COMPOSITES IN BUILDINGS AND CIVIL INFRASTRUCTURE

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Abstract
Composites give architects' freedom of design since complicated geometries are possible to do in composites. Low weight and great stiffness provides great benefits, smaller cranes can be used and/or bigger panels can be made. Composite parts are easy to transport and can be manufactured outside the building site, good insolation property is achieved and often no extra or minimum added insulation needed. Composites give good structural properties and it is possible to attach tiles, masonry or glass without any extra steel and concrete reinforcements. Common structural calculation software is possible to be used and the knowledge of how composite behaves is well documented. Manufacturing composites requires low energy and the lifecycle for composite is long. Very large scale structures can be built using composite materials. It is also possible to achieve a class A surface finishing.

1 Introduction
Composites in buildings and infrastructure give designers, architects and contractors many advantages compared to traditional materials such as steel and concrete.

1.1 Lightweight and Stiff
- Allows flexibility of design.
- Larger structures.
- Increased spans.
- Reduced support requirements.
- Quick installation.
- Ease of large volume transportation.

1.2 Freedom of design
- Large structures can be made in organic shapes and with modular design thanks to the self supporting sandwich composite.
- The composite can carry all kinds of façade materials such as stone, sheet metal, tiles, wood or surface left in FRP enabling excellent surface finish.
- These two in combination provide the architect with an unrivaled freedom of design.

1.3 Longevity, strong and long lasting
- Composites sandwich structures have been used in harsh environments since long, renowned for their longevity and resistance to degradation.
- The skin of the sandwich panel determines weather resistance.
- Closed cell core material resists moisture absorption, maintaining long term dimensional stability and part longevity.
- Damaged FRP Sandwich structures are easily repaired on-site.

1.4 Energy efficiency

- High R-value of core material gives inherent insulation properties.
- Reduces or eliminate need for additional insulation. Closed cell structure ensures minimum moisture absorption
- Designable with no thermal bridges

1.5 Acoustic performance

Sandwich construction is ideal in applications requiring sound **attenuation** in addition to high strength, low weight, and thermal insulation.

- Attenuation of sound caused by absorption, spreading and scattering.
- Design variables:
- Source of sound
- Path of sound
- Frequency of sound
- Panel size

1.6 Energy absorption

- A sandwich structure can take large impact loads, reducing damages at installation and use.
- Very good fatigue properties withstand cyclic loads (from passing trains, earth tremors, rotating antennas etc.).
- Crack resistant.

1.7 FST qualities

- FST requirements to meet transport standards can also meet requirements for façade cladding.
- Sandwich designs are often use in applications requiring high FST performance like trains, aircraft & ships

1.8 Sustainable

- Sandwich Composite Construction has low environmental impact:
- Low Embodied Energy
- Less weight, less mass, less energy and raw materials used .
- Light weight solution
- Reduces frame/structural materials required.
- Reduces transportation energy demands.
- Inherent thermal insulation reduces energy consumption of building.
- Durable with low maintenance and little part replacement.
- Simple repairs.
- Core materials can be recyclable or reusable

1.9 Design flexibility with structural properties

Composites analyzed with traditional design tools.Taking into account;

- wind loads
- dead loads
- cyclic loads
- thermal expansion
- deflection etc.

1.10 Repeatable modular production

Manufacturing can be

- Automated for repeatable, high quality parts or
- Customized for smaller details.

1.11 Ease of installation

- Modules lifted into place and installed upon the building.
- No traditional steel lattice – attached to concrete slab.
- Each four man team can weather seal 200 m2 a day!
- Standard industry fixings adapted easily.
- High Strength-to-Weight ratio:
  - reduce lifting capacity demands.
  - reduce transport & installation time & cost.
  - easy reach of remote installation site.

2 What to consider with composites in buildings

2.1 Creep

For 25 year of life span, we consider a drop of 50% in laminates elastic modulus - if the stiffness requirements is L/300 - we design for 1/600

- Panel: 2.5x0.5 m
  Beam in flexure, simply supported (SS-SS)
  Laminate: 2x Biax 600/Mat 300/ P100 80 mm/Mat 300/2x Biax 600, with UP resin loaded with 100pp of ATH.
  Load: 1.5 kN/m2 wind
  Deflection with Intact core: 8.2 mm
  Stiffness: 1/300
  Deflection with degraded to 50% core: 8.9
  Increase of deflection: 8,0%
  Both deflections include core shear effects.

As this % deflection depends on the thickness/span ratio, this must be considered when designing panels under flexural heavy long term/high Tª loading. In this case cores must not only rely on thermoplastic - fiber laminates must be connected to both sandwich skins. Laminates under axial loading suffer much less from creeping and this 50% criteria reduction in modulus is conservative.

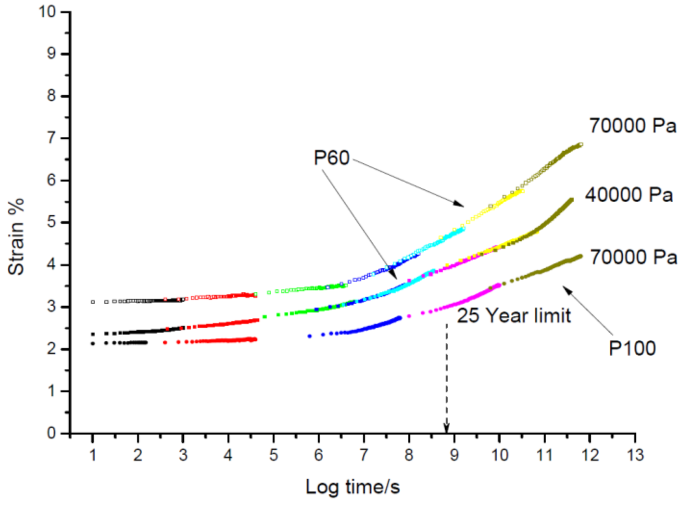

Figure 1. The figure shows the creep in Divinycell P60 and P100.

2.2 Fire, Smoke & Toxicity (FST)

Fire Smoke & Toxicity is very important in the building industry and there are solutions to fulfill most requirements. Fire retardant resins and systems, such as expanding coating solutions or Phenolic resins (handled with care), can be used. Fire rated foams such as PET should be used. Resins with ATH fillers can help to increase FST properties- special care need though to be taken with vacuum infusion. Resins with Halogens can be used with infusion, but has negative toxic aspects when burning

We have made approved design for standard E84, EN 13501, BS 476

2.3 Joining solutions

To make installation easy and to avoid high tension in the composites, it is important that the joints are made in a good way. Use single laminate if possible, or connect joints with both skins of a sandwich. A stainless steel plate can be integrated in the sandwich panel.

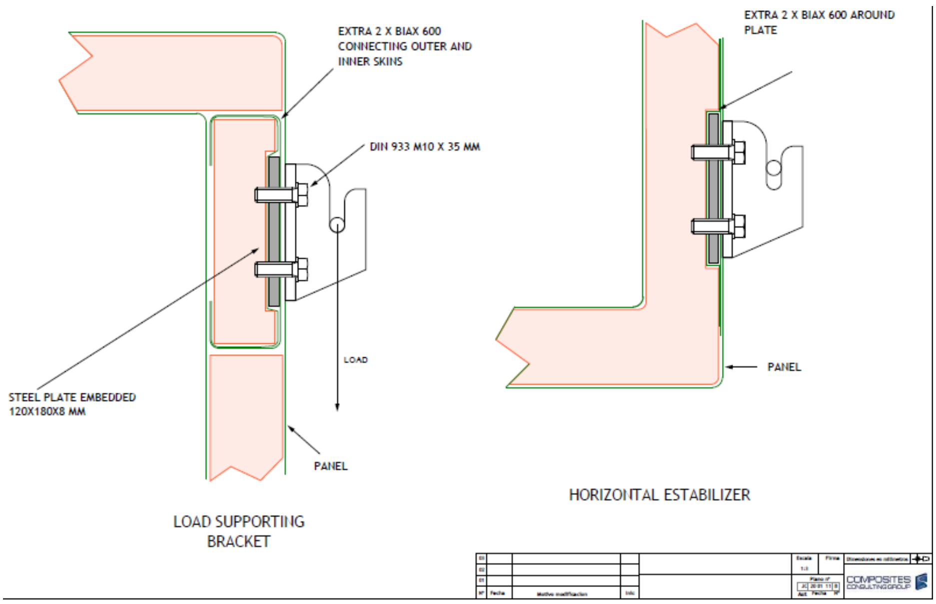

Figure 2. The figure shows examples of joining in a composite

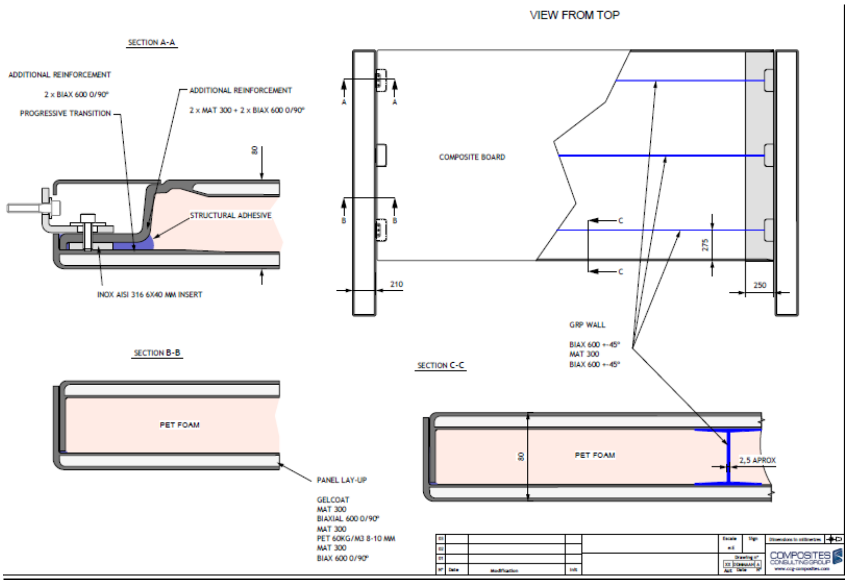

Figure 3. The figure shows another example of joining in a composite panel.