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Characterization of Soil from Central Region of India

Siddharth P. Hedaoo[1], Harendra Prakash [2],Shahid Noor [3], Manish Gupta [4] , R. Chitra [5]

[1]Scientist 'B', Central Soil and Materials Research Station, New Delhi, India, PIN- 110016
[2]Scientist 'C', Central Soil and Materials Research Station, New Delhi, India, PIN- 110016
[3]Scientist 'E, Central Soil and Materials Research Station, New Delhi, India, PIN- 110016
[4]Scientist 'E', Central Soil and Materials Research Station, New Delhi, India, PIN- 110016
[5]Director, Central Soil and Materials Research Station, New Delhi, India, PIN- 110016

Abstract: Soil characterization is a fundamental component in Civil Engineering which provides essential data for understanding physical, chemical and mechanical properties of soil and its behavior with other elements when it comes into contact. The elementary data are important for the design, construction, and maintenance of infrastructure projects. This study examines various soil characterization techniques used to evaluate key soil properties, such as Grain Size Distribution, Compaction, Specific Gravity, Atterberg's Limit and Moisture Content. These properties are critical for understanding soil behavior under different loading conditions and assessing its suitability for foundations, pavements, embankments and other Civil Engineering structures. The advantages of comprehensive soil characterization include more accurate and cost-effective designs, enhanced safety and durability of infrastructure, reduced risk of failure, and optimized use of materials. Soil characterization also aids in the assessment of soil-structure interaction, ensuring long-term performance and sustainability of civil engineering projects.

The present paper highlightsthe laboratory investigations carried out on the representative soil samples collected from central India, Madhya Pradesh. A total 12 numbers of representative soil samples were collected from 12 numbers of different trial pits depth ranging from 2.0 to 3.0 m. these soil samples were subjected to different laboratory tests to characterize the collected soil.

Index Terms—Atterberglimits, Specific Gravity, Compaction curve, Moisture Content and Grain Size analysis.

I. INTRODUCTION

Soil characterization is an important process in Civil Engineering, as it helps engineers understand the properties and behavior of soil at a construction site. This information is crucial for ensuring the safety, stability, and longevity of structures built on or within the ground. For understanding the strength of the soil, the important parameter is to determine the bearing capacity, which tells engineers how much load the soil can support without failure. Different soil types (e.g., clay, sand, silt) have varying bearing capacities, and proper characterization allows for the design of foundations that can safely support the loads of the intended structure. Engineers often need to predict how much the soil will settle under the load of a building or other infrastructure. Excessive settlement can lead to structural damage or failure. Soil characterization helps estimate the expected settlement and provides solutions to minimize it. In projects involving embankments, retaining walls, or cut slopes, soil characterization is crucial for assessing the stability of slopes. Proper testing helps predict the potential for landslides or soil movement, allowing engineers to design appropriate measures to prevent failures. Soil properties like cohesion, compaction, and permeability influence erosion risk. Understanding these factors allows for the design of erosion-resistant structures, such as dams, embankments, or roads. Considering shear strength criteria, soils can behave differently when subjected to various stress conditions. Soil characterization provides data on parameters such as cohesion and internal friction angle, which define the soil's shear strength. This is vital for ensuring that the soil can withstand the stresses imposed by construction and use. The plasticity of the soil (whether it can deform without cracking) and its ability to be compacted are key to determining how well soil can be worked with and how it will behave under load. These properties influence the design and construction process. Similarly the other properties of soil such as permeability determines how easily water can flow through the soil. This is essential for designing drainage systems, foundations, and basements. The ground water table also affect the behavior of foundations, roads, and other structures. Soil characterization helps predict how water might interact with the soil over time, influencing design decisions related to drainage and waterproofing.[1]

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II. RESEARCH METHODOLOGY

2.1 Study Area

The study was conducted on the soil samples collected from central part of India, Madhya Pradesh state, the second largest state covering an area approximately 3,08,250 square kilometers. The location was situated in Dhar district, near second largest city Indore. The elevation of the area varies from 275 meters in the north to 150 meters in the south west. The study area was well covered with plateu surrounded with small hills and mountains forms a part of the watershed for the river Karam a tributary of river Narmada. It has sub-tropical climate with temperature rising to 44-45°C during summer season [2].

Figure 1**: Location of Sample Area**

The borrow area locations were identified and representative soil samples were collected from the identified locations. Further laboratory testing's were conducted to identify the soil characteristics and other parameters in the lab of CSMRS. The trial pits were excavated to a depth ranging from 2.0 to 3.0 meter and soil samples were collected from each pit.

2.2 Laboratory Investigations and Results

All the soilsamples from the borrow area were tested in the Laboratory. The tests include Mechanical Analysis, Atterberg Limit, Specific Gravity, Compaction, Consolidation, Permeability, Shrinkage limit and Soil Dispersivity test (Free swell Index, Crumb test and Double Hydrometer Test). However, for conducting this studymuch concentration was given to the tests such as Grain size analysis, Specific Gravity, Atterberg Limits and Standard Proctor Compaction.

2.3 Tests Results

2.2.1.1 Grain size Analysis Test(IS:2720 (Part-4) -1985)

The soil samples were tested in accordance with IS:2720 (Part-4)-1985 "Methods of Tests for Soil (Part-4 Grain Size Analysis)." And Figure 2 shows particle size distribution of these soil samples.

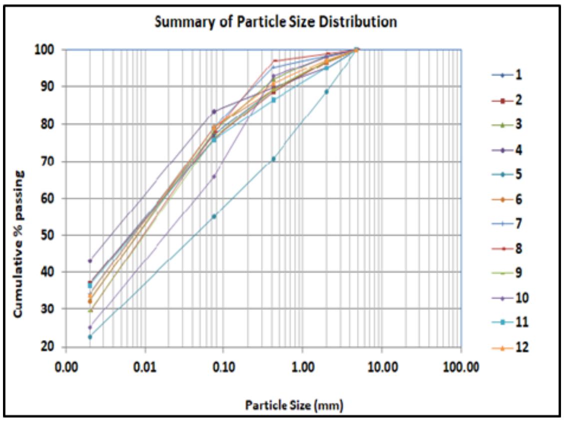

Figure2: Summary of Particle size distribution curve

2.3.2Specific Gravity of soil(IS:2720 (Part-III/Sec-1)-1980)

The specific gravity of each type of soil was determined according to IS:2720 (Part-III/Sec-1)-1980 "Determination of Specific Gravity of Fine Grained Soils". And the values of specific gravity for tested soil samples vary from 2.65 to 2.69.

2.3.3 Atterberg Limit Tests (IS:2720 (Part-5)-1985

The liquid limit test for of soil is conducted in accordance with IS:2720 (Part-5)-1985 "Determination of Liquid and Plastic Limit".Table 2.2 shows the values Liquid Limit for tested soil samples vary from 36.3 to 66.0.the value of the plastic limit vary from 20.5 to 23.8. thepaltcity index of the tested soil samples vary from 15.7 to 27.8.

2.3.4 Standard Proctor Compaction Test(IS: 2720 (Part- 7)-1980)

Dry Density-Moisture content Relationships: the soil samples retrieved from each borrow area locations were initially air dried and then sieved through 4.75 mm IS sieve for testing in IS light compaction machine with mould diameter of 100 mm and capacity of 1000 cm^3. The soil samples were placed in the mould in three numbers of layers and each layer was compacted by giving 25 numbers of blows with 2.60 kg. Weight of hammer and 310 mm height of fall. The standard test procedure was followed as per IS:2720 (Part-7)-1980 "Determination of Water Content-Dry Density

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Relation using Light Compaction". After compacting each soil samples with incremental percentage increase of water, weight of compacted soil in the mould was taken and bulk density were calculated followed by determining the moisture content of soil by oven drying method for each repetitive steps of compaction process according to IS:2720 (Part-II)-1973 "Methods of Test for Soil-Determination of Water Content."

Finally, the maximum dry unit weight and corresponding optimum moisture content were computed by plotting the compaction graph representing percentage moisture content on abscissa and dry density as ordinate.Figure 3 presents the MDD Vs. OMC curves.

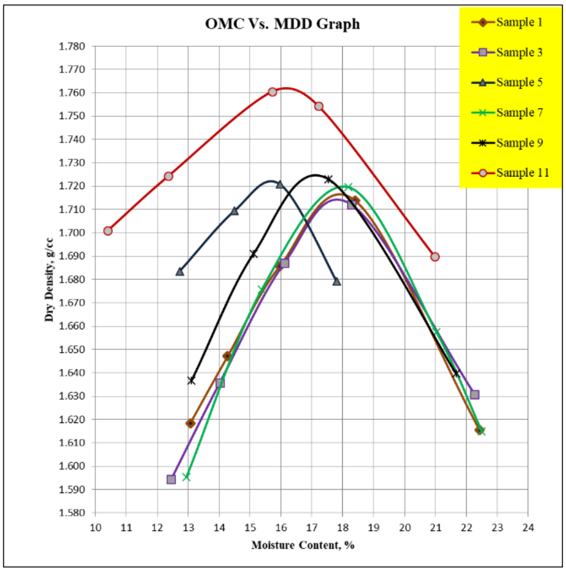

Figure 3: MDD Vs. OMC curves.

III. RESULTS AND DISCUSSIONS

After conducting the various laboratory tests on soil samples the results are analysed by means of statistical and graphical interpretation method. The various tests includes Grain size distribution, Atterberg's Limit,Specific Gravity, Moisture content, Compaction characteristics. These tests are essential to understand the suitability of the soil for various engineering applications, such as foundation design, construction, and agriculture. The wet sieve analysis were conducted to determine the particle size distribution in the representative tested soil samples. The results indicates that soil particles in the tested samples are varying from clay sized particles to gravel content. The concentration of clay particles are in the range of 22.76% to 43%, Silt particles of 54.91% to 83.40%, Fine Sand-70.80% to 97%, Medium Sand -88.74% to 99%. The results of Atterberg's limit shows the LL are in the range of 33.60% to 66.0%, PL -20.33 to 27.26% and PI-15.74% to 38.74%. The Specific Gravity of the tested soil samples indicate a range varying from 2.61 to 2.71. The result of Standard Proctor Light compaction test indicates the dry density of soil ranging from 1693 Kg/m3 to 1782 Kg/m3 whereas Optimum Moisture Content (OMC) are in the range of 16.60%-18.70%.

IV. CONCLUSIONS

After conducting the lab test on soil samples, it is observed that the soil category comes under Clay of Medium Plasticity (CI) except one sample which falls under clay of high compressibility (CH). The CI and CH types of soil are classified from the Bureau of Indian Soil Classification System, which is widely used in geotechnical engineering to categorize soils based on their physical properties. These soil types play an important role in water resource structures (such as dams, levees, canals, reservoirs, etc.), as their permeability, cohesion, and stability affect water retention, flow, and the structural integrity of these systems.CI soil, with its medium plasticity, is likely to exhibit moderate swelling and shrinkage behavior under changing moisture conditions. In contrast, the CH soil, with its high plasticity, is expected to show more significant changes in volume with moisture fluctuations, potentially leading to higher risks of foundation instability if not properly managed. The higher plasticity of the CH soil indicates a greater susceptibility to plastic deformation under loading.CI and CH type of soil can be utilized in many engineering and water resources structures with the following advantages.

1. **<u>Water Retention & Seepage Control:</u>** Both CI and CH soils have low permeability, which makes them effective at reducing water seepage. This is particularly beneficial in the construction of dams, embankments, and canals where leakage control is crucial.

- CH& CI soils, due to their very low permeability, are often used in the construction of core materials for dams or cutoff walls to prevent water from passing through the structure.

2. **<u>Structural Stability:</u>**

- Cohesion: The cohesive nature of both CI and CH soils gives them the ability to withstand compressive forces, contributing to the stability of structures like embankments or levees.
- However, the high plasticity of CH soils can
sometimes be a concern in shrink-swell conditions,

which could lead to settlement or cracking of the structure under wet-dry cycles.

- CI soils, with intermediate plasticity, are less prone to these volume changes compared to CH soils, making them more stable under varying moisture conditions.

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