Doubly Reinforced Concrete Beam Moment Capacity

Moment capacity of a rectangular concrete beam with tension and compression steel by the rectangular stress block and strain compatibility, with steel stresses.

Method: Equivalent rectangular stress block with strain compatibility

Input parameters

Unit system: SI

Parameter	Value	Unit
Concrete strength	30.000	MPa
Steel yield strength	500.00	MPa
Beam width	300.00	mm
Effective depth to the tension steel	550.00	mm
Depth to the compression steel	50.000	mm
Tension steel area	3,000.0	mm^2
Compression steel area	1,000.0	mm^2
Stress block intensity factor	0.85000	
Stress block depth factor	0.85000	
Ultimate concrete strain	0.003000	
Steel modulus	200.00	GPa
Strength reduction factor	90.000	%

Calculated results

Parameter	Value	Unit
Neutral axis depth	169.54	mm
Tension steel stress	500.00	MPa
Compression steel stress	423.05	MPa
Nominal moment capacity	725.69	kN·m
Design moment capacity	653.12	kN·m
Tension steel strain	0.006732	

Notes for this case

- The compression block $\alpha_1 f'_c b \beta_1 c$ and the compression steel $A'_s f'_s$ (less the concrete it displaces) balance the tension steel $A_s f_s$; both steel stresses follow from the strain profile, so the compression steel may or may not yield. Factors α_1, β_1, φ and limits on steel come from the design code you use.
- The compression steel does not yield at the ultimate state.

Formula and method

$$\alpha_1 f'_c b \beta_1 c + A'_s(f'_s - \alpha_1 f'_c) = A_s f_s, \quad M_n = \alpha_1 f'_c b a \left(d - \frac{a}{2}\right) + A'_s(f'_s - \alpha_1 f'_c)(d - d')$$

Variables

f'_c	Concrete strength	Pa
f_y	Steel yield strength	Pa
b	Beam width	m
d	Effective depth to the tension steel	m
d'	Depth to the compression steel	m

A_s	Tension steel area	m²
A'_s	Compression steel area	m²
α_1	Stress block intensity factor	-
β_1	Stress block depth factor	-
ε_{cu}	Ultimate concrete strain	-
E_s	Steel modulus	Pa
ϕ	Strength reduction factor	-
c	Neutral axis depth	m
f_s	Tension steel stress	Pa
f'_s	Compression steel stress	Pa
M_n	Nominal moment capacity	N·m
ϕM_n	Design moment capacity	N·m
ε_s	Tension steel strain	-

Method and standards

Doubly reinforced beam.

Assumptions and limits

- Plane sections; rectangular stress block; elastic-perfectly plastic steel.

References

Equivalent rectangular stress block with strain compatibility

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/doubly-reinforced-beam-capacity

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Reopens the calculator with the inputs of this report.