

*Note to the Engineer: - Use this special provision on all LRFD Projects to modify the determination of driving resistance by using the Pile Driving Analyzer (PDA), static load test, or Gates Formula and require the Contractor to perform the WEAP analysis. The date in the top right hand corner is a revision date and should not be changed. In addition, delete this note when you prepare and print this special provision.*

**DEPARTMENT OF TRANSPORTATION  
STATE OF GEORGIA**

**SPECIAL PROVISION**

**PROJECT NO. , County  
P.I. NO.**

**SECTION 520—PILING**

*Delete Sub-Section 520.3.05.D.1 and substitute the following:*

**520.3.05.D.1. Determine Driving Resistance**

Drive piles in one continuous operation. Determine the driving resistance of the piling based on the method specified in the plans, which will be one of the following methods (a – c):

- a. Upon completion of the dynamic pile testing in accordance with Special Provision Section 523. The pile bearing will be determined by computing the penetration per blow with less than ¼-inch (6-mm) rebound averaged through 12 inches (305 mm) each of penetration. When it is considered necessary by the Engineer, the average penetration per blow may be determined by averaging the penetration per blow through the last 10 to 20 blows of the hammer. In soft material the driving resistance may be determined, at the Engineer’s discretion, after delaying driving operations and performing pile re-strikes.
- b. Upon completion of the loading test in accordance with Sub-Section 520.3.05.D.2.
- c. Using FHWA-modified Gates Formula as provided below. Shall not be used when driving pile to hard rock.:

$$R_{ndr} = 1.75 (E_d)^{0.5} \log_{10} (10N_b) - 100 \quad (\text{kips}) \quad \text{U.S units}$$

$$R_{ndr} = 7 (E_d)^{0.5} \log_{10} (10N_b) - 550 \quad (\text{kN}) \quad \text{S.I. units}$$

Where:

$R_{ndr}$  = nominal pile driving resistance measured during pile driving

$E_d$  = developed hammer energy. This is the kinetic energy in the ram at impact for a given blow. If ram velocity is not measured, it may be assumed equal to the potential energy of the ram at the height of the stroke, taken as the ram weight times the actual stroke (ft-lb for U.S units, kN-m for S.I. units)

$N_b$  = Number of hammer blows for 1.0 inch of pile permanent set (blows/in)

These resistance formulas apply only when:

- The hammer has a free fall.
- The head of the pile is not broomed, crushed, spalled, or excessively crimped.
- The penetration rate is reasonably uniform.

Determining driving resistance by formula is not a Pay Item. Provide the facilities for determining driving resistance by formula as an incidental part of the work.

Once the driving resistance has been determined by one of the methods noted above, do not continue to drive piles if the Engineer determines that the piles have reached practical refusal. Practical refusal is defined as 20 blows per inch with the hammer operating at the highest setting or setting determined by the Engineer and less than ¼-inch (6-mm) rebound per blow. The Engineer will generally make this determination within 2 inches (51 mm) of driving. However, the Engineer will not approve the continuation of driving at practical refusal for more than 12 inches (305 mm). When the required pile penetration cannot be achieved by driving without exceeding practical refusal, use other penetration aids such as jetting, spudding, predrilling or other methods approved by the Engineer.

- d. Wave Equation:** Use the Wave Equation Analysis for Piles (WEAP) program to evaluate the suitability of the proposed driving system chosen from the methods noted above (including the hammer, follower, capblock and pile cushions) as well as to estimate the driving resistance to achieve the pile bearing requirements and to evaluate pile driving stresses. Use the WEAP program to show that the hammer is capable of driving to a resistance equal to at least twice the factored design load plus the scour and down drag resistance (if applicable) shown in the Plans without overstressing the piling in compression or tension.

Perform the WEAP analysis with personnel who are experienced in this type work, and have performed this analysis on a minimum of 15 projects. Provide a list of the qualifications and experience of the personnel to perform the WEAP analysis for this Project.

The Engineer may modify the scour resistance shown in the plans if the dynamic pile test is used to determine the actual soil resistance through the scour zone. Also, the Engineer may make modifications in scour resistance when the Contractor proposes drilling and/or jetting to reduce the soil resistance in the scour zone.

A minimum of two weeks prior to beginning any pile driving operations, submit to the Engineer for evaluation and approval the following information on all of the proposed pile driving system(s) to be used on the Project including but not limited to:

- i. Pile driving hammer
- ii. Hammer and pile cushion types, properties and thicknesses
- iii. Drive head weight
- iv. Pile type, properties and length
- v. Other information on the driving system required by the Engineer
- vi. A WEAP program output indicating the approximate depth or elevation where the pile will achieve the bearing required

If WEAP analyses show that the hammer(s) will overstress the pile, modify the driving system or method of operation as required to prevent overstressing the pile. Resubmit the modified pile driving system information and WEAP program output to the Engineer for re-evaluation. Do not begin pile driving operations until the Engineer has approved the qualifications of the personnel, the WEAP program output, and the pile driving system(s).

Approval of the pile driving system(s) is also based on satisfactory field trials with dynamic pile testing. Obtain approval from the Engineer for the pile driving system(s) based on satisfactory field performance.

If piles require different hammer sizes, the Contractor may elect to drive with more than one size hammer or with a variable energy hammer, provided that the hammer is properly sized and cushioned, will not damage the pile, and will develop the required resistance.

For penetration of weak soils by concrete piles, use thick cushions and/or reduced stroke to control tension stresses during driving.

Office of Materials and Testing