Banked Curve: Safe Speed and Required Banking Angle

Speed for no side friction on a banked curve, the maximum speed before skidding with side friction, and the banking angle or rail superelevation for a design speed.

Method: Meriam and Kraige; Engineering Mechanics: Dynamics; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Curve radius	300.00	m
Banking angle	4.0107	°
Side friction coefficient	0.15000	
Design speed (for required banking)	80.000	km/h
Rail gauge (for superelevation)	1.6760	m

Calculated results

Parameter	Value	Unit
Speed for no side friction	51.704	km/h
Maximum speed before skidding	92.097	km/h
Banking for the design speed (no friction)	9.5285	°
Rail superelevation for the design speed	281.32	mm

Notes for this case

- Point-mass model without overturning; road and rail design use codes with comfort limits on unbalanced lateral acceleration.

Formula and method

$$v_0 = \sqrt{gR\tan\theta}, \quad v_{max} = \sqrt{gR\frac{\tan\theta+\mu}{1-\mu\tan\theta}}, \quad \tan\theta_{req} = \frac{v^2}{gR}, \quad e = \frac{Gv^2}{gR}$$

Variables

R	Curve radius	m
θ	Banking angle	rad
μ	Side friction coefficient	-
v	Design speed (for required banking)	m/s
G	Rail gauge (for superelevation)	m
v_0	Speed for no side friction	m/s
v_{max}	Maximum speed before skidding	m/s
θ_{req}	Banking for the design speed (no friction)	rad
e	Rail superelevation for the design speed	m

Method and standards

Curvilinear dynamics.

Assumptions and limits

- Point mass; steady speed.
- Rail superelevation e = Gv²/(gR) is the small-angle form (G tan θ in place of G sin θ); the difference is under 0.5 % for usual cant, larger for steep angles. Whether the required angle is practicable (cant limits) is not checked.

References

- Meriam and Kraige

- Engineering Mechanics: Dynamics
- 8th ed. (Wiley, 2015)
- ch. 3 (curvilinear motion with friction)

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/mechanical/statics-dynamics/banking-safe-speed

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.