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PRACTICE IMPLEMENTATION ON STRENGTH PARAMETERS OF CONCRETE BY PARTIAL REPLACEMET OF CEMENT WITH COAL DUST AND SAND WITH IRON SLAG

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ABSTRACT:

Due to growing environmental awareness, as well as stricter regulations on managing industrial waste, the world is increasingly turning to researching properties of industrial waste and finding solutions on using its valuable component parts so that those might be used as secondary raw material in other industrial branches. Concrete a composite material made from cement, water, fine aggregate and coarse aggregate. But present researchers are in interest of finding new cement materials by waste materials or waste products produced from industries which are harmful to environment. M20 grades of concrete have been chosen as the reference concrete specimen. This project deals with partial replacement of cement with coal dust (0%, 10%, 20% and 30%) and fine aggregates with iron slag (0%, 40%, 50% and 60%). In this study Fresh and Harden properties of concrete was evaluated to investigate the optimal use of coal dust as cement and iron slag as fine aggregates replacement in concrete.

Keywords: M20, cement, water, coal dust, iron slag, concrete.

1. INTRODUCTION:

In Civil Engineering "Cement" plays an important role as it is impossible to produce any sustainable infrastructure without use of cement. We can say everything is incomplete without "Cement", as construction industries rapidly growing with new innovations and ideas. Leaving waste materials in to environment directly results to damage of natural climatic conditions, hence use of waste materials is made at most importance in present study.

Now a day's consumption of natural aggregate and cement as the largest concrete component is constantly and rapidly increasing with the increase in the production and utilization of concrete. The demand for construction material is also increasing, at the same time the cost of the construction material is also increasing, To overcome these type of problems are want to found the new composition with low cost is the ultimate aim of our project. Waste management has become one of the most complex and challenging problem in the world which is affecting the environment. The rapid growth of industrialization gave birth to numerous kinds of waste by products which are environmentally hazard and creates problems of storage. Always, construction industry has been at forefront in consuming these waste products in large quantities.

1.2 Iron slag

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 by product 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, aluminium silicates calcium and manganese in various arrangements. Even though the chemical composition of slag same but the physical properties of the slag vary with the varying method of cooling. The slags can be used as cement major constituents as they have greater pozzolanic properties.

The history of the use of iron and steel slag dates back a long way. European Slag Association (2006) has reported about the earliest reports on the use of slag, where in it is mentioned that Aristotle used slag as a medicament as early as 350 B.C. In the past, the application of steel slag was not noticeable because enormous volumes of blast furnace slag were available. Through awareness of environmental considerations and more recently the concept of sustainable development, extensive research and development has transformed slag into modern industrial product which is effective and beneficial. The American Society of Testing and Materials (ASTM) (1999) define blast furnace slag as "the non-metallic product consisting essentially of calcium silicates and other bases that is developed in a molten condition at the same time with iron in a blast furnace." Slag was considered to be essential in the production of iron, but once it served its purpose in refining the metal, it was strictly a nuisance with little or no use. The usefulness of slag was realized with the first ore smelting process. The use of slag became a common practice in Europe at the turn of the 19th century, where the incentive to make all possible use of industrial by-products was strong and storage space for by-products was lacking. Shortly after, many markets for slag opened in Europe, the United States, and elsewhere in the world.

1.3 Coal Dust

Coal dust a waste obtained from mining process is used as partial replacement to cement a pozzolonic material also used after identifying the optimum usage of coal dust in partial replacement of cement. Cement, at the time of production produces equal amounts of Co_2. Hence the partial replacement of cement can be made practice to optimize the cement content effects the production of cement and CO_2 content production.

According to Ahmaruzzaman, it was estimated that the production of coal ash is around 600 million tons worldwide per year, with Coal dust constituting around 500 million. The fly ash has similar properties to cement and has been adopted as a supplementary cementitious substance in concrete, but Coal dust is not frequently utilized in any form. The current disposal practice of Coal dust in ponds poses a high risk to human health and the environment. The utilization of coal dust is still limited due to its comparatively higher content of unburned carbon and diverse structural features, compared to fly ash. Considering the environmental benefits, the reuse of industrial waste in concrete production is the best alternative. The particle size of Coal dust is large and similar to fine and coarse aggregates, therefore, previously researchers considered Coal as a fine aggregate replacement in concrete. Coal dust has pozzolanic characteristics and could potentially be utilized in concrete as a cement replacement material, by reducing its particle sizes.

OBJECTIVE OF THE STUDY:

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- To replace cement in concrete with coal dust and fine aggregates with iron slag without compromising in strength and durability.
- To reduce the emission of CO_2 in atmosphere by reducing the requirement of cement.
- To develop mix design methodology for mix 20MPa .
- To study the effect of adding different percentages (0% - 30%) of cement with coal dust and (0% - 60%) fine aggregates with iron slag in the preparation of concrete mix.
- To determine the workability of freshly prepared concrete by Slump test and Compaction factor test.
- To determine the compressive strength of cubes at 7, 14, 28 days.
- To determine the flexural strength of cubes at 28 days

2. LITERATURE SURVEY:

Ismail and Al-Hashmi [1]observed an increase in compressive and flexural strength when 20% of sand was replaced with waste iron. An increase of 17% and 28% (compared to the reference concrete) was found for compressive and flexural strength, respectively. Other researchers reported that iron fillings can replace even higher percentages of sand without compromising the properties of concrete.

Satyaprakash et al. [2]found that the compressive and splitting tensile strength of concrete made with 100% iron filings is about 26% higher than the concrete made with 100% natural sand. Furthermore, the replacement of NS with iron fillings resulted in significantly better abrasion resistance of concrete. Improvement of mechanical properties compared to normal concrete was also observed for concrete made with recycled scale and steel chips [3,4]. Other researchers found that the compressive strength of concrete containing iron filings was higher than the plain concrete. Besides, the presence of iron filings enhances the ductility of concrete [5].

Kumar et al. [6]investigated the effect of partial/total replacement of sand by iron ore tailing, as the fine aggregate on the compressive and flexural strength of reinforced concrete. The compressive strength

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was increased by up to 40% with the replacement of sand by iron ore tailing, while there was an enhancement of flexural strength for all percentages of sand replacement (10%, 20%, 30%, 40%, 60%, 80% and 100%).

Singh and Siddique [7,8]studied the mechanical, microstructural, and durability performances of self-compacting concrete made with four different replacement percentages (0%, 10%, 25% and 40%) of natural fine aggregate by iron slag. Enhancement of mechanical strength (compressive, splitting tensile, and flexural) was observed for the concrete containing iron slag as the reference concrete. Furthermore, the durability of concrete made with iron slag was better than reference concrete due to dense microstructure of iron concrete.

Tayeh and Saffar [10] found that the incorporation of iron powder decreased the compressive strength of mortar due to a higher amount of voids, which may affect the compressive strength. In contrast, they observed a significant increase in flexural strength of mortar with the increased content of the iron powder. However, they also observed a reduction in workability with the increased percentage of iron powder due to heterogeneity and higher angularity of the waste iron powder. Other authors also reported that an increasing percentage of steel scale waste results in decreased compressive strength [9]. Therefore, the influence of the addition of RIP on the mechanical properties of concrete remains an open issue due to contradictory trends reported in the literature.

Sajjad Ali Mangi, Mohd Haziman Wan Ibrahim, Norwati Jamaluddin , Mohd Fadzil Arshad and Sri Wiwoho Mudjanarko [11] Concrete construction offers a great opportunity to replace the cement with a coal-based power plant waste known as coal bottom ash (CBA) which offers great environmental and technical benefits. These are significant in sustainable concrete construction. This study aims to recycle CBA in concrete and evaluate its particle fineness influence on workability, compressive and tensile strength of concrete. In this study, a total of 120 specimens were prepared, in which ground CBA with a different fineness was used as a partial cement replacement of 0% to 30% the weight of cement. It was noticed that workability was decreased due to an increased amount of ground CBA, because it absorbed more water in the concrete mix. The growth in the compressive and tensile strength of concrete with ground CBA was not significant at the early ages. At 28 days, a targeted compressive strength of 35 MPa was achieved with the 10% ground CBA. However, it required a longer time to achieve a 44.5 MPa strength of control mix. This shows that the pozzolanic reaction was not initiated up to 28 days. It was experimentally explored that 10% ground CBA having particle fineness around 65% to 75% and passed through 63 µm sieve could achieve the adequate compressive and tensile strength of concrete. This study confirmed that the particle fineness of cement replacement materials has a significant influence on strength performance of concrete.

3. MATERIALS AND METHODOLOGY

3.1 Materials

The properties of material used for making concrete mix are determined in laboratory as per relevant codes of practice. Different materials used in present study were cement, coarse aggregates, fine aggregates, in addition to iron slag and coal dust. The aim of studying of various properties of material is used to check the appearance with codal requirements and to enable an engineer to design a concrete mix for a particular strength. The description of various materials which were used in this study is given below:

3.2 Portland Cement

Although all materials that go into concrete mix are essential, cement is very often the most important because it is usually the delicate link in the chain. The function of cement is first of all to bind the sand and stone together and second to fill up the voids in between sand and stone particles to form a compact mass. It constitutes only about 20 percent of the total volume of concrete mix; it is the active portion of binding medium and is the only scientifically controlled ingredient of concrete. Any variation in its quantity affects the compressive strength of the concrete mix. Portland cement referred as (Ordinary Portland Cement) is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 Grade, 43 Grade, 53 Grade depending upon the strength of 28 days. It has been possible to upgrade the qualities of cement by using high quality limestone, modern equipments, maintaining better particle size distribution, finer grinding and better packing. Generally use of high grade cement offers many advantages for making stronger concrete.

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Although they are little costlier than low grade cement, they offer 10-20% saving in cement consumption and also they offer many hidden benefits. One of the most important benefits is the faster rate of development of strength. Ordinary Portland Cement (OPC) of 53 Grade from a single lot was used throughout the course of the investigation. It was fresh and without any lumps.

Fig.3.1. Cement.

Coarse aggregates

The aggregate which is retained over IS Sieve 4.75 mm is termed as coarse aggregate. The coarse aggregates may be the types crushed graves or stone obtained by crushing of gravel or hard stone.

The properties of coarse aggregates are

a) Colour: Gray
b) Maximum Size: 20mm
c) Shape: Angular
d) Specific gravity : 2.8
e) Fineness modulus: 6.95.

Fig.3.2. Coarse aggregates.

Fine aggregates

The aggregates most of which pass through 4.75 mm IS sieve are termed as fine aggregates.

The fine aggregate may be of following types:

i) Natural sand, i.e. fine aggregate resulting from natural disintegration of rocks.
ii) Crushed stone sand, i.e. fine aggregate produced by crushing hard stone.
iii) Crushed gravel sand, i.e. fine aggregate produced by crushing natural gravel.

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Fig.3.3. Fine aggregates.

Iron slag

In this work, the Iron Slag is taken from the Indian mart. It is gray in color as shown in below figure 4.4. The sieve analysis of iron slag given below table 4.3.

Fig. 3.4: Iron slag

Weight of sample taken = 1000 gm					
S.NO	**IS Sieve (mm)**	**Wt. retained (gm)**	**% Retained**	**% Passing**	**Cummulative % Retained**
1	4.75	14	1.4	98.6	1.4
2	2.36	28	2.8	95.8	4.2
3	1.18	94.5	9.45	86.35	13.65
4	600 µ	184.5	18.45	67.8	32.1
5	300 µ	329.5	32.95	34.95	65.05
6	150 µ	291.5	29.15	5.8	94.2
	Pan	58	5.8	-	-
	Total	1000		SUM	210.6
				FM	2.10

Coal Dust

Coal dust is a fine powdered type of coal, which is made by the devastating, pounding, or beating of coal. On account of the fragile way of coal, coal dust can be made amid mining, transportation, or by mechanically taking care of coal. Coal dust suspended in air is hazardous; coal dust has significantly more surface region per unit weight than pieces of coal, and is more helpless to sudden ignition. Subsequently, an about unfilled coal store is a more noteworthy blast hazard than an entire one. For use in warm power plants, coal is ground into dust utilizing a gadget called a powdered coal plant.

Results Explanation:

As per experimental programme results for different experiments were obtained. They are shown in table format and graph.

Fresh Properties of Concrete

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The slump test was performed to check the workability of it at different replacements viz. 10 % , 20 %, 30% of coal dust with cement and 40%, 50%, 60% iron slag with fine aggregates the following results were obtained. The slump test is performed to know about workability. The plot of the slump test values for different dosages of coal dust and iron slag is shown in below. The following are the observations on slump test.

Coal Dust	Iron slag	Slump value(mm)
0%	0%	57
10%	40%	54
20%	50%	55.5
30%	60%	58

Fig.3.1. Slump test values.

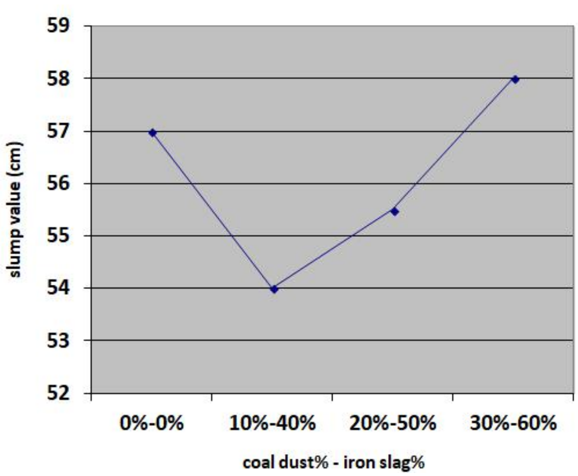

Fig.3.2. Slump test graph.

From the above Fig it is been observed that in case of specimens with 30% coal dust & 60% iron slag of 1.72% is more compared to control mix (0% & 0%).

Compaction factor test

The compaction factor test was performed to check the workability of it at different replacements viz. 10 % , 20 %, 30% of coal dust with cement and 40%, 50%, 60% iron slag with fine aggregates the following results were obtained.

S.No	Coal Dust	Iron slag	Value of compaction factor (%)
1	0%	0%	0.79
2	10%	40%	0.82
3	20%	50%	0.83
5	30%	60%	0.85

Fig.3.3. Results of compaction factor test.

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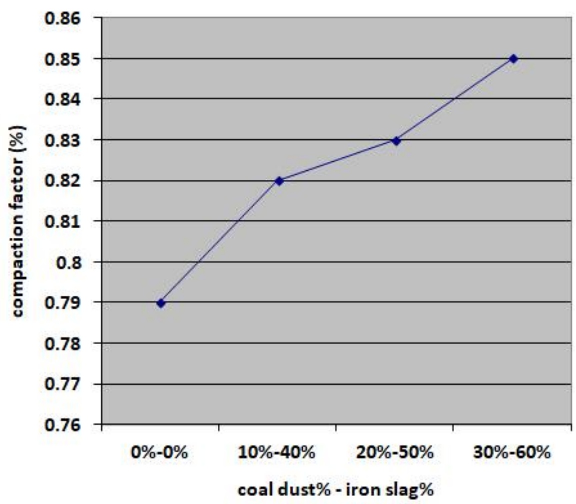

Fig.3.5. Compacting factor test.

The above figure shows the result of the compacting factor. The results show that, the compacting factor increases as the coal dust and iron slag was increased.

Harden Properties of Concrete

Compressive strength

The compressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm to check the compressive strength of concrete and the results obtained are given in below Table.

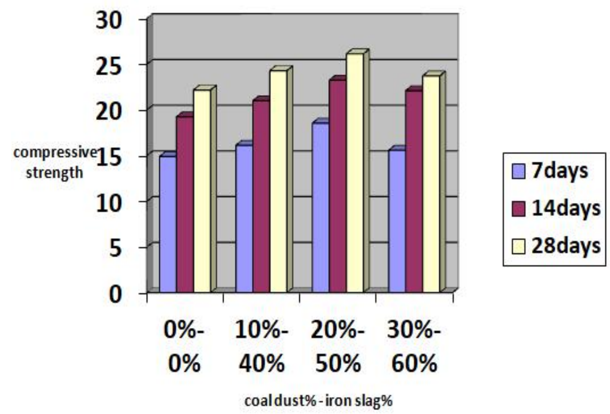

Fig.3.6. Output results.

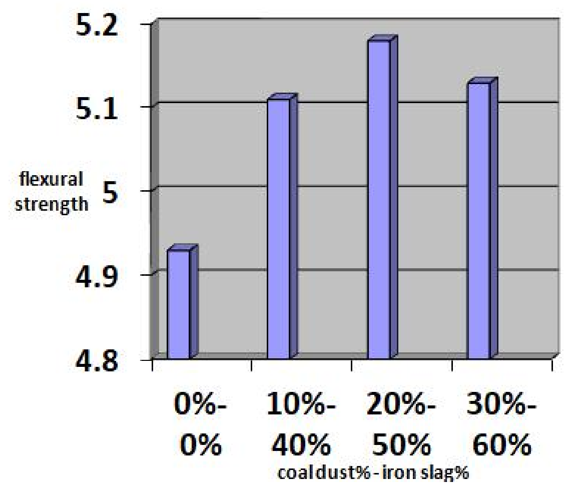

Fig: 3.7 Comparison of flexural strength results

The flexural strength is increases upto replacement of 20% Coal Dust & 50% Iron slag in the concrete M20 mix after that the replacement of 30% Coal Dust & 60% Iron slag compressive strength was decreases but its more than that of control mix (0% - 0%).

4. CONCLUSION:

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The strength characteristics of concrete mixtures have been computed in the present work by replacing 10%, 20% and 30% coal dust with the cement and 40%, 50%, 60% iron slag with sand (fine aggregates). On the basis of present study, following conclusions are drawn.

1. The compressive strength of cubes were increased with addition of coal dust and iron slag up to 20% & 50 % respectively by weight in place of cement and sand, further any addition of coal dust and iron slag the compressive strength decreases.
2. In M20 grade of concrete, the maximum compressive strength is obtained at 28 days for the mix proportion of 20% Coal Dust & 50% Iron Slag. The strength is increased by 15.12 % as compare to the control mix.
3. In M20 grade of concrete, the maximum flexural strength is obtained at 28 days for the mix proportion of 20% Coal Dust & 50% Iron Slag. The strength is increased by 4.82 % as compare to the control mix.
4. The workability of the concrete with increased with addition of coal dust and iron slag in the replacement of cement and sand.
5. The Coal dust and iron slag waste can be utilized in concrete and hence solve a potential disposal problem. The Coal dust in concrete can save the coal & thermal industry disposal costs and produce a greener concrete for construction.
6. The use of coal dust and iron slag in concrete might be cost effective because this material is available at half the rate of sand and cement respectively.

FUTURE SCOPE

1. Split tensile strength test for 28 days was conducted on various concrete specimens in order to know the tensile property of concrete in the partial replacement of cement by coal dust and sand by iron slag. It is important to know the tensile strength of the concrete since it acts as a resistance towards the tensile stresses acting on it.
2. To Determine the durability properties and water absorption values of concrete in the partial replacement of cement by coal dust and sand by iron slag.

3. However, it is recommended that more research regarding the topic should be done and more trial sections should be laid and their performance should be studied.

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