Block Machine Foundation: Vertical Natural Frequency and Amplitude

Vertical stiffness, natural frequency, damping ratio and steady vibration amplitude of a rigid block on an elastic half-space by Lysmer's analog.

Method: Lysmer's analog for vertical vibration

Input parameters

Unit system: SI

Parameter	Value	Unit
Block length	6.0000	m
Block width	4.0000	m
Mass of block and machine	250.00	t
Soil shear modulus	60.000	MPa
Soil Poisson's ratio	0.33000	
Soil density	1,800.0	kg/m³
Unbalanced force amplitude	20.000	kN
Operating speed	600.00	rpm

Calculated results

Parameter	Value	Unit
Equivalent radius	2.7640	m
Vertical stiffness	990,073	kN/m
Undamped natural frequency	10.016	Hz
Geometric damping ratio	0.40490	
Frequency ratio	0.99843	
Vertical amplitude	24.984	µm

Notes for this case

• Lysmer's analog: k_z = 4Gr₀/(1 − ν), mass ratio B_z = (1 − ν)m/(4ρr₀³), D_z = 0.425/√B_z, A = (F₀/k_z)/√[(1 − r²)² + (2D_zr)²]. Common practice keeps the operating frequency at least 20–30 % away from resonance and amplitudes within the machine maker's limits. Use G at the small strains of machine vibration, not static values.

Formula and method

$$k_z = \frac{4Gr_0}{1-\nu}, \quad B_z = \frac{(1-\nu)m}{4\rho r_0^3}, \quad D_z = \frac{0.425}{\sqrt{B_z}}, \quad A_z = \frac{F_0/k_z}{\sqrt{(1-r^2)^2 + (2D_z r)^2}}$$

Variables

L	Block length	m
B	Block width	m
m	Mass of block and machine	kg
G	Soil shear modulus	Pa
ν	Soil Poisson's ratio	-
ρ_s	Soil density	kg/m³
F_0	Unbalanced force amplitude	N
n	Operating speed	rad/s

r_0	Equivalent radius	m
k_z	Vertical stiffness	N/m
f_n	Undamped natural frequency	1/s
D_z	Geometric damping ratio	-
r	Frequency ratio	-
A_z	Vertical amplitude	m

Method and standards

Block foundation.

Assumptions and limits

- Rigid block on surface of elastic half-space; vertical mode only; constant force amplitude.

References

Lysmer's analog for vertical vibration

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/foundations/machine-foundation-vertical-vibration

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.