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EFFECT OF MINERAL ADMIXTURES ON THE PROPERTIES OF SINTERED FLY ASH AGGREGATE CONCRETE

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Abstract - This paper presents an experimental investigation on the effect of mineral admixtures on the properties of sintered fly ash aggregate concrete. The mineral admixtures are added in replacement of cement by 10% and 20%. The mineral admixtures used in this work are fly ash, ground granulated blast furnace slag and metakaolin. The experiment was conducted on M60 grade concrete produced by sintered fly ash aggregate. The strength properties studied in this work are compressive strength, tensile strength, shear strength, flexural strength and impact strength. Also, the workability characteristics are studied through slump cone test, compaction factor test, Vee-Bee consistometer test. Along with these, near surface characteristics like water absorption and sorptivity are also studied.

***Key Words*: Sintered fly ash aggregate; mineral admixtures; workability; sorptivity; strength.**

1. INTRODUCTION

The important material in the construction industry is concrete over a long period of time. It has wide range of application and utilization in construction field. Technology advancement and increasing economy leads to construction industry to grow rapidly. This growth leads to demand of massive amount of concrete to be produced to satisfy the need. This in turn leads to increase in the production of raw material which is to be used in the production of concrete. The raw materials include cement, aggregates etc. The raw material which is used in the production of concrete is the second largest consumed material by humans. This leads to shortage of raw materials which in turn reduces the production of concrete. This shortage makes way to invent new type of material or source of material which can be effectively be used in the production of concrete with the same results obtained using conventional concrete. In this era of technology advancement, one of the better concepts is to use waste materials or materials which cannot be disposed easily to produce concrete. There are plenty of waste materials which can be used as raw materials. In that first stands fly ash which is a waste material produced in thermal power plant. Also blast furnace slag, silica fume belongs to the list. These materials will not only solve the disposal problem but also form a substitute for conventional materials in civil engineering applications. Also using these materials will prove to be cost effective. Usage of industrial waste materials such as fly ash, ground granulated blast furnace slag in civil engineering applications not only solve disposal problem but also offer a cost-effective substitute for the conventional raw materials in the production of concrete.

The most commonly utilized pozzolanic waste material and has the biggest potential to use in concrete is the Fly ash (also known as pulverized fuel ash). In coal based power plants fly ash is the waste product.

The molten iron slag from the blast furnace when quenched in water or steam ground granulated blast furnace slag (GGBFS or GGBS) is obtained. It is dried and grind into fine powder.

Mineral clay kaolinate when dehydroxylates to form metakaolin. Kaolin commonly known as china clay is rich in kaolinate. Metakaolin particle size is as fine as cement particles but not as fine as silica fume.

2. EXPERIMENTAL PROGRAM

2.1 Materials used

2.1.1 Cement

The type of cement used in the experimentation is OPC-43. The properties of cement are ascertained as per the IS 8112–1989 and the table 1 gives the physical property of cement.

Table 1: Physical properties of cement:

Physical properties	Test results
Specific gravity	3.15
Consistency	31%
Initial setting time	90min
Final setting time	330min

2.1.2 Fine aggregates:

Natural sand having specific gravity of 2.60 is used as fine aggregate corresponding to zone- II of IS: 383-1970 which is locally available. Table 2 gives the properties of fine aggregates.

Table 2: Physical properties of fine aggregates:

Physical properties	Test results
Fineness modulus	2.5
Specific gravity	2.60
Water absorption (%)	0.93
Zone	II

2.1.3 Sintered fly ash aggregates:

Specific gravity, water absorption, bulk density of sintered fly ash aggregate was calculated as per IS 2386 (Part 3): 1963. The sintered fly ash aggregates physical properties are given in Table 3

Table 3: Physical properties of sintered fly ash aggregates:

Physical properties	Test results
Specific gravity	2.02
Water absorption (%)	20
Bulk density (Kg/m^3)	890
Sizes produced(mm)	4.70-10

2.1.4 Super plasticiser:

Conplast 430 is based on Sulphonated Naphthalene polymers. It is of brown solution immediately dispersible in water.

2.1.5 Fly ash:

The fly ash used is obtained from the silos of Raichur thermal power plant corresponding to IS: 3812(Part 1)-2003. This fly ash contains low calcium and is classified under class F.

2.1.6Ground granulated blast furnace slag (GGBFS):

The ground granulated blast furnace slag used is of JSW brand conforming to IS: 3812 ((part 1)-2003.

2.1.7 Metakaolin:

The Metakaolin used in the experiment is conforming to IS: 3812 (part1)-2003.

2.2 Mix proportion

The experimental investigation is based on a reference concrete mix of grade M60 using sintered fly ash aggregate. The mix proportion of reference mix is 1:0.81:0.8.

2.3 Preparation of specimens

The procedure used to cast the specimens is as follows.

- Moulds should be placed on the vibrating table and wet mix should be poured in three layers in to the moulds and thoroughly compacted.
- After well compaction of concrete, level the surface and name the specimens.
- Demould the specimen after 24 hours of casting the specimen.
- Keep the specimens for curing.

2.4 Testing of concrete

Concrete cubes of size 150x150x150 mm were tested for compressive strength as per IS 516:1959. To get the tensile strength, cylindrical specimens of size 150mm diameter and 300mm length were tested as per IS 5816:1999. For flexural strength, beam specimens of size 100x100x500mm were tested. Two-point loading was adopted on an effective span of 400mm to get pure bending, as per IS 516:1959. Shear strength specimens were of L shape with 150x90x60mm. For impact strength specimens were of 150mm diameter and 60mm height. Water absorption and sorptivity test were performed on cube specimens.

2.5 Results and discussion

2.5.1 Workability results

Table 4 gives the workability test results as measured from slump test, compaction factor test, Vee-Bee test and flow table test carried out on reference mix and sintered fly ash aggregate concrete with mineral admixtures.

The observation made from the experimentation clearly indicates that, the workability as measured from slump, compaction factor, Vee-Bee and

percentage flow is higher for sintered fly ash aggregate concrete produced by replacing 20% cement by metakaolin. The least value of workability is observed for sintered fly ash aggregate concrete with no mineral admixtures. The other categories of sintered fly ash aggregate concrete wherein the cement is replaced by either fly ash or GGBFS or combination of these mineral admixtures show relatively higher workability values as compared to the reference mix.

2.5.2 near surface characteristics test results

Table 5 gives the near surface characteristics test results i.e. water absorption and sorptivity test carried out on reference mix and sintered fly ash aggregate concrete with mineral admixtures.

The observation made from the experimentation clearly indicates that the water absorption of concrete produced by replacing 20% of cement by either fly ash or GGBFS or metakaolin or combination of these is more as compared to the reference mix where mineral admixtures are not used. The sintered fly ash aggregate concrete produced by replacing 20% cement by different mineral admixtures show slightly higher values of water absorption.

Table 4 Workability test results of sintered fly ash aggregate concrete with different mineral admixtures

Cement replaced by mineral admixtures	Slump, (mm)	Compaction factor	Vee-Bee (secs)	Flow table (%)
Reference	10	0.670	52	1.30
20% Fly ash	10	0.760	42	1.46
20% GGBFS	20	0.806	18	1.76
20% Metakaolin(MK)	40	0.900	10	2.23
10% FA+10% GGBFS	20	0.801	35	1.61
10% FA+ 10% MK	40	0.886	15	2.07

Table 5 Near surface characteristics test results of sintered fly ash aggregate concrete with different mineral admixtures

Cement replaced by mineral admixtures	Water absorption (%)	Sorptivity ($mm/min^{0.5}$)
Reference	0.290	2.74
20% Fly ash	0.296	3.65
20% GGBFS	0.330	3.65
20% Metakaolin(MK)	0.447	3.65
10% FA+10% GGBFS	0.588	5.47
10% FA+ 10% MK	0.603	5.47

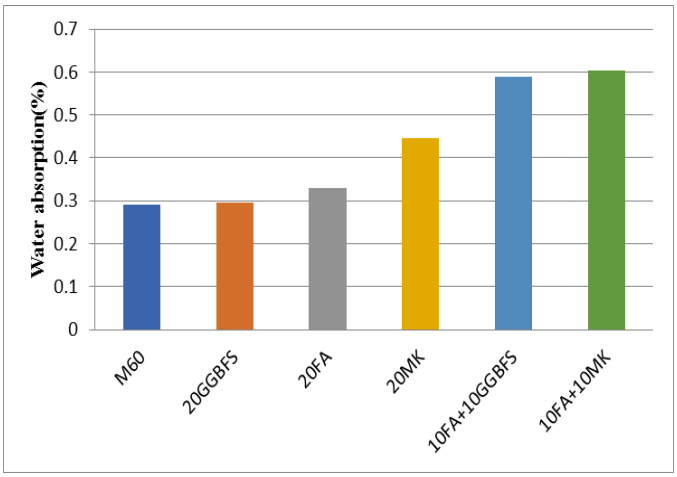

Fig 1 Variation of water absorption test values

2.5.3 Strength test results

Table 6 gives the strength test results of sintered fly ash aggregate concrete with mineral admixtures. The strength test includes compressive strength, tensile strength, flexural strength, shear strength and impact strength.

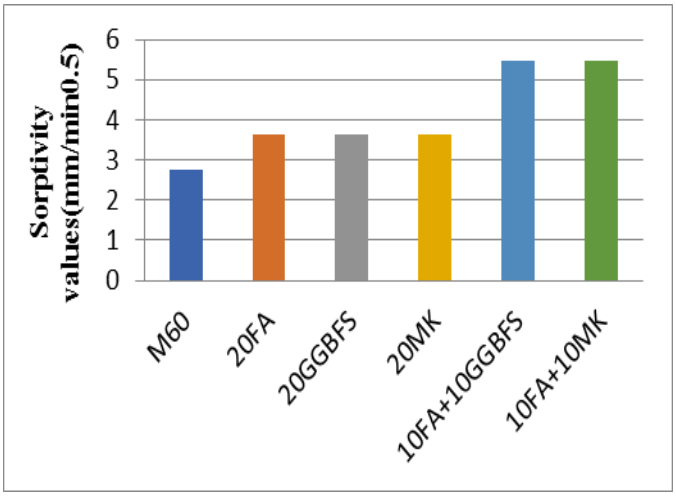

Fig 2 Variation of sorptivity test values

Table 6 Overall results of strength test

Cement replaced by mineral admixtures	Compressive strength(MPa)	Tensile strength (MPa)	Flexural strength (MPa)	Shear strength (MPa)	Impact strength (N-m)
M60	60.44	3.2	5.2	13.51	4841.1
20% GGBFS	56.14	2.92	4.93	11.67	4377.7
20%FA	52.73	2.78	4.2	10.55	3126
20% MK	48.29	2.73	4.06	9.55	2946.1
10%FA+10% GGBFS	44.44	2.68	3.93	8.88	1708.2
10%FA+ 10%MK	42.22	2.26	3.73	7.95	1597.5

2.5.3.1 Compressive strength test results

Figure 3 gives the variation of compressive strength of sintered fly ash aggregate concrete with mineral admixtures. The observation made from the experimentation clearly indicates that the compressive strength of sintered fly ash aggregate concrete produced without any mineral admixtures show the higher results. The compressive strength is slightly affected in sintered fly ash aggregate concrete where different mineral admixtures or combination of mineral admixtures is used.

2.5.3.2 Tensile strength results

Figure 4 gives the variation of tensile strength of sintered fly ash aggregate concrete with mineral admixtures. The observation made from the experimentation clearly indicates that the tensile strength of sintered fly ash aggregate concrete produced without any mineral admixtures show the higher results. The tensile strength is slightly affected in sintered fly ash aggregate concrete where different mineral admixtures or combination of mineral admixtures is used.

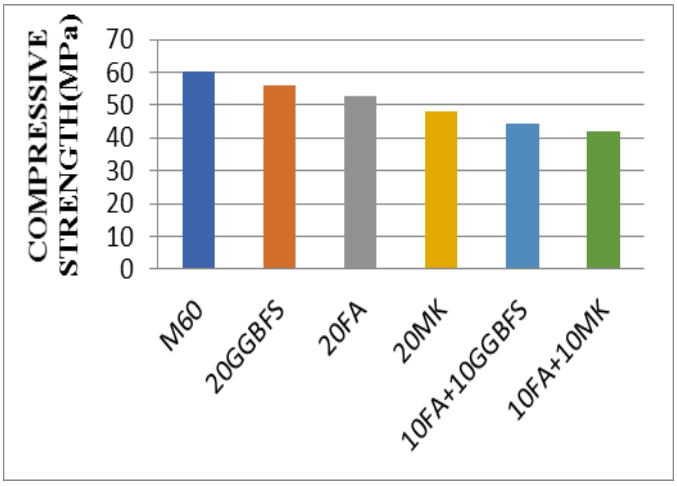

Figure 3 Variation of compressive strength.

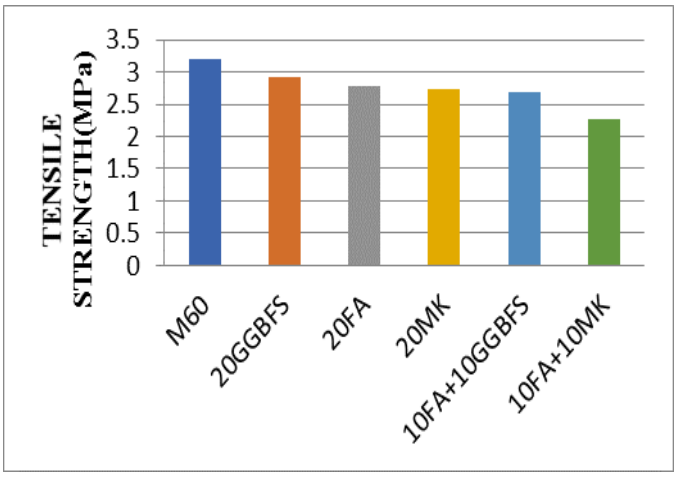

Figure 4 Variation of tensile strength.

2.5.3.3 Flexural strength results

Figure 5 gives the variation of flexural strength of sintered fly ash aggregate concrete with mineral admixtures. The observation made from the experimentation clearly indicates that the flexural

strength of sintered fly ash aggregate concrete produced without any mineral admixtures show the higher results. The flexural strength is slightly affected in sintered fly ash aggregate concrete where different mineral admixtures or combination of mineral admixtures is used.

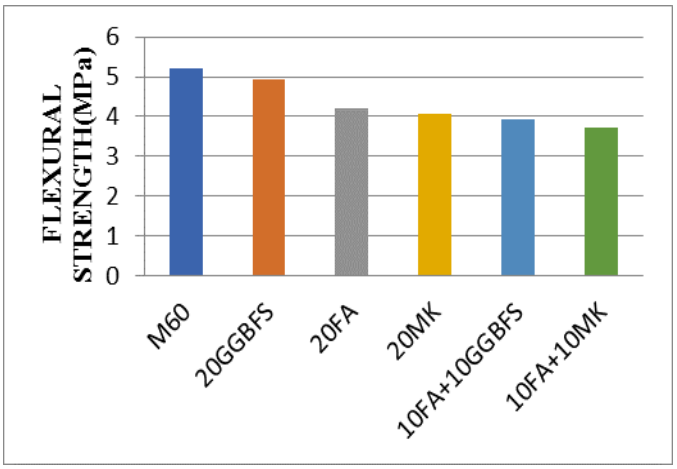

Figure 5 Variation of flexural strength.

2.5.3.4 Shear strength results

Figure 6 gives the variation of shear strength of sintered fly ash aggregate concrete with mineral admixtures. The observation made from the experimentation clearly indicates that the shear strength of sintered fly ash aggregate concrete produced without any mineral admixtures show the higher results. The shear strength is slightly affected in sintered fly ash aggregate concrete where different mineral admixtures or combination of mineral admixtures is used.

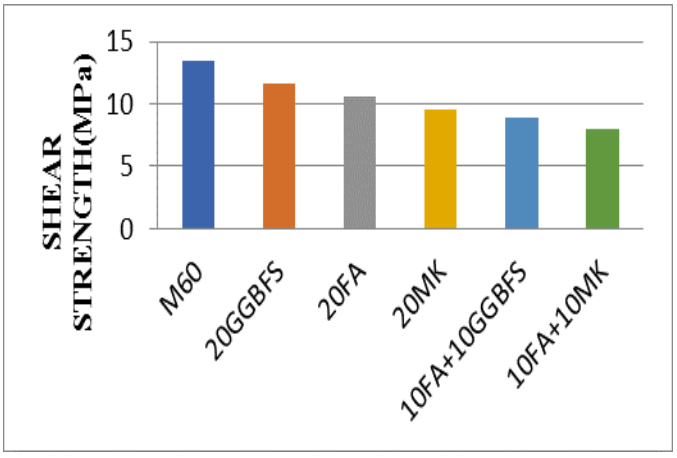

Figure 6 Variation of shear strength.

2.5.3.5 Impact strength results

Figure 7 gives the variation of impact strength of sintered fly ash aggregate concrete with mineral admixtures. The observation made from the experimentation clearly indicates that the impact strength of sintered fly ash aggregate concrete produced without any mineral admixtures show the higher results. The impact strength is slightly affected in sintered fly ash aggregate concrete where different mineral admixtures or combination of mineral admixtures is used.

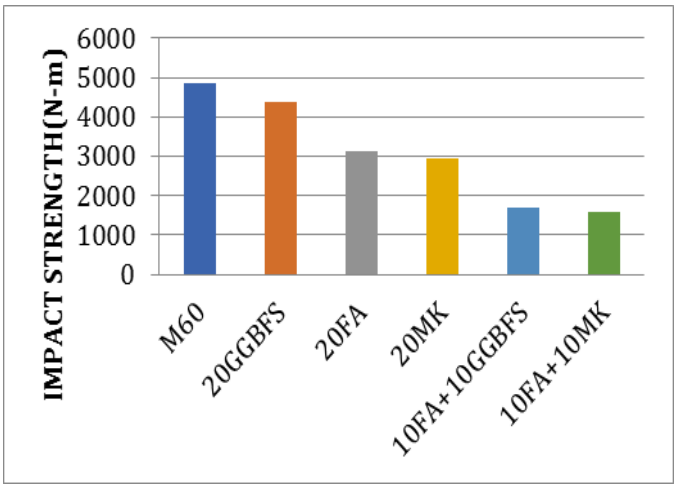

Figure 7 Variation of impact strength.

3. CONCLUSIONS

Following conclusions are obtained based on the observation made on the effect of mineral admixture on the properties of sintered fly ash aggregate concrete

- Workability of sintered fly ash aggregate concrete is high when 20% of cement is replaced by metakaolin.
- Water absorption of sintered fly ash aggregate concrete is low for reference mix where no mineral admixtures are used.
- Sorptivity of sintered fly ash aggregate concrete is low for reference mix where no mineral admixtures are used.
- Compressive strength of sintered fly ash aggregate concrete is high when no mineral admixtures are used.
- Tensile strength of sintered fly ash aggregate concrete is high when no mineral admixtures are used.

- Flexural strength of sintered fly ash aggregate concrete is high when no mineral admixtures are used.
- Shear strength of sintered fly ash aggregate concrete is high when no mineral admixtures are used.
- Impact strength of sintered fly ash aggregate concrete is high when no mineral admixtures are used.

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BIOGRAPHIES

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