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EXPERIMENTAL STUDIES ON FLEXURAL BEHAVIOUR AND DURABILITY PROPERTIES OF CONCRETE BY USING ARTIFICIAL AGGREGATES

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Abstract

In this project the artificial aggregates were manufactured using the waste materials like ground granulated blast furnace slag. The artificial aggregates are prepared by pelletization method for various proportions of cement and waste material ground granulated blast furnace slag. In this floor hardening powder to be used in artificial aggregates prepared by pelletization method to increase the strength of artificial aggregates. The properties of the materials were studied and compared with natural aggregate for a durability property. Artificial aggregates were prepared for the ratio of 1:2. Then the strength properties like specific gravity, water absorption test, sieve analysis, impact test, abrasion test, aggregate crushing test of the prepared artificial aggregates is tested. In for upcoming phase the ratio, proportion of concrete varies 20%, 40%, 60%, 60%, 80%, 100% to choose an optimum level of aggregate percentage using of casting for beam. The conventional aggregate concrete mix has been designed for M30 grade of concrete using IS method. Finally the normal aggregate is compared with artificial aggregate where flexural strength and durability properties are determined. Then the results are numerically analyzed.

***Keywords**:* Artificial aggregates, GGBFS, Surface hardening powder, Durability properties.

1. INTRODUCTION

One of the field investigation for a concrete construction project is to search for sources of aggregates which will give material of good quality at economical rates. Suitability of aggregate will depend upon the geological history of the region. The aggregate as per nature of formation may be divided into two types like natural and artificial aggregates.

Cheapest among them will be the natural sand and gravel which have been reduced to their present size by natural agents such as water, wind and snow etc.

River deposits are the most common and have good quality and also used source of aggregates are made by breaking down natural bed rocks into requisite graded particles through a series of blasting, crushing, screening, etc. Amongst the artificial aggregates brick ballast and air cooled blast furnace slag are most common. Broken brick may be used for mass concrete but is not for reinforced concrete work unless the crushing strength is high.

Blast furnace slag is not commonly used on account of the possible corrosion of steel due to the sulphur content of slag. Concrete made with blast furnace slag aggregate has good fire resisting qualities. Other artificial aggregates such as foamed slag, expanded clay, shale and salte are also used for producing light weight concrete.

The aggregates normally used for concrete are natural deposits of sand and gravel, where available. Amongst the artificial aggregates brick ballast and air cooled blast furnace slag are most common. Broken brick may be used for mass concrete but is not for reinforced concrete work unless the crushing strength is high.

2. MATERIALS PROPERTIES

2.1 Ground granulated blast furnace slag

GGBFS is obtained by quenching molten iron slag (a by-product of iron and steel- making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. The chemical composition of a slag varies considerable depending on the composition of the raw material in the iron production process.

Silicate and acuminate impurities from the ore and coke are combined in the blast furnace with a flux which lowers the viscosity of the slag in the case of pig iron production the flux consist mostly of a mixture of limestone forsterite or in some cases dolomite. In the blast furnace the slag floats on top of the iron and is decanted for separation. So cooling of slag melts results in a unreactive crystalline material consisting of an assemblage of Ca-AL-Mg silicate.

To obtain a good slag reactivity or hydraulicity , the slag melt needs to be rapidly cooled or quenched below 800˚c in order to prevent the crystallization of merwinite and metltilite. To cool and fragment the slag a granulation process can be applied in which molten slag in subjected to jet streams of water or air under pressure.

Alternatively, in the pelletization process the liquid slag is partially cooled with water and subsequently projected into the air by a rotating drum. In order to obtain a suitable reactivity, the obtained fragment is ground to reach the same fineness as Portland cement.

Figure: 1 Ground granulated blast furnace slag

2.2 Chemical Properties of GGBFS

GGBFS comprise mainly CaO, SiO_2, Al_2O_3, MgO, it contains less than 1% crystalline silica, and contains less than 1 PPM water soluble chromium IV. The chemical properties are

CONSTITUENT	*PERCENTAGE (%)*
CaO	40
SiO	35
Al_2O_3	12
MgO	8.2
Fe_2O3	0.2
K_2O	0.4
Na_2O	0.10
SO_3	0.22
Cl	0.018
Others	5

Table: 1 Chemical properties of GGBFS

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2.3 Physical Properties of GGBFS

The ground cement powder is near white in colour and is a hardening through chemical reaction with water.

S.NO	DESCRIPTION	VALUE
1	Colour	Off-White Powder
2	Bulk density	1.0-1.1 tonnes/m^3
3	Bulk density	1.2-1.3 tonnes/m^3
4	Relative density	2.85-2.95
5	Specific gravity	2.83

Table: 2 Physical properties of GGBFS

2.4 Surface hardening powder

Many a time surface of a concrete floor is not hard enough for the type of use it is put to. The result is that it bears or dusts off rapidly. It is possible to increase the life of such floors by application of certain materials known as “hardeners”. Floor hardness is generally used for the purpose of hardening the upper matrix of Portland cement concrete surface, reducing the suction of liquids into the surface pores, and minimizing or preventing possible chemical attack. They are effective if the floor is of good quality, although they have sometimes been used successfully on the interior quality concrete surface.

3. ARTIFICIAL AGGREGATES

3.1 Manufacturing Procedure

The constituents like cement, GGBFS, surface hardening powder and water produce the GGBFS slag aggregates. Water is the binding material that paves the way for the function of the aggregate with good bond property. The GGBFS and cement are dry mixed in a pelletizer.

The angle of rotation of the drum of the pelletizer is set as 25 degrees and speed of revolution is 26 rpm. The water is sprayed to the rotating drum containing dry mix and the hardening powder is spread on the surface of wet artificial aggregates to get harden conditions.

Figure: 2 Mixer Machine

3.2 Proportions of Aggregates

Cement and GGBFS were mixed in above six proportions in a concrete mixer. Water was added to the mix by adopting the water cement ratio of 0.4. The contents were thoroughly mixed in the drum until the complete formation of GGBFS aggregates. This method of formation of GGBFS aggregates is called pelletisation.

Figure: 3 Artificial Aggregates

Properties	Natural aggregates	Artificial aggregates
Specific gravity	2.72	1
Bulk density	433 Kg/m³	307 Kg/m³
Impact test	23.86	18
Size	20mm	20mm

Table: 3 Properties of aggregates

4. EXPERIMENTAL STUDY

Testing specimen like cube and cylinder to be tested for compressive strength and split tensile test conducted. Finally, from the test result will be selected for an optimum level of artificial aggregate by by using in concrete.

Figure: 4 Split tensile test

Figure: 5 Compressive strength

4.1 Compressive strength

The compressive strength test results of the mechanical tests are shown in the graph. The compressive strength after 28 days, generally decrease with an increase in the percentage replacement for artificial aggregates beyond 80%.

The strength of artificial aggregate which is compare to concrete normal aggregate concrete is very good strength up to 100% replacement.

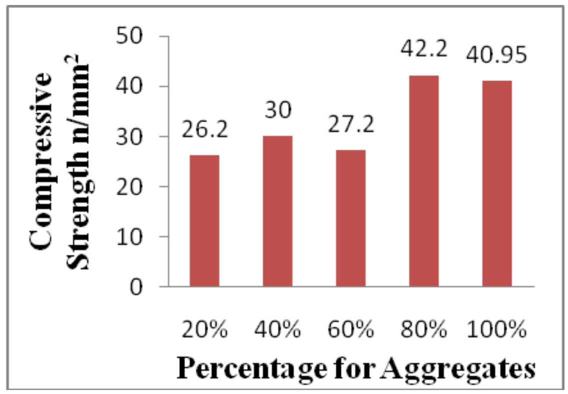

Figure: 6 Optimum percentage for artificial aggregates

4.2 Split Tensile Strength Test

The spilt tensile strength test results shown in the graph. The spilt tensile strength after 28 days, generally decrease with an increase in the percentage replacement for artificial aggregates upto 80% is respectively.

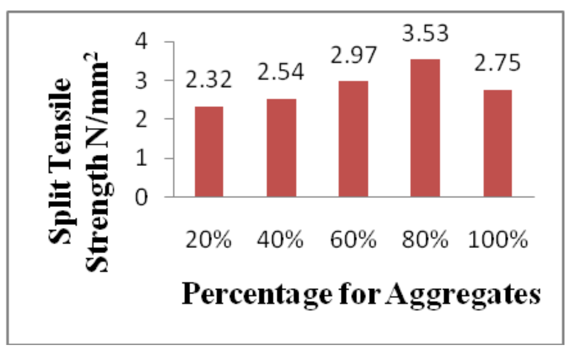

Figure:7 Optimum percentage for spilt tensile test

Percentage of mix proportions (%)	Compressive strength (N/mm^2)	Spilt tensile strength (N/mm^2)
20	26.2	2.05
40	30	2.54
60	27.2	2.97
80	42.2	3.53
100	40.95	2.75
Conventional	34.5	3.46

Table: 4 Test result for strength

4.3 Acid Attack Test

The concrete cubes of sizes 150mm×150mm×150mmm are prepared for various percentages and cured in curing tank for 28 days. After 28 days all the specimens are kept in the atmosphere for 2 days for constant weight. Select optimum percentage for artificial aggregates is 80% suitable for concrete for increasing compressive strength. Subsequently, the specimen is weighed and immersed in 5% sulphuric acid solution for 28 days. After 28 days of immersion, the specimen is taken out and kept in atmosphere for 2 days for constant weight. After drying, the changes in weight and the compressive strength of concrete cubes were determined.

Figure: 8 Cube after acid attack

4.3.1 Result of Acid Attack Test

Table 5 show the acid attack test result percentage loss in weight and strength of concrete cube specimen with compare to control concrete cube.

S.No	Mix	Compressive strength N/mm^2	% Weight loss
1	M30	34.5	3.38
2	Cube1	34	1.08
3	Cube2	32.5	1.21

Table: 5 Percentage loss in weight of acid attack

4.4 Sulphate Attack Test

When concrete is exposed to environmental containing aggressive chemicals, it leads to deterioration of concrete which can be assessed in terms of loss of weight of concrete. The acid attack of concrete, the cubes of concrete were cured and then immersed in 3% $MgSO_4$ solution up to 28 days.

Figure: 9 Cube after sulphate attack

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4.4.1 Result of Sulphate Attack Test

Table 6 show the acid attack test result percentage loss in weight and strength of concrete cube specimen with compare to control concrete cube.

S.No	Mix	Compressive strength N/mm^2	% weight loss
1	M30	34.5	3.38
2	Cube 1	34.4	3.63
3	Cube 2	33.6	6.33

Table: 6 Percentage loss in weight of sulphate attack

4.5 Scanning Electron Microscopy

Scanning electron microscopy with energy dispersive X-ray analysis is an important supplement to the optical microscopy when examining new, old and deteriorated concrete. Identify the tiny micron size mineral phases not visible in the optical microscope. Important quality assurance is degree of hydration of cement and adhesion to aggregates. The artificial aggregate concrete sample was tested. The images of the artificial aggregates images are a various sizes to be tested. In this photography shows GGBFS aggregate how to propagate in concrete to various sizes.

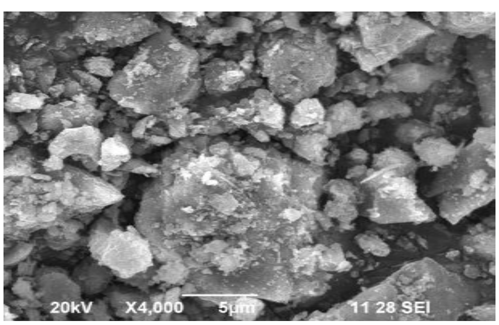

Figure: 10.a

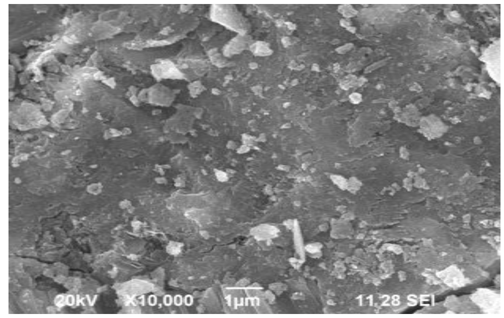

Figure: 10.b

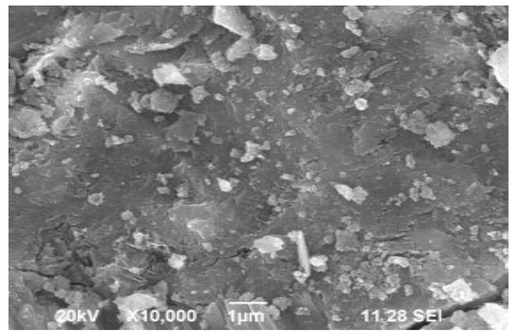

Figure: 10.c

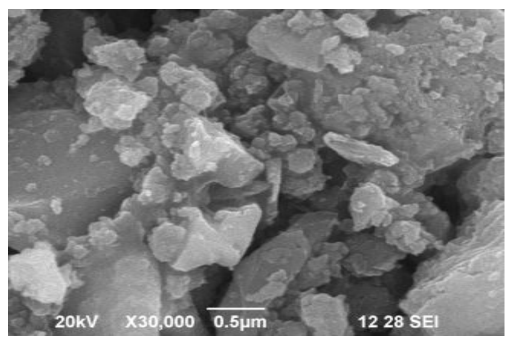

Figure: 10.d

Figure: 10 Scanning electron microscopy image for artificial aggregate concrete

4.6 Energy Dispersive X-Ray Spectroscopy

EDX is an analytical technique used for the element analysis or chemical characterization of a sample.

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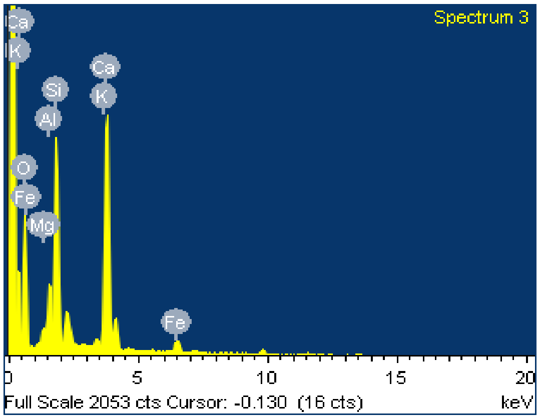

Figure: 11 X-ray for GGBFS aggregate in concrete

Its characterization capabilities are due in large part to the fundamental principle that each element has a unique atomic structure allowing a unique set of peaks on its X-ray emission spectrum. In this X-ray 100% variation of chemicals propagate in concrete.

5. CONCLUSION

The unit weight of concrete gets reduced through the addition of GGBFS aggregates as partial replacement for coarse aggregate since it has a lower specific gravity than coarse aggregate.The density of concrete reduces with increase in percentage of GGBFS aggregates.The compressive and split tensile strength of concrete has obtained at 80% replacement of natural aggregate by GGBFS aggregates.The impact strength increase with replacement of natural aggregate. GGBFS is good, corrrosion resistance were compare to different wastage materials.The result will be evaluated that the optimum percentage for GGBFS artificial aggregates was the 80% replacement with natural aggregates in concrete. SEM analysis images showing in the varying sizes of aggregate propagate in concrete.EDX is used to determine the amount of chemicals composition present in the hardened concrete after curing.

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