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Original Article

Influence of Treated Grey Water on Properties of Concrete Using Silica Fume as Admixture

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Abstract *- Concrete is also one of the most water-intensive industries. Water is undoubtedly vital in civil engineering, and there are no suitable substitutes now. Chemical water limits for concrete indicate that non-potable water can be used as mixing water, according to various concrete standards. Grey water, for example, might be repurposed to alleviate pressure on freshwater supplies. Traditional concrete production mainly relies on freshwater resources for mixing and curing, resulting in water scarcity in many areas. The construction sector may drastically cut its water usage and environmental footprint by substituting treated Grey water for some freshwater. Following proper treatment and purification, Grey water can partially replace fresh water in concrete mixtures without harming the material's performance, durability, or strength. This study aims to determine how the use of Grey water affects the quality of concrete. A M 40 concrete mix was blended with silica fume to increase the strength of the concrete.*

Keywords *- Treated grey water, Mechanical properties, Electrocoagulation, Durability, Rapid Chloride Penetration Test.*

1. Introduction

Grey water, often known as grey water, is wastewater produced by domestic activities such as bathing, showering, dishwashing, and laundry. Grey water, as opposed to black water (from toilets), which is significantly contaminated with faecal matter and requires considerable treatment, is generally clean and can be helpful when managed and exploited efficiently [1-3]. Grey water inclusion in concrete manufacturing is an innovative and sustainable application of grey water. The most unclear issue is water scarcity. Even though over 1 billion people lack access to clean and safe drinking water due to its decreasing availability, we continue to take it for granted, waste it, and even overpay it in small plastic bottles [4]. Grey water use in concrete is a possible method to manage water scarcity, reduce freshwater use, and reduce the environmental effect of typical concrete production [5].

Traditional concrete production primarily relies on freshwater, which leads to the loss of local water supplies in many parts of the world [6]. We can save valuable water resources and minimize the carbon footprint associated with concrete manufacturing by replacing some freshwater used in concrete mixing with treated grey water [7]. 1m^3 of concrete requires 186 litres of water, according to IS10262-2009 [10]. A double-lane flyover of the same size can consume 70 million gallons of water. Water is also used in the building industry for mixing, washing aggregates, and curing concrete [12].

At least twice yearly, two-thirds of the world's population (4 billion people) face severe water scarcity. Even today, many people in various parts of India spend their entire day seeking water [13]. The IWMI predicts that India will face a water crisis by 2025. (The International Water Management Institute). The construction industry utilizes much water, which is becoming increasingly scarce [14]. With India's expanding population and construction, treated grey water might become a dependable and sustainable water source [10]. Because it contains fewer bacteria, grey water is frequently safer to handle and treat than household wastewater. Grey water incorporation into concrete is a forward-thinking solution to sustainable construction methods [15].

We can contribute to water conservation efforts, lessen the environmental impact of building, and develop a more sustainable and Resilient future by utilizing the potential of this vital resource [16]. This introduction examines the benefits, problems, treatment procedures, and potential uses of putting grey water into concrete [17]. We can progress toward more sustainable construction techniques while addressing the pressing global water crisis by grasping the possibilities of grey water in concrete [19].

1.1. Research Gap

A thorough gap analysis promotes the ethical and sustainable use of grey water in concrete buildings, potentially resulting in reduced water consumption, lower environmental consequences, and cost savings in the construction industry.

2. Scope of Study

The potential for using treated grey water in concrete to reduce water usage and environmental effects is intriguing, but it requires careful planning, treatment, and adherence to local rules. It is best suited for specific applications where water quality and compatibility can be efficiently maintained and monitored. Before integrating grey water reuse in concrete buildings, consulting with specialists and conducting site-specific analyses is best. Using treated grey water in concrete construction has the potential to be an environmentally friendly technique, with benefits such as saving freshwater resources and lowering the environmental effect of concrete production.

3. Future Scope

The future potential of treated grey water in concrete is bright, but it will depend on technological improvements, regulatory changes, and the building industry's willingness to adopt sustainable methods.

4. Materials and Methodology

The methodology for working with concrete often entails numerous crucial phases to ensure the concrete is mixed, put, and finished correctly to obtain the appropriate strength and durability.

- Project planning- Grey water was gathered with everyday kitchen utensils. Samples were collected and brought to a laboratory for testing and research on the early qualities of grey water. Grey water is treated with Electrocoagulation for 4 to 6 hours.
- Material selection-Grey water, Silica fume as admixture, Aggregates.
- Mix design-M40
- Concrete mixing and casting-Cubes and cylinders cast for mechanical properties.
- Testing of specimen- After curing, the strength qualities and acid test were carried out.

4.1. Silica Fume

It is a fine-grained, highly reactive substance frequently used as an additive in concrete to improve its qualities. Because of its potential to improve the material's strength, durability, and other critical features, silica fume is a valuable component in concrete production. It should, however, be used with caution and in compliance with a suitable mix of design and safety recommendations.

5. Test and Results

5.1. Water Sample Test

In the concrete production process, adhering to industry norms and requirements for water quality testing is critical. The specific criteria and allowable limitations may differ depending on area legislation and project requirements. Regular testing and quality control techniques help to ensure that the concrete construction performs as expected and lasts as long as possible.

5.1.1. Electrocoagulation

Electrocoagulation is an electrochemical water treatment that removes pollutants and impurities from water. It employs an electric current to destabilize and coagulate suspended particles, ions, and organic matter in water, making separating and removing these contaminants easier. This procedure is particularly effective in treating wastewater and industrial effluents [20-22], but it can also be utilized in drinking water under certain conditions.

Fig. 1 Water treatment using electrocoagulation

5.2. Cement Paste Consistency

The degree of wetness or fluidity of a cement-water mixture is called cement paste consistency. It is a significant aspect in construction and concrete work since it can alter the final tangible product's qualities and performance. When treated grey water is utilized instead of potable water, the fluidity of cement paste increases by 1.785%. According to I.S. specifications, cement consistency should be between 24% and 30%.

As a result, the obtained results are within acceptable limits**.** It is critical to note that achieving the proper consistency is essential for appropriate concrete placement, compaction, and curing, as it directly influences the strength, durability, and overall performance of the finished construction. Particular attention should be paid to mix design and cement paste consistency testing to suit the project's specific needs.

5.3. Compression Strength Test

It assesses concrete's ability to sustain axial loads (push or compressive forces) without severe deformation or failure. This test is essential in the building and engineering industries to guarantee that the concrete used in projects satisfies the requisite strength criteria. [18] Concrete compressive strength is vital since it determines the concrete's ability to support structural loads properly.

Engineers and builders use this information to ensure concrete structures meet design specifications and safety norms. [12] The results of these tests can also be used to improve quality control and assurance during construction projects. The following figure shows the compressive strength results for 4 and 6 hours treated water with various percentages of silica fume.

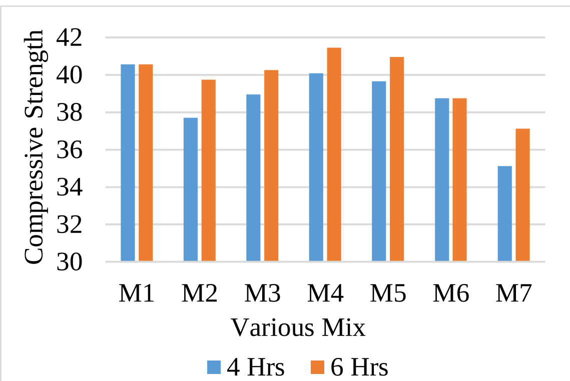

Fig. 2 Compression strength test for 4 hours and 6 hours

5.4. Tensile Strength Test

Tensile strength is a material's ability to withstand being pulled apart or stretched. Unlike compressive strength, which examines a material's resistance to forces that tend to pull it apart, split tensile strength evaluates its resistance to forces that tend to pull it apart. Engineers and construction professionals must understand the split tensile strength of concrete to ensure the longevity and safety of concrete constructions. It aids in selecting appropriate concrete mixtures and reinforcement procedures to achieve the necessary performance levels. The following figure shows the split tensile strength results for 4 hours and 6 hours treated water with various percentages of silica fume.

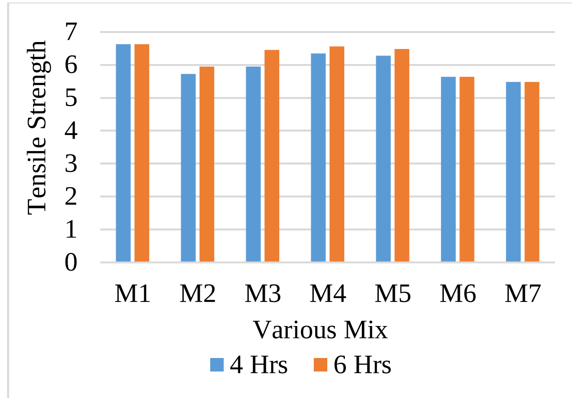

Fig. 3 Tensile strength test for 4 hours and 6 hours

5.5. Durability Test

Concrete durability testing is essential to guarantee it can endure various environmental and structural pressures over its projected lifespan. Several tests are carried out to evaluate the durability of concrete structures, emphasizing aspects such as moisture resistance, chemical attack, and physical deterioration. It should be noted that exact tests and standards may differ according to local building codes, project needs, and environmental circumstances. A combination of these tests performed throughout the design, construction, and maintenance phases can aid in the long-term durability of concrete structures.

5.6. Rapid Chloride Penetration Test

The RCPT is a valuable tool for determining the endurance of concrete structures, particularly in marine and coastal regions or when de-icing salts are regularly used on highways [24]. It assists engineers and researchers in determining whether the concrete mix and curing processes used are sufficient to prevent chloride-induced corrosion of reinforcing steel, which can lead to structural damage and reduced service life. The Rapid Chloride Penetration Test (RCPT) is a laboratory test to determine concrete's resistance to chloride ion penetration. Chloride ions can pass through concrete and reach reinforcing steel causing corrosion and structural damage. As a result, this test aids in determining the durability and longevity of concrete structures, particularly those exposed to hostile environments such as coastal areas where they may be exposed to saltwater [25]. The chloride ion penetrability based on charges passed are given in Table 1.

Table 1. Chloride ion permeability recommended values

S. No.	Charge Passed	Chloride Ion Penetrability
1	>4000	High
2	2000-4000	Moderate
3	1000-2000	Low
4	100-1000	Very low
5	<100	Negligible

Fig. 4 RCPT test apparatus

Table 2. RCPT value for different mix

Mix	% of S.F.	28 Days	56 Days	90 Days
M1	Tap Water	250	150	64
M2	TGW	273	163	75
M3	3%SF+TGW	310	178	87
M4	6%SF+TGW	325	196	92
M5	9%SF+TGW	454	217	98
M6	12%SF+TGW	515	258	125
M7	15%SF+TGW	685	325	167

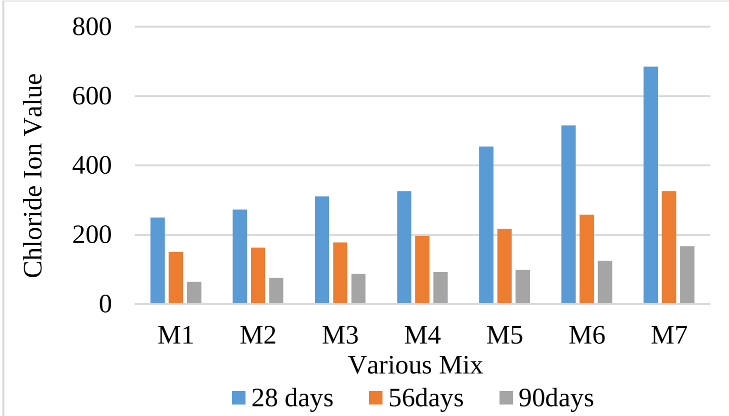

Fig. 5 RCPT values for various mix

Table 3. Acid alkali test values for various mix

Mix	% of SF	Loss of Weight in %	Loss of Strength in %
M1	Tap Water	5.82	28.8
M2	TGW	5.88	25.9
M3	3%SF+TGW	5.68	27.7
M4	6%SF+TGW	5.79	26.8
M5	9%SF+TGW	5.98	29.8
M6	12%SF+TGW	6.56	32.9
M7	15%SF+TGW	7.25	38.7

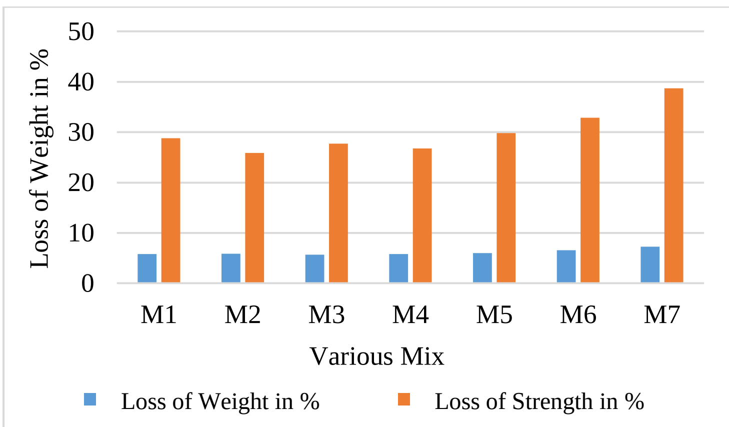

Fig. 6 Acid alkali test for various mix

5.7. Acid Alkali Test

In solution, aggressive acids such as sulphuric acid, acetic acid, hydrochloric acid, and nitric acid inflict significant damage to concrete. Acid combines with calcium hydroxide to form soluble salts in an acidic environment. After consuming calcium hydroxide, more aggressive acids such as sulphuric and acetic acid react with C-S-H gel. As a result, the solids in concrete begin to degrade, and the concrete becomes weakened. If the pH falls below the stability limits of cement hydrates, the hydrate loses calcium and decomposes into the amorphous hydrogel.

6. Results and Conclusion

The following effects are observed in multiple tests conducted. The I.S. limit is met for mixing treated wastewater’s initial and final cement setting times. According to the findings, water treated for 6hrs has got better strength when compared to 4 hours. The compressive and tensile strength graph in Figure 1 and Figure 2 show that there is considerable strength up to M4 mix ratio. Also, there is little difference in power between concrete built using TGW and tap water containing up to 9% silica fume. Due to shrinkage and cracking, adding more admixture reduces the strength. In some ways, concrete built with TGW can overcome water scarcity.

Plain concrete is better suited to TGW-produced concrete. Also, there is a loss in the strength of concrete in the acid attack test when the mix is above 9 % of silica fume. RCPT test results in Figure 3 show for the M4 mix, there is a decrease in the chloride ion value up to 9 % silica fume mixed with treated grey water.

Using treated wastewater in concrete can produce low cost and environmentally friendly concrete. Nowadays, there is such a scarcity of water that other sources of water for concrete or the construction of building units are required.

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