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An Experimental Study of Fibrous Triple Blended High Strength Concrete with Fly Ash and Condensed Silica Fume

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***Abstract* - Concrete is the most widely used construction material employed for the construction of various types of structures including buildings, roads, bridges, dams etc. Since many centuries, there have been several mere structures and some civil engineering marvels that have been constructed over time all over the world. Some with the idea to shelter people or to store water etc. while some with the idea of creating a historical symbol like the India Gate.**

Keywords: Compressive Strength Flexural Strength Of Concrete Flyash And Silica Fume.

INTRODUCTION

Concrete, is one of the key construction materials having good compressive &, flexural strengths and durable properties among others. With comparative low cost made from some of the most widely available elements, it has found wide usage. It is mouldable, adaptable and relatively fire resistant. The fact that it is an engineered material which satisfy almost any reasonable set of performance specifications, more than any other material currently available has made it immensely popular construction material. In fact, every year more than 1 m^3 of concrete is produced per person (more than 10 billion tonnes) worldwide.

What is trible blended concrete?

Triple blended concretes belong to that strata of concretes where the strength and durability characteristics are maximized to the highest extent possible, in comparison to various other types of concretes, by subtle tailoring of its chemical composition, fineness and particle size distribution. Greater varieties are introduced by the incorporation of additives like pozzolana, granulated slag or inert fillers. These lead to different 'specification' of cements in national and international standards.

EXPERIMENTAL INVESTIGATIONS

Materials Used In Present Work Cement

Ordinary Portland cement 53 grade brand conforming to I.S.I standard is used in the present investigation. The physical properties of cement are listed in the Table 1.1

Table 1.1	Physical properties of cement		
	Components	*Results*	*Requirements*
1.	Normal consistency	28.66%	Min 300
2.	Specific gravity	2.99	------
3.	Initial setting time Final setting time	30 min 160 min	Min 30
4.	Soundness (expansion) lechatlier Method	2 min	Max 600
5.	Fineness of cement	3050	Max 10
6.	Compressive strength of cement mortar cubes a) 7 days b) 28 days	 33 N/mm² 52 N/mm²	Min 33

Fine Aggregate

The locally available sand is used as fine aggregate in the present investigation. The sand is free from clayey matter, salt and organic impurities. The sand is tested for various properties like specific gravity, bulk density etc., in accordance with IS 2386-1963(28). Grain size distribution of sand shows that it is close to the zone 1 of IS 383-1970(29). The properties of sand are shown in Table 1.2

Table 1.2	Physical properties of fine aggregate		
	Property	Result	Remarks
1.	Specific gravity	2.68	--------
2.	Density	1640 kg/m³	---------
3.	Fineness Modulus	2.78	--------

Coarse Aggregate

Machine crushed angular granite metal from the local source is used as coarse aggregate. It is free from impurities such as dust, clay particles and organic matter etc. The coarse aggregate is also tested for its various properties.

The specific gravity and fineness modulus of coarse aggregate are 2.64, 7.14 respectively. The bulk density of coarse aggregate is 1700 kg/m³. The details are tabulated in table 3.6. Sieve analysis is carried out ant grading results are shown in the Table 1.3.

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Table 1.3	Properties of coarse aggregate		
	Property	*Value*	*Remarks*
1.	Specific Gravity	2.64	-------
2.	Density	1700kg/m³	--------
3.	Fineness Modulus	7.14	--------

Fly Ash

Fly ash, an artificial pozzolanna is the unburned residue resulting, from combustion of pulverized coal or lignite. It is collected by mechanical or electrostatic separators called hoppers from flue gasses of power plants where powdered coal is used as fuel. This material, once considered as a by-product finding difficulty to dispose off, has now become a material of considerable value when used in conjunction with concrete as an admixture. Its physical and chemical properties are shown in the table 1.4 & 1.5.

Table-1.4	physical properties of fly ash	
	Property	*Results*
1	Particle Size	1 to 150 µm
2	Fineness	7-12 µm
3	Specific Gravity	1.3-4.8

Table 1.5	Chemical properties of fly ash		
	Constituents	*Value(%)*	*Remarks*
	SiO_2	49-67	
	Al_2O_3	16-33	
	Fe_2O_3	4-10	
	CaO	1-4	
	MgO	0.2-2.0	----
	SO_3	0.1-2.0	
	Na_2O	0.1-0.2	
	K_2O	0.1-1.0	
	LOI	0.1-1.6	

Silica Fume

Condensed Silica fume, also known as microsilica, is a dry amorphous powder which, when added with standard cements will increase the durability and strength of the concrete as well as reducing permeability and improving abrasion-erosion resistance. It may also be used in many applications where high strength is required.

The addition of silica fume produces concrete with reduced permeability resulting in increased water tightness enhanced chemical resistance and reduced corrosion of reinforcing steel. Its physical and chemical properties are shown in the table 1.6 & 1.7

Table-1.6	Physical properties of fly ash	
	Property	*Results*
1	Particle Size	< 1 µm
2	Bulk Density	130-430 kg/m³
3	Specific Gravity	1.3-4.8
4	Specific Surface	15000-30000 m²/kg

Table 1.7	Chemical properties of fly ash		
	Constituents	*Value(%)*	*Remarks*
1	SiO_2	>85%	----
2	Amorphous	highly	------

Water

Potable water has been used in the experiment for mixing and curing.

Super Plasticizer

The super plasticizer used in this experiment is SP430. It is manufactured by FOSROC.

Super plasticizers are new class of generic materials which when added to the concrete causes increase in the workability. They consists mainly of naphthalene or melamine sulphonates, usually condensed in the presence of formaldehyde.

RESULTS AND DISCUSSION

Compressive Strength

Compressive strength of M80 grade concrete cubes with various percentages of Fly ash, Silica Fume & Fibre:

1. Variation of compressive strength at 28 days with addition of 0% fibre by volume of concrete and with various % of Silica Fume and Fly ash

Table-1.8	Compressive Strength (MPa) of Concrete			
	Silica fume %	*Fly ash %*	*Compressive Strength, MPa*	
			28 days	*% increase over 0%*
1	0	0	76.24	
2	5	0	77.89	2.16
3	10	0	78.94	3.54
4	15	0	78.42	2.85
5	0	20	77.59	1.77
6	5	20	78.50	2.96
7	10	20	79.48	4.24
8	15	20	79.25	3.94
9	0	40	77.12	1.15
10	5	40	78.26	2.64
11	10	40	79.19	3.86
12	15	40	78.75	3.29

2. Variation of compressive strength at 28 days with addition of 0.5% fibre by volume of concrete and with various % of Silica Fume and Fly ash

Table-1.9	Compressive Strength (MPa) of Concrete			
	Silica fume %	*Fly ash %*	*Compressive Strength, MPa* 28 days	*% increase over 0%*
1	0	0	77.21	
2	5	0	78.94	2.24
3	10	0	79.47	2.92
4	15	0	79.15	2.51
5	0	20	78.14	1.20
6	5	20	79.59	3.08
7	10	20	79.96	3.56
8	15	20	79.56	3.04
9	0	40	77.83	0.80
10	5	40	79.18	2.55
11	10	40	79.62	3.12
12	15	40	79.38	2.81

3. Variation of compressive strength at 28 days with addition of 1% fibre by volume of concrete and with various % of Silica Fume and Fly ash

Table-2.0	Compressive Strength (MPa) of Concrete			
	Silica fume %	*Fly ash %*	*Compressive Strength, MPa* 28 days	*% increase over 0%*
1	0	0	79.69	
2	5	0	80.23	0.67
3	10	0	80.68	1.24
4	15	0	80.29	0.75
5	0	20	80.17	0.60
6	5	20	80.78	1.36
7	10	20	81.20	1.89
8	15	20	80.64	1.19
9	0	40	79.98	0.36
10	5	40	80.51	1.02
11	10	40	80.82	1.41
12	15	40	80.40	0.89

Flexural strength

Flexural strength of M80 grade concrete beams with various percentages of Fly ash, Silica Fume & Fibre:

1. Variation of flexural strength at 28 days with addition of 0% fibre by volume of concrete and with various % of Silica Fume and Fly ash

Table-2.1	Flexural Strength (MPa) of Concrete			
	Silica fume %	*Fly ash %*	*flexural Strength, MPa* 28 days	*% increase over 0%*
1	0	0	6.40	
2	5	0	6.90	7.81
3	10	0	7.10	10.93
4	15	0	6.90	7.81
5	0	20	6.60	3.12
6	5	20	7.10	10.93
7	10	20	7.31	14.21
8	15	20	7.10	10.93
9	0	40	6.50	1.56
10	5	40	7.00	9.37
11	10	40	7.20	12.50
12	15	40	7.02	9.68

2. Variation of flexural strength at 28 days with addition of 0.5% fibre by volume of concrete and with various % of Silica Fume and Fly ash

Table-2.2	Flexural Strength (MPa) of Concrete			
	Silica fume %	*Fly ash %*	*flexural Strength, MPa* 28 days	*% increase over 0%*
1	0	0	7.17	
2	5	0	7.40	3.20
3	10	0	7.70	7.39
4	15	0	7.60	5.99
5	0	20	7.30	1.81
6	5	20	7.60	5.99
7	10	20	7.90	10.18
8	15	20	7.80	8.78
9	0	40	7.20	0.41
10	5	40	7.50	4.60
11	10	40	7.80	8.78
12	15	40	7.70	7.39

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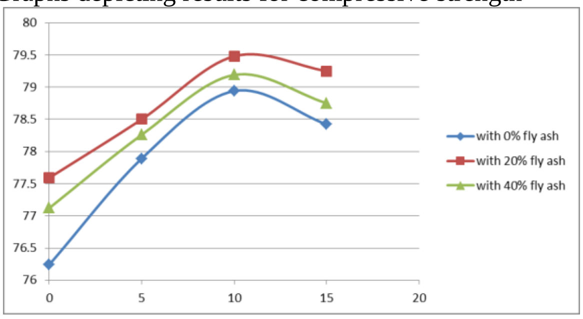
3. Variation of flexural strength at 28 days with addition of 1% fibre by volume of concrete and with various % of Silica Fume and Fly ash

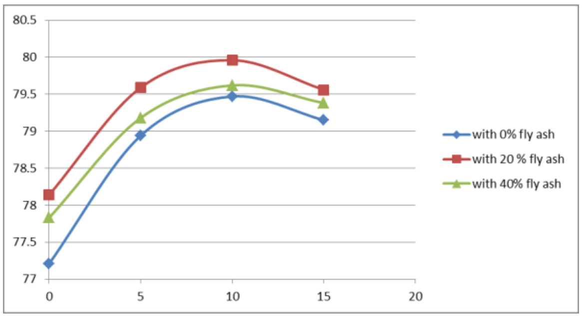
Table-2.3	Flexural Strength (MPa) of Concrete			
	Silica fume %	*Fly ash %*	*flexural Strength, MPa*	
			28 days	*% increase over 0%*
1	0	0	7.50	
2	5	0	7.80	4.0
3	10	0	8.10	8.0
4	15	0	8.00	6.66
5	0	20	7.70	2.66
6	5	20	8.04	7.2
7	10	20	8.40	12.0
8	15	20	8.20	9.33
9	0	40	7.60	1.33
10	5	40	7.90	5.33
11	10	40	8.20	9.33
12	15	40	8.10	8.0

Graphs

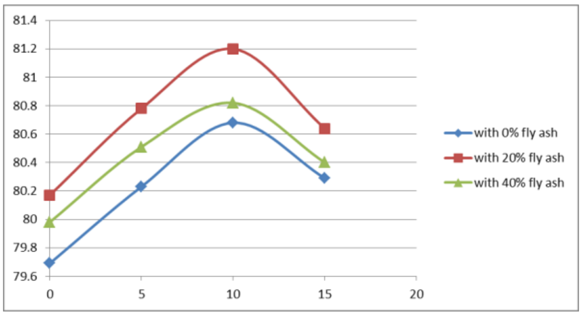
1. Graphs depicting results for compressive strength



Graph 1: variation of compressive strength with various percentages of Fly ash and Silica Fume with 0% fibre

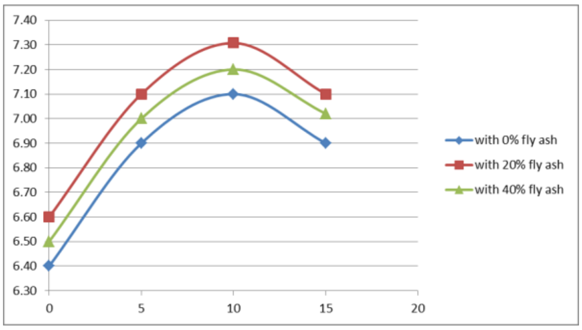


Graph 2: variation of compressive strength with various percentages of Fly ash and Silica Fume with 0.5% fibre

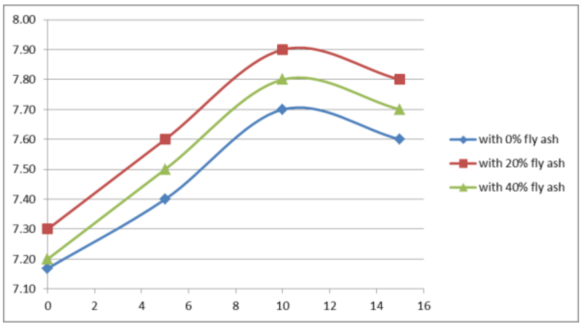


Graph 3: variation of compressive strength with various percentages of Fly ash and Silica Fume with 1% fibre

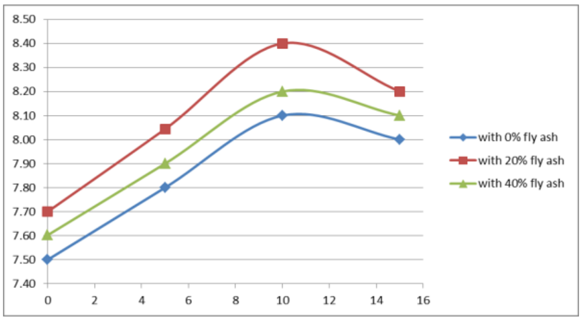
2. Graphs depicting results for flexural strength



Graph 1: variation of flexural strength with various percentages of Fly ash and SilicaFume with 0% fibre



Graph 2: variation of flexural strength with various percentages of Fly ash and SilicaFume with 0.5% fibre



Graph 3: variation of flexural strength with various percentages of Fly ash and SilicaFume with 1% fibre

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CONCLUSIONS

The following conclusions are drawn from this study:

1. Higher dosages of superplasticizer are required for high strength concrete mixes particularly when mineral admixtures and fibres were employed to maintain workability.
2. For this combination of 10% silica fume with 20% fly ash the compressive strength has shown an increase from 2 to 7 % with various percentages of fibre
3. 20% fly ash generates marginal increase in strength. To compensate for the loss of strength when higher percentages of fly ash is used silica fume is added
4. Fly ash is pozzolanic in nature and slowly reacting and it requires longer curing periods even beyond 28 days to generate high strength particularly when percentage is more
5. As the percentage of steel fibre is increased there is marginal increase in the compressive strength for all the combinations
6. For this combination of 10% silica fume with 20% fly ash the compressive strength has shown an increase from 15 to 31.5 % with various percentages of fibre
7. As the percentage of steel fibre is increased there is higher increase in the flexural strength for all the combinations
8. An optimum high strength concrete mix possessing optimum strength properties can be obtained resorting to triple blending.

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