EXPERIMENTAL STUDY ON MECHANICAL AND DURABILITY PROPERTIES OF MORTAR WITH FLY ASH AND COPPER SLAG

R.Guru Lakshmi [1], S.Vignesh [2], D.Prasanya[3], B.Booma priya[4]

1 Assistant professor civil Engineering, sri vidya college of engineering & Technology, Tamil nadu, India

2 Assistant professor civil Engineering, sri vidya college of engineering & Technology, Tamil nadu, India

3 Assistant professor civil Engineering, sri vidya college of engineering & Technology, Tamil nadu, India

3 Assistant professor civil Engineering, sri vidya college of engineering & Technology, Tamil nadu, India

---***---

Abstract - *Utilization of industrial waste or secondary material that has to be encouraged in the construction field for the production of cement which is turn reduces the consumption of natural resources. In this project cement and sand is partially replaced by fly ash and copper slag respectively. In order to reduce the cement and sand due to construction activities. The main objective of this study is to determine the optimum content of copper slag and fly ash in mortar as partial replacement as fine aggregate and cement. In this research work 1:3 cement mortar prepared in which fine aggregate is replaced by copper slag 0 -100 % and also cement is partially replaced by fly ash from 0- 30 %. Compressive strength of mortar conducted at 7, 28days. From this test results, high compressive strength is achieved when increasing the quantity of fly ash from 0 - 20% and copper slag from 0 – 80% used in cement mortar. After that increasing the fly ash and copper slag, compressive strength was decreased. And also compressive strength is increased when increasing the curing period. Durability test such as water absorption, porosity, Abrasion test were conducted at 28 and days. From this test results, water absorption, porosity, show the low value and give the better result when compared to the control concrete for increasing the curing period. Due to this, this type of mortar used for external plastering.*

***Key Words*: fly ash, copper slag, compressive strength, water absorption, porosity, abrasion test**

1. INTRODUCTION

Mortar is a composite material composed mainly of water, cement, fine aggregate. Cement and sand are an important material for preparing of mortar. Fly ash is an industrial waste and a material of pozzolanic characteristics occurring due to burning the pulverized coal from thermal power plants. In the
Construction sector, fly ash is used in the production of cement as an additive material. The fly ash, similar to other pozzolans, affects the technical properties of the concretes and mortars by its pozzolanic characteristics and filler effect. It is known that the filler effect of the fly ash is more effective than the pozzolanic characteristics when affecting the properties of concrete. The fly ashes have pozzolanic activity because they contain surplus amount of silica, alumina and iron oxide; they have a structure with very fine particles and amorphous. Materials with silica and alumina in the structure of fly ashes make additional calcium silicate hydrate (C-S-H) by reacting with calcium hydroxide occurring as a consequence of hydration of the cement. The resultant C-S-H gels cause increase in strength of the concrete. Furthermore, the fact that fly ash contains very fine particle increases compactness in the concretes or mortar and causes filling of the spaces. Using the fly ash in the concrete generally increases the workability of the fresh concrete, decreases the bleeding, decreases the hydration temperature, decreases the permeability of the hardened concrete, increases resistance of the concrete to the chemical effects, and decreases the costs

Now days, the demand of natural sand is very high in the developing countries like India, due to the large usage of concrete to satisfy the rapid infrastructure growth. In India, there is a serious threat to environment and society due to large usage of natural sand deposits. Rapid extraction of sand from river bed causes many problems like loss of vegetation, lowering of water table and also it causes disturbance to aquatic life. The cost of the sand has increased due to its demand. Because of this condition, researches began cheaply available material as an alternative for natural sand. Currently about 2600 tons of copper slag is produced and a total accumulation of around 1.5 million tons.

The durability of mortar depends largely on the movement of water and gas enters and moves through it. The permeability is an indicator of mortar's ability to transport water more precisely with both mechanism that is controlling the uptake and transport of water and gaseous substances into cementitious material. While Sorptivity is material is ability to absorb and transmit water through it by capillary suction. Uptake of water by unsaturated, hardened mortar may be characterized by the sorptivity. This is a simple parameter to determine and is increasingly being used as a measure of mortar resistance to exposure in aggressive environments. Sorptivity, or capillary suction, is the transport of liquids in porous solids due to surface tension acting in capillaries. It is a function of the viscosity, density and surface tension of the liquid and also the pore structure (radius, tortuosity and continuity of capillaries) of the porous solid. It is measured as the rate of uptake of water.

2 MATERIALS AND METHODS

2.1 Fly ash

Fly ash is an industrial waste and a material of pozzolanic characteristic occurring due to burning the pulverized coal in the thermal power plants.fly ash closely resembles volcanic ashes used in production of the earliest known hydraulic cement about 2,300 years ago. Those cements were made near the small Italian town of Pozzuoli-which later gave its name to the term "pozzolan". According to ASTM C618, there are two basic types of FA: Class F(low-calcium FA)and class C (high-calcium FA).

2.2 Copper slag

Copper slag used in this investigation is black glassy granular passing through 4.75 mm sieve which is obtained from Sterlite Industries, Tuticorin

Table-1: Properties of copper slag

Sl.No	Specifications	Results
1	Type	Glassy granular
2	Specific gravity	3.52
3	Fineness Modulus	3.51

2.3 Cement

Cement is the most important constituent of concrete, in that it forms the blinding medium for the discrete ingredients made out of naturally occurring raw material and sometimes blended with industrial wastes. The quantity required for this work was assessed and the entire quantity was purchased and stored properly in casting yard. The cement used in this experimental investigation is 43 grade OPC manufactured by Chettinad cements.

Table-2- Properties of chettinad opc 43 grade cement

Sl.no	Specifications	results
1	Type	OPC 43 grade
2	Specific gravity	3.15
3	Consistency	36%
4	Initial setting time	90 minutes
5	Final setting time	420
6	Fineness	5%

2.4 Sand

Fine aggregate used in this investigation is clean river sand without impurities like clay, shell and organic matters. It is passing through 4.75mm sieve. The fine aggregate were tested, as per Indian Specification IS 383-1970

Table-3- Properties of sand

Sl.no	Specifications	Results
1	Bulk density	1.6 gm/cc
2	Specific gravity	2.6
3	Fineness Modulus	2.66
4	Void ratio	0.468

3 DESIGN MIX METHODOLOGY

3.1 Design mix

A cement mortar mix 1:3 was designed as per IS: 269 methods and the same were used to prepare the test samples. Three cube sample were cast on the mould size 70.6 x 70.6 x70.6 mm for 24 mix proportion of 1:3 cement mortars, with partial replacement of cement with FA as 10%, 20%, 30% and fine aggregate replaced by copper slag from 0-100%.

Fig-1 casting of mortar cube

3.2 Compressive strength test

At 7, 28, 56 and 90 days compressive strength of OPC and OPC partially replaced with fly ash, and fine aggregate replaced with copper slag from 0 -100% at an increment 20%. The load was applied by 2000kN compression testing machine, in the ultimate load stage, the cube get cracked and load was observed and compressive strength was calculated.

Compressive strength = Load (P)/Area (A)

Where,

Load P in kN
Area A in mm^2

3.3 Water absorption & porosity test

At 28days, Water absorption and Porosity of OPC and OPC partially replaced with fly ash, and fine aggregate replaced with copper slag from 0 -100% at an increment 20%. Casted cube were immersed in water for 28days. These specimens were then oven dried for 24 hours at the temperature 85°C until the mass became constant and again weighed (W1) shown in fig. The specimen was kept in water for 48 hours. Then this weight was noted as the wet weight (W2) of the cube.

Percentage of water absorption = [(W2– W1) / W1] x 100
Where,
W1 = Oven dry weight of cubes in grams
W2 = After 48 hours wet weight of cubes in grams.

Percentage of porosity = [(W2– W1) / (W2- Wsub)] x 100
Where,
W1 = Oven dry weight of cubes in grams
W2 = After 48 hours wet weight of cubes in grams.
Wsub = Submerged weight of cubes in grams

Fig-2 Specimen dried in oven

4 EXPERIMENTAL RESULTS

4.1 Compressive strength test result

Table 4 and 5 gives the compressive strength at 7 and 28 days result of % replacement of fly ash and copper slag in mortar for 7 and 28 days curing. Table 6 and 7 gives water absorption & porosity and abrasion results at 28 days

Table 4- Compressive strength at 7 days

Sl.No	Mix proportion	Average Compressive Strength (N/mm²)	Percentage	
			Increased	Decreased
1	F_0CS_0	21.06		
2	F_0CS_{20}	24.07	14.29	
3	F_0CS_{40}	28.08	33.33	
4	**F_0CS_{60}**	**30.09**	**42.87**	
	F_0CS_{80}	25.07	19.04	
6	F_0CS_{100}	22.06	4.74	
7	$F_{10}CS_0$	18.05		14.29
8	$F_{10}CS_{20}$	22.06	4.74	
9	$F_{10}CS_{40}$	24.07	14.29	
10	$F_{10}CS_{60}$	22.06	4.74	
11	$F_{10}CS_{80}$	26.08	23.08	
12	**$F_{10}CS_{100}$**	**30.09**	**42.87**	
13	$F_{20}CS_0$	24.07	14.29	
14	$F_{20}CS_{20}$	26.08	23.08	
15	$F_{20}CS_{40}$	22.06	4.74	
16	$F_{20}CS_{60}$	20.6		2.18
17	$F_{20}CS_{80}$	18.05		14.29
18	$F_{20}CS_{100}$	16.05		23.78
19	$F30CS_0$	14.04		33.33
20	$F_{30}CS_{20}$	18.05		14.29
21	$F_{30}CS_{40}$	20.6		2.18
22	$F_{30}CS_{60}$	24.07	14.29	
23	$F_{30}CS_{80}$	22.06	4.74	
24	$F_{30}CS_{100}$	16.05		23.78

Compressive strength at 7 days

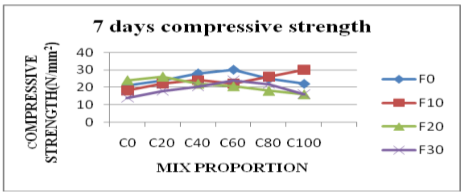

Fig- 3 % of replacement of cement V_s copper slag

Table 5- Compressive strength at 28 days

Sl.No	Mix proportion	Average Compressive Strength (N/mm²)	Percentage	
			Increased	Increased
1	F_0CS_0	26.08		
2	F_0CS_{20}	30.09	16.37	
3	F_0CS_{40}	32.10	23.08	
4	**F_0CS_{60}**	32.10	23.08	
	F_0CS_{80}	28.08	7.66	
6	F_0CS_{100}	24.07		7.70
7	$F_{10}CS_0$	20.6		21
8	$F_{10}CS_{20}$	22.06		15.41
9	$F_{10}CS_{40}$	26.08	-	
10	$F_{10}CS_{60}$	28.08	7.66	
11	$F_{10}CS_{80}$	28.08	7.66	
12	**$F_{10}CS_{100}$**	**32.11**	**23.12**	
13	$F_{20}CS_0$	26.08	-	
14	$F_{20}CS_{20}$	28.08	7.66	
15	$F_{20}CS_{40}$	32.1	23.08	
16	$F_{20}CS_{60}$	30.09	16.37	
17	$F_{20}CS_{80}$	26.08	-	
18	$F_{20}CS_{100}$	22.06		15.41
19	$F30CS_0$	20.06		23.08
20	$F_{30}CS_{20}$	24.07		7.70
21	$F_{30}CS_{40}$	24.07		7.07
22	$F_{30}CS_{60}$	26.08	-	
23	$F_{30}CS_{80}$	24.07		7.07
24	$F_{30}CS_{100}$	20.06		23.08

compressive strength at 28 days

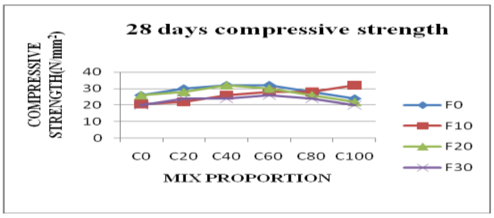

Fig- 4 % of replacement of cement V_s copper slag

4.2 Water absorption and porosity test results for 28days

For28 days strength, where percentage decrease in water absorption is observed to be 1.06 % for replacement of cement by 20 % of fly ash and replacement of sand by 60% of copper slag. Maximum value of water absorption obtained at 30% of fly ash and 80% of copper slag.

Partial replacement of fly ash and copper slag gives better porosity result than control mortar at 28 days. For

28 days strength, where percentage decrease in porosity is found to be 2.54 % for replacement of cement by 20 % of fly ash and replacement of sand by 60% of copper slag. Maximum value of porosity obtained at increment of fly ash and copper slag

Table 6-% of Water absorption and porosity at 28 days

MIX PROPORTION	DRY WEIGHT (gms)	IMMERSED WEIGHT(gms)	SATURATED WATER ABSORPTION (%)	POROSITY (%)
F0C0	723	734	1.52	3.12
F0C20	755	767	1.58	3.4
F0C40	840	852	1.42	3.4
F0C60	913	930	1.86	4.81
F0C80	946	965	2	5.39
F0C100	1008	1031	2.28	6.53
F10C0	720	736	2.22	4.53
F10C20	780	798	2.3	5.09
F10C40	783	795	1.53	3.40
F10C60	849	867	2.12	5.09
F10C80	878	898	2.27	5.84
F10C100	938	962	2.55	6.79
F20C0	747	764	2.27	4.81
F20C20	772	782	1.29	2.84
F20C40	823	835	1.45	3.39
F20C60	845	854	**1.06**	**2.54**
F20C80	938	957	2.02	5.38
F20C100	985	1006	2.13	5.94
F30C0	747	758	1.47	3.12
F30C20	776	798	2.83	6.23
F30C40	859	879	2.32	5.66
F30C60	852	867	1.76	4.24
F30C80	895	921	2.9	7.36
F30C100	1040	1070	2.88	8.49

% of Water absorption at 28 days

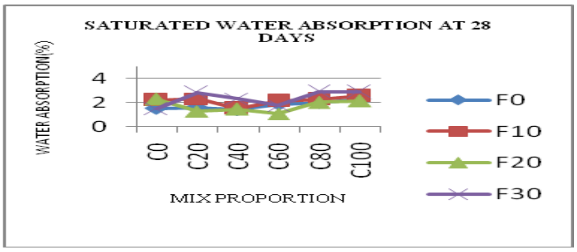

Fig- 5 % of replacement of cement V_s copper slag

% of porosity at 28 days

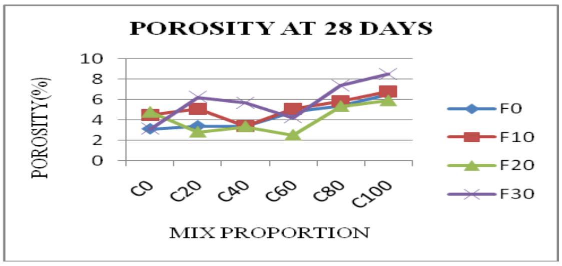

Fig- 6 % of replacement of cement V_s copper slag

4.3 Abrasion test

This test is used for the determination of resistance to wear for cement concrete flooring tiles. The wear of the tile is measured on a thickness gauge.

Table 7- Abrasion resistance at 28 days

Sl.no	Mix proportion	Average loss in thickness (mm)	Percentage of abrasion resistance	
			Increased	Decreased
1	F0C0	1.12		
2	F0C20	0.51	**54.46**	
3	F0C40	0.51	**54.46**	
4	F0C60	0.67	40.17	
5	F0C80	1.37		22.32
6	F0C100	0.5	**54.46**	
7	F10C0	1.78		58.92
8	F10C20	1.75		56.25
9	F10C40	1.17		4.46
10	F10C60	1.04	7.14	
11	F10C80	1.04	7.14	
12	F10C100	1.12	-	-
13	F20C0	0.7	37.5	
14	F20C20	1.35		20.53
15	F20C40	1.52		35.71
16	**F20C60**	1.15		2.67
17	F20C80	1.22		8.92
18	F20C100	0.87	22.32	
19	F30C0	1.61		43.75
20	F30C20	1.94		73.21
21	F30C40	0.96	14.28	
22	F30C60	1.15		2.67
23	F30C80	1.23		9.82
24	F30C100	1.07	4.46	

Abrasion test at 28days

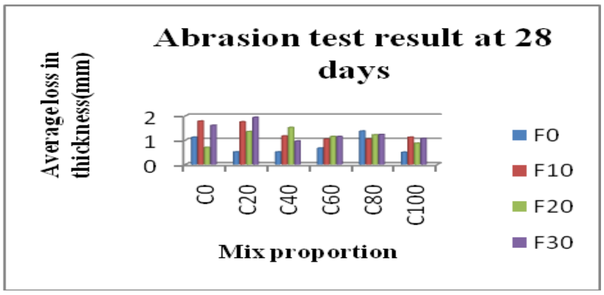

Fig- 7 % of replacement of cement V_s copper slag

5 CONCLUSION

Based on limited experimental investigation concerning the compressive strength, water absorption, porosity, and abrasion test of mortar, the following observations are made regarding the resistance of partially replaced 1:3 proportion mortar

- The optimum compressive strength of cement mortar with cement is replaced by fly ash 0 % and 10 % and sand is replaced by copper slag 60 % and 100% which gives 42.87 % higher compressive strength than control mortar at 7days.
- Optimum compressive strength 32.11 N/mm^2 is achieved when cement with 10% fly ash and fine aggregate with 100% copper slag which is 23.12% higher than control mortar at 28 days.
- For28 days strength, where percentage decrease in water absorption is found to be 1.06 % for

replacement of cement by 20 % of fly ash and replacement of sand by 60% of copper slag

- The percentage decrease in porosity is found to be 2.54 % for replacement of cement by 20 % of fly ash and replacement of sand by 60% of copper slag than control mortar at 28 days.
- At 28 days, 54.46 % of abrasion resistance was founded by adding 0% replacement of fly ash with cement and 20% replacement of sand by copper slag and same percentage of abrasion resistance was obtained by adding 0% replacement of fly ash with cement and 40% replacement of sand by copper slag

REFERENCES

1. Sivakumar Naganathan and Tan Linda "Effect of fly Ash fineness on the performance of cement mortar". (2013)
2. Rushabh A. Shah, Jayeshkumar Pitroda "Effect of water absorption and sorptivity on durability of pozzocrete mortar". (2013)
3. Jayeshkumar Pitroda, Dr F S Umrigar (2013) "Evaluation of sorptivity and water absorption of concrete with partial replacement of cement by thermal industry waste (fly ash)". (2013)
4. K.Bazzar, M.R.Bouatiaoui, A.Hafidi Alaoui "Performance approach the durability of high volume fly ash concrete". (2013)
5. Satish Chandra.C, Gyanen.Takhelmayum, Deepa.T "Study on flow and compressive strength properties of mortars using fly ash and lime". (2013)
6. B. Damodhara Reddy, I.V. Ramana Reddy, S. Aruna Jyothy "Effect of water absorption, porosity and sorptivity on durability of geopolymer mortars". (2013)
7. Suresh Thokchom, Partha Ghosh and Somnath Ghosh "An Experimental investigation on the performance of mortar cubes by partial replacement of portland slag cement with and without admixtures". (2009)
8. Semsi yazici and Hasan Sahan Arel "Effects of fly ash fineness on the mechanical properties of concrete". (2012)
9. Rushabh A. Shah, JayeshkPitroda "Fly Ash Class F: Opportunities for development of low cost mortar". (2013)
10. Khalifa S. Al-Jabri, Makoto Hisada, Salem K. Al-Orami, Abdulla H. Al-Saidy "Copper slag as sand replacement for high performance concrete". (2009)
11. Khalifa S. Al-Jabri , Abdullah H. Al-Saidy, RamziTaha. "Effect of copper slag as a fine aggregate on the properties of cement mortars and concrete". (2011)
12. Wei Wu, Weide Zhang, Guowei Ma "Optimum content of copper slag as a fine aggregate in high strength concrete". (2009)
13. Khalifa S. Al-Jabri, Makoto Hisada, Abdulla H. Al-Saidy, S.K. Al-Orami. "Performance of high strength concrete made with copper slag as fine aggregate". (2009)
14. R R Chavan, D B Kulkarni "Performance of copper slag on strength properties as partial replace of fine aggregate in concrete mix design"
15. D.Brindha, S.Nagan "Utilization of copper slag as a partial replacement of fine aggregate in concrete". (2010)
16. MeenakshiSudarvizhi. S, Ilangovan. R "performance of copper slag and ferrous slag as partial replacement of sand in concrete"

BIOGRAPHIES

1'st Author

R.Gurulakshmi completed her B.E(CIVIL) Engineering from Anna University Trichy in 2013, M.E(STRUCTURAL) Engineering from Alagappa Chettiar College of Engineering & Technology, Karaikudi 2015. She is working as Assistant Professor in Sri Vidya College of Engineering & Technology, Virudhunagar

2nd Author

S.VIGNESH completed her B.E(CIVIL) Engineering from Dr.Sivanthi Adithanar College of Engineering 2011, M.E(STRUCTURAL) Engineering from Sardar Raja College of Engineering Allangulam 2013. She is working as Assistant Professor in Sri Vidya College of Engineering & Technology, Virudhunagar

3rd Author

D.PRASANYA completed her B.E(CIVIL) Engineering from Mepco Schlenk Engineering college from sivakasi in 2010, M.E(STRUCTURAL) Engineering from Thiyagarajar college, Madurai 2012. She is working as Assistant Professor in Sri Vidya College of Engineering & Technology, Virudhunagar

4th Author

B.BOOMA PRIYA completed her B.E(CIVIL) Engineering Mepco Schlenk Engineering college from sivakasi in 2011,M.E(CONSTRUCTION ENGINEERING AND MANAGEMENT) from The Rajaas Engineering College , Tirunelveli 2015 .She is working as Assistant Professor in Sri Vidya College of Engineering & Technology, Virudhunagar