Fibre Critical Length and Short Fibre Composite Strength

Critical fibre length from fibre strength, diameter and interface shear strength, and the strength of an aligned discontinuous fibre composite.

Method: Shear-lag critical length (Kelly–Tyson)

Input parameters

Unit system: SI

Parameter	Value	Unit
Fibre tensile strength	3,400.0	MPa
Fibre diameter	10.000	µm
Fibre-matrix bond (shear) strength	40.000	MPa
Fibre length	3.0000	mm
Fibre volume fraction	30.000	%
Matrix stress at composite failure	50.000	MPa

Calculated results

Parameter	Value	Unit
Critical fibre length	0.42500	mm
Length ratio	7.0588	
Composite strength	982.75	MPa
Strength if fibres were continuous	1,055.0	MPa
Strength efficiency	93.152	%

Notes for this case

• Stress builds up along a fibre by interface shear and reaches the fibre strength only beyond half the critical length l_c = σ*_fd/(2τ_c). For l > l_c: σ*_cd = σ*_fV_f(1 − l_c/2l) + σ′_m(1 − V_f); for l < l_c the fibres never break and σ*_cd′ = (lτ_c/d)V_f + σ′_m(1 − V_f). Fibres longer than about 15 l_c behave almost as continuous.

Formula and method

$$l_c = \frac{\sigma_f^* d}{2\tau_c}, \quad \sigma_{cd}^* = \sigma_f^* V_f \left(1 - \frac{l_c}{2l}\right) + \sigma_m{}'(1 - V_f)$$

Variables

σ_f^*	Fibre tensile strength	Pa
d	Fibre diameter	m
τ_c	Fibre-matrix bond (shear) strength	Pa
l	Fibre length	m
V_f	Fibre volume fraction	-
$\sigma_m{}'$	Matrix stress at composite failure	Pa
l_c	Critical fibre length	m
l/l_c	Length ratio	-
σ_{cd}^*	Composite strength	Pa
σ_{cl}^*	Strength if fibres were continuous	Pa
$\sigma_{cd}^*/\sigma_{cl}^*$	Strength efficiency	-

Method and standards

Critical length.

Assumptions and limits

- Aligned fibres; constant interface shear (Kelly–Tyson).

References

Shear-lag critical length (Kelly–Tyson)

Report details

Report reference	FCC-ZDQF-9JAW (the same inputs always give the same reference)
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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-critical-length

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.