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EXPERIMENTAL STUDY ON USE OF CRUSHED STONE DUST AND MARBLE SLUDGE POWDER AS REPLACEMENT TO NATURAL SAND IN SELF COMPACTION CONCRETE

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ABSTRACT

This paper presents the use of crushed rock dust and marble sludge powder as replacement to natural sand in preparation of self compaction concrete. The mixture of crushed rock dust and marble sludge powder with three different proportions of super plasticizer (0.35, 0.3, 0.25 were used for making concrete flow. The tests carried out for evaluation of mix design are compressive, split tensile, flexural strength and acid immersion tests of 5% of H_2SO_4 and HCL solutions. Results showed that the use of crushed rock dust and marble sludge powder can be used as substitute for natural sand replacement.

KEYWORDS: Self compaction concrete, compressive strength, split tensile strength, flexural strength, durability of concrete.

INTRODUCTION

Self Compacting Concrete (SCC) has had a remarkable impact on the concrete construction industry, especially the precast concrete industry. Since its first development in Japan in 1988, SCC has gained wider acceptance in Japan, Europe and USA due to its inherent distinct advantages. SCC provides structures that are more aesthetic while providing quality strength and durability performance, giving designers more flexibility to produce complex designs, and allowing constructors more options in construction techniques. The use of SCC shortens the construction period and also ensures quality and durability of concrete. SCC allows faster placement and less finishing time, leading to improved productivity. Green concrete has not anything to do with colour. Concrete which utilizes waste products as a partial substitute for cement or fine aggregate (FA) is known as green concrete. The potential environmental benefit to society of being able to build with green concrete is huge. Charges for the disposal of waste are avoided, energy consumption in production is lower and durability is greater.

Availability of natural sand for concrete is alarming in the last decades as a result of ecological and environmental limitations. Disposal of wastes has become a major problem in metropolitan areas in India especially the disposal of Crusher Rock Dust (CRD) generated from stone crusher industry and Marble Sludge Powder (MSP) generated from the stone processing industry in the country. Therefore, a replacement of CRD and MSP is motivating in this context. For sustainable development of this industry, technological developments are urgently required to deal with the ever increasing CRD and MSP. Therefore, civil engineers have been challenged to convert these industrial wastes as useful building and construction materials.

LITERATURE REVIEW

The purpose for development of SCC is the social problem on durability of concrete structures that arose around 1983 in Japan. Due to a gradual decrease in the number of skilled workers in Japan's construction industry, a similar decrease in the quality of construction work took place. As a result of this fact, one solution for the achievement of durable concrete structures independent of the quality of construction work is the implementation of SCC. Development of the first practicable SCC by researchers Okamura and Ozawa, around 1986, at the University of Tokyo and the large Japanese contractors (e.g. Kajima Co., Maeda Co., Taisei Group Co., etc.) quickly took up the idea.

Bouzoubaa et al (2001) referred that researcher at the University of Tokyo, Japan, started in late 1980's to develop SCC to be mainly used for highly congested reinforced structures in seismic regions. The reason behind developing this concrete is the concerns regarding the homogeneity and compaction of cast-in-place concrete within intricate highly reinforced structures, improvement of overall durability and quality of concrete etc., due to lack of skilled labor in Japan. In the early 1990's there was only a limited public knowledge about SCC, mainly in the Japanese language. Concurrently with the Japanese developments in the SCC area, research and development continued in mix-design and placing of underwater concrete where new admixtures are producing SCC mixes with performance identical that of the Japanese SCC concrete (e.g. University of Paisley / Scotland, University of Sherbrooke / Canada) as stated by Ferraris (1999).

A major limitation of SCC is that there is a lack of globally agreed upon test standards and mix designs. The contractors used their large in-house research and development facilities to develop their own SCC technologies. Each company developed their own mix designs and skilled their own staff to act as technicians for testing on sites their SCC mixes. Special applications such as underwater concreting have always required concrete, which could be placed without the need for compaction. A very important aspect is that each of the large contractors also developed their own testing devices and test methods as presented by Bartos (2000).

Objective and Scope:

To investigate the fresh properties of concrete mixes of different grade, abundant with fine fillers. Furthermore, it is aimed to find out the influence of super plasticizer (SP) on the fresh properties of concrete. Strength is one of the most important properties of concrete in structural design that the structural elements must be capable of carrying their own self weight and imposed loads. The study on physical, chemical and mechanical properties of various concrete specimens include compressive strength, modulus of elasticity, split tensile strength, flexural strength and bond strength. The durability and deterioration tests include water absorption test, chloride penetration, acid and sulphate attack. The above tests are the main focuses in this research in order to find the influence of CRD and MSP on the quality and performance of concrete.

Results:

Table 7,8,9 gives the details of slump flow, v-funnel test and compressive strength details of the self compaction concrete for super plasticizer content of 0.25%, 0.3%, 0.35% respectively. Table 10, details the split tensile strength and flexural strength of the considered self compaction concrete.

MATERIALS AND METHODS

The properties of cement used in this study are given in Table 1. Natural sand available locally in Sattenapalli, Guntur district are used for this study. Specific gravity of fine aggregate used was 2.67 and specific gravity of coarse aggregate used was of 2.73. Mix proportions used for this experimental study are given in Table 2 and 3. The details of mix proportions cast for the experimental study were shown in table 4, Table 5, Table 6 for different super plasticizers content of 0.35, 0.3, 0.25 respectively. The percentage of replacement levels of fine and coarse aggregates are kept constant and the use of super plasticizer is changed here, ceraplast super plasticizer is used for increasing flowablility of concrete and for bonding effect which increases the strength parameter also. Percentage of super plasticizer is varied by 0.25% 0.30% and 0.35% where the effect is made in water to powder adjustment.

Specimen details:

Cubes of size 150mm were cast for conduction of compressive strength of considered concrete mix proportions. Cylinders of size 150mm x 300mm were cast for conducting split tensile strength or indirect tensile strength. Beams of size 150mm x 150mm x 700mm were cast for finding of flexural strength of the considered mix proportions of self compaction concrete.

All the specimens were cast using pan mixture and were compacted using table vibrator. The cubes are subject to cure for 7 days and 28 days for conduction of tests. For finding of acid resistance to the mix proportions, cube of size 150mm were cured for 28 days of age and were then immersed in 5% H_2So_4 and 5% HCL solutions for 28 days of curing age. The specimens were kept of air dried for 4 hours before test were conducted.

Details of durability tests:

Durability study is to identify and estimate the effect of H2 S04, HCl on concrete made up of partial

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replacement of cement with quarry dust. The studies conducted on the durability of the concrete against the attack of H2 So4, HCL.

For M40 grade concrete 5 cubes for each mix were prepared for 0% replacement of fine aggregate are cast for 0.25%, 0.30%, 0.35%. Similarly for 0%, 20%, 40%, 60%, 80%, 100% replacement of MSP and 0%, 20%, 40%, 60%, 80%, 100% for CSD are cast and cured for 28 days for testing of flexural strength. Results of the flexural s strength test on concrete with varying proportions of replacement of MSP and CSD at the age of 28 days are given in below.

After 28 days of curing in water of 120 cubes is immersed in 5% concentrated H2SO4 and another 120 cubes are immersed in 5% concentrated HCL. The percentage weight loss, compressive strength loss is taken for a set of cubes at 7days and 28 days for both HCL and H2SO4. The below given tables details the effects of loss of mass, strength of the concrete cubes cast for conduction of finding effect of acid immersion tests.

Table 1 : Physical properties of cement:

Physical property	Obtained Value	IS: 8112-2007 Specifications
Fineness (retained on IS sieve 90-µm sieve)	5 %	As per IS:269-1976, max:10%
Normal Consistency	30.5 %	
Vicat initial setting time (minutes)	90 min	As per IS:4031-1968, Min:30min
Vicat final setting time (minutes)	150 min	As per IS:4031-1968, Max:600min
Specific gravity	3.15	As per IS: 2383-(part-3)1963

Table 2: Mix proportions:

Water	Cement	Fine aggregate	Coarse aggregate
191.58	510.88	497.0	1158.87
0.375	1.0	0.973	2.26

Table 3:Details of the table shows the mix proportions:

Mix No:	Water	Cement	MSP		CSD		Coarse aggregate
M1	191.58	510.88	0% Nominal mix with fine aggregate (%)	Kgs	0% Nominal mix with fine aggregate		1158.87
M2	191.58	510.88	0%	0	100%	497	1158.87
M3	191.58	510.88	20%	99.4	80%	397.6	1158.87
M4	191.58	510.88	40%	198.8	60%	298.2	1158.87
M5	191.58	510.88	60%	298.2	40%	198.8	1158.87
M6	191.58	510.88	80%	397.6	20%	397.6	1158.87
M7	191.58	510.88	100%	497	0%	0	1158.87

Table 4:For super plasticizer of 0.35% the variation of w/p and SP content are stated below:

Mix No:	Water (lts)	SP(lts)	Cement	MSP		CSD		Coarse aggregate
M1	214.01	7.74	510.88	0% Nominal mix with fine aggregate (%)	Kgs	0% Nominal mix with fine aggregate		1158.87
M2	205.53	7.35	510.88	0%	0	100%	497	1158.87
M3	1297.04	6.69	510.88	20%	99.4	80%	397.6	1158.87
M4	188.65	6.57	510.88	40%	198.8	60%	298.2	1158.87
M5	180.08	6.18	510.88	60%	298.2	40%	198.8	1158.87
M6	185.40	6.18	510.88	80%	397.6	20%	397.6	1158.87
M7	185.40	6.18	510.88	100%	497	0%	0	1158.87

Table 5:For super plasticizer of 0.3% the variation of w/p and SP content are stated below:

Mix No:	Water (lts)	SP(lts)	Cement	MSP		CSD		Coarse aggregate
M1	217.45	7.84	510.88	0% Nominal mix with fine aggregate (%)	Kgs	0% Nominal mix with fine aggregate		1158.87
M2	208.1	7.41	510.88	0%	0	100%	497	1158.87
M3	199.18	7.00	510.88	20%	99.4	80%	397.6	1158.87
M4	190.26	6.59	510.88	40%	198.8	60%	298.2	1158.87
M5	181.35	6.18	510.88	60%	298.2	40%	198.8	1158.87
M6	181.35	6.18	510.88	80%	397.6	20%	397.6	1158.87
M7	181.35	6.18	510.88	100%	497	0%	0	1158.87

Table 6:For super plasticizer of 0.25% the variation of w/p and SP content are stated below:

Mix No:	Water (lts)	SP(lts)	Cement	MSP		CSD		Coarse aggregate
M1	304.43	7.84	510.88	0% Nominal mix with fine aggregate (%)	Kgs	0% Nominal mix with fine aggregate		1158.87
M2	291.34	7.41	510.88	0%	0	100%	497	1158.87
M3	278.85	7.00	510.88	20%	99.4	80%	397.6	1158.87
M4	266.37	6.59	510.88	40%	198.8	60%	298.2	1158.87
M5	253.88	6.18	510.88	60%	298.2	40%	198.8	1158.87
M6	252.11	6.18	510.88	80%	397.6	20%	397.6	1158.87
M7	252.11	6.18	510.88	100%	497	0%	0	1158.87

Table 7:For super plasticizer of 0.25% content are stated below:

Mix No:	Slump flow (mm)	V funnel (sec)	Compressive strength 7 days	Compressive strength 28 days
M1	595	10	32.52	45.78
M2	605	9	34.10	49.21
M3	630	8	28.93	44.85
M4	630	8	30.15	47.21
M5	640	8	31.75	48.10
M6	665	7	31.10	46.21
M7	680	6	28.12	43.82

Table 8:For super plasticizer of 0.3% content are stated below:

Mix No:	Slump flow (mm)	V funnel (sec)	Compressive strength 7 days	Compressive strength 28 days
M1	730	8	26.10	41.76
M2	730	8	27.25	42.55
M3	745	7	27.85	43.12
M4	760	6	29.15	44.20
M5	770	6	26.85	43.10
M6	780	6	25.42	43.83
M7	790	6	25.20	42.12

Table 9:For super plasticizer of 0.35% content are stated below:

Mix No:	Slump flow (mm)	V funnel (sec)	Compressive strength 7 days	Compressive strength 28 days
M1	765	8	28.12	43.1
M2	775	8	29.10	43.82
M3	790	7	30.15	45.11
M4	805	6	30.76	45.95
M5	802	6	29.75	44.30
M6	808	6	28.14	43.75
M7	812	6	28.35	43.86

Table 10 :For super plasticizer of 0.25%, 0.30%, 0.35% content are stated below:

Mix No:	Split tensile strength 0.25%	Split tensile strength 0.30%	Split tensile strength 0.35%	Flexural strength 0.25%	Flexural strength 0.30%	Flexural strength 0.35%
M1	3	3.18	3.25	5.07	5.54	5.48
M2	2.79	3.12	3.14	4.98	5.32	5.65
M3	2.86	3.0	3.10	5.16	4.87	5.23
M4	2.86	2.79	2.95	5.33	4.21	5.20
M5	2.89	2.64	2.85	5.42	4.11	4.98
M6	2.90	2.55	2.84	5.51	3.85	4.76
M7	2.35	2.50	2.73	4.98	3.76	4.51

Table 11:M40 average % of mass loss after immersion in H_2SO_4

Mix. No	3 Days Avg. % of weight loss	7 Days Avg. % of weight loss	28 Days Avg. % of weight loss
M1	1.8	6.1	9.7
M2	1.4	6.9	11.1
M3	2.1	6.6	11.3
M4	2.5	9.9	12.2
M5	2.2	6.6	11.6
M6	2.5	6.8	12.6
M7	2.6	7.2	12.8

Table 12:M40 average % of mass loss after immersion in HCL

Mix. No	3 Days Avg. % of weight loss	7 Days Avg. % of weight loss	28 Days Avg. % of weight loss
M1	0.8	3.1	0.1
M2	0.7	2.8	1.9
M3	1.5	2.5	3.5
M4	0.3	0.2	1.4
M5	0.8	1.8	2.6
M6	1.0	1.6	2.8
M7	1.3	1.9	3.2

Table 13:M40 average % of 7 days strength deterioration when immersed in H_2SO_4

Mix.No	7days Avg. Compressive Strength before immersion(MPa)	7days Avg. Compressive Strength after immersion(MPa)	Average % of Strength deterioration
M1	35.1	26.9	24.7
M2	35.2	17.0	51.3
M3	35.2	17.0	52.0
M4	34.5	17.0	49.5
M5	33.7	18.5	46.3
M6	32.8	18.2	44.3
M7	33.5	17.6	45.3

Table 14:M40 average % of 28 days strength deterioration when immersed in H_2SO_4

Mix.No	28days Avg. Compressive Strength before immersion(MPa)	28days Avg. Compressive Strength after immersion(MPa)	Average % of Strength deterioration
M1	53.9	15.0	71.8
M2	53.5	13.0	74.3
M3	53.0	12.4	76.4
M4	52.0	14.5	73.3
M5	52.6	14.5	72.3
M6	53.7	14.3	73.5
M7	53.4	14.9	72.6

Table 15:M40 average % of 7 days strength deterioration when immersed in HCL

Mix.No	7days Avg. Compressive Strength before immersion(MPa)	7days Avg. Compressive Strength after immersion(MPa)	Average % of Strength deterioration
M1	35.1	39.5	-11.2
M2	35.2	40.8	-14.7

M3	35.2	36.3	-1.62
M4	34.5	29.3	14.32
M5	33.7	30.2	10.03
M6	34.8	34.7	11.45
M7	33.5	37.6	12.43

Table 16:M40 average % of 28 days strength deterioration when immersed in HCL

Mix.No	28days Avg. Compressive Strength before immersion(MPa)	28days Avg. Compressive Strength after immersion(MPa)	Average % of Strength deterioration
M1	53.9	34.6	35.9
M2	53.5	33.2	37.9
M3	53.0	31.6	40.4
M4	52.0	29.5	44.8
M5	52.6	28.3	45.4
M6	51.6	29.4	48.3
M6	51.4	31.2	48.7
M7	50.4	34.3	49.2

CONCLUSIONS

1. From the experimental conditions it is examined that the replacement of fine aggregate can be made by MSP but not much high in volume with CSD.
2. It was observed that the high water requirement was needed when the replacement of CSD was increased
3. The behaviour of concrete with 0% replacement of fine aggregates shows similar results with MSP and CSD replacement level at 60% of MSP and 40% CSD where the water content and SP content is limited and can achieve good compressive strength.
4. The behaviour of concrete with 0% replacement of fine aggregates shows similar results with MSP and CSD replacement level at 60% of MSP and 40% CSD where the effect of acids is similar with out replacement
5. Water absorption was done to observe the absorption content capacity of concrete which is made with waste usage where there are more MSP and CSD materials which are tended with high water absorption content
6. In all the mixes the compressive strength at 7 days of 70% was achieved and 28 days strength of the self compacting concrete specimens at all the replacement levels of MSP and CSD.
7. The strength properties shows that the participation of MSP and CSD was good in self compaction concrete with low w/c ratios and with super plasticizer used.
8. The flow conditions show that the self compaction of concrete was high in M6 and M7 where there is an increase in fine materials content and hence as a result the strength was also affected.
9. At mixes M6, M7 the mixes for acid attacks of H_2SO_4 and HCL are week in nature as the replacement levels increased the interlocking property of the concrete have failed and as a result the mix designed specimens containing high volumes of CSD and MSP have failed to acid resistance.
10. Flexural strength at all the mix grades was up to the mark of mix grade M40, shows the density of concrete increased with addition of considered waste materials and also resulted in increase of bending strength.
11. Split tensile strength was within the limits of mix grade shows the self compacted concrete made with MSP and CSD helps in improvement of green concrete.

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