NCDOT SPT HAMMER ENERGY MEASUREMENT REQUIREMENT

North Carolina Department of Transportation
Geotechnical Engineering Unit

Effective Date: May 7, 2012
Updated: February 7, 2017; June 25, 2018; May 1, 2019; February 25, 2020, July 13, 2022

REVISION DETAILS

Date: July 13, 2022
- Measure SPT hammer energy every 2 years instead of annually.

Date: February 25, 2020
- Item No.10 of Energy Measurement and Report Requirements has been revised.

Date: May 1, 2019
- Item No.1 of Energy Measurement and Report Requirements has been revised to match NCDOT Work Code 3060 requirement.

Date: June 25, 2018
- Use a unique boring for SPT hammer energy measurements for each drill rig.

Date: February 7, 2017
- Hammer energy measurement must be conducted by an experienced engineer for testing and data analysis. The engineer must possess Advanced rank or higher Certificate of Proficiency issued by Pile Dynamics. A copy of the certificate must be included in the report.
- SPT drives shall be at 5-foot increments between each energy measuring depth.
- Energy measurement equipment calibration frequency
- PDA raw data required
- Sample plots for reference

ENERGY MEASUREMENT TEST SITE CONSIDERATION

- Do not conduct energy measurement tests on the following sites:
  - Weathered rock (possibility of inflated energy transfer due to superimposed compressive down and up waves)
  - Very soft clay soils with a BPF < 8 (possibility of reduced energy transfer due to superimposed compressive down and tension up waves)
- Ideally, energy measurements should be acquired in materials with consistencies between 8 bpf and 50 bpf.
- Energy measurements conducted on non-NCDOT or out-of-state projects are acceptable.

ENERGY MEASUREMENT EQUIPMENT CALIBRATION FREQUENCY

ASTM D4633 Section 6.3 Frequency of Calibration states: "Calibrate force and acceleration transducers at regular time periods or at frequency of use as required in the quality assurance plan for the company, project, or as recommended by the manufacturer, or every three years whichever is least."

SPT HAMMER ENERGY MEASUREMENT FREQUENCY

- Measure SPT hammer energy every 2 years.
- Measure SPT hammer energy when SPT hammer has a major repair

ENERGY MEASUREMENT AND REPORT REQUIREMENT:

1. Hammer energy measurement shall be conducted by an engineer who has experience with Pile Driving Analyzer (PDA) and meeting NCDOT Work Code 3060 Field Engineer requirement. PDA data analysis shall be conducted by a professional engineer who has experience with PDA and CAse Pile Wave Analysis Program (CAPWAP) and meeting NCDOT Work Code 3060 Project Engineer requirement.
2. Report shall be sealed by a professional engineer registered in the State of North Carolina.
3. Report should be submitted within one (1) month after the initial test was completed.
4. Use the most current ASTM Standard D4633 "Standard Test Method for Energy Measurement for Dynamic Penetrometers" for energy measurement.
5. Report an average transferred energy in percentage as compared to the theoretical energy of a 140-pound ram falling 30 inches (ASTM D1586).
6. Energy evaluation of the hammer system is more reliable when the length L is 9 to 12 m (30 to 39 ft) or more (see Section 7.3 Note 8 of ASTM D4633). Energy measurement taken at a depth of less than 30 ft will be rejected unless a reasonable explanation is provided and accepted by Engineer.
7. Perform measurements for at least 3 depths of quality data with 5 depths preferred (see Section 7.9 of ASTM D4633).
8. Use a unique boring for SPT hammer energy measurements for each drill rig.
9. SPT drives shall be at 5-foot increments between each energy measuring depth.
10. Submit electronic file copy of the reports in portable document format (pdf). For record keeping, each hammer shall have its own individual energy measurement report. Do not lump several reports together.

ENERGY MEASUREMENT REPORT CONTENT INFORMATION:

The following are general guidelines on what information should be presented in the report. Actual report can be varied depending upon a consultant's common practice.

1. General Information

- Consultant company name
- Project number
- Project description
- Boring name
- Report date
- Test date
- Test personnel (testing and report)
- Test location: county and state

- Client information (company name, contact, address)
- Geologist or engineer name
- General description of subsurface soils

2. Introduction
- Purpose and scope of work
- Test method and test standard

3. Test Equipment
- Main test unit maker and serial number (place in main report)
- SPT Rod manufacturer, type (AW or AWJ), serial number, and dimensions – OD, ID, cross-sectional area, and typical length in main report (place in main report)
- Strain gauges and accelerometers manufacturer, serial number, and certificate of calibration (place in appendix)

4. Drill Rig Information
- Owner information (name, contact, address, phone number)
- Manufacturer
- Model
- Type (Trailer, ATV, Track, Truck, …)
- Serial number (manufacturer)
- Equipment number (NCDOT rigs)
- Rig operator

5. Hammer Information
- Type (automatic, manual, …)
- Ram weight
- Drop height

6. Boring Information
- County and State
- TIP number or state project number, if applicable
- Station and offset, if applicable
- Bore log report or field bore log, if available

7. Energy Measurement Method, Results, and Rating
- Method – most current ASTM D4633
- Results – include the following information
    - LE: Length below gauges to pile bottom
    - LP: Length of penetration (at the end of driving)
    - BPF (or BLC): Blow count per foot (including blow count per each 6-inch increment)
    - BPM: Blow per minute
    - AET: Average transfer energy, in ft-lbs or kip-ft
    - ETR: Energy transfer ratio, in percentage
    - Soil sample description
- Rating – Report an energy measurement rating, in percentage

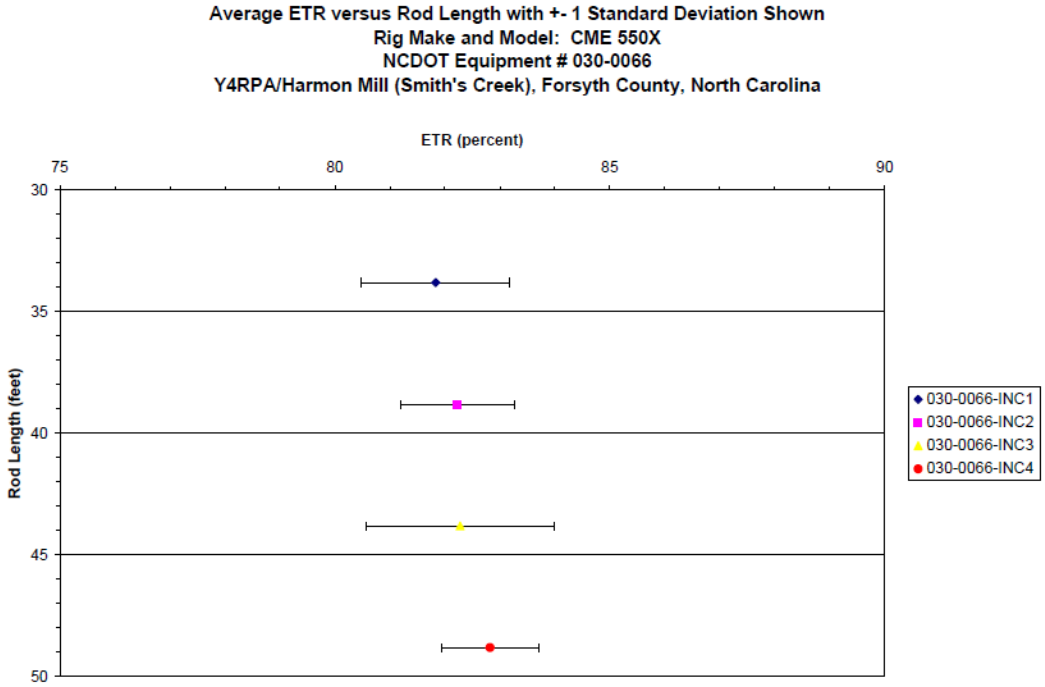
8. Attachments

The following items shall be included in your report. Incomplete submittal may be rejected.

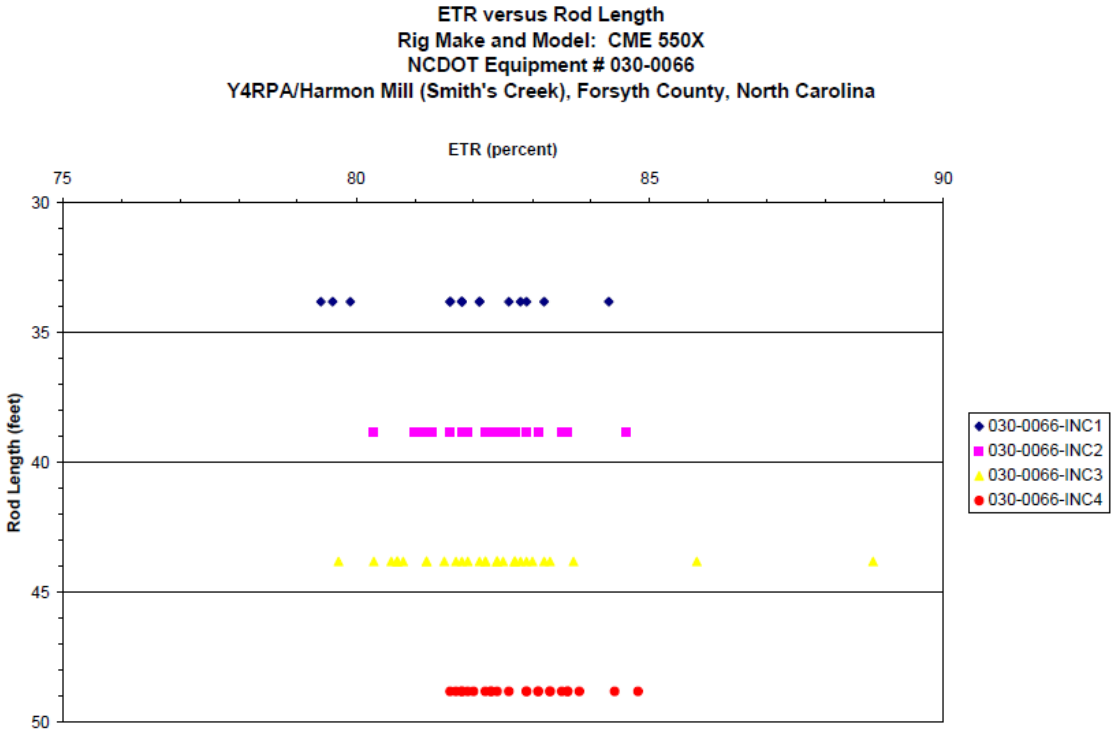
- Overview of SPT hammer energy measurement method
- Plots show –
    - Average ETR versus rod length
    - ETR versus rod length
- Plots show –
    - FMX: Penetration vs. maximum force
    - EFV: Penetration vs. energy of FV
    - ETR: Penetration vs. energy transfer ratio
    - BPF (or BLC): Penetration vs. Blow count per foot
    - And any other additional information
- Table shows depth versus the following quantities –
    - BPF (or BLC): blow count per foot
    - BPM: blow count per minute
    - EFV: energy of FV
    - ETR: energy transfer ratio
    - FMX: maximum force
    - VMX: maximum velocity
    - DMX: maximum displacement
    - CSX: maximum compression stress
    - DFN: final displacement
    - And any other additional information (or quantities)
- Plot of typical wave forms showing the following information
    - force and velocity vs. time
    - project information
    - BN: blow count
    - All quantity results
    - Pile properties
    - Sensors information
- PDA Raw Data
    - Raw data for each SPT hammer energy measurement test shall be provided either by email communication or on a CD or USB flash drive for NCDOT's review and evaluation.
    - For clarity, make sure to store raw data for each rig separately with a unique number assigned to the rig calibrated.
- Boring log or field log, if available
- All information related to accelerometer and strain gauge serial numbers and calibration information
- A copy of Certificate of Proficiency issued by Pile Dynamics based on Dynamic Measurement and Analysis Proficiency Test.

SAMPLE PLOTS

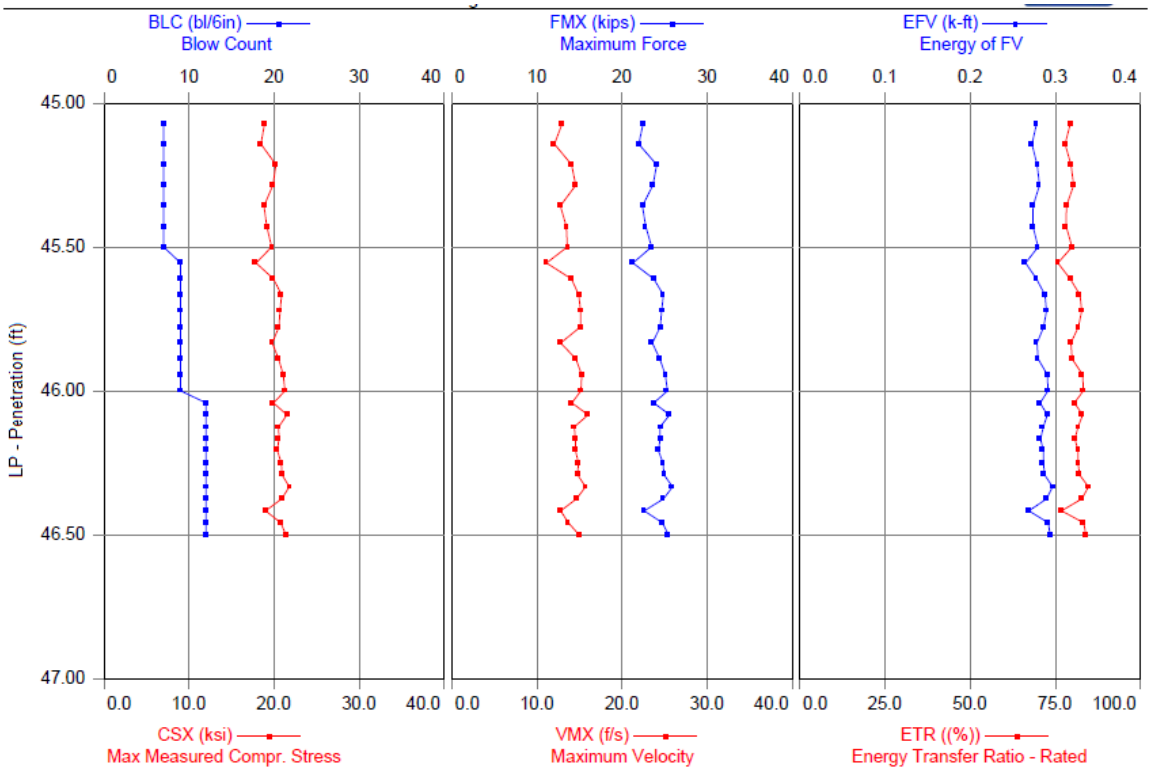
- **Plot: Average ETR versus Rod Length**



- **Plot: ETR versus Rod Length**



- **Plot: FMX, EFV, ETR, BPF (or BLC), etc.**



- **Plot: Typical Wave Forms**