Partial Replacement of Cement with Egg Shell Powder and Fine Aggregate with Iron Slag in Concrete

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Abstract: ***Day by day different kinds of waste produced from different industries and they dispose this waste in the form of landfill or they dump in the ocean. Disposal of waste affect the environment so it became important to reuse the waste in any form. Eggs shell is the waste produced from the poultry farms which is further dumped in landfills which affect the environment, as the membrane inside the egg shell attract vermin's, which cause the problems associated with human health and environment. As it is a natural solid waste and non hazardous which attract rats and worms due to the protein matrix which may also cause problem to the public. Similarly iron slag is the industrial waste which is produced from the steel and iron industries. Iron slag is the byproduct of obtained in the manufacturing of the iron, it mostly consist of the magnesium, aluminum, silicates, calcium and manganese in various arrangements. Therefore, an investigation was conducted to study the properties of concrete containing egg shell powder and iron slag in a concrete mix. Egg shell powder is used in research as the partial replacement of cement and iron slag is used as the partial replacement of the fine aggregates. Different ratios of egg shell powder and iron slag combination were developed by replacing 2.5-7.5% of egg shell powder for cement and 20-40% of iron slag for fine aggregates respectively by weight. Various tests were conducted on M30 grade of concrete to know the compressive strength, flexure strength and split tensile strength. The results obtained were further compared with the usual concrete, thereby we can get to know about the change in the property of concrete containing egg shell powder and iron slag.***

Index Terms: Egg Shell Powder, Iron Slag, Strength, Ratio.

I. INTRODUCTION

The usage of secondary material has advocated the production of cement and concrete in construction field. New byproduct and waste substances are being generated by numerous industries. Discarding of waste material causes various an environmental and health issues. Therefore, recycling of waste material is an extremely good capability in concrete industries. Various by products obtained from the industries like fly ash, silica fumes and slag were considered as a waste material. The use of such by products in concrete mix enhances the properties of concrete in regards of its strength, workability and durability compared to the normal concrete. Construction waste, blast furnace, steel slag, coal fly ash have been accepted in many places as alternative aggregate 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).

Slag is the waste product produced in steel industries. Depending on the composition of the steel and on the steel manufacture process, One ton of steel produce 130- 200 kg of slag. Slag seems as a granulated material containing cluster, coarse and fine particle. Because of heavy dependency on metallic industries it is generating in this type of huge quantity which create the environmental nuisance. Presently the consumption of slag in India is mark-able up to 20 to 25%.

II. EXPERIMENTAL STUDY

Experimental study was conduct to estimate the physical and mechanical property of concrete by use of egg shell powder and iron slag in a concrete mix. The material was incorporated in partial substitution of cement and fine aggregate as egg shell powder and iron slag correspondingly. General portable water free from any kind of suspended solid was used for mixing.

2.1 Material used

1. Cement- The existing experimental study used the OPC 43 grade fly ash conforming to IS 269:1976. Table given below, show the physical properties of cement used in concrete.

Sr. No	Physical Property	Portland Cement
1	Fineness (%)	1
2	Specific Gravity	2.32
3	Initial setting time (min)	115
4	Final setting time (min)	256

2. Egg Shell Powder: ESP is the waste produced from the poultry farms. ESP was prepared by collecting solid egg shells then shell was cleaned through washing in warm water, afterwards shells were dried naturally and then finally grinded in powder form.

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For this study, Egg shell powder was ordered from the company named Natures Egg Ltd, Ghaziabad. Table given below, shows the physical properties of Egg shell powder used in concrete.

Sr. No	Physical Property	ESP
1	Specific Gravity	3
2	Fineness (%)	1.9
3	Color	White

3. Fine Aggregate: Sieve analysis was conducted to determine the gradation of fine aggregate and particle size should be less than 4.75mm according to IS code. Fine aggregate confirming to IS 383-1970 used. Table given below, shows the physical properties of the fine aggregate used in concrete.

Sr.No	Physical Property	F.A.
1	Fineness (%)	2.62
2	Specific Gravity	2.72
3	Water Absorption	0.86

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4. Iron Slag: Iron Slag is the byproduct produce from the iron and steel production industries. Slag is prepared by grinding the solid slag into powdered form. For the purpose of research work the slag was bought from the grinder near to the railway station, Chandigarh. Table given below, shows the physical properties of iron Slag.

Sr. No	Physical Property	Iron Slag
1	Fineness (%)	3.83
2	Specific Gravity	2.66
3	Water absorption (%)	0.95

5. Coarse Aggregate: The angular coarse aggregate is used conforming to IS 383-1970. Table given below, shows the physical characteristics of coarse aggregate used in concrete.

Sr. No	Physical Property	C.A.
1	Fineness (%)	5.82
2	Specific Gravity	2.63
3	Color	Grey

2.2 Mix design

Mix design of M30 mark of concrete was designed as per specifications of IS: 10262:2009. Ten different mix proportion were performed consisting of control mix (i.e. mix prepared by mixing cement, coarse aggregate, fine aggregate, water) and other nine mix (i.e. mix prepared by mixing cement, egg shell powder, coarse aggregate, fine aggregate, iron slag, water). All mix proportions molded and tested indoor. The percentage replacement of egg shell powder partially with cement were 2.5%, 5% and 7.5% and similarly the percentage replacement of iron slag partially with fine aggregate were 20%, 30% and 40%. Certain proportion has been evaluated to determine the accurate results. Table given below, illustrates the mix composition for 10 different mixes.

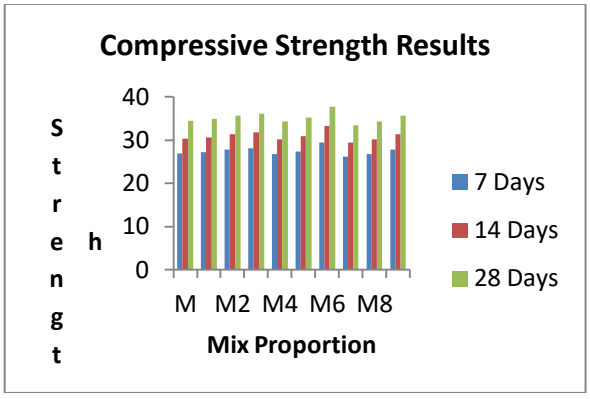
Mix	M	M1	M2	M3	M4
ESP %	-	2.5	2.5	2.5	5
Iron Slag %	-	20	30	40	20
Cement (Kg/m^3)	388.8	379.08	379.08	379.08	369.36
Water (Kg/m^3)	175	175	175	175	175
Coarse Agg (Kg/m^3)	1169.9	1169.9	1169.9	1169.9	1169.9
Fine Agg (Kg/m^3)	749	599.2	524.3	449.4	599.2
ESP (Kg/m^3)	-	9.72	9.72	9.72	19.44
Iron Slag (Kg/m^3)	-	149.8	224.7	299.6	149.8

Mix	M5	M6	M7	M8	M9
ESP %	5	5	7.5	7.5	7.5
Iron Slag %	30	40	20	30	40
Cement (Kg/m^3)	369.36	369.36	359.64	359.64	359.64
Water (Kg/m^3)	175	175	175	175	175
Coarse Agg (Kg/m^3)	1169.9	1169.9	1169.9	1169.9	1169.9
Fine Agg (Kg/m^3)	524.3	449.4	599.2	524.3	449.4
ESP (Kg/m^3)	19.44	19.44	29.16	29.16	29.16
Iron Slag (Kg/m^3)	224.7	299.6	149.8	224.7	299.6

III. TEST RESULTS

3.1 Compressive Strength

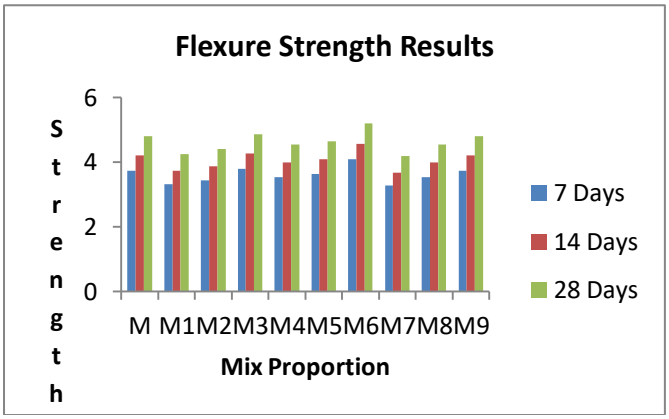
The strength of concrete was investigated for 7, 14 and 28 days after casting of concrete. The cubes of (150x150x150) mm were moulded according to the IS: 10262:1082. Experimental investigation shows high value of 29.48 MPa for M6 concrete proportion. The specified value of M6 increased to 8.6% to control concrete. Fig 1, shows different mix proportion compared with control concrete. However the value found from the experimental practice that 33.26 MPa for M6 is the high value among all other mix after 14 days of testing. The results were evaluated on different mix proportion of concrete. It is observed that 5% of ESP with 40% of iron slag replacement enhances the strength of concrete. The maximum strength of M6 mix proportion obtains the value of 37.8 MPa.



Mix No	ESP %	Iron Slag %	Compressive Strength (N/mm^2)		
			7 Days	14 Days	28 Days
M	-	-	26.94	30.4	34.54
M1	2.5	20	27.22	30.71	34.9
M2	2.5	30	27.76	31.33	35.6
M3	2.5	40	28.16	31.76	36.1
M4	5	20	26.75	30.18	34.3
M5	5	30	27.45	30.97	35.2
M6	5	40	29.48	33.26	37.8
M7	7.5	20	26.13	29.48	33.5
M8	7.5	30	26.78	30.21	34.33
M9	7.5	40	27.84	31.42	35.7

3.2 Flexural Strength

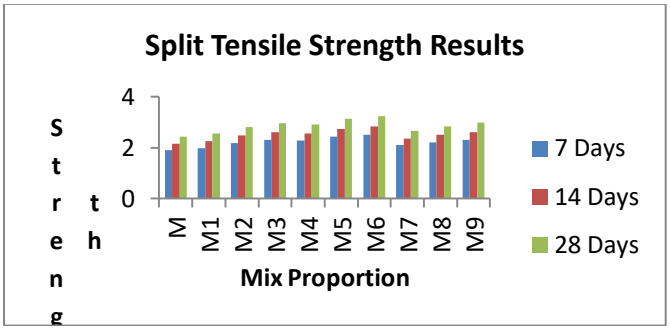
Flexure strength of concrete was conducted as per IS: 10262:1082. The flexure strength of specimen was determined after 7, 14 and 28 days. The results shows the highest value of all the trial mixes on 7 days strength is for M6 i.e. 4.1 MPa. Similarly results shows the value for M6 mix proportion is 4.57 MPa. It has been calculated that there is 7.7% raise in strength as compared to the control mix i.e. M. Fig. 2, shows the results for all mix proportions for 7, 14 and 28 days in that order. The outcome illustrate for 28 days that M6 has got 5.2 MPa as the highest value as compared to the control mix. It consists of 5% partial substitution of cement with ESP and 40% partial alternate of fine aggregate with Iron Slag.



Mix No	ESP %	Iron Slag %	Flexure Strength (N/mm^2)		
			7 Days	14 Days	28 Days
M	-	-	3.74	4.22	4.8
M1	2.5	20	3.31	3.74	4.25
M2	2.5	30	3.43	3.87	4.4
M3	2.5	40	3.79	4.28	4.86
M4	5	20	3.54	4	4.55
M5	5	30	3.63	4.1	4.65
M6	5	40	4.1	4.57	5.2
M7	7.5	20	3.28	3.67	4.2
M8	7.5	30	3.54	3.99	4.54
M9	7.5	40	3.74	4.22	4.8

3.3 Split Tensile Strength

Split tensile i.e. mechanical strength of concrete was conducted as per IS: 10262:1082. The Split tensile strength of specimen was tested after 7, 14 and 28 days. Fig. 3, shows the results of 7, 14 and 28 days for split tensile strength. The results signified that the optimum value of M6 mix proportion i.e. 2.52 MPa at 7 days of testing as compared to the control mix. It is noted that every mix gain some amount of strength as compared to the control mix at 14 days of testing. The optimum value for M6 concrete was obtained at 28 days of testing i.e. 3.23 MPa. As it has proportion of 5% of ESP with 40% of Iron Slag which gain 24.4% strength as compare to the controlled proportion.



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Mix No	ESP %	Iron Slag %	Split Tensile Strength (N/mm^2)		
			7 Days	14 Days	28 Days
M	-	-	1.91	2.15	2.44
M1	2.5	20	1.99	2.25	2.56
M2	2.5	30	2.19	2.48	2.82
M3	2.5	40	2.31	2.6	2.96
M4	5	20	2.28	2.57	2.92
M5	5	30	2.44	2.75	3.13
M6	5	40	2.52	2.84	3.23
M7	7.5	20	2.1	2.35	2.67
M8	7.5	30	2.22	2.51	2.85
M9	7.5	40	2.32	2.62	2.98

IV. CONCLUSIONS

1. The mechanical properties result has shown radical improvement than conventional mix.
2. The optimum value of ESP is 5% and Iron Slag is 40%, alter the harden property of concrete (i.e. compressive, flexure, split tensile strength).
3. The compressive strength enhance up to 8.64% as compare to the conventional mix at twenty eight days of testing.
4. The Flexure strength enhance up to 7.7% as compare to the control mix at 28 days of testing
5. The Split Tensile strength enhance up to 24.40% as with respect to the control mix at twenty eight days of testing.

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