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EVALUATION OF FRESH AND HARDENED PROPERTIES OF SCC BY PARTIAL REPLACEMENT OF CEMENT WITH EGG SHELL POWDER AND FINE AGGREGATE WITH FOUNDRY SAND

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Abstract: The aim of this research is to know the behaviour and mechanical properties of self-compacting concrete after addition of industrial waste in different proportions. The experimental program is carried out by making use of this waste by-product can reduce the environmental problems and out to produce a low-cost and eco-friendly concrete. So as the researches has been done on this eggshell powder by partial replacement of cement in concrete with different percentages and concluded that it has increased the strength of concrete. Foundry sand is high quality silica sand used as a moulding material by ferrous and non-ferrous metal casting industries. Due to the improper disposal of this waste foundry sand causes environmental problems. Thus, by making use of this waste by-product can reduce the environmental problems. Natural sand will be replaced with waste foundry sand in different percentages like 0%, 20%, 30% and 40% and the cement with eggshell powder in the range of 0%, 2%, 4%, and 5% for M-25 grade concrete. The standard cube specimens of 150 mm size will be casted with foundry sand and egg shell powder. The different tests on SCC will be performed to assess the properties such as L-Box test, U-Box test, V-Funnel test and slump test. From this experimental program the combination of eggshell powder with cement and natural sand with foundry sand we shall assess the strength of this blended concrete mix. The specimens will be tested for its 7 days, 14 days and 28 days compressive strength and split tensile strength, flexural strength and the results will be compared with test results of control specimens.

Keywords: Foundry sand; Egg shell powder; High quality silica; Compressive strength; Flexural strength; Split tensile strength.

1. Introduction

In 1988 Japan is the nation that initially created to accomplish durable concrete structure. Before 1988 and furthermore for quite a long while starting in 1983 the Japan was exceptionally intrigued to take care of the issue of toughness of concrete. Self-compacting concrete (SCC) can be described

as a fresh concrete which has unrivalled flow limit under cared for strength (i.e. no separation) in this way allowing self-compaction—that is, material mix without development of imperativeness. The three properties that portray a concrete as self-compacting are

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- Flowing capacity—the ability to absolutely fill all area and corners of the formwork into which it is stored.

- Passing capacity— the ability to experience congested reinforcement without division of the constituents or blocking.

- Resistance to setting apart —the ability to hold the coarse sections of the mix in suspension so as to proceed with a homogeneous material.

Introduction of self compacting concrete with waste foundry sand

Currently, the creation of waste foundry sand as a by consequence of metal casting ventures causes different ecological issues. Utilization of this loss in building material would help in decrease of weight on condition. Utilization foundry sand which is uniform estimated, high standard silica sand.Utilization of waste

foundry sand as a halfway substitution or aggregate substitution by fine aggregate in concrete leads underway of financial, light weight and high quality concrete. Concrete is a material which is made out of coarse aggregate, fine aggregate, concrete, admixtures and water these every material in concrete contributes its quality. In this way, by incomplete or rate supplanting of material influences distinctive properties of cement. By utilizing such waste material which hurts nature can be utilized for the advancement of ease and eco-accommodating building materials. In this examination a test examination is completed by fluctuating level of fine aggregate with utilized foundry sand to deliver minimal effort and eco-accommodating concrete.

Egg shell powder

Table 1. Chemical composition of egg shell powder

constituent	value%
SiO ₂	0.14
Al ₂ O ₃	0.09
TiO ₂	<0.01
CaO	51.25
MgO	0.56
Na ₂ O	0.22
SO ₃	0.6
Fe ₂ O ₃	0.04
LOI	47.25

Table 2. Physical properties of egg shell powder(ESP)

Name	physical property
specific gravity	0.85
moisture content	1.18
bulk density(g/m ³)	0.8
particle density(g/m ³)	1.012
porosity(%)	22.4BET
surface area(m ² /g)	21.2

Eggshell is for the most part discarded as a waste. The egg shell additionally makes a few sensitivities when kept for a more drawn out time in refuse. Destruction is an issue. It makes foul smell which

can cause inconvenience. The chemical composition of Eggshell powder and cement were observed to be comparative. The principle segment of eggshell was calcium carbonate (around 51%) as mentioned in table 1.



Figure1. Eggshell powder

Eggshell comprises of a few commonly developing layers of CaCO_3 , and the inner layer is maxillary, in egg shell 3 layers will developed on outer most part. These layers create the base for the eggshell. The layers creates base on the palisade layer which was the thickest part of the eggshell. The shell itself is around 95% CaCO_3 (which is likewise the primary fixing in ocean shells). The rest of the 5% incorporates Al_2O_3 , MgO , P , K , SiO_2 , Fe_2O_3 and Silica Na_2O . Eggshell has a cellulosic structure and contains amino acids; in this way, it is relied upon to be a decent bio-sorbent and it was accounted for that a lot of eggshells are created in a few nations, as waste items and arranged in landfills every year. The top most and best layer is an upstanding layer enclosed by the cuticle which looks like the dead skin at the base of the finger nail. The ESP principally contains Ca , MgCO_3 (lime) and protein. In numerous different nations, it is the accepted and following for feeding the ESP as calcium content in animal forms. The lime which present in ESP was significantly good and which can resist the degree of presentation to daylight, crude water and brutal climate conditions. These ESP will be grained like fine powder with appropriate and required size before use with concrete/mortar Eggshell squander been advanced from poultry homesteads, eateries and inns. These squanders are utilized as a part of creature nourishes and in numerous nations they are distracted. Such waste is gathered and executed in our project. Ozawa et al (1989) concentrated because of mineral

admixtures, similar to fly ash and blast furnace slag on the streaming capacity and setting a part to with stand of self-compacting concrete. They discovered that on halfway substitution of OPC by fly ash and blast furnace slag the streaming capacity of the concrete enhanced surprisingly. He reasoned that the best streaming capacity and quality attributes 10-20% of fly fiery remains and 25-45% of slag cement by mass. Nan Su et al (2001) proposed mix configuration design procedure for self-compacting concrete. In any case, the measure of aggregates required was settled, and the paste of spreads was then filled into the voids of aggregates to ensure that the concrete along these lines gained has flow capacity, self-compacting capacity and other needed SCC properties. The proportion of aggregates, binders and stirring water, and also make and measurements out of super plasticizer to be used are the principle contemplations affecting the properties of SCC. slump flow, V-funnel, L-box, U-box and compressive strength tests were done to take a investigate at the execution of SCC, and the outcomes exhibited that the proposed procedure could be utilized to make reasonably SCC of high grade. Analogize from the procedure made by the Japanese Ready-Mixed Concrete Association (JRMCA), this system is more effortless, less challenging for use and less repetitive, requires a smaller proportion of binders and extras cost. Dinesh et al (2001) has driven the fundamental by supplanting fine aggregate by rice husk ash and ESP. Here they had supplanted the ESP up to 10%, 20%, 30%, 40% and half utilizing M25

grade concrete. They had test for 7 days, 14 days and for 28 days. In light of the examination in the present test work, they had expected that the tensile, flexural strength was decreased with developing ESP percent. The compressive strength of the concrete is to meet required strength with 20% of the ESP meanwhile weight of the cubes are decreased upto 2kg to 2.8kg.

Miao (2010) drove an examination on working up a SCC with solid substitution up to 80% in every one of the mixes and reviewing its firm properties. Result shows that the fly ash remains goes about as an ointment material; it doesn't respond with super plasticizer and create a horrible power and the super plasticizer may just follow up on the bond. Thus, the bigger the measure of fly ash contained, lesser the super plasticizer required. The main objectives of this paper, To produce low cost and eco-friendly concrete. To evaluate the physical properties and chemical properties of FS and ESP. To study the compressive and split tensile

strength of concrete by partial replacement of fine aggregate with foundry sand with various percentages. To study the compressive and split tensile strength of concrete by partial replacement of cement with eggshell powder with various percentages. Scope of Study-The cement which used in this experimental work is Ordinary Portland Cement (OPC) of 53 grade concrete mix. The course aggregate size which used is 12mm. All the concrete samples are subjected to wet curing. The suitable tests and assessments of concrete samples are done in lab scaled sample. The testing and assessment of concrete chiefly on workability, compressive strength, split tensile of concrete samples.

2. Materials used

Typical particle size and shape

Foundry sand is regularly sub pointed and circular in form. In the wake of being utilized as a part of the foundry procedure, a critical number of sand agglomerations. At the point when these are separated, the state of the individual sand grains is obvious.



Figure 2 foundry rock Figure 3 foundry sand

Grain size analysis of foundry sand

The grain measure appropriation of spent foundry sand is extremely uniform, with around 90 to 98 percent of the material in the vicinity of 4.75mm and 600micron sifter sizes. Five to 20 percent of foundry sand can be relied upon to be littler than 300 micron sifter estimate. The molecule shape is commonly

sub precise to round. A Waste foundry sand degree has been observed to be too fine to fulfil some detail for fine aggregate.

Colour of foundry sand

Green sand is commonly dark or dim in shading. Artificially fortified sand is ordinarily a medium tan or off - white shading.

Chemical properties Foundry sand

Table 3. Chemical composition of used-foundry sand

Constituent	Value (%)
SiO ₂	98.51
Al ₂ O ₃	0.36
Fe ₂ O ₃	0.36
CaO	0.02
MgO	0.01

Na ₂ O	0.05
K ₂ O	0.05
TiO ₂	0.03
M _n 2O ₃	<0.01
LOI	0.32

Spent foundry sand (chemically binded sand) comprises fundamentally of silica sand as shown in Table 1. Following table records the chemical synthesis of run of the mill test of spent foundry sand. According to our finding the sand has exact moment loss of ignition on start which is around 8.90 % .It shows that if the foundry sand is utilized as a part of the development it also can be utilized as a part of the locales where the temperatures are high acid soluble solvent issue in foundry sand

has no impact on concrete since its quality is in extremely insignificant sum. Alternate substance of the foundry sand are the same as found in the characteristic sand that is utilized for the development reason, for example, silica, alumina and ferrous oxide. The nearness of lime i.e. calcium oxide builds the coupling property of the sand to shape blend. In this manner the general impact of the compound substance of foundry sand on the solid is the same than sand.

Table 4.Physical properties of used-foundry sand (UFS)

Property	UFS
Specific gravity	2.2
unit weight kg/m ³	1520
Absorption (%)	1.3
fineness modulus	1.6
Clay lumps and friable particles (%)	0.9
Materials finer than 75µm (%)	8

Super plasticizer

CHRYSO®Fluid Optima S612 is a new generation super plasticizer based on POLYCARBOXYLIC ETHER. It has a high dispersion capability and therefore imparts very high plasticizing effect,acts as a High range water reducer for concrete.



Figure 4 chryso fluid optima S612 (superplastisizer)

Advantages:

CHRYSO®Fluid Optima S612 enables the concrete manufacturer to produce high performance, flow able concrete of all grades with medium to high fines content. It also minimizes the risk of excess retardation though retains the Flow / Workability for

longer time period, often to the tunes of 3-4 hours. Thereby green concrete can be hauled for longer distances and still be placed conveniently around congested reinforcement. The bond strength of concrete to reinforcement steel is considerably

increased. High water reduction minimizes shrinkage or cracking yielding better surface finish. For a given concrete mix, keeping the cement consumption and workability constant, substantial reduction in the amount of mixing water (up to 40%) can be achieved, to produce concrete of high compressive strength. Alternatively, for the same concrete mix, keeping everything else constant, a definite economy in cement content, ranging from 20% to 30%, can be achieved.

Application:

Domains of application

- All cement types
- Pumped concrete with moderate SCM usage
- Slump retention at high ambient temperature
- Self Consolidating Concrete
- Ready mix concrete & Jobsites
- Concrete for highly reinforced structures
- High to very high performance concrete

Characteristics:

- Appearance : Colorless to Light brown liquid
- Specific Gravity : 1.10 ± 0.02
- Air entrainment: ≤ 1.5 % over control mix.
- pH : ≥ 6
- Chloride Content : Nil, as per BS - 5075 (Part-I)
- Compatibility: OPC, PSC, PPC, and SRC.
- Method of use:

Dosage: Optimum dosage can only be established after trials, taking into account the

Mix proportions table 5

Self-compacting concrete is set up by incomplete supplanting of the cementitious material with fly ash of 36% and 5% of lime in M25 grade.

Constituents	FSM 0%	FSM 20%	FSM 30%	FSM 40%	ESP & FS 0%	ESP2% & FS20%	ESP4% & FS20%	ESP4% & FS20%
Cement	13.9	13.9	13.9	13.97	22.870	21.269	20.812	20.584
Flyash	7.86	7.86	7.86	7.86	12.86	11.964	11.7072	11.5786
Lime Powder	.....	.....	.....	.....	.....	1.786	1.786	1.786
Egg Shell Powder	.....	.....	.....	.....	.....	0.714	1.429	1.786
Fine Aggregate	21.84	17.47	15.2	13.10	35.73	28.5891	28.5891	28.5891

rheological characteristics and the required mechanical performances. Rate of addition is generally in the range of 0.2-1.5% by wt of cementitious material.

Hardened concrete properties

48 concrete cubes were examining for compressive strength, the 150mm diameter and 300mm height concrete cylinders were tested for tensile strength and 150mm*150mm*700mm flexural were also tested. Tests were performed at the ages of 7, 14 and 28 days.

3. **Methodology**

Workability

Workability of SCC can be portrayed by three parameters:

- Filling capacity - The capacity of the new concrete to flow under attractive energy, or under strain. (E.g. pumping) and absolutely fill formwork and encase support.
- Passing capacity - The capacity of the new concrete to pass limited segment of the formwork, Thick reinforcement, and so on, without the aggregate blocking.
- Resistance to isolation - The capacity of the new concrete to hold its homogeneity amid the casting procedure and when the concrete has stopped.

Properties of fresh concrete: The properties of new concrete, for example, slump, passing capacity; filling capacity and isolation protection were resolved by particulars. The tests completed to decide these properties were droop stream test, T – 500 tests, L – box test, J-ring test, V – funnel test and U – box test.

Foundry Sand	.....	4.36	6.55	8.736	.....	7.146	7.146	7.146
Course Aggregate	43.68	43.68	43.6	43.68	71.470	71.4703	71.4703	71.4703
Water	8.73	8.73	8.73	8.73	14.294	14.294	14.294	14.294
Super Plastisizer	0.1	0.15	0.15	0.15	0.232	0.232	0.232	0.232



S.NO	METHOD	PROPERTY	EXPERIMENTAL VALUE	AS PER EFNARC
1	Slump flow	Filling ability(mm)	600	900
2	T50cm slump flow test	Filling ability(sec)	3	5
3	V funnel	Filling ability(sec)	10	12
4	V funnel 5min	Segregation resistance(sec)	12.5	15
5	L-Box	Passing ability H2/H1	0.8	1

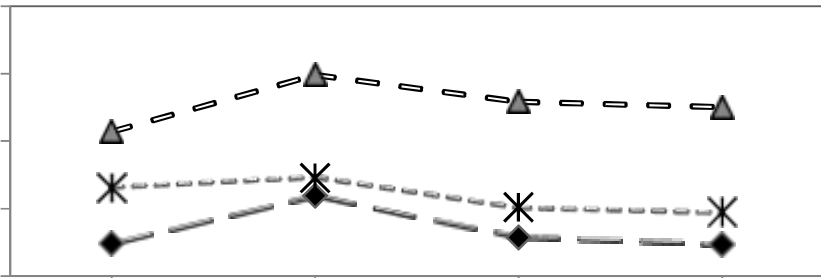
4. Results

5Compressive strength (CS) values for cubes in replacement of fine aggregate (FA) with foundry sand (FS)

From the above figure 5 it shows that the CS is gradually increasing with the increasing of FS percentage in replacement of FA. For M25 grade of scc the CS is 40.17 N/mm². In this figure, the increasing of CS depends up on the increasing of FS in FA. For 20% of FS in replacement of FA, the CS of scc is 29.03 & for 30% of FS the CS is 31.06



Figure 7 compression test for 30% of foundry sand



8 Compressive strength values for cubes with combination of ESP and FS

From the above figure the value of CS shows that the combination of ESP & FS has increased the strength of the cubes. In this figure, it's clearly showing that there is another supplement which added in concrete. Some amount of cement is replaced with ESP. The ESP & FS is replaced with both cement and FA. As 20% of FS is taken as constant replacement of FA, the ESP varies with different percentages. From the graph the results clearly explains the strength of concrete increase till the 2% of ESP. After adding more than 2% of ESP, the graph slowly decreases with the increase of ESP. The 5% of ESP in cement has reached or crossed more than the target mean strength. By this result, it clearly shows that the additional high content of calcium has decreased the strength of the concretes



Figure 8 sample 1

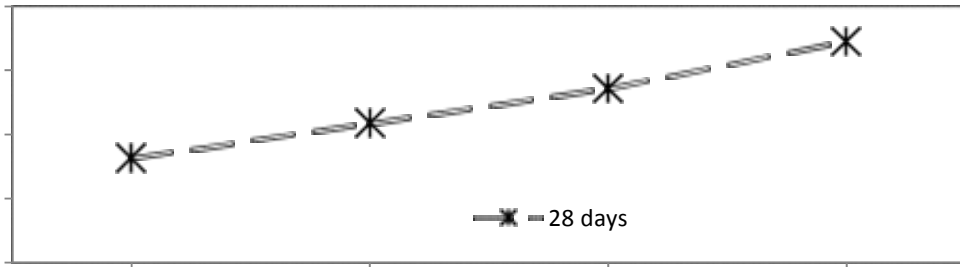


Figure 9 sample 2

Figure 10 sample 3

Figure 11 sample 4

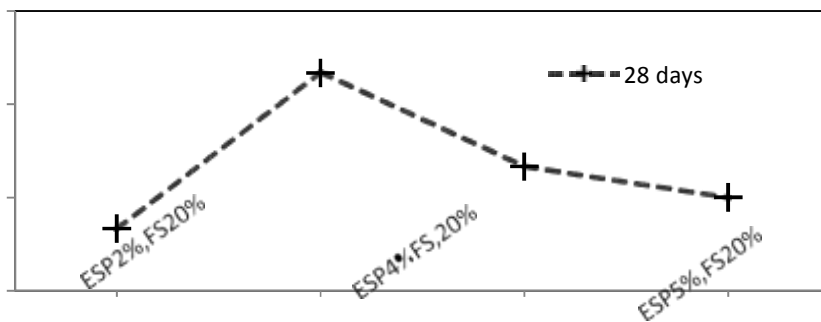




FS proportions

Figure 10 Split tensile strength (TS) values for cylinders in replacement of FA with FS

By this figure 10, I conclude that the TS increase by increasing the FS%. In FS the silica content is more when compared to natural sand. In natural sand or the sand which comes from the earth crust the silica percentage is 59%. In foundry sand the silica content is 98.51%. Due to having high content of silica the TS increase with the increasing of FS.



ESP & FS Proportions

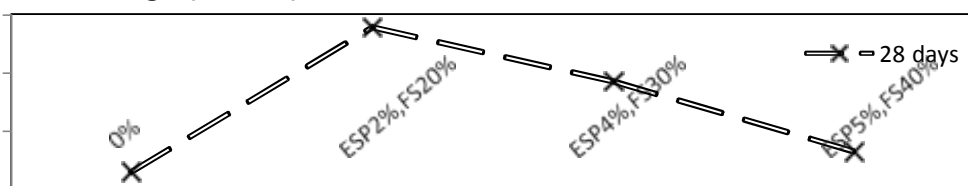
Figure 12 Tensile strength (TS) values for cubes with combination of ESP and FS

In this figure 12, the TS increases till certain point & starts decreasing. In this TS the strength, the strength gained by the combination of FS & ESP. By taking 20% of FS as constant the ESP varies in 2, 4, 5 percentages. In ESP the calcium content is high. So the strength has gained till 2% of ESP with the combination of 20%. After that more than the 2% of ESP limit, the ST decreases with increases of ESP because the calcium increases in concrete & it reduces the strength of the concrete, if the calcium is more than the limit.



Figure-13 Split tensile test

Flexural Strength(N/mm²)



ESP & FS Proportions

Figure 14 Flexure strength values with combination of ESP and FS

The FS increases till the ESP is 2% & the FS starts decreasing in additional of ESP. In this FS the silica plays a key role to maintain the strength of the concrete. In international concrete abstracts portal (volume 89, issue-4) The American Concrete institute has accepted that the strength o the concrete increases with the silica content. It has declared in past 7/1/1992 itself. In IJERT it also concluded that because of silica fume. There will be high early CS, high TS & FS because of silica, in volume 6, issue 1 on January 2015. By this from the above figure the additional of calcium (51.25) in the form of ESP has decreased the FS.

CONCLUSION

From the above data there are many conclusions to conclude. As the silica content is high in foundry sand, the research has been performed for different proportions of 20, 30, and 40.

From based on this result I have taken 20 percent of foundry sand as constant the eggshell percent varies with 2, 4, 5 percentages. The following conclusions are made from above study.

1. The availability of the waste materials likes foundry sand and eggshell powder is abundant, using these materials will be economical.
2. The use of foundry sand as a partial replacement of fine aggregate and eggshell as partial replacement of cement in scc the compressive strength of concrete has increased.
3. Up to 40% fine aggregate can be replaced with foundry sand.
4. The compressive and tensile strength of scc containing 20% of foundry sand and 2% of eggshell powder gave the better results when compared with the other proportions.
5. Foundry sand having about 98.51 of silica content, the presence of silica increases the compressive strength of concrete.

Future scope

1. By varying the water cement ratio, the compression strength of cubes can be checked for the same proportions of the material.
2. The admixture can be replaced by another admixture which is economical and durable.

3. The experimental work can be done by varying the foundry sand percentages and keeping the eggshell power as constant of 2%.

4. By keeping the foundry sand as constant material, the eggshell powder can be replaced with any natural disposable waste.

5. With the same proportions the experimental work can be done with different grades.

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