Reinforced Concrete Beam: Cracked Transformed Section Stresses

Neutral axis depth, cracked moment of inertia, lever arm and the concrete and steel stresses of a singly reinforced rectangular concrete beam under service moment.

Method: Elastic cracked transformed-section analysis of a reinforced concrete beam

Input parameters

Unit system: SI

Parameter	Value	Unit
Beam width	300.00	mm
Effective depth	500.00	mm
Tension steel area	1,473.0	mm²
Steel modulus	200.00	GPa
Concrete modulus	25.000	GPa
Service bending moment	120.00	kN·m

Calculated results

Parameter	Value	Unit
Modular ratio E_s/E_c	8.0000	
Neutral axis depth (cracked)	162.77	mm
Cracked moment of inertia	177,137	cm⁴
Lever arm d − x/3	445.74	mm
Maximum concrete compressive stress	11.027	MPa
Steel tensile stress	182.76	MPa
Steel ratio A_s/(bd)	0.98200	%

Notes for this case

- Elastic cracked-section analysis: concrete in tension ignored, linear stress in the compression zone, steel transformed by n. Used for service stresses, crack control and deflection (I_cr); not an ultimate-strength design check.

Formula and method

$$\frac{bx^2}{2} = nA_s(d-x), \quad I_{cr} = \frac{bx^3}{3} + nA_s(d-x)^2, \quad f_c = \frac{Mx}{I_{cr}}, \quad f_s = \frac{nM(d-x)}{I_{cr}}$$

Variables

b	Beam width	m
d	Effective depth	m
A_s	Tension steel area	m²
E_s	Steel modulus	Pa
E_c	Concrete modulus	Pa
M	Service bending moment	N·m
n	Modular ratio E_s/E_c	-
x	Neutral axis depth (cracked)	m
I_{cr}	Cracked moment of inertia	m⁴
jd	Lever arm d − x/3	m

f_c	Maximum concrete compressive stress	Pa
f_s	Steel tensile stress	Pa
ρ	Steel ratio A_s/(bd)	-

Method and standards

Transformed-section elastic analysis.

Assumptions and limits

- Plane sections remain plane, linear elastic materials, tension concrete cracked.

References

Elastic cracked transformed-section analysis of a reinforced concrete beam

Report details

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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/civil/concrete/rc-cracked-section

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.