FHWA-NJ-2018-009

Implementation Plan for Alternatives to Nuclear Density Testing

FINAL REPORT
January 2018

Submitted by

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Department of Transportation
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Federal Highway Administration

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16. Abstract:
The primary goal of this study was to develop an implementation plan for the Dynamic Cone Penetrometer (DCP) device and specifications. In an effort to reach this goal, two field demonstrations of the DCP were conducted for contractors and NJDOT personnel on active NJDOT job sites. Each job site also conducted compaction quality testing using the nuclear density gauge (NDG) in order to evaluate the accuracy of the previously developed DCP compaction quality specifications. At the conclusion of each field demonstration, questionnaires were distributed to the attendees to obtain feedback regarding feasibility of implementation, difficulty of operation, overall quality of the demonstration, etc. Finally, a training video was developed for any additional personnel that was unable to attend the field demonstrations. This study showed success in introducing the DCP to relevant personnel as a majority of the personnel marked 4 out of 5 (5 being the highest) with regards to comfort in operating the DCP after training. Additionally, the DCP and NDG agreed in their compaction quality findings giving further validation to use and implementation of the DCP. Based on the feedback from the questionnaires, it was also recommended that a portion (or total) automation of the DCP would be preferable for widespread implementation due to physical requirements needed to operate the DCP device.

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BACKGROUND

In the state of New Jersey (NJ) the nuclear density gauge (NDG) is used as the method to determine if the compaction quality of a soil layer is passing or failing. Alternative methods for determining the compaction quality because the NDG is (1) expensive, (2) difficult to maintain and transport, and (3) an overall safety hazard. Several types of compaction tests were evaluated through an NJDOT funded project (Alternatives to Nuclear Density Testing, Report No. FHWA-NJ-2016-003). From this project, it was concluded that the Dynamic Cone Penetrometer (DCP) was the best alternative non-nuclear compaction testing method. To facilitate using the DCP, a draft standard specification document was developed; governing how the DCP can be used to evaluate the quality of compacted unbound (aggregate and soil) pavement layers. To advance NJDOT's implementation efforts for the outcomes of the "Alternatives to Nuclear Density Testing" project, this study was initiated with the goal of providing training to NJDOT personnel and contractors in the State of New Jersey on how to use the DCP and the developed specifications.

The primary objective was to identify and evaluate non-nuclear-based testing methods for replacing the nuclear density gauge (NDG) during the acceptance of compacted soil and quarry produced aggregate pavement layers. This objective was successfully fulfilled through a funded NJDOT project (Alternatives to Nuclear Density Testing; Report No. FHWA-NJ-2016-003) and the dynamic cone penetrometer (DCP) was selected as the most suitable device for replacing the NDG. This conclusion generated a secondary goal focusing on a well-defined plan for advancing the efforts of implementing the DCP device and specifications developed as part of the referenced NJDOT project.

OBJECTIVES

The specific objectives to be fulfilled as part of this project are summarized as follows:

- Conduct field demonstrations on how to use the developed DCP specifications in the field.
- Collect additional field testing results to refine and improve developed specifications from these field sections.
- Provide assistance and support to contractors and NJDOT when utilizing the DCP as a quality control tool for evaluating the quality of compacted unbound pavement layers. This involves preparing a training video on how to use the DCP and specifications developed as part of FHWA-NJ-2016-003.

FIELD SITES

First Field Visit

Location

The first field visit was made to NJDOT field office located at 1149 Bloomfield Ave Suite E Clifton, NJ 07012 and the location of the job site was Rt. 3 & 46, Valley Rd. & Notch Rd. Clifton, NJ 07012. The project was a grading and paving of a ramp with approximately 2000 SY. Photos taken during the site visit are presented in Appendix B.

Materials

The compaction testing was conducted on a six inch dense-graded aggregate (DGA) base layer that had been laid and compacted prior to our visit. The gradation and optimum moisture content were provided by NJDOT senior engineer and other attendees on-site. A summary of the DGA base layer is provided in Table 1. The actual moisture content of the layer was determined by drying soil samples at Rowan University laboratory. The optimum moisture content difference was found to be -4.06% and a summary of the moisture content laboratory data is provided in Table 2.

Table 1: Base layer information for Rt. 3 & Rt. 46 Ramp

Layer Material	Dense-Graded Aggregate (DGA)
Gradation:	
% Passing No. 4 Sieve	41%
% Passing No. 200 Sieve	4.1%
Optimum Moisture Content	11.6%

Table 2: Moisture content determination for Rt. 3 & Rt. 46 Ramp

Test Location	In-situ wt. (g)	Oven dry wt. (g)	MC	OMC Diff
1	93.65	88.2	6.2%	-5.4%
2	142.9	135.3	5.6%	-6.0%
3	98.1	93.1	5.4%	-6.2%
4	94.2	86.6	8.8%	-2.8%
5	147.3	134.1	9.9%	-1.8%
6	125.87	115	9.5%	-2.2%
7	210	194.1	8.2%	-3.4%
8	197.8	185.6	6.6%	-5.0%
9	175	163.7	6.9%	-4.7%
10	163.6	150.8	8.5%	-3.1%

Compaction Test Results

DCP testing was conducted on ten random locations throughout the jobsite. The number of blows to penetrate the six inch DGA layer varied from a maximum of 59 blows to a minimum of 6 blows with an average of approximately 26 blows. A detailed description of the number of blows needed to penetrate the base layer at each test location is provided in Table 3.

Table 3: DCP field results for Rt. 3 & Rt. 46 Ramp

Test Location	Blows	Depth (in)	DCP value (blows/in.)
1	24	6	4
2	21	6.1	3.4
3	59	6	9.8
4	34	6	5.7
5	6	6	1
6	33	6	5.5
7	27	6.1	4.4
8	33	6	5.5
9	11	6.1	1.8
10	14	6.2	2.6

Questionnaire

A short questionnaire was distributed to all attendees at the end of the field visit to measure the effectiveness of the field demonstration and better understand the response of NJDOT personnel to the implementation of the DCP. A majority of the attendees marked a 4 or 5 (out of 5) on the presenter's ability to present the information and stated that they feel comfortable using the DCP for compaction testing. The Clifton attendees felt the price was low and it's very easy to use and process data. The issues that were voiced were that they felt it would be affected by environmental factors/moisture content and time needed to conduct the testing is longer than the NDG. All questionnaires are provided in Appendix A.

Conclusions

Using the specifications provided in FHWA-NJ-2016-003 report along with gradation and moisture content properties, the minimum DCP value needed for the base layer was 4.1 blows per inch. The in-situ average DCP value for the job site was 4.34 blows per inch. Therefore, the compaction quality of the job site would be considered passing. This was verified with the NDG, which also determined that compaction quality was passing; therefore, the DCP and currently developed specifications were considered successful.

Second Field Visit

Location

The second field visit was made to NJDOT field office located at 614 Frelinghuysen Ave. Newark, NJ 07114 and the location of the job site is Rt. 1 and Rt. 9 Haynes Ave. Newark, NJ 07114. Photos taken during the site visit are presented in Appendix B.

Materials

The compaction testing was conducted on a six inch dense-graded aggregate (DGA) base layer that had been laid and compacted prior to our visit. No excessive moisture was visually seen on-site and soil samples were taken for precise moisture content determinations at Rowan University. The gradation, optimum moisture content, and NDG results were provided by NJDOT personnel on site. A summary of the

properties of the DGA base layer is provided in Table 4. The moisture content of the layer was determined by drying soil samples at the Rowan University laboratory. The optimum moisture content *difference* was found to be -2.01% and a summary of the moisture content laboratory data is provided in Table 5.

Table 4: Base layer information for Rt. 1 and Rt. 9 Haynes Ave.

Layer Material	Dense-Graded Aggregate (DGA)
Gradation:	
% Passing No. 4 Sieve	46%
% Passing No. 200 Sieve	5.1%
Optimum Moisture Content	8.4%

Table 5: Moisture content determination for Rt. 1 and Rt. 9 Haynes Ave.

Test Location	In-situ wt. (g)	Oven dry wt. (g)	MC	OMC Diff
1	106	100.6	5.4%	-3.0%
2	92	85.4	7.7%	-0.7%
3	98	91.4	7.2%	-1.2%
4	89	82.3	8.1%	-0.3%
5	99	93	6.5%	-1.9%
6	89	83.3	6.8%	-1.6%
7	96	90.9	5.6%	-2.8%
8	110	105.3	4.5%	-3.9%
9	102	97.7	4.4%	-4.0%
10	100	92.9	7.6%	-0.8%

Compaction Test Results

DCP testing was conducted on ten random locations throughout the jobsite. The number of blows to penetrate the six inch DGA layer varied from a maximum of 41 blows to a minimum of 7 blows with an average of approximately 23 blows. A detailed description of the number of blows needed to penetrate the base layer at each test location is provided in Table 6.

Table 6: DCP field results for Rt. 1 and Rt. 9 Haynes Ave.

Test Location	Blows	Depth (in)	DCP Value (blows/in.)
1	41	6.05	6.8
2	22	6.2	3.5
4	24	6	4
9	7	6	1.2
3	14	6	2.3
6	19	6.2	3.1
7	33	6	5.5
8	18	6.2	2.9
9	33	6.1	5.4
10	21	6.1	3.4

Questionnaire

Similar to the first site visit, a short questionnaire was distributed to all attendees at the end of the field visit. The majority of the attendees marked a 4 or 5 (out of 5) on the presenter's ability to present the information and stated that they feel comfortable using the DCP for compaction testing. The attendees at the Newark meeting, however, strongly felt this was not an effective method of compaction testing. This was mainly attributed to the physical strength and height needed to operate the DCP and the fact that there is greater room for human error with the DCP than the NDG. All questionnaires are provided in Appendix A.

Conclusions

Using the specifications in FHWA-NJ-2016-003 report along with gradation and moisture content properties, the minimum DCP value needed for the base layer was 3.8 blows per inch. The in-situ average DCP value for the job site was 3.81 blows per inch. Therefore, the compaction quality of the job site would be considered passing. This was verified with the NDG, which also determined that compaction quality was passing; therefore, the DCP and currently developed specifications were considered successful.

SUMMARY AND CONCLUSIONS

Overall, at both jobsite locations, the DCP provided the same compaction quality determinations as the NDG. Therefore, the DCP device and developed specifications can be considered acceptable. With regards to the success of the field visits, the presentation of setup, operation, and data analysis was effective as a majority of the attendees marked a 4 or 5 (out of 5) on the presenter's ability to present the information that they feel comfortable using the DCP for compaction testing.

Due to the need for future training and instruction, a high-quality training video on the DCP was developed and is included with the submission of this report as a CD-ROM. The training video includes:

- A description of the different parts of the DCP.
- An explanation of how to assemble the DCP.
- A step-by-step report of how to operate the DCP.
- A presentation of how to analyze and interpret the field data.

With regards to implementation, based on the experience of the research team and the results of the questionnaires, it is recommended to automate a portion, or the entire, DCP testing process through the use of additional equipment. Through automation of the DCP testing, the physical and strength requirements necessary for the operation of the DCP are alleviated and a lower number of operators is needed for operation. The field data can be collected and documented electronically through the use of a magnetic ruler at an additional cost of approximately $3,000 to $4,000. To fully automate the entire DCP testing procedure and documentation with a trailer-mounted DCP, the cost has been quoted between $30,000 and $40,000.

APPENDIX A

Copies of the questionnaires distributed to NJDOT personnel and contractors

RowanUniversity
CENTER FOR RESEARCH & EDUCATION IN ADVANCED TRANSPORTATION ENGINEERING SYSTEMS

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
   b. DOT Personnel/Engineer
   c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Expert [5]
3. Was the DCP presentation informative?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
4. Did this presentation cover all parts of the DCP and provide adequate step-by-step instructions on how to use it?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

5

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
   a. Yes
   b. No
   c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
   a. Yes
   b. No
   c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

13. Were there any questions not addressed during the presentation? If so, what are they?

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
   b. DOT Personnel/Engineer
   c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Expert [5]
3. Was the DCP presentation informative?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
4. Did this presentation cover all parts of the DCP and provide adequate step-by-step instructions on how to use it?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
   a. Yes
   b. No
   c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
   a. Yes
   b. No
   c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

Time it takes

13. Were there any questions not addressed during the presentation? If so, what are they?

None

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
   b. DOT Personnel/Engineer
   c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Expert [5]
3. Was the DCP presentation informative?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
4. Did this presentation cover all parts of the DCP and provide adequate step-by-step instructions on how to use it?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
    a. Yes
    b. No
    c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
    a. Yes
    b. No
    c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

Inspector's / Technician height restrictions

13. Were there any questions not addressed during the presentation? If so, what are they?

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
   b. DOT Personnel/Engineer
   c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
   a. Not at all [1]
   b. Slightly [2]
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   d. Substantial [4]
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3. Was the DCP presentation informative?
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   d. Substantial [4]
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4. Did this presentation cover all parts of the DCP and provide adequate step-by-step instructions on how to use it?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
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   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
   a. Yes
   b. No
   c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
   a. Yes
   b. No
   c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

NO CONCERNS AT THIS TIME.

13. Were there any questions not addressed during the presentation? If so, what are they?

MATERIAL COVERED. VERY INFORMATIVE!

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
   b. DOT Personnel/Engineer
   c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
   a. Not at all [1]
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   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
    a. Yes
    b. No
    c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
    a. Yes
    b. No
    c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

13. Were there any questions not addressed during the presentation? If so, what are they?

Contractor Questionnaire

1. Which of the following best describes your profession?
    a. Contractor
    b. DOT Personnel/Engineer
    c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
    a. Not at all [1]
    b. Slightly [2]
    c. Moderately [3]
    d. Substantial [4]
    e. Expert [5]
3. Was the DCP presentation informative?
    a. Not at all [1]
    b. Slightly [2]
    c. Moderately [3]
    d. Substantial [4]
    e. Extremely [5]
4. Did this presentation cover all parts of the DCP and provide adequate step-by-step instructions on how to use it?
    a. Not at all [1]
    b. Slightly [2]
    c. Moderately [3]
    d. Substantial [4]
    e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
    a. Not at all [1]
    b. Slightly [2]
    c. Moderately [3]
    d. Substantial [4]
    e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
    a. Not at all [1]
    b. Slightly [2]
    c. Moderately [3]
    d. Substantial [4]
    e. Extremely [5]

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
    a. Yes
    b. No
    c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
    a. Yes
    b. No
    c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

13. Were there any questions not addressed during the presentation? If so, what are they?

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
   b. DOT Personnel/Engineer
   c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Expert [5]
3. Was the DCP presentation informative?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
4. Did this presentation cover all parts of the DCP and provide adequate step-by-step instructions on how to use it?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
   a. Yes
   b. No
   c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
   a. Yes
   b. No
   c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

- More space for human error
- labor intense
-

13. Were there any questions not addressed during the presentation? If so, what are they?

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
   (b) DOT Personnel/Engineer
   c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Expert [5]
3. Was the DCP presentation informative?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
4. Did this presentation cover all parts of the DCP and provide adequate step-by-step instructions on how to use it?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
    a. Yes
    b. No
    c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
    a. Yes
    b. No
    c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

13. Were there any questions not addressed during the presentation? If so, what are they?

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
   b. DOT Personnel/Engineer
   c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
   a. Not at all [1]
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   c. Moderately [3]
   d. Substantial [4]
   e. Expert [5]
3. Was the DCP presentation informative?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
4. Did this presentation cover all parts of the DCP and provide adequate step-by-step instructions on how to use it?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
    a. Yes
    b. No
    c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
    a. Yes but not sure if better
    b. No
    c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

labor intensive, high testing time, height + strength requirements

13. Were there any questions not addressed during the presentation? If so, what are they?

N/A

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
   b. DOT Personnel/Engineer
   c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Expert [5]
3. Was the DCP presentation informative?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
4. Did this presentation cover all parts of the DCP and provide adequate step-by-step instructions on how to use it?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
   a. Not at all [1]
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   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
   a. Yes
   b. No
   c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
   a. Yes
   b. No
   c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

Time Consuming.
Very Heavy.
Too big.

13. Were there any questions not addressed during the presentation? If so, what are they?

All questions were addressed
testing, accuracy, moisture,

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
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   c. Other:
2. Prior to today, what is your experience with the Dynamic Cone Penetrometer (DCP)?
   a. Not at all [1]
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   c. Moderately [3]
   d. Substantial [4]
   e. Expert [5]
3. Was the DCP presentation informative?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
4. Did this presentation cover all parts of the DCP and provide adequate step-by-step instructions on how to use it?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
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6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
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7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
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f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
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d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
    a. Yes
    b. No
    c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
    a. Yes
    b. No
    c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

13. Were there any questions not addressed during the presentation? If so, what are they?

Contractor Questionnaire

1. Which of the following best describes your profession?
   a. Contractor
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   e. Expert [5]
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   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
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   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
5. Was the information, regarding the interpretation of data and acceptance criteria, clear and useable?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]
6. Did the presenter give the presentation in a clear and applicable way?
   a. Not at all [1]
   b. Slightly [2]
   c. Moderately [3]
   d. Substantial [4]
   e. Extremely [5]

7. Do you feel the dynamic cone penetrometer: (Where 1 is Strongly Disagree, 5 is Strongly Agree)

a. Has high repeatability and accuracy	(1) (2) (3) (4) (5)
b. Provides easy data processing	(1) (2) (3) (4) (5)
c. Has optimal operation and testing time	(1) (2) (3) (4) (5)
d. Contains high ease of use	(1) (2) (3) (4) (5)
e. Is not affected by enviro. factors (moisture)	(1) (2) (3) (4) (5)
f. Not negatively affected by lower layer properties	(1) (2) (3) (4) (5)
g. Has reasonable cost	(1) (2) (3) (4) (5)

8. Please rate the difficulty of implementing DCP in place of the NDG
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   d. Substantial [4]
   e. Extremely [5]

9. Which factors/obstacles do you feel will be most challenging in the widespread implementation of the DCP with (1) being not challenging and (5) being extremely challenging?

a. Ability to obtain a DCP	(1) (2) (3) (4) (5)
b. Lack of funds	(1) (2) (3) (4) (5)
c. Training	(1) (2) (3) (4) (5)
d. Familiarity of contractors with such devices	(1) (2) (3) (4) (5)
e. Resistance to policy change	(1) (2) (3) (4) (5)

10. After this presentation, do you feel comfortable using the DCP for compaction testing?
    a. Yes
    b. No
    c. Need more training

11. Ultimately, do you feel the DCP is a viable and feasible alternative to the NDG?
    a. Yes
    b. No
    c. I'm not sure

12. Based on today, please list any concerns you have with the testing ability of the DCP:

Need training more.

13. Were there any questions not addressed during the presentation? If so, what are they?

No

APPENDIX B
Photos taken at each field demonstration

Clifton Job Site

Newark Job Site