PARTIAL REPLACEMENT OF FINE AGGREGATE IN FIBRE REINFORCED CONCRETE WITH WATER TREATMENT SLUDGE AND GRAPE EXTRACT AS ADMIXTURE

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Abstract -*Coagulation, flocculation, sedimentation, and filtering techniques are frequently used in surface water treatment to remove colloidal and suspended particulates from raw water before it is made potable. During the process of purifying raw water, all water treatment facilities produce waste/residue known as water treatment sludge. It can be used in manufacturing low-strength concrete blocks for applications in construction. Drinking water treatment sludge is collected from Kerala Water Authority Water treatment plant and is dried. The dried sludge is tested for its components. Steel fibre reinforced concrete cubes are casted with partial replacement of fine aggregates with drinking water sludge and the compressive and tensile strengths are determined. For improving the strength and quality of the prepared concrete mix, natural admixture like grape extract is used. Usage of natural admixture helps in reduction of cost and producing environmental-friendly construction material.*

Key Words: **Water treatment sludge, Steel fibre, Grape extract**

1. INTRODUCTION

Concrete is a composite material composed of aggregate bonded together with a fluid cement that cures over time. It is a material that is widely used in building and is produced by combining aggregate, cement, small stones, sand, and water. Together, all the elements form a substance that is similar to stone. Concrete's strength and quality can be changed by appropriately changing the materials that make up the concrete, such as the binders, aggregates, water, etc. Fibre reinforced concrete is a composite material with concrete and fibres, which strengthens its structural stability. It comprises blends of appropriate fibres that are discrete, uniformly scattered, cement, mortar, or concrete. Fibres are typically utilized in concrete to prevent cracking brought on by drying and shrinking of plastic. Additionally, they lessen the permeability of concrete, which in turn lessens bleeding of water.

Increase in amount of sludge rises a problem of to a particular limit. It is a sustainable solution, to use sludge in the production of concrete for various purposes. But addition of sludge seemed to be decreasing the strength of concrete due to the presence of organic content and also due to porous interfacial transition zone between cement matrix and sludge particles. Hence it is important to improve the properties of concrete using some methods. Use of natural admixtures have positive impacts on the quality of concrete compared to other chemical or mineral admixtures.

2. MATERIALS USED

2.1 Cement

Ordinary Portland cement of 53 grade was selected for the investigation. It was powdery, dry and free of lumps. All possible contact with moisture was avoided while storing cement. The specific gravity of cement is 3.11, fineness of cement is 7%, consistency is 32%. The initial setting time is found to be 190 minutes.

2.2 Coarse aggregates

The 20 mm and 12 mm coarse aggregates were taken in the proportion of 43% and 57%, respectively. Fineness modulus was found using sieve analysis. According to IS 2386 (1963), the specific gravity, bulk density, porosity, void ratio and water absorption is determined and found to be within the range. The Crushing value is 21.35%.

2.3 Crushed sand

Crushed sand passing 4.75mm IS sieve is used for the investigation. The specific gravity is 2.68. From particle size distribution curve it falls under Zone II. The maximum bulking of sand is 25.3% at 6% moisture content.

2.4 Water treatment Sludge

The drinking water treatment sludge after backwashing is collected from Kerala Water Authority Water Treatment Plant, Peruvalathuparamba. The specific gravity is 2.2. It is also falling under Zone II from particle size distribution curve. Fig -1 shows the dried drinking water treatment sludge.

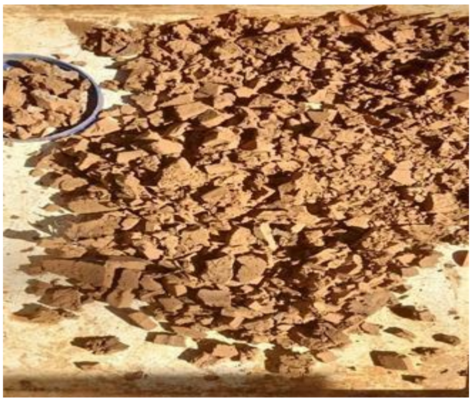

Fig -1: Drinking water treatment sludge

Table -1: Chemical composition of Water treatment sludge (XRF analysis)

Component	%W/W	Component	%W/W
SiO_2	42.380	Ca	1.0160
Al_2O_3	40.640	K	0.3843
Fe_2O_3	11.940	Mn	0.2154
MgO	1.8060	S	0.2104
CaO	1.4220	P	0.1633
SO_3	0.5253	Zn	0.0959
K_2O	0.4629	Cl	0.0458
P2O5	0.3742	Cr	0.0368
Al	22.430	V	0.0257
Si	19.000	Ni	0.0142
Fe	8.3480	Ba	0.0142
Mg	1.0890	Cu	0.0117

2.5 Steel fibres

Steel fibres with a length and diameter of 30mm and 0.55mm respectively, and with an equivalent aspect ratio 55 is selected for the investigation. Fig – 2 shows the crimped steel fibres.

Fig -2: Steel fibres

2.6 Grape extract powder (Admixture)

The grape (*Vitis vinifera*) extract is prepared and kept for drying under sun for 2 days and for oven drying for 1 day. The obtained dry form is crushed into powder form. The specific gravity is 1.1. Fig – 3 depicts grape extract powder.

Table -2: Mineral composition of Grape extract powder (XRF analysis)

Minerals	Composition (ppm)
K	12890
Mg	2077
P	1992
Ca	1535
S	1002
Al	479
Si	456
Cl	363
Fe	44.7
Zn	19.5

Fig -3: Grape extract powder

3. EXPERIMENTAL METHODS AND PROCEDURE

3.1 Mix Design

We have adopted M25 grade for our inquiry. The mix ratio obtained is M25 (1: 1.55: 2.79), in compliance with the mix design as per IS 10262: 2019. The final mix proportion obtained is depicted in Table -3.

Table -3: Final mix proportion for M25 grade concrete

Cement	Fine aggregate	Coarse aggregate	Water
426 kg/m³	662 kg/m³	1186 kg/m³	192 kg/m³
1	1.55	2.79	0.45

3.2 Preparation of Steel Fibre Reinforced Concrete (SFRC) (Mix A)

SFRC was prepared by adding 2% steel fibres of total concrete volume for concrete cubes and cylinders.

Total quantity of materials used for 1 cum of concrete = 426 + 662 + 1186 = 2274kg

Fibres quantity for 2% total fibre content

= 2274 × 0.02 = 45.48kg

Total number of cubes to be casted= 3 Nos

Concrete quantity for 3 cube

= 0.15 × 0.15 × 0.15 × 3 = 0.01cum

Quantity of fibre for 3 concrete cubes = 0.01 × 45.48

= 0.455 kg

3.3 Preparation of SFRC with sludge (Mix B)

SFRC with sludge is prepared by the replacement of 20% of fine aggregates with water treatment sludge (WTS).

3.4 Preparation of SFRC with sludge and grape extract powder (Mix C)

Cubes were casted with the addition of 0.15%, 0.25%, 0.45%, 0.65% and 0.85% of grape extract as natural admixture in SFRC with sludge concrete mix. Trial mixes were prepared for the determination of optimum percentage of natural admixture required for concrete. 0.25% of grape extract by weight of cement was found to be the optimum percentage.

3.5 Preparation of SFRC with grape extract powder (Mix D)

SFRC with grape extract was prepared with the addition of 0.25% of grape extract by weight of cement in SFRC.

3.6 Mixing

Hand mixing of concrete was employed for our project. It was carried out over a solid concrete or brick surface large enough to hold one bag of cement. The measured amount of coarse aggregate and fine aggregate were layered in alternating fashion. The cement was poured on top of the dry components, then the mixture was well mixed with the shovel.

3.7 Curing

It is crucial to maintain a sufficient moisture content and temperature in concrete for the first few hours after placement in order to give the cement time to continue hydrating until the qualities necessary to meet the needs of service are fully established. The cubes and cylinders were immersed in water tanks for 7 and 28 days after casting them for 24 hours.

4. EXPERIMENTAL TESTS AND INVESTIGATIONS

4.1 Compressive strength test

The concrete cubes were taken out of the tank after curing. The cube is placed beneath the compressive testing apparatus once it had completely dried to determine the concrete's compressive strength. The sample specimen is introduced into the testing apparatus after properly cleaning the bearing surface. The specimen is placed in the device so that the load is distributed across the cube's opposing sides. The load is applied progressively until the specimen breaks. The highest load applied is noted.

Load divided by area will give compressive strength. Table -4 shows the compressive strength test results corresponding to 7 days and 28days. Chart -1 shows the comparison of compressive strength test results for different concrete mixes for 7 days and 28 days respectively.

Table -4: Compressive strength test results

Number of days	Average compressive strength (N/mm²)			
	Mix A	Mix B	Mix C	Mix D
7	33.65	26.06	28.69	36.34
28	42.05	29.69	40.38	43.30

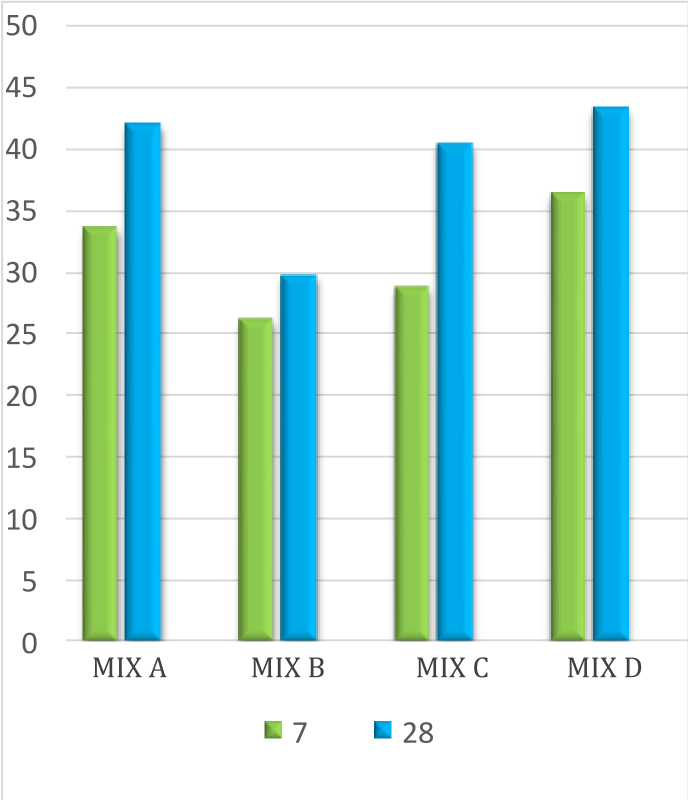

Chart -1: Compressive strength for 7 days and 28 days comparison chart

4.2 Split Tensile strength test

On the cylindrical specimen, split tensile strength tests are performed using compressive testing equipment. When the specimens split as a result of gradually applied the load, readings are taken. Table –5 represents the Split tensile strength test results for 28 days. Chart -2 represents the comparison chart of Split tensile strength results for the different concrete mixes.

Table -5: Split Tensile strength test results

Number of days	Average split tensile strength (N/mm^2)			
	Mix A	Mix B	Mix C	Mix D
28	2.69	2.39	3.04	2.74

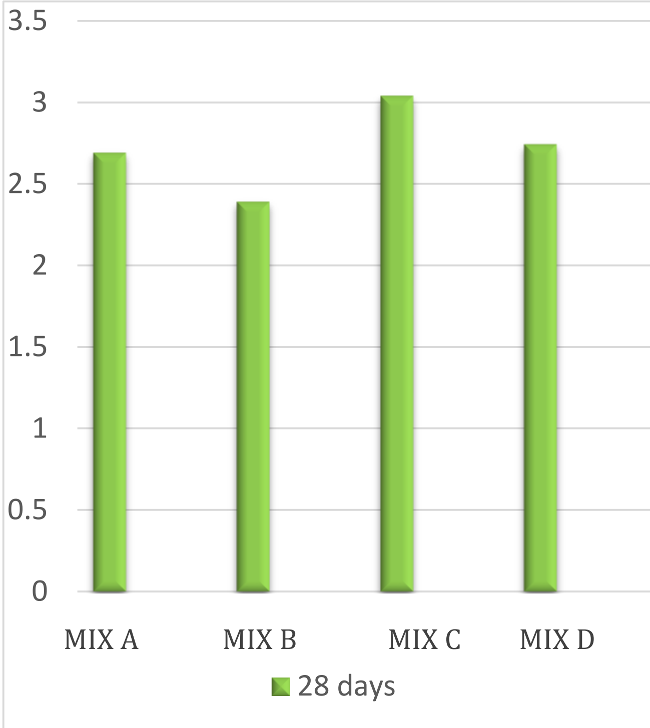

Chart -2: Split tensile strength comparison chart

4.3 Workability Test

Slump cone test is used to determine the workability or consistency of concrete mix prepared during the progress of the work for the concrete mixes. Chart -3 depicts the slump value for the four concrete mixes.

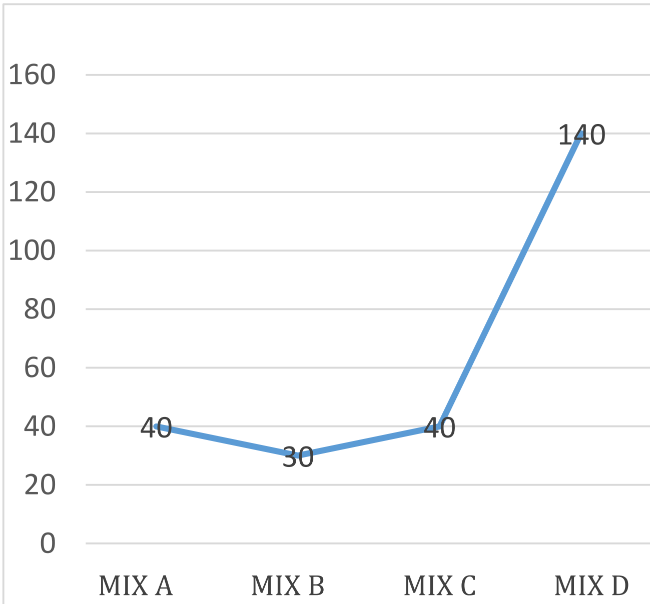

Chart -3: Slump value comparison chart

4.4 NDT test

Concrete's compressive strength can be quickly and easily evaluated using the non-destructive Rebound Hammer test. A spring-controlled mass with consistent energy is produced to impact the surface of the concrete when the rebound hammer's plunger is driven against it. The amount of rebound, which gauges surface hardness, is measured on a scale. Rebound Number is the name given to this measured number. It is used to evaluate the concrete's quality based on the required specifications.

Table -6: Rebound hammer test results

Number of days	Rebound Number			
	Mix A	Mix B	Mix C	Mix D
7	41.16	41.47	45.33	47.13
28	42.32	42.57	47.31	49.36
Quality of concrete	Very good hard layer			

5. CONCLUSIONS

- The compressive strength and split tensile strength of SFRC decreased with the partial replacement of fine aggregates with sludge
- The compressive strength and split tensile strength of SFRC with partial replacement of fine aggregates with sludge improved with the addition of 0.25% of grape extract powder
- When grape extract is added, compressive strength increases which may be due to carbohydrates and sugar present in the grapes
- Polymerization of tannin helps in filling micro structural cracks produced during hydration of cement
- Precipitation of potassium bitartrate inside the pore structure of hardened cement paste was identified in previous researches
- Improvement in workability by addition of grape extract is also observed
- SFRC with partial replacement of sludge with grape extract can be utilized for temporary constructions, shoulders in pavement etc.
- There is future scope of work by studying durability and making other improvements.

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