IJARSCT

International Journal of Advanced Research in Science, Communication and Technology

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

ISSN: 2581-9429

Volume 5, Issue 5, November 2025

Impact Factor: 7.67

Comparison the Different Types of Soil and their Properties

Gokul. A[1], Abishek. S[2], Pavithra. S[2], Ragul Dhanesh. D[2], Sudhi Sri. P[2], Thilak. R[2]

[1]Assistant professor, Department of Civil Engineering,

[2]Students, Department of Civil Engineering

Sri Shakthi Institute of Engineering and Technology, Coimbatore

Abstract: *Soils differ in their properties because of their parent rock, minerals, climate, and how they are formed. Among them, Red soil, Black soil, and Clay soil are very common in both civil engineering and agriculture.* ***Red soil*** *is formed from crystalline rocks and looks red due to iron. It has a sandy-loam texture, drains water moderately, and is easy to work with.* ***Black soil*** *comes from basalt rock and contains swelling clay minerals, which make it expand when wet and shrink when dry. It holds a lot of moisture but has low bearing capacity, which can cause problems in construction.* ***Clay soil*** *contains very fine particles, making it highly plastic, sticky when wet, and very slow in draining water. These three soils are compared based on how they form, their texture, water-holding capacity, strength, compaction, and swelling behavior. Understanding these differences helps engineers and farmers choose the right soil for foundations, roads, embankments, irrigation, and crop production.*

Keywords: Red soil; Black soil; Clay soil; Water holding; Strength; Fertility; Use in construction

I. INTRODUCTION

This invention relates to a comprehensive analytical framework for comparing the major soil types encountered in civil engineering, agricultural development, and geotechnical design. The study establishes a standardized methodology for evaluating sand, silt, clay, loam, laterite, and black cotton soil based on quantifiable engineering, physical, chemical, and mechanical characteristics.The comparative assessment utilizes parameters such as grain size distribution, Atterberg limits, permeability, shrink–swell characteristics, compaction behavior, unconfined compressive strength, shear strength, California Bearing Ratio (CBR), specific gravity, and moisture–density relationships. These parameters are measured using recognized geotechnical procedures including sieve analysis, hydrometer analysis, Proctor compaction, direct shear testing, liquid limit/plastic limit tests, and consolidation tests.The results demonstrate that sand, characterized by large particle sizes and negligible plasticity, provides
high permeability, low compressibility, and excellent drainage capacity, making it suitable for foundation

II. OBJECTIVE

The study aims to collect representative samples of **red, black, and clay** soils and analyze their engineering properties through laboratory tests. The investigation includes determining particle size distribution through sieve analysis, measuring field density, and calculating the specific gravity of soil solids. Soil pH is tested to understand its acidity or alkalinity, while the Atterberg limits (Liquid Limit and Plastic Limit) help assess soil plasticity. Proctor compaction tests are conducted to identify the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD). Based on these test results, the engineering behavior of the three soils is compared to evaluate their suitability for various construction purposes

III. METHODOLOGY

Soil Sample Collection: To collect soil that truly represents the site.
Sample Preparation: To clean and prepare the soil for correct testing.
Tabulation of Results: To neatly arrange the test results for easy understanding.

Comparison: To compare the properties of different soils.
Conclusion: To summarize the findings and decide which soil is suitable for construction

IV. LITERATUR REVIEW

1. Comparison of the physical properties of soils belonging to different reference soil groups.
Author : J.M.Moreno-Marotoetal.
Year: 2020
What they did: Compared physical properties across multiple soil reference groups over decades.
How: Field sampling + laboratory analyses (bulk density, porosity, water capacity) and statistical tests ($P < 0.05$).
Result: Significant differences found in particle density, permanent wilting point, available water. Bulk density increased and porosity decreased over 40+ years.

2. Engineering Properties of Soils (overview chapter).
Author:BrajaM.Das
Year: 2016
What they did: Comprehensive review of soil physical, chemical, biological and engineering properties.
How: Synthesis of standard tests (Atterberg limits, particle-size, compaction, permeability).
Result: Clear mapping of tests to engineering properties; provides standard methods for comparison.

3. Assessment of soil compaction properties: A review.
Author:A.Patel and S.K.Jain
Year: 2018
What they did: Systematic review of parameters controlling compaction characteristics.
How: Literature survey of proctor tests, correlations with index properties.
Result: Clay content, gradation, organic matter strongly influence maximum dry density & optimum moisture.

4. Comparative study of soil properties under various cultivation regimes.
Author: S. O. Adesemuyi, P. A. Akinola, and O. E. Aluko
Year: 2021
What they did: Compared soils under different cropping systems (legume, grass, rubber).
How: Field sampling, lab tests for fertility and physical parameters; statistical comparison.
Result: Management affects organic matter, porosity, fertility — significant differences by regime.10

5. Systematic review of soil classification methods.
Author: L. Zhang and M. Robertson
Year: 2022
What they did: Reviewed classification schemes and their applicability (USCS, AASHTO, WRB).
How: Systematic literature review and method comparison.
Result: Each classification has strengths; choice depends on project objective (agronomic vs geotechnical).

6. Effects of Soil Compaction on Soil Physical Properties (Chiagorom, 2025).
Author: Chiagorom, C. E.
Year: 2025
What they did: Explored compaction effect on porosity, bulk density, permeability.
How: Experimental compaction and subsequent lab measurements.
Result: Bulk density increases, porosity decreases; reduced water/air conductivity.

7. Physical properties of soils (educational/resource site).
Author: Soil Science Society of America (SSSA)
Year:2023
What they did: Describes texture, structure, density, porosity — educational overview.
How: Compiles definitions and standard measurement methods.
Result: Clear definitions and test procedures**.**

V. SOIL SAMPLE COLLECTION:

The first and most important step in this project is the collection of soil samples. Proper collection ensures that the data is representative and reliable

RED SOIL

Definition:

Red soil is a type of soil that gets its reddish color due to the presence of iron oxide. It is generally poor in nutrients but supports crops when properly fertilized

Formation:

Formed by the weathering of ancient crystalline and metamorphic rocks such as granite and gneiss.Develops under warm, temperate, and moist climates.

Major Locations (India) :

TamilNadu,Karnataka,Odisha,AndhraPradesh,Chhattisgarh,Jharkhand,MadhyaPradesh,Eastern Rajasthan.

Chemical Compositio :

• High in Iron: Fe_2O_3
• High in Potash: K_2O
• Low in Nitrogen: N
• Low in Phosphorus: P_2O_5
• Low in Humus
• Low in Lime: $CaCO_3$

Engineering Significance

Moderate strength and good drainage.
Used as subgrade material in road construction.
Less swelling and shrinkage than black soil – better for foundations.

CLAY SOIL

Introduction:

Clay soil is a fine-grained natural soil type that contains a high percentage of clay minerals. It becomes sticky and plastic when wet and hard when dry, making it one of the most important soils in civil engineering

Formation :

Clay soil is formed by the long-term weathering of feldspar-rich rocks such as granite. Physical and chemical processes break the rocks into extremely fine particles.

Composition:

• Major minerals: Silica, Alumina
• Clay minerals: Kaolinite, Illite, Montmorillonite
• Color: Brown, grey, black, or reddish
• Particle size: Less than 0.002 mm
• Organic matter: Low to moderate

Engineering Properties

• Dry Density: 1.6 – 2.0 g/cm³
• Plasticity Index: High

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• Shear Strength: Moderate but decreases when wet
• Permeability: Very low
• Compressibility: High
• Bearing Capacity: Low to moderate
• Shrinkage Limit: Low (shrinks a lot)

Engineering Significance of Clay Soil

• Construction of embankments
• Liners in ponds, canals, and reservoirs
• Brick and tile production
• Earthen dams
• As subgrade after stabilization

Uses: Used in pottery; challenging for construction due to shrinkage and expansion.

BLACK SOIL

Definition

Black soil is a type of clay-rich soil that appears dark due to its high humus and iron content. It is also called Regur Soil or Black Cotton Soil because it is ideal for growing cotton.

Formation

Formed from the weathering of volcanic rocks (mainly basalt). Found mostly in regions with low rainfall and high temperature.

Major Locations (India)

Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh, Tamil Nadu (parts), Karnataka.

Chemical Composition

Rich in Iron (Fe), Lime ($CaCO_3$), Alumina (Al_2O_3), Magnesia ($MgCO_3$), Potash (K_2O), and low in phosphorus and nitrogen.

A. SELECTION OF LOCATION:

• **Red Soil**: Typically found in areas with well-drained terrain, often in tropical and subtropical regions.
Example: areas in southern India, parts of Africa, etc.

• **Clay Soil**: Found in regions with heavy rainfall and lower drainage capacity. Example: areas with long-standing rain cycles like the delta regions.

• **Black Soil**: Found in areas of volcanic activity or in regions that are rich in organic material, often in semiarid climates. Example: areas in the Deccan Plateau, parts of the Midwest in the USA

B. SAMPLE COLLECTION PROCEDURE:

1. Tools Needed:

Soil auger or spade
Sterilized plastic or glass containers for collection
Labels and marker for identifying samples
Plastic bags for transporting samples to the lab (if necessary)

2. Collection Process:

Number of Samples: Collect **5 to 10 samples** from each type of soil at various locations within the study area. This helps to minimize the effects of spatial variability.

Depth: Soil should be collected from a **depth of 10 to 15 cm** (from the surface), which is typical for root growth in most crops.

3. Procedure:

▪ Dig a small hole and take a portion of soil at random (within the depth range).
▪ Mix the soil thoroughly in the container to create a composite sample.

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▪ Label each sample container with the **location**, **soil type** (Red, Clay, or Black), and **date** of collection.
Storage: Store the collected samples in clean containers, keeping them sealed to prevent contamination.

VI. SAMPLE PREPARATION

After collecting red,clay, and black soil from their respective locations,the next important step is preparing the soil samples for testing. Proper preparation ensures that all samples are clean, uniform, and ready for accurate physical and chemical analysis.

1. Drying the Soil Samples:
Spread each soil sample on clean sheets of paper or trays.
Keep them in a well-ventilated area at room temperature for 24–48 hours.
Break large lumps gently with your hands—do NOT crush completely.
Avoid drying in direct sunlight, as it may alter the chemical properties.
Purpose: Removes moisture so tests become more accurate.

2. Remove Impurities:
Pick out stones, pebbles, roots, leaves, or any organic debris.
Remove insects and other contaminants.
Make sure each sample contains only pure soil.
Purpose: Ensures fairness when comparing soil types

3. Grinding and Sieving:
After drying, gently crush the soil using a mortar and pestle.
Pass the soil through a 2 mm sieve.
Collect the fine soil that passes through — this will be used for most tests.
Purpose: Creates uniform particle size for chemical tests like pH, NPK, and organic matter. .
4. Divide Samples for Different Tests
Separate each soil type into smaller portions for:
Physical Tests (texture, water-holding capacity, drainage)
Chemical Tests (pH, NPK, organic matter)
Purpose: Avoids contamination and makes testing easier.
5. Store Samples Properly
Keep prepared soil in sealed, air-tight containers.
Store in a cool, dry place until testing begins.
Avoid exposing the soil to moisture or direct sunlight.
Purpose: Maintains the original properties of the soi

VII. NUMBER OF TEST TAKEN:

SPECIFIC GRAVITY TEST
SIEVE ANALYSIS
PH TEST USING PH PAPER
FIELD DENSITY TEST
LIQUID LIMIT TEST
OPTIMUM MOISTURE CONTENT

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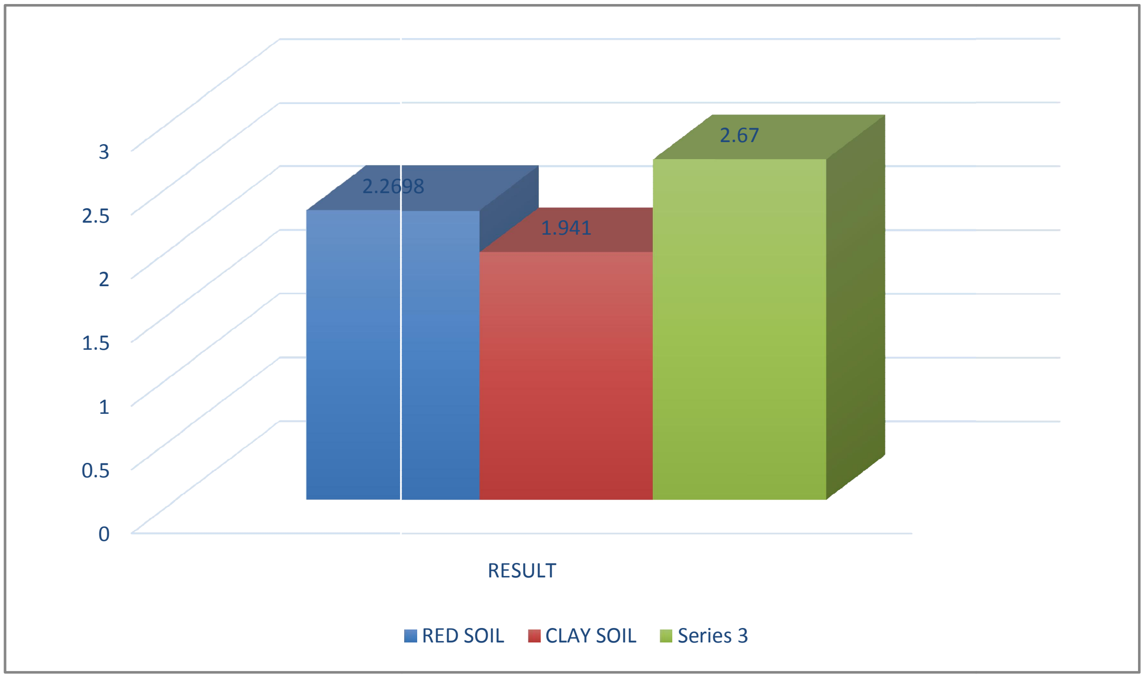
VIII. COMPARATIVE SUMMARY OF SOIL PROPERTIES

TEST 1: SPECIFIC GRAVITY TEST

SOIL NAME	RED SOIL	CLAY SOIL	BLACK SOIL
RESULT	2.2698	1.941	2.67



TEST 2: SIEVE ANALYSIS

SIEVE SIZE	RETAINED IN RED SOIL	RETAINED IN CLAY SOIL	RETAINED IN BLACK SOIL
4.75	24	149	2
1.18	65	225	68
750	18	42	90
600	842	120	160
300	362	238	282
90	404	216	342
75	12	6	20
PAN	31	4	36

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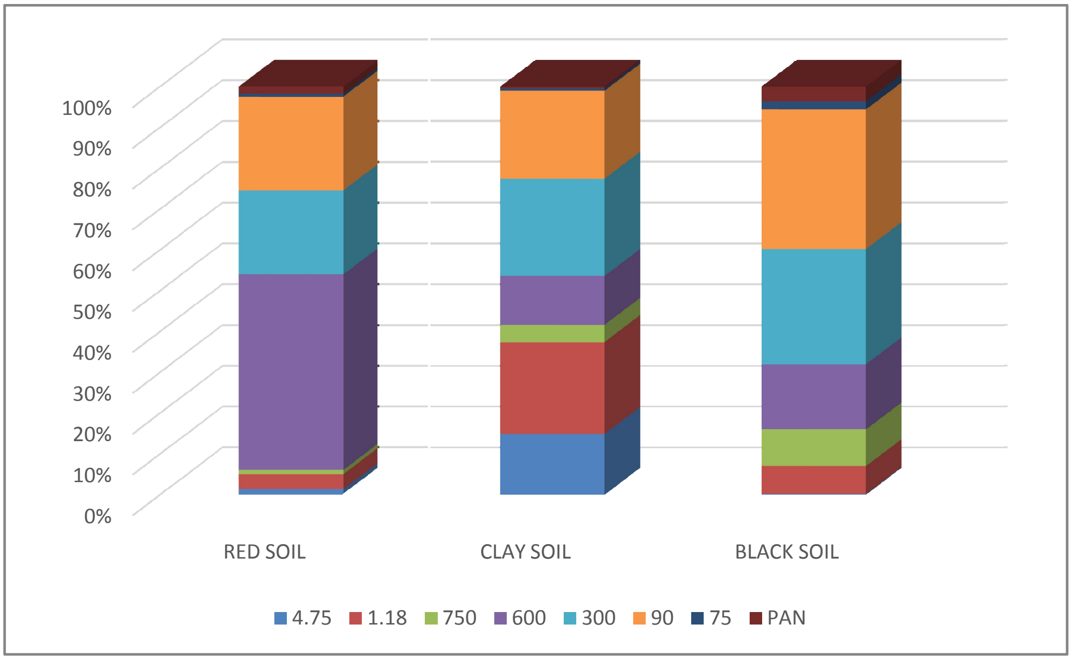
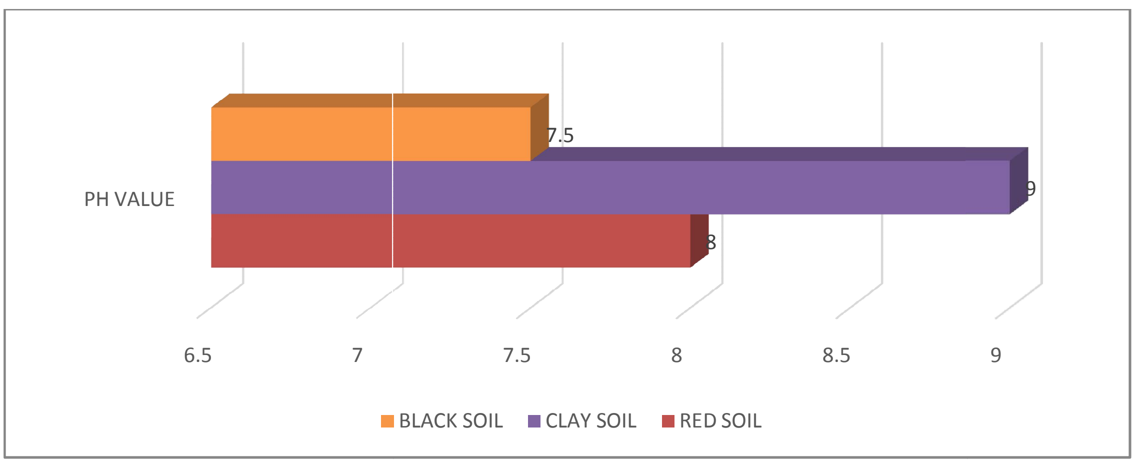


TEST 3: PH TEST USING PH PAPER

SOIL NAME	RED SOIL	CLAY SOIL	BLACK SOIL
PH VALUE	8	9	7.5



DOI: 10.48175/IJARSCT-30075

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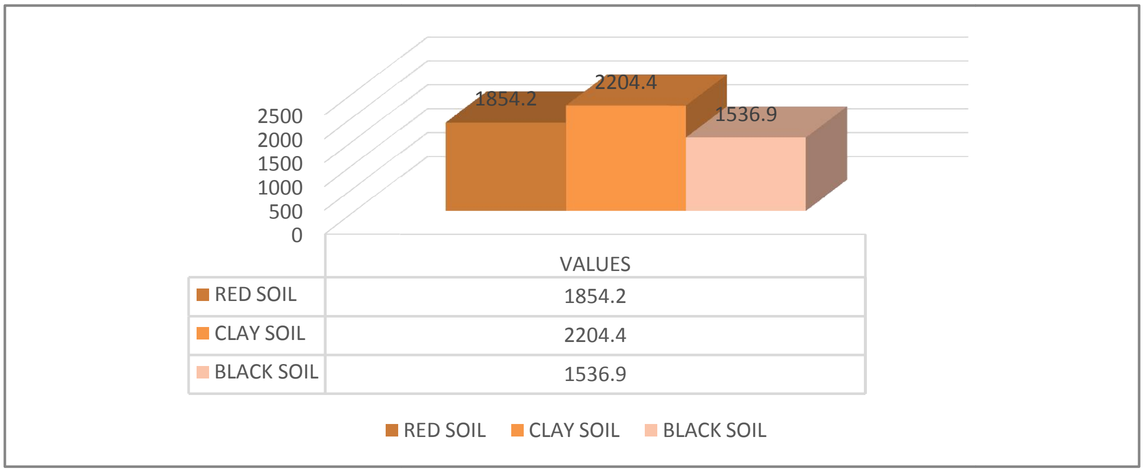
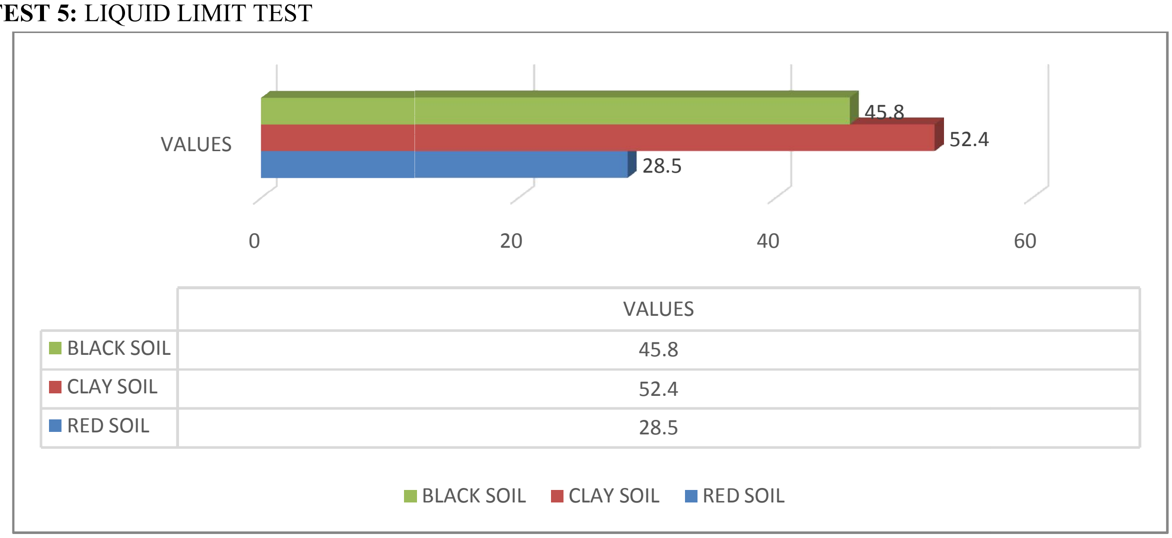
TEST 4: FIELD DENSITY TEST



TEST 5: LIQUID LIMIT TEST



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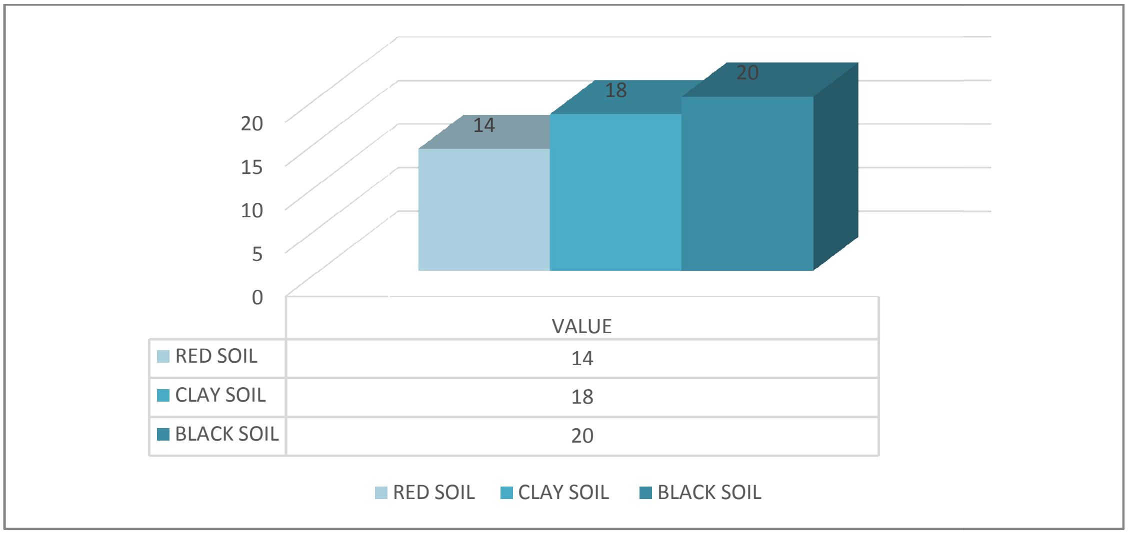
TEST 6: OPTIMUM MOISTURE CONTENT



IX. COMPARISON TABLE

PROPERTY	RED SOIL	CLAY SOIL	BLACK SOIL
Specific Gravity	2.269	1.941	2.67
pH Value	8.0(Neutral)	7.5(Neutral)	9.0(Alkaline)
Field Density (kg/ m³)	1854.2	2204.4	1536.9
Liquid Limit (%)	28.5	52.4	45.8
Optimum Moisture Content	14	18	20
Texture	Sandy Loam	Stricky Clay	Clayey
Drainage	Good	Poor	Poor
Fertility	Low	Moderate	High
Engineering Suitability	Good for bases	Weak, needs help	Needs fixing

X. CONCLUSION

Red soil is generally coarser, less plastic, and better drained, making it suitable for agriculture in dry areas but prone to erosion and low fertility. Clay soil excels in water retention but is challenging for construction due to high plasticity and poor drainage. Black soil is fertile and expansive, ideal for crops like cotton but problematic for foundations due to 29 cracking. Overall, black and clay soils are more cohesive and moisture-sensitive, while red soil is more granular. These properties influence applications: red for roads, clay for pottery, black for farming. Testing is essential for site-specific use, as variations exist

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