Kansas State University | Salina

Soils Field Tester Workbook

Certified Inspector Training Program

Kansas Department of Transportation

Soils Field Tester Certification Workbook

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Last Updated: September 2020

SOILS FIELD TESTER
CIT PROGRAM

Written Test: Open book – 90 multiple choice questions

Grading: Must score at least 60% on each section of the written exam with an overall score of 70% or better to pass. Failure on any part of the written exam requires retaking the entire exam.

Must pass all performance exam sections. Failure of three or less performance subtest requires retest on only the subtest(s) failed. Failure of four or more subtests of the performance exam requires retest on the entire performance exam.

Exam Results: Exams will be graded in two to three weeks. Exam results are mailed to the student. Exam results are not given over the phone.

Exam Re-takes: Students who need to re-take either the written and/or performance exam need to register to do so. The re-take registration form can be found on the CIT website at www.citksu.com.

To be Certified: Students must successfully pass the written exam and the performance exam. The student will be mailed a certification card and letter.

Reasons for Certified Inspector Training (CIT) Training Program

Overview

The Kansas Department of Transportation (KDOT) has established this training program to educate, test and certify those individuals responsible for performing inspection and testing functions on KDOT construction projects. KDOT's Bureau of Construction and Materials has responsibility for the establishment and administration of the materials portion of the KDOT's Quality Control/Quality Assurance (QC/QA) Program. The Bureau develops standards and specifications for materials, establishes sampling procedures and frequencies, and test procedures used in the laboratory and the field in order to assure compliance with specifications. It performs materials testing to assist each of the six KDOT districts in administering quality assurance functions of the QC/QA Program. Such testing includes tests on materials purchased by contractors or the State for use in maintenance or construction activities. The Bureau also conducts tests on soils, concrete, bituminous mixtures and numerous other specialized materials, the results of which are used by others for a variety of reasons.

Quality control and quality assurance activities involve the routine sampling, testing and analysis of various materials to determine the quality of a given product and to attain a quality product. The goal of the Certified Inspection and Testing Training Program (CIT^2) is to provide persons engaged in the inspection and/or testing of KDOT construction projects specific training in, but not limited to, soils, aggregates, and concrete and/or asphalt disciplines.

Each student is required to demonstrate specific abilities as defined by the training modules described in the CIT^2 manual. The manual can be found online at: http://www.ksdot.org/descons.asp#CIT.

Federal Funding

On projects involving federal funds, KDOT must certify to the Federal Highway Administration as to the quality of each type of material used on each project before the State is completely reimbursed by the federal government.

The certification and training requirements contained in this manual are intended to comply with the requirements of 23 CFR Part 637 which states, "After June 29, 2000, all sampling and testing data to be used in the acceptance decision or the IA (Independent Assurance) program shall be executed by qualified sampling and testing personnel."

Reasons for Quality Control/Quality Assurance

Inspectors fulfill a very important job on any project—they safeguard the public interest in a number of ways.

The primary reason for materials inspection, sampling and testing requirements is to verify that all materials incorporated into the work will meet the requirements of the contract documents, including the plans, specifications, and special provisions.

Plans and specifications are prepared to require the use of certain specific materials known or expected to perform satisfactorily with minimum maintenance throughout the life of the facility or infrastructure project. Any material that deviates appreciably from the specifications requirements will not perform as expected and, in all probability, will shorten the useful life of the facility or add unexpected costs in maintenance. Because there are limited dollars available for transportation infrastructure, the useful life and long-term maintenance costs of every project are critical considerations.

Secondly, all contractors bidding or furnishing materials to a project should be treated equally. That is, the contract documents provide a fair and uniform basis for bidding because they define the requirements to be met--ideally with the least possible difference of interpretation. The contractor commits to furnish materials and complete work that will equal or exceed such requirements. For this reason it is essential that quality assurance be correctly understood and applied uniformly by engineers and inspectors from project-to-project so that all contractors and suppliers are treated alike.

Thirdly, the expenditure of public funds must be documented to substantiate whether taxpayers actually received the quantity and quality of materials specified in exchange for tax dollars spent. Whether or not to pay the costs invoiced by contractors is a decision which relies heavily upon inspection reports and test results. In a fundamental way, inspectors play a key role in serving the public--to justify the expenditure of public monies and the acceptance of any contractor’s work. Through the work of knowledgeable, competent and skilled inspectors, KDOT can verify and confirm whether or not the contractor has fulfilled its obligations to build the project as intended.

Finally, the specification requirements for materials are constantly evolving, based on new developments, past performance of material in the field, research and technological innovations. Accurate recordkeeping of materials and test results using consistent inspection practices provides a basis to compare results over time—an indispensable advantage for meaningful research. Data properly collected and recorded by inspectors can confirm whether or not changes in material specifications and testing requirements have, in fact, resulted in a better product, state-wide or in a particular location or application.

All inspectors should review the applicable clauses of the Standard Specifications at regular intervals to refresh their understanding of material and testing requirements.

5.2.2.2. RANDOM SAMPLING

1. SCOPE

This method covers procedures for securing random samples from a lot by the use of random numbers obtained from tables or generated by other methods.

Nothing in this method is intended to preclude additional testing if failing or suspect materials or construction is encountered. Testing that is additional to the scheduled testing should occur immediately if failing test results occur or if materials or work appears to be substandard.

2. DEFINITIONS

2.1. Lot: An isolated or defined quantity of material from a single source or a measured amount of construction assumed to be produced by the same process. Specified amounts of asphalt concrete mix, a stockpile of aggregates, or linear feet of roadway constructed in a day are examples of a lot.

2.1.1. Sublot: A portion of a lot. When it is not convenient to sample the entire lot, such as a specified amount of hot mix, then it can be divided into equal sized sublots. The sublots, when combined, would constitute the entire lot.

2.1.2. Random: Without aim or pattern, depending entirely on chance alone (not to be construed as haphazard).

2.1.3. Sample: A small part of a lot or sublot which represents the whole. A sample may be made up of one or more increments or test portions.

2.1.4. Random number: A number selected entirely by chance. Random numbers may be generated electronically such as with a random number function on a calculator or spreadsheet or selected from a table of random numbers (See **Table 1**).

2.1.5. Seed number: A number to provide a starting point for selection of the random numbers. The seed number may be generated from an odometer reading, random number function on a calculator or spreadsheet, or by pointing at the random number table.

3. USE OF RANDOM NUMBERS IN SAMPLING

3.1. Most sampling and testing for construction materials should be randomized to prevent any unintentional bias of the results. Randomization of sampling times or locations is accomplished by using a set of random numbers to determine the time or location for the sample. A table of random numbers is included below.

3.1.1. Example 1: Determining when to sample.

3.1.1.1. As an example, assume ten trucks carrying equal loads are going to be used to deliver concrete during a bridge deck placement. Select which truck to sample for compressive strength cylinders to be molded.

In cases such as number of trucks or tons of production, etc. round up to the next whole number because there will not be a truck "0". In cases involving things such as stationing there is a zero point so rounding to the nearest number may be justified.

Generate a random number using one of the methods below. Use .456 in this example. Multiply .456 by 10 (the number of trucks) for a result of 4.56. Round this result up to a whole number, 5 in this case. Take the concrete sample from the fifth truck.

This method can be used to select a time of day or the day of the week. If production was to occur during an 8 hour day, multiply 8 by the selected random number, .456, to obtain a result of 3.648. If rounding is used the sample should be taken in the fourth hour of production. Refinement could be used to select a time down to the nearest minute if needed by using the integer, three in this case, as the hour and then multiplying the decimal by 60 to obtain the minute, 60 X .648 or $\pm$ 39 in this case. Sampling would occur three hours thirty nine minutes into production. Use the number seven multiplied by a random number to determine a day of the week. Sampling during production according to units, such as tons of material produced, can be handled in the same fashion. Multiply the lot or sublot size, as required, by the random number selected.

3.2. Example 2: Determining location for sampling.

3.2.1. Given random numbers selected:

X	Y
0.338	0.922
0.763	0.198
0.043	0.737
0.810	0.747

ENGLISH EXAMPLE:

Sampling a large lot may require division into sublots to ensure all portions of a lot are represented. Stratification into sublots is accomplished by dividing the "Lot" material (in this case, a mile of construction or 5280 feet, 12'6" wide) into "four sublots" (each of 1320' or 1/4 mile).

To locate a sample point station in sublot No. 1, the length of that sublot is multiplied by the "X" coordinate for the "sublot" and the product added to the beginning station for that sublot.

Starting Station = 486 + 15	486 + 15
$(X_1)(1320) = (0.338)(1320) = 446'$	4 + 46
Sample Station =	490 + 61

The sample point distance from the base line (generally centerline or the edge of pavement) is determined by multiplying Y_1 by the available width, in this case, 12.5 feet.

$(Y_1)(12.5') = (0.922)(12.5') = 11.5'$ from base line.

Thus the sample location is Sta. 490 + 61, 11.5' from base line. Keeping in mind that the second sublot begins at station 499 + 35 (sta. 486 + 15 + 1320'), the second, third and fourth locations are determined by the same technique. These values are:

Sublot # 2 Sta. 509 + 42, 2.5’ from base line.
Sublot # 3 Sta. 513 + 12, 9.2’ from base line.
Sublot # 4 Sta. 536 + 44, 9.3’ from base line.

SI EXAMPLE:

Stratification into sublots is accomplished by dividing the “Lot” material (in this case, 2,000 meters) into “four sublots” [each of 500 meters (2,000/4) long].

To locate a sample point station in sublot No. 1, the length of that sublot is multiplied by the “X” coordinate for the “sublot” and the product added to the beginning station for that sublot.

Starting Station = 1 + 525	1 + 525
$(X_1)(500) = (0.338)(500) = 169$ meters	169
Sample Station =	1 + 694

The sample point distance from the base line (generally centerline or the edge of pavement) is determined by multiplying Y_1 by the available width.

$(Y_1)(3.7\text{ m}) = (0.922)(3.7\text{ m}) = 3.4$ m from base line.

Thus the sample location is Sta. 1 + 694, 3.4 m from base line. Keeping in mind that the second sublot begins at station 2 + 025 (sta. 1 + 525 + 500 m), the second, third and fourth locations are determined by the same technique. These values are:

Sublot # 2 Sta. 2 + 407, 0.7 m from base line.
Sublot # 3 Sta. 2 + 547, 2.7 m from base line.
Sublot # 4 Sta. 3 + 430, 2.8 m from base line.

4. Methods for selection of random numbers.

4.1. Use of calculators or spreadsheet functions.

4.1.1. Many calculators have a random function. Review the manual for a given calculator to determine how to access this function. Sets of random numbers may be generated directly from the calculator by repeated use of this function.

4.1.2. Most spreadsheets also have a function to generate random numbers. Insert the random number function into a cell and press enter. A random number will be generated. Copy that cell as needed to produce the required quantity of random numbers. It may be necessary to reformat the cells to have only three decimal places. Read the manual for the specific spreadsheet for more detail on use.

NOTE: The District Materials Engineer may require a different method of generating random numbers to be used if an electronic method is determined to not be truly random.

4.2. Use of the Random Number Table **(Table 1)**.

4.2.1. Use of the random number table requires the use of “seed” numbers to provide starting points for selection of the random numbers. A seed number can be obtained by several methods including odometer readings, generation by a random number function of a calculator or spreadsheet or by "pointing" if necessary.

4.2.1.1. Using an odometer reading such as 78642 as a seed number, use the digit farthest to the right (2) to select the column in the table. Use the next two digits to the left (64) to select the row.

In this case finding the intersection of the row and the column yields the number 0.338. Use this as a starting position and count down the column for the required number of samples. Selecting numbers for an X coordinate for three samples yields 0.338, 0.763 and 0.043.

If a Y coordinate is also required use the fourth digit from the right for the column and the next two digits to the left, for the row. In this example that would yield column 8 and row 07 producing a starting point at number 0.521. If a total of three samples are required, counting down two more places yields numbers 0.937 and 0.912.

Using this example, pairs of numbers for determining three X and Y coordinates are obtained, (0.338, 0.521), (0.763, 0.937) and (0.043, 0.912). Any amount of numbers required may be selected this way. If ten samples are required count down the column until ten numbers are selected.

Once the bottom of a column has been reached go to the top of the next column to the right and countdown to obtain more numbers, if the bottom of column 10 is reached go to the top of column 1.

If the column value from the seed number 0, then use column 10. If the row value from the seed number is 00, then use row 100.

Use of the odometer to generate seed numbers is not recommended if more than one set of X and Y pairs of random numbers is required in a relatively short period of time due to the slow change of the left odometer numbers.

4.2.1.2. Seed numbers may be obtained by using the random number function of a calculator or spreadsheet. In the above example the same results would have occurred if a calculator returned .264 for the first seed number. Use the first digit (2) to select a column and the second two digits (64) for the row. If using the random number function again produced 0.837, and then the same numbers would have been generated for the Y coordinate as in Example 2.

4.2.1.3. Seed numbers may be obtained by "pointing" also. Lay copies of both pages of **Table 1** side by side and with eyes closed place a pointer on the table to select a seed number. Use this number as in the above example. Suitable pointers would be any device with a small tip such as a pin or a mechanical pencil.

Table 1 Random Numbers

Table 1 (Cont)

	1	2	3	4	5	6	7	8	9	10
1	0.293	0.971	0.892	0.865	0.500	0.652	0.058	0.119	0.403	0.234
2	0.607	0.840	0.428	0.857	0.125	0.143	0.562	0.692	0.743	0.306
3	0.161	0.182	0.544	0.646	0.548	0.384	0.347	0.330	0.869	0.958
4	0.856	0.103	0.019	0.990	0.370	0.094	0.967	0.642	0.332	0.717
5	0.779	0.795	0.262	0.276	0.236	0.537	0.465	0.712	0.358	0.090
6	0.036	0.475	0.100	0.813	0.191	0.581	0.350	0.429	0.768	0.574
7	0.028	0.569	0.915	0.344	0.009	0.523	0.520	0.521	0.002	0.970
8	0.442	0.320	0.084	0.623	0.859	0.608	0.714	0.937	0.559	0.943
9	0.045	0.878	0.108	0.876	0.466	0.117	0.005	0.912	0.150	0.887
10	0.625	0.906	0.957	0.145	0.616	0.606	0.279	0.207	0.337	0.242
11	0.962	0.457	0.424	0.102	0.462	0.885	0.710	0.352	0.617	0.781
12	0.938	0.696	0.085	0.916	0.844	0.281	0.254	0.528	0.470	0.267
13	0.431	0.960	0.653	0.256	0.944	0.928	0.809	0.543	0.739	0.776
14	0.755	1.000	0.072	0.501	0.805	0.884	0.322	0.235	0.348	0.900
15	0.139	0.365	0.993	0.091	0.599	0.954	0.693	0.249	0.925	0.637
16	0.064	0.040	0.219	0.199	0.055	0.732	0.105	0.505	0.661	0.579
17	0.701	0.450	0.950	0.218	0.067	0.531	0.979	0.783	0.934	0.096
18	0.659	0.406	0.800	0.525	0.339	0.936	0.719	0.029	0.825	0.215
19	0.804	0.580	0.754	0.690	0.629	0.794	0.841	0.131	0.388	0.168
20	0.261	0.456	0.158	0.774	0.673	0.289	0.982	0.371	0.666	0.121
21	0.604	0.471	0.020	0.870	0.624	0.349	0.426	0.529	0.634	0.214
22	0.587	0.083	0.635	0.038	0.767	0.473	0.939	0.647	0.449	0.691
23	0.947	0.292	0.217	0.183	0.366	0.172	0.156	0.570	0.583	0.185
24	0.351	0.025	0.224	0.432	0.752	0.636	0.664	0.582	0.622	0.213
25	0.165	0.184	0.516	0.099	0.353	0.920	0.097	0.519	0.197	0.126
26	0.725	0.931	0.309	0.436	0.782	0.389	0.707	0.297	0.709	0.803
27	0.253	0.506	0.656	0.343	0.974	0.898	0.162	0.879	0.393	0.231
28	0.498	0.414	0.576	0.427	0.662	0.345	0.877	0.385	0.122	0.051
29	0.104	0.301	0.346	0.905	0.918	0.572	0.838	0.092	0.282	0.260
30	0.035	0.075	0.518	0.280	0.115	0.611	0.362	0.062	0.578	0.567
31	0.503	0.421	0.697	0.610	0.147	0.049	0.545	0.452	0.852	0.497
32	0.274	0.205	0.778	0.472	0.245	0.951	0.671	0.932	0.713	0.731
33	0.314	0.032	0.468	0.493	0.252	0.833	0.812	0.445	0.904	0.324
34	0.400	0.422	0.592	0.854	0.832	0.527	0.605	0.797	0.089	0.455
35	0.807	0.593	0.989	0.997	0.910	0.722	0.645	0.534	0.021	0.327
36	0.118	0.377	0.711	0.871	0.024	0.251	0.433	0.814	0.577	0.216
37	0.007	0.288	0.372	0.727	0.014	0.259	0.037	0.922	0.460	0.230
38	0.476	0.011	0.265	0.188	0.317	0.603	0.981	0.198	0.853	0.977
39	0.275	0.700	0.745	0.535	0.179	0.902	0.706	0.737	0.133	0.748
40	0.721	0.237	0.283	0.070	0.644	0.614	0.942	0.747	0.123	0.880
41	0.980	0.716	0.819	0.079	0.526	0.071	0.828	0.536	0.463	0.909
42	0.359	0.789	0.135	0.555	0.394	0.444	0.775	0.269	0.510	0.845
43	0.733	0.598	0.059	0.921	0.816	0.381	0.454	0.477	0.596	0.250
44	0.192	0.968	0.430	0.699	0.295	0.383	0.266	0.401	0.542	0.286
45	0.354	0.799	0.004	0.232	0.633	0.682	0.638	0.897	0.485	0.695
46	0.496	0.012	0.243	0.985	0.355	0.612	0.315	0.760	0.392	0.541
47	0.494	0.113	0.773	0.867	0.824	0.976	0.323	0.134	0.761	0.911
48	0.780	0.687	0.318	0.202	0.331	0.264	0.670	0.848	0.114	0.495
49	0.023	0.027	0.930	0.031	0.843	0.730	0.919	0.858	0.866	0.360
50	0.086	0.335	0.631	0.247	0.120	0.965	0.675	0.999	0.601	0.948

	1	2	3	4	5	6	7	8	9	10
51	0.940	0.312	0.994	0.564	0.946	0.886	0.016	0.112	0.169	0.241
52	0.547	0.336	0.382	0.017	0.836	0.632	0.175	0.053	0.441	0.821
53	0.376	0.620	0.399	0.765	0.618	0.203	0.530	0.124	0.132	0.326
54	0.586	0.268	0.109	0.378	0.434	0.734	0.551	0.894	0.464	0.321
55	0.018	0.409	0.539	0.144	0.703	0.180	0.478	0.688	0.929	0.674
56	0.588	0.227	0.896	0.758	0.826	0.504	0.512	0.026	0.863	0.481
57	0.305	0.689	0.137	0.319	0.558	0.418	0.277	0.992	0.766	0.447
58	0.831	0.899	0.208	0.698	0.676	0.195	0.808	0.759	0.738	0.439
59	0.626	0.827	0.959	0.440	0.411	0.861	0.850	0.686	0.159	0.374
60	0.201	0.895	0.480	0.270	0.369	0.407	0.082	0.749	0.057	0.435
61	0.030	0.167	0.509	0.419	0.508	0.181	0.490	0.875	0.830	0.482
62	0.136	0.065	0.416	0.116	0.907	0.556	0.095	0.110	0.395	0.736
63	0.591	0.600	0.405	0.657	0.013	0.651	0.225	0.340	0.146	0.155
64	0.487	0.338	0.170	0.006	0.263	0.173	0.228	0.008	0.010	0.313
65	0.364	0.763	0.391	0.790	0.589	0.003	0.998	0.257	0.984	0.437
66	0.996	0.043	0.793	0.522	0.705	0.248	0.924	0.609	0.639	0.423
67	0.063	0.810	0.189	0.769	0.488	0.152	0.221	0.978	0.329	0.229
68	0.513	0.333	0.540	0.160	0.461	0.683	0.285	0.750	0.557	0.311
69	0.176	0.054	0.341	0.484	0.860	0.046	0.278	0.244	0.222	0.864
70	0.549	0.835	0.398	0.829	0.459	0.153	0.728	0.822	0.106	0.756
71	0.298	0.514	0.945	0.648	0.784	0.154	0.499	0.415	0.397	0.255
72	0.888	0.764	0.602	0.220	0.684	0.081	0.868	0.272	0.987	0.802
73	0.654	0.995	0.073	0.655	0.041	0.811	0.367	0.226	0.438	0.107
74	0.650	0.467	0.210	0.204	0.762	0.420	0.680	0.334	0.723	0.446
75	0.039	0.022	0.823	0.087	0.076	0.568	0.515	0.223	0.561	0.316
76	0.291	0.791	0.788	0.396	0.212	0.138	0.357	0.304	0.575	0.342
77	0.834	0.373	0.584	0.694	0.613	0.817	0.129	0.546	0.425	0.290
78	0.511	0.375	0.048	0.923	0.001	0.088	0.258	0.166	0.787	0.837
79	0.538	0.174	0.068	0.052	0.640	0.148	0.093	0.553	0.565	0.862
80	0.560	0.724	0.975	0.818	0.796	0.379	0.069	0.034	0.792	0.757
81	0.492	0.820	0.489	0.872	0.770	0.991	0.704	0.050	0.874	0.621
82	0.890	0.356	0.451	0.554	0.649	0.507	0.061	0.479	0.211	0.273
83	0.966	0.798	0.917	0.141	0.368	0.193	0.443	0.751	0.458	0.746
84	0.517	0.715	0.777	0.742	0.839	0.307	0.246	0.956	0.665	0.111
85	0.786	0.328	0.015	0.643	0.882	0.815	0.963	0.590	0.855	0.891
86	0.047	0.702	0.287	0.177	0.164	0.552	0.296	0.413	0.941	0.849
87	0.681	0.678	0.563	0.851	0.726	0.801	0.573	0.056	0.140	0.641
88	0.404	0.842	0.412	0.893	0.935	0.744	0.386	0.299	0.178	0.881
89	0.033	0.042	0.753	0.660	0.685	0.171	0.408	0.060	0.550	0.302
90	0.128	0.658	0.667	0.926	0.239	0.127	0.903	0.483	0.300	0.597
91	0.973	0.933	0.361	0.595	0.186	0.901	0.914	0.190	0.303	0.098
92	0.672	0.729	0.163	0.310	0.196	0.964	0.486	0.308	0.735	0.474
93	0.524	0.402	0.628	0.410	0.846	0.206	0.585	0.566	0.044	0.627
94	0.720	0.157	0.238	0.078	0.233	0.771	0.533	0.986	0.077	0.101
95	0.983	0.669	0.927	0.066	0.080	0.740	0.969	0.630	0.619	0.200
96	0.294	0.387	0.988	0.961	0.913	0.679	0.284	0.949	0.380	0.785
97	0.668	0.149	0.972	0.187	0.151	0.502	0.718	0.453	0.953	0.491
98	0.130	0.708	0.417	0.594	0.209	0.663	0.908	0.271	0.532	0.741
99	0.883	0.677	0.615	0.469	0.363	0.142	0.952	0.325	0.194	0.847
100	0.889	0.772	0.390	0.571	0.873	0.806	0.448	0.955	0.240	0.074

Soils Field Tester

INSTRUCTOR: ISAAC M. FERGUSON

Section 2

Dry Preparation of Disturbed Soil and Soil –Aggregate Samples for Test

Scope

- This method describes the dry preparation of soil and soil aggregate as received from the field, for mechanical analysis, physical test, and other test as may be desired.

3. APPARATUS

- 3.1 Balance
- 3.2 Drying Apparatus

3.2 Drying Apparatus

Oven 140°F (60°C)

3.3 Sieves

3.4 Pulverizing Apparatus

- Mortar and rubber-covered pestle

3.4 Pulverizing Apparatus

- Mechanical device consisting of a power-driven, rubber-covered muller

3.4 Pulverizing Apparatus

3.4 Pulverizing Apparatus

3.5 Sample Splitter

- Riffle Splitter

Standard Practice for

Dry Preparation of Disturbed Soil and Soil–Aggregate Samples for Test

AASHTO Designation: R 58-11 (2019)[1]

Technical Subcommittee: 1a, Soil and Unbound Recycled Materials

Release: Group 3 (July)

American Association of State Highway and Transportation Officials
555 12th Street NW, Suite 1000
Washington, DC 20004

Standard Practice for

Dry Preparation of Disturbed Soil and Soil–Aggregate Samples for Test

AASHTO Designation: R 58-11 (2019)[1]

Technical Subcommittee: 1a, Soil and Unbound Recycled Materials

Release: Group 3 (July)

AASHTO

1. SCOPE

1.1. This method describes the dry preparation of soil and soil–aggregate samples, as received from the field, for mechanical analysis, physical tests, and other tests as may be desired.

1.2. The values stated in SI units are to be regarded as the standard.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:
- M 231, Weighing Devices Used in the Testing of Materials
- R 76, Reducing Samples of Aggregate to Testing Size
- T 88, Particle Size Analysis of Soils
- T 89, Determining the Liquid Limit of Soils
- T 90, Determining the Plastic Limit and Plasticity Index of Soils
- T 100, Specific Gravity of Soils

2.2. *ASTM Standard*:
- E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

3. APPARATUS

3.1. The balance shall conform to the requirements of M 231, for the class of general purpose balance required for the principal sample mass of the sample being tested.

3.2. *Drying Apparatus*—Any suitable device capable of drying samples at a temperature not exceeding 60°C [140°F].

3.3. *Sieves*—A series of sieves of the following sizes: 4.75 mm (No. 4), 2.00 mm (No. 10), 0.425 mm (No. 40), and others as required for preparing the sample for a specific test. The sieves shall conform to ASTM E11.

3.4. *Pulverizing Apparatus*—Either a mortar and rubber-covered pestle or a mechanical device consisting of a power-driven, rubber-covered muller suitable for breaking up the aggregations of soil particles without reducing the size of the individual grains.

Note 1—Other types of apparatus, such as a revolving drum into which the soil sample and rubber-covered rollers are placed and tumbled until soil aggregations are pulverized, are satisfactory if the aggregations of soil particles are broken up without reducing the size of the individual grains.

3.5. *Sample Splitter*—A suitable riffle sampler or sample splitter for proportional splitting of the sample and capable of obtaining representative portions of the sample without appreciable loss of fines. The width of the container used to feed the riffle sample splitter should be equal to the total combined width of the riffle chutes. Proportional splitting of the sample on a canvas cloth is also permitted.

Note 2—The procedure for proportional splitting is described in R 76.

4. SAMPLE SIZE

4.1. *The amounts of soil material required to perform the individual tests are as follows*:

4.1.1. *Particle Size Analysis of Soils (T 88)*—For the particle size analysis, material passing a 2.00-mm (No. 10) sieve is required in amounts equal to approximately 110 g for sandy soils and approximately 60 g for silty or clayey soils. A sufficient amount of material retained on either the 4.75-mm (No. 4) sieve or 2.00-mm (No. 10) sieve is required (Note 3) to obtain a representative gradation, and, depending on the maximum particle size, shall not be less than the amount shown in the following table:

Diameter of Largest Particle, mm (in.)	Approximate Minimum Mass of Portion, kg
9.5 ($^3/_8$)	0.5
25 (1)	2.0
50 (2)	4.0
75 (3)	5.0

Note 3—The material for coarse sieve analysis may be separated by either of two alternate methods, Section 5.2.1 (2.00-mm sieve) or Section 5.2.2 (4.75-mm sieve). When only a small percentage of the material will be retained on the 4.75-mm or 2.00-mm sieve, a considerable total mass of sample will be required to provide the minimum quantity shown in the above table; consequently, adherence to the minimum mass requirements in the above table may not be necessary if the material represented by the sample is not to be used in a base or subbase course, select borrow, or other item having a requirement for coarse aggregate.

4.1.2. *Specific Gravity (T 100)*—For the specific gravity test performed in conjunction with T 88, material passing the 2.00-mm (No. 10) sieve is required in the amounts (oven-dry) of at least 25 g when the volumetric flask is used and at least 10 g when the stoppered bottle is used.

4.1.3. *Physical Tests*—For the physical tests, material passing the 0.425-mm (No. 40) sieve is required in the total amount of at least 300 g, allocated approximately as follows:

Test (and AASHTO Designation)	Approximate Mass, g
Liquid limit (T 89)	100
Plastic limit (T 90)	20
Shrinkage factors	30
Field moisture equivalent	50
Check and referee tests	100

5. INITIAL PREPARATION OF TEST SAMPLES

5.1. Dry the soil sample as received from the field thoroughly in air or in the drying apparatus at a temperature not exceeding 60°C [140°F]. Obtain a representative test sample of the amount required to perform the desired tests (Section 4) with the sampler, or by splitting or quartering. Break up the aggregations of soil particles in the pulverizing apparatus in such a way as to avoid reducing the natural size of individual particles.

Note 4—Samples dried in an oven or other drying apparatus at a temperature not exceeding 60°C [140°F] are considered to be air dried.

5.2. Weigh the portion of the dried sample selected for particle-sized analysis and physical tests (including specific gravity), and record that mass as the mass of total sample uncorrected for hygroscopic moisture. Separate this portion into fractions by one of the following methods:

5.2.1. *Alternate Methods Using 2.00-mm (No. 10) Sieve*—Separate the dried sample into two fractions using a 2.00-mm sieve. Grind the fraction retained on the sieve with the pulverizing apparatus until the aggregations of soil particles are broken into separate grains. Separate the ground soil into two fractions using the 2.00-mm sieve.

5.2.2. *Alternate Method Using 4.75-mm and 2.00-mm (Nos. 4 and 10) Sieves*—Separate the dried sample into two fractions using a 4.75-mm sieve. Grind the fraction retained on this sieve with the pulverizing apparatus until the aggregation of soil particles is broken into separate grains, and then separate these grains on the 4.75-mm sieve. Thoroughly mix the fractions passing the 4.75-mm sieve and, by the use of the sampler or by splitting and quartering, obtain a representative portion adequate for the desired tests. Separate this portion on the 2.00-mm sieve and process it as described in Section 5.2.1. Record the mass of the material from this split-off fraction that is retained on the 2.00-mm sieve for later use in coarse sieve analysis computations.

6. TEST SAMPLE FOR PARTICLE SIZE ANALYSIS AND SPECIFIC GRAVITY

6.1. Set aside the fraction retained on the 2.00-mm (No. 10) sieve in Section 5.2.1, or that retained on the 4.75-mm (No. 4) sieve in Section 5.2.2 after the second sieving, for use in sieve analysis of the coarse material.

6.2. Thoroughly mix the fractions passing the 2.00-mm (No. 10) sieve in both sieving operations in Sections 5.2.1 or 5.2.2 and, by the use of the sampler or by splitting or quartering, obtain representative portions having approximate masses as follows: (1) for the hydrometer analysis and sieve analysis of the fraction passing the 2.00-mm sieve, 110 g for sandy soil and 60 g for silty or clayey soils; and (2) for specific gravity, 25 g when the volumetric flask is to be used and 10 g when the stoppered bottle is to be used.

7. TEST SAMPLE FOR PHYSICAL TESTS

7.1. Separate the remaining portion of the material passing the 2.00-mm (No. 10) sieve into two parts by means of a 0.425-mm (No. 40) sieve. Grind the fraction retained on the 0.425-mm (No. 40) sieve with the pulverizing apparatus in such a manner as to break up the aggregations without fracturing the individual grains. If the sample contains brittle particles, such as flakes of mica, fragments of sea shells, etc., carefully perform the pulverizing operation with just enough pressure to free the finer material that adheres to the coarser particles. Separate the ground soil into two fractions by means of the 0.425-mm (No. 40) sieve, and regrind the material retained on the sieve. When repeated grinding produces only a small quantity of soil passing the 0.425-mm sieve, discard the material retained on the 0.425-mm sieve. Thoroughly mix the several fractions passing the 0.425-mm sieve obtained from the grinding and sieving operations and set aside for use in performing the physical tests.

8. KEYWORDS

8.1. Sample preparation; soil sample; soil–aggregate sample; test sample.

[1] Formerly T 87. Reclassified as a standard practice in 2011.

Soils Field Tester

INSTRUCTOR: ISAAC FERGUSON

Atterberg Demonstration

- https://www.youtube.com/watch?v=EcXJ961qjGA

5.9.10 PLASTICITY TESTS (Kansas Test Method KT-10)

1. SCOPE

This method of test covers the procedures for determining the liquid limit, plastic limit and plastic index of soils and the minus No. 40 (425 µm) portions of aggregates. For aggregates, use the wet preparation method described in **Section 9** of this test method. **KT-10** reflects testing procedures found in **AASHTO R-58, T 89** and **T 90**.

2. REFERENCED DOCUMENTS

2.1. Part V, 5.9; Sampling and Test Methods Foreword

2.2 KT-11; Moisture Tests

2.3. ASTM E11; Woven Wire Test Sieve Cloth and Test Sieves

2.4. AASHTO T 89; Determining the Liquid Limit of Soils

2.5. AASHTO T 90; Determining the Plastic Limit and Plasticity Index of Soils

3. APPARATUS

3.1. The balance shall conform to the requirements of **Part V, Section 5.9; Sampling and Test Methods Foreword** for the class of general purpose required for the principal sample mass of the sample being tested.

3.2. A suitable device capable of drying samples at a temperature not exceeding 140°F (60°C), for the preparation of the samples.

3.3. Oven thermostatically controlled capable of maintain a uniform temperature of 230 ± 9°F (110 ± 5°C), for drying of moisture samples.

3.4. A porcelain-evaporating dish, preferably unglazed about 4.5 in (115 mm) in diameter.

3.5. Spatula having a blade about 0.75 in (20 mm) wide and 3 in (75 mm) long.

3.6. A mechanically operated Liquid Limit Device consisting of a brass cup and carriage meeting the requirements of **AASHTO T 89, Figure 1** and **Sections 4.3.1 and 4.3.2** of this test method.

3.7. A manually operated device constructed in accordance with **AASHTO T 89, Section 3.3.1.**

3.8. Curved grooving tool meeting the requirements of **AASHTO T 89, Figure 1**.

3.9. A gage whether attached to the grooving tool or separate, conforming to the critical dimension "d" shown in **AASHTO T 89 Figure 1** and may be, if separate, a metal bar 0.394 ± 0.008 in. (10.0 ± 0.2 mm) thick and approximately 2 in 950 mm) long.

NOTE: All Liquid Limit Devices and curved grooving tools should be examined for conformance with the requirements of **AASHTO T 89** before they are used.

3.10. Suitable containers made of material resistant to corrosion and not subject to change in mass or disintegration on repeated heating and cooling. Containers shall have close-fitting lids to prevent loss of moisture from samples before initial mass determination and to prevent absorption of moisture from the atmosphere following drying and before final mass determination. One container is needed for each moisture content determination.

3.11. Pulverizing apparatus: Either a mortar and rubber-covered pestle or a mechanical device consisting of a power driven rubber-covered muller suitable for breaking up the aggregation of soil particles without reducing the size of the individual grains.

NOTE: Other types of apparatus, such as a revolving drum into which the soil sample and rubber-covered rollers are placed and tumbled until soil aggregations are pulverized, are satisfactory if the aggregations of soil particles are broken up without reducing the size of the individual grains.

3.12. Series of sieves including No. 4 (4.75 mm), No. 10 (2.00 mm), and No. 40 (425 µm) conforming to **ASTM E11**.

3.13. Standard KDOT 16 by 10 by 5.5 in (400 by 250 by 140 mm) wash pan equipped with No. 40 (425 µm) screen (optional).

3.14. Ground glass plate. The finish on the ground glass plate is obtained using a medium to fine grade of abrasive dust. An emery dust essentially passing the No. 60 (250 µm) sieve and retained on the No. 100 (150 µm) sieve has been found to be satisfactory.

A small amount of water is sprinkled on a glass plate along with the abrasive dust. Another plate is laid on top and the plates are rubbed together until a uniform frosty finish is obtained.

3.15. Plastic Limit Device such as a Gilson SA-18. (See **Figure 2**) This is used for the alternate procedure using the Plastic Limit Device, see **Section 6.4** of this test method.

4. LIQUID LIMIT TEST[1]

4.1. Definition: The liquid limit of a material is the water content, when determined in accordance with this test method, at which the material passes from a plastic to a liquid state. This corresponds to a theoretical moisture content at which the material will flow in such a manner as to produce a 0.5 in (13 mm) closure of a groove when jarred by 25 drops of the cup on the Liquid Limit Device.

4.2. Preparation of Sample: Dry the material at a temperature not exceeding 140°F (60°C). See **Section 9**, aggregate material preparation.

4.2.1. The dried sample shall be separated into two fractions using a No. 10 (2.00 mm) sieve. The fraction retained on the sieve shall be ground with the pulverizing apparatus until the aggregations of soil particles are broken into separate grains. The ground soil shall then be separated into two fractions using the No. 10 (2.00 mm) sieve. Discarding the material retained on the sieve.

4.2.2. Dry-screen the material over a No. 40 (425 µm) sieve to remove as much of the portion passing the No. 40 (425 µm) sieve as possible.

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[1] **AASHTO T 89 and ASTM D4318** allow for both method "A" and method "B". **KT-10** allows for method "A" only.

4.2.3. The fraction retained on the No. 40 (425 µm) sieve shall be ground with the pulverizing apparatus in such a manner as to break up the aggregations without fracturing the individual grains. If the sample contains brittle particles, such as flakes of mica, fragments of seashells, etc., the pulverizing operation shall be done carefully and with just enough pressure to free the finer material that adheres to the coarser particles. The ground soil shall then be separated into two fractions by means of the No. 40 (425 µm) sieve and the material shall be reground as before. When the repeated grinding produces only a small quantity of soil passing the No. 40 (425 µm) sieve, the material retained on the No. 40 (425 µm) sieve shall be discarded. The several fractions passing the No. 40 (425 µm) sieve obtained from the grinding and sieving operations just described shall be thoroughly mixed together and set aside for use in performing the physical tests.

4.3. Test Procedure

4.3.1. Adjust the height of drop of the brass cup on the Liquid Limit Device by means of the adjustment plate. The height to which the cup is lifted by the cam is adjusted so that the point on the cup which comes in contact with the base is 0.394 ± 0.008 in (10.0 ± 0.2 mm) above the base. Secure the adjustment plate by tightening the appropriate screws.

Place a piece of masking tape across the outside bottom of the cup parallel with the axis of the cup hanger pivot (**See Figure 3**). Place the tape between the wear spot and the pivot so that the edge of the tape away from the cup hanger bisects the spot on the cup that contacts the base. Slide the height gauge under the cup to the device and turn the crank until the cup is raised to its maximum height.

The adjustment is checked with the gauge in place by revolving the crank several times. If the adjustment is correct, a slight ringing sound will be heard when the cam strikes the cam follower. If the cup is raised off the gauge or no sound is heard, further adjustment is made.

Remove the tape after adjustment.

4.3.2. Inspect the Liquid Limit Device to be sure that it is in good working order and that there are no worn or "out of alignment" parts that will affect the test results.

4.3.3. Take a sample weighing approximately 100 g and place in the mixing dish. The sample shall be thoroughly mixed with 15 to 20 mL of distilled or demineralized water by alternately and repeatedly stirring, kneading and chopping with a spatula. Further additions of water shall be made in 1 to 3 mL increments. Each increment of water shall be thoroughly mixed with the soil, as previously described, before another increment of water is added. Once testing has begun, no additional dry soil should be added to the moistened soil. The cup of the Liquid Limit Device shall not be used for mixing soil and water. If too much moisture has been added to the sample, the sample shall either be discarded, or mixed and kneaded until the natural evaporation lowers the closure point into acceptable range.

NOTE: Some soils are slow to absorb water; therefore, it is possible to add increments of water so fast that a false liquid limit value is obtained. This can be avoided if more mixing and/or time is allowed. Tap water may be used for routine testing if comparative tests indicate no differences in results between using tap water and distilled or demineralized water. However, referee, or disputed tests shall be performed using distilled or demineralized water.

4.3.4. When sufficient water has been thoroughly mixed with the soil to form a uniform mass of stiff consistency, a sufficient quantity of this mixture shall be placed in the cup above the spot where the cup rests on the base and shall be squeezed and spread with the spatula to level and at the same time trimmed to a depth of 10 mm at the point of maximum thickness. As few strokes of the spatula as possible shall be used, care being taken to prevent the entrapment of air bubbles within the mass. The excess soil shall be returned to the mixing dish. The soil in the cup of the device shall be divided by a firm stroke of the grooving tool along the diameter through the centerline of the cam follower so that a clean sharp groove of proper dimensions will be formed. To avoid tearing the sides of the groove or slipping of the soil cake on the cup, up to six strokes from front to back or from back to front counting as one stroke shall be permitted. The depth of the groove should be increased with each stroke and only the last stroke should scrape the bottom of the cup.

4.3.5. The cup containing the sample prepared as described in **Section 4.3.4** of this test method, shall be lifted and dropped by turning the crank at the rate of approximately two revolutions per second until the two sides of the sample come in contact at the bottom of the groove along a distance of about 0.5 in (13 mm). The number of shocks required to close the groove this distance shall be recorded. The base of the machine shall not be held with the free hand while the crank is turned.

NOTE: Some soils tend to slide on the surface of the cup instead of flowing. If this occurs, more water should be added to the sample and remixed, then the soil-water mixture placed in the cup, a groove cut with grooving tool and **Section 4.3.5** repeated. If the soil continues to slide on the cup at a lesser number of blows than 25, the test is not applicable and a note should be made that the liquid limit could not be determined.

4.3.6. A slice of soil approximately the width of the spatula, extending from the edge to edge of the soil cake at right angles to the groove and including that portion of the groove in which the soil flowed together, shall be removed and placed in suitable container. Record the sample mass to the nearest 0.01 g. The soil in the container shall be dried in accordance with **KT-11** to determine the moisture content. The use of a lid for the container as stated in KT-11 is required. Record the results.

4.3.7. The soil remaining in the cup shall be transferred to the mixing dish. The cup and grooving tool shall be washed and dried in preparation for the next trial.

4.3.8. The foregoing operations shall be repeated for at least two additional portions of the sample to which sufficient water has been added to bring the soil to a more fluid condition. The object of this procedure is to obtain samples of such consistency that at least one determination will be made in each of the following ranges of shocks: 25-35, 20-30, 15-25. The range of the three determinations shall be at least 10 shocks.

5. CALCULATIONS

5.1. Calculate the moisture content of the sample as follows:

$$\text{Moisture Content} = \frac{100 \times (A-C)}{(C-B)}$$

Where:
A= Mass of wet soil and container, g
B= Mass of container, g
C= Mass of dry soil and container, g

5.1.1. Record the moisture content to the nearest 0.1%.

5.2. A "Flow Curve" representing relation between moisture content and corresponding number of shocks shall be plotted on a semi-logarithmic graph with the moisture contents as abscissa on the arithmetical scale, and the number of shocks as ordinates on the logarithmic scale. The flow curve shall be a straight line drawn as nearly as possible through the three plotted points. (Figure 1)

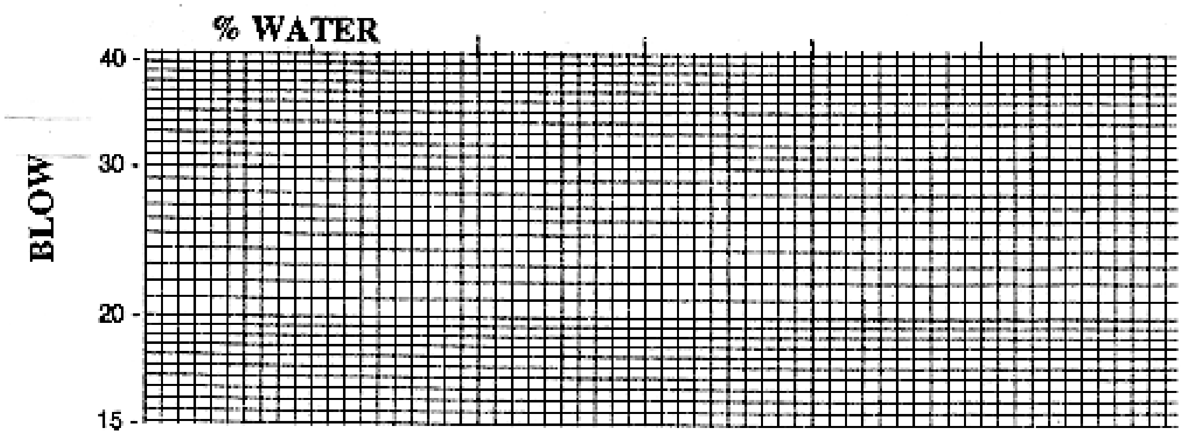


Figure 1
Flow Curve Chart
(KDOT Form No. 664)

5.3. The moisture content corresponding to the intersection of the flow curve with the 25 shock ordinate shall be taken as the liquid limit of the soil. Report this value to the nearest whole number.

6. PLASTIC LIMIT TEST

6.1. Definition: The plastic limit of a material is the lowest water content, when determined in accordance with this test method, at which the material remains plastic.

6.2. Preparation of Sample: The test is conducted using material finer than the No. 40 (425 µm) sieve. The minus No. 40 (425 µm) material is prepared as outlined in **Section 4.2** of this test method.

6.3. Test Procedure

6.3.1. Thoroughly mix the minus No. 40 (425 µm) material and place approximately 20 g in an evaporation dish.

6.3.2. Thoroughly mix with distilled or demineralized water until the mass becomes plastic enough to be easily shaped into a ball. Take a portion of this ball with a mass of about 10 g for the test sample.

NOTE: Tap water may be used for routine testing if comparative tests indicate no differences between using tap water and distilled or demineralized water. However, referee or disputed tests shall be performed using distilled or demineralized water.

6.3.3. If both the liquid and plastic limits are required, take a test sample with a mass of about 10 g from the thoroughly wet and mixed portion of the soil prepared in accordance with **Section 4.3.3** of this test method. Take the sample at any stage of the mixing process at which the mass becomes plastic enough to be easily shaped into a ball without sticking to the fingers excessively when squeezed. If the sample is taken before completion of the liquid limit test, set it aside and allow it to season in air until the liquid limit test has been completed. If the sample taken during the liquid limit test is too dry to permit rolling to a 1/8 in (3.0 mm) thread, add more water and remix.

6.3.4. Select 1.5 to 2.0 g of soil taken in **Section 6.3.3** of this test method. Form into an ellipsoidal mass.

6.3.5. Roll this mass between the fingers and the palm of the hand and a ground glass plate with just sufficient pressure to roll the mass into a thread of uniform diameter throughout its length. The rate of rolling shall be between 80 and 90 strokes per minute, counting a stroke as one complete motion of the hand forward and back to the starting position again. Reduce the diameter of the thread to 1/8 in (3.0 mm), taking no more than 2 min. Quickly squeeze and reform the thread into an ellipsoidal shaped mass and re-roll. Continue this alternate reforming and re-rolling to a thread 1/8 in (3.0 mm) in diameter, gathering together, kneading and re-rolling, until the thread crumbles under the pressure required for rolling and the material can no longer be rolled into a thread. The crumbling may occur when the thread is greater than 1/8 in (3.0 mm) in diameter. This shall be considered a satisfactory end point, provided the material has been rolled to a thread of 1/8 in (3.0 mm) during the previous rolling. The crumbling will manifest itself differently with various types of material. Some materials fall apart in numerous small aggregations of particles; others may form an outside tubular layer that starts splitting at both ends. Splitting progresses toward the middle, and finally, the thread falls apart in many small platy particles. It is not practical to define crumbling to an exact degree since, as stated above, crumbling will manifest itself differently for different materials. At no time shall the operator attempt to produce failure at exactly 1/8 in (3.0 mm) diameter by allowing the thread to reach 1/8 in (3.0 mm), then reducing the rate of rolling or the hand pressure or both, and continuing the rolling without further deformation until the thread falls apart. It is permissible, however, to reduce the total amount of deformation for feebly plastic soils by making the initial diameter of the ellipsoidal shaped mass nearer to the required 1/8 in (3.0 mm) final diameter.

6.3.6. Place the crumbled thread in a watch glass or other suitable container of known mass and close to prevent evaporation loss. Repeat steps 6.3.4. to 6.3.6. until the entire 10 gram sample has been tested.

6.3.7. Gather the portions of the crumbled soil together and place in a suitable tared container. Record the sample mass to the nearest 0.01 g. The soil in the container shall be dried in accordance with **KT-11 Sections 3 through 5**, to determine the moisture content. The use of a lid for the container as stated in KT-11 is required. Record the results.

6.4. Alternate procedure using the Plastic Limit Device

6.4.1. Attach smooth unglazed paper to both the bottom fixed plate and the top of the Plastic Limit Device.

6.4.2. Split the 10 g. test sample taken in **Section 6.3.3 and 6.3.4** of this test method into four or five masses of 1.5 to 2.0 g each. Squeeze into an ellipsoidal-shape and place two to three masses on the bottom plate. Place the top plate in contact with the soil masses. Simaltaneously with a slight downward force, apply a back-and-forth rolling motion with the top plate until the top plate comes into contact with the 3.2 mm side rails, within two minutes. Do not allow the soil thread to come into contact with the side rails.

6.4.3. Continue the test as outlined in **Sections 6.3.5, 6.3.6, and 6.3.7** of this test method.

7. CALCULATIONS

7.1. Calculate the moisture content of the sample at its plastic limit as follows:

$$\text{Plastic Limit} = \frac{100 \times (\text{A -C})}{(\text{C-B})}$$

Where: A= Mass of wet soil and container, g
B= Mass of container, g
C= Mass of dry soil and container, g

7.2. Record all masses to the nearest 0.01 g. Calculate and record the percentage of moisture to the 0.1%, report the percentage of moisture to the nearest whole percent.

8. PLASTIC INDEX

8.1. Definition: The plastic index of a material is the numerical difference between the liquid limit and the plastic limit.

8.2. Calculations: Calculate the plastic index as follows, or calculate on **KDOT Form 663**.

Plastic Index = Liquid Limit (as recorded) – Plastic Limit (as recorded).

8.3. Reporting: Report the plastic index and liquid limit (when required) to the nearest whole number.

NOTE: When testing extremely sandy samples, it is permissible to conduct the plastic limit test first. If the plastic limit cannot be determined, report the plastic index as NP (i.e. nonplastic). If the plastic limit is equal to or greater than the liquid limit, report the plastic index as NP.

9. WET PREPARATION (FOR AGGREGATE MATERIAL ONLY)

9.1. The following "wash" method of preparation shall be used for all types of aggregates, binder soil and mineral fillers. However, in the case of a mineral filler which all passes a No. 40 (425 µm) sieve, the washing process may be waived and the sample prepared for testing by reducing it to particle size using the pulverizing apparatus.

9.2.1. Dry the material to a moisture condition at which it can be pulverized and dry-screened without sticking or clogging the screens.

9.2.2. Dry-screen the material over a No. 40 (425 µm) sieve to remove as much of the portion passing the No. 40 (425 µm) sieve as possible before washing. Several larger sieves may be used in this process to keep part of the load off the No. 40 (425 µm) sieve. This initial dry-screening is very important as it helps to reduce the time and water required for the washing process which follows. Set aside the minus No. 40 (425 µm) material obtained in this manner for recombination with material obtained by later steps.

9.2.3. Place the material retained on the No. 40 (425 µm) sieve in a pan, cover with water and soak for a minimum of 30 minutes.

9.2.4. Following the soaking period, wash the material, using not less than four applications of wash water, including the soaking water. Each application of water must cover the entire sample. The washing for each application is accomplished by a "sloshing" action of the pan. Should an appreciable amount of plastic material remain with the sample after four applications of water, use additional applications accompanied by more vigorous agitation of the material. Decant each application of the wash water through a No. 40 (425 µm) sieve, saving all of the wash water and material.

9.2.5. Evaporate the water from the washed plus No. 40 (425 µm) material and from the material washed through the No. 40 (425 µm) sieve using an oven with temperature settings not to exceed 140°F (60°C). In most cases, after a short period of heating, the particles in suspension will settle out so that the clear water at the top of the pan may be siphoned off to reduce the drying time.

9.2.6. If the material in the retained wash water becomes caked during the drying process, break it down to pass the No. 40 (425 µm) sieve with the pulverizing apparatus. This pulverizing shall be done, insofar as possible, in a manner which will not change the characteristics of the material.

9.2.7. Dry-screen the dried material, retained on the No. 40 (425 µm) sieve during the washing process, over a No. 40 (425 µm) sieve after which the material retained on the sieve may be discarded.

9.2.8. Recombine and thoroughly mix the minus No. 40 (425 µm) material obtained by the initial dry-screening, that obtained by washing and that obtained by re-screening the coarse material after washing. The sample thus prepared is ready for testing.

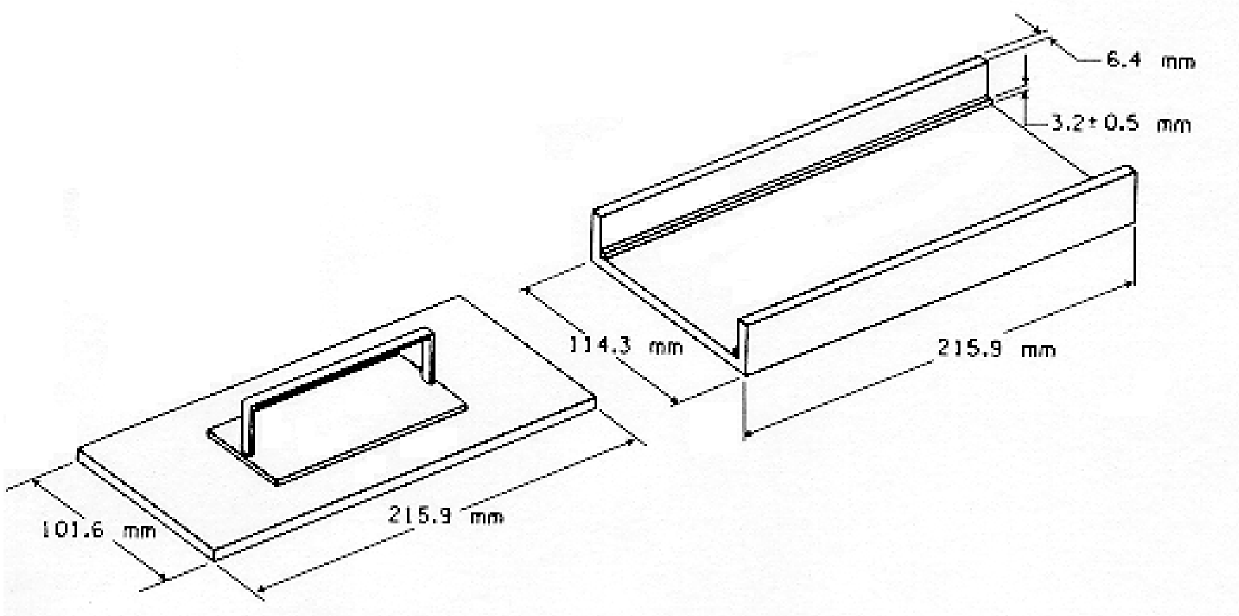
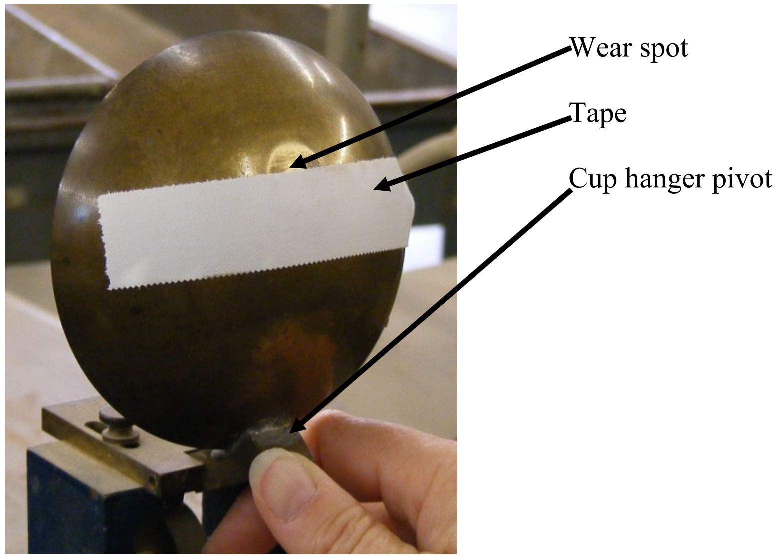


Figure 2
Plastic Limit Device

Figure 3
Brass Cup Calibration



Soils Field Tester

INSTRUCTOR: ISAAC M. FERGUSON

KT-11: Moisture Test

Constant Mass

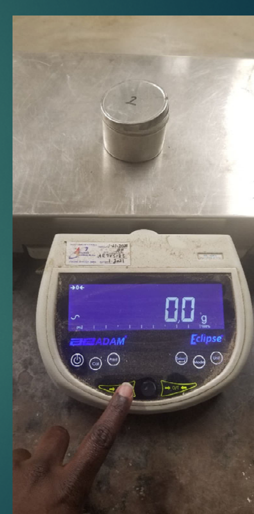
Speedy Method

Constant Mass Method

How to determine moisture content in soil

Constant Mass Method

1. Weigh empty soil can with lid



Constant Mass Method

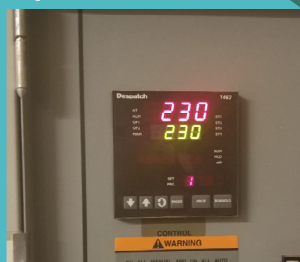
1. Weigh empty soil can with lid

Constant Mass Method

1. Weigh empty soil can with lid
2. **Weigh moist sample with can**

Constant Mass Method

1. Weigh empty soil can with lid
2. Weigh moist sample with can
3. **Remove Lid and Place container with moist sample into a oven (230°F +/- 9°F ; 110° C +/-5° C)to dry**




Constant Mass Method

1. Weigh empty soil can with lid
2. Weigh moist sample with can
3. Remove Lid and Place container with moist sample into a oven (**230°F +/- 9°F ; 110° C +/-5° C**)to dry
4. **Remove from oven replace the lid and allow the sample to cool to room temperature**

Constant Mass Method

1. Weigh empty soil can with lid
2. Weigh moist sample with can
3. Remove Lid and Place container with moist sample into a oven (**230°F +/- 9°F ; 110° C +/-5° C**)to dry
4. Remove from oven replace the lid and allow the sample to cool to room temperature
5. **Weigh the container and the sample with the lid**

Constant Mass Method

1. Weigh empty soil can with lid
2. Weigh moist sample with can
3. Remove Lid and Place container with moist sample into a oven (**230°F +/- 9°F ; 110° C +/-5° C**)to dry
4. Remove from oven replace the lid and allow the sample to cool to room temperature
5. Weigh the container and the sample with the lid

6. **Record moisture to nearest 0.01%**

Constant Mass Method

1. Weigh empty soil can with lid
2. Weigh moist sample with can
3. Remove Lid and Place container with moist sample into a oven (**230°F +/- 9°F ; 110° C +/-5° C**)to dry
4. Remove from oven replace the lid and allow the sample to cool to room temperature
5. Weigh the container and the sample with the lid

6.Record moisture to nearest 0.01%

7. Report to nearest 0.1%

Speedy Method

Demonstrate in the lab

5.9.11 MOISTURE TESTS (Kansas Test Method KT-11)

1. SCOPE

This method of test covers the procedure for the determination of the moisture content of soil and aggregate. **KT-11** reflects testing procedures found in **AASHTO T 217** and **T 265**.

2. REFERENCED DOCUMENTS

2.1. Part V, 5.9; Sampling and Test Methods Foreword

2.2. AASHTO T 217; Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester

2.3. AASHTO T 265; Laboratory Determination of Moisture Content of Soils

3. CONSTANT MASS METHOD

3.1. Apparatus:

3.1.1. The balance shall conform to the requirements of **Part V, 5.9**, **Sampling and Test Methods Foreword** for the class of general-purpose balance required for the principal sample mass of the sample being tested.

3.1.2. Drying oven should be thermostatically controlled, preferably of the forced-draft type. It shall be capable of being heated continuously at a temperature of 230 ± 9°F (110 ± 5°C).

3.1.3. Drying pans.

4. TEST PROCEDURE FOR CONSTANT MASS METHOD

4.1. Select a representative quantity of sample in the amount indicated in the method of test. If no amount is indicated, the minimum mass of the sample shall be in accordance with the following table:

Maximum Particle Size	Minimum Mass of Sample, g
No. 40 (425 µm) sieve	10
No. 4 (4.75 mm) sieve	100
1/2 in (12.5 mm) sieve	300
1 in (25.0 mm) sieve	500
2 in (50.0 mm) sieve	1000

4.2. Weigh a clean, dry container (with its lid if used for soils) and place the moisture content sample in the container. Replace the lid (if used) immediately, and weigh the container, including the lid (if used) and moist sample. Remove the lid (if used) and place the container with the moist sample in the drying oven maintained at a temperature of 230 ± 9°F (110 ± 5°C) and dry to a constant mass. Immediately upon removal from the oven, replace the lid (if used) and allow the sample to cool to room temperature. Weigh the container including lid (if used) and dried sample.

NOTE: Checking every moisture content sample to determine that it is dried to a constant mass is impractical. In most cases, drying of a moisture sample over-night (15 to 16 hours) is sufficient. In cases where there is doubt concerning the adequacy of overnight drying, drying should be continued until the mass after two successive periods of drying indicate no change in mass. Samples of sand may often be dried to constant mass in a period of several hours. Since dry samples may absorb moisture from wet samples, dried samples should be removed before placing wet samples in the oven.

NOTE: (for bulk soil samples): A container without a lid may be used provided the moist sample is weighed immediately after being taken and providing the dried sample is weighed immediately after being removed from the oven or after cooling in a desiccators. This provision does not apply to samples used for plasticity index determination; lids must be used.

NOTE: Moisture content samples for soils should be discarded and should not be used in any other tests.

5. CALCULATIONS

5.1. Calculate the moisture content as follows:

$$w=[(\text{mass of moisture})/(\text{mass of oven-dried sample})]\times 100$$

$$w=[(W_1-W_2)/(W_2-W_c)]\times 100$$

Where:
- w = moisture content, percent
- W_1 = mass of container and moist sample, g
- W_2 = mass of container and oven-dried sample, g
- W_c = mass of container, g

5.2. Calculate the percent of moisture content.

6. REPORT

6.1. Record the moisture content to the nearest 0.01% of mass of the oven dried sample. Report the percent of moisture content to the nearest 0.1%.

7. GAS PRESSURE (‘SPEEDY”) METHOD

7.1 Significance and Use

This test method outlines procedures for determining the moisture content of soil by chemical reaction using calcium carbide as a reagent to react with the available water in the soil producing a gas. A measurement is made of the pressure produced when a specified mass of wet or moist soil is placed in a testing device with an appropriate volume of reagent and mixed.

This method is not intended as a replacement for Section 3, Constant Mass Method, but as a supplement when rapid results are required, for field use some distance from a lab or where an oven is not practical for use on the project.

This method is applicable for most soils, however, some soils that contain highly plastic clays that are not friable and do not break down may not produce representative results as the reagent may not react with all

the moisture contained in the sample. It is recommended to use Section 3 if highly accurate results are needed.
NOTE: This method shall not be used on granular materials having more than 5% particles large enough to be retained on a No. 4 (4.75 mm) sieve as determined by a visual estimate. The Super 200 D Tester is intended to be used when testing aggregate.

7.2. Apparatus

7.2.1. Calcium carbide pressure moisture tester. **(Figure 1)**

7.2.2. The balance shall conform to the requirements of **Part V, 5.9**, **Sampling and Test Methods Foreword.**

7.2.3. Two 1.25 in (31.75 mm) steel balls.

7.2.4. Cleaning brush and cloth.

7.2.5. Scoop for measuring calcium carbide reagent.

8. MATERIAL

8.1. Calcium carbide reagent.

NOTE: The calcium carbide must be finely pulverized and should be of a grade capable of producing acetylene gas in the amount of at least 2.25 ft^3/lb (90.14 m^3/kg) of carbide.

NOTE: The "shelf life" of the calcium carbide reagent is limited, so it should be used according to manufacturer recommendations.

NOTE: When combined with water, the calcium carbide reagent produces a highly flammable or explosive acetylene gas. Testing should not be carried out in confined spaces or in the vicinity of open flame or other source of heat that could cause combustion.

9. TEST PROCEDURE FOR SPEEDY METHOD

9.1. When using the 20 g or 26 g tester, place three scoops (approximately 24 g) of calcium carbide in the body of the moisture tester. When using the Super 200 D Tester to test aggregate, place 6 scoops (approximately 48 g) of calcium carbide in the body of the moisture tester.

NOTE: Care must be exercised to prevent the calcium carbide from coming into direct contact with water.

9.2. Weigh a sample of the exact mass specified by the manufacturer of the instrument in the balance provided and place the sample in the cap of the tester. When using the 20 g or 26 g size tester, place two 1.25 in (31.75 mm) steel balls in the body of the tester with the calcium carbide.

NOTE: If the moisture content of the sample exceeds the limit of the pressure gauge (12% moisture for aggregate tester or 20% moisture for soil tester), a one-half size sample must be used and the dial reading must be multiplied by 2. This proportional method is not directly applicable to the dry mass percent scale on the Super 200 D Tester.

9.3. With the pressure vessel in an approximately horizontal position, insert the cap in the pressure vessel and seal the unit by tightening the clamp, taking care that no carbide comes in contact with the soil until a complete seal is achieved.

9.4. Raise the moisture tester to a vertical position so that the soil in the cap will fall into the pressure vessel.

9.5. Shake the instrument vigorously so that all lumps will be broken up to permit the calcium carbide to react with all available free moisture. When steel balls are being used in the tester and when using the larger tester to test aggregate, the instrument should be shaken with a rotating motion so the steel balls or aggregate will not damage the instrument or cause soil particles to become embedded in the orifice leading to the pressure diaphragm.

NOTE: Shaking should continue for at least 60 seconds with granular soils and for up to 180 seconds for other soils so as to permit complete reaction between the calcium carbide and the free moisture. Time should be permitted to allow dissipation of the heat generated by the chemical reaction.

9.6. When the needle stops moving, read the dial while holding the instrument in a horizontal position at eye level.

9.7. Record the dial reading.[1]

9.8. With the cap of the instrument pointed away from the operator, slowly release the gas pressure. Empty the pressure vessel and examine the material for lumps. If the sample is not completely pulverized, the test should be repeated using a new sample. Clean the cap thoroughly of all carbide and soil before running another test.

NOTE: When removing the cap, care should be taken to point instrument away from the operator to avoid breathing the fumes and away from any potential source of ignition for the acetylene gas.

9.9. The dial reading is the percent of moisture by wet mass and must be converted to dry mass. With the Super 200 D Tester the dial reading is the percent of moisture by dry mass, and no further calculation is required.

10. CALCULATION

10.1 The percentage of moisture by dry mass of the soil may be determined from the conversion curve either provided with the device, a curve developed from local soils or the calculation provided with the device. Preference should be given to a curve developed from local soils that are to be used on a project.

10.2 Calibration curves are produced by selecting several samples representing the range of soil materials to be tested and having a relatively wide range of moisture content. Utilize the method in Section 3 alongside the Speedy to develop the curve.

[1] **AASHTO T 217** requires recording sample mass and dial reading.

NOTE: A conversion curve, similar to **Figure 2,** is normally supplied with the moisture tester. However, check each moisture tester for accuracy of its gage, or the accuracy of the conversion curve annually[2]. Accuracy of the tester gage may be checked by using a calibration kit (obtainable from the tester manufacturer), equipped with the standard gage; in case of discrepancy, the gage tester should be adjusted to conform to the standard gage. For checking the accuracy of the conversion curve, a calibration should be made for meter readings using locally prepared soils at known moisture contents. Also, additional testing may be necessary to extend the conversion curve (**Figure 2**) beyond 44% moisture content.

NOTE: It may be convenient for field use of the apparatus to prepare a table of moisture tester readings versus oven-dry moisture content for the moisture tester.

11. REPORT

11.1. Record the dial reading to the nearest 0.1% and determine the percent moisture from the conversion chart. Report the percentage of moisture to the nearest whole percent.

[2] KDOT requires that each Speedy Moisture tester be checked annually for accuracy of reading.

Figure 1 Calcium Carbide Gas Pressure Moisture Meter

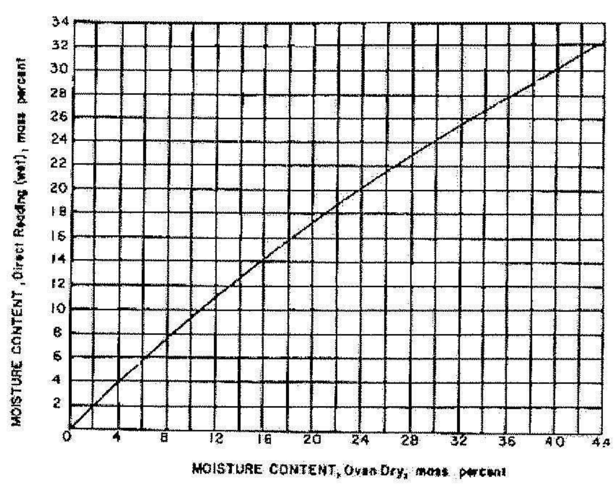
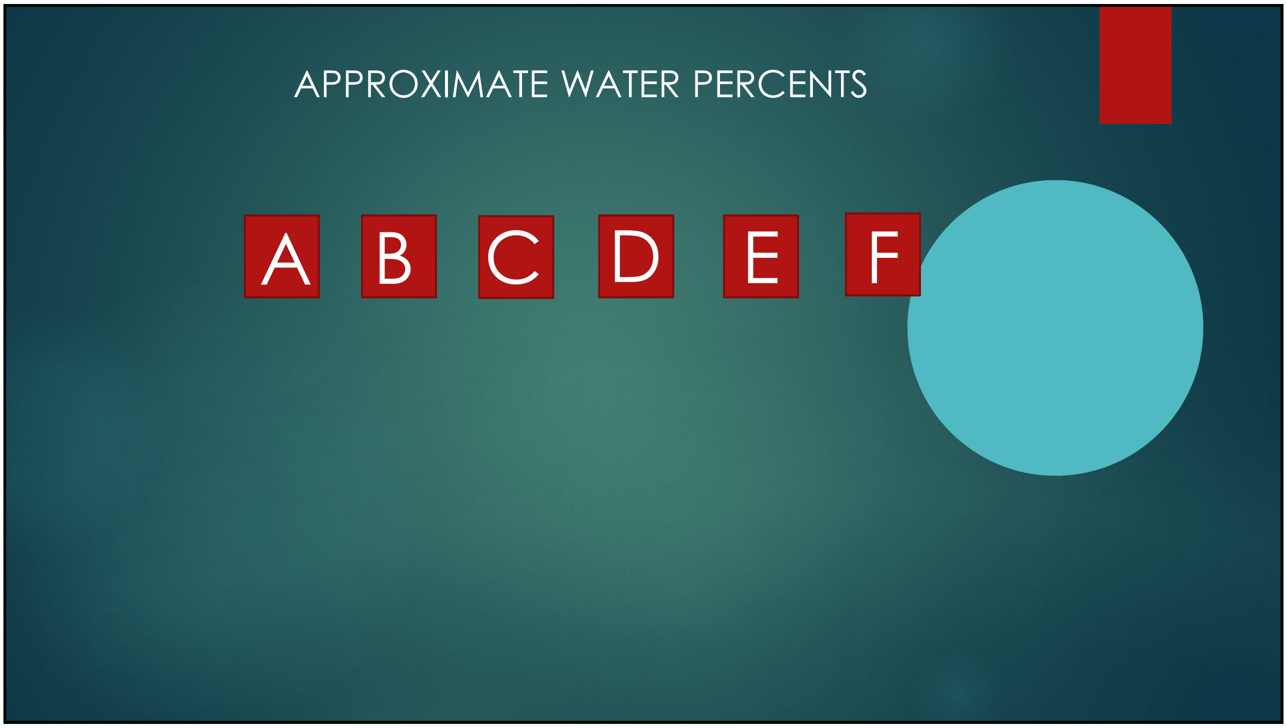


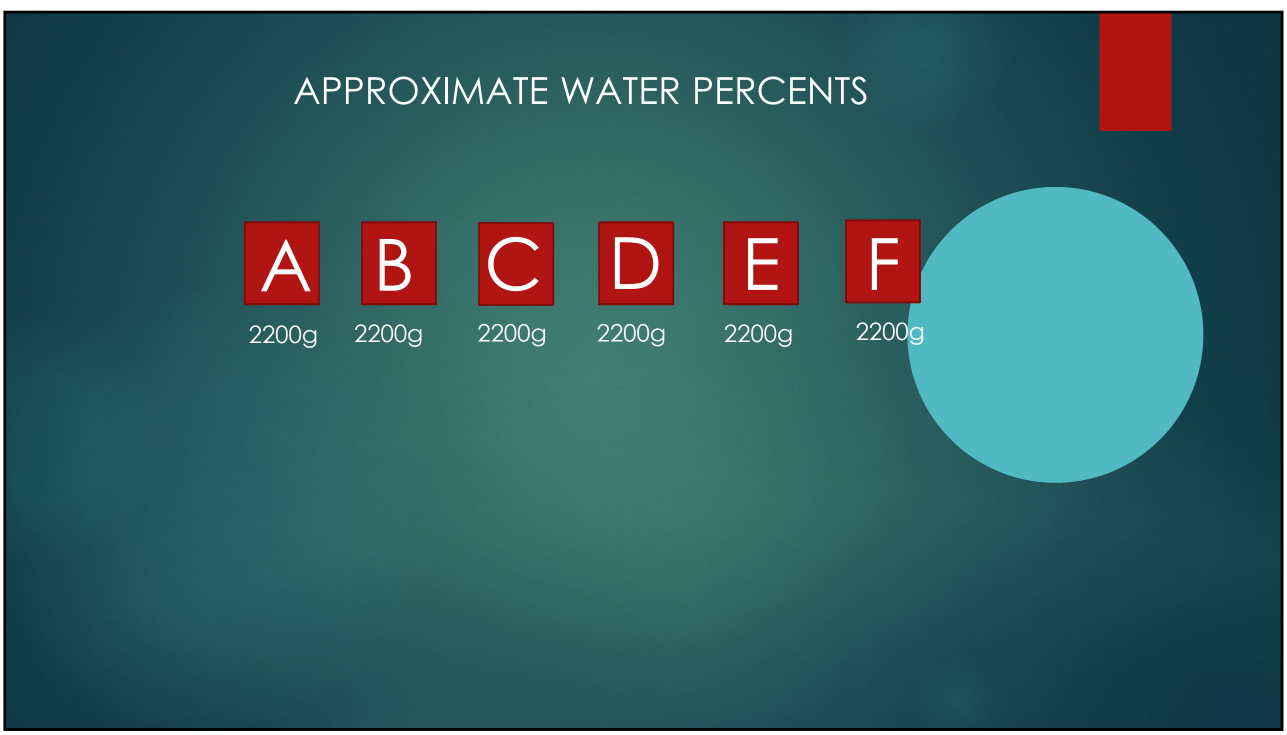
Figure 2 Conversion Curve for Moisture Tester Reading

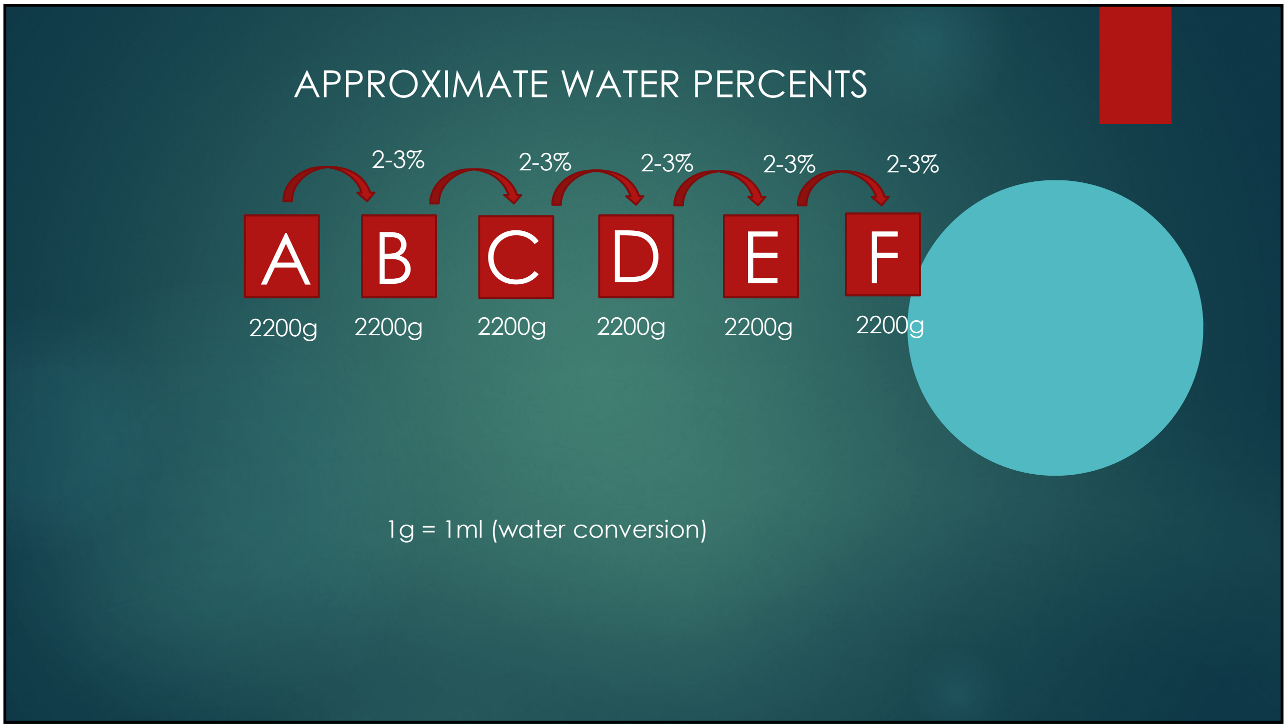
Soils Field Tester

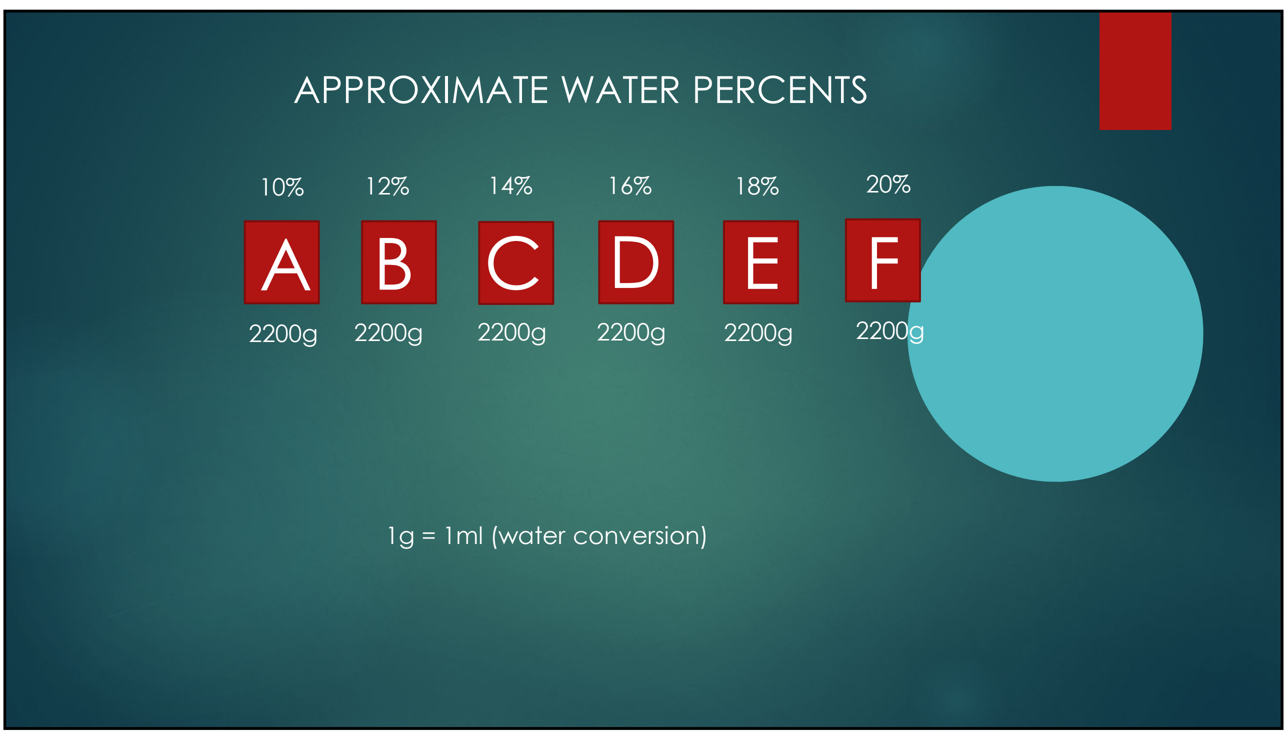
INSTRUCTOR: ISAAC FERGUSON

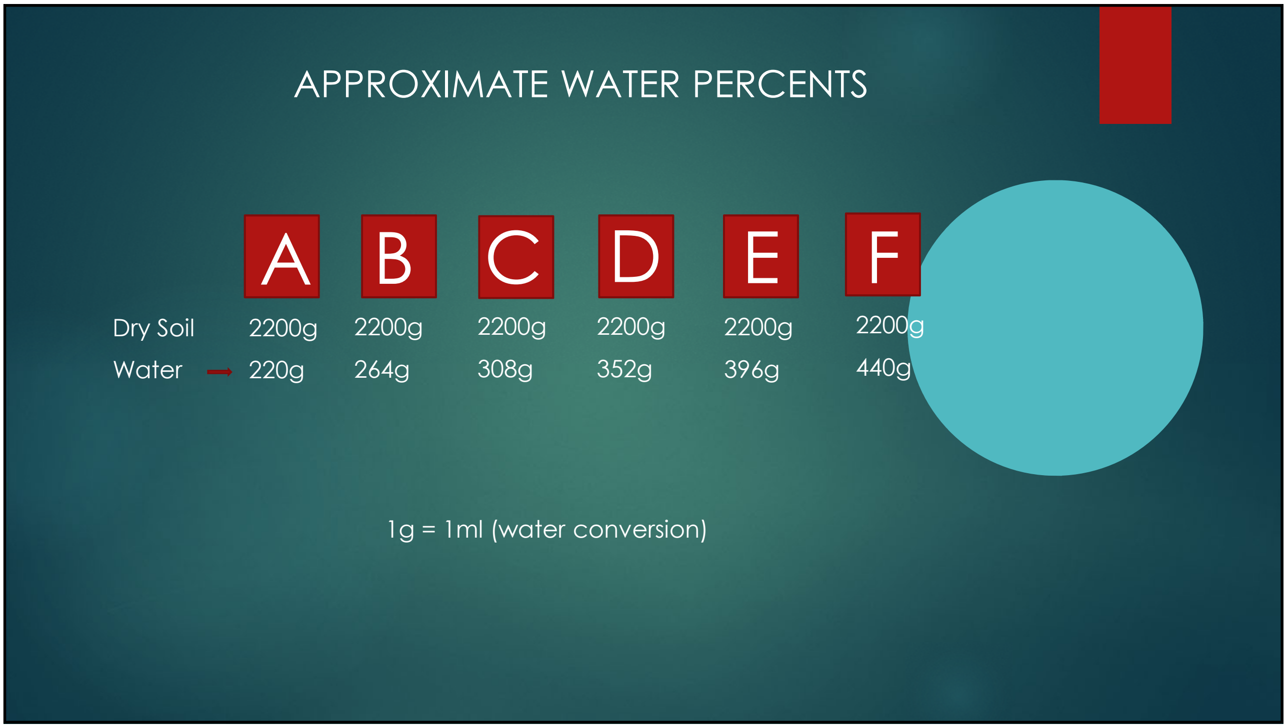
KT-12 Standard Compaction

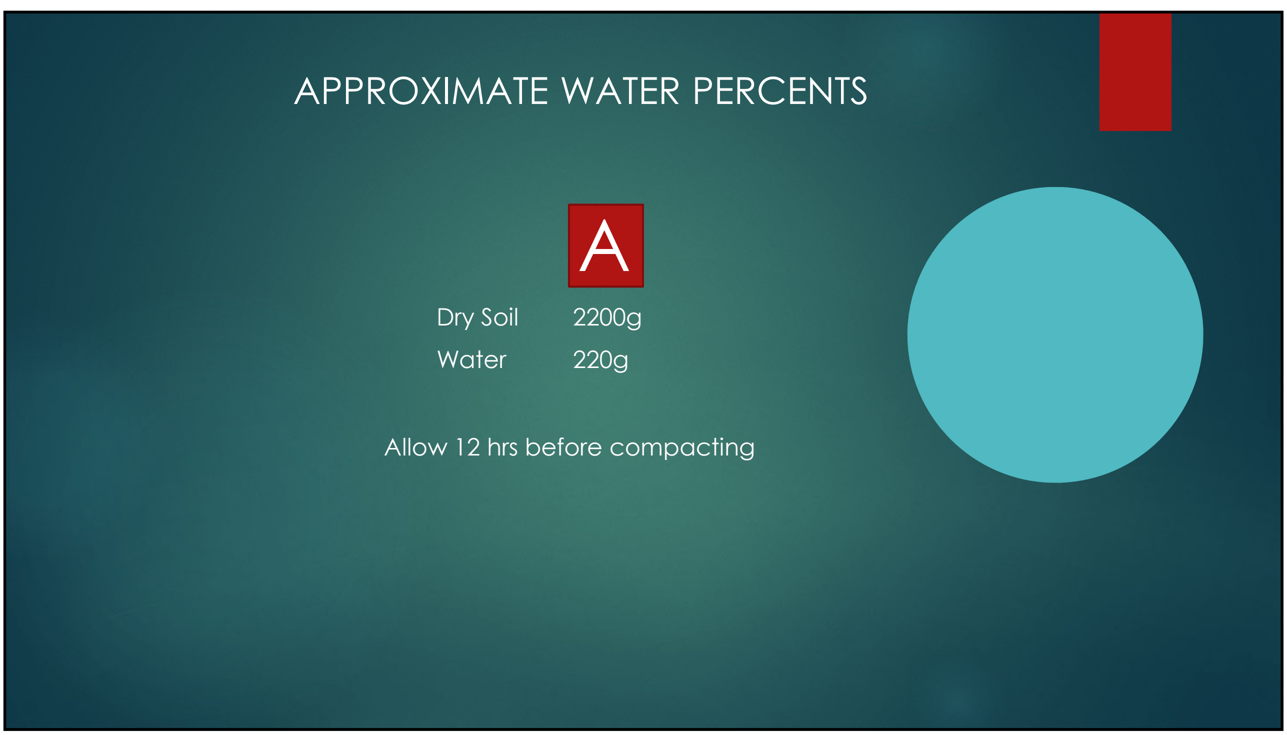

APPROXIMATE WATER PERCENTS
A
B
C
D
E
F


APPROXIMATE WATER PERCENTS
A
B
C
D
E
F
2200g
2200g
2200g
2200g
2200g
2200g


APPROXIMATE WATER PERCENTS
2-3%
2-3%
2-3%
2-3%
2-3%
A
B
C
D
E
F
2200g
2200g
2200g
2200g
2200g
2200g
1g = 1ml (water conversion)


APPROXIMATE WATER PERCENTS
10%
12%
14%
16%
18%
20%
A
B
C
D
E
F
2200g
2200g
2200g
2200g
2200g
2200g
1g = 1ml (water conversion)

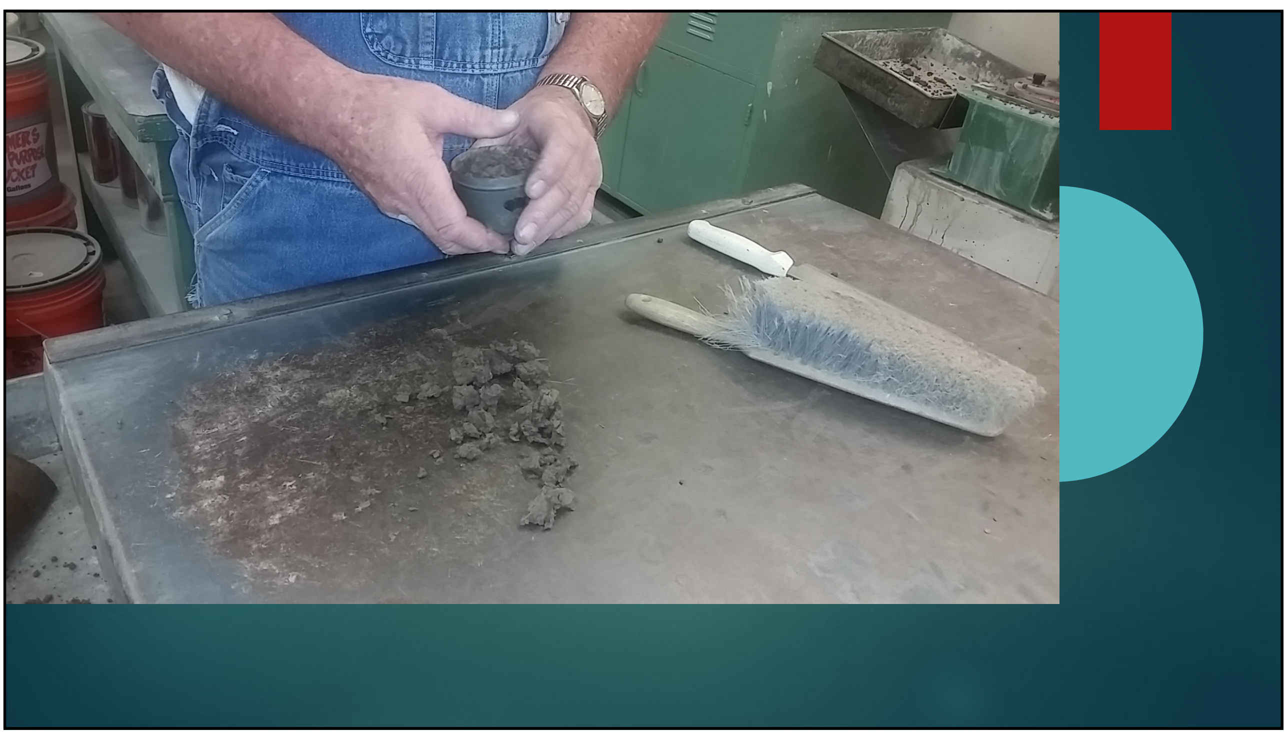

APPROXIMATE WATER PERCENTS
A B C D E F
Dry Soil 2200g 2200g 2200g 2200g 2200g 2200g
Water 220g 264g 308g 352g 396g 440g
1g = 1ml (water conversion)


APPROXIMATE WATER PERCENTS
A
Dry Soil 2200g
Water 220g
Allow 12 hrs before compacting


A
Allow 12 hrs before compacting

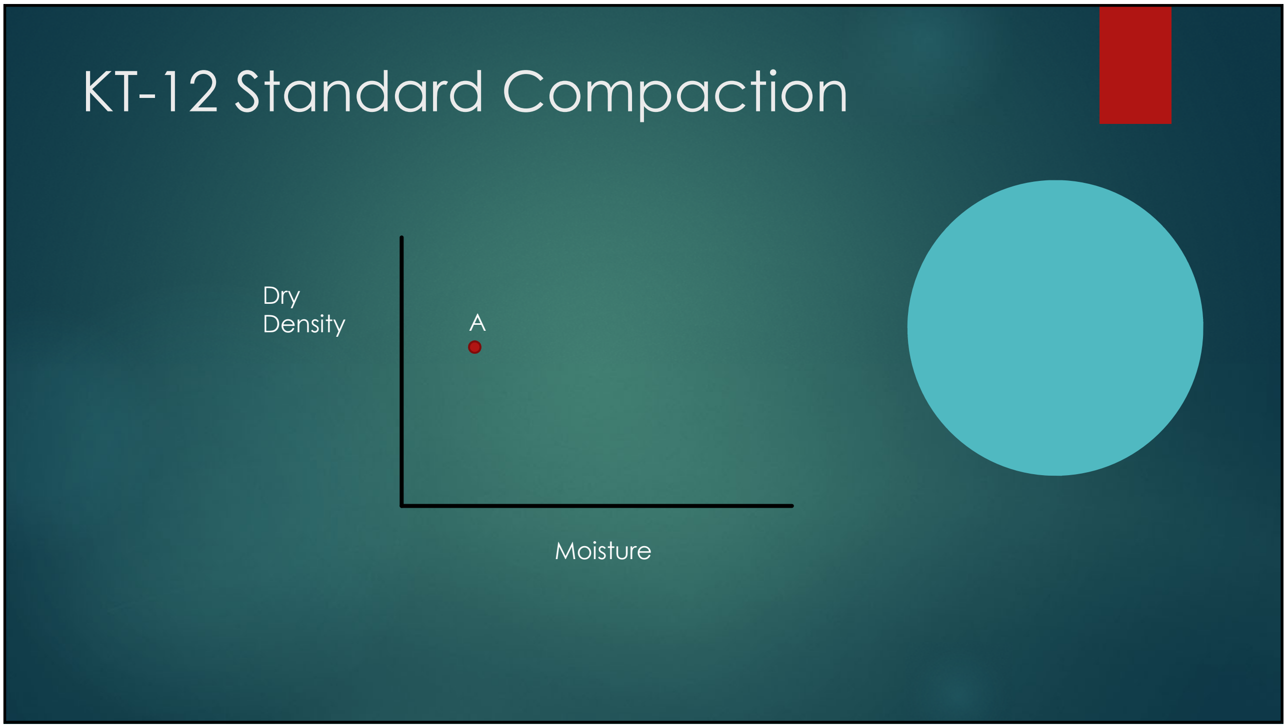

ENGINEERING CO.

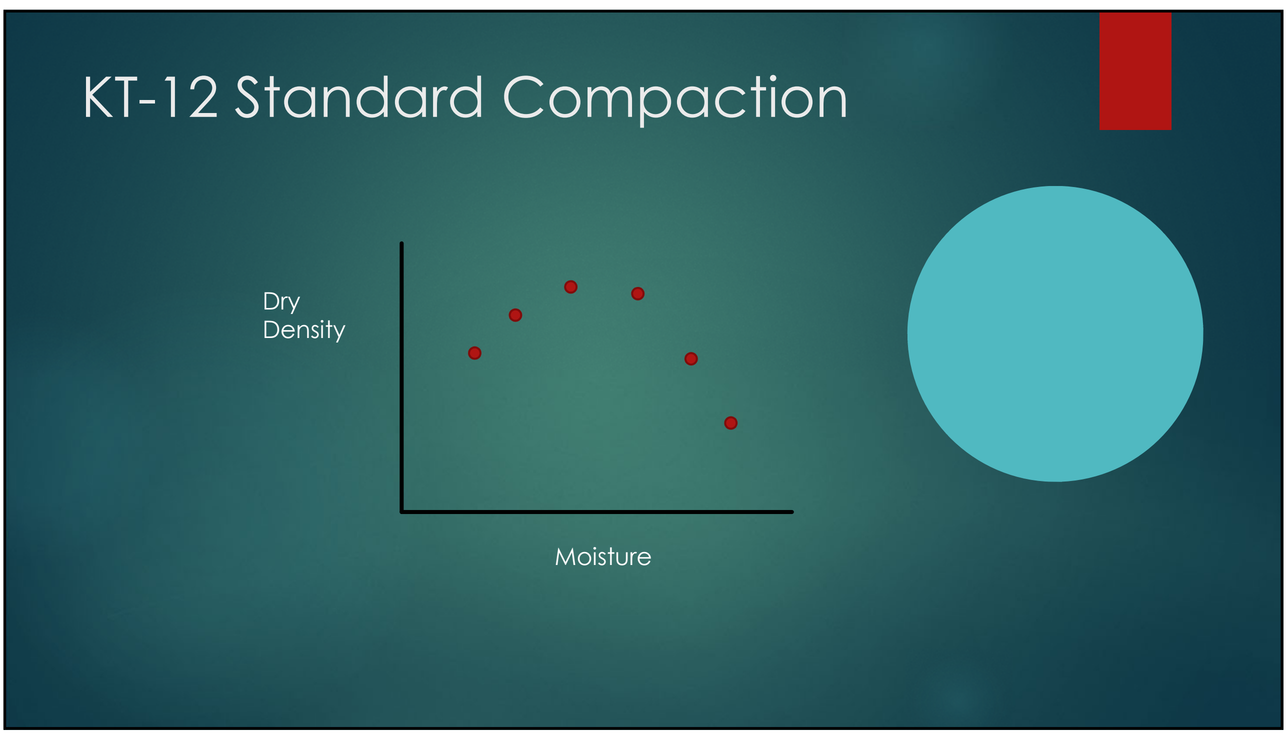

GILSON



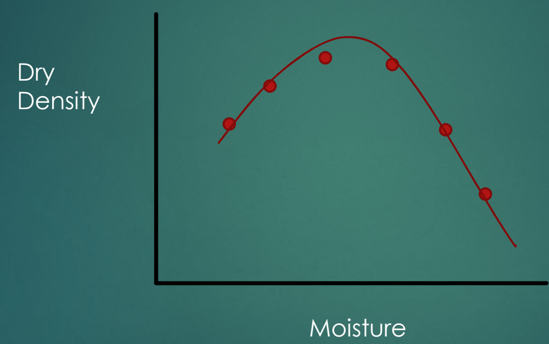
PERFORM KT-11 MOISTURE TEST CONSTANT MASS

KT-12 Standard Compaction

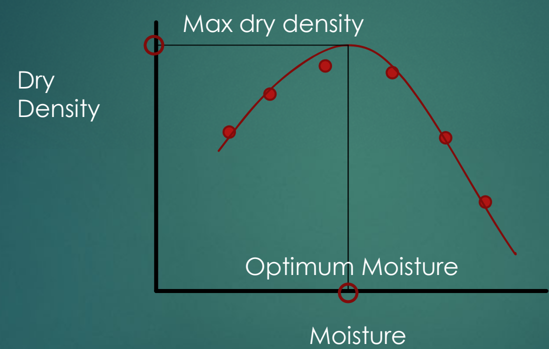

KT-12 Standard Compaction
Dry
Density
A
Moisture

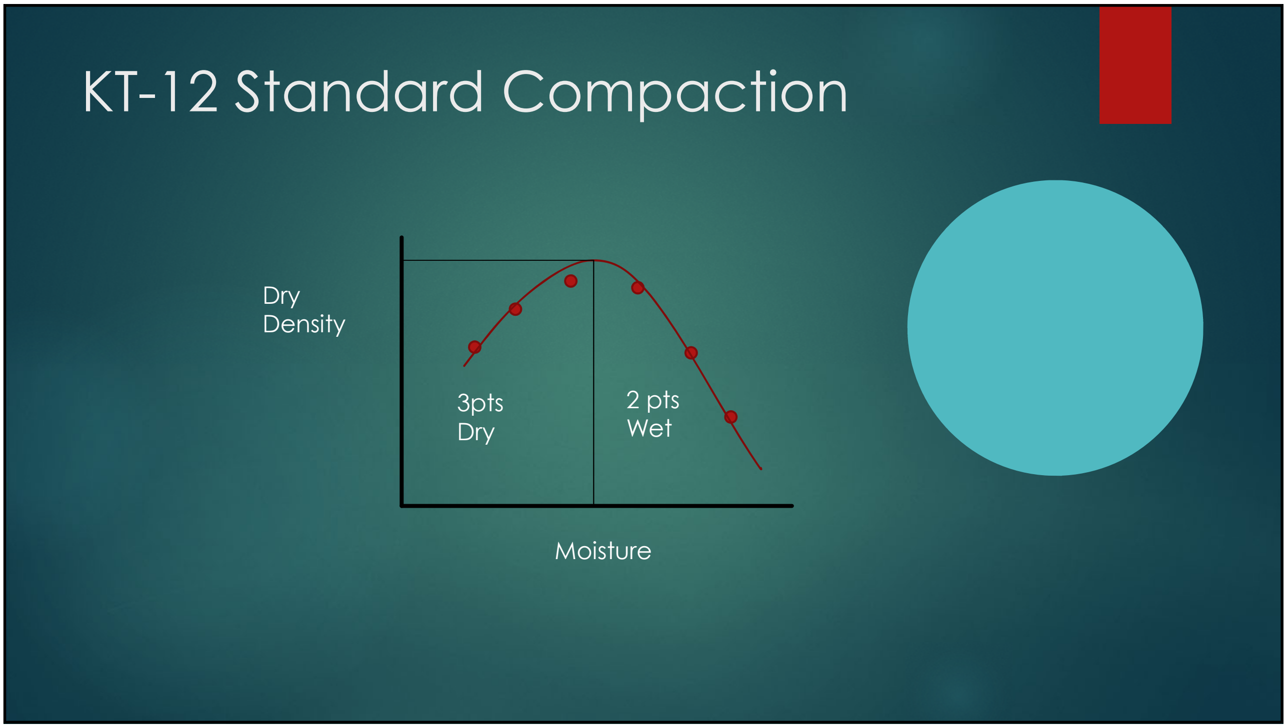

KT-12 Standard Compaction
Dry
Density
Moisture

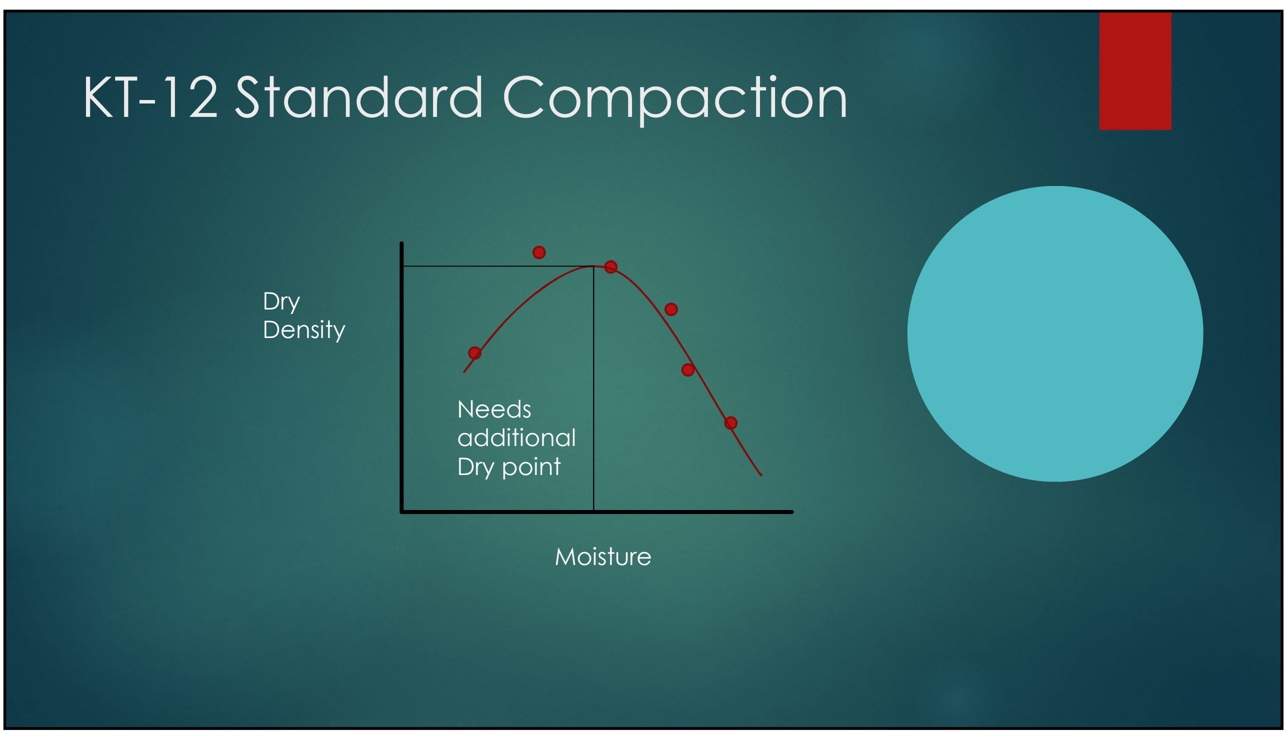
KT-12 Standard Compaction



KT-12 Standard Compaction




KT-12 Standard Compaction
Dry
Density
3pts
Dry
2 pts
Wet
Moisture


KT-12 Standard Compaction
Dry
Density
Needs
additional
Dry point
Moisture

5.9.12 STANDARD COMPACTION TEST (Kansas Test Method KT-12)

1. SCOPE

1.1. Fine Grained Materials (**Section 4.**): This method of test is used to determine the relation between the moisture content and density of soils or other fine grained materials when subjected, at various moisture contents, to a standard compactive effort while confined in a rigid metal mold. **KT-12** reflects testing procedures found in **AASHTO T 99**.

The procedure for compaction of "fine grained materials" shall be followed whenever:

(1) The material has less than 10% retained on the No. 4 (4.74 mm) sieve, or

(2) The material has more than 10 % but less than 30% retained on the No. 4 (4.75 mm) sieve and the fraction passing the No. 40 (425 µm) sieve has a plastic index greater than 8.

1.2. Granular Materials (**Section 5.**): This method of test is used to determine the relation between the moisture content and density of granular materials, when subjected, at various moisture contents, to a standard compactive effort while confined in a rigid mold. **KT-12** reflects testing procedures found in **AASHTO T 99**.

Granular materials are classified as materials passing the 3/4 in (19.0 mm) sieve.

2. REFERENCED DOCUMENTS

2.1. Part V, 5.9; Sampling and Test Methods Foreword

2.2 KT-11; Moisture Tests

2.3. AASHTO T 19; Bulk Density ("Unit Weight") and Voids in Aggregate

2.4. AASHTO T 99; Moisture-Density Relations of Soils Using a 5.5 lb (2.5 kg) Rammer and a 12 in (305 mm) Drop

2.5. AASHTO T 265; Laboratory Determination of Moisture Content of Soils

2.6. ASTM D2168; Test Methods for Calibration of Laboratory Mechanical-Rammer Soil Compactors

3. APPARATUS

3.1. Fine Grained Material:

3.1.1. The mold shall be solid wall, metal cylinders 4 in (101.6 mm) with a capacity of 0.0333 ± 0.0005 ft^3 (0.000943 ± 0.000014 m^3) and an internal diameter of 4.000 ± 0.016 in (101.60 ± 0.40 mm) and a height of 4.584 ± 0.018 in (116.40 ± 0.50 mm). It shall have a detachable collar assembly approximately 2.375 in (60 mm) in height. The mold and collar assembly shall be constructed so that it can be fastened firmly to a detachable base plate made of the same material. The base plate shall be plane to 0.005 in.

3.1.1.1. A mold that fails to meet manufacturing tolerances after continued service may remain in use provided those tolerances are not exceeded by more than 50%; and the volume of the mold calibrated in accordance with **AASHTO T 19, Section 8,** for Unit Mass of Aggregate, is used in the calculations.

3.1.1.2. Any correction to the volume requires a new calculated multiplier (*F*). The multiplier is an inverse function of the mold volume.

NOTE: The volume of the mold (without the collar) is measured by coating one end with cup grease or Vaseline to form a seal and then placing it on a glass plate which should be placed in a level position on a scale. The other end of the mold is coated with cup grease or Vaseline and then the mold and two glass plates are weighed. The mold may then be filled with 77 ± 2°F (25 ± 1° C)[1] water after which the second glass plate should be placed on top of the mold in such a way as to eliminate air bubbles and excess water. Any excess water thus removed must be carefully wiped off after which the final weight of the mold, water and glass plates may be determined. The volume of the mold may then be calculated using 62.243 lb/ft^3 (997 kg/m^3) as the density of water.

3.1.2. Rammer

3.1.2.1. Manually operated. A metal rammer with a mass of 5.5 ± 0.02 lb (2.495 ± 0.009 kg) and having a flat circular face of 2.000 in (50.80 mm) diameter with a tolerance of ± 0.01 in (0.25 mm). The in-service diameter of the flat circular face shall be not less than 1.985 in (50.42 mm). The rammer shall be equipped with a suitable guide-sleeve to control the height of drop to a free fall of 12.00 ± 0.06 in (305 ± 2 mm) above the elevation of the soil. The guide-sleeve shall have at least 4 vent holes, no smaller than 3/8 in (9.5. mm) diameter spaced at 90 degrees (1.57 rad) apart and 3/4 in (19 mm) from each end; and shall provide sufficient clearance so the free fall of the rammer shaft and head is unrestricted.

3.1.2.2. Mechanically operated. A mechanically operated metal rammer is equipped to control the height of drop to 12 ± 0.06 in (305 ± 2.0 mm) above the elevation of the soil and to distribute the blows over the soil surface. The rammer has a 2 in (50.8 mm) diameter, flat circular face and has a mass of 5.5 ± 0.02 lb (2.495 ± 0.009 kg).

NOTE: The mechanically operated rammer must be calibrated as directed by **ASTM D 2168, Method A.**

3.1.3. Sample extruder (desirable) should consist of, a frame, jack and circular metal loading plate or other suitable device for removing specimens from the mold.

3.1.4. The balance shall conform to the requirements of **Part V, 5.9; Sampling and Test Methods Foreword**, for the class of general purpose balance required for the principal sample mass of the sample being tested.

3.1.5. A thermostatically controlled drying oven capable of maintaining a temperature of 230 ± 9°F (110 ± 5°C) for drying moisture samples.

3.1.6. A hardened-steel straightedge at least 10 in (250 mm) in length. It shall have one beveled edge, and at least one longitudinal surface shall be plane within 0.01 in per 10 in (0.250 mm per 250 mm) (0.1%) of length within the portion used for trimming the soil.

3.1.7. No. 4 (4.75 mm) sieve.

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[1] **AASHTO T 99** references **AASHTO T 19** to calibrate the mold. **AASHTO T 19** permits the use of varying temperatures 77 ± 2°F (25 ± 1°C) with correction factors to compensate for the water density. By using the fixed temperature requirement, KDOT uses a single value (62.243 lb/ft^3 [997 kg/m^3]) for the density of water during the calibration of such apparatuses.

3.1.8. Drying pans.

3.1.9. Trowels, spatulas and other mixing tools or a mechanical mixer that will thoroughly mix the material and water.

3.2. Granular Material:

3.2.1. The mold shall be solid wall, metal cylinders 6 in (152.4 mm) with a capacity of 0.07500 ± 0.0009 ft^3 (0.002124 ± 0.000025 m^3) and an internal diameter of 6.000 ± 0.026 in (152.40 ± 0.70 mm) and a height of 4.584 ± 0.018 in (116.40 ± 0.50 mm). It shall have a detachable collar assembly approximately 2.375 in (60 mm) in height. The mold and collar assembly shall be constructed so that it can be fastened firmly to a detachable base plate made of the same material. The base plate shall be plane to 0.005 in.

3.2.1.1. A mold that fails to meet manufacturing tolerances after continued service may remain in use provided those tolerances are not exceeded by more than 50%; and the volume of the mold calibrated in accordance with **AASHTO T 19, Section 7,** for Unit Mass of Aggregate, is used in the calculations.

3.2.2. A hardened-steel straightedge at least 10 in (250 mm) in length. It shall have one beveled edge, and at least one longitudinal surface shall be plane within 0.01 in per 10 in (0.250 mm per 250 mm) (0.1%) of length within the portion used for trimming the soil.

3.2.3. Other apparatus as listed under **Section 3.1** of this test method.

NOTE: When a mechanical compactor is used, the 2 in (50.8 mm) diameter circular face foot may be replaced with a rigid "pie-shaped" foot. The "pie-shaped" foot shall be a sector of a 6 in (152.4 mm) diameter circle and shall have an area equal to that of the circular face foot.

4. FINE GRAINED MATERIALS

4.1. Sample Preparation.

4.1.1. Obtain a 60 to 80 lbs (30 to 35 kg) sample, dry at 140°F (60°C) if necessary and break it down to pass the No. 4 (4.75 mm) sieve. Discard granular particles retained on the sieve.

4.1.2. Mix thoroughly and weigh out six portions, each weighing 5 lbs (2200 g).

4.2. Test Procedure.

4.2.1. Add a measured amount of water (approximately 12% by dry mass) to one 5 lb (2200 g) portion and thoroughly mix it into the sample.

4.2.2. The sample of soil-water mixture shall be placed in a closed container to minimize moisture loss. The sample shall then be allowed to stand for a minimum of 12 hours before compacting.

NOTE: When testing a mixture containing cementitious material such as cement or fly ash, skip section **4.2.2** to minimize the effects of hydration on the sample.

4.2.3. Obtain the mass of the mold to the nearest 0.0001 lb (0.0001 kg). It is suggested that the mold and collar be lightly coated with a light lubricant.

4.2.4. Place the assembled mold on the rigid base and fill the mold so that the compacted layer will equal 1/3 of the mold volume.

4.2.5. Compact the material with 25 blows of the rammer dropped from a height of 12 in (304.8 mm) above the surface of the material. Distribute the blows of the rammer evenly over the surface.

4.2.6. Place two more layers of the material in the mold and compact each layer as stipulated in **Section 4.2.3** above.

4.2.7. Remove the top collar and trim the excess material level with the top of the mold.

4.2.8. Remove the base and trim excess material level with the bottom of the mold.

4.2.9. Weigh the sample to the nearest 5 g while it is in the mold and multiply the mass of the sample and the mold, minus the mass of the mold, by 30 (1060), and record the result as the wet density, D_w, in pounds per cubic foot, (kilograms per cubic meter), of the compacted soil.

4.2.10. Repeat the compaction procedure using the other 5 lb (2200 g) increments of the sample to which different measured amounts of water have been added, thoroughly mixed and cured as in the note following **Section 4.2.1** of this test method. This procedure will be continued with varying moisture contents until at least three points are obtained on the dry side of "optimum moisture" and at least two points are obtained on the wet side of "optimum moisture." This can usually be accomplished by compacting different specimens at moisture intervals of 2 to 3%, starting on the dry side of "optimum moisture" and ending on the wet side.

4.2.11. Remove the material from the mold and slice vertically through the center. Take a representative sample, weighing a minimum of 100 g of the material from one of the cut faces, determine the mass immediately and dry in accordance with **KT-11**, to determine the moisture content.

4.3. Calculations:

The calculations used are given in **Section 6.** of this test method.

4.4. Compaction Curve

4.4.1 Plot a density/moisture curve on coordinate paper (**KDOT Form No. 638**) to determine the maximum density and optimum moisture. The dry density values are plotted as ordinates, the corresponding moisture contents are plotted as abscissa and a smooth curve is drawn to best fit the points.

NOTE: In drawing a curve by this method, all of the points will not necessarily be on the curve and the maximum density may be more or less than the highest test point. (See example at the end of this test method.)

The optimum moisture content is the moisture content at which the maximum density occurs on the curve.

5. GRANULAR MATERIALS

5.1. Sample Preparation.

5.1.1. Obtain approximately 100 lbs (45 kg) of the material to be tested, dry to maximum of 140°F if necessary and pulverize in such a manner as to avoid reducing the natural size of individual particles.

5.1.1.1. Sieve an adequate quantity of the pulverized soil over the 3/4 in (19.0 mm) sieve. Discard the coarse material, if any, retained on the 3/4 in (19.0 mm) sieve.

5.1.2. Thoroughly mix and weigh out six portions, each weighing 16 lbs (7 kg).

5.2. Test Procedure.

5.2.1. Add a measured amount (approximately 5%) of water and thoroughly mix one 16 lbs (7 kg) portion. After the addition of water and thorough mixing, the sample shall be placed in a covered container and allowed to stand for a minimum of 2 hours before conducting the moisture-density test.

5.2.2. Place the assembled mold on the rigid base and fill in three approximately equal layers. Compact each layer with 56 blows of the rammer with the blows being distributed uniformly over the surface of the layer.

5.2.3. After the third layer has been compacted, remove the collar and trim excess material level with the top of the mold.

5.2.4. Remove the base and trim excess material level with the bottom of the mold.

5.2.5. Weigh the sample while it is in the mold and multiply the mass of the sample and the mold, minus the mass of the mold, by 13.33 (471), and record the result as the wet density, D_w, in lb/ft^3 (kg/m^3), of the compacted soil.

5.2.6. Repeat the compaction procedure using the other 16 lbs (7 kg) increments of the sample to which different measured amounts of water have been added, thoroughly mixed and cured as in the note following **Section 5.2.1** of this test method. This procedure will be continued with varying moisture contents until at least three points are obtained on the dry side of “optimum moisture” and at least two points are obtained on the wet side of “optimum moisture.” This can usually be accomplished by compacting different specimens at moisture intervals of 2 to 3%, starting on the dry side of “optimum moisture” and ending on the wet side.

5.2.7. Remove the material from the mold and slice vertically through the center. Take a representative sample, weighing a minimum of 300 g of the material from one of the cut faces, determine the mass immediately and dry in accordance with **KT-11**, to determine the moisture content.

5.3. Calculations.

The calculations used are given in **Section 6**. of this test method.

5.4. Plot a density/moisture curve on coordinate paper (**KDOT Form No. 638**) to determine the maximum density and optimum moisture. The dry density values are plotted as ordinates, the corresponding moisture contents are plotted as abscissa and a smooth curve is drawn to best fit the points.

NOTE: In drawing a curve by this method, all of the points will not necessarily be on the curve and the maximum density may be more or less than the highest test point. (See example at the end of this test method.)

The optimum moisture content is the moisture content at which the maximum density occurs on the curve.

The data for this test may be recorded on the "Work Sheet for Standard Compaction Tests" (**KDOT Form No, 676**) which is in bound book form.

6. CALCULATIONS

$$W=\frac{A - B}{B - C}\times 100$$

And

$$D=\frac{D_w}{W + 100}\times 100$$

Where:
- W= percentage of moisture in the specimen, based on oven dry mass of soil
- A= mass of container and wet soil
- B= mass of container and dry soil
- C= mass of container
- D= dry density, in lb/ft^3 (kg$^/$m^3) of compacted soil
- D_w= wet density, in lb/ft^3 (kg$^/$m^3) of compacted soil

Where:

$$D_W = (A - C)F$$

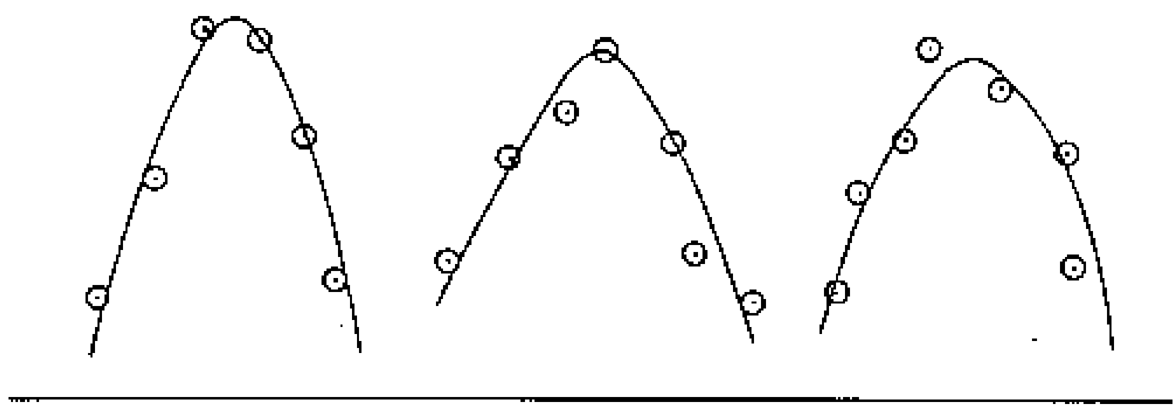
F = 30 for the 4 in mold and 13.33 for the 6 in mold (see **Section 5.2.5.)** (1060 for 101.6 mm mold and 471 for 152.4 mm mold)

7. RECORD AND REPORT

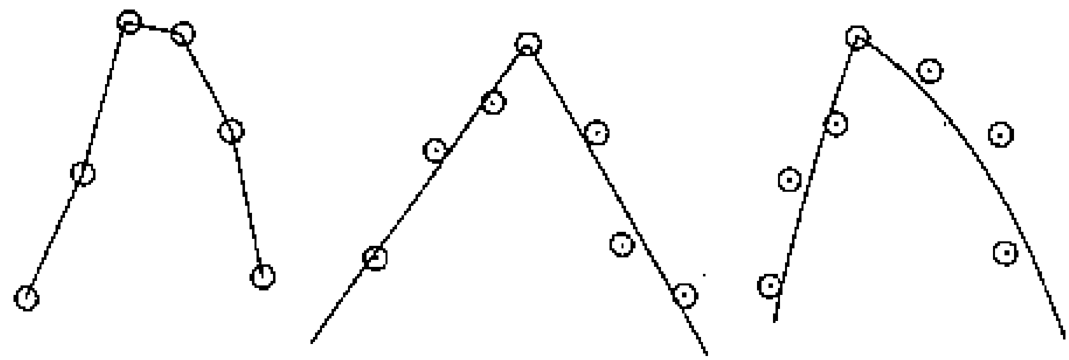
7.1. Record the density to the nearest 0.1 lb/ft^3 (1 kg$^/$m^3). Report the density to the nearest whole number. Record the moisture to the nearest 0.1%. Report the moisture to the nearest whole number.

COMPACTION CURVE EXAMPLES

CORRECT



INCORRECT



5.9.13 FIELD DENSITY TESTS OF SOILS, TREATED BASE COURSES AND WATER BOUND BASE COURSES (Kansas Test Method KT-13)

1. **SCOPE**

This method of test covers the procedure for measuring the "in-place" density of soils and granular base courses. The density of a material is defined as the ratio of the mass of material to the volume of the same mass of material. The tests described consist of measuring the volume that a given mass of soil or base material occupies when it is in-place. **KT-13** reflects testing procedures found in **AASHTO T 191.**

2. REFERENCED DOCUMENTS

2.1. Part V, 5.9; Sampling and Test Methods Foreword

2.2 KT-11; Moisture Tests

2.3. KT-15; Bulk Specific Gravity and Unit Weight of Compacted Hot Mix Asphalt Mixtures (HMA)

2.4. KT-43; Moisture Content of Asphalt Mixtures or Mineral Aggregates - Microwave Oven Method

2.5. AASHTO T 99 Test for Moisture-Density Relations of Soils

2.6. AASHTO T 180; Moisture-Density Relations of Soils Using a 10 lb (4.54 kg) Rammer and an 18" (457 mm) Drop

2.7. AASHTO T 191; Density of Soil In-Place by the Sand-Cone Method

3. APPARATUS

3.1. General for all tests.

3.1.1. The balance shall conform to the requirements of **Part V, 5.9; Sampling and Test Methods Foreword**, for the class of general purpose balance required for the principal sample mass of the sample being tested.

3.1.2. Oven capable of maintaining a uniform temperature of approximately 230°F (110°C) or a hot plate with a buffer consisting of a pan of sand or thick steel plate placed between the drying pan and the flame. If available, a microwave oven as described in **KT-43** may be used.

3.1.3. Equipment or shelter to protect balance from wind currents and the samples from exposure to the sun and wind.

3.1.4. Soil auger.

3.1.5. Speedy Moisture equipment as described in **KT-11**.

3.1.6. Miscellaneous equipment including standard drying pans, trowel, large spoon, hammer, chisels, heavy bladed knife, square point shovel and 12 in (300 mm) straight edge.

3.2. Sand Density Apparatus.

3.2.1. A cylindrical container of known volume usually between 0.05 and 0.10 ft^3.

3.2.2. A pouring container with a volume larger than the volume of the test hole. A one pound coffee can with the rim bent into a "V" shape have previously been used as a pouring container, for shallow holes.

3.2.3. Any clean, dry, free-flowing, uncemented sand having few, if any, particles passing the No. 200 (75 µm) or retained on the No. 10 (2.00 mm) sieves. In selecting sand for use, several bulk density determinations should be made using the same representative sample for each determination. To be acceptable the sand shall not have a variation in bulk density greater than 1%.

3.3. Sand Cone Apparatus.

3.3.1. The density apparatus shall consist of a 1 gal (4 L) jar and a detachable appliance consisting of a cylindrical valve with an orifice 1/2 in (12.7 mm) in diameter and having a small funnel continuing to standard G mason jar on one end and a large funnel on the other end. The valve shall have stops to prevent rotating the valve past the completely closed positions. (See **Figure 1** and **Figure 2**)

NOTE: The apparatus[1] describe here represents a design that has proven satisfactory. Other apparatus of similar proportions will perform equally well so long as the basic principles of the sand-volume determination are observed. This apparatus, when full, can be used with test holes having a volume of approximately 0.1 ft^3 (2.7 L). The base plate is optional; its use may make leveling more difficult but permits test holes of larger diameter and may reduce loss in transferring soil from test-hole to container as well as afford a more constant base for tests in soft soils. When the base plate is used it shall be considered a part of the funnel in the procedures of this test method.

3.3.2. Any clean, dry, free-flowing, uncemented sand having few, if any, particles passing the No. 200 (75 µm) or retained on the No. 10 (2.00 mm) sieves. In selecting sand for use, several bulk density determinations should be made using the same representative sample for each determination. To be acceptable the sand shall not have a variation in bulk density greater than 1%.

3.4. Alternate Test Method Apparatus.

3.4.1. Small pipe about 3/4 in diameter.

3.4.2. 1/10 ft^3 bucket.

3.4.3. Funnel fitting small pipe in **Section 3.4.1.**

4. TEST PROCEDURE

4.1. Sand Density Method[2].

4.1.1. Determine the loose unit weight of sand in lb/ft^3 (kg/m^3) as follows:

[1] See **AASHTO T 191 Figure 1** for size requirements.
[2] Sand Density Method is **KDOT** method only. **AASHTO** has no similar method.

4.1.1.1. Fill the cylinder of known volume and mass to slightly overflowing by pouring the dry sand at a uniform rate from the spout of the pouring container. The spout is held approximately 2 in (50 mm) above the top of the container.

4.1.1.2. Strike off the excess sand level with top of the container, being extremely careful to avoid jarring the container during the process. Weigh the cylinder and sand. Conduct a total of three tests to determine the loose unit weight of the sand and use the average value obtained when computing the "in-place" density of the material being tested.

4.1.2. Select the area where density is to be measured, determine and record the station, distance from center line, and elevation as distance below the final grade.

4.1.3. Trim off all raised or uneven spots to produce a smooth, flat surface not less than 18 in (450 mm) square, using a square point shovel or other suitable tool, and remove all loose material from the area.

4.1.4. Drill or cut a test hole through the depth of the material being tested and save all material removed, protecting the sample from weather conditions which might change the moisture content.

4.1.5. Weigh the material, record the mass, and dry the entire sample or a representative portion to constant mass. Weigh and record the dry mass.

NOTE: If the "Speedy" moisture tester is used to determine the moisture content, the procedure set forth in **KT-11** is followed. The dry mass of material is calculated as shown in **Section 5.1.5** of this test method.

4.1.6. Determine and record the mass of the pouring container with a volume of sand somewhat greater than the volume of the test hole.

4.1.7. Fill the hole level full of sand by pouring the sand at a uniform rate while holding the spout 2 in (50 mm) above the top of the test hole, as was done when calibrating the sand. The straight edge should be used to ensure that the sand is level with the surface of the material surrounding the test hole.

4.1.8. Weigh the pouring container and remaining sand and record the mass.

4.2. Alternate Sand Density Method for Test Holes Exceeding Two Feet in Depth.

4.2.1. Using a funnel, deposit the sand through a small pipe (about 3/4 of an inch in diameter).

4.2.2. Let the pipe rest on the bottom of the hole and pour the sand into the pipe until it is full, then raise the pipe about 8". Continue to pour sand until the pipe is again full, and again raise the pipe the same distance, being careful not to let the pipe settle in the sand. The number of sections of pipe used does not affect the accuracy of the results, and each section may be removed as necessary. Care must be taken to prevent the pipe from settling in the sand during this process.

4.2.3. Use fine sand as described in **Section 3.2.** of this test method.

4.2.4. The sand must be calibrated by the same method as it is deposited, that is, by setting a short section of pipe in the bottom of the 1/10 ft^3 bucket and pouring sand into the pipe until it is full. Raise it 8" and continue to pour sand, keeping the pipe full, until the bucket is filled with sand.

5. CALCULATIONS

5.1. Density of dry sand (D_S):

$$D_S=\frac{M_{SC}}{V_C}$$

Where: M_{SC}= Mass of sand in container lb (kg)
V_C= Volume of container ft^3 (m^3)

NOTE: 1 **m^3 = 1000 L** **1 L = 1000 mL** **1000 kg = 1 m^3 Water**

5.1.1. Percent moisture content of material (W):

$$W=\frac{100\ (M_W-M_D)}{M_D}$$

Where: M_W= Wet Mass of material removed from test hole
M_D= Dry Mass of material removed from test hole

5.1.2. Mass of sand in test hole lb (kg) (M_{SH}):

$$M_{SH}=(M_I-M_F)$$

Where: M_I= Initial Mass of sand plus pouring container
M_F= Final Mass of sand plus pouring container

5.1.3. Volume of test hole (V) ft^3 (m^3):

$$V=\frac{M_{SH}}{D_S}$$

Where: M_{SH} = Mass of sand in test hole lb (kg)
D_S= Density of sand lb/ft^3 (kg/m^3)

5.1.4. In-place dry density of material being tested (D) lb/ft^3 (kg/m^3):

$$D=\frac{M_D}{V}$$

Where: M_D= Dry mass of material removed from test hole
V= Volume of test hole

5.1.5. Mass of dry material removed from the test hole (when "Speedy" moisture tester or a portion of the sample is used to determine moisture content) (M_D):

$$M_D=\frac{100\ (M_W)}{(W+100)}$$

Where: M_W= Mass of wet material removed from test hole, lb (kg)
W= Percent moisture of wet material removed from test hole

6. SAND CONE METHOD

6.1. Determination of volume of jar and attachment up to and including the volume of the valve orifice as follows:

NOTE: The volume in this procedure is constant as long as the jar and attachment are in the same relative position. If the two are to be separated, match marks should be made to permit reassembly to this position.

6.1.1. Weigh the assembled apparatus and record.

6.1.2. Place the apparatus upright and open the valve.

6.1.3. Fill the apparatus with water until it appears over the valve.

6.1.4. Close the valve and remove excess water.

6.1.5. Weigh the apparatus and water.

6.1.6. Repeat the procedure described in **Section 6.1.2 to 6.1.3** of this test method, at least twice. Convert the mass of water, in grams, to milliliters. The volume used shall be the average of three determinations with a maximum variation of 3 mL.

6.1.7. Calculate the volume of the density apparatus as follows:

English:

$$V_1 = \frac{G}{62.4 \text{ lb/ft}^3}$$

Metric:

$$V_1 = \frac{G}{1000 \text{ kg/m}^3}$$

Where: V_1= volume of the density apparatus, ft^3 (m^3)
G= mass of water required to fill apparatus lbs (kg)

Calculate the volume of the density apparatus to the nearest 0.001 ft^3 (0.00003 m^3).

6.2. Determination of Bulk Density of Sand.

NOTE: Vibration of the sand during any mass-volume determination may increase the bulk density of sand and decrease the accuracy of the determination. Appreciable time intervals between the bulk density determinations of the sand and its use in the field may result in change in the bulk density caused by a change in the moisture content or effective gradation.

NOTE: It is possible to determine the bulk density of the sand in other containers of known volume that dimensionally approximate the largest test hole that will be dug. The general procedure used is that given in **Section 4.1.1** of this test method, for determining the density of dry sand. If this procedure is to be followed it shall be determined that the resulting bulk density equals that given by the jar determination.

6.2.1. Place the empty apparatus upright on a firm, level surface; close the valve and fill the funnel with sand.

6.2.2. Open the valve and keeping the funnel at least half full of sand, fill the apparatus. Close the valve sharply and empty excess sand.

6.2.3. Weigh the apparatus and sand. Determine the net mass of sand by subtracting the mass of the apparatus.

6.2.4. Calculate the bulk density of the sand as follows:

$$D_S = \frac{M_{SA}}{V_1}$$

Where: D_S= Bulk density of the sand, lb/ft^3 (kg/m^3)
M_{SA}= Mass of sand required to fill apparatus lb (kg) and
V_1= Volume of apparatus in ft^3 (m^3)

Calculate the bulk density of the sand to the nearest 0.1 lb/ft^3 (1 kg/m^3).

6.3. Determination of mass of sand filling the funnel.

NOTE: This determination may be omitted if the procedure given in **NOTE** in **Section 6.2** regarding bulk densities is followed. When the base plate is used, it shall be considered a part of the funnel.

NOTE: Where test holes of maximum volume are desired it is possible, after the bulk density determination, to settle the sand by vibration and increase the mass of sand available shall be determined by re-weighing.

6.3.1. Put sand in the apparatus and obtain the mass of the apparatus and sand.

6.3.2. Seat the inverted apparatus on a clean, level, plane surface.

6.3.3. Open the valve and keep open until the sand stops running.

6.3.4. Close the valve sharply. Weigh the apparatus with remaining sand and determine the loss of the sand. This loss represents the mass of sand required to fill the funnel.

NOTE: For each container/bag of sand there will be a unique cone correction and sand calibration factor. Each sand-cone and matched base plate will also have a set of unique cone corrections and bulk sand densities. If more than one sand-cone apparatus is available, the sand-cone and base plate should be marked and the associated correction/density factors recorded.

6.3.5. Replace the sand removed in the funnel determination and close the valve.

6.4. Determination of Density of Soil In-Place.

6.4.1. Prepare the surface of the location to be tested so that it is a level plane.

6.4.2. Seat the inverted apparatus on the prepared plane surface and mark the outline of the funnel. Drill or cut a test hole. Carefully save all material.

NOTE: In soils such that leveling is not successful, a preliminary test shall be run at this point measuring the volume bounded by the funnel and ground surface. This step requires balances at the test site or emptying and refilling the apparatus. After this measurement is complete, carefully brush the sand from the prepared surface.

6.4.3. Seat the apparatus in the previously marked position, open the valve, and after the sand has stopped flowing, close the valve.

6.4.4. Weigh the apparatus and remaining sand. Determine the mass of sand used in the test.

6.4.5. Weigh the material that was removed from the test hole.

6.4.6. Mix the material thoroughly and secure and weigh a representative sample for moisture determination.

6.4.7. Determine the moisture content in accordance with **KT-11**.

6.4.8. The minimum test hole volumes suggested in determining the in-place density of soil mixtures are given in **Table 1.** This table shows the suggested minimum mass of the moisture content sample in relation to the maximum particle size in soil mixtures.

Table 1
Minimum Field Test Hole Volumes and Minimum Moisture Content Sample Sizes Based on Maximum Size of Particle

Maximum Particle Size		Minimum Test Hole Volume		Minimum Moisture Content Sample
Sieve	mm	ft^3	cm^3	g
No. 4	(4.75)	0.025	(700)	100
1/2 in	(12.5)	0.050	(1400)	250
1 in	(25.0)	0.075	(2100)	500
2 in	(50.0)	0.100	(2800)	1000

6.5. Calculations.

6.5.1. Calculate the volume of the hole:

$$V_H = \frac{M_{SH}}{D_S}$$

$$M_{SH} = M_I - M_C - M_F$$

Where:
- D_S= Bulk density of the sand, lb/ft^3 (kg/m^3)
- M_{SH}= Mass of sand required to fill hole lb (kg)
- V_H= Volume of hole in ft^3 (m^3)
- M_C= Mass of the sand in the cone lb (kg)
- M_I= Initial Mass of the apparatus + sand lb (kg)
- M_F= Final mass of the apparatus + sand lb (kg)

Calculate the volume of the hole to the nearest 0.001 ft^3 (0.00003 m^3)

6.5.2. Calculate the wet density of the material removed from the hole:

$$D_w = \frac{M_W}{V_H}$$

Where: D_w= Wet density of the material, lb/ft^3 (kg/m^3)
M_W= Mass of material from the hole, lb (kg)
V_H= Volume of hole in ft^3 (m^3)

Calculate the wet density of the material to the nearest 0.1 lb/ft^3 (1 kg/m^3)

6.5.3. Calculate the in-place dry density of the material tested:

$$D = \frac{D_w}{W + 100} \times 100$$

Where: D_w= Wet density of the material, lb/ft^3 (kg/m^3)
D= Dry density of the material, lb/ft^3 (kg/m^3)
W= Percent moisture as determined per **Section 5.1.1** of this test method.

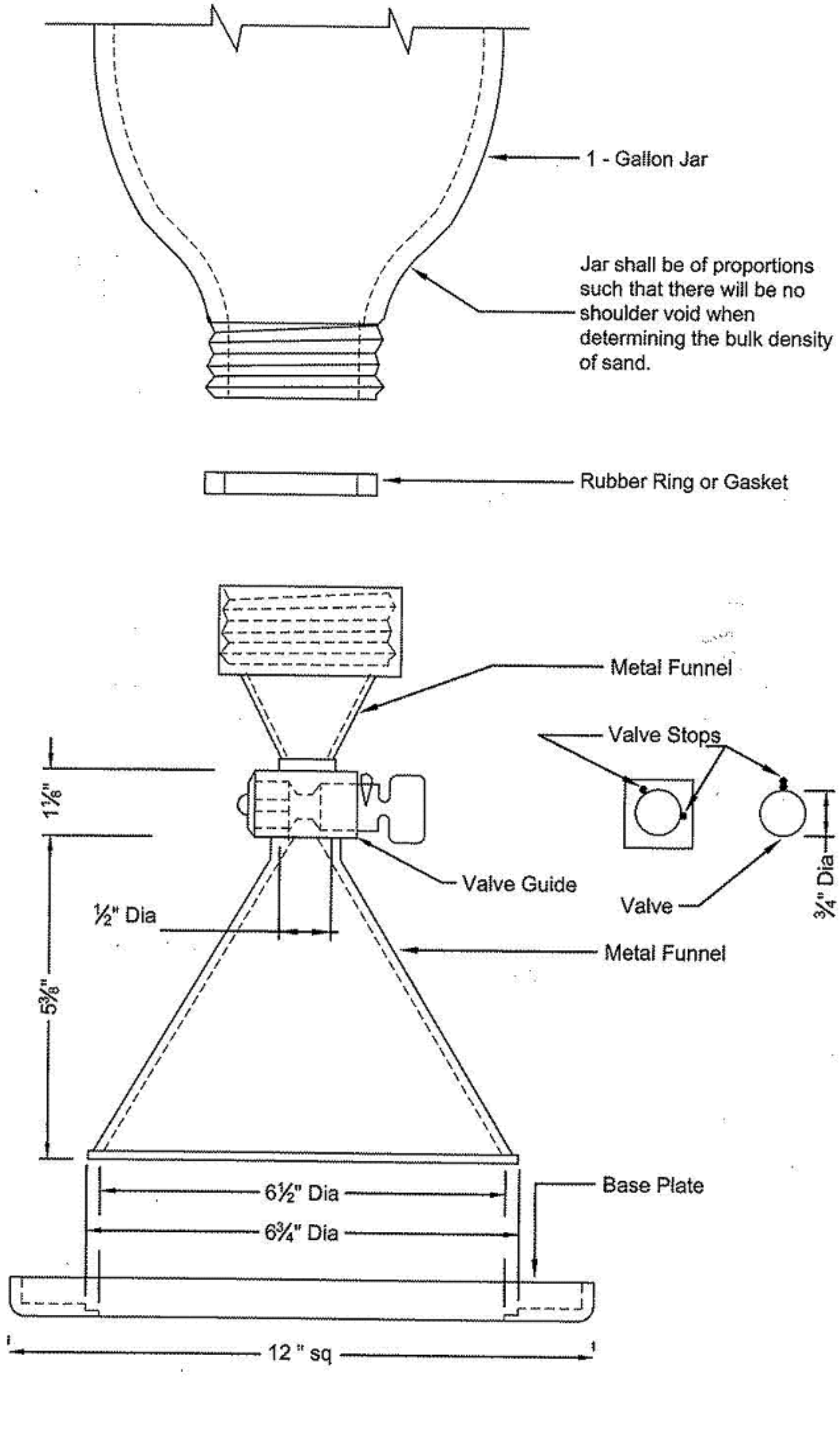
Calculate the in-place dry density of the material tested to the nearest 0.1 lb/ft^3

NOTE: It may be desired to express the in-place density as a percentage of some other density, for example, the laboratory maximum density determined in accordance with **AASHTO T 99**. This relation can be determined by dividing the in-place density by the maximum density and multiplying by 100.

NOTE: 0.001 g/cm^3 = 1 kg/m^3

Figure 1

Figure 2



1 - Gallon Jar
Jar shall be of proportions such that there will be no shoulder void when determining the bulk density of sand.
Rubber Ring or Gasket
Metal Funnel
Valve Stops
1⅛"
Valve Guide
Valve
¾" Dia
½" Dia
Metal Funnel
5⅜"
Base Plate
6½" Dia
6¾" Dia
12 " sq

Soil Field Tester

INSTRUCTOR: ISAAC M FERGUSON

Section 7 - KT-37
Making, Curing, and Testing Cement treated and Unbound Bases

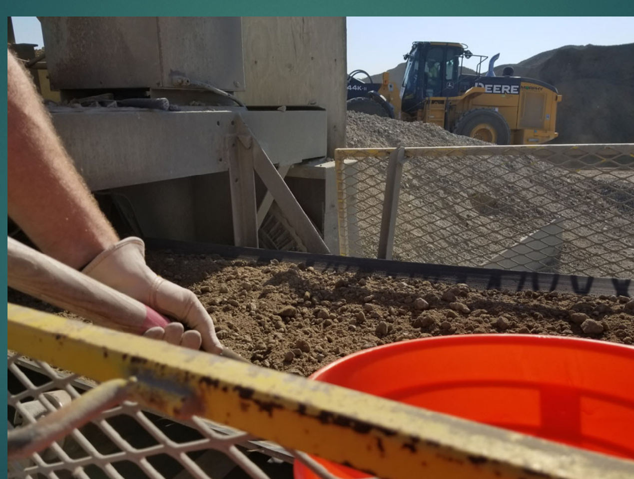
Cement Treated Base Mixture

Aggregate
Before added Cement + Water

Second Stage
Cement is Added to Aggregate

Final Stage
Water is Added to Cement + Aggregate mixture

Collect Aggregate Sample

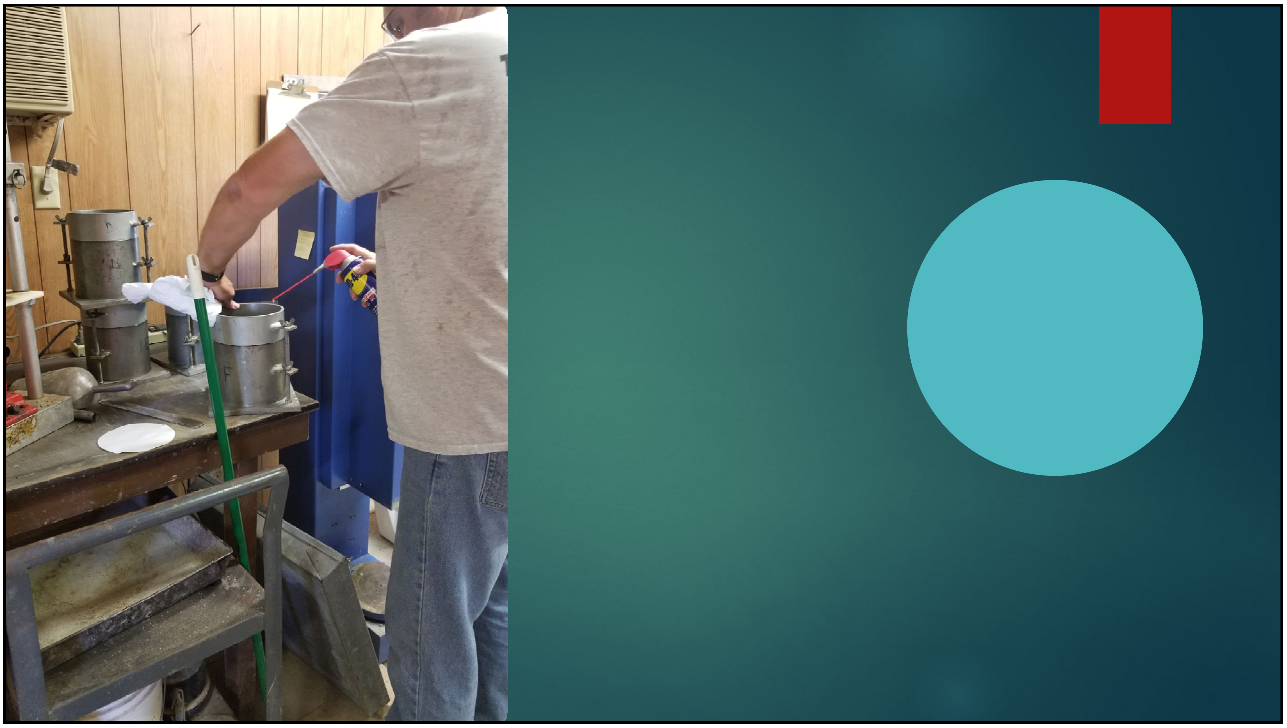


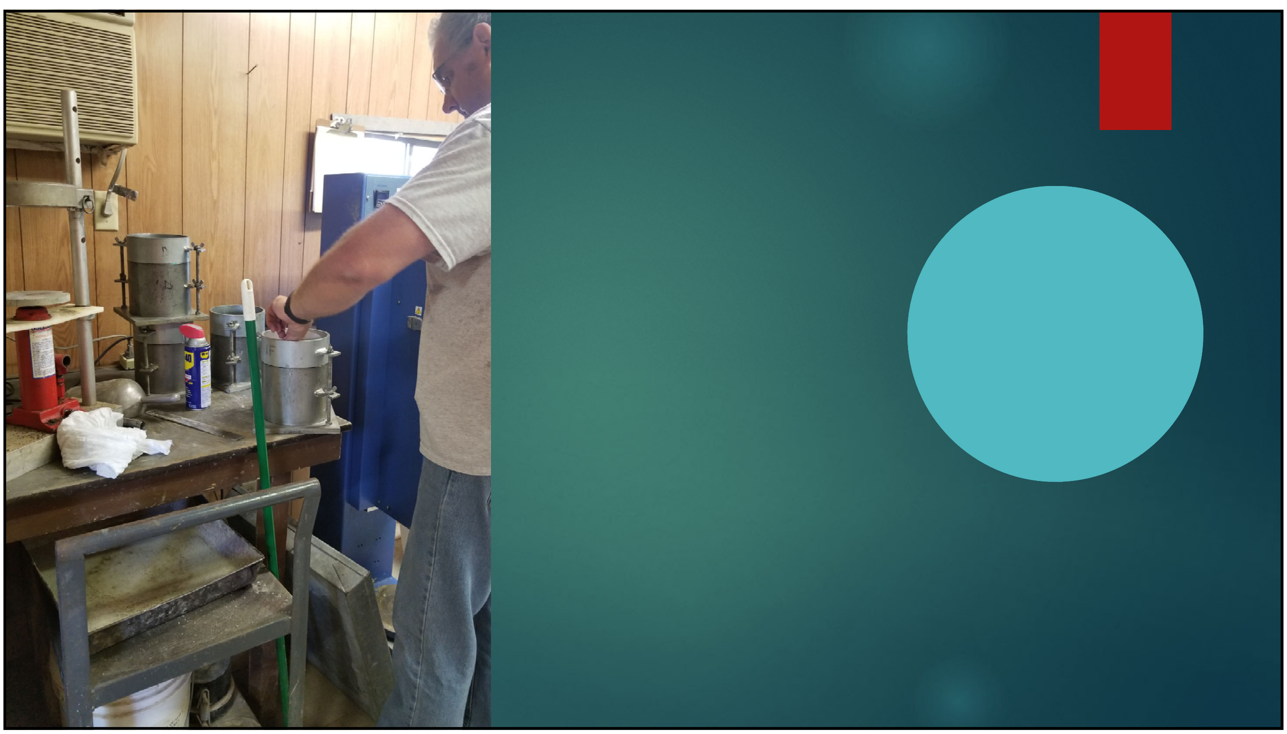
Collect CTB Sample

Collect CTB Sample


DEERE


WD-40





5.9.37 MAKING, CURING AND TESTING CEMENT TREATED AND UNBOUND BASES (Kansas Test Method KT-37)

1. SCOPE

This method covers the procedure for making and curing compression test specimens of Cement Treated and Unbound Base under accurate control of quantities of materials and test conditions. Bound bases are considered the same as Cement Treated Bases.

2. REFERENCED DOCUMENTS

2.1. Part V, 5.9; Sampling and Test Methods Foreword

2.2. KT-11; **Section 2**. Moisture Tests, **Section 4**. Constant Mass Method

2.3. KT-12; Standard Compaction Test

2.4. ASTM E11; Woven Wire Test Sieve Cloth and Test Sieves

2.5. AASHTO T 99; Moisture-Density Relations of Soils Using a 5.5 lb (2.5kg) Rammer and a 12 in (305 mm) Drop

2.6. ASTM C1231; Use of Unbonded Caps in Determination of Compressive Strength of Hardened Cylindrical Concrete Specimens

3. APPARATUS

3.1. A calibrated cylindrical mold, solid or split, of predetermined volume approximately 6 in (150 mm) in diameter and 6 in (150 mm) in height and having a volume of approximately 1/10 ft^3 (2.8 L). The mold is equipped with a removable base plate. Example of acceptable mold assembly is the Humboldt compaction mold, model number H-4163, Durham GEO S-328, or a Durham GEO S-319. Note that a minimum of 3 molds are required for production testing and a minimum of 9 molds are required for mix design.

NOTE: The volume of the mold (without the collar) is measured by coating one end with cup grease or Vaseline to form a seal and then placing it on a glass plate which should be placed in a level position on a scale. The other end of the mold is coated with cup grease or Vaseline and then the mold and two glass plates are weighed. The mold may then be filled with 77 ± 2°F (25 ± 1° C) water after which the second glass plate should be placed on top of the mold in such a way as to eliminate air bubbles and excess water. Any excess water thus removed must be carefully wiped off after which the final weight of the mold, water and glass plates may be determined. The volume of the mold may then be calculated using 62.243 lb/ft^3 (997 kg/m^3) as the density of water.

3.2. Rigid steel straight edge meeting standards set forth in **AASHTO T 99, Section 3.6.**

3.3. A mechanically operated metal rammer equipped to control the height of drop to 12.00 + 0.06 in (305 + 2 mm) above the elevation of the material and to distribute the blows uniformly over the material surface. The rammer has a rigid "pie-shaped" (sector) foot. The foot shall be a sector of a 6 in (150 mm) diameter circle and shall have an area equal to that of a 2 in (50 mm) diameter circle. The nominal mass of the rammer is 5.50 ± 0.02 lb. (2.495 ± 0.009 kg).

3.4. Manually operated. Metal rammer with a mass of 5.5 ± 0.02 lb (2.495 ± 0.009 kg) and having a flat circular face of 2.000 in (50.80 mm) diameter with a tolerance of ± 0.01 in (± 0.25 mm). The in-service diameter of the flat circular face shall be not less than 1.985 in (50.42 mm). The rammer shall be equipped with a suitable guide-sleeve to control the height of drop to a free fall of 12.00 ± 0.06 in (305 ±2 mm) above the elevation of the soil. The guide-sleeve shall have at least 4 vent holes, no smaller than 3/8 in (9.5 mm) diameter spaced at 90 degrees apart and 3/4 in (19 mm) from each end; and shall provide sufficient clearance so the free fall of the rammer shaft and head is unrestricted.

3.5. Sieves meeting requirements set forth under for 1 in (25.0 mm), 3/4 in (19.0 mm), 1/2 in (12.5 mm), 3/8 in (9.5mm), No. 4 (4.75 mm), No. 8 (2.36 mm **ASTM E11** and No. 16 (1.18 mm).

3.6. The balance shall conform to the requirements of **Part V, 5.9; Sampling and Test Methods Foreword**, for the class of general purpose balance required for the principal sample mass of the sample being tested.

3.7. A thermostatically controlled drying oven capable of maintaining a temperature of 230 ± 9°F (110 ± 5°C).

3.8. Sample extruder (desirable) should consist of a frame, jack and circular metal loading plate or other suitable device for removing specimens from the mold.

3.9. Drying pans.

3.10. Trowels, spatulas and other mixing tools or a mechanical mixer that will thoroughly mix the material, cementitious material and water.

3.11. A moist room or cabinet (CTB only) capable of maintaining a temperature of 73 ± 3°F (23 ± 2°C) and a relative humidity of not less than 96%.

3.12. A tamping rod (CTB only) 5/8 in (16 mm) diameter and approximately 24 inches (600 mm) in length that is round with at least one end having a hemispherical tip.

3.13. Soft rubber mallet.

4. SAMPLE PREPARATION.

4.1. For mix design, dry the base aggregate to a constant mass at approximately 230°F (110°C).

Separate the base aggregate by dry screening into the desired fractions and compute the percentage retained on each sieve. The following size fractions are recommended as a minimum:

1 1/2 in to 1 in (37.5 mm to 25 mm)	No. 4 to No. 8 (4.75 mm to 2.36 mm)
1 in to 3/4 in (25 mm to 19 mm)	No. 8 to No. 16 (2.36 mm to 1.18 mm)
3/4 in to 1/2 in (19 mm to 12.5 mm)	No. 16 to No. 30 (1.18 mm to 600 µm)
1/2 in to 3/8 in (12.5 mm to 9.5 mm)	No. 30 to No. 100 (600 µm to 150 µm)
3/8 in to No. 4 (9.5 mm to 4.75 mm)	No. 100 to No. 200 (150 µm to 75 µm)

4.2. Make six portions of base aggregate for each percent of cementitious material to be tested. Recombine the aggregate fractions at the percentage determined in **Section 4.1** of this test method. Each portion shall weigh 7000 g minus the amount of cementitious material to be added.

4.3 Thoroughly mix each sample portion of aggregate with the required amount of cementitious material and place the mixture in a separate pan if applicable.

4.4. For production (QC/QA) control, prepare field material in the following manner:

4.4.1. Acquire a random sample of at least 35 lbs (15 kg) of material. Split the material as follows:

4.4.1.1. Place the sample on clean sheet metal and mix thoroughly with a trowel.

4.4.1.2. Divide the pile into two equal halves with a straightedge (trowel or similar metal blade) and completely remove the back half of the sample.

4.4.1.3. If the sample isn't the proper size (approximately 7000 g), then use the trowel (or metal blade) to remove or add a portion to achieve the proper size.

5. MOISTURE DENSITY RELATIONSHIP TEST PROCEDURE

5.1. For mix design purposes, add a measured amount (approximately 5%) of water and thoroughly mix with one-7000 g portion. After the addition of water and thorough mixing, compact immediately. DO NOT CURE OR AGE THE SPECIMEN AT THIS POINT. For field production obtain a 7000 g portion of combined material.

5.2. Determine the mass of the mold. Place the assembled mold and collar on the rigid base and compact by one of the following methods:

5.2.1. For samples with 1 in (25 mm) slump or less, compact the material in four lifts. Place enough loose moist material in the mold to fill half the mold (not the collar and mold depth). Compact the layer with 56 blows of the rammer with the blows being distributed uniformly over the surface of the layer. Place three, approximately equal, additional layers of material in the mold and compact each layer in a similar manner.

5.2.2. For samples with a slump greater than 1 inch (25 mm), it may be more appropriate to rod the sample instead of using the rammer. Compact the material in three lifts. Place enough material in the mold to fill half the mold (not the collar and mold depth). Rod the material 25 times throughout its depth with the strokes being uniformly distributed over the cross section of the mold. After rodding, tap the outsides of the mold lightly 10 to 15 times with a soft rubber mallet, to close any holes left by rodding and to release any large air bubbles that may have been trapped. Repeat this process for the second and third lifts. The second lift should completely fill the mold, while the third lift should come close to filling the mold and collar. While rodding the second and third lifts, be sure to penetrate the lower lifts by about 1/2 in (12 mm).

5.3. After the final layer has been compacted, remove the collar and trim excess material level with the top of the mold.

5.4. Remove the base and weigh the specimen while it is in the mold. Subtract the mass of the mold to determine the wet mass of the compacted specimen. Then remove the specimen from the mold and place it in an individual drying pan.

5.5. (For Laboratory Prepared Material Only): Repeat the compaction procedure using the other 7000 g increments of the sample to which different measured amounts of water have been added and thoroughly mixed. This procedure will be continued with varying moisture contents until at least three points are obtained on the dry side of "optimum moisture" and at least two points are obtained on the wet side of "optimum moisture." This can usually be accomplished by compacting different specimens at moisture intervals of 2 to 3%, starting on the dry side of "optimum moisture" and ending on the wet side.

5.6. Dry each specimen to constant mass or remove a small representative increment from each specimen (at least 500 g) and determine its moisture content in accordance with **KT-11, Section 3.**

6. CALCULATIONS

6.1. When the entire specimen is dried:

$$\text{Moisture Content \%} = \frac{100(\text{Wet Mass-Dry Mass})}{\text{Dry Mass}}$$

$$\text{Dry Density} = \frac{\text{Dry Mass of Specimen}}{\text{Volume of Mold}}$$

Where:	Dry density	= lb/ft^3 (kg/m^3)
	Dry mass of specimen	= lb (kg)
	Volume of mold	= ft^3 (m^3)

6.2. When a small increment of each specimen is dried, compute dry mass of specimen as follows:

$$\text{Dry Mass of Specimen} = \frac{100(\text{Wet Mass of Specimen})^{1}}{100 + \%\ \text{Moisture}}$$

Compute dry density of specimen as in **Section 6.1** of this test method.

7. LABORATORY PREPARED MATERIAL COMPACTION CURVE

7.1. Plot a density/moisture curve on coordinate paper (**KDOT Form No. 638**) to determine the maximum density and optimum moisture. The dry density values are plotted as ordinates, the corresponding moisture contents are plotted as abscissa and a smooth curve is drawn to best fit the points.

NOTE: In drawing a curve by this method all of the points will not necessarily be on the curve and the maximum density may be more or less than the highest test point (See **KT-12** for examples).

The optimum moisture content is the moisture content at which the maximum density occurs on the curve.

8. COMPRESSION TEST PROCEDURE (FOR CTB ONLY)

8.1. Prepare the molds by lightly oiling the inside of the mold and placing a filter paper disk in the bottom of the mold prior to introducing the material for the first lift.

8.1.1. For mix designs: Prepare nine essentially identical specimens at the selected mix design parameter by the procedures shown in **Section 4. through Section 5.3** of this test method except scratch the surface of each lift after it is compacted to facilitate bonding between lifts.

.

[1] "Wet mass of the specimen" is the mass of the molded plug.

8.1.2. For production (QC/QA) control: Mold 1 specimen per test as stated in **Section 4. through Section 5.4**.of this test method except scratch the surface of each lift after it is compacted to facilitate bonding between lifts.

8.2. Cure the specimens in a moist room from the time compaction is complete until tested.

NOTE: If a moisture room is not available, then place each of the specimens in a sealable plastic container (plastic bags are not acceptable), drape a damp cotton towel over the specimen and seal the container for the specified time. The object is to achieve and maintain near 100% moisture conditions throughout the curing process.

8.2.1. For mix designs: demold 3 specimens at 24 ± 4 hours, three at 48 ± 4 hours, and three at 72 ± 4 hours.

8.2.2. For production (QC/QA) control: demold specimen at 24 ± 4 hours. If this falls on a non-working day, then adjust as stipulated in **Section 9.4** of this test method.

8.3. When the cure is completed; the specimens are removed from the moist room, measured for diameter, capped, weighed and measured for height after capping and broken. **Use sulfur or unbonded caps to cap the CTB specimens.** Follow the procedures set forth in KT-77 for sulfur caps and ASTM C1231 for unbonded caps. Allow sulfur caps to cure for a minimum of 2 hours prior to breaking.

8.4. Test specimens at 7 days ± 4 hours. Place the specimen on the table of the compression-testing machine. Make sure the vertical axis of the specimen is aligned with the center of thrust of the load head. Apply the load continuously and without shock. Adjust the loading to a constant rate of 10-12 psi/sec (69-83 kPa/sec) for a hydraulic system. Record the total load to the nearest 10 lbf (50 N).

8.5. After testing, place each specimen in a drying pan and put in a 230°F (100°C) oven for 24 to 48 hours until a constant mass is attained. Determine the mass of the dry specimen.

9. CALCULATIONS

9.1. Determine the moisture content at the time of testing and the dry density of the specimen using the methods shown in **Section 6.1** of this test method.

NOTE: The moisture and density determined in this section will not be used in the plotting of the control charts, but can be used for comparison purposes should other tests results fail to meet criteria.

9.2. Determine the correction factor for the value of the ratio of the length of the specimen to the diameter (L/D) from the following table:

L/D	Correction Factor	L/D	Correction Factor
1.94 – 2.00	1.00	1.23 – 1.28	0.93
1.82 – 1.93	0.99	1.19 – 1.22	0.92
1.69 – 1.81	0.98	1.15 – 1.18	0.91
1.56 – 1.68	0.97	1.11 – 1.14	0.90
1.46 – 1.55	0.96	1.06 – 1.10	0.89
1.38 – 1.45	0.95	1.02 – 1.05	0.88
1.29 – 1.37	0.94	1.00 – 1.01	0.87

9.3. Multiply the failure load by the correction factor determined from the table above and divide by the area of the test specimen to determine the corrected compressive strengths in psi (kPa)] at failure. Record this value as P.

$$P = \frac{Fcor}{A}$$

Where:

Fcor = failure load x correction factor

$A = \pi r^2$

9.4. Design: During the Design phase develop a time adjustment factor for the 48-hour and 72-hour molded specimens to correlate back to the 24-hour molded specimens in the following manner:

9.4.1. Determine the average corrected compressive strengths for each of the three sets (24, 48, 72-hour) of molded specimens.

9.4.2. Determine the time adjustment factor by dividing the base time compressive strength (24-hour) by the extended times compressive strengths in the following manner:

$$T_{48}=\frac{P_{24}}{P_{48}}$$

$$T_{72}=\frac{P_{24}}{P_{72}}$$

Where: T_{48}, T_{72}= Time adjustment factor for a given (either 48-hour or 72-hour) molded specimen. P_{24}, P_{72}= Average compressive strength values for a given (either 48-hour or 72-hour) set of molded specimens.

9.5. Production: During the field production phase, apply the appropriate time adjustment whenever specimens are not removed from the mold in 24 ± 4 hours in the following manner:

$P_{adj} = P \times T_{48}$ or $P_{adj} = P \times T_{72}$

10. REPORTING

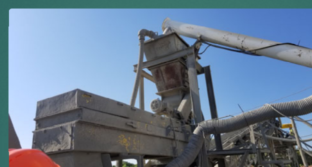
10.1. For laboratory prepared material, report the pressure at failure of each specimen in the three-specimen set in addition to the average failure pressure of the three specimens. For field prepared material, report the pressure at failure for each specimen. The report should reference this test procedure. Record the compressive strength to the nearest 1 psi (0.01 MPa). Report the compressive strength to the nearest 10 psi (0.1 MPa). Record the density to 0.1 lb/ft^3 (1 kg/m^3). Report the density to the nearest to whole number.

Soil Field Tester

INSTRUCTOR: ISAAC M FERGUSON

Section 8 – KT 65
Sampling & Splitting Cement Treated Base Mixtures

Cement Treated Base Mixture



Aggregate

Before added Cement + Water

Second Stage

Cement is Added to Aggregate

Final Stage

Water is Added to Cement + Aggregate mixture

Sampling Procedure

- 3.1 Truck Beds

Sampling Procedure

- 3.1 Truck Beds
- 3.2 Conveyor Belt

Sampling Procedure

- 3.1 Truck Beds
- 3.2 Conveyor Belt
- 3.3 Sampling from Discharge or Flowing Streams

Sampling Procedure

- 3.1 Truck Beds

Sampling Procedure

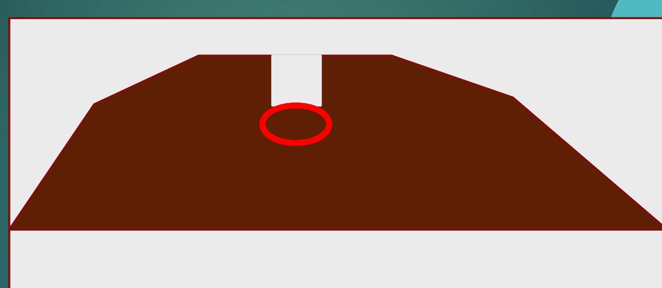
- 3.1 Truck Beds

Sampling Procedure

- 3.1 Truck Beds

Sampling Procedure

- 3.1 Truck Beds

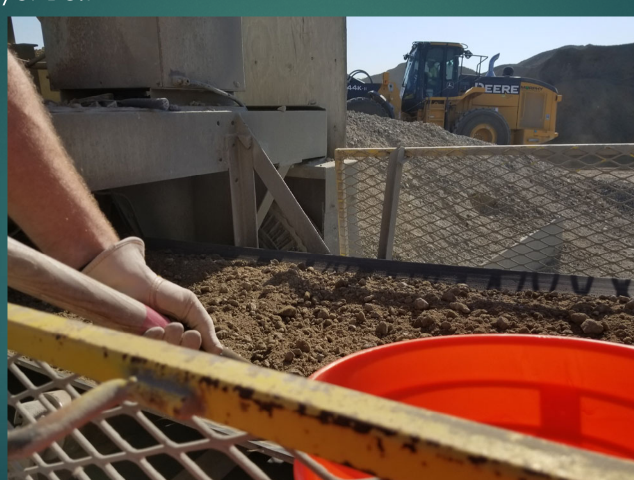


Sampling Procedure

- 3.2 Conveyor Belt

Collect Aggregate Sample

- 3.2 Conveyor Belt



Sampling Procedure

- 3.3 Sampling from Discharge or Flowing Streams

Sampling Procedure

- 3.3 Sampling from Discharge or Flowing Streams

Sampling Procedure

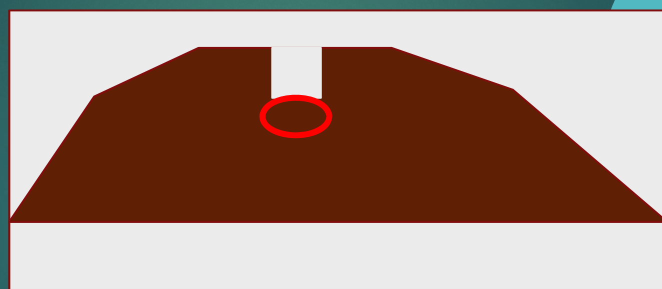
- 3.3 Sampling from Discharge or Flowing Streams

Sampling Procedure

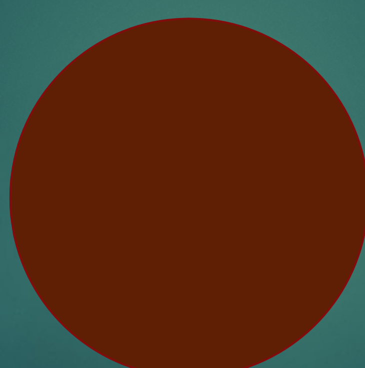
- 3.3 Sampling from Discharge or Flowing Streams

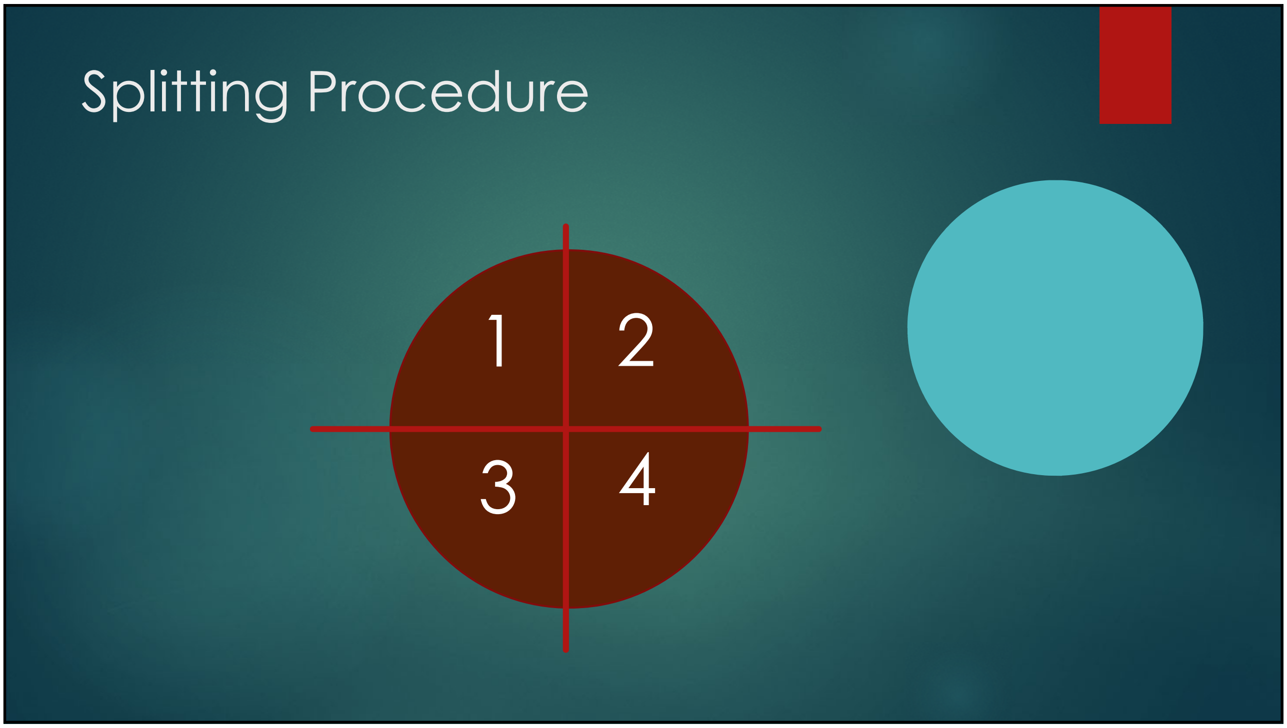
Sampling Procedure

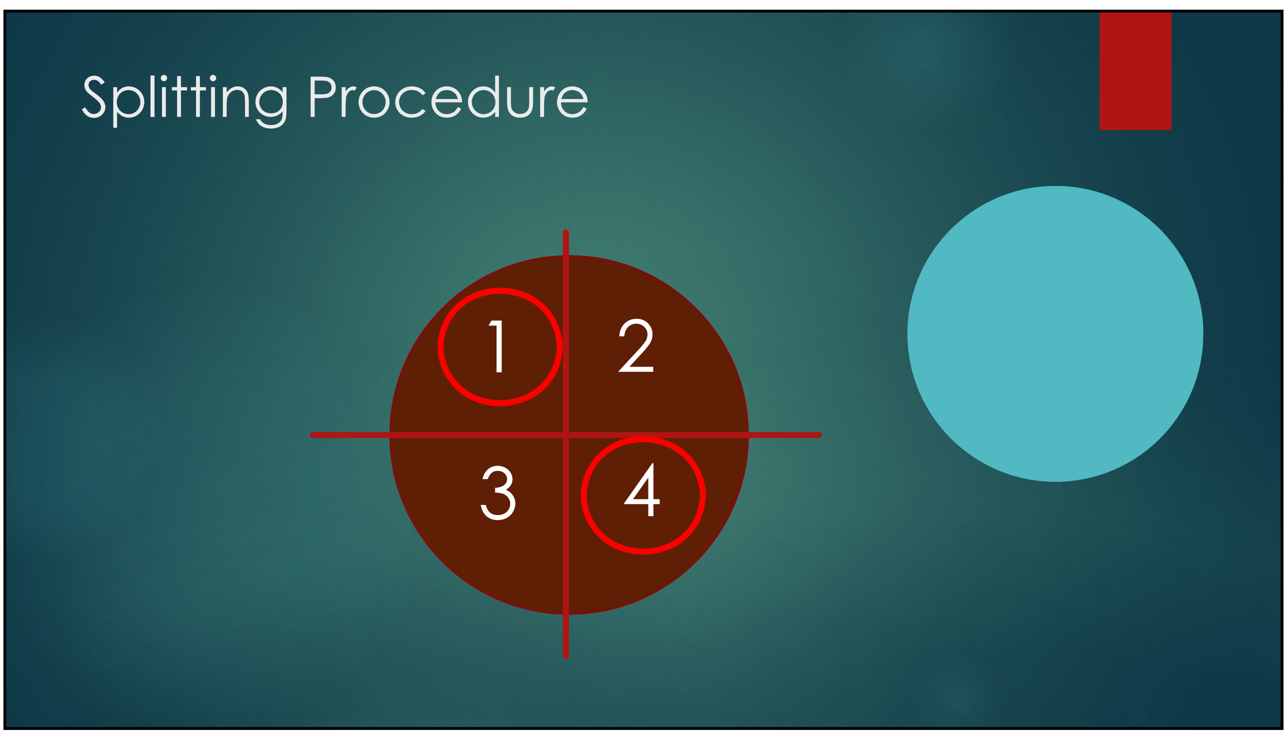
- 3.3 Sampling from Discharge or Flowing Streams



Splitting Procedure




Splitting Procedure
1
2
3
4


Splitting Procedure
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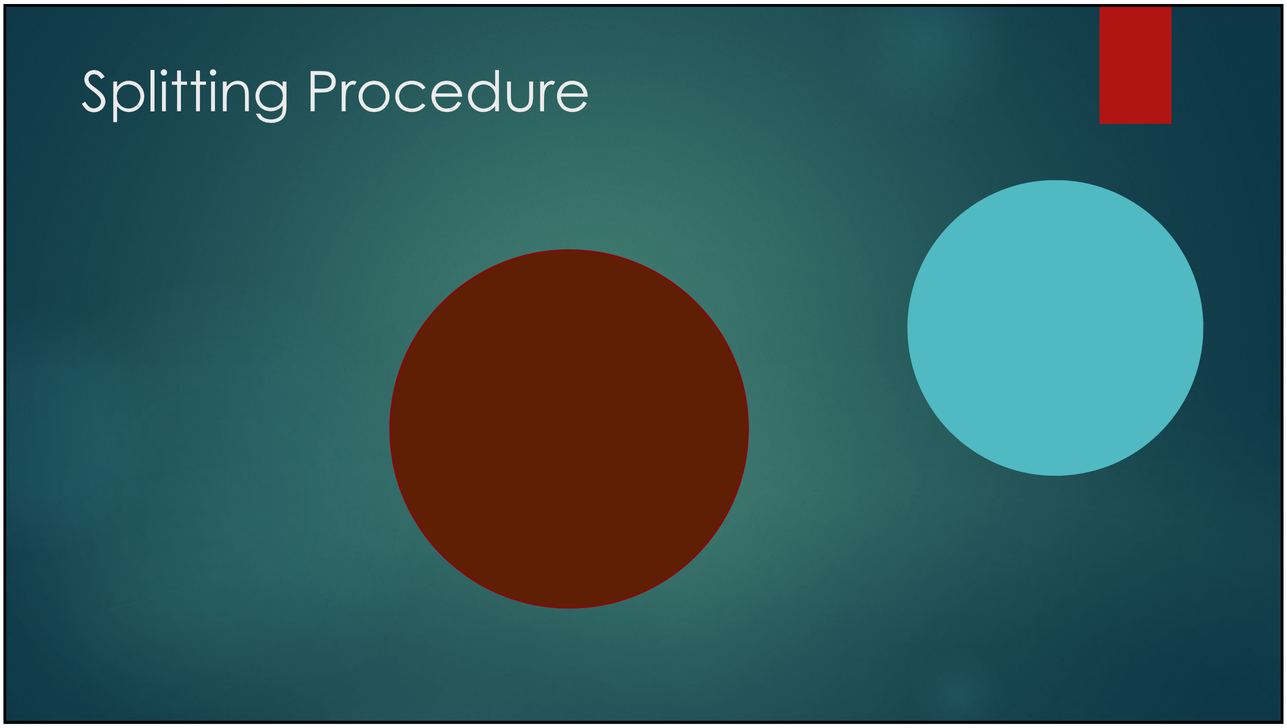
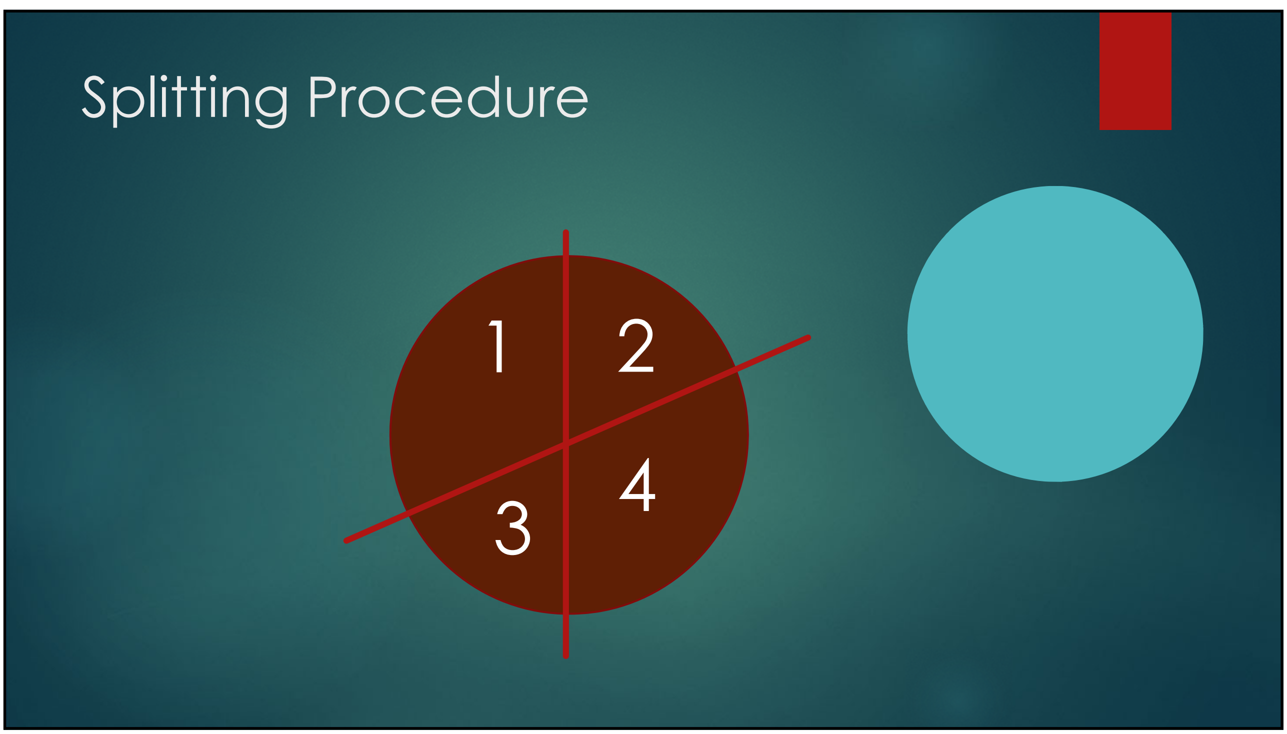

Splitting Procedure


Splitting Procedure
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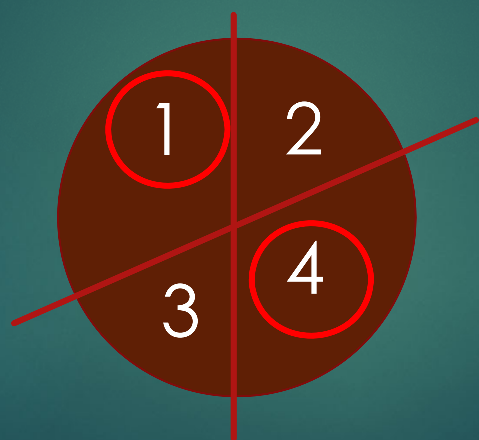
2
3
4

Splitting Procedure



END OF PRESENTATION

5.9.65 SAMPLING AND SPLITTING CEMENT TREATED BASE MIXTURES
(Kansas Test Method KT-65)

1. SCOPE

This method covers the procedure for sampling cement treated base mixtures from truck beds, batch plants, and continuous mix plants.

NOTE: The total length of time required to sample and split the material shall take no longer than 45 minutes.

2. **APPARTUS**

2.1. Square pointed shovel or scoop.

2.2. A five-gallon container that will be filled with loose, cement treated base mixture. The container should be equipped with a handle that will permit it to be carried easily. The container should also have a lid to prevent moisture loss during transport.

3. SAMPLING PROCEDURE

3.1. Truck beds.

3.1.1. Divide the truck bed into at least three areas of approximately equal size.

3.1.2. Dig a hole about 1 ft (0.3 m) deep at a point that will be representative of each area.

3.1.3. Take a sample near the bottom of each hole and place in container, taking care to prevent segregation.

3.1.4. Combine the individual samples into a single sample and mix thoroughly[a].

3.1.5. The combined sample size shall be at least four times the amount required for testing.

3.2. Conveyor Belt.

3.2.1. Stop the conveyor belt while the sample increments are being obtained. Insert two templates, the shape of which conforms to the shape of the belt in the mixture stream on the belt. Space the templates such that the material contained between will yield an increment of the required mass.

3.2.2. Obtain at least three approximately equal increments, selected at random, from the unit being sampled.

3.2.3. Carefully scoop all material between the templates into the container and collect the fines from the belt with a brush and dust pan and add to the container.

3.2.4. Combine the individual samples into a single sample and mix thoroughly.

3.2.5. The combined sample size shall be at least four times the amount required for testing.

3.3. Sampling from Discharge or Flowing Streams.

3.3.1. The batch mixer or the continuous mixer (pugmill) shall be capable of sampling at the discharge outlet. When a sample is taken from the discharge, use a loader(s) or other heavy equipment capable of intercepting the entire cross section of the discharge stream.

3.3.2. Divide the material in the loader bucket into at least three areas of approximately equal size. Obtain a sample from each of the three sections.

3.3.3. Combine the individual samples into a single sample and mix thoroughly[a].

3.3.4. The combined sample size shall be at least four times the amount required for testing.

NOTE a: After mixing, place the lid securely on the container immediately following sampling to prevent moisture loss in the material. The lid shall not be removed until the splitting procedure begins.

4. SPLITTING PROCEDURE

4.1. During mixing and reducing, care must be exercised to prevent moisture loss within the sample.

4.2. Reduce sample to the required size by splitting or quartering in the following manner:

4.2.1. Spread a sheet of paper (Kraft or similar) on a hard, clean smooth and level surface. Place the sample in a pile near the center of the paper and mix by alternately lifting each corner towards the opposite corner thereby rolling the mixture to the opposite corner. This should be performed in a vigorous manner. Placing the sample on clean sheet metal and mixing thoroughly with a trowel is an acceptable alternative.

4.2.2. Divide the pile into four equal quarters with a straightedge (trowel or similar metal blade) and completely remove two pre-selected diagonally opposite quarters.

4.2.3. Continue this quartering procedure until the original sample is reduced to the approximately desired size. On the final quartering step, if the sample is too large before quartering, but will be too small after quartering, the sample pile is divided into equal opposite sectors but unequal adjacent sectors. This can be accomplished by varying the dividing angle at the center of the sample pile from the normal 90 degrees. Opposite sections can then be selected to obtain the desired sample size.

Soils Field Tester

INSTRUCTOR: ISAAC M. FERGUSON

Soil Survey

Section 9

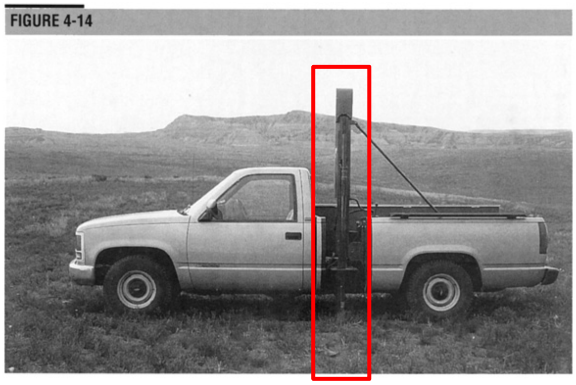
Example of Proposed Project

Existing Road

New Alignmenthttps://support.apple.com/en-us/HT201222

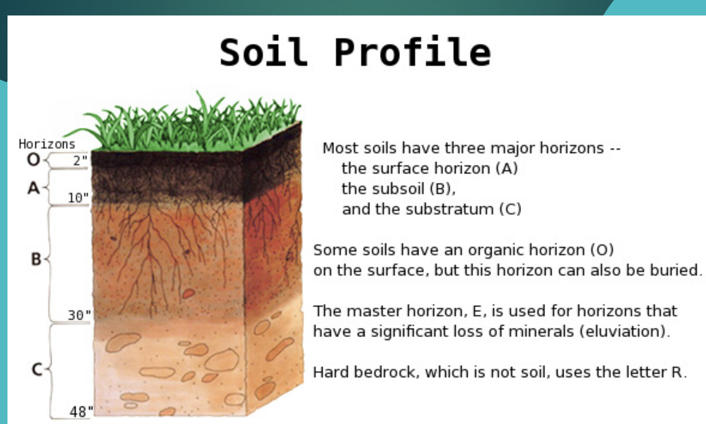
Example of a truck mounted Hydraulic Soil Sampler

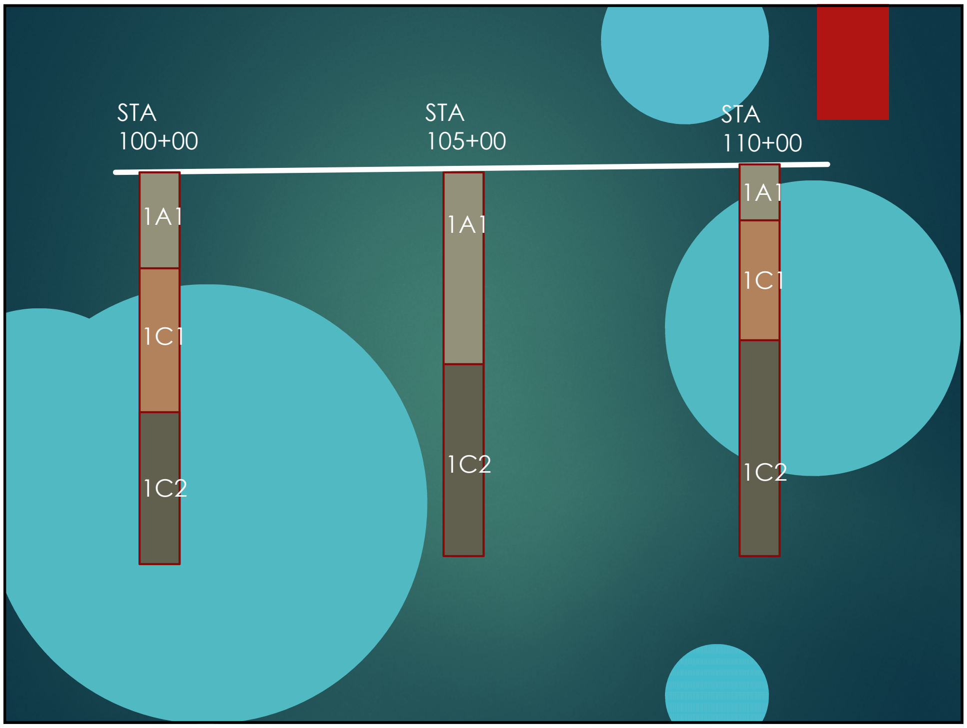
FIGURE 4-14



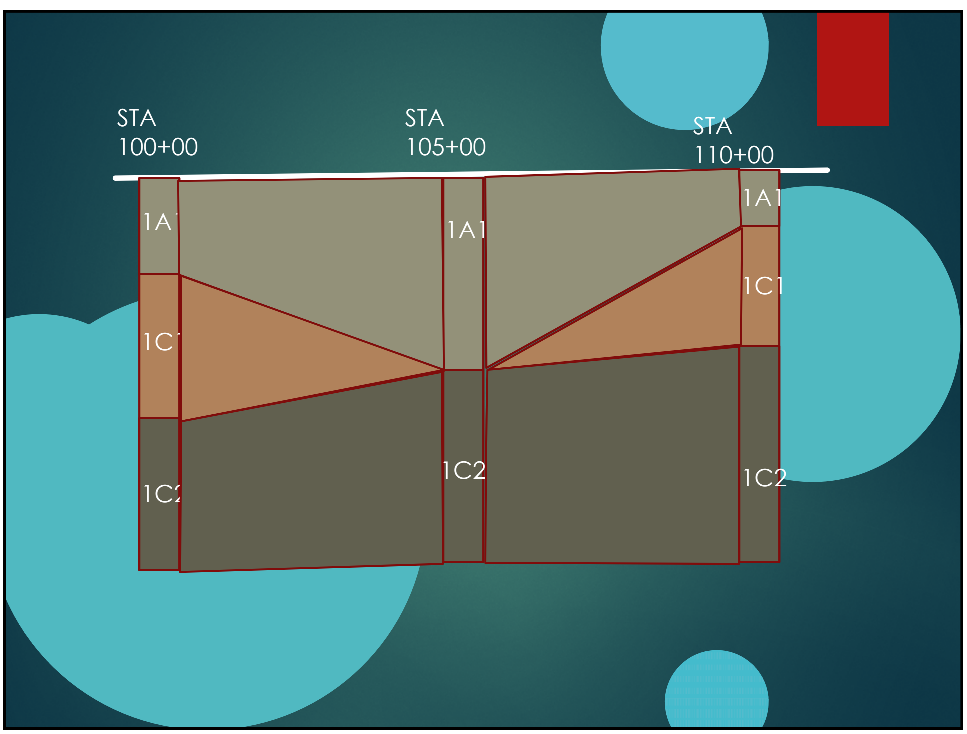
A hydraulically operated sampling tube mounted on a pickup truck. The open-faced tube is in place. Hydraulic controls are at the right.

Example of a sample rod





STA
100+00
STA
105+00
STA
110+00
1A1
1C1
1C2
1A1
1C2
1A1
1C1
1C2



STA
100+00
STA
105+00
STA
110+00
1A1
1C2
1A1
1C1
1C2

Use overhead

REPORT OF SOIL SURVEY

83-41 KA-1008-03 and 83-41 KA-1008-05
US-83
Haskell and Finney Counties

James J. Brennan, P.E.
Asst. Geotechnical Engineer

Luke Metheny, P.E.
Soils Engineer

Isaac M. Ferguson, E.A.II
Soils Foundation Specialist

February 2013

Kansas
Department of Transportation

Bureau of Materials and Research
Geotechnical Unit

SOIL SURVEY NOTES

PROJECT NUMBER: 83-41 KA-1008-03, 83-41 KA-1008-05 DATE: 8/7/2012 COUNTY: Haskell

Sta	Dist. C/L (ft)	Depth in (ft)	Similar to Sample	Sample Taken	Remarks:
					Survey Party: Isaac Ferguson, Kevin Vaughn, Arthur Peterson, John Nelson
438+81	10 Lt	0-1.5		1A1	10YR 3/2, very dark grayish brown
		1.5-8.1		1C1	10YR 7/4, very pale brown. Loess
		8.1-10.6		1C2	10 YR 3/2 ,very dark-brown. Firm with traces of calcareous
453+00	7 Lt	0-0.4	1A1		
		0.4-13.2	1C1		
		13.2-15.0		1C3	10 YR 6/4 light yellowish brown
468+00	6 Lt	0-1.2	1A1		
		1.2-6.1	1C1		
		6.1-9.8	1C3		
		9.8-11.1	1C2		
		11.1-13.8	1C1		
		13.8-15.1	1C3		
483+00	226.7 Lt	0-1.1	1A1		
		1.1-7.0	1C1		
		7.0-11.0	1C2		
		11.0-15	1C3		
498+00	498.0 Lt	0-2.0	1A1		
		2.0-4.0	1C3		
		4.0-15.0		1C4	5YR 5/5, Reddish brown, Silt w/ 40% sand

1

Rev. 10/98

Table I
Soil Characteristics

Project Number: 83-41 KA-1008-03 & 83-41 KA-1008-05 Laboratory Number: 12-2701
County: Haskell and Finney County Date: 11/26/12

Sample Number	% Class	% Sand	% Clay	L.L.	P.L.	P.I.	Standard Density (pcf)	Optimum Moisture	Average Thickness (ft)	% Occurrence	Remarks	% Swell *	Comparative Quality: Slope	Comparative Quality: Subgrade
1A1	C	8	41	42	20	22	97	21	2.2	96		1.9	D	O
1C1	SiC	4	34	40	20	20	97	21	5.2	40	Similar to 1A1	2.3	D	O
1C2	C	25	30	36	17	19	106	16	5.7	82		1.8	U	U
1C3	C	10	34	36	19	17	106	16	4.2	18		1.9	U	U
1C4	SCL	44	20	26	16	10			5.3	39		1.5	O	D
1C5	CL	15	28	34	18	16	106	16	8.1	4	Similar to 1C2 and 1C3	1.6	U	U

Note:
Soils 1A1 and 1C1 are considered the same soil.
Soils 1C2, 1C3, and 1C5 are considered the same soil.

D=Desirable, S=Satisfactory, U=Usable, O=Objectionable.
* Estimated Swell Potential

Rev. 10/98

Table I

Soil Characteristics

Project Number: 83-41 KA-1008-03 & 83-41 KA-1008-05

County: Haskell and Finney County

Laboratory Number: 12-2701

Date: 11/26/12

Sample Number	% Class	% Sand	% Clay	L.L.	P.L.	P.I.	Standard Density (pcf)	Optimum Moisture	Average Thickness (ft)	% Occurrence	Remarks	% Swell *	Comparative Quality: Slope	Comparative Quality: Subgrade
1A1	C	8	41	42	20	22	97	21	2.2	96		1.9	D	O
1C1	SiC	4	34	40	20	20	97	21	5.2	40	Similar to 1A1	2.3	D	O
1C2	C	25	30	36	17	19	106	16	5.7	82		1.8	U	U
1C3	C	10	34	36	19	17	106	16	4.2	18		1.9	U	U
1C4	SCL	44	20	26	16	10			5.3	39		1.5	O	D
1C5	CL	15	28	34	18	16	106	16	8.1	4	Similar to 1C2 and 1C3	1.6	U	U

Note:

Soils 1A1 and 1C1 are considered the same soil.

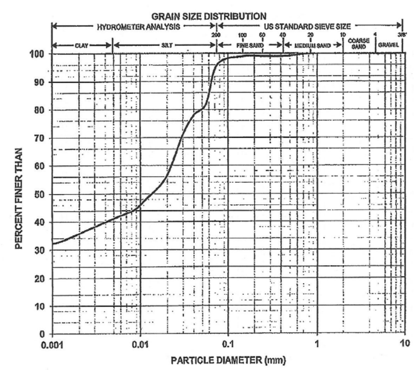
Soils 1C2, 1C3, and 1C5 are considered the same soil.

D=Desirable, S=Satisfactory, U=Usable, O=Objectionable.

* Estimated Swell Potential

KANSAS DEPARTMENT OF TRANSPORTATION
REPORT OF SOIL TESTS

SUBMITTED BY: Isaac Ferguson		ADDRESS:	2300 Van Buren	LAB NO.	012-2701
PROJECT:	83-41 KA-1008-5	COUNTY:	Haskell	DATE:	9/4/12



PHYSICAL PROPERTIES

SAMPLE NUMBER	STATION	CL DIST.	DEPTH (ft)	L.L.	P.L.	P.I.	% RET. ON 10 SEIVE	SPEC. GRAV. (PASS NO. 10)	CLASS KS/UNIF.
1-A1	463+00	7Lt	0-3.0	42	20	22	0.0	2.63	C / CL

Test Method: AASHTO T-88 (Iowa Air Dispersion)

REMARKS

R.E. Kreider, P.E.

Chief of Bureau of Materials and Research

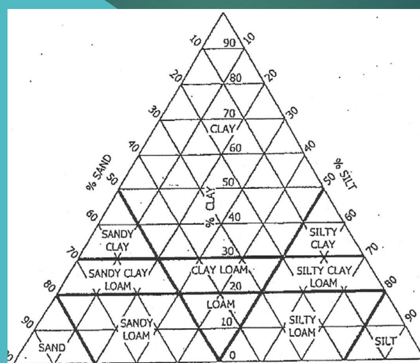
By [signature]

Luke Metheny, P.E., Soils Engineer

Rev. 3-99

D.O.T. NO. 635

CLASS		PERCENTAGE OF SOIL FRACTIONS PRESENT		
NAME		SAND	SILT	CLAY
Sand	S	80 - 100	0-20	0-20
Sandy Loam	SL	50-80	0-50	0-20
Sandy Clay Loam	SCL	50 - 80	0-30	20-30
Sandy Clay	SC	50-70	0-20	30-50
Silt	Si	0-20	80-100	0-20
Silty Loam	Sil	0-50	50-80	0-20
Silty Clay Loam	SicL	0-30	50-80	20-30
Silty Clay	SiC	0-20	50-70	30-50
Clay	C	0-50	0-50	30 - 100
Clay Loam	CL	20-50	20-50	20-30
Loam	L	30 - 50	30 - 50	0-20



Rev. 10/98

Table I
Soil Characteristics

Project Number: 83-41 KA-1008-03 & 83-41 KA-1008-05 Laboratory Number: 12-2701
County: Haskell and Finney County Date: 11/26/12

Sample Number	% Class	% Sand	% Clay	L.L.	P.L.	P.I.	Standard Density (pcf)	Optimum Moisture	Average Thickness (ft)	% Occurrence	Remarks	% Swell *	Comparative Quality	
													Slope	Subgrade
1A1	C	8	41	42	20	22	97	21	2.2	96		1.9	D	O
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1C3	C	10	34	36	19	17	106	16	4.2	18		1.9	U	U
1C4	SCL	44	20	26	16	10			5.3	39		1.5	O	D
1C5	CL	15	28	34	18	16	106	16	8.1	4	Similar to 1C2 and 1C3	1.6	U	U

Note:
Soils 1A1 and 1C1 are considered the same soil.
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D=Desirable, S=Satisfactory, U=Usable, O=Objectionable.
* Estimated Swell Potential

Rev. 10/98

Table I

Soil Characteristics

Project Number: 83-41 KA-1008-03 & 83-41 KA-1008-05 Laboratory Number: 12-2701

County: Haskell and Finney County Date: 11/26/12

Sample Number	% Class	% Sand	% Clay	L.L.	P.L.	P.I.	Standard Density (pcf)	Optimum Moisture	Average Thickness (ft)	% Occurrence	Remarks	% Swell *	Comparative Quality: Slope	Comparative Quality: Subgrade
1A1	C	8	41	42	20	22	97	21	2.2	96		1.9	D	O
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1C2	C	25	30	36	17	19	106	16	5.7	82		1.8	U	U
1C3	C	10	34	36	19	17	106	16	4.2	18		1.9	U	U
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Note:

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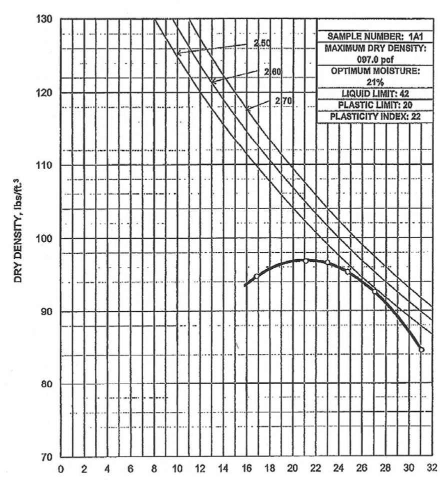
* Estimated Swell Potential

KANSAS DEPARTMENT OF TRANSPORTATION

REPORT OF SOIL COMPACTION TESTS

SUBMITTED BY Isaac Ferguson ADDRESS 2300 Van Buren LAB. NO 012-2701

PROJECT 83-41 KA-1008-5 COUNTY Haskell DATE 9-18-12



TEST METHOD AASHTO-T99

REMARKS

R.E. Kreider, P.E.

Chief, Bureau of Materials and Research

BY

Luke Metheny, P.E., Soils Engineer.

D.O.T. Form No. 638

COMPACTION CONTROL

Subgrade Soils: The subgrade should be compacted to Type AA specifications with MR 3-3 moisture control beneath flexible and rigid pavement.

Embankment Soils: Soils used in embankment construction below the top 18 inches and outside of the pavement limits should be compacted to Type A specifications with MR 5-5 moisture control.

Compaction for Backfill Soils: Soils used to backfill CMP structures should be compacted to Type AA specifications with MR 5-5 moisture control.

Compaction for Widening Soils: All embankment and subgrade soils used to widen the existing roadway should be compacted to Type A specifications with MR 5-5 moisture control. A minimum of 6 inches of compaction should be shown beneath the widened portion of the roadway.

EARTHWORK ADJUSTMENTS

A Volume Multiplication Factor (VMF) has been computed from tests and historical data. We recommend a VMF of 0.86 be used for all soils encountered along this project and soils obtained from borrow areas. The recommended VMF does not include quantities for initial consolidation (Qic) and settlement (Qs); These values should be included in the earthwork balance quantities and are listed in Table II.

CONCLUSION

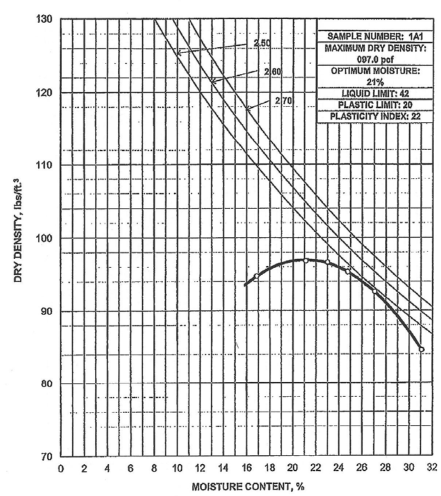
This report completes the involvement of the Soil Section with this phase of the project. If any questions regarding this report arise, please contact Mr. Isaac Ferguson, Mr. Luke Metheny, or Mr. Jim Brennan. We can be reached by phone at (785)296-3008 or by email at ferguson@ksdot.org, lukem@ksdot.org, and brennan@ksdot.org.

2

KANSAS DEPARTMENT OF TRANSPORTATION

REPORT OF SOIL COMPACTION TESTS

SUBMITTED BY Isaac Ferguson ADDRESS 2300 Van Buren LAB. NO 012-2701
PROJECT 83-41 KA-1008-5 COUNTY Haskell DATE 9-18-12



TEST METHOD AASHTO-T99
REMARKS

R.E. Kreider, P.E.
Chief, Bureau of Materials and Research
BY
Luke Metheny, P.E., Soils Engineer
D.O.T. Form No. 638

TABLE 205-2: SOIL MOISTURE CONTENT REQUIREMENTS	
Moisture Range	Moisture Content
0-5 (MR-0-5)	A maximum of 5 percentage points above optimum, nor less than optimum.
3-3 (MR-3-3)	A maximum of 3 percentage points above optimum, and a maximum of 3 percentage points below optimum.
5-5 (MR-5-5)	A maximum of 5 percentage points above optimum, and a maximum of 5 percentage points below optimum.
90 (MR-90)	Sufficient to allow the type of compaction specified in the Contract Documents. If Type B compaction is specified, the Engineer will determine by visual inspection if satisfactory moisture control and compaction are obtained.

i. Foundation Treatment. If an embankment is started less than 4 feet below the finished subgrade, remove all vegetation from the surface where the embankment will be placed. Plow, scarify or break up the cleared surface to a minimum depth of 6 inches (foundation area). Adjust the foundation area to a moisture content within the specified moisture range. Compact the foundation area as specified in the Contract Documents for the embankment.

If an embankment is placed over an existing surface (PCCP, HMA, gravel), plow, scarify or break up the full depth of the existing surface regardless of the height of the embankment.

j. Embankment Requirements. Construct the embankment from material classified as Soil, Rock/Soil or Rock, as defined in **TABLE 205-3**.

TABLE 205-3: EMBANKMENT GRADATION CLASSIFICATION	
Classification	Gradation Criteria
Soil	≤ 20% retained on the ¾ inch sieve
Rock/Soil	> 20%, but < 80% retained on the ¾ inch sieve
Rock*	≥80% retained on the ¾ inch sieve

*Could include concrete pavement.

If frozen soil is encountered in the surface of the original ground or in the surface of a partially constructed embankment, remove the frozen material or allow the frozen material to thaw before continuing construction of the embankment.

Unless shown otherwise in the Contract Documents, if shale (all shale classified as non-durable or common excavation) is used as embankment material, manipulate the shale with equipment and water until it complies with **subsection 205.4c**. Adjust the moisture content and compact the shale as specified in the Contract Documents.

Construct and backfill culverts and other structures below the embankment surface before the embankment is constructed.

When the embankment is placed against a hillside or an existing embankment with slopes steeper than 4:1, bench the existing slope with each lift of the embankment. Cut the benches wide enough to accommodate the hauling and compacting equipment. Begin cutting (horizontally) each new bench at the intersection of the original ground and the vertical side of the previous bench. Use the material excavated from the benches in the embankment.

Exercise care placing and compacting the embankment, when placed on only one side of a structure (such as abutments, piers and wingwalls). Do not put excessive pressure against the structure.

Place soil embankment material in horizontal lifts approximately 8 inches thick (loose measurement). Compact the earthen material as specified in the Contract Documents before placing the next lift. Compact manipulated (sized) non-durable shale to the compaction requirement in the Contract Documents and adjust the moisture content of the manipulated non-durable shale to MR-5-5. Use compaction equipment as specified in **DIVISION 150**. Provide sufficient motorgraders and tamping rollers to adequately blade and compact the material delivered to the embankment. Route the construction equipment uniformly over the entire surface of each lift. Continuously use a motorgrader to level and manipulate the material during the placing and compacting of each lift of the embankment. If the material delivered to the embankment is not properly placed and compacted, suspend delivery of materials to the embankment until the problem is corrected.

TABLE 205-1: SOIL COMPACTION REQUIREMENTS	
Type	**Minimum Compacted Soil Density**
Type AAA	100% of Standard Density
Type AA	95% of Standard Density
Type A	90% of Standard Density
Type B	Such that no further consolidation is gained by additional rolling. The Engineer will visually determine acceptable Type B compaction based on the following: • Acceptable Type B compaction is demonstrated if the tamping feet of a tamping (sheepsfoot) roller "walks out" of the soil and rides on top of the lift being compacted. • In soil with low plasticity or nonplastic fine-grained materials, the tamping feet may not "walk out" of the material being compacted. With these materials, acceptable Type B compaction is demonstrated if the tamping feet support the weight of the roller (without the drum of the roller contacting the lift being compacted). • In sand and gravel, where the use of a tamping roller produces unacceptable results, use other types of rollers (such as a pneumatic-tired) to compact this type of material. With these materials, acceptable Type B compaction is demonstrated if no further consolidation is evident after additional passes of the roller. • In small irregular areas where the use of conventional compaction equipment is impracticable, use other equipment and methods to obtain compaction. The Engineer will determine by visual inspection if Type B compaction is obtained. • If the Engineer is unable to visually determine that Type B compaction is obtained, the Engineer may conduct density tests on the compacted soil. If tested, the compacted soil density shall be at least 90% of the standard density.

h. Moisture Control Requirements. At the time of compaction, use soil with uniform moisture content within the moisture range designated in the Contract Documents.

Adjust the moisture content of the soil by adding water to or aerating the material to bring soil within the required moisture content.

If the soil is unstable within the designated moisture range, the DME will adjust the moisture range.

Water may be added to the soil in borrow and cut areas (before hauling) or on the embankment (after hauling). Use methods and equipment that will prevent undue loss of moisture. Add only the quantity of water necessary to provide a moisture content within the required moisture range plus a reasonable quantity to compensate for evaporation and other unavoidable losses.

Excavation areas may be pre-watered to provide uniform moisture content. Submit sketches of the areas with details of the proposed methods and equipment for the pre-watering for approval by the Engineer. Provide drilling equipment to obtain samples for moisture determination before, during and after the pre-watering. Using the results of the moisture samples, the Contractor and Engineer will jointly determine the quantities of water necessary to bring the soils to optimum moisture. The Engineer will allow sufficient water to bring the full depth and width of the excavation to optimum moisture plus up to 20% for evaporation.

In areas to be pre-watered, leave the vegetation in place until the watering is completed. If runoff is observed during the pre-watering, rip the area on the contour to a depth of approximately 2 feet at 4-foot intervals. To permit penetration to the full depth of the excavation (for uniform moisture content), allow a curing period after the pre-watering is completed. The Contractor and Engineer will use the moisture samples obtained by the Contractor (at locations and depth agreed to by the Contractor and Engineer) to determine moisture content and uniformity for the pre-watered areas. Strip the vegetation from the areas after the water has penetrated the soils.

Requirements for the various moisture ranges are shown in **TABLE 205-2**.

Rev. 10/98

Table I

Soil Characteristics

Project Number: 83-41 KA-1008-03 & 83-41 KA-1008-05 Laboratory Number: 12-2701
County: Haskell and Finney County Date: 11/26/12

Sample Number	% Class	% Sand	% Clay	L.L.	P.L.	P.I.	Standard Density (pcf)	Optimum Moisture	Average Thickness (ft)	% Occurrence	Remarks	% Swell *	Comparative Quality	
													Slope	Subgrade
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1C1	SiC	4	34	40	20	20	97	21	5.2	40	Similar to 1A1	2.3	D	O
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1C3	C	10	34	36	19	17	106	16	4.2	18		1.9	U	U
1C4	SCL	44	20	26	16	10			5.3	39		1.5	O	D
1C5	CL	15	28	34	18	16	106	16	8.1	4	Similar to 1C2 and 1C3	1.6	U	U

Note:
Soils 1A1 and 1C1 are considered the same soil.
Soils 1C2, 1C3, and 1C5 are considered the same soil.

D=Desirable, S=Satisfactory, U=Usable, O=Objectionable.
* Estimated Swell Potential

Rev. 10/98

Table I

Soil Characteristics

Project Number: 83-41 KA-1008-03 & 83-41 KA-1008-05 Laboratory Number: 12-2701
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													Slope	Subgrade
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1C2	C	25	30	36	17	19	106	16	5.7	82		1.8	U	U
1C3	C	10	34	36	19	17	106	16	4.2	18		1.9	U	U
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1C5	CL	15	28	34	18	16	106	16	8.1	4	Similar to 1C2 and 1C3	1.6	U	U

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D=Desirable, S=Satisfactory, U=Usable, O=Objectionable.
* Estimated Swell Potential

Rev. 10/98

Table I

Soil Characteristics

Project Number: 83-41 KA-1008-03 & 83-41 KA-1008-05 Laboratory Number: 12-2701

County: Haskell and Finney County Date: 11/26/12

Sample Number	% Class	% Sand	% Clay	L.L.	P.L.	P.I.	Standard Density (pcf)	Optimum Moisture	Average Thickness (ft)	% Occurrence	Remarks	% Swell *	Comparative Quality: Slope	Comparative Quality: Subgrade
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INTRODUCTION

This report contains recommendations for the grading portion of project 83-41KA-1008-03 and 83-41KA-1008-05. The information for this report covers the area along the proposed alignment of US-83 from one mile south of the US-83/US-160/K-144 junction to one mile north of the Haskell/Finney County Line. The information contained in this report was compiled from a field investigation conducted jointly by the Soils and Geology Sections of the Geotechnical Unit and a review of historical information.

SOIL CHARACTERISTICS

The soils encountered on this project are loessial. The soils through this corridor are classified as silty clay loams having a low to moderate swell potential ranging from one to three percent. Swell percentages two percent and above typically necessitate subgrade treatment. A summary of soil characteristics can be found in Table I.

SOIL SELECTION

Subgrade Soil: The top 6 inches of subgrade should be treated with 15% Type C Fly Ash; therefore, all of the soils encountered are usable in the subgrade.

Select Soil for Slopes: The general use of select soil is not recommended for this project. If select soil is needed in areas determined during construction, soils listed as "D", desirable in the comparative quality column for slopes in Table I are best suited for use as select soil for slopes to promote the growth of vegetation.

Backfill Soils for CMP's: All of the soils encountered on this project may be used to backfill CMP's. The Designer should use an E' value of 750 psi for designing CMP structures. The pipe bedding should be left uncompacted directly under the pipe to reduce invert-bending moments. The installations described would be a Type 3 SIDD installation as described in the AASHTO Standard Specifications for Bridges.

Embankment: All soil used in the top 18" of the embankment should conform to the following requirements: $8 \le PI \le 25$ and $20 \le LL \le 45$. Soils which contain substantial organic material, classified as OL or OH, according to the Unified Soil Classification System (ASTM D2487), should not be used to construct the embankment or subgrade. The organic material may be used as select soil to cap the sideslopes of the embankment.

Erosion Potential: The loessial soils in this area are low to moderately erodible on steep slopes when vegetation has been removed. These soils can be highly erodible on flatter slopes and may form erosion channels. To help prevent erosion, the slope should be seeded quickly and watered if necessary to assist in germination and growth. The use of erosion control blankets on slopes should help to prevent the slope from eroding and help establish vegetation.

1

COMPACTION CONTROL

Subgrade Soils: The subgrade should be compacted to Type AA specifications with MR 3-3 moisture control beneath flexible and rigid pavement.

Embankment Soils: Soils used in embankment construction below the top 18 inches and outside of the pavement limits should be compacted to Type A specifications with MR 5-5 moisture control.

Compaction for Backfill Soils: Soils used to backfill CMP structures should be compacted to Type AA specifications with MR 5-5 moisture control.

Compaction for Widening Soils: All embankment and subgrade soils used to widen the existing roadway should be compacted to Type A specifications with MR 5-5 moisture control. A minimum of 6 inches of compaction should be shown beneath the widened portion of the roadway.

EARTHWORK ADJUSTMENTS

A Volume Multiplication Factor (VMF) has been computed from tests and historical data. We recommend a VMF of 0.86 be used for all soils encountered along this project and soils obtained from borrow areas. The recommended VMF does not include quantities for initial consolidation (Qic) and settlement (Qs); These values should be included in the earthwork balance quantities and are listed in Table II.

CONCLUSION

This report completes the involvement of the Soil Section with this phase of the project. If any questions regarding this report arise, please contact Mr. Isaac Ferguson, Mr. Luke Metheny, or Mr. Jim Brennan. We can be reached by phone at (785)296-3008 or by email at ferguson@ksdot.org, lukem@ksdot.org, and brennan@ksdot.org.

2

COMPACTION CONTROL

Subgrade Soils: The subgrade should be compacted to Type AA specifications with MR 3-3 moisture control beneath flexible and rigid pavement.

Embankment Soils: Soils used in embankment construction below the top 18 inches and outside of the pavement limits should be compacted to Type A specifications with MR 5-5 moisture control.

Compaction for Backfill Soils: Soils used to backfill CMP structures should be compacted to Type AA specifications with MR 5-5 moisture control.

Compaction for Widening Soils: All embankment and subgrade soils used to widen the existing roadway should be compacted to Type A specifications with MR 5-5 moisture control. A minimum of 6 inches of compaction should be shown beneath the widened portion of the roadway.

EARTHWORK ADJUSTMENTS

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2

Volume Multiplication Factor (VMF)

$$\text{VMF} = \frac{\text{FIELD DENSITY}}{\text{STANDARD COMPACTION}}$$

Soil Survey VMF Calculations

Project 83-41 KA-1008 County Haskell Date 12/17/2012

Station (2012)	Station (1954)	Distance from Center Line (ft)	Depth (ft)	Lab. No.	Sample No.	Cut Density (Dc) (pcf)	Standard Compaction (pcf)	Present Field Moisture (%)	Probable Rolled Density*(Df)	Computed Shrinkage	VMF	GROSS	USE
960+00	560+00	14 Lt	0-21.1	"	1A1,1C5, 1C4	83	104	16	94	21	0.84	0.72	0.72
975+00	580+00	CL	0-16.1	"	1A1, 1C2, 1C4	81	104	16	94	11	0.82	0.7	0.7
989+99	600+00	CL	0-21	"	1A1,1C2,1 C4	81	97	22	92	3	0.88	0.76	0.76
1160+00	620+00	40 Lt.	0.1-3.5	"	1A, 1B, 1C	87	99	12	94	8	0.93	0.81	0.81
1180+00	640+00	40 Lt.	.1-3.5	"	1A, 1B, 1C 1	86	98	13	93	8	0.92	0.8	0.8
1200+00	660+00	40 Lt.	0.1-3.5	"	1A, 1B, 1C 1	90	98	12	93	3	0.97	0.85	0.85
1220+00	682+50	40 Rt.	0.2-8.5	"	1A, 1C, 1C 2	101	112	7	106	5	0.95	0.83	0.83
1240+00	695+00	50 Lt.	0.1-3.5	"	1A, 1B, 1C 1	83	98	11	93	12	0.89	0.77	0.77
				Final Averages:		**83**	**101**	**15**	**94**	**13.4**	**0.86**	**0.74**	**0.74**

*Based on 95% Standard Compaction

**Volume Multiplication Factor =D_c/D_f = The amount of embankment which can be constructed from on cubic yard of excavation.

REPORT OF SOIL SURVEY

83-41 KA-1008-03 and 83-41 KA-1008-05

US-83

Haskell and Finney Counties

James J. Brennan, P.E.
Asst. Geotechnical Engineer

Luke Metheny, P.E.
Soils Engineer

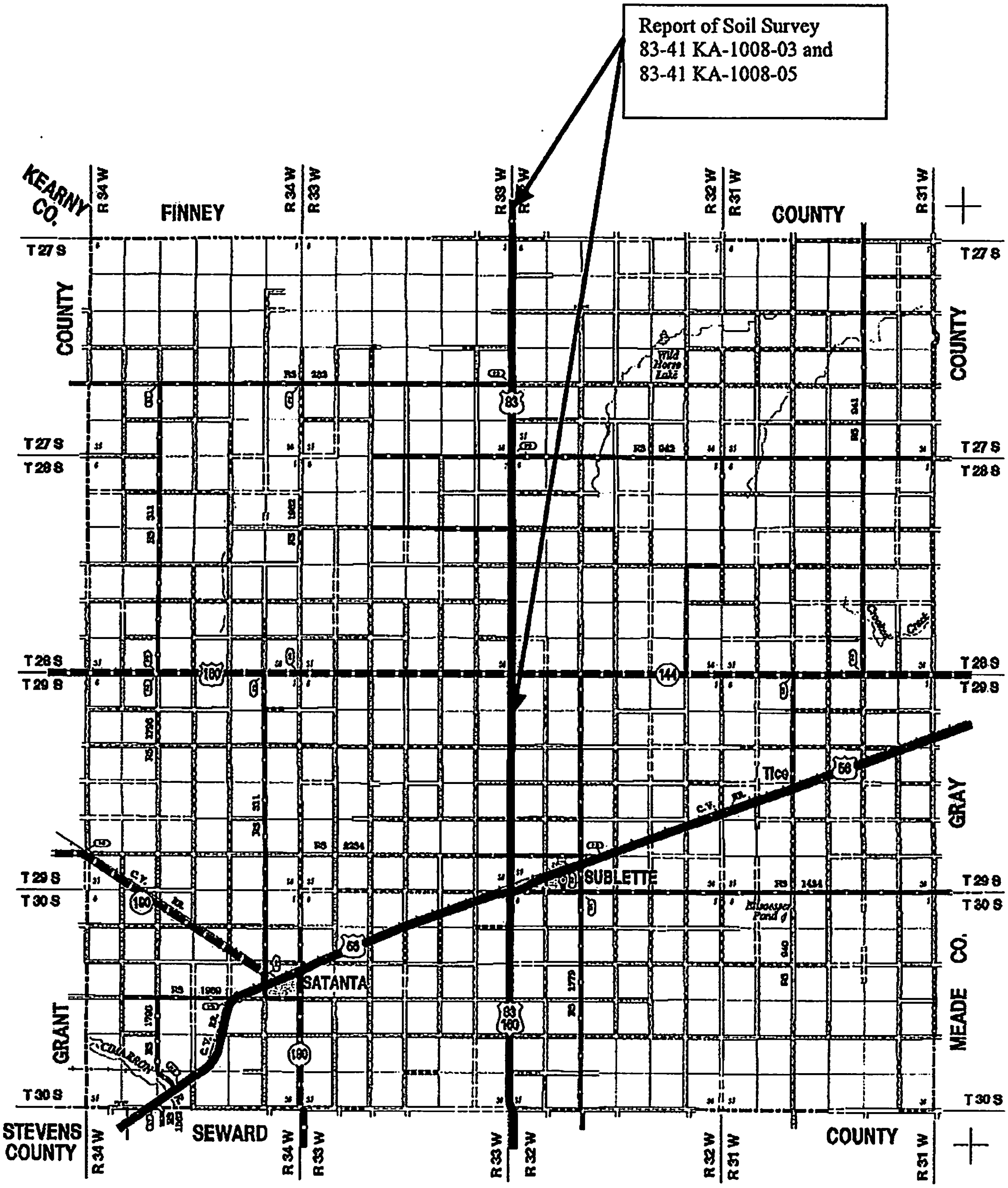
Isaac M. Ferguson, E.A.II
Soils Foundation Specialist

February 2013

Kansas
Department of Transportation

Bureau of Materials and Research

Geotechnical Unit



GENERAL HIGHWAY MAP

HASKELL COUNTY

KANSAS

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INTRODUCTION

This report contains recommendations for the grading portion of project 83-41KA-1008-03 and 83-41KA-1008-05. The information for this report covers the area along the proposed alignment of US-83 from one mile south of the US-83/US-160/K-144 junction to one mile north of the Haskell/Finney County Line. The information contained in this report was compiled from a field investigation conducted jointly by the Soils and Geology Sections of the Geotechnical Unit and a review of historical information.

SOIL CHARACTERISTICS

The soils encountered on this project are loessial. The soils through this corridor are classified as silty clay loams having a low to moderate swell potential ranging from one to three percent. Swell percentages two percent and above typically necessitate subgrade treatment. A summary of soil characteristics can be found in Table I.

SOIL SELECTION

Subgrade Soil: The top 6 inches of subgrade should be treated with 15% Type C Fly Ash; therefore, all of the soils encountered are usable in the subgrade.

Select Soil for Slopes: The general use of select soil is not recommended for this project. If select soil is needed in areas determined during construction, soils listed as "D", desirable in the comparative quality column for slopes in Table I are best suited for use as select soil for slopes to promote the growth of vegetation.

Backfill Soils for CMP's: All of the soils encountered on this project may be used to backfill CMP's. The Designer should use an E' value of 750 psi for designing CMP structures. The pipe bedding should be left uncompacted directly under the pipe to reduce invert-bending moments. The installations described would be a Type 3 SIDD installation as described in the AASHTO Standard Specifications for Bridges.

Embankment: All soil used in the top 18" of the embankment should conform to the following requirements: $8 \leq PI \leq 25$ and $20 \leq LL \leq 45$. Soils which contain substantial organic material, classified as OL or OH, according to the Unified Soil Classification System (ASTM D2487), should not be used to construct the embankment or subgrade. The organic material may be used as select soil to cap the sideslopes of the embankment.

Erosion Potential: The loessial soils in this area are low to moderately erodible on steep slopes when vegetation has been removed. These soils can be highly erodible on flatter slopes and may form erosion channels. To help prevent erosion, the slope should be seeded quickly and watered if necessary to assist in germination and growth. The use of erosion control blankets on slopes should help to prevent the slope from eroding and help establish vegetation.

COMPACTION CONTROL

Subgrade Soils: The subgrade should be compacted to Type AA specifications with MR 3-3 moisture control beneath flexible and rigid pavement.

Embankment Soils: Soils used in embankment construction below the top 18 inches and outside of the pavement limits should be compacted to Type A specifications with MR 5-5 moisture control.

Compaction for Backfill Soils: Soils used to backfill CMP structures should be compacted to Type AA specifications with MR 5-5 moisture control.

Compaction for Widening Soils: All embankment and subgrade soils used to widen the existing roadway should be compacted to Type A specifications with MR 5-5 moisture control. A minimum of 6 inches of compaction should be shown beneath the widened portion of the roadway.

EARTHWORK ADJUSTMENTS

A Volume Multiplication Factor (VMF) has been computed from tests and historical data. We recommend a VMF of 0.86 be used for all soils encountered along this project and soils obtained from borrow areas. The recommended VMF does not include quantities for initial consolidation (Qic) and settlement (Qs); These values should be included in the earthwork balance quantities and are listed in Table II.

CONCLUSION

This report completes the involvement of the Soil Section with this phase of the project. If any questions regarding this report arise, please contact Mr. Isaac Ferguson, Mr. Luke Metheny, or Mr. Jim Brennan. We can be reached by phone at (785)296-3008 or by email at ferguson@ksdot.org, lukem@ksdot.org, and brennan@ksdot.org.

Table I

Soil Characteristics

Project Number: 83-41 KA-1008-03 & 83-41 KA-1008-05

County: Haskell and Finney County

Laboratory Number: 12-2701

Date: 11/26/12

Sample Number	% Class	% Sand	% Clay	L.L.	P.L.	P.I.	Standard Density (pcf)	Optimum Moisture	Average Thickness (ft)	% Occurrence	Remarks	% Swell *	Comparative Quality	
													Slope	Subgrade
1A1	C	8	41	42	20	22	97	21	2.2	96		1.9	D	O
1C1	SiC	4	34	40	20	20	97	21	5.2	40	Similar to 1A1	2.3	D	O
1C2	C	25	30	36	17	19	106	16	5.7	82		1.8	U	U
1C3	C	10	34	36	19	17	106	16	4.2	18		1.9	U	U
1C4	SCL	44	20	26	16	10			5.3	39		1.5	O	D
1C5	CL	15	28	34	18	16	106	16	8.1	4	Similar to 1C2 and 1C3	1.6	U	U

Note:

Soils 1A1 and 1C1 are considered the same soil.

Soils 1C2, 1C3, and 1C5 are considered the same soil.

D=Desirable, S=Satisfactory, U=Usable, O=Objectionable.

* Estimated Swell Potential

TABLE-II
Quantities for Initial Consolidation and Settlement

Project:83-41 KA-1008-03 and 83-41 KA-1008-05

County:Haskell and Finney County

83-41 KA-1008-05			
Stationing		Qic (CYD)	Qs (CYD)
448+00	457+00	1220	1748
457+00	468+00	1426	1748
468+00	483+00	2222	3118
483+00	498+00	2222	3118
498+00	513+00	2267	3513
513+00	521+00	1185	1844
521+00	528+00	985	1183
528+00	542+33	2123	2979
542+33	545+00	396	471
545+00	558+00	1926	2996
558+00	580+00	3113	4423
580+00	603+00	3254	3920
603+00	618+00	2222	3118
618+00	633+00	2356	2773
633+00	648+00	2233	2665
648+00	663+00	2311	2730
663+00	676+00	1993	2366
676+00	678+00	307	233
678+00	693+00	2311	2730
693+00	702+00	1387	1638
702+00	705+00	444	339
705+00	729+00	3787	4472
729+00	731+00	296	226
731+00	749+00	2560	2517
749+00	758+00	1253	967
758+00	786+00	3899	3849
Totals		49,698	61,684

83-41 KA-1008-03			
Stationing		Qic (CYD)	Qs (CYD)
786+00	822+00	5173	5077
822+00	847+00	3704	4406
847+00	863+00	3212	2996
863+00	881+00	3680	4907
881+00	916+00	4978	5966
916+00	932+00	2264	2238
932+00	949+00	2733	1485
949+00	981+00	6945	7812
981+00	1001+00	3630	3437
1001+00	1030+00	4124	4943
1030+00	1091+00	8811	10573
1091+00	1121+00	4756	5590
1121+00	1166+00	6900	8190
1166+00	1169+00	473	459
1169+00	1174+00	148	0
1174+00	1179+00	770	583
1179+00	1181+00	296	226
1181+00	1213+50	4646	4584
1213+50	1233+00	2932	4567
1233+00	1250+00	2607	1983
1250+00	1259+00	1253	1237
1259+00	1265+00	844	650
1265+50	1272+00	1083	1658
Totals		75,962	83,567

Interchange Ramps			
Stationing		Qic (CYD)	Qs (CYD)
Ramp A			
10+00	15+00	196	290
15+00	19+00	228	352
19+00	24+29.62	761	2451
Ramp B			
10+00	14+00	196	318
14+00	17+00	304	819
17+00	19+80.58	484	1849
Ramp C			
24+67	26+00	247	907
26+00	29+00	393	1480
29+00	34+00	341	642
34+00	37+94.52	172	296
Ramp D			
20+17.69	24+00	595	1996
24+00	26+00	166	416
26+00	31+00	600	973
Totals		4,683	12,789

APPENDIX A

SOIL SURVEY NOTES

SOIL SURVEY NOTES

PROJECT NUMBER: 83-41 KA-1008-03 83-41 KA-1008-05 DATE: 8/7/2012 COUNTY: Haskell

Sta	Dist. C/L (ft)	Depth in (ft)	Similar to Sample	Sample Taken	Remarks:
					Survey Party: Isaac Ferguson, Kevin Vaughn,
					Arthur Peterson, John Nelson
438+81	10 Lt	0-1.5		1A1	10YR 3/2, very dark grayish brown
		1.5-8.1		1C1	10YR 7/4, very pale brown. Loess
		8.1-10.6		1C2	10 YR 3/2 ,very dark-brown. Firm with traces of calcareous
453+00	7 Lt	0-0.4	1A1		
		0.4-13.2	1C1		
		13.2-15.0		1C3	10 YR 6/4 light yellowish brown
468+00	6 Lt	0-1.2	1A1		
		1.2-6.1	1C1		
		6.1-9.8	1C3		
		9.8-11.1	1C2		
		11.1-13.8	1C1		
		13.8-15.1	1C3		
483+00	226.7 Lt	0-1.1	1A1		
		1.1-7.0	1C1		
		7.0-11.0	1C2		
		11.0-15	1C3		
498+00	498.0 Lt	0-2.0	1A1		
		2.0-4.0	1C3		
		4.0-15.0		1C4	5YR 5/5, Reddish brown, Silt w/ 40% sand

Sta	Dist. C/L (ft)	Depth in (ft)	Similar to Sample	Sample Taken	Remarks:
513+00	656.0 Lt	0-0.7	1A1		
		0.7-7.1	1C1		
		7.1-12.3	1C4		
		12.3-15.1	1C3		
528+00	696.0 Lt	0-0.3	1A1		
		0.3-3.9	1C1		
		3.9-12.9	1C3		
		12.9-15.1	1C4		
					8/14/2012
542+33	CL	0-3.0	1A1		
		3.0-10.5	1C2		
		10.5-19.0	1C4		
					8/7/2012
558+00	705.0 Lt	0-4.0	1A1		
		4.0-11.2	1C3		
		11.2-14.5	1C4		Refused in sand.
					8/8/2012
573+00	673.0 Lt	0-7.0	1A1		
		7.0-15.0	1C4		
588+00	516.5 Lt	0-2.5	1A1		
		2.5-7.5	1C3		
		7.5-11.1	1C2		
603+00	242 Lt	0-2.7	1A1		
		2.7-7.3	1C1		
		7.3-15.0	1C4		

Sta	Dist. C/L (ft)	Depth in (ft)	Similar to Sample	Sample Taken	Remarks:
618+00	537 Lt	0-3.9	1A1		
		3.9-7.1	1C1		
		7.1-11.1	1C2		
		11.1-15.1	1C4		
633+00	4 Rt	0-3.8	1A1		
		3.8-7.0	1C1		
		7.0-11.0	1C2		
		11.0-15.0	1C4		
648+00	4 Rt	0—1.7	1A1		
		1.7-7.3	1C1		
		7.3-10.6	1C2		Refusal
663+00	4 Rt	0-2.0	1A1		
		2.0-10.8	1C1		
		10.8-11.0	1C2		
		11.0-15.0	1C4		
678+00	3.5 Rt	0-1.1	1A1		
		1.1-6.0	1C1		
		6.0-7.0	1C3		
		7.0-11.3	1C2		
		11.3-15.3	1C4		

Sta	Dist. C/L (ft)	Depth in (ft)	Similar to Sample	Sample Taken	Remarks:
693+00	4 Rt	0-2.0	1A1		
		2.0-6.9	1C1		
		6.9-11.2	1C2		
		11.2-15.2	1C4		
708+00	5 Lt	0-2.0	1A1		
		2.0-7.2	1C1		
		7.2-9.4	1C2		Refusal
723+00	5 Lt	0-3.9	1A1		
		3.9-7.1	1C2		
		7.1-11.1	1C4		
		11.1-13.8	1C2		Refusal
738+00	5 Lt	0-1.3			Fill from ditch line
		1.3-3.0	1A1		
		3.0-3.4	1C1		
		3.4-7.2	1C2		
753+00	5.5 Lt	0-1.0			Fill
		1.0-3.5	1A1		
		3.5-6.5	1C1		
		6.5-6.9	1C2		
		6.9-12.5	1C4		
		12.5-12.9	1C2		Refused

Sta	Dist. C/L (ft)	Depth in (ft)	Similar to Sample	Sample Taken	Remarks:
					8/9/12
					Equipment: CME 45 and Bull Probe
					Survey Party: Isaac Ferguson, Kevin Vaughn, Arthur Peterson, Clint Hutchinson, and John Nelson
768+00	5.0 Lt	0-2.8	1A1		
		2.8-9.8	1C1		
		9.8-16.1	1C4		
783+00	5.5 Lt	0-1.1			Fill
		1.1-1.4	1A1		
		1.4-7.1	1C1		
		7.1-11.1	1C2		
		11.1-15.1	1C4		
798+00	4.4 Lt	0-1.8	1A1		
		1.8-7.3	1C1		
		7.3-10.5	1C2		Traces of calcareous. Refused.
813+00	3.9 Rt	0-3.6	1A1		
		3.6-7.1	1C2		
		7.1-9.9	1C4		
		9.9-11.1	1C2		Refused
828+00	11.6 Lt	0-4.0	1C1		
		4.0-10.4	1C2		
		10.4-15.2	1C4		

Sta	Dist. C/L (ft)	Depth in (ft)	Similar to Sample	Sample Taken	Remarks:
843+00	22.0 Lt	0-1.8	1A1		
		1.8-7.3	1C1		
		7.3-8.8	1C2		Refused
858+00	4.4 Rt	0-2.9	1A1		
		2.9-4.7	1C1		
		4.7-5.0	1C2		Refused
873+00	3.9 Rt	0-2.7	1A1		
		2.7-6.0	1C1		
		6.0-6.1	1C2		Refused
888+00	4.7 Rt	0-1.5	1A1		
		1.5-8.9	1C2		
					8/14/2012
903+00	3.5 Rt	0-0.5	1A1		
		0.5-3.0	1C3		
		3.0-6.9	1C2		
		6.9-14.9	1C4		
918+00	4.3 Rt	0-0.6	1A1		
		0.6-7.5	1C2		
		7.5-15.0	1C4		
933+00	11.9 Rt	0-2.9	1A1		
		2.9-9.1	1C2		
		9.1-14.1	1C4		

Sta	Dist. C/L (ft)	Depth in (ft)	Similar to Sample	Sample Taken	Remarks:
945+00	CL	0-3.8			Fill
		3.8-5.5	1A1		
		5.5-13.0	1C2		
		13.0-16.2	1C4		
960+00	14 Lt	0-2.8	1A1		
		2.8-11.0		1C5	
		11.0-21.1	1C4		
975+00	CL	0-3.0	1A1		
		3.0-12.0	1C2		
		12-16.1	1C4		
989+99	CL	0-4.5	1A1		
		4.5-13.0	1C2		
		13.0-21.0	1C4		
1005+00	1 Rt	0-3.0	1A1		
		3.0-11.0	1C2		
		11.0-16.0	1C4		
1020+02	1 Rt	0-1.5	1A1		
		1.5-12.0	1C2		
		12.0-16.0	1C4		
1035+00	3 Rt	0-2.5	1A1		
		2.5-14.0	1C2		
		14.0-15.0	1C4		

Sta	Dist. C/L (ft)	Depth in (ft)	Similar to Sample	Sample Taken	Remarks:
1050+00	2 Rt	0-3.0	1A1		
		3.0-9.0	1C2		
		9.0-15.0	1C4		
1065+00	2 Rt	0-1.4	1A1		
		1.4-11.0	1C2		
		11.0-20.0	1C4		
1080+00	2 Rt	0-3.0	1A1		
		3.0-13.0	1C2		
		13.0-16.0	1C4		
1095+02	CL	0-2.5	1A1		
		2.5-11.5	1C2		
		11.5-16.1	1C4		
1110+00	1 Rt	0-2.5			Shoulder Fill
		2.5-9.5	1C2		
		9.5-16.0	1C4		
1125+00	2 Rt	0-2.0	1A1		
		2.0-7.5	1C2		
		7.5-15.8	1C4		
1140+00	1 Rt	0-2.5	1A1		
		2.5-13.0	1C2		
		13.0-16.2	1C4		

Sta	Dist. C/L (ft)	Depth in (ft)	Similar to Sample	Sample Taken	Remarks:
1155+00	7 Rt	0-3.5	1A1		
		3.5-13.5	1C2		
		13.5-16.5	1C4		
1170+00	22 Rt	0-1.5	1A1		
		1.5-11.0	1C2		
		11.0-16.0	1C4		
1185+00	14.2 Rt	0-1.5	1A1		
		1.5-7.6	1C2		Refused
1200+00	14 Rt	0-0.5	1A		
		0.5-7.6	1C3		
1215+00	16 Rt	0-0.5	1A1		
		0.5-7.1	1C2		SIS
1230+00	14 Rt	0-3.9	1A1		
		3.9-7.0	1C2		
1245+00	6 Lt	0-2.5	1A1		
		2.5-14.0	1C2		
		14.0-16.2	1C4		
1260+00	6 Lt	0-2.5	1A1		
		2.5-10.0	1C2		
		10.0-16.5	1C4		
1275+00	6 Lt	0-0.5	1A1		
		0.5-7.0	1C2		
		7.0-16.5	1C4		

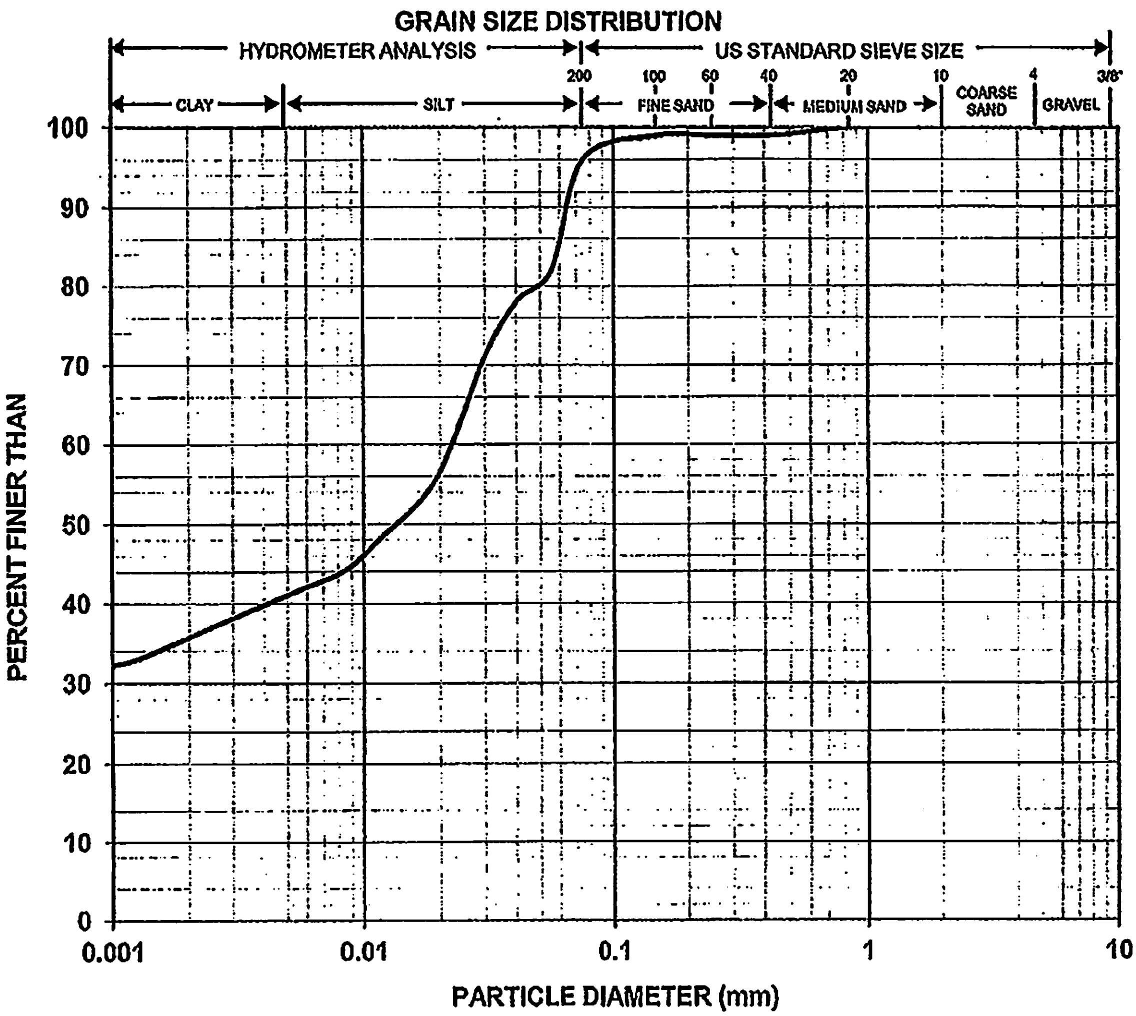
APPENDIX B

LABORATORY TESTS RESULTS

KANSAS DEPARTMENT OF TRANSPORTATION
REPORT OF SOIL TESTS

SUBMITTED BY: Isaac Ferguson **ADDRESS:** 2300 Van Buren **LAB NO.** 012-2701

PROJECT: 83-41 KA-1008-5 **COUNTY:** Haskell **DATE:** 9/4/12



PHYSICAL PROPERTIES

SAMPLE NUMBER	STATION	CL DIST.	DEPTH (ft)	L.L.	P.L.	P.I.	% RET. ON 10 SEIVE	SPEC. GRAV. (PASS NO. 10)	CLASS KS/UNIF.
1-A1	453+00	7Lt	0-3.0	42	20	22	0.0	2.63	C / CL

Test Method: AASHTO T-88 (Iowa Air Dispersion)

REMARKS

R.E. Kreider, P.E.
Chief of Bureau of Materials and Research

By [signature]
Luke Metheny, P.E., Soils Engineer

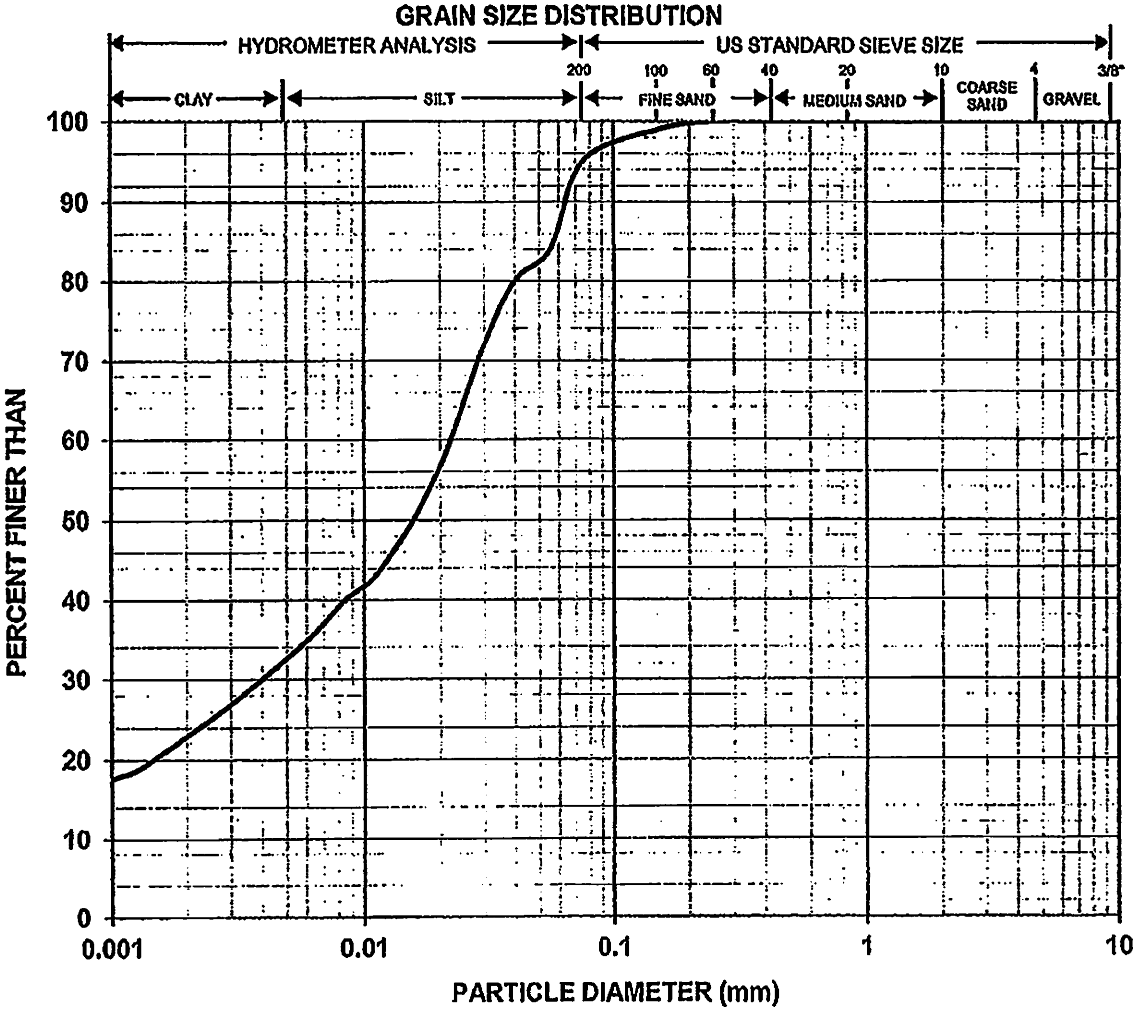
Rev. 3-99 D.O.T. NO. 635

KANSAS DEPARTMENT OF TRANSPORTATION
REPORT OF SOIL TESTS

SUBMITTED BY: Isaac Ferguson **ADDRESS:** 2300 Van Buren **LAB NO.** 012-2701

PROJECT: 83-41 KA-1008-5 **COUNTY:** Haskell **DATE:** 9/5/12

GRAIN SIZE DISTRIBUTION



PHYSICAL PROPERTIES

SAMPLE NUMBER	STATION	CL DIST.	DEPTH (ft)	L.L.	P.L.	P.I.	% RET. ON 10 SEIVE	SPEC. GRAV. (PASS NO. 10)	CLASS KS/UNIF.
1-C1	463+00	7Lt	3.0-5.0	40	20	20	0.0	2.61	SIC / CL

Test Method: AASHTO T-88 (Iowa Air Dispersion)

REMARKS

R.E. Kreider, P.E.
Chief of Bureau of Materials and Research

By [signature] for
Luke Metheny, P.E., Soils Engineer

Rev. 3-99

D.O.T. NO. 635

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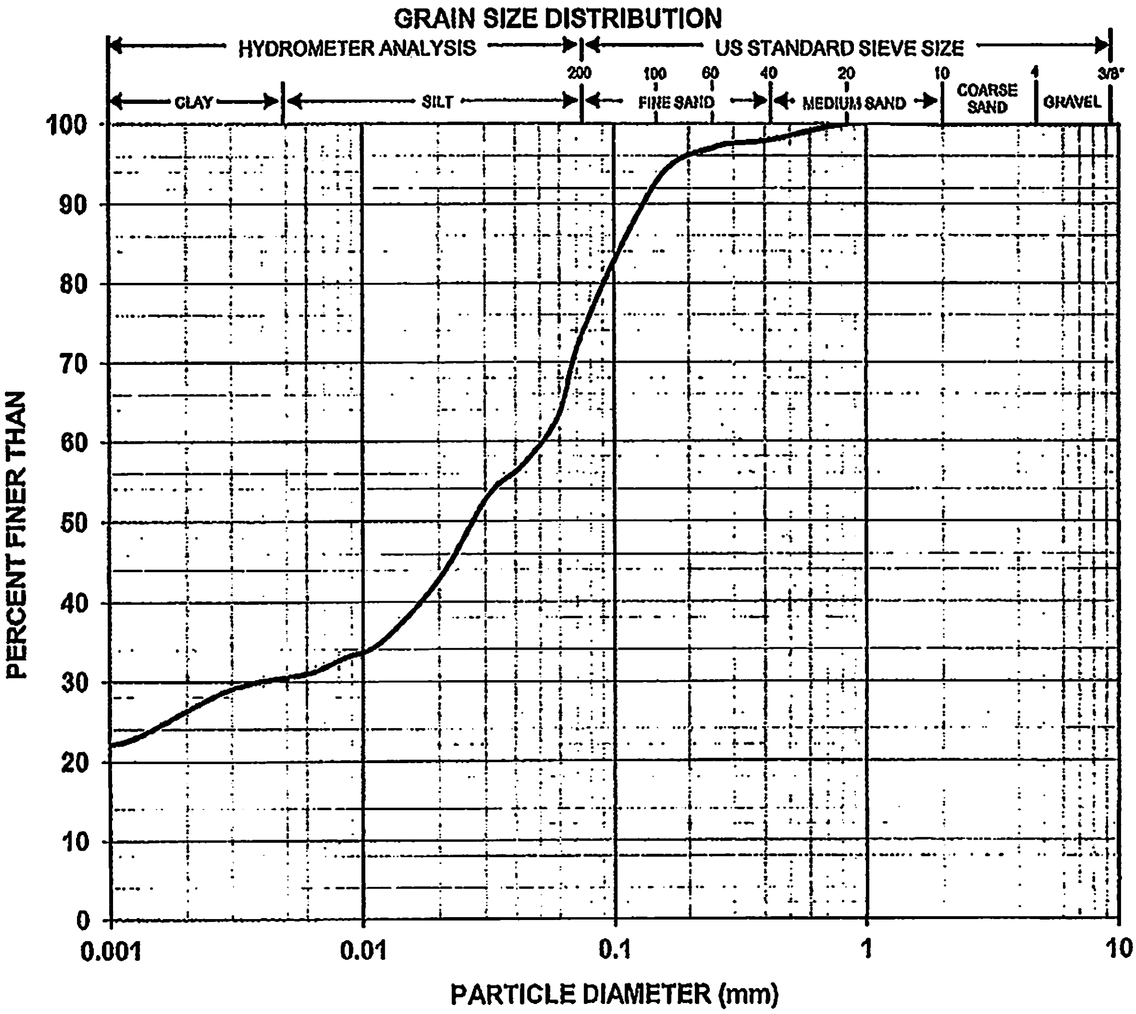
REPORT OF SOIL TESTS

SUBMITTED BY: Isaac Ferguson **ADDRESS:** 2300 Van Buren **LAB NO.** 012-2701

PROJECT: 83-41 KA-1008-5 **COUNTY:** Haskell **DATE:** 9/4/12



PHYSICAL PROPERTIES

SAMPLE NUMBER	STATION	CL DIST.	DEPTH (ft)	L.L.	P.L.	P.I.	% RET. ON 10 SEIVE	SPEC. GRAV. (PASS NO. 10)	CLASS KS/UNIF.
1-C2	463+00	7Lt	5.0-6.0	36	17	19	0.0	2.67	C / CL

Test Method: AASHTO T-88 (Iowa Air Dispersion)

REMARKS

R.E. Kreider, P.E.
Chief of Bureau of Materials and Research

By
Luke Metheny, P.E., Soils Engineer

Rev. 3-99

D.O.T. NO. 635

KANSAS DEPARTMENT OF TRANSPORTATION
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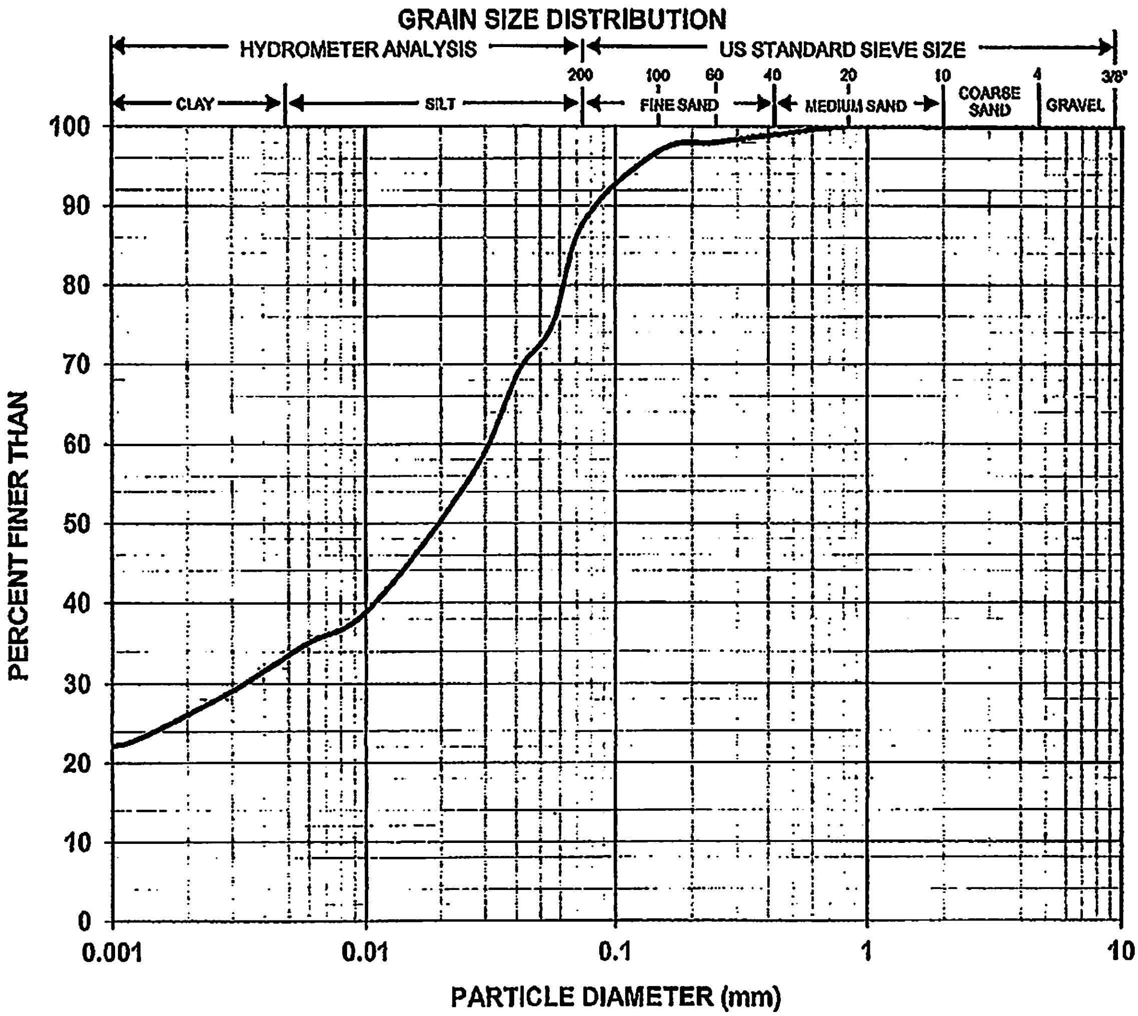


PHYSICAL PROPERTIES

SAMPLE NUMBER	STATION	CL DIST.	DEPTH (ft)	L.L.	P.L.	P.I.	% RET. ON 10 SEIVE	SPEC. GRAV. (PASS NO. 10)	CLASS KS/UNIF.
1-C3	468+00	6Lt	7.0-11.0	36	19	17	0.0	2.67	C / CL

Test Method: AASHTO T-88 (Iowa Air Dispersion)

REMARKS

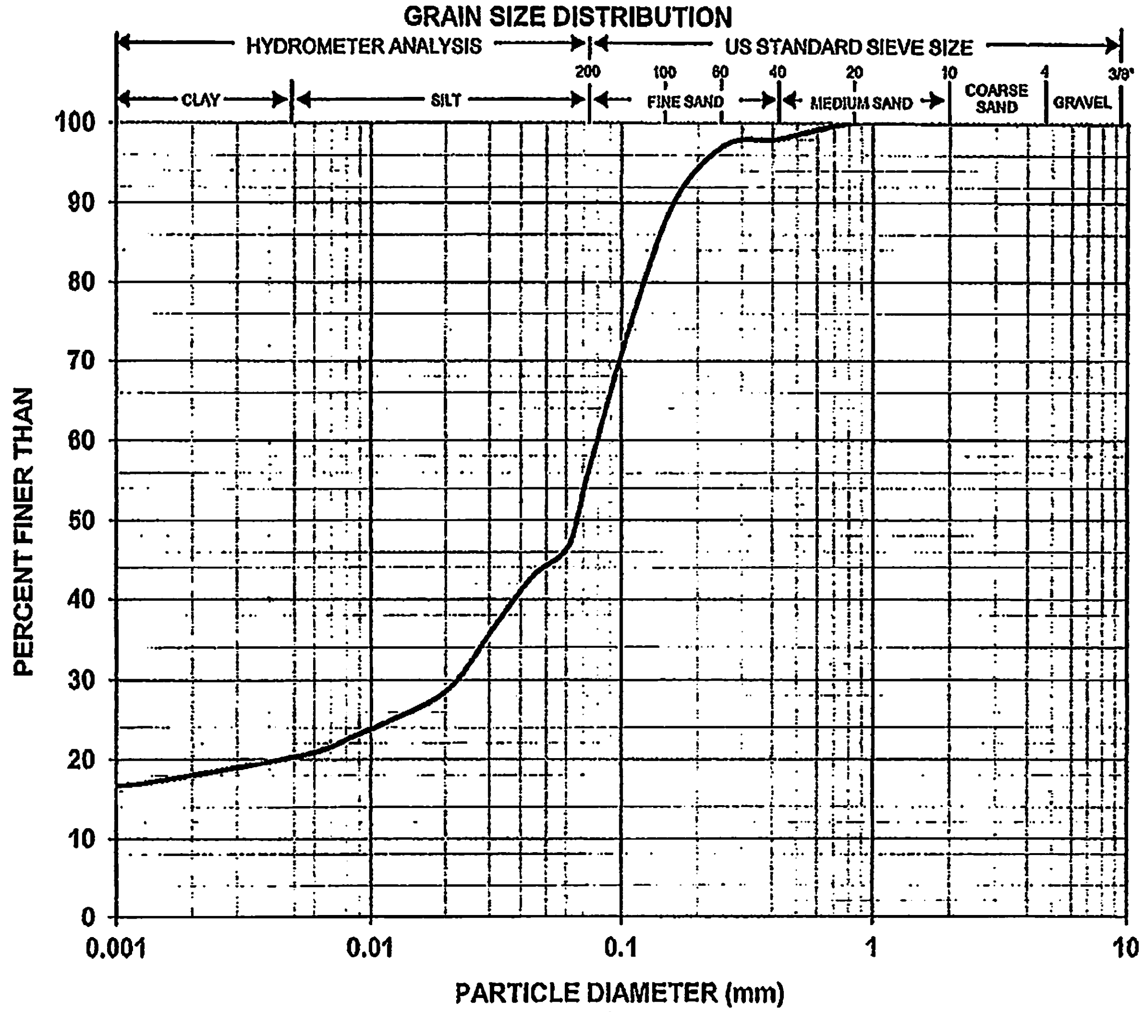
R.E. Kreider, P.E.
Chief of Bureau of Materials and Research

By [signature] for
Luke Metheny, P.E., Soils Engineer

Rev. 3-99 D.O.T. NO. 635

KANSAS DEPARTMENT OF TRANSPORTATION
REPORT OF SOIL TESTS

SUBMITTED BY: Isaac Ferguson	**ADDRESS:**	2300 Van Buren	**LAB NO.**	012-2701
PROJECT:	83-41 KA-1008-5	**COUNTY:** Haskell	**DATE:**	9/5/12



PHYSICAL PROPERTIES

SAMPLE NUMBER	STATION	CL DIST.	DEPTH (ft)	L.L.	P.L.	P.I.	% RET. ON 10 SEIVE	SPEC. GRAV. (PASS NO. 10)	CLASS KS/UNIF.
1-C4	498+00	498Lt	7.0-15.0	26	16	10	0.0	2.69	SCL / CL

Test Method: AASHTO T-88 (Iowa Air Dispersion)

REMARKS

R.E. Kreider, P.E.
Chief of Bureau of Materials and Research

By
Luke Metheny, P.E., Soils Engineer

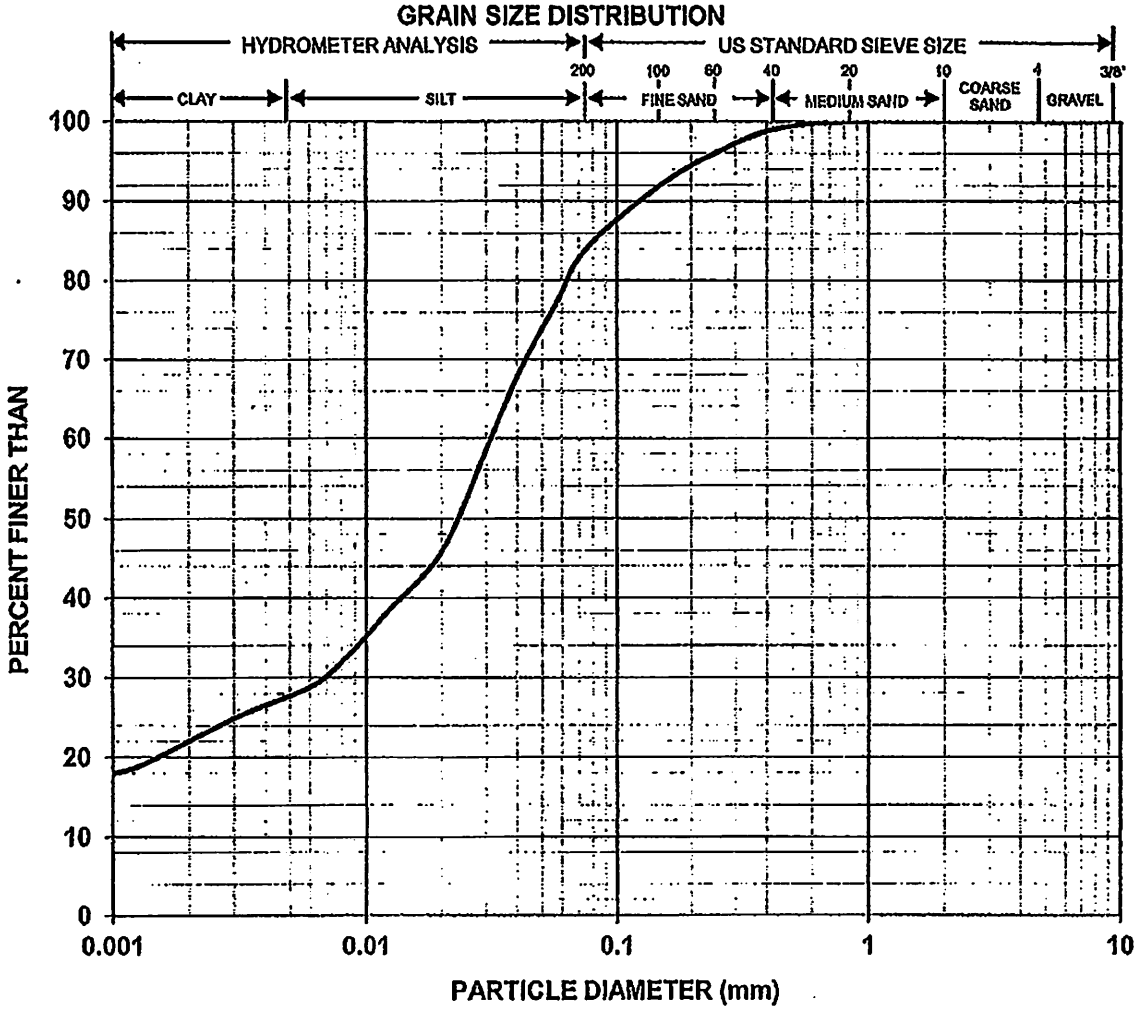
Rev. 3-99

D.O.T. NO. 635

KANSAS DEPARTMENT OF TRANSPORTATION
REPORT OF SOIL TESTS

SUBMITTED BY: Isaac Ferguson **ADDRESS:** 2300 Van Buren **LAB NO.** 012-2701

PROJECT: 83-41 KA-1008-5 **COUNTY:** Haskell **DATE:** 9/4/12



PHYSICAL PROPERTIES

SAMPLE NUMBER	STATION	CL DIST.	DEPTH (ft)	L.L.	P.L.	P.I.	% RET. ON 10 SEIVE	SPEC. GRAV. (PASS NO. 10)	CLASS KS/UNIF.
1-C5	960+00	14Lt	3.0-5.0	34	18	16	0.0	2.63	CL / CL

Test Method: AASHTO T-88 (Iowa Air Dispersion)

REMARKS

R.E. Kreider, P.E.
Chief of Bureau of Materials and Research

By [signature] for
Luke Melhony, P.E., Soils Engineer

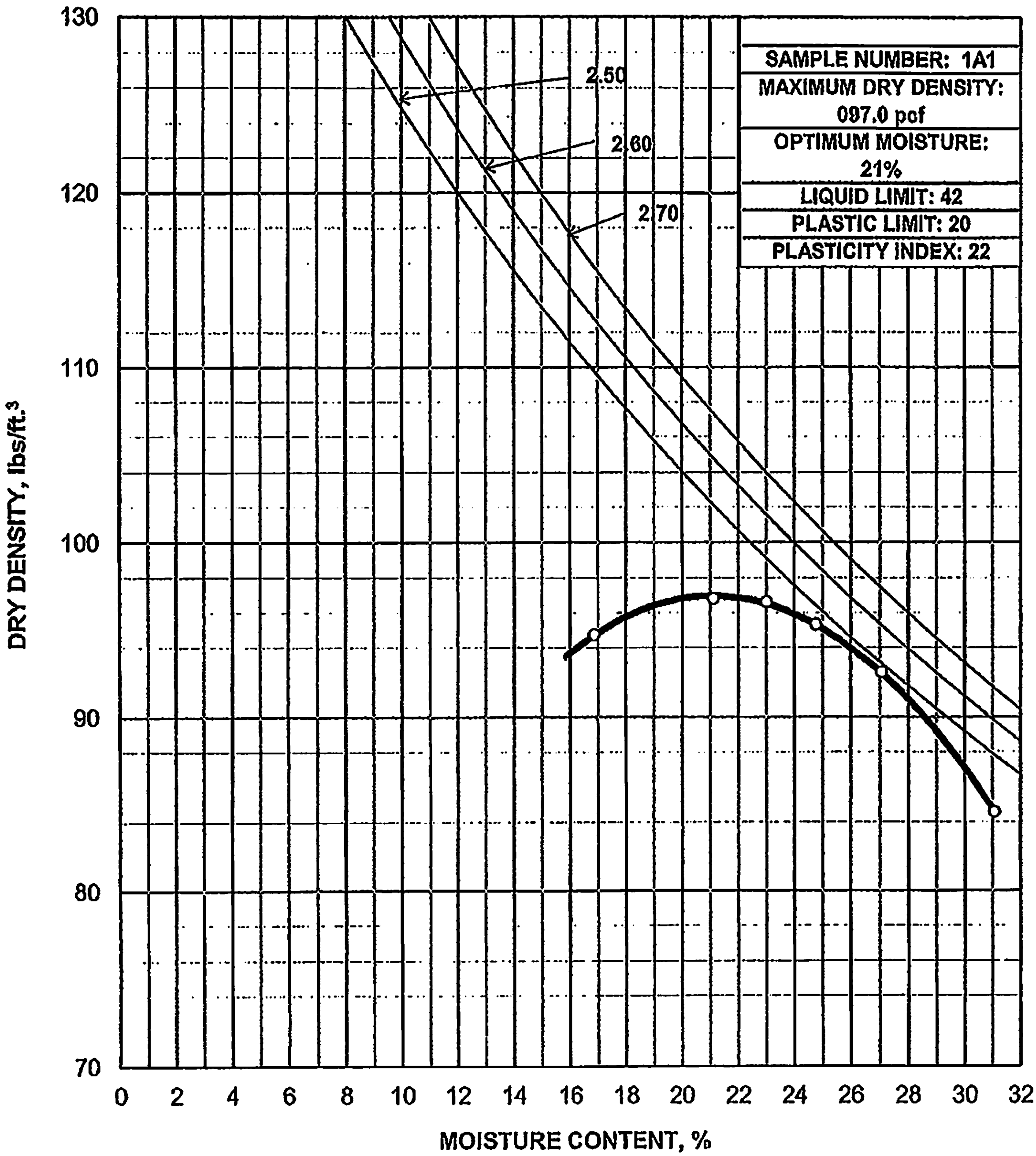
Rev. 3-99 D.O.T. NO. 635

KANSAS DEPARTMENT OF TRANSPORTATION

REPORT OF SOIL COMPACTION TESTS

SUBMITTED BY Isaac Ferguson **ADDRESS** 2300 Van Buren **LAB. NO** 012-2701

PROJECT 83-41 KA-1008-5 **COUNTY** Haskell **DATE** 9-18-12



TEST METHOD AASHTO-T99

REMARKS

R.E. Kreider, P.E.
Chief, Bureau of Materials and Research
BY [signature] for
Luke Metheny, P.E., Soils Engineer

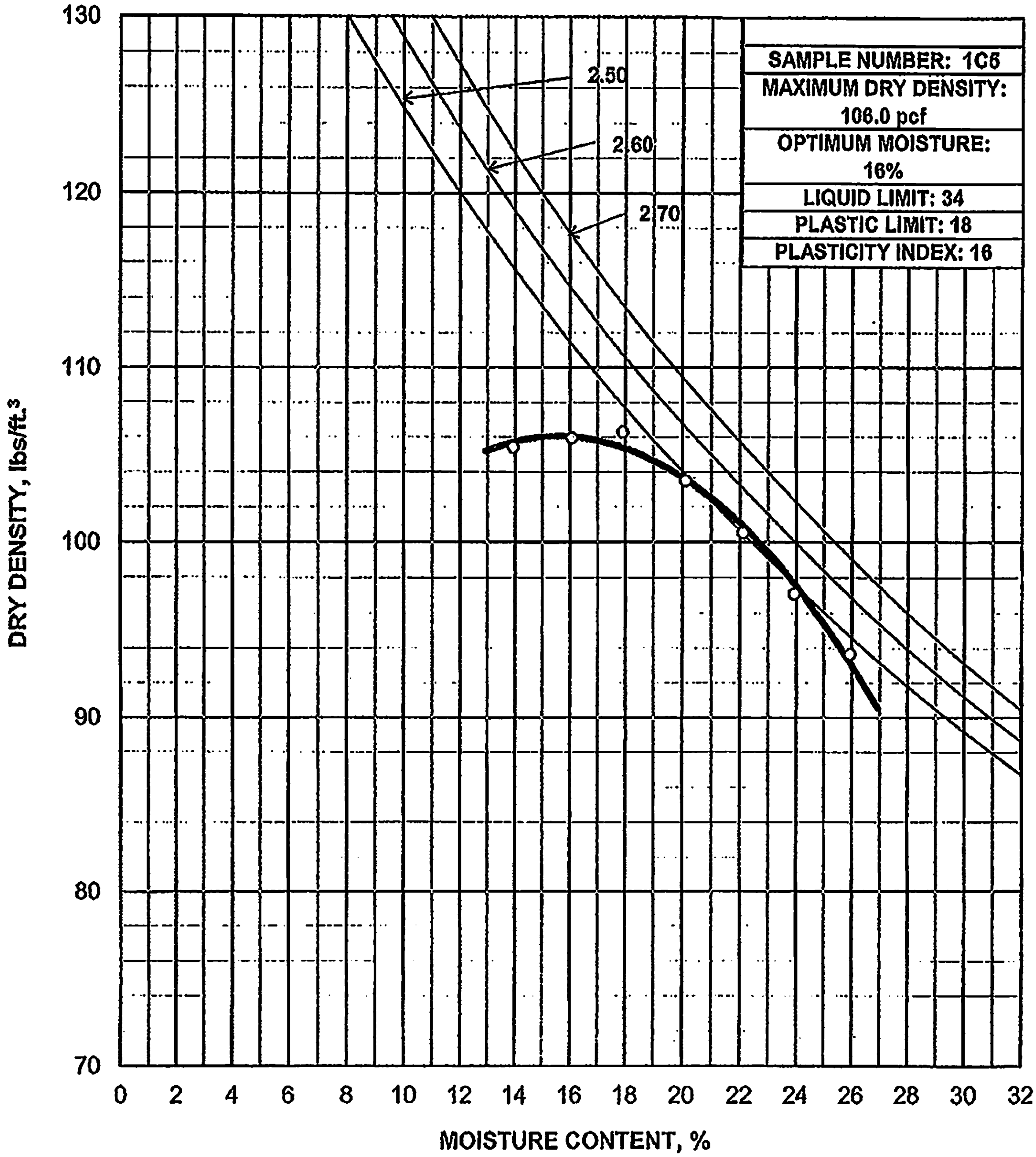
D.O.T. Form No. 638

KANSAS DEPARTMENT OF TRANSPORTATION

REPORT OF SOIL COMPACTION TESTS

SUBMITTED BY Isaac Ferguson **ADDRESS** 2300 Van Buren **LAB. NO** 012-2701

PROJECT 83-41 KA-1008-5 **COUNTY** Haskell **DATE** 11-21-12



TEST METHOD AASHTO-T99

REMARKS

R.E. Kreider, P.E.

~~Chief, Bureau of Materials and Research~~

BY [signature] for

~~Luke Metheny, P.E., Soils Engineer~~

D.O.T. Form No. 638

APPENDIX C

SOIL SURVEY VMF CALCULATIONS

Soil Survey VMF Calculations

Project 83-41 KA-1008 County Haskell Date 12/17/2012

Station (2012)	Station (1954)	Distance from Center Line (ft)	Depth (ft)	Lab. No.	Sample No.	Cut Density (Dc) (pcf)	Standard Compaction (pcf)	Present Field Moisture (%)	Probable Rolled Density*(Df)	Computed Shrinkage	VMF	GROSS	USE
588+00	50+00	516.5 Lt	0-11.1	12-2701	1A1,1C3,1C4	81	104	14	94	16	0.82	0.7	0.7
603+00	80+00	242 Lt	0-15	"	1A1,1C1	80	97	15	94	21	0.87	0.75	0.75
618+00	100+00	537 Lt	0-15.1	"	1A1,1C1,1C2,1C4	78	100	15	93	13	0.82	0.7	0.7
633+00	120+00	4 Rt	0-15	"	1A1,1C1,1C2,1C4	81	100	21	94	27	0.85	0.73	0.73
648+00	140+00	4 Rt	0-10.6	"	1A1,1C1,1C2	78	100	19	94	8	0.82	0.7	0.7
663+00	160+00	4 Rt	0-15	"	1A1,1C1,1C2,1C4	74	97	16	93	13	0.8	0.68	0.68
678+00	180+00	3.5 Rt	0-15.3	"	1A1,1C1,1C2,1C3,1C4	87	101	13	94	22	0.91	0.79	0.79
693+00	200+00	4 Rt	0-15.2	"	1A1,1C1,1C2,1C4	82	100	19	94	25	0.86	0.74	0.74
708+00	220+00	5 Lt	0-9.4	"	1A1,1C1,1C2	80	99	13	93	12	0.85	0.73	0.73
723+00	240+00	5 Lt	0-13.8	"	1A1,1C2,1C4	77	103	13	93	7	0.79	0.67	0.67
738+00	260+00	5 Lt	0-7.2	"	1A1,1C1,1C2	75	103	23	94	7	0.77	0.65	0.65
753+00	280+00	5.5 Lt	1-12.9	"	1A1, 1C1, 1C2,1C4	80	99	16	94	12	0.85	0.73	0.73

Soil Survey VMF Calculations

Project 83-41 KA-1008 County Haskell Date 12/17/2012

Station (2012)	Station (1954)	Distance from Center Line (ft)	Depth (ft)	Lab. No.	Sample No.	Cut Density (Dc) (pcf)	Standard Compaction (pcf)	Present Field Moisture (%)	Probable Rolled Density*(Df)	Computed Shrinkage	VMF	GROSS	USE
768+00	300+00	5 Lt	0-16.1	"	1A1, 1C1, 1C4	85	97	15	94	22	0.92	0.8	0.8
783+00	320+00	5.5 Lt	0-15.1	"	1A1,1C1,1C2,1C4	87	101	12	94	22	0.91	0.79	0.79
798+00	340+00	4.4 Lt	0-10.5	"	1A1, 1C2, 1C4	88	100	14	94	21	0.93	0.81	0.81
813+00	360+00	3.9 Rt	0-11.1	"	1A1, 1C2, 1C4	86	103	15	93	7	0.88	0.76	0.76
828+00	380+00	11.6 Lt	0-15.2	"	1C1,1C2,1C4	81	103	18	93	8	0.83	0.71	0.71
843+00	400+00	22 Lt	0-8.8	"	1A1, 1C1, 1C2	77	99	14	93	13	0.82	0.7	0.7
858+00	420+00	4.4 Rt	0-5	"	1A1, 1C1, 1C2	77	98	11	94	13	0.83	0.71	0.71
873+00	440+00	3.9 Rt	0-6.1	"	1A1, 1C1, 1C2	77	97	12	94	16	0.84	0.72	0.72
888+00	460+00	4.7 Rt	0-8.9	"	1A1, 1C2	82	104	15	94	16	0.95	0.83	0.83
903+00	480+50	3.5 Rt	0-14.9	"	1A1,1C2,1C3,1C4	87	105	12	94	15	0.87	0.75	0.75
918+00	500+00	4.3 Rt	0-15	"	1A1,1C2, 1C4	86	105	15	93	9	0.86	0.74	0.74
933+00	520+00	11.9 Rt	0-14.1	"	1A1, 1C2, 1C4	83	103	24	92	10	0.85	0.73	0.73
945+00	540+00	CL	3.8-16.2	"	1A1,1C2,1C4	82	104	19	94	16	0.83	0.71	0.71

Soil Survey VMF Calculations

Project 83-41 KA-1008 County Haskell Date 12/17/2012

Station (2012)	Station (1954)	Distance from Center Line (ft)	Depth (ft)	Lab. No.	Sample No.	Cut Density (Dc) (pcf)	Standard Compaction (pcf)	Present Field Moisture (%)	Probable Rolled Density*(Df)	Computed Shrinkage	VMF	GROSS	USE
960+00	560+00	14 Lt	0-21.1	"	1A1,1C5, 1C4	83	104	16	94	21	0.84	0.72	0.72
975+00	580+00	CL	0-16.1	"	1A1, 1C2, 1C4	81	104	16	94	11	0.82	0.7	0.7
989+99	600+00	CL	0-21	"	1A1,1C2,1C4	81	97	22	92	3	0.88	0.76	0.76
1160+00	620+00	40 Lt.	0.1-3.5	"	1A, 1B, 1C	87	99	12	94	8	0.93	0.81	0.81
1180+00	640+00	40 Lt.	.1-3.5	"	1A, 1B, 1C1	86	98	13	93	8	0.92	0.8	0.8
1200+00	660+00	40 Lt.	0.1-3.5	"	1A, 1B, 1C1	90	98	12	93	3	0.97	0.85	0.85
1220+00	682+50	40 Rt.	0.2-8.5	"	1A, 1C, 1C2	101	112	7	106	5	0.95	0.83	0.83
1240+00	695+00	50 Lt.	0.1-3.5	"	1A, 1B, 1C1	83	98	11	93	12	0.89	0.77	0.77
			Final Averages:			**83**	**101**	**15**	**94**	**13.4**	**0.86**	**0.74**	**0.74**

*Based on 95% Standard Compaction

**Volume Multiplication Factor =D_c/D_f = The amount of embankment which can be constructed from on cubic yard of excavation.

GROUPING USED IN TEXTURAL CLASSIFICATION OF SOILS

CLASS		PERCENTAGE OF SOIL FRACTIONS PRESENT		
NAME		SAND	SILT	CLAY
Sand	S	80 - 100	0-20	0-20
Sandy Loam	SL	50-80	0-50	0-20
Sandy Clay Loam	SCL	50 - 80	0-30	20-30
Sandy Clay	SC	50-70	0-20	30-50
Silt	Si	0-20	80-100	0-20
Silty Loam	Sil	0-50	50-80	0-20
Silty Clay Loam	SicL	0-30	50-80	20-30
Silty Clay	SiC	0-20	50-70	30-50
Clay	C	0-50	0-50	30 - 100
Clay Loam	CL	20-50	20-50	20-30
Loam	L	30 - 50	30 - 50	0-20

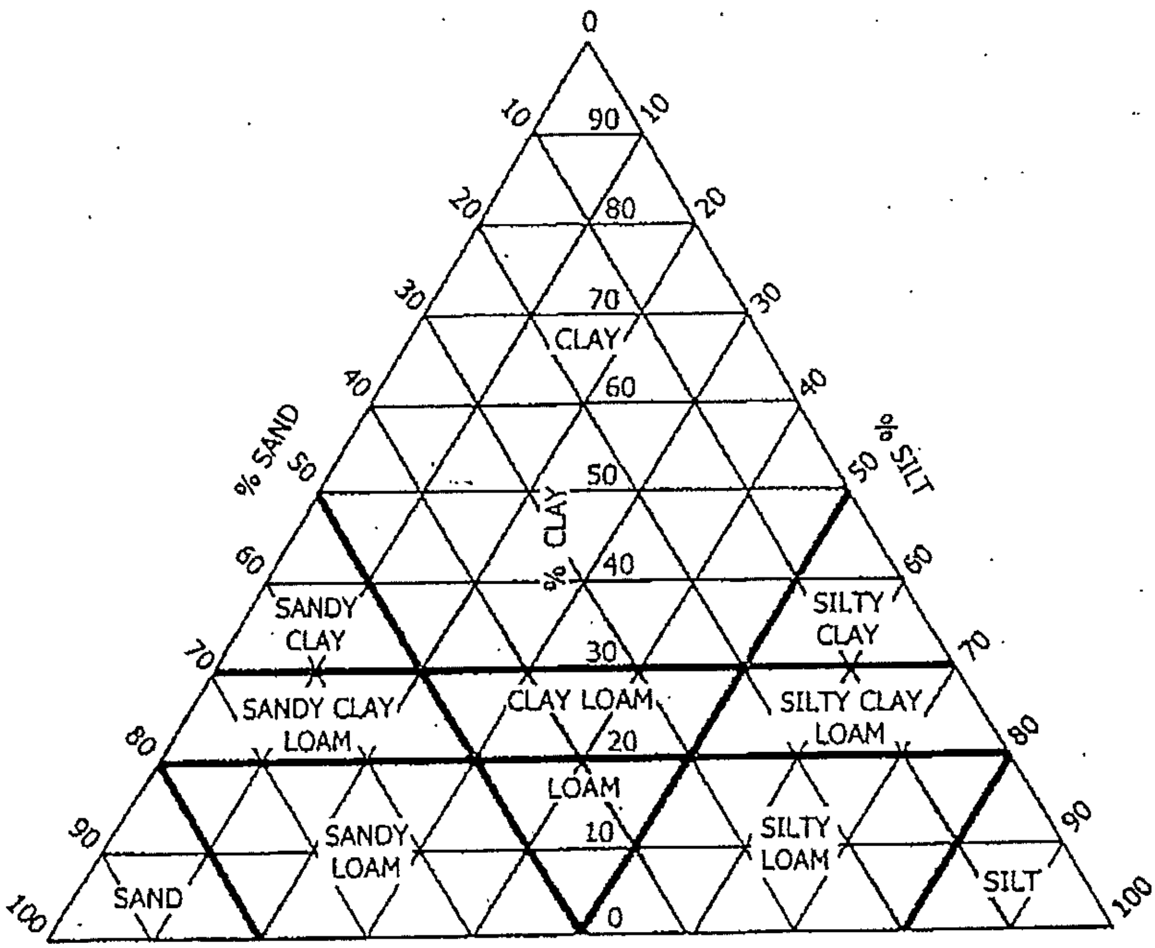


CHART FOR TEXTURAL CLASSIFICATION OF SOIL

SECTION 205

EXCAVATION AND EMBANKMENT FOR HIGHWAYS

205.1 DESCRIPTION

Excavate, haul, place, remove and dispose of the specified materials. Construct the embankments as specified in the Contract Documents. Compact the earthwork according to the requirements for the type of compaction and moisture range specified in the Contract Documents.

BID ITEMS	UNITS
Common Excavation	Cubic Yard
Common Excavation (Contractor-Furnished)	Cubic Yard
Rock Excavation	Cubic Yard
Rock Excavation (Non-Durable Shale)	Cubic Yard
Unclassified Excavation	Cubic Yard
Common Excavation (Unstable)	Cubic Yard
Common Excavation (Unsuitable)	Cubic Yard
Compaction of Earthwork (Type *) (MR-**)	Cubic Yard
Embankment	Cubic Yard
Embankment (Contractor-Furnished)	Cubic Yard
Eradication of Traveled Way	Station
Water (Grading) (Set Price)	M Gallon

*Type of Compaction
**Moisture Range

205.2 MATERIALS

Provide water for earthwork compaction that complies with **DIVISION 2400**.

If "Common Excavation (Contractor-Furnished)" is specified, provide soil or a mixture of soil and gravel, stone or other acceptable material. Provide material that is similar to the material shown in the Contract Documents or found in the Report of Soil Survey. Provide material with a quality satisfactory for the purpose intended. Do not use material that has sod, roots, stumps and other perishable and deleterious matter. Provide soil that complies with the requirements shown in the Contract Documents for the material used in the top 18 inches of the embankment.

The Engineer will accept the material based on compliance with these requirements and visual inspection of the material placed on the project.

Provide crushed stone for backfill that complies with **DIVISION 1100**.

205.3 CLASSIFICATION OF EXCAVATION

The geological information shown in the Contract Documents is based on studies made in the field, and represents the best information available to KDOT. The classification of embankment and drainage excavation as "Common Excavation", "Rock Excavation" or "Rock Excavation (Non-Durable Shale)", which classifications shall include all materials of whatever nature encountered, is shown in the Contract Documents. As the work is performed, the Engineer in conjunction with the Regional Geologist will determine if the classification of embankment and drainage excavation requires adjustment. The Engineer has the authority to identify and define the physical characteristics that determine the classification. The classification of materials for excavation is based on the materials in an unfrozen condition.

a. Common Excavation. Common excavation is all excavation not included as rock excavation or excavation otherwise classified. The following are included in common excavation: hot mix asphalt or concrete sidewalk, concrete ditch lining, concrete or stone wash checks and hot mix asphalt pavement 6 inches or less in thickness.

Depending on the makeup and characteristics of the common excavation, some material may or may not be used for embankment. The Engineer will identify which materials may not be used for embankment.

b. Common Excavation (Contractor-Furnished). Common excavation (Contractor-Furnished) is material provided by the Contractor that complies with the material requirements of this specification.

Non-durable shale provided as common excavation (Contractor-Furnished) shall be manipulated (sized) with equipment and water as required for non-durable shale excavation.

c. Rock Excavation. Rock excavation includes firm, rigid and unweathered sedimentary, igneous and metamorphic rock that is naturally in-place. Boulders or detached stones with a volume of 2 cubic yards or more are classified as rock excavation.

Portland cement concrete pavement, portland cement concrete base, cement treated base, hot mix asphalt pavement greater than 6 inches in thickness, concrete curb and gutter and any hot mix asphalt placed upon these structures is classified as rock excavation.

When common excavation is interlayered with the rock excavation, and the common excavation makes up 25% or less of the volume, the entire volume is classified as rock excavation.

d. Rock Excavation (Non-Durable Shale). Rock excavation (Non-Durable Shale) is non-durable rock shale that if used in embankments is required to be manipulated with construction equipment and water added until it is broken down to particle sizes shown in **subsection 205.4c**.

e. Unclassified Excavation. Unclassified excavation includes all excavation, regardless of type, nature or condition of materials encountered. When excavation is unclassified, the Contractor assumes full responsibility to estimate the kind and extent of the various materials to be encountered in order to accomplish the work. Unclassified excavation includes materials which, if classified, would be included in **subsections 205.3a.**, **b.**, **c.** and **d**.

f. Common Excavation (Unstable). Common excavation (Unstable) is considered to be material in the subgrade or embankment with any of the following characteristics:

- When the material encountered has a moisture content above the plastic limit of the soil.
- When the plastic limit of the soil is at or less than the optimum moisture content, the soil is not capable of being compacted at the optimum moisture content.

Suitable material with excess moisture caused by the Contractor's negligent operations is not classified as unstable excavation.

g. Common Excavation (Unsuitable). Common excavation (Unsuitable) is material encountered in the subgrade or embankment that contains a high organic content (such as peat or A-horizon soils).

205.4 CONSTRUCTION REQUIREMENTS

a. General Excavation Requirements. Before beginning the excavation, clear and grub all vegetation according to the Contract Documents. Remove existing structures as shown in the Contract Documents.

Strip and stockpile the existing topsoil from within the construction limits. To the extent practical use this material to cap the finished embankment and cut slopes. This work is subsidiary to grading items in the contract.

Where practical, do not store equipment or materials (including soil stockpiles) within 50 feet of rivers, streams or other surface waters. Where such storage is necessary, obtain the Engineer's written approval and include in the project SWPPP appropriate best management practices for the storage area.

Unless requested in writing from the Contractor, and approved in writing by the Engineer, or specified otherwise in the Contract Documents, do not exceed 750,000 square feet of surface area of erodible earth material per equipment spread at one time. The Engineer will limit the surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow (within right-of-way) and embankment operations. Limit the exposed erodible earth material according to the capability and progress, and in keeping with the approved schedule.

Areas will not count toward the 750,000 square feet limit, when the following conditions are met:

For areas that will not be disturbed again due to project phasing:

- Finish grade the completed area;
- Stabilize and maintain stabilization according to **SECTION 902**; and

- Do not disturb the area again without a written request from the Contractor and written approval from the Engineer;

For areas that will be disturbed again due to project phasing:

- Rough grade; and
- Stabilize and maintain stabilization according to **SECTION 902**.

DO NOT clear and grub areas unless work will actively be performed in the exposed area (or portions of the exposed area) within 7 calendar days on exposed steep slope areas (40% or greater) or within 14 calendar days for all other exposed areas. If areas are cleared and grubbed and not finish graded, not part of project phasing and no meaningful work toward the completion of the bid item is performed within the exposed area (or portions of the exposed area) for 7 calendar days on exposed steep slope areas (40% or greater) or 14 calendar days for all other exposed areas, stabilize and maintain stabilization at these exposed areas according to **SECTION 902** at no cost to KDOT.

Before beginning excavation or depositing waste at the Contractor-Furnished site, obtain all permits and clearances required for compliance as shown in **SECTION 107**, (which most commonly includes wildlife and archaeological clearances). See **SECTION 106** for requirements for use of private property.

Before incorporating any material from these areas into the project, the Engineer shall require a copy of the KDWP clearance and the KSHS clearance. Before depositing any project waste onto these waste sites, the Engineer shall require a copy of the KDWP clearance, the KSHS clearance, and when required, the KDHE waste disposal permit.

If the Contractor's excavation operations expose potentially historical or archaeological significant sites, discontinue the excavation of such sites until the Engineer determines the disposition of the discovery. The Engineer will contact the ESS to determine the proper course of action, according to **SECTION 107**.

Obtain the Engineer's approval before wasting surplus excavation material. Use approved surplus excavated material to widen embankments, flatten slopes, or as directed by the Engineer. If surplus excavation material is wasted on the project, place the material to provide a neat appearance. Do not place waste materials in a manner that is detrimental to the abutting property.

If the Contract Documents designate certain materials to be excavated and stockpiled for future use, do not contaminate these materials in the process. Stockpile the materials neatly and compactly at locations approved by the Engineer.

Before beginning excavation, allow the Engineer to define the limits and cross-section the borrow areas shown in the Contract Documents. The Contractor shall define the limits and cross-section Contractor-Furnished sites before beginning excavation. Do not remove any material beyond the dimensions and elevations established. When borrow excavation is complete, grade the site uniformly to drain. Comply with any permit requirements.

The Engineer may allow the use of borrow pits or waste areas other than those shown in the Contract Documents, provided the change does not increase the cost for KDOT.

If rock, shale or unsuitable material is encountered in cuts, excavate this material to the cross-section or limits shown in the Contract Documents.

Do not overbreak rock excavation below the cross-section shown in the Contract Documents. If overbreakage occurs, backfill the overbreakage with material designated in the Contract Documents. If the designated backfill is material obtained through normal excavation, compact the backfill to the density requirements shown in the Contract Documents. If the designated backfill is crushed aggregate or other special aggregate, make sure that there are no layers of earth or shale between the backfill material and the surface of the rock. Before backfilling overbreakage areas with crushed stone for backfill or other specified material, shape the rock overbreakage area to drain.

Trim all slopes to the lines shown on the cross-sections. When warranted, the Engineer may approve a modified slope in rock or other material. Remove rock so that the resulting rock slope has a uniform face. Do not disturb any materials beyond the limits of the excavation.

Excavate all side ditches as shown in the Contract Documents.

Provide temporary erosion and pollution control according to **DIVISION 900**.

b. Presplit Rock Excavation. If designated in the Contract Documents, use a presplitting technique to split the face of the rock along the designated backslope. Presplit along the backslope before blasting the interior portion of the rock cut.

Devise a plan for the diameter, spacing and loading of the presplit holes. Drill the presplit holes the full depth of the rock ledge. Demonstrate to the Engineer with a 100-foot test section that the presplitting plan will produce an acceptable backslope. If the backslope of the test section is unacceptable, establish additional test sections until satisfactory results are obtained.

c. Shale Excavation. Shale will be classified as durable or non-durable in the Contract Documents. Durable and non-durable shale is prohibited in the top 18 inches of the embankment, unless specified in the Contract Documents.

- Durable Shale. Durable shale may be used as any other rock in a fill.
- Non-Durable Shale. Manipulate non-durable shale with equipment and water until 100% of the material is smaller than 6 inches in all dimensions, and until a minimum of 90% of the material is smaller than 3 inches in all dimensions. The Engineer will verify manipulation requirements with a visual inspection (e.g. have the Contractor scarify a known area to a known depth, calculate theoretical volume scarified, calculate an average volume for the stones between 3 and 6 inches and if the volume for the stones exceeds 10%, the test fails). Continue manipulation and retest until the above requirements are met. Compact and adjust the moisture content of this material as specified in the Contract Documents.

The Contractor will determine whether to manipulate and use the non-durable shale on the project, or waste the non-durable shale and replace it with other suitable material.

d. Common Excavation (Unstable). Excavate unstable material encountered during construction to the limits designated by the Engineer. Allow the Engineer to measure the area before the backfill is placed. Backfill the area where the unstable material was removed with suitable material from the project.

Aerate the unstable material until the moisture content is acceptable. Use this material in the construction of the project.

Remove and dry unstable material caused by the Contractor’s negligence to an acceptable moisture content and use in the project.

e. Common Excavation (Unsuitable). If excavation to the finished graded section results in subgrade or slopes of unsuitable material, excavate the unsuitable material to the limits designated by the Engineer. Remove the unsuitable material from the project. Allow the Engineer to measure the area before placing the backfill. Backfill with suitable material from the project.

f. Eradication of Traveled Way. Remove the surfacing, if any, excavate the embankment and fill the ditches. Grade the traveled way to approximately the original ground contour, or as shown in the Contract Documents. Stockpile any materials designated for salvage at the locations shown in the Contract Documents. Do not contaminate the salvaged material. Dispose of excess excavation, base materials and surfacing not designated for salvage.

g. Compaction Requirements. Requirements for the various types of compaction are shown in **TABLE 205-1**.

TABLE 205-1: SOIL COMPACTION REQUIREMENTS	
Type	**Minimum Compacted Soil Density**
Type AAA	100% of Standard Density
Type AA	95% of Standard Density
Type A	90% of Standard Density
Type B	Such that no further consolidation is gained by additional rolling. The Engineer will visually determine acceptable Type B compaction based on the following: • Acceptable Type B compaction is demonstrated if the tamping feet of a tamping (sheepsfoot) roller “walks out” of the soil and rides on top of the lift being compacted. • In soil with low plasticity or nonplastic fine-grained materials, the tamping feet may not “walk out” of the material being compacted. With these materials, acceptable Type B compaction is demonstrated if the tamping feet support the weight of the roller (without the drum of the roller contacting the lift being compacted). • In sand and gravel, where the use of a tamping roller produces unacceptable results, use other types of rollers (such as a pneumatic-tired) to compact this type of material. With these materials, acceptable Type B compaction is demonstrated if no further consolidation is evident after additional passes of the roller. • In small irregular areas where the use of conventional compaction equipment is impracticable, use other equipment and methods to obtain compaction. The Engineer will determine by visual inspection if Type B compaction is obtained. • If the Engineer is unable to visually determine that Type B compaction is obtained, the Engineer may conduct density tests on the compacted soil. If tested, the compacted soil density shall be at least 90% of the standard density.

h. Moisture Control Requirements. At the time of compaction, use soil with uniform moisture content within the moisture range designated in the Contract Documents.

Adjust the moisture content of the soil by adding water to or aerating the material to bring soil within the required moisture content.

If the soil is unstable within the designated moisture range, the DME will adjust the moisture range.

Water may be added to the soil in borrow and cut areas (before hauling) or on the embankment (after hauling). Use methods and equipment that will prevent undue loss of moisture. Add only the quantity of water necessary to provide a moisture content within the required moisture range plus a reasonable quantity to compensate for evaporation and other unavoidable losses.

Excavation areas may be pre-watered to provide uniform moisture content. Submit sketches of the areas with details of the proposed methods and equipment for the pre-watering for approval by the Engineer. Provide drilling equipment to obtain samples for moisture determination before, during and after the pre-watering. Using the results of the moisture samples, the Contractor and Engineer will jointly determine the quantities of water necessary to bring the soils to optimum moisture. The Engineer will allow sufficient water to bring the full depth and width of the excavation to optimum moisture plus up to 20% for evaporation.

In areas to be pre-watered, leave the vegetation in place until the watering is completed. If runoff is observed during the pre-watering, rip the area on the contour to a depth of approximately 2 feet at 4-foot intervals. To permit penetration to the full depth of the excavation (for uniform moisture content), allow a curing period after the pre-watering is completed. The Contractor and Engineer will use the moisture samples obtained by the Contractor (at locations and depth agreed to by the Contractor and Engineer) to determine moisture content and uniformity for the pre-watered areas. Strip the vegetation from the areas after the water has penetrated the soils.

Requirements for the various moisture ranges are shown in **TABLE 205-2**.

TABLE 205-2: SOIL MOISTURE CONTENT REQUIREMENTS	
Moisture Range	Moisture Content
0-5 (MR-0-5)	A maximum of 5 percentage points above optimum, nor less than optimum.
3-3 (MR-3-3)	A maximum of 3 percentage points above optimum, and a maximum of 3 percentage points below optimum.
5-5 (MR-5-5)	A maximum of 5 percentage points above optimum, and a maximum of 5 percentage points below optimum.
90 (MR-90)	Sufficient to allow the type of compaction specified in the Contract Documents. If Type B compaction is specified, the Engineer will determine by visual inspection if satisfactory moisture control and compaction are obtained.

i. Foundation Treatment. If an embankment is started less than 4 feet below the finished subgrade, remove all vegetation from the surface where the embankment will be placed. Plow, scarify or break up the cleared surface to a minimum depth of 6 inches (foundation area). Adjust the foundation area to a moisture content within the specified moisture range. Compact the foundation area as specified in the Contract Documents for the embankment.

If an embankment is placed over an existing surface (PCCP, HMA, gravel), plow, scarify or break up the full depth of the existing surface regardless of the height of the embankment.

j. Embankment Requirements. Construct the embankment from material classified as Soil, Rock/Soil or Rock, as defined in **TABLE 205-3**.

TABLE 205-3: EMBANKMENT GRADATION CLASSIFICATION	
Classification	Gradation Criteria
Soil	≤ 20% retained on the ¾ inch sieve
Rock/Soil	> 20%, but < 80% retained on the ¾ inch sieve
Rock*	≥80% retained on the ¾ inch sieve

*Could include concrete pavement.

If frozen soil is encountered in the surface of the original ground or in the surface of a partially constructed embankment, remove the frozen material or allow the frozen material to thaw before continuing construction of the embankment.

Unless shown otherwise in the Contract Documents, if shale (all shale classified as non-durable or common excavation) is used as embankment material, manipulate the shale with equipment and water until it complies with **subsection 205.4c**. Adjust the moisture content and compact the shale as specified in the Contract Documents.

Construct and backfill culverts and other structures below the embankment surface before the embankment is constructed.

When the embankment is placed against a hillside or an existing embankment with slopes steeper than 4:1, bench the existing slope with each lift of the embankment. Cut the benches wide enough to accommodate the hauling and compacting equipment. Begin cutting (horizontally) each new bench at the intersection of the original ground and the vertical side of the previous bench. Use the material excavated from the benches in the embankment.

Exercise care placing and compacting the embankment, when placed on only one side of a structure (such as abutments, piers and wingwalls). Do not put excessive pressure against the structure.

Place soil embankment material in horizontal lifts approximately 8 inches thick (loose measurement). Compact the earthen material as specified in the Contract Documents before placing the next lift. Compact manipulated (sized) non-durable shale to the compaction requirement in the Contract Documents and adjust the moisture content of the manipulated non-durable shale to MR-5-5. Use compaction equipment as specified in **DIVISION 150**. Provide sufficient motorgraders and tamping rollers to adequately blade and compact the material delivered to the embankment. Route the construction equipment uniformly over the entire surface of each lift. Continuously use a motorgrader to level and manipulate the material during the placing and compacting of each lift of the embankment. If the material delivered to the embankment is not properly placed and compacted, suspend delivery of materials to the embankment until the problem is corrected.

Where it is impracticable to use a roller, use a mechanical tamper. Place the embankment material in horizontal lifts not to exceed 8 inches (loose measurement) capable of being compacted by the mechanical tampers. Compact the earthen material as specified in the Contract Documents before placing the next lift.

If the Contract Documents do not specify a compaction requirement for the earthwork, place the embankment in uniform lifts not to exceed approximately 8 inches thick (loose measurement). Compact the earthen material to the requirements of Type B, MR-90.

Place rock/soil embankment material in horizontal lifts approximately 10 inches thick (loose measurement). Compact the embankment by making consecutive passes of a vibratory roller, with a minimum weight of 16 tons, until no further increase in density is achieved by successive passes. The Engineer shall verify the density by using the nuclear moisture/density gauge.

Place rock embankment material in horizontal lifts approximately the average size of the larger rocks, a maximum of 2 feet thick (loose measurement). Make no more than 10% of the rock embankment material larger than 7 feet in circumference measured in any direction and no more than 10% passing the 1-inch sieve as determined by visual inspection. The maximum size of rock placed will be limited by the thickness of rock to be placed, as shown on the plans.

An embankment made up largely of rock consists of rock in interparticle contact with itself, with no intervening layers of soil. Distribute the large stones uniformly and fill the voids with smaller stones, earth, sand or gravel. Level and manipulate each lift with a motorgrader, bulldozer or similar equipment capable of shifting and shaping the material. Compact each lift by routing construction traffic over the lift until no further consolidation under the traffic is visible. When shown in the Contract Documents to construct the top 12 inches with rock excavation, finish the grade with crushed stone for backfill compacted to Type B, MR-90, **SECTION 204**. No shale is allowed in the top 12 inches.

If the embankment is constructed of rock mixed with enough compactable material to make rolling feasible, and if the Contract Documents specify compaction, compact the embankment to meet Type B compaction requirements (regardless of the type of compaction specified).

If possible, use rock embankment material to form the base (full width) of the embankment. If rock and other embankment material are delivered to the embankment at the same time, place the rock in the outer portions of the embankment and the other material in the center of the embankment. Adjust the hauling and compacting operations (for both materials) as necessary to construct the embankment in level lifts.

Before rock embankment material is placed on compacted embankment constructed of other material, shape the top of the compacted embankment to slope from centerline to the outside. Do not build undrained pockets of rocks into the embankment.

Do not place rocks, broken concrete or other solid materials in embankment areas where piling will be driven or where culverts will be installed. Do not place rocks larger than 3 inches (in any dimension) in the top 12 inches of the embankment.

Where a grass median is constructed, do not place any rock excavation material or shale in the top 18 inches of the median area. Construct the top 18 inches of medians with earthen material suitable for growth of vegetation.

Dispose of all loose rocks within the right-of-way that will interfere with mechanical mowing.

Apply water as needed to control dust on the project.

k. Compaction in Cuts. Plow, scarify or break up the soil 6 inches below the grade line in cut sections. If necessary to obtain compaction, adjust the soil to a moisture content within the specified moisture range. Compact the soil as specified in the Contract Documents.

If the depth of compaction in cut sections is greater than 6 inches, excavate all material to within 6 inches of the lower limit of compaction. Plow, scarify or break up the material left in place. If necessary to obtain compaction, adjust the soil to a moisture content within the specified moisture range. Compact the soil as specified in the Contract Documents. Replace and compact (as embankment) the excavated material until the cut is compacted to the grade line shown in the Contract Documents.

205.5 MEASUREMENT AND PAYMENT

a. Contract Quantities. Provided the project is constructed essentially to the lines and grades shown in the Contract Documents, the quantities shown in the Contract Documents for the various balances will be the quantities for which payment is made.

If the Contract Documents are altered, or if the Engineer or Contractor questions the accuracy of the contract quantities in any balance, either party may request the quantities involved be measured by the cross-section method. Unless errors are noted or the original ground was disturbed before the work started, the cross-sections shown in the Contract Documents will be used as the original field cross-sections. Additional original cross-sections may be interpolated, or determined by other approved methods, at points necessary to accurately determine the quantities.

If the Contractor elects to waste the non-durable shale, or fraction thereof, and provide Common Excavation (Contractor-Furnished) in lieu of manipulating the non-durable shale, payment will be made for "Rock Excavation (Non-Durable Shale)," as though it was not wasted, not "Common Excavation (Contractor-Furnished)" actually used.

b. Measured Quantities. The Engineer will measure excavation and borrow (including rock, shale, unstable and unsuitable) by the cubic yard. The Engineer will measure quantities for the various types of excavation by cross-sectioning the area. The Engineer will compute the quantities (volume) by the average end area method. Where it is not possible to measure material by the cross-section method, the Engineer may use 3-dimensional measurements. If the depth of compaction through cut areas is greater than 6 inches, the material excavated to gain access to the lower 6-inch layer will be measured for payment. The excavation of unstable and unsuitable material necessary to obtain compaction in cut sections and in foundations for fill sections will be measured for payment. The Engineer will not measure rock overbreakage (below the depth shown in the Contract Documents) for payment. Excavation required for benching into an existing slope will not be measured for payment. The excavation required to remove unstable material caused by the Contractor's negligent operations will not be measured for payment.

If either the Contractor or Engineer questions the accuracy of the plan quantity for non-durable shale excavation, contact the Regional Geologist for guidance.

The Engineer will measure compaction of earthwork (in place after the rolling or tamping is complete) by the cubic yard. The Engineer will measure compaction of earthwork by cross-sectioning the area. The Engineer will compute the quantities (volume) by the average end area method. Where it is impractical to measure material by the cross-section method, the Engineer may use 3-dimensional measurements. The Engineer will not measure for payment the compaction of foundation area under a fill or the bottom 6-inch layer in a cut section.

The Engineer will measure water used for earthwork compaction and non-durable shale manipulation and compaction by the M Gallon by means of calibrated tanks or water meters.

If the Contractor uses non-durable shale for "Common Excavation (Contractor-Furnished)", the Engineer will not measure the manipulation water for payment. However, the Engineer will measure the water required to meet moisture requirements for compaction.

The Engineer will not measure water used for dust control, water wasted through the Contractor's negligence or water in excess of the quantity required to obtain the proper moisture content.

If the Contract Documents include the bid items "Embankment" or "Embankment (Contractor-Furnished)", the Engineer will not measure excavation, compaction and water separately for payment. The Engineer will measure the embankment in place by the cubic yard. The Engineer will measure quantities for the embankment by cross-sectioning the area. The Engineer will compute the quantities (volume) by the average end area method. Where it is impractical to measure material by the cross-section method, the Engineer may use 3-dimensional measurements. No payment will be made for quantities beyond the limits of the Contract Documents.

If the Contract Documents include the bid item "Eradication of Traveled Way", the Engineer will measure this item by the station along the centerline of the traveled way being eradicated. If the Contract Documents do not include the bid item "Eradication of Traveled Way", excavation required for this activity is measured for payment.

c. Payment.

(1) General. Payment for "Common Excavation", "Common Excavation (Contractor-Furnished)", "Rock Excavation", "Rock Excavation (Non-Durable Shale)", "Unclassified Excavation", "Compaction of Earthwork", "Embankment", "Embankment (Contractor-Furnished)" and "Eradication of Traveled Way" at the contract unit prices is full compensation for the specified work. Deduct any measured quantities placed beyond the limits of the Contract Documents, unless the placement was authorized by the Engineer.

Payment for "Water (Grading) (Set Price)" at the contract set unit price is full compensation for the specified work. Payment for water used for pre-watering excavation areas at 75% of the contract set unit price for

Water (Grading) (Set Price) is full compensation for the specified work. The contract set unit price will govern regardless of the accepted quantity provided.

(2) Common Excavation (Unstable). Payment for "Common Excavation (Unstable)", as provided below, is full compensation for the specified work to remove, manipulate and replace material, including any additional material needed to fill the created void.

Compaction for backfill of areas removed as Common Excavation (Unstable) will be paid for at the appropriate contract unit prices.

- Rural Projects (outside incorporated city limits): 1½ times the contract unit price for "Common Excavation", up to a maximum of $6.00 per cubic yard. If the contract unit price for "Common Excavation" is greater than $6.00 per cubic yard, the contract unit price is the maximum paid per cubic yard for this item.
  If the Contract Documents have the bid item of "Embankment" instead of "Common Excavation" the Engineer will pay for Common Excavation (Unstable) at 1½ times the contract unit price for "Embankment", up to a maximum of $6.00 per cubic yard.
- Urban Projects (inside incorporated city limits): 1½ times the contract unit price for "Common Excavation", up to a maximum of $10.00 per cubic yard. If the contract unit price for "Common Excavation" is greater than $10.00 per cubic yard, the contract unit price is the maximum paid per cubic yard for this item.
  If the Contract Documents have the bid item of "Embankment" instead of "Common Excavation," the Engineer will pay for Common Excavation (Unstable) at 1½ times the contract unit price for "Embankment", up to a maximum of $10.00 per cubic yard.

(3) Common Excavation (Unsuitable). Payment for the "Common Excavation (Unsuitable)", as provided below, is full compensation for the specified work.

Compaction for backfill of areas removed as Common Excavation (Unsuitable) will be paid for at the appropriate contract unit prices.

Excavation to replace unsuitable material removed from the project will be paid for at the appropriate contract unit price.

- Common Excavation (Unsuitable) not designated in the Contract Documents and encountered during construction is paid for at 3 times the contract unit price for "Common Excavation", up to a maximum of $12.00 per cubic yard, which price shall include the disposal of materials. If the contract unit price for "Common Excavation" is greater than $12.00 per cubic yard, the contract unit price will be the maximum paid per cubic yard for this item, which price shall include the disposal of materials.
  If the Contract Documents have the bid item of "Embankment" instead of "Common Excavation", the Engineer will pay for Common Excavation (Unsuitable) at $12.00 per cubic yard.

5.9. SAMPLING AND TEST METHODS FOREWORD

1. SAFETY

The responsibility for safety rests with each and every employee in the laboratory or field. You must use common sense and work carefully to avoid the hazards your job may expose you to like hazardous chemicals, flying particles and heavy or awkward lifting are a few of the hazards you will be exposed to.

You are responsible to know the hazards that each test may expose you to so that you can work with the right level of protection while completing certain test procedures. Through OSHA 1910 and 1926 and KDOT SOM 2.6.2 your employer is required to tell you what hazards you will be exposed to and how to protect yourself from those hazards.

OSHA 1910 and 1926 also makes it the employee's responsibility to understand and follow the safety programs provided by their employers to protect them. SOM 2.6.2 refers to the KDOT safety Manual which requires employees to follow the guidelines of KDOT Hazardous Communications Program and the KDOT Personal Protection Program. These two programs will assist you with how to read an MSDS and provide information on the type of personal protection required to protect you from the physical, chemical, biological and ergonomic hazards you will be exposed to while performing the tests in this manual.

2. SCOPE

The purpose of this section is to standardize the testing procedures used throughout the State by all laboratories. A hierarchy for test methods exists in order to establish a specific test procedure for a given circumstance.

Test method hierarchy corresponds to the following publications unless otherwise stated in the Standard Specifications, plans or project specifications:

First - Kansas Department of Transportation Construction Manual, Part V.

Second - Standards published by the American Association of State Highway and Transportation Officials (AASHTO).

Third - Standards published by the American Society for Testing and Materials (ASTM).

Each test method is an independent document, page numbered and printed individually. The primary number linking it to this manual is the sub-paragraph number. Any future corrections, additions or revisions will be printed and forwarded to the manual holders at the time they occur, to reflect current testing procedures.

Footnotes at the bottom of the page of a test procedure are a quick check for contractors or consultants to determine differences between KT methods and AASHTO/ASTM standards. **ALL PROCEDURES ARE TO BE PERFORMED AS STATED WITHIN KT METHODS, EXCLUDING THE INFORMATION FOUND IN THE KT FOOTNOTES**.

Unless noted in the test method, the use of potable water is required.

Unless otherwise stated in the test method, drying to a constant mass means less than 0.1% mass decrease from the previous measurement after 1 hour following the temperature requirements in the test method.

Consult the Bureau of Construction and Materials and in case of ambiguity or difficulty in the interpretation of testing procedures.

3. ACCURACY

As a general guideline use the following for an accuracy requirement when not stated within the test procedure:

Thermometers: Temp $\leq$ 140ºF (60ºC), accuracy of 0.2ºF (0.1ºC); Temp > 140ºF (60ºC), accuracy of 2ºF (1ºC).

Balances/Scales: Accuracy is equal to the mass stated or 0.1 percent of the test load, whichever is greater, throughout the range of use. The following table shows the various classes as established in AASHTO M 231:

Class	Readability and Sensitivity	Accuracy*
G1	0.01 g	0.02 g or 0.1 percent
G2	0.1 g	0.2 g or 0.1 percent
G5	1 g	2 g or 0.1 percent
G20	5 g	5 g or 0.1 percent
G100	20 g	20 g or 0.1 percent

* Accuracy equal to the mass stated or 0.1 percent of the test load, whichever is greater, throughout the range of use.

4. SI UNITS

The following information provides the user of these test procedures with specific comparisons between metric (SI) and English units and nomenclature.

Where possible, "Hard Conversion" practices are used converting the testing procedures from English to SI units. This system establishes an approximate measurement in SI units compared to the English units. An example of this is to convert one inch to SI units. One inch is equal to 25.4 millimeters (1 in = 25.4 mm). Using Hard Conversion, 25 mm is the new measurement, and compared to the 25.4 mm, is easier to verify. However, where test methods requires rigidly specified equipment or procedures measured in English units, a soft conversion will be shown. These cases should be obvious due to the outrageous metric number presented.

The nomenclature used to represent SI units are as follows (conversions originated or derived from ASTM E 380):

SI (full name) = ENGLISH (full name) X Conversion

AREA

mm^2 ($millimeter^2$)	in^2 ($inches^2$)	645.16
m^2 ($meters^2$)	ft^2 ($feet^2$)	0.092903
m^2	yd^2 ($yard^2$)	0.8361274

DENSITY (MASS PER UNIT VOLUME)

kg kilogram lb or pound 16.01846

m^3 meter^3 ft^3 feet^3
(also known as PCF)

FORCE

N (Newton) lbf (pound-force) 4.448222

LENGTH

mm (millimeters) in (inches) 25.4

m (meters) ft (feet) 0.3048

km (kilometer) (mile) 1.609347

SI (full name) = ENGLISH (full name) X Conversion

MASS

g (gram) lb (pound) 453.5924

kg (kilogram) lb (pound) 0.4535924

Mg (megagram) TONS 0.9071847

PRESSURE (FORCE PER UNIT AREA)

kPa (kilopascal) psi or $\frac{\text{pound-force}}{\text{inches}^2}$ 6.894757

TEMPERATURE

ºC (Celsius) ºF (Fahrenheit) $t_C = (t_F - 32)/1.8$

VOLUME

mm^3 (millimeters^3) in^3 (inches^3) 16,387.06

m^3 (meters^3) ft^3 (feet^3) 0.02831685

m^3 yd^3 (yards^3) 0.7645549

mL (milliliter) in^3 16.38706

L (Liter) qt (quart) 0.9463529

L gal (gallon) 3.785412

L ft^3 28.31685

NOTE: $1\ m^3 = 1{,}000\ L$
$1\ L = 1{,}000\ mL$

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	**TESTS REQUIRED (RECORDED TO)**	**TEST METHOD**	**CODE**	**QUALITY CONTROL BY CONTRACTOR**	**CODE**	**VERIFICATION BY KDOT**
DIVISION 300						
CEMENT TREATED BASE (CTB) Sec. 306 & 1105	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c h	1 per day.		1 per week.
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11 or KT-41		4 per day per design.		1 per week.
	Density (0.1 lb/ft^3 or 0.1% of optimum density)	KT-37 or KT-20*		1 per day per design (* KT-20 option is only permitted in conjunction with a fluid mix.)		1 per project per design.
	Compressive Strength (1 psi)	KT-37		1 specimen per sublot		1 specimen per lot.
Completed Base	Field Density Tests (0.1 lb/ft^3 or 0.1% of optimum density)	KT-13 or KT-41		4 per day per design.		1 per week per design.
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11 or KT-41		4 per day per design.		1 per week per design.
DIVISION 500						
PORTLAND CEMENT CONCRETE PAVEMENT Sec. 501 & 503	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c m	1 per 350 TONS of combined aggregate.		1 per project.
Individual Aggregates	Clay Lumps and Friable Particles in Aggregate (0.1 g or 0.01% of mass)	KT-07	c h			As required.

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 500 (continued)						
PORTLAND CEMENT CONCRETE PAVEMENT Sec. 501 & 503 (continued) **Individual Aggregates (continued)**	Shale or Shale-Like Materials in Aggregate (0.1 g or 0.01% of mass)	KT-08	c h			As required.
	Sticks in Aggregate (0.01% of mass)	KT-35	c h			As required.
	Unit Weight – lightweight aggregates only (0.1 lb or 0.1% of mass)	KT-05	c k			As required.
	Moisture in Aggregate (0.1 g or 0.01% of mass)	KT-24	p	1 per 1/2 day.		1 per week.
	Coal	AASHTO T 113				As required.
	Organic Impurities	AASHTO T 21				As required.
Concrete	Mass per cubic foot (0.1 lb/ft^3)	KT-20	a	1 per 500 yd^3.		1 per day.
	Slump (0.25 in)	KT-21	a	1 per 500 yd^3.		1 per day.
	Temperature (1 °F)	KT-17	a	1 per 500 yd^3.		1 per day.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 500 (continued)						
PORTLAND CEMENT CONCRETE PAVEMENT Sec. 501 & 503 (continued) **Concrete (continued)**	Air Content (0.25%)	KT-18 or KT-19	a	1 per 500 yd^3 or every 2 hours (mainline), every 4 hours (other slipformed pvmt), whichever is more frequent. Determine the air loss due to paving operations once in the AM and once in the PM. Determine the difference between the air content from concrete sampled before the paver, and concrete sampled behind the paver.		1 per day.
	Density of Fresh Concrete (0.1 lb/ft^3)	KT-38		Initially, 1 complete transverse profile, then 1 density per ½ day.		1 density per week.
	Beams (1 psi)	KT-22 & KT-23		1 set of 3 as required for opening to traffic.		1 set of 3 per week as required for opening to traffic.
	Cores (1 lbf, 0.01 in, 1 psi)	KT-49		As required in SS 2015 section 501.5g.		Thickness measurement and compression test – 1 per lot.

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 500 (continued)						
PORTLAND CEMENT CONCRETE PAVEMENT Sec. 501 & 503 (continued) **Concrete** (continued)	Air Void Analyzer (0.0001 in)	KT-71		Prequalification of mix required as per SS 2015 sec. 403.4.		1 test randomly during every 4 weeks of production.
	Permeability (0.01%, KT-73; 10 coulomb, AASHTO T 277; nearest 0.1 kΩ-cm, KT-79	KT-73 or AASHTO T 277 or KT-79	o			1 per mix design per project.
	Profilograph	KT-46		2 tracks per 12 ft of width for the full length of the project.		At the Engineer's discretion.
	Vibrator Frequency Per Standard Specification 154.2e	SS 154.2e		Every 4 hours		Daily
ON-GRADE CONCRETE (OGCA)						See 5.6 Section 5.4.4 of this manual.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	**TESTS REQUIRED (RECORDED TO)**	**TEST METHOD**	**CODE**	**QUALITY CONTROL BY CONTRACTOR**	**CODE**	**VERIFICATION BY KDOT**
DIVISION 600						
HMA (Plant Mix) Sec. 602, 603, 611 & 1103						
Individual Aggregates	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c	1 per 1000 TONS for each individual aggregate.		1 during the first 5000 TONS of HMA produced for each individual aggregate.
	Clay Lumps and Friable Particles in Aggregate (0.1 g or 0.01% of mass)	KT-07	c h			As required.
	Shale or Shale-Like Materials in Aggregate (0.1 g or 0.01% of mass)	KT-08	c h			As required.
	Sticks in Aggregate (0.01% of mass)	KT-35	c h			As required.
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50	l	1 on the first lot then 1 per 10,000 TONS of crushed gravel.		1 during the first 5000 TONS of HMA produced.
	Uncompacted Void Content of Coarse Aggregate (0.01%)	KT-80	l	1 on the first lot then 1 per 10,000 TONS of crushed gravel.		1 during the first 5000 TONS of HMA produced.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
HMA (Plant Mix) continued Sec. 602, 603, 611 & 1103						
Mineral Filler Supplement	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c h	1 per 250 TONS.		1 during the first 5000 TONS of HMA produced.
	Plasticity Tests (0.01 g or 0.1% of mass)	KT-10	c h	1 per 250 TONS.		
Combined Aggregate	Coarse Aggregate Angularity (Determination of Crushed Particles in Crushed Gravel) (0.1% of mass)	KT-31	c g	1 per lot		1 per week or 1 per 10,000 TONS.
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50		1 on the first lot then 1 per 10,000 TONS of combined aggregate.		1 during the first 5000 TONS of HMA produced.
	Sand Equivalent Test (1%)	KT-55	f	1 per lot.		
	Flat or Elongated Particles (1%)	KT-59		1 on the first lot.		
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11		1 per lot.		
Asphalt Material	Sampling	KT-26	b e	Sample per sampling frequency level chart		
HMA Mixtures	Percent Moisture in Mixture (0.1 g or 0.01% of mass)	KT-11		1 per lot.		1 during the first 5000 TONS of HMA produced.
	Air Voids (V_a = 0.01%; G_{mm} & G_{mb} = 0.001)	KT-15, KT-39, KT-58, & SF Manual	q	1 per sublot. (See code n for G_{mm})	j	1 per lot. [Compact split sample on KDOT Gyratory – 1 per week or every 15,000 TONS]

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
HMA (Plant Mix continued) Sec. 602, 603, 611 & 1103						
HMA Mixtures (continued)	Binder Content (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 per sublot.	j	1 per lot.
	Mix Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per sublot.		1 per lot.
	Moisture Damage to Mix (Modified Lottman) (0.1%)	KT-56	d	1 on first lot then 1 per week or every 10,000 TONS.		1 during the first 5000 TONS of HMA produced. Performed by the District Lab.
Reclaimed Asphalt Pavement (RAP)	Binder Content in RAP (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 during the first lot then 1 per 1000 TONS of RAP.	j	1 during the first lot then 1 per 4000 TONS of RAP.
	RAP Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per 1000 TONS of RAP.		1 during the first 5000 TONS of HMA produced.
	Percent Moisture in RAP (0.1 g or 0.01% of mass)	KT-11		1 per lot.		
Recycled Asphalt Shingles (RAS)	Binder Content in RAS (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 during the first lot then 1 per 1000 TONS of RAP + RAS.	j	1 during the first lot then 1 per 4000 TONS of RAP + RAS.
	RAS Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per 1000 TONS of RAP + RAS.		1 during the first 5000 TONS of HMA produced.
	Percent Moisture in RAS (0.1 g or 0.01% of mass)	KT-11		1 per lot.		

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
HMA (Plant Mix continued) Sec. 602, 603, 611 & 1103						
Completed Road Work Field Density Tests (Use Cores or Nuclear Density Gauge on all HMA roadway or shoulder construction greater than or equal to 1.5 inches)	Field Density - Cores or Nuclear Density Gauge (G_{mb} = 0.001; 0.1 lb/ft^3 or 0.01% of G_{mm})	KT-15 or KT-32	i	10 tests per lot.	i	5 companion tests per lot.
(Use approved rolling procedure and Nuclear Density Gauge on all HMA roadway or shoulder construction less than 1.5 inches)	Field Density -Nuclear Density Gauge (G_{mb} = 0.001; 0.1 lb/ft^3 or 0.01% of G_{mm})	KT-32	i	10 Nuclear Gauge readings per lot Verify Approved Rolling Procedure every 2 hours		
	Profilograph	KT-46		2 tracks per 12 ft of width for the full length of the project.		At the Engineer's discretion.
Cold In-Place Recycle (CIR) Sec. 604	Sampling Aggregate	KT-01		2 per mile. (Sieve according to specification.)	k	1 per day.
	Percent Retained on the #200 Sieve by Dry Screen	KT-04		2 per day.		
	Field Moisture Tests (0.1 g or 0.01% of mass)	KT-32				Minimum 1 per day. Use nuclear gauge w/o correction. (Test before overlay or seal.)
	Field Density (G_{mb} = 0.001; 0.1 lb/ft^3 or 0.01% of G_{mm})	KT-32				3 locations per width laid per mile per lift. Minimum of 1 per day.

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
Asphalt Material (Emulsion)	Sampling	KT-26	b	1 sample for every 3 loads.	b	
Lime Slurry	Percent Solids of Lime Slurry	KT-62		1 at beginning of project then 1 at each mix design change.	k	
MICROSURFACING Sec. 606 & 1109	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c	1 per 250 TONS for each individual aggregate.		1 per day.
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11		3 per day.		1 per day.
	Emulsified Asphalt	KT-26		1 per project.	k	
	Sampling Cement	KT-29		1 per project.	k	
	Percent Crushed Particles in Crushed Gravel (0.1%)	KT-31		1 per project.	k	
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50		1 per project.	k	
	Sand Equivalent Test (1%)	KT-55		1 per project.	k	
ULTRATHIN BONDED ASPHALT SURFACE (UBAS) Sec. 613 & 1103						
Individual Aggregates	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c h	1 per 1000 TONS for each individual aggregate.		1 per project per individual aggregate.
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50	l	1 on the first lot then 1 per 10,000 TONS of crushed gravel.		1 per project.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
ULTRATHIN BONDED ASPHALT SURFACE (UBAS) Sec. 613 & 1103 (continued)						
Mineral Filler Supplement	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c h	1 per 250 TONS.		1 per project.
	Plasticity Tests (0.01 g or 0.1% of mass)	KT-10	c h	1 per 250 TONS.		1 per project.
Combined Aggregate	Coarse Aggregate Angularity (0.1% of mass)	KT-31	c g h	1 per lot of combined aggregate		1 per week or 1 per 10,000 TONS.
	Uncompacted Void Content of Fine Aggregate (0.1%)	KT-50	f	1 on the first lot then 1 per 10,000 TONS of combined aggregate.		1 per project.
	Sand Equivalent Test (1%)	KT-55	f	1 per lot.		1 per project.
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11		1 per 2000 TONS of combined mix.		1 per project.
Asphalt Material	Sampling	KT-26	b e	Sample per sampling frequency level chart		
HMA Mixtures	Percent Moisture in Mixture (0.1 g or 0.01% of mass)	KT-11		1 per 2000 TONS of combined mix.		1 per project.
	Theoretical Maximum Specific Gravity (Rice) (G_{mm} = 0.001)	KT-39	n	1 per sublot.		1 per lot.
	Binder Content (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 per sublot.	j	1 per lot.
	Mix Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per sublot.		1 per lot.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
HMA Base [Reflective Crack Interlayer (RCI)] Sec. 614						
Individual Aggregates	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c	1 per 1000 TONS for each individual aggregate.		1 during the first 5000 TONS of HMA produced for each individual aggregate.
	Clay Lumps and Friable Particles in Aggregate (0.1 g or 0.01% of mass)	KT-07	c h			As required.
	Shale or Shale-Like Materials in Aggregate (0.1 g or 0.01% of mass)	KT-08	c h			As required.
	Sticks in Aggregate (0.01% of mass)	KT-35	c h			As required.
Mineral Filler Supplement	Sieve Analysis of Aggregate (1%, 0.1% for No. 200 sieve, of mass)	KT-02	c h	1 per 250 TONS.		1 during the first 5000 TONS of HMA produced.
	Plasticity Tests (0.01 g or 0.1% of mass)	KT-10	c h	1 per 250 TONS.		
Combined Aggregate	Sand Equivalent Test (1%)	KT-55	f	1 per lot.		
	Flat or Elongated Particles (1%)	KT-59		1 on the first lot.		
	Moisture Tests (0.1 g or 0.01% of mass)	KT-11		1 per lot.		
Asphalt Material	Sampling	KT-26	b e	Sample per sampling frequency level chart		
HMA Mixtures	Percent Moisture in Mixture (0.1 g or 0.01% of mass)	KT-11		1 per lot.		1 during the first 5000 TONS of HMA produced.

SAMPLING AND TESTING FREQUENCY CHART
CONTRACTOR QUALITY CONTROL TESTING

CONSTRUCTION OR MATERIAL TYPE 2015 Std. Spec. (SS 2015)	TESTS REQUIRED (RECORDED TO)	TEST METHOD	CODE	QUALITY CONTROL BY CONTRACTOR	CODE	VERIFICATION BY KDOT
DIVISION 600 (continued)						
HMA Base [Reflective Crack Interlayer RCI)] Sec. 614 (continued)						
HMA Mixtures (continued)	Air Voids (Va = 0.01%; G_{mm} & G_{mb} = 0.001)	KT-15, KT-39, KT-58, & SF Manual	q	1 per sublot. (See code n for G_{mm})	j	1 per lot. [Compact split sample on KDOT Gyratory – 1 per week or every 15,000 TONS]
	Binder Content (by ignition) (0.1 g or 0.01% of mass)	KT-57		1 per sublot.	j	1 per lot.
	Mix Gradation (after ignition) (0.1 g or 0.01% of mass)	KT-34		1 per sublot.		1 per lot.
Completed Road Work	Field Density Approved Rolling Procedure Nuclear Gauge (Gmb = 0.001; 0.1 lb/ft^3 or 0.01% of Gmm)	KT-32		Verify Approved Rolling Procedure every 2 hours 10 Nuclear Gauge readings per day		

Designation: D2488 – 09a

INTERNATIONAL

Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)[1]

This standard is issued under the fixed designation D2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (either intact or disturbed).

NOTE 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 8.

1.6 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D1452 Practice for Soil Exploration and Sampling by Auger Borings
D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils
D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
D2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)

3. Terminology

3.1 *Definitions:*

3.1.1 Except as listed below, all definitions are in accordance with Terminology D653.

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

NOTE 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:
Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and
Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

3.1.2 *clay*—soil passing a No. 200 (75-µm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D2487).

3.1.3 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a ¾-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

3.1.4 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.5 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.6 *peat*—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.1.7 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425-µm) sieve and is retained on a No. 200 (75-µm) sieve.

3.1.8 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D2487).

4. Summary of Practice

4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.

4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

NOTE 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols.*
Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.
Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

5. Significance and Use

5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D2487.

5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.

5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.

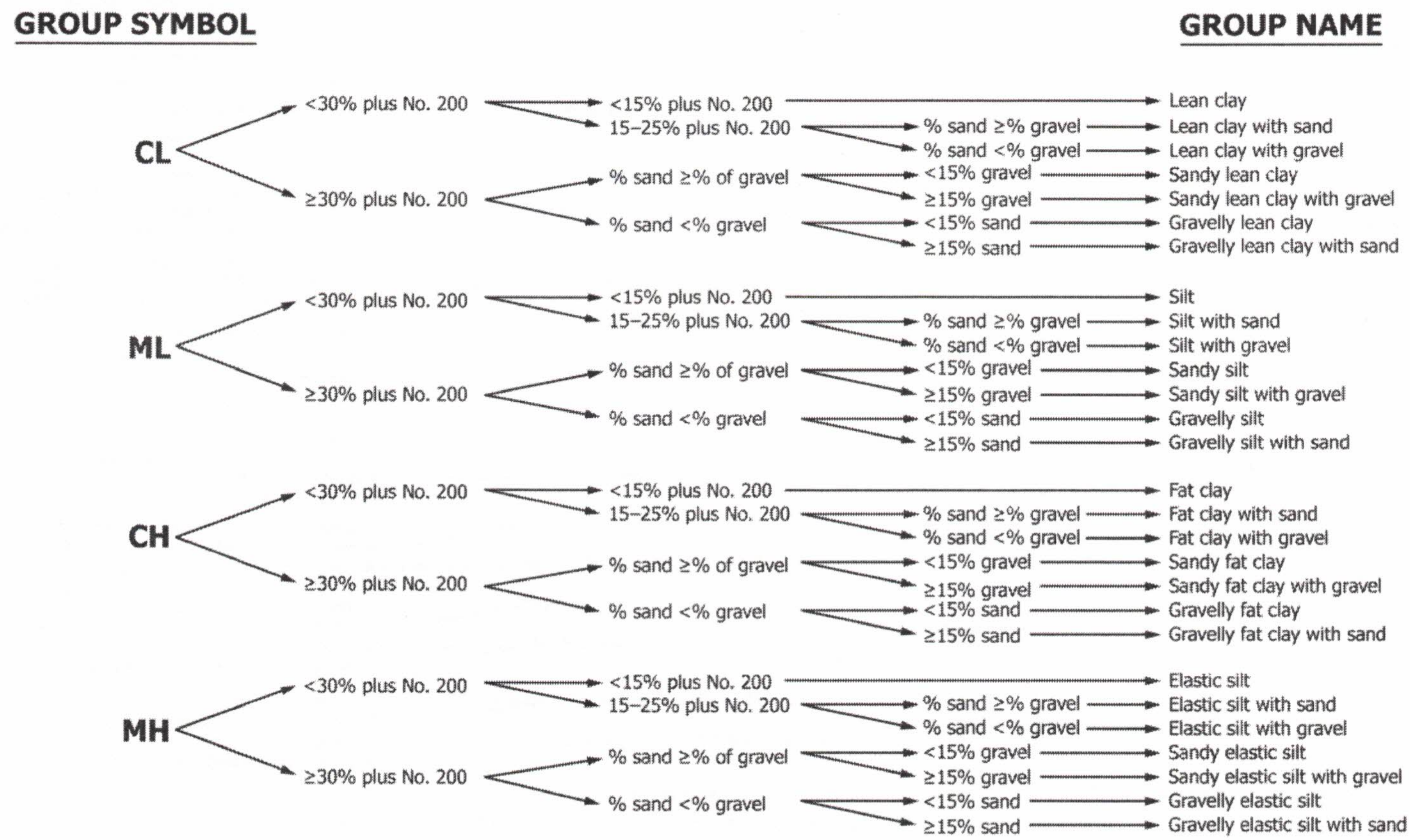
5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.

NOTE 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.

5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.

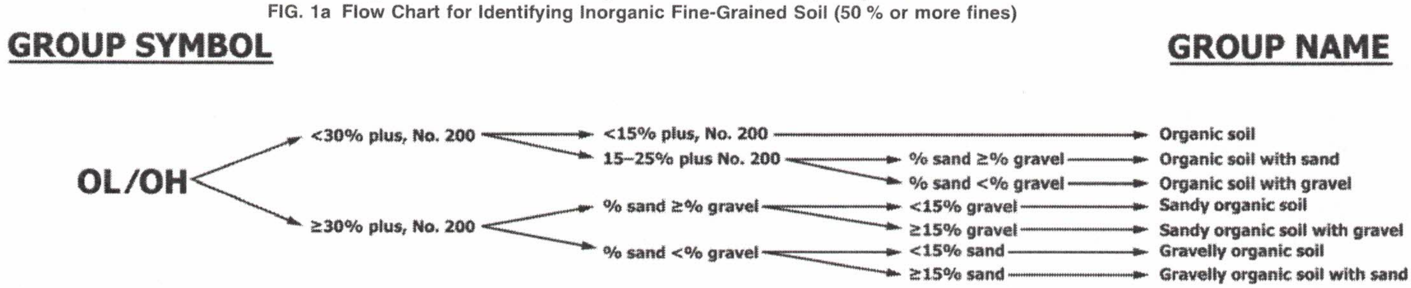
5.7 This practice may be used in combination with Practice D4083 when working with frozen soils.

NOTE 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D3740 does not in itself assure reliable testing. Reliable testing



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

depends on several factors; Practice D3740 provides a means for evaluating some of those factors.

6. Apparatus

6.1 *Required Apparatus:*

6.1.1 *Pocket Knife or Small Spatula.*

6.2 *Useful Auxiliary Apparatus:*

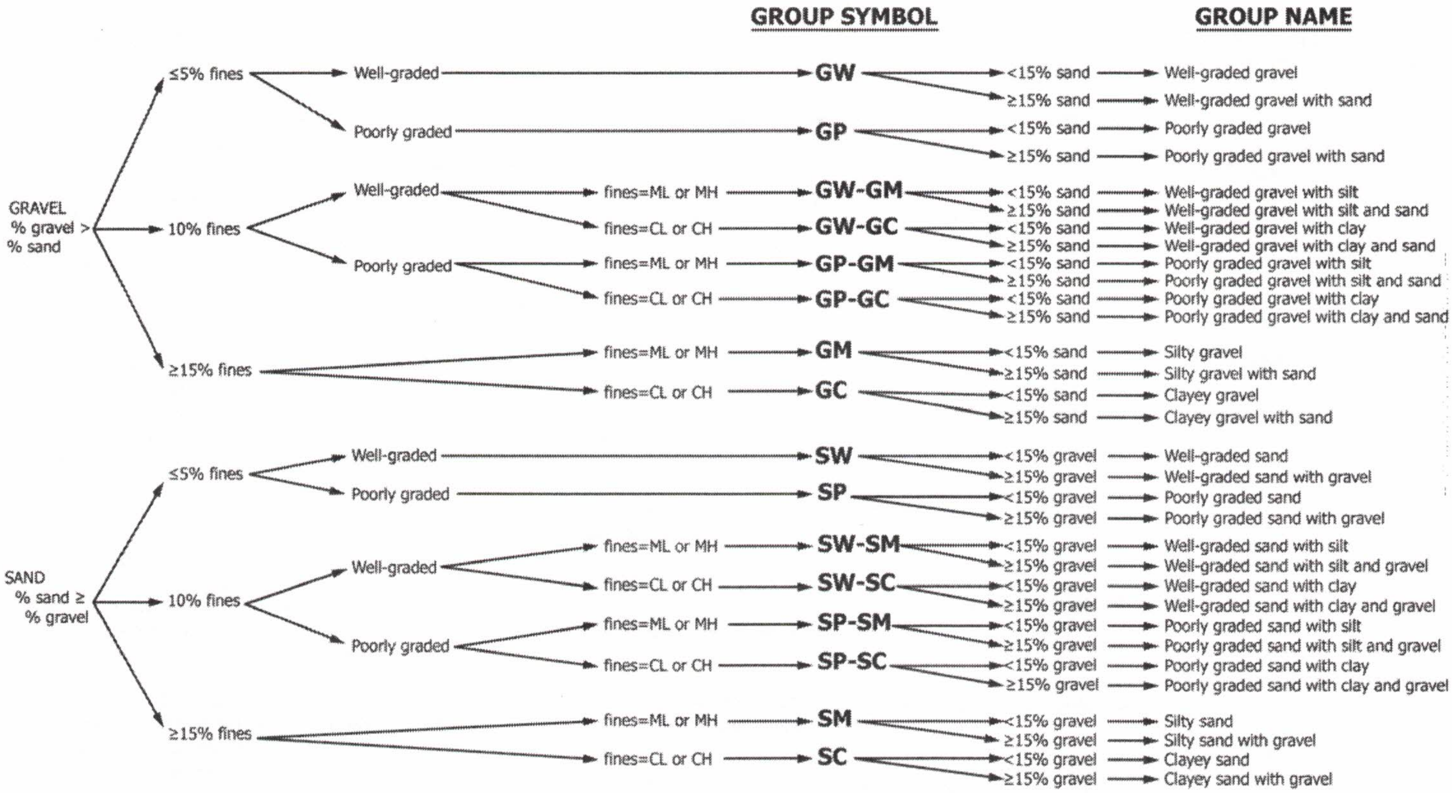
6.2.1 *Test Tube and Stopper* (or jar with a lid).

6.2.2 *Hand Lens.*

7. Reagents

7.1 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 *Hydrochloric Acid*—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 *N*) to three parts water (This reagent is optional for use with this practice). See Section 8.



NOTE 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %.

FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

8. Safety Precautions

8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 *N*) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.

8.2 **Caution**—Do not add water to acid.

9. Sampling

9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

NOTE 6—Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D1452, D1587, or D2113, or Test Method D1586.

9.2 The sample shall be carefully identified as to origin.

NOTE 7—Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

NOTE 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

10. Descriptive Information for Soils

10.1 *Angularity*—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 *Shape*—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

10.3 *Color*—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 *Odor*—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 *HCl Reaction*—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

10.7 *Consistency*—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.

10.8 *Cementation*—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.

10.9 *Structure*—Describe the structure of intact soils in accordance with the criteria in Table 7.

10.10 *Range of Particle Sizes*—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.

10.11 *Maximum Particle Size*—Describe the maximum particle size found in the sample in accordance with the following information:

10.11.1 *Sand Size*—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.

10.11.2 *Gravel Size*—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a ¾-in. square opening).

10.11.3 *Cobble or Boulder Size*—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 *Hardness*—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

12. Preparation for Identification

12.1 The soil identification portion of this practice is based on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

NOTE 9—Since the percentages of the particle-size distribution in Test Method D2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

NOTE 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5 % of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*,

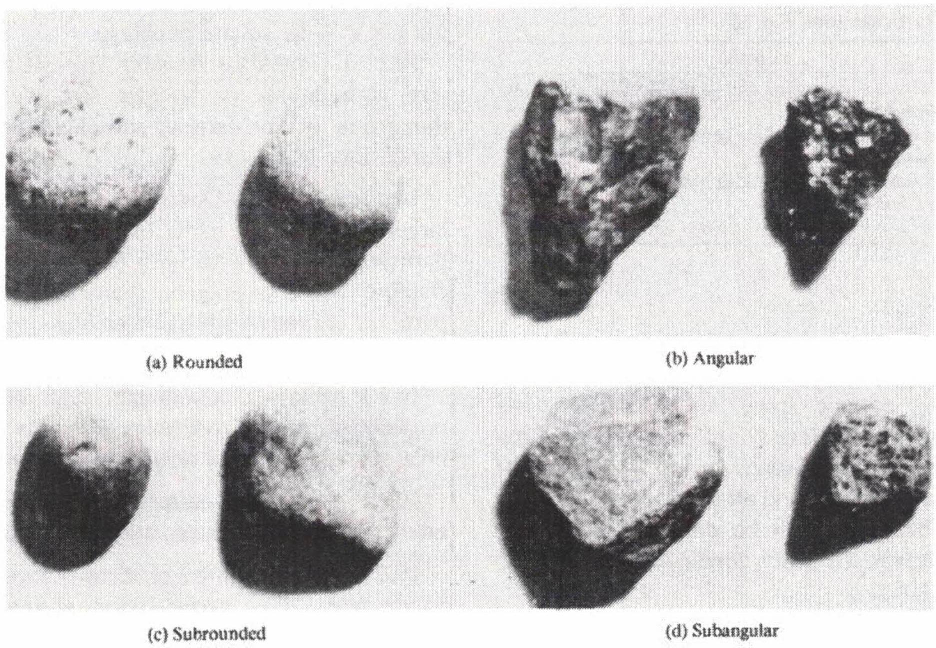


FIG. 3 Typical Angularity of Bulky Grains

TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat	Particles with width/thickness > 3
Elongated	Particles with length/width > 3
Flat and elongated	Particles meet criteria for both flat and elongated

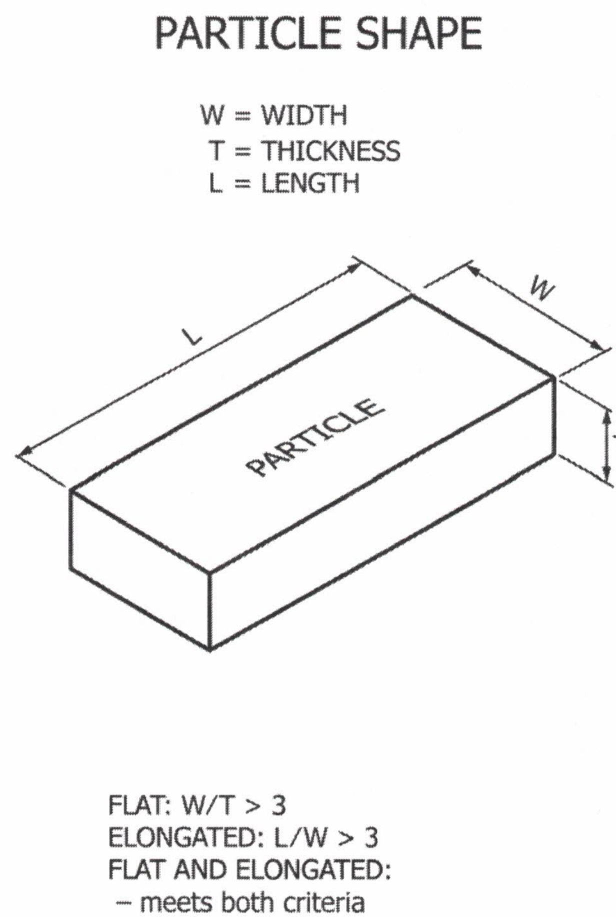


FIG. 4 Criteria for Particle Shape

for example, trace of fines. A trace is not to be considered in the total of 100 % for the components.

13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 *Dry Strength:*

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about ½

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

TABLE 4 Criteria for Describing the Reaction With HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about ¼ in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

TABLE 7 Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed 60°C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

NOTE 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface
Very high	The dry specimen cannot be broken between the thumb and a hard surface

14.3 *Dilatancy:*

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 *Toughness:*

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ⅛ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about ⅛ in. The thread will crumble at a diameter of ⅛ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness and Plasticity
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 *Identification of Inorganic Fine-Grained Soils:*

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

NOTE 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 *Identification of Organic Fine-Grained Soils:*

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

NOTE 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A ⅛-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

15. Procedure for Identifying Coarse-Grained Soils

(Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a *gravel with fines* or a *sand with fines* if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

16. Report

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

NOTE 14—*Example: Clayey Gravel with Sand and Cobbles, GC*—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions—Firm, homogeneous, dry, brown

Geologic Interpretation—Alluvial fan

NOTE 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

NOTE 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace—Particles are present but estimated to be less than 5 %

Few—5 to 10 %

Little—15 to 25 %

Some—30 to 45 %

Mostly—50 to 100 %

16.2 If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

TABLE 13 Checklist for Description of Soils

1. Group name
2. Group symbol
3. Percent of cobbles or boulders, or both (by volume)
4. Percent of gravel, sand, or fines, or all three (by dry weight)
5. Particle-size range:
   Gravel—fine, coarse
   Sand—fine, medium, coarse
6. Particle angularity: angular, subangular, subrounded, rounded
7. Particle shape: (if appropriate) flat, elongated, flat and elongated
8. Maximum particle size or dimension
9. Hardness of coarse sand and larger particles
10. Plasticity of fines: nonplastic, low, medium, high
11. Dry strength: none, low, medium, high, very high
12. Dilatancy: none, slow, rapid
13. Toughness: low, medium, high
14. Color (in moist condition)
15. Odor (mention only if organic or unusual)
16. Moisture: dry, moist, wet
17. Reaction with HCl: none, weak, strong

For intact samples:

18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
19. Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
20. Cementation: weak, moderate, strong
21. Local name
22. Geologic interpretation
23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.

18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.

X1.1.2 *Silty Sand with Gravel (SM)*—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).

In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft^3; in-place moisture 9 %.

X1.1.3 *Organic Soil (OL/OH)*—About 100 % fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).

X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.

X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown.

X2.4.3 *Broken Shells*—About 60 % uniformly graded gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % nonplastic fines; "Poorly Graded Gravel with Silt and Sand (GP-GM)."

X2.4.4 *Crushed Rock*—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.

X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.

X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.

X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.

X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

X3.1.5 A borderline symbol may be used when a fine-grained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.

X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.

X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay
ML/CL clayey silt
CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

X4.1 *Jar Method*—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

X4.2 *Visual Method*—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present. The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

X4.3 *Wash Test (for relative percentages of sand and fines)*—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.

X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.

X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.

X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	b = with boulders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel	(SP-SM)g
GP, poorly graded gravel with sand, cobbles, and boulders	(GP)scb
ML, gravelly silt with sand and cobbles	g(ML)sc

SUMMARY OF CHANGES

Committee D18 has identified the location of selected changes to this standard since the last issue (D2488 – 09) that may impact the use of this standard. (Approved June 15, 2009.)

(1) Revised Section 1.2.3.

5.9.15 BULK SPECIFIC GRAVITY AND UNIT WEIGHT OF COMPACTED HOT MIX ASPHALT (HMA) (Kansas Test Method KT-15)

1. SCOPE

This method of test covers the procedure for determining the bulk specific gravity of specimens of compacted asphalt mixtures. The specimens may have been molded in the laboratory or cut or cored from compacted pavements. **KT-15** reflects testing procedures found in **AASHTO T 166** and **AASHTO T 331.**

2. REFERENCED DOCUMENTS

2.1. Part V, 5.9.; Sampling and Test Methods Foreword

2.2. AASHTO T 166; Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface – Dry Specimens

2.3. AASHTO T 331; Bulk Specific Gravity and Density of Compacted Hot Mix Asphalt (HMA) Using Automatic Vacuum Sealing Method

3. APPARATUS

3.1. The balance shall conform to the requirements of **Part V, 5.9; Sampling and Test Methods Foreword**, for the class of general purpose balance required for the principal sample mass of the sample being tested.

3.2. Wire basket formed of No. 4 (4.75 mm) mesh hardware cloth, 1/4 in (6.3 mm) mesh or perforated shelf or suitable bucket. The size shall be sufficient to fully support the specimen.

3.3. Container with overflow device, for immersing the wire basket, shelf or bucket in water and maintaining a constant water level.

3.4. Measuring device to establish the physical dimensions of a specimen.

3.5. Vacuum chamber with a 1.25 h (0.93kW) pump capable of evacuating a sealed and enclosed chamber to 29.5 in Hg vacuum (100 kPa vacuum) in less than 60 seconds. The chamber shall be large enough to seal samples of 6 in (150 mm) wide by 14 in (350 mm) long by 6 in (150 mm) thick. The device shall automatically seal the plastic bag and exhaust air back into the chamber in a controlled manner to ensure proper conformance of the plastic to the asphalt specimen.

3.6. Plastic bags used with the vacuum device shall be one of the two following sizes. The smaller bags shall have a minimum opening of 9.25 in (235 mm) and a maximum opening 10.25 in (260 mm). The larger bags shall have a minimum opening of 14.75 in (275 mm) and a maximum opening of 15.5 in (294 mm).

3.7. Specimen sliding plate used within the vacuum chamber for reduction of friction on the plastic bags.

4. PROCEDURE

4.1. The bulk specific gravity of a compacted asphalt mix specimen is determined by computing the ratio of its mass in air to its bulk volume. Procedure I is a rapid method which generally provides sufficient accuracy for the routine testing of specimens with dense, impermeable surfaces. Procedure II corresponds to **AASHTO T 331** test method for Bulk Specific Gravity and Density of Compacted Hot Mix Asphalt (HMA) Using Automatic Vacuum Sealing Method. Procedure III is a laboratory method which is used to determine the bulk specific gravity of saturated specimens, and corresponds to **AASHTO T 166, Method A.** This method is most suitable for testing specimens with slightly permeable surfaces in order to obtain the water absorption. Procedure IV is a method which establishes the bulk specific gravity of specimens which are composed of "open" mixes that typically display high porosity and permeability. In the event of dispute, Procedure IV will take precedence over Procedures I & II. Marshall and Superpave design specimens molded at the estimated "optimum" asphalt content will be subjected to Procedure III to determine the water absorption (by volume). If the water absorption is equal to or greater than 2.0%, Procedure II shall be used for both design and routine or field purposes.

4.1.1. Constant mass shall be defined as the mass at which further drying does not alter the mass by more than 0.05%. Initially dry the specimen overnight by either placing in an oven at 125 ± 5° F (52 ± 3°C) or by placing in front of a fan on an elevated wire rack and then weigh the next day at one-hour[1] intervals.

4.1.2. Specimens are defined to be at room temperature when meeting the following procedure: Check surface temperature. Let the specimen set for 5 minutes while at ambient air conditions (no flow of any type should be flowing across the specimen). Recheck the surface temperature. The original check and recheck must fall within 77 ± 5°F (25 ± 3°C) or the specimen temperature has not stabilized to room temperature.

4.2. Procedure I

4.2.1. Weigh specimen at room temperature to the nearest 0.1 g after it has attained room temperature.

4.2.2. Place the specimen in the basket or bucket and determine it's mass to the nearest 0.1 g while immersed in water with a temperature of 77 ± 2°F (25 ± 1°C). The mass of the specimen in water shall be determined as quickly as possible after the specimen is immersed. This method should not be used if the specimen contains open or interconnecting voids.

4.3. Procedure II

4.3.1. Dry the specimen to constant mass and weigh it to the nearest 0.1g.

4.3.2. Cool the specimen to room temperature.

4.3.3. Select an appropriate size bag. For all 4 in (100 mm) diameter samples and samples with 6 in (150 mm) diameter and less than 2 in (50 mm) thickness, it is possible to use the bag with the smaller opening size.

4.3.4. Place a bag inside the vacuum chamber on top of the sliding plate.

4.3.5. Gently open the bag and place the specimen in the plastic bag on top of the sliding plate, while being careful not to handle the bag in such a manner that would create a puncture.

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[1] **AASHTO T 166** and **T 331** require a two-hour interval.

4.3.6. Allow the vacuum chamber to remove the air from the chamber and the plastic bag. The vacuum chamber shall automatically seal the bag once the air is removed.

4.3.7. Exhaust air into the chamber until the chamber door opens indicating atmospheric pressure within the chamber. The chamber door latch can be used to avoid automatic opening of the door after completion of the test.

4.3.8. Remove the sealed specimen from the vacuum chamber. Handle the sealed specimen with extreme care.

4.3.9. Weigh the sealed specimen in air to the nearest 0.1g.

4.3.10. Weigh the sealed specimen while immersed in water at 77 ± 2°F (25 ± 1°C) to the nearest 0.1 g. Verify that no air bubbles are entrapped underneath the plastic bag material. This can be accomplished by placing the sealed specimen in water with the plastic bag oriented in a vertical direction.

4.3.11. Reweigh the sealed specimen in air to the nearest 0.1 g.

4.4. Procedure III

4.4.1. For cores, dry the specimen to constant mass. Cool the specimen to room temperature and weigh the dry mass to the nearest 0.1 g, and record as A. Immerse the specimen in a 77 ± 2°F (25 ± 1°C) water bath, let saturate for 4 ± 1 minutes, then weigh and record mass as C. Remove the immersed and saturated specimen from the water bath, quickly damp dry the saturated specimen with a damp absorbent cloth and as quickly as possible, weigh and record the specimen as B. Any water which seeps from the specimen during the weighing operation is considered as part of the saturated specimen.

NOTE: If desired, the sequence of testing operations can be changed to expedite the test results. For example, first the mass of saturated damp dry specimen can be taken. Then the saturated specimen in water can be weighed. The dry mass of the specimen can be determined last.

NOTE: Terry cloth has been found to work well for an absorbent cloth. Damp is considered to be when no water can be wrung from the towel.

4.5. Procedure IV

4.5.1. Dry the specimen to constant mass.

4.5.2. After the specimen has cooled to room temperature, weigh it to the nearest 0.1 g (see **Section 4.4.1.1** of this test method).

4.5.3. Measure the height of the specimen to the nearest 0.001 in (0.025 mm) at four approximately equally spaced locations and average the four measurements. The diameter of the test specimen shall be determined to the nearest 0.001 in (0.025 mm) by averaging three diameters measured at approximately 120° from each other at about mid-height of the specimen. The average diameter shall be used in calculations.

5. CALCULATIONS

A = Mass of dry specimen in air, g.
B = Mass of saturated specimen in air after 4 minutes in water, g.
C = Mass of saturated specimen in water, g.
D = Mass of sealed specimen in air, g.
E = Mass of sealed specimen in water, g.
F = Apparent specific gravity of plastic sealing material at 77 ± 2°F (25 ± 1°C).
V = Calculated volume of specimen at 77 ± 2°F (25 ± 1°C).
G = Mass of specimen weighed immediately in water, g.
d = Specimen diameter (in [mm]).
h = Specimen height (in [mm]).

5.1. Procedure I: Bulk Specific Gravity (G_{mb})

$$G_{mb} = \frac{A}{(A-G)}$$

5.2. Procedure II: Bulk Specific Gravity of Plastic Sealed Specimens

$$G_{mb} = \frac{A}{(D-E)-\left(\frac{D-A}{F}\right)}$$

5.3. Procedure III: Bulk Specific Gravity and Absorption of Saturated Samples

$$G_{mb} = \frac{A}{(B-C)}$$

Calculate the percent of water absorbed by the specimen as follows:

$$\%\ \text{Water Absorbed (Volume Basis)} = \frac{100 \times (B-A)}{(B-C)}$$

5.4. Procedure IV: Bulk Specific Gravity by Physical Dimensions

Vol (in^3) = (0.7854) (d^2) (h) (English)

Vol (mm^3) = (0.7854) (d^2) (h) (SI)

$$\text{Unit wt. } (lb/ft^3) = \frac{3.8096 \text{ (mass in grams)}}{\text{Volume in } in^3} \quad \text{(English)}$$

$$\text{Unit wt. } (kg/m^3) = \frac{1{,}000{,}000 \text{ (mass in grams)}}{\text{Volume in } mm^3} \quad \text{(SI)}$$

$$G_{mb} = \frac{\text{Unit weight in } lb/ft^3}{62.243^d} \quad \text{(English)}$$

$$G_{mb} = \frac{\text{Unit weight in } kg/m^3}{997.04^d} \quad \text{(SI)}$$

NOTE: Density of water varies based on temperature. Since the water bath temperature is fixed at 77 ± 2°F (25 ± 1°C), use the specified values. For tests not restrained by the 77 ± 2°F (25 ± 1°C) requirement, temperature correction can be determined by selecting the proper density for water from **Table 1**.

Table 1
Density of Water

Temperature		Density	
°C	°F	kg/m^3	lb/ft^3
15	59.0	999.09	62.371
16	60.8	998.94	62.362
17	62.6	998.77	62.351
18	64.4	998.60	62.341
19	66.2	998.40	62.328
20	68.0	998.20	62.316
21	69.8	997.99	62.302
22	71.6	997.77	62.289
23	73.4	997.54	62.274
24	75.2	997.30	62.259
25	77.0	997.04	62.243
26	78.8	996.78	62.227
27	80.6	996.50	62.209
28	82.4	996.23	62.193
29	84.2	995.94	62.175
30	86.0	995.65	62.156
31	87.8	995.34	62.137
32	89.6	995.03	62.118
33	91.4	994.70	62.097
34	93.2	994.37	62.077
35	95.0	994.03	62.055

NOTE: The table was derived from the table 10-28 of Lange's Handbook of Chemistry; Twelfth Edition; Copyright 1979.

5.5. $SG_{corr.}$

$$SG_{corr.} = \left(\frac{d_w}{997.04}\right)$$

Where: d_w = density of water at temperature other than 77 ± 2°F (25 ± 1°C).

6. PRECISION

6.1. Duplicate determinations by multi laboratory, multi operator shall check to within 0.031. This value is derived from the 2006 Independent Assurance Gyratory Comparisons.

5.9.20 MASS PER CUBIC FOOT (METER), YIELD, AND AIR CONTENT (GRAVIMETRIC) OF FRESHLY MIXED CONCRETE (Kansas Test Method KT-20)

1. SCOPE

This method of test covers the procedure for determining the mass per cubic foot (meter) of freshly mixed concrete and gives formulas for calculating the following values: Yield, Relative Yield, Actual Cement Factor and Air Content. **KT-20** reflects testing procedures found in **AASHTO T 121.**

2. REFERENCED DOCUMENTS

2.1. Part V, 5.9; Sampling and Test Methods Foreword

2.2. KT-05 Unit Weight of Aggregate

2.3. KT-17; Sampling Freshly Mixed Concrete

2.4. KT-18; Air Content of Freshly Mixed Concrete by the Pressure Meter

2.5. KT-19; Air Content of Freshly Mixed Concrete by the Volumetric Method

2.6 AASHTO T 121; Weight per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete

3. APPARATUS

3.1. The balance shall conform to the requirements of **Part V, 5.9; Sampling and Test Methods Foreword**, for the class of general purpose balance required for the principal sample mass of the sample being tested.

3.2. Tamping rod shall be a straight steel rod, 5/8 in (16 mm) in diameter and approximately 24 in (600 mm) in length with both ends rounded to a hemispherical tip of the same diameter.

3.3. A cylindrical container made of steel or other suitable material. It shall be watertight and sufficiently rigid to retain its form and calibrated volume under rough usage. Measures that are machined to accurate dimensions on the inside and provided with handles are preferred. The minimum capacity of the measure shall conform to the requirements in **Table 1**. All measures, except for measuring bowls of air meters which are also used for **KT-20** of this manual, shall conform to the requirements of **KT-05** of this manual. When measuring bowls of air meters are used, they shall conform to the requirements of **KT-18** of this manual. The top rim of the air meter bowls shall be smooth and plane within 0.01 in (0.25 mm).

NOTE: The metal or other suitable material should not be readily subject to attack by cement paste. However, reactive materials such as aluminum alloys may be used in instances where, as a consequence of an initial reaction, a surface film is rapidly formed which protects the metal against further corrosion.

NOTE: The top rim is satisfactorily planed if a 0.01 in (0.25 mm) feeler gauge cannot be inserted between the rim and a piece of 1/4 in (6 mm) or thicker glass plate laid over the top of the measure.

Table 1
Minimum Capacity of Measures

Maximum Nominal Size of Coarse Aggregate		Capacity of Measure, min	
in	Mm	ft^3	m^3
1	25.0	0.2	0.006
1 1/2	37.5	0.4	0.011
2	50	0.5	0.014
3	75	1.0	0.028
4 1/2	114	2.5	0.017
6	152	3.5	0.099

NOTE: For maximum nominal aggregate sizes 1 in (25 mm) or less, the pressure meter bowl may be used.

NOTE: Aggregate of a given maximum nominal size may contain up to 10% of particles retained on the sieve referred to.

NOTE: To provide for wear, measures may be up to 5% smaller than indicated in this table.

3.4. [1]A rigid, flat glass or heavy plastic cover plate at least 1/2 (13 mm) thick and at least 2 in (50 mm) larger than the diameter of the measure for accurately striking off and leveling the surface of the concrete. The edges of the plate shall be straight and smooth with a tolerance of 1/16 in (1.6 mm).

3.5. Hand scoop.

3.6. Trowel.

3.7. Mallet with rubber or rawhide head having a mass approximately 1.25 ± 0.50 lb (600 ± 200 g) for use with measures of 0.5 ft^3 (0.014 m^3) or smaller. Mallet having a mass of 2.25 ± 0.50 lb (1000 ± 200 g) for use with measures larger than 0.5 ft^3 (0.014 m^3).

3.8. Internal vibrators may have rigid or flexible shafts, preferably powered by an electric motor. The diameter of the vibrating element shall be not less than 0.075 in (19 mm) or more than 1.50 in (38 mm) and the length of the shaft should be 24 in (600 mm) or more. The frequency of vibration shall be 7000 vibrations per minute (117 Hz) or greater. A tachometer should be used to check the frequency of vibration.

4. CALIBRATION OF MEASURE, AND CALIBRATION FACTOR

4.1. Determine the mass of the empty measure to the nearest 0.05 lb (20 g) and record this mass as A. Determine the mass of the empty measure (coated with grease on the top rim if necessary) and cover plate to the nearest 0.05 lb (20 g) and record this mass as C.

4.2. Fill the measure with water, using the cover plate to ensure that it is exactly full. Wipe excess water from sides and bottom of the measure with an absorbent cloth.

[1] **AASHTO T 121** allows the use of a metal plate.

4.3. Weigh and record the mass of the measure, water, and cover plate. Record this mass as B.

4.4. Measure and record the temperature of the water and determine the density as found in **KT-15**, interpolating if needed.

4.5. Calculations:

$$V = \frac{B - C}{D}$$

Where: V = Volume of the measure, ft^3 (m^3)
B = Mass of the measure filled with water plus cover plate, lb (kg)
C = Mass of the measure and cover plate, lb (kg)
D = Density of water (see **KT-15**), lb/ft^3 (kg/m^3)

$$F = \frac{D}{B - C} = \frac{1}{V}$$

Where: F = Calibration factor, $1/ft^3$ ($1/m^3$)

5. TEST PROCEDURE

5.1. Obtain a sample of freshly mixed concrete in accordance with **KT-17** of this manual.

5.2. Weigh the measure and record the mass as A.

5.3. Concrete at different slump levels requires different methods of consolidation to prepare satisfactory test specimens. The methods listed below should be used as a guide in determining the type of consolidation to use:

Slump of Concrete	Type of Consolidation
More than 3 in (75 mm)	Rodding
1 to 3 in (25 to 75 mm)	Rodding or Vibration
Less than 1 in (25 mm)	Vibration

5.4. Rodding procedure.

5.4.1 Place concrete in the measure in three equal layers.

5.4.2. Rod each layer 25 times when 0.5 ft^3 (0.014 m^3) or smaller measures are used and 50 times when the 1 ft^3 (0.28 m^3). When rodding the first layer, avoid striking the bottom of the container and when rodding successive layers, use only enough force to penetrate the surface of the underlying layer about 1 in (25 mm).

5.4.3. After each layer is rodded, tap the sides of the measure smartly 10 to 15 times with the mallet to close any voids left by the tamping rod and to release any large bubbles of air that may have been trapped.

5.4.4. After consolidation, strike-off the top surface of the concrete and finish it smoothly with the flat strike-off plate using great care to leave the measure just full. The strike-off is best accomplished by pressing the strike-off plate on the top surface of the measure to cover about 2/3 of the surface and withdrawing the plate with a sawing motion to finish only the area originally covered. Then place the plate on the top of the measure to cover the original 2/3 of the surface and advance it with a vertical pressure and a sawing motion to cover the whole surface of the measure. Several final strokes with the inclined edge of the plate will produce a smooth finished surface.

5.4.5. Clean all excess concrete from the exterior of the filled measure. Weigh the filled measure to the nearest 0.1 lb (50 g) and record the mass as D.

5.5. Vibration Procedure.

5.5.1. Fill the measure approximately 1/2 full of concrete. Place all the concrete required for the layer in the measure before starting vibration.

5.5.2. Consolidate the layer by three insertions of the vibrator evenly distributed over the surface. Do not let the vibrator rest or touch the bottom or sides of the measure. The duration of vibration will depend on the effectiveness of the vibrator and the consistency of the concrete, but usually sufficient vibration has been applied when the surface of the concrete becomes relatively smooth in appearance.

5.5.3. Fill the measure to an elevation somewhat above the top rim and vibrate this second layer. In compacting the final layer, the vibrator shall penetrate into the underlying layer approximately 1 in (25 mm). Take care that the vibrator is withdrawn in such a manner that no air pockets are left in the specimen. A small quantity of concrete may be added to correct a deficiency. If the measure contains a great excess of concrete at completion of consolidation, remove most of the excess concrete with a trowel or scoop immediately before the measure is struck-off.

5.5.4. Strike-off the surface as in **Section 5.4.4** of this test method**.**

5.5.5. Proceed as in **Section 5.4.5** of this test method**.**

6. CALCULATIONS

6.1. Mass per cubic foot (meter) of fresh concrete.

W = F (D- A)

Where: W = Mass of concrete lb/ft^3 (kg/m^3)
D = Mass of measure filled with concrete, lb (kg)
A = Mass of measure, lb (kg)
F = Calibration factor

6.2. Volume of Concrete produce per batch.

$$S = \frac{W_c + W_{fa} + W_{ca} + W_w + W_o}{W}$$

Where: S = Volume of concrete produced per batch, ft^3 (m^3)
W_c = Total mass of cement in batch, lb (kg)
W_{fa} = Total wet mass of fine aggregate in batch, lb (kg)
W_{ca} = Total mass of coarse aggregate in batch lb (kg)
W_w = Total mass of mixing water added to batch, lb (kg)
W_o = Total mass of any other solid or liquid material used, lb (kg)

6.3. Relative yield is the ratio of actual volume of concrete obtained to the volume as designed for the batch and shall be calculated as follows:

(English)

$$RY = \frac{S}{27(V_d)}$$

(SI)

$$RY = \frac{S}{V_d}$$

Where; RY = Relative density
V_d = Volume of concrete which the batch was designed to produce, yd^3 (m^3)
S = Volume of concrete produced per batch, ft^3 (m^3)

NOTE: A value for RY greater than 1.00 indicates that an excess volume of concrete is being produced. Whereas, a value less than 1.00 indicates the batch to be "short" of its designed volume.

6.4. Air Content: calculate as follows:

$$A = \frac{100(T - W)}{T}$$

Where: A = Air content in the concrete
T = Theoretical mass of the concrete, lb/ft^3 (kg/m^3), air free basis
W = Mass of concrete lb/ft^3 (kg/m^3)

NOTE: When the same materials and proportions are used to prepare different batches of concrete, it is assumed that the theoretical, air free, mass per cubic foot (meter) of the concrete is constant for all batches. It is calculated from the formula:

$$T = \frac{W_1}{V}$$

Where: $W_1 = W_c + W_{fa} + W_{ca} + W_w + W_o$
V = Total absolute volume of the component ingredients in the batch, ft^3 (m^3)

The absolute volume of each ingredient is calculated in accordance with **subsection 5.10.1** of this manual. For aggregate components, the bulk specific gravity and mass should be based on the saturated, surface-dry condition.

6.5. Actual Cement Factor: Cement factor based on theoretical yd^3 (m^3) of concrete required and actual quantity of cement used is calculated as follows:

$$ACF = \frac{A}{B}$$

Where: A = Actual cement used lb (kg)
B = Theoretical volume of concrete, yd^3 (m^3)

Soils Field Testing Technician
KT 10 Plasticity Tests (LL)
Revised July 2016

Two attempts may be made by the applicant. The applicant may stop themselves once and not have that count as one of the two attempts. If the applicant stops voluntarily, draw a line at that point and note that the applicant stopped themselves then restart at the top of the next attempt.

Applicant: ______________________________ **CIT #:** ____________________

Employer: ____

		1st Test	Stopped Test	Re-Test
	Sample Preparation			
1.	Dry the material at a temperature not exceeding 140ºF (60ºC). (4.2.)	PASS FAIL	PASS FAIL	PASS FAIL
2.	Separate into two fractions using a No. 10 (2.00 mm) sieve. Grind the material retained on the sieve until the aggregations of soil particles are broken into separate grains. Ground soil shall then be separated into two fractions using the No. 10 (2.00 mm) sieve. Discarding the material retained on the sieve. (4.2.1.)	PASS FAIL	PASS FAIL	PASS FAIL
3.	Dry-screen the material over a No. 40 (425 µm) sieve. (4.2.2.)	PASS FAIL	PASS FAIL	PASS FAIL
	Test Procedure			
4.	Place a piece of masking tape across the outside bottom of the cup parallel with the axis of the cup hanger pivot. Place the tape between the wear spot and the pivot so that the edge of the tape away from the cup hanger bisects the spot on the cup that contacts the base. Slide the height gauge under the cup to the device and turn the crank until the cup is raised to its maximum height. If the adjustment is correct, a slight ringing sound will be heard when the cam strikes the cam follower. Remove the tape after adjustment. (4.3.1.1. and 4.3.1.)	PASS FAIL	PASS FAIL	PASS FAIL
5.	Inspect the liquid limit device to be sure that it is in good working order and that there are no worn or "out of alignment" parts that will affect the test results. (4.3.2.)	PASS FAIL	PASS FAIL	PASS FAIL

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		1st Test		Stopped Test		Re-Test	
6.	Take a sample weighing approximately 100 g and place in the mixing dish. The sample shall be thoroughly mixed with 15 to 20 mL of distilled or demineralized water by alternately and repeatedly stirring, kneading, and chopping with a spatula. (4.3.3.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
7.	Additions of water shall be made in 1 to 3 mL increments. Each increment of water shall be thoroughly mixed with the soil before another increment is added. Once testing has begun no additional dry soil is to be added to the moistened soil. (4.3.3.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
8.	The liquid limit device shall not be used for mixing the soil and water. If too much moisture has been added to the sample, the sample shall either be discarded, or mixed and kneaded until the natural evaporation lowers the closure point into acceptable range. (4.3.3.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
9.	A sufficient quantity of this mixture shall be placed in the cup above the spot where the cup rests on the base and shall be squeezed and spread with the spatula to level and at the same time trimmed to a depth of 10 mm at the point of maximum thickness. (4.3.4.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
10.	The soil in the cup shall be divided by a maximum of six firm strokes of the grooving tool. The depth of the grove should be increased with each stroke and only the last stroke should scrape the bottom of the cup. (4.3.4.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
11.	The cup containing the sample shall be lifted and dropped by turning the crank at the rate of approximately two revolutions per second until the two sides of the sample come in contact at the bottom of the groove along a distance of about 0.5 in. (13 mm). DO NOT hold the base with the free hand while crank is turned. (4.3.5.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
12.	Record the number of shocks. (4.3.5.)	PASS	FAIL	PASS	FAIL	PASS	FAIL

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KT 10 Plasticity Tests (LL)
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		1st Test	Stopped Test	Re-Test
13.	Remove a slice of the soil approximately the width of the spatula, extending from edge to edge of the soil cake at right angles to the groove and including that portion of the groove in which the soil flowed together, and place in a suitable container. (4.3.6.)	PASS FAIL	PASS FAIL	PASS FAIL
14.	Record the sample mass to the nearest 0.01 g. The soil in the container (with lid) shall be dried in accordance with KT-11 to determine the moisture content. Record the results. (4.3.6.)	PASS FAIL	PASS FAIL	PASS FAIL
15.	Transfer the soil remaining in the cup to the mixing dish. (4.3.7.)	PASS FAIL	PASS FAIL	PASS FAIL
16.	Wash and dry the grooving tool and cup. (4.3.7.)	PASS FAIL	PASS FAIL	PASS FAIL
17.	Add water to the sample in the mixing dish to bring the soil to a more fluid condition. (4.3.8.)	PASS FAIL	PASS FAIL	PASS FAIL
18.	The object of this procedure is to obtain samples of such consistency that at least one determination will be made in each of the following ranges of shocks: 25-35, 20-30, 15-25. The range of the three determinations shall be at least 10 shocks. (4.3.8)	PASS FAIL	PASS FAIL	PASS FAIL
19	Calculate the moisture content. (5.1)	PASS FAIL	PASS FAIL	PASS FAIL
20	Draw a flow curve on a semi-logarithmic graph by plotting moisture contents on the arithmetical scale and number of shocks on the logarithmic scale, then drawing a straight line as nearly as possible through three plotted points. (5.2.)	PASS FAIL	PASS FAIL	PASS FAIL
21	Determine the liquid limit of the soil by locating the intersection of the flow curve with the 25 shock ordinate and report to the nearest whole number. (5.3.)	PASS FAIL	PASS FAIL	PASS FAIL

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KT 10 Plasticity Tests (LL)
Revised July 2016

Overall Score

Circle One

1st Test	**Stopped Test**	**Re-Test**
PASS	PASS	PASS
FAIL	FAIL	FAIL

Witness Examiner:
(First Try) ______________________ Signature ______________________ Date

Witness Examiner:
(Stopped Try) ______________________ Signature ______________________ Date

Witness Examiner:
(Re-Test) ______________________ Signature ______________________ Date

Soils Field Testing Technician
KT 10 Plasticity Tests (PL)
Revised September 2022

Two attempts may be made by the applicant. The applicant may stop themselves once and not have that count as one of the two attempts. If the applicant stops voluntarily, draw a line at that point and note that the applicant stopped themselves then restart at the top of the next attempt.

Applicant: ______________________ **CIT #:** ______________

Employer: ______________________________

		1st Test	Stopped Test	Re-Test
	Sample Preparation			
1.	<u>The test is conducted using material finer than the No. 40 (425 µm) sieve. (6.2.)</u>	PASS FAIL	PASS FAIL	PASS FAIL
	Procedure			
2.	Thoroughly mix the minus No. 40 (425 µm) material and place approximately 20 g in an evaporating dish. (6.3.1.)	PASS FAIL	PASS FAIL	PASS FAIL
3.	Thoroughly mix with distilled or demineralized water until the mass becomes plastic enough to be easily shaped into a ball. Take a portion of this ball with a mass of about 10 g for the test sample. (6.3.2.)	PASS FAIL	PASS FAIL	PASS FAIL
4.	Select 1.5 to 2.0 g of sample, form into an ellipsoidal mass. (6.3.4.)	PASS FAIL	PASS FAIL	PASS FAIL
5.	Form the mass into a uniform 1/8 in (3 mm) diameter thread by rolling it at a rate between 80 and 90 strokes per minute between the palm or fingers and a ground-glass plate or paper laying on a smooth surface. (6.3.5.)	PASS FAIL	PASS FAIL	PASS FAIL
6.	Reduce the diameter of the thread to 1/8 in (3 mm) taking no more than 2 min. (6.3.5.)	PASS FAIL	PASS FAIL	PASS FAIL
7.	Quickly squeeze and reform the thread into an ellipsoidal shaped mass and re-roll. Continue this alternate reforming and re-rolling, until the thread crumbles under the pressure required for rolling and the material can no longer be rolled into a thread. (6.3.5.)	PASS FAIL	PASS FAIL	PASS FAIL

Soils Field Testing Technician
KT 10 Plasticity Tests (PL)
Revised September 2022

		1st Test	Stopped Test	Re-Test
8.	The crumbling may occur when the thread is greater than 1/8 in (3 mm) in diameter. This shall be considered a satisfactory end point, provided the material has been rolled to a thread of 1/8 in (3 mm) during the previous rolling. (6.3.5.)	PASS FAIL	PASS FAIL	PASS FAIL
9.	At no time shall the operator attempt to produce failure at exactly 1/8 in (3 mm) diameter by allowing the thread to reach 1/8 in (3 mm), then reducing the rate of rolling or the hand pressure or both, and continuing the rolling without further deformation until the thread falls apart. (6.3.5.)	PASS FAIL	PASS FAIL	PASS FAIL
10.	Place the crumbled thread in a watch glass or other suitable container of known mass and close to prevent evaporation loss. (6.3.6.)	PASS FAIL	PASS FAIL	PASS FAIL
11.	Record the sample mass to the nearest 0.01 g. (6.3.7.)	PASS FAIL	PASS FAIL	PASS FAIL
12.	The soil in the container shall be dried in accordance with **KT-11**, to determine the moisture content. The use of a lid for the container as stated in KT-11 is required. Record the results. (6.3.7.)	PASS FAIL	PASS FAIL	PASS FAIL
	Alternate procedure using the Plastic Limit Device			
13.	Attach smooth unglazed paper to both the bottom fixed plate and the top plate of the plastic limit device. (6.4.1.)	PASS FAIL	PASS FAIL	PASS FAIL
14.	Split the 10 g test sample into four or five masses of 1.5 to 2.0 g each. Squeeze into an ellipsoidal-shape and place two to three masses on the bottom plate. (6.4.2.)	PASS FAIL	PASS FAIL	PASS FAIL
15.	Place the top plate in contact with the soil masses. Simultaneously with a slight downward force, apply a back-and forth-rolling motion with the top plate until the top plate comes into contact with the 3.2 mm side rails, within two minutes. (6.4.2.)	PASS FAIL	PASS FAIL	PASS FAIL

Soils Field Testing Technician
KT 10 Plasticity Tests (PL)
Revised September 2022

		1st Test	Stopped Test	Re-Test
16.	Do not allow the soil thread to come into contact with the side rails. (6.4.2.)	PASS FAIL	PASS FAIL	PASS FAIL
	Calculations			
17.	Calculate and record the percentage of moisture to the 0.1%, report the percentage of moisture to the nearest whole percent. (7.2.)	PASS FAIL	PASS FAIL	PASS FAIL
18.	Calculate the plastic index as follows: Plastic Index= Liquid Limit – Plastic Limit (8.2) Report to the nearest whole number. (8.3)	PASS FAIL	PASS FAIL	PASS FAIL

Overall Score

Circle One

1st Test	Stopped Test	Re-Test
PASS	PASS	PASS
FAIL	FAIL	FAIL

Witness Examiner: ______________________ ______________________
(First Try) Signature Date

Witness Examiner: ______________________ ______________________
(Stopped Try) Signature Date

Witness Examiner: ______________________ ______________________
(Re-Test) Signature Date

Soils Field Testing Technician
KT-11 Moisture Tests (Constant Mass Method)
Revised July 2016

Two attempts may be made by the applicant. The applicant may stop themselves once and not have that count as one of the two attempts. If the applicant stops voluntarily, draw a line at that point and note that the applicant stopped themselves then restart at the top of the next attempt.

Applicant: ______________________________ **CIT #:** ____________________

Employer: ____

		1st Test	Stopped Test	Re-Test
	Test Sample			
1.	Select a representative quantity of sample in the amount indicated in the appropriate table. (4.1.)	PASS FAIL	PASS FAIL	PASS FAIL
	Procedure			
2.	Weigh a clean, dry container (with lid for soils). Record the weight. (4.2.)	PASS FAIL	PASS FAIL	PASS FAIL
3.	Place the moisture sample in the container and weigh. (with lid for soils) Record the weight. (4.2.)	PASS FAIL	PASS FAIL	PASS FAIL
4.	Place the container with the sample in the drying oven 230 +/- 9 º F (110 º +/- 5º C) and dry to a constant mass. (remove lid) (4.2.)	PASS FAIL	PASS FAIL	PASS FAIL
5.	Immediately upon removal from the oven, replace the lid and allow sample to cool to room temperature. (replace lid) (4.2.)	PASS FAIL	PASS FAIL	PASS FAIL
6.	Weigh the container and the dried sample (with lid). (4.2.)	PASS FAIL	PASS FAIL	PASS FAIL
7.	Calculate the moisture content. (5.1.)	PASS FAIL	PASS FAIL	PASS FAIL

Soils Field Testing Technician
KT-11 Moisture Tests (Constant Mass Method)
Revised July 2016

Overall Score

Circle One

1st Test	Stopped Test	Re-Test
PASS	PASS	PASS
FAIL	FAIL	FAIL

Witness Examiner: ____________________ ____________________

(First Try) Signature Date

Witness Examiner: ____________________ ____________________

(Stopped Try) Signature Date

Witness Examiner: ____________________ ____________________

(Re-Test) Signature Date

Soils Field Testing Technician
KT-11 Moisture Tests (Gas Pressure Method)
Revised July 2015

Two attempts may be made by the applicant. The applicant may stop themselves once and not have that count as one of the two attempts. If the applicant stops voluntarily, draw a line at that point and note that the applicant stopped themselves then restart at the top of the next attempt.

Applicant: ______________________ **CIT #:** ______________

Employer: ______________________________

	Procedure	**1st Test**	**Stopped Test**	**Re-Test**
1.	Using 20 g or 26 g tester, place three scoops of calcium carbide in the body of the moisture tester. (9.1.)	PASS FAIL	PASS FAIL	PASS FAIL
2.	Weigh a sample of the exact mass specified by manufacturer of the instrument in the balance provided, and place the sample in the cap of the tester. (9.2.)	PASS FAIL	PASS FAIL	PASS FAIL
3.	Place two steel balls in the body of the tester with the calcium carbide (9.2.).	PASS FAIL	PASS FAIL	PASS FAIL
4.	With the vessel in a horizontal position, insert the cap in the vessel and seal unit tight, make sure no carbide comes into contact with the soil. (9.3.)	PASS FAIL	PASS FAIL	PASS FAIL
5.	Raise the moisture tester to a vertical position so that the soil in the cap will fall into the pressure vessel. (9.4.)	PASS FAIL	PASS FAIL	PASS FAIL
6.	Shake the instrument so that the lumps will be broken up to permit the calcium carbide to react with all available free moisture. (9.5.)	PASS FAIL	PASS FAIL	PASS FAIL
7.	Make sure instrument is shaken with a rotating motion. (9.5.)	PASS FAIL	PASS FAIL	PASS FAIL
8.	Shaking should continue for at least 60 seconds with granular soils and for up to 180 seconds for soils so as to permit complete reaction between the calcium and the free moisture. (Note: 9.5)	PASS FAIL	PASS FAIL	PASS FAIL

Soils Field Testing Technician
KT-11 Moisture Tests (Gas Pressure Method)
Revised July 2015

		1st Test		Stopped Test		Re-Test	
9.	When needle stops moving, read the dial while holding the instrument in a horizontal position at eye level. (9.6.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
10.	Record the dial reading. (9.7.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
11.	With the cap pointed away from operator, slowly release the gas pressure. (9.8.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
12.	Empty the pressure vessel and examine the material for lumps. If sample is not completely pulverized, the test should be repeated using a new sample (9.8.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
13.	The percentage of moisture by dry mass of the soil may be determined from the conversion curve. (9.9.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
14.	Record the dial reading to the nearest 0.1% and determine the percentage of moisture from the conversion chart. Report the percentage of moisture to the nearest whole percent. (11.1.)	PASS	FAIL	PASS	FAIL	PASS	FAIL

Overall Score

Circle One

1st Test	**Stopped Test**	**Re-Test**
PASS	PASS	PASS
FAIL	FAIL	FAIL

Witness Examiner: ______________________ ______________________

(First Try) Signature Date

Witness Examiner: ______________________ ______________________

(Stopped Try) Signature Date

Witness Examiner: ______________________ ______________________

(Re-Test) Signature Date

Soils Field Testing Technician
KT-12 Standard Compaction Test (Fine)
Revised May 2015

Two attempts may be made by the applicant. The applicant may stop themselves once and not have that count as one of the two attempts. If the applicant stops voluntarily, draw a line at that point and note that the applicant stopped themselves then restart at the top of the next attempt.

Applicant: ______________________ **CIT #:** ______________

Employer: ______________________

		1st Test		Stopped Test		Re-Test	
	Sample Preparation Fine						
1.	Obtain a 60 to 80 lb (30 to 35 kg) sample, dry at 140ºF (60ºC) if necessary. Break it down to pass the No. 4 (4.75 mm) sieve. Discard granular particles retained on the sieve. (4.1.1.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
2.	Mix thoroughly and weigh out six portions, each weighing 5 lb (2200 g). (4.1.2.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
	Test Procedure						
3.	Add a measured amount of water (approximately 12% by dry mass) to one 5 lb (2200 g) portion and thoroughly mix it into the sample. (4.2.1.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
4.	The sample of soil water mixture shall be placed in a closed container to minimize moisture loss. The sample shall then be allowed to stand for a minimum of 12 hours before conducting the moisture density test. (4.2.2.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
5.	Obtain the mass of the mold. (4.2.3.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
6.	Place the assembled mold on the rigid base and fill the mold so that the compacted layer will equal 1/3 of the mold volume. (4.2.4.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
7.	Compact the material with 25 blows of the rammer dropped from a height of 12 in (304.8 mm) above the surface of the material. Distribute the blows of the rammer evenly over the surface. (4.2.5.)	PASS	FAIL	PASS	FAIL	PASS	FAIL

Soils Field Testing Technician
KT-12 Standard Compaction Test (Fine)
Revised May 2015

		1st Test		Stopped Test		Re-Test	
8.	Place two more layers of the material in the mold and compact each layer as stipulated above. (4.2.6.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
9.	Remove the top collar and trim the excess material level with the top of the mold. (4.2.7.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
10.	Remove the base and trim excess material level with the bottom of the mold. (4.2.8.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
11.	Weigh the sample to the nearest 5 g while it is in the mold. (4.2.9.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
12.	Repeat the compaction procedure using the other 5 lb (2200 g) increments of the sample to which different measured amounts of water have been added. (4.2.10.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
13.	This procedure will be continued with varying moisture contents until at least three points are obtained on the dry side of “optimum moisture” and at least two points are obtained on the wet side of “optimum moisture”. (4.2.10.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
14.	Remove the material from the mold and slice vertically through the center. Take a representative sample, weighing a minimum of 100 g, of the material from one of the cut faces, determine the mass immediately and dry in accordance with KT-11 to determine moisture content. (4.2.11.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
	Calculations						
15.	Calculate the dry mass and the wet mass of compacted soil. (6.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
16.	Report the density to the nearest whole number. Report the moisture to the nearest whole number. (7.1.)	PASS	FAIL	PASS	FAIL	PASS	FAIL

Soils Field Testing Technician
KT-12 Standard Compaction Test (Fine)
Revised May 2015

		1st Test		Stopped Test		Re-Test	
17.	Plot a density/moisture curve on coordinate paper (KDOT Form 638) to determine the maximum density and optimum moisture. The dry density values are plotted as ordinates, the corresponding moisture contents are plotted as abscissa and a smooth curve is drawn to best fit the points. (5.4.)	PASS	FAIL	PASS	FAIL	PASS	FAIL

Overall Score

Circle One

1st Test	Stopped Test	Re-Test
PASS	PASS	PASS
FAIL	FAIL	FAIL

Witness Examiner: ______________________ ______________________

(First Try) Signature Date

Witness Examiner: ______________________ ______________________

(Stopped Try) Signature Date

Witness Examiner: ______________________ ______________________

(Re-Test) Signature Date

Soils Field Tester Technician
KT-13 Field Density Tests of Soils, Treated Base Courses, and Water Bound Base Courses (Sand Cone Method)
Revised July 2016

Two attempts may be made by the applicant. The applicant may stop themselves once and not have that count as one of the two attempts. If the applicant stops voluntarily, draw a line at that point and note that the applicant stopped themselves then restart at the top of the next attempt.

Underlined items will be administered orally

Applicant: ______________________ **CIT #:** ______________

Employer: ______________________________

TEST TRIAL

		1st Test	Stopped Test	3rd Test
	Determine the Volume of Jar & Attachment			
1.	<u>Weigh the assembled apparatus and record.</u> (6.1.1.)	PASS FAIL	PASS FAIL	PASS FAIL
2.	<u>Place the apparatus up right and open the valve.</u> (6.1.2.)	PASS FAIL	PASS FAIL	PASS FAIL
3.	<u>Fill the apparatus with water until it appears over the valve.</u> (6.1.3.)	PASS FAIL	PASS FAIL	PASS FAIL
4.	<u>Close the valve and remove excess water.</u> (6.1.4)	PASS FAIL	PASS FAIL	PASS FAIL
5.	<u>Weigh the apparatus and water</u>. (6.1.5)	PASS FAIL	PASS FAIL	PASS FAIL
6.	<u>Repeat the procedure described above at least twice. The volume used shall be the average of three determinations with a maximum variation of 3 mL</u>. (6.1.6.)	PASS FAIL	PASS FAIL	PASS FAIL
	Determination of Bulk Density of Sand			
7.	<u>Place the empty apparatus upright on a firm, level surface; close the valve and fill the funnel with sand.</u> (6.2.1.)	PASS FAIL	PASS FAIL	PASS FAIL

		1st Test		Stopped Test		3rd Test	
8.	Open the valve and keeping the funnel at least half full of sand, fill the apparatus. Close the valve sharply and empty excess sand. (6.2.2.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
9.	Weigh the apparatus and sand. Determine the net weight of sand by subtracting the mass of the apparatus. (6.2.3)	PASS	FAIL	PASS	FAIL	PASS	FAIL
	Determination of mass of sand filling the funnel						
10.	Put sand in the apparatus and obtain the mass of the apparatus and sand. (6.3.1.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
11.	Seat the inverted apparatus on a clean, level, plane surface. (6.3.2.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
12.	Open the valve and keep open until the sand stops running. (6.3.3.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
13.	Close the valve sharply. Weigh the apparatus with remaining sand and determine the loss of sand. This loss represents the mass of sand required to fill the funnel. (6.3.4.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
14.	Replace the sand removed in the funnel determination and close the valve. (6.3.5.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
	Determination of Density of Soil in-place						
15.	Prepare the surface of the location to be tested so that it is a level plane. (6.4.1)	PASS	FAIL	PASS	FAIL	PASS	FAIL
16.	Seat the inverted apparatus on the prepared plane surface and mark the outline of the funnel. (6.4.2.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
17.	Drill or cut a test hole. Carefully save all material. (6.4.2.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
18.	Seat the apparatus in the previously marked position, open the valve, and after the sand has stopped flowing, close the valve. (6.4.3.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
19.	Weigh the apparatus and remaining sand. Determine the mass of sand used in the test. (6.4.4.)	PASS	FAIL	PASS	FAIL	PASS	FAIL

		1st Test		Stopped Test		3rd Test	
20.	Weigh the material that was removed from the test hole. (6.4.5.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
21.	Mix the material thoroughly and secure and weigh a representative sample for moisture determination. (6.4.6.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
22.	Determine the moisture content in accordance with KT-11. (6.4.7.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
23.	Calculate the volume of the density apparatus. (6.1.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
24.	Calculate the bulk density of sand. (6.2.4.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
25.	Calculate the wet density of the material removed from the hole. (6.5.2.)	PASS	FAIL	PASS	FAIL	PASS	FAIL
26.	Calculate the in place dry density of the material tested to the nearest 0.1 lb/ft^3 (6.5.3.)	PASS	FAIL	PASS	FAIL	PASS	FAIL

Overall Score

Circle One

1st Test	Stopped Test	3rd Test
PASS	PASS	PASS
FAIL	FAIL	FAIL

Witness Examiner: ______________________________ ______________________

(First Try) Signature Date

Witness Examiner: ______________________________ ______________________

(Stopped Try) Signature Date

Witness Examiner: ______________________________ ______________________

(Re-Test) Signature Date

Soils Field Testing Technician
KT-13 Field Density Tests of Soils, Treated Base Courses and Water Bound Base Courses (Sand Density)
Revised July 2016

Two attempts may be made by the applicant. The applicant may stop themselves once and not have that count as one of the two attempts. If the applicant stops voluntarily, draw a line at that point and note that the applicant stopped themselves then restart at the top of the next attempt.

Applicant: ______________________________ **CIT #:** ________________

Employer: ____

	Test Procedure	1st Test	Stopped Test	Re-Test
	Loose Unit Weight of Sand			
1.	Fill the cylinder of known volume to slightly overflowing by pouring the dry sand at a uniform rate from the spout of the pouring container. (4.1.1.1.)	PASS FAIL	PASS FAIL	PASS FAIL
2.	Hold spout approximately 2 in (50 mm) above the top of the container. (4.1.1.1.)	PASS FAIL	PASS FAIL	PASS FAIL
3.	Strike off the excess sand level with top of the container, avoid jarring the container. Weigh the cylinder and sand.(4.1.1.2.)	PASS FAIL	PASS FAIL	PASS FAIL
4.	Conduct a total of three tests to determine the loose unit weight of the sand and use the average value obtained when computing the "in-place" density. (4.1.1.2.)	PASS FAIL	PASS FAIL	PASS FAIL
	Density Determination			
5.	Select test site, determine and record the station, distance from centerline, and elevation as distance below the final grade. (4.1.2.)	PASS FAIL	PASS FAIL	PASS FAIL
6.	Trim off all raised or uneven spots to produce a smooth, flat surface not less than 18 in (450 mm) square, using a point shovel or other suitable tool, and remove all loose material from the area. (4.1.3.)	PASS FAIL	PASS FAIL	PASS FAIL

Soils Field Testing Technician
KT-13 Field Density Tests of Soils, Treated Base Courses and Water Bound Base Courses (Sand Density)
Revised July 2016

		1st Test	Stopped Test	Re-Test
7.	Drill or cut a test hole through the depth of the material being tested and save all material removed, protecting the sample from weather conditions which might change the moisture content. (4.1.4.)	PASS FAIL	PASS FAIL	PASS FAIL
8.	Weigh the material, record the mass, and dry the entire sample or a representative portion to constant mass. Weigh and record the dry mass. (4.1.5.)	PASS FAIL	PASS FAIL	PASS FAIL
9.	Determine and record the mass of the pouring container with a volume of sand somewhat greater than the volume of the test hole. (4.1.6.)	PASS FAIL	PASS FAIL	PASS FAIL
10.	Fill the hole level full of sand by pouring the sand at a uniform rate while holding the spout 2 in (50 mm) above the top of the test hole. (4.1.7.)	PASS FAIL	PASS FAIL	PASS FAIL
11.	The straight edge should be used to insure that the sand is level with the surface of the material surrounding the test hole. (4.1.7.)	PASS FAIL	PASS FAIL	PASS FAIL
12.	Weigh the pouring container and remaining sand and record the mass. (4.1.8.)	PASS FAIL	PASS FAIL	PASS FAIL
	Alternate Method			
13.	Using a funnel, deposit the sand through a small pipe (about 3/4 in. in diameter). (4.2.1.)	PASS FAIL	PASS FAIL	PASS FAIL
14.	Let the pipe rest on the bottom of the hole and pour the sand into the pipe until it is full, then raise the pipe about 8 in. Repeat this step. (4.2.2.)	PASS FAIL	PASS FAIL	PASS FAIL
15.	Do not let the pipe settle in the sand. The number of sections of pipe used does not affect the accuracy of the results, and each section may be removed as necessary. (4.2.2.)	PASS FAIL	PASS FAIL	PASS FAIL

Soils Field Testing Technician
KT-13 Field Density Tests of Soils, Treated Base Courses and Water Bound Base Courses (Sand Density)
Revised July 2016

		1st Test	Stopped Test	Re-Test
16.	Do the following calculations: Density of dry sand Percent moisture content of material Mass of sand in test hole Volume of test hole In place dry density of material being tested Mass of dry material removed from the test hole. (5.)	PASS FAIL	PASS FAIL	PASS FAIL

Overall Score

Circle One

1st Test	Stopped Test	Re-Test
PASS	PASS	PASS
FAIL	FAIL	FAIL

Witness Examiner:

(First Try) Signature __________ Date __________

Witness Examiner:

(Stopped Try) Signature __________ Date __________

Witness Examiner:

(Re-Test) Signature __________ Date __________

Soils Field Testing Technician

KT-65 Sampling and Splitting Cement Treated Base Mixtures

Revised July 2016

Two attempts may be made by the applicant. The applicant may stop themselves once and not have that count as one of the two attempts. If the applicant stops voluntarily, draw a line at that point and note that the applicant stopped themselves then restart at the top of the next attempt.

Applicant: ______________________________ **CIT #:** ____________________

Employer: ____

	Procedure	**1st Test**	**Stopped Test**	**3rd Test**
1.	The total length of time required to sample and split the material shall take no longer than 45 minutes. (Note)	PASS FAIL	PASS FAIL	PASS FAIL
	Truck Beds			
2.	Divide the truck bed into at least three areas of approximately equal size (3.1.1)	PASS FAIL	PASS FAIL	PASS FAIL
	_			
3.	Dig a hole about 1 ft (0.3m) deep at a point that will be representative of each area. (3.1.2.)	PASS FAIL	PASS FAIL	PASS FAIL
	_			
4.	Take a sample near the bottom of each hole and place in container, taking care to prevent segregation (3.1.3.)	PASS FAIL	PASS FAIL	PASS FAIL
	_			
5.	Combine the individual samples into a single sample and mix thoroughly (3.1.4.)	PASS FAIL	PASS FAIL	PASS FAIL
	_			
6.	The combined sample size shall be at least four times the amount required for testing. (3.1.5)	PASS FAIL	PASS FAIL	PASS FAIL
	Conveyor Belt			
7.	Stop the belt, Insert two templates, Space the templates such that the material contained between will yield an increment of the required mass (3.2.1)	PASS FAIL	PASS FAIL	PASS FAIL

Soils Field Testing Technician

KT-65 Sampling and Splitting Cement Treated Base Mixtures

Revised July 2016

		1st Test		**Stopped Test**		**3rd Test**	
8.	Obtain at least three approximately random equal increments, selected at random, from the unit being sampled. (3.2.2)	PASS	FAIL	PASS	FAIL	PASS	FAIL
9.	Carefully scoop all material between the templates into the container and collect the fines from the belt with a brush and dust pan and add to the container.(3.2.3)	PASS	FAIL	PASS	FAIL	PASS	FAIL
10.	Combine the individual samples into a single sample and mix thoroughly.(3.2.4)	PASS	FAIL	PASS	FAIL	PASS	FAIL
11.	The combined sample size shall be at least four times the amount required for testing.(3.2.5)	PASS	FAIL	PASS	FAIL	PASS	FAIL
12.	The batch mixer or the continuous mixer (pugmill) shall be capable of sampling at the discharge outlet. When a sample is taken from the discharge, use a loader(s) or other heavy equipment capable of intercepting the entire cross section of the discharge stream. (3.3.1)	PASS	FAIL	PASS	FAIL	PASS	FAIL
13.	Divide the material in the loader bucket into at least three areas of approximately equal size. Obtain a sample from each of the three sections. (3.3.2)	PASS	FAIL	PASS	FAIL	PASS	FAIL
14.	Combine the individual samples into a single sample and mix thoroughly. (3.3.3)	PASS	FAIL	PASS	FAIL	PASS	FAIL
15.	The combined sample size shall be at least four times the amount required for testing.(3.3.4)	PASS	FAIL	PASS	FAIL	PASS	FAIL

Soils Field Testing Technician

KT-65 Sampling and Splitting Cement Treated Base Mixtures

Revised July 2016

Overall Score

Circle One

1st Test	Stopped Test	Re-Test
PASS	PASS	PASS
FAIL	FAIL	FAIL

Witness Examiner:

(First Try) __________________ Signature __________________ Date

Witness Examiner:

(Stopped Try) __________________ Signature __________________ Date

Witness Examiner:

(Re-Test) __________________ Signature __________________ Date

SOILS FIELD TESTER

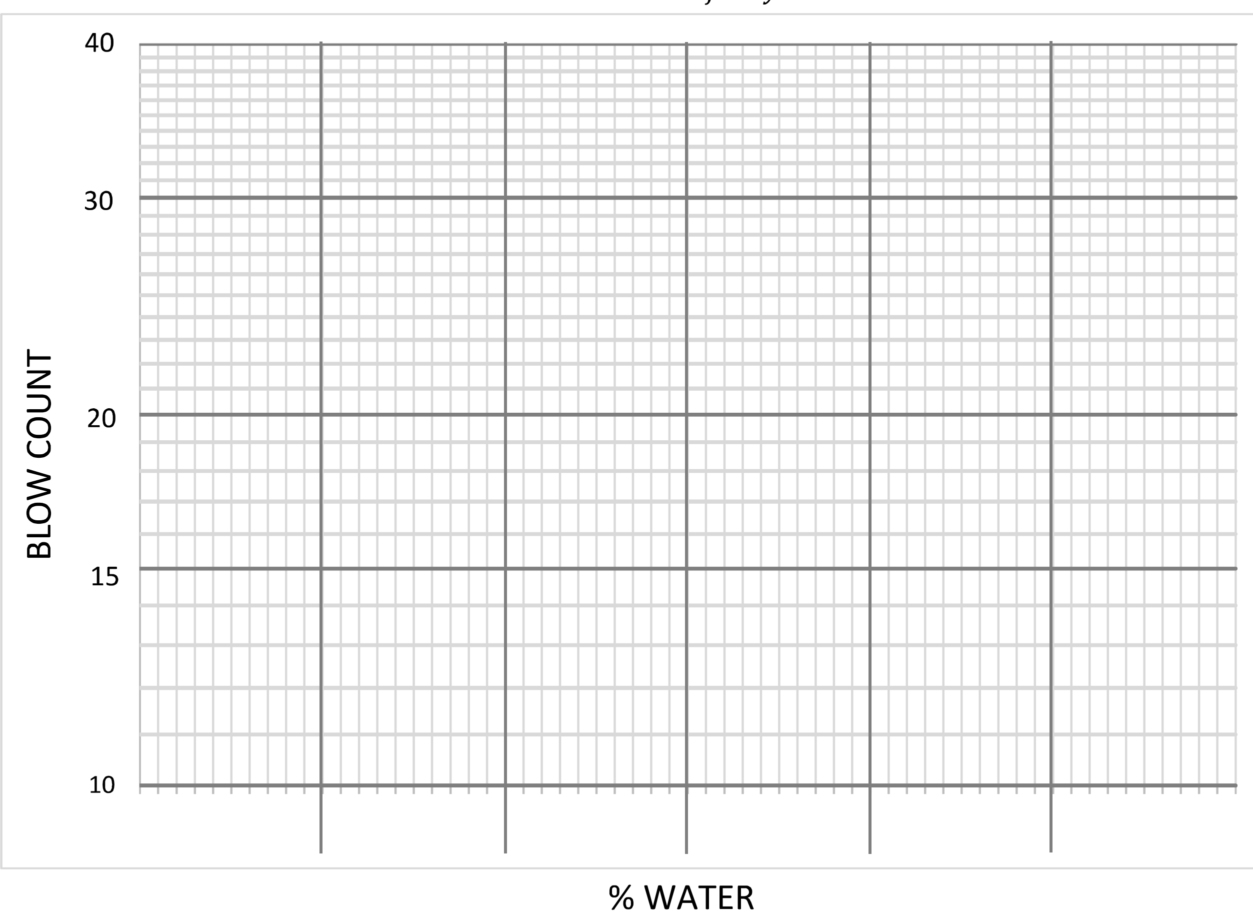
KT-10

PLASTICITY TESTS

Sample Information	Liquid Limit Computation Data			Plastic Limit Computation Data
Dish No.	A	B	C	D
Blow Count	15	23	32	
Dish + Wet Soil (g)	55.76	56.40	50.95	46.02
Dish + Dry Soil (g)	50.61	52.00	47.10	44.94
Wt. of Dish (g)	39.77	42.20	38.12	39.35
Wt. of Dry Soil (g)				
Wt. of Water (g)				
% of Water				

Liquid Limit___________ Plastic Limit_________ Plasticity Index________

$$Percent\ of\ Water = \frac{Mass\ of\ Water}{Mass\ of\ Dry\ Soil} \times 100\%$$



SOILS FIELD TESTER

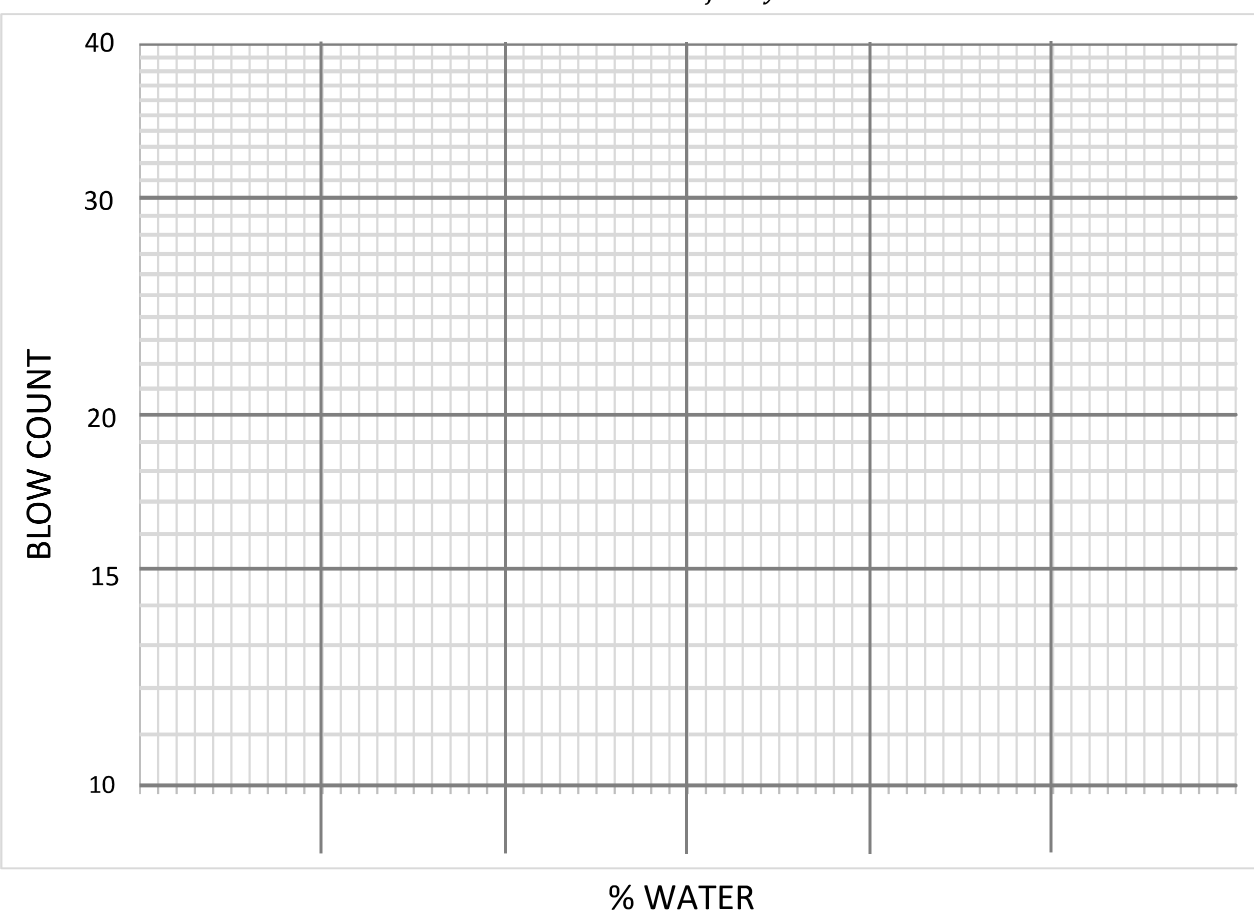
KT-10

PLASTICITY TESTS

Sample Information	Liquid Limit Computation Data			Plastic Limit Computation Data
Dish No.	A	B	C	D
Blow Count	19	26	35	
Dish + Wet Soil (g)	55.37	55.39	56.48	41.77
Dish + Dry Soil (g)	48.66	49.51	50.12	40.40
Wt. of Dish (g)	37.96	39.69	38.86	35.40
Wt. of Dry Soil (g)				
Wt. of Water (g)				
% of Water				

Liquid Limit____________ Plastic Limit__________ Plasticity Index_________

$$Percent\ of\ Water = \frac{Mass\ of\ Water}{Mass\ of\ Dry\ Soil} \times 100\%$$



SOILS FIELD TESTER

KT-11

MOISTURE TESTS

NAME: ____________________

Variables	Description	Test Number				
	Moisture Can Number	1	2	3	4	5
W_1, A	Mass of Can and Moist Soil (g)	140.1	121	165	135	173.7
W_2, B	Mass of Can and Dry Soil (g)	118.7	103.5	132.7	109.9	139.6
W_C, C	Mass of Moisture Can (g)	20.6	11.0	13.0	18.0	24.8
	Mass of Water (g)					
	Mass of Dry Soil (g)					
W	Moisture Content (%) (record)					
W	Moisture Content (%) (report)					

$$W = \frac{(W_1 - W_2)}{(W_2 - W_c)} \times 100\%$$

$$Mass\ of\ Water = (W_1 - W_2)$$

$$Mass\ of\ Dry\ Soil = (W_2 - W_c)$$

or

$$W = \frac{(A - B)}{(B - C)} \times 100\%$$

$$Mass\ of\ Water = (A - B)$$

$$Mass\ of\ Dry\ Soil = (B - C)$$

SOILS FIELD TESTER

KT-12

PROCTOR TEST

Name ______________________________

Steps	Description	Units	A	B	C	D	E	F
1	Volume (Factor for 4 inch Mold)	Cu. Ft.	30	30	30	30	30	30
2	Mass of Mold	g	907	907	907	907	907	907
3	Mass of Mold + Sample	g	2719	2787	2847	2877	2832	2800
4	Mass of Sample (steps 3-step 2)	g						
5	Convert grams to lbs Multiplying Step 5 by 0.0022	lb						

Moisture Content Data and Calculations

6	Moisture Can Identifications		A	B	C	D	E	F
7	Mass of Moisture Can + Moist Soil	g	217.37	216.20	203.38	208.65	202.19	221.84
8	Mass of Moisture Can + Dry Soil	g	199.93	196.02	181.89	184.06	175.66	189.95
9	Mass of Can	g	27.65	29.22	27.29	28.08	27.52	28.75
10	Mass of Water	g						
11	Mass of Dry Sample	g						
12	$\% \, Moisture = \frac{Step\ 10}{Step\ 11} x100\%$	%						

Density Calculations

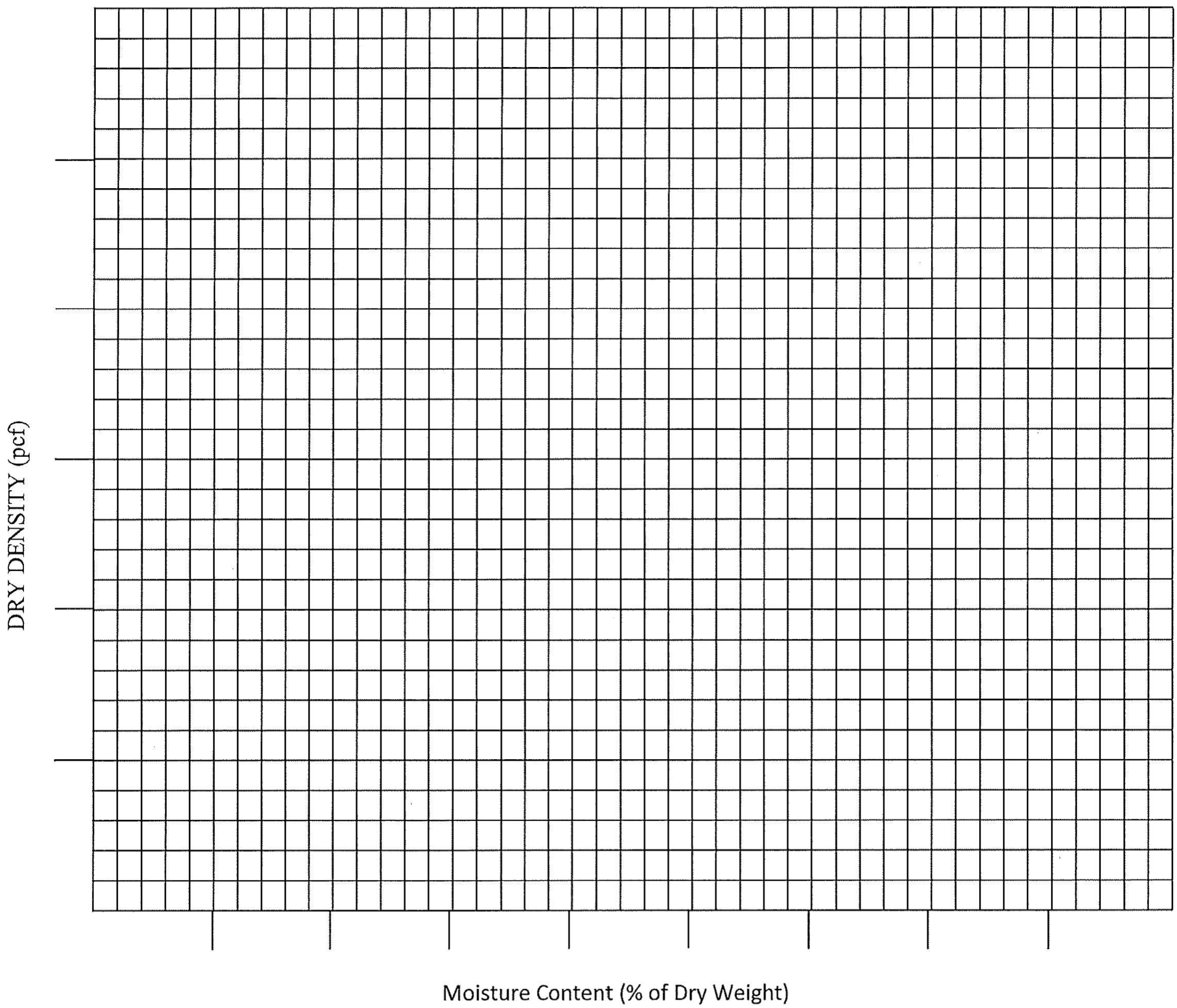
13	Wet Density (Step 5 x Step 1)	pcf						
14	$Dry\ Density = \frac{Step\ 13}{Step\ 12 + 100} x100$	pcf						

Maximum Dry Density ______________ pcf

Optimum Moisture Content ______________ %

note: 453.59 grams = 1 pound

PROCTOR GRAPH



SOILS FIELD TESTER
SAND CONE WORKSHEET
KT-13

Container Volume Determination

1	Weight of empty apparatus		lb
2	Weight of apparatus and water		lb
3	Unit weight of water	62.243	lb/ft^3
4	Voume of apparatus		ft^3

Calculate the volume of the density apparatus to the nearest 0.001 cu. ft

Bulk Density Determination

5	Mass of apparatus + sand		lbs
6	Mass of empty apparatus		lbs
7	Volume of apparatus { from jar calibration }		Cu. Ft.
8	Mass of sand		lbs
9	Bulk Density of sand		lbs/Cu. Ft.

Calculate the bulk density of the sand to the nearest 0.1 pcf

Cone Calibration

10	Mass of apparatus + sand { initial }		lbs
11	Mass of apparatus + sand { after filling cone }		lbs
[A]	Mass of sand in cone		lbs

Volume of Hole

[B]	Mass of apparatus + sand { initial }		lbs
[C]	Mass of apparatus + sand { after filling hole}		lbs
[D]	Mass of sand in hole { [B] - [A] - { C] }		lbs
[E]	Volume of hole = $\frac{[D]}{\text{Bulk Density of Sand}}$		Cu. Ft.

Density of Soil

[F]	Mass of wet material from hole	2.88	lbs
[G]	Wet density = $\frac{[F]}{[E]}$		lbs/Cu. Ft.
[H]	Moisture content { Speedy Moisture Meter }	11	%
[I]	Dry density = $\frac{[G]}{[H] + 100} \times 100$		lbs/Cu. Ft.

SOILS FIELD TESTER
SAND CONE WORKSHEET
KT-13

Container Volume Determination

1 Weight of empty apparatus	*1.528*	lb
2 Weight of apparatus and water	*10.579*	lb
3 Unit weight of water	62.243	lb/ft^3
4 Voume of apparatus		ft^3

Calculate the volume of the density apparatus to the nearest 0.001 cu. ft

Bulk Density Determination

5 Mass of apparatus + sand		*16.335*	lbs
6 Mass of empty apparatus		*1.528*	lbs
7 Volume of apparatus	{ from jar calibration }		Cu. Ft.
8 Mass of sand			lbs
9 Bulk Density of sand			lbs/Cu. Ft.

Calculate the bulk density of the sand to the nearest 0.1 pcf

Cone Calibration

10 Mass of apparatus + sand { initial }	*16.335*	lbs
11 Mass of apparatus + sand { after filling cone }	*12.725*	lbs
[A] Mass of sand in cone		lbs

Volume of Hole

[B] Mass of apparatus + sand { initial }	*16.335*	lbs
[C] Mass of apparatus + sand { after filling hole}	*10.388*	lbs
[D] Mass of sand in hole { [B] - [A] - { C] }		lbs
[E] Volume of hole = $\frac{[D]}{\text{Bulk Density of Sand}}$		Cu. Ft.

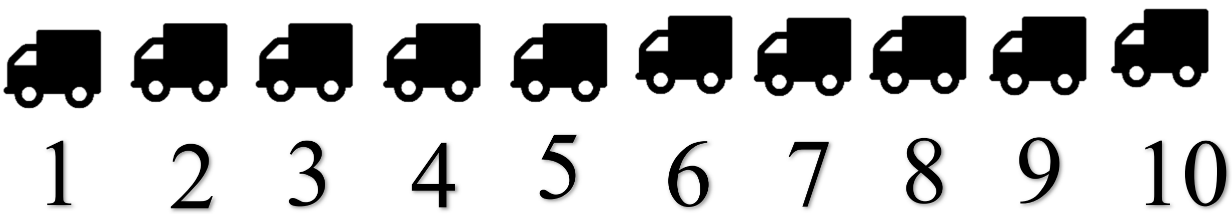
Density of Soil

[F] Mass of wet material from hole	2.88	lbs
[G] Wet density = $\frac{[F]}{[E]}$		lbs/Cu. Ft.
[H] Moisture content { Speedy Moisture Meter }	11	%
[I] Dry density = $\frac{[G]}{[H] + 100} \times 100$		lbs/Cu. Ft.

RANDOM SAMPLING EXAMPLE 1

3.1 Example 1:Determine when to sample

As an example, assume ten trucks carrying equal loads are going to be used to deliver concrete during a bridge deck placement. Select which truck to sample for compressive strength cylinders to be molded. Use a random number of 0.456 for this example.



If production was to occur during an 8-hour day that begins at 6:00 AM, what time should the sample be collected?

______ hrs

______hrs______min

____

RANDOM SAMPLING EXAMPLE 2