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Cube Compressive Strength Behavior of Cement Mortar With Lime and Treated Domestic Water

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ABSTRACT

This paper presents the effect of Treated Domestic Waste water (TDW) and lime dosage on cube compressive strength of cement mortar prepared with ordinary port land cement and Portland pozzolana cement. The treated domestic waste water was used as replacement to portable water in the proportion of 0,25,50,75 and 100%. From all the replacements, 50% TDW is noticed as effective based on cube compressive strength. This replacement was kept constant and the lime is added to the effective replacement of portable water in the proportion of 0 to 30 with an increment of 5% by weight of water. From the results is found that, for OPC and PPC mortars the optimum dosages were noticed as 20 and 25% respectively. To compute compressive strength results for lime based mixes a regression model was developed and it was verified with experimental results.

I. Introduction

In the globe water is precious and scarce in the areas where water is not available abundantly. If this case arises it is essential to reduce the portable water and keep the technology to utilize the waste water generated by the industries, factories and also from the public. In general the effluents were discharges to the nearby water bodies with and without treatments. Many times as per regulations of Government of India before discharging to any river or water bodies it is necessary to treat the waste effluents up to desirable limits and also the same was following by the state governments and public sectors. In concern of concrete industry, many codes recommends, if the waste water uses for the cement concrete cubes, the strength of this should not fall below 90% of cube strength made with portable water (Taha (2010)). Neville (2000) has provided some limits for the water to be use for cement concrete industry, however still research works are to be needed to ascertain and modify the limits for concrete works. In this way few works has been carried by the previous researchers like Cebeci and Saatci (1989), Mujahed (1989), El-Nawawy and Ahmad (1991), Chini et al. (1999), Taha et al. (2005), Al-Jabri et al. (2010). To enhance the cement mortar or concrete strengths, many works has been taken place with usage of industrial by products like silica fume, rice husk ash, wood ash, slag etc. Rafat Siddique and Rachid Bennacer (2012) provided a review article on cement paste and mortar, in their article, they mainly focused on the usage of iron by product of GGBS to enhance the compressive strengths and also explained the sulphate resistance mechanism. Alaa M Rashad (2018) has been provided the information of high volume slag effect on cement mortar and concrete to enhance strength and durability properties. Hence in the present study, the experimental work is planned to use the treated domestic waste water and lime to study the cement mortar performance.

II. Need of the present study

From the above introduction it came to know that, many works on cement mortar has been carried out with different reactive materials. Few works has been carried out with different treated effluents obtained from the different industries. Hence in this article, the TDW would like to use as replacement to portable water and also lime was used for the effective replacement of TDW, so that, it can be use the waste water effectively to minimize the pure water problem.

III. Plan of program

The experimental work has been carried in two phases; the primary phase is to evaluate the effective replacement of portable water with TDW. This can be decide based on the compressive strength results, the compressive strength of mix should not be less than the pre design value of the mortar mix (55MPA). In the second phase and for effective replacement of TDW, lime is added to the water by weight in the proportion of 0,5,10,15,20,25 and 30%. This water can use for the cement mortar mixes and all mixes were provided with cement to sand ratio as 1:3 along water cement ratio as 0.45 (super plasticizer 0.2% by weight of cement). From these mixes again significant or noticeable lime dosage is to found with concern of cube compressive strength. For first phase, total 60 cubes (50.06x50.06x50.06mm) are cast and tested and in the similar way for second phase 96 cubes were cast.

IV. Materials for the experimental investigation

PPC (fly ash based), OPC grade 55, manufacture sand, portable water, treated domestic waste water and lime was used. The cement, sand and portable water properties were analyzed and those were made of good compatibility with IS specifications. The lime was purchased from the local source and added in required quantity with water so as to prepare for

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pre planned mixes. The TDW and portable water properties are presented in the Table 1, including IS, ASTM and BS code specification limits.

Table 1. Properties of TDW and Portable water (PW)

Description	TDWW	PW	Limits as per codes		
			IS456-2000	**ASTM C1602**	**BS EN 1008**
pH	6.9	7.2	≮ 6	----	> 4
TS	850	220	----	50000	
TDS	825	210		----	2000
TSS	25	10	2000	----	2000
Organic solids	350	60	200	----	----
Inorganic solids	500	160	3000	----	----
Alkalinity	45	150	250	----	1000
Acidity	25	5	50	----	----
Chlorides for RCC	300	200	500	1000	1000
Chlorides for PCC	300	200	2000		4500
Sulphates	202	85	400	3000	2000
Note: Except pH, all are in mg/L					

V. TDW effect on Cube compressive strength

The cube compressive strengths for various mixes are presented in Table 2 and figure 1. From the results it is noticed that, for OPC and PPC mixes the strengths are increasing as the age of specimens increases. The mix with **0T** was taken as reference mix for comparison of other results. For 28 days, 25T, 50T, 75T and 100T mixes the compressive strength was decreased from 4.25 to 24.00%. In the similar line for 90 days observations the strength was varied from 4.12 to 22.90%. For PPC mixes the 28 days compressive strength was decreased and it ranges from 2.18 to 22.52%, in the similar way for 90 days it ranges from 3.04 to 21.22%. From the results and observation, the 28 days PPC mixes shows lesser strengths than the 28 days OPC mixes. Probably this may be due to presence of fly ash in the PPC; this may not react at early stage to attain the effective CSH gel. In PPC the fly ash used as replacement to cement but in OPC this was not appearing. Hence the variation in strengths apparently noticed. From 90 days compressive strengths it is observed that, the PPC shown higher strengths than the OPC mixes. The trend is reverse to the 28 strengths discussions because in PPC the fly ash plays major role to attribute CSH gel but this is not so in the OPC mixes since the absence of fly ash.

The cement mortar mix was designed to arrive 55MPa and from the Table 2 it is observed that, the design strength was noticed for 50% TDW and for other more than 50% TDW the strengths are less. Hence in this case the effective replacement was declared as 50% and this is considered as effective replacement for the cement mortar mixes.

Table 2. Compressive strength (MPa).

Sl.No.	Mix name	% TDW	OPC		PPC	
			28 days	**90 days**	**28 days**	**90 days**
1	0T	0	61.95	63.10	59.50	64.10
2	25T	25	59.32	60.50	58.20	62.15
3	50T	50	55.69	56.91	53.25	57.60
4	75T	75	51.10	52.16	50.20	54.15
5	100T	100	47.08	48.65	46.10	50.50

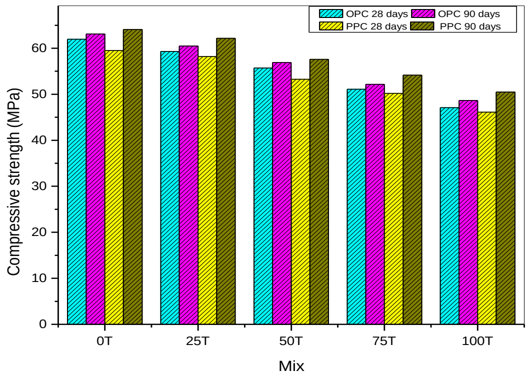

Fig 1. Compressive strength vs Mix

VI. Lime effect on effect replacement of TDW mix

With different lime dosages, total seven mixes were considered for the effective TDW mix. In addition to those mixes one reference mix with portable water (without TDW) was consider and this was taken for comparison of strength results. The results for all eight mixes are presented in Table 3 and figure 2. From the compressive strengths it is observed that, the results are increasing as the age of mix increases here also. From all the results it is noticed that, for OPC mixes the maximum strength is 77.53 and 79.56 MPa at 28 and 90 days respectively, this is achieved to 20% lime dosage. For PPC mixes the maximum strengths (71.97MPa -28 days, 82.23MPa-90 days) was noticed to 25% lime dosage.

For OPC mixes the compressive strengths are increasing from 0% to 20% lime and later the strengths are slowly decreasing for 25 and 30% lime dosage. When compared with reference mix the strengths are increasing for the dosages of 10-30% lime and it varies from 7.94 to 20.13%. Similarly for 90 days the strengths are increasing from 7.35 to 19.89%. But the 0 and 5%Lime dosages the compressive strength is decreeing for 28 and 90 days. Probably these may not contribute the any effect for strength enhancement.

For PPC mixes the similar trend of above was noticed but the effective dosage of lime is varied and it is 25%. For 28 and 90 days the strength increments are varied from 4.50 to 20.07% and 6.41 to 25.09%, respectively when compared with 28 days of PPC reference mix. In this case also the 0 and 5% lime dosage does not attribute significantly to enhance strengths both 28 and 90 days aged specimens.

Table 3. Compressive strength (MPa).

Sl.No	Nomenclature of the mix	Proportions		OPC		PPC	
		%Lime	**%TDW**	**28 days**	**90 days**	**28 days**	**90 days**
1	R	0	0	61.95	63.10	59.50	64.10
2	0L	0	50	55.69	56.91	54.12	57.26
3	5L	5	50	59.25	61.71	58.53	62.15
4	10L	10	50	66.87	67.74	62.18	68.21
5	15L	15	50	71.32	71.60	66.44	73.13
6	20L	20	50	77.53	79.96	69.49	78.28
7	25L	25	50	75.91	78.55	71.97	82.23
8	30L	30	50	74.42	75.65	71.44	80.18

Table 4. Performance of model

Sl. No	Nomenclature of the mix	OPC						PPC					
		28 days			90 days			28 days			90 days		
		Exp (E)	Model (M)	E/M	Exp (E)	Model (M)	E/M	Exp (E)	Model (M)	E/M	Exp (E)	Model (M)	E/M
1	R	61.95	62.72	0.99	63.10	62.72	1.01	59.50	61.54	0.97	64.10	61.54	1.04
2	0L	55.69	58.57	0.95	56.91	58.57	0.97	54.12	57.39	0.94	57.26	57.39	1.00
3	5L	59.25	62.21	0.95	61.71	62.21	0.99	58.53	61.02	0.96	62.15	61.02	1.02
4	10L	66.87	65.84	1.02	67.74	65.84	1.03	62.18	64.66	0.96	68.21	64.66	1.05
5	15L	71.32	69.48	1.03	71.60	69.48	1.03	66.44	68.29	0.97	73.13	68.29	1.07
6	20L	77.53	73.11	1.06	79.96	73.11	1.09	69.49	71.93	0.97	78.28	71.93	1.09
7	25L	75.91	76.75	0.99	78.55	76.75	1.02	71.97	75.56	0.95	82.23	75.56	1.09
8	30L	74.42	80.38	0.93	75.65	80.38	0.94	71.44	79.20	0.90	80.18	79.20	1.01

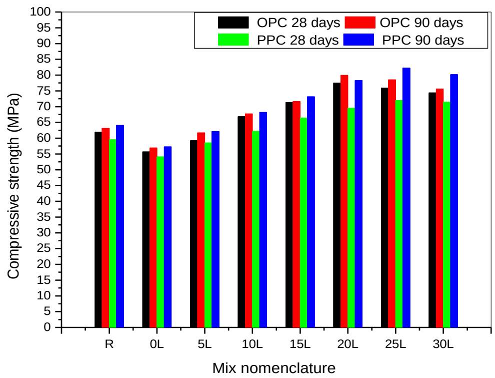

Fig 2. Compressive strength vs lime mix

Mathematical Model

To arrive the strength results, in this section a model is deduced with principle of least square and the developed model has a regression coefficient 0.80464. During deducing the model % lime and % of TDW was consider as variables along with 28 cube compressive strength of correspond OPC and PPC mixes. The develop model was presented below and this was checked to arrive the experimental results (Table 4), form the observations it came to know that, the model provided a maximum deviation of 7%. Hence this model provided herein shown good consistency with the experimental data.

$$f_c = 32.80 + 0.727(\%Lime) - 0.083(\%TDW) + 0.483(fc_{28})$$

Where, f_c= cube compressive strength in MPa of the mix

fc_{28}= 28 days cube compressive strength in MPa for OPC / PPC

VII. Conclusions

From the experimental investigation it is observed that, the effective replacement of TDW is 50% to the portable water and the optimum dosage of lime for the effective TDW is 20% for OPC mixes and 25% for PPC mixes. To estimate the cube compressive strength results for lime based mixes a model has been provided in this article and this provided good consistency with experimental results. The maximum compressive strengths are 79.96MPa and 82.23MPa for OPC and PPC mixes and these were noticed for 90 days aged specimens. Hence lime addition to the TDW mixes is viable.

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