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Michigan cone test : a reliability study

Karl M. Krueger
Michigan Technological University

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The Michigan Cone Test: A Reliability Study

By

Karl M. Krueger

A REPORT

Submitted in partial fulfillment of the requirements for the degree of

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This report, “The Michigan Cone Test: A Reliability Study,” is hereby approved in partial fulfillment of the requirements for the Degree of MASTER OF SCIENCE IN CIVIL ENGINEERING.

Department of Civil and Environmental Engineering

Signatures:

Dr. Stan Vitton - Report Advisor ________________________________

Dr. Ralph J. Hodek, P.E. - Committee Member ________________________________

Dr. Roger Turpening - Committee Member ________________________________

Dr. David Hand - Department Chair ________________________________

Date ________________________________

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Problem Statement

The Michigan cone test is a field compaction test used by the Michigan Department of Transportation (MDOT) to determine the maximum density of granular materials and has been used for over 50 years. While most state DOTs (including the MDOT) use the modified Proctor compaction test to determine the required compaction for specific soils, Michigan is the only state that uses the cone test to do compaction testing in the field. That is, the cone test is used in the field to simulate the modified Proctor test in the laboratory. Both the cone test and the modified Proctor test are used to set the required compaction while the nuclear density gauge, sand cone, or rubber balloon are used to verify whether the required level of compaction has been met.

Recently, questions have risen concerning the accuracy and reliability of the cone test. Specifically, does the Michigan cone test lead to better overall compaction control than use of the modified Proctor test would? Additional issues concerning the cone test include: (1) how was the test developed, (2) does the cone test yield a density that is comparable to the modified Proctor test, (3) is the cone test repeatable between multiple technicians, and (4) what should be done for compaction testing on MDOT projects. The purpose of this report is to address the following specific issues

- Research the origins of the cone test and gain insight into the compaction principles behind it.
- How well does the cone test compare with the modified Proctor test.
- Determine the repeatability of the cone test for a single user as well as for multiple users.
- Make recommendations regarding the cone test.

Introduction: Importance of Compaction Quality Control

Compaction quality control is an essential component of roadway construction. Good compaction results in high quality, long lasting roadways, while poor or uneven compaction often leads to failures such as settlement, cracks, and rutting. The purpose of compaction is to improve the engineering properties of the road base material. Compaction increases the shear strength of soil, reduces the compressibility, but also reduces the permeability (R. Holtz 1990). For cohesionless soils, the most common form of compaction is by pressure and vibration using rollers (Terzaghi and Peck 1948). Vehicles driving on a pavement section also generate dynamic vibration loads similar to that of a roller, but smaller in magnitude. Over time, these small vibrations may cause additional compaction of the base material, which would result in settlement underneath the pavement. Obviously, the nearer the granular base material can be compacted to its respective maximum density, the less potential there is for settlement in the future. It is especially important that the level of compaction be uniform throughout the project to reduce the potential for local differential settlement.

In general, cohesionless soils are less dependent on moisture content, while the energy input is the main controlling factor (Hilf 1975). The main difference between cohesionless soils and clay, in general is that cohesionless soils are free draining. In sands and gravels with minimal fines, excess water can drain away rapidly during the compaction process. Water does not act as much of a lubricant and does not aid significantly in compaction of cohesionless material. Evidence of this is that the total stress friction angle of sands is similar to the effective stress friction angle. Bulking also leads to a poorly defined moisture density relationship for cohesionless soils. Bulking occurs in partially saturated sands, where capillary forces trap air voids and resist compaction. For this reason, sands reach higher densities when completely dry or saturated with lower densities when partially saturated. For these reasons, the Proctor compaction curve does not provide a well-defined optimum moisture content to obtain the maximum density (Hilf 1975).

Compaction Quality Control Criteria – Relative Density

Relative density is generally accepted as a better alternative as a compaction criteria for cohesionless soils compared to percent compaction. Relative density is expressed as the percentage that the density is currently at relative to the maximum and minimum values for that soil. Relative density can be expressed in terms of void ratio or in terms of dry unit weight (density).

$$D_R = \frac{e_{max} - e}{e_{max} - e_{min}} \tag{1.1}$$

$$D_R = \frac{\gamma_{\mathrm{d,max}}(\gamma_d - \gamma_{d,min})}{\gamma_d(\gamma_{d,max} - \gamma_{d,min})} \tag{1.2}$$

The benefit of using relative density instead of percent compaction is the quality of correlations between relative density and engineering properties such as compressibility and shear strength (Lee 1971). For example, sand with a relative density near 40% can be expected to be twice as compressible as sand at a relative density of 70% (Hilf 1975). Shear strength also correlates well with relative density for sands and gravels. The weakness of using relative density is that a small change in any of the input parameters results in a significant change in the result. The confidence interval for measurement of maximum and minimum densities in sand and gravel is plus or minus five pounds per cubic foot (pcf), and the measurement of in place field density with the sand cone method varies as much as plus or minus two pcf. The resulting relative density calculation can range by as much as 95% due to the combined error in the measurements (Tavenas, Ladd and LaRochelle 1973). The main drawback of using relative density over percent compaction is clearly the combined error involved in the calculation reduces the confidence in the result to the equivalent of a random guess. For this reason, percent compaction is more often used as acceptance criteria.

Compaction Control Criteria – Percent Compaction

Percent compaction, or relative compaction, is simply the percent of the measured field density relative to maximum laboratory density, and is determined by the following equation.

$$Percent\ Compaction = \frac{\gamma_d(field)}{\gamma_{d,max}(lab)} \qquad 1.3$$

The benefit of using this criterion instead of relative density is that one less measurement needs to be taken, thereby decreasing the compounding error problem previously mentioned. Percent compaction is also used in the case of cohesive soils and is very well understood by contractors and engineers. Another benefit of using percent compaction is that the engineer has a good idea of potential settlement for each percent of compaction. It is easy for an engineer to specify a required percent compaction once the acceptable settlements are known.

Field Compaction Quality Control

Compaction quality control is performed by measuring the field density of soil after it has been compacted and relating it to the same material compacted in the lab, similar to percent compaction. Implied by the specifications is that engineering properties such as strength and stiffness are acceptable at the required level of compaction. Compaction tests considered in this report include: the standard Proctor, modified Proctor, and Michigan cone. The modified Proctor test is viewed as being very near the maximum density of the soil, even though higher densities can be achieved. However, based on practical considerations and typical compaction equipment used in the field, the modified Proctor density is generally considered the soils maximum density.

Density inspectors for MDOT measure field density using a nuclear density gauge, then perform a cone test on the same soil to determine compliance with the specifications. The compaction test to be used depends on the type of soil being tested. For granular soils, sands and gravels with less than 15% fines, the Michigan cone test is used. Cohesive soils are tested using the standard Proctor, AASHTO T-99 test, and recycled material is tested according to the modified Proctor, AASHTO T-180 test (M-DOT 2003).

Field testing is done to ensure sufficient compaction in all areas of the project, and is meant to identify less compacted areas. Density related problems are still a common occurrence, because of significant uncertainties involved. Only a small portion of compacted material is field tested. For example, the sampling rate for compaction tests is about one test for 500 feet of roadway. In addition, uncertainty arises within the testing itself. A Troxler 3440 nuclear density gauge, which is used by MDOT, measures density with a composite error of 1.25 pcf for a customary one minute reading (Troxler 2007). Furthermore, every laboratory compaction test has a certain error associated with it depending on the method used as well as soil type and operator. The combined error in both laboratory and field testing may result in substandard compaction being accepted. The largest uncertainty lies with correlating stiffness and compressibility to density. Even with acceptable density levels, soil may still lack adequate engineering properties for a given application.

Historical Review

The three compaction tests conducted by the MDOT, the standard and modified Proctor and cone test, are briefly discussed below.

The Standard Proctor Test

Compaction control was developed by R.R. Proctor and presented in a series of articles published in Engineering News Record (Proctor 1933). This series of articles discusses how compaction control was used on an earth dam project and how engineering properties such as strength and permeability could be estimated from the moisture content and dry density of the compacted material. The standard Proctor test was later accepted as the standard for compaction testing of soils. The standard Proctor test is an impact type test where a 5.5 pound hammer is dropped 12 inches, 25 times per layer, using three layers to fill the mold. The benefit of this test is that it is simple, repeatable, and the energy applied to compact the soil is constant for every test. The standard Proctor test also gives a well-defined compaction curve for cohesive soils. However, the standard Proctor level of compaction was insufficient for quality performance of roads with heavy loads operating on them. In response, the modified Proctor test was developed.

The Modified Proctor Test

The modified Proctor test was developed to account for heavy loads applied by aircraft on runways. The modified Proctor test uses a larger 10 pound hammer dropped 18 inches, 25 times per layer, and five layers of compaction per mold compared to three for the standard. The modified Proctor test was created to increase the compaction effort applied during the test to better match the capabilities of new equipment. "For all soils, in field or in laboratory compaction, increasing the energy applied per unit volume of soil results in an increase in the maximum unit weight and a decrease in the optimum moisture content." (Johnson and Sallberg 1960).

Both Proctor tests work well in most cases, but is time consuming to perform, especially on large projects where materials often change. Tavenas et. al. 1973 studied the statistical accuracy of relative density measurements, considering the Proctor tests as the maximum density. He found that for Proctor tests on sands that the standard deviation was approximately two pcf and the single user reproducibility standard deviation was near one pcf (Tavenas, Ladd and LaRochelle 1973). This results in a 95% confidence interval on the order of two pcf to four pcf when the modified Proctor test is used as the reference value.

The Michigan Cone Test

The Michigan cone test was developed by William Housel at the University of Michigan at about the same time the modified Proctor test was becoming popular (Housel 1958). The cone test can be described as an impact vibratory type compaction test, where the soil and the mold are both impacted against a hardwood block to compact the soil. Figure 1 shows the Michigan cone mold and the block. In Housel's original submittal for the compaction procedure, he specifies, "keep adding soil and tamping until cone cannot accommodate additional soil" (Housel 1958). The test was considered completed upon the tester's judgment. Numerous other tests for determining the maximum density of cohesionless soils were submitted at this time as well. ASTM Committee D-18 met at a symposium to discuss and propose which test should be adopted as the standard for finding maximum density of cohesionless soil. A study done by Felt examined methods including the standard Proctor test, the cone test, and several vibratory table type tests. Felt determined that the vibratory table test worked better than the cone test and Proctor test in that it produced a higher maximum density for almost every type of granular material considered. Felt's study did show that the cone test yielded the maximum density when the soils tested were dry or saturated, and lower densities were achieved at intermediate moisture contents (Felt 1958). Felt's study did not make any attempt to determine the variability or repeatability associated with the tests. The result of Committee D-18's research, however, was the adoption of what is now, "ASTM D-4253 Standard Test Methods for Maximum Index Density of Soils Using a Vibratory Table."

Figure 1 - Michigan cone test apparatus.

The procedure for conducting the Michigan cone test has since changed significantly over the years to improve on the maximum density and also the consistency of results. Primarily, the terminology has changed from tamping to "striking sharply", and a specified minimum 25 blows per layer is included The MDOT Density Testing and Inspection Manual. To determine when the test is completed, the total weight, meaning the weight of the soil, must increase less than 10 grams over a 20 blow interval. This is known as the 20/10 rule. The manual also specifies that material tested must be between 5% and optimum moisture to be considered a valid one-point test. The purpose of the moisture content limitation is to ensure that the soil is tested as near optimum moisture as possible to limit error generated through use of the one point chart (M-DOT 2003).

MDOT highway projects use the one-point method for determining the laboratory maximum density and optimum moisture for soil compaction. The one-point test was first developed for use as a rapid field method for determining maximum dry density and optimum moisture (R.C. Mainfort 1963). The one-point method shortens a typical standard Proctor test, which is a lengthy procedure, in that only a single mold need be compacted to estimate maximum density and optimum moisture. In 1963, Report No. R-412 presented a one-point chart to speed the time in performing standard Proctor T-99 tests. The chart could be used to predict maximum density and optimum moisture effectively based on a single compaction point as a starting reference. A single chart was generated for Michigan soils using compaction curves of more than 100 soils. The chart obviously works best when points are compacted near optimum moisture. The chart significantly loses accuracy when samples are compacted wet of optimum, and when samples are compacted very dry.

Michigan cone tests are used by MDOT for compaction control of granular soils containing 15% or less fine material. In 1967, a one-point chart was designed for Michigan cone tests, which is described in Report No. 658 (R. Mainfort 1967). Again, the chart and the one-point test are most reliable when the compacted sample is near optimum moisture. The results of the report indicate that the one-point method correlates very well with the conventional Michigan cone method, where multiple cone molds are compacted to obtain a compaction curve.

Field Testing Procedures

The Michigan cone test is most often performed as a one point test, where a single test is compacted to determine optimum moisture and maximum density. The test procedure is designed to save time in the field. The benefit of a field test over a lab reference test is that site soils can be tested during construction at a site. Therefore construction decisions can be quickly made as to whether a soil is acceptable or not. Material used in the test can be taken from the exact location of a nuclear density field test to avoid the problem of non-representative material. A new field sample can be tested whenever the density inspector notices or suspects that the material being placed has changed.

Equipment required for the test include: a scale, a cone shaped mold with a solid large end, a hardwood block to compact samples on, and a stopper to close the open end of the cone (M-DOT 2003). A water bottle and work gloves are also useful in performing tests. As noted, the sample to be tested should be course grained material, with less than 15% passing the No. 200 sieve.

The compaction test is performed by striking the cone squarely against the block. Compaction is done in three lifts; approximately one third of the cone height is compacted on each lift. Each lift is struck against the block at least 25 times, but may be struck more if it appears necessary to complete compaction of the lift (M-DOT 2003). After the three lifts, more material must be added to completely fill the mold. Ten or more blows are required each time additional material is added to the mold. When no additional material can be added to the mold, it is near maximum compaction. The mold is weighed, material is added to the top, and the mold is stuck 20 additional times (M-DOT 2003). The sample is weighed again. If the total mass increased by less than 10 grams, the final weight is recorded. If the mass increased by more than 10 grams, the process is repeated until the step change is less than 10 grams. The moisture content of the sample is obtained in the field using the Speedy moisture content test (M-DOT 2003).

To determine the maximum dry density and optimum moisture content of the test material, the one-point Michigan cone test chart is used. The chart uses the compacted wet density and moisture content as inputs to determine maximum dry density and optimum moisture. In some cases, such as aggregate base course, the standard Michigan cone test may be more appropriate than the one-point test. In such an instance, 2 or 3 cones are compacted of the same material at varying moisture contents within 5 to 8 percent moisture (M-DOT 2003). The dry density of each cone is determined directly without use of the one-point chart. The maximum density and optimum moisture is simply the maximum of the tests.

Compaction Principles Influence on Test Results

Soil compaction is conducted by rapidly applying mechanical energy to rearrange particles into a denser configuration. For granular soils in the field, compaction is usually done with some type of vibratory mechanism, typically a roller. Clean sands and gravels are not affected by moisture content to the degree that cohesive soils are. The reason for this is that clean granular soils rapidly drain water even after compaction (Hilf 1975). Dry density of these soils will be high when the soil is completely dry and high when completely saturated, with somewhat lower density values when partially saturated. The result is a poorly defined compaction curve for these materials. The phenomenon which results in poor compaction curves is known as bulking (Hilf 1975). Pore pressure in partially saturated granular soils tends to resist compaction effort. Therefore, relative density may be a better criterion than a compaction curve for such materials.

The compaction mechanism for the Michigan cone test is the dynamic impulse from striking the mold against the block. Vibrations generated from striking the block rearrange the particles into a denser configuration. Loose soils compact much faster than dense soils. That is to say, there comes a limit where additional vibration or applied energy no longer densifies the soil. At this point, the soil is said to be at its maximum density. The energy applied must be large enough to overcome particle friction and interlock in order to get to the maximum density. Larger more angular particles should be expected to require a greater force in order to achieve compaction. Large downward accelerations, from forcefully driving the cone into the block do not necessarily provide better compaction, and may be counterproductive for some soils. In the first lifts when there is space in the cone for particles to move upward, a forceful blow will loosen the material each time before it is re-densified upon striking the mold. The sudden impulse of the mold striking the block also caused segregation of particles with the largest particles floating on top. This was evident in the compaction of coarse aggregate samples. The shape of the cone does aid in compaction to a degree. As the soil is compacted, it generates an increase in lateral pressure which tends to force the soil outward. Soil in contact with the edge of the cone will be compacted down as well as out, leading to better compaction along the edges than if the mold were cylinder shaped.

Proctor tests use a drop weight hammer to perform compaction. The energy input can be calculated by controlling the drop height of the hammer and the number of blows applied. This method was designed to provide compaction in a manner similar to that of a static or vibratory roller. The benefit of this method is that the energy required to reach a specified level of compaction can be calculated. The standard Proctor can be specified in areas expected to carry small loads, and the modified Proctor can be used in areas where loads are high.

Differences between the cone test and Proctor tests that may influence results include: mold shape and boundary effects, particle crushing, particle angularity, and total compaction energy applied. It is reasonable to assume that larger samples are more likely to be representative for granular soils. Therefore, the test method that uses the most material per test is likely to have less error due to material inconsistencies. Similarly, boundary effects can be compared by looking at the ratio of boundary area to sample volume for each test. Soil particles compacted against the edge of the mold may include larger void spaces than particles in the center of the mold. The cone mold has the highest ratio of surface area to volume, and the six inch Proctor mold has the lowest ratio. The conclusion to draw from this is that the cone test will have a greater error due to boundary effects than the Proctor test.

Particle angularity influences results in that the method of compaction likely has different efficiencies. Specifically, a larger impact force will be more efficient than a light force when compacting angular soils. The large force is necessary to overcome particle interlock that develops with angular soils.

Materials and Testing Methods

In order to access the accuracy and repeatability of the Michigan cone test, a number of tests were conducted over a range of materials. In total, eleven samples were identified for testing: three 22A road gravels, one 21AA road gravel, three Class 2 sands, three Class 3 sands, and one 4G open graded crushed stone. All materials were collected in Michigan. These soils were specifically selected to match up with the most common soil specifications in use on MDOT projects. Gradations for each material used in the study are shown in figure 2 through figure 4. In total, each sample was tested 10 times as repeat trials for the cone tests. A standard Proctor, a modified Proctor, full Michigan cone test, and three grain size analyses were completed as the first phase of the testing program.

Upon completion of phase one, a second technician was employed to perform additional Michigan cone tests to better estimate variability between users. Additional tests were completed using soft or very hard hitting styles to simulate multiple users. Finally, a force accelerometer was also installed in the base of the cone to accurately determine the energy applied to the soil during the course of one test cycle. Several students were also asked to complete a series of tests after being instructed how to properly perform the test to determine variations in cone-block hitting effort. The accelerometer data was then used to quantify the extent of variability due to multiple users. A PCB Model 353B15 force accelerometer was mounted to the bottom of the cone. The accelerometer was capable of measuring large impact accelerations up to 10,000 g within a precision of ten percent. The ideal measuring range of the instrument was 500 g or less. The accelerometer was linked directly into data acquisition software system called DASYLab. A photo of the experimental setup is shown in figure 5. A program was set up within DASYLab to record the accelerations and to integrate the data to determine velocities. Acceleration measurements were sampled at a rate of 5000 Hz to ensure that the peak acceleration was recorded.

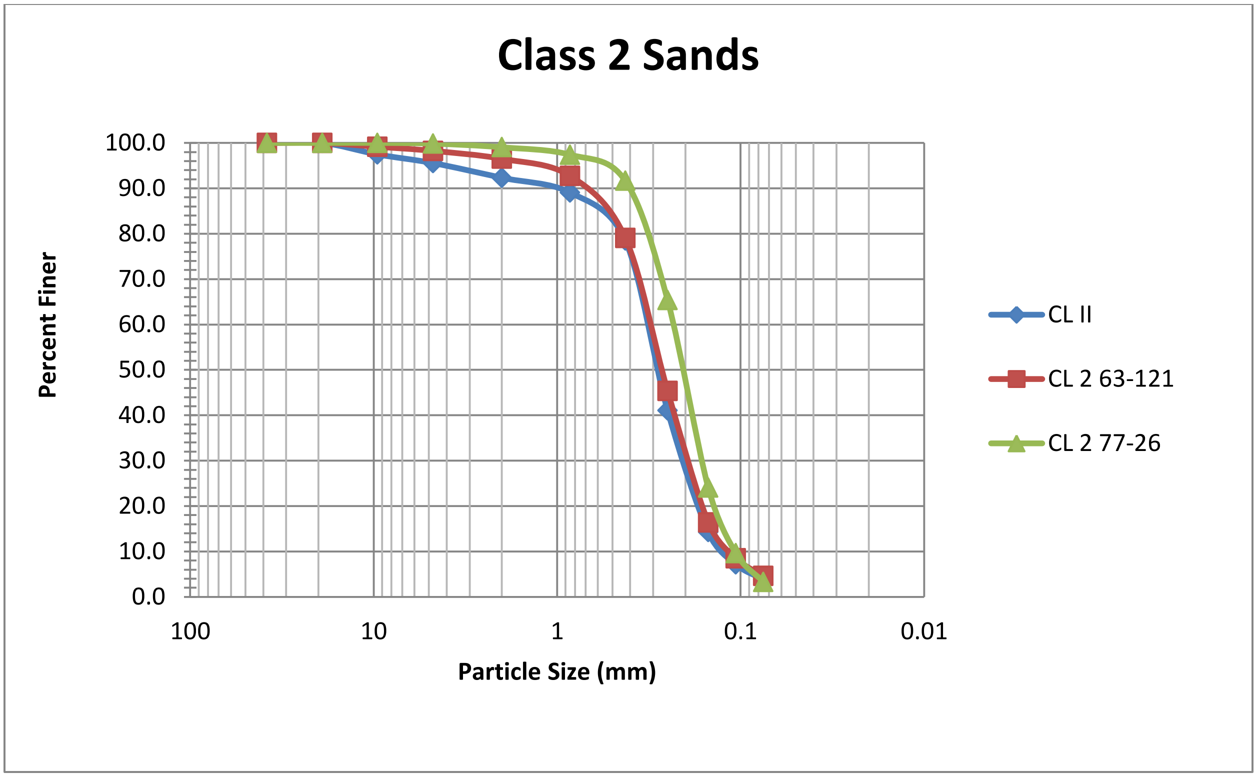

Figure 2 - Class 2 sand samples.

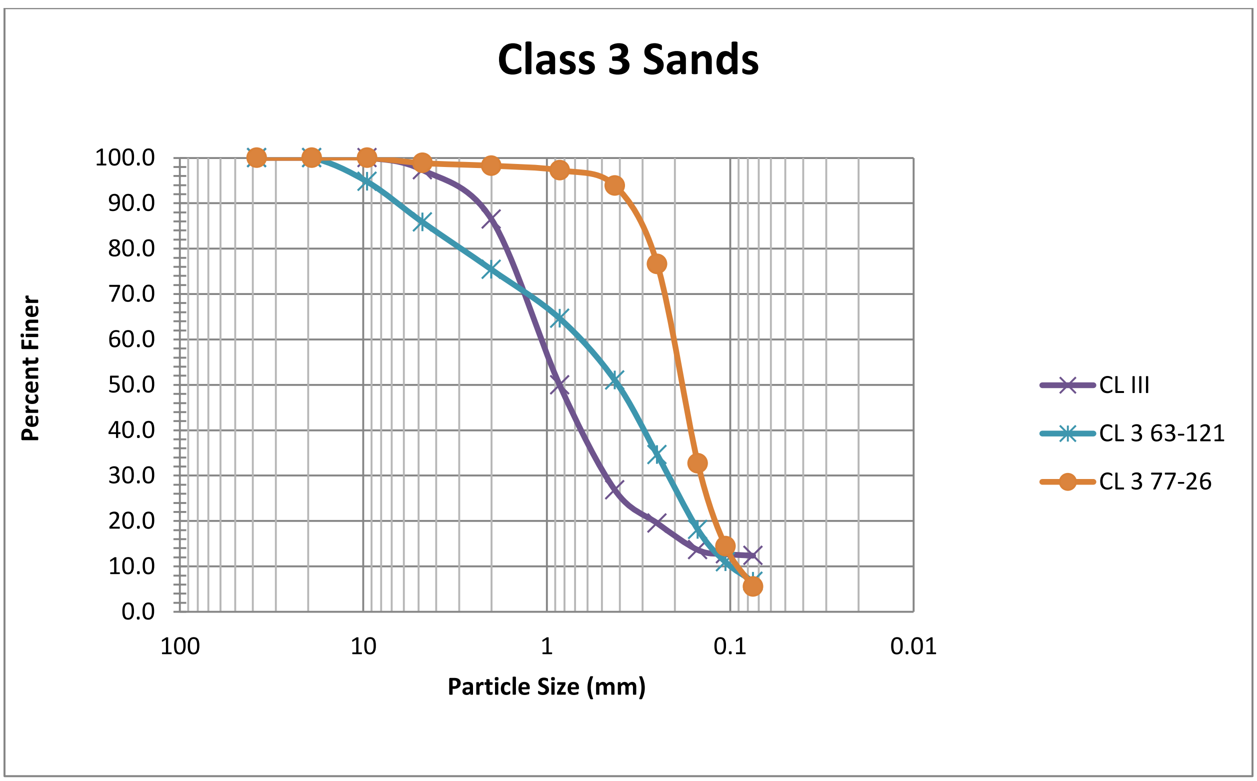

Figure 3 - Class 3 sand samples.

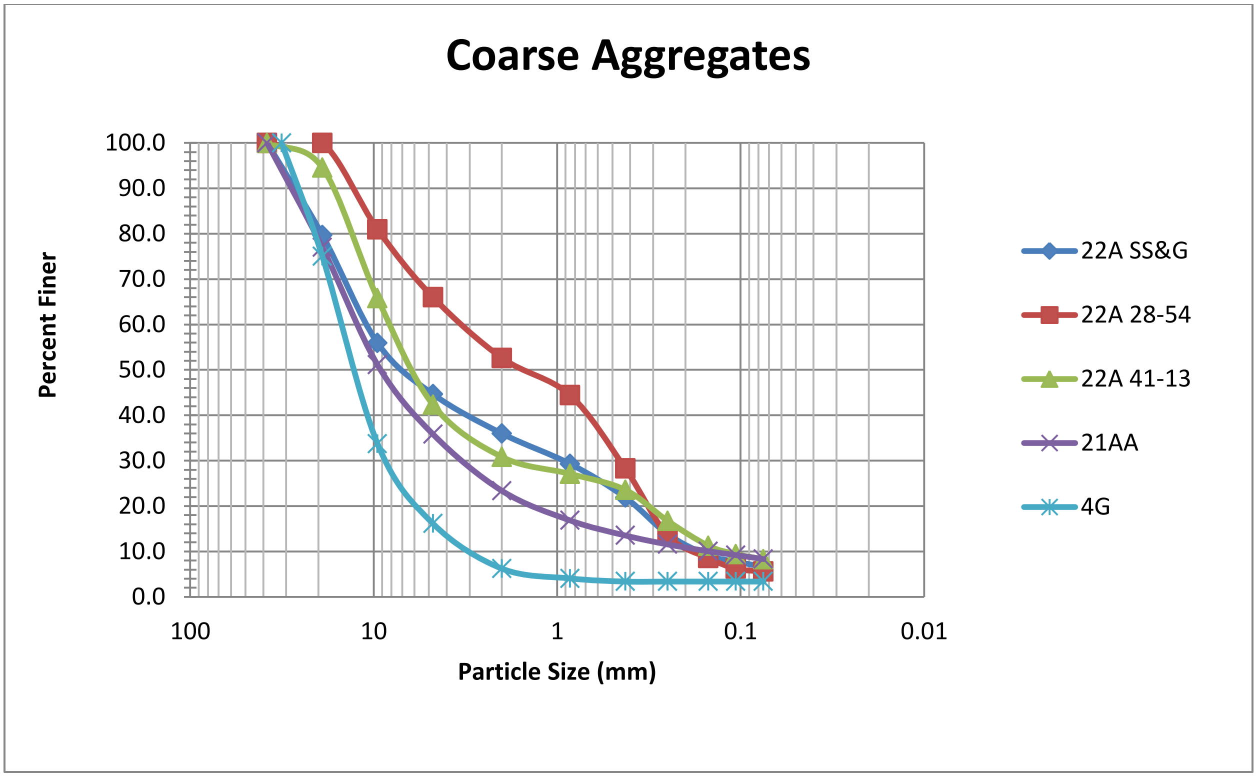

Figure 4 - Coarse aggregate samples.

Figure 5 - Accelerometer test setup.

Results

Comparison of cone test to standard and modified Proctor tests

Figures 6 through 16 present the moisture density relationships for the samples tested. As a general observation, the cone test matched up well with the modified Proctor test in the shape and the magnitude of the moisture density relationship curves. These compaction curves also show the limited effect moisture has on the resulting dry density.

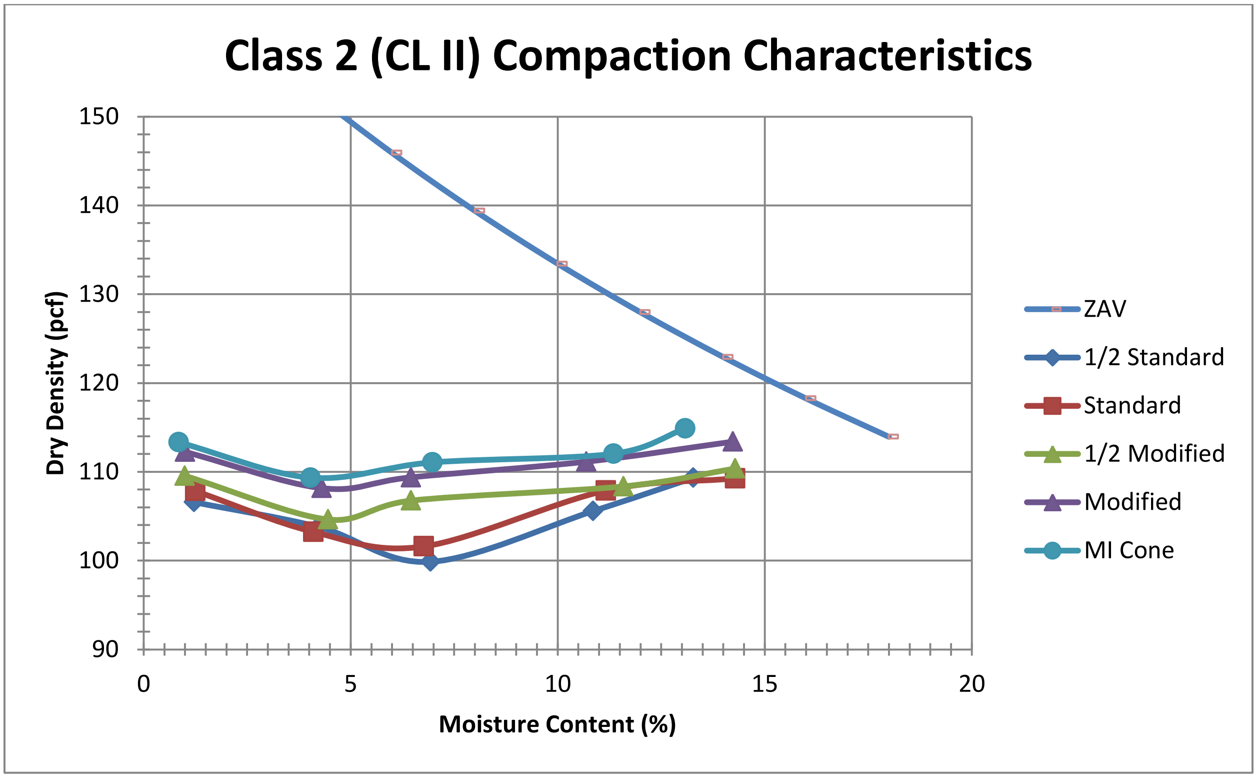

Figure 6 – Class2 (CL II) sand moisture density relationships.

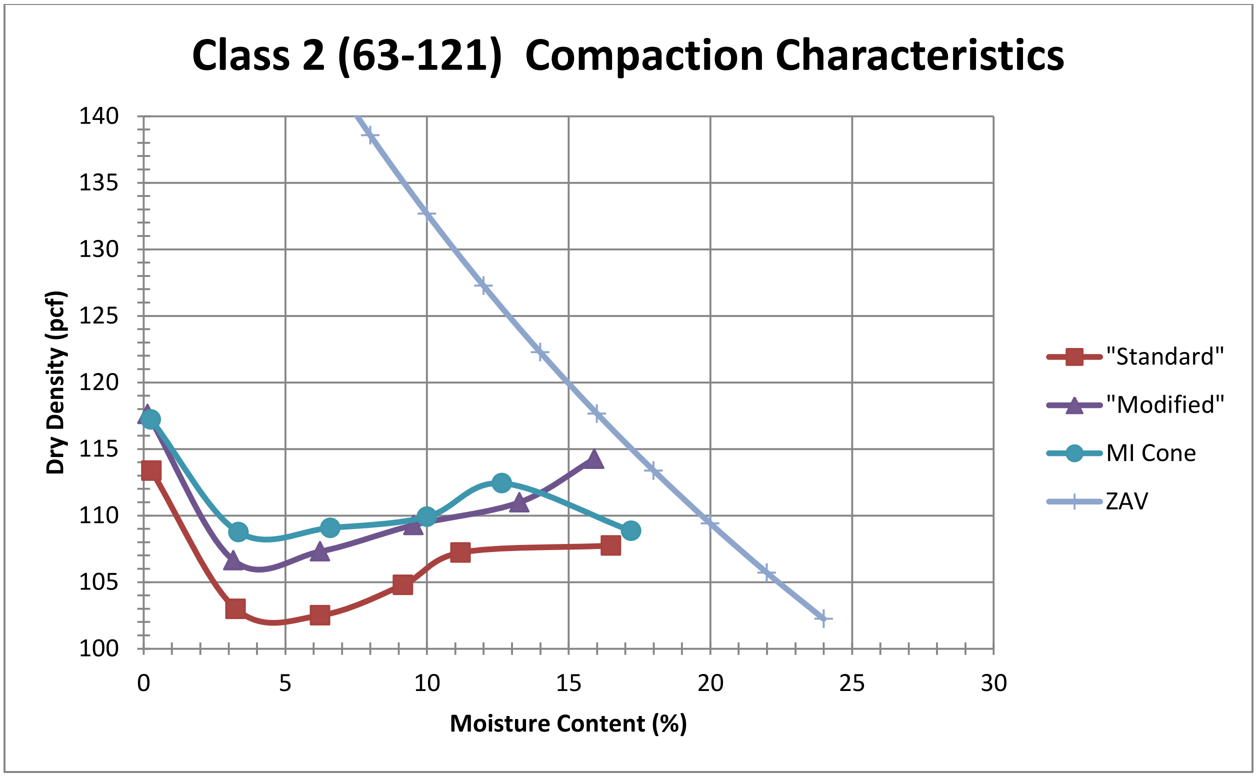

Figure 7 - Class 2 (63-121) sand moisture density relationships.

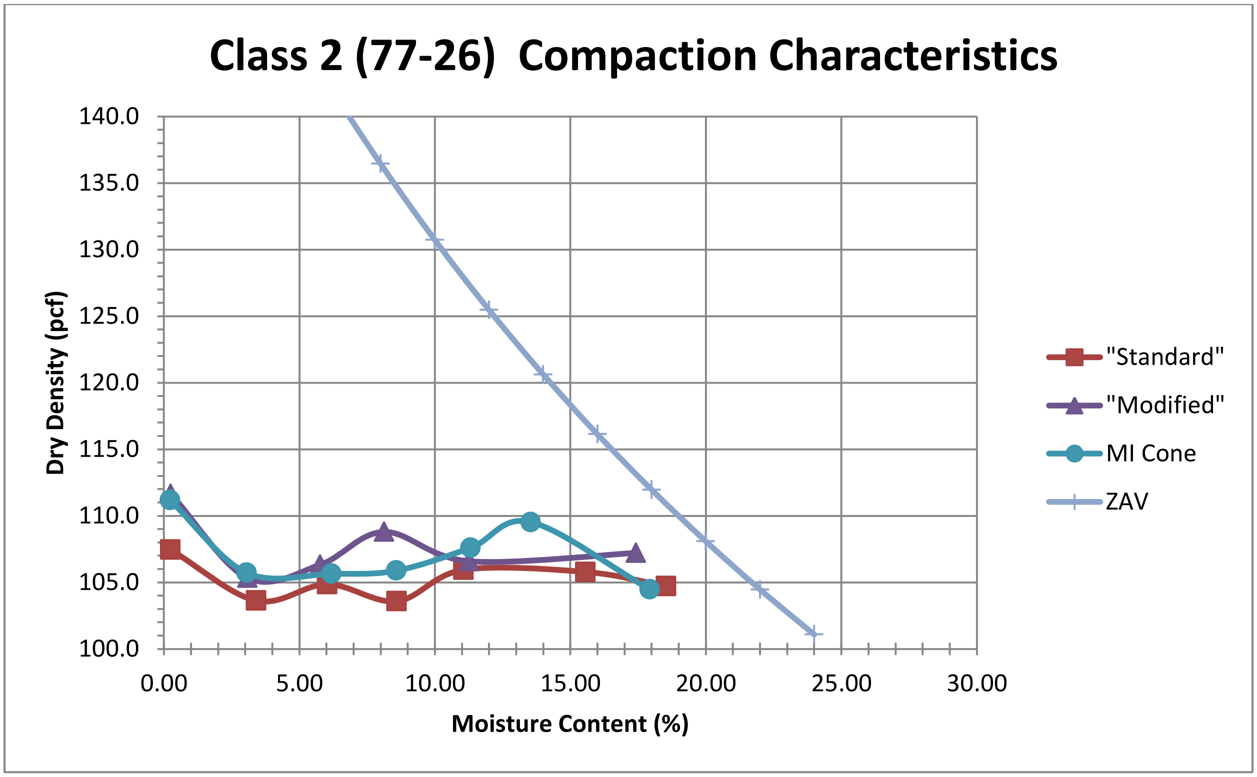

Figure 8 - Class 2 (77-26) sand moisture density relationships.

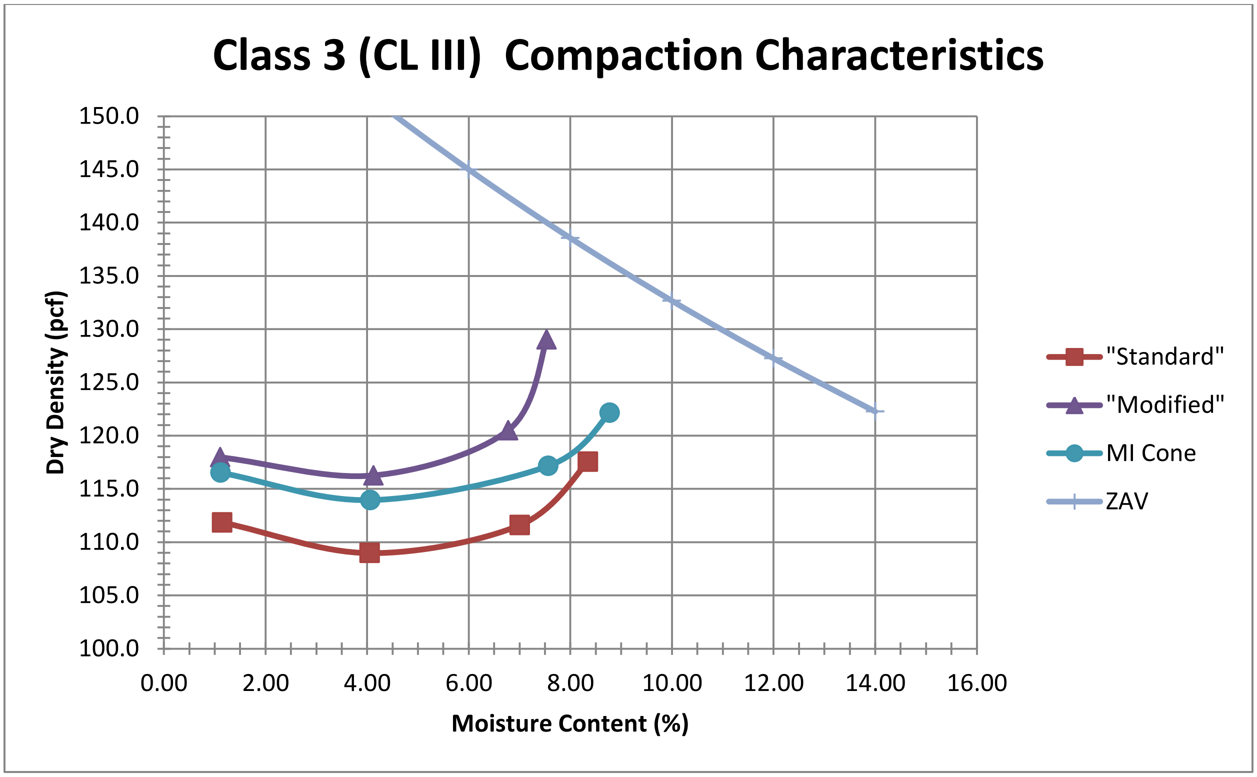

Figure 9 – Class 3 (CL III) sand moisture density relationships.

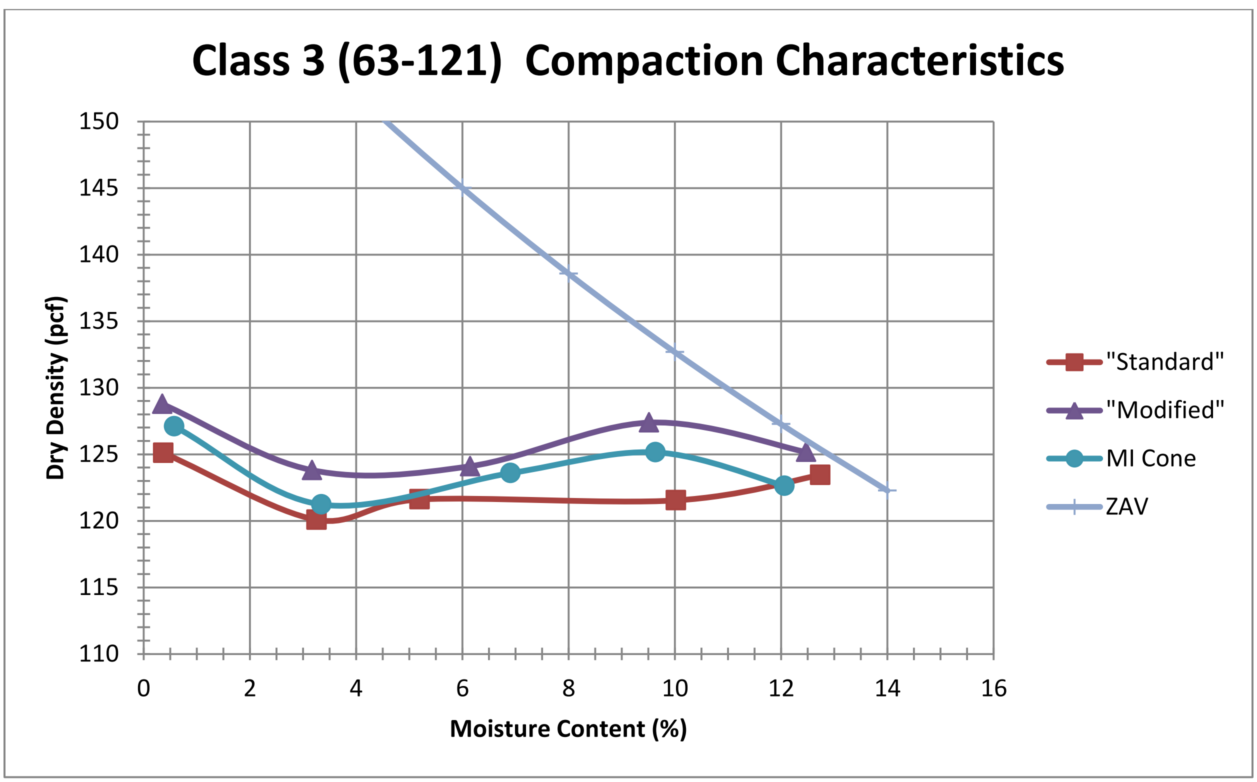

Figure 10 - Class 3 (63-121) sand moisture density relationships.

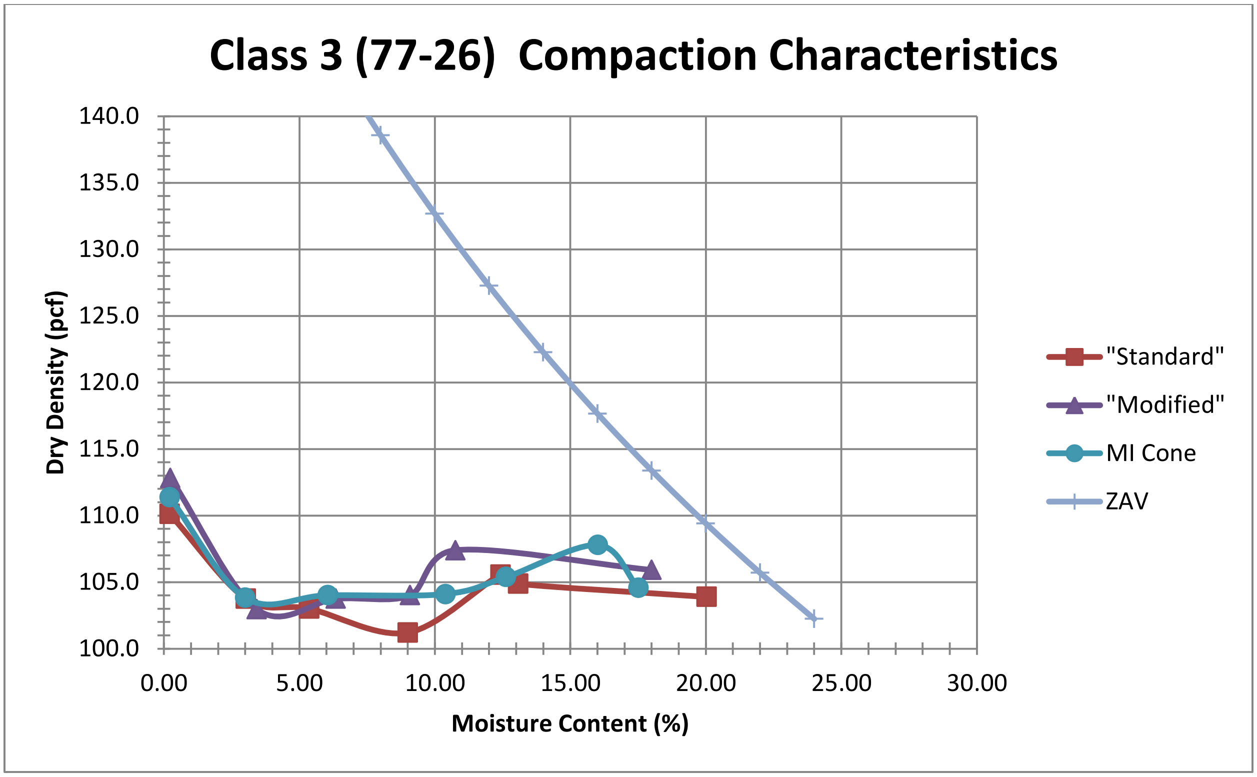

Figure 11 - Class 3 (77-26) sand moisture density relationships.

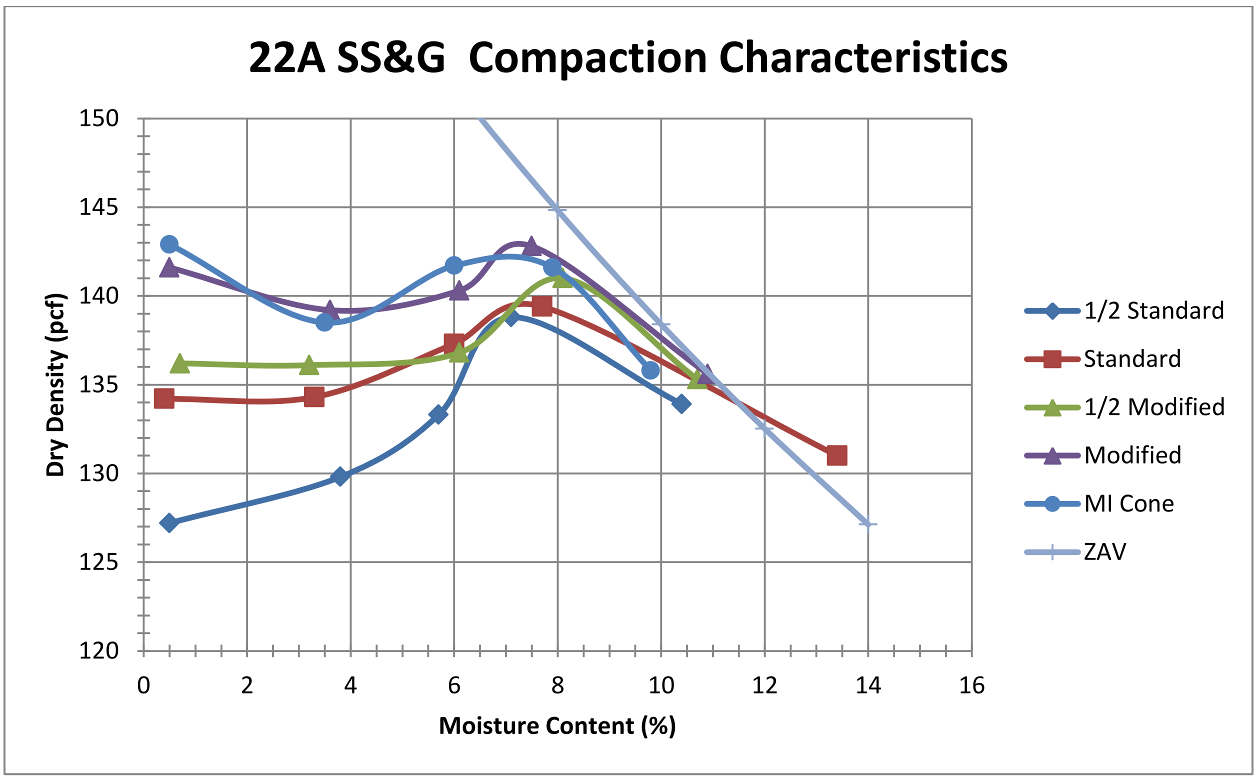

Figure 12 - 22A SS&G dense graded aggregate base moisture density relationships.

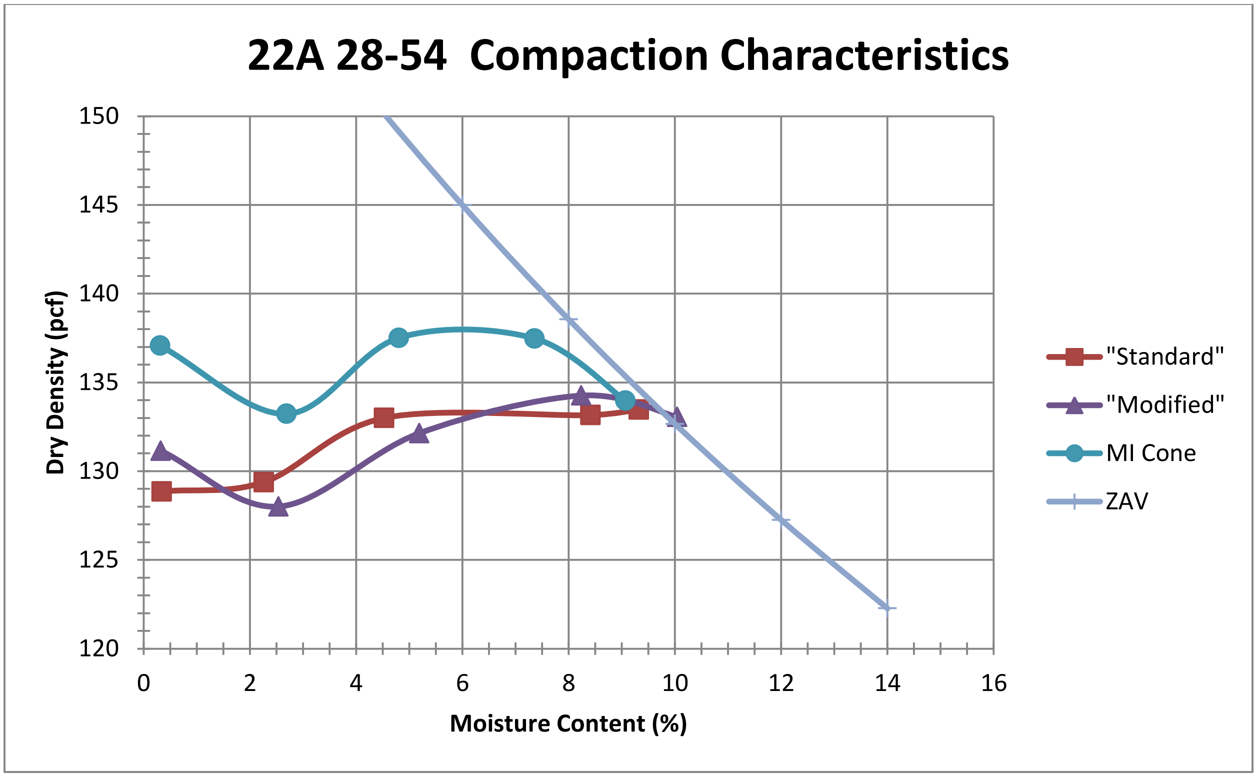

Figure 13 – 22A 28-54 dense graded aggregate base moisture density relationships.

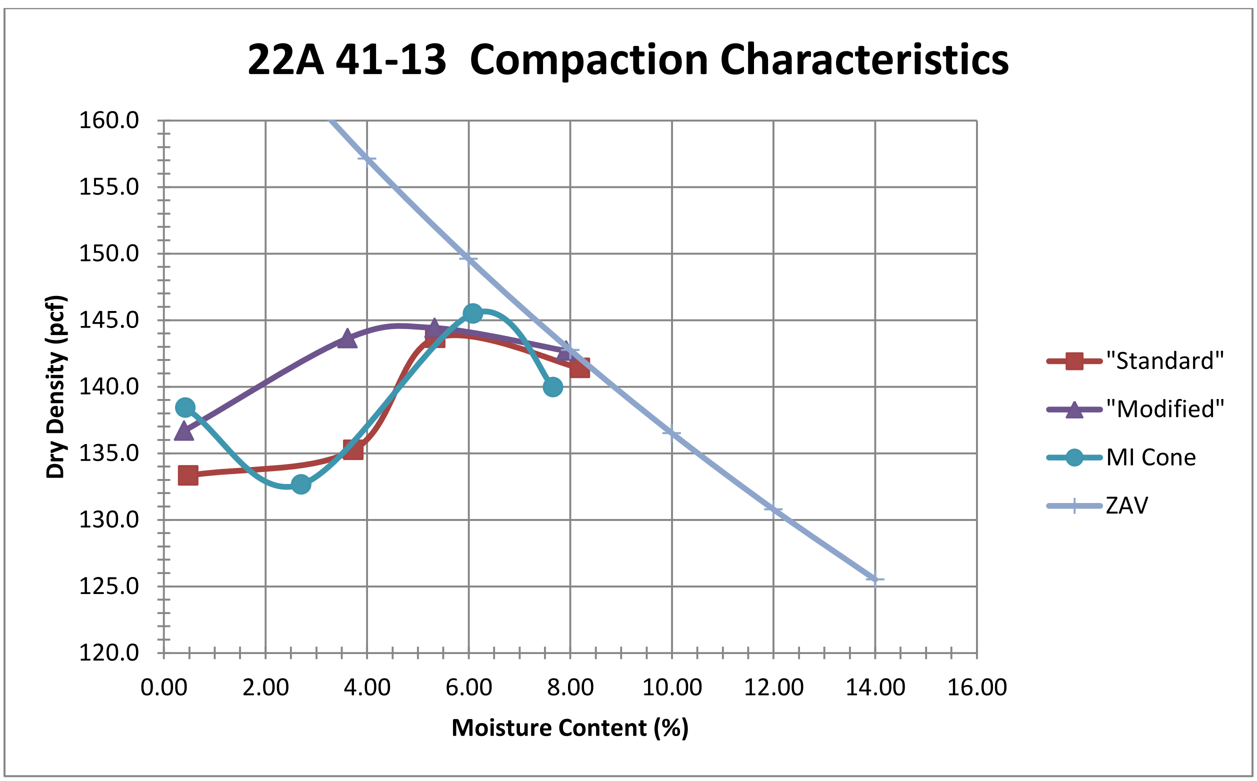

Figure 14 - 22A 41-13 dense graded aggregate base moisture density relationships.

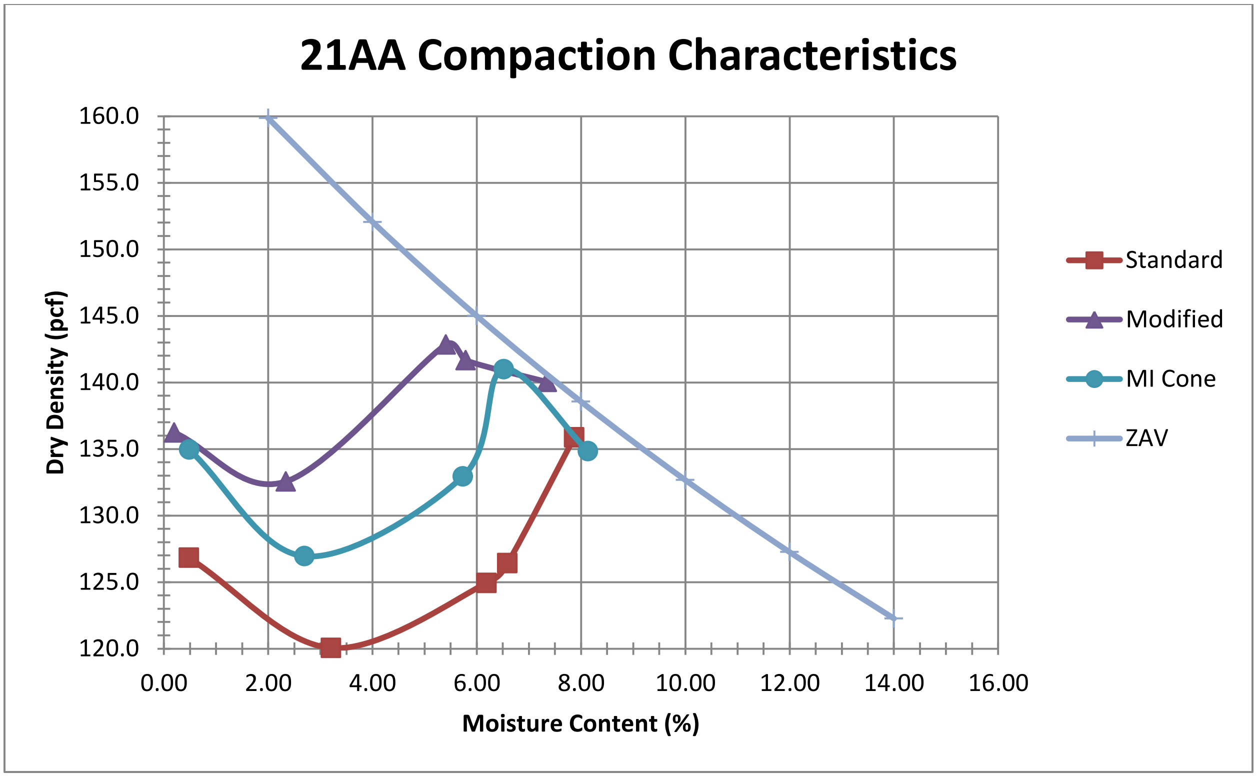

Figure 15 - 21AA dense graded aggregate base moisture density relationships.

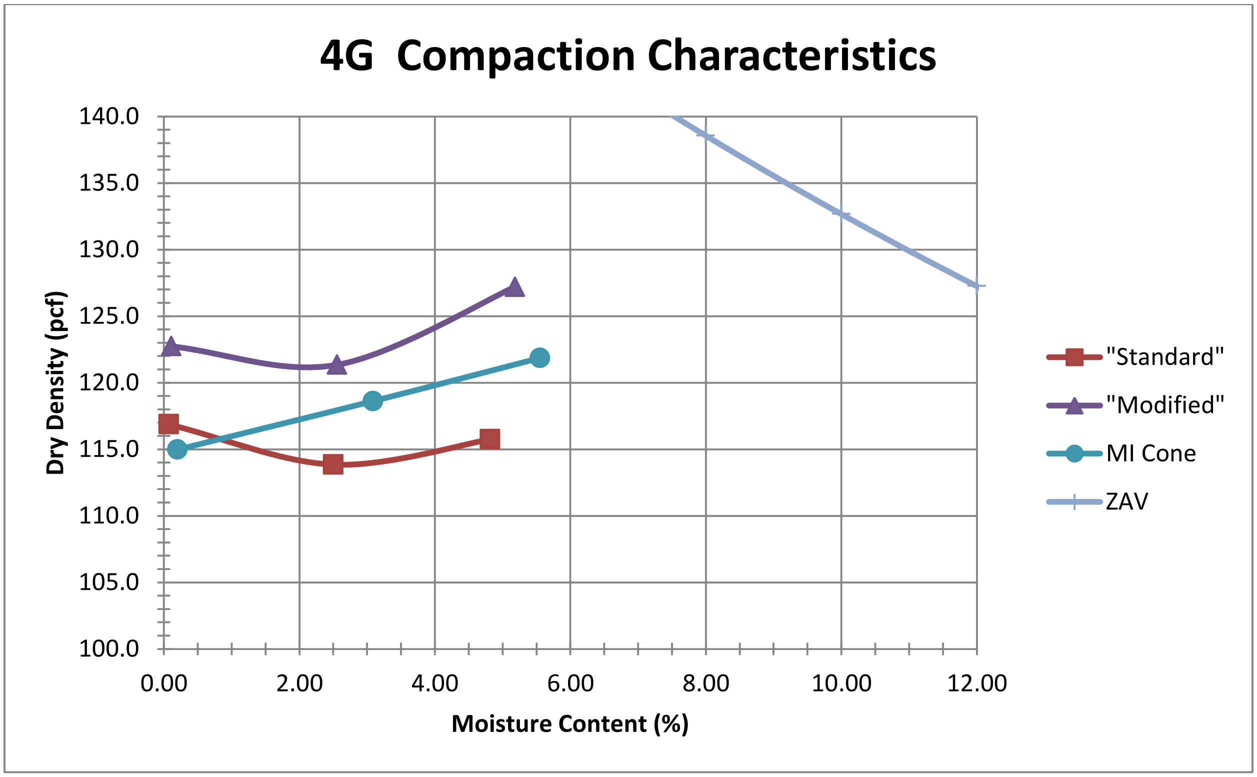

Figure 16 - 4G open graded aggregate moisture density relationships.

Data Analysis

Based on the above results, a number of factors are presented and discussed. These factors include the following items:

- Comparison of compaction methods
- Effects of particle crushing
- Single user repeatability
- Multiple user repeatability
- Particle segregation
- Proctor test input energy
- Michigan cone test input energy

Comparison of the standard Proctor, modified Proctor, and Michigan cone test results.

A summary of all peak dry densities for each sample is presented in Table 1. The Michigan cone values shown in Table 1 is an average of 15 tests for class 2, class 3, and 22A materials. For the 21AA material the average of 10 tests is reported for the Michigan cone, while five tests were averaged for the 4G material. As expected, the modified Proctor consistently yielded higher peak densities than the standard Proctor. The Michigan cone test matched the modified Proctor relatively closely. In some cases, the Michigan cone test had a higher density than the modified Proctor, and in some cases it was lower. However, in all cases the Michigan cone test had a higher density than the standard Proctor test.

Table 1 - Compaction Characteristic Results

Soil	Modified Proctor (MP) (pcf)	Standard Proctor (SP) (pcf)	(SP/MP) %	MI Cone (MI) (pcf)	(MI/MP) %
Class II	113.4	109.3	96%	111.1	98%
Class 2 77-26	108.8	105.9	97%	107.4	99%
Class 2 63-121	111.0	107.2	97%	110.5	100%
Class III	120.5	111.6	93%	120.4	100%
Class 3 77-26	107.4	105.5	98%	105.5	98%
Class 3 63-121	127.4	121.6	95%	125.4	98%
22A SS&G	142.8	139.4	98%	145.2	102%
22A 28-54	134.3	133.5	99%	138.8	103%
22A 41-13	144.4	143.7	100%	147.9	102%
21 AA	142.8	126.4	89%	133.3	93%
4G	127.2	115.7	91%	125.6	99%

Gradation Analysis: Effects of Particle Crushing

To determine the effects of particle crushing, each sample gradation was tested before and after compaction for the Michigan cone and modified Proctor tests. The reason this analysis was conducted was due to the observation of large particles crushing during the modified Proctor test. Figures 17 through 19 show the results of the before and after compaction testing. For sands (figure 17), particle crushing was not observed, since there is no change in the gradation before and after compaction. Sands transfer force through many more contact points than gravels or larger stones. This transfer results in minimal particle breakage.

Figure 18 shows the results for the 22A gradation. This gradation includes between 15 and 35 percent gravel. It is shown that there is a significant amount of crushing large particles from to the modified Proctor test. Note on figure 18 that the results of the before and after cone test are essentially identical and plot as one line.

Figure 19 shows the results for the 4G gradations. This gradation contains approximately 70 percent gravel. It can be seen that a large amount of crushing occurs with the modified Proctor. As is well known, particle crushing does occur with the modified Proctor test. In comparison, the Michigan cone test produces minimal crushing during compaction. This is beneficial, because the Michigan cone test is performed on post compacted material, so the cone test does not add additional breakage to the material. Additional particle crushing analyses for remaining samples can be found in appendix 1.

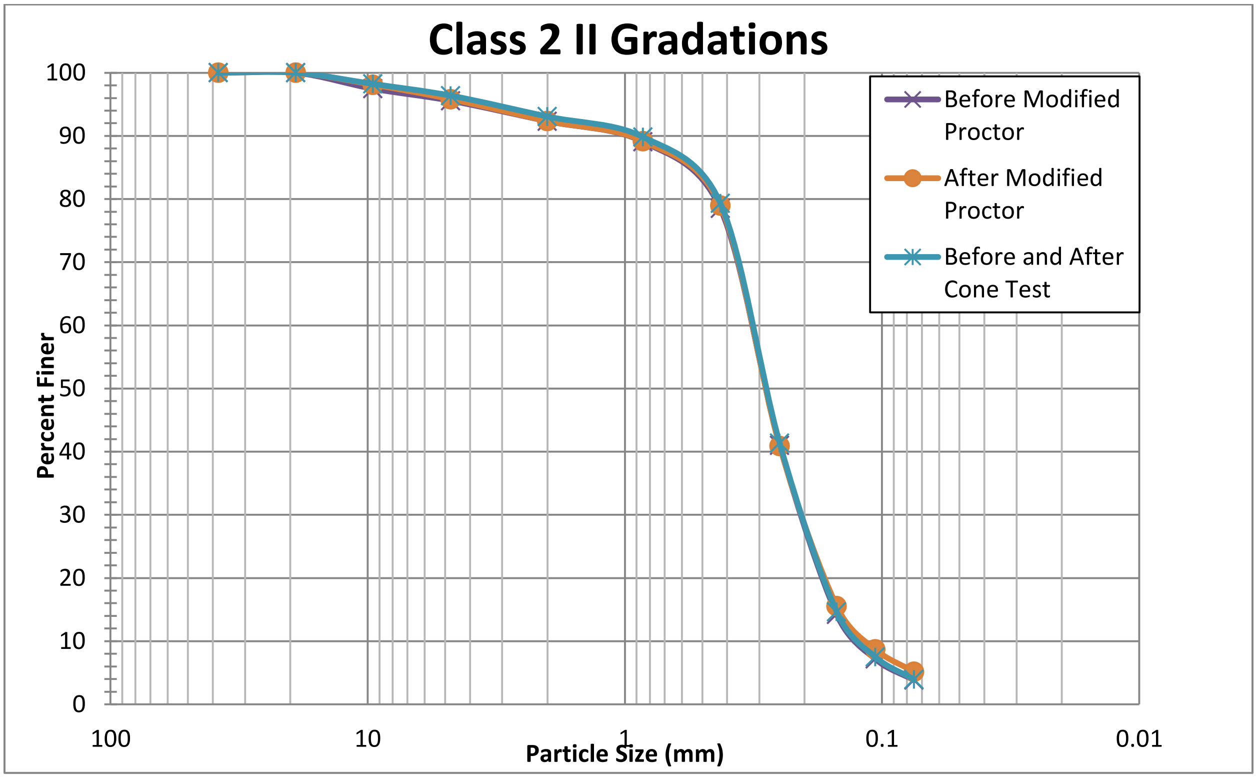

Figure 17 - Class 2 Sand particle crushing analysis.

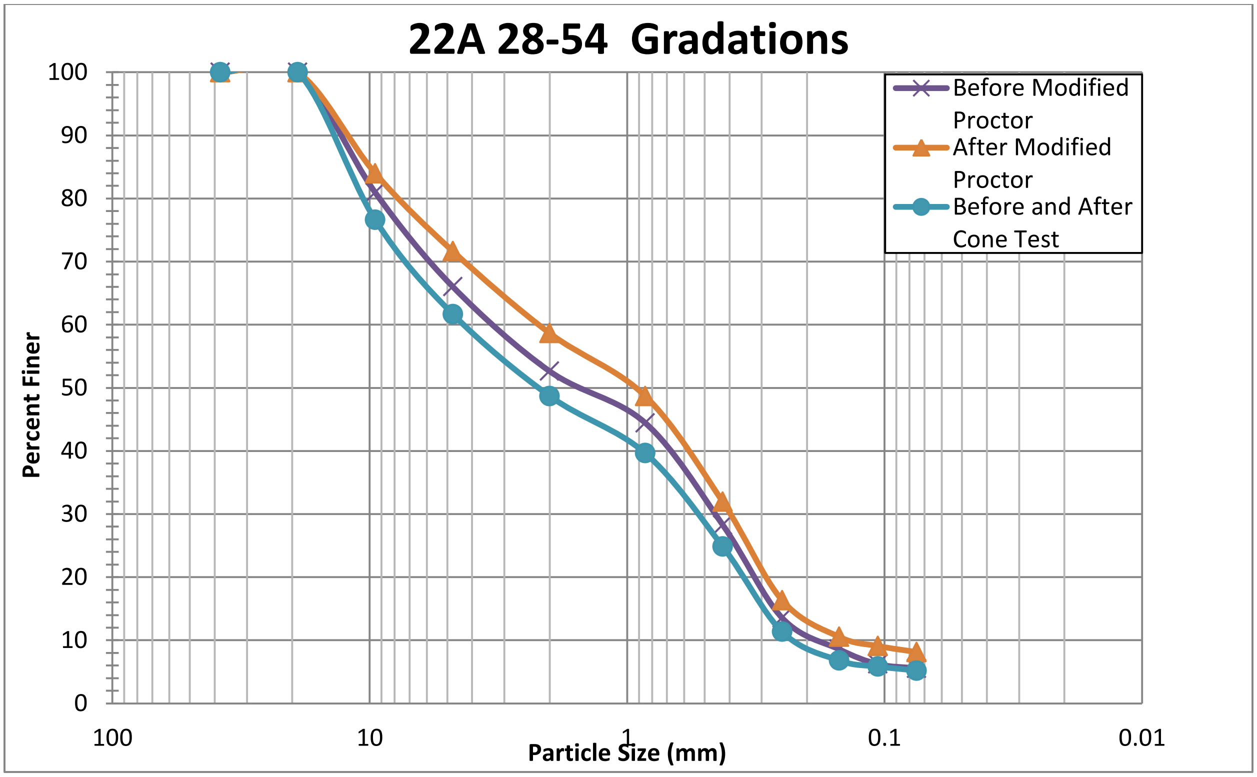

Figure 18 - 22A Gradation Analysis

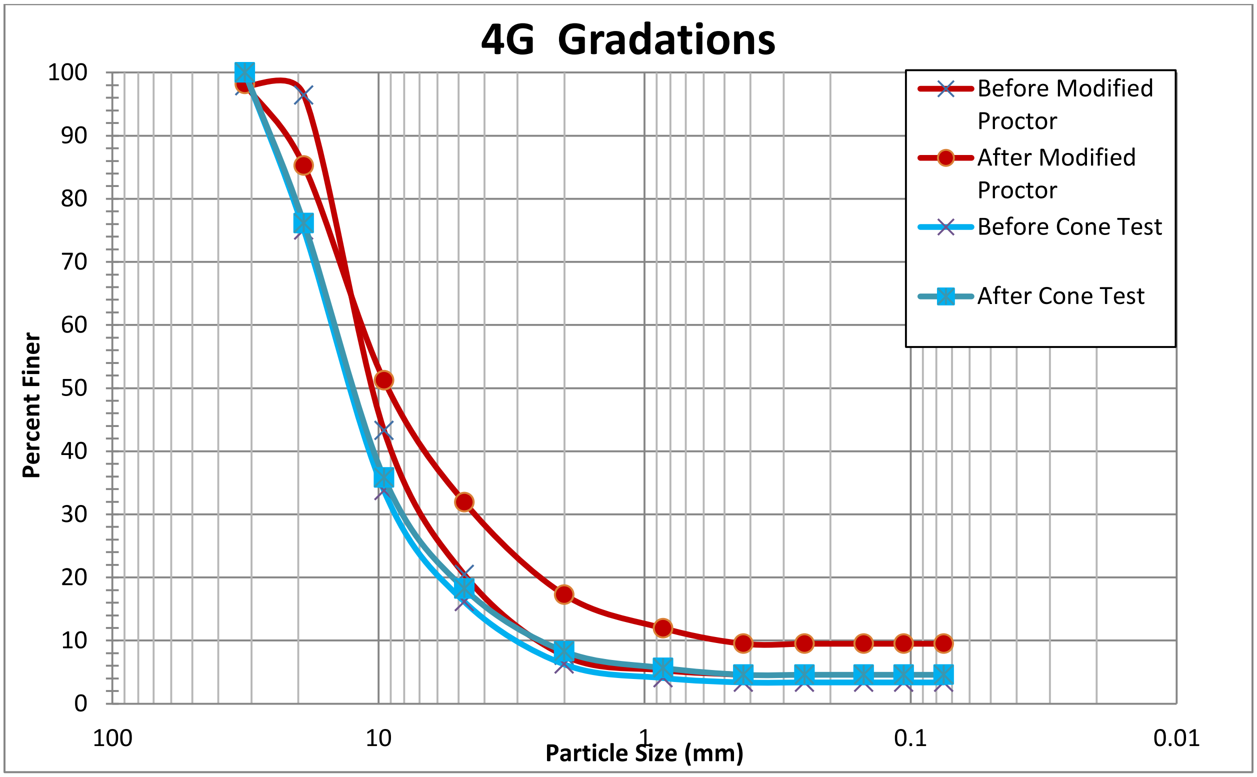

Figure 19 - 4G particle crushing analysis.

Single User Repeatability for the Michigan Cone Test

One of the main issues to be answered in this research is to determine the variability of the test with a single user. Table 2 presents the results of the Michigan cone tests from a single user. In general, the test data followed a normal distribution. This can be seen in figure 20, where the cone maximum densities for sample 22A are plotted against frequency forms a reasonable normal distribution. This distribution is based on 30 tests.

Based on research by Tavenas, Ladd and LaRochelle (1973), the modified Proctor method has a standard deviation of approximately 2.5 pcf for sands and gravels. Table 2 also presents one and two standard deviation results for a single user. For sands and 22A, the standard deviation for the cone test falls between 0.3 pcf and 2.2 pcf, which is less than what was found by Tavenas, Ladd and LaRochelle (1973). However, the larger gradations (21AA and 4G), had a standard deviation on the order of 4.1 pcf to 4.8 pcf, although fewer tests were conducted on these materials. Based on this limited amount of data, it can be concluded that the Michigan cone test is well within the repeatability of the modified Proctor test for a single user.

Table 2 - Single technician repeatability results.

Soil	Number of Tests	Average (pcf)	STDEV (pcf)	Min (pcf)	Max (pcf)	95% Confidence Interval (pcf)
CL II	10	111.1	0.3	110.7	111.7	±0.6
CL 2 77-26	10	107.4	0.9	106.7	109.5	±1.8
CL 2 63-121	10	110.5	1.2	108.3	112.5	±2.4
CL III	10	120.4	1.7	118.0	122.9	±3.4
CL 3 77-26	10	105.5	1.0	104.6	108.2	±2.0
CL 3 63-121	10	125.4	1.6	122.5	127.2	±3.2
22A SS&G	30	145.2	2.2	140.0	149.8	±4.4
22A 28-54	10	138.8	1.2	136.9	141.2	±2.4
22A 41-13	10	146.7	1.2	144.7	148.6	±2.4
21 AA	8	133.3	4.8	141.6	127.1	±9.6
4G	4	121.9	4.1	116.1	125.5	± 8.1

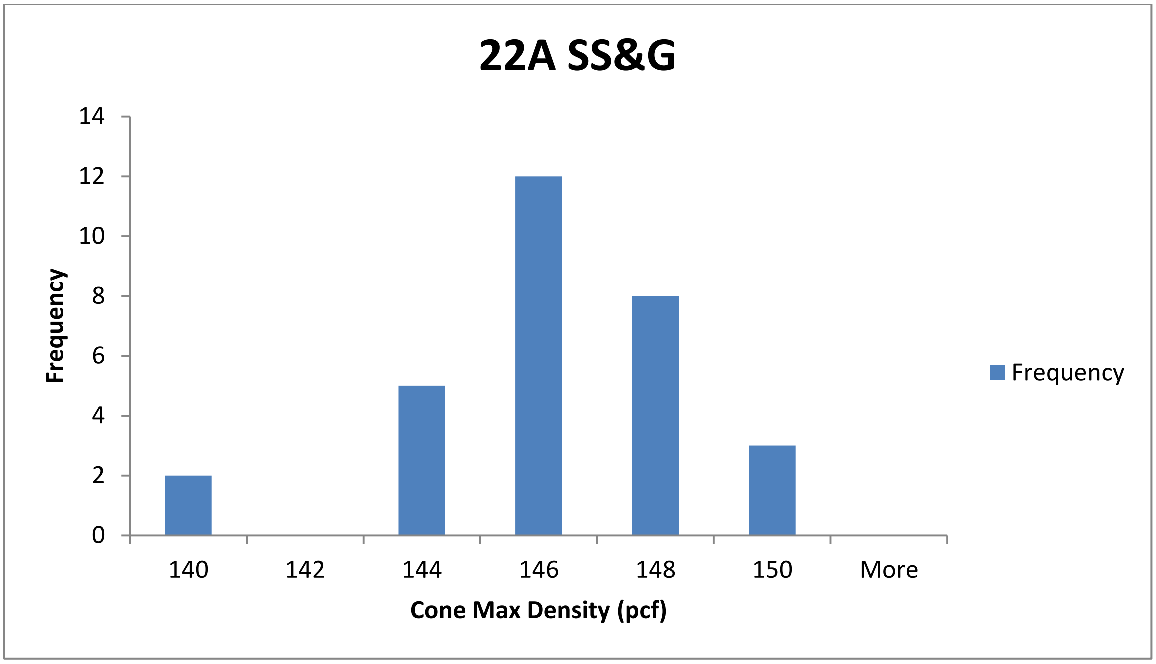

Figure 20 - Histogram of sample 22A SS&G data points, showing a normal distribution trend.

Multiple User Repeatability of the Michigan Cone Test

Table 3 and table 4 show the repeatability statistics for multiple users performing Michigan cone test. Three technicians each performed five repeat trials on six selected soils. The technicians each employed a different hitting style when performing the tests in an attempt to better determine the effects of multiple users. Consequently, the purpose of varying the styles for each technician was to maximize the variability associated with the user input. The resulting data therefore represents the widest possible range to be expected from the cone test. The confidence interval shown in table 3 takes into consideration data from all three technicians. When comparing the standard deviation for multiple technicians to that of a single technician in table 4, it can be observed that the variability increases and almost doubles when multiple technicians are performing the tests. It should be noted that for most soils, excluding 21 AA and 4G, the standard deviation ranges from 1.5 pcf to 2.2 pcf, still better than the Tavenas, Ladd and LaRochelle (1973) estimation of repeatability using the modified Proctor. However, the larger gradations increased to 5.8 pcf to 6.1 pcf. Based on this limited amount of data, it can be concluded that the Michigan cone test is still within the repeatability of the modified Proctor test for a multiple user. Consequently, based on this data, it appears that the repeatability of the Michigan cone test is well within the repeatability of the laboratory based modified Proctor test for class 2 and class 3 sands as well as 22A. For 21AA and 4G, the cone test does produce slightly less reliable results than the modified Proctor test.

Table 3 - Multiple technician repeatability data.

<table>
<tr><td>Technician</td><td>Soil</td><td>CL II</td><td>CL 3 63-121</td><td>22A 28-54</td><td>22A 41-13</td><td>21 AA</td><td>4G</td></tr>
<tr><td rowspan="3">KMK</td><td>Number of Tests</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>4</td></tr>
<tr><td>Average (pcf)</td><td>114.2</td><td>126.6</td><td>138.1</td><td>147.9</td><td>139.0</td><td>121.9</td></tr>
<tr><td>STDEV (pcf)</td><td>0.6</td><td>1.3</td><td>1.2</td><td>1.4</td><td>2.4</td><td>4.1</td></tr>
<tr><td rowspan="3">JV</td><td>Number of Tests</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>3</td></tr>
<tr><td>Average (pcf)</td><td>115.6</td><td>128.0</td><td>140.4</td><td>148.4</td><td>140.3</td><td>125.6</td></tr>
<tr><td>STDEV (pcf)</td><td>0.5</td><td>1.5</td><td>0.7</td><td>1.5</td><td>2.2</td><td>4.9</td></tr>
<tr><td rowspan="3">#3</td><td>Number of Tests</td><td>5</td><td>5</td><td>5</td><td>5</td><td>5</td><td>3</td></tr>
<tr><td>Average (pcf)</td><td>112.5</td><td>123.9</td><td>136.2</td><td>146.0</td><td>128.4</td><td>113.5</td></tr>
<tr><td>STDEV (pcf)</td><td>1.2</td><td>1.6</td><td>1.1</td><td>1.3</td><td>2.1</td><td>1.3</td></tr>
<tr><td rowspan="3">Combined</td><td>Min (pcf)</td><td>111.2</td><td>122.3</td><td>134.5</td><td>144.1</td><td>125.8</td><td>112.4</td></tr>
<tr><td>Max (pcf)</td><td>116.1</td><td>122.3</td><td>141.2</td><td>150.2</td><td>143.3</td><td>130.0</td></tr>
<tr><td>95% Confidence Interval</td><td>±3.0</td><td>±4.4</td><td>±4.0</td><td>±3.4</td><td>±11.6</td><td>±12.2</td></tr>
</table>

Table 4 - MI cone repeatability comparison.

	Single User		Multiple Users	
Soil	**Average (pcf)**	**STDEV (pcf)**	**Average (pcf)**	**STDEV (pcf)**
CL II	111.1	0.3	114.1	1.5
CL 3 63-121	125.4	1.6	126.2	2.2
22A 28-54	138.8	1.2	138.2	2.0
22A 41-13	146.7	1.2	147.4	1.7
21 AA	133.3	4.8	135.9	5.8
4G	121.9	4.1	120.5	6.1

Particle Segregation During the Michigan Cone Test

During compaction of the larger aggregate gradations 22A, 21AA, and 4G, it was very apparent that larger particles were segregating upwards during the compaction. This was observed especially with the first two compacted layers. In addition, when the cone was almost filled, but yet needed additional material to top the cone off, only the smaller particles could be used, causing an additional stratification of the compacted material. Thus, small particles dominate the upper and lower regions of the mold while large particles concentrate in the center.

The effect of this on the resulting maximum density is difficult to quantify. If the segregation is severe, the result is most likely a lower density. Small material will have to filter down through the dense upper portion to fill voids in between the larger particles in the middle. Evidence of small particles filtering down can possibly be inferred by observing how the total weight of the sample increases by regular, small amounts after successive 20 hit intervals. For example, a sample with a large amount of segregation, i.e., large particles segregated towards the center of the cone, may require an additional five or more 20/10 trials before the maximum density is reached. However, according to the MDOT 20/10 rule, the test could be stopped before the maximum density is actually reached. That is, additional material can still be added after the test is considered complete, even though it increases less than 10 grams per interval, thus over several intervals a significant amount of material could be added. A possible solution to this segregation problem for larger size materials (21AA and 4G), would be to reduce the 20/10 rule to a 20/5 rule. One additional observation concerning segregation is that the total number of hits required to densify the 21AA and 4G was significantly greater than class 2, class

3, and 22A. A later section will discuss the total number of hits required to densify the aggregates in the Michigan cone test.

Evaluation of Energy Input for the Standard and Modified Proctor Test

The amount of energy input during compaction has a significant impact on the resulting dry density of the compacted soil. Loose soils will compact rapidly with small additions of energy, while more dense soils will require larger amounts of energy to see an appreciable increase in density. The standard Proctor test inputs a moderate energy level; therefore the resulting densities are always less than the modified Proctor. The modified Proctor on the other hand inputs a high level of energy, and is often assumed to compact the soil to the maximum density. As noted previously, the maximum density here refers to the limit that conventional compaction equipment can achieve.

To illustrate the relationship between compaction energy of the standard and modified Proctor test, the energy input during a Proctor test was determined by multiplying the weight of the hammer, times the height of the drop, times the number of drops. The energy input was also normalized to the volume of the compacted sample. Four compaction tests using a 22A aggregate were tested. Two of the tests were conducted using the standard and modified Proctor test procedure, while two additional tests were conducted applying only half of the required hits for a standard and modified Proctor test respectively. The results of the testing are presented in figure 21. The trend, shown in figure 21, is clearly logarithmic suggesting that the modified Proctor is near the maximum density for the aggregate. Additional energy input will continue to increase the density of the sample, but with minimal gain.

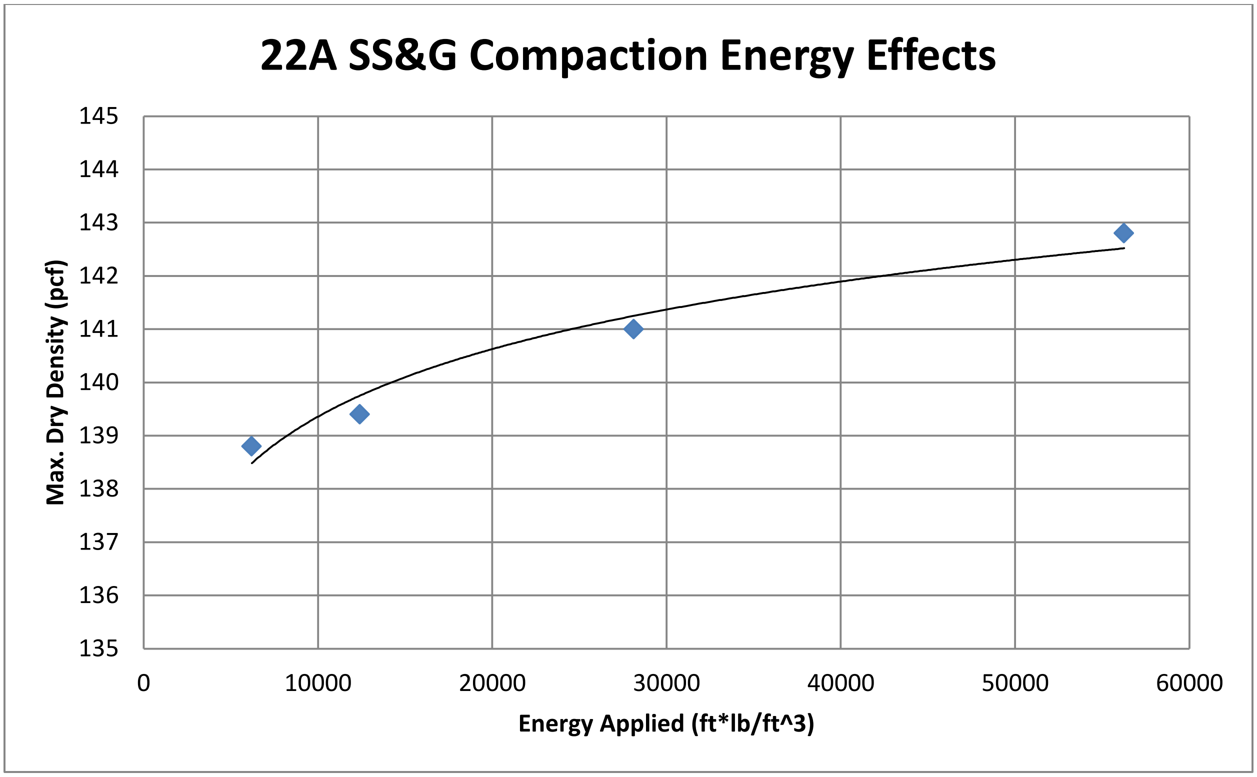

Figure 21 – Proctor energy density relationship.

Evaluation of Energy Input During the Cone Test

A set of three cone tests were performed with modifications of the standard procedure to track the densification as the test progressed. The procedure was modified by filling the cone completely at the beginning of the test, weighing it to determine the density, and compacting with 20 blows. The test continued with filling the cone and compacting it with 20 blows, until the cone was completely filled, meeting the 20/10 rule. This way the density could be calculated at each stage of the test. This procedure was conducted three times using different energy inputs, which consisted of striking the cone lightly (first test), moderately (second test), and lastly hard (third test).

The results from this testing are shown in figure 22, where the relationship between dry density and the number of hits applied is presented. The number of hits applied is directly proportional to the energy input for each test. It can be seen from figure 22 that for the early stages of the test when the sample is loose, the soil compacts at the same rate regardless of the energy per hit. This portion of the curve is controlled by the number of hits, not necessarily the total energy input. However, as the test progresses and the soil becomes denser, the energy input per hit becomes significant. Figure 22 also shows that the level of energy input of the cone striking the block does not necessarily have to be hard. That is, moderate hitting of the wooden block produced the same results as the hard hitting.

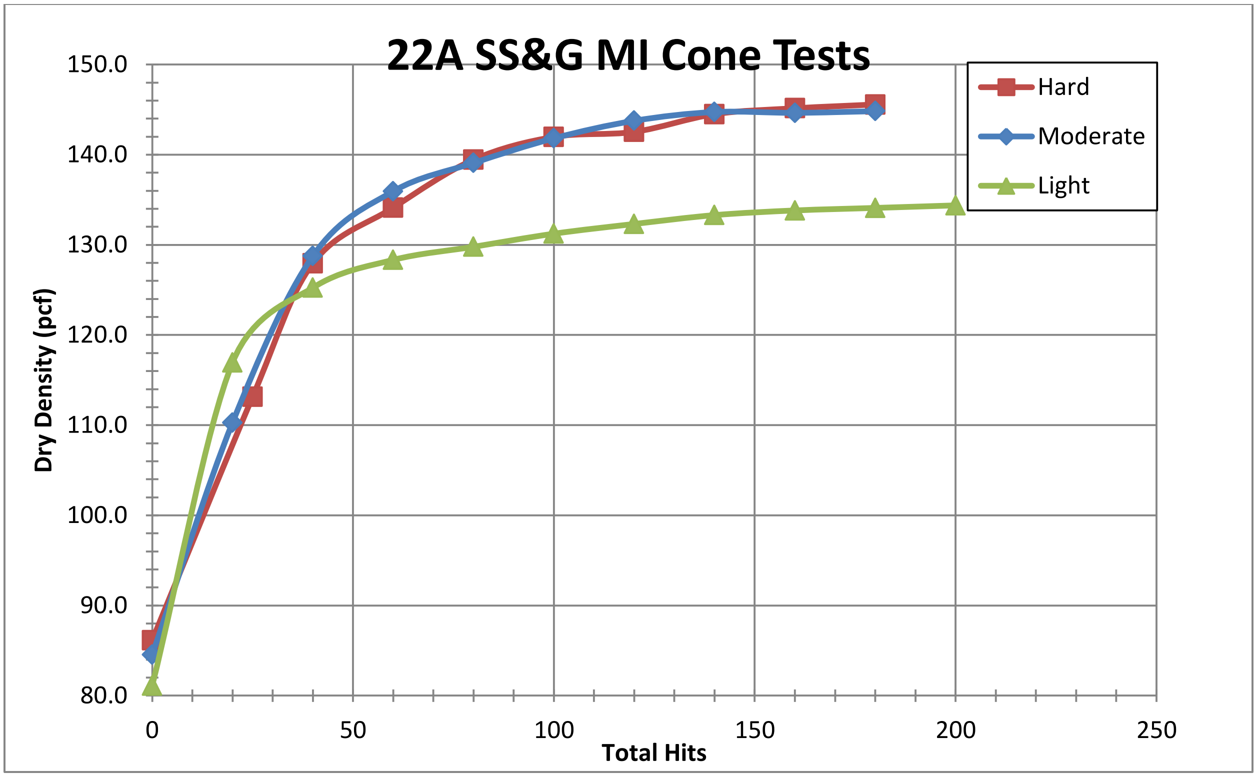

Figure 22 - MI cone energy density relationship

To investigate the actual force of the cone hitting the wooden block, a force accelerometer was attached to the base of the cone as described above. An additional consideration was the surface on which the block was placed. In the field, blocks are generally placed on soil, while in a laboratory a block is generally placed on a concrete floor. Figure 23 and figure 24 show the acceleration time histories of the cone hitting the block placed on both sand and concrete surfaces. The peak acceleration, shown in figure 23, was very similar for both the concrete base and sand base when normal hits were used; the peak accelerations were 629 g and 615 g respectively, however the first rebound acceleration varies greatly with material. Sand rebound was 488 g and concrete was 586 g. The variation in rebound acceleration can be explained by the damping effect sand has on the system. Concrete is a rigid material, which transmits energy well. On the other hand, sand is a particulate material which damps energy. Figure 24 shows a detailed acceleration time history of a single hit on both concrete and sand. Both hits have similar peak accelerations; however the concrete hit takes more time to damp out. The resulting densities for testing on sand versus on concrete, however, indicated that there was no difference even though the acceleration curves show different damping characteristics.

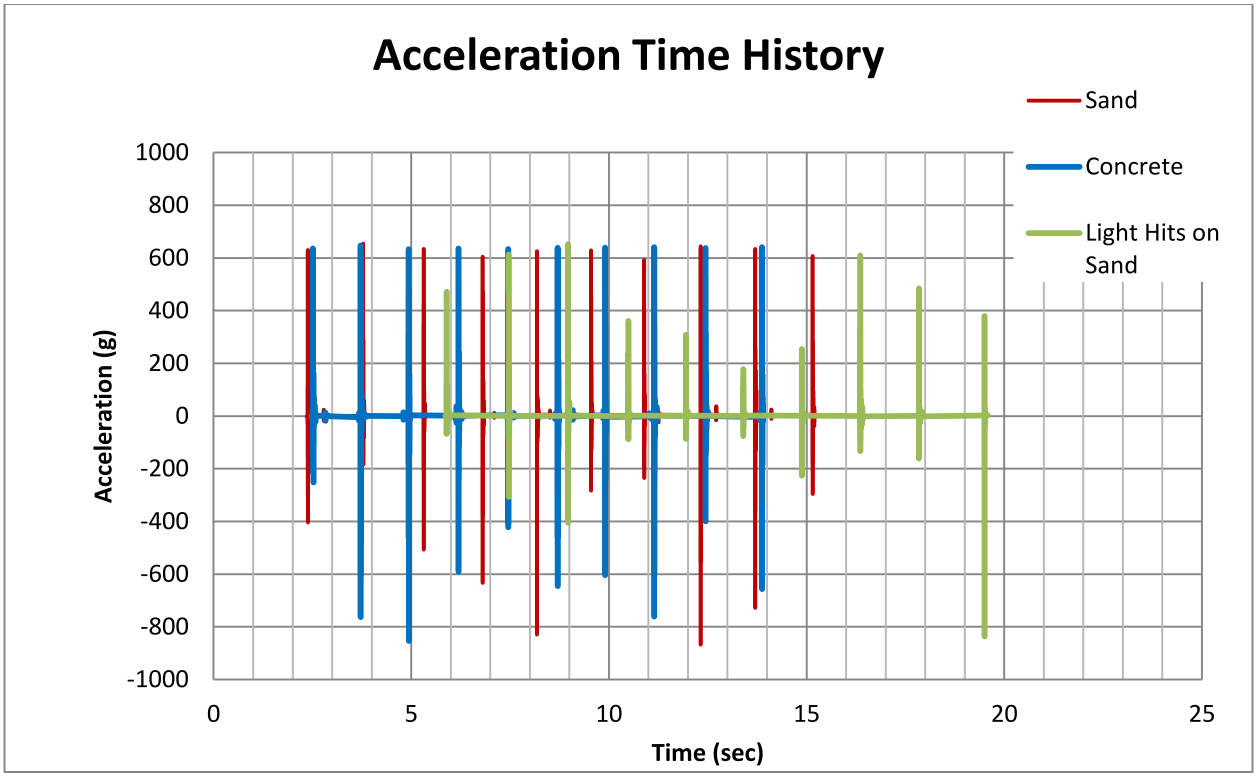

Figure 23 - Comparison of different base materials.

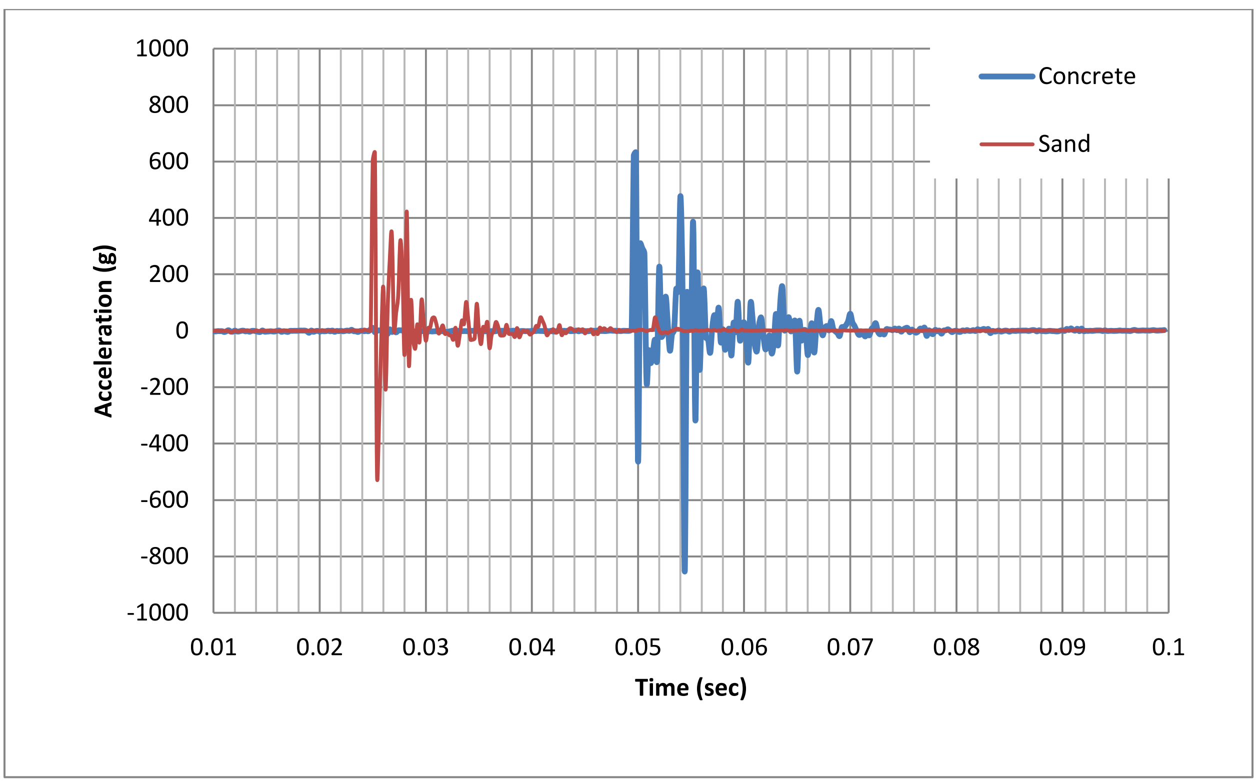

Figure 24 - Detailed base material comparison.

Figure 25 compares the acceleration time histories for two experienced technicians, where tests were performed with sand below the block. Both records are extremely similar, indicating that trained testers should generate reliable results.

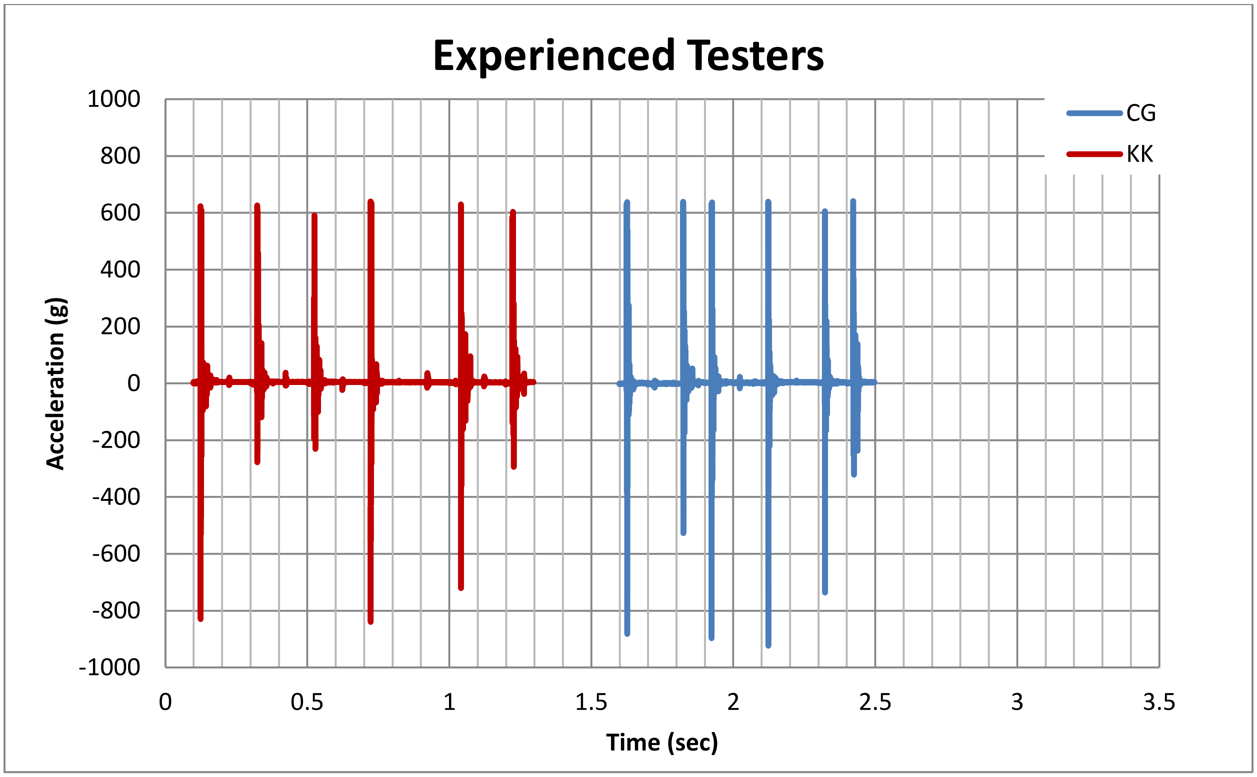

Figure 25 - Trained technician accelerometer comparison.

Figure 26 shows the acceleration time histories for five students with no prior experience with the cone. Students were instructed in the proper method for hitting the cone according to the M-DOT Density Testing and Inspection Manual (M-DOT 2003). This data shows that for the majority of hits, the inexperienced students perform as consistently as a trained technician. However, in some instances, the students did not hit the cone sharply or as square as directed. These are indicative in the peak accelerations lower than the 600 g peak. It is expected that with even little practice, an inexperienced technician will be able to perform a test as reliably as a fully trained and experienced technician, based on the acceleration records. In general, it appears that minimal error can be attributed to differences in hitting style.

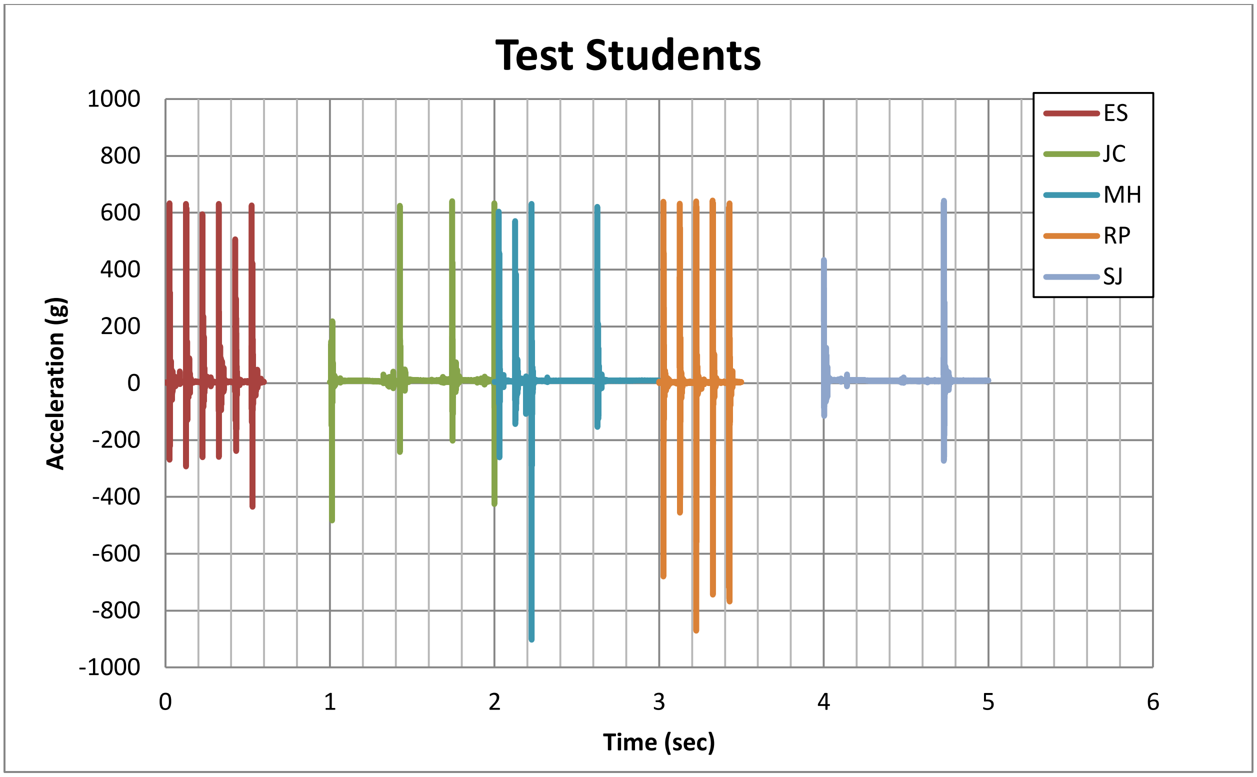

Figure 26 - Inexperienced student accelerometer comparison.

The acceleration records can also be used to determine the energy input for a cone test. A typical acceleration curve was analyzed by integrating the area under the first peak of the acceleration curve to determine velocity. Velocity was then used to calculate an approximate amount of energy input per hit. This was accomplished by multiplying one half the mass of the soil in the cone times the velocity squared ($E=\frac{1}{2}mv^2$). Only the first peak was integrated, with the assumption that the additional vibrations canceled each other out and could be neglected. The calculation showed that approximately 20 ft*lb of energy was input by each hit. The total amount of energy was determined by multiplying the total number of hits by 20 ft*lb per hit. The total energy input during the test was normalized by the volume of the sample. Table 5 presents the energy estimated for each type of aggregate tested in this research. It can be seen from table 5, that for all samples, the average energy input during the Michigan cone test is greater than the energy input for modified Proctor test, which is approximately 56,300 ft*lb/ft^3.

Table 5 - Hit counts required to complete cone tests

Soil	Number of Tests	Minimum Blows per Test	Maximum Blows per Test	Average # of Blow per Test	Average Energy Per Test (ft*lb/ft^3)
CL II	25	120	170	136	65,400
CL 2 77-26	10	130	150	136	65,400
CL 2 63-121	10	130	160	150	72,100
CL III	10	140	190	172	82,700
CL 3 77-26	10	130	170	141	67,800
CL 3 63-121	25	130	170	141	67,800
22A SS&G	21	140	230	172	82,700
22A 28-54	25	130	170	148	71,200
22A 41-13	25	150	200	169	81,300
21 AA	21	230	350	274	131,700
4G	10	180	370	275	132,200

Conclusions and Recommendations

The Michigan cone test has been used for over 50 years in the state of Michigan. Recently, questions have been raised concerning the accuracy and reliability of this test. To address these concerns, a research program was conducted to investigate the history of the cone test, its accuracy compared to the modified Proctor test, which it is assumed to be equivalent to, and to determine the reliability of the cone test. The testing program investigated 11 aggregate types consisting of class 2, class 3, 22A, 21AA, and 4G gradations. The major conclusions from this research are provided below.

1. The Michigan cone test was developed by William Housel in the 1940's at about the same time the modified Proctor was developed. In 1958, the cone test was considered by ASTM as a suggested test method for compaction of soils, but was not accepted. However, the MDOT did adopt the test as a method for field testing. At some point during the early use of the cone test, it was found that the Michigan cone test simulated the modified Proctor test. However, there was no data to collaborate this claim.
2. The testing of the 11 samples, which represented five gradations, determined that the Michigan cone test, in general, replicates the modified Proctor test, and in all cases is greater than the standard Proctor test.
3. Particle crushing was observed in the modified Proctor test, especially with the larger gradations such as 21AA and 4G. The Michigan cone test, however, showed minimal crushing. Since the Michigan cone test is conducted on post compacted materials, particle breakage is minimized and thus is more representative of the required compacted density in the field.
4. The results of the cone density testing generally followed a normal distribution, allowing for the use of averages and standard deviations to be calculated.
5. Single user repeatability tests showed that the standard deviations for the Michigan cone test were less than published results for the modified Proctor test for class 2, class 3, and 22A. However, the standard deviations for 21AA and 4G were slightly higher than published results for the modified Proctor test.
6. Multiple user repeatability tests showed that the standard deviations for the Michigan cone test were still less than published results for the modified Proctor test for class 2, class 3, and 22A. However, the standard deviations for 21AA and 4G were slightly higher than published results for the modified Proctor test.
7. Particle segregation during testing was observed for the larger gradations 21AA and the 4G, which the larger particles tended to concentrate towards the center of the cone. This could be inferred by the large number of hits required to reach maximum density. In general, the number of hits required for 21AA and 4G was almost twice that of the class 2, class 3, and 22A gradations. The reason speculated for this is that the finer materials must migrate into the large openings in the center of the cone, requiring additional hits to accomplish maximum compaction. However, the amount of increase is relatively small

and could be in the range of 10 grams or less, which according to the 20/10 rule, causes the test to stop, therefore not reaching maximum compaction. That is, small amounts of finer material are possibly still working their way into the voids of the larger particle sizes.

8. Analysis of tests in which the cone was hit lightly, moderately, and hard indicated that the same density can be achieved by either moderate or hard hitting.
9. The resulting densities for testing with the block placed on sand versus on concrete bases, however, indicated that there was no difference in density results even though the acceleration curves show different damping characteristics between the sand and the concrete base.
10. The recorded accelerations between two trained technicians showed virtually identical results. Additional testing with non-trained individuals also showed relatively consistent recorded accelerations.
11. The cone test inputs more energy per volume of soil compacted than the modified Proctor test.

Based on testing results presented in this report and the above conclusions, the following recommendations are made.

1. The cone test is a viable and repeatable test, however, additional testing should be conducted, especially with the larger gradation sizes such as 21AA and 4G. There is clear segregation occurring which needs to be better understood in regards to its effect on maximum density.
2. In addition, a major problem is that larger gradations require at least twice the number of hits per test. It is possible that a larger cone may work better, but this would increase the weight of the cone, making it a more difficult test to conduct.
3. Class 3 materials, especially materials near the 15% fines limit, should be investigated as to whether these materials do not reach maximum density due to the possibility of pumping.
4. The Michigan cone test could be automated with the design of a mechanical apparatus to perform the compaction.

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Appendix

Appendix 1 – Gradation Curves

Appendix 2 – Soil Testing Data

4G

21AA

22A SS&G

22A 28-54

22A 41-13

CL II

CL 2 63-121

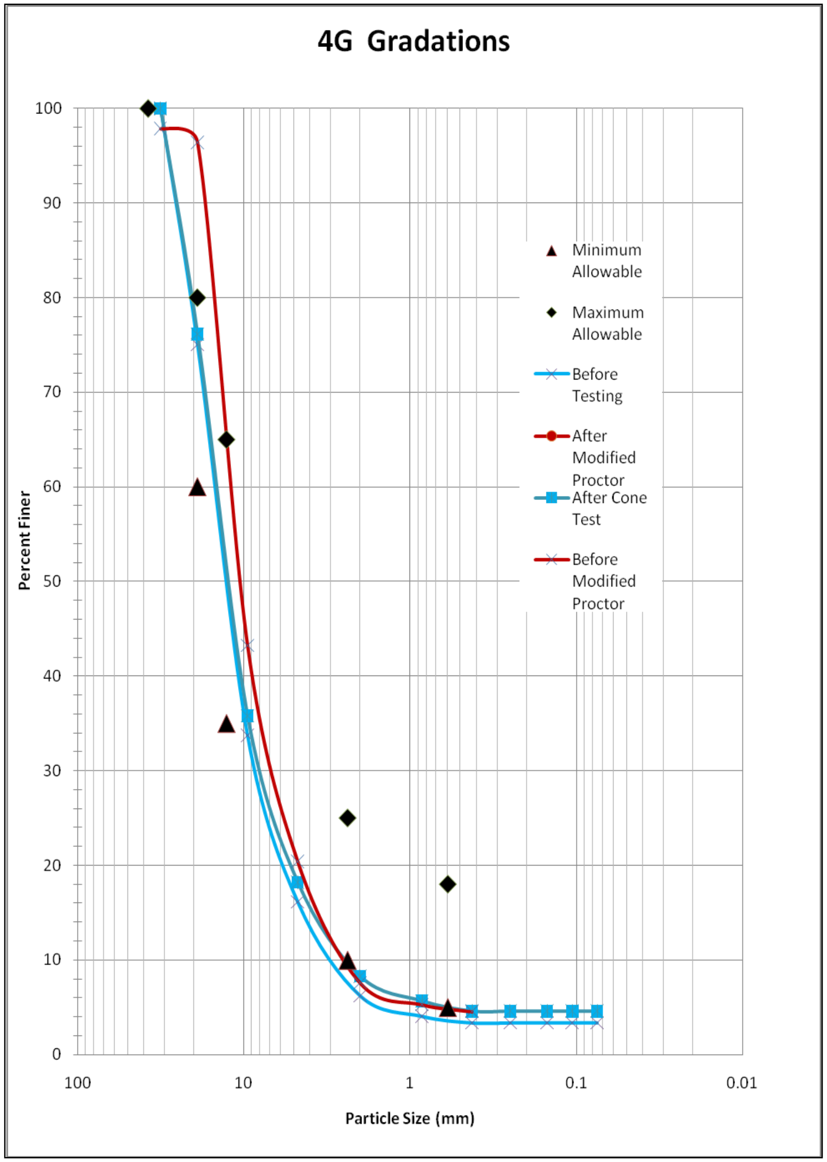
CL2 77-26

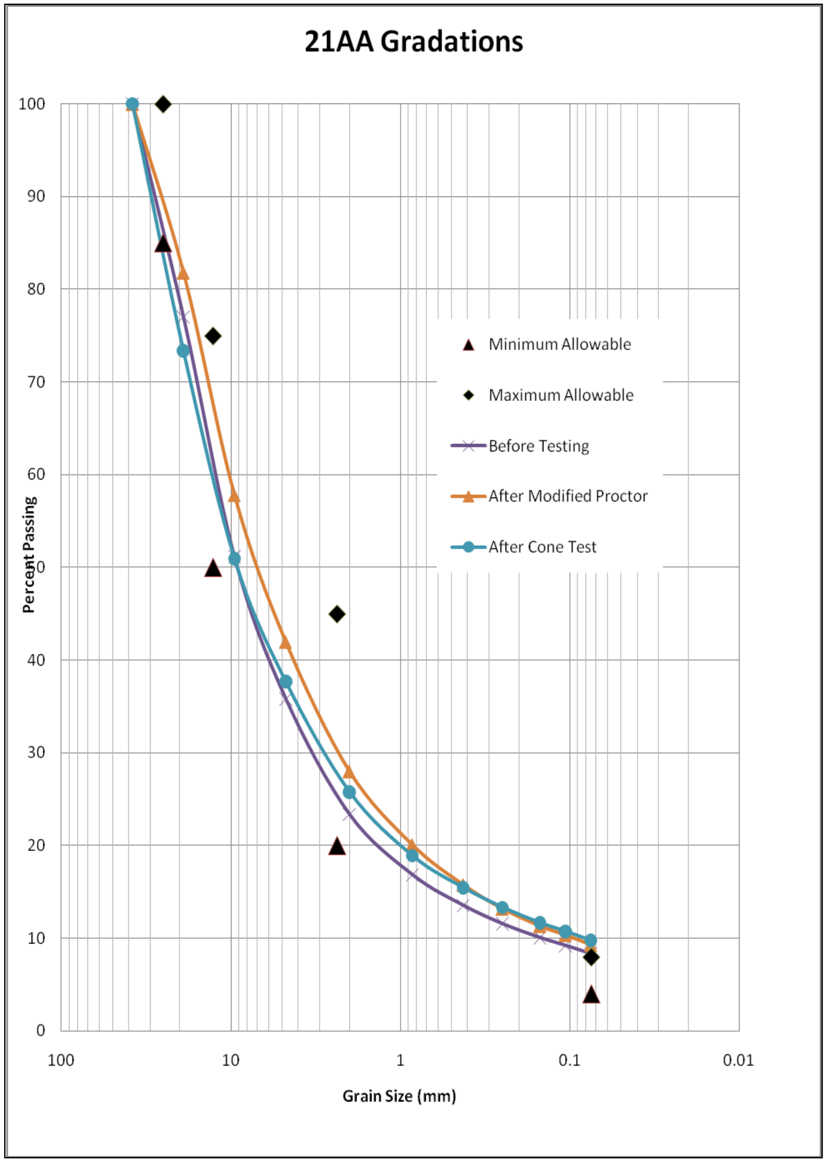
CL III

CL 3 63-121

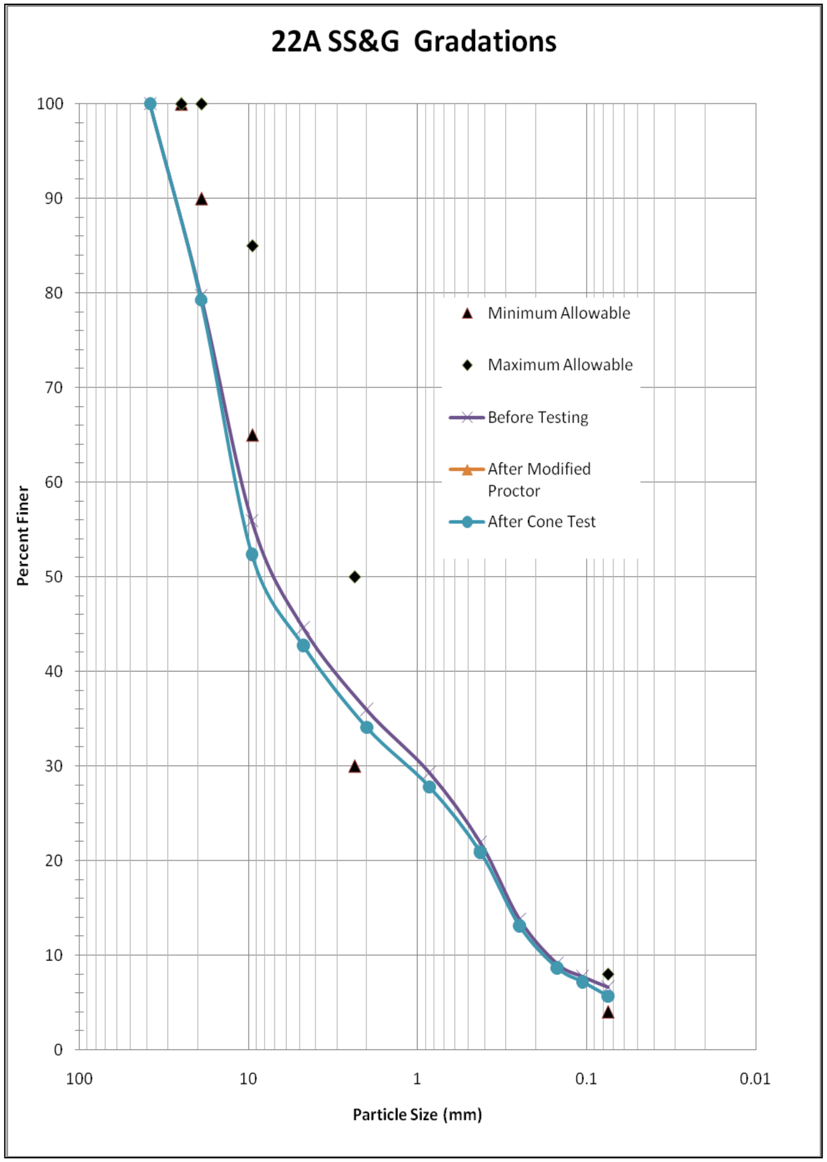
CL 3 77-26

Appendix 1 – Gradation Curves

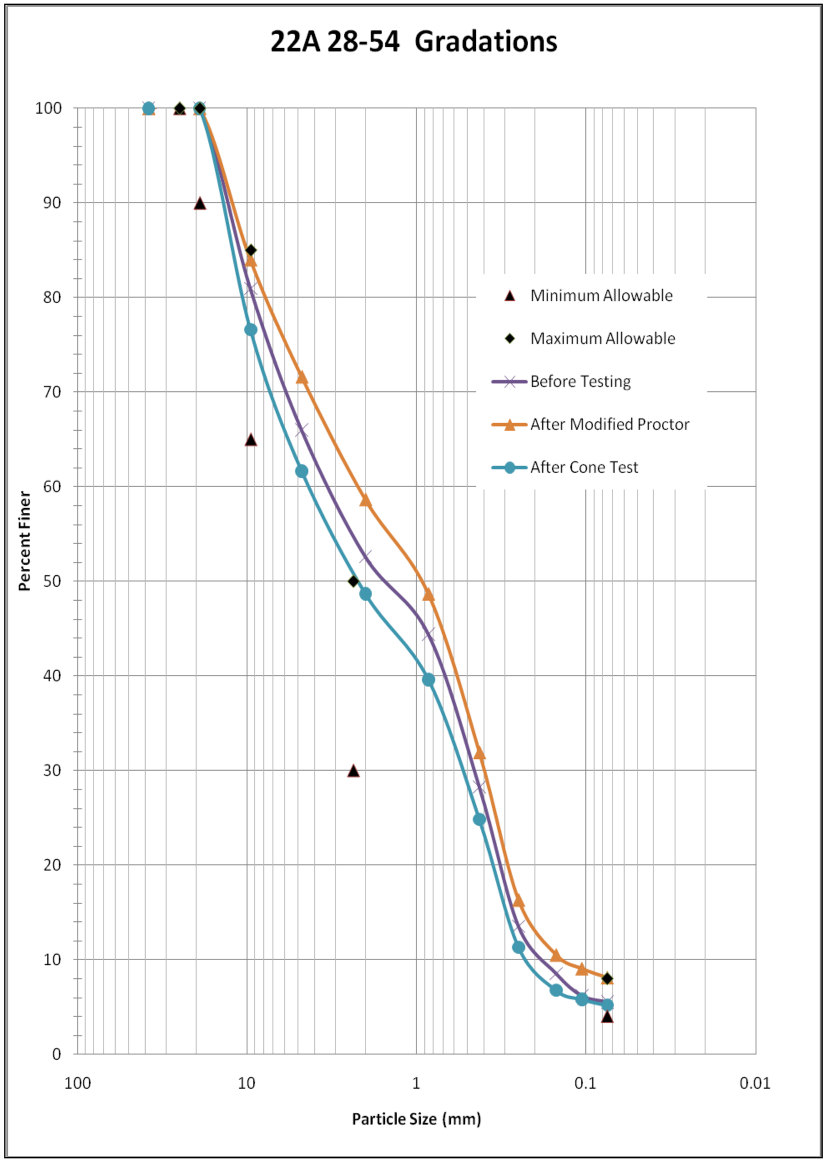




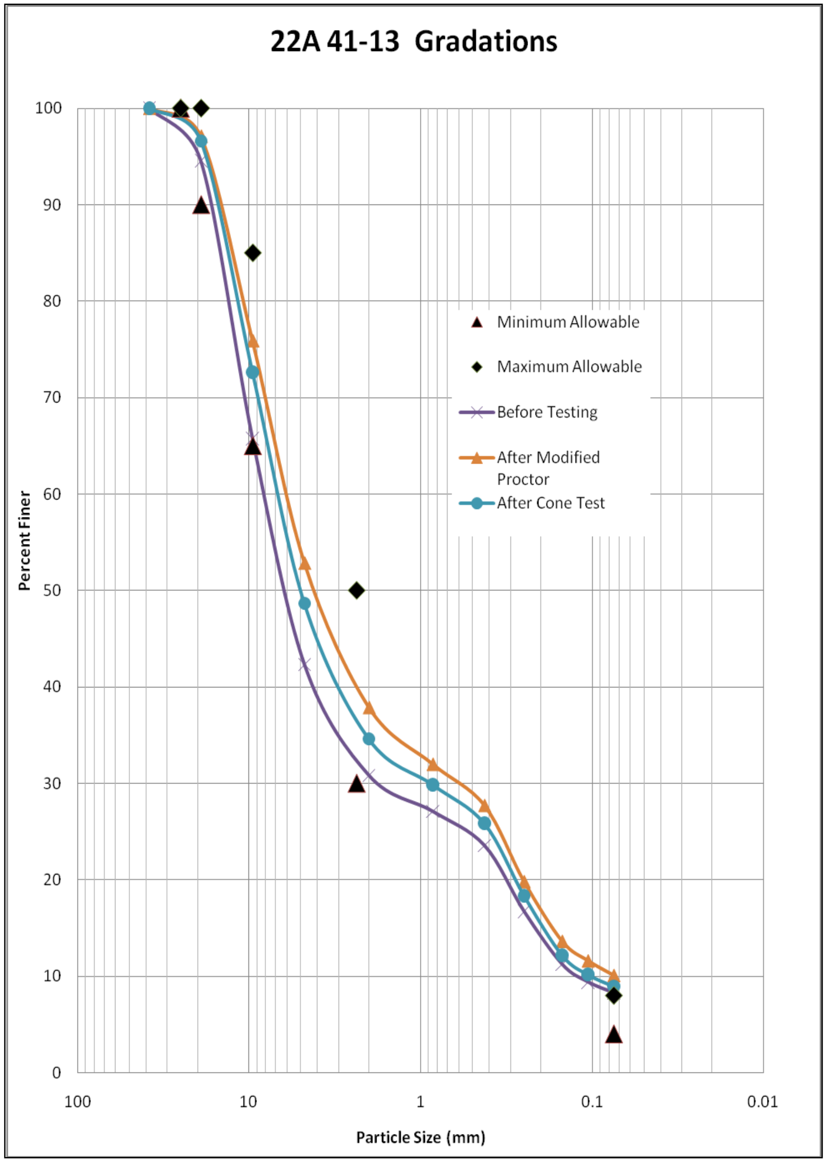
21AA Gradations
Percent Passing
Grain Size (mm)
Minimum Allowable
Maximum Allowable
Before Testing
After Modified Proctor
After Cone Test
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01



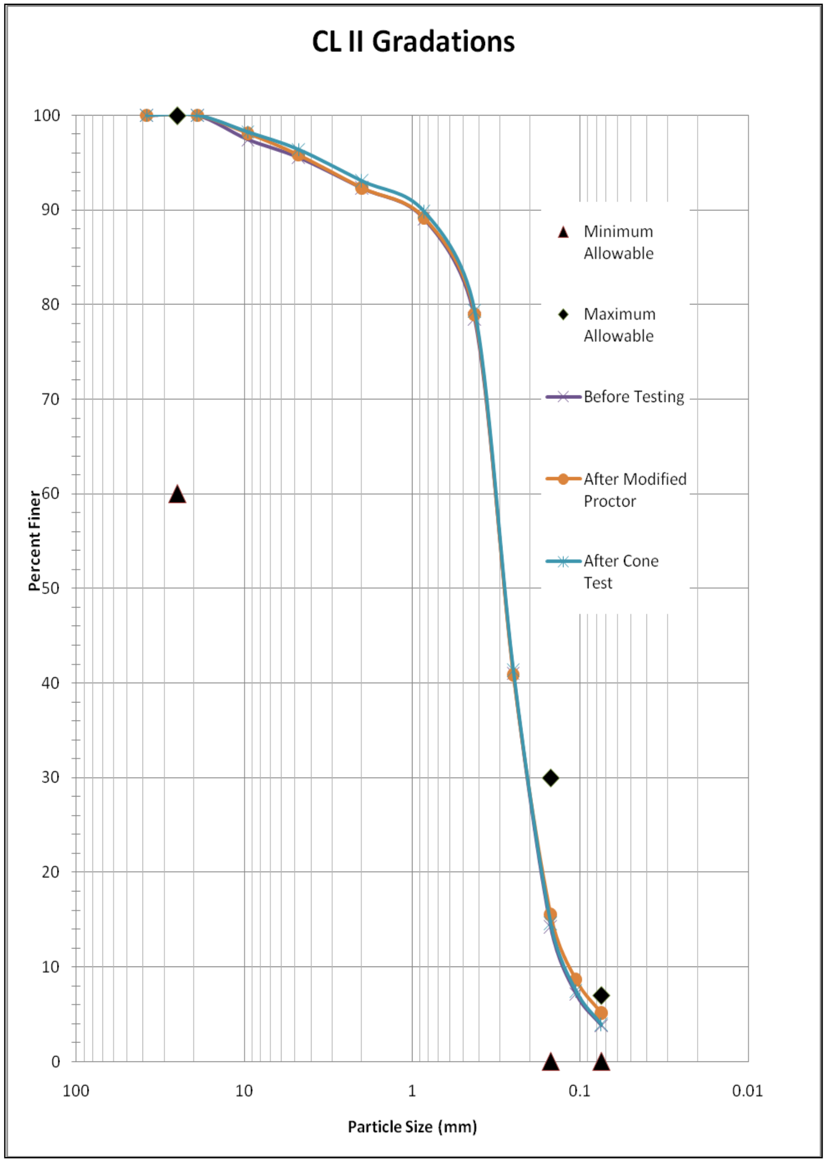
22A SS&G Gradations
Percent Finer
Particle Size (mm)
Minimum Allowable
Maximum Allowable
Before Testing
After Modified Proctor
After Cone Test
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01

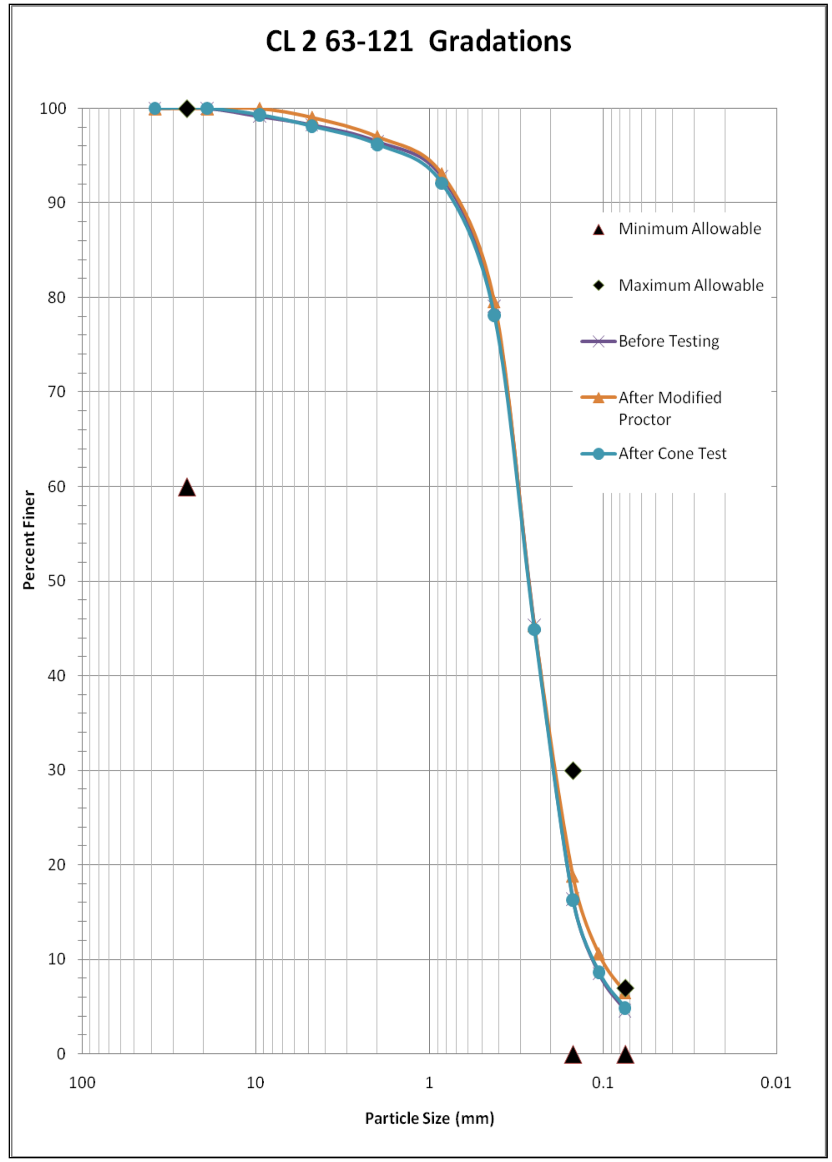


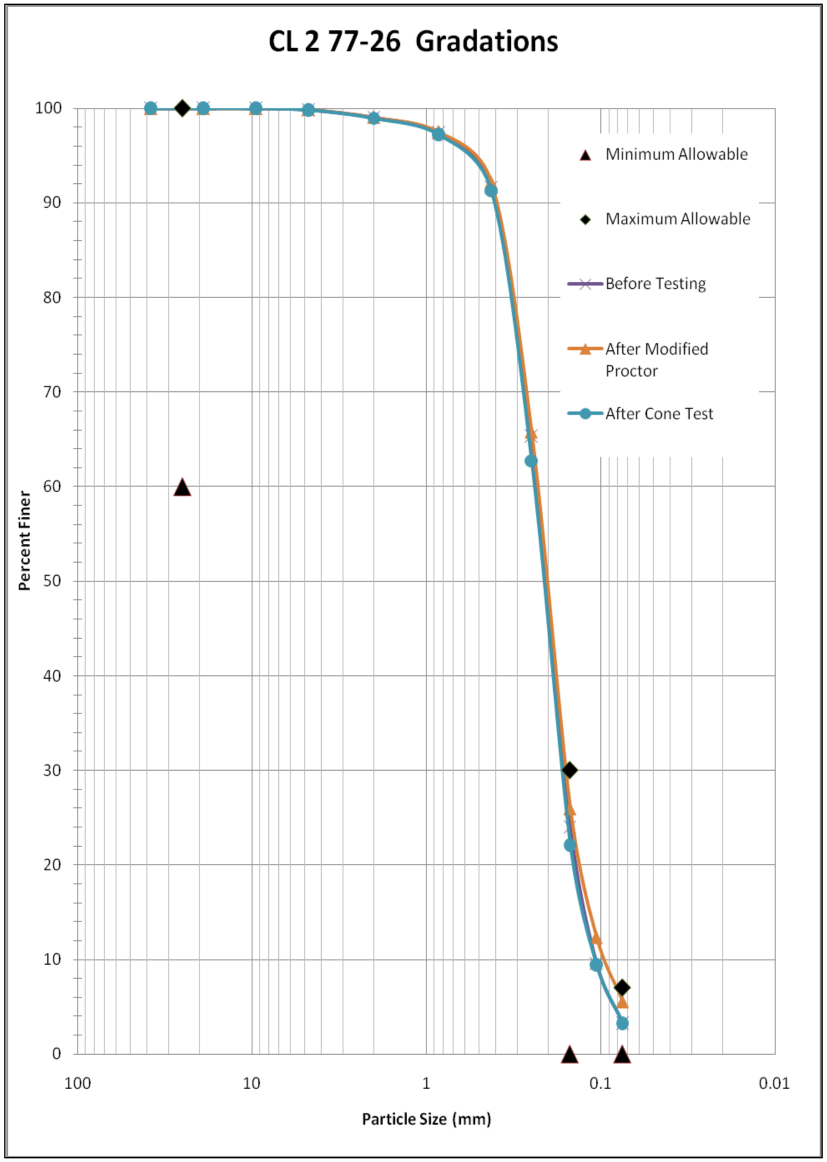
22A 28-54 Gradations
Percent Finer
Particle Size (mm)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
Minimum Allowable
Maximum Allowable
Before Testing
After Modified Proctor
After Cone Test

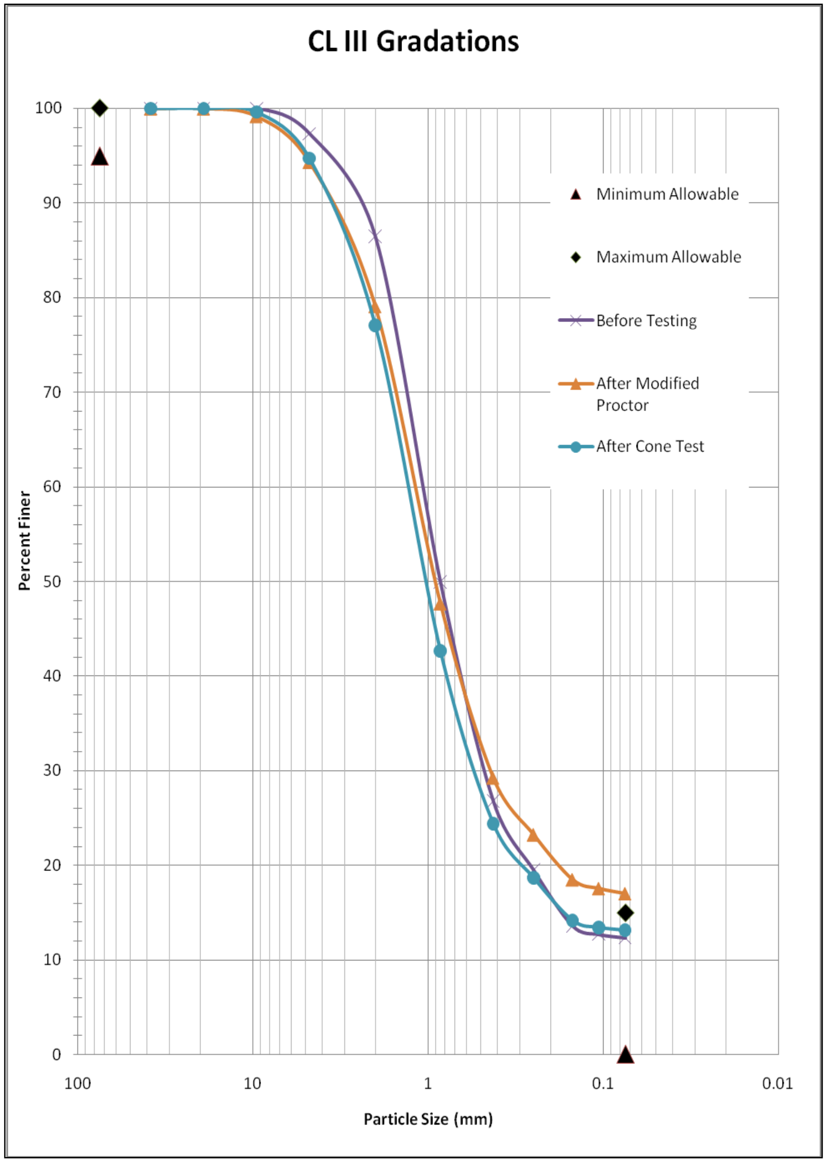


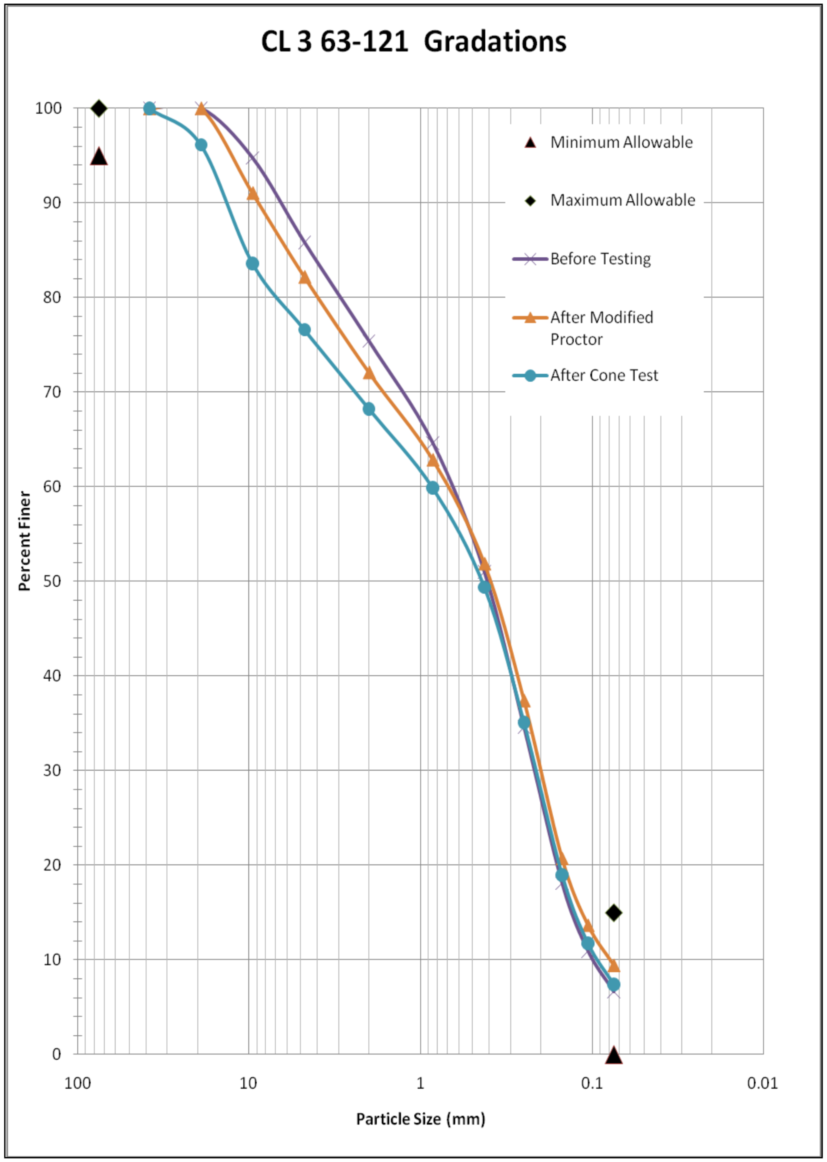
22A 41-13 Gradations
Percent Finer
Particle Size (mm)
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01
Minimum Allowable
Maximum Allowable
Before Testing
After Modified Proctor
After Cone Test

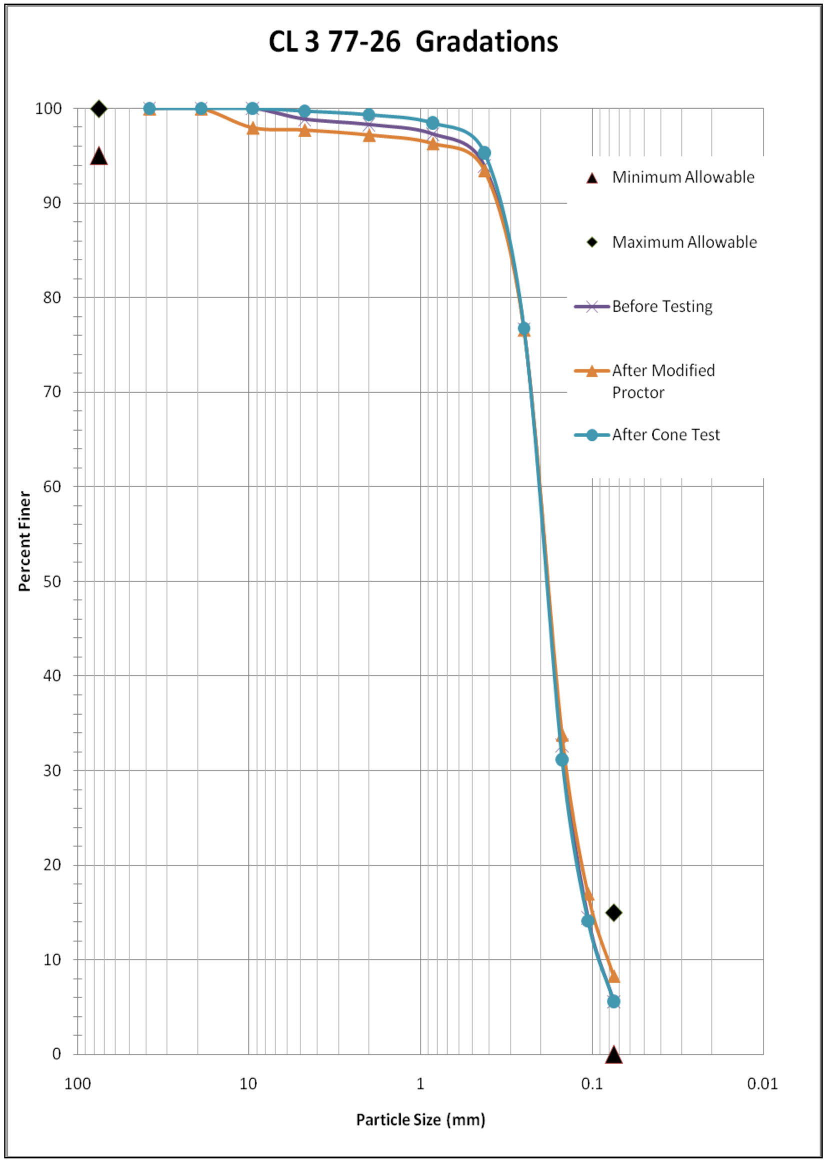

CL II Gradations
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100
10
1
0.1
0.01
Particle Size (mm)
Minimum Allowable
Maximum Allowable
Before Testing
After Modified Proctor
After Cone Test


CL 2 63-121 Gradations
100
90
80
70
60
50
40
30
20
10
0
Percent Finer
100
10
1
0.1
0.01
Particle Size (mm)
Minimum Allowable
Maximum Allowable
Before Testing
After Modified Proctor
After Cone Test


CL 2 77-26 Gradations
Percent Finer
0
10
20
30
40
50
60
70
80
90
100
100
10
1
0.1
0.01
Particle Size (mm)
Minimum Allowable
Maximum Allowable
Before Testing
After Modified Proctor
After Cone Test


CL III Gradations
Percent Finer
0
10
20
30
40
50
60
70
80
90
100
100
10
1
0.1
0.01
Particle Size (mm)
Minimum Allowable
Maximum Allowable
Before Testing
After Modified Proctor
After Cone Test


CL 3 63-121 Gradations
Percent Finer
Particle Size (mm)
Minimum Allowable
Maximum Allowable
Before Testing
After Modified Proctor
After Cone Test
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01


CL 3 77-26 Gradations
Percent Finer
Particle Size (mm)
Minimum Allowable
Maximum Allowable
Before Testing
After Modified Proctor
After Cone Test
100
90
80
70
60
50
40
30
20
10
0
100
10
1
0.1
0.01

Appendix 2 – Soil Data

Sample ID: 2

Description: 4G Before Modified Proctor

Date: 8/24/2011

Bowl ID: g F

Mass of Sample Oven Dry: 2172.4 g

After Wash: g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/4"	31.75	**564.9**	**518.6**	46.3	2.1	97.9
3/4"	19.05	1365.3	824.3	77.9	3.6	96.4
3/8"	9.525	1709.5	554.4	1155.1	53.2	43.2
4	4.75	961.4	465.6	495.8	22.8	20.4
10	2	767.6	488.9	278.7	12.8	7.6
20	0.85	457.3	407.5	49.8	2.3	5.3
40	0.425	404.7	388.6	16.1	0.7	4.6
60	0.25			0.0	0.0	4.6
100	0.15			0.0	0.0	4.6
140	0.106			0.0	0.0	4.6
200	0.075			0.0	0.0	4.6
Pan	--	346.6	274.9	71.7	3.3	1.3
			∑	2191.4		

Table 902-1 Grading Requirements for Coarse Aggregates, Dense-Graded Aggregates, and Open-Graded

Sieve Size	Opening (mm)	Maximum Allowable	Minimum Allowable
1.5"	37.5	100	
3/4"	19.0	80	60
1/2"	12.7	65	35
No. 8	2.38	25	10
No. 30	0.595	18	5

Sample ID: 4G
Date: 8/24/2011
Description:
Bowl ID: g
After 1 Modified Proctor Test
Mass of Sample Oven Dry: 2463.4 g
After Wash: g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/4"	31.75	**563.9**	**518.5**	45.4	1.8	98.2
3/4"	19.05	1200.2	836.1	364.1	14.8	85.2
3/8"	9.525	1395.6	557.6	838.0	34.0	51.2
4	4.75	940.4	464.9	475.5	19.3	31.9
10	2	849.6	489.0	360.6	14.6	17.3
20	0.85	538.3	407.4	130.9	5.3	11.9
40	0.425	448.9	388.5	60.4	2.5	9.5
60	0.25			0.0	0.0	9.5
100	0.15			0.0	0.0	9.5
140	0.106			0.0	0.0	9.5
200	0.075			0.0	0.0	9.5
Pan	--	463.4	274.8	188.6	7.7	1.8
			∑	2463.5		

Sample ID: 1 Date: 8/24/2011
Description: 4G Bowl ID: g
Before MI Cone Test Mass of Sample Oven Dry: 3047.8 g
After Wash: g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/4"	31.75	**518.6**	**518.6**	0.0	0.0	100.0
3/4"	19.05	1583.8	822.4	761.4	25.0	75.0
3/8"	9.525	1812.9	554.4	1258.5	41.3	33.7
4	4.75	1000.2	464.1	536.1	17.6	16.1
10	2	792.0	489.8	302.2	9.9	6.2
20	0.85	473.4	407.6	65.8	2.2	4.1
40	0.425	410.0	388.8	21.2	0.7	3.4
60	0.25			0.0	0.0	3.4
100	0.15			0.0	0.0	3.4
140	0.106			0.0	0.0	3.4
200	0.075			0.0	0.0	3.4
Pan	--	373.3	274.9	98.4	3.2	0.1
			∑	3043.6		

Sample ID: 4G Date: 8/24/2011
Description: Bowl ID: g
After 1 Cone Test Mass of Sample Oven Dry: 3014.2 g
After Wash: g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/4"	31.75	**518.6**	**518.6**	0.0	0.0	100.0
3/4"	19.05	1541.9	822.4	719.5	23.9	76.1
3/8"	9.525	1769.5	554.3	1215.2	40.3	35.8
4	4.75	995.5	464.7	530.8	17.6	18.2
10	2	788.4	489.0	299.4	9.9	8.3
20	0.85	486.4	407.6	78.8	2.6	5.7
40	0.425	421.1	388.6	32.5	1.1	4.6
60	0.25			0.0	0.0	4.6
100	0.15			0.0	0.0	4.6
140	0.106			0.0	0.0	4.6
200	0.075			0.0	0.0	4.6
Pan	--	410.3	274.8	135.5	4.5	0.1
			∑	3011.7		

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C: Full Energy 12400 ft*lb/ft^3
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil 4G Crushed Limestone Sample No. 4G
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 8/24/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	6507.5	6507.5	6507.5		
Weight of Mold, Base, and Soil	10486.1	10477.3	10634.7		
Weight of moist Soil	3978.6	3969.8	4127.2		
Moist Unit Weight (pcf)	117.0	116.7	121.3		
Moisture Tin ID	44	12	40		
Mass of Moisture Tin	61.9	63.4	62.4		
Mass of Tin and Moist Soil	656.3	507.8	529.1		
Mass of Tin and Dry Soil	655.9	497.0	507.6		
Moisture Content	0.07	2.50	4.82		
Dry Unit Weight (pcf)	116.9	113.8	115.7		

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C: Full Energy 56250 ft*lb/ft^3

Description of Soil 4G Sample No 4G
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 8/24/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	6546.9	6546.9	6546.9		
Weight of Mold, Base, and Soil	10726.8	10780.4	11098.2		
Weight of moist Soil	4179.9	4233.5	4551.3		
Moist Unit Weight (pcf)	122.9	124.4	133.8		
Moisture Tin ID	33	4	47		
Mass of Moisture Tin	62.5	61.5	63.1		
Mass of Tin and Moist Soil	553.4	330.8	514.4		
Mass of Tin and Dry Soil	552.8	324.0	492.2		
Moisture Content	0.11	2.56	5.18		
Dry Unit Weight (pcf)	122.7	121.3	127.2		

M-DOT Michigan Cone Testing Cone Tests Karl Krueger

Description of Soil	4G		Sample No.	
Location	Dillman B003			
Volume of Mold	0.0459	ft^3		
Weight of Mold	1421	g		
Tested By	KMK		Date	8/24/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	4099	4197.4	4206.2		
Wet Soil (g)	2678	2776.4	2785.2		
Wet Soil (lb)	5.90	6.12	6.14		
Compacted Soil Wet (pcf)	128.6	133.4	133.8		
Compacted Soil Dry (pcf)	122.4	122.2	124.9		
Moisture Tin ID	46	45	37		
Mass of Moisture Tin	63.76	63.81	63.84		
Mass of Tin and Moist Soil	656.17	575.76	595.6		
Mass of Tin and Dry Soil	627.5	532.8	560.3		
Moisture Content	5.09	9.16	7.11		
Max Density (pcf)	123.5	122.5	125.5		
Optimum Moisture %	10.9	11.1	10.3		
Total Hits	290.0	280.0	260.0		
After Full					

Soft Test No.	6	7	8	9	10
Wet Soil + Mold (g)	3918				
Wet Soil (g)	2497				
Wet Soil (lb)	5.50				
Compacted Soil Wet (pcf)	119.9				
Compacted Soil Dry (pcf)	116.1				
Moisture Tin ID	49				
Mass of Moisture Tin	62.92				
Mass of Tin and Moist Soil	629.55				
Mass of Tin and Dry Soil	611.2				
Moisture Content	3.35				
Max Density (pcf)	116.1				
Optimum Moisture %					
Total Hits	260.0				
After Full					

Description of Soil		Sample No.	
Location	Dillman B003		
Volume of Mold	0.04439 ft^3		
Weight of Mold	1940 g		
Tested By	JV	Date	8/24/2011

Test No.	11	12	13	14	15
Wet Soil + Mold (g)	4549.1	4654.8	4605.2		
Wet Soil (g)	2609.1	2714.8	2665.2		
Wet Soil (lb)	5.75	5.99	5.88		
Compacted Soil Wet (pcf)	129.6	134.8	132.4		
Compacted Soil Dry (pcf)	119.6	127.9	125.3		
Moisture Tin ID	200	14	20		
Mass of Moisture Tin	63.82	62.55	62.52		
Mass of Tin and Moist Soil	781.27	633.31	638.64		
Mass of Tin and Dry Soil	726.2	604.1	608		
Moisture Content	8.31	5.39	5.62		
Max Density (pcf)	120.3	130.0	126.5		
Optimum Moisture %	11.8	9.2	10.1		
Total Hits	300.0	370.0	340.0		
After Full					

soft Test No.	16	17	18	19	20
Wet Soil + Mold (g)	4291.3	4340.2	4305		
Wet Soil (g)	2351.3	2400.2	2365		
Wet Soil (lb)	5.18	5.29	5.21		
Compacted Soil Wet (pcf)	116.8	119.2	117.5		
Compacted Soil Dry (pcf)	111.8	114.2	112.8		
Moisture Tin ID	34	31	18		
Mass of Moisture Tin	63.21	64.67	61.91		
Mass of Tin and Moist Soil	558.09	734.48	591.26		
Mass of Tin and Dry Soil	536.99	706.4	570.3		
Moisture Content	4.45	4.38	4.12		
Max Density (pcf)	112.4	115	113.1		
Optimum Moisture %	14.3	13.4	14.1		
Total Hits	240.0	180.0	230.0		
After Full					

MI Cone Curve

Description of Soil		Sample No.	
Location	Dillman B003		
Volume of Mold	0.0459 ft^3		
Tested By	KMK	Date	24-Aug

Test	1	2	3	4	5	6
Weight of Mold	1421	1421	1421			
/eight of Mold and Soil	3819.5	3966.7	4099			
Weight of moist Soil	2398.5	2545.7	2678	0	0	0
/loist Unit Weight (pcf)	115.2	122.3	128.6	0.0	0.0	0.0
Moisture Tin ID		50	46			
Mass of Moisture Tin		42.0	63.8			
s of Tin and Moist Soil		348.3	656.2			
lass of Tin and Dry Soil		339.1	625.0			
Moisture Content	0.20	3.09	5.55			
Dry Unit Weight (pcf)	115.0	118.6	121.9			
Total Blows						
After Full						
Energy/20 Blows						

Sample ID: 21AA	Date: 7/25/2011
Description: 21AA	Bowl ID: 304.4 g
Before Testing	Mass of Sample Oven Dry: 2772.3 g
After Wash: 2561.8 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1	**518.5**	**518.5**	0.0	0.0	100.0
3/4"	19.05	1458.6	821.2	637.4	23.0	77.0
3/8"	9.525	1272.3	554.3	718.0	25.9	51.1
4	4.75	886.9	463.1	423.8	15.3	35.8
10	2	834.1	488.6	345.5	12.5	23.4
20	0.85	588.4	407.6	180.8	6.5	16.8
40	0.425	480.6	388.7	91.9	3.3	13.5
60	0.25	421.9	367.2	54.7	2.0	11.5
100	0.15	397.0	355.5	41.5	1.5	10.1
140	0.106	362.9	339.3	23.6	0.9	9.2
200	0.075	356.7	332.2	24.5	0.9	8.3
Pan	--	390.1	373.5	16.6	0.6	7.7
			∑	2558.3		

Sample ID: 21AA	Date: 7/25/2011
Description: 21AA	Bowl ID: 207.7 g
After 1 Cone Test	Mass of Sample Oven Dry: 1626.7 g
After Wash: 1481.4 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1	**518.5**	**518.5**	0.0	0.0	100.0
3/4"	19.05	1254.8	821.1	433.7	26.7	73.3
3/8"	9.525	920.1	555.5	364.6	22.4	50.9
4	4.75	678.7	463.1	215.6	13.3	37.7
10	2	682.4	489.1	193.3	11.9	25.8
20	0.85	519.9	407.8	112.1	6.9	18.9
40	0.425	444.9	388.9	56.0	3.4	15.5
60	0.25	401.9	367.4	34.5	2.1	13.3
100	0.15	382.7	355.6	27.1	1.7	11.7
140	0.106	354.6	339.5	15.1	0.9	10.7
200	0.075	348.5	332.4	16.1	1.0	9.7
Pan	--	384.9	373.5	11.4	0.7	9.0
			∑	1479.5		

Sample ID: 21AA
Description: 21AA
After 1 Modified Proctor Test

Date: 7/25/2011
Bowl ID: 206.8 g
Mass of Sample Oven Dry: 2509 g
After Wash: 2292.9 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1	**518.5**	**518.5**	0.0	0.0	100.0
3/4"	19.05	1277.6	821.1	456.5	18.2	81.8
3/8"	9.525	1156.9	554.3	602.6	24.0	57.8
4	4.75	860.3	463.0	397.3	15.8	42.0
10	2	839.4	488.8	350.6	14.0	28.0
20	0.85	607.1	408.0	199.1	7.9	20.0
40	0.425	497.2	389.0	108.2	4.3	15.7
60	0.25	431.7	367.3	64.4	2.6	13.2
100	0.15	402.5	355.5	47.0	1.9	11.3
140	0.106	363.8	339.3	24.5	1.0	10.3
200	0.075	358.6	332.3	26.3	1.0	9.3
Pan	--	390.1	373.6	16.5	0.7	8.6
			∑	2293.0		

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C: Full Energy 12400 ft*lb/ft^3
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil 21AA Sample No. 21AA
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 7/25/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	14.4335	14.4335	14.4335	14.4335	14.4335
Weight of Mold, Base, and Soil	23.9905	23.726	24.382	24.539	25.426
Weight of moist Soil	9.557	9.2925	9.9485	10.1055	10.9925
Moist Unit Weight (pcf)	127.4	123.9	132.6	134.7	146.6
Moisture Tin ID	3	31	3140	49	31
Mass of Moisture Tin	38.1	61.7	61.7	62.1	61.9
Mass of Tin and Moist Soil	284.5	556.9	613.7	450.1	620.4
Mass of Tin and Dry Soil	283.4	541.5	581.6	426.2	579.6
Moisture Content	0.48	3.21	6.19	6.59	7.87
Dry Unit Weight (pcf)	126.8	120.1	124.9	126.4	135.9

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C: Full Energy 56250 ft*lb/ft^3

Description of Soil 21AA Sample No 21AA
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 7/25/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	14.4335	14.4335	14.4335	14.4335	14.4335
Weight of Mold, Base, and Soil	24.6715	24.6085	25.726	25.6725	25.708
Weight of moist Soil	10.238	10.175	11.2925	11.239	11.2745
Moist Unit Weight (pcf)	136.5	135.7	150.6	149.9	150.3
Moisture Tin ID	bl14	20	314	p200	45
Mass of Moisture Tin	35.2	62.3	62.0	61.9	62.0
Mass of Tin and Moist Soil	342.5	504.5	480.8	565.3	733.6
Mass of Tin and Dry Soil	341.9	494.3	459.3	537.8	687.6
Moisture Content	0.20	2.34	5.41	5.79	7.35
Dry Unit Weight (pcf)	136.2	132.6	142.8	141.7	140.0

Description of Soil	21AA	Sample No.	21AA
Location	Dillman B003		
Volume of Mold	0.0459 ft^3		
Weight of Mold	1421 g		
Tested By	KMK	Date	7/25/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	4416.5	4485.1	4309.3	4313.7	4183.9
Wet Soil (g)	2995.5	3064.1	2888.3	2892.7	2762.9
Wet Soil (lb)	6.60	6.76	6.37	6.38	6.09
Compacted Soil Wet (pcf)	143.9	147.2	138.7	138.9	132.7
Compacted Soil Dry (pcf)	134.2	137.3	127.0	130.3	125.8
Moisture Tin ID	33	31	14	20	314
Mass of Moisture Tin	61.42	62.07	61.6	61.04	62.14
Mass of Tin and Moist Soil	648	481.96	569.66	616.28	568.64
Mass of Tin and Dry Soil	608.48	453.81	526.77	581.57	542.31
Moisture Content	7.22	7.19	9.22	6.67	5.48
Max Density (pcf)	135.0	137.7	127.2	131.7	127.1
Optimum Moisture %	8.1	7.6	9.9	8.8	9.9
Total Hits	250.0	260.0	240.0	230.0	260
After Full	80.0	80.0	60.0	40.0	80

Test No.	6	7	8	9	10
Wet Soil + Mold (g)	4201.4	4311.2	4377.3	4347.4	4547.8
Wet Soil (g)	2780.4	2890.2	2956.3	2926.4	3126.8
Wet Soil (lb)	6.13	6.37	6.52	6.45	6.89
Compacted Soil Wet (pcf)	133.5	138.8	142.0	140.6	150.2
Compacted Soil Dry (pcf)	126.5	130.8	133.9	132.9	141.0
Moisture Tin ID	45	pd	40		
Mass of Moisture Tin	61.78	41.55	61.87		
Mass of Tin and Moist Soil	577.92	382.51	419.95		
Mass of Tin and Dry Soil	550.76	362.76	399.48		
Moisture Content	5.55	6.15	6.06	5.73	6.52
Max Density (pcf)	128	132.8	136.1	135.6	141.6
Optimum Moisture %	9.7	8.6	7.9	8	6.9
Total Hits	270.0	270.0	240.0	270.0	230
After Full	40.0	120.0	60.0	120.0	60

Chart Results	Average	133.3 pcf	Max	141.6 pcf
	STDEV	4.8398347 pcf	Min	127.1 pcf
	Average Hit Count	252		

Description of Soil	21AA	Sample No.	
Location	Dillman B003		
Volume of Mold	0.0459 ft^3		
Weight of Mold	1421 g		
Tested By	KMK	Date	8/18/2011

Test No.	11	12	13	14	15
Wet Soil + Mold (g)	4468	4438.6	4431.4	4354.8	4462.2
Wet Soil (g)	3047	3017.6	3010.4	2933.8	3041.2
Wet Soil (lb)	6.72	6.65	6.64	6.47	6.70
Compacted Soil Wet (pcf)	146.4	144.9	144.6	140.9	146.1
Compacted Soil Dry (pcf)	138.5	136.9	135.8	133.2	138.5
Moisture Tin ID	20	18	45	14	40
Mass of Moisture Tin	62.44	61.66	63.55	62.2	62.11
Mass of Tin and Moist Soil	756.06	681.24	596.41	674.1	680.55
Mass of Tin and Dry Soil	718.99	646.68	563.85	640.73	648.64
Moisture Content	5.65	5.91	6.51	5.77	5.44
Max Density (pcf)	141.1	139.2	137.2	135.9	141.5
Optimum Moisture %	7.0	7.3	7.7	7.9	7
Total Hits	290.0	300.0	280.0	280.0	270
After Full					

Test No.	16	17	18	19	20
Wet Soil + Mold (g)	4194.7	4299.6	4225.9		
Wet Soil (g)	2773.7	2878.6	2804.9		
Wet Soil (lb)	6.11	6.35	6.18		
Compacted Soil Wet (pcf)	133.2	138.3	134.7		
Compacted Soil Dry (pcf)	126.0	129.9	127.5		
Moisture Tin ID	46	13	314		
Mass of Moisture Tin	63.33	62.83	62.48		
Mass of Tin and Moist Soil	659.87	758.43	643.12		
Mass of Tin and Dry Soil	627.36	716.28	611.92		
Moisture Content	5.76	6.45	5.68		
Max Density (pcf)	127.2	131.5	129.2		
Optimum Moisture %	9.9	8.9	9.4		
Total Hits	260.0	240.0	280.0		
After Full					

Description of Soil			Sample No.	
Location	Dillman B003			
Volume of Mold	**0.04439** ft^3			
Weight of Mold	**1946** g			
Tested By	JV		Date	8/18/2011

Test No.	21	22	23	24	**25**
Wet Soil + Mold (g)	4813.4	4920.4	4861.6	4822.4	4881.3
Wet Soil (g)	2867.4	2974.4	2915.6	2876.4	2935.3
Wet Soil (lb)	6.32	6.56	6.43	6.34	6.47
Compacted Soil Wet (pcf)	142.4	147.7	144.8	142.9	145.8
Compacted Soil Dry (pcf)	134.9	140.3	137.9	136.0	137.1
Moisture Tin ID	200	33	50	31	49
Mass of Moisture Tin	62.05	62.44	41.99	64.09	62.38
Mass of Tin and Moist Soil	706.51	694.89	439.27	715.06	668.25
Mass of Tin and Dry Soil	672.62	662.9	420.2	683.68	632.31
Moisture Content	5.55	5.33	5.04	5.06	6.31
Max Density (pcf)	137.9	143.3	141.7	139.8	138.8
Optimum Moisture %	7.6	6.7	6.9	7.2	7.4
Total Hits	270.0	320.0	350.0	320.0	250
After Full					

Test No.	**26**	**27**	**28**	**29**	**30**
Wet Soil + Mold (g)	4584.5	4647.0			
Wet Soil (g)	2638.5	2701.0			
Wet Soil (lb)	5.82	5.95			
Compacted Soil Wet (pcf)	131.0	134.1			
Compacted Soil Dry (pcf)	124.6	126.9			
Moisture Tin ID	47	37			
Mass of Moisture Tin	61.93	62.74			
Mass of Tin and Moist Soil	709.54	660.03			
Mass of Tin and Dry Soil	677.92	627.75			
Moisture Content	5.13	5.71			
Max Density (pcf)	125.8	128.4			
Optimum Moisture %	10.2	9.6			
Total Hits	270.0	300.0			
After Full					

MI Cone Curve

Description of Soil 21AA Sample No 21AA
Location Dillman B003
Volume of Mold 0.0459 ft^3
Tested By KMK Date 7/25/2011

	Test	1	2	3	4	5	6
Weight of Mold		1421	1421	1421	1421	1421	
Weight of Mold and Soil		4244.3	4135.2	4347.4	4547.8	4456.5	
Weight of moist Soil		2823.3	2714.2	2926.4	3126.8	3035.5	
Moist Unit Weight (pcf)		135.6	130.4	140.6	150.2	145.8	
Moisture Tin ID		mdh	pd	14	47	rtfo	
Mass of Moisture Tin		41.2	41.0	61.5	61.6	37.0	
Mass of Tin and Moist Soil		237.5	307.8	437.3	620.4	389.7	
Mass of Tin and Dry Soil		236.6	300.8	416.9	586.2	363.2	
Moisture Content		0.49	2.70	5.73	6.52	8.13	
Dry Unit Weight (pcf)		135.0	126.9	132.9	141.0	134.8	
Total Blows		190	220	270	230		
	After Full	60	80	120	60		
Energy/20 Blows							

Sample ID: 2
Date: 2/8/2011
Description: 22A Aggregate Base, Superior Sand and Gravel
Bowl ID: 105 g F
Mass of Sample Oven Dry: 671.4 g
After Wash: 634.3 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			77.9	11.6	88.4
3/8"	9.525	975	800.3	174.7	26.0	62.4
4	4.75	535.9	467.1	68.8	10.2	52.1
10	2	557.7	488.9	68.8	10.2	41.9
20	0.85	477.7	424.2	53.5	8.0	33.9
40	0.425	386.7	329.4	57.3	8.5	25.4
60	0.25	384.4	315.8	68.6	10.2	15.2
100	0.15	384.6	347.3	37.3	5.6	9.6
140	0.106	317.7	304.1	13.6	2.0	7.6
200	0.075	301.2	291.6	9.6	1.4	6.2
Pan	--	288.9	285.9	3.0	0.4	5.7
			∑	633.1		

Table 902-1 Grading Requirements for Coarse Aggregates, Dense-Graded Aggregates, and Open-Graded

Sieve Size	Opening (mm)	Maximum Allowable	Minimum Allowable
1"	25.0	100	100
3/4"	19.0	100	90
3/8"	9.5	85	65
No. 8	2.36	50	30
No. 200	0.075	8	4

Sample ID: 1 Date: 7/8/2011

Description: 22A Aggregate Base, Superior Sand and Gravel Bowl ID: 332.3 g

After 1 Modified Proctor Test Mass of Sample Oven Dry: 2278 g

After Wash: 2154.7 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05	1191.2	821.1	370.1	16.2	83.8
3/8"	9.525	1230.9	779.5	451.4	19.8	63.9
4	4.75	1004.7	710.7	294.0	12.9	51.0
10	2	746.5	484.9	261.6	11.5	39.5
20	0.85	604.4	424.5	179.9	7.9	31.7
40	0.425	505.4	330.2	175.2	7.7	24.0
60	0.25	559.5	370.0	189.5	8.3	15.6
100	0.15	466.2	352.5	113.7	5.0	10.6
140	0.106	335.8	297.1	38.7	1.7	9.0
200	0.075	375.7	334.5	41.2	1.8	7.1
Pan	--	320.4	278.5	41.9	1.8	5.3
			∑	2157.2		

Sample ID: 1 Date: 7/8/2011
Description: 22A Aggregate Base, Superior Sand and Gravel Bowl ID: 208.78 g
Before Testing Mass of Sample Oven Dry: 2065.8 g
After Wash: 1929.2 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05	1240.5	821.3	419.2	20.3	79.7
3/8"	9.525	1270.6	779.3	491.3	23.8	55.9
4	4.75	941.8	708.9	232.9	11.3	44.7
10	2	661.9	482.7	179.2	8.7	36.0
20	0.85	561.1	423.2	137.9	6.7	29.3
40	0.425	481.8	328.9	152.9	7.4	21.9
60	0.25	536.6	369.5	167.1	8.1	13.8
100	0.15	448.9	352.3	96.6	4.7	9.1
140	0.106	325.7	297.1	28.6	1.4	7.8
200	0.075	357.5	334.6	22.9	1.1	6.6
Pan	--	288.6	278.6	10.0	0.5	6.2
			∑	1938.6		

Sample ID: 1 Date: 7/8/2011
Description: 22A Aggregate Base, Superior Sand and Gravel Bowl ID: 109.2 g
After 1 Cone Test Mass of Sample Oven Dry: 1915.7 g
After Wash: 1835.8 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05	1218.1	821.2	396.9	20.7	79.3
3/8"	9.525	1295.2	779.6	515.6	26.9	52.4
4	4.75	893.9	709.7	184.2	9.6	42.8
10	2	650.3	484.1	166.2	8.7	34.1
20	0.85	544.2	423.5	120.7	6.3	27.8
40	0.425	461.6	329.4	132.2	6.9	20.9
60	0.25	519.1	369.9	149.2	7.8	13.1
100	0.15	437.2	352.4	84.8	4.4	8.7
140	0.106	325.8	297.2	28.6	1.5	7.2
200	0.075	363.2	334.5	28.7	1.5	5.7
Pan	--	307.9	278.5	29.4	1.5	4.1
			∑	1836.5		

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C: 1/2 Energy 6200 ft*lb/ft^3
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil 22A - Superior Sand and Gravel - P3/4" Sample No. 2
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 6/28/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	14.4355	14.4355	14.4355	14.4355	14.4355
Weight of Mold, Base, and Soil	24.034	24.549	25.001	25.583	25.526
Weight of moist Soil	9.5985	10.1135	10.5655	11.1475	11.0905
Moist Unit Weight (pcf)	128.0	134.8	140.9	148.6	147.9
Moisture Tin ID	KK3	KK2	3KL	X6	#3
Mass of Moisture Tin	30.8	30.5	29.8	30.8	29.6
Mass of Tin and Moist Soil	98.3	110.3	139.5	167.1	207.0
Mass of Tin and Dry Soil	97.9	107.4	133.6	158.1	190.3
Moisture Content	0.6%	3.8%	5.7%	7.1%	10.4%
Dry Unit Weight (pcf)	127.2	129.8	133.3	138.8	133.9

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C: Full Energy 12400 ft*lb/ft^3
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil 22A - Superior Sand and Gravel - P3/4" Sample No. 2
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 6/28/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	14.4355	14.4355	14.4355	14.4355	14.4355
Weight of Mold, Base, and Soil	24.544	24.8405	25.356	25.6905	25.5775
Weight of moist Soil	10.1085	10.405	10.9205	11.255	11.142
Moist Unit Weight (pcf)	134.8	138.7	145.6	150.1	148.6
Moisture Tin ID	#1	RC	#2	HOP	9C
Mass of Moisture Tin	32.5	30.3	31.0	30.5	30.7
Mass of Tin and Moist Soil	120.3	135.9	128.6	169.5	206.7
Mass of Tin and Dry Soil	119.9	132.6	123.0	159.6	185.9
Moisture Content	0.4%	3.3%	6.0%	7.7%	13.4%
Dry Unit Weight (pcf)	134.2	134.3	137.3	139.4	131.0

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C: 1/2 Energy 28125 ft*lb/ft^3
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil 22A - Superior Sand and Gravel - P3/4" Sample No 2
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 6/28/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	14.4355	14.4355	14.4355	14.4355	14.4355
Weight of Mold, Base, and Soil	24.7275	24.9695	25.3205	25.871	25.664
Weight of moist Soil	10.292	10.534	10.885	11.4355	11.2285
Moist Unit Weight (pcf)	137.2	140.5	145.1	152.5	149.7
Moisture Tin ID	3LL	2A	8C	2	PE
Mass of Moisture Tin	31.5	33.1	31.1	31.2	31.3
Mass of Tin and Moist Soil	100.2	213.6	137.7	189.3	181.2
Mass of Tin and Dry Soil	99.7	208.0	131.6	177.5	166.8
Moisture Content	0.7%	3.2%	6.1%	8.1%	10.7%
Dry Unit Weight (pcf)	136.2	136.1	136.8	141.0	135.3

M-DOT Michigan Cone Testing Proctor Test Worksheet Karl Krueger

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C: Full Energy 56250 ft*lb/ft^3
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil 22A - Superior Sand and Gravel - P3/4" Sample No 2
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 6/28/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	14.4355	14.4355	14.4355	14.4355	14.4355
Weight of Mold, Base, and Soil	25.107	25.2535	25.6005	25.942	25.7135
Weight of moist Soil	10.6715	10.818	11.165	11.5065	11.278
Moist Unit Weight (pcf)	142.3	144.2	148.9	153.4	150.4
Moisture Tin ID	2	267	A2	Jadd	JJAD
Mass of Moisture Tin	30.4	29.7	31.3	29.5	30.5
Mass of Tin and Moist Soil	147.1	209.8	168.9	222.6	163.5
Mass of Tin and Dry Soil	146.6	203.5	161.0	209.2	150.4
Moisture Content	0.5%	3.6%	6.1%	7.5%	10.9%
Dry Unit Weight (pcf)	141.6	139.2	140.3	142.8	135.6

Description of Soil	22A Aggregate, Superior Sand and Gravel	Sample No.	2
Location	Dillman B003		
Volume of Mold	0.0459 ft^3		
Weight of Mold	1421 g		
Tested By	KMK	Date	2/4/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	4571.3	4516.5	4611.2	4594	4556.7
Wet Soil (g)	3150.3	3095.5	3190.2	3173	3135.7
Wet Soil (lb)	6.95	6.82	7.03	7.00	6.91
Compacted Soil Wet (pcf)	151.3	148.7	153.2	152.4	150.6
Compacted Soil Dry (pcf)	144.3	139.3	143.9	143.7	142.2
Moisture Tin ID	SPA 5	12-2A	4 MDH	Team x4	10
Mass of Moisture Tin	30.1	31	30.9	31.1	29.6
Mass of Tin and Moist Soil	142.1	202.5	212.5	195.7	238.8
Mass of Tin and Dry Soil	136.9	191.7	201.4	186.3	227.1
Moisture Content	4.9%	6.7%	6.5%	6.1%	5.9%
Max Density (pcf)	147.1	140.0	144.0	144.6	143.8
Optimum Moisture %	6.2	7.0	6.6	6.5	6.6

Test No.	6	7	8	9	10
Wet Soil + Mold (g)	4627.9	4663.2	4641.7	4621.9	4635.6
Wet Soil (g)	3206.9	3242.2	3220.7	3200.9	3214.6
Wet Soil (lb)	7.07	7.15	7.10	7.06	7.09
Compacted Soil Wet (pcf)	154.0	155.7	154.7	153.7	154.4
Compacted Soil Dry (pcf)	144.6	147.6	144.7	144.4	146.9
Moisture Tin ID	#4	9C	JADD	#5	1Soil A-1
Mass of Moisture Tin	32.3	30.6	29.5	30.9	30.8
Mass of Tin and Moist Soil	245.7	242.9	278.6	250.4	231.2
Mass of Tin and Dry Soil	232.7	231.8	262.5	237.1	221.5
Moisture Content	6.5%	5.5%	6.9%	6.5%	5.1%
Max Density (pcf)	144.6	148.8	144.7	144.4	149.1
Optimum Moisture %	6.5	6.0	6.9	6.5	6.0

Description of Soil	22A Aggregate, Superior Sand and Gravel	Sample No.	2
Location	Dillman B003		
Volume of Mold	0.0459 ft^3		
Weight of Mold	1421 g		
Tested By	KMK	Date	7/11/2011

Test No.	11	12	13	14	15
Wet Soil + Mold (g)	4670.64	4635.9	4608	4547	4480
Wet Soil (g)	3249.64	3214.9	3187	3126	3059
Wet Soil (lb)	7.16	7.09	7.03	6.89	6.74
Compacted Soil Wet (pcf)	156.1	154.4	153.1	150.1	146.9
Compacted Soil Dry (pcf)	146.9	145.1	142.1	141.6	138.4
Moisture Tin ID	38	9c	kk5	x4	kk5
Mass of Moisture Tin	30.48	30.56	29.25	31.02	29.25
Mass of Tin and Moist Soil	190.74	156.99	166.14	123.79	158.09
Mass of Tin and Dry Soil	181.28	149.37	156.31	118.5	150.62
Moisture Content	6.3%	6.4%	7.7%	6.0%	6.2%
Max Density (pcf)	147.5	145.2	143.8	143.1	140.0
Optimum Moisture %	6.3	6.4	6.8	6.7	7.2

Test No.	16	17	18	19	20
Wet Soil + Mold (g)	4658.5	4655.7	4640.2	4635.5	4640.6
Wet Soil (g)	3237.5	3234.7	3219.2	3214.5	3219.6
Wet Soil (lb)	7.14	7.13	7.10	7.09	7.10
Compacted Soil Wet (pcf)	155.5	155.4	154.6	154.4	154.6
Compacted Soil Dry (pcf)	146.2	145.7	144.7	145.9	143.6
Moisture Tin ID	1	hop	2	x6	x4
Mass of Moisture Tin	31.07	30.71	31.02	30.8	30.92
Mass of Tin and Moist Soil	189.05	181.98	226.14	222.61	199.91
Mass of Tin and Dry Soil	179.58	172.56	213.61	212.04	187.89
Moisture Content	6.4%	6.6%	6.9%	5.8%	7.7%
Max Density (pcf)	146.2	146.1	145.3	146.9	143.6
Optimum Moisture %	6.3	6.3	6.4	6.2	7.7

Description of Soil	22A Aggregate, Superior Sand and Gravel	Sample No.	2
Location	Dillman B003		
Volume of Mold	**0.04439** ft^3		
Weight of Mold	**1946** g		
Tested By	KMK	Date	7/12/2011

Test No.	21	22	23	24	**25**
Wet Soil + Mold (g)	4660.1	4655.8	4689.3	4653.7	5039.4
Wet Soil (g)	3239.1	3234.8	3268.3	3232.7	3093.4
Wet Soil (lb)	7.14	7.13	7.21	7.13	6.82
Compacted Soil Wet (pcf)	155.6	155.4	157.0	155.3	153.6
Compacted Soil Dry (pcf)	145.6	145.0	148.8	144.2	145.3
Moisture Tin ID	pe	jjad	x4	pl	jjad
Mass of Moisture Tin	31.32	30.38	30.93	31.05	30.31
Mass of Tin and Moist Soil	179.16	174.13	190.08	151.65	187.39
Mass of Tin and Dry Soil	169.64	164.51	181.8	143.08	178.9
Moisture Content	6.9%	7.2%	5.5%	7.6%	5.7%
Max Density (pcf)	145.6	145.0	149.8	144.2	146.6
Optimum Moisture %	6.9	7.2	5.9	7.6	6.3

Test No.	**26**	**27**	**28**	**29**	**30**
Wet Soil + Mold (g)	5040.6	5011.0	5040.8	5034.9	4974.0
Wet Soil (g)	3094.6	3065.0	3094.8	3088.9	3028.0
Wet Soil (lb)	6.82	6.76	6.82	6.81	6.68
Compacted Soil Wet (pcf)	153.7	152.2	153.7	153.4	150.4
Compacted Soil Dry (pcf)	145.6	143.4	144.2	145.0	142.9
Moisture Tin ID	x6	b3	4	1	3rc
Mass of Moisture Tin	30.87	30.45	30.82	31.05	30.29
Mass of Tin and Moist Soil	172.2	157.92	167.8	186.88	210.87
Mass of Tin and Dry Soil	164.72	150.49	159.3	178.38	201.84
Moisture Content	5.6%	6.2%	6.6%	5.8%	5.3%
Max Density (pcf)	147	144.2	144.1	146.2	145.5
Optimum Moisture %	6.2	6.6	6.6	6.3	6.4

MI Cone Curve Weak Hits: 18" free fall

Description of Soil	22A - Superior Sand and Gravel - P3/4"	Sample No.	2
Location	Dillman B003		
Volume of Mold	0.0459 ft^3		
Tested By	KMK	Date	6/28/2011

	Test	1	2	3	4	5
Weight of Mold		3.126	3.126	3.126	3.126	3.126
Weight of Mold and Soil		9.571	9.5715	9.878	10.1005	9.9665
Weight of moist Soil		6.445	6.4455	6.752	6.9745	6.8405
Moist Unit Weight (pcf)		140.4	140.4	147.1	151.9	149.0
Moisture Tin ID		TA	LL	KK%	KI	bJc
Mass of Moisture Tin		28.9	33.4	29.3	31.7	30.0
Mass of Tin and Moist Soil		170.8	153.6	158.1	164.3	242.1
Mass of Tin and Dry Soil		170.0	149.8	150.6	155.1	224.6
Moisture Content		0.6%	3.3%	6.2%	7.4%	9.0%
Dry Unit Weight (pcf)		139.6	135.9	138.6	141.4	136.8
	Total Blows	155	220	175	135	105
	After Full	60	120	40	20	20
Energy/20 Blows						

MI Cone	Curve	Hard Hits: 18" driven		
Description of Soil		22A - Superior Sand and Gravel - P3/4"	Sample No.	2
Location		Dillman B003		
Volume of Mold		0.0459 ft^3		
Tested By		KMK	Date	6/28/2011

	Test	1	2	3	4	5
Weight of Mold		3.126	3.126	3.126	3.126	3.126
Weight of Mold and Soil		9.717	9.707	10.0245	10.1385	9.9675
Weight of moist Soil		6.591	6.581	6.8985	7.0125	6.8415
Moist Unit Weight (pcf)		143.6	143.4	150.3	152.8	149.1
Moisture Tin ID		3	H4	X4	38	WRS
Mass of Moisture Tin		31.0	31.1	31.0	30.3	29.7
Mass of Tin and Moist Soil		159.2	104.6	123.8	165.9	206.9
Mass of Tin and Dry Soil		158.6	102.1	118.5	155.9	191.1
Moisture Content		0.5%	3.5%	6.0%	7.9%	9.8%
Dry Unit Weight (pcf)		142.9	138.5	141.7	141.6	135.8
	Total Blows	155	220	175	135	105
	After Full	60	120	40	20	20
Energy/20 Blows						

Sample ID: 22A 28-54
Description:
Before Testing

Date: 8/2/2011
Bowl ID: 209.8 g
Mass of Sample Oven Dry: 1291.24 g
After Wash: 1219.6 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	1025.6	779.7	245.9	19.0	81.0
4	4.75	902.5	709.4	193.1	15.0	66.0
10	2	655.5	482.8	172.7	13.4	52.6
20	0.85	530.0	424.2	105.8	8.2	44.4
40	0.425	538.3	329.6	208.7	16.2	28.3
60	0.25	559.5	369.4	190.1	14.7	13.5
100	0.15	416.5	352.2	64.3	5.0	8.6
140	0.106	309.3	279.0	30.3	2.3	6.2
200	0.075	342.9	334.3	8.6	0.7	5.6
Pan	--	374.9	374.0	0.9	0.1	5.5
			∑	1220.4		

Sample ID: 22A 28-54
Description:
After 1 Cone Test

Date: 8/2/2011
Bowl ID: 206.8 g
Mass of Sample Oven Dry: 1314.9 g
After Wash: 1245.2 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	1088.4	780.9	307.5	23.4	76.6
4	4.75	906.1	709.4	196.7	15.0	61.7
10	2	656.1	485.8	170.3	13.0	48.7
20	0.85	545.5	426.3	119.2	9.1	39.6
40	0.425	525.2	330.7	194.5	14.8	24.8
60	0.25	547.3	369.8	177.5	13.5	11.3
100	0.15	412.1	352.2	59.9	4.6	6.8
140	0.106	309.3	296.8	12.5	1.0	5.8
200	0.075	342.8	334.4	8.4	0.6	5.2
Pan	--	374.7	374.0	0.7	0.1	5.2
			∑	1247.2		

Sample ID:
Description:

After 1 Modified Proctor Test

Date: 8/12/2011
Bowl ID: 208.97 g
Mass of Sample Oven Dry: 1565.61 g
After Wash: 1441.01 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	1051.9	801.4	250.5	16.0	84.0
4	4.75	916.4	722.8	193.6	12.4	71.6
10	2	881.0	677.9	203.1	13.0	58.7
20	0.85	580.8	424.7	156.1	10.0	48.7
40	0.425	602.3	340.0	262.3	16.8	31.9
60	0.25	787.3	543.2	244.1	15.6	16.3
100	0.15	438.1	347.2	90.9	5.8	10.5
140	0.106	354.4	331.7	22.7	1.4	9.1
200	0.075	366.4	351.5	14.9	1.0	8.1
Pan	--	380.0	376.0	4.0	0.3	7.9
			∑	1442.2		

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C: Full Energy 12400 ft*lb/ft^3
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil 22A 28-54 Sample No. 22A 28-54
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 8/11/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	6507.3	6507.3	6507.3	6507.3	6507.3
Weight of Mold, Base, and Soil	10905.8	11008.4	11236.6	11418.1	11471.2
Weight of moist Soil	4398.5	4501.1	4729.3	4910.8	4963.9
Moist Unit Weight (pcf)	129.3	132.3	139.0	144.4	145.9
Moisture Tin ID	z67	tsa	rtfo	kk7	3
Mass of Moisture Tin	29.9	21.5	38.3	31.2	38.5
Mass of Tin and Moist Soil	177.8	154.3	227.6	204.5	349.6
Mass of Tin and Dry Soil	177.3	151.4	219.4	191.1	323.1
Moisture Content	0.34	2.26	4.53	8.41	9.32
Dry Unit Weight (pcf)	128.9	129.4	133.0	133.2	133.5

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C: Full Energy 56250 ft*lb/ft^3

Description of Soil 22A 28-54 Sample No 22A 28-54
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 8/11/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	6547.2	6547.2	6547.2	6547.2	6547.2
Weight of Mold, Base, and Soil	11023.2	11012.4	11275.6	11490.9	11528.1
Weight of moist Soil	4476	4465.2	4728.4	4943.7	4980.9
Moist Unit Weight (pcf)	131.6	131.3	139.0	145.3	146.4
Moisture Tin ID	kk6	r2d	y2m	ki	1
Mass of Moisture Tin	31.5	29.4	29.7	31.7	30.4
Mass of Tin and Moist Soil	252.3	208.0	165.7	207.7	253.6
Mass of Tin and Dry Soil	251.6	203.6	159.0	194.3	233.2
Moisture Content	0.32	2.54	5.19	8.24	10.05
Dry Unit Weight (pcf)	131.1	128.0	132.1	134.3	133.0

Description of Soil	22A 28-54	Sample No.	22A 28-54
Location	Dillman B003		
Volume of Mold	0.04439 ft^3		
Weight of Mold	1944.4 g		
Tested By	KMK	Date	8/1/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	4868.1	4897.4	4879.6	4885.3	4887.6
Wet Soil (g)	2923.7	2953	2935.2	2940.9	2943.2
Wet Soil (lb)	6.45	6.51	6.47	6.48	6.49
Compacted Soil Wet (pcf)	145.2	146.7	145.8	146.1	146.2
Compacted Soil Dry (pcf)	136.6	138.2	137.4	136.3	137.0
Moisture Tin ID	3	21	14	22	2b
Mass of Moisture Tin	37.98	28.96	35.32	32.62	30.44
Mass of Tin and Moist Soil	383.28	225.41	394.06	234.71	218.11
Mass of Tin and Dry Soil	362.73	214.01	373.37	221.2	206.36
Moisture Content	6.33	6.16	6.12	7.16	6.68
Max Density (pcf)	138.3	139.9	139.3	136.9	138.1
Optimum Moisture %	7.5	7.2	7.3	7.8	7.5
Total Hits	150.0	170.0	130.0	170.0	170
After Full	40.0	60.0	20.0	60.0	60

Test No.	6	7	8	9	10
Wet Soil + Mold (g)	4867.7	4872.7	4941.4	4846.2	4916.1
Wet Soil (g)	2923.3	2928.3	2997	2901.8	2971.7
Wet Soil (lb)	6.44	6.46	6.61	6.40	6.55
Compacted Soil Wet (pcf)	145.2	145.4	148.8	144.1	147.6
Compacted Soil Dry (pcf)	137.0	136.9	139.0	137.5	137.5
Moisture Tin ID	3kl	2a	pl	7`	11
Mass of Moisture Tin	29.81	33.06	30.78	31.12	30.53
Mass of Tin and Moist Soil	205.96	246.57	195.91	173.56	191.8
Mass of Tin and Dry Soil	196.04	233.99	185	167.03	180.75
Moisture Content	5.97	6.26	7.07	4.80	7.36
Max Density (pcf)	139.2	138.7	139.2	141.2	137.6
Optimum Moisture %	7.3	7.4	7.3	7	7.6
Total Hits	150.0	150.0	140.0	130.0	130
After Full	40.0	40.0	20.0	20.0	20

Chart Results	**Average**	138.8 pcf	Max	141.2 pcf
	STDEV	1.2167352 pcf	Min	136.9 pcf
	Average Hit Count	149		

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Description of Soil	22A 28-54	Sample No.	
Location	Dillman B003		
Volume of Mold	0.0459 ft^3		
Weight of Mold	1421 g		
Tested By	KMK	Date	8/23/2011

Test No.	11	12	13	14	15
Wet Soil + Mold (g)	4419.2	4400.1	4434.2	4441.7	4404.2
Wet Soil (g)	2998.2	2979.1	3013.2	3020.7	2983.2
Wet Soil (lb)	6.61	6.57	6.64	6.66	6.58
Compacted Soil Wet (pcf)	144.0	143.1	144.7	145.1	143.3
Compacted Soil Dry (pcf)	136.3	135.4	136.2	136.9	134.5
Moisture Tin ID	37	49	4	45	200
Mass of Moisture Tin	63.82	64.16	61.59	63.79	64.19
Mass of Tin and Moist Soil	617.13	668.24	625.76	677.41	650.78
Mass of Tin and Dry Soil	587.46	635.73	592.7	642.94	614.95
Moisture Content	5.67	5.69	6.22	5.95	6.51
Max Density (pcf)	139.1	138.2	138.1	139.2	136.1
Optimum Moisture %	7.4	7.5	7.5	7.3	7.9
Total Hits	170.0	130.0	150.0	170.0	130
After Full					
average	1.2 pcf				

Test No.	16	17	18	19	20
Wet Soil + Mold (g)	4386	4343			
Wet Soil (g)	2965	2922			
Wet Soil (lb)	6.54	6.44			
Compacted Soil Wet (pcf)	142.4	140.3			
Compacted Soil Dry (pcf)	134.1	132.3			
Moisture Tin ID	13	50			
Mass of Moisture Tin	63.78	42.07			
Mass of Tin and Moist Soil	664.3	481.74			
Mass of Tin and Dry Soil	629.05	456.62			
Moisture Content	6.24	6.06			
Max Density (pcf)	136	134.5			
Optimum Moisture %	7.9	8.2			
Total Hits	170.0	160.0			
After Full					
average	1.1202678 pcf				

Description of Soil	22A 28-54	Sample No.	
Location	Dillman B003		
Volume of Mold	**0.04439** ft^3		
Weight of Mold	**1940** g		
Tested By	JV	Date	8/23/2011

Test No.	21	22	23	24	25
Wet Soil + Mold (g)	4875.7	4897.5	4871.5	4901.1	4872.2
Wet Soil (g)	2935.7	2957.5	2931.5	2961.1	2932.2
Wet Soil (lb)	6.47	6.52	6.46	6.53	6.46
Compacted Soil Wet (pcf)	145.8	146.9	145.6	147.1	145.6
Compacted Soil Dry (pcf)	138.3	138.8	137.5	138.3	137.8
Moisture Tin ID	20	18	33	14	46
Mass of Moisture Tin	62.74	62.04	62.77	62.55	63.66
Mass of Tin and Moist Soil	594.84	714.67	757.69	678.21	728.91
Mass of Tin and Dry Soil	567.31	678.58	719.02	641.36	693.09
Moisture Content	5.46	5.85	5.89	6.37	5.69
Max Density (pcf)	141.2	140.9	139.8	139.6	140.4
Optimum Moisture %	7.0	7.1	7.2	7.3	7.1
Total Hits	140.0	160.0	140.0	140.0	140
After Full					
average	0.7 pcf				

Test No.	26	27	28	29	30
Wet Soil + Mold (g)	4772.6	4766.9	4769.2		
Wet Soil (g)	2832.6	2826.9	2829.2		
Wet Soil (lb)	6.24	6.23	6.24		
Compacted Soil Wet (pcf)	140.7	140.4	140.5		
Compacted Soil Dry (pcf)	133.4	133.8	133.3		
Moisture Tin ID	34	31	44		
Mass of Moisture Tin	62.95	65.41	61.64		
Mass of Tin and Moist Soil	799.94	746.73	645.23		
Mass of Tin and Dry Soil	761.81	714.72	615.15		
Moisture Content	5.46	4.93	5.43		
Max Density (pcf)	136.5	137.6	136.4		
Optimum Moisture %	7.8	7.6	7.8		
Total Hits	150.0	160.0	140.0		
After Full					
average	136.8 pcf				

MI Cone Curve

Description of Soil	22A 28-54	Sample No	22A 28-54
Location	Dillman B003		
Volume of Mold	0.04439 ft^3		
Tested By	KMK	Date	5-Aug

Test	1	2	3	4	5	6
Weight of Mold	1944.4	1944.4	1944.4	1944.4	1944.4	
Weight of Mold and Soil	4712.8	4699.1	4846.2	4916.1	4886.3	
Weight of moist Soil	2768.4	2754.7	2901.8	2971.7	2941.9	
Moist Unit Weight (pcf)	137.5	136.8	144.1	147.6	146.1	
Moisture Tin ID	kk6	1	kk7	kk11	a1	
Mass of Moisture Tin	31.5	30.0	31.1	30.5	30.6	
Mass of Tin and Moist Soil	183.9	213.9	173.6	191.8	234.2	
Mass of Tin and Dry Soil	183.4	209.1	167.0	180.8	217.3	
Moisture Content	0.31	2.69	4.80	7.36	9.07	
Dry Unit Weight (pcf)	137.1	133.2	137.5	137.5	134.0	
Total Blows	150	150	130	130		
After Full	40	40	20	20		
Energy/20 Blows						

Sample ID: 22A 41-13
Description:
Before Testing

Date: 8/8/2011
Bowl ID: 333.54 g
Mass of Sample Oven Dry: 1757.32 g
After Wash: 1614.15 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05	932.9	837.2	95.7	5.4	94.6
3/8"	9.525	1305.9	800.3	505.6	28.8	65.8
4	4.75	1132.9	720.7	412.2	23.5	42.3
10	2	878.8	676.7	202.1	11.5	30.8
20	0.85	489.6	424.1	65.5	3.7	27.1
40	0.425	401.6	339.6	62.0	3.5	23.6
60	0.25	662.9	543.0	119.9	6.8	16.7
100	0.15	443.4	346.9	96.5	5.5	11.3
140	0.106	364.1	331.8	32.3	1.8	9.4
200	0.075	371.6	351.6	20.0	1.1	8.3
Pan	--	381.8	376.1	5.7	0.3	8.0
			∑	1617.5		

Sample ID: 22A 41-13
Description:
After 1 Cone Test

Date: 8/8/2011
Bowl ID: 333.64 g
Mass of Sample Oven Dry: 1341.59 g
After Wash: 1225.79 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05	882.5	837.2	45.3	3.4	96.6
3/8"	9.525	1122.2	800.6	321.6	24.0	72.7
4	4.75	1045.2	723.3	321.9	24.0	48.7
10	2	866.6	678.2	188.4	14.0	34.6
20	0.85	487.8	424.3	63.5	4.7	29.9
40	0.425	393.8	339.9	53.9	4.0	25.9
60	0.25	643.2	542.9	100.3	7.5	18.4
100	0.15	429.8	346.9	82.9	6.2	12.2
140	0.106	358.8	331.9	26.9	2.0	10.2
200	0.075	368.1	351.6	16.5	1.2	9.0
Pan	--	381.5	376.2	5.3	0.4	8.6
			∑	1226.5		

Sample ID: 22A 41-13
Description:
After 1 Modified Proctor Test

Date: 8/24/2011
Bowl ID: 330.44 g
Mass of Sample Oven Dry: 2429.25 g
After Wash: 2207.46 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05	908	837.3	70.7	2.9	97.1
3/8"	9.525	1007.9	492.9	515.0	21.2	75.9
4	4.75	1026.7	466.7	560.0	23.1	52.8
10	2	796.7	432.8	363.9	15.0	37.9
20	0.85	514.3	371.6	142.7	5.9	32.0
40	0.425	441.8	338.0	103.8	4.3	27.7
60	0.25	507.1	315.3	191.8	7.9	19.8
100	0.15	497.1	346.8	150.3	6.2	13.6
140	0.106	353.9	304.7	49.2	2.0	11.6
200	0.075	371.1	334.3	36.8	1.5	10.1
Pan	--	398.9	377.5	21.4	0.9	9.2
			∑	2205.6		

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C: Full Energy 12400 ft*lb/ft^3
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil 22A 41-13 Sample No. 22A 41-13
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 8/16/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	6507.6	6507.6	6507.6	6507.6	
Weight of Mold, Base, and Soil	11065	11280.5	11655.7	11711.5	
Weight of moist Soil	4557.4	4772.9	5148.1	5203.9	
Moist Unit Weight (pcf)	134.0	140.3	151.3	153.0	
Moisture Tin ID	r2d	1	z67	kk8	
Mass of Moisture Tin	29.4	31.3	30.0	30.0	
Mass of Tin and Moist Soil	144.4	215.3	248.0	294.0	
Mass of Tin and Dry Soil	143.9	208.7	237.0	271.0	
Moisture Content	0.48	3.73	5.34	9.52	
Dry Unit Weight (pcf)	133.3	135.3	143.7	139.7	

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C: Full Energy 56250 ft*lb/ft^3

Description of Soil 22A 41-13 Sample No 22A 41-13
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date 8/16/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	6546.9	6546.9	6546.9	6546.9	
Weight of Mold, Base, and Soil	11215.1	11609.7	11721.5	11785.3	
Weight of moist Soil	4668.2	5062.8	5174.6	5238.4	
Moist Unit Weight (pcf)	137.2	148.8	152.1	154.0	
Moisture Tin ID	ckba	y2m	1a	80	
Mass of Moisture Tin	29.9	29.7	33.4	30.8	
Mass of Tin and Moist Soil	301.3	213.7	237.0	239.7	
Mass of Tin and Dry Soil	300.3	207.3	226.7	219.9	
Moisture Content	0.40	3.62	5.33	10.47	
Dry Unit Weight (pcf)	136.7	143.6	144.4	139.4	

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C: Full Energy 56250 ft*lb/ft^3

Description of Soil 22A 41-13 Sample No 22A 41-13
Location Dillman B003
Volume of Mold 0.075 ft^3
Tested By KMK Date

	Test	1	2	3	4	5
Weight of Mold and Baseplate		14.4255	14.4255	14.4255	14.4255	14.4255
Weight of Mold, Base, and Soil		25.9335	25.942	26.061	25.736	25.8245
Weight of moist Soil		11.508	11.5165	11.6355	11.3105	11.399
Moist Unit Weight (pcf)		153.4	153.6	155.1	150.8	152.0
Moisture Tin ID		49	12	422	50	47
Mass of Moisture Tin		62.5	62.1	61.8	62.6	63.0
Mass of Tin and Moist Soil		576.1	468.8	608.8	548.6	605.5
Mass of Tin and Dry Soil		554.2	447.2	578.1	523.8	576.6
Moisture Content		4.45	5.60	5.94	5.38	5.63
Dry Unit Weight (pcf)		146.9	145.4	146.4	143.1	143.9

average 145.1
STDEV 1.6275666

Description of Soil	22A 41-13	Sample No.	22A 41-13
Location	Dillman B003		
Volume of Mold	0.04439 ft^3		
Weight of Mold	1944.4 g		
Tested By	KMK	Date	8/8/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	5066.2	5053.3	5048.4	5043.7	5056.6
Wet Soil (g)	3121.8	3108.9	3104	3099.3	3112.2
Wet Soil (lb)	6.88	6.85	6.84	6.83	6.86
Compacted Soil Wet (pcf)	155.0	154.4	154.2	153.9	154.6
Compacted Soil Dry (pcf)	146.2	145.2	146.5	144.6	146.8
Moisture Tin ID	4	rtfo	1ll	14	78
Mass of Moisture Tin	30.64	36.91	33.38	35.27	29.94
Mass of Tin and Moist Soil	182.18	316.79	219.21	301.03	256.01
Mass of Tin and Dry Soil	173.53	300.18	210.01	284.95	244.61
Moisture Content	6.05	6.31	5.21	6.44	5.31
Max Density (pcf)	146.6	145.4	148.6	144.7	148.5
Optimum Moisture %	6.3	6.4	6.0	6.5	6
Total Hits	180.0	160.0	180.0	160.0	150
After Full	40.0	20.0	40.0	20.0	20

Test No.	6	7	8	9	10
Wet Soil + Mold (g)	5057.6	5058.7	5058.2	5061.7	5052
Wet Soil (g)	3113.2	3114.3	3113.8	3117.3	3107.6
Wet Soil (lb)	6.86	6.87	6.86	6.87	6.85
Compacted Soil Wet (pcf)	154.6	154.7	154.6	154.8	154.3
Compacted Soil Dry (pcf)	145.9	145.9	145.8	146.6	145.5
Moisture Tin ID	ki	ta	g2c	3	x4
Mass of Moisture Tin	31.35	30.36	31.34	38.18	30.92
Mass of Tin and Moist Soil	212.66	230.6	156.13	252.17	162.03
Mass of Tin and Dry Soil	202.39	219.19	149.03	240.75	154.51
Moisture Content	6.00	6.04	6.03	5.64	6.08
Max Density (pcf)	146.5	146.4	146.4	147.6	146
Optimum Moisture %	6.3	6.3	6.3	6.1	6.3
Total Hits	160.0	160.0	150.0	160.0	180
After Full	20.0	20.0	20.0	20.0	20

Chart Results	**Average**	146.7 pcf	Max	148.6 pcf
	STDEV	1.2499333 pcf	Min	144.7 pcf
	Average Hit Count	164		

Description of Soil	22A 41-13	Sample No.	
Location	Dillman B003		
Volume of Mold	0.0459 ft^3		
Weight of Mold	1421 g		
Tested By	KMK	Date	8/16/2011

Test No.	11	12	13	14	15
Wet Soil + Mold (g)	4689.5	4671.6	4646.7	4659.2	4655.9
Wet Soil (g)	3268.5	3250.6	3225.7	3238.2	3234.9
Wet Soil (lb)	7.21	7.17	7.11	7.14	7.13
Compacted Soil Wet (pcf)	157.0	156.1	154.9	155.5	155.4
Compacted Soil Dry (pcf)	148.4	148.1	146.5	147.3	146.1
Moisture Tin ID	78	200	47	49	50
Mass of Moisture Tin	30.22	61.89	61.67	62.11	41.73
Mass of Tin and Moist Soil	263.66	637.41	659.92	628.87	432.51
Mass of Tin and Dry Soil	250.82	607.85	627.35	598.7	409.12
Moisture Content	5.82	5.41	5.76	5.62	6.37
Max Density (pcf)	148.7	149.4	147.4	148.3	145.9
Optimum Moisture %	6.0	6.0	6.2	6.1	6.3
Total Hits	180.0	200.0	180.0	190.0	170
After Full					

Test No.	16	17	18	19	20
Wet Soil + Mold (g)	4581.9	4564.5			
Wet Soil (g)	3160.9	3143.5			
Wet Soil (lb)	6.97	6.93			
Compacted Soil Wet (pcf)	151.8	151.0			
Compacted Soil Dry (pcf)	143.1	143.3			
Moisture Tin ID	rtfo	4b			
Mass of Moisture Tin	38.24	61.91			
Mass of Tin and Moist Soil	335.52	729.55			
Mass of Tin and Dry Soil	318.36	695.36			
Moisture Content	6.13	5.40			
Max Density (pcf)	144.1	145.6			
Optimum Moisture %	6.6	6.4			
Total Hits					
After Full					

Description of Soil	22A 41-13	Sample No.	
Location	Dillman B003		
Volume of Mold	**0.04439** ft^3		
Weight of Mold	**1946** g		
Tested By	JV	Date	8/16/2011

Test No.	21	22	23	24	**25**
Wet Soil + Mold (g)	5090.3	5088.3	5074.7	5068	5082.9
Wet Soil (g)	3144.3	3142.3	3128.7	3122	3136.9
Wet Soil (lb)	6.93	6.93	6.90	6.88	6.92
Compacted Soil Wet (pcf)	156.2	156.1	155.4	155.1	155.8
Compacted Soil Dry (pcf)	148.6	147.7	147.1	146.0	147.8
Moisture Tin ID	3	14	45	31	20
Mass of Moisture Tin	38.74	62.11	64.15	62.54	62.29
Mass of Tin and Moist Soil	459.11	608.85	718.2	682.31	812
Mass of Tin and Dry Soil	438.65	579.7	683.24	646.18	773.32
Moisture Content	5.12	5.63	5.65	6.19	5.44
Max Density (pcf)	150.2	148.6	148.1	146.2	149.1
Optimum Moisture %	5.7	6.0	6.1	6.3	6
Total Hits	150.0	170.0	150.0	150.0	170
After Full					

Test No.	**26**	**27**	**28**	**29**	**30**
Wet Soil + Mold (g)	5017.9	5039.2	5058.1		
Wet Soil (g)	3071.9	3093.2	3112.1		
Wet Soil (lb)	6.77	6.82	6.86		
Compacted Soil Wet (pcf)	152.6	153.6	154.6		
Compacted Soil Dry (pcf)	145.0	144.9	146.2		
Moisture Tin ID	33	46	18		
Mass of Moisture Tin	61.5	62.52	61.4		
Mass of Tin and Moist Soil	753.53	678.7	771.2		
Mass of Tin and Dry Soil	719.31	643.86	732.83		
Moisture Content	5.20	5.99	5.71		
Max Density (pcf)	147.4	145.8	147.2		
Optimum Moisture %	6.2	6.4	6.2		
Total Hits	190.0	170.0	170.0		
After Full					

MI Cone Curve

Description of Soil	22A 41-13	Sample No	22A 41-13
Location	Dillman B003		
Volume of Mold	0.04439 ft^3		
Tested By	KMK	Date	8-Aug

	Test	1	2	3	4	5	6
Weight of Mold		1944.4	1944.4	1944.4	1944.4		
eight of Mold and Soil		4743.3	4687.4	5052	4978.3		
Weight of moist Soil		2798.9	2743	3107.6	3033.9		
loist Unit Weight (pcf)		139.0	136.2	154.3	150.7		
Moisture Tin ID		4	1	x4	kk9		
Mass of Moisture Tin		31.2	31.1	30.9	29.3		
s of Tin and Moist Soil		198.2	179.3	162.0	245.7		
ass of Tin and Dry Soil		197.5	175.4	154.5	230.3		
Moisture Content		0.42	2.70	6.08	7.66		
Dry Unit Weight (pcf)		138.4	132.6	145.5	140.0		
Total Blows		220	160	180	140		
	After Full	40	40	20			
Energy/20 Blows							

Sample ID: CL II
Description: CL II
Before Testing

Date: 7/20/2011
Bowl ID: 16-209.0 g
Mass of Sample Oven Dry: 611 g
After Wash: 593.8 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	569.8	554.3	15.5	2.5	97.5
4	4.75	474.5	462.9	11.6	1.9	95.6
10	2	507.6	487.8	19.8	3.2	92.3
20	0.85	427.2	407.3	19.9	3.3	89.1
40	0.425	453.0	388.4	64.6	10.6	78.5
60	0.25	596.1	367.1	229.0	37.5	41.0
100	0.15	519.0	355.4	163.6	26.8	14.2
140	0.106	382.6	339.3	43.3	7.1	7.2
200	0.075	352.6	332.2	20.4	3.3	3.8
Pan	--	379.9	373.6	6.3	1.0	2.8
			∑	594.0		

Sample ID: CL II
Description: CL II
After 1 Cone Test

Date: 7/20/2011
Bowl ID: x-332.5 g
Mass of Sample Oven Dry: 534.7 g
After Wash: 520.7 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	563.8	554.3	9.5	1.8	98.2
4	4.75	473.1	463.2	9.9	1.9	96.4
10	2	505.9	488.2	17.7	3.3	93.1
20	0.85	424.7	407.4	17.3	3.2	89.8
40	0.425	446.2	390.1	56.1	10.5	79.3
60	0.25	571.3	368.1	203.2	38.0	41.3
100	0.15	498.5	355.7	142.8	26.7	14.6
140	0.106	377.4	339.2	38.2	7.1	7.5
200	0.075	351.2	332.2	19.0	3.6	3.9
Pan	--	381.1	373.4	7.7	1.4	2.5
			∑	521.4		

Sample ID: CL II
Description: CL II
After 1 Modified Proctor Test

Date: 7/20/2011
Bowl ID: I12-330.1 g
Mass of Sample Oven Dry: 642.1 g
After Wash: 622.1 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	566.4	554.2	12.2	1.9	98.1
4	4.75	477.5	462.8	14.7	2.3	95.8
10	2	510.9	488.7	22.2	3.5	92.4
20	0.85	428.2	407.7	20.5	3.2	89.2
40	0.425	454.4	389.0	65.4	10.2	79.0
60	0.25	612.2	367.6	244.6	38.1	40.9
100	0.15	518.5	355.7	162.8	25.4	15.5
140	0.106	383.4	339.4	44.0	6.9	8.7
200	0.075	354.9	332.3	22.6	3.5	5.2
Pan	--	385.2	373.6	11.6	1.8	3.3
			∑	620.6		

Method (Circle)
Standard Method A:
Standard Method B: 1/2 Energy 6200 ft*lb/ft^3
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil CL II Sample No. CL II
Location Dillman B003
Volume of Mold 0.0333333 ft^3
Tested By KMK Date 7/19/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	9.408	9.408	9.408	9.408	9.408
Weight of Mold, Base, and Soil	13.004	13.014	12.9675	13.3095	13.5355
Weight of moist Soil	3.596	3.606	3.5595	3.9015	4.1275
Moist Unit Weight (pcf)	107.9	108.2	106.8	117.0	123.8
Moisture Tin ID	x6	pe3	ki	pl	g2
Mass of Moisture Tin	30.87	31.36	31.72	31.23	31.44
Mass of Tin and Moist Soil	151.07	117.77	144.88	152.53	149.55
Mass of Tin and Dry Soil	149.62	114.27	137.55	140.65	135.71
Moisture Content	1.2	4.2	6.9	10.9	13.3
Dry Unit Weight (pcf)	106.6	103.8	99.9	105.6	109.3

Method (Circle)
Standard Method A:
Standard Method B: Full Energy 12400 ft*lb/ft^3
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil CL II Sample No. CL II
Location Dillman B003
Volume of Mold 0.0333333 ft^3
Tested By KMK Date 7/21/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	9.408	9.408	9.408	9.408	9.408
Weight of Mold, Base, and Soil	13.0475	12.9905	13.024	13.406	13.5705
Weight of moist Soil	3.6395	3.5825	3.616	3.998	4.1625
Moist Unit Weight (pcf)	109.2	107.5	108.5	119.9	124.9
Moisture Tin ID	pl	1a	kk3	k6	1
Mass of Moisture Tin	31.11	33.38	30.85	31.13	31.13
Mass of Tin and Moist Soil	163.97	154.47	128.15	139.85	149.68
Mass of Tin and Dry Soil	162.33	149.70	121.98	128.93	134.86
Moisture Content	1.25	4.10	6.77	11.17	14.29
Dry Unit Weight (pcf)	107.8	103.2	101.6	107.9	109.3

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B: 1/2 Energy 28125 ft*lb/ft^3
Modified Method C:

Description of Soil CL II Sample No CL II
Location Dillman B003
Volume of Mold 0.0333333 ft^3
Tested By KMK Date 7/19/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	9.408	9.408	9.408	9.408	9.408
Weight of Mold, Base, and Soil	13.096	13.051	13.1965	13.4385	13.6125
Weight of moist Soil	3.688	3.643	3.7885	4.0305	4.2045
Moist Unit Weight (pcf)	110.6	109.3	113.7	120.9	126.1
Moisture Tin ID	1	kk5	3ll	2a	jjad
Mass of Moisture Tin	31.09	29.34	31.53	31.18	30.46
Mass of Tin and Moist Soil	127.95	165.94	155.29	144.32	134.60
Mass of Tin and Dry Soil	127.00	160.11	147.78	132.57	121.58
Moisture Content	0.99	4.46	6.46	11.59	14.29
Dry Unit Weight (pcf)	109.6	104.6	106.8	108.4	110.4

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B: Full Energy 56250 ft*lb/ft^3
Modified Method C:

Description of Soil CL II Sample No CL II
Location Dillman B003
Volume of Mold 0.0333333 ft^3
Tested By KMK Date 7/19/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	9.408	9.408	9.408	9.408	9.408
Weight of Mold, Base, and Soil	13.187	13.1685	13.2895	13.509	13.726
Weight of moist Soil	3.779	3.7605	3.8815	4.101	4.318
Moist Unit Weight (pcf)	113.4	112.8	116.4	123.0	129.5
Moisture Tin ID	kk2	38i	kk2	3kl	112
Mass of Moisture Tin	30.48	30.30	30.48	29.85	29.76
Mass of Tin and Moist Soil	115.39	155.89	145.86	161.42	177.73
Mass of Tin and Dry Soil	114.55	150.71	138.86	148.71	159.29
Moisture Content	1.0	4.3	6.5	10.7	14.2
Dry Unit Weight (pcf)	112.2	108.2	109.4	111.1	113.4

Description of Soil	CL II	Sample No.	CL II
Location	Dillman B003		
Volume of Mold	0.04439 ft^3		
Weight of Mold	1946 g		
Tested By	KMK	Date	7/19/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	4325.2	4338.8	4323.8	4332	4327.3
Wet Soil (g)	2379.2	2392.8	2377.8	2386	2381.3
Wet Soil (lb)	5.25	5.28	5.24	5.26	5.25
Compacted Soil Wet (pcf)	118.2	118.8	118.1	118.5	118.3
Compacted Soil Dry (pcf)	110.7	110.6	110.1	110.2	110.4
Moisture Tin ID	kk3	wrs	k6	3rc	ll
Mass of Moisture Tin	30.86	29.64	31.13	30.32	30.63
Mass of Tin and Moist Soil	130.69	174.63	155.88	149.91	139.40
Mass of Tin and Dry Soil	124.38	164.58	147.48	141.49	132.13
Moisture Content	6.7	7.4	7.2	7.6	7.2
Max Density (pcf)	111.5	110.7	110.9	110.8	111.1
Optimum Moisture %	14.6	14.9	14.8	14.9	14.8
Total Hits	120	120	120	120	130
After Full	20	40	20	20	20

Test No.	6	7	8	9	10
Wet Soil + Mold (g)	4460.1	4448.5	4443.4	4428.9	4422.1
Wet Soil (g)	2514.1	2502.5	2497.4	2482.9	2476.1
Wet Soil (lb)	5.54	5.52	5.51	5.47	5.46
Compacted Soil Wet (pcf)	124.9	124.3	124.0	123.3	123.0
Compacted Soil Dry (pcf)	111.2	111.5	110.8	110.8	110.7
Moisture Tin ID	x6	jjad	jadd	kk2	38
Mass of Moisture Tin	30.85	30.4	29.44	30.46	30.28
Mass of Tin and Moist Soil	145.07	158.93	156.94	154.28	162.45
Mass of Tin and Dry Soil	132.6	145.72	143.31	141.68	149.26
Moisture Content	12.3	11.5	12.0	11.3	11.1
Max Density (pcf)	111.3	111.7	110.9	111	110.9
Optimum Moisture %	14.7	14.6	14.8	14.8	14.8
Total Hits	130.0	130.0	140.0	140.0	130
After Full	20.0	20.0	40.0	40.0	20

Chart Results	**Average**	111.1 pcf	Max	111.7 pcf
	STDEV	0.3224903 pcf	Min	110.7 pcf
	Average Hit Count	128		

Description of Soil	CL II		Sample No.	CL II
Location	Dillman B003			
Volume of Mold	0.0459 ft^3			
Weight of Mold	1421 g			
Tested By	KMK		Date	8/17/2011

Test No.	11	12	13	14	15
Wet Soil + Mold (g)	3960.1	3979.7	3954.7	3972.1	3985.7
Wet Soil (g)	2539.1	2558.7	2533.7	2551.1	2564.7
Wet Soil (lb)	5.60	5.64	5.59	5.62	5.65
Compacted Soil Wet (pcf)	122.0	122.9	121.7	122.5	123.2
Compacted Soil Dry (pcf)	112.6	113.7	113.0	113.6	114.0
Moisture Tin ID	78	47	31	37	45
Mass of Moisture Tin	30.16	61.71	62.44	29.6	63.49
Mass of Tin and Moist Soil	200.44	481.79	463.75	244.54	465.1
Mass of Tin and Dry Soil	187.37	450.35	434.92	228.8	435.07
Moisture Content	8.31	8.09	7.74	7.90	8.08
Max Density (pcf)	113.3	114.6	113.8	114.5	114.8
Optimum Moisture %	14.0	13.6	13.8	13.6	13.5
Total Hits	150.0	170.0	150.0	150.0	150
After Full	40.0	60.0	40.0	40.0	40
Average	114.2 pcf				

Test No.	16	17	18	19	20
Wet Soil + Mold (g)	3913.8	3921.8	3941		
Wet Soil (g)	2492.8	2500.8	2520		
Wet Soil (lb)	5.50	5.51	5.56		
Compacted Soil Wet (pcf)	119.7	120.1	121.0		
Compacted Soil Dry (pcf)	110.6	112.8	111.9		
Moisture Tin ID	8	2	14		
Mass of Moisture Tin	30.5	29.35	62.06		
Mass of Tin and Moist Soil	191.83	205.05	496.16		
Mass of Tin and Dry Soil	179.55	194.37	463.3		
Moisture Content	8.24	6.47	8.19		
Max Density (pcf)	111.2	113.9	112.6		
Optimum Moisture %	14.7	13.8	14.2		
Total Hits	150.0	130.0	130.0		
After Full	40.0	20.0	20.0		
average	112.56667				

Description of Soil	CL II	Sample No.	
Location	Dillman B003		
Volume of Mold	**0.04439** ft^3		
Weight of Mold	**1946** g		
Tested By	JV	Date	8/17/2011

Test No.	21	22	23	24	25
Wet Soil + Mold (g)	4362.9	4378.9	4397	4394.8	4398.9
Wet Soil (g)	2416.9	2432.9	2451	2448.8	2452.9
Wet Soil (lb)	5.33	5.36	5.40	5.40	5.41
Compacted Soil Wet (pcf)	120.0	120.8	121.7	121.6	121.8
Compacted Soil Dry (pcf)	112.5	113.5	113.7	113.3	113.1
Moisture Tin ID	46	49	18	3	40
Mass of Moisture Tin	63.32	62.2	61.65	38.81	62
Mass of Tin and Moist Soil	595.91	521.93	434.88	302.48	624.53
Mass of Tin and Dry Soil	562.5	493.9	410.32	284.41	584.35
Moisture Content	6.69	6.49	7.04	7.36	7.69
Max Density (pcf)	114.9	115.9	116.1	115.6	115.3
Optimum Moisture %	13.5	13.1	13.1	13.2	13.3
Total Hits	140.0	140.0	120.0	120.0	130
After Full	40.0	40.0	20.0	20.0	20
Average	115.6 pcf				

Test No.	26	27	28	29	30
Wet Soil + Mold (g)	4326.4	4380.0			
Wet Soil (g)	2380.4	2434.0			
Wet Soil (lb)	5.25	5.37			
Compacted Soil Wet (pcf)	118.2	120.9			
Compacted Soil Dry (pcf)	109.4	111.4			
Moisture Tin ID	33	50			
Mass of Moisture Tin	61.65	41.8			
Mass of Tin and Moist Soil	607.14	425.44			
Mass of Tin and Dry Soil	566.21	395.4			
Moisture Content	8.11	8.50			
Max Density (pcf)	111.20	113.40			
Optimum Moisture %	14.7	14.0			
Total Hits	150.0	150.0			
After Full	40.0	40.0			
average	112.30				

MI Cone Curve

Description of Soil CL II Sample No.
Location Dillman B003
Volume of Mold 0.0459 ft^3
Tested By KMK Date 7/19/2011

	Test	1	2	3	4	5
Weight of Mold		1421	1421	1421	1421	1421
eight of Mold and Soil		3800.3	3789.4	3894.6	4018.3	4125.5
Weight of moist Soil		2379.3	2368.4	2473.6	2597.3	2704.5
loist Unit Weight (pcf)		114.3	113.8	118.8	124.8	129.9
Moisture Tin ID		zg7	jadd	3rc	cl	x6
Mass of Moisture Tin		29.7	29.5	30.3	30.6	30.9
s of Tin and Moist Soil		170.6	168.0	142.3	136.2	160.1
ass of Tin and Dry Soil		169.4	162.6	135.0	125.5	145.1
Moisture Content		0.84	4.03	6.98	11.35	13.08
Dry Unit Weight (pcf)		113.3	109.3	111.1	112.0	114.9
Total Blows		140	120	120	120	140
	After Full	40	20	20	40	40
Energy/20 Blows						

Sample ID: CL 2 63-121
Description:
Before Testing

Date: 8/8/2011
Bowl ID: 299.5 g
Mass of Sample Oven Dry: 599.03 g
After Wash: 582.08 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	805.3	800.2	5.1	0.9	99.1
4	4.75	725.9	720.5	5.4	0.9	98.2
10	2	686.7	676.2	10.5	1.8	96.5
20	0.85	446.1	423.6	22.5	3.8	92.7
40	0.425	421.1	339.2	81.9	13.7	79.1
60	0.25	744.2	542.3	201.9	33.7	45.4
100	0.15	520.2	346.6	173.6	29.0	16.4
140	0.106	378.5	331.2	47.3	7.9	8.5
200	0.075	375.0	351.6	23.4	3.9	4.6
Pan	--	388.0	376.2	11.8	2.0	2.6
			∑	583.4		

Sample ID: CL 2 63-121
Description:
After 1 Cone Test

Date: 8/8/2011
Bowl ID: 390.03 g
Mass of Sample Oven Dry: 596.21 g
After Wash: 579.62 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	804.4	800.3	4.1	0.7	99.3
4	4.75	727.7	720.5	7.2	1.2	98.1
10	2	687.8	676.4	11.4	1.9	96.2
20	0.85	448.3	423.8	24.5	4.1	92.1
40	0.425	422.6	339.3	83.3	14.0	78.1
60	0.25	740.5	542.5	198.0	33.2	44.9
100	0.15	517.5	346.9	170.6	28.6	16.3
140	0.106	377.3	331.7	45.6	7.6	8.6
200	0.075	374.3	351.6	22.7	3.8	4.8
Pan	--	389.4	376.1	13.3	2.2	2.6
			∑	580.7		

Sample ID: CL 2 63-121
Date: 8/12/2011
Description:
Bowl ID: 207.22 g
After 1 Modified Proctor Test
Mass of Sample Oven Dry: 773.92 g
After Wash: 740.53 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	801.3	801.3	0.0	0.0	100.0
4	4.75	730.9	723.6	7.3	0.9	99.1
10	2	694.6	678.9	15.7	2.0	97.0
20	0.85	455.3	424.8	30.5	3.9	93.1
40	0.425	444.5	340.0	104.5	13.5	79.6
60	0.25	808.7	543.4	265.3	34.3	45.3
100	0.15	552.0	346.9	205.1	26.5	18.8
140	0.106	395.6	331.8	63.8	8.2	10.6
200	0.075	383.3	351.5	31.8	4.1	6.5
Pan	--	393.1	375.9	17.2	2.2	4.2
			∑	741.2		

Method (Circle)
Standard Method A:
Standard Method B: Full Energy 12400 ft*lb/ft^3
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil CL 2 63-121 Sample No. CL 2 63-121
Location Dillman B003
Volume of Mold 0.0333333 ft^3
Tested By KMK Date 8/10/2011

Test	1	2	3	4	5	6
Weight of Mold and Baseplate	4252	4252	4252	4252	4252	4252
Weight of Mold, Base, and Soil	5970.7	5859.8	5898.1	5981.5	6054.4	6149.7
Weight of moist Soil	1718.7	1607.8	1646.1	1729.5	1802.4	1897.7
Moist Unit Weight (pcf)	113.7	106.3	108.9	114.4	119.2	125.5
Moisture Tin ID	4	10	21	2	2	1
Mass of Moisture Tin	29.6	14.0	31.8	30.5	31.4	30.2
Mass of Tin and Moist Soil	195.4	75.0	169.8	193.7	139.7	172.9
Mass of Tin and Dry Soil	195.0	73.1	161.7	180.0	128.8	152.7
Moisture Content	0.27	3.25	6.22	9.16	11.19	16.50
Dry Unit Weight (pcf)	113.4	103.0	102.5	104.8	107.2	107.7

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B: Full Energy 56250 ft*lb/ft^3
Modified Method C:

Description of Soil CL 2 63-121 Sample No CL 2 63-121
Location Dillman B003
Volume of Mold 0.033333 ft^3
Tested By KMK Date 8/10/2011

Test	1	2	3	4	5	6
Weight of Mold and Baseplate	4252	4220.4	4220.4	4220.4	4220.4	4220.4
Weight of Mold, Base, and Soil	6032.9	5883.8	5943.8	6030.2	6121.3	6222.5
Weight of moist Soil	1780.9	1663.4	1723.4	1809.8	1900.9	2002.1
Moist Unit Weight (pcf)	117.8	110.0	114.0	119.7	125.7	132.4
Moisture Tin ID	spa	kk6	1	kk10	ki	mdh
Mass of Moisture Tin	30.2	31.6	31.3	30.7	31.4	41.9
Mass of Tin and Moist Soil	116.8	109.9	110.8	104.7	138.3	172.7
Mass of Tin and Dry Soil	116.7	107.5	106.1	98.3	125.7	154.8
Moisture Content	0.14	3.17	6.23	9.53	13.27	15.90
Dry Unit Weight (pcf)	117.6	106.6	107.3	109.3	111.0	114.2

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Description of Soil	CL 2 63-121	Sample No.	CL 2 63-121
Location	Dillman B003		
Volume of Mold	0.04439 ft^3		
Weight of Mold	1944.4 g		
Tested By	KMK	Date	8/5/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	4346.8	4324.1	4332.9	4348.9	4378.9
Wet Soil (g)	2402.4	2379.7	2388.5	2404.5	2434.5
Wet Soil (lb)	5.30	5.25	5.27	5.30	5.37
Compacted Soil Wet (pcf)	119.3	118.2	118.6	119.4	120.9
Compacted Soil Dry (pcf)	110.1	109.2	109.6	110.3	110.1
Moisture Tin ID	z67	jj	ki	ckba	37
Mass of Moisture Tin	29.6	30.3	31.7	29.4	29.54
Mass of Tin and Moist Soil	203.2	164.3	174.1	176.4	180.48
Mass of Tin and Dry Soil	189.74	154.12	163.3	165.16	166.97
Moisture Content	8.41	8.22	8.21	8.28	9.83
Max Density (pcf)	110.6	109.8	110.2	110.9	110.5
Optimum Moisture %	14.9	15.2	15.1	14.8	15
Total Hits	150.0	130.0	160.0	150.0	150
After Full	40.0	20.0	40.0	40.0	40

Test No.	6	7	8	9	10
Wet Soil + Mold (g)	4483.6	4285.2	4378.7	4494.2	4319.2
Wet Soil (g)	2539.2	2340.8	2434.3	2549.8	2374.8
Wet Soil (lb)	5.60	5.16	5.37	5.62	5.24
Compacted Soil Wet (pcf)	126.1	116.3	120.9	126.6	117.9
Compacted Soil Dry (pcf)	112.1	109.1	109.9	112.4	107.8
Moisture Tin ID	kk20				z67
Mass of Moisture Tin	33.1	29.3	29.34	30.6	29.91
Mass of Tin and Moist Soil	222.2	144.18	143.93	181.6	162.55
Mass of Tin and Dry Soil	201.13	137.08	133.51	164.65	151.11
Moisture Content	12.54	6.59	10.00	12.64	9.44
Max Density (pcf)	112.1	109.9	110.3	112.5	108.3
Optimum Moisture %	14.4	15.2	15	14.3	15.8
Total Hits	155.0	150.0	150.0	150.0	150
After Full	40.0	40.0	40.0	40.0	40

Chart Results	**Average**	110.5 pcf	Max	112.5 pcf
	STDEV	1.1808189 pcf	Min	108.3 pcf
	Average Hit Count	150		

MI Cone Curve 18" free fall

Description of Soil Sample No.

Location Dillman B003

Volume of Mold 0.04439 ft^3

Tested By KMK Date

	Test	1	2	3	4	5	6
Weight of Mold		1944.4	1944.4	1944.4	1944.4	1944.4	1944.4
eight of Mold and Soil		4310.7	4207.5	4285.2	4378.7	4494.2	4513.1
Weight of moist Soil		2366.3	2263.1	2340.8	2434.3	2549.8	2568.7
loist Unit Weight (pcf)		117.5	112.4	116.3	120.9	126.6	127.6
Moisture Tin ID		4ll	s3db	2	r2d	kk11	jjad
Mass of Moisture Tin		30.8	32.5	29.3	29.3	30.6	30.5
s of Tin and Moist Soil		180.6	156.1	144.2	143.9	181.6	149.3
ass of Tin and Dry Soil		180.2	152.1	137.1	133.5	164.7	131.9
Moisture Content		0.25	3.34	6.59	10.00	12.64	17.20
Dry Unit Weight (pcf)		117.2	108.8	109.1	109.9	112.4	108.8
Total Blows		150	150	150	150	150	100
	After Full	40	40	40	40	40	0
Energy/20 Blows							

Sample ID: CL 2 77-26

Description:

Before Testing

Date: 8/12/2011

Bowl ID: 332.54 g

Mass of Sample Oven Dry: 530.79 g

After Wash: 520.44 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525			0.0	0.0	100.0
4	4.75	723.5	722.7	0.8	0.2	99.8
10	2	683.2	678.9	4.3	0.8	99.0
20	0.85	433.9	425.2	8.7	1.6	97.4
40	0.425	370.8	340.2	30.6	5.8	91.6
60	0.25	682.5	543.0	139.5	26.3	65.4
100	0.15	566.3	346.9	219.4	41.3	24.0
140	0.106	408.4	331.8	76.6	14.4	9.6
200	0.075	385.0	351.5	33.5	6.3	3.3
Pan	--	384.3	376.0	8.3	1.6	1.7
			∑	521.7		

Sample ID: CL 2 77-26

Description:

After 1 Cone Test

Date: 8/12/2011

Bowl ID: 208.91 g

Mass of Sample Oven Dry: 818.47 g

After Wash: 800.4 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	801.3	801.3	0.0	0.0	100.0
4	4.75	723.8	722.5	1.3	0.2	99.8
10	2	685.5	678.3	7.2	0.9	99.0
20	0.85	439.2	424.9	14.3	1.7	97.2
40	0.425	388.7	340.1	48.6	5.9	91.3
60	0.25	776.7	543.0	233.7	28.6	62.7
100	0.15	679.4	347.1	332.3	40.6	22.1
140	0.106	435.6	331.8	103.8	12.7	9.4
200	0.075	402.3	351.5	50.8	6.2	3.2
Pan	--	386.2	376.1	10.1	1.2	2.0
			∑	802.1		

Sample ID: CL 2 77-26
Date: 8/12/2011
Description:
Bowl ID: 108.99 g
After 1 Modified Proctor Test
Mass of Sample Oven Dry: 739.48 g
After Wash: 708.99 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	801.3	801.3	0.0	0.0	100.0
4	4.75	723.0	722.1	0.9	0.1	99.9
10	2	684.1	678.0	6.1	0.8	99.1
20	0.85	436.2	424.7	11.5	1.6	97.5
40	0.425	379.3	340.0	39.3	5.3	92.2
60	0.25	738.3	543.1	195.2	26.4	65.8
100	0.15	641.7	347.4	294.3	39.8	26.0
140	0.106	432.6	331.9	100.7	13.6	12.4
200	0.075	401.8	351.6	50.2	6.8	5.6
Pan	--	388.0	376.0	12.0	1.6	4.0
			∑	710.2		

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C: Full Energy 56250 ft*lb/ft^3

Description of Soil CL 2 77-26 Sample No CL 2 77-26
Location Dillman B003
Volume of Mold 0.033333 ft^3
Tested By KMK Date 8/11/2011

Test	1	2	3	4	5	6	7
Weight of Mold and Baseplate	4220	4220	4220	4220	4220	4220	4252
Weight of Mold, Base, and Soil	5912.2	5861.7	5920.4	5998.5	6013.1	6123.4	6276.6
Weight of moist Soil	1692.2	1641.7	1700.4	1778.5	1793.1	1903.4	2024.6
Moist Unit Weight (pcf)	111.9	108.6	112.5	117.6	118.6	125.9	133.9
Moisture Tin ID	jjad	1	1a	78	4	2b	2mk
Mass of Moisture Tin	30.5	31.3	30.9	30.0	30.7	30.4	30.52
Mass of Tin and Moist Soil	122.4	171.6	150.7	204.0	152.8	206.5	204.15
Mass of Tin and Dry Soil	122.2	167.4	144.2	190.9	140.5	180.4	171.95
Moisture Content	0.25	3.08	5.77	8.13	11.27	17.42	22.77
Dry Unit Weight (pcf)	111.6	105.3	106.3	108.8	106.6	107.2	109.1

Method (Circle)
Standard Method A:
Standard Method B: Full Energy 12400 ft*lb/ft^3
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil CL 2 77-26 Sample No. CL 2 77-26
Location Dillman B003
Volume of Mold 0.0333333 ft^3
Tested By KMK Date 8/11/2011

Test	1	2	3	4	5	6	7
Weight of Mold and Baseplate	4220	4220	4220	4220	4220	4220	4252
Weight of Mold, Base, and Soil	5848.6	5840.1	5900.9	5920.5	5998.9	6068.2	6128.8
Weight of moist Soil	1628.6	1620.1	1680.9	1700.5	1778.9	1848.2	1876.8
Moist Unit Weight (pcf)	107.7	107.2	111.2	112.5	117.7	122.2	124.1
Moisture Tin ID	5	a2	ckba	mdh	4	3	80
Mass of Moisture Tin	30.4	31.5	30.2	44.8	31.2	29.9	30.7
Mass of Tin and Moist Soil	149.4	173.4	206.2	228.1	165.1	195.7	167.2
Mass of Tin and Dry Soil	149.2	168.7	196.2	213.6	151.8	173.4	145.9
Moisture Content	0.24	3.40	6.02	8.58	11.05	15.56	18.53
Dry Unit Weight (pcf)	107.5	103.6	104.9	103.6	105.9	105.8	104.7

Description of Soil	CL 2 77-26	Sample No.	
Location	Dillman B003		
Volume of Mold	0.04439 ft^3		
Weight of Mold	1944.4 g		
Tested By	KMK	Date	8/12/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	4202.8	4259.1	4356.1	4448.3	4261.8
Wet Soil (g)	2258.4	2314.7	2411.7	2503.9	2317.4
Wet Soil (lb)	4.98	5.10	5.32	5.52	5.11
Compacted Soil Wet (pcf)	112.2	115.0	119.8	124.4	115.1
Compacted Soil Dry (pcf)	105.6	105.9	107.6	109.5	106.4
Moisture Tin ID	x4	kk2	kk22	kk9	kk7
Mass of Moisture Tin	37.1	30.5	32.6	29.7	31.43
Mass of Tin and Moist Soil	131.6	190.8	131.8	162.5	138.28
Mass of Tin and Dry Soil	126.1	178.1	121.7	146.7	130.24
Moisture Content	6.17	8.58	11.32	13.54	8.14
Max Density (pcf)	106.7	106.7	108.0	109.5	107.2
Optimum Moisture %	16.4	16.4	15.9	15.3	16.2
Total Hits	150.0	130.0	130.0	130.0	130
After Full	40.0	20.0	20.0	20.0	20

Test No.	6	7	8	9	10
Wet Soil + Mold (g)	4266.6	4249.6	4309.3	4305.7	4308.2
Wet Soil (g)	2322.2	2305.2	2364.9	2361.3	2363.8
Wet Soil (lb)	5.12	5.08	5.21	5.21	5.21
Compacted Soil Wet (pcf)	115.3	114.5	117.5	117.3	117.4
Compacted Soil Dry (pcf)	106.4	105.8	107.0	106.2	106.7
Moisture Tin ID	2	4	g2c	kk7	tsa
Mass of Moisture Tin	29.38	30.75	31.38	31.22	31.42
Mass of Tin and Moist Soil	197.46	191.29	174.95	116.88	161.11
Mass of Tin and Dry Soil	184.38	179.17	162.16	108.76	149.33
Moisture Content	8.44	8.17	9.78	10.47	9.99
Max Density (pcf)	107.1	106.7	107.6	106.7	107.3
Optimum Moisture %	16.2	16.4	16	16.4	16.1
Total Hits	150.0	150.0	130.0	130.0	130
After Full	40.0	40.0	20.0	20.0	20

Chart Results	**Average**	107.4 pcf	Max	109.5 pcf
	STDEV	0.8746428 pcf	Min	106.7 pcf
	Average Hit Count	136		

MI Cone Curve

Description of Soil CL 2 77-26 Sample No CL 2 77-26

Location Dillman B003

Volume of Mold 0.04439 ft^3

Tested By KMK Date 11-Aug

	Test	1	2	3	4	5	6	7
Weight of Mold		1944.4	1944.4	1944.4	1944.4	1944.4	1944.4	1944.4
Weight of Mold and Soil		4188	4138	4202.8	4259.1	4356.1	4448.3	4425.2
Weight of moist Soil		2243.6	2193.6	2258.4	2314.7	2411.7	2503.9	2480.8
Moist Unit Weight (pcf)		111.4	108.9	112.2	115.0	119.8	124.4	123.2
Moisture Tin ID		kk10	spa	x4	kk2	kk22	kk9	a1
Mass of Moisture Tin		30.8	30.2	37.1	30.5	32.6	29.7	30.8
Mass of Tin and Moist Soil		221.3	158.7	131.6	190.8	131.8	162.5	127.6
Mass of Tin and Dry Soil		220.8	154.9	126.1	178.1	121.7	146.7	112.8
Moisture Content		0.23	3.05	6.17	8.58	11.32	13.54	17.94
Dry Unit Weight (pcf)		111.2	105.7	105.6	105.9	107.6	109.5	104.5
	Total Blows	130	150	150	130	130	130	
	After Full	20	40	40	20	20	20	
Energy/20 Blows								

Sample ID: CL III Date: 7/29/2011
Description: CL III Bowl ID: 332.4 g
Before Testing Mass of Sample Oven Dry: 547.1 g
After Wash: 479.87 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	779.5	779.5	0.0	0.0	100.0
4	4.75	724.9	710.2	14.7	2.7	97.3
10	2	541.5	482.1	59.4	10.9	86.5
20	0.85	622.5	422.7	199.8	36.5	49.9
40	0.425	455.3	328.8	126.5	23.1	26.8
60	0.25	409.3	369.4	39.9	7.3	19.5
100	0.15	384.4	352.1	32.3	5.9	13.6
140	0.106	302.0	297.1	4.9	0.9	12.7
200	0.075	336.4	334.4	2.0	0.4	12.4
Pan	--	279.0	278.5	0.5	0.1	12.3
			∑	480.0		

Sample ID: CL III Date: 7/29/2011
Description: CL III Bowl ID: 208.1 g
After 1 Cone Test Mass of Sample Oven Dry: 644.1 g
After Wash: 560.03 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	781.9	779.5	2.4	0.4	99.6
4	4.75	741.0	709.5	31.5	4.9	94.7
10	2	596.5	482.7	113.8	17.7	77.1
20	0.85	645.4	423.7	221.7	34.4	42.6
40	0.425	446.5	329.0	117.5	18.2	24.4
60	0.25	406.4	369.5	36.9	5.7	18.7
100	0.15	381.3	352.3	29.0	4.5	14.2
140	0.106	301.8	297.1	4.7	0.7	13.4
200	0.075	336.5	334.5	2.0	0.3	13.1
Pan	--	279.3	278.5	0.8	0.1	13.0
			∑	560.3		

Sample ID:	CL III	Date:	7/29/2011
Description:	CL III	Bowl ID:	330.2 g
	After 1 Modified Proctor Test	Mass of Sample Oven Dry:	759.7 g
		After Wash:	634.7 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	785.7	779.5	6.2	0.8	99.2
4	4.75	746.0	709.2	36.8	4.8	94.3
10	2	598.8	483.0	115.8	15.2	79.1
20	0.85	662.2	423.5	238.7	31.4	47.7
40	0.425	469.0	329.1	139.9	18.4	29.3
60	0.25	415.3	369.6	45.7	6.0	23.2
100	0.15	388.5	352.4	36.1	4.8	18.5
140	0.106	304.4	297.3	7.1	0.9	17.6
200	0.075	338.8	334.7	4.1	0.5	17.0
Pan	--	280.2	278.7	1.5	0.2	16.8
			∑	631.9		

M-DOT Michigan Cone Testing Proctor Test Worksheet Karl Krueger

Method (Circle)
Standard Method A:
Standard Method B: Full Energy 12400 ft*lb/ft^3
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil CL III Sample No. CL III
Location Dillman B003
Volume of Mold 0.0333333 ft^3
Tested By KMK Date 7/29/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	9.4065	9.4065	9.4065	9.4065	
Weight of Mold, Base, and Soil	13.1775	13.186	13.387	13.6515	
Weight of moist Soil	3.771	3.7795	3.9805	4.245	
Moist Unit Weight (pcf)	113.1	113.4	119.4	127.4	
Moisture Tin ID	kk11	kk8	2a	g2c	
Mass of Moisture Tin	30.6	29.3	31.0	31.4	
Mass of Tin and Moist Soil	197.4	218.4	188.8	203.9	
Mass of Tin and Dry Soil	195.5	211.0	178.4	190.6	
Moisture Content	1.15	4.05	7.01	8.34	
Dry Unit Weight (pcf)	111.8	109.0	111.6	117.5	

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B: Full Energy 56250 ft*lb/ft^3
Modified Method C:

Description of Soil CL III Sample No CL III
Location Dillman B003
Volume of Mold 0.033333 ft^3
Tested By KMK Date 7/29/2011

Test	1	2	3	4	5
Weight of Mold and Baseplate	9.4065	9.4065	9.4065	9.4095	
Weight of Mold, Base, and Soil	13.3825	13.442	13.6955	14.035	
Weight of moist Soil	3.976	4.0355	4.289	4.6255	
Moist Unit Weight (pcf)	119.3	121.1	128.7	138.8	
Moisture Tin ID	mdh	ta	kk23	78	
Mass of Moisture Tin	41.7	30.6	37.0	29.9	
Mass of Tin and Moist Soil	166.2	200.7	179.2	231.5	
Mass of Tin and Dry Soil	164.8	193.9	170.2	217.4	
Moisture Content	1.11	4.13	6.78	7.54	
Dry Unit Weight (pcf)	118.0	116.3	120.5	129.0	

Description of Soil	CL III	Sample No.	CL III
Location	Dillman B003		
Volume of Mold	0.0459 ft^3		
Weight of Mold	1421 g		
Tested By	KMK	Date	7/29/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	4032.2	4047.5	4187.2	4098.8	4101
Wet Soil (g)	2611.2	2626.5	2766.2	2677.8	2680
Wet Soil (lb)	5.76	5.79	6.10	5.90	5.91
Compacted Soil Wet (pcf)	125.4	126.2	132.9	128.6	128.7
Compacted Soil Dry (pcf)	117.0	117.9	122.1	119.3	119.5
Moisture Tin ID	si	x4	2ah	a1	2mdh
Mass of Moisture Tin	30.7	30.96	30.85	30.66	30.7
Mass of Tin and Moist Soil	180.22	181.69	150.45	189.92	202.75
Mass of Tin and Dry Soil	170.17	171.78	140.8	178.44	190.43
Moisture Content	7.21	7.04	8.78	7.77	7.71
Max Density (pcf)	118.0	118.8	122.6	120.1	120.3
Optimum Moisture %	12.5	12.2	11.1	11.8	11.8
Total Hits	170.0	170.0	140.0	180.0	180
After Full	60.0	40.0	40.0	60.0	60

Test No.	6	7	8	9	10
Wet Soil + Mold (g)	4140.2	4116.9	4109	4169.4	4044.6
Wet Soil (g)	2719.2	2695.9	2688	2748.4	2623.6
Wet Soil (lb)	5.99	5.94	5.93	6.06	5.78
Compacted Soil Wet (pcf)	130.6	129.5	129.1	132.0	126.0
Compacted Soil Dry (pcf)	121.1	120.2	120.1	122.3	117.2
Moisture Tin ID	x6	pl	y2m	7a	mk
Mass of Moisture Tin	30.84	30.84	29.7	29.5	30.23
Mass of Tin and Moist Soil	192.66	214.32	239.12	174.69	158.21
Mass of Tin and Dry Soil	180.84	201.15	224.56	164.04	149.23
Moisture Content	7.88	7.73	7.47	7.92	7.55
Max Density (pcf)	121.7	120.9	120.9	122.9	118.1
Optimum Moisture %	11.3	11.6	11.6	11	12.4
Total Hits	180.0	180.0	190.0	180.0	150
After Full	60.0	60.0	60.0	60.0	40

MI Cone Curve

Description of Soil CL III Sample Nc CL III

Location Dillman B003

Volume of Mold 0.0459 ft^3

Tested By KMK Date 29-Jul

	Test	1	2	3	4	5	6
Weight of Mold		1421	1421	1421	1421		
Weight of Mold and Soil		3873.9	3889.9	4044.6	4187.2		
Weight of moist Soil		2452.9	2468.9	2623.6	2766.2		
Moist Unit Weight (pcf)		117.8	118.6	126.0	132.9		
Moisture Tin ID		kk10	4	mk	2ah		
Mass of Moisture Tin		30.7	31.1	30.2	30.9		
Mass of Tin and Moist Soil		138.7	192.3	158.2	150.5		
Mass of Tin and Dry Soil		137.5	186.0	149.2	140.8		
Moisture Content		1.11	4.07	7.56	8.78		
Dry Unit Weight (pcf)		116.5	113.9	117.2	122.1		
	Total Blows	170	150	150	140		
	After Full	40	40	40	40		
Energy/20 Blows							

Sample ID: CL 2 63-121 | Date: 8/8/2011
Description: | Bowl ID: 299.5 g
Before Testing | Mass of Sample Oven Dry: 599.03 g
After Wash: 582.08 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	805.3	800.2	5.1	0.9	99.1
4	4.75	725.9	720.5	5.4	0.9	98.2
10	2	686.7	676.2	10.5	1.8	96.5
20	0.85	446.1	423.6	22.5	3.8	92.7
40	0.425	421.1	339.2	81.9	13.7	79.1
60	0.25	744.2	542.3	201.9	33.7	45.4
100	0.15	520.2	346.6	173.6	29.0	16.4
140	0.106	378.5	331.2	47.3	7.9	8.5
200	0.075	375.0	351.6	23.4	3.9	4.6
Pan	--	388.0	376.2	11.8	2.0	2.6
			∑	583.4		

Sample ID: CL 2 63-121 | Date: 8/8/2011
Description: | Bowl ID: 390.03 g
After 1 Cone Test | Mass of Sample Oven Dry: 596.21 g
After Wash: 579.62 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	804.4	800.3	4.1	0.7	99.3
4	4.75	727.7	720.5	7.2	1.2	98.1
10	2	687.8	676.4	11.4	1.9	96.2
20	0.85	448.3	423.8	24.5	4.1	92.1
40	0.425	422.6	339.3	83.3	14.0	78.1
60	0.25	740.5	542.5	198.0	33.2	44.9
100	0.15	517.5	346.9	170.6	28.6	16.3
140	0.106	377.3	331.7	45.6	7.6	8.6
200	0.075	374.3	351.6	22.7	3.8	4.8
Pan	--	389.4	376.1	13.3	2.2	2.6
			∑	580.7		

Sample ID: CL 2 63-121
Date: 8/12/2011
Description:
Bowl ID: 207.22 g
After 1 Modified Proctor Test
Mass of Sample Oven Dry: 773.92 g
After Wash: 740.53 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	801.3	801.3	0.0	0.0	100.0
4	4.75	730.9	723.6	7.3	0.9	99.1
10	2	694.6	678.9	15.7	2.0	97.0
20	0.85	455.3	424.8	30.5	3.9	93.1
40	0.425	444.5	340.0	104.5	13.5	79.6
60	0.25	808.7	543.4	265.3	34.3	45.3
100	0.15	552.0	346.9	205.1	26.5	18.8
140	0.106	395.6	331.8	63.8	8.2	10.6
200	0.075	383.3	351.5	31.8	4.1	6.5
Pan	--	393.1	375.9	17.2	2.2	4.2
			∑	741.2		

Method (Circle)
Standard Method A:
Standard Method B: Full Energy 12400 ft*lb/ft^3
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil CL 2 63-121 Sample No. CL 2 63-121
Location Dillman B003
Volume of Mold 0.0333333 ft^3
Tested By KMK Date 8/10/2011

Test	1	2	3	4	5	6
Weight of Mold and Baseplate	4252	4252	4252	4252	4252	4252
Weight of Mold, Base, and Soil	5970.7	5859.8	5898.1	5981.5	6054.4	6149.7
Weight of moist Soil	1718.7	1607.8	1646.1	1729.5	1802.4	1897.7
Moist Unit Weight (pcf)	113.7	106.3	108.9	114.4	119.2	125.5
Moisture Tin ID	4	10	21	2	2	1
Mass of Moisture Tin	29.6	14.0	31.8	30.5	31.4	30.2
Mass of Tin and Moist Soil	195.4	75.0	169.8	193.7	139.7	172.9
Mass of Tin and Dry Soil	195.0	73.1	161.7	180.0	128.8	152.7
Moisture Content	0.27	3.25	6.22	9.16	11.19	16.50
Dry Unit Weight (pcf)	113.4	103.0	102.5	104.8	107.2	107.7

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B: Full Energy 56250 ft*lb/ft^3
Modified Method C:

Description of Soil CL 2 63-121 Sample No CL 2 63-121
Location Dillman B003
Volume of Mold 0.033333 ft^3
Tested By KMK Date 8/10/2011

Test	1	2	3	4	5	6
Weight of Mold and Baseplate	4252	4220.4	4220.4	4220.4	4220.4	4220.4
Weight of Mold, Base, and Soil	6032.9	5883.8	5943.8	6030.2	6121.3	6222.5
Weight of moist Soil	1780.9	1663.4	1723.4	1809.8	1900.9	2002.1
Moist Unit Weight (pcf)	117.8	110.0	114.0	119.7	125.7	132.4
Moisture Tin ID	spa	kk6	1	kk10	ki	mdh
Mass of Moisture Tin	30.2	31.6	31.3	30.7	31.4	41.9
Mass of Tin and Moist Soil	116.8	109.9	110.8	104.7	138.3	172.7
Mass of Tin and Dry Soil	116.7	107.5	106.1	98.3	125.7	154.8
Moisture Content	0.14	3.17	6.23	9.53	13.27	15.90
Dry Unit Weight (pcf)	117.6	106.6	107.3	109.3	111.0	114.2

Description of Soil	CL 2 63-121	Sample No.	CL 2 63-121
Location	Dillman B003		
Volume of Mold	0.04439 ft^3		
Weight of Mold	1944.4 g		
Tested By	KMK	Date	8/5/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	4346.8	4324.1	4332.9	4348.9	4378.9
Wet Soil (g)	2402.4	2379.7	2388.5	2404.5	2434.5
Wet Soil (lb)	5.30	5.25	5.27	5.30	5.37
Compacted Soil Wet (pcf)	119.3	118.2	118.6	119.4	120.9
Compacted Soil Dry (pcf)	110.1	109.2	109.6	110.3	110.1
Moisture Tin ID	z67	jj	ki	ckba	37
Mass of Moisture Tin	29.6	30.3	31.7	29.4	29.54
Mass of Tin and Moist Soil	203.2	164.3	174.1	176.4	180.48
Mass of Tin and Dry Soil	189.74	154.12	163.3	165.16	166.97
Moisture Content	8.41	8.22	8.21	8.28	9.83
Max Density (pcf)	110.6	109.8	110.2	110.9	110.5
Optimum Moisture %	14.9	15.2	15.1	14.8	15
Total Hits	150.0	130.0	160.0	150.0	150
After Full	40.0	20.0	40.0	40.0	40

Test No.	6	7	8	9	10
Wet Soil + Mold (g)	4483.6	4285.2	4378.7	4494.2	4319.2
Wet Soil (g)	2539.2	2340.8	2434.3	2549.8	2374.8
Wet Soil (lb)	5.60	5.16	5.37	5.62	5.24
Compacted Soil Wet (pcf)	126.1	116.3	120.9	126.6	117.9
Compacted Soil Dry (pcf)	112.1	109.1	109.9	112.4	107.8
Moisture Tin ID	kk20				z67
Mass of Moisture Tin	33.1	29.3	29.34	30.6	29.91
Mass of Tin and Moist Soil	222.2	144.18	143.93	181.6	162.55
Mass of Tin and Dry Soil	201.13	137.08	133.51	164.65	151.11
Moisture Content	12.54	6.59	10.00	12.64	9.44
Max Density (pcf)	112.1	109.9	110.3	112.5	108.3
Optimum Moisture %	14.4	15.2	15	14.3	15.8
Total Hits	155.0	150.0	150.0	150.0	150
After Full	40.0	40.0	40.0	40.0	40

Chart Results	**Average**	110.5 pcf	Max	112.5 pcf
	STDEV	1.1808189 pcf	Min	108.3 pcf
	Average Hit Count	150		

MI Cone Curve 18" free fall

Description of Soil Sample No.

Location Dillman B003

Volume of Mold 0.04439 ft^3

Tested By KMK Date

	Test	1	2	3	4	5	6
Weight of Mold		1944.4	1944.4	1944.4	1944.4	1944.4	1944.4
eight of Mold and Soil		4310.7	4207.5	4285.2	4378.7	4494.2	4513.1
Weight of moist Soil		2366.3	2263.1	2340.8	2434.3	2549.8	2568.7
loist Unit Weight (pcf)		117.5	112.4	116.3	120.9	126.6	127.6
Moisture Tin ID		4ll	s3db	2	r2d	kk11	jjad
Mass of Moisture Tin		30.8	32.5	29.3	29.3	30.6	30.5
s of Tin and Moist Soil		180.6	156.1	144.2	143.9	181.6	149.3
ass of Tin and Dry Soil		180.2	152.1	137.1	133.5	164.7	131.9
Moisture Content		0.25	3.34	6.59	10.00	12.64	17.20
Dry Unit Weight (pcf)		117.2	108.8	109.1	109.9	112.4	108.8
Total Blows		150	150	150	150	150	100
	After Full	40	40	40	40	40	0
Energy/20 Blows							

Sample ID: CL 3 77-26
Description:
Before Testing

Date: 8/12/2011
Bowl ID: 206.31 g
Mass of Sample Oven Dry: 502.38 g
After Wash: 489.59 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	801.3	801.3	0.0	0.0	100.0
4	4.75	727.7	721.9	5.8	1.2	98.8
10	2	680.5	677.6	2.9	0.6	98.3
20	0.85	429.5	424.5	5.0	1.0	97.3
40	0.425	356.6	339.6	17.0	3.4	93.9
60	0.25	629.6	542.9	86.7	17.3	76.6
100	0.15	567.6	346.8	220.8	44.0	32.7
140	0.106	423.3	331.6	91.7	18.3	14.4
200	0.075	395.9	351.4	44.5	8.9	5.6
Pan	--	392.2	375.8	16.4	3.3	2.3
			∑	490.8		

Sample ID: CL 3 77-26
Description:
After 1 Cone Test

Date: 8/12/2011
Bowl ID: 208.94 g
Mass of Sample Oven Dry: 625.82 g
After Wash: 604.46 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525			0.0	0.0	100.0
4	4.75	723.5	721.8	1.7	0.3	99.7
10	2	679.8	677.3	2.5	0.4	99.3
20	0.85	429.8	424.3	5.5	0.9	98.5
40	0.425	359.2	339.6	19.6	3.1	95.3
60	0.25	658.9	542.8	116.1	18.6	76.8
100	0.15	632.5	347.0	285.5	45.6	31.1
140	0.106	438.4	331.7	106.7	17.0	14.1
200	0.075	404.7	351.5	53.2	8.5	5.6
Pan	--	391.3	375.9	15.4	2.5	3.1
			∑	606.2		

Sample ID: CL 3 77-26

Description:

After 1 Modified Proctor Test

Date: 8/12/2011

Bowl ID: 207.31 g

Mass of Sample Oven Dry: 723.65 g

After Wash: 687.12 g

Sieve Size	Opening (mm)	Sieve and Retained (g)	Sieve (g)	Retained (g)	% Retained	% Passing
1-1/2"	38.1			0.0	0.0	100.0
3/4"	19.05			0.0	0.0	100.0
3/8"	9.525	14.6	0	14.6	2.0	98.0
4	4.75	723.7	721.9	1.8	0.2	97.7
10	2	681.1	677.3	3.8	0.5	97.2
20	0.85	430.9	424.4	6.5	0.9	96.3
40	0.425	360.5	339.9	20.6	2.8	93.5
60	0.25	665.1	543.1	122.0	16.9	76.6
100	0.15	657.1	347.1	310.0	42.8	33.8
140	0.106	453.5	331.9	121.6	16.8	17.0
200	0.075	414.6	351.5	63.1	8.7	8.2
Pan	--	400.3	375.9	24.4	3.4	4.9
			∑	688.4		

Method (Circle)
Standard Method A:
Standard Method B: Full Energy 12400 ft*lb/ft^3
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C:

Description of Soil CL 3 77-26 Sample No. CL 3 77-26
Location Dillman B003
Volume of Mold 0.0333333 ft^3
Tested By KMK Date 8/12/2011

Test	1	2	3	4	5	6	7
Weight of Mold and Baseplate	4251.6	4251.6	4251.6	4251.6	4251.6	4251.6	4251.6
Weight of Mold, Base, and Soil	5920.1	5867.7	5892.5	5919.6	6045.8	6044.5	6136.9
Weight of moist Soil	1668.5	1616.1	1640.9	1668	1794.2	1792.9	1885.3
Moist Unit Weight (pcf)	110.4	106.9	108.5	110.3	118.7	118.6	124.7
Moisture Tin ID	4	y2m	2	spa	mk	kk10	kk8
Mass of Moisture Tin	29.7	29.6	30.9	30.2	30.4	30.8	29.4
Mass of Tin and Moist Soil	169.1	165.0	173.9	137.8	153.2	127.0	189.5
Mass of Tin and Dry Soil	168.8	161.0	166.6	128.9	139.7	115.9	162.8
Moisture Content	0.22	3.03	5.37	9.01	12.43	13.07	20.03
Dry Unit Weight (pcf)	110.1	103.7	103.0	101.2	105.5	104.9	103.9

Method (Circle)
Standard Method A:
Standard Method B:
Standard Method C:
Modified Method A:
Modified Method B:
Modified Method C: Full Energy 56250 ft*lb/ft^3

Description of Soil CL 3 77-26 Sample No CL 3 77-26
Location Dillman B003
Volume of Mold 0.033333 ft^3
Tested By KMK Date 8/12/2011

Test	1	2	3	4	5	6	7
Weight of Mold and Baseplate	4251.6	4251.6	4251.6	4251.6	4251.6	4251.6	4251.6
Weight of Mold, Base, and Soil	5961.5	5861.6	5919.8	5967.1	6050	6141.1	6228.3
Weight of moist Soil	1709.9	1610	1668.2	1715.5	1798.4	1889.5	1976.7
Moist Unit Weight (pcf)	113.1	106.5	110.3	113.5	118.9	125.0	130.7
Moisture Tin ID	1a	3	r2d	kk10	tsa	r2d	g2c
Mass of Moisture Tin	30.9	39.2	29.3	30.7	31.4	29.5	31.45
Mass of Tin and Moist Soil	172.5	199.2	182.7	117.8	152.8	163.2	182.66
Mass of Tin and Dry Soil	172.2	193.9	173.6	110.6	141.0	142.8	157.01
Moisture Content	0.24	3.43	6.35	9.09	10.76	18.00	20.43
Dry Unit Weight (pcf)	112.8	103.0	103.7	104.0	107.4	105.9	108.6

Description of Soil	CL 3 77-26		Sample No.	
Location	Dillman B003			
Volume of Mold	0.04439 ft^3			
Weight of Mold	1944.4 g			
Tested By	KMK		Date	8/12/2011

Test No.	1	2	3	4	5
Wet Soil + Mold (g)	4310.1	4283.2	4285.9	4270.1	4281.4
Wet Soil (g)	2365.7	2338.8	2341.5	2325.7	2337
Wet Soil (lb)	5.22	5.16	5.16	5.13	5.15
Compacted Soil Wet (pcf)	117.5	116.2	116.3	115.5	116.1
Compacted Soil Dry (pcf)	104.7	104.7	104.3	104.0	105.1
Moisture Tin ID	1	ckba	78	kk2	ki3
Mass of Moisture Tin	31.24	29.68	30.14	30.55	31.42
Mass of Tin and Moist Soil	167.43	190.71	188.47	181.51	153.84
Mass of Tin and Dry Soil	152.6	174.85	172.09	166.51	142.27
Moisture Content	12.22	10.93	11.54	11.03	10.44
Max Density (pcf)	105.2	105.3	104.8	104.6	105.7
Optimum Moisture %	17.0	16.9	17.1	17.2	16.7
Total Hits	170.0	160.0	130.0	130.0	150
After Full	60.0	40.0	20.0	20.0	40

Test No.	6	7	8	9	10
Wet Soil + Mold (g)	4271.3	4165.2	4258.2	4334.1	4462.1
Wet Soil (g)	2326.9	2220.8	2313.8	2389.7	2517.7
Wet Soil (lb)	5.13	4.90	5.10	5.27	5.55
Compacted Soil Wet (pcf)	115.6	110.3	114.9	118.7	125.0
Compacted Soil Dry (pcf)	104.4	104.0	104.1	105.4	107.8
Moisture Tin ID	kk7	kk6	z67	1	kk2
Mass of Moisture Tin	31.31	31.56	29.85	31.21	30.5
Mass of Tin and Moist Soil	126.4	89.81	125.47	194.94	214.07
Mass of Tin and Dry Soil	117.22	86.49	116.47	176.58	188.73
Moisture Content	10.69	6.04	10.39	12.63	16.01
Max Density (pcf)	105	105.1	104.8	105.8	108.2
Optimum Moisture %	17	17.0	17.1	16.7	15.8
Total Hits	130.0	130.0	130.0	130.0	150
After Full	20.0	20.0	20.0	20.0	40

Chart Results	Average	105.5 pcf	Max	108.2 pcf
	STDEV	1.0394977 pcf	Min	104.6 pcf
	Average Hit Count	141		

MI Cone Curve

Description of Soil CL 3 77-26 Sample No. CL 3 77-26

Location Dillman B003

Volume of Mold 0.04439 ft^3

Tested By KMK Date 12-Aug

	Test	1	2	3	4	5	6	7
Weight of Mold		1944.4	1944.4	1944.4	1944.4	1944.4	1944.4	1944.4
Weight of Mold and Soil		4191.4	4097.6	4165.2	4258.2	4334.1	4462.1	4418.8
Weight of moist Soil		2247	2153.2	2220.8	2313.8	2389.7	2517.7	2474.4
Moist Unit Weight (pcf)		111.6	106.9	110.3	114.9	118.7	125.0	122.9
Moisture Tin ID		4		kk6	z67	1	kk2	kk2
Mass of Moisture Tin		13.8		31.6	29.9	31.2	30.5	30.5
Mass of Tin and Moist Soil		89.3		89.8	125.5	194.9	214.1	137.1
Mass of Tin and Dry Soil		89.1		86.5	116.5	176.6	188.7	121.2
Moisture Content		0.21	3.00	6.04	10.39	12.63	16.01	17.51
Dry Unit Weight (pcf)		111.4	103.8	104.0	104.1	105.4	107.8	104.6
Total Blows		130	130	130	130	150	170	
	After Full	20	20	20	20	40	60	
Energy/20 Blows								