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Experimental Study on Cement and Fine Aggregate Partially Replaced by Fly ash and Red soil in Concrete

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Abstract - *The depletion of natural resources and environmental concerns have led to a growing interest in sustainable construction materials and practices. In this research, we look at the possibility of using red soil and fly ash in lieu of some of the cement and fine aggregate in concrete. Investigating these substitute materials' ability to improve concrete's mechanical and environmental performance is the main objective.*

The experimental program involves varying proportions of red soil and fly ash as substitutes for conventional fine aggregate and cement in concrete mix designs. The workability, compressive, flexural, and tensile strengths of the final concrete are the primary metrics being studied. The performance of the modified concrete mixes is evaluated using a battery of laboratory experiments, including slump, compressive, and tensile strength tests.

Here we have used M25 grade concrete and also we have replaced the 20% of cement by fly ash and 10%, 20%, 30% & 40% of fine aggregate by the red soil.

This research holds significance for sustainable construction practices, offering potential solutions for both waste management and the conservation of natural resources. Researchers and engineers working to improve concrete mix designs using locally accessible ingredients, encouraging eco-friendly building methods, and decreasing the industry's dependence on conventional raw materials may find some useful information in the results.

1. INTRODUCTION

Environmental concerns and the pursuit of sustainable building techniques have recently shifted the focus to the use of alternative materials in concrete manufacturing. Substituting fly ash for some of the cement and red soil for some of the fine aggregate is one such method. The goal of this experimental investigation is to find out how adding these different components to concrete changes its performance and characteristics.

The pozzolanic characteristics of fly ash, a waste product of coal combustion in power plants, may improve the strength and longevity of concrete by aiding in the hydration process of cement. However, red soil is a great alternative to fine aggregate in concrete mixes due to its abundance and low cost. This research aims to investigate the possible advantages in mechanical characteristics, workability, and environmental sustainability by partly replacing standard components with fly ash and red soil.

The results of this experimental investigation shed light on the practicality and efficiency of using red soil and fly ash in lieu of some of the cement and fine aggregate in concrete. The findings of this research could potentially contribute to the development of sustainable construction practices, reducing the environmental impact associated with conventional concrete production while maintaining or improving the performance of concrete structures.

2. LITERATURE REVIEW

Mr. Ashok Raajiv, (2015): used Red soil as the partially Replacement to the sand in M20 Grade concrete by adding the chemical properties of test like iron, aluminum, organic matter, magnesium, lime, potash, soda, phosphorus, Nitrogen for the red soil is replacement of fine aggregate. The following tests are performed: compressive strength (19.24 N/mm2 for 28 days), split tensile strength (1.81 N/mm2 for 28 days), water content, specific gravity (2.6) of red soil, and a partial replacement of sand with red soil. Using a blended M20 grade of 1:1.5:3 mix proportion of cement, fine aggregate, and coarse aggregate, the sand in concrete has been completed using red soil. The physical features of the tests are the basis for all of the excellent and correct outcomes that have been produced by the tests. Based on the results of the 28-day compressive strength test and split tensile tests, the red soil may be used as a substitute for fine aggregate.

Dr. K. K Jain, Et al. (2001) : had substituted some of the cement with neutralized red dirt. Soil has a specific gravity of 3.15 with a particle size distribution of 12% clay, 80% silt, and 8% sand. The Ultratech grade is M43, and the concert grade is M45. The primary evaluation is the compressive strength test after 28 days. There was a drop in compressive strength at the 5% cement-neutralized red mud replacement level, but at the 10% and 15% levels, compressive strength rose. Various tests are conducted by the Replacement of cement by Neutralized Red mud by two types, a) Test on the cement and b) Test on hardened concrete. Test on cement- a) Standard consistency of

cement (33.50 for 15%). b) Initial setting time(102 min for 15%). c) Final setting time(232 min for 15%).

James Alexander . Et al. Issue-3, Jun.-2016 : recycled red dirt is added to concrete as an additive to make it work better. By using red soil that is readily accessible in the area as a substitute for fine aggregate, an experimental inquiry is conducted to examine the behaviour of concrete. We need to learn how to make concrete with excellent strength, how to determine how impermeable red soil is, and what characteristics of red soil make it effective against pests. In order to distinguish between plain concrete and concrete mixed with red soil, tests were conducted on its compressive strength, split tensile strength, flexural strength, and durability characteristics such porosity and water permeability. Based on its chemical characteristics, red dirt may be used to replace fine aggregate in concrete, making it an effective pesticide.

Mr. G.Pradeep,Et.al.: By substituting locally available red soil for the fine aggregate, an experimental inquiry is conducted to examine the behaviour of concrete. Previous research published in the journal found that adding additional red soil weakens concrete and increases water absorption. To prevent water absorption and porosity, lime powder is also added to the concrete in our project. The appropriate percentages of red soil to add to the M20 concrete mix are 15%, 30%, and 45%, and their strength should be evaluated in this project. According to the findings, the strength and imperviousness of red soil mixed concrete are much greater than those of plain concrete. Compressive strength after 28 days is 19.6 N/mm2 for plain concrete and 22.3 N/mm2 for concrete mixed with red soil. When lime powder is added to red soil, experimental results show that the concrete's strength is significantly increased.

S. Sebastin , M. Franchis David, Et al. (Published 1 July 2022): One of the main components of the concrete mix is river sand. Red dirt and manufactured sand (M-Sand) are two examples of locally available replacement materials that this activity replaces. This article examines the mechanical characteristics and longevity of concrete that incorporates red soil and M-Sand. Two sets of combinations were tested in this experiment using M30 grade concrete. Twenty percent, thirty percent, forty percent, fifty percent, and sixty percent of river sand seems to be red soil; sixty percent, fifty percent, forty percent, thirty percent, and twenty percent of manufactured sand (M-Sand) appears to be red soil. Three different strengths: compressive (7 days, 28 days, 90 days), split tensile (28 days), and flexural (28 days).The red soil in concrete starts reacting with the cementatious elements after 28 days, increasing the product's strength and durability by 15%.

3. MATERIALS USED

3.1 CEMENT

Cement is a material that joins. It is the grade that complies with IS456-2000-53. It comprised of milling the raw materials, blending them intently in certain proportion depending on such homogeneity and proportions burning them in a furnace at a temp of around 1350 – 1450 degree centigrade where at temperature, the content cinder and partially binds to construct stackable chapped clinker. Grinding the clinker into a fine powder after it has cooled and added 2% to 3% gypsum is the process. The end result of this process is Portland cement. Cement, which bonds sand and aggregate so that concrete can resist atmospheric action, is the most important component that affects concrete's behaviour.

Properties of Cement

Table 1 Properties of cement

Sl. No	Properties	Values
1	Specific Gravity	3.00
2	Soundness	2 mm
3	Initial Setting Time	205 min
4	Final Setting Time	270 min
5	Consistency of Cement	32 %

3.2 FINE AGGREGATE :

Fine aggregates are defined as particles with a size less than 4.75 mm. Fine aggregate is the primary use of river sand. As a fine material substitute, river sand was used in this exploratory investigation.

Properties of Fine Aggregate

Table 2 Properties of Fine Aggregate

Sl. No	Properties	Values
1	Specific Gravity	2.63
2	Finess Modulus	2.892
3	Zone	II
4	Water Absorption	1.01 %

3.3 COARSE AGGREGATE :

Coarse aggregates were made from appropriately graded granite that was found naturally. The aggregates were typically bigger than 4.75 mm but less than 16 mm, and they had a fineness value of 2.71.

Properties of coarse aggregate

Table 3 Properties of Coarse Aggregate

Sl. No	Properties	Values
1	Specific Gravity	2.80
2	Finess Modulus	6.51
3	Crushing Strength	27.72
4	Water Absorption	0.301 %

3.4 RED SOIL :

Iron oxide is abundant in red soil, whereas lime and nitrogen are scarce. The presence of iron oxides, in the form of hematite (a reddish-brown color) and limonite (a yellow hue) in the hydrated phase, gives the soil its characteristic hue. The crimson dirt gives way to a yellowish hue as it sinks toward the horizon.

Properties of red soil

Table 4 Properties of Red Soil

Sl. No	Properties	Values
1	Specific Gravity	2.38
2	Liquid Limit	51 %
3	Plastic Limit	30.1%
4	Void Ratio	0.327

3.5 FLY ASH :

It is the finely separated byproduct that is carried out of the combustion chamber by exhaust gases as a byproduct of burning pulverized coal.

Properties of Fly ash

Table 5 Properties of Fly ash

Sl. No	Properties	Values
1	Specific Gravity	2.225
2	Fineness	452 m^2/kg

4. MIX DESIGN

It is essential to be meticulous at every stage of the concrete-making process in order to fabricate high-quality concrete. The end product is likely to be subpar concrete if all necessary precautions are not taken and directions are not followed precisely. Everyone must be aware of the best practices that must be followed at every stage of the concrete production process in order to produce concrete of a high quality.

4.1 Batching

The correct way to measure the ingredients is by batching. Always use the weigh batching technique for essential concrete. The precision, flexibility, and simplicity of batching are all improved by using the weighing technique. There are many different kinds of weigh batchers available; picking the right one depends on the job at hand. Accurate water evaluation using measure jars is essential when weigh batching is used.

4.2 Blending

Hand blending is done for relatively small concrete jobs. Manual blending must be done on an impermeable concrete or brick surface of sufficiently big size to accommodate one bag of cement. Distributing the specified quantity of fine and coarse aggregate in successive levels. However, after that, pour the cement on top and mix the ingredients using a shovel, rotating the mixture repeatedly until a uniform color is reached. This uniform mixture is spread out across an area about 20 cm thick.

This process is repeated until a uniform, well-shaped block of concrete is produced. Make sure the water is sprayed, not poured, since that's an important detail to check. Even a little bit of water makes a difference at that time. The next step is to mix half of the red soil with lime powder, and then introduce the red soil into the concrete in varying proportions.

4.3 Positioning

The most important thing is a concrete mix that is properly planned, batched, and mixed, yet it may not be enough. The concrete should be laid in organized way to produce optimal outcomes. The measures should be taken and ways adopted when laying concrete in the castings.

4.4 Tamping

Manual pounding of concrete is employed in event of minor concrete works. When a large quantity of reinforcing is needed, which cannot be compacted using traditional techniques, this procedure is often used as well. The three main methods of manual compaction are hammering, pounding, and rodding. The uniformity of concrete is maintained to a great extent when compacting it by hand. When compacting roof or subfloor or highway pavements, tamping is a popular strategy. This is especially true when the concrete thickness is relatively thin and the surface to be finished is level and smooth.

4.5 Curing

Concrete gains its capacity through the hydration of cement molecules. The cement hydration is just not an instantaneous activity but a cycle lasting for lengthy time. More precisely, it may be stated as the technique of preserving a suitable amount of moisture and an optimum warmth in concrete at the time of placement and shortly upon installation, whereby the hydration of plaster may persist until the required qualities are evolved to a considerable degree to fulfil the criteria of utility. Squares and cylinders that have been formed are immersed in water for seven and twenty-eight days, respectively.

5. EXPERIMENTAL INVESTIGATIONS

Compressive Strength Test:

Moulding is done using the standard cast size of 150mm × 150mm x 150mm. Cube specimens of concrete are left to cure for 7 or 28 days, and then subjected to a compression test machine (CTM) strength test in accordance with IS 516:1959 for both the standard mix and the samples that include major substitutes.

Split tensile strength test:

A standard casting measuring 150mm × 300mm is used for the audition process. Curing is done for either seven or twenty-eight days. The testing machine (CTM) was used to conduct the split tensile test on both the ordinary mixture and the partly supplemented samples in accordance with IS 5816:1999 standards.

Flexural strength test:

For the moulding process, the standard mould with dimensions of 750mm × 150mm × 150mm is used. Seven and twenty-eight days are used for curing. The typical mix and half-substituted samples undergo flexural strength testing in a universal testing machine (UTM) in accordance with IS 516: 1959.

6. EXPERIMENTAL RESULTS

Graphs and charts are used to describe the results of the current research, which looked at using fly ash as a 20% cement replacement and different percentages of red soil as a fine aggregate replacement. The percentages of concrete replacement, namely 10%, 20%, 30%, and 40%, are as follows.

Compressive Strength Test:

Table 6 Compressive Strength of concrete

Curing [days]	7	28
Conventional concrete [N/mm²]	23.340	29.830
Red soil 10% [N/mm²]	18.725	28.200
Red soil 20% [N/mm²]	17.010	26.615
Red soil 30% [N/mm²]	16.465	25.535
Red soil 40% [N/mm²]	10.160	23.205

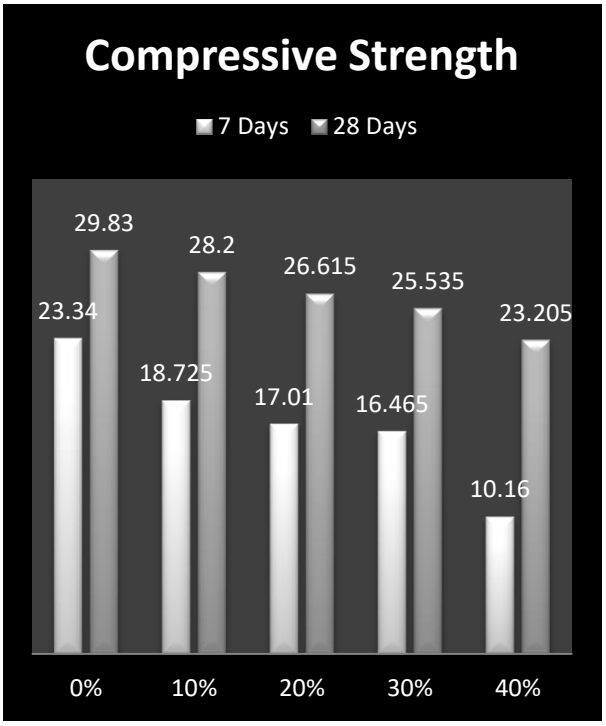

Fig 1 Comparison of strength for 7&28 days

Split tensile strength test:

Table 7 Split Tensile Strength of Concrete

Curing [days]	7	28
Conventional concrete [N/mm²]	2.293	2.986
Red soil 10% [N/mm²]	1.830	2.865
Red soil 20% [N/mm²]	1.755	2.655
Red soil 30% [N/mm²]	1.720	2.600
Red soil 40% [N/mm²]	1.625	2.490

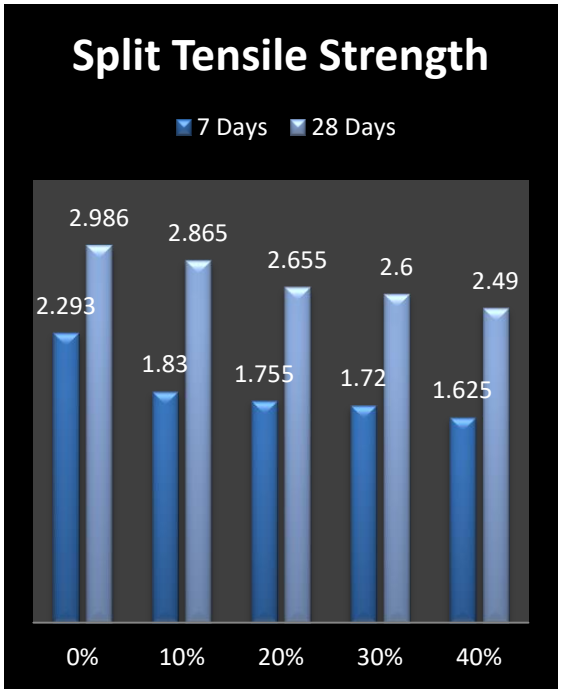

Fig 2 Comparison of strength for 7&28 days

Flexural strength test:

Table 8 Flexural Strength of Concrete

Curing [days]	56 Days
Conventional concrete [N/mm²]	3.62
Red soil 10% [N/mm²]	3.48
Red soil 20% [N/mm²]	3.39
Red soil 30% [N/mm²]	3.28
Red soil 40% [N/mm²]	3.11

7. CONCLUSION

- ✓ Research showing that red soil mixed cement outperforms regular concrete in terms of toughness and impermeability is provided in the following paper.
- ✓ While 25 N/mm2 is the number for basic concrete's compressive strength, values ranging from 23.215 to 29.830 N/mm2 are much higher in concrete mixed with red soil.
- ✓ Ordinary concrete's split tensile strength is just 7–11% of its compressive strength, however concrete mixed with red dirt shows a remarkable improvement in this area. Red soil mixed concrete typically has a split tensile strength ranging from 10.73% on average.
- ✓ When comparing red soil mixed concrete to regular concrete, the former shows a remarkable improvement in strength, with a value ranging from 3.25 N/mm2. A flexural strength of 3.28 to 3.62 N/mm2 is typical of red soil mixed concretes.

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