STRENGTH VARIATION IN M30 GRADE OF CONCRETE WITH PARTIAL REPLACEMENT OF POTABLE WATER BY TREATED WASTE WATER

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ABSTRACT

Concrete is the generally used construction material in the world. Scarcity of water is perhaps the most critical environmental problem in several countries. Fresh water records for only 2.5% of the Earth's water. The concrete industry alone usages over one trillion gallons of water each annually worldwide. In accumulation, the use of water for industrial purposes increases. So, it is important to conduct investigate of replacement of potable water by treated waste water partially or totally to produce concrete. The whole thing included severe laboratory experiments, for preparing concrete cubes with sewage treatment plant water from different points of the treatment process and different proportion in the preparation of concrete mixes. The strategy is to test reclaimed water samples in different blending with potable water by 0%,25%, 50%, 75% and 100%. Compressive strength, for concrete cubes was casted for 7 and 28 days. Split tensile strength for 28 days. Results showed that the treated waste water tested in this study meet the requirements to be used in mixing concrete. Hence results suggested that treated waste water are suitable for using in construction industry.

KEY WORDS: Portable water, sewage treated waste water, compressive strength, split tensilestrength

I.INTRODUCTION

1.1 GENERAL

A number of researches around the world have studied the utilization of reclaimed water in concrete, with various levels of success. In housing industry water is employed for mixing, aggregate washing, curing of concrete. The mixing of water which is fit drinking purpose and also fit concreting. 150 litres of water is required for 1cubic meter of concrete. Some samples of successful water reuse projects are the utilization of reclaimed water in situ of potable water to be used in irrigation, and industrial uses. In present, research is to work out the suitability of using treated wastewater for mixing concrete. we waste it and even we are paying a lot for getting unpolluted drinking water from little plastic bottles. Water is the fundamental establishment for life till today so money countries are stressed for pointed a fresh water.

1.2. Treatment of Wastewater

1.2.1. Origin of Sewage

Sewage is produced via residential, commercial, institutional and industrial institutions. It contains household waste liquid from baths, toilets, showers, sinks, kitchens, and so out that is disposed of via drains. In various areas, sewage also contains liquid waste from industry and commerce. Sewage may contain storm water runoff. As rainfall travels over roofs and therefore the ground, it may unplanned various toxins including soil elements and other deposit, organiccompounds, heavy metals, oil, animal waste and grease.

1.2.2. Collection System

The purpose of a sewage collection system stays to remove wastewater as of points of source to a treatment facility otherwise place of dumping. The collection system contains of the sewers in addition plumbing essential to carry sewage from the point of source to the treatment system or else place of disposal.

1.2.3. Treatment Process

Sewage can be treated near to where the sewage is created, a decentralized system, or be collected and transported through a system of pipes and pump stations to a municipal treatment plant, a centralized system. Sewage collection and treatment is typically topic to resident, state and federal guidelines and standards. Industrial sources of sewage frequently require specialized treatment processes.

Sewage treatment generally contains three stages,

1. Primary treatment.
2. Secondary treatment.
3. Tertiary treatment

Primary Treatment

Primary treatment comprises of temporarily holding the sewage in a quiescent basin where heavy solids can settle down to the bottom while oil, grease and lighter solids hang to the surface. The settled and floating materials are detached and the remaining liquid can be discharged to secondary treatment.

Screening

The inflowing sewage water passes through a bar screen to eliminate all large items like cans, rags, sticks, plastic packets etc. carried in the sewage watercourse. This is record commonly finished with an automatic mechanically scraped bar screen in modern plants serving large populations, whereas in smaller modern plants.

Grit Chamber

Pre treatment can contain a grit chamber, where the velocity of the arriving sewage is adjusted to permit the settlement of grit, sand, stones, and broken glass. These particles are detached because they may harm pumps and additional equipment.

Primary Clarifier

From here it is pumped as slurry near a storage tank meant for subsequent treatment. Mostof the objects in wastewater are removed in this process and focused into thick slurry which have a capacity less than 1% of the sewage. The slurry is identified as sewage sludge and it is dealt with isolated. The liquid portion flows over a weir to the succeeding stage of treatment.

Secondary Treatment

Secondary treatment eradicates dissolved and suspended biological substance. Secondary treatment is regularly performed by native, water-borne micro-organisms in a accomplished habitation. Secondary treatment may involve a separation process to eliminate the micro-creatures from the treated water preceding to discharge.

1.3. OBJECTIVE OF THE PRESENT STUDY

The main objective of this research is to investigate the strength of M30 grade of concrete with partial replacement of potable water by treated waste water. The compressive strength of concrete cubes at 7days and 28 days with partial replacement of potable water by 0%, 25%, 50%, 75% and 100% treated waste water. And split tensile strength of concrete at 28 days. The treated waste water collected from SEWAGE TREATMENT PLANT (STP)-200KLD constructed wetland system, at CMR GROUP OF INSTITUTIONS, Hyderabad.

II.METHODOLOGY

Generally, quality of water for construction works are similar as beverage. This is often confirmed that the water is fairly free from such impurities as suspended solids, organic matter and dissolved salts, which can adversely affect the properties of the concrete, especially the hardening, strength, durability, etc. The water intended to be clean and shall not comprise sugar, molasses and their byproducts, or sewage, lubricants, organic substances. There are various tests on water to see its quality for suitability of concrete construction. The tests are done as per clause 3.1.1 of IS 3025-1964.

2.1 Water quality tests for concrete construction:

1. pH value test
2. Limits of acidity test
3. Limits of alkalinity test
4. percentage of solids
    - Chlorides
    - Suspended mater
    - Sulphates
    - Inorganic solids
    - Organic solids

pH value of water shall not be less than 6.

Limits of acidity: To neutralize 200ml sample should not require more than 10ml of 0.1 normal HCL using methyl orange as an indicator. The details of test shall be as given in IS 3025 (para22).

Limits of alkalinity: To neutralize 200ml sample of water should not require more than 2ml of 0.1 normal NaOH (Caustic soda). The details of examinations shall be as given in IS 3025(para 23).

Percentage of solids:

Maximum permissible limits of solids when confirmed in accordance with IS 3025 shall beas under:

Table 2.1 Permissible limits for water

Types of solids	Limits
Organic solids	200mg/l
Inorganic solids	3000mg/l
Sulphates	400mg/l
Chlorides	2000mg/l for concrete not containing embedded steel, and 500mg/l for reinforced concrete work
Suspended matter	2000mg/l
BOD	20mg/l
COD	250mg/l

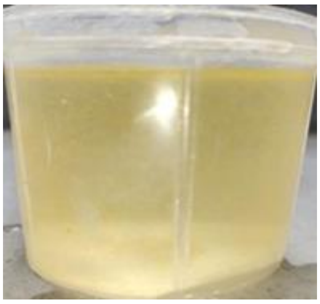


Fig.2.1. treated waste water

2.1. CEMENT:

Cement is that the material that has cohesive properties within the existence of water. Natural cement is found by burning and pulverizing the stones comprising clay, carbonate of lime and a few measure of carbonate of magnesia. Natural cement takes to lime. It sets rapidly after addition of water. It is not as pretty much as artificial cement. Artificial cement was concocted by Mason Joseph of England. This cement closely resembles a spread of sandstone, which is found in abundance in Portland in England. It is therefore sometimes mentioned as hydraulic cement. Extremely fine material having adhesive and cohesive properties. After grinding the OPC is finally bagged weighing 50kg per bag. For 53 grade of OPC, IS code is12269.

The chief chemical constituents of Portland cement:

Table 2.2. chemical composition of cement

Chemical composition	percentage
Lime (Cao)	62 to 67%
Silica (SiO2)	17 to 25%
Alumina (Al2O3)	3 to 8%
Iron oxide (Fe2O3)	0.5 to 6%
Magnesia (Mgo)	0.1 to 4%
Sulphur trioxide (SO3)	1 to 3%
Alkalis	0.1 to 2%

Fig .2.2. OPC COMENT

2.1.1. Bogues compounds:

Tri calcium aluminate (C3A): (4 to 14%)

Imparts harmful properties. Undergoes hydration within 24 hours of addition of water. Responsible for "flash setting". Evolves maximum heat of hydration. Decreases resistance against attack of sulphur.

Tetra calcium alumino ferrite (C4AF): (10 to 18%)

Doesn't impart any engineering property. Undergoes hydration in 24 hours. Also decreases resistance against attack of sulphur.

Tri calcium silicate: (45 to 65%)

This is answerable for strength of cement. Undergoes hydration within a work week or two. Responsible for development of early strength. Best Cementous property among all bogues compounds. Increases the resistance against frost action.

Di calcium silicate: (15 to 35%)

Undertakes hydration within a year after addition of water. Accountable for ultimate strength of cement. Increases resistance against the attack of chemicals.

The extends of the over four mi vary in the various Portland cements. Tri calcium silicate and di-calcium silicate contribute most to the inevitable strength. Initial setting of Portland cement is because of tri calcium aluminate. Tri calcium silicate hydrates rapidly and offers additional to the first strength. The involvement of di calcium silicate happens following 7 days and may proceed for as long as 1 year. Tri calcium aluminate hydrates rapidly, creates proportion of heat and makes only a little contribution to the strength within the first 24 hours. Tetra calcium alumino-ferrite is relatively inactive. Every one of the four mixtures create heat when blended with water, the aluminate producing the most extreme heat and the di calcium silicate producing the minimum. Because of this, tri calcium aluminate is liable for the most of the unfortunate properties of concrete. Cement having less C3A will have higher ultimate strength, less age of heat and less cracking.

Heat of hydration of cement isC3A>C3S>C4AF>C2S Cementous property is C3S>C2S>C3A>C4AF

Ordinary Portland cement is most appropriate for use in general concrete constructionthere is no exposure to sulphate in the loam or ground water. This cement fundamentally comprises of silicates and aluminates of lime acquired from stone and clay. This mixture is grounded, blended, fused in kiln at high temperatures of 1450^0c and a product called clinker is obtained. The clinker is cooled and granulated to cement. The cement is formed in maximum quantity than the other cements as of its durability and resistance to atmosphere and other attacks. It is produced by grinding Portland clinker with possible quantity of gypsum, water or both less than 1% of air entraining elements.

2.2. Aggregates

2.2.1.Coarse aggregate

The aggregate like stone, sand and bricks are inert materials. Their properties greatly impact the behaviour of concrete since they occupy about

80% of the total volume of concrete. It is reasonable to utilze maximum of aggregates since they are less posh than cement and are freely available in nature. The aggregates were classified as fine aggregate and coarse aggregate with the

requirements of IS383-1970.

When the aggregate is sieved through 4.75mm sieve, the aggregate retained on the sieve is called as coarse aggregate. Gravel, cobble, and boulders return underneath this class. The

foremost extreme mixture size utilized may well be necessitous upon certain conditions.

In general purpose 40mm size aggregate utilized for mean strength and 20mm size utilized for higher strength.

Table 2.3. coarse aggregate size variation

Coarse aggregate	Size
Fine gravel	4mm-8mm
Medium gravel	8mm-16mm
Coarse gravel	16mm-64mm
Cobbles	64mm-256mm
Boulders	>256mm

Fig. 2.3. 20mm size Coarse aggregate

2.2.2.Fine aggregate:

The role of fine aggregate on strength and workability must be deciphered before examining the possibility of total replacement of fine aggregate. The purpose of mix proportioning is to yield the required properties in both plastic and hardened by the most cheap and real combination of materials available. In the present work, fine aggregate consisting of natural sand conforming to grading zone 2 of IS 383-1970 is used.

Once the mixture is sieved through 4.75mm sieve, the aggregate went through it referred to fine aggregate. Natural sand is often utilized in place of fine aggregate, silt andclay or in addition gone underneath this family. The soft deposit consisting of sand, silt, and clay is termed a loam. The perform of the fine aggregate is to fill the voids with in thecoarse aggregate and act as a workability agent.

Table 2.4. Fine aggregate size variation

Fine aggregate	Size variation
Coarse sand	2.0mm-0.5mm
Medium sand	0.5mm-0.25mm
Fine sand	0.25mm-0.06mm
Silt	0.06mm-0.002mm
Clay	<0.002

Fig 2.4. Fine aggregate

2.3. TESTS ON MATERIALS

- **Test on cement**
    1. Specific gravity of cement
    2. Initial and final setting of time
    3. Soundness
    4. Compressive strength test
- Test on fine and coarse aggregates
    1. Sieve analysis
    2. Specific gravity of aggregates
    3. Water absorption
    4. Crushing and impact values of CA

2.4. MATERIALS PROPERTIES:

2.4.1. Cement properties

Table 2.5. cement properties

Grade	OPC 53 grade
Specific gravity	3.12
Fineness of cement	6%
Consistency	31%
Initial setting time	35 min
Final setting time	10 hours
Soundness (Le-chatelier)	5mm

2.4.2. Fine aggregate properties

Table 2.6. fine aggregate properties

Specific gravity	2.60
Fineness modulus	2.67
Water absorption	4%

2.4.3. Coarse aggregate properties

Table 2.7. coarse aggregate properties

Specific gravity	2.81
Impact value	9.20
Crushing value	0.82
Water absorption	0.4%

Table 2.8. Tests on water

S.NO	PARAMETERS	POTABLE WATER mg/l	TREATED SEWAGE WASTE WATER mg/l
1	pH	7.2	7.5
2	BOD5	-	280
3	COD	-	860
4	SUSPENDED SOLIDS	110	130
5	CHLORIDES	201	209
6	COLOUR	COLOURLESS	GRAYISH
7	SULPHATE	171	44
8	TOTAL SOLIDS	920	1022

III.MIX DESIGN

3.1 Requirements of concrete mix design

a) The least compressive strength from structural consideration.

b) The acceptable workability essential for complete compaction with the compacting equipment existing.

c) Maximum w/c ratio and extreme cement content to give suitable durability for the actual siteconditions.

d) Extreme cement content to avoid reduction cracking due to temperature in mass concrete.

3.2 Procedure

1. The mean target strength is resolute from the characteristic compressive strength at 28daysf_{ck} and the quality control.

$f_t = f_{ck} + 1.65$ S

Where, S is standard deviation from the Table 8 of IS 456-2000.

2. W/C ratio for the desired mean target is obtained using the empirical between compressive strength and W/C ratio. W/C ratio so chosen is checked against the limiting W/C ratio for the requirements of durability given in table 5 of IS 456-2000 depending upon exposure conditionsand the zones.

3. The water content is selected for the essential workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table 2 of IS 10262-2009.

4. The cement content is calculated by the ratio of water content to the w/c ratio and further checked by the minimum cement content from table 5 of IS 456- 2000 for different exposure conditions. Maximum of both the values is considered.

5. The percentage of coarse aggregate in total aggregate by absolute volume is determined from table for the concrete using coarse aggregate.

6. Volume of fine aggregates per unit volume of total aggregates is determined.

7. The volume of concrete as one cubic metre and the volume of cement, water and aggregates are calculated. Finally, mass of materials is calculated by volumes.

8. The concrete mix proportions for trial mix are determined.

3.3. Mix Design calculations

3.3.1 M30 grade Mix Design

Material description

Table 3.1 Material properties

Cement grade	53 OPC
Cement specific gravity	3.12
Coarse aggregate 1) 20-12.2mm 2) 10-6.5mm	2.81 2.73
Fine aggregate	2.60
Zone corresponding to fine aggregate	Zone II
Slump	100mm
Exposure Conditions	Severe
Target strength	38.25MPa
w/c ratio	0.45
Minimum cement content	320 kg/m³
Maximum cement content	450 /m³

3.4.MIX PROPORTIONS FOR 1m³

TABLE 3.2 Mix proportions for 1m³

Mix designation	Cement (kg)	Fine aggregate(kg)	Coarse aggregate (kg)	Potable water (litres)	Treated wastewater (litres)
Mix 1 (PW100%) + (TWW0%)	438.13	746.40	1056.33	197.16	0
Mix 2 (PW75%) + (TWW25%)	438.13	746.40	1056.33	147.87	49.29
Mix 3 (PW50%) + (TWW50%)	438.13	746.40	1056.33	98.58	98.58
Mix4 (PW25%) + (TWW75%)	438.13	746.40	1056.33	49.29	147.87
Mix5 (PW0%) + (TWW100%)	438.13	746.40	1056.33	0	197.16

IV.EXPERIMENTL INVESTIGATON

4.1 Test procedures

4.1.1. Slump cone test

Objective

The slump cone test is that the utmost typically used methodology of measure the workability of concrete which might use either within the laboratory or at the field. It doesn't quantify all elements adding to the functionality, nor it is consistently delegate of the placeability of the concrete.

It displays the concrete characteristics are additional to the slump value. On the chance cone slides down the one portion, its know as shear slump.

Apparatus required

a) A metallic shape of a cone. Its having the interior measurements as bottom distance across 20cm, top width 10cm, height 30cm and the thickness of the metallic sheet forthe form ought not to be more slender than 1.6mm.
b) Tamper (16mm in distance across and 600mm length. The packing end of the bar willbe adjusted to a hemispherical tip)
c) Ruler.

Fig.4.1. slump cone test

Procedure

- The test is being done in the ground, the example blended concrete will be gotten.In the case of concrete containing aggregate of greatest size in excess of 38 mm, the concrete will be wet sieved through one and half inch screen to prohibit aggregate particles greater than 38mm.
- The mould will be placed one smooth, horizontal, inflexible and non absorbent surface, for example, flat metal plate, the mould being held set up while it is beingfilled.
- The mould should be filled in four layers, every roughly 25% of the peak of the mould. Each layer shall be tamped with 25 blows by tamping rod.
- The concrete are affected off level by using trowel, so that the mould is exactly filled.
- After the tamping of top layer, strike off the top of the concrete by ways for screeding and resonant movement by using tamping rod.
- The mould should be lift up gradually and carefully in vertical direction.
- This permits the concrete to subside and therefore know the slump shall be straight way by measuring the distinction between the peak of the mould & tested specimenhighest point. The above activities are done at place free from vibration, and within two minutes subsequent to testing.

4.1.2. compaction factor test

Objective

The method applies to plain and air entrained concrete, made with light weight, ordinaryweight or substantial aggregate shaving an nominal extreme size of 38mm or less however notto circulated air through concrete or no fines concrete.

Apparatus required

4.1.2.1. Compacting factor apparatus
4.1.2.2. Balance
4.1.2.3. Trowel
4.1.2.4. Tamper (16mm diameter and 600mm length)

Fig.4.2. compaction factor test

Procedure

- The concrete to be tested shall be placed softly in upper container, utilizing the hand scoop. The filled the container and level with its edge and the snare entryway will be opened then concrete falls into lower container.
- Certain blends tend to stick in either of the containers. On the off chance the happens, the concrete may be helped through by pushing the bar gently into the concrete at the top. During this procedure, the trowels are covered the cylinder.
- Immediately when the concrete had stopped, the cylinders are revealed, the lower container trap door is opened % therefore the concrete fall to show the cylinder.
- The surface of the cylinder should be cleaned. The top process shall be allotted at free from vibration. The cylinder with concrete weight shall than be determined to the closest 10g.
- The surplus of concrete remaining staying above the cylinder can at that time be removing by trowel.
- This weight will be called as the weight of partially compacted concrete. The cylinder is filled with concrete by layers approximately 5cm deep, and rammed or vibrated to acquire full compaction.
- The cylinder surface will at that point be cleaned off.

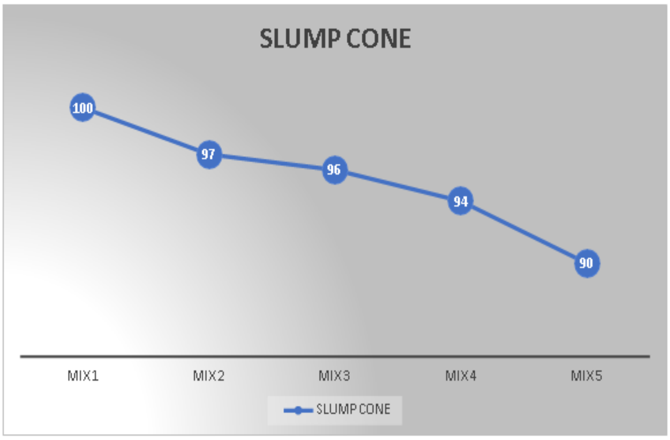
V. TESTDATA AND RESULTS

5.1. TEST RESULTS FOR VARYING PERCENTAGES OF PARTIALREPLACEMENT OF POTABLE WATER BY TREATED WASTE WATER

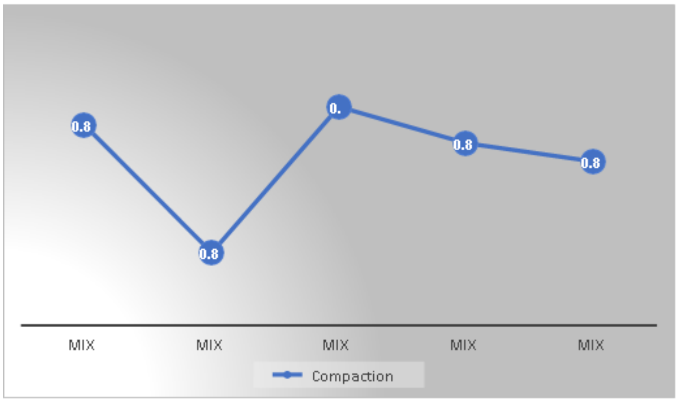
5.1.1. Workability of concrete with partial replacement of potable water by treated wastewater

Table 5.1. workability of concrete tests results

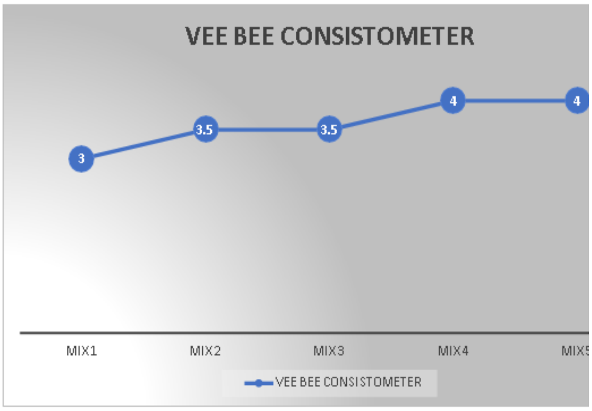
MIX	SLUMP CONE	COMPACTION FACTOR	VEE-BEE CONSISTOMETER (SCE)
MIX 1 (PW 100%) +(TWW 0%)	100	0.89	3
MIX 2 (PW 75%) + (TWW 25%)	97	0.82	3.5
MIX 3 (PW 50%) + (TWW50%)	96	0.90	3.5
MIX 4 (PW 25%) + (TWW 75%)	94	0.88	4
MIX 5 (PW 0%) + (TWW100%)	90	0.87	4



Graph 5.1 slump cone test results



Graph 5.2. compaction factor test results

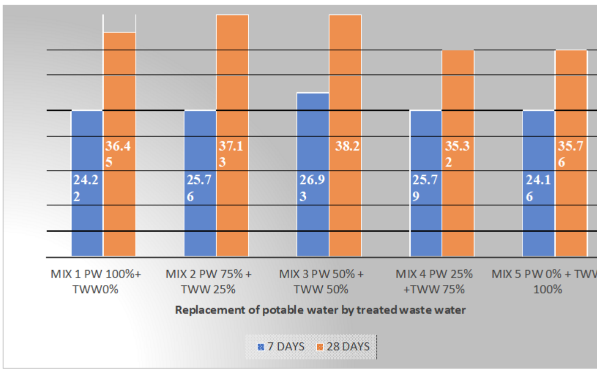


Graph 5.3. vee bee consistometer test results.

5.1.2. Compressive strength results for concrete with partial replacement of potable waterby treated waste water

Table 5.2. compressive strength test results of concrete cubes for 7&28 days

S.NO	Replacement potable water by treated waste water
1	Mix 1 potable water 100% +treated waste water 0%
2	Mix 2 potable water 75% +treated waste water 25%
3	Mix 3 potable water 50%+treated waste water 50%
4	Mix 4 potable water 25%+ treated waste water 75%
5	Mix 5 potable water 0%+ treated waste water 100%



Graph 5.4. compressive strength of concrete

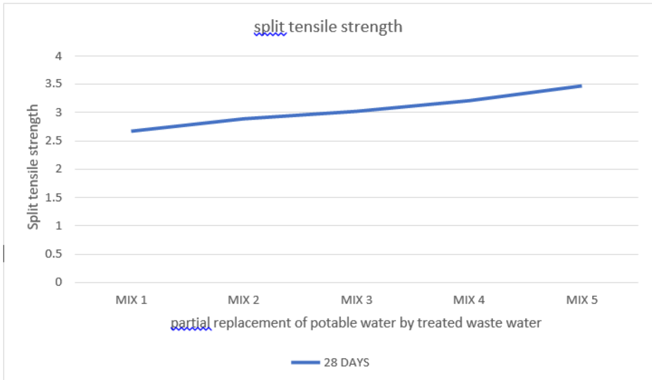
The above chart indicates the compressive strength of concrete with partial replacement of potable water by treated waste water. The highest compressive strength got at mix 3 potable water 50% and treated waste water 50%. After that mix 3 the compressive strength of mixes are decreased.

The compressive strength of concrete increased by 4.8% at mix3 potable water 50% and treated waste water 50%.
The compressive strength of concrete decreased by 2% when cubes equipped by only mix of treated waste water.

5.1.3. Split tensile strength results for concrete with partial replacement of potable waterby treated waste water

Table 5.3. split tensile strength test results of concrete at 28 days

S.NO.	PARTIAL REPLACEMENT OF POTABLE WATER BY TREATED WASTE WATER	SPLIT TENSILE STRENGTH @28DAYS
1	MIX 1 PW 100% +TWW 0%	2.67
2	MIX 2 PW 75% +TWW 25%	2.89
3	MIX 3 PW 50% +TWW 50%	3.02
4	MIX 4 PW 25% +TWW 75%	3.21
5	MIX 5 PW 0% +TWW 100%	3.47



Graph 5.5 split tensile strength of concrete

Above graph shows the split tensile strength of concrete increases when the partial replacement potable water by treated waste water.

VI.CONCLUSION

6.1. conclusion drawn from the study:

1. The compressive strength of concrete with partial replacement of potable water by treated waste water. The maximum compressive strength conquered at mix 3 potable water 50% and treated waste water 50% at 28 days.

2. After Mix 3 the compressive strength of mixes are decreased.
3. The compressive strength of concrete increased by 4.8% at mix3 potable water 50%and treated waste water 50% at 28days.
4. The compressive strength of concrete decreased by 2% when cubes prepared by onlymix of treated waste water.
5. the split tensile strength of concrete increases when the partial replacement potablewater by treated waste water.
6. The workability of concrete is medium. The pattern of slump is true.
7. Minimize the need of potable water for concrete manufacturing, and use potable waterfor drinking purpose only.
8. Low cost and eco-friendly concrete can be prepared by treated waste water.

6.2. scope for future studies

6.2.1. Study the corrosion of steel when utilized in treated waste water concrete mix.
6.2.2. Study the durability of concrete.
6.2.3. Research on treated waste water for use in concrete industry.

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