JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Effective Utilization of Magnetic Sand in Fly Ash Concrete Mixture

[1]Joseph Vianny X, [2]Karthikeyan P, [3]Nithisrajan R, [4]Vasudevan R, [5]Prasanth M
[1]Assistant Professor, [2]Student, [3]Student, [4]Student, [5]Student
[1]Department of Civil Engineering,[2]Department of Civil Engineering, [3]Department of Civil Engineering, [4]Department of Civil Engineering, [5]Department of Civil Engineering
[1]V.S.B Engineering College (Autonomous), Karur, Tamilnadu, India, [2]V.S.B Engineering College (Autonomous), Karur, Tamilnadu, India, [3]V.S.B Engineering College (Autonomous), Karur, Tamilnadu, India, [4]V.S.B Engineering College(Autonomous), Karur, Tamilnadu, India, [5]V.S.B Engineering College, Karur, Tamilnadu, India,

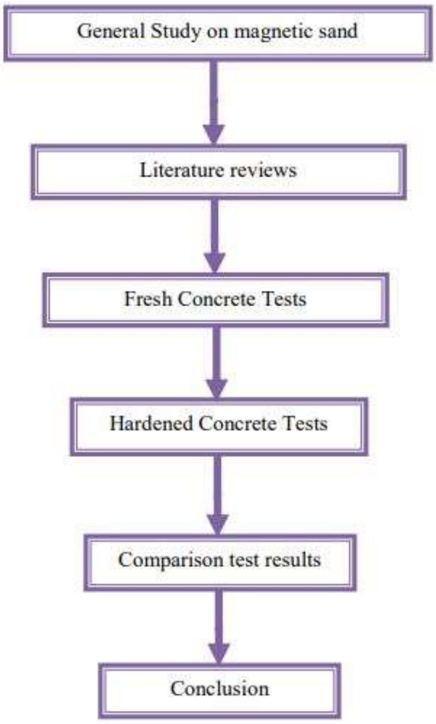
Abstract: The strength and durability of concrete majorly affects due to porosity of concrete. The porosity of concrete can be decreased using selective additive materials to the concrete. In this experimental investigation the magnetic sand has used as an additive to the concrete to reduce the porosity occurred in the concrete. Magnetic sand has been extracted from heap of river sand with the help of magnet and it has been replaced as 10%, 20% and 30% by the replacement of fine aggregate in the concrete. Eventually the strength of magnetic sand replaced concrete have been investigated experimentally by conducting compression strength test, split tensile strength test and flexural test on cubes, cylinders and prisms specimen and the test results have been compared with conventional M20 grade of concrete to estimate the effective utilization of magnetic sand in concrete with effective results.

Index Terms **-Porosity, magnetic sand, compression strength test, split tensile strength test and flexural test.**

I. GENERAL

Magnetic sand, also known as iron-sand is a type of sand with heavy concentrations of iron. It is typically dark grey or blackish in color. It is composed mainly of magnetite, Fe_3O_4, and also contains small amounts of titanium, silica, manganese, calcium and vanadium. As slag is an industrial by- product, its productive use grant an chance to relocate the utilization of limited natural resources on a large scale. Iron slag is a byproduct obtained in the manufacture of pig iron in the blast furnace and is produced by the blend of down to earth constituents of iron ore with limestone flux. Iron and steel slag can be differentiating by the cooling processing when removed from the furnace in the industry. Mostly, the slag consists of magnesium, aluminum silicates calcium and manganese in various arrangements. Iron sand is found worldwide. Although the iron mineral composition of the iron sand is mostly magnetite, the sand is usually mixed with other types of sand that washes downriver or ashore from mountainous or underwater deposits. The exact composition of the sand mixture may vary drastically even in the same geographic region. In some areas the sand may contain mostly quartz, while in others the sand may be made primarily from volcanic rock such as basalt, depending on the types of minerals along the water's path. The iron sand is typically picked up along the way from beds, veins, or inclusions of magnetite, which may originate a great distance from the sand deposits, and washed downstream or along the currents with the rest of the sand. Being heavier than the other sands, it is often deposited in areas where the water experiences a sudden change in direction or speed, such as the widening of a river or where the waves ebb and flow against the shoreline.

II. METHODOLOGY



III. MATERIALS USED

3.1 Cement

Cement is a binding material when it mixed with water. It is grey in colour with finely powdered material. The Portland Pozzolana Cement is a kind of Blended Cement which is produced by either intergrading of OPC clinker along with gypsum and pozzolanic materials in certain proportions or grinding the OPC clinker, gypsum and Pozzolanic materials separately and thoroughly blending them in certain proportions.

Table 1 Chemical constituents of PPC

Lime(Cao)	60to67%
Silica(Sio_2)	17to25%
Alumina(Al_2O_3)	3to 8%
IronOxide(Fe_2O_3)	0.5to 6%
Magnesia(MgO)	0.1to 4%
SulphurTrioxide(SO_3)	1to 3%
Sodaand/orPotash($Na_2O + K_2O$)	0.5 to 1.3%

3.2 Magnetic Sand

This black mineral is composed of iron oxide, so magnets are able to pick it up. Because magnetite is also very heavy, when the wind blows, the lighter weight sand is blown away, leaving magnetite behind in patches. These black patches can be seen in the dunefield from a distance. Magnetite 12 is a type of iron oxide that is naturally occurring, and it is what makes black sand magnetic. Iron sand is naturally ferromagnetic (magnetic properties with strong magnetic attraction) with magnetic minerals such as magnetite (Fe_3O_4), hematite (Į-Fe_2O_3) and maghemite (Fe_2O_3) in sand has strong magnetic properties. Iron sand which has a high magnetic mineral content will provide strong magnetic properties. It has a nominal iron content of 57%. Bulk density: 2,740 - 2,820 kg/m^3.

3.3 Fine Aggregate

Fine Aggregate are the material passing through an IS sieve that is less than 4.75mm. Gauge usually natural sand is used as a fine aggregate at places where natural sand is not available crushed stone is used as a fine aggregate. The sand is used for the experimental works that was procured and conformed to grading zone II. Sieve analysis of the fine aggregate was carried out in the laboratory as per IS 383-1970. The fine aggregate was first sieved through 4.75mm sieve to remove any particle greater than 4.75mm sieve and then was washed to remove the dust. According to IS 383-1970 the fine aggregate is being classified in to four different zone, that is zone I, zone II, zone III, zone IV.

Table 2 Types of fine aggregates

Fine Aggregates	Size
Coarse Sand	2.0mm–0.5mm
Medium sand	0.5mm–0.25mm
Fine sand	0.25mm–0.06mm
Silt	0.06mm–0.002mm
Clay	<0.002

3.4 Coarse Aggregate

The materials which are retained on 4.75mm sieve are called coarse aggregate. The broken stone is generally used as a coarse aggregate. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20mm was used in the present work. According to IS 383-1970 coarse aggregate maximum 20mm coarse aggregate is suitable for concrete work. But where there is no restriction 40mm or large size may be permitted.

Table 3 Coarse Aggregate Grading (AsperIS: 383)

63mm	40mm	20mm	16mm	12.5mm	10mm
100	–	–	–	–	–
85-100	100	–	–	–	–
0-30	85-100	100	–	–	–
0-5	0-20	85-100	100	–	–
–	–	–	85-100	100	–
–	–	–	–	85-100	100
0-5	0-5	0-20	0-30	0-45	85-100
–	–	0-5	0-5	0-10	0-20
–	–	–	–	–	0-5

3.5 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully. Potable water is generally considered satisfactory. In the present investigation, tap water was used for both mixing and curing purposes. The water quality for construction shall be tested or monitored regularly, as it affects the overall strength of concrete. For plain and reinforced cement concrete permissible limits for solids shall be as follows.

Table 4 Permissible limits for solids

Type of Solid in water	Permissible Limits for Construction
Organic matter	200mg/l
Inorganic matter	3000mg/l
Sulphates (SO4)	500mg/l
Chlorides (Cl)	a)1000mg/l for RCC work and, b)2000mg/l for PCC work
Suspended matter	2000mg/l

IV. LABORATORY INVESTIGATIONS

4.1 Tests on Cement

Various tests are to be conducted on cement like Fineness, Consistency, Initial and Final setting time their results as follows.

4.1.1Fineness of Cement

The fineness of cement is done by dry sieving as per IS: 4031 (Part 1) – 1996.The principle of this is to determine the proportion of cement whose grain size is larger than specified mesh size. The apparatus used are 90µm IS Sieve, Balance capable of weighing 10g to the nearest 10mg, A nylon or pure bristle brush, preferably with 25 to 40mm, bristle, for cleaning the sieve.

4.1.2Consistency Test on Cement

Vicat apparatus (confirming to IS: 5513-1968) with plunger (10mmin diameter).The standard consistency of a cement paste is defined as that consistency which will permit the Vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the vicat mould, when the cement paste is tested as described in the following procedures.

4.1.3 Initial Setting Time of Cement

The Vicat apparatus (conforming to IS: 5513-1968) has been used to find the initial setting time of cement.

Table 5 Test results of Cement

Properties	Test Value	Standard Value
Consistency	30%	30%
Initial setting time	35minutes	30minutes
Fineness	6%	<10%

4.2 Test on Fine Aggregate

4.2.1Specific Gravity Test

The specific gravity test helps in the identification of stone. Water absorption gives an idea of strength of aggregate. Aggregates having more water absorption are more porous in nature and are generally considered unsuitable unless they are found to be acceptable based on strength, impact and hardness tests.

4.2.2Fineness Modulus of Fine Aggregate

Fineness modulus of sand (fine aggregate) is an index number which represents the mean size of the particles in sand. It is calculated by performing sieve analysis with standard sieves. The cumulative percentage retained on each sieve is added and subtracted by 100 gives the value of fineness modulus.

Table 6 Test results of Fine Aggregate

Characteristics	Test Value	Standard Value
Type	Natural sand	Natural sand
Specific Gravity	2.74	2.8
Fineness modulus	2.865	2.6- 2.9

4.2.3Test on Coarse Aggregate

Fineness modulus of coarse aggregates represents the average size of the particles in the coarse aggregate by an index number. It is calculated by performing sieve analysis with standard sieves. The cumulative percentage retained on each sieve is added and subtracted by 100 gives the value of fine aggregate.

Table 7 Test results of Coarse Aggregate

Characteristics	Test Value	Standard Value
Type	Crushed Stone	Crushed Stone
Specific Gravity	2.78	2.5-2.8
Maximum Size	20mm	20mm
Fineness modulus	3.42	2.9-3.5
Impact value	44%	<45%
Crushing value	42.2%	<45%

4.3 Fresh Concrete Test

4.3.1 Slump Test on Concrete

The apparatus for conducting the slump test essentially consists of a frustum of a cone having the bottom diameter of 20 cm, top diameter of 10 cm and height of 30 cm. For slump test, tamping rod of steel 16 mm in 25 diameters, 0.6 m long and rounded at one end is used for compaction. The internal surface of slump cone shall be thoroughly cleaned and should be placed on smooth horizontal, rigid and non-absorbent surface such as carefully leveled metal plate. The mould should be filled in four layers each approximately one quarter of the height of mould. Each layer shall be tamped with 25 blows. The bottom layer should be tamped throughout its depth. After the top layer has been ridded the concrete shall be struck off level with trowel rod. The mould shall be removed from the concrete immediately by raising it slowly and carefully in vertical direction. This will allow the concrete to subside and slump shall be measured immediately by determining the difference between height of mould and that of highest point of slumped concrete specimen.

Table 8 Slump values

S.NO	Degree of Workability	%of Magnetic sand	Slump Value
1	Slump Value (50–100)Medium	10	85
2		20	70
3		30	62

4.3.2 Compaction Factor Test on Concrete

It gives the measure of workability. The amount of water needed to compact a given mass of concrete is its compact ability. Practically, the compaction factor may be defined as the ratio of the weight of partially filled concrete (concrete from hoppers) to fully compacted concrete. Its value is always less than unity. This test is more accurate than slump test and its results are suitable for low and medium workability (i.e. CF: 0.8 - 0.9). The very low workable concrete (CF ≤ 0.7) cannot be fully compacted and thus this test will not be suitable.

The compaction factor value has obtained as 0.86 and which has medium degree of workability.

V. SPECIMEN CASTING

5.1 General

The specimens are cast by using required size moulds. The concrete is compacted by the trowel rod. The concrete is placed by the three layers for proper compaction. After casting, specimens are left for 24 hours for setting and then it is remoulded. Identification marks are made on face of the specimen and it is allowed for curing.

5.2Cube Specimen

24 cubes are prepared with different percentage of Magnetic sand as additives of concrete. The size of cube is 150 x 150 x 150 mm.

Table 9 List of cubes

Cubes	No. of Cubes		
	3days	7days	28days
Conventional concrete	3	3	3
10%ofMagneticsand	3	3	3
20%ofMagneticsand	3	3	3
30%ofMagneticsand	3	3	3

5.3 Cylinder Specimen

The split tensile test is an indirect way of evaluating the tensile test of concrete. In this test, a standard cylindrical specimen is laid horizontally, and the force is applied on the cylinder radially on the surface which causes the formation of a vertical crack in the specimen along its diameter. Concrete cylinders cast for acceptance testing are typically 4x8in or 6x12in (100x200mm or 150x300mm) in diameter by length. In this project cylindrical specimen is 150 mm in diameter and 300 mm in height has been casted.

Table 10 List of Cylinder

Cylinders	No. of Cylinders		
	3days	7days	28days
Conventional concrete	3	3	3
10%ofMagneticsand	3	3	3
20%ofMagneticsand	3	3	3
30%ofMagneticsand	3	3	3

5.4Prism Specimen

Indian standard determined the size of the concrete specimen as 150mm width, 150mm depth, and span of 700mm. It also states that a size of 100mm width, 100mm depth, and span of 500mm can be used if the maximum aggregate size used is not greater than 20 mm.

Table11 List of Prism

Prisms	No. of Prisms		
	3days	7days	28days
Conventional concrete	3	3	3
10%ofMagneticsand	3	3	3
20%ofMagneticsand	3	3	3
30%ofMagneticsand	3	3	3

VI. EXPERIMENTAL INVESTIGATION

6.1 Compressive Strength Test

As per IS: 516-1959 Compressive testing machine (2000KN), 15cm×15cm×15cm steel cube moulds. Concrete gains maximum strength at 28days. Since in construction sector great amount of capital is at stake, so instead of checking strength at 28 days we can check strength in terms of concrete strength psi at 7 and 14 days to predict the target strength of construction work. The maximum load applied to the specimen shall than be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

Table 12 Compressive Strength test result of Cubes

S. No	Cube Description	Sample	Compressive strength (3days) N/mm^2	Compressive strength (7days)N/mm^2	Compressive Strength (28days)N/mm^2
1	Conventional Concrete	S1	7.8	13.20	20.20
		S2	8.3	13.40	20.67
		S3	7.9	13.10	21.40
2	10% of Magnetic sand	S1	8.1	14.24	21.86
		S2	7.7	14.54	21.53
		S3	8.6	14.34	21.24
3	20% of Magnetic and	S1	8.7	15.80	21.63
		S2	9.3	14.10	21.86
		S3	9.6	15.20	21.95
4	30% of Magnetic sand	S1	9.7	16.38	22.45
		S2	10.4	16.46	22.40
		S3	10.2	16.52	22.60

6.2 Split Tensile Strength Test on Cylinder

As per IS 5816: 1999 the splitting tensile strength test is performed on hardened concrete to determine its tensile strength. Marginal variations in water to cement ratio, ingredient proportioning, and increase in a slump, etc impacts the desired concrete strength. This in turn affects the strength and stability of structures. There are several tests to determine the strength of concrete. The unit of tensile strength is N/mm. The splitting test is easy to perform and we can get uniform results. It is a simple, reliable and convenient method to determine the strength of concrete.

Table 13 Split Tensile test result of Cylinders

S. No	Cylinder Description	Sample	Split Tensile strength (3days) N/mm^2	Split Tensile strength (7days) N/mm^2	Split Tensile Strength (28days) N/mm^2
1	Conventional Concrete	S1	0.84	1.83	2.28
		S2	0.96	1.71	2.75
		S3	1.14	1.43	2.62
2	10% of Magnetic sand	S1	1.46	1.94	2.88
		S2	1.54	1.81	2.98
		S3	1.32	1.93	2.76
3	20% of Magnetic sand	S1	1.76	2.23	3.10
		S2	1.84	2.34	3.24
		S3	1.72	2.64	3.18
4	30% of Magnetic sand	S1	1.96	2.86	3.43
		S2	1.89	2.94	3.64
		S3	2.02	2.72	3.52

6.3 Flexural Strength Test on Prism

Flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand failure in bending. The results of flexural test on concrete expressed as a modulus of rupture which denotes as (*MR*) in MPa or psi. The flexural test on concrete can be conducted using either three point load test (ASTM C78) or centre point load test (ASTM C293). According to ASTM the size of the specimen is 150mm width, 150mm depth and the length should not be at least three times the depth of the specimen. Indian standard determined the size of the concrete specimen as 150mm width, 150mm depth, and span of 700mm. It also states that a size of 100mm width, 100mm depth, and span of 500mm can be used if the maximum aggregate size used is not greater than 20 mm. British standards specifies square specimen cross section with 100mm or 150mm dimension and the span ranges from four to five times specimen depth. However, it preferred 150mm width, 150mm depth, and span of 750mm for the specimen.

Table 14 Flexural Strength test result of Prisms

S. No	Prism Description	Sample	Flexural strength (3 days)N/mm^2	Flexural strength (7 days)N/mm^2	Flexural Strength (28days)N/mm^2
1	Conventional Concrete	S1	0.78	1.66	2.23
		S2	0.86	1.78	2.65
		S3	0.94	1.88	2.72
2	10% of Magnetic sand	S1	1.34	1.84	2.88
		S2	1.28	1.77	2.98
		S3	1.36	1.94	2.76
3	20% of Magnetic sand	S1	1.84	2.32	3.10
		S2	1.68	2.24	3.24
		S3	1.76	2.52	3.18
4	30% of Magnetic sand	S1	1.98	2.77	3.43
		S2	1.78	2.84	3.64
		S3	2.08	2.97	3.52

VII. CONCLUSION

Magnetic sand was used as additive to M20 grade concrete and based on experimental investigation following conclusions were drawn.

- Addition of 10 %, 20% and 30% of Magnetic sand to M20 grade concrete gave notable compressive strength than conventional M20 grade concrete. At the age of 3 days, 7 days and 28 days the compressive strength has improved to extra 26% than the conventional M20 grade concrete strength.
- Similarly addition of 30% Magnetic sand, gave higher split tensile strength than other proportions of Magnetic sand. At the age of 7 days and 28 days the split tensile strength increased to extra 20% effectively compared to other conventional M20 grade concrete.

- Also for addition of 30% Magnetic sand gave effective flexural strength than conventional M20 grade concrete. At the age of 7 days and at the 28 days the flexural strength achieved as extra 18% standard value compared to conventional M20 grade concrete.
- In this experimental investigation, we concluded that addition of Magnetic sand as a replacement of fine aggregate to the concrete will give effective result rather than conventional concrete.

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