

Studies on the Blended Concrete Prepared with Tannery Effluent

K. Nirmalkumar

Abstract—There is a acute water problem especially in the dry season in and around Perundurai (Erode district, Tamil Nadu, India) where there are more number of tannery units. Hence an attempt was made to use the waste water from tannery industry for construction purpose. The mechanical properties such as compressive strength, tensile strength, flexural strength etc were studied by casting various concrete specimens in form of cube, cylinders and beams etc and were found to be satisfactory. Hence some special properties such as chloride attack, sulphate attack and chemical attack are considered and comparatively studied with the conventional potable water. In this experimental study the results of specimens prepared by using treated and untreated tannery effluent were compared with the concrete specimens prepared by using potable water. It was observed that the concrete had some reduction in strength while subjected to chloride attack, sulphate attack and chemical attack. So admixtures were selected and optimized in suitable proportion to counter act the adverse effects and the results were found to be satisfactory.

Keywords—Calcium nitrite, concrete, fly ash.

I. INTRODUCTION

THE sulphate attack on the concrete is mainly due to the chemical reaction that occurs between the calcium aluminate hydrate and sulphate ions. The result of the chemical reaction is calcium sulphotoaluminate hydrate, commonly referred to as ettringite ($3\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot 3\text{CaSO}_4 \cdot 32\text{H}_2\text{O}$) which results in the reduction of bond strength and internal disintegration of the concrete [1], [2]. These solids (ettringite) have a very much higher volume up to 225% of the concrete specimen. As a consequence, stresses are produced in the concrete structure which may result in the breakdown of the cement paste and it ultimately results in the breakdown or total collapse of the concrete.

The chloride attack on the concrete is particularly significant since it primarily induces the corrosion of reinforcement bar embedded in the concrete. It was observed that more amount of failure and collapse of structures are due to corrosion of reinforcement bar embedded in the concrete. The concrete subjected to chloride attack is essentially characterized by efflorescence and persistent dampness found in the concrete structure.

Chemical attack generally occurs when calcium hydroxide present in the concrete is continuously attacked. The acidic solutions both mineral (such as sulphuric, hydrochloric, nitric, and phosphoric chemicals) and organic (such as lactic, acetic,

formic, tannic chemicals) are the most aggressive agents inducing the chemical attack on the concrete. The chemical attack on the concrete will not cause deterioration in the interior of the concrete structure without the cement paste on the outer portion being completely destroyed. The rate of penetration is inversely proportional to the quantity of chemical neutralizing material, such as the calcium hydroxide, cement gel (C-S-H gel) and limestone aggregates. In practice, the degree of chemical attack on the concrete goes on increasing with an increase in acidity of the concrete. The chemical attack on the concrete occurs at values of pH below 6.5, a pH of less than 4.5 leading to severe chemical attack. Indirectly due to the chemical attack, when pH of the concrete reduces below 6.5, it gives rise to the corrosion of the reinforcement bar embedded in the concrete[3]. The rate of chemical attack also depends on the ability of hydrogen ions to be diffused through the cement gel (C-S-H) after calcium hydroxide ($\text{Ca}(\text{OH})_2$) has been dissolved and leached out of the concrete.

In this study comparison was studied between specimens (cubes and cylinder) prepared by using treated tannery effluent, untreated tannery effluent and potable water. The experimental study was conducted for M30 grade of concrete. The specimens were tested after 28 days and 90 days of curing.

II. EXPERIMENTAL WORK

The natural river sand was used for which the fines modulus is 2.79 with a specific gravity of 2.51. A good quality crushed granite coarse aggregates was used. The cement used was 53 grade Portland Pozzalonc cement. The concrete mix was designed for M30 to study the mechanical strength properties and durability properties as per IS 10262-1982 [4]. The admixture was selected and used based on the guidelines of the specifications IS 9103-1978 [5].

A. Determination of Sulphate Attack on the Concrete

Sulphate attack test was carried out on the concrete cubes of size 150 mm x 150mm x 150 mm. The concrete cubes were dried in normal room temperature after 28 days of curing and the weight (W_1) of the cubes were noted. A sodium sulphate solution was prepared by adding 5 % sodium sulphate (by volume of water) to 50 litres of distilled water. In this experimental study the concrete cubes were immersed in 5 % sodium sulphate (Na_2SO_4) solution for a period of three months. The observations were then made after 28 days and 90 days from the date of immersion in the sodium sulphate solution. A characteristic whitish appearance was the indication of sulphate attack. After drying the cubes in

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normal room temperature for a period of 24 hours, the weight (W_2) of concrete cubes were noted. The compressive strength and loss of weight were calculated using the following formula [1] [6];

$$\text{Compressive strength} = \left(\frac{P}{A} \right)$$

where

P is ultimate load (load of failure) in Newton

A is area of cube in mm^2

$$\text{Loss of weight} = \left(\frac{W_1 - W_2}{W_1} \right) \times 100 (\%)$$

where

W_1 is initial weight of the concrete specimen

W_2 is final weight of the concrete specimen

B. Determination of Chloride Attack on the Concrete

Chloride attack test was carried out on the concrete cubes of size 150 mm x 150mm x 150 mm. The concrete cubes were dried in normal room temperature after 28 days of curing and the weight (W_1) of the cubes were noted. The sodium chloride solution was prepared by adding 3.5 % sodium chloride salt (by volume of water) to 50 litres of distilled water. In this experimental study the concrete cubes were immersed in 3.5 % sodium chloride (NaCl) solution for a period of three months. The observations were then made after 28 days, 180 days, 1 year, 2 years and 2.5 years from the date of immersion in the sodium chloride solution. After drying the cubes in normal room temperature for a period of 24 hours, the weight (W_2) of concrete cubes were noted. The compressive strength and loss of weight were calculated using the formula [7];

$$\text{Compressive strength} = \left(\frac{P}{A} \right)$$

where

P is ultimate load (load of failure) in Newton

A is area of cube in mm^2

$$\text{Loss of weight} = \left(\frac{W_1 - W_2}{W_1} \right) \times 100 (\%)$$

where

W_1 is initial weight of the concrete specimen

W_2 is final weight of the concrete specimen

C. Determination of Chemical Attack on the Concrete

Chemical attack was carried out on the concrete cubes of size 150 mm x 150mm x 150 mm. The concrete cubes were dried in normal room temperature after 28 days of curing and the weight (W_1) of cubes were noted. Sulphuric acid solution was prepared by adding 2.0 % sulphuric acid (by volume of water) to 20 litres of distilled water. The concrete cubes were then immersed in 2.0 % sulphuric acid solution for a period of 7 (seven) days. The observations were then made after 28

days and 90 days from the date of immersion in sulphuric acid solution. After drying, the cubes were kept in room temperature for a period of 24 hours, the weight (W_2) of concrete cubes was noted. The compressive strength and loss of weight were calculated using the following formula [8],[9];

$$\text{Compressive strength} = \left(\frac{P}{A} \right)$$

where

P is ultimate load (load of failure) in Newton

A is area of cube in mm^2

$$\text{Loss of weight} = \left(\frac{W_1 - W_2}{W_1} \right) \times 100 (\%)$$

where

W_1 is Initial weight of the concrete specimen

W_2 is Final weight of the concrete specimen

III. RESULT AND DISCUSSION

A. Selection and Optimization of Admixture

Several admixtures such as metakaolin, rice husk ash, calcium nitrite, fly ash, chemical admixtures were considered to counteract the effects due to chloride attack, sulphate attack and chemical attack. Based on many trials in various combinations, it was found and optimized that 4.0 % of Calcium Nitrite and 7.5% of fly ash is the best combination along with the cement to counteract the effect due the above said effects.

B. Sulphate Attack on the Concrete

The loss of weight of the concrete prepared by using the potable water, untreated and treated tannery effluents after 28 days are 0.51%, 0.95% and 0.84% respectively which is portrayed in the Fig. 1. It is observed that the loss of weight of the concrete prepared using the untreated and treated tannery effluents is higher than that of the concrete prepared using the potable water and this is due to the presence of more amount of sulphate content in the untreated and treated tannery effluents, untreated and treated textile effluents. The same trend is observed for result after 90 days. When 4.0% calcium nitrite and 7.5% fly ash are added, the loss of weight got reduced which is apparently shown in the Fig. 1.

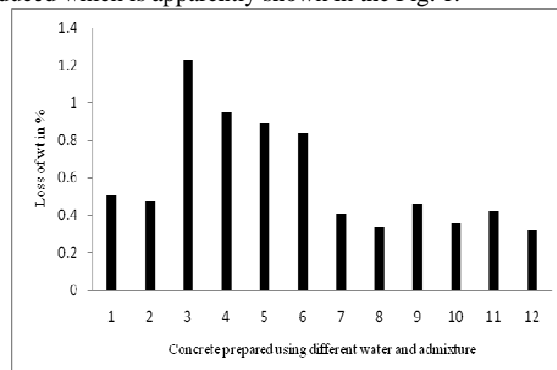


Fig. 1 Loss of Weight due to Sulphate Attack

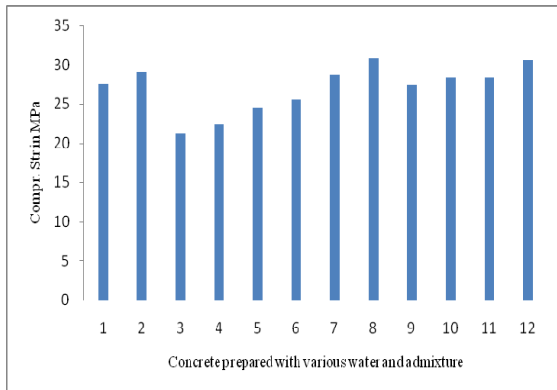


Fig. 2 Compressive Strength due to Sulphate Attack

It is evident from the Fig. 2, the compressive strength of the concrete prepared by using the potable water is 27.52MPa after 28 days and 29.12MPa after 90 days. It was also observed that the compressive strength of the concrete prepared by using untreated and treated tannery effluents are 21.26MPa and 24.45 MPa after 28 days and 22.42MPa and 25.58 MPa after 90 days. The great loss in compressive strength is due to the sulphate attack. When the admixture is added, the compressive strengths prepared by using potable water and tannery effluents are almost same.

C. Chloride Attack on the Concrete

The loss of weight of the concrete prepared by using the potable water, untreated and treated tannery effluents after 28 days are 0.41%, 0.90% and 0.47% respectively which is portrayed in the Fig. 3. It is observed that the loss of weight of the concrete prepared using the untreated and treated tannery effluents is higher than that of the concrete prepared using the potable water and this is due to the presence of more amount of sulphate content in the untreated and treated tannery effluents, untreated and treated textile effluents. The same trend is observed for result after 90 days. When 4.0% calcium nitrite and 7.5% fly ash are added, the loss of weight got reduced which is apparently shown in the Fig. 3.

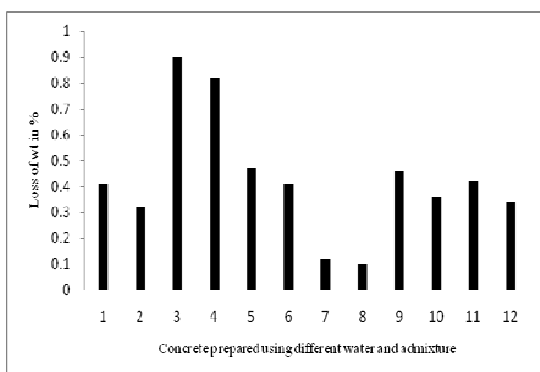


Fig. 3 Loss of Weight due to Chloride Attack

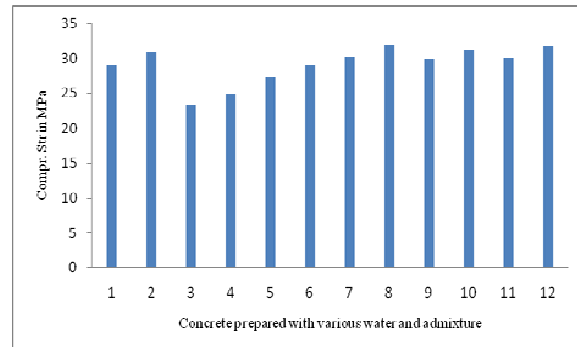


Fig. 4 Compressive Strength due to Chloride Attack

It is evident from the Fig. 4, the compressive strength of the concrete prepared by using the potable water is 28.94MPa after 28 days and 30.87MPa after 90 days. It was also observed that the compressive strength of the concrete prepared by using untreated and treated tannery effluents are 23.32MPa and 27.32MPa after 28 days and 24.87MPa and 28.98MPa after 90 days. The great loss in compressive strength is due to the sulphate attack. When the admixtures are added, the compressive strengths prepared by using potable water and tannery effluents are almost same which is clear from the Fig. 4.

D. Chemical Attack on the Concrete

The loss of weight of the concrete prepared by using the potable water, untreated and treated tannery effluents after 28 days are 3.14%, 5.37% and 3.82% respectively which is portrayed in the Fig. 5. It is observed that the loss of weight of the concrete prepared using the untreated and treated tannery effluents is higher than that of the concrete prepared using the potable water and this is due to the presence of more amount of sulphate content in the untreated and treated tannery effluents, untreated and treated textile effluents. The same trend is observed for result after 90 days. When 4.0% calcium nitrite and 7.5% fly ash are added, the loss of weight got reduced which is apparently shown in the Fig. 5.

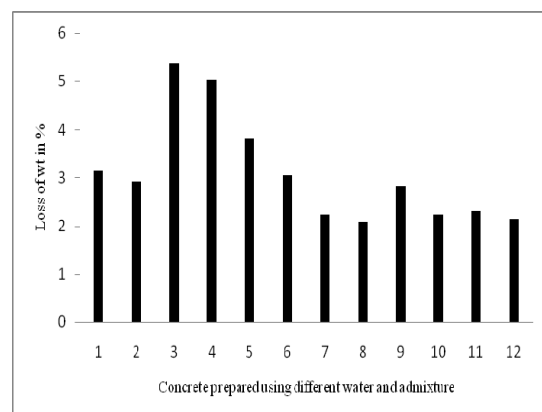


Fig. 5 Loss of Weight due to Chemical Attack

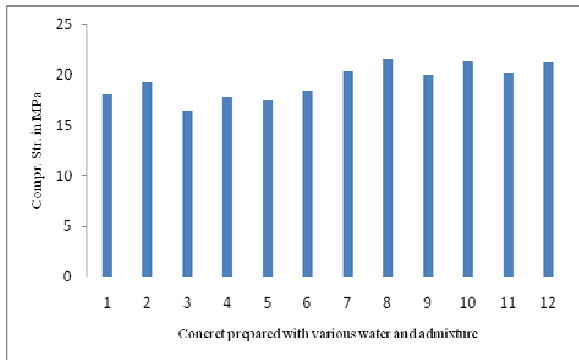


Fig. 6 Compressive Strength due to Chemical Attack

It is evident from the Fig. 6, the compressive strength of the concrete prepared by using the potable water is 18.14MPa after 28 days and 19.26MPa after 90 days. It was also observed that the compressive strength of the concrete prepared by using untreated and treated tannery effluents are 16.41MPa and 17.56MPa after 28 days and 17.82MPa and 18.42MPa after 90 days. The great loss in compressive strength is due to the sulphate attack. When the admixtures are added, the compressive strength prepared by using potable water and tannery effluents are almost same which is clear from the Fig. 6.

IV. CONCLUSION

From the discussion it is clear that the treated and untreated tannery effluent can be used for construction purpose after adding suitable admixture in optimized proportion as far as the sulphate attack, chloride attack and chemical attack is concerned. It will be a boon for the environment if the industrial effluent can be used for the construction purpose. The problem of disposal of the effluent will be greatly reduced.

NOTATIONS

Graph:

- Concrete prepared by using Potable Water – 28 days result.
- Concrete prepared by using Potable Water – 90 days result.
- Concrete prepared by using Untreated Tannery Effluent– 28 days result.
- Concrete prepared by using Untreated Tannery Effluent– 90 days result.
- Concrete prepared by using Treated Tannery Effluent– 28 days result.
- Concrete prepared by using Treated Tannery Effluent– 90 days result.
- Concrete prepared by using Potable Water & Admixture Added–28 days result.
- Concrete prepared by using Potable Water & Admixture Added–90 days result.

- Concrete prepared by using Untreated Tannery Effluent & Admixture Added –28 days.
- Concrete prepared by using Untreated Tannery Effluent & Admixture Added –90 days.
- Concrete prepared by using Treated Tannery Effluent & Admixture Added –28 days result.
- Concrete prepared by using Treated Tannery Effluent & Admixture Added –90 days result.

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