Structural profiles in composites: what are the technical and economic benefits compared to metals?

The structures, frameworks, platforms, frames, armatures, which carry the majority of the forces of a construction, a machine or a product are still mostly metallic.

Yet, those who convert to pultruded fiberglass & polyester resin composites for these functions are becoming more and more numerous. Why are they doing so? What do they find in this technology to adopt it and never go back?

Some answers that show how to make the best of the characteristics of composites to allow sometimes spectacular progress in terms of economic, environmental and technical performance…

1 - What is a pultruded composite?

Only 5% of the parts made of composite materials are manufactured in a continuous way, and not in an individual way, mainly by moulding.

Pultrusion, which is similar to aluminum extrusion, is the most energy and cost efficient composite manufacturing process.

It consists in shaping and cooking the reinforcements (glass, carbon, hybrid fibers, etc.) unwound and impregnated in a bath of thermosetting matrix (epoxy resin, polyester, vinylester, PU, etc...)

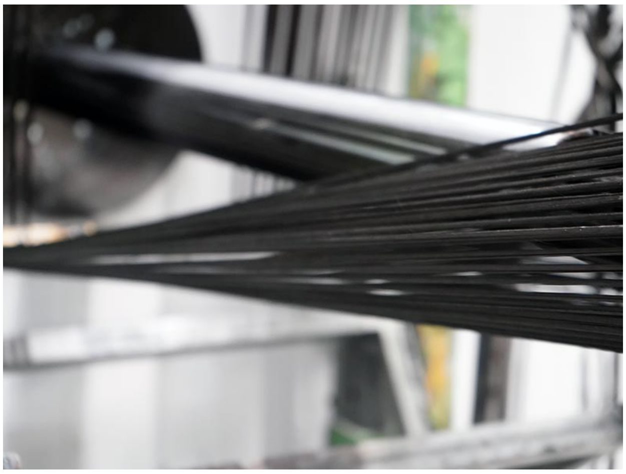


Illustration video: https://www.youtube.com/watch?v=DJUIRhBxejc

Pultrusion is often used to design parts with custom geometries and characteristics for each specific application. However, there are standards with universal
geometries and mechanical characteristics of reference: the fiberglass / polyester resin profiles known as 'Structural'.

They are widely used in industries where durability and lack of maintenance in a very corrosive environment is essential (chemical industry, water treatment, marine or radioactive environment...)


They are also often used as a first approach to build prototypes, before optimizing the solution with a custom formulation and geometry.

2 - What are the mechanical differences from conventional metals?

If we want to summarize these differences simply, let's say "lighter, equally strong, more flexible, and anisotropic"

Property	Unit	E23 putrid composite	Steel	Aluminium
Density	g/cm3	1,8	7,85	2,7
Modulus of elasticity in tension	GPa	23	210	70
Maximum tensile stress	Mpa	240	250	240
Elongation at break	%	1	0,1	0
Shear modulus	GPa	3	81	27

30% lighter than aluminum, 5 times lighter than steel: significant savings in transportation and assembly costs

3 times more flexible than aluminum, 9 times more flexible than steel, no plastic deformation range

Equivalent strength to both metals in the longitudinal direction, much less in the transverse direction.

It is important to remember that the pultruded composite, due to the preferential direction of the fibers, introduced in a longitudinal way during the continuous manufacturing process, differs from metals by this anisotropic character, and that this, combined with its stronger deformation induced by its flexibility, requires adapted dimensioning tools.

Mechanical properties (E23 European standard)

Property	Unit	E23	E17
Full section bend test	GPa	23	17
Tension modulus - axial	GPa	23	17
Tension modulus - transverse	GPa	7	5
Tension strength - axial	MPa	240	170
Tension strength - transverse	MPa	50	30
Pin bearing strength - axial	MPa	150	90
Pin bearing strength - transverse	MPa	70	50
Flexural strength - axial	MPa	240	170
Flexural strength - transverse	MPa	100	70
Interlaminar shear strength - axial	MPa	25	15

Recommended references for use of pultruded profiles in structural applications:

EN13706: European standard for structural pultrusions
EN14122: European standards for access structures
DIN 18829
- Reduction factors for long term loadings
- Chemical resistance tables

Eurocomp Design guidance

Physical properties

Property	Method	Unit	Typical value
Density	ISO1183	g/cm^3	1.7 - 2.0
Barcol hardness	ASTM D2583	Barcol	50
Water absorption	ISO62	%	0.7 max
Electrical strength	DIN53481	kV/mm	5-10
Coefficient of linear thermal expansion	BS6319	10/ºK	6-10
Heat distortion temperature	ISO75	ºC	>150

3 - Other singular points: Zero maintenance and carbon footprint

It is often said that one does not choose composites for ONE reason, but for a bundle of benefits. One could add that the more one evaluates his project in the long term, the more their benefits assert themselves.

First, the lifetime corrosion resistance without any treatment or maintenance is a decisive factor if the operating cost is taken into account from the design stage. Combined with a more resource-efficient manufacturing process, this also means that the overall environmental impact is half that of metals:

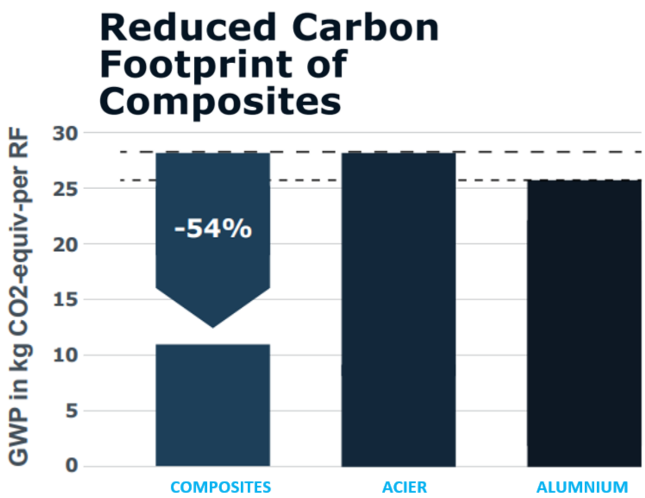


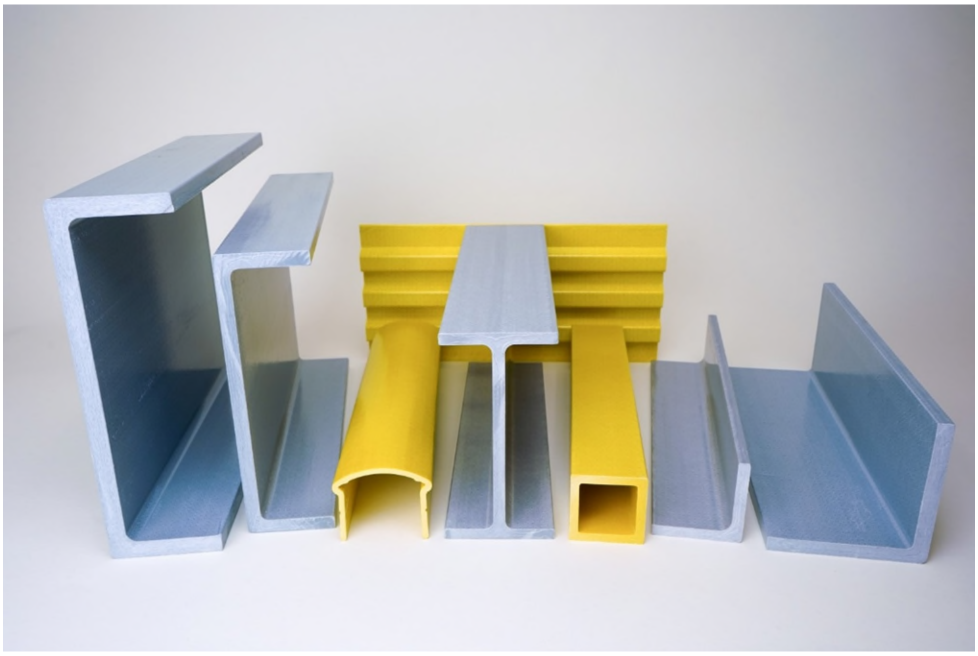
Fig.6 : LCA results for a stationary application with more than 30-yrs lifetime warranty, comparing composites with steel and aluminium

Source : https://eucia.eu/userfiles/files/20130207_eucia_brochure_recycling.pdf

We can add:

- their electrical insulation does not require grounding
- their dimensional stability in the face of temperature changes
- their 'warm' touch thanks to an effusivity close to that of wood
- their coloring in the mass without the need of painting
- their availability in qualified antibacterial or antiviral Coronavirus version

3 - What standards and at what price?



The range of structural profiles is largely inspired by metal shapes, and consists of I-beams, U-beams, squares, flats and angles, with thicknesses ranging from 3 to 12mm.

It is interesting to note that combination tools, i.e. adjustable tools, allow the production of angle or flat shapes on demand without tooling costs.

Availability is generally in 6 or 12m lengths, and prices are in the range of 4 to 8 euro/kg.

They are usually kept in stock and dispatched, even for small quantities from our stock.