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APPLICATION OF INNOVATIVE ADMIXTURES FOR ECONOMICAL CONCRETE BLOCKS

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Abstract

In India the old tradition of production of concrete is still prevalent as some argue that these are the best ways to give strength to construction materials. But nowadays with innovative ideas and new materials the construction industry is on the path of developing new building blocks using industrial waste materials, the researchers all across the globe are not just focusing on manufacturing stronger concrete blocks, but also thinking about making them more environmentally friendly. Foundry sand is an excellent non hazardous admixture which gives enhanced strength to concrete. It is a by-product of iron and steel industries or automobile industries and its part suppliers, which cause environmental problems due to its improper disposal. In India and all across the globe, there is scarcity of land for the disposal of this industrial waste therefore these can be utilized as additive materials in construction firms. In this paper the author proposes the use of foundry sand in the preparation of concrete blocks for sustainable building material. Test samples containing foundry sand as a partial replacement of fine aggregate from 0% to 40% of M_{25} grade concrete by weight were casted and tested for their workability and compressive strength. The test samples yielded good strength with the increase in the partial replacement of sand by foundry sand.

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1. Introduction

Foundry sand is also known as green sand, it is uniformly sized, high quality silica sand generated as a by-product of ferrous and non ferrous metal castings. It is can be used as a potential substitute of sand in standard grade concrete because it is readily available and inexpensive and provides enhanced strength and durability[1-4].The main constituent of foundry sands is silica (SiO_2), present in the form of quartz. It may contain some impurities, such as ilmenite ($FeO\text{-}TiO_2$), magnetite (Fe_3O_4), or olivine, which is composed of magnesium and ferrous orthosilicate [(Mg,Fe) SiO_4]. The casting production is considered the main source of foundry production that influences the world economy. China is the leader in the casting production and India holds second position in the world producing, thus our country is producing large amount of foundry sand. This waste material requires large land areas for dumping, that causes environmental degradation. The reuse of this in development of new construction materials provides practical solution to this problem; moreover the material gains extra strength on its addition [5-7]. This paper demonstrates the development of concrete blocks made by partial replacement of fine aggregate with foundry sand for concrete of grade M_{25} by weight. The effect of addition of foundry sand was investigated by varying the percentage from 0 to 40% by weight. Five test samples of concrete blocks of each composition were produced and examined for workability and strength characteristics of concrete mix after curing for 7 days, 14 days and 28 days. The slump values showed a decrease while compressive strength showed remarkable improvement.

2. Materials and methods

2.1 MATERIALS

This work was executed at JK Cement works at Jharli plant, Jhajjar, Haryana, India. Concrete blocks were made by partial replacement of fine aggregate with foundry sand for concrete of grade M_{25} by weight. The raw materials required for the preparation of concrete blocks were cement, sand, coarse aggregate and foundry sand. Ordinary Portland Cement of grade 53 (having specific gravity 2.78), sand and coarse aggregate were available at Jharli plant, while foundry sand an industrial waste (having specific gravity 2.61and bulk density 1638 Kg/m^3) was obtained from iron and steel plant[8]. It is important to clean the sand because it may contain some clay and silt. Therefore the sand to be used was washed, dried then passed through IS sieve no. 4.75 mm having 2.4 fineness modulus. The percentage of foundry sand replaced was 0-40% in preparation method of blocks. Water content also principally decides the workability and strength of concrete. Larger the amount of water, greater will be the workability of concrete as fluidity increases but it reduces the strength of concrete. But on keeping too low water concentration workability reduces. Hence, it becomes difficult to use such concrete in the structure. Amount of water required may vary for same volume of concrete for various grades of concrete. Hence, a balance has to be found in the construction site during concrete mixing. In this experiment the water cement ratio of M_{25} grade of concrete was kept 0.5(w/c). The workability and strength was determined experimentally for at least 5 test blocks of each composition having the percentage of foundry sand as depicted in Table 1.

Table1 Percentages of different samples of concrete cubes

Sample No.	Percentages of replacement in mix	
	Sand %	Foundry Sand %
F_0	100	0
F_1	95.0	5.0
F_2	90.0	10.0
F_3	85.0	15.0
F_4	80.0	20.0
F_5	75.0	25.0
F_6	70.0	30.0
F_7	65.0	35.0
F_8	60.0	40.0

2.1 Method

The concrete cubes of size 150mm×150mm×150mm were produced to investigate the compression strength test. In the process of formation, first the appropriate amount of ingredients (cement, sand, foundry sand, coarse aggregates of size 20 mm and water) were fed in conventional rotary drum concrete mixer and blended for 3-4 minutes. After the mixture having different percentage of foundry sand was blended properly it resulted in a homogeneous mixture. This was then transferred in vibrating machine and cubes were casted in moulds of given size and covered with wet gunny bags. Then after 24 hours all the samples were demoulded to give samples F_0 to F_8 of specified dimensions. All the sample cubes after being cured for 7 days, 14 days and 28 days were tested according to the Indian standard codes. i.e IS 456: 2000 for workability and compressive strength.

3. Results and discussion

3.1 Workability of Concrete

Workability is a property of freshly mixed concrete. It simply means the ability to work with concrete. The ease of placing, compacting, and finishing of concrete in the desired manner is called its workability [9]. The single most important nature of workable concrete is its lubricating nature. If a concrete shows more lubricating nature, then it will have many advantages, such as it will exhibit little internal friction between particle and particle, also it will overcome the frictional resistance offered by the surface and reinforcement contained in the concrete. It can be consolidated with minimum compacting effort. Mostly slump test is used on construction sites to determine the workability as it is simple and can be done easily. Slump cone is employed for conducting the slump test. Slump test was conducted to know the workability of samples F_0 to F_8. The slump for F_0 sample was found to be 69 mm. For concrete mixes of different composition (little variation was observed, the values are tabulated in Table 2 and graphically shown in Figure 1.

Table 2 Slump on partial replacement with foundry sand

Sample No.	Slump (mm)	Sample No.	Slump (mm)
F_1	67	F_5	52
F_2	64	F_6	48
F_3	62	F_7	41
F_4	57	F_8	34

The figure 1 shows that the slump value decreases with the increase in amount of industrial waste (foundry sand). The workability deteriorates by 30.43% for F_6 sample while the compressive strength for the same was maximum and then for 40% increase in foundry sand the deterioration is to a large extent in the concrete mix than the standard concrete.

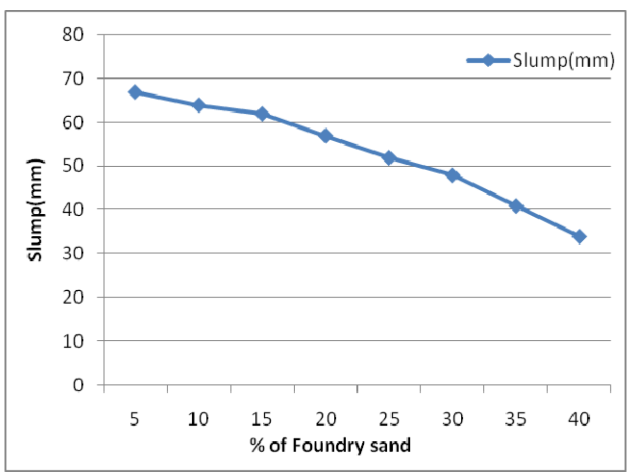

Figure 1 Slump on partial replacement with foundry sand

3.2 Compressive strength

Compressive strength of concrete was determined by compressive strength test on F_0 to F_8 samples cubes which were compacted by means of a standard vibration machine. The test was done for all six test samples after curing for 7 days, 14 days and 28 days in order to check the load bearing capacity of the cubes for construction work. The test samples were kept on the surface of compressor after cleaning it, then the load was applied and increased continuously till the samples showed failure. The readings were recorded from the meter of the testing machine. The average of three readings was taken to calculate the compressive strength of concrete cubes in N/mm^2. Then, compressive strength was calculated using formula as given below.

$$\text{Compressive Strength } (N/mm^2) = \frac{\text{Maximum load at failure in N}}{\text{Cross sectional area in mm2}}$$

The cross sectional area of cubes were calculated for each sample with varying amount of foundry sand and then the average was taken. The maximum load failure was also determined by keeping the concrete mould in testing machine one by one in the laboratory. Then compressive strength of samples F_0 to F_8 were determined by using the above mentioned formula and tabulated in Table 3.

Table 3 Average Compressive Strength of samples

Sr. No.	Specimen Designation	Average Compressive Strength ($N\ mm^{-2}$)		
		7 Days	14 Days	28 Days
1.	F_0	15.65	23.12	25.54
2.	F_1	16.92	24.35	26.87
3.	F_2	18.43	25.96	28.38
4.	F_3	19.67	27.45	30.73
5.	F_4	20.36	29.26	33.14
6.	F_5	21.94	31.63	35.62
7.	F_6	22.87	33.78	37.25
8.	F_7	22.14	32.43	36.33
9.	F_8	20.82	30.37	34.74

The comparative plot of average compressive strength of concrete cubes with respect to percentage of foundry sand (0 to 40%) is illustrated in Figure 2, which clearly shows that with each addition of foundry sand to standard M_{25} concrete cube in the sample the average compressive strength increases till F_6 specimen. In F_7 ($36.33 N/mm^2$) and F_8 ($34.74 N/mm^2$) the compressive strength decreases showing a decrease in strength of concrete cubes. Hence it can be visualized that addition of foundry sand greater than 30% decreases the strength. It is suggested that 30% of foundry sand can provide enhanced strength than conventional concrete mix of M_{25}. The addition of pozollanic additive plays an important role to enhance the strength of material [10-11]. These pozollanic characteristics of admixture in standard concrete mix accounted for increase in compressive strength of the cube. Another reason for enhanced compressive strength is the improved bonding between foundry sand and cement.

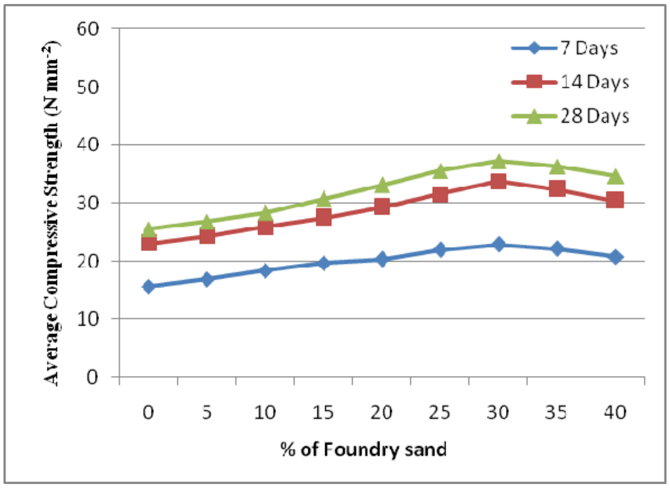

Figure 2 Average Compressive Strength on partial replacement with foundry sand

4. Conclusion

In conclusion, the rationally designed cubes of grade M_{25} by weight were prepared using industrial waste foundry sand. The slump value decreased with the increase in the foundry sand content. The slump value was found to be 48mm for F_6 sample i.e. a decrease of 30.43% compared to F_0 sample. The compressive strength of concrete cubes containing foundry sand was found to be more than that of conventional concrete mix. Experimental investigations revealed that compressive strength increased by 45.84% for F_6 sample, beyond this content of foundry sand the strength started to decline. The optimal percentage of foundry sand to be used was found to be 30% i.e. for F_6 sample which showed enough workability and enhanced compressive strength. Performance of all samples in terms of compressive strength was pretty well, hence the cubes made by partial replacement of sand by foundry sand finds applications in various construction works and is cost effective as well as environmental friendly.

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