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Examining the Impact of Bio-Additives in Fly Ash-Based Geopolymers

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Abstract

With the paucity of freshwater in densely populated regions, there is a pressing need for new and inventive experiments to turn wastewater into potable water. There has been a lot of discussion lately about the influence of Cashew Nut Shell Liquid (CNSL) industry treated wastewater (TWLW) on the following characteristics of concrete strength. This study effort is one of such discussions. They are compressive and split tensile in nature, and are tested in relation to portable water (PW). The TWW and PW samples were employed in four different ways in that application of a concrete mix of M30, which are designated as S-1, S-2, S-3, and S-4. The cubes and cylinders were cast and cured using these four water samples, which were aged for seven, fourteen, and twenty-eight days, respectively. The hardened concrete was subjected to compressive and split tensile strength tests, and the characteristics of TWW samples were evaluated before and after the concrete had been allowed to cure for 28 days, respectively. When the S-4 sample was compared to the Portable water S-1 sample, the results showed that the compressive and split tensile strengths were both enhanced. Because of this, CNSL TWW is confirmed to be suitable for use as mixing and curing water for M30 concrete with no harmful impacts on the concrete mix.

Keywords*: - Freshwater, concrete, CNSL TWW, Geopolymers, Bio-Additives*

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INTRODUCTION

Freshwater is the most readily available element of nature's renewable resources, and it is also the most widely used on our world [1]. It is estimated that more than 326 million trillion gallons of freshwater are stored on and underneath the surface of the earth's surface. Every year, 4 trillion cubic metres of freshwater are consumed[2], which is a significant amount. Because of the fast rise of urbanisation, growing levels of population, the use of concrete in building industries, and the increasing richness of human living standards in cities, the extraction of groundwater and freshwater has become excessive[1,3–6]. In the wake of industrialization, the output of wastewater is increasing at an exponential rate, polluting the water resources of the world. Consequently, it has become an environmental issue that must be taken into consideration.

In recent years, as a result of more strict environmental rules and regulations, as well as increased public consciousness about the environment, the treatment of industrial wastewater, which has always been a vital part of research, has become increasingly important. As with the production of cashew nut shell liquid, the consumption of a greater amount of freshwater results in the generation of large amounts of wastewater[7]. Similarly, in the production of cashew nut shell liquid, the consumption of a greater amount of freshwater results in the generation of large amounts of wastewater. As a result, it was frequently in short supply in densely populated and dry areas.

India is the world's leading producer, processor, and exporter of cashew nuts. Since 1960, India has exported cashew kernels to more than 60 nations, accounting for more than 65 percent of worldwide exports of cashew kernels in the aggregate. In India, there are around 1500 cashew nut processing industries, with an annual production of 6,20,000 MT[7,8] of cashew nuts.

The major liquid waste from the cashew nut processing is polluted with CNSL during the manufacturing process (Cashew Nut Shell Liquid). CNSL is a caustic, viscous liquid that includes phenolics, with cardanol accounting for 60–65 percent of the total. In the manufacturing of phenolics, a large quantity of wastewater is created by the industry; on average, 12000 litres of water per day is discharged as waste, which contains phenols, aldehydes, and amines, all of which are extremely reactive and harmful to the environment.

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Figure 1 depicts how the wastewater generated by this process is treated at the plant using batch procedures that include the addition of chemical and biological coagulants such as aluminium sulphate and seashells to the effluent. It is possible to pollute freshwater by disposal of treated wastewater on earth fields, especially in cases when the CNSL treated wastewater includes mostly oil pollutants [8]. As a result, proper management and usage of freshwater are required in order to protect it from contamination. Because of this, researchers investigated its use and determined that exempting the construction industry from using fresh water would be a significant advantage.

When it comes to usage, concrete is second only to water in terms of usage; on the other hand, the amount of water required for one cubic metre of concrete is around 150 litres, and it is utilised widely in the building area [9,10].

Consumption of freshwater has become more important for the complete chemical hydration of cement and the preparation of concrete, among other things.

The use of CNSL treated wastewater in the preparation and curing of concrete specimens was investigated in this article and compared with the use of portable water for M-30 grade concrete in order to address these shortages.

Program for Experimentation

The goal of this experimental endeavour is to investigate the asset of concrete by utilising CNSL treated wastewater and portable water. Figure 2 depicts how these two samples were utilised in the production and curing of the concrete in four different ways (Table 1), and how three different curing ages of 7, 14, and 28 days were investigated for the purpose of this study. Compressive and split tensile tests on concrete were performed to determine the influence of casting and curing on the strength properties of the concrete. The impact of treated water on the propagation of cement hydration and surface porosity was also investigated.

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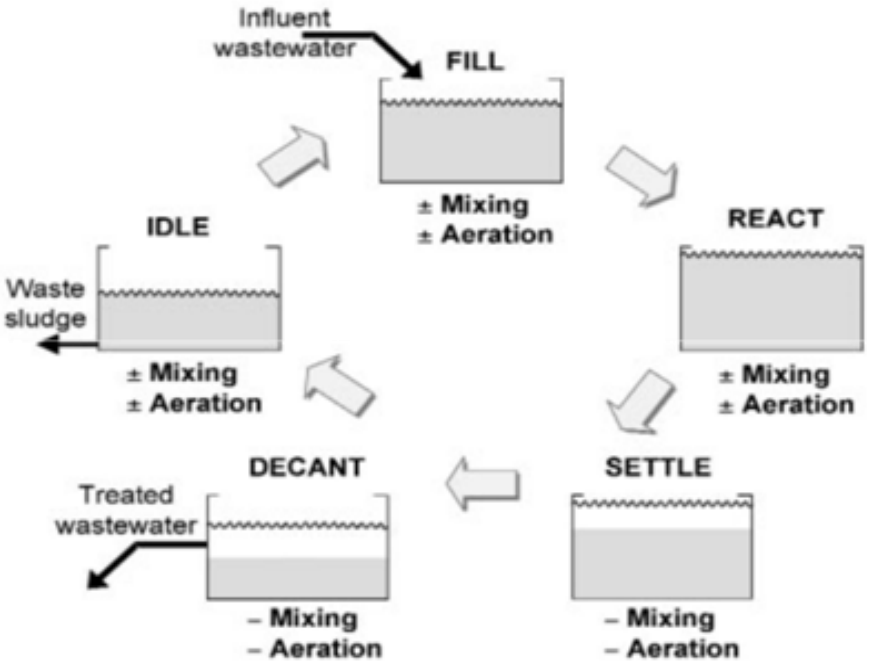


Figure 1: Major phases of batch reactor operational cycle

Table 1: Type of samples was used for curing and in mixing of concrete

Types of samples	Preparation	Curing
S-1	PW	PW
S-2	PW	TWW
S-3	TWW	PW
S-4	TWW	TWW



Figure 2: PW and CNSL TWW samples were used in this study

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MATERIALS

Every sample of ordinary Portland cement (OPC) 53-grade (which has a composition and qualities that comply with IS 12269:2013[11] and IS 4031:1988)[12] was made using OPC 53-grade throughout the experiment. Fine aggregate (FA) collected from river sand that corresponds to Zone II according to IS 383-2016[13] and coarse aggregate (CA) collected from crushed rock that corresponds to Grade I according to IS 383:2016 with a graded crushed rock of 10 mm and 20 mm are employed in the study study. The physical parameters of coarse aggregates conform to the requirements of IS 2386:1963 parts 3 and 5[14].

These samples were taken at CNSL's Karkalla industries treatment facility and the PW samples were taken from NITK in India for use in this research. Physical and chemical features of PW and TW, as well as the accompanying standard limits for individual fragments, are displayed in Table 3. It is possible to determine the suitability of TWW in the concrete manufacturing process by comparing TWW characteristics against standard limitations.

Mix Design

As recommended, the use of an Indian standard for control concrete mix design will be used. The concrete mix for this study activity is of M30 grade with a target strength of 30 N/mm2 and is designed in accordance with IS 10262-2019[15].

Preparation and test procedure of specimen

Four water samples were used to test the compressive strength of 36 cubes with a side dimension of 150*150mm. Four water samples were used to cast 36 cylinders with a 150 mm diameter and a 300 mm height for the purpose of determining split tensile strength.

It was necessary to comply with IS 516:1959[16] when mixing the concrete specimens and casting the final product. In order to complete the hydration process, freshly made cast specimens were put for 24 hours before being removed from the moulds and analysed. Figure 3 depicts the cubes and cylinders that were cured under conventional settings in accordance with IS requirements and then tested on days 7, 14, and 28[17,18].

Following the completion of curing at the prescribed ages, the concrete specimens were successfully subjected to

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compression tests in a standard compressive testing machine and tensile tests in a universal tensile testing machine by applying load to the cubes. As a result, the specimen's compressive and split tensile strength were measured and recorded.

Ingredients	
Cement (Kg/m^3)	413.33
Water (Kg/m^3)	186
CA – 10mm (Kg/m^3)	447.71
CA – 20mm(Kg/m^3)	692
FA (Kg/m^3)	659.87
W/C ratio	0.40

Table 2: Mix design details



Figure 3: Specimens placed in curing tubs

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RESULTS AND DISCUSSIONS

Listed in Table 3 are the results of TWW and PW in terms of outcomes. According to the findings of this inquiry, the values of TWW were within the ideal range according to IS limitations and somewhat better than PW. When comparing TWW to PW, it is discovered that the typical consistency of cement paste is slightly increased by 1 percent. In general, the IS requirements for consistency of cement are in the 24-30 percent range, according to the manufacturer. As a result, the results obtained are within allowed ranges of variation. In accordance with IS 1199, the slump test was carried out on new concrete with both samples PW and TWW; however, the range of the sump value for TWW was enlarged by 10 mm when compared to PW. After the concrete specimen had been cured for 28 days, the curing regime (CR) was collected and examined in a laboratory, and the findings were compared to those obtained from the TWW and PW tests.When the concrete was allowed to cure for 28 days, the findings showed that there was a considerable absorption of the TWW parameter values into the concrete.

Table 3: Characteristics of Portable water and Treated water

Parameter	**Concentration (mg/l except for pH)**			**Permissible limits**
	PW	**TW**	**CR**	
pH	6.58	7.53	9.63	≥6
Total hardness	122.2	103.4	50.76	300
Chlorides	10.45	5.87	47.46	500
Iron	0.083	0.52	0	>0.3
Nitrates	0.12	1.58	1.50	>10
Sulphates	9.5	93.55	41.49	400
Alkalinity*	-	20.49	54.69	250

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Acidity*	-	-	15	50
Calcium	200	80.84	18.8	200
Magnesium	100	22.56	31.96	100
TS	500	910	470	50000
TSS	-	185	170	2000
TDS	-	725	660	2000
COD	-	83.2	28.8	500

Expressed as CaCO3 equivalent.

This study examined the result values of compressive and split tensile strengths at seven, fourteen, and twenty-eight days after their inception. In this study, the effects of mixing and curing with four different materials (S-1, S-2, S-3, and S-4) on concrete specimens during the course of the study are demonstrated. The compressive outcome values of the tested materials are depicted in Figure 4, and the stated values correspond to an average of three test results [1, as mentioned in the table below]. Figure 4: Compressive outcome values of the tested materials Following the data, it was discovered that the compressive strength of concrete at 7 days was greater than S-1, and that the strength of concrete increases more slowly at the age of 14, but that the strength of concrete increased gradually at the end of 28 days as compared to S-1, with 4.36 percent, 3.98 percent, and 12.81 percent of strength being gained as compared to S-1.

Figure 6 is a graph depicting an example of compressive strengths rising by a percentage, as seen in the example. The split tensile strength of tested samples generated by mixing and curing concrete with TWW and PW is depicted in Figure 5. Unless otherwise noted, the reported values represent the average of three test results, as illustrated in Figure 1. It can be seen in Figure 7 that the split tensile strength of concrete is normally increased at 7 days, but that the strength gained at 14 days is slower, and that at the end of 28 days, a statistically significant increase in strength has been observed when compared to S-1, with increments of 10.52

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percent, 14.43 percent, and 25.99 percent, respectively, when compared to S-1. TWW (S-4) was found to have much higher compressive and split tensile strengths than PW (S-1), when measured after 28 days of mixing and curing. TWW (S-4) was found to have significantly higher compressive and split tensile strengths when measured after 28 days of mixing and curing.

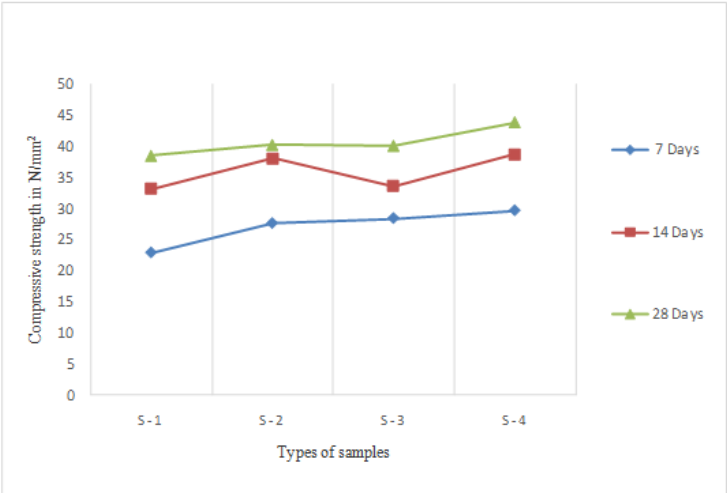


Figure 4: Compressive Strength of Concrete

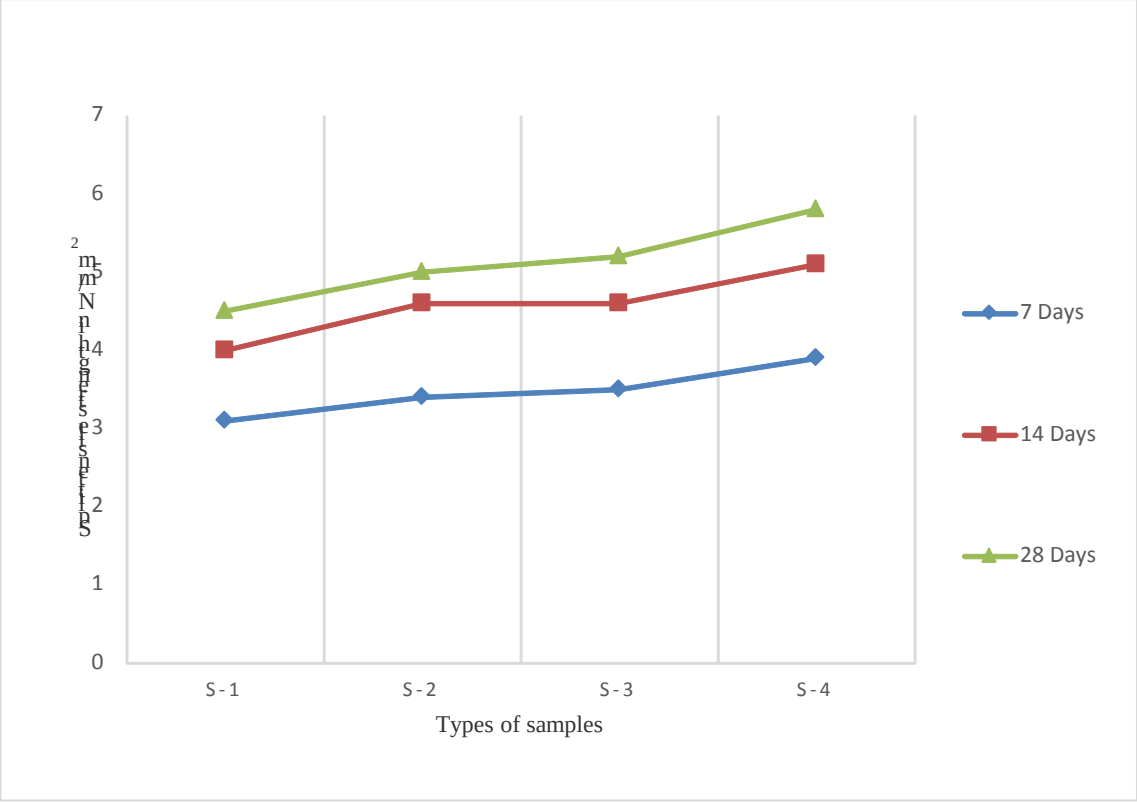
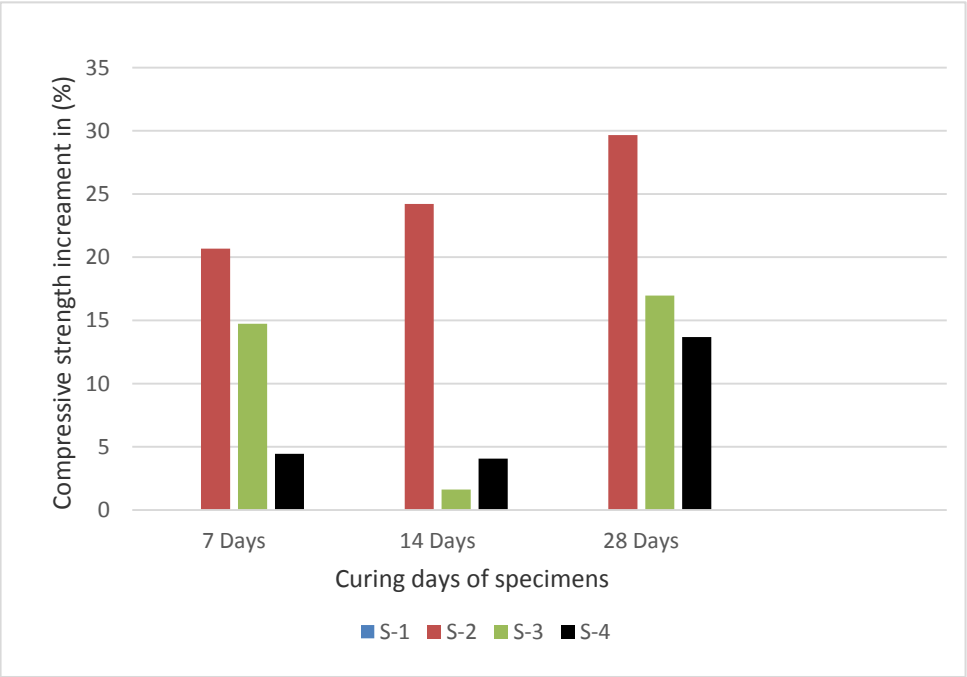


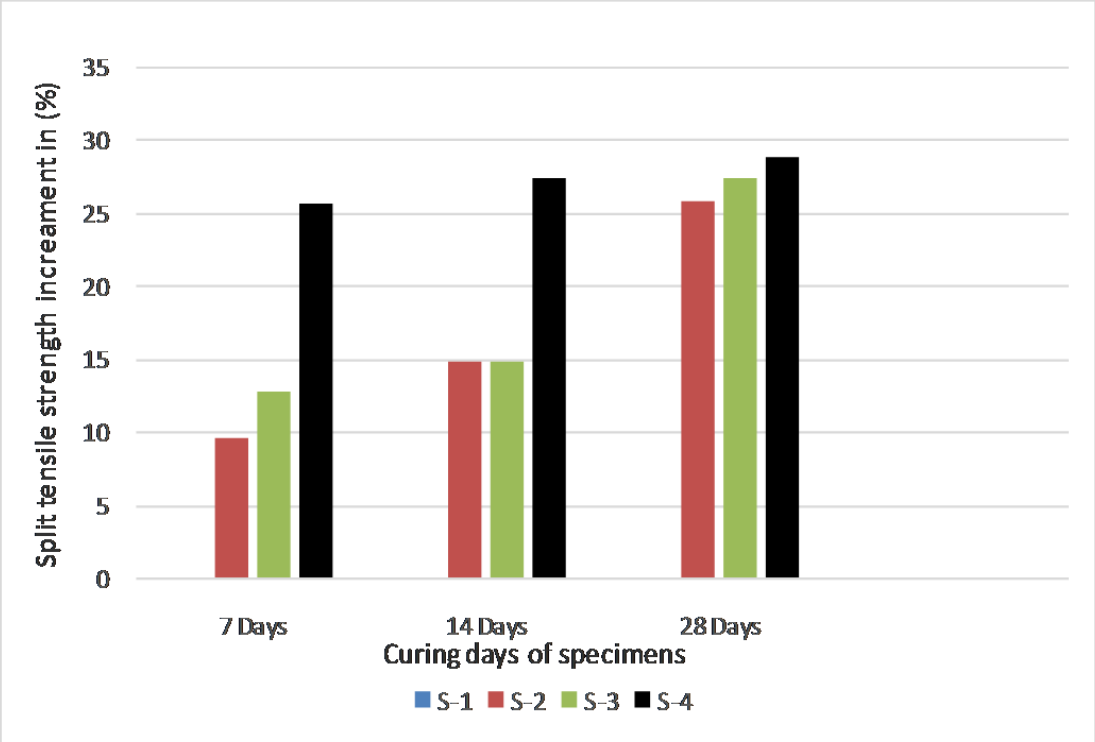
Figure 5: Split Tensile Strength of Concrete

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(S-1=0)*

Figure 6: Percentage Increment of Compressive Strength Results Compared With S-1



(S-1=0)*

Figure 7: Percentage Increment of Split Tensile Strength Results Compared With S-1

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CONCLUSION

The problem of insufficient water availability in urban and rural communities around the world, as well as in dry regions, served as the inspiration for this experimental endeavour. The purpose of the current study study is to determine whether or not it is possible to construct appropriate mixing and curing schemes for concrete that may be used as a substitute to freshwater. Overall, this study illustrates the feasibility of CNSL treated wastewater by demonstrating improved strength findings. The findings of the TWW were determined to be 43.85 N/mm2 in compressive strength and 5.8 N/mm2 in split tensile strength, with the latter increasing by 12.81 percent and 25.24 percent in strength, respectively, when compared to the results of the portable water test. Because of the existence of oil contents and perception of dissolved particles in CNSL TWW, which function as a cooling substance in the cement hydration process[8,] this is achieved. As a result, it has been noticed that the use of cashew nut shell liquid treated wastewater on concrete applications produces stronger results than the use of portable water.

The corresponding author declares that there is no conflict of interest on behalf of all of the writers in this paper.

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