Study of Self Compacting Concrete Using Brick Dust and Marble Powder

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Abstract

In recent years, Self Compacting Concrete (SCC) has gained a wide use for placement in congested reinforcement concrete structures where casting conditions are difficult and in high rise buildings where pump ability properties are required. For such applications the fresh concrete must possess high fluidity and good cohesiveness. The use of fine materials such as brick dust, marble powder and viscosity modifying agent can ensure the required concrete properties. In this experimental work attempt has been made to replace fine aggregate with brick dust and marble powder. Both brick kiln dust and marble powder are waste materials and are dumped as waste, causing land scarcity and environmental pollution. Using these types of waste material for concrete is a bigger step towards sustainable infrastructure development.

Introduction

Self Compacting Concrete as the name implies is the concrete requiring no vibration to fill the form homogeneously. Self Compacting Concrete (SCC) is defined by two primary properties. Ability to flow or deform under its own weight and the ability remain homogeneous while doing so. Flow ability is achieved by utilizing high proportion of water reducing admixtures and segregation resistance is ensured by introducing a chemical called viscosity modifying admixture (VMA) or increasing the amount of fines in the concrete. The study focuses on comparison of SCC containing varying amounts of brick dust and marble powder. In recent years, self compacting concrete has gained a wide use for placement in congested reinforcement concrete structures where casting conditions are difficult and in high rise buildings where pump ability properties are required.

Material Aspects of Self Compacting Concrete

Self-consolidating concrete is designed to meet specific applications requiring high deformability, high flow ability and high passing ability. The rheological properties and robustness of SCC vary in a wide range. It is more susceptible to changes than ordinary concrete because of a combination of detailed requirements, more complex mix design and inherent low yield stress and viscosity. Variations in properties (and robustness) are attributed therefore to the specific effects of the ingredients on the rheological properties of the mixture, effects of the physical properties (i.e. size and specific density) of the aggregate and the mixing history. Aggregates, cement, water and HRWR are the principal materials of SCC where as SCM, VMA and other chemicals can be used as the optional materials. The brief illustration of component materials of SCC is given below.

Coarse Aggregate

Coarse aggregates significantly influence the performance of SCC by affecting the flowing ability, segregation resistance, and strength of concrete. The nominal maximum size for SCC can be 20 or 25 mm. However, the smaller size is preferable to produce higher strength and to reduce segregation in fresh SCC. Round aggregates are better than angular aggregates for flowing ability of SCC while rough and angular aggregates are conducive to high strength and strong interfacial bond due to rough surface texture and interlocking characteristic. The gradation of coarse aggregates affects the flow properties and segregation resistance of SCC. The well-graded coarse aggregates contribute to produce the optimum mixture with least particle interference and thus enhance the flowing ability and reduce the tendency of segregation in fresh concrete. They also improve the hardened properties and durability of concrete due to dense particle packing.

Fine aggregate

Fine aggregates increase the flowing ability and segregation resistance when used at a suitable amount. In addition, they modify the strength of concrete when used in varying proportion with cement and coarse aggregates. Particle shape, surface texture, surface area and void content affect the mixing water requirement and compressive strength of concrete .The fine aggregates for SCC should be sharp, angular, chemically inert, sound, low absorbent and free from deleterious substances to attain high strength and good durability. Well-graded fine aggregates increase the flow of mortar and hence may improve the flowing ability of SCC.

Furthermore, the well-graded fine aggregates contribute to improve the packing density and thus the hardened properties and durability of concrete. A fineness modulus in the range of 2.5 to 3.2 is generally recommended for SCC.

Cement

Portland cement is most widely used to produce various types of concrete. The cement used for SCC should have sound flow and setting properties. It should enhance the fluidity of concrete and should be compatible with the chemical admixtures such as HRWR and VMA. The cement should possess carefully controlled fineness, and should produce low or moderate heat of hydration to control the volume changes in concrete.

Brick Dust

Brick dust is a waste product obtained from different brick kilns and tile factories. There are numerous brick kiln which have grown over the decades in an unplanned way in different part of the country. Tons of waste products like brick dust or broken pieces or flakes of bricks (brickbat) come out from these kilns and factories. So far, such materials have been used just for filling low lying areas or are dumped as waste material.

Marble Powder

Marble has been commonly used as a building material since the ancient times. The industry's disposal of the marble powder material, consisting of very fine powder, today constitutes one of the environmental problems around the world. Marble blocks are cut into smaller blocks in order to give them the desired smooth shape. During the cutting process about 25% the original marble mass is lost in the form of dust. In India marble dust is settled by sedimentation and then dumped away which results in environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health.

Viscosity modifying admixture

VMA improves the viscosity and cohesion of fresh concrete and thus reduces the bleeding, surface settlement and aggregate sedimentation resulting in a more stable and uniform mix. The mechanism of viscosity enhancement depends on the type of Objectives of Study.

Present Work

The objectives of this investigation is to carry out the detailed study of various performance based characteristics of self compacting concrete with different proportions of Brick dust and marble powder as fine aggregate replacement. Following investigation has ben attempted in the present work:

- Compressive strength at the age of 7 and 28 days by replacing fine aggregate with brick dust and marble powder at 25% and 50% replacement levels.
- Ultrasonic pulse velocity and rebound hammer testing at the age of 7 and 28 days by replacing fine aggregate with brick dust and marble powder at 25% and 50% replacement levels.

Compressive Strength Test

The test was conducted according to IS 516-1959.Specimens were taken out from curing tank at the age of 7, 28 and tested immediately after removal from water. Surface water was allowed to drip down. The position of cube while testing was at right angles to that of casting position. The load was gradually applied without any shock and increased at constant rate of 14N/mm^2/minute until failure of specimen takes place. It was tested on compression testing machine.

Ultrasonic Pulse Velocity Test

A pulse of longitudinal vibrations is produced by an electro-acoustical transducer, which is held in contact with one surface of the concrete under test. When the pulse generated is transmitted into the concrete from the transducer using a liquid coupling material such as grease or cellulose paste, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves develops, which include both longitudinal and shear waves, and propagates through the concrete. The first waves to reach the receiving transducer are the longitudinal waves, which are converted into an electrical signal by a second transducer. Electronic timing circuits enable the transit time T of the pulse to be measured.

Longitudinal pulse velocity (in km/s or m/s) is given by:

$v = L/T$

Where:

v is the longitudinal pulse velocity,

L is the path length,

T is the time taken by the pulse to traverse that length.

Schmidt Rebound Hammer Test

The Schmidt rebound hammer is principally a surface hardness tester. It works on the principle that the rebound of an elastic mass depends on the hardness of the surface against which the mass impinges. There is little apparent theoretical relationship between the strength of concrete and the rebound number of the hammer. However, within limits, empirical correlations have been established between strength properties and the rebound number. Further, Kolek has attempted to establish a correlation between the hammer rebound number and the hardness as measured by the Brinell method. In the present study we determine the compressive strength and flexural strength by replacement of cement by different percentages of brick dust and marble powder.

Result. and Discussion

Physical Properties of Cement (Is:12269-1987)

Cement used in experiment has obtained 37% standard consistency, 3.15 specific gravity, initial and final setting time was 125 min and 215 min respectively with 330kg/m^2 fineness.

Compressive Strength of Cement (Grade 43)

Cement used in experiment is of grade 43 and their compressive strength after 3days, 7days and 28 days were 26.5 N/mm^2,38.3 N/mm^{2}and 51.1 N/mm^2 respectively

Physical Properties of Coarse Aggregates

Coarse aggregate which is used in experiment is of grey colour with angular shape having specific gravity 2.65, water absorption capacity of coarse aggregate was 1% and having fineness modulus 7.87.

Table 1- Sieve Analysis Of Coarse Aggregates (as per IS:383-1970)

IS:Sieve designation	Wt retained on sieve(gm	%wt retained	cumulative% wt retained	% passing
40mm	0	0.00	0.00	100
20mm	200	4.0	4.00	96
10mm	4200	84.0	88.0	12
4.75mm	355	7.1	95.1	4.9
pan	245	4.9	100	

Physical Properties of Fine Aggregates

Fine aggregate which is used in experiment is of grey colour with angular shape having specific gravity 2.65, water absorption capacity of coarse aggregate was 1.1% , having fineness modulus 2.2 .

Table 2 - Sieve Analysis of Fine Aggregates (As Per IS:383-1970)

IS: Sieve designation	Wt retained on sieve(gm	%wt retained	cumulative% wt retained	% passing	IS 383-1970 requirements for zone II
4.75mm	6 0	0.6	0.6	99.4	90-100
2.36mm	94	9.4	10	90.0	75-100
1.18mm	274	27.4	37.4	62.6	55-90
600 micron	234	23.4	60.8	39.2	35-40
300 micron	286	28.6	89.4	10.6	8-30
150 micron	79	7.9	97.3	2.7	0-10
0.75 micron	18	1.8	99.1	0.9	0-5
Pan	9	0.9	100	0.0	

Table 3 – 0%replacement of fine aggregate with brick dust and marble powder (7 & 28 days)

Material used as replacement	Compressive Strength by UPV(Mpa)		Compressive Strength by Rebound hammer(Mpa)		Cube Compressive Strength(Mpa)	
	7 day	28 day	7 day	28 day	7 day	28 day
-	46	56	44	60	48	68

Table 4 – 25%replacement of fine aggregate with brick dust and marble powder (7 & 28 day)

Material used as replacement	Compressive Strength by UPV(Mpa)		Compressive Strength by Rebound hammer(Mpa)		Cube Compressive Strength(Mpa)	
	7 day	28 day	7 day	28 day	7 day	28 day
Brick dust	36	56	34	56	37	55
Marble powder	48	68	45	72	50	70

Table 6 – 50%replacement of fine aggregate with brick dust and marble powder(7 & 28 days)

Material used as replacement	Compressive Strength by UPV(Mpa)		Compressive Strength by Rebound hammer(Mpa)		Cube Compressive Strength(Mpa)	
	7 day	28 day	7 day	28 day	7 day	28 day
Brick dust	30	42	29	44	30	43
Marble powder	35	47	32	50	34	48

Conclusions

- All concretes mixes using brick dust and marble powder fulfilled the performance criteria for fresh and hardened SCC.
- Good hardened properties were achieved for the concretes with 25% marble powder which can be considered as the optimum content for high compressive strength.
- The hardened properties of the SCCs were improved at 28 days due to greater hydration of cement
- Brick dust and marble powder can be efficiently used to produce good quality self compacting concrete with satisfactory slump and setting times.
- Under certain conditions, replacement of fine aggregate by brick dust and marble powder appears to increase the strength of self compacting concrete.
- In this study an effort has been made to evaluate the usefulness of brick kiln dust and marble powder both of which are waste material to produce cost effective self compacting concrete.

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