EXPERIMENTAL STUDY ON PROPERTIES OF STRENGTH AND DURABILITY OF CONCRETE BY PARTIAL REPLACEMENT OF FINE AGGREGATE WITH COPPER SLAG AND CEMENT WITH EGG SHELL POWDER FOR M30 AND M40 GRADE CONCRETE

T.KARUN KUMAR[1], N.PRIYANKA[2]

[1]M.Tech(structural Engineering),Department of Civil Engineering, Vikas Group of Institutions,Vijayawada mandal,Krishna District,A.P.,India

[2]Assistant Professor (M.Tech), Department of Civil Engineering, Vikas Group of Institutions,Vijayawada mandal,Krishna District,A.P.,India

ABSTRACT

Concrete is always expected to be stronger and more durable than in the past while being cost and energy efficient. Moreover the major advantages that concrete possesses over the construction materials have to be conserved. The possibility of being fabricated practically anywhere, the ability to make the form imposed by the shape of a mould and a low cost of components and manufacture. These factors have driven advances in improving the performance of concrete over years and continue to do so the need for improving the performance of concrete and concern for the environmental impact arising from the continually increasing demand for concrete has lead the growing use of alternative material components.

An experimental investigation will be conducted to study the properties of concrete containing copper slag as a partial replacement of fine aggregates in the concrete mix design. Various durability tests will be conducted on such concrete of M30 grade and M40 grade to know the compressive strength, split tensile strength, flexural strength by varying proportions of copper slag (CS) with fine aggregates by 0%, 5%, 10%, 15%, 20%,25%,30% and Egg shell powder (ESP) as cement by 0%, 5%, 10%, 15%, 20%, 25%,30% by weight. The obtained results will be compared with the conventional concrete, there by knowing the changes in the properties of concrete containing copper slag as a partial replacement of fine aggregates.

INTRODUCTION

The utilization of industrial waste or secondary materials has encouraged the production of cement and concrete in construction field. 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 great potential in concrete industry. For many years, by-products such as fly ash, silica fume and slag were considered as waste materials. Concrete prepared with such materials showed improvement in workability and durability compared to normal concrete and has been used in the construction of power, chemical plants and under-water structures. Over recent decades, intensive research studies have been carried out to explore all possible reuse methods. Construction waste, blast furnace, steel slag, coal fly ash and bottom ash have been accepted in many places as alternative aggregates in embankment, roads, pavements, foundation and building construction, raw material in the manufacture of ordinary Portland cement pointed out by Teik thye luin et al (2006).

Copper slag is an industrial by-product material produced from the process of manufacturing copper. For every ton of copper production, about 2.2 tonnes of copper slag is generated. It has been estimated that approximately 24.6 million tons of slag are generated from the world copper industry (Gorai et al 2003). Although copper slag is widely used in the sand blasting industry and in the manufacturing of abrasive tools, the remainder is disposed of without any further reuse or reclamation. Copper slag possesses mechanical and chemical characteristics that qualify the material to be used in concrete as a partial replacement for Portland cement or as a substitute for aggregates. For example, copper slag has a number of favourable mechanical properties for aggregate use such as excellent soundness characteristics, good abrasion resistance and good stability reported by (Gorai et al 2003). Copper slag also exhibits pozzolanic properties since it contains low CaO. Under activation with NaOH, it can exhibit cementitious property and can be used as partial or full replacement for Portland cement. The utilization of copper slag for applications such as Portland cement replacement in concrete, or as raw material has the dual benefit of eliminating the cost of disposal and lowering the cost of the concrete. The use of copper slag in the concrete industry as a replacement for cement can have the benefit of reducing the costs of disposal and help in protecting the environment. Despite the fact that several studies have been reported on the effect of copper slag replacement on the properties of Concrete, further investigations are necessary in order to obtain a comprehensive understanding that would provide an engineering base to allow the use of copper slag in concrete.

SCOPE & OBJECTIVE:

As the copper slag and egg shell power considered to be a waste product and the land for its dumping increasing day by day showing a serious impact on environment, hence to reduce it we are making use of copper slag in construction field. Although copper slag has many uses but to a little percent when it compared to its use in construction.

The main objective is to study the feasibility of use of copper slag as fine aggregate in concrete. The scope of the work includes knowing the strength parameters of concrete such as compressive strength, split tensile strength, flexural strength in which copper slag and egg shell powder replaced with fine aggregates and cement by by 0%, (5%+5%), (10%+10%), (15%+15%), (20%+20%), (25%+25%), and (30%+30%) using M30 and M40 grades of concrete.

LITERATURE REVIEW

Okonkwo et al., (2012)

Eggshell ash has been established to bç good accelerator for cement bound material because of extra calcium oxide by addition of eggshell ash. He concludes that the increase in the eggshell ash content will increase the strength of properties of the cement stabilized matrix up about 35% averagely. That show the usage of eggshell ash as an additive will increase the strength of the concrete. In another hand, according to

Mtalib et al., (2009)

Mtalib et al. (2009) said that the addition of eggshell ash to the Ordinary Portland Cement decrease the setting time of the cement. So they conclude that the eggshells ash as an accelerator in a concrete because the higher content of the faster rate of setting. But it is different the effect of eggshell to the soil.

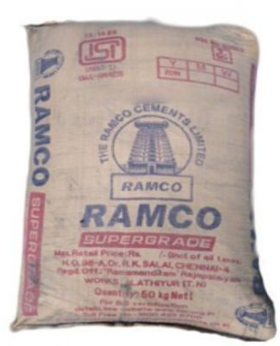
Amu et al., (2005)

He investigated that the eggshell powder could be good replacement in industrial lime because they have similarity in chemical composition. The eggshell can be stabilizing potential of lime on an expansive clay soil. Stabilization is aimed at improving the properties of soil including the increasing the soil density, increase in cohesion, frictional resistance and reduction of plasticity index such as lime, cement and fly ash. So they conclude that eggshell powder can be supplement in lime stabilization.

MATERIALS USED

Cement:

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete- which is a combination of cement and an aggregate to form a strong building material.



Ordinary Portland cement 53 grade

The ordinary Portland cement of 53 grade is used in accordance with IS: 12269-1987.

Aggregates:

Construction aggregate, or simply "aggregate", is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geo-synthetic aggregates. Aggregates are the most mined materials in the world.

Coarse aggregate:

Crushed stone aggregate of 20mm size is brought from nearby quarry. Aggregates of size more than 20mm size are separated by sieving. Tests are carried in order to find out the

Coarse aggregate

Fine aggregate

Locally available fresh sand, free from organic matter is used. The result of sieve analysis confirms it to Zone-II (according to IS: 383-1970).The tests conducted and results plotted below.

Fine aggregates

Copper slag

The copper slag which we used had collected from a dealer of 'Hindustan copper limited' at Vishakhapatnam. The wholesale price of the copper slag is about ₹650/ton and is also economical to use copper slag at the places where it is available.

Copper slag

Egg shell powder

Eggshell consists of several mutually growing layers of CaCO3, the innermost layer-maxillary 3 layer grows on the outermost egg membrane and creates the base on which palisade layer constitutes the thickest part of the eggshell. The top layer is a vertical layer covered by the organic cuticle.

Egg shell powder

Water

Generally potable water should be used. This is to ensure that the water is reasonable free from such impurities as suspended solids, organic matter and dissolved salts, which may adversely affect the properties of the concrete, especially the setting, hardening, strength, durability, pit value, etc.

Mix design for M30 grade concrete

1:1.58:2.23 at w/c 0.45

Mix design for M40 grade concrete

1:1.52:2.21 at w/c 0.4

RESULTS AND DISCUSSIONS

MATERIAL PROPERTIES

CEMENT

Sl.no	Test	Results	IS code used	Acceptable limit
1	Specific gravity of cement	3.160	IS:2386:1963	3 to 3.2
2	Standard consistency of cement	6mm at 34% w/c	IS:4031:1996	w/c ratio 28%-35%
3	Initial and final setting time	45mins and 10 hours	IS:4031:1988	Minimum 30mins and should not more than 10 hours
4	Fineness of cement	3.00%	IS:4031:1988	<10%

COARSE AGGREGATES

Sl.no	Test	Results	Is code used	Acceptable limit
1	Fineness modulus	6.5	IS:2386:1963	6.0 to 8.0mm
2	Specific gravity	2.90	IS:2386:1963	2 to 3.1mm
3	Porosity	46.83%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.8855	IS:2386:1963	Any value
5	Bulk density	1.50g/cc	IS:2386:1963	-
6	Aggregate impact value	37.5	IS:2386:1963	Less than 45%
7	Aggregate crushing value	26.6%	IS:2386:1963	Less than 45%

FINE AGGREGATES

Sl.no	Test	Result	Is code used	Acceptable limits
1	Fineness modulus	4.305	IS:2386:1963	Not more than 3.2 mm
2	Specific gravity	2.43	IS:2386:1963	2.0 to 3.1
3	Porosity	36.6%	IS:2386:1963	Not greater than 100%
4	Voids ratio	0.577	IS:2386:1963	Any value
5	Bulk density	1.5424	IS:2386:1963	-
6	Bulking of sand	3.0%	IS:2386:1963	Less than 10%

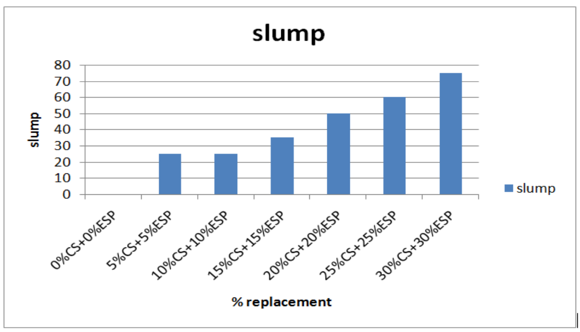
CONCRETE TESTS

FRESH CONCRETE TESTS

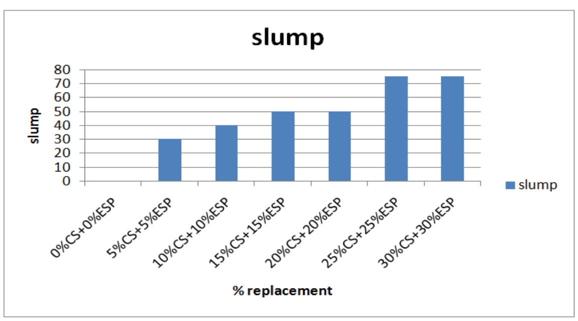
SLUMP CONE TEST

S.NO	% Replacement	Slump for M30grade	Slump for M40 grade
1	0%CS+0%ESP	0	0
2	5%CS+5%ESP	25mm	30mm
3	10%CS+10%ESP	25mm	40mm
4	15%CS+15%ESP	35mm	50mm
5	20%CS+20%ESP	50mm	50mm
6	25%CS+25%ESP	60mm	75mm
7	30%CS+30%ESP	75mm	75mm

Graph: For M30 grade concrete



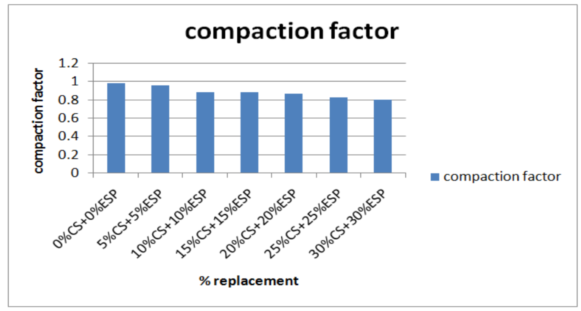
Graph: For M40 grade concrete



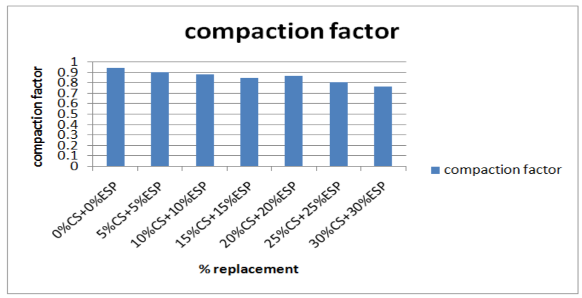
COMPACTION FACTOR TEST

S.NO	% Replacement	Compaction factor for M30 grade concrete	Compaction factor for M40 grade concrete
1	0%CS+0%ESP	0.98	0.94
2	5%CS+5%ESP	0.95	0.90
3	10%CS+10%ESP	0.88	0.88
4	15%CS+15%ESP	0.88	0.84
5	20%CS+20%ESP	0.86	0.86
6	25%CS+25%ESP	0.82	0.80
7	30%CS+30%ESP	0.80	0.76

Graph: For M30 grade concrete



Graph: For M40 grade concrete

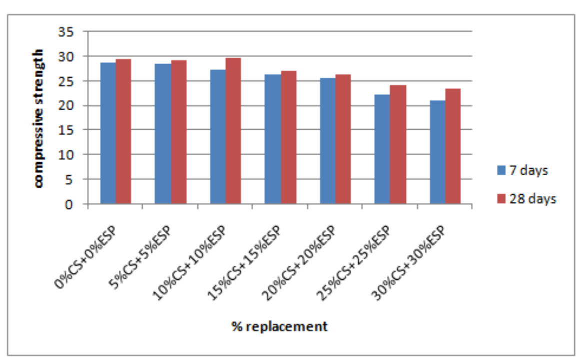


TESTS ON HARDENED CONCRETE

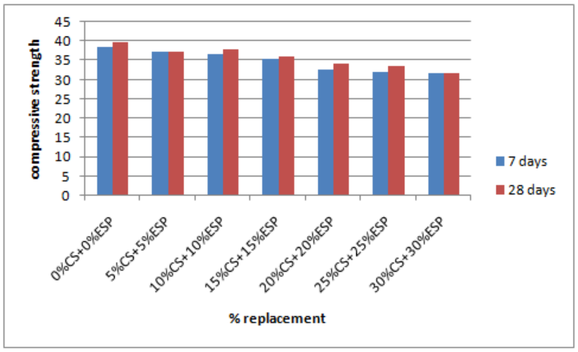
COMPRESSIVE STRENGTH OF CONCRETE

s.no	% replacement	Compressive strength of concrete			
		M30 grade concrete		M40 grade concrete	
		7 days	28 days	7 days	28 days
1	0%CS+0%ESP	28.84	29.60	38.60	39.86
2	5%CS+5%ESP	28.60	29.20	37.24	37.44
3	10%CS+10%ESP	27.40	29.80	36.60	37.90
4	15%CS+15%ESP	26.40	27.00	35.40	36.20
5	20%CS+20%ESP	25.60	26.40	32.80	34.22
6	25%CS+25%ESP	22.20	24.20	32.20	33.45
7	30%CS+30%ESP	21.00	23.60	31.60	31.62

Graph: Compressive strength for M30 grade concrete



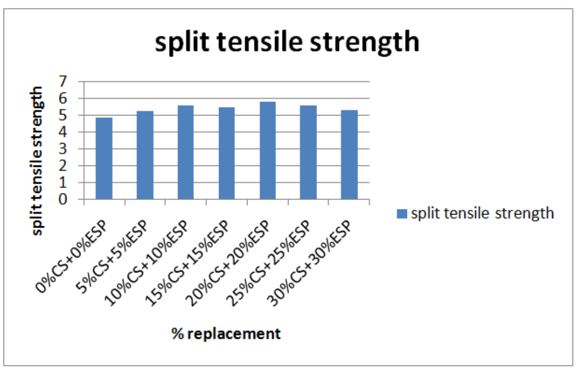
Graph: Compressive strength for M40 grade concrete



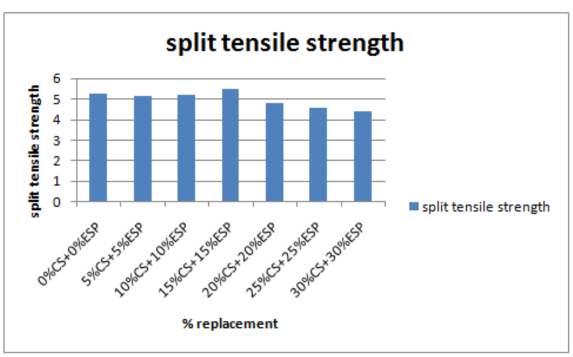
SPLIT TENSILE STRENGTH OF CONCRETE

S.no	% Replacement	28 days split tensile strength for M30 grade	28 days split tensile strength for M40 grade
1	0%CS+0%ESP	4.82	5.28
2	5%CS+5%ESP	5.21	5.16
3	10%CS+10%ESP	5.53	5.20
4	15%CS+15%ESP	5.45	5.46
5	20%CS+20%ESP	5.80	4.80
6	25%CS+25%ESP	5.53	4.60
7	30%CS+30%ESP	5.30	4.40

Graph: Split tensile strength for M30 grade concrete



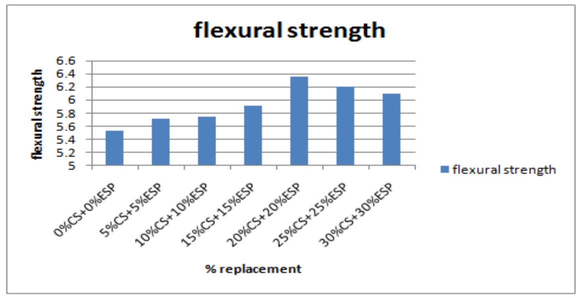
Graph: Split tensile strength for M40 grade concrete



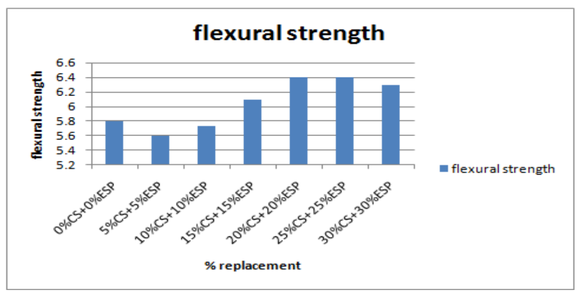
FLEXURAL STRENGTH OF CONCRETE

S.no	% Replacement	28 days flexural strength for M30 grade concrete	28 days flexural strength for M40 grade concrete
1	0%CS+0%ESP	5.54	5.80
2	5%CS+5%ESP	5.71	5.60
3	10%CS+10%ESP	5.74	5.74
4	15%CS+15%ESP	5.92	6.10
5	20%CS+20%ESP	6.36	6.40
6	25%CS+25%ESP	6.20	6.40
7	30%CS+30%ESP	6.10	6.30

Graph: Flexural strength for M30 grade concrete



Graph: Flexural strength for M40 grade concrete

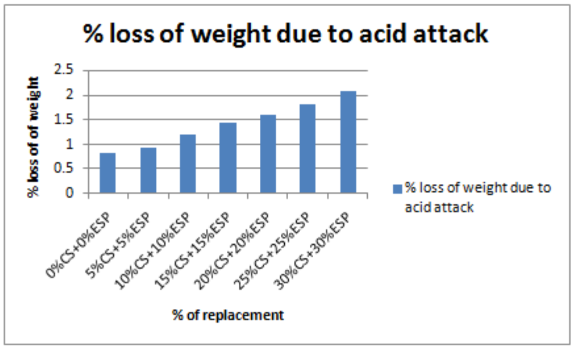


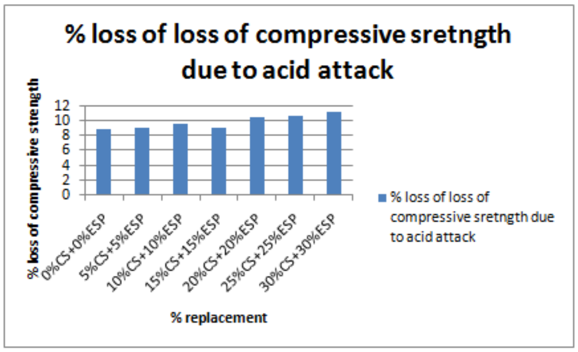
DURABILITY TESTS

I. For M30 grade concrete

1. Acid attack

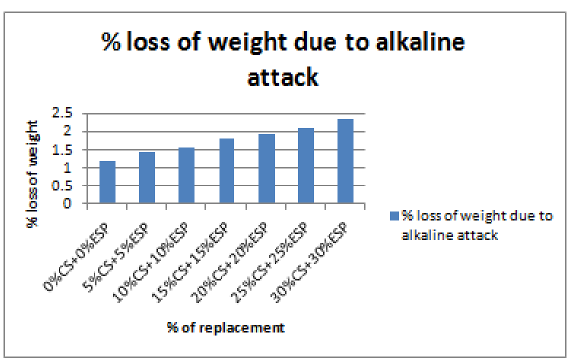
Sl.no	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0%CS+0%ESP	2261	2242	0.82	29.60	26.95	8.96
2	5%CS+5%ESP	2340	2318	0.94	29.20	26.51	9.20
3	10%CS+10%ESP	2351	2323	1.20	29.80	26.94	9.60
4	15%CS+15%ESP	2234	2202	1.44	27.00	24.50	9.20
5	20%CS+20%ESP	2394	2356	1.60	26.40	23.60	10.60
6	25%CS+25%ESP	2382	2338	1.84	24.20	21.58	10.80
7	30%CS+30%ESP	2274	2226	2.10	23.60	20.95	11.20

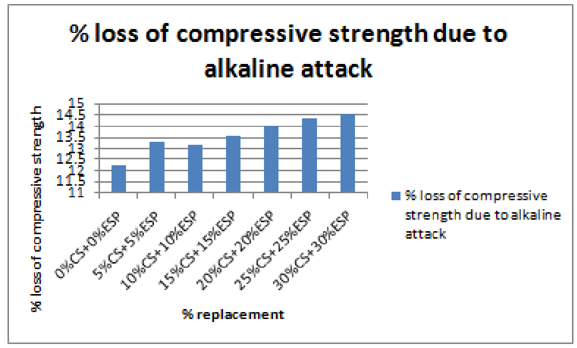




2. Alkaline attack

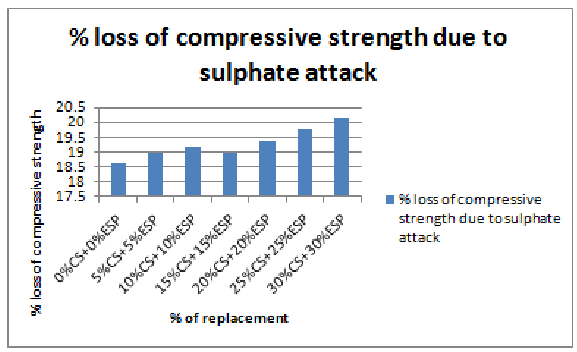
Sl. No	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	0%CS+0%ESP	2286	2259	1.20	29.60	25.98	12.26
2	5%CS+5%ESP	2340	2306	1.44	29.20	25.30	13.34
3	10%CS+10%ESP	2280	2244	1.60	29.80	25.86	13.20
4	15%CS+15%ESP	2310	2268	1.84	27.00	23.32	13.62
5	20%CS+20%ESP	2296	2251	1.96	26.40	22.67	14.10
6	25%CS+25%ESP	2352	2302	2.14	24.20	20.71	14.40
7	30%CS+30%ESP	2334	2279	2.36	23.60	20.15	14.60





3. Sulphate attack

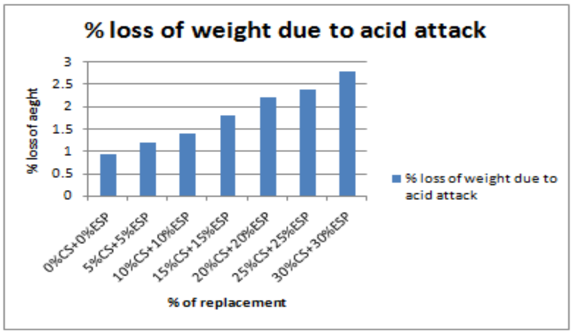
Sl. no	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0%CS+0%ESP	29.60	24.07	18.66
2	5%CS+5%ESP	29.20	23.65	18.98
3	10%CS+10%ESP	29.80	24.07	19.20
4	15%CS+15%ESP	27.00	21.87	18.98
5	20%CS+20%ESP	26.40	21.27	19.40
6	25%CS+25%ESP	24.20	19.40	19.80
7	30%CS+30%ESP	23.60	18.83	20.20

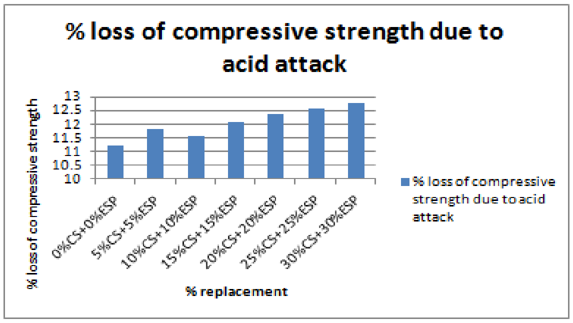


II for M40 grade concrete

1. Acid attack

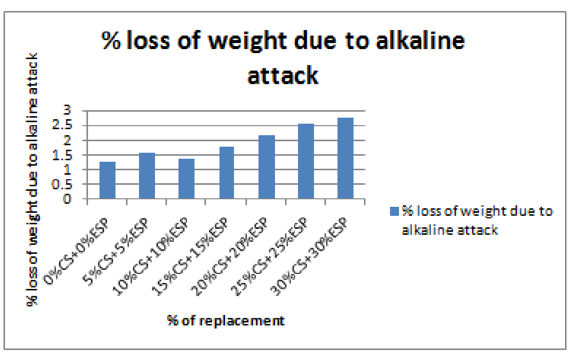
Sl.no	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to acid attack
1	0%CS+0%ESP	2261	2240	0.93	39.86	35.40	11.24
2	5%CS+5%ESP	2340	2312	1.20	37.44	33	11.84
3	10%CS+10%ESP	2351	2318	1.40	37.90	33.50	11.60
4	15%CS+15%ESP	2234	2194	1.80	36.20	31.81	12.12
5	20%CS+20%ESP	2394	2341	2.20	34.22	29.98	12.40
6	25%CS+25%ESP	2382	2325	2.40	33.45	29.24	12.60
7	30%CS+30%ESP	2274	2210	2.80	31.62	27.57	12.80

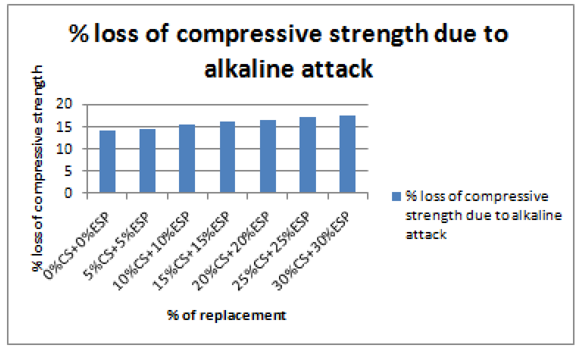




2. Alkaline attack

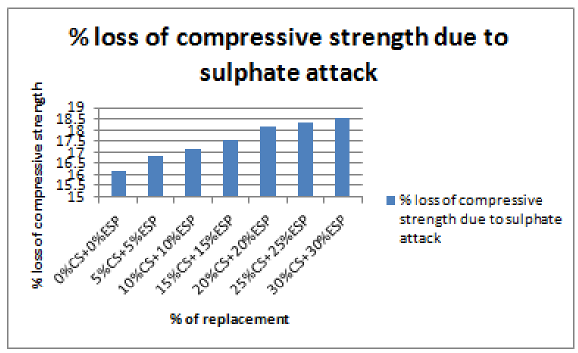
Sl. No	% replacement	Initial weight of cube after 28days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to alkaline attack
1	0%CS+0%ESP	2351	2320	1.30	39.86	34.12	14.40
2	5%CS+5%ESP	2340	2302	1.60	37.44	31.90	14.80
3	10%CS+10%ESP	2260	2228	1.40	37.90	32	15.60
4	15%CS+15%ESP	2245	2205	1.80	36.20	30.33	16.20
5	20%CS+20%ESP	2260	2210	2.20	34.22	28.52	16.66
6	25%CS+25%ESP	2354	2293	2.60	33.45	27.70	17.22
7	30%CS+30%ESP	2320	2255	2.80	31.62	26.07	17.55





3. Sulphate attack

Sl. no	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cubes after 90days curing	% loss of compressive strength due to sulphate attack
1	0%CS+0%ESP	39.86	33.40	16.22
2	5%CS+5%ESP	37.44	31.13	16.84
3	10%CS+10%ESP	37.90	31.37	17.22
4	15%CS+15%ESP	36.20	29.82	17.60
5	20%CS+20%ESP	34.22	28	18.20
6	25%CS+25%ESP	33.45	27.30	18.40
7	30%CS+30%ESP	31.62	25.73	18.60



CONCLUSIONS

From the above experimental program the following conclusions were made

1. The material properties of the cement, fine aggregates and coarse aggregates are within the acceptable limits as per IS code recommendations so we will use the materials for research.

2. Slump cone value for the copper slag concrete increases with increasing in the percentage of copper slag so the concrete was not workable.
3. Compaction factor value of copper slag concrete decreases with increase in the percentage of copper slag.
4. The compressive strength of concrete is maximum at 20% replacement of copper slag and is the optimum value for 7days curing and 28days curing
5. Split tensile strength for the cylindrical specimens is maximum at 40% of replacement of copper slag for 28days curing.
6. The flexural strength of copper slag concrete is also maximum at 40% replacement of copper slag for 28 days of curing.

So the replacement of 20% to 40% of copper slag is generally useful for better strength values in M30 grade of concrete.

REFERENCES

[1] Brindha, D and Nagan, S (2010). "Utilization of copper slag as a partial replacement of fine aggregate". International Journal of Earth Sciences and Engineering,Vol.3, No.4, pp.579-585

[2] Wei Wu, Weide Zhang, Guowei Ma "Optimum content of copper slag as a fine aggregate in high strength concrete" Materials and Design, Elsevier science Ltd, Vol. 31, 2010, pp. 2878–2883.

[3] Pazhani K, Jeyaraj R, "Study on durability of high performance concrete with industrial wastes", Peer-reviewed & Open access journal, ATI- Applied Technologies & Innovations, Vol. 2, Issue 2, August 2010, pp. 19-28.

[4] Khalifa S Al-Jabri, Abdullah H Al-Saidy, Ramzi Taha, "Effect of copper slag as a fine aggregate on the properties of cement mortars and concrete", Construction and Building Materials, Vol. 25, 2011, pp. 933 – 938

[5] Mostafa Khanzadi, Ali Beholds(2009), " Mechanical properties of high strength concrete incorporating copper slag as coarse aggregate" , Construction and Building Materials 23 pp 2183–2189.

[6] Meenakshi Sudarvizhi, S. and Ilangovan, R. "Performance of copper slag and ferrous slag as partial replacement of sand in concrete", International Journal of Civil and Structural Engineering, Vol.1, No.4, 2011.

[7] Chavan, R.R. and Kulkarni, D.B. "Performance of copper slag on strength properties as partial replacement of fine aggregate in concrete mix design", International Journal of Advanced Research and Studies, Vol.2, No.4, pp.95-98, 2013.

[8] IS: 10262 – 2009, Concrete Mix Proportioning, Bureau of Indian Standards, New Delhi.

[9] IS 516 (1959): Method of Tests for Strength of Concrete [CED 2: Cement and Concrete]

[10] IS 2386-1 (1963): Methods of Test for Aggregates for Concrete, Part I: Particle Size and Shape [CED 2: Cement and Concrete]

[11] IS 2386-3 (1963): Methods of test for aggregates for concrete, Part 3: Specific gravity, density, voids, absorption and bulking [CED 2: Cement and Concrete

[12] IS 4031-1 (1996): Methods of physical tests for hydraulic cement, Part 1: Determination of fineness by dry sieving [CED 2: Cement and Concrete]

[13] IS 4031-4 (1988): Methods of physical tests for hydraulic cement, Part 4: Determination of consistency of standard cement paste [CED 2: Civil Engineering]

[14] IS 4031-5 (1988): Methods of physical tests for hydraulic cement, Part 5: Determination of initial and final setting times [CED 2: Civil Engineering]

[15] IS 4031-11 (1988): Methods of physical tests for hydraulic cement, Part 11: Determination of density [CED 2: Cement and Concrete

AUTHOR'S PROFILE:

Mr. T.KARUN KUMAR was born in Krishna,AP on November 25, 1990 . He graduated from the Jawaharlal Nehru Technological University,Kakinada. His special fields of interest included concrete technology and structures. Presently He is studying M.Tech in Vikas Group of Institutions, Nunna

Ms.N.PRIYANKA was born Ongole,AP, on October 05, 1992. He graduated from the Nagarjuna University,AP. Presently He is working as a Asst Prof in Vikas Group of Institutions, Nunna. She is having 1 Year of Teaching Experience in engineering college.