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Experimental investigation on partial replacement of sand and cement with copper slag and dolomite powder

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Abstract

Cement is one of the most important constituents of concrete. Most of the properties of the concrete depend on cement. Cement is manufactured by calcining argillaceous and calcareous materials at a high temperature. During this process, a large amount of CO2 is released into the atmosphere. India is the second largest producer of cement in the world. It is estimated that the production of one ton of cement results in the emission of 0.8 ton of CO_2. The reduction in the consumption of cement will not only reduce the cost of concrete but also the emission of CO2.Common river sand is an expensive cost of transportation from natural sources. Also, large-scale depletion of these sources creates environmental problems. As environmental transportation and other constraints make the availability and use of river sand less attractive, a substitute or replacement product for concrete industry needs to be found. River sand is most commonly used fine aggregate in the production of concrete poses the problem of acute shortage in many areas. In such a situation the dolomite powder and copper slag can be an economical alternative for partial replacement of cement and sand. Coming to dolomite powder which is obtained by powdering the sedimentary been developed forM30 grade using design approach IS for both conventional and dolomite powder, copper slag mixed concrete. Tests were conducted on cubes and beams to study the strength of concrete made of dolomite powder, copper slag concrete, and the results were compared with natural sand concrete. The results show that the strength parameters are better than in dolomite powder, copper slag concrete compared to natural concrete in normal condition.

Keywords:M30 grade, compressive strength, split tensile strength, copper slag ,dolomite power etc,.

1.Introduction

Concrete is one of the most durable building materials and have high compressive strength compared to other building materials. It provides superior fire resistance compared with wooden construction and gains strength overtime. Structures made of concrete can have a long service life. Concrete is widely used material than any other manmade material in the world.Asof2014, about 9.8 billion cubic meters of concrete are made each year, more than one cubic meter for every person on Earth.

Concrete is a non-homogeneous material. It consists of cement, sand and mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement has chemically reacted with the water(hydrated),it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete or each full hardness and strength. Aggregate is the important constituent in concrete. Aggregates are divided into two categories from the consideration of size (i) coarse aggregate and (ii) fine aggregate. The size of aggregate is bigger than 4.75mm is considered as coarse aggregate and whose size is 4.75mm and less is considered as fine aggregate. Hard Broken Grain test one is most commonly used coarse aggregate material and river sand can be used as fine aggregate material in conventional concrete. Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt.

Copperslag:

Copper slag is one of the material for sand replacement material.It is an industrial by-product material produced from the process of manufacturing copper .For every ton of copper production, about 2.2 w tonne of copper slag is generated .It has been estimated that approximately 24.6 million tons of slag are generated from the world copper industry.

Fig no 1:copper slag sample in dump yard

Dolomite powder

Dolomite is an anhydrous carbonate mineral composed of calcium magnesium carbonate, ideally $CaMg(CO_3)_2$. The term is also used for a sedimentarycarbonate rock composed mostly of the mineral dolomite. An alternative name sometimes used for the dolomitic rock type is dolostone.The mineral dolomite crystallizes in the trigonal-rhombohedral system.It forms white, tan, gray, or pink crystals. Dolomite is a double carbonate, having an alternating structural arrangement of calcium and magnesium ions.

Fig no 2: Dolomite powder

Objectives of the work:

The objectives of the present investigation are as follows.

1. To study the optimum percentage composition of dolomite powder and copper slag replacing conventional cement and sand which does not affect the concrete strength.

2. To identify the compressive strength, flexural strength and split tensile strength of M30 grade concrete for 7, 28, 56 and 90 days with copper slag replacement in fine aggregates.

3. To identify the compressive strength ,split tensile strength and flexural strength of M30 grade concrete for 7, 28, 56 and 90 days with combination of dolomite powder and copper slag replacement in cement and fine aggregate.

Scope of the work

The scope of this project work was carried out to study the material properties such as compressive strength, split tensile strength and flexural strength of theM30grade concrete by replacing fine aggregate with copper slag and combination of replacement of fine aggregate and cement with copper slag and dolomite powder. Arrive at a mix proportion for the corresponding concrete by replacing fine aggregate of conventional concrete with dolomite powder and copper slag as cement and fine aggregate using ordinary Portland Cement. The scope of this project work was to use the industrial waste material in conventional concrete to some extent and economical for construction..

2.Literature review

Literature review on copper slag

Many researchers have investigated worldwide on the possible use of copper slag as a concrete aggregate and dolomite powder as cement. Some of the important and published works are reviewed and presented briefly below.

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R RChavan& D B Kulkarni (2013) conducted experimental investigations to study the effect of using copper slag as a replacement of fine aggregate on the strength properties and concluded that Maximum Compressive strength of concrete increased by 55% at 40% replacement of fine aggregate by copper slag and flexural strength increased by 14 % for 40 % replacement.

Al-Jabri et al (2011) investigated the performance of high strength concrete made with copper slag as a replacement for fine aggregate at constant workability and studied the effect of super plasticizer addition on the properties of High Strength Concrete made with copper slag. They observed that the water demand reduced by about 22% for 100% copper slag replacement. The strength and durability of High Strength Concrete improved with the increase in the content of copperslag of upto 50%.The test results also show that there is a slight increase in the density of nearly 5% with the increase of copperslag content, whereas the workability increased rapidly with increase in copper slag percentage.

Literature review on dolomite powder

J. Kiran and P. Rangarajan (2017) carried out an investigation to know the fesability of using dolomite powder as cement replacement for the production of concrete the hardened concrete mix with dolomite powder is passed through tests of compressive, splittensile, flexuralstrength.The test results obtained from the compressive, split tensile and flexural strength describes that it is satisfactory upto5% replacement of cement with dolomite powder in structural applications.

Marija Jelcic Rukavina, (2015) fresh and hardened properties of self-compacting concretes made with dolomite filer and mineral additives as cement replacement were investigated. For that purpose, seven self-compacting concrete mixtures were prepared. The binder for the control of self-compacting mixture included ordinary Portland cement (PC) and dolomite filler (D), while in six of the mixtures' ,beside cement and dolomite, part of the cement was replaced with5 ÷ 15 % of metakaolin (MK) and 20 ÷ 40 % fly ash (FA)(by weight). Fresh properties included filling, passing ability and segregation resistance of SCC, while the hardened properties included compressive strength and modulus of elasticity development up to 365 days.

3. Materials used

Cement

Cement is a material that has cohesive and adhesive properties in the presence of water. Such cements are called hydraulic cements .These consist primarily silicates and aluminates of lime obtained from limestone and clay. There are different types of cement,

- ordinary Portland cement

- portland slag cement

Fig no 3: ordinary Portland cement 53 grade

Aggregates

Aggregate properties greatly influence the behaviour of concrete ,since they occupy about 80% of the total volume of concrete. The aggregates are classified as

- fine aggregates

- coarse aggregates

Fig no 4: fine aggregate **Fig no 5: coarse aggregate**

Copper slag

Industries produces copperslag during the manufacture of copper metal .Currently, about 2600 tons of copper slag is produce per day and a total accumulation of around 1.5 million tons. This slag is currently being used for many purposes ranging from land-filling to grit blasting.

Table 1 Properties of copper slag

S.No	Property	Copper slag
1	Specific gravity	3.2-3.7
2	Colour	Black
3	Moisture content	Nil
4	Hardness	5 to 7 moh's scale

Dolomite powder

Dolomite is a carbonate material constituted with calcium magnesium carbonate CaMg (CO3)2. The term dolostone describes the sedimentary carbonate rock. Dolostone (dolomite rock) is composed predominantly of the mineral dolomite with a stoichiometric ratio of 50% or greater content of magnesium replacing calcium, 16 often as a result of digenesis. Dolomite is a rock forming mineral which is noted for its remarkable wet ability and dispensability. Dolomite has a good weathering resistance. Dolomite is a preferred for construction material due to its higher surface hardness and density. Asphalt and concrete applications prefer dolomite as a filler material due to its higher strength and hardness.

Table 2 Physical Properties of dolomite powder

S.No	Property	Dolomite powder
1	Formula	$CaMg(CO_3)_2$
2	Specific gravity	2.84-2.86
3	Colour	White, grey to pink
4	Moisture content	Nil
5	Crystal system	Triagonal

Table 3. Composition of dolomite powder

Chemical	Percentage
Total carbonate	97.5%
Caco3	61.4%
Mgco3	32.9%
Sio2	5.1%

4 Experimental procedure

objective

It was proposed to investigate the behaviour of concrete in which coarse aggregate is partially replaced with copper slag, dolomite powder and it is compared with the regular mix.

Experimental setup

In this stage collection of materials required and the data required for mix design are obtained by sieve analysis and specific gravity test. Sieve analysis is carried out from various fine aggregate and coarse aggregate samples and the sample which suits the requirement is selected. Specific gravity tests are carried out for fine and coarse aggregate. The various materials used were tested as per Indian standard specifications.

Materials Raw materials required for the concreting operations of the present work are.

1. Cement.
2. Fine aggregate.
3. Coarse aggregate.
4. Water.
5. Dolomite powder.
6. Copper slag.

Cement: (cement of 53grade ordinary Portland cement was used) Testing for cement

1. Fineness
2. Standard consistency of cement
3. Specific gravity of cement

Fineness The degree to which the cement is ground to smaller and smaller particles is called fineness of cement. Finer cement offers a greater surface area for hydration and hence faster the development of strength. The fineness of grinding has increased over the years. But now it has got nearly stabilized. The particle size fraction below 3 micron has been found to have the predominant effect on the strength at one day while 3-25 micron fraction has a major influence on the 28 days strength. The apparatus and test should be conducting according relevant IS code.

Table 4 Fineness modulus of cement

S.No	Description	Weight	Fineness of cement
1.	Initial weight of sample(g)	100	5.66
2.	Weight of residue in 90µ sieve(g)	5.66	
3.	Fineness of cement in (%)	5.66	

Standard consistency of cement A certain minimum quantity of water is required to be mixed with cement so as to complete chemical reaction between water and cement, less water than this quantity would not complete chemical reaction thus resulting in reduction of strength and more water would increase water cement ratio and so would reduce its strength. So correct proportion of water to cement is required to be known to achieve proper strength while using cement in structure. For finding out initial setting time, final setting time and soundness of cement, and strength a parameter known as standard consistency has to be used. The apparatus and test should be conducting according relevant IS code.

Table 5 Consistency of cement

S.No	% of water to the weight of cement sample	Quantity of water (ml)	Penetration of standard needle(mm)
1	28	104	23
2	29	112	16
3	30	120	09
4	31	124	05

Fine aggregate (sand)

The size of the fine aggregate is below 4.75mm, natural sand or fly ash used as the fine aggregate in concrete mix. Sand may be obtained from rivers, lakes but when used in concrete mix, it should be properly washed and tested to ascertain the total percentage of clay silt, slit and other organic matters does not exceed the specified limit. For the experimental investigation locally available river sand which is free from organic impurities is used.

Determination of specific gravity of sand

$$\text{Specific Gravity} = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$$

$$= 2.67$$

coarse aggregate The material whose particles of size retained on I.S. sieve no. 4.75mm is termed as coarse aggregate. The size of coarse aggregate depends upon the nature of the work. The coarse aggregate used in the experimental investigation is 20mm size crushed on angular in shape. The aggregates are free from dust before used in th concrete.

Determination of specific gravity of coarse aggregate

$$\text{Specific Gravity} = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)}$$

$$= 2.83$$

Dolomite powder Before using dolomite powder as replacement of cement it must be sieved using IS sieves of size 90µm. Because to know the fineness of cement sieving is carried out by using IS sieve 90µm.
Specific gravity= 2.82

copper slag The size of copper slag must be below 4.75mm. So, the copper slag material is sieved by using IS sieve of 4.75mm. Make sure that the material is free from fine particles.
Specific gravity=3.23

water to be used in the concrete work should have following properties:

- It should be free from injurious amount of oil, acids, alkalis or other organic or inorganic impurities.
- It should be free from iron, vegetable matter or other any type of substances, which likely to have adverse effect on concrete or reinforcement.

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Mixing The object of mixing is to coat the surface of all aggregate particles with cement paste and to blend all the ingredients of concrete into a uniform mass. Thorough mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency.

compacting The test cube specimens are made as soon as practicable after mixing and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. The concrete is filled into the mould in layers approximately 5cm deep. In placing each scoopful of concrete. In order to ensure the symmetrical distribution of the concrete with in the mould. Each layer is compacted by either by hand or by vibration. After the top of the layer has been compacted the surface of the concrete is brought to the finished level with top of the mould, using a trowel, the top is covered with a glass or a metal plate to prevent evaporation.

Tests for compression and split tensile strength of concrete In this study, the compression testing machine having capacity of 2000KN was used for finding compressive strength of concrete cubes and split tensile strength of concrete cylinders.

Fig no 6:compression testing machine

Fig no 7: split tensile strength

Flexural strength of concrete

Flexural strength, also known as modulus of rupture, bond strength, or fracture strength a mechanical parameter for brittle material, is defined as materials ability to resist deformation under load. The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross section is bent until

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fracture or yielding using a three point flexural test technique. The flexural strength represents the highest stress experience with in the material at its moment of rupture.

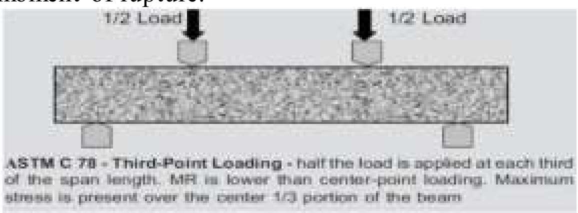

Fig no 8: split tensile strength

Calculations

The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross sectional area calculated from mean dimensions of the section and shall be expressed to the nearest N/mm2, average of all values shall be taken as the representation of the batch provided and individual variation is not more that -15 percent of average. Compressive strength = max $load/area$ Split tensile strength = $2P/\pi DL$

Flexural strength = PL/bd2

5 concrete mix design

Introduction The process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredient of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted.

The property of workability, Aggregates; batching and mixing; placing, compaction and curing. The cost of concrete is made up of the cost of materials, plant and labour. The variations in the cost of materials arise from the fact that the cement is several times costly than the aggregate, thus the aim is to produce as lean a mix as possible.

Types Of Mix

Nominal Mix In the past the specifications for concrete prescribed the proportions of cement, fine and coarse aggregates. These mixes of fixed cement-aggregate ratio which ensures adequate strength are termed nominal mixes. These offer simplicity and under normal circumstances, have a margin of strength above that specified. However, due to the variability of mix ingredients the nominal concrete for a given workability varies widely in strength.

Standard Mix The nominal mixes of fixed cement-aggregate ratio (by volume) vary widely in strength and may result in under- or over-rich mixes. For this reason, the minimum compressive strength has been included in many specifications. These mixes are termed standard mixes. IS 456-2000 has designated the concrete mixes into a number of grades as M10, M15, M20, M25, M30, M35 and M40. In this designation the letter M refers to the mix and the number to the specified 28 day cube strength of mix in N/mm2. The mixes of grades M10, M15, M20 and M25 correspond approximately to the mix proportions (1:3:6), (1:2:4), (1:1.5:3) and (1:1:2) respectively.

3 Designed Mix In these mixes the performance of the concrete is specified by the designer but the mix proportions are determined by the producer of concrete, except that the minimum cement content can be laid down. This is most rational approach to the selection of mix proportions with specific materials in mind possessing more or less unique characteristics. The approach results in the production of concrete with the appropriate properties most economically.

Mix Design For M 30 Grade

Table 6 Mix Design For M 30 Grade

Material	Water	Cement	Fine aggregate	Coarse aggregate
Kgs/cum	192	399	715	1155
Ratio	0.48	1	1.79	2.89

6 Results And Discussion

Compressive Strength Studies

For Compressive strength test standard cube size of 150mm x 150mm x150mm are used. An average of three specimens are taken for all mixes after a curing period of 7 days , 28 days,56 days and 90 days. The cubes are taken out from the curing tank after attaining days of curing .AS per IS 516-1969.

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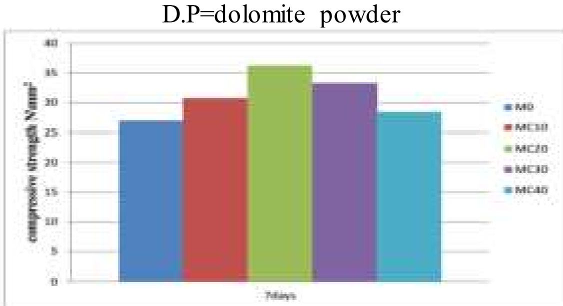
Fig No 8compression Testing Of Cube Fixed In Machine.

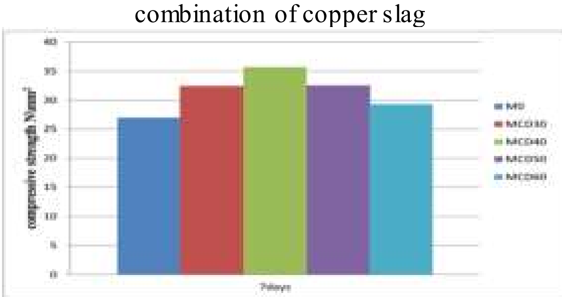
Table:7 Mean Compressive Strength Of M30 Grade Concrete.

Mix design-ation	Cement	F.A Used	%Replaceme nt in F.A		C.A used	Comp strength (7d)	Comp strength (28d)	Comp strength (56d)	Comp strength (90d)
			C.S	D.P					
M0	100	100	-	-	100	26.97	37.27	39.78	41.15
MC10	100	90	10	-	100	30.73	40.97	44.38	46.03
MC20	100	80	20	-	100	36.33	48.13	49.37	50.47
MC30	100	70	30	-	100	33.27	40.83	45.47	45.93
MC40	100	60	40	-	100	28.43	38.80	42.43	42.74
MCD30	90	80	20	10	100	32.47	44.25	47.17	49.73
MCD40	80	80	20	20	100	35.72	40.69	43.93	45.36
MCD50	70	80	20	30	100	32.54	37.21	39.62	41.02
MCD60	60	80	20	40	100	29.27	33.14	36.12	36.45

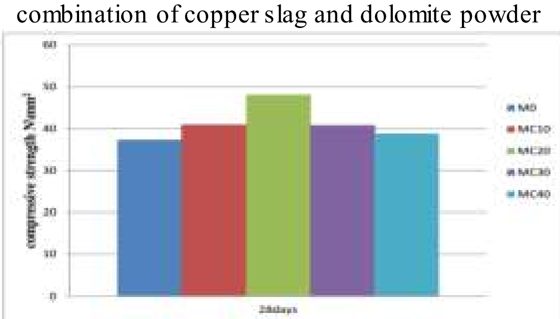
Where, F.A=fine aggregate
C.A=coarse aggregate
C.S=copper slag
D.P=dolomite powder



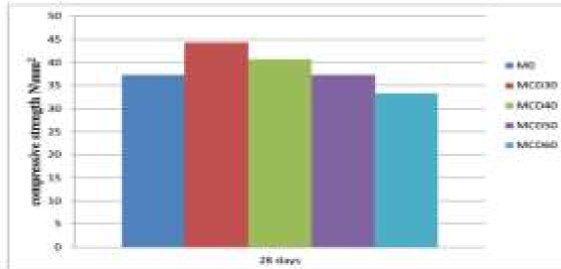
Graph 1compressive strength at 7 days with combination of copper slag



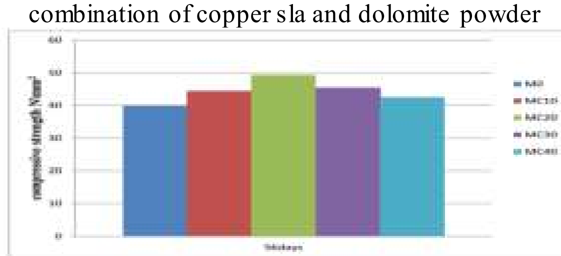
Graph2 compressive strength at 7 days with combination of copper slag and dolomite powder

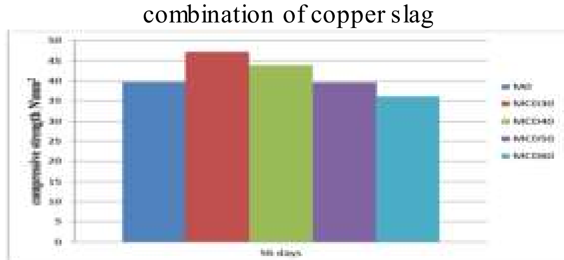


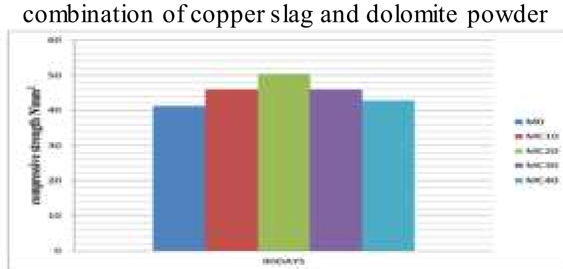
Graph 3 compressive strength at 28 days with combination of copper slag

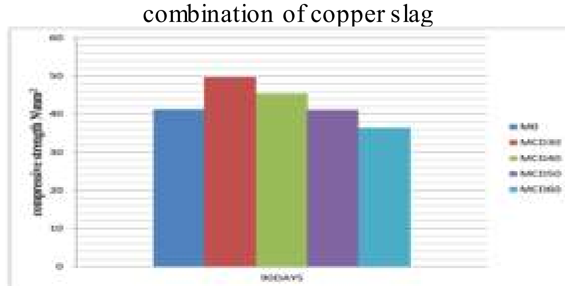


Graph4 compressive strength at 28 days with combination of copper sla and dolomite powder


Graph 5 compressive strength at 56 days with combination of copper slag


Graph 6 compressive strength at 56 days with combination of copper slag and dolomite powder


Graph 7 compressive strength at 90 days with combination of copper slag


Graph 8 compressive strength at 90 days with combination of copper slag and dolomite powder

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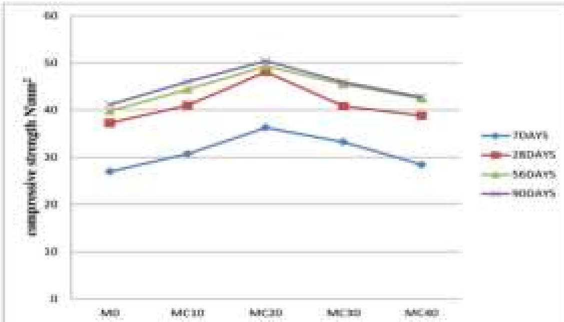
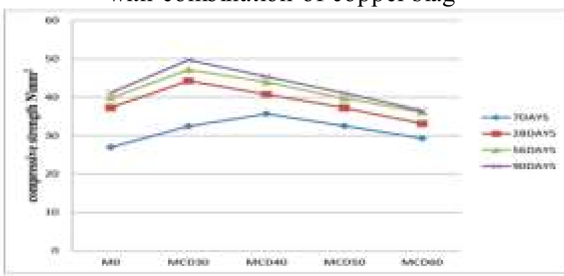


Graph 9 comparison of compressive strength results with combination of copper slag



Graph 10 comparison of compressive strength results with combination of copper slag and dolomite powder

Flexural Strength Studies

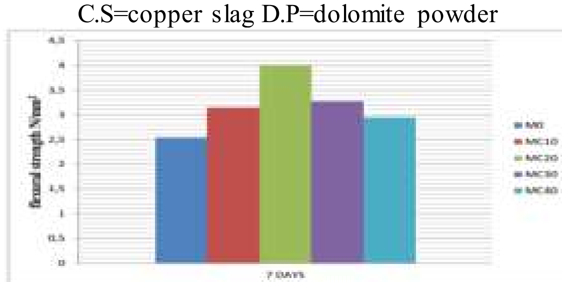
For Flexural strength test standard prism of size 500mm x 100mm x 100mm are used. An average of 3 specimens is taken for all mixes after a curing period 7 days , 28 days, and 56 days . For testing of beams the bearing Surfaces of the supporting and loading rollers shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers. The specimen was placed in the machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould along two lines spaced 20.0 or 13.3 cm apart. The axis of the specimen is carefully aligned with the axis of the loading device

FIG 9 Flexural Strength Of The Beam Fixed In Machine.

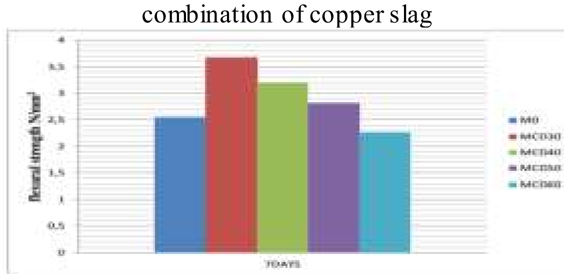
Table:8 Mean Flexural Strength Of M30 Grade Concrete.

Mix design ation	Cemen t	F.A Used	%Replace ment in F.A		C.A used	Flexural strength (7d)	Flexural strength (28d)	Flexural strength (56d)	Flexural strength (90d)
			C.S	D.P					
M0	100	100	-	-	100	2.54	4.34	4.54	4.67
MC10	100	90	10	-	100	3.14	5.24	5.61	5.86
MC20	100	80	20	-	100	4.03	6.67	6.93	7.09
MC30	100	70	30	-	100	3.27	5.35	5.64	6.01
MC40	100	60	40	-	100	2.94	4.88	5.12	5.45
MCD30	90	80	20	10	100	3.67	6.10	6.47	6.85
MCD40	80	80	20	20	100	3.20	5.35	5.37	5.94
MCD50	70	80	20	30	100	2.81	4.75	5.03	5.22
MCD60	60	80	20	40	100	2.26	3.77	4.18	4.19

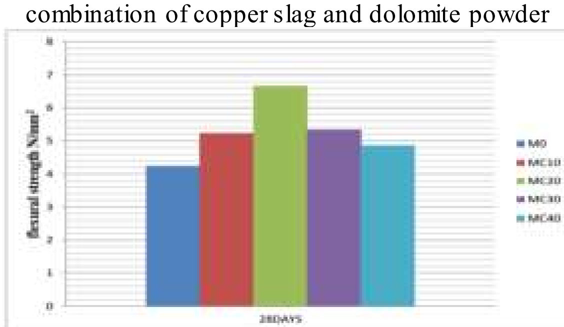
Where, F.A=fine aggregate
C.A=coarse aggregate
C.S=copper slag D.P=dolomite powder



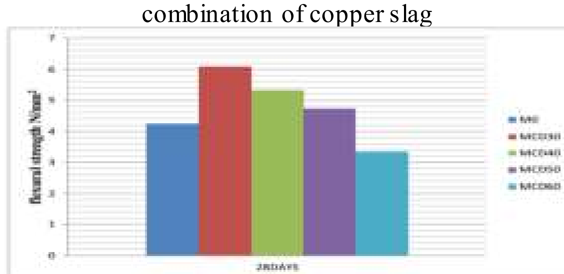
Graph 11:Flexural strength of beam at 7 days with combination of copper slag



Graph 12: Flexural strength of beam at 7 days with combination of copper slag and dolomite powder

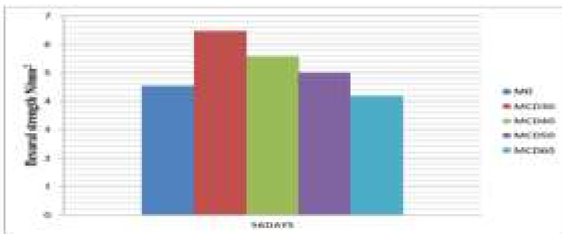


Graph 13: Flexural strength of beam at 28 days with combination of copper slag

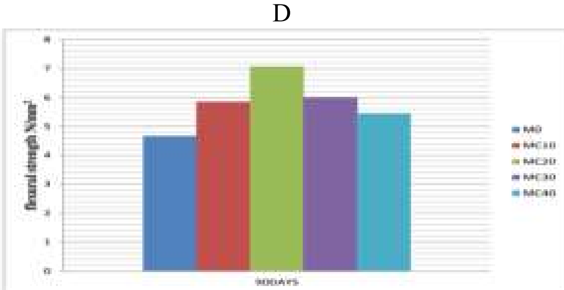


Graph 14: Flexural strength of beam at 28 days with combination of copper slag and dolomite powder

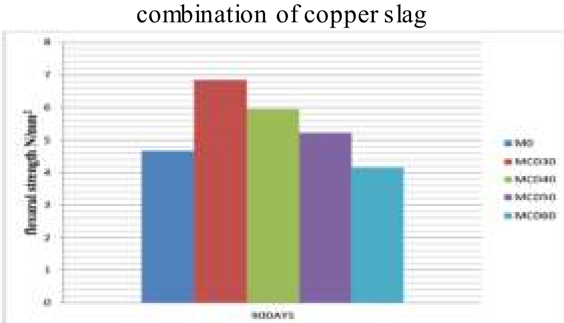
Graph 15: Flexural strength of beam at 56 days with combination of copper slag



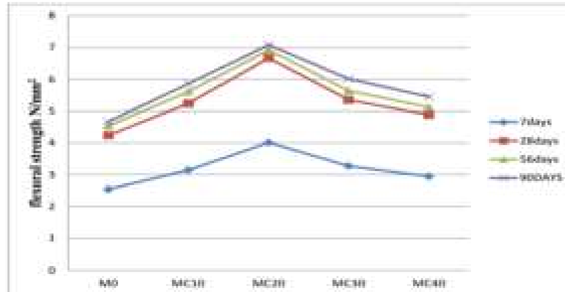
Graph 16: Flexural strength of beam at 56 days with combination of copper slag and dolomite powder D



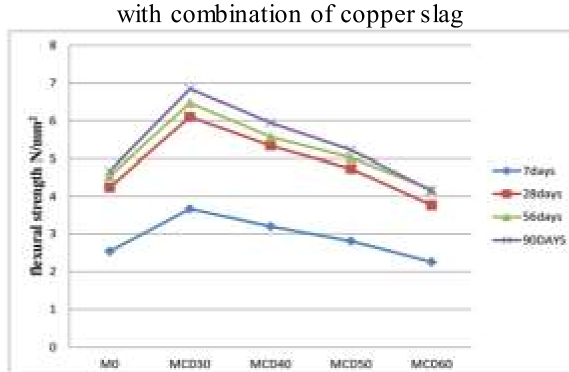
Graph 17: Flexural strength of beam at 90 days with combination of copper slag



Graph 18: Flexural strength of beam at 90 days with combination of copper slag and dolomite powder



Graph 19: Comparison of flexural strength results with combination of copper slag



Graph 20: Comparison of flexural strength results with combination of copper slag and dolomite powder

Split Tensile Strength Studies

Testing for split tensile strength of concrete is done as per IS5816-1959. The test is conducted on compression testing machine of capacity 3000 KN as shown in below The cylinder of dimensions 300 mm x 150 mm diameter is placed horizontally between the loading surfaces of compression testing machine and the load is applied till failure of the cylinder. Packing material such as plywood is used to avoid any sudden loading. During the test the platens of the testing machine should not be allowed to rotate in a plane perpendicular to the axis

Fig 10 Split Tensile Strength Of Cylinder Fixed To Machine

Table:9 Mean Split Tensile Strength Of M30 Grade Concrete.

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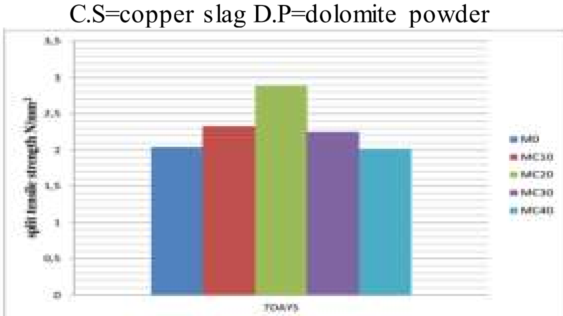
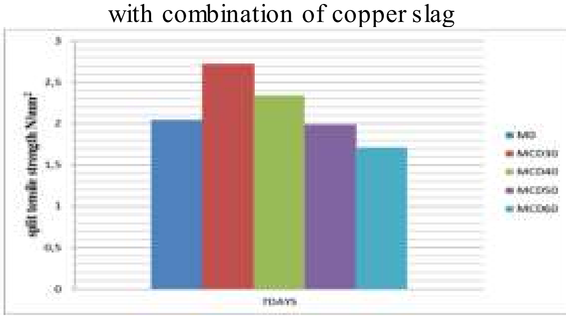
Mix design-ation	Cement	F.A Used	%Replacement in F.A		C.A used	Split tensile strength (7d)	Split tensile strength (28d)	Split tensile strength (56d)	Split tensile strength (90d)
			C.S	D.P					
M0	100	100	-	-	100	2.04	3.35	3.62	3.69
MC10	100	90	10	-	100	2.33	3.89	4.12	4.23
MC20	100	80	20	-	100	2.89	4.81	5.21	5.37
MC30	100	70	30	-	100	2.25	3.63	3.97	4.06
MC40	100	60	40	-	100	2.02	3.34	3.58	3.83
MCD30	90	80	20	10	100	2.72	4.53	4.89	5.09
MCD40	80	80	20	20	100	2.34	3.74	4.06	4.03
MCD50	70	80	20	30	100	1.98	3.37	3.53	3.72
MCD60	60	80	20	40	100	1.71	2.89	3.12	3.16

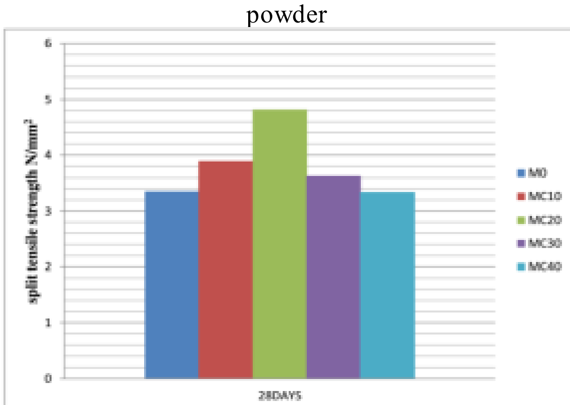
Where, F.A=fine aggregate C.A=coarse aggregate C.S=copper slag D.P=dolomite powder



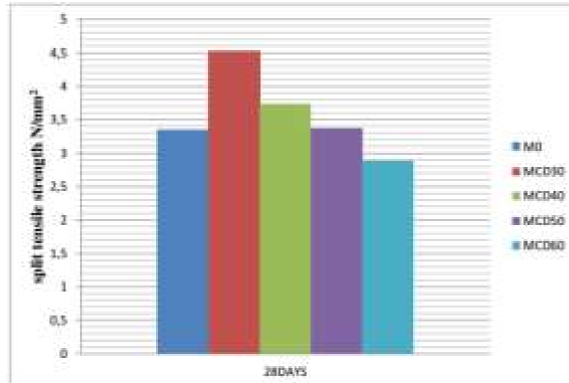
Graph 21: split tensile strength of cylinder at 7 days with combination of copper slag



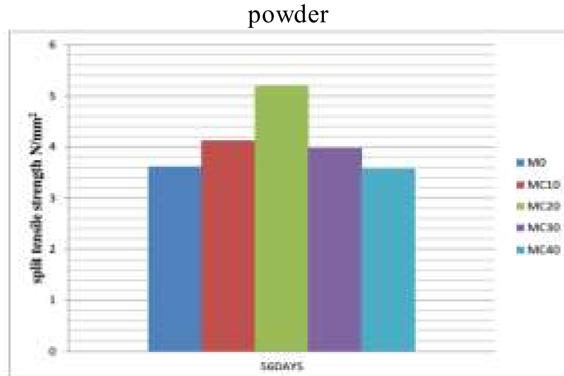
Graph 22: split tensile strength of cylinder at 7 days with combination of copper slag and dolomite powder



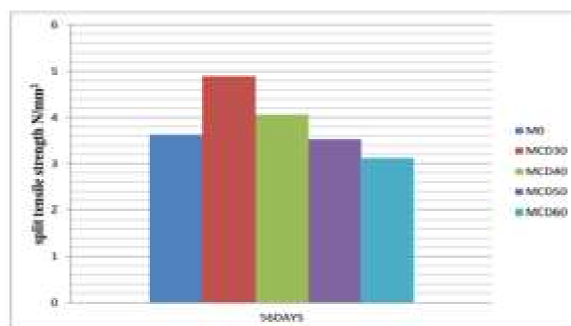
Graph 23: split tensile strength of cylinder at 28 days with combination of copper slag



Graph 24: split tensile strength of cylinder at 28 days with combination of copper slag and dolomite powder



Graph 25: split tensile strength of cylinder at 56 days with combination of copper slag



Graph 26: split tensile strength of cylinder at 56 days with combination of copper slag and dolomite powder

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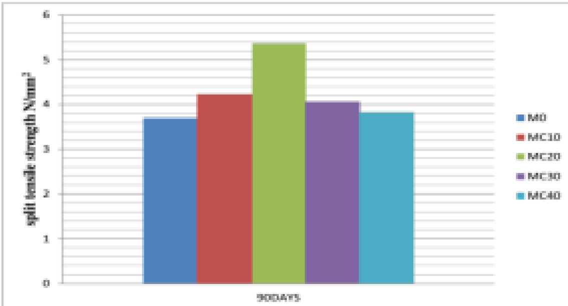
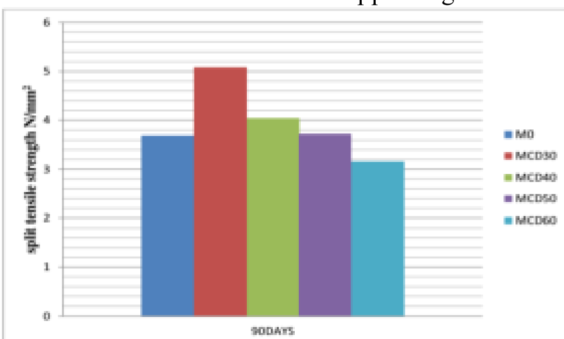
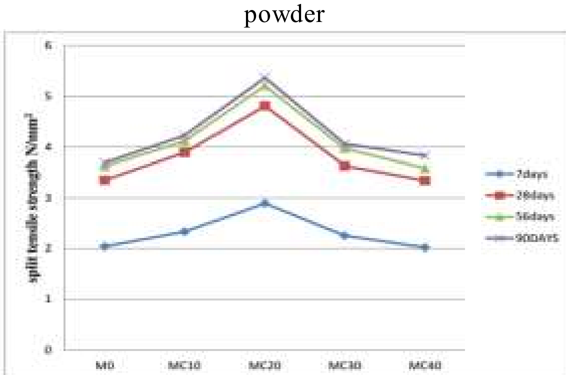


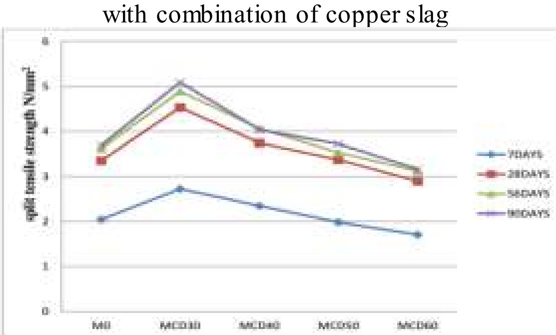
Graph 27: split tensile strength of cylinder at 90 days with combination of copper slag



Graph 28: split tensile strength of cylinder at 90 days with combination of copper slag and dolomite powder



Graph 29: Comparison of split tensile strength results with combination of copper slag



Graph 30: Comparison of split tensile strength results with combination of copper slag and dolomite powder

7 Conclusion

- The density of copper slag concrete is found to be higher than the normal concrete.
- The slump values of copper slag concrete are observed to be relatively more when compared to the normal concrete. Therefore the workability of concrete increases significantly with the increase of copper slag content.
- When compared to normal concrete strength variation in all the copper slag mixes is observed more than 10%.
- For the concrete made with replacement of sand with copper slag the compressive strength increases as the % replacement increases and all the mixes reached the target mean strength.
- The maximum compressive strength of copper slag concrete is about 50.47N/mm2
- The maximum split tensile strength of copper slag concrete is about 5.37N/mm2.
- The maximum flexural strength of copper slag concrete is about 7.09N/mm2.
- For the concrete made with replacement of sand with copper slag and cement with dolomite powder the compressive strength increases as the % replacement increases and all the mixes are not reached target mean strength.
- The maximum compressive strength of copper slag and dolomite powder concrete is about 49.73 N/mm2. The maximum split tensile strength of copper slag and dolomite powder concrete is about 5.09 N/mm2. The maximum flexural strength of copper slag and dolomite powder concrete is about 6.85 N/mm2.
- On replacement with dolomite powder and copper slag there is an increment in strength at MCD30.
- From the above results copper slag and dolomite powder concrete can be considerable as alternative. By substitution the sand with copper slag and cement with dolomite powder results in the reduction of consumption of sand and cement.

Scope For The Future Work

- Other materials such as geo-polymers can be used as a cement replacement instead of dolomite powder for future work.
- Likewise foundry sand, quarry dust can be used as replacement for fine aggregate.

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