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Utilization of Copper Slag to Enhance the Impact Strength of concrete

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Abstract : India is a fastest developing country, due to the increase in the growth of industry, the production of goods has been increased and at the same time the waste products coming out of these industries has considerably increased. From the study it was noted that disposal of these waste material has been a major problem and has created many environmental issues. One of such material is copper slag which has 42% to 65% of silica content. Since availability of river sand is decreasing day by day, copper slag can be used as a partial replacement of fine aggregate. Here in this experimental study, fine aggregate is replaced with 0%,10%,20%, 30%,40% & 50% of copper slag for M_{20}, M_{30}, M_{40} & M_{50} grade of concrete. Impact resistance of concrete was studied by Drop Weight Method. It was found that 20%-30% replacement of copper slag was found economical.
Key words : copper slag, impact strength, drop weight method, fine aggregate, grade of concrete.

1.0 Introduction

Copper slag is one of the material that is considered as a waste material which could have a promising future in construction industry as partial or full substitute of either cement or aggregates. It is a by-product obtained during the smelting and refining of copper. The use 1of copper slag in cement and concrete provides potential environmental as well as economic benefits for all related industries, particularly in areas where a considerable amount of copper slag is produced.

Wei Wu, Weide zhang and Guowei Ma (2009)[9] investigated the mechanical properties of high strength concrete using split Hopkinson pressure bar. The micro structure of control concrete and copper slag reinforced concrete (CSRC) with various contents of copper slag as replacement of sand were investigated. The dynamic compressive strength of the CSRC was generally improved with the control concrete, with the increase of copper slag replacement up to 20%, due excellent physical and mechanical properties of copper slag. The dynamic compressive strength of the CSRC with 40% copper slag is closed to that of control concrete and beyond which the strength generally reduces. Patil M.V and Patil Y.D (2016)[1] studied the performance of copper slag as sand replacement in concrete. It was found that concrete flexural and compressive strength increased due to the replacement of copper slag. Khalifa S, Al- Jabri, Abdullah H, Al- Saidy and Ramzi Taha (2009)**[10]** investigated the performance of high strength concrete (HSC) made with copper slag as a fine aggregate. Conclusion there was general increase in in the compressive strength as copper slag proportion increase and 20% improvement in the compressive strength of HSPC with 100% copper slag substitution in comparison with the control mixture at the workability, therefore use of copper slag as sand substitution

improves HSC and durability character. Madhavi.T.C and Abilaash.V (2016)[2] studied split tensile strength of copper slag concrete, where sand is replaced from 0% to 60% this research was done by replacing copper slag with sand from 0% to 60%. It was found that the tensile strength of copper slag concrete is more than control mix. Madhavi T.C and Aravind.S (2016)[3] investigated on compressive strength of copper slag concrete. For M_{30} concrete mix 0% to 60% of fine aggregate is partially replaced. It was found the compressive strength, density of concrete and workability increases with increase in copper slag content. Madhavi T.C and Hari Prasanth .R (2016)[4] investigated on flexural behavior of copper slag concrete beam at early age. On 7 days curing and replacement of sand by copper slag (0% to 60%). It was found that the flexural strength of beam increased by 11% to 21%. Bose Christyarun and preethi ramaswamy (2016)[5] investigated the properties of concrete with copper slag replacing fine aggregate and ceramic tile waste partially replacing coarse aggregate. It was found that concrete with 40 % Copper Slag content as fine aggregate and 10 % Ceramic tile waste yielded best results both in strength and durability. Boyani Madhu and Prof G.Venkataratnam (2015)[6] studied about the use of copper slag as fine aggregate in rigid pavements. It was concluded that 40% replacement of fine aggregate by copper slag concrete is denser, compact, free from pores and more impermeable than control concrete. It was also concluded that replacement of copper slag as fine aggregate in concrete mixes, reduces the cost of concrete production. R. Chavan and D.B. Kulkarni (2013)[8] studied on M25 grade concrete where fine aggregate is replaced by 0% to 100% of copper slag found to be in concrete. Compressive strength and flexural Strength is increasing due to high toughness of Copper slag. Arivalagan. S (2013)[7] experimental investigated the compressive strength of cubes, flexural strength of beams and split tensile strength of cylinders for copper slag concrete. It was found the value of slump varies between 90 to 120 mm value of slump which lies between 90 to 120 mm and the strength increased between 21% to 51%. In this paper an attempt has been made to determine the impact resistance of copper slag concrete.

2.0 Experimental Investigation

Copper slag is used as a replacement of fine aggregate. The fineness modulus of sand is 3.16 and copper slag is 3.17. The grading of fine aggregate was almost similar, hence copper slag is used as fine aggregate

A .Materials Used

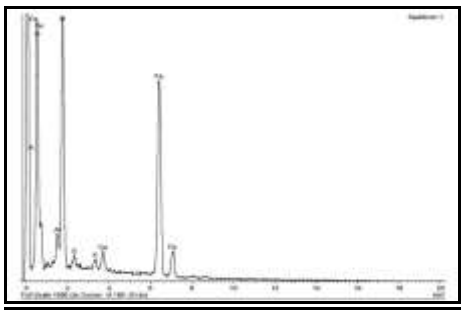
Cement: 53 Grade ordinary Portland cement conforming to IS 12269 may be used. The setting time of cement is 25 minutes.

Fine Aggregate: fine aggregate passing through 4,75mm I.S. sieve and conforming to I.S. The sand used is clean, sharp, hard, strong and durable. It is free from dust, vegetable substances, adherent coating, clay, loam, alkali, organic matter, mica, salt or other deleterious substances which can be injurious to the setting qualities/strength/durability of concrete.

Coarse Aggregate: It is aggregate most of which is retained on 4.75 mm I.S. sieve. Aggregate shall comply with requirement of IS 383. As far as possible preference shall be given to machine broken and graded aggregate affect adversely the strength (or) durability of concrete.

Water: Potable water is used for both mixing and curing shall be clean and the amounts of deleterious materials such as Vinz oils, acids, alkalis, salts, sugar, organic materials or other substances should be less.

Copper Slag: Copper slag is a black, glassy and granulated material produced as a by-product of copper refineries. It is a non-hazardous and inert material. The physical properties of copper slag are similar to those of natural sand. From the EDAX tests results for this study found that copper slag contains more than45%of silica.



2.1 Mix Proportion

The Indian Standard code is the requirements for selection of W/C ratio, water content and estimation of coarse aggregate and fine aggregate content. This standard provides the proportioning concrete making material. Normal Cement Concrete (0%) for M20, M30, M40, M50 grade of concrete and Replacement of 10%, 20%, 30%, 40%, 50% of Fine aggregate by copper slag for M20, M30, M40, M50 grade of concrete. The mix proportion obtained for various grade of concrete is given below,

Grade (N/mm^2)	W/C Ratio	Water (Lit)	Cement (Kg)	Fine Aggregate (Kg)	Coarse Aggregate (Kg)
M20	0.54	197	1	1.75	3.47
M30	0.44	197	1	1.28	2.76
M40	0.37	197	1	1.04	2.24
M50	0.31	197	1	0.83	1.85

3.0 Production of Test Samples and Test Conducted

Impact strength test is done as per (ASTM D 1557-70). Cylinder of size 150mm dia * 64mm height is casted for different grades of concrete i.e. (M20, M30, M40, M50). For each grade of concrete 0% to 50% of fine aggregate is replaced with copper slag. This equipment consists of a standard manually operated 10 lb. (45KN) compaction hammer with an 18 inch drop (457mm) (ASTM D 1557-70), a hardened steel ball and a flat base plate with positioning bracket. In addition to the above mould to cast 150mm diameter and 64mm thick concrete specimens is needed. Thickness of the specimens is recorded to the nearest millimetre at its center and at the ends prior to the test. The specimen is placed on the base plate with the finished face up and positioned with in four legs of the impact testing equipment. The bracket with the cylindrical sleeve is fixed in place and the hardened steel ball is placed on the top of the specimen at its center. The drop hammer is then placed with its base upon the steel cylinder and held vertically and the hammer is dropped repeatedly. The number of blows required for the first visible crack to form at the top surface of the specimen and for ultimate failure is to be recorded. The loading is continued until the disc fails and opens up such that failed specimen touches three or four guide plates. The strength corresponding to this condition is recorded as failure strength. Results of these tests exhibit high variability. A minimum of three samples was tested for each test condition. The impact energy calculation of

IE= N x W x H

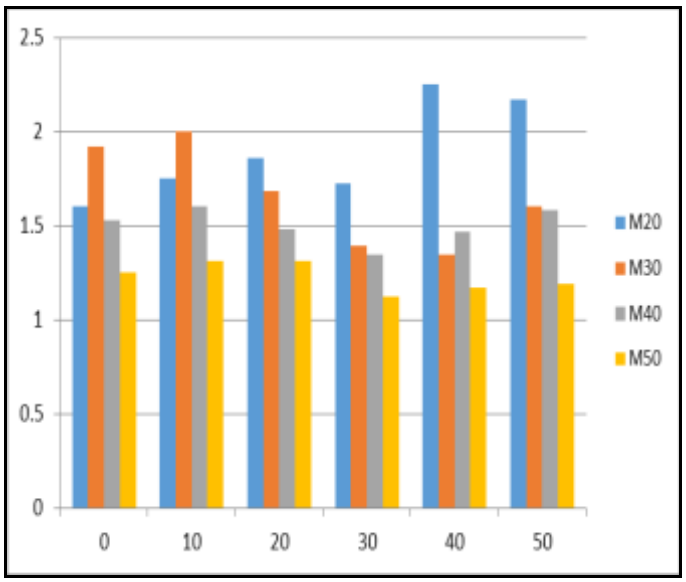
Where,

N - No of blows,
W - Weight of hammer,
H- Height of fall of hammer

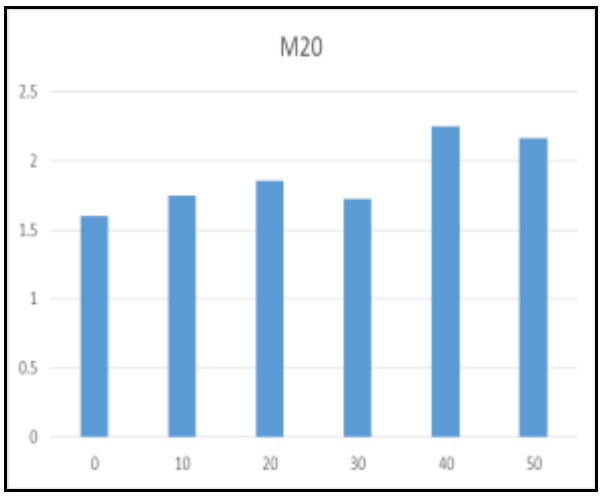


Fig 1: cylinder mould Fig2: drop weight impact test appratus fig3: impact testing for concrete

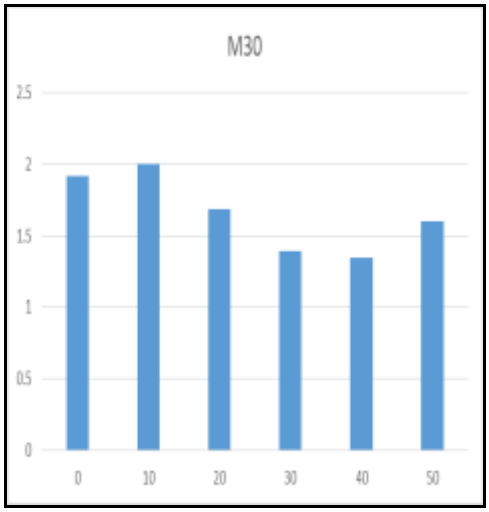
4.0 Discussion of Results



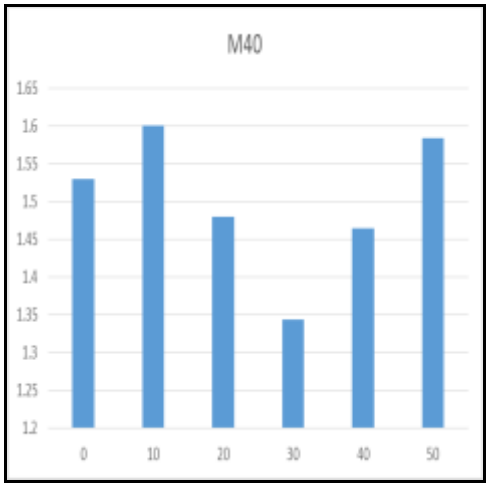
28 Days Ductility Index of Impact Strength Test



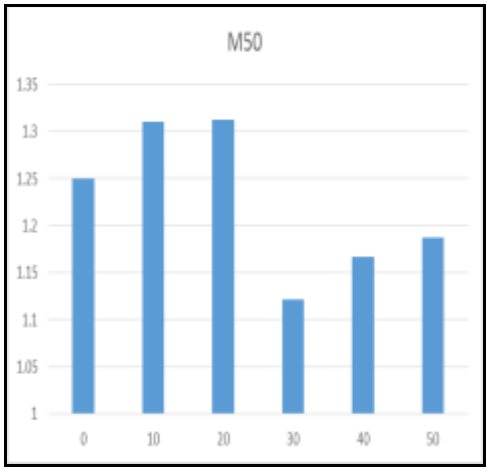
The percentage increase of first crack and failure crack of impact strength for 50% replacement of Copper slag with fine aggregate was found to be higher than that of M20 grade of concrete of Normal Cement Concrete for 28 days.



- The percentage increase of first crack and failure crack of impact strength for 10% replacement of copper slag with fine aggregate was found to be higher than that of M30 grade of concrete of Normal Cement Concrete for 28 days.



- The percentage increase of first crack and failure crack of impact strength for 10% to 20% replacement of copper slag with fine aggregate was found to be higher than that of M40 grade of concrete of Normal Cement Concrete for 28 days.



- The percentage increase of first crack and failure crack of impact strength for 10%and 20% replacement of copper slag with fine aggregate was found to be higher than that of M50 grade of concrete of Normal Cement Concrete for 28 days.

5.0 Conclusion

An attempt has been made find out the impact resistance of copper slag concrete. It has been made to use copper slag for making M_{20}, M_{30}, M_{40} and M_{50} grade of concrete. Copper slag was brought local copper industries, which was the waste product of copper industries. It is found that replacement of sand with copper slag increased strength upto certain percentage of replacement. From this research work it is found that when we are going for M20 concrete we can replace copper slag 40% to 50%. And if we are going for higher grades replacement can be made from 10% to 20% of copper slag.

- The percentage increase of first crack and failure crack of impact strength for 50% replacement of Copper slag with fine aggregate was found to be higher than that of M20 grade of concrete of Normal Cement Concrete for 28 days.
- The percentage increase of first crack and failure crack of impact strength for 10% replacement of copper slag with fine aggregate was found to be higher than that of M30 grade of concrete of Normal Cement Concrete for 28 days.
- The percentage increase of first crack and failure crack of impact strength for 10% to 20% replacement of copper slag with fine aggregate was found to be higher than that of M40 grade of concrete of Normal Cement Concrete for 28 days.
- The percentage increase of first crack and failure crack of impact strength for 10%and 20% replacement of copper slag with fine aggregate was found to be higher than that of M50 grade of concrete of Normal Cement Concrete for 28 days.
- From this research work it is found that when we are going for M20 concrete we can replace copper slag 40% to 50%. And if we are going for higher grades replacement can be made from 10% to 20% of copper slag.

6.0 References

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