Pile Driving Acceptance Criteria

Projects with standard driven pile foundations specify the Gates Formula to determine nominal driving resistance. The Gates Formula is:

\[ R_u = (7 \times (E_r)^{1/2} \log_{10} (0.83 \times N)) - 550 \]

Where:
- \( R_u \) = Calculated nominal driving resistance in kiloNewtons.
- \( E_r \) = Energy rating of hammer at observed field drop height in Joules.
- \( N \) = Number of blows per 300 millimeters (maximum of 96).

In US Customary units:

\[ R_u = (1.83 \times (E_r)^{1/2} \log_{10} (0.83 \times N)) - 124 \]

Where:
- \( R_u \) = Calculated nominal driving resistance in Kips.
- \( E_r \) = Energy rating of hammer at observed field drop height in foot-pounds.
- \( N \) = Number of blows per foot (maximum of 96).

In order to verify that the proposed hammer can develop the required minimum energy as required by the specifications\(^1\), use the manufacturer’s maximum energy rating and the nominal driving resistance to calculate the maximum acceptable blow count (not exceeding 96 blows per foot which is equivalent to a penetration rate of not less than 1/8 inch per blow). Hammer data is typically submitted by the Contractor and can be found at the hammer manufacturer website or by contacting the Foundation Testing Branch (FTB). See BCM 130-1.0, Foundation Testing Branch.

When calculating the number of blows for the required nominal driving resistance, \( E_r \) can be calculated by multiplying the hammer ram weight by the observed stroke.

A simple spreadsheet (PileEquation-Gates.xls) used to calculate the \( N \) value can be found on the SC Homepage under Downloads/Forms\(^2\):

Appendix E of the Foundation Manual provides examples for calculations for minimum hammer energy, establishing a blow count chart, battered pile blow count chart, and other examples.

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\(^1\) 2010 SS, Section 49-2.01C(2), Driving Equipment, or 2006 SS Section 49-1.05, Driving Equipment.

It is important to note that:

- The *Gates Formula* uses nominal values. Nominal resistance and nominal driving resistance of a given pile are shown in the Pile Data Table on the contract plans.

- The nominal driving resistance is always equal to or greater than the nominal resistance. This is because the nominal driving resistance accounts for driving resistance through unsuitable penetrated soil layers (very soft, liquefiable, scorable, etc.) which do not contribute to the design nominal resistance.

- Even under ideal hammer operations, the energy dissipation from impact and losses to the hammer mechanism may greatly reduce the actual energy delivered to the pile during driving. Additional losses may occur due to improper or inadequate hammer use, changing fuel setting, using interchangeable ram, etc. Be aware of reductions in actual hammer energy. Using a false high hammer energy value in the *Gates Formula* will give false high nominal resistance results.

When requested by the geotechnical designer, the special provisions will include a driving system submittal section. When submitted by the Contractor, forward this submittal to the FTB for review.

The *Gates Formula* should not be used when the driven pile diameter is greater than or equal to 18-inches or the required nominal driving resistance exceeds 600 kips. In such cases the Special Provisions will include appropriate test method(s) for the verification of the axial nominal resistance during installation and the pile acceptance criteria. These tests include pile dynamic monitoring and/or a pile load test. Contact the FTB for dynamic monitoring or a pile load test.