Quality Assessment of concrete utilizing treated waste water

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Abstract: concrete is the most extensively used construction material. Every year about 1.5 to 3 tonne/capita of concrete being produced using fresh water in developing countries. Approximately about 150 litres of portable water is required for producing 1m3 of concrete [1]. The present use of portable water for the preparation of concrete imposes a heavy burden on the cost of production, especially at places where there is high demand and shortage of supply of portable water for domestic consumption. Hence measures to be taken to conserve portable water as much as possible to prevent the shortage in the future. A practical solution would be the use of treated effluent from the wastewater treatment plant for concrete production, which will economically benefit the construction industries and conserve portable water.

The suitability of using wastewater for mixing in concrete was experimentally studied by moulding the concrete cubes using tap water (TW), treated wastewater (TWW). From the results it was observed that standard consistency, setting time and strength of concrete are found to be satisfactory in compression strength.

The average compressive strength was also being posh by the type of mixing water. It was found that the compressive strength of cubes obtained from TWW is almost same as that of TW. Hence, from this study it is concluded that treated wastewater (TWW) can be used in place of tap water for production of concrete. The environmental degradation can be reduced by using the treated effluent for concrete production and cost of the concrete can be reduced considerably. Hence, portable water can be conserved

Keywords: Treated waste water, tap water, concrete, compression strength.

1. Introduction

Concrete is mainly used material in the construction field worldwide. Concrete industries are more responsible towards environmental and social development.

The main problem with the concrete industries are air pollution, large consumer of vast quantities of natural materials, high energy requirements, demolition waste, water consumption, and generation of construction waste [2]. Concrete is not environmental friendly due to CO2 emissions caused during the production of Portland cement and high volume of material needed to produce the billion tons of concrete worldwide every year [3].

In the present day of new technologies and growing world population coupled with the need for more investment in different sectors, attention has been given to resource reuse wherever possible. A common principle about the suitability of water for mixing concrete is the idea the idea that if water is suitable for drinking it is suitable for mixing concrete is that if water is suitable for drinking it is suitable for producing concrete. Certain Criteria intended to ensure the suitability of fresh concrete water for batching include that the water be safe and free from hazardous materials. However, these requirements cannot be the best criterion for determining the suitability of water as a mixing medium. Some water that does not follow these standards has been found to generate concrete of acceptable quality.

Every year about 1.5 to 3 ton/capita of concrete is being produced by using fresh water in developing countries [4]. Approximately, about 150 liters of portable water is required for producing $1m^3$ of concrete. The present use of portable water for the preparation of concrete imposes a heavy burden on the cost of production, especially at places where there is high demand and scarcity of portable water for domestic consumption. Hence, measures to be taken to conserve portable water as much as possible to prevent the shortage in the future. A practical solution would be the use of treated effluent from the wastewater plant for concrete production, which will economically benefit the construction industries and conserve portable water.

2. Scope Of The Study

Water is available natural with plenty, but as a human being we are wasting it and paying amount to the drinking water. Now a day’s clean and safe water is difficult to get. Water is basic need for the human life. Today's dynamic world of researchers. Concentrated on the use of treated waste water for the manufacture of concrete in effect on the frequency of the concrete compression, the need for water, the setting of time and the practicality of the concrete. Development initiatives to minimize high costs Drinking water use in the manufacture of concrete, the use of treated waste water it has been considered for this reason.

In an age of increasing human population and decreasing resources coupled with the need to curb expenditure in various sectors of the government budget, attention has been brought to the reuse of resources wherever possible. Perhaps one of the most valuable resources is water. About 1.5 to 3 ton/capita of concrete being produced using fresh water in developing countries every year, which is around 16% of fresh water [9]. Therefore, efforts towards wastewater reuse have lately gained worldwide consideration and attention in construction industry, which is the second largest industry next to agriculture. There is limited information on the quality of water which is acceptable for use as concrete mixing water. The present study is carried out to determine the feasibility of using treated effluent for concrete mixing. The use of treated effluent for concrete mixing reduces environmental degradation and in addition, the cost of the concrete can be reduced considerably and also portable water can be conserved [10].

3. Objectives Of The Study

The objectives of our research work are as follows:

- To characterize the tap water and used for the treated wastewater study.
- To investigate the compressive strength of concrete.
- To compare the strength of different grades of concrete produced by treated wastewater with tap water.
- To propose best suitable water for mixing the concrete.

4. Methodology

Samples of treated wastewater were collected from the sewage treatment plant. The wastewater was chemically analyzed as per standard methods for water and wastewater examination given by APHA and AWWA. The analysis was carried out in the environmental engineering laboratory (fig:4).

Concrete cubes made for different grades with tap water and wastewater were prepared and tested for compression test for 14 days and 28 days(fig:6 & fig:7).

For the preparation of concrete specimens, 53 grade of ordinary Portland cement conforming to IS: 12269-1987(reaffirmed 2007) was used. Natural river sand satisfying the required properties conforming to IS 383-1970(reaffirmed 1997) was used. The maximum size of the aggregate was limited to 20mm and down size to get the maximum compressive strength.

The concrete mix design was carried out as per IS: 10262-2009.

The mix design of concrete for M20 and M30 grades of concrete were taken and experiment were conducted for both tap water and treated wastewater in the laboratory (ref table-1,2,3,4).

The strength, durability and workability of the concrete are the essential parameters that remain in view when designing the concrete mixtures. Appropriate alteration was made on the basis of the materials, the properties found and even the basic specifications of the job. Concrete cubes are cast and tested for compressive strength at the end of 14 days and 28 days (see figures-6,7).

Parameter Of Treated Wastewater Required For Preparing Concrete

The concepts of water and wastewater monitoring Include quantitative analysis of impurities by analytical techniques. Numerous water and wastewater studies have been carried out in compliance with conventional procedures

Following tests have been conducted on tap water and treated wastewater used for concrete

Chloride test, Alkalinity test, Hardness test, Dissolved oxygen test, Bio chemical oxygen demand, Chemical Oxygen Demand, pH test, Conductivity, Suspended Solids, Dissolved Solids, Sulphate test (fig:4) (table-5).

The concrete mix design for M20 and M30 grades were carried out using IS 10262:2009.

Design Stipulation:-

- The Mix Design is Carried out as per IS 10262:2009
- Desired characteristic strength (fck) = 20 N/mm2 & 30 N/mm2
- Degree of workability = 80mm Slump

Table:1 Mix Design of M20 Grade Concrete for Tap Water (Using 53 Grade Birla Super Cement)

Type of exposure= mild

Proportion by ratio:

Cement	Water	Fine aggregate	Coarse aggregate
1	0.58	1.98	2.94

Table:2 Mix Design of M30 Grade Concrete for Tap Water (Using 53 Grade Birla Super Cement)

Type of exposure= Severe

Proportion by ratio:

Cement	Water	Fine aggregate	Coarse aggregate
1	0.47	1.56	2.31

Table:3 Mix Design of M20 Grade Concrete for Treated Wastewater (Using 53 Grade Birla Super Cement)

Type of exposure= Mild

Proportion by ratio:

Cement	Water	Fine aggregate	Coarse aggregate
1	0.57	1.95	2.80

Table:4 Mix Design of M30 Grade Concrete for Treated Wastewater (Using 53 Grade Birla Super Cement)

Type of exposure = Severe

Proportion by ratio:

Cement	Water	Fine aggregate	Coarse aggregate
1	0.46	1.54	2.20

Size of Test Specimens – 150 x 150 x 150 mm Test specimens cubical in shape.

Curing

The cubes taken out from molds were cured in different containers having Treated Wastewater (TWW), Tap Water (TW). Cubes were kept for required number of days in respective water container with which they were prepared.

Age at Test - Tests be going to made at recognized ages of the test Specimens, the most usual being 14 and 28 days.

Compressive Strength = Failure load ×1000/ (150×150) N/mm^2.

Testing Machine

The test machine is used to assess the compressive strength of the concrete specimens. The test machine with a adequate capacity of 2000 KN for testing and capable of performing loads with a reasonable error shall not exceed ±2 per cent of the full load. Two steel bearing plates with hardened faces (fig:5) shall be mounted to the test unit.

Compacting by hand – Compacting by hand – When compacting by hand, the regular tapping bar shall be used and the bars shall be uniformly distributed around the cross-section of the mold. The number of blows per layer needed for the development of specified conditions varies depending on the form of concrete. For cubic specimens, no less than 35 blows per layer shall be made to the concrete.

The blows shall penetrate into the underlying layer and the bottom layer shall be rounded in its width, where the tapping bar is left empty, the sides of the mold shall be tapped to close the holes left by the tapping bar.

Fig1: Slump test being conducted.

Source: Author

Fig2: Mixing Concrete for casting the cubes.

Source: Author

Fig3: Sewage Treatment plant.

Source: Author

Fig4: Sample analysis in Environmental Laboratory.

Source: Author

Table5: Characteristics of treated wastewater& Tap water

Sl. No	Parameter	Unit	Treated Wastewater	Tap water	Permissible limit as per Standards
1	pH	-	6.10	7.20	Shall be not less than 6
2	Electrical Conductivity	µS/cm	1187.7	682	Not Specified
3	Suspended solids	mg/l	810.00	nil	2000
4	Dissolved solids	mg/l	772.00	800	Not Specified
5	Total Hardness	mg/l	250.00	269	Not Specified
6	Total Alkalinity	mg/l	216.00	203	Not Specified
7	Chloride	mg/l	242.00	58.92	2000 for PCC 500 for RCC
8	Sulphate	mg/l	69.00	16	400
9	Dissolved Oxygen	mg/l	Nil	6.4	1-2 mg/l
10	Biochemical Oxygen Demand	mg/l	180.00	7.80	200
11	Chemical Oxygen Demand	mg/l	288.00	88	3000

5. Results

Compressive Strength of Concrete Cubes Produced by Treated wastewater and Tap water.

The compressive strength of M20 and M30 grade concrete for 14 days and for 28 days for different mixing water were evaluated in the laboratory separately. The concrete cubes were prepared by different mixing water. The average value is taken as the compressive strength for particular age for each type of mixing water.

Fig5: Compression test carried out by group members

Source: Author

Fig6: Compression Test on Cubes

Source: Author

Fig7: Cubes after Compression Test

Source: Author

Table6: Strength of M20 Cubes Produced by TWW & TW for 14 & 28 days curing using TWW & TW.

CUBES	CURING	NO OF DAYS	AVG COMPRESSIVE STRENGTH
TWW	TWW	14	21.14
TWW	TWW	28	29.14
TWW	TW	14	23.55
TWW	TW	28	30.96
TW	TWW	14	23.7
TW	TWW	28	31.1
TW	TW	14	22.96
TW	TW	28	30.07

Graphical Representations

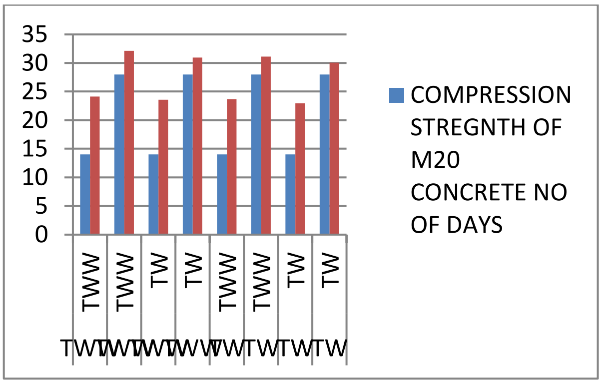

Fig8: Compressive strength of M20 for 14 days & 28 days curing with treated waste water and tap water.

Table7: Strength of M30 Cubes Produced by TWW & TW for 14 & 28 days curing using TWW & TW.

CUBES	CURING	NO OF DAYS	AVG COMPRESSIVE STRENGTH
TWW	TWW	14	26.96
TWW	TWW	28	41.15
TWW	TW	14	28.88
TWW	TW	28	41.92
TW	TWW	14	29.77
TW	TWW	28	42.21
TW	TW	14	27.1
TW	TW	28	41.62

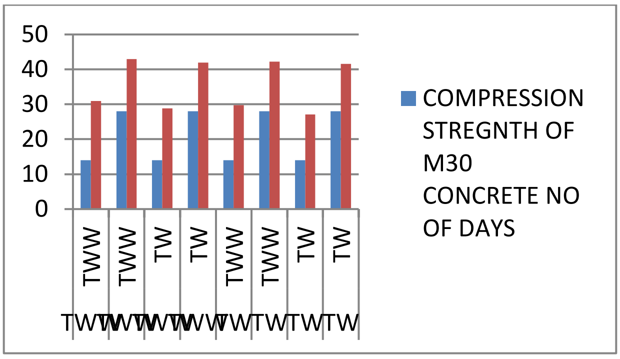

Fig9: Compressive strength of M30 for 14 days & 28 days curing with treated waste water and tap water.

6. CONCLUSIONS

The need for a sustainable and environmentally friendly concrete industry is motivated by population growth and water scarcity. Water shortage could be the most important

Environmental issue in a number of counties.

Therefore, the use of treated waste water in concrete does not affect the consistency of the cement. The compressive strength of concrete made from treated wastewater is about the same as the compressive strength of concrete made from fresh water. The tap water can therefore be replaced by treated wastewater, especially in places where fresh water is scarce.

Wastewater would be an alternative to water in concrete construction, which would not only conserve precious fresh water, but will also provide an incentive for wastewater management.

The use of wastewater instead of fresh water for construction purposes would also reduce the cost of production of construction

References

1. FAO. 2011. The state of the world's land and water resources for food and agriculture (SOLAW) – Managing systems at risk. Food and Agriculture Organization of the United Nations, Rome and Earthscan, London.
2. By C. Meyer, "Concrete and Sustainable Development" Special Publication ACI 206, 2002 Concrete Materials Science to Application.
3. Nurdeen M. Altwair and Shahid Kabir "Green concrete structures by replacing cement with pozzolanic materials to reduce greenhouse gas emissions for sustainable environment, ASCE, 6th International Engineering and Construction, Conference, Cairo, Egypt, June 28-30, 2010.
4. Alberto boretti, Lorenzo rosa "Reassessing the projections of the world water development report" Article number: 15 (2019), 31st july 2019.
5. William J. Cosgrove1 and Daniel P. Loucks "Water management: Current and future challenges and research directions" Agus publication report, 28 june 2015.
6. Dr. John O. Kakonge (2002) Water scarcity and related environmental problems in parts of sub-Saharan Africa: the role of the transboundary Environmental Impact Assessment Convention, Impact Assessment and Project Appraisal, 20:1, 49-59, DOI: 10.3152/147154602781766861 Neville AM (1994) "Properties of concrete", 4th edition, Longman scientific & Technical, Essex, U.K.
7. UNEP, World Water Assessment Programme (WWAP), Global Environment Outlook: Environment for Development (GEO-4), Human Development Report 2006, World Business Council For Sustainable Development (WBCSD), Food and Agriculture Organization of the United Nations, Sweden.
8. Marcia Silva and Tarun R. Naik, "Sustainable Use of Resources – Recycling of Sewage Treatment Plant Water in Concrete" the university of Wisconsin Milwaukee center for By-products utilization, second international conference on sustainable construction matarials and technologies june 28- june 30, 2010.
9. NATURE-BASED SOLUTIONS FOR WATER, Published in 2018 by the United Nations Educational, Scientific and Cultural Organization, 7, Place de Fontenoy, 75352 Paris 07 SP, France.
10. Ningaraju H.J, Prashant and H.N.Rajakumara, "Treated wastewater: An alternative for concrete industry" Cement and Concrete Composite, Elixir Cement & Con. Com. 61 (2013) 16931-16934, 3rd August 2013.

11. 6th International Engineering and Construction
12. Conference (IECC'6), Cairo, Egypt, June 28-30, 2010
13. Patil G.K., Jamkar S.S., Sadgir P.A (2011) "Effects Of Chemicals As Impurities In Mixing Water On Properties Of Concrete" IJRCE Vol. 1 Issue , July 2011.
14. NASER ALENEZI (2010) "Evaluation And Assessment Of Concrete Produced By Utilizing Of Treated Wastewater" Concrete Sustainability Conference By National Ready Mixed Concrete Association.
15. APHA, AWWA (1995), Standard Methods for Water and Wastewater Examination, Tata Mcgrawill.
16. Ibrahim Al-Ghusainand Mohammad J. Terro (2003) "Use of Wastewater for Concrete Mixing in Kuwait" Kuwait.J.Sci.Eng.30.
17. IS-10262-(2009) "Concrete mix proportioning guidelines", Bureau of Indian Standards, New Delhi.
18. IS: 456-2000 "Code of practice for plain and RCC", Bureau of Indian standards, New Delhi