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# A STUDY ON THE DURABILITY IMPACT OF CONCRETE BY USING RECYCLED WASTE WATER

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## ABSTRACT

**The waste water from tannery industry can be used for the construction purpose, so that the shortage in water can be greatly reduced. In addition the problem of disposal of waste water from these industries can be solved if the water is reused for some other purposes. The basic properties of the treated and untreated water from the tannery industry were tested and the results were found to be satisfactory such that it can be used for construction purposes with some minimal treatment. Even the mechanical properties of the concrete using these effluents are also found to be satisfactory. By using the waste water from the tannery industry, cubes and cylinders were casted and tested for its durability (sulphate attack, chloride attack and corrosion impact). The result shows some deviation compared to specimens casted using potable water and so chemicals in form of inhibitors were used and the results were found to be satisfactory.**

## INTRODUCTION

Nowadays ground water is depleting in a fast manner and lot of money are required and spent for search of water in the vicinity of water source (Garg, 1998). So, the used water in the industry can be recycled and used for industrial activities like construction purposes, if the water is found to be suitable. The Tannery and Textile water which joins the river is only partially treated. The partially treated water consist lot of Total dissolved solids which affect water so much. The tannery waste water even if it is stored unused also it is a major pollution problem to the environment. (Anbalagan *et al. 1997)* in their paper have briefly discussed about the problem. Since the water that is let out from the textile and tannery industries after the process are 80-140 kilo litres and 40 kilo litres per unit production respectively (Garg, 1998). The wastewater available from the tannery and textile industries in and around Erode can be used for the construction purpose after suitable treatment. So, an attempt is made to utilize the polluted tannery and textile water for construction purposes by making some primary treatments.

In addition to this, ground water as well as cultivable lands is also polluted. If the water is utilized for some other domestic purposes it leads to a lot of human illness (Amirthalingam and Larson, 2006) in their study have given the impact of this problem in detail. To minimize these problems this waste water can be used for construction purposes without affecting the surrounding environment. By utilization of this water, water scarcity can be reduced.

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## EXPERIMENTAL PROGRAMME

### Mix Design

For preparing test specimens 53 grade ordinary Portland cement conforming to IS 12269-1987 is used which should undergone field tests before casting ( Sheety, 2001) and natural river sand and stone aggregate satisfying the required properties conforming to IS 383-1970 were used. The maximum size of the coarse aggregate was limited to 20 mm to get the maximum increase in compressive strength. A sieve analysis conforming to IS 2386 (Part I)-1963 was carried out for both fine and coarse aggregate and other tests were carried out as per IS 2386(Part II-V)-1963. The concrete mix proportion $M_{20}$ adopted is 1: 1.38: 3.09 (cement: sand: coarse aggregate) with water cement ratio of 0.5, $M_{25}$ adopted is 1:1.31:2.94 (cement: sand: coarse aggregate) with a water cement ratio of 0.45 and $M_{30}$ adopted is 1:1.06:2.51 (cement: sand: coarse aggregate) with a water cement ratio of 0.39 respectively with respect to the mix design as per IS 10262-1982. The Specimens were casted and cured for 28 days in water after 24 hours of their casting as per IS 2250-1981. The specimen is removed from the curing tank before two days of testing and they were dried for one day.

All the specimens were casted using potable water, untreated tannery water and treated tannery water respectively. The specimens were casted first without adding the admixture. Then the specimens were also casted by adding the concare admixture with dosages of 0.5%, 1.0%, 1.5%, 2.0% and 2.5%. The specimens were tested for durability properties for 28 days, 90 days and 365 days.

### Durability Study

To study the durability aspects, the following tests on the concrete specimens are conducted as per the standard procedure.

#### *Sulphate Attack*

Solid sulphates do not attack the concrete severely but when other chemicals come into contact, they try to find entry into porous concrete and react with the hydrated cement products. Sulphate attack on concrete results due to the chemical reaction between the sulphate ion and hydrated calcium aluminate or the calcium hydroxide components of hardened cement paste in the presence of water. The products resulting from these reactions are calcium sulphoaluminate hydrate, commonly referred to as ettringite, and calcium sulphate hydrate, known better as gypsum. These solids have a very much higher volume than the solid reactants and, as a consequence, stresses are produced that may result in breakdown of the paste and ultimately in breakdown of the concrete.

The concrete cubes of size 150 mm x 150mm x 150 mm have to be casted . These cubes are then cured for 28 days in fresh water. Then these cubes are dried and weight of each cube is noted. In this experimental study the concrete cubes are subjected to 3 % sulphate solution keeping in mind that even in worse environmental conditions the presence of sulphur is below is 2.5 percent. A non-porous container is selected and sulphate solution has been prepared by adding 3 % of concentrated sulphuric acid to 50 litres of distilled water. They are then immersed in the sulphate solution and kept undisturbed for 28 days. The observations are made after taking the concrete cubes from sulphate solution and cleaning it in fresh water. After drying the cubes the change in weight is found and also the compressive strength of concrete cubes is to be determined.

#### *Chloride Attack*

Large number of concrete structures is exposed to seawater, where seawater contains 3.5% of salt by weight. The ionic concentration of $Na^+$ and $cl^-$ are the highest, typically 11,000 and 20,000 mg/L respectively. It is commonly observed that deterioration of concrete in seawater is often not characterized by the expansion found in concrete exposed to sulphate action, but takes more of the form of erosion or loss of constituents from the parent mass without exhibiting undue expansion. Also the concrete that is subjected to chloride attack may cause efflorescence and persistent dampness. But the research workers are unanimous in their opinion that seawater can be used in unreinforced concrete or mass concrete.

A non-porous container is selected and chloride solution has been prepared by adding 3.5% sodium chloride to 50 litres of distilled water. This solution is stirred well so that all the sodium chloride salts gets dissolved in the solution. The cubes after 28 days of curing has been taken out and dried. The initial weights of these cubes are found. They are then immersed in the chloride solution for a period of 28 days and kept undisturbed. The observations are made after taking the concrete cubes from chloride solution and cleaning it in fresh water. After drying the cubes the change in weight and compressive strength of concrete cubes are to be determined.

#### *Corrosion Attack*

A reinforcement steel bar of 20mm diameter and

300mm long is weighed and noted down. A cylinder of 150mm diameter and 300mm height is used for preparing the specimen. The steel bar is held in position and concreting is done. Care should be taken so that the rod stays in position while compacting. The specimen is allowed to cure for 28 days.

The test setup that essentially measures resistivity of concrete consists of a constant DC supply providing constant voltage of 120 Volts through a shunt in a constant voltage mode and 80 million Ampere in constant current mode. The test was carried out in a 6% NaCl solution with an embedded reinforcement bar as a working electrode a shown in Fig.1 and a copper bar as a counter electrode. The variable parameter voltage was recorded at every 15 minutes interval for 6 hours in constant current study. The set up is kept for 15 days without disrupting the power supply.

The solution turns to reddish brown in color due to the formation of rust. Then the specimens are removed from the set up, dried in air, visually inspected and carefully split open to access the corroded steel bar. The reinforcement bar was then cleaned as per ASTM G1 of 1981 by dipping it in Clark's solution (HCl of specific gravity 1019 litre + antimony trioxide 20gm + stannous chloride 50gm) for 25 minutes. Each bar was weighed again to the accuracy of 0.1mg to find out the change in weight. Fig.1 shows the view of test setup.

## TEST RESULTS AND EVALUATION

The specimens were casted and tested for its sulphate attack, chloride attack and corrosion attack for 28 days, 90 days and 365 days of casting of cube and cylinders. By trial and error method it was determined that by using 2.0% of concare admixture, the results were almost equal for chloride attack and corrosion attack. Hence only the test results of all the three parameters using 2.0% of concare are given and compared. The model graphs are plotted for 365 days result for sulphate attack, chloride attack and corrosion attack and shown in Fig. 1-6.

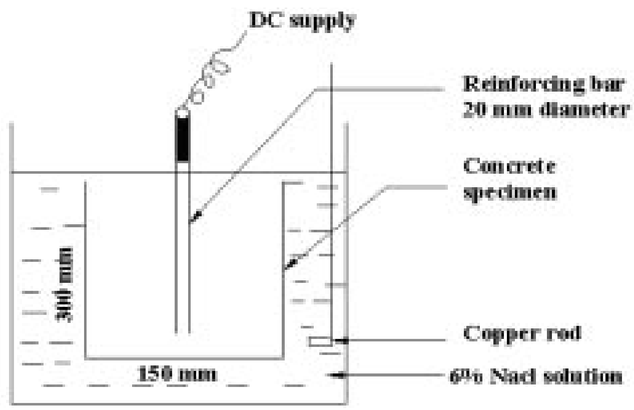


**Fig.1** Accelerated corrosion test setup

## CONCLUSION

The maximum increase in weight due to sulphate attack is 2.01% by using untreated tannery effluent, 1.46% by using treated tannery effluent and 1.10% by using potable water specimens, which are very negligible. When 2.0% of concare was added, the maximum increase in weight is for untreated tannery effluent which is only 1.74%. This implies that the sulphate attack is slightly reduced when added with concare admixture.

The maximum increase in weight due to chloride attack is 2.25% by using untreated tannery effluent, 1.40% by using treated tannery effluent and 1.05% by using potable water specimens, which are very negligible. When 2.0% of concare was added, the maximum increase in weight is for untreated tannery effluent which is only 0.16%. Almost the chloride attack for all the specimens casted by using untreated tannery effluent, treated tannery effluent and potable water are almost same ranging from 0.10 to 0.15% which is very much negligible. This implies that the chloride attack is greatly reduced when added with concare admixture.

The loss of weight due to corrosion is 6.01% for $M_{30}$ grade of concrete by using untreated tannery effluent and that of specimen casted by using potable water is only 2.94%. This implies that corrosion is more when untreated tannery water is used. But when 2.0% of concare was added the loss in weight is almost same for the specimens casted by using various waters ranging from 0.09 to 0.13%.

From the various study conducted on the concrete using untreated tannery effluent and treated tannery effluents, the behavior of the concrete is found to be satisfactory. Hence the effluent water can be used for construction purpose by giving a minimal treatment to sulphate attack if necessary.

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MIXING OF CONCRETE

CASTING OF CUBE

CORROSION TEST SETUP

CORRODED SAMPLE

SPECIMEN SUBJECTED TO SULPHATE ATTACK

SPECIMEN SUBJECTED TO CHLORIDE ATTACK

## Sulphate attack

**Table1.** Increase in weight due to sulphate attack for untreated tannery effluent, treated tannery effluent and potable water specimens

| Grade of Concrete | Average Increase in weight in percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Potable Water | | | Untreated Tannery Water | | | Treated Tannery Water | | |
| | 28 days | 90 days | 365days | 28 days | 90 days | 365days | 28 days | 90 days | 365days |
| $M_{20}$ | 0.78 | 0.92 | 0.96 | 1.81 | 1.84 | 1.88 | 1.21 | 1.25 | 1.28 |
| $M_{25}$ | 0.81 | 0.96 | 1.03 | 1.91 | 1.93 | 1.95 | 1.37 | 1.39 | 1.41 |
| $M_{30}$ | 0.83 | 1.02 | 1.10 | 1.94 | 1.96 | 2.01 | 1.42 | 1.44 | 1.46 |

**Table 2.** Increase in weight due to sulphate attack for untreated tannery effluent, treated tannery effluent and potable water specimens mixed with 2.0% concare

| Grade of Concrete | Average Increase in weight in percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Potable Water | | | Untreated Tannery Water | | | Treated Tannery Water | | |
| | 28 days | 90 days | 365days | 28 days | 90 days | 365days | 28 days | 90 days | 365days |
| $M_{20}$ | 0.65 | 0.68 | 0.70 | 1.61 | 1.66 | 1.69 | 1.15 | 1.28 | 1.31 |
| $M_{25}$ | 0.68 | 0.69 | 0.71 | 1.68 | 1.70 | 1.71 | 1.25 | 1.41 | 1.44 |
| $M_{30}$ | 0.69 | 0.71 | 0.73 | 1.70 | 1.72 | 1.74 | 1.35 | 1.50 | 1.51 |

**Chloride attack**

**Table 3**. Increase in weight due to chloride attack for untreated tannery effluent, treated tannery effluent and Potable water specimens

| Grade of Concrete | Average Increase in weight in percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Potable Water | | | Untreated Textile Water | | | Treated Textile Water | | |
| | 28 days | 90 days | 365days | 28 days | 90 days | 365days | 28 days | 90 days | 365days |
| $M_{20}$ | 0.95 | 0.99 | 1.01 | 2.16 | 2.18 | 2.19 | 1.27 | 1.28 | 1.30 |
| $M_{25}$ | 0.96 | 1.01 | 1.02 | 2.20 | 2.21 | 2.22 | 1.30 | 1.32 | 1.33 |
| $M_{30}$ | 0.99 | 1.03 | 1.05 | 2.21 | 2.23 | 2.25 | 1.34 | 1.36 | 1.40 |

**Table 4.** Increase in weight due to chloride attack for untreated tannery effluent, treated tannery effluent and potable water specimens mixed with 2.0% concare

| Grade of Concrete | Average Increase in weight in percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Potable Water | | | Untreated Textile Water | | | Treated Textile Water | | |
| | 28 days | 90 days | 365days | 28 days | 90 days | 365days | 28 days | 90 days | 365days |
| $M_{20}$ | 0.10 | 0.11 | 0.13 | 0.11 | 0.12 | 0.14 | 0.10 | 0.12 | 0.14 |
| $M_{25}$ | 0.12 | 0.12 | 0.14 | 0.13 | 0.13 | 0.15 | 0.11 | 0.13 | 0.14 |
| $M_{30}$ | 0.12 | 0.14 | 0.15 | 0.13 | 0.14 | 0.16 | 0.12 | 0.12 | 0.15 |

**Corrosion**

**Table 5.**Loss of weight due to corrosion for untreated tannery effluent, treated tannery effluent and potable water specimens

| Grade of Concrete | Average Loss in weight in percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Potable Water | | | Untreated Tannery Water | | | Treated Tannery Water | | |
| | 28 days | 90 days | 365days | 28 days | 90 days | 365days | 28 days | 90 days | 365days |
| $M_{20}$ | 2.85 | 2.88 | 2.91 | 5.56 | 5.58 | 5.70 | 3.12 | 3.17 | 3.20 |
| $M_{25}$ | 2.89 | 2.91 | 2.92 | 5.89 | 5.92 | 5.99 | 3.19 | 3.22 | 3.26 |
| $M_{30}$ | 2.90 | 2.92 | 2.94 | 5.92 | 5.98 | 6.01 | 3.24 | 3.26 | 3.32 |

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**Table 6**. Loss of weight due to corrosion for untreated tannery effluent, treated tannery effluent and potable water specimens mixed with 2.0% concare

| Grade of Concrete | Average Loss in weight in percentage (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Potable Water | | | Untreated Tannery Water | | | Treated Tannery Water | | |
| | 28 days | 90 days | 365days | 28 days | 90 days | 365days | 28 days | 90 days | 365days |
| $M_{20}$ | 0.09 | 0.10 | 0.11 | 0.12 | 0.12 | 0.13 | 0.10 | 0.11 | 0.12 |
| $M_{25}$ | 0.11 | 0.11 | 0.11 | 0.11 | 0.12 | 0.13 | 0.11 | 0.11 | 0.12 |
| $M_{30}$ | 0.12 | 0.13 | 0.14 | 0.12 | 0.13 | 0.14 | 0.11 | 0.12 | 0.13 |

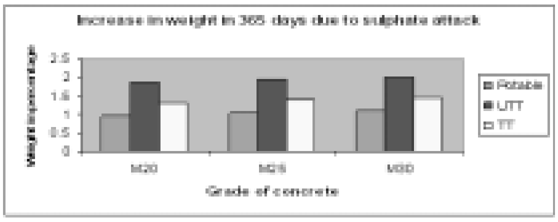


**Fig. 1** Increase of weight in 365 days due to sulphate attack without adding concare

**Fig. 2** Increase of weight in 365 days due to sulphate attack after adding concare

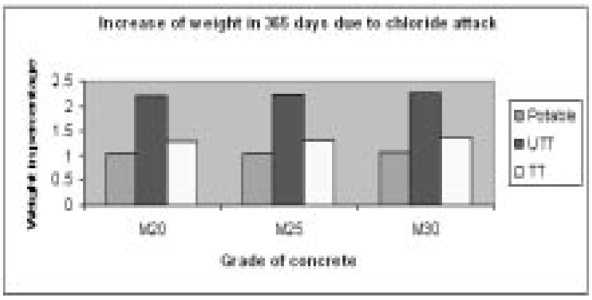


**Fig. 3** Increase of weight in 365 days due to chloride attack without adding concare

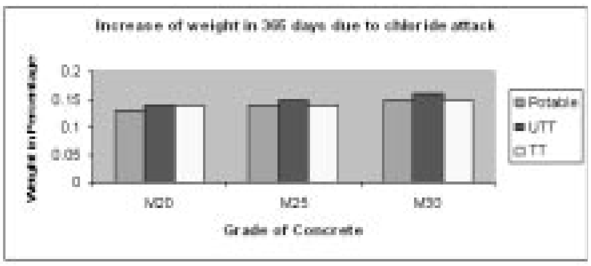


**Fig. 4** Increase of weight in 365 days due to chloride attack after adding concare

**Fig. 5** Loss of weight in 365 days due to corrosion without adding concare

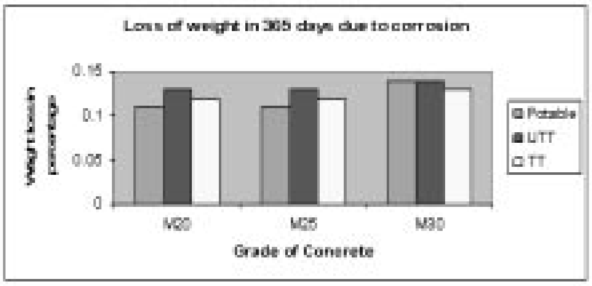


**Fig. 6** Loss of weight in 365 days due to corrosion after adding concare

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