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Research Article

Influence of Steel Crystal Bonding Powder as Partial Replacement to Cement in Concrete

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Abstract

This paper presents the salient features of an experimental study on concrete using S.C.B. Powder. Concrete blocks prepared by partially replacing cement with S.C.B. powder are tested for the compressive strength, water absorption capacity and density characteristics with varying replacement percentage of cement with S.C.B. powder. Honey-combing remain in concrete during concreting work is the major concern to the civil engineer, structural engineers. The effect on the formation of honey combing is critically examined by casting concrete block using SCBP. S.C.B. powder, the waste obtained from steel factories, M.S. steel workshops if used for partially replacing cement can influence compressive strength of concrete to a considerable extent. Keeping this in view an experimental study has been carried out to test the performance of S.C.B. powder in cement concrete blocks. Effect of type of curing on compressive strength, density etc. have also been carried out on various proportions of cement and S.C.B. powder partially replaced with varying % of cement by weight. Blocks of 150 150* 150 mm are considered for test report. The results of the various tests are sufficiently encouraging and author suggests to use up to 6% S.C.B. powder. Since compressive strength for this ratio is found to be 20.14 N/MM² under gunny bag curing condition and provides optimum & desired result for M15 grade of concrete. Other parameters are also found improved.*

Keyword: *SCBP, compressive strength, Water cement ratio, Density*

1. Introduction

[1]Steel crystal bonding powder is an industrial waste material which is obtained from steel manufacturing industries, leath machine, ironed depot and workshops, in various shapes and sizes as shown in fig.1. In India proper utilization of such waste has not been given due attention nor it has been properly reused. This S.C.B. powder dust there by constitutes an environmental nuisance as they form refuse heaps in the premises of steel/rolling mills and workshops.

Fig.1 Different particle shape and size of SCB powder

Similarly cement is a factory made construction product consumed energy and natural resources for its production and producing large amount of carbon dioxide in the atmosphere. Huge consumption of

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cement in concrete structures also facing a acute shortage of silica. According to the environmentalist removal of silica from its sources may create environmental problems in future to come.

Compressive strength of blocks is a measure of their resistance to load application when placed in the crushing machine. I.S./ B.S recommends 1.5 N/mm^2 mean strength for M15 grade of concrete . (Neville A. M. 1983).

Little research have been carried out on such industrial waste to provide solution of getting better quality concrete.

As by product of steel manufactory industry, steel slag is discharged @ 0.12-0.13 T/T· steel produced. China's steel slag output in 2011 was 90.42 million tons, of which the utilization ratio was about 25%. Resource recovery has become an important issue of steel manufactory industries. This steel slag powder has been used in manufacturing of concrete and results are found favorable to replace cement with S.S.P. Study proves that Concrete produced by steel slag powder as admixture can obtain an increased strength. (G. Zhu, Y. Hao, *et al*, 2013)

In one of the research study Steel fiber was used to solve the brittle failure problem observed in concrete at high- intensity stress. To develop ultra- high strength powder concrete, coarse aggregate was replaced with 0.6 mm and smaller Ferro- silicon, bauxite, dolomite, and silicon, which finally showed that the effect of aggregates on the compressive strength was favorable in the order of : Ferro-silicon > bauxite > dolomite > silicon. In addition, it was also found that cement paste was highly strengthened by fine aggregates, compactly filling powder, and the use of reactive materials. Ferro-silicon showed the highest strength when its mixture was 110% on the basis of cement weight. (Byun g-Wan Jo, Kwan g-Won Yoon *et al*, 2012)

Similar study on steel fiber reinforced concrete has been carried out. Study reveals that, Flexural bending strength can be increased of up to 3 times more compared to conventional concrete. The amount of fibers added to the concrete mix is expressed as a percentage of total volume of the composite (concrete and fibers). Other interesting results of using steel fiber in concrete are, Fatigue Resistance increases Almost 1 1/2 times, Greater resistance to damage in case of a heavy impact, The concrete become less porous, More effective composition against abrasion and spalling and Shrinkage cracks can be eliminated. (Barros J.A.O., Figuerios 1999; Balendra R.V., F.P.Zhou *et al*, 2002; Amit Rana, 2013).

Thus research on steel slag, steel fiber has been carried out at many places. However, the industrial waste which content steel crystal powder (F.M. @ 0.69) on which little research work has been carried out nor any attempt for its replacement with cement has also not been carried out. The attempt in this report is to use to replace cement by steel crystal bonding powder in manufacturing concrete for desire result. As case study M-15 grade of concrete is taken for this study.

Keeping all the above issues in mind object of the study was to

- Investigate the performance of S.C.B. powder as partial replacement of cement in manufacturing cement concrete blocks in order to reduce overall construction cost and to minimize the environmental issues created due to excessive use of cement.
- To suggest a rational proportion of cement: S.C.B. powder: sand: course aggregate & w/c ratios based on experimental observation which will effectively produce high strength, water proof concrete.

Various test carried out are cube compressive strength under different curing condition on M-15 grade of concrete, density relationship, water absorption etc. However, fire resistance, weather, resistance, thermal and sound insulation though important are beyond the scope of this study and needs separate investigation.

2. Materials & Method

The materials used to manufacture light weight cement sandcrete mortar block consist of:

- Cement (OPC)
- Local sand (fineness modules 3.37)
- S.C.B. powder obtained from steel industries, rolling mills, sugar factories of Pusad (India) town (fineness modules 0.69. & density 7980 kg./cum.)

150x150x150 mm solid blocks were produced under laboratory condition. The mix ratio used was 1:2:4 with different replacement percentage of cement with S.C.B. powder. For each replacement percentage 30 blocks sample were casted. The replacement percentage and water cement ratio to make workable mix at each level used is shown in table 1.

Mixing: - The required quantities of material were weighted out as per proportions and mixing was done as per IS specification. Drum type mixer was used for mixing the material.

Moulding: -Casting was affected as per IS specification and compacted with the help of electrically operated vibrating machine. Size of block used was 150mm* 150x 150mm. various mix proportions providing (cement: S.C.B. powder: fine aggregate: course aggregate) tested were:

1:2:4 (0%, 2%, 4%, 6%, 8% & 10% cement replacement with S.C.B. powder)

Curing: Specimens were divided into two sets for curing under sprinkling method and submergence under tank method and was affected up to 6 days,13 days, 27 days, for testing the blocks for 7 days, 14 days & 28 days. De molding was affected after 24 hours.

Testing: -Blocks were tested for compressive strength separately and density of block at 7 days, 14 days and

28 days. Effect of type of curing on compressive strength, effect of S.C.B. powder on water observation % has also been tested. (B. I. S. 2009; B. I. S. 1970; Shetty M. S, 1982)

Materials used for preparing concrete blocks were tested as per IS specification.

(B. I. S., 1991-07; Shetty M. S, 1982) and following are the observations.

- Fineness modulus of S.C.B. powder was found to be 0.69.
- Fineness modulus of sand was found to be 3.37.
- Fineness modulus of course aggregate was found to be 4.14.
- Moisture content of S.C.B. Powder was found to be 1.00% which is negligible.
- Silt content in local sand was found to be only 3%.

Curing and its types plays vital role on the effect of compressive strength. The main objective of curing is to keep concrete / saturated or nearly saturated so as to support the hydration of cement, eliminating problem likes plastic shrinkage cracking. (Neville A. M. 1983). The concrete blocks with varying percentage replacement of cement with S.C.B. powder under, Sprinkler curing and tank curing are tested for compressive strength at 7,14 and 28 days.

3. Result and discussion

The variation of compressive strength with curing age for different ratio of partially replacement of cement with S.C.B. powder under above curing conditions are presented in Table 1. The result of compressive strength of concrete blocks and its trend with reference to proportion, age of curing and type of curing are represented in fig. 2 & 3.

Table 1: Compressive strength on various proportions of cement: S.C.B. P.: Sand: aggregate under sprinkler curing

Sr.	Grade of concrete (M-15)			Compressive strength N/mm^2 & Curing period			Type of curing
	Cement (%)	S.C.B.P.(%)	w/c Ratio	7 days	14 days	28 days	
	1:2:4 (M-15)						
1	100	0%	0.5	7.2	14.40	18.51	S.C.
2	98	2 %	0.6	9.3	18.20	22.15	S.C.
3	96	4%	0.6	10.00	18.50	22.20	S.C.
4	94	6%	0.7	10.6	20.14	22.50	S.C.
5	92	8%	0.87	8.59	17.11	19.30	S.C.
6	90	10%	0.5	8.70	15.30	18.60	S.C.

S.C. – Sprinkler curing

Table 2: Compressive strength on various proportions of cement: S.C.B. P.: Sand: aggregate under Tank curing

Sr.	Grade of concrete (M-15)			Compressive strength N/mm^2 & Curing period			Type of curing
	Cement (%)	S.C.B.P.(%)	w/c Ratio	7 days	14 days	28 days	
	1:2:4						
1	100	0%	0.5	7.5	15.00	18.00	T.C.
2	98	2 %	0.6	9.5	17.05	21.50	T.C.
3	96	4%	0.6	10.00	18.00	22.00	T.C.
4	94	6%	0.7	10.2	19.50	22.00	T.C.
5	92	8%	0.87	8.50	17.00	19.00	T.C.
6	90	10%	0.5	7.5	15.00	17.00	T.C.

T.C. –Tank curing

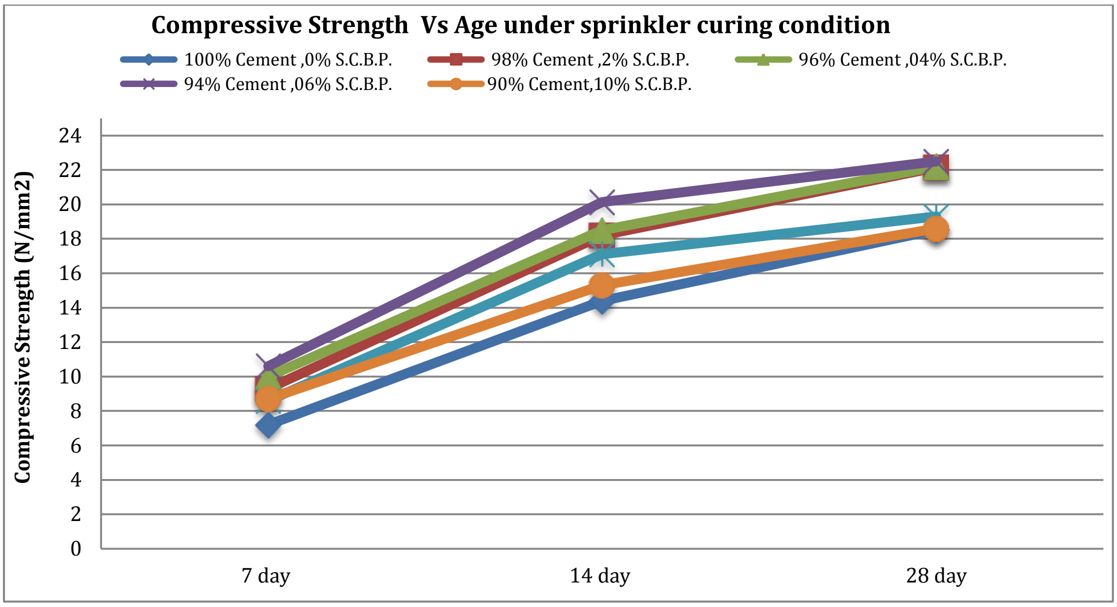

Fig.2 Compressive Strength Vs Age under sprinkler curing condition

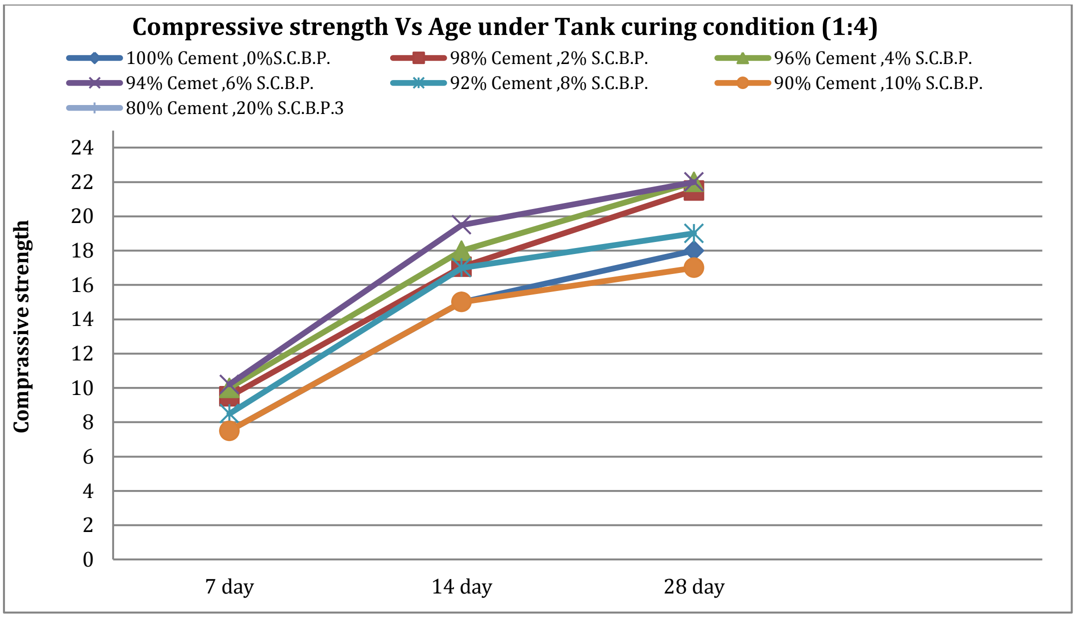

Fig.3 Compressive strength Vs Age under Tank curing condition

Density

It is observed that there is hardly any significant change in the density as percentage of S.C.B. powder increase in concrete. The variation of density for varying percentage of S.C.B..powder replacement is presented in Table 3.

Table 3: Density – S.C.B.P. content relationship

Sr.no.	Grade of concrete (M-15)		Curing period & Density kg/m^3		
	Cement (%)	S.C.B.Powder (%)	7 days	14days	28days
1	100	0%	2536	2536	2536
2	98	2%	2532	2446	2446
3	96	4%	2518	2506	2506
4	94	6%	2532	2502	2502
5	92	8%	2510	2509	2509
6	90	10%	2509	2510	2510

Water Absorption

S. C. B. powder is more susceptible to moisture and hence water absorption test on each concrete blocks was carried at 28 days and the result are presented in Table 3 and water absorption trend is represented in Fig. 9. Water absorption is within reasonable limit for any replacement percentage of S.C.B. powder.
Table 4 Water absorption of Concrete with different replacement percentage.

Table 4: Water absorption – S.C.B.P. content relationship

Sr.No.	Cement (%)	S.C.B.powder (%)	Water observation (%) at 28 days
1	100	0%	3.0
2	98	2%	2.8
3	96	4%	3.2
4	94	6%	3.3
5	92	8%	3.0
6	90	10%	2.4

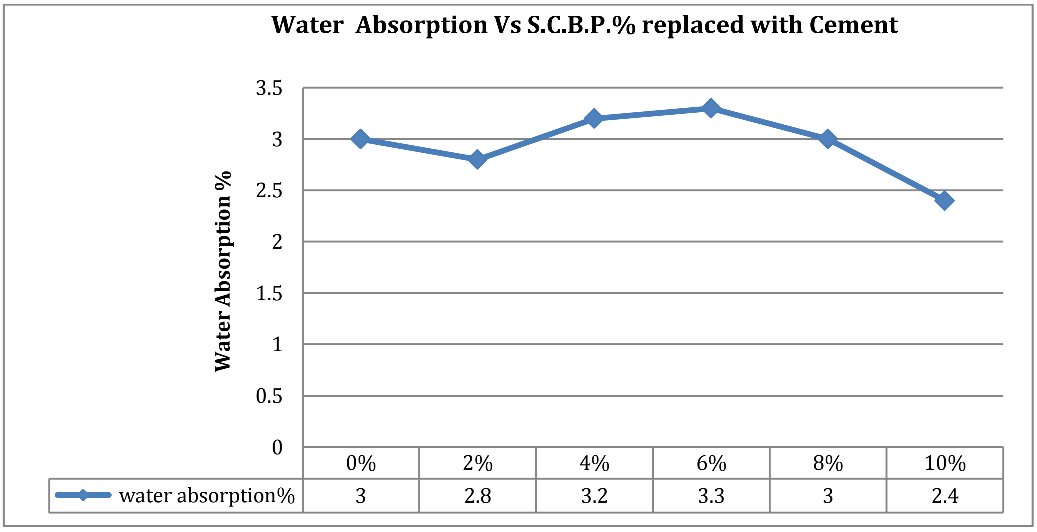

Fig.9 Water Absorption Vs S.C.B.P.% replaced with Cement

4. Analysis of result and discussion

To introduce the use of S.C.B.P. in concrete, the experimental analysis has been carried out. All experimental data and their results have been presented in the form of Tables and Graphs.

The Table 1 and typical nature of graph shown in Fig. 2 & 3 shows that as the percentage of S.C.B.P. increases, there is increasing in compressive strength significantly. The behavior of block in compression as shown in fig. 2 & 3 reveals that compressive strength is more under sprinkler curing as compared to tank curing. This may be due to the fact that, the sprinkler provides higher range of hydration to the block, that lead to desirable results.

The average value of the strength of concrete of nominal mix of 1:2:4 varies from 15 to 16 N/mm^2. It is worth noting here that the sprinkler curing to 6% replacement of cement with S.C.B.P. provides sufficient compressive strength (22.25 .N/mm^2) at 28 days.

Density analysis shows that as % of S.C.B.P. increases, there is hardly any change in density. The results are shown in Table 3. It is worth noting here that the to 6% replacement of cement with S.C.B.P. provides value of density is 2502 kg/m^3.

The absorption of water to some extent is appreciable and advisable, but excessive of it causes various defects in the block. Seepage of rain water, shrinkage of block after drying, thus cracking of blocks, opening of the joints are few points to be taken in to consideration. The addition of S.C.B.P. to the block raises the limit of its water absorption to significant extent. Test results are mentioned in Table 4. Experimental results show that water absorption % of concrete for a various proportion of S.C.B.P. % ranges from 2.00.% to 3.4 For 6% replacement of cement with S.C.B.P. provides water absorption capacity was found to be only 3.3%, which is within permissible limit.

Conclusion

The objective of this study was to focus the attention on performance of S.C.B.P.in concrete.

Detailed study was carried out and experimental work was done. Final conclusions of the study are as below.

Compressive strength of the block is the major factor to be taken into account for the construction purpose. It varies with the addition of the S.C.B.P. As the present study emphasizes on the replacement of the cement with S.C.B.P. and to check the influence of powder on concrete properties. For 6% replacement of cement by S.C.B.P. gives strength of 22.50 N/mm^2 which is reasonable. For m 15 grade of concrete. Hence 6% replacement is recommended. Here our ultimate aim is to reduce cement consumption. For M-15 grade strength received is 22.50 N/mm^2 which is characteristics strength of all most M-20 grade concrete.

Density of concrete shows very negligible changes on replacement of cement with of S.C.B.P. At 6% replacement of cement with S.C.B.P. density is 2502 kg/m$^{3.}$

Water absorption capacity increases with increase % of S.C.B.P. Larger absorption of water causes the reduction in the strength. However for 6% replacement, water absorption found to be within reasonable limit.

Two types of the curing method were adopted for the experimental work. (Sprinkler & Tank curing). The result of first method of curing was appreciable. This was due to the fact that S.C.P.B. contained blocks required light but regular moisture content for hydration purpose.

It is observed that the results of the tests are sufficiently encouraging to replace cement by 6% with S.C.B.P. The saving in terms of materials are appreciable.

Fire proof, thermal resistance properties, quality of S.C.B.P. and its effect on compressive strength, bending strength, statics hardness and shear strength require further study. Scope of the study can further be extended on other proportions of concrete.

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