An Experimental Study on Use of Secondary Treated Wastewater for Concrete Mixing

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Abstract - *Water is one of the basic and important necessities for all living beings on the Earth. Water is used for many purposes such as cooking, irrigation, power generation, drinking purposes and construction, etc. Increasing dependence on water, changing lifestyle and continuous depletion of water table is leading to water scarcity. This scarcity will worsen more with the current rate of population increase. As per the facts, a huge amount of water is used in the construction sector, so to preserve the potable water (tap water); we can replace the potable water with secondary treated wastewater (STWW) from sewage treatment plant. This will also help in saving the cost associated with the further treatment of STWW. Therefore, this paper evaluated the use of STWW in production of concrete and the properties such as workability, setting times, compressive strength, and tensile strength were compared to the properties of concrete formed with tap water. With this even the wastewater can be properly managed in an environment friendly manner.*

By evaluating and comparing the compressive, tensile strength of the tap water concrete and STWW concrete it is found that the strength obtained is greater in secondary treated wastewater except, the tensile strength of STWW concrete was found to be 3.95% less than tap water concrete at 28 days. The workability of both concrete mixtures was similar whereas the setting time of concrete with STWW was slightly higher.

***Key Words*: Concrete, Wastewater, Compressive strength, Tensile Strength**

1. INTRODUCTION

Due to rapid urbanization and industrialization the water table is falling day by day which ultimately is leading to the scarcity potable water availability. The construction industry is one of the industries with high water usage and especially this usage is associated with concrete. Concrete is a mixture of cement, sand aggregates and water in a particular specified ratio. The concrete industry on an average utilizes about 1 billion tonnes of potable water annually. This high water consumption has therefore serious impacts on the environment [1]. In this era of development where the concrete is extensively used we need a substitute for the fresh/ tap water use. One such alternative to potable water is secondary treated wastewater (STWW) for making concrete; on an average about 70 million cubic meters (MCM) of wastewater is treated annually, which can be used for hydration of cement and curing of concrete if handled carefully. This will not only ensure proper wastewater management but also save huge cost associated with making this STWW to potable water. There is ample literature available on the utilization of wastewater in concrete. Some of these works are: a) Al-Jabri et al. in 2010 investigated that the usage of wastewater generated form car washing station in concrete, this highlighted that the strength of concrete mixtures prepared using wastewater was equivalent to the normal concrete mixture's strength and also proved that the water absorption is not affected by using waste water [3]. b) Ibrahim et al. pointed that the treated wastewater also gives good results for the concrete casting with no affect on slump value and density [4]. c) Gadzama et al. also investigated the use of sugar industry wastewater for casting and curing of the concrete. The results indicated an increase in the strength with an increase in curing duration in case of wastewater but hair-like cracks developed all over the casted cubes with a substantial volume change in the cube's dimension [5].

Therefore, this paper also aims to investigate the usage of STWW in concrete.

2. MATERIALS AND METHODS

2.1. Secondary Treated Wastewater (STWW) for mixing

The treated wastewater for conducting this research work was taken from sewage treatment plant, Ludhiana (SBR technology) after the secondary treatment of wastewater. The characteristics of STWW were: $BOD_5 \leq 20$ mg/l, pH: 7.8, COD ≤ 35 mg/l, TSS: ~ 500 mg/l. The STWW was collected in 20 liter opaque plastic bottles. While for normal concrete mixture normal tap water was used.

2.2. Cement

The Portland Pozzolana Cement (PPC) was used for the study. Cement was dry in state and free from lumps. The physical properties of cement were in accordance to IS 1489-1991 part (1).

2.3. Fine aggregates

The locally available sand conforming to IS 383- 1973 was used for the study. The sand was thoroughly sieved through 4.75 mm sieve to remove bigger size particles. The properties of fine aggregates used were: specific gravity- 2.49, water absorption- 0.98, fineness modulus- 2.28, bulk density- 1.3 kg/m3.

2.4. Coarse Aggregates

Locally procured grey colored crushed coarse aggregates of size 20mm were used for the study. The properties of coarse aggregates used were: fineness modulus- 6.78, specific gravity- 2.61, and water absorption- 1.90.

2.5. Concrete

The study was conducted on M25 mix design with ratio 1:1:2 and, the W/C ratio were taken 0.45. The ingredients were mixed homogeneously in dry state. Firstly, tap water was used and later it was replaced 100% by secondary treated wastewater. The mixing was done at room temperature. No additives were used.

2.6. Analytical Methods

The compressive strength test of concrete cubes of 150mm size was tested at 7 days and 28 days as per Indian Standards (IS 516: 1959, 2013).The tensile strength test of concrete cylinders of 150mm diameter and 300mm height was tested at 7 days and 28 days as per Indian Standards (IS 516: 1959). Whereas, the slump test was performed on freshly mixed concrete as per IS: 1199- 1959. And the setting time test was conducted on freshly mixed concrete according to ISS-8142-1976.

3. RESULTS AND DISCUSSION

The properties for concrete were tested for slump, initial setting time, final setting time, along with and compressive strength and tensile strength of the hardened concrete at 7 and 28 days, with the M25 concrete specimens made with tap water (TW) and secondary treated wastewater (STWW). The summary of results is listed below in Table1.

Table 1: Test result values

Test Description	Trial No.	Potable (Tap) water		Secondary Treated wastewater	
		7 days	28 days	7 days	28 days
Compressive Strength (N/mm2)	Trial 1	18.12	24.88	19.78	25.47
	Trial 2	19.63	25.68	20.59	26.87
	Trial 3	20.58	26.25	21.37	26.98
	Average	**19.44**	**25.60**	**20.58**	**26.44**
Tensile Strength (N/mm2)	Trial 1	2.78	3.16	2.82	2.87
	Trial 2	2.85	3.31	3.16	3.23
	Trial 3	2.98	3.39	3.28	3.38
	Average	**2.87**	**3.29**	**3.09**	**3.16**
Slump Test (mm)	Trial 1	114		115	
	Trial 2	116		118	
	Trial 3	119		120	
	Average	**116.34**		**117.67**	
Initial Setting time (minute)	Trial 1	30		30	
	Trial 2	30		32	
	Trial 3	32		32	
	Average	**30.67**		**31.34**	
Final Setting time (minute)	Trial 1	590		610	
	Trial 2	600		600	

Trial 3	600	610
Average	**596.67**	**606.67**

The results highlighted that it is safe and efficient to use STWW in concrete. The key observations are listed below.

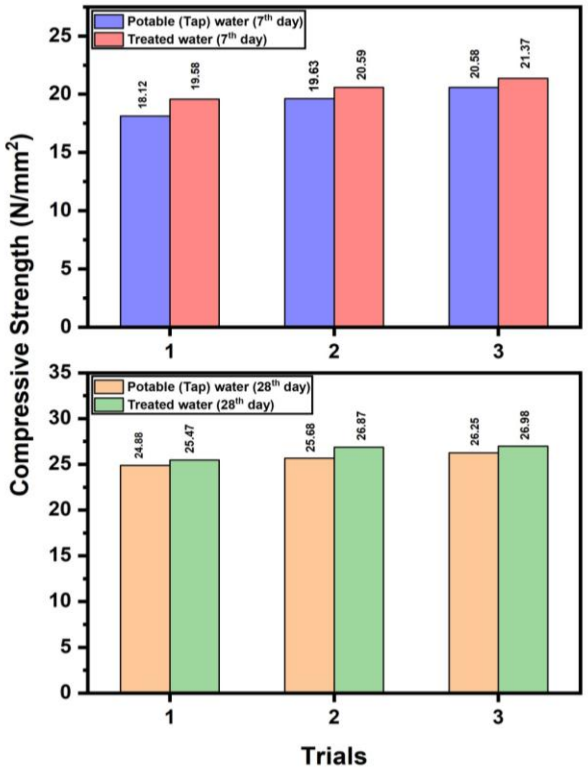

Figure 1: Values of compressive strength of concrete cubes with TW and STWW at 7 days (a) and 28 days (b) respectively

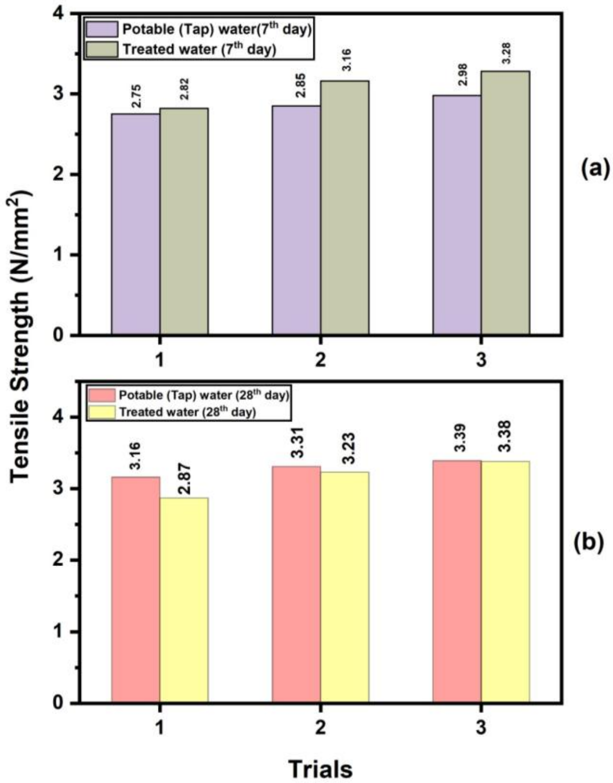

Figure 2: Values of tensile strength of concrete cubes with TW and STWW at 7 days (a) and 28 days (b) respectively

- The compressive strength of concrete with STWW is found out to be more than the concrete with TW as shown in figure 1, i.e. 5.86% higher at 7 days and 3.28% higher at 28 days. The similar increasing trends are also reported by Aqel W. J., 2015 [9]; More et al., 2014 [11] and Ooi et al., 2001 [10].
- The tensile strength of concrete with STWW at 7 days was 7.66% higher than TW whereas the strength at 28 days of the former was found to be 3.95% less than concrete with TW. (Figure 2).
- The slump values in case of STWW were a slightly higher than that of with TW. However, the values in both cases were in similar range depicting high workability.
- The setting time was slightly affected by type of water mixed in the concrete. The concrete with STWW was having high retarding time values comparatively. This is also predicted in a research by Al-Ghusain & Terro, 2003 [12].
- No odor problems were observed.
- The colors of concrete cubes casted with STWW were comparatively darker.

Figure 3 presents the comparison of concrete with tap water (TW) and secondary treated wastewater (STWW).

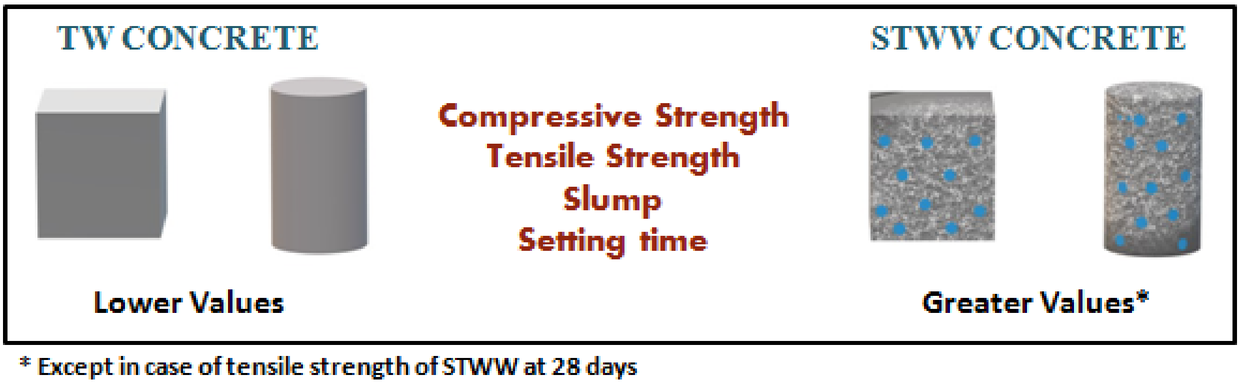

Figure 3: Comparison between TW concrete and STWW concrete

4. CONCLUSION

This study shows that the compressive strength and tensile strength of the concrete increases with use of secondary treated wastewater except, for the tensile strength of concrete after 28 days decreased as compared to that of conventional concrete. The workability was not impacted by the addition of STWW however; the setting time was slightly increased in case of STWW. It can be concluded that the secondary treated wastewater is a sustainable and feasible option to use at the place of tap water and this can also save the cost associated with the further treatment to convert it into potable water.

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