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AN EXPERIMENTAL STUDY ON COMPARATIVE ANALYSIS OF M25 GRADE CONCRETE BY PARTIAL REPLACEMENT OF CONVENTIONAL MATERIALS WITH ALTERNATIVE MATERIALS

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Abstract— In today's era natural resources are getting exhausted as there's a huge volume of construction activities being done, which has increased exponentially in the last few decades. Cement is the primary ingredient of concrete and it is a major source of global warming by realizing CO_2. Due to demolition of buildings, unused concrete debris is also of a great concern. Usage of Industrial waste (Fly Ash), Manufactured Sand (Robo Sand) and Concrete debris (Reuse of coarse aggregate -RCA) is a significant effort towards the development and preservation of the environment. The traditional concrete mix of M25 GRADE is designed by using IS 10262-2009 and is taken as reference sample.

The aim of this research thesis work is to determine the strength properties of different concrete mix variations by partially replacing cement with Fly ash, FA with Robo sand & CA with Concrete debris. The first phase involves collection and studying the physical properties of Cement, FA,CA, Robo Sand, Flyash, and Recycle debris (recycle coarse aggregate). Basic tests like sieve analysis, specific. gravity, water absorption were performed. Six distinct concrete mixes with replacement variations from 0.0% to 50.0% at an increment of 10.0% casted, cured, tested and results compared.

To find the mechanical properties of these concrete mixes the strength tests i.e. compression test, splittingt tensile test, and flexural test was performed at age of 3, 7 and 28 days of curing. Cube, Cylinder and Beam (Prism) samples were casted and tested respectively. It is found that the 28 days Compressive strength(CS) for conventional concrete (0.0%) - 26.2 N/mm^2, for 10.0 %- 21.15 N/mm^2, for 20.0% -20.17 N/mm^2, for 30.0% - 17.9N/mm^2 , for 40.0%-14.77N/mm^2 and for 50.0%-11.66N/mm^2. Simultaneously for tensile strength (TS) and flexural strength (FS) for 28 days tests. Splitting tensile strength - 0.0% -2.69N/mm^2, 10.0%- 2.05N/mm^2 , 20.0%- 1.98 N/mm^2, 30.0% - 1.421 N/mm^2, 40.0% - 1.13 N/mm^2 and 50.0% - 0.99 N/mm^2. Flexural strength - 0.0% - 6.50N/mm^2,10.0% - 6.25 N/mm^2 , 20.0% - 6.00 N/mm^2 , 30.0% - 5.75 N/mm^2, 40.0% - 5.00 N/mm^2 and 50.0% - 4.0. N/mm^2 .

It is concluded from the results that as the replacement increases the strengths are decreasing. It is found that at 20% replacement the compressive strength achieved is equal to M20 which is the minimum grade of RCC as per IS 456-2000 so 20% of fly ash, robo sand, and concrete debris can be used.

Key Word : Fly Ash (FA), Reuse Coarse Aggregate (RCA), Robo Sand (RS), Compressive strength (CS), Tensile strength (TS) and Flexural strength (FS)

I. INTRODUCTION

In the present age there is huge volume of construction activities is being carried out leading to depletion of natural resources. For use in concrete, CA is extracted from natural rocks, FA from rivers, and Cement is produced by using huge amount of natural materials.
With 460 million tons (MPTA) of cement production in 2018, India is the 2nd largest Concrete consumer on earth It is the primary ingredients of concrete. FA, CA and water together into a single, useful material i.e concrete which is a enormous source of planet warming CO_2. Today, cement's production is responsible for 8.0% of humanity's CO_2 released - that's more than airplanes, ships, and long distance trucking put together.

As concrete is the major structural material around the world and 2/3rd of the concrete comprises of aggregates. In the measure of aggregate the significant part comprise of CA, it is extracted from mountains causing ecological imbalance like landslide, soil erosion etc.

There is an urgent need to look for alternate materials in order to decrease the rate of depletion of natural resources.

Fly ash which is a waste material in coal based power generation plants, manufactured sand (robo sand) and concrete debris (RCA) can be used as partial replacement of the above concrete components. The basic aim of this project is to find the strength of CS, TS, and FS of concrete for above partial replacements.

II. LITERATURE REVIEW

S.Rukmengadhara Rao, G.Himallee Kumari, & N.Vidiya Sagar, 2015 has studied the effect of workability

and strength of the M25and M35 grade of concrete by substituting the FA with robo sand in percentages of 0.0%,50.0%,75.0%,and 100.0%. Casting of specimens was done and tested after 7 and 28 days of curing and compared with traditional mix(0%).The outcomes of their investigation revealed that there was an incremented in the TS, CS and FS for 50.0% substitution of robo sand and also beyond 50.0% substitution, decremented in the strength, is observed. In comparison with the Traditional mix, for 50.0% substitution the CS increased to 12.0% to 15.0%, FS increment was 20.0% to 22.0% and TS increased in the order of 7.0% to 9.0%.Similarly, for 100.0% substitution of Robo sand the FS, CS and TS was increased in the order of 5.0% to 8.0%, 3.0% to 4.0%, 3..0% to 4.0% when compared with Traditional mix.

T.Subaramani, K.S.Ramish, 2015 has completed examination on M30 GRADE of concrete mix to evaluate the Mechanical properties like FS &TS, CS by partial substitution of cement with Fly ash in percentages viz., 25.0%,30.0%,35.0% & complete substitution of FA with M sand. Test were done on the specimens after is cured in water for 7, 14 & 28days.The conclusions drawn from their study are, the CS decremented when the Fly ash is used in replacement of cement. As the %age of Fly ash increased, the CS and TS was getting diminished.

S. Mothu Lekshmi & R. R. Nivedhithaa 2015, In this research it is concluded that the Optimum replacement of NCA (Natural Coarse Aggregates) and NFA (Natural Fine Aggregates) with RCA (Recycle Coarse Aggregate) and RFA (Recycled Fine Aggregate) separately was seen as 10.0% from CS perspective. Reused concrete with 10.0 to 20.0% reused aggregate make use of blocks of concrete, Pavements of concrete and so on as the CS is higher than that of Normal concrete. CS of concrete with RFA was seen as more than that of concrete with RCA. For TS, ideal replacement of NCA and NFA with RCA and RFA individually was seen as 20%. TS of concrete with RCA was viewed as more than that of concrete with RFA. FS of reused concrete got less than that of PCC and diminishing with increasing level of reused aggregates.

Mallesh M, Chiranjeevi B, Nandeesh M, 2018, in this project they investigated the CS of M20 GRADE concrete by partially substituting the cement with fly ash in the different percentages viz., 0%.0,10.0%,20.0%,&25.0% by weight of cement & also FA was replaced with waste foundry sand 0.0% to 30.0% (0.0%, 10.0%, 20.0%, 25.0% & 30.0%) by weight of FA. The specimen were tested after 7 and 28dys of curing. Finally, the result were compared with traditional mix cube. It was found that for 7 & 28 days the optimum CS was seen in the mix case with 20.0% substitute of cement with Fly Ash and of FS with foundry sand. There was an increase of 30.0% increase in the CS. When compared with traditional concrete of M20 mix.

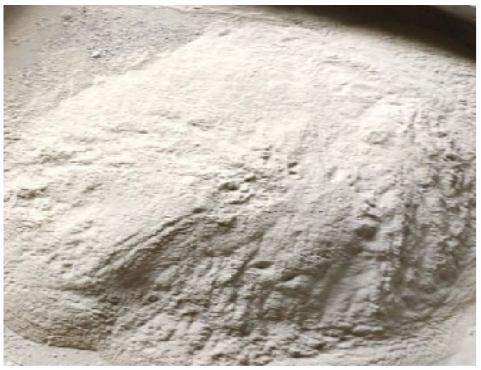
K. Lochan Sai Teja, M. Surya Teja, V. Gokulnath , 2018, in this project they studied CS at 7, 14 & 28days for 100 mm cubes using recycled aggregates substitute, FA&CA) in increment of, (i.e., 10.0%, 15.0% & 20.0%) as RFA and 10.0% using RCA respectively, the result shows the maximum strength by substitution of 15.0% Recycle Aggregate (RA) was found high CS for 7, 14 and 28 days. By the workability of substitution of RA is absorption of water due to huge voids are present in the RA as compare with other material i.e., Natural Aggregate.

III. MATERIALS USED

In the present work, experimental investigations has done to know how effectively we can replace cement concrete ingredients. A detail description of the materials followed in the design is shown below.

The phase involves collection and studying the properties of Cement, FA, CA Robo Sand, Fly ash and Recycle debris (RCA). Fly ash, Robo sand & RCA is procured from thermal plants, local quarry, & demolished structure respectively. CA passing IS 20.0 mm sieves is considered for experimental program.

Fig 1. Fly Ash



. Fig. 2. Robosand

Fig. 3 Recycled Coarse Aggregate

TABLE 1. PROCUREMENT OF MATERIALS :

S.No	Name of Material	Place of Procurement	Zone
1	Cement-OPC	Kodad (A.P)	5
2	FA (River sand)	Karimnagar (T.S)	5
3	Natural coarse aggregate (NCA)-20 mm	Nanakramguda (T.S)	6
4	Concrete Debris (RCA)-20 mm	Moinabad (T.S)	6
5	Robo sand	Nanakramguda (T.S)	5
6	Fly ash	Singereni mines SCCL Kothagudem, bhadradri dist (T.S)	4

DESIGN CONSIDERATION

Nominal concrete mix design of M25 was done as per IS 1026 - 2009 for grade of concrete, quantity of material for $1m^3$ is given below in table 2.

TABLE 2. MIX QUANTITIES FOR $1M^3$:

S.No	Materials	Quantities (KgS)
1.	Cement	437.78
2.	FA	661.00
3.	CA	1120.00
4.	Water	197.16

M0 conventional (0% replacement), Keeping the same grade mix, five mix design variations with partial replacement in increment of 10% is taken M1-10%, M2-20%, M3-30%, M4-40%, and M5-50% percentages replacement Equations. All the steps of experimental work is shown as flow chart in figure 4.

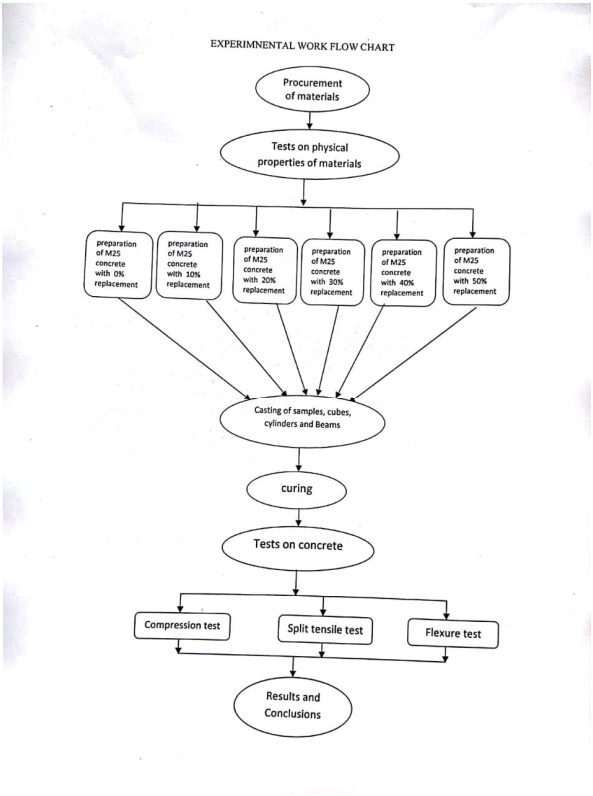


Fig. 4. Experimental Flow Chart

IV. CASTING

The quantity of raw materials cement, FA ,CA and water, Fly Ash, Robo sand, concrete debris are taken as per design mix calculations, mixed in a mechanical mixer, slump cone test performed, casted , cured by following the standard procedure; depicted in figures below. The specimens used for compression test were cube of standard size 150x150x150 mm, for splitting tensile cylinder of standard size 150x300 mm, for flexural test beam of standard size 500x100x100 mm. The above tests were performed at the age of 3, 7 & 28 days.

Fig. 5. Concrete Mixer

Fig. 6. Fresh Concrete

Fig. 7. Slump Tests

Fig. 8. Casted Cubes

Fig. 9. Casted Cylinders

Fig. 10. Casted Beams

V. TESTING

A. *Compressive Test*

The Compressive strength of concrete is defined as maximum resistance of concrete in an axial loading condition.

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The specimen are removed from the curing just before testing on the specified day and The key specimen is placed on the lower plate of the compressive testing machine such that the load is applied centrally on the faces other than top and bottom faces of casting

It was conducted in the laboratory on the compression testing machine (CTM) of 2000 kN capacity as per IS 516-2002. The maximum load reading at failure of specimen is noted. Compressive strength is taken as maximum load applied on the specimen divided by the area of the load bearing surface of the specimen, calculated by the formula Load/Area (P/A). where P is maximum load, A is Area of the loading surface. Care should be taken that load should be applied continuously without shock as per rate of loading specified in IS 516 -2002

Fig. 11. Cube in CTM

Fig. 12. Tested Cubes

B. *Splitting Tensile Test*

The splitting tensile strength of concrete is defined as maximum resistance of concrete in an perpendicular axis loading condition.

It was conducted in the laboratory on the compression testing machine (CTM) of 2000 kN capacity as per IS 516-2002. Two pieces of wood can be used to prevent the slipping of the specimen and ensuring that the applied load is perpendicular to axis. The maximum load reading at failure of specimen is noted. Splitting tensile calculated by the formula $2P/\pi LD$. Where P is Max load at breaking, L is length of specimen, D is the diameter of the sample.

Fig. 13. Tested Cylinder

C. *Flexural Strength Test*

It is the ability of a prism (Beam) to resist failure in bending. It is conducted in the laboratory on flexural testing machine as per IS 516-2002. Three point loading method is used in this research project. The maximum load reading at failure of specimen is noted. Flexural strength is calculated by the formula PL/BD^2. Where P is Max load at breaking, L is length of specimen, D is the diameter of the sample.

Fig. 14. Flexural Test

VI. RESULTS

The results summary of all mix variations at 28 days for the above mentioned tests along with slump cone is given in table 3 as below;.

TABLE 3. RESULTS SUMMARY AT 28 DAYS

Mix Variations	**PARAMETERS**			
	Slump (mm)	**Comp Strength (N/mm^2)**	**Split Strength (N/mm^2)**	**Flexure Strength (N/mm^2)**
Ref M 25	70	26.20	2.69	6.50
10%	62	21.05	2.05	6.25
20%	50	20.17	1.98	6.01
30%	32	17.97	1.41	5.75
40%	16	14.77	1.13	5.00
50%	7	10.66	0.99	4.00

VII. CONCLUSIONS

- In present work it is found that substitution of all the ingredients upto 20 % attains strength approximately equal to the mix design for M20 rather than M25, hence it can be adopted for M20 as it is the minimum concrete GRADE prescribed in the latest IS456.
- It is found that the 28 days compressive strength is 0% - 26.2 N/mm^2 for traditional concrete at 28days, for 10% - 21.05 N/mm^2 , 20% - 20.17 N/mm^2, 30% - 17.97 N/mm^2, 40% - 14.77 N/mm^2 and 50 % - 10..66 N/mm^2. Simultaneously for
- Flexural strength and Splitting tensile strength are as follows for 28 days tests.
- Splitting tensile strength is 0% - 2.69 N/mm2,10% - 2.05N/mm2 , 20% - 1.98 N/mm2, 30% - 1.41 N/mm^2,40% - 1.13 N/mm^2 and 50% - 0.99 N/mm^2.
- Flexural strength - 0% - 6.50N/mm^2 ,10% - 6.25 N/mm^2 , 20% - 6.01 N/mm^2, 30% - 5.75 N/mm^2 ,40% - 5.00 N/mm^2 and 50% - 4.00 N/mm^2 .
- Due to high water absorption of substitutes there is reduced in workability in the mix variations (0.0% to 50.0%) , as percentages of substitutes increases water absorption increases and slump decreaes.

- As fly ash percentages increases in the mix there is diminished in the strength (compressive-tensile-flexural) .
- From above results, flyash, robo sand, recycled coarse aggregate (concrete debris), can be used as an alternative material for the ordinary Portland cement, natural coarse aggregate, and river.
- This will also decrease the carbon foot print and other ecological imbalances and depletion of earth's natural resources .

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