# An Experimental investigation on Mechanical & Physical properties of Concrete by the partial replacement of fine aggregate with Laterite Soil

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***Abstract*: The Hike in cost of materials for building construction is creating a lot of concern due to more utilization of building materials like as fine aggregate, coarse aggregate for the construction of civil engineering structures, creating need for research into materials as alternatives in building and rural infrastructure & framework. Research attempts are directed towards improving the use of locally and readily accessible material such as lateritic soils for the construction. The presented experimental program deals with the study on possibility of proper application or utilization of laterite soil as a partial replacement fine aggregate into concrete. Concrete is the most commonly used composite material today. The constituents of concrete being Cement, Coarse / fine aggregate, and water. A rapid expansion in construction activities leads to an acute scarcity of conventional construction/building materials. Habitually, sand is being used as fine aggregate in the concrete. The function of the fine aggregate in concrete is to aid in producing workability ad uniformity in the concrete mixture. The river deposits are the most common source of fine aggregate. So, there are substantial demands within the construction industries for river sand as fine aggregate used in the preparation of concrete. This has created a very difficult situation, also there is great fear from environmentalist that the ecology will be distorted. Hence, there is a need to find the materials which are inexpensive and available partially or totally replaced river sand in the production of concrete. Hence, we are forced to think about the alternative materials. This research paper aims to contemplates the study conducted to establish scientific information regarding the Compressive strength, Tensile strength of concrete by partial replacement of fine aggregate with laterite soil in concrete mix of M15 grade with a water cement ratio of 0.45. The sand shall be replaced gradually in the mentioned grade of concrete by 0%, 7.5%, 15%, 22.5% and 30% with laterite soil and the specimen shall be tested for Workability, Compressive strength & Tensile strength for a curing interval of 7 days, 14 days and 28 days. As percentage of laterite soil increases, the compressive strength & tensile strength of concrete made with laterite also increases. The result revealed the concrete containing 22.5% of laterite soil exhibited higher strength, indicating that it can be utilized for a maximum of 22.5% substitution compared to other percentages of replacement in concrete.**

***Keywords:* Concrete, Building material, Fine aggregate, Partial Replacement, Compressive strength, Tensile strength, Laterite Soil**

## I. INTRODUCTION

Concrete is the most commonly used construction factual in India and other countries also. It is extremely difficult to point out another construction material which is as flexible as concrete. It is a product of choice where strength, flexural structure, superior workability, better conduction, durability, impermeability, fire resistance and abrasion resistance are needed. Cement concrete is one of the outwardly simple but actually complex materials. Many of its compound behaviours are yet to be identified to employ this material advantageously and frugally. [1] Concrete is so closely related with every construction activity that it touches every human being in his day-to-day living. It is a feigned compound generally made by blending of binding material (Cement), fine aggregates, coarse aggregates, water and admixtures in appropriate proportions. Concrete does not solidify from drying after mixing and placement; the water reacts with the cement in a chemical process known as hydration.[6] In India the annual consumption of cement is in the order of approximately 22 million tons.[1] Concrete is a site-made material unlike any other materials of construction and as such can vary to a very great extent in its quality, properties and conduct due to the use of natural materials except cement. From materials of varying properties, to prepare concrete of stipulated qualities, a familiar awareness of the interaction of varying ingredients that go into the preparation of concrete is essential, both in the fresh and hardened state. This knowledge is essential for concrete technologists as well as for site engineers. The increase in the demand for the usage of the huge quantity of concrete leads to rise in cost of binding material (cement) and depletion of natural sources of fine aggregate which in turn leads to expansion in the cost of concrete.[1] Due to above cause alternative materials are required to partially or fully replacement for Portland cement or fine aggregate or coarse aggregate in the concrete mixture to continue the construction work, without changing the previous properties of the concrete like strength, workability and durability.[1]

Laterite is a medium of intense sub aerial weathering. Laterization process involves leaching of alkalis, basis and silica with complimentary enrichment of alumina, iron and some trace elements.[1] In general, laterite can be considered as a material, highly weathered, rich in secondary oxides of iron, aluminium or both formed in hot and wet tropical areas. Laterites vary in colours but are generally bright & vivid. The usual colour shades being pink, red and brown, mainly due to the iron oxides in different states of hydration.[2] Francis Buchanan – Hamilton was the first person to describe and name the laterite formation in southern India in 1807. He named it laterite, derived from the Latin word "later", which means a brick highly compacted and cemented & which can be effortlessly moulded into brick-shaped blocks for building. When moist in nature, laterites can effortlessly be cut with a spade into regular – sized blocks. Laterite is extracted while it is beneath the water table, so it is wet and soft. Upon exposure to air, it gradually hardens as the moisture between the flat clay particles evaporates and becomes resistant to atmospheric conditions.[2] The art of quarrying laterite material into masonry is suspected to have been acquaint from the Indian subcontinent. Iron oxides and aluminium oxides are abundant in weathered laterite soil. Moist or dry, it is either hard or soft, is capable of undergoing hardening when wet or dried. It is almost entirely devoid of bases and primary silicates. Laterite is the product of widespread and long-term tropical rock weathering exacerbated by excessive rainfall and high temperatures, according to a recent interpretation. As the world's infrastructure projects increase at a rapid rate. The availability of river sand is dwindling.[3][1] Due to a serious scarcity of river sand, indiscriminate sand mining has become common. Sand mining has serious backlashes such as River bank deterioration, river bed decline, loss in biodiversity. Researchers are undertaking several investigations to find substitutes to river sand, which can be incorporated as fine aggregate in mortars and concretes, to address the issues raised above.

Laterite has historically been one of the local resources. Laterite is soil and rock rich in iron and aluminium that is considered to have formed in hot, humid tropical settings. This soil has a rusty red colour due to the significant iron oxide content. Weathering of the parent rock causes them to develop. Its chemical composition varies widely depending on its origin, climate conditions and age. Lateritic soil has a high concentration of Fe (Iron) and just a moderate proportion of Al (Aluminum). According to chemical tests, Indian soils have significant quantities of iron and Aluminum but low levels of nitrogen, potassium, lime and organic matter.[3]

**Need of the study:** A major factor affecting the construction industry in developing countries is the cost of building materials most of which have to be imported from other parts of the country. Frequent increase in prices of building materials across India has reawakened serious awareness to relate research to production, especially in the use of local materials as alternatives in Construction of low-cost dwellings both in the urban and rural areas. One such regional material that is being researched is lateritic soils. Lateritic blocks have been one among of the considerable building materials in India for a prolonged time. The main reason is because it is the best soil type for construction due to its ideal combination of silt, sand & clay. It merges the best of all their qualities into the composed balance for supporting the foundation. The soil doesn't expand, shift or shrink drastically & handles the presence of water very well. The major reason for laterite soil being used in construction is When laterites are dried out, irreversible hardening occurs. It is locally available and the cost of obtaining it is very low. Results obtained from the previous researches show that it has already been successfully used as a base & sub base material for road construction. It is also suitable for being used as a filler material in embankment & dam constructions. This study is continuing effort to investigate the properties of lateritic soils with the view to improving such properties.

## II. OBJECTIVES OF THE PROJECT

- Studying the feasibility of Laterite soil as a construction Material & to evaluate its suitability for use either in partial or full replacement to Sand in concrete.
- Partial replacement of cement with the Laterite Soil & determining the workability, Compression strength & Split Tensile strength of concrete for 7, 14 & 28 days & to assess the optimum percentage of Laterite Soil to be added as a partial replacement for sand.
- Also, to Studying the variation in the effects of the Laterite Soil on the properties of concrete as a partial replacement of Sand
- To demonstrate laterite soil as economical replacement to sand due to the regional availability.

## III. MATERIALS & METHODOLOGY

**CEMENT**: Ordinary Portland Cement (OPC) is the basic cement which is best suited for use in general concrete construction. In the present investigation, BIS mark 53 grade cement was used for all concrete mixes. The cement used was fresh and free from lumps. Testing of cement was carried out as per the guidelines of BIS: 12269-2010. The various tests results conducted on the cement are tabulated below

**Table 01: Test results for Cement**

| Sl. No | Characteristics | Value Obtained | As per BIS:12269- 2010 |
|---|---|---|---|
| 1. | Normal Consistency (%) | 34.% | _ |
| 2. | Initial setting time (minutes) | 43 min | Not less than 30 |
| 3. | Final setting time (minutes) | 300 min | Less than 600 |
| 4. | Fineness (%) | 6.43 % | Max 10 |
| 5. | Specific Gravity | 3.1 | 3.15 |

**FINE AGGREGATE:** Manufactured Sand was used as fine aggregate for the experimental program. The sand used in this research work was locally procured and conformed to grading zone III as per BIS: 383-2007. The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and then was washed to remove the dust. The results of physical properties of the fine aggregates are represented below.

**Table 02: Test results for Fine aggregate**

| Sl. No | Characteristics | Value |
|---|---|---|
| 1. | Type | Manufactured |
| 2. | Specific Gravity | 2.4 |
| 3. | Packing Factor | 1.08 |
| 4. | Density | 1620 kg/m3 |
| 5. | Fineness Modulus | 2.41 |
| 6. | Grading Zone | Zone III |

**COARSE AGGREGATE:** The crushed stone are mainly used as aggregates. Locally available coarse aggregates having the maximum size of 20mm passing and 16mm retained were used in the present study. Testing of coarse aggregates was done as per BIS: 2386-1963. The results of physical properties of coarse aggregate are shown in the table below

**Table 03: Test results for Coarse Aggregate**

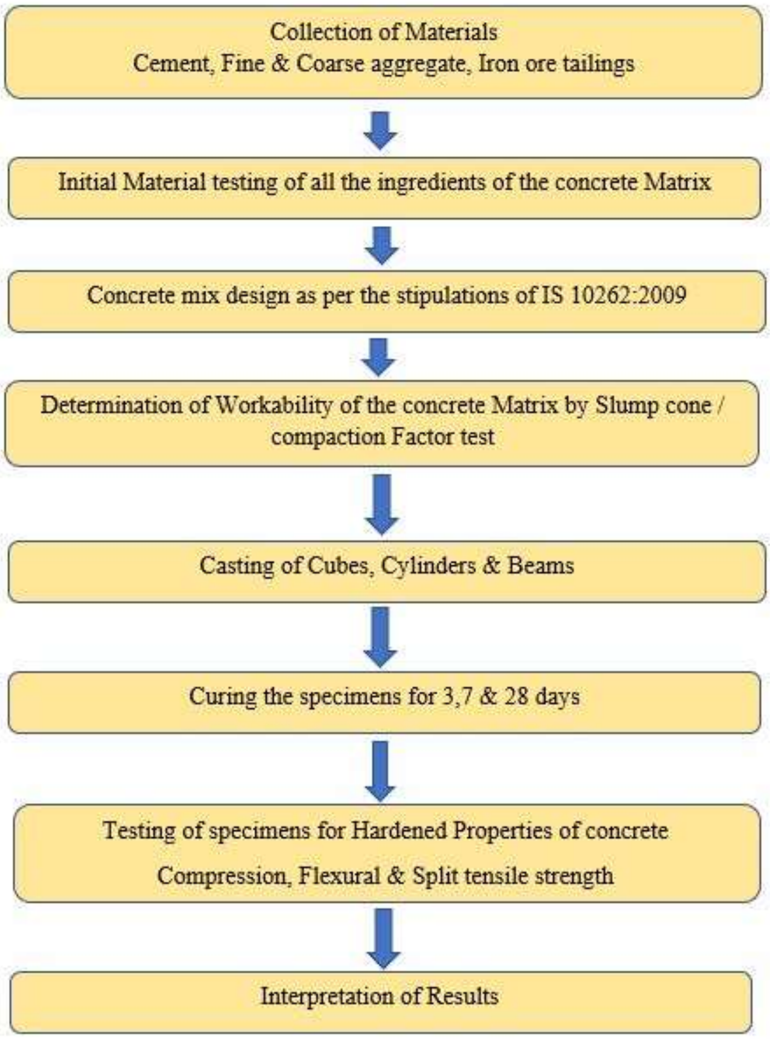
| Sl. No | Tests | Results | As per BIS 2386-1963 | BIS-Codes |
|---|---|---|---|---|
| 1. | Specific gravity | 2.63 | 2.5-2.9 | IS-2386 Part III |
| 2. | Crushing Value | 23.35% | Max 30% | IS-2386 Part IV |
| 3. | Abrasion Value | 21.5% | Max 35% | IS-2386 Part IV |
| 4. | Impact Value | 14% | Max 30% | IS-2386 Part IV |
| 5. | Elongation Index | 8.8% | Max 2% | IS-2386 Part III |
| 6. | Flakiness Index | 3.2% | Max 30% | IS-2386 Part I |

**LATERITE SOIL:** The word laterite is derived from Latin word "later", which means a brick, Laterite is soil and rock rich in iron and aluminium that is considered to have formed in hot, humid tropical settings. This soil has a rusty red colour due to the significant iron oxide content. Weathering of the parent rock causes them to develop [3]. Its chemical composition varies widely depending on its origin, climate conditions and age. Lateritic soil has a high concentration of Fe (Iron) and just a moderate proportion of Al (Aluminum). When moist laterites can easily be cut with a spade into regular – sized blocks. Laterite is mined while it is below the water table, so it is wet and soft. Upon exposure to air, it gradually hardens as the moisture between the flat clay particles evaporates and becomes resistant to atmospheric conditions According to chemical tests, Indian soils have significant quantities of iron and Aluminum but low levels of nitrogen, potassium, lime and organic matter.[3]

**WATER:** Water is the most important ingredient of a concrete as hydration of cement is possible only in the presence of water. It helps in bonding between cementitious materials and the aggregates portable water confirming to the requirements as per IS 456-2000 which is free from salts and impurities is used for washing aggregates, mixing and curing purposes.

The flow diagram below describes about the detailed experimental program which was followed for the conduction of the research work

**Figure 01: Steps involved in the Research Work**




## IV. RESULTS & DISCUSSIONS

**Determination of Workability by Slump Cone & Compaction Factor Method -** the freshly mixed lateritized concrete sample was checked for workability by both the methods (slump & compaction factor) and the results are as listed below. The graphical variation clearly describes that, as the percentage of laterite soil in concrete increases, there is a decrease in the workability of the concrete mixture.

**Table 04: Test results for Variation in Workability by Slump cone & Compaction factor Method**

| % Of Replacement | Slump in Cm | Compaction factor |
|---|---|---|
| **0** | 28 | 0.98 |
| **7.5** | 27 | 0.921 |
| **15** | 26 | 0.903 |
| **22.5** | 26 | 0.850 |
| **30** | 24 | 0.813 |

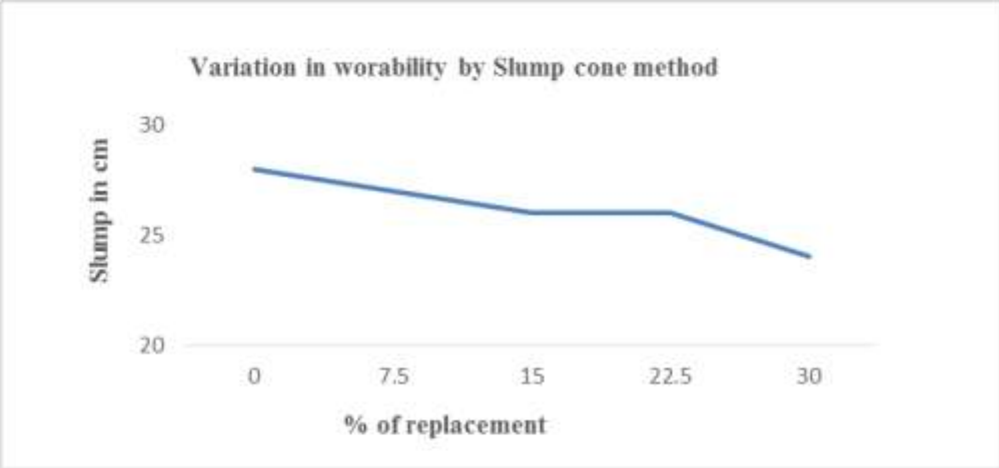



**Fig 2: variation in workability by slump cone method**

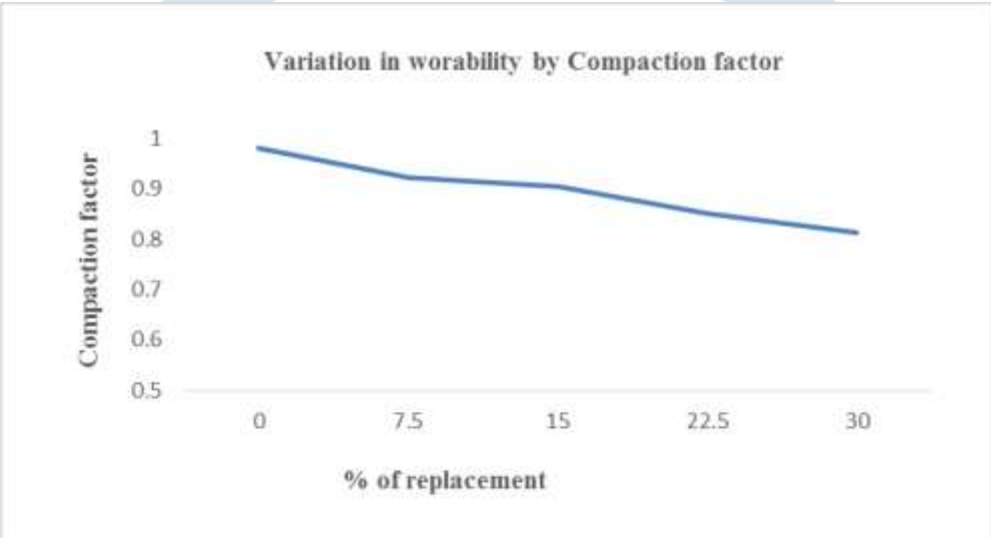



**Fig 03 – variation in workability by Compaction factor**

**Determination of Compressive strength –** Concrete cubes of standard size 150 * 150 * 150 mm were casted and the cubes were kept in a curing tank for a period of 7,14 & 28 days and later were surface dried in sunlight for 24 hours & were tested for compressive strength in a compression testing machine. The results for compressive strength obtained after 7,14 & 28 days of curing are as described below.

**Table 05: Variation in 7 days compressive strength**

| % Replacement | Variation in 7 days Compressive strength in Mpa |
|---|---|
| 0 | 12.57 |
| 7.5 | 13.12 |
| 15 | 15.19 |
| 22.5 | 16.078 |
| 30 | 12.46 |

**Fig 04: Variation in 7 days compressive strength**

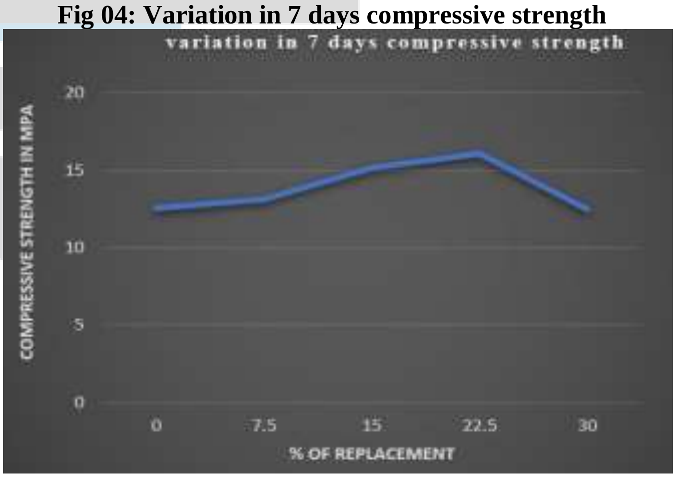


**Table 06: Variation in 14 days compressive strength**

| % Replacement | Variation in 14 days Compressive strength in Mpa |
|---|---|
| 0 | 17.7 |
| 7.5 | 18.07 |
| 15 | 18.91 |
| 22.5 | 19.29 |
| 30 | 13.70 |

**Fig 05: Variation in 14 days compressive strength**

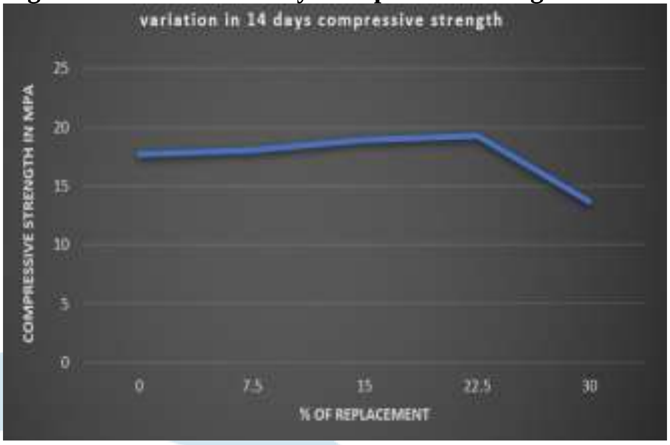



**Table 07: Variation in 28days compressive strength**

| % Replacement | Variation in 28 days Compressive strength in Mpa |
|---|---|
| 0 | 19.44 |
| 7.5 | 19.54 |
| 15 | 21.02 |
| 22.5 | 23.57 |
| 30 | 12.60 |

**Fig 06: Variation in 28 days compressive strength**


**Determination of Split Tensile strength –** Concrete cylinders of standard size 150 mm diameter & 300 mm height were casted and the cubes were kept in a curing tank for a period of 7,14 & 28 days and later were surface dried in sunlight for 24 hours & were tested for split tensile strength in a compression testing machine. The results for the same obtained after 7,14 & 28 days of curing are as described below.

**Table 08: Variation in 7 days Split Tensile strength**

| % Replacement | Variation in 7 days Split Tensile strength in Mpa |
|---|---|
| 0 | 12.57 |
| 7.5 | 13.12 |
| 15 | 15.19 |
| 22.5 | 16.07 |
| 30 | 12.46 |

**Fig 07: Variation in 7 days Split Tensile strength**

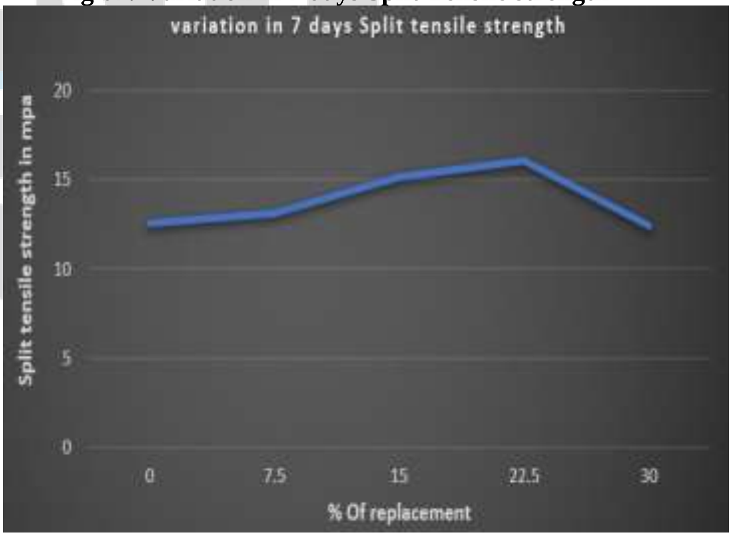


**Table 09: Variation in 14 days Split Tensile strength**

| % Replacement | Variation in 14 days Split Tensile strength in Mpa |
|---|---|
| 0 | 17.7 |
| 7.5 | 18.07 |
| 15 | 18.91 |
| 22.5 | 19.29 |
| 30 | 13.7 |

**Fig 08: Variation in 14 days Split Tensile strength**

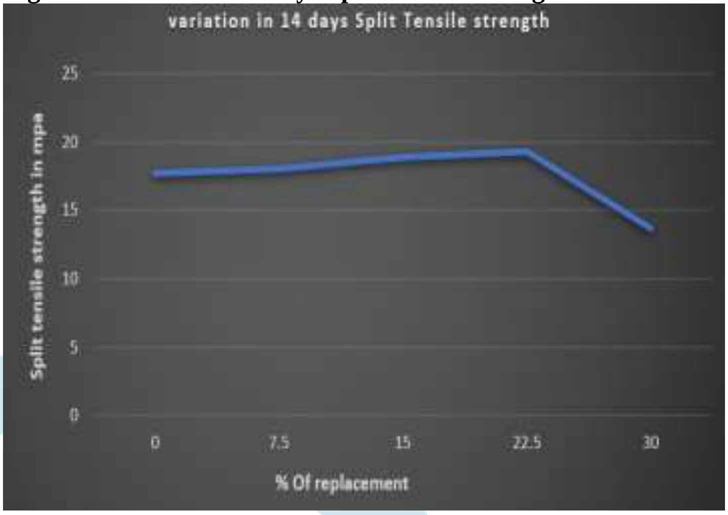
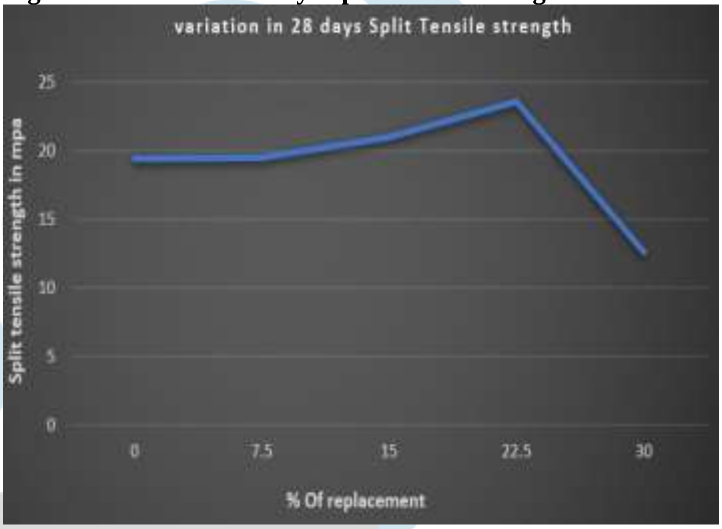



**Table 10: Variation in 28 days Split Tensile strength**

| % Replacement | Variation in 28 days Split Tensile strength in Mpa |
|---|---|
| 0 | 19.44 |
| 7.5 | 19.54 |
| 15 | 21.02 |
| 22.5 | 23.57 |
| 30 | 12.6 |

**Fig 09: Variation in 28 days Split Tensile strength**




## V. CONCLUSIONS

This Experimental research was conducted to evaluate the effects on the physical & mechanical properties of concrete by the partial replacement of fine aggregate with laterite soil. The following conclusions drawn are based on the result of the investigation:

1. Specific gravity of laterite soil (2.42) is near to the Specific gravity of manufactured sand (2.62).
2. Laterite soil replaced concrete shows lesser workability when compared to that of normal concrete. Reduction in workability may be due to the presence of finer particles like clay, which demands more water content.
3. The compressive strength value increases as the replacement levels of laterite soil increases up to 22.5%. For 22.5% replacement gives highest strength valve as compared to other replacements and this strength is greater than the compressive strength of conventional concrete (M20 Grade). Hence 22.5% of replacement can be considered as the optimum percentage of replacement.
4. It was also observed the split tensile strength value increases as the replacement levels of laterite Soil increases for 22.5% replacement. This percentage of replacement gives highest tensile strength value as compared to the other replacement percentages
5. The use of laterite soil as partial replacement for Fine aggregate should be embraced and not be frightened for the production of concrete during construction.
6.further research on durability and chemical composition aspects of laterite soil replaced concrete is essential to recommend this material for sustainable concrete practice.

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