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Research Article

Investigation on Mechanical and Durability Performance of Reinforced Concrete Containing Red Soil as Alternate for M-Sand

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The river sand is a primary parameter in the concrete structure. This work replaces accessible locally accessible substitution materials like red soil and manufactured sand (M-Sand). In this paper, the mechanical properties and durability of concrete containing red soil and M-Sand have been studied. In this investigation, M30 grade concrete was used, and tests were conducted for two sets of combinations; i.e., red soil as a partial replacement for river sand seems to be 20%, 30%, 40%, 50%, and 60%, and red soil as a partial replacement for manufactured sand (M-Sand) seems to be 60%, 50%, 40%, 30%, and 20%. The compressive strength (7 days, 28 days, 90 days), split tensile strength (28 days), and flexural strength (28 days) have been determined. The combination S4-50% river sand + 50% red soil and S9-70% M-Sand + 30% red soil gives more compressive strength than other combinations. Similarly, the combination S3-60% river sand + 40% red soil and S6-40% M-Sand + 60% red soil gives more flexural and split tensile strength than other combinations. The scanning electron microscope (SEM) analysis, EDAX analysis, and durability tests like alkalinity, sulfate attack, and chloride attack have also been studied.

1. Introduction

Sand near the water's edge has long been prized for its suitability as a building material. The use of natural river sand is being expanded to increase its use. River sand may not be of adequate quality to be used for construction in any case. River sand (M-Sand) can be substituted for M-Sand to support solid growth. Smashing hard rock yields manufactured sand. Washing and inspecting the smashed sand are done to use it for development purposes. M-Sand has a diameter of less than 4.75 mm. The demand for waterway sand for construction has led to an increase in the use of M-Sand. The total development cost can be reduced by using M-Sand as an optional fine entire material. There are no natural and dissolvable compounds in cement and pollutions, such as residue, dirt, or dust, that can affect its quality. To achieve cubical M-Sand, new technology is used. Machines currently in use are being used to get the fundamental evaluation zone.

Indian states like Tamil Nadu, Kerala, and Karnataka, located in the southern part of the country, have some of the best red soil. When compared to the other soil, the red one has more waste properties. Mud and limestone have molded it into its current form. When the limestone is raised, the earth on the land's periphery is mixed together and turned into red soil. Iron oxide builds up and turns the dirt red during this process, which generates heat and causes it to interact with one another. Because of the sun's heat, the color of the dirt is turning red in areas with little rainfall. Indian red soil contains less phosphorus, nitrogen, and lime than other soils in the world. Despite this, certain grains like wheat, rice, cotton, sugarcane, and heartbeats can grow on red soil if the manures are appropriate.

The concrete's compressive strength for 7 days, 14 days, and 28 days increases at a rate of up to 30% M-Sand, then decreases as the M-Sand rate increases. It was found that 30% M-Sand was the ideal percentage for compressive strength considerations. The concrete's split tensile and flexural quality decrease as the percentage of M-Sand increases for the first seven and 28 days, respectively. It was found that 30% M-Sand was the ideal percentage for compressive strength considerations. As a result, the compressive, tensile, and flexural strengths increased by up to 30 percent. M-Sand was the most crucial factor in each case [1].

Red mud can be used up to 15% of the weight of cement in concrete, based on the results of a study on concrete subjected to different rates of reddish mud. There was an increase in workability with an increase in the amount of red soil in concrete, while there was a decrease in workability with an increase in the red mud percentage. We can conclude that the increase in compressive quality is a result of the lengthy contemplation. At the same time, the rate of red mud has increased by up to 15%. After that, the percentage of ruddy mud in concrete as a cement replacement decreased significantly. The flexural strength of concrete increased up to 15% of the red mud substance, but its restraint also reduced as the red mud substance increased in concrete. The part's pliable strength increased as the red mud's extents grew to a specific limit. The ideal amount of red earth to substitute for cement was 15%. Quality deteriorated after that. The need for water maintenance decreased as the amount of red mud in concrete increased. It implies that red mud has pushed concrete's toughness to new heights. Elasticity decreased as red mud content in concrete increased [2].

The quality and invulnerability of red soil blended cement surpass those of plain cement. When it comes to porosity, red soil blended solid has a higher porosity than bare concrete. Penetrability is nonexistent in red soil that has been separated from a plain concrete. Small pores in fine soil allow it to hold water more firmly, making it more porous. It is a waste of liquid. On the off chance that you utilize this solid as part of RCC, there will be no steel utilization. It is possible to use red soil as a component of RCC and prestressed concrete. Inquire about shell structures, prestressed, and RCC, to confirm that red soil can be used as a parcel of multistory building after development is finished [3].

The earth soil is not a standalone aggregate material appropriate for construction work most particularly concrete generation. The production of the concrete requires the good amount of the M-Sand for better performance [4].

Appropriate measurement of self-curing gels will increment the quality and serviceability of concrete. M40 grade concrete is compared with the conventional concrete with the various proportions such as 0.1%, 0.2%, and 0.3% [5].

Replace natural coarse aggregates with E-plastic waste within the run of 0–16.5% and full substitution of fine aggregates with M-Sand for M30 mix. The flexural strength and tensile strength increased by 11% and 6%, respectively, due to the addition of the E-waste [6].

The red clay-concrete interface shows softening behavior beneath distinctive ordinary stress levels. The mobilized shear stress decreases decently with the number of cycles and, in this way, remains consistent after 500 cycles of loading. The reaction of interface subjected to cyclic loading appears clear aeolotropy due to shear directions in each cycle. Interface shear stiffness and damping ratio decrease with expanding cycle numbers. The red clay-concrete interface speaks to a generally contraction behavior in cyclic and postcyclic direct shear tests. The cyclic loading does not lead to degradation for postcyclic shear strength [7].

The expansion of red mud improved 7 days toughness due to the quickened hydration prepare, whereas decreased the workability and the mechanical properties of UHPC. The debased workability may influence the application within the building with complex shapes, but it can still be connected in common development. An ultra-high strength of UHPC counting 40% red mud can be produced after high-temperature curing, in spite of the fact that the addition of red mud decreases the compressive strength [8].

The comprehensive utilization of red mud is primarily found in three areas: the development and chemical industry, the natural assurance and horticulture industry, and the profitable component extraction industry. A brief report is additionally made on the related research of ruddy mud within the areas of cement, concrete, glass, ceramics, adsorbents, geopolymers, catalysts, composite materials, sewage treatment, squander gas treatment, soil advancement, and profitable component recuperation [9].

The axial compressive behaviour of concrete column is improved significantly, by partial substitution of sand with 60% M-Sand for M30 grade concrete [10].

The exploratory work carried out by preparing five concrete mixtures changing 10% of M-Sand extending 60–100 percent by weight of fine aggregate, 15% by weight of cement, and 1% by volume of steel fiber; the fraction kept consistent based on past considers. Different extents of M30 grade concrete were inspected by conducting mechanical and flexural conduct tests. The results obtained are palatable for 80% of the M-Sand substitution. Extra M-Sand substitution tends to decrease concrete strength [11].

Manufactured fine total (M-Sand) was partly replaced by E-waste (E-sand) in several rates (0%, 10%, 20%, 30%, and 40%), with 0.45 water cement (W.C) proportion. With reference of Indian standard (IS) 10262 : 2019 rules, M30 grade concrete was arranged. The flexural, compressive, split tensile strength, and chloride permeability tests were performed on concrete with different mix extents, and test results were related with the result of reference concrete. Partly replacing of 20% factory-made sand (M-Sand) by E-waste (E-sand) yields greatest strength and superior chloride permeability with progressed smaller scale structure than ordinary concrete [12].

The main objective is to move forward strength of concrete by utilizing pozzolanic materials such as silica rage, metakaolin, GGBS as partial substitution to weight of cement by changing percentages (5, 10, and 15), and M-Sand as complete substitution to river sand. In this article, the test work is primarily concentrated on analyzing the mechanical strength, split tensile strength conjointly nondestructive tests like rebound hammer, and ultrasonic pulse velocity tests was performed at an age of 7 days and 28 days [13].

The behavior of concrete utilizes M-Sand at M30 and M65 grades for which test work is carried out to know the compressive strength, flexural strength, and split tensile strength of concrete. The examples were tried at the ages of 7, 28, 56, and 91 days of curing. The test results have appeared that the need of water required to fulfill the workability condition and subsequently quality of cement is additionally marginally expanded. The results appear way better execution to replace with natural sand [14].

The GGBS is replaced for the manufactured sand by 30%, 35%, 40%, and 45%. At that point, the strength is gotten by carrying out compression, split tensile, and the flexural tests. At that point, the optimization value of the GGBS is found as 30%, and the impact of measure of coarse aggregate is found out with the optimized value of GGBS. Then, the durability tests are carried out for the corrosive activity due to sulfate, chloride, etc. At last, the results are examined, and the conclusions are obtained [15].

Slump decreases as GGBS content increases. When fine aggregate is replaced by 30% GGBS, the compressive strength increases by 8%. When 30% GGBS with fine aggregate is substituted for the fine total, the ductile strength increases by 17%. When 30% GGBS with fine aggregate is substituted for the fine total, the flexural strength increases by 44%. 30% GGBS for M-Sand is the ideal replacement for fine aggregate, as the quality improves when the fine aggregate is replaced with 30% GGBS. Compressive strength increases with the addition of each additional 20 mm of aggregate. The strength of an aggregate decreases as the size of the aggregate decreases.

There were issues related to the extended W/B proportion and decreased mechanical properties because the cement substance decreased and the water substance expanded compared to the planned blend. Because of this, compared to the substitution method, the expansion strategy utilizing liquefied red mud is recommended. Liquefied red mud was used to replace some cement because of concerns about changes in smoothness and mechanical properties of the concrete. The mechanical properties of the liquid red soil-included concrete were affected by the high alkaline environment created by the development of red mud on the hydration things of cement. Testing shows that slag cement contains 20% LRM in addition to liquefied red mud (LRM) in the concrete mixture [16].

A superplasticizer can improve the workability of manufactured sand concrete, which is lower than regular concrete. Compressive strength, split tensile strength, and flexural strength of M-Sand have all increased in comparison to standard concrete as a result of its expansion. All grades of manufactured sand concrete have low water absorption and low penetration. Conventional concrete, on the other hand, appears to have lower corrosion and sulfate- and carbonation-resistance in all grades of concrete. In the interfacial move zone (ITZ), the unpleasant and prolonged structure of M-Sand helped reduce microcracks and, as a result, a strong bond between the cement network and the M-Sand at ITZ [17].

Using neutralized red mud as a partial replacement for cement, it can be said that 15% neutralized red mud is the perfect amount to use in blended cement tests (0% to 20% substitution of cement by neutralized red mud). When it comes to compressive strength, M 30 grade neutralized red mud concrete (i.e., 15% substitution) expands 21.712% within 28 days [18].

Compared to sweater curing in the development of fly ash class-C (20%), concrete's compressive strength decreases in the M20 and M30 grades when used in ordinary water curing. For seawater curing, compressive strength is 35.13 N/sq. mm, and for seawater curing without fly ash on the 84th day, compressive strength is 15.57 N/sq. mm. Due to a lack of consideration for seawater curing in red soil, the ultrasonic beat speed appears to have been created. In comparison to conventional water curing, the concrete's rebound pound resistance value is increased by 20% with fly ash class C to 38 in the 84th day using seawater mending for M30 concrete in red soil [19].

In the three-day and seven-day tests, the quality of the sand substituted for river sand was superior to that of regular concrete. When compared to regular concrete, the three-day strength of the 100 percent smash sand blend is about a seven-day improvement. There were no noticeable differences in the results when 30% fly ash was substituted for cement, and 0.3 M NaOH was used. The blend with stream sand replaced by 100% pulverised is stronger after 28 days than the regular mix [20].

When it comes to fine aggregate, manufactured sand could be a viable alternative. The close proximity of nanosilica makes significant progress in the strength of concrete with counterfeit sand at a much earlier age than in standard concrete. Nondestructive tests like rebound pound yielded values of compressive strength that met the requirements of IS codes for both mixes without and with 2% nanosilica development. The ultrasonic pulse velocity (UPV) test results show that both concrete blends for the M20 survey are excellent and palatable. Increasing the rate of substitution of characteristic sand with made sand increases the modulus of flexibility [21].

The main difference between stream sand and fabricated sand was the shape and conduct of the sand when it was incorporated into a concrete mixture. Aside from its roundness, the material's length-to-width ratio (L/W) was significantly larger than that of waterway sand, which had a lower L/W ratio than the manufactured sand. Concrete conduct is less dependent on the sand's molecule size, shape, and surface. Making sand management solid requires a higher water-decreasing operator in order to achieve the comparative usefulness of stream sand containing concrete. High-quality concrete can be produced by using sand that has a higher roundness and length-to-width ratio.

The expansion of red soil as a stream sand alternative shows excellent results in terms of quality and impenetrability. When red soil was added to cement as a substitute, the material's mechanical properties were significantly improved. The quality and obscurity of the solid are greatly improved when red soil is used in place of stream sand. Contrasting stream sand and red soil, the effect quality property of red soil is usually quite good [22]. In place of stream sand, it is possible to use the powdered waste generated during the cleaning of fired tiles.

As solid properties improve in solidarity, engineered sand becomes a more important component in the production of superior cement. It is possible to reduce the environmental impact of solid concrete projects by using ultra-high-quality cement and fabricated sand instead of readily available waterway sand. When compared to regular, customary cement, the ultra-high quality cement made with made sand offers superior performance. The manufactured sand can be used in concrete as a partial or complete replacement for stream sand. When compared to typical regular cement, produced sand exhibits superior compressive quality when used in its place 100% [23].

Fractional substitution of metakaolin for cement and M-Sand for fine aggregate can significantly improve the compressive and flexural strength of concrete, allowing for new designs. M-Sand can be used as a limited substitute for conventional sand in specific applications. Using M-Sand in place of regular sand has a perfect substitution rate of 100%. Strength also rises as the rate at which metakaolin and M-Sand are produced and consumed increases [24].

Three grinding stages are recognized and shown for the red clay-concrete interface shear practices, to be specific coordinate adaptable stages, plastic softening stages, and remaining contact stages. Clay matrix furrowing developments on the interface are at the heart of each one of these examples. When the clay and concrete surfaces are in close contact, the shear quality on the interface is primarily influenced by an increased cohesion and grinding strength. The measured peak and remaining shear strength values in the smooth interface tests are remarkably close to each other with no shear development observed in the tests. It is clear that the shear failure plane lies on the clay–concrete smooth interface because the red clay's strength parameters are higher than those of the smooth interface [25].

Expansion of nanosilica leads to a noteworthiness increase within the characteristic strength and durability of concrete. Substitution of cement with 0.5% of nanosilica gives more strength than the M-Sand mix conjointly; the durability has been extended compared to the M-Sand mix. The self-weight of the nanoblend is lighter than the M-Sand and the conventional blend. The workability decreases with the addition of nanosilica compared to the routine blend and the M-Sand mix. The infiltration level of chlorides and acids is less in nanoconcrete compared to that of conventional and M-Sand blend [26]. Increment in red mud substance diminishes the compressive strength as well as tensile strength of concrete. Ideal rate of the substitution of cement by weight is found to be 25%. Concrete organized by utilizing red mud is sensible in enhancing works and gives beautifully brilliant appearance. Workability of concrete may get affected with increase of red mud but it can be made strides by counting superplastcizers. We utilize mix of red mud and cement for nonfundamental work [27].

Table 1: Properties of fine aggregates.

Particular	River sand	M-Sand	Red soil
Specific gravity	2.633	2.623	2.537
Water absorption	1% by wt	2% by wt	4% by wt

The compressive strength and flexure strength of concrete can be moved forward by halfway substitution of silica fume for cement and M-Sand for fine aggregate. M-Sand can be utilized as halfway substitution for the normal sand, and the compressive and flexure strengths are expanded as the rate of M-Sand is extended up to perfect level. The ideal rate of substitution of normal sand by M-Sand is 50% [28, 29]. In this work, an endeavour is made to replace normally accessible waterway sand with locally accessible substitution materials. In this examination, the result of red soil as a replacement for sand and M-Sand for mechanical properties and durability of concrete has been researched. The mechanical properties for concrete specimens have been done for samples containing red soil and fabricated sand (M-Sand). In this examination, two arrangements of various mixes were considered.

2. Experimental Procedures

2.1. Materials Used. All blends use Ordinary Portland cement (OPC-53 grade). Cement has a specific gravity of 3.15. The river sand used in concrete has a specific gravity of 2.63. The specific gravity of M-Sand used in concrete is 2.623, which is an essential source of fine aggregate replacement.

Red soil has a specific gravity of 2.546, which is closer to that of river sand and M-Sand than other types of sand. To make up for the lack of stream and M-Sand, it is now used as a partial replacement in concrete. As a fine aggregate material in the concrete mix, red soil is sieved through a 420 micron strainer. Both strong and union fewer particles are present in it. A 20 mm sifter and a 12.5 mm filter are used to sieve the coarse total. All blends have a specific gravity of 2.78, which is the same for all.

2.2. Chemical Composition of Red Soil. The chemical composition of red soil are nonsoluble material (90.45%), iron (3.60%), aluminium (2.90%), organic matter (1%), magnesium (0.70%), lime (0.55%), carbon dioxide (0.30%), potash (0.23%), soda (0.10%), phosphorus (0.09%), and nitrogen (0.08%).

2.3. Material Testing

2.3.1. Fineness Modulus of Fine Aggregate. In order to control fine totals, sieve analysis is employed. They used

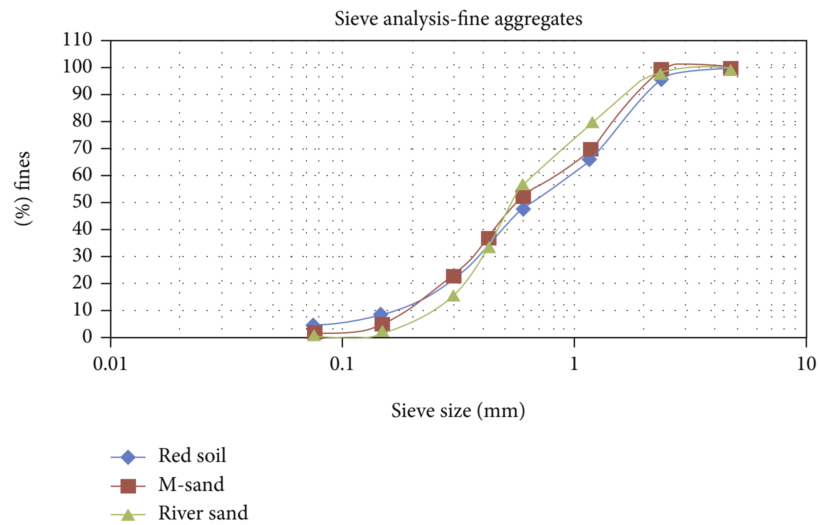


FIGURE 1: Sieve analysis graph for fine aggregates. Note: reviewing fine total materials was affirmed to zone II of table-9 of IS: 383-2016.

4.75 mm, 2.36 mm, and 1.18 m and 600 microns, 300 microns, and 150 microns and a container as filters for the study. Sifters were used to sieve the fine totals for a period of 10 minutes. The weight of the example was measured on each filter, and the total weight of the example was calculated. According to IS 383-2016, the strainer examination result for fine total materials and their prescribed range are shown in Table 1. In order to control fine totals, sieve analysis is employed. They used 4.75 mm, 2.36 mm, and 1.18 m and 600 microns, 300 microns, and 150 microns and a container as filters for the study. Sifters were used to sieve the fine totals for a period of 10 minutes. The weight of the example was measured on each filter, and the total weight of the example was calculated. The graphical portrayal of the sieve analysis result for fine total materials and their prescribed range as per IS 383-2016 is shown in Figure 1.

2.4. Properties of Fine Aggregate and Coarse Aggregate. The properties of the fine total exposed to explicit gravity and water ingestion test as indicated by IS 2386 (part III) are shown in Table 1.

The properties of the coarse total exposed to explicit gravity, water ingestion, and fineness modulus test as indicated by IS 2386 (part III) are shown in Table 2.

2.5. Quality of Water. As per IS456:2000, the water quality must be fulfilled. The accompanying boundaries are shown in Table 3.

The test results of the sample water are shown in Table 4.

2.6. Mix Proportions. During this study, eleven different blends were analyzed in total. Fine natural river sand was used as the main ingredient in the control mix. Red soil is a partial replacement for a fine aggregate in the S1, S2, S3, S4, and S5 mixes, each of which has 20%, 30%, 40%, and 60%, respectively. S5, S6, S7, S8, and S10 are the mix of M-Sand and red soil that are traded for ordinary river sand.

TABLE 2: Properties of coarse aggregates.

S. no	Particulars	Values
1.	Specific gravity	2.78
2.	Water absorption	0.5% by weight
3.	Fineness modulus	2.175

TABLE 3: Water quality parameter as per IS456:2000.

Quality parameters	Minimum limit (ppm)
Chlorides	500
SO3	1000
Alkali carbonates and bicarbonates	1000
Turbidity	2000

TABLE 4: Sample water quality parameter.

Quality parameters	Minimum limit (ppm)
Chlorides	99.28
SO3	237
Alkali carbonates and bicarbonates	268
Turbidity	1.37

All the mix proportions have been listed in Table 5 with their corresponding mix extents.

2.7. Mix Ratios. According to IS 10262 : 2009, the solid blend proportions utilized for each blend extents are determined and are shown in Table 6.

2.8. Mechanical Properties. Compressive and flexural strengths of specimens have been described. The specimens' mechanical properties have been conveyed. At a time of 7 days, 28 days, and 90 days, the compressive strength, split tensile strength, and flexural strength of all cement were

Table 5: Mix proportions of various samples.

Sample name	Cement (%)	Fine aggregate			Coarse aggregate (%)
		River sand (%)	M-Sand (%)	Red soil (%)	
CC	100	100	—	—	100
S1	100	80	—	20	100
S2	100	70	—	30	100
S3	100	60	—	40	100
S4	100	50	—	50	100
S5	100	40	—	60	100
S6	100	—	40	60	100
S7	100	—	50	50	100
S8	100	—	60	40	100
S9	100	—	70	30	100
S10	100	—	80	20	100

Table 6: Mix ratios.

Sample name	Cement	Fine aggregate	Coarse aggregate
CC	1	1.459	2.64
S1	1	1.441	2.64
S2	1	1.432	2.64
S3	1	1.422	2.64
S4	1	1.413	2.64
S5	1	1.404	2.64
S6	1	1.396	2.64
S7	1	1.403	2.64
S8	1	1.410	2.64
S9	1	1.417	2.64
S10	1	1.425	2.64

Figure 2: Concrete immersed 5% Na_2SO_4 and 5% $MgSO_4$ solution and surface change.

tested. There were 150 mm × 150 mm × 150 mm cube specimens and 150 mm diameter × 300 mm height cylindrical specimens used for the compressive strength and split tensile strength, respectively. Prisms of 100 mm × 100 mm × 500 mm have passed the flexural strength.

2.9. Durability Test. Red soil was used as a fractional substitute for river sand and M-Sand in concrete specimens that were tested for their strength. The cube specimens have been subjected to a durability test. Water curing has been applied to the cast specimens. For a period of 28 days, the models were subjected to three different types of durability tests to determine the durability of concrete samples containing red soil and M-Sand. These tests examined the resistance to alkalinity, sulfate attack, and chloride attack.

2.9.1. Alkalinity Test. Alkaline attack on different concrete blends has been tested in accordance with IS 456 : 2000. Five percent sodium hydroxide (NaOH) water was used to immerse the concrete cubes. For this, three concrete

Table 7: Compressive strength of river sand and red soil combination.

Sample names	Compressive strength (N/mm^2) Seven days	28 days	90 days
CC	28.31	42.96	43.70
S1	26.52	41.04	45.48
S2	27.71	39.55	46.81
S3	29.63	41.11	52.45
S4	30.32	42.22	53.48
S5	25.56	40.44	49.63

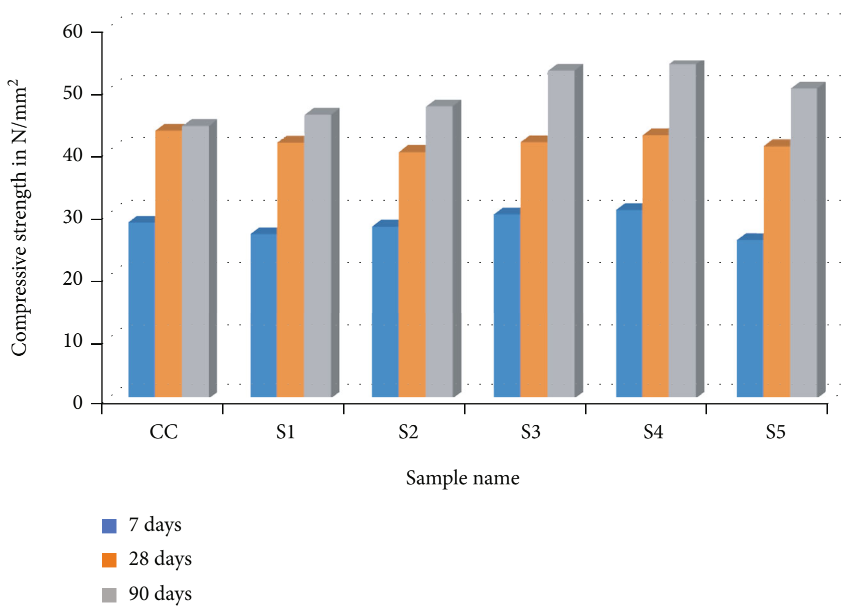


Figure 3: Compressive strength of red soil and river sand combination.

Table 8: Compressive strength of M-Sand and red soil combination.

Sample names	Compressive strength (N/mm^2) Seven days	28 days	90 days
CC	28.31	42.96	43.70
S6	29.81	38.22	45.19
S7	32.80	35.85	45.33
S8	31.56	33.85	45.78
S9	27.40	38.67	46.00
S10	28.46	36.22	45.48

specimens were tested, one with red soil as a partial substitute for river sand and another with red soil as a partial substitute for M-Sand, immersed in a tub of soluble water containing 5% sodium hydroxide arrangement for aged 28 days. The results of tests conducted before and after treatment have been compared in terms of their weight. All examples show that the weight loss rate is the same. Percentage misfortune of significance of show and compressive strength was used to determine concrete's alkaline resistance [30–35].

2.9.2. Sulfate Attack Test. According to ASTM C1012:2004, the resistance of concrete to sulfate attacks has been considered. The concrete cubes were submerged in sulfate water, having 5% of sodium sulfate (Na_2SO_4) and 5% magnesium sulfate ($MgSO_4$) by volume of water. For these two arrangements of concrete specimens that were taken, one set of concrete models was made with red soil as a fractional swap for river sand and another set containing red soil as a partial substitution for M-Sand, for aged 28 days and permitted to dry for one day. At that point, specimens were dunked

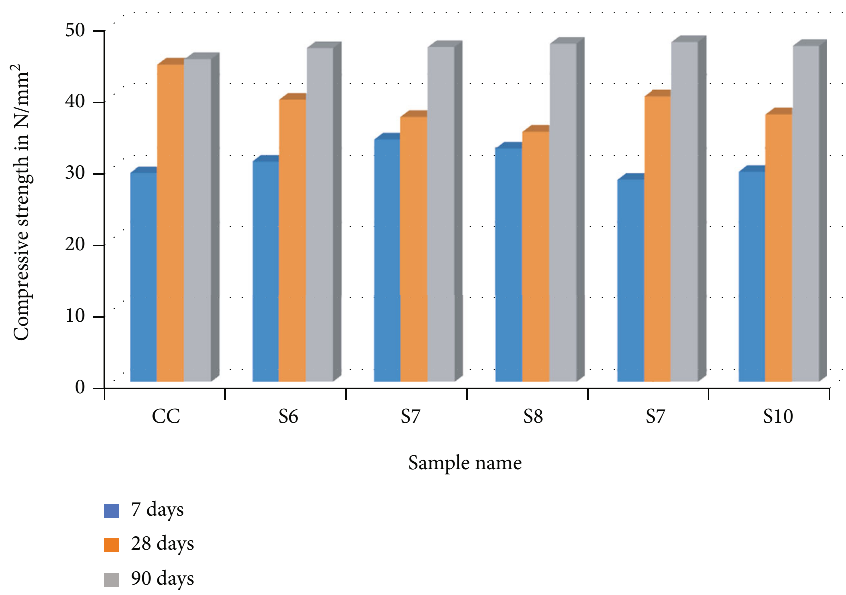


FIGURE 4: Compressive strength for M-Sand and red soil combination.

totally in a tub containing sulfate water having 5% of sodium sulfate (Na_2SO_4) and 5% magnesium sulfate ($MgSO_4$) for 28 days [36–40]. Following a time of 28 days, the specimens were taken and dried out. The weight of the models before treatment and after treatment is being looked at. The regular rate decrease in weight is found out for all the specimens as shown in Figure 2.

2.9.3. Chloride Attack Test. Two sets of concrete specimens were taken, one containing three concrete samples made with red soil as a partial substitution for sand and the other containing red soil as a partial substitution for M-Sand, for aged 28 days and allowed to dry for a day, according to BS 1881 standards. By completely immersing the models in a tub containing concentrated hydrochloric acid (HCL) with a normality of 1 N, the chloride attack test was carried out on concrete samples. It is necessary to add a certain volume of water to the water for 28 days [41–45]. These concrete samples were removed from the acid bath and dried out after a period of 28 days. There is a comparison of the specimens' weight before and after treatment. All samples' weight loss is averaged out to arrive at an overall weight loss percentage.

3. Results and Discussion

3.1. Compressive Strength. The compressive strength for concrete specimens containing red soil as a substitution of sand is shown in Table 7.

According to the above findings, the strength of the red soil and river sand-concrete samples was inferior to that of the standard mix after 28 days. However, after 28 days, the red soil in concrete begins to react with the cementitious materials in the concrete, resulting in a strong and durable product. In comparison to a standard mix, the strength of the concrete was increased by 1.5% [46–50]. The strength for concrete samples containing red soil as partial substitution of sand is shown in Figure 3.

TABLE 9: Split tensile strength for red soil and river sand combination.

Sample name	28-day strength (MPa)
CC	3.11
S1	2.46
S2	2.53
S3	2.56
S4	2.84
S5	2.85

The compressive strength for concrete samples that have red soil as a replacement for M-Sand is shown in Table 8.

The compressive strength for concrete samples containing red soil as partial substitution of M-Sand is shown in Figure 4.

The results suggested that up to 70% of red soil as replacement material by weight of cement with M-Sand shows good compressive strength compared to conventional mix, but further addition of red soil results in the decrease of power. Similar to the previous results, the addition of red soil shows good strength in the later stage of concrete.

3.2. Split Tensile Strength. The tensile strength for samples containing red soil as a substitution for sand is shown in Table 9.

The split tensile strength for concrete samples containing red soil as a substitution for sand is shown in Figure 5.

The results suggest that up to 28 days, tensile strength for concrete samples containing both red soil and river sand was low compared to that of the standard mix. But after 28 days, the red soil present in concrete may react

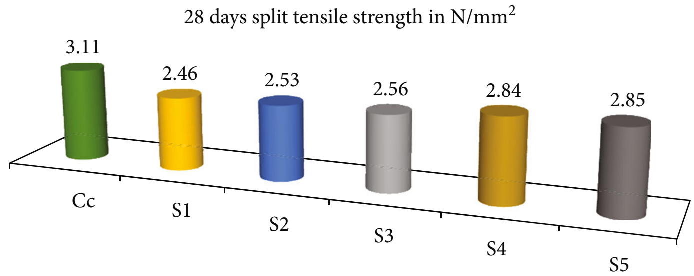


Figure 5: 28-day split tensile strength for red soil and river sand combination.

with the cementitious materials in concrete and show good tensile strength [50–54]. Tensile strength for concrete samples containing red soil as a replacement for M-Sand is shown in Table 10.

The split tensile strength for concrete samples containing red soil as substitution of M-Sand is shown in Figure 6.

The results suggested that up to 60% substitution for red soil by weight of cement with M-Sand shows good split tensile strength compared to conventional mix, but on further addition of red soil results in a decrease in strength. Similar to previous results, the addition of red soil shows good stability in the later concrete stage as shown in Figure 7.

3.3. Flexural Strength. The flexural strength of samples containing red soil as a replacement for normal river sand is shown in Table 11. The flexural test specimen is presented in Figure 8.

The flexural strength for concrete samples containing red soil as substitution of sand is shown in Figure 9.

The flexural strength of the concrete samples containing red soil shows less power than that of the standard mix. The addition of red soil affects the flexural behaviour of the concrete to some extent. The flexural strength of the concrete samples containing red soil as a limited substitution for M-Sand is shown in Table 12.

The flexural strength for concrete samples containing red soil as a partial replacement for river sand is shown in Figure 10.

The flexural strength of the concrete samples containing 60% of red soil as a replacement along with M-Sand shows the same strength as that of the conventional mix, so this type of concrete can be used as a replacement in terms of flexural strength over the traditional concrete.

3.4. Durability Test. The compressive strength for concrete samples containing red soil as a substitution for sand after the durability test is shown in Table 13.

For testing the durability of concrete samples, three different tests (i.e., alkalinity, sulfate, and chloride attack test) were conducted for concrete. In this investigation, the durability tests were conducted for 28 days. The 28-day durability test results for the concrete samples are shown in Table 14. The results indicate a slight reduction in the strength of concrete in the range of 4 to 7% as shown in Figure 11.

Table 10: Split tensile strength for M-Sand and red soil combination.

Sample name	28-day strength (MPa)
Cc	3.25
S6	3.34
S7	3.14
S8	3.11
S9	3.30
S10	3.23

The percentage reduction in weight of the concrete samples containing red soil as substitution of sand after the durability test is shown in Table 15.

The compressive test results of samples having red soil as a replacement for M-Sand after durability test are shown in Table 14.

The percentage reduction in weight of the concrete samples containing red soil as a sand replacement after durability test is shown in Table 16.

Similar to the river sand and red soil combinations, durability is also being conducted for samples containing M-Sand and red soil. But compared to the previous results, the reduction in strength was quite lofty in contrast to earlier combinations. So, these river and red soil combinations are light ahead in preference in terms of durability as shown in Figure 12.

When combining the test results of all the experiments, it can conclude that the S9 combination shows promising result in terms of both strength and durability perspectives. Moreover, for detailed understanding regarding the compositions and microstructure of red soil in both the combinations, the scanning electron microscope analysis was conducted for both the variety samples.

3.5. Scanning Electron Microscope (SEM) Analysis Test. The microstructure of the concrete mixes was examined utilizing scanning electron microscope (SEM) which for all intents and purposes makes a difference to imagine the microstructure of the hydrated cement paste. The SEM analysis of S9 combinations is illustrated in Figure 13. The figure shows that the soil particles in the concrete samples show a sponge-like structure and have a wide variation of diameter in size. Due to the existence of minerals, CSH gel formation

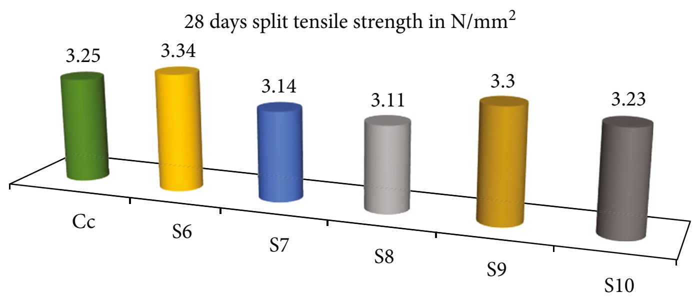


Figure 6: 28-day split tensile strength for M-Sand and red soil combination.

Figure 7: The split tensile test specimen.

Table 11: Flexural strength for river sand and red soil combination.

Sample name	28-day strength (MPa)
Cc	5.33
S1	4.54
S2	4.67
S3	4.40
S4	4.67
S5	5.07

Figure 8: Flexural test specimen.

is more for S9 combination (70% M-Sand +30% red soil) that leads to give better compressive strength.

3.6. EDAX Analysis. To determine the purity of the red soil particles, EDAX analysis was conducted on the concrete samples. The samples were placed on the copper grid coated with carbon, and the whole setup was placed inside an air evacuated chamber.

The EDAX results for S9 combination (70% M-Sand +30% red soil) show that the silica level has tremendously increased to 77.48% atom as shown in Figure 14.

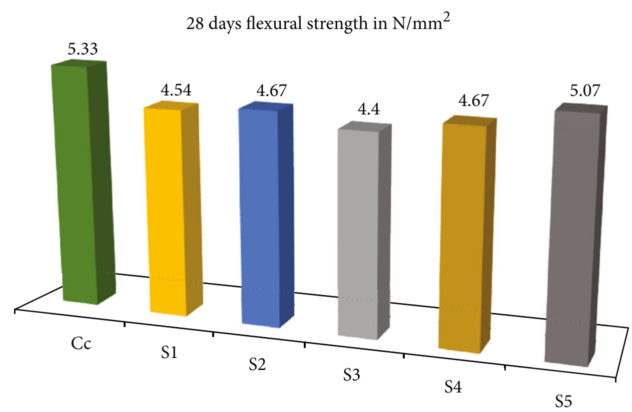


Figure 9: 28-day flexural strength for river sand and red soil combination.

Table 12: Flexural strength for M-Sand and red soil combination.

Sample name	28-day strength (MPa)
Cc	5.47
S6	5.47
S7	5.33
S8	5.20
S9	5.33
S10	5.20

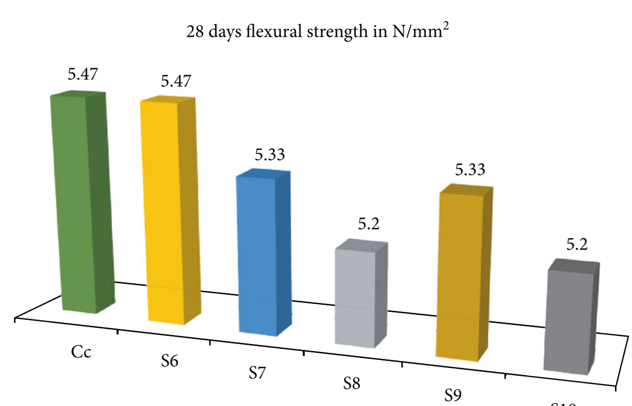


Figure 10: 28-day flexural strength for M-Sand and red soil combination.

Table 13: Compressive strength of river sand and red soil combination after the durability test.

Test name	Compressive strength (MPa)	% reduction in strength
Control-mix (without any solution)	42.22 (S4)	—
Alkalinity test	39.11	7.37
Sulfate attack test	40.00	5.26
Chloride attack test	40.44	4.21

Table 14: Compressive test results for M-Sand and red soil combination in the durability test.

Test name	Compressive strength (MPa)	% reduction in strength
Control-mix (without any solution)	38.67 (S9)	—
Alkalinity test	36.00	6.90
Sulfate attack test	35.11	9.20
Chloride attack test	36.44	5.75

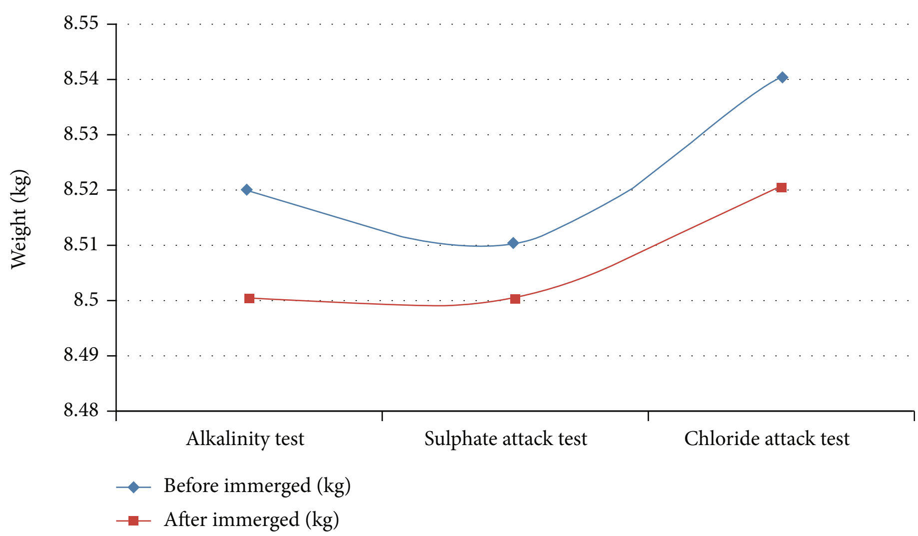


Figure 11: Before and after immersion weight for river sand and red soil combination.

Table 15: Weight loss for river sand and red soil combination after the durability test.

Test name	Before immersion Weight (kg)	After immersion Weight (kg)	% reduction in weight
Alkalinity test	8.52	8.50	2.35
Sulfate attack test	8.51	8.50	1.76
Chloride attack test	8.54	8.52	2.34

Table 16: Weight loss for M-Sand and red soil combination after the durability test.

Test name	Before immersion Weight (kg)	After immersion Weight (kg)	% reduction in weight
Alkalinity test	8.41	8.40	1.19
Sulfate attack test	8.57	8.54	3.50
Chloride attack test	8.42	8.39	3.56

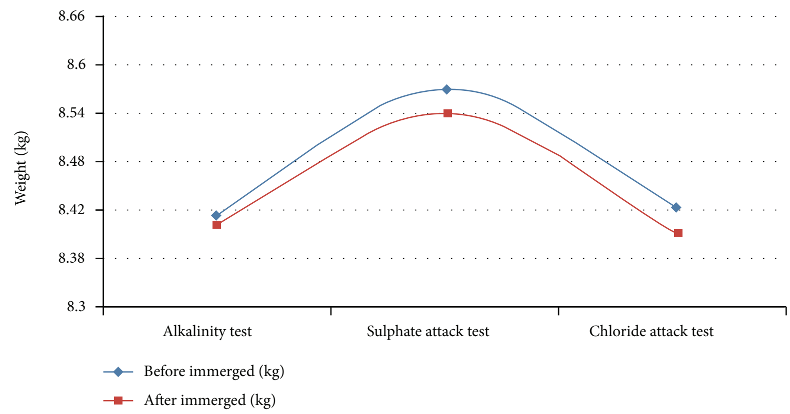


Figure 12: Before and after immersion weight for M-Sand and red soil combination.

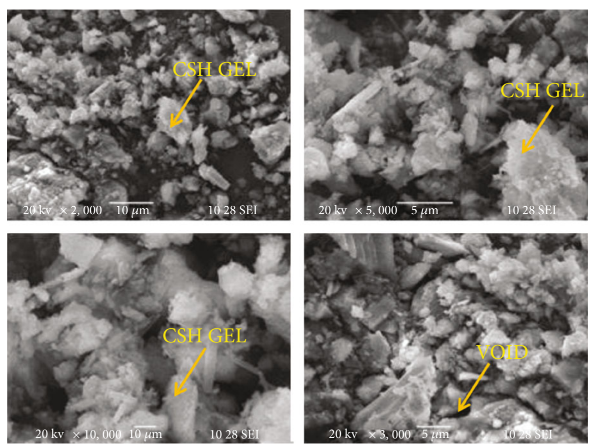
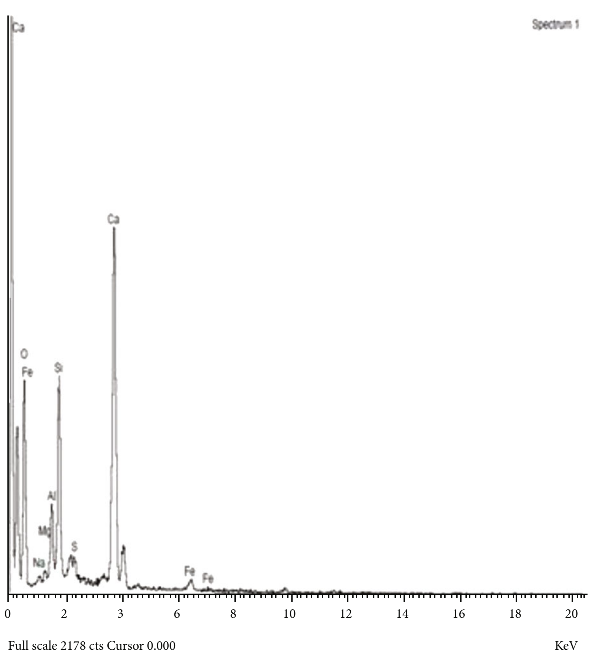


Figure 13: SEM analysis for S9 combination (70% M-Sand + 30% red soil).



Spectrum processing :
Peak possibly omitted : 9.799 keV

Processing option : All elements analyzed (Normalised)
Number of iterations = 6

Standard :

O	SiO2	1-Jun-1999 12:00 AM
Na	Albite	1-Jun-1999 12:00 AM
Mg	MgO	1-Jun-1999 12:00 AM
Al	Al2O3	1-Jun-1999 12:00 AM
Si	SiO2	1-Jun-1999 12:00 AM
S	FeS2	1-Jun-1999 12:00 AM
Ca	Wollastonite	1-Jun-1999 12:00 AM
Fe	Fe	1-Jun-1999 12:00 AM

Element	App Conc.	Intensity Corrn.	Weight%	Weight% Sigma	Atomic%
O K	31.23	0.6146	61.72	0.80	77.48
Na K	0.40	0.6745	0.73	0.23	0.63
Ng K	0.39	0.6531	0.72	0.18	0.60
Al K	2.04	0.7673	3.23	0.22	2.40
Si K	6.92	0.8322	10.10	0.33	7.22
S K	0.35	0.8701	0.49	0.18	0.30

Figure 14: EDAX analysis for S9 combination (70% M-Sand + 30% red soil).

4. Conclusion

In this paper, we have tried out two sets of combinations, one set of manufactured sand with red soil and another set of river sand with the red soil of 10 proportions, based on the following results.

4.1. The Combination of River Sand and Red Soil

(i) The sample name S4 (50% of red soil and 50% of river sand) gives the better compressive strength when compared to all other proportions of river sand with red soil

(ii) Likewise, sample name S5 (60% of river sand and 40% of red soil) gives better flexural strength and split tensile strength compared to all other proportions of river sand with red soil

4.2. The Combinations of Manufactured Sand (M-Sand) and Red Soil

(i) The sample name S9 (30% of red soil and 70% of manufactured sand) gives high compressive strength compared to all other proportions

(ii) Likewise, the sample name S6 (60% of red soil and 40% of manufactured sand) gives better flexural strength and tensile strength in contrast against various proportions

4.3. Durability Tests

(i) For the durability test, the S4 and S9 combination samples have been taken, which shows high 28-day compressive strength

4.4. Justification

(i) Red soil has high porosity and less permeability, and it can absorb a considerable quantity of water compared to ordinary river sand due to its minor pores. The concrete surface is low in permeability, increasing the durability of concrete where the steel corrosion can be prohibited. Compared to 100% river sand as a fine aggregate in concrete, the complete substitution of M-Sand and red soil concrete has shown better performance. Still, in the future, these are potential materials for replacing river sand

(ii) The manufactured sand has many fine particles, which is more than that of natural aggregate, so it may give a large contact area, which is the ultimate reason behind the increased strength of samples. But there will be a decrease in the workability of samples due to the fine particles present, which absorbs the large quantity of water. Thus, to keep the surface of the concrete in wet conditions, a large amount of mater has to be added. Therefore, strength is significantly high for the samples containing manufactured sand as sand replacement

(iii) Red soil is used as a best replacement material for sand to reduce the demand that developed on river sand. The concrete samples containing red soil and river sand show higher compressive strength than the mix containing M-Sand and red soil

Data Availability

The data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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