Experimental study on properties of strength and durability of concrete by partial replacement of fine aggregate with copper slag and cement with egg shell power for M30 and M40 grade of concrete

Y.Yugenderan[1], V.R. Raji[2], J.P. Praveena[3], J.Sandhiya[4]

[1] PG Student, Civil Engineering, Jaya Engineering College, India
[2] Assistant Professor, Civil Engineering, Jaya Engineering College, India
3 Assistant Professor, Civil Engineering, Jaya Engineering College, India
4 Assistant Professor, Civil Engineering, Jaya Engineering College, 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

Keyword: - *copper slag and egg shell powder, Compressive Strength, Flexural Strength, Split Tension Test, and Concrete Pavement etc…*

1. 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, byproducts 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 favorable 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

1.1 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 0%, (5%+5%), (10%+10%), (15%+15%), (20%+20%), (25%+25%), and (30%+30%) using M30 and M40 grades of concrete

2. Materials Used

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

2.1.1 Test on cement

a) **Specific Gravity of Cement:**

The method used to calculate specific gravity of Cement is Le-chatlier's flask method. In this cement is tested by using Kerosene.

b) **Normal Consistency of Cement:**

Normal Consistency test is conducted as per IS 4031 (part -IV) -1980. The main purpose of conducting Normal consistency is to find the amount of water to be added for producing Cement paste standard consistency. Vicat apparatus generally used to confirming to IS 5513-1976 *A.* Fineness of Cement

The Fineness of cement is calculated by the 90 microns sieve method. In this method amount of Cement on the sieve should not be more than 10% ordinary cement.

B. Initial and Final Setting Time

Initial and Final setting test is conforming to IS 4031(part

In this test we use Vi-cat apparatus, gauging trowel and balance.

Observations:

Time at which the water is first added to the cement(t_1) = 5min
Time at which the needle fails to penetrate a depth of 5- 7mm(t_2) = 50 min Time at which needle fails to impression

the block (t_3) => 10hrs min.

2.2 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.

2.3 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.

2.3.1 Test on Coarse Aggregate

The maximum size of Coarse Aggregates used in this process is 20mm. The test reports are tabulated as follows.

Sieve Analysis of Coarse Aggregate:

Sieve analysis helpful in determining the practice size distribution of the aggregate. It is Conforming to is I S 2386-1963 (Part - 1).
Grading limits(as per IS 383-1970, clause 4.1 and 4.2)

Specific gravity of Coarse Aggregate

Specific gravity is the major property of the Coarse aggregate. Specific gravity is calculated by the Cylindrical (Pycnometer Bottle) method.
Specific gravity(G)=$(W_2-W_1)/(W_2-W_1)-(W_3-W_4)$

Bulk Density of Coarse Aggregate

Bulk density is defined as the ratio of weight of aggregates to its volume. Bulk density is the very important property in preparing the Mix design. Bulk density is directly proportional to the weight of the building.

2.3.2 Water Absorption of Coarse Aggregates

The water Absorption of aggregates will greatly affects the workability of concrete. The ratio increase in the weight of the sample to weight dry sample is called Water Absorption..

2.4 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).

2.4.1 Test on Fine Aggregate

Specific gravity of Fine Aggregate
Specific Gravity is the Major Property of the aggregate Specific gravity is calculated by the cylindrical (Pycnometer Bottle) method.
The specific gravity can be calculated by the formula Specific gravity(G) = $(W2W1)/(W_2-W1)-(W_3-W_4)$

Bulk Density of Fine Aggregate

Bulk density of is the very important property in preparing the Mix design. Bulk density is directly proportional to the weight of the building. The table 5 mentioned the sieve analysis

2.4.2 Water Absorption of Fine Aggregate

The water absorption of Aggregates will greatly effects the workability of concrete. The ratio increase in weight of the sample to the weight dry sample is called water absorption. The above table 6 mentioned the summary results.

2.5 Copper slag

Copper slag is a by-product of copper extraction by smelting. During smelting, impurities become slag which floats on the molten metal. Copper slag is used in the concrete as one of the alternative materials. It is the waste product of copper from various industries. The safe disposal of this waste is a lack, costly and causes environmental pollution. The construction industry is the only area where the safe use of waste material (copper slag) is possible. When it is introduced in concrete as a replacement material, it reduces the environmental pollution, space problem and also reduces the cost of concrete

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.

2.6 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.

The egg shell wastelands in the poultry manufacturing have been highlighted because of its recovery potential. Egg shell waste is available in huge amounts from the food processing, egg breaking, and shading industries. The food indulgence industry is in need of investigation to find another methods for processing and using egg shells waste in an ecological friendly way. There is a need to find a low cost solution. Removal of egg shell waste are usually not income centers but cost centers. Therefore, the least cost of removal is most necessary.

2.7 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.

3 MIX DESIGN

3.1 CONCRETE MIX DESIGN FOR GRADE M30

Concrete mix design for grade M30 is designed as per 1S 10262-2009.

STEP 1: STIPULATION FOR PROPORTIONING

a) Grade designation: M30

b) Type of Cement: OPC 53 grade

c) Max. nominal size of aggregate : 20mm

d) Maximum cement content: 320kg/m³

e) Maximum water cement ratio: 0.45

f) Workability: (50-75) mm slump

g) Exposure condition: Normal

h) Degree of supervision: Good

i) Type of aggregate: Angular aggregate

STEP 2: TEST DATA FOR MATERIALS

a) Cement used : OPC 53 grade

b) Specific gravity of cement: 3.15

c) Specific gravity of coarse aggregate: 2.70

d) Specific gravity of fine aggregate: 2.55

e) Water absorption of coarse aggregate: 0.5

f) Sieve analysis of coarse aggregate: separate analysis is done

g) Sieve analysis of fine aggregate: separate analysis is done

h) Free moisture of coarse aggregate: Nil

i) Free moisture of fine aggregate: Nil

STEP 3: TARGET STRENGTH FOR MIX PROPORTIONING

Target mean Strength, fck = fck + 1.65 S = 30 + (1.65 x 5.0) fck

= 38.25 N/mm²

STEP 4: SELECTION OF WATER CEMENT RATIO

As per IS 456: 2000 table no.5,
Maximum water cement ratio = 0.45
But adopted water cement ratio as =0.40 0.40 < 0.45 Hence ok.

STEP 5: CALCULATION OF CEMENT CONTENT

As per IS 10262 : 2009 Table No.2,
Maximum water content for 10mm aggregate = 186 litre Estimated water content for 50-100mm slump = 186 + (3/100) x208
Hence water content = 191.58 litre

STEP 6: CALCULATION OF CEMENT CONTENT

Water Cement Ratio = 0.40
Cement Content = 191.58/0.40
= 478.95 Kg/m³ As per IS 456: 2000

Table No.5,

Minimum Cement Content for 'severe' exposure condition =320 Kg/m³ 478.95 Kg/m³ > 320 Kg/m³

Hence ok.

STEP 7: PROPORTION OF VOLUME OF COARSE AGGREGATE & FINE AGGREGATE CONTENT

Water cement ratio = 0.40
Volume of Coarse Aggregate = 0.62
Volume of fine Aggregate = 1 - 0.62 = 0.38

STEP 8: MIX CALCULATIONS

Volume of Concrete in m³ = 1m³
Volume of Cement in m³ = (478.95 /3.15) x (1/1000)

=0.152 m3
Volume of Water in m³ = (191.58/1) x (1/1000)
= 0.191m3
Volume of All in Aggregate in m³ = 1- (0.152 + 0.191) = 0.657 m° Volume of Coarse Aggregate in m³ =

0.657 × 0.62 x2.70 x1000

= 1099.81Kg
Volume of fine Aggregate in m³ = 0.657 x 0.38 x 2.55 x 1000
= 636.63 Kg

STEP 9: MIX PROPORTIONS

Cement: Fine Aggregate: Coarse Aggregate : Water
478.95 : 636.63 : 1099.81 : 191.58
Mix ratio = 1 : 1.33 : 2.29 : 0.40

3.2 CONCRETE MIX DESIGN FOR GRADE M40

Concrete mix design for grade M40 is designed as per 1S 10262-2009.
STEP 1: STIPULATIONS FOR PROPORTIONING

a) Grade designation : M40
b) Type of cement : OPC 53 Grade conforming IS 12269
c) Maximum nominal size of aggregate : 20mm
d) Minimum cement content : 360 kg/m^3 (IS 456:2000)
e) Maximum water-cement ratio : 0.40 (Table 5 of IS 456:2000)
f) Workability : 100-120mm slump
g) Exposure condition : Moderate (For Reinforced Concrete)
h) Degree of supervision : Good
i) Type of aggregate : Crushed Angular Aggregates
j) Maximum cement content : 420 kg/m^3

STEP 2: TEST DATA FOR MATERIALS

a) Cement used : OPC 53 Grade conforming IS 12269
b) Specific gravity of cement : 3.15
c) Specific gravity of coarse aggregate 20mm : 2.67
d) Specific gravity of fine aggregate : 2.65
e) Water absorption of coarse aggregate : 0.5 %
f) Water absorption of fine aggregate (M.sand) : 2.5 %
g) Free (surface) moisture of coarse aggregate : Nil (Absorbed Moisture also Nil)
h) Free (surface) moisture of fine aggregate : Nil
i) Sieve analysis of coarse aggregate: Conforming to all in aggregates of Table2 of IS 383
j) Sieve analysis of fine aggregate : Conforming to Grading Zone II of Table 4 of IS 383

STEP 3: TARGET STRENGTH FOR MIX PROPORTIONING

Target mean strength, fck = fck +1.65 S = 40 + (1.65 x 5)
= 48.25 N/mm^2.

STEP 4: SELECTION OF WATER CEMENT RATIO

Adopted maximum water-cement ratio = 0.36

From the Table 5 of IS 456 for Very severe Exposure maximum Water Cement Ratio is 0.40

0.36 < 0.40

Hence ok.

STEP 5: SELECTION OF WATER CONTENT

From Table 2 of IS 10262:2009,

Maximum water content for 20 mm aggregate = 186 litre (for 25 to 50 mm slump range)

Estimated water content for 100 mm slump = 186+ (6/186) = 197 litre.

Hence the arrived water content = 197-[197 x (23/100)] = 151 litre.

STEP 6: CALCULATION OF CEMENT CONTENT

Adopted w/c Ratio = 0.36

Cement Content = 151/0.36 = 420 kg/m^3

From Table 5 of IS 456, Minimum cement content for 'Very severe' exposure conditions 360kg/m^3

420 kg/m^3 > 360 kg/m^3 Hence ok.

STEP 7: PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

Water cement ratio = 0.50

Volume of coarse aggregate = 0.65

Volume of fine aggregate content = 1 – 0.585= 0.415

STEP 8: MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows:

Volume of concrete = 1 m^3

Volume of cement = [Mass of cement] / {[Specific Gravity of Cement] x 1000}
= 420/{3.15 x 1000}
= 0.133 m^3

Volume of water = [Mass of water] / {[Specific Gravity of water] x 1000}
= 151/{1 x 1000}
= 0.151m^3

Volume of chemical admixture = 1.89 litres/ m^3 (By Trial and Error Method used 0.4% by the weight cement)

Volume of all in aggregate = [a-(b+c+d)]
= [1-(0.133+ 0.151+ 0.0045)]
= 0.7115 m^3

Mass of coarse aggregate = e x Volume of Coarse Aggregate x Specific Gravity of Fine Aggregate x 1000
= 0.7115x 0.585 x 2.67 x 1000
= 1111 kg/m^3

Mass of fine aggregate= e x Volume of Fine Aggregate x Specific Gravity of Fine Aggregate x 1000

= 0.7115 x 0.415 x 2.60 x 1000

= 768 kg/m^3

STEP 9: MIX PROPORTIONS

Cement : Fine aggregate : Coarse aggregate : Water

Mix ratio = 1:1.83:2.65

4 RESULTS AND DISCUSSIONS

4.1 MATERIAL PROPERTIES

4.1.1 CEMENT

Table 4.1 Test on cement:

SI.No	Test	Results	Acceptable limit
1	Specific gravity of cement	3.160	3 to 3.2
2	Standard consistency of cement	6mm at 34% w/c	w/c ratio 28%-35%
3	Initial and final setting time	45mins and 10 hours	Minimum 30mins and should not more than 10 hours
4	Fineness of cement	3.00%	<10%

4.1.2 COARSE AGGREGATES

Table 4.2 Test on Coarse aggregate:

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

4.1.3 FINE AGGREGATES

Table 4.3: Test on Fine aggregate:

SI.No	Test	Results	Acceptable limit
1	Fineness modulus	4.305	Not more than 3.2mm
2	Specific gravity	2.43	2 to 3.1mm
3	Porosity	36.6%	Not greater than 100%
4	Voids ratio	0.577	Any value
5	Bulk density	1.5424	-
6	Bulking of sand	3.0%	Less than 10%

4.1.4 Copper Slag

Table 4.4: Test on Copper slag

SI.no	Test	Range
1	Hardness	6.0-7.0
2	Specific Gravity	3.51
3	Bulk Density	1.9-2.4
4	Electrical Conductivity	2 mS/m
5	Moisture	Nil

4.1.5 Egg Shell Powder

Table 4.5: Test on Egg Shell Powder:

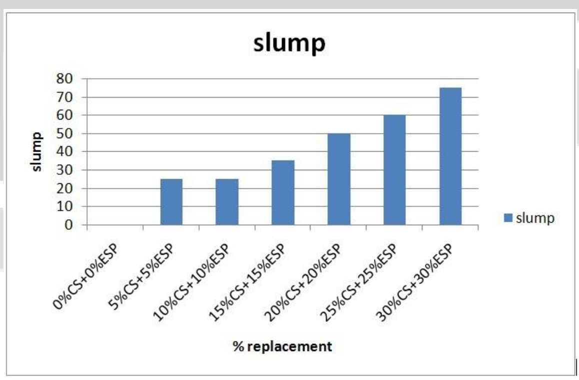
SI. No	Properties	Test Value
1	Specific Gravity	2.44
2	Standard Consistency	39%
3	Initial setting time	38 mins

4.2 FRESH CONCRETE TESTS

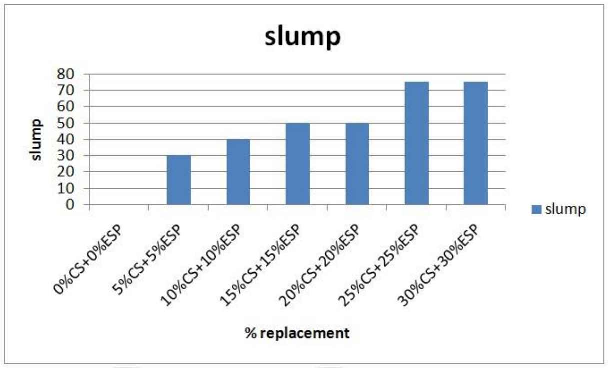
4.2.1 SLUMP CONE TEST Table 6.6: Slump cone test on M30 and M40 Grade

SI.No	% replacement	Slump for M30 grade	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



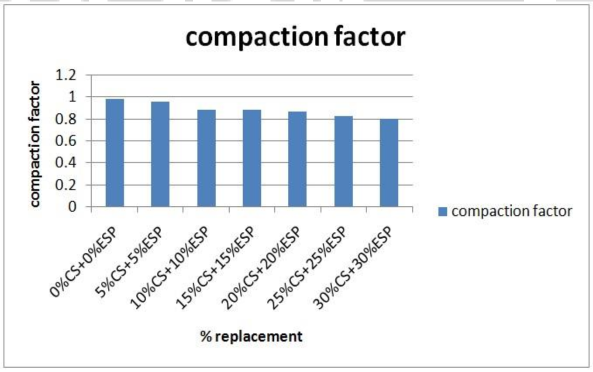
Graph: For M40 grade concrete



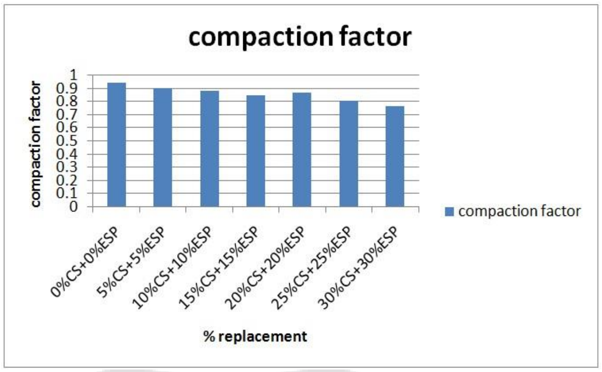
4.2.2 COMPACTION FACTOR TEST Table 4.7: Compaction Factor test on M30 and M40 Grade

SI.No	% replacement	Compaction factor for M30 grade	Compaction factor for M40 grade
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



4.3 TESTS ON HARDENED CONCRETE

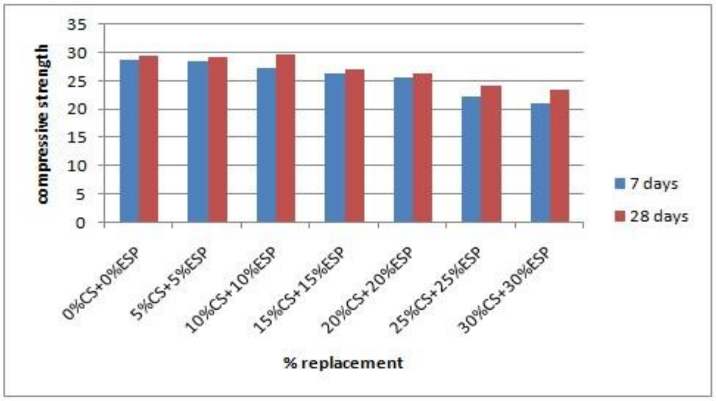
4.3.1 COMPRESSIVE STRENGTH OF CONCRETE

Compressive strength is obtained by applying crushing load on the cube surface load on the cube surface. So it is also called as crushing strength. Compressive strength of concrete is calculated by casting 150mm×150mm×150mm cubes. The test results are presented here for the compressive strength of 7 days and 28 days. A compressive strength test requires precise measurements, so the "squashing" process of a compressive stress test must be done under carefully controlled conditions, including the equal-and-opposing forces applied to compress the material from both top and bottom.

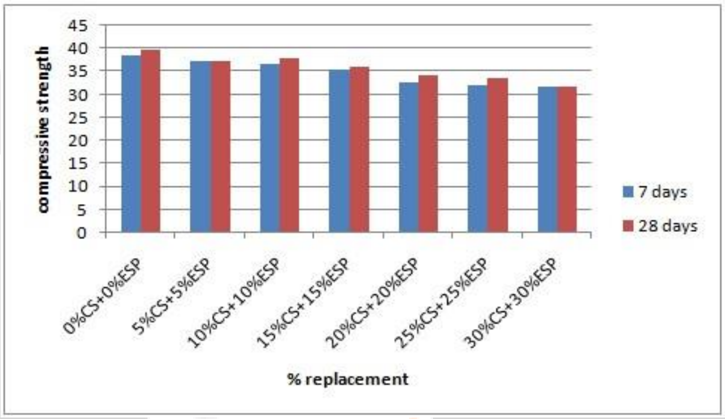
Table 4.8: Compressive strength of concrete in M30 and M40 Grade

SI.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



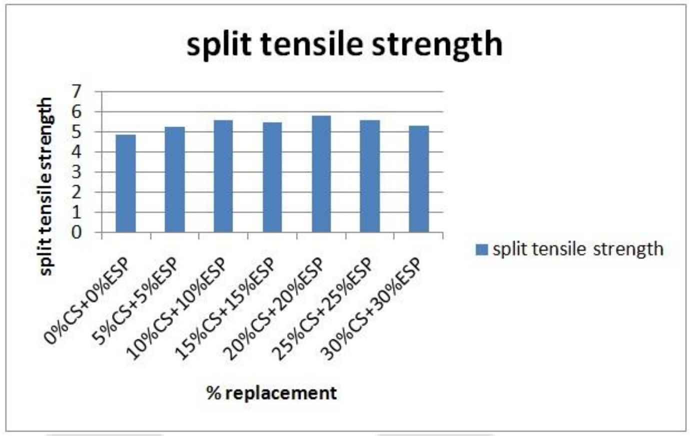
4.3.2 SPLIT TENSILE STRENGTH OF CONCRETE

The tensile strength is evaluated using cylindrical specimens of size 300mm height and 150mm diameter. The specimens are tested for 7 days and 28 days of curing.

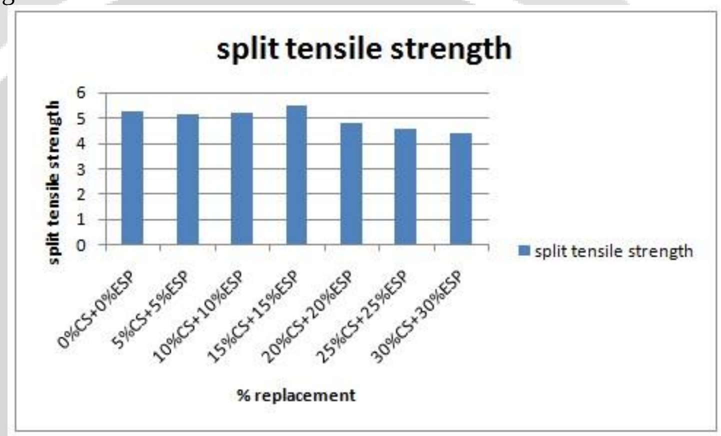
Table 4.9: Split tensile strength of concrete in M30 and M40 Grade

SI.No	% replacement	28 days split tensile strength for M30 grade	28 days split tensile strenght 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



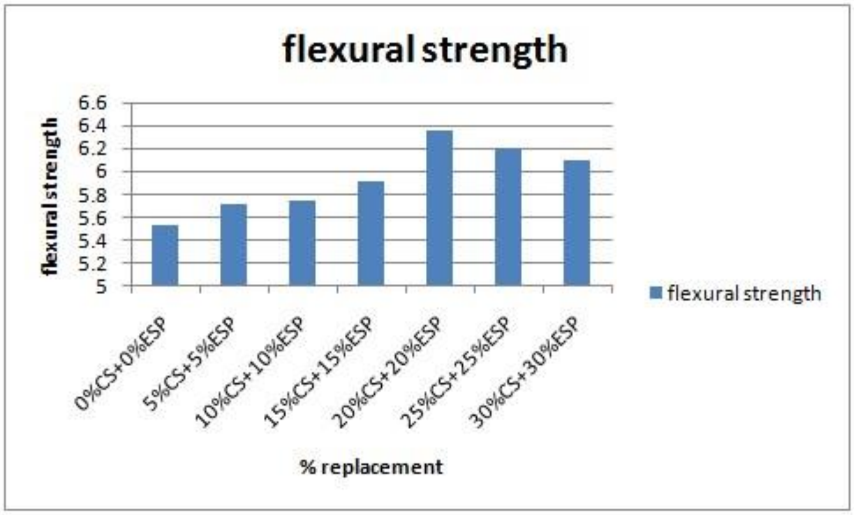
4.3.3 FLEXURAL STRENGTH OF CONCRETE

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 6 x 6-inch (150 x 150-mm) concrete beams with a span length at least three times the depth**.**

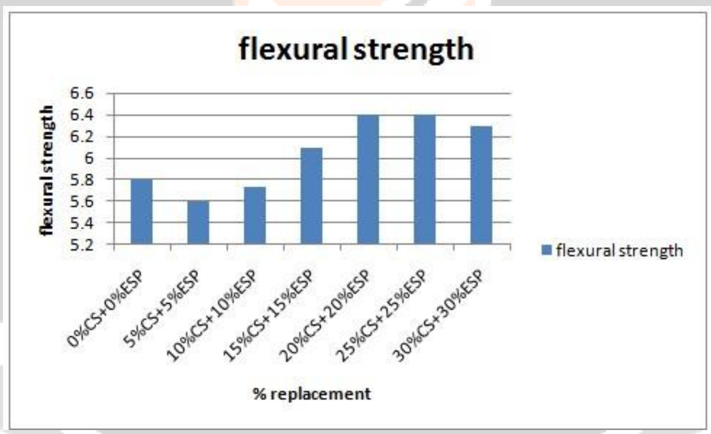
Table 4.10: Flexural strength of concrete in M30 and M40 Grade

SI.No	% replacement	28 days flexural strenght for M30 grade	28 days flexural strenght for M40 grade
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



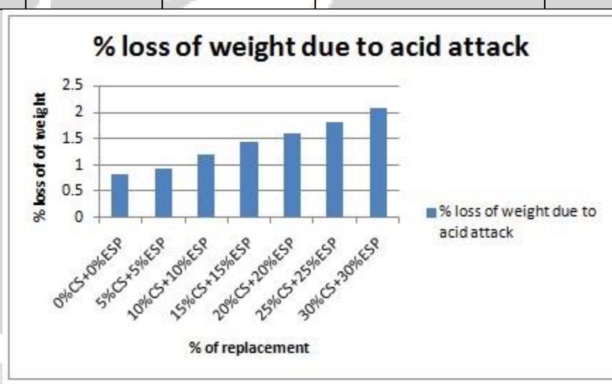
4.4 DURABILITY TESTS (I for M30 grade concrete)

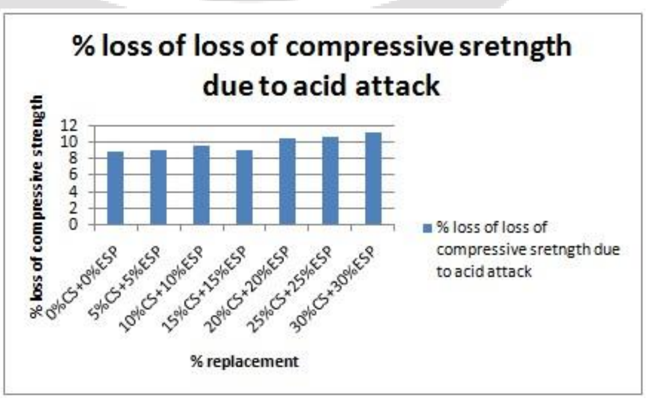
Ductility involves determining the extent by which a material can withstand plastic deformation without rupture. Bend test for ductility provides a simple way to evaluate the quality of materials by their ability to resist cracking or other surface irregularities during one continuous bend.

4.4.1 Acid attack

Table 4.11: Durability test for acid attack in M30 Grade concrete

SI.No	% replacement	Initial weight of cube after 28 days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive of 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

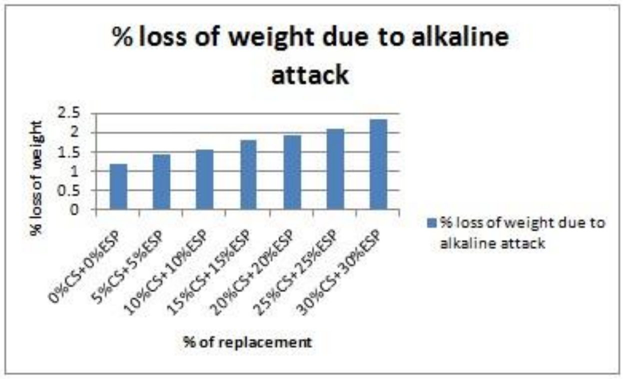


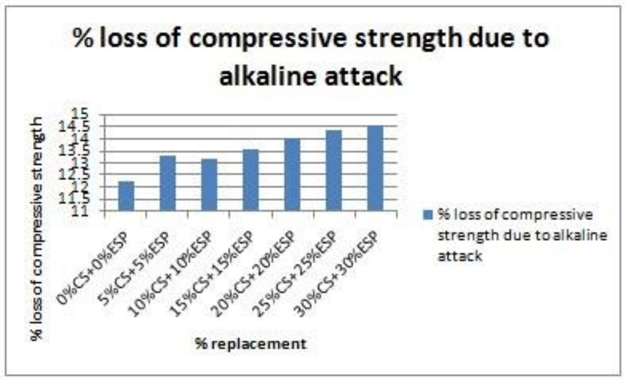


4.4.2 Alkaline attack

Table 4.12: Durability test for alkaline attack in M30 Grade concrete

SI.No	% replacement	Initial weight of cube after 28 days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive of 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



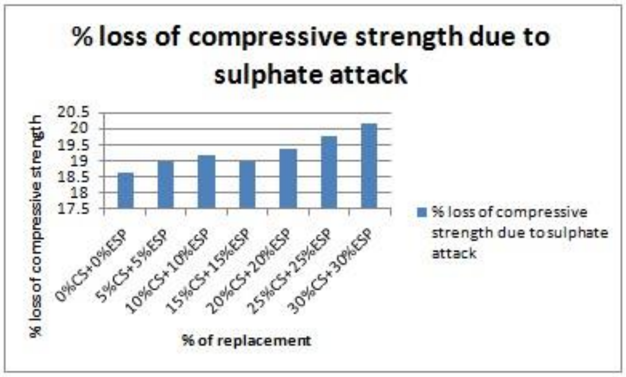


4.4.3 Sulphate attack

Table 4.13: Durability test for Sulphate attack in M30 Grade Concrete

SI.No	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cube 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

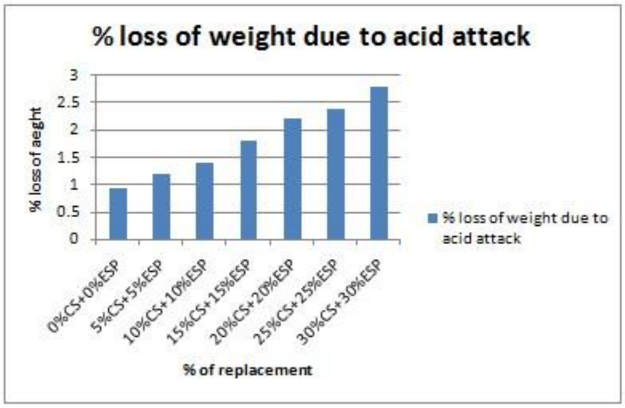


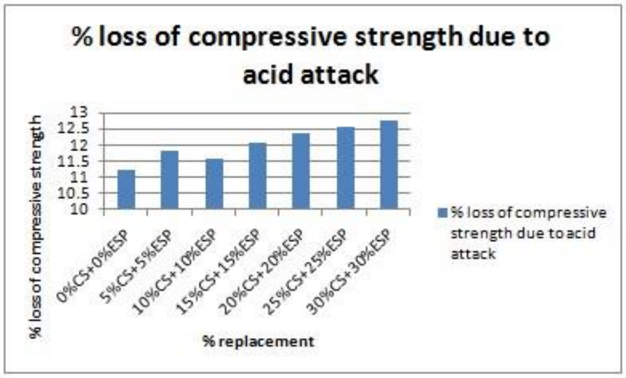
4.5 DURABILITY TEST (II for M40 grade concrete)

4.5.1 Acid attack

Table 4.14: Durability test for acid attack in M40 Grade concrete

SI.No	% replacement	Initial weight of cube after 28 days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to acid attack	Compressive of 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	2192	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

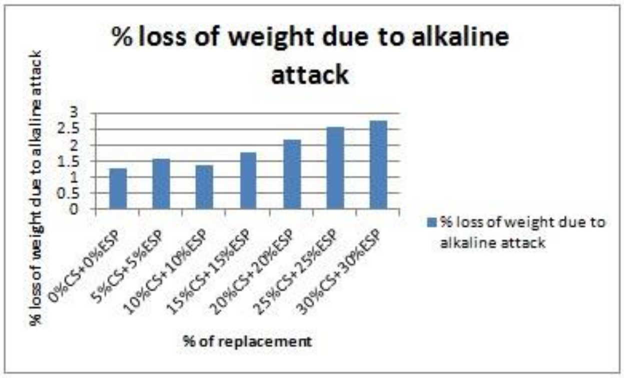


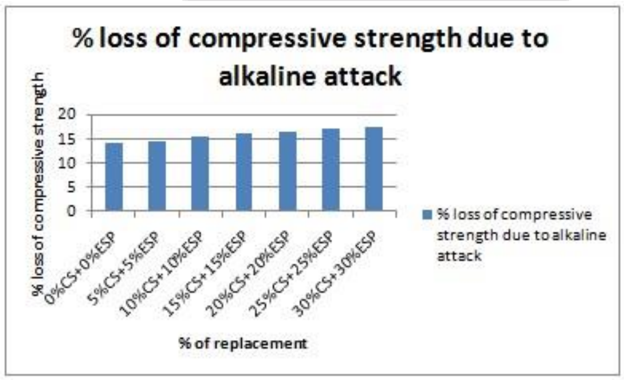


4.5.2 Alkaline attack

Table 4.15: Durability test for alkaline attack in M40 Grade concrete

SI.No	% replacement	Initial weight of cube after 28 days curing in grams	Final weight of cubes after 90days curing in grams	% loss of weight due to alkaline attack	Compressive of 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	37.80	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

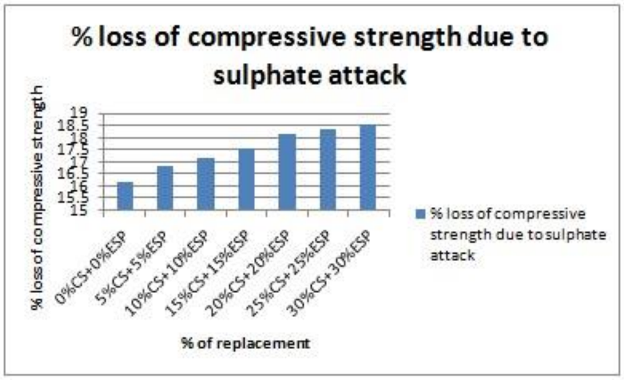




4.5.3 Sulphate attack

Table 4.16: Durability test for Sulphate attack in M40 Grade Concrete

SI.No	% replacement	Compressive strength of cube after 28days curing	Compressive strength of cube 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



5.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.

6. REFERENCE:

[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]