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Effects of Soil and Air Drying Methods on Soil Plasticity of Different Cities of Pakistan

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ABSTRACT
Atterberg Limits were initially defined in 1911, by Albert Atterberg, a Swedish scientist. Their purposes are to classifying cohesive soils and determine engineering properties of soils. According to ASTM, all the soils tested by Atterberg limits should be oven dried, it is because drying the soils in different degree will alter their properties significantly. Some of the physical properties of soils will undergo changes that appear to be permanent. Therefore, the soil samples should be in natural or air-dried form. However, in reality, due to time constraint and other factors, many will run the tests by using soil samples that are prepared by oven drying method. They assumed that there is no difference between the results of two types of drying method. However, in reality, the properties of soil will be affected and thus give a misleading result. The objective of this study is to determine the effect of two drying methods, air-drying method and oven drying method, on the soil plasticity. Six soil samples from different cities were tested. These tests include sieve analysis, specific gravity test, hydrometer analysis, Plastic limit and liquid limit test. Conclusively, the oven drying method could not replace the air-drying method in soil preparation for both Atterberg limits tests.
***Keywords* -** Plasticity, Atterberg Limits, Clay

I. INTRODUCTION

Almost all civil engineering structures are in contact with soil mass or rock. Either soil in this case in the undisturbed natural state (in-situ or in-place condition) or artificially placed, for example under the foundation of structures of the soil, in general, is in-situ state whereas, the backfill behind the retaining wall is artificially placed. Similarly, soil used in the construction structures such as in dams, levees, embankments, for roads and railways, airfield is artificially placed Irrespective of the fact whether soil is used as a supporting material (under foundations) or as constructional material (in earth structures) in either situations, there is an interaction between the structures and the adjacent soil; and as a result stresses develop in both causing some changes in shape and size of the structure and of adjacent soil mass.

To design stable and durable structures, an engineer must therefore, be able to visualize these changes and forecast their behavior any time. Soil being the natural product is a very complex engineering material and to understand its behavior, study of soil properties is essential. More specifically it is required for Design of foundations, Stability of slopes and cuts, Design of earth structures (earth dams, retaining walls, sheet piles etc.), Design of roads and airfields At present times, civil engineers usually depend upon Atterberg limits for the indication of soil characteristics, which is Plasticity. The Atterberg limits are liquid limit, plastic limit and shrinkage limit, and the tests to determine those limits are explained in ASTM standards. Method of drying the soil samples before the tests are carried out have been clearly stated in ASTM standards, it is because drying the soils in different degree will alter their properties significantly. Some of the physical properties of soil will undergo changes that appear to be permanent. Soil can dried in two different ways, by air or by oven drying techniques.

This study is to determine the effect of two drying methods, air drying method and oven drying method on the soil plasticity.

II. SAMPLE SELECTION

In this work, our target was to test the clayey soil. So we could get the definite soil plasticity and compare the oven dried and air dried sample. Initially we obtained ten samples from ten different cities. Sites were selected keeping in mind the clay content of soil. Field test were performed on these samples in search of the clayey soil. Out of ten, six samples from cities, i.e. Lahore, Sialkot, Murree, Faisalabad, Rawalpindi and Nandipur were selected. Samples varied in clay content from high to low plastic clay. Several tests were carried out to find the clay content later. Once the site was selected, sample was obtained at the depth of 1m from the surface. Samples were immediately put in zip-lock bags. So that they retained their moisture until ready for the laboratory testing.

III. Factors affecting Soil

1. Soil Mineralogy

The properties of a soil are determined by the mineralogical composition, shape and size distribution of its component particles, the interaction of these particles with each other and with water and dissolved salts, and the effect of cementing. This paper considers the influence of clay mineral composition on the plasticity of soils, and considers cases in which particle size distribution, particle shape, and cementing have an effect. Plasticity is the most outstanding characteristic of clay soils. It is measured by routine tests on nearly all soils before they are used in an engineering structure, and gives a good general indication of their other engineering properties.

The factors which affect the plasticity of soils for the most part act simultaneously, and it is therefore difficult to isolate the effect due to the individual factors. For instance, in addition to natural soils containing variable amounts of clay size material, clay generally comprises more than one type of clay mineral. Furthermore, samples of clay minerals of the same mineralogical type, but of different origins, may show considerable variation in physical properties

2. Soil Texture

Soil texture is one of the most important single properties of soil. It influences water movement and retention. It determines the amount of surface area, affecting chemical reactivity and nutrient-holding capacity. And texture is a factor in the erosion potential of the soil. There are twelve soil textural classes comprised of various proportions of sand, silt and clay—the three soil separates.

Organic matter is not included as a soil separate and therefore cannot change the texture of a soil. If the percentages of sand and clay, with or without silt, are known, the Textural Triangle can be used to find the textural class name, for example loam, or sandy clay. There are two main classes of clay minerals, described by the ratio of primary building blocks of tetrahedrons and octahedrons. Each type of clay has different properties and behaviors. First are the 1:1 clay minerals like kaolinite. A relatively large-sized clay mineral, kaolinite is a non-expanding clay well suited to construction activities, septic leach fields, or ceramics (whether industrial or hobby). The second type is the 2:1 clay minerals. Many of these are expanding clays, which shrink when dry, and swell when wet. These types of clay have very large surface to volume ratios and have the capacity to hold large quantities of water and cations.

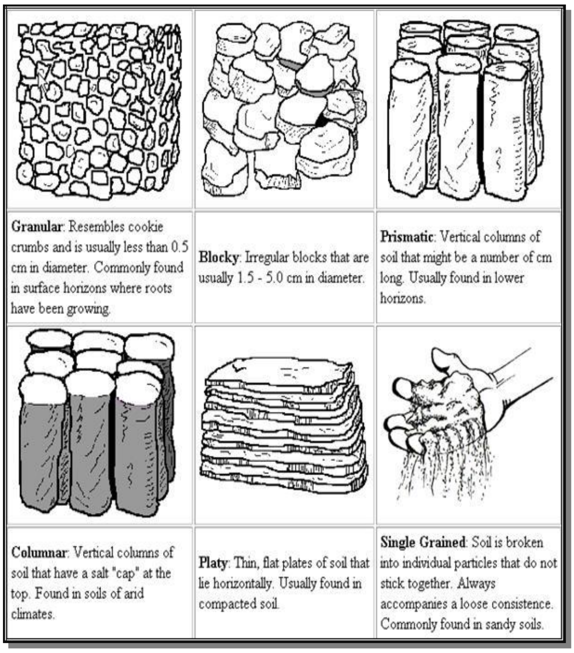
3. Soil Aggregates

Generally, only the very small particles form aggregates, which includes silicate clays, volcanic ash minerals, organic matter, and oxides. There are various mechanisms of soil aggregation.

3.1. Mechanisms of soil aggregation:

a) Soil microorganisms excrete substances that act as cementing agents and bind soil particles together. b) Fungi have filaments, called hyphae, which extend into the soil and tie soil particles together. c) Root also execute sugars into the soil that help bind minerals. d) Oxides also act a glue and join particles together. This aggregation process is very common to many highly weathered tropical soils and is especially prevalent in Hawaii. e) Finally, soil particles may naturally be attracted one another through electrostatic forces, much like the attraction between hair and a balloon.

Figure 1. Soil Texture



3.2. Aggregate Stability

Stable soil aggregation is a very valuable property of productive soils. Yet, the stability of soil aggregation is very reliant on the type of minerals present in the soil. Certain clay minerals form very stable aggregates, while other clay minerals form weak aggregates that fall apart very easily.

Highly weathered silicate clays, oxides, and amorphous volcanic materials tend to form the most stable aggregates. The presence of organic matter with these materials improves stable aggregate formation. In nutrient management, the aggregate stability is important because well-aggregated minerals are well drained and quite workable.

In contrast, less weathered silicate clays, such as montmorillonite, form weak aggregates. Some silicate clays are said to have a shrink-swell potential. This means that the soil minerals expand, or swell, when wet, causing the soil to become sticky and drain poorly. When dry, these soils shrink and form cracks. The make-up of the lattice structure of silicate clays determines the shrink-swell potential.

4. Organic Matter

Most soil organic matter accumulates within the surface layer of the soil. This organic matter may be divided into two groups: non-humic matter and humic matter. Non-humic matter includes all undecomposed organic material within the soil. Examples of non-humic matter are twigs, roots, and living organisms. Humic matter includes humic acids, fulvic acids, and humin. (Humin is the dark material in soil that is highly resistant to decomposition.) Due to its tremendous surface area, soil organic matter:

Acts like a sponge to store water. Retains and provides nutrients (CEC). Glues and binds soil particles into stable aggregates. Reduces the occurrence of aluminum toxicities. Like low activity clays, organic matter may have either CEC or AEC, depending upon soil ph. However, it will rarely have AEC. In fact, the pH must fall to approximately 2.0 before it will have AEC. Soil organic matter may have both AEC and CEC. However, the charges on organic matter are dependent upon soil ph. For soil organic matter to generate an AEC, the soil pH must be 2.0.Without additions of organic matter, tillage practices will greatly reduce organic matter content in the soil. Therefore, no-till and minimum tillage systems with the return of organic matter to the soil are gaining favor by farmers to improve and conserve soil quality.

IV. RESEARCH METHODOLOGY

As mentioned earlier, six different samples were obtained from six different cities. Approximately, each sample weighed 5 kgs. These samples were split in two halves for oven and air-drying respectively. Oven drying procedure in ASTM D2216-71 was adopted for oven drying of the sample. Sample was put in the oven at 105° C and left overnight. For Air Drying, Soil was exposed to sunlight for whole day and moisture content was determined. This process was repeated until soil start giving constant moisture content and soil had no more moisture to be eliminated.

The main concern of this work was to find the Atterberg limits. However, other tests like Specific Gravity, Sieve Analysis, and Hydrometer Analysis were also carried out. Specific Gravity test helped in the confirmation of soil type whether it was clay or not. As Clay was our required material. Further, it helped later on in better analysis of the results.

Sieve and Hydrometer Analysis were carried out letter to find out the composition of the soil sample. Which further elaborated the plastic behavior of these soils as they contained clay content. In last, Atterberg limits were determined, which gave the ultimate idea of plastic behavior. Above tests were performed on both air and oven dried samples. Results of the laboratory testing are displayed with the help of Graphs and are compared.

V. PRESENTATION AND ANALYSIS OF RESULTS

Results are displayed in tabular form a well-represented with the help of graphs. Oven dried samples are compared with air dried samples. Results of each sample are made in tabular form and corresponding graphs are also presented. Comparison graphs of air dried and oven dried samples of each sample are presented. Results of various samples are presented in the sequence of tests performed. For the better understanding and comparison of results, same graph of different samples are accumulated in one graph. Further, an effort is put to make the oven and air dried sample results are shown in tables.

Table 1. Atterberg's Limits

Samples	Oven Dried				Air Dried		
	Specific Gravity	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
Lahore	2.66	26.5	19.36	7.14	30.1	19.44	10.66
Murree	2.72	39.7	23.12	16.58	42.5	23.82	18.97
Sialkot	2.68	35.49	21.27	14.22	36.9	21.47	15.43
Faisalabad	2.68	31.1	22.01	9.09	32.2	22.1	10.1
Rawalpindi	2.72	30.8	20.83	10.07	33.5	21.4	12.1
Nandipur	2.78	58	23.5	34.5	61	24.36	36.64

Table 2. Sieve and Hydrometer Analysis

Sample	Coarse Gravel	Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay
Lahore	0	0	0	3%	9%	60%	28%
Murree	0	0	0	1%	8%	50%	41%
Sialkot	0	0	0	1%	6%	56%	37%
Faisalabad	0	0	0	1%	9%	55%	35%
Rawalpindi	0	0	0	1%	7%	58%	34%
Nandi Purr	0	0	0	2.16%	9.84%	45%	43%

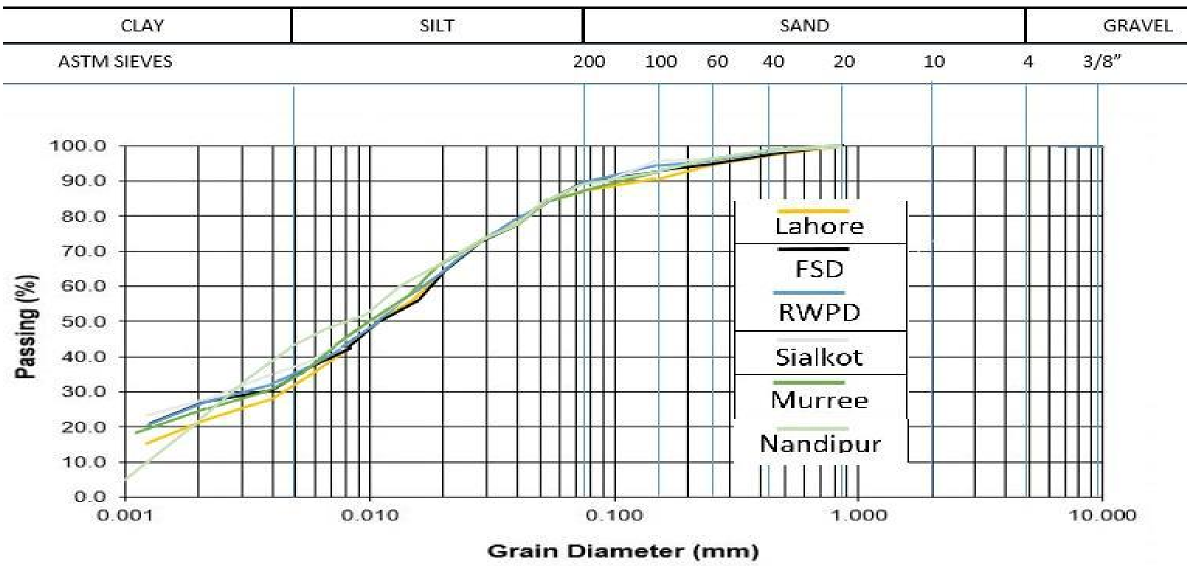


Figure 3. Gradation Curve

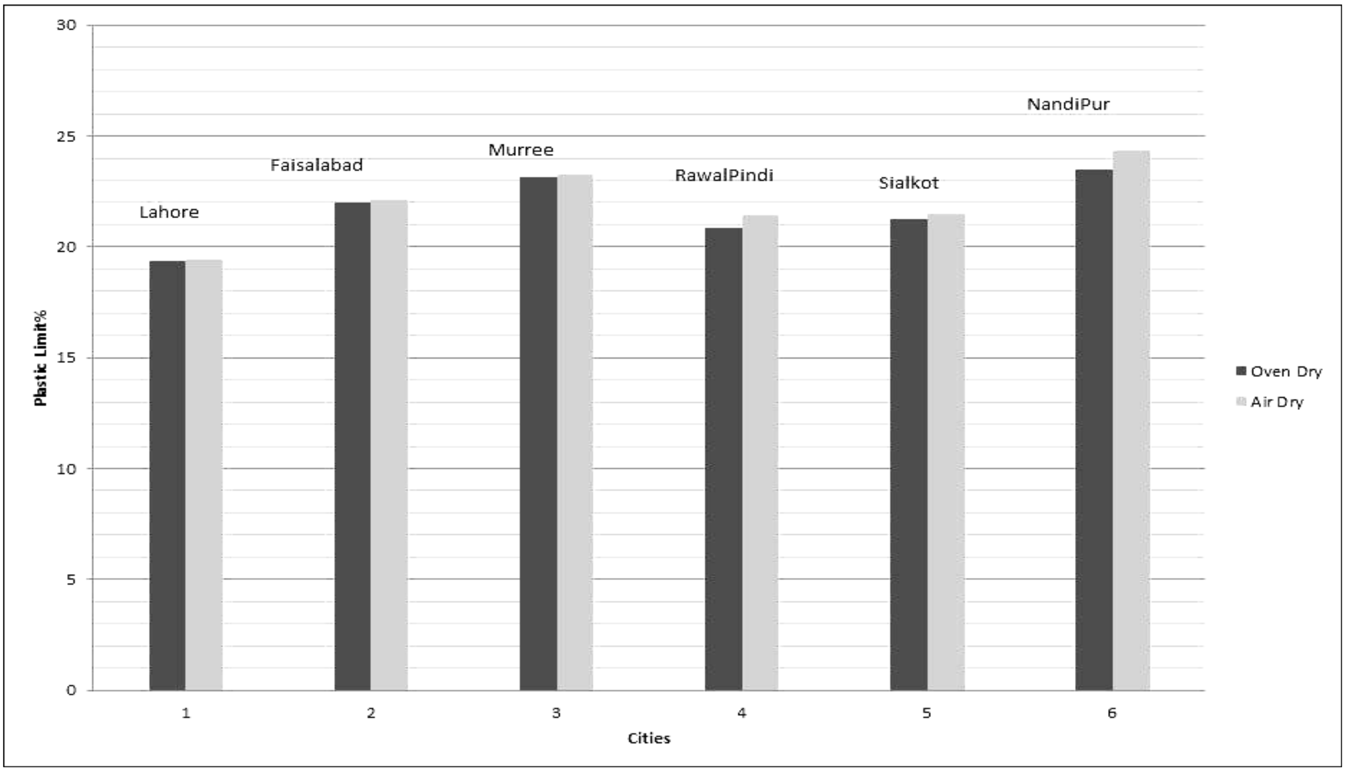


Figure 4. Plasticity Index

VI. Interpretation of Results and Conclusion

In addition to the other tastings, soil samples were also classified using unified soil classification system. Soil classification is shown in Figure 3. All the sample fell into CL category except Nandipur sample which came out to be CH. The plastic limit and liquid limit tests value obtained from two drying method are different, the liquid limit of oven dried soil samples are lower than the liquid limit of air dried samples. Due to the different value of the plastic limit and liquid limit, the plasticity indexes of samples determined are different, and thus results in different subgroups in classification. Plasticity index as shown in Figure 4 is more for air dried samples as compared to the oven dried sample. Figure 4 show that in Lahore, Faisalabad, Murree and Sialkot the result of soil plasticity obtained using air dry and oven dry method differ by small amount, so here it might be the possibility that we can use any of method. But for Rawalpindi and Nandipur their lies appreciable difference in results of air dry and oven dry methods. So here it is proved that the oven drying method could not be used to replace the air drying method in preparation work of Atterberg limit tests. Oven dried sample showed decreased plasticity. The reason for that is organic matter were burnt during the overnight drying process in the oven. Moreover, minerals present in soil were largely affected by the oven burning.

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