Three-Hinged Parabolic Arch: Thrust and Moments

Horizontal thrust, support reactions and bending moment under a point load of a three-hinged parabolic arch carrying a uniform load and a point load.

Method: Three-hinged arch statics

Input parameters

Unit system: SI

Parameter	Value	Unit
Span	30.000	m
Rise at the crown hinge	6.0000	m
Uniform load over the full span (horizontal)	15.000	kN/m
Point load	80.000	kN
Point load position from the left support	8.0000	m

Calculated results

Parameter	Value	Unit
Horizontal thrust	334.58	kN
Left vertical reaction	283.67	kN
Right vertical reaction	246.33	kN
Bending moment under the point load	219.02	kN·m
Resultant reaction at the left springing	438.65	kN

Notes for this case

• A three-hinged arch is statically determinate: the vertical reactions follow from beam statics and the horizontal thrust from zero moment at the crown hinge. A parabolic arch y = 4hx(L − x)/L² under a uniform load over the full span carries it in pure compression (thrust wL²/8h, no bending); a point load adds bending, M = (beam moment) − H·y. Flatter arches give larger thrust, which the abutments or a tie must resist.

Formula and method

$$H = \frac{V_A \frac{L}{2} - \frac{wL^2}{8} - P\left(\frac{L}{2} - a\right)^+}{h}, \quad M_P = V_A a - \frac{wa^2}{2} - Hy(a)$$

Variables

L	Span	m
h	Rise at the crown hinge	m
w	Uniform load over the full span (horizontal)	N/m
P	Point load	N
a	Point load position from the left support	m
H	Horizontal thrust	N
V_A	Left vertical reaction	N
V_B	Right vertical reaction	N
M_P	Bending moment under the point load	N·m
R_A	Resultant reaction at the left springing	N

Method and standards

Three-hinged arch.

Assumptions and limits

- Parabolic axis; loads vertical; hinges frictionless.

References

Three-hinged arch statics

Report details

Report reference	FCC-F4CQ-HBC5 (the same inputs always give the same reference)
Generated	23 November 2026, 18:08 UTC
Calculator	Three-Hinged Parabolic Arch: Thrust and Moments
Method last reviewed	17 November 2026
Software release	FireCAD Calc, release of 22 November 2026
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/three-hinged-parabolic-arch

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Reopens the calculator with the inputs of this report.