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On The Strength of Concrete Pressure Bearing Blast Furnace Slag Powder

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ABSTRACT:

The construction industry is the largest consumer of natural resources which led to depletion of good quality natural sand (Fine aggregates). This situation led us to explore alternative materials and granular slag a waste industrial byproduct is one such material identified for utilization it as replacement of natural sand. This paper highlights upon the feasibility study for the utilization of granular slag as replacement of natural fine aggregate in construction applications (Masonry &plastering). In this investigation, concrete mixes 1:1.46:3.35 by volume were selected for 0, 20, 40, 60,80& 100% replacements of natural sand with granular slag for w/c ratios of 0.45,respectively. The study gave comparative results for concrete flow behaviors, compressive & split tensile strengths, brick mortar crushing & pulls strengths and their co-relations. The study comprises of The experimental results obtained show that partial substitution of ordinary sand by slag gives better results in both the applications i.e. masonry &plastering. Cement, sand and aggregate are basic needs for any construction industry.

Sand is a prime material used for preparation of mortar and concrete and which plays a major role in mix design. Now a day's erosion of rivers and considering environmental issues, there is a scarcity of river sand. The non-availability or shortage of river sand will affect the construction industry, hence there is a need to find the new alternative material to replace the river sand, such that excess river erosion and harm to environment is prevented. Many researchers are finding different materials to replace sand and one of the major materials is quarry stone dust. Using different proportion of these quarry dust along with sand the required concrete mix can be obtained. This paper presents a review of the different alternatives to natural sand in preparation of mortar and concrete. The paper emphasize on the physical and mechanical properties and strength aspect on mortar and concrete.

I.INTRODUCTION:

Cement, sand and aggregate are essential needs for any construction industry. Sand is a major material used for preparation of mortar and concrete and plays a most important role in mix design. In general consumption of natural sand is high, due to the large use of concrete and mortar. Hence the demand of natural sand is very high in developing countries to satisfy the rapid infrastructure growth. The developing country like India facing shortage of good quality natural sand and particularly in India, natural sand deposits are being used up and causing serious threat to environment as well as the society. Rapid extraction of sand from river bed causing so many problems like losing water retaining soil strata, deepening of the river beds and causing bank slides, loss of vegetation on the bank of rivers, disturbs the aquatic life as well as disturbs agriculture due to lowering the water table in the well etc are some of the examples. The heavy-exploitation of river sand for construction purposes in Sri Lanka has led to various harmful problems.

Options for various river sand alternatives, such as offshore sand, quarry dust and filtered sand have also been made (W.P.S. Dias et al 2008). Physical as well as chemical properties of fine aggregate affect the durability, workability and also strength of concrete, so fine aggregate is a most important constituent of concrete and cement mortar. Generally river sand or pit sand is used as fine aggregate in mortar and concrete. Together fine and coarse aggregate make about 75- 80 % of total volume of concrete and hence it is very important to fine suitable type and good quality aggregate nearby site (Hudson 1997). Recently natural sand is becoming a very costly material because of its demand in the construction industry due to this condition research began for cheap and easily available alternative material to natural sand. Some alternatives materials have already been used as a replacement of natural sand such as fly-ash, quarry dust or limestone and siliceous stone powder,

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filtered sand, copper slag are used in concrete and mortar mixtures as a partial or full replacement of natural sand (Chandana Sukesh et al 2013). Even though offshore sand is actually used in many countries such as the UK, Sri Lanka, Continental Europe, India and Singapore, most of the records regarding use of this alternative found mainly as a lesser extent of practice in the construction field. Due to shortage of river sand as well as its high the Madras High Court restrictions on sand mining in rivers Cauvery and Tamirabharani. The facts like in India is almost same in others countries also. So therefore the need to find an alternative concrete and mortar aggregate material to river sand in construction works has assumed greater importance now a days. Researcher and Engineers have come out with their own ideas to decrease or fully replace the use of river sand and use recent innovations such as M-Sand (manufactured sand), robot silica or sand, stone crusher dust, filtered sand, treated and sieved silt removed from reservoirs as well asdams besides sand from other water bodies.

II.RELATED WORK:

India is one of the fast developing countries in the world. Various fields like Industry, Infrastructure, Construction, Agriculture etc., have a major role in achieving an all round development. This development has urged the industrial sector to produce various goods that are necessary. These industries and factories besides producing various useful goods have also become a source of waste products. And it has become necessary to find ways and means of disposing off or utilizing these waste materials, which may otherwise end up in polluting the surroundings. This led to the investigation of searching fields of utilization of these waste products for a better purpose. Research work was carried out on this subject not only in India but also all over the world. The results of such works showed that there could be no better place other than the construction field, where a large quantity of such materials can be utilized in a better and economical way. On the other hand the field of Construction has also its role to play in the development of the country by not only in increasing the construction work but also in a more sophisticated manner. This in turn has an effect on the various materials and their quantities that are to be used. Therefore, this also led to the investigation of new materials, which can be utilized for the purpose even more economically. Especially work has done on the utilization of the by-products obtained from various industries.

In this way the construction field and the industrial sector have been linked together, reducing the environmental hazards and serving the economical problems. The granulated blast furnace slag (GBFS) is glassy particle and granular materials in nature and has a similar particle size range like sand. The specific gravity of the slag is 2.63. The bulk density of granulated slag varies from 1430 kg/m3 which were almost similar to bulk density of convectional fine aggregate. The water absorption of slag was found to be less than 2.56 %.The presence of silica in slag is about 26% which is desirable since it is one of the constituents of the natural fine aggregate used in normal concreting operations.

III.SYSTEM PREMELIRES:

The world is resting over a landfill of waste hazardous materials which may substitutes for natural sand. Irrespective of position, location, scale, type of any structure, concrete is the base for the construction activity. In fact, concrete is the second largest consumable material after water, with nearly three tonnes used annually for each person on the earth. India consumes an estimated 450 million cubic meter of concrete annually and which approximately comes to 1 tonne per Indian. We still have a long way to go by global consumption levels but do we have enough sand to make concrete and mortar? Value of construction industry grew at staggering rate of 15 % annually even in the economic slowdown and has contributed to 7-8 % of the country’s GDP (at current prices) for the past eight years.

A.COPPER SLAG:

At present about 33 million tonnes of copper slag is generating annually worldwide among that India contributing 6 to 6.5 million tonnes. 50 % copper slag can be used as replacement of natural sand in to obtain mortar and concrete with required performance, strength and durability. (Khalifa S. Al-Jabri et al 2011). In India a study has been carried out by the Central Road Research Institute (CRRI) shown that copper slag may be used as a partial replacement for river sand as fine aggregate in concrete up to 50 % in pavement concrete without any loss of compressive and flexural strength and such concretes shown about 20 % higher strength than that of conventional cement concrete of the same grade.

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B.GRANULATED BLAST FURNACE SLAG:

According to the report of the Working Group on Cement Industry for the 12th five year plan, around 10 million tonnes blast furnace slag is currently being generated in the country from iron and steel industry. The compressive strength of cement mortar increases as the replacement level of granulated blast furnace slag (GGBFS) increases. He further concludes that from the test results it is clear that GGBFS sand can be used as an alternative to natural sand from the point of view of strength. Use of GGBFS up to 75 per cent can be recommended (M C Nataraja 2013)[6]. A mix of copper slag and ferrous slag can yield higher compressive strength of 46.18MPa (100 per cent replacement of sand) while corresponding strength for normal concrete was just 30.23MPa. Though she warns that with higher levels of replacements (100 per cent) there might be some bleeding issues and, therefore, she recommended that up to 80 per cent copper slag and ferrous slag can be used as replacement of sand (Meenakshi Sudarvizhi 2011)[7].

C.WASHED BOTTOM ASH (WBA):

Currently India is producing in over 100 million tons of coal ash. From which total ash produced in any thermal power plant isapprox 15 –20 per cent of bottom ash and the rest is fly ash. Fly ash has found many users but bottom ash still continues to pollute the environment with unsafe disposal mechanism on offer.The mechanical properties of special concrete made with 30 per cent replacement of natural sand with washed bottom ash by weight has an optimum usage in concrete in order to get a required strength and good strength development pattern over the increment ages (MohdSyahrulHisyam 2010).

D.QUARRY DUST :

About 20 to 25 per cent of the total production in each crusher unit is left out as the waste material- quarry dust. The ideal percentage of the replacement of sand with the quarry dust is 55 per cent to 75 per cent in case of compressive strength. He further says that if combined with fly ash (another industrial waste), 100 per cent replacement of sand can be achieved. The use of fly ash in concrete is desirable because of benefits such as useful disposal of a byproduct, increased workability, reduction of cement consumption, increased sulfate resistance, increased resistance to alkali-silica reaction and decreased permeability. However, the use of fly ash leads to a reduction in early strength of concrete. Therefore, the concurrent use of quarry dust and fly ash in concrete will lead to the benefits of using such materials being added and some of the undesirable effects being negated (Chandana Sukesh 2013).

E.FOUNDRY SAND:

India ranks fourth in terms of total foundry production (7.8 million tonnes) according to the 42nd Census of World Casting Production of 2007. Foundry sand which is very high in silica is regularly discarded by the metal industry. Currently, there is no mechanism for its disposal, but international studies say that up to 50 per cent foundry sand can be utilized for economical and sustainable development of concrete (Vipul D. Prajapati 2013)[10].

F.CONSTRUCTION AND DEMOLITION WASTE:

There is no documented quantification of amount of construction and demolition (C&D) waste being generated in India. Municipal Corporation of Delhi says it is collecting 4,000 tonnes of C&D waste daily from the city which amounts to almost 1.5 million tonnes of waste annually in the city of Delhi alone. Even if we discount all the waste which is illegally dump around the city, 1.5 million of C&D waste if recycled can significantly substitute demand for natural sand by Delhi. Recycled sand and aggregate from C&D waste is said to have 10-15 per cent lesser strength then normal concrete and can be safely used in non-structural applications like flooring and filling. Delhi already has a recycling unit in place and plans to open more to handle its disposal problem. Construction and demolition waste generated by the construction industry and which posed an environmental challenge can only be minimized by the reuse and recycling of the waste it generates (Akaninyene A. Umoh 2012).

G.SPENT FIRE BRICKS (SFB):

An experimental investigation on strength and durability was undertaken to use “Spent Fire Bricks” (SFB) (i.e. waste material from foundry bed and walls; and lining of chimney which is adopted in many industries) for partial replacement of fine aggregate in concrete (S. Keerthinarayana and R. Srinivasan 2010).

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H.SHEET GLASS POWDER (SGP) :

Natural sand was partially replaced (10%, 20%, 30%, 40% and 50%) with SGP. Compressive strength, Tensile strength (cubes and cylinders) and Flexural strength up to 180 days of age were compared with those of concrete made with natural fine aggregates Attempts have been made for a long time to use waste glasses as an aggregate in concrete, but it seems that the concrete with waste glasses always cracks .Very limited work has been conducted for the use of ground glass as a concrete replacement. (M. Mageswari and Dr. B.Vidivelli 2010).

IV.EXPERIMENTAL INVESTIGATION A.GENERAL:

Experimental investigation was planned to study the effects of partial replacement of sand by GGBFS on strength properties of concrete. To achieve the objectives of the investigation the experimental program was planned to cast and test the cubes and cylinders to study Strength. The details of the experimental program for cylinders are mentioned.

B.SIEVE ANALYSIS FINE AGGREGATE:

Sl.no	Sieve Size	Mass retained (gm)	% Mass retained	Cumulative %Of mass retained	%passing(100-cummulative % mass retained)
1	4.75	4	0.4	0.4	99.6
2	2.36	16	1.6	2	98
3	1.18	100	10	12	88
4	600µ	115	11.5	23.5	76.5
5	300 µ	510	51	74.5	25.5
6	150 µ	205	20.5	95	5
7	Pan	50	5	100	0
		Fineness modulus=307.4/100 =>3.074			

C.Zone of sand:

From the above table it has been observed that sand conforming to grading zone III

D.COARSE AGGREGATE:

Crushed granite stone aggregate of 20mm nominal size was used throughout the work. Specific gravity of stone aggregate was found to be 2.745. The fineness modulus is 7.048.

E.SIEVE ANALYSIS FINE AGGREGATE:

Sl.no	Sieve Size	Mass retained (gm)	% Mass retained	Cumulative %Of mass retained	%passing(100-cummulative % mass retained)
1	80	0	0	0	100
2	40	0	0	0	100
3	20	415	8.3	8.3	91.7
4	10	4410	88.2	96.5	3.5
5	4.75	175	3.5	100	0
6	2.36	0	0	100	0
7	1.18	0	0	100	0
8	600 µ	0	0	100	0
9	300 µ	0	0	100	0
10	150 µ	0	0	100	0
Fineness modulus of coarse aggregate=704.8/100=>7.048					

V.RESULTS & DISCUSSIONS:

Varying the percentages of fly ash and GGBFS we tried to study the effect of partial replacement of sand on the properties of concrete GGBFS in percentages of' 10,20, 40,60,80 and 100 by weight. With cement, natural sand, coarse aggregate GGBFS constituting the basic materials, number of cylinders was cast varying the percentages of GGBfS. The mix design for M30 grade concrete was done in accordance with IS-10262 method and the same was adopted for the work. Therefore, concrete with GGBFS replacement was tested for strength studies.

A. RESULTS OF COMPRESSIVE STRENGTH(MPa) OF CUBES:

S no	Description	Compressive strength values(N/mm2)
1	Plain(0%)	39.18
2	20%	42.51
3	40%	43.91
4	60%	40.05
5	80%	38.5
6	100%	38.1

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B.RESULTS OF SPLIT-TENSILE:

S no	Description	Tensile strength values(N/mm2)
1	Plain(0%)	3.215
2	20%	3.06
3	40%	3.04
4	60%	3.39
5	80%	2.825
6	100%	3.11

STRENGTH(MPa) OF CYLINDER:
VI.GRAPHS:

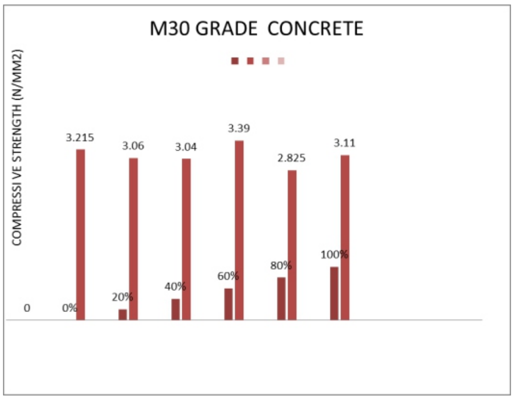

FIG :Graphical representation of compressive strength on replacement of sand with GGBFS

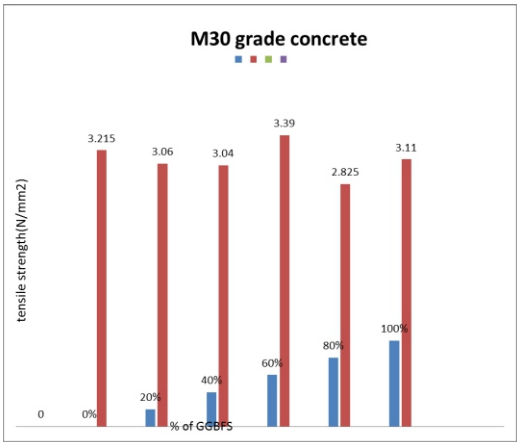

FIG :Graphical representation of tensile strength on replacement of sand with

VII.CONCLUSIONS:

The compressive strength was found to be maximum at 30% replacement of cement with fly ash. The compressive strength was found to be maximum at 30% replacement of cement with GGBS.

The compressive strength was found to be maximum at 30% replacement of cement with flyash + GGBS. The split-tensile strength was found maximum at 30% replacement of cement with flyash. The split-tensile strength was found maximum at 30% replacement of cement with GGBS. The Split-tensile strength was found maximum at 30% replacement of cement with flyash+ GGBS.

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