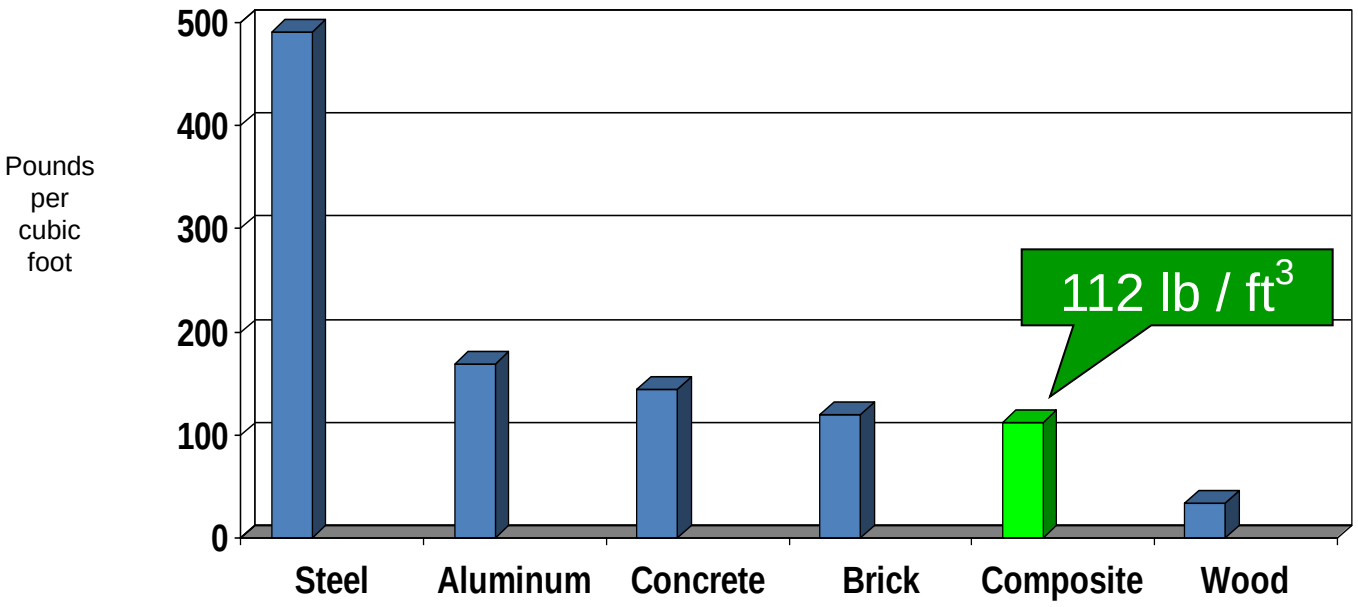
More Structural ⟷ *More Aesthetic*



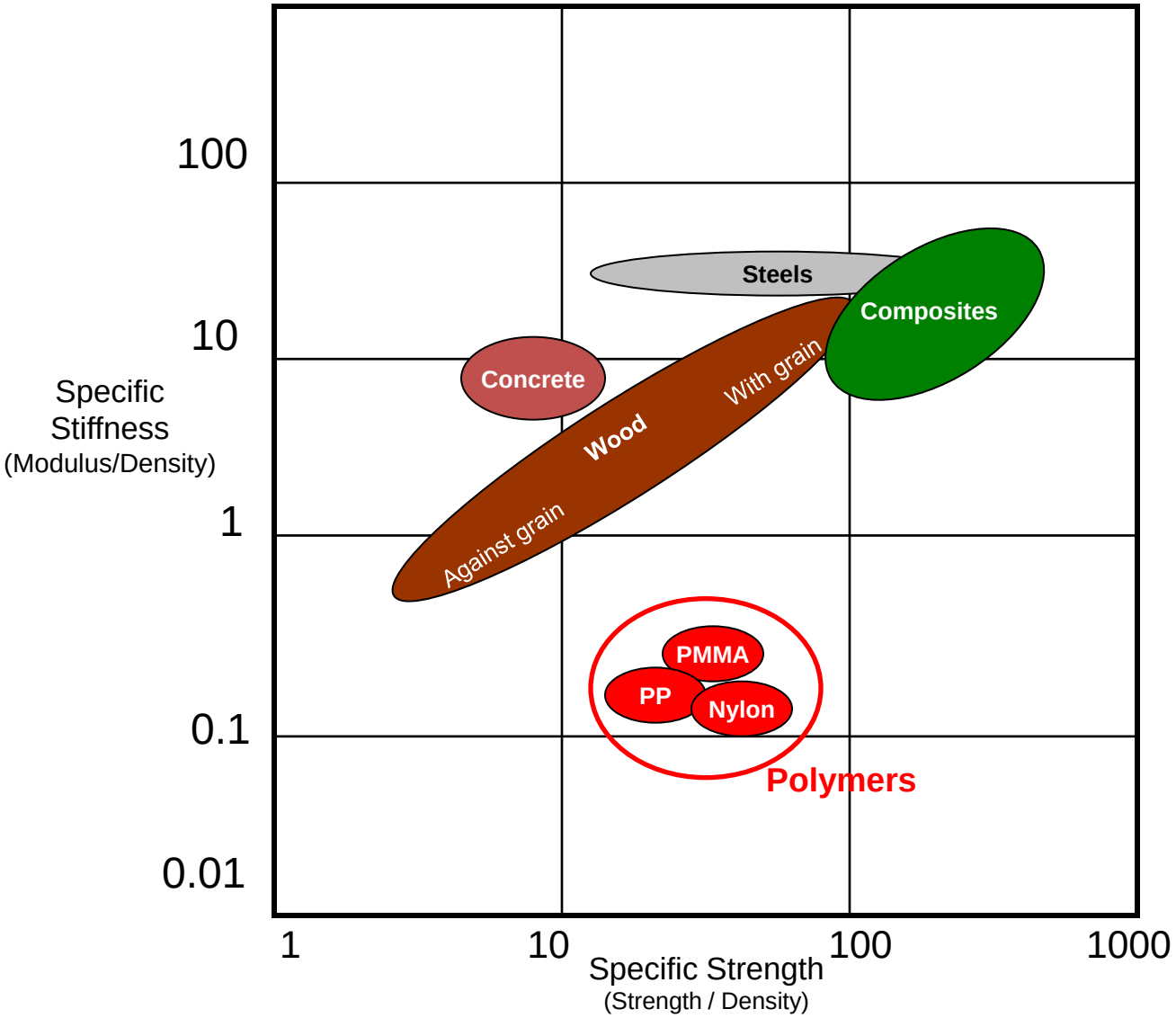


Composites Are Lightweight

Polymer matrix composites are lighter than steel, aluminum, concrete and brick.



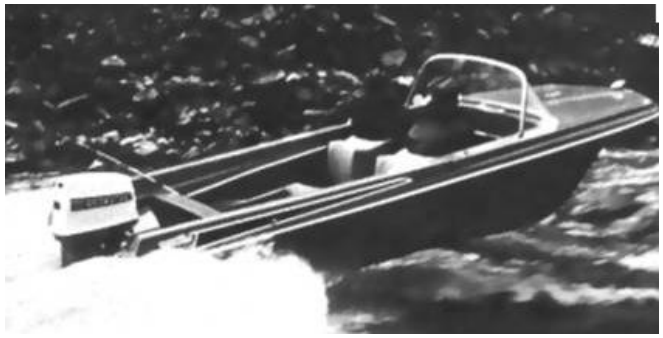
Composites Have High Strength to Weight Ratio



- Composites are lightweight materials that are strong and stiff.
- Composites are much stronger and stiffer than pure polymers.
- Relative to wood, composites are stronger and stiffer.
- Relative to concrete, composites offer superior strength.
- Composites can have specific strength & specific stiffness similar to steels.

Composites Use in Other Industries

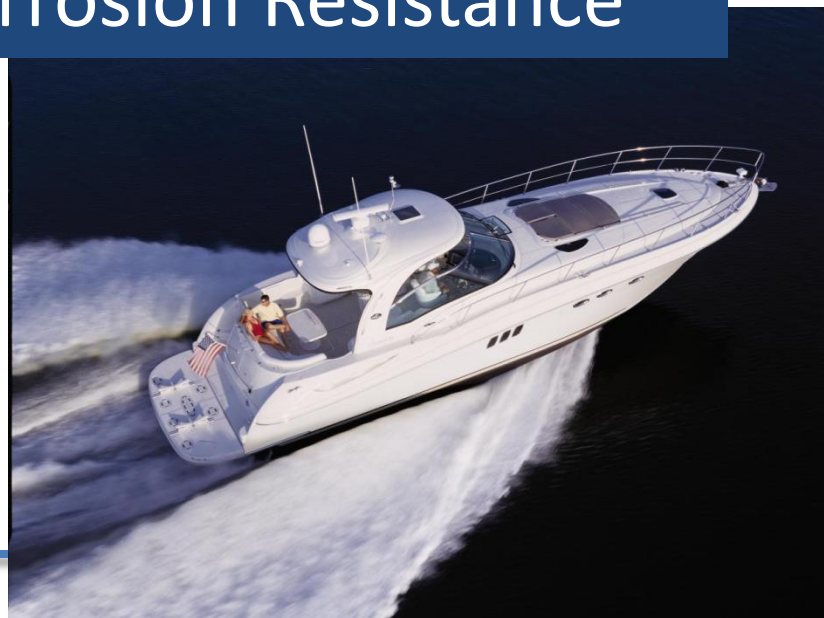
Marine Applications



- Late 1940's: First boats constructed of composites

- Durability
- Design Flexibility
- Impact Resistance
- Corrosion Resistance

- Now: >90% of hulls are composite



Automotive

- Early 1950's: First commercial car bodies

- Design Freedom
- Low Weight
- Part Consolidation
- Corrosion Resistance

- Now: Significant utilization on unique design models

Automotive

- Early 1950's: First commercial car bodies

- Corrosion Resistance
- Low Weight
- Part Consolidation
- Design Freedom

- Now: Body Panels, Valve covers, Truck beds

Heavy Truck

- Late 1960's saw first use in heavy truck

- Low Weight
- Corrosion Resistance
- High Heat
- Durability

- Now: 90%+ of heavy trucks are composite body

Heavy Truck

- Beyond Body Panels

- Low Weight
- Corrosion Resistance
- High Heat
- Durability

- Now: Low weight and high heat components

Aerospace

- Mid-1970's: Concorde was ~8% Composites

- Low Weight
- High Strength
- Design / Aerodynamics
- Sound Dampening

- Now: Boeing 787
  - 80% by volume
  - 50% by weight

Wind Energy

- 1980's
  - 15 meter diameter
  - 50 kW turbines

- High Strength
- Low Weight
- Toughness
- Corrosion Resistance

- Today
  - 150 meter diameter
  - 7.5 MW

Industrial

- Storage Tanks
- Electrical Components

- Durability
- Insulating Properties
- Corrosion Resistance

- Extending life of equipment
- Facilitate safer handling

What does all this mean for the Building & Construction Industry?

Benefits of Composites

- Extremely Durable
- Low Weight
- Impact Resistance
- Design Flexibility
- High Strength to Weight ratio
- Part Consolidation
- Corrosion Resistance
- Heat Resistance
- Toughness
- Sound Dampening
- Insulation Properties

Applicability to B&C

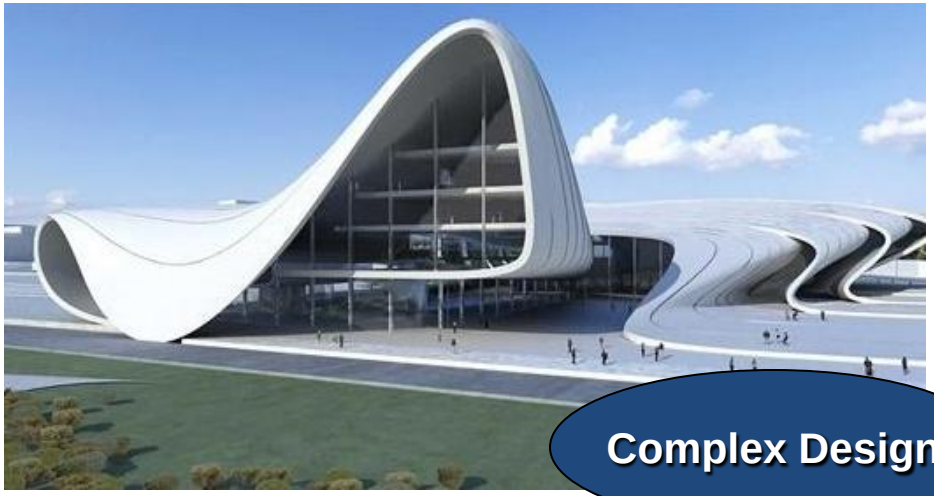
Design Flexibility

Design Flexibility

High & Goodale – Columbus, OH

Historical Replication

Courtesy: Kreysler & Associates



Complex Design

Composites Offer Flexibility in Design

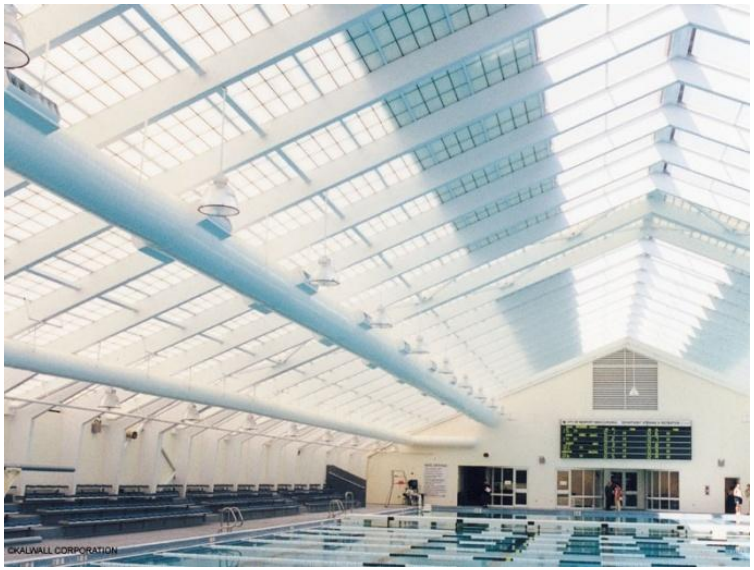
Process	Wood	Concrete	Metals	Composites
Cast		●	●	●
Laminate	●		●	●
Infuse		●		●
Continuous Panel	●		●	●
Extrude / Pultrude			●	●
Stamp / Press Mold			●	●

Applicability to B&C

Corrosion Resistance

Corrosion Resistance

- Composites offer very good corrosion resistance and find widespread use in corrosive environments.
  - Cladding for roofs & walls
  - Duct work and ventilation
  - Salt water environments
  - Seawalls, decks & railings
  - Water handling systems
  - Underground applications



Courtesy: Kalwall

Courtesy: Creative Pultrusion

Applicability to B&C

Strength to Weight

Strength to Weight

Prototype Investigation

- Replace failing masonry cladding in high rise building
- The **low weight composite** allows floor space to be added
- Uses existing building structure and foundations

Courtesy: Craft Engineering Studio

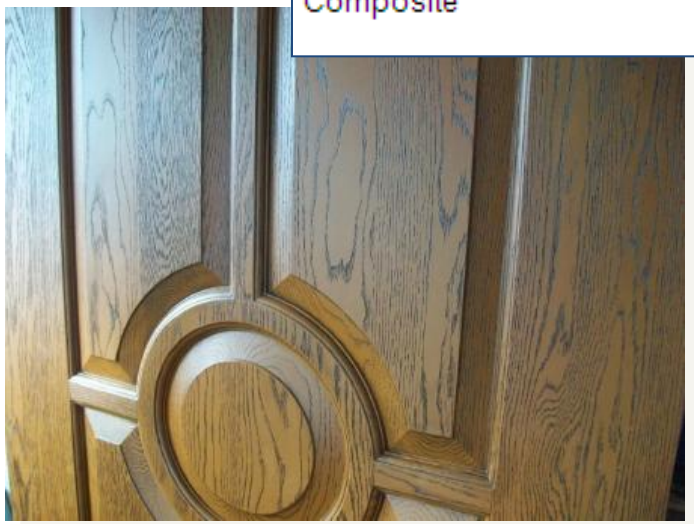
Applicability to B&C

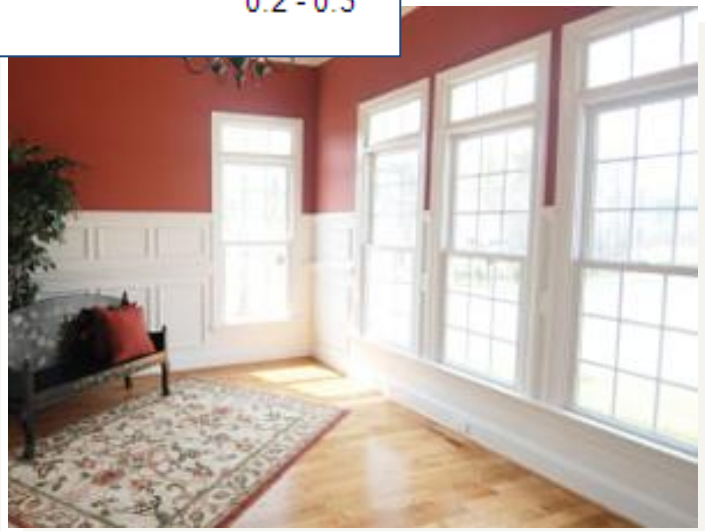
Low Thermal & Electrical Conductivity

Thermal Properties

- Composite have a very low coefficient of thermal expansion.
  - Not prone to expansion & contraction
- Composites offer low thermal conductivity

	U-Factor
Aluminum (no thermal break)	1.9 - 2.2
Aluminum (thermal break)	1.0
Aluminum clad wood/reinforced vinyl	0.4 - 0.6
Wood and vinyl	0.3 - 0.5
Composite	0.2 - 0.3





Applicability to B&C

Control of Water & Moisture

Water Exposure

Composites perform well in water exposed conditions.

- Holds water in or keeps water out!
- Does not rot, swell, rust, or spall

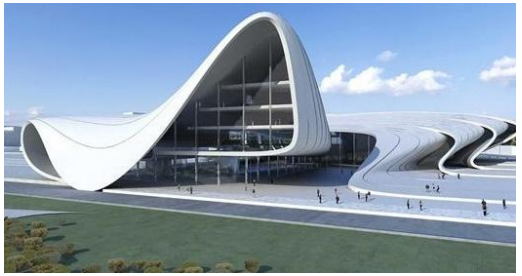
Applicability to B&C





Durability





Durability

Composites have very good environmental durability.

- Do not swell, warp, rot
- No rust or spalling
- Resistant to animals and insects




Durability

Composites are Extremely Durable

This attribute is welcome during use

Becomes challenging for end-of-life

How do Composites Support Sustainable Building Programs?

Composites & Sustainability

Alternative Energy

Government Initiatives

USDA BioPreferred℠

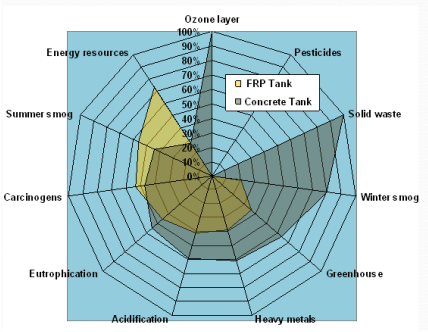
Weight Reduction

Pollution Prevention Applications

Green Building Programs

U.S. GREEN BUILDING COUNCIL MEMBER®

Life Cycle Impacts



Composites & Green Building

Can't Build the Same Way & Expect a Better Outcome

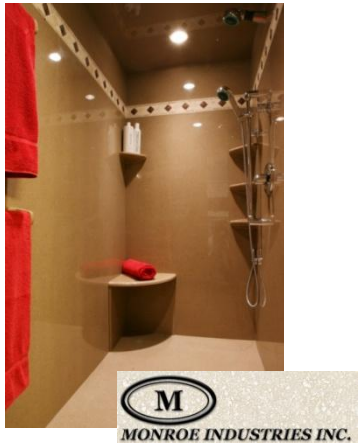
- Composites have inherent benefits that are of interest to green builders
  - Durability; Insulation; Low Weight (transportation); Re-Use
  - Can incorporate bio & recycle content
  - Can offer material reduction

Composites & Green Building

Composite fabricators are responding to the demand for more sustainable products

Recycle Content

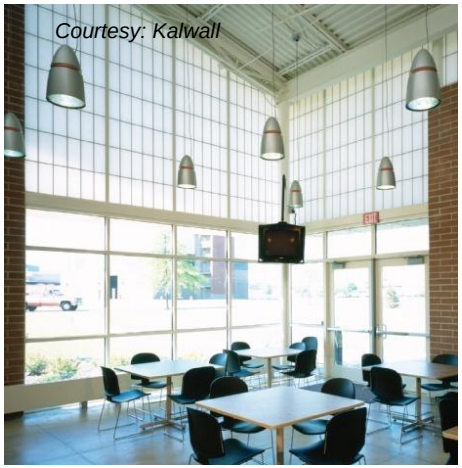
Renewable Content



Renewable &
Recycle Content

Composites & Green Building

Composites products offer functional applicability to green building programs.



Day Lighting

Storm Water Handling

Renewable Energy

How to Learn More?

CompositeBuild.com

CompositeBuild.com

- Enable the design/build community to:
  - **Learn** about the benefits of composites
  - Find **case studies** of composites used in construction
  - Easily **connect** with composite material fabricators & distributors

CompositeBuild.com

Connecting the building industry to composite materials

BE INSPIRED.

View case studies of building applications that utilized composite materials and learn why composites were the material of choice.

Sheraton Milan Malpensa

Featured Application

The use of pultruded composite panels allows a unique shape while reducing weight and maintaining a weather tight enclosure. The composite system also allowed for a reduced build schedule for the Sheraton Milan Malpensa Airport Hotel and Conference Center.

Robal Glass Surfaces

Featured Product

Design freedom is a hallmark of composite materials, as evident in the variety of shapes, colors and styles of composite surfacing materials. See how this product has incorporated more than 80% recycled glass and a bio-containing binder to produce a stunning

WHAT'S HAPPENING

Architectural Conference

Join us at CMI in Denver, CO, USA on May 15, 2013 for a conference covering composites in architectural applications. Learn More

Recent Article

Read about the use of composites in building enclosure applications as featured in Composites Technology magazine. Visit Link

Composite & Architecture Site

Visit this site to see more examples of

CompositeBuild.com

Connecting the building industry to composite materials

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COMPOSITES IN ARCHITECTURAL APPLICATIONS

Rain Screen

Building Facade

Curtain Wall

Inspirational and educational examples of composites in architectual applications.

Hotel Cladding

Choose a case study To learn more

Exterior Cladding

Composite Housing

Structual Cladding

Composite Material Case Study

A Hotel Ahead of the Curve

Application / Environment
A continuous surface that encloses a three story hotel, offices, restaurants, and conference center.

The 420 linear meters of façade incorporates bi-directional curvature into the design and allows for weather tight conditions with temperature swings as large as 70°C.

Location / Year
The Sheraton Milan Malpensa Airport Hotel and Conference Center. Complete September of 2010.

Architect
King Roselli Architetti (Rome, Italy)

Composite Design & Fabrication
Progettazione Construczione Ricerca (PCR) based in Milan, Italy.

Fabrication
The façade was constructed using a framework of pultruded FRP channel covered by a pultruded FRP skin that was curved around the framework in lengths up to 22 meters.

Technical Data
Fiberglass reinforcements were pultruded using direct roving for tensile strength and continuous strand mat for off-axis strength and impact resistance. Additional corrosion, water and fire resistance are provided through the unsaturated polyester resin binder system. The combination meets M1F0 fire ratings.

Why This Solution?
Many other material choices were considered, but pultruded composite offered the best solution package:

- Light weight, reducing structural loading
- Reduced costs and construction times
- Durability and corrosion resistance
- Weather tight through temperature extremes

CompositeBuild.com

Connecting the building industry to composite materials

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BUILDING ENVELOPE

EXTERIOR

INTERIOR

UTILITIES


Entry Doors


Exterior Cladding

Learn about a Product type


Light Panels


Skylights


Sliders and Patio Doors


Windows


Roofing


Composite Wall Systems


Structural Insulated Panels


Framing


Siding

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- BUILDING ENVELOPE
- EXTERIOR
- INTERIOR
- UTILITIES

Exterior Cladding

Composites offer design freedom that is unma… …itional building materials. Composite cladding can be tailored to meet the style desired while providing an extremely durable surface at a lower weight than most traditional materials. This reduced weight will often allow for a lower cost structural support system for new construction applications.

Identify General Material Attributes

Kreysler & Associates

Kreysler & Associates is a custom design, engineering a… …pecializing in the use of advanced manufacturing techniques to address complex construction challenges for architecture, sculpture and industrial applications.

kreysler.com — American Canyon, CA

Learn about a Company's Offering

Find Regional Suppliers

PCR

PCR is a technology innovator active in moulding, pultrusion and synthetic quartz. The company offers a wide range of products and solutions along the industry value chain, from R&D and industrial design to finished goods. PCR offerings include: R&D, engineering, mould construction, turn-key plants, components and finished products.

pcr-srl.com — Milan, Italy

Connect to a Supplier

PolyProducts

compositesandarchitecture.com

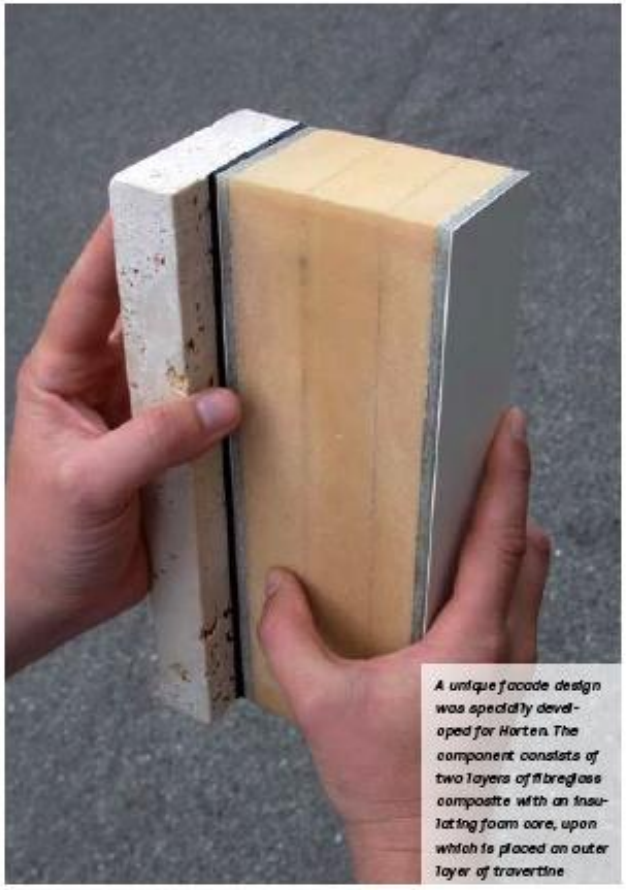
Case studies of composites in architecture

- Enable the architectural community to:
  - **Be inspired** by use of composites in applications around the world
  - **Understand** how composites can be used to address architectural challenges

Site maintained by Kreysler & Associates

COMPOSITES and ARCHITECTURE

Horten Headquarters



A unique facade design was specially developed for Horten. The component consists of two layers of fibreglass composite with an insulating foam core, upon which is placed an outer layer of travertine

New Materials

With its unique design, the facade is also unique in its material composition. To adapt to the special geometry, it was natural to design using new and innovative building materials and methods. If the same facade was to be built using traditional construction methods (ie. steel frames), it would be a challenge to build each element separately and therefore difficult to keep uniformity. By contrast, by taking the decision to build completely out of fiberglass, it becomes possible to mass produce with much fewer discrepancies amongst the various building elements.

COMPOSITES and ARCHITECTURE

Cerresco Airport Cladding

This relatively new terminal in Uruguay for this building was designed by architect **Rafael Viñoly** in the shape of a paraglider. This form, while seductive in its low lying curved profile, introduced a number of challenges due to its three axis of curvature and design suction forces of up to 1.8 kPa.

IIFC's report states "MVC's eventual solution was to cover the bottom surface with sandwich panels made of composite plates having a gelcoat finish and expanded polystyrene and polyurethane core. These were attached to the building's main structure by a secondary aluminum structure so as to allow for the correction of imperfections present in the main structure. 24,000 m² of panels were supplied and assembled, without interfering with the other activities at the construction site, over a period of 9 months." Read more **here**

Connecting Our Industries

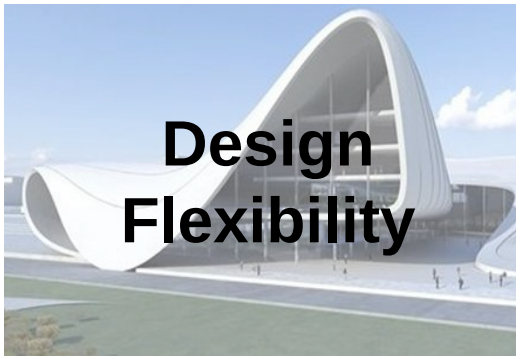
- Compositebuild.com
  - Connect design/build industry to composite products and fabricators

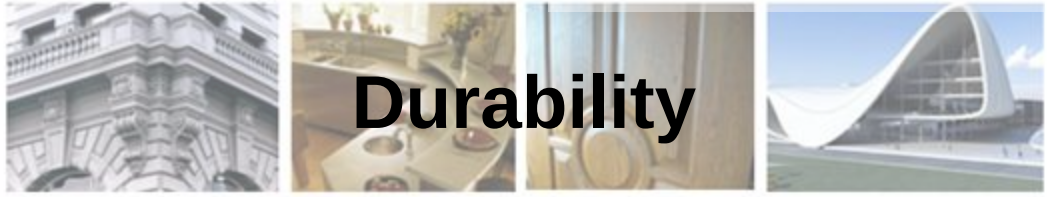
- Compositesandarchitecture.com
  - Further innovation and inspiration in the world of architecture, design, digital fabrication and composite technology

- ACMAnet.org
  - American Composite Manufacturer's Association

- ICPA-hq.org
  - International Cast Polymer Association

Composites in Architecture





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