Recycled Concrete With Waste Materials

Presenter: Konner Stephen; Faculty Advisor: Dr. Shohana Iffat
Civil Engineering Technology, Farmingdale State College

Farmingdale State College
State University of New York

ASEE
AMERICAN SOCIETY FOR ENGINEERING EDUCATION

ABSTRACT

Concrete serves as one of the fundamental materials in modern-day construction. The production of concrete from natural aggregates come with financial costs and environmental disadvantages, so the implementation of recycled materials is a more sustainable alternative for certain constructions.

INTRODUCTION

With the heavy use of concrete in modern-day construction and the growing need for energy and materials, attempting to create environmentally friendly concrete has been a goal for the construction industry in recent years. It is the most commonly used material in the industry, and its production negatively affects the environment. Natural aggregates are typically crushed stone and sand, obtained from quarries, deposits, and natural mines of sand and gravel. This process can lead to soil erosion, the contamination of surface water, and loss of biodiversity, all of which dramatically affect the local environment. Styrofoam, another environmentally unfriendly product, makes up many landfills and poses a danger to the Earth's environment. People have been making strides in reducing its impact by banning its use [Department of Environmental Conservation. (n.d.) 2021]. Others have been trying to find alternative uses for what's left. However, it, like concrete waste, makes up a large amount of waste in landfills, many of which are unsanitary and exposed, contributing to the contamination of drinking water and resulting in infections and transmitted diseases. The transportation of concrete waste, and its disposal, significantly contribute to water and air emissions, with many research [Suhendro and Bambang 2014] claiming 8% to 10% of the world's total carbon emissions originate from the manufacturing process alone. With so many negative impacts, using recycled aggregates or recycled styrofoam as an alternative is an endeavor beneficial to the environment.

HYPOTHESIS

Concrete made with recycled aggregates or recycled styrofoam can retain/compare the qualities of concrete made with natural aggregates, to such an extent that it can serve as a sustainable alternative while confronting the issues of cost, carbon emissions, and waste generation that typical concrete brings about.

MATERIAL PROPERTIES

Recycled concrete aggregates (RCA) tend to have a comparatively higher water absorption than natural aggregates (NCA), but a lower apparent density. RCAs typically have rougher surfaces and rounder overall shapes, whereas NCAs commonly have smooth surfaces and obvious edges and angles. Many of the physical properties of recycled aggregates are accredited to the old mortar attached to the RCA. This amount of mortar is proportional to the length of the crushing process. The bulk specific gravity (dry) of RCA was estimated to be 1.99, and the absorption percentage was estimated to be 9.9%.


Fig. 1


Fig. 2.


Fig. 3.


Fig. 4


Fig. 5


Fig. 6

Styrofoam was cut into pieces smaller than ½" squares. The sample was determined to have a density of 13.657 kg/m³. Gravel was screened through sieve analysis, which was well-graded, and most of the particles passed through a 9.5 mm sieve opening. The bulk specific gravity of coarse aggregate was found to be 2.744 and the absorption capacity was approximately 0.42%. After being put in the moisture content analyzer, the moisture content of the coarse aggregate was found to be 0%.

APPLICATION IN A PROJECT


Fig. 7


Fig. 8.


Fig. 9


Fig. 10

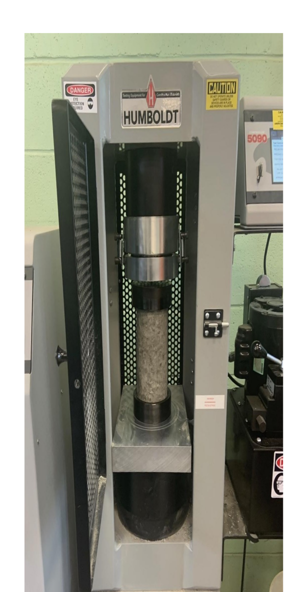
Fig. 11


Fig. 12

The RCA was donated by a local contractor. These particles were screened and added to cement, sand, water, and gravel with 50% to 100% of natural aggregate being replaced by RCA. After the ingredients: Styrofoam, cement, sand, water, RCA and gravel were weighed, they were properly mixed through the concrete mixer (one with Styrofoam, one control, one with 50% RCA, one with 100% RCA). After mixing, each mixture's workability was determined via a slump test. After pouring the mixes into cylinder and beam molds and cured for approximately 28 days, the samples were tested. All samples were tested in flexure and compression depending on their sizes (compressive strength for cylinders, flexural strength for beams).

CONCLUSIONS

The substitution of recycled aggregates in concrete production proved to be a sustainable route. Completely replacing natural aggregates with recycled aggregate tend to reduce the compressive strength of the concrete compared to natural aggregate concrete, due to the physical properties of RCA e.g., high porosity, low density. So, it is more beneficial to produce concrete that is a mix of both RCA and NCA. Hypothetically, 30% to 50% of the natural aggregates can be recycled without a drastic change in the performance of the concrete. The styrofoam-concrete was not comparable in compressive strength to normal concrete and was much lighter in weight, causing a decrease in strength, proved by the quicker failure time in the compression machine. It should be noted that some of the Styrofoam pieces floated to the surface of the cylinders (segregation), creating an uneven surface which may have slightly skewed the results. However, flexural strength of Styrofoam added concrete was comparable to the conventional concrete. As Styrofoam is a good insulator, this type of concrete could be utilized in lightweight flexural members in the areas those require thermal insulation.

FUTURE DIRECTIONS

We plan to use a more effective combination of recycled concrete aggregates with natural aggregates, to where the density and the compressive strength of the resultant concrete will be comparable to conventional concrete, while still being composed of enough RCA to where the negative costs of NCA will significantly be reduced. In the future, more mixes will be evaluated and allowed to settle for different curing times, before estimating compressive strength, flexural strength, and density. In case of styrofoam, changing the dimensions of styrofoam pieces to smaller sizes, using different percentages of styrofoam in the mixture, and using additives such as fly ash could create concrete capable of performing on a comparable level to normal concrete.

REFERENCES

De Brito, J., et al. "Structural, Material, Mechanical and Durability Properties and Behaviour of Recycled Aggregates Concrete." Journal of Building Engineering, vol. 6, June 2016, pp. 1–16.
Duan, Zhen Hua, and Chi Sun Poon. "Properties of Recycled Aggregate Concrete Made with Recycled Aggregates with Different Amounts of Old Adhered Mortars." Materials & Design, vol. 58, June 2014, pp. 19–29,Accessed 26 Feb. 2020.
Lima, Carmine, et al. "Physical Properties and Mechanical Behaviour of Concrete Made with Recycled Aggregates and Fly Ash." Construction and Building Materials, vol. 47, Oct. 2013, pp. 547–559.
McNeil, Katrina, and Thomas H.-K. Kang. "Recycled Concrete Aggregates: A Review." International Journal of Concrete Structures and Materials, vol. 7, no. 1, Mar. 2013, pp. 61–69.
Suhendro, Bambang. "Toward Green Concrete for Better Sustainable Environment." Procedia Engineering, vol. 95, no. 95, 2014, pp. 305–320.
Zhang, Yancong, et al. "Mechanical Performance of Concrete Made with Recycled Aggregates from Concrete Pavements." Advances in Materials Science and Engineering, vol. 2020, 15 Sept. 2020, p. e5035763.
National Center for Biotechnology Information (2024). PubChem Compound Summary for CID 7501, Styrene. Retrieved August 1, 2024.
Dec reminds New Yorkers: Statewide ban on polystyrene foam containers and loose fill starts (2021). Department of Environmental Conservation. (n.d.).
Iano, J., & Allen, E. (2008). Fundamentals of Building Construction: Materials and Methods, 5th Edition. John Wiley & Sons.