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Analysis of the Concrete Properties Prepared with Partial Replacement of Flyash

Prof. Nidhi Tiwari[1], Prof. Shobha Kundu[2], Prof. Prajkta Bondre[3], Prof. Pravin Sahare[4], Prof. Apurva Jibhkate[5]
[1, 2, 3, 4, 5] *Assistant Professor, G.H. Raisoni Academy of Engineering& Technology, Nagpur, India.*

Abstract: ***With advent of new generation admixtures, it is possible to achieve higher grades of concrete with high workability levels economically. Use of mineral admixtures like fly ash, slag, metakaolin and silica fume have revolution is the concrete technology by increasing strength and durability of concrete by many folds.***
Study the performance of fly ash as a sand replacing material (SRM) in concrete. The data analysis suggests that this concrete has a better strength to weight ratio and strength to energy ratio and hence it is a more eco-friendly and less energy intensive material.
The compressive strength of hardened concrete which is generally considered to be an index of its other properties depends upon many factors, e.g. quality and quantity of cement, water and aggregates, batching and mixing, placing, compaction and curing.
The cost of concrete is made up of the cost of materials, plant and labour.
From technical point of view the rich mixes may lead to high shrinkage and cracking in the structural concrete, and to evolution of high heat of hydration in mass concrete which may cause cracking.
The main objective of present article is giving a clear vision about to prepare the concrete mix design by IS 10262-1982 and IS 10262-2009, casting to enable a concrete technologist to design a economical concrete mix using Fly ash for a particular strength and durability, curing as well as compare the compressive strength for M20 grade of concrete with & without replacement of sand with fly ash.
Keywords: Fly ash, Mix Design, Compressive Strength of concrete.

I. 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.
Design of concrete mixes involves determination of the proportions of the given constituents namely cements, fine aggregate, coarse aggregate, water which would produce concrete possessing specified properties of both fresh and hardened states of the concrete with the maximum overall economy.
The proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely the plastics and hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted therefore, the property of workability becomes of vital importance.
Concrete mix design is the science of deciding relative proportions of ingredients of concrete, to achieve the desired properties in the most economical way.
Study the performance of fly ash as a sand replacing material (SRM) in concrete.
The data analysis suggests that this concrete has a better strength to weight ratio and strength to energy ratio and hence it is a more eco-friendly and less energy intensive material.
The present study focuses the comparative analysis of compressive strength of normal concrete with Flyash Concrete. As from the technical point of view the rich mixes with use of fly ash as a partial replacement of cement and sand is good Proposal to increase strength, workability & pump ability of concrete.

A. Objectives

1) The main objective is to perform various tests on ingredients of concrete and to determine the concrete mix constituents like cement, fine aggregate, coarse aggregate, fly-ash and water as per IS 10262:2009.
2) To prepare the concrete mix design by IS 10262-1982 and IS 10262-2009, casting and curing.
3) To find out the strength for M20 grade of concrete with & without replacement of sand with fly ash.
4) To study the effect of fly ash on properties of concrete.

5) To rectify the clause on fly ash given in IS 10262:2009.

B. Concept of fly ash

Fly ash is a by-product from coal-fired electricity generating power plants. Fly ash use improves concrete performance, making it stronger, more durable, and more resistant to chemical attack. Fly ash use also creates significant benefits for our environment.
The fly ash is generally used in the concrete in the following ways.

1) As partial replace for cement.
2) As partial replacement for sand.
3) As simultaneous replacement for both cement and sand.

It is found that fly ash replacement from l0 to 30% increases the development of strength up to 3 month or even more depending on the fineness of fly ash & its reaction with Calcium hydroxide released during primary hydration of cement.

C. Advantages Of Concrete Mix Design

Mix design aims to achieve good quality concrete at site economically.

1) Quality concrete means
a) Better strength
b) Better imperviousness and durability
c) Dense and homogeneous concrete
2) Economy Economy in cement consumption: It is possible to save up to 15% of cement for M20 grade of concrete with the help of concrete mix design.
3) Best use of available materials
4) Other properties: Mix design can help us to achieve form finishes, high early strengths. As fly ash become a common ingredient in concrete particularly for making high strength and high performance concrete, both in the fresh and hardened state. The few most important advantages can be summarized as follows:
a) Use of right quantity of fly ash, results in reduction of unit water content, bleeding and drying shrinkage will also be reduced.
b) The use of fly ash particles stimulating early strength development.
c) Better off-shutter finish and aesthetics
d) Improved long term strength and durability performance
e) Lower permeability and better resistance to chloride ingress and sulphate attack
f) The use of fly ash as concrete admixture not only extends technical advantages to the properties of concrete but also contributes to the environmental pollution control.

II. LITERATURE REVIEW

Raffat Siddique (1), evaluated the mechanical properties of concrete mixtures partially replaced with Class F fly ash. This study concluded indicate significant improvement in the strength properties of plain concrete by the inclusion of fly ash as partial replacement of fine aggregate (sand), and can be effectively used in structural concrete.
A.D. Pofale and S.V. Deo (2), Concluded, concrete aggregate will have early strength development as well as will enhance its strength on long term basis. Concrete with fly-ash was also found to be about 25% economical Prof. Jayeshkumar Pitroda(3),
Cement will reduce the permeability of concrete and calcium silicate hydrate(C-S H) adding fly-ash to concrete, will benefit both fresh & hardened states.
This improved workability allows for lower w/c ratios, which later leads to higher compressive strengths. In hardened state, fly-ash contributes in a number of ways including strength & durability.

III. METHODOLOGY

A. Testing of Materials.

1) Experimental Results

Materials	Parameters	Test Value
Coarse Sand	Fineness Modulus	2.42
	Specific gravity(10mm)	2.86
	Specific gravity(30mm)	2.77
	Water Absorption	93.98%
	Bulk density	1.386
Fine Aggregate	Fineness Modulus	2.39
	Specific gravity (30 mm)	2.76
	Water absorption	101.79%
	bulk density	1.588
Water	pH	7.05
Concrete	Slump	75 mm
Fly Ash	Specific gravity	2.173
	Fineness by Blains Air Permeability(kg/m^2)	420

2) *Concrete Mix Design:* The bureau of Indian standards, recommended a set of procedures for the design of concrete mix mainly based on the work done in national laboratories. The Mix design procedures are sentenced in IS 10262.The methods given can be applied for both medium and high strength concrete

3) Concrete Mix Design Calculation By IS 10262-1982:

Materials	*Parameters*	*Values*
Natural Sand	*Dry Bulk density*	*1.588 kg/lit*
	Source	*Bhandara*
	Specific gravity	*2.76*
	Fineness Modulus(FM)	*2.39*
Coarse Aggregate-I (10 mm)	*Dry Bulk density*	*1.386 kg/lit*
	Source	*Pachgaon*
	Specific gravity	*2.86*
	Fineness Modulus(FM)	*2.42*
Coarse Aggregate-I (30 mm)	*Dry Bulk density*	*1.434 kg/lit*
	Source	*Pachgaon*
	Specific gravity	*2.77*
	Fineness Modulus(FM)	*2.48*

B. Stipulatons for Proportioning

1) Grade Designation M20
2) Type of Cement OPC 43 grade confirming to IS- 8112:198
3) Maximum Nominal Aggregate Size 30 mm
4) Minimum Cement Content - 300 kg/m^3
……..(Table 1.a)
5) Maximum Water Cement Ratio - 0.55
…….(Table 1.a)
6) Workability – Medium (50mm -100 mm Slump)
……(Table-3)
7) Exposure Condition - Mild …...(Table 1.c)

8) Degree of Supervision - Good
9) Type of Aggregate - Crushed Angular Aggregate
10) Maximum Cement Content - 450 kg/m^3
(As per IS 456-2000,Clause 8.2.4.2)

C. Test Data for Materials
1) Cement Used - OPC 43 grade conforming to
IS 8112:1989
2) Fly Ash used – Conforming to IS 3812 (Part-I) 3. Sp. Gravity :
a) Cement - 3.15
b) Fly Ash – 2.173
c) Water - 1.00
d) 10 mm aggregate 2.86
e) 30 mm aggregate 2.77
f) Fine aggregate 2.605
3) Water Absorption:
a) Water Absorption of 20 mm Aggregate 0.7%
b) Water Absorption of 10 mm Aggregate 0.3%
c) Water Absorption of Sand 1%
4) Free (Surface) Moisture:
a) Coarse aggregate(10 mm)- Nil(absorbed moisture also nil)
b) Coarse aggregate(30 mm)- Nil
c) Fine aggregate – Nil

D. Target Strength for Mix Proportioning
Target Mean Strength
f'ck = fck +1.65 s
= 20 + 1.65 x 5= 28.25 N/sq.mm

E. Selection of Water Cement Ratio
From table 5 of IS 456, Maximum Water Cement Ratio=0.55 Based on experience, adopt water- cement ratio 0.50
0.50<0.55, hence ok

F. Selection of Water Content
Maximum Water content (10262-2009 table-2) – 175.5 lit. ….. (25-50mm slump range) (An increase by about 3% for every additional 25 mm slump as per IS 10262-2009) Estimated Water content for 75 mm Slump=175.5 + $\frac{6}{100}$ x 175.5 = 186 lit.

G. Calculation of Cement Content
W/C Ratio 0.5 Cement Content (186/0.5) = 372 kg/m^3 Minimum cement content for 'mild' exposure condition = 300 kg/m^3. (Table:5-IS 456) 372 kg/m^3 > 300 kg/m^3 Hence ok.

H. Proportion of Volume of Coarse Aggregate & Fine Aggregate Content
Volume of coarse aggregate corresponding to 30mm and 10mm size aggregate and fine aggregate Zone II for w/c ratio 0.50=0.60. (Table: 3-IS 456)
The volume of coarse aggregate required to increase to decrease the fine aggregate content as w/c ratio increase by 0.01%. Therefore, volume of coarse aggregate =0.60 + 0.01=0.61% For Aggregate size, 10 mm - 30% total volume of C.A = 0.183% 30 mm - 70% total volume of C.A = 0.427% Volume of F.A = 1-0.61 = 0.39%.

I. Mix Calculation

Materials	Values
Volume of concrete	1 m^3
Volume of cement	0.118 m^3
Volume of water	0.186 m^3
Volume of all in aggregate	0.696 m^3
Mass of Coarse Aggregate For, 10 mm 30 mm	359.56 kg. 812.57 kg.
Volume of fine aggregate	739.48 kg.

Volume of fine aggregate =0.696 x 0.39 x 0.9 x 2.76
x 1000 = 674.25 kg.
Volume of fly-ash = f x vol. of fly-ash x
sp.gr.of fly-ash x 1000
Volume of fly-ash = 0.696 x 0.39 x 0.1 x 2.173
x 1000 = 58.98 kg.

Similarly, all calculations are done for 20%, 30% & 40% replacement:

Replacement	Cement	Coarse Agg. Kg/Cu.m		Fine Agg. Kg/ Cu.m	Flyash Kg/ Cu.m	Water Kg/ Cu.m	Water/ Cement Ratio
(%)	(Kg)	10 mm	30 mm				
0	383.2	359.56	812.57	739.48	0	191.58	0.50
10	383.2	359.5	812.5	674.25	58.98	191.58	0.50
20	383.2	359.5	812.5	599.34	117.96	191.58	0.50
30	383.2	359.5	812.5	524.42	176.95	191.58	0.50
40	383.2	359.5	812.5	449.50	235.93	191.58	0.50

Fig-1: Fresh Concrete

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Fig-2: Checking compression of cubes

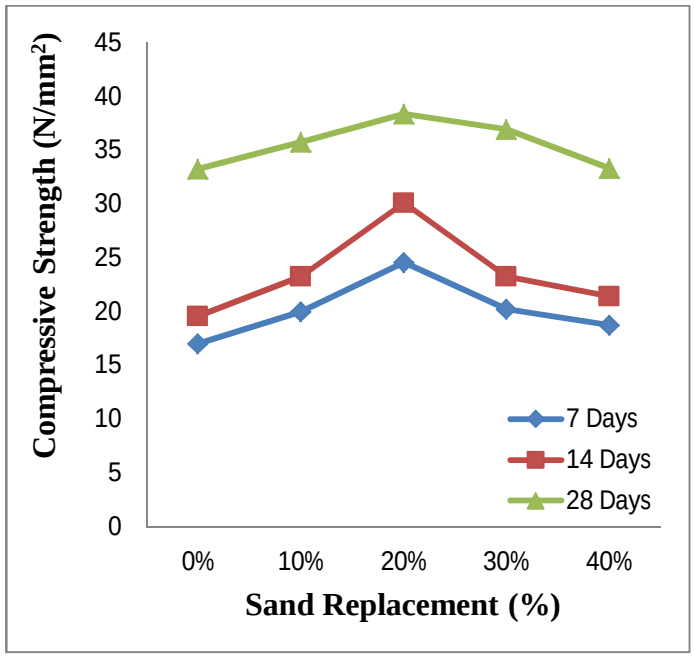
Sr No	Points	Nominal Mix Design	Concrete Mix Design
1	Ratio	M20 :-1 : 1.5 : 3 M25 :-1 : 1 : 2	M20 :-1 : 2.38 : 3.39 M25:- 1: 2.15: 3.20
2	Material	More Requirment	Less Requirment
3	Strength	M20 :-219 kg/cm^2 M25:- 336 kg/ cm^2	M20 :- 444 kg/ cm^2 M25 :- 537.67 kg/ cm^2
4	Workability	High	Medium

IV. CONCLUSION

The main key factor of designing concrete is to achieve the compressive strength of concrete.
The systematic processing and working of concrete mix design improves the quality and performance of concrete structures.
It also helps in economic usage of construction material such as sand, aggregate used in concreting ultimately making the project economical and viable.

A. Comparision

While comparing concrete mix design by 10262-1982 and concrete mix design by 10262-2009 with sand replacement we have observed that the strength and workability achieved in case of concrete having mix design proportion is high and far better as compare concrete having nominal mix proportion.



Graph-1: Compressive Strength compared for different % of Flyash Replacement with Sand.

The strength given by cube with the replacement of fly ash by sand 20% is more as compared to 0%, 10%, 20%, 30%. The reduction in strength of concrete with the increase of fly ash more than 20%.The result or conclusion will help to design the concrete mix with the replacement of fly ash up till 20% top achieve good strength and to make concrete more economical.

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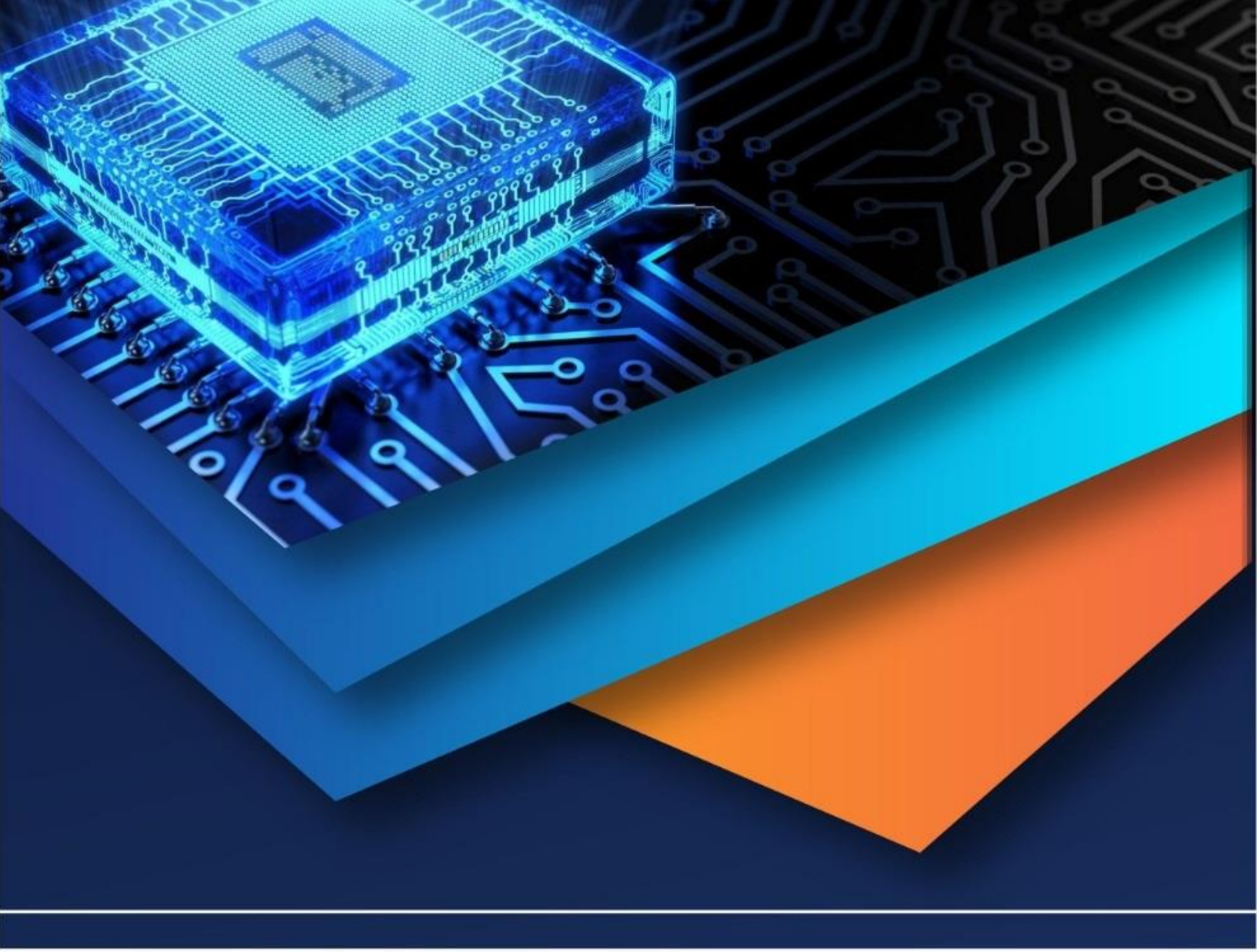

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