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Study on Methods of Drying on Soils

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ABSTRACT: Naturally soils are formed by weathering of parent rock. These soils are generally subjected to drying due to natural environmental fluctuations, human interventions and various engineering activities. During drying, the soil loses insitu moisture content from the soil matrix and exhibits volumetric reduction, i.e. shrinkage. Due to this, soil loses its integrity and in given situations, may lead to erosion and cracking. Such cracking can adversely affect the applications and properties of fine-grained soils. Cracking has been reported to be detrimental in case of soil applications such as moisture barriers, landfill liners, embankment cores, excavations and stability of slopes. This loss of moisture content from soils mainly depends on ambient temperature, humidity, chemicals. However, most of natural soils are saturated or unsaturated, subjected to drying. With this in view, efforts have been made to determine evaporation rate from extensive drying laboratory methods such as Temperature controlled oven, desiccator and Air drying. Using these methods, studies were conducted for various types of soils. From the results it has been observed that evaporation rate is high at temperature 50⁰C, whereas constant at 40⁰C with air drying and low in desiccator drying. Also, it has been observed that drying time varies with method and soil.

KEYWORDS: Soils, Drying, Moisture content, Laboratory methods, Evaporation rate.

I.INTRODUCTION

Soils are formed by process of weathering of parent rock. Due to different climatic environmental conditions soils are subjected to drying (i.e., temperature, radiation, humidity) and due to human intervention (i.e., conduit leakages disposal of industrial Hazardous wastes). Drying of soils depend upon the temperature, evaporation rate, humidity, chemicals. During drying the soil losses its insitu moisture content and exhibits volumetric reduction known as 'shrinkage'. This shrinkage results in cracking in some soils mainly in fine- grained soils (clayey soils). These clayey soils (Black cotton) are present mostly in worldwide [1] as these are expansive soils causes cracking in soils during drying. The presence of cracking in clay soils can significantly alter its hydrological, physico-chemical and thermal properties. This problem has been a stumbling block in numerous disciplines such as geotechnical, geo-environmental, agricultural and transportation engineering. Despite soil cracking has been a major issue in a wide range of applications moisture barriers, landfill liners, embankment cores, excavations and stability of slopes. Further it has been demonstrated that drying effects its swelling behaviour[4], shearstrength[12], Soil water characteristic curve(SWCC)[2,3], stress-strain behaviour[11]. Though the devices such as Tempe pressure cell[2], oven[5], stove, hot air circulator[4], Infrared oven[6] and many methods have been employed for drying of soils. However, there have been very limited understanding on the effect of chemicals on drying of soils.

The objective of this study is, therefore to investigate the environmental effects of drying on soils by different methods due to variation in temperature, chemicals. The primary purpose is to evaluate the efficiency of evaporation rate of different soils by different methods and secondary costs associated with it. Drying characteristics of various types of soils were studied and recommendations are made for estimating the drying time. For drying, the soils from

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 4, Issue 6, June 2015

granular materials (sand) to fine grained (silt and clay) are taken. The amount of water in the soil matrix and the compactness of the grains vary from one soil sample to another soil sample.

II. MATERIALS AND METHODOLOGY

Materials

Three different types of soils are taken mainly Black cotton, Silt, Sand obtained from in and around Hyderabad. The properties of these soils and the test procedures have been discussed in detail here with.

Experimentation

Basic Index tests:

Specific gravity

The Specific gravity (G) of the soil has been determined by exploited some density bottle and pycnometer as per the guidelines provided by [7]. The average value has been taken from the three trials and the results for different soils are shown in the table.

Wet sieve analysis and hydrometer test

According to IS: 2720 (part 4)-1985[8] the wet sieve analysis and hydrometer tests are conducted to determine the particle size of the soils.

Liquid limit and plastic limit

According to the IS: 2720 (part V) - 1985 [9] the liquid limit (LL) and plastic limit (PL) are conducted.

Standard Proctor test

According to IS: 2720 (part VII) – 1985[10] the standard proctor test is conducted to determine the Optimum Moisture Content (OMC) and Maximum Dry density (MDD) of the soil.

Drying Tests:

The expulsion of water from the soil sample or specimen is termed as ‘desiccation’ or ‘drying’. The drying rate depends on the ambient conditions (i.e., temperature, humidity, pressure and chemicals). To investigate the influence of these parameters on drying characteristics of soils, the following methodology was developed.

A certain amount of soil passing through 425 μ sieve size was thoroughly mixed with the desired amount of distilled water using an electric operated stirrer for some time, to obtain slurry for certain consistency, with pre-determined initial moisture content. Later this slurry was poured into a Petri dish (70mm in diameter and 14 mm thick) and to remove entrapped air or air voids, the dish was tapped on wooden platform. The petridish used in this study were defect-free (i.e., protrusions on the inner side and no concentric depressions). The weight of Petri dish with soil slurry (W) is noted on weighing balance accurate to 0.01g and the dish with different soils was placed in the methods followed below. The weights of soil specimens are noted over a period of time (t), until three consecutive readings were observed to be same.

Three different methods used in this study are Temperature-controlled oven, Desiccator (Vacuum type) and Air drying. These three methods are explained in detail below as these are conducted in laboratory considering the environmental effects on soils.

Temperature controlled oven: The Oven is used for drying of soils at a specified temperatures. These soil specimens are kept in oven and allowed for drying for varying temperatures (i.e., 30°C, 40°C, 50°C). The variation of temperature may vary approximately $\pm 2^\circ\text{C}$ in oven.

Desiccator: A Desiccator or desiccant container is an air tight chamber that removes water under constant temperature and humidity conditions. It consists of two chambers at bottom chamber desiccant (silica gel) is placed and soil specimens were placed over the porous plate and allowed for drying. The whole assembly desiccators placed at room temperature $26\pm 2^\circ\text{C}$.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

Air drying: In this method soil samples were subjected to drying at room temperature $26\pm 2^{\circ}\text{C}$. The soil specimens are placed in a platform subjected to drying. During drying the readings are noted over a period of time(t), until three consecutive readings were observed to be same.

III. EXPERIMENTAL RESULTS

The soils are collected in and around Hyderabad city. These soils have been analysed for various physical and mechanical properties and are as listed in the **Table 3.1**

Table 3.1. Properties of soils

Properties	Soil samples		
	Black cotton	Silt	Sand
Specific Gravity	2.62	2.66	2.69
Gravel%	0	0	2
Sand %	5	6	98
Silt%	43	76	0
Clay%	52	18	0
Liquid limit (%)	42	26	-
Plastic limit (%)	20	18	-
Plasticity Index	22	8	-
Soil Classification	CL	ML	SW
OMC (%)	16	14	6
MDD (g/cm^3)	1.67	1.80	1.74

Temperature controlled oven: The soils are subjected to drying for three different temperatures (i.e., 30°C , 40°C , 50°C). It has been observed that drying time depends on temperature and type of soil.

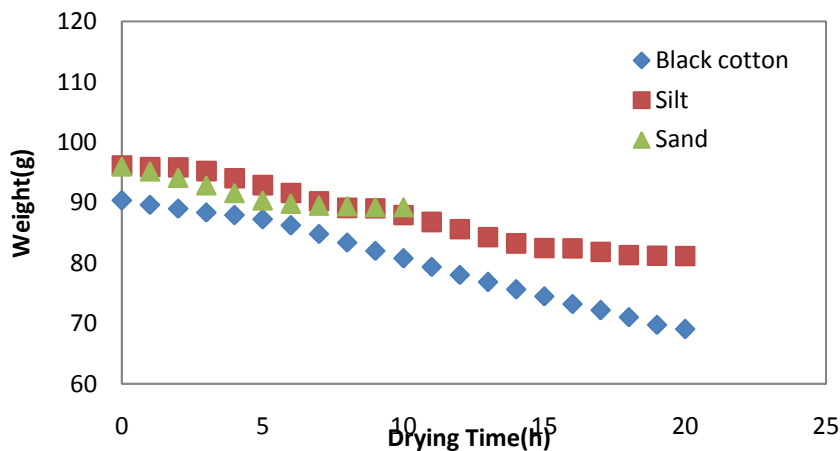


Figure: 3.1. (a) The weight loss undergone by the soil specimen with respect to time at temperature 50°C . From the figure 3.1 (a) it has been observed that that drying time is maximum for black cotton soil, moderate for silty soil and minimum for sand. It also been observed that more cracks are formed for black cotton and no cracks are observed for silty soil and sand.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

The soils black cotton, silty soil and sand were subjected to drying in temperature controlled oven at temperature 40°C. The variation of weight loss with respect to time is shown in figure: 3.1.(b) below.

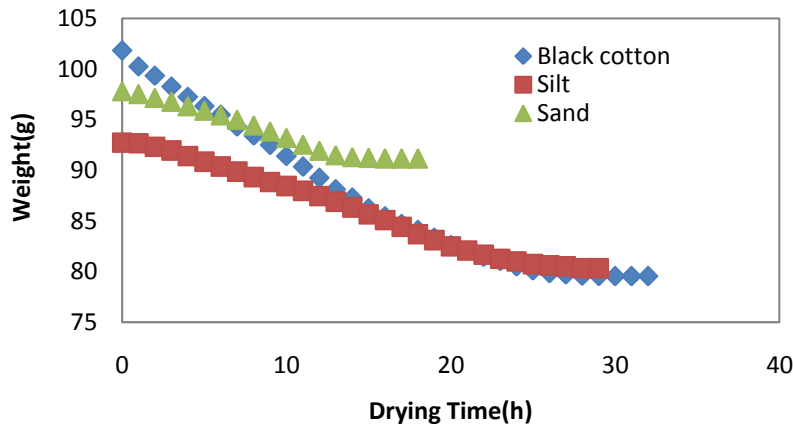


Figure: 3.1. (b) The weight loss undergone by the soil specimen with respect to time at temperature 40°C.

From the Figure 3.1. (b) It has been observed that that drying time is maximum for black cotton soil, moderate for silty soil and minimum for sand. It also been observed that more cracks are formed for black cotton but less than the cracks at temperature 50°C and no cracks are observed for silty soil and sand.

The soils black cotton, silty soil and sand were subjected to drying in temperature controlled oven at temperature 30°C. The variation of weight loss with respect to time is shown in figure: 3.1. (c) Below.

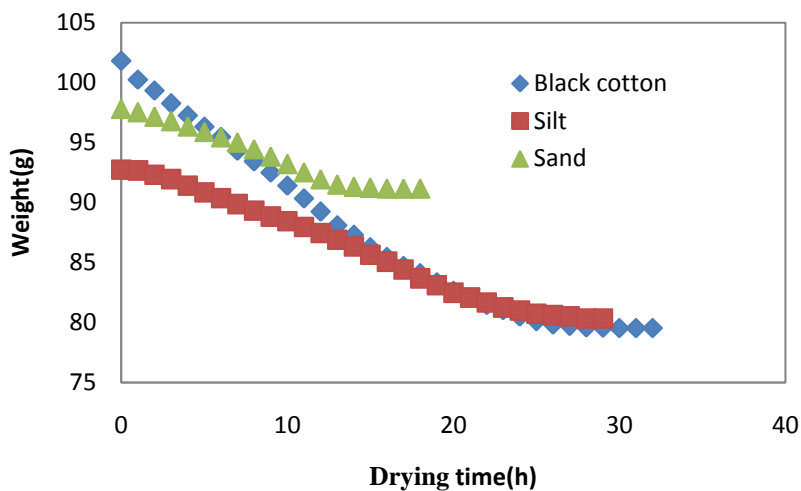


Figure: 3.1. (c) The weight loss undergone by the soil specimen with respect to time at temperature 30°C

From thfigure 3.1. (c) It has been observed that that drying time is maximum for black cotton soil, moderate for silty soil and minimum for sand. It also been no cracks are observed for Black cotton, silty soil and sand. The weight loss observed to be smooth curves.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

Air drying: The soils are subjected to air drying at room temperature $26\pm 2^\circ\text{C}$. The variation of drying time for soils is shown in Figure.3.2 below.

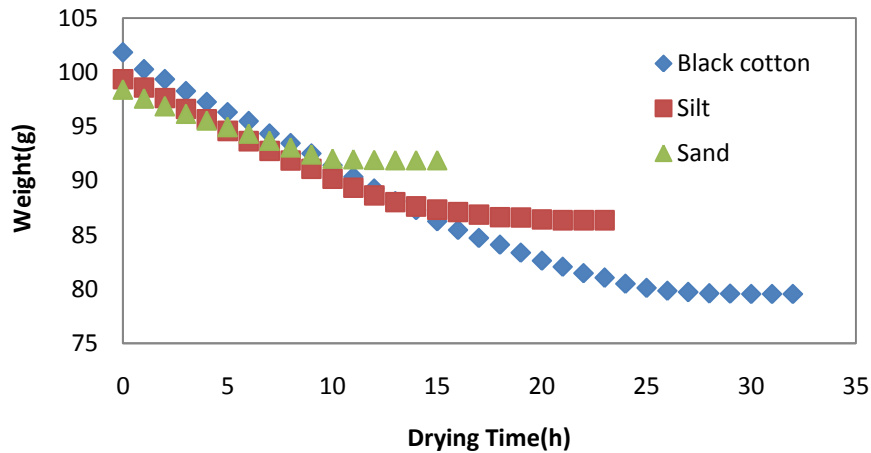


Figure: 3.2 the weight loss undergone by the soil specimen with respect to time in air drying

From the 3.2 it has been observed that drying time is high for black cotton soil, and low for sand. It has observed that the lines are smooth curves. It has also been observed that cracks formed for black cotton and no cracks for silty soil and clay

Desiccator drying: The soils are subjected to drying in desiccator with desiccant (silica gel) at room temperature $26\pm 2^\circ\text{C}$. The variation of drying time is shown in Figure: 3.3 below

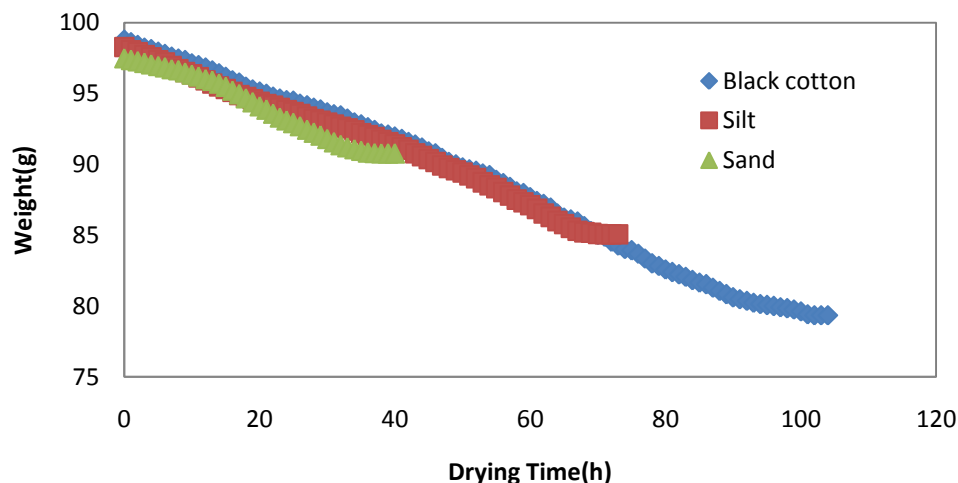


Figure3.3 The weight loss undergone by the soil specimen with respect to time in desiccator drying

From the Figure: 3.3 it has been observed that drying time is maximum for black cotton, moderate for silty soil, and minimum for sand. The cracks are formed for black cotton but less compared to temperature at 50°C and air drying. And no cracks observed for silty soil and sand.

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 4, Issue 6, June 2015

Cracking in soils: Cracking can adversely affect fine-grained soils. The presence of high amounts of clay particles in a soil (fine-grained soil), particularly highly active clay minerals such as smectites and vermiculites, promotes the formation of cracks. The Desiccation cracks form as a result of water loss to the atmosphere from a drying soil mass and also due to chemicals drying of soil takes place. Drying causes shrinkage and subsequent cracking of the soil mainly in expansive soils. As the black cotton soil in this study contains high clay content results when subjected to drying causes shrinkage and results in cracking.

The variation of cracks in different methods (temperature controlled oven, air drying and desiccators drying) for black cotton soil is shown in Figure 3.4 below.

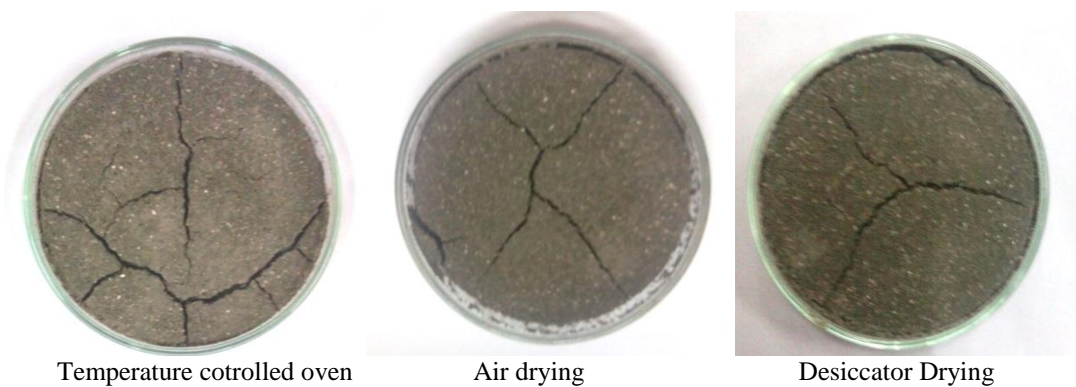


Figure 3.4 the cracking patterns of the specimen of the Black cotton corresponding to different methods of temperature controlled oven (50°C), Air drying, desiccator drying

From the figure: 3.4 for black cotton it has been observed that cracks are reduced from method to method. More cracks are formed at temperature controlled oven and less cracks in desiccator drying. It can be observed that the cracking density/intensity is decreasing with the decreasing evaporation rate. Hence, it can be postulated that the cracking characteristics are dependent on evaporation rates as reported [13, 14]

Evaporation rate: Evaporation rate is obtained from the slope of weight loss undergone by soil specimens with respect to time for black cotton, silty soil and sand for methods air drying, desiccators drying and oven drying at temperatures (50°C, 40°C, 30°C). Evaporation rate depends on method and the type of soil.

The evaporation rate for black cotton, silt and sand for drying methods of air drying, desiccators drying, oven drying for temperature(50°C, 40°C, 30°C) is tabulated in table 3.2 below.

Soils	Evaporation Rate (g/hr)				
	Air drying	Desiccator drying	oven drying		
			50°C	40°C	30°C
1.Black cotton	1.0018	0.2269	1.2604	0.9934	0.8363
2.Silt	0.8965	0.2046	1.1748	0.8747	0.5444
3.Sand	0.6362	0.1774	1.147	0.5001	0.4696

Table: 3.2 Evaporation rate for black cotton, silty soil and sand for different methods

From the table: 3.2 it has been observed that the evaporation rate is decreasing from black cotton, silty soil and sand. It is observed that evaporation rate for soils are highest for oven drying at temperature 50°C and lowest in desiccators

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

drying. Also it has been observed that evaporation rate for soils in air drying and in oven drying at temperature 40°C is approximately equal and for temperature 30°C is less.

In figure 3.4 the evaporation rate for three different methods i.e., for Air drying, desiccators drying and temperature controlled oven drying (50°C, 40°C, 30°C) for black cotton, silty soil and sand the graph is plotted below.

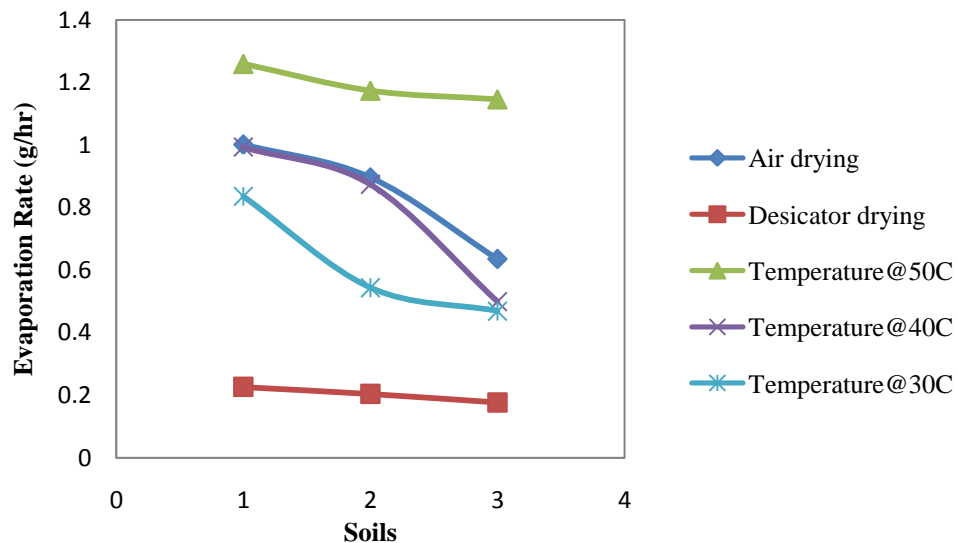


Figure: 3.5. Evaporation for different soils

From the Figure 3.5 it has been observed that evaporation rate is high at temperature 50°C, whereas constant at temperature 40°C with air drying, low at temperature 30°C and very low in desiccator drying for soils. Thus the evaporation rate varies from method.

IV. CONCLUSION

The present study was taken up, to study the effect of temperature and chemicals on different types of soils varying from granular to fine grained soils. Based on extensive investigations it has been observed that the drying time varies from method and type of soil. It also been observed that evaporation rate is high at temperature 50°C, whereas constant at temperature 40°C with air drying, low at temperature 30°C, and very low in desiccator drying. Also, it has been observed that the cracking patterns are observed to differ with the evaporation rate, qualitatively it has been depicted that the cracking intensity decreases with the decrease in the evaporation rate.

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