Composite Steel–Concrete Beam: Plastic Neutral Axis and Moment

Plastic neutral axis and plastic moment of a steel I-beam with a concrete slab in full shear connection, with the axis in the slab or in the top flange.

Method: Rigid-plastic analysis of composite sections

Input parameters

Unit system: SI

Parameter	Value	Unit
Steel beam area	5,380.0	mm²
Steel beam depth	350.00	mm
Top flange width	140.00	mm
Top flange thickness	12.200	mm
Steel design strength	250.00	MPa
Effective slab width	1.5000	m
Slab thickness	120.00	mm
Concrete stress-block strength	17.000	MPa

Calculated results

Parameter	Value	Unit
Slab compressive force	1,345.0	kN
PNA depth below slab top	52.745	mm
PNA location (0 slab, 1 top flange)	0	
Plastic moment	361.30	kN·m

Notes for this case

• PNA in the slab: x = A_sf_y/(f_cd·b_eff), M_p = A_sf_y(t_s + h/2 − x/2) (symmetric steel section). Full shear connection is assumed: check the studs carry A_sf_y between zero and maximum moment.

Formula and method

$$x = \frac{A_s f_y}{f_{cd} b_{eff}}, \quad M_p = A_s f_y \left(t_s + \frac{h}{2} - \frac{x}{2} \right) \quad (x \le t_s)$$

Variables

A_s	Steel beam area	m²
h	Steel beam depth	m
b_f	Top flange width	m
t_f	Top flange thickness	m
f_y	Steel design strength	Pa
b_{eff}	Effective slab width	m
t_s	Slab thickness	m
f_{cd}	Concrete stress-block strength	Pa
C_c	Slab compressive force	N
y_{pna}	PNA depth below slab top	m

case	PNA location (0 slab, 1 top flange)	-
M_p	Plastic moment	N·m

Method and standards

Composite section.

Assumptions and limits

- Doubly symmetric steel section; full shear connection; concrete tension ignored.

References

Rigid-plastic analysis of composite sections

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/steel/composite-beam-plastic-moment

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.