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Partial Replacement of Cement with Corn Cob Ash and Saw Dust Ash and Fine Aggregates with Steel Slag in Concrete

V. Rushendramani [1], G. Ganesh Naidu [2]
M. Tech student [1], Assistant Professor [2]
Department of Civil Engineering
PACE Institute of technology
India

ABSTRACT

Corn cob ash-Saw dust ash and Steel slag are the most used among such materials to replace cement and fine aggregate which can be used as alternative to cement and fine aggregate in concrete. In the present investigation workability and strength of concrete was evaluated by replacement of natural sand by steel slag and cement by corn cob ash-saw dust ash in equal proportions of 0%,10%,15%,20% is studied for M25grade concrete cubes. Slump cone and compaction factor method is taken for finding workability. For strength parameters for each grade of concrete Cubes were casted and tested at the age of 7, 14 and 28 days. In this present experimental study on concrete having grades of M25 are prepared by replacing natural sand by steel slag and cement by corn cob ash-saw dust ash.

Concrete is the most versatile heterogeneous construction material and the impetus of infrastructural development of any nation in civil engineering practice and construction works around the world depend to a very large extent on concrete. Corn cob ash is a low cost material and can be used for the construction of any type of structure. Because, the cement remains the most expensive ingredient in making a concrete. Saw dust ash is a waste deposit of the wood mill and the steel slag is the byproduct of steel production. In this we move on to analyze the performance of concrete by partial replacement of these three materials at 10%,15%,20% for cement by the combination of corn cob ash and wood ash, and the same percentage for the fine aggregates we use steel slag by using the mix design of M25 based on the IS standards.
Keywords :- Steel slag, Conventional concrete, Corn cob ash-Saw dust ash, Natural sand

I. INTRODUCTION

Concrete is by far the most widely used construction material today. The versatility and flexibility in concrete, its high compressive strength and the discovery of the reinforcing and pre stressing techniques which help to make up for its load tensile strength have contributed largely to its widespread use. We can rightly say we are in age of concrete. But now a Day's due to rapid growth in construction cement is very costly. Also due to large growth in industrialization there is a large amount of wastes generated, which is hazardous to environment and living beings. To overcome above problems wastes generated can be used as alternative materials. Corn cob ash, wood ash can be used as replacement for cement and steel slag as a replacement for fine aggregate.

Corn cob is produced from the corn processing, saw dust is the byproduct cutting of wood and steel slag is the byproduct of steel production plant. During this process, corn cob and saw dust were made into ash by open burning and then the ash is collected and it is sieve in order avoid the hard particles. Steel slag is an industrial byproduct obtained from the steel manufacturing industry. It is a non-metallic ceramic material formed from the reaction flux such as calcium oxide with the inorganic, non-metallic components present in the steel slag. Thus, utilizing these materials in construction industry itself would help to protect the environment from dumpsites of marble and also limit the excessive mining of natural resources of sand.

Construction activities are taking place on huge scale all over the world and demand of construction materials are increasing day by day. Production of concrete and utilization of concrete has rapidly increased, which results in increased consumption of natural aggregates and sand. Aggregate is one of the main ingredients in producing concrete which covers 75% of the total for any concrete mix. Strength of concrete produced is dependent on the properties of aggregates used. Conventionally concrete is mixture of cement, sand and aggregates. Appropriate utilization of these materials as a partial replacement for cement and fine aggregate will bring ecological and economic benefits to the country. These wastes are disposed in the form of landfills causes an enormous amount of land pollution. Utilization various materials for the concrete by replacing the materials, tends to minimize the economic background of concrete.

1.2 Influence of corn cob ash and saw dust ash as a partial replacement of cement in concrete:

This paper aims to focus on the possibilities of using waste materials from different manufacturing activities in the preparation of innovative mortar and concrete. The use of waste corn cob ash and saw dust ash combined was proposed in partial replacement of cement, for the production of Mortar and Concrete Mix. In particular, tests were conducted on the mortars and concrete mix cured for different times in order to determine their workability, flexural as well as compressive strength. Partial replacement of cement by varying percentage of corn cob ash reveals that increased waste corn cob ash (CCA) and wood ash ratio result in increased workability and compressive strengths of the mortar and concrete.

In the same way cube specimens and beams samples of M30 grade of concrete have been tested in laboratory for which each percentage of corn cob ash i.e. 0% 10%, 15% and 20%. Three properties of concrete namely workability, compressive strength and flexural strength have been selected for study and evaluated according to IS: 1199-1959 and IS: 516-1959 respectively. Before initiating the test properties of materials were determined according to respective IS codes.

1.3 Influence of steel slag as partial replacement of fine aggregates in concrete:

Resolution for taking up this investigation owing to the fact that nowadays natural aggregate (coarse and fine) confirming to Indian Standards is becoming scarcer and costlier due to its non- availability in time because of law of land, illegal dredging by sand mafia and accessibility to the river source during rainy season. Keeping this in view, this study was undertaken to evaluate the effect of partial replacement of natural sand with steel slag (SS) in concrete. Experimental programme was conducted using 0%, 10%, 15% and 20% partial replacement of fine aggregate with stone dust has been taken for concrete of M30 grade with 0.45 water cement ratio. In this study, set of cubes and beams were cast for compressive and split tensile strength respectively. Concrete specimens were tested after 7 and 28 days moist curing. It has been observed that 30% replacement of fine aggregate with steel slag is adaptable.

II. MATERIALS AND PROPERTIES

2.1 MATERIALS USED

In this investigation, the following materials were used:

- Ordinary Portland Cement of 53 Grade cement conforming to IS: 169-1989
- Fine aggregate and coarse aggregate conforming to IS: 2386-1963.
- Corn cob ash (CCA) and Saw dust ash (SDA) as a replacement of cement.
- Steel slag as a replacement of fine aggregate.

2.1.1 CEMNT:

Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It developed from other types of hydraulic lime in England in mid 19th century and usually originates from limestone. It is a fine powder produced by heating materials to form clinker. After grinding the clinker we will add small amounts of remaining ingredients. Many types of cements are available in market. When it comes to different grades of cement, the 53 Grade OPC Cement provides consistently higher strength compared to others. As per the Bureau of Indian Standards (BIS), the grade number of a cement highlights the minimum compressive strength that the cement is expected to attain within 28 days. For 53 Grade OPC Cement, the minimum compressive strength achieved by the cement at the end of the 28th day shouldn't be less than 53MPa or 530 kg/cm^2. The color of OPC is grey color and by eliminating ferrous oxide during manufacturing process of cement we will get white cement also.

Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being effected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for chemical requirement in accordance IS: 4032-1988. The physical properties of the cement are listed in Table – 1.

2.1.1.1 Tests for cement:

The tests which are usually conducted as follows;

1. Specific gravity of cement
2. Fineness of cement
3. Soundness of cement
4. Consistency of cement paste
5. Initial setting time of cement
6. Final setting of cement

2.2 Aggregates*:*

Aggregates are the important constituents in concrete. They give body to concrete, reduce shrinkage and effect economy. Earlier, aggregates were considered as chemically inert materials but now it has been recognized that some of the aggregates are chemically active and also that certain aggregates exhibit chemical bond at the interface of aggregates and paste. The mere fact that the aggregates occupy 70-80% of the volume of concrete.

Aggregates comprise as much as 60% to 80% of a typical concrete mix, so they must be properly selected to be durable, blended for optimum efficiency, and properly controlled to produce consistent concrete strength, workability and durability

2.2.1 Classification:

According to size the aggregates are classified as:

- Fine Aggregate
- Coarse Aggregate

2.2.1.1 Fine Aggregate [IS 2386 – 1963 Part 3]

It is the aggregate most of which passes 4.75 mm IS sieve and contains only so much coarser as is permitted by specification. According to source fine aggregate may be described as:

2.2.1.1.1 **Natural Sand**– it is the aggregate resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies

2.2.1.1.2 **Crushed Stone Sand**– it is the fine aggregate produced by crushing hard stone.

2.2.1.1.3 **Crushed Gravel Sand**– it is the fine aggregate produced by crushing natural gravel.

2.2.1.2 COARSE AGGREGATES:

Fig.10 Coarse aggregates

Crushed aggregates of less than 12.5mm size produced from local crushing plants were used. The aggregate exclusively passing through 12.5mm sieve size and retained on 10mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963. The individual aggregates were mixed to induce the required combined grading. The particular specific gravity and water absorption of the mixture are given in table.

Table – 9 Properties of coarse aggregate

S.No	Description	Test Results
1	Nominal size used	20mm
2	Specific gravity	2.70
3	Impact value	10.5
4	Water absorption	0.15%
5	Sieve analysis	20mm
6	Aggregate crushing value	21.19%

2.3 WATER:

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about $3/10^{th}$ of its weight of water. It is practically proved that minimum water -cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers. Hence it may avoid bleeding. If water content exceeds permissible limits it may cause bleeding. If less water is used, the required workability is not achieved. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.

2.4 Steel slag properties as a replacement of fine aggregate:

Fine aggregates were partially replaced with steel slag. The below table represents the properties of steel slag. Steel slag is a waste from steel production. It can be categorized as carbon steel slag and stainless steel slag according to type of steel, The density of steel slag lies between 3.3- 3.6g/cm3. In appearance, steel slag looks slag a loose collection and appears hard and wear- resistant due to its high Fe content.

III. CONCRETE MIX DESIGN (AS PER IS: 10262-2009)

3.1. DESIGN OF CONCRETE MIX:

3.1.1 Introduction:

The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in 2 states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance.

Final Mix Proportions:

C	:	FA	:	CA	:	WATER
380	:	634	:	1339	:	175
1	:	1.67	:	3.52	:	0.44

IV. TEST RESULTS

The ideal concrete is the one which is workable in all conditions i.e, can prepared easily placed, compacted and moulded. In this chapter, the workability is assessed by two methods as follows:

4.1(a) Slump Cone Test:. The test was conducted for fresh concrete prepared before the moulding process. A total of 13 concrete mixes are prepared at different times. Workability Results obtained from slump cone test for M25 grade of concrete is shown in table.

Table – 13 Slump cone test result

S.No	Mix Designation	Replacements % (CCA&SDA+SS)	Workability (mm)
			M25
1	M0	0+0	62
2	M1	10+0	65
3	M2	15+0	68
4	M3	20+0	73
5	M4	0+10	78
6	M5	0+15	81
7	M6	0+20	63
8	M7	10+10	67
9	M8	10+15	71
10	M9	10+20	76
11	M10	10+15	72
12	M11	15+15	79
13	M12	20+15	86

The workability from the slump cone test is in increasing manner as the mix proportion replacement increasing. The workability range of concrete increasing as mentioned while being in medium range overall.

4.1(b) Compaction Factor Test:

The compaction factor test was conducted to the same mix that tested for workability by slump cone. The results obtained from the compaction factor test for the workability of various mixes of replacements of M25 grade of concrete are tabulated as follows:

Table - 14 Test results of compaction factor test for workability

S.No	Mix Designation	Replacements % (CCA&SDA+SS)	Compaction Factor
			M25
1	M0	0+0	0.82
2	M1	10+0	0.84
3	M2	15+0	0.855
4	M3	20+0	0.87
5	M4	0+10	0.89
6	M5	0+15	0.93
7	M6	0+20	0.83
8	M7	10+10	0.86
9	M8	10+15	0.88

10	M9	10+20	0.91
11	M10	10+15	0.85
12	M11	15+15	0.90
13	M12	20+15	0.93

The workability of M25 grade of concrete by compaction factor test is similar to that of slump cone test. The pattern of increment for the mixes is quite same which will be discussed in detail further.

4.2 Compressive strength:

A total of 42 cubes of size 150 x 150 x 150mm were casted and tested for 7 days, 14 days and 28 days testing each of 13 specimens after conducting the workability tests. The results are tabulated below:

Table - 15 Compressive strength results of M25 grade of concrete

S.No	Mix Designation	Replacements % (CCA&SDA+SS)	Compressive strength of M25 grade in N/mm^2		
			7 days	14 days	28 days
1	M0	0+0	20.57	28.54	33.18
2	M1	10+0	24.09	31.39	36.5
3	M2	15+0	26.27	32.8	37.5
4	M3	20+0	27.05	37.53	39.14
5	M4	0+10	23.96	31.77	37.16
6	M5	0+15	22.22	28.83	34.18
7	M6	0+20	21.98	29	35.17
8	M7	10+10	23.41	31.6	37.16
9	M8	10+15	26.5	34.4	38.5
10	M9	10+20	20.01	26.65	32.9
11	M10	10+15	21.05	28.64	34.5
12	M11	15+15	24.6	33.58	36.5
13	M12	20+15	28.1	38.4	39.23

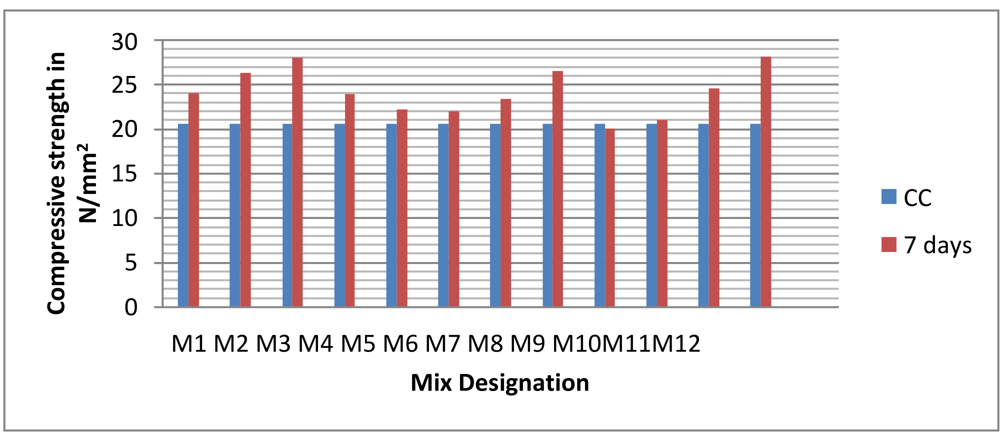

Fig.19 Compressive strength of M25 concrete at 7 days

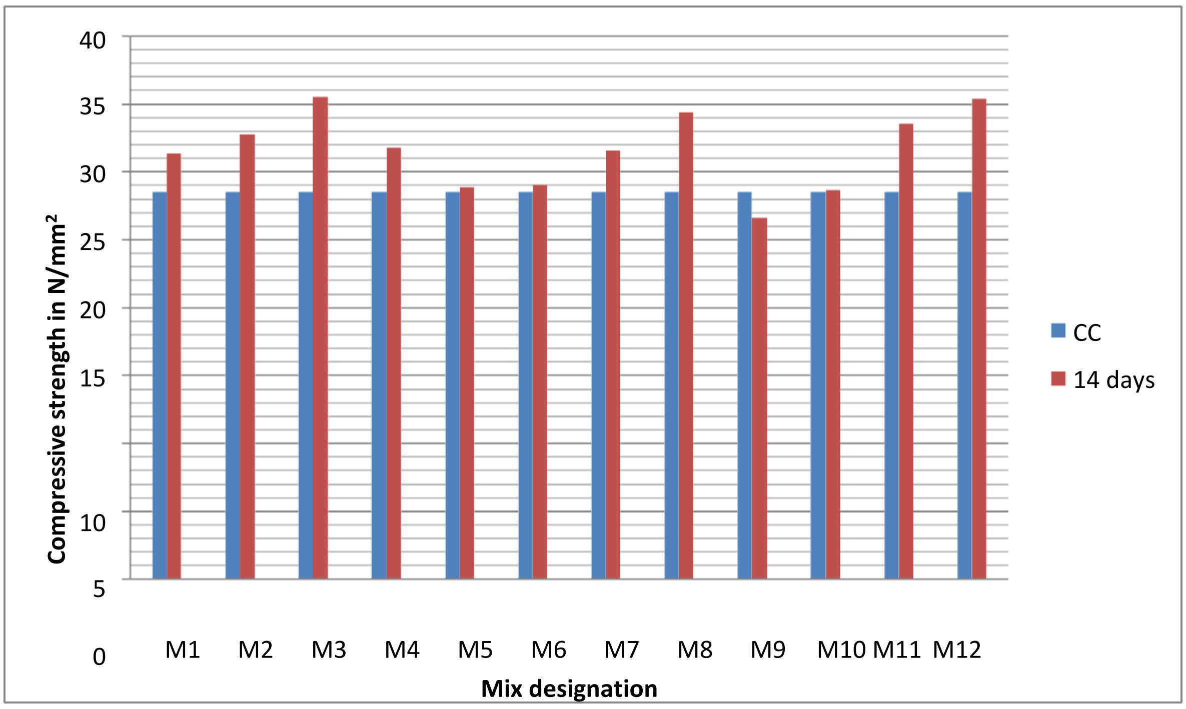

Fig.20 Compressive strength of M25 concrete at 14 days

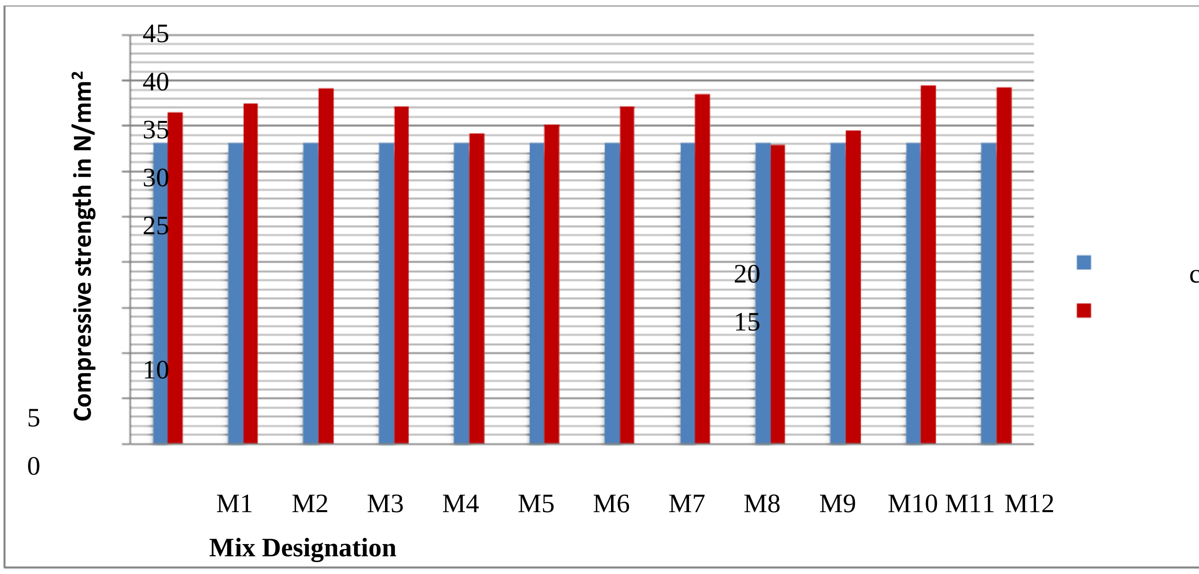

Fig.21 Compressive strength of M25 concrete at 28 days

The results obtained from compression testing gives comprehensive outcome of the project as the replacement the replacement of tile aggregates produces a concrete with suitable properties as conventional.

4.3 Split Tensile strength:

The split tensile strength obtained by testing the cylindrical specimen for M25 grade of concrete to all the mixes designed for various replacements are given below:

Table – 16 Split tensile strength results for M25 grade of concrete

S.No	Mix Designation	Replacements % (CCA&SDA+SS)	Split Tensile Strength of M25 grade in N/mm^2		
			7 days	14 days	28 days
1	M0	0+0	1.67	2.18	2.56
2	M1	10+0	1.67	2.19	2.61
3	M2	15+0	1.69	2.24	2.615
4	M3	20+0	1.71	2.26	2.65
5	M4	0+10	1.69	2.21	2.59
6	M5	0+15	1.67	2.16	2.52
7	M6	0+20	1.69	2.18	2.57
8	M7	10+10	1.69	2.21	2.61
9	M8	10+15	1.70	2.23	2.64
10	M9	10+20	1.65	2.19	2.50
11	M10	10+15	1.68	2.20	2.58
12	M11	15+15	1.71	2.21	2.65
13	M12	20+15	1.72	2.24	2.66

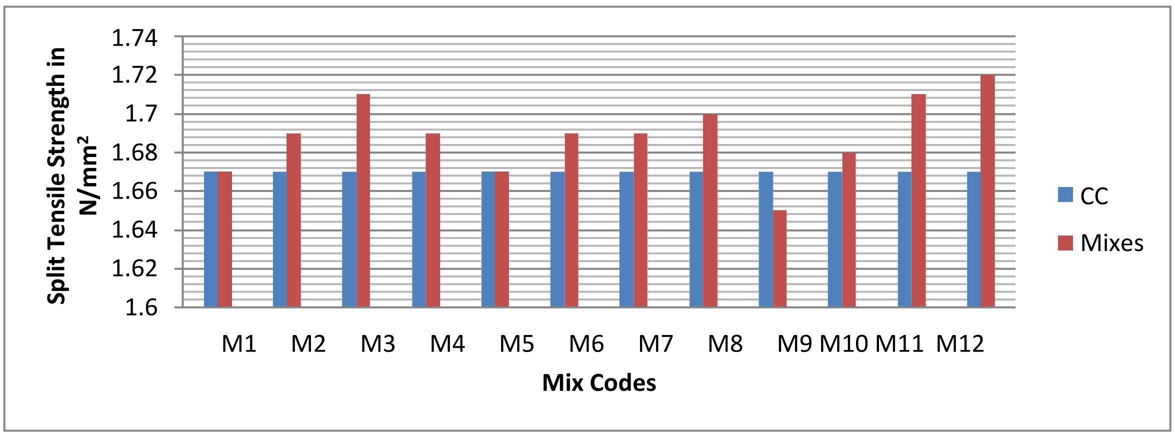

Fig.22 Split tensile strength for M25 at 7days

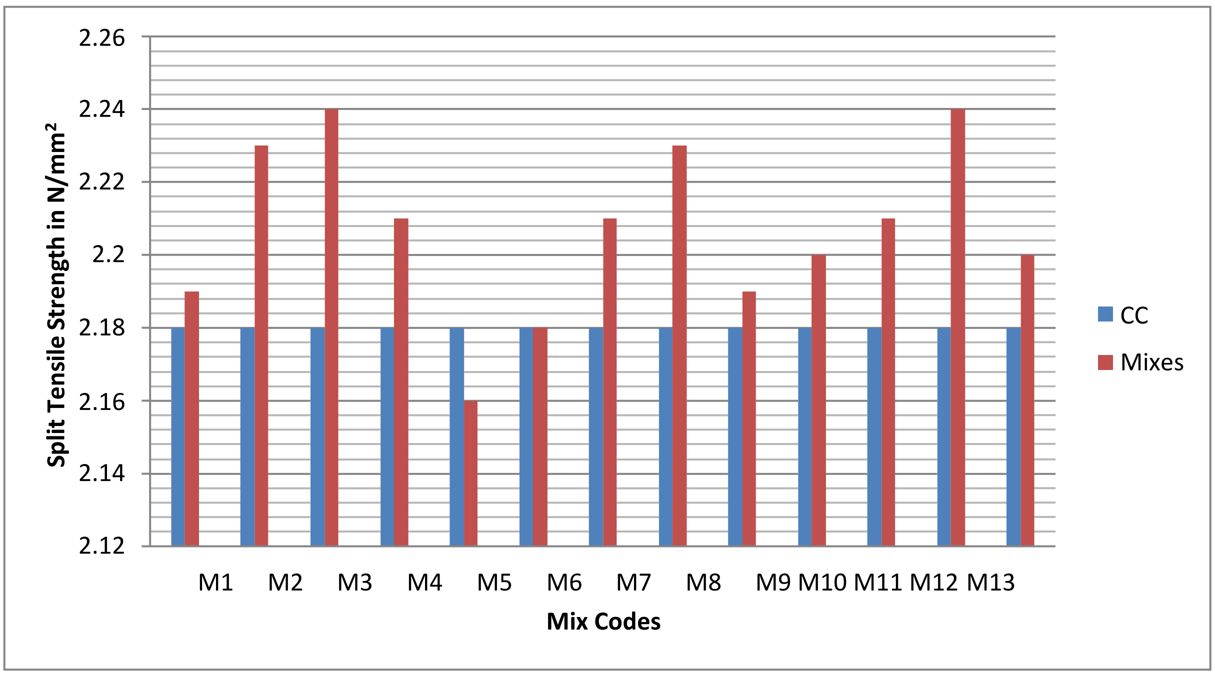

Fig.23 Split tensile strength of M25 concrete at 14days

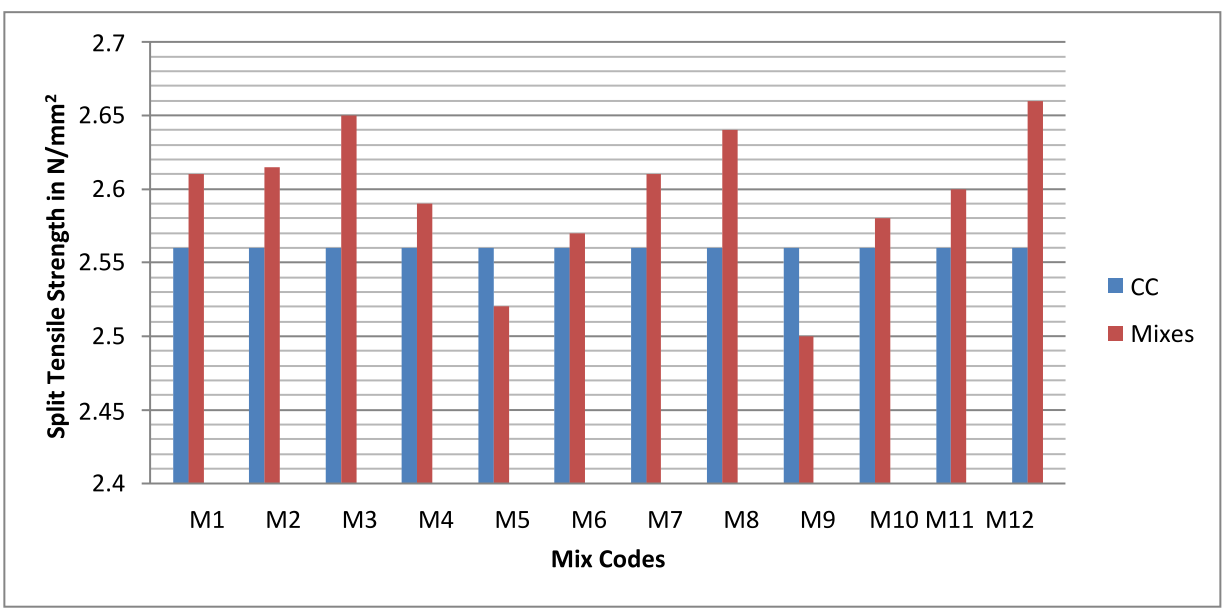

Fig.24 Split tensile strength of M25 concrete at 28days

The strength i.e., the tensile strength, from the results is clearly in an increment way compared to the conventional concrete at all the curing ages of 7days, 14 days and 28 days. The replacement of aggregates by various proportions has positive effect on the strength of the concrete.

4.4 Flexural Strength:

The flexural test was conducted for M3 mix only since it has the highest compressive and split tensile strength to compare it with conventional i.e.,M0. A Total of 2 beams were casted and tested as follows:

Table - 16 Flexural test results

S.No	Grade of concrete	Mix Code	Flexural Strength in N/mm^2		
			7days	14 days	28 days
2	M25	M0	3.25	4.75	5.3
3	M25	M3	3.19	4.81	5.33

V. DISCUSSION

5.1 Workability:

5.1.1 Slump Cone Test:

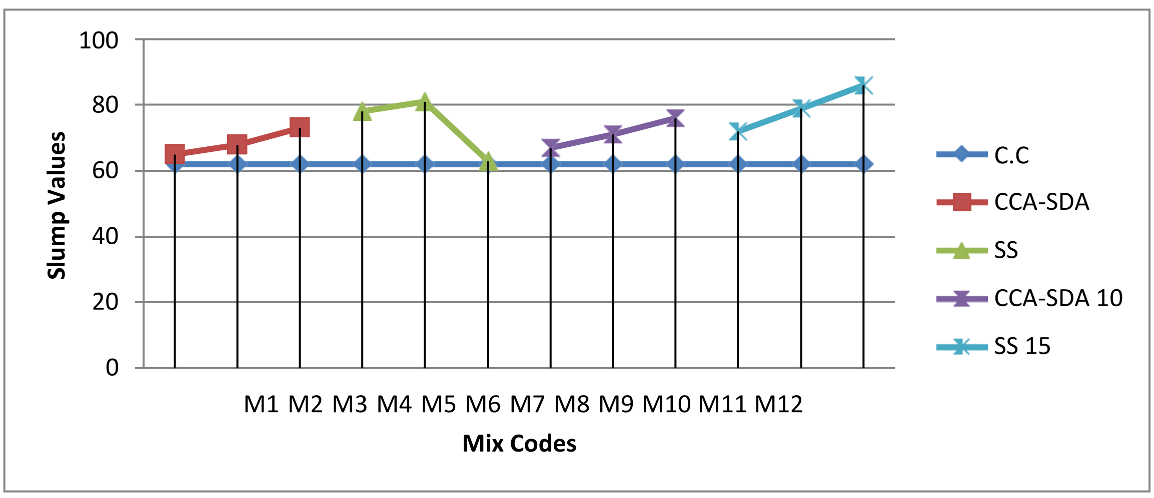

Fig.25 Comparison of slump cone test results

From the results it is observed that the workability is increased by an amount of 4.8%, 9.6%, 17.7%, 25.8%, 30.6%, 1.6%, 8%, 14.5%, 22.5%, 16.1%, 27.4%, 38.7% and 64.5% for M1, M2, M3, M4, M5,M6,M7,M8,M9,M10,M11,M12 mixes respectively over conventional M25 concrete grade(M0).

5.1.1 Compaction Factor Test:

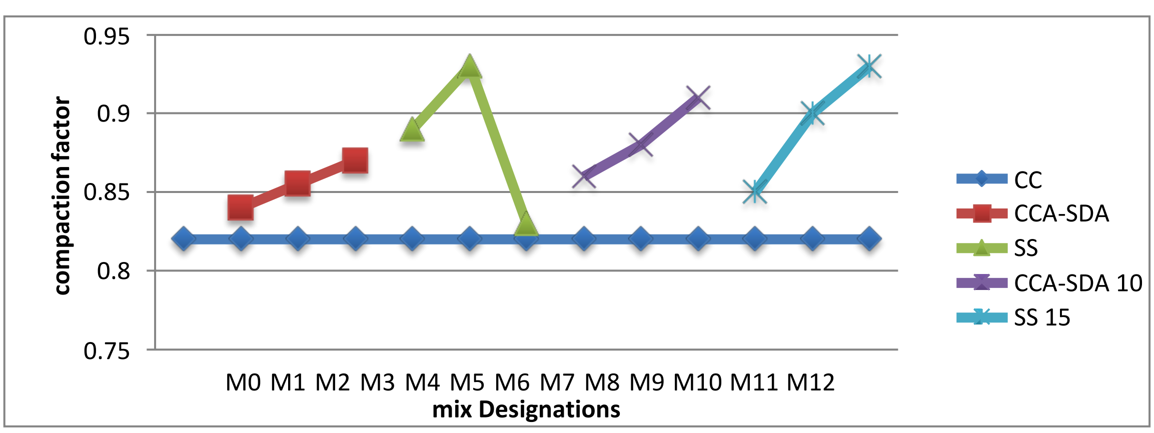

Fig.26: Comparison of compaction factor test results

From the results it is observed that the workability is increased by an amount of 2.4%, 4.3%, 6.1%, 8.5%, 13.4%, 1.2%, 4.9%, 7.3%, 10.9%, 3.6%, 9.7%, 13.4% and 15.8% and 64.5% for M1, M2, M3, M4, M5,M6,M7,M8,M9,M10,M11,M12 mixes respectively over conventi onal M25 concrete grade(M0).

The workability from both slump cone and compaction factor tests is similar in increasing manner.

The workability increases with increase in ceramic coarse tile aggregate but a little deviation with the addition of ceramic fine aggregate. The addition of granite powder has significant improvement on the workability of concrete.

5.2 Compressive strength:

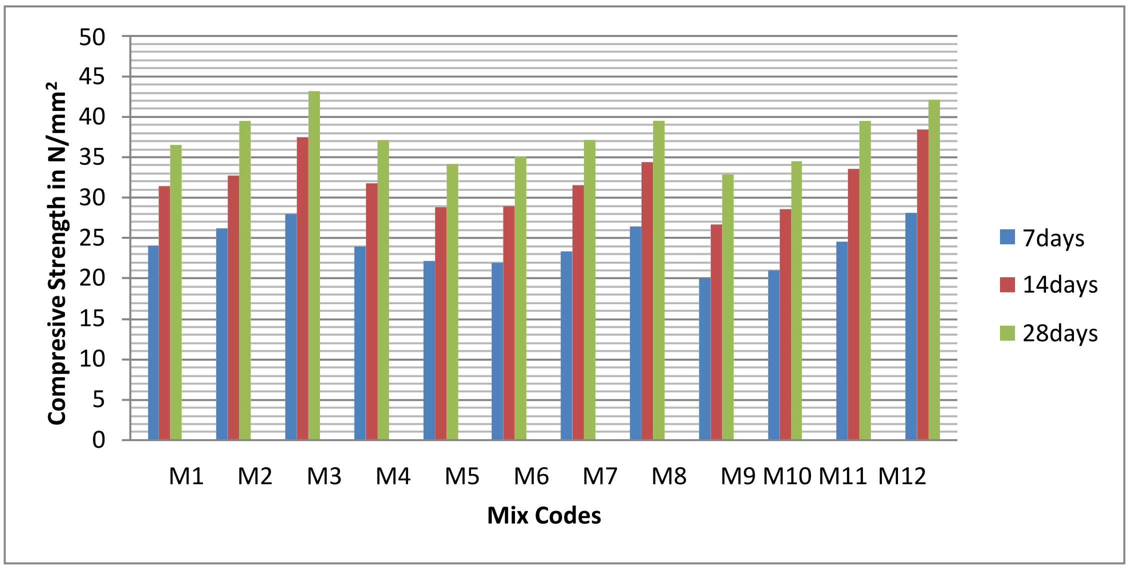

Fig.27: Comparison of Compressive Strength test results

The Compressive strength of concrete varies as 17.11%, 27.7%, 36.36%, 16.4%, 8.02%, 6.85%, 13.8%, 28.82%, -2.72%, 2.33%, 19.59%, 36.6% for M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11 and M12 compared with the conventional concrete after 7days of curing.

The Compressive strength of concrete varies as 9.99%, 14.92%, 31.49%, 11.31%, 1.19%, .61%, 10.72%, 20.53%, -6.62%, 0.3%, 17.65%, 34.54% for M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12 and M13 compared with the conventional concrete after 14days of curing.

The Compressive strength of concrete varies as 10%, 19.04%, 30%, 11.99%, 3.01%,5.99%, 11.99%, 19.04%, 0.8%, 3.97%, 19.04%, 27% for M1, M2, M3, M4, M5, M6, M7, M8,M9, M10, M11, M12 compared with the conventional concrete after 28days of curing.

On comparing the strengths of all mixes, M3, M8 and M12 has the highest i.e., 30% replacement of coarse aggregate. The addition of granite powder has positive effect on strength while improving the workability also.

5.3 SPLIT TENSILE STRENGTH:

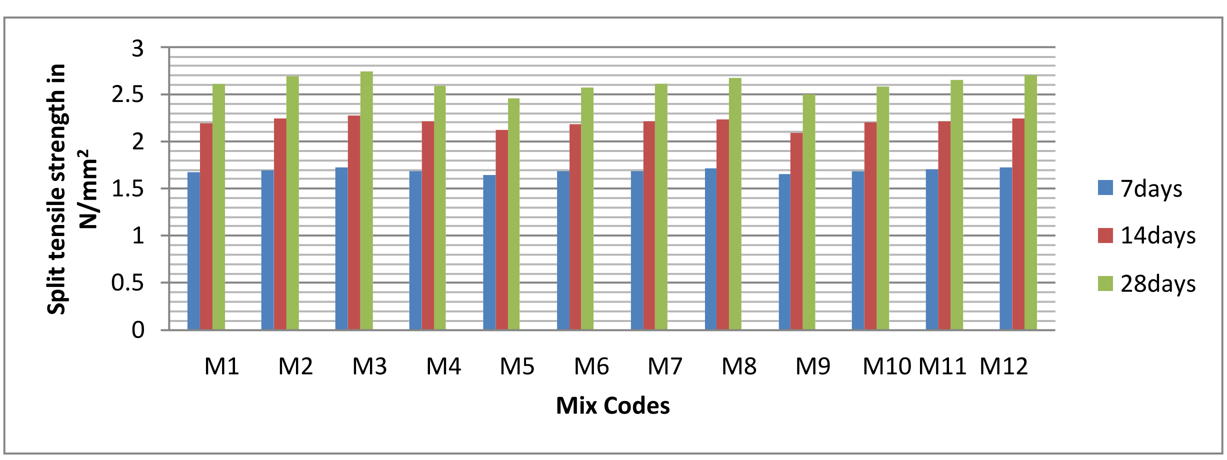

Figure 28 Comparison of Split tensile strength test results

The split tensile strength of concrete varies as 0%, 1.2%, 2.4%, 1.2%, 0%, 1.2%, 1.2%,1.8%, -1.2%, 0.59%, 2.4%, 3.0% for M1, M2, M3, M4, M5,M6,M7,M8,M9,M10,M11,M12compared with the conventional concrete after 7days of curing.

The split tensile strength of concrete varies as 0.46%, 2.7%, 4.6%, 1.4%, -2.7%, 0%,1.37%, 2.3%, 0.46%, 0.92%, 1.37%, 2.75% for M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12 compared with the conventional concrete after 14days of curing.

The split tensile strength of concrete varies as 1.95%, 5%, 7%, 1.18%, -1.6%, 0.39%, 1.9%, 3.1%,-2.3%, 0.78%, 3.5%, 3.9% for M1, M2, M3, M4, M5, M6, M7, M8, M9, M10, M11, M12 compared with the conventional concrete after 28days of curing.

5.4 Flexural Test:

The flexural test is conducted for the mix, which has maximum compressive strength and split tensile strength i.e., M3 (20% of CCA-SDA) and the results are plotted below:

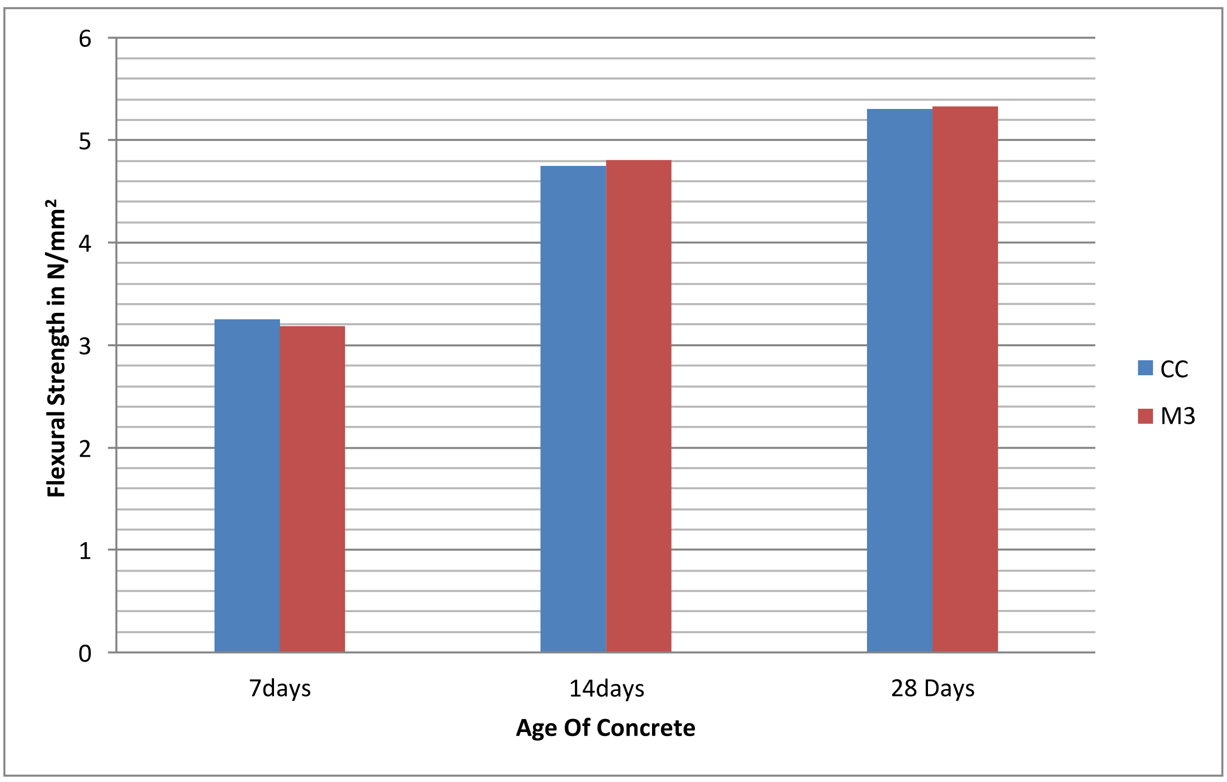

Figure 29 Comparison of flexural strength test results

The strength gaining of beam is linearly increasing. The strength variation for three grades is in increasing manner. The flexural strength of conventional varies as 12.6%, 1.8% and 3.32% of increment at 7, 14 and 28 days respectively for M3 mix. The 7days strength gain is quite same for three grades but after 14 days M25 has the rapid growth of strength. Even though we are not comparing with the conventional concrete but the attainment of strength for is satisfactory.

GENERAL: SUMMARY AND CONCLUSION

The basic objective of the study is to prepare a concrete much more stable and durable than the conventional by replacing aggregates both coarse and fine. Mix designs for all the replacements of materials has done and a total of 84 specimens (39 cubes, 39 cylinders, 6 beams) are prepared and tested in the aspect of strength calculation and also comparisons has done.

VI. CONCLUSIONS

The following conclusions are made based on the experimental investigations on compressive strength, split tensile strength and flexural strength considering the environmental aspects also:

- The increase in compressive strength of concrete with 10% replacement of cement with a CCA&SDA and 20% replacement of fine aggregates with steel slag were found to be given better strength.
- Steel slag can affectively be used in plain cement concrete in place of fine aggregates.
- Non availability of sand at reasonable costs as fine aggregate in cement concrete for various reasons, search for alternative materials steel slag qualifies itself as a suitable substitute for sand at very low cost.
- M3 sample has the highest compressive strength value when compared

remaining samples.

- The flexural strength of M3 sample was linearly increasing with respect to days
- The standard percentage of CCA-SDA has more compressive strength improvement compared to SS.
- Workability of concrete is increases in CCA-SDA than to the steel slag.
- The addition of granite powder along with the ceramic coarse aggregate improves the mechanical properties of concrete.

VII. FUTURE SCOPE OF WORK

There is a vast scope of research in the CCA-SDA and SS usage in concrete especially steel slag wastes in the future. The possible research investigations that can be done are mentioned below:

This project was mainly focused on the partial replacement of Portland slag cement with CCA&SDA at different percentage in concrete. Research may be conducted on other properties and uses of CCA&SDA in the near future to make this product a precious building material to improve the quality of building construction industry. Other types of study that can be included with CCA&SDA may be listed below; here CCA&SDA is Corn cob ash and Saw dust ash.

a) CCA&SDA concrete as an acoustic building structure.
b) The chemical attack on CCA&SDA concrete structure.
c) The durability of CCA&SDA concrete is light in weight.
d) CCA&SDA concrete structure for low cost building.
e) CCA&SDA concrete with plasticizer for higher grade of concrete.
f) Study of CCA&SDA concrete varying the water cement ratio.
g) Only the basic study of use of CCA&SDA in concrete production is investigated; therefore, further investigation is required on the study of durability of concrete made by CCA&SDA blended cement.
h) Further study can be done for determining the deflections and durability of concrete containing CCA&SDA.
i) Further study on the seepage characteristics of the CCA&SDA concrete.
j) In future the flexural strength of beam may be observed by increasing the sizes of beam.

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