

SOIL PROPERTIES PATTERN OF MARATHWADA REGION IN MAHARASHTRA STATE

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Abstract— Soil Mechanics Division of Maharashtra Engineering Research Institute, Nasik, has been carrying out tests on soil samples from all over Maharashtra since 1959. Various tests are carried out on soil samples viz. Grain size / Mechanical Analysis, Liquid Limit & Plastic Limit, Shrinkage Limit, Specific Gravity, Compaction test, Shear test, Consolidation test, Swelling Pressure, Permeability test. These tests are carried out mainly to identify Density, Permeability, Compressibility and Shear strength of Soil, which are useful in design of earthen dams, Canal embankments, and lining etc. Huge data of these test results is generated in the process. The purpose of the study is to prepare long term integrated plan for Soil parameter and derive Soil properties pattern for Marathwada region in the Maharashtra State. Though soil being heterogeneous in nature and no two samples even from same location are same, it is felt that data presented will definitely provide preliminary guide for soil property values for users.

Index Terms— Soil Mechanics, Soil properties, Classification of soil, type of soil, Marathwada region soil pattern, Soil properties pattern.

I. INTRODUCTION

The Maharashtra Engineering Research Institute (MERI) is established in the year 1959. It is the prime institute of Maharashtra state under Water Resources Department. It is entrusted with the work of basic, applied research in various disciplines of civil engineering like soil mechanics, construction material studies, testing, highway, coastal, remote sensing and GIS, seismology, hydraulic model studies, reservoir sedimentation studies etc. It is largely dealing with field problems of applied research pertaining to various projects.

Since Maharashtra is a part of Deccan Plateau except Vidarbha Region, the geology of the state is overall similar, however physiographically it is not similar in all over Maharashtra. Maharashtra can be divided in to three divisions according to Physiography viz. Coastal Strip (Konkan) Mountainous Hilly Region (Western Ghat Sahyadri Ranges) Maharashtra Plateau (Deccan Plateau) Vidarbha Region (Eastern).

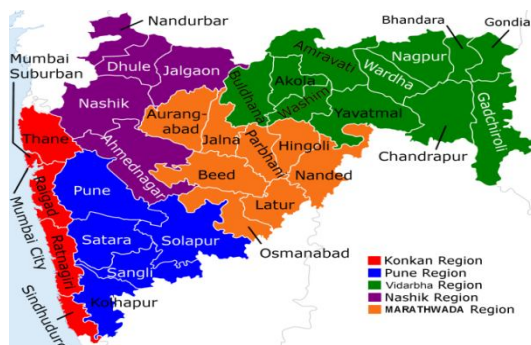


Figure 1: Regional Map of Maharashtra

Maharashtra state comprises thirty six districts. At present there are 5 Irrigation Development Corporations such as MKVDC, VIDC, TIDC, GMDC, KIDC as shown in Figure 1.

The Irrigation Development Corporations have Geographical Jurisdiction based on river basin boundaries and are mainly responsible for planning and development of new surface water schemes for irrigation / multipurpose use, construction of ongoing project and also management of existing schemes.

II. SOIL MECHANICS

Soil Mechanics Division of MERI, Nasik, is carrying out various tests on soil samples from all over Maharashtra. The selection of topic is influenced by availability of huge data of these test results which are generated in the process. The study is restricted within Marathwada region only.

Soil samples received from different Irrigation Projects in Marathwada region are as shown in Fig. II. About 130 soil samples are tested during the year 2009 to 2015 in the laboratory.

Soil tests are classified as Index Tests and Engineering tests. These tests are conducted as per I.S.¹ Index tests are Grain size Analysis (Mechanical Analysis), Liquid Limit, Plastic Limit (Atterberg's Limit), Specific Gravity and Engineering tests are Compaction test (O.M.C. and O.D.D. determination), Relative Density (RD), Direct Shear test (Cohesion and ϕ), Consolidation Test, Permeability (By Constant and Variable Head).

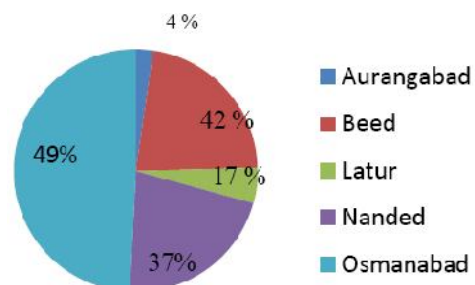


Figure 2: Projects in Marathwada region

III. INDEX TESTS OF SOIL

A. Grain size Analysis, Plastic and liquid limit

Soil is the product of parent rocks. Grain size Analysis Test is carried out for determining percentage by weight of grains of various sizes deciding soil classification. Plastic limit with liquid limit forms the basis for the soil classification system for soils. These limits along with results of grain size analysis help in classification soils.

Table 1. Laboratory Classification of soil samples

Laboratory Classification	No. of Sample
GW	0
GP	31
GM	9
GC	2
SW	0
SP	1
SM	34
SC	1
MH	38
MI	8
ML	0
CH	2
CI	4
CL	0

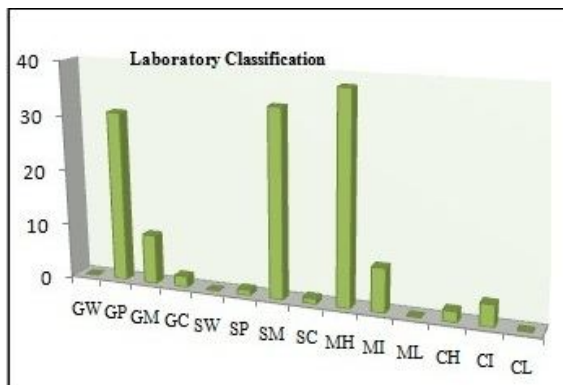


Figure 3: Chart of Laboratory Classification of soil samples

Soil is classified into fourteen groups as GW, GP, GM, GC, SW, SP, SM, SC, MH, MI, ML, CH, CI, CL. The graphical presentations of data shown in Fig.III. In Marathwada region among 130 samples 56% samples found in SM and MH groups. District wise location of samples groups are shown in table given below.

Table 2. District wise Location of Samples

Name of District	No. Samples
Aurangabad	3
Beed	29
Latur	6
Nanded	28
Osmanabad	64

B. Specific Gravity

Specific gravity of soil is the ratio of the weight in air of a given volume of soil solids, at a stated temperature to the weight in air of an equal volume of distilled water at that temperature. The value of specific gravity of the soil finds application in calculating void ratio, porosity, degree of saturation. Table 3 gives the range of specific gravity according to their groups of soil. The graphical representation is as shown in Figure 4.

Table 3: Specific Gravity of soil samples.

Laboratory Classification	Range of G _s
GW	2.121 - 3.081
GP	2.601 - 2.980
GM	2.578 -2.850
GC	-----
SW	-----
SP	2.507 -2.808
SM	-----
SC	1.928 - 2.760
MH	2.587 - 2.770
MI	-----
ML	-----
CH	2.068 - 2.713
CI	2.121 - 3.081
CL	2.601 - 2.980

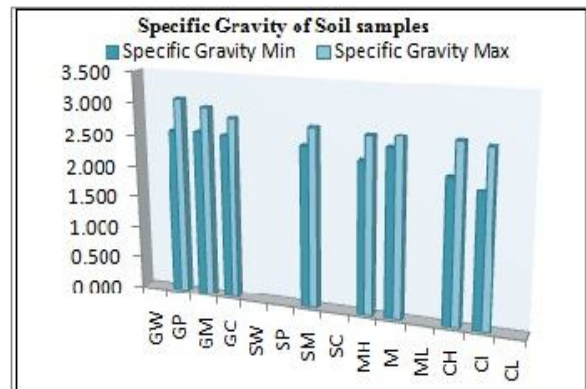


Figure 4: Specific Gravity of soil samples

IV. ENGINEERING TESTS

A. Compaction test (O.M.C. and O.D.D.)

The laboratory compaction test helps to determine the relation between moisture content during compaction of a soil and density of the compacted soil under a given effort of compaction. This relation gives values of the optimum moisture content (O.M.C.) and optimum dry density (O.D.D.). The range of optimum moisture contents and densities are as shown below table 4 and 5 respectively. Graphical representation of both moisture contents and densities is given below Figure 5 and 6. Moisture content corresponding to GW samples not observed because the density calculated by relative density method.

Table 4. Optimum moisture content of soil samples

Laboratory Classification	Range of Density (in g/cm ³)
GW	-----
GP	1.646 - 2.269
GM	1.574 - 1.856
GC	1.597 - 1.777
SW	-----
SP	-----
SM	1.340 - 1.880
SC	-----
MH	1.342 - 1.638
MI	1.495 - 1.632
ML	-----
CH	-----
CI	1.507 - 1.671
CL	-----

Table 5. Density of soil samples

Laboratory Classification	Range of Moisture content (in %)
GW	-----
GP	6.09 - 14.75
GM	1.574 - 1.856
GC	1.597 - 1.777
SW	-----
SP	-----
SM	1.340 - 1.880
SC	-----
MH	1.342 - 1.638
MI	1.495 - 1.632
ML	-----
CH	-----
CI	1.507 - 1.671
CL	-----

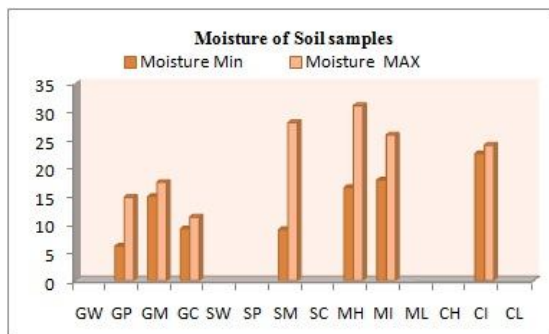


Figure 5: Specific Gravity of soil samples

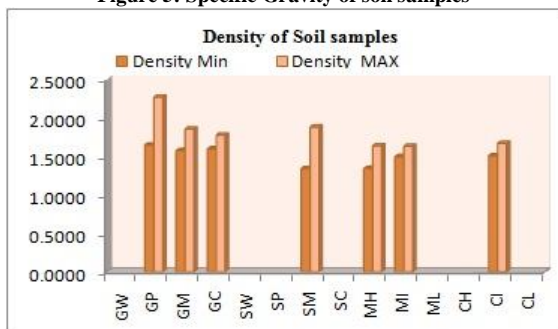


Figure 6: Density of soil samples

B. DIRECT SHEAR TEST

The shear strength of soil is the maximum resistance offered by soil to shearing stress. The shear strength of a soil is its ability to resist sliding & comprises of either cohesion (C) or friction (Tan ϕ) or both . The principal application of this test, in soil and foundation work, is in the determination of the maximum shearing strength and angle of shearing resistance of soils for use in stability analysis.

Table 6. Cohesion (C) of soil samples

Laboratory Classification	Range of Cohesion (C in kg /cm ²)
GW	-----
GP	0.050 - 1.100
GM	0.150 - 0.250
GC	0.090 - 0.090
SW	-----
SP	-----
SM	0.068 - 0.300
SC	-----
MH	0.110 - 0.300
MI	0.140 - 0.160
ML	-----
CH	-----
CI	0.140 - 0.160
CL	-----

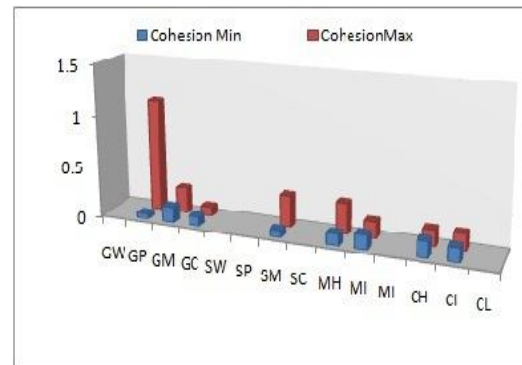


Figure 7: Cohesion (C) of soil samples

Table 7. Tan ϕ of soil samples

Laboratory Classification	Range of Tan ϕ
GW	-----
GP	0.4656 - 0.7822
GM	0.4111 - 0.6756
GC	0.3956 - 0.5467
SW	-----
SP	-----
SM	0.4444 - 0.6089
SC	-----
MH	0.2756 - 0.6556
MI	0.3733 - 0.4667
ML	-----
CH	-----
CI	0.3422 - 0.4022
CL	-----

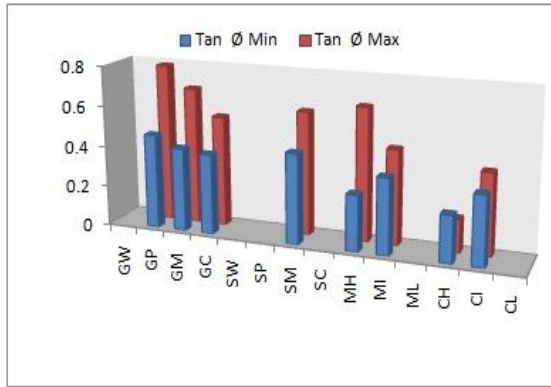


Figure 8: Tan Ø of soil samples

C. PERMEABILITY TEST

The property of the soil which permits percolation of water through it is known as permeability. The coefficient of permeability is the rate of flow of water under laminar flow conditions through a unit cross sectional area under unit hydraulic gradient at specified temperature.

The knowledge of permeability of soil is useful in estimating flow of water through soil, in the solution of problems involving dewatering, yield of water bearing strata, seepage through earth dams, stability of earth dams and embankments arisen out of seepage, settlement etc. The value of coefficient of permeability indicates the suitability of soils in different zones of the embankment.

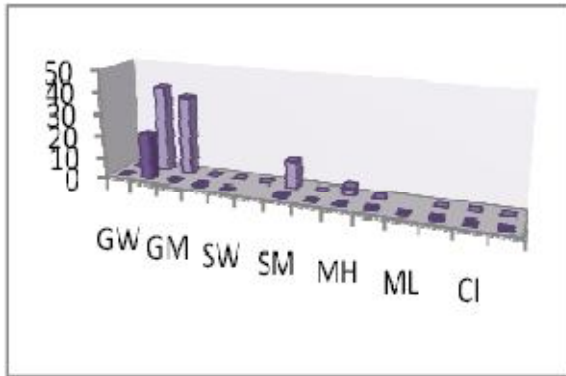


Figure 9 : Permeability of soil samples

Table 8. Permeability of soil samples

Laboratory Classification	Range of Permeability (10 ⁻⁶ cm/Sec)
GW	-----
GP	21 - 40074
GM	0.314 - 3627
GC	-----
SW	-----
SP	-----
SM	1.149 - 12.05
SC	-----
MH	0.11 - 3.595
MI	0.243 - 0.358
ML	-----
CII	-----
CI	-----
CL	-----

Range of permeability of tested soil samples are listed in above table. Among them very few number of GW samples are tested so Soil Mechanics division cannot derive their range of permeability. The figure 9 (not to the scale) shows the graphical representation of range of permeability.

V. ABBREVIATIONS AND ACRONYMS

- CH Clay with high plasticity
- CI Clay with intermediate plasticity
- CL Clay with low plasticity
- GC Gravals with clay
- GIS Geo Informatics' System
- GM Gravals with silt
- GP Gravals with poorly graded
- Gs Specific Gravity
- GW Gravals with well graded
- LLPL Liquid Limit and Plastic Limit
- MA Mechanical Analysis
- MERI Maharashtra Engineering Research Institute
- MH Silt with high plasticity
- MI Silt with intermediate plasticity
- ML Silt with low plasticity
- O.D.D Optimum Dry Density
- O.M.C Optimum Moisture Contain
- PBT Plate Bearing Test
- SC Sand with Clay
- SM Sand with silt
- SP Sand with poorly graded
- SW Sand with well graded

CONCLUSION

From all above test results this institute derives the soil properties pattern for Marathwada region and shown in following table 9.

Table 9. Properties of soil samples

Laboratory Classification	No. of Sample	Range of Gs	Range of Moisture content (in %)	Range of Density (in g/cm ³)	Range of Cohesion (C in kg/cm ²)	Range of Tan Ø	Range of Permeability (10 ⁻⁶ cm/Sec)
GW	0	-----	-----	-----	-----	-----	-----
GP	31	2.121 - 3.081	6.09 - 14.75	1.646 - 2.269	0.05 - 1.100	0.4656 - 0.7822	21 - 40074
GM	9	2.601 - 2.980	1.574 - 1.856	1.574 - 1.856	0.150 - 0.250	0.4111 - 0.6756	0.314 - 3627
GC	2	2.578 - 2.850	1.597 - 1.777	1.597 - 1.777	0.09 - 0.09	0.3956 - 0.5467	-----
SW	0	-----	-----	-----	-----	-----	-----
SP	1	-----	-----	-----	-----	-----	-----
SM	34	2.507 - 2.808	1.340 - 1.880	1.340 - 1.880	0.068 - 0.300	0.4444 - 0.6089	1.149 - 12.05
SC	1	-----	-----	-----	-----	-----	-----
MH	38	1.928 - 2.760	1.342 - 1.638	1.342 - 1.638	0.110 - 0.300	0.2756 - 0.6556	0.11 - 3.595
MI	8	2.587 - 2.770	1.495 - 1.632	1.495 - 1.632	0.14 - 0.160	0.3733 - 0.4667	0.243 - 0.358
ML	0	-----	-----	-----	-----	-----	-----
CH	2	-----	-----	-----	-----	-----	-----
CI	4	2.068 - 2.713	1.507 - 1.671	1.507 - 1.671	0.140 - 0.160	0.3422 - 0.4022	-----
CL	0	-----	-----	-----	-----	-----	-----

Note : Blank field in tables indicate that data found is too less to derive their properties.

- In Marathwada region among 130 samples 56% samples found in SM and MH groups.
- MH group soil impervious in nature so suitable for Hearting zone and SM soil pervious in nature so suitable for casing zone.
- Specific gravity of GP group is minimum and MH group is maximum.
- Moisture content of GP group is minimum and SM group is maximum.
- Density of SM group is minimum and GP group is maximum.
- Cohesion of GP sample is minimum and MH and MI sample are maximum.
- Tan Ø of MH and MI sample is minimum and GP group is maximum.
- Permeability of MH and MI group is minimum and GP group is maximum.

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