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COMPARATIVE STUDY ON EFFECT OF POTABLE WATER AND TREATED WATER ON CONCRETE

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ABSTRACT

Concrete is the most widely used unnatural complex blend on the planet. Furthermore, concrete is one of the industries that use a lot of water. Beyond the considerations of other water exercises in the construction industry, approximately 130–150 liters of water are required per cubic metre of the concrete mixture. Water is an essential environmental problem, and its supply and quality are becoming increasingly limited around the world. As a result, there is a demand to conserve water, while millions of litres of wastewater are produced and wasted every day from various sources. The use of treated wastewater in the production of concrete is critical in the current situation. With this in mind, an experimental study was conducted to evaluate the mechanical properties of conventional concrete (CC) using treated wastewater (TWW). An M20 grade of concrete was used for this study.The concrete mixes used in this study had a water-to-cement ratio of about 0.50. The strength and durable properties of each concrete mixture were evaluated by IS code provisions. Furthermore, three of each specimen were cured separately in potable water and treated wastewater to assess the effect of treated wastewater as curing water. The results show that concrete mixtures made with treated wastewater have similar strength properties to concrete made with potable water.

Keywords: Conventional concrete (CC), Treated wastewater (TWW), Potable water (PW)

1. INTRODUCTION

It is becoming increasingly difficult to obtain potable water as a result of rapid urbanization and industrialization. A large amount of water is used in the construction industry because of the use of concrete. Concrete is the predetermined proportion of cement, sand, aggregates, and water. On average, the concrete industry consumes about 1 billion metric tonnes of potable water per year. Consequently, excessive water use has negative consequences for the environment. As a result, the concrete industry will need to find a new source of freshwater. The ultimate and final option will be to treat the wastewater, which will then be used for drinking purposes. So, to save freshwater, use this treated wastewater in the construction industry. Wastewater impurities may not affect all of the properties of concrete, but they may affect some of them. Water samples were collected from the campus of our college. The wastewater was tested in a lab to determine its chemical properties such as pH, TSS, hardness, BOD, and COD. So, if we can use treated wastewater in the construction industry for the aforementioned purposes, we can save a lot of freshwater while also raising awareness about the importance of water. The primary objective of this experimental study is to determine the feasibility of using treated wastewater for concrete production alone or in combination, particularly for concrete casting and curing.

2. LITERATURE REVIEW

Nirmalkumar and SivaKumar (2008) investigated the impact of recycled wastewater on the durability of concrete. They used recycled wastewater from the tannery industry for construction, which greatly reduced the water shortage by performing some primary treatment. The specimens were then cast by adding the concrete admixture at 0.5 percent, 1.0 percent, 1.5 percent, 2.0 percent, and 2.5 percent concentrations. The specimens were subjected to 28-day, 90-day, and 365-day durability tests.

E.W.Gadzama (2015) investigated the effect on the properties of normal strength concrete of using wastewater from a sugar factory as mixing water**.** Sugar wastewater from the factory was discovered to be acidic, since the setting time of wastewater increases with percentage replacement. There were also hair-like cracks visible all over the cubes. Concentrations of metallic elements measured in wastewater and compared to potable water revealed that zinc, lead, and sodium were within the WHO standard range, and the wastewater had an acidic pH, which was outside the quoted standard.

Adeyemiand (2014) investigated the impact of seawater on concrete's compressive strength. 50 percent of the concrete cubes were made with freshwater, while the other 50 percent were made with seawater. Curing times were 7, 14, 21, 28, and 90 days. Their research shows that when concrete is mixed with seawater and cured with freshwater, its compressive strength increases.

Mohanapriya etal. (2015) conducted a comparative study with textile wastewater and ordinary water on concrete. The mechanical strength properties showed that that the similar to potable water and also, the cube specimens were subjected to acid attack. When compared to potable water, the acid attack behaviour on concrete cubes made with TCW was less. In terms of compressive strength after acid curing, a fly ash concrete cube outperforms regular cubes.

Mayuresh et al. (2020) explored the impact of domestic wastewater on the concrete mixing and curing process. The results of the tests revealed that the compressive strength of specimens containing wastewater increased noticeably.

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3. MATERIALS

3.1 Cement

Ordinary Portland cement (OPC) 53 grade cement was used in this study. It was procured from the local market. The results acquired are under the specifications laid out by IS 12269:2013. The physical properties of cement are presented in table 3.1.

Table 3.1 - Physical Properties of Cement

S.NO	Characteristics	Values	Standard value as per IS 12269 : 2013
1	Normal consistency	31%	-
2	Initial setting time(minutes)	36min	Not less than 30
3	Final setting time (minutes)	210 min	Not greater than
4	Fineness (%)	3%	<10
5	Specific gravity	3.15	-
6	Compressive strength		
i	3 days	23.8 N/mm^2	Not less than 33 N/mm^2
ii	7 days	34.2 N/mm^2	Not less than 43 N/mm^2
iii	28 days	45.0 N/mm^2	Not less than 53 N/mm^2

3.2 Coarse Aggregate

A coarse aggregate with a size of 20 mm was employed. IS 383-2016 is used to test the aggregate. The aggregate has a specific gravity of **2.7.**

3.3 Fine Aggregate

As a fine aggregate, ordinary river sand was utilized. It is locally sourced and conforms to IS: 383-1970 grading Zone II and the sand have a specific gravity of **2.6.**

3.4 Water.

Potable tap water was used, which was readily available on our college campus. The wastewater was collected from a nearby wastewater treatment plant. It is satisfied under IS 10500:2012. The chemical analysis of wastewater is given in Table 3.2. To compare water quality with standards, the following parameters were measured for both potable and treated water.

Table 3.2 - Chemical Analysis of Wastewater

Parameters	Treated water	Potable water	Permissible Limits As per IS 10500:2012
pH Value	7.4	6.9	Not less than 6
Chloride	150 mg/L	210 mg/L	2000mg/L
Sulphate	233 mg/L	187 mg/L	400mg/L
Hardness	200 mg/L	300 mg/L	Not exceed 500 mg/L
Total Suspended Solids	924 mg/L	749 mg/L	2000 Mg/L
Alkalinity	275	391 mg/L	Not less than 200

Fig 3.1 - Testing of Treated Wastewater

Table 3.3 - Mix proportions of M20 Grade of Concrete

Materials	Cement Kg/m^3	Fine Aggregate Kg/m^3	Coarse Aggregate Kg/m^3	Water Kg/m^3
Control Concrete	394	652	1153	197
Mix Ratio	1	1.6	3.00	0.50

4 CASTING AND TESTING OF SPECIMENS

150 mm size cube specimens were cast for compressive strength test, Cylinder specimen of the dimension of 150mm of diameter X 300mm of length was used for split tensile strength. The cast specimens, such as cubes and cylinders, are stored in the curing tank until the testing day.

4.1 Compressive Strength Test

Test specimens were tested after 7, 28, and 56 days of curing. Following the curing time, all prepared specimens are crushed and tested using a compression testing machine. The compressive force is given to concrete cubes until the specimen fails. Compressive strength is computed for the prepared concrete cube using the formula: compressive strength of cube specimens = maximum compressive crushing load/area of concrete cube. The average compressive strength of cube specimens prepared with potable and treated water is summarised in Table 4.1. Figure 4.1 depicts an experimental setup for cube compressive strength.

Table 4.1 - Compressive Strength of Cube Specimens

Type of water used	Percentage of water used	Average Compressive strength N/mm^2		
		7 days	28 days	56 days
Potable water	100	21.02	26.43	29.11
Treated water	100	22.07	26.14	28.93

Fig 4.1 - Test Setup for Compressive Strength

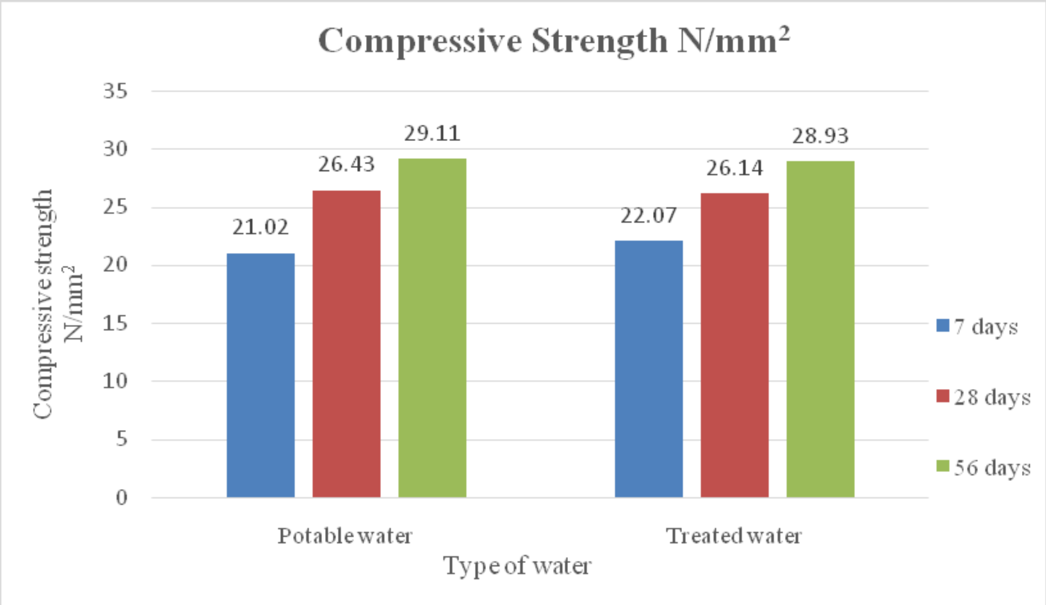

Fig 4.2 - Compressive Strength of PW& TWW Concrete Cube Specimens

4.2 Split Tensile Strength Test

The cylinder specimens were tested for split tensile strength after 7 and 28 days. The formula was used to calculate the tensile strength of the specimen.

Split tensile strength = 2P/LD.

According to IS 456:2000, the split tensile strength is 0.7 f ck.

Where fck = 28-day characteristic strength, the split tensile strength tests on concrete cylinders are shown in the table 4.2 and figure 4.3.

Table 4.2 - Split Tensile Strength of PW AND TW Specimens

Type of water used	Percentage of water used	Average Split Tensile strength N/mm^2	
		7 days	28 days
Potable water	100	2.85	3.3
Treated water	100	2.79	3.34

Fig 4.3 - Test Setup for Split Tensile Strength

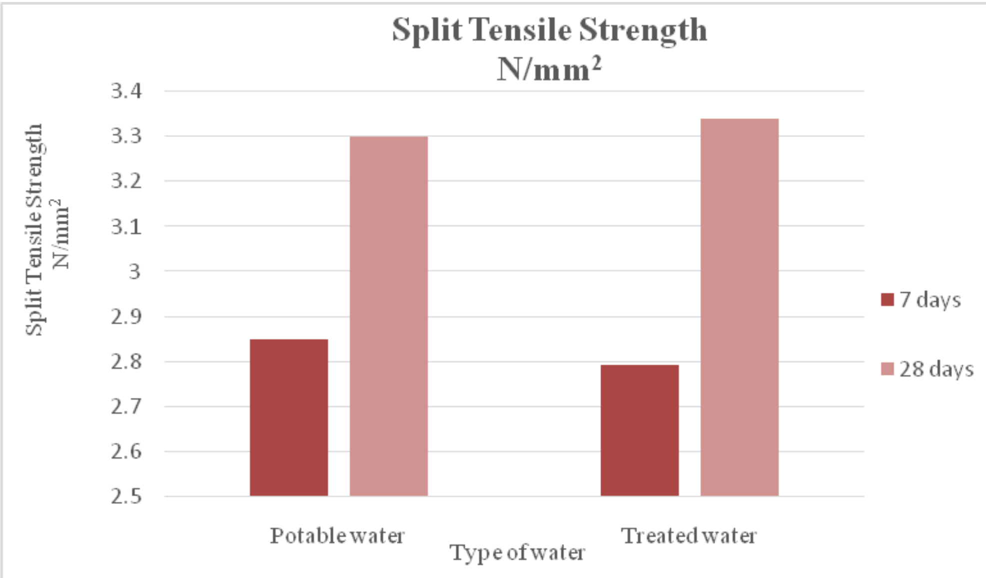

Fig 4.4 - Split Tensile Strength of PW& TWW

4.3 Durability Tests

4.3.1 Water Absorption Test

According to ASTM C642, the water absorption of concrete mixes was measured on 150 mm cube specimens after 28 days of curing. When it comes to the durability of structures, water absorption is an important factor to consider. The cube specimens were placed in the oven. For 72 hours, the specimens were dried in an oven set to 110ºC.After being removed from the oven; the specimens were allowed to cool for 24 hours in an airtight container. The weight of each specimen was recorded. The specimens were then immersed in water for 30 hours. The specimens were then removed from the water tank and shaken to remove any excess water. The specimens were then wiped dry with a soft cloth. The weights of the specimens were also recorded. Water absorption is expressed as a percentage of the weight of water absorbed to the dry weight of the sample.

Table 4.3 - Water Absorption Test Results

Mix	Dry weight (kg)	Wet weight (kg)	Water absorption (%)
Potable water(PWC)	8.12	8.38	3.20
Treated water(TWWC)	8.20	8.51	3.78

4.3.2 Rapid Chloride Permeability Test (RCPT)

The rapid chloride permeability test (RCPT) was performed in accordance with ASTM C1202 standards. Figure 4.5 shows the test setup for RCPT. To evaluate the test, concrete disc specimens with a diameter of 100 mm and a thickness of 50 mm were cast to evaluate the test. The disc specimens were removed from the mould after 24 hours and cured for 90 days. Following the curing process, chloride permeability was determined on the specimens. Prior to testing, all specimens were completely dried. The disc specimen is sandwiched between two compartments of the cell assembly and examined for air and water tightness. The cathode chamber is filled with a 3% sodium chloride solution, while the anode compartment is filled with a 0.3 normality sodium hydroxide solution.

Table 4.4 - Limits of Rapid Chloride Permeability of Concrete as per ASTM C1202

Charge passed (Coulombs)	Chloride ion permeability indicator
More than 4000	High
2000 to 4000	Moderate
1000 to 2000	Low
100 to 1000	Very low
Less than 100	Negligible

Fig 4.5 - Test Setup for RCPT

Table 4.5 - RCPT for PWC and TWWC SPECIMENS

Mix ID	Charge passed	Chloride permeability
PWC	2341	Moderate
TWWC	2129	Moderate

4.4 Discussion on Test Results

Chemical analysis of potable and treated water conforms to the IS codal requirement, as indicated in Table 2. Figure 3 illustrates the compression test results of PW and TWW specimens after 7, 28, and 56 days of curing. For 7, 28 and 56 days, PW concrete reached strength of 21.02 N/mm^2, 26.43 N/mm^2, and 29.11 N/mm^2 respectively. Whereas the average compressive strength of the TWW concrete sample was 22.07 N/mm^2, 26.14 N/mm^2, and 28.93 N/mm^2. The split tensile strength of the specimens is shown in Table 5. The split tensile strength of the TWW concrete cylindrical specimen and the PW specimen was 3.34 N/mm^2 and 3.3 N/mm^2, respectively. There is no noticeable variation in strength; indeed, it is less than 1%. When it comes to water absorption, PW specimens have 3.2 % while TWW specimens have 3.78 %, indicating that PW specimens have less water absorption than TWW specimens. The results of the rapid chloride permeability test on concrete mixes are listed in Table 8. As shown in this table, PWC and TWWC exhibited moderate resistance to chloride ion penetration. According to ASTM C1202, these concrete specimens have a moderate level of chloride ion penetration.

5 CONCLUSION

Based on the study following conclusions have been drawn

a) Based on the test results, slight variations in the mechanical properties of concrete were observed when potable water concrete (PW) and treated wastewater concrete (TWW) were compared.
b) According to the chemical analysis test for treated wastewater, all parameters fulfilled the permissible limits as per IS Code, As a result, treated water can be used for concrete preparation and curing.
c) According to the RCPT results, the specimens had moderate chloride ion penetration.
d) Chlorides present in treated water have a hardening effect, resulting in a slight difference in split tensile strength.
e) Thus, it is possible to reduce construction expenditures by utilizing treated wastewater in construction activities.

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