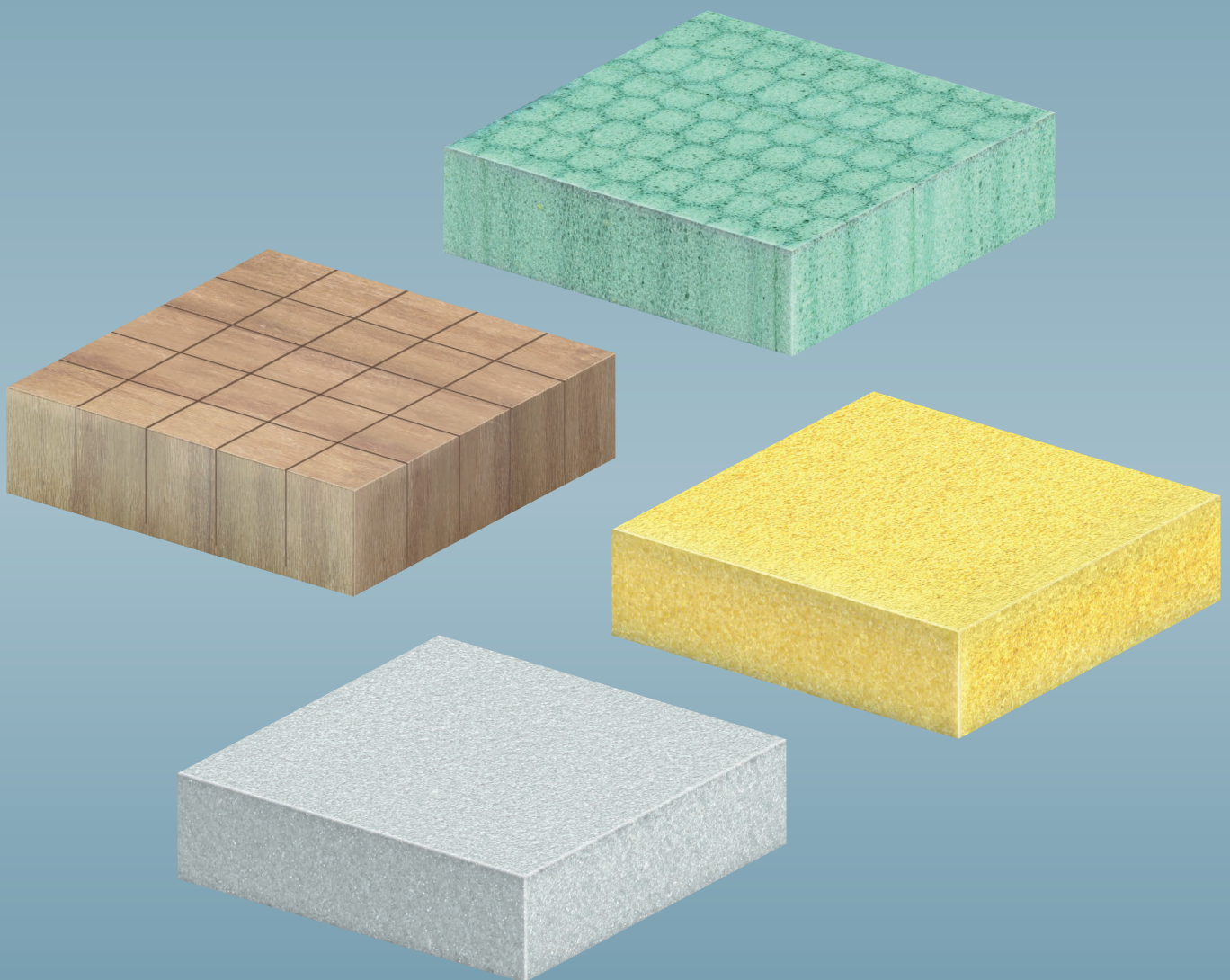


PRODUCT OVERVIEW

CORE MATERIALS





GURIT CORE MATERIAL OFFERING

Gurit is a technical leader in the development and manufacture of structural core materials. Cores in a sandwich construction are specified by designers and architects to increase stiffness and reduce the weight of a composite structure. Gurit has a range of core materials to fit any specification or manufacturing process. Structural core materials are offered in sheet form and with a variety of cut patterns or finishes, tailored to customer needs or processing choice.

Gurit® Balsaflex™ END GRAIN BALSA WOOD CORE is the classic end-grain balsa wood core, featuring very high strength to weight ratio and is available in range of densities, thickness and format/finish. Gurit® Balsaflex™ is approved by Germanischer Lloyd (GL) / Det Norske Veritas (DNV).



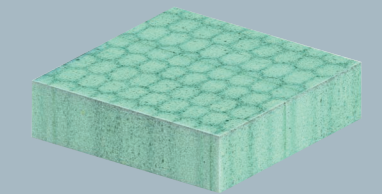
Gurit® Corecell™ SAN STRUCTURAL FOAM

Gurit® Corecell™ is a structural foam core material using a SAN (styrene acrylonitrile) polymer base featuring high toughness and impact resistant characteristics. Gurit® Corecell™ has become widely accepted for the construction of large, high performance structures through a wide range of processing methods.



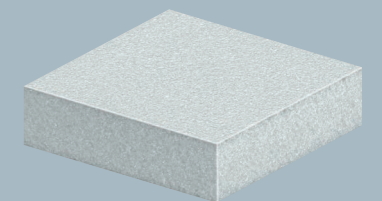
Gurit® Kerdyn™ Green THERMOPLASTIC RECYCLED FOAM CORE

Gurit® Kerdyn™ Green is an up to 100% recycled PET content structural foam. Offering a perfect solution for application requiring a good balance of mechanical performance, top-in-class resin uptake performance as well as a more sustainable approach to the light weight composite sandwich solution. With highly adaptable and recyclable capabilities, this thermoplastic PET (polyethylene-terephthalate) core material provides an adequate solution with a wide range of applications and processes.



Gurit® PVC & Gurit® PVC HT CROSS-LINKED PVC FOAM

Gurit® PVC is a closed cell, cross-linked PVC (polyvinyl chloride) foam. It provides high strength to weight ratio for all composite applications. Other key features of Gurit® PVC include outstanding chemical resistance, low water absorption and excellent thermal insulation capabilities. The HT option offers high temperature processing up to 140°C.



GURIT'S RANGE OF STRUCTURAL CORE MATERIALS

	PRODUCT	MAIN FEATURES	SHEAR			COMPRESSION		DYNAMIC		FIRE, SMOKE & TOXICITY	PROCESSIBILITY							COMPATIBILITY			3RD PARTY CERTIFICATIONS	PAGE
			STRENGTH	MODULUS	ELONGATION	STRENGTH	MODULUS	IMPACT RESISTANCE	FATIGUE		HEAT STABILITY	HDT	PRU	OUT-GASSING	WATER ABSORPTION	MACHINABILITY	THERMOFORMING	RECYCLABILITY	VE	PE		
PET	Gurit® Kerdyn™ Green	<ul style="list-style-type: none"> → Up to 100% recycled PET content → All-purpose foam → Suitable for all sandwich applications → Superior strength & stiffness:weight → Outstanding chemical resistance → FR version 	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	✓ ✓	FR version	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	Y	Y	Y	→ DNV-GL	6
PVC	Gurit® PVC	<ul style="list-style-type: none"> → All-purpose foam → Suitable for all sandwich applications → Superior strength & stiffness:weight → Outstanding chemical resistance 	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	Self Extinguishing	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	Y	Y	Y	→ DNV-GL → RINA → Lloyds Register	7	
	Gurit® PVC HT	<ul style="list-style-type: none"> → High temperature processing up to 140°C 	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	Self Extinguishing	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	Y	Y	Y	→ DNV-GL → RINA → Lloyds Register	7	
SAN	Gurit® Corecell™ T	<ul style="list-style-type: none"> → Industrial grade structural foam → Compatible with prepreg processing → Superior strength & stiffness:weight → Cost-effective 	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	N/A	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	Y	Y	Y	→ DNV-GL → ABS	8	
	Gurit® Corecell™ M	<ul style="list-style-type: none"> → High performance foam, ideal for marine applications → High shear strength and low density → Compatible with prepreg processing → High elongation for toughness 	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	N/A	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	Y	Y	Y	→ DNV-GL → Lloyds Register → BV → ABS → RINA	8	
	Gurit® Corecell™ S	<ul style="list-style-type: none"> → Sub-sea buoyancy foam 	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	N/A	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	✓ ✓ ✓ ✓	Y	Y	Y	→ Hydrostatic Crush Pressure tested to ASTM D-2736	9	
BALSA	Gurit® Balsaflex™	<ul style="list-style-type: none"> → Classic wood core → Available in typical densities & formats → Very high mechanical properties → Sustainably and responsibly sourced 	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	N/A	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	✓ ✓ ✓ ✓ ✓	Y	Y	Y	→ DNV-GL	9		

* Please contact your local sales representative for further information on the products.

Key: ✓✓ Fair ✓✓✓ Good ✓✓✓✓ Excellent ✓✓✓✓✓ Outstanding

Key: PRU = Panel Resin Uptake VE = Vinylester PE = Polyester EP = Epoxy

GURIT'S RANGE OF STRUCTURAL CORE MATERIALS

DENSITY	SHORT EDGE MARKING	NOMINAL DENSITY		HALF SHEET SIZE		NOMINAL SHEET SIZE		THICKNESS RANGE	
		(kg/m ³)	(lb/ft ³)	(mm)	(inches)	(mm)	(inches)	(mm)	(inches)
80	Blue	80	4.99	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-200	13/64 - 7 7/12
100	Green	100	6.24	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-200	13/64 - 7 7/12
115	Black	115	7.18	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-175	13/64 - 6 57/64
135	Black	135	8.43	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-150	13/64 - 5 29/32
150	Orange	150	9.36	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-135	13/64 - 5 5/16
200	Black	200	12.49	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-100	13/64 - 3 15/16
250	Black	250	15.61	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-80	13/64 - 3 5/32
235	Black	235	14.67	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-200	13/64 - 7 7/11
300	Black	300	18.73	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-80	13/64 - 3 5/32
80 FR	Blue	80	5	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-200	13/64 - 7 7/11
115 FR	Black	115	7.18	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-175	13/64 - 6 57/64
180 FR	Brown	180	11.24	1005/1220 x 1220	39.5/48 x 48	1005/1220 x 2440	39.5/48 x 96	5-110	13/64 - 4 21/64

Gurit® Kerdyn™ Green

DENSITY	FOAM COLOUR	NOMINAL DENSITY		HALF SHEET SIZE		NOMINAL SHEET SIZE		UNBONDED THICKNESS	
		(kg/m ³)	(lb/ft ³)	(mm)	(inches)	(mm)	(inches)	(mm)	(inches)
40	Azure	40	2.5			1330 x 2850	52.4 x 112.2	3-84	1/8 - 3 5/16
48	Lilac	48	3			1270 x 2730	50 x 107.5	3-80	1/8 - 3 5/32
60	Yellow	60	3.75			1150 x 2450	45.3 x 96.4	3-78	1/8 - 3 5/64
HT60	Pink	60	3.75			1120 x 2400	44.1 x 94.5	3-78	1/8 - 3 5/64
80	Green	80	5			1020 x 2180	40.2 x 85.8	3-72	1/8 - 2 59/64
HT80	Light Yellow	80	5			1005 x 2150	39.6 x 84.6	3-75	1/8 - 2 61/64
100	Red	100	6.24			950 x 2050	37.4 x 80.7	3-68	1/8 - 2 43/64
HT100	Light Orange	100	6.24			940 x 2030	37 x 79.9	3-65	1/8 - 2 9/16
130	Blue	130	8.12			850 x 1900	33.5 x 74.8	3-58	1/8 - 2 9/32
HT130	Orange	130	8.12			850 x 1900	33.5 x 74.8	3-58	1/8 - 2 9/32
200	Brown	200	12.5			750 x 1600	29.5 x 63	3-48	1/8 - 1 57/64
250	Green	250	15.6			700 x 1500	27.6 x 59	3-47	1/8 - 1 27/32

Gurit® PVC & Gurit® PVC HT

Please contact local Gurit representative

PLEASE NOTE: Maximum unbonded thicknesses can vary across Gurit sites. Please contact your local sales representative for more information. Gurit® Kerdyn™ Green product width are depend to production sites; please check with your regional Gurit Sales contact. Kerdyn™ 300 is solely available from Gurit Tianjin production site.

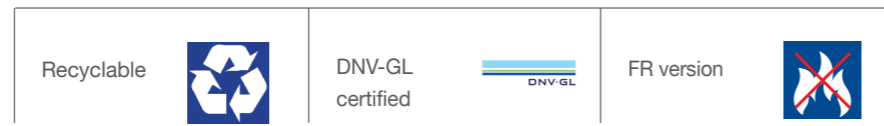
DENSITY	SHORT EDGE MARKING	NOMINAL DENSITY		HALF SHEET SIZE		NOMINAL SHEET SIZE		UNBONDED THICKNESS	
		(kg/m ³)	(lb/ft ³)	(mm)	(inches)	(mm)	(inches)	(mm)	(inches)
T400	White	71	4.4	1285 x 1285	50.5 x 50.5	1285 x 2605	50.5 x 102.5	3-50	1/8 - 2
T500	White	94	5.9	1195 x 1220	47 x 48	1195 x 2440	47 x 96	3-40	1/8 - 1 9/16
M60	Yellow	65	4.1	1285 x 1285	50.5 x 50.5	1285 x 2605	50.5 x 102.5	3-50	1/8 - 2
M80	Yellow	85	5.3	1220 x 1220	48 x 48	1220 x 2440	48 x 96	3-50	1/8 - 2
M100	Yellow	107.5	6.7	1130 x 1130	44.5 x 44.5	1130 x 2275	44.5 x 89.5	3-48	1/8 - 1 7/8
M130	Yellow	140	8.7	1015 x 1015	40 x 40	1015 x 2045	40 x 80.5	3-44	1/8 - 1 3/4
M200	Yellow	200	12.5	915 x 915	36 x 36	915 x 1830	36 x 72	3-31	1/8 - 1 1/4
S1200	Red	210	13.1	890 x 890	35 x 35	890 x 1830	35 x 72	21-24	53/64 - 15/16
S1800	Red	315	19.7	785 x 785	31 x 31	785 x 1600	31 x 63	16-21	5/84 - 59/64

Gurit® Corecell™

Balsaflex™

DENSITY	SHORT EDGE MARKING	NOMINAL DENSITY		SPECIAL SHEET (FLEXIBLE PANEL ONLY)		NOMINAL SHEET SIZE		UNBONDED THICKNESS	
		(kg/m ³)	(lb/ft ³)	(mm)	(inches)	(mm)	(inches)	(mm)	(inches)
150	Written	155	9.7	1220 x 1220	48 x 48	610 x 1220	24 x 48	6.35-55	1/4 - 2

PLEASE NOTE: Maximum unbonded thicknesses can vary across Gurit sites. Please contact your local sales representative for more information.

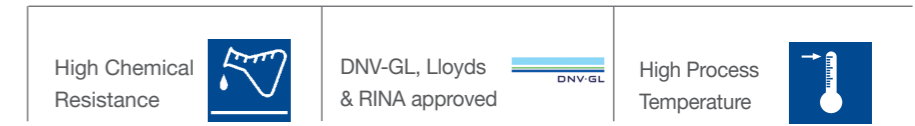


- Up to 100% recycled PET content
- Improved mechanical properties
- Recyclable
- Compatible with all types of composite manufacturing techniques
- New Gurit PET product line
- Reduced resin uptake
- FR version

Gurit® Kerdyn™ Green is a new recyclable, thermoplastic foam with an improved balance of mechanical properties, enhanced resin uptake performance, and good temperature resistance for a wide range of applications and production processes.

TYPICAL APPLICATIONS

Gurit® Kerdyn™ is used extensively in wind turbine blades, civil and marine structures. Gurit® Kerdyn™ is available in plain sheet form. A fire retardant version is also available with certification under review.



- Suitable for all composite sandwich applications
- Superior strength and stiffness to weight ratio
- Self extinguishing
- Outstanding chemical resistance
- Excellent thermal insulation capabilities
- High temperature resistance up to 140°C with Gurit® PVC HT

Gurit® PVC is a closed cell, cross-linked PVC foam. It provides superior strength to weight ratio for all composite applications.

Other key features of Gurit® PVC include outstanding chemical resistance, negligible water absorption, and excellent thermal insulation capabilities. It is compatible with most common resin systems including epoxy, polyester and vinylester.

Gurit® PVC is available in a wide range of formats with all standard cut patterns and finishes possible.

TYPICAL APPLICATIONS

Gurit® PVC is an all purpose core and can be used in decks, hull sides, bulkheads, floors and wind turbine blade shells.



Gurit® Corecell™ T

Structural Foam Core

High Chemical Resistance



DNV-GL, ABS approved



High Process Temperature



- Suitable for all PVC core applications
- Outstanding chemical resistance
- Ideal for resin infusion
- Excellent mechanical properties
- 120°C processing

Gurit® Corecell™ T has been developed as a technological step-change from traditional PVC and Balsa structural core. Gurit® Corecell™ T is an outstanding core material in every application where balsa or cross-linked PVC is commonly used. High mechanical toughness and thermal stability give Gurit® Corecell™ T excellent fatigue characteristics. This reliability makes Gurit® Corecell™ T a natural replacement for cross-linked PVC or balsa in applications where a significant service life is required.

The high temperature stability of Gurit® Corecell™ T also means that it can be used in manufacturing processes to at least 120°C / 250°F with short durations during a cure cycle to over 150°C / 300°F. This makes it ideal for use with conventional prepregs and in some liquid infusion processes where high resin exotherms can often be seen. Gurit® Corecell™ T is available in every resin infusion format and is compatible with polyester, vinylester and epoxy resin systems. Low resin absorption characteristics of Gurit® Corecell™ and unique knife cut formats allow for higher performing infusions, lower resin cost and lower weight than any other structural core.

TYPICAL APPLICATIONS

Ideal for applications where loads are less dynamic in nature, such as above the waterline on yachts, on wind turbines and in mass transport.



Gurit® Corecell™ M

The Marine Foam

High Chemical Resistance



DNV-GL, ABS, BV, Lloyds, IRS & RINA approved



High Process Temperature



- Low resin absorption
- High temperature processing (prepreg compatible)
- High shear strength & elongation – ideal for areas subjected to slamming loads
- Good compressive strength and stiffness
- DNV-GL, RINA, BV, Lloyds, IRS and ABS certification
- Suitable for prepreg, SPRINT®, infusion and wet lamination

Gurit® Corecell™ is a structural foam core material using a SAN polymer base featuring high toughness and impact resistant characteristics. It offers very reliable processing without outgassing for high quality parts. Gurit® Corecell™ M is the newest addition to the Gurit® Corecell™ range and shares the benefits of SAN chemistry common to all Gurit® Corecell™ products.

TYPICAL APPLICATIONS

Gurit® Corecell™ M has been developed to deliver one product for all Marine applications. It provides a combination of high shear strength with low density, high elongation, high temperature resistance and low resin uptake. Gurit® Corecell™ M is the perfect choice whether your application is slamming area or superstructure, hull or deck, using hand lamination, infusion or prepreg.



Gurit® Corecell™ S

Sub-sea Foam

High Water Resistance



Ultra-fine Cell Size



High Hydrostatic Crush Strength



- Sub-sea buoyancy foam
- Ultra-fine cell size
- High hydrostatic crush strength and water resistance
- Outstanding mechanical properties
- Lower density than resin-based syntactics

Gurit® Corecell™ S has been designed specifically for use in sub-sea buoyancy applications. Its resistance to crushing means that it can withstand depths of over 900m, and its closed-cell structure gives it a high water resistance that ensures buoyancy is maintained over time. With its very high compressive strength, Gurit® Corecell™ S can also replace other materials, such as plywood, when creating high strength inserts for through-bolting in composite laminates.

TYPICAL APPLICATIONS

Gurit® Corecell™ S has been used in a variety of demanding sub-sea applications from buoys, civil and military submarines as well as highly loaded marine applications units. Gurit® Corecell™ S can be supplied in sheet form or kit-cut format. This is a Gurit special product.



Gurit® Balsaflex™

Classic Wood Core

Natural and Sustainable



DNV-GL certified



High strength to weight ratio



- High quality composite core material made from end grain balsa
- Highest strength to weight ratio of any structural core
- Natural, sustainable and responsibly sourced

Gurit® Balsaflex™ is the classic end-grain balsa wood core, featuring very high strength to weight ratio. When an application requires high-strength and stiffness and cost effectiveness, Gurit® Balsaflex™ is a suitable solution due to a good balance between cost, properties and weight. Gurit® Balsaflex™ is available in a range of densities, thicknesses, formats and finishes. Gurit® Balsaflex™ is GL approved.

TYPICAL APPLICATIONS

Gurit® Balsaflex™ is used for wind turbine blades and nacelles, marine, automotive, truck, rail and aircraft parts. Gurit® Balsaflex™ can be supplied in sheet form or kit-cut to customer's desired shapes.



FINISHING

Complete Core Solutions

Gurit standard product forms are described in the following tables toward faster response. Gurit can also tailor sheets to your own specification depending on lead-time and volume - please call to discuss your requirements.

PL – Plain Sheet – Optimum material properties. Limited bending in-mould.

PH – Plain with Bleeder Holes – Assists air release in vacuum bag processes.

CUTS FOR CONFORMABILITY (FOAM)

Gurit double-cut finish is standard for Gurit® Corecell™ and Gurit® Kerdyn™ Green; and can be also considered for Gurit® PVC. Alternatives single-cut or the less common triple-cut can also be performed. Please be advised that cuts are dependent upon the density and thickness of the material. Higher density and thickness materials may need to be saw cut (0,9/1mm), rather than knife cut (0,5mm) although the spacing will be constant.

Knife cuts are not visible when the sheets lie flat and these narrow knife-cuts minimize overall resin consumption compared to saw-cut core finishes. Maximum sheet size is half of a full-size sheet. Please contact your customer support representative for more information.

SC – Single Cut – Provides flexibility in a single direction on one or both sides of a sheet. If done on both sides, the cuts intersect so no bleeder holes are necessary for vacuum bagging. Max sheet size is half of a full-size sheet.

DC – Double Cut – Provides flexibility in two directions on one or both sides of the sheet. If Double Cut on both sides, the intersecting cuts make DC a highly effective resin infusion medium. The cuts are not visible when the sheets lie flat and these narrow knife-cuts minimise unnecessary resin accumulations compared to sawn core materials.

CS – Contour Scrim – provides optimum flexibility in two directions. Sheets are cut in squares and bonded to a glass scrim. Available on sheets up to 25mm (0.98") thick (dependent on density). Maximum standard sheet size is half the full sheet.

SURFACE GROOVES FOR INFUSION (FOAM)

VIC – Vacuum Infusion Core – There are several VIC options and Gurit can customize grooving patterns and bleeder holes as required. For curved laminate sections, double-sided DC is very effective system for resin infusion with low weight gain. Heat-forming VIC surface cut also useful for obtaining curved panels with minimal resin uptake.

Combination – Combinations of these aforementioned formats are also available.

PRODUCT FORMATS (BALSA)

Gurit® Balsaflex™ is available plain or with typical formats including perforations, grooves, contour scrim and with optional coating.

OTHER PRODUCT FORMATS

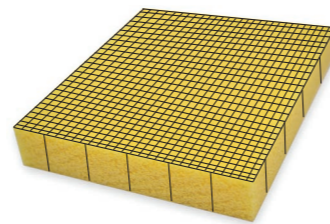
Fillet strips – Triangular edge strips to create tapered panel edge drop-offs, or stringer base fillets.



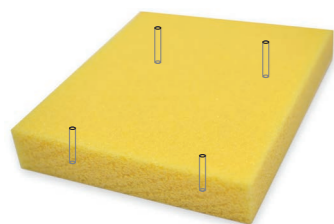
PL - Plain



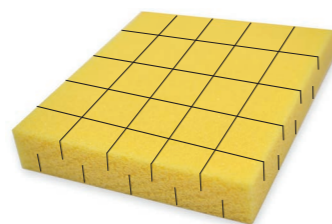
SC - Single Cut



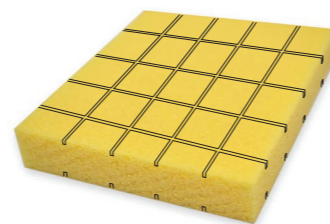
CS - Contour/Scrim



PH - Plain/Bleeder Holes



DC - Double Cut



VIC - Typical VIC

FINISHING CONT'D

Complete Core Solutions

DETAILS	GURIT® Corecell™	GURIT® KERDYN™ GREEN	GURIT® PVC	GURIT® BALSAFLEX™
PL				
PH	Spacing = 50 x 50mm Dia. = 1.6/2mm (with 25 x 25 option)		Spacing = 20 x 20mm Dia. = 2mm (with 40 x 40 option)	Spacing = 25.4 x 25.4mm Dia. = 3mm (with 50.8 x 50.8 option)
CS	Spacing = 30 x 30mm Width = Knife <0.5mm / Saw 0.9/1mm			Spacing = 25.4 x 50.8mm Width = <0.5mm
DC (TC/SC)	Spacing = 30 x 30mm Width = <0.5mm / Saw 0.9/1mm			N/A
VIC	Spacing = 30 x 30mm Width = 0.9mm Depth = 2mm		Spacing = 20 x 20mm Width = 2mm Depth = 2mm	Spacing = 19 x 19mm Width = 1mm Depth = 2.5mm
VIC+PH	As above		Spacing = 20 x 20mm Width = 2mm Depth = 2mm + Spacing = 20 x 20mm Dia. = 2mm Intersection	As above

For details regarding the maximum window of capabilities related to core type, thickness and density, please contact your local Sales Team: www.gurit.com/contact.aspx

KITTING

Complete Core Solutions

Gurit has an extensive kitting capability to provide all the Gurit® Corecell™ formats in customised, numbered, ready to use, CNC machined kits. Gurit can make comprehensive kits using either full customer drawings or their B³ SmartPac software solution. All types of core can be supplied and machined including Gurit® Corecell™ (SAN), Gurit® PVC, Gurit® Kerdyn™ Green and Gurit® Balsaflex™.

Gurit use either 5-Axis, or 3-Axis CNC machines along with a range of semi-automatic and manual machines to provide the optimum kitting solution depending upon kit complexity. Gurit has developed specific knowledge and experience on the correct flute and clearance angles to provide optimum cutting conditions. This allows for quick cutting to minimise cost, accurate cutting for component dimensions and fine cutting to allow the best nesting routines so maximising yield rates and minimising waste.

Gurit's machining strategy for core is to develop a range of cutting techniques that provide a cost-effective and flexible kitting solution to satisfy customer requirements.



SANDWICH PANEL ENGINEERING THEORY

Single skin laminates, made from glass, carbon, aramid, or other fibers may be strong, but they can lack stiffness due to their relatively low thickness. Traditionally the stiffness of these panels has been increased by the addition of multiple frames and stiffeners, adding weight and construction complexity.

A sandwich structure consists of two high strength skins separated by a core material. Inserting a core into the laminate is a way of increasing its thickness without incurring the weight penalty that comes from adding extra laminate layers. In effect the core acts like the web in an I-beam, where the web provides the lightweight 'separator' between the load-bearing flanges. In an I-beam the flanges carry the main tensile and compressive loads and so the web can be relatively lightweight. Core materials in a sandwich structure are similarly low in weight compared to the materials in the skin laminates.

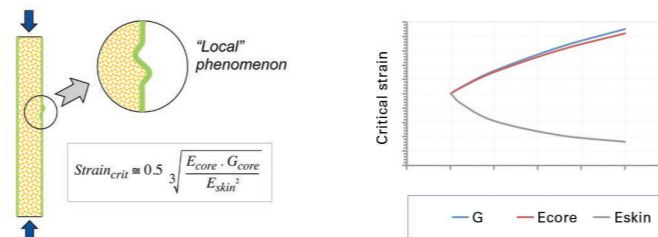
Engineering theory shows that the failure mode of the sandwich panel can be linked to specific properties of the core material used.

	SKIN WRINKLING	SHEAR CRIMPING	PANEL BUCKLING	IMPACT RESISTANCE	SHEAR FAILURE
Thickness		✓✓	✓✓✓		✓✓
Shear elongation				✓✓	
Shear modulus	✓	✓✓	✓		
Shear strength					✓✓
Compressive modulus	✓				

SKIN WRINKLING

Core provides insufficient out-of-plane support to skins allowing local, independent buckling.

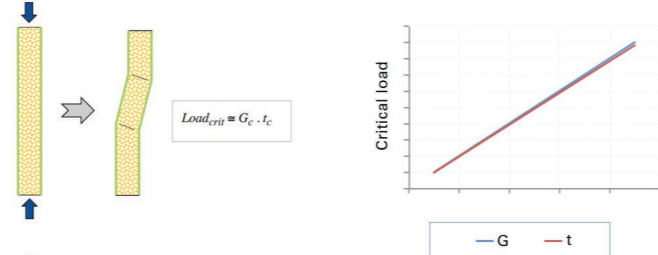
Occurs on panels subjected to high compressive strains, independently of panel width.



SHEAR CRIMPING

Core shear modulus is too low to transfer loads between outer laminate skins.

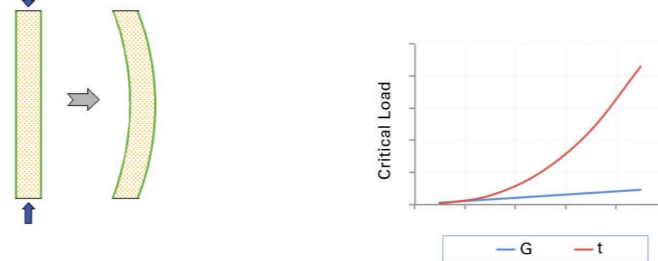
Occurs on panels subjected to high compressive loads, independently of panel width.



PANEL BUCKLING

The panel has insufficient bending stiffness to prevent buckling.

Occurs on wide flat panels subjected to high compressive load (Euler buckling), or on deep panels subjected to high shear load (Shear buckling).



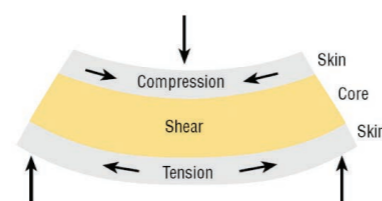
IMPACT RESISTANCE

Core toughness and resistance to cracking is too low to absorb high energy slamming loads. Occurs in core materials with low shear elongation.

SHEAR FAILURE

Core shear strength is too low to carry shear stress.

Occurs on panels subjected to high bending loads



STRUCTURAL ENGINEERING WITH CORE MATERIALS

Gurit's heritage lies in engineering high performance yachts such as Americas Cup, Open 60's and Volvo 70's. However, over the past 30 or so years, Gurit has been involved with almost every type of marine craft including military power boats, production cruisers, and some of the world's most spectacular superyachts. Whilst Gurit is most widely recognised for its marine expertise, the team has considerable experience in the provision of innovative engineering solutions to many different structures.

The range of projects worked on covers any large composite structural application and includes:

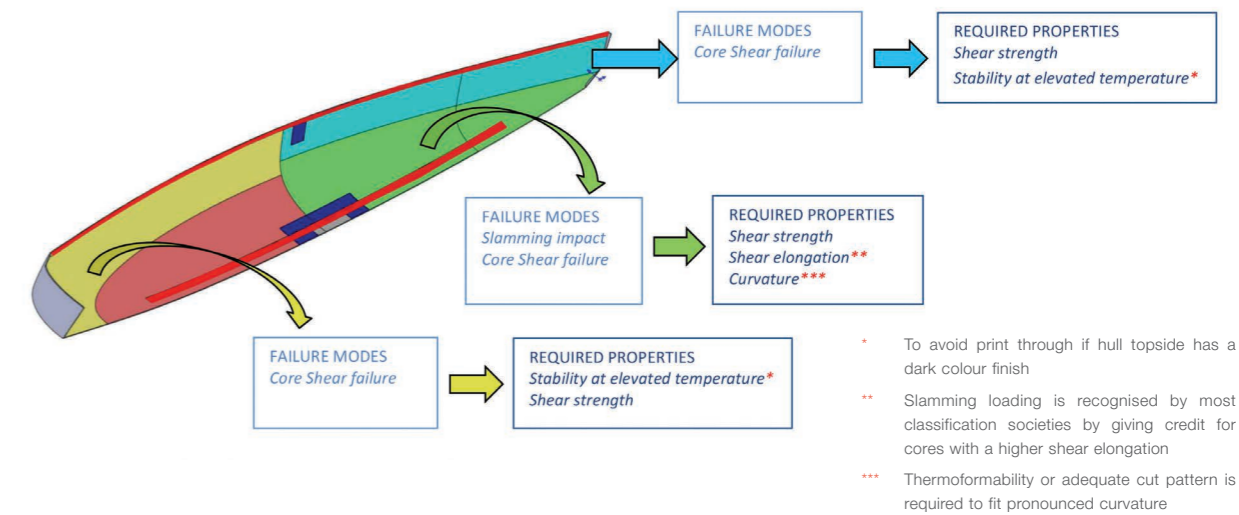
- Raceboats
- Wind turbines
- Civil Engineering
- Superyachts
- Underwater turbines
- Architectural features

To show how different core materials are considered in industry, some of the challenges that designers face for superyachts and wind energy turbine blades are discussed below.

SUPERYACHT DESIGN

Hulls

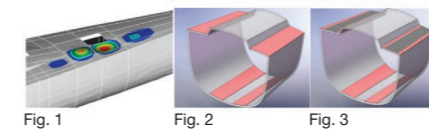
The hull and deck shells of a boat provide the watertight safety cell for the crew and also the foundation to support the rig and keel. The amount of pressure from the water that the hull of a yacht has to sustain varies along the length of the boat and also from the bottom to the shearline. Classification societies adopt a quasi-static analysis, which defines a hydrostatic pressure distribution. The hull bottom panels see higher pressure than the topside panels because they are submersed deeper in the water. The pressure distribution also decreases from the bow to the stern due to decreasing exposure to waves.



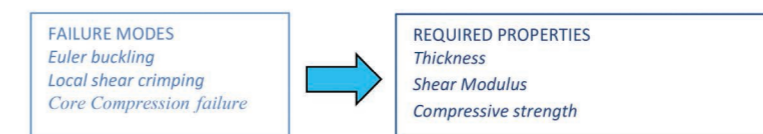
Decks

As superyacht length increases, boats get sleeker and the fore and aft bending stiffness becomes an increasing challenge, putting decks under increased compression loads.

For smaller size boats, deck stiffening tapes are added over the full width of the deck. The critical failure mode is likely to be Euler Buckling (Fig.1 & 2). As boat size increases, the most common solution is to concentrate the deck tapes at the edges of the panel. This changes the critical failure mode from Euler Buckling of the overall side deck panel to shear crimping in way of the concentrated tapes (Fig. 3).

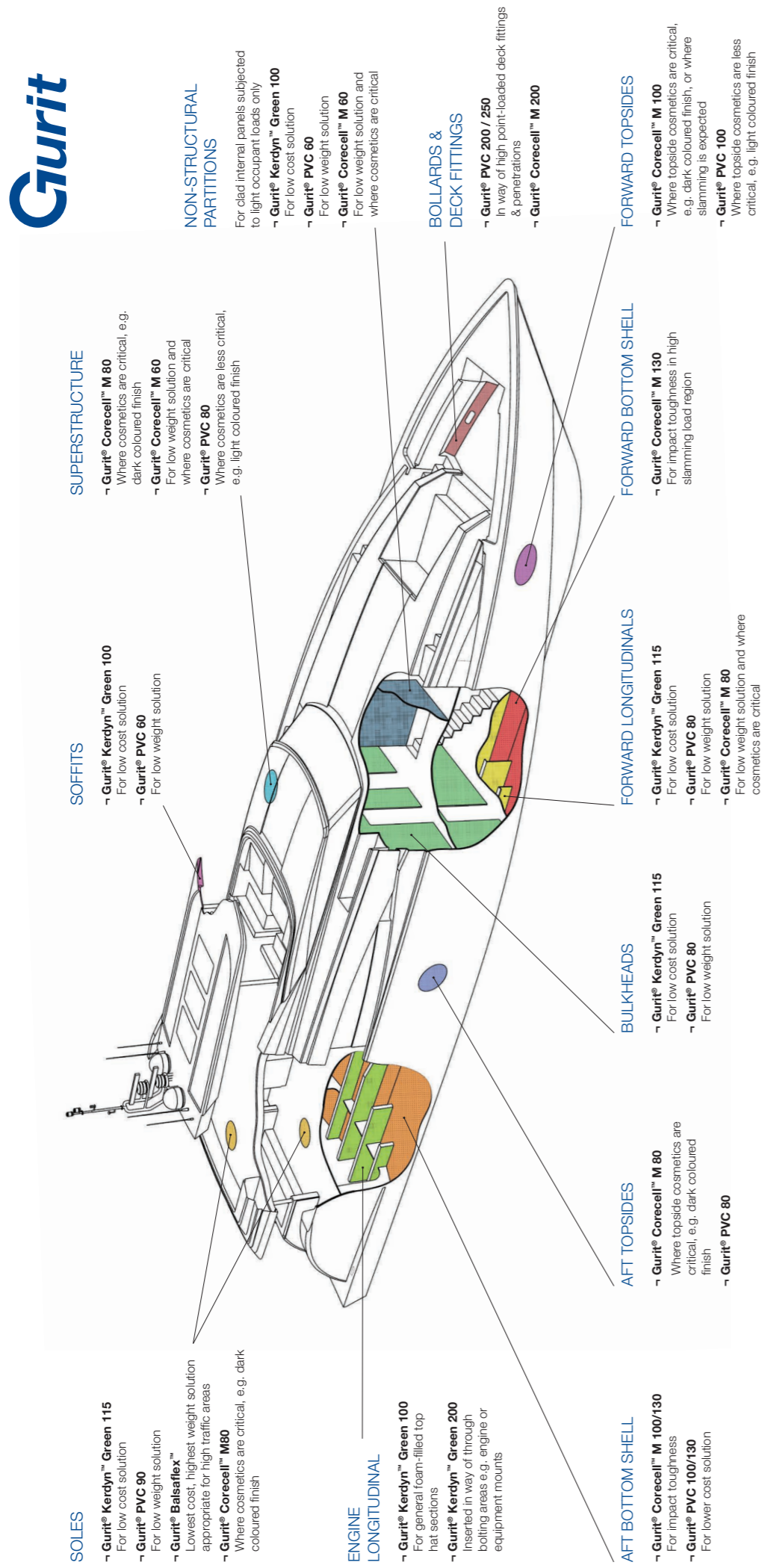


Decks also have to support water pressure and local indentation from walking loads and deck gear.



STRUCTURAL CORE MATERIAL APPLICATIONS IN SUPERYACHTS

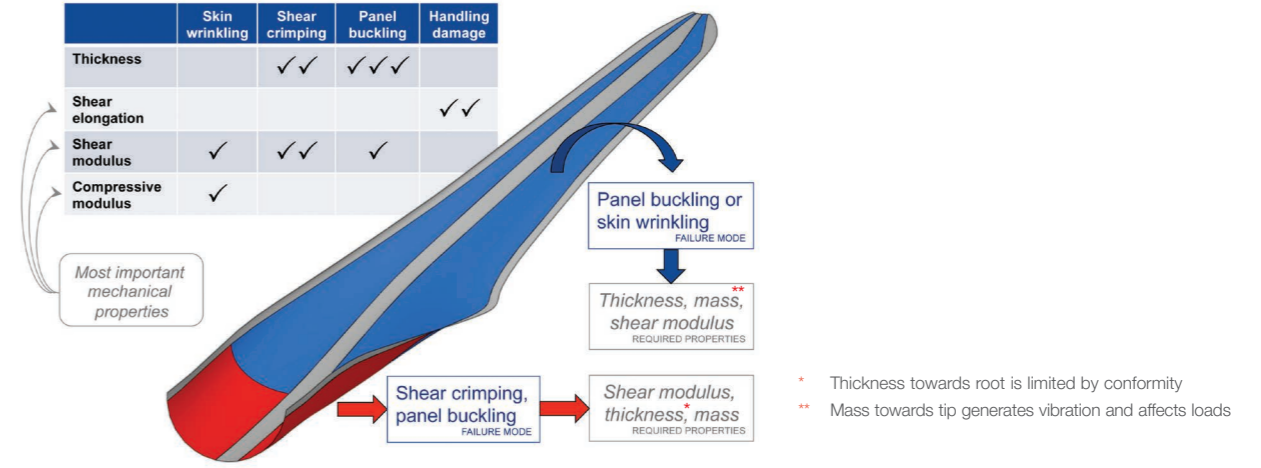
The diagram below shows a limited range of possible options. The Gurit Engineering Team will be available to support the adequate material selection and suitable design for your component.



Exterior geometry provided by Warwick Yacht Design

WIND ENERGY TURBINE BLADES

Material solutions developed by Gurit for manufacturers of wind turbine blades have continuously contributed to the increasing efficiency of wind power installations. This progress is most visible when looking at the increase of a typical blade size from 23m to over 80m+. The growing dimensions create enormous challenges for wind turbine blade manufacturers as the longest blades today weigh in excess of 20 tons each. New materials solutions were needed to keep the weight of the blades as light as possible, yet maximising their strength, stiffness and durability.



The blade shells are manufactured using sandwich structures due to the large panel size and the requirement for good bending stiffness at the lowest design weight. As the main requirement of the shell panels is to resist deformation under aerodynamic loading, the core's primary function is to provide stability (resistance to buckling of the load carrying laminate) under compressive, shear and out of plane loading. Three types of buckling failure mode can be considered:

Euler buckling: Panel bending stiffness failure - dependent on thickness and shear modulus of the core

Skin wrinkling: Local skin deformation - dependent on the shear and tensile modulus of the core and the skin thickness of the laminate

Shear crimping: Core failure - Shear modulus is too low to transfer the loads between the skins and especially relevant for thicker skin laminates

When you consider the design of the structural shell for a wind blade the loading profile of the shell changes considerably from the root to the tip and furthermore the blade geometry places further constraints on possible laminate configurations. Therefore, the requirements for the core properties change along a shell structure.

Due to the high loads in the root section the laminate thickness is high and therefore shear crimping becomes a driving design criterion. Therefore, balsa is widely used in these areas due to its very high shear modulus. Further outboard along the blade the loads are lower but the strains become higher and the failure of the core is more likely to be due to skin wrinkling or panel (Euler) buckling. For this area of a blade the thickness of the sandwich structure has much more influence to resist these failure modes and therefore a core with lower shear modulus can be used. It is also desirable to reduce weight of the panel the further you move away from the root area due to the increased bending moment. Therefore, core density and resin uptake is a key consideration.

The most common cores used for wind blade manufacture are PVC followed by SAN foam as they have good properties for their density and are relatively competitive with respect to their cost. They also have significantly lower resin uptake characteristics than Balsa and have higher strain capability which is useful for the transport and handling of blades after manufacture and before service life begins.

PET has also made some progress and is now extensively used in blade design, but it does have a weight disadvantage over PVC and SAN cores and can be too brittle for blade lifting points.



STRUCTURAL CORE	
■ Gurit® Corecell™ T	✓
■ Gurit® Kerdyn™ Green	✓
■ Gurit® PVC	✓
■ Gurit® Balsaflex™	✓

	1 Root	2 Shear Web	3 Spar	4 Shell
1	✓			
2		✓		
3			✓	
4				✓

TECHNICAL INFORMATION

For more detailed information on core materials, as well as the complete Gurit product portfolio, please visit: www.gurit.com to view the following:

- Product Data Sheets
- News / Case Studies
- Events Schedules
- Product Brochures
- Corporate Videos
- Composite Guides
- Representatives Contact Details

For pricing or other enquiries, please contact customer.support@gurit.com



Product Datasheets



Case Studies

