Aligned Fibre Composite: Longitudinal Strength and Load Share

Longitudinal tensile strength of a continuous aligned fibre composite, the share of load carried by the fibres, composite density and specific strength.

Method: Rule of mixtures for aligned continuous fibres

Input parameters

Unit system: SI

Parameter	Value	Unit
Fibre tensile strength	3,500.0	MPa
Matrix stress at fibre failure strain	50.000	MPa
Fibre modulus	230.00	GPa
Matrix modulus	3.5000	GPa
Fibre volume fraction	60.000	%
Fibre density	1,800.0	kg/m³
Matrix density	1,200.0	kg/m³

Calculated results

Parameter	Value	Unit
Longitudinal strength	2,120.0	MPa
Load carried by fibres	98.996	%
Longitudinal modulus	139.40	GPa
Composite density	1,560.0	kg/m³
Specific strength	1,359.0	kJ/kg

Notes for this case

• Rule of mixtures for continuous aligned fibres loaded along their length: σ*_cl = σ′_m(1 − V_f) + σ*_fV_f, where σ′_m is the matrix stress at the strain where fibres break (E_m × fibre failure strain for an elastic matrix). Isostrain gives the fibre load share E_fV_f/(E_fV_f + E_mV_m). Real laminates fall below this because of misalignment, voids and fibre strength scatter.

Formula and method

$$\sigma_{cl}^{*} = \sigma_m{}'(1 - V_f) + \sigma_f^{*} V_f, \quad \frac{F_f}{F_c} = \frac{E_f V_f}{E_f V_f + E_m V_m}$$

Variables

σ_f^{*}	Fibre tensile strength	Pa
$\sigma_m{}'$	Matrix stress at fibre failure strain	Pa
E_f	Fibre modulus	Pa
E_m	Matrix modulus	Pa
V_f	Fibre volume fraction	-
ρ_f	Fibre density	kg/m³
ρ_m	Matrix density	kg/m³
σ_{cl}^{*}	Longitudinal strength	Pa
F_f/F_c	Load carried by fibres	-

E_{cl}	Longitudinal modulus	Pa
ρ_c	Composite density	kg/m³
σ^*_{cl}/ρ_c	Specific strength	J/kg

Method and standards

Composite strength.

Assumptions and limits

- Continuous aligned fibres; perfect bonding; isostrain.

References

Rule of mixtures for aligned continuous fibres

Report details

Report reference	FCC-MNM3-98MW (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/materials/properties/fibre-composite-longitudinal-strength

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.