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COMPARATIVE STUDY OF SOIL CHARACTERISTICS FOR ROAD CONSTRUCTION IN SELECTED OMANI REGIONS

Ranganath T. V. L.[1] and N. Syed Aleem[2]
[1,2] Lecturers, Civil and Architectural Engineering Section,
Department of Engineering, University of Applied Science and Technology,
Muscat, Sultanate of Oman.

ABSTRACT :

This study presents a comparative geotechnical assessment of soil samples collected from three regions in Oman—Hima, Ibri, and Badiyeh—to evaluate their suitability for road infrastructure development. A series of laboratory tests were conducted, including bulk density, dry density, moisture content determination, California Bearing Ratio (CBR), and specific gravity tests. The results were systematically tabulated and analyzed using relevant graphical representations to highlight the engineering behavior of soils from each region. The findings aim to identify the most suitable region for road construction based on key geotechnical parameters, contributing to informed decision-making in infrastructure planning and development. The study concludes with a recommendation of the region exhibiting the most favorable soil characteristics for sustainable road construction.

KEYWORDS : *Soil characterization, Road infrastructure, Soil suitability, Moisture content, Bulk density and Specific gravity.*

1.INTRODUCTION

Infrastructure development is a cornerstone of national progress, serving as the foundation for economic growth, social connectivity, and regional integration. Among various infrastructure components, road networks play a pivotal role in facilitating trade, mobility, and access to essential services. Roads are vital infrastructure that significantly contributes to the economic development of a country by facilitating the efficient movement of people and goods. Roads are vital infrastructure that significantly contributes to the economic development of a country by facilitating the efficient movement of people and goods.

The design and durability of road pavements are heavily influenced by the geotechnical properties of the underlying soil. Parameters such as bulk density, dry density, moisture content, California Bearing Ratio (CBR), and specific gravity are critical in determining the load-bearing capacity, stability, and long-term performance of road structures. Inadequate assessment of these properties can lead to premature pavement failures, increased maintenance costs, and safety hazards.
This study aims to evaluate the suitability of soils from three distinct regions in Oman—Hima, Ibri, and Badiyeh—for road construction. By conducting a series of standardized laboratory tests on soil samples

collected from these regions, the research seeks to identify the most geotechnical favorable location for road infrastructure development. The findings are expected to contribute to more informed decision-making in infrastructure planning, aligning with the broader goals of Oman Vision 2040.

2. METHODOLOGY:

The present study was conducted to evaluate the soil stability in three distinct regions of Oman: Haima, Al Bidiya, and Ibri. The primary objective was to assess the suitability of these regions for road design and construction based on their geotechnical properties.

2.1 Soil Sampling

Representative soil samples were collected from multiple locations within each of the three regions. Care was taken to ensure that the samples were undisturbed and reflective of the in-situ conditions. The samples were then transported to the laboratory for testing under controlled conditions.

2.2 Laboratory Testing

To determine the engineering properties of the collected soil samples, the following laboratory tests were conducted in accordance with standard geotechnical testing procedures:

2.2.1 Moisture Content Determination

The natural moisture content of the soil was determined using the oven-drying method. This test helps in understanding the water content present in the soil at the time of sampling, which is crucial for evaluating its strength and compaction characteristics.

2.2.2 Bulk Density Test

The bulk density of the soil was measured to assess the mass of soil per unit volume, including the pore spaces. This parameter is essential for understanding the load-bearing capacity and compaction behavior of the soil.

2.2.3California Bearing Ratio (CBR) Test

The CBR test was performed to evaluate the strength of the subgrade soil and its suitability for road construction. The CBR value is a critical factor in pavement design, indicating the soil's ability to support road loads.

2.3 Data Analysis and Site Evaluation

The results obtained from the above tests were analyzed and compared across the three regions. Based on the comparative analysis of moisture content, bulk density, and CBR values, the most suitable site for road construction was identified.

The methodology adopted in the research study is as shown in the figure below

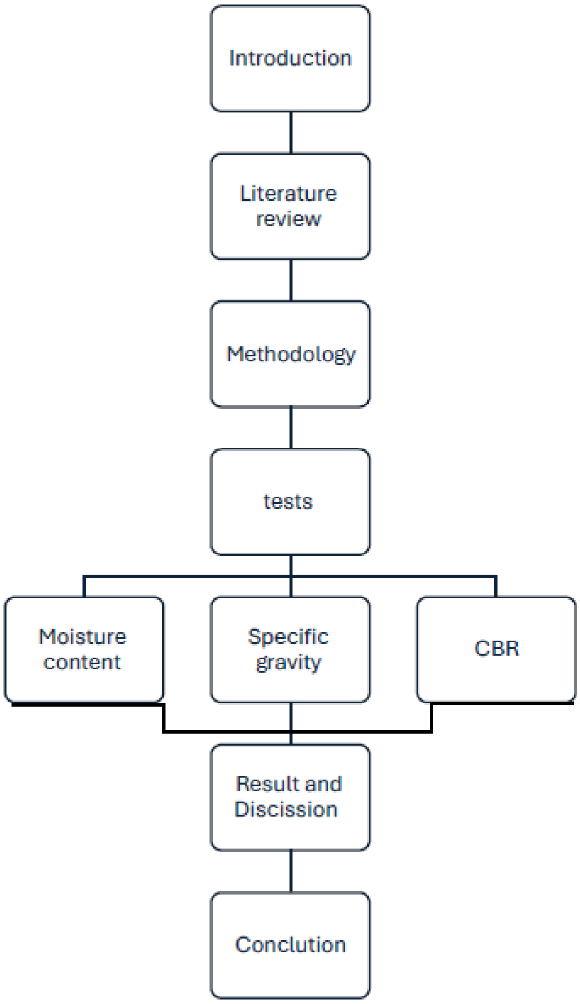


FIGURE 3-0-1 FLOW CHART

3. TESTING PROCEDURE

To evaluate the suitability of subgrade soils for road construction and ensure the design of sustainable, durable, and safe road infrastructure, a series of geotechnical tests were conducted. These tests were carried out on soil samples collected from various locations across Oman, specifically from Haima, Ibri, and Bidiya regions. The primary objective was to assess key engineering properties of the soils that influence pavement performance and structural integrity.

The following laboratory tests were performed in accordance with standard procedures:

3.1 Moisture Content Test

This test was conducted to determine the natural water content present in the soil at the time of sampling. Moisture content significantly affects the soil's compaction characteristics, strength, and overall behavior underload. The oven-drying method was used to measure the moisture content, which involves weighing the soil before and after drying it in an oven at a controlled temperature.

Procedure:
1- weigh the sample before drying to determine its initial weight.
2- set the time and temperature, then dry the sample.
3- to determine the loss on drying, weigh the sample after it has dried and compare it to the initial weight.

Moisture Content (w)= (w2-w3)/(w3-w1) ×100%
Where:
- W1$W1$ = Weight of empty can
- W2$W2$ = Weight of can + moist soil
- W3$W3$ = Weight of can + dry soil

3.2 Bulk Density Test

This test was conducted to determine the mass of soil per unit volume, including the air space and moisture content. Bulk density is a critical parameter for understanding soil compaction and load-bearing capacity. The test was carried out using the core cutter method, and the results were used to assess the relative compaction of the soil in its natural state.

Procedure:
- Clean and dry the cutter.
- Weigh the empty core cutter and record the weight as $\mathbf{W_1}$.
- Select a flat area of soil free from debris.
- Place the steel dolly on top of the core cutter and drive it vertically into the soil using the rammer until the top of the dolly is flush with the ground.
- Carefully excavate the soil around the cutter.
- Remove the cutter containing the soil sample without disturbing the contents.
- Trim the excess soil flush with the ends of the core cutter using a straight edge or knife.
- Weigh the core cutter with the soil and record the weight as $\mathbf{W_2}$.
- Measure the **internal dimensions** of the core cutter (diameter and height) or use standard values.
- Calculate volume **V** of the core cutter using:

$$V = \pi D^2 \mathrm{H}/4$$

Where:
- D = internal diameter of the core cutter
- HH= internal height of the core cutter

2. Bulk Density Calculation:
Bulk Density(ρ)= $(w2 - W1)/V$

3.3 California Bearing Ratio (CBR) Test

The CBR test is a penetration test used to evaluate the strength of subgrade soil and base materials. It provides an index of soil strength and is widely used in the design of flexible pavements. The test was performed on remolded soil samples at optimum moisture content, and the CBR values were determined under soaked and unsoaked conditions to simulate field performance.

Procedure:

CBR is the force per unit area required to penetrate a standard 50 mm diameter circular plunger into a soil mass at a rate of 1.25 mm/min divided by the force required to penetrate a standard material at the same rate. This ratio is expressed as a percentage.

Features a movable head or base that enables a 50 mm diameter plunger to enter the specimen at a rate of 1.25 mm per minute, and a loading mechanism with a minimum capacity of 5000 kg.

FIGURE3-1C B R TEST APPARATUS

3.4 Specific Gravity Test

This test was conducted to determine the specific gravity of soil solids, which is essential for various calculations in soil mechanics, including void ratio and degree of saturation. The test was performed using a pycnometer, and the values obtained were used to classify the soil and understand its mineralogical composition.

Specific gravity (GS) is the ratio of soil solid mass to water mass at the same temperature, usually at 20°c. It helps calculate soil phase relationships and density.

Procedure:

- Clean and dry the pycnometer.
- Weigh the empty pycnometer and record the weight as $\mathbf{W_1}$.
- Add about 200–300 g of oven-dried soil into the pycnometer.
- Weigh the pycnometer with the dry soil and record the weight as $\mathbf{W_2}$.

- Add distilled water to the pycnometer until it is about half full.
- Stir thoroughly to remove air bubbles (use a vacuum pump if available).
- Fill the pycnometer completely with distilled water and clean the outside.
- Weigh the pycnometer with soil and water. Record the weight as $\mathbf{W_3}$.
- Empty and clean the pycnometer.
- Fill it completely with distilled water only.
- Weigh and record this as $\mathbf{W_4}$.

Calculations:

Specific Gravity (G)= $(w2 - W1)/\{(w2 - W1) - (W3 - W4)\}$

Where:

- W1 = Weight of empty pycnometer
- W2 = Weight of pycnometer + dry soil
- W3 = Weight of pycnometer + soil + water
- W4 = Weight of pycnometer + water only

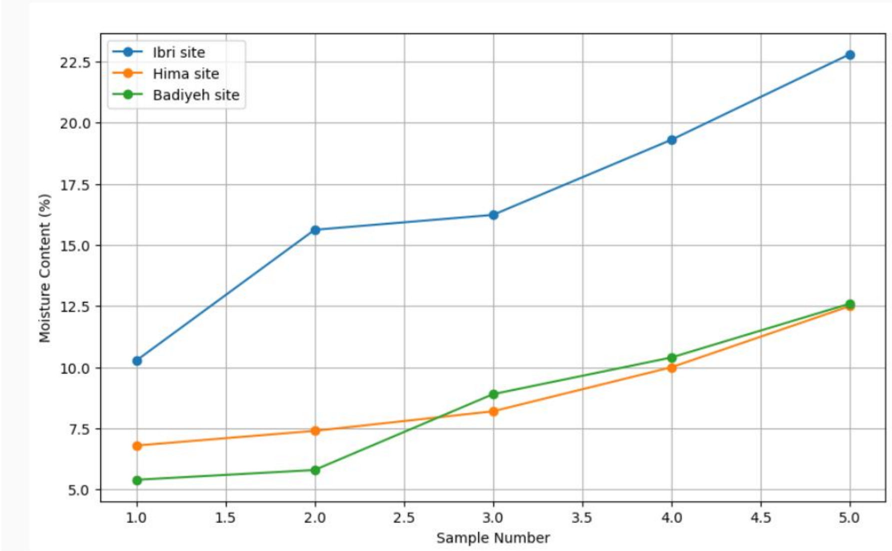
4. TEST RESULTS

4.1 Moisture Content Test results

Moisture Content tests were conducted on the five samples collected from each site and the test results and the comparative graph is as shown below.

TABLE 1 MOISTURE CONTENT TEST RESULTS

	1	2	3	4	5
Moisture content (%) of soil at Ibri site	10.27	15.62	16.23	19.3	22.8
Moisture content (%) of soil at Hima site	6.8	7.4	8.2	10	12.5
Moisture content (%) of soil at Badiyeh site	5.4	5.8	8.9	10.4	12.6



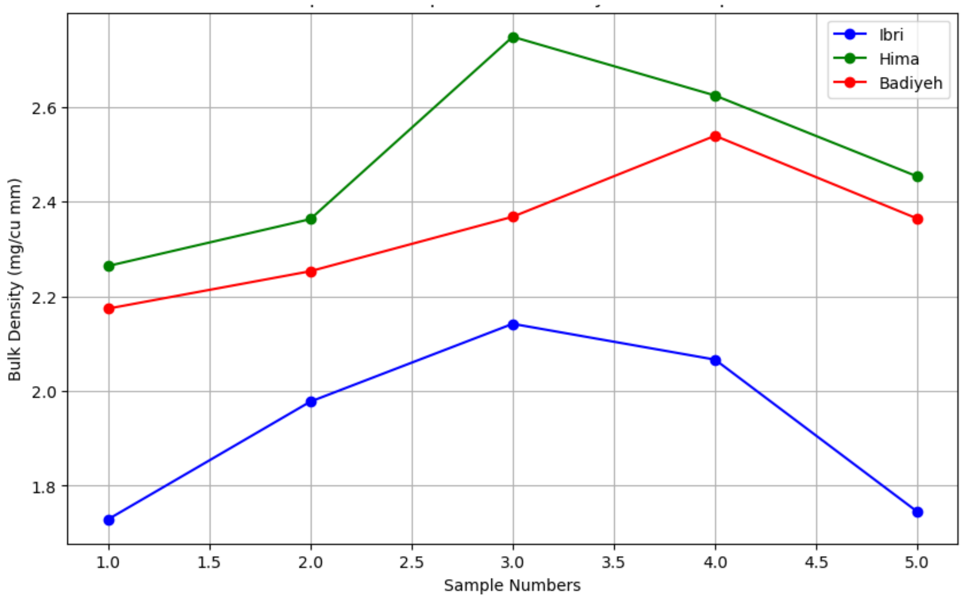
Comparative Moisture Content of Soil at Different Sites

4.2 Bulk density Test results.

A bulk density test was conducted on five soil samples collected from each of the three sites: **Ibri**, **Hima**, and **Badiyeh**. The objective of this test was to determine the compactness and porosity of the soil, which are critical indicators of soil health and suitability for various land uses. The results obtained from the test were analyzed and compared across the sites to identify variations in soil structure and composition. The comparative study is illustrated in the graph below, highlighting the differences in bulk density values among the samples from each location.

TABLE 2 BULK DENSITY TEST RESULTS

Sample numbers	1	2	3	4	5
Bulk density of soil at Ibri site in mg/mm^3	1.729	1.9776	2.1419	2.0663	1.745
Bulk density of soil at Hima site in mg/mm^3	2.264	2.363	2.748	2.624	2.453
Bulk density of soil at Badiyeh site in mg/mm^3	2.174	2.253	2.368	2.539	2.364



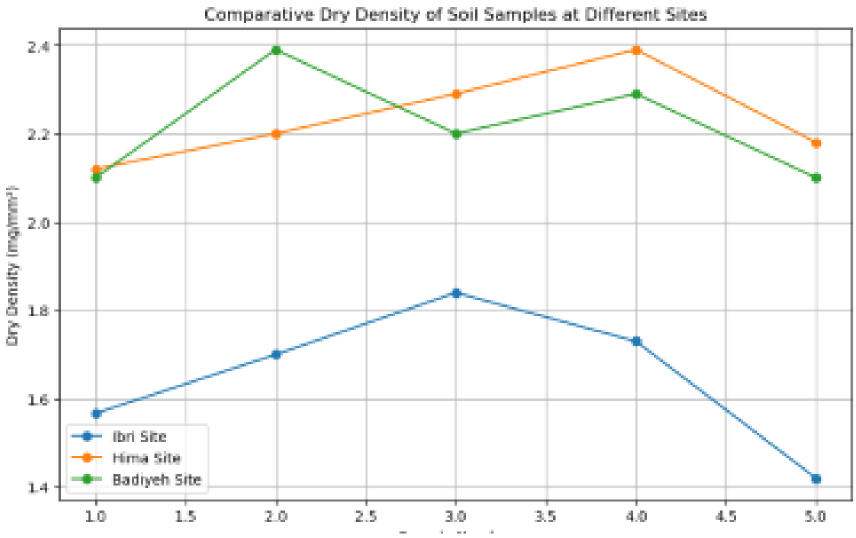
Comparative Graph of Bulk Density of Soil Samples

4.3 Dry density of soil samples

TABLE 3 DRY DENSITY RESULTS

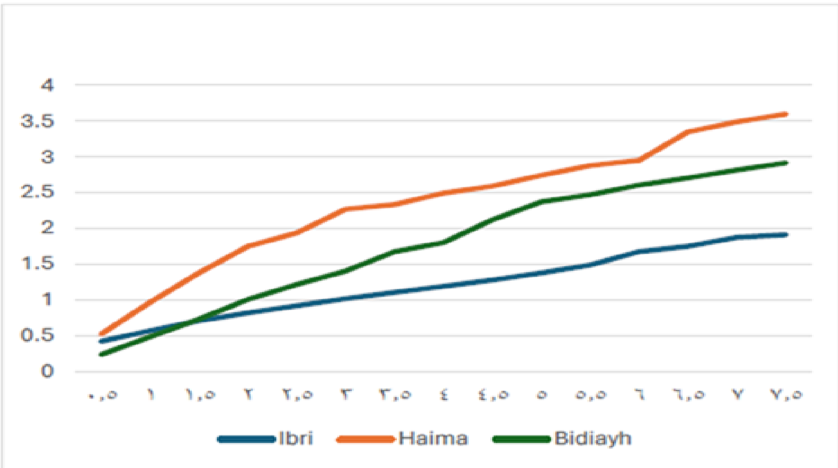
The dry density of soil samples collected from various sites were tested and the results are tabulated. Further a comparison of these values is represented through a graph.

Sample numbers	**1**	**2**	**3**	**4**	**5**
Dry density of soil at Ibri site in mg/mm^3	1.567	1.7	1.84	1.73	1.42
Dry density of soil at Hima site in mg/mm^3	2.12	2.2	2.29	2.39	2.18
Dry density of soil at Badiyeh site in mg/mm^3	2.1	2.39	2.2	2.29	2.1



4.4 California Bearing Ratio (CBR) Test Results

The California Bearing Ratio (CBR) test was performed on soil samples collected from the Ibri, Hima, and Badiyeh sites to evaluate their subgrade strength and suitability for pavement construction. The CBR values provide insight into the load-bearing capacity of the soil, which is essential for designing road and foundation structures. The graph below presents a comparative analysis of the CBR values obtained from each site, highlighting the differences in soil strength characteristics.



C B R Test Results

5. CONCLUSIONS AND INFERENCES

Based on the test results the following conclusions were drawn.

5.1 Moisture Content

Conclusion: The soil from the Ibri site has the highest moisture content.
Inference: This could indicate poor drainage or a higher clay content in the Ibri soil, which retains more water compared to the soils from Hima and Badiyeh.

5.2 Bulk Density

Conclusion: Ibri soil has the lowest bulk density, while Hima soil has the highest.
Inference: Lower bulk density in Ibri suggests a looser, more porous soil structure, possibly due to higher organic matter or less compaction. Hima's higher bulk density indicates a denser, more compact soil.

5.3 Dry Density

Conclusion: Ibri soil has the lowest dry density; Hima and Badiyeh soils have similar, higher values.
Inference: This supports the idea that Ibri soil is less compact and possibly less suitable for load-bearing applications compared to the other two sites.

5.4 California Bearing Ratio (CBR)

Conclusion: Hima soil performed best in the CBR test, while Ibri soil performed the worst.
Inference: Hima soil is more suitable for supporting road and pavement structures, indicating better strength and load-bearing capacity. Ibri soil may require stabilization before use in construction.

5.5 Specific Gravity

Conclusion: Badiyeh soil has slightly lower specific gravity; Hima and Ibri soils are nearly the same.
Inference: The slightly lower specific gravity in Badiyeh may suggest a higher presence of lighter minerals or organic matter. The similarity between Hima and Ibri indicates comparable mineral compositions.

5.6 Final Conclusions

5.6.1 Ibri Soil

Exhibits high moisture content, low bulk and dry density, and poor CBR performance.
Inference: The soil is less compact and has lower strength, making it less suitable for construction without stabilization.

5.6.2 Hima Soil

Shows high bulk and dry density, best CBR results, and moderate moisture content.
Inference: This soil is well-compacted and strong, making it the most suitable for engineering and construction purposes among the three.

5.6.3 Badiyeh Soil

Has moderate dry density, slightly lower specific gravity, and average CBR performance.
Inference: The soil is moderately suitable for construction, with acceptable strength and compaction characteristics.

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