Mechanical Properties of Self-Compacting Ferrocement with Partial Replacement of Cement by Egg-Shell Powder

Balram Lagad[1] Prof. R. S. Talikoti[2] Prof. K. K. Tolani[3] Nilesh More[4]
[1,4]PG Student [2]Professor and Co-guide, [3]Professor and Guide
[1,2,3,4]Department of Civil Engineering
[1,2,3]Late G.N. Sapkal College of Engineering, Maharashtra India [4]S.N.D.C.O.E., Yeola, Nashik, Maharashtra India

Abstract— Concrete are widely used material in the world and it plays very important role in construction industry. Ordinary. The huge amount of Carbon-dioxide released during the production of cement. For Production of 1000kg of cement, 900kg of carbon dioxide get released. On other hand a large quantity of Egg-shell wastes are produced every year in the world and it cause the problems of landfilling and human diseases. The aim of present study is to check the feasibility of egg-shell powder as a partial replacement of cement in self-compacting ferrocement. In current work, a combination of Egg shell with silica fumes are used in different proportions in self-compacting ferrocement to find the feasibility of using the Egg shells as an alternate to cement. Egg shell powder replaces 5%, 10%, 15%, 20% and 25% in addition with the silica fume at proportion of 1:1.5 of weight of Egg-shell powder. Mortar were cast and Compressive test, Split Tensile and Flexural tests were carried out to find the best combination which results in optimum percentage of strength.

Key words: Egg-Shell Powder, Self-Compacting Mortar, Ferrocement

I. INTRODUCTION

A. General

Now a days in India, environmental pollution due to carbon dioxide is a major problem. To reduce the release of carbon dioxide from cement manufacturing processes, the construction industries search such a type of waste material which can partially replace the amount of cement. Calcium rich egg-shell is a poultry waste with chemical composition nearly same as that of limestone. Use of egg-shell waste as a partial replacement of cement in concrete may have benefits like minimizing use of cement, conserving natural lime and utilizing waste material.

B. Ferrocement

Ferrocement is a type of thin walled reinforced concrete construction, where usually a hydraulic cement mortar is reinforced with layers of continuous and relatively small diameter wire meshes. The mesh may be made of metallic or other suitable material. Ferrocement is an ideal material of construction, as it gives maximum strength output with the minimum energy input. Ferrocement mostly adopt to achieve small thickness and reduce the use of different construction materials.

C. Self-Compacting Mortar

Self-compacting mortar is defined as "A mortar which able to flow under its own weight and completely fill the formwork, even in the presence of dense reinforcement, without the need of any vibration. Self-compacting mortar has now been taken up with enthusiasm across India, for both site and precast concrete work. Superplasticizers are an essential component of Self compacting mortar to provide necessary workability. The main characteristics of Self compacting mortar are the properties in the fresh state.

D. Self-Compacting Ferrocement

Unlike conventional reinforced concrete, ferrocement reinforcement is assembled into its final desired shape using closely space layer of continuous and relative small aperture sized wire mesh tied on small rods. Traditional cement mortar is then plaster over the reinforcement cage ether by hand (pressfilling) or by mechanized pressure technique, without used of conventional formwork. Most commonly, ferrocement element are constructed by unskilled labour for fabricating the skeletal reinforcement cage and semi-skilled labour for pressfilling cement mortar on it. The process is very time consuming extra effect has for the quality control for development of more efficient technique add both ferrocement and self-compacting concrete the quality of SCC is that it self-compact by its own weigth and it also labour and time saving and quality product. Ferrocement is a composite construction material commonly prepared using hydraulic cement mortar reinforced with layer of steel mesh. Use of formwork for ferrocement have better result in time saving in larger constructions but due to closed spaced reinforcement self-compacting mortar can only get compacted by its own weight into the reinforcement without blockage.

E. Egg-Shell Powder

India is the second largest eggs producing country in the world. As a waste material, disposal of egg-sell is a major problem because if egg-shells are send to landfills attracts vermin and cause problem of human health and environment. Chemical composition of egg-shell powder is nearly same as limestone which is used for cement manufacturing. Use of egg-shells as a replacement of cement can have benefits like saving of cement and utilizing waste materials.

II. LITERATURE REVIEW

D. Gowsika., S. Sarankokila., K. Sargunan have reported experimental investigation of egg shell powder as partial replacement with cement in concrete. According to this study, they reported that there was a sharp decrease in compressive strength beyond 5% ESP substitution. In this study it was found that replacement of 5% egg shell powder + 20% Microsilica can be added without any reduction in compressive properties in conventional concrete. Replacement of 5% ESP + 10% Microsilica replacement in cement yields similar flexural strength and higher split tensile strength than conventional concrete.(1)

M. Sivakumar., Dr. N. Mahendran., have investigated strength and permeability properties of concrete using fly ash, rise husk ash and Egg-shell powder. In this study, cement concrete cubes are casted in various proportions of fly ash, rise husk and Egg-shell powder as a replacement of cement. The proportion which contains 15% fly ash + 15% rise husk ash + 5% egg shell powder with replacement of cement gives maximum compressive strength, tensile strength, Same proportion gives 56.8% decrease in water permeability, 75.55% decline in chlorine penetration.(2)

Dhanlakshmi M., Dr. Sowmya N. J., Dr. Chandrashekar have studied the comparison between Egg shell concrete and a concrete with partial replacement of cement by fly ash. In this study they concluded that addition of ESP to cement concrete leads to reduction in workability, density decreased with addition of ESP to cement concrete, compressive strength of egg shell concrete was lower than control concrete mix. In this article, they concluded that the combination of ESP + FA showed the reduction in compressive strength compared control concrete and egg shell powder concrete.(3)

Amaranth Yerramala have investigated the properties of concrete with eggshell powder as cement replacement. In this study he reported that the compressive strength was higher than control concrete for 5 percent ESP replacement at 7 and 28 days of curing ages. ESP replacements greater than 10 percent had lower strength than control concrete. Addition of fly ash improved compressive strength of ESP concrete. In this study the results demonstrated that, irrespective of ESP % replacement there was good relationship between compressive strength and split tensile strength. The overall study concluded that sorptivity of concrete was comparable with control concrete up to 10% ESP replacement. The maximum sorptivity was for ESP and fly ash replaced concrete with 0.17 mm/s.(4)

J.karthick, R. Jeyanthi, M. Petchiyammal had investigated "experimental study on usage of egg shell as a partial replacement for sand in concrete." In this study they concluded that the egg shell as a useful material instead of waste material (harm to the environment) that they were hurled in many hundred tons annually had been use in an engineering applications. They also stated that the tensile, flexural strength was decreased with increasing egg shells percent. This tensile strength decreased from (2.36N/mm2) to (0.21N/mm2) with increasing egg shell from (0 wt %) to (50 wt %).(5)

Praveen Kumar R., Vijaya Sarathy. R., Jose Ravindraraj. B., have investigated the experimental study on partial replacement of cement with egg shell powder. In this study they reported that the compressive strength of concrete having egg-shell powder as cement replacement was increases upto 15 percent without silica fume. They also stated that addition of silica fumes enhances the strength but to achieve economy, egg-shell powder replacement is sufficient to achieve higher strength. In this article they concluded that the flexural strength of egg-shell concrete was more than controlled concrete upto 15 percent and split tensile strength of egg-shell concrete decreases with addition of more egg-shell powder beyond 15 percent.(6)

Gaikwad M. J., Shah, S. N., Patil. S. V., Dhonde. H. B., have developed a self-compacting mortar for prefab ferrocement. According to this work, certain limitations in traditional ferrocement construction would be overcome by using mass scale prefabrication of ferrocement product with the help of stronger, durable, better quality self-compacting mortar. This article reported SCM with relatively low w/c ratio provide improve bond characteristics between cement mortar and reinforcement, thus enhancing the mechanical and durability characteristics. According to this article, marsh cone test is not adequate to ascertain the powder- HRWR compatibility. Fly ash replacement provide significant improvement in slump flow, stability and strength of SCM.(7)

A. Problem Statement

From review of literatures it is observed that, only a limited number of studies have been evaluated the properties of concrete with partial replacement of cement by Egg-shell powder. Not even one literature is available in the published works regarding the use of Egg-shells powder in self-compacting ferrocement. Hence initial objective of this study is characterization of self-compacting ferrocement with partial replacement of cement by Egg-shell powder.

B. Objectives of study

- To develop an Eggshell powder based self-compacting ferrocement.
- To study the workability properties of fresh self-compacting ferrocement with partial replacement of cement by Eggshell powder.
- To study the effect of Eggshell powder on mechanical properties of self-compacting ferrocement with partial replacement of cement by Eggshell powder.

III. METHODOLOGY

Literature review indicates that, Egg shell powder is suitable for making concrete with partial replacement of cement.

A. Materials

In present experimental work, white colored eggshells collected from restaurants and small Omelets stalls at mahatma nagar, Nashik is to be used as source material. Godavari River Sand is used as filler material. The sand is sieved and size fractions are combine in equal proportion to maintain grading complying with standard sand as per IS 650:1991. Square mesh of size 19_{mm} X 19_{mm} is used in two layers as a ferrocement reinforcement. Ordinary Portland cement of 53 grade is used. Table 1 shows the test results of basic properties of cement.

Properties	Results
Specific Gravity	3.1
Standard consistency	31%
Initial Setting time	38 min
Final Setting time	480 Min
Fineness	5.3%

Table 1: Properties of Ordinary Portland cement

Superplasticizer (SP): (KEMIFLOW SR-5W)

Since the silica content in Egg shell is very low, Silica fume is added as an admixture with the Concrete to provide the necessary strength and the addition will enhance the durability of concrete in the Chlorine

Environment. Silica fume is added in egg-shell powder in proportion of 1:1.5. Table 2 shows the chemical composition of cement, Egg-Shell and silica fume.

Sr. No.	Oxide Contents	Cement	Egg-Shell	Silica Fume
01	CaO	50.7	60-67	0.30
02	SiO_2	0.09	17-25	90.21
03	Al_2O_3	0.03	3-8	0.12
04	MgO	0.01	0.1-0.4	0.73
05	Fe_2O_3	0.02	0.5-0.6	0.15
06	Na_2O	0.19	0.4-1.3	0.46
07	SO_3	0.57	1.3-3.0	0.01

Table 2: Chemical compositions

B. Method of cast and testing of specimens

Concrete cubes having size 70_{mm} X 70_{mm} X 70_{mm} has been cast and specimens were tested. Following mix combinations were used for casting of self-compacting ferrocement.

Sr. no	Mix Name	Cement	ESP	Silica Fume	W/C ratio	Ad.
01	C100E0S0	100	0	0	0.28	1.7
02	C90E10S0	90	10	0	0.30	1.6
03	C85E15S0	85	15	0	0.33	1.5
04	C80E20S0	80	20	0	0.35	1.5
05	C95E3S2	95	3	2	0.30	1.7
06	C90E6S4	90	6	4	0.33	1.6
07	C85E9S6	85	9	6	0.35	1.6
08	C80E12S8	80	12	8	0.38	1.5
09	C75E15S10	75	15	10	0.4	1.5

Table 3: Mix Combination

C. Testing

1) Workability Test

The workability of SCGM is checked based on mini slump cone test.

Fig. 1: Flow Test of C90E6S4

2) Test for Compressive Strength

After water curing of SCEM cubes, compression strength test is carried out after a test period of 7, 14, 21, 28 days. Results of workability and compressive strength test are shown in table 04

Sr. No.	Mix Identity	Mini slump (mm)	Compressive strength (Mpa)	
			7 Days	14 Days
01	C100E0S0	200	40.25	44.50
02	C90E10S0	215	30.20	36.50
03	C85E15S0	220	27.55	32.35
04	C80E20S0	225	25.60	28.10
05	C95E3S2	205	38.50	43.50
06	C90E6S4	205	34.50	40.30
07	C85E9S6	210	30.67	35.50
08	C80E12S8	220	28.70	32.20
09	C75E15S10	220	26.25	29.80

Table 4: Compressive Strength at 7 and 14 days

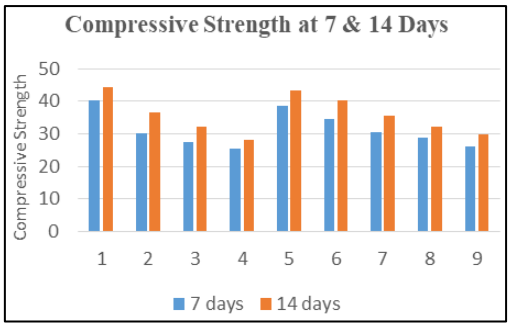

Fig. 2: Graphically represents the Compressive Strength of egg shell concrete Cubes.

3) Test for Flexural Strength

After water curing of SCEM beams of size 500_{mm} X 100_{mm} X 100_{mm}, Flexural strength test is carried out after a test period of 7, 14 days. Chart 2 graphically represents the Flexural Strength of egg shell concrete Beams.

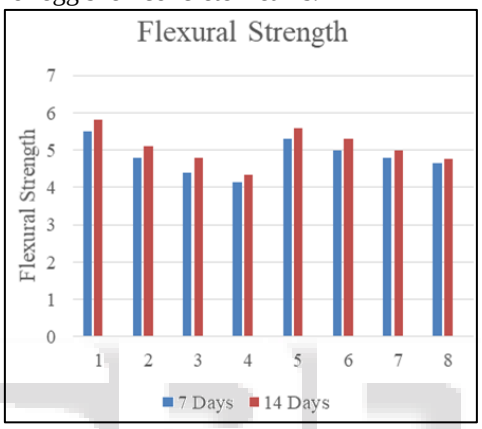

Fig. 3: Test for Flexural Strength

4) Test for Split Tensile Strength

After water curing of SCEM cylinders of size 150_{mm} X 150_{mm} X 300_{mm}, Split Tensile strength test is carried out after a test period of 7, 14 days. Chart 3 graphically represents the Split Tensile strength of egg shell concrete.

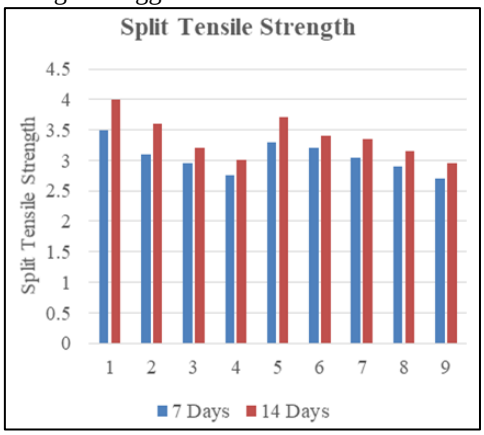

Fig. 4: Test for Split Tensile Strength

D. Results and Discussions

Bleeding can be reduced by using Eggshell powder as a replacement of cement in self-compacting mortar.

Workability of Eggshell mortar calculated from flow test is more than controlled mortar.

It can be concluded that replacement of cement by Eggshell powder is possible upto some percentage in case when strength is not major factor.

IV. CONCLUSION

1) Compressive strength of Egg-shell based self-compacting ferrocement is very less as compare to controlled self-compacting ferrocement because Egg-shell powder is rich in calcium content but silica content is very less. If silica fume was added into egg-shell based self-compacting ferrocement then compressive strength as well as split tensile strength get increased.
2) Egg shell powder obtained from industrial wastes is added in various ratios with addition of silica fume for cement replacement and it was found that replacement of 3% Egg shell powder + 2 % silica fume can be added without any reduction in compressive strength properties of conventional self-compacting ferrocement. And replacement of 6% Egg shell powder + 4% silica fume gives 5% reduction in compressive strength of conventional self-compacting ferrocement.
3) Replacement of 3% Egg shell powder + 2% silica fume in cement gives higher Split Tensile strength than controlled self-compacting ferrocement.
4) Replacement of 3% Egg shell powder + 2% silica fume in cement gives 2 % reduction in flexural strength of controlled self-compacting ferrocement and replacement of 6% eggshell powder and 4% silica fume gives 4 % reductiuon in flexural strength.

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