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Experimental Investigation on High Performance Concrete with Partial Replacement of Cement by Fly Ash and Fully Replacement of Sand by Stone Dust

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Abstract: *High Performance Concrete (HPC) now a days used widely in the construction industry worldwide. High performance concrete appears to be a better choice for a strong and durable structure. Normal and special materials are used to make these specially designed concrete that must meet a combination of performance requirements. In this project, investigations were carried out on strength properties such as compressive strength, split tensile strength and flexural strength of M40 grade of HPC mixes with different replacement levels such as 25%,30%,35% & 40% of cement by fly ash and 60%,65%,70%,75% &100% of stone dust with sand by adopting water-binder ratio of 0.35. Super plasticizer (BASF) is used for better workability for high performance concrete. The HPC mix, grade M40 concrete is designed as per IS: 10262-1982 IS: 456-200, which is conventional. Mechanical characteristics like Compressive strength, Split-tensile strength, Flexural strength were examined. The result of these investigations demonstrates the strength characteristics of stone dust and the properties of fly ash based concrete mixes. Based on the results obtained, the replacement of 100% stone dust and 25% fly ash with 1.2% of super plasticizer which superior characteristics was arrived .The details of the investigations along with the results are presented in this report.*

Keywords: *High Performance Concrete, Fly Ash, M-Sand, Compressive Strength, Split Tensile, Flexural Strength, super plasticizer.*

1. INTRODUCTION

High performance concrete (HPC) is a concrete that meets special combinations of performance and uniformity requirements which cannot always be achieved routinely using conventional constituents and normal mixing and placing and curing practices. To produce high performance concrete it is generally essential to use chemical and mineral admixtures in addition to the same ingredients, which are generally used for normal concrete. In recent times, many researches are going on for improving the properties of concrete with respect to strength, durability, and performance as a structural material. There are many materials like fly ash, furnace slag, stone dust and silica fume etc. One among these special concrete is the stone dust which is new emerging as one of new generation construction material in producing high strength and performance concrete for special structures. The interest in fly ash and stone dust started in enforcement of air pollution control in many countries. This implies that the industry had to stop releasing fly ash into the atmosphere. To find solution to this problem studies were initiated and after some investigations, it was found that the fly ash and stone dust could be used as a very useful material in concrete. In India, improved stone dust and fly ash is finding its use now a day.

1.1. Need for High Performance Concrete

The large scale production of cement has imposed many environmental problems on one hand and unrestricted depletion of natural resources on the other land. This threat to our ecology has led to many investigations in the usage of industrial by- products as supplementary cementations material in making concrete. Another problem in this fast growing world is to encompass the durability and the strength of the concrete structures. High performance concrete (HPC) partakes been developed over the last two decades, and was primarily introduced through private sector architectural design and

construction such as high rises and parking garages. By using by- products such as fly ash and stone dust with super plasticizers we can achieve high performance concrete, which possess high workability, high strength, and high modulus of elasticity, high density, high dimensional stability, low permeability and resistance to chemical attack.

1.2. Objectives of this Project

To experimentally investigate the effect of replacing 25%,30%,35% & 40% replacement of cement by fly ash and replacement 60%,65%,70%,75%&100% of sand by stone dust on strength characteristics namely compressive strength, flexural strength and split tensile strength.

2. MATERIALS USED

2.1. Cement

Ordinary Portland cement-53 grade have used in the investigation. The cement was tested according to IS 4031:1988. It confirmed to IS 12269:1987. Its Properties is given in Table 2.I

Table2.1. *Show physical property of cement*

S.NO	PROPERTY OF CEMENT	VALUES	As per IS:4031 part(I-V)-1996
1	Specific gravity	3.15	3.15
3	Normal Consistency	30%	30%-35%
4	Initial setting time	90min	>30
5	Final setting time	350min	<600
6	fineness	1.6%	<10%

2.2. Fine Aggregate (IS: 2386 part (I-III)-1963)

Clean and dry river sand available locally was used. Sand confirming to Zone-II. Specific gravity and fineness modulus is 2.65 and 3.15 respectively.

2.3. Coarse Aggregate (IS: 2386part (I-III)-1963, IS: 9376)

Coarse aggregate passing through 20 mm sieve as given in IS 383 – 1970 was used for all the specimens. In addition to cement paste- aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

S.No	Property of aggregate	Values	As per IS:2386, IS:5640,IS:9376
1	Specific gravity	2.75	2.7-2.8
2	Sieve analysis	Well graded	Good
3	Water absorption	0.5%	Less than 1.5%
4	Aggregate impact value	15%	Less than 30% for concrete
5	Aggregate crushing value	16%	Less than 30% for concrete
6	Flakiness & Elongation index	23.4%	Less than 25%

2.4. Stone Dust

A fine aggregate produced by crushing of stone or natural gravel to be used as an alternate of natural sand is called as Stone dust. The angular shaped stone dust has a good inter locking that gives better binding strength and saves cement. Stone dust is totally inert material and its physical properties are similar to natural sand. Stone dust can be used as a partial or fully replacement for fine aggregate, the use of stone dust as a construction raw material neither imposes risks to the human kind nor to the environment. Specific gravity of Stone dust is 2.65 and fineness modulus is 3.17. Stone dust is confirming to Zone-III.

2.5. Fly Ash

Fly ash is finely divided residue resulting from the combustion of ground or powered coal. The hardened fly ash concrete shows increased strength together with a lower permeability, where the latter leads to a higher resistance towards aggressive admixtures in addition, partial replacement of cement with fly ash reduces the production cost of concrete due to the lower price of fly ash compared to cement . Class F Fly ash (contains less than 20% lime) is collected from Narla Thatha Rao Thermal Power Station (NTPS), Vijayawada. Specific gravity of fly ash 2.30 is and fineness modulus (passing through 45 micro meter) is 7.86.

Table2.2. *Show chemical property of fly ash –class f*

S.No	Chemical properties	Compounds (%)Fly Ash-class-F
1	SiO2	45.98
2	Al2O3	45.98
3	Fe2O3	4.91
4	CaO	18.67
5	MgO	1.54
6	Na_2O	0.24
7	K_2O	0.24

2.6. Super Plasticizer

Super plasticizer BASF, it gives good workability to fresh concrete.

3. MIX DESIGN

In this investigation concrete mix design M40 was designed based on IS: 10262-1982, IS: 456-2000. This code presents a generally applicable method for selecting mixture proportion for high strength concrete and optimizing this mixture proportion on basis of trial batches. The method is limited to high strength concrete production using conventional materials and production techniques. Mix Design are given below in table 1. Mix proportioning for the mixes adopted in the study details are given below in tables the mix ratio is 1:0.78:2.43 and w/c is 0.35 is adopted.

Mix proportions

Cement	Fine Aggregate	Coarse aggregate	W/C
1	0.78	2.43	0.35

4. METHOD OF EXPERIMENT

It is important that the constituent material of concrete remain uniformly distributed within the concrete mass during the various stages of handling and that full compaction is achieved, and making sure that the characteristics of concrete which affect full compaction like consistency, mobility and compatibility are in conformity with relevant codes of practice. The tests were carried out in accordance with relevant IS Standards. The aggregates were tested for physical properties such as specific gravity and particle distribution test. The fresh concrete was subjected to the slump test followed by casting of concrete in moulds for further investigations. All the mixes were prepared by mixing the concrete in laboratory mixer along with water and super plasticizer. For compressive strength 144 NOS cube specimens of size 150 mm x 150 mm x 150 mm, for flexural strength studies, 45 NOS prism specimens of size 100 mm x 100 mm x 500 mm and 45 NOS cylinder specimens of size 300 mm height and 150 mm diameter for split tensile strength studies were prepared.

5. ANALYSIS AND TEST RESULT

5.1. Compression Test

*A*fter 7 days, 14 days and 28 days of curing, three 150mm cubes of a concrete mixture were tested using the compression machine. These cubes were loaded on their sides during compression testing such that the load was exerted perpendicularly to the direction of casting. The average value of the three cubes was taken as the compressive strength.

5.2. Split Tensile Test

The test was carried out by placing the cylindrical specimen horizontally between the loading surfaces of a compression testing machine and load is applied until the initial crack of the specimen occurs, along the diameter.

5.3. Flexural Strength

The test was carried out on 100mm X100mm X500mm size prism. The test was carried out on a universal testing machine of 400kN capacity, adopting two point loading. The bearing surfaces of the supporting and loading rollers are wiped clean, and any loose sand or other material removed from the surfaces of the specimen. The specimen was placed in the UTM and that the load was applied to the uppermost surface as cast in the mould, along two lines spaced 20cm apart. The load was increased until the specimen fails, and the maximum load applied to the specimen during the test was recorded and appearance of the fractured faces of concrete was noted.

Table1. *Results for conventional materials mix(c)*

Compressive Strength (N/mm^2)			Split tensile strength (N/mm^2)	Flexural strength (N/mm^2)	Workability Slump(mm)
7 Days	14 Days	28 Days			
46.26	64.06	71.18	4.5	5.0	55

Table2. *Compressive strength (n/mm^2) - fly ash*

S.No	Specimen	7 Days	14 Days	28 Days
1	C	46.26	64.06	71.18
2	C1-25%	38.25	50.29	58.50
3	C2-30%	35.34	50.12	55.92
4	C3-35%	34.49	47.14	54.6
5	C4-40%	31.2	43.2	48.00

Table3. *Split tensile strength (n/mm^2) - fly ash*

S.No	Specimen	7 Days	14 Days	28 Days
1	C	2.82	3.95	4.5
2	C1-25%	2.82	3.95	4.5
3	C2-30%	2.66	3.63	4.1
4	C3-35%	2.47	3.42	3.8
5	C4-40%	2.34	3.24	3.6

Table4. *Flexural strength (n/mm^2) - fly ash*

S.No	Specimen	7 Days	14 Days	28 Days
1	C	3.44	4.67	5.3
2	C1-25%	3.37	4.52	5.23
3	C2-30%	3.34	4.47	5.15
4	C3-35%	3.28	4.43	5.06
5	C4-40%	3.15	4.39	4.86

Table5. *Compressive strength (n/mm^2) - stone dust*

S.No	Specimen	7 Days	14 Days	28 Days
1	C	46.26	64.06	71.18
2	S1-60%	35.48	48.98	54.66
3	S2-65%	35.02	49.43	55.08
4	S3-70%	35.79	49.57	55.38
5	S4-75%	40.17	55.62	61.8
6	S5-100%	43.95	60.85	67.62

Table6. *Split Tensile Strength (N/mm^2) - Stone Dust*

S.No	Specimen	7 Days	14 Days	28 Days
1	C	2.82	3.95	4.5
2	S1-60%	2.47	3.42	3.81
3	S2-65%	2.48	3.43	3.82
4	S3-70%	2.37	3.29	3.66
5	S4-75%	2.62	3.63	4.04
6	S5-100%	3.00	4.15	4.62

Table7. *Split Tensile Strength (N/mm^2) - Stone Dust*

S.No	Specimen	7 Days	14 Days	28 Days
1	C	3.44	4.67	5.3
2	S1-60%	3.13	4.38	4.98
3	S2-65%	3.15	4.48	5.0
4	S3-70%	3.28	4.65	5.2
5	S4-75%	3.35	4.67	5.31
6	S5-100%	3.64	5.04	5.6

Table8

Wokability	Fly Ash		Stone Dust	
S.No	Specimen	Slump(mm)	Specimen	Slump(mm)
1	C	30	C	30
2	C1-25%	50	S1-60%	45
3	C2-30%	51	S2-65%	43
4	C3-35%	53	S3-70%	40
5	C4-40%	55	S4-75%	37
6	---	----	S5-100%	35

Table9. *Final Mix – 1:0.35:2.43:0.78 with 25% Fly Ash &100% Stone Dust*

Compressive Strength (N/mm^2)	Split Tensile Strength (N/mm^2)	Flexural Strength (N/mm^2)	Workability (mm)
61.2	4.05	5.3	45

6. CONCLUSION

In this the Concrete Mix M_{40} has been designed as 1:2.43:0.78:0.35. The concrete with optimum replacement percentage of 25% replacement of cement by fly ash and 100% fully replacement of fine aggregate by Stone dust in concrete mix quantities also arrived.

The slump value for M40 grade using Stone dust and fly ash gets increased, when 100% replacement of Stone dust and 25% replacement of fly ash with 1.2% super plasticizer. Hence fly ash and stone dust replacement is effective for HPC in order to attain high strength.

Compare to nominal concrete M_{40} grade concrete attain increase % strength by using lower water/binder ratio. Also reduce the segregation and bleeding.

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