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FEASIBILITY STUDY ON UTILISATION OF RED SOIL AS REPLACEMENT OF FINE AGGREGATE IN CONCRETE

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ABSTRACT
Numerous analysts are managing different types of admixtures to enhance the mechanical and durability properties of cement. In this present study, red soil is utilized as an admixture to improve the performance of cement. An experimental investigation is conducted to assess the behavior of cement by replacing fine aggregate with locally available red soil. It includes specific tests to determine the quality change of concrete when red soil is added. The partial replacement of sand with red soil is achieved by varying the mix proportion to enhance the strength of concrete and to evaluate the workability of red soil. Compressive strength tests and split tensile strength tests have been performed for red soil blended concrete and plain cement to compare the strength. The red soil is of uniform size and is considered as a viable alternative to traditional sand, which performs better when compared to red soil. The substitution of sand in concrete has been carried out using red soil in a mix proportion of M20 with a ratio of 1:1.5:3.

INTRODUCTION
On May 6, 2017, all sand quarries in Tamil Nadu were scheduled to be shut down within three years. The government aimed to regulate the mining, storage, and sale of sand at affordable rates. Tamil Nadu Chief Minister Edapaddi K. Palaniswami stated that the government would encourage manufacturers to adopt an alternative to sand. Illegal sand mining has not only led to a decrease in groundwater levels but has also disrupted the flow of rivers across the state. Addressing this issue is crucial, and exploring alternative materials is essential to meet the demand for fine aggregates. Consequently, this project aims to conduct an experimental study by preparing cement with the complete replacement of sand using readily available local red soil.

PROPERTIES OF RED SOIL
1. Chemical Properties of Red Soil

Composition	Percentage by Weight (%)
Iron	3.61
Aluminum	2.92
Organic Matter	1.01
Magnesium	0.70
Lime	0.56
Potash	0.24
Soda	0.12

Phosphorus	0.09
Nitrogen	0.08

B. Properties to Be Studied

- **Compressive Strength:** Measuring the load-bearing capacity of red soil blended concrete.
- **Fineness Modulus:** Evaluating the particle size distribution of red soil for its use as a fine aggregate.
- **Specific Gravity of Red Soil:** Determining the density of red soil relative to water.
- **Water Content:** Assessing the moisture level in red soil to ensure proper mixing and curing.
- **Complete Replacement of Sand with Red Soil:** Investigating the impact on performance and durability when sand is fully replaced with red soil in concrete.

MATERIALS USED

A. Cement

Cement is a fine substance made with calcined lime and clay. It is blended with water and sand to form mortar, and mixed with sand, gravel, and water to make concrete. In the manufacturing of concrete specimens and barrels, PPC – 43 grade cement was used.

B. Red Soil

Red soil is used in this study as a replacement for fine aggregate. It is sieved through a 4.75 mm I.S. sieve to ensure appropriate particle size for the concrete mix. The mix proportion for fine aggregate is set as 1.5.

C. Coarse Aggregate

The coarse aggregates used for the production of concrete are free from impurities, sound defects, and honeycombing. Coarse aggregates are defined as particles retained predominantly on a 4.75 mm I.S. sieve. The nominal size of the coarse aggregate used in this work is 20 mm.

D. Mixing

For all specimens, the materials are mixed and cast either mechanically or manually. The M20 mix proportion of 1:1.5:3 is used, where:

- **1** represents cement,
- **1.5** represents fine aggregate (red soil), and
- **3** represents coarse aggregate.

METHODOLOGY

A. Specific Gravity Test

The specific gravity of the aggregates is determined by following the Indian Standards specifications as per IS 2386 (Part III) – 1963. The procedure involves the use of a pycnometer, which is thoroughly cleaned and dried before testing.

1. The empty weight of the pycnometer is recorded (W1).
2. About 150 g of dry soil is taken and placed in the bottle.
3. Further steps include adding water, ensuring no air bubbles are present, and recording subsequent weights to calculate the specific gravity.

Fig 1.1 Materials used

1.
2. The pycnometer is emptied, thoroughly cleaned, and then filled completely with water up to the mark. The weight of the water-filled pycnometer is recorded as **W4**.
3. These weights are used to calculate the specific gravity of the soil using the formula:

$$\text{Specific Gravity (G)} = \frac{\text{W2 - W1}}{\text{(W4 - W1) - (W3 - W2)}}$$

B. Sieve Analysis Test

Sieve analysis is conducted for both sand and red soil following IS 2386 (Part I) – 1963. The procedure is as follows:

1. Take an appropriate quantity (approximately 1000 g) of oven-dried soil retained on a 75 µm sieve.
2. Sieve the soil through a series of sieves (4.75 mm, 2.36 mm, 1.18 mm, 1 mm, 600 µm, 300 µm, 150 µm, and pan) using a mechanical sieve shaker for 2 minutes.
3. Carefully weigh the soil retained on each sieve and the pan. Record the weights in the observation table.
4. The sum of the retained soil weights is checked against the original mass of the soil sample to ensure accuracy.
5. The gradation of soil is then analyzed to determine its suitability for use as a fine aggregate in concrete.

A. Pycnometer
B.Sieve shaker

C. Water Absorption Test

1. The sample is thoroughly washed to remove fine particles and dust, drained, and then placed in a wire basket.
2. Submerge the basket with the sample in water at a temperature between 22°C and 32°C for a period of 24 hours.
3. Remove the basket and sample, spread the sample on a cloth, and expose it to air away from direct sunlight until it appears surface dry.
4. Weigh the surface-dry aggregate and record it as **A**.
5. Place the aggregate in an oven at a temperature of 100°C to 110°C for 24 hours.
6. Remove the aggregate from the oven, cool it, and weigh it again. Record this weight as **B**.
7. The water absorption is calculated using the formula:

$$\text{Water Absorption (\%)} = \frac{A - B}{B} \times 100$$

D. Compressive Strength Test (Cube)

1. The compressive strength of a material is determined by testing its resistance to crushing under an applied load.
2. Prepare three cube specimens of dimensions 15 cm x 15 cm x 15 cm for testing at 7, 14, and 28 days.
3. After the curing period, remove the specimens from water and wipe off excess surface water.
4. Clean the bearing surface of the testing machine.
5. Place the specimen in the machine such that the load is applied to opposite faces of the cube.
6. Align the specimen centrally on the base plate of the machine.
7. Gradually apply the load without shock until the specimen fails.
8. Record the maximum load applied and note any unusual failure patterns.
9. The compressive strength is calculated using the formula:

$$\text{Compressive Strength (N/mm}^2) = \frac{\text{Maximum Load (N)}}{\text{Area of Specimen (mm}^2)}$$

E. Split Tensile Strength Test (Cylinder)

1. The split tensile strength test is conducted similarly to the compressive strength test.
2. Prepare three cylinder specimens with a diameter of 15 cm and height of 30 cm for testing at 7, 14, and 28 days.
3. Remove the specimen from water and wipe off excess surface water.
4. Place the specimen horizontally in the compression testing machine so that the load is applied along its diameter.
5. Lower the upper plate to touch the specimen.
6. Gradually apply the load continuously without shock until the specimen fails.
7. Record the breaking load (**P**).
8. The split tensile strength is calculated using the formula:

$$\text{Split Tensile Strength (N/mm}^2) = \frac{2P}{\pi dl}$$

where:

- **P** = Breaking load (N)
- **d** = Diameter of the cylinder (mm)
- **l** = Length of the cylinder (mm)

RESULTS

A) Specific Gravity Calculation
The specific gravity of red soil (**G**) is calculated using the formula:

$$G = \frac{W2 - W1}{(W2 - W1) - (W3 - W4)}$$

Given:

$$G = 2.6$$

The specific gravity of red soil is **2.6**, which falls within the standard range of **2.3 to 2.7** for Zone II sand. Therefore, red soil is deemed suitable for full replacement of fine aggregate in this experiment.

B) Fineness Modulus Calculation

Fineness modulus is calculated as:

Given:

$$\text{Fineness Modulus} = \frac{253}{1000} = 0.253$$

D) Compressive Strength Test
Compressive Strength Test (7 Days)
The compressive strength is calculated as:

$$\text{Compressive Strength} = \frac{\text{Load}}{\text{Area}}$$

Sample Details:

Sample No.	Area (mm²)	Maximum Crushing Load (N)	Compressive Strength (N/mm²)
1	22500	326.8×103326.8 \times 10^3326.8×103	14.52

2	22500	308.8×103308.8 \times 10^3308.8×103	13.72
3	22500	316.4×103316.4 \times 10^3316.4×103	14.06

- **Load** = 326.8×10^3 N
- **Area** = $22500\,\text{mm}^2$

$$\text{Strength} = \frac{326.8 \times 10^3}{22500} = 14.52\,\text{N/mm}^2$$

The **mean compressive strength** after 7 days of curing is:

$$\text{Average Strength} = 14.16\,\text{N/mm}^2$$

Concrete achieves approximately **65% of its design strength** after 7 days of curing.

2) Compressive Strength Test (14 Days)

- **Load** = 365.8×10^3 N
- **Area** = $22500\,\text{mm}^2$

$$\text{Strength} = \frac{365.8 \times 10^3}{22500} = 16.25\,\text{N/mm}^2$$

The compressive strength of concrete after **14 days of curing** is calculated to be **16.25 N/mm^2**.

E) Split Tensile Strength Test

1) Split Tensile Strength Test (7 Days)

The split tensile strength is calculated using the formula:

$$\text{Split Tensile Strength} = \frac{2P}{\pi DL}$$

Sample Details:

Sample No.	πDL Value (mm^2)	Maximum Load (N)	Split Tensile Strength (N/mm^2)
1	141.37×10^3	84.2×10^3	1.19
2	141.37×10^3	94.5×10^3	1.33
3	141.37×10^3	99.3×10^3	1.40

- **Load** = 84.2×10^3 N
- **πDL Value** = 141.37×10^3 mm^2

$$\text{Strength} = \frac{2 \times 84.2 \times 10^3}{141.37 \times 10^3} = 1.19\,\text{N/mm}^2$$

The **mean split tensile strength** after 7 days is:

$$\text{Average Strength} = 1.30\,\text{N/mm}^2$$

2) Split Tensile Strength Test (14 Days)

Sample Details:

Sample No.	πDL Value (mm^2)	Maximum Load (N)	Split Tensile Strength (N/mm^2)
1	141.37×10^3	101.10×10^3	1.43
2	141.37×10^3	111.4×10^3	1.57
3	141.37×10^3	115.7×10^3	1.63

- Load = 101.10×10^3 N

$$\text{Strength} = \frac{2 \times 101.10 \times 10^3}{141.37 \times 10^3} = 1.43\,\text{N/mm}^2$$

The **mean split tensile strength** after 14 days is:

$$\text{Average Strength} = 1.54\,\text{N/mm}^2$$

3) Split Tensile Strength Test (28 Days)

Sample Details:

Sample No.	πDL Value (mm^2)	Maximum Load (N)	Split Tensile Strength (N/mm^2)
1	141.37×10^3	128.6×10^3	1.81

- Load = 128.6×10^3 N

$$\text{Strength} = \frac{2 \times 128.6 \times 10^3}{141.37 \times 10^3} = 1.81\,\text{N/mm}^2$$

CONCLUSION

The results from various tests indicate that red soil blended concrete demonstrates superior quality and lower permeability compared to plain concrete. Although red soil blended concrete exhibits higher porosity than plain concrete, its permeability is significantly lower due to the small pores in fine soil, which tightly retain water, thereby reducing permeability and resisting fluid penetration, making it impermeable. When used in Reinforced Cement Concrete (RCC) structures, red soil blended concrete ensures the prevention of steel corrosion. It can be effectively utilized in RCC as well as in prestressed concrete applications. Further research is recommended to explore its application in shell structures, prestressed concrete, and RCC to validate its usability in multi-storied buildings.

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