

# RESPONSE OF COCONUT FIBER CONCRETE CONTAINING RICE HUSK ASH AS A CEMENT SUBSTITUTE TO SALT ATTACK EXPOSURE

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**Abstract:** Many recent studies related to environmentally friendly concrete utilizing organic materials are considered as major breakthroughs. However, research related to corrosive environments is still limited. In this study, the resistance to salt-attack on coconut fiber (CF) concrete as reinforcement and rice husk ash (RHA) as a cement substitute was carried out. 3 variations of coconut fiber 0.3%, 0.5%, and 1% of the concrete weight were used. While 1% RHA was used to replace some of the cement. All concrete specimens were soaked in sea salt water until 90 days old. The results showed a decrease in compressive strength based on age when immersed in salt solution. The largest decrease in concrete strength occurred in the 1% variation with a percentage decrease of 30.58%. Visually, it was found that there was a change in color in the test specimen to yellowish and there was erosion damage on the concrete surface. The greatest damage occurred in the 0.1% variation, while in the 0.3% variation there was no significant physical change. The results showed that the greater the fiber composition, the lower the durability against salt attack. The use of coconut fiber with a variation of 0.3% has the greatest durability.

**Keywords:** Durability, Salt-Attack, fiber-concrete, Rice-Husk-Ash

## Introduction

Concrete durability is one of the properties that must be met by concrete and in its implementation, durability is influenced by air and physical contact of fluids on the surface of the concrete pores. Application of concrete in aggressive environments such as seawater or groundwater that contains a lot of sulfate salts can have a negative impact on the quality of the concrete. Where in this environment there are many chemical substances that are reactive to the elements contained in the concrete, and can eventually cause disintegration in the concrete. The disintegration process is a process of separation or release of a large material and unite into small and separate materials (Papadakis et al., 2022)(Nepomuceno et al., 2025). In cases of concrete abrasion by seawater, this is caused by the salt and sulfate content which erodes the concrete surface (Bassuoni & Rahman, 2016). In addition, the salt crystallization process in the concrete pores can cause cracks in the concrete (Sakr & Bassuoni, 2021). In several previous studies, the use of fiber as a reinforcement in concrete can reduce premature cracking and can delay collapse (Wang et al., 2025)(Chen et al., 2025). The addition of fiber to the concrete mixture which is spread evenly can increase the strength of the concrete against tension and can prevent small

cracks in the concrete so that it can increase the strength performance of the concrete (Tan et al., 2025)(Wang et al., 2025)(Pham, 2025). In previous research, the use of coconut fiber as a concrete reinforcement can delay concrete failure and prevent cracks on the concrete surface (Ahmad et al., 2021)(Zaid et al., 2025)(García et al., 2024). Coconut fiber is a natural fiber that can be used because it is abundantly available in the world and is considered waste because it has not been utilized optimally. In this study, the use of coconut fiber as an additional material is intended to determine the extent to which the role of coconut fiber as a reinforcement can prevent cracks and delay failure in concrete due to salt attacks. In addition, the use of RHA in this study is intended to utilize abundant discarded waste. As long as the content is low in concrete, RHA as a pozzolan can replace cement and increase the hydration process in cement (Syahida Adnan et al., 2021). Pozzolan has the properties of making concrete denser, less absorptive, and less permeable (Islam et al., 2018).

**Materials and Method**

**Materials and Mix Proportion**

Some material factors that are taken into account for the characteristics of concrete strength in this study are the number of fibers, the aspect ratio of fibers to cement, fiber size, water-cement factor, the ratio of concrete components such as aggregate and cement. In this study, coconut fibers were cut to a length of 50 mm (Lertwattanakruk & Suntijitto, 2015). Coconut fiber (CF) as reinforcement is included in the concrete mixture with variations in composition, 0.3%, 0.5%, and 1% of the weight of cement. In each cylindrical concrete sample with a diameter of 150mm and a height of 300mm, a mixture of rice husk ash (RHA) of 1% of the weight of cement is given as a filler. The concrete mixture has a water-cement ratio of 0.50 and a percentage of sand to the total aggregate content of 32% with a concrete unit weight of 2350 kg/m<sup>3</sup>. The amount of cement, aggregate, and water is adjusted to the concrete design strength of 20 MPa. Fresh concrete mix is given additional superplasticizer to improve workability due to the presence of coconut fiber (Poongodi et al., 2020)(Ahmad et al., 2021). The concrete mixture was made using a cylindrical mold with 10 samples for each ratio as shown in Table 1.

**Experiment and Methods**

The test specimens were removed from the mold and cured for 28 days in tap water at a temperature of 23±2°C. Two types of samples were made, for the first sample variation soaked in salt water for 56 days and the second sample variation soaked in salt water for 90 days at a temperature of 23±2°C. Changes in mass, visual observation, and compressive strength were obtained from laboratory tests. The immersion of concrete samples carried out in this study was based on salt attacks caused by seawater, where the use of seawater was substituted with water to which sulfate salt was added with a ratio of 1:30 or had a concentration of around 3.5%. Measurements were made on changes in mass and visual observations were made on the test object after the salt water immersion was complete. Furthermore, the test object was capped on both sides so that the surface became flat so that the compressive strength test obtained was more accurate.

**Table 1.** Mix design samples of every cylindrical concrete

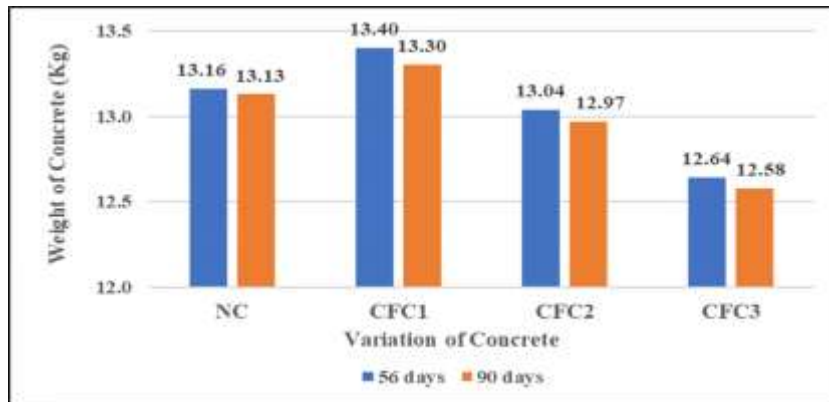
No.	Samples	saltwater immersion (days)	Concrete Materials (kg)					Sample weight (kg)
			FA	CA	Cement	RHA	CF	
1	NC <sub>56</sub>	56	3.44	7.20	1.98	0	0	13.70
2	NC <sub>90</sub>	90	3.44	7.20	1.98	0	0	13.68

3	CFC1 <sub>56</sub>	56	3.44	7.20	1.96	0.02	0.041	13.79
4	CFC2 <sub>56</sub>	56	3.44	7.20	1.96	0.02	0.069	13.86
5	CFC3 <sub>56</sub>	56	3.44	7.20	1.96	0.02	0.137	14.01
6	CFC1 <sub>90</sub>	90	3.44	7.20	1.96	0.02	0.041	13.79
7	CFC2 <sub>90</sub>	90	3.44	7.20	1.96	0.02	0.069	13.86
8	CFC1 <sub>90</sub>	90	3.44	7.20	1.96	0.02	0.137	14.01

**Result and Discussion**

**Mass Changes**

The change in concrete mass in question is the decrease in the mass of the concrete test object after being soaked in a sulfate salt solution where the value of this decrease can provide an overview of the concrete's resistance to salt solutions. Figure 1 shows that the concrete mass decreases as the fiber dose increases in the concrete. The decrease in mass which increases in line with the increase in fiber content is caused by a reduction in the density of the concrete so that the concrete surface becomes more porous which causes a reduction in the mass of the concrete (Ahmad et al., 2021)(Pham, 2025). This causes a reaction to occur between the salt immersion and the concrete which causes the bonds between particles on the concrete surface to weaken, causing some of the particles to break and come loose from the concrete (Sakr & Bassuoni, 2021). In addition, the presence of coconut fiber increases cracks in concrete due to the presence of excessive fibers (Ramli et al., 2013). The addition of coconut fiber in concrete can worsen mass changes compared to conventional concrete (Ramli et al., 2013). In this case, it indicates that coconut fiber has a relationship with changes in mass in concrete.



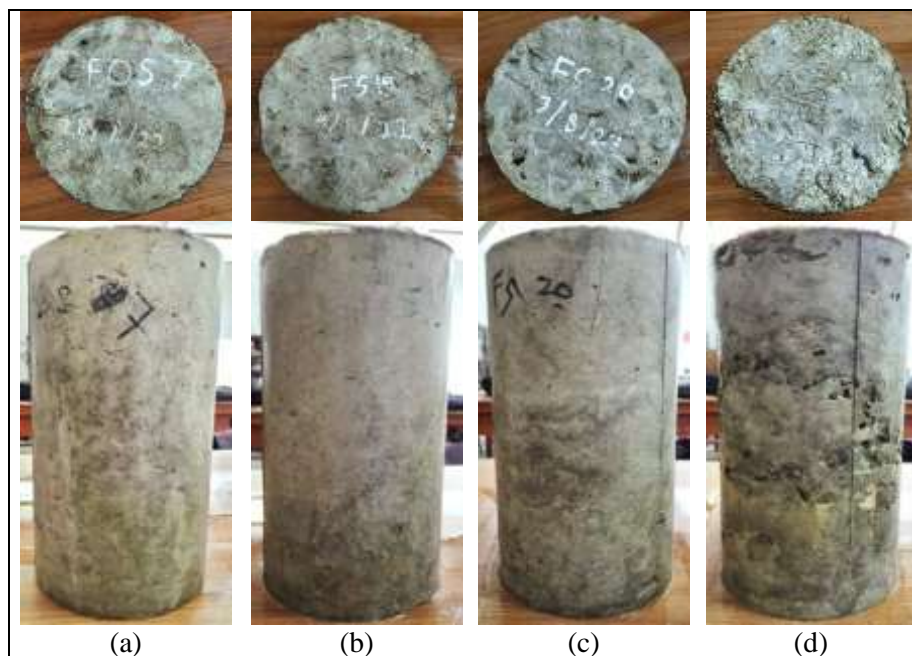
**Figure 1.** Comparison of changes in concrete mass for 56 and 90 days

**Physical Changes**

Visual observation was conducted to determine the extent of physical damage to the concrete after it was immersed in salt solution. Figures 2 and 3 show concrete samples soaked for 56 and 90 days respectively. The color change in concrete is very significant after reaching 90 days. The color changes from creamy white to gray, which this color change occurs due to salt deposition. Visually, damage can be seen on the surface randomly (Ragab et al., 2016)(Tang et al., 2021)(Abushanab et al., 2025).



**Figure 2.** Visuals appearance of concrete sample due to salt attack for 56 days soaking, which is the CF content: (a) 0%; (b) 0.3%; (c) 0.5%; (d) 1.0%

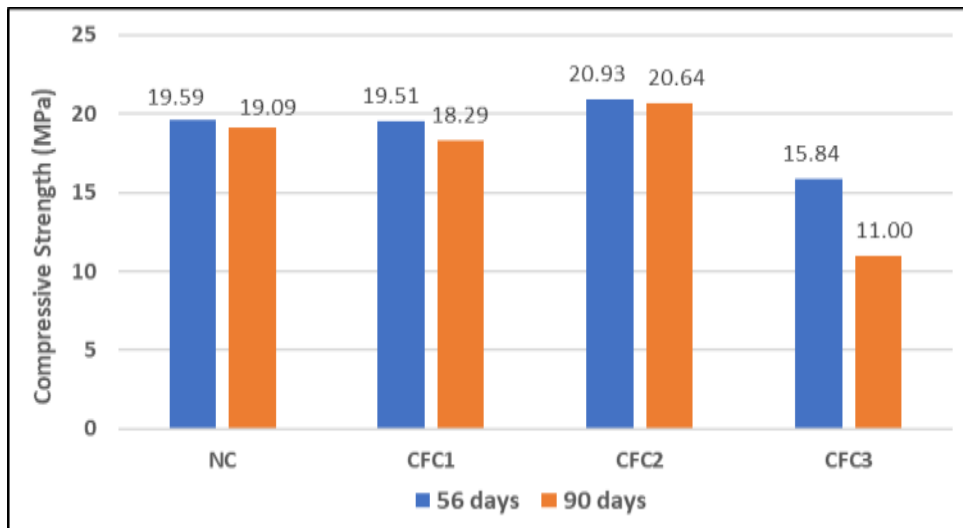


**Figure 3.** Visuals appearance of concrete sample due to salt attack for 90 days soaking, which is the CF content: (a) 0%; (b) 0.3%; (c) 0.5%; (d) 1.0%

### Compressive Strength

Figure 4 shows the strength of Normal Concrete (NC) and CFC fiber concrete after immersion in sulfate salt solution for 56 and 90 days. NC did not experience a decrease in strength of 2.55% at the age of 90 days from the age of 56 days. CFC2 has the highest strength and has the lowest reduction in concrete strength. The reduction ratio between CFC1, CFC2, and CFC3 were 6.67%, 1.41%, and 44.00% respectively. These data show that in addition to salt attack, coconut fiber also has a major impact on strength. Excess fibers form many pores in the

concrete matrix and salt water can easily enter. So, sulfate salts cause disintegration in concrete (Dhondy et al., 2019)(Tang et al., 2021)(Sakr & Bassuoni, 2021). Sulfate attack that produces expansive products and spreads throughout the concrete uncontrollably, causing cracks in the concrete (Ramli et al., 2013).



**Figur 4.** Comparison of compressive strength of concrete soaked for 56 and 90 days in sulfate salt solution

**Conclusion**

The addition of high doses of coconut fiber to the concrete mixture can reduce its durability against seawater. The results of the experiment showed a decrease in mass due to the reaction between the sulfate salt immersion and the concrete which caused the effect of eroding the concrete surface particles which caused some of the particles to be damaged and released from the bonds between the particles in the concrete. The release of some of these particles clearly reduces the mass of the concrete itself. The presence of concrete in a salt environment also causes the process of salt crystallization in the pores of the concrete surface as shown in the visual observation experiment, where the crystals will tend to expand which causes damage to the concrete surface so, that it affects the texture and strength of the concrete itself.

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