

## An Experimental Study on Reuse of Treated Waste Water in Concrete – A Sustainable Approach

Mr. Manjunatha.M<sup>1</sup>

Research Scholar, Dept. Of Civil Engineering,  
GITAM UNIVERSITY,  
Bangalore, India.

Mr. Dhanraj M R<sup>2</sup>

Research Scholar, Dept. Of Civil Engineering,  
MANIPAL UNIVERSITY,  
MANIPAL, India.

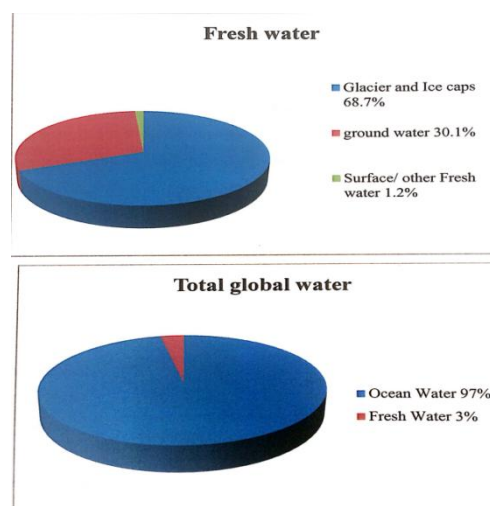
**Abstract:** As a sustainable approach this project is conducted to study the possibility of reuse of treated waste water in concrete, concrete is the most widely used construction material in the world. Production of Portland cement used in concrete produces 2.5 billion tonne's of carbon dioxide and other greenhouse gases worldwide. In addition concrete is one of the largest water consuming industries. Approximately about 150 litres of water is required for per cubic metre of concrete mix. Demand of fresh water by the construction sector is expected to increase due to high increase in the growth of construction activities in India. Without considering the other applications of water at the concrete industry, water is a critical environmental issue and water supplies, water quality are becoming more limited worldwide.

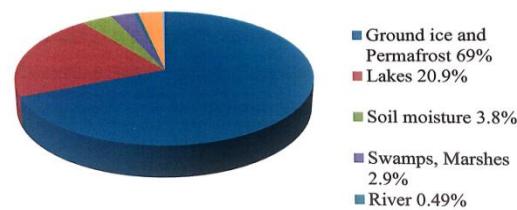
This project presents the reuse of treated waste water and potable water in concrete for both mixing and curing. Concrete is prepared for M-20 grade concrete with SNF super plasticizer for both treated waste water and portable water and cured for a age of 7 day, 14 days and 28 days. Compressive strength, durability properties and microscopic study both concrete prepared with treated waste water and portable water is studied.

### I. Introduction

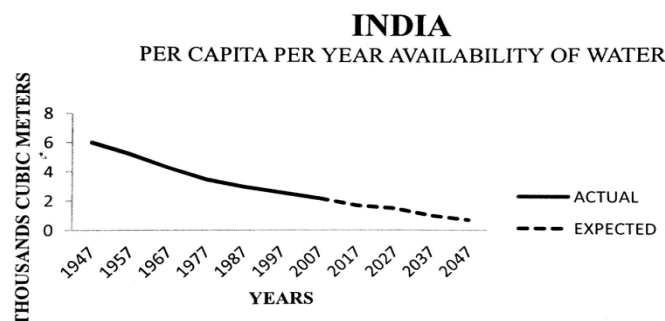
Water is a colorless and chemical substance. Water is the main constituents of earth's streams, lakes & oceans, and the fluids of most living organisms. The chemical formulae of water is H<sub>2</sub>O, means each molecules of water contains 2 atoms of hydrogen and one atom of oxygen. It also occurs in nature as snow, glaciers, icepacks, icebergs, clouds, fog, dew, aquifers and atmospheric humidity. The following pie chart shows the availability of fresh water in the world.

Water is mainly used for agriculture, drinking, washing, transportation, chemical uses, heat exchange, fire extinction, recreation, industries, food processing and for medical uses etc.,



**Surface water and other fresh water****Figure1.** Distribution of water

Day by day due to less availability of clean and safe drinking water today nearly about 1 billion people don't have access to it, yet we take it for granted, we waste it and even we are paying too much for getting pure drinking water from little plastic bottles. Water is the main foundation for life till today so money countries are struggling for searching a fresh water. The below shown graph gives the per capita per yearly availability of fresh water from this graph availability of water is keep on decreasing year by year. This graph shows the world scarcity of water. Concrete is the second industry to consume more water for preparing concrete, for hydration purpose and for curing, etc., to overcome these water scarcity problems and as a sustainability approach to the world regarding scarcity of water in our paper we used treated waste water in concrete instead of portable water.

**Figure2.** Water scarcity

Treated waste water is water obtained from treatment plant after treating municipal waste water. Treated waste water is mainly used for gardening and in some situation for agricultural purpose. Treated waste water is hard water it mainly contains sulphate and chloride content. Day by day the production of bacteria's are more in treated waste water so while handling treated waste water proper care must be taken. Water in the concrete controls many fresh and hardened properties such as workability, compressive strength, permeability, durability, drying shrinkage and bonding properties. So for these reasons fresh and safe drinking quality water is required for concrete. For one cubic meter of concrete about 140 – 160 liters of water is required for the complete chemical hydration process. In this paper we replaced fresh water to treated waste water in concrete and compared with the concrete produced with portable water for M-20grade concrete.

**II. Literature survey**

In this paper “domestic waste water reuse in concrete using bench scale testing and full scale implementation”<sup>[1]</sup> the author used treated domestic waste water in concrete. He used primary treated waste water, secondary treated waste water and distilled water were used to cast the concrete specimen. And he concluded that compressive strength of the concrete produced with distilled water and secondary treated waste water is more or less equal and the compressive strength of the concrete is reduced by up to 16.2%.

In this paper “sustainable use of resources – Recycling of sewage treatment plant water in concrete”<sup>[2]</sup> the author used treated waste water obtained from the sewage treatment plant and he concluded that as a sustainability approach the preliminary research findings suggested that significant differences do not exist between mortar cubes made of portable water versus sewage treated waste water.

In this paper “use of treated waste water for concrete mixing in Kuwait”<sup>[3]</sup> the author clearly explained about the type water used for mixing do not affect to concrete slump and density. Here he mainly considered use

of water in mixing concrete and studied the properties such as slump and density and he concluded that there is greater difference between these two parameters.

In this paper “utilization of waste water to check strength parameters of concrete”<sup>[4]</sup> here the author reviews possibility of replacing fresh water with the waste water and he concluded that workability of the concrete goes on decreases with the increase in percentage of waste water and compressive strength of the concrete is slightly increased with the increase in percentage of treated waste water in concrete.

### III. Methodology

The methodology adopted consists of both preliminary investigations and experimental investigations.

#### Preliminary investigations:

**Cement:** Cement is a basic binding material used in concrete and for all the construction works. In our project we used Portland pozzalana cement. Portland pozzalana cement is blended cement it is produced by intergrading OPC clinker along with pozzolanic materials in certain proportions. In our project we used PPC 33 grade cement. The below table -1 shows the general test results of PPC 33 grade cement.

**Table1:** General Test Results Of PPC 33 Grade cement

| Sl. No. | PROPERTY            | RESULT        |
|---------|---------------------|---------------|
| 01      | COLOR               | GREYISH       |
| 02      | PARTICLE SIZE       | 3 - 100 $\mu$ |
| 03      | GRADE               | 33            |
| 04      | TYPE                | PPC           |
| 05      | SPECIFIC GAVITY     | 3.10          |
| 06      | INITIAL ETTING TIME | 33 Minutes    |
| 07      | FINAL SETTING TIME  | 11 Hours      |

**Aggregates:** aggregates are mainly considered as a filler material to increase the strength of the concrete. About 70-75% of concrete consists of both fine and coarse aggregate. Fine aggregate we collected from locally. Fine aggregate of 4.75mm down size are used in concrete. Similarly coarse aggregate of 20mm nominal size is used in concrete.

**Water:** water is essentially required in concrete for complete chemical hydration of cement in concrete. Water used in concrete should be free from suspended solids, alkali, organic impurities etc., and it should be equal to drinking water quality standards or else it directly affects on the strength of concrete. in our project we prepared a concrete with portable drinking water versus treated waste water.

**Super Plasticizers:** super plasticizers also called as high range water reducers mainly super plasticizers are used in concrete to reduce the water content, to increase the workability and strength of the concrete. in our project we used SNF type super plasterers of about 0.6% by weight of water.

**Water Quality Parameters:** general water quality parameters were tested for both portable water and treated waste water to examine the quality of water. The below table-2 shows the general test results of both treated and portable water.

**Table2:** Water Quality Parameters

| Parameter        | Portable Water (mg/l) | Treated Waste Water (mg/l) | Permissible Limit (mg/l) |
|------------------|-----------------------|----------------------------|--------------------------|
| pH               | 6.5 – 7.5             | 7.49                       | >6                       |
| DO               | --                    | 5.6                        | --                       |
| COD              | 10                    | 46.7                       | 3000                     |
| Chloride Content | 250                   | 59.98                      | 2000                     |

|                                     |     |             |          |
|-------------------------------------|-----|-------------|----------|
| Acidity                             | --  | 200         | 300      |
| Alkalinity                          | 280 | 480         | >200     |
| Sulphate Content                    | 200 | 70          | 400      |
| Calcium Content                     | 200 | 1.72        | 75 – 200 |
| Magnesium Content                   | 100 | 0.307       | 30 – 100 |
| Total Hardness as CaCO <sub>3</sub> | 300 | 3           | 300      |
| Electrical Conductivity             |     | 666 $\mu$ s | --       |

**Experimental Investigations:**

**Preparation of Specimen:** Totally 18 concrete cubes are prepared by using both treated waste water and portable water. Concrete is prepared and casted in standard concrete mould of size 150\*150mm. freshly prepared concrete cubes are kept in room temperature for 24 hours for the complete hydration process. There after cubes are demoulded and submerged in water bath for curing. Prepared concrete cubes are cured at an age of 7days, 14days and 28days. The below table -3 shows the number of concrete cubes casted and testing age.

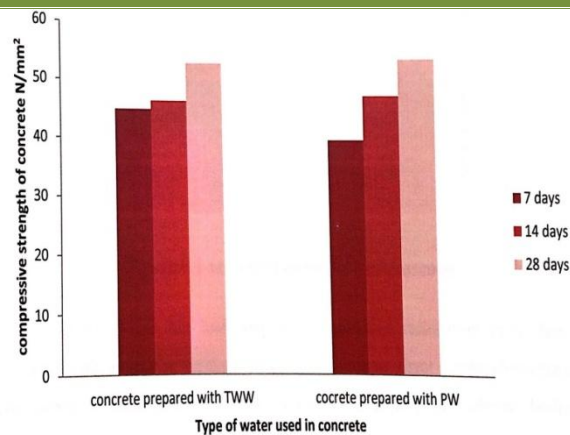
**Table3:** Number of specimens and curing period of concrete

| SPECIMEN                                   | CURING PERIOD (DAYS) |    |    |
|--|----------------------|----|----|
|  | 7                    | 14 | 28 |
| Concrete Prepared With Treated Waste Water | 3                    | 3  | 3  |
| Concrete Prepared With Portable Water      | 3                    | 3  | 3  |

**Mix proportioning:** Concrete is prepared for M-20 grade mix design. Mix proportioning by weight are used.

**Testing Specimens:** Concrete is prepared for M-20 grade and cured for 7days, 14days and 28 days. After the successful curing of concrete all prepared specimens are tested in compression testing machine by applying compressive load. Compressive load is applied on concrete cubes until the failure of prepared specimen. Compressive strength of the prepared concrete cube is calculated by using the formulae, compressive strength = Maximum compressive breaking load / area of concrete cube. Table-4 shows the compression test results of concrete at 7days, 14days and 28days.

| Specimen                                   | Average Compressive Strength Of Concrete (N/mm <sup>2</sup> ) |         |         |
|--|---|---------|---------|
|  | 7 Days  | 14 Days | 28 Days |
| Concrete Prepared With Treated Waste Water | 45.03   | 46.5    | 53.03   |
| Concrete Prepared With Portable Water      | 39.85   | 47.40   | 53.62   |



**Figure3:** Bar graph showing Compressive Strength Test results at 7, 14 and Days

**Scanning Electron Microscope:** concrete is used as a construction material for more than a century, it still a popular building material due to low cost greater compressive strength and durability make concrete an ideal construction material.

Concrete is basically a mixture of two phase cement phase and aggregate phase. The paste phase primarily consists of cement and water. the fundamental element of microscopic study of concrete is preparation of sample and examination thick section of concrete. the use of scanning electron microscope in order to assert:

- Quality assurance.
- Properties of concrete.
- Long term performance.
- Durability of concrete and other materials.
- Evaluation of deterioration.
- Development and improvement of new materials.

Initially after compressive strength of concrete select a concrete piece consists of both aggregate phase and cement phase. Before examining the microscopic view of concrete specimen is over dried at a temperature of 108° – 140°C for about 3-4 hours. After that sputtering is done for concrete specimen to make material conductive sputtering of thick concrete section is necessary. In sputtering vacuum pressure is created when the vacuum pressure in sputtering comes from 30 – 10, the specimen is ready to get microscopic view, after that specimen is placed in scanning electron microscope to examine microscopic images of concrete.



**Figure4:** Scanning Electron Microscope



**Microscopic Images Of Concrete Produced With Treated Waste Water:**

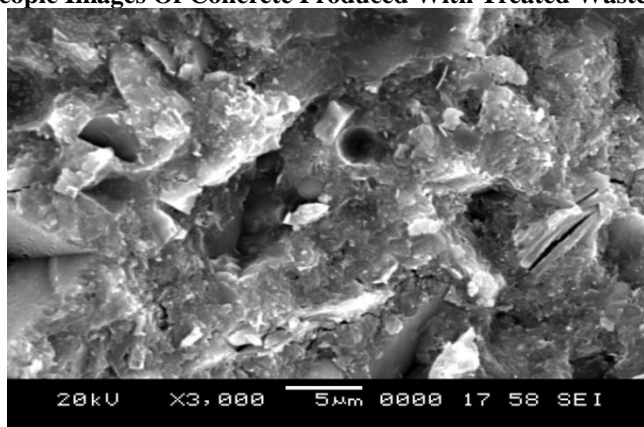


Figure 5

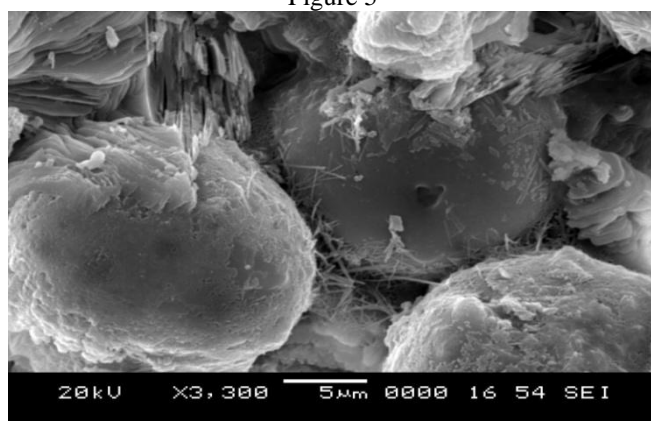


Figure 6

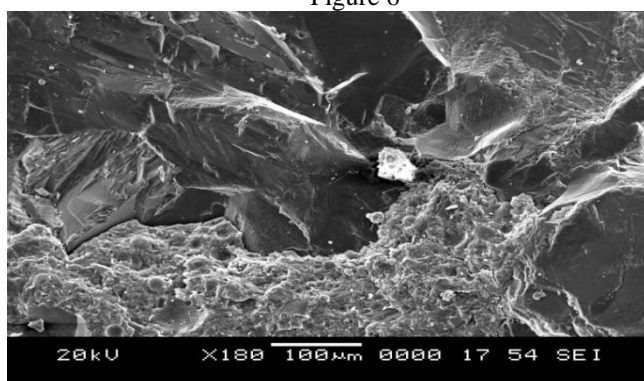


Figure 7



Figure 8

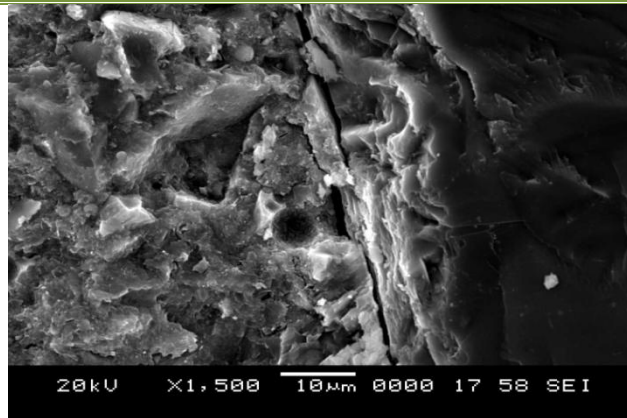


Figure 9



Figure 10

The above images shows the microscopic pictures of concrete prepared with treated waste water. Figure 5 shows the paste phase of concrete. Here we can see the very good binding between cement and sand particles and here we can clearly examine the sand and cement particles. In figure 6 at 3300x zooming level we can see cement and fly ash particles, C-S-H gel formation, calcium hydroxides and ettringites. The cement & fly ash particles are rounded in shape and the bonding between each cement particle is very good. In figure 7 at 1000x zooming level we can see the cement paste phase of concrete, C-S-H gel formation, sand particles, cement particles, ettringites & calcium hydroxides. Figure 8 shows the aggregate phase of concrete. In figure 9 we can clearly see the difference between cement paste phase and aggregate phase. The bonding and C-S-H gel formation between the aggregate and concrete is very good. So the compressive strength of the concrete produced with treated waste water is good. In figure 10 we can clearly see the paste phase of concrete, pores created in concrete, fly ash particles and sand particles.

#### Microscopic Images Of Concrete Produced with Portable Water:

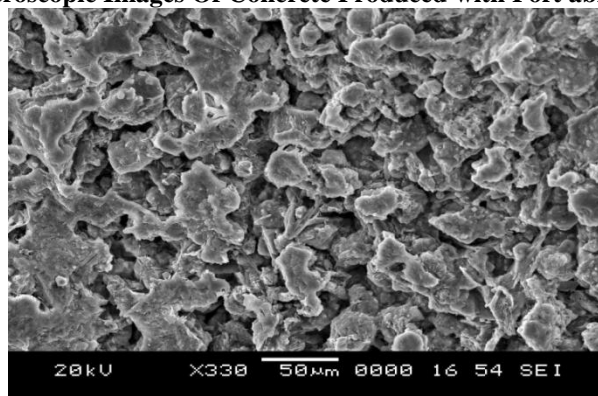


Figure 11

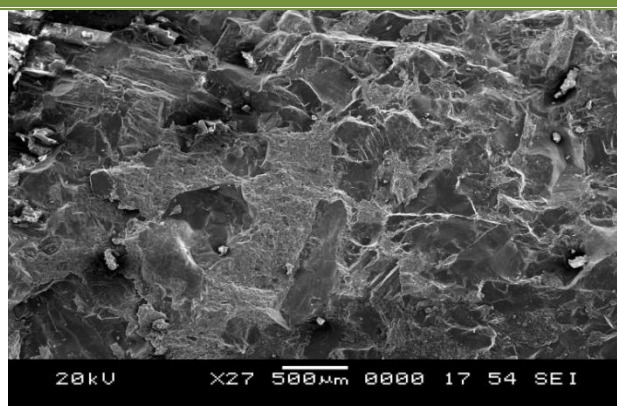


Figure 12

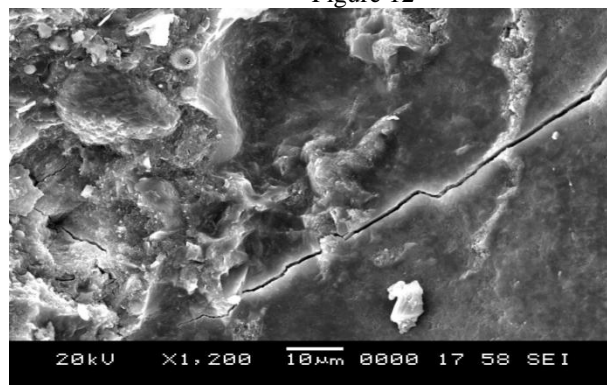


Figure 13

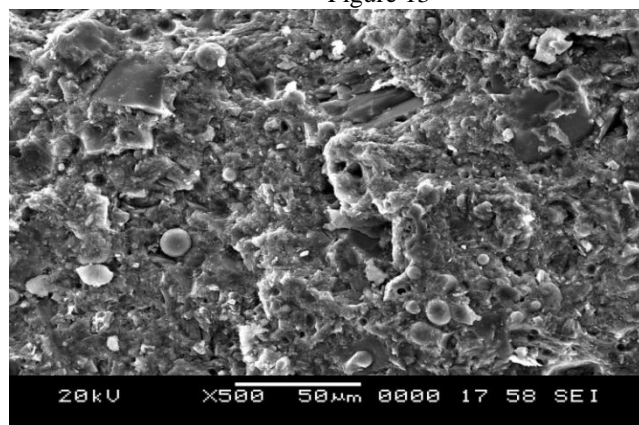


Figure 14

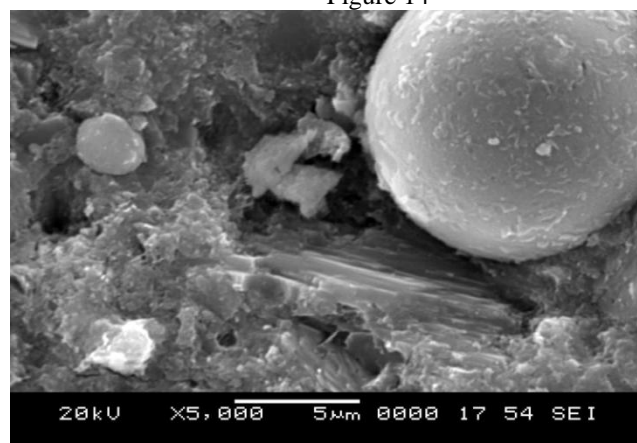


Figure 15



The above pictures shows the microscopic images of concrete prepared with portable water. Figure 11 shows the cement and sand paste phase of concrete. In this figure bonding between cement & sand particles are very good in concrete. In figure 12 we can see the aggregate phase of concrete prepared with portable water. In figure 13 we can clearly examine the difference between aggregate phase and paste phase. The bonding between cement paste phase and aggregate phase is very good i.e. strength of the concrete is high and also here we can see the minute cracks developed in concrete, this crack is developed due to the application of compressive load on concrete while testing. In figure 14 we can clearly see the cement and paste phase of concrete, fly ash particles, cement particles and minute cracks. In figure 15 we can clearly examine the cement and sand paste phase of concrete at 500x zooming level in this image we can clearly see the C-S-H gel formation and the bonding between cement and sand particles. From this microscopic study there is no difference in properties of concrete prepared with portable water and treated waste water, C-S-H gel formation in concrete is good, so the strength of the concrete is more.

#### **IV. Conclusions**

- The study has evaluated the use of treated waste water for concrete production.
- The water quality analysis showed that treated waste water is suitable for concrete production according to permissible limits of mixing water for concrete.
- The consistency, initial and final setting time of cement by mixing treated waste water is within the IS limit.
- The compressive strength of the concrete is increased by mixing treated waste water at the end of 7 days.
- S The preliminary research findings suggested that significant differences do not exist between concrete cubes made of both treated waste water & portable water.
- Treated waste water can be used in the preparation of concrete for both casting & curing purposes without affecting the target mean strength of the concrete at the age of 28 days curing for M-20 grade concrete.
- Workability of concrete is good.
- With the comparison of concrete prepared with treated waste water and portable water gives similar results.
- Now a days there is so much scarcity of water i.e. there is a need to arrange other sources of water for concrete or construction of building uits.
- Low cost and environmental friendly concrete can be produced by using treated waste water in concrete.
- Concrete cost can be reduced by using treated waste water in concrete.

#### **References**

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