Use of Treated Domestic Waste Water as Mixing Water in Cement Mortar

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Abstract— This study deals with the effect of treated domestic wastewater (TDWW) on properties of cement blended with 20% fly ash such as compressive strength, setting times and soundness. Water used for mortar includes portable water (PW), treated domestic wastewater (TDWW) and treated domestic wastewater (TDWW) partially replaced with portable water. This study analyses the quality of these types of waters as for standard methods for the examination of water and wastewater, APHA 1992. Then, tests were conducted on mortar. The setting times and soundness of blended cement with treated domestic wastewater (TDWW) and treated domestic wastewater (TDWW) partially replaced with portable water is as good as that with portable water. The compressive strength of blended cement mortar mixed with treated domestic wastewater and treated domestic wastewater partially replaced with portable water has very insignificantly affected. Therefore, it is suggested that treated domestic wastewater may be considered as mixing water for blended cement mortar where portable water resources are scarce. However, it is advised that long-term strength development and durability be studied before use.

Key words: TDWW, PW, CPCB

I. INTRODUCTION

Water is life that is why it is called "Jeevan" in Sanskrit. Water sustains all biological life, eco-systems and human activities. It makes up 65% of our bodies and covers 70% of the area of our planet "earth". It is essential for all food production from fields or healthy. Although water seems to be a common commodity, it is actually scarce on the earth and it has no substitute. Most of the world's water is saline and is contained in the oceans. Only about 2% of it is fresh and of its 97% is tied up in the polar caps in the form of permanent snow and in deep depths below ground. The remainder (i.e.3%) is renewable through the cycle of precipitation and evaporation form the oceans and the surface sources on earth and even this is often not available where or when required. The population of the world was 2.8 billion in the year 1955, 5.3 billion in 1990 and over 6 billion in 1999 while that projected in the year 2025 is between7.9 to9.1 billion. The renewable fresh water falling on the continents and islands each year is only about 41000Cu.km, which is hardly 0.03% of the total water on earth. In India the fresh water available in surface sources is estimated at 1680 Km^3 and that easily extractable from underground sources is 420 Km^3. All this quantity is again very much unevenly distributed. Thus Rajasthan with a population of about 8% of the country has got only 1% of its water resources while the state of Bihar with 10% population is having only 5% of it. The country as a whole at present has about 2200 Cu.m of water available per capita per year, while Rajasthan gets only 500 Cu.m which are less than 24% of the country's average. When the availability of water at a place is more than 1700 Cu.m per capita per year, there is not much difficulty felt by the people in satisfying their different requirements. However, when it is less than that depending upon the actual availability, water stress of different orders is felt. The magnitude of this stress also depends upon increase in population, irrigation, energy, industries, domestic and other needs also go on increasing. The report of the United nations in this respect states that about 1/3 of the world's population today is living in countries facing moderate to high water stress. In India 6 river basins are under water stress and 40 to 70% of the basins have less than the average country per capita availability of water. As against the problem of increased demand for water, the availability of usable quality of water is again getting diminished every year all over the world and particularly in the developing countries, on account of the discharge of different types of industries discharging of treated and untreated wastewater into the environment, which are polluting the surface and subsurface sources of water. Particularly Industrial activities, which are growing rapidly, are also leading to generation of large quantities of wastewater and are also adversely polluting varies segments of the environment.

As per Central Statistical Organization (CSO), there are about 32 lakhs industries in India in the year 1998-99, out of which 1,35,551 are registered manufacturing industries. Remaining industries like taxi stands, restaurants, hotels, tailoring etc. As per the latest inventory of Central Pollution Control Board (CPCB), there are about 8432 large and medium polluting industries in India. The number of small scale industries, which are established in unplanned areas and in an unsystematic manner. Such industries are located even in residential areas. A large number of them are not even registered. As per Central Water Commission (CWC,2005), the total wastewater generated from all major industrial sources is about 82,446 million liters per day. Water demand for industries in the year 2000 was 30 billion cubic meters, but water demand for industries is projected to be as high as 120 billion cubic meters in the year 2025. As against the problem of increased demand for water, the availability of limited usable quality of water is again getting diminished every year all over the world and particularly in the developing countries. Hence, the demand for the use of treated wastewater from industries and domestic is bound to increase in the future. Efforts towards wastewater reuse have lately gained worldwide consideration and attention in both the agricultural and industrial fields. With all these consequences, reuse of

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treated and partially treated industrial wastewater will have to be practiced extensively to conserve precious water resources and to get sustainable development. But a close scrutiny and a guide line document on the use of treated and partially treated wastewater is urgently needed.

All consequences are certainly being emphasized that Recycling and Reuse of wastewater will have to be practiced extensively for the sustainable development. Recycling and Reuse of various by-products i.e. industrial sludge, copper slag and iron steel slag etc. have been and being used for replacement of constituents of construction materials and obtained positive. Reuse of wastewater contaminated with chemical and biological substances and treated wastewater as mixing water in concrete have been studied few. In this connection, the present experimental studies are intended to use of treated industrial wastewater as mixing water in cement works. The parameters considered for strength development of cement include: Setting times, Compressive strength and Soundness of cement mortar cubes at different ageing periods (3 day, 7 day, 28 day, 75 day). IS 456:2000 specified that in cases of regarding development of strength, the suitability of water for making concrete shall be ascertained by the compressive strength and setting time tests.

II. MATERIALS

A. Cement:

53- Grade Cement is used in this Investigation.

S. No	Oxides	Percentage of contents
1	CaO	65.49
2	SiO_2	21.67
3	Al_2O_3	5.97
4	Fe_2O_3	3.85
5	SO_3	1.66
6	MgO	0.78
7	K_2O	0.46
8	Na_2O	0.12

Table I: Chemical Combination of Cement

B. Sand:

The Sand used throughout the experimental work was obtained from the right side bank of river Krishna in Amaravathi Town, Guntur District.

C. Water:

Portable water (PW) and Treated Domestic waste water (TDWW) was used in our Investigation.

Impurity (mg/l)	PW	TDWW	75% TDWW + 25% PW	50% TDWW +50% PW	25%TDWW + 75% PW
P^H	7.5	10.99	10	9.8	9.1
Total solids	400	600	600	600	600
Total organic solids	400	400	400	400	400
Total inorganic solids	NIL	200	200	200	100

Table II: Characteristics of PW & TDWW

III. RESULT AND DISCUSSION

The results of the present investigation are presented both in tabular and graphical forms. The interpretation of the results is based on the current knowledge available in the literature as well as on the nature of results obtained. The significance of the result is assessed with reference to the standards specified by the relevant IS Codes. Average of initial and final setting times of three cement samples prepared from different types of mixing water under consideration were compared with those of the cement specimens prepared from deionised water. As per (IS 456:2000), if the difference in setting times is less than 30 minutes, the change is considered to be insignificant. However, if the difference is more than 30 minutes, then the change is considered to be significant. The limits for significance criteria in setting times of all these samples under consideration are within the range of standards specified in IS 8112:1989. This IS Code prescribed that initial setting time should not be less than 30 minutes and final setting time should not be more than 600 minutes. An average compressive strength of at least three test specimens are compared with that of three similar reference specimens. As per (IS 456:2000), if the difference in the strength is less than 10 percent, it is considered to be insignificant and if greater than 10 percent, then the change is considered to be significant.

Average soundness test results of three samples were obtained. The unsoundness of the specific test sample of particular mixing water is significant if the results of Le-Chatelier's test are more than 10mm as per (IS 456:2000). The IS 269:1976 code specifies the limit for soundness that the Le–Chatelier's test result should not be more than 10 mm for ordinary Portland cements.

Table-II shows that the characteristics of the potable water (PW), and treated domestic waste water (TDWW), 75 % TDWW + 25% PW, 50 % TDWW + 50 % PW, and 25 % TDWW + 75 % PW used in this experimental study.

A. Setting Times:

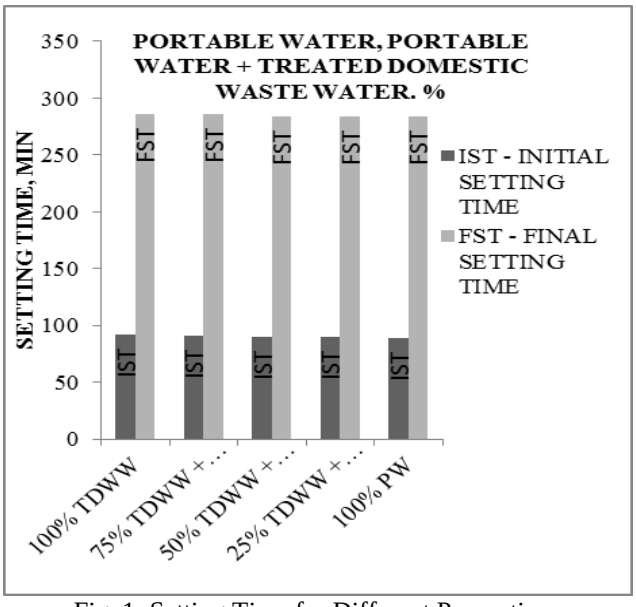

Fig. 1: Setting Time for Different Proportions

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The effect of TDWW on setting times is given in Tables-III and shown in Fig.1. As shown in table and figure, the initial and final setting times are 3 and 2 minutes increased respectively, when compared with potable water. The effect of 75%TDWW+25%PW on setting times is given in Tables – III and shown in Fig.1. As shown in table and figure, the initial and final setting times are 2 and 2 minutes increased respectively, when compared with potable water. The effect of 50% TDWW+50%PW, and 25%TDWW+75%PW on setting times is given in Tables 4.1 and shown in Fig.4.1. As shown in table and figures, the initial and final setting times are 1 and 0 minutes increased respectively, when compared with potable water.

B. Compressive Strength:

When curing carried out in potable water, the effect of TDWW on compressive strength development is given in Table-IV and shown Fig.2. As shown in tables and figures, slow strength development is observed at early age (3 days). At 7, 28 and 75 days ,compressive strength is reduced by 4.84, 1.67, and 2.72 percent as compared to potable water respectively; however, decrease in compressive strength is insignificant in all specimens.

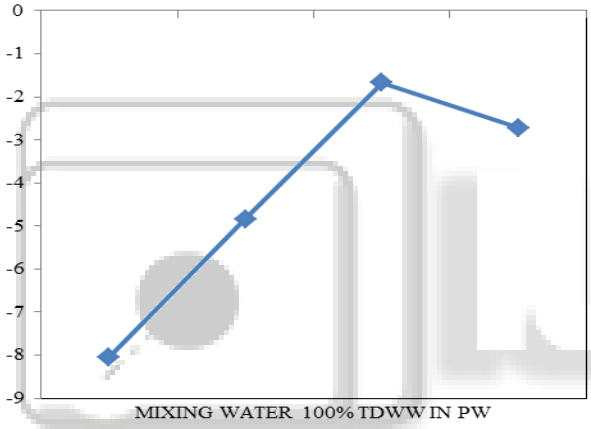

Fig. 2: Effect of Treated Domestic Waste Water on % Change in Compressive Strength

When curing carried out in TDWW, the effect of TDWW on compressive strength development is given in Tables IV and shown Fig.3. As shown in tables and figures, at early age 3 days, decrease in compressive strength is observed by 8.88%. At 7 days 28 and 75 days compressive strength is reduced by 2.14, 1.59, and 3.01 percent as compared to potable water respectively; however, decrease in compressive strength is insignificant in all specimens.

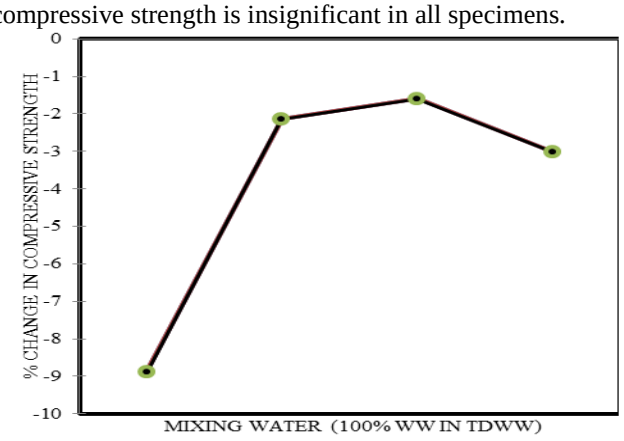

Fig. 3: Effect of mixing water on % change in Compressive Strength

The effect of 75%TDWW+25%PW on compressive strength development is given in Tables–IV and shown Fig.4. As shown in tables and figures, at early age 3 days, decrease in compressive strength is observed by 3.09%. At 7 days, 28 and 75 days compressive strength is reduced by 3.74, 1.95, and 3.60 percent as compared to potable water respectively; however, decrease in compressive strength is insignificant in all the specimens.

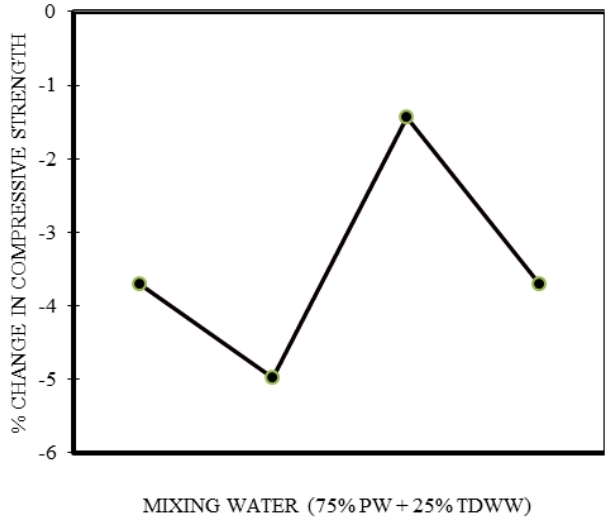

Fig. 4: Effect of mixing water on % change in Compressive Strength

The effect of 50%TDWW+50%PW on compressive strength development is given in Tables-IV and shown Fig.5. As shown in tables and figures, at early age 3 days, decrease in compressive strength is observed by 3.52%. At 7 days 28 and 75 days, compressive strength is decreased by 4.67, 1.87, and 2.45 percent as compared that of potable water respectively; however, decreased in compressive strength is insignificant in all the specimens.

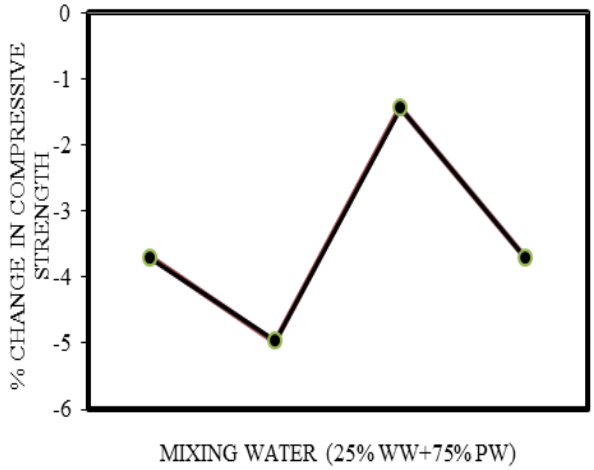

Fig. 5: Effect of mixing water on % change in Compressive Strength

The effect of 25%TDWW+75%PW on compressive strength development is given in Tables-IV and shown Fig.6. As shown in tables and figures, at early age 3 days, decrease in compressive strength is observed by 3.71%. At 7 days, 28 and 75 days compressive strength is reduced by 4.97, 1.43, and 3.71 percent as compared to potable water respectively; however, decrease in compressive strength is insignificant in all the specimens.

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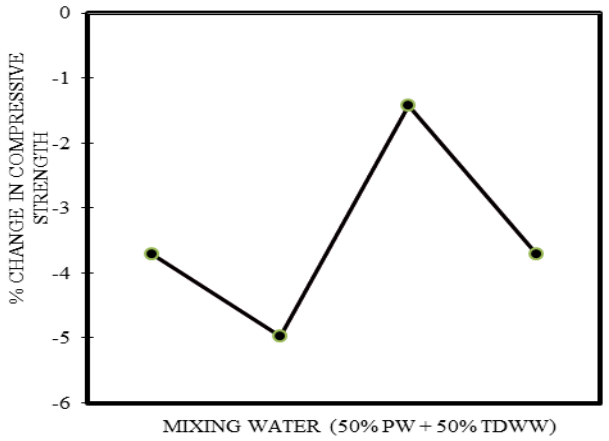

Fig. 6: Effect of mixing water on % change in Compressive Strength

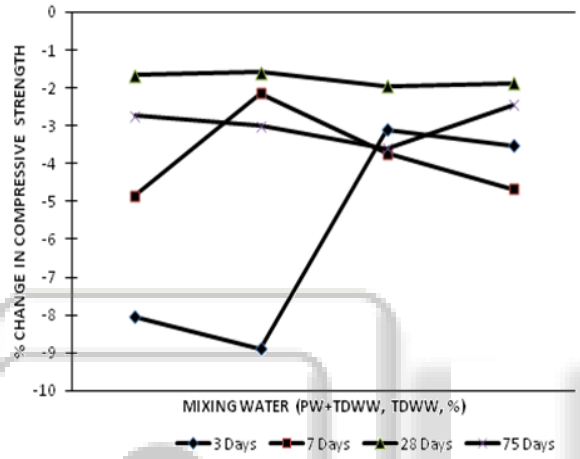

Fig. 7: Effect of mixing water on % change in Compressive Strength

S.no	Description	Initial (min)	Final (min)	Soundness (mm)
1	100% TDWW cured in PW	92	286	1.05
2	100% TDWW cured in TDWW	92	286	1.05
3	75% TDWW + 25% PW cured in PW	91	286	1.05
4	50% TDWW + 50% PW cured in PW	90	284	0.7
5	25% TDWW + 75% PW cured in PW	90	284	0.7
6	100% PW cured in PW	89	284	0.7

Table III: Initial Setting, Final Setting Time & Soundness for Different Mixes

S.no	Description	3-days	7-days	28-days	75-days
1	100% TDWW cured in PW	43.36 mpa	50.16 mpa	61.93 mpa	68.73 mpa
2	100% TDWW cured in TDWW	42.97 mpa	51.58 mpa	61.98 mpa	68.52 mpa
3	75% TDWW + 25% PW cured in PW	45.70 mpa	50.74 mpa	61.74 mpa	68.11 mpa
4	50% TDWW + 50% PW cured in PW	45.50 mpa	50.25 mpa	61.80 mpa	68.92 mpa
5	25% TDWW + 75% PW cured in PW	45.41 mpa	50.09 mpa	62.06 mpa	68.03 mpa
6	100% PW cured in PW	47.16 mpa	52.71 mpa	62.98 mpa	70.65 mpa

Table IV: Compressive Strength of Different Mixes

C. Soundness:

The effect of different mixing waters on Soundness is given in table-III and shown in fig 8. The expansion measured are 0.5mm, 0.67 mm for PW, TDWW, 75% TDWW + 25%PW, 50% TDWW + 50% PW, and 25% TDWW + 75%PW respectively.

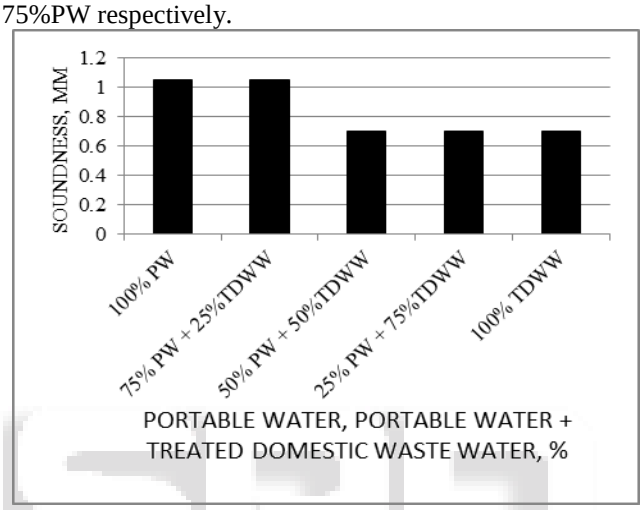

Fig. 8: Soundness for Different Proportions

IV. Conclusion

Setting times are found to very insignificantly increase in all types of mixing water when compared with potable water. There are no adverse effects on resulting in compressive strength, when cement mortar specimens made with TDWW and cured in same water. As the measured values are less than 10 mm; all the samples are considered sound. The present experimental study confirms the feasibility of using TDWW in cement mortar.

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