2012 Road School

Dynamic Cone Penetrometer (DCP)

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Outline

- Current Earth Work Specifications
- INDOT Quality Control (QC) issues
- Uniform Compaction & Design Issues
- Use of Dynamic Cone Penetrometer for Earthwork (Reoccurring Spec's.)
- DCP use in 2011 Construction Season
- Other State's Spec's
- Conclusions
- Notes
- Questions

Current Earthwork Specifications

Requirements:

Compaction: 95% of Max Density within of -3 to +1 of Optimum Moisture Content

Lab Testing: Std. Proctor Test (T-99) for Dry Density vs water content curve.

Modified Proctor (T-180) for Railroad Approach backfill

Field Testing: Nuclear Gauge, Sand Cone, Moisture Test by Stove top & Microwave, and 1-Point Proctor Test

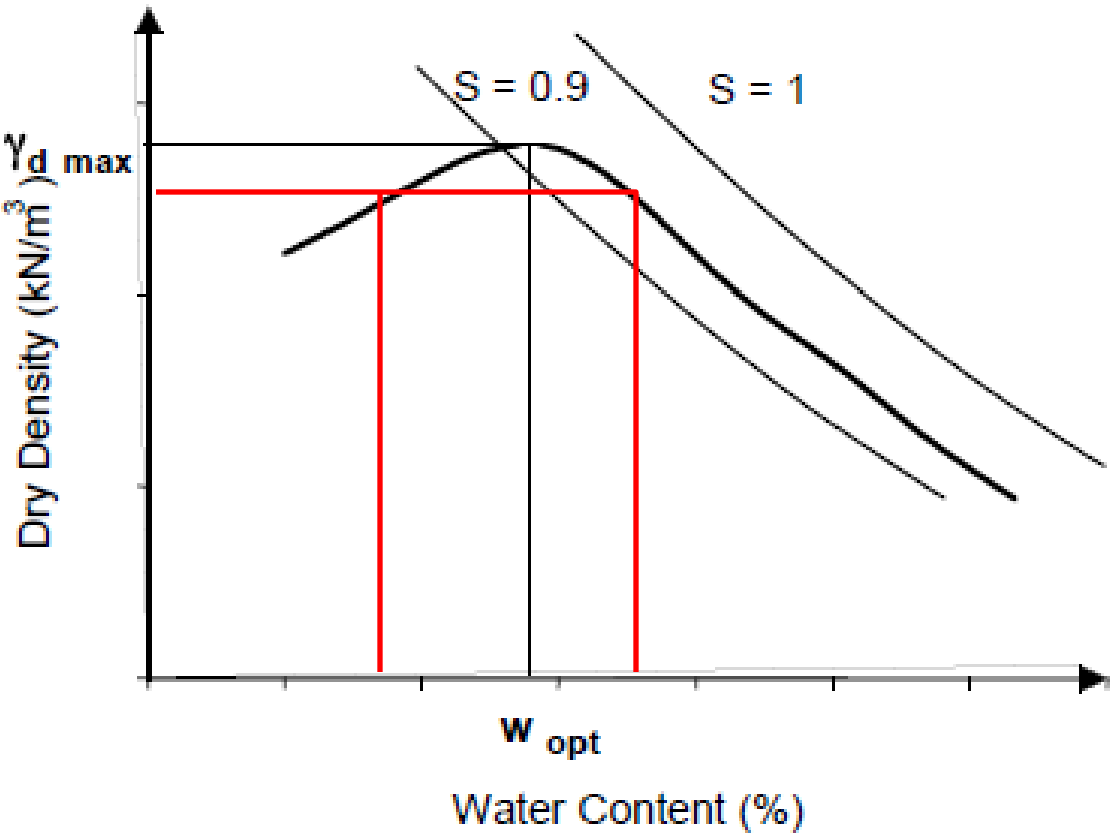
Moisture Density Curve: Y:\Div.material& Test\Moisture Density Curve

INDOT Quality Control Issues

- INDOT provides QC for compaction
- Takes several days for lab testing (Standard Proctor, etc.)

INDOT QC Issues (Con't.)

Std. Proctor Curve



INDOT QC Issues (Con't.)

- Variation of Soils during placement: Required additional one-point Proctor tests (AASHTO T-272)
- Safety issues: The use of Nuclear Gauge
- Time consuming: Sand Cone.
- Low production: contractors waiting for INDOT testing & approval

Uniform Compaction & Design Issues

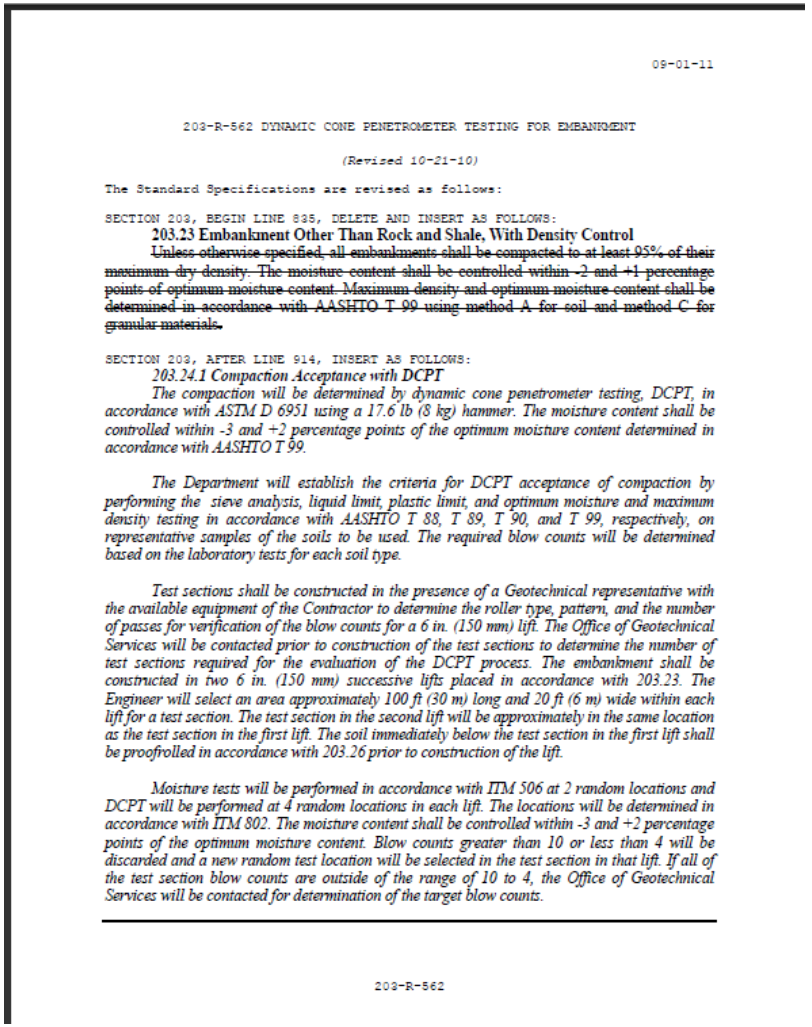
Soil Variability --example

Grain Size Distribution	Sta. 33+00	Sta. 34+00	Sta. 35+00
	% passing	% passing	% passing
#10	96	97	95
#40	85	89	85
#200	52	56	52.5
Liquid Limit	27	34	29
Plastic Limit	17	19	18
ASTM	CL	CL	CL
Proctor Density (lb/ft^3)	111.4	109.9	117.3
Optimum Moisture (%)	15.7	16.8	13.0

Note:
No uniform compaction if the target number is not recognized.

Use of Dynamic Cone Penetrometer for Earthwork (Recurring Spec's.)

- http://www.in.gov/dot/div/contracts/standards/rsp/sep11/200/203-R-562%20110901.pdf



09-01-11

203-R-562 DYNAMIC CONE PENETROMETER TESTING FOR EMBANKMENT

(Revised 10-21-10)

The Standard Specifications are revised as follows:

SECTION 203, BEGIN LINE 835, DELETE AND INSERT AS FOLLOWS:

203.23 Embankment Other Than Rock and Shale, With Density Control

~~Unless otherwise specified, all embankments shall be compacted to at least 95% of their maximum dry density. The moisture content shall be controlled within -2 and +1 percentage points of optimum moisture content. Maximum density and optimum moisture content shall be determined in accordance with AASHTO T 99 using method A for soil and method C for granular materials.~~

SECTION 203, AFTER LINE 914, INSERT AS FOLLOWS:

203.24.1 Compaction Acceptance with DCPT

The compaction will be determined by dynamic cone penetrometer testing, DCPT, in accordance with ASTM D 6951 using a 17.6 lb (8 kg) hammer. The moisture content shall be controlled within -3 and +2 percentage points of the optimum moisture content determined in accordance with AASHTO T 99.

The Department will establish the criteria for DCPT acceptance of compaction by performing the sieve analysis, liquid limit, plastic limit, and optimum moisture and maximum density testing in accordance with AASHTO T 88, T 89, T 90, and T 99, respectively, on representative samples of the soils to be used. The required blow counts will be determined based on the laboratory tests for each soil type.

Test sections shall be constructed in the presence of a Geotechnical representative with the available equipment of the Contractor to determine the roller type, pattern, and the number of passes for verification of the blow counts for a 6 in. (150 mm) lift. The Office of Geotechnical Services will be contacted prior to construction of the test sections to determine the number of test sections required for the evaluation of the DCPT process. The embankment shall be constructed in two 6 in. (150 mm) successive lifts placed in accordance with 203.23. The Engineer will select an area approximately 100 ft (30 m) long and 20 ft (6 m) wide within each lift for a test section. The test section in the second lift will be approximately in the same location as the test section in the first lift. The soil immediately below the test section in the first lift shall be proofrolled in accordance with 203.26 prior to construction of the lift.

Moisture tests will be performed in accordance with ITM 506 at 2 random locations and DCPT will be performed at 4 random locations in each lift. The locations will be determined in accordance with ITM 802. The moisture content shall be controlled within -3 and +2 percentage points of the optimum moisture content. Blow counts greater than 10 or less than 4 will be discarded and a new random test location will be selected in the test section in that lift. If all of the test section blow counts are outside of the range of 10 to 4, the Office of Geotechnical Services will be contacted for determination of the target blow counts.

203-R-562

Use of Dynamic Cone Penetrometer for Earthwork (Recurring Spec's.) (Con't.)

Lab Testing Requirements for borrow:

Sample from the representative soils from project limit or borrow pit:

Sieve Analysis.....AASHTO T-88, T-89, ASTM D-1140
Atterberg Limits.....AASHTO T-90
Density and Moisture.....AASHTO T-99
Loss on Ignition.....AASHTO T-267
Ca/Mg Carbonate.....ITM-507

DCP use in 2011 Construction Season

Classification	Lab	Field	Total Count	Total > 10 %	Total > 20 %
A-1, A-2, A-3 (0 – 12 in.)	8 or 9	13.97	1795	95.1%	84.8%
A-4 (0 – 12 in.)	8 or 9	14.84	1832	96.1%	91.0%
A-6, A-7 (0 – 6 in.)	4	6.91	649	88.8%	88.8%

SPR-3009 (JTRP)

Recommendations:

1. A-2, A-3, b-borrow or soils with sandy behavior (PI < 8)

(N_{DCP}) req/ 0~12” = 4.0 in (*Cu*) + 2.6

Cu = coefficient of uniformity

(N_{DCP}) req/0~12” = minimum required blow count for 0 – 12 inch

SPR-3009 (JTRP) Con't.

2. Silty and Clay Soils (PI > 8)

   (N_{DCP}) req/ 0 ~6" = 17 exp [-0.07(PI)(% passing #40)/100]

   (N_{DCP}) req/ 0~ 6" = minimum required blow count for 0 – 6 inch

   PI – Plasticity Index

Other States' Spec's

DCP Specifications of Other States

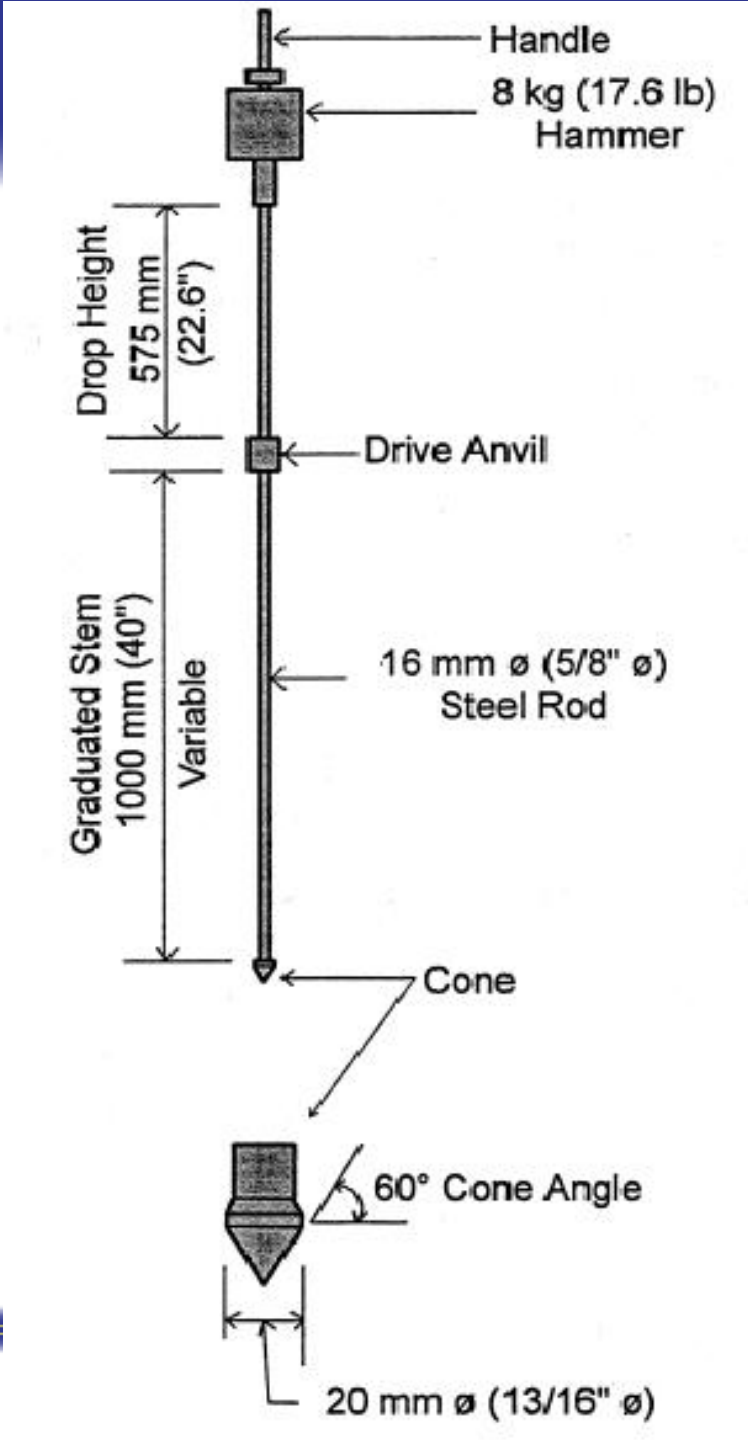
Material Type	Blow Counts Minnesota DOT	Blow Counts Iowa DOT
Silty/clay Subgrade	6	2
Select Granular Aggregate	21	----
Select Granular Subgrade	----	4
Class 3 Special Gradation Granular Base Materials	6	3

DCP – Dynamic Cone Penetrometer

1-17.6 lb Drop hammer

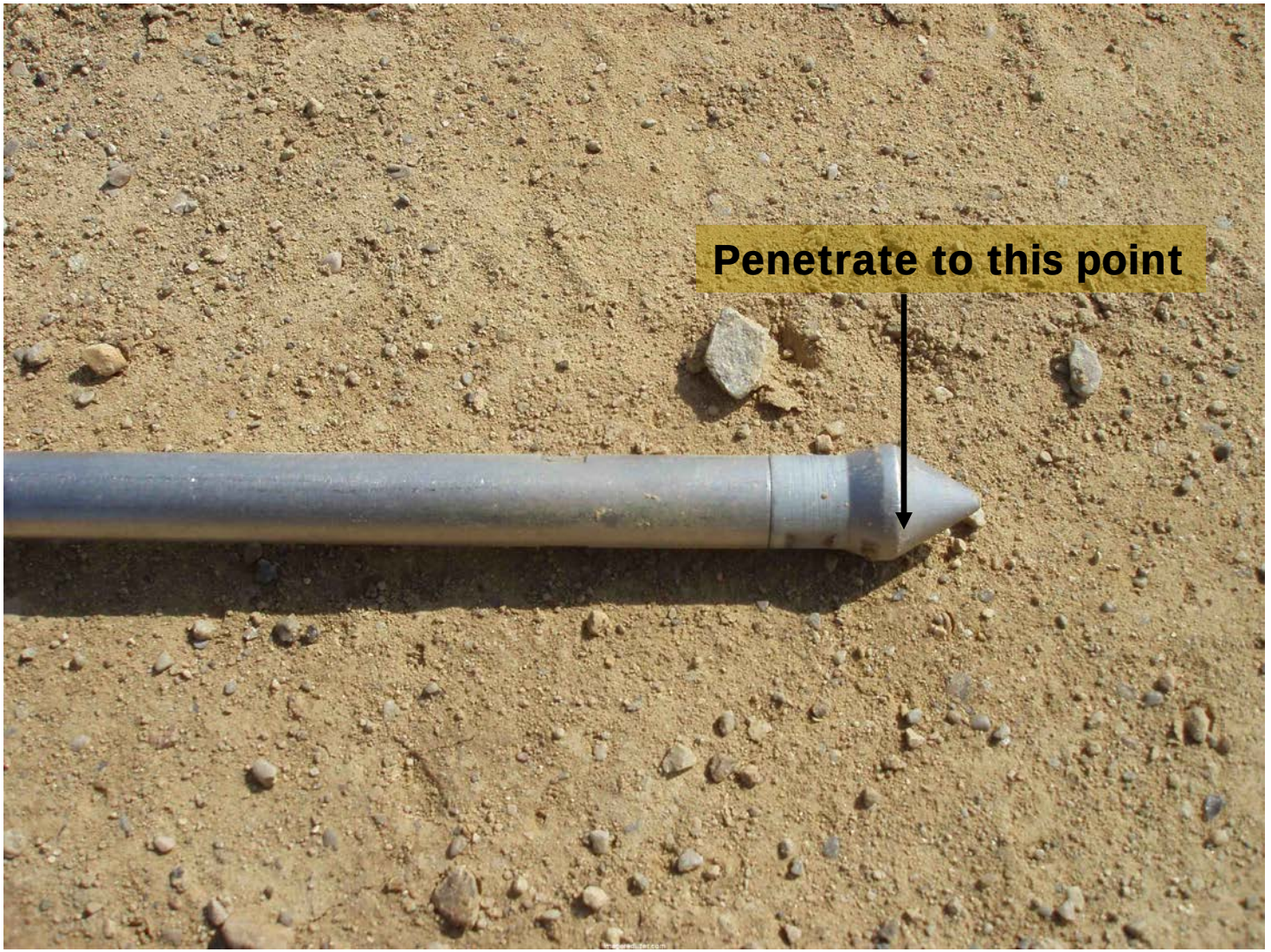
2-22.6 in Drop Height

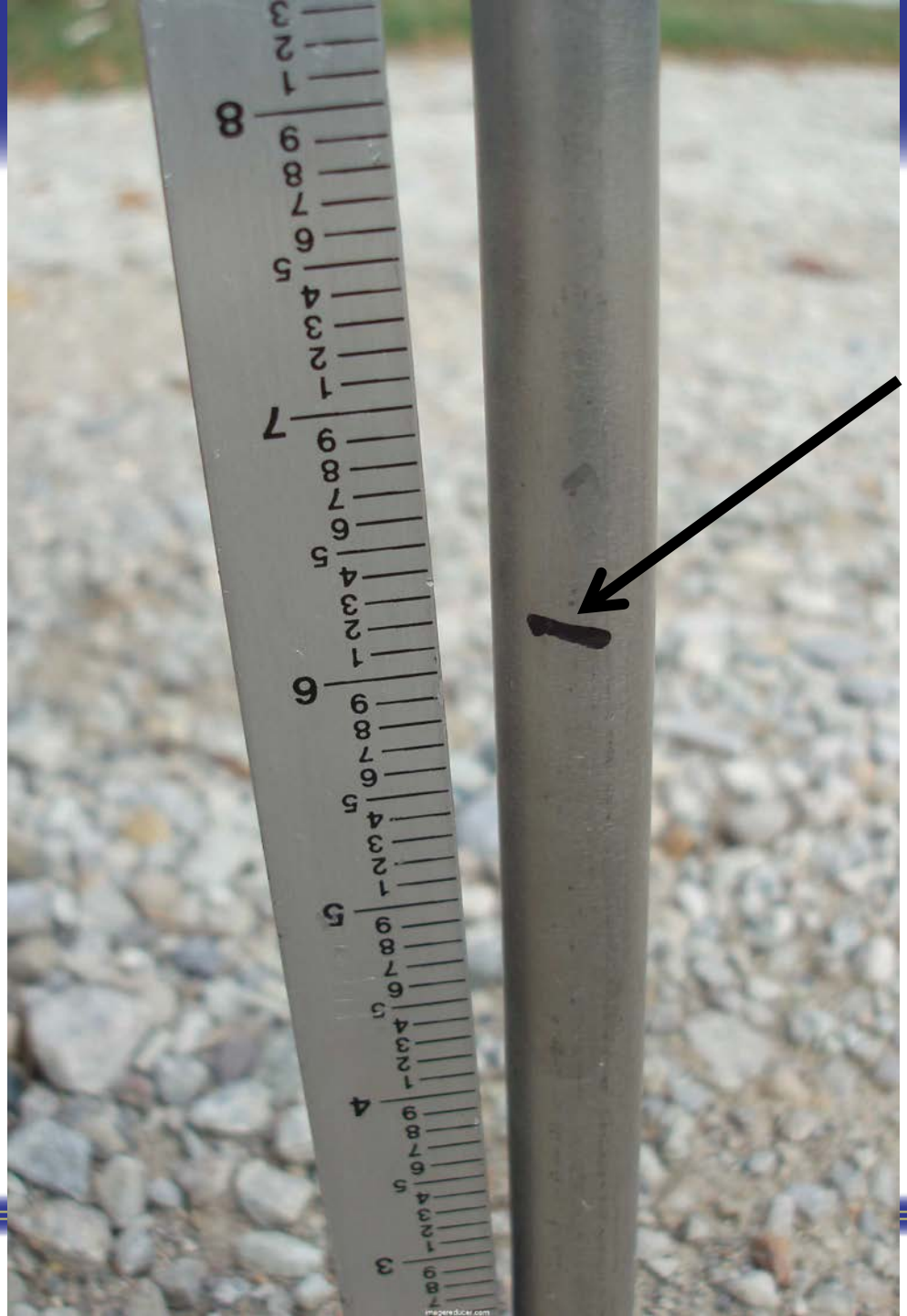
3-60^{o} angle



Disposable DCP cone slides on end of attachment

If using a non-disposable cone penetrate the cone to the top of the cone apex





6” Mark on rod

Record the number of hammer drops it takes to reach 6 in.

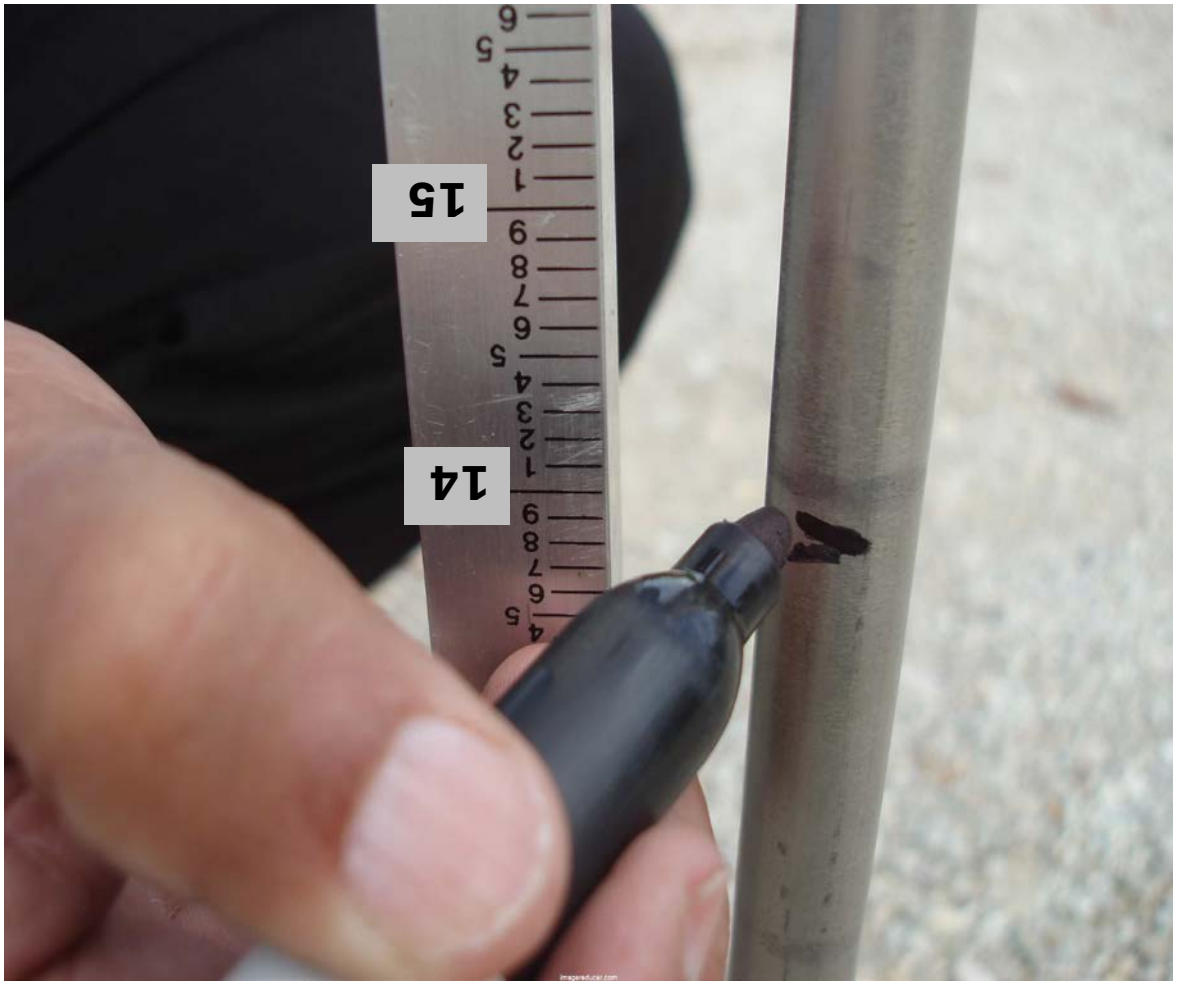
Section 215.09 - Compaction

•Acceptance testing shall be performed with a Dynamic Cone Penetrometer (DCP) in accordance with ASTM D-6951. The chemically modified soil lift shall meet the following requirements for compaction:

1. A minimum DCP blow count of 17 for the top 6 in. of a 14 in. lift
2. A minimum DCP blow count of 16 for the bottom 8 in. of a 14 in. lift
3. A minimum DCP blow count of 20 for an 8 in. lift
4. A minimum of 1 passing test for each 1,500 ft of chemically modified soil for each two-lane pavement

***Suggestion: Terminate DCP test at 25 blow counts even if DCP does not penetrate to a specified depth of 6 or 8 in. in Cement-modified soils.**

For lime modified soils make another mark at 14 inches



Record the drops from 6 in. to 14 in.

Conclusions:

1. **The DCP is portable, easy to operate, and requires no electronics. It takes only a couple of minutes to learn how to use the DCP.**
2. **It is an effective tool to identify weak layers when penetration rates are plotted vs. depth.**
3. **DCPs can take deeper measurements.**
4. **DCP readings are not affected by minor shrinkage cracks in soils.**
5. **CBR and resilient modulus values can be reliably predicted using DCP test results. Hence, the stiffness of the materials can be represented by blow counts or DCP penetration rates.**

Conclusions, Con't.

6. Improve inspector safety
7. Directly related to Design
8. Very sensitive to water content
9. Increase compaction uniformity
10. Increase productivity due to less time per test
11. DCP is a good indicator of strength and moisture conditions.
12. Reduce the reliance of the Nuclear Gauge
13. Improve documentation and reporting.

Conclusions, Con't.

- DCP is suitable for:
  - Cohesive Soils
  - Granular Soils w/Aggregate Passing ¾ in., b-borrow and structural backfill sizes 1 in., ½ in., No. 4 and No. 30
  - Chemically Modified Soils

Notes:

- If the DCP is bouncing and does not appear to be penetrating it could be on a rock. If that is the case remove the DCP and start another test nearby.
- In most cases disposable cones are recommended. The disposable cones cause less wear and tear on the equipment when it is being removed from the ground.

Questions?