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Feasibility to use of Fly Ash & Stone Dust as Partial Replacement with Cement & Sand in M30 Concrete

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***Abstract*— Concrete has been used in various structures all over the world since last two decades. Recently a few infrastructure projects have also seen specific application of concrete. The development of concrete has brought about the essential need for additives both chemical and mineral to improve the performance of concrete. Most of the developments across the work have been supported by continuous improvement of these admixtures. Hence varieties of admixtures such as fly ash, stone dust have been used. An attempt has been made in the present investigation to study the behavior of concrete by Partial Replacement of Cement with Fly Ash and Sand with Stone Dust. To attain the setout objectives of the present investigation, Partial Replacement of Cement with Fly Ash and Sand with stone quarry dust Used in Concrete by 5, 10, 15, 20% and 30 % respectively to produce Concrete. Concrete is tested for Compression, split tension and flexural strengths. The results are quite encouraging for use of fly ash and stone quarry dust in producing Concrete.**

Index Terms— Experimental, Investigation, Partial Replacement, Cement with Fly Ash, Sand with stone quarry dust.

I. INTRODUCTION

Concrete is a mixture of cement, sand, coarse, aggregate and water. River sand which is most commonly used as fine aggregate in the production of concrete. Many state Governments have imposed ban on sand mining from river beds. In such a situation quarry waste from crusher are being as an alternative to river sand.

Similarly, Indian thermal power stations are generating millions of tons of fly ash every year. Fly ash is a major product by waste material generated by the thermal power plants. Disposal of fly ash has become great problem and is aggravating day by day. Fly ash is characteristics to get heated very fast and cool down as well. Disposal and utilization of fly ash has become challenge all over the world. Engineers are continually pushing the limits to improve its performance with the help of innovative chemical admixtures and supplementary cementitious materials. The main benefit of fly ash are their ability to replace certain amount of cement and still able to display cementitious properties, thus reducing the cost of using Portland cement.

In India about 200 million tons of fly ash has been produced by 68 major thermal power station and are likely to be double within a next 10 years. A partial replacement of cement with fly ash is desirable and indeed essential due to variety of technical, economic and ecological reasons. In the present work, primary aim is to study the feasibility of use of stone quarry dust, fly ash.

II. MATERIALS USED AND MATERIAL PROPERTY

A. Cement:

The cement used was Portland Pozzolana cement 53 (PPC 53). All properties of cement were determined by referring IS 12269 - 1987. The specific gravity of cement is 3.15. The initial and final setting times were found as 55 minutes and 258 minutes respectively. Standard consistency of cement was 30%.

B.Coarse Aggregate 20mm size aggregates:

The course aggregates with size of 20mm were tested and the specific gravity value of 2.78 and fineness modulus of 7 was found out. Aggregates were available from local sources.

C. Fine Aggregate:

The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity

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of fine aggregate was 2.60.

D. Stone Quarry Dust:

The particle size of crushed Fine Aggregate I.e. Stone Quarry Dust range from 4.75mm to 75micron and below. Presence of angular shape fractions give better interlocking properties since it binds each and every particle. The angular shape particles may impart improved qualities for split tensile strength & flexural strength of concrete.

E. Water:

The water used for experiments was potable water.

F. Fly Ash:

Fly Ash is one of the residue generated in the combustion of coal and transported by the flue gases and collected by electrostatics precipitator. Fly ash is generally captured from the chimneys of coal-fired power plants, and is the one of the two types of ash that jointly are knows coal ash; the other, bottom ash, is removed from the bottom of coal furnaces. Depending upon the sources and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO2) and calcium oxide (CaO). Fly ash is varying in color from light to dark grey its depend on its carbon content.

•Advantages of Fly Ash in Concrete

1) It is a pozzolanic material.
2) It improves concrete workability and lowers water demand.
3) It generally exhibits less bleeding and segregation than plain concretes.
4) It is Sulfate and Alkali Aggregate Resistance.
5) It has a lower heat of hydration.
6)It is generally reducing the permeability and adsorption of concrete.
7) It is a raw material.

III. PROPERTIES OF CONCRETE

A. Fresh Concrete Properties

• Workability:

The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product. To serve this Slump Test is performed.

1. Slump Test

Fresh concrete when unsupported will flow to the sides and sinking in height will take place. This vertical settlement is known as slump. The workability of concrete depends on wetness of concrete i.e., water content as well as proportions of fine aggregate to coarse aggregate and aggregate to cement ratio. This test is performed by filling fresh concrete in the mould and measure the settlement i.e., slump.

2. Compaction Factor Test

The sample of concrete to be tested is placed in the upper hopper up to the brim. The trap door is opened and the concrete is allowed to fall into the cylinder. The is filled up to the top level of the cylinder. This weight is known as "weight of partially compacted concrete." The cylinder is emptied and then refilled with the concrete from the same sample in layer approximately 5 cm deep. the layers are heavily rammed to obtain full compaction. this weight is known as "weight of fully compacted concrete.

B. Hardened Concrete Properties:

1. Compression Test On Concrete

The concrete has been tested using nominal maximum size of aggregate 20mm test specimens of size 15cm x 15cm x 15cm are prepared and tested after 7 days, 14days, and 28days of curing.

Fig. Curing

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Fig. Compression Test

2. Split Tensile Test

The concrete has been tested using nominal maximum size of aggregate 20mm test specimens of 15cm diameter and 30 cm height are prepared and tested after 7 days, 14days, and 28days of curing.

Fig. Split Tensile Test

3.Flexural Test On Beams

The concrete has been tested using nominal maximum size of aggregate 20mm test specimens of size 10cm x 10cm x 50cm are prepared and tested after 7 days, 14days, and 28days of curing.

Fig. Flexural Strength Test

IV. MIX DESIGN

Mix design is the process of selecting suitable ingredient of concrete and determines their relative proportions with the object of certain minimum strength and durability as economically as possible. Mix design has been carried out for M30 grade of concrete for conventional ingredients by I.S. Method (IS 10262-1982).

1. Mix Design for M30 Concrete as per Indian standard recommended method of concrete mix design (IS 10262-1982).

i. Characteristic compressive strength required in the field at 28 days.

f_{ck} =30Mpa

ii. Target mean strength of concrete

$F_t = f_{ck}+1.65\ S$

F_t = Target mean strength

f_{ck} = Characteristic strength

S = Standard deviation = 5.00

F_t = 30+ 1.65 (5)

= 38.25 Mpa

iii. Maximum size of aggregate = 20 mm

iv. Assume w/c ratio as 0.45

v. Selection of water & sand content

For 20 mm maximum size of aggregate, water content per cubic meter of

Concrete = 300 kg & sand content as % of total aggregate = 35 %

Select water content = 300 kg

vi. Determination of cement content

W/c ratio = 0.45

Cement = 186/0.45

= 413.33 kg/m3

vii. Determination of coarse & fine aggregate contents

$V = [\ w+c/S_c + f_a/p.\ Sf_a]\ 1/1000$

$0.98 = [300 + (413.33 /3.15) + \{(1/0.35) \times (Fa/2.66)\}] \times 1/1000$

F_a = 510.918 kg/m3

$C_a = [(1-p) / p\ ] \times fa \times (Sca/ Sfa)$

$= (1-0.35/0.35) \times (510.918 \times 2.85/2.26)$

C_a = 764.660 kg/m3

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Where,

V = absolute volume of fresh concrete, which is equal to gross volume(m3) Volume of entrapped air,
W = Mass of water (kg) per m3 of concrete
C = Mass of cement (kg) per m3 of concrete
S_c = Specific gravity of cement
P = Ratio of FA to total aggregate by absolute volume
F_a, C_a = Total masses of FA and CA (kg) per m3 of concrete respectively and
S_{fa} S_{ca} = Specific gravities of saturated, surface dry fine aggregate and coarse aggregate respectively.

Mix Proportion then becomes

Cement	Fine Aggregate	Coarse aggregate
413.33	510.918	764.660
1	1.23	1.84

Mix proportion for M30 grade of concrete is 1 : 1.23 : 1.84

2. Investigational work conducted on concrete by replacing cement with flyAsh and sand stone dust with 0.5 % super plasticizer.

• Preparation of Specimens

Constant parameters
Mix proportion of concrete selected : 1:1.23:1.84
Type of cement : PPC
Type of aggregate
i. Sand : <1.47mm
ii. Stone dust : 150u – 4.75 mm
iii. Coarse Aggregates for compressive Test and split tensile test : <25mm
Period of curing : 7, 28 days
Super plasticizer : 0.5 %
Water cement ratio : 0.45

• Variable Parameters

Cement replaced by fly ash from 0% to 15% at the increment of 5%

• Details of mix designation:

Sr. No.	Mix Designation	Binding materials		Fine aggregate		Coarse aggregate	Admixture
		Cement	Fly-ash	Sand	Stone dust		Super Plasticizer
1.	F05	95%	5%	70%	30%	100%	0.5%
2.	F10	90%	10%	70%	30%	100%	0.5%
3.	F15	85%	15%	70%	30%	100%	0.5%
4.	F20	80%	20%	70%	30%	100%	0.5%

V. TEST RESULT

A. Effect of fly ash on Compressive Strength of concrete (N/mm2)

Mix Designation	7 Day	14 Day	28 Day
F05	23.51	25.65	32.30
F10	22.23	24.69	31.20
F15	19.22	21.79	26.93
F20	14.80	17.88	19.42

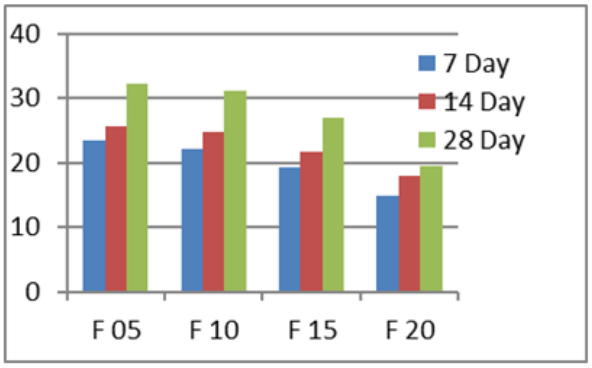

Fig. Variation in Compressive Strength

B. Effect of fly ash on split tensile Strength of concrete (N/mm2)

Mix Designation	7 Day	14 Day	28 Day
F05	2.33	3.32	3.79
F10	2.13	3.04	3.56
F15	1.88	2.75	3.23
F20	1.82	2.68	3.11

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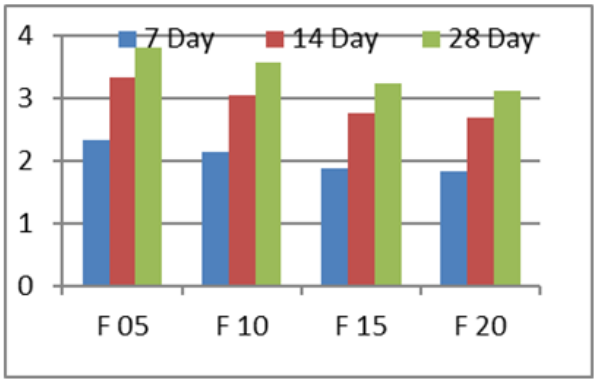

Fig. Variation in split tensile Strength.

C. Effect of fly ash on flexural Strength of concrete (N/mm2)

Mix Designation	7 Day	14 Day	28 Day
F05	2.22	4.08	6.68
F10	1.95	4.32	5.86
F15	1.81	3.90	5.43
F20	1.66	3.80	4.98

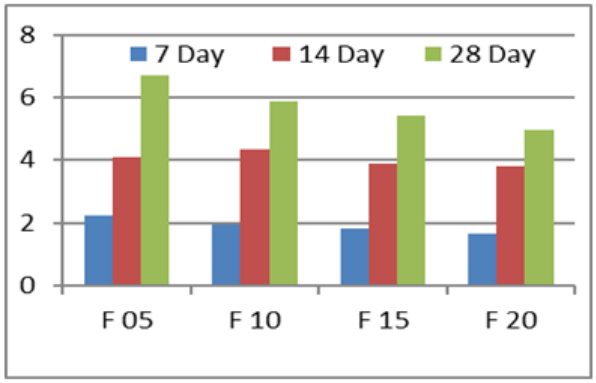

Fig. Variation in flexural Strength

Where,
F05 - 5% Replacement of Cement with Fly Ash & 30% of Sand with Stone Dust.
F10 - 10% Replacement of Cement with Fly Ash & 30% of Sand with Stone Dust.
F15 - 15% Replacement of Cement with Fly Ash & 30% of Sand with Stone Dust.
F20 - 20% Replacement of Cement with Fly Ash & 30% of Sand with Stone Dust.

VI. DICISION

• Due to addition of fly ash workability of concrete is reduced to vary low, hence there is need to super plasticizer.
• Compressive strength of concrete found within limit, up to 10% replacement, beyond which it reduces.
• Compressive strength of concrete is found to be good up to 30% replacement of sand with stone quarry dust.
• Split tensile strength and flexural strength of concrete goes on decreasing with the increase in percentage of added fly ash.

CONCLUSION

From the experimental investigation it can be concluded that,

• Concrete mix M30 (Design mix 1:1.2:1.8) gives satisfactory mechanical properties like compressive strength, split tensile strength and flexural strength up to 10% replacement of cement by fly ash and 30% replacement of sand by stone quarry dust with 0.5% super plasticizer.
• Concrete mix with above ingredient can be called as green concrete which should be promoted for its use which indirectly help to save environment and economy.

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