SSRG International Journal of Civil Engineering
ISSN: 2348-8352/ https://doi.org/10.14445/23488352/IJCE-V11I5P106

Volume 11 Issue 5, 56-62, May 2024
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Original Article

Durability Assessment of Grey Water in Performance of Concrete Using Admixture

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Received: 05 March 2024 Revised: 07 April 2024 Accepted: 06 May 2024 Published: 31 May 2024

Abstract **-** *When Portland cement, a necessary component of concrete, is manufactured, 2.5 billion tons of greenhouse gases, including carbon dioxide, are released into the atmosphere. Despite its undeniable relevance, there are yet no effective substitutes for water in the field of civil engineering. If specific conditions are met, water that is not fit for human consumption can be utilized as mixing water. This rule is applied to concrete using chemical water limitations. Grey water recycling is one possible technique to reduce the demand for freshwater resources. The primary purpose of this research project is to determine how adding grey water to the concrete production process affects the end product's quality. Prior to mixing, silica fume and filtered grey water were added to an M-40 concrete mix to improve its durability. The following phase entails determining the extent to which treated grey water and tap water samples affect concrete strength.*

Keywords - *Treated Grey Water, Drying Shrinkage Testing of Concrete, Sorptivity, Water Permeability, Carbonation*.

1. Introduction

The one that is thought to need the least amount of understanding is that of a limited water supply. Because of the potential effects over the next 10 years, the World Economic Forum classified it as one of the major global risks in 2019. This ranking was based on the potential effects that it might have [1]. We throw it out, we take it for granted, and even if we spend money on tiny plastic bottles of pure drinking water, we are still denying access to it to a greater number of people since there is less clean and safe drinking water available [2]. As a consequence of this, the number of individuals who do not have access to potable water that is free from contaminants is increasing. There are around one billion people who do not have access to it at present. In spite of all of this, we yet continue to drink it without giving it any attention 2 [2].

At least two-thirds of the world's population, which is equivalent to four billion people, is affected by a severe scarcity of potable water at least once per year. There are a variety of distinct regions where this takes place. According to the International Water Management Institute (IWMI), it is expected that India will be facing a water crisis by the year 2025 [3]. The IWMI made this prediction. The acronym "W.M.I.E." comes from the phrase "Water Management Institute for International Exchange." Despite the fact that it does not take into consideration the amount of water that is necessary for washing and curing concrete, the concrete industry alone is responsible for the use of more than one trillion gallons of water annually. A volume of approximately 150 litres of water is required for the production of one cubic meter of concrete [5]. The construction sector continues to consume a substantial amount of water despite the fact that the quantity of potable water that is now accessible is decreasing. This purified Grey water has the potential to become a stable and sustainable source of water for India, which is undergoing fast population growth and economic expansion. The liquid that is created in the kitchen as a result of numerous fixtures and appliances, such as sinks, showers, washing machines, and dishwashers, is referred to as "Grey water." The word "Grey water" is used to describe this liquid [7]: Many different types of pollutants may be found in Grey water. Some of these contaminants include filth, food, grease, hair, and other chemicals that are used for cleaning the house. When compared to wastewater from households, grey water is often safer to handle and clean. This is due to the fact that it includes a lower concentration of bacteria [8].

1.1. Problem Statement

There is an urgent need to examine and investigate the potential of using grey water in the building industry. This is owing to the building industry's increasing demand for potable water. Since this is the case, efforts are being made to mix grey water into concrete while keeping its characteristic properties.

1.2. Gap Analysis

Concrete manufacturers must do all they can to ensure the quality and consistency of treated grey water. Research is needed to develop long-term solutions for managing the quality of grey water. These solutions should account for variations in the quality of the source water and treatment procedures.

Conduct a thorough economic analysis of the use of treated grey water in the production of concrete. This includes assessing the cost-effectiveness of treatment technologies, investing in infrastructure, and identifying potential water savings.

1.3. Scope of Study

The ultimate goal of using treated grey water in the concrete production process is to explain the qualities of the completed product. This study examines the concrete production process, with an emphasis on the functions of silica fume and grey water [9].

1.4. Future Scope

When it comes to the creation of concrete, the utilization of treated grey water serves the purpose of determining the qualities of the final product. The utilization of silica fume and grey water in the production of concrete is the subject of discussion in this particular piece of writing.

1.5 Methodology

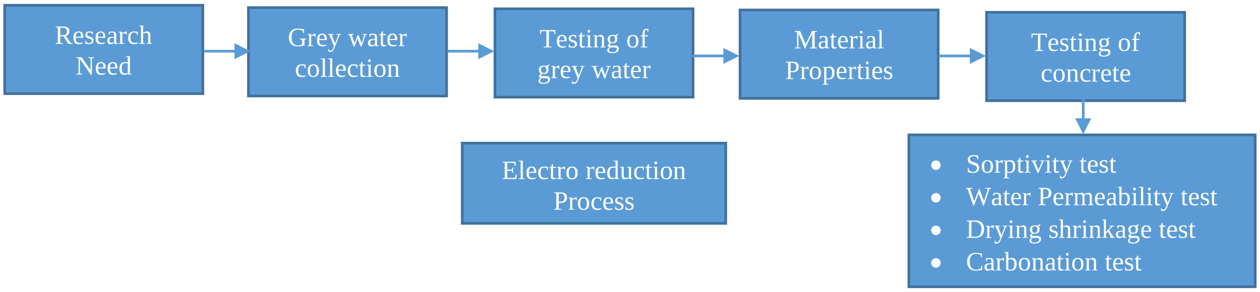

Fig. 1 Methodology

Table 1. Cement properties

S.No	Bulk Density	Setting Time	Consistency	Soundness
1.	1.35kg/m^3.	Initial 30 min Final 9 hr 15 min	30%	9 MM

Table 2. Carbonation test for 2 Hrs treated water

MIX	% of Silica Fume	Depth of Carbonation
M1	Tap Water	1.5 mm
M2	TGW	3 mm
M3	3% +TGW	4.5 mm
M4	6% +TGW	5.6 mm
M5	9% +TGW	7.2 mm
M6	12% +TGW	9.3 mm
M7	15% +TGW	11.5 mm

Table 3. Carbonation test for 4 Hrs treated water

MIX	% of Silica Fume	Permeability
M1	Tap Water	1.5 mm
M2	TGW	2.2 mm
M3	3% +TGW	3.8 mm
M4	6% +TGW	4.6 mm
M5	9% +TGW	5.3 mm
M6	12% +TGW	6.2 mm
M7	15% +TGW	7.8 mm

Table 4. Carbonation test for 6 Hrs treated water

MIX	% of Silica Fume	Permeability
M1	Tap Water	1.5 mm
M2	TGW	1.55 mm
M3	3% +TGW	1.68 mm
M4	6% +TGW	1.75 mm
M5	9% +TGW	2.00 mm
M6	12% +TGW	3.58 mm
M7	15% +TGW	4.5 mm

2. Cement

Cement is a crucial component in concrete production, serving as the binding agent that holds the other ingredients together. Portland cement is the most common type of cement used in concrete. As research and technology advance, there may be future developments in cement production to reduce its environmental impact and improve overall sustainability.

3. Carbonation Test

One of the most common causes of reinforcement corrosion is the carbonation of concrete. Other components required for embedded steel corrosion include oxygen and moisture. This test determines the depth of carbonation. The pace of carbonation relies on the grade of concrete, its permeability, whether it is protected or not, the depth of cover, time, etc. [30].

From the below graph, it is observed that 6hrs treated water sample with 9 % silica fume has a depth of carbonation in the accepted range; also, the depth increases with an increase in silica fume beyond 9 % in 2 and 4 hrs treated water sample.

4. Water Permeability Test

Concrete must be tested for water permeability to determine its durability and quality. To establish the concrete's durability and susceptibility to corrosion, the test is conducted to measure the concrete's resistance to water penetration, which is especially significant [11].

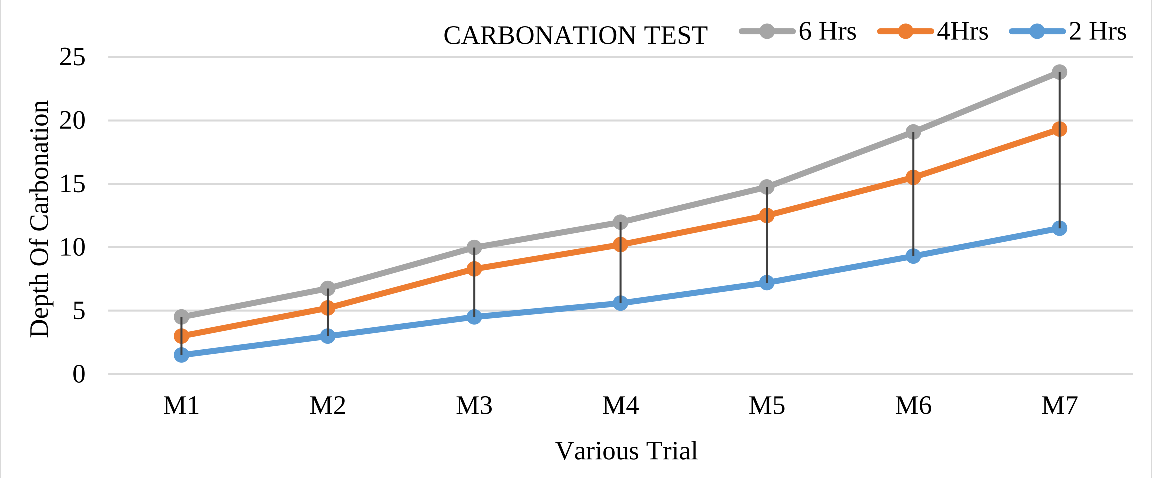

Fig. 2 Carbonation test for 2,4 and 6 Hrs treated water

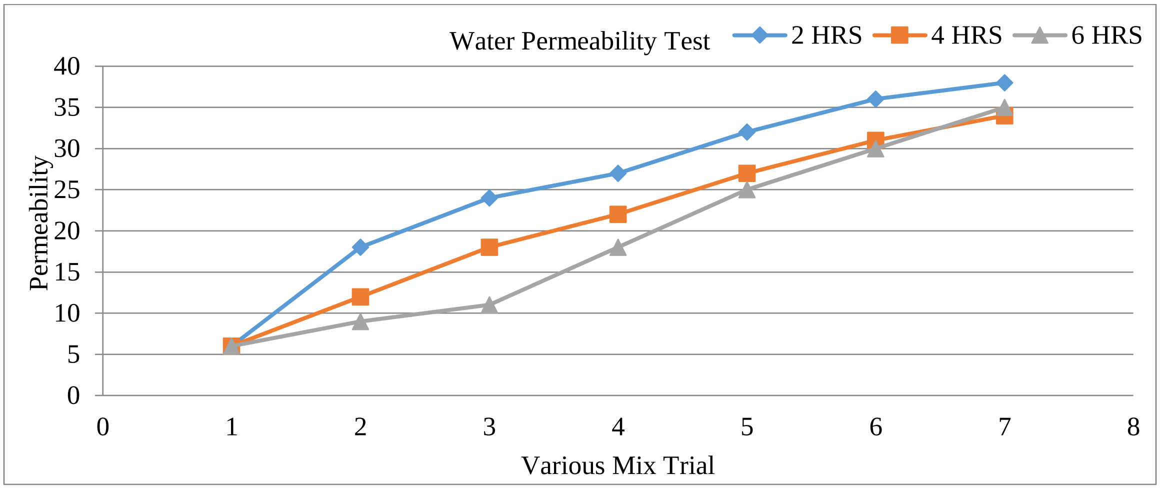

Fig. 3 Water permeability Test for 2,4 and 6 Hrs treated water

Water permeability testing evaluates a substance's ability to enable water to travel through it, such as concrete [12]. In cases where resistance to water penetration is critical, the test is particularly helpful in determining the longevity and quality of concrete [15]. From the Figure 3, When more silica fume is added to treated grey water, the permeability value increases, and less than 25 millimetres is regarded acceptable. See the figure for more information-furthermore, six-hour-treated water yields better results than two- or four-hour-treated water.

Table 5. Water permeability test for 2 Hrs treated water

MIX	% of Silica Fume	Permeability
M1	Tap Water	7 mm
M2	TGW	19 mm
M3	3% +TGW	25 mm
M4	6% +TGW	28 mm
M5	9% +TGW	33 mm
M6	12% +TGW	37 mm
M7	15% +TGW	39 mm

Table 6. Water permeability test values for 4 Hrs treated water

MIX	% of Silica Fume	Permeability
M1	Tap Water	7 mm
M2	TGW	13 mm
M3	3% +TGW	19 mm
M4	6% +TGW	23 mm
M5	9% +TGW	28 mm
M6	12% +TGW	32 mm
M7	15% +TGW	35 mm

Table 7. Water permeability test values for 6 Hrs treated water

MIX	% of Silica Fume	Permeability
M1	Tap Water	7 mm
M2	TGW	10 mm
M3	3% +TGW	12 mm
M4	6% +TGW	19 mm
M5	9% +TGW	26 mm
M6	12% +TGW	31 mm
M7	15% +TGW	36 mm

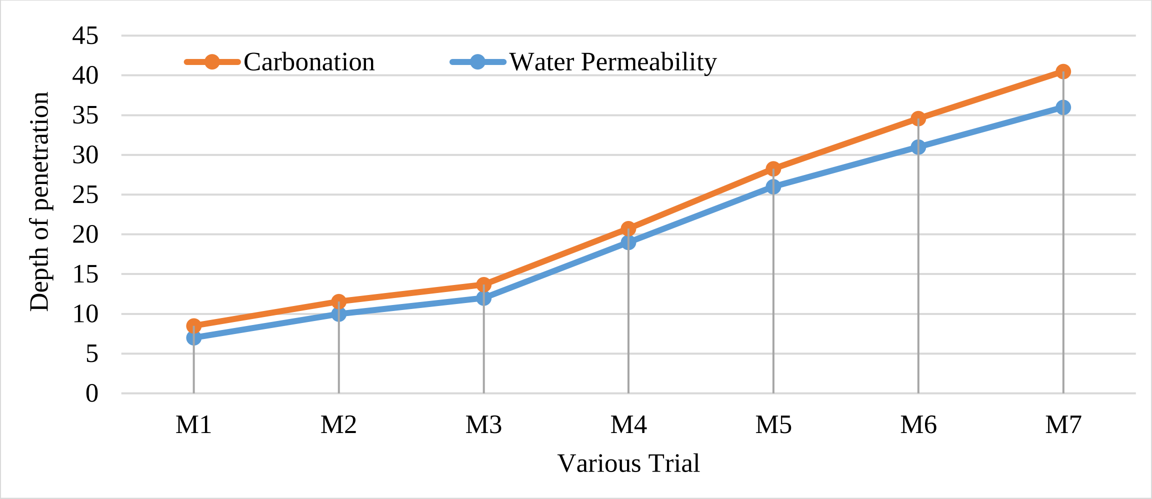

Fig. 4 Comparison of carbonation and water permeability test

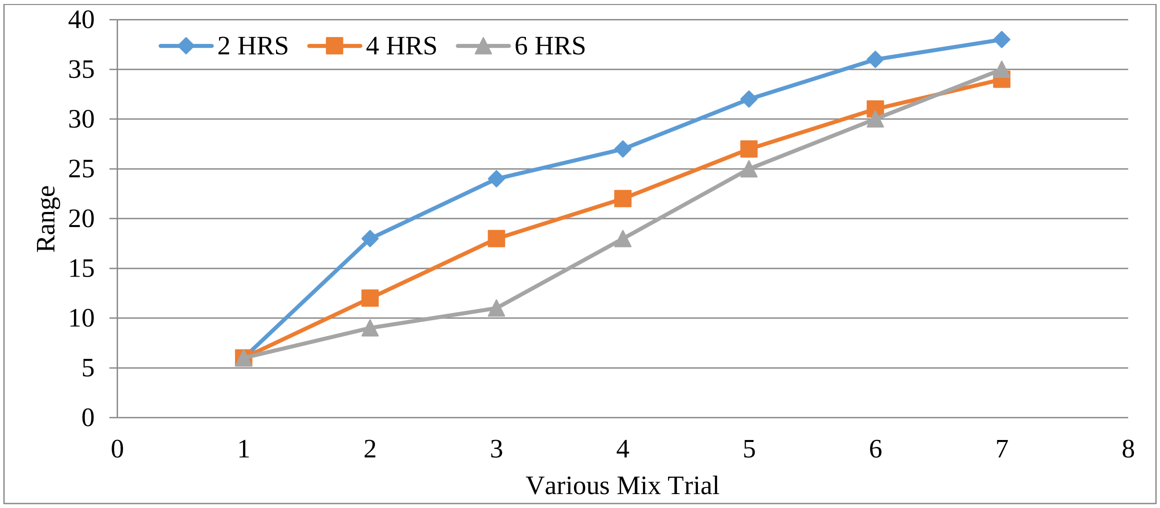

Fig. 5 Sorptivity Results for 2,4 and 6 Hrs Treated Water

4.1. Comparision of Carbonation and Water Permeability Test

On comparing the water permeability and carbonation test it is clear that both the durability test shown a result of 6 Hrs treated water is comparatively performing well than 2 and 4 hrs treated water. Also 9% silica fume is the optimum range for 6 hrs of treated water in both the test.

5. Sorptivity Test

The concrete sorptivity test determines the rate at which concrete absorbs water. When assessing the durability and permeability of concrete structures, this is a crucial factor to consider [13]. During the test, the concrete specimen's surface is wetted, and the rate at which water enters the substance is measured.

Table 8. Sorptivity values of 2 Hrs treated water

Trial	% of Silica Fume	Sorptivity
T 1	Tap Water	2
T 2	TGW	7
T 3	3% +TGW	10
T 4	6% +TGW	15
T 5	9% +TGW	19
T 6	12% +TGW	24
T 7	15% +TGW	31

Table 9. Sorptivity values of 4 Hrs treated water

Trial	% of Silica Fume	Sorptivity
T 1	Tap Water	2
T 2	TGW	6
T 3	3% +TGW	9
T 4	6% +TGW	11
T 5	9% +TGW	15
T 6	12% +TGW	19
T 7	15% +TGW	27

Table 10. Sorptivity values of 6 Hrs treated water

Trial	% of Silica Fume	Sorptivity
T 1	Tap Water	2
T 2	TGW	4
T 3	3% +TGW	5
T 4	6% +TGW	6
T 5	9% +TGW	9
T 6	12% +TGW	11
T 7	15% +TGW	15

Table 11. Shrinkage values of 2 Hrs treated water

Trial	% of Silica Fume	Shrinkage Percentage
T 1	Tap Water	0.045
T 2	TGW	0.125
T 3	3% SF+TGW	0.156
T 4	6%SF+TGW	0.168
T 5	9%SF+TGW	0.215
T 6	12%SF+TGW	0.235
T 7	15%SF+TGW	0.315

Typically, water is applied to the surface of a cylindrical concrete specimen, and the amount of water that penetrates the concrete is monitored at various time intervals. The data can be used to calculate the sorptivity of the concrete, which is a measure of its ability to absorb water. Concrete buildings benefit from having a lower sorptivity rating because it increases resistance to water infiltration.

This is beneficial for concrete construction since it helps to avoid problems like reinforcing corrosion and other issues. Based on Figure 2, As the amount of silica fume in grey water-treated concrete grows, so does its sorptivity. Furthermore, the results of the six-hour-treated water sample outperformed those obtained after two and four hours of treatment.

Table 12. Shrinkage values of 4 Hrs treated water

Trial	% of Silica Fume	Shrinkage Percentage
T 1	Tap Water	0.045
T 2	TGW	0.089
T 3	3% SF+TGW	0.092
T 4	6%SF+TGW	0.112
T 5	9%SF+TGW	0.125
T 6	12%SF+TGW	0.198
T 7	15%SF+TGW	0.268

Table 13. Shrinkage values of 6 Hrs treated water

Trial	% of Silica Fume	Shrinkage Percentage
T 1	Tap Water	0.045
T 2	TGW	0.050
T 3	3% SF+TGW	0.055
T 4	6%SF+TGW	0.061
T 5	9%SF+TGW	0.065
T 6	12%SF+TGW	0.095
T 7	15%SF+TGW	0.115

6. Drying Shrinkage Test

It measures the volumetric contraction of concrete caused by moisture loss. The biggest issue in terms of durability is the likelihood of cracking. Depending on the exposure conditions, cracking may allow for faster entry of harmful elements, particularly chlorides, which can induce corrosion of embedded reinforcement. Concrete will shrink and crack if it is sufficiently restricted. As a result, drying shrinkage should be considered in any application where cracking is unacceptable.

From the below graph, it is observed that 6 hrs treated water sample has the permissible shrinkage percentage range of 0.45 to 0.65 percentage compared to 2 and 4 hrs treated water samples. Also, beyond 9% silica fume the shrinkage percentage is exceeding the permissible range.

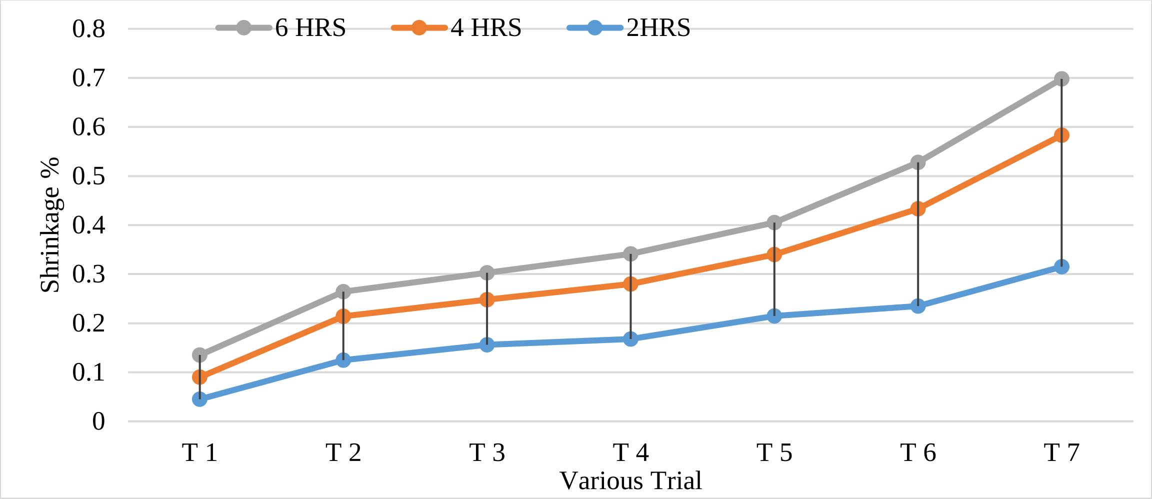

Fig. 6 Shrinkage test value for 2,4 and 6 Hrs treated water

7. Conclusion

Making concrete was one of the possible applications for the treated wastewater that this study looked at. One of the potential uses was this concept. According to the I.S., cement produced by the mixing of several kinds of treated wastewater is allowed for both its initial and final setting times. The findings indicated that water treated for six hours yielded more meaningful outcomes than water treated for four hours at the same dose. The researchers arrived at this conclusion. Additionally, there is no discernible difference in the strength between TGW-made concrete and tap water-created concrete, which may include up to 9% silica fume. This is true since TGW is a product that is better for the environment. Both types of concrete are produced using the same procedure. The material's strength diminishes in direct proportion to the quantity of admixture added due to the effects of shrinking and breaking.

Though the values of TGW concrete are lower than those of tap water concrete, the two types of concrete are almost identical, making it difficult to discern any differences. It is plausible that the use of TGW-containing concrete might help alleviate some of the problems caused by a shortage of easily available water. It is recommended that plain concrete be utilized as the basic material for manufacturing concrete for TGW. When an acid assault is applied to concrete that has a silica fume level of more than nine percent, the concrete will become less strong.

The results show that water treated for six hours is more powerful than water treated for two or four hours combined. Furthermore, there is not much of a strength difference between tap water, which includes up to 9% silica fume, and concrete that was made with TGW. Because of shrinkage and cracking, adding more admixture causes the strength to drop. Although the TGW concrete has lower values than the tap water concrete, the variances between the two values are not very great. There are certain ways in which TGW-built concrete could help with water scarcity. Conversely, TGW-produced concrete is more suited for plain concrete.

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