International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 5, pp: 19-24 www.ijaem.net ISSN: 2395-5252

Experimental studies on cement mortar with Copper slag and Cerafiber- mix

T. Veda Bharathi
Assistant Professor, Department of Civil Engineering, Narasaraopeta Engineering College, Narasaraopeta, Guntur, Andhra Pradesh.

Date of Submission: 05-08-2020 Date of Acceptance: 22-08-2020

ABSTRACT: The utilization of industrial waste or secondary materials has been encouraged in the production of cement and concrete. New by-products and waste materials are being generated by various industries. Dumping or disposal of waste materials causes environmental and health problems. Therefore, recycling of waste materials is a necessary step towards keeping the environment safe.Thepresent investigation deals with the effect of Copper slag and Cerafiber-mixin cement mortar thereby studying its mechanical and durability properties in hardened state. The cement mortar was produced by partial replacement of ordinary Portland cement with copper slag in percentages of 0%, 5%, 10%, 15%, 20%, 25% and 30% with the addition of Cerafiber-mixas 1% by weight of cement. The flexural strength, compressive strength and split tensile strength were found out for the prism specimens of size 160×40×40mm. Test specimens were cured in acidic water in which Sulphuric acid was added in required proportion. All the results are tabulated.

KEYWORDS: Copper slag, cerafiber-mix, polypropelene fibers, flexural strength, compressive strength, split tensile strength, durability, sulphuric acid, binder (cement &copper slag mixture)

I. INTRODUCTION

Sustainable development in construction involves the use of non-conventional and innovative materials and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment.

The concept of reuse of waste/by-product has now-a-days become both environmental concern and resources management. Construction waste, blast furnace slag, steel slag, and fly ash have been acceptedas alternative aggregates. Copper slag possess many mechanical and chemical characteristics that qualify the material to be used in the concrete as partial replacement for Portland cement or as substitute for aggregates. Such concrete and mortar which is blended with by-products as substitutes is termed as high-performance concrete and mortar (HPC & HPCM).

The role of cement mortar in concrete is to fill the voids in between coarse aggregates imparting denseness to concrete and to bind aggregates. The property of concrete mostly depends upon the properties of cement mortar matrix in concrete. Not only the strength, the degree of harshness of the environment condition to which concrete is exposed over its entire life is equally important. Therefore, both strength and durability must be considered explicitly at the design state. It is interesting to consider yet another viewpoint regarding strength and durability relationship.

Objectives:

The principle objective of this investigation is to acquire a better understanding factors which influence the strength and durability properties of cement mortars. It is proposed to find out the effectiveness of copper slag as cement replacement material in addition to cerafiber-mix content in cement mortars.

The mortar mixes which are studied are:

Control mix 1:2 (cement: sand by weight)

Adopting different levels of replacement of cement with copper slag in control mix, keeping theCerafiber-mix content and water- binder ratio same.

Establishing the following mechanical properties of mortars through testing of the mortar specimens in the laboratory:

•Flexural strength, Compressive strengthand Split tensile strength at the age of 3, 7,14,28,56 daysfrom the day of casting.

II. MATERIALS USED

Cement

Ordinary Portland Cement of 53 grade is used for this investigation. All the properties were tested referring to IS 12269:1987 Indian Standard

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 5, pp: 19-24 www.ijaem.net ISSN: 2395-5252

code of practice for 53 grade OPC and results are tabulated.

Table 1: Properties of cement

S.NO	Property of cement	Values
1	Fineness of cement	5%
2	Grade of cement	53
3	Specific gravity	3.2
4	Initial setting time	30min
5	Final setting time	535min
6	Normal consistency	29%

Fine aggregate:

Locally available river sand is used for the present study. The sand is tested for various properties referring to IS 383:1970. The specific gravity of fine aggregate is found to be 2.64. Fineness modulus of natural sand is 2.507

Water:

Potable water is used for mixing as well as curing of concrete as prescribed in IS 456:2000

Copper slag:

Copper slag is a by-product of copper extraction by smelting. Appropriate use of the copper slag in the manufacture of concrete and cement mortars is a good opportunity to recycle by-products, for what would otherwise be massive hazard to the environment.

There are various uses of copper slag:

- Used in blended cement
- Used in cutting and abrasive tools
- Copper slag can also be used as a building material, formed into blocks.
- Copper slag is widely used in the sand blasting industry.
- Copper slag isused as an abrasive media to remove rust, old coatings.

Physical properties of copper slag:

The bulk density of granulated copper slag is varying from 1.9 to 2.15 kg/ m3 which is similar to the bulk density of fine aggregate. The hardness of the slag lies between 6 and 7 in Moh scale, which is almost equal to the hardness of gypsum. The fineness of copper slag was calculated as 125 m2 /kg.

Table 2: Physical properties of copper slag.

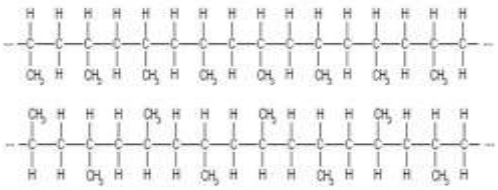
Physical property	**Copper slag**
Particle shape	Irregular
Appearance	Black & glassy
Type	Air cooled
Specific gravity	3.91
Hardness	Between 6 and 7 mohs

Table 3: Chemical properties of copper slag

S.No	**Chemical Component**	**%of Chemical Component**
1.	SiO_2	25.84
2.	Fe_2O_3	68.29
3.	Al_2O_3	0.22
4.	CaO	0.15
5.	Na_2O	0.58
6.	K_2O	0.23
7.	LoI	6.59
8.	Mn_2O_3	0.22
9.	TiO_2	0.41
10.	SO_3	0.11
11.	CuO	1.20
12.	Sulphide	0.25
13.	Insoluble residue	14.88
14.	Chloride	0.018

Fibers:

The usage of waste fibrous materials in the building construction industry is nowadays a reality, namely in the production of thermal and acoustic insulation panels. The fibers used for present experiment are Cerafiber mix.Cerafiber-mix is a high performance multi filament polypropylene fiber, which is readily available and easy to use. It is available in different lengths to serve various construction needs.



Polypropylene polymer chain $(C_3H_6)_n$

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 5, pp: 19-24 www.ijaem.net ISSN: 2395-5252

Advantages:

Cerafiber-mix is uniformly dispersed throughout the concrete mix forming a network of 3-dimensionnal additional reinforcement resulting in increased strength, making it ideal for seismic designs and high strength concrete. When the fibers are uniformly distributed into the mortar, plastic shrinkage may be minimisedand macro cracks are prevented. Cerafiber-mix holds together fine particles of sand, cement and stone chips increasing the abrasion and impact resistance making it perfect for areas exposed to excessive wear and tear, impact etc. During fires,cerafiber-mix melt and form channels to relieve volatile steam pressure in concrete, thereby mitigating the explosive tendency of concrete. Environment friendly and non-hazardous.

Direction for use as given on package:

For best results use mechanized mixer, add fibers along with chips/sand/cement. For manual mixing, add fibers in a bucket containing half the requirement of mixing water, along with admixtures if any and mix vigorously. Spread the water along with fibers over the dry mixture.

DOSAGE:

For motor:-900gms/m3(minimum)

For concrete:-600 gms/m3(minimum)

1.6Kg/m3 (minimum) when used as primary reinforcement.

It is recommended to optimize the dosage depending on the requirement.

Properties of polypropylene fibers

Property	**Value**
Melting point	160 C
Specific gravity	0.91
Ignition point	360 C
Conductivity	Low
Moisture absorption	Nil
Alkali resistant	100%
Acid & salt resistance	High

III. EXPERIMENTAL INVESTIGATIONS

Investigations were carried out on cement mortar with copper slag as cement replacement and cerafiber-mix as additional fiber. The binder-sand ratio and water-binder ratio is maintained constant for all the mixtures.

MIX PROPORTIONS:

For the experiments, control mortar mixture of cement**:** sand of 1:2 by weight was used with a constant water-cement ratio 0.45. Cement of the control mixture was replaced at levels of 5,10,15,20,25, and 30% by weight with copper slag and are classified as M_0, M_1,M_2, M_3, M_4,M_5, M_6Water to binder ratio is same for all mixes as 0.45 and Cerafiber- mix at 1% by weight of cement.

Table 4: Mix proportions of mortar (by weight)

S.no	Mix classification	Cement	Copper slag	Fine aggregate	Water Binder ratio	Cerafiber-mix 1% of binder(gm/kg)
1	M_0	1.00	00	2.00	0.45	0.010
2	M_1	0.95	0.5	2.00	0.45	0.0095
3	M_2	0.9	0.10	2.00	0.45	0.009
4	M_3	0.85	0.15	2.00	0.45	0.0085
5	M_4	0.8	0.20	2.00	0.45	0.008
6	M_5	0.75	0.25	2.00	0.45	0.0075
7	M_6	0.7	0.3	2.00	0.45	0.007

Method of mixing:

The required quantity of ingredients,i.e. cement, sand, copper slag, cerafiber-mix and water are weighed by using electronic balance. Blending of the cement and copper slag is first done to get uniform mix. The respective fine aggregate quantity is added over the binder and dry mixing is done for few minutes. As manual mixing is done, fibers are added in a bucket containing half the requirement of mixing water, and vigorously mixed. Then, spread the water along with fibers over the dry mixture. All the components are mixed for 5 minutes until fibers get uniformly mixed, adding remaining water in small quantities.

Preparation of specimens:

Prism specimens of size 160×40×40mm were cast to carry out tests for flexural strength, compressive strength and split tensile strength at the ages of 3,7,14,28,56 days. Also, specimens were casted to carry out durability test using Sulphuric acid.

Curing for the specimens:

Beam specimens were subjected to moist curing by immersing in water. The specimens to be tested at 3,7,14,28,56 days are removed from curing

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 5, pp: 19-24 www.ijaem.net ISSN: 2395-5252

and tested accordingly to find out the mechanical properties.

TEST METHODS

A new test method, which was adopted in Japan was planned to test the mechanical properties of hardened cement mortar. Instead of casting separate specimens for each test, only one set of specimens of size 160×40×40mm were casted and used to carry out different strength tests.Consumption of materials for preparation of specimens for this test method is much less and there is saving in labour employed for specimen preparation.

At first, flexural strength test was carried out on the prismspecimen by applying two- point loading. During this test, the specimen breaks at its middle third part, leaving two pieces each having size of 40×40mmcross section and length of minimum 60mmto 80mm (approximate). These two pieces are in turn used to carrying the test for compressive strength and split tensile strength.

Flexural strength test:

Two- point load was applied to find out the modulus of rupture of mortar specimens as per IS 4031:1968. The average strength of three identical specimens were used for flexural strength test for all the known mixtures at the ages of 3,7,14,28,56 days. Modulus of rupture was calculated using the formula:

$\sigma = PL/bd^2$

Where

P = load applied

L = span of the beam

b = breadth of the beam

d = depth of the beam

Compressive strength test:

As stated earlier, compressive strength of mortar specimens was found out by using one of broken pieces obtained from flexural test. Two steel plates of 40mm width and 10mm thickness were kept at top and bottom of broken specimen in the same line and load was applied.

The average strength of three identical specimens were used for all the tests. Compressive strength was calculated using the formula P/A

Where,

P = load applied

A = area

Split tensile strength test:

Split tensile strength test was found out by using second broken piece obtained from flexural test. Split tensile strength was calculated using the formula:

$\sigma t = 2P/\pi (bd)$

where,

σt = split tensile strength in MPa

P = load applied

b = breadth of the beam in mm

d = depth of the beam in mm

Durability:

Durability is the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties. Concreteingredients, their proportioning, interactions between them, placing and curing practices and theenvironment determine thelife of concrete. A durable material helps the environment by conserving resources and reducing wastes and environmental impacts of repair and replacement. Chemical attack by aggressive water is one of the factors responsible for damage to mortar. Frequently it is the presence of Sulphate ions in water that accounts for its aggressive behaviour to mortar

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 5, pp: 19-24 www.ijaem.net ISSN: 2395-5252

because certain constituents of cement paste can enter to deleterious soluble alkali sulphates.

Preparation and testing of specimen:

Test specimens which are cured in water for 28 days are set for curing in sulphuric acid. High amounts of Sulphuric acid may lead to complete degradation of cement mortar specimen. Hence,1% of acid was added for every 30litres of water and the weight of the specimen before and after curing in acid was recorded. The specimens were tested for compression at 28 days.

IV. RESULTS AND DISCUSSIONS

The results obtained by conducting respective tests are tabulated as follows:

Table 5: Flexural strength of specimens (N/mm^2)

Mix	3days	7days	14days	28days	56 days
M_0	3.42	4.83	7.95	7.5	7.45
M_1	4.58	5.83	7.58	7.33	6.25
M_2	4.62	4.54	7.37	6.45	7.33
M_3	5.16	5.16	7.29	6.66	7.75
M_4	5.83	6.33	9.29	8.45	8.79
M_5	5.67	5.54	5.33	7.04	7.29
M_6	5.75	5.58	5.62	7.20	7.87

Table 6: Compressive strength of specimens (N/mm^2)

Mix	3 days	7 days	14 days	28 days	56 days
M_0	36.28	24.08	26.19	27.85	27.74
M_1	24.8	17.9	22.83	20.6	28.91
M_2	27.98	19.7	22.88	23.59	28.88
M_3	17.01	19.4	28.41	26.04	30.62
M_4	22.10	22.32	30.47	29.34	31.36
M_5	16.42	15.22	15.88	20.04	30.52
M_6	15.13	10.12	16.91	17.65	25.45

Table 6: Split tensile strength of specimens (N/mm^2)

Mix	3days	7days	14days	28days	56 days
M_0	1.55	2.06	2.52	2.47	2.0
M_1	1.59	1.27	1.84	2.43	1.98
M_2	1.88	1.23	1.87	2.82	2.63
M_3	1.64	2.27	2.18	3.0	3.76
M_4	1.59	1.50	1.79	1.77	2.50
M_5	1.56	1.85	1.67	1.67	2.22
M_6	1.96	1.62	1.33	2.15	1.96

Acid effect on specimens with different ratios of copper slag

S.No	Copper slag %	Water (lit)	Acid %	Compressive strength
M_0	0	30	1	21.86
M_1	5	30	1	20.31
M_2	10	30	1	26.71
M_3	15	30	1	27.47
M_4	20	30	1	28.68
M_5	25	30	1	17.68
M_6	30	30	1	10.16

V. CONCLUSIONS

The following conclusions were drawn from the present investigation:

•There is no noticeable change in the workability of the cement mortar by replacing it with copper slag.

•Flexural strength, compressive strength and split tensile strength were increased marginally up to 20% replacement of copper slag and 1% of cerafiber-mix and then decreased.

•The failure of specimens during testing is not sudden due to addition of fibers in mortar.

•The deposits on the surface of specimens due to acid attack is more in case of fiber less specimens when compared to the specimen with fibers.

•There is no appreciable increment in water absorption with the increment in percentage of copper slag.

REFERENCES

[1]. Pranshu Saxena and Ashish Simalti, Scope of replacing fine aggregate with copper slag in concrete- A review, International Journal of

Technical Research and Applications Volume 3, Issue 4 (July-August 2015)

[2]. Srinivas and Murana, Study of the properties of concrete containing copper slag as fine aggregate, International Journal of Technical Research and Applications, vol. 3, issue 4,2014.

[3]. T. Ch. Madhavi, copper slag in concrete as replacement, International Journal of civil Engineering and Technology (IJCIET) vol.5, Issue 3,2014.

[4]. R R Chavan & D B Kulkarni, Performance of copper slag on strength properties as partial replace of fine aggregate in concrete mix design. International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974, 2013.

[5]. Arivalagan. S, Experimental Study on the Flexural Behavior of Reinforced Concrete beams as Replacement of Copper Slag as Fine Aggregate, Journal of Civil Engineering and Urbanism volume 3, issue 4:176-182, 2013.

[6]. M. Chockalingam et al., Scope for reuse of copper slag in concrete, International Journal of Civil Engineering and Technology (IJCIET), vol. 4, issue 6, 2013.

[7]. IS 12269:1987- Indian standard code of practice for 53 grade ordinary Portland cement.