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Advanced Lightweight Composite Materials for Railway Interiors

November 2011

Dr. Richard Horn - Rail Market Manager

Composites can Reduce the Weight of Trains

- Use less fuel
- Reduce track wear and track costs
- Increase capacity
  - Exploit double-decker capacity within axle load constraints
  - Longer trains, more frequent trains without accelerating damage to the track

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What is a Composite?

- Composite is a generic term for a material manufactured from a fibre reinforcement embedded in a matrix material which is usually a resin or polymer.

- Examples of a fibre reinforcement are:
  - Glass
  - Carbon
  - Synthetic and natural fibres

- Any format: woven, unidirectional, knit, etc.

- Examples of a resin are:
  - Epoxy
  - Polyester
  - Phenolic

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The Composite Advantage

Composites offer engineers a new freedom to design structures of optimum performance.

Composites have several advantages:

- High specific modulus and strength
- Low density
- Fibre orientation with the direction of principle stresses
- Good environmental and corrosion resistance
- Very low coefficient of thermal expansion
- Low thermal conductivity
- Improved vibration damping properties
- Good fatigue resistance
- Repairability of damaged structures
- Ability to manufacture complex shape

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Metal vs. Composites

- Material Properties
  - Metal: Uniform
  - Composite: Directional
- Loads
  - Metal: Uniformly distributed
  - Composite: Follow fibres
- Structure
  - Metal: Change only geometry
  - Composite: Tailor structure with materials and geometry

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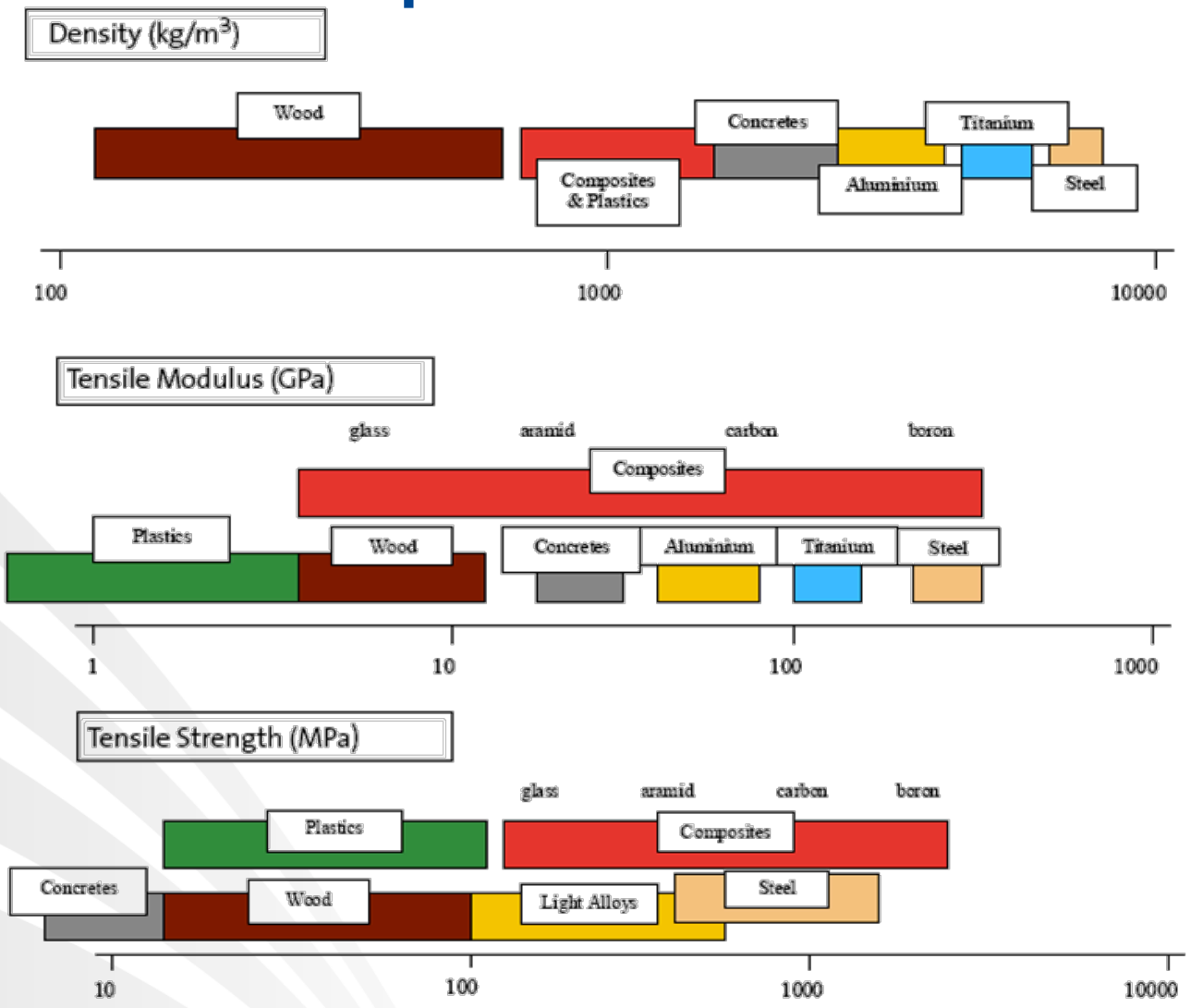
Comparison of Materials



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Rail Interior Materials

Metals

- Aluminium 2700 kg/m³
- Steel 7100 kg/m³

Composites

- Glass 1660 kg/m³
- Carbon 1450 kg/m³

GRP (glass reinforced plastics)

- Wet Lay up
- Press Moulding 1600 -1800 kg/m³

Advanced Composites (Prepregs)

- 1450-1660 kg/m³

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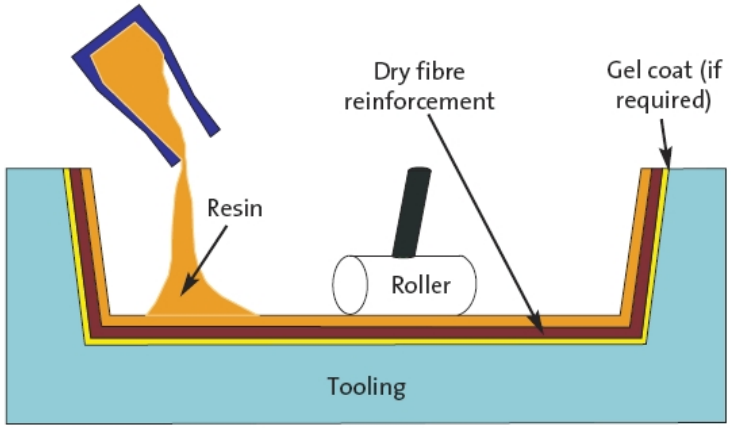
GRP (Glass Reinforced Plastics) Wet Layup



Positives

- Low cost, simple technique
- Complex shapes easily moulded

Negatives

- Laminate quality operator dependent
- Poor part repeatability, quality control, health & safety issues

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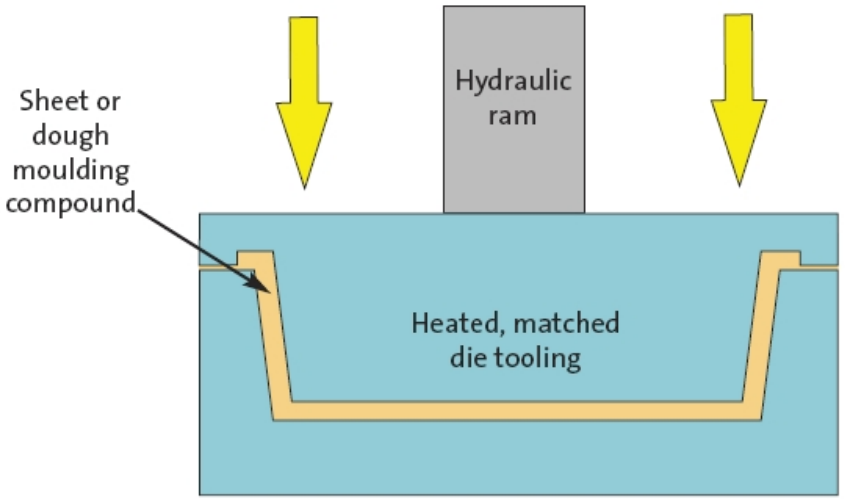
GRP (Glass Reinforced Plastics) Press Moulding



Positives

- Rapid manufacturing, low labour content
- Good repeatability
- Two moulded faces

Negatives

- Large production quantities required to amortise high tooling costs
- Poor mechanical performance
- Heavy parts

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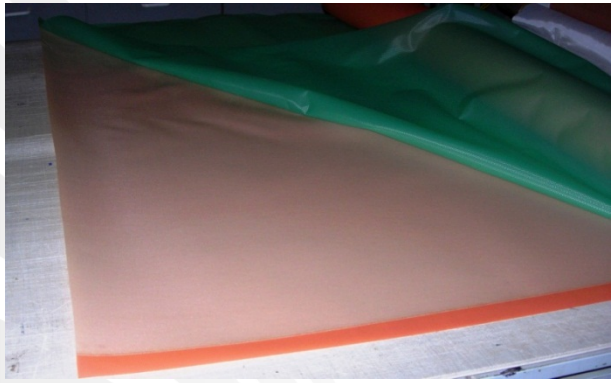
Advanced Composite (Prepreg)

- An ‘advanced composite’ usually refers to a structure where high performance composite materials and component geometry work in harmony to optimise performance

- A prepreg consists of a reinforced material pre-impregnated with a polymer or resin matrix in a controlled ratio

- Focus upon woven glass/phenolic prepreg for railway interiors



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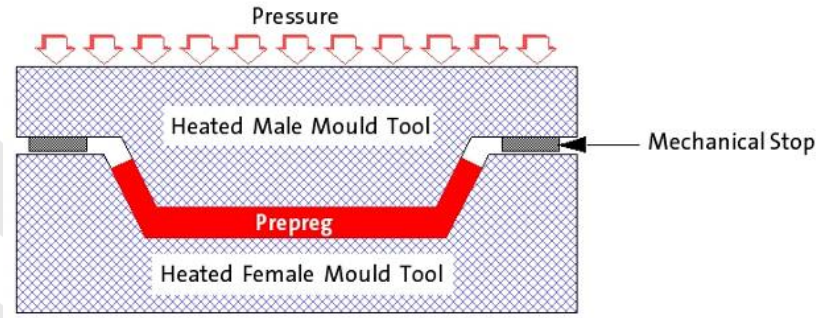
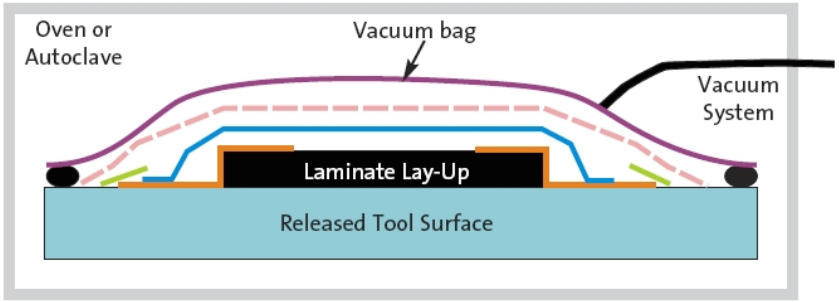
Advanced Composite Prepreg Processing

Prepreg Press Moulding



Prepreg Vacuum Processing



Positives

- Very high mechanical performance
- Labour saving and significant potential for automation

Negatives

- Increased raw material costs
- Increased processing costs

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Mechanical Properties

	Wet Lay up		Press Moulding	Glass/Phenolic Prepreg	
Flexural Strength (MPa)					
Flexural Modulus (Gpa)					
Tensile Strength (MPa)					

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Mechanical Properties

	Wet Lay up		Press Moulding	Glass/Phenolic Prepreg	
Composition	20% Glass	30% Glass	30% glass , 40% filler	60% glass	60% carbon
Flexural Strength (MPa)					
Flexural Modulus (Gpa)					
Tensile Strength (MPa)					

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Mechanical Properties

	Wet Lay up		Press Moulding	Glass/Phenolic Prepreg	
Composition	20% Glass	30% Glass	30% glass , 40% filler	60% glass	60% carbon
Flexural Strength (MPa)	115	200	140	500	640
Flexural Modulus (Gpa)	6.5	11	9	23	44
Tensile Strength (MPa)	45	101	58	291	513

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Reduce weight by using glass/phenolic prepregs

- Prepregs allows thinner structures to be made:
  - 2mm MTM82S-C glass/phenolic against
  - 4-6mm press moulding and wet layup
- Prepreg technology offers weight saving and better mechanical performance

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Railway Interiors

- Seats and tables
- Standbacks
- Ceilings
- Floors
- Internal doors
- Walls
- Window frames
- Luggage racks

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Cost Issues

Property	Wet Lay up	Press Moulding	Glass/Phenolic Prepreg
Material Cost			
Labour Cost			
Tooling Cost			
Performance			
Part Weight			
Surface Quality			

Key: 1 = Worst, 5 = Best

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Cost Issues

Property	Wet Lay up	Press Moulding	Phenolic Glass Prepreg
Material Cost	4	5	2 to 3
Labour Cost	3	5	3 to 4
Tooling Cost	4	1	3
Performance	2 to 3	1	5
Part Weight	2 to 3	1	5
Surface Quality	3	5	3

Key: 1 = Worst, 5 = Best

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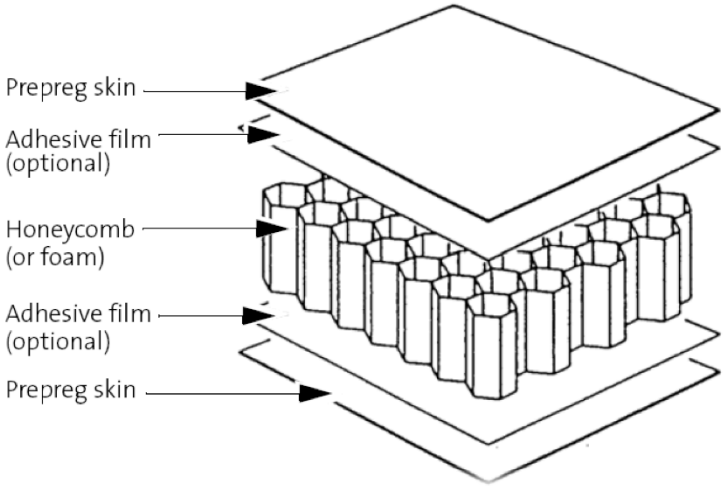
Sandwich Panel Constructions



- Honeycomb Panels
  - Laminate phenolic/glass prepreg to a Nomex honeycomb core
- Foam Core Panels
  - Laminate phenolic/glass prepreg to a foam core

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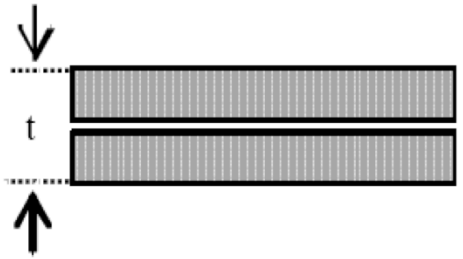
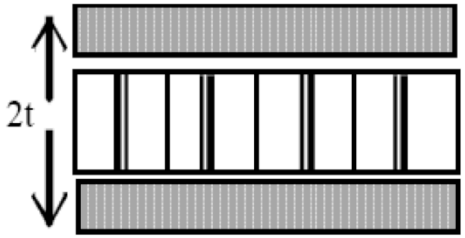
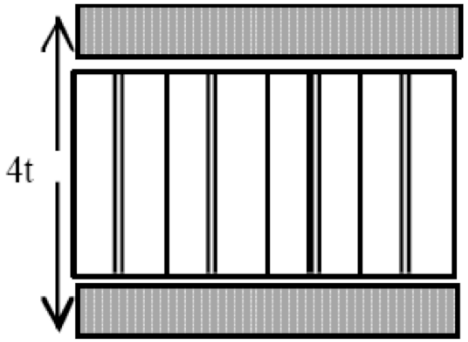
Sandwich Panel Performance

	Solid Laminate	Core Thickness t	Core Thickness t
			
Relative Stiffness	1	7	37
Relative Flexural Strength	1	3.5	9.25
Relative Weight	1	1.03	1.06

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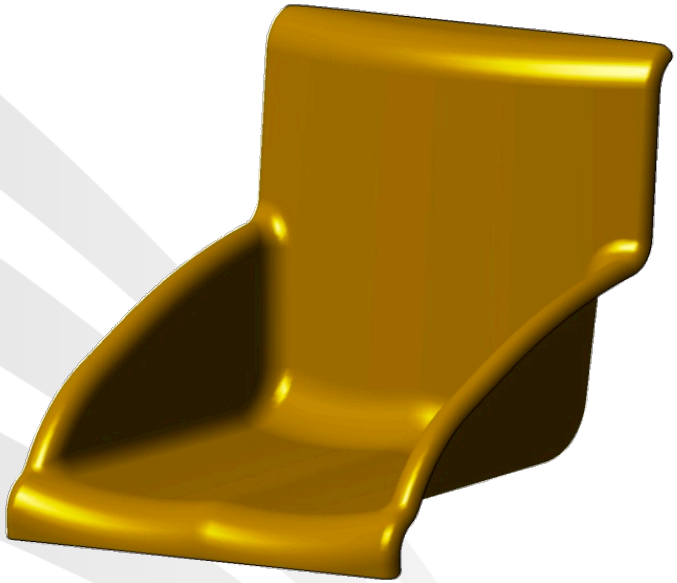
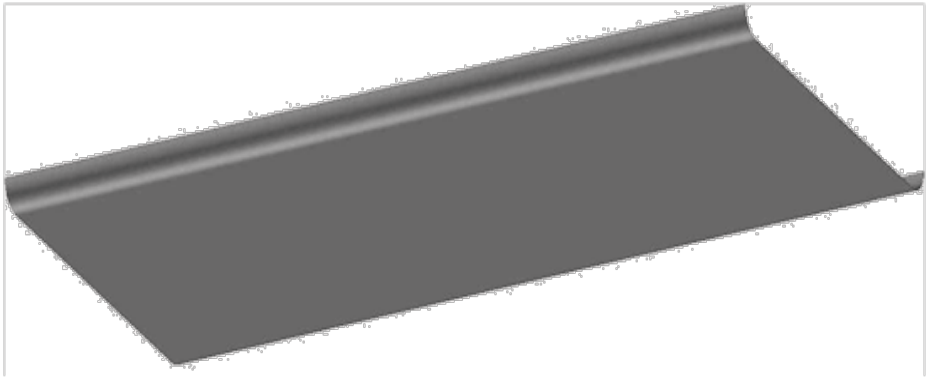
Examples on Stand 9245

Foam Sandwich Seat



Foam Sandwich Ceiling Panel



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Glass/Phenolic Prepreg MTM®82S-C

- Suitable for autoclave/press moulding/vacuum bag
- Broad cure range 80-180°C
- Excellent Fire Smoke & Toxicity performance
  - BS 6853 Rating Category 1a
  - NF F 16-101 Rating M1 F1
  - DIN 5510-2 Rating S4, SR2, ST2
- Impact performance

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Case Study

- Bombardier Transportation UK won a contract to supply 30 Electrostar EMUs to the UK Train Operator National Express East Anglia
- Requirement for 960 standbacks
- Fire Performance to BS6853 Cat 1a was specified
- Ipeco Composites won the contract

- Ipeco Composites has a history in aircraft interiors

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Material and Process Selection

- BS 6853 Cat 1a was specified
- MTM82S-C glass/phenolic prepreg was chosen with a 300gsm satin weave glass
- Processed by autoclave

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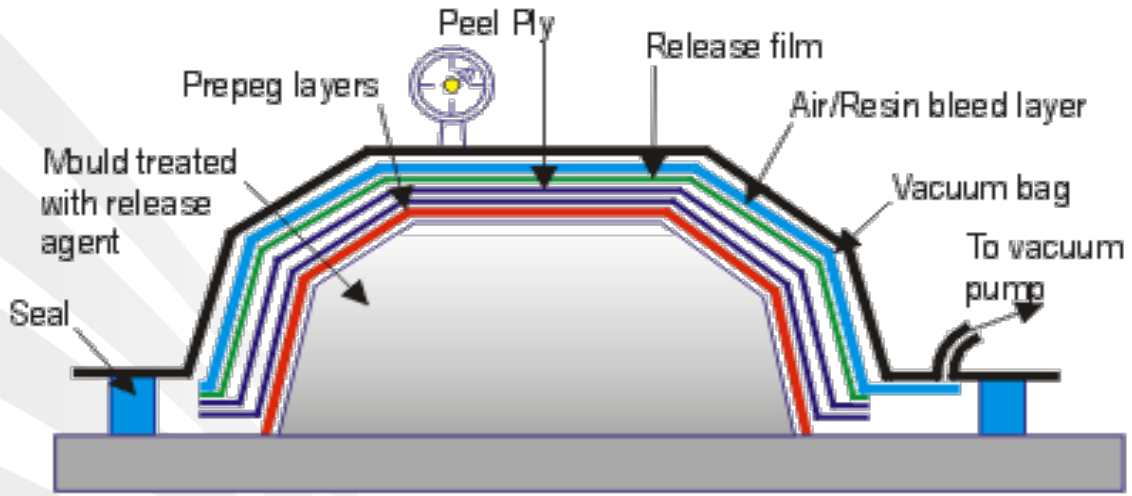
- Layup prepreg on the mould
- Release film
- Air/resin bleed layer
- Vacuum bag
- Evacuate, cure in an autoclave



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Processing

Laid up

Autoclave

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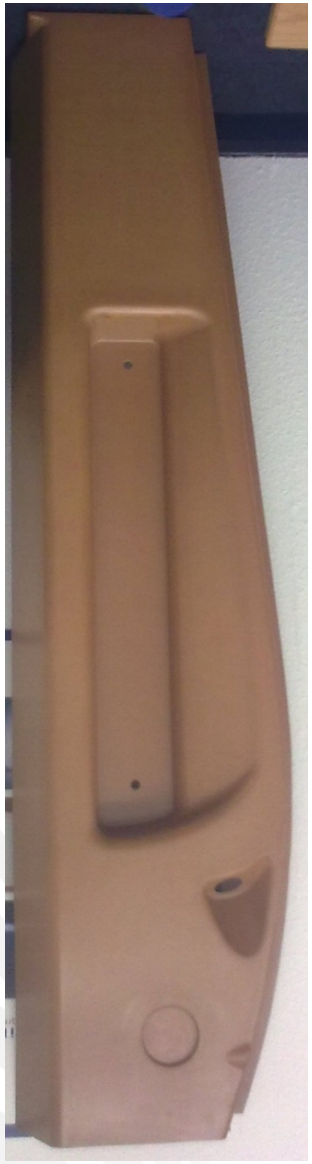
Finished Standback



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Standback Installed

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Gains

- Excellent surface finish
- Improved quality
- Improved dimensional tolerances
- On-time delivery
- No rework
- Reduced installation costs
- No rejects
- Compliant with BS6853 Cat 1a
- Reduced overall weight, 6.4kg against 10.5kg

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In Conclusion

- If you want to take weight out of rail interiors then consider the prepreg route
- Suitable for all structures
- Can be more expensive than GRP
- Set against weight saving
- Set against installation costs
- Fire performance
- Impact performance
- Sandwich construction

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Thank you

Come and see us on Stand 9245

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