Experimental Investigation on Usage of Waste Material as Partial Replacement for Cement and Fine Aggregates

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***Abstract*— In today's world the main importance is given to green, renewable and sustainable development. Huge amount of fly ash is produced in thermal power plants as a waste product which has a bad impact on environment and human health. Attempts were made to partially replace cement with other waste materials like fly ash and egg shell powder. Glass powder is a good material that can replace sand. Glass powder in mortar will lead to green environment as it is not recycled and is often disposed into landfills and also natural resources are depleted due to collection of sand. However, scarcity of natural sand arises and we find ourselves in the need to look for an alternative material. Egg shells contain calcium carbonate while fly ash is rich in siliceous matter and can be used to partially replace cement in mortar. In this paper, attempt has been made to study effect of addition of egg shell powder and fly ash as partial replacement of cement and addition of glass powder as replacement of sand by comparing the compressive strength of cement with control mix. Experimental investigation was done on mortar cubes maintaining cement to sand ratio of 1:3. The hardened specimens were tested for compressive strength after 7 days and 28 days. The optimum results of ESP (Egg Shell Powder) and FAP (Fly Ash Powder) were combined to partially replace cement and replace sand with glass powder. The hardened specimen was tested for compressive strength for 7 days for this ternary combination. It was found that the compressive strength of mortar increased above the control mix on partial replacement of cement by 7.5% of egg shell powder. However no increase in compressive strength above the control mix was found on partial replacement with fly ash powder. Partial replacement of sand with glass powder showed a gradual increase in mortar strength up 40% and then a decrease. Hence the maximum compressive strength for partial replacement of sand with glass powder was found at 40% partial replacement.**

Keywords—Egg shell powder, fly ash, glass powder

I. INTRODUCTION

Mortar and concrete are the main ingredients used for infrastructure development. Cement is the major building block to produce mortar. Cement is produced by using natural limestone and when limestone is burnt for cement production, carbon dioxide gas is emitted which leads to global warming as it is main contributor of greenhouse effect. Disposal of wastes such as fly ash, glass into the environment is hazardous. In this view, management of such waste materials and their disposal should be environment friendly and economically feasible. Therefore these materials can be used to produce mortar. Our project attempts to study the effect of replacement of cement partially with waste materials like eggshell powder and fly ash and also to study the effect of replacement of fine aggregate i.e. sand by glass powder in mortar.

The study made by Rajan S N (2016), shows that fly ash and lime was replaced with cement and different proportions like water demand, compressive strength, split tensile strength were studied on different mortar specimen. Specimens were tested on 7th and 28th day of curing. It was concluded that water demand increases with increase in lime content. It was found that the compressive strength was more than 15 MPa by using lime and fly ash. Another study describes the effect and experimental result of replacement of egg shell powder in cement. After carrying out test it was found that egg shell powder can successfully be used as a replacement material for cement (Mohamed Ansari 2016)

II. MATERIALS AND METHODOLOGY

A. Materials

Egg Shell Powder: Egg shell powder is an effective calcium supplement. Egg shell consists of calcium carbonate along with small amounts of proteins and other organic compounds. It is also the cheapest and most widely available form of calcium in supplement. Thus used in partially replacing it with cement.

Fly ash: It is a pozzolana, a substance containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water, fly ash forms a compound similar to Portland cement. This makes fly ash suitable as a prime material in blended cement, mosaic tiles, and hollow blocks among other building materials. When used in concrete mixes, fly ash improves the strength and segregation of the concrete. In the present project work we have used class F fly ash. Class F fly ash contains particles covered in kind of melted glass. This greatly reduces risk of expansion due to sulfate attack.

Glass Powder: Efforts have been made in the concrete industry to use waste glass as a partial replacement of coarse or fine aggregates and cement. In the present project work we have partially replaced sand with glass powder.

Cement: Cement is a binder, a substance used for construction that sets, hardens and adheres to other material to bind them together. It is a basic binder material in mortar

and concrete. In this, JK cement brand of OPC 43 Grade was used.

Fine Aggregates: It is used in the construction industry mainly for concrete production and cement sand mortar production. It is generally gathered from the banks of the river and has a fine quality

Water: It is an essential element to produce a good and quality mortar. Bad quality of water could cause corrosion to the steel reinforcement. This is important to ensure that water used for mortar production should be free from deleterious substances like oil, acids, alkali, salt, sugar, silt and organic matter. Water used as per IS 4031 (part 6)-1988.

B. METHODOLOGY

Various tests were carried out on the materials incorporated in this paper such as standard consistency test, particle size distribution of fine aggregates by sieve analysis, specific gravity test, etc. Once the preliminary tests were done the mortar cubes were cast following suitable mix proportions and then cast as per the specifications.

The mix proportions are as per IS: 4031 (Part 6)-1988
The material for each cube shall be mixed separately and the quantity of cement, standard sand and water to prepare mortar of ratio 1:3 shall be as follows:

- Cement = 200 g
- Standard Sand = 600 g
- Water = (P/4+ 3) percent of combined mass of cement and sand, whether P is the percentage of water required to produce a paste of standard consistency determined as described in IS: 4031 (Part4) - 1988

The percentage of water required for standard consistency is 32%
Water= (32/4+3) % × (200+600)
= (11%) × 800
= 88 g

III. TEST RESULTS

TABLE I. CONTROL MIX

Number of Days	Compressive Strength (N/mm2)
7 Days	14.5
28 Days	15.12

TABLE II. COMPRESSIVE STRENGTH OF MORTAR CUBE FOR REPLACEMENT OF CEMENT WITH EGG SHELL POWDER FOR 7 DAYS AND 28 DAYS

Percentage	Compressive Strength (N/mm2)	
	7 Days	*28 Days*
2.5	10.49	14.78
5	9.56	13.71
7.5	10.26	15.49
10	11.01	11.4
12.5	8.4	14.01
15	10.1	13.21

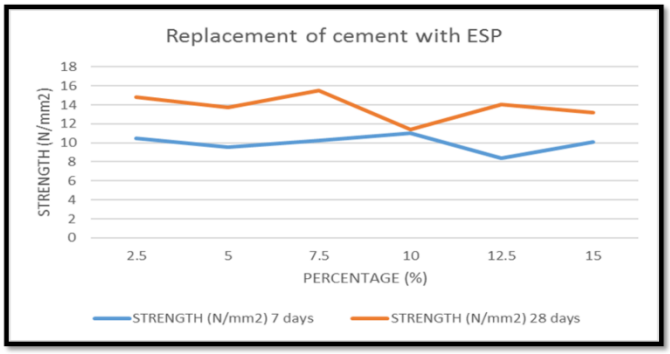

Fig. I. Variation of compressive strength of mortar cube for replacement of cement with egg shell powder for 7 and 28 days

TABLE III. COMPRESSIVE STRENGTH OF MORTAR CUBE FOR REPLACEMENT OF CEMENT WITH FLY ASH POWDER FOR 7 DAYS AND 28 DAYS

Percentage	Compressive Strength (N/mm2)	
	7 Days	*28 Days*
7	-	10.2
8	-	11.31
9	-	10.42
10	11.21	12.41
11	-	13.4
12	-	12.99
15	6.73	12.37
20	8.83	8.63
25	8.83	9.47
30	8.07	10.06
35	7.5	11

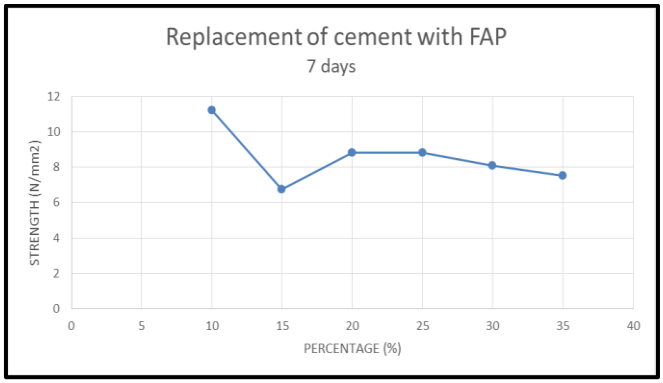

Fig. II. Variation of compressive strength of mortar cube for replacement of cement with fly ash powder for 7 days

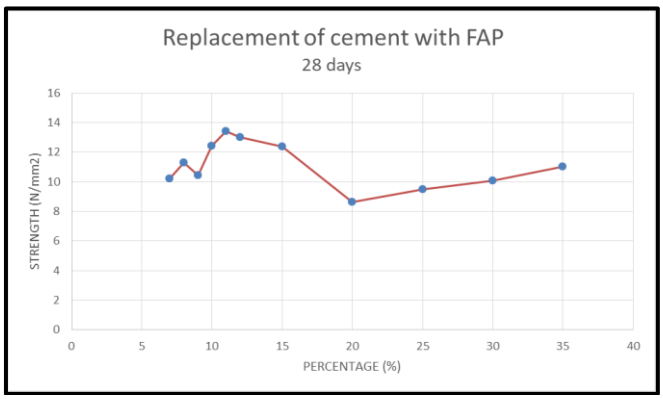

Fig. III. Variation of compressive strength of mortar cube for replacement of cement with fly ash powder for 28 days

TABLE IV. COMPRESSIVE STRENGTH OF MORTAR CUBE FOR REPLACEMENT OF CEMENT WITH GLASS POWDER FOR 7 DAYS AND 28 DAYS

Percentage	Compressive Strength (N/mm2)	
	7 Days	*28 Days*
10	15.34	16.10
20	12.57	17.29
30	14.68	19.86
40	14.06	21.66
50	15.13	16.18

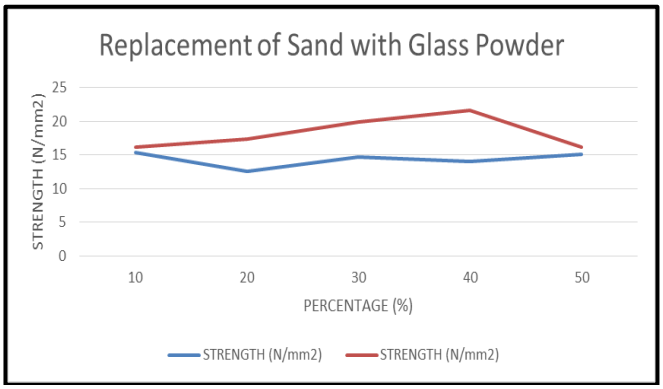

Fig. IV. Compressive strength of mortar cube for replacement of sand with glass powder for 7 days and 28 days

IV. CONCLUSION

The maximum compressive strength for 7 days was found to be at 10% replacement of cement with egg shell powder which was lesser than that of the control mix. The maximum compressive strength obtained for Egg Shell Powder replacement after 28 days of curing is at 7.5% replacement of cement which is 0.37N/mm2 greater than that of the control mix. The maximum compressive strength for 7 days was found to be at 10% replacement of cement with fly ash but was found less when compared with the control mix. The maximum compressive strength of cement mortar after 28 days is at 11% replacement of cement with Fly Ash Powder and was found lesser than that of the control mix. For 7 days curing period, it is observed that the compressive strength is maximum for 10% replacement of sand with Glass Powder and it is greater than that of the control mix. When Glass Powder was used, it is observed that the compressive strength of cement mortar after 28 days is maximum for 40% replacement of sand and it is greater than that of the control mix. Hence it can be concluded that the replacement of cement and sand with waste materials gives more strength than the minimum compressive strength specified by the IS code.

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REFERENCES

[1] Rajan S N, S.M.Maheswarappa, J.K.Dattatreya, "Perfomance Evaluation of Cement Mortar by Using Fly Ash And Lime as Partial Replacement for Cement", IJERAT, vol. 02, June 2016.

[2] Mohamed Ansari M, Dinesh Kumar M, Milan Charles J, Dr.Vani G, "Replacement of cement using Eggshell Powder", International Journal of Civil Engineering, vol 3, March 2016.

[3] Kamran Basit, Nitish Kumar Sharma, Brij Kishor, "A Review on Partial Replacement of Cement by Eggshell powder", International Journal of Engineering nd Technology, vol 06, March 2019.

[4] Shaik Mohammed Ghouse, Dr. C. Rama Chandrudu, D. Mohammed Rafi, "An Experimental Study on the Properties of Concrete by the Partial Replacement of Sand with Glass Powder", IJSRST, vol. 4, 2018.

[5] Nurhayat Degirmenci,Arin Yilmaz & Ozge Andic Cakir, "Utilization of waste Glass as sand replacement in Cement Mortar", Indian Journal of Engineering and Materials Sciences, vol 18, pp. 303-308, August 2011.

[6] C Freeda Christy & D Tensing, "Effect of Class-F fly ash as Partial Replacement with cement and Fine Aggregate in Mortar", Indian Journal of Engineering and Materials Sciences vol 17, pp. 140-144, April 2010.

[7] Parthasarathi Narayanaswamy, M.Prakash, K.s. Satyanarayanan, "Experimental study on partial replacement of cement with egg shell powder and silica fume", Rasayan Journal of Chemistry, vol 10, pp.442-449, April 2017.