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Using the Dynamic Cone Penetrometer and Light Weight Deflectometer for Construction Quality Assurance

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16. Abstract (Limit: 200 words)

Specification target values for granular materials and fine grained soils are proposed. For granular material, the grading number and field moisture content are used to select the dynamic cone penetrometer (DCP) and light weight deflectometer (LWD) target values. A sieve analysis is used to determine the grading number and an oven dry test to determine the field moisture content. For compacted fine grained soil, the plastic limit and field moisture content are used to determine the target values. The plastic limit is used to classify the soil and to estimate the optimum moisture content for compaction. This report also provides further standardization of the LWD and DCP testing procedures and recommends three seating drops to ensure greater uniformity during testing.

The DCP and LWD estimate the strength and modulus of compacted materials. More specifically, they measure the penetration and deflection. When measuring penetration and deflection, the moisture content remains a critical quality control parameter for all compaction operations. Therefore, the moisture content needs to be measured, or estimated confidently, at each location. The LWD and DCP are performance related construction quality assurance tests that are expected to: increase compaction uniformity, lower life cycle pavement costs, increase inspector presence at the construction site, improve documentation, and increase inspector safety and productivity.

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Final Report

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Executive Summary

The final products resulting from this research implementation project are the specification target values for both granular materials and fine grained soils. For compacted granular material, the grading number and field moisture content are used to select the appropriate DCP and LWD target value. A sieve analysis is used to determine the grading number and an oven dry test or reagent test is typically performed to determine the field moisture content. For compacted fine grained soil, the plastic limit and field moisture content are used to determine DCP and LWD target values. In this case, the plastic limit is used rather than the grading number to classify the soil and is also used to estimate the optimum moisture content for compaction.

In addition to these target values, this report provides further standardization of the testing procedures for both the LWD and DCP. This will ensure greater uniformity by personnel conducting these tests. Currently, the method for obtaining a DPI value is varied, involving different numbers of seating drops and measurement drops. Using three seating drops and five to ten measurement drops, depending on the material type, is recommended in this report.

LWD testing includes variations as well and the Mn/DOT Grading and Base section is currently defining the seating depth and other aspects of the procedure for implementation during the 2009 construction season. The LWD device is currently non-standardized nationally, allowing manufacturers to develop different models, which produce different measurements. Because Mn/DOT has decided to establish predetermined target values it is necessary to select a specific LWD such that the buffer and plate stiffnesses are also constant along with the specified falling mass, peak force, and plate diameter.

This project leveraged previous research sponsored by Mn/DOT and the LRRB. One primary resource was report 2006-20, *Validation of DCP and LWD Moisture Specifications for Granular Materials*. Two other studies also drawn upon extensively to better understand the effect of soil moisture on stiffness and strength were reports: 2006-26, *Moisture Effects on PVD and DCP Measurements* and 2007-11, *Pavement Design Using Unsaturated Soil Technology*.

In conclusion, LWDs and DCPs should be implemented more widely in the state of Minnesota. This should be done using the standardized testing procedures and the defined target values in this report as reasonable starting points from which project specific verification or modification would occur. The recommended target values in this report are intended to be estimates that need to be verified as appropriate for specific projects. The draft specification produced by this project will be further refined and incorporated into Mn/DOT's *Standard Specifications, Grading and Base Manual, and Geotech and Pavement Manual*, as well as the inspector and technician certification classes already required for DCP and LWD use. As the benefits of these technologies become increasingly apparent, more counties, cities, and consultants are expected to acquire these tools.

Chapter 1 – Introduction

The Minnesota Local Road Research Board (LRRB) and the Minnesota Department of Transportation (Mn/DOT) continue to strive to improve testing methods for unbound materials during pavement construction. Mn/DOT has implemented the dynamic cone penetrometer (DCP) and light weight deflectometer (LWD) in place of current methods on many projects. This report discusses DCP and LWD use and recommends standard test methods and model specifications for quality assurance. When compared to current practices, these performance related testing methods are expected to:

- Increase compaction uniformity
- Lower life cycle pavement costs
- Increase inspector presence at the construction site
- Improve inspector safety
- Increase productivity due to less time per test
- Improve documentation and reporting.

1.1 History

Mn/DOT has traditionally verified the quality of pavement foundations by comparing lift densities to a "relative maximum" density identified for each unbound material. In order to calculate the relative maximum density, Mn/DOT's Standard Specifications for Construction require that samples of potential subbase and soil foundation materials be compacted at different moisture contents using standard Proctor effort. The dry densities of the resulting laboratory specimens are calculated and plotted versus moisture content. A curve is fit through the data and the peak represents an optimum moisture content and a maximum dry density for this method of compaction known as the standard Proctor test (ASTM D698, AASHTO T99, Mn/DOT Grading and Base Manual).

A sand cone test (ASTM D 1556-00) is performed on a lift of material in the field to determine whether its density meets or exceeds a designated percentage of the standard Proctor maximum density. The test is performed by scooping a small amount of material from the compacted layer and carefully filling the hole created with a measurable mass of sand. Because the sand used in these tests has a known density, the volume of the hole can be calculated. The density of the layer is calculated using this volume and the dry weight of the material removed from the hole. Compaction is deemed acceptable if the density measured during the sand cone test meets or exceeds a particular percentage (usually 100 percent) of the standard Proctor maximum density. This process is known as the specified density method (Mn/DOT Standard Specification 2105.3 F1).

While the specified density method is simple in theory and still widely practiced in the United States (using a nuclear density gauge), it presents a number of challenges for inspectors and designers. On a practical level, sand cone tests are time consuming, imprecise even when performed by skilled inspectors, difficult to perform in materials containing large aggregate particles, and responsible for placing inspectors in unsafe, low-visibility positions. The Proctor test is limited in that it determines the density of a variable material from a very small sample. More Proctor tests could be performed to increase the statistical confidence, but this is impractical as the tests are time consuming (Davich *et al.*, 2006). In addition, the impact method of compaction and the energy applied during the standard Proctor test, which was first implemented more than half a century ago, does not accurately represent the range of compaction methods and energy levels currently applied on construction sites.

Other problems with the specified density method arise from the pavement performance perspective. While relatively easy to understand, a material's density can be a poor indicator of performance compared to parameters such as stiffness and strength, which are sensitive to both moisture content and stress state. Variations in density can have relatively large effects on the properties that determine pavement performance. Therefore, the errors that accumulate during the specified density procedure have the potential to greatly influence the load bearing capacity of the pavement foundation materials. Lastly, design engineers would be better equipped to adapt pavement designs to differing conditions, soil classifications, construction methods, and other innovations if stiffness and strength parameters were used in place of density.

To take advantage of these possibilities, highway agencies, universities, and equipment manufactures have developed in situ test devices designed to measure the strength and modulus, (more specifically, the penetration rate or deflection) of compacted materials. These devices use several methods to calculate modulus. Some, such as the LWD and the falling weight deflectometer (FWD), use falling weights to generate a soil response. The DCP and rapid compaction control device (RCCD), drive a cone into the soil to produce a measure of shear strength. Whether measuring density, modulus, or shear strength, the moisture content remains a critical quality control parameter for all compaction operations regardless of the quality control and quality assurance test methodology. Therefore, the moisture content needs to be measured, or estimated with a high degree of confidence, at each location.

1.2 DCP Background

Mn/DOT implemented an aggregate base quality assurance specification for the DCP in 1998. The DCP's falling mass drops from a specified height to drive the cone into the pavement foundation material. The DCP penetration distance per drop is known as the DCP penetration index (DPI). The DPI is used to estimate the shear strength and modulus of unbound materials using empirical relationships.

The original DCP specification was designed for use on aggregate base. This specification was later modified to take gradation and moisture effects into account in order to increase its accuracy and expand its applications to other granular materials. Both the grading number and moisture content have a strong influence on the DPI, and therefore, target DPI values are determined according to a soil's grading number and moisture content (Oman, 2004).

1.3 LWD Background

The FWD is a larger trailer mounted device that estimates the in situ modulus of a material using the impulse load produced by the impact of a falling weight. FWDs are particularly useful for estimating the moduli of asphalt, aggregate base, granular subbase and subgrade pavement layers. These trailer-mounted units use a large weight, load cell, and several geophones to calculate the layer moduli through a back-calculation procedure and are most commonly used to investigate pavement moduli following construction of the complete pavement structure. While FWDs work well on finished pavement structures, FWDs are difficult to use on aggregate base, granular subbase, and soil subgrade due to the irregular surface and the difficulty of maneuvering the FWD trailer on an active construction site. Therefore, a second generation of portable FWD devices was developed to meet this need.

The portable FWD, now commonly referred to as a light weight deflectometer (LWD) (ASTM E 2583-07), consists of a lighter mass (often 10 kg), an accelerometer or geophone, and a data collection unit. LWDs are designed to be light enough to be moved and operated by one person. LWDs are often used to spot check unbound material compaction in parts of Europe (Fleming *et al.*, 2007), and are beginning to be used in the United States (Mooney *et al.*, 2008 and White *et al.,* 2007, 2009).

Mn/DOT has purchased several dozen LWDs and is in the process of refining its specification. An important issue that has arisen during the implementation of LWD technology is whether or not it is necessary to measure, or if it is acceptable to estimate, the load generated by the falling weight. This load estimation is not necessary for all LWD models because some include a load cell that measures the load as a function of time during impact. Other LWDs use one fixed peak load estimate, which is determined during trial testing in the laboratory (see Appendix B and C).

LWD quality assurance procedures offer several advantages over the specified density method. On a practical level, LWD tests take less time, have greater precision, and are able to accurately test more material types. For example, large aggregate creates problems for other tests. In addition, LWD testing is safer because the field inspector is able to remain standing and visible during most of the testing process (Davich *et al.*, 2006).

1.4 Definitions

There is some ambiguity regarding the terminology applied to quality assurance testing and mechanistic pavement design. To provide consistency, the following terms have been defined (Newcomb and Birgisson, 1999):

- *Elastic Modulus* – The applied axial stress divided by the resulting axial strain within the linear range of stress-strain behavior of a material.

- *Modulus of Subgrade Reaction* – The applied stress imposed by a loaded plate of a specified dimension acting on a soil mass divided by the displacement of the plate within the linear portion of the stress-deformation curve.

- *Resilient Modulus* – The stress generated by an impulse load divided by the resulting recoverable strain after loading.

- *Shear Strength* – A combination of a material's interparticle friction and its cohesion in resisting deformation from an applied stress. This is the largest stress that the material can sustain.

- *Stiffness* – A qualitative term meaning a general resistance to deformation. It is often used interchangeably with elastic modulus, modulus of subgrade reaction, and resilient modulus. It largely determines the strains and displacements of the subgrade as it is loaded and unloaded.

1.5 DCP Equipment

The structure of the DCP consists of two vertical shafts connected to each other at the anvil (ASTM D 6951-03). The upper shaft has a handle and hammer. The handle is used to provide a standard drop height of 575 mm (22.6 in) for the hammer as well as a way for the operator to easily hold the DCP vertical. The hammer is 8 kg (17.6 lb) and provides a constant impact force. The lower shaft has an anvil at the top and a pointed cone on the bottom. The anvil stops the hammer from falling any further then the standard drop height. When the hammer is dropped and hits the anvil, the cone is driven into the ground. Photos of the DCP are shown in Figure 1.1.

Figure 1.1. Photos of the dynamic cone penetrometer

There are a few configuration options available for the DCP, which include changing the mass of the hammer, type of tip, and recording method. The standard hammer mass is 8 kg, but there is also a 4.6 kg alternative. For pavement applications, the 8 kg mass is used due to the highly compacted soil. The DCP tip can either be a replaceable point or a disposable cone. The replaceable point stays on the DCP for an extended period of time, until damaged or worn beyond a defined tolerance, and then replaced. The disposable cone remains in the soil after every test, making it easier to remove the DCP. A new disposable cone must be placed onto the DCP before the next test. Manual or automated methods are available to gather penetration measurements. The reference ruler can be attached or unattached to the DCP. The automated ruler provides equivalent results as the reference ruler, but allows for a single operator instead of two. It also electronically records the data, making it more practical to record the penetration for each drop of the hammer and transfer the data to other computing devices.

1.6 LWD Equipment

There are several types of LWDs. The following is a general description of the LWD shown in Figure 1.2. Moving from top to bottom, the handle is used to keep the shaft vertical. Next along the shaft is a release trigger, which holds the mass in place prior to dropping, thereby ensuring a standard drop height. The mass is dropped to provide an impact force. Buffers, made of either rubber pads or steel springs, catch the falling mass and transfer the impact force to the loading plate. Below the buffers is a measurement device that measures the deflection, and for some models the force. On the bottom there is a loading plate, which must be in full contact with the ground.

Figure 1.2. Photo of light weight deflectometer

Seven LWD models have been (or are being) used in Minnesota and there are a variety of differences between these devices shown in Table 1.1. Please note that Mn/DOT currently supports only the ZFG 2000 for quality assurance in order to achieve measurement consistency state-wide.

Measurement differences are caused by several factors. LWDs can have a fixed drop height, while others have adjustable drop heights. Some measure deflection using an accelerometer fixed inside the load plate, while others use a geophone that passes through a hole on the bottom of the plate to directly contact the surface. Some assume a peak load established during trial testing, while others include a load cell. Finally, the buffer and plate stiffness affect how the energy of the falling mass is transferred to the ground (Mooney and Miller, 2009 and Vennapusa and White, 2009). Due to all these factors and practical considerations, Mn/DOT has elected to support only one LWD model for quality assurance testing.

Table 1.1. LWD models

Model	Company	Current Mn/DOT Use	Load Cell	Geophone	Accelerometer	Wireless	Adjustable Drop Height	Adjustable Mass	Adjustable Plate Size
Loadman I	Al-Eng Oy				X				
Loadman II	Al-Eng Oy	X	X		X				X
ZFG 2000	Gerhard Zorn	X			X				
Prima	Carl Bro	X	X	X		X	X	X	X
LWD v1	Dynatest/ Keros	X	X	X		X	X	X	X
LWD 3031	Dynatest/ Keros	X	X	X		X	X	X	X
Mini FWD	Keros		X	X			X	X	X

1.7 DCP Test Procedure

The DCP test procedure is currently standardized by both ASTM D 6951-03 and the Mn/DOT Grading and Base Manual. The following is a brief description of the test procedure used during this project.

First, the equipment should be inspected for any fatigue or damaged parts, and that all connections are securely tightened. The operator holds the device vertical by the handle on the top shaft. A second person records the height at the bottom of the anvil in reference to the ground. The operator lifts the hammer from the anvil to the handle, and then releases the hammer. The second person records the new height at the bottom of the anvil. In general, this process is repeated until twelve drops are preformed, two for the seating, five for the first DPI calculation, and another five for the second DPI calculation. The DCP should be taken out of the newly formed hole using an extraction jack. If the tip is disposable, hitting the hammer lightly on the handle is acceptable.

Small penetration rates represent better soil compaction. The current methods of compacting pavement foundation material involve building thin individually compacted layers less than 12 inches (30 cm). This causes the material closer to the surface to be less confined and less compacted then the deeper material. Therefore, the deeper into the soil the DCP penetrates, typically, the stronger the material. For this reason, the DPI is calculated three times; once near the surface (seating drops), and twice more using the deeper drops. DPI_1 describes the soil near the surface, while DPI_2 describes the deeper soil.

$$DPI_{Seating} = \frac{D_2 - D_{initial\ reading}}{2\ drops} \quad [1.1]$$

$$DPI_1 = \frac{D_7 - D_3}{5\ drops} \quad [1.2]$$

$$DPI_2 = \frac{D_{12} - D_8}{5\ drops} \quad [1.3]$$

where:

DPI	=	DCP penetration index [mm/drop]
$D_\#$	=	depth of penetration after drop number # [mm]

The modulus of the soil can be estimated using the following equation:

$$E_{DPI} = 10^{3.04758-[1.06166\log(DPI)]} \quad [1.4]$$

where:

E_{DPI}	=	modulus [MPa]
DPI	=	DCP penetration index [mm/drop]

Equation 1.4 is for standard DCP equipment only (drop height of 575 mm and a hammer mass of 8 kg). Transportek, a South African research organization, derived the equation from rigorous testing (Lockwood *et al.,* 1992).

1.8 LWD Test Procedure

LWD devices are configured and used differently depending on the model and testing agency. The purpose of the details provided in this section is to make certain that LWD test procedures in the state of Minnesota are standardized. ASTM recently published a national standard for LWDs with load cells (ASTM E 2583-07). A national standard for LWDs without load cells is currently being finalized by ASTM. In another paper about to be published by ASTM, several

LWDs are compared with respect to measurement of applied force, type and location of deflection sensor, plate diameter and rigidity, and buffer stiffness (Vennapusa and White, 2009).

In the case of Zorn LWDs, the applied force from the falling mass is measured at the factory and used for all future modulus calculations for that particular LWD. Equation 1.5 can be used to estimate the applied load for Zorn LWDs.

$$F_Z = \sqrt{2 \times m \times g \times h \times k} \qquad [1.5]$$

where:

F_Z	=	estimated force [N]
m	=	mass of falling weight [kg]
g	=	acceleration due to gravity [9.81 m/s^2]
h	=	drop height [m]
k	=	spring constant [362396.2 N/m]

Other LWDs include a load cell to measure the load and then combine this load with the deflection to estimate the modulus for each drop. Although it is inevitable that the applied force will not be the same for materials of different stiffnesses, White reported that the "assumption of constant applied force does not lead to significant variations in the estimated modulus" (White *et. al.,* 2007). Please see Appendix B and C for additional discussion and conclusions.

Another factor that affects the estimated modulus in all LWDs is the plate size. Equations 1.6 and 1.7 show the commonly used calculations used to estimate the modulus.

$$E_{LWD} = 2 r_p \sigma (1 - \nu^2) \frac{(1 \times 10^6) R}{\Delta} \qquad [1.6]$$

$$\sigma = \frac{F}{1000 \pi r_p^2} \qquad [1.7]$$

where:

E_{LWD}	=	Young's modulus [MPa]
r_p	=	plate radius [m]
σ	=	peak stress applied to the soil [MPa]
ν	=	Poisson's ratio of the soil
R	=	plate rigidity (0.79 for rigid, 1.0 for flexible)
Δ	=	peak soil deflection [μm]
F	=	peak force applied to the soil [kN]

As previously stated, Zorn LWDs use a steel spring buffer and an accelerometer embedded in the plate, combined with double integration, to measure deflection. Other LWD models use rubber buffers and a geophone in contact with the ground, combined with single integration, to measure deflection. Previous studies have found that Dynatest/Keros moduli were about 1.75 times greater than Zorn moduli when the drop height, mass, and plate size were constant (White *et. al.,* 2007).

A previous study completed by Mn/DOT recommended standardizing the LWD mass at 10 kg (22.0 lb), the drop height at 50 cm (19.7 in), and the plate diameter at 20 cm (7.9 in) for ease of use and in order to have an appropriate influence depth to test for a lift of compacted pavement foundation material (Davich *et al.*, 2006). Plate size affects the measurement depth, confinement, and stress level applied to stress dependent materials. Standardizing the LWD plate size to 20 cm reduces these variables and allows the target modulus to be estimated. Because the buffer type affects the force delivered to the ground, Mn/DOT now specifies that a force of 6.28 kN be delivered to the ground. This equates to a stress of 0.2 MPa for a 20 cm diameter plate. LWD tests in Minnesota are currently conducted using that configuration, along with the following test guidelines and advice contained in the manufacturer's literature.

Prior to placing the LWD on the material to be tested, the surface is leveled. Particularly loose or rutted surface material is removed to a depth of about 15 cm. Three seating drops are performed prior to data collection to ensure that plastic deformation of the surface material does not affect the measurements. Once the LWD has been seated, the data collection should consist of three measurement drops. The three values resulting from these measurement drops are averaged to create one mean value for that test location. The operator will often notice that the modulus values increase slightly during the three measurement drops from a fixed height. If this increase exceeds 10 percent it is probable that the material has not been adequately compacted. Reliable measurement values cannot be obtained until the material has been corrected.

LWD devices should not be used when the temperature falls below 5 degrees Celsius (41 degrees Fahrenheit) to ensure that the device's components, particularly the rubber buffers, work as intended. There is no practical upper limit on the temperature. While most LWDs will work in the rain, it should be noted that moisture greatly affects the strength and stiffness characteristics of the unbound materials. It is necessary to measure the moisture content in conjunction with every test using an in situ moisture testing device or by removing a sample for an oven-dry test.

When control strips are used to verify the LWD target value, it is important that the layer structure of the control strip is considered. This is because deeper layers within the pavement foundation can affect LWD measurements even though the primary depth of influence is close to the plate diameter.

Chapter 2 – Soil Descriptions

This chapter describes the granular material and fine grained soils used in this report. The granular material was tested during a Mn/DOT study sponsored by the LRRB (Davich *et al.*, 2006). The fine grained soil was tested during a University of Minnesota study sponsored by Mn/DOT (Swenson *et al.*, 2006).

2.1 Granular Material Description

Mn/DOT District personnel collected granular material samples from fifteen different construction sites across Minnesota in order to represent each of the eight districts. The gradation, optimum moisture content, and standard Proctor maximum density were measured on those samples and eight of those samples were chosen for further testing and analysis (Davich *et al.*, 2006). Those same granular samples are also included in this report and are denoted as DN, FHJ, and KLO in Figure 2.1.

The eight samples were combined into blended groups of two or three samples each creating three blended group samples for testing. The group sample with the largest percent fines was labeled FHJ. In comparison to FHJ, the blended sample DN was a relatively coarse-grained and well-graded with the least percent fines. The blended sample KLO's gradation falls between the gradations of DN and FHJ, but was slightly more similar to DN. Index properties of the three blended samples are shown in Table 2.1.

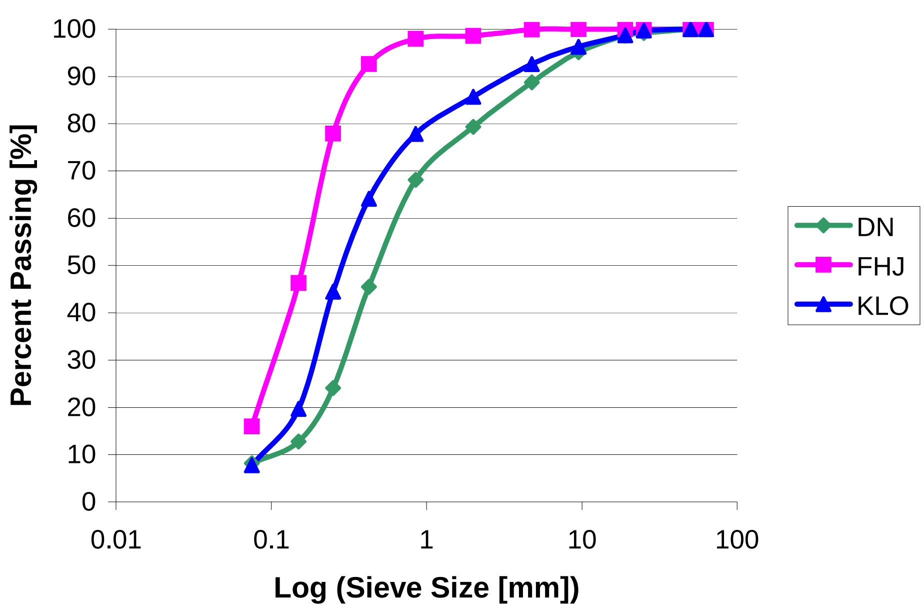

Figure 2.1. Plot of granular sample gradations

Table 2.1. Select granular and granular index properties

Sample	Mn/DOT Class	Grading Number	% Fines [%]	Optimum Moisture Content [%]	Maximum Density Standard Proctor [kg/m^3]
DN	Select Granular	5.1	7.6	8.1	1942.4
FHJ	Granular	6.1	16.0	10.3	1753.4
KLO	Select Granular	5.4	10.6	8.8	1874.2

2.2 Granular Material Preparation

The test specimens were prepared in a steel cylinder (bottom half of a 55-gallon barrel) and compacted using a scaled-up Proctor hammer with a mass of 23 kg (51 lb). This hammer applied defined compaction energies by repeated drops from a standard height of 85 cm (33 in). Three different granular samples were each prepared and tested at three different moisture contents aimed to be below, near, and above the optimum moisture content obtained using the standard Proctor test. The compaction effort was adjusted to obtain the desired densities, which were targeted to be equal to or slightly greater than 100 percent of the standard Proctor “relative maximum” density. Four sand cone and thirteen oven-dry moisture content measurements were performed on each specimen in order to verify that these targets were reached uniformly within the specimen containers. Furthermore, the density of the entire barrel was calculated to verify the accuracy of the sand cone measurements. A total of twenty-two different test specimens were prepared and their densities ranged from 99 to 111 percent of the standard Proctor maximum density. Of these, six were prepared using the select granular sample denoted as DN, eight were prepared using FHJ, and eight were prepared using KLO. The measured values for each specimen are shown in Table 2.2.

Table 2.2. Select granular and granular moisture contents and densities

Specimen	Grading Number	Optimum Moisture Content [%]	Actual Moisture Content [%]	Percent of Optimum Moisture Content [%]	Standard Procotr Density [kg/m^3]	Barrel Density [kg/m^3]	Relative Barrel Compaction [%]
DN05	5.1	8.1	5.1	62	1942.4	1988.6	103
DN5	5.1	8.1	5.1	63	1942.4	-	-
DN07	5.1	8.1	6.4	79	1942.4	2042.8	105
DN7	5.1	8.1	7.2	89	1942.4	1950.7	100
DN10	5.1	8.1	10.0	123	1942.4	1999.1	103
DN10X2	5.1	8.1	10.0	123	1942.4	1976.2	102
DN10S	5.1	8.1	9.7	119	1942.4	1984.9	102
DN10C	5.1	8.1	9.2	113	1942.4	2076.0	107
FHJ8	6.1	10.3	7.8	75	1753.4	1763.9	101
FHJ8X1.125	6.1	10.3	7.5	73	1753.4	1819.8	104
FHJ8X1.333	6.1	10.3	8.0	77	1753.4	1945.3	111
FHJ8X2	6.1	10.3	8.1	78	1753.4	1839.3	105
FHJ10	6.1	10.3	9.5	92	1753.4	1790.6	102
FHJ11	6.1	10.3	10.6	103	1753.4	1801.9	103
FHJ11X.5	6.1	10.3	11.4	111	1753.4	1772.5	101
FHJ13	6.1	10.3	12.7	124	1753.4	1790.1	102
KLO7	5.4	8.8	7.1	80	1862.3	1847.3	99
KLO7X1.33	5.4	8.8	7.1	80	1862.3	1936.6	104
KLO8X1.5	5.4	8.8	7.9	90	1862.3	1962.8	105
KLO9	5.4	8.8	8.9	102	1862.3	1881.3	101
KLO9X.5	5.4	8.8	8.8	100	1862.3	1881.8	101
KLO10	5.4	8.8	10.5	119	1862.29	1915.5	103
KLO10X.5	5.4	8.8	10.3	117	1862.3	1916.3	103
KLO11	5.4	8.8	12.0	137	1862.3	1868.6	100

The specimens were labeled by their sample group, moisture content, and compaction effort. The letters in the specimen label identify the blended group. The first number represents the target moisture content. The last number, following an "X" in the name, is the multiplication factor that describes the relative change in compaction energy. The initial compaction energy (X1) was targeted at standard Proctor effort (600 kN-m/m^3, 12,400 lbf-ft/ft^3). X2 indicates that the compaction energy was 2 times standard Proctor effort, which would be 1200 kN-m/m^3 (24,800 lbf-ft/ft^3).

2.3 Fine Grained Soil Description

The fine grained soil samples were collected by Mn/DOT and provided to the University of Minnesota for testing (Swenson *et al.*, 2006). In order to represent the range of fine grained soils found in Minnesota, samples were obtained from four locations across the state: MnROAD, Duluth, Red Wing, and Red Lake Falls. Figure 2.2 and Table 2.3 include the gradation plots and index parameters for these four samples.

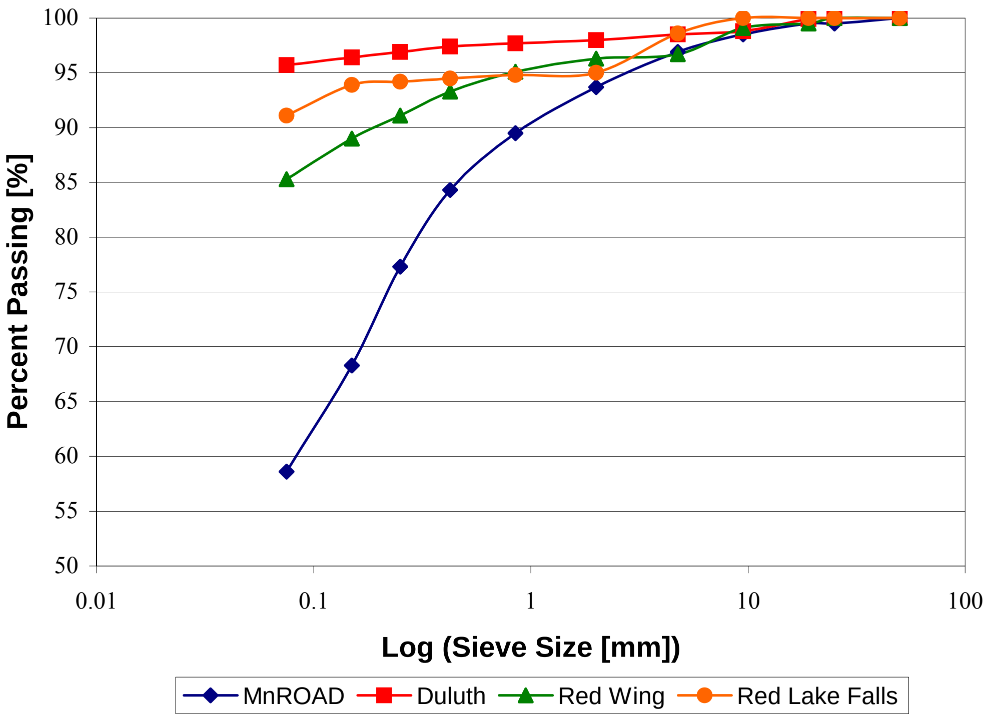

Figure 2.2. Plot of fine grained soil gradations

Table 2.3. Fine grained index parameters

Name	MnROAD		Duluth		Red Wing		Red Lake Falls			
	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1*	Trial 2	Trial 3	Trial 4
Standard Proctor Dry Unit Weight [kg/m^3]	1720.1	1684.9	1447.8	1436.6	1789.0	1785.8	1720.1	1592.0	1527.9	1547.1
Optimum Moisture Content [%]	16.1	14.4	26.5	27.0	13.2	13.2	16.3	20.4	22.7	22.4
Liquid Limit [%]	25.8	30.5	84.9	84.3	0.0	0.0	31.8	44.4	48.4	48.9
Plastic Limit [%]	16.4	17.4	32.9	32.6	0.0	0.0	21.7	21.1	23.8	21.9
% Silt	45.3	46.0	21.2	16.9	80.4	82.4	67.0	63.8	51.4	44.1
% Clay	14.5	12.6	75.2	78.8	4.8	5.7	24.3	27.3	41.6	49.0
R-Value	17.5	15.6	12.4	9.3	54.6	52.9	25.6	17.0	10.7	9.3
Mn/DOT Textural Classification	L	L	C	C	Si	Si	SiCL	SiCL	C	C
AASHTO Group	A-4	A-6	A-7-6	A-7-6	A-4	A-4	A-4	A-7-6	A-7-6	A-7-6

*Results from Red Lake Falls, Trial 1, did not represent soil sample well enough to include in further analysis.

Two trials were completed on each sample to verify that the index parameters were a good representation of the soil. The results from Red Lake Falls differed significantly and therefore two additional trials were done. It was concluded that data from Red Lake Falls Trial 1 did not represent the sample well and therefore the Trial 1 test results were not used in further analyses.

2.4 Fine Grained Soil Preparation

In order to ensure uniformity of the samples prior to constructing specimens at the target moisture content and density, the following process was preformed. First, the soil was passed through a 1-inch sieve to break up any large clumps. Then, the soil was oven dried in a pan for twenty-four hours at 250°F (121°C) to eliminate most of the pre-existing moisture. Finally, the soil was pulverized to ease mixing as water was added to reach the target moisture (Swenson *et al.,* 2006).

Specimens were prepared at three different moisture contents and two different densities, which resulted in a total of twenty-four specimens. The target values for the moisture contents were determined using a percentage of the optimum moisture content. The target densities were 98 and 103 percent of standard Proctor maximum relative density for all specimens excluding MnROAD, which targeted 100 and 105 percent. The average of two moisture and two density tests from each specimen are shown in Table 2.4 (Swenson *et al.,* 2006).

Once the target moisture content and density was determined for a specimen, the soil was mixed with the appropriate amount of water to obtain the desired moisture content. Next, oven-dried tests were preformed on the specimens to determine the actual moisture content. Then the soil was compacted to a depth of 27 cm (10.5 in.) in a prismatic steel container measuring 58 x 58 x 38 cm (23 x 23 x 15 in). The compaction took place with three layers each compacted by a padfoot plate fixed to the crosshead of a load frame. The padfoot plate was used to apply some kneading action to the mostly static compaction method (Swenson *et al.,* 2006).

Table 2.4. Fine grained specimen moisture content and density values

Specimen	Location	Optimum Moisture Content [%]	Target Percent Optimum Moisture Content [%]	Target Moisture Content [%]	Actual Moisture Content [%]	Percent of Optimum Moisture Content [%]	Standard Proctor Density [kg/m^3]	Target Percent Standard Proctor [%]	Target Density [kg/m^3]	Actual Density [kg/m^3]	Standard Proctor [%]
1	MnROAD	15.3	90	13.7	14.1	92	1702.5	105	1787.6	1752.0	103
2	MnROAD	15.3	70	10.7	11.2	73	1702.5	105	1787.6	1678.0	99
3	MnROAD	15.3	50	7.6	7.7	50	1702.5	105	1787.6	1670.0	98
4	MnROAD	15.3	100	15.3	15.6	102	1702.5	100	1702.5	1659.0	97
5	MnROAD	15.3	80	12.2	11.5	75	1702.5	100	1702.5	1685.0	99
6	MnROAD	15.3	60	9.2	10.9	71	1702.5	100	1702.5	1587.0	93
7	Duluth	26.8	90	24.1	23.6	88	1442.2	103	1485.5	1484.0	103
8	Duluth	26.8	75	20.1	19.2	72	1442.2	103	1485.5	1444.0	100
9	Duluth	26.8	60	16.1	17.4	65	1442.2	103	1485.5	1505.0	104
10	Duluth	26.8	100	26.8	26.1	98	1442.2	98	1413.4	1399.0	97
11	Duluth	26.8	80	21.4	22.0	82	1442.2	98	1413.4	1387.0	96
12	Duluth	26.8	60	16.1	16.3	61	1442.2	98	1413.4	1409.0	98
13	Red Wing	13.2	90	11.9	11.3	86	1787.4	103	1841.0	1700.0	95
14	Red Wing	13.2	75	9.9	9.4	71	1787.4	103	1841.0	1777.0	99
15	Red Wing	13.2	60	7.9	8.4	64	1787.4	103	1841.0	1725.0	97
16	Red Wing	13.2	100	13.2	12.4	94	1787.4	98	1751.7	1613.0	90
17	Red Wing	13.2	80	10.6	10.1	77	1787.4	98	1751.7	1721.0	96
18	Red Wing	13.2	60	7.9	8.4	64	1787.4	98	1751.7	1705.0	95
19	Red Lake Falls	21.8	90	19.7	16.3	75	1555.7	103	1602.3	1640.0	105
20	Red Lake Falls	21.8	75	16.4	13.3	61	1555.7	103	1602.3	1697.0	109
21	Red Lake Falls	21.8	60	13.1	10.6	49	1555.7	103	1602.3	1665.0	107
22	Red Lake Falls	21.8	100	21.8	18.6	85	1555.7	98	1524.6	1609.0	103
23	Red Lake Falls	21.8	80	17.5	14.2	65	1555.7	98	1524.6	1614.0	104
24	Red Lake Falls	21.8	60	13.1	10.7	49	1555.7	98	1524.6	1494.0	96

The percent of optimum moisture content actually achieved in the prepared specimens varied between 49 and 102 percent. And the relative compaction for the specimens ranged from 90 to 109 percent of the standard Proctor maximum relative density (Swenson *et al.*, 2006).

Chapter 3 – DCP for Select Granular and Granular Materials

3.1 Discussion

Tests were done to analyze select granular and granular materials using a DCP. The testing was preformed by Mn/DOT and first analyzed for the Davich *et al.*, 2006 report. Three different granular material samples were tested. The three samples consisted of sample DN with a low amount of percent fines, sample FHJ with a high amount of percent fines, and sample KLO with an intermediate amount of percent fines. The descriptions and preparation of the test samples is explained in Chapter 2.

A standard Mn/DOT DCP (ASTM D 6951–03) was used to measure the penetration rate and estimate the shear strength of the granular material. The DCP used had a 20 mm diameter replaceable cone tip, a 575 mm drop height, and an 8 kg falling mass. The DCP measurements consisted of two seating drops, followed by five measured drops. The top few inches of tested material was not as uniform, confined or as compacted as the material further down, so the data from the seating drops was recorded separately from the deeper measurement drops. The DCP penetration index (DPI) is the depth that the DCP travels per drop (Mn/DOT standard is currently three measurement drops for aggregate base and five measurement drops for select granular and granular materials). An example of the depth versus the DPI per each drop is displayed in Figure 3.1 (more results can be viewed in Appendix G). This figure shows that the first few drops have greater penetration due to the unconfined material close to the surface.

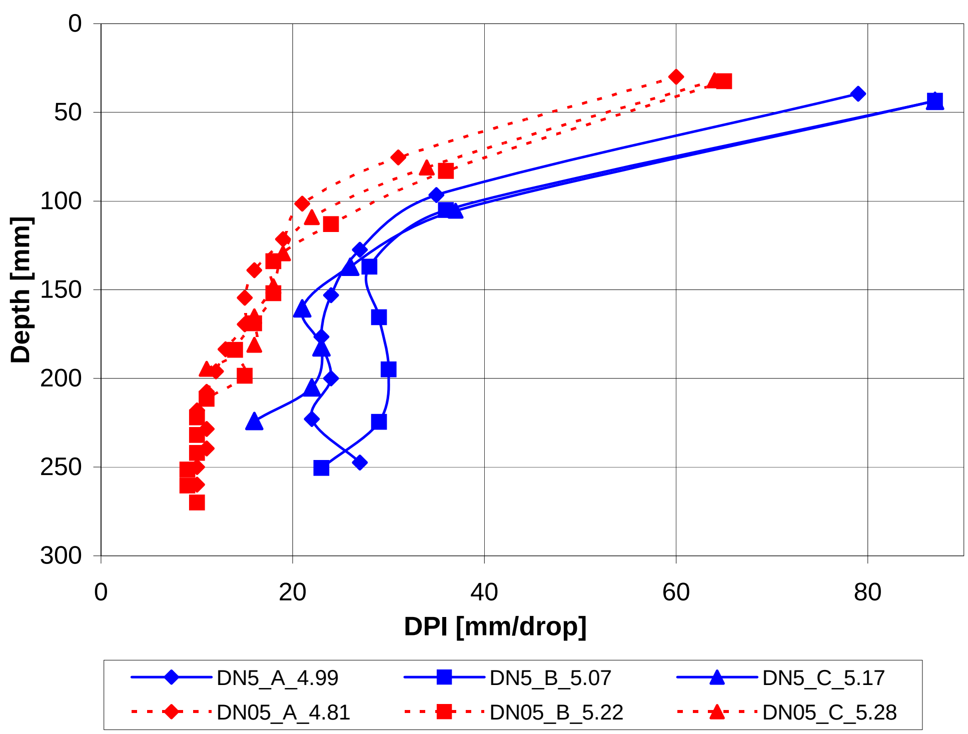

Figure 3.1. Sample DPI versus depth plot

DCP data from the select granular and granular material was analyzed in order to compare how estimates of the materials' modulus were affected by the number of seating drops and the equation used to calculate the DPI. The modulus was first calculated using the Mn/DOT's standard of first performing two seating drops and then calculating the DPI using the readings from the next five drops. In the second method, the modulus was calculated with the weighted average of the five drops, which followed the two seating drops. These two methods were found to produce similar results because of the small variation in the penetration per drop. Therefore, when estimating the average modulus it is not necessary to weight the average using the depth of penetration per drop.

The modulus was also calculated by averaging the five drops that followed three seating drops. This was compared to the modulus results using only two seating drops. The comparison resulted in a significant increase of modulus values. This increase in modulus is visible in the select granular and granular material due to their lack of compaction and confinement near the surface. Therefore, it is advisable to use three seating drops with granular material, as is done during the LWD procedure. A comparison of these modulus estimates with respect to the standard averaging of the five drops after seating is shown in Figure 3.2.

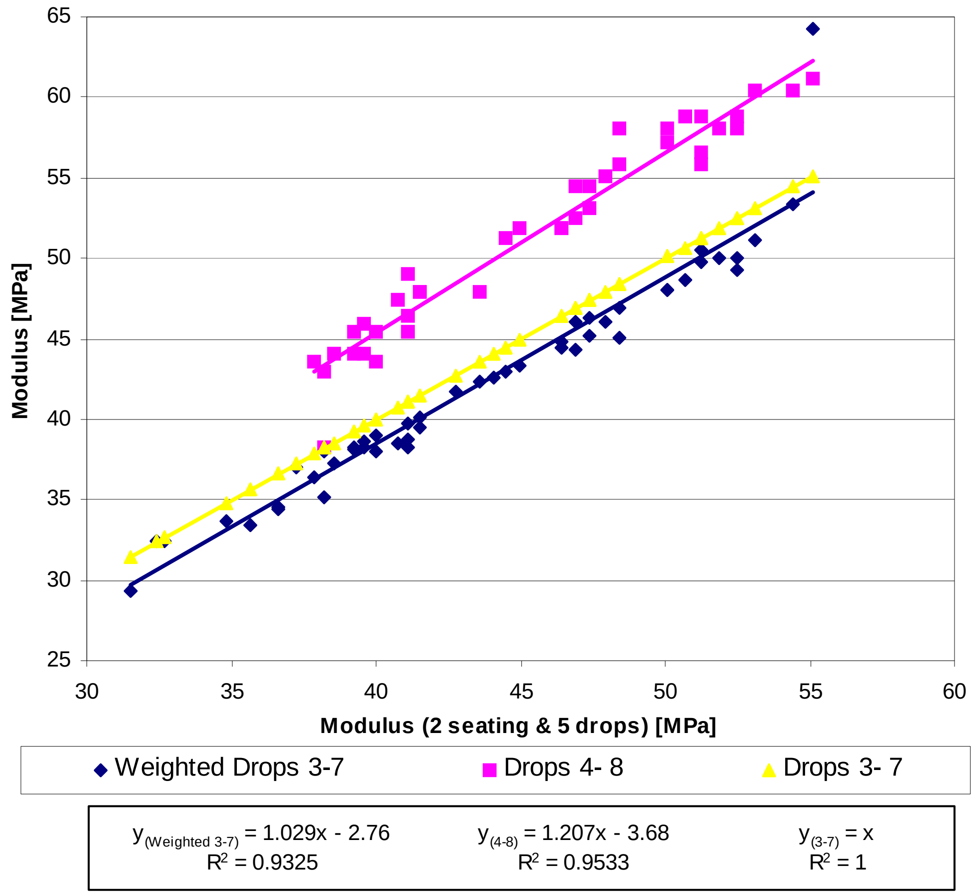

Figure 3.2. Effects of seating drops and weighting on the DPI

The DPI measurements can be used to estimate the modulus of a soil. However, it is more common that only the DPI values are calculated. Figures 3.3-3.5 display the effects of the percent of optimum moisture content and relative compaction on the average DPI values for the tested samples.

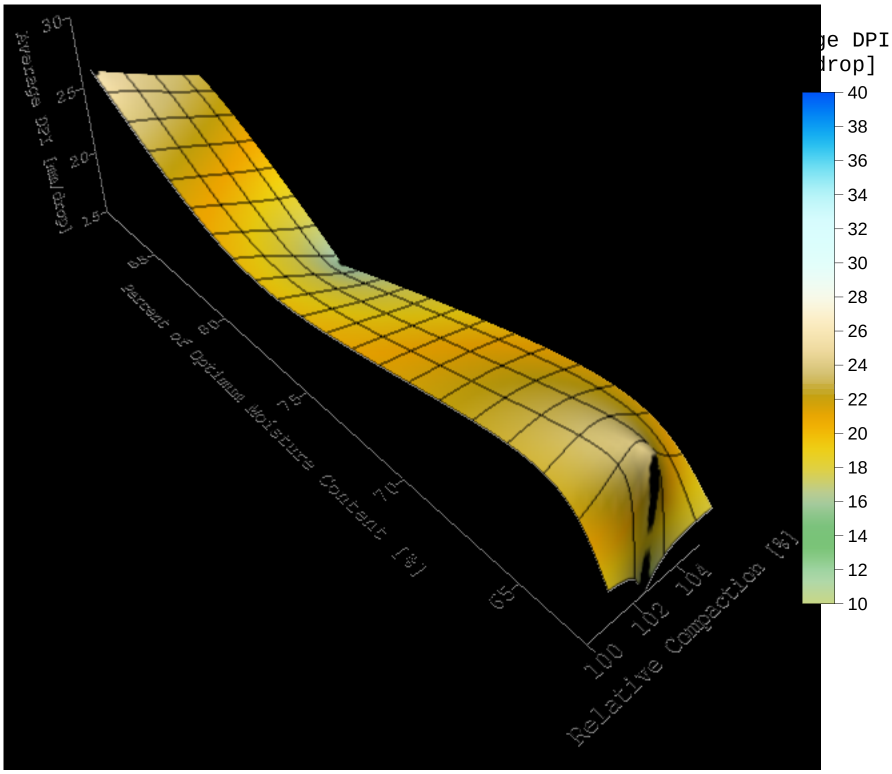

Figure 3.3. Effects of percent of optimum moisture content and relative compaction on average DPI for select granular sample DN

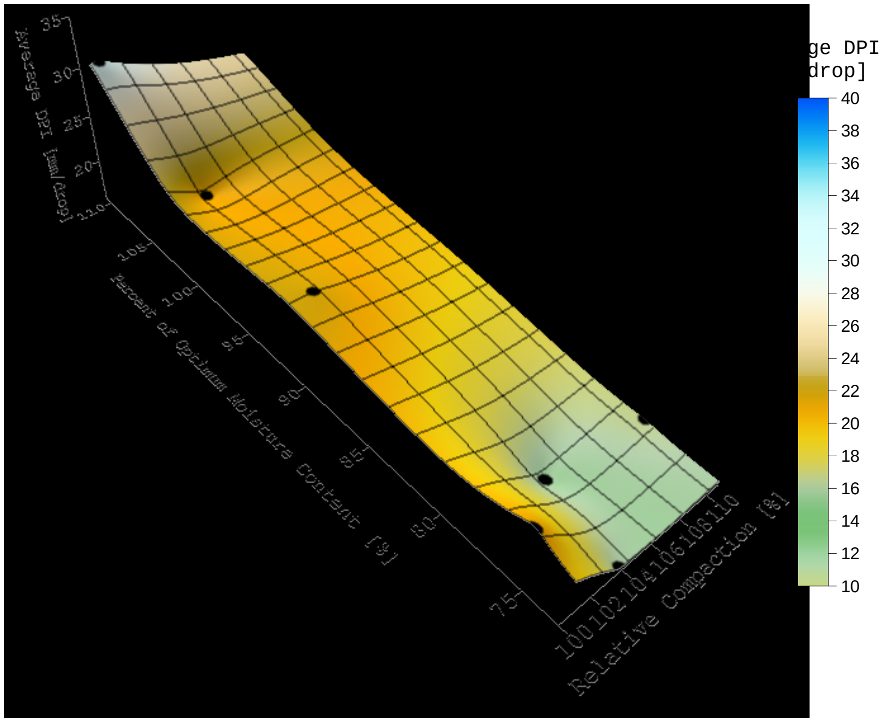

Figure 3.4. Effects of percent of optimum moisture content and relative compaction on average DPI for granular sample FHJ

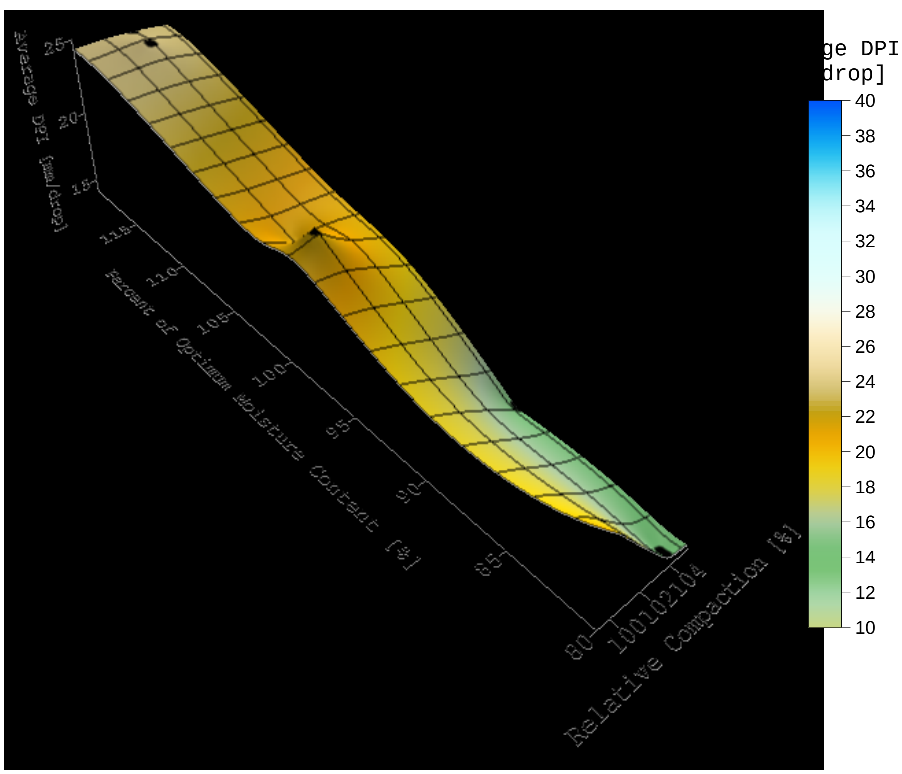

Figure 3.5. Effects of percent of optimum moisture content and relative compaction on average DPI for select granular sample KLO

The moduli were estimated using the DPI_1 value obtained from Equation 1.6. Figures 3.6-3.8 are plots comparing the modulus, percent of optimum moisture content, and the relative compaction of select granular and granular material.

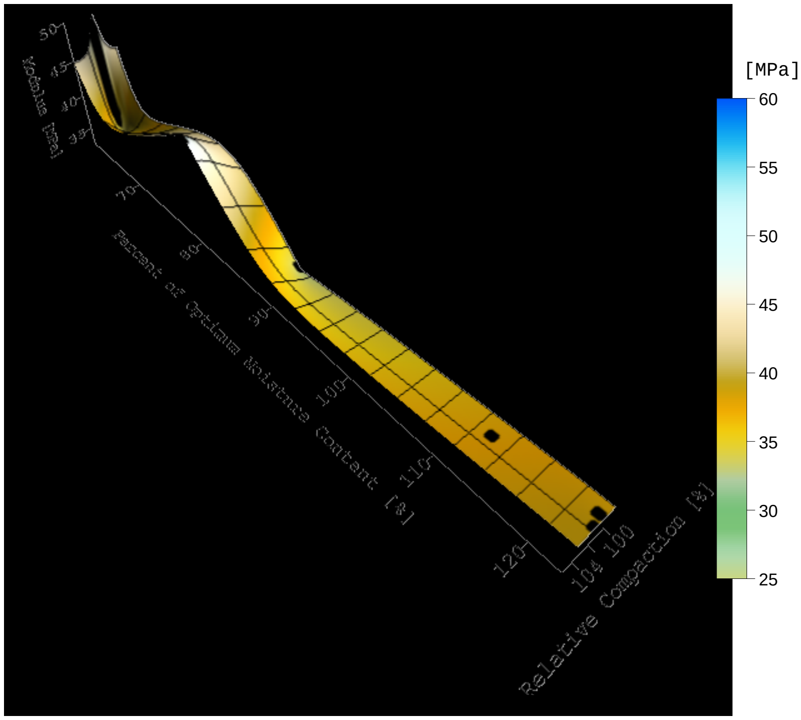

Figure 3.6. Effects of percent of optimum moisture content and relative compaction on DCP modulus for select granular sample DN

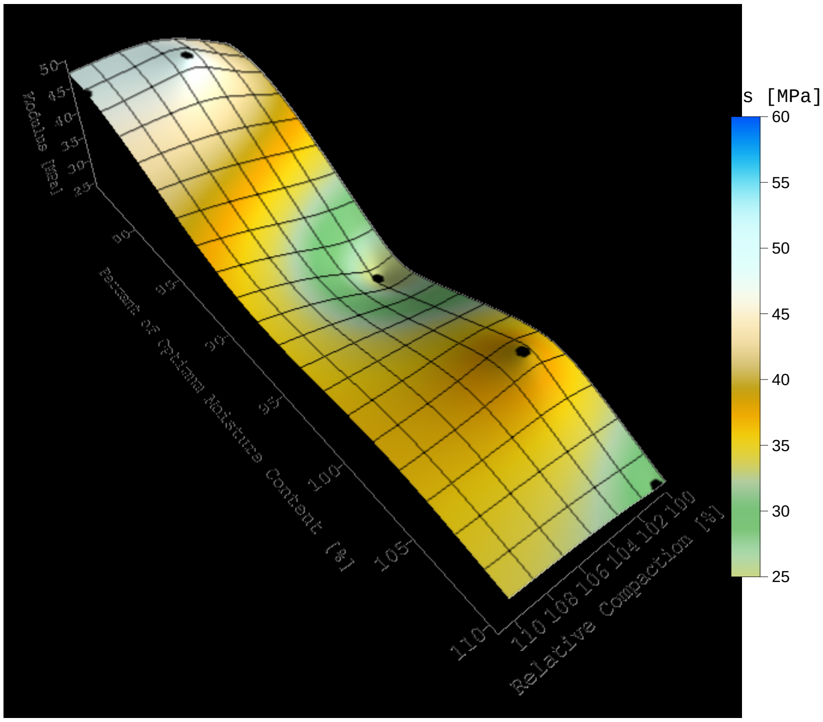

Figure 3.7. Effects of percent of optimum moisture content and relative compaction on DCP modulus for granular sample FHJ

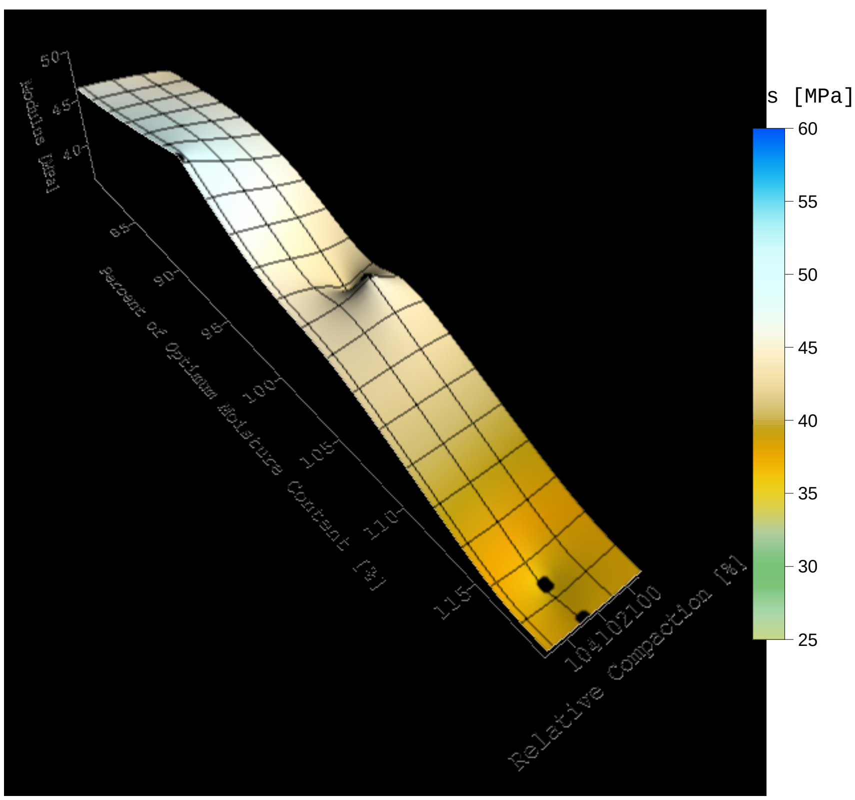

Figure 3.8. Effects of percent of optimum moisture content and relative compaction on DCP modulus for select granular sample KLO

As presented in Figures 3.3-3.5, the material weakens as the percent of optimum moisture content increases and therefore, both the penetration and DPI increase. Similarly, Figures 3.6-3.8 show that as the percent of optimum moisture content increases, the material weakens and the modulus decreases. In all three granular samples there is a sudden drop in strength and moduli around ninety percent of the optimum moisture content. This is more noticeable in the FHJ sample (Figure 3.7) than it is in the DN sample (Figure 3.6) or the KLO sample (Figure 3.8). The relationship between the moduli and the relative compaction is not as clear due to the limited range of density tested (99% to 111% of standard Proctor density, Table 2.2). The moduli show a slight increase as the relative compaction increases on the FHJ sample (Figure 3.7) and sample KLO (Figure 3.8).

3.2 Conclusion

Figure 3.2 shows that the recommended number of DCP seating drops should be increased from two to three for granular and select granular materials. This should be considered for all DCP testing and would also be consistent with the three seating drops required during LWD testing. Due to the narrow range of density acceptable during road construction, the moisture content has a more significant influence on the DCP penetration rate. Therefore moisture content must be included in quality assurance procedures. Consequently, DPI target values are determined for moisture content ranges for a material defined by its grading number as described in Chapter 7.

Chapter 4 - LWD for Select Granular and Granular Materials

4.1 Discussion

The LWD was used to test the same select granular and granular samples (DN, FHJ, and KLO) tested using the DCP as described in Chapter 3. Details on the sample classifications and the preparation prior to testing are found in Chapter 2.

The LWD used for this analysis was the Dynatest/Keros model, which included the Mn/DOT standard 10 kg falling mass and 20 cm diameter base. The testing was done at the following drop heights: 25, 50, and 75 cm. The results and analysis of the affect of drop height on the modulus can be found in Appendix D. For the analysis in this chapter, only the data collected from the Mn/DOT standard drop height of 50 cm was used. The LWD modulus shown is the average of three consecutive drops from the 50 cm drop height. The modulus results from the material were plotted against the percent of optimum moisture content and relative compaction, as shown in Figures 4.1-4.3.

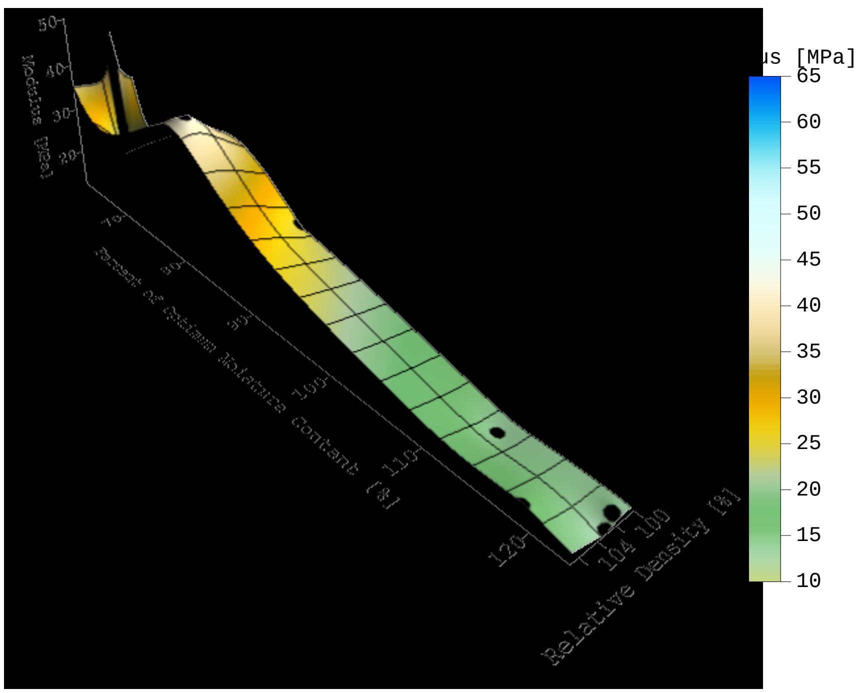

Figure 4.1. Effects of percent of optimum moisture content and relative compaction on LWD modulus for select granular sample DN

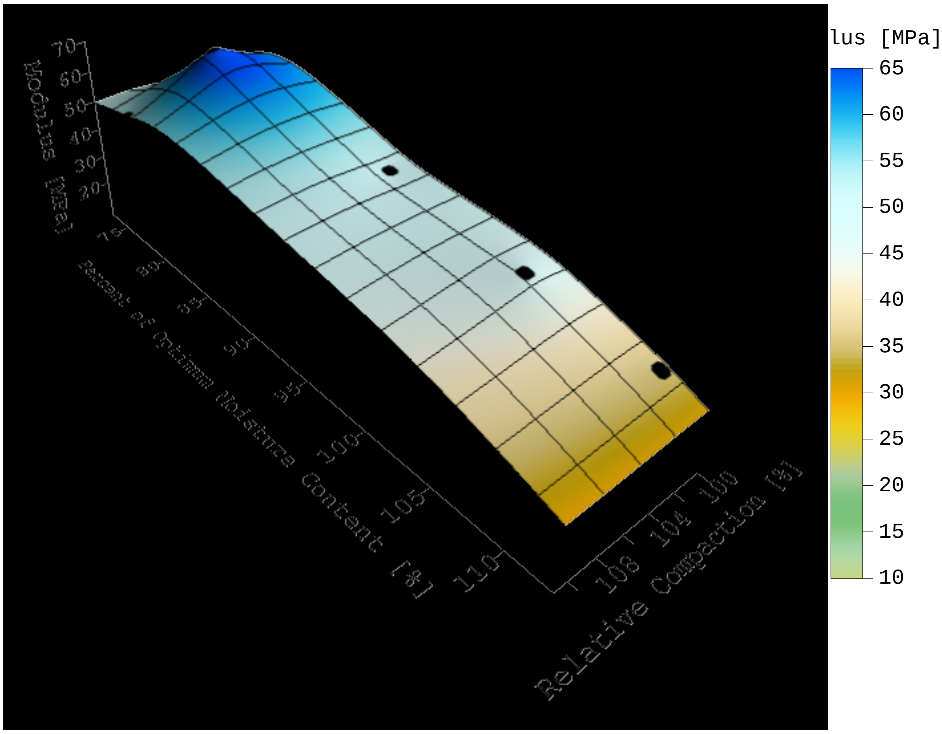

Figure 4.2. Effects of percent of optimum moisture content and relative compaction on LWD modulus for granular sample FHJ

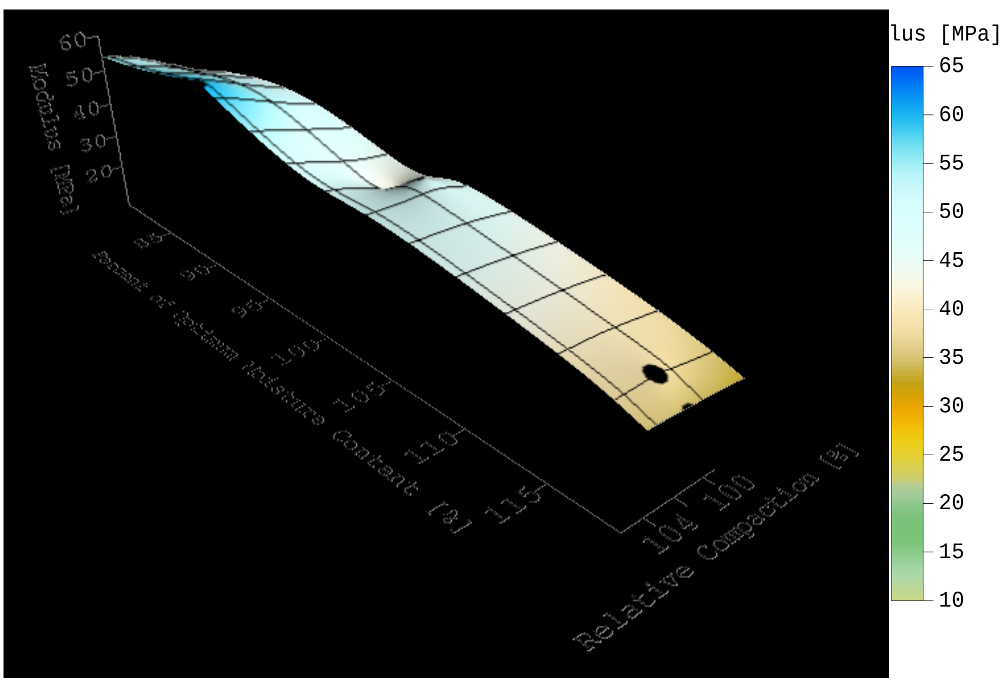

Figure 4.3. Effects of percent of optimum moisture content and relative compaction on LWD modulus for select granular sample KLO

Figures 4.1-4.3 illustrate that the moduli of the select granular and granular materials are influenced by the percent of optimum moisture and relative compaction. The percent of optimum moisture has a strong influence on the modulus and the modulus increases as the percent of optimum moisture decreases. The relative compaction also influences the modulus of the granular material, but to a much lesser degree for the narrow range of densities acceptable during road construction.

4.2 Conclusion

The moisture content and gradation have a significant influence on the LWD measured moduli. Therefore, LWD target values can be estimated for select granular and granular materials using the same method applied to the DCP (grading number and moisture content). It is also recommended that three seating drops be used during LWD testing prior to the three measurement drops.

Chapter 5 – DCP for Fine Grained Soils

5.1 Discussion

The following is a further analysis of DCP measurements originally preformed on fine grained soils by Swenson *et al.*, 2006. In order to get a range of fine grained soils, four samples were collected from across the state of Minnesota. These locations were MnROAD (loam), Duluth (clay), Red Wing (silt), and Red Lake Falls (silty clay). Please see Chapter 2 for more information about the description and preparation of these soil samples.

A Mn/DOT standard DCP (ASTM D 6951-03) was used to collect the data for this study. The DCP used had a 20 mm diameter replaceable cone tip, a 575 mm drop height, and an 8 kg falling mass. As part of the DCP procedure, two seating drops followed by five measurement drops were taken. Since the soil is less confined near the surface, the DCP was able to penetrate further per drop, making the first two drops unreliable. Figure 5.1, a diagram of the DCP penetration index (DPI) versus depth, shows how the first drops do not accurately represent the average DPI. For this reason, the first two drops, known as the seating drops, are disregarded. Six DCP tests are shown in Figure 5.1. The red, green, and blue represent results for moisture contents of 71.5, 75.4, and 102.3 percent of standard Proctor optimum, respectively. Two DCP tests were performed in the specimens constructed at these moisture contents. Additional graphs showing the effect of depth on DPI are presented in Appendix G.

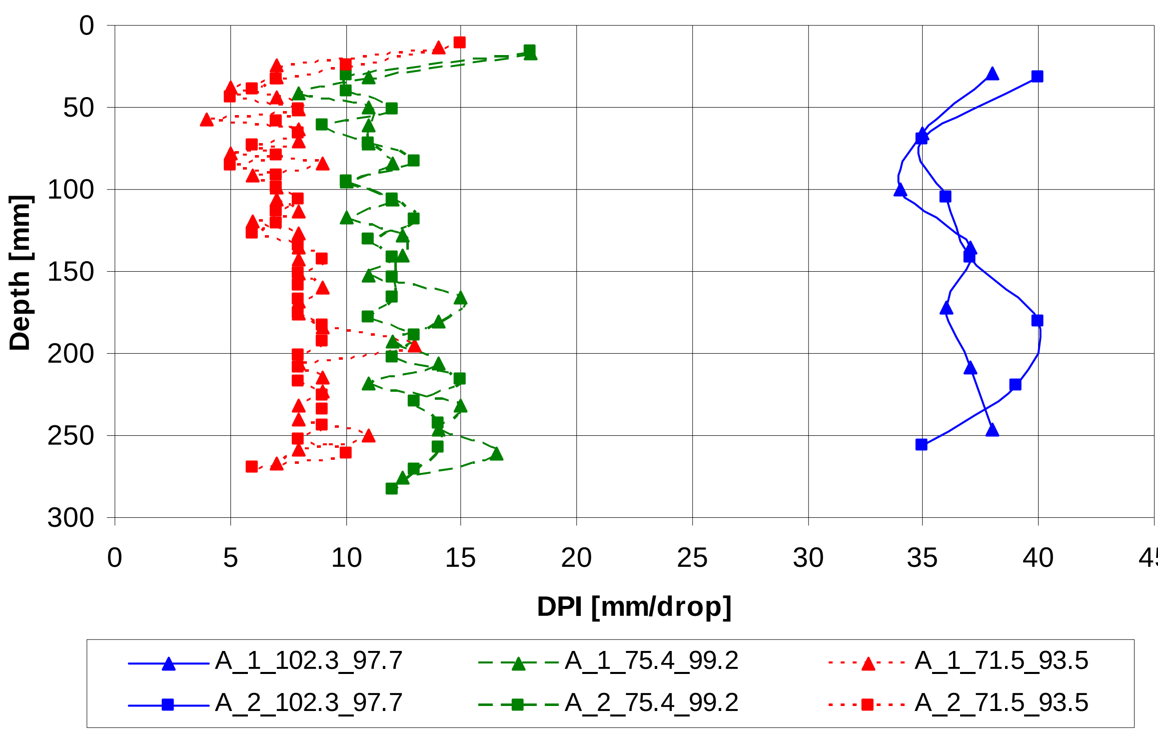

Figure 5.1. Sample DPI versus depth plot

The DPI results for fine grained soil are shown in Figures 5.2-5.5 in comparison to the percent of optimum moisture content and the relative compaction.

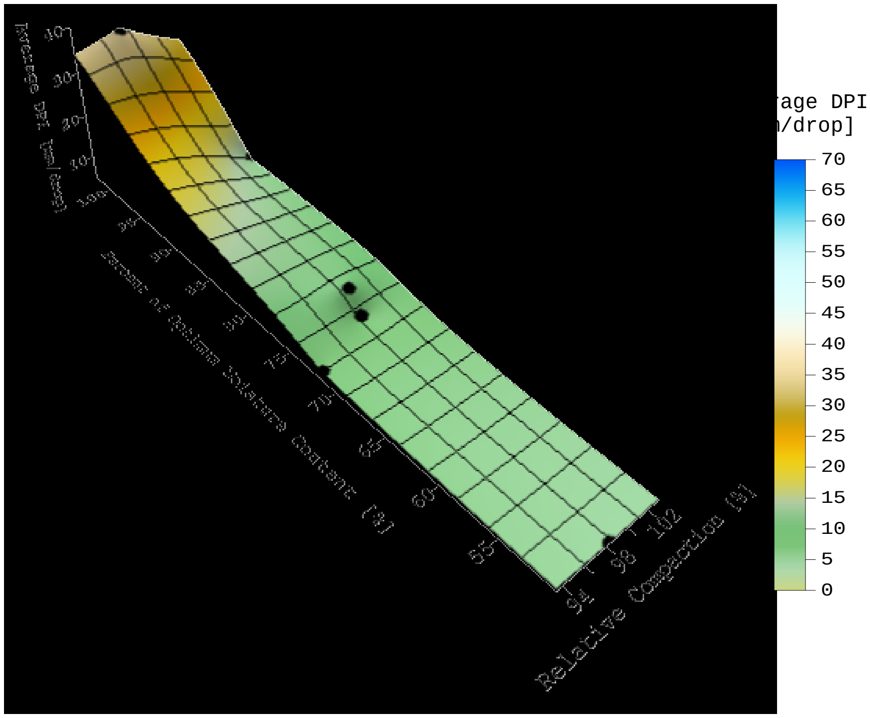

Figure 5.2. Effects of percent of optimum moisture content and relative compaction on average DPI for fine grained sample MnROAD

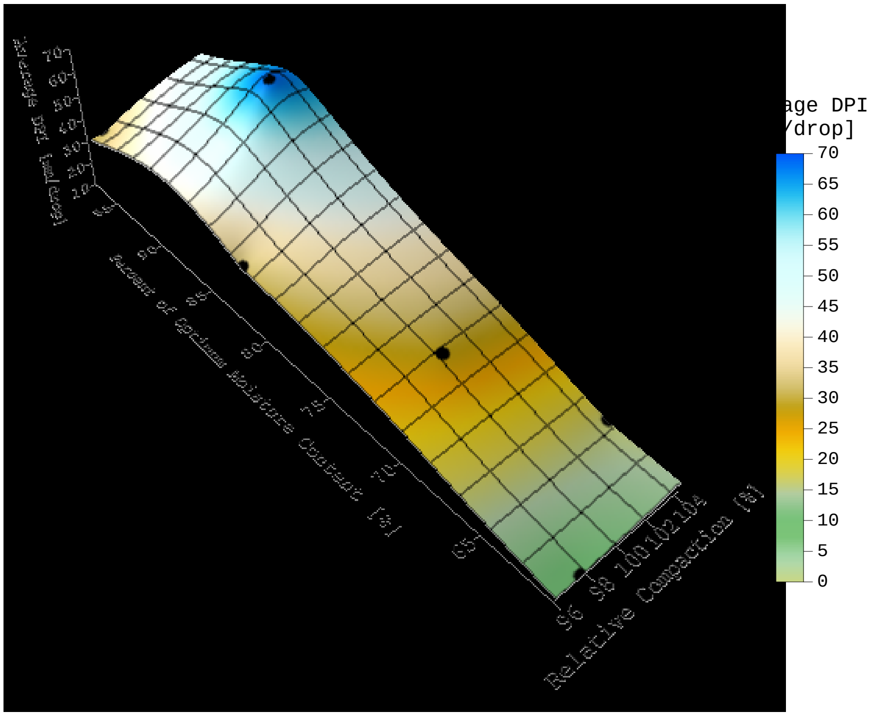

Figure 5.3. Effects of percent of optimum moisture content and relative compaction on average DPI for fine grained sample Duluth

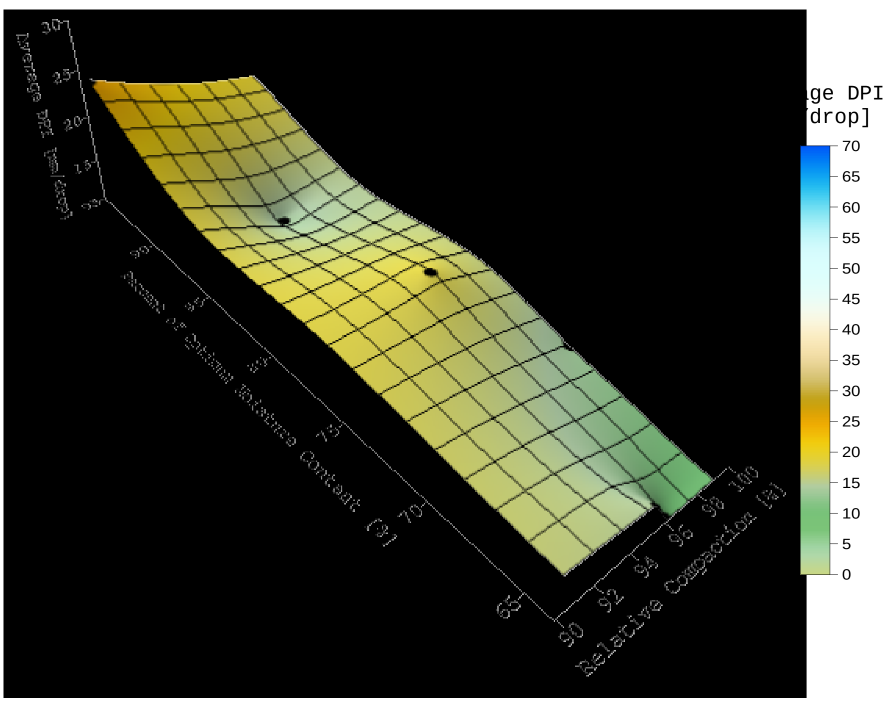

Figure 5.4. Effects of percent of optimum moisture content and relative compaction on average DPI for fine grained sample Red Wing

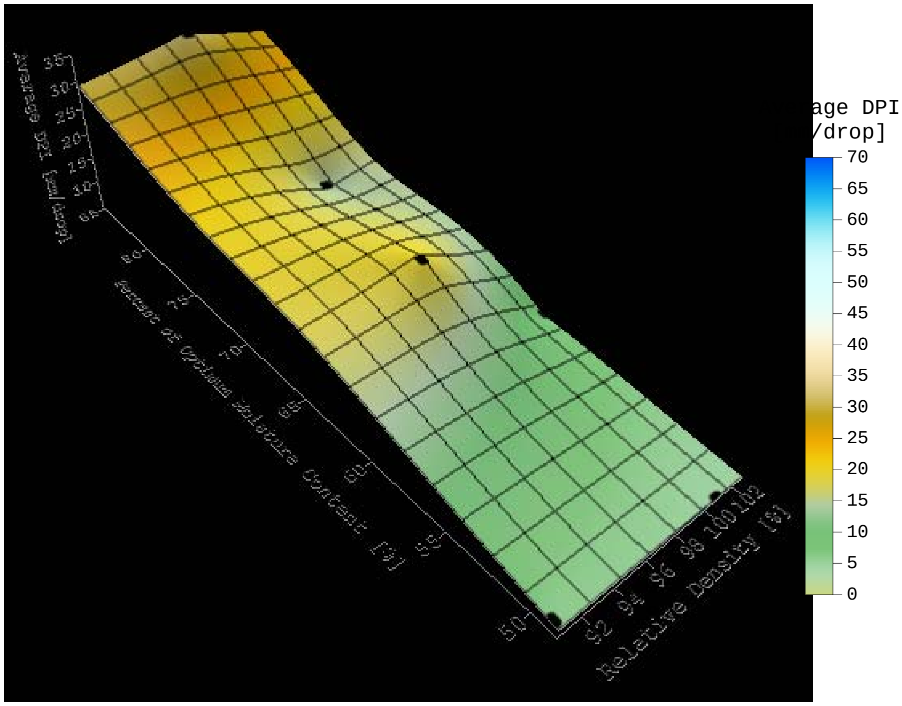

Figure 5.5. Effects of percent of optimum moisture content and relative compaction on average DPI for fine grained sample Red Lake Falls

Using the process described in Chapter 1, the DCP modulus is estimated using the DPI. The DCP modulus of the soil in each of the tests was calculated and compared to the percent of optimum moisture content and the relative compaction. These comparisons are shown in Figures 5.6-5.9.

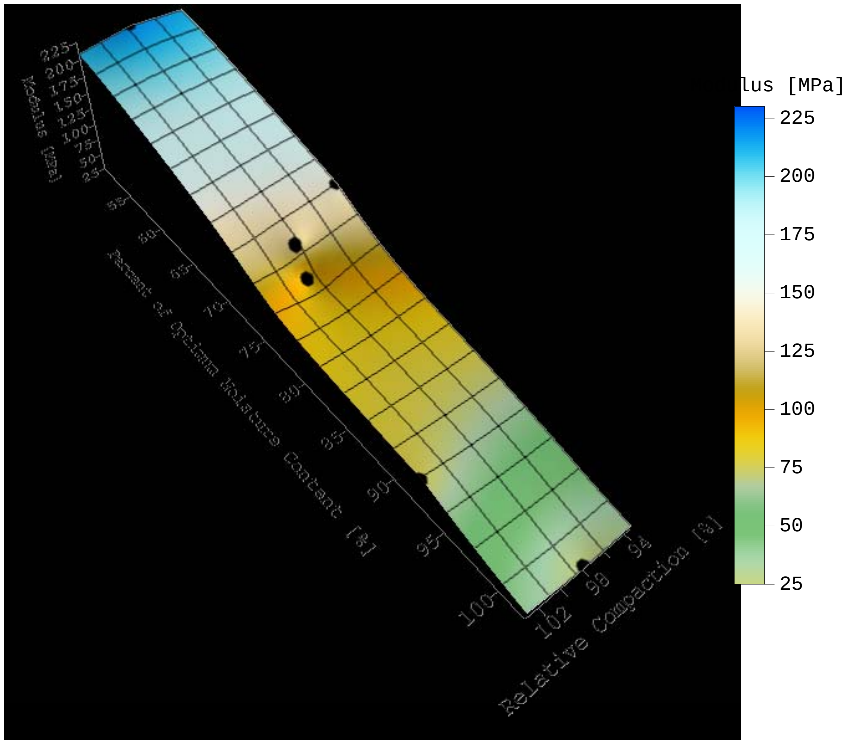

Figure 5.6. Effects of percent of optimum moisture content and relative compaction on DCP modulus for fine grained sample MnROAD

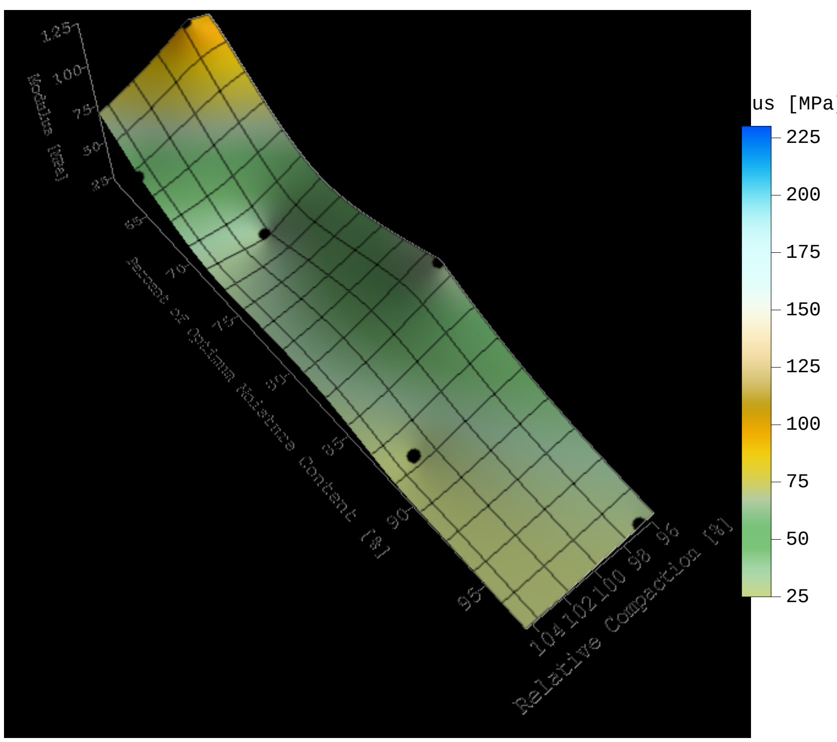

Figure 5.7. Effects of percent of optimum moisture content and relative compaction on DCP modulus for fine grained sample Duluth

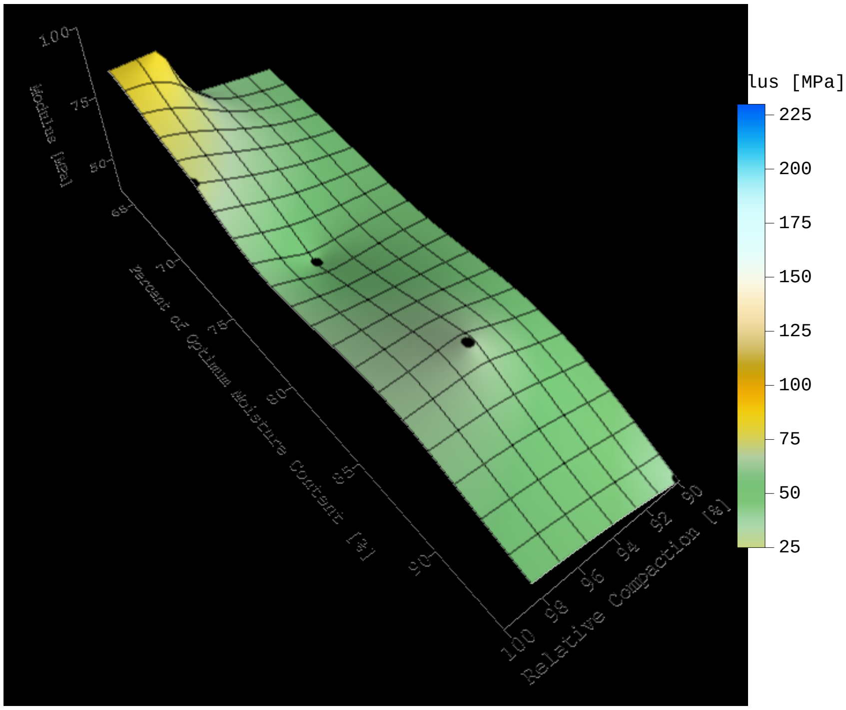

Figure 5.8. Effects of percent of optimum moisture content and relative compaction on DCP modulus for fine grained sample Red Wing

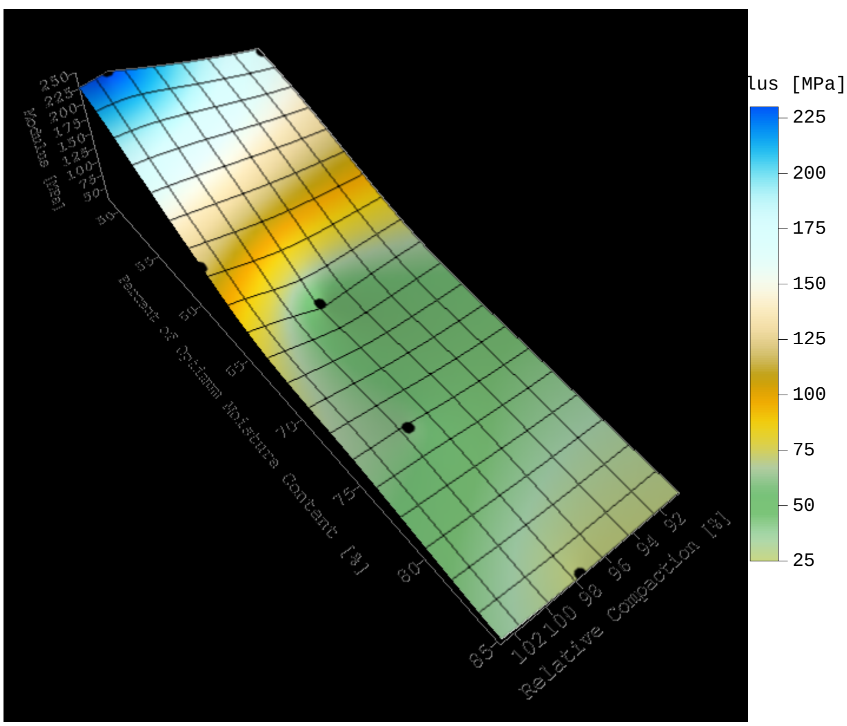

Figure 5.9. Effects of percent of optimum moisture content and relative compaction on DCP modulus for fine grained sample Red Lake Falls

As presented in Figures 5.2-5.5, there is a wide range of average DPI values varying from 5 to 70 mm/drop. As expected, as the percent of optimum moisture content increases, the DPI increases as well. Figures 5.6-5.9 illustrate that as the percent of optimum moisture decreases from 85 to 50 percent, the modulus increases from 25 to 230 MPa. This can be explained by unsaturated soil mechanics theory (Gupta *et al.,* 2007). As the soil dries, suction increases resulting in an increase in strength and stiffness. It is difficult to observe a strong relationship between the modulus and the relative compaction due to the narrow density range studied.

5.2 Conclusion

The moisture content and the soil type have a significant influence on the DCP penetration rate. Density is less important for the narrow range acceptable during road construction. Therefore, target DPI values can be estimated using the in situ moisture content and a mechanistic-based description of soil type. Please see Appendix E for a description of how the plastic limit can be used to classify fine grained soil and estimate optimum moisture.

Chapter 6 – LWD for Fine Grained Soils

6.1 Discussion

The following is a further analysis of the LWD testing of fine grained soils by Swenson *et al.*, 2006. Four soil samples from across Minnesota were used to represent a range of fine grained soils. These locations were MnROAD (loam), Duluth (clay), Red Wing (silt), and Red Lake Falls (silty clay). Please see Chapter 2 for more detailed information on the fine grained soil description and preparation.

A Prima 100 LWD was used for this study. It had a mass of 10 kg and a plate diameter of 20 cm. For each specimen, five drops were performed at three different drop heights: 10, 50, and 90 cm (two seating drops, followed by three measurement drops). In this analysis, the modulus for each of the specimens was calculated using values from a drop height of 50 cm, as recommended by Beyer *et al.*, 2007. An exception to this drop height was made for the MnROAD samples because only drop height data from 90 cm was collected. For an in-depth analysis of the effects of drop height on modulus, please see Appendix D. The LWD testing procedure explained in Chapter 1 was used to estimate the modulus of the soil specimens. For each specimen, the modulus is compared to the percent of optimum moisture content and the relative compaction. These comparisons are represented in Figures 6.1-6.4.

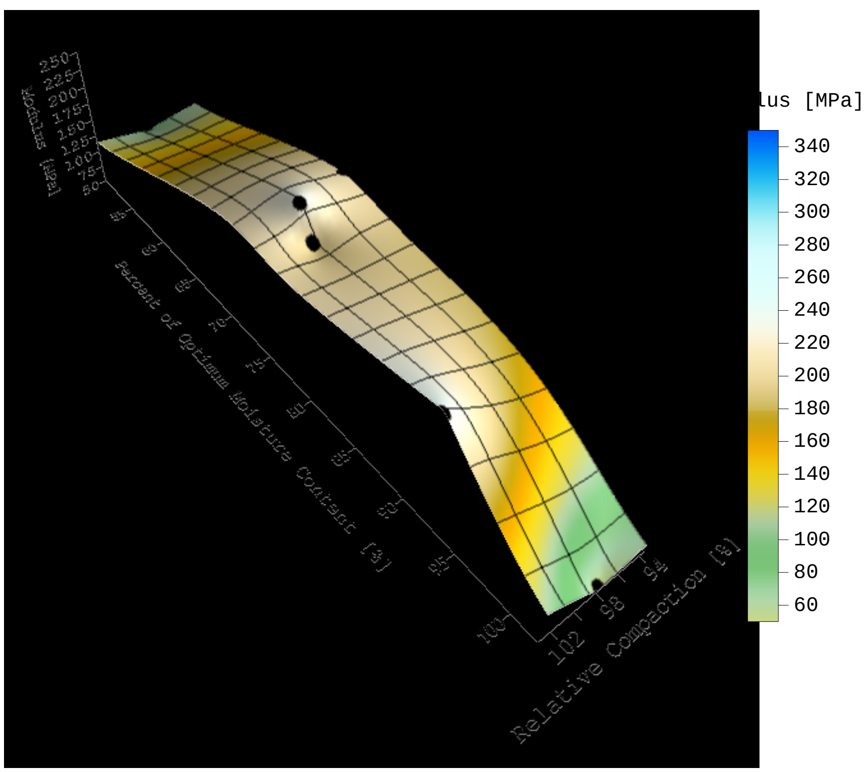

Figure 6.1. Effects of percent of optimum moisture content and relative compaction on LWD modulus for fine grained sample MnROAD

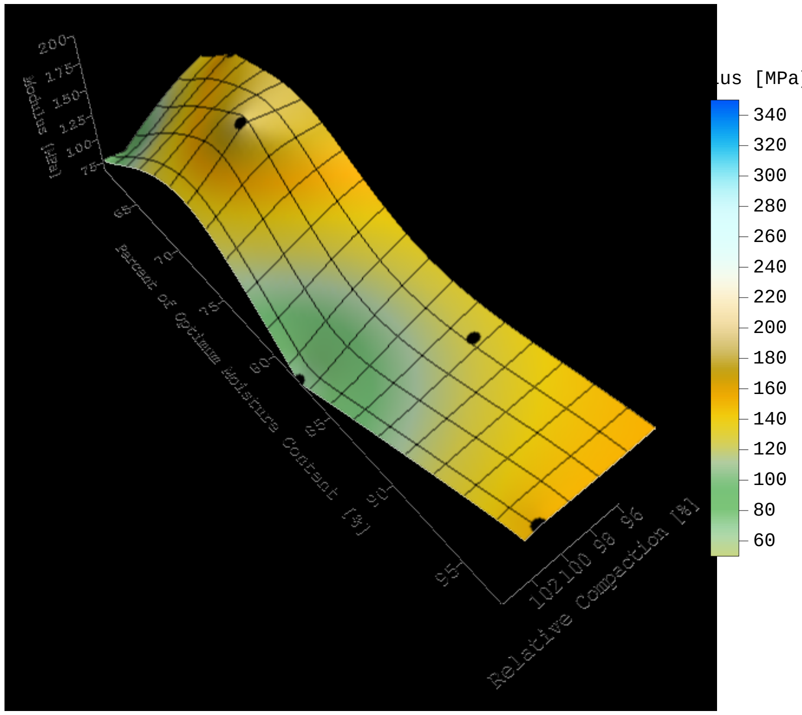

Figure 6.2. Effects of percent of optimum moisture content and relative compaction on LWD modulus for fine grained sample Duluth

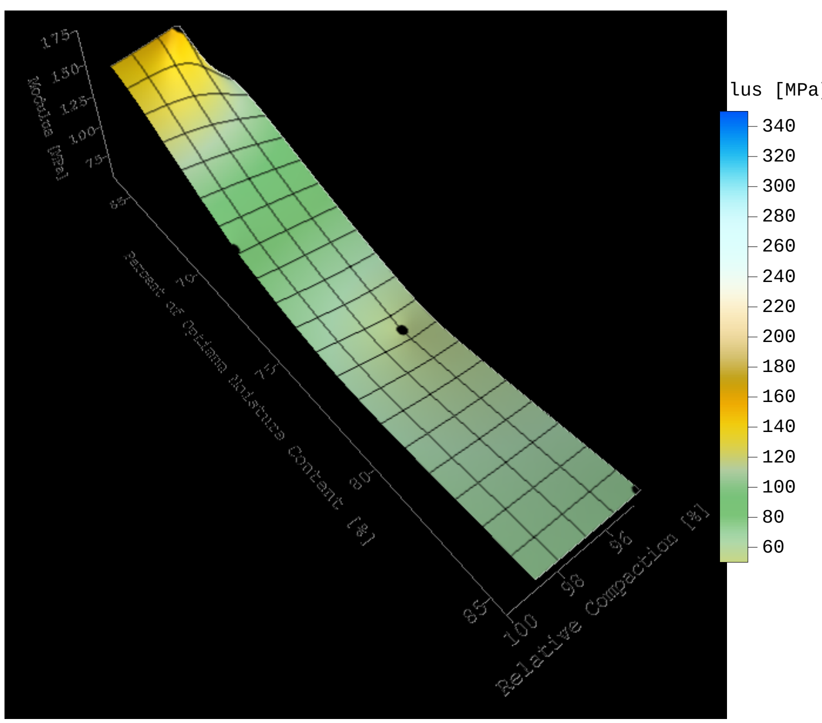

Figure 6.3. Effects of percent of optimum moisture content and relative compaction on LWD modulus for fine grained sample Red Wing

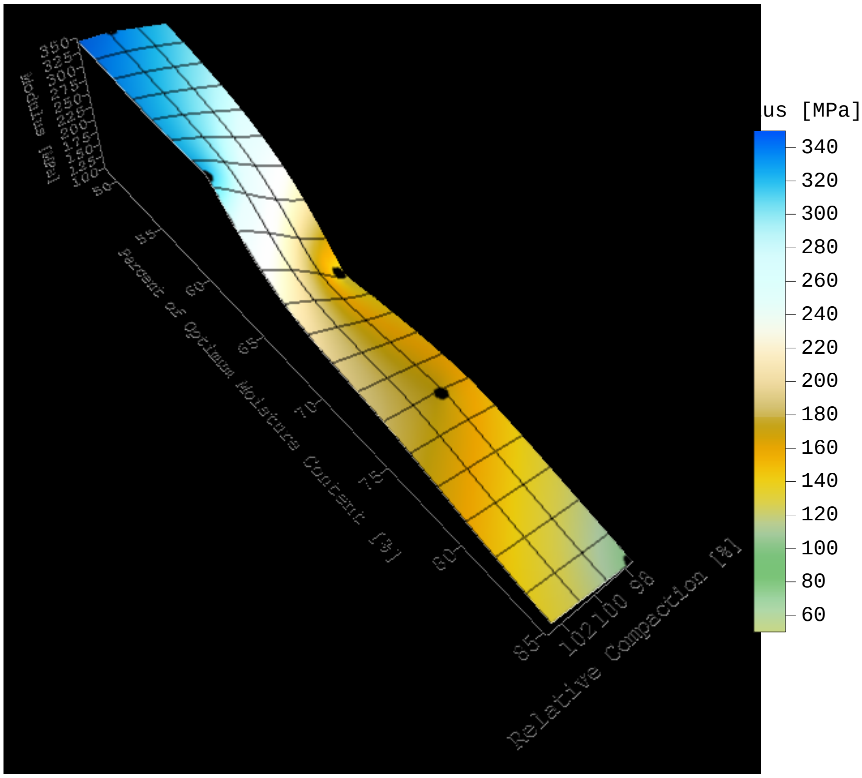

Figure 6.4. Effects of percent of optimum moisture content and relative compaction on LWD modulus for fine grained sample Red Lake Falls

6.2 Conclusion

By examining Figures 6.1-6.4, it can be seen that all of the specimens have highly varied modulus values. In general, as the percent of optimum moisture decreases, the modulus of the soil increases. However, it should be noted that both the MnROAD and Duluth samples vary from this general trend slightly in some regions of Figures 6.1 and 6.2, respectively. The relative compaction has a lesser affect than moisture content due to the narrow range of density acceptable during road construction. Therefore, the target LWD values can be estimated using the in situ moisture content and a mechanistic-based description of soil type. Please see Appendix E for a description of how the plastic limit can be used to classify fine grained soil and estimate optimum moisture.

Chapter 7 – Target Values and Conclusion

The Minnesota Department of Transportation (Mn/DOT) is currently improving the quality assurance testing of unbound materials during pavement construction by implementing the DCP and LWD. Standard testing procedures and model specifications for quality assurance are being developed in order to increase the accuracy, efficiency, and safety during construction testing.

7.1 Background

In this report the unbound materials used during pavement construction are divided into two general groups: granular and fine grained. Granular material is identified as soil having up to 20 percent fines whereas fine grained soil is identified as having more than 20 percent fines. Note that the four different fine grained soils used in this report had fine percentages from about 50 to more than 90 percent. This means that soils with fines in the range of 20 to 50 percent have not been used in the preparation of this report. The DCP and LWD testing was performed on each group separately, ensuring coverage of a wide range of unbound materials. Fortunately, the granular and fine grained groups tested tend to bracket the DPI and LWD target values for materials with fines contents between 20 to 50 percent. The DCP penetration index (DPI) is commonly used because it is a direct measurement of how far the DCP penetrates per drop. Similarly, the LWD directly measures the deflection of a plate due to the impact of a falling mass. Therefore target values for the DCP and the LWD are based on the DPI and the deflection respectively.

7.2 Granular Target Values

The grading number and moisture content are used to select the appropriate target value for compacted granular material. A sieve analysis is used to determine the grading number and an oven dry test or reagent test is typically performed to determine the moisture content. The grading number is the sum of the percentages of particles passing each sieve, as described in Appendix J.

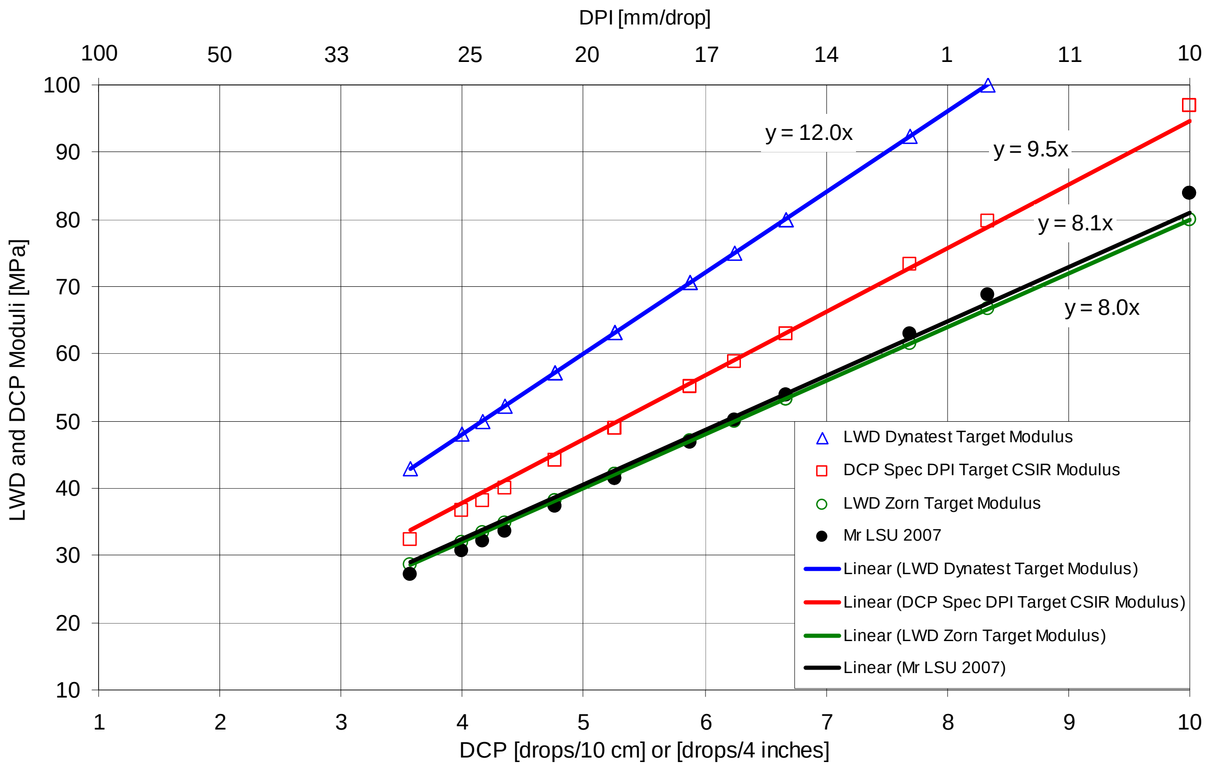

Figure 7.1. DCP and LWD modulus comparison

Table 7.1 provides DPI and LWD target values according to a material's grading number and moisture content derived from Figure 7.1. The moduli for the Dynatest/Keros LWD were calculated using Equation 1.8 using a Poisson's ratio of 0.35 and a plate rigidity of 0.79 (Davich *et. al.*, 2006), whereas the Zorn LWD has these two constants set by the manufacturer (Poisson's ratio of 0.5 and a plate rigidity of 1.0). This difference between the two LWDs has a direct affect on the calculated moduli. Because all of the granular material testing contributed to this report used the Dynatest/Keros model, modulus values for the Zorn were estimated using a conversion factor of 0.67. For comparison, the Mr LSU moduli shown are estimated from the DPI using a relationship based on an extensive laboratory and field testing program of subgrade soils (Mohammad *et. al.*, 2007).

In order to avoid the extra modulus calculations and associated assumptions, a better option is to just compare the deflection measured by the Zorn LWD to a deflection target value. A requirement for this approach is that the impact force must be specified within a relatively tight tolerance because the deflection target values are dependant on the force applied. Please see Appendix D for a discussion on the influence of drop height (force) on deflection. Please note that Mn/DOT is currently implementing a quality assurance system based on deflection target values rather than modulus targets.

Table 7.1. DCP and LWD target values for granular materials

Grading Number	Moisture Content	Target DPI	Target DPI Modulus CSIR	Target LWD Modulus Dynatest	Target LWD Modulus Zorn	Target LWD Deflection Zorn
GN	%	mm/drop	MPa	MPa	MPa	mm
3.1-3.5	5 - 7	10	97	120	80	0.38
	7 - 9	12	80	100	67	0.45
	9 - 11	16	59	75	50	0.60
3.6-4.0	5 - 7	10	97	120	80	0.38
	7 - 9	15	63	80	53	0.56
	9 - 11	19	49	63	42	0.71
4.1-4.5	5 - 7	13	73	92	62	0.49
	7 - 9	17	55	71	47	0.64
	9 - 11	21	44	57	38	0.79
4.6-5.0	5 - 7	15	63	80	53	0.56
	7 - 9	19	49	63	42	0.71
	9 - 11	23	40	52	35	0.86
5.1-5.5	5 - 7	17	55	71	47	0.64
	7 - 9	21	44	57	38	0.79
	9 - 11	25	37	48	32	0.94
5.6-6.0	5 - 7	19	49	63	42	0.71
	7 - 9	24	38	50	33	0.90
	9 - 11	28	32	43	29	1.05

♦ Please see Appendix J for current DCP specification target values
* Keros/Dynatest LWD target values assume ν = 0.35, and R = 0.79
† Target LWD modulus values assume falling mass = 10 kg, plate diameter = 20 cm, and drop height = 50 cm
‡ Zorn LWD target deflection values assume ν = 0.5, R = 1, and peak force = 6.28 kN resulting in a peak stress of 0.2 MPa

7.3 Fine Grained Target Values

The plastic limit and moisture content are used to determine DCP and LWD target values when evaluating the compacted condition of fine grained soil during embankment construction. In this case, the plastic limit is used in place of the grading number to classify the soil. For fine grained soils, a sieve analysis and a hydrometer test are time consuming. The plastic limit, on the other hand, is relatively simple and has a successful history of use (Black, 1962, Kersten, 1944, Swanberg and Hansen, 1946, and Woods and Litehiser, 1938). The plastic limit test determines when a soil changes from a plastic to a solid-like consistency and is defined as the moisture content at which the soil begins to crumble when it is rolled into a three millimeter thread. The moisture content is determined by an oven dry test or an alternative test.

For this report, a standard Proctor test was used to determine the optimum moisture content. Appendix E demonstrates that using the plastic limit to estimate the optimum moisture content is also feasible. Table 7.2 demonstrates this concept and provides DCP and LWD target values according to the soil's plastic limit and moisture content. For example, a soil with a plastic limit of 20 to 24 percent has an estimated optimum moisture content of 15 to 19 percent. When the field moisture content is 75 to 79 percent of optimum moisture content, the target DPI is 21 mm/drop and a target Zorn LWD maximum deflection is 1.6 mm.

Table 7.2. Target DPI and LWD deflection values for fine grained soils

Plastic Limit	Estimated Optimum Moisture	Field Moisture as a Percent of Optimum Moisture	DCP Target DPI at Field Moisture	Zorn Deflection Target at Field Moisture minimum	Zorn Deflection Target at Field Moisture maximum
[%]	[%]	[%]	[mm/drop]	[mm]	[mm]
non-plastic	10-14	70-74	12	0.5	1.1
		75-79	14	0.6	1.2
		80-84	16	0.7	1.3
		85-89	18	0.8	1.4
		90-94	22	1.0	1.6
15-19	10-14	70-74	12	0.5	1.1
		75-79	14	0.6	1.2
		80-84	16	0.7	1.3
		85-89	18	0.8	1.4
		90-94	22	1.0	1.6
20-24	15-19	70-74	18	0.8	1.4
		75-79	21	0.9	1.6
		80-84	24	1.0	1.7
		85-89	28	1.2	1.9
		90-94	32	1.4	2.1
25-29	20-24	70-74	24	1.0	1.7
		75-79	28	1.2	1.9
		80-84	32	1.4	2.1
		85-89	36	1.6	2.3
		90-94	42	1.8	2.6
30-34	25-29	70-74	30	1.3	2.0
		75-79	34	1.5	2.2
		80-84	38	1.7	2.4
		85-89	44	1.9	2.7
		90-94	50	2.2	3.0

The soils tested by Swenson *et al.*, 2006 were used to define the surfaces in Figure 7.2 and 7.3 for fine grained soils. Recall that four different soils from different locations around the state were used: MnROAD, Duluth, Red Wing, and Red Lake Falls. The plastic limit was plotted against the percent of optimum moisture content to produce figures of DPI and modulus values. This method was used to create Figures 7.2 and 7.3, which show the target DPI as well as the target LWD modulus for the Prima 100 model LWD used by Swenson.

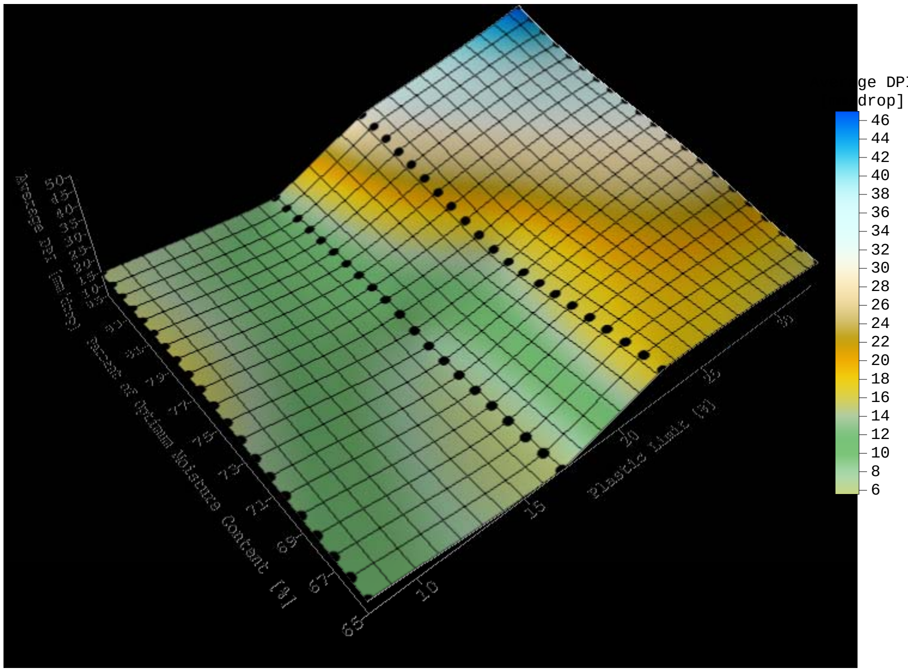

Figure 7.2. Effects of percent of optimum moisture content and relative compaction on average DPI target values for fine grained soils

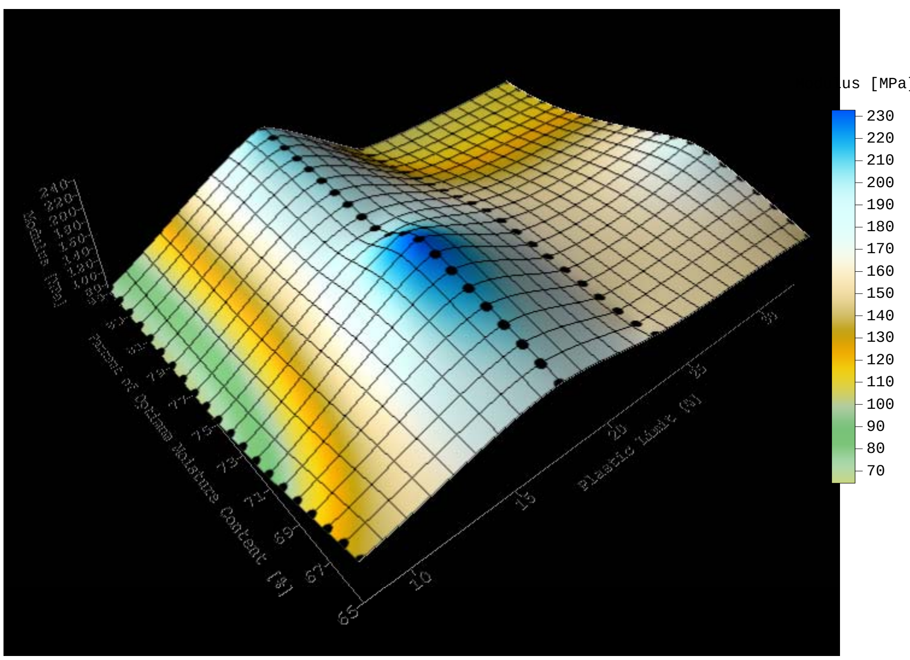

Figure 7.3. Effects of percent of optimum moisture content and relative compaction on LWD modulus values for fine grained soils

Figures 7.2 and 7.3 can be incrementally split into sections defined by the plastic limit ranges and percent of optimum moisture content shown in Table 7.2. Note that the LWD testing of fine grained soils documented in this report was performed with a Prima 100 model LWD. That

LWD model had a 20 cm plate diameter, 10 kg falling mass, and a 50 cm drop height, but also had significant design differences that have been described earlier. Additional field testing has been completed and more field testing is underway to refine the relationship between that previously used LWD and the current LWD model used in Minnesota. Please see Appendix L for a construction site analysis of how these proposed target values compare to field measured values.

The target values is Table 7.2 may be generally adequate, however those target values may not accurately represent every soil type and moisture content within the particular plastic limit and percent of optimum moisture content range described in Table 7.2. In order to select a more appropriate target value, a contour map was created. Instead of rigid increments, the contour map displays contour lines to achieve an accuracy of about 2 mm/drop. Figure 7.4 shows the average DPI contours versus plastic limit and percent of optimum moisture content for fine grained soils.

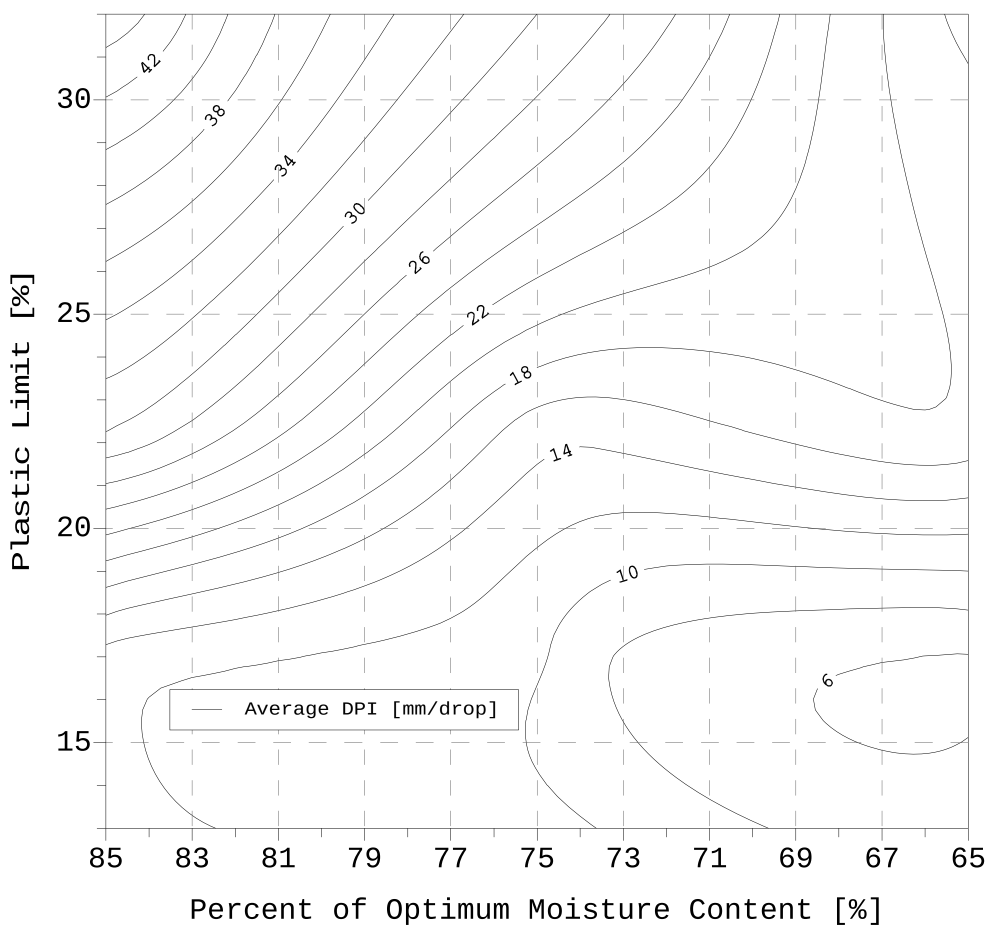

Figure 7.4. Average DPI versus percent of optimum moisture content and plastic limit for fine grained soils

As can be seen, the contours of Figure 7.4 are somewhat irregular. This is due to the fact that there is insufficient data in some regions of the plot. Using Figure 7.4 as a guide, Figure 7.5 was created to ease implementation and prevent the misinterpretation of the target values. Additional field verification testing will be required to validate and/or modify the target values determined using Figure 7.5.

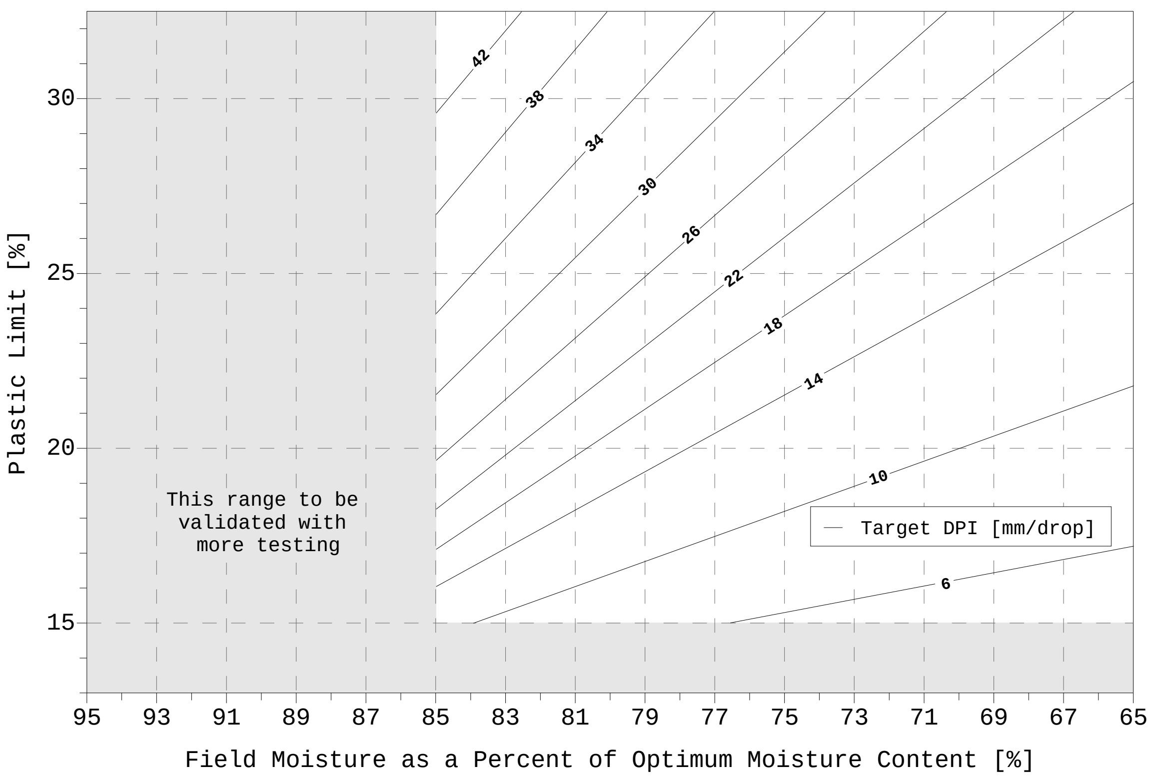

Figure 7.5. Average DPI simplified target values versus percent of optimum moisture content and plastic limit for fine grained soils

Figure 7.5 is an efficient and relatively simple method of for estimating DPI target values on construction sites. To determine the DPI target value two variables need to be determined: the plastic limit (from which the optimum moisture content is estimated) and the field moisture content (which must be compared to the estimated optimum moisture content).

In order to estimate the target values for the Prima 100 LWD modulus, a contour version of Figure 7.3 was made. Figure 7.6 is a plot of the LWD modulus values versus the plastic limit and the percent of optimum moisture content. Note the target values shown in Figure 7.6 are for the Prima 100 LWD model. An appropriate conversion factor will be needed when testing with a different type of LWD.

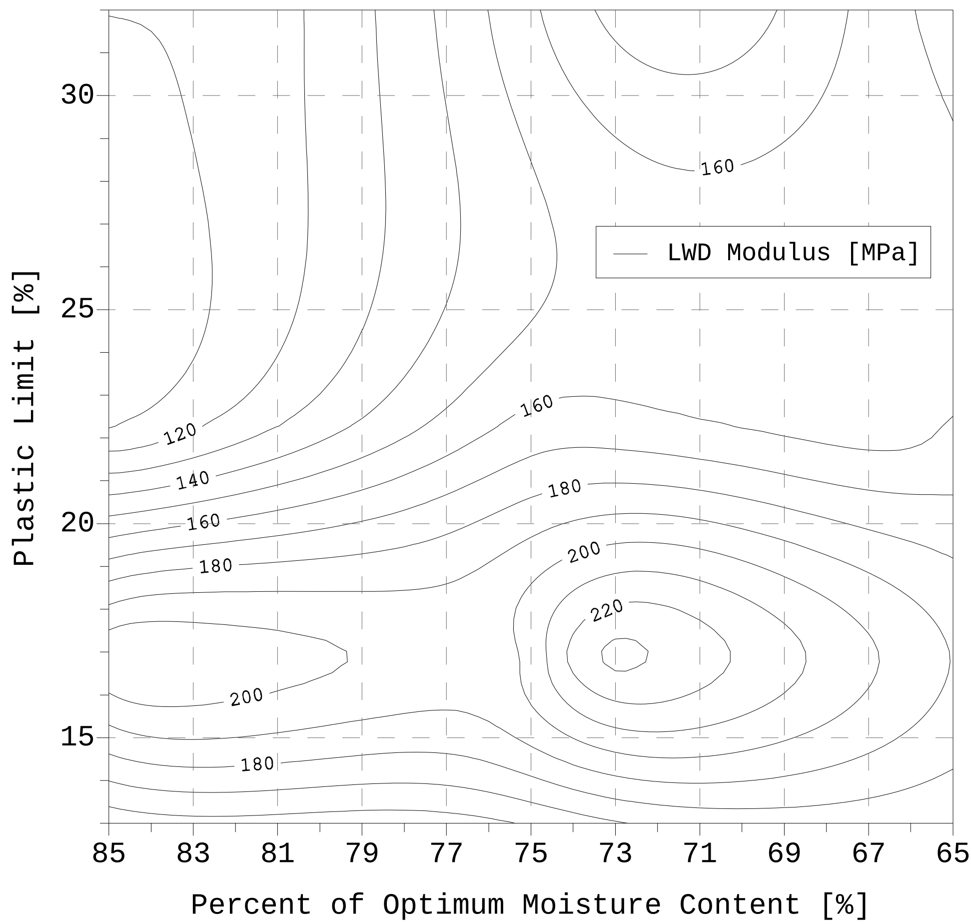

Figure 7.6. LWD modulus versus percent of optimum moisture content and plastic limit for fine grained soils

As can be seen in Figure 7.6, the contours of LWD moduli are highly irregular. For this reason, another figure of LWD moduli values was created. Figure 7.7 shows moduli values estimated from the DPI values in Figure 7.4 using Equation 1.6. This was done in order to determine if the trends of the two figures generally agree. Note that values in Figure 7.7 should not be used as LWD modulus target values directly because they are derived from DCP data, not LWD data.

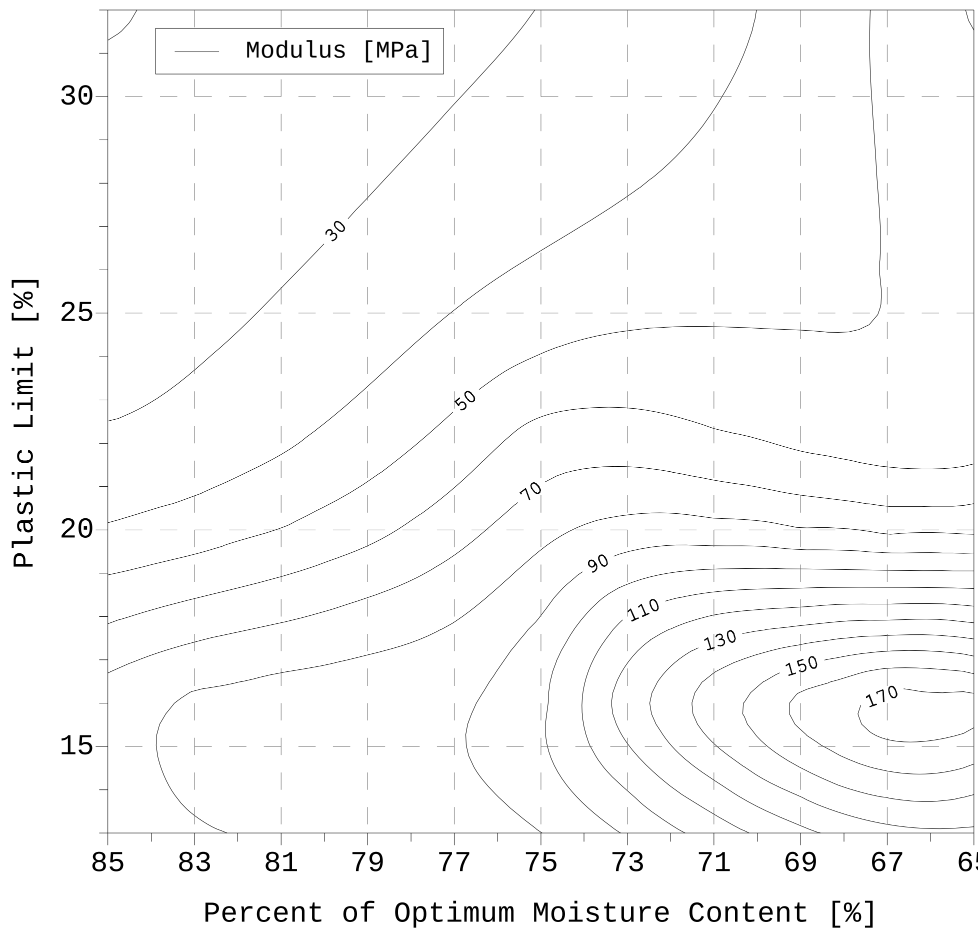

Figure 7.7. DCP modulus calculated from DPI versus percent of optimum moisture content and plastic limit for fine grained soils

The contours of Figure 7.7 show trends similar to Figure 7.6, however the magnitude of the actual modulus values in these figures do not agree. This is due to the fact that Figure 7.7 used test data from a DCP while Figure 7.6 used test data from the Prima LWD. In summary, the general trends of Figure 7.7 validate those of Figure 7.6, which was the intent of this analysis.

Similar to the DCP analysis, simplified target values were drawn for both the moduli estimated with the DCP and Prima LWD. Like the actual data contours of Figures 7.6 and 7.7, it is expected that while actual modulus values between the devices will be different, the general trends will be similar. Figure 7.8 shows the simplified DCP modulus values calculated from the simplified DPI target values from Figure 7.5 using Equation 1.4. Figure 7.9 shows the simplified LWD modulus target values derived from the contour lines of Figure 7.6.

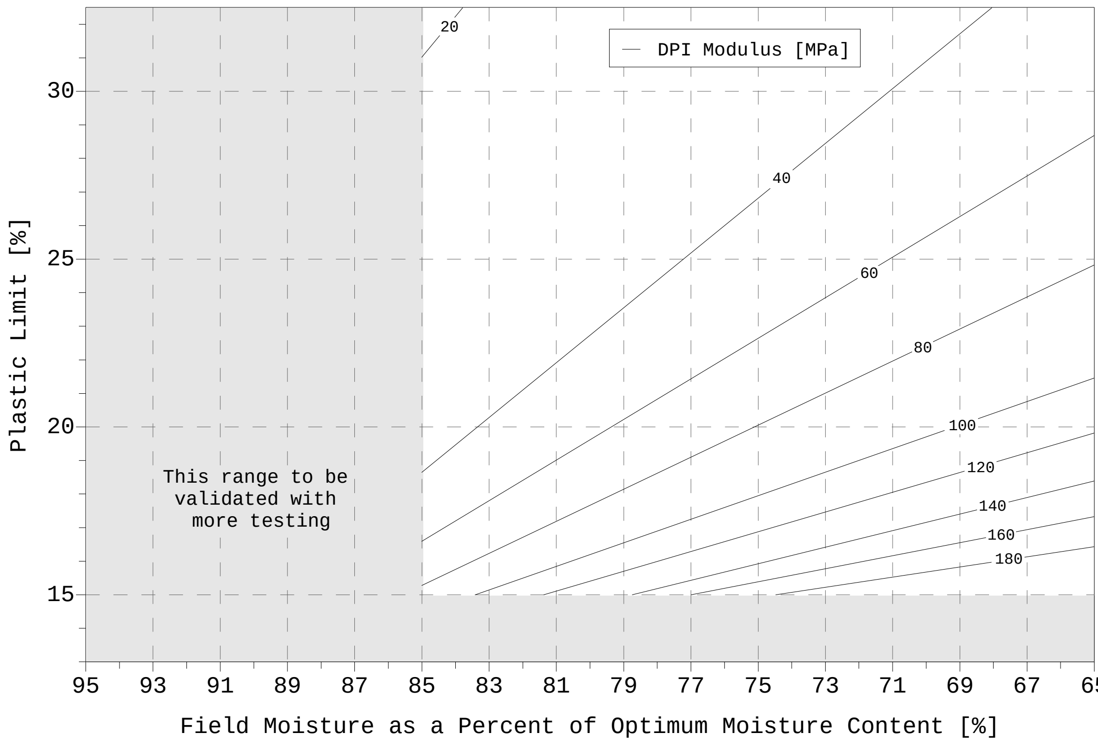

Figure 7.8. DCP modulus calculated from simplified DPI versus percent of optimum moisture content and plastic limit for fine grained soils

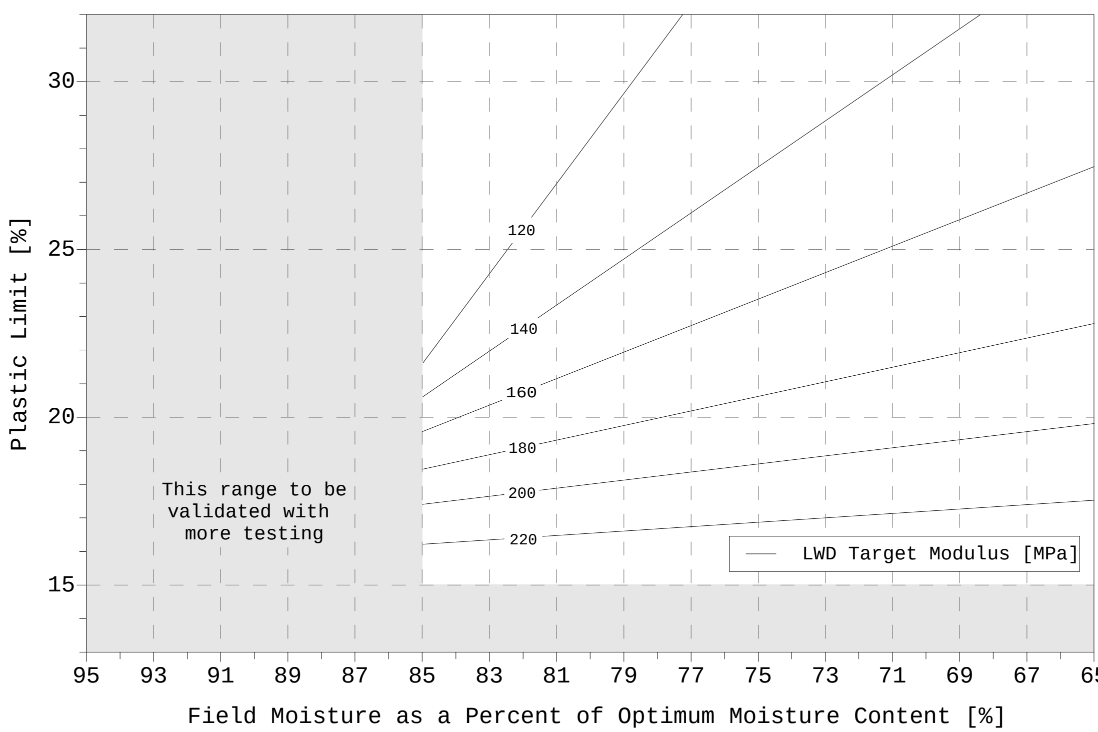

Figure 7.9. Prima modulus simplified target values versus percent of optimum moisture content and plastic limit for fine grained soils

As can be seen from Figures 7.8 and 7.9, the general trend of the modulus values is similar for both devices even though the magnitude of the actual values varies greatly. This shows that while each device produces unique values, there is a reasonable correlation between them.

7.4 Conclusion

The final products resulting from this research implementation project are the target values for both granular materials and fine grained soils shown in Tables 7.1 and 7.2. These target values can be used for quality assurance of unbound materials during pavement foundation construction with minimal verification at specific project locations.

In addition to these target values, further standardization of the testing procedures for both LWDs and DCPs is important. This will ensure greater uniformity by personnel conducting these tests. Currently, the method for obtaining a DPI value is varied, involving different numbers of seating drops and measurement drops. Using three seating drops and five to ten measurement drops, depending on the material type, is recommended in this report.

LWD testing includes variations as well and the Mn/DOT Grading and Base section is currently defining the seating depth and other aspects of the procedure for implementation during the 2009 construction season. The LWD device is currently non-standardized nationally, allowing manufacturers to develop different models, which produce different measurements. Because Mn/DOT has decided to establish predetermined target values it is necessary to select a specific LWD such that the buffer and plate stiffnesses are also constant along with the specified falling mass, peak force, and plate diameter.

This project leveraged previous research sponsored by Mn/DOT and the LRRB. One primary resource was report 2006-20, *Validation of DCP and LWD Moisture Specifications for Granular Materials*, which validated the use of DCP and LWD technology. Two other studies also drawn upon extensively to better understand the effect of soil moisture on stiffness and strength were reports: 2006-26, *Moisture Effects on PVD and DCP Measurements* and 2007-11, *Pavement Design Using Unsaturated Soil Technology*.

In conclusion, LWDs and DCPs should be implemented more widely in the state of Minnesota. This should be done using the standardized testing procedures and the defined target values in this report as reasonable starting points from which project specific verification or modification would occur. The recommended target values in this report are intended to be estimates that need to be verified as appropriate for specific projects.

The draft specification produced by this project will be further refined and incorporated into Mn/DOT's *Standard Specifications, Grading and Base Manual, and Geotech and Pavement Manual*, as well as the inspector and technician certification classes already required for DCP and LWD use. As the benefits of these technologies become increasingly apparent, more counties, cities, and consultants are expected to acquire these tools.

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Appendix A – Analysis of LWD Energy Distribution

A.1 Discussion

Light weight deflectometer (LWD) devices are becoming established tools for estimating moduli during quality control and quality assurance procedures in the United States. These devices are appealing because they provide a relatively accurate estimation of a soil's modulus from a mechanically simple test. For a more detailed description of a LWD, see Chapter 1.

The physics of such a system are readily understood. The potential energy of the raised mass is converted into kinetic energy as it falls. As the mass strikes the plate's buffer, some of its energy is transferred to the soil, which deflects. However, because energy is stored in the buffer, only a fraction of the initial potential energy is transferred to the soil (Equation A.1). Figure A.1 contains a plot of the energy ratio (Equation A.2) versus deflection measured by the LWD's geophone in contact with the ground.

$$PE \rightarrow KE \rightarrow W_{BUFFER} + W_{SOIL} \quad \text{[A.1]}$$

$$Energy\ \ Ratio = \frac{W_{SOIL}}{PE} \quad \text{[A.2]}$$

where:

PE	=	potential energy
KE	=	kinetic energy
W_{BUFFER}	=	work done by the buffer
W_{SOIL}	=	work done by the soil

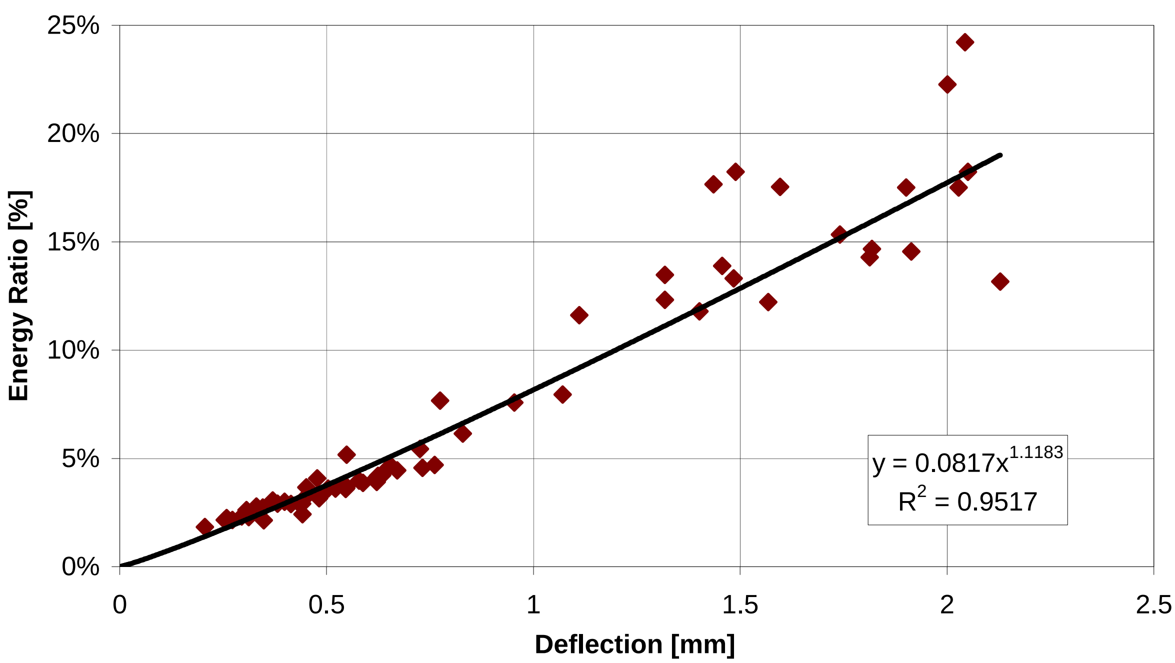


Figure A.1. Energy ration versus deflection

The potential energy is:

$$PE = mgh \qquad [A.3]$$

where:

PE	=	potential energy [N·m]
m	=	mass [10 kg]
g	=	acceleration of gravity [9.81 m/s^2]
h	=	drop height of falling mass [0.25, 0.50, or 0.75 m]

The energy transferred to the soil can be calculated from the work done by the soil, which is the integral of the force measured over the observed deflection range, shown in Figure A.2. This integral was estimated using the area under the curve for the force versus deflection plot for a particular drop. An example of this trapezoidal integration is included in Figure A.3 and is defined by Equation A.4. This method consists of approximating the region under the curve of a given function using many trapezoids and summing their respective areas.

$$W_{SOIL} = \int F \; dx = \sum \frac{(f_2 + f_1)}{2(x_2 - x_1)} \qquad [A.4]$$

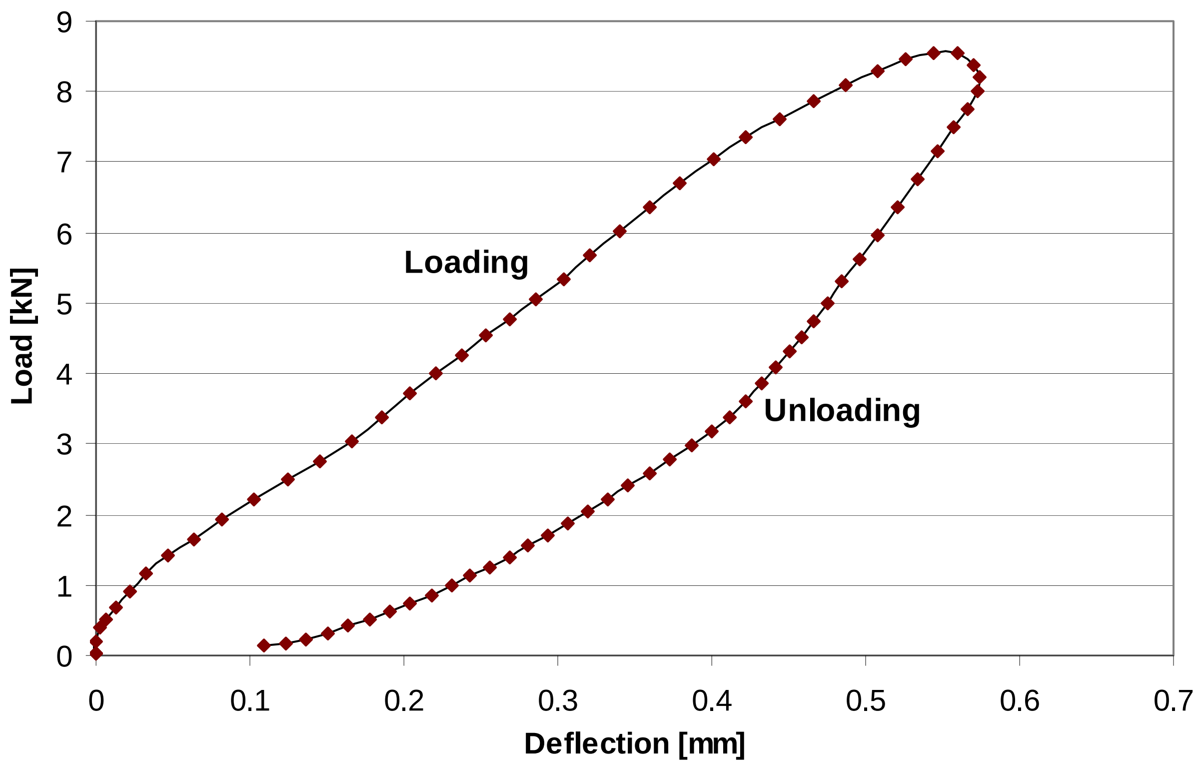


Figure A.2. Load versus deflection

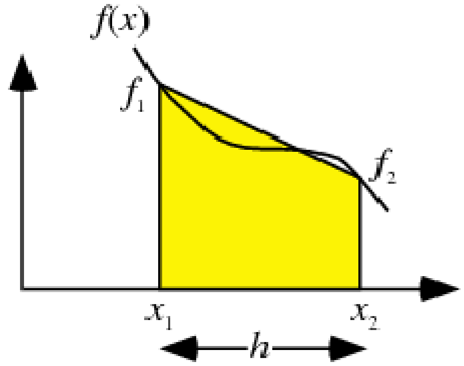


Figure A.3. Trapezoidal integration (courtesy of Wolfram Mathworld)

The LWD system can be modeled as a mass falling on a spring, the buffer, resting on another spring, the soil layer. Because the stiffness of the soil layer is the desired quantity, the deflection and load on the lower spring, the soil layer, are needed. However, energy is stored in the upper spring, the buffer, as well. As can be seen in Figure A.1 a large portion of the system's energy is not transferred to the soil. Rather the buffer stores energy until it is used to rebound the mass up the guide rod or this energy is dissipated as heat within the buffer. The large rebound of the mass when the LWD is used on stiff materials demonstrates this conclusion.

A.2 Conclusion

A large percent of the LWD's energy can be stored in the buffers, resulting in a small percentage of the mass's original potential energy to be transferred to the soil. In order to determine the amount of energy that is delivered to the soil, the force must be measured during the field test or prior to the field test, during the calibration procedure performed by the manufacturer.

The precision of the LWD is affected by the relative stiffness of the material tested and the buffers. Other things that can affect the precision of the measurements, due to the limited sensitivity of the load cell and geophone or accelerometer, are low energy from low drop heights, small deflections from stiff materials, and low stiffness buffers. Another factor that affects the accuracy of the LWD calculated modulus is when measurements are taken with a non-load cell LWD testing less stiff materials after the assumed load has been determined on a near-rigid material. Issues, such as the extent at which buffer stiffness affects LWD measurements and how temperature influences the rubber buffers, need further evaluation in order to be more fully understood.

Appendix B – Analysis of LWD Load Estimation for Granular Material

B.1 Introduction

It is known that the amount of load transferred to a material by a falling mass varies in response to the stiffness of the underlying material. For example, the falling mass delivers a greater force to the foundation if the material provides a relatively small deflection. As a result, the fixed load estimates may or may not be accurate enough to estimate the modulus of the material tested, which are used by certain models of light weight deflectometer (LWD) devices. A load estimate can be established by placing the LWD device on a concrete slab while independently measuring the load. This type of rigid foundation test results in a very small deflection and the load estimate produced may be significantly larger than the load generated on soils. The objective of the testing reported in this appendix is to determine if there is a need to correct the modulus values from LWD devices that estimate load in this manner. This appendix deals with granular soil, while fine grained soil is the focus of Appendix C.

The LWD used in this study was a Dynatest/Keros model. The standard test sequence for the device included two seating drops followed by three measurement drops performed at each of the following three heights: 25, 50, and 75 cm. This study was conducted in parallel with Davich *et al.*, 2006, using the same granular materials, preparation, and instruments.

B.2 Results

The loads applied to the specimens varied from 3 to 9 kN depending on the drop height. This resulted in an applied stress of 0.095 - 0.286 MPa while using the 20 cm diameter plate. The deflection of the soil varied from 0.2 to 2.5 mm, with large deflection values usually associated with the high moisture content specimens. The load versus deflection data is plotted in Figure B.1.

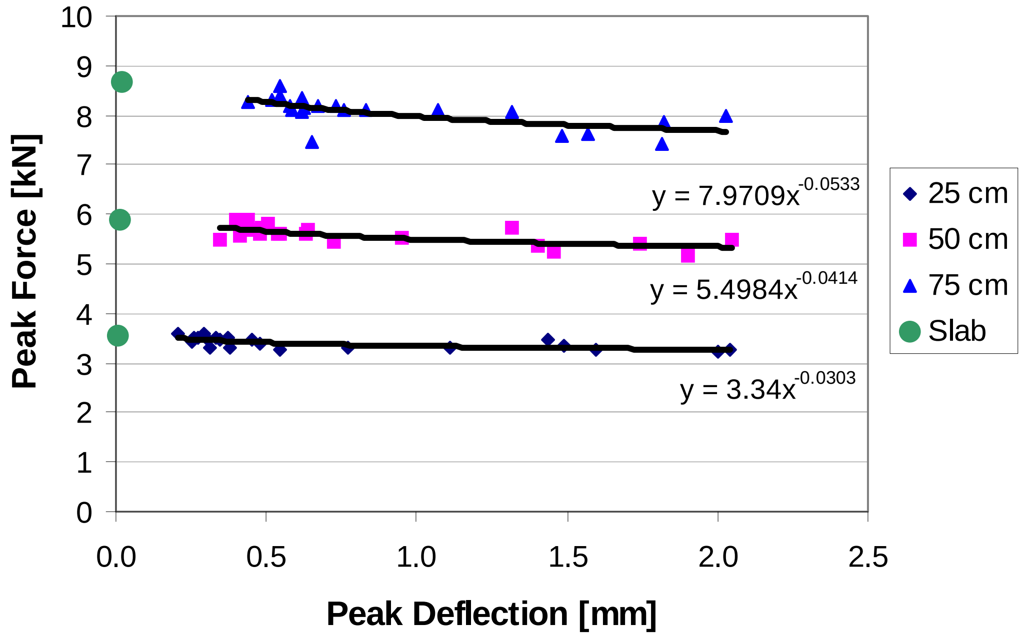


Figure B.1. LWD peak deflection versus peak force

The trend lines in Figure B.1 make it clear that the measured peak force values slowly decreased as the peak deflection of the soil increased. This decrease was 7.8 percent from the beginning to the end of the test range for the 75 cm drop height, 7.2 percent for 50 cm, and 7.0 percent for 25 cm.

Some LWD devices do not utilize a load cell, but instead estimate a modulus from fixed load values measured at near zero deflection (on a concrete slab). These peak force values are most likely larger than the values measured on soil materials. Therefore, the LWD used in this study was placed on a concrete slab to determine its force measurements at "zero" deflection. The average values recorded during this test are included on Figure B.1 at all three drop heights in the "slab" series. It can be seen that these slab values are larger than the force values in the soil material range. On average, modulus values calculated using the slab force values would be 7.8 percent larger than the modulus values calculated from measured loads at the 75 cm drop height, 5.4 percent larger at 50 cm, and 4.0 percent larger at 25 cm.

Figure B.2 shows the difference between modulus values calculated from the measured forces and the values calculated from forces that were estimated from the deflections using the equations found in Figure B.1. Figure B.3 shows the difference between the deflection estimated modulus values and the slab force modulus values. LWD devices that make use of a load cell achieve results that are only slightly more accurate than the results that could be obtained using the above equations to estimate the force. LWD devices that estimate modulus from slab force values would overestimate the modulus by about 5-6 percent at a 50 cm drop height based on the results obtained during this study.

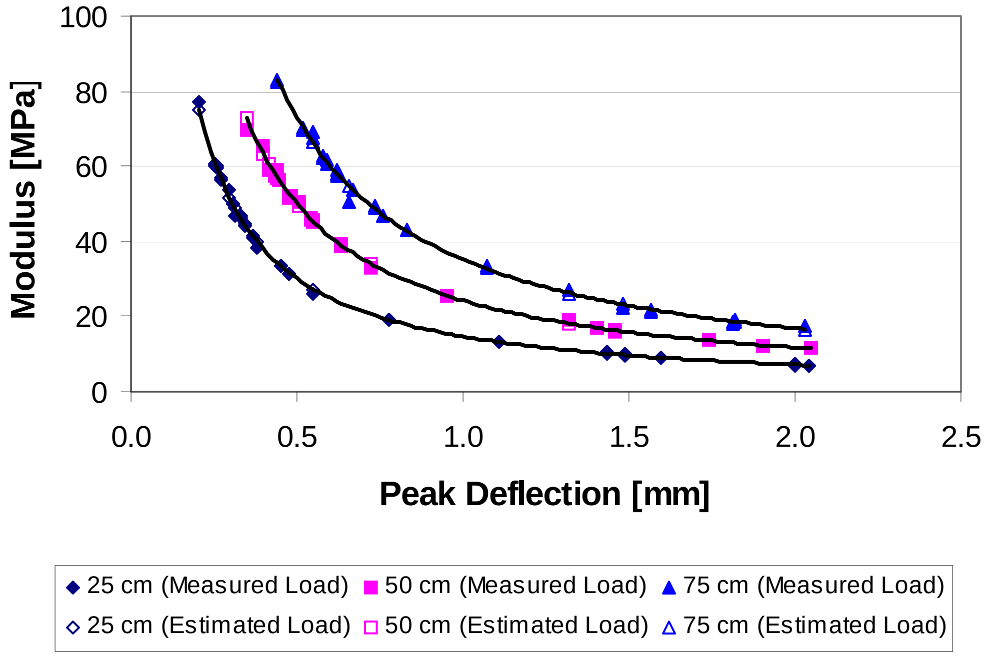


Figure B.2. Modulus values from measured and estimated loads

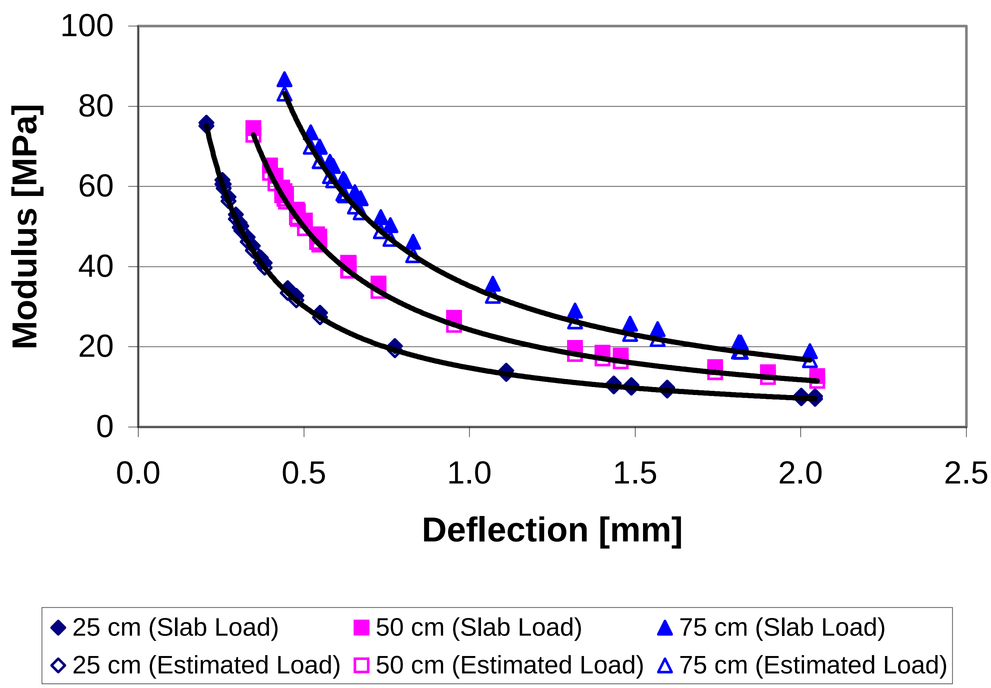


Figure B.3. Modulus values from slab and estimated loads

B.3 Conclusion

The practice of using slab force values to calculate modulus results in an overestimation on the order of 4-8 percent. This overestimation may be significant depending on how the LWD is utilized during quality control and quality assurance. Therefore, four options for obtaining a peak load value exist:

1) Purchase an LWD that incorporates a load cell. This would solve the load estimation problem, but the improvement is relatively minor compared to the additional cost and complexity of the device.

2) Use one of the equations in Figure B.1, or a similar equation, to estimate the load from the deflection at a given drop height. Figure B.2 makes it clear that this level of accuracy seems acceptable for granular soil. However, it has yet to be verified that these equations are valid for different LWDs. Therefore, it would be best to reproduce these figures for each device. These types of figures could be produced by the manufacturer and accompany the LWD upon delivery. This method appears to present the best combination of accuracy, cost, and effort.

3) Measure or estimate the average dynamic force at the most common level of deflection experienced during unbound material testing rather than the zero-deflection value. For the data presented in this appendix, the majority of deflection values were near 0.5 mm. An average dynamic force measured at this level of deflection (for example, 5.7 kN at a 50 cm drop height) is a better estimate of the force experienced on those soils than the rigid force (5.9 kN at 50 cm). This method would be simpler than using an equation to determine the force and nearly as accurate.

4) Use a fixed peak force measured independently on a concrete slab. This modulus estimation is hardwired into some LWD devices so no additional effort is required. However, as demonstrated above, it results in a modulus overestimation of 4-8 percent.

An important conclusion is to standardize the LWD falling mass, drop height, plate size, plate rigidity, buffer stiffness, and test procedure so that moduli estimates are more consistent between different LWD models. The geophone versus accelerometer based deflection sensors remain as important variables that require standardization and greater understanding. To remain consistent, a mass of 10 kg, a drop height of 50 cm, and a rigid plate with a diameter of 20 cm are recommended. A recommended test sequence for granular material is three seating drops followed by three measurement drops.

Appendix C – Analysis of LWD Load Estimation for Fine Grained Soil

C.1 Introduction

The previous Appendix B discussed light weight deflectometer (LWD) load estimation for granular material and recommended that a similar analysis be completed for fine grained soil. This appendix investigates if there is a need to correct modulus values for LWD devices that estimate load when these devices are used on fine grained soil.

The LWD used in this study was the Prima 100 model manufactured by Carl Bro. The standard test sequence for the device included two seating drops followed by three measurement drops at each of the following drop heights: 10 cm, 50 cm, and 90 cm. The LWD data used in this appendix was collected by Swenson *et al.*, 2006.

C.2 Results

The loads applied to the specimens varied between 1.7 and 9.3 kN; depending on the drop height. These loads resulted in a applied stress range of 0.054 to 0.296 MPa for a plate diameter of 20 cm. The deflection of the soil varied from near 0 to 0.95 mm. The load versus deflection data is plotted in Figure C.1. Figure C.2 contains a plot of specimen moisture content versus peak deflection. For the select granular materials discussed in Appendix B, high deflection values were usually associated with the high moisture content specimens. Figure C.2 shows that a similar trend is not as clear for the fine grained specimens tested by Swenson *et al.*, 2006. This may be due to somewhat large variations in density not accounted for in Figure C.2.

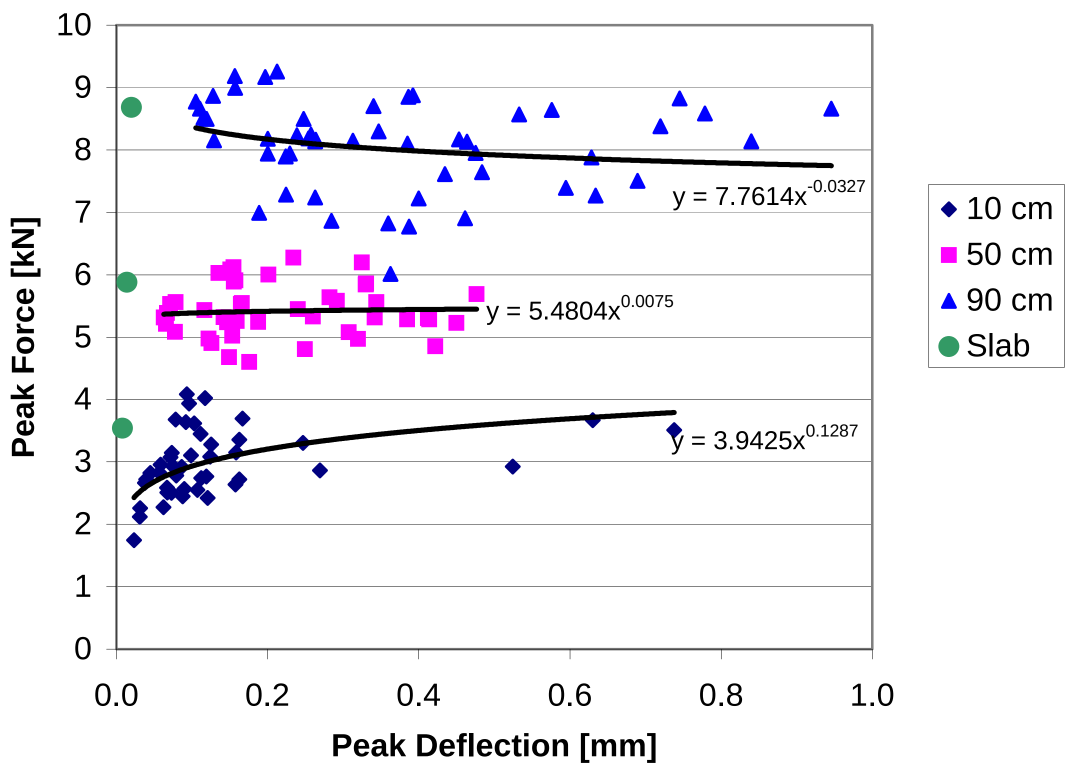


Figure C.1. LWD peak deflection versus peak force

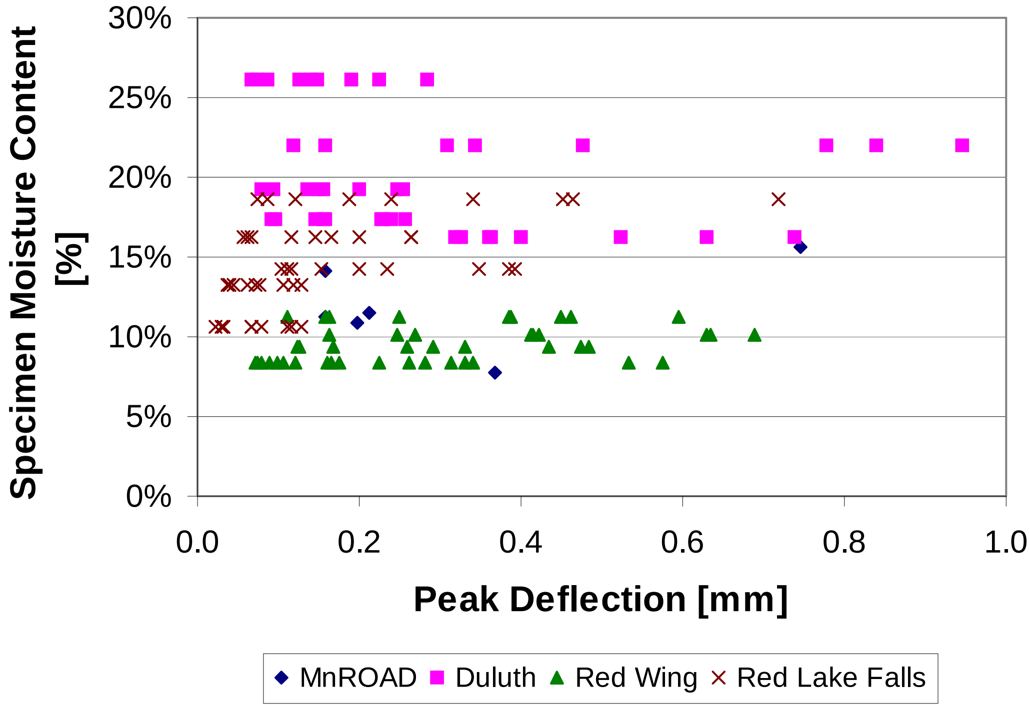


Figure C.2. Peak deflection versus specimen moisture content

The trend lines in Figure C.1 show the relationship between measured force and soil deflection for fine grained soils. Measured force values decreased roughly 7 percent from the beginning to the end of the test range for the 90 cm drop height, while a slight increase of 1.5 percent was seen for the 50 cm drop height. The 10 cm drop height had an increase in measured force values of roughly 56 percent from the beginning to the end of the test range. Clearly the data from the 10 cm height is irregular and should be investigated more thoroughly. The lack of precision at very small deflections may indicate that deflection data less than 0.1 mm should be disregarded (Davich *et al.*, 2006).

To calculate the near-zero deflection force modulus values, the LWD was used to record force measurements on a concrete slab. The average values recorded during that testing are included in Figure C.1 at all three drops heights in the "slab" series. The slab values from figure B.1 are used in figure C.1 because the Prima LWD was not used on a concrete slab by Swensen *et. al.,* 2006. On average, modulus values calculated using these slab force values would, on average, be 8.4 percent larger than measured force modulus values at the 90 cm drop height and 8.9 percent larger at 50 cm, and 22.8 percent larger at 10 cm.

Figure C.3 shows the difference between modulus values calculated from the measured forces and the values calculated from forces that were estimated from the deflections using the best fit equations found in Figure C.1. Figure C.4 shows the difference between the deflection estimated modulus values and the slab force modulus values. LWD devices that make use of a load cell achieve results that are only slightly more accurate that the results that could be obtained using the equations to estimate the force. LWD devices that utilize near-zero deflection force values tend to overestimate modulus values based on the results of this study. For 50 cm drop height the modulus would be expected to be overestimated by about 9 percent.

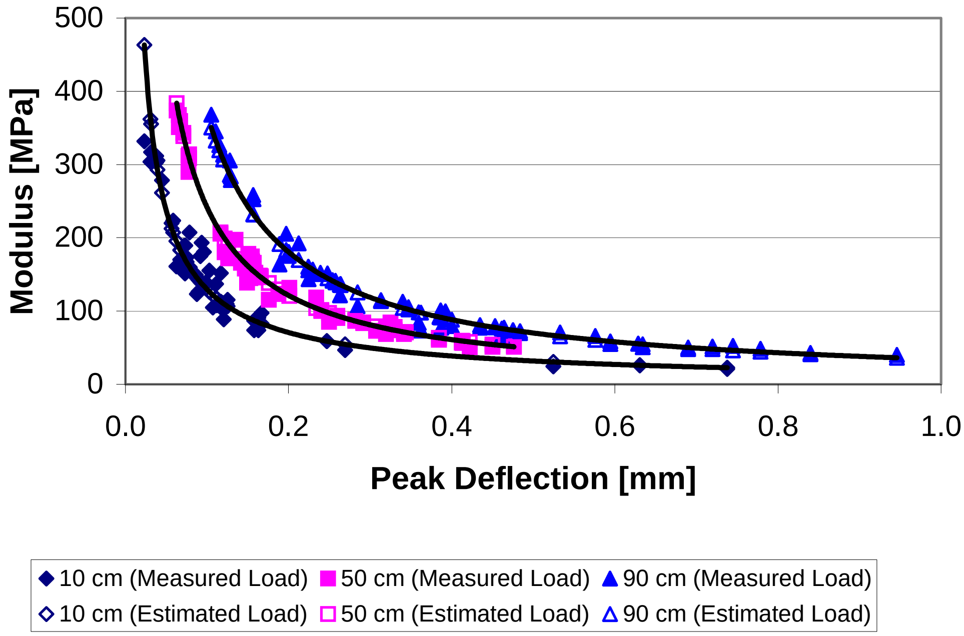


Figure C.3. Modulus values from measured and estimated loads

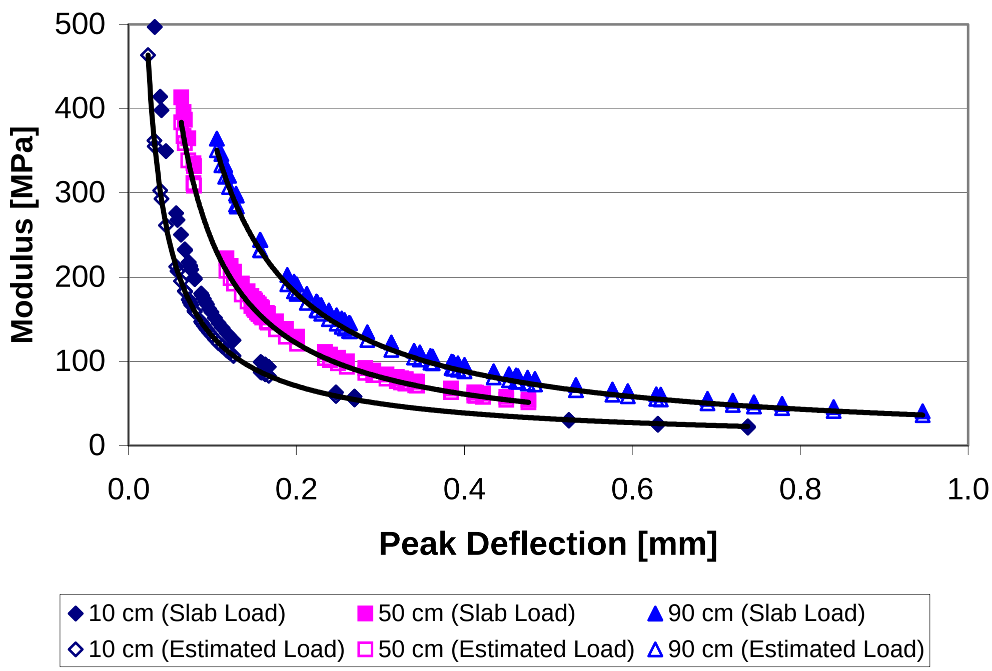


Figure C.4. Modulus values from slab and estimated loads

C.3 Conclusion

The conclusions from Appendix B remain valid for the fine grained soils described in this appendix. The data from these fine grained soil tests indicates that the moduli estimated, using slab force values, are overestimated by about 9 percent for the 50 cm drop height. This compares to the 5-6 percent overestimation during the granular testing described in Appendix B.

Appendix D - Influence of LWD Drop Height on Force, Deflection and Modulus

D.1 Introduction

Tests performed for the LRRB sponsored Investigation 829 "Validation of DCP and LWD Moisture Specifications for Granular Materials" (Davich *et al.*, 2006) used a light weight deflectmeter (LWD) to record the deflection and load applied to three select granular and granular samples. Select granular material consists of fines less than 12 percent where granular material contains less than 20 percent fines. A LWD test was conducted at three different drop heights of 25, 50, and 75 cm to determine how the height difference affects measurements of the material. The LWD tests were used to measure the force generated by the falling mass of the LWD and the deflection of the granular sample. These measurements were then used to calculate the modulus of the granular material.

The tests were performed on three different granular samples created by blending two or three smaller granular samples. Sample DN consisted of select granular with the lowest fines content. The sample FHJ consisted of granular with the most fines. The third sample KLO consisted of select granular with a percent passing gradation between the test samples DN and FHJ. The properties of the select granular and granular samples can be seen in Table D.1 (Beyer *et al.,* 2007).

Table D.1. Select granular and granular index properties

Sample	Mn/DOT Class	Grading Number	% Fines (%)	Density Standard Proctor Maximum (kg/m^3)	Moisture Standard Proctor Optimum (%)
DN	Select Granular	5.1	7.6	1942.4	8.1
FHJ	Granular	6.1	16.0	1753.4	10.3
KLO	Select Granular	5.4	10.6	1874.2	8.8

The select granular and granular sample groups were tested at three target moisture contents. The moisture contents were aimed to be near the optimal moisture content, as determined by the standard Proctor test. Within each of the moisture contents, the targeted compaction effort was applied using a large free falling impact hammer. The specimen densities were also measured.

The granular samples were labeled for testing by their sample group, moisture content and compaction effort. The first letters in the test name were the sample group. The numbers following the sample group indicate the moisture content. The numbers following a "X" in the name indicate the multiplication change in compaction effort. If there was no second number, then the compaction effort was targeted at 12,400 lbf-ft/ft^3 (standard Proctor effort). For example, test DN10X2 is from the DN sample with a moisture content of 10 percent and compaction energy twice the standard Proctor effort (24,800 lbf-ft/ft^3).

D.2 Procedure

As described in Davich *et al.*, 2006, the testing was done in the bottom half of a 55-gallon steel drum. The required amount of water to achieve the target moisture content was calculated and evenly sprinkled over the granular material prior to placing it in the drum in order to thoroughly and evenly distribute moisture throughout the sample. The granular material was added into the drum in three layers. Each layer was compacted with 93 drops by a 51-lb hammer. The granular material was then tested with the LWD to measure the force and deflection.

D.3 Discussion of Results

The data taken from Davich *et al.*, 2006 is analyzed here to compare how the measurements were affected by different drop heights. The data from the granular tests FHJ13 and test KLO11 were not included in this analysis due to their high moisture content resulting in particularly large deflection readings and small modulus readings. The DN10S test was also excluded from the data due to drum instability during testing. The mean and coefficient of variation were calculated using test results from a drop height of 50 cm.

$$Mean_{force} = \frac{\Sigma(measured\ value)}{number\ of\ samples} \qquad [D.1]$$

$$CoeVar_{force} = \frac{stdev(measured\ values)}{mean\ of\ samples} \qquad [D.2]$$

$$Median_{force} = middle\ value\ measured \qquad [D.3]$$

$$Mean\ CoeVar_{force} = \frac{\Sigma(CoeVar)}{number\ of\ samples} \qquad [D.4]$$

D.3.1 Force

The measured force [kN] was compared to the drop height [cm] for each different granular test shown in Figures D.1-D.3. A best-fit trend line was used to represent the correlation between force and drop height for each soil specimen (Figure D.4).

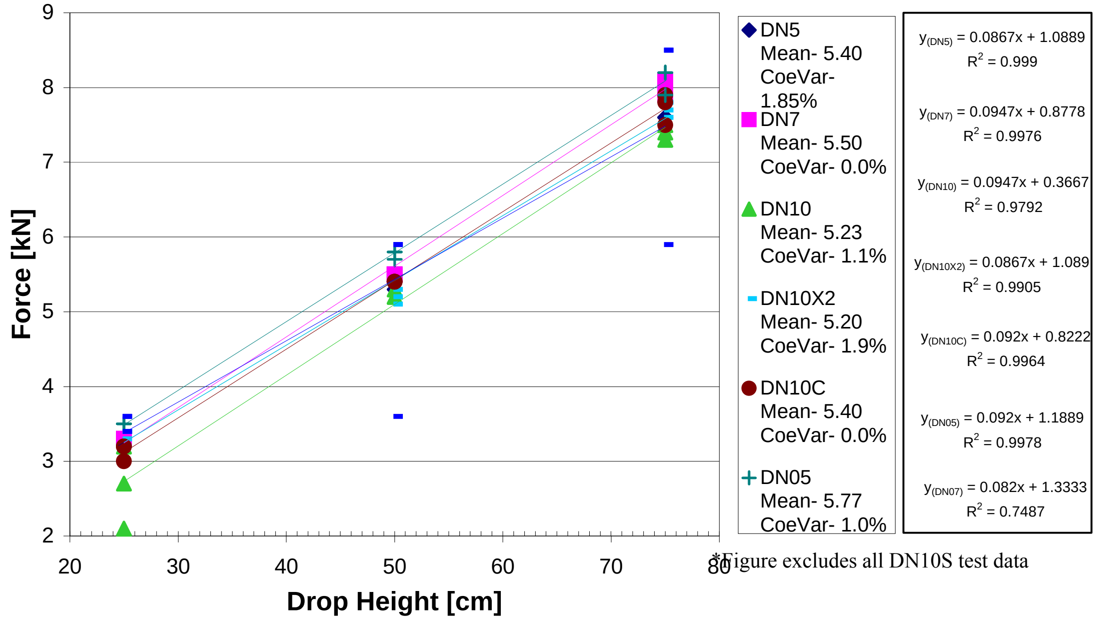


*Figure excludes all DN10S test data

Figure D.1. Force versus drop height for select granular sample DN

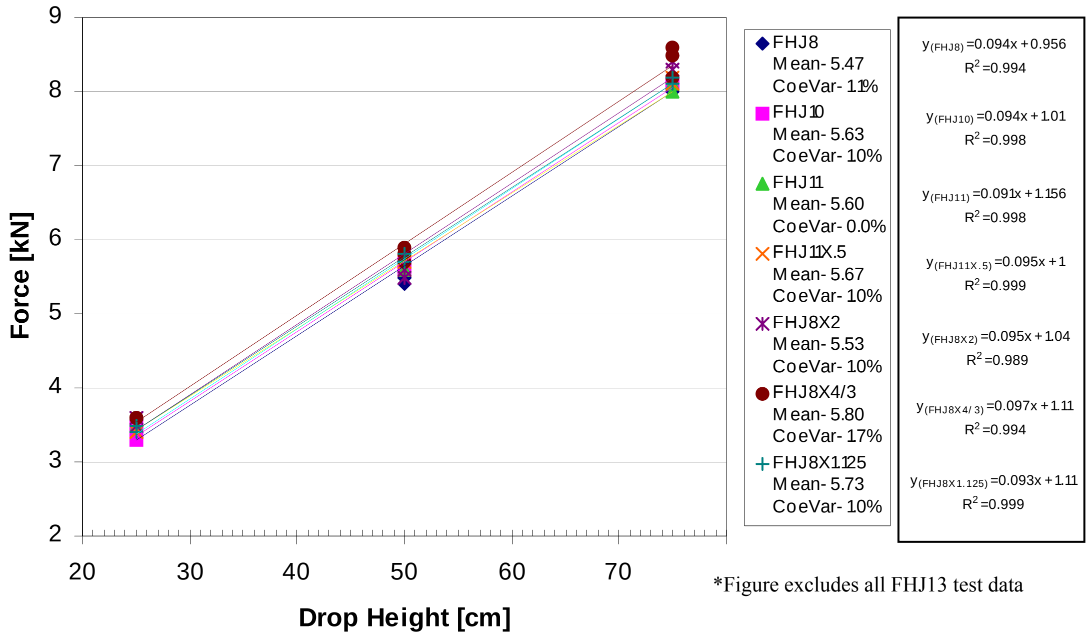


*Figure excludes all FHJ13 test data

Figure D.2. Force versus drop height for granular sample FHJ

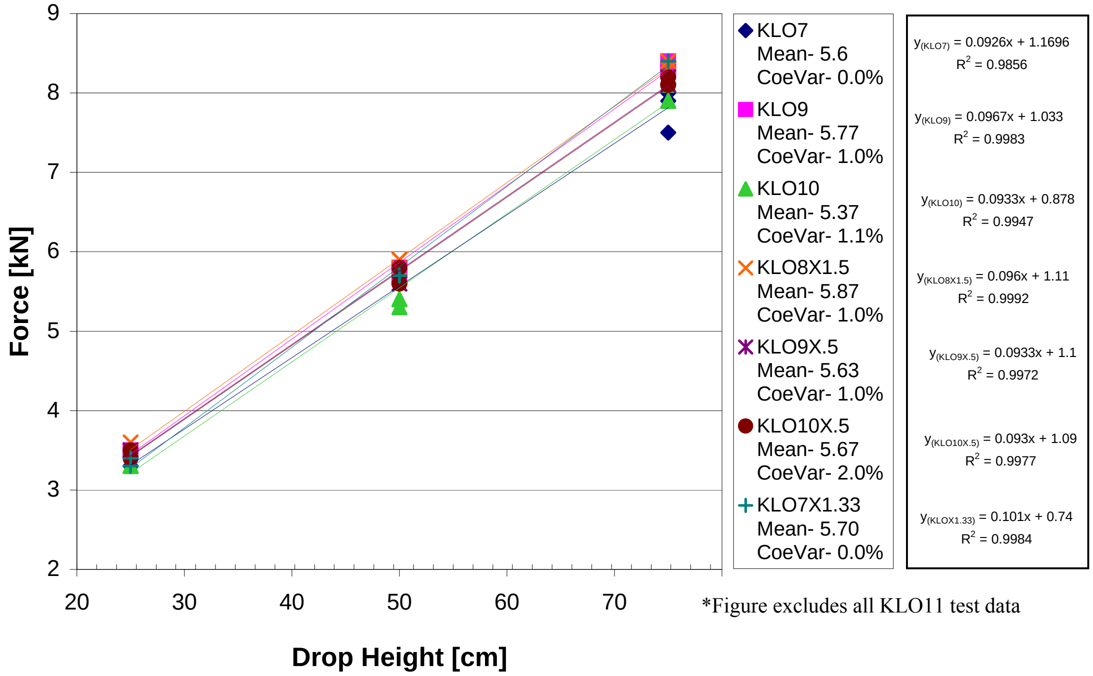


*Figure excludes all KLO11 test data

Figure D.3. Force versus drop height for select granular sample KLO

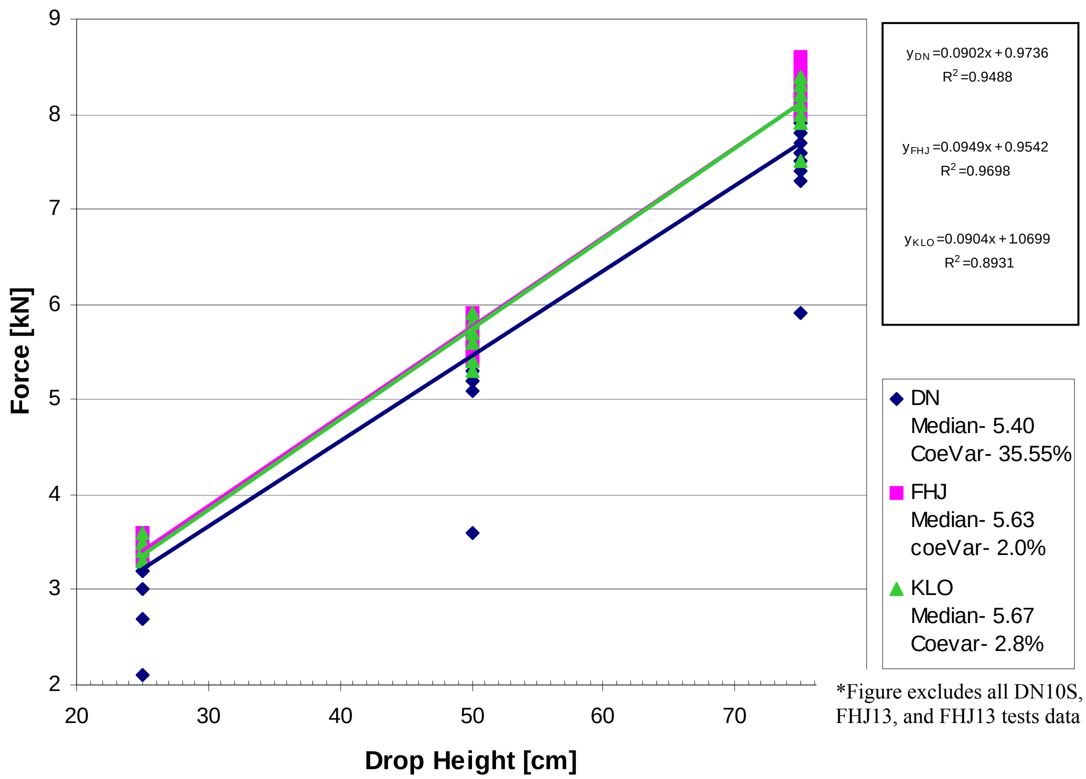


*Figure excludes all DN10S, FHJ13, and FHJ13 tests data

Figure D.4. Force versus drop height for all three granular samples

The mean and coefficient of variation for each test specimen is marked under the tests name in the legend. The median and coefficient of variation are based on the values from a drop height of 50 cm for all tests. The median force and coefficient of variation for the sample DN was 5.40 kN and 4.54 percent, respectively. Sample FHJ was found to have a median force of 5.63 kN and a coefficient of variation of 0.89 percent. A median force of 5.67 kN and a coefficient of variation of 0.87 percent was found for the sample KLO. All three of the different material samples combined had a median force and coefficient of variation of 5.60 kN and 2.13 percent, respectively. These results are summarized in Table D.2.

Table D.2. Median force and coefficient of variation results

Sample	DN	FHJ	KLO	ALL
Median Force [kN]	5.40	5.63	5.67	5.60
Coefficient of Variation [%]	4.54	0.89	0.87	2.13

All three of the different samples are graphed in the same graph (Figure D.4). The three different granular types had a similar increase of force for increasing drop height. The average force increase for the three granular types was found to be about 0.092 kN/cm increase in height drop. The percent change of the force was calculated to be 1.6 percent per centimeter based on the median force measured of 5.60 kN at 50 cm drop height.

$$Percent\ change = \left(\frac{average\ slope}{median\ \ force_{50\ cm}} \right) \qquad [D.5]$$

D.3.2 Deflection

The deflection [mm] was also compared to the drop height [cm] for each granular test in Figures D.5-D.8. A best-fit trend line was used to represent the correlation between deflection and drop height for each test specimen as shown in Figure D.9.

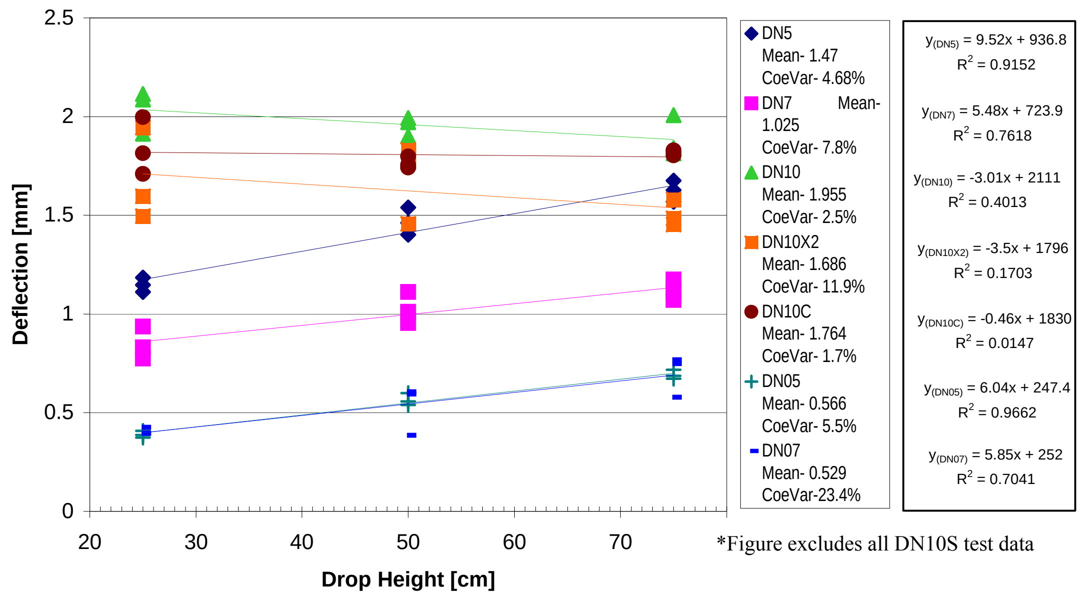


*Figure excludes all DN10S test data

Figure D.5. Deflection versus drop height for select granular sample DN

The DN select granular samples that had a moisture content of 10 percent resulted in a negative defection relationship with the increase of the mass drop height. This higher moisture content is believed to have resulted in partial liquefaction of the samples as additional impacts were applied at increasing drop heights. The standard Procter optimum moisture content of the DN sample in Table D.1 is 8.1 percent. For this reason, the DN select granular sample with a moisture content of 10 percent was excluded from further analysis in this section, which describes deflection (Figure D.6). However, these high moisture DN samples were included in the previous discussion of force and the following discussion of modulus.

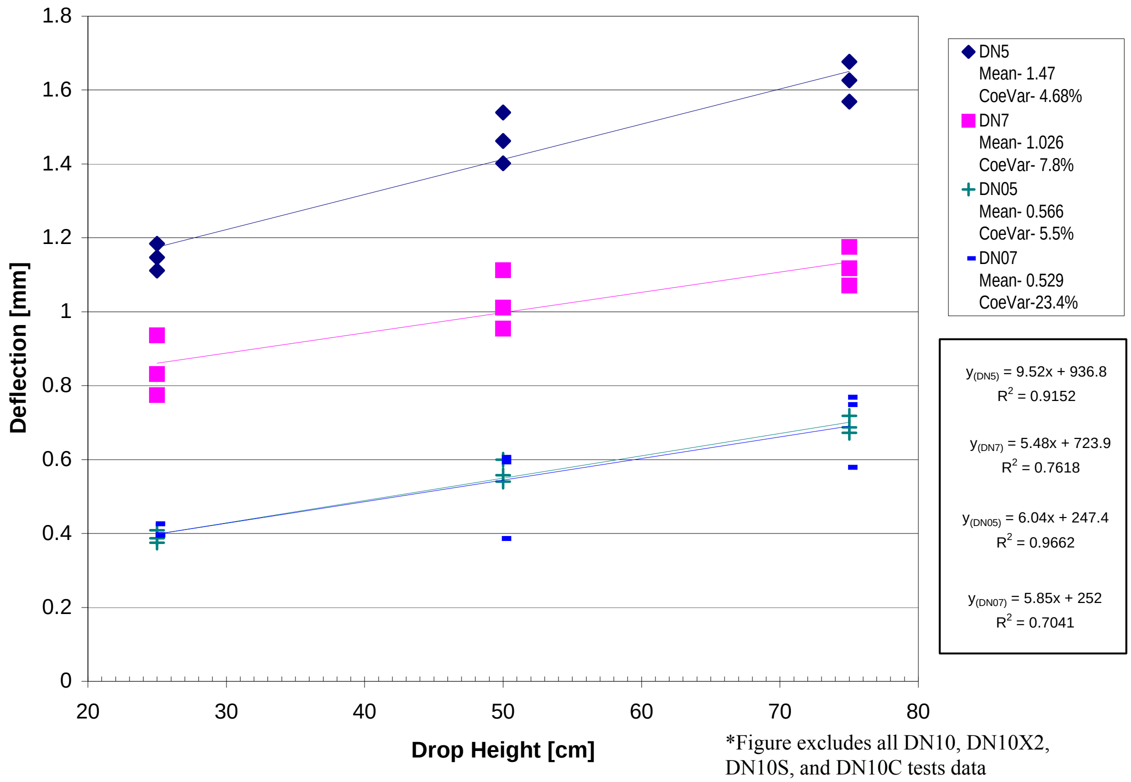


Figure D.6. Deflection versus drop height for select granular sample DN

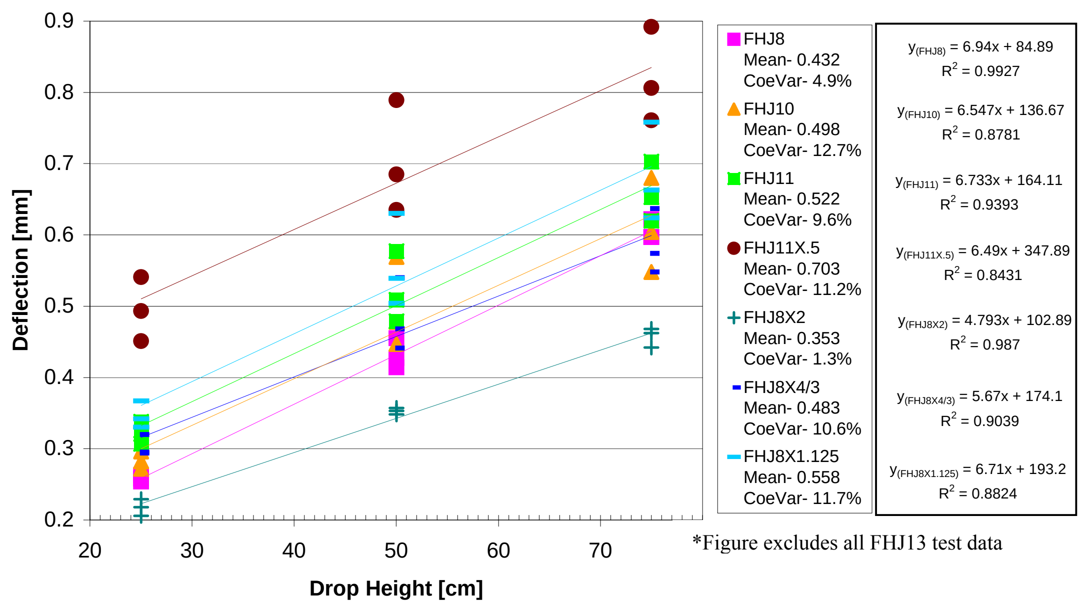


Figure D.7. Deflection versus drop height for granular sample FHJ

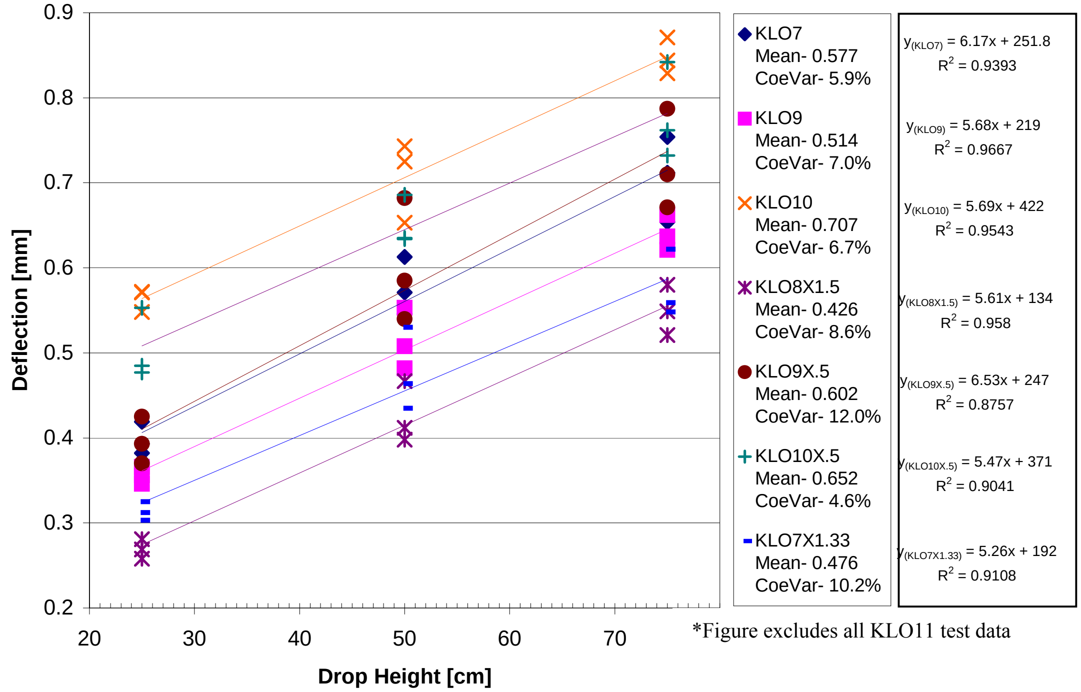


*Figure excludes all KLO11 test data

Figure D.8. Deflection versus drop height for select granular sample KLO

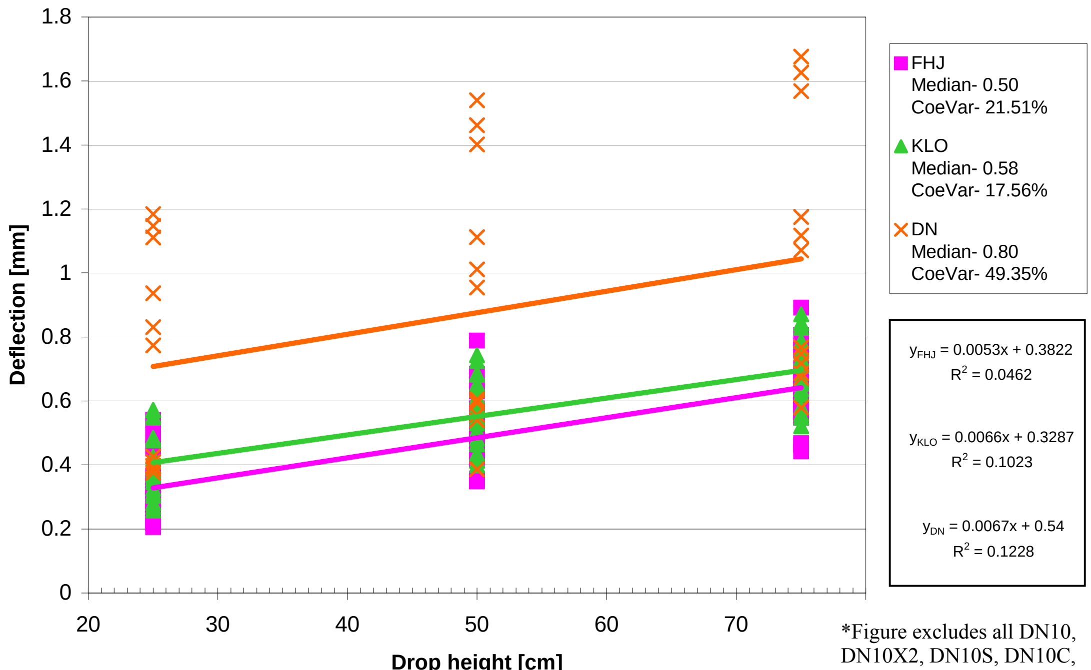


*Figure excludes all DN10, DN10X2, DN10S, DN10C, FHJ13, and KLO11 tests data

Figure D.9. Deflection versus drop height for all three granular samples

For each test specimen, the mean deflection and coefficient of variation is located in the legend under the tests name. The median deflection and coefficient of variation was also measured from a drop height of 50 cm for each group sample. The median deflection for sample DN was found to be 0.80 mm with a coefficient of variation of 10.34 percent. The median deflection and coefficient of variation for sample FHJ was 0.50 mm and 8.85 percent, respectively. Sample KLO had a median deflection of 0.58 mm and a coefficient of variation of 7.86 percent. All three of the samples combined were found to have a median deflection of 0.54 mm and a coefficient of variation of 8.8 percent. These results are summarized in Table D.3.

Table D.3. Median deflection and coefficient of variation results

Sample	DN	FHJ	KLO	ALL
Median Deflection [mm]	0.80	0.50	0.58	0.54
Coefficient of Variation [%]	10.34	8.85	7.86	8.80

The three different select granular and granular samples had a similar increase in deflection with increasing drop height when excluding the tests with high moisture contents. The average deflection increase for the three granular types was found to be about 0.0062 mm/cm. The percent change of the deflection was calculated to be 1.2 percent per centimeter based on the median deflection of 0.54 mm measured at a 50 cm drop height.

$$\text{Percent change} = \left(\frac{\text{average slope}}{\text{median deflection}_{50\ cm}} \right) \qquad [D.6]$$

D.3.3 Modulus

The modulus [MPa] was compared to drop height [cm] for each different granular test in Figures D.10-D.12. A best-fit trend line was used to represent the correlation between modulus and drop height for each soil specimen (Figure D.13).

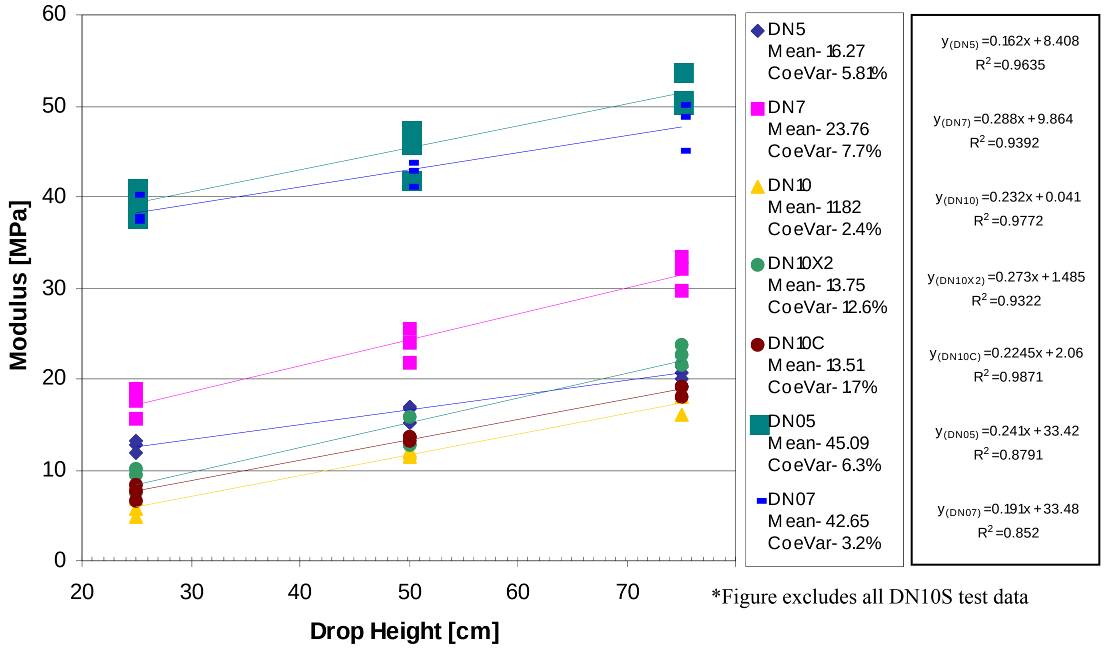


Figure D.10. Modulus versus drop height for select granular sample DN

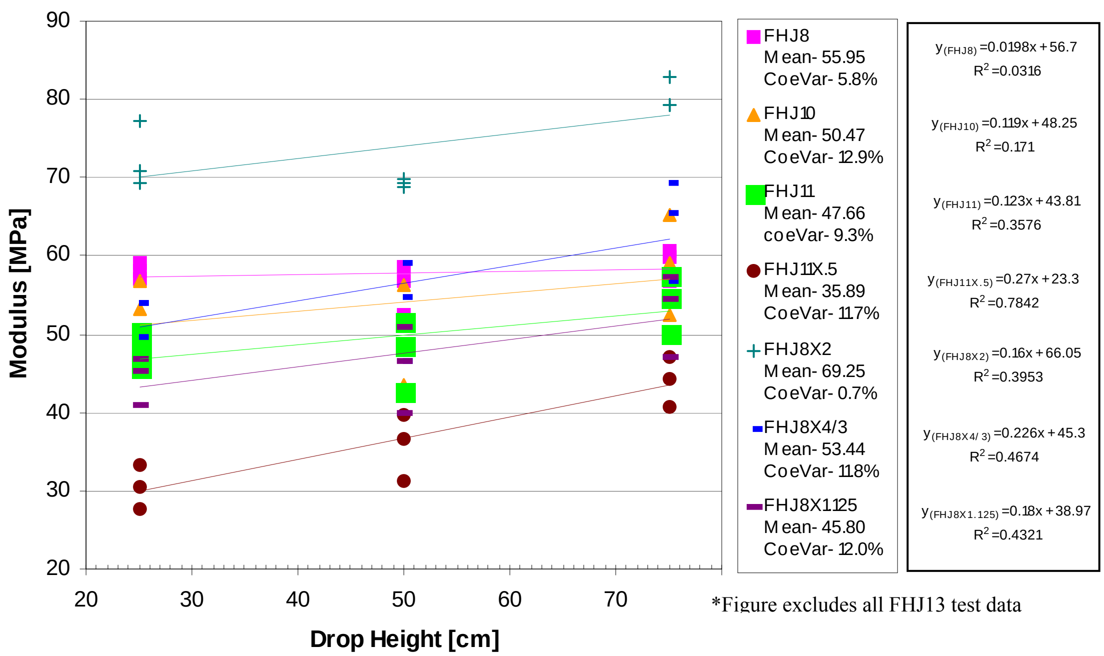


Figure D.11. Modulus versus drop height for granular sample FHJ

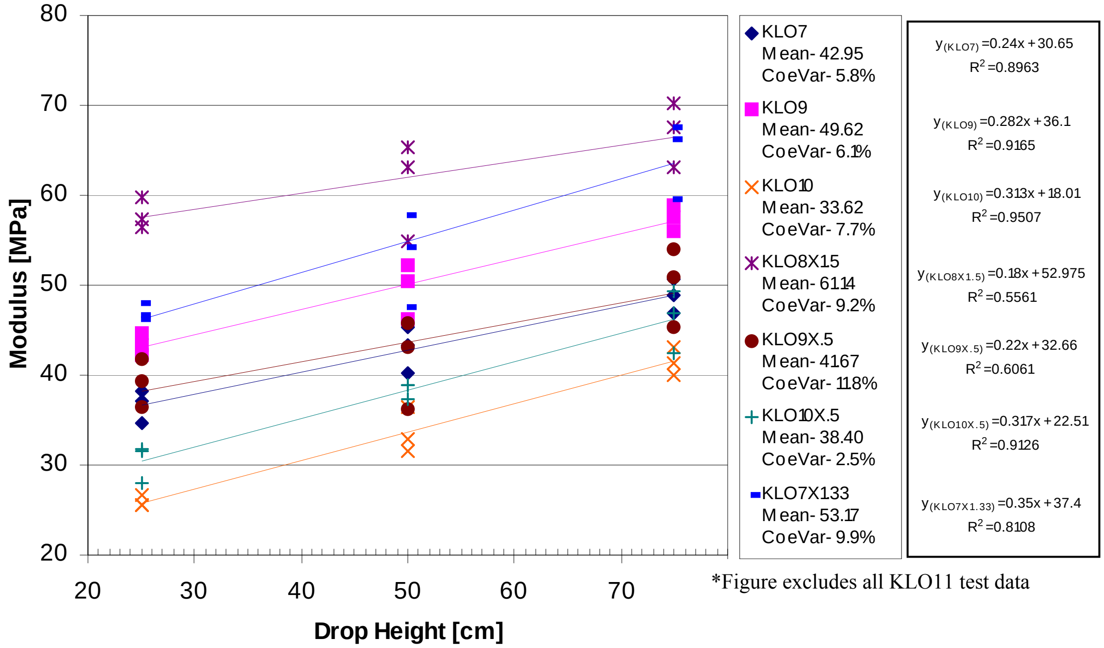


*Figure excludes all KLO11 test data

Figure D.12. Modulus versus drop height for select granular sample KLO

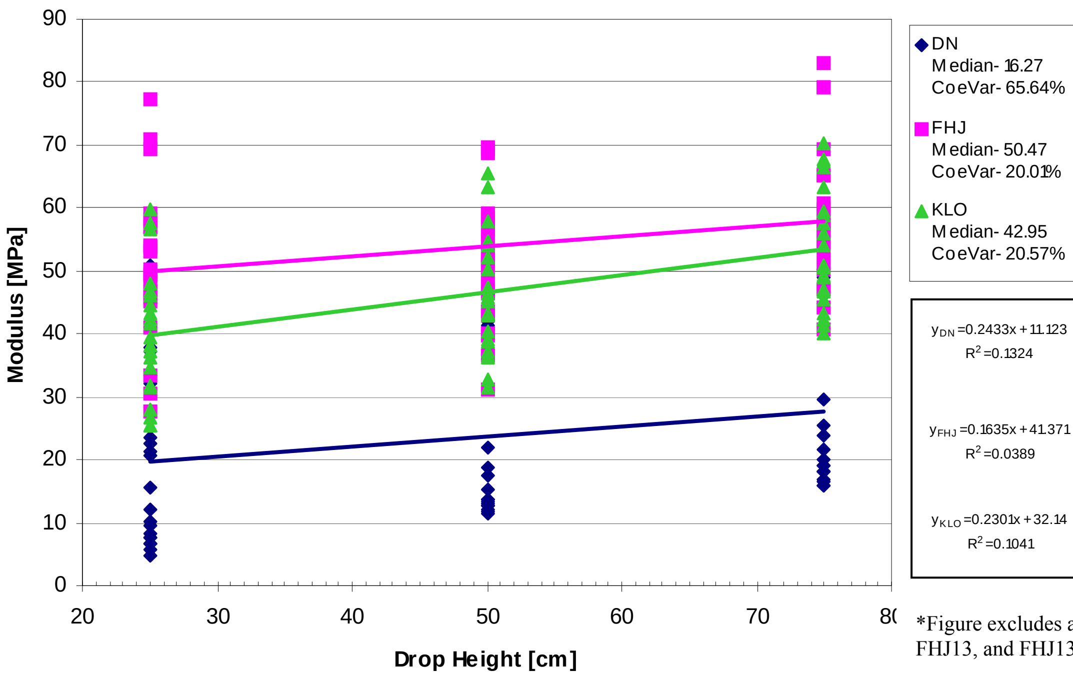


*Figure excludes all DN10S, FHJ13, and FHJ13 test data

Figure D.13. Modulus versus drop height for all three granular samples

In the legend under the tested sample's name, the mean modulus and coefficient of variation are listed. The median modulus and coefficient of variation for the group samples are performed from a drop height of 50 cm. The median modulus and coefficient of variation for the group sample DN was found to be 16.27 MPa and 5.66 percent, respectively. A median modulus of 50.47 MPa and a coefficient of variation of 9.18 percent were found for sample FHJ. Sample KLO was found to have a median modulus of 42.95 MPa and a coefficient of variation of 7.56 percent. The three samples combined were found to have a median modulus of 42.65 MPa and coefficient of variation of 7.55 percent. These results are summarized in Table D.4.

Table D.4. Median modulus and coefficient of variation results

Sample	DN	FHJ	KLO	ALL
Median Modulus [MPa]	16.27	50.47	42.95	42.65
Coefficient of Variation [%]	5.66	9.18	7.56	7.55

In Figure D.13, all three of the granular samples were graphed in the same plot area. The three granular types had a similar increase in the modulus for the increase in mass drop height. The average modulus increase for the three granular types was found to be about 0.212 MPa/cm increase in height drop. The percent change of the modulus difference was calculated to be 0.5 percent per centimeter change based on the median modulus measured at 50 cm drop height and a median modulus of 42.65 MPa.

$$Percent\ change = \left(\frac{average\ slope}{median\ modulus_{50\ cm}} \right) \qquad [D.7]$$

D.3.4 Example

In order to better understand the influence of the drop height, an example is presented in Table D.5. For a LWD manufactured with the Mn/DOT standard drop height of 50 cm, the expected value for the force is roughly 5.60 kN (buffer and material stiffness also should also be taken into consideration). In comparison, if the LWD had a drop height of 55 cm then the value of the force would have an expected difference of 0.46 kN. This force difference results in a percent change of 8.2 percent. The deflection for the same situation would have a difference of 0.03 mm, which equates to a percent change of about 5.7 percent. The modulus has a difference of 1.06 MPa for the same situation and a 2.5 percent change from the average 50 cm drop height.

Table D.5. Example of drop height influence

	Force [kN]	Deflection [mm]	E [MPa]
Expected value at 50 cm drop	5.60	0.54	42.65
Slope [unit per cm increase in drop height]	0.0918	0.0062	0.2123
Calculated for a 55 cm drop height	6.06	0.57	43.72
Difference	0.46	0.03	1.06
% change	8.2%	5.7%	2.5%

D.4 Conclusion and Recommendations

This analysis shows how the drop height affects the force, deflection, modulus and concludes that the effect is relatively small for small changes in drop height. Standardizing the plate size, falling mass, and the drop height also help control this variation. Drop height had the largest affect on the force. For each centimeter change in drop height the force varies by about 1.6 percent. The change in drop height had a small affect on the deflection of the granular material. The deflection increased by about 1.2 percent for each centimeter increase in drop height. It is important to note that there is a significant influence on the deflection due to water content in comparison to the drop height. If the water content is too high, deflections increase dramatically, as seen in the DN select granular samples. Small changes in the drop height had almost no affect on the modulus of the select granular samples. The modulus changed by about 0.5 percent for each centimeter increase in drop height. It is concluded that a small change in a manufactured drop height of 2-3 cm will not greatly affect the target values determined for 50 cm drop height. This conclusion assumes that the buffer configuration is the same for the LWD used to determine the target values and the LWD used during construction quality assurance.

Appendix E – Using the Plastic Limit to Estimate Optimum Moisture Content

E.1 Introduction

Currently the most common method for estimating the optimum moisture content for the compaction of a soil is to use the standard Proctor test, as defined by ASTM D 698 – 00a. By determining the dry unit weight of a soil for many different water contents, a compaction curve is found. On this curve, the water content that corresponds to the maximum dry unit weight is known as the optimum water content for that specified compaction energy and method of compaction. .

Another option for determining the optimum moisture content is to use a plastic limit test. This test, which is standardized by ASTM D 4318 – 05, measures the soil's moisture content while it is in the transition from a semi-solid consistency to a plastic consistency. In order to perform this test, a small, dry sample of the desired soil has water added to it, so that an appropriate moisture is achieved. Once the water is fully worked into the soil, the mix is shaped into a thread. The plastic limit is the water content at which the thread crumbles at a diameter of 3 mm. As will be shown in this appendix, the plastic limit is related to the optimum moisture content estimated by a standard Proctor test.

Grain size is another property of soil that can be measured and used to determine its Mn/DOT Textural Classification. This process uses a triaxial chart to classify soils using their unique grain size makeup. The triaxial chart, Figure E.1, has three axes, which are broken down by the soil's percentage composition of clay, silt and sand. These properties are found by performing a grain-size analysis, as defined in Mn/DOT's Grading and Base Manual – 5-692.600.

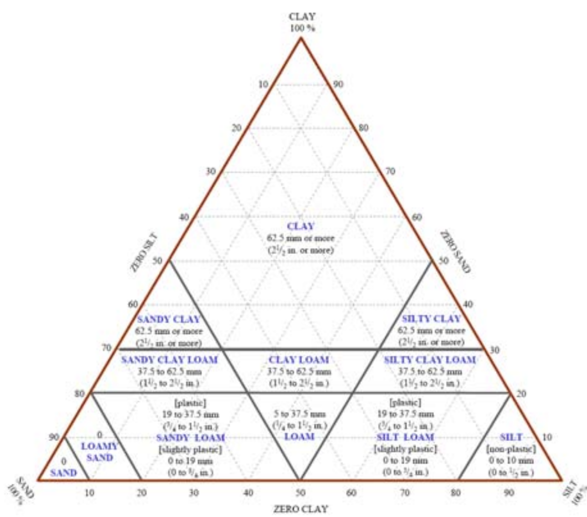


Figure E.1. Triaxial chart for Mn/DOT textural classification of soils

At the Mn/DOT Office of Materials and Road Research, most soil samples are tested for many properties, including the standard Proctor test and the plastic limit. In addition, each soil is described by its Mn/DOT Textural Classification. This data is stored in a central database and used in the following analysis.

E.2 Comparison

There are two main goals during the comparison of the plastic limit test and the standard Proctor test for determining optimum moisture content. The first goal is the show that there is a reasonable qualitative relationship between the standard Proctor optimum moisture and the plastic limit. The second goal is to show that this relationship is accurate enough to implement under field conditions.

Since this proposed method is mainly for field use, it was decided that a linear relationship would be desirable if it can be shown that the data is well represented by a linear relationship. If this can be done, then inspectors would need only one simple equation to estimate the optimum moisture content for compaction from the plastic limit.

In order to determine this correlation, the plastic limit was plotted against the standard Proctor optimum moisture. All soil specimens tested by the Office of Materials and Road Research from January 1992 to December 1998 were plotted in Figure E.2. For clarification, each soil type was fitted with a linear tread line. This was done in order to get an initial feel for the data as well as to show some possible data problems.

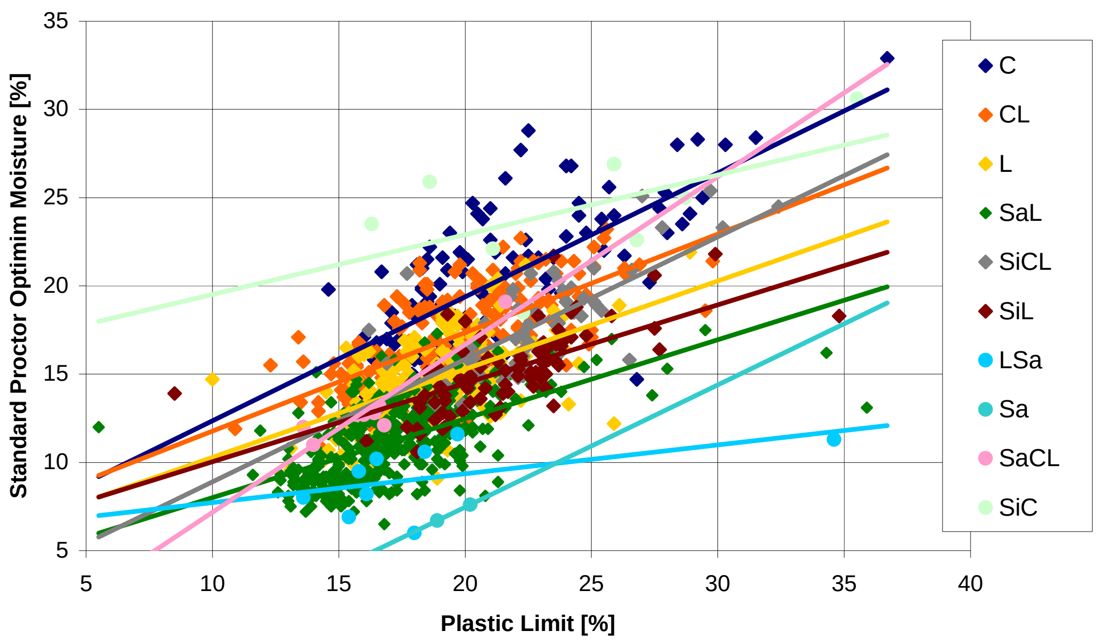
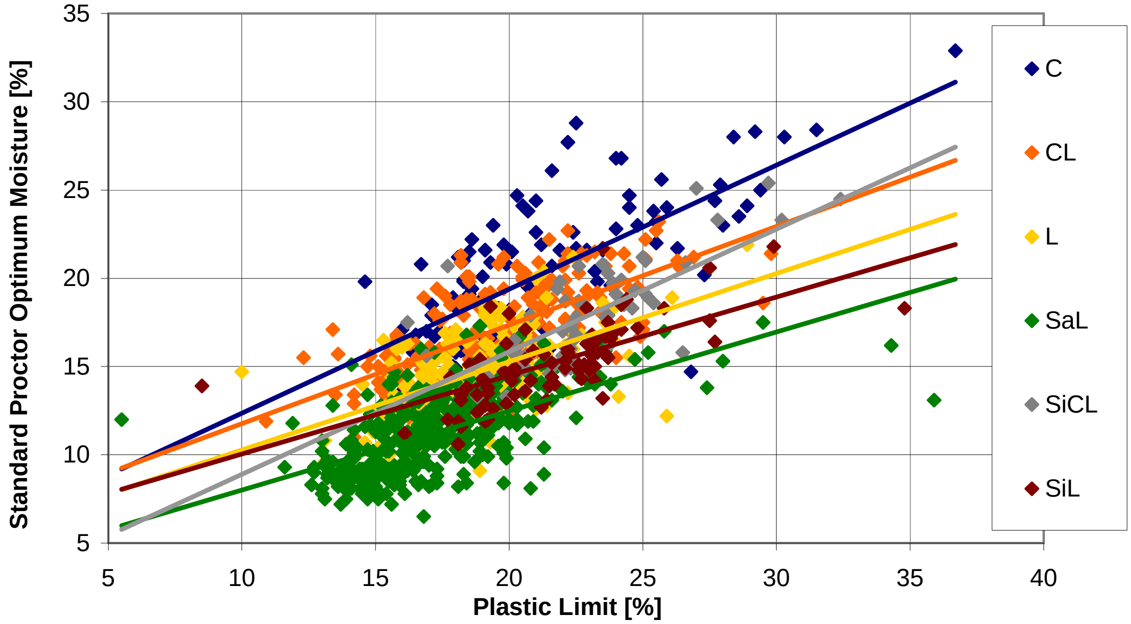


Figure E.2. Plastic limit versus standard proctor optimum moisture for all available soil types

As can be seen from Figure E.2, there is a high degree of disparity between the slopes of each of the different soil types. In part, these problems are caused by inadequate data. By reviewing each soil's data, four soil types don't have sufficient data to represent a proper trend line. These four soils are: Loamy Sand (LSa), Sand (Sa), Sandy Clay Loam (SaCL), and Silty Clay (SiC). Each of these soils have fewer than ten data points, because these soil types are not very common in Minnesota road construction or are non-plastic and therefore the plastic limit test is not preferred. Each of these four soils samples have a much different slope than that of the majority. For this reason, it was decided that the data for these four soils, (LSa, Sa, SaCL, and SiC), would not be included in this study. A modified version of the plot can be seen in Figure E.3. Figure E.3 also shows the equations of the trend lines, as they will be used to determine the relationship between the plastic limit and standard Proctor optimum moisture.



$Y_{(C)} = 0.70x + 5.33$ $R^2 = 0.47$	$Y_{(L)} = 0.50x + 5.28$ $R^2 = 0.30$	$Y_{(SiCL)} = 0.69x + 1.95$ $R^2 = 0.51$
$Y_{(CL)} = 0.56x + 6.18$ $R^2 = 0.44$	$Y_{(SaL)} = 0.45x + 3.53$ $R^2 = 0.37$	$Y_{(SiL)} = 0.44x + 5.59$ $R^2 = 0.44$

Figure E.3. Plastic limit versus standard proctor optimum moisture for all soil types with adequate data

As can be seen in Figure E.3, the trend lines are more similar to one another once the non-representative data is removed from the study. From these trend lines, an 'average' trend line can be made that will estimate the optimum moisture of the standard Proctor test using the plastic limit test. This is done by breaking each of the individual trend line equations into their slope and y-intercept. The average of each coefficient is taken and the end result is the 'average trend line.' In this study, the trend line is found to be:

$$Y_{AVE(1)} = 0.56X + 4.6 \quad [E.1]$$

where:

X = Plastic Limit [%]

Y_{AVE} = Standard Proctor Optimum Moisture [%]

A further simplification that may be accurate enough for the intended use is:

$$Y_{AVE(2)} = 0.5X + 5 \qquad \text{[E.2]}$$

This relationship between the plastic limit and standard Proctor optimum moisture can provide fairly accurate results, but the larger the plastic limit is, the less accurate the standard Proctor optimum moisture estimate will become. Figure E.4 shows these approximations for the relationship and all of the soil points with adequate data.

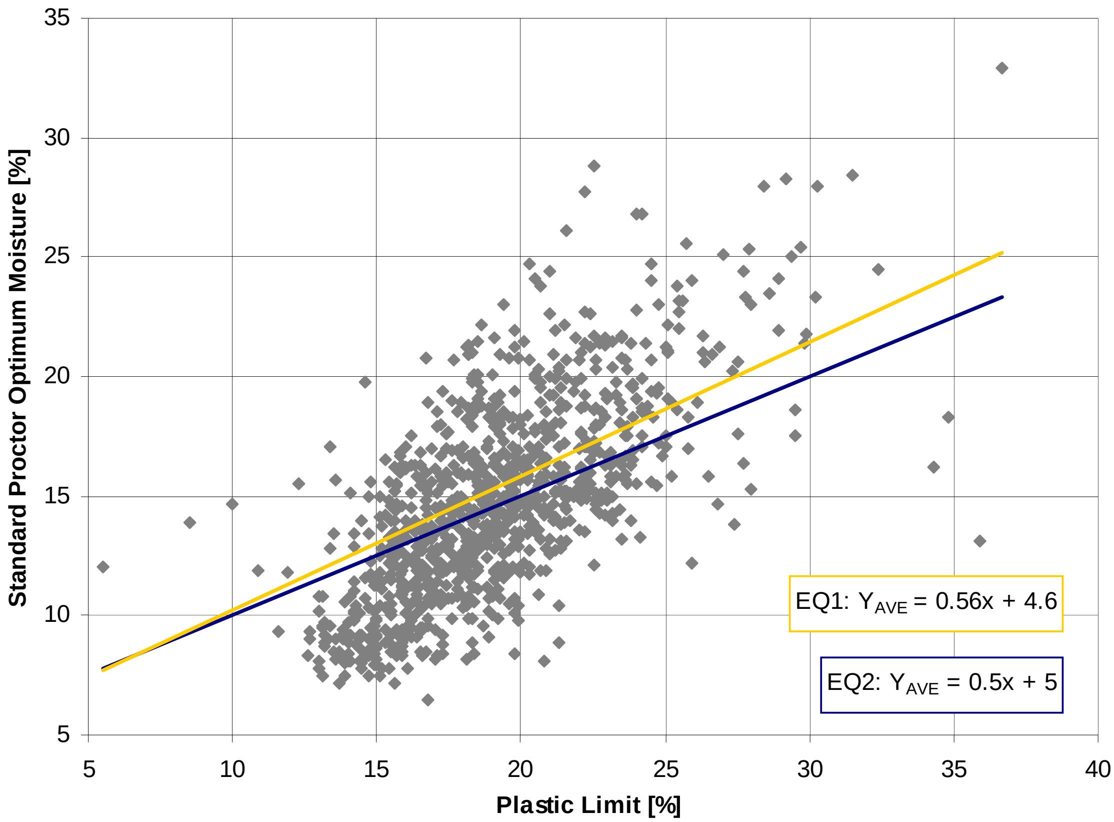


Figure E.4. Plastic limit versus standard proctor optimum moisture for all soil types with adequate data and approximations for the average trend line

Another option for determining a trend line that will best fit the data is to compile all of the points into one group and have Microsoft Excel plot a trend line through all data points. Just like before, finding the plastic limit and inputting it into the trend line equation would approximate the standard Proctor optimum moisture. Analysis will be performed on each of the equations to conclude which is more effective at determining the optimum moisture of the soil. Figure E.5 shows this statistical trend line from compiling all of the soil data into one group.

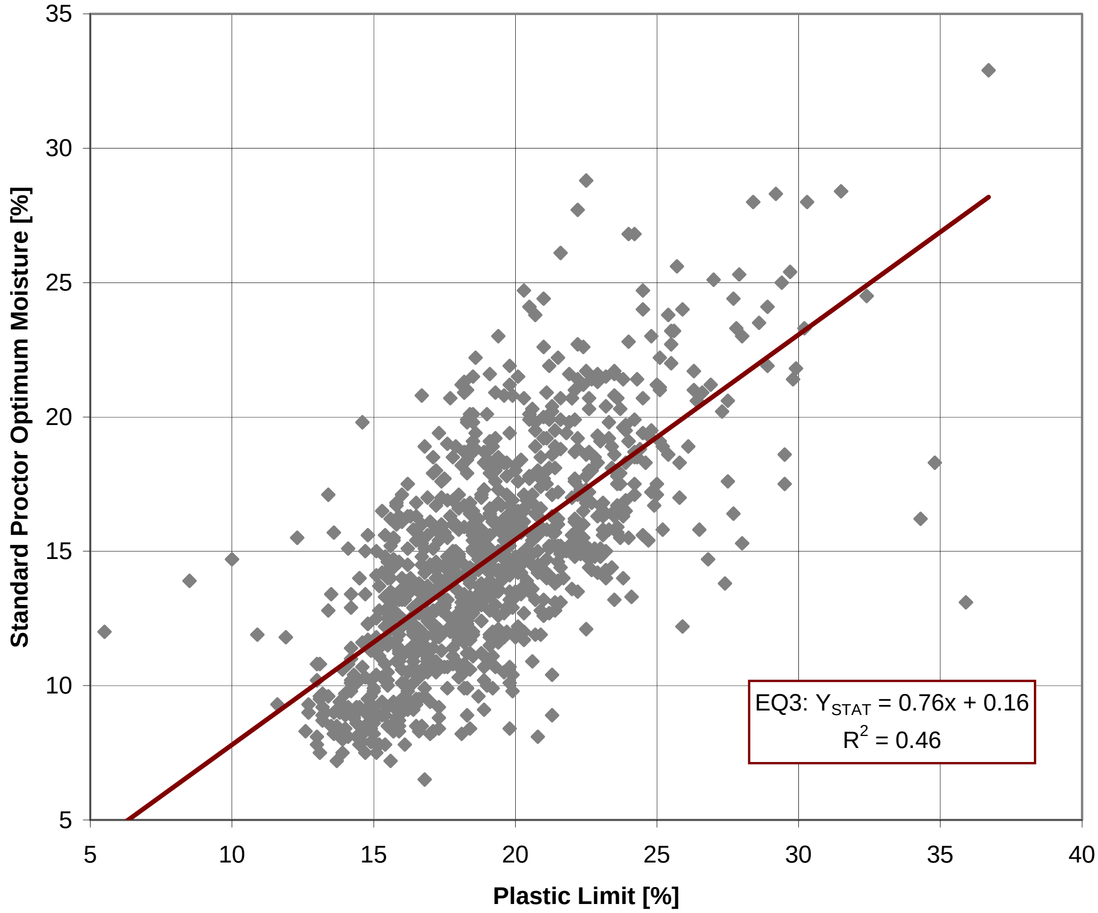


Figure E.5. Plastic limit versus standard proctor optimum moisture for all soil types with adequate data and the statistical trend line

From Figure E.5, the adequate soils data points have a trend line with the equation:

$$Y_{STAT} = 0.76X + 0.16 \qquad [E.3]$$

A third method for determining a trend line that will best fit the data is to approximate one by disregarding a few outliers. Upon reviewing a graphical representation of the data, one can estimate an appropriate linear trend line that will both fit the data and be easy to implement in the field. From all of the soils with sufficient data, an estimated trend line, Equation E.4, was found. A graphical representation of this trend line can be seen in Figure E.6.

$$Y_{EST} = X - 5 \qquad [E.4]$$

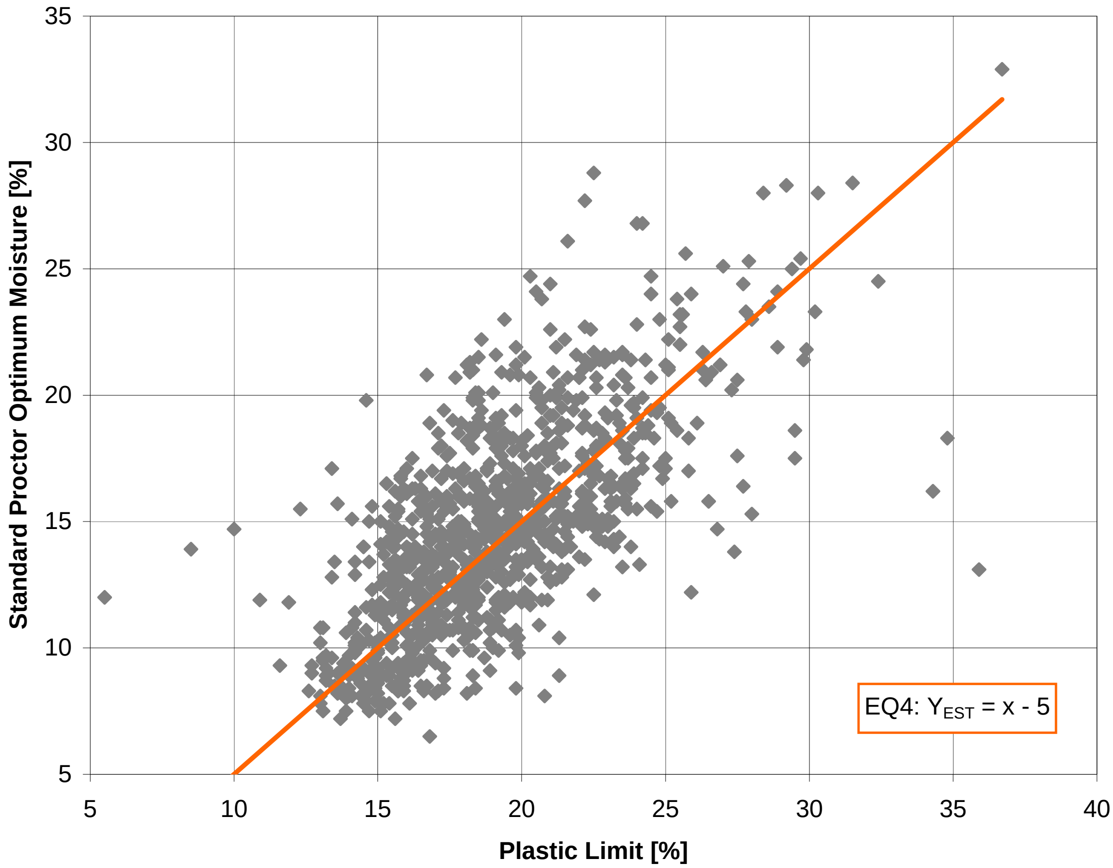


Figure E.6. Plastic limit versus standard proctor optimum moisture for all soil types with adequate data and the estimated trend line

As a summary and comparison, all of the trend lines (average, statistical, and estimated) as well as all data points with sufficient soil samples are plotted on Figure E.7. In addition, the range of the plastic limit shown on the table was reduced to between 15 to 30 percent because highway soil plastic limits are most commonly found between these boundaries.

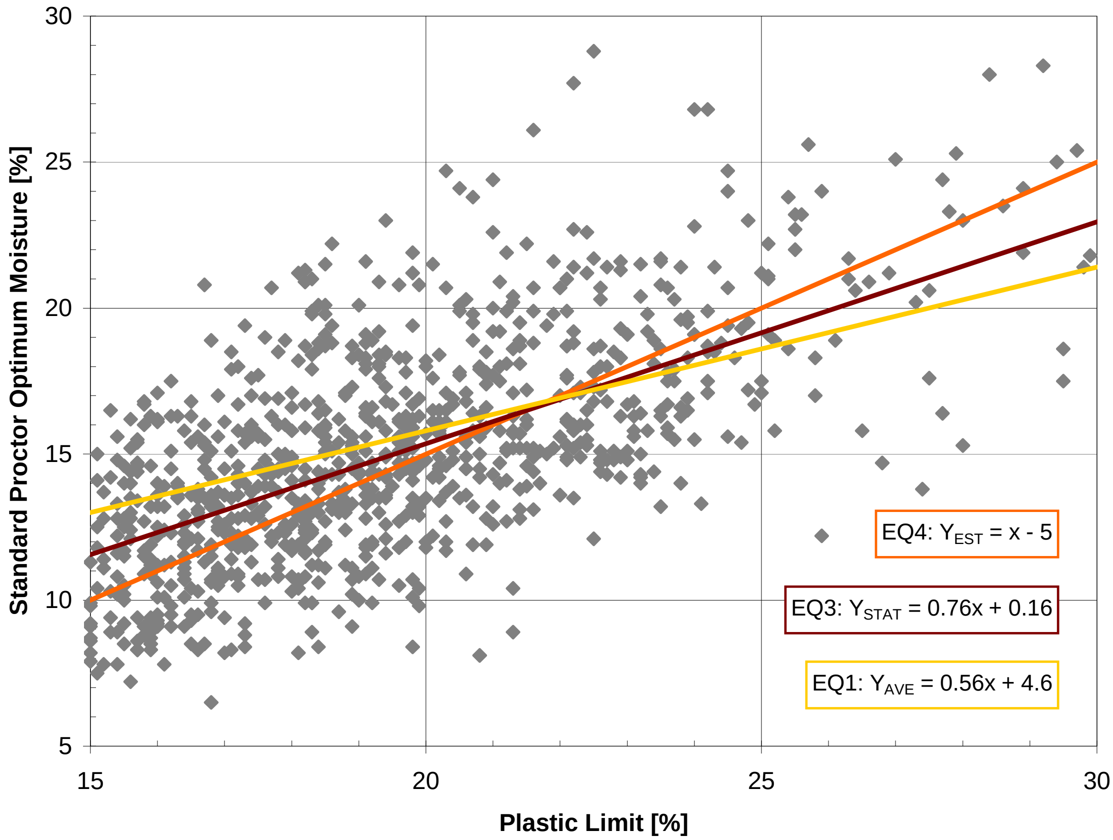


Figure E.7. Plastic limit versus standard proctor optimum moisture for all soil types with adequate data and the approximations to the average trend line, the statistical trend line, and the estimated trend line

E.3 Analysis

As is the case with any sort of estimation, it is important to demonstrate the accuracy of the results. In this case, the degree of accuracy for each estimate was found and compared. This way, an inspector is able to determine which estimate is better suited for the project, and more importantly, whether the result is accurate enough for its intended purpose.

In addition, the concept of using the plastic limit to determine the optimum moisture must be justified. This concept is different than the current practice, which uses the standard Proctor test and the percent sand, silt, and clay to classify the soil. The reason for this change is warranted for two reasons. The first is that this new process is quicker. The second is accuracy; if the data fits the trend line, then this new method is valid for use.

In order to determine how accurate these results are, each of the trend lines is assigned a reasonable range of values (±2 percent with respect to the standard Proctor optimum moisture); the confidence intervals of these ‘boundaries’ on the data are computed and compared. This is done by determining the ratio of data points that fall within the set boundaries and the total amount of data points. A visual representation of this analysis is shown in Figures E.8 through E.10.

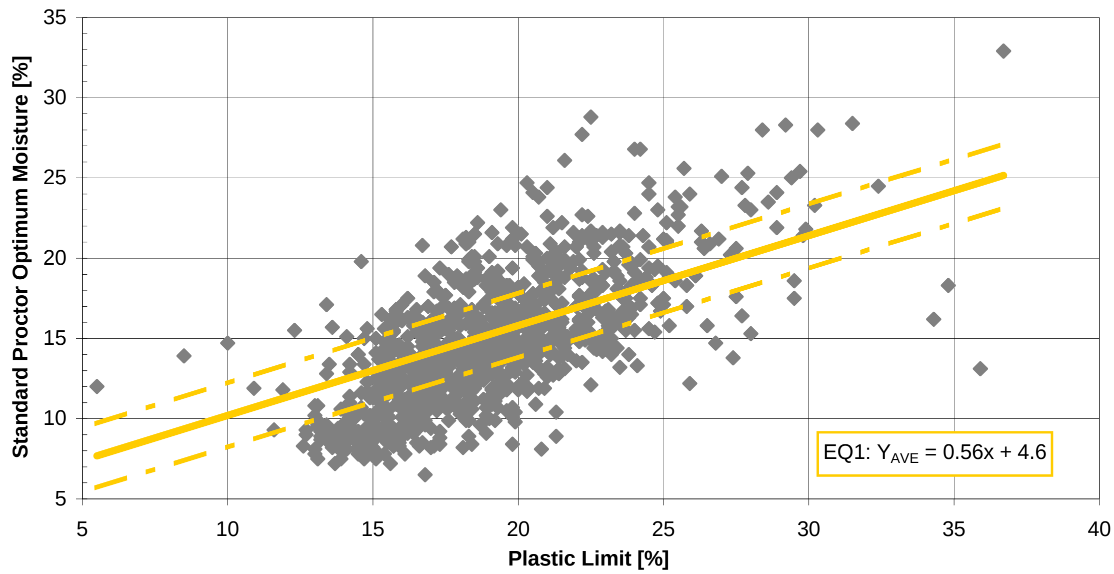


Figure E.8. Plastic limit versus standard proctor optimum moisture for all soil types with adequate data, average trend line, and accuracy boundaries

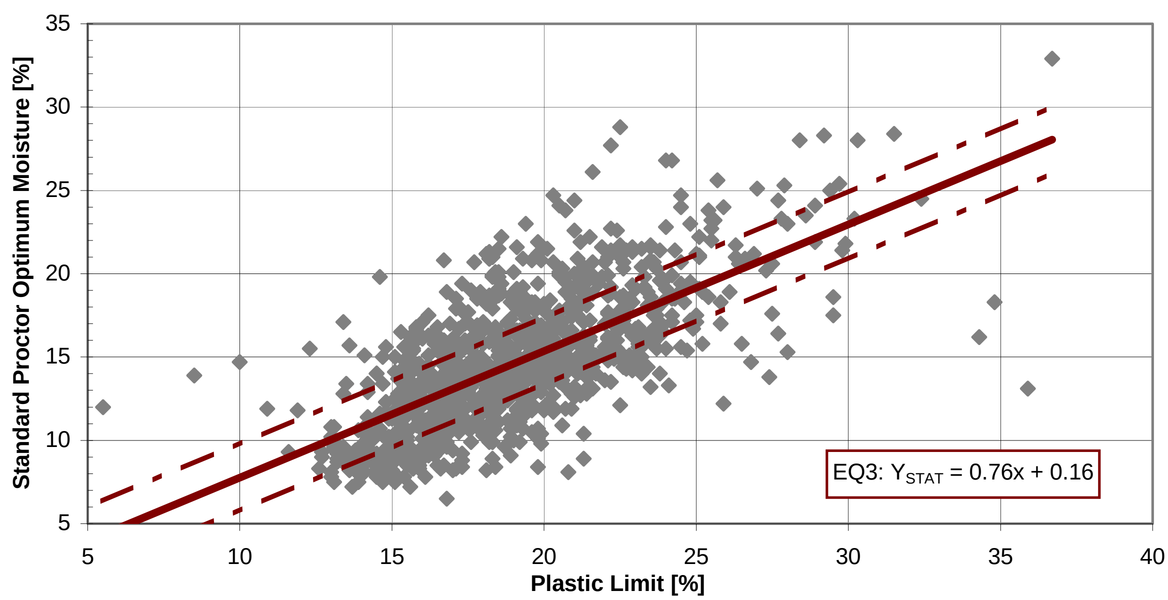


Figure E.9. Plastic limit versus standard proctor optimum moisture for all soil types with adequate data, statistical trend line, and accuracy boundaries

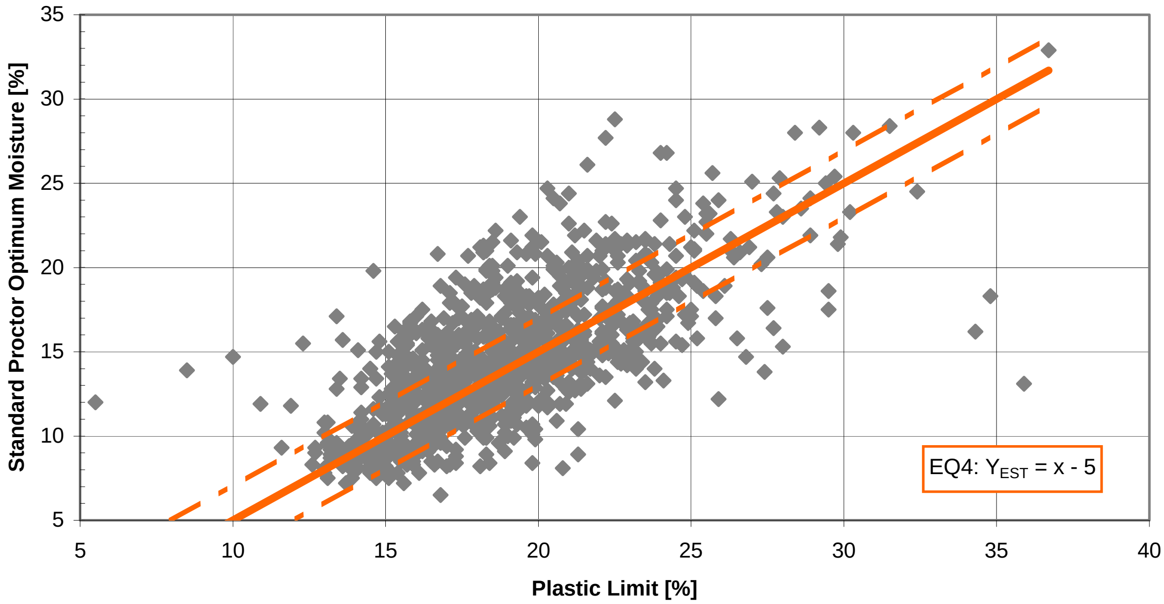


Figure E.10. Plastic limit versus standard proctor optimum moisture for all soil types with adequate data, estimated trend line, and accuracy boundaries

From this analysis, each of the confidence intervals is found. First, for the average trend line, there is a confidence interval of 46 percent. The statistical trend line has a confidence interval of 52 percent. Finally, the confidence interval for the estimated trend line is 55 percent. This shows that although all of the approximations are accurate, the estimated trend line is better suited for field use.

As a final check, it was decided to investigate whether the estimated trend line could be changed to yield better results. This was done using the Solver function in Microsoft's Excel, which allowed the slope and y-axis intercept to change until the confidence interval was maximized in Figure E.11. From this process, Equation E.5 was found to have the highest confidence interval (55.5 percent).

$$Y_{MOD-EST} = X - 5.2 \qquad [E.5]$$

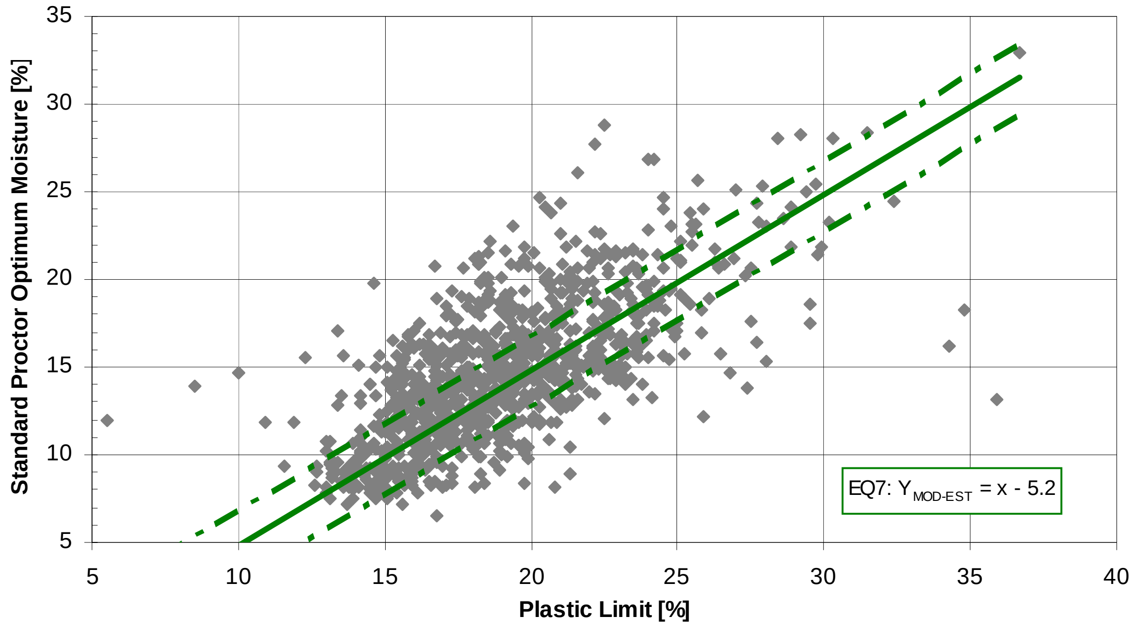


Figure E.11. Plastic limit versus standard proctor optimum moisture for all soil types with adequate data, modified-estimated trend line, and accuracy boundaries

E.4 Conclusion and Recommendation

Based on the previous discussion, it is concluded that the standard Proctor optimum moisture can be estimated by determining the plastic limit. It is recommended that the following relationship be used:

$$Y = X - 5 \quad \text{[E-6]}$$

where:

X = Plastic Limit [%]
Y = Standard Proctor Optimum Moisture [%]

By using this estimation, there is a confidence interval of 55 percent that the estimation will be within ±2 percent, for this set of data, which is better than other methods considered. It was decided to use Equation E.4 rather than the more accurate Equation E.5 first because it is simpler to use and there is only a 0.5 percent difference in the confidence interval.

Recall that the standard Proctor "optimum" moisture is also only an estimate of the appropriate moisture content for field compaction. It has long been known that this "optimum" may be too wet for some soils and for some modern high-energy compactors, which may use a combination of kneading and vibration to compact soils. The standard Proctor test does not replicate the actual field compaction conditions.

Appendix F – Commentary of LWD Loading Method

F.1 Commentary

LWD devices consist of a mass that falls onto some type of buffer system that then transfers load to an instrumented plate that subsequently transfers load to the soil surface. The mass is held above using a guide rod that attaches to the top of the plate. This rod makes certain that the mass falls vertically and smoothly as well as providing a convenient method for standardizing the drop height.

In general, such a system should be reliable. However, a Mn/DOT report written by the University of Minnesota (Hoffman *et al.*, 2003) suggests that some guide rod systems can result in erroneous modulus estimates for some LWD devices that incorporate load cells. Hoffmann concluded that the socket connecting the rod to the plate jostles under the impact loading, thereby interfering with both the load and deflection measurements. Additionally, it was observed that the bolts connecting the guide rod socket to the load plate sometimes contacted the socket in such a manner to transfer a fraction of the energy from the falling mass to the bolt heads. When this happens, the frame of the LWD transfers this energy to the plate and soil, bypassing the load cell and therefore the actual load delivered to the soil is not accurately represented in the load data collected by the load cell.

To correct these situations, Hoffmann suggested removing the guide rod and striking the load cell and plate directly with a rubber mallet. The force pulse delivered in this modified system would not be as repeatable as the pulse produced by a mass falling from a standardized height. However, the force from the hammer would be transferred directly to the soil through the load cell, allowing for an accurate force to be measured. An initial analysis of this modified configuration found that the load pulse produced by the rubber mallet was much shorter in duration than the pulse produced by the falling mass. This is due to the absence of the LWD standard rubber buffers, which have been partially replaced in function by the rubber head of the mallet. The hammer method resulted in significantly lower deflection values than the falling weight method for similar peak force values. This result again validates the shortcomings of using only the peak load and deflection to estimate the modulus.

F.2 Research Needs

1) Load pulse peak and duration for different LWD buffer configurations.
2) Accuracy and precision of load cell.
3) Accuracy and precision of geophone

Appendix G – DPI versus Depth Charts for Dynamic Cone Penetrometer Tests

G.1 Introduction

Figures G.2-G.39 are a visual representation of the dynamic cone penetrometer (DCP) penetrating the granular material and fine grained soil samples. The y-axis is a measurement of the DCP's depth, while the x-axis is the depth that the DCP penetrated per drop, also known as the DCP penetration index (DPI). As can be seen from the figures, the first few drops are not uniform and differ greatly from the lower drops. The lower drops are relatively uniform and therefore they are the desired values for calculating the DPI. Thus, in the current procedure standardized by Mn/DOT, the first two drops, known as the seating drops, are disregarded. This appendix investigates whether the first three drops should be considered seating drops and concludes that three seating drops are recommended as shown in Chapter 3, Figure 3.2.

The first graphs, Figures G.2-G.11, are from the select granular and granular material. The labeling on each briefly describes the sample, target moisture content, location of testing within the barrel, and the actual moisture content. For example, "DN5_A_4.99" represents sample DN with a target moisture content of 5 percent, DCP test location A, and an actual moisture content of 4.99 percent. DCP testing locations A, B, and C are shown in Figure G.1. Figures G.12-G14 consolidate all of the granular and select granular tests into three graphs, one for each granular material type; DN, FHJ, and KLO, respectively.

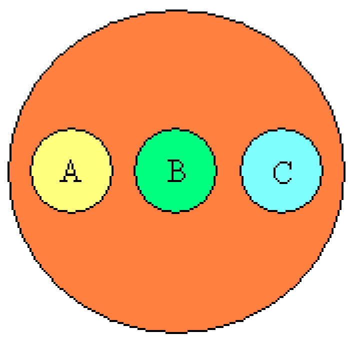


Figure G.1. Barrel locations A, B, and C

The second set of graphs, Figure G.15-G.32, are for the fine grained soil. The labeling on each of the soil samples briefly describes the soil type, DCP test number, percent of optimum moisture content, and standard Proctor density. For example "A_1_102.3_97.7" represents MnROAD soil, DCP test number 1, 102.3 percent of optimum moisture content, and 97.7 percent of standard Proctor density. For the fine grained soil, letter A represents MnROAD soil, B represents Duluth, C is Red Wing, D is Red Lake Falls, E is Steele CSAH 35, and F is for Steele T-145. For each target percent of optimum moisture content and target standard Proctor density, there are two DCP tests. Figures G.33-G39 consolidate all of the fine grained soil tests into seven graphs, one for each fine grained soil type, with an except for soil E, which has two graphs.

Steele County, in southern Minnesota, provided DCP data to help further develop our analysis on fine grained soil DCP data. Data from Steele CSAH 35 is represented in this Appendix as soil type E, which is classified as clay, sandy clay, and clay and silt. Data from Steele T-145 is represented as soil type F, which is classified as sandy clay.

G.2 Granular and Select Granular DPI Charts

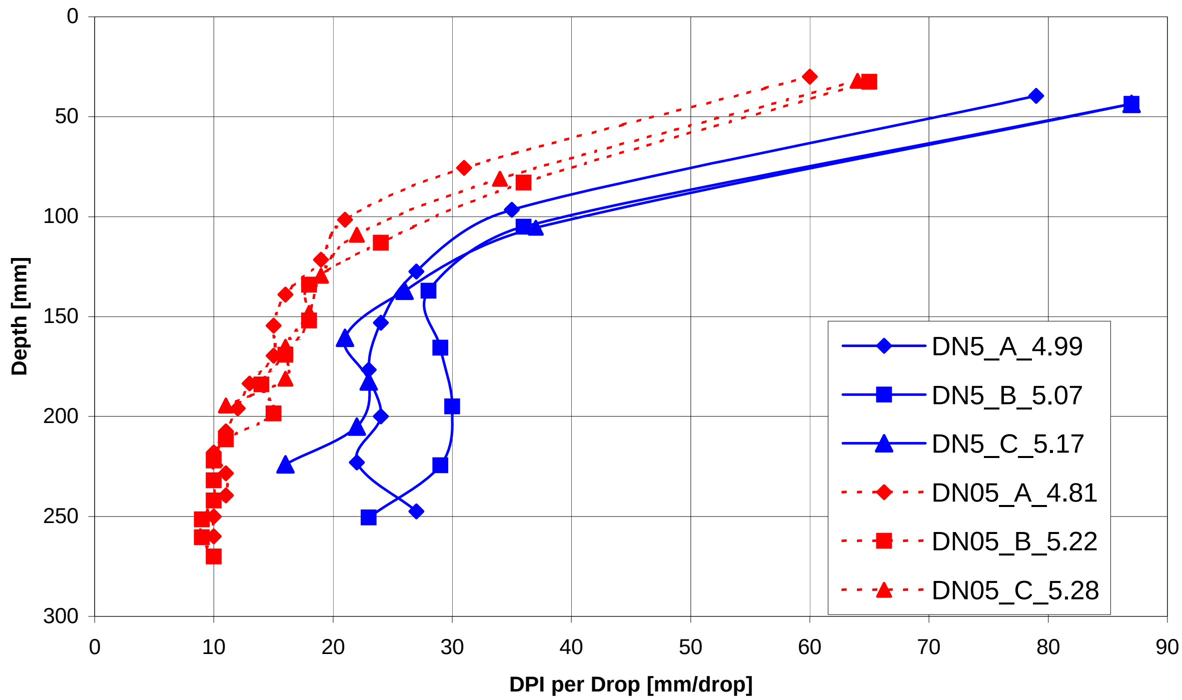


Figure G.2. DN5 and DN05 select granular samples

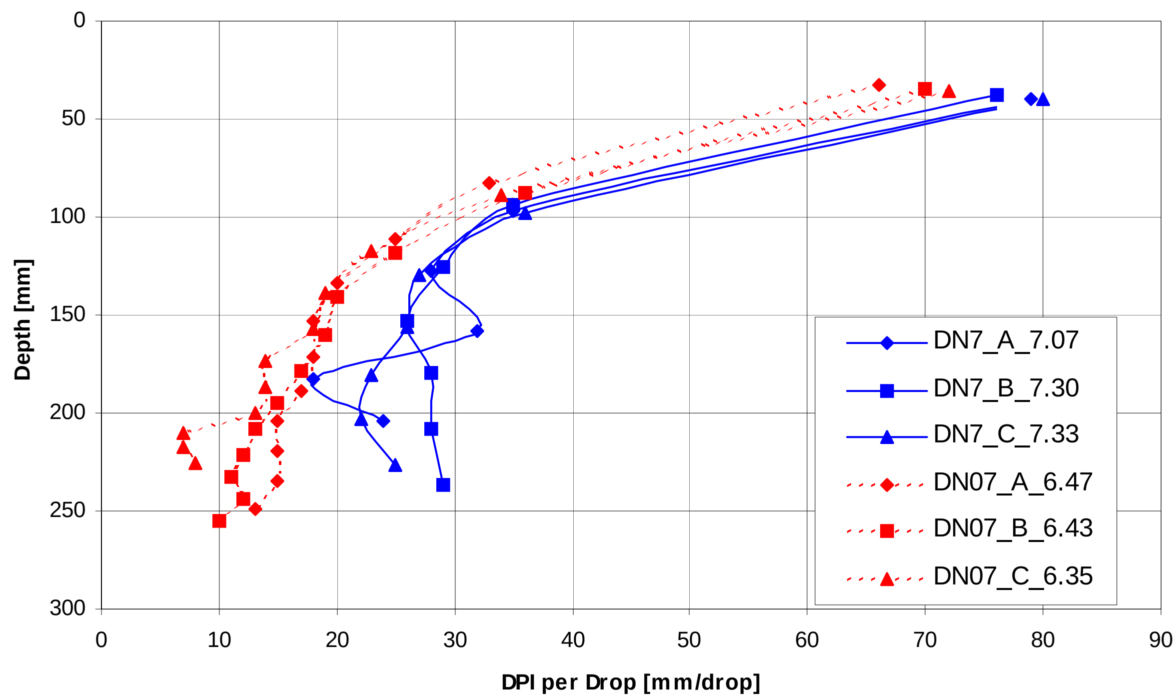


Figure G.3. DN7 and DN07 select granular samples

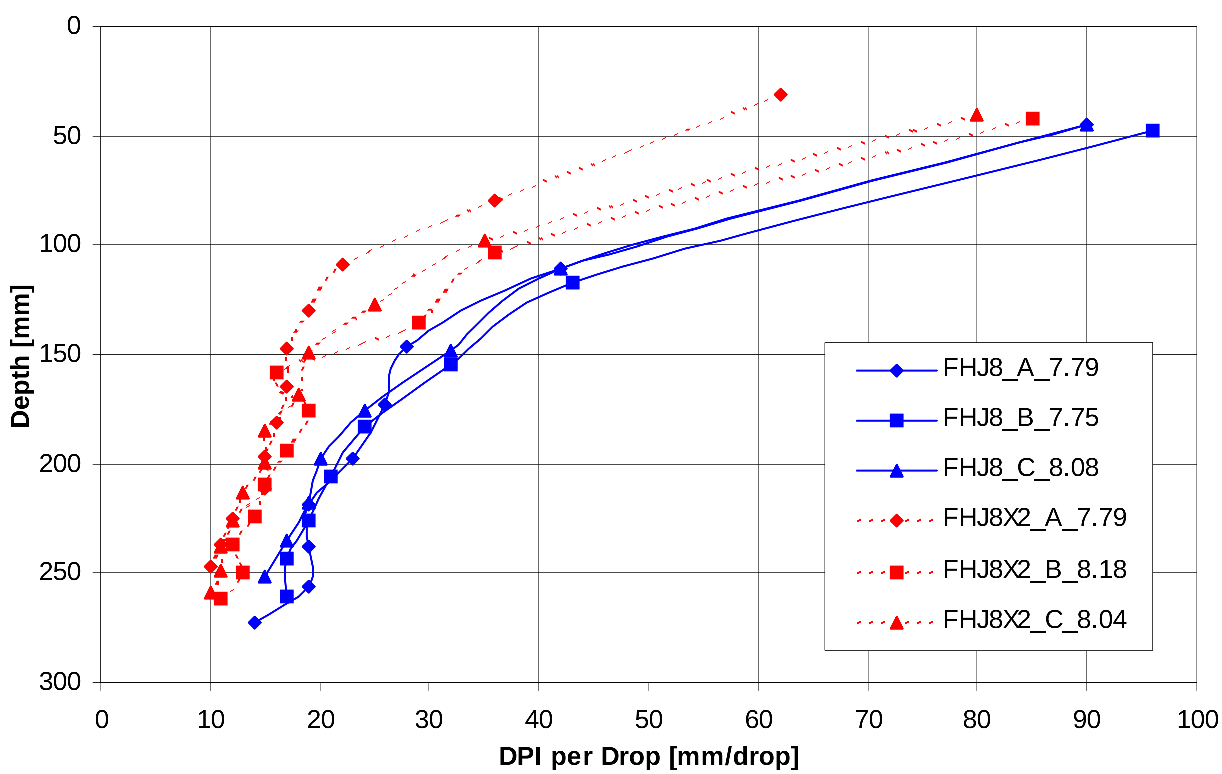


Figure G.4. FHJ8 and FHJ8X2 granular samples

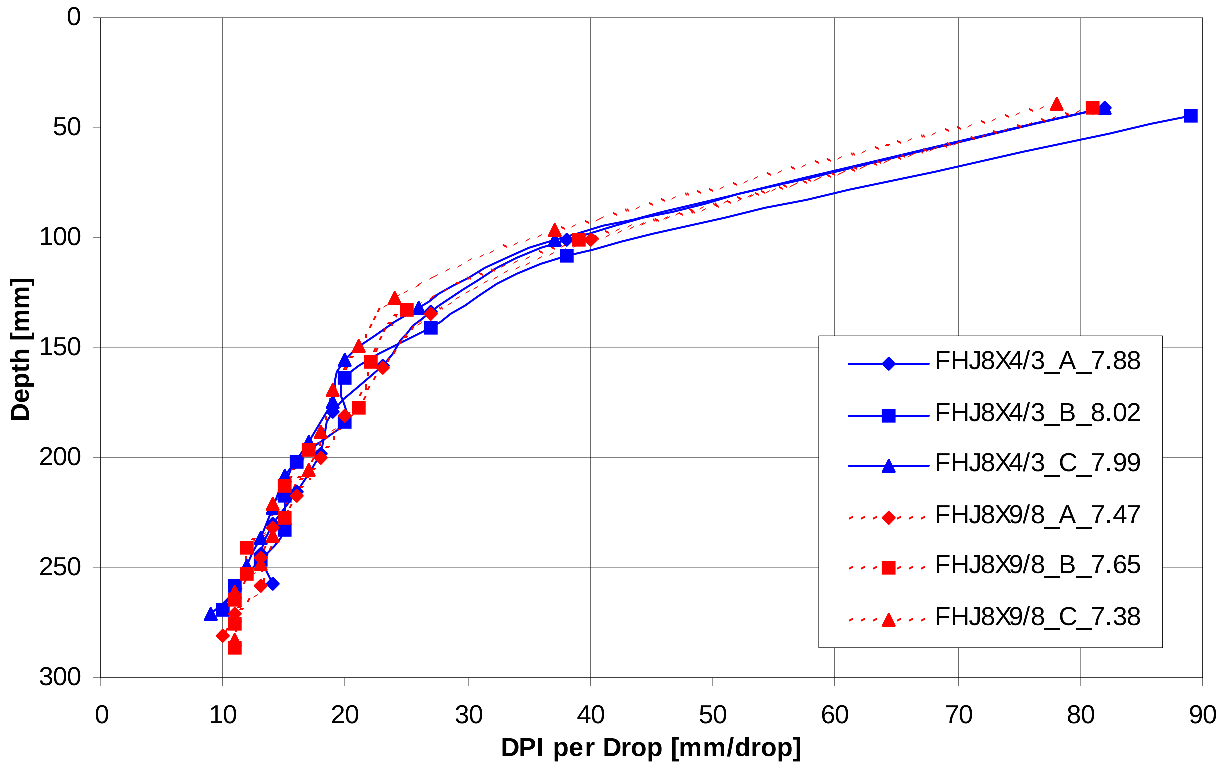


Figure G.5. FHJ8X1.33 and FHK8X1.125 granular samples

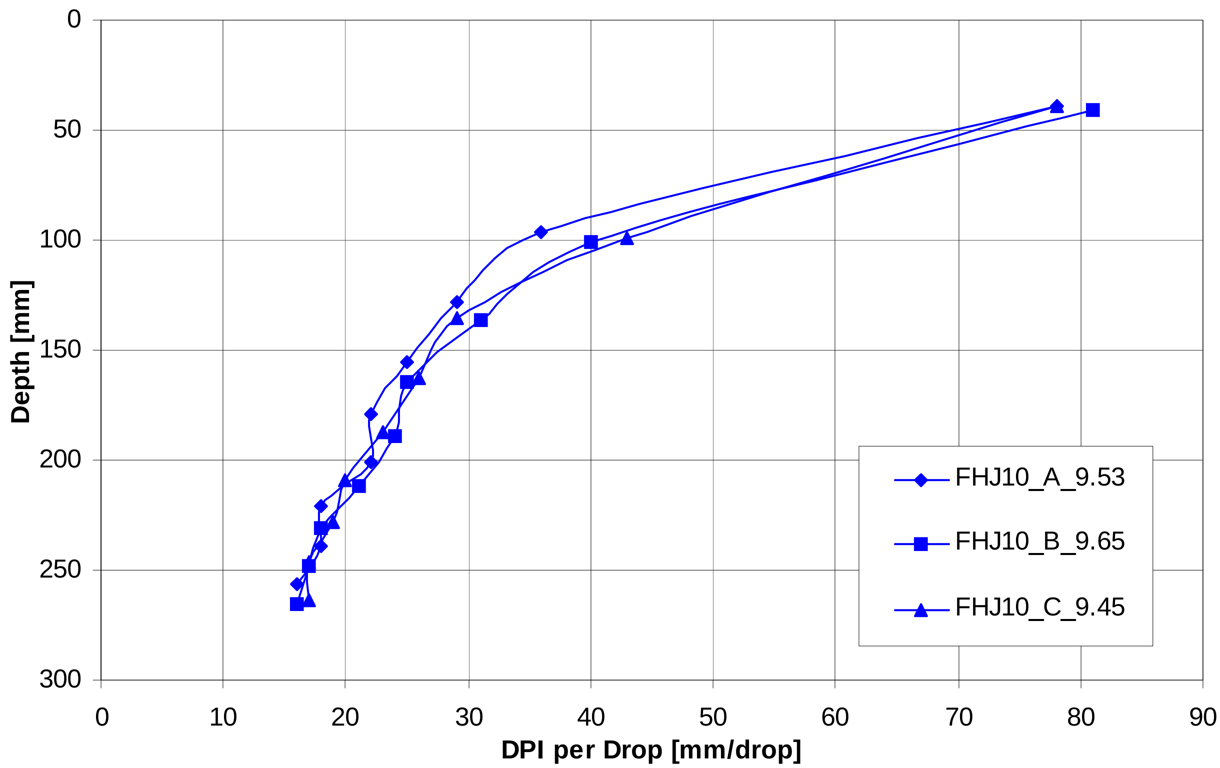


Figure G.6. FHJ10 granular sample

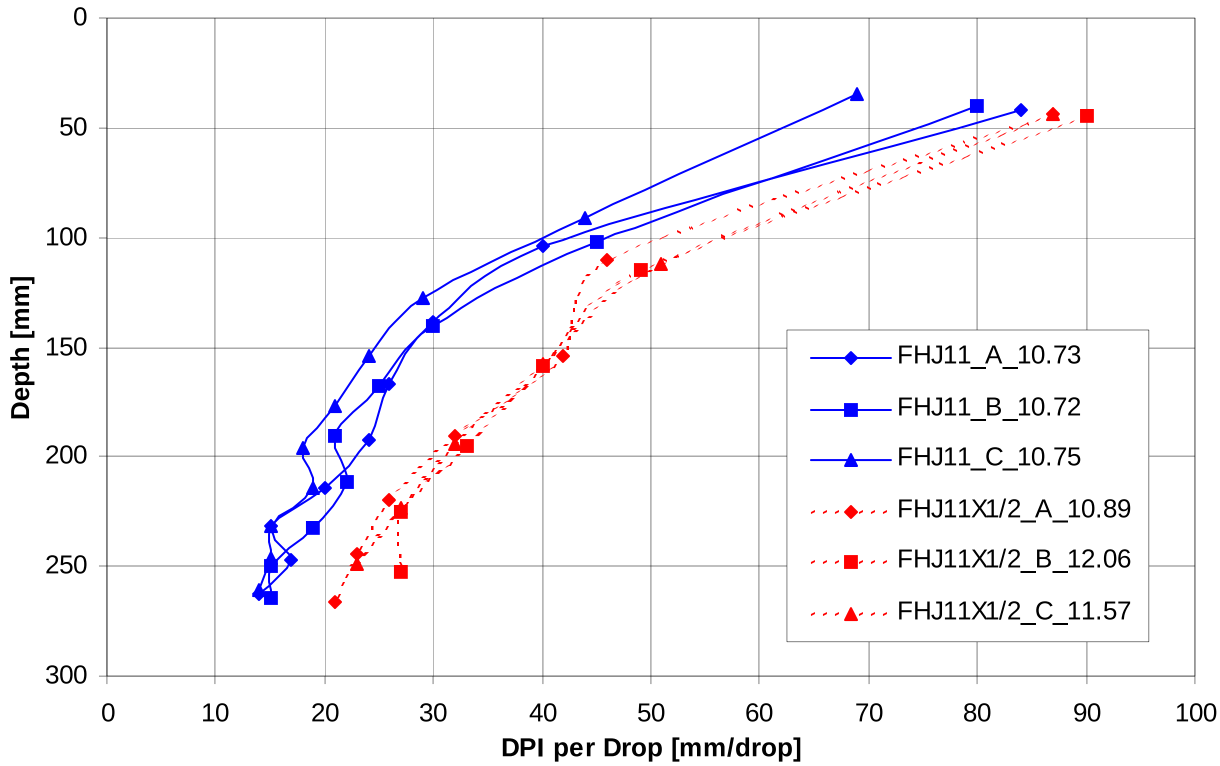


Figure G.7. FHJ11 and FHJ11X0.5 granular samples

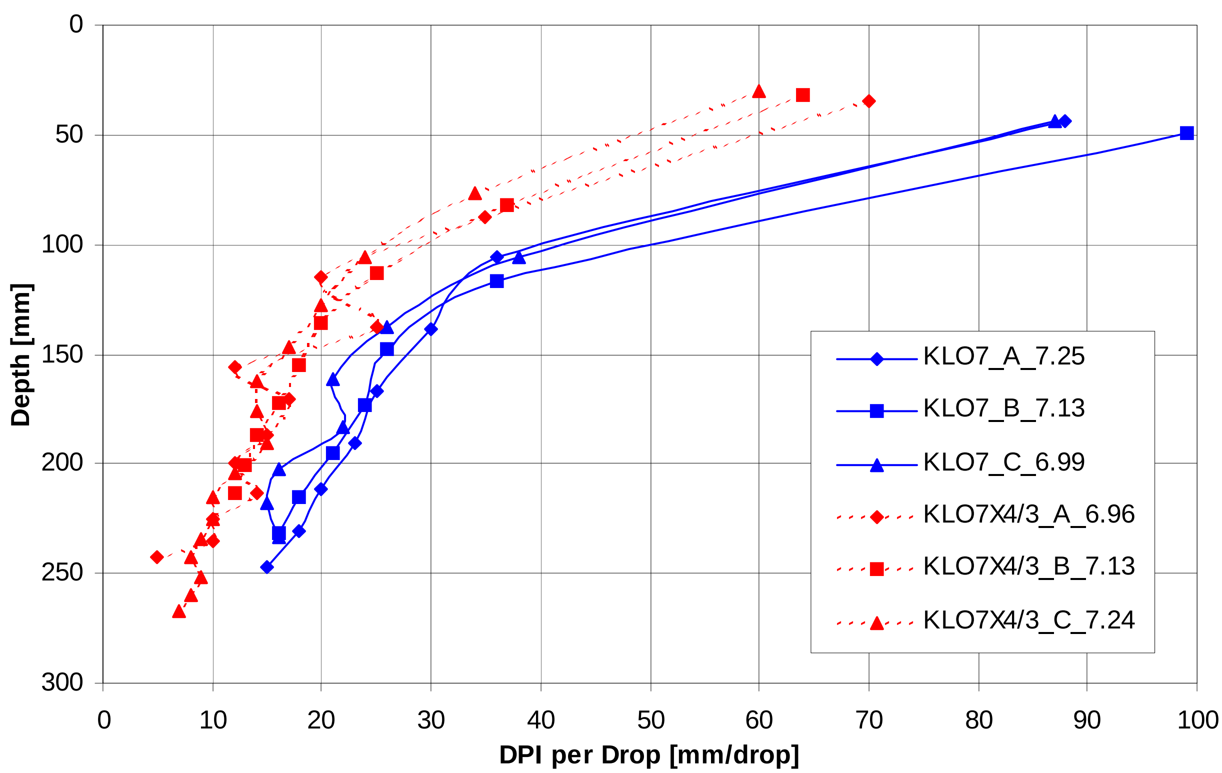


Figure G.8. KLO7 and KLO7X1.33 select granular samples

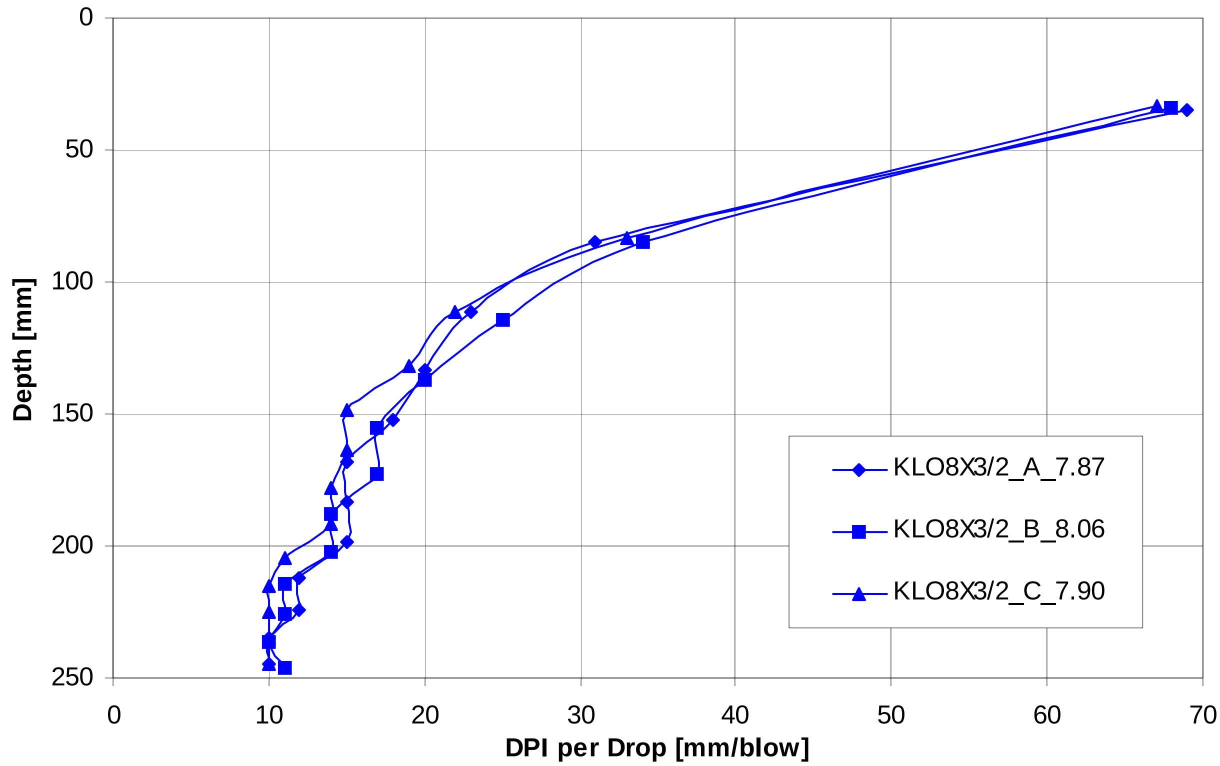


Figure G.9. KLO8X1.5 select granular sample

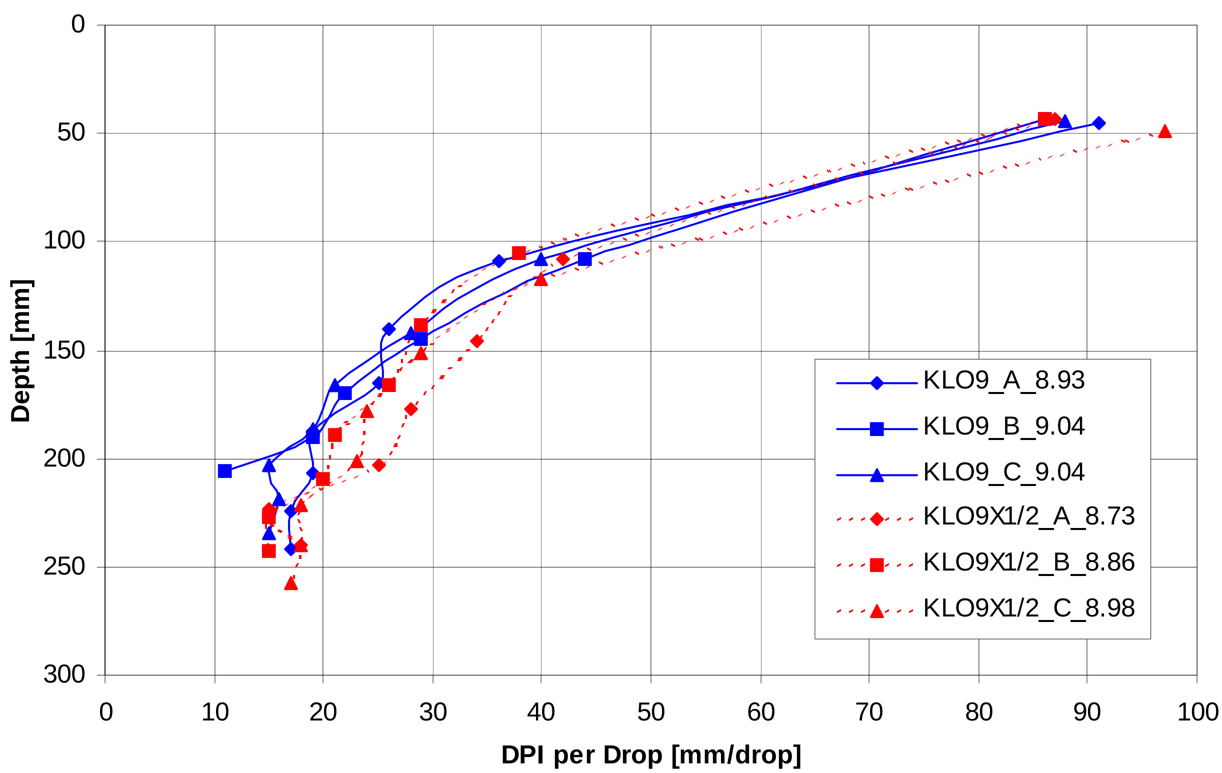


Figure G.10. KLO9 and KLO9X0.5 select granular samples

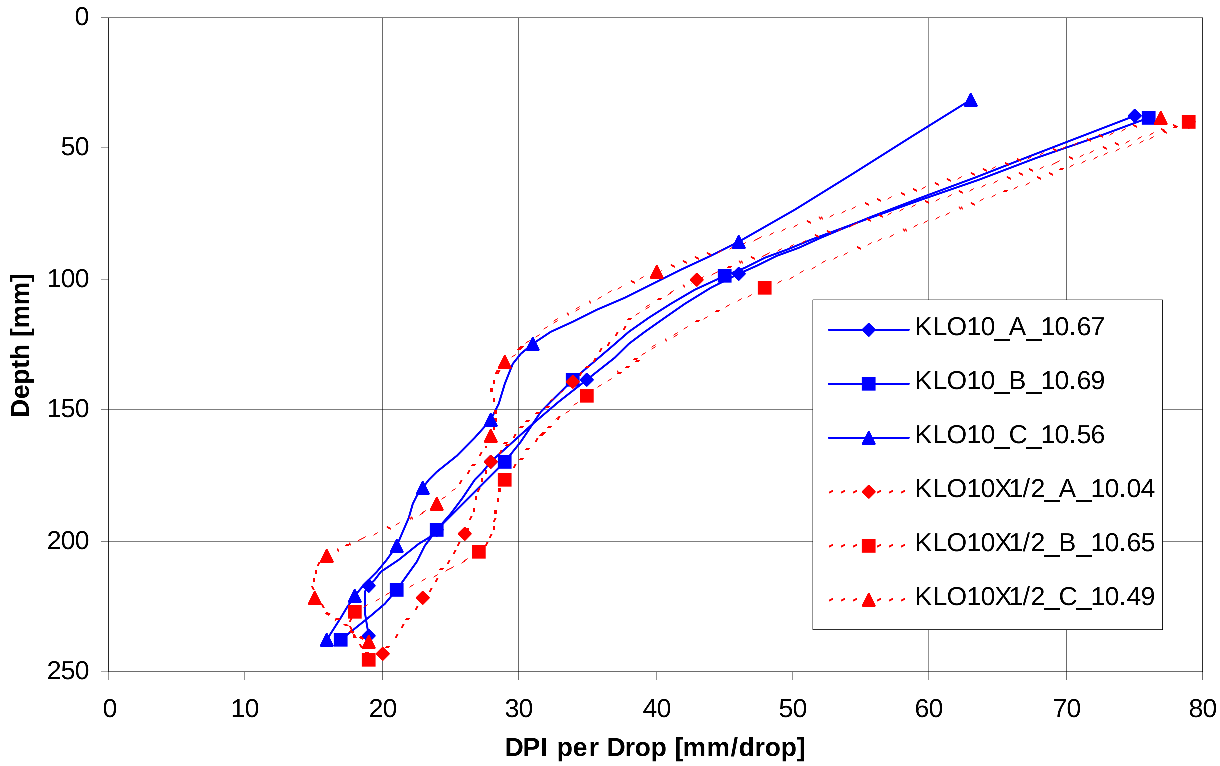


Figure G.11. KLO10 and KLO10X10.5 select granular samples

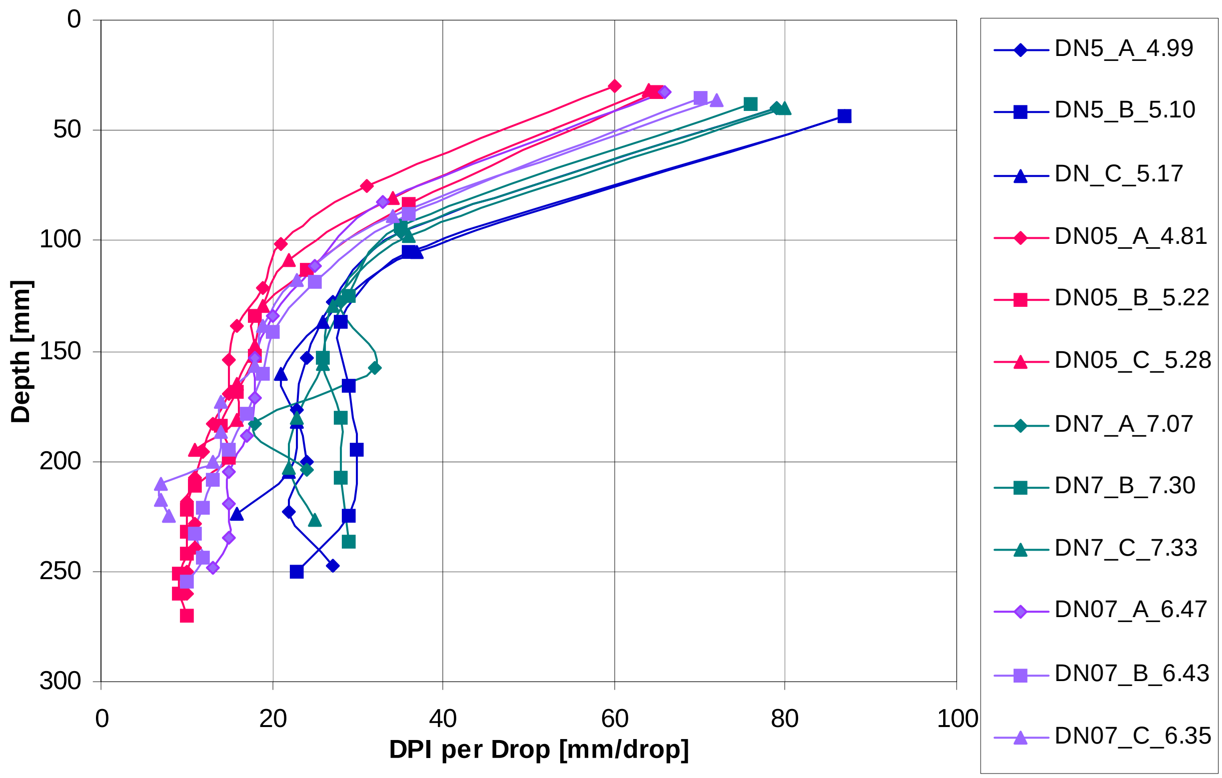


Figure G.12. All DN select granular samples

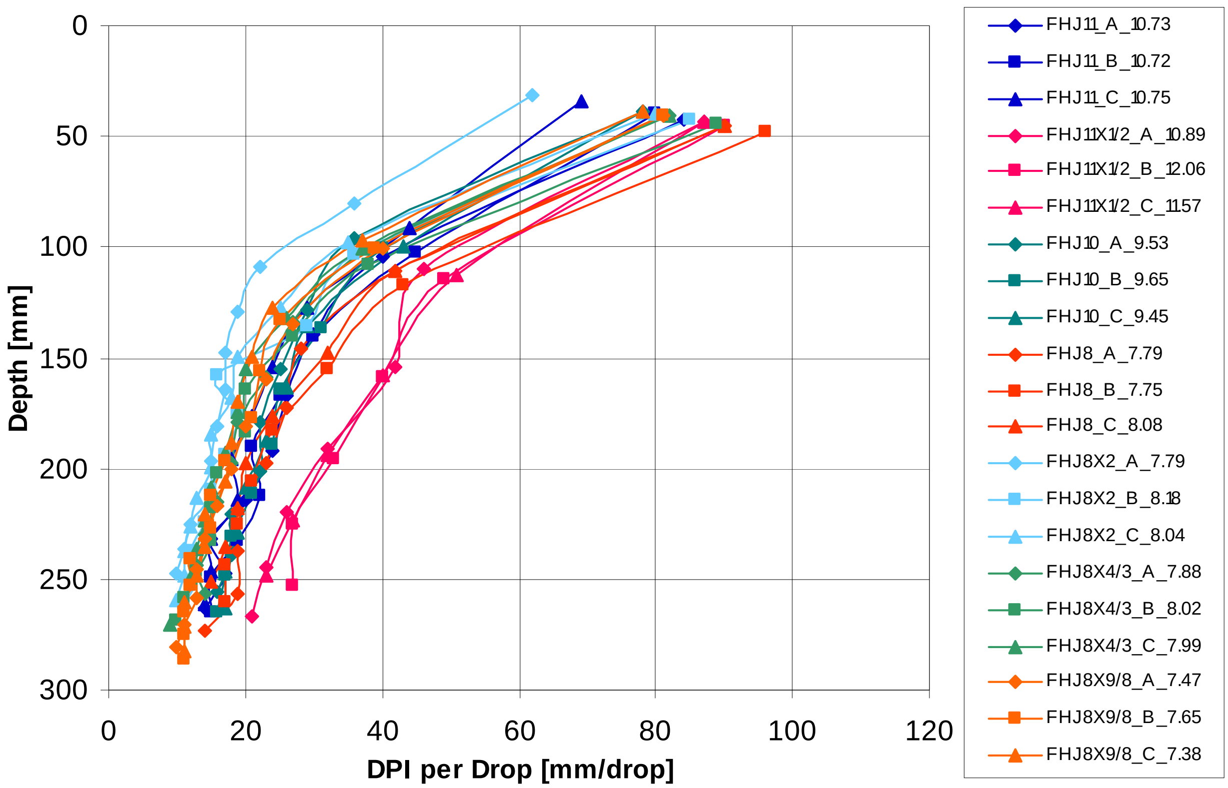


Figure G.13. All FHJ granular samples

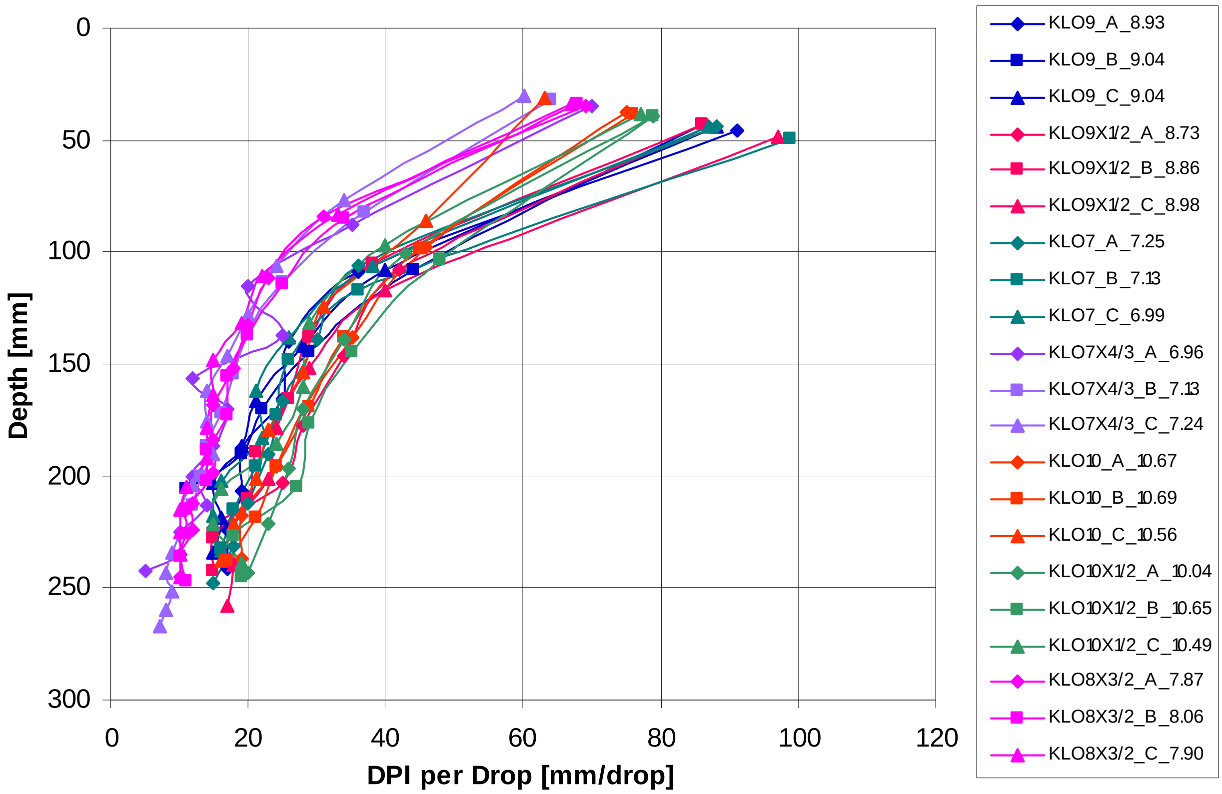


Figure G.14. All KLO select granular samples

G.3 Fine Grained DPI Charts

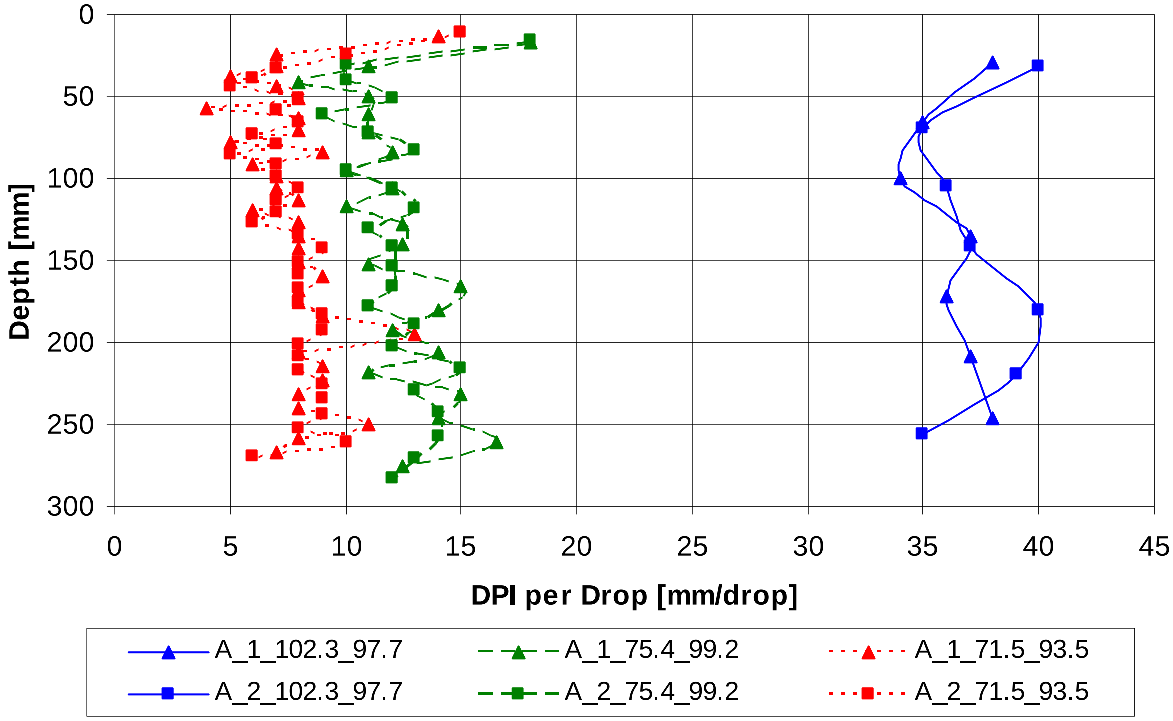


Figure G.15. MnROAD fine grained samples low target density

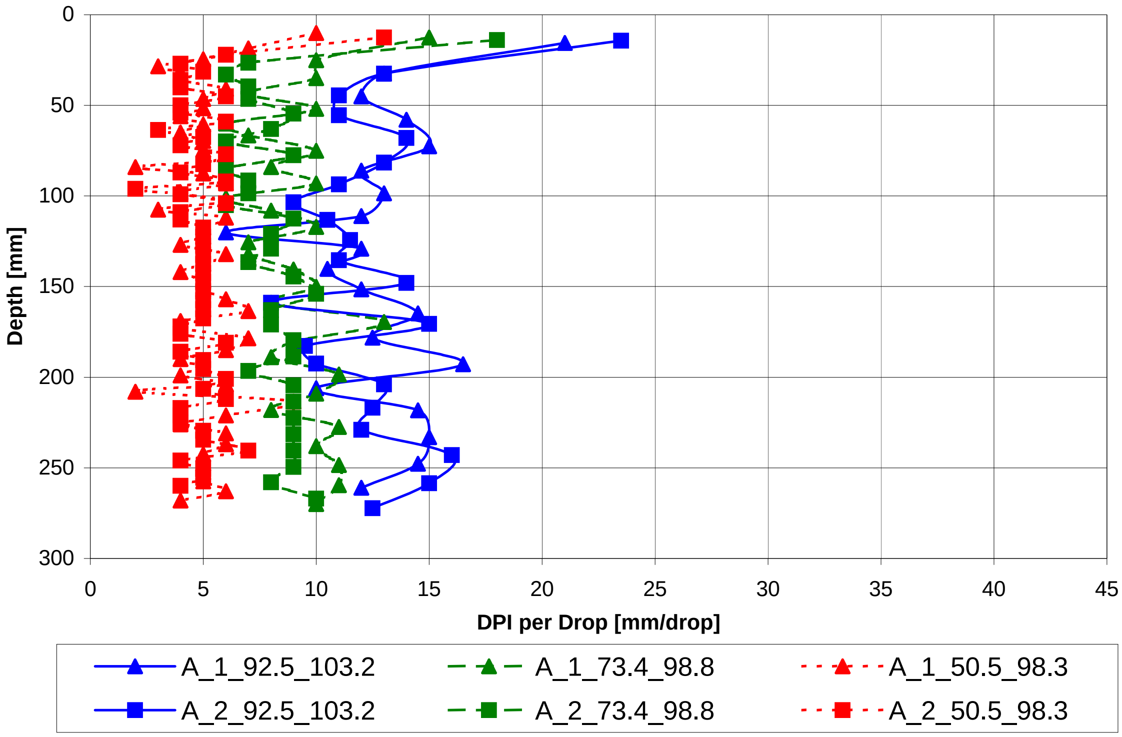


Figure G.16. MnROAD fine grained samples high target density

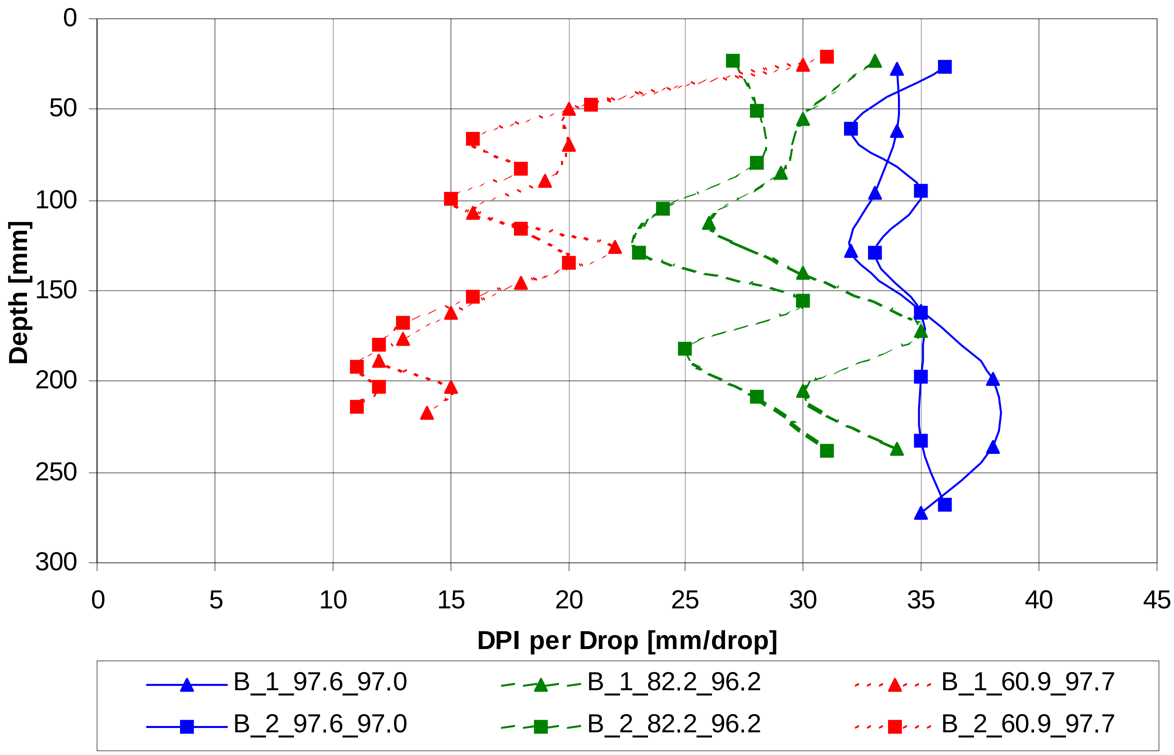


Figure G.17. Duluth fine grained samples low target density

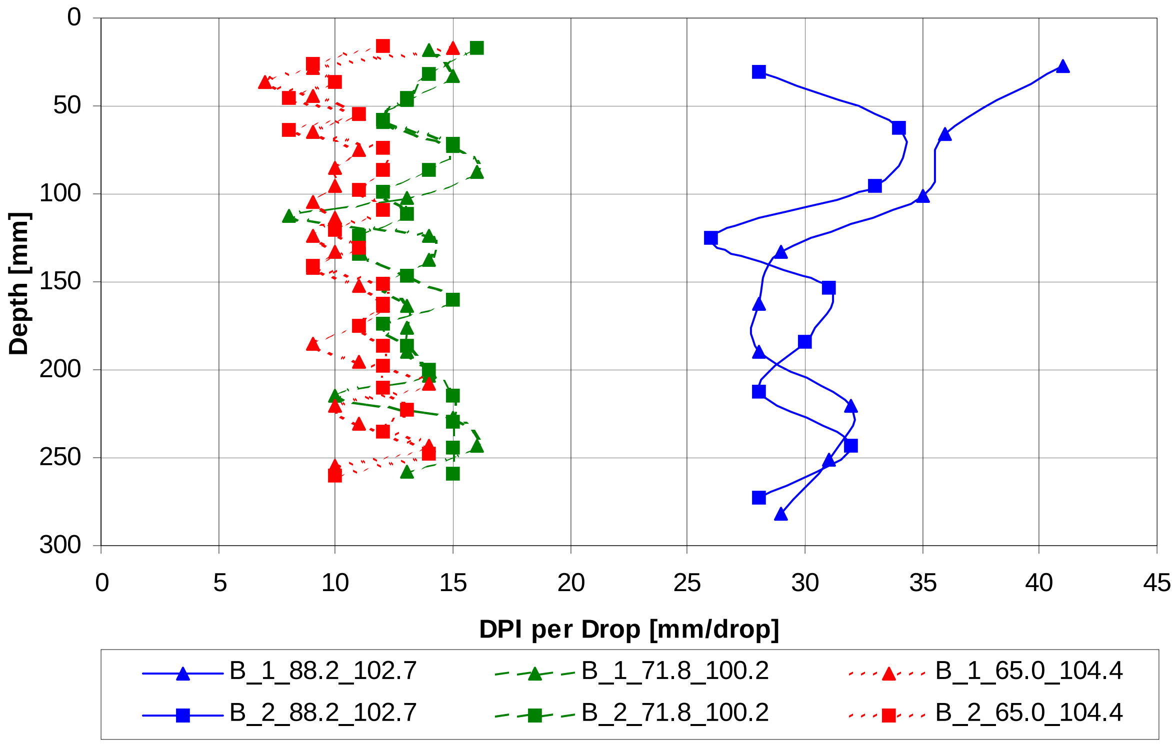


Figure G.18. Duluth fine grained samples high target density

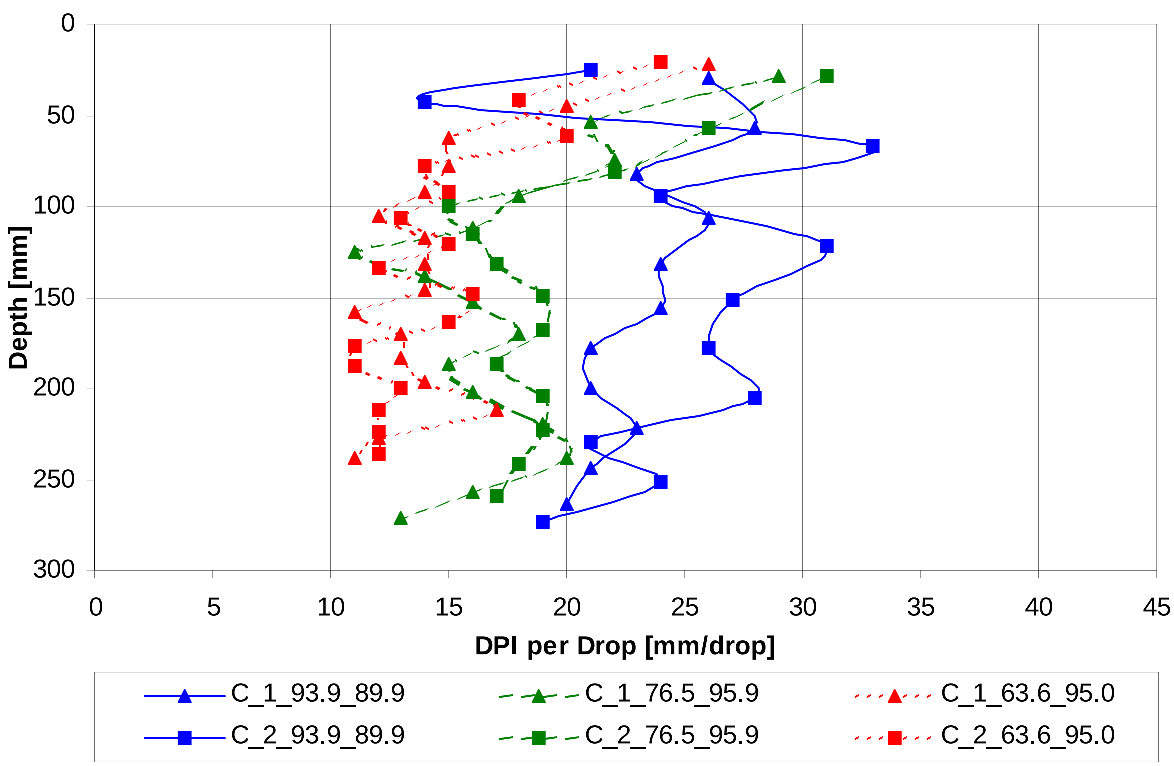


Figure G.19. Red Wing fine grained samples low target density

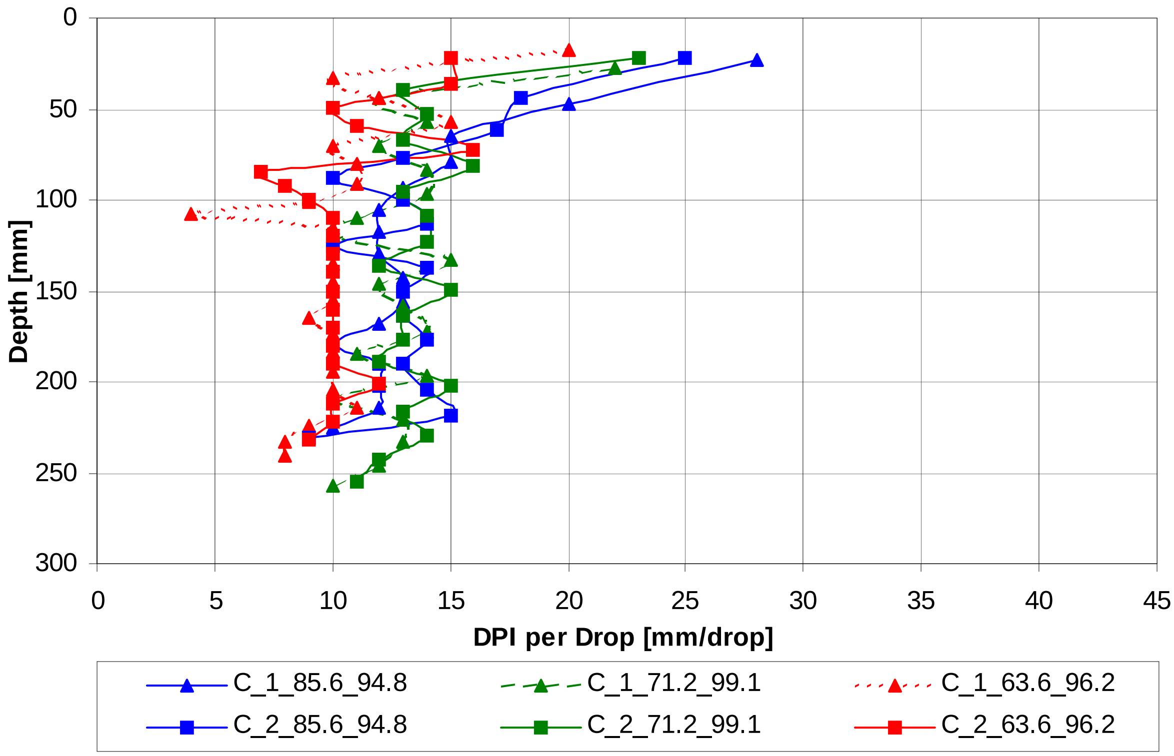


Figure G.20. Red Wing fine grained samples high target density

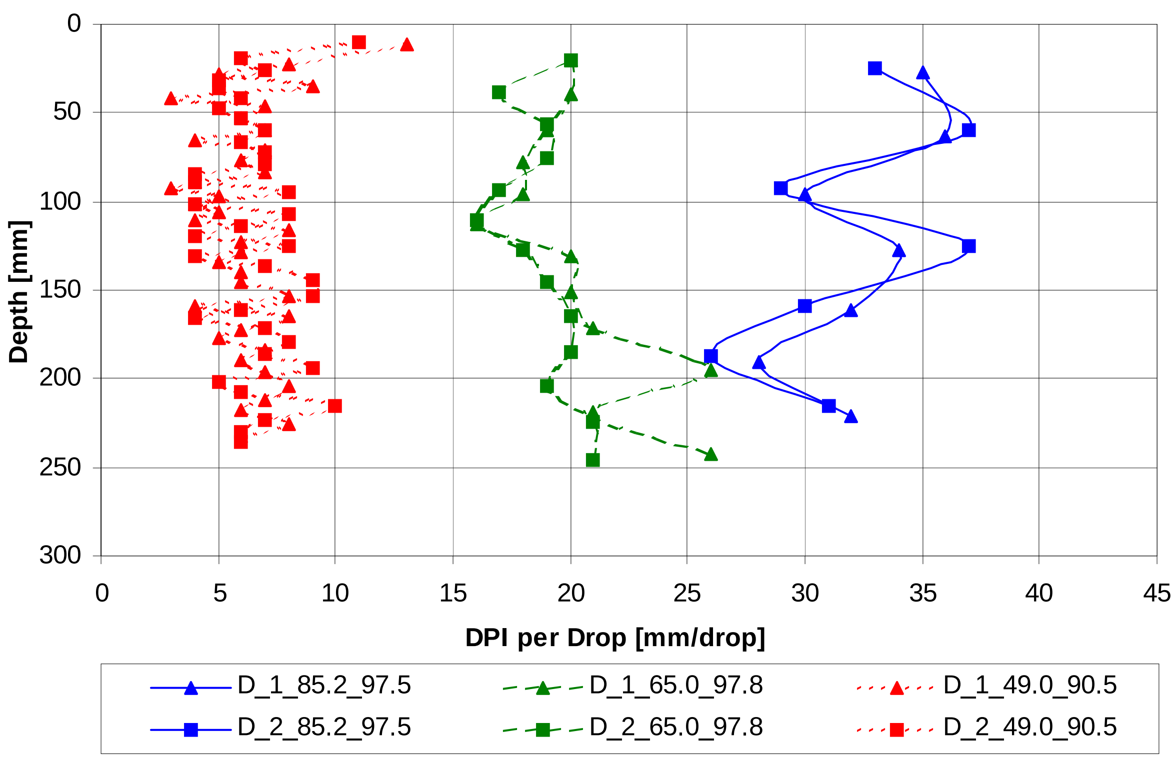


Figure G.21. Red Lake Falls fine grained samples low target density

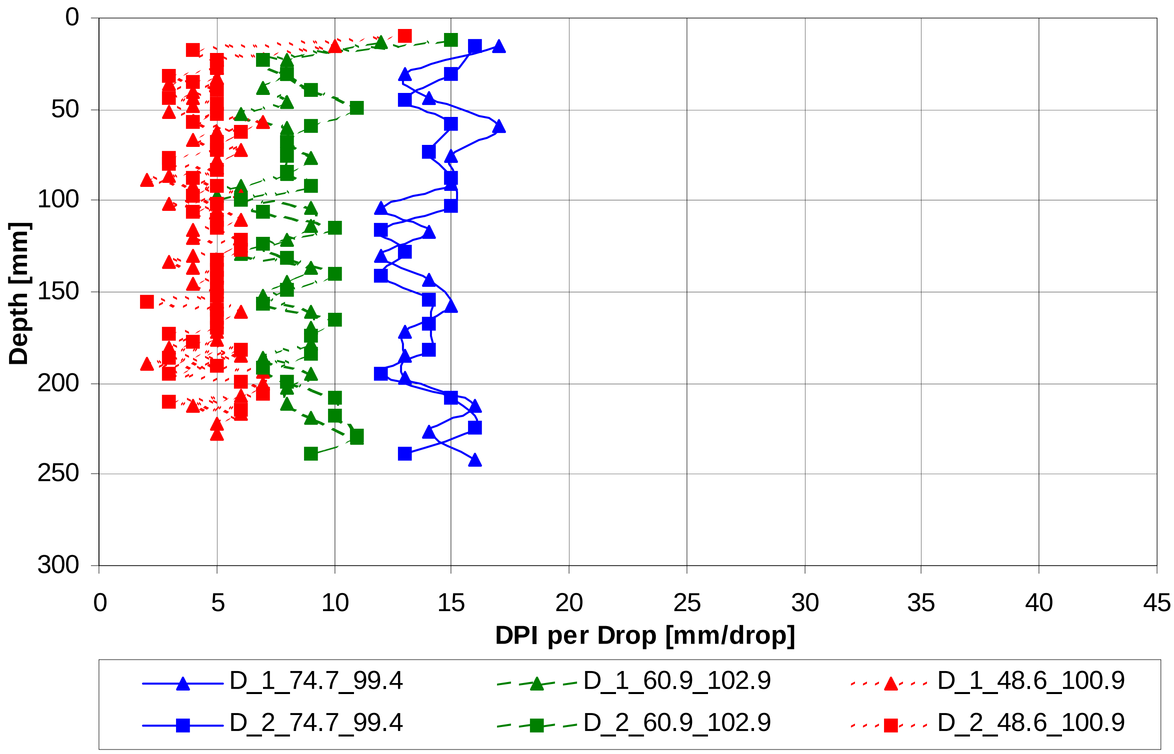


Figure G.22. Red Lake Falls fine grained samples high target density

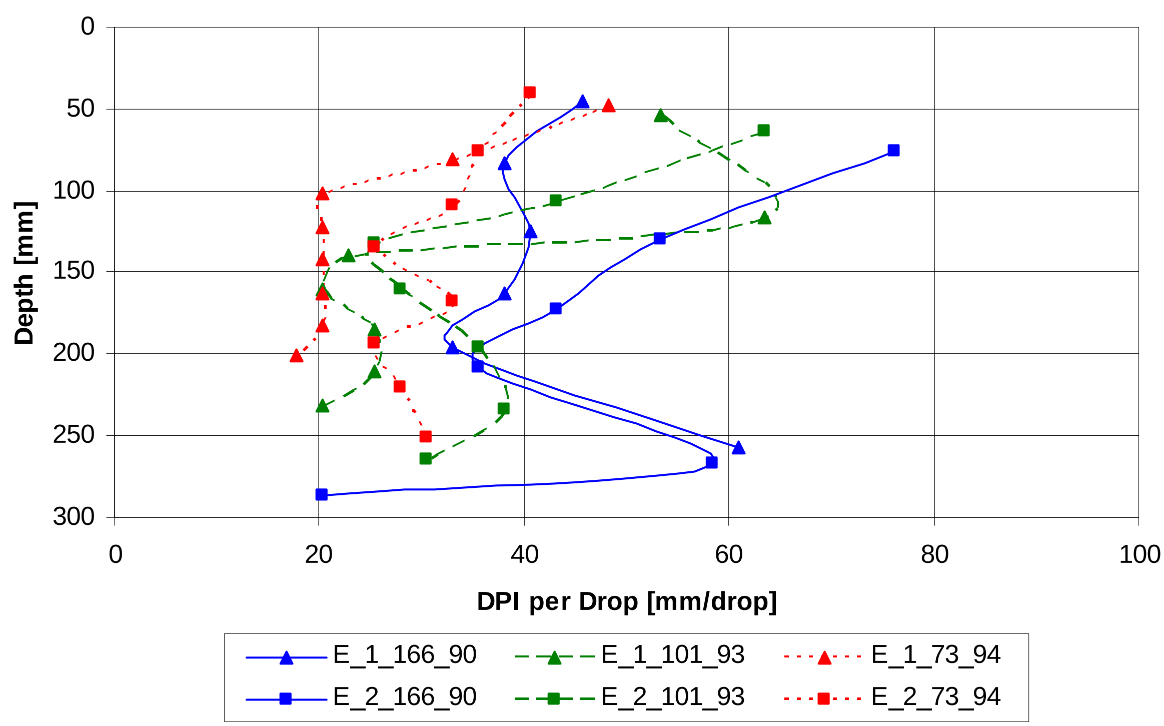


Figure G.23. Steele CSAH 35 fine grained samples low target density (90-94%)

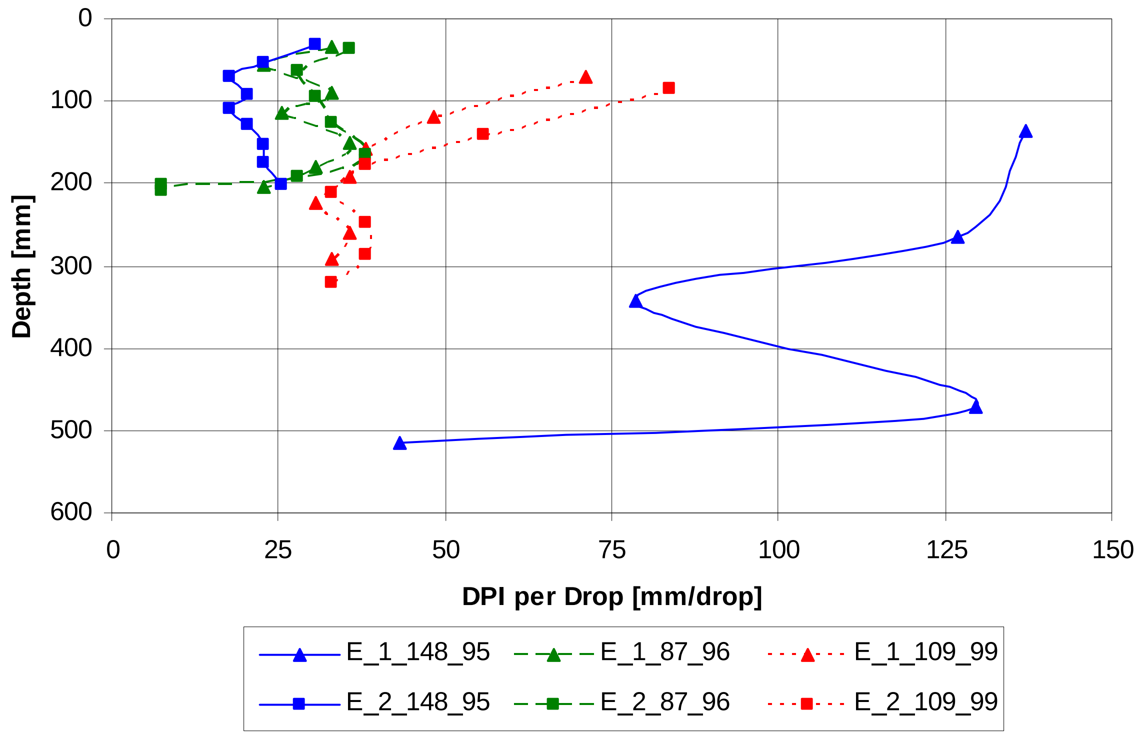


Figure G.24. Steele CSAH 35 fine grained samples low target density (95-99%)

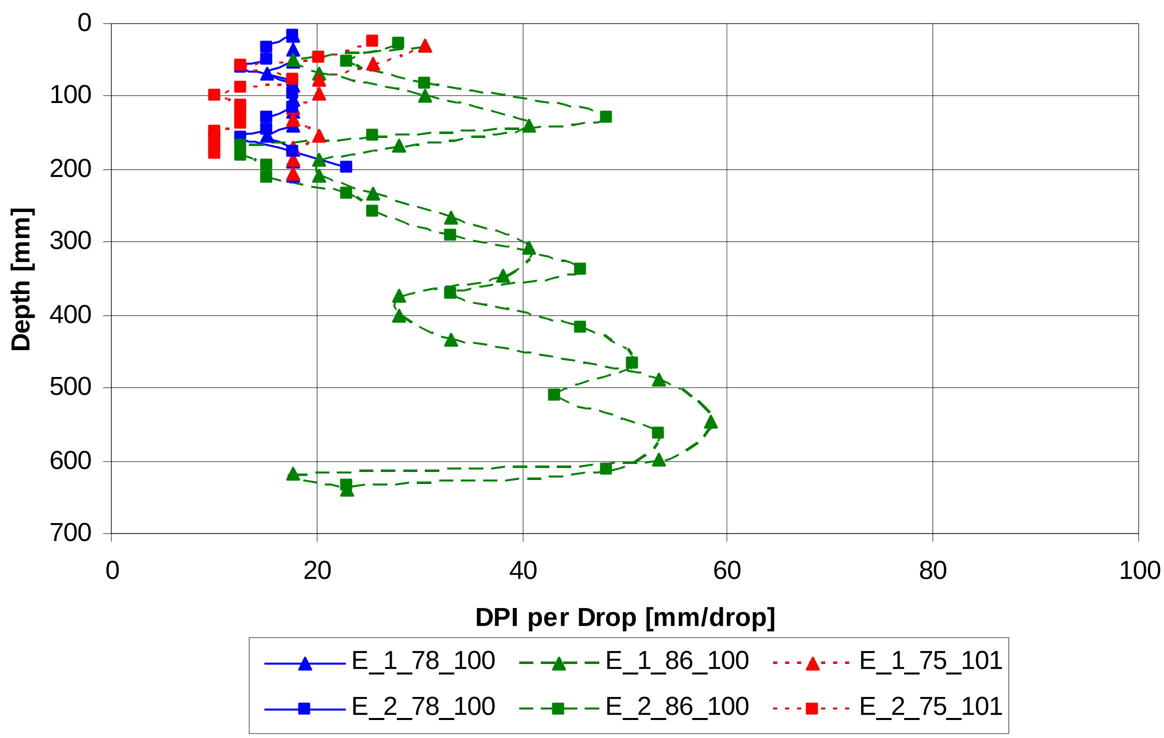


Figure G.25. Steele CSAH 35 fine grained samples high target density (100-101%)

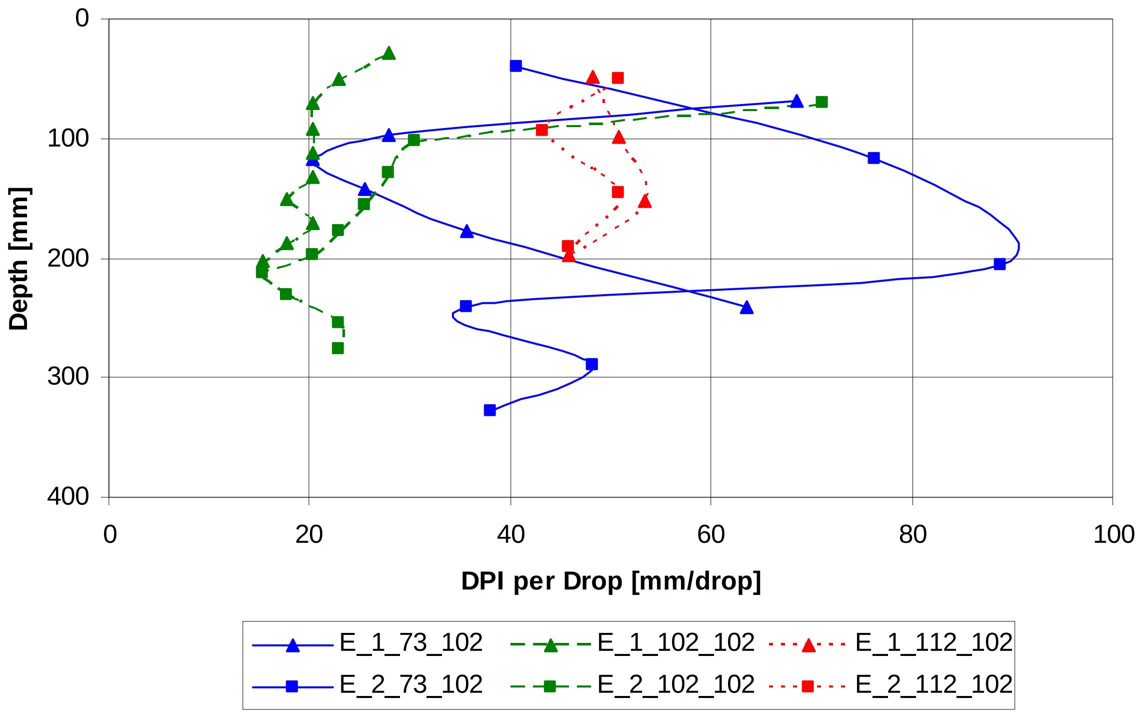


Figure G.26. Steele CSAH 35 fine grained samples high target density (102%)

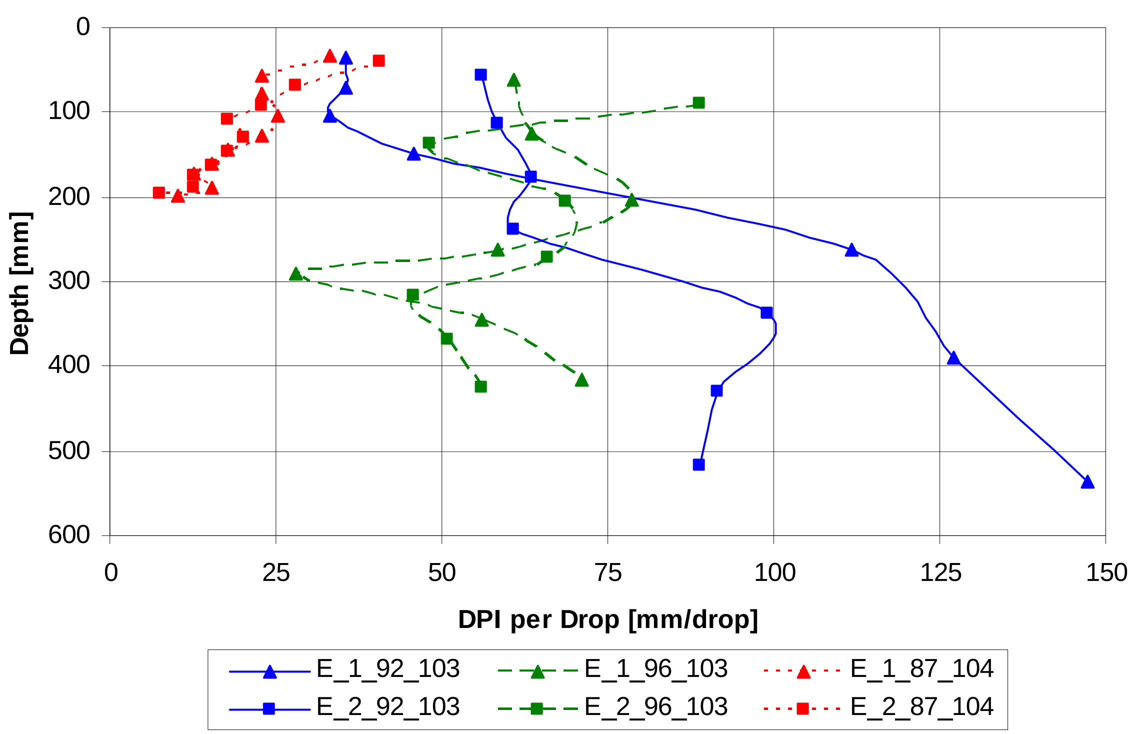


Figure G.27. Steele CSAH 35 fine grained samples high target density (103-104%)

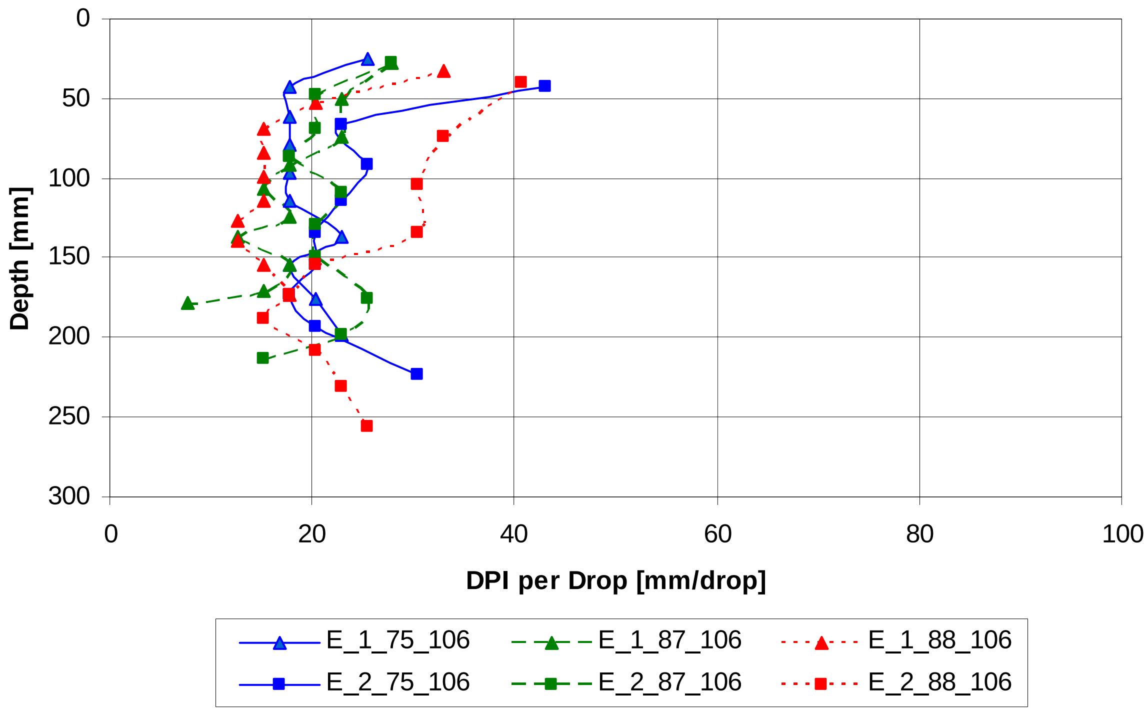


Figure G.28. Steele CSAH 35 fine grained samples high target density (106%)

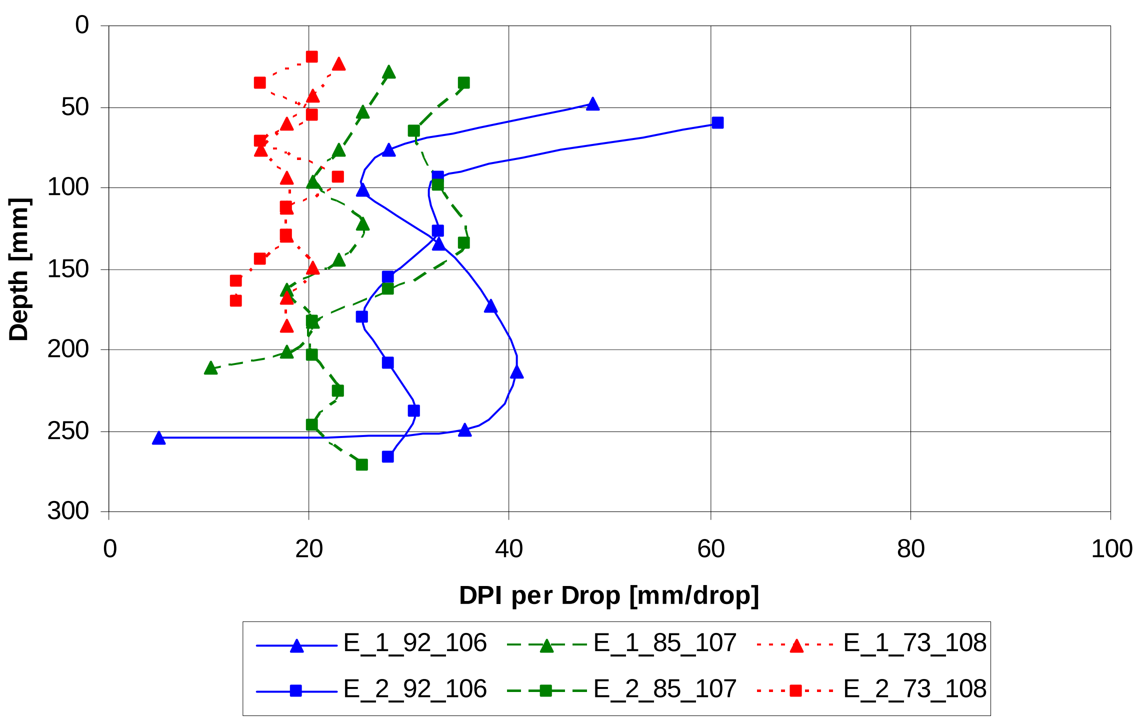


Figure G.29. Steele CSAH 35 fine grained samples high target density (106-108%)

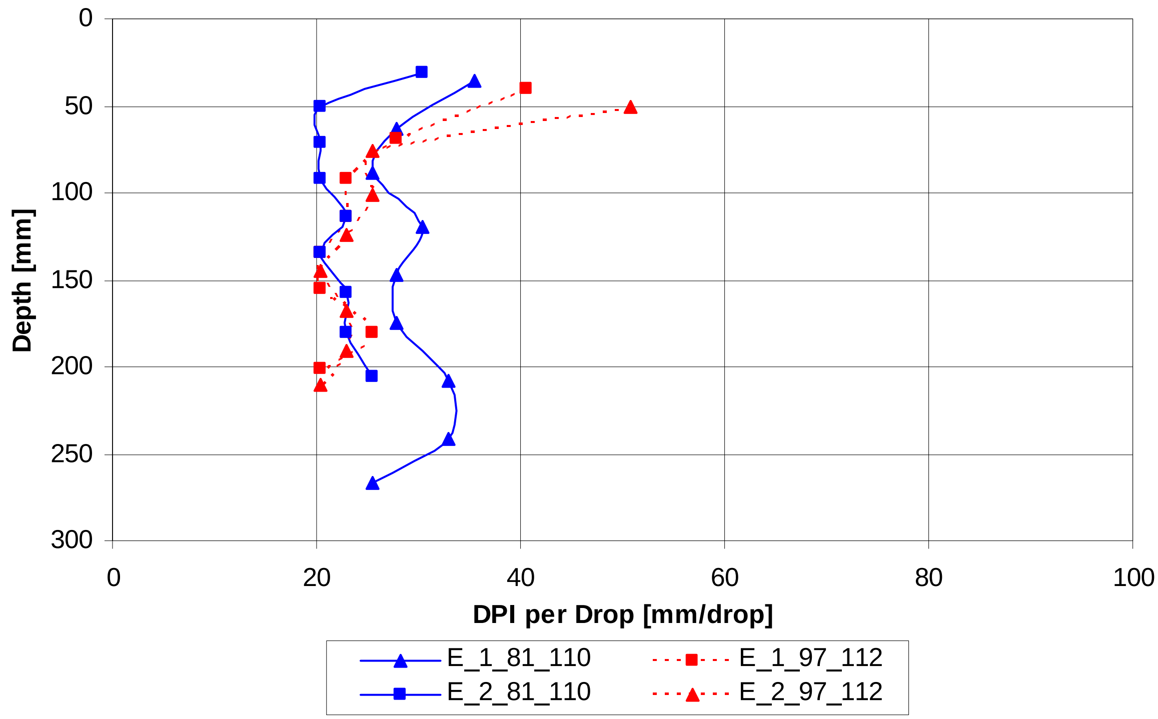


Figure G.30. Steele CSAH 35 fine grained samples high target density (110-112%)

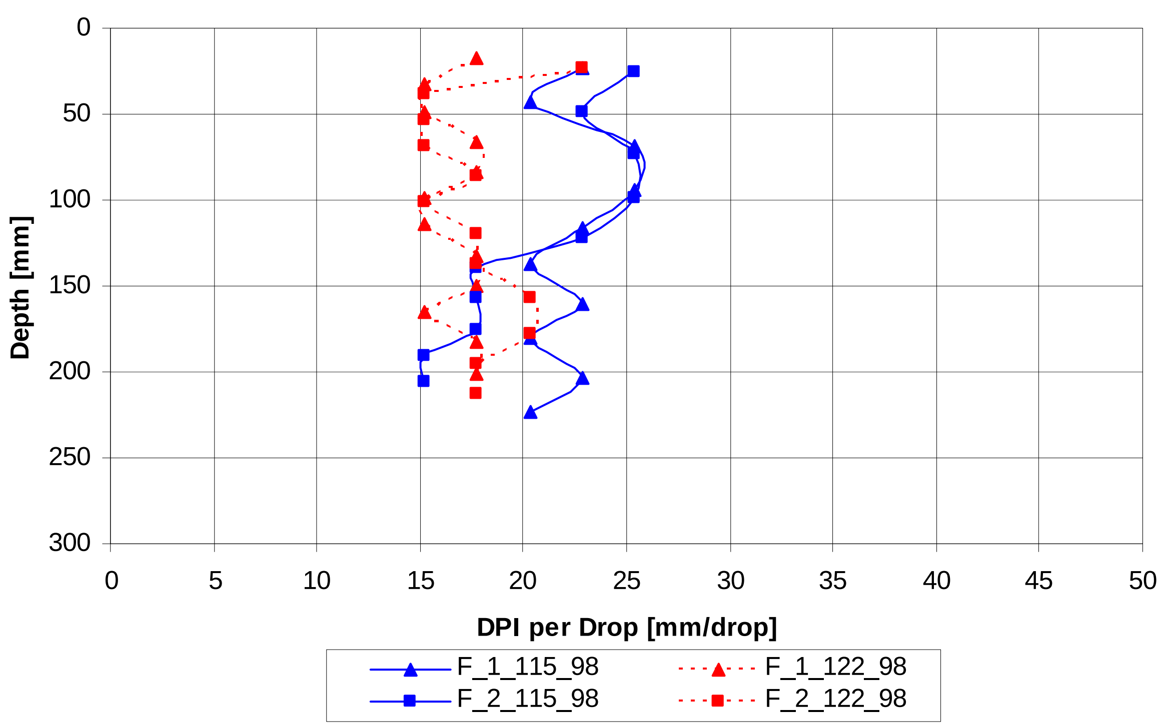


Figure G.31. Steele T-145 fine grained samples low target density

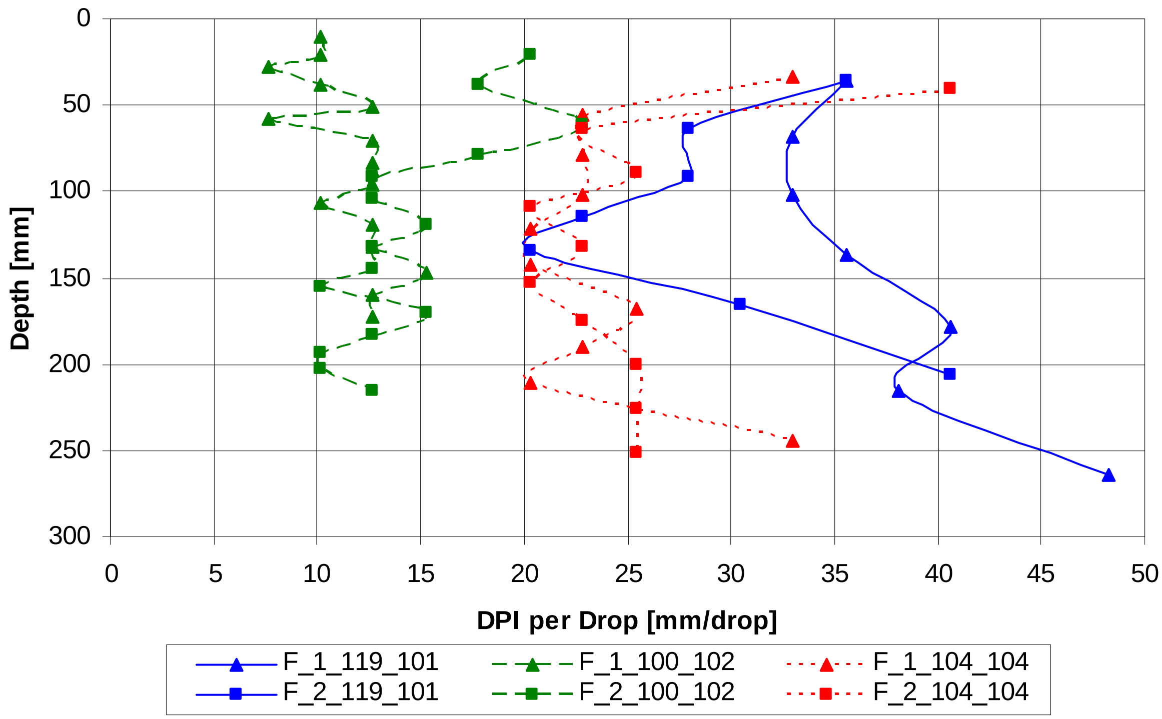


Figure G.32. Steele T-145 fine grained samples high target density

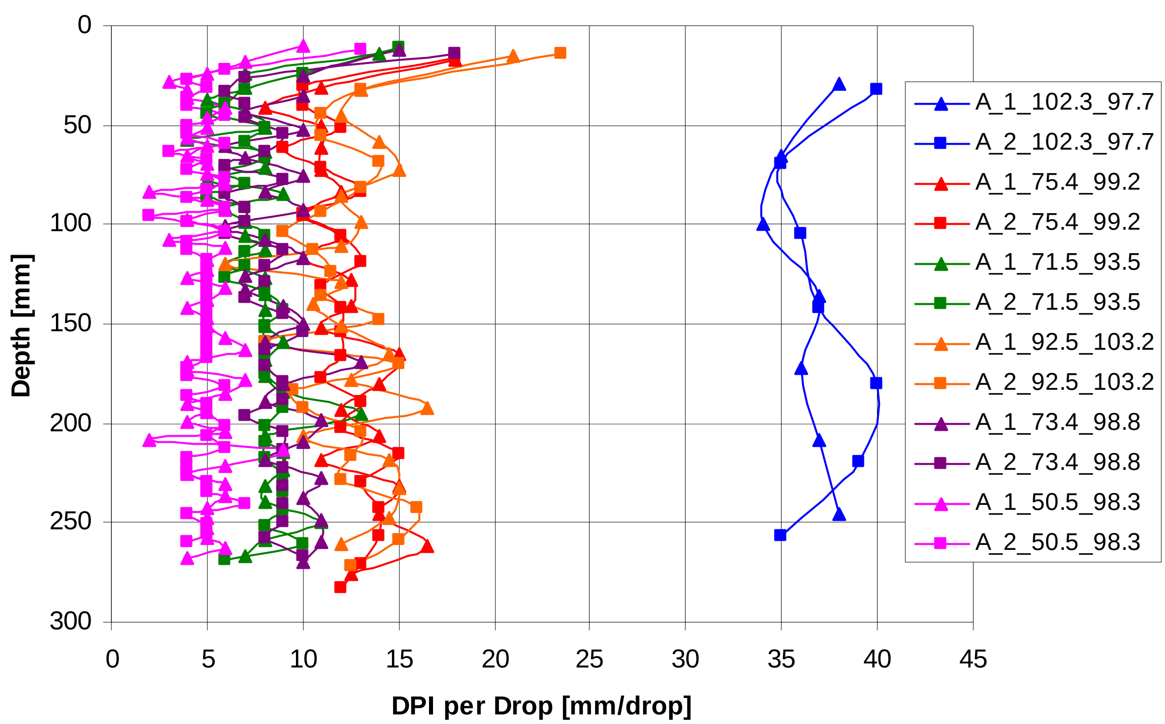


Figure G.33. All MnROAD fine grained samples

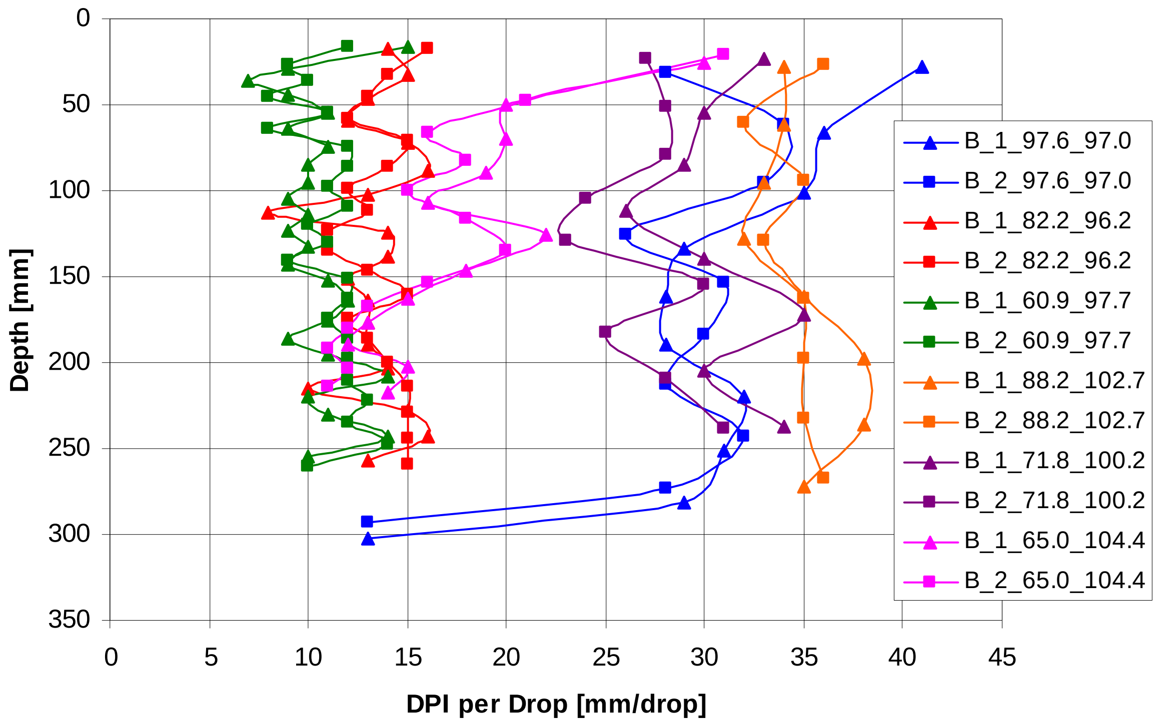


Figure G.34. All Duluth fine grained samples

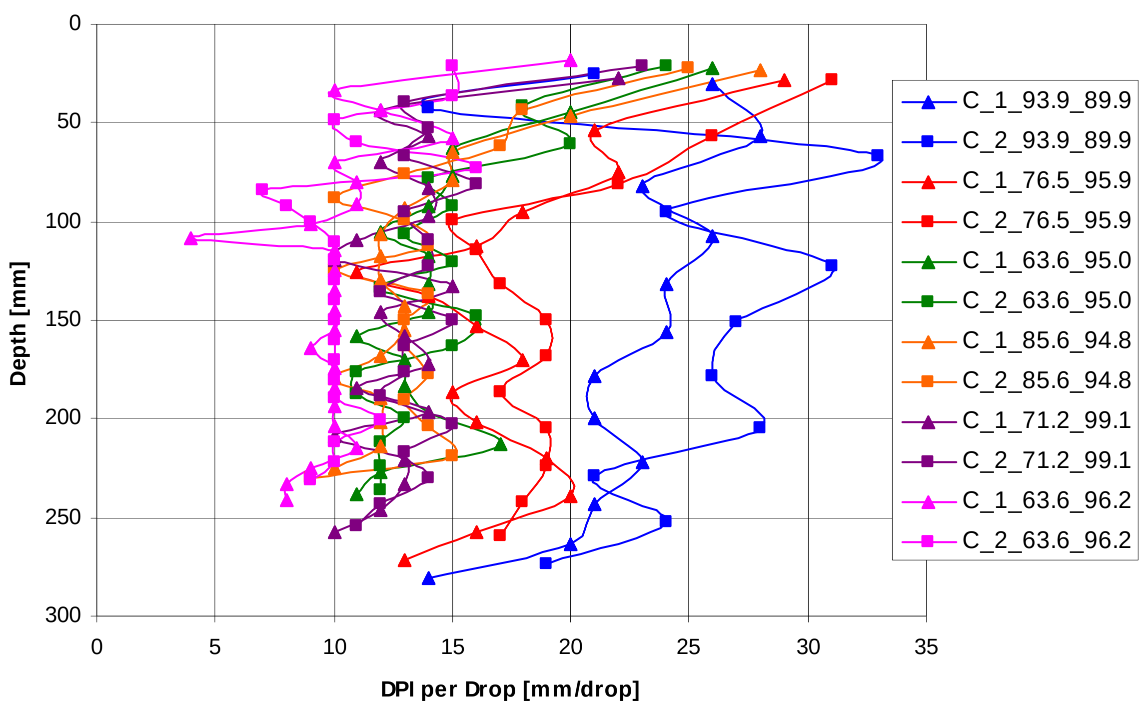


Figure G.35. All Red Wing fine grained samples

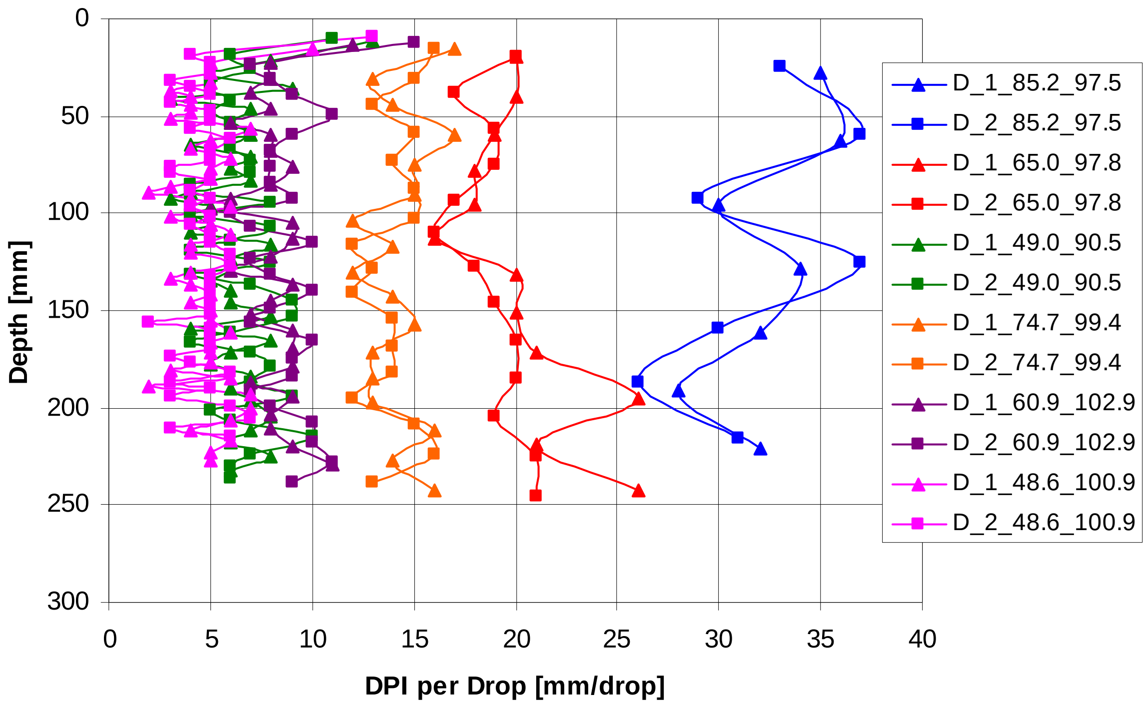


Figure G.36. All Red Lake Falls fine grained samples

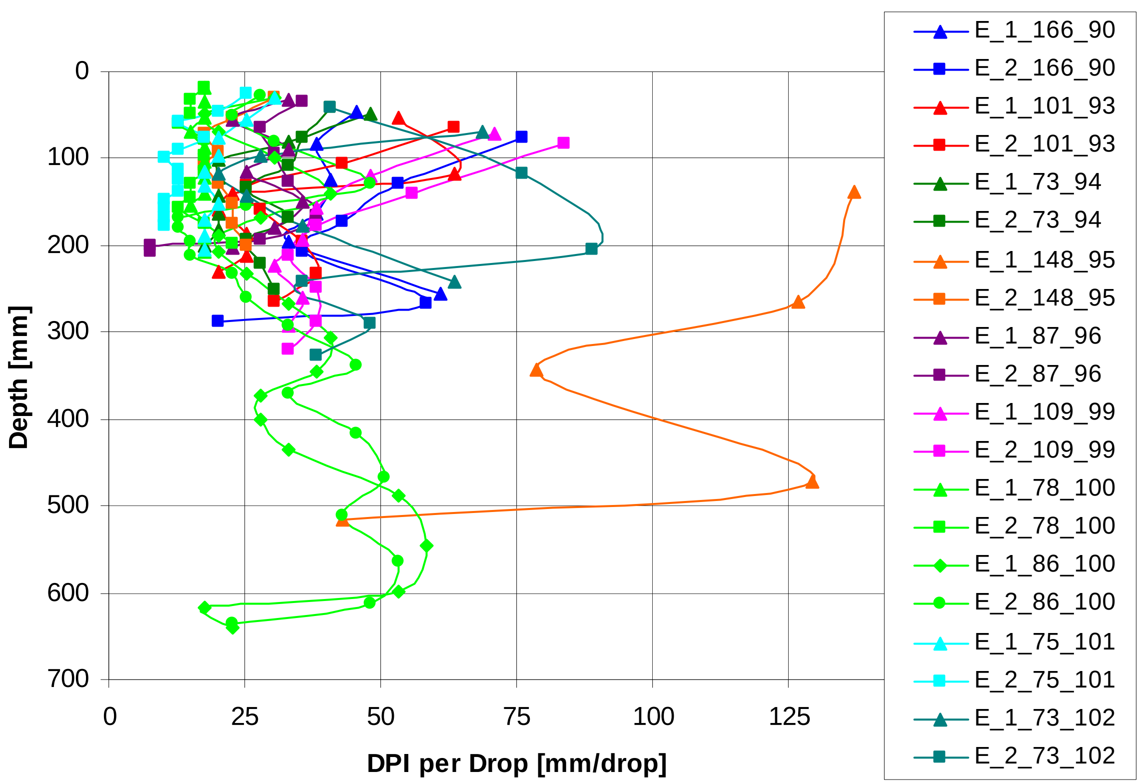


Figure G.37. Steele CSAH 35 fine grained samples low target density

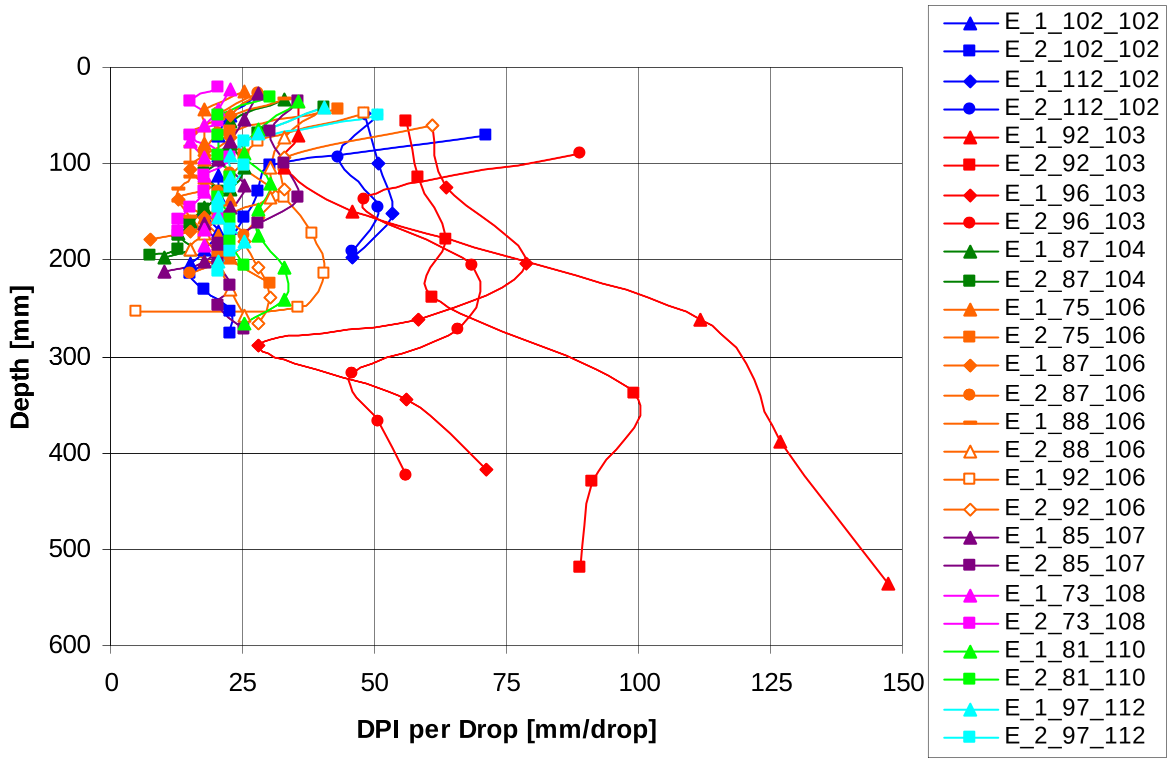


Figure G.38. Steele CSAH 35 fine grained samples high target density

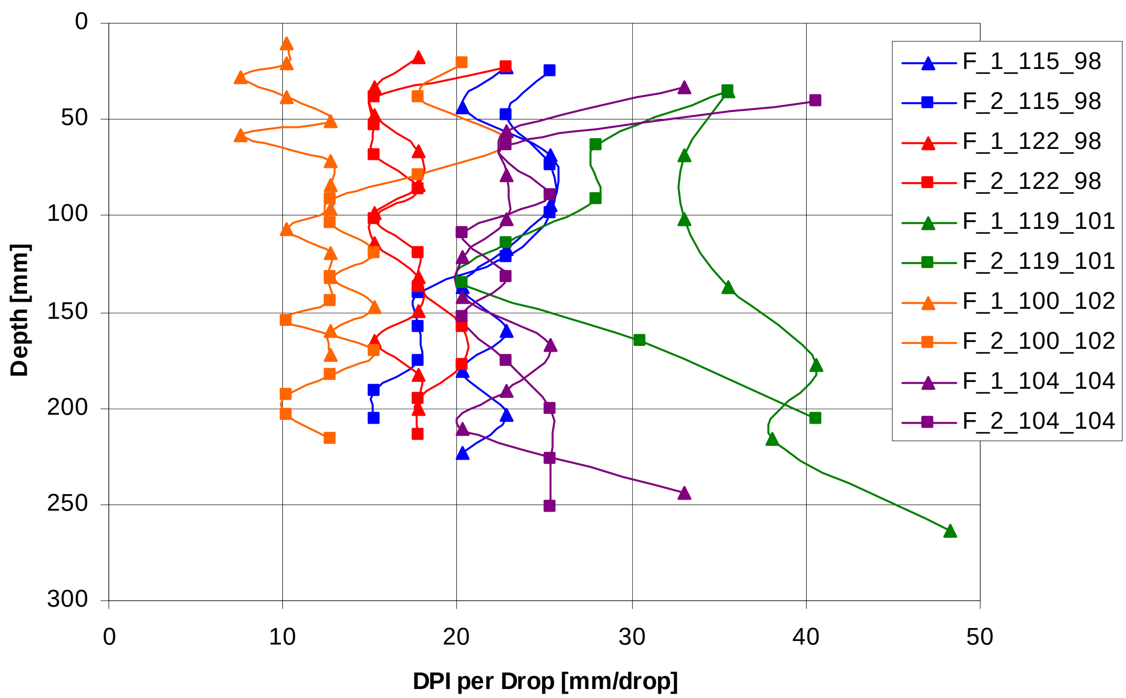


Figure G.39. All Steele T-145 fine grained samples

Appendix H – Select Granular and Granular Material Data

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
DN05	3.82	1.32	5.14	A	Initial					170											
DN05	3.82	1.32	5.14	A	S1					230	60		14.4								
DN05	3.82	1.32	5.14	A	S2					261	31		29.1								
DN05	3.82	1.32	5.14	A	1					282	21	37.3	44.0							4.86	
DN05	3.82	1.32	5.14	A	2					301	19	23.7	49.0							4.79	
DN05	3.82	1.32	5.14	A	3					317	16	18.7	58.8							4.78	
DN05	3.82	1.32	5.14	A	4					332	15	16.7	62.9								
DN05	3.82	1.32	5.14	A	5					347	15	15.3	62.9								
DN05	3.82	1.32	5.14	A	6					360	13	14.3	73.3								
DN05	3.82	1.32	5.14	A	7					372	12	13.3	79.8								
DN05	3.82	1.32	5.14	A	8					383	11	12.0	87.5								
DN05	3.82	1.32	5.14	A	9					393	10	11.0	96.8								
DN05	3.82	1.32	5.14	A	10					404	11	10.7	87.5								
DN05	3.82	1.32	5.14	A	11					415	11	10.7	87.5								
DN05	3.82	1.32	5.14	A	12					425	10	10.7	96.8								
DN05	3.82	1.32	5.14	A	13					435.0	10	10.3	96.8								
DN05	3.82	1.32	5.14	A	Median A						13		73.3								
DN05	3.82	1.32	5.14	A	W Mean A S1-end						26.6		34.3								
DN05	3.82	1.32	5.14	A	W Mean A S2-end						16.8		55.8								
DN05	3.82	1.32	5.14	A	W Mean A 1-end						14.3		66.3								
DN05	3.82	1.32	5.14	A	W Mean A 3-7						17.5		53.3								
DN05	3.82	1.32	5.14	A	Mean A 3-7						17.2		54.4								
DN05	3.82	1.32	5.14	A	Mean A 4-8						15.6		60.4								
DN05	3.82	1.32	5.14	A	Mean A 8-12						11.4		84.2								
DN05	3.82	1.32	5.14	A	Mean A						13.4		75.7							4.81	
DN05	3.82	1.32	5.14	A	CoeVar A						26.9%		24.4%							4.3%	
DN05	3.82	1.32	5.14	B	Initial					164											
DN05	3.82	1.32	5.14	B	S1	3.3	0.105	1610	9.0	229	65		13.3								
DN05	3.82	1.32	5.14	B	S2	3.5	0.111	449	34.4	265	36		24.8								
DN05	3.82	1.32	5.14	B	1	3.5	0.111	409	37.8	289	24	41.7	38.2							5.11	
DN05	3.82	1.32	5.14	B	2	3.5	0.111	387	39.9	307	18	26.0	51.9							5.14	
DN05	3.82	1.32	5.14	B	3	3.5	0.111	375	41.2	325	18	20.0	51.9							5.41	
DN05	3.82	1.32	5.14	B	4	5.7	0.181	600	41.9	341	16	17.3	58.8								
DN05	3.82	1.32	5.14	B	5	5.8	0.185	557	46.0	355	14	16.0	67.7								
DN05	3.82	1.32	5.14	B	6	5.8	0.185	540	47.4	370	15	15.0	62.9								
DN05	3.82	1.32	5.14	B	7	8.2	0.261	718	50.4	381	11	13.3	87.5								
DN05	3.82	1.32	5.14	B	8	8.2	0.261	672	53.9	391	10	12.0	96.8								
DN05	3.82	1.32	5.14	B	9	7.9	0.251	687	50.7	401	10	10.3	96.8								
DN05	3.82	1.32	5.14	B	10					411	10	10.0	96.8								
DN05	3.82	1.32	5.14	B	11					420	9	9.7	108.3								
DN05	3.82	1.32	5.14	B	12					429	9	9.3	108.3								
DN05	3.82	1.32	5.14	B	13					439	10	9.3	96.8								
DN05	3.82	1.32	5.14	B	Mean H1	3.50	0.11	390.33	39.62												
DN05	3.82	1.32	5.14	B	Mean H2	5.77	0.18	565.67	45.09												
DN05	3.82	1.32	5.14	B	Mean H3	8.10	0.26	692.33	51.67												
DN05	3.82	1.32	5.14	B	CoeVar H1	0.0%	0.0%	4.4%	4.4%												
DN05	3.82	1.32	5.14	B	CoeVar H2	1.0%	1.0%	5.5%	6.3%												
DN05	3.82	1.32	5.14	B	CoeVar H3	2.1%	2.1%	3.4%	3.7%												
DN05	3.82	1.32	5.14	B	Median B						14		67.7								
DN05	3.82	1.32	5.14	B	W Mean B S1-end						29.5		30.7								
DN05	3.82	1.32	5.14	B	W Mean B S2-end						18.5		50.5								
DN05	3.82	1.32	5.14	B	W Mean B 1-end						14.9		63.6								
DN05	3.82	1.32	5.14	B	W Mean B 3-7						18.6		50.0								
DN05	3.82	1.32	5.14	B	Mean B 3-7						18.0		51.9								
DN05	3.82	1.32	5.14	B	Mean B 4-8						16.2		58.0								
DN05	3.82	1.32	5.14	B	Mean B 8-12						11.2		85.8								
DN05	3.82	1.32	5.14	B	Mean B						10.9		91.3							5.22	
DN05	3.82	1.32	5.14	B	CoeVar B						42.3%		26.4%							16.4%	
DN05	3.82	1.32	5.14	C	Initial					174											
DN05	3.82	1.32	5.14	C	S1					238	64		13.5								
DN05	3.82	1.32	5.14	C	S2					272	34		26.4								
DN05	3.82	1.32	5.14	C	1					294	22	40.0	41.9							5.51	
DN05	3.82	1.32	5.14	C	2					313	19	25.0	49.0							5.15	
DN05	3.82	1.32	5.14	C	3					331	18	19.7	51.9							5.19	
DN05	3.82	1.32	5.14	C	4					347	16	17.7	58.8								
DN05	3.82	1.32	5.14	C	5					363	16	16.7	58.8								
DN05	3.82	1.32	5.14	C	6					374	11	14.3	87.5								
DN05	3.82	1.32	5.14	C	7					380	*Rock										
DN05	3.82	1.32	5.14	C	Median C						18.5		50.4								
DN05	3.82	1.32	5.14	C	W Mean C S1-end						35.3		25.4								
DN05	3.82	1.32	5.14	C	W Mean C S2-end						21.8		42.4								
DN05	3.82	1.32	5.14	C	W Mean C 1-end						17.7		52.9								
DN05	3.82	1.32	5.14	C	W Mean C 3-7						18.5		50.5								
DN05	3.82	1.32	5.14	C	Mean C 3-7						18.2		51.3								
DN05	3.82	1.32	5.14	C	Mean C 4-8						16.0		58.8								
DN05	3.82	1.32	5.14	C	Mean C						17.0		58.0							5.28	
DN05	3.82	1.32	5.14	C	CoeVar C						21.7%		38.6%							19.5%	
DN05	3.82	1.32	5.14	D	1									1988.6	1958.9		1942.4	100.8%	102.4%	4.66	
DN05	3.82	1.32	5.14	E	1									1988.6		1885.9	1942.4	97.1%	102.4%	5.30	
DN05	3.82	1.32	5.14	D	2									1988.6	2046.0		1942.4	105.3%	102.4%	4.62	
DN05	3.82	1.32	5.14	E	2									1988.6		2066.3	1942.4	106.4%	102.4%	5.13	
DN05	3.82	1.32	5.14	DE	Mean DE									1988.6	2002.4	1976.1	1942.4	102.4%		4.93	5.06
DN05	3.82	1.32	5.14	DE	CoeVar DE										3.1%	6.5%		4.2%		33.9%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
DN5	3.82	1.32	5.14	A	Initial					90											
DN5	3.82	1.32	5.14	A	S1					169	79		10.8								
DN5	3.82	1.32	5.14	A	S2					204	35		25.6								
DN5	3.82	1.32	5.14	A	1					231	27	47.0	33.7							5.37	
DN5	3.82	1.32	5.14	A	2					255	24	28.7	38.2							5.17	
DN5	3.82	1.32	5.14	A	3					278	23	24.7	40.0							4.42	
DN5	3.82	1.32	5.14	A	4					302	24	23.7	38.2								
DN5	3.82	1.32	5.14	A	5					324	22	23.0	41.9								
DN5	3.82	1.32	5.14	A	6					351	27	24.3	33.7								
DN5	3.82	1.32	5.14	A	7																
DN5	3.82	1.32	5.14	A	8																
DN5	3.82	1.32	5.14	A	Median A						25.5		35.8								
DN5	3.82	1.32	5.14	A	W Mean A S1-end						42.5		20.8								
DN5	3.82	1.32	5.14	A	W Mean A S2-end						26.6		34.2								
DN5	3.82	1.32	5.14	A	W Mean A 1-end						24.6		37.2								
DN5	3.82	1.32	5.14	A	W Mean A 3-7						24.1		38.0								
DN5	3.82	1.32	5.14	A	Mean A 3-7						24.0		38.2								
DN5	3.82	1.32	5.14	A	Mean A 4-8						24.0		38.2								
DN5	3.82	1.32	5.14	A	Mean A						24.5		37.6							4.99	
DN5	3.82	1.32	5.14	A	CoeVar A						8.5%		8.8%							0.10	
DN5	3.82	1.32	5.14	B	Initial					68											
DN5	3.82	1.32	5.14	B	S1	overload	na	na	na	155	87		9.7								
DN5	3.82	1.32	5.14	B	S2	3.3	0.105	1261	11.5	191	36		24.8								
DN5	3.82	1.32	5.14	B	1	3.2	0.102	1184	11.9	219	28	50.3	32.4							5.25	
DN5	3.82	1.32	5.14	B	2	3.3	0.105	1147	12.7	248	29	31.0	31.3							4.98	
DN5	3.82	1.32	5.14	B	3	3.3	0.105	1111	13.1	278	30	29.0	30.2							5.06	
DN5	3.82	1.32	5.14	B	4	5.3	0.169	1539	15.2	307	29	29.3	31.3								
DN5	3.82	1.32	5.14	B	5	5.5	0.175	1462	16.6	330	23	27.3	40.0								
DN5	3.82	1.32	5.14	B	6	5.4	0.172	1402	17.0												
DN5	3.82	1.32	5.14	B	7	7.6	0.242	1676	20.0												
DN5	3.82	1.32	5.14	B	8	7.6	0.242	1626	20.6												
DN5	3.82	1.32	5.14	B	9	7.6	0.242	1568	21.4												
DN5	3.82	1.32	5.14	B	Mean H1	3.27	0.104	1147.33	12.58												
DN5	3.82	1.32	5.14	B	Mean H2	5.40	0.17	1467.67	16.27												
DN5	3.82	1.32	5.14	B	Mean H3	7.60	0.24	1623.33	20.68												
DN5	3.82	1.32	5.14	B	CoeVar H1	1.8%	1.8%	3.2%	4.8%												
DN5	3.82	1.32	5.14	B	CoeVar H2	22.5%	22.5%	15.5%	10.8%												
DN5	3.82	1.32	5.14	B	CoeVar H3	16.3%	16.3%	8.9%	9.0%												
DN5	3.82	1.32	5.14	B	Median B						29		31.3								
DN5	3.82	1.32	5.14	B	W Mean B S1-end						48.7		18.0								
DN5	3.82	1.32	5.14	B	W Mean B S2-end						29.7		30.5								
DN5	3.82	1.32	5.14	B	W Mean B 1-end						28.0		32.4								
DN5	3.82	1.32	5.14	B	W Mean B 3-7						28.0		32.4								
DN5	3.82	1.32	5.14	B	Mean B 3-7						27.8		32.7								
DN5	3.82	1.32	5.14	B	Mean B 4-8						27.8		32.8								
DN5	3.82	1.32	5.14	B	Mean B						27.8		33.0							5.10	
DN5	3.82	1.32	5.14	B	CoeVar B						10.0%		12.0%							2.7%	
DN5	3.82	1.32	5.14	C	Initial					79											
DN5	3.82	1.32	5.14	C	S1					166	87		9.7								
DN5	3.82	1.32	5.14	C	S2					203	37		24.1								
DN5	3.82	1.32	5.14	C	1					229	26	50.0	35.1							5.05	
DN5	3.82	1.32	5.14	C	2					250	21	28.0	44.0							5.00	
DN5	3.82	1.32	5.14	C	3					273	23	23.3	40.0							5.46	
DN5	3.82	1.32	5.14	C	4					295	22	22.0	41.9								
DN5	3.82	1.32	5.14	C	5					311	16	20.3	58.8								
DN5	3.82	1.32	5.14	C	Median C						23		40.0								
DN5	3.82	1.32	5.14	C	W Mean C S1-end						48.8		18.0								
DN5	3.82	1.32	5.14	C	W Mean C S2-end						25.9		35.3								
DN5	3.82	1.32	5.14	C	W Mean C 1-end						22.1		41.7								
DN5	3.82	1.32	5.14	C	W Mean C 3-7						22.1		41.7								
DN5	3.82	1.32	5.14	C	Mean C 3-7						21.6		42.7								
DN5	3.82	1.32	5.14	C	Mean C 4-8						20.5		45.2								
DN5	3.82	1.32	5.14	C	Mean C						21.6		44.0							5.17	
DN5	3.82	1.32	5.14	C	CoeVar C						16.9%		20.3%							4.9%	
DN5	3.82	1.32	5.14	D	1										1978.5		1942.4	101.9%	0.0%	5.19	
DN5	3.82	1.32	5.14	E	1										1913.7		1942.4	98.5%	0.0%	5.13	
DN5	3.82	1.32	5.14	DE	Mean DE									-	1946.1	-	1942.4	100.2%		5.16	5.10
DN5	3.82	1.32	5.14	DE	CoeVar DE										2.4%			2.4%		0.9%	

ample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
DN07	3.82	1.32	5.14	A	Initial					63											
DN07	3.82	1.32	5.14	A	S1					129	66		13.1								
DN07	3.82	1.32	5.14	A	S2					162	33		27.3								
DN07	3.82	1.32	5.14	A	1					187	25	41.3	36.6							6.33	
DN07	3.82	1.32	5.14	A	2					207	20	26.0	46.4							6.71	
DN07	3.82	1.32	5.14	A	3					225	18	21.0	51.9							6.37	
DN07	3.82	1.32	5.14	A	4					243	18	18.7	51.9								
DN07	3.82	1.32	5.14	A	5					260	17	17.7	55.1								
DN07	3.82	1.32	5.14	A	6					275	15	16.7	62.9								
DN07	3.82	1.32	5.14	A	7					290	15	15.7	62.9								
DN07	3.82	1.32	5.14	A	8					305	15	15.0	62.9								
DN07	3.82	1.32	5.14	A	9					318	13	14.3	73.3								
DN07	3.82	1.32	5.14	A	10					327	HIT										
DN07	3.82	1.32	5.14	A	11																
DN07	3.82	1.32	5.14	A	12																
DN07	3.82	1.32	5.14	A	13																
DN07	3.82	1.32	5.14	A	Median A						18		51.9								
DN07	3.82	1.32	5.14	A	W Mean A S1-end						32.4		27.8								
DN07	3.82	1.32	5.14	A	W Mean A S2-end						20.6		44.9								
DN07	3.82	1.32	5.14	A	W Mean A 1-end						18.0		51.9								
DN07	3.82	1.32	5.14	A	W Mean A 3-7						20.0		46.3								
DN07	3.82	1.32	5.14	A	Mean A 3-7						19.6		47.4								
DN07	3.82	1.32	5.14	A	Mean A 4-8						17.6		53.1								
DN07	3.82	1.32	5.14	A	Mean A						17.3		56.0							6.47	
DN07	3.82	1.32	5.14	A	CoeVar A						20.6%		19.4%							20.6%	
DN07	3.82	1.32	5.14	B	Initial					58											
DN07	3.82	1.32	5.14	B	S1	3.2	0.102	963	14.7	128	70		12.3								
DN07	3.82	1.32	5.14	B	S2	3.5	0.111	453	34.1	164	36		24.8								
DN07	3.82	1.32	5.14	B	1	3.6	0.115	426	37.3	189	25	43.7	36.6							6.59	
DN07	3.82	1.32	5.14	B	2	3.4	0.108	397	37.8	209	20	27.0	46.4							6.25	
DN07	3.82	1.32	5.14	B	3	3.6	0.115	395	40.2	228	19	21.3	49.0							6.45	
DN07	3.82	1.32	5.14	B	4	3.6	0.115	386	41.2	245	17	18.7	55.1								
DN07	3.82	1.32	5.14	B	5	5.9	0.188	606	43.0	260	15	17.0	62.9								
DN07	3.82	1.32	5.14	B	6	5.9	0.188	594	43.8	273	13	15.0	73.3								
DN07	3.82	1.32	5.14	B	7	5.9	0.188	579	45.0	285	12	13.3	79.8								
DN07	3.82	1.32	5.14	B	8	8.5	0.271	768	48.8	296	11	12.0	87.5								
DN07	3.82	1.32	5.14	B	9	8.5	0.271	748	50.2	308	12	11.7	79.8								
DN07	3.82	1.32	5.14	B	10	8.5	0.271	733	51.2	318	10	11.0	96.8								
DN07	3.82	1.32	5.14	B	11	3.4	0.108	389	38.6	324	HIT										
DN07	3.82	1.32	5.14	B	12	3.5	0.111	383	40.3												
DN07	3.82	1.32	5.14	B	13	3.5	0.111	383	40.3												
DN07	3.82	1.32	5.14	B	14	3.4	0.108	166	90.4												
DN07	3.82	1.32	5.14	B	15	3	0.095	164	80.7												
DN07	3.82	1.32	5.14	B	Mean H1	3.53	0.11	406.00	38.44												
DN07	3.82	1.32	5.14	B	Mean H2	5.13	0.16	528.67	42.65												
DN07	3.82	1.32	5.14	B	Mean H3	7.63	0.24	698.33	47.99												
DN07	3.82	1.32	5.14	B	CoeVar H1	3.3%	3.3%	4.3%	4.1%												
DN07	3.82	1.32	5.14	B	CoeVar H2	25.9%	25.9%	23.4%	3.2%												
DN07	3.82	1.32	5.14	B	CoeVar H3	19.7%	19.7%	14.9%	5.6%												
DN07	3.82	1.32	5.14	B	Median B						16		58.8								
DN07	3.82	1.32	5.14	B	W Mean B S1-end						33.7		26.6								
DN07	3.82	1.32	5.14	B	W Mean B S2-end						20.4		45.4								
DN07	3.82	1.32	5.14	B	W Mean B 1-end						16.7		56.0								
DN07	3.82	1.32	5.14	B	W Mean B 3-7						19.8		46.9								
DN07	3.82	1.32	5.14	B	Mean B 3-7						19.2		48.4								
DN07	3.82	1.32	5.14	B	Mean B 4-8						16.8		55.8								
DN07	3.82	1.32	5.14	B	Mean B 8-12						11.6		82.7								
DN07	3.82	1.32	5.14	B	Mean B						15.4		86.0							6.43	
DN07	3.82	1.32	5.14	B	CoeVar B						31.1%		23.0%							17.1%	
DN07	3.82	1.32	5.14	C	Initial					59											
DN07	3.82	1.32	5.14	C	S1					131	72		11.9								
DN07	3.82	1.32	5.14	C	S2					165	34		26.4								
DN07	3.82	1.32	5.14	C	1					188	23	43.0	40.0							6.42	
DN07	3.82	1.32	5.14	C	2					207	19	25.3	49.0							6.33	
DN07	3.82	1.32	5.14	C	3					225	18	20.0	51.9							6.29	
DN07	3.82	1.32	5.14	C	4					239	14	17.0	67.7								
DN07	3.82	1.32	5.14	C	5					253	14	15.3	67.7								
DN07	3.82	1.32	5.14	C	6					266	13	13.7	73.3								
DN07	3.82	1.32	5.14	C	7					273	7	11.3	141.4								
DN07	3.82	1.32	5.14	C	8					280	7	9.0	141.4								
DN07	3.82	1.32	5.14	C	9					288	8	7.3	122.7								
DN07	3.82	1.32	5.14	C	10					295	*Rock										
DN07	3.82	1.32	5.14	C	Median C						14		67.7								
DN07	3.82	1.32	5.14	C	W Mean C S1-end						36.1		24.7								
DN07	3.82	1.32	5.14	C	W Mean C S2-end						19.7		47.1								
DN07	3.82	1.32	5.14	C	W Mean C 1-end						15.7		59.8								
DN07	3.82	1.32	5.14	C	W Mean C 3-7						18.3		51.1								
DN07	3.82	1.32	5.14	C	Mean C 3-7						17.6		53.1								
DN07	3.82	1.32	5.14	C	Mean C 4-8						15.6		60.4								
DN07	3.82	1.32	5.14	C	Mean C						16.8		58.3							6.35	
DN07	3.82	1.32	5.14	C	CoeVar C						23.0%		74.8%							6.5%	
DN07	3.82	1.32	5.14	D	1									2042.8	2013.4		1942.4	103.7%	105.2%	6.50	
DN07	3.82	1.32	5.14	E	1									2042.8		2056.2	1942.4	105.9%	105.2%	6.18	
DN07	3.82	1.32	5.14	D	2									2042.8	1929.1		1942.4	99.3%	105.2%	6.61	
DN07	3.82	1.32	5.14	E	2									2042.8		1978.7	1942.4	101.9%	105.2%	6.50	
DN07	3.82	1.32	5.14	DE	Mean DE									2042.8	1971.2	2017.4	1942.4	102.7%		6.45	6.42
DN07	3.82	1.32	5.14	DE	CoeVar DE										3.0%	2.7%		2.7%		18.3%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
DN7	3.82	1.32	5.14	A	Initial					82											
DN7	3.82	1.32	5.14	A	S1					161	79		10.8								
DN7	3.82	1.32	5.14	A	S2					196	35		25.6								
DN7	3.82	1.32	5.14	A	1					224	28	47.3	32.4							6.87	
DN7	3.82	1.32	5.14	A	2					256	32	31.7	28.2							7.15	
DN7	3.82	1.32	5.14	A	3					274	18	26.0	51.9							7.18	
DN7	3.82	1.32	5.14	A	4					298	24	24.7	38.2								
DN7	3.82	1.32	5.14	A	Median A						30		30.2								
DN7	3.82	1.32	5.14	A	W Mean A S1-end						47.1		18.7								
DN7	3.82	1.32	5.14	A	W Mean A S2-end						28.7		31.6								
DN7	3.82	1.32	5.14	A	W Mean A 1-end						26.5		34.3								
DN7	3.82	1.32	5.14	A	W Mean A 3-7						26.5		34.3								
DN7	3.82	1.32	5.14	A	Mean A 3-7						25.5		35.8								
DN7	3.82	1.32	5.14	A	Mean A 4-8						24.7		37.1								
DN7	3.82	1.32	5.14	A	Mean A						25.5		37.7							7.07	
DN7	3.82	1.32	5.14	A	CoeVar A						23.4%		27.4%							0.02	
DN7	3.82	1.32	5.14	B	Initial					68											
DN7	3.82	1.32	5.14	B	S1	overload	na	na	na	144	76		11.2								
DN7	3.82	1.32	5.14	B	S2	3.3	0.105	1211	12.0	179	35		25.6								
DN7	3.82	1.32	5.14	B	1	3.3	0.105	936	15.6	208	29	46.7	31.3							7.41	
DN7	3.82	1.32	5.14	B	2	3.3	0.105	831	17.5	234	26	30.0	35.1							7.16	
DN7	3.82	1.32	5.14	B	3	3.3	0.105	774	18.8	262	28	27.7	32.4							7.34	
DN7	3.82	1.32	5.14	B	4	5.5	0.175	1112	21.8	290	28	27.3	32.4								
DN7	3.82	1.32	5.14	B	5	5.5	0.175	1011	24.0	319	29	28.3	31.3								
DN7	3.82	1.32	5.14	B	6	5.5	0.175	954	25.4												
DN7	3.82	1.32	5.14	B	7	7.9	0.251	1175	29.7												
DN7	3.82	1.32	5.14	B	8	8.1	0.258	1117	32.0												
DN7	3.82	1.32	5.14	B	9	8.1	0.258	1071	33.4												
DN7	3.82	1.32	5.14	B	Mean H1	3.30	0.105	847.00	17.30												
DN7	3.82	1.32	5.14	B	Mean H2	5.50	0.175	1025.67	23.76												
DN7	3.82	1.32	5.14	B	Mean H3	8.03	0.256	1121.00	31.68												
DN7	3.82	1.32	5.14	B	CoeVar H1	0.0%	0.0%	9.7%	9.5%												
DN7	3.82	1.32	5.14	B	CoeVar H2	0.0%	0.0%	7.8%	7.7%												
DN7	3.82	1.32	5.14	B	CoeVar H3	1.4%	1.4%	4.6%	5.9%												
DN7	3.82	1.32	5.14	B	Median B						29		31.3								
DN7	3.82	1.32	5.14	B	W Mean B S1-end						43.5		20.3								
DN7	3.82	1.32	5.14	B	W Mean B S2-end						29.4		30.8								
DN7	3.82	1.32	5.14	B	W Mean B 1-end						28.0		32.4								
DN7	3.82	1.32	5.14	B	W Mean B 3-7						28.0		32.4								
DN7	3.82	1.32	5.14	B	Mean B 3-7						28.0		32.4								
DN7	3.82	1.32	5.14	B	Mean B 4-8						27.8		32.8								
DN7	3.82	1.32	5.14	B	Mean B						28.0		32.5							7.30	
DN7	3.82	1.32	5.14	B	CoeVar B						4.4%		4.8%							1.7%	
DN7	3.82	1.32	5.14	C	Initial					77											
DN7	3.82	1.32	5.14	C	S1					157	80		10.6								
DN7	3.82	1.32	5.14	C	S2					193	36		24.8								
DN7	3.82	1.32	5.14	C	1					220	27	47.7	33.7							7.46	
DN7	3.82	1.32	5.14	C	2					246	26	29.7	35.1							7.12	
DN7	3.82	1.32	5.14	C	3					269	23	25.3	40.0							7.40	
DN7	3.82	1.32	5.14	C	4					291	22	23.7	41.9								
DN7	3.82	1.32	5.14	C	5					316	25	23.3	36.6								
DN7	3.82	1.32	5.14	C	Median C						26		35.1								
DN7	3.82	1.32	5.14	C	W Mean C S1-end						44.9		19.6								
DN7	3.82	1.32	5.14	C	W Mean C S2-end						27.3		33.3								
DN7	3.82	1.32	5.14	C	W Mean C 1-end						24.7		37.0								
DN7	3.82	1.32	5.14	C	W Mean C 3-7						24.7		37.0								
DN7	3.82	1.32	5.14	C	Mean C 3-7						24.6		37.2								
DN7	3.82	1.32	5.14	C	Mean C 4-8						24.0		38.2								
DN7	3.82	1.32	5.14	C	Mean C						24.6		37.5							7.33	
DN7	3.82	1.32	5.14	C	CoeVar C						8.4%		9.1%							2.5%	
DN7	3.82	1.32	5.14	D	1									1950.7	1814.1		1942.4	93.4%	100.4%	6.95	
DN7	3.82	1.32	5.14	E	1									1950.7	1953.4		1942.4	100.6%	100.4%	7.19	
DN7	3.82	1.32	5.14	DE	Mean DE									1950.7	1883.8	-	1942.4	97.0%		7.07	7.19
DN7	3.82	1.32	5.14	DE	CoeVar DE										5.2%			5.2%		2.4%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
DN10	3.82	1.32	5.14	A	Initial					80											
DN10	3.82	1.32	5.14	A	S1					208	128		6.5								
DN10	3.82	1.32	5.14	A	S2					298	90		9.4								
DN10	3.82	1.32	5.14	A	1					330	HIT									10.07	
DN10	3.82	1.32	5.14	A	2															9.95	
DN10	3.82	1.32	5.14	A	3															10.27	
DN10	3.82	1.32	5.14	A	4																
DN10	3.82	1.32	5.14	A	Median A																
DN10	3.82	1.32	5.14	A	Mean A															10.10	
DN10	3.82	1.32	5.14	A	CoeVar A															0.02	
DN10	3.82	1.32	5.14	B	Initial					88											
DN10	3.82	1.32	5.14	B	S1	overload	na	na	na	201	113		7.4								
DN10	3.82	1.32	5.14	B	S2	overload	na	na	na	279	78		10.9								
DN10	3.82	1.32	5.14	B	1	2.7	0.086	2114	5.6	316	HIT									10.08	
DN10	3.82	1.32	5.14	B	2	3.2	0.102	2087	6.8											10.13	
DN10	3.82	1.32	5.14	B	3	2.1	0.067	1913	4.8											9.70	
DN10	3.82	1.32	5.14	B	4	5.3	0.169	1972	11.9												
DN10	3.82	1.32	5.14	B	5	5.2	0.166	1993	11.5												
DN10	3.82	1.32	5.14	B	6	5.2	0.166	1901	12.1												
DN10	3.82	1.32	5.14	B	7	7.3	0.232	2008	16.0												
DN10	3.82	1.32	5.14	B	8	7.5	0.239	1841	18.0												
DN10	3.82	1.32	5.14	B	9	7.4	0.236	1813	18.0												
DN10	3.82	1.32	5.14	B	Mean H1	2.67	0.085	2038.00	5.75												
DN10	3.82	1.32	5.14	B	Mean H2	5.23	0.167	1955.33	11.82												
DN10	3.82	1.32	5.14	B	Mean H3	7.40	0.236	1887.33	17.35												
DN10	3.82	1.32	5.14	B	CoeVar H1	20.7%	20.7%	5.4%	16.8%												
DN10	3.82	1.32	5.14	B	CoeVar H2	1.1%	1.1%	2.5%	2.4%												
DN10	3.82	1.32	5.14	B	CoeVar H3	1.4%	1.4%	5.6%	6.5%												
DN10	3.82	1.32	5.14	B	Median B																
DN10	3.82	1.32	5.14	B	Mean B															9.97	
DN10	3.82	1.32	5.14	B	CoeVar B															2.4%	
DN10	3.82	1.32	5.14	C	Initial					97											
DN10	3.82	1.32	5.14	C	S1					208	111		7.5								
DN10	3.82	1.32	5.14	C	S2					290	82		10.4								
DN10	3.82	1.32	5.14	C	1					333	HIT									10.25	
DN10	3.82	1.32	5.14	C	2															9.23	
DN10	3.82	1.32	5.14	C	3															9.64	
DN10	3.82	1.32	5.14	C	4																
DN10	3.82	1.32	5.14	C	Median C																
DN10	3.82	1.32	5.14	C	Mean C															9.71	
DN10	3.82	1.32	5.14	C	CoeVar C															5.3%	
DN10	3.82	1.32	5.14	D	1									1999.1	2068.2		1942.4	106.5%	102.9%	10.12	
DN10	3.82	1.32	5.14	E	1									1999.1	1958.9		1942.4	100.8%	102.9%	10.27	
DN10	3.82	1.32	5.14	DE	Mean DE									1999.1	2013.5	-	1942.4	103.7%		10.20	9.99
DN10	3.82	1.32	5.14	DE	CoeVar DE										3.8%			3.8%		1.1%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
DN10X2	3.82	1.32	5.14	A	Initial					108											
DN10X2	3.82	1.32	5.14	A	S1					211	103		8.1								
DN10X2	3.82	1.32	5.14	A	S2					292	81		10.5								
DN10X2	3.82	1.32	5.14	A	1					320	HIT									10.40	
DN10X2	3.82	1.32	5.14	A	2															10.51	
DN10X2	3.82	1.32	5.14	A	3															9.98	
DN10X2	3.82	1.32	5.14	A	4																
DN10X2	3.82	1.32	5.14	A	Median A																
DN10X2	3.82	1.32	5.14	A	Mean A															10.30	
DN10X2	3.82	1.32	5.14	A	CoeVar A															0.03	
DN10X2	3.82	1.32	5.14	B	Initial					86											
DN10X2	3.82	1.32	5.14	B	S1	overload	na	na	na	201	115		7.2								
DN10X2	3.82	1.32	5.14	B	S2	overload	na	na	na	270	69		12.5								
DN10X2	3.82	1.32	5.14	B	1	3.3	0.105	1944	7.5	299	HIT									10.56	
DN10X2	3.82	1.32	5.14	B	2	3.4	0.108	1596	9.4											9.95	
DN10X2	3.82	1.32	5.14	B	3	3.4	0.108	1495	10.0											10.16	
DN10X2	3.82	1.32	5.14	B	4	5.3	0.169	1831	12.8												
DN10X2	3.82	1.32	5.14	B	5	5.1	0.162	1770	12.7												
DN10X2	3.82	1.32	5.14	B	6	5.2	0.166	1457	15.8												
DN10X2	3.82	1.32	5.14	B	7	7.7	0.245	1580	21.5												
DN10X2	3.82	1.32	5.14	B	8	7.8	0.248	1453	23.7												
DN10X2	3.82	1.32	5.14	B	9	7.6	0.242	1484	22.6												
DN10X2	3.82	1.32	5.14	B	Mean H1	3.37	0.107	1678.33	8.98												
DN10X2	3.82	1.32	5.14	B	Mean H2	5.20	0.166	1686.00	13.75												
DN10X2	3.82	1.32	5.14	B	Mean H3	7.70	0.245	1505.67	22.60												
DN10X2	3.82	1.32	5.14	B	CoeVar H1	1.7%	1.7%	14.0%	14.8%												
DN10X2	3.82	1.32	5.14	B	CoeVar H2	1.9%	1.9%	11.9%	12.6%												
DN10X2	3.82	1.32	5.14	B	CoeVar H3	1.3%	1.3%	4.4%	4.8%												
DN10X2	3.82	1.32	5.14	B	Median B																
DN10X2	3.82	1.32	5.14	B	Mean B															10.22	
DN10X2	3.82	1.32	5.14	B	CoeVar B															3.0%	
DN10X2	3.82	1.32	5.14	C	Initial					83											
DN10X2	3.82	1.32	5.14	C	S1					188	105		8.0								
DN10X2	3.82	1.32	5.14	C	S2					266	78		10.9								
DN10X2	3.82	1.32	5.14	C	1					315	HIT									9.41	
DN10X2	3.82	1.32	5.14	C	2															9.32	
DN10X2	3.82	1.32	5.14	C	3															9.24	
DN10X2	3.82	1.32	5.14	C	4																
DN10X2	3.82	1.32	5.14	C	Median C																
DN10X2	3.82	1.32	5.14	C	Mean C															9.32	
DN10X2	3.82	1.32	5.14	C	CoeVar C															0.9%	
DN10X2	3.82	1.32	5.14	D	1									1976.2	2006.6		1942.4	103.3%	101.7%	9.74	
DN10X2	3.82	1.32	5.14	E	1									1976.2	2029.1		1942.4	104.5%	101.7%	10.19	
DN10X2	3.82	1.32	5.14	DE	Mean DE									1976.2	2017.9	-	1942.4	103.9%		9.96	9.95
DN10X2	3.82	1.32	5.14	DE	CoeVar DE										0.8%			0.8%		3.2%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
DN10S	3.82	1.32	5.14	A	Initial					106	na		na								
DN10S	3.82	1.32	5.14	A	S1					212	106		7.9								
DN10S	3.82	1.32	5.14	A	S2					282	70		12.3								
DN10S	3.82	1.32	5.14	A	1					328	46		19.2							10.46	
DN10S	3.82	1.32	5.14	A	2															9.64	
DN10S	3.82	1.32	5.14	A	3															9.78	
DN10S	3.82	1.32	5.14	A	4																
DN10S	3.82	1.32	5.14	A	Median A						70		12.3								
DN10S	3.82	1.32	5.14	A	W Mean A S1-end						82.2		10.3								
DN10S	3.82	1.32	5.14	A	W Mean A S2-end						60.5		14.3								
DN10S	3.82	1.32	5.14	A	W Mean A 1-end						46.0		19.2								
DN10S	3.82	1.32	5.14	A	W Mean A 3-7						46.0		19.2								
DN10S	3.82	1.32	5.14	A	Mean A 3-7						46.0		19.2								
DN10S	3.82	1.32	5.14	A	Mean A 4-8						0.0		-								
DN10S	3.82	1.32	5.14	A	Mean A						46.0		19.2							9.96	
DN10S	3.82	1.32	5.14	A	CoeVar A						-		-							0.04	
DN10S	3.82	1.32	5.14	B	Initial					82											
DN10S	3.82	1.32	5.14	B	S1	overload	na	na	na	183	101		8.3								
DN10S	3.82	1.32	5.14	B	S2	overload	na	na	na	253	70		12.3								
DN10S	3.82	1.32	5.14	B	1	3.2	0.102	2097	6.7	300	47		18.7							9.82	
DN10S	3.82	1.32	5.14	B	2	3.4	0.108	1669	9.0	314	HIT									9.74	
DN10S	3.82	1.32	5.14	B	3	3.5	0.111	1436	10.8											9.56	
DN10S	3.82	1.32	5.14	B	4	5.6	0.178	1723	14.3												
DN10S	3.82	1.32	5.14	B	5	5.7	0.181	1527	16.5												
DN10S	3.82	1.32	5.14	B	6	5.7	0.181	1318	19.1												
DN10S	3.82	1.32	5.14	B	7	8	0.255	1428	24.7												
DN10S	3.82	1.32	5.14	B	8	8	0.255	1412	25.0												
DN10S	3.82	1.32	5.14	B	9	8.1	0.258	1318	27.1												
DN10S	3.82	1.32	5.14	B	Mean H1	3.37	0.107	1734.00	8.83												
DN10S	3.82	1.32	5.14	B	Mean H2	5.67	0.180	1522.67	16.63												
DN10S	3.82	1.32	5.14	B	Mean H3	8.03	0.256	1386.00	25.62												
DN10S	3.82	1.32	5.14	B	CoeVar H1	4.5%	4.5%	19.3%	22.8%												
DN10S	3.82	1.32	5.14	B	CoeVar H2	1.0%	1.0%	13.3%	14.3%												
DN10S	3.82	1.32	5.14	B	CoeVar H3	0.7%	0.7%	4.3%	5.1%												
DN10S	3.82	1.32	5.14	B	Median B						70		12.3								
DN10S	3.82	1.32	5.14	B	W Mean B S1-end						79.4		10.7								
DN10S	3.82	1.32	5.14	B	W Mean B S2-end						60.8		14.3								
DN10S	3.82	1.32	5.14	B	W Mean B 1-end						47.0		18.7								
DN10S	3.82	1.32	5.14	B	W Mean B 3-7						47.0		18.7								
DN10S	3.82	1.32	5.14	B	Mean B 3-7						47.0		19.2								
DN10S	3.82	1.32	5.14	B	Mean B 4-8						0.0		-								
DN10S	3.82	1.32	5.14	B	Mean B						47.0		18.7							9.71	
DN10S	3.82	1.32	5.14	B	CoeVar B						-		-							1.3%	
DN10S	3.82	1.32	5.14	C	Initial					64											
DN10S	3.82	1.32	5.14	C	S1					168	104		8.1								
DN10S	3.82	1.32	5.14	C	S2					242	74		11.6								
DN10S	3.82	1.32	5.14	C	1					285	43		20.6							9.54	
DN10S	3.82	1.32	5.14	C	2					316	HIT									9.25	
DN10S	3.82	1.32	5.14	C	3															9.67	
DN10S	3.82	1.32	5.14	C	4																
DN10S	3.82	1.32	5.14	C	Median C						74		11.6								
DN10S	3.82	1.32	5.14	C	W Mean C S1-end						82.1		10.4								
DN10S	3.82	1.32	5.14	C	W Mean C S2-end						62.6		13.8								
DN10S	3.82	1.32	5.14	C	W Mean C 1-end						43.0		20.6								
DN10S	3.82	1.32	5.14	C	W Mean C 3-7						43.0		20.6								
DN10S	3.82	1.32	5.14	C	Mean C 3-7						43.0		20.6								
DN10S	3.82	1.32	5.14	C	Mean C 4-8						0.0		-								
DN10S	3.82	1.32	5.14	C	Mean C						43.0		20.6							9.49	
DN10S	3.82	1.32	5.14	C	CoeVar C						-		-							2.2%	
DN10S	3.82	1.32	5.14	D	1									1984.9	2007.3		1942.4	103.3%	102.2%	9.30	
DN10S	3.82	1.32	5.14	E	1									1984.9		2026.0	1942.4	104.3%	102.2%	9.67	
DN10S	3.82	1.32	5.14	DE	Mean DE									1984.9	2007.3	2026.0	1942.4	103.8%		9.49	9.66
DN10S	3.82	1.32	5.14	DE	CoeVar DE													0.7%		2.8%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
DN10C	3.82	1.32	5.14	A	Initial					37											
DN10C	3.82	1.32	5.14	A	S1					121	84		10.1								
DN10C	3.82	1.32	5.14	A	S2					202	81		10.5								
DN10C	3.82	1.32	5.14	A	1					229	27		33.7							9.38	
DN10C	3.82	1.32	5.14	A	2					258	HIT									9.38	
DN10C	3.82	1.32	5.14	A	3															8.65	
DN10C	3.82	1.32	5.14	A	4																
DN10C	3.82	1.32	5.14	A	Median A						81		10.5								
DN10C	3.82	1.32	5.14	A	W Mean A S1-end						74.7		11.4								
DN10C	3.82	1.32	5.14	A	W Mean A S2-end						67.5		12.7								
DN10C	3.82	1.32	5.14	A	W Mean A 1-end						27.0		33.7								
DN10C	3.82	1.32	5.14	A	W Mean A 3-7						27.0		33.7								
DN10C	3.82	1.32	5.14	A	Mean A 3-7						27.0		33.7								
DN10C	3.82	1.32	5.14	A	Mean A 4-8						0.0		-								
DN10C	3.82	1.32	5.14	A	Mean A						27.0		33.7							9.14	
DN10C	3.82	1.32	5.14	A	CoeVar A						-		-							0.05	
DN10C	3.82	1.32	5.14	B	Initial					18											
DN10C	3.82	1.32	5.14	B	S1	overload	na	na	na	119	101		8.3								
DN10C	3.82	1.32	5.14	B	S2	2.8	0.089	2219	5.6	192	73		11.7								
DN10C	3.82	1.32	5.14	B	1	3	0.095	1998	6.6	245	53		16.5							9.01	
DN10C	3.82	1.32	5.14	B	2	3.2	0.102	1814	7.8	247	HIT									9.73	
DN10C	3.82	1.32	5.14	B	3	3.2	0.102	1709	8.3											9.13	
DN10C	3.82	1.32	5.14	B	4	5.4	0.172	1798	13.3												
DN10C	3.82	1.32	5.14	B	5	5.4	0.172	1754	13.6												
DN10C	3.82	1.32	5.14	B	6	5.4	0.172	1741	13.7												
DN10C	3.82	1.32	5.14	B	7	7.5	0.239	1830	18.1												
DN10C	3.82	1.32	5.14	B	8	7.8	0.248	1803	19.1												
DN10C	3.82	1.32	5.14	B	9	7.9	0.251	1819	19.2												
DN10C	3.82	1.32	5.14	B	Mean H1	3.13	0.100	1840.33	7.56												
DN10C	3.82	1.32	5.14	B	Mean H2	5.40	0.172	1764.33	13.51												
DN10C	3.82	1.32	5.14	B	Mean H3	7.73	0.246	1817.33	18.78												
DN10C	3.82	1.32	5.14	B	CoeVar H1	3.7%	3.7%	7.9%	11.1%												
DN10C	3.82	1.32	5.14	B	CoeVar H2	0.0%	0.0%	1.7%	1.7%												
DN10C	3.82	1.32	5.14	B	CoeVar H3	2.7%	2.7%	0.7%	3.2%												
DN10C	3.82	1.32	5.14	B	Median B						73		11.7								
DN10C	3.82	1.32	5.14	B	W Mean B S1-end						80.8		10.5								
DN10C	3.82	1.32	5.14	B	W Mean B S2-end						64.6		13.4								
DN10C	3.82	1.32	5.14	B	W Mean B 1-end						53.0		16.5								
DN10C	3.82	1.32	5.14	B	W Mean B 3-7						53.0		16.5								
DN10C	3.82	1.32	5.14	B	Mean B 3-7						53.0		16.5								
DN10C	3.82	1.32	5.14	B	Mean B 4-8						0.0		-								
DN10C	3.82	1.32	5.14	B	Mean B						53.0		16.5							9.29	
DN10C	3.82	1.32	5.14	B	CoeVar B						-		-							4.1%	
DN10C	3.82	1.32	5.14	C	Initial					29											
DN10C	3.82	1.32	5.14	C	S1					125	96		8.8								
DN10C	3.82	1.32	5.14	C	S2					195	70		12.3								
DN10C	3.82	1.32	5.14	C	1					240	HIT									9.03	
DN10C	3.82	1.32	5.14	C	2															9.04	
DN10C	3.82	1.32	5.14	C	3															8.54	
DN10C	3.82	1.32	5.14	C	4																
DN10C	3.82	1.32	5.14	C	Median C																
DN10C	3.82	1.32	5.14	C	Mean C															8.87	
DN10C	3.82	1.32	5.14	C	CoeVar C															3.2%	
DN10C	3.82	1.32	5.14	D	1									2076.0	1954.8		1942.4	100.6%	106.9%	9.52	
DN10C	3.82	1.32	5.14	E	1									2076.0		1966.2	1942.4	101.2%	106.9%	9.54	
DN10C	3.82	1.32	5.14	D	2									2076.0	2050.2		1942.4	105.5%	106.9%	9.16	
DN10C	3.82	1.32	5.14	E	2									2076.0		2012.4	1942.4	103.6%	106.9%	9.16	
DN10C	3.82	1.32	5.14	DE	Mean DE									2076.0	2002.5	1989.3	1942.4	102.8%		9.35	9.16
DN10C	3.82	1.32	5.14	DE	CoeVar DE										3.4%	1.6%		2.2%		2.3%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
FHJ8	4.00	2.07	6.07	A	Initial					5											
FHJ8	4.00	2.07	6.07	A	S1					95	90		9.4								
FHJ8	4.00	2.07	6.07	A	S2					137	42		21.1								
FHJ8	4.00	2.07	6.07	A	1					165	28	53.3	32.4							7.62	
FHJ8	4.00	2.07	6.07	A	2					191	26	32.0	35.1							7.63	
FHJ8	4.00	2.07	6.07	A	3					214	23	25.7	40.0							8.12	
FHJ8	4.00	2.07	6.07	A	4					233	19	22.7	49.0								
FHJ8	4.00	2.07	6.07	A	5					252	19	20.3	49.0								
FHJ8	4.00	2.07	6.07	A	6					271	19	19.0	49.0								
FHJ8	4.00	2.07	6.07	A	7					285	14	17.3	67.7								
FHJ8	4.00	2.07	6.07	A	8					290	HIT										
FHJ8	4.00	2.07	6.07	A	Median A						23		40.0								
FHJ8	4.00	2.07	6.07	A	W Mean A S1-end						46.9		18.8								
FHJ8	4.00	2.07	6.07	A	W Mean A S2-end						26.5		34.4								
FHJ8	4.00	2.07	6.07	A	W Mean A 1-end						22.1		41.8								
FHJ8	4.00	2.07	6.07	A	W Mean A 3-7						23.6		39.0								
FHJ8	4.00	2.07	6.07	A	Mean A 3-7						23.0		40.0								
FHJ8	4.00	2.07	6.07	A	Mean A 4-8						21.2		43.6								
FHJ8	4.00	2.07	6.07	A	Mean A						22.3		42.4							7.79	
FHJ8	4.00	2.07	6.07	A	CoeVar A						17.8%		17.9%							0.04	
FHJ8	4.00	2.07	6.07	B	Initial					14											
FHJ8	4.00	2.07	6.07	B	S1	2.8	0.089	29	426.1	110	96		8.8								
FHJ8	4.00	2.07	6.07	B	S2	3.3	0.105	271	53.7	153	43		20.6								
FHJ8	4.00	2.07	6.07	B	1	3.4	0.108	263	57.1	185	32	57.0	28.2							8.07	
FHJ8	4.00	2.07	6.07	B	2	3.4	0.108	258	58.2	209	24	33.0	38.2							7.58	
FHJ8	4.00	2.07	6.07	B	3	3.4	0.108	254	59.1	230	21	25.7	44.0							7.59	
FHJ8	4.00	2.07	6.07	B	4	5.4	0.172	455	52.4	249	19	21.3	49.0								
FHJ8	4.00	2.07	6.07	B	5	5.5	0.175	427	56.8	266	17	19.0	55.1								
FHJ8	4.00	2.07	6.07	B	6	5.5	0.175	414	58.6	283	17	17.7	55.1								
FHJ8	4.00	2.07	6.07	B	7	8	0.255	622	56.8	295	HIT										
FHJ8	4.00	2.07	6.07	B	8	8.1	0.258	597	59.9												
FHJ8	4.00	2.07	6.07	B	9	8.2	0.261	597	60.6												
FHJ8	4.00	2.07	6.07	B	Mean H1	3.40	0.108	258.33	58.10												
FHJ8	4.00	2.07	6.07	B	Mean H2	5.47	0.174	432.00	55.95												
FHJ8	4.00	2.07	6.07	B	Mean H3	8.10	0.258	605.33	59.09												
FHJ8	4.00	2.07	6.07	B	CoeVar H1	0.0%	0.0%	1.7%	1.7%												
FHJ8	4.00	2.07	6.07	B	CoeVar H2	1.1%	1.1%	4.9%	5.8%												
FHJ8	4.00	2.07	6.07	B	CoeVar H3	1.2%	1.2%	2.4%	3.5%												
FHJ8	4.00	2.07	6.07	B	Median B						22.5		40.9								
FHJ8	4.00	2.07	6.07	B	W Mean B S1-end						52.2		16.7								
FHJ8	4.00	2.07	6.07	B	W Mean B S2-end						27.9		32.6								
FHJ8	4.00	2.07	6.07	B	W Mean B 1-end						22.9		40.1								
FHJ8	4.00	2.07	6.07	B	W Mean B 3-7						23.8		38.5								
FHJ8	4.00	2.07	6.07	B	Mean B 3-7						22.6		40.7								
FHJ8	4.00	2.07	6.07	B	Mean B 4-8						19.6		47.4								
FHJ8	4.00	2.07	6.07	B	Mean B						21.7		44.9							7.75	
FHJ8	4.00	2.07	6.07	B	CoeVar B						26.4%		23.4%							3.6%	
FHJ8	4.00	2.07	6.07	C	Initial					20											
FHJ8	4.00	2.07	6.07	C	S1					110	90		9.4								
FHJ8	4.00	2.07	6.07	C	S2					152	42		21.1								
FHJ8	4.00	2.07	6.07	C	1					184	32	54.7	28.2							8.16	
FHJ8	4.00	2.07	6.07	C	2					208	24	32.7	38.2							8.03	
FHJ8	4.00	2.07	6.07	C	3					228	20	25.3	46.4							8.04	
FHJ8	4.00	2.07	6.07	C	4					247	19	21.0	49.0								
FHJ8	4.00	2.07	6.07	C	5					264	17	18.7	55.1								
FHJ8	4.00	2.07	6.07	C	6					279	15	17.0	62.9								
FHJ8	4.00	2.07	6.07	C	7					294	HIT										
FHJ8	4.00	2.07	6.07	C	8																
FHJ8	4.00	2.07	6.07	C	Median C						22		41.9								
FHJ8	4.00	2.07	6.07	C	W Mean C S1-end						49.2		17.8								
FHJ8	4.00	2.07	6.07	C	W Mean C S2-end						27.4		33.1								
FHJ8	4.00	2.07	6.07	C	W Mean C 1-end						22.6		40.7								
FHJ8	4.00	2.07	6.07	C	W Mean C 3-7						23.7		38.8								
FHJ8	4.00	2.07	6.07	C	Mean C 3-7						22.4		41.1								
FHJ8	4.00	2.07	6.07	C	Mean C 4-8						19.0		49.0								
FHJ8	4.00	2.07	6.07	C	Mean C						21.2		46.6							8.08	
FHJ8	4.00	2.07	6.07	C	CoeVar C						28.9%		26.4%							0.9%	
FHJ8	4.00	2.07	6.07	D	1									1763.9	1788.9		1753.4	102.0%	100.6%	7.62	
FHJ8	4.00	2.07	6.07	E	1									1763.9		1714.6	1753.4	97.8%	100.6%	7.43	
FHJ8	4.00	2.07	6.07	D	2									1763.9	1759.4		1753.4	100.3%	100.6%	7.33	
FHJ8	4.00	2.07	6.07	E	2									1763.9		1875.4	1753.4	107.0%	100.6%	7.33	
FHJ8	4.00	2.07	6.07	DE	Mean DE									1763.9	1774.2	1795.0	1753.4	101.8%		7.43	7.76
FHJ8	4.00	2.07	6.07	DE	CoeVar DE										1.2%	6.3%		3.8%		1.8%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
FHJ8X1.125	4.00	2.07	6.07	A	Initial					175											
FHJ8X1.125	4.00	2.07	6.07	A	S1					256	81		10.5								
FHJ8X1.125	4.00	2.07	6.07	A	S2					296	40		22.2								
FHJ8X1.125	4.00	2.07	6.07	A	1					323	27	49.3	33.7							7.57	
FHJ8X1.125	4.00	2.07	6.07	A	2					346	23	30.0	40.0							7.32	
FHJ8X1.125	4.00	2.07	6.07	A	3					366	20	23.3	46.4							7.53	
FHJ8X1.125	4.00	2.07	6.07	A	4					384	18	20.3	51.9								
FHJ8X1.125	4.00	2.07	6.07	A	5					400	16	18.0	58.8								
FHJ8X1.125	4.00	2.07	6.07	A	6					414	14	16.0	67.7								
FHJ8X1.125	4.00	2.07	6.07	A	7					427	13	14.3	73.3								
FHJ8X1.125	4.00	2.07	6.07	A	8					440	13	13.3	73.3								
FHJ8X1.125	4.00	2.07	6.07	A	9					451	11	12.3	87.5								
FHJ8X1.125	4.00	2.07	6.07	A	10					461	10	11.3	96.8								
FHJ8X1.125	4.00	2.07	6.07	A	Median A						17		55.1								
FHJ8X1.125	4.00	2.07	6.07	A	W Mean A S1-end						39.0		22.8								
FHJ8X1.125	4.00	2.07	6.07	A	W Mean A S2-end						22.4		41.1								
FHJ8X1.125	4.00	2.07	6.07	A	W Mean A 1-end						18.1		51.4								
FHJ8X1.125	4.00	2.07	6.07	A	W Mean A 3-7						21.5		42.9								
FHJ8X1.125	4.00	2.07	6.07	A	Mean A 3-7						20.8		44.5								
FHJ8X1.125	4.00	2.07	6.07	A	Mean A 4-8						18.2		51.3								
FHJ8X1.125	4.00	2.07	6.07	A	Mean A 8-12						12.2		78.4								
FHJ8X1.125	4.00	2.07	6.07	A	Mean A						16.5		62.9							7.47	
FHJ8X1.125	4.00	2.07	6.07	A	CoeVar A						33.2%		32.6%							0.02	
FHJ8X1.125	4.00	2.07	6.07	B	Initial					171											
FHJ8X1.125	4.00	2.07	6.07	B	S1	3.2	0.102	1444	9.8	252	81		10.5								
FHJ8X1.125	4.00	2.07	6.07	B	S2	3.4	0.108	430	34.9	291	39		22.8								
FHJ8X1.125	4.00	2.07	6.07	B	1	3.4	0.108	367	40.9	316	25	48.3	36.6							7.40	
FHJ8X1.125	4.00	2.07	6.07	B	2	3.5	0.111	342	45.2	338	22	28.7	41.9							7.62	
FHJ8X1.125	4.00	2.07	6.07	B	3	3.5	0.111	330	46.8	359	21	22.7	44.0							7.93	
FHJ8X1.125	4.00	2.07	6.07	B	4	5.7	0.181	630	39.9	376	17	20.0	55.1								
FHJ8X1.125	4.00	2.07	6.07	B	5	5.7	0.181	539	46.7	391	15	17.7	62.9								
FHJ8X1.125	4.00	2.07	6.07	B	6	5.8	0.185	504	50.8	406	15	15.7	62.9								
FHJ8X1.125	4.00	2.07	6.07	B	7	8.1	0.258	758	47.2	418	12	14.0	79.8								
FHJ8X1.125	4.00	2.07	6.07	B	8	8.2	0.261	663	54.6	430	12	13.0	79.8								
FHJ8X1.125	4.00	2.07	6.07	B	9	8.1	0.258	624	57.3	441	11	11.7	87.5								
FHJ8X1.125	4.00	2.07	6.07	B	Mean H1	3.47	0.110	346.33	44.29	452	11	11.3	87.5								
FHJ8X1.125	4.00	2.07	6.07	B	Mean H2	5.73	0.182	557.67	45.80	463	11	11.0	87.5								
FHJ8X1.125	4.00	2.07	6.07	B	Mean H3	8.13	0.259	681.67	53.01	469	HIT										
FHJ8X1.125	4.00	2.07	6.07	B	CoeVar H1	1.7%	1.7%	5.5%	6.9%												
FHJ8X1.125	4.00	2.07	6.07	B	CoeVar H2	1.0%	1.0%	11.7%	12.0%												
FHJ8X1.125	4.00	2.07	6.07	B	CoeVar H3	0.7%	0.7%	10.1%	9.9%												
FHJ8X1.125	4.00	2.07	6.07	B	Median B						15		62.9								
FHJ8X1.125	4.00	2.07	6.07	B	W Mean B S1-end						37.7		23.6								
FHJ8X1.125	4.00	2.07	6.07	B	W Mean B S2-end						21.1		43.7								
FHJ8X1.125	4.00	2.07	6.07	B	W Mean B 1-end						17.1		54.8								
FHJ8X1.125	4.00	2.07	6.07	B	W Mean B 3-7						20.6		44.9								
FHJ8X1.125	4.00	2.07	6.07	B	Mean B 3-7						20.0		46.4								
FHJ8X1.125	4.00	2.07	6.07	B	Mean B 4-8						18.0		51.9								
FHJ8X1.125	4.00	2.07	6.07	B	Mean B 8-12						11.4		84.2								
FHJ8X1.125	4.00	2.07	6.07	B	Mean B						16.7		61.2							7.65	
FHJ8X1.125	4.00	2.07	6.07	B	CoeVar B						30.0%		32.0%							3.5%	
FHJ8X1.125	4.00	2.07	6.07	C	Initial					174											
FHJ8X1.125	4.00	2.07	6.07	C	S1					252	78		10.9								
FHJ8X1.125	4.00	2.07	6.07	C	S2					289	37		24.1								
FHJ8X1.125	4.00	2.07	6.07	C	1					313	24	46.3	38.2							7.25	
FHJ8X1.125	4.00	2.07	6.07	C	2					334	21	27.3	44.0							7.41	
FHJ8X1.125	4.00	2.07	6.07	C	3					353	19	21.3	49.0							7.49	
FHJ8X1.125	4.00	2.07	6.07	C	4					371	18	19.3	51.9								
FHJ8X1.125	4.00	2.07	6.07	C	5					388	17	18.0	55.1								
FHJ8X1.125	4.00	2.07	6.07	C	6					402	14	16.3	67.7								
FHJ8X1.125	4.00	2.07	6.07	C	7					416	14	15.0	67.7								
FHJ8X1.125	4.00	2.07	6.07	C	8					429	13	13.7	73.3								
FHJ8X1.125	4.00	2.07	6.07	C	9					440	11	12.7	87.5								
FHJ8X1.125	4.00	2.07	6.07	C	10					451	11	11.7	87.5								
FHJ8X1.125	4.00	2.07	6.07	C	11					462	11	11.0	87.5								
FHJ8X1.125	4.00	2.07	6.07	C	Median C						17		55.1								
FHJ8X1.125	4.00	2.07	6.07	C	W Mean C S1-end						36.0		24.8								
FHJ8X1.125	4.00	2.07	6.07	C	W Mean C S2-end						20.4		45.4								
FHJ8X1.125	4.00	2.07	6.07	C	W Mean C 1-end						16.8		55.6								
FHJ8X1.125	4.00	2.07	6.07	C	W Mean C 3-7						20.1		46.1								
FHJ8X1.125	4.00	2.07	6.07	C	Mean C 3-7						19.8		46.9								
FHJ8X1.125	4.00	2.07	6.07	C	Mean C 4-8						17.8		52.5								
FHJ8X1.125	4.00	2.07	6.07	C	Mean C 8-12						12.6		75.7								
FHJ8X1.125	4.00	2.07	6.07	C	Mean C						15.7		64.5							7.38	
FHJ8X1.125	4.00	2.07	6.07	C	CoeVar C						28.0%		28.1%							1.6%	
FHJ8X1.125	4.00	2.07	6.07	D	1									1819.8	1776.2		1753.4	101.3%	103.8%	7.64	
FHJ8X1.125	4.00	2.07	6.07	E	1									1819.8		1841.8	1753.4	105.0%	103.8%	7.26	
FHJ8X1.125	4.00	2.07	6.07	D	2									1819.8	1810.0		1753.4	103.2%	103.8%	7.85	
FHJ8X1.125	4.00	2.07	6.07	E	2									1819.8		1891.5	1753.4	107.9%	103.8%	7.43	
FHJ8X1.125	4.00	2.07	6.07	DE	Mean DE									1819.8	1793.1	1866.7	1753.4	104.4%		7.55	7.51
FHJ8X1.125	4.00	2.07	6.07	DE	CoeVar DE										1.3%	1.9%		2.7%		3.4%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
FHJ8X4/3	4.00	2.07	6.07	A	Initial					61											
FHJ8X4/3	4.00	2.07	6.07	A	S1					143	82		10.4								
FHJ8X4/3	4.00	2.07	6.07	A	S2					181	38		23.5								
FHJ8X4/3	4.00	2.07	6.07	A	1					208	27	49.0	33.7							7.88	
FHJ8X4/3	4.00	2.07	6.07	A	2					231	23	29.3	40.0							8.09	
FHJ8X4/3	4.00	2.07	6.07	A	3					250	19	23.0	49.0							7.68	
FHJ8X4/3	4.00	2.07	6.07	A	4					268	18	20.0	51.9								
FHJ8X4/3	4.00	2.07	6.07	A	5					284	16	17.7	58.8								
FHJ8X4/3	4.00	2.07	6.07	A	6					298	14	16.0	67.7								
FHJ8X4/3	4.00	2.07	6.07	A	7					311	13	14.3	73.3								
FHJ8X4/3	4.00	2.07	6.07	A	8					325	14	13.7	67.7								
FHJ8X4/3	4.00	2.07	6.07	A	Median A						18.5		50.4								
FHJ8X4/3	4.00	2.07	6.07	A	W Mean A S1-end						41.4		21.4								
FHJ8X4/3	4.00	2.07	6.07	A	W Mean A S2-end						23.1		39.8								
FHJ8X4/3	4.00	2.07	6.07	A	W Mean A 1-end						19.2		48.5								
FHJ8X4/3	4.00	2.07	6.07	A	W Mean A 3-7						21.3		43.3								
FHJ8X4/3	4.00	2.07	6.07	A	Mean A 3-7						20.6		44.9								
FHJ8X4/3	4.00	2.07	6.07	A	Mean A 4-8						18.0		51.9								
FHJ8X4/3	4.00	2.07	6.07	A	Mean A						18.0		55.3							7.88	
FHJ8X4/3	4.00	2.07	6.07	A	CoeVar A						27.2%		25.6%							0.03	
FHJ8X4/3	4.00	2.07	6.07	B	Initial					56											
FHJ8X4/3	4.00	2.07	6.07	B	S1	3.5	0.111	1266	12.2	145	89		9.5								
FHJ8X4/3	4.00	2.07	6.07	B	S2	3.6	0.115	333	47.7	183	38		23.5								
FHJ8X4/3	4.00	2.07	6.07	B	1	3.6	0.115	320	49.6	210	27	51.3	33.7							7.99	
FHJ8X4/3	4.00	2.07	6.07	B	2	3.6	0.115	294	54.0	230	20	28.3	46.4							8.06	
FHJ8X4/3	4.00	2.07	6.07	B	3	3.6	0.115	295	53.9	250	20	22.3	46.4							8.02	
FHJ8X4/3	4.00	2.07	6.07	B	4	5.7	0.181	540	46.6	266	16	18.7	58.8								
FHJ8X4/3	4.00	2.07	6.07	B	5	5.8	0.185	468	54.7	281	15	17.0	62.9								
FHJ8X4/3	4.00	2.07	6.07	B	6	5.9	0.188	441	59.0	296	15	15.3	62.9								
FHJ8X4/3	4.00	2.07	6.07	B	7	8.2	0.261	637	56.8	309	13	14.3	73.3								
FHJ8X4/3	4.00	2.07	6.07	B	8	8.5	0.271	574	65.4	320	11	13.0	87.5								
FHJ8X4/3	4.00	2.07	6.07	B	9	8.6	0.274	548	69.3	330	10	11.3	96.8								
FHJ8X4/3	4.00	2.07	6.07	B	Mean H1	3.60	0.115	303.00	52.51												
FHJ8X4/3	4.00	2.07	6.07	B	Mean H2	5.80	0.185	483.00	53.44												
FHJ8X4/3	4.00	2.07	6.07	B	Mean H3	8.43	0.268	586.33	63.81												
FHJ8X4/3	4.00	2.07	6.07	B	CoeVar H1	0.0%	0.0%	4.9%	4.7%												
FHJ8X4/3	4.00	2.07	6.07	B	CoeVar H2	1.7%	1.7%	10.6%	11.8%												
FHJ8X4/3	4.00	2.07	6.07	B	CoeVar H3	2.5%	2.5%	7.8%	10.0%												
FHJ8X4/3	4.00	2.07	6.07	B	Median B						16		58.8								
FHJ8X4/3	4.00	2.07	6.07	B	W Mean B S1-end						43.8		20.2								
FHJ8X4/3	4.00	2.07	6.07	B	W Mean B S2-end						22.0		41.9								
FHJ8X4/3	4.00	2.07	6.07	B	W Mean B 1-end						17.9		52.3								
FHJ8X4/3	4.00	2.07	6.07	B	W Mean B 3-7						20.5		45.2								
FHJ8X4/3	4.00	2.07	6.07	B	Mean B 3-7						19.6		47.4								
FHJ8X4/3	4.00	2.07	6.07	B	Mean B 4-8						17.2		54.4								
FHJ8X4/3	4.00	2.07	6.07	B	Mean B						16.3		63.2							8.02	
FHJ8X4/3	4.00	2.07	6.07	B	CoeVar B						32.4%		32.0%							0.4%	
FHJ8X4/3	4.00	2.07	6.07	C	Initial					55											
FHJ8X4/3	4.00	2.07	6.07	C	S1					137	82		10.4								
FHJ8X4/3	4.00	2.07	6.07	C	S2					174	37		24.1								
FHJ8X4/3	4.00	2.07	6.07	C	1					200	26	48.3	35.1							8.00	
FHJ8X4/3	4.00	2.07	6.07	C	2					220	20	27.7	46.4							7.92	
FHJ8X4/3	4.00	2.07	6.07	C	3					239	19	21.7	49.0							8.05	
FHJ8X4/3	4.00	2.07	6.07	C	4					256	17	18.7	55.1								
FHJ8X4/3	4.00	2.07	6.07	C	5					271	15	17.0	62.9								
FHJ8X4/3	4.00	2.07	6.07	C	6					285	14	15.3	67.7								
FHJ8X4/3	4.00	2.07	6.07	C	7					298	13	14.0	73.3								
FHJ8X4/3	4.00	2.07	6.07	C	8					310	12	13.0	79.8								
FHJ8X4/3	4.00	2.07	6.07	C	9					321	11	12.0	87.5								
FHJ8X4/3	4.00	2.07	6.07	C	10					330	9	10.7	108.3								
FHJ8X4/3	4.00	2.07	6.07	C	11					336	HIT										
FHJ8X4/3	4.00	2.07	6.07	C	Median C						16		58.8								
FHJ8X4/3	4.00	2.07	6.07	C	W Mean C S1-end						39.1		22.8								
FHJ8X4/3	4.00	2.07	6.07	C	W Mean C S2-end						20.9		44.3								
FHJ8X4/3	4.00	2.07	6.07	C	W Mean C 1-end						17.1		54.9								
FHJ8X4/3	4.00	2.07	6.07	C	W Mean C 3-7						20.1		46.1								
FHJ8X4/3	4.00	2.07	6.07	C	Mean C 3-7						19.4		47.9								
FHJ8X4/3	4.00	2.07	6.07	C	Mean C 4-8						17.0		55.1								
FHJ8X4/3	4.00	2.07	6.07	C	Mean C 8-12						11.8		81.2								
FHJ8X4/3	4.00	2.07	6.07	C	Mean C						15.6		66.5							7.99	
FHJ8X4/3	4.00	2.07	6.07	C	CoeVar C						32.3%		32.7%							0.8%	
FHJ8X4/3	4.00	2.07	6.07	D	1									1945.3	1810.2		1753.4	103.2%	110.9%	7.66	
FHJ8X4/3	4.00	2.07	6.07	E	1									1945.3		1867.8	1753.4	106.5%	110.9%	8.14	
FHJ8X4/3	4.00	2.07	6.07	D	2									1945.3	1891.1		1753.4	107.9%	110.9%	8.02	
FHJ8X4/3	4.00	2.07	6.07	E	2									1945.3		1876.9	1753.4	107.0%	110.9%	8.08	
FHJ8X4/3	4.00	2.07	6.07	DE	Mean DE									1945.3	1850.7	1872.3	1753.4	106.2%		7.97	7.97
FHJ8X4/3	4.00	2.07	6.07	DE	CoeVar DE										3.1%	0.3%		1.9%		2.7%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
FHJ8X2	4.00	2.07	6.07	A	Initial					69											
FHJ8X2	4.00	2.07	6.07	A	S1					131	62		14.0								
FHJ8X2	4.00	2.07	6.07	A	S2					167	36		24.8								
FHJ8X2	4.00	2.07	6.07	A	1					189	22	40.0	41.9							7.86	
FHJ8X2	4.00	2.07	6.07	A	2					208	19	25.7	49.0							7.85	
FHJ8X2	4.00	2.07	6.07	A	3					225	17	19.3	55.1							8.20	
FHJ8X2	4.00	2.07	6.07	A	4					242	17	17.7	55.1								
FHJ8X2	4.00	2.07	6.07	A	5					258	16	16.7	58.8								
FHJ8X2	4.00	2.07	6.07	A	6					273	15	16.0	62.9								
FHJ8X2	4.00	2.07	6.07	A	7					288	15	15.3	62.9								
FHJ8X2	4.00	2.07	6.07	A	8					300	12	14.0	79.8								
FHJ8X2	4.00	2.07	6.07	A	9					311	11	12.7	87.5								
FHJ8X2	4.00	2.07	6.07	A	10					321	10	11.0	96.8								
FHJ8X2	4.00	2.07	6.07	A	11					330	HIT										
FHJ8X2	4.00	2.07	6.07	A	Median A						16.5		56.9								
FHJ8X2	4.00	2.07	6.07	A	W Mean A S1-end						30.3		29.8								
FHJ8X2	4.00	2.07	6.07	A	W Mean A S2-end						19.9		46.5								
FHJ8X2	4.00	2.07	6.07	A	W Mean A 1-end						16.2		58.0								
FHJ8X2	4.00	2.07	6.07	A	W Mean A 3-7						18.5		50.5								
FHJ8X2	4.00	2.07	6.07	A	Mean A 3-7						18.2		51.3								
FHJ8X2	4.00	2.07	6.07	A	Mean A 4-8						16.8		55.8								
FHJ8X2	4.00	2.07	6.07	A	Mean A 8-12						12.6		75.7								
FHJ8X2	4.00	2.07	6.07	A	Mean A						15.4		65.0							7.97	
FHJ8X2	4.00	2.07	6.07	A	CoeVar A						23.9%		27.0%							0.02	
FHJ8X2	4.00	2.07	6.07	B	Initial					58											
FHJ8X2	4.00	2.07	6.07	B	S1	3.5	0.111	142	108.8	143	85		10.0								
FHJ8X2	4.00	2.07	6.07	B	S2	3.6	0.115	238	66.8	179	36		24.8								
FHJ8X2	4.00	2.07	6.07	B	1	3.6	0.115	229	69.4	208	29	50.0	31.3							8.45	
FHJ8X2	4.00	2.07	6.07	B	2	3.5	0.111	218	70.9	224	16	27.0	58.8							8.05	
FHJ8X2	4.00	2.07	6.07	B	3	3.6	0.115	206	77.1	243	19	21.3	49.0							8.03	
FHJ8X2	4.00	2.07	6.07	B	4	5.6	0.178	357	69.2	260	17	17.3	55.1								
FHJ8X2	4.00	2.07	6.07	B	5	5.5	0.175	353	68.8	275	15	17.0	62.9								
FHJ8X2	4.00	2.07	6.07	B	6	5.5	0.175	348	69.7	289	14	15.3	67.7								
FHJ8X2	4.00	2.07	6.07	B	7	8.4	0.267	468	79.2	301	12	13.7	79.8								
FHJ8X2	4.00	2.07	6.07	B	8	8.3	0.264	462	79.3	314	13	13.0	73.3								
FHJ8X2	4.00	2.07	6.07	B	9	8.3	0.264	442	82.9	325	11	12.0	87.5								
FHJ8X2	4.00	2.07	6.07	B	10					334	HIT										
FHJ8X2	4.00	2.07	6.07	B	Mean H1	3.57	0.114	217.67	72.45												
FHJ8X2	4.00	2.07	6.07	B	Mean H2	5.53	0.176	352.67	69.25												
FHJ8X2	4.00	2.07	6.07	B	Mean H3	8.33	0.265	457.33	80.46												
FHJ8X2	4.00	2.07	6.07	B	CoeVar H1	1.6%	1.6%	5.3%	5.7%												
FHJ8X2	4.00	2.07	6.07	B	CoeVar H2	1.0%	1.0%	1.3%	0.7%												
FHJ8X2	4.00	2.07	6.07	B	CoeVar H3	0.7%	0.7%	3.0%	2.6%												
FHJ8X2	4.00	2.07	6.07	B	Median B						16		58.8								
FHJ8X2	4.00	2.07	6.07	B	W Mean B S1-end						41.7		21.3								
FHJ8X2	4.00	2.07	6.07	B	W Mean B S2-end						21.4		43.1								
FHJ8X2	4.00	2.07	6.07	B	W Mean B 1-end						17.8		52.4								
FHJ8X2	4.00	2.07	6.07	B	W Mean B 3-7						20.5		45.1								
FHJ8X2	4.00	2.07	6.07	B	Mean B 3-7						19.2		48.4								
FHJ8X2	4.00	2.07	6.07	B	Mean B 4-8						16.2		58.0								
FHJ8X2	4.00	2.07	6.07	B	Mean B						14.6		66.8							8.18	
FHJ8X2	4.00	2.07	6.07	B	CoeVar B						36.9%		25.4%							2.9%	
FHJ8X2	4.00	2.07	6.07	C	Initial					59											
FHJ8X2	4.00	2.07	6.07	C	S1					139	80		10.6								
FHJ8X2	4.00	2.07	6.07	C	S2					174	35		25.6								
FHJ8X2	4.00	2.07	6.07	C	1					199	25	46.7	36.6							8.26	
FHJ8X2	4.00	2.07	6.07	C	2					218	19	26.3	49.0							7.86	
FHJ8X2	4.00	2.07	6.07	C	3					236	18	20.7	51.9							8.00	
FHJ8X2	4.00	2.07	6.07	C	4					251	15	17.3	62.9								
FHJ8X2	4.00	2.07	6.07	C	5					266	15	16.0	62.9								
FHJ8X2	4.00	2.07	6.07	C	6					279	13	14.3	73.3								
FHJ8X2	4.00	2.07	6.07	C	7					291	12	13.3	79.8								
FHJ8X2	4.00	2.07	6.07	C	8					302	11	12.0	87.5								
FHJ8X2	4.00	2.07	6.07	C	9					313	11	11.3	87.5								
FHJ8X2	4.00	2.07	6.07	C	10					323	10	10.7	96.8								
FHJ8X2	4.00	2.07	6.07	C	11					332	HIT										
FHJ8X2	4.00	2.07	6.07	C	Median C						15		62.9								
FHJ8X2	4.00	2.07	6.07	C	W Mean C S1-end						38.0		23.4								
FHJ8X2	4.00	2.07	6.07	C	W Mean C S2-end						19.8		46.9								
FHJ8X2	4.00	2.07	6.07	C	W Mean C 1-end						16.2		58.0								
FHJ8X2	4.00	2.07	6.07	C	W Mean C 3-7						19.1		48.6								
FHJ8X2	4.00	2.07	6.07	C	Mean C 3-7						18.4		50.7								
FHJ8X2	4.00	2.07	6.07	C	Mean C 4-8						16.0		58.8								
FHJ8X2	4.00	2.07	6.07	C	Mean C 8-12						11.4		84.2								
FHJ8X2	4.00	2.07	6.07	C	Mean C						14.9		68.8							8.04	
FHJ8X2	4.00	2.07	6.07	C	CoeVar C						31.2%		28.3%							2.5%	
FHJ8X2	4.00	2.07	6.07	D	1									1839.3	1751.48		1753.4	99.9%	104.9%	8.01	
FHJ8X2	4.00	2.07	6.07	E	1									1839.3		1822.2	1753.4	103.9%	104.9%	7.89	
FHJ8X2	4.00	2.07	6.07	D	2									1839.3	1870.60		1753.4	106.7%	104.9%	8.27	
FHJ8X2	4.00	2.07	6.07	E	2									1839.3		1930.4	1753.4	110.1%	104.9%	8.03	
FHJ8X2	4.00	2.07	6.07	DE	Mean DE									1839.3	1811.0	1876.3	1753.4	105.1%		8.05	8.06
FHJ8X2	4.00	2.07	6.07	DE	CoeVar DE										4.7%	4.1%		4.1%		2.0%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
FHJ10	4.00	2.07	6.07	A	Initial					166											
FHJ10	4.00	2.07	6.07	A	S1					244	78		10.9								
FHJ10	4.00	2.07	6.07	A	S2					280	36		24.8								
FHJ10	4.00	2.07	6.07	A	1					309	29	47.7	31.3							9.62	
FHJ10	4.00	2.07	6.07	A	2					334	25	30.0	36.6							9.56	
FHJ10	4.00	2.07	6.07	A	3					356	22	25.3	41.9							9.42	
FHJ10	4.00	2.07	6.07	A	4					378	22	23.0	41.9								
FHJ10	4.00	2.07	6.07	A	5					396	18	20.7	51.9								
FHJ10	4.00	2.07	6.07	A	6					414	18	19.3	51.9								
FHJ10	4.00	2.07	6.07	A	7					430	16	17.3	58.8								
FHJ10	4.00	2.07	6.07	A	8					444	HIT										
FHJ10	4.00	2.07	6.07	A	Median A						22		41.9								
FHJ10	4.00	2.07	6.07	A	W Mean A S1-end						40.6		21.9								
FHJ10	4.00	2.07	6.07	A	W Mean A S2-end						24.9		36.7								
FHJ10	4.00	2.07	6.07	A	W Mean A 1-end						22.3		41.4								
FHJ10	4.00	2.07	6.07	A	W Mean A 3-7						23.8		38.6								
FHJ10	4.00	2.07	6.07	A	Mean A 3-7						23.2		39.6								
FHJ10	4.00	2.07	6.07	A	Mean A 4-8						21.0		44.0								
FHJ10	4.00	2.07	6.07	A	Mean A						21.4		44.9							9.53	
FHJ10	4.00	2.07	6.07	A	CoeVar A						21.2%		21.6%							0.01	
FHJ10	4.00	2.07	6.07	B	Initial					169											
FHJ10	4.00	2.07	6.07	B	S1	3.1	0.099	1396	9.8	250	81		10.5								
FHJ10	4.00	2.07	6.07	B	S2	3.3	0.105	333	43.7	290	40		22.2								
FHJ10	4.00	2.07	6.07	B	1	3.3	0.105	296	49.2	321	31	50.7	29.1							10.07	
FHJ10	4.00	2.07	6.07	B	2	3.4	0.108	282	53.2	346	25	32.0	36.6							9.44	
FHJ10	4.00	2.07	6.07	B	3	3.5	0.111	272	56.8	370	24	26.7	38.2							9.44	
FHJ10	4.00	2.07	6.07	B	4	5.6	0.178	569	43.4	391	21	23.3	44.0								
FHJ10	4.00	2.07	6.07	B	5	5.6	0.178	478	51.7	409	18	21.0	51.9								
FHJ10	4.00	2.07	6.07	B	6	5.7	0.181	447	56.3	426	17	18.7	55.1								
FHJ10	4.00	2.07	6.07	B	7	8.1	0.258	680	52.6	442	16	17.0	58.8								
FHJ10	4.00	2.07	6.07	B	8	8.1	0.258	604	59.2	455	HIT										
FHJ10	4.00	2.07	6.07	B	9	8.1	0.258	548	65.2												
FHJ10	4.00	2.07	6.07	B	Mean H1	3.40	0.108	283.33	53.07												
FHJ10	4.00	2.07	6.07	B	Mean H2	5.63	0.179	498.00	50.47												
FHJ10	4.00	2.07	6.07	B	Mean H3	8.10	0.258	610.67	58.99												
FHJ10	4.00	2.07	6.07	B	CoeVar H1	2.9%	2.9%	4.3%	7.2%												
FHJ10	4.00	2.07	6.07	B	CoeVar H2	1.0%	1.0%	12.7%	12.9%												
FHJ10	4.00	2.07	6.07	B	CoeVar H3	0.0%	0.0%	10.8%	10.7%												
FHJ10	4.00	2.07	6.07	B	Median B						24		38.2								
FHJ10	4.00	2.07	6.07	B	W Mean B S1-end						42.6		20.8								
FHJ10	4.00	2.07	6.07	B	W Mean B S2-end						26.4		34.5								
FHJ10	4.00	2.07	6.07	B	W Mean B 1-end						22.8		40.3								
FHJ10	4.00	2.07	6.07	B	W Mean B 3-7						24.6		37.2								
FHJ10	4.00	2.07	6.07	B	Mean B 3-7						23.8		38.6								
FHJ10	4.00	2.07	6.07	B	Mean B 4-8						21.0		44.0								
FHJ10	4.00	2.07	6.07	B	Mean B						21.7		44.8							9.65	
FHJ10	4.00	2.07	6.07	B	CoeVar B						24.6%		24.2%							3.8%	
FHJ10	4.00	2.07	6.07	C	Initial					167											
FHJ10	4.00	2.07	6.07	C	S1					245	78		10.9								
FHJ10	4.00	2.07	6.07	C	S2					288	43		20.6								
FHJ10	4.00	2.07	6.07	C	1					317	29	50.0	31.3							9.86	
FHJ10	4.00	2.07	6.07	C	2					343	26	32.7	35.1							9.03	
FHJ10	4.00	2.07	6.07	C	3					366	23	26.0	40.0							9.48	
FHJ10	4.00	2.07	6.07	C	4					386	20	23.0	46.4								
FHJ10	4.00	2.07	6.07	C	5					405	19	20.7	49.0								
FHJ10	4.00	2.07	6.07	C	6					422	17	18.7	55.1								
FHJ10	4.00	2.07	6.07	C	7					439	17	17.7	55.1								
FHJ10	4.00	2.07	6.07	C	8					453	HIT										
FHJ10	4.00	2.07	6.07	C	Median C						23		40.0								
FHJ10	4.00	2.07	6.07	C	W Mean C S1-end						41.6		21.3								
FHJ10	4.00	2.07	6.07	C	W Mean C S2-end						27.0		33.8								
FHJ10	4.00	2.07	6.07	C	W Mean C 1-end						22.4		41.1								
FHJ10	4.00	2.07	6.07	C	W Mean C 3-7						24.0		38.2								
FHJ10	4.00	2.07	6.07	C	Mean C 3-7						23.4		39.3								
FHJ10	4.00	2.07	6.07	C	Mean C 4-8						21.0		44.0								
FHJ10	4.00	2.07	6.07	C	Mean C						21.6		44.6							9.45	
FHJ10	4.00	2.07	6.07	C	CoeVar C						21.4%		21.1%							4.4%	
FHJ10	4.00	2.07	6.07	D	1									1790.6	1769.5		1753.4	100.9%	102.1%	9.30	
FHJ10	4.00	2.07	6.07	E	1									1790.6		1870.4	1753.4	106.7%	102.1%	9.15	
FHJ10	4.00	2.07	6.07	D	2									1790.6	1854.7		1753.4	105.8%	102.1%	9.24	
FHJ10	4.00	2.07	6.07	E	2									1790.6		1866.6	1753.4	106.5%	102.1%	9.35	
FHJ10	4.00	2.07	6.07	DE	Mean DE									1790.6	1812.1	1868.5	1753.4	105.0%		9.26	9.48
FHJ10	4.00	2.07	6.07	DE	CoeVar DE										3.3%	0.1%		2.6%		1.0%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
FHJ11	4.00	2.07	6.07	A	Initial					166											
FHJ11	4.00	2.07	6.07	A	S1					250	84		10.1								
FHJ11	4.00	2.07	6.07	A	S2					290	40		22.2								
FHJ11	4.00	2.07	6.07	A	1					320	30	51.3	30.2							10.81	
FHJ11	4.00	2.07	6.07	A	2					346	26	32.0	35.1							10.50	
FHJ11	4.00	2.07	6.07	A	3					370	24	26.7	38.2							10.87	
FHJ11	4.00	2.07	6.07	A	4					390	20	23.3	46.4								
FHJ11	4.00	2.07	6.07	A	5					405	15	19.7	62.9								
FHJ11	4.00	2.07	6.07	A	6					422	17	17.3	55.1								
FHJ11	4.00	2.07	6.07	A	7					436	14	15.3	67.7								
FHJ11	4.00	2.07	6.07	A	8																
FHJ11	4.00	2.07	6.07	A	Median A						24		38.2								
FHJ11	4.00	2.07	6.07	A	W Mean A S1-end						44.1		20.0								
FHJ11	4.00	2.07	6.07	A	W Mean A S2-end						26.1		34.9								
FHJ11	4.00	2.07	6.07	A	W Mean A 1-end						22.3		41.2								
FHJ11	4.00	2.07	6.07	A	W Mean A 3-7						24.1		38.0								
FHJ11	4.00	2.07	6.07	A	Mean A 3-7						23.0		40.0								
FHJ11	4.00	2.07	6.07	A	Mean A 4-8						20.4		45.4								
FHJ11	4.00	2.07	6.07	A	Mean A						20.9		47.9							10.73	
FHJ11	4.00	2.07	6.07	A	CoeVar A						28.8%		30.1%							0.02	
FHJ11	4.00	2.07	6.07	B	Initial					165											
FHJ11	4.00	2.07	6.07	B	S1	3	0.095	1603	8.3	245	80		10.6								
FHJ11	4.00	2.07	6.07	B	S2	3.5	0.111	376	41.1	290	45		19.6								
FHJ11	4.00	2.07	6.07	B	1	3.5	0.111	338	45.7	320	30	51.7	30.2							10.68	
FHJ11	4.00	2.07	6.07	B	2	3.5	0.111	321	48.1	345	25	33.3	36.6							10.74	
FHJ11	4.00	2.07	6.07	B	3	3.5	0.111	307	50.3	366	21	25.3	44.0							10.74	
FHJ11	4.00	2.07	6.07	B	4	5.6	0.178	577	42.8	388	22	22.7	41.9								
FHJ11	4.00	2.07	6.07	B	5	5.6	0.178	509	48.6	407	19	20.7	49.0								
FHJ11	4.00	2.07	6.07	B	6	5.6	0.178	479	51.6	422	15	18.7	62.9								
FHJ11	4.00	2.07	6.07	B	7	8	0.255	703	50.2	437	15	16.3	62.9								
FHJ11	4.00	2.07	6.07	B	8	8.1	0.258	653	54.7	449	HIT										
FHJ11	4.00	2.07	6.07	B	9	8.1	0.258	620	57.7												
FHJ11	4.00	2.07	6.07	B	Mean H1	3.50	0.111	322.00	48.04												
FHJ11	4.00	2.07	6.07	B	Mean H2	5.60	0.178	521.67	47.66												
FHJ11	4.00	2.07	6.07	B	Mean H3	8.07	0.257	658.67	54.21												
FHJ11	4.00	2.07	6.07	B	CoeVar H1	0.0%	0.0%	4.8%	4.8%												
FHJ11	4.00	2.07	6.07	B	CoeVar H2	0.0%	0.0%	9.6%	9.3%												
FHJ11	4.00	2.07	6.07	B	CoeVar H3	0.7%	0.7%	6.3%	6.9%												
FHJ11	4.00	2.07	6.07	B	Median B						22		41.9								
FHJ11	4.00	2.07	6.07	B	W Mean B S1-end						43.0		20.6								
FHJ11	4.00	2.07	6.07	B	W Mean B S2-end						27.5		33.0								
FHJ11	4.00	2.07	6.07	B	W Mean B 1-end						22.2		41.5								
FHJ11	4.00	2.07	6.07	B	W Mean B 3-7						24.0		38.2								
FHJ11	4.00	2.07	6.07	B	Mean B 3-7						23.4		39.3								
FHJ11	4.00	2.07	6.07	B	Mean B 4-8						20.4		45.4								
FHJ11	4.00	2.07	6.07	B	Mean B						21.0		46.8							10.72	
FHJ11	4.00	2.07	6.07	B	CoeVar B						25.6%		26.7%							0.3%	
FHJ11	4.00	2.07	6.07	C	Initial					167	na		na								
FHJ11	4.00	2.07	6.07	C	S1					236	69		12.5								
FHJ11	4.00	2.07	6.07	C	S2					280	44		20.1								
FHJ11	4.00	2.07	6.07	C	1					309	29	47.3	31.3							10.83	
FHJ11	4.00	2.07	6.07	C	2					333	24	32.3	38.2							10.66	
FHJ11	4.00	2.07	6.07	C	3					354	21	24.7	44.0							10.77	
FHJ11	4.00	2.07	6.07	C	4					372	18	21.0	51.9								
FHJ11	4.00	2.07	6.07	C	5					391	19	19.3	49.0								
FHJ11	4.00	2.07	6.07	C	6					406	15	17.3	62.9								
FHJ11	4.00	2.07	6.07	C	7					421	15	16.3	62.9								
FHJ11	4.00	2.07	6.07	C	8					435	14	14.7	67.7								
FHJ11	4.00	2.07	6.07	C	Median C						20		46.4								
FHJ11	4.00	2.07	6.07	C	W Mean C S1-end						36.9		24.2								
FHJ11	4.00	2.07	6.07	C	W Mean C S2-end						25.8		35.5								
FHJ11	4.00	2.07	6.07	C	W Mean C 1-end						20.6		45.0								
FHJ11	4.00	2.07	6.07	C	W Mean C 3-7						22.9		40.2								
FHJ11	4.00	2.07	6.07	C	Mean C 3-7						22.2		41.5								
FHJ11	4.00	2.07	6.07	C	Mean C 4-8						19.4		47.9								
FHJ11	4.00	2.07	6.07	C	Mean C						19.4		51.0							10.75	
FHJ11	4.00	2.07	6.07	C	CoeVar C						26.6%		25.4%							0.8%	
FHJ11	4.00	2.07	6.07	D	1									1801.9	1752.6		1753.4	100.0%	102.8%	10.49	
FHJ11	4.00	2.07	6.07	E	1									1801.9		1872.4	1753.4	106.8%	102.8%	10.19	
FHJ11	4.00	2.07	6.07	D	2									1801.9	1894.7		1753.4	108.1%	102.8%	10.14	
FHJ11	4.00	2.07	6.07	E	2									1801.9		1873.9	1753.4	106.9%	102.8%	10.05	
FHJ11	4.00	2.07	6.07	DE	Mean DE									1801.9	1823.7	1873.1	1753.4	105.4%		10.22	10.60
FHJ11	4.00	2.07	6.07	DE	CoeVar DE										5.5%	0.1%		3.5%		1.9%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
FHJ11X 5	4.00	2.07	6.07	A	Initial					177											
FHJ11X 5	4.00	2.07	6.07	A	S1					264	87		9.7								
FHJ11X 5	4.00	2.07	6.07	A	S2					310	46		19.2								
FHJ11X 5	4.00	2.07	6.07	A	1					352	42	58.3	21.1							11.49	
FHJ11X 5	4.00	2.07	6.07	A	2					384	32	40.0	28.2							10.40	
FHJ11X 5	4.00	2.07	6.07	A	3					410	26	33.3	35.1							10.79	
FHJ11X 5	4.00	2.07	6.07	A	4					433	23	27.0	40.0								
FHJ11X 5	4.00	2.07	6.07	A	5					454	21	23.3	44.0								
FHJ11X 5	4.00	2.07	6.07	A	6					463	HIT										
FHJ11X 5	4.00	2.07	6.07	A	7																
FHJ11X 5	4.00	2.07	6.07	A	8																
FHJ11X 5	4.00	2.07	6.07	A	Median A						32		28.2								
FHJ11X 5	4.00	2.07	6.07	A	W Mean A S1-end						51.0		17.2								
FHJ11X 5	4.00	2.07	6.07	A	W Mean A S2-end						34.5		26.0								
FHJ11X 5	4.00	2.07	6.07	A	W Mean A 1-end						30.8		29.3								
FHJ11X 5	4.00	2.07	6.07	A	W Mean A 3-7						30.8		29.3								
FHJ11X 5	4.00	2.07	6.07	A	Mean A 3-7						28.8		31.5								
FHJ11X 5	4.00	2.07	6.07	A	Mean A 4-8						25.5		35.8								
FHJ11X 5	4.00	2.07	6.07	A	Mean A						28.8		33.7							10.89	
FHJ11X 5	4.00	2.07	6.07	A	CoeVar A						29.4%		27.3%							0.05	
FHJ11X 5	4.00	2.07	6.07	B	Initial					178											
FHJ11X 5	4.00	2.07	6.07	B	S1	overload	-		-	268	90		9.4								
FHJ11X 5	4.00	2.07	6.07	B	S2	3.4	0.108	704	21.3	317	49		17.9								
FHJ11X 5	4.00	2.07	6.07	B	1	3.4	0.108	541	27.7	357	40	59.7	22.2							11.62	
FHJ11X 5	4.00	2.07	6.07	B	2	3.4	0.108	493	30.4	390	33	40.7	27.3							11.68	
FHJ11X 5	4.00	2.07	6.07	B	3	3.4	0.108	451	33.3	417	27	33.3	33.7							12.86	
FHJ11X 5	4.00	2.07	6.07	B	4	5.6	0.178	789	31.3	444	27	29.0	33.7								
FHJ11X 5	4.00	2.07	6.07	B	5	5.7	0.181	685	36.7	462	HIT										
FHJ11X 5	4.00	2.07	6.07	B	6	5.7	0.181	635	39.6												
FHJ11X 5	4.00	2.07	6.07	B	7	8.2	0.261	892	40.6												
FHJ11X 5	4.00	2.07	6.07	B	8	8.1	0.258	806	44.4												
FHJ11X 5	4.00	2.07	6.07	B	9	8.1	0.258	761	47.0												
FHJ11X 5	4.00	2.07	6.07	B	Mean H1	3.40	0.108	495.00	30.48												
FHJ11X 5	4.00	2.07	6.07	B	Mean H2	5.67	0.180	703.00	35.89												
FHJ11X 5	4.00	2.07	6.07	B	Mean H3	8.13	0.259	819.67	43.96												
FHJ11X 5	4.00	2.07	6.07	B	CoeVar H1	0.0%	0.0%	9.1%	9.1%												
FHJ11X 5	4.00	2.07	6.07	B	CoeVar H2	1.0%	1.0%	11.2%	11.7%												
FHJ11X 5	4.00	2.07	6.07	B	CoeVar H3	0.7%	0.7%	8.1%	7.3%												
FHJ11X 5	4.00	2.07	6.07	B	Median B						36.5		24.5								
FHJ11X 5	4.00	2.07	6.07	B	W Mean B S1-end						55.1		15.8								
FHJ11X 5	4.00	2.07	6.07	B	W Mean B S2-end						37.2		24.0								
FHJ11X 5	4.00	2.07	6.07	B	W Mean B 1-end						32.7		27.6								
FHJ11X 5	4.00	2.07	6.07	B	W Mean B 3-7						32.7		27.6								
FHJ11X 5	4.00	2.07	6.07	B	Mean B 3-7						31.8		28.4								
FHJ11X 5	4.00	2.07	6.07	B	Mean B 4-8						29.0		31.3								
FHJ11X 5	4.00	2.07	6.07	B	Mean B						31.8		29.2							12.06	
FHJ11X 5	4.00	2.07	6.07	B	CoeVar B						19.5%		19.1%							5.8%	
FHJ11X 5	4.00	2.07	6.07	C	Initial					180											
FHJ11X 5	4.00	2.07	6.07	C	S1					267	87		9.7								
FHJ11X 5	4.00	2.07	6.07	C	S2					318	51		17.2								
FHJ11X 5	4.00	2.07	6.07	C	1					358	40	59.3	22.2							11.54	
FHJ11X 5	4.00	2.07	6.07	C	2					390	32	41.0	28.2							11.24	
FHJ11X 5	4.00	2.07	6.07	C	3					417	27	33.0	33.7							11.93	
FHJ11X 5	4.00	2.07	6.07	C	4					440	23	27.3	40.0								
FHJ11X 5	4.00	2.07	6.07	C	5					462	HIT										
FHJ11X 5	4.00	2.07	6.07	C	6																
FHJ11X 5	4.00	2.07	6.07	C	7																
FHJ11X 5	4.00	2.07	6.07	C	8																
FHJ11X 5	4.00	2.07	6.07	C	Median C						36		24.8								
FHJ11X 5	4.00	2.07	6.07	C	W Mean C S1-end						54.0		16.1								
FHJ11X 5	4.00	2.07	6.07	C	W Mean C S2-end						37.5		23.8								
FHJ11X 5	4.00	2.07	6.07	C	W Mean C 1-end						31.8		28.3								
FHJ11X 5	4.00	2.07	6.07	C	W Mean C 3-7						31.8		28.3								
FHJ11X 5	4.00	2.07	6.07	C	Mean C 3-7						30.5		29.6								
FHJ11X 5	4.00	2.07	6.07	C	Mean C 4-8						27.3		33.3								
FHJ11X 5	4.00	2.07	6.07	C	Mean C						30.5		31.0							11.57	
FHJ11X 5	4.00	2.07	6.07	C	CoeVar C						24.0%		24.5%							3.0%	
FHJ11X 5	4.00	2.07	6.07	D	1									1772.5	1782.0		1753.4	101.6%	101.1%	10.58	
FHJ11X 5	4.00	2.07	6.07	E	1									1772.5		1792.3	1753.4	102.2%	101.1%	11.19	
FHJ11X 5	4.00	2.07	6.07	D	2									1772.5	1801.0		1753.4	102.7%	101.1%	11.23	
FHJ11X 5	4.00	2.07	6.07	E	2									1772.5		1857.6	1753.4	105.9%	101.1%	11.05	
FHJ11X 5	4.00	2.07	6.07	DE	Mean DE									1772.5	1791.5	1825.0	1753.4	103.1%		11.01	11.38
FHJ11X 5	4.00	2.07	6.07	DE	CoeVar DE										0.7%	2.5%		1.9%		2.7%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
FHJ13	4.00	2.07	6.07	A	Initial					188											
FHJ13	4.00	2.07	6.07	A	S1					318	130		6.4								
FHJ13	4.00	2.07	6.07	A	S2					400	82		10.4								
FHJ13	4.00	2.07	6.07	A	1					447	HIT									13.35	
FHJ13	4.00	2.07	6.07	A	2															13.21	
FHJ13	4.00	2.07	6.07	A	3															13.56	
FHJ13	4.00	2.07	6.07	A	4																
FHJ13	4.00	2.07	6.07	A	5																
FHJ13	4.00	2.07	6.07	A	6																
FHJ13	4.00	2.07	6.07	A	7																
FHJ13	4.00	2.07	6.07	A	8																
FHJ13	4.00	2.07	6.07	A	Median A																
FHJ13	4.00	2.07	6.07	A	Mean A															13.37	
FHJ13	4.00	2.07	6.07	A	CoeVar A															0.01	
FHJ13	4.00	2.07	6.07	B	Initial					174											
FHJ13	4.00	2.07	6.07	B	S1	overload	-	na	-	295	121		6.9								
FHJ13	4.00	2.07	6.07	B	S2	overload	-	na	-	373	78		10.9								
FHJ13	4.00	2.07	6.07	B	1	1.9	0.060	2195	3.8	426	53	84.0	16.5							13.54	
FHJ13	4.00	2.07	6.07	B	2	3.2	0.102	2182	6.5	437	HIT									13.55	
FHJ13	4.00	2.07	6.07	B	3	3.5	0.111	2043	7.6											12.62	
FHJ13	4.00	2.07	6.07	B	4	overload	-	na	-												
FHJ13	4.00	2.07	6.07	B	5	overload	-	na	-												
FHJ13	4.00	2.07	6.07	B	6	3.6	0.115	2128	7.5												
FHJ13	4.00	2.07	6.07	B	7	7.8	0.248	2128	16.2												
FHJ13	4.00	2.07	6.07	B	8	7.8	0.248	2054	16.8												
FHJ13	4.00	2.07	6.07	B	9	8	0.255	2028	17.4												
FHJ13	4.00	2.07	6.07	B	Mean H1	2.87	0.091	2140.00	5.95												
FHJ13	4.00	2.07	6.07	B	Mean H2	3.60	0.115	2128.00	7.47												
FHJ13	4.00	2.07	6.07	B	Mean H3	7.87	0.250	2070.00	16.78												
FHJ13	4.00	2.07	6.07	B	CoeVar H1	29.7%	29.7%	3.9%	32.3%												
FHJ13	4.00	2.07	6.07	B	CoeVar H2	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!												
FHJ13	4.00	2.07	6.07	B	CoeVar H3	1.5%	1.5%	2.5%	3.7%												
FHJ13	4.00	2.07	6.07	B	Median B						78		10.9								
FHJ13	4.00	2.07	6.07	B	W Mean B S1-end						93.4		9.0								
FHJ13	4.00	2.07	6.07	B	W Mean B S2-end						67.9		12.7								
FHJ13	4.00	2.07	6.07	B	W Mean B 1-end						53.0		16.5								
FHJ13	4.00	2.07	6.07	B	W Mean B 3-7						53.0		16.5								
FHJ13	4.00	2.07	6.07	B	Mean B 3-7						53.0		16.5								
FHJ13	4.00	2.07	6.07	B	Mean B 4-8						0.0		-								
FHJ13	4.00	2.07	6.07	B	Mean B						53.0		16.5							13.24	
FHJ13	4.00	2.07	6.07	B	CoeVar B						-		-							4.0%	
FHJ13	4.00	2.07	6.07	C	Initial					162											
FHJ13	4.00	2.07	6.07	C	S1					281	119		7.0								
FHJ13	4.00	2.07	6.07	C	S2					352	71		12.1								
FHJ13	4.00	2.07	6.07	C	1					401	49	79.7	17.9							11.97	
FHJ13	4.00	2.07	6.07	C	2					433	HIT									12.33	
FHJ13	4.00	2.07	6.07	C	3															12.81	
FHJ13	4.00	2.07	6.07	C	4																
FHJ13	4.00	2.07	6.07	C	5																
FHJ13	4.00	2.07	6.07	C	6																
FHJ13	4.00	2.07	6.07	C	7																
FHJ13	4.00	2.07	6.07	C	8																
FHJ13	4.00	2.07	6.07	C	Median C						71		12.1								
FHJ13	4.00	2.07	6.07	C	W Mean C S1-end						90.4		9.4								
FHJ13	4.00	2.07	6.07	C	W Mean C S2-end						62.0		13.9								
FHJ13	4.00	2.07	6.07	C	W Mean C 1-end						49.0		17.9								
FHJ13	4.00	2.07	6.07	C	W Mean C 3-7						49.0		17.9								
FHJ13	4.00	2.07	6.07	C	Mean C 3-7						49.0		17.9								
FHJ13	4.00	2.07	6.07	C	Mean C 4-8						0.0		-								
FHJ13	4.00	2.07	6.07	C	Mean C						49.0		17.9							12.37	
FHJ13	4.00	2.07	6.07	C	CoeVar C						-		-							3.4%	
FHJ13	4.00	2.07	6.07	D	1									1790.1	1741.3		1753.4	99.3%	102.1%	12.59	
FHJ13	4.00	2.07	6.07	E	1									1790.1		1852.7	1753.4	105.7%	102.1%	12.32	
FHJ13	4.00	2.07	6.07	D	2									1790.1	1822.1		1753.4	103.9%	102.1%	11.55	
FHJ13	4.00	2.07	6.07	E	2									1790.1		1783.4	1753.4	101.7%	102.1%	11.54	
FHJ13	4.00	2.07	6.07	DE	Mean DE									1790.1	1781.7	1818.1	1753.4	102.7%		12.00	12.75
FHJ13	4.00	2.07	6.07	DE	CoeVar DE										3.2%	2.7%		2.7%		4.5%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
KLO7	3.85	1.57	5.42	A	Initial					178											
KLO7	3.85	1.57	5.42	A	S1					266	88		9.6								
KLO7	3.85	1.57	5.42	A	S2					302	36		24.8								
KLO7	3.85	1.57	5.42	A	1					332	30	51.3	30.2							7.09	
KLO7	3.85	1.57	5.42	A	2					357	25	30.3	36.6							7.19	
KLO7	3.85	1.57	5.42	A	3					380	23	26.0	40.0							7.46	
KLO7	3.85	1.57	5.42	A	4					400	20	22.7	46.4								
KLO7	3.85	1.57	5.42	A	5					418	18	20.3	51.9								
KLO7	3.85	1.57	5.42	A	6					433	15	17.7	62.9								
KLO7	3.85	1.57	5.42	A	7					447	HIT										
KLO7	3.85	1.57	5.42	A	8																
KLO7	3.85	1.57	5.42	A	Median A						24		38.2								
KLO7	3.85	1.57	5.42	A	W Mean A S1-end						47.2		18.6								
KLO7	3.85	1.57	5.42	A	W Mean A S2-end						25.7		35.5								
KLO7	3.85	1.57	5.42	A	W Mean A 1-end						22.9		40.1								
KLO7	3.85	1.57	5.42	A	W Mean A 3-7						23.9		38.3								
KLO7	3.85	1.57	5.42	A	Mean A 3-7						23.2		39.6								
KLO7	3.85	1.57	5.42	A	Mean A 4-8						20.2		45.9								
KLO7	3.85	1.57	5.42	A	Mean A						21.8		44.7							7.25	
KLO7	3.85	1.57	5.42	A	CoeVar A						24.5%		26.2%							0.03	
KLO7	3.85	1.57	5.42	B	Initial					186											
KLO7	3.85	1.57	5.42	B	S1	3.4	0.108	987	15.2	285	99		8.5								
KLO7	3.85	1.57	5.42	B	S2	3.4	0.108	457	32.8	321	36		24.8								
KLO7	3.85	1.57	5.42	B	1	3.3	0.105	419	34.8	347	26	53.7	35.1							7.34	
KLO7	3.85	1.57	5.42	B	2	3.3	0.105	393	37.1	371	24	28.7	38.2							6.58	
KLO7	3.85	1.57	5.42	B	3	3.3	0.105	382	38.1	392	21	23.7	44.0							7.48	
KLO7	3.85	1.57	5.42	B	4	5.6	0.178	613	40.3	410	18	21.0	51.9								
KLO7	3.85	1.57	5.42	B	5	5.6	0.178	571	43.3	426	16	18.3	58.8								
KLO7	3.85	1.57	5.42	B	6	5.6	0.178	546	45.3	437	HIT										
KLO7	3.85	1.57	5.42	B	7	8	0.255	754	46.8												
KLO7	3.85	1.57	5.42	B	8	7.9	0.251	712	49.0												
KLO7	3.85	1.57	5.42	B	9	7.5	0.239	654	50.6												
KLO7	3.85	1.57	5.42	B	Mean H1	3.30	0.105	398.00	36.65												
KLO7	3.85	1.57	5.42	B	Mean H2	5.60	0.178	576.67	42.95												
KLO7	3.85	1.57	5.42	B	Mean H3	7.80	0.248	706.67	48.80												
KLO7	3.85	1.57	5.42	B	CoeVar H1	0.0%	0.0%	4.8%	4.7%												
KLO7	3.85	1.57	5.42	B	CoeVar H2	0.0%	0.0%	5.9%	5.8%												
KLO7	3.85	1.57	5.42	B	CoeVar H3	3.4%	3.4%	7.1%	3.9%												
KLO7	3.85	1.57	5.42	B	Median B						24		38.2								
KLO7	3.85	1.57	5.42	B	W Mean B S1-end						55.7		15.6								
KLO7	3.85	1.57	5.42	B	W Mean B S2-end						25.3		36.1								
KLO7	3.85	1.57	5.42	B	W Mean B 1-end						21.6		42.6								
KLO7	3.85	1.57	5.42	B	W Mean B 3-7						21.6		42.6								
KLO7	3.85	1.57	5.42	B	Mean B 3-7						21.0		44.0								
KLO7	3.85	1.57	5.42	B	Mean B 4-8						19.8		47.0								
KLO7	3.85	1.57	5.42	B	Mean B						21.0		45.6							7.13	
KLO7	3.85	1.57	5.42	B	CoeVar B						19.6%		21.4%							6.8%	
KLO7	3.85	1.57	5.42	C	Initial					202											
KLO7	3.85	1.57	5.42	C	S1					289	87		9.7								
KLO7	3.85	1.57	5.42	C	S2					327	38		23.5								
KLO7	3.85	1.57	5.42	C	1					353	26	50.3	35.1							7.10	
KLO7	3.85	1.57	5.42	C	2					374	21	28.3	44.0							6.79	
KLO7	3.85	1.57	5.42	C	3					396	22	23.0	41.9							7.09	
KLO7	3.85	1.57	5.42	C	4					412	16	19.7	58.8								
KLO7	3.85	1.57	5.42	C	5					427	15	17.7	62.9								
KLO7	3.85	1.57	5.42	C	6					443	16	15.7	58.8								
KLO7	3.85	1.57	5.42	C	7					454	HIT										
KLO7	3.85	1.57	5.42	C	8																
KLO7	3.85	1.57	5.42	C	Median C						21.5		43.0								
KLO7	3.85	1.57	5.42	C	W Mean C S1-end						47.1		18.7								
KLO7	3.85	1.57	5.42	C	W Mean C S2-end						24.6		37.3								
KLO7	3.85	1.57	5.42	C	W Mean C 1-end						20.2		46.0								
KLO7	3.85	1.57	5.42	C	W Mean C 3-7						20.8		44.4								
KLO7	3.85	1.57	5.42	C	Mean C 3-7						20.0		46.4								
KLO7	3.85	1.57	5.42	C	Mean C 4-8						18.0		51.9								
KLO7	3.85	1.57	5.42	C	Mean C						19.3		50.3							6.99	
KLO7	3.85	1.57	5.42	C	CoeVar C						22.6%		22.6%							2.5%	
KLO7	3.85	1.57	5.42	D	1									1847.3	1778.3		1862.3	95.5%	99.2%	6.77	
KLO7	3.85	1.57	5.42	E	1									1847.3		1773.3	1862.3	95.2%	99.2%	7.00	
KLO7	3.85	1.57	5.42	D	2									1847.3	1845.1		1862.3	99.1%	99.2%	6.57	
KLO7	3.85	1.57	5.42	E	2									1847.3		1935.4	1862.3	103.9%	99.2%	7.01	
KLO7	3.85	1.57	5.42	DE	Mean DE									1847.3	1811.7	1854.4	1862.3	98.4%		6.84	7.05
KLO7	3.85	1.57	5.42	DE	CoeVar DE										2.6%	6.2%		4.1%		3.1%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
KLO7X1.33	3.85	1.57	5.42	A	Initial					59											
KLO7X1.33	3.85	1.57	5.42	A	S1					129	70		12.3								
KLO7X1.33	3.85	1.57	5.42	A	S2					164	35		25.6								
KLO7X1.33	3.85	1.57	5.42	A	1					184	20	41.7	46.4							6.88	
KLO7X1.33	3.85	1.57	5.42	A	2					209	25	26.7	36.6							6.95	
KLO7X1.33	3.85	1.57	5.42	A	3					221	12	19.0	79.8							7.05	
KLO7X1.33	3.85	1.57	5.42	A	4					238	17	18.0	55.1								
KLO7X1.33	3.85	1.57	5.42	A	5					253	15	14.7	62.9								
KLO7X1.33	3.85	1.57	5.42	A	6					265	12	14.7	79.8								
KLO7X1.33	3.85	1.57	5.42	A	7					279	14	13.7	67.7								
KLO7X1.33	3.85	1.57	5.42	A	8					289	10	12.0	96.8								
KLO7X1.33	3.85	1.57	5.42	A	9					299	10	11.3	96.8								
KLO7X1.33	3.85	1.57	5.42	A	10					304	5	8.3	202.1								
KLO7X1.33	3.85	1.57	5.42	A	11					313	HIT										
KLO7X1.33	3.85	1.57	5.42	A	Median A						14.5		65.3								
KLO7X1.33	3.85	1.57	5.42	A	W Mean A S1-end						34.2		26.3								
KLO7X1.33	3.85	1.57	5.42	A	W Mean A S2-end						19.8		46.8								
KLO7X1.33	3.85	1.57	5.42	A	W Mean A 1-end						16.1		58.6								
KLO7X1.33	3.85	1.57	5.42	A	W Mean A 3-7						18.9		49.2								
KLO7X1.33	3.85	1.57	5.42	A	Mean A 3-7						17.8		52.5								
KLO7X1.33	3.85	1.57	5.42	A	Mean A 4-8						16.2		58.0								
KLO7X1.33	3.85	1.57	5.42	A	Mean A 8-12						10.2		94.8								
KLO7X1.33	3.85	1.57	5.42	A	Mean A						14.0		82.4							6.96	
KLO7X1.33	3.85	1.57	5.42	A	CoeVar A						40.4%		56.5%							0.01	
KLO7X1.33	3.85	1.57	5.42	B	Initial					58											
KLO7X1.33	3.85	1.57	5.42	B	S1	3.5	0.111	1072	14.4	122	64		13.5								
KLO7X1.33	3.85	1.57	5.42	B	S2	3.5	0.111	372	41.5	159	37		24.1								
KLO7X1.33	3.85	1.57	5.42	B	1	3.4	0.108	325	46.2	184	25	42.0	36.6							6.79	
KLO7X1.33	3.85	1.57	5.42	B	2	3.3	0.105	303	48.1	204	20	27.3	46.4							7.50	
KLO7X1.33	3.85	1.57	5.42	B	3	3.3	0.105	312	46.7	222	18	21.0	51.9							7.11	
KLO7X1.33	3.85	1.57	5.42	B	4	5.7	0.181	530	47.5	238	16	18.0	58.8								
KLO7X1.33	3.85	1.57	5.42	B	5	5.7	0.181	464	54.2	252	14	16.0	67.7								
KLO7X1.33	3.85	1.57	5.42	B	6	5.7	0.181	435	57.8	265	13	14.3	73.3								
KLO7X1.33	3.85	1.57	5.42	B	7	8.4	0.267	622	59.6	277	12	13.0	79.8								
KLO7X1.33	3.85	1.57	5.42	B	8	8.4	0.267	559	66.3	288	HIT										
KLO7X1.33	3.85	1.57	5.42	B	9	8.4	0.267	548	67.6												
KLO7X1.33	3.85	1.57	5.42	B	10																
KLO7X1.33	3.85	1.57	5.42	B	11																
KLO7X1.33	3.85	1.57	5.42	B	Mean H1	3.33	0.106	313.33	46.97												
KLO7X1.33	3.85	1.57	5.42	B	Mean H2	5.70	0.181	476.33	53.17												
KLO7X1.33	3.85	1.57	5.42	B	Mean H3	8.40	0.267	576.33	64.52												
KLO7X1.33	3.85	1.57	5.42	B	CoeVar H1	1.7%	1.7%	3.5%	2.1%												
KLO7X1.33	3.85	1.57	5.42	B	CoeVar H2	0.0%	0.0%	10.2%	9.9%												
KLO7X1.33	3.85	1.57	5.42	B	CoeVar H3	0.0%	0.0%	6.9%	6.7%												
KLO7X1.33	3.85	1.57	5.42	B	Median B						18		51.9								
KLO7X1.33	3.85	1.57	5.42	B	W Mean B S1-end						34.6		25.9								
KLO7X1.33	3.85	1.57	5.42	B	W Mean B S2-end						22.5		41.0								
KLO7X1.33	3.85	1.57	5.42	B	W Mean B 1-end						17.9		52.1								
KLO7X1.33	3.85	1.57	5.42	B	W Mean B 3-7						19.4		48.0								
KLO7X1.33	3.85	1.57	5.42	B	Mean B 3-7						18.6		50.1								
KLO7X1.33	3.85	1.57	5.42	B	Mean B 4-8						16.2		58.0								
KLO7X1.33	3.85	1.57	5.42	B	Mean B						14.6		66.3							7.13	
KLO7X1.33	3.85	1.57	5.42	B	CoeVar B						31.2%		23.2%							5.0%	
KLO7X1.33	3.85	1.57	5.42	C	Initial					57											
KLO7X1.33	3.85	1.57	5.42	C	S1					117	60		14.4								
KLO7X1.33	3.85	1.57	5.42	C	S2					151	34		26.4								
KLO7X1.33	3.85	1.57	5.42	C	1					175	24	39.3	38.2							7.28	
KLO7X1.33	3.85	1.57	5.42	C	2					195	20	26.0	46.4							7.18	
KLO7X1.33	3.85	1.57	5.42	C	3					212	17	20.3	55.1							7.27	
KLO7X1.33	3.85	1.57	5.42	C	4					226	14	17.0	67.7								
KLO7X1.33	3.85	1.57	5.42	C	5					240	14	15.0	67.7								
KLO7X1.33	3.85	1.57	5.42	C	6					255	15	14.3	62.9								
KLO7X1.33	3.85	1.57	5.42	C	7					267	12	13.7	79.8								
KLO7X1.33	3.85	1.57	5.42	C	8					277	10	12.3	96.8								
KLO7X1.33	3.85	1.57	5.42	C	9					287	10	10.7	96.8								
KLO7X1.33	3.85	1.57	5.42	C	10					296	9	9.7	108.3								
KLO7X1.33	3.85	1.57	5.42	C	11					304	8	9.0	122.7								
KLO7X1.33	3.85	1.57	5.42	C	12					313	9	8.7	108.3								
KLO7X1.33	3.85	1.57	5.42	C	13					321	8	8.3	122.7								
KLO7X1.33	3.85	1.57	5.42	C	14					328	7	8.0	141.4								
KLO7X1.33	3.85	1.57	5.42	C	Median C						13		73.3								
KLO7X1.33	3.85	1.57	5.42	C	W Mean C S1-end						27.0		33.7								
KLO7X1.33	3.85	1.57	5.42	C	W Mean C S2-end						17.6		53.0								
KLO7X1.33	3.85	1.57	5.42	C	W Mean C 1-end						14.5		65.3								
KLO7X1.33	3.85	1.57	5.42	C	W Mean C 3-7						18.6		50.0								
KLO7X1.33	3.85	1.57	5.42	C	Mean C 3-7						17.8		52.5								
KLO7X1.33	3.85	1.57	5.42	C	Mean C 4-8						16.0		58.8								
KLO7X1.33	3.85	1.57	5.42	C	Mean C 8-12						11.2		85.8								
KLO7X1.33	3.85	1.57	5.42	C	Mean C						12.6		86.8							7.24	
KLO7X1.33	3.85	1.57	5.42	C	CoeVar C						39.7%		36.5%							0.8%	
KLO7X1.33	3.85	1.57	5.42	D	1									1936.6	1931.8		1862.3	103.7%	104.0%	6.81	
KLO7X1.33	3.85	1.57	5.42	E	1									1936.6		1964.4	1862.3	105.5%	104.0%	6.93	
KLO7X1.33	3.85	1.57	5.42	D	2									1936.6	1958.0		1862.3	105.1%	104.0%	7.16	
KLO7X1.33	3.85	1.57	5.42	E	2									1936.6		2754.9	1862.3	147.9%	104.0%	7.06	
KLO7X1.33	3.85	1.57	5.42	DE	Mean DE									1936.6	1944.9	2359.7	1862.3	115.6%		6.99	7.08
KLO7X1.33	3.85	1.57	5.42	DE	CoeVar DE										1.0%	23.7%		18.7%		2.2%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
KLO8X1.5	3.85	1.57	5.42	A	Initial					180											
KLO8X1.5	3.85	1.57	5.42	A	S1					249	69		12.5								
KLO8X1.5	3.85	1.57	5.42	A	S2					280	31		29.1								
KLO8X1.5	3.85	1.57	5.42	A	1					303	23	41.0	40.0							7.89	
KLO8X1.5	3.85	1.57	5.42	A	2					323	20	24.7	46.4							7.79	
KLO8X1.5	3.85	1.57	5.42	A	3					341	18	20.3	51.9							7.92	
KLO8X1.5	3.85	1.57	5.42	A	4					356	15	17.7	62.9								
KLO8X1.5	3.85	1.57	5.42	A	5					371	15	16.0	62.9								
KLO8X1.5	3.85	1.57	5.42	A	6					386	15	15.0	62.9								
KLO8X1.5	3.85	1.57	5.42	A	7					398	12	14.0	79.8								
KLO8X1.5	3.85	1.57	5.42	A	8					410	12	13.0	79.8								
KLO8X1.5	3.85	1.57	5.42	A	9					420	10	11.3	96.8								
KLO8X1.5	3.85	1.57	5.42	A	10					430	10	10.7	96.8								
KLO8X1.5	3.85	1.57	5.42	A	11					440	HIT										
KLO8X1.5	3.85	1.57	5.42	A	Median A						15		62.9								
KLO8X1.5	3.85	1.57	5.42	A	W Mean A S1-end						32.6		27.7								
KLO8X1.5	3.85	1.57	5.42	A	W Mean A S2-end						18.7		49.9								
KLO8X1.5	3.85	1.57	5.42	A	W Mean A 1-end						16.1		58.4								
KLO8X1.5	3.85	1.57	5.42	A	W Mean A 3-7						18.7		49.8								
KLO8X1.5	3.85	1.57	5.42	A	Mean A 3-7						18.2		51.3								
KLO8X1.5	3.85	1.57	5.42	A	Mean A 4-8						16.6		56.5								
KLO8X1.5	3.85	1.57	5.42	A	Mean A 8-12						11.8		81.2							7.87	
KLO8X1.5	3.85	1.57	5.42	A	Mean A						15.0		68.0							7.87	
KLO8X1.5	3.85	1.57	5.42	A	CoeVar A						49.5%		35.1%							0.01	
KLO8X1.5	3.85	1.57	5.42	B	Initial					179											
KLO8X1.5	3.85	1.57	5.42	B	S1	3.5	0.111	858	18.0	247	68		12.6								
KLO8X1.5	3.85	1.57	5.42	B	S2	3.6	0.115	307	51.8	281	34		26.4								
KLO8X1.5	3.85	1.57	5.42	B	1	3.6	0.115	281	56.5	306	25	42.3	36.6							8.39	
KLO8X1.5	3.85	1.57	5.42	B	2	3.5	0.111	269	57.4	326	20	26.3	46.4							7.74	
KLO8X1.5	3.85	1.57	5.42	B	3	3.5	0.111	258	59.9	343	17	20.7	55.1							8.05	
KLO8X1.5	3.85	1.57	5.42	B	4	5.8	0.185	467	54.8	360	17	18.0	55.1								
KLO8X1.5	3.85	1.57	5.42	B	5	5.9	0.188	412	63.2	374	14	16.0	67.7								
KLO8X1.5	3.85	1.57	5.42	B	6	5.9	0.188	398	65.4	388	14	15.0	67.7								
KLO8X1.5	3.85	1.57	5.42	B	7	8.3	0.264	580	63.2	399	11	13.0	87.5								
KLO8X1.5	3.85	1.57	5.42	B	8	8.4	0.267	549	67.5	410	11	12.0	87.5								
KLO8X1.5	3.85	1.57	5.42	B	9	8.3	0.264	521	70.3	420	10	10.7	96.8								
KLO8X1.5	3.85	1.57	5.42	B	10					431	11	10.7	87.5								
KLO8X1.5	3.85	1.57	5.42	B	11					441	HIT										
KLO8X1.5	3.85	1.57	5.42	B	Mean H1	3.53	0.112	269.33	57.94												
KLO8X1.5	3.85	1.57	5.42	B	Mean H2	5.87	0.187	425.67	61.14												
KLO8X1.5	3.85	1.57	5.42	B	Mean H3	8.33	0.265	550.00	67.00												
KLO8X1.5	3.85	1.57	5.42	B	CoeVar H1	1.6%	1.6%	4.3%	3.0%												
KLO8X1.5	3.85	1.57	5.42	B	CoeVar H2	1.0%	1.0%	8.6%	9.2%												
KLO8X1.5	3.85	1.57	5.42	B	CoeVar H3	0.7%	0.7%	5.4%	5.4%												
KLO8X1.5	3.85	1.57	5.42	B	Median B						15.5		60.8								
KLO8X1.5	3.85	1.57	5.42	B	W Mean B S1-end						32.7		27.5								
KLO8X1.5	3.85	1.57	5.42	B	W Mean B S2-end						19.6		47.3								
KLO8X1.5	3.85	1.57	5.42	B	W Mean B 1-end						16.4		57.3								
KLO8X1.5	3.85	1.57	5.42	B	W Mean B 3-7						19.3		48.1								
KLO8X1.5	3.85	1.57	5.42	B	Mean B 3-7						18.6		50.1								
KLO8X1.5	3.85	1.57	5.42	B	Mean B 4-8						16.4		57.3								
KLO8X1.5	3.85	1.57	5.42	B	Mean B 8-12						11.4		84.2								
KLO8X1.5	3.85	1.57	5.42	B	Mean B						13.1		75.6							8.06	
KLO8X1.5	3.85	1.57	5.42	B	CoeVar B						36.6%		27.0%							4.0%	
KLO8X1.5	3.85	1.57	5.42	C	Initial					180											
KLO8X1.5	3.85	1.57	5.42	C	S1					247	67		12.9								
KLO8X1.5	3.85	1.57	5.42	C	S2					280	33		27.3								
KLO8X1.5	3.85	1.57	5.42	C	1					302	22	40.7	41.9							8.10	
KLO8X1.5	3.85	1.57	5.42	C	2					321	19	24.7	49.0							7.89	
KLO8X1.5	3.85	1.57	5.42	C	3					336	15	18.7	62.9							7.71	
KLO8X1.5	3.85	1.57	5.42	C	4					351	15	16.3	62.9								
KLO8X1.5	3.85	1.57	5.42	C	5					365	14	14.7	67.7								
KLO8X1.5	3.85	1.57	5.42	C	6					379	14	14.3	67.7								
KLO8X1.5	3.85	1.57	5.42	C	7					390	11	13.0	87.5								
KLO8X1.5	3.85	1.57	5.42	C	8					400	10	11.7	96.8								
KLO8X1.5	3.85	1.57	5.42	C	9					410	10	10.3	96.8								
KLO8X1.5	3.85	1.57	5.42	C	10					420	10	10.0	96.8								
KLO8X1.5	3.85	1.57	5.42	C	11					430	10	10.0	96.8								
KLO8X1.5	3.85	1.57	5.42	C	Median C						14		67.7								
KLO8X1.5	3.85	1.57	5.42	C	W Mean C S1-end						31.1		29.0								
KLO8X1.5	3.85	1.57	5.42	C	W Mean C S2-end						18.0		51.8								
KLO8X1.5	3.85	1.57	5.42	C	W Mean C 1-end						14.7		64.2								
KLO8X1.5	3.85	1.57	5.42	C	W Mean C 3-7						14.7		64.2								
KLO8X1.5	3.85	1.57	5.42	C	Mean C 3-7						17.0		55.1								
KLO8X1.5	3.85	1.57	5.42	C	Mean C 4-8						15.4		61.2								
KLO8X1.5	3.85	1.57	5.42	C	Mean C 8-12						11.0		87.5								
KLO8X1.5	3.85	1.57	5.42	C	Mean C						13.6		75.2							7.90	
KLO8X1.5	3.85	1.57	5.42	C	CoeVar C						29.6%		27.3%							2.5%	
KLO8X1.5	3.85	1.57	5.42	D	1									1962.8	1890.1		1862.3	101.5%	105.4%	8.19	
KLO8X1.5	3.85	1.57	5.42	E	1									1962.8		2003.6	1862.3	107.6%	105.4%	7.87	
KLO8X1.5	3.85	1.57	5.42	D	2									1962.8	2001.1		1862.3	107.5%	105.4%	7.80	
KLO8X1.5	3.85	1.57	5.42	E	2									1962.8		2028.2	1862.3	108.9%	105.4%	7.77	
KLO8X1.5	3.85	1.57	5.42	DE	Mean DE									1962.8	1945.6	2015.9	1862.3	106.4%		7.91	7.93
KLO8X1.5	3.85	1.57	5.42	DE	CoeVar DE										4.0%	0.9%		3.1%		2.4%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
KLO9	3.85	1.57	5.42	A	Initial					66											
KLO9	3.85	1.57	5.42	A	S1					157	91		9.3								
KLO9	3.85	1.57	5.42	A	S2					193	36		24.8								
KLO9	3.85	1.57	5.42	A	1					219	26	51.0	35.1							8.75	
KLO9	3.85	1.57	5.42	A	2					244	25	29.0	36.6							8.53	
KLO9	3.85	1.57	5.42	A	3					263	19	23.3	49.0							9.52	
KLO9	3.85	1.57	5.42	A	4					282	19	21.0	49.0								
KLO9	3.85	1.57	5.42	A	5					299	17	18.3	55.1								
KLO9	3.85	1.57	5.42	A	6					316	17	17.7	55.1								
KLO9	3.85	1.57	5.42	A	7					329	HIT										
KLO9	3.85	1.57	5.42	A	8																
KLO9	3.85	1.57	5.42	A	Median A						22		41.9								
KLO9	3.85	1.57	5.42	A	W Mean A S1-end						48.7		18.0								
KLO9	3.85	1.57	5.42	A	W Mean A S2-end						24.5		37.4								
KLO9	3.85	1.57	5.42	A	W Mean A 1-end						21.1		43.7								
KLO9	3.85	1.57	5.42	A	W Mean A 3-7						21.8		42.3								
KLO9	3.85	1.57	5.42	A	Mean A 3-7						21.2		43.6								
KLO9	3.85	1.57	5.42	A	Mean A 4-8						19.4		47.9								
KLO9	3.85	1.57	5.42	A	Mean A						20.5		46.6							8.93	
KLO9	3.85	1.57	5.42	A	CoeVar A						19.5%		18.9%							0.06	
KLO9	3.85	1.57	5.42	B	Initial					76											
KLO9	3.85	1.57	5.42	B	S1	3.5	0.111	689	22.4	162	86		9.9								
KLO9	3.85	1.57	5.42	B	S2	3.5	0.111	398	38.8	206	44		20.1								
KLO9	3.85	1.57	5.42	B	1	3.5	0.111	366	42.2	235	29	53.0	31.3							9.55	
KLO9	3.85	1.57	5.42	B	2	3.5	0.111	356	43.4	257	22	31.7	41.9							8.72	
KLO9	3.85	1.57	5.42	B	3	3.5	0.111	346	44.6	276	19	23.3	49.0							8.86	
KLO9	3.85	1.57	5.42	B	4	5.8	0.185	553	46.3	287	11	17.3	87.5								
KLO9	3.85	1.57	5.42	B	5	5.8	0.185	508	50.4	294	HIT										
KLO9	3.85	1.57	5.42	B	6	5.7	0.181	482	52.2												
KLO9	3.85	1.57	5.42	B	7	8.4	0.267	662	56.0												
KLO9	3.85	1.57	5.42	B	8	8.3	0.264	637	57.5												
KLO9	3.85	1.57	5.42	B	9	8.3	0.264	621	59.0												
KLO9	3.85	1.57	5.42	B	Mean H1	3.50	0.111	356.00	43.41												
KLO9	3.85	1.57	5.42	B	Mean H2	5.77	0.184	514.33	49.62												
KLO9	3.85	1.57	5.42	B	Mean H3	8.33	0.265	640.00	57.50												
KLO9	3.85	1.57	5.42	B	CoeVar H1	0.0%	0.0%	2.8%	2.8%												
KLO9	3.85	1.57	5.42	B	CoeVar H2	1.0%	1.0%	7.0%	6.1%												
KLO9	3.85	1.57	5.42	B	CoeVar H3	0.7%	0.7%	3.2%	2.6%												
KLO9	3.85	1.57	5.42	B	Median B						25.5		35.8								
KLO9	3.85	1.57	5.42	B	W Mean B S1-end						52.8		16.6								
KLO9	3.85	1.57	5.42	B	W Mean B S2-end						29.9		30.2								
KLO9	3.85	1.57	5.42	B	W Mean B 1-end						22.3		41.3								
KLO9	3.85	1.57	5.42	B	W Mean B 3-7						22.3		41.3								
KLO9	3.85	1.57	5.42	B	Mean B 3-7						20.3		45.8								
KLO9	3.85	1.57	5.42	B	Mean B 4-8						17.3		54.0								
KLO9	3.85	1.57	5.42	B	Mean B						20.3		52.4							9.04	
KLO9	3.85	1.57	5.42	B	CoeVar B						36.8%		46.7%							4.9%	
KLO9	3.85	1.57	5.42	C	Initial					76											
KLO9	3.85	1.57	5.42	C	S1					164	88		9.6								
KLO9	3.85	1.57	5.42	C	S2					204	40		22.2								
KLO9	3.85	1.57	5.42	C	1					232	28	52.0	32.4							9.37	
KLO9	3.85	1.57	5.42	C	2					253	21	29.7	44.0							8.52	
KLO9	3.85	1.57	5.42	C	3					272	19	22.7	49.0							9.24	
KLO9	3.85	1.57	5.42	C	4					287	15	18.3	62.9								
KLO9	3.85	1.57	5.42	C	5					303	16	16.7	58.8								
KLO9	3.85	1.57	5.42	C	6					318	15	15.3	62.9								
KLO9	3.85	1.57	5.42	C	7					329	HIT										
KLO9	3.85	1.57	5.42	C	8																
KLO9	3.85	1.57	5.42	C	Median C						20		46.4								
KLO9	3.85	1.57	5.42	C	W Mean C S1-end						48.1		18.3								
KLO9	3.85	1.57	5.42	C	W Mean C S2-end						25.3		36.2								
KLO9	3.85	1.57	5.42	C	W Mean C 1-end						20.1		46.1								
KLO9	3.85	1.57	5.42	C	W Mean C 3-7						20.9		44.3								
KLO9	3.85	1.57	5.42	C	Mean C 3-7						19.8		46.9								
KLO9	3.85	1.57	5.42	C	Mean C 4-8						17.2		54.4								
KLO9	3.85	1.57	5.42	C	Mean C						19.0		51.7							9.04	
KLO9	3.85	1.57	5.42	C	CoeVar C						26.4%		23.5%							5.1%	
KLO9	3.85	1.57	5.42	D	1									1881.3	1829.5		1862.3	98.2%	101.0%	9.05	
KLO9	3.85	1.57	5.42	E	1									1881.3		1805.9	1862.3	97.0%	101.0%	8.77	
KLO9	3.85	1.57	5.42	D	2									1881.3	1843.1		1862.3	99.0%	101.0%	8.50	
KLO9	3.85	1.57	5.42	E	2									1881.3		1901.1	1862.3	102.1%	101.0%	8.60	
KLO9	3.85	1.57	5.42	DE	Mean DE									1881.3	1836.3	1853.5	1862.3	99.1%		8.73	8.94
KLO9	3.85	1.57	5.42	DE	CoeVar DE										0.5%	3.6%		2.2%		2.8%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
KLO9X 5	3.85	1.57	5.42	A	Initial					185											
KLO9X 5	3.85	1.57	5.42	A	S1					272	87		9.7								
KLO9X 5	3.85	1.57	5.42	A	S2					314	42		21.1								
KLO9X 5	3.85	1.57	5.42	A	1					348	34	54.3	26.4							9.10	
KLO9X 5	3.85	1.57	5.42	A	2					376	28	34.7	32.4							8.29	
KLO9X 5	3.85	1.57	5.42	A	3					401	25	29.0	36.6							8.80	
KLO9X 5	3.85	1.57	5.42	A	4					416	15	22.7	62.9								
KLO9X 5	3.85	1.57	5.42	A	5					434	18	19.3	51.9								
KLO9X 5	3.85	1.57	5.42	A	6					449	HIT										
KLO9X 5	3.85	1.57	5.42	A	7																
KLO9X 5	3.85	1.57	5.42	A	8																
KLO9X 5	3.85	1.57	5.42	A	9																
KLO9X 5	3.85	1.57	5.42	A	10																
KLO9X 5	3.85	1.57	5.42	A	11																
KLO9X 5	3.85	1.57	5.42	A	Median A						28		32.4								
KLO9X 5	3.85	1.57	5.42	A	W Mean A S1-end						50.0		17.5								
KLO9X 5	3.85	1.57	5.42	A	W Mean A S2-end						30.1		30.0								
KLO9X 5	3.85	1.57	5.42	A	W Mean A 1-end						26.0		35.2								
KLO9X 5	3.85	1.57	5.42	A	W Mean A 3-7						26.0		35.2								
KLO9X 5	3.85	1.57	5.42	A	Mean A 3-7						24.0		38.2								
KLO9X 5	3.85	1.57	5.42	A	Mean A 4-8						21.5		43.0								
KLO9X 5	3.85	1.57	5.42	A	Mean A						24.0		42.1							8.73	
KLO9X 5	3.85	1.57	5.42	A	CoeVar A						31.9%		35.7%							0.05	
KLO9X 5	3.85	1.57	5.42	B	Initial					180											
KLO9X 5	3.85	1.57	5.42	B	S1	3.1	0.099	2198	6.2	266	86		9.9								
KLO9X 5	3.85	1.57	5.42	B	S2	3.5	0.111	521	29.6	304	38		23.5								
KLO9X 5	3.85	1.57	5.42	B	1	3.5	0.111	425	36.3	333	29	51.0	31.3							8.81	
KLO9X 5	3.85	1.57	5.42	B	2	3.5	0.111	393	39.3	359	26	31.0	35.1							8.82	
KLO9X 5	3.85	1.57	5.42	B	3	3.5	0.111	370	41.7	380	21	25.3	44.0							8.94	
KLO9X 5	3.85	1.57	5.42	B	4	5.6	0.178	682	36.2	400	20	22.3	46.4								
KLO9X 5	3.85	1.57	5.42	B	5	5.7	0.181	585	43.0	415	15	18.7	62.9								
KLO9X 5	3.85	1.57	5.42	B	6	5.6	0.178	540	45.8	430	15	16.7	62.9								
KLO9X 5	3.85	1.57	5.42	B	7	8.1	0.258	787	45.4	442	HIT										
KLO9X 5	3.85	1.57	5.42	B	8	8.2	0.261	710	51.0												
KLO9X 5	3.85	1.57	5.42	B	9	8.2	0.261	671	53.9												
KLO9X 5	3.85	1.57	5.42	B	10																
KLO9X 5	3.85	1.57	5.42	B	11																
KLO9X 5	3.85	1.57	5.42	B	Mean H1	3.50	0.111	396.00	39.13												
KLO9X 5	3.85	1.57	5.42	B	Mean H2	5.63	0.179	602.33	41.67												
KLO9X 5	3.85	1.57	5.42	B	Mean H3	8.17	0.260	722.67	50.11												
KLO9X 5	3.85	1.57	5.42	B	CoeVar H1	0.0%	0.0%	7.0%	6.9%												
KLO9X 5	3.85	1.57	5.42	B	CoeVar H2	1.0%	1.0%	12.0%	11.8%												
KLO9X 5	3.85	1.57	5.42	B	CoeVar H3	0.7%	0.7%	8.2%	8.6%												
KLO9X 5	3.85	1.57	5.42	B	Median B						23.5		39.1								
KLO9X 5	3.85	1.57	5.42	B	W Mean B S1-end						46.6		18.9								
KLO9X 5	3.85	1.57	5.42	B	W Mean B S2-end						25.9		35.2								
KLO9X 5	3.85	1.57	5.42	B	W Mean B 1-end						22.3		41.3								
KLO9X 5	3.85	1.57	5.42	B	W Mean B 3-7						23.3		39.5								
KLO9X 5	3.85	1.57	5.42	B	Mean B 3-7						22.2		41.5								
KLO9X 5	3.85	1.57	5.42	B	Mean B 4-8						19.4		47.9								
KLO9X 5	3.85	1.57	5.42	B	Mean B						17.8		54.1							8.86	
KLO9X 5	3.85	1.57	5.42	B	CoeVar B						32.1%		24.9%							0.8%	
KLO9X 5	3.85	1.57	5.42	C	Initial					169											
KLO9X 5	3.85	1.57	5.42	C	S1					266	97		8.7								
KLO9X 5	3.85	1.57	5.42	C	S2					306	40		22.2								
KLO9X 5	3.85	1.57	5.42	C	1					335	29	55.3	31.3							9.09	
KLO9X 5	3.85	1.57	5.42	C	2					359	24	31.0	38.2							9.06	
KLO9X 5	3.85	1.57	5.42	C	3					382	23	25.3	40.0							8.78	
KLO9X 5	3.85	1.57	5.42	C	4					400	18	21.7	51.9								
KLO9X 5	3.85	1.57	5.42	C	5					418	18	19.7	51.9								
KLO9X 5	3.85	1.57	5.42	C	6					435	17	17.7	55.1								
KLO9X 5	3.85	1.57	5.42	C	7					443	HIT										
KLO9X 5	3.85	1.57	5.42	C	8																
KLO9X 5	3.85	1.57	5.42	C	9																
KLO9X 5	3.85	1.57	5.42	C	10																
KLO9X 5	3.85	1.57	5.42	C	11																
KLO9X 5	3.85	1.57	5.42	C	Median C						23.5		39.1								
KLO9X 5	3.85	1.57	5.42	C	W Mean C S1-end						52.2		16.7								
KLO9X 5	3.85	1.57	5.42	C	W Mean C S2-end						26.5		34.4								
KLO9X 5	3.85	1.57	5.42	C	W Mean C 1-end						22.3		41.2								
KLO9X 5	3.85	1.57	5.42	C	W Mean C 3-7						23.2		39.7								
KLO9X 5	3.85	1.57	5.42	C	Mean C 3-7						22.4		41.1								
KLO9X 5	3.85	1.57	5.42	C	Mean C 4-8						20.0		46.4								
KLO9X 5	3.85	1.57	5.42	C	Mean C						21.5		44.7							8.98	
KLO9X 5	3.85	1.57	5.42	C	CoeVar C						21.8%		21.4%							1.9%	
KLO9X 5	3.85	1.57	5.42	D	1									1881.8	1915.6		1862.3	102.9%	101.0%	8.26	
KLO9X 5	3.85	1.57	5.42	E	1									1881.8		1911.2	1862.3	102.6%	101.0%	8.89	
KLO9X 5	3.85	1.57	5.42	D	2									1881.8	1955.6		1862.3	105.0%	101.0%	9.06	
KLO9X 5	3.85	1.57	5.42	E	2									1881.8		1937.5	1862.3	104.0%	101.0%	8.90	
KLO9X 5	3.85	1.57	5.42	DE	Mean DE									1881.8	1935.6	1924.3	1862.3	103.6%		8.78	
KLO9X 5	3.85	1.57	5.42	DE	CoeVar DE										1.5%	1.0%		1.1%		4.0%	8.84

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
KLO10	3.85	1.57	5.42	A	Initial					62											
KLO10	3.85	1.57	5.42	A	S1					137	75		11.4								
KLO10	3.85	1.57	5.42	A	S2					183	46		19.2								
KLO10	3.85	1.57	5.42	A	1					218	35	52.0	25.6							11.00	
KLO10	3.85	1.57	5.42	A	2					246	28	36.3	32.4							10.62	
KLO10	3.85	1.57	5.42	A	3					270	24	29.0	38.2							10.39	
KLO10	3.85	1.57	5.42	A	4					289	19	23.7	49.0								
KLO10	3.85	1.57	5.42	A	5					308	19	20.7	49.0								
KLO10	3.85	1.57	5.42	A	6					325	HIT										
KLO10	3.85	1.57	5.42	A	7																
KLO10	3.85	1.57	5.42	A	8																
KLO10	3.85	1.57	5.42	A	Median A						28		32.4								
KLO10	3.85	1.57	5.42	A	W Mean A S1-end						44.9		19.6								
KLO10	3.85	1.57	5.42	A	W Mean A S2-end						31.7		28.4								
KLO10	3.85	1.57	5.42	A	W Mean A 1-end						26.5		34.5								
KLO10	3.85	1.57	5.42	A	W Mean A 3-7						26.5		34.5								
KLO10	3.85	1.57	5.42	A	Mean A 3-7						25.0		36.6								
KLO10	3.85	1.57	5.42	A	Mean A 4-8						22.5		40.9								
KLO10	3.85	1.57	5.42	A	Mean A						25.0		38.8							10.67	
KLO10	3.85	1.57	5.42	A	CoeVar A						27.0%		26.4%							0.03	
KLO10	3.85	1.57	5.42	B	Initial					69											
KLO10	3.85	1.57	5.42	B	S1	2.8	0.089	961	12.9	145	76		11.2								
KLO10	3.85	1.57	5.42	B	S2	3.3	0.105	597	24.4	190	45		19.6								
KLO10	3.85	1.57	5.42	B	1	3.3	0.105	571	25.5	224	34	51.7	26.4							10.36	
KLO10	3.85	1.57	5.42	B	2	3.3	0.105	572	25.5	253	29	36.0	31.3							10.83	
KLO10	3.85	1.57	5.42	B	3	3.3	0.105	548	26.6	277	24	29.0	38.2							10.87	
KLO10	3.85	1.57	5.42	B	4	5.4	0.172	653	36.5	298	21	24.7	44.0								
KLO10	3.85	1.57	5.42	B	5	5.3	0.169	743	31.5	315	17	20.7	55.1								
KLO10	3.85	1.57	5.42	B	6	5.4	0.172	725	32.9	329	HIT										
KLO10	3.85	1.57	5.42	B	7	7.9	0.251	871	40.0												
KLO10	3.85	1.57	5.42	B	8	7.9	0.251	844	41.3												
KLO10	3.85	1.57	5.42	B	9	8.1	0.258	829	43.1												
KLO10	3.85	1.57	5.42	B	Mean H1	3.30	0.105	563.67	25.85												
KLO10	3.85	1.57	5.42	B	Mean H2	5.37	0.171	707.00	33.62												
KLO10	3.85	1.57	5.42	B	Mean H3	7.97	0.254	848.00	41.49												
KLO10	3.85	1.57	5.42	B	CoeVar H1	0.0%	0.0%	2.4%	2.4%												
KLO10	3.85	1.57	5.42	B	CoeVar H2	1.1%	1.1%	6.7%	7.7%												
KLO10	3.85	1.57	5.42	B	CoeVar H3	1.4%	1.4%	2.5%	3.7%												
KLO10	3.85	1.57	5.42	B	Median B						29		31.3								
KLO10	3.85	1.57	5.42	B	W Mean B S1-end						45.1		19.5								
KLO10	3.85	1.57	5.42	B	W Mean B S2-end						31.3		28.8								
KLO10	3.85	1.57	5.42	B	W Mean B 1-end						26.4		34.5								
KLO10	3.85	1.57	5.42	B	W Mean B 3-7						26.4		34.5								
KLO10	3.85	1.57	5.42	B	Mean B 3-7						25.0		36.6								
KLO10	3.85	1.57	5.42	B	Mean B 4-8						22.8		40.5								
KLO10	3.85	1.57	5.42	B	Mean B						25.0		39.0							10.69	
KLO10	3.85	1.57	5.42	B	CoeVar B						26.7%		28.8%							2.6%	
KLO10	3.85	1.57	5.42	C	Initial					67											
KLO10	3.85	1.57	5.42	C	S1					130	63		13.7								
KLO10	3.85	1.57	5.42	C	S2					176	46		19.2								
KLO10	3.85	1.57	5.42	C	1					207	31	46.7	29.1							10.49	
KLO10	3.85	1.57	5.42	C	2					235	28	35.0	32.4							10.26	
KLO10	3.85	1.57	5.42	C	3					258	23	27.3	40.0							10.93	
KLO10	3.85	1.57	5.42	C	4					279	21	24.0	44.0								
KLO10	3.85	1.57	5.42	C	5					297	18	20.7	51.9								
KLO10	3.85	1.57	5.42	C	6					313	16	18.3	58.8								
KLO10	3.85	1.57	5.42	C	7					326	HIT										
KLO10	3.85	1.57	5.42	C	8																
KLO10	3.85	1.57	5.42	C	Median C						25.5		35.8								
KLO10	3.85	1.57	5.42	C	W Mean C S1-end						38.1		23.4								
KLO10	3.85	1.57	5.42	C	W Mean C S2-end						29.6		30.6								
KLO10	3.85	1.57	5.42	C	W Mean C 1-end						24.1		38.1								
KLO10	3.85	1.57	5.42	C	W Mean C 3-7						25.1		36.4								
KLO10	3.85	1.57	5.42	C	Mean C 3-7						24.2		37.9								
KLO10	3.85	1.57	5.42	C	Mean C 4-8						21.2		43.6								
KLO10	3.85	1.57	5.42	C	Mean C						22.8		42.7							10.56	
KLO10	3.85	1.57	5.42	C	CoeVar C						25.3%		26.5%							3.2%	
KLO10	3.85	1.57	5.42	D	1									1915.5	1843.12		1862.29	99.0%	102.9%	10.39	
KLO10	3.85	1.57	5.42	E	1									1915.5		1842.6	1862.3	98.9%	102.9%	10.36	
KLO10	3.85	1.57	5.42	D	2									1915.5	1937.59		1862.3	104.0%	102.9%	9.73	
KLO10	3.85	1.57	5.42	E	2									1915.5		1949.6	1862.3	104.7%	102.9%	9.97	
KLO10	3.85	1.57	5.42	DE	Mean DE									1915.5	1890.4	1896.1	1862.3	101.7%		10.11	10.51
KLO10	3.85	1.57	5.42	DE	CoeVar DE										3.5%	4.0%		3.1%		3.1%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
KLO10X 5	3.85	1.57	5.42	A	Initial					61											
KLO10X 5	3.85	1.57	5.42	A	S1					140	79		10.8								
KLO10X 5	3.85	1.57	5.42	A	S2					183	43		20.6								
KLO10X 5	3.85	1.57	5.42	A	1					217	34	52.0	26.4							9.79	
KLO10X 5	3.85	1.57	5.42	A	2					245	28	35.0	32.4							10.21	
KLO10X 5	3.85	1.57	5.42	A	3					271	26	29.3	35.1							10.12	
KLO10X 5	3.85	1.57	5.42	A	4					294	23	25.7	40.0								
KLO10X 5	3.85	1.57	5.42	A	5					314	20	23.0	46.4								
KLO10X 5	3.85	1.57	5.42	A	6					330	HIT										
KLO10X 5	3.85	1.57	5.42	A	7																
KLO10X 5	3.85	1.57	5.42	A	8																
KLO10X 5	3.85	1.57	5.42	A	9																
KLO10X 5	3.85	1.57	5.42	A	10																
KLO10X 5	3.85	1.57	5.42	A	11																
KLO10X 5	3.85	1.57	5.42	A	Median A						28		32.4								
KLO10X 5	3.85	1.57	5.42	A	W Mean A S1-end						46.0		19.2								
KLO10X 5	3.85	1.57	5.42	A	W Mean A S2-end						31.0		29.1								
KLO10X 5	3.85	1.57	5.42	A	W Mean A 1-end						27.1		33.6								
KLO10X 5	3.85	1.57	5.42	A	W Mean A 3-7						27.1		33.6								
KLO10X 5	3.85	1.57	5.42	A	Mean A 3-7						26.2		34.8								
KLO10X 5	3.85	1.57	5.42	A	Mean A 4-8						24.3		37.8								
KLO10X 5	3.85	1.57	5.42	A	Mean A						26.2		36.1							10.04	
KLO10X 5	3.85	1.57	5.42	A	CoeVar A						20.3%		21.0%							0.02	
KLO10X 5	3.85	1.57	5.42	B	Initial					69											
KLO10X 5	3.85	1.57	5.42	B	S1	3.2	0.102	1697	8.3	148	79		10.8								
KLO10X 5	3.85	1.57	5.42	B	S2	3.5	0.111	619	25.0	196	48		18.3								
KLO10X 5	3.85	1.57	5.42	B	1	3.5	0.111	553	27.9	231	35	54.0	25.6							10.29	
KLO10X 5	3.85	1.57	5.42	B	2	3.5	0.111	485	31.8	260	29	37.3	31.3							11.05	
KLO10X 5	3.85	1.57	5.42	B	3	3.4	0.108	477	31.5	287	27	30.3	33.7							10.61	
KLO10X 5	3.85	1.57	5.42	B	4	5.8	0.185	686	37.3	305	18	24.7	51.9								
KLO10X 5	3.85	1.57	5.42	B	5	5.6	0.178	635	38.9	324	19	21.3	49.0								
KLO10X 5	3.85	1.57	5.42	B	6	5.6	0.178	634	39.0	333	HIT										
KLO10X 5	3.85	1.57	5.42	B	7	8.1	0.258	842	42.5												
KLO10X 5	3.85	1.57	5.42	B	8	8.1	0.258	762	46.9												
KLO10X 5	3.85	1.57	5.42	B	9	8.2	0.261	732	49.4												
KLO10X 5	3.85	1.57	5.42	B	10																
KLO10X 5	3.85	1.57	5.42	B	11																
KLO10X 5	3.85	1.57	5.42	B	Mean H1	3.47	0.110	505.00	30.41												
KLO10X 5	3.85	1.57	5.42	B	Mean H2	5.67	0.180	651.67	38.40												
KLO10X 5	3.85	1.57	5.42	B	Mean H3	8.13	0.259	778.67	46.27												
KLO10X 5	3.85	1.57	5.42	B	CoeVar H1	1.7%	1.7%	8.3%	7.1%												
KLO10X 5	3.85	1.57	5.42	B	CoeVar H2	2.0%	2.0%	4.6%	2.5%												
KLO10X 5	3.85	1.57	5.42	B	CoeVar H3	0.7%	0.7%	7.3%	7.6%												
KLO10X 5	3.85	1.57	5.42	B	Median B						29		31.3								
KLO10X 5	3.85	1.57	5.42	B	W Mean B S1-end						47.2		18.7								
KLO10X 5	3.85	1.57	5.42	B	W Mean B S2-end						32.9		27.4								
KLO10X 5	3.85	1.57	5.42	B	W Mean B 1-end						27.2		33.5								
KLO10X 5	3.85	1.57	5.42	B	W Mean B 3-7						27.2		33.5								
KLO10X 5	3.85	1.57	5.42	B	Mean B 3-7						25.6		35.7								
KLO10X 5	3.85	1.57	5.42	B	Mean B 4-8						23.3		39.5								
KLO10X 5	3.85	1.57	5.42	B	Mean B						21.3		44.9							10.65	
KLO10X 5	3.85	1.57	5.42	B	CoeVar B						33.4%		25.7%							3.6%	
KLO10X 5	3.85	1.57	5.42	C	Initial					68											
KLO10X 5	3.85	1.57	5.42	C	S1					145	77		11.1								
KLO10X 5	3.85	1.57	5.42	C	S2					185	40		22.2								
KLO10X 5	3.85	1.57	5.42	C	1					214	29	48.7	31.3							9.63	
KLO10X 5	3.85	1.57	5.42	C	2					242	28	32.3	32.4							11.04	
KLO10X 5	3.85	1.57	5.42	C	3					266	24	27.0	38.2							10.81	
KLO10X 5	3.85	1.57	5.42	C	4					282	16	22.7	58.8								
KLO10X 5	3.85	1.57	5.42	C	5					297	15	18.3	62.9								
KLO10X 5	3.85	1.57	5.42	C	6					316	19	16.7	49.0								
KLO10X 5	3.85	1.57	5.42	C	7					330	HIT										
KLO10X 5	3.85	1.57	5.42	C	8																
KLO10X 5	3.85	1.57	5.42	C	9																
KLO10X 5	3.85	1.57	5.42	C	10																
KLO10X 5	3.85	1.57	5.42	C	11																
KLO10X 5	3.85	1.57	5.42	C	Median C						26		35.1								
KLO10X 5	3.85	1.57	5.42	C	W Mean C S1-end						42.6		20.8								
KLO10X 5	3.85	1.57	5.42	C	W Mean C S2-end						27.2		33.5								
KLO10X 5	3.85	1.57	5.42	C	W Mean C 1-end						23.2		39.6								
KLO10X 5	3.85	1.57	5.42	C	W Mean C 3-7						23.9		38.3								
KLO10X 5	3.85	1.57	5.42	C	Mean C 3-7						22.4		41.1								
KLO10X 5	3.85	1.57	5.42	C	Mean C 4-8						20.4		45.4								
KLO10X 5	3.85	1.57	5.42	C	Mean C						21.8		45.4							10.49	
KLO10X 5	3.85	1.57	5.42	C	CoeVar C						27.7%		29.8%							7.2%	
KLO10X 5	3.85	1.57	5.42	D	1									1916.3	1906.8		1862.3	102.4%	102.9%	10.31	
KLO10X 5	3.85	1.57	5.42	E	1									1916.3		1898.7	1862.3	102.0%	102.9%	10.09	
KLO10X 5	3.85	1.57	5.42	D	2									1916.3	1905.6		1862.3	102.3%	102.9%	9.87	
KLO10X 5	3.85	1.57	5.42	E	2									1916.3		1945.6	1862.3	104.5%	102.9%	10.23	
KLO10X 5	3.85	1.57	5.42	DE	Mean DE									1916.3	1906.2	1922.2	1862.3	102.8%		10.13	10.33
KLO10X 5	3.85	1.57	5.42	DE	CoeVar DE										0.0%	1.7%		1.1%		1.9%	

Sample ID	Gradation			Location		LWD				DCP				Density						Moisture Content	
Sample	CGN	FGN	GN	Section	Trial	Force	Stress	Deflection	E	Reading	DPI	3 pt avg	E	Barrel	S cone	L cone	Proctor	Relative cone	Relative barrel	Oven-dry	
					#	[kN]	[MPa]	[mm]	[MPa]	[mm]	[mm/blow]	[mm/blow]	[MPa]	[kg/m3]	[kg/m3]	[kg/m3]	[kg/m3]	[%]	[%]	[%]	[%]
KLO11	3.85	1.57	5.42	A	Initial					205											
KLO11	3.85	1.57	5.42	A	S1					312	107		7.8								
KLO11	3.85	1.57	5.42	A	S2					392	80		10.6								
KLO11	3.85	1.57	5.42	A	1					441	HIT									13.09	
KLO11	3.85	1.57	5.42	A	2															12.92	
KLO11	3.85	1.57	5.42	A	3															12.60	
KLO11	3.85	1.57	5.42	A	4																
KLO11	3.85	1.57	5.42	A	5																
KLO11	3.85	1.57	5.42	A	6																
KLO11	3.85	1.57	5.42	A	7																
KLO11	3.85	1.57	5.42	A	8																
KLO11	3.85	1.57	5.42	A	Median A																
KLO11	3.85	1.57	5.42	A	Mean A															12.87	
KLO11	3.85	1.57	5.42	A	CoeVar A															0.02	
KLO11	3.85	1.57	5.42	B	Initial					190											
KLO11	3.85	1.57	5.42	B	S1	overload	na	na	na	283	93		9.1								
KLO11	3.85	1.57	5.42	B	S2	overload	na	na	na	344	61		14.2								
KLO11	3.85	1.57	5.42	B	1	overload	na	na	na	399	55	69.7	15.8							11.95	
KLO11	3.85	1.57	5.42	B	2	no read	na	na	na	427	HIT									12.74	
KLO11	3.85	1.57	5.42	B	3	3.2	0.102	2066	6.8											12.68	
KLO11	3.85	1.57	5.42	B	4	3.1	0.099	2114	6.5												
KLO11	3.85	1.57	5.42	B	5	3.2	0.102	2001	7.1												
KLO11	3.85	1.57	5.42	B	6	overload	na	na	na												
KLO11	3.85	1.57	5.42	B	7	overload	na	na	na												
KLO11	3.85	1.57	5.42	B	8	5.4	0.172	2060	11.6												
KLO11	3.85	1.57	5.42	B	9	5.5	0.175	2050	11.8												
KLO11	3.85	1.57	5.42	B	Mean H1	3.20	0.10	2066.00	6.84												
KLO11	3.85	1.57	5.42	B	Mean H2	3.15	0.10	2057.50	6.76												
KLO11	3.85	1.57	5.42	B	Mean H3	5.45	0.17	2055.00	11.70												
KLO11	3.85	1.57	5.42	B	CoeVar H1	1.8%	1.8%	2.7%	4.3%												
KLO11	3.85	1.57	5.42	B	CoeVar H2	2.2%	2.2%	3.9%	6.1%												
KLO11	3.85	1.57	5.42	B	CoeVar H3	1.3%	1.3%	0.3%	1.6%												
KLO11	3.85	1.57	5.42	B	Median B						61		14.2								
KLO11	3.85	1.57	5.42	B	W Mean B S1-end						73.7		11.6								
KLO11	3.85	1.57	5.42	B	W Mean B S2-end						58.2		14.9								
KLO11	3.85	1.57	5.42	B	W Mean B 1-end						55.0		15.8								
KLO11	3.85	1.57	5.42	B	W Mean B 3-7						55.0		15.8								
KLO11	3.85	1.57	5.42	B	Mean B 3-7						55.0		15.8								
KLO11	3.85	1.57	5.42	B	Mean B 4-8						0.0		-								
KLO11	3.85	1.57	5.42	B	Mean B						55.0		15.8							12.46	
KLO11	3.85	1.57	5.42	B	CoeVar B						-		-							3.5%	
KLO11	3.85	1.57	5.42	C	Initial					190											
KLO11	3.85	1.57	5.42	C	S1					282	92		9.2								
KLO11	3.85	1.57	5.42	C	S2					343	61		14.2								
KLO11	3.85	1.57	5.42	C	1					394	51	68.0	17.2							11.39	
KLO11	3.85	1.57	5.42	C	2					432	HIT									10.86	
KLO11	3.85	1.57	5.42	C	3															11.14	
KLO11	3.85	1.57	5.42	C	4																
KLO11	3.85	1.57	5.42	C	5																
KLO11	3.85	1.57	5.42	C	6																
KLO11	3.85	1.57	5.42	C	7																
KLO11	3.85	1.57	5.42	C	8																
KLO11	3.85	1.57	5.42	C	Median C						61		14.2								
KLO11	3.85	1.57	5.42	C	W Mean C S1-end						72.5		11.8								
KLO11	3.85	1.57	5.42	C	W Mean C S2-end						56.4		15.4								
KLO11	3.85	1.57	5.42	C	W Mean C 1-end						51.0		17.2								
KLO11	3.85	1.57	5.42	C	W Mean C 3-7						51.0		17.2								
KLO11	3.85	1.57	5.42	C	Mean C 3-7						51.0		17.2								
KLO11	3.85	1.57	5.42	C	Mean C 4-8						0.0		-								
KLO11	3.85	1.57	5.42	C	Mean C						51.0		17.2							11.13	
KLO11	3.85	1.57	5.42	C	CoeVar C						-		-							2.4%	
KLO11	3.85	1.57	5.42	D	1									1868.6	1841.0		1862.3	98.9%	100.3%	12.05	
KLO11	3.85	1.57	5.42	E	1									1868.6		1870.4	1862.3	100.4%	100.3%	12.04	
KLO11	3.85	1.57	5.42	D	2									1868.6	1921.1		1862.3	103.2%	100.3%	11.49	
KLO11	3.85	1.57	5.42	E	2									1868.6		1888.8	1862.3	101.4%	100.3%	11.25	
KLO11	3.85	1.57	5.42	DE	Mean DE									1868.6	1881.0	1879.6	1862.3	101.0%		11.71	12.04
KLO11	3.85	1.57	5.42	DE	CoeVar DE										3.0%	0.7%		1.8%		3.4%	

Appendix I – Fine Grained Soil Data

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	100%	102.3%	97.7%	1

Depth of cone below surface at start [mm]: 10

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	$[mm^2/blow^2]$	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	$[mm^2/blow^2]$
0	10.0	0.0	10.0	--	--	–	--	–	–	--	–
1	48.0	38.0	48.0	29.0	38.0	1444.0	--	–	–	--	–
2	83.0	73.0	83.0	65.5	35.0	1225.0	--	35.0	35.0	--	–
3	117.0	107.0	117.0	100.0	34.0	1156.0	35.7	34.5	34.5	34.5	1173.0
4	154.0	144.0	154.0	135.5	37.0	1369.0	35.4	35.3	35.4	35.5	1313.5
5	190.0	180.0	190.0	172.0	36.0	1296.0	35.7	35.5	35.5	36.5	1314.0
6	227.0	217.0	227.0	208.5	37.0	1369.0	36.7	35.8	35.8	36.5	1350.5
7	265.0	255.0	265.0	246.0	38.0	1444.0	37.0	36.2	36.2	37.5	1425.0
8	--	--	–	--	--	–	--	–	–	--	–
9	--	--	–	--	--	–	--	–	–	--	–
10	--	--	–	--	--	–	--	–	–	--	–
11	--	--	–	--	--	–	--	–	–	--	–
12	--	--	–	--	--	–	--	–	–	--	–

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	36.13
E[1]	[MPa]	24.75
DPI5[2]	[mm/blow]	N/A
E[2]	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	100%	102.3%	97.7%	2

Depth of cone below surface at start [mm]: 12

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	$[mm^2/blow^2]$	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	$[mm^2/blow^2]$
0	12.0	0.0	12.0	--	--	–	--	–	–	--	–
1	52.0	40.0	52.0	32.0	40.0	1600.0	--	–	–	--	–
2	87.0	75.0	87.0	69.5	35.0	1225.0	--	35.0	35.0	--	–
3	123.0	111.0	123.0	105.0	36.0	1296.0	37.1	35.5	35.5	35.5	1278.0
4	160.0	148.0	160.0	141.5	37.0	1369.0	36.0	36.0	36.0	36.5	1350.5
5	200.0	188.0	200.0	180.0	40.0	1600.0	37.7	37.0	37.1	38.5	1540.0
6	239.0	227.0	239.0	219.5	39.0	1521.0	38.7	37.4	37.5	39.5	1540.5
7	274.0	262.0	274.0	256.5	35.0	1225.0	38.1	37.0	37.1	37.0	1295.0
8	--	--	–	--	--	–	--	–	–	--	–
9	--	--	–	--	--	–	--	–	–	--	–
10	--	--	–	--	--	–	--	–	–	--	–
11	--	--	–	--	--	–	--	–	–	--	–
12	--	--	–	--	--	–	--	–	–	--	–

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	37.45
E[1]	[MPa]	23.83
DPI5[2]	[mm/blow]	N/A
E[2]	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	100%	75.4%	99.2%	1

Depth of cone below surface at start [mm]: 8

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	8.0	0.0	8.0	--	--	--	--	--	--	--	--
1	26.0	18.0	26.0	17.0	18.0	324.0	--	--	--	--	--
2	37.0	29.0	37.0	31.5	11.0	121.0	--	11.0	11.0	--	--
3	45.0	37.0	45.0	41.0	8.0	64.0	13.8	9.5	9.7	9.5	76.0
4	56.0	48.0	56.0	50.5	11.0	121.0	10.2	10.0	10.2	9.5	104.5
5	67.0	59.0	67.0	61.5	11.0	121.0	10.2	10.3	10.4	11.0	121.0
6	78.0	70.0	78.0	72.5	11.0	121.0	11.0	10.4	10.5	11.0	121.0
7	90.0	82.0	90.0	84.0	12.0	144.0	11.4	10.7	10.8	11.5	138.0
8	100.0	92.0	100.0	95.0	10.0	100.0	11.1	10.6	10.7	11.0	110.0
9	112.0	104.0	112.0	106.0	12.0	144.0	11.4	10.8	10.9	11.0	132.0
10	122.0	114.0	122.0	117.0	10.0	100.0	10.8	10.7	10.8	11.0	110.0
11	134.5	126.5	134.5	128.3	12.5	156.3	11.6	10.9	11.0	11.3	140.6
12	147.0	139.0	147.0	140.8	12.5	156.3	11.8	11.0	11.1	12.5	156.3
13	158.0	150.0	158.0	152.5	11.0	121.0	12.0	11.0	11.1	--	--
14	173.0	165.0	173.0	165.5	15.0	225.0	13.0	11.3	11.5	--	--
15	187.0	179.0	187.0	180.0	14.0	196.0	13.6	11.5	11.7	--	--
16	199.0	191.0	199.0	193.0	12.0	144.0	13.8	11.5	11.8	--	--
17	213.0	205.0	213.0	206.0	14.0	196.0	13.4	11.7	11.9	--	--
18	224.0	216.0	224.0	218.5	11.0	121.0	12.5	11.6	11.9	--	--
19	239.0	231.0	239.0	231.5	15.0	225.0	13.6	11.8	12.1	--	--
20	253.0	245.0	253.0	246.0	14.0	196.0	13.6	11.9	12.2	--	--
21	269.5	261.5	269.5	261.3	16.5	272.3	15.2	12.2	12.5	--	--
22	282.0	274.0	282.0	275.8	12.5	156.3	14.5	12.2	12.5	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	10.58
E^1	[MPa]	91.23
$DPI5^2$	[mm/blow]	11.38
E^2	[MPa]	84.37

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	100%	75.4%	99.2%	2

Depth of cone below surface at start [mm]: 7

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	7.0	0.0	7.0	--	--	--	--	--	--	--	--
1	25.0	18.0	25.0	16.0	18.0	324.0	--	--	--	--	--
2	35.0	28.0	35.0	30.0	10.0	100.0	--	10.0	10.0	--	--
3	45.0	38.0	45.0	40.0	10.0	100.0	13.8	10.0	10.0	10.0	100.0
4	57.0	50.0	57.0	51.0	12.0	144.0	10.8	10.7	10.8	11.0	132.0
5	66.0	59.0	66.0	61.5	9.0	81.0	10.5	10.3	10.4	10.5	94.5
6	77.0	70.0	77.0	71.5	11.0	121.0	10.8	10.4	10.5	10.0	110.0
7	90.0	83.0	90.0	83.5	13.0	169.0	11.2	10.8	11.0	12.0	156.0
8	100.0	93.0	100.0	95.0	10.0	100.0	11.5	10.7	10.9	11.5	115.0
9	112.0	105.0	112.0	106.0	12.0	144.0	11.8	10.9	11.0	11.0	132.0
10	125.0	118.0	125.0	118.5	13.0	169.0	11.8	11.1	11.3	12.5	162.5
11	136.0	129.0	136.0	130.5	11.0	121.0	12.1	11.1	11.3	12.0	132.0
12	148.0	141.0	148.0	142.0	12.0	144.0	12.1	11.2	11.3	11.5	138.0
13	160.0	153.0	160.0	154.0	12.0	144.0	11.7	11.3	11.4	--	--
14	172.0	165.0	172.0	166.0	12.0	144.0	12.0	11.3	11.4	--	--
15	183.0	176.0	183.0	177.5	11.0	121.0	11.7	11.3	11.4	--	--
16	196.0	189.0	196.0	189.5	13.0	169.0	12.1	11.4	11.5	--	--
17	208.0	201.0	208.0	202.0	12.0	144.0	12.1	11.4	11.6	--	--
18	223.0	216.0	223.0	215.5	15.0	225.0	13.5	11.6	11.8	--	--
19	236.0	229.0	236.0	229.5	13.0	169.0	13.5	11.7	11.9	--	--
20	250.0	243.0	250.0	243.0	14.0	196.0	14.0	11.8	12.0	--	--
21	264.0	257.0	264.0	257.0	14.0	196.0	13.7	12.0	12.1	--	--
22	277.0	270.0	277.0	270.5	13.0	169.0	13.7	12.0	12.2	--	--
23	289.0	282.0	289.0	283.0	12.0	144.0	13.1	12.0	12.2	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	10.77
E^1	[MPa]	89.45
$DPI5^2$	[mm/blow]	11.72
E^2	[MPa]	81.83

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	100%	71.5%	93.5%	1

Depth of cone below surface at start [mm]: 7

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	7.0	0.0	7.0	--	--	--	--	--	--	--	--
1	21.0	14.0	21.0	14.0	14.0	196.0	--	--	--	--	--
2	28.0	21.0	28.0	24.5	7.0	49.0	--	7.0	7.0	--	--
3	35.0	28.0	35.0	31.5	7.0	49.0	10.5	7.0	7.0	7.0	49.0
4	40.0	33.0	40.0	37.5	5.0	25.0	6.5	6.3	6.5	6.0	30.0
5	47.0	40.0	47.0	43.5	7.0	49.0	6.5	6.5	6.6	6.0	42.0
6	55.0	48.0	55.0	51.0	8.0	64.0	6.9	6.8	6.9	7.5	60.0
7	59.0	52.0	59.0	57.0	4.0	16.0	6.8	6.3	6.6	6.0	24.0
8	67.0	60.0	67.0	63.0	8.0	64.0	7.2	6.6	6.9	6.0	48.0
9	75.0	68.0	75.0	71.0	8.0	64.0	7.2	6.8	7.0	8.0	64.0
10	80.0	73.0	80.0	77.5	5.0	25.0	7.3	6.6	6.9	6.5	32.5
11	89.0	82.0	89.0	84.5	9.0	81.0	7.7	6.8	7.1	7.0	63.0
12	95.0	88.0	95.0	92.0	6.0	36.0	7.1	6.7	7.1	7.5	45.0
13	102.0	95.0	102.0	98.5	7.0	49.0	7.5	6.8	7.0	--	--
14	109.0	102.0	109.0	105.5	7.0	49.0	6.7	6.8	7.0	--	--
15	117.0	110.0	117.0	113.0	8.0	64.0	7.4	6.9	7.1	--	--
16	123.0	116.0	123.0	120.0	6.0	36.0	7.1	6.8	7.1	--	--
17	131.0	124.0	131.0	127.0	8.0	64.0	7.5	6.9	7.1	--	--
18	139.0	132.0	139.0	135.0	8.0	64.0	7.5	6.9	7.2	--	--
19	147.0	140.0	147.0	143.0	8.0	64.0	8.0	7.0	7.2	--	--
20	155.0	148.0	155.0	151.0	8.0	64.0	8.0	7.1	7.3	--	--
21	164.0	157.0	164.0	159.5	9.0	81.0	8.4	7.2	7.4	--	--
22	172.0	165.0	172.0	168.0	8.0	64.0	8.4	7.2	7.4	--	--
23	180.0	173.0	180.0	176.0	8.0	64.0	8.4	7.2	7.5	--	--
24	189.0	182.0	189.0	184.5	9.0	81.0	8.4	7.3	7.5	--	--
25	202.0	195.0	202.0	195.5	13.0	169.0	10.5	7.5	7.9	--	--
26	210.0	203.0	210.0	206.0	8.0	64.0	10.5	7.6	7.9	--	--
27	219.0	212.0	219.0	214.5	9.0	81.0	10.5	7.6	8.0	--	--
28	228.0	221.0	228.0	223.5	9.0	81.0	8.7	7.7	8.0	--	--
29	236.0	229.0	236.0	232.0	8.0	64.0	8.7	7.7	8.0	--	--
30	244.0	237.0	244.0	240.0	8.0	64.0	8.4	7.7	8.0	--	--
31	255.0	248.0	255.0	249.5	11.0	121.0	9.2	7.8	8.2	--	--
32	263.0	256.0	263.0	259.0	8.0	64.0	9.2	7.8	8.2	--	--
33	270.0	263.0	270.0	266.5	7.0	49.0	9.0	7.8	8.1	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	6.61
E^1	[MPa]	150.18
$DPI5^2$	[mm/blow]	7.01
E^2	[MPa]	141.08

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	100%	71.5%	93.5%	2

Depth of cone below surface at start [mm]: 4

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	4.0	0.0	4.0	--	--	--	--	--	--	--	--
1	19.0	15.0	19.0	11.5	15.0	225.0	--	--	--	--	--
2	29.0	25.0	29.0	24.0	10.0	100.0	--	10.0	10.0	--	--
3	36.0	32.0	36.0	32.5	7.0	49.0	11.7	8.5	8.8	8.5	59.5
4	42.0	38.0	42.0	39.0	6.0	36.0	8.0	7.7	8.0	6.5	39.0
5	47.0	43.0	47.0	44.5	5.0	25.0	6.1	7.0	7.5	5.5	27.5
6	55.0	51.0	55.0	51.0	8.0	64.0	6.6	7.2	7.6	6.5	52.0
7	62.0	58.0	62.0	58.5	7.0	49.0	6.9	7.2	7.5	7.5	52.5
8	70.0	66.0	70.0	66.0	8.0	64.0	7.7	7.3	7.6	7.5	60.0
9	76.0	72.0	76.0	73.0	6.0	36.0	7.1	7.1	7.4	7.0	42.0
10	83.0	79.0	83.0	79.5	7.0	49.0	7.1	7.1	7.4	6.5	45.5
11	88.0	84.0	88.0	85.5	5.0	25.0	6.1	6.9	7.2	6.0	30.0
12	95.0	91.0	95.0	91.5	7.0	49.0	6.5	6.9	7.2	6.0	42.0
13	102.0	98.0	102.0	98.5	7.0	49.0	6.5	6.9	7.2	--	--
14	110.0	106.0	110.0	106.0	8.0	64.0	7.4	7.0	7.2	--	--
15	117.0	113.0	117.0	113.5	7.0	49.0	7.4	7.0	7.2	--	--
16	124.0	120.0	124.0	120.5	7.0	49.0	7.4	7.0	7.2	--	--
17	130.0	126.0	130.0	127.0	6.0	36.0	6.7	6.9	7.1	--	--
18	138.0	134.0	138.0	134.0	8.0	64.0	7.1	7.0	7.2	--	--
19	147.0	143.0	147.0	142.5	9.0	81.0	7.9	7.1	7.3	--	--
20	155.0	151.0	155.0	151.0	8.0	64.0	8.4	7.2	7.4	--	--
21	163.0	159.0	163.0	159.0	8.0	64.0	8.4	7.2	7.4	--	--
22	171.0	167.0	171.0	167.0	8.0	64.0	8.0	7.2	7.4	--	--
23	179.0	175.0	179.0	175.0	8.0	64.0	8.0	7.3	7.5	--	--
24	188.0	184.0	188.0	183.5	9.0	81.0	8.4	7.3	7.5	--	--
25	197.0	193.0	197.0	192.5	9.0	81.0	8.7	7.4	7.6	--	--
26	205.0	201.0	205.0	201.0	8.0	64.0	8.7	7.4	7.6	--	--
27	213.0	209.0	213.0	209.0	8.0	64.0	8.4	7.5	7.6	--	--
28	221.0	217.0	221.0	217.0	8.0	64.0	8.0	7.5	7.7	--	--
29	230.0	226.0	230.0	225.5	9.0	81.0	8.4	7.5	7.7	--	--
30	239.0	235.0	239.0	234.5	9.0	81.0	8.7	7.6	7.8	--	--
31	248.0	244.0	248.0	243.5	9.0	81.0	9.0	7.6	7.8	--	--
32	256.0	252.0	256.0	252.0	8.0	64.0	8.7	7.6	7.8	--	--
33	266.0	262.0	266.0	261.0	10.0	100.0	9.1	7.7	7.9	--	--
34	272.0	268.0	272.0	269.0	6.0	36.0	8.3	7.7	7.9	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	6.98
E^1	[MPa]	141.70
$DPI5^2$	[mm/blow]	6.65
E^2	[MPa]	149.25

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	105%	92.5%	103.2%	1

Depth of cone below surface at start [mm]: 5

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	5.0	0.0	5.0	--	--	--	--	--	--	--	--
1	26.0	21.0	26.0	15.5	21.0	441.0	--	--	--	--	--
2	39.0	34.0	39.0	32.5	13.0	169.0	--	13.0	13.0	--	--
3	51.0	46.0	51.0	45.0	12.0	144.0	16.4	12.5	12.5	12.5	150.0
4	65.0	60.0	65.0	58.0	14.0	196.0	13.1	13.0	13.1	13.0	182.0
5	80.0	75.0	80.0	72.5	15.0	225.0	13.8	13.5	13.6	14.5	217.5
6	92.0	87.0	92.0	86.0	12.0	144.0	13.8	13.2	13.3	13.5	162.0
7	105.0	100.0	105.0	98.5	13.0	169.0	13.5	13.2	13.3	12.5	162.5
8	117.0	112.0	117.0	111.0	12.0	144.0	12.4	13.0	13.1	12.5	150.0
9	123.0	118.0	123.0	120.0	6.0	36.0	11.3	12.1	12.6	9.0	54.0
10	135.0	130.0	135.0	129.0	12.0	144.0	10.8	12.1	12.6	9.0	108.0
11	145.5	140.5	145.5	140.3	10.5	110.3	10.2	12.0	12.4	11.3	118.1
12	157.5	152.5	157.5	151.5	12.0	144.0	11.5	12.0	12.4	11.3	135.0
13	172.0	167.0	172.0	164.8	14.5	210.3	12.6	12.2	12.6		
14	184.5	179.5	184.5	178.3	12.5	156.3	13.1	12.2	12.6	--	--
15	201.0	196.0	201.0	192.8	16.5	272.3	14.7	12.5	12.9	--	--
16	211.0	206.0	211.0	206.0	10.0	100.0	13.6	12.3	12.8	--	--
17	225.5	220.5	225.5	218.3	14.5	210.3	14.2	12.5	12.9	--	--
18	240.5	235.5	240.5	233.0	15.0	225.0	13.6	12.6	13.1	--	--
19	255.0	250.0	255.0	247.8	14.5	210.3	14.7	12.7	13.1	--	--
20	267.0	262.0	267.0	261.0	12.0	144.0	14.0	12.7	13.1	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	13.24
E^1	[MPa]	71.85
$DPI5^2$	[mm/blow]	10.76
E^2	[MPa]	89.53

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	105%	92.5%	103.2%	2

Depth of cone below surface at start [mm]: 2.5

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	2.5	0.0	2.5	--	--	--	--	--	--	--	--
1	26.0	23.5	26.0	14.3	23.5	552.3	--	--	--	--	--
2	39.0	36.5	39.0	32.5	13.0	169.0	--	13.0	13.0	--	--
3	50.0	47.5	50.0	44.5	11.0	121.0	17.7	12.0	12.1	12.0	132.0
4	61.0	58.5	61.0	55.5	11.0	121.0	11.7	11.7	11.7	11.0	121.0
5	75.0	72.5	75.0	68.0	14.0	196.0	12.2	12.3	12.4	12.5	175.0
6	88.0	85.5	88.0	81.5	13.0	169.0	12.8	12.4	12.5	13.5	175.5
7	99.0	96.5	99.0	93.5	11.0	121.0	12.8	12.2	12.3	12.0	132.0
8	108.0	105.5	108.0	103.5	9.0	81.0	11.2	11.7	11.9	10.0	90.0
9	118.5	116.0	118.5	113.3	10.5	110.3	10.2	11.6	11.8	9.8	102.4
10	130.0	127.5	130.0	124.3	11.5	132.3	10.4	11.6	11.7	11.0	126.5
11	141.0	138.5	141.0	135.5	11.0	121.0	11.0	11.5	11.7	11.3	123.8
12	155.0	152.5	155.0	148.0	14.0	196.0	12.3	11.7	11.9	12.5	175.0
13	163.0	160.5	163.0	159.0	8.0	64.0	11.5	11.4	11.7	--	--
14	178.0	175.5	178.0	170.5	15.0	225.0	13.1	11.7	12.0	--	--
15	187.5	185.0	187.5	182.8	9.5	90.3	11.7	11.5	11.9	--	--
16	197.5	195.0	197.5	192.5	10.0	100.0	12.0	11.4	11.8	--	--
17	210.5	208.0	210.5	204.0	13.0	169.0	11.1	11.5	11.8	--	--
18	223.0	220.5	223.0	216.8	12.5	156.3	12.0	11.6	11.9	--	--
19	235.0	232.5	235.0	229.0	12.0	144.0	12.5	11.6	11.9	--	--
20	251.0	248.5	251.0	243.0	16.0	256.0	13.7	11.8	12.2	--	--
21	266.0	263.5	266.0	258.5	15.0	225.0	14.5	12.0	12.4	--	--
22	278.5	276.0	278.5	272.3	12.5	156.3	14.6	12.0	12.4	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	12.26
E^1	[MPa]	77.99
$DPI5^2$	[mm/blow]	11.03
E^2	[MPa]	87.25

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	105%	73.4%	98.8%	1

Depth of cone below surface at start [mm]: 5

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	5.0	0.0	5.0	--	--	--	--	--	--	--	--
1	20.0	15.0	20.0	12.5	15.0	225.0	--	--	--	--	--
2	30.0	25.0	30.0	25.0	10.0	100.0	--	10.0	10.0	--	--
3	40.0	35.0	40.0	35.0	10.0	100.0	12.1	10.0	10.0	10.0	100.0
4	47.0	42.0	47.0	43.5	7.0	49.0	9.2	9.0	9.2	8.5	59.5
5	57.0	52.0	57.0	52.0	10.0	100.0	9.2	9.3	9.4	8.5	85.0
6	63.0	58.0	63.0	60.0	6.0	36.0	8.0	8.6	9.0	8.0	48.0
7	70.0	65.0	70.0	66.5	7.0	49.0	8.0	8.3	8.7	6.5	45.5
8	80.0	75.0	80.0	75.0	10.0	100.0	8.0	8.6	8.9	8.5	85.0
9	88.0	83.0	88.0	84.0	8.0	64.0	8.5	8.5	8.8	9.0	72.0
10	98.0	93.0	98.0	93.0	10.0	100.0	9.4	8.7	8.9	9.0	90.0
11	104.0	99.0	104.0	101.0	6.0	36.0	8.3	8.4	8.7	8.0	48.0
12	112.0	107.0	112.0	108.0	8.0	64.0	8.3	8.4	8.7	7.0	56.0
13	122.0	117.0	122.0	117.0	10.0	100.0	8.3	8.5	8.8	--	--
14	129.0	124.0	129.0	125.5	7.0	49.0	8.5	8.4	8.7	--	--
15	136.0	131.0	136.0	132.5	7.0	49.0	8.3	8.3	8.6	--	--
16	145.0	140.0	145.0	140.5	9.0	81.0	7.8	8.3	8.6	--	--
17	155.0	150.0	155.0	150.0	10.0	100.0	8.8	8.4	8.7	--	--
18	163.0	158.0	163.0	159.0	8.0	64.0	9.1	8.4	8.7	--	--
19	176.0	171.0	176.0	169.5	13.0	169.0	10.7	8.7	9.0	--	--
20	185.0	180.0	185.0	180.5	9.0	81.0	10.5	8.7	9.0	--	--
21	193.0	188.0	193.0	189.0	8.0	64.0	10.5	8.7	9.0	--	--
22	204.0	199.0	204.0	198.5	11.0	121.0	9.5	8.8	9.1	--	--
23	214.0	209.0	214.0	209.0	10.0	100.0	9.8	8.8	9.2	--	--
24	222.0	217.0	222.0	218.0	8.0	64.0	9.8	8.8	9.1	--	--
25	233.0	228.0	233.0	227.5	11.0	121.0	9.8	8.9	9.2	--	--
26	243.0	238.0	243.0	238.0	10.0	100.0	9.8	8.9	9.2	--	--
27	254.0	249.0	254.0	248.5	11.0	121.0	10.7	9.0	9.3	--	--
28	265.0	260.0	265.0	259.5	11.0	121.0	10.7	9.1	9.4	--	--
29	275.0	270.0	275.0	270.0	10.0	100.0	10.7	9.1	9.4	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	8.45
E^1	[MPa]	115.76
$DPI5^2$	[mm/blow]	8.36
E^2	[MPa]	117.13

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	105%	73.4%	98.8%	2

Depth of cone below surface at start [mm]: 5

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	5.0	0.0	5.0	--	--	--	--	--	--	--	--
1	23.0	18.0	23.0	14.0	18.0	324.0	--	--	--	--	--
2	30.0	25.0	30.0	26.5	7.0	49.0	--	7.0	7.0	--	--
3	36.0	31.0	36.0	33.0	6.0	36.0	13.2	6.5	6.5	6.5	39.0
4	43.0	38.0	43.0	39.5	7.0	49.0	6.7	6.7	6.7	6.5	45.5
5	50.0	45.0	50.0	46.5	7.0	49.0	6.7	6.8	6.8	7.0	49.0
6	59.0	54.0	59.0	54.5	9.0	81.0	7.8	7.2	7.3	8.0	72.0
7	67.0	62.0	67.0	63.0	8.0	64.0	8.1	7.3	7.5	8.5	68.0
8	73.0	68.0	73.0	70.0	6.0	36.0	7.9	7.1	7.3	7.0	42.0
9	82.0	77.0	82.0	77.5	9.0	81.0	7.9	7.4	7.5	7.5	67.5
10	88.0	83.0	88.0	85.0	6.0	36.0	7.3	7.2	7.4	7.5	45.0
11	95.0	90.0	95.0	91.5	7.0	49.0	7.5	7.2	7.4	6.5	45.5
12	102.0	97.0	102.0	98.5	7.0	49.0	6.7	7.2	7.3	7.0	49.0
13	108.0	103.0	108.0	105.0	6.0	36.0	6.7	7.1	7.2	--	--
14	117.0	112.0	117.0	112.5	9.0	81.0	7.5	7.2	7.4	--	--
15	125.0	120.0	125.0	121.0	8.0	64.0	7.9	7.3	7.5	--	--
16	133.0	128.0	133.0	129.0	8.0	64.0	8.4	7.3	7.5	--	--
17	140.0	135.0	140.0	136.5	7.0	49.0	7.7	7.3	7.5	--	--
18	149.0	144.0	149.0	144.5	9.0	81.0	8.1	7.4	7.6	--	--
19	159.0	154.0	159.0	154.0	10.0	100.0	8.8	7.6	7.8	--	--
20	167.0	162.0	167.0	163.0	8.0	64.0	9.1	7.6	7.8	--	--
21	175.0	170.0	175.0	171.0	8.0	64.0	8.8	7.6	7.8	--	--
22	184.0	179.0	184.0	179.5	9.0	81.0	8.4	7.7	7.8	--	--
23	193.0	188.0	193.0	188.5	9.0	81.0	8.7	7.7	7.9	--	--
24	200.0	195.0	200.0	196.5	7.0	49.0	8.4	7.7	7.9	--	--
25	209.0	204.0	209.0	204.5	9.0	81.0	8.4	7.8	7.9	--	--
26	218.0	213.0	218.0	213.5	9.0	81.0	8.4	7.8	8.0	--	--
27	227.0	222.0	227.0	222.5	9.0	81.0	9.0	7.8	8.0	--	--
28	236.0	231.0	236.0	231.5	9.0	81.0	9.0	7.9	8.1	--	--
29	245.0	240.0	245.0	240.5	9.0	81.0	9.0	7.9	8.1	--	--
30	254.0	249.0	254.0	249.5	9.0	81.0	9.0	8.0	8.1	--	--
31	262.0	257.0	262.0	258.0	8.0	64.0	8.7	8.0	8.1	--	--
32	272.0	267.0	272.0	267.0	10.0	100.0	9.1	8.0	8.2	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	7.39
E[1]	[MPa]	133.43
DPI5[2]	[mm/blow]	7.11
E[2]	[MPa]	138.97

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	105%	50.5%	98.3%	1

Depth of cone below surface at start [mm]: 5

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	5.0	0.0	5.0	--	--	--	--	--	--	--	--
1	15.0	10.0	15.0	10.0	10.0	100.0	--	--	--	--	--
2	22.0	17.0	22.0	18.5	7.0	49.0	--	7.0	7.0	--	--
3	27.0	22.0	27.0	24.5	5.0	25.0	7.9	6.0	6.2	6.0	30.0
4	30.0	25.0	30.0	28.5	3.0	9.0	5.5	5.0	5.5	4.0	12.0
5	34.0	29.0	34.0	32.0	4.0	16.0	4.2	4.8	5.2	3.5	14.0
6	38.0	33.0	38.0	36.0	4.0	16.0	3.7	4.6	5.0	4.0	16.0
7	44.0	39.0	44.0	41.0	6.0	36.0	4.9	4.8	5.2	5.0	30.0
8	49.0	44.0	49.0	46.5	5.0	25.0	5.1	4.9	5.2	5.5	27.5
9	54.0	49.0	54.0	51.5	5.0	25.0	5.4	4.9	5.2	5.0	25.0
10	58.0	53.0	58.0	56.0	4.0	16.0	4.7	4.8	5.0	4.5	18.0
11	63.0	58.0	63.0	60.5	5.0	25.0	4.7	4.8	5.0	4.5	22.5
12	67.0	62.0	67.0	65.0	4.0	16.0	4.4	4.7	5.0	4.5	18.0
13	72.0	67.0	72.0	69.5	5.0	25.0	4.7	4.8	5.0	--	--
14	77.0	72.0	77.0	74.5	5.0	25.0	4.7	4.8	5.0	--	--
15	83.0	78.0	83.0	80.0	6.0	36.0	5.4	4.9	5.1	--	--
16	85.0	80.0	85.0	84.0	2.0	4.0	5.0	4.7	5.0	--	--
17	90.0	85.0	90.0	87.5	5.0	25.0	5.0	4.7	5.0	--	--
18	96.0	91.0	96.0	93.0	6.0	36.0	5.0	4.8	5.0	--	--
19	100.0	95.0	100.0	98.0	4.0	16.0	5.1	4.7	5.0	--	--
20	106.0	101.0	106.0	103.0	6.0	36.0	5.5	4.8	5.1	--	--
21	109.0	104.0	109.0	107.5	3.0	9.0	4.7	4.7	5.0	--	--
22	115.0	110.0	115.0	112.0	6.0	36.0	5.4	4.8	5.1	--	--
23	120.0	115.0	120.0	117.5	5.0	25.0	5.0	4.8	5.1	--	--
24	125.0	120.0	125.0	122.5	5.0	25.0	5.4	4.8	5.1	--	--
25	129.0	124.0	129.0	127.0	4.0	16.0	4.7	4.8	5.0	--	--
26	135.0	130.0	135.0	132.0	6.0	36.0	5.1	4.8	5.1	--	--
27	140.0	135.0	140.0	137.5	5.0	25.0	5.1	4.8	5.1	--	--
28	144.0	139.0	144.0	142.0	4.0	16.0	5.1	4.8	5.0	--	--
29	149.0	144.0	149.0	146.5	5.0	25.0	4.7	4.8	5.0	--	--
30	154.0	149.0	154.0	151.5	5.0	25.0	4.7	4.8	5.0	--	--
31	160.0	155.0	160.0	157.0	6.0	36.0	5.4	4.8	5.1	--	--
32	167.0	162.0	167.0	163.5	7.0	49.0	6.1	4.9	5.2	--	--
33	171.0	166.0	171.0	169.0	4.0	16.0	5.9	4.9	5.1	--	--
34	175.0	170.0	175.0	173.0	4.0	16.0	5.4	4.8	5.1	--	--
35	182.0	177.0	182.0	178.5	7.0	49.0	5.4	4.9	5.2	--	--
36	188.0	183.0	188.0	185.0	6.0	36.0	5.9	4.9	5.2	--	--
37	192.0	187.0	192.0	190.0	4.0	16.0	5.9	4.9	5.2	--	--
38	197.0	192.0	197.0	194.5	5.0	25.0	5.1	4.9	5.2	--	--
39	201.0	196.0	201.0	199.0	4.0	16.0	4.4	4.9	5.2	--	--
40	207.0	202.0	207.0	204.0	6.0	36.0	5.1	4.9	5.2	--	--
41	209.0	204.0	209.0	208.0	2.0	4.0	4.7	4.9	5.1	--	--
42	218.0	213.0	218.0	213.5	9.0	81.0	7.1	5.0	5.3	--	--
43	224.0	219.0	224.0	221.0	6.0	36.0	7.1	5.0	5.3	--	--
44	228.0	223.0	228.0	226.0	4.0	16.0	7.0	5.0	5.3	--	--
45	234.0	229.0	234.0	231.0	6.0	36.0	5.5	5.0	5.3	--	--
46	240.0	235.0	240.0	237.0	6.0	36.0	5.5	5.0	5.3	--	--
47	245.0	240.0	245.0	242.5	5.0	25.0	5.7	5.0	5.3	--	--
48	250.0	245.0	250.0	247.5	5.0	25.0	5.4	5.0	5.3	--	--
49	255.0	250.0	255.0	252.5	5.0	25.0	5.0	5.0	5.3	--	--
50	260.0	255.0	260.0	257.5	5.0	25.0	5.0	5.0	5.3	--	--
51	266.0	261.0	266.0	263.0	6.0	36.0	5.4	5.0	5.3	--	--
52	270.0	265.0	270.0	268.0	4.0	16.0	5.1	5.0	5.3	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	4.64
E^1	[MPa]	218.94
$DPI5^2$	[mm/blow]	4.83
E^2	[MPa]	209.81

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
MnROAD	105%	50.5%	98.3%	2

Depth of cone below surface at start [mm]: 6

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	6.0	0.0	6.0	--	--	--	--	--	--	--	--
1	19.0	13.0	19.0	12.5	13.0	169.0	--	--	--	--	--
2	25.0	19.0	25.0	22.0	6.0	36.0	--	6.0	6.0	--	--
3	29.0	23.0	29.0	27.0	4.0	16.0	9.6	5.0	5.2	5.0	20.0
4	34.0	28.0	34.0	31.5	5.0	25.0	5.1	5.0	5.1	4.5	22.5
5	38.0	32.0	38.0	36.0	4.0	16.0	4.4	4.8	4.9	4.5	18.0
6	42.0	36.0	42.0	40.0	4.0	16.0	4.4	4.6	4.7	4.0	16.0
7	48.0	42.0	48.0	45.0	6.0	36.0	4.9	4.8	5.0	5.0	30.0
8	52.0	46.0	52.0	50.0	4.0	16.0	4.9	4.7	4.9	5.0	20.0
9	56.0	50.0	56.0	54.0	4.0	16.0	4.9	4.6	4.8	4.0	16.0
10	62.0	56.0	62.0	59.0	6.0	36.0	4.9	4.8	5.0	5.0	30.0
11	65.0	59.0	65.0	63.5	3.0	9.0	4.7	4.6	4.8	4.5	13.5
12	70.0	64.0	70.0	67.5	5.0	25.0	5.0	4.6	4.8	4.0	20.0
13	74.0	68.0	74.0	72.0	4.0	16.0	4.2	4.6	4.8	--	--
14	80.0	74.0	80.0	77.0	6.0	36.0	5.1	4.7	4.9	--	--
15	85.0	79.0	85.0	82.5	5.0	25.0	5.1	4.7	4.9	--	--
16	89.0	83.0	89.0	87.0	4.0	16.0	5.1	4.7	4.9	--	--
17	95.0	89.0	95.0	92.0	6.0	36.0	5.1	4.8	4.9	--	--
18	97.0	91.0	97.0	96.0	2.0	4.0	4.7	4.6	4.9	--	--
19	101.0	95.0	101.0	99.0	4.0	16.0	4.7	4.6	4.8	--	--
20	107.0	101.0	107.0	104.0	6.0	36.0	4.7	4.6	4.9	--	--
21	111.0	105.0	111.0	109.0	4.0	16.0	4.9	4.6	4.9	--	--
22	115.0	109.0	115.0	113.0	4.0	16.0	4.9	4.6	4.8	--	--
23	120.0	114.0	120.0	117.5	5.0	25.0	4.4	4.6	4.8	--	--
24	125.0	119.0	125.0	122.5	5.0	25.0	4.7	4.6	4.8	--	--
25	130.0	124.0	130.0	127.5	5.0	25.0	5.0	4.6	4.9	--	--
26	135.0	129.0	135.0	132.5	5.0	25.0	5.0	4.6	4.9	--	--
27	140.0	134.0	140.0	137.5	5.0	25.0	5.0	4.7	4.9	--	--
28	145.0	139.0	145.0	142.5	5.0	25.0	5.0	4.7	4.9	--	--
29	150.0	144.0	150.0	147.5	5.0	25.0	5.0	4.7	4.9	--	--
30	155.0	149.0	155.0	152.5	5.0	25.0	5.0	4.7	4.9	--	--
31	160.0	154.0	160.0	157.5	5.0	25.0	5.0	4.7	4.9	--	--
32	165.0	159.0	165.0	162.5	5.0	25.0	5.0	4.7	4.9	--	--
33	170.0	164.0	170.0	167.5	5.0	25.0	5.0	4.7	4.9	--	--
34	174.0	168.0	174.0	172.0	4.0	16.0	4.7	4.7	4.9	--	--
35	178.0	172.0	178.0	176.0	4.0	16.0	4.4	4.7	4.8	--	--
36	184.0	178.0	184.0	181.0	6.0	36.0	4.9	4.7	4.9	--	--
37	188.0	182.0	188.0	186.0	4.0	16.0	4.9	4.7	4.9	--	--
38	193.0	187.0	193.0	190.5	5.0	25.0	5.1	4.7	4.9	--	--
39	198.0	192.0	198.0	195.5	5.0	25.0	4.7	4.7	4.9	--	--
40	204.0	198.0	204.0	201.0	6.0	36.0	5.4	4.7	4.9	--	--
41	209.0	203.0	209.0	206.5	5.0	25.0	5.4	4.8	4.9	--	--
42	215.0	209.0	215.0	212.0	6.0	36.0	5.7	4.8	4.9	--	--
43	219.0	213.0	219.0	217.0	4.0	16.0	5.1	4.8	4.9	--	--
44	223.0	217.0	223.0	221.0	4.0	16.0	4.9	4.7	4.9	--	--
45	227.0	221.0	227.0	225.0	4.0	16.0	4.0	4.7	4.9	--	--
46	232.0	226.0	232.0	229.5	5.0	25.0	4.4	4.7	4.9	--	--
47	237.0	231.0	237.0	234.5	5.0	25.0	4.7	4.7	4.9	--	--
48	244.0	238.0	244.0	240.5	7.0	49.0	5.8	4.8	5.0	--	--
49	248.0	242.0	248.0	246.0	4.0	16.0	5.6	4.8	4.9	--	--
50	253.0	247.0	253.0	250.5	5.0	25.0	5.6	4.8	4.9	--	--
51	258.0	252.0	258.0	255.5	5.0	25.0	4.7	4.8	4.9	--	--
52	262.0	256.0	262.0	260.0	4.0	16.0	4.7	4.8	4.9	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	4.63
E^1	[MPa]	219.24
$DPI5^2$	[mm/blow]	4.52
E^2	[MPa]	224.79

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	103%	88.2%	102.7%	1

Depth of cone below surface at start [mm]: 11

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[mm^2/blow^2]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[mm^2/blow^2]
0	11.0	0.0	11.0	--	--	--	--	--	--	--	--
1	45.0	34.0	45.0	28.0	34.0	1156.0	--	--	--	--	--
2	79.0	68.0	79.0	62.0	34.0	1156.0	--	34.0	34.0	--	--
3	112.0	101.0	112.0	95.5	33.0	1089.0	33.7	33.5	33.5	33.5	1105.5
4	144.0	133.0	144.0	128.0	32.0	1024.0	33.0	33.0	33.0	32.5	1040.0
5	179.0	168.0	179.0	161.5	35.0	1225.0	33.4	33.5	33.5	33.5	1172.5
6	217.0	206.0	217.0	198.0	38.0	1444.0	35.2	34.4	34.5	36.5	1387.0
7	255.0	244.0	255.0	236.0	38.0	1444.0	37.1	35.0	35.2	38.0	1444.0
8	290.0	279.0	290.0	272.5	35.0	1225.0	37.1	35.0	35.1	--	--
9	--	--	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--

*Top layer only, first blow not included

DPI5^1	[mm/blow]	34.94
E^1	[MPa]	25.65
DPI5^2	[mm/blow]	N/A
E^2	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	103%	88.2%	102.7%	2

Depth of cone below surface at start [mm]: 9

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[mm^2/blow^2]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[mm^2/blow^2]
0	9.0	0.0	9.0	--	--	--	--	--	--	--	--
1	45.0	36.0	45.0	27.0	36.0	1296.0	--	--	--	--	--
2	77.0	68.0	77.0	61.0	32.0	1024.0	--	32.0	32.0	--	--
3	112.0	103.0	112.0	94.5	35.0	1225.0	34.4	33.5	33.6	33.5	1172.5
4	145.0	136.0	145.0	128.5	33.0	1089.0	33.4	33.3	33.4	34.0	1122.0
5	180.0	171.0	180.0	162.5	35.0	1225.0	34.4	33.8	33.8	34.0	1190.0
6	215.0	206.0	215.0	197.5	35.0	1225.0	34.4	34.0	34.0	35.0	1225.0
7	250.0	241.0	250.0	232.5	35.0	1225.0	35.0	34.2	34.2	35.0	1225.0
8	286.0	277.0	286.0	268.0	36.0	1296.0	35.3	34.4	34.5	--	--
9	--	--	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--

*Top layer only, first blow not included

DPI5^1	[mm/blow]	34.30
E^1	[MPa]	26.16
DPI5^2	[mm/blow]	N/A
E^2	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	103%	71.8%	100.2%	1

Depth of cone below surface at start [mm]: 7

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	7.0	0.0	7.0	--	--	--	--	--	--	--	--
1	40.0	33.0	40.0	23.5	33.0	1089.0	--	--	--	--	--
2	70.0	63.0	70.0	55.0	30.0	900.0	--	30.0	30.0	--	--
3	99.0	92.0	99.0	84.5	29.0	841.0	30.8	29.5	29.5	29.5	855.5
4	125.0	118.0	125.0	112.0	26.0	676.0	28.4	28.3	28.4	27.5	715.0
5	155.0	148.0	155.0	140.0	30.0	900.0	28.4	28.8	28.8	28.0	840.0
6	190.0	183.0	190.0	172.5	35.0	1225.0	30.8	30.0	30.3	32.5	1137.5
7	220.0	213.0	220.0	205.0	30.0	900.0	31.8	30.0	30.2	32.5	975.0
8	254.0	247.0	254.0	237.0	34.0	1156.0	33.1	30.6	30.8	--	--
9	--	--	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	30.15
E^1	[MPa]	29.99
$DPI5^2$	[mm/blow]	N/A
E^2	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	103%	71.8%	100.2%	2

Depth of cone below surface at start [mm]: 10

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	10.0	0.0	10.0	--	--	--	--	--	--	--	--
1	37.0	27.0	37.0	23.5	27.0	729.0	--	--	--	--	--
2	65.0	55.0	65.0	51.0	28.0	784.0	--	28.0	28.0	--	--
3	93.0	83.0	93.0	79.0	28.0	784.0	27.7	28.0	28.0	28.0	784.0
4	117.0	107.0	117.0	105.0	24.0	576.0	26.8	26.7	26.8	26.0	624.0
5	140.0	130.0	140.0	128.5	23.0	529.0	25.2	25.8	26.0	23.5	540.5
6	170.0	160.0	170.0	155.0	30.0	900.0	26.0	26.6	26.9	26.5	795.0
7	195.0	185.0	195.0	182.5	25.0	625.0	26.3	26.3	26.6	27.5	687.5
8	223.0	213.0	223.0	209.0	28.0	784.0	27.8	26.6	26.8	--	--
9	254.0	244.0	254.0	238.5	31.0	961.0	28.2	27.1	27.4	--	--
10	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	26.39
E^1	[MPa]	34.55
$DPI5^2$	[mm/blow]	N/A
E^2	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	103%	65.1%	104.4%	1

Depth of cone below surface at start [mm]: 10

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	10.0	0.0	10.0	--	--	--	--	--	--	--	--
1	40.0	30.0	40.0	25.0	30.0	900.0	--	--	--	--	--
2	60.0	50.0	60.0	50.0	20.0	400.0	--	20.0	20.0	--	--
3	80.0	70.0	80.0	70.0	20.0	400.0	24.3	20.0	20.0	20.0	400.0
4	99.0	89.0	99.0	89.5	19.0	361.0	19.7	19.7	19.7	19.5	370.5
5	115.0	105.0	115.0	107.0	16.0	256.0	18.5	18.8	18.9	17.5	280.0
6	137.0	127.0	137.0	126.0	22.0	484.0	19.3	19.4	19.6	19.0	418.0
7	155.0	145.0	155.0	146.0	18.0	324.0	19.0	19.2	19.3	20.0	360.0
8	170.0	160.0	170.0	162.5	15.0	225.0	18.8	18.6	18.8	16.5	247.5
9	183.0	173.0	183.0	176.5	13.0	169.0	15.6	17.9	18.3	14.0	182.0
10	195.0	185.0	195.0	189.0	12.0	144.0	13.5	17.2	17.8	12.5	150.0
11	210.0	200.0	210.0	202.5	15.0	225.0	13.5	17.0	17.6	13.5	202.5
12	224.0	214.0	224.0	217.0	14.0	196.0	13.8	16.7	17.3	14.5	203.0

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	19.25
E[1]	[MPa]	48.31
DPI5[2]	[mm/blow]	14.28
E[2]	[MPa]	66.34

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	103%	65.1%	104.4%	2

Depth of cone below surface at start [mm]: 6

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	6.0	0.0	6.0	--	--	--	--	--	--	--	--
1	37.0	31.0	37.0	21.5	31.0	961.0	--	--	--	--	--
2	58.0	52.0	58.0	47.5	21.0	441.0	--	21.0	21.0	--	--
3	74.0	68.0	74.0	66.0	16.0	256.0	24.4	18.5	18.8	18.5	296.0
4	92.0	86.0	92.0	83.0	18.0	324.0	18.6	18.3	18.6	17.0	306.0
5	107.0	101.0	107.0	99.5	15.0	225.0	16.4	17.5	17.8	16.5	247.5
6	125.0	119.0	125.0	116.0	18.0	324.0	17.1	17.6	17.8	16.5	297.0
7	145.0	139.0	145.0	135.0	20.0	400.0	17.9	18.0	18.2	19.0	380.0
8	161.0	155.0	161.0	153.0	16.0	256.0	18.1	17.7	18.0	18.0	288.0
9	174.0	168.0	174.0	167.5	13.0	169.0	16.8	17.1	17.5	14.5	188.5
10	186.0	180.0	186.0	180.0	12.0	144.0	13.9	16.6	17.0	12.5	150.0
11	197.0	191.0	197.0	191.5	11.0	121.0	12.1	16.0	16.6	11.5	126.5
12	209.0	203.0	209.0	203.0	12.0	144.0	11.7	15.6	16.3	11.5	138.0
13	220.0	214.0	220.0	214.5	11.0	121.0	11.4	15.3	16.0	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	17.55
E[1]	[MPa]	53.29
DPI5[2]	[mm/blow]	13.92
E[2]	[MPa]	68.13

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	98%	97.6%	97.0%	1

Depth of cone below surface at start [mm]: 7

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	7.0	0.0	7.0	--	--	--	--	--	--	--	--
1	48.0	41.0	48.0	27.5	41.0	1681.0	--	--	--	--	--
2	84.0	77.0	84.0	66.0	36.0	1296.0	--	36.0	36.0	--	--
3	119.0	112.0	119.0	101.5	35.0	1225.0	37.5	35.5	35.5	35.5	1242.5
4	148.0	141.0	148.0	133.5	29.0	841.0	33.6	33.3	33.6	32.0	928.0
5	176.0	169.0	176.0	162.0	28.0	784.0	31.0	32.0	32.4	28.5	798.0
6	204.0	197.0	204.0	190.0	28.0	784.0	28.3	31.2	31.6	28.0	784.0
7	236.0	229.0	236.0	220.0	32.0	1024.0	29.5	31.3	31.7	30.0	960.0
8	267.0	260.0	267.0	251.5	31.0	961.0	30.4	31.3	31.6	--	--
9	296.0	289.0	296.0	281.5	29.0	841.0	30.7	31.0	31.3	--	--
10	309.0	302.0	309.0	302.5	13.0	169.0	27.0	29.0	30.4	--	--
11	--	--	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	31.00
E[1]	[MPa]	29.12
DPI5[2]	[mm/blow]	N/A
E[2]	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	98%	97.6%	97.0%	2

Depth of cone below surface at start [mm]: 17

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	17.0	0.0	17.0	--	--	--	--	--	--	--	--
1	45.0	28.0	45.0	31.0	28.0	784.0	--	--	--	--	--
2	79.0	62.0	79.0	62.0	34.0	1156.0	--	34.0	34.0	--	--
3	112.0	95.0	112.0	95.5	33.0	1089.0	31.9	33.5	33.5	33.5	1105.5
4	138.0	121.0	138.0	125.0	26.0	676.0	31.4	31.0	31.4	29.5	767.0
5	169.0	152.0	169.0	153.5	31.0	961.0	30.3	31.0	31.3	28.5	883.5
6	199.0	182.0	199.0	184.0	30.0	900.0	29.2	30.8	31.1	30.5	915.0
7	227.0	210.0	227.0	213.0	28.0	784.0	29.7	30.3	30.6	29.0	812.0
8	259.0	242.0	259.0	243.0	32.0	1024.0	30.1	30.6	30.8	--	--
9	287.0	270.0	287.0	273.0	28.0	784.0	29.5	30.3	30.5	--	--
10	300.0	283.0	300.0	293.5	13.0	169.0	27.1	28.3	29.6	--	--
11	--	--	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	30.29
E[1]	[MPa]	29.85
DPI5[2]	[mm/blow]	N/A
E[2]	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	98%	82.2%	96.2%	1

Depth of cone below surface at start [mm]: 11

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	11.0	0.0	11.0	--	--	--	--	--	--	--	--
1	25.0	14.0	25.0	18.0	14.0	196.0	--	--	--	--	--
2	40.0	29.0	40.0	32.5	15.0	225.0	--	15.0	15.0	--	--
3	53.0	42.0	53.0	46.5	13.0	169.0	14.0	14.0	14.1	14.0	182.0
4	65.0	54.0	65.0	59.0	12.0	144.0	13.5	13.3	13.5	12.5	150.0
5	80.0	69.0	80.0	72.5	15.0	225.0	13.5	13.8	13.9	13.5	202.5
6	96.0	85.0	96.0	88.0	16.0	256.0	14.5	14.2	14.4	15.5	248.0
7	109.0	98.0	109.0	102.5	13.0	169.0	14.8	14.0	14.1	14.5	188.5
8	117.0	106.0	117.0	113.0	8.0	64.0	13.2	13.1	13.6	10.5	84.0
9	131.0	120.0	131.0	124.0	14.0	196.0	12.3	13.3	13.7	11.0	154.0
10	145.0	134.0	145.0	138.0	14.0	196.0	12.7	13.3	13.7	14.0	196.0
11	157.0	146.0	157.0	151.0	12.0	144.0	13.4	13.2	13.5	13.0	156.0
12	170.0	159.0	170.0	163.5	13.0	169.0	13.1	13.2	13.5	12.5	162.5
13	183.0	172.0	183.0	176.5	13.0	169.0	12.7	13.2	13.5	--	--
14	196.0	185.0	196.0	189.5	13.0	169.0	13.0	13.2	13.4	--	--
15	210.0	199.0	210.0	203.0	14.0	196.0	13.4	13.2	13.5	--	--
16	220.0	209.0	220.0	215.0	10.0	100.0	12.6	13.0	13.3	--	--
17	235.0	224.0	235.0	227.5	15.0	225.0	13.4	13.1	13.4	--	--
18	251.0	240.0	251.0	243.0	16.0	256.0	14.2	13.3	13.6	--	--
19	264.0	253.0	264.0	257.5	13.0	169.0	14.8	13.3	13.6	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	14.07
E^1	[MPa]	67.36
$DPI5^2$	[mm/blow]	12.34
E^2	[MPa]	77.47

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	98%	82.2%	96.2%	2

Depth of cone below surface at start [mm]: 9

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	9.0	0.0	9.0	--	--	--	--	--	--	--	--
1	25.0	16.0	25.0	17.0	16.0	256.0	--	--	--	--	--
2	39.0	30.0	39.0	32.0	14.0	196.0	--	14.0	14.0	--	--
3	52.0	43.0	52.0	45.5	13.0	169.0	14.4	13.5	13.5	13.5	175.5
4	64.0	55.0	64.0	58.0	12.0	144.0	13.1	13.0	13.1	12.5	150.0
5	79.0	70.0	79.0	71.5	15.0	225.0	13.5	13.5	13.6	13.5	202.5
6	93.0	84.0	93.0	86.0	14.0	196.0	13.8	13.6	13.7	14.5	203.0
7	105.0	96.0	105.0	99.0	12.0	144.0	13.8	13.3	13.4	13.0	156.0
8	118.0	109.0	118.0	111.5	13.0	169.0	13.1	13.3	13.4	12.5	162.5
9	129.0	120.0	129.0	123.5	11.0	121.0	12.1	13.0	13.1	12.0	132.0
10	140.0	131.0	140.0	134.5	11.0	121.0	11.7	12.8	12.9	11.0	121.0
11	153.0	144.0	153.0	146.5	13.0	169.0	11.7	12.8	12.9	12.0	156.0
12	168.0	159.0	168.0	160.5	15.0	225.0	13.2	13.0	13.1	14.0	210.0
13	180.0	171.0	180.0	174.0	12.0	144.0	13.5	12.9	13.1	--	--
14	193.0	184.0	193.0	186.5	13.0	169.0	13.5	12.9	13.0	--	--
15	207.0	198.0	207.0	200.0	14.0	196.0	13.1	13.0	13.1	--	--
16	222.0	213.0	222.0	214.5	15.0	225.0	14.0	13.1	13.3	--	--
17	237.0	228.0	237.0	229.5	15.0	225.0	14.7	13.3	13.4	--	--
18	252.0	243.0	252.0	244.5	15.0	225.0	15.0	13.4	13.5	--	--
19	267.0	258.0	267.0	259.5	15.0	225.0	15.0	13.4	13.6	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	13.44
E^1	[MPa]	70.73
$DPI5^2$	[mm/blow]	12.40
E^2	[MPa]	77.01

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	98%	60.9%	97.7%	1

Depth of cone below surface at start [mm]: 9

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	9.0	0.0	9.0	--	--	--	--	--	--	--	--
1	24.0	15.0	24.0	16.5	15.0	225.0	--	--	--	--	--
2	33.0	24.0	33.0	28.5	9.0	81.0	--	9.0	9.0	--	--
3	40.0	31.0	40.0	36.5	7.0	49.0	11.5	8.0	8.1	8.0	56.0
4	49.0	40.0	49.0	44.5	9.0	81.0	8.4	8.3	8.4	8.0	72.0
5	60.0	51.0	60.0	54.5	11.0	121.0	9.3	9.0	9.2	10.0	110.0
6	69.0	60.0	69.0	64.5	9.0	81.0	9.8	9.0	9.2	10.0	90.0
7	80.0	71.0	80.0	74.5	11.0	121.0	10.4	9.3	9.5	10.0	110.0
8	90.0	81.0	90.0	85.0	10.0	100.0	10.1	9.4	9.6	10.5	105.0
9	100.0	91.0	100.0	95.0	10.0	100.0	10.4	9.5	9.7	10.0	100.0
10	109.0	100.0	109.0	104.5	9.0	81.0	9.7	9.4	9.6	9.5	85.5
11	119.0	110.0	119.0	114.0	10.0	100.0	9.7	9.5	9.6	9.5	95.0
12	128.0	119.0	128.0	123.5	9.0	81.0	9.4	9.5	9.6	9.5	85.5
13	138.0	129.0	138.0	133.0	10.0	100.0	9.7	9.5	9.6	--	--
14	147.0	138.0	147.0	142.5	9.0	81.0	9.4	9.5	9.6	--	--
15	158.0	149.0	158.0	152.5	11.0	121.0	10.1	9.6	9.7	--	--
16	170.0	161.0	170.0	164.0	12.0	144.0	10.8	9.7	9.9	--	--
17	181.0	172.0	181.0	175.5	11.0	121.0	11.4	9.8	10.0	--	--
18	190.0	181.0	190.0	185.5	9.0	81.0	10.8	9.8	9.9	--	--
19	201.0	192.0	201.0	195.5	11.0	121.0	10.4	9.8	10.0	--	--
20	215.0	206.0	215.0	208.0	14.0	196.0	11.7	10.1	10.3	--	--
21	225.0	216.0	225.0	220.0	10.0	100.0	11.9	10.1	10.3	--	--
22	236.0	227.0	236.0	230.5	11.0	121.0	11.9	10.1	10.3	--	--
23	250.0	241.0	250.0	243.0	14.0	196.0	11.9	10.3	10.5	--	--
24	260.0	251.0	260.0	255.0	10.0	100.0	11.9	10.3	10.5	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	9.32
E[1]	[MPa]	104.34
DPI5[2]	[mm/blow]	9.81
E[2]	[MPa]	98.78

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Duluth	98%	60.9%	97.7%	2

Depth of cone below surface at start [mm]: 10

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	10.0	0.0	10.0	--	--	--	--	--	--	--	--
1	22.0	12.0	22.0	16.0	12.0	144.0	--	--	--	--	--
2	31.0	21.0	31.0	26.5	9.0	81.0	--	9.0	9.0	--	--
3	41.0	31.0	41.0	36.0	10.0	100.0	10.5	9.5	9.5	9.5	95.0
4	49.0	39.0	49.0	45.0	8.0	64.0	9.1	9.0	9.1	9.0	72.0
5	60.0	50.0	60.0	54.5	11.0	121.0	9.8	9.5	9.6	9.5	104.5
6	68.0	58.0	68.0	64.0	8.0	64.0	9.2	9.2	9.3	9.5	76.0
7	80.0	70.0	80.0	74.0	12.0	144.0	10.6	9.7	9.9	10.0	120.0
8	92.0	82.0	92.0	86.0	12.0	144.0	11.0	10.0	10.3	12.0	144.0
9	103.0	93.0	103.0	97.5	11.0	121.0	11.7	10.1	10.4	11.5	126.5
10	115.0	105.0	115.0	109.0	12.0	144.0	11.7	10.3	10.6	11.5	138.0
11	125.0	115.0	125.0	120.0	10.0	100.0	11.1	10.3	10.5	11.0	110.0
12	136.0	126.0	136.0	130.5	11.0	121.0	11.1	10.4	10.6	10.5	115.5
13	145.0	135.0	145.0	140.5	9.0	81.0	10.1	10.3	10.4	--	--
14	157.0	147.0	157.0	151.0	12.0	144.0	10.8	10.4	10.6	--	--
15	169.0	159.0	169.0	163.0	12.0	144.0	11.2	10.5	10.7	--	--
16	180.0	170.0	180.0	174.5	11.0	121.0	11.7	10.5	10.7	--	--
17	192.0	182.0	192.0	186.0	12.0	144.0	11.7	10.6	10.8	--	--
18	204.0	194.0	204.0	198.0	12.0	144.0	11.7	10.7	10.9	--	--
19	216.0	206.0	216.0	210.0	12.0	144.0	12.0	10.8	11.0	--	--
20	229.0	219.0	229.0	222.5	13.0	169.0	12.4	10.9	11.1	--	--
21	241.0	231.0	241.0	235.0	12.0	144.0	12.4	11.0	11.1	--	--
22	255.0	245.0	255.0	248.0	14.0	196.0	13.1	11.1	11.3	--	--
23	265.0	255.0	265.0	260.0	10.0	100.0	12.2	11.0	11.3	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	9.54
E[1]	[MPa]	101.76
DPI5[2]	[mm/blow]	11.32
E[2]	[MPa]	84.86

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	98%	93.9%	89.9%	1

Depth of cone below surface at start [mm]: 17

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[mm^2/blow^2]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[mm^2/blow^2]
0	17.0	0.0	17.0	--	--	--	--	--	--	--	--
1	43.0	26.0	43.0	30.0	26.0	676.0	--	--	--	--	--
2	71.0	54.0	71.0	57.0	28.0	784.0	--	28.0	28.0	--	--
3	94.0	77.0	94.0	82.5	23.0	529.0	25.8	25.5	25.7	25.5	586.5
4	120.0	103.0	120.0	107.0	26.0	676.0	25.8	25.7	25.8	24.5	637.0
5	144.0	127.0	144.0	132.0	24.0	576.0	24.4	25.3	25.4	25.0	600.0
6	168.0	151.0	168.0	156.0	24.0	576.0	24.7	25.0	25.1	24.0	576.0
7	189.0	172.0	189.0	178.5	21.0	441.0	23.1	24.3	24.5	22.5	472.5
8	210.0	193.0	210.0	199.5	21.0	441.0	22.1	23.9	24.1	21.0	441.0
9	233.0	216.0	233.0	221.5	23.0	529.0	21.7	23.8	24.0	22.0	506.0
10	254.0	237.0	254.0	243.5	21.0	441.0	21.7	23.4	23.7	22.0	462.0
11	274.0	257.0	274.0	264.0	20.0	400.0	21.4	23.1	23.3	20.5	410.0
12	288.0	271.0	288.0	281.0	14.0	196.0	18.9	22.3	22.8	17.0	238.0

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	24.34
E[1]	[MPa]	37.65
DPI5[2]	[mm/blow]	20.78
E[2]	[MPa]	44.54

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	98%	93.9%	89.9%	2

Depth of cone below surface at start [mm]: 15

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[mm^2/blow^2]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[mm^2/blow^2]
0	15.0	0.0	15.0	--	--	--	--	--	--	--	--
1	36.0	21.0	36.0	25.5	21.0	441.0	--	--	--	--	--
2	50.0	35.0	50.0	43.0	14.0	196.0	--	14.0	14.0	--	--
3	83.0	68.0	83.0	66.5	33.0	1089.0	25.4	23.5	27.3	23.5	775.5
4	107.0	92.0	107.0	95.0	24.0	576.0	26.2	23.7	26.2	28.5	684.0
5	138.0	123.0	138.0	122.5	31.0	961.0	29.8	25.5	27.7	27.5	852.5
6	165.0	150.0	165.0	151.5	27.0	729.0	27.6	25.8	27.5	29.0	783.0
7	191.0	176.0	191.0	178.0	26.0	676.0	28.2	25.8	27.3	26.5	689.0
8	219.0	204.0	219.0	205.0	28.0	784.0	27.0	26.1	27.4	--	--
9	240.0	225.0	240.0	229.5	21.0	441.0	25.3	25.5	26.7	--	--
10	264.0	249.0	264.0	252.0	24.0	576.0	24.7	25.3	26.4	--	--
11	283.0	268.0	283.0	273.5	19.0	361.0	21.5	24.7	25.9	--	--
12	--	--	--	--	--	--	--	--	--	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	26.84
E[1]	[MPa]	33.94
DPI5[2]	[mm/blow]	N/A
E[2]	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	98%	76.5%	95.9%	1

Depth of cone below surface at start [mm]: 14

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	14.0	0.0	14.0	--	--	--	--	--	--	--	--
1	43.0	29.0	43.0	28.5	29.0	841.0	--	--	--	--	--
2	64.0	50.0	64.0	53.5	21.0	441.0	--	21.0	21.0	--	--
3	86.0	72.0	86.0	75.0	22.0	484.0	24.5	21.5	21.5	21.5	473.0
4	104.0	90.0	104.0	95.0	18.0	324.0	20.5	20.3	20.5	20.0	360.0
5	120.0	106.0	120.0	112.0	16.0	256.0	19.0	19.3	19.5	17.0	272.0
6	131.0	117.0	131.0	125.5	11.0	121.0	15.6	17.6	18.5	13.5	148.5
7	145.0	131.0	145.0	138.0	14.0	196.0	14.0	17.0	17.9	12.5	175.0
8	161.0	147.0	161.0	153.0	16.0	256.0	14.0	16.9	17.6	15.0	240.0
9	179.0	165.0	179.0	170.0	18.0	324.0	16.2	17.0	17.7	17.0	306.0
10	194.0	180.0	194.0	186.5	15.0	225.0	16.4	16.8	17.4	16.5	247.5
11	210.0	196.0	210.0	202.0	16.0	256.0	16.4	16.7	17.3	15.5	248.0
12	229.0	215.0	229.0	219.5	19.0	361.0	16.8	16.9	17.4	17.5	332.5
13	249.0	235.0	249.0	239.0	20.0	400.0	18.5	17.2	17.7	--	--
14	265.0	251.0	265.0	257.0	16.0	256.0	18.5	17.1	17.6	--	--
15	278.0	264.0	278.0	271.5	13.0	169.0	16.8	16.8	17.3	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	17.64
E[1]	[MPa]	53.01
DPI5[2]	[mm/blow]	16.36
E[2]	[MPa]	57.42

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	98%	76.5%	95.9%	2

Depth of cone below surface at start [mm]: 13

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	13.0	0.0	13.0	--	--	--	--	--	--	--	--
1	44.0	31.0	44.0	28.5	31.0	961.0	--	--	--	--	--
2	70.0	57.0	70.0	57.0	26.0	676.0	--	26.0	26.0	--	--
3	92.0	79.0	92.0	81.0	22.0	484.0	26.8	24.0	24.2	24.0	528.0
4	107.0	94.0	107.0	99.5	15.0	225.0	22.0	21.0	22.0	18.5	277.5
5	123.0	110.0	123.0	115.0	16.0	256.0	18.2	19.8	20.8	15.5	248.0
6	140.0	127.0	140.0	131.5	17.0	289.0	16.0	19.2	20.1	16.5	280.5
7	159.0	146.0	159.0	149.5	19.0	361.0	17.4	19.2	19.9	18.0	342.0
8	178.0	165.0	178.0	168.5	19.0	361.0	18.4	19.1	19.8	19.0	361.0
9	195.0	182.0	195.0	186.5	17.0	289.0	18.4	18.9	19.5	18.0	306.0
10	214.0	201.0	214.0	204.5	19.0	361.0	18.4	18.9	19.4	18.0	342.0
11	233.0	220.0	233.0	223.5	19.0	361.0	18.4	18.9	19.4	19.0	361.0
12	251.0	238.0	251.0	242.0	18.0	324.0	18.7	18.8	19.3	18.5	333.0
13	268.0	255.0	268.0	259.5	17.0	289.0	18.0	18.7	19.1	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	18.83
E[1]	[MPa]	49.44
DPI5[2]	[mm/blow]	18.51
E[2]	[MPa]	50.35

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	98%	63.6%	95.0%	1

Depth of cone below surface at start [mm]: 9

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	9.0	0.0	9.0	--	--	--	--	--	--	--	--
1	35.0	26.0	35.0	22.0	26.0	676.0	--	--	--	--	--
2	55.0	46.0	55.0	45.0	20.0	400.0	--	20.0	20.0	--	--
3	70.0	61.0	70.0	62.5	15.0	225.0	21.3	17.5	17.9	17.5	262.5
4	85.0	76.0	85.0	77.5	15.0	225.0	17.0	16.7	17.0	15.0	225.0
5	99.0	90.0	99.0	92.0	14.0	196.0	14.7	16.0	16.3	14.5	203.0
6	111.0	102.0	111.0	105.0	12.0	144.0	13.8	15.2	15.7	13.0	156.0
7	125.0	116.0	125.0	118.0	14.0	196.0	13.4	15.0	15.4	13.0	182.0
8	139.0	130.0	139.0	132.0	14.0	196.0	13.4	14.9	15.2	14.0	196.0
9	153.0	144.0	153.0	146.0	14.0	196.0	14.0	14.8	15.1	14.0	196.0
10	164.0	155.0	164.0	158.5	11.0	121.0	13.2	14.3	14.7	12.5	137.5
11	177.0	168.0	177.0	170.5	13.0	169.0	12.8	14.2	14.6	12.0	156.0
12	190.0	181.0	190.0	183.5	13.0	169.0	12.4	14.1	14.4	13.0	169.0
13	204.0	195.0	204.0	197.0	14.0	196.0	13.4	14.1	14.4	--	--
14	221.0	212.0	221.0	212.5	17.0	289.0	14.9	14.3	14.6	--	--
15	233.0	224.0	233.0	227.0	12.0	144.0	14.6	14.1	14.5	--	--
16	244.0	235.0	244.0	238.5	11.0	121.0	13.9	13.9	14.3	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	14.69
E[1]	[MPa]	64.34
DPI5[2]	[mm/blow]	13.15
E[2]	[MPa]	72.41

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	98%	63.6%	95.0%	2

Depth of cone below surface at start [mm]: 9

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	9.0	0.0	9.0	--	--	--	--	--	--	--	--
1	33.0	24.0	33.0	21.0	24.0	576.0	--	--	--	--	--
2	51.0	42.0	51.0	42.0	18.0	324.0	--	18.0	18.0	--	--
3	71.0	62.0	71.0	61.0	20.0	400.0	21.0	19.0	19.1	19.0	380.0
4	85.0	76.0	85.0	78.0	14.0	196.0	17.7	17.3	17.7	17.0	238.0
5	100.0	91.0	100.0	92.5	15.0	225.0	16.8	16.8	17.1	14.5	217.5
6	113.0	104.0	113.0	106.5	13.0	169.0	14.0	16.0	16.4	14.0	182.0
7	128.0	119.0	128.0	120.5	15.0	225.0	14.4	15.8	16.2	14.0	210.0
8	140.0	131.0	140.0	134.0	12.0	144.0	13.5	15.3	15.7	13.5	162.0
9	156.0	147.0	156.0	148.0	16.0	256.0	14.5	15.4	15.8	14.0	224.0
10	171.0	162.0	171.0	163.5	15.0	225.0	14.5	15.3	15.7	15.5	232.5
11	182.0	173.0	182.0	176.5	11.0	121.0	14.3	14.9	15.3	13.0	143.0
12	193.0	184.0	193.0	187.5	11.0	121.0	12.6	14.5	15.0	11.0	121.0
13	206.0	197.0	206.0	199.5	13.0	169.0	11.7	14.4	14.9	--	--
14	218.0	209.0	218.0	212.0	12.0	144.0	12.1	14.2	14.7	--	--
15	230.0	221.0	230.0	224.0	12.0	144.0	12.4	14.1	14.5	--	--
16	242.0	233.0	242.0	236.0	12.0	144.0	12.0	13.9	14.4	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	15.94
E[1]	[MPa]	59.01
DPI5[2]	[mm/blow]	13.58
E[2]	[MPa]	69.97

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	103%	85.6%	94.8%	1

Depth of cone below surface at start [mm]: 9

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	9.0	0.0	9.0	--	--	--	--	--	--	--	--
1	37.0	28.0	37.0	23.0	28.0	784.0	--	--	--	--	--
2	57.0	48.0	57.0	47.0	20.0	400.0	--	20.0	20.0	--	--
3	72.0	63.0	72.0	64.5	15.0	225.0	22.4	17.5	17.9	17.5	262.5
4	87.0	78.0	87.0	79.5	15.0	225.0	17.0	16.7	17.0	15.0	225.0
5	100.0	91.0	100.0	93.5	13.0	169.0	14.4	15.8	16.2	14.0	182.0
6	112.0	103.0	112.0	106.0	12.0	144.0	13.5	15.0	15.5	12.5	150.0
7	124.0	115.0	124.0	118.0	12.0	144.0	12.4	14.5	15.0	12.0	144.0
8	136.0	127.0	136.0	130.0	12.0	144.0	12.0	14.1	14.7	12.0	144.0
9	149.0	140.0	149.0	142.5	13.0	169.0	12.4	14.0	14.5	12.5	162.5
10	162.0	153.0	162.0	155.5	13.0	169.0	12.7	13.9	14.3	13.0	169.0
11	174.0	165.0	174.0	168.0	12.0	144.0	12.7	13.7	14.1	12.5	150.0
12	184.0	175.0	184.0	179.0	10.0	100.0	11.8	13.4	13.8	11.0	110.0
13	196.0	187.0	196.0	190.0	12.0	144.0	11.4	13.3	13.7	--	--
14	208.0	199.0	208.0	202.0	12.0	144.0	11.4	13.2	13.6	--	--
15	220.0	211.0	220.0	214.0	12.0	144.0	12.0	13.1	13.5	--	--
16	230.0	221.0	230.0	225.0	10.0	100.0	11.4	12.9	13.3	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	14.38
E^1	[MPa]	65.83
$DPI5^2$	[mm/blow]	12.26
E^2	[MPa]	77.99

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	103%	85.6%	94.8%	2

Depth of cone below surface at start [mm]: 10

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	10.0	0.0	10.0	--	--	--	--	--	--	--	--
1	35.0	25.0	35.0	22.5	25.0	625.0	--	--	--	--	--
2	53.0	43.0	53.0	44.0	18.0	324.0	--	18.0	18.0	--	--
3	70.0	60.0	70.0	61.5	17.0	289.0	20.6	17.5	17.5	17.5	297.5
4	83.0	73.0	83.0	76.5	13.0	169.0	16.3	16.0	16.3	15.0	195.0
5	93.0	83.0	93.0	88.0	10.0	100.0	14.0	14.5	15.2	11.5	115.0
6	106.0	96.0	106.0	99.5	13.0	169.0	12.2	14.2	14.8	11.5	149.5
7	120.0	110.0	120.0	113.0	14.0	196.0	12.6	14.2	14.7	13.5	189.0
8	130.0	120.0	130.0	125.0	10.0	100.0	12.6	13.6	14.2	12.0	120.0
9	144.0	134.0	144.0	137.0	14.0	196.0	12.9	13.6	14.2	12.0	168.0
10	157.0	147.0	157.0	150.5	13.0	169.0	12.6	13.6	14.0	13.5	175.5
11	170.0	160.0	170.0	163.5	13.0	169.0	13.4	13.5	13.9	13.0	169.0
12	184.0	174.0	184.0	177.0	14.0	196.0	13.4	13.5	13.9	13.5	189.0
13	197.0	187.0	197.0	190.5	13.0	169.0	13.4	13.5	13.9	--	--
14	211.0	201.0	211.0	204.0	14.0	196.0	13.7	13.5	13.9	--	--
15	226.0	216.0	226.0	218.5	15.0	225.0	14.0	13.6	14.0	--	--
16	235.0	225.0	235.0	230.5	9.0	81.0	13.2	13.3	13.7	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	14.12
E^1	[MPa]	67.12
$DPI5^2$	[mm/blow]	12.84
E^2	[MPa]	74.27

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	103%	71.2%	99.1%	1

Depth of cone below surface at start [mm]: 16

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[mm^2/blow^2]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[mm^2/blow^2]
0	16.0	0.0	16.0	--	--	--	--	--	--	--	--
1	38.0	22.0	38.0	27.0	22.0	484.0	--	--	--	--	--
2	50.0	34.0	50.0	44.0	12.0	144.0	--	12.0	12.0	--	--
3	64.0	48.0	64.0	57.0	14.0	196.0	17.2	13.0	13.1	13.0	182.0
4	76.0	60.0	76.0	70.0	12.0	144.0	12.7	12.7	12.7	13.0	156.0
5	90.0	74.0	90.0	83.0	14.0	196.0	13.4	13.0	13.1	13.0	182.0
6	104.0	88.0	104.0	97.0	14.0	196.0	13.4	13.2	13.3	14.0	196.0
7	115.0	99.0	115.0	109.5	11.0	121.0	13.2	12.8	12.9	12.5	137.5
8	125.0	109.0	125.0	120.0	10.0	100.0	11.9	12.4	12.6	10.5	105.0
9	140.0	124.0	140.0	132.5	15.0	225.0	12.4	12.8	13.0	12.5	187.5
10	152.0	136.0	152.0	146.0	12.0	144.0	12.7	12.7	12.9	13.5	162.0
11	165.0	149.0	165.0	158.5	13.0	169.0	13.5	12.7	12.9	12.5	162.5
12	179.0	163.0	179.0	172.0	14.0	196.0	13.1	12.8	13.0	13.5	189.0
13	190.0	174.0	190.0	184.5	11.0	121.0	12.8	12.7	12.8	--	--
14	204.0	188.0	204.0	197.0	14.0	196.0	13.2	12.8	12.9	--	--
15	214.0	198.0	214.0	209.0	10.0	100.0	11.9	12.6	12.8	--	--
16	227.0	211.0	227.0	220.5	13.0	169.0	12.6	12.6	12.8	--	--
17	240.0	224.0	240.0	233.5	13.0	169.0	12.2	12.6	12.8	--	--
18	252.0	236.0	252.0	246.0	12.0	144.0	12.7	12.6	12.8	--	--
19	262.0	246.0	262.0	257.0	10.0	100.0	11.8	12.4	12.6	--	--

*Top layer only, first blow not included

DPI5^1	[mm/blow]	13.13
E^1	[MPa]	72.50
DPI5^2	[mm/blow]	12.59
E^2	[MPa]	75.79

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	103%	71.2%	99.1%	2

Depth of cone below surface at start [mm]: 10

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[mm^2/blow^2]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[mm^2/blow^2]
0	10.0	0.0	10.0	--	--	--	--	--	--	--	--
1	33.0	23.0	33.0	21.5	23.0	529.0	--	--	--	--	--
2	46.0	36.0	46.0	39.5	13.0	169.0	--	13.0	13.0	--	--
3	60.0	50.0	60.0	53.0	14.0	196.0	17.9	13.5	13.5	13.5	189.0
4	73.0	63.0	73.0	66.5	13.0	169.0	13.4	13.3	13.4	13.5	175.5
5	89.0	79.0	89.0	81.0	16.0	256.0	14.4	14.0	14.1	14.5	232.0
6	102.0	92.0	102.0	95.5	13.0	169.0	14.1	13.8	13.9	14.5	188.5
7	116.0	106.0	116.0	109.0	14.0	196.0	14.4	13.8	13.9	13.5	189.0
8	130.0	120.0	130.0	123.0	14.0	196.0	13.7	13.9	13.9	14.0	196.0
9	142.0	132.0	142.0	136.0	12.0	144.0	13.4	13.6	13.7	13.0	156.0
10	157.0	147.0	157.0	149.5	15.0	225.0	13.8	13.8	13.9	13.5	202.5
11	170.0	160.0	170.0	163.5	13.0	169.0	13.5	13.7	13.8	14.0	182.0
12	183.0	173.0	183.0	176.5	13.0	169.0	13.7	13.6	13.7	13.0	169.0
13	195.0	185.0	195.0	189.0	12.0	144.0	12.7	13.5	13.6	--	--
14	210.0	200.0	210.0	202.5	15.0	225.0	13.5	13.6	13.7	--	--
15	223.0	213.0	223.0	216.5	13.0	169.0	13.5	13.6	13.7	--	--
16	237.0	227.0	237.0	230.0	14.0	196.0	14.0	13.6	13.7	--	--
17	249.0	239.0	249.0	243.0	12.0	144.0	13.1	13.5	13.6	--	--
18	260.0	250.0	260.0	254.5	11.0	121.0	12.5	13.4	13.5	--	--

*Top layer only, first blow not included

DPI5^1	[mm/blow]	13.91
E^1	[MPa]	68.17
DPI5^2	[mm/blow]	13.51
E^2	[MPa]	70.31

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	103%	63.6%	96.2%	1

Depth of cone below surface at start [mm]: 8

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	8.0	0.0	8.0	--	--	--	--	--	--	--	--
1	28.0	20.0	28.0	18.0	20.0	400.0	--	--	--	--	--
2	38.0	30.0	38.0	33.0	10.0	100.0	--	10.0	10.0	--	--
3	50.0	42.0	50.0	44.0	12.0	144.0	15.3	11.0	11.1	11.0	132.0
4	65.0	57.0	65.0	57.5	15.0	225.0	12.7	12.3	12.7	13.5	202.5
5	75.0	67.0	75.0	70.0	10.0	100.0	12.7	11.8	12.1	12.5	125.0
6	86.0	78.0	86.0	80.5	11.0	121.0	12.4	11.6	11.9	10.5	115.5
7	97.0	89.0	97.0	91.5	11.0	121.0	10.7	11.5	11.8	11.0	121.0
8	106.0	98.0	106.0	101.5	9.0	81.0	10.4	11.1	11.4	10.0	90.0
9	110.0	102.0	110.0	108.0	4.0	16.0	9.1	10.3	11.1	6.5	26.0
10	120.0	112.0	120.0	115.0	10.0	100.0	8.6	10.2	11.0	7.0	70.0
11	130.0	122.0	130.0	125.0	10.0	100.0	9.0	10.2	10.9	10.0	100.0
12	140.0	132.0	140.0	135.0	10.0	100.0	10.0	10.2	10.8	10.0	100.0
13	150.0	142.0	150.0	145.0	10.0	100.0	10.0	10.2	10.7	--	--
14	160.0	152.0	160.0	155.0	10.0	100.0	10.0	10.2	10.7	--	--
15	169.0	161.0	169.0	164.5	9.0	81.0	9.7	10.1	10.6	--	--
16	179.0	171.0	179.0	174.0	10.0	100.0	9.7	10.1	10.5	--	--
17	189.0	181.0	189.0	184.0	10.0	100.0	9.7	10.1	10.5	--	--
18	199.0	191.0	199.0	194.0	10.0	100.0	10.0	10.1	10.5	--	--
19	209.0	201.0	209.0	204.0	10.0	100.0	10.0	10.1	10.4	--	--
20	220.0	212.0	220.0	214.5	11.0	121.0	10.4	10.1	10.5	--	--
21	229.0	221.0	229.0	224.5	9.0	81.0	10.1	10.1	10.4	--	--
22	237.0	229.0	237.0	233.0	8.0	64.0	9.5	10.0	10.3	--	--
23	245.0	237.0	245.0	241.0	8.0	64.0	8.4	9.9	10.2	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	11.80
E^1	[MPa]	81.23
$DPI5^2$	[mm/blow]	8.98
E^2	[MPa]	108.57

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Wing	103%	63.6%	96.2%	2

Depth of cone below surface at start [mm]: 14

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	14.0	0.0	14.0	--	--	--	--	--	--	--	--
1	29.0	15.0	29.0	21.5	15.0	225.0	--	--	--	--	--
2	44.0	30.0	44.0	36.5	15.0	225.0	--	15.0	15.0	--	--
3	54.0	40.0	54.0	49.0	10.0	100.0	13.8	12.5	13.0	12.5	125.0
4	65.0	51.0	65.0	59.5	11.0	121.0	12.4	12.0	12.4	10.5	115.5
5	81.0	67.0	81.0	73.0	16.0	256.0	12.9	13.0	13.5	13.5	216.0
6	88.0	74.0	88.0	84.5	7.0	49.0	12.5	11.8	12.7	11.5	80.5
7	96.0	82.0	96.0	92.0	8.0	64.0	11.9	11.2	12.2	7.5	60.0
8	105.0	91.0	105.0	100.5	9.0	81.0	8.1	10.9	11.8	8.5	76.5
9	115.0	101.0	115.0	110.0	10.0	100.0	9.1	10.8	11.6	9.5	95.0
10	125.0	111.0	125.0	120.0	10.0	100.0	9.7	10.7	11.4	10.0	100.0
11	135.0	121.0	135.0	130.0	10.0	100.0	10.0	10.6	11.3	10.0	100.0
12	145.0	131.0	145.0	140.0	10.0	100.0	10.0	10.5	11.2	10.0	100.0
13	155.0	141.0	155.0	150.0	10.0	100.0	10.0	10.5	11.1	--	--
14	165.0	151.0	165.0	160.0	10.0	100.0	10.0	10.5	11.0	--	--
15	175.0	161.0	175.0	170.0	10.0	100.0	10.0	10.4	10.9	--	--
16	185.0	171.0	185.0	180.0	10.0	100.0	10.0	10.4	10.9	--	--
17	195.0	181.0	195.0	190.0	10.0	100.0	10.0	10.4	10.8	--	--
18	207.0	193.0	207.0	201.0	12.0	144.0	10.8	10.5	10.9	--	--
19	217.0	203.0	217.0	212.0	10.0	100.0	10.8	10.4	10.9	--	--
20	227.0	213.0	227.0	222.0	10.0	100.0	10.8	10.4	10.8	--	--
21	236.0	222.0	236.0	231.5	9.0	81.0	9.7	10.4	10.7	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	11.48
E^1	[MPa]	83.61
$DPI5^2$	[mm/blow]	9.62
E^2	[MPa]	100.85

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	98%	85.2%	97.5%	1

Depth of cone below surface at start [mm]: 10

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	10.0	0.0	10.0	--	--	--	--	--	--	--	--
1	45.0	35.0	45.0	27.5	35.0	1225.0	--	--	--	--	--
2	81.0	71.0	81.0	63.0	36.0	1296.0	--	36.0	36.0	--	--
3	111.0	101.0	111.0	96.0	30.0	900.0	33.9	33.0	33.3	33.0	990.0
4	145.0	135.0	145.0	128.0	34.0	1156.0	33.5	33.3	33.5	32.0	1088.0
5	177.0	167.0	177.0	161.0	32.0	1024.0	32.1	33.0	33.2	33.0	1056.0
6	205.0	195.0	205.0	191.0	28.0	784.0	31.5	32.0	32.3	30.0	840.0
7	237.0	227.0	237.0	221.0	32.0	1024.0	30.8	32.0	32.2	30.0	960.0
8	--	--	--	--	--	--	--	--	--	--	--
9	--	--	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	31.63
E^1	[MPa]	28.51
$DPI5^2$	[mm/blow]	N/A
E^2	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	98%	85.2%	97.5%	2

Depth of cone below surface at start [mm]: 8

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	8.0	0.0	8.0	--	--	--	--	--	--	--	--
1	41.0	33.0	41.0	24.5	33.0	1089.0	--	--	--	--	--
2	78.0	70.0	78.0	59.5	37.0	1369.0	--	37.0	37.0	--	--
3	107.0	99.0	107.0	92.5	29.0	841.0	33.3	33.0	33.5	33.0	957.0
4	144.0	136.0	144.0	125.5	37.0	1369.0	34.7	34.3	34.7	33.0	1221.0
5	174.0	166.0	174.0	159.0	30.0	900.0	32.4	33.3	33.7	33.5	1005.0
6	200.0	192.0	200.0	187.0	26.0	676.0	31.7	31.8	32.4	28.0	728.0
7	231.0	223.0	231.0	215.5	31.0	961.0	29.2	31.7	32.2	28.5	883.5
8	--	--	--	--	--	--	--	--	--	--	--
9	--	--	--	--	--	--	--	--	--	--	--
10	--	--	--	--	--	--	--	--	--	--	--
11	--	--	--	--	--	--	--	--	--	--	--
12	--	--	--	--	--	--	--	--	--	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	31.34
E^1	[MPa]	28.79
$DPI5^2$	[mm/blow]	N/A
E^2	[MPa]	N/A

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	98%	65.0%	97.8%	1

Depth of cone below surface at start [mm]: 10

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	10.0	0.0	10.0	--	--	--	--	--	--	--	--
1	30.0	20.0	30.0	20.0	20.0	400.0	--	--	--	--	--
2	50.0	40.0	50.0	40.0	20.0	400.0	--	20.0	20.0	--	--
3	69.0	59.0	69.0	59.5	19.0	361.0	19.7	19.5	19.5	19.5	370.5
4	87.0	77.0	87.0	78.0	18.0	324.0	19.0	19.0	19.0	18.5	333.0
5	105.0	95.0	105.0	96.0	18.0	324.0	18.3	18.8	18.8	18.0	324.0
6	121.0	111.0	121.0	113.0	16.0	256.0	17.4	18.2	18.3	17.0	272.0
7	141.0	131.0	141.0	131.0	20.0	400.0	18.1	18.5	18.6	18.0	360.0
8	161.0	151.0	161.0	151.0	20.0	400.0	18.9	18.7	18.8	20.0	400.0
9	182.0	172.0	182.0	171.5	21.0	441.0	20.3	19.0	19.1	20.5	430.5
10	208.0	198.0	208.0	195.0	26.0	676.0	22.6	19.8	20.1	23.5	611.0
11	229.0	219.0	229.0	218.5	21.0	441.0	22.9	19.9	20.2	23.5	493.5
12	255.0	245.0	255.0	242.0	26.0	676.0	24.6	20.5	20.9	23.5	611.0

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	18.24
E^1	[MPa]	51.16
$DPI5^2$	[mm/blow]	22.33
E^2	[MPa]	41.25

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	98%	65.0%	97.8%	2

Depth of cone below surface at start [mm]: 10

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	10.0	0.0	10.0	--	--	--	--	--	--	--	--
1	30.0	20.0	30.0	20.0	20.0	400.0	--	--	--	--	--
2	47.0	37.0	47.0	38.5	17.0	289.0	--	17.0	17.0	--	--
3	66.0	56.0	66.0	56.5	19.0	361.0	18.8	18.0	18.1	18.0	342.0
4	85.0	75.0	85.0	75.5	19.0	361.0	18.4	18.3	18.4	19.0	361.0
5	102.0	92.0	102.0	93.5	17.0	289.0	18.4	18.0	18.1	18.0	306.0
6	118.0	108.0	118.0	110.0	16.0	256.0	17.4	17.6	17.7	16.5	264.0
7	136.0	126.0	136.0	127.0	18.0	324.0	17.0	17.7	17.7	17.0	306.0
8	155.0	145.0	155.0	145.5	19.0	361.0	17.8	17.9	17.9	18.5	351.5
9	175.0	165.0	175.0	165.0	20.0	400.0	19.0	18.1	18.2	19.5	390.0
10	195.0	185.0	195.0	185.0	20.0	400.0	19.7	18.3	18.4	20.0	400.0
11	214.0	204.0	214.0	204.5	19.0	361.0	19.7	18.4	18.5	19.5	370.5
12	235.0	225.0	235.0	224.5	21.0	441.0	20.0	18.6	18.7	20.0	420.0
13	256.0	246.0	256.0	245.5	21.0	441.0	20.4	18.8	19.0	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	17.74
E^1	[MPa]	52.67
$DPI5^2$	[mm/blow]	19.52
E^2	[MPa]	47.60

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	98%	49.0%	90.5%	1

Depth of cone below surface at start [mm]: 5

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	5.0	0.0	5.0	--	--	--	--	--	--	--	--
1	18.0	13.0	18.0	11.5	13.0	169.0	--	--	--	--	--
2	26.0	21.0	26.0	22.0	8.0	64.0	--	8.0	8.0	--	--
3	31.0	26.0	31.0	28.5	5.0	25.0	9.9	6.5	6.8	6.5	32.5
4	40.0	35.0	40.0	35.5	9.0	81.0	7.7	7.3	7.7	7.0	63.0
5	43.0	38.0	43.0	41.5	3.0	9.0	6.8	6.3	7.2	6.0	18.0
6	50.0	45.0	50.0	46.5	7.0	49.0	7.3	6.4	7.1	5.0	35.0
7	56.0	51.0	56.0	53.0	6.0	36.0	5.9	6.3	6.9	6.5	39.0
8	63.0	58.0	63.0	59.5	7.0	49.0	6.7	6.4	7.0	6.5	45.5
9	67.0	62.0	67.0	65.0	4.0	16.0	5.9	6.1	6.7	5.5	22.0
10	74.0	69.0	74.0	70.5	7.0	49.0	6.3	6.2	6.8	5.5	38.5
11	80.0	75.0	80.0	77.0	6.0	36.0	5.9	6.2	6.7	6.5	39.0
12	87.0	82.0	87.0	83.5	7.0	49.0	6.7	6.3	6.7	6.5	45.5
13	91.0	86.0	91.0	89.0	4.0	16.0	5.9	6.1	6.6	--	--
14	94.0	89.0	94.0	92.5	3.0	9.0	5.3	5.8	6.4	--	--
15	99.0	94.0	99.0	96.5	5.0	25.0	4.2	5.8	6.3	--	--
16	103.0	98.0	103.0	101.0	4.0	16.0	4.2	5.7	6.2	--	--
17	108.0	103.0	108.0	105.5	5.0	25.0	4.7	5.6	6.2	--	--
18	112.0	107.0	112.0	110.0	4.0	16.0	4.4	5.5	6.1	--	--
19	120.0	115.0	120.0	116.0	8.0	64.0	6.2	5.7	6.2	--	--
20	126.0	121.0	126.0	123.0	6.0	36.0	6.4	5.7	6.2	--	--
21	132.0	127.0	132.0	129.0	6.0	36.0	6.8	5.7	6.2	--	--
22	137.0	132.0	137.0	134.5	5.0	25.0	5.7	5.7	6.1	--	--
23	143.0	138.0	143.0	140.0	6.0	36.0	5.7	5.7	6.1	--	--
24	149.0	144.0	149.0	146.0	6.0	36.0	5.7	5.7	6.1	--	--
25	157.0	152.0	157.0	153.0	8.0	64.0	6.8	5.8	6.2	--	--
26	161.0	156.0	161.0	159.0	4.0	16.0	6.4	5.7	6.2	--	--
27	169.0	164.0	169.0	165.0	8.0	64.0	7.2	5.8	6.3	--	--
28	175.0	170.0	175.0	172.0	6.0	36.0	6.4	5.8	6.3	--	--
29	180.0	175.0	180.0	177.5	5.0	25.0	6.6	5.8	6.2	--	--
30	187.0	182.0	187.0	183.5	7.0	49.0	6.1	5.8	6.3	--	--
31	193.0	188.0	193.0	190.0	6.0	36.0	6.1	5.8	6.2	--	--
32	200.0	195.0	200.0	196.5	7.0	49.0	6.7	5.9	6.3	--	--
33	208.0	203.0	208.0	204.0	8.0	64.0	7.1	5.9	6.3	--	--
34	215.0	210.0	215.0	211.5	7.0	49.0	7.4	6.0	6.4	--	--
35	221.0	216.0	221.0	218.0	6.0	36.0	7.1	6.0	6.4	--	--
36	229.0	224.0	229.0	225.0	8.0	64.0	7.1	6.0	6.4	--	--
37	235.0	230.0	235.0	232.0	6.0	36.0	6.8	6.0	6.4	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	6.25
E^1	[MPa]	159.45
$DPI5^2$	[mm/blow]	6.15
E^2	[MPa]	162.34

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	98%	49.0%	90.5%	2

Depth of cone below surface at start [mm]: 5

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	5.0	0.0	5.0	--	--	--	--	--	--	--	--
1	16.0	11.0	16.0	10.5	11.0	121.0	--	--	--	--	--
2	22.0	17.0	22.0	19.0	6.0	36.0	--	6.0	6.0	--	--
3	29.0	24.0	29.0	25.5	7.0	49.0	8.6	6.5	6.5	6.5	45.5
4	34.0	29.0	34.0	31.5	5.0	25.0	6.1	6.0	6.1	6.0	30.0
5	39.0	34.0	39.0	36.5	5.0	25.0	5.8	5.8	5.9	5.0	25.0
6	45.0	40.0	45.0	42.0	6.0	36.0	5.4	5.8	5.9	5.5	33.0
7	50.0	45.0	50.0	47.5	5.0	25.0	5.4	5.7	5.8	5.5	27.5
8	56.0	51.0	56.0	53.0	6.0	36.0	5.7	5.7	5.8	5.5	33.0
9	63.0	58.0	63.0	59.5	7.0	49.0	6.1	5.9	6.0	6.5	45.5
10	69.0	64.0	69.0	66.0	6.0	36.0	6.4	5.9	6.0	6.5	39.0
11	76.0	71.0	76.0	72.5	7.0	49.0	6.7	6.0	6.1	6.5	45.5
12	83.0	78.0	83.0	79.5	7.0	49.0	6.7	6.1	6.2	7.0	49.0
13	87.0	82.0	87.0	85.0	4.0	16.0	6.3	5.9	6.1	--	--
14	91.0	86.0	91.0	89.0	4.0	16.0	5.4	5.8	6.0	--	--
15	99.0	94.0	99.0	95.0	8.0	64.0	6.0	5.9	6.2	--	--
16	103.0	98.0	103.0	101.0	4.0	16.0	6.0	5.8	6.1	--	--
17	111.0	106.0	111.0	107.0	8.0	64.0	7.2	5.9	6.2	--	--
18	117.0	112.0	117.0	114.0	6.0	36.0	6.4	5.9	6.2	--	--
19	121.0	116.0	121.0	119.0	4.0	16.0	6.4	5.8	6.1	--	--
20	129.0	124.0	129.0	125.0	8.0	64.0	6.4	5.9	6.3	--	--
21	133.0	128.0	133.0	131.0	4.0	16.0	6.0	5.9	6.2	--	--
22	140.0	135.0	140.0	136.5	7.0	49.0	6.8	5.9	6.2	--	--
23	149.0	144.0	149.0	144.5	9.0	81.0	7.3	6.0	6.4	--	--
24	158.0	153.0	158.0	153.5	9.0	81.0	8.4	6.2	6.6	--	--
25	164.0	159.0	164.0	161.0	6.0	36.0	8.3	6.2	6.6	--	--
26	168.0	163.0	168.0	166.0	4.0	16.0	7.0	6.1	6.5	--	--
27	175.0	170.0	175.0	171.5	7.0	49.0	5.9	6.1	6.5	--	--
28	183.0	178.0	183.0	179.0	8.0	64.0	6.8	6.2	6.6	--	--
29	190.0	185.0	190.0	186.5	7.0	49.0	7.4	6.2	6.6	--	--
30	199.0	194.0	199.0	194.5	9.0	81.0	8.1	6.3	6.7	--	--
31	204.0	199.0	204.0	201.5	5.0	25.0	7.4	6.3	6.7	--	--
32	210.0	205.0	210.0	207.0	6.0	36.0	7.1	6.3	6.6	--	--
33	220.0	215.0	220.0	215.0	10.0	100.0	7.7	6.4	6.8	--	--
34	227.0	222.0	227.0	223.5	7.0	49.0	8.0	6.4	6.8	--	--
35	233.0	228.0	233.0	230.0	6.0	36.0	8.0	6.4	6.8	--	--
36	239.0	234.0	239.0	236.0	6.0	36.0	6.4	6.4	6.8	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	5.75
E^1	[MPa]	174.21
$DPI5^2$	[mm/blow]	6.42
E^2	[MPa]	154.86

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	103%	74.7%	99.4%	1

Depth of cone below surface at start [mm]: 7

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	7.0	0.0	7.0	--	--	--	--	--	--	--	--
1	24.0	17.0	24.0	15.5	17.0	289.0	--	--	--	--	--
2	37.0	30.0	37.0	30.5	13.0	169.0	--	13.0	13.0	--	--
3	51.0	44.0	51.0	44.0	14.0	196.0	14.9	13.5	13.5	13.5	189.0
4	68.0	61.0	68.0	59.5	17.0	289.0	14.9	14.7	14.9	15.5	263.5
5	83.0	76.0	83.0	75.5	15.0	225.0	15.4	14.8	14.9	16.0	240.0
6	98.0	91.0	98.0	90.5	15.0	225.0	15.7	14.8	14.9	15.0	225.0
7	110.0	103.0	110.0	104.0	12.0	144.0	14.1	14.3	14.5	13.5	162.0
8	124.0	117.0	124.0	117.0	14.0	196.0	13.8	14.3	14.4	13.0	182.0
9	136.0	129.0	136.0	130.0	12.0	144.0	12.7	14.0	14.2	13.0	156.0
10	150.0	143.0	150.0	143.0	14.0	196.0	13.4	14.0	14.2	13.0	182.0
11	165.0	158.0	165.0	157.5	15.0	225.0	13.8	14.1	14.2	14.5	217.5
12	178.0	171.0	178.0	171.5	13.0	169.0	14.0	14.0	14.1	14.0	182.0
13	191.0	184.0	191.0	184.5	13.0	169.0	13.7	13.9	14.1	--	--
14	204.0	197.0	204.0	197.5	13.0	169.0	13.0	13.8	14.0	--	--
15	220.0	213.0	220.0	212.0	16.0	256.0	14.1	14.0	14.1	--	--
16	234.0	227.0	234.0	227.0	14.0	196.0	14.4	14.0	14.1	--	--
17	250.0	243.0	250.0	242.0	16.0	256.0	15.4	14.1	14.3	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	14.79
E[1]	[MPa]	63.91
DPI5[2]	[mm/blow]	13.52
E[2]	[MPa]	70.27

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	103%	74.7%	99.4%	2

Depth of cone below surface at start [mm]: 7

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	7.0	0.0	7.0	--	--	--	--	--	--	--	--
1	23.0	16.0	23.0	15.0	16.0	256.0	--	--	--	--	--
2	38.0	31.0	38.0	30.5	15.0	225.0	--	15.0	15.0	--	--
3	51.0	44.0	51.0	44.5	13.0	169.0	14.8	14.0	14.1	14.0	182.0
4	66.0	59.0	66.0	58.5	15.0	225.0	14.4	14.3	14.4	14.0	210.0
5	80.0	73.0	80.0	73.0	14.0	196.0	14.0	14.3	14.3	14.5	203.0
6	95.0	88.0	95.0	87.5	15.0	225.0	14.7	14.4	14.4	14.5	217.5
7	110.0	103.0	110.0	102.5	15.0	225.0	14.7	14.5	14.5	15.0	225.0
8	122.0	115.0	122.0	116.0	12.0	144.0	14.1	14.1	14.2	13.5	162.0
9	135.0	128.0	135.0	128.5	13.0	169.0	13.5	14.0	14.1	12.5	162.5
10	147.0	140.0	147.0	141.0	12.0	144.0	12.4	13.8	13.9	12.5	150.0
11	161.0	154.0	161.0	154.0	14.0	196.0	13.1	13.8	13.9	13.0	182.0
12	175.0	168.0	175.0	168.0	14.0	196.0	13.4	13.8	13.9	14.0	196.0
13	189.0	182.0	189.0	182.0	14.0	196.0	14.0	13.8	13.9	--	--
14	201.0	194.0	201.0	195.0	12.0	144.0	13.4	13.7	13.8	--	--
15	216.0	209.0	216.0	208.5	15.0	225.0	13.8	13.8	13.9	--	--
16	232.0	225.0	232.0	224.0	16.0	256.0	14.5	13.9	14.0	--	--
17	245.0	238.0	245.0	238.5	13.0	169.0	14.8	13.9	14.0	--	--

*Top layer only, first blow not included

DPI5[1]	[mm/blow]	14.41
E[1]	[MPa]	65.69
DPI5[2]	[mm/blow]	13.12
E[2]	[MPa]	72.59

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	103%	60.9%	102.9%	1

Depth of cone below surface at start [mm]: 7

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	7.0	0.0	7.0	--	--	--	--	--	--	--	--
1	19.0	12.0	19.0	13.0	12.0	144.0	--	--	--	--	--
2	27.0	20.0	27.0	23.0	8.0	64.0	--	8.0	8.0	--	--
3	35.0	28.0	35.0	31.0	8.0	64.0	9.7	8.0	8.0	8.0	64.0
4	42.0	35.0	42.0	38.5	7.0	49.0	7.7	7.7	7.7	7.5	52.5
5	50.0	43.0	50.0	46.0	8.0	64.0	7.7	7.8	7.8	7.5	60.0
6	56.0	49.0	56.0	53.0	6.0	36.0	7.1	7.4	7.5	7.0	42.0
7	64.0	57.0	64.0	60.0	8.0	64.0	7.5	7.5	7.6	7.0	56.0
8	72.0	65.0	72.0	68.0	8.0	64.0	7.5	7.6	7.6	8.0	64.0
9	81.0	74.0	81.0	76.5	9.0	81.0	8.4	7.8	7.8	8.5	76.5
10	89.0	82.0	89.0	85.0	8.0	64.0	8.4	7.8	7.9	8.5	68.0
11	95.0	88.0	95.0	92.0	6.0	36.0	7.9	7.6	7.7	7.0	42.0
12	100.0	93.0	100.0	97.5	5.0	25.0	6.6	7.4	7.5	5.5	27.5
13	109.0	102.0	109.0	104.5	9.0	81.0	7.1	7.5	7.7	--	--
14	118.0	111.0	118.0	113.5	9.0	81.0	8.1	7.6	7.8	--	--
15	126.0	119.0	126.0	122.0	8.0	64.0	8.7	7.6	7.8	--	--
16	132.0	125.0	132.0	129.0	6.0	36.0	7.9	7.5	7.7	--	--
17	141.0	134.0	141.0	136.5	9.0	81.0	7.9	7.6	7.8	--	--
18	149.0	142.0	149.0	145.0	8.0	64.0	7.9	7.6	7.8	--	--
19	156.0	149.0	156.0	152.5	7.0	49.0	8.1	7.6	7.8	--	--
20	165.0	158.0	165.0	160.5	9.0	81.0	8.1	7.7	7.9	--	--
21	174.0	167.0	174.0	169.5	9.0	81.0	8.4	7.8	7.9	--	--
22	183.0	176.0	183.0	178.5	9.0	81.0	9.0	7.8	8.0	--	--
23	190.0	183.0	190.0	186.5	7.0	49.0	8.4	7.8	7.9	--	--
24	199.0	192.0	199.0	194.5	9.0	81.0	8.4	7.8	8.0	--	--
25	207.0	200.0	207.0	203.0	8.0	64.0	8.1	7.8	8.0	--	--
26	215.0	208.0	215.0	211.0	8.0	64.0	8.4	7.8	8.0	--	--
27	224.0	217.0	224.0	219.5	9.0	81.0	8.4	7.9	8.0	--	--
28	235.0	228.0	235.0	229.5	11.0	121.0	9.5	8.0	8.2	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	7.42
E^1	[MPa]	132.92
$DPI5^2$	[mm/blow]	7.72
E^2	[MPa]	127.38

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	103%	60.9%	102.9%	2

Depth of cone below surface at start [mm]: 5

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[mm^2/$blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[mm^2/$blow^2$]
0	5.0	0.0	5.0	--	--	--	--	--	--	--	--
1	20.0	15.0	20.0	12.5	15.0	225.0	--	--	--	--	--
2	27.0	22.0	27.0	23.5	7.0	49.0	--	7.0	7.0	--	--
3	35.0	30.0	35.0	31.0	8.0	64.0	11.3	7.5	7.5	7.5	60.0
4	44.0	39.0	44.0	39.5	9.0	81.0	8.1	8.0	8.1	8.5	76.5
5	55.0	50.0	55.0	49.5	11.0	121.0	9.5	8.8	9.0	10.0	110.0
6	64.0	59.0	64.0	59.5	9.0	81.0	9.8	8.8	9.0	10.0	90.0
7	72.0	67.0	72.0	68.0	8.0	64.0	9.5	8.7	8.8	8.5	68.0
8	80.0	75.0	80.0	76.0	8.0	64.0	8.4	8.6	8.7	8.0	64.0
9	88.0	83.0	88.0	84.0	8.0	64.0	8.0	8.5	8.6	8.0	64.0
10	97.0	92.0	97.0	92.5	9.0	81.0	8.4	8.6	8.7	8.5	76.5
11	103.0	98.0	103.0	100.0	6.0	36.0	7.9	8.3	8.5	7.5	45.0
12	110.0	105.0	110.0	106.5	7.0	49.0	7.5	8.2	8.4	6.5	45.5
13	120.0	115.0	120.0	115.0	10.0	100.0	8.0	8.3	8.5	--	--
14	127.0	122.0	127.0	123.5	7.0	49.0	8.3	8.2	8.4	--	--
15	135.0	130.0	135.0	131.0	8.0	64.0	8.5	8.2	8.4	--	--
16	145.0	140.0	145.0	140.0	10.0	100.0	8.5	8.3	8.5	--	--
17	153.0	148.0	153.0	149.0	8.0	64.0	8.8	8.3	8.5	--	--
18	160.0	155.0	160.0	156.5	7.0	49.0	8.5	8.2	8.4	--	--
19	170.0	165.0	170.0	165.0	10.0	100.0	8.5	8.3	8.5	--	--
20	179.0	174.0	179.0	174.5	9.0	81.0	8.8	8.4	8.6	--	--
21	188.0	183.0	188.0	183.5	9.0	81.0	9.4	8.4	8.6	--	--
22	195.0	190.0	195.0	191.5	7.0	49.0	8.4	8.3	8.5	--	--
23	203.0	198.0	203.0	199.0	8.0	64.0	8.1	8.3	8.5	--	--
24	213.0	208.0	213.0	208.0	10.0	100.0	8.5	8.4	8.6	--	--
25	223.0	218.0	223.0	218.0	10.0	100.0	9.4	8.5	8.6	--	--
26	234.0	229.0	234.0	228.5	11.0	121.0	10.4	8.6	8.8	--	--
27	243.0	238.0	243.0	238.5	9.0	81.0	10.1	8.6	8.8	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	8.99
E^1	[MPa]	108.41
$DPI5^2$	[mm/blow]	7.76
E^2	[MPa]	126.67

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	103%	48.6%	100.9%	1

Depth of cone below surface at start [mm]: 10

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	10.0	0.0	10.0	--	--	--	--	--	--	--	--
1	20.0	10.0	20.0	15.0	10.0	100.0	--	--	--	--	--
2	25.0	15.0	25.0	22.5	5.0	25.0	--	5.0	5.0	--	--
3	30.0	20.0	30.0	27.5	5.0	25.0	7.5	5.0	5.0	5.0	25.0
4	35.0	25.0	35.0	32.5	5.0	25.0	5.0	5.0	5.0	5.0	25.0
5	38.0	28.0	38.0	36.5	3.0	9.0	4.5	4.5	4.7	4.0	12.0
6	42.0	32.0	42.0	40.0	4.0	16.0	4.2	4.4	4.5	3.5	14.0
7	46.0	36.0	46.0	44.0	4.0	16.0	3.7	4.3	4.5	4.0	16.0
8	50.0	40.0	50.0	48.0	4.0	16.0	4.0	4.3	4.4	4.0	16.0
9	53.0	43.0	53.0	51.5	3.0	9.0	3.7	4.1	4.3	3.5	10.5
10	60.0	50.0	60.0	56.5	7.0	49.0	5.3	4.4	4.8	5.0	35.0
11	65.0	55.0	65.0	62.5	5.0	25.0	5.5	4.5	4.8	6.0	30.0
12	69.0	59.0	69.0	67.0	4.0	16.0	5.6	4.5	4.7	4.5	18.0
13	75.0	65.0	75.0	72.0	6.0	36.0	5.1	4.6	4.9	--	--
14	80.0	70.0	80.0	77.5	5.0	25.0	5.1	4.6	4.9	--	--
15	85.0	75.0	85.0	82.5	5.0	25.0	5.4	4.6	4.9	--	--
16	88.0	78.0	88.0	86.5	3.0	9.0	4.5	4.5	4.8	--	--
17	90.0	80.0	90.0	89.0	2.0	4.0	3.8	4.4	4.7	--	--
18	94.0	84.0	94.0	92.0	4.0	16.0	3.2	4.4	4.7	--	--
19	100.0	90.0	100.0	97.0	6.0	36.0	4.7	4.4	4.8	--	--
20	103.0	93.0	103.0	101.5	3.0	9.0	4.7	4.4	4.7	--	--
21	108.0	98.0	108.0	105.5	5.0	25.0	5.0	4.4	4.7	--	--
22	114.0	104.0	114.0	111.0	6.0	36.0	5.0	4.5	4.8	--	--
23	118.0	108.0	118.0	116.0	4.0	16.0	5.1	4.5	4.8	--	--
24	122.0	112.0	122.0	120.0	4.0	16.0	4.9	4.4	4.7	--	--
25	128.0	118.0	128.0	125.0	6.0	36.0	4.9	4.5	4.8	--	--
26	132.0	122.0	132.0	130.0	4.0	16.0	4.9	4.5	4.8	--	--
27	135.0	125.0	135.0	133.5	3.0	9.0	4.7	4.4	4.7	--	--
28	139.0	129.0	139.0	137.0	4.0	16.0	3.7	4.4	4.7	--	--
29	144.0	134.0	144.0	141.5	5.0	25.0	4.2	4.4	4.7	--	--
30	148.0	138.0	148.0	146.0	4.0	16.0	4.4	4.4	4.7	--	--
31	153.0	143.0	153.0	150.5	5.0	25.0	4.7	4.4	4.7	--	--
32	158.0	148.0	158.0	155.5	5.0	25.0	4.7	4.5	4.7	--	--
33	164.0	154.0	164.0	161.0	6.0	36.0	5.4	4.5	4.8	--	--
34	169.0	159.0	169.0	166.5	5.0	25.0	5.4	4.5	4.8	--	--
35	174.0	164.0	174.0	171.5	5.0	25.0	5.4	4.5	4.8	--	--
36	179.0	169.0	179.0	176.5	5.0	25.0	5.0	4.5	4.8	--	--
37	182.0	172.0	182.0	180.5	3.0	9.0	4.5	4.5	4.8	--	--
38	188.0	178.0	188.0	185.0	6.0	36.0	5.0	4.5	4.8	--	--
39	190.0	180.0	190.0	189.0	2.0	4.0	4.5	4.5	4.8	--	--
40	197.0	187.0	197.0	193.5	7.0	49.0	5.9	4.5	4.9	--	--
41	204.0	194.0	204.0	200.5	7.0	49.0	6.4	4.6	4.9	--	--
42	210.0	200.0	210.0	207.0	6.0	36.0	6.7	4.6	5.0	--	--
43	214.0	204.0	214.0	212.0	4.0	16.0	5.9	4.6	5.0	--	--
44	220.0	210.0	220.0	217.0	6.0	36.0	5.5	4.7	5.0	--	--
45	225.0	215.0	225.0	222.5	5.0	25.0	5.1	4.7	5.0	--	--
46	230.0	220.0	230.0	227.5	5.0	25.0	5.4	4.7	5.0	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	4.38
E^1	[MPa]	232.52
$DPI5^2$	[mm/blow]	4.76
E^2	[MPa]	212.87

Dynamic Cone Penetrometer

Soil Origin	Target Density	Actual Moisture	Actual Desnity	Trial No.
Red Lake Falls	103%	48.6%	100.9%	2

Depth of cone below surface at start [mm]: 3

Blow	Reading	Cone Depth From Start	Total Cone Depth	Average Cone Depth	DPI	DPI^2	Three Blow Weighted Average DPI	Non-Weighted Average DPI*	Weighted Average DPI*	Average DPI	DPI x Average DPI
	[mm]	[mm]	[mm]	[mm]	[mm/blow]	[$mm^2/blow^2$]	[mm/blow]	[mm/blow]	[mm/blow]	[mm/blow]	[$mm^2/blow^2$]
0	3.0	0.0	3.0	--	--	--	--	--	--	--	--
1	16.0	13.0	16.0	9.5	13.0	169.0	--	--	--	--	--
2	20.0	17.0	20.0	18.0	4.0	16.0	--	4.0	4.0	--	--
3	25.0	22.0	25.0	22.5	5.0	25.0	9.5	4.5	4.6	4.5	22.5
4	30.0	27.0	30.0	27.5	5.0	25.0	4.7	4.7	4.7	5.0	25.0
5	33.0	30.0	33.0	31.5	3.0	9.0	4.5	4.3	4.4	4.0	12.0
6	37.0	34.0	37.0	35.0	4.0	16.0	4.2	4.2	4.3	3.5	14.0
7	42.0	39.0	42.0	39.5	5.0	25.0	4.2	4.3	4.5	4.5	22.5
8	45.0	42.0	45.0	43.5	3.0	9.0	4.2	4.1	4.3	4.0	12.0
9	50.0	47.0	50.0	47.5	5.0	25.0	4.5	4.3	4.4	4.0	20.0
10	55.0	52.0	55.0	52.5	5.0	25.0	4.5	4.3	4.5	5.0	25.0
11	59.0	56.0	59.0	57.0	4.0	16.0	4.7	4.3	4.4	4.5	18.0
12	65.0	62.0	65.0	62.0	6.0	36.0	5.1	4.5	4.6	5.0	30.0
13	70.0	67.0	70.0	67.5	5.0	25.0	5.1	4.5	4.7	--	--
14	75.0	72.0	75.0	72.5	5.0	25.0	5.4	4.5	4.7	--	--
15	78.0	75.0	78.0	76.5	3.0	9.0	4.5	4.4	4.6	--	--
16	81.0	78.0	81.0	79.5	3.0	9.0	3.9	4.3	4.5	--	--
17	86.0	83.0	86.0	83.5	5.0	25.0	3.9	4.4	4.6	--	--
18	90.0	87.0	90.0	88.0	4.0	16.0	4.2	4.4	4.5	--	--
19	95.0	92.0	95.0	92.5	5.0	25.0	4.7	4.4	4.6	--	--
20	99.0	96.0	99.0	97.0	4.0	16.0	4.4	4.4	4.5	--	--
21	104.0	101.0	104.0	101.5	5.0	25.0	4.7	4.4	4.6	--	--
22	108.0	105.0	108.0	106.0	4.0	16.0	4.4	4.4	4.5	--	--
23	113.0	110.0	113.0	110.5	5.0	25.0	4.7	4.4	4.6	--	--
24	118.0	115.0	118.0	115.5	5.0	25.0	4.7	4.4	4.6	--	--
25	124.0	121.0	124.0	121.0	6.0	36.0	5.4	4.5	4.7	--	--
26	130.0	127.0	130.0	127.0	6.0	36.0	5.7	4.6	4.7	--	--
27	135.0	132.0	135.0	132.5	5.0	25.0	5.7	4.6	4.7	--	--
28	140.0	137.0	140.0	137.5	5.0	25.0	5.4	4.6	4.8	--	--
29	145.0	142.0	145.0	142.5	5.0	25.0	5.0	4.6	4.8	--	--
30	150.0	147.0	150.0	147.5	5.0	25.0	5.0	4.6	4.8	--	--
31	155.0	152.0	155.0	152.5	5.0	25.0	5.0	4.6	4.8	--	--
32	157.0	154.0	157.0	156.0	2.0	4.0	4.5	4.5	4.7	--	--
33	162.0	159.0	162.0	159.5	5.0	25.0	4.5	4.6	4.8	--	--
34	167.0	164.0	167.0	164.5	5.0	25.0	4.5	4.6	4.8	--	--
35	172.0	169.0	172.0	169.5	5.0	25.0	5.0	4.6	4.8	--	--
36	175.0	172.0	175.0	173.5	3.0	9.0	4.5	4.5	4.7	--	--
37	179.0	176.0	179.0	177.0	4.0	16.0	4.2	4.5	4.7	--	--
38	185.0	182.0	185.0	182.0	6.0	36.0	4.7	4.6	4.8	--	--
39	188.0	185.0	188.0	186.5	3.0	9.0	4.7	4.5	4.7	--	--
40	193.0	190.0	193.0	190.5	5.0	25.0	5.0	4.5	4.7	--	--
41	196.0	193.0	196.0	194.5	3.0	9.0	3.9	4.5	4.7	--	--
42	202.0	199.0	202.0	199.0	6.0	36.0	5.0	4.5	4.8	--	--
43	209.0	206.0	209.0	205.5	7.0	49.0	5.9	4.6	4.8	--	--
44	212.0	209.0	212.0	210.5	3.0	9.0	5.9	4.6	4.8	--	--
45	218.0	215.0	218.0	215.0	6.0	36.0	5.9	4.6	4.8	--	--

*Top layer only, first blow not included

$DPI5^1$	[mm/blow]	4.36
E^1	[MPa]	233.50
$DPI5^2$	[mm/blow]	4.57
E^2	[MPa]	222.56

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
MnROAD	15	100	15.6	97.7	1	900	1	0.82	820.00	8.93	0.28	48.06	
MnROAD	15	100	15.6	97.7	1	900	2	0.84	844.00	8.99	0.29	47.01	
MnROAD	15	100	15.6	97.7	1	900	3	0.77	768.00	8.84	0.28	50.80	48.62
MnROAD	15	100	15.6	97.7	1	900	4	0.82	822.00	8.93	0.28	47.94	48.58
MnROAD	15	100	15.6	97.7	1	900	5	0.75	745.00	8.82	0.28	52.25	50.33
MnROAD	15	100	15.6	97.7	1	900	mean3-5	0.78	778.33	8.86	0.28	50.33	
MnROAD	15	100	15.6	97.7	1	900	stddev3-5	0.04	39.53	0.06	0.00	2.19	
MnROAD	15	100	15.6	97.7	1	900	coefvar3-5	5.08	5.08	0.66	0.66	4.35	
MnROAD	15	100	15.6	97.7	2	100	1						
MnROAD	15	100	15.6	97.7	2	100	2						
MnROAD	15	100	15.6	97.7	2	100	3						
MnROAD	15	100	15.6	97.7	2	100	4						
MnROAD	15	100	15.6	97.7	2	100	5						
MnROAD	15	100	15.6	97.7	2	100	mean3-5						
MnROAD	15	100	15.6	97.7	2	100	stddev3-5						
MnROAD	15	100	15.6	97.7	2	100	coefvar3-5						
MnROAD	12	100	11.5	99.2	1	900	1	0.21	209.00	9.20	0.29	194.27	
MnROAD	12	100	11.5	99.2	1	900	2	0.21	210.00	9.20	0.29	193.34	
MnROAD	12	100	11.5	99.2	1	900	3	0.21	206.00	9.07	0.29	194.31	193.97
MnROAD	12	100	11.5	99.2	1	900	4	0.21	213.00	9.18	0.29	190.20	192.62
MnROAD	12	100	11.5	99.2	1	900	5	0.21	213.00	9.26	0.29	191.86	192.12
MnROAD	12	100	11.5	99.2	1	900	mean3-5	0.21	210.67	9.17	0.29	192.12	
MnROAD	12	100	11.5	99.2	1	900	stddev3-5	0.00	4.04	0.10	0.00	2.07	
MnROAD	12	100	11.5	99.2	1	900	coefvar3-5	1.92	1.92	1.04	1.04	1.08	
MnROAD	12	100	11.5	99.2	2	100	1						
MnROAD	12	100	11.5	99.2	2	100	2						
MnROAD	12	100	11.5	99.2	2	100	3						
MnROAD	12	100	11.5	99.2	2	100	4						
MnROAD	12	100	11.5	99.2	2	100	5						
MnROAD	12	100	11.5	99.2	2	100	mean3-5						
MnROAD	12	100	11.5	99.2	2	100	stddev3-5						
MnROAD	12	100	11.5	99.2	2	100	coefvar3-5						
MnROAD	9	100	10.9	93.5	1	900	1	0.20	196.00	9.29	0.30	209.18	
MnROAD	9	100	10.9	93.5	1	900	2	0.19	193.00	9.07	0.29	207.40	
MnROAD	9	100	10.9	93.5	1	900	3	0.19	186.00	9.17	0.29	217.58	211.38
MnROAD	9	100	10.9	93.5	1	900	4	0.20	197.00	8.90	0.28	199.38	208.12
MnROAD	9	100	10.9	93.5	1	900	5	0.20	197.00	9.17	0.29	205.43	207.46
MnROAD	9	100	10.9	93.5	1	900	mean3-5	0.19	193.33	9.08	0.29	207.46	
MnROAD	9	100	10.9	93.5	1	900	stddev3-5	0.01	6.35	0.16	0.00	9.27	
MnROAD	9	100	10.9	93.5	1	900	coefvar3-5	3.28	3.28	1.72	1.72	4.47	
MnROAD	9	100	10.9	93.5	2	100	1						
MnROAD	9	100	10.9	93.5	2	100	2						
MnROAD	9	100	10.9	93.5	2	100	3						
MnROAD	9	100	10.9	93.5	2	100	4						
MnROAD	9	100	10.9	93.5	2	100	5						
MnROAD	9	100	10.9	93.5	2	100	mean3-5						
MnROAD	9	100	10.9	93.5	2	100	stddev3-5						
MnROAD	9	100	10.9	93.5	2	100	coefvar3-5						

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
MnROAD	13.5	105	14.1	103.1	1	900	1	0.16	157.00	9.06	0.29	254.67	
MnROAD	13.5	105	14.1	103.1	1	900	2	0.17	172.00	9.25	0.29	237.34	
MnROAD	13.5	105	14.1	103.1	1	900	3	0.17	167.00	9.19	0.29	242.86	244.96
MnROAD	13.5	105	14.1	103.1	1	900	4	0.17	168.00	9.25	0.29	242.99	241.06
MnROAD	13.5	105	14.1	103.1	1	900	5	0.16	157.00	8.99	0.29	252.71	246.18
MnROAD	13.5	105	14.1	103.1	1	900	mean3-5	0.16	164.00	9.14	0.29	246.18	
MnROAD	13.5	105	14.1	103.1	1	900	stddev3-5	0.01	6.08	0.14	0.00	5.65	
MnROAD	13.5	105	14.1	103.1	1	900	coefvar3-5	3.71	3.71	1.49	1.49	2.29	
MnROAD	13.5	105	14.1	103.1	2	100	1						
MnROAD	13.5	105	14.1	103.1	2	100	2						
MnROAD	13.5	105	14.1	103.1	2	100	3						
MnROAD	13.5	105	14.1	103.1	2	100	4						
MnROAD	13.5	105	14.1	103.1	2	100	5						
MnROAD	13.5	105	14.1	103.1	2	100	mean3-5						
MnROAD	13.5	105	14.1	103.1	2	100	stddev3-5						
MnROAD	13.5	105	14.1	103.1	2	100	coefvar3-5						
MnROAD	10.5	105	11.2	98.8	1	900	1	0.17	168.00	9.15	0.29	240.36	
MnROAD	10.5	105	11.2	98.8	1	900	2	0.17	169.00	8.99	0.29	234.76	
MnROAD	10.5	105	11.2	98.8	1	900	3	0.17	172.00	9.25	0.29	237.34	237.49
MnROAD	10.5	105	11.2	98.8	1	900	4	0.19	187.00	9.15	0.29	215.94	229.35
MnROAD	10.5	105	11.2	98.8	1	900	5	0.16	157.00	9.19	0.29	258.33	237.20
MnROAD	10.5	105	11.2	98.8	1	900	mean3-5	0.17	172.00	9.20	0.29	237.20	
MnROAD	10.5	105	11.2	98.8	1	900	stddev3-5	0.02	15.00	0.05	0.00	21.19	
MnROAD	10.5	105	11.2	98.8	1	900	coefvar3-5	8.72	8.72	0.55	0.55	8.93	
MnROAD	10.5	105	11.2	98.8	2	100	1						
MnROAD	10.5	105	11.2	98.8	2	100	2						
MnROAD	10.5	105	11.2	98.8	2	100	3						
MnROAD	10.5	105	11.2	98.8	2	100	4						
MnROAD	10.5	105	11.2	98.8	2	100	5						
MnROAD	10.5	105	11.2	98.8	2	100	mean3-5						
MnROAD	10.5	105	11.2	98.8	2	100	stddev3-5						
MnROAD	10.5	105	11.2	98.8	2	100	coefvar3-5						
MnROAD	7.5	105	7.7	98.3	1	900	1	0.38	380.00	8.91	0.28	103.48	
MnROAD	7.5	105	7.7	98.3	1	900	2	0.38	381.00	9.10	0.29	105.41	
MnROAD	7.5	105	7.7	98.3	1	900	3	0.42	421.00	8.75	0.28	91.72	100.20
MnROAD	7.5	105	7.7	98.3	1	900	4	0.38	381.00	9.07	0.29	105.06	100.73
MnROAD	7.5	105	7.7	98.3	1	900	5	0.39	386.00	8.50	0.27	97.18	97.99
MnROAD	7.5	105	7.7	98.3	1	900	mean3-5	0.40	396.00	8.77	0.28	97.99	
MnROAD	7.5	105	7.7	98.3	1	900	stddev3-5	0.02	21.79	0.29	0.01	6.70	
MnROAD	7.5	105	7.7	98.3	1	900	coefvar3-5	5.50	5.50	3.26	3.26	6.84	
MnROAD	7.5	105	7.7	98.3	2	100	1						
MnROAD	7.5	105	7.7	98.3	2	100	2						
MnROAD	7.5	105	7.7	98.3	2	100	3						
MnROAD	7.5	105	7.7	98.3	2	100	4						
MnROAD	7.5	105	7.7	98.3	2	100	5						
MnROAD	7.5	105	7.7	98.3	2	100	mean3-5						
MnROAD	7.5	105	7.7	98.3	2	100	stddev3-5						
MnROAD	7.5	105	7.7	98.3	2	100	coefvar3-5						

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Duluth	27	98	26.1	103	1	100	1	0.09	93.00	2.86	0.09	135.72	
Duluth	27	98	26.1	103	1	100	2	0.09	93.00	2.86	0.09	135.72	
Duluth	27	98	26.1	103	1	100	3	0.08	83.00	2.92	0.09	155.26	142.23
Duluth	27	98	26.1	103	1	100	4	0.08	83.00	2.92	0.09	155.26	148.75
Duluth	27	98	26.1	103	1	100	5	0.09	87.00	2.92	0.09	148.12	152.88
Duluth	27	98	26.1	103	1	100	mean3-5	0.08	84.33	2.92	0.09	152.88	
Duluth	27	98	26.1	103	1	100	stddev3-5	0.00	2.31	0.00	0.00	4.12	
Duluth	27	98	26.1	103	1	100	coefvar3-5	2.74	2.74	0.00	0.00	2.70	
Duluth	27	98	26.1	103	2	100	1	0.07	71.00	2.93	0.09	182.12	
Duluth	27	98	26.1	103	2	100	2	0.08	81.00	2.91	0.09	158.55	
Duluth	27	98	26.1	103	2	100	3	0.08	75.00	2.92	0.09	171.82	170.83
Duluth	27	98	26.1	103	2	100	4	0.07	68.00	2.92	0.09	189.51	173.29
Duluth	27	98	26.1	103	2	100	5	0.08	75.00	2.93	0.09	172.41	177.91
Duluth	27	98	26.1	103	2	100	mean3-5	0.07	72.67	2.92	0.09	177.91	
Duluth	27	98	26.1	103	2	100	stddev3-5	0.00	4.04	0.01	0.00	10.05	
Duluth	27	98	26.1	103	2	100	coefvar3-5	5.56	5.56	0.20	0.20	5.65	
Duluth	27	98	26.1	103	3	100	1	0.07	72.00	2.55	0.08	156.30	
Duluth	27	98	26.1	103	3	100	2	0.07	71.00	2.47	0.08	153.53	
Duluth	27	98	26.1	103	3	100	3	0.08	76.00	2.60	0.08	150.98	153.60
Duluth	27	98	26.1	103	3	100	4	0.07	67.00	2.48	0.08	163.35	155.95
Duluth	27	98	26.1	103	3	100	5	0.07	67.00	2.58	0.08	169.94	161.42
Duluth	27	98	26.1	103	3	100	mean3-5	0.07	70.00	2.55	0.08	161.42	
Duluth	27	98	26.1	103	3	100	stddev3-5	0.01	5.20	0.06	0.00	9.63	
Duluth	27	98	26.1	103	3	100	coefvar3-5	7.42	7.42	2.52	2.52	5.96	
Duluth	27	98	26.1	103	1	500	1	0.15	151.00	4.65	0.15	135.90	
Duluth	27	98	26.1	103	1	500	2	0.15	152.00	4.66	0.15	135.30	
Duluth	27	98	26.1	103	1	500	3	0.15	154.00	4.64	0.15	132.97	134.72
Duluth	27	98	26.1	103	1	500	4	0.15	151.00	4.60	0.15	134.44	134.24
Duluth	27	98	26.1	103	1	500	5	0.15	149.00	4.68	0.15	138.62	135.34
Duluth	27	98	26.1	103	1	500	mean3-5	0.15	151.33	4.64	0.15	135.34	
Duluth	27	98	26.1	103	1	500	stddev3-5	0.00	2.52	0.04	0.00	2.93	
Duluth	27	98	26.1	103	1	500	coefvar3-5	1.66	1.66	0.86	0.86	2.16	
Duluth	27	98	26.1	103	2	500	1	0.14	141.00	5.30	0.17	165.89	
Duluth	27	98	26.1	103	2	500	2	0.15	145.00	5.29	0.17	161.01	
Duluth	27	98	26.1	103	2	500	3	0.14	143.00	5.35	0.17	165.11	164.00
Duluth	27	98	26.1	103	2	500	4	0.14	143.00	5.29	0.17	163.26	163.12
Duluth	27	98	26.1	103	2	500	5	0.14	142.00	5.32	0.17	165.34	164.57
Duluth	27	98	26.1	103	2	500	mean3-5	0.14	142.67	5.32	0.17	164.57	
Duluth	27	98	26.1	103	2	500	stddev3-5	0.00	0.58	0.03	0.00	1.14	
Duluth	27	98	26.1	103	2	500	coefvar3-5	0.40	0.40	0.56	0.56	0.69	
Duluth	27	98	26.1	103	3	500	1	0.13	134.00	4.82	0.15	158.74	
Duluth	27	98	26.1	103	3	500	2	0.13	127.00	4.92	0.16	170.97	
Duluth	27	98	26.1	103	3	500	3	0.16	160.00	4.73	0.15	130.47	153.39
Duluth	27	98	26.1	103	3	500	4	0.13	129.00	4.87	0.16	166.61	156.01
Duluth	27	98	26.1	103	3	500	5	0.13	126.00	4.90	0.16	171.62	156.23
Duluth	27	98	26.1	103	3	500	mean3-5	0.14	138.33	4.83	0.15	156.23	
Duluth	27	98	26.1	103	3	500	stddev3-5	0.02	18.82	0.09	0.00	22.46	
Duluth	27	98	26.1	103	3	500	coefvar3-5	13.61	13.61	1.88	1.88	14.37	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Duluth	27	98	26.1	103	1	900	1	0.27	267.00	7.19	0.23	118.84	
Duluth	27	98	26.1	103	1	900	2	0.27	268.00	7.16	0.23	117.91	
Duluth	27	98	26.1	103	1	900	3	0.27	271.00	7.20	0.23	117.25	118.00
Duluth	27	98	26.1	103	1	900	4	0.26	264.00	7.07	0.23	118.19	117.78
Duluth	27	98	26.1	103	1	900	5	0.29	285.00	6.86	0.22	106.23	113.89
Duluth	27	98	26.1	103	1	900	mean3-5	0.27	273.33	7.04	0.22	113.89	
Duluth	27	98	26.1	103	1	900	stddev3-5	0.01	10.69	0.17	0.01	6.65	
Duluth	27	98	26.1	103	1	900	coefvar3-5	3.91	3.91	2.44	2.44	5.84	
Duluth	27	98	26.1	103	2	900	1	0.22	215.00	7.32	0.23	150.25	
Duluth	27	98	26.1	103	2	900	2	0.22	222.00	7.29	0.23	144.92	
Duluth	27	98	26.1	103	2	900	3	0.22	222.00	7.33	0.23	145.72	146.96
Duluth	27	98	26.1	103	2	900	4	0.23	229.00	7.37	0.23	142.03	144.22
Duluth	27	98	26.1	103	2	900	5	0.23	225.00	7.28	0.23	142.79	143.51
Duluth	27	98	26.1	103	2	900	mean3-5	0.23	225.33	7.33	0.23	143.51	
Duluth	27	98	26.1	103	2	900	stddev3-5	0.00	3.51	0.05	0.00	1.94	
Duluth	27	98	26.1	103	2	900	coefvar3-5	1.56	1.56	0.62	0.62	1.36	
Duluth	27	98	26.1	103	3	900	1	0.19	185.00	7.01	0.22	167.22	
Duluth	27	98	26.1	103	3	900	2	0.18	183.00	7.07	0.23	170.50	
Duluth	27	98	26.1	103	3	900	3	0.19	188.00	7.00	0.22	164.32	167.35
Duluth	27	98	26.1	103	3	900	4	0.20	195.00	7.07	0.23	160.01	164.94
Duluth	27	98	26.1	103	3	900	5	0.19	189.00	6.99	0.22	163.22	162.52
Duluth	27	98	26.1	103	3	900	mean3-5	0.19	190.67	7.02	0.22	162.52	
Duluth	27	98	26.1	103	3	900	stddev3-5	0.00	3.79	0.04	0.00	2.24	
Duluth	27	98	26.1	103	3	900	coefvar3-5	1.99	1.99	0.62	0.62	1.38	
Duluth	22	98	22	103.9	1	100	1	0.12	115.00	2.62	0.08	100.54	
Duluth	22	98	22	103.9	1	100	2	0.11	109.00	2.65	0.08	107.29	
Duluth	22	98	22	103.9	1	100	3	0.11	112.00	2.64	0.08	104.03	103.95
Duluth	22	98	22	103.9	1	100	4	0.11	110.00	2.68	0.09	107.52	106.28
Duluth	22	98	22	103.9	1	100	5	0.11	114.00	2.70	0.09	104.52	105.36
Duluth	22	98	22	103.9	1	100	mean3-5	0.11	112.00	2.67	0.09	105.36	
Duluth	22	98	22	103.9	1	100	stddev3-5	0.00	2.00	0.03	0.00	1.89	
Duluth	22	98	22	103.9	1	100	coefvar3-5	1.79	1.79	1.14	1.14	1.80	
Duluth	22	98	22	103.9	2	100	1	0.18	179.00	2.61	0.08	64.35	
Duluth	22	98	22	103.9	2	100	2	0.16	155.00	2.74	0.09	78.01	
Duluth	22	98	22	103.9	2	100	3	0.12	120.00	2.16	0.07	79.44	73.93
Duluth	22	98	22	103.9	2	100	4	0.16	160.00	2.64	0.08	72.82	76.76
Duluth	22	98	22	103.9	2	100	5	0.16	158.00	2.64	0.08	73.74	75.33
Duluth	22	98	22	103.9	2	100	mean3-5	0.15	146.00	2.48	0.08	75.33	
Duluth	22	98	22	103.9	2	100	stddev3-5	0.02	22.54	0.28	0.01	3.59	
Duluth	22	98	22	103.9	2	100	coefvar3-5	15.44	15.44	11.17	11.17	4.76	
Duluth	22	98	22	103.9	3	100	1	0.12	119.00	2.80	0.09	103.84	
Duluth	22	98	22	103.9	3	100	2	0.09	89.00	2.19	0.07	108.59	
Duluth	22	98	22	103.9	3	100	3	0.12	117.00	2.80	0.09	105.62	106.02
Duluth	22	98	22	103.9	3	100	4	0.12	119.00	2.74	0.09	101.62	105.27
Duluth	22	98	22	103.9	3	100	5	0.12	119.00	2.77	0.09	102.73	103.32
Duluth	22	98	22	103.9	3	100	mean3-5	0.12	118.33	2.77	0.09	103.32	
Duluth	22	98	22	103.9	3	100	stddev3-5	0.00	1.15	0.03	0.00	2.06	
Duluth	22	98	22	103.9	3	100	coefvar3-5	0.98	0.98	1.08	1.08	2.00	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic Load	Dynamic Stress	Modulus	Three Blow Average Modulus
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Duluth	22	98	22	103.9	1	500	1	0.30	302.00	5.14	0.16	75.11	
Duluth	22	98	22	103.9	1	500	2	0.30	300.00	5.14	0.16	75.61	
Duluth	22	98	22	103.9	1	500	3	0.31	309.00	5.02	0.16	71.70	74.14
Duluth	22	98	22	103.9	1	500	4	0.32	319.00	5.11	0.16	70.69	72.67
Duluth	22	98	22	103.9	1	500	5	0.31	307.00	5.08	0.16	73.03	71.81
Duluth	22	98	22	103.9	1	500	mean3-5	0.31	311.67	5.07	0.16	71.81	
Duluth	22	98	22	103.9	1	500	stddev3-5	0.01	6.43	0.05	0.00	1.17	
Duluth	22	98	22	103.9	1	500	coefvar3-5	2.06	2.06	0.90	0.90	1.63	
Duluth	22	98	22	103.9	2	500	1	0.46	463.00	5.67	0.18	54.05	
Duluth	22	98	22	103.9	2	500	2	0.47	472.00	5.78	0.18	54.04	
Duluth	22	98	22	103.9	2	500	3	0.47	474.00	5.65	0.18	52.60	53.56
Duluth	22	98	22	103.9	2	500	4	0.48	475.00	5.71	0.18	53.05	53.23
Duluth	22	98	22	103.9	2	500	5	0.48	476.00	5.69	0.18	52.75	52.80
Duluth	22	98	22	103.9	2	500	mean3-5	0.48	475.00	5.68	0.18	52.80	
Duluth	22	98	22	103.9	2	500	stddev3-5	0.00	1.00	0.03	0.00	0.23	
Duluth	22	98	22	103.9	2	500	coefvar3-5	0.21	0.21	0.54	0.54	0.43	
Duluth	22	98	22	103.9	3	500	1	0.33	332.00	5.58	0.18	74.17	
Duluth	22	98	22	103.9	3	500	2	0.35	349.00	5.56	0.18	70.31	
Duluth	22	98	22	103.9	3	500	3	0.35	346.00	5.58	0.18	71.17	71.88
Duluth	22	98	22	103.9	3	500	4	0.35	350.00	5.53	0.18	69.73	70.40
Duluth	22	98	22	103.9	3	500	5	0.34	344.00	5.56	0.18	71.33	70.74
Duluth	22	98	22	103.9	3	500	mean3-5	0.35	346.67	5.56	0.18	70.74	
Duluth	22	98	22	103.9	3	500	stddev3-5	0.00	3.06	0.03	0.00	0.88	
Duluth	22	98	22	103.9	3	500	coefvar3-5	0.88	0.88	0.45	0.45	1.25	
Duluth	22	98	22	103.9	1	900	1	0.74	743.00	7.97	0.25	47.34	
Duluth	22	98	22	103.9	1	900	2	0.78	782.00	8.15	0.26	45.99	
Duluth	22	98	22	103.9	1	900	3	0.81	814.00	8.12	0.26	44.02	45.79
Duluth	22	98	22	103.9	1	900	4	0.83	831.00	8.02	0.26	42.59	44.20
Duluth	22	98	22	103.9	1	900	5	0.84	840.00	8.14	0.26	42.77	43.13
Duluth	22	98	22	103.9	1	900	mean3-5	0.83	828.33	8.09	0.26	43.13	
Duluth	22	98	22	103.9	1	900	stddev3-5	0.01	13.20	0.06	0.00	0.78	
Duluth	22	98	22	103.9	1	900	coefvar3-5	1.59	1.59	0.79	0.79	1.81	
Duluth	22	98	22	103.9	2	900	1	0.86	855.00	8.44	0.27	43.56	
Duluth	22	98	22	103.9	2	900	2	0.89	892.00	8.52	0.27	42.15	
Duluth	22	98	22	103.9	2	900	3	0.92	920.00	8.58	0.27	41.16	42.29
Duluth	22	98	22	103.9	2	900	4	0.94	937.00	8.58	0.27	40.41	41.24
Duluth	22	98	22	103.9	2	900	5	0.95	946.00	8.66	0.28	40.40	40.66
Duluth	22	98	22	103.9	2	900	mean3-5	0.93	934.33	8.61	0.27	40.66	
Duluth	22	98	22	103.9	2	900	stddev3-5	0.01	13.20	0.05	0.00	0.43	
Duluth	22	98	22	103.9	2	900	coefvar3-5	1.41	1.41	0.54	0.54	1.07	
Duluth	22	98	22	103.9	3	900	1	0.70	698.00	8.48	0.27	53.62	
Duluth	22	98	22	103.9	3	900	2	0.75	754.00	8.54	0.27	49.99	
Duluth	22	98	22	103.9	3	900	3	0.75	749.00	8.66	0.28	51.03	51.54
Duluth	22	98	22	103.9	3	900	4	0.77	770.00	8.65	0.28	49.58	50.20
Duluth	22	98	22	103.9	3	900	5	0.78	779.00	8.58	0.27	48.61	49.74
Duluth	22	98	22	103.9	3	900	mean3-5	0.77	766.00	8.63	0.27	49.74	
Duluth	22	98	22	103.9	3	900	stddev3-5	0.02	15.39	0.04	0.00	1.22	
Duluth	22	98	22	103.9	3	900	coefvar3-5	2.01	2.01	0.51	0.51	2.45	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Duluth	16	98	16.3	102.3	1	100	1	0.79	790.00	3.47	0.11	19.38	
Duluth	16	98	16.3	102.3	1	100	2	0.79	790.00	3.47	0.11	19.38	
Duluth	16	98	16.3	102.3	1	100	3	0.76	760.00	3.55	0.11	20.61	19.79
Duluth	16	98	16.3	102.3	1	100	4	0.75	745.00	3.50	0.11	20.73	20.24
Duluth	16	98	16.3	102.3	1	100	5	0.74	738.00	3.51	0.11	20.99	20.78
Duluth	16	98	16.3	102.3	1	100	mean3-5	0.75	747.67	3.52	0.11	20.78	
Duluth	16	98	16.3	102.3	1	100	stddev3-5	0.01	11.24	0.03	0.00	0.19	
Duluth	16	98	16.3	102.3	1	100	coefvar3-5	1.50	1.50	0.75	0.75	0.92	
Duluth	16	98	16.3	102.3	2	100	1	1.02	1017.00	3.60	0.11	15.62	
Duluth	16	98	16.3	102.3	2	100	2	0.66	663.00	3.55	0.11	23.63	
Duluth	16	98	16.3	102.3	2	100	3	0.64	644.00	3.60	0.11	24.67	21.31
Duluth	16	98	16.3	102.3	2	100	4	0.65	647.00	3.55	0.11	24.21	24.17
Duluth	16	98	16.3	102.3	2	100	5	0.63	631.00	3.67	0.12	25.67	24.85
Duluth	16	98	16.3	102.3	2	100	mean3-5	0.64	640.67	3.61	0.11	24.85	
Duluth	16	98	16.3	102.3	2	100	stddev3-5	0.01	8.50	0.06	0.00	0.74	
Duluth	16	98	16.3	102.3	2	100	coefvar3-5	1.33	1.33	1.67	1.67	2.99	
Duluth	16	98	16.3	102.3	3	100	1	1.07	1065.00	3.81	0.12	15.79	
Duluth	16	98	16.3	102.3	3	100	2	0.68	675.00	3.74	0.12	24.45	
Duluth	16	98	16.3	102.3	3	100	3	0.65	649.00	3.80	0.12	25.84	22.03
Duluth	16	98	16.3	102.3	3	100	4	0.64	642.00	3.83	0.12	26.33	25.54
Duluth	16	98	16.3	102.3	3	100	5	0.53	525.00	2.93	0.09	24.63	25.60
Duluth	16	98	16.3	102.3	3	100	mean3-5	0.61	605.33	3.52	0.11	25.60	
Duluth	16	98	16.3	102.3	3	100	stddev3-5	0.07	69.66	0.51	0.02	0.87	
Duluth	16	98	16.3	102.3	3	100	coefvar3-5	11.51	11.51	14.52	14.52	3.42	
Duluth	16	98	16.3	102.3	1	500	1	---	---	---	---	---	
Duluth	16	98	16.3	102.3	1	500	2	0.29	291.00	5.71	0.18	86.60	
Duluth	16	98	16.3	102.3	1	500	3	0.32	317.00	5.76	0.18	80.19	---
Duluth	16	98	16.3	102.3	1	500	4	0.35	349.00	5.81	0.18	73.47	80.08
Duluth	16	98	16.3	102.3	1	500	5	0.34	344.00	5.91	0.19	75.82	76.49
Duluth	16	98	16.3	102.3	1	500	mean3-5	0.34	336.67	5.83	0.19	76.49	
Duluth	16	98	16.3	102.3	1	500	stddev3-5	0.02	17.21	0.08	0.00	3.41	
Duluth	16	98	16.3	102.3	1	500	coefvar3-5	5.11	5.11	1.31	1.31	4.46	
Duluth	16	98	16.3	102.3	2	500	1	0.38	381.00	5.84	0.19	67.65	
Duluth	16	98	16.3	102.3	2	500	2	0.35	349.00	5.99	0.19	75.75	
Duluth	16	98	16.3	102.3	2	500	3	0.36	360.00	5.98	0.19	73.31	72.23
Duluth	16	98	16.3	102.3	2	500	4	0.35	353.00	6.01	0.19	75.14	74.73
Duluth	16	98	16.3	102.3	2	500	5	0.32	320.00	5.98	0.19	82.47	76.97
Duluth	16	98	16.3	102.3	2	500	mean3-5	0.34	344.33	5.99	0.19	76.97	
Duluth	16	98	16.3	102.3	2	500	stddev3-5	0.02	21.36	0.02	0.00	4.85	
Duluth	16	98	16.3	102.3	2	500	coefvar3-5	6.20	6.20	0.29	0.29	6.30	
Duluth	16	98	16.3	102.3	3	500	1	0.39	393.00	6.13	0.20	68.84	
Duluth	16	98	16.3	102.3	3	500	2	0.49	490.00	6.25	0.20	56.29	
Duluth	16	98	16.3	102.3	3	500	3	0.31	313.00	6.13	0.20	86.43	70.52
Duluth	16	98	16.3	102.3	3	500	4	0.47	474.00	6.18	0.20	57.54	66.75
Duluth	16	98	16.3	102.3	3	500	5	0.33	325.00	6.20	0.20	84.19	76.05
Duluth	16	98	16.3	102.3	3	500	mean3-5	0.37	370.67	6.17	0.20	76.05	
Duluth	16	98	16.3	102.3	3	500	stddev3-5	0.09	89.69	0.04	0.00	16.07	
Duluth	16	98	16.3	102.3	3	500	coefvar3-5	24.20	24.20	0.58	0.58	21.13	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic Load	Dynamic Stress	Modulus	Three Blow Average Modulus
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Duluth	16	98	16.3	102.3	1	900	1	0.40	398.00	8.08	0.26	89.59	
Duluth	16	98	16.3	102.3	1	900	2	0.33	334.00	8.18	0.26	108.08	
Duluth	16	98	16.3	102.3	1	900	3	0.36	359.00	8.22	0.26	101.05	99.58
Duluth	16	98	16.3	102.3	1	900	4	0.37	373.00	8.27	0.26	97.85	102.33
Duluth	16	98	16.3	102.3	1	900	5	0.36	362.00	8.24	0.26	100.46	99.78
Duluth	16	98	16.3	102.3	1	900	mean3-5	0.36	364.67	8.24	0.26	99.78	
Duluth	16	98	16.3	102.3	1	900	stddev3-5	0.01	7.37	0.03	0.00	1.70	
Duluth	16	98	16.3	102.3	1	900	coefvar3-5	2.02	2.02	0.31	0.31	1.71	
Duluth	16	98	16.3	102.3	2	900	1	0.34	344.00	8.67	0.28	111.23	
Duluth	16	98	16.3	102.3	2	900	2	0.36	357.00	8.66	0.28	107.05	
Duluth	16	98	16.3	102.3	2	900	3	0.35	353.00	8.75	0.28	109.39	109.23
Duluth	16	98	16.3	102.3	2	900	4	0.39	385.00	8.73	0.28	100.07	105.51
Duluth	16	98	16.3	102.3	2	900	5	0.40	400.00	8.82	0.28	97.31	102.26
Duluth	16	98	16.3	102.3	2	900	mean3-5	0.38	379.33	8.77	0.28	102.26	
Duluth	16	98	16.3	102.3	2	900	stddev3-5	0.02	24.01	0.05	0.00	6.33	
Duluth	16	98	16.3	102.3	2	900	coefvar3-5	6.33	6.33	0.54	0.54	6.19	
Duluth	16	98	16.3	102.3	3	900	1	0.34	342.00	8.82	0.28	113.81	
Duluth	16	98	16.3	102.3	3	900	2	0.36	364.00	8.91	0.28	108.03	
Duluth	16	98	16.3	102.3	3	900	3	0.34	339.00	8.93	0.28	116.25	112.70
Duluth	16	98	16.3	102.3	3	900	4	0.31	313.00	8.99	0.29	126.76	117.01
Duluth	16	98	16.3	102.3	3	900	5	0.36	360.00	9.01	0.29	110.45	117.82
Duluth	16	98	16.3	102.3	3	900	mean3-5	0.34	337.33	8.98	0.29	117.82	
Duluth	16	98	16.3	102.3	3	900	stddev3-5	0.02	23.54	0.04	0.00	8.26	
Duluth	16	98	16.3	102.3	3	900	coefvar3-5	6.98	6.98	0.46	0.46	7.01	
Duluth	24	103	23.6	97.3	1	100	1						
Duluth	24	103	23.6	97.3	1	100	2						
Duluth	24	103	23.6	97.3	1	100	3						
Duluth	24	103	23.6	97.3	1	100	4						
Duluth	24	103	23.6	97.3	1	100	5						
Duluth	24	103	23.6	97.3	1	100	mean3-5						
Duluth	24	103	23.6	97.3	1	100	stddev3-5						
Duluth	24	103	23.6	97.3	1	100	coefvar3-5						
Duluth	24	103	23.6	97.3	2	100	1						
Duluth	24	103	23.6	97.3	2	100	2						
Duluth	24	103	23.6	97.3	2	100	3						
Duluth	24	103	23.6	97.3	2	100	4						
Duluth	24	103	23.6	97.3	2	100	5						
Duluth	24	103	23.6	97.3	2	100	mean3-5						
Duluth	24	103	23.6	97.3	2	100	stddev3-5						
Duluth	24	103	23.6	97.3	2	100	coefvar3-5						

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Duluth	19.5	103	19.2	99.8	1	100	1	0.09	85.00	3.58	0.11	185.87	
Duluth	19.5	103	19.2	99.8	1	100	2	0.08	78.00	3.87	0.12	218.96	
Duluth	19.5	103	19.2	99.8	1	100	3	0.08	77.00	3.87	0.12	221.81	208.88
Duluth	19.5	103	19.2	99.8	1	100	4	0.08	76.00	3.89	0.12	225.89	222.22
Duluth	19.5	103	19.2	99.8	1	100	5	0.08	77.00	3.88	0.12	222.38	223.36
Duluth	19.5	103	19.2	99.8	1	100	mean3-5	0.08	76.67	3.88	0.12	223.36	
Duluth	19.5	103	19.2	99.8	1	100	stddev3-5	0.00	0.58	0.01	0.00	2.21	
Duluth	19.5	103	19.2	99.8	1	100	coefvar3-5	0.75	0.75	0.26	0.26	0.99	
Duluth	19.5	103	19.2	99.8	2	100	1	0.09	93.00	4.01	0.13	190.29	
Duluth	19.5	103	19.2	99.8	2	100	2	0.10	96.00	4.11	0.13	188.94	
Duluth	19.5	103	19.2	99.8	2	100	3	0.09	93.00	4.03	0.13	191.24	190.16
Duluth	19.5	103	19.2	99.8	2	100	4	0.09	93.00	4.00	0.13	189.82	190.00
Duluth	19.5	103	19.2	99.8	2	100	5	0.09	93.00	4.08	0.13	193.61	191.56
Duluth	19.5	103	19.2	99.8	2	100	mean3-5	0.09	93.00	4.04	0.13	191.56	
Duluth	19.5	103	19.2	99.8	2	100	stddev3-5	0.00	0.00	0.04	0.00	1.92	
Duluth	19.5	103	19.2	99.8	2	100	coefvar3-5	0.00	0.00	1.00	1.00	1.00	
Duluth	19.5	103	19.2	99.8	3	100	1	0.08	78.00	3.70	0.12	209.34	
Duluth	19.5	103	19.2	99.8	3	100	2	0.08	77.00	3.69	0.12	211.49	
Duluth	19.5	103	19.2	99.8	3	100	3	0.08	77.00	3.66	0.12	209.77	210.20
Duluth	19.5	103	19.2	99.8	3	100	4	0.08	78.00	3.69	0.12	208.78	210.01
Duluth	19.5	103	19.2	99.8	3	100	5	0.08	79.00	3.68	0.12	205.58	208.04
Duluth	19.5	103	19.2	99.8	3	100	mean3-5	0.08	78.00	3.68	0.12	208.04	
Duluth	19.5	103	19.2	99.8	3	100	stddev3-5	0.00	1.00	0.02	0.00	2.19	
Duluth	19.5	103	19.2	99.8	3	100	coefvar3-5	1.28	1.28	0.42	0.42	1.05	
Duluth	19.5	103	19.2	99.8	1	500	1	0.13	130.00	5.96	0.19	202.33	
Duluth	19.5	103	19.2	99.8	1	500	2	0.13	133.00	5.99	0.19	198.76	
Duluth	19.5	103	19.2	99.8	1	500	3	0.13	130.00	5.94	0.19	201.65	200.91
Duluth	19.5	103	19.2	99.8	1	500	4	0.13	129.00	5.89	0.19	201.50	200.64
Duluth	19.5	103	19.2	99.8	1	500	5	0.14	135.00	6.03	0.19	197.12	200.09
Duluth	19.5	103	19.2	99.8	1	500	mean3-5	0.13	131.33	5.95	0.19	200.09	
Duluth	19.5	103	19.2	99.8	1	500	stddev3-5	0.00	3.21	0.07	0.00	2.57	
Duluth	19.5	103	19.2	99.8	1	500	coefvar3-5	2.45	2.45	1.19	1.19	1.29	
Duluth	19.5	103	19.2	99.8	2	500	1	0.15	154.00	6.06	0.19	173.66	
Duluth	19.5	103	19.2	99.8	2	500	2	0.15	151.00	6.02	0.19	175.94	
Duluth	19.5	103	19.2	99.8	2	500	3	0.15	152.00	6.10	0.19	177.11	175.57
Duluth	19.5	103	19.2	99.8	2	500	4	0.16	156.00	6.08	0.19	172.00	175.02
Duluth	19.5	103	19.2	99.8	2	500	5	0.15	151.00	6.08	0.19	177.70	175.60
Duluth	19.5	103	19.2	99.8	2	500	mean3-5	0.15	153.00	6.09	0.19	175.60	
Duluth	19.5	103	19.2	99.8	2	500	stddev3-5	0.00	2.65	0.01	0.00	3.13	
Duluth	19.5	103	19.2	99.8	2	500	coefvar3-5	1.73	1.73	0.19	0.19	1.78	
Duluth	19.5	103	19.2	99.8	3	500	1	0.15	151.00	6.07	0.19	177.41	
Duluth	19.5	103	19.2	99.8	3	500	2	0.15	148.00	6.06	0.19	180.70	
Duluth	19.5	103	19.2	99.8	3	500	3	0.15	150.00	5.99	0.19	176.23	178.11
Duluth	19.5	103	19.2	99.8	3	500	4	0.15	151.00	6.03	0.19	176.24	177.72
Duluth	19.5	103	19.2	99.8	3	500	5	0.16	155.00	6.12	0.19	174.25	175.57
Duluth	19.5	103	19.2	99.8	3	500	mean3-5	0.15	152.00	6.05	0.19	175.57	
Duluth	19.5	103	19.2	99.8	3	500	stddev3-5	0.00	2.65	0.07	0.00	1.15	
Duluth	19.5	103	19.2	99.8	3	500	coefvar3-5	1.74	1.74	1.10	1.10	0.65	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic Load	Dynamic Stress	Modulus	Three Blow Average Modulus
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Duluth	19.5	103	19.2	99.8	1	900	1	0.20	196.00	8.01	0.25	180.36	
Duluth	19.5	103	19.2	99.8	1	900	2	0.20	198.00	7.93	0.25	176.75	
Duluth	19.5	103	19.2	99.8	1	900	3	0.20	199.00	8.04	0.26	178.30	178.47
Duluth	19.5	103	19.2	99.8	1	900	4	0.20	199.00	7.96	0.25	176.53	177.19
Duluth	19.5	103	19.2	99.8	1	900	5	0.20	200.00	7.94	0.25	175.20	176.68
Duluth	19.5	103	19.2	99.8	1	900	mean3-5	0.20	199.33	7.98	0.25	176.68	
Duluth	19.5	103	19.2	99.8	1	900	stddev3-5	0.00	0.58	0.05	0.00	1.55	
Duluth	19.5	103	19.2	99.8	1	900	coefvar3-5	0.29	0.29	0.66	0.66	0.88	
Duluth	19.5	103	19.2	99.8	2	900	1	0.24	240.00	8.50	0.27	156.30	
Duluth	19.5	103	19.2	99.8	2	900	2	0.24	238.00	8.31	0.26	154.09	
Duluth	19.5	103	19.2	99.8	2	900	3	0.24	236.00	8.38	0.27	156.71	155.70
Duluth	19.5	103	19.2	99.8	2	900	4	0.24	240.00	8.34	0.27	153.36	154.72
Duluth	19.5	103	19.2	99.8	2	900	5	0.25	248.00	8.50	0.27	151.26	153.77
Duluth	19.5	103	19.2	99.8	2	900	mean3-5	0.24	241.33	8.41	0.27	153.77	
Duluth	19.5	103	19.2	99.8	2	900	stddev3-5	0.01	6.11	0.08	0.00	2.75	
Duluth	19.5	103	19.2	99.8	2	900	coefvar3-5	2.53	2.53	0.99	0.99	1.79	
Duluth	19.5	103	19.2	99.8	3	900	1	0.24	240.00	8.09	0.26	148.76	
Duluth	19.5	103	19.2	99.8	3	900	2	0.25	250.00	8.20	0.26	144.75	
Duluth	19.5	103	19.2	99.8	3	900	3	0.25	249.00	8.20	0.26	145.33	146.28
Duluth	19.5	103	19.2	99.8	3	900	4	0.25	249.00	8.20	0.26	145.33	145.14
Duluth	19.5	103	19.2	99.8	3	900	5	0.25	254.00	8.18	0.26	142.13	144.27
Duluth	19.5	103	19.2	99.8	3	900	mean3-5	0.25	250.67	8.19	0.26	144.27	
Duluth	19.5	103	19.2	99.8	3	900	stddev3-5	0.00	2.89	0.01	0.00	1.85	
Duluth	19.5	103	19.2	99.8	3	900	coefvar3-5	1.15	1.15	0.14	0.14	1.28	
Duluth	16	103	17.4	95.8	1	100	1	0.09	90.00	3.95	0.13	193.69	
Duluth	16	103	17.4	95.8	1	100	2	0.13	127.00	3.76	0.12	130.66	
Duluth	16	103	17.4	95.8	1	100	3	0.10	95.00	3.88	0.12	180.24	168.20
Duluth	16	103	17.4	95.8	1	100	4	0.10	96.00	3.96	0.13	182.04	164.32
Duluth	16	103	17.4	95.8	1	100	5	0.10	96.00	3.94	0.13	181.13	181.14
Duluth	16	103	17.4	95.8	1	100	mean3-5	0.10	95.67	3.93	0.12	181.14	
Duluth	16	103	17.4	95.8	1	100	stddev3-5	0.00	0.58	0.04	0.00	0.90	
Duluth	16	103	17.4	95.8	1	100	coefvar3-5	0.60	0.60	1.06	1.06	0.50	
Duluth	16	103	17.4	95.8	2	100	1	0.09	91.00	3.61	0.11	175.07	
Duluth	16	103	17.4	95.8	2	100	2	0.09	92.00	3.63	0.12	174.13	
Duluth	16	103	17.4	95.8	2	100	3	0.09	91.00	3.61	0.11	175.07	174.76
Duluth	16	103	17.4	95.8	2	100	4	0.09	85.00	3.67	0.12	190.55	179.92
Duluth	16	103	17.4	95.8	2	100	5	0.09	92.00	3.64	0.12	174.61	180.08
Duluth	16	103	17.4	95.8	2	100	mean3-5	0.09	89.33	3.64	0.12	180.08	
Duluth	16	103	17.4	95.8	2	100	stddev3-5	0.00	3.79	0.03	0.00	9.07	
Duluth	16	103	17.4	95.8	2	100	coefvar3-5	4.24	4.24	0.82	0.82	5.04	
Duluth	16	103	17.4	95.8	3	100	1	0.09	85.00	3.71	0.12	192.62	
Duluth	16	103	17.4	95.8	3	100	2	0.09	88.00	3.76	0.12	188.56	
Duluth	16	103	17.4	95.8	3	100	3	0.07	66.00	3.01	0.10	201.27	194.15
Duluth	16	103	17.4	95.8	3	100	4	0.09	86.00	3.75	0.12	192.44	194.09
Duluth	16	103	17.4	95.8	3	100	5	0.07	67.00	2.96	0.09	194.97	196.23
Duluth	16	103	17.4	95.8	3	100	mean3-5	0.07	73.00	3.24	0.10	196.23	
Duluth	16	103	17.4	95.8	3	100	stddev3-5	0.01	11.27	0.44	0.01	4.55	
Duluth	16	103	17.4	95.8	3	100	coefvar3-5	15.44	15.44	13.65	13.65	2.32	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Duluth	16	103	17.4	95.8	1	500	1	0.15	154.00	5.88	0.19	168.50	
Duluth	16	103	17.4	95.8	1	500	2	0.15	154.00	5.83	0.19	167.07	
Duluth	16	103	17.4	95.8	1	500	3	0.16	155.00	5.91	0.19	168.27	167.95
Duluth	16	103	17.4	95.8	1	500	4	0.16	155.00	5.89	0.19	167.70	167.68
Duluth	16	103	17.4	95.8	1	500	5	0.16	155.00	5.89	0.19	167.70	167.89
Duluth	16	103	17.4	95.8	1	500	mean3-5	0.16	155.00	5.90	0.19	167.89	
Duluth	16	103	17.4	95.8	1	500	stddev3-5	0.00	0.00	0.01	0.00	0.33	
Duluth	16	103	17.4	95.8	1	500	coefvar3-5	0.00	0.00	0.20	0.20	0.20	
Duluth	16	103	17.4	95.8	2	500	1	0.15	152.00	5.88	0.19	170.72	
Duluth	16	103	17.4	95.8	2	500	2	0.15	154.00	5.89	0.19	168.79	
Duluth	16	103	17.4	95.8	2	500	3	0.15	154.00	5.89	0.19	168.79	169.43
Duluth	16	103	17.4	95.8	2	500	4	0.16	155.00	5.85	0.19	166.56	168.05
Duluth	16	103	17.4	95.8	2	500	5	0.16	158.00	5.91	0.19	165.08	166.81
Duluth	16	103	17.4	95.8	2	500	mean3-5	0.16	155.67	5.88	0.19	166.81	
Duluth	16	103	17.4	95.8	2	500	stddev3-5	0.00	2.08	0.03	0.00	1.87	
Duluth	16	103	17.4	95.8	2	500	coefvar3-5	1.34	1.34	0.52	0.52	1.12	
Duluth	16	103	17.4	95.8	3	500	1	0.15	145.00	5.64	0.18	171.66	
Duluth	16	103	17.4	95.8	3	500	2	0.14	141.00	5.69	0.18	178.09	
Duluth	16	103	17.4	95.8	3	500	3	0.15	149.00	5.69	0.18	168.53	172.76
Duluth	16	103	17.4	95.8	3	500	4	0.14	144.00	5.67	0.18	173.77	173.46
Duluth	16	103	17.4	95.8	3	500	5	0.15	146.00	5.66	0.18	171.09	171.13
Duluth	16	103	17.4	95.8	3	500	mean3-5	0.15	146.33	5.67	0.18	171.13	
Duluth	16	103	17.4	95.8	3	500	stddev3-5	0.00	2.52	0.02	0.00	2.62	
Duluth	16	103	17.4	95.8	3	500	coefvar3-5	1.72	1.72	0.27	0.27	1.53	
Duluth	16	103	17.4	95.8	1	900	1	0.27	265.00	8.16	0.26	135.89	
Duluth	16	103	17.4	95.8	1	900	2	0.27	267.90	8.25	0.26	135.91	
Duluth	16	103	17.4	95.8	1	900	3	0.27	266.50	8.21	0.26	135.96	135.92
Duluth	16	103	17.4	95.8	1	900	4	0.27	265.80	8.18	0.26	135.82	135.89
Duluth	16	103	17.4	95.8	1	900	5	0.27	267.80	8.25	0.26	135.96	135.91
Duluth	16	103	17.4	95.8	1	900	mean3-5	0.27	266.70	8.21	0.26	135.91	
Duluth	16	103	17.4	95.8	1	900	stddev3-5	0.00	1.01	0.04	0.00	0.08	
Duluth	16	103	17.4	95.8	1	900	coefvar3-5	0.38	0.38	0.43	0.43	0.06	
Duluth	16	103	17.4	95.8	2	900	1	0.24	237.00	8.19	0.26	152.51	
Duluth	16	103	17.4	95.8	2	900	2	0.24	242.00	8.27	0.26	150.81	
Duluth	16	103	17.4	95.8	2	900	3	0.24	240.00	8.11	0.26	149.13	150.82
Duluth	16	103	17.4	95.8	2	900	4	0.25	245.00	8.19	0.26	147.53	149.16
Duluth	16	103	17.4	95.8	2	900	5	0.24	239.00	8.24	0.26	152.15	149.60
Duluth	16	103	17.4	95.8	2	900	mean3-5	0.24	241.33	8.18	0.26	149.60	
Duluth	16	103	17.4	95.8	2	900	stddev3-5	0.00	3.21	0.07	0.00	2.35	
Duluth	16	103	17.4	95.8	2	900	coefvar3-5	1.33	1.33	0.80	0.80	1.57	
Duluth	16	103	17.4	95.8	3	900	1	0.23	228.00	7.96	0.25	154.08	
Duluth	16	103	17.4	95.8	3	900	2	0.23	227.00	7.97	0.25	154.95	
Duluth	16	103	17.4	95.8	3	900	3	0.24	237.00	8.01	0.25	149.16	152.73
Duluth	16	103	17.4	95.8	3	900	4	0.23	230.00	7.85	0.25	150.62	151.58
Duluth	16	103	17.4	95.8	3	900	5	0.23	230.00	7.94	0.25	152.35	150.71
Duluth	16	103	17.4	95.8	3	900	mean3-5	0.23	232.33	7.93	0.25	150.71	
Duluth	16	103	17.4	95.8	3	900	stddev3-5	0.00	4.04	0.08	0.00	1.60	
Duluth	16	103	17.4	95.8	3	900	coefvar3-5	1.74	1.74	1.01	1.01	1.06	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Wing	13	98	12.4	89.9	1	100	1						
Red Wing	13	98	12.4	89.9	1	100	2						
Red Wing	13	98	12.4	89.9	1	100	3						
Red Wing	13	98	12.4	89.9	1	100	4						
Red Wing	13	98	12.4	89.9	1	100	5						
Red Wing	13	98	12.4	89.9	1	100	mean3-5						
Red Wing	13	98	12.4	89.9	1	100	stddev3-5						
Red Wing	13	98	12.4	89.9	1	100	coefvar3-5						
Red Wing	13	98	12.4	89.9	2	100	1						
Red Wing	13	98	12.4	89.9	2	100	2						
Red Wing	13	98	12.4	89.9	2	100	3						
Red Wing	13	98	12.4	89.9	2	100	4						
Red Wing	13	98	12.4	89.9	2	100	5						
Red Wing	13	98	12.4	89.9	2	100	mean3-5						
Red Wing	13	98	12.4	89.9	2	100	stddev3-5						
Red Wing	13	98	12.4	89.9	2	100	coefvar3-5						
Red Wing	10	98	10.1	95.9	1	100	1	0.42	418.00	3.41	0.11	36.00	
Red Wing	10	98	10.1	95.9	1	100	2	0.27	268.00	3.34	0.11	55.00	
Red Wing	10	98	10.1	95.9	1	100	3	0.26	257.00	3.30	0.11	56.67	49.22
Red Wing	10	98	10.1	95.9	1	100	4	0.24	243.00	3.26	0.10	59.21	56.96
Red Wing	10	98	10.1	95.9	1	100	5	0.25	247.00	3.31	0.11	59.14	58.34
Red Wing	10	98	10.1	95.9	1	100	mean3-5	0.25	249.00	3.29	0.10	58.34	
Red Wing	10	98	10.1	95.9	1	100	stddev3-5	0.01	7.21	0.03	0.00	1.45	
Red Wing	10	98	10.1	95.9	1	100	coefvar3-5	2.90	2.90	0.80	0.80	2.48	
Red Wing	10	98	10.1	95.9	2	100	1	0.44	437.00	3.07	0.10	31.00	
Red Wing	10	98	10.1	95.9	2	100	2	0.27	267.00	2.96	0.09	48.93	
Red Wing	10	98	10.1	95.9	2	100	3	0.27	267.00	2.96	0.09	48.93	42.95
Red Wing	10	98	10.1	95.9	2	100	4	0.25	252.00	2.92	0.09	51.14	49.66
Red Wing	10	98	10.1	95.9	2	100	5	0.27	269.00	2.93	0.09	48.07	49.38
Red Wing	10	98	10.1	95.9	2	100	mean3-5	0.26	262.67	2.94	0.09	49.38	
Red Wing	10	98	10.1	95.9	2	100	stddev3-5	0.01	9.29	0.02	0.00	1.58	
Red Wing	10	98	10.1	95.9	2	100	coefvar3-5	3.54	3.54	0.71	0.71	3.21	
Red Wing	10	98	10.1	95.9	3	100	1	0.21	207.00	2.78	0.09	59.27	
Red Wing	10	98	10.1	95.9	3	100	2	0.14	142.00	2.70	0.09	83.91	
Red Wing	10	98	10.1	95.9	3	100	3	0.18	181.00	2.72	0.09	66.32	69.83
Red Wing	10	98	10.1	95.9	3	100	4	0.16	155.00	2.65	0.08	75.45	75.23
Red Wing	10	98	10.1	95.9	3	100	5	0.16	163.00	2.73	0.09	73.91	71.90
Red Wing	10	98	10.1	95.9	3	100	mean3-5	0.17	166.33	2.70	0.09	71.90	
Red Wing	10	98	10.1	95.9	3	100	stddev3-5	0.01	13.32	0.04	0.00	4.89	
Red Wing	10	98	10.1	95.9	3	100	coefvar3-5	8.01	8.01	1.61	1.61	6.80	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Wing	10	98	10.1	95.9	1	500	1	0.47	466.00	5.18	0.16	49.06	
Red Wing	10	98	10.1	95.9	1	500	2	0.44	443.00	5.26	0.17	52.40	
Red Wing	10	98	10.1	95.9	1	500	3	0.43	429.00	5.21	0.17	53.60	51.68
Red Wing	10	98	10.1	95.9	1	500	4	0.43	431.00	5.33	0.17	54.58	53.52
Red Wing	10	98	10.1	95.9	1	500	5	0.41	414.00	5.28	0.17	56.28	54.82
Red Wing	10	98	10.1	95.9	1	500	mean3-5	0.42	424.67	5.27	0.17	54.82	
Red Wing	10	98	10.1	95.9	1	500	stddev3-5	0.01	9.29	0.06	0.00	1.36	
Red Wing	10	98	10.1	95.9	1	500	coefvar3-5	2.19	2.19	1.14	1.14	2.48	
Red Wing	10	98	10.1	95.9	2	500	1	0.45	450.00	4.88	0.16	47.86	
Red Wing	10	98	10.1	95.9	2	500	2	0.43	425.00	4.80	0.15	49.84	
Red Wing	10	98	10.1	95.9	2	500	3	0.41	413.00	4.79	0.15	51.18	49.63
Red Wing	10	98	10.1	95.9	2	500	4	0.42	417.00	4.80	0.15	50.80	50.61
Red Wing	10	98	10.1	95.9	2	500	5	0.42	422.00	4.85	0.15	50.72	50.90
Red Wing	10	98	10.1	95.9	2	500	mean3-5	0.42	417.33	4.81	0.15	50.90	
Red Wing	10	98	10.1	95.9	2	500	stddev3-5	0.00	4.51	0.03	0.00	0.25	
Red Wing	10	98	10.1	95.9	2	500	coefvar3-5	1.08	1.08	0.67	0.67	0.49	
Red Wing	10	98	10.1	95.9	3	500	1	0.51	514.00	5.31	0.17	45.59	
Red Wing	10	98	10.1	95.9	3	500	2	0.45	447.00	5.30	0.17	52.33	
Red Wing	10	98	10.1	95.9	3	500	3	0.42	423.00	5.32	0.17	55.50	51.14
Red Wing	10	98	10.1	95.9	3	500	4	0.32	323.00	4.01	0.13	54.79	54.21
Red Wing	10	98	10.1	95.9	3	500	5	0.41	412.00	5.31	0.17	56.88	55.72
Red Wing	10	98	10.1	95.9	3	500	mean3-5	0.39	386.00	4.88	0.16	55.72	
Red Wing	10	98	10.1	95.9	3	500	stddev3-5	0.05	54.84	0.75	0.02	1.06	
Red Wing	10	98	10.1	95.9	3	500	coefvar3-5	14.21	14.21	15.44	15.44	1.91	
Red Wing	10	98	10.1	95.9	1	900	1	0.67	668.00	7.19	0.23	47.50	
Red Wing	10	98	10.1	95.9	1	900	2	0.63	634.00	7.25	0.23	50.47	
Red Wing	10	98	10.1	95.9	1	900	3	0.62	619.00	7.28	0.23	51.90	49.96
Red Wing	10	98	10.1	95.9	1	900	4	0.62	619.00	7.13	0.23	50.83	51.07
Red Wing	10	98	10.1	95.9	1	900	5	0.63	634.00	7.27	0.23	50.61	51.11
Red Wing	10	98	10.1	95.9	1	900	mean3-5	0.62	624.00	7.23	0.23	51.11	
Red Wing	10	98	10.1	95.9	1	900	stddev3-5	0.01	8.66	0.08	0.00	0.69	
Red Wing	10	98	10.1	95.9	1	900	coefvar3-5	1.39	1.39	1.16	1.16	1.36	
Red Wing	10	98	10.1	95.9	2	900	1	0.73	730.00	7.58	0.24	45.82	
Red Wing	10	98	10.1	95.9	2	900	2	0.70	697.00	7.56	0.24	47.87	
Red Wing	10	98	10.1	95.9	2	900	3	0.71	708.00	7.57	0.24	47.19	46.96
Red Wing	10	98	10.1	95.9	2	900	4	0.70	700.00	7.57	0.24	47.73	47.59
Red Wing	10	98	10.1	95.9	2	900	5	0.69	690.00	7.51	0.24	48.03	47.65
Red Wing	10	98	10.1	95.9	2	900	mean3-5	0.70	699.33	7.55	0.24	47.65	
Red Wing	10	98	10.1	95.9	2	900	stddev3-5	0.01	9.02	0.03	0.00	0.43	
Red Wing	10	98	10.1	95.9	2	900	coefvar3-5	1.29	1.29	0.46	0.46	0.90	
Red Wing	10	98	10.1	95.9	3	900	1	0.68	679.00	7.79	0.25	50.63	
Red Wing	10	98	10.1	95.9	3	900	2	0.67	669.00	7.83	0.25	51.65	
Red Wing	10	98	10.1	95.9	3	900	3	0.66	655.00	7.83	0.25	52.76	51.68
Red Wing	10	98	10.1	95.9	3	900	4	0.65	650.00	7.85	0.25	53.30	52.57
Red Wing	10	98	10.1	95.9	3	900	5	0.63	629.00	7.88	0.25	55.29	53.78
Red Wing	10	98	10.1	95.9	3	900	mean3-5	0.64	644.67	7.85	0.25	53.78	
Red Wing	10	98	10.1	95.9	3	900	stddev3-5	0.01	13.80	0.03	0.00	1.33	
Red Wing	10	98	10.1	95.9	3	900	coefvar3-5	2.14	2.14	0.32	0.32	2.48	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Wing	8	98	8.4	95	1	100	1	0.14	144.00	2.65	0.08	81.22	
Red Wing	8	98	8.4	95	1	100	2	0.10	102.00	2.56	0.08	110.76	
Red Wing	8	98	8.4	95	1	100	3	0.11	109.00	2.55	0.08	103.24	98.41
Red Wing	8	98	8.4	95	1	100	4	0.11	109.00	2.55	0.08	103.24	105.75
Red Wing	8	98	8.4	95	1	100	5	0.09	90.00	2.57	0.08	126.02	110.84
Red Wing	8	98	8.4	95	1	100	mean3-5	0.10	102.67	2.56	0.08	110.84	
Red Wing	8	98	8.4	95	1	100	stddev3-5	0.01	10.97	0.01	0.00	13.15	
Red Wing	8	98	8.4	95	1	100	coefvar3-5	10.68	10.68	0.45	0.45	11.86	
Red Wing	8	98	8.4	95	2	100	1	0.14	135.00	2.64	0.08	86.30	
Red Wing	8	98	8.4	95	2	100	2	0.10	101.00	2.68	0.09	117.10	
Red Wing	8	98	8.4	95	2	100	3	0.10	102.00	2.63	0.08	113.79	105.73
Red Wing	8	98	8.4	95	2	100	4	0.11	107.00	2.67	0.08	110.12	113.67
Red Wing	8	98	8.4	95	2	100	5	0.11	107.00	2.60	0.08	107.24	110.38
Red Wing	8	98	8.4	95	2	100	mean3-5	0.11	105.33	2.63	0.08	110.38	
Red Wing	8	98	8.4	95	2	100	stddev3-5	0.00	2.89	0.04	0.00	3.29	
Red Wing	8	98	8.4	95	2	100	coefvar3-5	2.74	2.74	1.33	1.33	2.98	
Red Wing	8	98	8.4	95	3	100	1	0.11	111.00	2.95	0.09	117.29	
Red Wing	8	98	8.4	95	3	100	2	0.08	75.00	2.75	0.09	161.82	
Red Wing	8	98	8.4	95	3	100	3	0.07	71.00	2.82	0.09	175.29	151.46
Red Wing	8	98	8.4	95	3	100	4	0.07	73.00	2.81	0.09	169.88	168.99
Red Wing	8	98	8.4	95	3	100	5	0.08	79.00	2.78	0.09	155.30	166.82
Red Wing	8	98	8.4	95	3	100	mean3-5	0.07	74.33	2.80	0.09	166.82	
Red Wing	8	98	8.4	95	3	100	stddev3-5	0.00	4.16	0.02	0.00	10.34	
Red Wing	8	98	8.4	95	3	100	coefvar3-5	5.60	5.60	0.74	0.74	6.20	
Red Wing	8	98	8.4	95	1	500	1	0.37	371.00	5.97	0.19	71.02	
Red Wing	8	98	8.4	95	1	500	2	0.34	340.00	5.98	0.19	77.62	
Red Wing	8	98	8.4	95	1	500	3	0.34	341.00	6.03	0.19	78.04	75.56
Red Wing	8	98	8.4	95	1	500	4	0.34	338.00	5.98	0.19	78.08	77.91
Red Wing	8	98	8.4	95	1	500	5	0.33	330.00	5.85	0.19	78.23	78.12
Red Wing	8	98	8.4	95	1	500	mean3-5	0.34	336.33	5.95	0.19	78.12	
Red Wing	8	98	8.4	95	1	500	stddev3-5	0.01	5.69	0.09	0.00	0.10	
Red Wing	8	98	8.4	95	1	500	coefvar3-5	1.69	1.69	1.56	1.56	0.13	
Red Wing	8	98	8.4	95	2	500	1	0.30	304.00	5.58	0.18	81.01	
Red Wing	8	98	8.4	95	2	500	2	0.28	279.00	5.59	0.18	88.42	
Red Wing	8	98	8.4	95	2	500	3	0.28	281.00	5.61	0.18	88.11	85.85
Red Wing	8	98	8.4	95	2	500	4	0.28	282.00	5.57	0.18	87.17	87.90
Red Wing	8	98	8.4	95	2	500	5	0.28	282.00	5.64	0.18	88.26	87.85
Red Wing	8	98	8.4	95	2	500	mean3-5	0.28	281.67	5.61	0.18	87.85	
Red Wing	8	98	8.4	95	2	500	stddev3-5	0.00	0.58	0.04	0.00	0.59	
Red Wing	8	98	8.4	95	2	500	coefvar3-5	0.20	0.20	0.63	0.63	0.67	
Red Wing	8	98	8.4	95	3	500	1	0.17	169.00	5.22	0.17	136.31	
Red Wing	8	98	8.4	95	3	500	2	0.16	159.00	5.27	0.17	146.27	
Red Wing	8	98	8.4	95	3	500	3	0.16	161.00	5.23	0.17	143.36	141.98
Red Wing	8	98	8.4	95	3	500	4	0.16	160.00	5.30	0.17	146.19	145.27
Red Wing	8	98	8.4	95	3	500	5	0.16	159.00	5.26	0.17	146.00	145.18
Red Wing	8	98	8.4	95	3	500	mean3-5	0.16	160.00	5.26	0.17	145.18	
Red Wing	8	98	8.4	95	3	500	stddev3-5	0.00	1.00	0.04	0.00	1.58	
Red Wing	8	98	8.4	95	3	500	coefvar3-5	0.63	0.63	0.67	0.67	1.09	

Light Weight Deflectometer

Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Wing	8	98	8.4	95	1	900	1	0.61	611.00	8.51	0.27	61.47	
Red Wing	8	98	8.4	95	1	900	2	0.58	579.00	8.53	0.27	65.02	
Red Wing	8	98	8.4	95	1	900	3	0.57	567.00	8.62	0.27	67.09	64.53
Red Wing	8	98	8.4	95	1	900	4	0.58	577.00	8.65	0.28	66.16	66.09
Red Wing	8	98	8.4	95	1	900	5	0.58	576.00	8.64	0.28	66.20	66.48
Red Wing	8	98	8.4	95	1	900	mean3-5	0.57	573.33	8.64	0.27	66.48	
Red Wing	8	98	8.4	95	1	900	stddev3-5	0.01	5.51	0.02	0.00	0.53	
Red Wing	8	98	8.4	95	1	900	coefvar3-5	0.96	0.96	0.18	0.18	0.79	
Red Wing	8	98	8.4	95	2	900	1	0.54	539.00	8.40	0.27	68.78	
Red Wing	8	98	8.4	95	2	900	2	0.52	523.00	8.52	0.27	71.89	
Red Wing	8	98	8.4	95	2	900	3	0.54	535.00	8.63	0.27	71.19	70.62
Red Wing	8	98	8.4	95	2	900	4	0.53	527.00	8.54	0.27	71.52	71.53
Red Wing	8	98	8.4	95	2	900	5	0.53	533.00	8.57	0.27	70.96	71.22
Red Wing	8	98	8.4	95	2	900	mean3-5	0.53	531.67	8.58	0.27	71.22	
Red Wing	8	98	8.4	95	2	900	stddev3-5	0.00	4.16	0.05	0.00	0.28	
Red Wing	8	98	8.4	95	2	900	coefvar3-5	0.78	0.78	0.53	0.53	0.39	
Red Wing	8	98	8.4	95	3	900	1	0.33	331.00	8.61	0.27	114.80	
Red Wing	8	98	8.4	95	3	900	2	0.38	378.00	8.62	0.27	100.64	
Red Wing	8	98	8.4	95	3	900	3	0.34	338.00	8.70	0.28	113.59	109.68
Red Wing	8	98	8.4	95	3	900	4	0.35	345.00	8.69	0.28	111.16	108.47
Red Wing	8	98	8.4	95	3	900	5	0.34	340.00	8.70	0.28	112.93	112.56
Red Wing	8	98	8.4	95	3	900	mean3-5	0.34	341.00	8.70	0.28	112.56	
Red Wing	8	98	8.4	95	3	900	stddev3-5	0.00	3.61	0.01	0.00	1.26	
Red Wing	8	98	8.4	95	3	900	coefvar3-5	1.06	1.06	0.07	0.07	1.12	
Red Wing	12	103	11.3	94.8	1	100	1	0.16	164.00	2.83	0.09	76.15	
Red Wing	12	103	11.3	94.8	1	100	2	0.12	117.00	2.74	0.09	103.35	
Red Wing	12	103	11.3	94.8	1	100	3	0.12	121.00	2.71	0.09	98.84	92.78
Red Wing	12	103	11.3	94.8	1	100	4	0.12	123.00	2.73	0.09	97.95	100.05
Red Wing	12	103	11.3	94.8	1	100	5	0.11	112.00	2.74	0.09	107.97	101.59
Red Wing	12	103	11.3	94.8	1	100	mean3-5	0.12	118.67	2.73	0.09	101.59	
Red Wing	12	103	11.3	94.8	1	100	stddev3-5	0.01	5.86	0.02	0.00	5.54	
Red Wing	12	103	11.3	94.8	1	100	coefvar3-5	4.94	4.94	0.56	0.56	5.46	
Red Wing	12	103	11.3	94.8	2	100	1	0.23	227.00	3.40	0.11	66.10	
Red Wing	12	103	11.3	94.8	2	100	2	0.17	171.00	3.32	0.11	85.68	
Red Wing	12	103	11.3	94.8	2	100	3	0.20	195.00	3.35	0.11	75.82	75.87
Red Wing	12	103	11.3	94.8	2	100	4	0.17	174.00	3.38	0.11	85.73	82.41
Red Wing	12	103	11.3	94.8	2	100	5	0.16	163.00	3.36	0.11	90.97	84.17
Red Wing	12	103	11.3	94.8	2	100	mean3-5	0.18	177.33	3.36	0.11	84.17	
Red Wing	12	103	11.3	94.8	2	100	stddev3-5	0.02	16.26	0.02	0.00	7.70	
Red Wing	12	103	11.3	94.8	2	100	coefvar3-5	9.17	9.17	0.45	0.45	9.14	
Red Wing	12	103	11.3	94.8	3	100	1	0.21	208.00	3.16	0.10	67.05	
Red Wing	12	103	11.3	94.8	3	100	2	0.21	212.00	2.99	0.10	62.24	
Red Wing	12	103	11.3	94.8	3	100	3	0.21	213.00	3.00	0.10	62.16	63.82
Red Wing	12	103	11.3	94.8	3	100	4	0.17	167.00	3.11	0.10	82.19	68.86
Red Wing	12	103	11.3	94.8	3	100	5	0.16	159.00	3.15	0.10	87.43	77.26
Red Wing	12	103	11.3	94.8	3	100	mean3-5	0.18	179.67	3.09	0.10	77.26	
Red Wing	12	103	11.3	94.8	3	100	stddev3-5	0.03	29.14	0.08	0.00	13.34	
Red Wing	12	103	11.3	94.8	3	100	coefvar3-5	16.22	16.22	2.52	2.52	17.26	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic Load	Dynamic Stress	Modulus	Three Blow Average Modulus
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Wing	12	103	11.3	94.8	1	500	1	0.25	252.00	4.85	0.15	84.94	
Red Wing	12	103	11.3	94.8	1	500	2	0.25	246.00	4.90	0.16	87.91	
Red Wing	12	103	11.3	94.8	1	500	3	0.25	246.00	4.90	0.16	87.91	86.92
Red Wing	12	103	11.3	94.8	1	500	4	0.24	244.00	4.87	0.16	88.08	87.96
Red Wing	12	103	11.3	94.8	1	500	5	0.25	250.00	4.81	0.15	84.91	86.97
Red Wing	12	103	11.3	94.8	1	500	mean3-5	0.25	246.67	4.86	0.15	86.97	
Red Wing	12	103	11.3	94.8	1	500	stddev3-5	0.00	3.06	0.05	0.00	1.78	
Red Wing	12	103	11.3	94.8	1	500	coefvar3-5	1.24	1.24	0.94	0.94	2.05	
Red Wing	12	103	11.3	94.8	2	500	1	0.30	303.00	5.32	0.17	77.49	
Red Wing	12	103	11.3	94.8	2	500	2	0.32	315.00	5.35	0.17	74.95	
Red Wing	12	103	11.3	94.8	2	500	3	0.30	302.00	5.38	0.17	78.62	77.02
Red Wing	12	103	11.3	94.8	2	500	4	0.31	306.00	5.32	0.17	76.73	76.77
Red Wing	12	103	11.3	94.8	2	500	5	0.39	385.00	5.28	0.17	60.52	71.96
Red Wing	12	103	11.3	94.8	2	500	mean3-5	0.33	331.00	5.33	0.17	71.96	
Red Wing	12	103	11.3	94.8	2	500	stddev3-5	0.05	46.81	0.05	0.00	9.95	
Red Wing	12	103	11.3	94.8	2	500	coefvar3-5	14.14	14.14	0.94	0.94	13.82	
Red Wing	12	103	11.3	94.8	3	500	1	0.39	394.00	5.43	0.17	60.82	
Red Wing	12	103	11.3	94.8	3	500	2	0.38	382.00	5.36	0.17	61.92	
Red Wing	12	103	11.3	94.8	3	500	3	0.38	384.00	5.41	0.17	62.18	61.64
Red Wing	12	103	11.3	94.8	3	500	4	0.45	450.00	5.23	0.17	51.29	58.46
Red Wing	12	103	11.3	94.8	3	500	5	0.45	450.00	5.23	0.17	51.29	54.92
Red Wing	12	103	11.3	94.8	3	500	mean3-5	0.43	428.00	5.29	0.17	54.92	
Red Wing	12	103	11.3	94.8	3	500	stddev3-5	0.04	38.11	0.10	0.00	6.28	
Red Wing	12	103	11.3	94.8	3	500	coefvar3-5	8.90	8.90	1.96	1.96	11.44	
Red Wing	12	103	11.3	94.8	1	900	1	0.39	392.00	6.84	0.22	77.01	
Red Wing	12	103	11.3	94.8	1	900	2	0.39	392.00	6.76	0.22	76.11	
Red Wing	12	103	11.3	94.8	1	900	3	0.39	394.00	6.77	0.22	75.83	76.31
Red Wing	12	103	11.3	94.8	1	900	4	0.40	403.00	6.74	0.21	73.81	75.25
Red Wing	12	103	11.3	94.8	1	900	5	0.39	387.00	6.77	0.22	77.20	75.61
Red Wing	12	103	11.3	94.8	1	900	mean3-5	0.39	394.67	6.76	0.22	75.61	
Red Wing	12	103	11.3	94.8	1	900	stddev3-5	0.01	8.02	0.02	0.00	1.71	
Red Wing	12	103	11.3	94.8	1	900	coefvar3-5	2.03	2.03	0.26	0.26	2.26	
Red Wing	12	103	11.3	94.8	2	900	1	0.46	462.00	6.96	0.22	66.48	
Red Wing	12	103	11.3	94.8	2	900	2	0.46	457.00	6.93	0.22	66.92	
Red Wing	12	103	11.3	94.8	2	900	3	0.47	465.00	6.97	0.22	66.15	66.52
Red Wing	12	103	11.3	94.8	2	900	4	0.46	455.00	6.95	0.22	67.41	66.83
Red Wing	12	103	11.3	94.8	2	900	5	0.46	462.00	6.91	0.22	66.01	66.52
Red Wing	12	103	11.3	94.8	2	900	mean3-5	0.46	460.67	6.94	0.22	66.52	
Red Wing	12	103	11.3	94.8	2	900	stddev3-5	0.01	5.13	0.03	0.00	0.77	
Red Wing	12	103	11.3	94.8	2	900	coefvar3-5	1.11	1.11	0.44	0.44	1.16	
Red Wing	12	103	11.3	94.8	3	900	1	0.59	591.00	7.29	0.23	54.44	
Red Wing	12	103	11.3	94.8	3	900	2	0.56	563.00	7.31	0.23	57.30	
Red Wing	12	103	11.3	94.8	3	900	3	0.56	559.00	7.33	0.23	57.87	56.54
Red Wing	12	103	11.3	94.8	3	900	4	0.68	679.00	7.26	0.23	47.19	54.12
Red Wing	12	103	11.3	94.8	3	900	5	0.60	595.00	7.39	0.24	54.81	53.29
Red Wing	12	103	11.3	94.8	3	900	mean3-5	0.61	611.00	7.33	0.23	53.29	
Red Wing	12	103	11.3	94.8	3	900	stddev3-5	0.06	61.58	0.07	0.00	5.50	
Red Wing	12	103	11.3	94.8	3	900	coefvar3-5	10.08	10.08	0.89	0.89	10.32	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Wing	9.5	103	9.4	99.1	1	100	1	0.16	164.00	3.74	0.12	100.64	
Red Wing	9.5	103	9.4	99.1	1	100	2	0.16	159.00	3.75	0.12	104.09	
Red Wing	9.5	103	9.4	99.1	1	100	3	0.16	160.00	3.65	0.12	100.68	101.80
Red Wing	9.5	103	9.4	99.1	1	100	4	0.17	172.00	3.78	0.12	96.99	100.58
Red Wing	9.5	103	9.4	99.1	1	100	5	0.17	167.00	3.69	0.12	97.51	98.39
Red Wing	9.5	103	9.4	99.1	1	100	mean3-5	0.17	166.33	3.71	0.12	98.39	
Red Wing	9.5	103	9.4	99.1	1	100	stddev3-5	0.01	6.03	0.07	0.00	2.00	
Red Wing	9.5	103	9.4	99.1	1	100	coefvar3-5	3.62	3.62	1.80	1.80	2.03	
Red Wing	9.5	103	9.4	99.1	2	100	1	0.15	148.00	3.09	0.10	92.14	
Red Wing	9.5	103	9.4	99.1	2	100	2	0.13	129.00	3.09	0.10	105.71	
Red Wing	9.5	103	9.4	99.1	2	100	3	0.12	123.00	3.00	0.10	107.64	101.83
Red Wing	9.5	103	9.4	99.1	2	100	4	0.12	124.00	3.08	0.10	109.62	107.66
Red Wing	9.5	103	9.4	99.1	2	100	5	0.12	124.00	3.08	0.10	109.62	108.96
Red Wing	9.5	103	9.4	99.1	2	100	mean3-5	0.12	123.67	3.05	0.10	108.96	
Red Wing	9.5	103	9.4	99.1	2	100	stddev3-5	0.00	0.58	0.05	0.00	1.14	
Red Wing	9.5	103	9.4	99.1	2	100	coefvar3-5	0.47	0.47	1.51	1.51	1.05	
Red Wing	9.5	103	9.4	99.1	3	100	1	0.16	159.00	3.23	0.10	89.65	
Red Wing	9.5	103	9.4	99.1	3	100	2	0.12	123.00	3.22	0.10	115.53	
Red Wing	9.5	103	9.4	99.1	3	100	3	0.12	122.00	3.23	0.10	116.84	107.34
Red Wing	9.5	103	9.4	99.1	3	100	4	0.13	125.00	3.25	0.10	114.74	115.71
Red Wing	9.5	103	9.4	99.1	3	100	5	0.13	125.00	3.28	0.10	115.80	115.80
Red Wing	9.5	103	9.4	99.1	3	100	mean3-5	0.12	124.00	3.25	0.10	115.80	
Red Wing	9.5	103	9.4	99.1	3	100	stddev3-5	0.00	1.73	0.03	0.00	1.05	
Red Wing	9.5	103	9.4	99.1	3	100	coefvar3-5	1.40	1.40	0.77	0.77	0.91	
Red Wing	9.5	103	9.4	99.1	1	500	1	0.36	358.00	5.84	0.19	71.99	
Red Wing	9.5	103	9.4	99.1	1	500	2	0.33	332.00	5.88	0.19	78.16	
Red Wing	9.5	103	9.4	99.1	1	500	3	0.33	329.00	5.80	0.18	77.80	75.98
Red Wing	9.5	103	9.4	99.1	1	500	4	0.34	336.00	5.82	0.19	76.44	77.47
Red Wing	9.5	103	9.4	99.1	1	500	5	0.33	330.00	5.86	0.19	78.37	77.54
Red Wing	9.5	103	9.4	99.1	1	500	mean3-5	0.33	331.67	5.83	0.19	77.54	
Red Wing	9.5	103	9.4	99.1	1	500	stddev3-5	0.00	3.79	0.03	0.00	0.99	
Red Wing	9.5	103	9.4	99.1	1	500	coefvar3-5	1.14	1.14	0.52	0.52	1.28	
Red Wing	9.5	103	9.4	99.1	2	500	1	0.31	308.00	5.58	0.18	79.95	
Red Wing	9.5	103	9.4	99.1	2	500	2	0.29	292.00	5.64	0.18	85.24	
Red Wing	9.5	103	9.4	99.1	2	500	3	0.29	291.00	5.66	0.18	85.84	83.68
Red Wing	9.5	103	9.4	99.1	2	500	4	0.29	294.00	5.59	0.18	83.91	85.00
Red Wing	9.5	103	9.4	99.1	2	500	5	0.29	292.00	5.58	0.18	84.33	84.69
Red Wing	9.5	103	9.4	99.1	2	500	mean3-5	0.29	292.33	5.61	0.18	84.69	
Red Wing	9.5	103	9.4	99.1	2	500	stddev3-5	0.00	1.53	0.04	0.00	1.01	
Red Wing	9.5	103	9.4	99.1	2	500	coefvar3-5	0.52	0.52	0.78	0.78	1.20	
Red Wing	9.5	103	9.4	99.1	3	500	1	0.28	284.00	5.27	0.17	81.89	
Red Wing	9.5	103	9.4	99.1	3	500	2	0.27	266.00	5.29	0.17	87.77	
Red Wing	9.5	103	9.4	99.1	3	500	3	0.26	264.00	5.32	0.17	88.93	86.20
Red Wing	9.5	103	9.4	99.1	3	500	4	0.27	266.00	5.31	0.17	88.10	88.27
Red Wing	9.5	103	9.4	99.1	3	500	5	0.26	260.00	5.33	0.17	90.47	89.17
Red Wing	9.5	103	9.4	99.1	3	500	mean3-5	0.26	263.33	5.32	0.17	89.17	
Red Wing	9.5	103	9.4	99.1	3	500	stddev3-5	0.00	3.06	0.01	0.00	1.20	
Red Wing	9.5	103	9.4	99.1	3	500	coefvar3-5	1.16	1.16	0.19	0.19	1.35	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Wing	9.5	103	9.4	99.1	1	900	1	0.51	509.00	7.58	0.24	65.72	
Red Wing	9.5	103	9.4	99.1	1	900	2	0.50	499.00	7.53	0.24	66.60	
Red Wing	9.5	103	9.4	99.1	1	900	3	0.49	489.00	7.71	0.25	69.58	67.30
Red Wing	9.5	103	9.4	99.1	1	900	4	0.48	476.00	7.58	0.24	70.28	68.82
Red Wing	9.5	103	9.4	99.1	1	900	5	0.48	484.00	7.64	0.24	69.66	69.84
Red Wing	9.5	103	9.4	99.1	1	900	mean3-5	0.48	483.00	7.64	0.24	69.84	
Red Wing	9.5	103	9.4	99.1	1	900	stddev3-5	0.01	6.56	0.07	0.00	0.38	
Red Wing	9.5	103	9.4	99.1	1	900	coefvar3-5	1.36	1.36	0.85	0.85	0.54	
Red Wing	9.5	103	9.4	99.1	2	900	1	0.48	480.00	7.90	0.25	72.63	
Red Wing	9.5	103	9.4	99.1	2	900	2	0.47	471.00	7.89	0.25	73.93	
Red Wing	9.5	103	9.4	99.1	2	900	3	0.48	475.00	7.89	0.25	73.31	73.29
Red Wing	9.5	103	9.4	99.1	2	900	4	0.48	480.00	7.90	0.25	72.63	73.29
Red Wing	9.5	103	9.4	99.1	2	900	5	0.48	475.00	7.95	0.25	73.86	73.27
Red Wing	9.5	103	9.4	99.1	2	900	mean3-5	0.48	476.67	7.91	0.25	73.27	
Red Wing	9.5	103	9.4	99.1	2	900	stddev3-5	0.00	2.89	0.03	0.00	0.62	
Red Wing	9.5	103	9.4	99.1	2	900	coefvar3-5	0.61	0.61	0.41	0.41	0.84	
Red Wing	9.5	103	9.4	99.1	3	900	1	0.46	462.00	7.46	0.24	71.26	
Red Wing	9.5	103	9.4	99.1	3	900	2	0.45	448.00	7.62	0.24	75.06	
Red Wing	9.5	103	9.4	99.1	3	900	3	0.43	434.00	7.62	0.24	77.49	74.60
Red Wing	9.5	103	9.4	99.1	3	900	4	0.44	439.00	7.60	0.24	76.40	76.32
Red Wing	9.5	103	9.4	99.1	3	900	5	0.44	435.00	7.62	0.24	77.31	77.06
Red Wing	9.5	103	9.4	99.1	3	900	mean3-5	0.44	436.00	7.61	0.24	77.06	
Red Wing	9.5	103	9.4	99.1	3	900	stddev3-5	0.00	2.65	0.01	0.00	0.58	
Red Wing	9.5	103	9.4	99.1	3	900	coefvar3-5	0.61	0.61	0.15	0.15	0.75	
Red Wing	8	103	8.4	96.2	1	100	1	0.08	78.00	3.18	0.10	179.92	
Red Wing	8	103	8.4	96.2	1	100	2	0.08	78.00	3.18	0.10	179.92	
Red Wing	8	103	8.4	96.2	1	100	3	0.08	76.00	3.16	0.10	183.50	181.11
Red Wing	8	103	8.4	96.2	1	100	4	0.07	74.00	3.19	0.10	190.25	184.55
Red Wing	8	103	8.4	96.2	1	100	5	0.07	73.00	3.15	0.10	190.43	188.06
Red Wing	8	103	8.4	96.2	1	100	mean3-5	0.07	74.33	3.17	0.10	188.06	
Red Wing	8	103	8.4	96.2	1	100	stddev3-5	0.00	1.53	0.02	0.00	3.95	
Red Wing	8	103	8.4	96.2	1	100	coefvar3-5	2.05	2.05	0.66	0.66	2.10	
Red Wing	8	103	8.4	96.2	2	100	1	0.11	112.00	3.17	0.10	124.91	
Red Wing	8	103	8.4	96.2	2	100	2	0.11	111.00	3.20	0.10	127.23	
Red Wing	8	103	8.4	96.2	2	100	3	0.10	101.00	3.11	0.10	135.89	129.34
Red Wing	8	103	8.4	96.2	2	100	4	0.10	100.00	3.16	0.10	139.46	134.19
Red Wing	8	103	8.4	96.2	2	100	5	0.10	99.00	3.11	0.10	138.64	138.00
Red Wing	8	103	8.4	96.2	2	100	mean3-5	0.10	100.00	3.13	0.10	138.00	
Red Wing	8	103	8.4	96.2	2	100	stddev3-5	0.00	1.00	0.03	0.00	1.87	
Red Wing	8	103	8.4	96.2	2	100	coefvar3-5	1.00	1.00	0.92	0.92	1.35	
Red Wing	8	103	8.4	96.2	3	100	1	0.08	84.00	2.88	0.09	151.31	
Red Wing	8	103	8.4	96.2	3	100	2	0.07	65.00	2.99	0.10	203.01	
Red Wing	8	103	8.4	96.2	3	100	3	0.07	74.00	2.91	0.09	173.55	175.95
Red Wing	8	103	8.4	96.2	3	100	4	0.06	64.00	2.95	0.09	203.42	193.33
Red Wing	8	103	8.4	96.2	3	100	5	0.07	72.00	3.07	0.10	188.17	188.38
Red Wing	8	103	8.4	96.2	3	100	mean3-5	0.07	70.00	2.98	0.09	188.38	
Red Wing	8	103	8.4	96.2	3	100	stddev3-5	0.01	5.29	0.08	0.00	14.94	
Red Wing	8	103	8.4	96.2	3	100	coefvar3-5	7.56	7.56	2.80	2.80	7.93	

Light Weight Deflectometer														
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Wing	8	103	8.4	96.2	1	500	1	0.16	155.00	5.59	0.18	159.16	
Red Wing	8	103	8.4	96.2	1	500	2	0.16	159.00	5.72	0.18	158.76	
Red Wing	8	103	8.4	96.2	1	500	3	0.16	161.00	5.62	0.18	154.05	157.33
Red Wing	8	103	8.4	96.2	1	500	4	0.17	166.00	5.54	0.18	147.28	153.37
Red Wing	8	103	8.4	96.2	1	500	5	0.17	166.00	5.54	0.18	147.28	149.54
Red Wing	8	103	8.4	96.2	1	500	mean3-5	0.16	164.33	5.57	0.18	149.54	
Red Wing	8	103	8.4	96.2	1	500	stddev3-5	0.00	2.89	0.05	0.00	3.91	
Red Wing	8	103	8.4	96.2	1	500	coefvar3-5	1.76	1.76	0.83	0.83	2.61	
Red Wing	8	103	8.4	96.2	2	500	1	0.16	155.00	4.80	0.15	136.67	
Red Wing	8	103	8.4	96.2	2	500	2	0.16	156.00	4.73	0.15	133.81	
Red Wing	8	103	8.4	96.2	2	500	3	0.16	156.00	4.81	0.15	136.07	135.52
Red Wing	8	103	8.4	96.2	2	500	4	0.15	153.00	4.83	0.15	139.32	136.40
Red Wing	8	103	8.4	96.2	2	500	5	0.18	176.00	4.78	0.15	119.86	131.75
Red Wing	8	103	8.4	96.2	2	500	mean3-5	0.16	161.67	4.81	0.15	131.75	
Red Wing	8	103	8.4	96.2	2	500	stddev3-5	0.01	12.50	0.03	0.00	10.43	
Red Wing	8	103	8.4	96.2	2	500	coefvar3-5	7.73	7.73	0.52	0.52	7.91	
Red Wing	8	103	8.4	96.2	3	500	1	0.12	119.00	4.99	0.16	185.06	
Red Wing	8	103	8.4	96.2	3	500	2	0.12	120.00	4.88	0.16	179.47	
Red Wing	8	103	8.4	96.2	3	500	3	0.13	132.00	4.83	0.15	161.48	175.34
Red Wing	8	103	8.4	96.2	3	500	4	0.12	122.00	4.98	0.16	180.15	173.70
Red Wing	8	103	8.4	96.2	3	500	5	0.12	122.00	4.97	0.16	179.78	173.80
Red Wing	8	103	8.4	96.2	3	500	mean3-5	0.13	125.33	4.93	0.16	173.80	
Red Wing	8	103	8.4	96.2	3	500	stddev3-5	0.01	5.77	0.08	0.00	10.67	
Red Wing	8	103	8.4	96.2	3	500	coefvar3-5	4.61	4.61	1.70	1.70	6.14	
Red Wing	8	103	8.4	96.2	1	900	1	0.30	300.00	8.25	0.26	121.36	
Red Wing	8	103	8.4	96.2	1	900	2	0.31	308.00	8.26	0.26	118.35	
Red Wing	8	103	8.4	96.2	1	900	3	0.30	303.00	8.13	0.26	118.41	119.38
Red Wing	8	103	8.4	96.2	1	900	4	0.31	311.00	8.31	0.26	117.92	118.23
Red Wing	8	103	8.4	96.2	1	900	5	0.31	313.00	8.15	0.26	114.91	117.08
Red Wing	8	103	8.4	96.2	1	900	mean3-5	0.31	309.00	8.20	0.26	117.08	
Red Wing	8	103	8.4	96.2	1	900	stddev3-5	0.01	5.29	0.10	0.00	1.90	
Red Wing	8	103	8.4	96.2	1	900	coefvar3-5	1.71	1.71	1.20	1.20	1.62	
Red Wing	8	103	8.4	96.2	2	900	1	0.25	251.00	7.00	0.22	123.08	
Red Wing	8	103	8.4	96.2	2	900	2	0.25	248.00	7.07	0.23	125.81	
Red Wing	8	103	8.4	96.2	2	900	3	0.26	256.00	7.03	0.22	121.19	123.36
Red Wing	8	103	8.4	96.2	2	900	4	0.26	257.00	7.09	0.23	121.75	122.92
Red Wing	8	103	8.4	96.2	2	900	5	0.26	263.00	7.24	0.23	121.49	121.48
Red Wing	8	103	8.4	96.2	2	900	mean3-5	0.26	258.67	7.12	0.23	121.48	
Red Wing	8	103	8.4	96.2	2	900	stddev3-5	0.00	3.79	0.11	0.00	0.28	
Red Wing	8	103	8.4	96.2	2	900	coefvar3-5	1.46	1.46	1.52	1.52	0.23	
Red Wing	8	103	8.4	96.2	3	900	1	0.23	227.00	7.76	0.25	150.87	
Red Wing	8	103	8.4	96.2	3	900	2	0.22	223.00	7.93	0.25	156.94	
Red Wing	8	103	8.4	96.2	3	900	3	0.23	230.00	7.81	0.25	149.86	152.55
Red Wing	8	103	8.4	96.2	3	900	4	0.23	226.00	7.93	0.25	154.85	153.88
Red Wing	8	103	8.4	96.2	3	900	5	0.22	224.00	7.90	0.25	155.64	153.45
Red Wing	8	103	8.4	96.2	3	900	mean3-5	0.23	226.67	7.88	0.25	153.45	
Red Wing	8	103	8.4	96.2	3	900	stddev3-5	0.00	3.06	0.06	0.00	3.14	
Red Wing	8	103	8.4	96.2	3	900	coefvar3-5	1.35	1.35	0.79	0.79	2.04	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Lake Falls	18	98	18.6	97.5	1	100	1	---	---	---	---	---	
Red Lake Falls	18	98	18.6	97.5	1	100	2	0.07	73.00	2.36	0.08	142.67	
Red Lake Falls	18	98	18.6	97.5	1	100	3	0.07	74.00	2.48	0.08	147.90	---
Red Lake Falls	18	98	18.6	97.5	1	100	4	0.07	74.00	2.56	0.08	152.67	147.75
Red Lake Falls	18	98	18.6	97.5	1	100	5	0.07	73.00	2.50	0.08	151.14	150.57
Red Lake Falls	18	98	18.6	97.5	1	100	mean3-5	0.07	73.67	2.51	0.08	150.57	
Red Lake Falls	18	98	18.6	97.5	1	100	stddev3-5	0.00	0.58	0.04	0.00	2.44	
Red Lake Falls	18	98	18.6	97.5	1	100	coefvar3-5	0.78	0.78	1.66	1.66	1.62	
Red Lake Falls	18	98	18.6	97.5	2	100	1	0.09	89.00	2.36	0.08	117.02	
Red Lake Falls	18	98	18.6	97.5	2	100	2	0.09	92.00	2.35	0.07	112.73	
Red Lake Falls	18	98	18.6	97.5	2	100	3	0.09	89.00	2.34	0.07	116.03	115.26
Red Lake Falls	18	98	18.6	97.5	2	100	4	0.09	89.00	2.37	0.08	117.52	115.43
Red Lake Falls	18	98	18.6	97.5	2	100	5	0.09	88.00	2.45	0.08	122.87	118.81
Red Lake Falls	18	98	18.6	97.5	2	100	mean3-5	0.09	88.67	2.39	0.08	118.81	
Red Lake Falls	18	98	18.6	97.5	2	100	stddev3-5	0.00	0.58	0.06	0.00	3.59	
Red Lake Falls	18	98	18.6	97.5	2	100	coefvar3-5	0.65	0.65	2.38	2.38	3.03	
Red Lake Falls	18	98	18.6	97.5	3	100	1	0.12	115.00	2.28	0.07	87.50	
Red Lake Falls	18	98	18.6	97.5	3	100	2	0.12	119.00	2.36	0.08	87.52	
Red Lake Falls	18	98	18.6	97.5	3	100	3	0.12	118.00	2.37	0.08	88.64	87.89
Red Lake Falls	18	98	18.6	97.5	3	100	4	0.12	123.00	2.39	0.08	85.75	87.30
Red Lake Falls	18	98	18.6	97.5	3	100	5	0.12	121.00	2.42	0.08	88.26	87.55
Red Lake Falls	18	98	18.6	97.5	3	100	mean3-5	0.12	120.67	2.39	0.08	87.55	
Red Lake Falls	18	98	18.6	97.5	3	100	stddev3-5	0.00	2.52	0.03	0.00	1.57	
Red Lake Falls	18	98	18.6	97.5	3	100	coefvar3-5	2.09	2.09	1.05	1.05	1.79	
Red Lake Falls	18	98	18.6	97.5	1	500	1	0.19	188.00	5.17	0.16	121.36	
Red Lake Falls	18	98	18.6	97.5	1	500	2	0.19	186.00	5.22	0.17	123.85	
Red Lake Falls	18	98	18.6	97.5	1	500	3	0.19	187.00	5.24	0.17	123.66	122.96
Red Lake Falls	18	98	18.6	97.5	1	500	4	0.19	186.00	5.18	0.16	122.91	123.47
Red Lake Falls	18	98	18.6	97.5	1	500	5	0.19	188.00	5.25	0.17	123.24	123.27
Red Lake Falls	18	98	18.6	97.5	1	500	mean3-5	0.19	187.00	5.22	0.17	123.27	
Red Lake Falls	18	98	18.6	97.5	1	500	stddev3-5	0.00	1.00	0.04	0.00	0.38	
Red Lake Falls	18	98	18.6	97.5	1	500	coefvar3-5	0.53	0.53	0.72	0.72	0.31	
Red Lake Falls	18	98	18.6	97.5	2	500	1	0.23	234.00	5.38	0.17	101.47	
Red Lake Falls	18	98	18.6	97.5	2	500	2	0.24	241.00	5.50	0.18	100.72	
Red Lake Falls	18	98	18.6	97.5	2	500	3	0.24	240.00	5.51	0.18	101.32	101.17
Red Lake Falls	18	98	18.6	97.5	2	500	4	0.18	175.00	4.34	0.14	109.45	103.83
Red Lake Falls	18	98	18.6	97.5	2	500	5	0.24	240.00	5.45	0.17	100.22	103.66
Red Lake Falls	18	98	18.6	97.5	2	500	mean3-5	0.22	218.33	5.10	0.16	103.66	
Red Lake Falls	18	98	18.6	97.5	2	500	stddev3-5	0.04	37.53	0.66	0.02	5.04	
Red Lake Falls	18	98	18.6	97.5	2	500	coefvar3-5	17.19	17.19	12.92	12.92	4.86	
Red Lake Falls	18	98	18.6	97.5	3	500	1	0.33	332.00	5.30	0.17	70.45	
Red Lake Falls	18	98	18.6	97.5	3	500	2	0.33	329.00	5.34	0.17	71.63	
Red Lake Falls	18	98	18.6	97.5	3	500	3	0.34	340.00	5.35	0.17	69.44	70.51
Red Lake Falls	18	98	18.6	97.5	3	500	4	0.33	333.00	5.31	0.17	70.37	70.48
Red Lake Falls	18	98	18.6	97.5	3	500	5	0.34	342.00	5.31	0.17	68.52	69.45
Red Lake Falls	18	98	18.6	97.5	3	500	mean3-5	0.34	338.33	5.32	0.17	69.45	
Red Lake Falls	18	98	18.6	97.5	3	500	stddev3-5	0.00	4.73	0.02	0.00	0.93	
Red Lake Falls	18	98	18.6	97.5	3	500	coefvar3-5	1.40	1.40	0.43	0.43	1.33	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic Load	Dynamic Stress	Modulus	Three Blow Average Modulus
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Lake Falls	18	98	18.6	97.5	1	900	1	0.42	419.00	8.16	0.26	85.95	
Red Lake Falls	18	98	18.6	97.5	1	900	2	0.43	425.00	8.09	0.26	84.01	
Red Lake Falls	18	98	18.6	97.5	1	900	3	0.45	445.00	8.21	0.26	81.42	83.79
Red Lake Falls	18	98	18.6	97.5	1	900	4	0.45	449.00	8.15	0.26	80.11	81.84
Red Lake Falls	18	98	18.6	97.5	1	900	5	0.45	453.00	8.17	0.26	79.59	80.37
Red Lake Falls	18	98	18.6	97.5	1	900	mean3-5	0.45	449.00	8.18	0.26	80.37	
Red Lake Falls	18	98	18.6	97.5	1	900	stddev3-5	0.00	4.00	0.03	0.00	0.94	
Red Lake Falls	18	98	18.6	97.5	1	900	coefvar3-5	0.89	0.89	0.37	0.37	1.17	
Red Lake Falls	18	98	18.6	97.5	2	900	1	0.43	432.00	8.08	0.26	82.54	
Red Lake Falls	18	98	18.6	97.5	2	900	2	0.45	445.00	8.10	0.26	80.33	
Red Lake Falls	18	98	18.6	97.5	2	900	3	0.46	455.00	8.02	0.26	77.79	80.22
Red Lake Falls	18	98	18.6	97.5	2	900	4	0.47	469.00	8.14	0.26	76.60	78.24
Red Lake Falls	18	98	18.6	97.5	2	900	5	0.46	464.00	8.13	0.26	77.33	77.24
Red Lake Falls	18	98	18.6	97.5	2	900	mean3-5	0.46	462.67	8.10	0.26	77.24	
Red Lake Falls	18	98	18.6	97.5	2	900	stddev3-5	0.01	7.09	0.07	0.00	0.60	
Red Lake Falls	18	98	18.6	97.5	2	900	coefvar3-5	1.53	1.53	0.82	0.82	0.78	
Red Lake Falls	18	98	18.6	97.5	3	900	1	0.67	667.00	8.47	0.27	56.04	
Red Lake Falls	18	98	18.6	97.5	3	900	2	0.69	685.00	8.49	0.27	54.70	
Red Lake Falls	18	98	18.6	97.5	3	900	3	0.70	702.00	8.48	0.27	53.31	54.68
Red Lake Falls	18	98	18.6	97.5	3	900	4	0.71	714.00	8.41	0.27	51.98	53.33
Red Lake Falls	18	98	18.6	97.5	3	900	5	0.72	720.00	8.38	0.27	51.36	52.22
Red Lake Falls	18	98	18.6	97.5	3	900	mean3-5	0.71	712.00	8.42	0.27	52.22	
Red Lake Falls	18	98	18.6	97.5	3	900	stddev3-5	0.01	9.17	0.05	0.00	0.99	
Red Lake Falls	18	98	18.6	97.5	3	900	coefvar3-5	1.29	1.29	0.61	0.61	1.90	
Red Lake Falls	14	98	14.2	97.8	1	100	1	0.10	104.00	3.60	0.11	152.76	
Red Lake Falls	14	98	14.2	97.8	1	100	2	0.10	102.00	3.54	0.11	153.16	
Red Lake Falls	14	98	14.2	97.8	1	100	3	0.11	105.00	3.63	0.12	152.57	152.83
Red Lake Falls	14	98	14.2	97.8	1	100	4	0.10	103.00	3.69	0.12	158.10	154.61
Red Lake Falls	14	98	14.2	97.8	1	100	5	0.10	103.00	3.62	0.12	155.10	155.26
Red Lake Falls	14	98	14.2	97.8	1	100	mean3-5	0.10	103.67	3.65	0.12	155.26	
Red Lake Falls	14	98	14.2	97.8	1	100	stddev3-5	0.00	1.15	0.04	0.00	2.77	
Red Lake Falls	14	98	14.2	97.8	1	100	coefvar3-5	1.11	1.11	1.04	1.04	1.78	
Red Lake Falls	14	98	14.2	97.8	2	100	1	0.12	124.00	3.68	0.12	130.97	
Red Lake Falls	14	98	14.2	97.8	2	100	2	0.11	109.00	3.50	0.11	141.71	
Red Lake Falls	14	98	14.2	97.8	2	100	3	0.11	109.00	3.44	0.11	139.28	137.32
Red Lake Falls	14	98	14.2	97.8	2	100	4	0.11	108.00	3.43	0.11	140.16	140.38
Red Lake Falls	14	98	14.2	97.8	2	100	5	0.11	111.00	3.45	0.11	137.17	138.87
Red Lake Falls	14	98	14.2	97.8	2	100	mean3-5	0.11	109.33	3.44	0.11	138.87	
Red Lake Falls	14	98	14.2	97.8	2	100	stddev3-5	0.00	1.53	0.01	0.00	1.54	
Red Lake Falls	14	98	14.2	97.8	2	100	coefvar3-5	1.40	1.40	0.29	0.29	1.11	
Red Lake Falls	14	98	14.2	97.8	3	100	1	0.16	157.00	4.08	0.13	114.69	
Red Lake Falls	14	98	14.2	97.8	3	100	2	0.12	116.00	4.10	0.13	155.98	
Red Lake Falls	14	98	14.2	97.8	3	100	3	0.12	118.00	4.10	0.13	153.34	141.34
Red Lake Falls	14	98	14.2	97.8	3	100	4	0.12	119.00	4.07	0.13	150.94	153.42
Red Lake Falls	14	98	14.2	97.8	3	100	5	0.12	117.00	4.02	0.13	151.63	151.97
Red Lake Falls	14	98	14.2	97.8	3	100	mean3-5	0.12	118.00	4.06	0.13	151.97	
Red Lake Falls	14	98	14.2	97.8	3	100	stddev3-5	0.00	1.00	0.04	0.00	1.24	
Red Lake Falls	14	98	14.2	97.8	3	100	coefvar3-5	0.85	0.85	0.99	0.99	0.81	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic Load	Dynamic Stress	Modulus	Three Blow Average Modulus
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Lake Falls	14	98	14.2	97.8	1	500	1	0.17	171.00	5.25	0.17	135.49	
Red Lake Falls	14	98	14.2	97.8	1	500	2	0.16	155.00	4.98	0.16	141.79	
Red Lake Falls	14	98	14.2	97.8	1	500	3	0.16	159.00	5.03	0.16	139.61	138.97
Red Lake Falls	14	98	14.2	97.8	1	500	4	0.16	156.00	4.96	0.16	140.32	140.57
Red Lake Falls	14	98	14.2	97.8	1	500	5	0.16	158.00	5.02	0.16	140.22	140.05
Red Lake Falls	14	98	14.2	97.8	1	500	mean3-5	0.16	157.67	5.00	0.16	140.05	
Red Lake Falls	14	98	14.2	97.8	1	500	stddev3-5	0.00	1.53	0.04	0.00	0.38	
Red Lake Falls	14	98	14.2	97.8	1	500	coefvar3-5	0.97	0.97	0.76	0.76	0.27	
Red Lake Falls	14	98	14.2	97.8	2	500	1	0.24	236.00	6.16	0.20	115.19	
Red Lake Falls	14	98	14.2	97.8	2	500	2	0.23	230.00	6.10	0.19	117.05	
Red Lake Falls	14	98	14.2	97.8	2	500	3	0.23	232.00	6.16	0.20	117.18	116.47
Red Lake Falls	14	98	14.2	97.8	2	500	4	0.24	235.00	6.22	0.20	116.81	117.01
Red Lake Falls	14	98	14.2	97.8	2	500	5	0.23	234.00	6.28	0.20	118.44	117.48
Red Lake Falls	14	98	14.2	97.8	2	500	mean3-5	0.23	233.67	6.22	0.20	117.48	
Red Lake Falls	14	98	14.2	97.8	2	500	stddev3-5	0.00	1.53	0.06	0.00	0.86	
Red Lake Falls	14	98	14.2	97.8	2	500	coefvar3-5	0.65	0.65	0.96	0.96	0.73	
Red Lake Falls	14	98	14.2	97.8	3	500	1	0.20	198.00	5.96	0.19	132.84	
Red Lake Falls	14	98	14.2	97.8	3	500	2	0.20	203.00	6.06	0.19	131.74	
Red Lake Falls	14	98	14.2	97.8	3	500	3	0.20	203.00	6.01	0.19	130.66	131.75
Red Lake Falls	14	98	14.2	97.8	3	500	4	0.20	203.00	6.11	0.19	132.83	131.74
Red Lake Falls	14	98	14.2	97.8	3	500	5	0.20	201.00	6.00	0.19	131.74	131.74
Red Lake Falls	14	98	14.2	97.8	3	500	mean3-5	0.20	202.33	6.04	0.19	131.74	
Red Lake Falls	14	98	14.2	97.8	3	500	stddev3-5	0.00	1.15	0.06	0.00	1.09	
Red Lake Falls	14	98	14.2	97.8	3	500	coefvar3-5	0.57	0.57	1.01	1.01	0.83	
Red Lake Falls	14	98	14.2	97.8	1	900	1	0.32	323.00	8.09	0.26	110.54	
Red Lake Falls	14	98	14.2	97.8	1	900	2	0.32	323.00	8.10	0.26	110.67	
Red Lake Falls	14	98	14.2	97.8	1	900	3	0.32	323.00	8.06	0.26	110.13	110.44
Red Lake Falls	14	98	14.2	97.8	1	900	4	0.33	329.00	8.18	0.26	109.73	110.17
Red Lake Falls	14	98	14.2	97.8	1	900	5	0.35	347.00	8.29	0.26	105.43	108.43
Red Lake Falls	14	98	14.2	97.8	1	900	mean3-5	0.33	333.00	8.18	0.26	108.43	
Red Lake Falls	14	98	14.2	97.8	1	900	stddev3-5	0.01	12.49	0.12	0.00	2.60	
Red Lake Falls	14	98	14.2	97.8	1	900	coefvar3-5	3.75	3.75	1.41	1.41	2.40	
Red Lake Falls	14	98	14.2	97.8	2	900	1	0.40	404.00	8.80	0.28	96.13	
Red Lake Falls	14	98	14.2	97.8	2	900	2	0.40	395.00	9.04	0.29	101.00	
Red Lake Falls	14	98	14.2	97.8	2	900	3	0.40	402.00	8.97	0.29	98.47	98.53
Red Lake Falls	14	98	14.2	97.8	2	900	4	0.40	401.00	8.88	0.28	97.73	99.07
Red Lake Falls	14	98	14.2	97.8	2	900	5	0.39	392.00	8.88	0.28	99.97	98.73
Red Lake Falls	14	98	14.2	97.8	2	900	mean3-5	0.40	398.33	8.91	0.28	98.73	
Red Lake Falls	14	98	14.2	97.8	2	900	stddev3-5	0.01	5.51	0.05	0.00	1.14	
Red Lake Falls	14	98	14.2	97.8	2	900	coefvar3-5	1.38	1.38	0.58	0.58	1.16	
Red Lake Falls	14	98	14.2	97.8	3	900	1	0.36	363.00	8.75	0.28	106.38	
Red Lake Falls	14	98	14.2	97.8	3	900	2	0.38	375.00	8.78	0.28	103.33	
Red Lake Falls	14	98	14.2	97.8	3	900	3	0.38	375.00	8.56	0.27	100.74	103.48
Red Lake Falls	14	98	14.2	97.8	3	900	4	0.38	375.00	8.74	0.28	102.86	102.31
Red Lake Falls	14	98	14.2	97.8	3	900	5	0.39	386.00	8.85	0.28	101.18	101.59
Red Lake Falls	14	98	14.2	97.8	3	900	mean3-5	0.38	378.67	8.72	0.28	101.59	
Red Lake Falls	14	98	14.2	97.8	3	900	stddev3-5	0.01	6.35	0.15	0.00	1.12	
Red Lake Falls	14	98	14.2	97.8	3	900	coefvar3-5	1.68	1.68	1.68	1.68	1.10	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Lake Falls	11	98	10.7	90.5	1	100	1						
Red Lake Falls	11	98	10.7	90.5	1	100	2						
Red Lake Falls	11	98	10.7	90.5	1	100	3						
Red Lake Falls	11	98	10.7	90.5	1	100	4						
Red Lake Falls	11	98	10.7	90.5	1	100	5						
Red Lake Falls	11	98	10.7	90.5	1	100	mean3-5						
Red Lake Falls	11	98	10.7	90.5	1	100	stddev3-5						
Red Lake Falls	11	98	10.7	90.5	1	100	coefvar3-5						
Red Lake Falls	11	98	10.7	90.5	2	100	1						
Red Lake Falls	11	98	10.7	90.5	2	100	2						
Red Lake Falls	11	98	10.7	90.5	2	100	3						
Red Lake Falls	11	98	10.7	90.5	2	100	4						
Red Lake Falls	11	98	10.7	90.5	2	100	5						
Red Lake Falls	11	98	10.7	90.5	2	100	mean3-5						
Red Lake Falls	11	98	10.7	90.5	2	100	stddev3-5						
Red Lake Falls	11	98	10.7	90.5	2	100	coefvar3-5						
Red Lake Falls	16	103	16.3	99.4	1	100	1	0.06	58.00	2.88	0.09	219.14	
Red Lake Falls	16	103	16.3	99.4	1	100	2	0.06	58.00	2.84	0.09	216.09	
Red Lake Falls	16	103	16.3	99.4	1	100	3	0.06	59.00	2.92	0.09	218.42	217.88
Red Lake Falls	16	103	16.3	99.4	1	100	4	0.06	58.00	2.88	0.09	219.14	217.88
Red Lake Falls	16	103	16.3	99.4	1	100	5	0.06	57.00	2.83	0.09	219.11	218.89
Red Lake Falls	16	103	16.3	99.4	1	100	mean3-5	0.06	58.00	2.88	0.09	218.89	
Red Lake Falls	16	103	16.3	99.4	1	100	stddev3-5	0.00	1.00	0.05	0.00	0.41	
Red Lake Falls	16	103	16.3	99.4	1	100	coefvar3-5	1.72	1.72	1.57	1.57	0.19	
Red Lake Falls	16	103	16.3	99.4	2	100	1	0.06	62.00	2.25	0.07	160.16	
Red Lake Falls	16	103	16.3	99.4	2	100	2	0.06	64.00	2.24	0.07	154.46	
Red Lake Falls	16	103	16.3	99.4	2	100	3	0.06	60.00	2.31	0.07	169.91	161.51
Red Lake Falls	16	103	16.3	99.4	2	100	4	0.06	63.00	2.34	0.07	163.92	162.76
Red Lake Falls	16	103	16.3	99.4	2	100	5	0.06	62.00	2.28	0.07	162.29	165.37
Red Lake Falls	16	103	16.3	99.4	2	100	mean3-5	0.06	61.67	2.31	0.07	165.37	
Red Lake Falls	16	103	16.3	99.4	2	100	stddev3-5	0.00	1.53	0.03	0.00	4.01	
Red Lake Falls	16	103	16.3	99.4	2	100	coefvar3-5	2.48	2.48	1.30	1.30	2.43	
Red Lake Falls	16	103	16.3	99.4	3	100	1	0.07	72.00	2.54	0.08	155.69	
Red Lake Falls	16	103	16.3	99.4	3	100	2	0.07	70.00	2.49	0.08	156.98	
Red Lake Falls	16	103	16.3	99.4	3	100	3	0.07	69.00	2.56	0.08	163.74	158.80
Red Lake Falls	16	103	16.3	99.4	3	100	4	0.07	70.00	2.57	0.08	162.03	160.92
Red Lake Falls	16	103	16.3	99.4	3	100	5	0.07	67.00	2.51	0.08	165.33	163.70
Red Lake Falls	16	103	16.3	99.4	3	100	mean3-5	0.07	68.67	2.55	0.08	163.70	
Red Lake Falls	16	103	16.3	99.4	3	100	stddev3-5	0.00	1.53	0.03	0.00	1.65	
Red Lake Falls	16	103	16.3	99.4	3	100	coefvar3-5	2.22	2.22	1.26	1.26	1.01	

Light Weight Deflectometer														
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Lake Falls	16	103	16.3	99.4	1	500	1	0.12	116.00	5.39	0.17	205.06	
Red Lake Falls	16	103	16.3	99.4	1	500	2	0.12	117.00	5.40	0.17	203.69	
Red Lake Falls	16	103	16.3	99.4	1	500	3	0.12	119.00	5.39	0.17	199.89	202.88
Red Lake Falls	16	103	16.3	99.4	1	500	4	0.12	117.00	5.40	0.17	203.69	202.42
Red Lake Falls	16	103	16.3	99.4	1	500	5	0.12	117.00	5.43	0.17	204.82	202.80
Red Lake Falls	16	103	16.3	99.4	1	500	mean3-5	0.12	117.67	5.41	0.17	202.80	
Red Lake Falls	16	103	16.3	99.4	1	500	stddev3-5	0.00	1.15	0.02	0.00	2.58	
Red Lake Falls	16	103	16.3	99.4	1	500	coefvar3-5	0.98	0.98	0.39	0.39	1.27	
Red Lake Falls	16	103	16.3	99.4	2	500	1	0.15	147.00	5.24	0.17	157.31	
Red Lake Falls	16	103	16.3	99.4	2	500	2	0.16	156.00	5.34	0.17	151.07	
Red Lake Falls	16	103	16.3	99.4	2	500	3	0.15	151.00	5.35	0.17	156.36	154.91
Red Lake Falls	16	103	16.3	99.4	2	500	4	0.15	150.00	5.24	0.17	154.17	153.87
Red Lake Falls	16	103	16.3	99.4	2	500	5	0.15	146.00	5.24	0.17	158.39	156.31
Red Lake Falls	16	103	16.3	99.4	2	500	mean3-5	0.15	149.00	5.28	0.17	156.31	
Red Lake Falls	16	103	16.3	99.4	2	500	stddev3-5	0.00	2.65	0.06	0.00	2.11	
Red Lake Falls	16	103	16.3	99.4	2	500	coefvar3-5	1.78	1.78	1.20	1.20	1.35	
Red Lake Falls	16	103	16.3	99.4	3	500	1	0.16	163.00	5.41	0.17	146.48	
Red Lake Falls	16	103	16.3	99.4	3	500	2	0.16	163.00	5.43	0.17	147.02	
Red Lake Falls	16	103	16.3	99.4	3	500	3	0.16	162.00	5.52	0.18	150.38	147.96
Red Lake Falls	16	103	16.3	99.4	3	500	4	0.16	164.00	5.42	0.17	145.85	147.75
Red Lake Falls	16	103	16.3	99.4	3	500	5	0.17	165.00	5.53	0.18	147.91	148.05
Red Lake Falls	16	103	16.3	99.4	3	500	mean3-5	0.16	163.67	5.49	0.17	148.05	
Red Lake Falls	16	103	16.3	99.4	3	500	stddev3-5	0.00	1.53	0.06	0.00	2.27	
Red Lake Falls	16	103	16.3	99.4	3	500	coefvar3-5	0.93	0.93	1.11	1.11	1.53	
Red Lake Falls	16	103	16.3	99.4	1	900	1	0.20	196.00	8.09	0.26	182.16	
Red Lake Falls	16	103	16.3	99.4	1	900	2	0.20	198.00	8.16	0.26	181.88	
Red Lake Falls	16	103	16.3	99.4	1	900	3	0.20	198.00	8.22	0.26	183.21	182.42
Red Lake Falls	16	103	16.3	99.4	1	900	4	0.20	202.00	8.17	0.26	178.49	181.20
Red Lake Falls	16	103	16.3	99.4	1	900	5	0.20	200.00	8.18	0.26	180.50	180.74
Red Lake Falls	16	103	16.3	99.4	1	900	mean3-5	0.20	200.00	8.19	0.26	180.74	
Red Lake Falls	16	103	16.3	99.4	1	900	stddev3-5	0.00	2.00	0.03	0.00	2.37	
Red Lake Falls	16	103	16.3	99.4	1	900	coefvar3-5	1.00	1.00	0.32	0.32	1.31	
Red Lake Falls	16	103	16.3	99.4	2	900	1	0.26	256.00	8.08	0.26	139.29	
Red Lake Falls	16	103	16.3	99.4	2	900	2	0.26	257.00	8.02	0.26	137.72	
Red Lake Falls	16	103	16.3	99.4	2	900	3	0.26	259.00	8.11	0.26	138.19	138.40
Red Lake Falls	16	103	16.3	99.4	2	900	4	0.26	257.00	8.11	0.26	139.27	138.39
Red Lake Falls	16	103	16.3	99.4	2	900	5	0.26	263.00	8.14	0.26	136.59	138.02
Red Lake Falls	16	103	16.3	99.4	2	900	mean3-5	0.26	259.67	8.12	0.26	138.02	
Red Lake Falls	16	103	16.3	99.4	2	900	stddev3-5	0.00	3.06	0.02	0.00	1.35	
Red Lake Falls	16	103	16.3	99.4	2	900	coefvar3-5	1.18	1.18	0.21	0.21	0.97	
Red Lake Falls	16	103	16.3	99.4	3	900	1	0.26	258.00	8.12	0.26	138.90	
Red Lake Falls	16	103	16.3	99.4	3	900	2	0.26	263.00	8.24	0.26	138.27	
Red Lake Falls	16	103	16.3	99.4	3	900	3	0.26	259.00	8.16	0.26	139.04	138.74
Red Lake Falls	16	103	16.3	99.4	3	900	4	0.27	268.00	8.30	0.26	136.68	138.00
Red Lake Falls	16	103	16.3	99.4	3	900	5	0.26	264.00	8.17	0.26	136.58	137.43
Red Lake Falls	16	103	16.3	99.4	3	900	mean3-5	0.26	263.67	8.21	0.26	137.43	
Red Lake Falls	16	103	16.3	99.4	3	900	stddev3-5	0.00	4.51	0.08	0.00	1.40	
Red Lake Falls	16	103	16.3	99.4	3	900	coefvar3-5	1.71	1.71	0.95	0.95	1.02	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic		Modulus	Three Blow Average Modulus
										Load	Stress		
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Lake Falls	13	103	13.3	102.9	1	100	1	0.04	37.00	2.72	0.09	324.43	
Red Lake Falls	13	103	13.3	102.9	1	100	2	0.04	38.00	2.74	0.09	318.22	
Red Lake Falls	13	103	13.3	102.9	1	100	3	0.04	37.00	2.75	0.09	328.01	323.55
Red Lake Falls	13	103	13.3	102.9	1	100	4	0.04	38.00	2.70	0.09	313.57	319.93
Red Lake Falls	13	103	13.3	102.9	1	100	5	0.04	39.00	2.72	0.09	307.79	316.46
Red Lake Falls	13	103	13.3	102.9	1	100	mean3-5	0.04	38.00	2.72	0.09	316.46	
Red Lake Falls	13	103	13.3	102.9	1	100	stddev3-5	0.00	1.00	0.03	0.00	10.41	
Red Lake Falls	13	103	13.3	102.9	1	100	coefvar3-5	2.63	2.63	0.92	0.92	3.29	
Red Lake Falls	13	103	13.3	102.9	2	100	1	0.04	41.00	2.66	0.08	286.32	
Red Lake Falls	13	103	13.3	102.9	2	100	2	0.04	44.00	2.72	0.09	272.82	
Red Lake Falls	13	103	13.3	102.9	2	100	3	0.04	44.00	2.81	0.09	281.84	280.33
Red Lake Falls	13	103	13.3	102.9	2	100	4	0.04	43.00	2.82	0.09	289.42	281.36
Red Lake Falls	13	103	13.3	102.9	2	100	5	0.05	45.00	2.82	0.09	276.56	282.61
Red Lake Falls	13	103	13.3	102.9	2	100	mean3-5	0.04	44.00	2.82	0.09	282.61	
Red Lake Falls	13	103	13.3	102.9	2	100	stddev3-5	0.00	1.00	0.01	0.00	6.47	
Red Lake Falls	13	103	13.3	102.9	2	100	coefvar3-5	2.27	2.27	0.20	0.20	2.29	
Red Lake Falls	13	103	13.3	102.9	3	100	1	0.04	38.00	2.57	0.08	298.47	
Red Lake Falls	13	103	13.3	102.9	3	100	2	0.04	36.00	2.62	0.08	321.18	
Red Lake Falls	13	103	13.3	102.9	3	100	3	0.03	28.00	2.13	0.07	335.72	318.46
Red Lake Falls	13	103	13.3	102.9	3	100	4	0.03	25.00	1.73	0.06	305.39	320.77
Red Lake Falls	13	103	13.3	102.9	3	100	5	0.04	38.00	2.66	0.08	308.92	316.68
Red Lake Falls	13	103	13.3	102.9	3	100	mean3-5	0.03	30.33	2.17	0.07	316.68	
Red Lake Falls	13	103	13.3	102.9	3	100	stddev3-5	0.01	6.81	0.47	0.01	16.58	
Red Lake Falls	13	103	13.3	102.9	3	100	coefvar3-5	22.44	22.44	21.47	21.47	5.24	
Red Lake Falls	13	103	13.3	102.9	1	500	1	0.07	73.00	5.47	0.17	330.69	
Red Lake Falls	13	103	13.3	102.9	1	500	2	0.07	72.00	5.48	0.17	335.89	
Red Lake Falls	13	103	13.3	102.9	1	500	3	0.07	73.00	5.55	0.18	335.52	334.04
Red Lake Falls	13	103	13.3	102.9	1	500	4	0.07	73.00	5.52	0.18	333.71	335.04
Red Lake Falls	13	103	13.3	102.9	1	500	5	0.07	71.00	5.53	0.18	343.73	337.66
Red Lake Falls	13	103	13.3	102.9	1	500	mean3-5	0.07	72.33	5.53	0.18	337.66	
Red Lake Falls	13	103	13.3	102.9	1	500	stddev3-5	0.00	1.15	0.02	0.00	5.34	
Red Lake Falls	13	103	13.3	102.9	1	500	coefvar3-5	1.60	1.60	0.28	0.28	1.58	
Red Lake Falls	13	103	13.3	102.9	2	500	1	0.08	77.00	5.04	0.16	288.86	
Red Lake Falls	13	103	13.3	102.9	2	500	2	0.08	76.00	5.02	0.16	291.50	
Red Lake Falls	13	103	13.3	102.9	2	500	3	0.08	75.00	5.04	0.16	296.57	292.31
Red Lake Falls	13	103	13.3	102.9	2	500	4	0.08	78.00	5.16	0.16	291.95	293.34
Red Lake Falls	13	103	13.3	102.9	2	500	5	0.08	77.00	5.08	0.16	291.16	293.23
Red Lake Falls	13	103	13.3	102.9	2	500	mean3-5	0.08	76.67	5.09	0.16	293.23	
Red Lake Falls	13	103	13.3	102.9	2	500	stddev3-5	0.00	1.53	0.06	0.00	2.92	
Red Lake Falls	13	103	13.3	102.9	2	500	coefvar3-5	1.99	1.99	1.20	1.20	1.00	
Red Lake Falls	13	103	13.3	102.9	3	500	1	0.07	69.00	5.30	0.17	338.99	
Red Lake Falls	13	103	13.3	102.9	3	500	2	0.07	71.00	5.21	0.17	323.84	
Red Lake Falls	13	103	13.3	102.9	3	500	3	0.07	71.00	5.20	0.17	323.22	328.68
Red Lake Falls	13	103	13.3	102.9	3	500	4	0.07	71.00	5.23	0.17	325.09	324.05
Red Lake Falls	13	103	13.3	102.9	3	500	5	0.06	63.00	5.32	0.17	372.67	340.33
Red Lake Falls	13	103	13.3	102.9	3	500	mean3-5	0.07	68.33	5.25	0.17	340.33	
Red Lake Falls	13	103	13.3	102.9	3	500	stddev3-5	0.00	4.62	0.06	0.00	28.03	
Red Lake Falls	13	103	13.3	102.9	3	500	coefvar3-5	6.76	6.76	1.19	1.19	8.24	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic Load	Dynamic Stress	Modulus	Three Blow Average Modulus
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Lake Falls	13	103	13.3	102.9	1	900	1	0.11	113.00	8.39	0.27	327.67	
Red Lake Falls	13	103	13.3	102.9	1	900	2	0.11	111.00	8.39	0.27	333.57	
Red Lake Falls	13	103	13.3	102.9	1	900	3	0.11	111.00	8.49	0.27	337.55	332.93
Red Lake Falls	13	103	13.3	102.9	1	900	4	0.11	111.00	8.52	0.27	338.74	336.62
Red Lake Falls	13	103	13.3	102.9	1	900	5	0.12	120.00	8.50	0.27	312.60	329.63
Red Lake Falls	13	103	13.3	102.9	1	900	mean3-5	0.11	114.00	8.50	0.27	329.63	
Red Lake Falls	13	103	13.3	102.9	1	900	stddev3-5	0.01	5.20	0.02	0.00	14.76	
Red Lake Falls	13	103	13.3	102.9	1	900	coefvar3-5	4.56	4.56	0.18	0.18	4.48	
Red Lake Falls	13	103	13.3	102.9	2	900	1	0.13	127.00	8.09	0.26	281.12	
Red Lake Falls	13	103	13.3	102.9	2	900	2	0.13	132.00	8.29	0.26	277.16	
Red Lake Falls	13	103	13.3	102.9	2	900	3	0.13	131.00	8.24	0.26	277.59	278.63
Red Lake Falls	13	103	13.3	102.9	2	900	4	0.13	130.00	8.34	0.27	283.12	279.29
Red Lake Falls	13	103	13.3	102.9	2	900	5	0.13	129.00	8.15	0.26	278.82	279.85
Red Lake Falls	13	103	13.3	102.9	2	900	mean3-5	0.13	130.00	8.24	0.26	279.85	
Red Lake Falls	13	103	13.3	102.9	2	900	stddev3-5	0.00	1.00	0.10	0.00	2.90	
Red Lake Falls	13	103	13.3	102.9	2	900	coefvar3-5	0.77	0.77	1.15	1.15	1.04	
Red Lake Falls	13	103	13.3	102.9	3	900	1	0.11	107.00	8.67	0.28	357.59	
Red Lake Falls	13	103	13.3	102.9	3	900	2	0.11	105.00	8.67	0.28	364.40	
Red Lake Falls	13	103	13.3	102.9	3	900	3	0.17	168.00	8.67	0.28	227.75	316.58
Red Lake Falls	13	103	13.3	102.9	3	900	4	0.10	102.00	8.66	0.28	374.69	322.28
Red Lake Falls	13	103	13.3	102.9	3	900	5	0.11	105.00	8.77	0.28	368.61	323.68
Red Lake Falls	13	103	13.3	102.9	3	900	mean3-5	0.13	125.00	8.70	0.28	323.68	
Red Lake Falls	13	103	13.3	102.9	3	900	stddev3-5	0.04	37.27	0.06	0.00	83.13	
Red Lake Falls	13	103	13.3	102.9	3	900	coefvar3-5	29.82	29.82	0.70	0.70	25.68	
Red Lake Falls	11	103	10.6	100.9	1	100	1	0.03	25.00	1.70	0.05	300.10	
Red Lake Falls	11	103	10.6	100.9	1	100	2	0.02	24.00	1.74	0.06	319.96	
Red Lake Falls	11	103	10.6	100.9	1	100	3	0.02	23.00	1.75	0.06	335.79	318.61
Red Lake Falls	11	103	10.6	100.9	1	100	4	0.02	24.00	1.74	0.06	319.96	325.23
Red Lake Falls	11	103	10.6	100.9	1	100	5	0.02	23.00	1.74	0.06	333.87	329.87
Red Lake Falls	11	103	10.6	100.9	1	100	mean3-5	0.02	23.33	1.74	0.06	329.87	
Red Lake Falls	11	103	10.6	100.9	1	100	stddev3-5	0.00	0.58	0.01	0.00	8.64	
Red Lake Falls	11	103	10.6	100.9	1	100	coefvar3-5	2.47	2.47	0.33	0.33	2.62	
Red Lake Falls	11	103	10.6	100.9	2	100	1	0.03	30.00	2.08	0.07	305.98	
Red Lake Falls	11	103	10.6	100.9	2	100	2	0.03	31.00	2.10	0.07	298.96	
Red Lake Falls	11	103	10.6	100.9	2	100	3	0.03	31.00	2.09	0.07	297.54	300.83
Red Lake Falls	11	103	10.6	100.9	2	100	4	0.03	25.00	1.63	0.05	287.74	294.75
Red Lake Falls	11	103	10.6	100.9	2	100	5	0.03	31.00	2.12	0.07	301.81	295.69
Red Lake Falls	11	103	10.6	100.9	2	100	mean3-5	0.03	29.00	1.95	0.06	295.69	
Red Lake Falls	11	103	10.6	100.9	2	100	stddev3-5	0.00	3.46	0.27	0.01	7.21	
Red Lake Falls	11	103	10.6	100.9	2	100	coefvar3-5	11.95	11.95	14.11	14.11	2.44	
Red Lake Falls	11	103	10.6	100.9	3	100	1	0.03	29.00	2.18	0.07	331.75	
Red Lake Falls	11	103	10.6	100.9	3	100	2	0.03	33.00	2.26	0.07	302.24	
Red Lake Falls	11	103	10.6	100.9	3	100	3	0.03	31.00	2.26	0.07	321.74	318.58
Red Lake Falls	11	103	10.6	100.9	3	100	4	0.03	32.00	2.30	0.07	317.20	313.72
Red Lake Falls	11	103	10.6	100.9	3	100	5	0.03	31.00	2.26	0.07	321.74	320.22
Red Lake Falls	11	103	10.6	100.9	3	100	mean3-5	0.03	31.33	2.27	0.07	320.22	
Red Lake Falls	11	103	10.6	100.9	3	100	stddev3-5	0.00	0.58	0.02	0.00	2.62	
Red Lake Falls	11	103	10.6	100.9	3	100	coefvar3-5	1.84	1.84	1.02	1.02	0.82	

Light Weight Deflectometer													
Soil Origin	Target Moisture Content	Target Density	Actual Moisture Content	Actual Density	Test Point	Drop Height	Drop Number	Deflection		Dynamic Load	Dynamic Stress	Modulus	Three Blow Average Modulus
	[%]	[%]	[%]	[%]		[mm]		[mm]	[µm]	[kN]	[MPa]	[MPa]	[MPa]
Red Lake Falls	11	103	10.6	100.9	1	500	1	0.07	69.00	5.31	0.17	339.63	
Red Lake Falls	11	103	10.6	100.9	1	500	2	0.07	70.00	5.45	0.17	343.60	
Red Lake Falls	11	103	10.6	100.9	1	500	3	0.07	69.00	5.39	0.17	344.74	342.66
Red Lake Falls	11	103	10.6	100.9	1	500	4	0.07	67.00	5.27	0.17	347.13	345.16
Red Lake Falls	11	103	10.6	100.9	1	500	5	0.07	67.00	5.39	0.17	355.03	348.97
Red Lake Falls	11	103	10.6	100.9	1	500	mean3-5	0.07	67.67	5.35	0.17	348.97	
Red Lake Falls	11	103	10.6	100.9	1	500	stddev3-5	0.00	1.15	0.07	0.00	5.39	
Red Lake Falls	11	103	10.6	100.9	1	500	coefvar3-5	1.71	1.71	1.29	1.29	1.54	
Red Lake Falls	11	103	10.6	100.9	2	500	1	0.08	75.00	5.35	0.17	314.81	
Red Lake Falls	11	103	10.6	100.9	2	500	2	0.08	76.00	5.34	0.17	310.09	
Red Lake Falls	11	103	10.6	100.9	2	500	3	0.08	75.00	5.44	0.17	320.10	315.00
Red Lake Falls	11	103	10.6	100.9	2	500	4	0.07	73.00	5.38	0.17	325.25	318.48
Red Lake Falls	11	103	10.6	100.9	2	500	5	0.08	78.00	5.56	0.18	314.58	319.98
Red Lake Falls	11	103	10.6	100.9	2	500	mean3-5	0.08	75.33	5.46	0.17	319.98	
Red Lake Falls	11	103	10.6	100.9	2	500	stddev3-5	0.00	2.52	0.09	0.00	5.33	
Red Lake Falls	11	103	10.6	100.9	2	500	coefvar3-5	3.34	3.34	1.68	1.68	1.67	
Red Lake Falls	11	103	10.6	100.9	3	500	1	0.07	67.00	5.19	0.17	341.86	
Red Lake Falls	11	103	10.6	100.9	3	500	2	0.07	65.00	5.24	0.17	355.77	
Red Lake Falls	11	103	10.6	100.9	3	500	3	0.07	66.00	5.20	0.17	347.71	348.45
Red Lake Falls	11	103	10.6	100.9	3	500	4	0.07	68.00	5.19	0.17	336.83	346.77
Red Lake Falls	11	103	10.6	100.9	3	500	5	0.07	66.00	5.21	0.17	348.38	344.30
Red Lake Falls	11	103	10.6	100.9	3	500	mean3-5	0.07	66.67	5.20	0.17	344.30	
Red Lake Falls	11	103	10.6	100.9	3	500	stddev3-5	0.00	1.15	0.01	0.00	6.48	
Red Lake Falls	11	103	10.6	100.9	3	500	coefvar3-5	1.73	1.73	0.19	0.19	1.88	
Red Lake Falls	11	103	10.6	100.9	1	900	1	0.11	111.00	8.47	0.27	336.76	
Red Lake Falls	11	103	10.6	100.9	1	900	2	0.11	112.00	8.64	0.28	340.45	
Red Lake Falls	11	103	10.6	100.9	1	900	3	0.11	108.00	8.48	0.27	346.52	341.24
Red Lake Falls	11	103	10.6	100.9	1	900	4	0.11	114.00	8.60	0.27	332.93	339.96
Red Lake Falls	11	103	10.6	100.9	1	900	5	0.11	111.00	8.66	0.28	344.31	341.25
Red Lake Falls	11	103	10.6	100.9	1	900	mean3-5	0.11	111.00	8.58	0.27	341.25	
Red Lake Falls	11	103	10.6	100.9	1	900	stddev3-5	0.00	3.00	0.09	0.00	7.29	
Red Lake Falls	11	103	10.6	100.9	1	900	coefvar3-5	2.70	2.70	1.07	1.07	2.14	
Red Lake Falls	11	103	10.6	100.9	2	900	1	0.13	129.00	8.83	0.28	302.08	
Red Lake Falls	11	103	10.6	100.9	2	900	2	0.09	90.00	6.33	0.20	310.40	
Red Lake Falls	11	103	10.6	100.9	2	900	3	0.13	129.00	8.90	0.28	304.48	305.65
Red Lake Falls	11	103	10.6	100.9	2	900	4	0.13	129.00	8.89	0.28	304.13	306.34
Red Lake Falls	11	103	10.6	100.9	2	900	5	0.13	128.00	8.87	0.28	305.82	304.81
Red Lake Falls	11	103	10.6	100.9	2	900	mean3-5	0.13	128.67	8.89	0.28	304.81	
Red Lake Falls	11	103	10.6	100.9	2	900	stddev3-5	0.00	0.58	0.02	0.00	0.89	
Red Lake Falls	11	103	10.6	100.9	2	900	coefvar3-5	0.45	0.45	0.17	0.17	0.29	
Red Lake Falls	11	103	10.6	100.9	3	900	1	0.12	116.00	8.61	0.27	327.57	
Red Lake Falls	11	103	10.6	100.9	3	900	2	0.12	116.00	8.61	0.27	327.57	
Red Lake Falls	11	103	10.6	100.9	3	900	3	0.12	119.00	8.75	0.28	324.50	326.54
Red Lake Falls	11	103	10.6	100.9	3	900	4	0.12	117.00	8.59	0.27	324.01	325.36
Red Lake Falls	11	103	10.6	100.9	3	900	5	0.12	115.00	8.52	0.27	326.96	325.16
Red Lake Falls	11	103	10.6	100.9	3	900	mean3-5	0.12	117.00	8.62	0.27	325.16	
Red Lake Falls	11	103	10.6	100.9	3	900	stddev3-5	0.00	2.00	0.12	0.00	1.58	
Red Lake Falls	11	103	10.6	100.9	3	900	coefvar3-5	1.71	1.71	1.37	1.37	0.49	

Appendix J – Modified DCP Test Form and Instructions

Modified DCP Procedure: 2005-06 (English)

SP		Highway		Engineer		Inspector	
Material		Date		Notes			

Procedure

- Enter Project info and Gradation Data. Calculate the Grading Number **(GN)** (electronic version calculated automatically)

$$SEAT = Pen_{2\,blows} - Pen_{0\,blows} \qquad DPI = \frac{Pen_{5\,blows} - Pen_{2\,blows}}{3\,blows}$$

Electronic Version
- Determine the test location and conduct the DCP test.
- Measure the moisture content (***MC***) at the DCP test location.
- Enter the Test Information and DCP Data in table.
- The test results will be determined automatically.

Hard Copy
- Determine the test location and conduct the DCP test.
- Measure the moisture content (***MC***) at the DCP test location.
- Enter the Test Information and DCP Data in table.
- Establish the allowable values for ***SEAT*** and ***DPI*** based on ***GN*** and ***MC***.
- Compute ***SEAT*** and ***DPI*** test results.
- Compare ***SEAT*** and ***DPI*** to Maximum Requirements. *Both must pass to accept test*.

Gradation Data (use % **passing** in formulas)

$$GN = \frac{1" + 3/4" + 3/8" + \#4 + \#10 + \#40 + \#200}{100}$$

Sieve	% Passing
1"	
3/4"	
3/8"	
#4	
#10	
#40	
#200	
GN =	

Penetration Requirements

GN	MC (% dry)	Maximum Allowable SEAT (in)	Maximum Allowable DPI (in/blow)	Approximate Test Layer (in)
3.1-3.5	<5.0	1.6	0.4	4.0 - 6.0
	5.0-8.0	1.6	0.5	
	>8.0	1.6	0.6	
3.6-4.0	<5.0	1.6	0.4	4.0 - 6.0
	5.0-8.0	1.7	0.6	
	>8.0	2.1	0.7	
4.1-4.5	<5.0	2.0	0.5	4.0 - 6.0
	5.0-8.0	2.4	0.7	
	>8.0	2.8	0.8	

GN	MC (% dry)	Maximum Allowable SEAT (in)	Maximum Allowable DPI (in/blow)	Approximate Test Layer (in)
4.6-5.0	<5.0	2.6	0.6	5.0 - 7.0
	5.0-8.0	3.0	0.7	
	>8.0	3.4	0.9	
5.1-5.5	<5.0	3.3	0.7	6.0 - 12.0
	5.0-8.0	3.7	0.8	
	>8.0	4.1	1.0	
5.6-6.0	<5.0	4.0	0.8	7.0 - 12.0
	5.0-8.0	4.5	0.9	
	>8.0	4.9	1.1	

DCP Data

☐ Metric DCP Measurements (check if Metric, un-check to return to English)

Test Information							Requirements		DCP Data **(in)**			Test Results					
Test #	Date	Station	Offset	Test Layer Depth (in)	GN	MC (%)	Maximum Allowable SEAT (in)	Maximum Allowable DPI (in/blow)	Initial Reading	Reading after seating (2 Blows)	Reading after test (3 Blows)	SEAT (in)	SEAT: Pass or Fail	DPI (in/blow)	DPI: Pass or Fail	(1) Adequate Layer?	**TEST**: Pass or Fail

(1) [Reading after test (3 Blows) - Initial Reading] < Test Layer Depth = Adequate Layer

5-692.255 mod MODIFIED DYNAMIC CONE PENETROMETER (DCP)

History and Development

The Dynamic Cone Penetrometer was first introduced to the Minnesota Department of Transportation (Mn/DOT) at the Minnesota Road Research Project (Mn/ROAD). Since 1993 the DCP has been used by Mn/DOT as an acceptance tool for the compaction of pavement edge drain trenches. In 1999, the Penetration Index Method for compaction acceptance of base aggregate Classes 5, 6, and 7 was adapted by Mn/DOT, which requires the use of the DCP as the testing device.

Description of Device

The Dynamic Cone Penetrometer consists of two 16 mm (5/8-inch) diameter shafts coupled near the midpoint. The lower shaft contains an anvil and a pointed tip, which is driven into unbound materials by dropping a sliding hammer contained on the upper shaft onto the lower anvil. The strength is determined by measuring the penetration of the lower shaft into the unbound materials. This value is recorded in millimeters (inches) per blow and is know as the Penetration Index (PI).

Equipment

The DCP is comprised of the following elements. (See Fig. 1 5-692.255 mod)

Handle: The handle is located at the top of the device. It is used to hold the DCP shafts plumb and to limit the upward movement of the hammer.

Hammer: The 8 kg (17.61 lb.) Hammer is manually raised to the bottom of the handle and then dropped (allowed to free fall) to transfer energy through the lower shaft to the cone tip. The upper shaft guides the hammer.

Upper Shaft: The upper shaft is a 16 mm (5/8-inch) diameter steel shaft on which the hammer moves. The length of the upper shaft allows the hammer to drop a distance 575 mm (22.6 inches).

Anvil: The anvil serves as the lower stopping mechanism for the hammer. It also serves as a connector between the upper and lower shaft. This allows for disassembly, which reduces the size of the instrument for transport.

Lower Shaft: The lower shaft is a 16 mm (5/8-inch) diameter steel shaft, of variable length up to 1 m (39.4 inches) in length, marked in 5mm (0.2-inch) increments for recording the penetration after each hammer drop.

Cone: The cone measures 20 mm (0.787-inch) in diameter. The cone tip has a 60-degree angle. (See Fig. 2 5-692.255 mod)

Operation Points of Caution

Always use caution to avoid pinching fingers between the hammer and the anvil during testing, use the handle to hold shafts plumb. Do not hold the DCP near the anvil area**.**

It is important to lift the hammer slowly and drop it cleanly, allowing it to rest on the anvil for at least one second before raising it for another drop. Lifting and dropping too rapidly may affect results because the hammer's full energy may not be allowed to transfer to the lower shaft. This will cause incorrect test results.

Test Procedure - Base Aggregate (2211.3C3)

Record the gradation % passing values that represent the area to be tested by the DCP, on the attached Modified DCP Procedure 2005-06 form or spreadsheet. If using the form, calculate the Grading Number (GN) by using the formula on the form. If using the spreadsheet, the computer calculates this information. (See Fig. 3 5-692.255 mod)

Locate a level and undisturbed area (test site) that is representative of the material to be tested.

Record the Test #, Date, Station, Offset, and Test Layer Depth on the Modified DCP Procedure 2005-06 form or spreadsheet, in the DCP Data table. (See Fig. 3 5-692.255 mod)

Place the DCP device on the base aggregate test site. Record the initial reading using the graduated rule on the DCP. The measurement is taken to the nearest 2.5 mm (0.1 inch). (Place this information on the attached Modified DCP Procedure 2005-06 form or spreadsheet, in the DCP Data table, under **Initial Reading** column.)

To properly seat the DCP (cone tip), two hammer blows are required. Therefore, carefully raise the sliding weighted hammer until it meets the handle, and then release the hammer under its own weight. Repeat this process one more time for a total of two complete blows.

Record the penetration measurement after seating using the graduated rule on the DCP. The measurement is taken to the nearest 2.5 mm (0.1 inch). (Place this information on the attached Modified DCP Procedure 2005-06 form or spreadsheet, in the DCP Data table, under **Reading after seating (2 blows)** column.) (See Fig. 3 5-692.255 mod)

Carefully raise the hammer until it meets the handle, and then release the hammer under its own weight. Repeat this process two more times for a total of three times.

Record the final penetration measurement using the graduated rule on the DCP. The measurement is taken to the nearest 2.5 mm (0.1 inches). (Place this information on the attached Modified DCP Procedure 2005-06 form or spreadsheet, in the DCP Data table, under **Reading after test (3 blows)** column.) (See Fig. 3 5-692.255 mod)

After using the DCP, obtain a sample of material and determine the moisture content of the aggregate base by using the pan drying method or a Super Speedy. Record the moisture content on the Modified DCP Procedure 2005-06 form or spread sheet, in the DCP Data table, under **MC (%)** column. (See Fig. 3 5-692.255 mod)

If using the Modified DCP Procedure 2005-06 form, fill in the **Maximum Allowable SEAT** & **Maximum Allowable DPI** columns; this information is in the Penetration Requirements table by using the recorded **GN** & **MC**. Next calculate the **SEAT** by using the following formula:

SEAT = Reading after seating (2 blows) – Initial Reading

Compare the calculated **SEAT** and compare it the **Maximum Allowable SEAT column**, if **SEAT** is larger than the **Maximum Allowable SEAT**, the **SEAT** <u>fails</u>. If the **SEAT** is smaller than the **Maximum Allowable SEAT**, the **SEAT** <u>passes</u>.

Next calculate the **DPI** by using the following formula:

$$\textbf{DPI} = \frac{\{\textbf{Reading after test (3 blows) - Reading after seating (2 blows)}\}}{3}$$

Compare the calculated **DPI** and compare it the **Maximum Allowable DPI** column, if the **DPI** is larger than the **Maximum Allowable DPI**, the **Ave. DPI** <u>fails</u>. If the **DPI** is smaller than the **Maximum Allowable DPI**, the **DPI** <u>passes</u>.

Next determine the **Adequate Layer?** by using the following formula:

Adequate Layer? = {Reading after test (3 blows) – Initial Reading} < Test Layer Depth

If the **{Reading after test (3 blows) – Initial Reading}** is larger than the **Test Layer Depth,** the answer is <u>No</u>. If the **{Reading after test (3 blows) – Initial Reading}** is less than the **Test Layer Depth,** the answer is <u>Yes</u>.

To determine whether the **Test Pass or Fail**, check the **Seat Pass or Fail**, **DPI Pass or Fail**, and **Adequate Layer?** columns, if any of the three columns has Fail or No, the **Test** <u>Fails</u>. If all three columns have Pass or Yes, the **Test** <u>Passes</u>.

If using the Modified DCP Procedure 2005-06 spreadsheet, all the above information is calculated by the computer and to determine if the test passes or fails look in the **Test Pass or Fail** column for the answer. (See Fig. 3 5-692.255 mod)

For test purposes, the approximate test layer in compacted thickness is located in the Penetration Index chart on Fig. 3 5-692.255 mod.

Test Procedure - Granular Subgrade Material (2105.3F3)

Record the gradation % passing values that represent the area to be tested by the DCP, on the attached Modified DCP Procedure 2005-06 form or spreadsheet. If using the form, calculate the Grading Number (GN) by using the formula on the form. If using the spreadsheet, the computer calculates this information. (See Fig. 3 5-692.255 mod)

Locate a level and undisturbed area (test site) that is representative of the material to be tested.

Record the Test #, Date, Station, Offset, and Test Layer Depth on the Modified DCP Procedure 2005-06 form or spreadsheet, in the DCP Data table. (See Fig. 3 5-692.255 mod)

Place the DCP device on the granular material test site. Record the initial reading using the graduated rule on the DCP. The measurement is taken to the nearest 2.5 mm (0.1 inch). (Place this information on the attached Modified DCP Procedure 2005-06 form or spreadsheet, in the DCP Data table, under **Initial Reading** column.) (See Fig. 3 5-692.255 mod)

To properly seat the DCP (cone tip), two hammer blows are required. Therefore, carefully raise the sliding weighted hammer until it meets the handle, and then release the hammer under its own weight. Repeat this process one more time for a total of two complete blows.

Record the penetration measurement after seating using the graduated rule on the DCP. The measurement is taken to the nearest 2.5 mm (0.1 inch). (Place this information on the attached Modified DCP Procedure 2005-06 form or spreadsheet, in the DCP Data table, under **Reading after seating (2 blows)** column.) (See Fig. 3 5-692.255 mod)

Carefully raise the hammer until it meets the handle, and then release the hammer under its own weight. Repeat this process two more times for a total of three times.

Record the final penetration measurement using the graduated rule on the DCP. The measurement is taken to the nearest 2.5 mm (0.1 inches). (Place this information on the attached Modified DCP Procedure 2005-06 form or spreadsheet, in the DCP Data table, under **Reading after test (3 blows)** column.) (See Fig. 3 5-692.255mod)

After using the DCP, obtain a sample of material and determine the moisture content of the granular material by using the pan drying method or a Super Speedy. Record the moisture content on the Modified DCP Procedure 2005-06 form or spread sheet, in the DCP Data table, under **MC (%)** column. (See Fig. 3 5-692.255 mod)

If using the Modified DCP Procedure 2005-06 form, fill in the **Maximum Allowable SEAT** & **Maximum Allowable DPI** columns; this information is in the Penetration Requirements table by using the recorded **GN** & **MC**. Next calculate the **SEAT** by using the following formula:

SEAT = Reading after seating (2 blows) - Initial Reading

Compare the calculated **SEAT** and compare it the **Maximum Allowable SEAT column**, if **SEAT** is larger than the **Maximum Allowable SEAT**, the **SEAT** <u>fails</u>. If the **SEAT** is smaller than the **Maximum Allowable SEAT**, the **SEAT** <u>passes</u>.

Next calculate the **DPI** by using the following formula:

$$\textbf{DPI} = \frac{\{\textbf{Reading after test (3 blows) - Reading after seating (2 blows)}\}}{3}$$

Compare the calculated **DPI** and compare it the **Maximum Allowable DPI** column, if the **DPI** is larger than the **Maximum Allowable DPI**, the **Ave. DPI** <u>fails</u>. If the **DPI** is smaller than the **Maximum Allowable DPI**, the **DPI** <u>passes</u>.

Next determine the **Adequate Layer?** by using the following formula:

Adequate Layer? = {Reading after test (3 blows) – Initial Reading} < Test Layer Depth

If the **{Reading after test (3 blows) – Initial Reading}** is larger than the **Test Layer Depth,** the answer is <u>No</u>. If the **{Reading after test (3 blows) – Initial Reading}** is less than the **Test Layer Depth,** the answer is <u>Yes</u>.

To determine whether the **Test Pass or Fail**, check the **Seat Pass or Fail**, **DPI Pass or Fail**, and **Adequate Layer?** columns, if any of the three columns has Fail or No, the **Test** <u>Fails</u>. If all three columns have Pass or Yes, the **Test** <u>Passes</u>.

If using the Modified DCP Procedure 2005-06 spreadsheet, all the above information is calculated by the computer and to determine if the test passes or fails look in the **Test Pass or Fail** column for the answer. (See Fig. 3 5-692.255 mod)

For test purposes, a layer will be considered 300 mm (1-foot) in compacted thickness.

Test Procedure - Edge Drain Trench Filter Aggregate (2502)

After the compaction of the first 15 m (50 feet) of filter aggregate within the edge drain trench has been completed, determine the location of three test sites that are 3 m (10 feet) apart within that first 15 m (50 feet).

Calculate the number of hammer drops (blows) necessary to 'properly test the trench filter aggregate but not damage the edge drain pipe by subtracting 150 mm (6-inches) from the depth of the trench to be tested and dividing that total by 75 for metric measurements or 3 for English measurements. If necessary, round this number down to the next whole number. (See Fig. 4 5-692.225 mod)

Example: If the trench depth equals 650 mm (26-inches). Then 650 mm (26-inches) minus 150mm (6 inches) equals 500 mm (20 inches). Then 500 mm (20 inches) divided by 75 (for Metric) or 3 (for English) equals 6.7 or 6.

Place the DCP on test site #1 and seat the coned tip of the device by slightly tapping the lower anvil with the hammer until the coned tip is just out of sight.

After seating, record the penetration measurement using the graduated rule on the DCP. The measurement is taken to the nearest 2.5 mm (0.1 inch). [Use form TP-2170 –02(rev 11/05)] (See Fig. 5 5-692.255 mod)

Carefully raise the hammer until it meets the handle, and then release the hammer under its own weight. Repeat this process until the total number of hammer drops equals the required number of blows as calculated in step 2. Also, beware and avoid the chance of penetrating the edge drain pipe at the bottom of the trench when the compaction of the trench is less than passing.

Record the final penetration measurement from the graduated rule on the DCP. The measurement is taken to the nearest 2.5 mm (0.1 inch).

Subtract the measurement in step 4 from the measurement in, step 6 and then divide the difference of the measurements by the number of blows required for testing. The result is the penetration index. If necessary, follow the formula on the test form to convert from mm to inches.

Use the same procedures as outlined above for testing sites #2 and #3.

Add the three penetration index results from test site #1, #2, and #3 and divide that total by 3 in order to calculate the average of all three tests. Round off the average of the tests to the nearest 1 mm (0.1-inch). (See Grading and Base Manual 5-692.805)

Maintenance and Handling

Because the Dynamic Cone Penetrometer is driven into the ground, sometimes into very hard soil layers, regular maintenance and care are required. To ensure that the DCP operates properly, the following guidelines must be followed.

Monitor the condition of the connections to the anvil and handle. When the connections uses bolts, pins, or set screws, extra bolts, pins, or set screws should be kept in the DCP carrying cases because they frequently become stripped or broken and may need to be replaced during testing.

Keep the upper shaft clean. Lubricate very lightly with oil if binding develops. Frequently wipe both shafts clean with a soft cloth during use.

Monitor the DCP for excessive wear on any of the components and make repairs as needed. Because the DCP is a standardized testing device, its overall weight and dimensions must not change from specifications.

The cone tip should be replaced when the diameter of its widest section is reduced by more than 10 percent (2 mm [0.08 inch]) or rocks gouge the cone's surface. Inspect the cone tip before and after each test. Nevertheless, the cone tip should be replaced at least once a year.

Never extract the DCP from the test hole by forcefully striking the hammer against the handle. Striking the handle causes accelerated wear and may lead to broken welds and connections. At least once a year, all welds on the DCP should be critically inspected for hairline or larger cracks.

Do not lay the device on the ground when not in use. The DCP should be kept in its carrying case to avoid bending the shafts. Straightness of the shafts is extremely important. The hammer cannot free fall if the shafts are bent. The straightness of the shafts should be critically measured and reviewed each year prior to the start of construction season.

Appendix K – Field Data Sheets

LWD, DCP, & SC TEST DATA
GRADING & BASE CONSTUCTION

Project No:	T.H.	Page No:

Test No.						
Date						
Inspector Initials or Cert. No.						
Location Data						
Station						
Roadway Lane and Offset						
Depth from Grading Grade						
Material Data						
Material Type						
Dry Density Measured (pcf)						
Dry Measured Moisture Content (%)						
Proctor Max Dry Density (pcf)						
Proctor Optimum Moisture (%)						
LWD Data						
LWD Plate Diameter (mm)						
LWD Drop Height (mm)						
LWD Falling Mass (kg)						
Deflection	**4th Drop**	**µm**				
	5th Drop	**µm**				
	6th Drop	**µm**				
Modulus (Evd)	**Average**	**MPa**				
Force (if measured)	**4th Drop**	**kN**				
	5th Drop	**kN**				
	6th Drop	**kN**				

Notes:

(1) Locate the weakest area to be tested.
(2) Upper 50 to 100 mm (2” – 4”) of soil should be removed to produce a flat testing area, especially on non-granular soils.
(3) The surface should be level so that the shaft is vertical and plate must be in full contact with the surface.
(4) The LWD should be turned on for at least 1 minute prior to testing.
(5) Drop the LWD weight three (3) times for seating [1^{st}, 2^{nd}, 3^{rd} drop].
(6) Drop the LWD weight three (3) times for testing and collect & record the data points for the 4^{th}, 5^{th}, 6^{th} drop.
(7) The deflection range should be between 0.3 to 3.0 mm to obtain reliable measurements.
(8) Plate diameter should be 200 mm (8”), drop height should be 500 mm (19.7”), and mass should be 10 kg (22.1 lbs).
(9) The soil influenced by the LWD extends about 1 plate diameter deep and 1 plate diameter laterally.

DCP Data

	mm	mm/blow	mm	mm/blow	mm	mm/blow	mm	mm/blow
Initial Reading								
2nd Blow								
5th Blow								
10th Blow								
15th Blow								
20th Blow								

LWD Plate Force and Stress							
Plate Diameter		Plate Area		Force		Stress	
mm	in	mm^2	in^2	kN	kips	MPa	psi
100	4	7,854	12	5	1.12	0.64	92
150	6	17,671	27	5	1.12	0.28	41
200	8	31,416	49	5	1.12	0.16	23
300	12	70,686	110	5	1.12	0.07	10
100	4	7,854	12	6	1.35	0.76	111
150	6	17,671	27	6	1.35	0.34	49
200	8	31,416	49	6	1.35	0.19	28
300	12	70,686	110	6	1.35	0.08	12
100	4	7,854	12	7	1.57	0.89	129
150	6	17,671	27	7	1.57	0.40	57
200	8	31,416	49	7	1.57	0.22	32
300	12	70,686	110	7	1.57	0.10	14
100	4	7,854	12	8	1.79	1.02	148
150	6	17,671	27	8	1.79	0.45	66
200	8	31,416	49	8	1.79	0.25	37
300	12	70,686	110	8	1.79	0.11	16
100	4	7,854	12	9	2.02	1.15	166
150	6	17,671	27	9	2.02	0.51	74
200	8	31,416	49	9	2.02	0.29	42
300	12	70,686	110	9	2.02	0.13	18

Drop Height		Estimated Force Dynatest Rubber Buffer		Estimated Force Zorn Steel Spring	
cm	inches	kN	kips	kN	kips
25	10			4.2	0.95
50	20	5.5	1.23	6.0	1.34
75	30			7.3	1.64
90	35			8.0	1.79

*Estimated force for Dynatest is calibrated by testing preformed throughout this report
*Estimated force for Zorn is calibrated by Zorn manufactures

Appendix L – Construction Site Analysis of Target Values

Construction Site Analysis of Light Weight Deflectometer and Dynamic Cone Penetrometer Target Values

Prepared for:

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January 30, 2009

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Introduction

Report Background and Purpose

The objective of this project is to implement data analysis procedures for the Light Weight Deflectometer (LWD) and the Dynamic Cone Penetrometer (DCP), comparing the test results to companion moisture content tests and to proposed LWD and DCP target values developed by Mn/DOT. The goal is to relate the quality control and quality assurance on the job site to the material properties used during the pavement design. The LWD and DCP testing methods provide an effective way to make this link.

This report discusses the testing and the results from a site located in Olmsted County, near Rochester. American Engineering Testing, Inc. (AET) provided the nuclear density testing as well as the moisture content of the samples. AET also provided the use of a Dynatest LWD. Mn/DOT provided the use of a Zorn LWD. CNA Engineers performed the LWD and DCP testing.

Testing Protocol

Site Location and Schedule

The test site was located along a portion of County State Aid Highway (CSAH) 2 in Rochester, Minnesota. The CSAH 2 Reconstruction project consisted of expanding a portion of the existing two-lane road to a four-lane road with center median and turn lanes. Visits were made to the site on September 10, 18, and 26 and on October 1 and 2. During the site visits, subgrade soils were tested using the methods discussed in Section 0. AET was onsite during each visit performing all density tests and many companion laboratory tests.

Description of Field Tests

Test Sequence

A test area approximately 100 feet long by 10 feet wide was chosen upon arriving at the site. Within this test area, three test pads were marked and prepared for testing. These test pads were approximately five feet by five feet with one test at each corner. The test pads were prepared by scraping off the top two to three inches of soil to make a flat level surface. After preparing the surface, in-situ testing was completed at each location using the LWD (Zorn and Dynatest), followed by nuclear gauge, sand cone, and DCP. Approximately two sand cones were performed each day. The sand cones were generally performed at locations containing seemingly inconsistent or irregular soils and were used to verify the nuclear gauge readings. After testing, representative soil samples were collected for gravimetric moisture content testing by AET and for plastic limit testing by Mn/DOT. Representative soil samples were taken from each five foot by five foot test pad for standard moisture-density Proctor, sieve analysis and plasticity testing by Mn/DOT. AET took additional representative soil samples according to industry standard practice for moisture-density Proctor testing.

Test Locations

The test pads were prepared with 4 tests at each pad. The test pads were labeled A to O for a total of 15 test pads and each test within a pad was numbered 1 to 4 for a total of 60 tests. Tests are referred to in this report and in all field and laboratory notes by test number followed by pad letter (e.g. the test location of test 2 in the third test pad is labeled 2C). **Table 1** lists each test location.

Table 1 - Test Locations

Date	Test	Station	Offset
9/10/2008	1A	152+00	Back of the westbound curb
9/10/2008	2A	152+05	Back of the westbound curb
9/10/2008	3A	152+05	5' right of the back of the westbound curb
9/10/2008	4A	152+00	5' right of the back of the westbound curb
9/10/2008	1B	152+40	Back of the westbound curb
9/10/2008	2B	152+45	Back of the westbound curb
9/10/2008	3B	152+45	5' right of the back of the westbound curb
9/10/2008	4B	152+40	5' right of the back of the westbound curb
9/10/2008	1C	152+80	Back of the westbound curb
9/10/2008	2C	152+85	Back of the westbound curb
9/10/2008	3C	152+85	5' right of the back of the westbound curb
9/10/2008	4C	152+80	5' right of the back of the westbound curb

Date	Test	Station	Offset
9/18/2008	1D	150+49	10' right of the back of the westbound curb
9/18/2008	2D	150+54	10' right of the back of the westbound curb
9/18/2008	3D	150+54	15' right of the back of the westbound curb
9/18/2008	4D	150+49	15' right of the back of the westbound curb
9/18/2008	1E	151+00	10' right of the back of the westbound curb
9/18/2008	2E	151+05	10' right of the back of the westbound curb
9/18/2008	3E	151+05	15' right of the back of the westbound curb
9/18/2008	4E	151+00	15' right of the back of the westbound curb
9/18/2008	1F	151+71	10' right of the back of the westbound curb
9/18/2008	2F	151+76	10' right of the back of the westbound curb
9/18/2008	3F	151+76	15' right of the back of the westbound curb
9/18/2008	4F	151+71	15' right of the back of the westbound curb
9/26/2008	1G	148+00	16' right of the back of the westbound curb
9/26/2008	2G	148+05	16' right of the back of the westbound curb
9/26/2008	3G	148+05	21' right of the back of the westbound curb
9/26/2008	4G	148+00	21' right of the back of the westbound curb
9/26/2008	1H	148+50	16' right of the back of the westbound curb
9/26/2008	2H	148+55	16' right of the back of the westbound curb
9/26/2008	3H	148+55	21' right of the back of the westbound curb
9/26/2008	4H	148+50	21' right of the back of the westbound curb
9/26/2008	1I	149+00	16' right of the back of the westbound curb
9/26/2008	2I	149+05	16' right of the back of the westbound curb
9/26/2008	3I	149+05	21' right of the back of the westbound curb
9/26/2008	4I	149+00	21' right of the back of the westbound curb
10/1/2008	1J	145+00	15' left of the back of the westbound curb
10/1/2008	2J	145+05	15' left of the back of the westbound curb
10/1/2008	3J	145+05	10' left of the back of the westbound curb
10/1/2008	4J	145+00	10' left of the back of the westbound curb
10/1/2008	1K	145+50	15' left of the back of the westbound curb
10/1/2008	2K	145+55	15' left of the back of the westbound curb
10/1/2008	3K	145+55	10' left of the back of the westbound curb
10/1/2008	4K	145+50	10' left of the back of the westbound curb
10/1/2008	1L	146+00	15' left of the back of the westbound curb
10/1/2008	2L	146+05	15' left of the back of the westbound curb
10/1/2008	3L	146+05	10' left of the back of the westbound curb
10/1/2008	4L	146+00	10' left of the back of the westbound curb
10/2/2008	1M	139+50	15' right of the back of the westbound curb
10/2/2008	2M	139+57	15' right of the back of the westbound curb
10/2/2008	3M	139+57	18' right of the back of the westbound curb
10/2/2008	4M	139+50	18' right of the back of the westbound curb
10/2/2008	1N	140+00	15' right of the back of the westbound curb
10/2/2008	2N	140+08	15' right of the back of the westbound curb
10/2/2008	3N	140+08	18' right of the back of the westbound curb
10/2/2008	4N	140+00	18' right of the back of the westbound curb
10/2/2008	1O	140+50	15' right of the back of the westbound curb
10/2/2008	2O	140+58	15' right of the back of the westbound curb
10/2/2008	3O	140+58	18' right of the back of the westbound curb
10/2/2008	4O	140+50	18' right of the back of the westbound curb

Zorn Light Weight Deflectometer

The Zorn LWD is a portable, light falling weight deflectometer which can be used to measure in-situ material deflection. The device consists of a control box, falling mass, guide rod, and a 200 mm diameter loading plate containing an imbedded accelerometer. A mass freely falls from a preset fixed height along the guide rod and impacts a steel spring at the lower end of the rod. On the rebound the mass is caught by the operator to control the amount of energy imparted to the soil. The deflection is a calculation based on an accelerometer measurement using the manufacturer's hard wired calibrated method.

Following is the testing procedure used for this project:

1. Locate a relatively smooth and level spot for the test.
Assemble Zorn and turn it on.
Place the Zorn on the testing location, and then rotate it slightly to smooth out the contact surface.
Verify that the trigger mechanism is set to the calibrated drop height (approximately 50 cm).
Press the start button on the control box.
Lift the weight until it connects with the trigger mechanism.
Activate the trigger mechanism while holding the top of the guide rod to keep the instrument steady and vertical.
Record the displacement displayed.
Repeat steps 6 through 8 until three drops have been performed.
Record the average displacement and modulus.
Repeat steps 6 through 10 until a total of six drops have been performed.

The first three drops are seating drops. The reason for the seating drops is that in general, deflections decrease after each drop is performed. Typically after three drops, the deflections become uniform and repeatable.

During testing, the Zorn must be held steady and vertical. The operator should ensure that surface is even and smooth.

Dynatest Light Weight Deflectometer

The Dynatest 3031 LWD is a portable, light falling weight deflectometer which can be used to measure in-situ material stiffness. The device consists of a handheld computer, mass, guide rod, load cell, velocity transducer and a 200 mm diameter plate. A mass freely falls from a known height along the guide rod and impacts a rubber buffer, which transfers the load to a load cell at the lower end of the rod. A velocity transducer, which protrudes through the center of the plate, measures velocity. Velocity is integrated to determine displacement and a time history of the impact load and displacement are displayed. The Dynatest weighs about 40 lbs with approximately half of its weight being in the falling mass (i.e. 22 lbs).

Following is the testing procedure used for this project:

2. Assemble the Dynatest and turn it on.
Turn on the handheld computer and load the program.
Place the Dynatest in the footprint of the Zorn.
Set the trigger mechanism to a 50cm drop height.
Lift the weight until it connects with the trigger mechanism.
Press the go button on the handheld computer.
Release the trigger mechanism while holding the top of the guide rod to keep the instrument steady.
Record the load and displacement displayed.
Repeat steps 5 through 8 until three tests have been performed.
Turn the Dynatest and handheld computer off and place them back in the case.

Seating drops were not completed for the Dynatest, since measurements were performed in the same footprint as the Zorn.

Dynamic Cone Penetrometer

Dynamic Cone Penetrometer (DCP) measurements were performed according to ASTM D 6951-03. The DCP is a device that measures soil shear strength. It functions by striking a cone-tipped rod with an 8 kg mass, thereby driving the cone into the soil. The distance the cone penetrates is measured and the process is repeated until the desired depth is achieved. The recorded data is most commonly plotted as the penetration of the cone divided by the number of drops. This value is referred to as the DCP Penetration Index (DPI). The DPI is inversely proportional to strength.

Nuclear Gauge

A Troxler nuclear gauge was used to determine soil density and moisture at all test locations. AET performed all nuclear density testing according to ASTM D2922 standards. At each location, the probe was extended 12 inches into the soil and the measurement was performed.

Sand Cone

Sand cones were performed by AET to determine soil density and moisture according to ASTM D1556 standards.

Description of Laboratory Tests

Sieve Analysis and Plasticity

Sieve Analysis and plasticity was performed by Mn/DOT on select samples according to Mn/DOT standards.

Moisture-Density Relationship

Standard Proctor tests were performed by both Mn/DOT and AET. AET performed all Proctor tests according to ASTM D698 method A standards. Mn/DOT Proctor tests were performed according to Mn/DOT modified AASHTO T-99 method "C" standards. Soil samples collected by AET for Proctor testing were independent of the samples taken by Mn/DOT. The AET samples were collected using industry standard practice. The Mn/DOT samples were collected at a much higher frequency than typical of industry standards in order to better assess the soil variability. The test results from Mn/DOT Proctor tests are found in **Table 6**. Test results from Proctor tests performed by AET are found in **Table 7.** The variability in the results is very distinct and may be attributed to a number of reasons ranging from technique to sampling.

Gravimetric Moisture Content

Gravimetric moisture content was determined at all test locations by the oven dry method following ASTM D2216 standards. Samples were collected below the LWD footprint to a depth of approximately 6 inches immediately after field tests were complete. **Table 3** lists the gravimetric moisture content as measured by the oven dry method and the nuclear density gauge method.

Measurements and Analysis

Field Test Results

Density

The nuclear gauge method was used by AET to measure dry density and moisture at all locations. The sand cone method was used by AET to measure dry density and moisture content at selected locations. A comparison of the companion density measurements is shown in **Figure 1**. This comparison demonstrates that the nuclear density method estimates a slightly lower density than does the sand cone method. The depth at which the test is taken may play a part in the difference. The sand cone method only samples the soil up to approximately six inches while the nuclear gauge is run at a depth of twelve inches. This difference in depth may account for the variability of the density results. The DCP results indicate that there is increased penetration per drop at greater depth. This may be due to a lower density at depths greater than about six inches. Therefore, since the nuclear density gauge includes this deeper material, the nuclear density tends to be lower than the sand cone density.

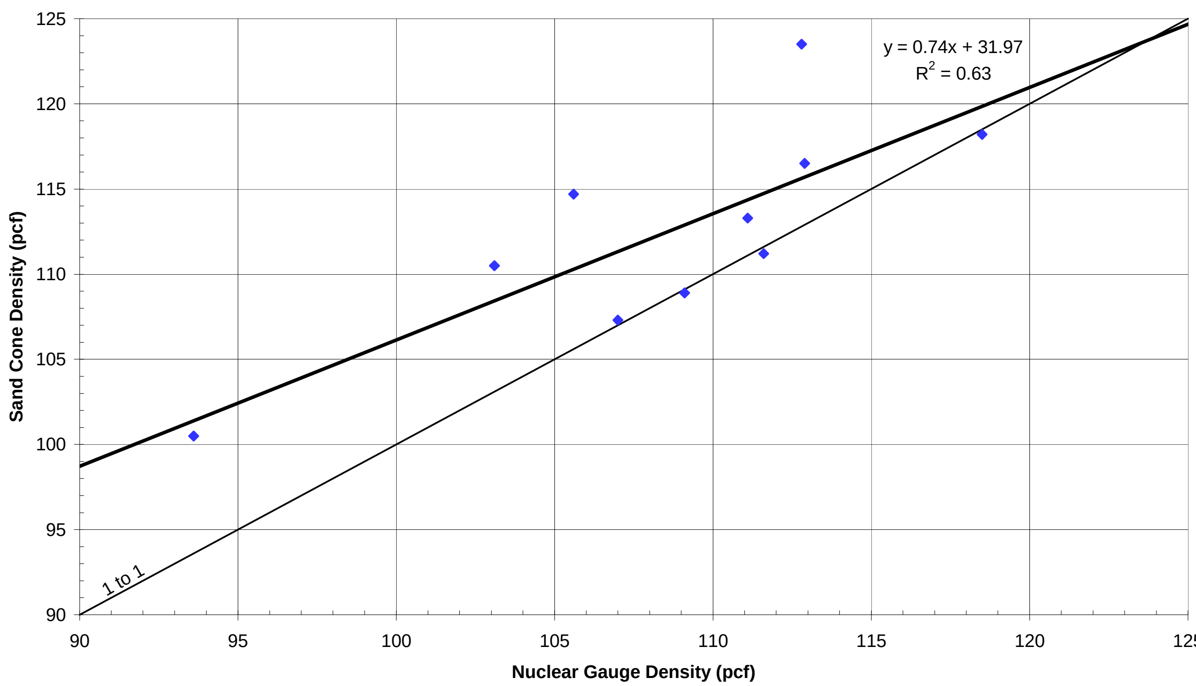

Figure 1 - Comparison of Density Measurements

Table 2 lists the results of density testing performed for the project.

Table 2 - Summary of Density Testing

Date Sampled: 9/10/2008		
Test	Sand Cone Density (pcf)	Nuclear Gauge Density (pcf)
1A	-	110.70
2A	-	109.20
3A	118.2	118.50
4A	-	118.60
1B	-	113.50
2B	-	113.20
3B	-	117.20
4B	-	114.90
1C	123.5	112.80
2C	-	113.50
3C	-	118.50
4C	-	120.20

Date Sampled: 9/18/2008		
Test	Sand Cone Density (pcf)	Nuclear Gauge Density (pcf)
1D	-	106.20
2D	-	105.00
3D	-	107.60
4D	-	108.70
1E	110.5	103.10
2E	-	106.50
3E	-	110.20
4E	-	108.50
1F	-	96.90
2F	-	95.20
3F	-	97.60
4F	100.5	93.60

Date Sampled: 9/26/2008		
Test	Sand Cone Density (pcf)	Nuclear Gauge Density (pcf)
1G	-	107.30
2G	116.5	112.90
3G	-	108.30
4G	-	107.50
1H	-	104.20
2H	-	105.70
3H	-	107.80
4H	-	106.80
1I	-	110.20
2I	-	110.40
3I	114.7	105.60
4I	-	106.60

Date Sampled: 10/1/2008		
Test	Sand Cone Density (pcf)	Nuclear Gauge Density (pcf)
1J	-	104.70
2J	-	109.00
3J	-	109.30
4J	-	111.60
1K	108.9	109.10
2K	-	107.50
3K	-	109.30
4K	-	111.20
1L	107.3	107.00
2L	-	107.50
3L	-	107.00
4L	-	107.00

Date Sampled: 10/2/2008		
Test	Sand Cone Density (pcf)	Nuclear Gauge Density (pcf)
1M	-	131.30
2M	-	128.30
3M	-	128.40
4M	-	130.90
1N	-	128.10
2N	-	132.80
3N	-	134.70
4N	-	128.80
1O	-	111.10
2O	113.3	111.10
3O	-	114.00
4O	111.2	111.60

Moisture Content

In addition to field moisture measurements determined by the nuclear density gauge soil samples were obtained from each test location for determination of moisture content using the oven dry method. **Table 3** summarizes the moisture content results by date and test location.

Table 3 - Summary of Gravimetric Moisture Contents

Date Sampled: 9/10/2008		
Test	Oven Dried Method (%)	Nuclear Density Gauge Method (%)
1A	24.6	14.7
2A	19.5	14.9
3A	14.8	12.7
4A	15.7	12.6
1B	15.1	15.8
2B	14.1	14.5
3B	13.6	14.4
4B	16.8	16.6
1C	12.7	13.7
2C	17	13.5
3C	16.7	15.4
4C	17.2	15.6

Date Sampled: 9/18/2008		
Test	Oven Dried Method (%)	Nuclear Density Gauge Method (%)
1D	24.5	18.1
2D	22.9	19
3D	22.5	16.6
4D	20.8	17.2
1E	21.1	19.1
2E	21.4	19
3E	19.5	17.5
4E	20.9	18.6
1F	24.9	21.9
2F	24.9	23.7
3F	24.1	22.9
4F	24.9	24.9

Date Sampled: 9/26/2008		
Test	Oven Dried Method (%)	Nuclear Density Gauge Method (%)
1G	15.8	15.1
2G	15.1	13.9
3G	15.2	14.1
4G	14.2	14.2
1H	15	15.6
2H	15.6	14.7
3H	14.9	12.9
4H	14.8	13.5
1I	13.8	12.9
2I	15	13.9
3I	14.9	13.5
4I	14	12.7

Date Sampled: 10/1/2008		
Test	Oven Dried Method (%)	Nuclear Density Gauge Method (%)
1J	16.2	15
2J	17.2	15.7
3J	15.4	13.1
4J	14.9	11.7
1K	17.9	15.8
2K	19.1	16.8
3K	17.5	15
4K	16.2	13.6
1L	17.7	15.9
2L	18.1	15.3
3L	16.8	13.3
4L	17.7	15

Date Sampled: 10/2/2008		
Test	Oven Dried Method (%)	Nuclear Density Gauge Method (%)
1M	11.8	10.4
2M	11.7	11.4
3M	11.1	11
4M	11.3	10.2
1N	11.1	11.3
2N	10.9	11.1
3N	10.9	9.8
4N	11.1	11
1O	19.2	16.9
2O	18.8	17.3
3O	15.7	14.2
4O	17.6	14.7

Figure 2 shows the comparison of gravimetric moisture contents as measured by the nuclear density gauge and the oven dry method. The soil samples collected for the oven dry method were taken to a depth of roughly six inches. This sampling depth is roughly twice the measurement depth of the nuclear density gauge. This difference in depth may account for some of the variation in the moisture content values. This comparison indicates that the nuclear density gauge tends to measure lower moisture contents, especially in soils that have high moisture content.

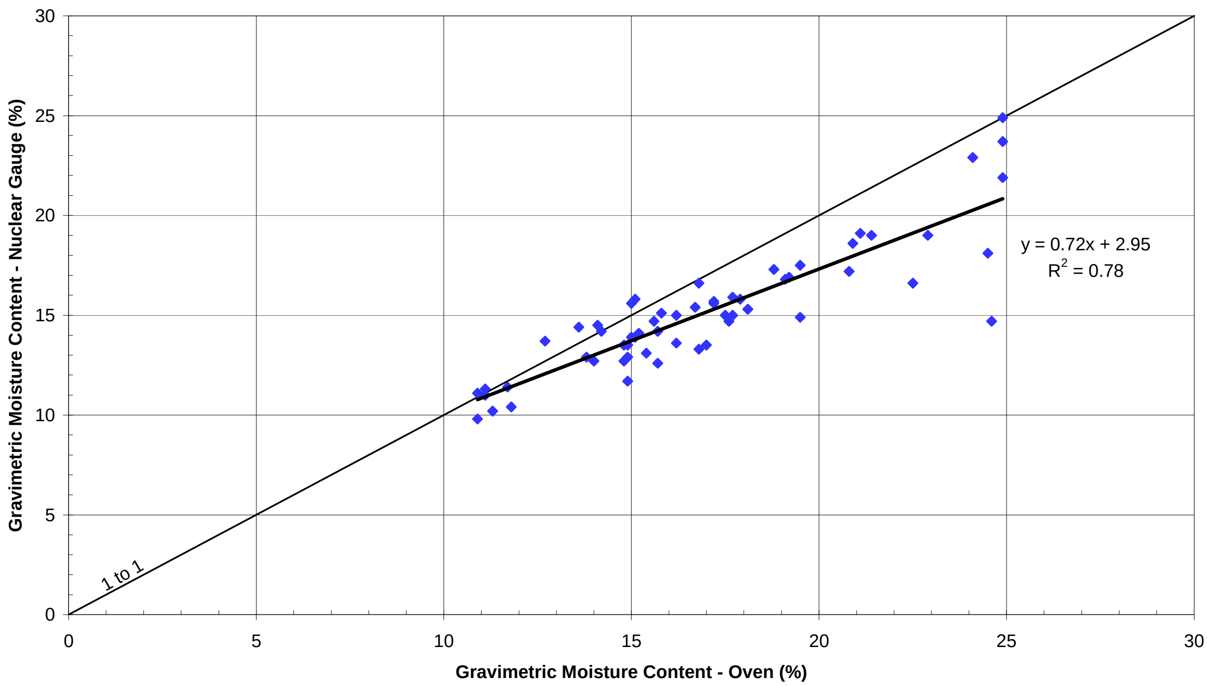

Figure 2 - Comparison of Nuclear and Oven Dried Moisture Contents

Dynamic Cone Penetrometer

A DCP test was conducted at each test location. Total penetration depths were generally 13 to 14 inches. Test procedures followed those described in Section 0.

The DCP is the sole device used in the demonstration that provides a profile of soil characteristics with depth in a near nondestructive manner. The soil profiles obtained by the DCP are useful for determining whether soft layers are present and at what depth the soft layers occur.

Figure 3 shows two soil profiles sampled with the DCP during this project. Note that the soil strength decreased in the first couple inches. This decrease in strength near the surface occurred in several of the tests and is likely a result of the surface having less confinement than the underlying soil. Because of this phenomenon, the first 3 drops were not included in the calculation of DPI for any of the tests.

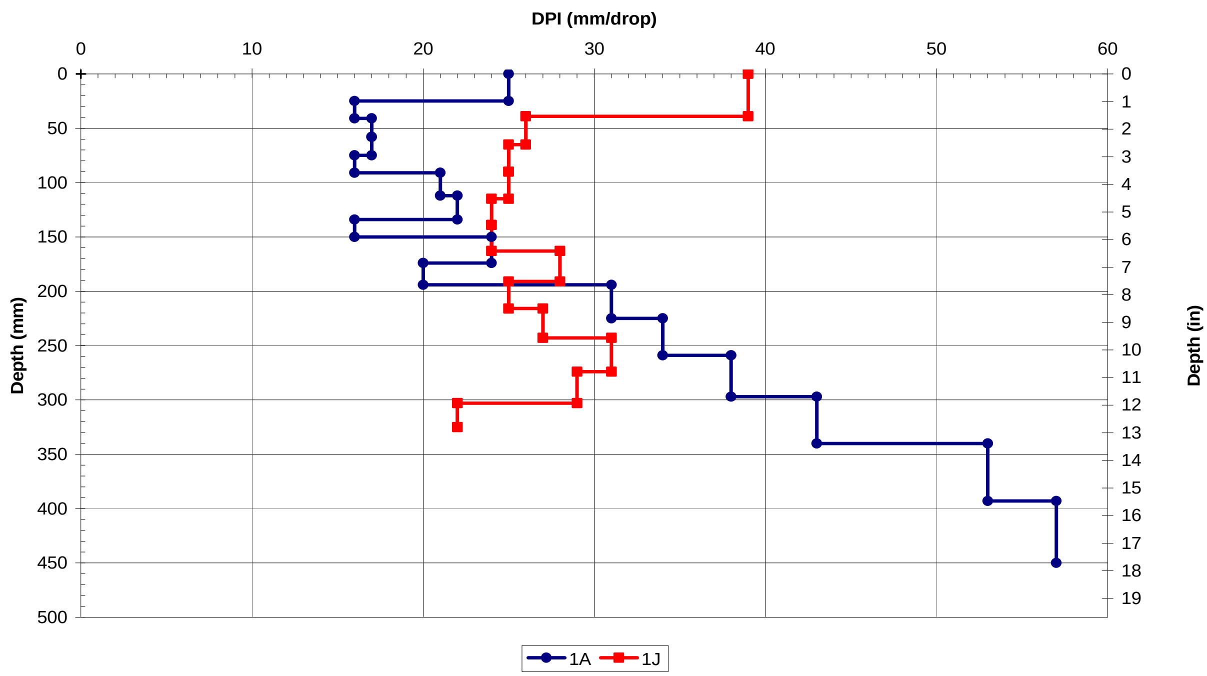

Figure 3 – DCP Soil Profile

Measuring the soil profile is a benefit of the DCP; however, comparing the many DPI values obtained during each test to target values can be cumbersome. Other testing devices such as the LWD and nuclear density gauge obtain one value for each test. This value can be seen as a weighted average of the thickness of soil being measured based on the depth of influence of the measurement in the case of the LWD, or depth of the probe in the case of the nuclear density gauge. We used a simple weighted average method to obtain a single DPI value for each test based on drops 4 to 13. A weighting factor was determined for each drop based on the depth of penetration per drop. The weighted average for the test was then calculated by summing the product of weighting factors and corresponding DPI values. Weighted average DPI values ranged from 11.8 mm/drop to 68.3 mm/drop.

Table 4 summarizes the DCP measurements.

Table 4 - Summary of Dynamic Cone Penetrometer Testing

9/10/2008	
Test	DPI Weighted Average (mm/drop)
1A	26.2
2A	42.4
3A	12.2
4A	12.4
1B	25.5
2B	26.2
3B	33.9
4B	30.8
1C	15.2
2C	19.0
3C	21.8
4C	21.2

9/18/2008	
Test	DPI Weighted Average (mm/drop)
1D	22.2
2D	25.4
3D	20.8
4D	22.4
1E	63.1
2E	49.7
3E	32.9
4E	44.2
1F	50.3
2F	68.3
3F	49.8
4F	49.6

9/26/2008	
Test	DPI Weighted Average (mm/drop)
1G	15.6
2G	13.7
3G	14.4
4G	14.0
1H	13.8
2H	13.7
3H	14.4
4H	14.7
1I	12.9
2I	13.9
3I	15.3
4I	16.2

10/1/2008	
Test	DPI Weighted Average (mm/drop)
1J	26.4
2J	35.6
3J	26.4
4J	21.9
1K	53.6
2K	44.7
3K	54.0
4K	23.8
1L	39.7
2L	38.6
3L	27.1
4L	32.9

10/2/2008	
Test	DPI Weighted Average (mm/drop)
1M	12.5
2M	17.5
3M	14.4
4M	12.6
1N	12.9
2N	11.8
3N	12.3
4N	16.9
1O	22.0
2O	22.0
3O	16.9
4O	21.6

Figure 4 shows the comparison of dry density and DPI. As the soil strength increases, the soil density tends to increase as well.

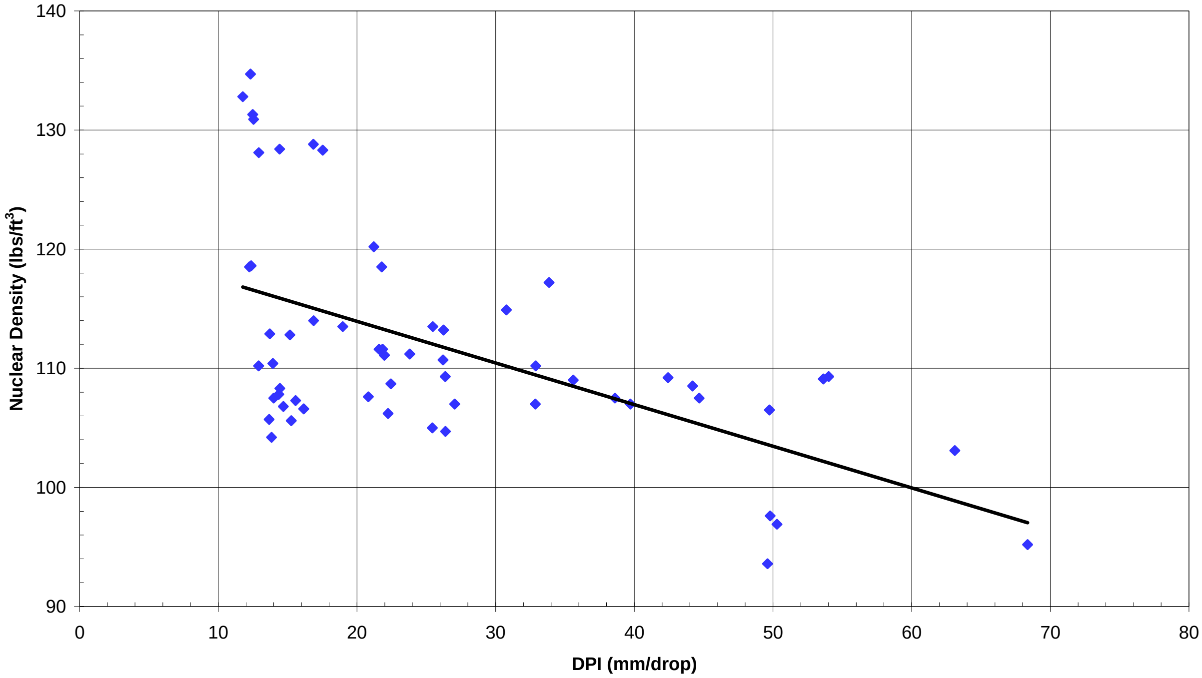

Figure 4 – Comparison of Dry Density and DPI

Light Weight Deflectometer

LWD tests were conducted at all 60 test locations, producing the results shown in **Table 5**. The tests followed the procedures identified in Sections 0 and 0. The deflection value for the Zorn is the average of drops 4, 5, and 6 (drops 1, 2, and 3 being seating drops) and the deflection value of the Dynatest is the average of drops 1, 2, and 3. The LWD tests may be conducted at various drop heights, yielding different stress states during testing. The Zorn is calibrated to deliver a force of 6.28 kN at a drop height of about 50 cm. Therefore, the height used for testing during this project using this particular Zorn LWD was 53 cm. To obtain similar surface stress, the Dynatest was set at the same drop height as the Zorn. Actual surface stress can be estimated using the recorded load cell data.

Table 5 - LWD Deflection

9/10/2008		
Test	Zorn LWD Deflection (mm)	Dynatest LWD Deflection (mm)
1A	1.47	0.74
2A	1.58	0.81
3A	1.81	0.91
4A	1.22	0.49
1B	1.65	0.99
2B	1.23	0.65
3B	3.98	2.22
4B	4.58	n/a
1C	0.84	0.27
2C	1.06	0.57
3C	2.56	1.25
4C	3.14	2.00

9/18/2008		
Test	Zorn LWD Deflection (mm)	Dynatest LWD Deflection (mm)
1D	1.75	0.97
2D	2.15	1.39
3D	1.65	0.96
4D	1.13	0.59
1E	2.72	1.22
2E	2.81	1.65
3E	4.57	n/a
4E	5.67	n/a
1F	2.24	1.01
2F	3.63	1.68
3F	1.98	0.91
4F	2.08	1.08

9/26/2008		
Test	Zorn LWD Deflection (mm)	Dynatest LWD Deflection (mm)
1G	1.12	0.43
2G	0.94	0.38
3G	1.21	0.50
4G	1.33	0.59
1H	0.69	0.31
2H	0.83	0.44
3H	1.04	0.50
4H	0.89	0.31
1I	1.18	0.57
2I	1.33	0.56
3I	0.86	0.47
4I	0.97	0.31

10/1/2008		
Test	Zorn LWD Deflection (mm)	Dynatest LWD Deflection (mm)
1J	1.51	0.70
2J	3.28	2.08
3J	1.24	0.70
4J	1.97	0.70
1K	6.02	n/a
2K	7.66	n/a
3K	3.21	2.04
4K	1.39	0.76
1L	2.6	1.45
2L	2.14	1.45
3L	1.86	1.08
4L	2.16	1.23

10/2/2008		
Test	Zorn LWD Deflection (mm)	Dynatest LWD Deflection (mm)
1M	1.32	0.59
2M	2.09	1.29
3M	2.06	1.19
4M	1.44	0.64
1N	1.41	0.70
2N	1.71	0.97
3N	1.65	1.16
4N	2.32	1.34
1O	2.28	1.19
2O	1.71	0.93
3O	1.45	0.63
4O	2.01	1.02

The scope of this project called for the use of the Zorn LWD, however, a Dynatest unit was made available by AET for no additional cost and was used at all test locations. A comparison of measured deflection between the Zorn and the Dynatest is shown in **Figure 5**. This relationship is generally consistent with previous measurements and is believed to be due to the different buffers which results in different load pulses. Recall that the Zorn LWD uses a steel spring buffer where as the Dynatest LWD uses rubber buffers. Also note that for both LWD instruments deflection measurements are independently verified by the manufacturer and that the drop height, falling mass, and plate sizes are identical.

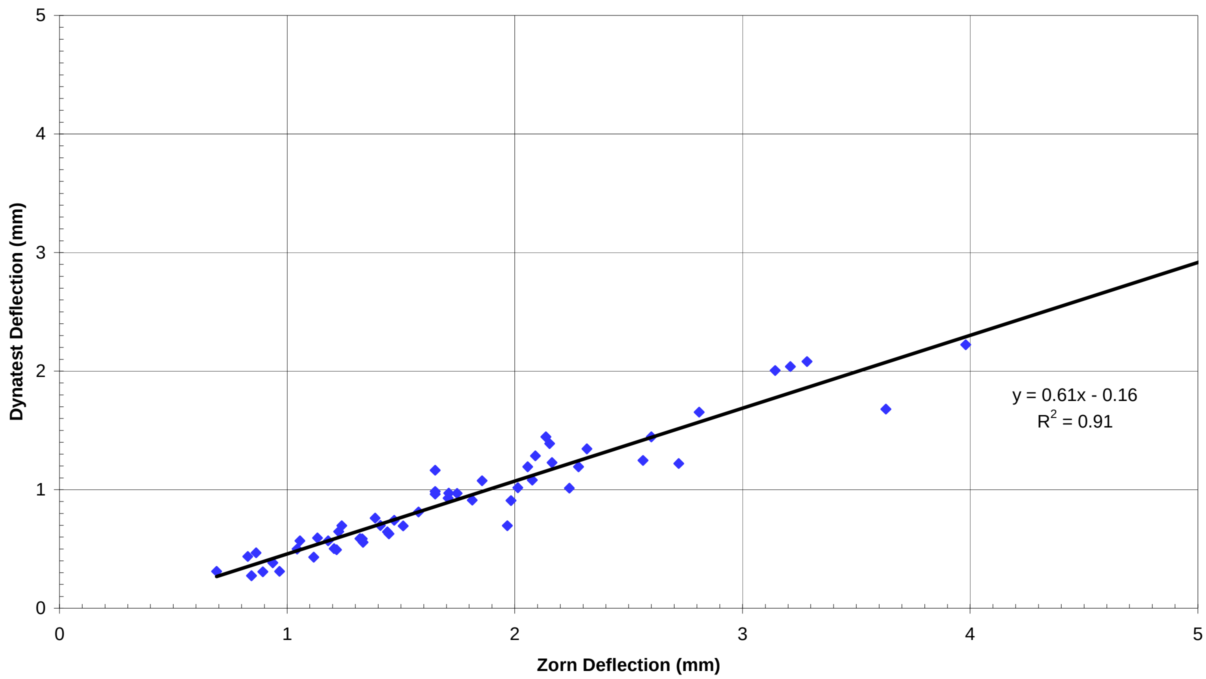

Figure 5 - Comparison of Deflection Measurements

Laboratory Test Results

The laboratory tests consisted of Proctor tests and plastic limit tests. **Table 6** lists the Mn/DOT plastic limit and Proctor test results from each test area. One plastic limit test was performed for each test pad. The target values are based on the plastic limit of the soils and are used to determine if the soil passes or fails based on the combination of LWD or DCP and the gravimetric moisture content of the soil. Mn/DOT samples were collected at a rate of one sample per test pad.

Table 6 – Mn/DOT Standard Proctor and Plastic Limit Testing

Date Sampled	Test Pad Sampled	Maximum Dry Density (pcf)	Optimum Moisture (%)	AASHTO Group	Group Index	Mn/DOT Class	Plastic Limit*
9/10/2008	A	115.0	13.3	A-4	4	SiL	23.2
9/10/2008	B	115.3	12.9	A-4	3	SiL	23.2
9/10/2008	C	112.7	13.5	A-4	5	SiL	23.2
9/18/2008	D	104.9	18.4	A-4	0	Si	non-plastic
9/18/2008	E	109.5	16.8	A-4	11	Si	24.2
9/18/2008	F	105.2	18.0	A-6	13	SiCL	27.2
9/26/2008	G	112.2	14.3	A-4	0	Si	non-plastic
9/26/2008	H	109.3	15.3	A-4	0	Si	non-plastic
9/26/2008	I	110.8	14.2	A-4	0	Si	non-plastic
10/1/2008	J	110.9	15.6	A-4	1	SiL	25.5
10/1/2008	K	111.8	15.5	A-4	0	Si	non-plastic
10/1/2008	L	110.0	15.6	A-4	0	Si	non-plastic
10/2/2008	M	123.0	11.0	A-4	1	SiL	18.7
10/2/2008	N	122.7	10.8	A-4	1	SiL	17.6
10/2/2008	O	109.7	15.1	A-4	5	Si	21.2

* Plastic limit testing was performed on samples collected from test number 2 at each of the test pads.

The results from AET Proctor tests can be found in **Table 7**. AET Proctor testing and sampling was independent of the Mn/DOT sampling and testing. AET performed a Proctor test when the soil seemed to change in the field and a previous Proctor could not be applied to the current soil condition. As a result only 5 Proctors were performed by AET.

Table 7 – AET Standard Proctor Testing

Date Sampled	Proctor Number	Maximum Dry Density (pcf)	Optimum Moisture (%)	AASHTO Group	Description
9/10/2008	1	111.7	16.8	A-7	Clay, brown
9/18/2008	2	101.5	20.2	A-6	Silty clay loam, brown
9/26/2008	3	109.1	16.0	A-4	Silt, brown
10/1/2008	4	109.5	16.7	A-4	Silt, brown
10/2/2008	5	106.6	18.3	A-4	Silt loam, bark brown

Figure 6 is a comparison of both the AET Proctor tests and the Mn/DOT Proctor tests. There is a slight difference between the two labs which may be attributed to personnel, equipment or sampling location.

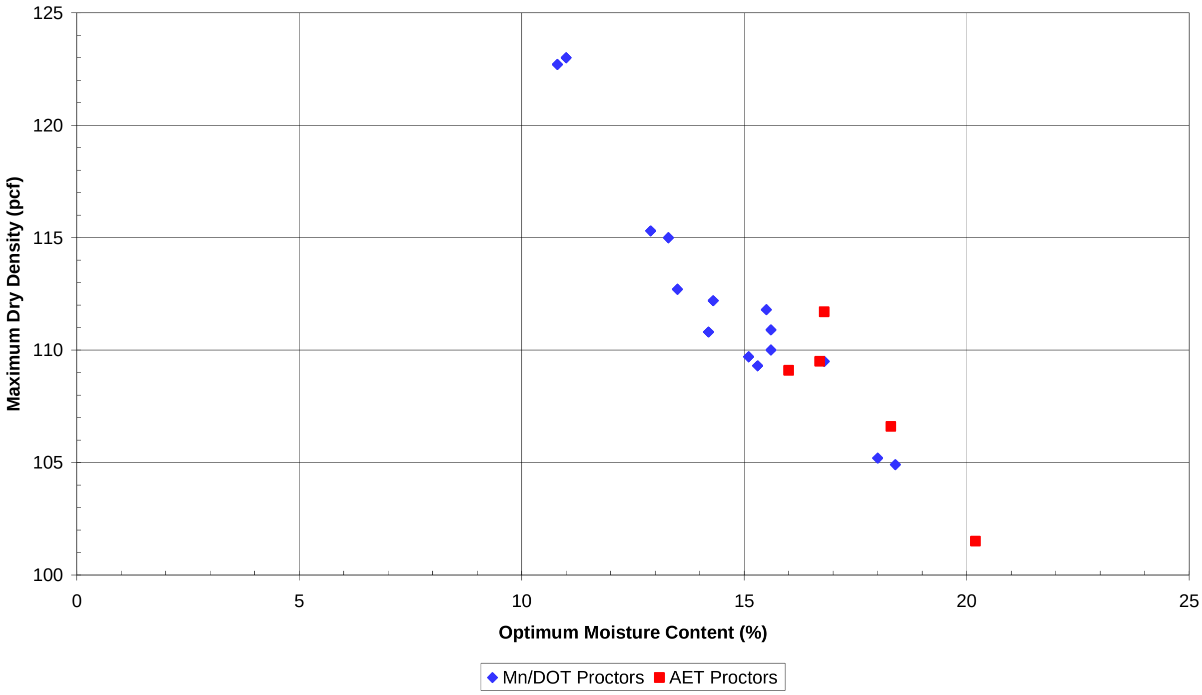

Figure 6 – Mn/DOT and AET Proctors

Table 8 summarizes the results of the density, DCP, Zorn LWD, plastic limit, and moisture content testing that was done. It is important to clarify that Olmsted County does not approve or reject soil based on density tests. The locations chosen were randomly selected and may or may not have been approved by the county inspector. The density results were meant only to show the relationship between the different methods used to measure compaction of the soil.

Table 8 – Comparison of Tests

Test	AET Proctor Based Compaction	Mn/DOT Proctor Based Compaction	DPI (mm/drop)	Zorn Deflection (mm)	Plastic Limit (%)	Moisture Content (%)
1A	99%	96%	26.2	1.47	23.2	24.6
2A	98%	95%	42.4	1.58	23.2	19.5
3A	106%	103%	12.2	1.81	23.2	14.8
4A	106%	103%	12.4	1.22	23.2	15.7
1B	102%	98%	25.5	1.65	23.2	15.1
2B	101%	98%	26.2	1.23	23.2	14.1
3B	105%	102%	33.9	3.98	23.2	13.6
4B	103%	100%	30.8	4.58	23.2	16.8
1C	101%	100%	15.2	0.84	23.2	12.7
2C	102%	101%	19.0	1.06	23.2	17.0
3C	106%	105%	21.8	2.56	23.2	16.7
4C	108%	107%	21.2	3.14	23.2	17.2
1D	95%	101%	22.2	1.75	Non-plastic	24.5
2D	94%	100%	25.4	2.15	Non-plastic	22.9
3D	96%	103%	20.8	1.65	Non-plastic	22.5

Test	AET Proctor Based Compaction	Mn/DOT Proctor Based Compaction	DPI (mm/drop)	Zorn Deflection (mm)	Plastic Limit (%)	Moisture Content (%)
4D	97%	104%	22.4	1.13	Non-plastic	20.8
1E	102%	94%	63.1	2.72	24.2	21.1
2E	95%	97%	49.7	2.81	24.2	21.4
3E	99%	101%	32.9	4.57	24.2	19.5
4E	107%	99%	44.2	5.67	24.2	20.9
1F	95%	92%	50.3	2.24	27.2	24.9
2F	94%	90%	68.3	3.63	27.2	24.9
3F	96%	93%	49.8	1.98	27.2	24.1
4F	92%	89%	49.6	2.08	27.2	24.9
1G	98%	96%	15.6	1.12	Non-plastic	15.8
2G	103%	101%	13.7	0.94	Non-plastic	15.1
3G	99%	97%	14.4	1.21	Non-plastic	15.2
4G	99%	96%	14.0	1.33	Non-plastic	14.2
1H	96%	95%	13.8	0.69	Non-plastic	15.0
2H	97%	97%	13.7	0.83	Non-plastic	15.6
3H	99%	99%	14.4	1.04	Non-plastic	14.9
4H	98%	98%	14.7	0.89	Non-plastic	14.8
1I	101%	99%	12.9	1.18	Non-plastic	13.8
2I	101%	100%	13.9	1.33	Non-plastic	15.0
3I	97%	95%	15.3	0.86	Non-plastic	14.9
4I	98%	96%	16.2	0.97	Non-plastic	14.0
1J	96%	94%	26.4	1.51	25.5	16.2
2J	100%	98%	35.6	3.28	25.5	17.2
3J	100%	99%	26.4	1.24	25.5	15.4
4J	102%	101%	21.9	1.97	25.5	14.9
1K	100%	98%	53.6	6.02	Non-plastic	17.9
2K	98%	96%	44.7	7.66	Non-plastic	19.1
3K	100%	98%	54.0	3.21	Non-plastic	17.5
4K	102%	99%	23.8	1.39	Non-plastic	16.2
1L	98%	97%	39.7	2.60	Non-plastic	17.7
2L	98%	98%	38.6	2.14	Non-plastic	18.1
3L	98%	97%	27.1	1.86	Non-plastic	16.8
4L	98%	97%	32.9	2.16	Non-plastic	17.7
1M	-	107%	12.5	1.32	18.7	11.8
2M	-	104%	17.5	2.09	18.7	11.7
3M	-	104%	14.4	2.06	18.7	11.1
4M	-	106%	12.6	1.44	18.7	11.3
1N	-	104%	12.9	1.41	17.6	11.1
2N	-	108%	11.8	1.71	17.6	10.9
3N	-	110%	12.3	1.65	17.6	10.9
4N	-	105%	16.9	2.32	17.6	11.1
1O	104%	101%	22.0	2.28	21.2	19.2
2O	104%	101%	22.0	1.71	21.2	18.8
3O	107%	104%	16.9	1.45	21.2	15.7
4O	105%	102%	21.6	2.01	21.2	17.6

A comparison of measured DPI and Zorn deflection values is shown in **Figure 7**. As expected, the comparison shows that as DPI increases, the deflection tends to increase as well.

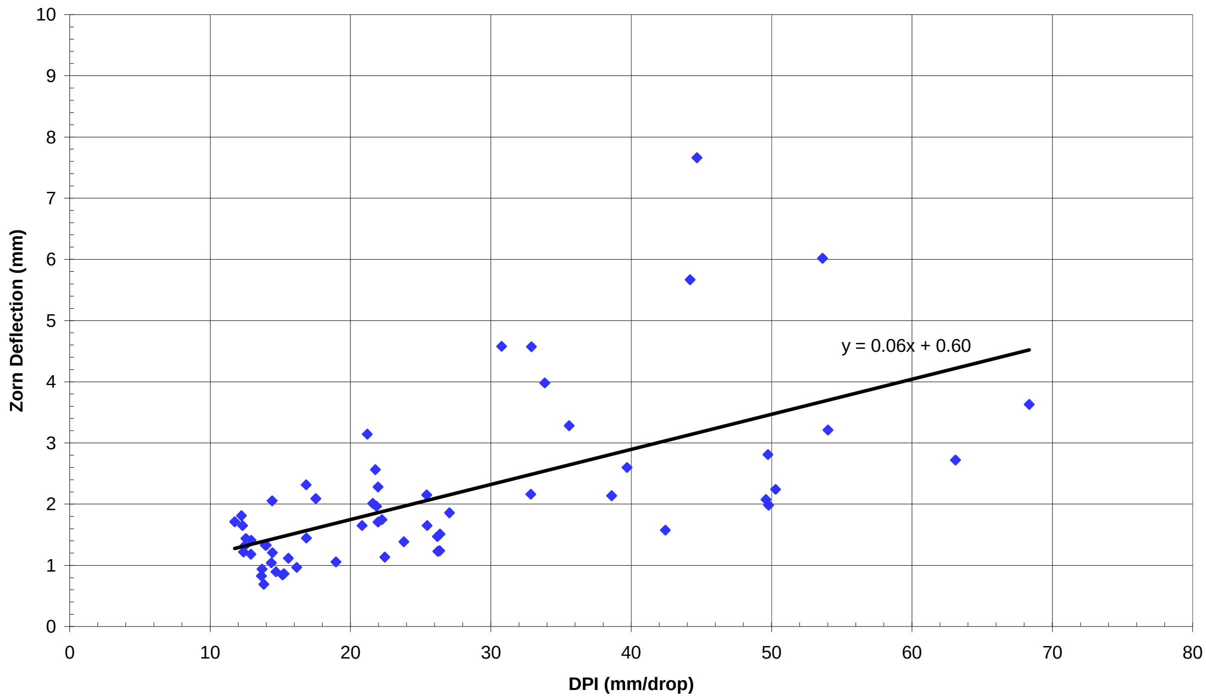

Figure 7 - Comparison of DPI and Zorn Deflection

Target Value Analysis

DPI Target Values

Mn/DOT supplied target values for comparison to DPI values. **Figure 8** shows weighted average DPI values versus oven dried gravimetric moisture content. This figure also includes the DPI target values for plastic limits of 15, 20, 25 and 30 percent. DPI target value curves can be used as pass/fail criteria. The target value criterion in this report is applied by first determining the plastic limit of the soil, then comparing the DPI of the test with the nearest curve that has a plastic limit equal to or less than the test value. If the DPI lies below the curve, the test passes. If it lies above, it fails.

Maximum DPI criteria should also be applied in combination with target value criteria. If maximum DPI criteria are not applied, subgrade strengths may not meet minimum design criteria. For this project, the following values were used as maximum DPI pass/fail criteria:

- Non-plastic soils = less than 25mm/drop
- Soils with a plastic limit from 15% to 19% = less than 25 mm/drop
- Soils with a plastic limit from 20% to 24% = less than 35 mm/drop
- Soils with a plastic limit from 25% to 29% = less than 45 mm/drop

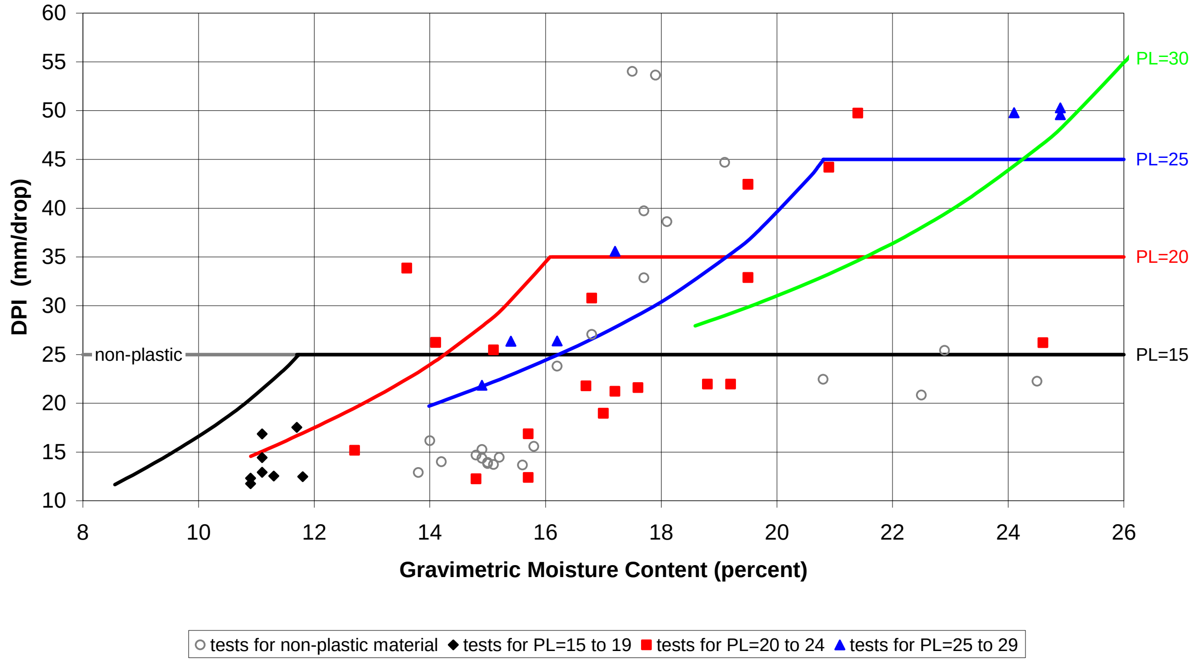

Figure 8 - DPI vs. Moisture Content and Target Values

Zorn Deflection Target Values

Mn/DOT supplied target values for comparison to Zorn LWD values. **Figure 9** shows all Zorn deflection values versus oven dried gravimetric moisture content. This figure also includes the deflection target values for plastic limits of 15, 20, 25 and 30 percent. Target value curves can be used as pass/fail criteria. The target value criterion in this report is applied by first determining the plastic limit of the soil, then comparing the deflection of the test with the nearest curve with a plastic limit equal to or less than the test value. If the deflection lies below the curve, the test passes. If it lies above, it fails.

Maximum deflection criteria should also be applied in combination with target value criteria. If maximum deflection criteria are not applied, subgrade deflections may not meet minimum design criteria. For this project, the following values were used as maximum deflection pass/fail criteria:

- Non-plastic soils = less than 1.8 mm
- Soils with a plastic limit from 15% to 19% = less than 1.8 mm
- Soils with a plastic limit from 20% to 24% = less than 2.2 mm
- Soils with a plastic limit from 25% to 29% = less than 2.6 mm

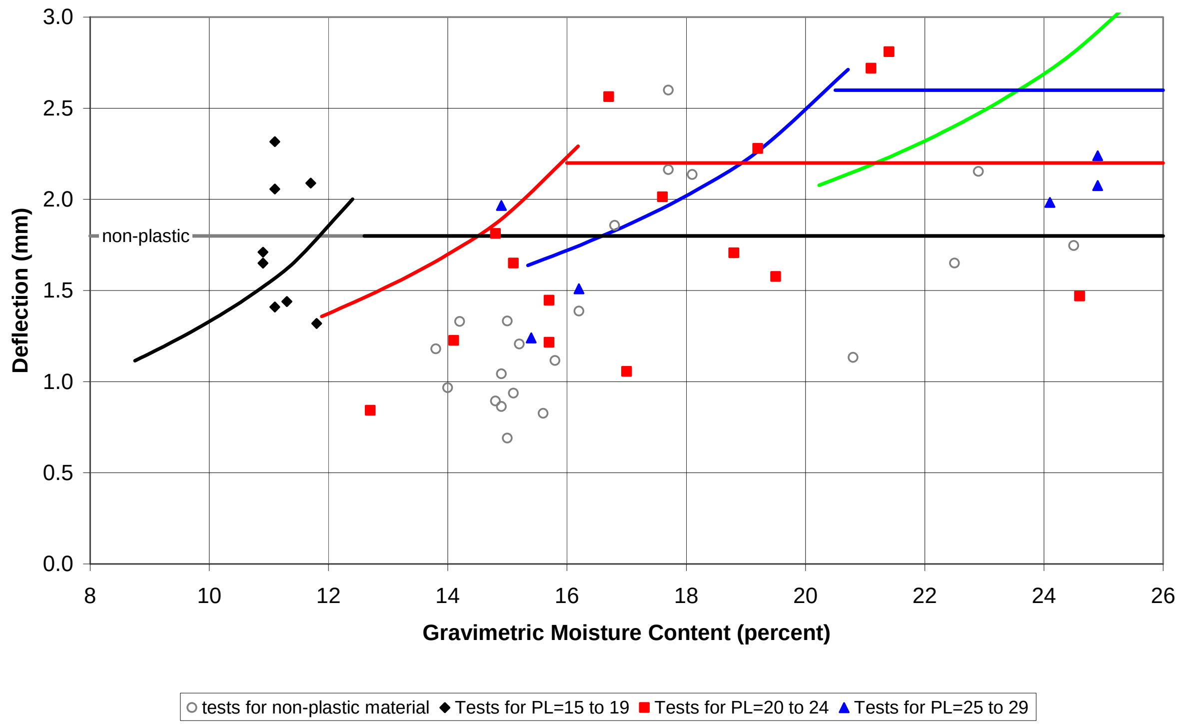

Figure 9 - Zorn Deflection vs. Moisture Content and Target Values

Comparison of Pass/Fail Criteria

Table 9 applies various pass/fail criteria to tests of plastic soils. Pass/fail criteria for percent compaction is based on 100% of standard Proctor. Pass/fail criteria for DPI is based on the curves and data shown in **Figure 8**. Pass/fail criteria for the Zorn LWD is based on the curves and data shown in **Figure 9**.

Table 9 – Pass/Fail Comparison of Plastic Soils

Test	Plastic Limit (%)	Nuclear Gauge Relative Density	Sand Cone Relative Density	DPI Target Value Criteria	Zorn Deflection Target Value Criteria
1A	23.2	96%	-	Pass	Pass
2A	23.2	95%	-	Fail	Pass
3A	23.2	103%	103%	Pass	Pass
4A	23.2	103%	-	Pass	Pass
1B	23.2	98%	-	Pass	Pass
2B	23.2	98%	-	Fail	Pass
3B	23.2	102%	-	Fail	Fail
4B	23.2	100%	-	Pass	Fail
1C	23.2	100%	110%	Pass	Pass
2C	23.2	101%	-	Pass	Pass
3C	23.2	105%	-	Pass	Fail
4C	23.2	107%	-	Pass	Fail
1E	24.2	94%	101%	Fail	Fail
2E	24.2	97%	-	Fail	Fail
3E	24.2	101%	-	Pass	Fail
4E	24.2	99%	-	Fail	Fail
1F	27.2	92%	-	Fail	Pass
2F	27.2	90%	-	Fail	Fail
3F	27.2	93%	-	Fail	Pass
4F	27.2	89%	96%	Fail	Pass
1J	25.5	94%	-	Fail	Pass
2J	25.5	98%	-	Fail	Fail
3J	25.5	99%	-	Fail	Pass
4J	25.5	101%	-	Pass	Fail
1M	18.7	107%	-	Pass	Pass
2M	18.7	104%	-	Pass	Fail
3M	18.7	104%	-	Pass	Fail
4M	18.7	106%	-	Pass	Pass
1N	17.6	104%	-	Pass	Pass
2N	17.6	108%	-	Pass	Fail
3N	17.6	110%	-	Pass	Fail
4N	17.6	105%	-	Pass	Fail
1O	21.2	101%	-	Pass	Pass
2O	21.2	101%	103%	Pass	Pass
3O	21.2	104%	-	Pass	Pass
4O	21.2	102%	101%	Pass	Pass

Table 10 applies various pass/fail criteria to tests of non-plastic soils. Pass/fail criteria for relative density is based on 100% of standard Proctor. Pass/fail criteria for DPI is based on the curves and data shown in **Figure 8**. Pass/fail criteria for the Zorn LWD is based on the curves and data shown in **Figure 9**.

Table 10 – Pass/Fail Comparison of Non-Plastic Soils

Test	Nuclear Gauge Relative Density	Sand Cone Relative Density	DPI Target Value Criteria	Zorn Deflection Target Value Criteria
1D	101%	-	Pass	Pass
2D	100%	-	Fail	Fail
3D	103%	-	Pass	Pass
4D	104%	-	Pass	Pass
1G	96%	-	Pass	Pass
2G	101%	104%	Pass	Pass
3G	97%	-	Pass	Pass
4G	96%	-	Pass	Pass
1H	95%	-	Pass	Pass
2H	97%	-	Pass	Pass
3H	99%	-	Pass	Pass
4H	98%	-	Pass	Pass
1I	99%	-	Pass	Pass
2I	100%	-	Pass	Pass
3I	95%	-	Pass	Pass
4I	96%	104%	Pass	Pass
1K	98%	97%	Fail	Fail
2K	96%	-	Fail	Fail
3K	98%	-	Fail	Fail
4K	99%	-	Fail	Pass
1L	97%	98%	Fail	Fail
2L	98%	-	Fail	Fail
3L	97%	-	Fail	Pass
4L	97%	-	Fail	Fail

Summary

Road work was done in Olmsted County during the 2008 construction season. Field tests were performed on subgrade soils with the Zorn LWD, Dynatest LWD, DCP, nuclear density gauge, and sand cone. Laboratory testing was done on samples obtained from the field including moisture content, standard Proctor, and plastic limit. DPI and Zorn deflection criteria provided by Mn/DOT and the 100% standard Proctor criterion were applied to the tests and compared. The test locations were not representative of the final subgrade. Most of the tests were performed when convenient and not necessarily after compaction was complete or accepted by Olmsted County.

The DCP results for plastic soils show good correlation with nuclear density gauge results. The DPI target value pass/fail criteria for plastic soils correlates well with the 100% standard Proctor criterion. In addition to being used as pass fail/criteria, DCP testing provides useful information about soil strength and soil profile data. The results for Zorn LWD for plastic soils were mixed. The Zorn target value pass/fail criteria for plastic soils do not correlate as well with the 100% standard Proctor criterion.

The results for non-plastic soils show good correlation between sand cone, Zorn, and DCP testing. The results show poor correlation between the nuclear density gauge and the other testing methods. Test pads G, H, and I all fail when applying the 100% standard Proctor criteria to nuclear gauge densities, but pass when applying the DPI and Zorn deflection criteria. Additionally, test pads G and I both pass when applying the 100% standard Proctor criteria to the sand cone densities. This difference between sand cone density and nuclear gauge density could be a result of the variable soils at the site, apparatus that were out of calibration, depth of sampling, or any other of a number of reasons. Regardless of the differences between density test methods, the application of 100% standard Proctor criteria to sand cone measurements correlates well with DPI and Zorn target value pass/fail criteria for non-plastic soils.

The testing methods and criteria discussed in this report are useful for analyzing properties of compacted material. Together, the methods give a good indication of the subgrade properties. However, none of these test methods should be used alone to determine final acceptance of subgrade compaction. Engineering judgment is always important.