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STUDY OF THE PROPERTIES OF HIGH STRENGTH CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH

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ABSTRACT

in concrete imparts several environmental benefits and thus it is eco- friendly. It saves the cement requirement for the same strength thus saving of raw materials such as limestone, coal etc required for manufacture of cement. Cement is a costly component of concrete. Even though, it is available without any scarcity, it involves high energy consumption for it"s production. Hence, it is advisable to minimize the use of cement. However, concrete is a highly versatile construction material because of it's strength, durability and mould ability. Therefore, it is highly worthful to search for an alternate material which can replace cement without compromising the quality of concrete. Fly ash is one such material which is considerably cementitious in nature.

Therefore, the search of any other such material which can be used as an alternative to cement should lead to lowest possible environmental impact. The fly ash obtained by combustion of coal can be used as partial replacement for cement owing to its pozzolanic nature, which provides strength to cement. The huge quantity of fly ash being accumulated over the years is likely to pose a serious threat for its disposal and cause environmental problems.

In this project, an effort has been made to determine the effect on strength characteristics of high strength concrete by partial replacement of cement with 0%, 10%, 20%, 30% and 40% of cement with fly ash for M30 and M40 grade of concrete. Test results indicate that workability and durability of concrete increases with increase in fly ash content. It has also been obtained that with increase in fly ash content, there is reduction in compressive strength of concrete. The optimum replacement of cement with fly ash is 30%.

1. INTRODUCTION

Use of industrial by-products in concrete will show the way to green environment and such concrete can be called as "Green Concrete". There are various types of industrial wastes which can be considered for usage in concrete. The most commonly used industrial waste to replace sand and cement in concrete are Fly Ash, Rice Husk Ash, Blast Furnace Slag, Pond ash, Red Mud and Phosphor, Gypsum, Silica Fume, Fumed silica, Crushed glass, Eggshells. India depends primarily on coal for the necessity of power and its power generation and it is likely to go up with each passing day. The fly ash generation in Indian Thermal Stations is likely to shoot up to several million tonnes. The dumping of fly ash will be a huge problem to environment, especially when the quantity increases from the present level. Ash is the residue generated after combustion of coal in Thermal Power Plants. Size of the particles of ash varies from 1 micron to 600 microns. The very fine particles (Fly ash) collected from this ash collected by electrostatic precipitators are being used in the manufacture of blended cements. Unused Fly ash and Bottom ash (residue collected at the bottom of furnace) are mixed in slurry form and deposited in ponds which are called as Ash ponds. Hence worldwide research work is focused to find alternative use of this waste material and its use in concrete industry is one of the effective methods of utilization. Increase in demand and decrease in natural resource of fine aggregate for the production of concrete has resulted in the need of identifying a new source of fine aggregate. The possibility of utilization of Thermal Power Plant by-product Pond ash, as replacement to fine aggregate in concrete is taken into consideration.Cement is a costly component of concrete. Even though, it is available without any scarcity, it involves high energy consumption for it"s production. Hence, it is advisable to minimize the use of cement. However, concrete is a highly versatile construction material because of it"s strength, durability and mouldability. Therefore, it is highly worthful to search for an alternate material which can replace cement without compromising the quality of concrete. Fly ash is one such material which is considerably cementitious in nature.

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2. CONSTITUENT MATERIALS USED

The constituent materials used are cement, fine aggregate, coarse aggregate, stone dust and water. The recommended materials have been described below.

Cement

Various types of cement can be used in concrete with stone dust. The cement should be fresh, free from foreign matters and of uniform consistency. Usually ordinary Portland cement is used in normal conditions.

Fine Aggregate

The most common fine aggregate used in concrete is sand. The sand should be clean, hard, strong and free from organic impurities and deleterious substances. It should be capable of producing a sufficiently workable mix with a minimum water-cement ratio.

Coarse Aggregate

The aggregates are formed due to natural disintegration of rocks or by artificial crushing of the rock or gravels. The properties of coarse aggregate are chemical and mineral composition, spectrographic description, specific gravity, hardness, strength, physical and chemical stability, pore structure and color. Some other properties of the aggregate not possessed by the parent rocks are particle size and shape, surface texture and absorption etc. All these properties may have a considerable effect on the quality of concrete in fresh and hardened states.

Fly Ash

Fly ash Class F fly ash is used in this study. Fly ash is a waste product generated in thermal power plants. During the combustion of pulverized Coal in thermal power plants, the volatile matter is vaporized and the majority of Carbon is burnt off. The mineral matter associated with coal such as Clay, quartz and felsbar will disintegrate to varying degree. This unburnt Carbon is collected as ash. The coarser particles fall in the bottom of the furnace. The finer particles are collected using cyclone separators. It is termed as fly ash. In this study the Fly ash has been procured from ready mix plants Situated near industrial area Nalagarh -Bhud road Baddi.

Water

Mixing water should be fresh, clean and potable. Water should be free from impurities like clay, loam, soluble salts which lead to deterioration in the properties of concrete. Potable water is fit for mixing or curing of concrete.

3. MIX DESIGN

Design Mix For M30 Grade Concrete

Mix design is made according to the IS specifications [BIS 10262-1982 and BIS 456-2000]. The sand used is of zone II obtained from Dera Bassi Panjab. moulds are made on the basis of mix design and various tests are done on these moulds in order to check the strength parameters. The mix design is as follows:

Mix design by Indian standard method:
28 day Compressive strength = 30 N/mm2
Degree of quality control = Good
Maximum size of coarse aggregate = 20 mm
Degree of workability (Compaction Factor) = 0.9
Value of statistical coefficient(K) =2 (Refer IS 456-2000 clause 9.2.2)
Value of standard deviation (S) =4.00 (refer IS 456-2000 Table 8)
Type of Exposure = Mild

Test data of materials:

- Cement used = OPC 53 grade
- Specific gravity of cement =3.01
- Specific gravity of fine aggregate =2.64
- Specific gravity of coarse aggregate =2.72

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Mix Proportion of M-30 concrete

Mix designation	Sand confirming to zone	Water	Cement	Fine aggregate	Coarse aggregate
M30 X	**II**	**175 lt/m³**	**350 kg/m³**	**687.042 kg/m³**	**1241.479 kg/m³**
			1	**1.96**	**3.54**

Design Mix For M40 Grade Concrete
Mix design by Indian standard method:
28 day Compressive strength = 30 N/mm2
Degree of quality control = Good
Maximum size of coarse aggregate = 20 mm
Degree of workability (Compaction Factor) = 0.9
Value of statistical coefficient(K) =2 (Refer IS 456-2000 clause 9.2.2)
Value of standard deviation (S) =4.00 (refer IS 456-2000 Table 8)
Type of Exposure = Mild

Test data of materials:
- Cement used = OPC 53 grade
- Specific gravity of cement =3.01
- Specific gravity of fine aggregate =2.64
- Specific gravity of coarse aggregate =2.72

Mix Proportion of M-40 concrete

Mix designation	**Sand confirming to zone**	**Water**	**Cement**	**Fine aggregate**	**Coarse aggregate**
M X40	II	175 lt/m³	437.5 kg/m³	663.882 kg/m³	1164.64 kg/m³
			1	1.52	2.66

4. NOMENCLATURE OF TEST SPECIMENS

Mix Designation for M-30 Concrete

MIX DESIGNATION	**Fly Ash (%)**	**Water kg/m³**	**Cement kg/m³**	**Fine aggregate kg/m³**	**Coarse aggregate kg/m³**	**Fly Ash kg/m³**
MX30-A	0	175	350	687.042	1241.479	0
MX30-B	10	175	315	687.042	1241.479	35
MX30-C	20	175	280	687.042	1241.479	70
MX30-D	30	175	245	687.042	1241.479	105
MX30-E	40	175	210	687.042	1241.479	140

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Mix Designation for M-40 concrete

MIX DESIGNATION	Fly Ash (%)	Water kg/m³	Cement kg/m³	Fine aggregate kg/m³	Coarse aggregate kg/m³	Fly Ash kg/m³
MX40-A	0	175	437.5	663.882	1164.64	0
MX40-B	10	175	393.75	663.882	1164.64	43.75
MX40-C	20	175	350	663.882	1164.64	87.5
MX40-D	30	175	306.25	663.882	1164.64	131.25
MX40-E	40	175	262.5	663.882	1164.64	175

5. TESTING OF SPECIMENS

The cubes were tested in compression testing machine after 7 and 28 days with uniformly increasing loads capacity compression testing machine. The loading was transmitted from loading machine to the specimen by rigid steel plates placed on both above and below the specimen. The load was applied until needle started deflecting backward after crushing of the specimen and the last reading was noted.

The beams were tested in a frame having varying capacity with two point load test. The specimens were divided in three parts equally and two point loads were kept at the end of middle third part of specimen and the load was applied through cylindrical iron piece kept below the dial gauge.

The cylinders were tested in compression testing machine with uniformly increasing capacity compression testing machine. The test consists of applying a compressive line load along the opposite generators of a concrete cylinder placed with its axis horizontal between the compressive platens

6. RESULT ANAYLSIS

SLUMP TEST: The mould was cleaned from inside and was filled in four layers with concrete. Each layer was compacted by twenty-five strokes of the rounded end of 16 mm diameter tamping rod. The strokes were distributed uniformly over the cross section of the mould. The excess mass of concrete was struck off with the help of trowel after tamping the top layer. The mould was removed from concrete immediately by raising it slowly and carefully in a vertical direction.

Slump flow test result for M-30 concrete

S.No.	MIX DESIGNATION	Slump Height(mm)
1	MX30-A	54
2	MX30-B	56
3	MX30-C	59
4	MX30-D	60
5	MX30-E	58

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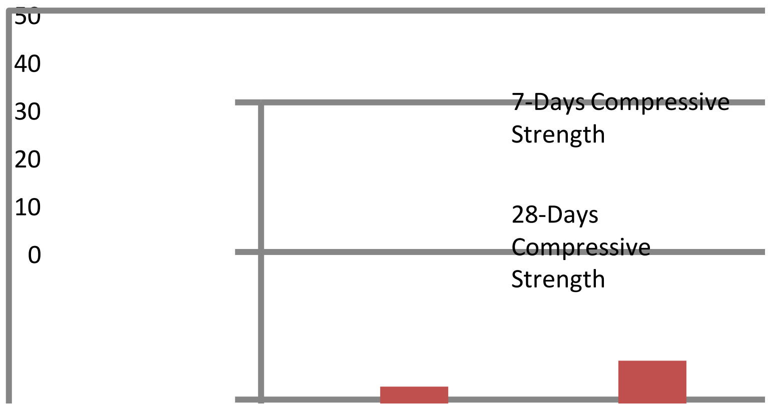
Slump flow test result for M-40 concrete

S.No.	MIX DESIGNATION	Slump Height(mm)
1	MX40-A	62
2	MX40-B	64
3	MX40-C	67
4	MX40-D	69
5	MX40-E	67

- **COMPRESSIVE STRENGTH OF M30 AND M40 CONCRETE:** The compressive strength was conducted on various specimens as per the guidelines given in IS 516-1959.Compressive strength of cube at 7 days and 28 days are shown in table

Compressive Strength for M-30 Concrete

Mix Designation	7-Days Compressive Strength	28-Days Compressive Strength
MX30-A	20.49	30.82
MX30-B	22.07	32.68
MX30-C	22.85	34.21
MX30-D	23.12	**38.16**
MX30-E	**22.86**	37.04



Graph Comparison of Compressive Strength for M-30 Concrete

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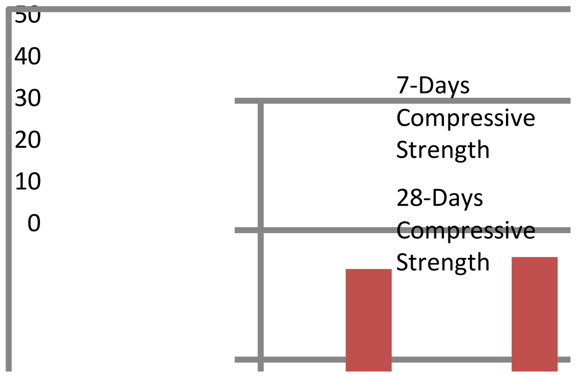
Compressive Strength for M-40 Concrete

Mix Designation	7-Days Compressive Strength	28-Days Compressive Strength
MX40-A	25.08	37.07
MX40-B	26.07	37.92
MX40-C	27.64	40.79
MX40-D	**31.05**	**44.27**
MX40-E	27.15	38.74



Graph Comparison of Compressive Strength for M-40 Concrete

FLEXURE STRENGTH TEST: Although the concrete is not designed to resist tension, the knowledge of tensile strength of concrete is of value in assessing the load at which crack will start appearing in concrete. Flexural Strength of specimen at 7 Days and 28 days are shown in Table

Flexural Strength for M-30 Concrete

Mix Designation	7-Days Flexural Strength	28-Days Compressive Strength
MX30-A	20.49	30.82
MX30-B	22.07	32.68
MX30-C	22.85	34.21
MX30-D	23.12	**38.16**
MX30-E	**22.86**	37.04

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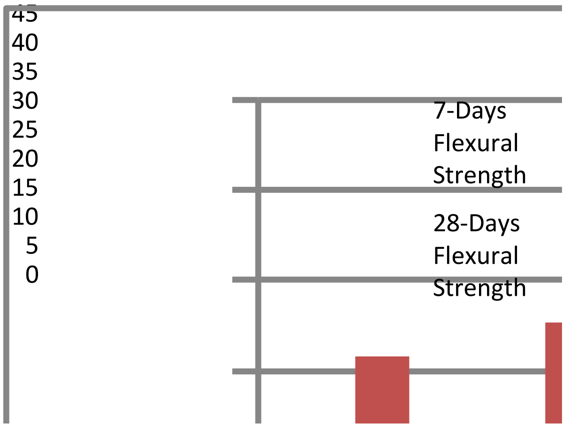
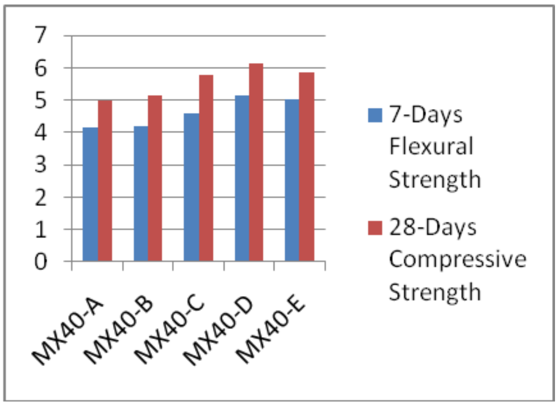


Graph Comparison of Flexural Strength for M-30 Concrete

Flexure Strength for M-40 Concrete

Mix Designation	7-Days Flexural Strength	28-Days Flexural Strength
MX40-A	4.15	4.98
MX40-B	4.2	5.15
MX40-C	4.58	5.79
MX40-D	**5.15**	**6.12**
MX40-E	5.02	5.85



Graph Comparison of Flexural Strength for M-40 Concrete

- **SPLIT TENSILE STRENGTH TEST** : The split tensile strength of concrete was conducted on various mixes as per guidelines of IS 516-1970.Split Tensile strength of 7 and 28 days are shown in Table.

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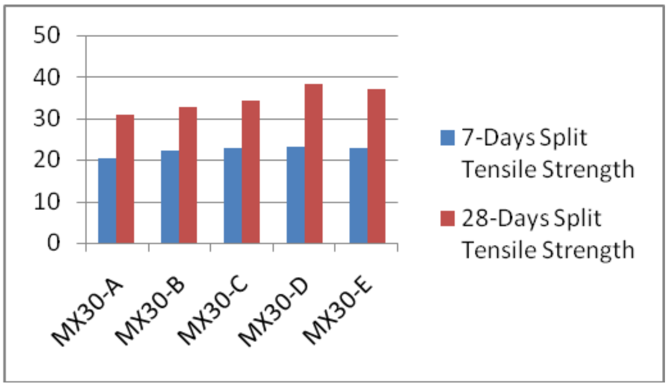
Split Tensile Strength for M-30 Concrete

Mix Designation	7-Days Split Tensile Strength	28-Days Split Tensile Strength
MX30-A	20.49	30.82
MX30-B	22.07	32.68
MX30-C	22.85	34.21
MX30-D	23.12	**38.16**
MX30-E	**22.86**	37.04



Graph comparison of Split Tensile Strength for M-30 Concrete

Split Tensile Strength for M-40 Concrete

Mix Designation	7-Days Split Tensile Strength	28-Days Split Tensile Strength
MX40-A	4.15	4.98
MX40-B	4.2	5.15
MX40-C	4.58	5.79
MX40-D	**5.15**	**6.12**
MX40-E	5.02	5.85

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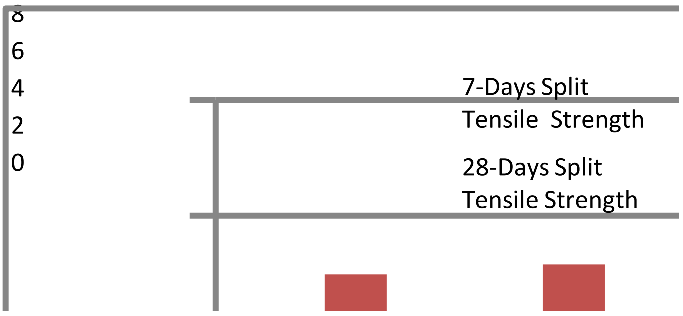

Graph comparison of Split Tensile Strength for M-40 Concrete

7. CONCLUSIONS

A series of laboratory experiments was conducted to find the fresh properties of concrete like Workability and also the testing on hardened concrete is also done to find compressive strength, split tensile strength, and flexural strength of concrete with several percentage of marble powder. The effects of fly ash on these properties are studied. The following are the conclusions that can be drawn from the experimental investigation.

- As shown from the values obtained the slump value increased for partial replacement cement with fly ash up to 30% and then it decreased.
- Compressive strength of the mortar design mix was check by casting and testing of cubes after the curing period of 7 days & 28days and the optimium value is obtained at 30%.
- The optimum value for flexural strength is obtained from the replacement of 30%.
- The optimum value for split tensile testis obtained from the replacement of 30%.

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