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EXPERIMENTAL INVESTIGATION ON CONCRETE USING LATERITE SOIL AS PARTIAL REPLACEMENT TO SAND

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Abstract— Development that regards sustainability has become a policy in the construction industry and often the search for new, innovative and ecofriendly materials have been appreciated. Construction industry has been growing in India for the past many years and so is the difficulty of getting materials. Research in replacement techniques for concrete constituents has been successful since the materials replaced often conform to local availability and economy. This paper presents an effort to highlight the use of Laterized concrete i.e. the replacement of conventional sand by laterite soil for Normal Strength Concrete (NSC). For the purpose of the experimental study, M30 grade of concrete has been chosen. The percentages of replacements are 15%, 20%, 25% and 30% by weight of laterite soil. Tests were carried out for compressive strength and split tensile strength of concrete for all substitution levels of fine aggregate at a curing period of 3 days, 7 days and 28 days. The experimental work revealed that compression strength increases at later stages with usage of laterite soil. Moreover the experimental work showed that 15% replacement is optimum for NSC i.e. M30 grade.

Index Terms— *Concrete, Compressive strength, Laterite, Sand*

1. INTRODUCTION

Basic Concrete i.e. normal concrete is a combination of cementitious material, fine and coarse aggregates and water. There are lots of formulations of concrete, which give varied properties. Concrete is the blend of fine and coarse aggregates with cement paste of desired consistency. Given that aggregates are an important constituent, the availability of especially fine aggregates has been challenging for the past decade. Aggregate mining has affected the provision, protection and regulation of ecosystem services. Sand and gravel are mined world-wide and account for the largest volume of solid material extracted globally. Formed by erosive processes over thousands of years, they are now being extracted at a rate far greater than their renewal. Furthermore, the volume being extracted is having a major impact on rivers, deltas and coastal and marine ecosystems, results in loss of land through river or coastal erosion, lowering of the water table and decreases in the amount of sediment supply.

A conservative estimate for the world consumption of aggregates exceeds 40 billion tonnes a year. One way to reduce consumption of sand is to optimize the use of buildings and infrastructure. Recycled building and quarry dust material can be a substitute for sand. As per the investigations carried out, Laterite soil can be used to replace sand in concrete structures. New laws and regulations, and incentives are needed to initiate a shift for lowering our dependency on sand. Renewable and recycled materials need to be targeted for building houses and roads.

2. LITERATURE

UTOEYO et al (2015) conducted an experiment to investigate the mechanical characteristics of concrete containing laterite as a partial and full replacement of sand. Sand in a concrete of mix ratio 1:2:4 with the 0.56 water cement ratio was replaced with 0, 20, 40, 60, 80, 100% laterite soil. The result showed that the concrete with 40% replacement of sand by laterite attained the designed strength of 20Mpa. SABARISH et al (2015) investigated on the strength and durability performance of Laterized concrete. In this investigation % of laterite content (0, 10, 20, 30, 40 & 50) To the curing period of 7, 28, 60 & 90 days compressive, flexure and tensile strength test of Laterized concrete were studied. The result

shows that the compressive strength of all Laterized concrete specimen increases with age but decreases with increase in the replacement level of sand. RANGARAJU et al (2015) this study presents, the results of an experimental program to study the strength and durability performance of Laterized concrete. To perform this investigation, M30 grade concrete is used, mix proportions 1: 1.274: 3.126 (Cement: sand/laterite: granite) with water/cement ratio of 0.45 was used, the laterite content of 0%, 10%, 20%, 30%, 40% and 50% were replaced for periods of 7, 28, 60, and 90 days to study the compressive, flexure and splitting tensile strength tests of Laterized concrete. It was found that the compressive strength of all laterite concrete specimens increased with age but decreased with increase in the replacement level of sand. COCINA et al (2003) discussed the mechanical stability is an important factor that should be considered in the use of lateritic materials. On the other hand, mechanical instability may manifest in form of remoulding and recasting and breakdown of cementation and structure. MATHEW et al (2013) conducted an experimental investigation by partial replacement of fine aggregates with laterites The natural sand was replaced with laterite at the rate of 10%, 20% and 30% by weight for design mix of M25 controlled concrete. A total of 36 specimens prepared to determine the cube compressive strength, and flexural strength. From the studies, addition of laterite reduces workability in concrete; this is because of water absorption capacity of laterite. Compressive strength decreases with increases in % of laterite replacement with sand. Laterite of 20% by weight of sand content has shown the best results, thus indicating possibility of using laterite as a partial replacement.

3. EXPERIMENTAL DATA

A. Materials

The strength of the concrete is based on the properties of its materials used. The basic ingredients used in current work are cement, fine aggregate, coarse aggregate and laterite soil. Cement used in this project is ordinary Portland cement (OPC)43 which is grey in color.OPC 43 cement shall confirm to IS: 8112-1989 and the designed strength of 28 days shall be minimum 43MPa or 430 kg/cm^2. The aggregates used were conforming to IS: 383-1970. The selection is based on the recommendations directed in IS-456:2000. Additionally the quantity of fines less than 0.12mm is to be measured as fine particles. The aggregates used were in compliance to zone II according to IS: 383-1970.Laterite soil samples are composed of kaolinite and illite clay minerals with some quartz and feldspar. They were found to be rich in SiO_2 (45%) Fe_2O_3, (16%) and Al_2O_3(10%).

TABLE I: PHYSICAL PROPERTIES OF CEMENT

Tests Conducted	Results Obtained	Requirements as per IS:12269-1987
Fineness (%)	4.6	10 (max)
Normal Consistency (%)	31	
Specific Gravity	3.12	2.99 to 3.15

TABLE II: PHYSICAL PROPERTIES OF COARSE AGGREGATE

Tests Conducted	Results Obtained	Requirements as per IS:383-1970
Specific Gravity	2.76	2.85 (max)
Water Absorption Test (%)	0.07	0.6 (max)
Water Content (%)	0.03	-

TABLE III: PHYSICAL PROPERTIES OF FINE AGGREGATE

Tests Conducted	Results Obtained	Requirements as per IS:383-1970
Fineness (%)	4.6	10 (max)
Normal Consistency (%)	31	
Specific Gravity	3.12	2.99 to 3.15

TABLE IV: PHYSICAL PROPERTIES OF LATERITE SOIL

Tests Conducted	Results Obtained
Specific Gravity	2.62
Water Absorption Test (%)	13.32
Water Content (%)	12.92

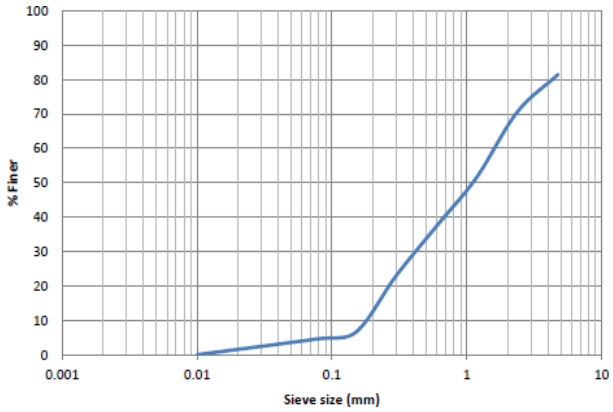

Fig. 1. Graph showing sieve analysis of laterite soil.

4. METHODOLOGY

Strength is the very important property of the concrete, because of the first consideration in structural design is that the structural members should be able of carrying the imposed loads. The mix of concrete used in this study is M30. Concrete mix with 0% waste material is the control mix accordance with the Indian Standards specification IS 10262 – 2009. The percentages of replacements are 15%, 20%, 25% and 30% by weight of laterite soil. Tests were carried out for compressive strength and split tensile strength of concrete for all substitution levels of fine aggregate at a curing period of 3 days, 7 days and 28 days.

A. Preparation of Resources

The cement would be stored in an arid space. Trial of aggregates on behalf of each group of concrete would be of the required grade and would be in an air-dried. The ultratech brand OPC cementvis used in the present investigation.

B. Proportioning

All the materials were maintained as per the IS prescription. The proportioning of materials in concrete blend was done based on IS 10262 code book, and the laterite soil is brought from moodabidri, Dakshina kannada district.

C. Weighing and Mixing of Concrete

The quantity of aggregate, cement, water and laterite soil for every batch would be determined by mass (weight batching).The concrete mix was prepared in a lab batch blender, in a manner so as to avoid the loss of water or any other ingredients. Each batch of concrete would be of such a mass so as to run off about 10% more moulding than the required figure of experiment specimen.

D. Compaction of Concrete

The test specimens would be casted as quickly as succeeding to mixing, and in such a manner so as to make full compaction of concrete by either segregation or excessive laitance. In insertion every scoopful of concrete, the shovel would be enthused about the apex rim of the mould so as the concrete glide as of it, in command to make sure a regular sharing of the concrete inside the mould. Each level would be packed together also by hand over or through vibration. Following the peak layer will be packed in; the exterior of the concrete would be leveled with the apex of the mould, by means of a trowel.

E. Curing and Testing of Specimens

The casted concrete cubes and cylinders were soaked in curing tanks for 3, 7 & 28 days. After the specimens were taken out from curing tank. Test specimens were dried and kept aside for 24 hours prior to the commencement of test. After which the tests like compression test and split tensile tests were carried out.

5. RESULTS & DISCUSSION

In the present study the laterite soil is used in development of M30 grade concrete where sand has been replaced by laterite soil in the range of 15 to 30% at an interval of 5%. The fresh and hardened properties of developed concrete mix has been studied and discussed below.

A. Fresh Property – Slump Cone Test:

TABLE 5. SLUMP CHECK FOR M30 GRADE CONCRETE

SL. NO	Type of Concrete	Slump (mm)
1	M30, 0%	95
2	M30, 15%	82
3	M30, 20%	79
4	M30, 25%	73
5	M30, 30%	69

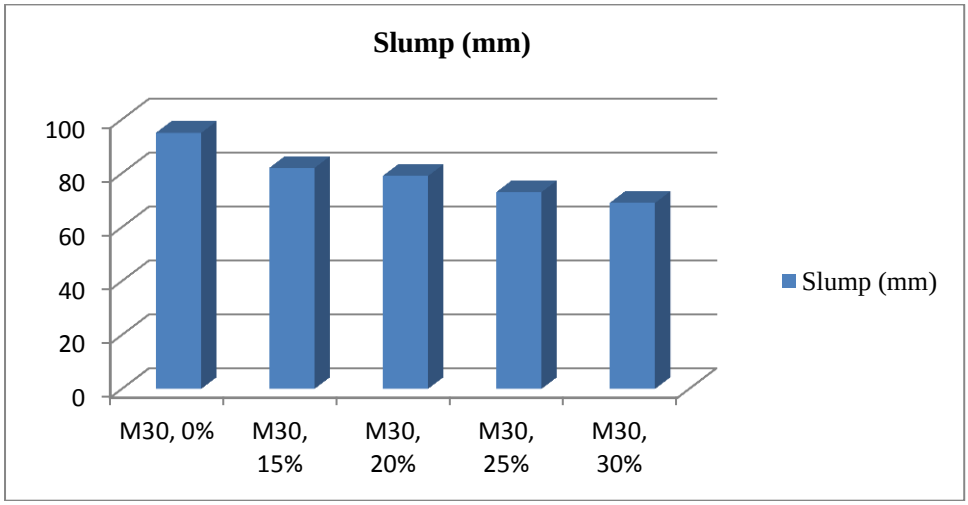

Fig.2: Graph showing slump values for M30 Grade concrete

The above Fig 2 shows the variations of slump corresponding to the varying percentage of Laterized concrete. The values plotted reveals that the slump of the concrete mix decreases with the increase in the percentage of laterites, which can be attributed to water absorption of laterite soil, used.

B. Hardened Property – CompressiveStrength

TABLE 6 COMPRESSIVE STRENGTH OF CUBES FOR M30 GRADE AT 3, 7 AND 28 DAYS

Sl. No	Type of Concrete	Avg Ultimate Comp. Strength 3 days (MPa)	Avg Ultimate Comp. Strength 7 days (MPa)	Avg Ultimate Comp. Strength 28 days (MPa)
1	M30, 0%	18.26	27.83	38.04
2	M30, 15%	21.40	29.86	40.92
3	M30, 20%	25.21	29.71	37.62
4	M30, 25%	15.45	23.14	36.28
5	M30, 30%	9.92	18.52	34.25

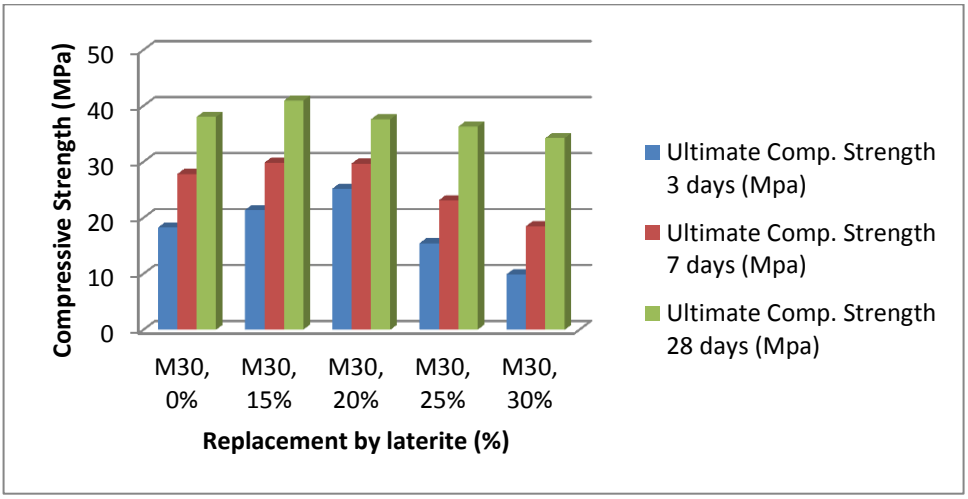

Fig. 3. Graph showing compressive strength values for M30 Grade concrete

The Fig. 3 indicates that as the age increases the compressive strength increases and the maximum compressive strength is obtained at 15% replacement of laterite soil and it is noted that the compressive strength increases by 7.03%.when compared to conventional concrete. It is even observed that the compressive strength increased at the later stage also. This may be attributed because of the triggered hydration process at later ages.

C. Hardened Property – Split Tensile Strength

TABLE 7 SPLIT TENSILE STRENGTH OF CUBES FOR M30 GRADE AT 3, 7 AND 28DAYS

Sl. No	Type of Concrete	Avg Ultimate Split Tensile Strength 3 days Mpa	Avg Ultimate Split Tensile Strength 7 days Mpa	Avg Ultimate Split Tensile Strength 28 days Mpa
1	M30, 0%	2.21	2.45	3.54
2	M30, 15%	2.11	2.53	2.95
3	M30, 20%	2.10	2.41	2.79
4	M30, 25%	2.04	2.37	2.63
5	M30, 30%	1.89	2.29	2.58

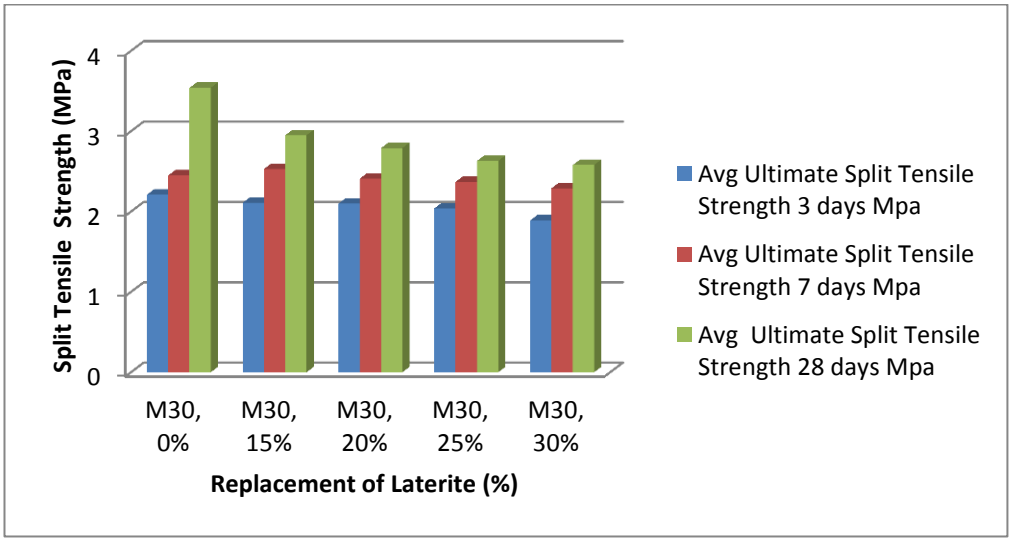

Fig.4: Graph showing Tensile strength values for M30 Grade concrete

From Fig. 4 it is pragmatic that the tensile strength of Laterized concrete mixes keeps on decreasing as the percentage of laterite addition increases and it is noted that the tensile strength decreases by 16% when compared with respect to conventional concrete.

6. CONCLUSIONS

Compressive strength of the concrete improved as the sand replacement with substitution level of 15% laterite soil. Regarding the experiment work conducted the subsequent remarks concerning the performance and characteristic of concrete on fractional substitute of fine aggregate by laterite soil are:

- Laterite soil can be effectively used as an alternative for sand in developing NSC.
- Compression strength of concrete increases with usage of laterite soil as a partial replacement to sand up to 15% in the present investigation.
- It is cost effective and environmental friendly compared to conventional concrete.
- The experimental work revealed that 15% replacement is optimum for NSC, i.e. M30 grade.

- Split tensile strength decreased with increase in percentage of laterite soil.
- The ever increasing demand and cost of sand, along with scarcity can be dimensioned up to certain extent in the coastal region.

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