Wave Force on a Vertical Pile (Morison Equation)

Maximum drag, inertia and total wave force on a vertical cylindrical pile from the wave height, period, water depth and pile diameter, with linear wave kinematics.

Method: Morison equation with linear wave kinematics

Input parameters

Unit system: SI

Parameter	Value	Unit
Wave height	3.0000	m
Wave period	9.0000	s
Water depth	15.000	m
Pile diameter	0.80000	m
Drag coefficient (0.6–1.2)	1.0000	
Inertia coefficient (1.5–2.0)	2.0000	
Water density	1,025.0	kg/m³

Calculated results

Parameter	Value	Unit
Wavelength	95.551	m
Maximum drag force	7.0543	kN
Maximum inertia force	11.456	kN
Maximum total force	11.706	kN
Phase of the maximum before the crest (0 at the crest)	54.293	°
Keulegan–Carpenter number u_max T/D	15.587	
Diameter-to-wavelength ratio (Morison valid below about 0.2)	0.008372	

Notes for this case

• Morison: F = ∫[C_M ρ(πD²/4)u̇ + ½ρC_D D u|u|]dz from the bed to the still-water level, with linear wave kinematics. Wave crest kinematics above still water, current and marine growth are not included.

Formula and method

$$F = \int_{-d}^{0} \left[C_M \rho \frac{\pi D^2}{4} \dot{u} + \frac{1}{2} \rho C_D D u|u| \right] dz, \quad F_{max} = F_D + \frac{F_I^2}{4F_D} \ (F_I < 2F_D), \text{ else } F_I$$

Variables

H	Wave height	m
T	Wave period	s
d	Water depth	m
D	Pile diameter	m
C_D	Drag coefficient (0.6–1.2)	-
C_M	Inertia coefficient (1.5–2.0)	-
ρ	Water density	kg/m³
L	Wavelength	m
$F_{D,max}$	Maximum drag force	N
$F_{I,max}$	Maximum inertia force	N

F_{max}	Maximum total force	N
θ_{max}	Phase of the maximum before the crest (0 at the crest)	rad
KC	Keulegan–Carpenter number u_max T/D	-
D/L	Diameter-to-wavelength ratio (Morison valid below about 0.2)	-

Method and standards

Morison wave force.

Assumptions and limits

- Linear waves, slender vertical cylinder, integration to still water level.

References

Morison equation with linear wave kinematics

Report details

Report reference	FCC-SV79-VKTQ (the same inputs always give the same reference)
Generated	23 November 2026, 18:00 UTC
Calculator	Wave Force on a Vertical Pile (Morison Equation)
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/mechanical/marine/morison-wave-force-pile

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Reopens the calculator with the inputs of this report.