isrjournals

International Journal of Advanced Research in Civil,Structural,Environmental and Infrastructure Engineering and Developing

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

A STUDY ON THE COMPRESSIVE STRENGTH OF DREDGED MARINE SAND CONCRETE

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ABSTRACT: In this study, compressive strength of dredged marine sand concrete have been studied in detail. Two concrete grades were used: M25 and M40. Three different mixes containing 100% natural sand river, 50% natural sand river and 100% replacement of natural sand by dredged marine sand were used. The main aim of the study was to determine that whether or not dredged marine sand can be used as a replacement of fine aggregate in concrete. The result of compressive strength test showed that dredged marine sand provides the concrete with sufficient amount of strength and that it can be used as a substitute of fine aggregate in concrete.

KEYWORDS: dredged marine sand, compressive strength, natural sand, concrete

1. INTRODUCTION:

Concrete is a basic material for construction of any structure. The sand which is taken generally from quarries or alluvial rivers is a basic ingredient for manufacturing the concrete. But this source of sand is in a state of depletion and their further extraction may cause harmful effects on environment. To counteract this problem some other sources have to be found out and studied as well as experimented. Some of the alternates are dredged marine sand, off shore sand, dune sand, quarry dust and washed soil which also has to be used for replacing the fine aggregate.

In this study, Two concrete grades have been used in i.e. M25 and M40. Two types of cements are used in the concrete i.e. OPC and PPC. Three different concrete mixes are taken into consideration for the experiment i.e. Mix-A (concrete made using 100% natural river sand), Mix-B (concrete made using 50% replacement of natural river sand with dredged marine sand) and Mix-C (concrete made using 100%replace-ment of natural river sand with dredged marine sand).

The project mainly concentrates on the use of Dredged marine sand (DMS)

as a fine aggregate during casting of concrete and evaluating the compressive strength property for plain concrete cubes. Standard size concrete cubes are cast as per IS provisions. The result for all concrete mixes have suggested adequate performance of concrete made with dredged marine sand as compared to the concrete with natural river sand. Mechanical properties of concrete made with dredged marine sand indicate higher results for concrete Mix-C made with 100% dredged marine sand as compared to that of concrete Mix-B made with 50% replacement of river sand with dredged marine sand and concrete Mix-A made using 100% natural river sand at the end of 56 days curing.

Thus investigation suggests successful use of dredged marine sand in concrete as a fine aggregate in construction activities.

2. MATERIALS:

2.1. Aggregates:

Cement which is used for the casting work is 53 grade OPC. The physical properties of cement are shown in Table 1. Aggregates are procured locally for the casting work of concrete specimens. The aggregates are tested for their properties in accordance with the IS standards. Locally available river sand is used as a fine aggregate for concrete. Also locally available coarse aggregates of two grades are used in the concrete i.e.10mm and 20 mm. The sieve analysis of the fine aggregate is performed as per IS 2386 (1963) part-1.[25]

Table 1: Physical properties of cement

Properties	Results achieved	Specification in IS 12269:1987 for 53 grade OPC
Fineness in m^2/kg	351	Min. 225
Soundness by Le chatelier method in mm	0.4	Max. 10
Initial setting time in minutes	35	Min. 30
Final setting time in minutes	240	Max. 600
3 days compressive strength in MPa	28.75	Min. 27
7 days compressive strength in MPa	39.85	Min. 37
28 days compressive strength in MPa	54.47	Min. 53

The sieve analysis results are shown in Table 2 for natural river sand. To determine fineness modulus and zone of the sand the tests are conducted.

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

Table 2: Sieve analysis results of natural river sand

Sieve Size	Mass retained (grams)	% mass retained	Cumulative % of mass retained	Cumulative % of passing
4.75 mm	40	4	4	96
2.36 mm	227	22.7	26.7	73.3
1.18 mm	35	3.5	30.2	69.8
600 µm	144	14.4	44.6	55.4
300 µm	308	30.8	75.4	24.6
150 µm	165	16.5	91.9	8.1
Below 150 µm	81	8.1	-	0
Total	1000	100	268.8	-

Test performed for determining the specific gravity for natural river sand. Results of these parameters for natural river sand are given in Table 3.

Table 3:Results for various parameters of natural river sand

Type of Sand	Parameter	Result
Natural river sand	Fineness modulus	2.68
Natural river sand	Zone	2
Natural river sand	Specific gravity	2.6

Sieve analysis results for coarse aggregate of 10mm and 20mm are presented in Table 4 and Table 5 respectively.

Table 4: Sieve analysis results for 10 mm aggregate

Sieve Size	Mass retained (grams)	% mass retained	Cumulative % of mass retained	Cumulative % of passing
80 mm	0.0	0.0	0.0	100.0
40 mm	0.0	0.0	0.0	100.0
20 mm	0.0	0.0	0.0	100.0
10 mm	46.0	4.6	4.6	95.4
4.75 mm	875.0	87.5	92.1	7.9
2.36 mm	39.0	3.9	100.0	0.0
1.18 mm	0.0	0.0	100.0	0.0
600 µm	0.0	0.0	100.0	0.0
300 µm	0.0	0.0	100.0	0.0
150 µm	0.0	0.0	100.0	0.0
Below 150 µm	0.0	0.0	-	0.0
Total	1000	100		
Fineness modulus = 596.7/100 = 5.967				

Table 5: Sieve analysis results for 20 mm aggregate

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

Sieve Size	Mass retained (grams)	% mass retained	Cumulative % of mass retained	Cumulative % of passing
80 mm	0.0	0.0	0.0	100.0
40 mm	0.0	0.0	0.0	100.0
20 mm	660.0	33.0	33.0	67.0
10 mm	1270.0	63.5	96.5	3.5
4.75 mm	70.0	3.5	100.0	0.0
2.36 mm	0.0	0.0	100.0	0.0
1.18 mm	0.0	0.0	100.0	0.0
600 µm	0.0	0.0	100.0	0.0
300 µm	0.0	0.0	100.0	0.0
150 µm	0.0	0.0	100.0	0.0
Below 150 µm	0.0	0.0	-	0.0
Total	2000	100	729.5	
Fineness modulus = 729.5/100 = 7.295				

2.2. Superplasticizer

There are two different concrete grades which were considered in the experimental work i.e. M25 and M40. For M40 concrete grade, super plasticizer has been used for achieving required workability of the concrete. FosrocConplast SP 430 was used as an admixture to improve workability of the fresh concrete.

2.3. Marine sand

Physical properties:

The test is performed to determine the fineness modulus and zone of the dredged marine sand. Results are given in Table 6 and Table 7respectively.

Table 6: Sieve analysis results of the dredged marine sand

Sieve Size	Mass retained (grams)	% of mass retained	Cumulative % of mass retained	Cumulative % of passing
4.75 mm	0	0	0	100
2.36 mm	44	4.4	4.4	95.6
1.18 mm	121	12.1	16.5	83.5
600 µ	276	27.6	44.1	55.9
300µ	516	51.6	95.7	4.3
150µ	27	2.7	98.4	1.6
Below 150µ	16	1.6	-	0
Total	1000	100	259.1	-

Table 7: Results for various parameters for dredged marine sand

Type of Sand	Parameter	Result
Dredged marine sand	Fineness modulus	2.59
Dredged marine sand	Zone	2
Dredged marine sand	Specific gravity	2.56

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

Chemical properties:

The chemical properties of marine sand are investigated by two other laboratories and results are presented in Table 3.9 and 3.10 respectively. Sample taken for test=35kg, Moisture condition when received= Surface dry.

Table 8: Chemical analysis results provided by Geo Test house

Sr. no.	Test name	Test method	Test result	Specification requirement (IS 383-1970)
1	Organic content	IS 2386 : Part-2 Cl-6.0	Not detected	-
2	Chloride (%)	B.S. 812 : P-117	0.034	Max 0.04%
3	Sulfur as SO_3 (%)	B.S. 812 : P-118	0.794	Max 0.05%
4	Presence of deleterious material (%)	IS 2386 : P-2 Cl-2 & 3	6.847	Max 5%
5	Volatile solids	IS 3025 : P-18	0.084	-

Table 9: Results of chemical analysis related with Alkali aggregate reactivity pro- vided by K.C.T. Consultancy Services

No.	Alkali aggregate reactivity test	Fine aggregate
1	Reduction in alkalinity (milimol / l)	132.19
2	Silica dissolved from 300 µm size aggregate material (milimol / l)	1.78

Table 10: Results of chemical test for deleterious material of marine sand provided by K.C.T. Consultancy Services

No.	Test description	Results (%)	Requirement as per IS 383 (%)
1	Coal and Lignite	Nil	Max 1%
2	Clay lumps	Nil	Max 1%
3	Material finer than75 µ	1.5	Max 3%
4	Shale	6.60	Max 1%
5	Total % of all deleterious material	8.10	Max 5%

3. Concrete mix design:

The concrete mix proportioning using dredged marine sand is not different than the usual mix design of concrete using natural river sand. All the constituents are same for both the cases i.e. concrete using dredged marine sand and natural river sand. The mix design is done based on provisions of IS 10262 (2009).[19]

The w/c ratio is selected 0.5 for M25 grade concrete and 0.4 for M40 grade

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

concrete. For the concrete grade M40, the superplasticizer is added forcasting of concrete. The amount of 0.8% of total mass of cement was taken as a superplasticizer for M40 grade concrete. No super plasticizer is used for M25 grade concrete. Table 11 presents concrete mix proportioning for both concrete grades and for all concrete mixes respectively.

Table 11: Concrete mix proportion for all concrete mixes

Grade of concrete	w/c ratio	Water content (kg/m^3)	Cement Content (kg/m^3)	Fine Aggregate (kg/m^3)	20 mm aggregate (kg/m^3)	10 mm aggregate (kg/m^3)
M25	0.5	191.8	383.16	630.47	733.15	488.78
M40	0.4	143.8	359.22	599.88	761.67	507.78

4. TESTING:

The mechanical properties of hardened concrete are determined after performing compression test on plain concrete specimens. The compression test is done using 2000Kn capacity hydraulic testing machine. Compressive strength is determined after testing plain concrete cubes of dimension 150mmX150mmX150mm as per IS 516 (1959). [20] Fig 3.6 shows plain concrete specimen which is being tested in compression testing machine.

For evaluating the compressive strength of concrete cubes, following Eq3.1is used.

$$\text{Compressive strength of concrete } (N/mm^2) = P/A$$

Where P = Failure load in N

A=Area of concrete specimen in mm^2 (150mmX150mm)

5. Results:

The evaluation of compressive strength of concrete mixes at 7, 28 and 56 days are presented in Table 12, 13 and 14 respectively. Graphical representation of the comparison of average compressive strength for all concrete mixes for OPC based concrete and PPC based concrete for M25 grade has been

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

presented in Fig 1 and 2 respectively. For M40 grade, graphical representation of compressive strength for all concrete mixes for OPC based concrete and PPC based concrete has been given in Fig 3 and 4 respectively.

Table 12: Compressive strength of concrete mixes after 7days

Concrete grade	Type of cement	Mix	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
M25	OPC	A	24	22.67
			22.7	
			21.3	
		B	24.4	23.4
			24	
			21.78	
		C	26.2	27.4
			25.3	
			30.7	
M25	PPC	A	20	19.93
			20.9	
			18.9	
		B	21.8	22.52
			22.2	
			23.6	
		C	20.4	21.19
			21.3	
			21.8	
M40	OPC	A	31.1	32.14
			32	
			33.3	
		B	37.3	37.11
			38.9	
			35.1	
		C	40	42.96
			43.1	
			45.8	
M40	PPC	A	28.9	26.7
			24.4	
			26.7	
		B	27.6	27.7
			28	
			27.6	
		C	28	27.7
			27.6	
			27.6	

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

Table 13: Compressive strength of concrete mixes after 28days

Concrete grade	Type of cement	Mix	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
M25	OPC	A	36	35.4
			34.7	
			35.6	
		B	42.7	41.6
			40.9	
			41.3	
		C	43.11	43.26
			42.2	
			44.4	
M25	PPC	A	34.7	32.9
			31.1	
			32.9	
		B	31.6	32.9
			34.2	
			32.9	
		C	31.56	33.18
			34.67	
			33.3	
M40	OPC	A	45.8	48.74
			49.8	
			50.7	
		B	53.3	54.07
			55.6	
			53.3	
		C	53.3	54.52
			55.6	
			54.7	
M40	PPC	A	43.11	42.96
			43.56	
			42.2	
		B	48.9	43.11
			40	
			40.4	
		C	47.56	47.4
			46.22	
			48.4	

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

Table 14: Compressive strength of concrete mixes after 56days

Concrete grade	Type of cement	Mix	Compressive strength (N/mm^2)	Average compressive strength (N/mm^2)
M25	OPC	A	52.9	48.6
			46.7	
			46.2	
		B	48	49.8
			48.4	
			52.9	
		C	53.3	52.9
			52.4	
			52.9	
M25	PPC	A	40	39.4
			39.6	
			38.7	
		B	43.56	42.37
			41.3	
			42.2	
		C	42.66	43.56
			43.56	
			44.4	
M40	OPC	A	55.6	53.63
			52.4	
			52.9	
		B	54.7	54.07
			53.3	
			54.2	
		C	59.6	58.52
			58.7	
			57.3	
M40	PPC	A	51.1	51.85
			52.4	
			52	
		B	52.4	52.9
			53.3	
			52.9	
		C	52	49.03
			43.56	
			44.9	

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

Figure 1: Compressive strength for M25 grade concrete with OPC

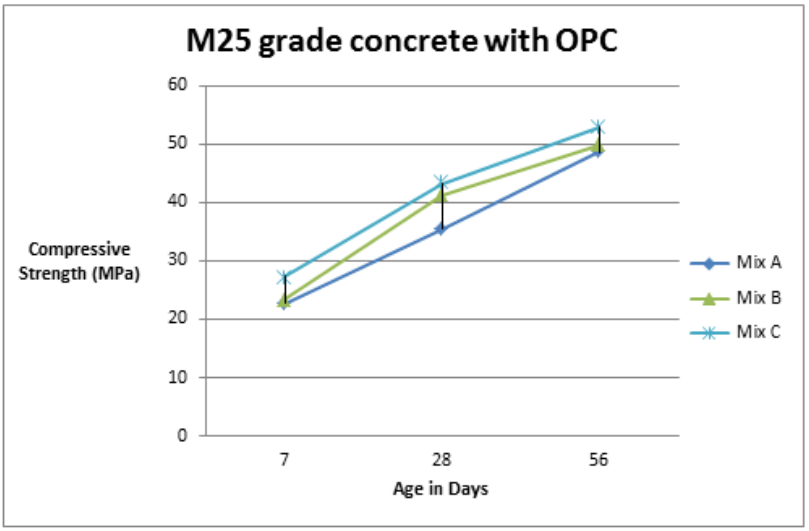
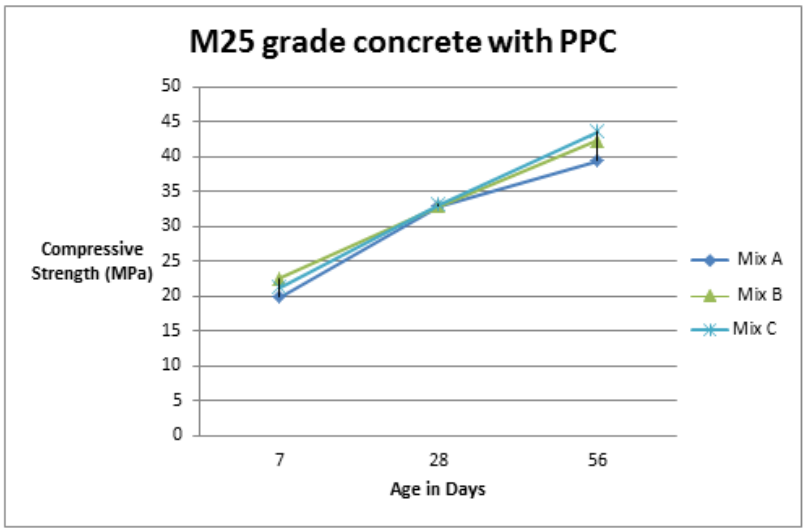


Figure 2: Compressive strength for M25 grade concrete with PPC



Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

Figure 3: Compressive strength for M40 grade concrete with OPC

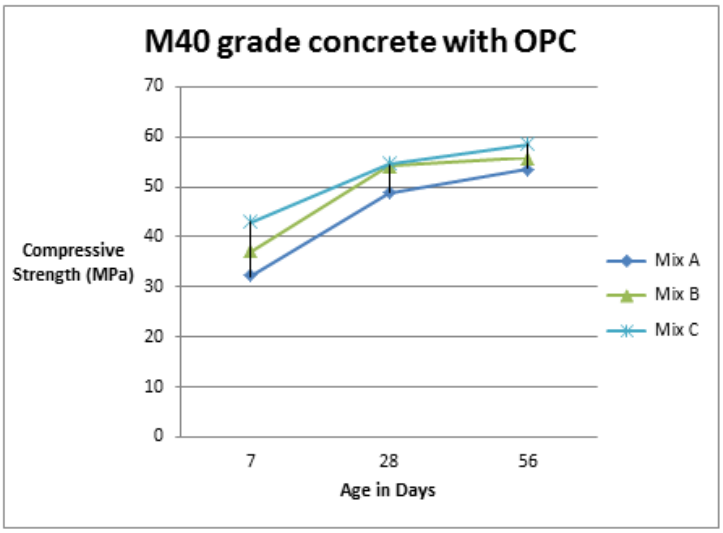
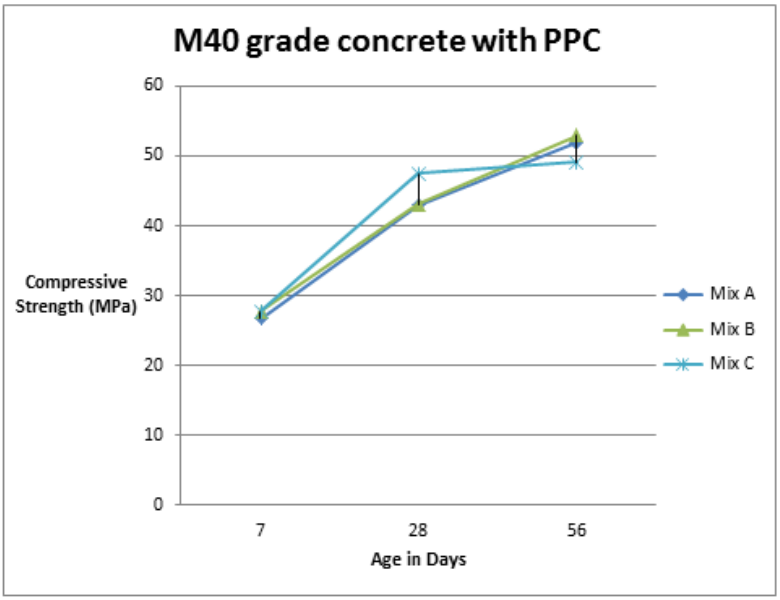


Figure 4: Compressive strength for M40 grade concrete with PPC



Increase in compressive strength of all concrete mixes is observed with change in age for both types of cements i.e. OPC and PPC as well as for both concrete grades i.e. M25 and M40 respectively.

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

Table 15: % change in compressive strength for M25 grade OPC based concrete

Curing age in days	Mix	7 days			28 days			56 days		
		A	B	C	A	B	C	A	B	C
7	A	0	-	-	-	-	-	-	-	-
	B	3.22	0	-	-	-	-	-	-	-
	C	20.86	17.09	0	-	-	-	-	-	-
28	A	56.15	51.28	29.19	0	-	-	-	-	-
	B	82.17	76.49	50.72	16.66	0	-	-	-	-
	C	90.82	84.87	57.88	22.20	4.74	0	-	-	-
56	A	114.3	107.64	77.33	37.25	17.65	12.32	0	-	-
	B	119.58	112.73	81.67	40.62	20.53	15.07	2.44	0	-
	C	133.3	126.02	93.02	49.40	28.06	22.26	8.84	6.24	0

Table 15 shows % change in compressive strength for M25 grade OPC based concrete after 7, 28 and 56 days.

Increase in compressive strength of 3.22% and 20.86% is observed for M25 grade concrete with OPC for Mix-B and Mix-C respectively as compared to Mix-A after 7 days. Increase of 16.66% and 22.20% in compressive strength is observed for M25 grade concrete with OPC for Mix-B and Mix-C respectively as compared to Mix-A after 28 days. Increase of 2.44% and 8.84% in compressive strength is observed for M25 grade concrete with OPC for Mix-B and Mix-C respectively as compared to that of Mix-A after 56 days.

Increase in compressive strength is observed for M25 grade OPC based concrete for Mix-B and Mix-C with increase in age. Compressive strength gain in M25 grade OPC based concrete for Mix-C is more up to 56 days age as compared to that of Mix-A and Mix-B.

Table 16 shows % change in compressive strength for M25 grade PPC based concrete after 7, 28 and 56days.

Increase in compressive strength of 13% and 6.32% is observed for M25 grade concrete with PPC for Mix-B and Mix-C respectively as compared to Mix-A after 7days. Almost same compressive strength is observed for M25 grade concrete with PPC for Mix-B and Mix-C respectively as compared to Mix-A after 28days. Increase of 7.54% and 10.6% in compressive strength is observed for M25 grade concrete with PPC for Mix-B and Mix-C respectively as compared to that of Mix-A after 56 days.

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

Table 16: % change in compressive strength for M25 grade PPC based concrete

Mix	7 days			28 days			56 days		
	A	B	C	A	B	C	A	B	C
A	0	-	-	-	-	-	-	-	-
B	13	0	-	-	-	-	-	-	-
C	6.32	-	0	-	-	-	-	-	-
A	65.1	46.09	55.2	0	-	-	-	-	-
B	65.1	46.09	55.26	0	0	-	-	-	-
C	66.5	47.38	56.63	0.88	0.88	0	-	-	-
A	97.7	74.96	85.93	19.75	19.8	18.71	0	-	-
B	113	88.14	99.9	28.78	28.8	27.66	7.54	0	-
C	119	93.43	105.57	32.40	32.4	31.24	10.6	2.81	0

The results showed that after 28 days the performance of all the three mixes is similar. Up to 56 days increase in compressive strength of M25 grade PPC based concrete for Mix-C is observed as compared to that of Mix-A and Mix-B.

Table 17: % change in compressive strength for M40 grade OPC based concrete

Mix	7 days			28 days			56 days		
	A	B	C	A	B	C	A	B	C
A	0	-	-	-	-	-	-	-	-
B	15.4	0	-	-	-	-	-	-	-
C	33.6	15.76	0	-	-	-	-	-	-
A	51.6	31.34	13.45	0	-	-	-	-	-
B	68.2	45.7	25.86	10.93	0	-	-	-	-
C	69.6	46.91	26.90	11.85	0.83	0	-	-	-
A	66.8	44.49	24.81	10.01	-	-	0	-	-
B	73.3	50.09	29.65	14.28	3.01	2.16	3.88	0	-
C	82	57.67	36.19	20.04	8.21	7.31	9.12	5.04	0

Table 17 shows % change in compressive strength for M40 grade OPC based concrete after 7, 28 and 56 days.

Increase in compressive strength of 15.4% and 33.6% is observed for M40 grade concrete with OPC for Mix-B and Mix-C respectively as compared to Mix-A after 7 days. Increase of 10.9% and 11.85% in compressive strength is observed for M40 grade concrete with OPC for Mix-B and Mix-C respectively as compared to Mix-A after 28 days. Increase of 4% and 9.1% in

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

compressive strength is observed for M40 grade concrete with OPC for Mix-B and Mix-C respectively as compared to that of Mix-A after 56 days.
The results show that increase in compressive strength for M40 grade OPC based concrete for Mix-C is observed than Mix-A and Mix-B.

Table 18: % change in compressive strength for M40 grade PPC based concrete

Mix	7 days			28 days			56 days		
	A	B	C	A	B	C	A	B	C
A	0	-	-	-	-	-	-	-	-
B	-	0	-	-	-	-	-	-	-
C	-	0	0	-	-	-	-	-	-
A	53.4	55.09	55.09	0	-	-	-	-	-
B	54	55.63	55.63	0.34	0	-	-	-	-
C	69.3	71.12	71.11	10.33	9.95	0	-	-	1.26
A	85.2	87.18	87.18	20.69	20.3	9.38	0	-	10.77
B	88.9	90.94	90.93	23.11	22.7	11.58	2.01	0	12.99
C	67.2	68.99	68.98	8.96	8.58	-1.24	-9.7	-11.5	0

Table 18 shows % change in compressive strength for M40 grade PPC based concrete after 7, 28 and 56 days.
Almost similar compressive strength is observed for M40 grade concrete with PPC for Mix-B and Mix-C respectively as compared to Mix-A after 7 days. Increase of 0.34% and 10.33% in compressive strength is observed for M40 grade concrete with PPC for Mix-B and Mix-C respectively as compared to Mix-A after 28 days. Almost similar compressive strength is observed for M40 grade concrete with PPC for Mix-B as compared to Mix-A after 56 days. Due to poor workmanship or any other reason Mix-C shows 9% less results as compared to that of Mix-A.
The increment observed in compressive strength of concrete using DMS is due to the higher chloride content in DMS as compared to natural river sand. The chloride content present in DMS accelerates the compressive strength during 28 days curing.

Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X

CONCLUSION:

- Increase in compressive strength of all concrete mixes is observed with change in age for both types of cements i.e. OPC and PPC as well as for both concrete grades i.e. M25 and M40respectively.
- Compressive strength gain in M25 grade OPC based concrete for concrete Mix-C is more up to 56 days age as compared to that of concrete Mix-A and Mix-B.
- Up to 56 days, increase in compressive strength of M25 grade PPC based concrete for concrete Mix-C is observed as compared to that of concrete Mix-A and Mix-B.
- For M40 grade concrete made using OPC, compressive strength is higher for Mix-C and Mix-B as compared to that of concrete Mix-A.
- Increase in compressive strength is slightly higher for M40 grade PPC based concrete for Mix-B as compared to that for concrete Mix-C and Mix-A, respectively.
- No major change is observed in compressive strength of concrete for M25andM40 grade OPC based concrete for Mix-B and Mix-C from 28 days to 56days.
- The increment observed in compressive strength of concrete using DMS is due to the higher chloride content in DMS as compared to natural river sand. The chloride content present in DMS accelerates the compressive strength during 28 days curing.

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Volume: 2 Issue: 3 Feb,2016,ISSN_NO: 2320-723X