SUITABILITY OF CONCRETE BY USING CUPOLA SLAG AS PARTIAL REPLECEMENT OF COARSE AGGREGATE AND FOUNDRY SAND AS PARTIAL REPLECEMENT OF FINE AGGREGATE: A CRITICAL REVIEW

Mr. Kiran Bhagat[1], Mr. N. R. Pokar[2], Mr. H. M. Rabadiya[3]
[1]P.G. Student, Civil (Structure), H.J.D.Institute of Technical Education and Research - Kera (Kutch), Gujarat, India
[2]Assistant Prof., Civil Department, H.J.D.Institute of Technical Education and Research – Kera (Kutch), Gujarat, India
[3]Assistant Prof., Civil Department, H.J.D.Institute of Technical Education and Research – Kera (Kutch), Gujarat, India

Abstract: The simplest way of getting aggregate is from naturally available sources. Excavation of rocks from valley which is generally produces worst environmental impacts. Cutting and screening out of coarse aggregate makes the conventional concrete more costly and scarce due to small sized limited quantity of natural materials which is used. Cupola slag can be use in construction industry as replacement of coarse aggregate and Foundry sand as fine aggregate. Cupola slag is the byproduct of cast iron manufacturing, produced when molten steel is separated from impurity in cupola furnace. Foundry sand is also byproduct, which is gathered in foundry where it is not reused in foundry. Cupola slag is replaced with coarse aggregate and Foundry sand is replaced with fine aggregate with optimum percentage of replacement to check the suitability of concrete to Mechanical properties, Durability, Workability and Environmental feasibility. In this paper, the past work and the experimental work done by various people according to their views is studied. To conclude in the end, from physical properties of cupola slag that there are similarities between cupola slag and coarse aggregates and physical properties of foundry sand that there are similarities between foundry sand and fine aggregate. Both materials are eco-friendly building material. The problem of the disposal and maintenance problem of land filling is reduced. They are taken 0 to 100% replacement and get different strength but required and appropriate result get up to 60% replacement to use both byproduct materials.

Key Words: Cupola slag, Foundry sand, Coarse aggregate, Fine aggregate.

1. INTRODUCTION

Generally natural aggregates are obtained by rock quarries. Rock quarries are working from last 30 to 35 years. Properly controlled explosion is required to break the rocks which are then transported to crushers. Natural aggregates are obtained after crushing and sieving these crushed rocks. India is the second largest country in world after china in concrete consumption. As these natural resources are limited since the quantity of aggregate obtained is also limited by seeing large consumption and it grown more & more. Natural sand is obtained by the river. It is also available in limited quantity. So there is a need to replace these natural materials by alternative options which are obtained to industrial byproduct like Cupola slag and Foundry sand. Now a day, sustainable infrastructural growth demands the alternative material that should satisfy technical requirements of natural aggregate as well as it should be available great quantity. The cheapest and the easiest way of getting substitute for natural aggregates is by crushing Cupola slag to get artificial aggregates of desired size and grade and foundry sand to get silica sand of desired grade and quality.

Industry produced a large amount of by-product material during casting process. It also has environmental issues in disposal of these by product since it cannot be used anywhere expect the land filling at present. So by there is a need to replace natural aggregates by cupola slag and foundry sand to solve concrete as well as environmental and industry problem.

The present work aims to contribute at studies on the Cupola slag and foundry sand as construction material. In particular, it focuses on structural concretes, by investigating the feasibility to partially or fully replace natural aggregates by cupola slag and foundry sand.

1.1 CUPOLA SLAG

Cupola slag is by-product material which is gathered from cast iron manufacturing unit. It is produced during melting of cast iron in cupola furnaces. The slag occurs as a molten liquid which solidifies upon cooling. Cupola slag is a complex solution of silicates and oxides. Cupola furnace is cylindrical shaped melting device which is used in steel industries for melting of cast iron ranging from 0.5 to 4 m in diameter. Bottom of furnace having a door which can swing in and out. Top of the furnace is kept open. Air vent is arranged to supply the air in Furnace. Shells of furnace are made up of steel, refractory bricks. There is one slag hole from which slag comes out at higher temperature with low viscosity that solidifies in black colored lumps upon cooling. Lumps size varied from 100 mm to 450 mm. Cupola slag is tends to be dense solid material that varies in color from Grey to black. A physical property of cupola slags to be used as compared with natural coarse aggregates and IS 383-1970 requirements for material to be used as aggregates.

Fig -1: Lump sized of Cupola Slag aggregate
(**Source:** Image Capture)

Fig -2: 20mm sized of Cupola Slag aggregate
(**Source:** Image Capture)

1.2 FOUNDRY SAND

Foundry sand is the fine aggregate to be used in concrete, other than normal sand. Metal foundries use large amounts of natural sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in a foundry. When the sand can no longer be reused in the foundry, it is removed from the foundry and is throwing anywhere. So it is known as "foundry sand". Now in days, generally Foundry sand is used for earth filling. Physical properties of foundry sand to be used as fine aggregate was found and compared with natural fine aggregates and IS 383-1970 requirements for material to be used as fine aggregates.

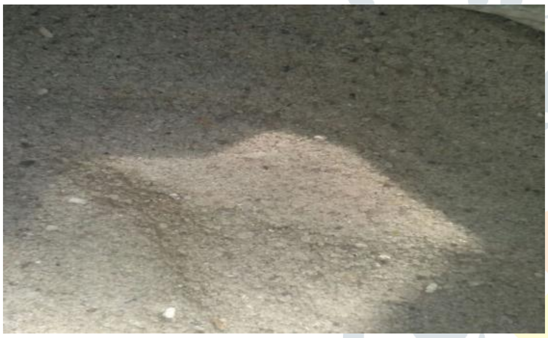

Fig -3: Foundry Sand
(**Source:** Image Capture)

There are mainly two types of foundry sand available, which are

1) Green Sand (Referred to as molding sand material)
2) Chemically bonded sand

Green sand or molding sand uses clay as the binder material in foundry and chemically bonded sand that uses polymers to bind the sand grains together.

2. LITERATURE REVIEW

R.Balaraman and S. Anne Ligoria et al. (2015) [1] they had partially replaced fine aggregate and coarse aggregate by Cupola Slag. They were taken 0, 5, 10, 15, 20, 25, 50,and 100 % replacement. They only measure Compressive strength and split tensile strength. Maximum Value of compressive strength is 31.555 N/mm^2 for M20 grade when coarse aggregate is replaced by 5% of cupola slag, but the required strength is achieved up to 20% replacement. Maximum value of compressive strength is 25.778 N/mm^2 for 5% replacement in the case of M25 grade concrete. The split tensile strength gradually decreases when coarse aggregate is replaced by cupola slag in both the grades of concrete. No any test is done for workability of concrete.

Joseph O. Afolayan, Stephan A. Alabi et al. (2013) [2] they replaced coarse aggregates fully with cupola slag in all mix and partial replaced of cement by slag cement. 0%, 2%, 4%, 6%, 8%, and 10% replacement of cement was taken. They conclude that higher strength is obtained for 2% cement replacement, while using 100% cupola slag aggregate. They only measure compressive strength, no study on about split tensile, flexure, and durability test.

Mohammed Nadeem and Arun D. Pofale et al. (2012) [3] they replaced Coarse and fine aggregate by using industrial slag of partial replacement of 0, 30, 50, 70 and 100%. They Prepared M20, M30, and M40 grades were considers for a W/C ratio of 0.55, 0.45 and 0.40. They study in all the parameters compressive strength, split tensile strength and flexural strength, also they observed workability properties of concrete. They observed as 100% replacement there is 2 to 7% increased in compressive strength while in split tensile strength and flexural strength they observed increment is range of 5 to 8%.

Mr. T. Yuvraj et al. (2015) [4] they replaced coarse aggregates by 16, 33, 50, 66, 83, 100 % with cupola slag and fine aggregate by 100 % with quarry dust. They only measure compressive strength no study on tensile strength and workability properties of concrete. In this paper shows that strength decrease as replacement percentage of cupola slag increase. The analysis of metals for leachate was found to be within limits. Hence there is no environment pollution in use of foundry solid waste (slag) and quarry dust in concrete preparation. In this paper, They suggested the mix ratio which was taken with solid waste use for pavers and hollow-block construction only and it could be recommended that slag could be effectively utilized as partial replacement of normal coarse aggregate and quarry dust as complete replacement of fine aggregate in most applications a per this part of study.

D.Baricova, Pribulova and P. Demeter et al. (2010) [5] they measure both compressive and Flexural strength. They replaced N.A. by cupola slag and blast furnace slag in varying ratio of 90:10, 80:20, and 70:30. They observed compressive strength increase as ratio of cupola slag increased achieve maximum at 20% replacement. In flexural strength same strength increased and get maximum strength at 30% replacement. In this study they conduct different experiments, various ratio of these slag were combined. It results from the measured mechanical properties that such concrete do not suit for very stressed road concretes, but they are suitable for common grades of concrete. They are plain concrete with volume mass of 2,000 – 2,400 kg.m^{-3}. It is possible to use these concretes for building of base or levelling layers, foundations of structures, core parts of framed structures, etc.

Christina Mary V. and Kishore CH et al. (2015) [6] In this paper, cement is replaced by granulated slag 10% to 50%. They had measure all the parameters of concrete strength criteria as well as durability criteria. They conclude that compressive strength obtained with replacement of cement and sand by 10% GGBS and 50% m-Sand with increase strength by 10.25%, 6.12% and 5.66% at 14-days, 28-days and 56-days respectively, compared to conventional concrete. Higher flexural strength is obtained at replacement of cement and sand by 305 GGBFS and 50% M-sand. Compared to conventional concrete. They also conclude that concrete made with 10% GGBS and 50% M-sand gives better results in split tensile strength.

Vema Reddy Chevuri, S. Sridhar et al. (2015) [7] they had conclude that the workability of foundry sand increases. The compressive strengths were increased with increase in the foundry sand in the concrete mix up to 60% and will decrease after 60% up to 100%. The split tensile strengths were increased with increase in the foundry sand in the concrete mix up to 60% and will decrease after 60% up to 100%. There is an enhancement in the strengths for respective replacement of aggregate with incorporation of foundry sand with natural sand. The failure modes are similar for both natural sand and foundry sand. The use of foundry sand for concrete works is demonstrated in compression, split tensile strength. This study could enlighten the people to use foundry sand for concrete works.

Pranita Bhandari, Dr. K. M. Tajne et al. (2016) [8] they research was carried out to produce a low-cost concrete. An experimental investigation was carried out on a concrete containing waste foundry sand in the range of 0%, 10%, 20%, 30%, 40%, 60%, 80% and 100% by weight for M-25 grade concrete. The concrete containing foundry sand was tested and compared with conventional concrete in terms of workability, compressive strength and acid attack. Cubes were casted and compression test was performed on 3rd, 7th and 28th day for mix of 1:1.01:2.5 at a w/c of 0.4. Through experimental result they conclude that after 20% partial replacement of foundry sand the compressive strength decreases with increase in partial replacement of waste foundry sand. The aim of this research is to know the mechanical properties of concrete after adding optimum quantity of waste Foundry sand in different proportion.

Amitkumar D. Raval, Arti Pamnani, Alefiya I. Kachwala et al. (2015) [9] they research was carried out in this study, effect of foundry sand as fine aggregate replacement on the compressive strength of concrete with a M25 mix proportion investigated at different limited curing periods (7 days, 14 days and 28 days). The percentage of foundry sand used for replacement were 10%, 20%, 30%, 40% and 50% by weight of fine aggregate. Test showed impressive results, showing capability of foundry sand for being a component in concrete for imparting strength. Making concrete from recycled materials saves energy and conserves resources which lead to a safe sustainable environment. The increase in strength parameters may be due to fineness of the foundry sand. The foundry sand fineness is higher than fine aggregate and reduces the porous nature in concrete thereby increasing density and strength. But reduction in compressive strength of concrete specimen with replacement percentage beyond 30 % is attributed to binders present in foundry sand, composed of very fine powder of clay and carbon, which results in a weak bond between cement paste and aggregate. Making concrete using recycled materials (foundry sand) saves energy and conserve primary resources and it is concluded that the more material was reused, the fewer resources were consumed which leads to a safe, sustainable environment.

Sarita Chandrakanth, Ajay.A.Hamane et al. (2016) [10] they identifies a potential use of wastes from foundry industry and construction industry for utilization in construction industry and represents the experimental investigation on utilization of foundry waste as a partial replacement of natural sand by 0%, 20%, 40%, 60% and recycled aggregate as a partial replacement of natural coarse aggregate by 0%, 20%, 40% and 60%. Concrete mixtures were produced, tested and compared in terms of strength with the conventional concrete. These tests were carried out to evaluate the strength for 7 and 28 days. It is found that compressive strength of concrete mix is increases with increase in percentage of waste foundry sand and recycled aggregate as compare to normal concrete. It was maximum for 40% replacement after that it reduces. It is also found that split tensile strength increases with increase in percentage of waste foundry sand and recycled aggregate up to 40% replacement after that it reduces. It is also found that flexural strength increases with increase in percentage of waste foundry sand and recycled aggregate up to 40% replacement after that it reduces. Average compressive strength at 28days increased by 3.96%, 8.857% & 5.37% at as compared to conventional concrete. Average split tensile strength at 28days increased by 9.3088%, 22.07% & 7.048% at 28 days as compared to conventional concrete. Average flexural strength at 28days increased by 21.29%, 28.07% & 15.93% as compared to conventional concrete. The possibility of substituting natural fine aggregate with industrial by-product aggregate such as waste foundry sand and recycled aggregate offers technical, economic and environmental advantages which are of great importance in the present context of sustainability in the construction sector.

3. CONCLUSIONS

From above Literature Review we have conclude that, There is no big effect on compressive strength and flexure strength w.r.t. strength decrement but Split Tensile strength of concrete little bit decreases when using higher percentage of cupola slag as coarse aggregate and for batter workability of concrete need more water. By using Foundry sand, it gives more workability and strength. There is no clear information about combined use of cupola slag as partial replacement of coarse aggregate and foundry sand as partial replacement of fine aggregate in concrete w.r.t. Mechanical properties, durability and environmental feasibility. So we conclude that the combined use of cupola slag and foundry sand may be getting effective use in concrete which are also eco-friendly materials.

REFERENCES

[1] R.Balaraman and S. Anne Ligoria “UTILIZATION OF CUPOLA SLAG IN CONCRETE AS FINE AND COARSE AGGREGATE” International Journal of Civil Engineering and Technology (IJCIET)-Aug 2015, Volume 6, pp. 06-14.

[2] Joseph O. Afolayan, Stephan A. Alabi “INVESTIGATION ON THE POTENTIALS OF CUPOLA FURNACE SLAG IN CONCRETE” International Journal of Integrated Engineering– 2013, Volume 5, pp. 59-62.

[3] Mohammed Nadeem and Arun D. Pofale “EXPERIMENTAL INVESTIGATION OF USING SLAG AS AN ALTERNATIVE TO NORMAL AGGREGATE (COARSE AND FINE) IN CONCRETE” International Journal of Civil And Structural Engineering– 2012, Volume 3, pp. 117-127

[4] Mr. T. Yuvraj “ENVIRONMENT FEASIBILITY IN UTILIZATION OF FOUNDRY SOLID WASTE FOR M20 CONCRTE MIX” IOSR Journal of Environment Science and Toxicology and Food Technology-Jan. 2015, Volume 9, pp. 16-23.

[5] D.Baricova, Pribulova and P. Demeter “COMPARISON OF POSSIBILITIES THE BLAST FURNACE AND CUPOLA SLAG UTILIZATION BY CONCRETE PRODUCTION” Archives of Foundry Engineering, June-2010, Volume 10, pp. 15-18.

[6] Christina Mary V. and Kishore CH “EXPERIMENTAL INVESTIGATION ON STRENGTH AND DURABILITY CHARACTERISTICS OF HIGH PERFORMANCE CONCRETE USING GGBS AND MSAND” ARPN Journal of Engineering and applied science, June-2015, Volume 10, pp. 4852-4856.

[7] Vema Reddy Chevuri, S.Sridhar “USAGE OF WASTE FOUNDRY SAND IN CONCRETE” SSRG International Journal of Civil Engineering (SSRG-IJCE), December-2015, Volume 2, pp. 5-12.

[8] Pranita Bhandari, Dr. K. M. Tajne “USE OF FOUNDRY SAND IN CONVENTIONAL CONCRETE” International Journal of Latest Trends in Engineering and Technology (IJLTET), January-2016, Volume 6, pp. 249-254.

[9] Amitkumar D. Raval, Arti Pamnani, Alefiya I. Kachwala “FOUNDRY SAND: UTILISATION AS A PARTIAL REPLACEMENT OF FINE AGGREGATE FOR ESTABLISHING SUSTAINABLE CONCRETE” International Journal of Engineering Sciences and Research Technology (IJESRT), January-2015, pp. 308-311.

[10] Sarita Chandrakanth, Ajay.A.Hamane “PARTIAL REPLACEMENT OF WASTE FOUNDRY SAND AND RECYCLED AGGREGATE IN CONCRETE” International Journal of Modern Trends in Engineering Research, May-2016, Volume 3, pp. 173-181.