Three-Hinged Parabolic Arch: Thrust and Bending Moment

Support reactions, horizontal thrust and bending moment at a section of a three-hinged parabolic arch under a uniform load over the span and a point load.

Method: Statics of the three-hinged arch (Timoshenko and Young, Theory of Structures, 2nd ed. (McGraw-Hill))

Input parameters

Unit system: SI

Parameter	Value	Unit
Span	20.000	m
Rise at the crown	4.0000	m
Uniform load over the span	10.000	kN/m
Point load	40.000	kN
Point load distance from the left support	5.0000	m
Section distance from the left support	5.0000	m

Calculated results

Parameter	Value	Unit
Left vertical reaction	130.00	kN
Right vertical reaction	110.00	kN
Horizontal thrust	150.00	kN
Arch height at the section	3.0000	m
Bending moment at the section	75.000	kN·m

Notes for this case

• Parabolic axis y = 4hx(L − x)/L². Under a uniform load over the whole span the parabolic arch has no bending (funicular shape): the moment comes only from point loads. Positive moment is sagging.

Formula and method

$$H = \frac{M_{crown}}{h}, \quad M_x = V_A x - \frac{w x^2}{2} - P\langle x - a\rangle - H y, \quad y = \frac{4hx(L-x)}{L^2}$$

Variables

L	Span	m
h	Rise at the crown	m
w	Uniform load over the span	N/m
P	Point load	N
a	Point load distance from the left support	m
x	Section distance from the left support	m
V_A	Left vertical reaction	N
V_B	Right vertical reaction	N
H	Horizontal thrust	N
y	Arch height at the section	m
M_x	Bending moment at the section	N·m

Method and standards

Equilibrium and crown hinge.

Assumptions and limits

- Parabolic axis; supports at the same level.

References

- Statics of the three-hinged arch (Timoshenko and Young, Theory of Structures, 2nd ed. (McGraw-Hill))

Report details

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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/civil/steel/three-hinged-arch

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Reopens the calculator with the inputs of this report.