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A Study on Self-Compacting Concrete by Replacing Fine Aggregate and Cement by Foundry Sand and Dolomite Powder

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Abstract : In recent years, Self-Compacting Concrete (SCC) has gained wide use for placement in congested reinforced concrete structures with difficult casting conditions. This project explores the Strength studies of Self-Compacting Concrete by using Foundry sand and Dolomite powder. Foundry sand consists primarily of silica sand, burnt carbon, binder and dust. It can be used to improve the strength and durability properties of concrete. Foundry Sand can be used as a partial replacement of fine aggregates or total replacement of fine aggregate and as supplementary addition. Dolomite powder is obtained by powdering the sedimentary rock forming mineral dolostone which can be used as a replacement material for cement in concrete. Dolomite powder has some similar characteristics as of cement. In the present study, sand is being replaced with Foundry sand and Dolomite powder is chosen as replacement for cement. Viscocrete-20 HE is preferred as super-plasticizer. The Mix design for SCC is arrived using the guidelines of EFNARC. The percentage replacement for foundry sand with sand includes 10%, 20%, 30%, 40% and cement is replaced with dolomite powder for 5, 10 & 15% and tests were performed for all replacement levels for M30 grade concrete at different curing periods.

1.0 Introduction

The invention of Self Compacting Concrete (SCC) is considered as a major evolution in construction industry[1]. As the name says the concrete flows under its own weight without any vibration. This concrete type finds major application where congested reinforcement are used and in places which requires higher mechanical compaction. SCC also provides better surface finish, segregation resistance, uniform consolidation, etc. When large quantity of heavy reinforcement is to be cast in a reinforced concrete member, it is difficult to ensure that the formwork gets completely filled with concrete[2,5]. Metal foundries use higher amounts of sand as part for the metal casting process. After casting process foundries recycle and reuse this sand several times. But after several cycles it becomes useless and it is known as Waste Foundry Sand (Green Sand)[6]. The application of waste foundry sand to various engineering sector can solve the problems of its disposal and harmful effects to the environment. Being used in metal casting industry this soil type contains some properties of the metals casted using it. Dolomite Powder is the Limestone Powder with composition of CaCo3 and MgCo3 pertaining to 100% in combination, the proportion being varied as per Mining Zone. Dolomite powder has some similar characteristics of cement[4]. Using dolomite powder in concrete can reduce the cost of concrete and may increase the strength to some extent. The cost of dolomite is less than that of cement.

1.1 Objective of the Work

- To determine the properties and strength of SCC for different foundry sand and dolomite powder ratios.
- To investigate the structural performance of SCC.
- To overcome the high utilization of cement and natural sand due to the developing infrastructure.

2.0 Materials Used

2.1 Cement

Cement is a binder which can bind other materials together. Several types of Portland cement are available and the most common is Ordinary Portland Cement (OPC) which is grey in color. OPC of 53 grade is used in the experiment.

Table 2.1 Properties of cement

S.No	Properties	Values
1.	Specific Gravity	3.15
2.	Bulk Density	1440 kg/m^3
3.	Initial setting time	30 min
4.	Final setting time	600 min

2.2 Fine Aggregate

Sand is a naturally available granular material composed of finely divided rock and mineral particles. Its size is defined as being finer than gravel and coarse than silt. River sand conforming to Zone-II of IS 383- 1970 is used in this investigation and it was well graded, which passes through 4.75mm sieve.

Table 2.2 Properties of fine aggregate

S.No	Properties	Values
1.	Specific Gravity	2.63
2.	Bulk Density	1660 kg/m^3

2.3 Coarse Aggregate

The coarse aggregate used for SCC must typically be round in shape, well graded, and smaller in size than the aggregate which is used for conventional concrete. Gradation is an important factor in choosing coarse aggregate, especially in typical uses of SCC. Typically, the maximum size of coarse aggregate used in SCC ranges from approximately 10 mm to 20 mm. The coarse aggregate should have a maximum of 12mm. Using lesser size aggregates improves the flowability of the concrete better.

Table 2.3 Properties of coarse aggregate

S.No	Properties	Values
1.	Specific Gravity	2.7
2.	Bulk Density	1660 kg/m^3
3.	Size	10 mm

2.4 Water

Generally, water which is used for drinking is satisfactory for usage in concrete. The water used in concrete plays an important part in mixing, laying and compaction, setting and hardening of concrete. The strength of concrete directly depends on the quantity and quality of water used in the mix. Ordinary potable water of pH 7 is normally used for mixing and curing the concrete specimen.

2.5 Foundry Sand

Foundry sand (FS) is high quality silica sand that is a by-product from the production of both ferrous and nonferrous metal castings. The physical and chemical characteristics of foundry sand will depend in great part on the type of casting process and the industry sector from which it originates[4,8]. It can be reused several times in foundries but, after a certain period, cannot be used further and becomes waste material, referred to as used or spent foundry sand. Foundry sand is clean, uniformly sized, high-quality silica sand which is basically used as a fine aggregate. It can be used in many of the same ways as natural or manufactured sands. Foundry sand is classified based upon the type of binder systems used in metal castings. They are generally of two types, Clay bonded systems (Green sand) Chemically bonded systems.

Table 2.4 Physical Properties of Foundry Sand

S.No	Physical Properties	Range
1.	Specific Gravity	2.39 – 2.55
2.	Bulk Density ($kg/m^{3)}$	2590(160)
3.	Absorption (%)	0.45
4.	Moisture content (%)	0.1 – 10.1
5.	Plastic index	Non-plastic

Fig 2.1 Foundry Sand

2.6 Dolomite Powder

Dolomite Powder (DP) is the Limestone Powder with composition of CaCo3 and MgCo3 pertaining to 100% in combination, the proportion being varied as per Mining Zone. Dolomite powder has some similar characteristics of cement[11]. Using dolomite powder in concrete can reduce the cost of concrete and may increase the strength to some extent. The cost of dolomite is less than that of cement. The reduction in the consumption of cement will reduce the emission of green-house gas. Since the cost of dolomite is less than that of cement. The reduction in the consumption of cement will reduce the emission of green-house gas. Dolomite is also used in paints, wall putty, ceramics, plastics industry, glass industry and fillers in detergents. Its use improves properties such as weathering action, reduces shrinkage, fissure development and water absorption. Dolomite have different grades and are available in different mesh size

Table 2.5 Properties of Dolomite Powder

S.NO	PROPERTY	DESCRIPTION
1.	Formula	CaMg(CO3)2
2.	Specific gravity	2.85
3.	Color	White
4.	Tenacity	Brittle

Fig 2.2 Dolomite Powder

2.7 Poly Carboxylate Ether

The use of admixtures is based on the fact that it should improve the flow characteristics and workability of the concrete. Super-plasticizer Poly Carboxylate Ethers being very relevant to SCC is to be used. The presence of poly carboxylate admixture retards the initial cement hydration reactions. They may also increase the diffusion in later stages. The admixture induces the microstructural modifications in the pastes which slightly reduces porosity, but does not affect the mechanical strength of the concrete. The high degree and duration of the fluidity that this admixture affords concrete are related to structural factors the shorter the main chain and the longer and more numerous the lateral chains. They affect the rheology properties of cement paste providing information on the following aspects,

- Evolution of hydrated products
- Relative behavior of different super-plasticizer
- Admixture compatibility

The physical and chemical characteristics of poly-carboxylate ether are shown below,

Table 2.6 Characteristics of Poly Carboxylated Ether

S. No	Characteristics	Values
1.	Appearance	Yellowish Brown
2.	pH	5.3-5.4
3.	Specific gravity	1.09
4.	C	52.5%
5.	Na (ppm)	9200
6.	K (ppm)	160

Fig 2.3 Poly Carboxylate Ether

3.0 Results and Discussion

3.1 Fresh Concrete Properties

Workability properties for various replacement percentages are given below.

Table 3.1 Fresh Concrete Test Results

S. No	Combi-Nation	Slump Flow Test (mm)	T50 Slump Flow (sec)	V-Fun Nel (mm)
1.	R–1	750	3	6
2.	R–2	730	3	6
3.	R–3	700	4	7
4.	R–4	680	5	9

As per guidelines of EFNARC, for slump flow, the typical range of value is 650-800 mm, for T50cm, range is 2 to 5 sec and for V-funnel, range is 6-12 sec. The addition of foundry sand reduces the workability of fresh concrete. But the mix almost satisfies the range specified by EFNARC guidelines.

R-1 mix contains the mix ratio of DP-10%,FS-10%, R-2 contains DP-10%,FS-20%, R-3 contains DP-10%,FS-30% and the mix R-4 contains DP-10%,FS-40%.

3.2 Hardened Properties of Concrete

3.2.1 Compressive Strength Test

Compressive strength tests are carried out on cubes of size 150 mm x 150 mm x150 mm. The specimens are tested after keeping it for curing at the age of 7 and 28 days. The results obtained are compared with the results of a control mix specimens. Effect of compressive strength for R-1 (DP-10%,FS-10%), R-2 (DP-10%,FS-20%), R-3 (DP-10%,FS-30%) and R-4 (DP-10%,FS-40%) at 7days and 28days are tabulated below.

Table 3.2 Compressive Strength Test

S. No	Combination	Compression Test	
		7 Days Result (N/mm^2)	28 Days Result (N/mm^2)
1.	R–1	20.88	31.11
2.	R–2	23.11	36
3.	R–3	24.44	38.66
4.	R–4	24	34.88

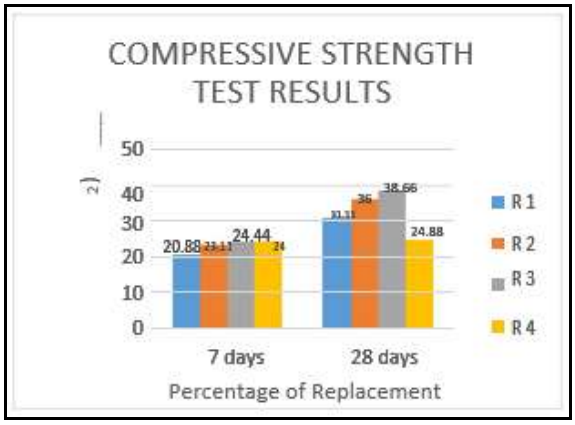

Fig 3.1 Graph Showing Compressive Test Results

3.2.2 SplitTensile Strength Test

For the determination of split tensile strength test of concrete cylinder specimens of diameter 150 mm and height 300 mm were casted. The cylinders were casted for the optimum values obtained from compression test. The tests were conducted on cylinders at an age of 7 and 28 days. Effect of split tensile strength for R-1 (DP-10%,FS-10%), R-2 (DP-10%,FS-20%), R-3 (DP-10%,FS-30%) and R-4 (DP-10%,FS-40%) at 7days and 28days are tabulated below.

Table 3.3 Split Tensile Strength Test

S.N	Combination	Tensile Test	
		7 Days Result (N/mm^2)	**28 Days Result (N/mm^2)**
1.	R-1	3.18	3.56
2.	R-2	3.43	3.82
3.	R–3	3.82	4.20
4.	R-4	3.56	4.07

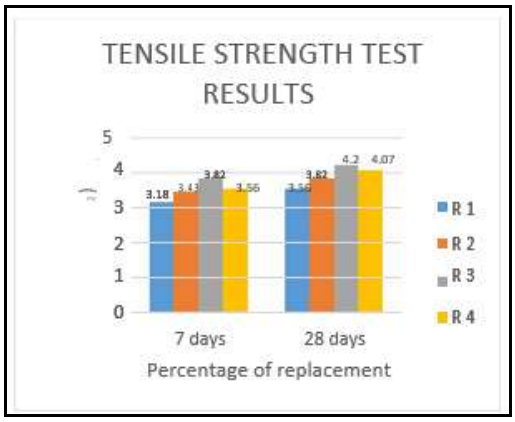

Fig 3.2 Graph Showing Tensile

Strength Test Results

3.2.3 Flexural Strength Test

Flexural strength test is carried out on prism specimens of dimensions 100 mm x 100 mm x 500 mm. The test is carried out by applying two point loading on the prism at the age of 7 and 28 days. Effect of flexural strength for R-1 (DP-10%,FS-10%), R-2 (DP-10%,FS-20%), R-3 (DP-10%,FS-30%) and R-4 (DP-10%,FS-40%) at 7days and 28days are tabulated below.

Table 3.4 Flexural Strength Test

S. No	Combination	Flexural Test	
		7 DAYS RESULT (N/mm^2)	**28 DAYS RESULT (N/mm^2)**
1.	R-1	3.19	3.9
2.	R-2	3.36	4.2
3.	R–3	3.46	4.35
4.	R-4	3.43	4.13

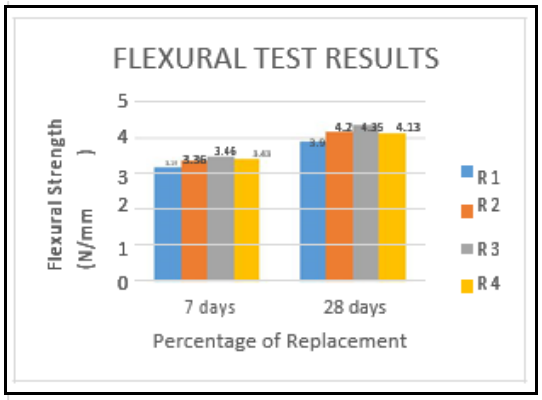

Fig 3.3 Graph Showing Flexural Test Results

4.0 Conclusion

The Self compacting concrete with the use of foundry sand and dolomite powder is found to be economical and environment friendly. The conclusions arrived from the project are:

- From the study, it is evident that foundry sand can be replaced partially for sand upto 30% and the hardened concrete test results obtained were satisfactory for this replacement of foundry sand.
- The maximum compressive strength is obtained for Mix R–3 (DP-10%, FS-30%) with an strength of 38.66 MPa at 28 days.
- Thus, the optimum value is chosen as mix R3 which consists of Dolomite Powder 10% and Foundry Sand of 30%
- Satisfactory workability was maintained while mixing the concrete.
- The main aspect followed in this project is to reduce the waste disposal and save the earth from environmental hazards.

5.0 References

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