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Experimental Study on the Mechanical behaviour of Concrete by Partial Replacement of Waste Iron Powder as Fine Aggregate: A Green Concrete Approach

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ABSTRACT

The environment issues and its problems are very common in India due to growing of industrial by-products. Due to industrialization enormous by-products are produced and to utilize these by-products is the main challenge faced in India. Iron slag is one of the industrial by-product from the iron and steel making industries. Now from this study confirm that the use of iron slag overcome the pollution problems in the environment and save the world from global warming. In the current research work the properties of concretes with waste iron dust as fine aggregate were investigated. Waste iron dust was used as a partial replacement for sand at 10%, 20%,30% and 40% of concrete mixes. Compression strength, split tensile strength and flexural strength for 7, 14 and 28 days concrete of age were compared with those of concrete made with natural fine aggregates. From this experimental work it was proven that the waste iron powder added to the concrete had increases strength than the plain concrete. Increasing strength has been observed when replacing of waste iron powder by natural sand.

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KEYWORDS: *Waste iron powder, Eco-friend environment, compressive strength, split tensile strength , flexural strength test.*

I. INTRODUCTION

Cement and aggregate, which are the most important constituents materials used in production of concrete. These materials are the vital materials needed for the construction industry. Due to this led to a continuous and increasing demand of natural materials used for their production. Infrastructure development across the world created demands for construction material. Concrete manufacturing involve consumption of ingredients like cement, aggregates, water & admixtures. Among all the ingredients, aggregates form the major parts. Iron slag is a by product obtained in the manufacture of pig iron in the blast furnace and is produced by the blend of constituents of iron ore with limestone flux. Iron and steel slags 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. Reuse of industrial solid waste as a partial replacement of aggregate in construction activities not only saves landfill space but also reduces the demand for extraction of natural raw materials also preserving natural aggregates. The primary objective is to utilize as much waste glass powder as possible in construction materials. This research has been conducted to identify the suitable composition of waste iron powder as fine aggregate replacement material in concrete and also to study the mechanical properties of concrete.

II. LITERATURE REVIEW

Harsh Gupta et al (2017) in their studies entitled Strength properties of steel slag in concrete were investigate the management of solid waste practices has identified the reduction recycling and reuse of wastes as important for management of sustainable resources. Steel slag, a by-product obtained from steel formation during separation of themolten steel from impurities in furnance. The aim of this experiment is to study the effect of steel slag as partial replacement for fine aggregate with 0%, 10%, 20%, 30%, and 40% are tested for M25& M30 grade of concrete after 7, 14, 28 and 50 days water curing. The result shows that variation in much strength for fine aggregate replacement by steel slag for 7, 14, 28 and 50 days of age. Liwu mo et al (2017) in their studies entitled Accelerated carbonation and performance of concrete made with steel slag as binding materials and aggregates. Experimental study, 60% of steel slag powders containing high free-CaO content, 20% of Portland cement and up to 20% of reactive magnesia and lime were mixed to prepare the binding blends. carbonation directly reduced the contents of periclase and free-CaO in the concrete. Results show that the compressive strength of the steel slag concrete after CO2 curing was significantly increased. Ismail et al (2015) in this experiment entitled Reuse of waste iron as a partial replacement of sand in concrete the test of these waste –iron concrete mixes revealed that this method performed efficiently to improve the properties of the waste iron concrete mix. In this paper waste iron were partially replaced sand at 10%, 15% and 20% in total 1730 kg concrete mixtures. This test performed to evaluate waste iron concrete quality slump. Raheem et al,(2012) the study investigated the physical properties and chemical composition of glass waste powder ash (SDA) as well as the workability, and compressive strength properties of the concrete produced by replacing 5%, 10%, 15%, 20% and 25% by weight of ordinary Portland cement with SDA. Slump and compacting factor tests were carried out on the fresh concrete and compressive strength test on hardened concrete. It was concluded that 5% SDA substitution is adequate to enjoy maximum benefit of strength gain. B.Ayeni I.S and Ayodele F.O(2015) in their research aims to find out the optimum compressive strength of concrete produced with partial replacement of cement with cow dung and fine aggregates with sawdust. The concrete mix of 1:2:4 was prepared using water/cement ratio of 0.65 with 0%, 2%, 4% and 6%.Sawdust and cow dung were used concurrently as partial replacement for fine aggregates and cement respectively. The Compressive strength value obtained were found to conform to the minimum requirement of 17N/mm2 for light weight concrete especially when 2% cement and fine aggregate were replaced with cow dung and sawdust respectively. EboziegbePatrickAigbomian&MiziFan,(2014) studied, used different variables in terms of sawdust particle size, sawdust waste source and sawdust quantities to replace sand on top of that need, there were four cube specimens size 100×100×100 mm were produced and tested. The conventional concrete contains 0% sawdust while other specimens contain 5%, 10% and 15% of sawdust replacing fine aggregate by volume. Khan et al (2017) analyzed brick dust and marble powder as cement replacement. Results shows that workability is increased by using both ingredients in certain proportion, compressive strength is reduced by increasing brick dust content beyond 10% replacement. Rakesh Sakale et. al (2015) studied the replacement of fine aggregate by waste glass powder in steps of 10%, 20%, 30% and 40% respectively by volume of cement and its effects on compressive strength, split tensile strength, workability and flexural strength are determined. It is found that the compressive, flexural and split tensile strengths of concrete increase initially as glass powder increases and become maximum at about 20% and later decrease. The workability of concrete reduces monotonically as the replacement percentage increases. The replacement of cement up to about 20% by glass powder can be done without sacrificing the compressive strength. Sanusi Gambo et al.(2018) examined the types of sawdust suitable as partial replacements of fine aggregate in concrete. Two different types of sawdust sourced from Afara and Doka wood species were used for the experiment. DoE Method was used to design and produce three sets of concrete cube samples, i.e. Control concrete, Doka sawdust concrete and Afara sawdust concrete, each of grade 20. The cubes were subjected to compressive strength and water absorption tests.The control and Doka sawdust concretes exhibited low water absorption when compared with Afara sawdust concrete. This revealed Doka sawdust as more suitable than Afara sawdust for partial replacement of fine aggregate in concrete. To study the structural behaviour of concrete by waste iron powder as partial replacement fine aggregate. To study and effectiveness of uses of waste iron powder in strength enhancement. To evaluate and compare the strength behaviour of conventional concrete and waste iron powder concrete. The scope of this research has many advantages over traditional concrete, such as Lower pollution and efficient disposal of waste iron powder is possible. Lack of availability of fine aggregate can be compensated.

III. MATERIALS USED

Cement

The cement used in this research should confirm IS specifications. There are several types of cements available commercially in the market of which Portland cement is very common and it is well known and available everywhere. PPC 43 grade was used for this study. The physical properties of the cement tested according to standard procedure confirm to the requirement of IS 12269:1989. The physical properties of the cement are listed in the Table 1.

Fine Aggregate

Locally available river sand passing through 4.75mm sieve conforming to the recommendation of IS 383:1970 is used. Specific Gravity of fine aggregate of the sand is2.54 shown in Table 2 and the particle size distribution is listed below in the Table 3. From the sieve analysis results fine aggregate is graded to Zone II and medium sand shown in Figure 1.

Waste Iron Powder

In this current research work, the Iron Slag is taken out from the Iron and Steel Industry located at Gummidipoondi ,Tiruvallur Taluk,Tamilnadu. It is black in colour as shown in Figure3(b). Its physical properties as shown in Table 4. Waste iron powder material is sieved in 2.36mm sieve. Then it is used by replacing fine aggregate in different percentages. The material is fine. Table 4 shows the physical properties of waste iron powder.

Coarse Aggregate

Coarse aggregate to be used for production of concrete must be strong, impermeable, durable and capable of producing a sufficient workable mix with minimum water cement ratio to achieve proper strength. Locally available coarse aggregate retaining on 4.75 mm sieve is used. The physical properties of coarse aggregate is shown in Table 5 and the particle size distribution for coarse aggregate is listed below in Table 6. From the sieve analysis results shown in Figure 3 it was found that the combined aggregate of in the range of nominal size of coarse aggregate is 20mm.

Water

The water used in this research work was , the water available in the laboratory has used. Its PH value is 6.5 to 8. It must be absolutely free from vegetable substances, soils, acids, alkalis and other organic and inorganic impurities to made concrete or even reinforcement. Also it must be totally free from iron. Mostly it should be fit for drinking purpose. Portable water available inside the laboratory it was used for mixing and curing of concrete.

IV. EXPERIMENTAL INVESTIGATION

The concrete mix was designed as per IS: 10262-1982], IS: 456-2000 for the normal concrete. The grade of concrete, which adopted, is M20. The concrete mix proportion (cement: fine aggregate: coarse aggregate) is 1:1.5: 3 by volume and a water cement ratio of 0.45.Figure 5 shows the methodology of current research work. The study is conducted to analyze the compressive strength, Split tensile strength and Flexural strength of concrete when the natural coarse aggregate is partially replaced with waste iron powder . Compressive strength and split tensile strength tests were done on compression testing machine of 200 tonne capacity available in the laboratory using cube specimens. The flexural strength test was conducted in flexural testing machine of capacity of 40 tonne. Three samples per batch were tested with the average strength values reported in this article. The natural fine aggregates were replaced as 0%, 10%, 20%, 30% and 40% by weight of M-20 grade concrete.

V. RESULTS AND DISCUSSIONS

The Compression Strength test

The compressive test was conducted in universal testing machine (UTM) in a capacity of 40 tonne was used. Three concrete cubes of 150mm size for M20 using the above mentioned mix ratio were prepared. For each mix ratio, three waste replacement cubes plus one with normal aggregates cubes were casted for testing. The compressive strength test values displayed in Figure 4 shows that waste iron powder has effect on the compressive strength of concrete. The compressive strength values were increased when increases of waste iron powder replacement level of percentage in concrete. The maximum compressive strengths were recorded in Table 7,for concrete is 30% replacement of waste iron powder. A steady fall of strength with replacement beyond this optimum point was observed.

The split tensile strength test

The test was conducted using the same UTM to determine the tensile strength of concrete specimens. The split tensile test was done using cylindrical specimens of 150mm diameter, and 300mm length. The specimens also were tested immediately after taking them from water at 7th, 14th and 28th day. From it was observed that after beyond 30% replacement of waste iron powder the strength was reduced. Table 8 shows the split tensile strength of the waste iron powder and normal concrete specimens and Figure 5 shows its visual observation. Split tensile strength decreases steadily with increasing percentage of waste iron powder replacement and the optimum strength is at 30 % replacement level.

The Flexural Strength Test

The test was to check the ability of concrete to resist against failure in bending. It was measured by loading an unreinforced concrete beam of 100x100x750 mm size. The material placed under load in a two point loading testing setup. The strength of a material in bending, expressed as the stress on the outermost fibres of a bent test specimen, at the instant of failure. The average value of specimens for each category at the age of 7 days, 14 days and 28 days is tabulated as shown in Table 9 . There is consistency in the flexural strength of concrete with the inclusion and increase in the percentage of waste iron powder as fine aggregate upto 30% when compared to other percentage of replacement of waste iron powder. The flexural strength results is shown in Figure 6. Optimum flexural strength was obtained at 30% replacement than the natural fine aggregate.

IV. CONCLUSIONS

Based on the experimental study for the use of waste iron powder in concrete as a replacement of fine aggregate, the following conclusions were observed.

Slump gradually decreased with increase in waste iron powder percentage.

The compressive strength, splitting tensile strength and flexural strength of the concrete is increased upto 30% when replacing waste iron powder as fine aggregate in nominal mix concrete.

The utilisation of waste iron powder in concrete provides additional environmental as well as technical benefits for all related industries.

Upto 30% of natural fine aggregates saves form this replacement of waste iron powder as fine aggregate.

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