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Strength Properties of Concrete with Partial Replacement of Cement by Flyash and Fine Aggregate by Granite Powder

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Abstract : The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on environment. Presently large number of Granite powder is generated in natural stone processing plants with an impact on environment and humans[1]. And also Fly ash is generally considered as a waste material that is produced as a by-product of coal combustion process. The physical and chemical properties of fly ash are similar to cement, which allows it to be used in concrete. Granite powder is one of the waste materials obtained during extraction, cutting and polishing granite stones from the quarries and commercial industries. The main objective of this project is to study the mechanical properties of concrete mixtures in which fine aggregate (sand) and cement were partially replaced with Granite powder and Fly ash. The replacement is done by 5%, 10%, 15% , 20% and 20% of cement by fly ash and 5%, 10%, 15%,20% and 25% of fine aggregate by granite powder to evaluate the effect of presence of these replacement materials on the strength of specimens.
Keywords : Concrete, Compressive strength, Industrial waste, Low cost, Fly ash, Granite powder, OPC cement.

Introduction

1.0 Flyash

Fly ash is a by-product from coal based thermal power plants as shown in fig 1. It has been generally considered a waste material in the past and disposal of which has posed numerous ecological and environmental problems[2]. However, recent researches have shown that fly ash has potential to act as invaluable ingredient in cement and concrete. The fly ash is now considered as a resource material rather than a waste in civil engineering and material science. In addition fly ash can be gainfully used for various other applications. In developing countries like India power generation is most important requirement for economic and social development[4,6]. In India, about 67% of electricity requirements are fulfilled by the coal fired thermal power plants. The generation of 1 MW power with Indian coal results in co-generation of nearly 1800t of fly ash. As per Central Electricity Authority, India, report (CEA)[8], 143 no coal fired thermal power plants with installed capacity of 133381 MW produced about 200 million tons of coal ash annually. With the capacity addition of 22282 MW by the end of 2017, the production of coal ash is estimated to about 185 million tons per year[5,7]. Nearly 100 million tons of fly ash is being utilized out of 185 million tons generated. Though percentage utilization has gone to nearly 56% but in absolute terms, very large quantity of fly ash still remains unutilized. This huge quantity is being stored or disposed off in ash pond areas. The ash ponds acquire large areas of agricultural land. Use of fly ash reduces area requirement for pond, thus saving of good agricultural land.

Fig 1 (fly ash)

1.1 Types of Fly Ash

Fly ash has been divided into following two types, these classifications based on the chemical compositions of the fly ash.

(i) Class F fly ash
(ii) Class C fly ash

1.1.1 Class F

Fly ash normally produced from burning anthracite or bituminous coal that meets the applicable requirements for this class as given herein. This class of fly ash has pozzolanic properties

$SiO_2 + Al_2O_3 + Fe_2O_3 \geq 70\%$

1.1.2 Class C

Fly ash normally produced from lignite or sub-bituminous coal that meets the applicable requirements for this class as given herein .This class of fly ash, in addition to having pozzolanic properties, also has some cementitious properties.

Note: Some Class C fly ashes may contain lime contents higher than 10%.

$SiO_2 + Al_2O_3 + Fe_2O_3 \geq 50\%$

1.2 Why class F is preferred instead of Class c

Class F fly ash is designated in ASTM C 618 and originates from anthracite and bituminous coals. It consists mainly of alumina and silica and has a higher loss on ignition than Class C fly ash. Class F fly ash also has a lower calcium content than Class C fly ash.

1.3 Granite Powder

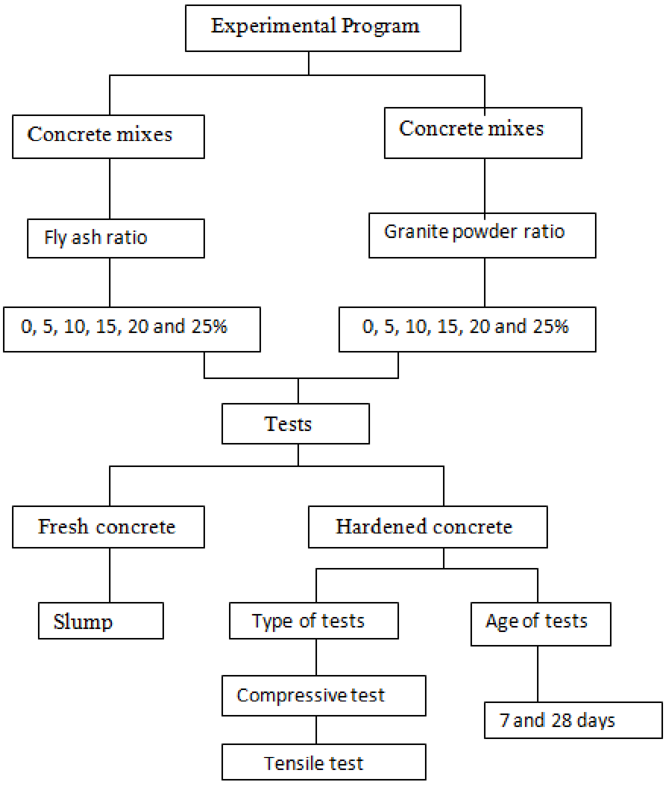
The Granite stone industry generates different types of waste. Solid waste and stone slurry, whereas solid waste is resultant from rejects at the time of cutting or at the processing unit. Stone slurry is a semi liquid substance consisting of particles originated from the sawing and polishing process and water used to cool and lubricate the sawing and polishing machines[3]. The slurry is stored in tanks for evaporation. To conserve water the slurry is passed through filtration and slurry compacting machine. The compacted granite fine cakes are transported and disposed in landfills. Its water content are drastically reduced (Approx 2%) and the granite fines as shown in fig 2. resulting from this will have environmental impacts. The stone slurry generated during the processing will be around 40% of the final product. Disposing of compacted granite fine slurry cakes is a major problem anywhere. The factories were used to dispose these granite fines around their own factories.

Fig 2 (granite powder)

1.4 Objectives

- To investigate the effect of replacing 10%,, 20%, 30% of cement by fly ash and 30%, 40%, 50% of fine aggregate by granite powder to evaluate the effect of presence of these replacement materials on the strength of specimens.
- To investigate the effects of concrete mixes with different combination of granite and fly ash using Super plasticizer.
- To determine the suitability percentage of replacement by fly ash and granite with respect to strength characteristics.

2.0 Methodology



2.1 Materials

Concrete is a composite material formed by combining coarse aggregate known as blue metal with fine aggregate which is commonly known as sand using a binder named cement with right proportion of water.Blue metal is the material which gives strength to the concrete and sand is used to fill the voids that the formed due to the angular or irregular shape of the aggregate. These materials are bonded using cement paste formed by mixing cement and water in the required proportion.

2.1.1 Cement

The most commonly used cement is ordinary Portland cement. Out of total cement production OPC accounts for 80-90%. In our study OPC of 53 grades is used. Many tests were conducted on cement. Some of them are consistency test, setting time test, specific gravity, etc.

2.1.2 Fine Aggregate

Locally available, debris free riverbed sand is used as fine aggregate. The sand particle should also be packed to give minimum void content leads to requirement of more water while mixing. In this study sand confirming to zone III as per Indian standards has been used.

2.1.3 Coarse Aggregate

The crushed aggregate used are of sizes 20mm and 12.5mm and are tested as per Indian standards and the results are within permissible limits.

2.1.4 Fly Ash

Fly ash is a by-product from coal based thermal power plants. It has been generally considered a waste material in the past and disposal of which has posed numerous ecological and environmental problems. However, recent researches have shown that fly ash has potential to act as invaluable ingredient in cement and concrete.The fly ash is now considered as a resource material rather than a waste in civil engineering and material science. In addition fly ash can be gainfully used for various other applications.

2.1.5 Granite Powder

Granite belongs to igneous rock family. Granite powder obtained from the polishing units and the properties were found. Since the granite powder was fine, Hydrometer analysis was carried out on the powder to determine the particle size distribution. From hydrometer analysis it was found that coefficient of curvature was 1.95 and coefficient of uniformity was 7.82.

Table 1. Mix Proportion

Mix	Materials		Mix Proportion
	% Marble	% Granite	C:fa:Ca
M40	5	5	1:1.8:3.5
	10	10	1:1.8:3.5
	15	15	1:1.8:3.5
	20	20	1:1.8:3.5
	25	25	1:1.8:3.5

2.2 Casting

The cube, cylinder and slab specimens were prepared for the mixes.

150 x 150 x 150 mm standard cubes for compressive strength

150 mm diameter and 300 mm height standard cylinders for cylindrical compressive strength and split tensile strength

Cubes and cylinders are cast with standard cube and cylinder moulds the slump were measured at the time of casting cubes and listed in table. The cube and cylinder.specimens are demoulded after 24 hrs and were cured for 28 days.

Table 2. Number of Specimen

Mix	% of replacement of marble and granite powder	Number of cube specimen		Number of cylinder specimens	
		7 days	28 days	7 days	28 Days
M40	5	3	3	3	3
	10	3	3	3	3
	15	3	3	3	3
	20	3	3	3	3
	25	3	3	3	3

2.3 Compressive Strength

Compressive strength of concrete is tested on cube at differentpercentage of marble powder content in concrete. The strengthof concrete has been tested on cube at 7 days and 28 days.7 days test has been conducted to check the gainin initial strength of concrete shown in fig3.and 28 daystest gives the data of final strength of concreteas shown in fig 4.At 28 dayscuring. Compression testing machine is used for testing thecompressive strength test on concrete. At the time of testingthe cube is taken out of water and dried and then testedkeeping the smooth faces in upper and lower part.On partial replacement of OPC by 5% and 10% of flyashand fine aggregate by granite powder gives a gradual increase in compressive strength when compared to conventional mix. Whereas at 15% replacement the compressive strength is equal to that of conventional concrete it decreases at 20% and 25%.

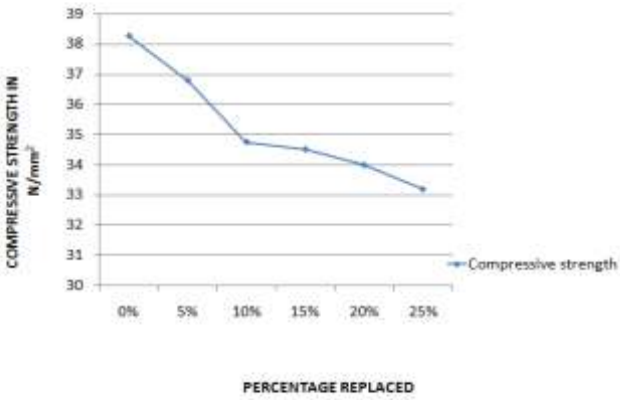


Fig 3.Test result of Compressive strength of 7 days

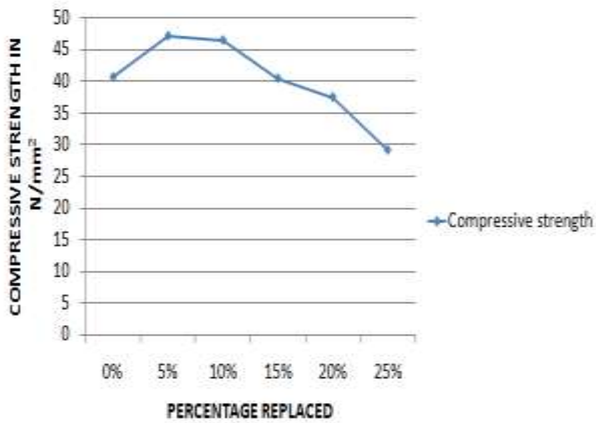


Fig 4.Test result of compressive strength of 28 days

2.4 Split tensile strength

Split Tensile strength of concrete is tested on cylinders at different percentage of marble powder Content in concrete. The strength of concrete has been tested on cylinder at 7 days curing and 28 days. 7days test has been conducted to check the gain in initial strength of concrete as shown in fig 5. 28 days test gives the data of final strength of concrete shown in fig 6 at 28 days curing .Compression testing machine is used for testing the Split Tensile strength test on concrete along with two wooden boards. At the time of testing the cylinder taken out of water and dried and then tested. On partial replacement of OPC by 5% and 10% of fly ash and fine aggregate by granite powder gives a gradual increase in tensile strength when compared to conventional mix. Whereas at 15% replacement the tensile strength is equal to that of conventional concrete tensile strength decreases at 20% and 25%.

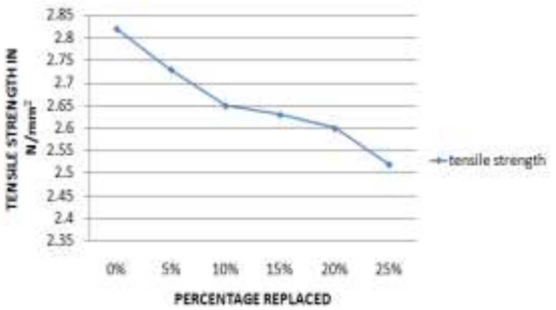


Fig 5.Test result of tensile strength of 7 days

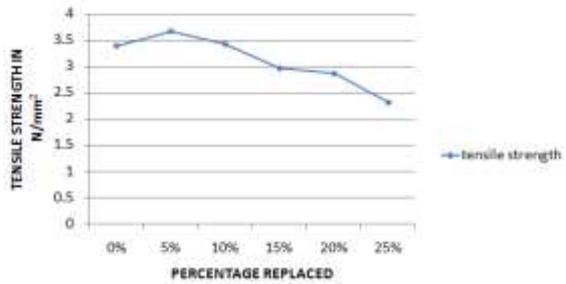


fig 6. Test result of tensile strength of 28 days

Fig 7.Testing of specimens.

3.0 Conclusions

1. The test results show clearly that fly ash and granite powder as partial sand replacement has beneficial effects of Concrete.
2. On partial replacement of OPC by 5%, 10% and 15% of fly ash and fine aggregate by granite powder gives a gradual increase in compressive strength and also in tensile strength when compared to conventional mix.
3. To minimize the costs for construction with usage of fly ash and granite powder which is freely or cheaply available; more importantly.
4. The cost for conventional concrete mix is Rs.6000 per m3 and for concrete mix with 5% replacement is Rs.5700 per m3 which is 5% less than the cost of conventional mix.
5. For 10% replacement the cost is Rs.5400 which is 10% less than cost of conventional mix.

Thus the environmental effects from the industrial waste can be significantly reduced and also the cost of fine aggregate can be reduced a lot by the replacement of this waste material from thermal power plants and granite factories.

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