Manufactured Sand And Mineral Admixture

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Abstract— Concrete is one of the most widely used construction materials in the world. However, the production of Portland cement, an essential constituent of concrete, leads to the release of significant amounts of CO_2, a greenhouse gas GHG; production of one ton of Portland cement produces about one ton of CO_2 and other GHGs. The environmental issues associated with GHGs, in addition to natural resources issues, will play a leading role in the sustainable development of the cement and concrete industry during this century.A sustainable concrete structure is constructed to ensure that the total environmental impact during its life cycle, including its use, will be minimal. Sustainable concrete should have a very low inherent energy requirement, be produced with little waste, be made from some of the most plentiful resources on earth, produce durable structures, have a very high thermal mass, and be made with recycled materials. Sustainable concrete have a small impact on the environment. Concrete must keep evolving to satisfy the increasing demands of all its users. This paper is based on experimental study carried out to obtain Sustainable Concrete by using Manufactured sand as replacement of River Sand and Mineral Admixtures (Metakeolin and Fly ash) as replacement of Cement in Concrete

Key words: Cement, Compressive Strength, Sustainable Concrete, Metakeolin, Fly ash, Manufactured sand.

I. Introduction

Concrete is one of the most widely used construction materials in the world. However, the production of Portland cement, an essential constituent of concrete, leads to the release of significant amounts of CO_2, a greenhouse gas GHG; production of one ton of Portland cement produces about one ton of CO_2 and other GHGs. The environmental issues associated with GHGs, in addition to natural resources issues, will play a leading role in the sustainable development of the cement and concrete industry during this century. For example, as the supply of good-quality limestone to produce cement decreases, producing adequate amounts of Portland cement for construction will become more difficult. There is a possibility that when there is no more good-quality limestone in, say, a geographical region, and thus no Portland cement, all the employment associated with the concrete industry, as well as new construction projects, will be terminated. Because of limited natural resources, concern over GHGs, or, both, cement production is being curtailed, or at least cannot be increased to keep up with the population increase, in some regions of the world. It is therefore necessary to look for sustainable solutions for future concrete construction. A sustainable concrete structure is constructed to ensure that the total environmental impact during its life cycle, including its use, will be minimal. Sustainable concrete should have a very low inherent energy requirement, be produced with little waste, be made from some of the most plentiful resources on earth, produce durable structures, have a very high thermal mass, and be made with recycled materials. Sustainable concrete have a small impact on the environment. Concrete must keep evolving to satisfy the increasing demands of all its users.

Sustainable development refers to a mode of human development in which resource use aims to meet human needs while ensuring the sustainability of natural systems and the environment, so that these needs can be met not only in the present, but also for generations to come. The term 'sustainable development' was used by the Brundtland Commission, which coined what has become the most often-quoted definition of sustainable development:
“Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”
For sustainable development, the three major points to be considered are: Reduce, Reuse, Recycle

II. Design mix materials

A. Cement:

The cement used is SANGHI OPC 53 grade cement. The Ordinary Portland Cement of 53 grade conforming to IS: 12269-2013 was used. Testswere conducted on cement like Consistency tests, Setting tests, Soundness, Compressive strength N/mm^2 at 28 days.

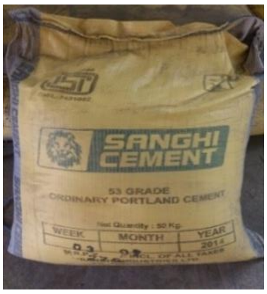

Fig. 1: Sanghi Cement (OPC 53 Grade)
Source: S.N.P.I.T & R.C, Umrakh

Item	Tests	Results Obtained	Requirement as per IS: 12269-2013
1	Consistency (%)	33.5	
2	Fineness	7 %	< 10 %
3	Initial Setting Time (minutes)	128	> 30
4	Final Setting Time (minutes)	216	< 600
5	Compressive		

	Strength (N/mm^2)		
	3 days	29	> 27
	7 days	40	> 37
	28 days	56	> 53
6	Soundness (Le-Chetelier Method)	2 mm	< 10 mm

Table 1: Properties of Cement
Source: Tested at S.N.P.I.T & R.C, Umrakh

B. Coarse Aggregate:

The fractions above 4.75 mm are termed as coarse aggregate. Two types of Coarse Aggregates from crushed Basalt rock, conforming to IS: 383-1970were used as shown in table II & III below

Fig. 2: Coarse Aggregate 1 (20 mm Nominal)
Source: S.N.P.I.T & R.C, Umrakh

Sr. No.	**Tests**	**Results**	**Requirement as per IS : 383-1970**
1	Gradation precent passing on IS sieve		
	40mm	100%	100 %
	20mm	97%	95 to 100 %
	10mm	31%	25 to 55 %
	4.75mm	2%	0 to 10 %
2	Impact value (%)	13.62	Sub base < 50 %
			Base course < 40 %
			Surface course < 30 %
3	Specific Gravity	2.81	----
4	Water absorption (%)	0.91	< 2 %

Table 2: Properties Of Coarse Aggregate 1 (20 Mm Nominal) Source: Tested at S.N.P.I.T & R.C, Umrakh.

Fig. 3: Coarse Aggregate 2 (10 mm Nominal)
Source: S.N.P.I.T & R.C, Umrakh

Sr. No.	**Tests**	**Results**	**Requirement as per IS : 383-1970**
1	Gradation precent passing on IS sieve		
	12.5mm	100%	100 %
	10mm	92%	95 to 100 %
	4.75mm	17%	25 to 55 %
	2.76mm	3%	0 to 10 %
2	Specific Gravity	2.79	----
3	Water absorption (%)	0.96	< 2 %

Table 3: Properties Of Coarse Aggregate 1 (10 Mm Nominal) Source: Tested at S.N.P.I.T & R.C, Umrakh

C. Sand:

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river fine aggregate was used asfineaggregate conforming to the requirements of IS: 383-1970. The river fine Aggregate is washed and screened, to eliminate deleterious materials and over size particles.

Fig. 5: Manufactured Sand
Source: S.N.P.I.T & R.C, Umrakh

Sr. No.	**Tests**	**Results**
1	Gradation percent Passing on IS Sieve	
	4.75 mm	100 %
	2.36 mm	86 %
	1.18 mm	67 %
	600 micron	40 %
	300 micron	16 %
	150 micron	3 %
2	Grading Zone	II
3	Fineness modulus	2.88
4	Specific gravity	2.69
5	Water absorption (%)	1.41
6	Silt Content	1%

Table 4: Properties Of Manufactured Sand Source: Tested at S.N.P.I.T & R.C, Umrakh

D. Metakeolin:

Metakaolin is the most recent mineral to be commercially introduced to the concrete construction industry. A few report investigated the potential of local kaolin from several areas. Metakaolin the product of processed heat treatment of natural kaolin is widely reported as a quality.

Fig. 6: METAKEOLIN
Source: S.N.P.I.T & R.C, Umrakh

Specifications	
Lime Reactivity (Chappelle Test)	740-1000 mg/gm
+300 mesh w/w % (Max)	10 %
Moisture w/w % (Max)	0.5-1.0
XRD	Metakaolin
Loss on Ignition (%)	0.5-1/5 %
Physical Analysis	
Appearance	Off- White
pH (10% solids)	4.0-5.0
Bulk Density (Kg/1)	0.4-0.5
Blaine value (cm2/g)	22000-25000
Specific Gravity	2.6
Chemical Analysis (Mass %)	
SIO_2	52.0-54.0
Al_2O_3	44.0-46.0
Fe_2O_3 (Max)	0.60-1.2
TiO_2(Max)	0.65
CaO (Max)	0.09
MgO (Max)	0.03
Na_2O (Max)	0.10
K_2O (Max)	0.03

Table 5: Properties of metakeolin

E. Fly ash:

Fly ash is by product of coal combustion in the thermal power plants. India produces over 100million tons of fly ash annually, the disposal of which being a grooving problem in the country. Owing to its large size, the concrete industry is probably the ideal home for safe and economical disposal of fly ash besides as landfills and road bases. It may be noted that the utilization of fly ash in concrete is not just for reason of environmental obtained or ecological concerns with regard to conservation of natural resources and sustainable development.

Fig. 7: FLY ASH

Test Detail	Result
SIO_2	46.99 %
Al_2O_3	4.45 %
CaO	16.02 %
MgO	5.31 %
SO_3	6.20 %
Loss on Ignition (%)	4.63 %

Table 6: Properties Offly Ash

III. DESIGN MIX METHODOLOGY

A Concrete M25 grade was designed as per IS: 10262-2009 method and the same was used as reference mix. The design mix proportion is as below :

For 1 m^3	Water	Cement	Fine Aggregate	Coarse Aggregate
By Weight [kg]	200 L	400	665	1085

Table 7: Mix Design Proportion

IV. COMPRESSIVE STRENGTH TEST

Compressive strength tests were performed on compression testing machine using cube samples at 7 days and 14 days. Three samples for each component were casted and then tested.The average strength values are reported in this paper.

Fig. 8: Set up of Compressive Testing Machine
Source: S.N.P.I.T & R.C, Umrakh.

V. WORKABILITY AS SLUMP (MM)

Each proportion of Experimental Concrete mix was tested for workability by slump test as per Indian standard. The results of workability are shown in Table X.

Fig. 9: Slump cone test for Workability
Source : S.N.P.I.T. & R.C., Umrakh

VI. RATE OF MATERIALS

Sr. No.	**Material**	**Rate (Rs/Kg)**
1	Cement	6.5
2	Sand	0.70
3	Coarse Aggregate	0.72
4	Manufactured sand	0.70
5	Fly ash	0.372
6	Metakaolin	15

Table 8: Material Rate Per Kg

VII. RESULTS OF EXPERIMENTAL STUDY

ID Mark	Manufactured sand	Fly ash	Metakeolin	Workability as Slump (mm)	Compressive Strength of Concrete (N/mm^2)				Cost per m^3
					7 days	14 days	28 days	56 days	
BK-1	0 %	0 %	0 %	32	23.45	30.85	33.31	38.70	3847
BK-2	60 %	25 %	5 %	21	16.85	21.48	23.25	25.23	3403
BK-3	60 %	25 %	7.5 %	19	15.25	19.12	21.57	23.82	3488
BK-4	60 %	25 %	10 %	16	13.95	17.25	19.91	21.14	3573
BK-5	60 %	30 %	5 %	17	18.17	22.87	24.59	27.69	3281
BK-6	60 %	30 %	7.5 %	14	15.30	20.60	23.83	26.06	3366
BK-7	60 %	30 %	10 %	12	13.08	19.65	22.61	24.39	3451
BK-8	60 %	35 %	5 %	14	15.03	19.84	23.71	27.32	3158
BK-9	60 %	35 %	7.5 %	12	13.46	18.72	22.44	25.82	3243
BK-10	60 %	35 %	10 %	11	12.30	17.31	19.05	23.23	3328
BK-11	80 %	25 %	5 %	18	17.69	22.07	24.04	26.14	3403
BK-12	80 %	25 %	7.5 %	16	15.96	20.76	22.13	24.42	3488
BK-13	80 %	25 %	10 %	15	14.42	19.06	21.55	22.77	3573
BK-14	80 %	30 %	5 %	15	18.65	23.15	25.97	28.31	3281
BK-15	80 %	30 %	7.5 %	12	16.04	20.83	24.19	26.89	3366
BK-16	80 %	30 %	10 %	10	13.87	20.16	23.35	25.13	3451
BK-17	80 %	35 %	5 %	12	16.57	20.89	24.07	28.03	3158
BK-18	80 %	35 %	7.5 %	9	14.63	19.66	22.97	26.15	3243
BK-19	80 %	35 %	10 %	8	13.91	18.79	20.59	24.44	3328
BK-20	100 %	25 %	5 %	16	18.55	22.71	24.36	27.33	3403
BK-21	100 %	25 %	7.5 %	13	16.76	21.09	22.82	25.48	3488
BK-22	100 %	25 %	10 %	11	15.61	20.01	22.17	23.08	3573
BK-23	**100 %**	**30 %**	**5 %**	**12**	**20.12**	**23.58**	**27.85**	**32.07**	**3281**
BK-24	100 %	30 %	7.5 %	10	17.33	21.70	25.62	30.15	3366
BK-25	100 %	30 %	10 %	8	15.48	20.71	25.08	29.87	3451
BK-26	100 %	35 %	5 %	10	17.36	21.14	24.52	28.19	3158
BK-27	100 %	35 %	7.5 %	8	15.12	19.72	23.70	26.78	3243
BK-28	100 %	35 %	10 %	7	14.78	19.35	21.26	25.24	3328

Table 9: Compressive Strength Of Cement Conrete Cubes

VIII. CONCLUSION

From this study the following conclusion can be drawn:

(1) The workability of concrete decreases with increase in percentage replacement of river sand by Manufactured sand.

(2) The workability of concrete decreases with increase in percentage replacement of cement by Metakeolin.

(3) The compressive strength of concrete decreases with increase in percentage replacement of cement by Metakeolin

for the same content of Manufactured sand replacement for river sand and fly ash replacement for cement.

(4) 30 % fly ash + 5 % Metakeolin is the optimum replacement level for cement which gives maximum compressive strength at 7, 14, 28 & 56 days.

(5) By using 30% fly ash + 5 % Metakeolin as replacement of cement and 100 % Manufactured sand as replacement of river sand, we can save 566 Rs./m^3.

(6) The methodology appears to be successful for sustainable development as we are using 30 % fly ash which is an environmental & disposal problem. Also we are using 100 % Manufactured sand as replacement of river sand hence the problems associated with extraction of river sand are avoided.

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