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Study of Partial Replacement of Fine Aggregate With Laterite

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Abstract – *Cement, sand and coarse aggregate are the basic ingredients for any construction. Sand is a prime material used for preparation of mortar and concrete and which plays a major role in mix design. Nowadays erosion of rivers and considering environmental issues there is a scarcity of river sand. The less availability or shortage of river sand will affect the construction industry. Hence there is a need to find the new alternatives to river sand. There is a need for different materials to replace fine aggregate and one of the major materials is locally available soil. Laterite soil is one of the easily available local soils and using different proportion of available soil along with river sand the required concrete mix can be obtained.*

Key Words*: *Concrete, Laterite, Compressive strength, Split tensile strength, Flexural tensile strength

1.INTRODUCTION

The most widely used construction material in the world is concrete. The demand for these materials constituents has increased significantly as a result of their use in various structures. Continued exploitation of our river sand for its purposes has led to a degradation of the environment and undisturbed depletion of nature reserves. But because of the environmental damage they are causing, for instance by soil erosion or surface water contamination, several sand mining sites have been closed which has resulted in product shortages. In addition, it travels from relatively far locations at high costs because of its scarcity. There have been several attempts to replace river sand with other materials to produce concrete, one of the materials used in this research is lateritic soil.

Laterite is a highly weathered soil rich in iron and aluminum oxides, predominantly found in tropical and subtropical regions. Laterite's composition varies depending on geological conditions and weathering. It exhibits diverse geotechnical properties, such as liquid limit, plasticity, and density, influencing its engineering behavior. Chemically, laterite is rich in silica, alumina, and iron oxide, with trace elements affecting reactivity and stability. Its mineralogical composition, primarily kaolinite, quartz, goethite, and hematite, determines its mechanical properties. Laterite also shows thermal stability, making it suitable for various engineering applications. In modern construction, laterite is increasingly incorporated into concrete mix designs as a partial replacement for fine aggregates, offering an environmentally responsible alternative to river sand. Its application extends to road pavements and low-cost housing solutions, particularly in regions where conventional construction materials are scarce or expensive. Concrete where laterite replaces a portion of fine aggregate, has demonstrated mechanical properties comparable to or even superior to traditional concrete, depending on the proportion used. Studies indicate that optimal replacement levels, typically ranging from 20% to 30%, contribute to enhanced compressive strength, improved durability, and resistance to environmental degradation, including water absorption, chloride ion penetration, and sulfate attack. While moderate incorporation of laterite contributes to structural integrity, excessive replacement may lead to reduced compressive strength and increased permeability. As a sustainable construction material, laterite presents a viable solution for reducing reliance on depleting natural resources while maintaining structural efficiency. Its integration into concrete and other building materials not only mitigates the environmental impact associated with excessive sand extraction but also aligns with global efforts toward sustainable development.

Fig 1: Laterite

2. MATERIALS AND METHODOLOGY

2.1 Materials

A. Cement

Cement acts as the binder material, a substance used in construction that adheres sets and hardens the material for proper binding. It achieves strength through a chemical reaction with water. It was noticed that Portland pozzolana cement of 53 grade has a specific gravity of 2.91.

B. Fine aggregate

Fine aggregate, or natural sand, is an accumulation of mineral grains derived from the disintegration of rocks. It is distinguished from gravel only by the size of the grains or particles.

C. Coarse Aggregate

Coarse aggregates, characterized by their large particle size, are a crucial component in construction materials. Defined as aggregates retaining a significant proportion of particles on a 5mm (0.197 inches) sieve in the US or 4.75mm (0.187 inches) sieve elsewhere, they differ from finer materials.

D. Laterite

The fine aggregate in concrete is partially or fully replaced with laterite. To reduce the cost of production of concrete, the use of laterite as a partial replacement of the fine aggregate is used.

E. Water

Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalis, vegetables or other organic Impurities.

2.2 METHODOLOGY

- Topic selection
- Material collection
- Mix design
- Casting
- Curing
- Testing
- Result and discussion

3. MIX PROPORTION

Table 1: mix proportion

	Cement	Fine aggregate	Coarse aggregate	Water
Mix ratio	1	1.12	2.41	0.4
Composition	493.95	550.73	1188.32	197.38

4. RESULT AND DISCUSSION

4.1 Slump Test

Table 2: Slump test result

SI No.	Laterite %(by weight of fine aggregate) added in concrete	Slump value (mm)	Remarks
1	0	25	True slump
2	25	30	True slump
3	30	32	True slump
4	35	33	True slump

4.2 Compaction factor

Table 3: Compaction factor test result

SI No.	Laterite % (by weight of fine aggregate) added in concrete	Compaction factor value	Remarks
1	0	0.9	High workable
2	25	0.86	Low workable
3	30	0.94	Low workable
4	35	0.91	Low workable

4.3 Compressive Strength

Fig 2: Compressive strength test

Table 4: Result of compressive strength

SI No.	Laterite % (by weight of fine aggregate) added in concrete	Compressive strength N/mm²
1	0	26.07
2	25	30.22
3	30	41.85
4	35	36.22

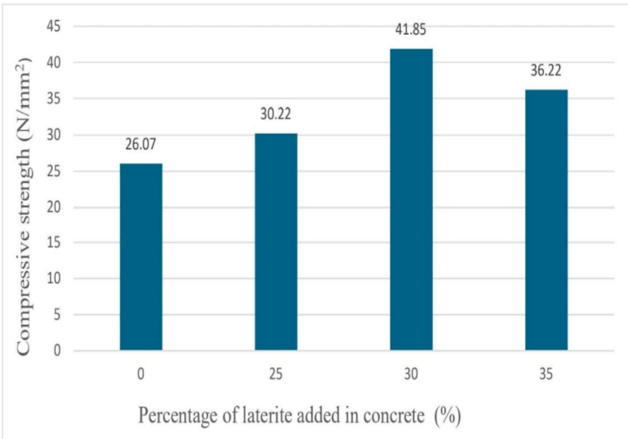

Fig 3: compressive strength in different proportion

The replacement of fine aggregate with laterite in concrete significantly boosts compressive strength, peaking at 30% content. With 25% laterite, strength increased by 15.92% compared to conventional concrete. At 30%, there was a 60.53% increase, while at 32%, it decreased by 13.45% compared with 30% of laterite. This underscores laterite effectiveness in concrete, with the greatest enhancement seen at 30% content.

4.4 Flexural strength

Fig 3: Flexural strength test

Table 5: Result of flexural strength test

SI No.	Laterite % (by weight of fine aggregate) added in concrete	Flexural strength N/mm²
1	0	5.61
2	25	9.24
3	30	11.09
4	35	9.85

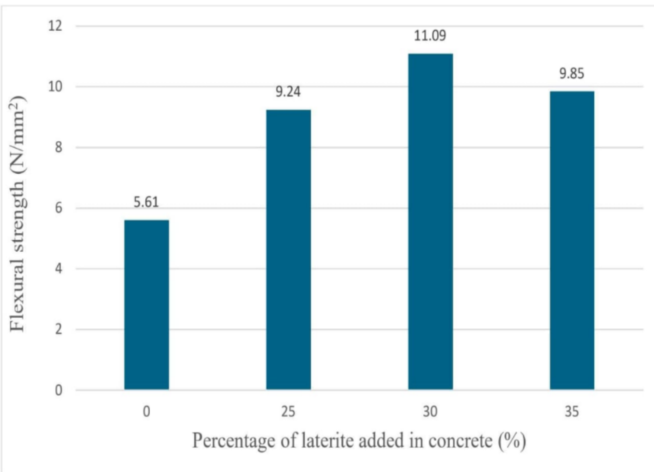

Fig 4: Flexural strength in different proportion

The flexural strength of fine aggregate replaced with laterite in concrete increases consistent with the addition of laterite, peaking at 30% content. With 25% laterite, strength increased by 64.7% compared to conventional concrete. At 30%, the increase was 97.68%. At 35% laterite content, 11.04% flexural strength decreases compared with 30%. This improvement underscores the laterite content in concrete matrix, with the highest enhancement at 30% content.

4.5 Split Tensile strength

Fig 5: Split tensile strength test

Table 6: Result of split tensile strength test

SI No.	Laterite % (by weight of fine aggregate) added in concrete	Split tensile strength N/mm²
1	0	2.38
2	25	2.42
3	30	2.97
4	35	2.49

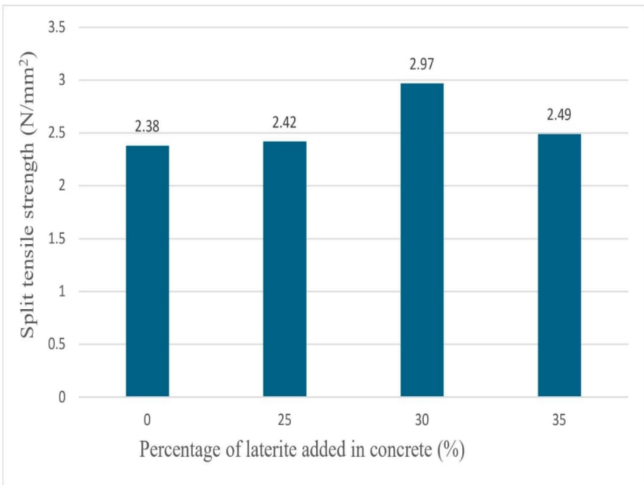

Fig 5: Split tensile strength in different proportion

The split tensile strength of concrete also improves with the replacement of fine aggregate with laterite, increasing up to 30% of laterite content. Incorporating 25% laterite results in a significant 1.68% increase compared to conventional concrete. At 30% laterite content, the split tensile strength rises by 24.79% demonstrating further enhancement. While at 35%, it decreased by 16.16% compared with 30% of laterite. The optimum improvement occurs at 30% fine aggregate replaced with laterite content, reaching a split tensile strength 24.79% increase over conventional concrete.

5. CONCLISIONS

The replacement of fine aggregate with laterite at 30% resulted in a 60.53% increase in compressive strength, confirming it as the best proportion for improving load-bearing capacity. For laterite replacement, the peak improvement in flexural strength occurred at 30% laterite, showing a 97.68% increase, whereas further replacement led to a reduction in strength. The maximum split tensile strength increase of 24.79% was achieved at 30% replacement, confirming its effectiveness in improving durability against cracking.

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