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Experimental Evaluation of Potential of Treated Domestic Waste Water as a Partial Substitute of Potable Water in Concrete Mix

Amrita Kumari[1], Janardan Tiwari[2]

[1]M.Tech Scholar, Jan Nayak Chaudhary Devi Lal Memorial College of Engineering, Sirsa, Haryana, India
[2]Assistant Professor, Jan Nayak Chaudhary Devi Lal Memorial College of Engineering, Sirsa, Haryana, India

ABSTRACT

Water is a highly required natural resource for the execution of life on earth. So, the importance of water cannot be compared with anything else. There is no alternative for water. We live on a planet which is called “Blue Planet” due to ample sources of water. The major source of water on earth is sea. But sea water is neither suitable to intake nor suitable for construction industry. This is due to the fact that sea water is rich of different salts. 2/3rd of earth is covered with water, out of which only 3% is potable water rest is saline. With booming population no later than a decade there came a time when there is scarcity or even no water to drink or survive.

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1. INTRODUCTION

There is no doubt that, water is key building material in construction industry. Strength of cement mortar/concrete particularly relies on the eminence and quantity of water. The water has both negative and useful effects on concrete [Neville, 2000]. The water is appropriate for concrete and cement mortar although it is not potable whilst their chemical composition is nicely regulated [Cebecei and Saatci, 1989 and Kosmatka and Panarese, 1995]. Water standards are outlined in both IS as well as ASTM standards for its utilization in construction industry. Worldwide studies and European laureates reviewed on particular pointers about the usage of water, as the quality of water ascertain the quality of produced concrete, in accordance with environmental elements. BS 3148 furnished the specs approximating strength and setting time of concrete produced with the use of water having inorganic contaminations (like total sulphates, Alkali carbonates, dissolved solids 2 hundred mg/L, bicarbonates a thousand mg/L, and suspended solids 2 hundred mg/L). To prevent health issues and to maintain water standards as per requirement of construction industry, its chemical composition is required to be catered within tolerance restriction and ought to suit to drink. Concrete industries and present day cement units are going through issues of preserving the first-class of water and exact raw substances (Idorm 1977). In most of the regions sparkling-water is not available and it became a pertinent requirement to live on. Industries generate ample amount of wastes which may be solid waste or waste in the form of water. This is called industrial waste water (IWW), which comprises excessive chemical composition. Treatment of industrial waste water is hard task to muster up. Not only this but also residences also generate waste water from various household chores like bath, laundry, dish washing, rubbish disposal, toilets and so forth is termed as domestic waste water (DWW).

2. Literature review

Neville et al. (2000) detailed in their paper that the level of impurities in domestic water and the water used for washing is up to tolerable limits and does not debar its usage in cement or cement product. For better justification of their above statement they tested different engineering properties of concrete cured by domestic water or wash water.

Su. Nan et al. (2000) in their study examined the behavior of concrete altered by two substitutes namely granular blast furnace slag(GBFS) and magnetic water. Properties of both concrete and cement mortar are affected by this alteration which are studied in detail. As per their investigation with variation in both the substitutes the property of green concrete viz. workability and the property of hardened concrete viz. showed enhancement. This enhancement validated the usage of these substitutes in manufacturing of concrete and in concreting. The best part evaluated from their study is the concrete mix obtained from these partial substitutes has better 3 and 7 day strength as compared to the control/conventional concrete mix.

X.D Li et al. (2001) discussed chemistry behind the behavior of OPC when mixed using sludge. The main property studied by them was leaching. They discussed each and every equation the mix undergoes during leaching test and suggested that leaching mainly relies on these three ingredients of mix:

- Buffering capacity of acid
- Solid matrix, and
- Alkalinity of sludge.

Neville A et al., (2001) in their investigation replaced potable water in mixing concrete by sea water. The concrete used in their study was RCC and its properties like durability and strength are studied. Durability of RCC is mainly deteriorated by corrosion of rebars. As a conventional theory sea water accelerates the corrosion of rebars. But in their study they used sea water in curing and suggested that if membrane curing method is used then sea water does not elevate the corrosion of rebars rather improves overall strength of concrete. Thus sea water can be used as an alternative of potable water in mixing of concrete.

Lee et al. (2001) scrutinized the behavior of concrete mixed by using TWW (treated waste water). In their exploration they concluded from various experimentations that TWW is not only an alternative to potable water but a superior substitute of potable water in concrete mix, which improved the following properties:

- Made concrete impervious or reduces permeability
- The setting of cement mixed by TWW was prolonged when compared with normal/Conventional mortar.
- The strength whether it is split tensile, compressive or against flexure all showed positive deviation than conventional concrete mix.

Franco Sandrolini and Elisa Franzoni (2001) in their investigation explored both physical as well as mechanical properties of concrete mixed by using recycled water from a RMC plant. The effluent from RMC plant is complete waste and is of no use but from their investigation possibility of usage of this waste water in mixing concrete is stressed. This water can be used as complete substitute of water in concrete mixed accompanied with betterment in properties like durability, strength and water absorption capacity.

Nan Su et al. (2002) in their study used four categories of water as briefed below as a complete substitute of water for mixing concrete:

- Underground water (UGW)
- Wash water (WW)
- Tap Water (TW)
- Middle wash water (MWW)

The concrete produced from these waters are tested for properties like slump value, setting time (both IST & FST) and Comp. strength. The properties impacted by these waters are tabulated in the table below:

Table 2.1 Effect of different water on properties of concrete

Sr. No	Type of water	Impact
1	UGW	Increased comp. strength and slump value
2	WW	Reduces slump value as well as values of IST &FST
3	TW	Increased comp. strength and slump value but a bit lower than the increase caused by UGW
4	MWW	Reduces slump value

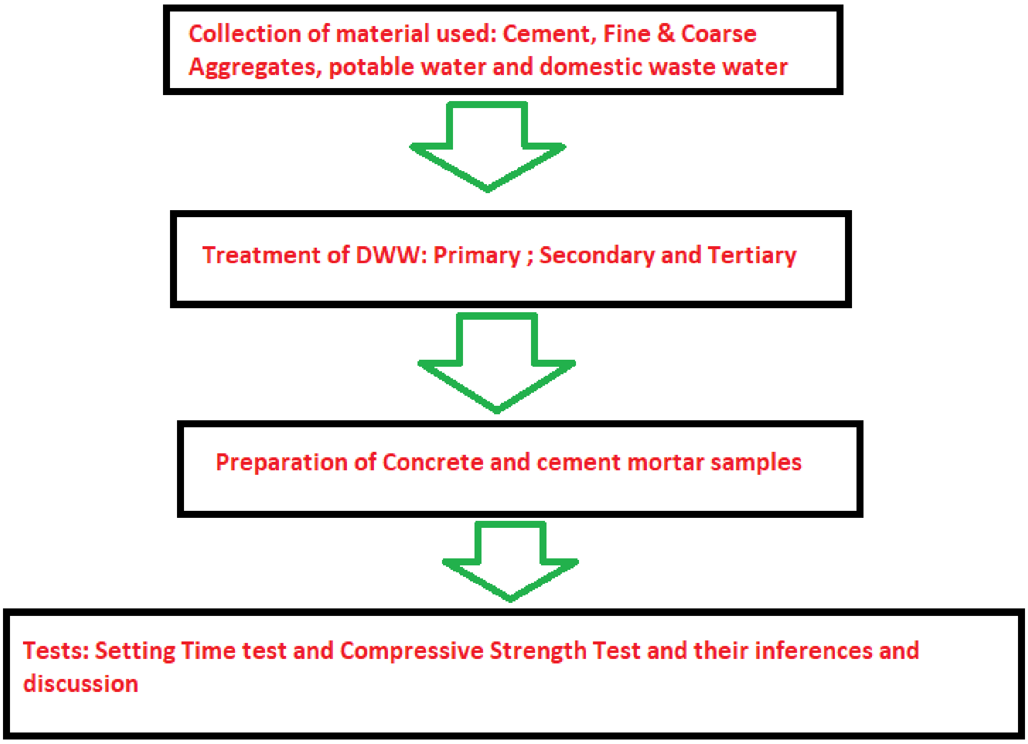
Ibrahim Al-Ghusain et al. (2003) in their exploration explained the effect of different level of treatment of waste water on properties of concrete. They used four water samples: TW, Primary TWW, Secondary TWW and Tertiary/Advanced TWW. The inferences made from various experimentations vide their work are briefed as:

- TW and Tertiary TWW behaved quite similar in all the experimentations and suggested that Tertiary TWW can be used as a complete substitute of TW.
- Primary TWW works as a retarder and prolonged setting also adversely affected the strength. This

water when used RCC mix causes corrosion of rebars thus decaying the RCC structure.
- Secondary TWW also have detrimental impacts on concrete alike primary TWW but the extent is bit lesser in case of Secondary TWW.

3. Material Used

In this part actual work done to reach the objectives is detailed. Methodological approach for the present investigation is defined in the flow chart below:



Methodology

Collection of Material: Materials used in present research are Cement, Fine and Coarse aggregates, fly ash, potable and DWW. All the materials are collected from my vicinity and briefed as subsequent sub-headings.

Cement: Inorganic binding material in concrete mix is known as cement. Ingredients mainly present in cement are oxides of calcium, silicon oxide, aluminum oxide, iron oxide and alkalis, etc. the raw materials are limestone and clay or minerals, which are rich in lime, and rich in silica and alumina, these materials are burnt together at a temperature of 1400 degree Celsius or so to form what is known as clinker, which is nothing but a solid solution of these minerals forming cement compounds. Clinker is grinded further and mixed with a little bit of gypsum, of the order around 5% gypsum to control the setting properties. Cement used for present work OPC 43

Aggregates: Two types of aggregates are used in this research which are discussed in subsequent sub-headings.

Fine Aggregate: The small size filler materials in concrete are termed as fine aggregates. These are the particles which passes through 4.75mm sieve whereas unable to pass through 0.075mm sieve. Eg Sand, stone screenings, surkhi, cinders, burnt clay, etc. River sand, crushed stone sand, crushed gravel sand are the major sources of fine aggregates. The surface area of fine aggregate is higher than that of coarse aggregates. They are used to fill the voids between coarse aggregates.

Purpose – They are used to fill the voids between coarse aggregates.

Sand-The small size filler materials generally used in concrete are termed sand particles. Sand imparts quality to the concrete mix. Air may be taken into consideration an important issue of concrete. Air bubbles are shaped in finished concrete via the addition of special components to the mixture. Sand usually makes up about 25 percentage of a wet concrete mixture. There are a few reasons that's why we make use of sand in making concrete.

1. Sand affords bulk to the concrete.
2. Sand enables to make concrete unfastened from voids. I suggest sand allows offering similarity to some extent. But thoughts that concrete is a heterogeneous material.
3. Sand indirectly allows increasing energy of concrete.
4. Sand Helps to growth workability of concrete.

Coarse Aggregates: The large size inert skeleton materials in concrete are termed as coarse aggregates. These are the particles which are of size greater than 4.75mm. Eg: gravels, pebbles, brick chips, broken stones, etc. Dolomite aggregates, crushed gravel or stone, natural disintegration of rock are the major sources of coarse aggregates

Fly ash: Combustion of any solid material results in production of ash. Thermal power plants use coal as fuel to heat the water in boiler to generate steam from water. This steam in turn runs the turbines to generate electricity. But from burning of coal the residue left is a pulverized ash generally termed as "Fly ash". It is very light weighted and it can rise with gases this is the reason it is called Fly ash. Electrostatic precipitator collects the fly ash from gas flowing out of chimney. 73% of total power production is catered by thermal power plant, and 90% of thermal power stations run of coal as a fuel. Today 60% of total fly ash produced in India is used by the construction industry in partial replacement of cement, but the target is to use 100% fly ash, so as to revert positive effect to environment.

Water for the mix: In present investigation two types of water are used: Potable water and DWW

Potable water: The quality of water is of extreme importance in concrete mix, it should be neither too basic nor too acidic. The water fine for drinking is the best, if available. Sea water is always avoided in construction industry. Water is important role in concrete as it hydrates the cement and helps in getting desired Strength. Graduated jars are used to quantify the volume/mass of water. Content of water should be incompliance with the mix-proportion. Quality standards of potable water are tabulated as below:

Domestic Waste Water: Residences generate waste water from various household chores like bath, laundry, dish washing, rubbish disposal, toilets and so forth is termed as domestic waste water (DWW). Two sorts of waste water are found in DWW which are as follows:

A. **Gray Water:** The water derived from kitchen sinks, laundry washing, wash basins, showers, baths etc., is in gray colour, thus termed gray water.
B. **Black water:** The water derived from lavatories and urinals is brackish water/black water.

Conventional Concrete: Concrete is a composite material, the ordinary/conventional concrete, which is most popular and most commonly used. Ordinarily concrete is made by mixing an in-organic material called cement with water together with some natural sand or stone dusts and natural stones that may be crushed or may be uncrushed.

When water is added to cement, it reacts forming an artificial stone like structure as solid hardened mass and that is what give us the cementing property as far as concrete is concerned. But since cement is costliest of all the materials in case of concrete, therefore we should restrict its use in concrete. Besides, there are some other associated problems of shrinkage, etc. So, bulk of the material in concrete system, it is formed by the aggregates and cement and water are used as binding material. In other words, concrete can be set in artificial stone, made up of stone, sand and binding material. Cement and water reacts together and binds the skeleton.

4. Methodology & Experimentations

The methods opted for various experimentations are as per standard procedures prescribed in codes of Bureau of Indian Standards (BIS). Different experimentations are briefed under following sub-sections.

Test Programme: i) Vicat's test: **This test is carried out to find out initial as well as final setting time. Setting time of cement is generally a logical division of time viz. IST & FST.**

IST: It is conceptually considered as the time elapsed from the addition of water to dry cement to the extent when cement paste loses its plasticity and start becoming hard.

FST: It is basically the period extent between addition of water to dry cement and stiffening of cement paste.

The results are tabulated in subsequent table and compared by the graph.

Table Results of Setting time test

Sample No.	Sample Description	Setting Time (in min.)			
		IST	Diff.	FST	Diff.
CM	Ref. sample with potable water	65	00	198	00
M1	95% PW+5%TDWW	65	00	199	01
M2	90% PW+10%TDWW	68	03	205	07
M3	80% PW+20%TDWW	71	06	212	14
M4	70% PW+30%TDWW	74	09	224	26
M5	60% PW+40%TDWW	85	20	240	42
M6	50% PW+50%TDWW	66	01	200	02
M7	10%flyash+95% PW+5%TDWW	68	03	200	02
M8	10%flyash+90% PW+10%TDWW	69	04	206	08
M9	10%flyash+80% PW+20%TDWW	72	07	214	16
M10	10%flyash+70% PW+30%TDWW	74	09	224	26
M11	10%flyash+60% PW+40%TDWW	76	11	225	27
M12	10%flyash+50% PW+50%TDWW	68	03	205	07

Slump Test/workability test: In simpler words the dexterity of working with green concrete is termed as Workability. It is not merely a characteristic of the concrete, rather it a major property that govern the nature of the application of concrete mix, The durability (or life) and strength of hardened concrete in turn depends on it.

Table Results of Workability Test

S. No.	Sample Description	Workability
1	CM	75mm
2	M1	75mm
3	M2	75mm
4	M3	74.8mm
5	M4	74.5mm
6	M5	72mm
7	M6	70mm
8	M7	75mm
9	M8	74.9mm
10	M9	74.8mm
11	M10	74.2mm
12	M11	74mm
13	M12	73mm

Compressive strength test: The strength of mix proportioned sample against compression is ascertained by this experiment.

Arithmetically, the value of strength of any material against compression is

Comp. Strength = Failure load/area of cross-section

Table: Results of compressive strength test

S. No.	Sample Description	Compressive Strength (in MPa.)	
		7d	Diff in 7d
1	CM	31.24	00
2	M1	31.29	0.05
3	M2	32	0.76
4	M3	32.40	1.16
5	M4	32.65	1.41
6	M5	33.10	1.86
7	M6	27.76	-3.48
8	M7	33.00	1.76
9	M8	34	2.76
10	M9	35.40	4.16
11	M10	35.65	4.41
12	M11	36.70	5.46
13	M12	30.70	-0.54

5. Conclusions and Discussion

Based on detailed experimental program and discussion of results, following conclusions can be made:-

- Disposal of waste product is a burdensome job due to stringent restrictions of waste disposal rules. So, finding alternative use of wastes then dumping them off is better. DWW is a waste product and it can be re-used in concrete production.
- The IST value of conventional concrete marked 65mins, with replacement of potable water by TDWW upto 10% there seen an insignificant increase in IST value and after 10% significant increase was seen. But after 40% replacement of PW with TDWW the reverse trend follows and IST begun to decline and at 50% replacement regains original IST. While with addition of 10%flyash similar trend was seen but lesser variation than the conventional mix.
- The FST value of conventional concrete marked 198mins, with replacement of potable water by TDWW upto 10% there seen an insignificant increase in FST value and after 10% significant increase was seen. But after 40% replacement of PW with TDWW the reverse trend follows and FST begun to decline and at 50% replacement regains original FST. While with addition of 10%flyash similar trend was seen but lesser variation than the conventional mix.
- Workability value of conventional concrete marked 75mm, with substitution of potable water by TDWW there seen an insignificant decrease in Compressive strength value. Also, the addition of flyash lessens the workability but to an insignificant extent.
- The Compressive strength value of conventional concrete marked 31.24 MPa after 7 days, with substitution of potable water by TDWW there seen an insignificant decrease in Compressive strength value. But after 40% substitution reverse trend follows with a steep decline in strength. With replacement of cement with 10% alongwith substitution of flyash similar trend was seen with better enhancement in strength, and even after 40% replacement of potable water with TDWW the addition of flyash lessens the quantum of reduction in strength.
- The Compressive strength value of conventional concrete marked 51.26 MPa after 28 days, with substitution of potable water by TDWW there seen an insignificant decrease in Compressive strength value. But after 40% substitution reverse trend follows with a steep decline in strength. With replacement of cement with 10% alongwith substitution of flyash similar trend was seen with better enhancement in strength, and even after 40% replacement of potable water with TDWW the addition of flyash lessens the quantum of reduction in strength.

On a closure note from various experimentations the contents of flyash and TWW which shows best results are as follows:

TDWW- 40% substitute of potable water

Flyash- 10% substitute of cement.

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