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Abstract

This study explores how adding sargassum to concrete affects its compression strength. The research aims to evaluate the potential of sargassum as a sustainable material in concrete production. 84 mortar samples were prepared with pulverized sargassum, replacing the fine aggregate. Compressive tests were conducted on these samples after curing periods of 7, 14, and 21 days. The results revealed a noticeable increase in the concrete strength during the early curing process with 2.5% sargassum. For the 14 and 21 days, the control samples reached higher compressive strength than the samples with sargassum. The study concludes that sargassum could be considered for non-structural applications. Further research is recommended to optimize the mix design, investigate the long-term durability, and assess the possible impact of sargassum polymers in reducing CO₂ emissions during curing, a final goal of this initial investigation.

Introduction

Over four billion tons of cement are produced annually (about one hundred million tons in the USA), accounting for about 8% of global CO₂ emissions (Anleu et al., 2023). This contributes to the climate emergency caused by the greenhouse gas emissions in the manufacturing of construction materials. Carbon capture and storage (CCS) is increasingly used in the construction industry to reduce the CO₂ emissions (Arehart et al., 2020). Portland cement is the most widely used type of cement because of its low cost per volume, early-age strength development, and satisfactory structural and durability performance (Anleu et al., 2023). According to the International Energy Agency (IEA), the main challenge facing the cement industry is reducing CO₂ emissions while meeting global demand.

Since sargassum is known to have properties that can absorb CO₂ emissions, it has potential as an additive in concrete mixture. Before it could be tested for CO₂, sargassum's overall effects on a concrete mix needed to be determined. Therefore, the focus of this research project was to determine if the sargassum has a significant impact on the compression strength of concrete when replacing part of the fine aggregate.

Objectives

Mortar was used instead of concrete due to the smaller samples needed for testing, allowing more tests with the amount of sargassum available for the experiments. The goal of this research project is to determine the impact on the compressive strength of cement mortar mixes when replacing part of the fine aggregate by pulverized sargassum. To achieve this goal, we compared the compressive strength of mortar mixes containing Portland type 1 cement, 0.15 mm sand, and water, both with and without sargassum powder, while increasing the amount of sargassum over the course of four batches.

Methodology

The primary task was to make a series of mortar batches. Three control groups were developed, one with lime as the binding material, and two with cement. Twelve cubes were prepared for each batch to perform 3 compressive tests at 7, 14, and 21 days. The lime batch was discarded due to its shape instability and low strength, and the second cement control batch was adopted after perfecting the mixing procedure. Each batch was made from 2.093 lb of type 1 cement, 2.093 lb of water, and 6.113 lb of sand. After the control was made and tested, the experimental batches were developed by replacing 2.5%, 5.0%, 7.5%, and 10.0% of the sand with sargassum powder by weight. Once the mortar mix was completed, it was placed in 2" x 2" cube molds and left to dry for 48 hours. After this initial drying, the cubes were placed in a curing bath of water and calcium carbonate. Later, all of these were subjected to compression tests after their curing periods of 7, 14, and 21 days. Using a hydraulic press and load cells, four cubes were tested each week. A total of 84 cubes were tested, 28 at each 7 days curing interval. The sargassum used in this project was gathered from beaches in Fajardo, PR, and processed as depicted in the schematic representation of the process in Figure 1.



Figure 1: Schematic Representation of Experimental Procedure

Analysis & Results

Figure 2: Control Group Compressive Strength Results

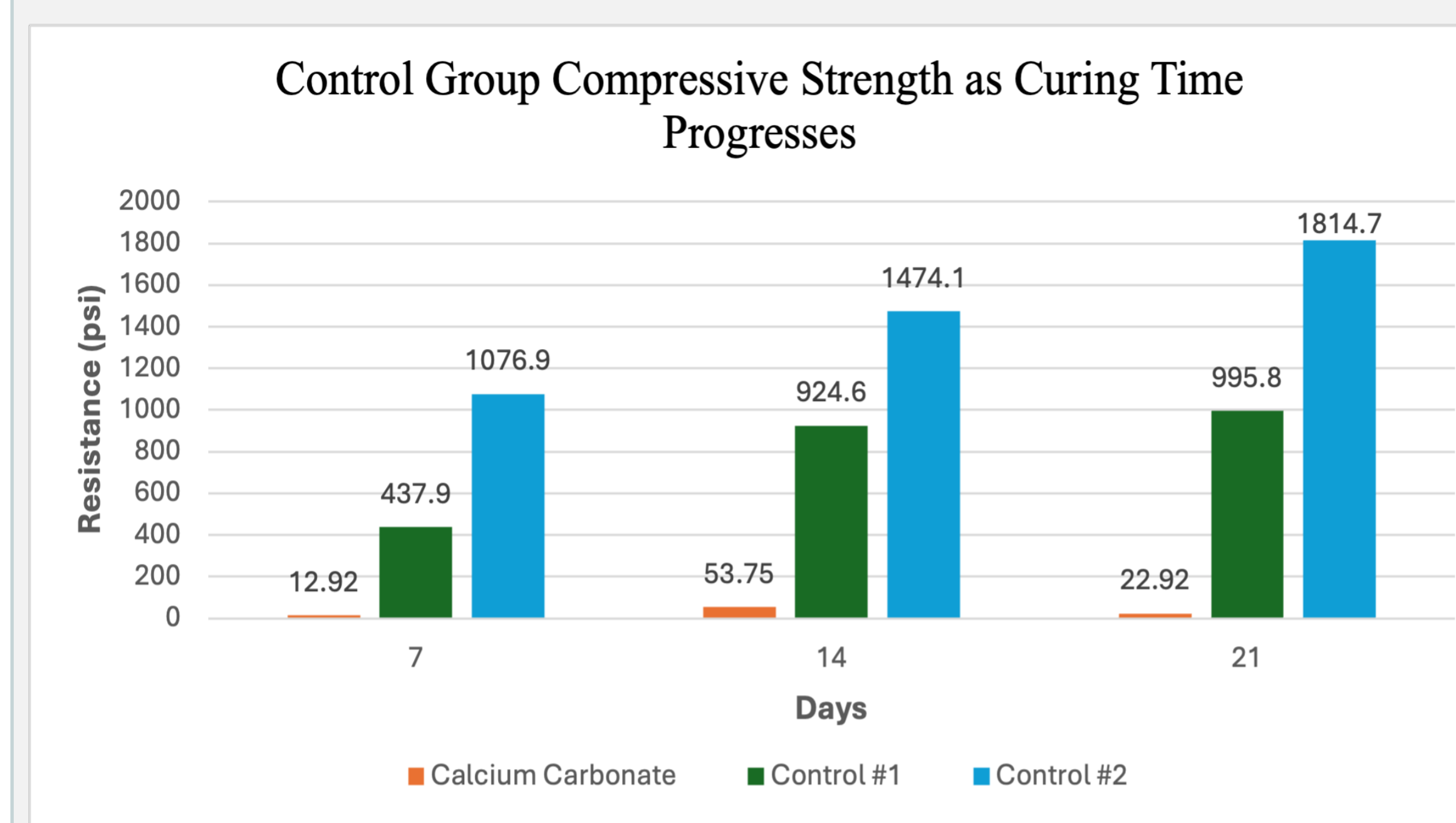
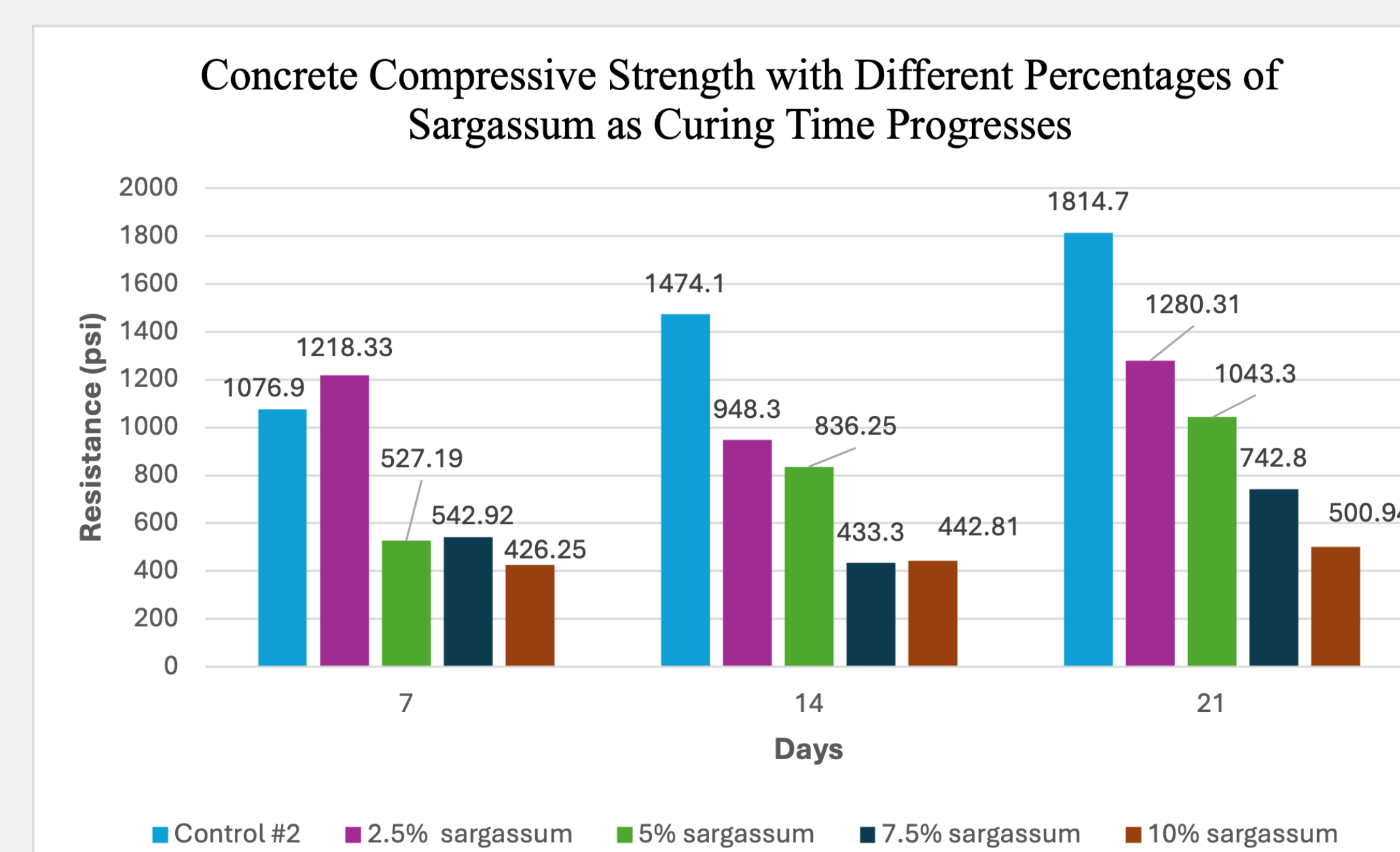


Figure 3: Compressive Strength Results for Sargassum-Cement Blends



The effects of using 2.5%, 5%, 7.5%, and 10% replacement in fine aggregate with a curing time of 7, 14, and 21 days are shown in the charts. The initial batch made from calcium carbonate and water was not chosen as the control group since its resistance was minimal and would greatly affect comparisons with the mortars containing sargassum.

Sargassum as an additive to concrete reduced compression resistance as the percentage increased; specifically, 10% sargassum had a lower resistance than 2.5%. It can be observed on day 14, the 2.5% sargassum mix had a greater resistance than the initial control batch. However, the 2.5% sargassum mix exhibited a decrease on day 14 that could have been the result of improper handling of these specimens.

These results may indicate that a small amount of sargassum could be beneficial for improving the concrete early resistance gain, a desirable property when pouring concrete that could allow earlier form removal and reuse. Further investigation is required to determine which percentage exhibits the best properties in subsequent tests.

Conclusion

The results reveal that the use of sargassum as a replacement for fine aggregate in cementitious materials reduces the compressive strength, but in small amounts, has potential in the concrete industry for low-strength concretes, providing an increase in early resistance development. The 2.5% and 5% sargassum mixes had the best compressive strength test outcomes when compared to control group #2. Additional study is advised to determine the appropriate mix.

Recommendations/Future work

According to the concluded results, the future research is recommended to be divided into three stages:

First Stage: Carry out test for water absorption, porosity, real density, compressive strength, and life cycle assessment (LCA) (Lyra et al., 2024) to determine the properties of the cementitious material with sargassum as an additive and to establish whether they follow the ASTM standards to confirm usability for the next stage. When making a new mix, it's advised to calculate the percentages of sargassum that replaces fine aggregates based on volume rather than weight. The blending process should be mechanized to achieve more homogeneous mixtures in all samples.

Second Stage: Determine the quantity of carbon dioxide absorbed by the concrete to establish whether the addition of sargassum increases carbon dioxide absorption from the environment, thereby reducing CO₂ pollution caused by the concrete industry.

Third Stage: Implement this cementitious material to additive manufacturing.

References

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