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INVESTIGATION OF SOIL CHARACTERISTICS OF SAJJANGAD PLATEAU

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ABSTRACT

Maharashtra, a state in the western part of India, is prone to landslides, particularly in the Western Ghats (Sahyadri Mountains) and the Konkan region. Lower content of organic matter offers the landslide incidents and also urbanization and deforestation increase, the susceptibility to landslides has grown. Landslide is the most hazardous natural disaster involves of deaths of human and animal lives. In Maharashtra there is ambulatory heavy rainfall every year. The Maharashtra has jointed basalt bed rock and having most of black cotton soil, red Soil & Murum. Understanding the characteristics of Soil like bulk density, atterberg limits and organic matter in soil. Introducing the properties of soil texture such as clay, silt, coarse soil and fine soil percentages. Analyzing the specifications of soil which helps to minimizing the risk of landslide.

Key Word: Soil Organic Matter, Bulk Density, Atterberg Limit, Clay, Silt, Coarse Soil, Fine Soil.

1. INTRODUCTION

The western Maharashtra region also known as Kokan region is undergoes through the three climatic conditions such as hot summer, heavy rainfall and winter season. The soil of these region is black cotton and reddish coloured obtained also the type of soil is laterite and gravelly. The change in atmospheric temperature during variation of climatic conditions has ability to change the geotechnical properties of soil by weathering of soil particles and erosion of soil, those reduces bearing capacity of soil as well as organic matter present in soil. In future, urban development established the infrastructure and building towers, they also need to check the geotechnical properties of soil before construction. Sajjangad plateau has jointed basalt rock as a bed rock while some part has brittle murum rock leads low load bearing capacity. In western Maharashtra region landslide occurred due to heavy rainfall, earthquake, and human activities. Human activities such as deforestation, construction on unstable slopes, improper land management and indiscriminate hill cutting aggravate the landslide risks in Maharashtra. These activities often disturb the natural balance of the ecosystem and weaken the stability of slopes making it susceptible to landslides. In response to the inherent risks associated with landslides, effective prevention strategies are imperative to safeguard communities and mitigate the potential consequences.

Sajjangad plateau is a one of the famous tourism place located in western Maharashtra, India. The Sajjangad plateau is only 14Km far from Satara city and has its own nature beauty which attracts tourists to visit it, either the

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Sajjangad fort is the historical memory of Swami Ramdas Samarth and ancient Shri Ram temple. Lots of devotee are visiting the place and spend some time in Shri Ram temple to get peace. Sajjangad plateau is a historical place while Chhatrapati Shivaji Maharaj captured Sajjangad fort since 2 April 1673 and it is the final resting place of Sant Ramdas Swami.

The Maharashtra's biggest Chalakewadi Wind Energy project generates 49.5MW electricity and it was commissioned on 2012. Chalakewadi is a village of Satara district 34.3Km away from Satara city, placed at high altitude of Sajjangad plateau and most of the tourists specially visit the wind farm during monsoon season, also photo shoots and film shooting on plateau is observed in rainy season. Chalakewadi Wind Energy project provide electricity to the Satara city as well as neighboring places such as Mahabaleshwar and Panchgani.

The famous Thoseghar waterfall is a beauty of Satara in monsoon season, it is also known as heaven of Satara city. The Thoseghar waterfall is located on Sajjangad plateau and 5 Km away from Sajjangad fort. The waterfall is 26.5 Km far from Satara and also known as backyard of Satara city. There are two waterfalls where one is smallest with 20 feet height and second is big with 1600 feet height. Every year huge crowd of tourists visit the place to see huge waterfall view and feel the nature during monsoon and click some picture as memory of Thoseghar waterfall.

Fig.1.1 Sajjangad Plateau

Fig.1.2 Chalakewadi Wind Farm

Fig.1.3 Thoseghar Waterfall

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2. LITERATURE REVIEW

1) Bamboo performing a protective role for soil management; Puri Goswami, S., Gohar Ansari, Z., Chauhan Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, S., Pradesh, M., Kundan Singh, I., Puri Gowami, S., Mishra, U., Chauhan, S., & Singh, K. (2022). [18]

   This research paper shows the structural properties of bamboo; its elasticity and strength parameters are more efficient that steel material. The shallow root of bamboo tree helps to tightly bonded with top surface soil and reduces soil erosion. Bamboo roots make good bond between the soil particles and work as a good soil stabilizer.

2) Potential impacts in soil slope of deformation and water content on elastic wave amplitude;
   Ming Xie a, Jiahao Liu a,*, Song Lu b. [21]

   In this research paper the impacts in the soil of water content is determined and realize early warning deformation on elastic wave amplitude. Model box tests were designed to Study the action of one factor, volumetric water content, on the elastic wave amplitude. Early warning during rainfall-induced landslides employs widely to save economic losses and casualties. Elastic wave velocity used for early warning benefits from the relationship between water content, shear deformation, and elastic wave velocity of unsaturated soil slope.

3) Study Index Properties of Soil from Geotechnical Test in their Relation to Landslide;
   Ikah N. P. Permanasari1,*, Wita Ekysta1, Vico L. Ipmawan1, M.Y. Darmawan1, Rahmatnawi Siregar1, Alamta Singarimbun2. [16]

   In this research study the several test on soil conducted such as unit weight, Moisture content, Hydrometer test. Also sieve analysis test carried out to find soil type creeps were found at the bottom of slope along with road caused by vibrations from vehicles. This makes unstable geometry of slope may leads to increase risk of landslide.

4) Investigation on Geotechnical Properties Before and After the Construction of Earth Retaining Structures-West Konkan a Case Study. Dhawale, A., Bobade, S. S., Tapase, A., & Garg, V. [23]

   This research paper shows the change in geotechnical properties of soil before and after earth retaining structure construction. The crucial role of earth retaining structure constructed due to increasing population of India. Rise in population makes accommodation problem, while people are forced to reside landslide prone area.

5) Landslide-induced changes of soil physicochemical properties in Xitou, Central Taiwan;
   Chih-Hsin Cheng, Sheng-Che Hsiao, Yu-Sheng Huang, Chih-Yu Hung, Chuang-Wen Pai, Chiou-Pin Chen, Oleg V.Menyailo. [3]

   In this research paper the dataset comprised historical soil survey data obtained in 1976 and data from soil samples taken in 2012 at the same locations to compare differences in soil properties after landslide deposition, and also conducted soil sampling along a landslide/non-landslide affected sequence to determine how the degree of landslide deposition affected soil physicochemical properties. The results indicated that rock fragment content, soil pH value, bulk density, inorganic carbon, and base saturation increased following landslide deposition and that severe landslide deposition caused more substantial increases.

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6) Forensic analysis of Malin landslide in India:
Pinom Ering, Ramesh Kulkarni, Yashwant Kolekar, Satyanarayan Murty Dasaka and G.L. Sivakumar Babu. [4]
This paper represents the detailed soil properties of landslide of Malin. The soil testing consists of cohesion properties, frictional angle of soil crystals, count of saturation and stability analysis of unsaturated soil slope. The geotechnical test of soil sample includes Moisture content, Dry density, Liquid limit, Plastic Limit, Plasticity Index, Specific Gravity, Grain Size Analysis, Cohesion and Frictional angle. The failure occurs due to loss of suction strength at the interface between bedrock and topsoil.

3. IMPORTANCE OF SOIL STUDY

Understanding soil characteristics which affect on human life as well as on environment and infrastructure.

1) Safety: Understanding the causes of soil failure will give awareness about the region to make a prevention plan for instable soil accidents.
2) Infrastructure Resilience: Analyzing the bearing capacity of soil leads to stable structure construction helps engineers design more resilient infrastructure.
3) Environmental Management: Studying soil characteristics provides insights into the local terrain, soil composition, and environmental factors, aiding in better soil stabilization efforts and guiding sustainable land management.
4) Environmental Health: Soil serves as a natural filter for water, air, and contaminants. Studying soil composition and processes helps identify potential risks to environmental health, such as soil contamination from industrial activities, mining, or improper waste disposal.
5) Ecosystem Functioning: Soils support diverse ecosystems by providing habitat for microorganisms, plants, and animals. Soil studies elucidate the relationships between soil organisms, nutrient cycling, and plant growth, contributing to ecosystem conservation and restoration efforts.

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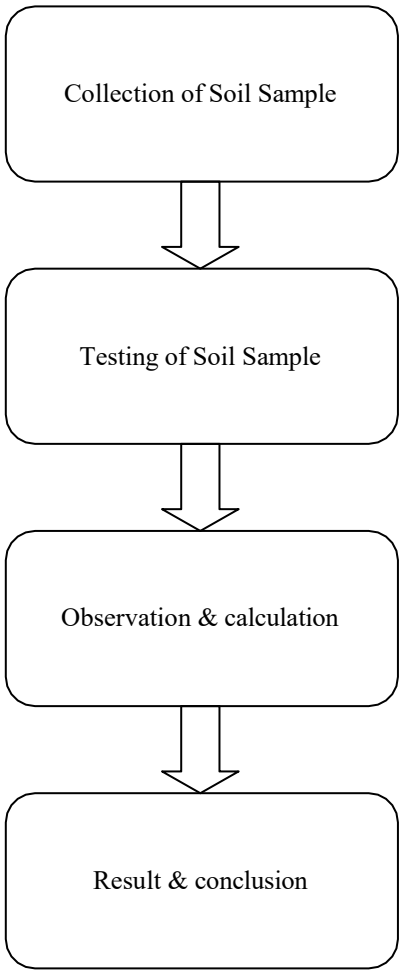
4. RESEARCH METHODOLOGY

Research methodology to investigate soil characteristics of Sajjangad plateau referred as collection of soil sample as per requirement of each kind of soil test. Collecting soil samples numbers of three for each test about 10 meter distance according Indian Standard code. Performing the soil tests as per IS code of test such as IS 2720-4 (1985), IS 2720-2 (1973), IS 2720-3 (1980), IS 2720-17 (1986), IS 2720-28 (1974), IS 2720-7 (1974), IS 2720-26 (1987), IS 2720-22 (1972). Each test is conducted three time and take an average value and after the laboratory tests providing results and conclusion of test.



5. COLLECTION OF SOIL SAMPLE

Identify sampling site location based on topography, land use, and history of landslide in existing area with different slope gradients, soil types and vegetation cover. Collecting the soil sample regarding to type of test as per Indian Standard code of Soil Test IS 2720-1 (1983) [24] with help of sample containers, metal tray, trowel, shovels and core cutter under the guidance of project guide.

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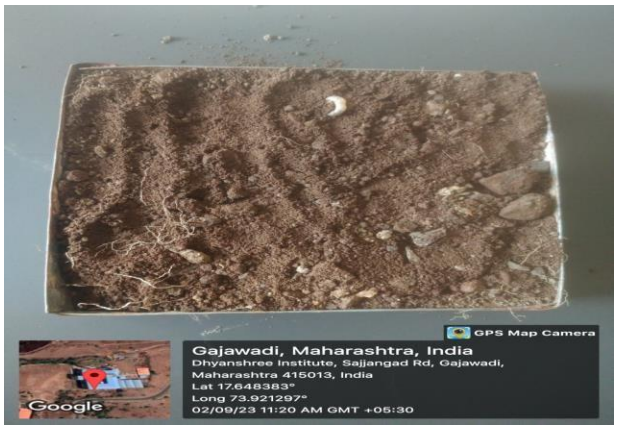

Fig. 5.1 Soil Sample Collection

Fig. 5.2 Soil after Sieve Analysis

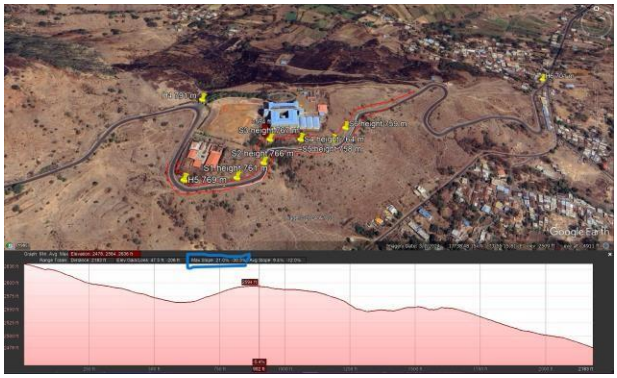

Fig. 5.3 Ghat Section Topography

Fig. 5.4 Satara-Sajjangad Road

Fig. 5.5 Landslide Zone

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6. EXPERIMENTAL INVESTIGATION

Soil tests conducted to identify the properties and characteristics of soil are follows:

1) Core Cutter Test (IS 2720-1975/88 Part XXIX)
2) Determination of Specific Gravity by Pycnometer (IS 2720-1980 Part III)
3) Determination of Particle Size Distribution of Soil by Sieve Analysis (IS 2720-1985 Part IV)
4) Determination of Moisture Content by Oven Drying (IS 2720-1973 Part II)
5) Determination of Atterberg's Limit (IS 2720-1985 Part V)
6) Standard Proctor Test (IS 2720-1974 Part VII)
7) Loss on Ignition Method. (IS 2720-Part XXII)
8) pH Test of Soil. (IS 2720-Part XXVI)

7. RESULT TABLE

1. Core Cutter Test:

Sr. No.	Particular	Sample 1	Sample 2
1	Mass of Core Cutter and Wet Soil (g)	2305	2580
2	Mass of Core Cutter (g)	940	940
3	Mass of Wet Soil (g)	1365	1640
4	Volume of Core Cutter (cm^3)	981.75	981.75
5	Field Density (g/cm^3)	1.39	1.67

a) Volume of Core Cutter (V) = $(\pi d^2 h)/4$

b) Field Density of sample 1 = (Mass of wet soil)/ (Volume of core cutter)

2. Specific Gravity by Pycnometer:

Sr. No.	Particular	Sample 1	Sample 2
1	Mass of Pycnometer (M_1) (g)	695	645
2	Mass of Pycnometer + Soil (M_2) (g)	995	845
3	Mass of Pycnometer + Soil + Water (M_3) (g)	1740	1615
4	Mass of Pycnometer + Water (M_4) (g)	1605	1525
5	Specific Gravity of Soil (G)	1.81	1.82

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The specific Gravity is calculated by

Sr. No.	Sieve Size	Particle Size (mm)	Mass Retained	%Mass Retained	Cumulative Retained	Cumulative % of Finer
1	4.75 (mm)	4.75	160	32	32	68
2	4 (mm)	4	20	4	36	64
3	2.36 (mm)	2.36	70	14	50	50
4	2 (mm)	2	1.80	0.36	50.36	49.64
5	1.18 (mm)	1.18	60	12	62.36	37.64
6	425 (μ)	0.425	110	22	84.36	15.64
7	150 (μ)	0.150	50	10	94.36	5.64
8	90 (μ)	0.090	8.35	1.63	95.99	4.01
9	Pan		20	4	99.99	0.01

$$G = (M_2 - M_1)/ [(M_2 - M_1) - (M_3 - M_4)]$$

3. Particle Size Distribution:

1) Total mass of dry soil = 500 gram
2) Mass of Soil retained on 4.75 mm sieve = 180 gram
3) Mass of soil passing 4.75 mm sieve = 320 gram.

4. Moisture Content:

Sr. No.	Particular	Sample 1	Sample 2	Sample 3
1	Mass of Container (M_1) in gram	46	46.50	46.51
2	Mass of Container and Wet Soil (M_2) in gram	96	96.5	95.59
3	Mass of Container and Dry Soil (M_3) in gram	89.33	94.72	94.72
4	Mass of Dry Soil ($M_3 - M_1$) in gram	43.38	48.22	48.22
5	Mass of Water ($M_2 - M_3$) in gram	6.62	1.789	1.78
6	Water Content in percentage	15.26	3.69	3.69

$$\text{Water Content} = (M_2 - M_3) / (M_3 - M_1)$$

Average Water Content = 7.54 %

Maximum Water Content = 15.26%

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Fig. 7.4.1 Oven Drying

Fig. 7.5.2 Soil filling in mould

Fig. 7.5.2 Water Content addition

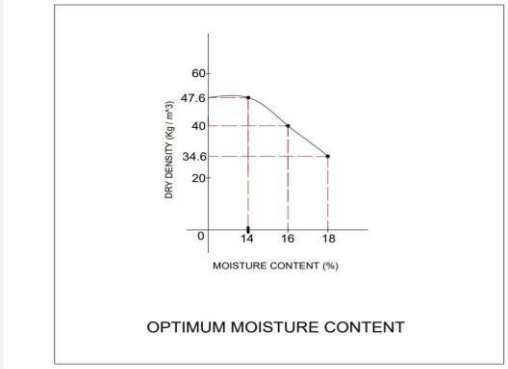

Fig. 7.5.1 Optimum Moisture Content

5. Standard Proctor Test:

Sr. No.	Dry Density (Kg/m^3)	Moisture Content (%)	Optimum Moisture Content
1	47.6	14	Obtained
2	40	16	---
3	34.6	18	---

6. Loss of Ignition Method:

Sr. No.	Container	Oven Dried Weight	Weight After Burning	Organic Matter
1	A13	44.54	35.91	8.63
2	A22	46.63	29.35	17.28
3	A32	39.74	29.83	9.91

Average value of Organic Matter Present in Soil = 11.94 gram per 50 gram of soil sample

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Percentage of Organic Matter in Soil = 5.97 %

7. pH Test of Soil:

The pH value of soil at Sajjangad plateau is 6.

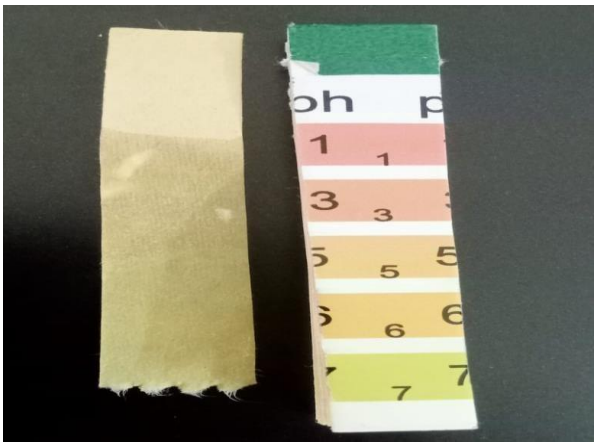

Fig.7.1 Soil pH Test

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8. RESULTS & CONCLUSION

1. Core Cutter Test:
   Higher the dry density indicates lower landslide susceptibility. The average dry density of the landslide soil was found to be 1.53 g/cm³. [5]

2. Determination of Void Ratio and Specific Gravity by Pycnometer:
   High Void ratio results to rise of air voids in soil that leads to imbalance the soil stability , the minimum void ratio is required for soil is 0.98 and maximum void ratio is 1.47. In ghat section of Sajjangad plateau void ratio is obtain as 1.975 which is greater than 1.47so hence the area is under landslide prone. [7]

3. Particle Size Distribution:
   Present clay content in soil is obtained about 5.64%, According to reference [9] landslide soil required clay content greater than 2.5%. [9]

4. Moisture Content:
   Moisture content for cohesive soil are ranged between 14% to 22%, while moisture content is obtained about 15.26%.

5. Standard Proctor Test**:**
   Optimum moisture content of soil is 14.59 % obtained at 14% of water content add in soil, hence the maximum compaction of soil is occurred at 14% of water content. [5]

6. Loss of Ignition Method:
   Low organic matter is obtained about 5.97% in soil it may results to increase landslide susceptibility.[11]

7. pH Test of Soil:
   The pH value of soil at Sajjangad plateau is 6, therefore the soil is slightly acidic. The more acidic soil increases landslide susceptibility. [6]

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