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Mechanical Behavior of Flyash Concrete

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ABSTRACT

The utilization of fly-ash in concrete as partial replacement of cement is gaining huge importance these days, principally on account of the development within the future sturdiness of concrete combined with ecological advantages. Technological enhancements in thermal power station operations and fly-ash assortment systems have resulted in up the consistency of fly-ash. To review the impact of partial replacement of cement by fly ash studies are conducted on concrete mixes with 300 to 500 kg/cum cementious materials at 15%, 20%, 25%,30% & 35% fly ash replacement levels. during this project the result of fly-ash on workability, setting time, density, air content, compressive strength, durability, size of aggregate, modulus of elasticity Slump test and Compaction test are studied based on this study compressive strength of different mixes v/s No of days curves are planned so concrete mixture of grade M25 with distinction proportion of fly-ash are often directly designed.

Keywords: fly-ash, impact of partial replacement workability, setting time, density, air content, compressive strength, durability, size of aggregate, modulus of elasticity Slump test and Compaction test

1. INTRODUCTION

Concrete is the manmade material widely used for construction purposes. The usual ingredients in concrete are cement, fine aggregate, coarse aggregate, and water. It was recognized long time ago that the suitable mineral admixtures are mixed in optimum proportions with cement improves the many qualities in concrete. With increasing scarcity of river sand and natural aggregate across the country, researches began cheaply available material as an alternative for natural sand. Utilization of industrial waste or secondary material has increased in construction field for the concrete production because it contributes to reducing the consumption of natural resources. In India, there is great demand of aggregates mainly from civil engineering industry for road and concrete constructions. But, now days it is very difficult problem for availability of fine aggregates. So researchers developed waste management strategies to apply for replacement of fine aggregates for specific need. Natural resources are depleting worldwide while at the same time the generated wastes from the industry are increasing substantially. The sustainable development for construction involves the use of nonconventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment.

There are many types of concrete available, created by varying the proportions of the main ingredients below. In this way or by substitution for the cementitious and aggregate phases, the finished product can be tailored to its application with varying strength, density, or chemical and thermal resistance properties.

"Aggregate" consists of large chunks of material in a concrete mix, generally a coarse gravel or crushed rocks such as limestone, or granite, along with finer materials such as sand. Cement, commonly Portland cement, and other cementitious materials such as fly ash and slag cement, serve as a binder for the aggregate. Water is then mixed with this dry composite, which produces a semi-liquid that workers can shape (typically by pouring it into a form). The concrete solidifies and hardens to rock-hard strength through a chemical process called hydration.

Figure 1: Flyash

1.1 Objective and scope Of This Study

The main objective of replacement of fine aggregate and cement is to increase the strength of concrete by partial replacement of cement by fly ash. Specific objectives are To experimentally investigate the strength of concrete with partial replacement of cement with Fly ash and to compare convectional concrete by conducting, Compressive test & Split tensile strength.

To study the workability of concrete containing fly ash.

Total 51 concrete specimens, representing one batch of concrete is made and tested as part of this study. While mixing procedure and slump were kept constant, the variables studied included fly ash content, cementitious content, mixing temperature, the effect of mixing time, test age, and curing conditions. In this study, the research approach followed was to investigate the basic interactions among concrete components in mix proportions which are suitable for producing concrete containing fly ash, i.e., fly ash content, and cementitious content.

2. LITERATURE REVIEW

Aman Jatale, Kartiey Tiwari, Sahil Khandelwal (2013), "A study on Effects on Compressive Strength When Cement is Partially Replaced by Fly Ash". The present paper deals with the effect on strength and mechanical properties of cement concrete by using fly ash. The utilization of fly- ash in concrete as partial replacement of cement is gaining immense importance today, mainly on account of the improvement in the long term durability of concrete combined with ecological benefits. Technological improvements in thermal power plant operations and fly-ash collection systems have resulted in improving the consistency of fly-ash. To study the effect of partial replacement of cement by fly-ash, studies have been conducted on concrete mixes with 300 to 500 kg/cum cementitious materials at 20%, 40%, 60% replacement levels.

Arivalagan. S (2013), A Study on Experimental Study on the Flexural Behavior of Reinforced Concrete Beams as Replacement of cement by fly ash". In this investigation replacement of cement by fly ash was done to depict the compressive strength of cubes, flexural strength of beams and split tensile strength of cylinders. The fly ash added with cement to find out the results of concrete proportion ranging from 15%, 20%, 35%, 40%, 50%. The maximum (35.11Mpa) compressive strength was obtained in 40% replacement. The results also revealed the effect of fly ash on RCC concrete elements which shows increment in all compressive strength, split tensile, flexural strength and energy absorption characters

Prof. JayeshkumarPitrod, Dr. L.B.Zala, Dr.F.S.Umrigar, (2012) A study on Experimental investigations on partial Replacement of cement with fly ash in design Mix concrete. In recent years, many researchers have established that the use of supplementary cementitions materials (SCMs) like fly ash (FA), blast furnace slag, silica fume, metakaolin, and rice husk ash (RHA), hypo sludge etc. can, not only improve the various properties of concrete - both in its fresh and hardened states, but also can contribute to economy in construction costs. This research work describes the feasibility of using the thermal industry waste in concrete production as partial replacement of Replacement of cement with fly ash.

Rafat Siddique,(2004) A study on Effect of fine aggregate replacement with class F fly ash on the properties of concrete. This paper presents the results of an experimental investigations carried out to evaluate the mechanical properties of concrete mixtures in which fine aggregate (sand) was partially replaced with class F Fly ash. Fine aggregate was replaced with five percentages (10%, 20%, 30%, 40%, 50%) of class F Fly ash by weight.

T.G.S Kiran, and M.K.M.V Ratnam, (2014), A study on Fly Ash as a Partial Replacement of Cement in Concrete and Durability Study of Fly Ash in Acidic (H2SO4) Environment. In this project report the results of the tests carried out on Sulphate attack on concrete cubes in water curing along with H2SO4 solution. Also, aiming the use of fly-ash as cement replacement. The present experimental investigation were carried on fly ash and has been chemically and physically characterized, and partially replaced in the ratio of 0%, 5%, 10%, 15%, 20% by weight of cement in concrete

3. MATERIALS AND METHODOLOGY

The properties of each material in a concrete mix were studied at this stage. Different tests were conducted for each material as specified by relevant IS codes. Ordinary Portland cement, fine aggregate, coarse aggregate, super plasticizer, fly ash and water were used for making the various concrete mixes considered in this study.

Cement: Ordinary Portland cement (OPC) confirming to IS 12269-1987 (53 Grade) was used for the experimental work. Laboratory tests were conducted on cement to determine specific gravity, fineness, standard consistency, initial setting time, final setting time and compressive strength. The results are presented in below table.

Table 1: Properties of Cement

Particulars	Values
Grade	53
Specific gravity	3.15
Standard consistency %	32
Fineness %	3
Initial setting time in minutes	30
Final setting time in minutes	600
Compressive strength 7th day (N/mm²)	37
Compressive strength 28th day (N/mm²)	53

Fly ash: Fly ash produced from the burning of younger lignite or sub-bituminous coal, in addition to having pozzolonic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO).

Fine aggregate: Manufactured sand was used as fine aggregate. Laboratory tests were conducted on fine aggregate to determine the different physical properties as per IS 2386 (Part III)-1963. Fineness modulus is the index of coarseness or fineness of material. It is an empirical factor obtained by adding cumulative percentage of aggregate retained on each of the standard sieves and dividing this by 100. The properties of fine aggregate are presented in Table 2.

Table 2: Properties of fine aggregate

Particulars	Values
Specific gravity	2.386
Fineness modulus	3.06
Bulk density	1.451
Void ratio	0.644
D_{10} (mm)	0.37

Coarse aggregate: The size of aggregate between 20mm and 4.75mm is considered as coarse aggregate. Laboratory tests were conducted on coarse aggregates to determine the different physical properties as per IS 2386 (Part III)-1963.This test was conducted for 20mm size aggregate. This method is useful for finding the particle size distribution of aggregates. They were considered as per IS 383 -1970. The properties of coarse aggregate are shown in Table 3.

Table 3: Properties of coarse aggregate

Particulars	Values
Specific gravity	2.994
Fineness modulus	7.17
Bulk density	1.594
Void ratio	0.878
D_{10} (mm)	11

3.1 Design Mix of Concrete

The mix proportion for the M25 grade of concrete was arrived through trial mixes. Mix design is done as per IS: 10262-2009.The mix proportion for M25 grade of concrete

Table 4: Mix Proportion for 1m³

Mix designation	Water (liters)	Cement (kg/m³)	Fly ash (kg/m³)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)	Test specimen	
						cubes	cylinders
N	186	372	0	662	1107	6	3
S1	186	316.2	55.8	662	1107	6	3
S2	186	297.6	74.4	662	1107	6	3
S3	186	279	93	662	1107	6	3
S4	186	260.4	111.6	662	1107	6	3
S5	186	241.8	130.2	662	1107	6	---

4. RESULTS AND DISCUSSIONS

4.1.1 4.1 Slump tests results

Slump test is used to determine the workability of fresh concrete. The apparatus used for doing slump test are Slump cone and Tamping rod. This is the most commonly used test of measuring the consistency of concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing neither workability, nor it is always representative of the place ability of the concrete. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. It is performed with the help of a vessel, shaped in form of a frustum of a cone opened at both ends. Diameter of top end is 10 cm while that of the bottom end is 20 cm. Height of the vessel is 30 cm. A 16 mm diameter and 60 cm long steel rod is used for tamping purposes.

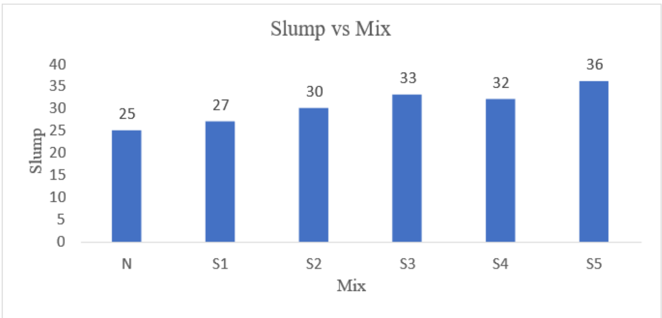

Figure 2: Results of slump test

4.2 Compacting factor

Compacting factor of fresh concrete is done to determine the workability of fresh concrete. The compacting factor test is designed primarily for use in the laboratory but can also be used in the field. It is more precise and sensitive than the slump test. Such dry concrete are insensitive to slump test. The equipment used for conducting this experiment consists of three containers A, B and C. A and B are of truncated cone shaped vessels fixed to a stand and C is a detached cylinder, which can be opened downwards. The apparatus used is Compacting factor apparatus.

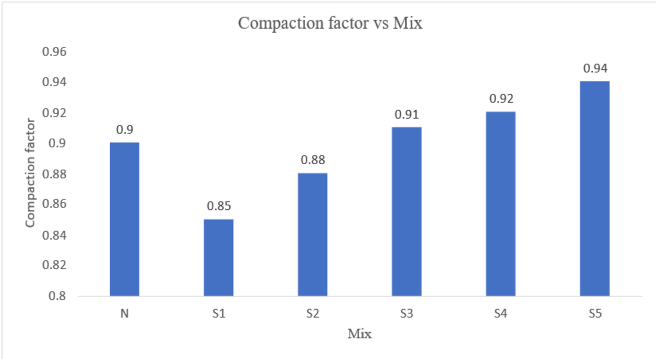

Figure 2: Compaction factor test

4.3 Compressive strength of concrete

For cube test two types of specimens either cube of 15 cm X 15 cm X 15 cm upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimens should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Table 5: Results of compressive strength

Mix	7th day (N/mm²)	28th day(N/mm²)
N	18.4	32.1
S1	19.6	32.4
S2	20.5	32.9
S3	21.2	33.6
S4	20.4	32.4
S5	18.2	31.6

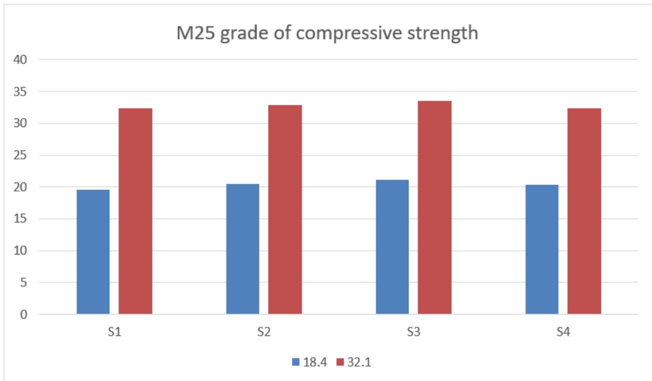

Figure 3: Results of compressive strength

It can be seen that there is increase in strength with the increase in fly ash percentages. The highest compressive strength was achieved by 25% replacement of fly ash, which was found about 33.6Mpa compared with

32.1Mpa for the control mixture at 28th day. The compressive strength of concrete is increased as fly ash content increases up to 30%, beyond that compressive strength was significant decreases due to increases free water content in the mixes. This means that there is an increase in the strength of 20% compared to the control mix. However, mixtures with 35% replacement of fly ash gave the lowest compressive strength 31.6Mpa. It is recommended that up to 35% of fly ash can be use as replacement of cement.

4.4 Split tensile tests

The concrete is not usually expected to resist the direct tension because of its low tensile stress and brittle nature. However, the determination of tensile strength of concrete is necessary to determine the load at which the concrete members may crack. The cracking is a form of tension failure. The split tensile strength was determined by testing cylinders of size 150mm diameter and 300mm height in compressive testing machine. The split tensile strength of concrete was then calculated using the equation.

Table 6: Results of split tensile strength

Mix	28th day
N	2.73
S1	2.85
S2	2.98
S3	3.66
S4	2.61

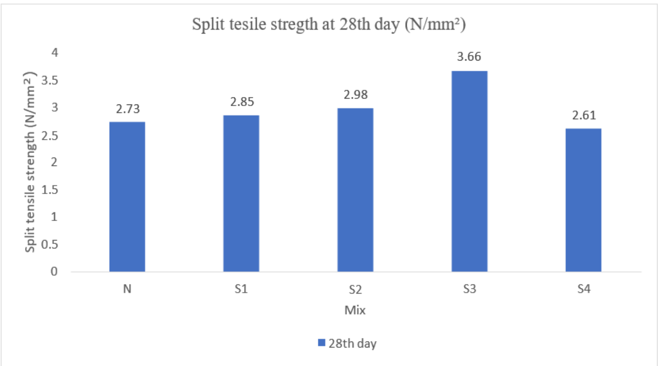

Figure 4: Results of split tensile strength

The highest split tensile strength was achieved by 25% replacement of fly ash, which was found about 3.66N/mm² compared with 2.73 N/mm² for the control mix. This means that there is an increase in the strength of almost 35% compared to the control mix at 28 days.

5. CONCLUSIONS

- By our project, we conclude that the strength of concrete increased by the replacement of cement by fly ash. Fly ash replaces Portland cement, save concrete materials costs. Here we using OPC of 53 grade, class F fly ash, well graded coarse and fine aggregate.
- 35% fly ash replacement showed maximum workability. The workability of concrete had been found to decrease after 40% in concrete.
- Among different mixes of concrete 25% showed maximum compressive strength at later ages.
- Maximum split tensile strength is obtained for S3 mix which is 25% replacement of cement.
- The cost analysis indicates that percent of cement reduction decrease the cost of concrete, but at the same time strength increases.
- It has been shown that concrete containing fly ash is more economical than ordinary concrete. Concrete containing fly ash, delivered to the construction site, can be from 10 to 35% more economical than ordinary concrete. The main factor affecting the reduction in cost is the fly ash content of the mix. The user should be aware of concrete containing fly ash requiring a high dosage of air-entraining admixture for the development of a proper air-void system. In many cases, the increase in cost due to the admixture requirements may eliminate any savings in cost obtained by the use of fly ash.
- Concrete containing fly ash having a slump in the range of 7.5 to 10.5cm. can be produced even when mixing temperatures are of the order of 1000 F and the total period of mixing does not exceed 60 minutes.
- Improved workability. The spherical shaped particles of fly ash act as miniature ball bearings within the concrete mix, thus providing a lubricant effect. This same effect also improves concrete pumpability by reducing frictional losses during the pumping process and flat work finishability.
- Decreased water demand. The replacement of cement by fly ash reduces the water demand for a given slump. When fly ash is used at about 20 percent of the total cementitious, water demand is reduced by approximately 1 percent. Higher fly ash contents will yield higher water reductions. The

decreased water demand has little or no effect on drying shrinkage/cracking. Some fly ash is known to reduce drying shrinkage in certain situations.

- Reduced heat of hydration. Replacing cement with the same amount of fly ash can reduce the heat of hydration of concrete. This reduction in the heat of hydration does not sacrifice long-term strength gain or durability. The reduced heat of hydration lessens heat rise problems in mass concrete placements.
- Increased ultimate strength. The additional binder produced by the fly ash reaction with available lime allows fly ash concrete to continue to gain strength over time. Mixtures designed to produce equivalent strength at early ages (less than 90 days) will ultimately exceed the strength of straight cement concrete mixes.
- Reduced permeability. The decrease in water content combined with the production of additional cementitious compounds reduces the pore interconnectivity of concrete, thus decreasing permeability. The reduced permeability results in improved long-term durability and resistance to various forms of deterioration.
- Improved durability. The decrease in free lime and the resulting increase in cementitious compounds, combined with the reduction in permeability enhance concrete durability. This affords several benefits:
- The observed slow set and low early strength obtained with fly ash has caused a reduction in the amount of this mineral admixture used in concrete. Although some fly ash materials will reduce early strength and slow the setting time it does not have to be the case today. Some fly ash actually accelerates set. The addition of accelerators, plasticizers and/or a small amount of additional CSF, as well as the proper beneficiated fly ash, can mitigate this problem.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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