Wind Turbine Blade Flapwise Natural Frequencies

First three flapwise natural frequencies of a blade treated as a uniform cantilever, the stiffening by rotation, and the margin to the 1P and 3P excitation.

Method: Uniform cantilever modes with Southwell rotational stiffening

Input parameters

Unit system: SI

Parameter	Value	Unit
Blade length	60.000	m
Young's modulus of the spar material	40.000	GPa
Second moment of area (equivalent uniform)	0.020000	m^4
Mass per unit length (average)	300.00	kg/m
Rotor speed	12.000	rpm
Southwell coefficient (about 1.2 for the first flap mode)	1.2000	

Calculated results

Parameter	Value	Unit
First flap frequency (non-rotating)	0.25384	Hz
Second flap frequency	1.5908	Hz
Third flap frequency	4.4542	Hz
First flap frequency rotating	0.33531	Hz
Once-per-revolution frequency	0.20000	Hz
Ratio to blade-passing frequency (three blades)	0.55885	

Notes for this case

• Uniform cantilever: f_n = (β_nL)²/(2π)·√(EI/m'L⁴) with β₁L = 1.875, 4.694, 7.855. Rotation stiffens the blade: f² = f₀² + K_s(Ω/2π)². Real blades taper, so use these as first estimates; keep frequencies clear of 1P, 3P and 6P.

Formula and method

$$f_n = \frac{(\beta_n L)^2}{2\pi}\sqrt{\frac{EI}{m' L^4}}, \quad f_{1,rot}^2 = f_1^2 + K_s\left(\frac{\Omega}{2\pi}\right)^2$$

Variables

L	Blade length	m
E	Young's modulus of the spar material	Pa
I	Second moment of area (equivalent uniform)	m^4
m'	Mass per unit length (average)	kg/m
n	Rotor speed	rad/s
K_s	Southwell coefficient (about 1.2 for the first flap mode)	-
f_1	First flap frequency (non-rotating)	1/s
f_2	Second flap frequency	1/s
f_3	Third flap frequency	1/s
$f_{1,rot}$	First flap frequency rotating	1/s
f_{1P}	Once-per-revolution frequency	1/s
$f_{1,rot}/f_{3P}$	Ratio to blade-passing frequency (three blades)	-

Method and standards

Blade modal estimate.

Assumptions and limits

- Uniform cantilever; flapwise bending only.

References

Uniform cantilever modes with Southwell rotational stiffening

Report details

Report reference	FCC-FV67-0S9J (the same inputs always give the same reference)
Generated	23 November 2026, 17:34 UTC
Calculator	Wind Turbine Blade Flapwise Natural Frequencies
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/environmental/wind-power/wind-blade-natural-frequency

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.