



Eco-Friendly Concrete Innovation in Civil Engineering

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ABSTRACT

Recently, the weather changes that have occurred are very unconditioned. This feels natural because it has often been felt, even though the heat that occurs is beyond its limit. This is one of the effects of global warming. Concrete is one of the most widely used materials in construction. In fact, cement production is included in the less environmentally friendly category. The purpose of this study is to find out how research on green concrete and whether it has an impact in the world of civil engineering. This research is using a quantitative method. This research describes only a few of the results of trials conducted by several researchers in the world, which prove that there is environmentally friendly concrete that can be applied and some are not. The results of this study showed that most of the innovation of green concrete is not good enough to be applied in the field. This is because in several studies it has been proven that the mixture in the manufacture of green concrete does not qualify as an aggregate material. The conclusion is that there is no innovation in the manufacture of green concrete that has worked so as not to cause damage to the earth. Therefore, other research on green concrete is very necessary to do.

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1. INTRODUCTION

Concrete is one of the most widely used materials in construction. Both from the construction of houses, bridges, office buildings, railroad construction, drainage, and many more. The main ingredients of concrete are cement, gravel, sand, and water. Apparently, cement production is included in the category of less environmentally friendly, because every 1 ton of cement is produced, 1 ton of carbon dioxide gas is also produced and then released into the atmosphere. Carbon dioxide gas is classified as a greenhouse gas that has an impact on world climate change. Cement production also requires a lot of energy.

It is well known that the effects of global warming are very detrimental to humans. Therefore, nowadays many people are trying to develop this innovation from concrete, namely environmentally friendly concrete. Green concrete is defined as concrete, which uses waste material as at least one of its components, or its production process does not lead to environmental destruction, or it has high performance and life cycle [sustainability \(Suhendro, 2014\)](#). Green concrete is concrete that uses less energy in its production and produces less carbon dioxide gas than normal or ordinary concrete in general.

Several innovations in the manufacture of green concrete have actually been done. High Volume Fly Ash (HVFA) Concrete is one of the technologies. This technology has begun to be applied in the field. This technology was originally developed by Malhotra and his colleagues at CANMET Canada in the 1980s ([Yu et al., 2018](#)). However, the quality of the concrete produced in this study did not meet the requirements for strong concrete.

Another research is using tile fragments as coarse aggregate derived from clay and artificial aggregates from crushed concrete waste as a substitute for split stones. Based on this research it is proven that the average compressive strength value of green concrete with an aggregate of tile fragments is 21.88 MPa, which does not reach the targeted average compressive strength of 27 MPa ([Widyawati, 2011](#)).

Besides that, other studies say that the use of mortar and seaweed as natural polymers. The research has shown that natural polymer-modified mortar with seaweed powder performed great value of compressive strength and splitting tensile compared to control specimens. KM-0.5 is the optimum mix composition. This research is very promising to become green construction material for sustainable concrete ([Susilorini et al., 2014](#)).

The novelty of making green concrete still needs to be researched until it has a good impact on sustainable development. The study to know more about green concrete innovation in civil engineering and I hope readers will have the desire to find and apply the use of green concrete in civil engineering. This study uses quantitative methods and the author reads several journals about what research has been done in the manufacture and application of green concrete. The research questions are:

- (i) What is the definition of Green Concrete/Eco-friendly concrete?
- (ii) Why we should apply the concept of green concrete in civil engineering?
- (iii) What innovations have been made about green concrete?
- (iv) How is the strength of green concrete?
- (v) Is green concrete good enough to be applied in green concrete?

2. METHODS

This research is a quantitative method. Quantitative research is 'Explaining phenomena by collecting numerical data that are analyzed using mathematically based methods (in particular statistics). The design of this study is a systematic review. This design of the study is a systematic way of collecting, evaluating, integrating, and presenting findings from various

research studies. We intend to find out what is meant by environmentally friendly concrete, what innovations have been made to date in the world of civil engineering, and how strong the results of these experiments are. Given the current global warming is still an unsolved problem.

This study compiled articles from various articles regarding environmentally eco-friendly concrete and other titles related to environmentally eco-friendly concrete. Especially, this study compiled from eleven articles regarding environmentally eco-friendly concrete and other titles related to environmentally eco-friendly concrete. The articles started from 2006 until the latest in research in 2020. These journals were collected from various sources, including the International Journal of Engineering Trends and Technology (IJETT), Journal of Green Engineering, Environmental Engineering & Management Journal (EEMJ), Procedia Engineering, and the University Civil Engineering Student Journal.

3. RESULTS

Several studies by trying various other materials as a substitute for cement have been done by several people. High Volume Fly Ash (HVFA) Concrete is one of the technologies. This technology has begun to be applied in the field. This technology was originally developed by Malhotra and his colleagues at CANMET Canada in the 1980s. Malhotra and his friends used fly ash which is the residue of burning coal as a substitute for cement in making concrete, which is 50% -60% (Yu *et al.*, 2018). This innovation has begun to be applied to the manufacture of bridges, foundations, and superstructures to road pavements.

The use of natural lime and sea sand as fine aggregate is an example of another innovation. The result of the quality test obtained that the concrete with natural limestone has compressive strength and split tensile strength is smaller than the normal concrete and does not reach the compressive strength of the plan. While the concrete using sea, sand is concrete which produces compressive strength and split tensile strength greater than normal concrete (Kandi *et al.*, 2012).

In 2020, there is an experiment of using steel slag as an eco-friendly material in concrete for construction. In this research, the percentage of replacement steel slag increases, and the strength of the concrete also increases by up to 30%. The strength of the concrete subsequently decreases significantly due to lower binder content, lower porosity, and lower workability. Meanwhile, the concrete will assume strong and detailed properties with various concentrations of steel slag up to 30% replacement (Tangadagi *et al.*, 2020).

Other than that, Millet Husk Ash (MSA) had ever done as the experiment of partial replacement material with the different percentages. Start from 0, 5, 10, 15, to and 20% by the weight of cement. In conclusion, the workability of fresh concrete blended with MHA is reduced with the increase in percentages of MHA content.

There is also the experiment by using three types of waste, there are polystyrene granules, chopped plastic bottles (PET), and wood waste. That is all were used as a substitution of 0-4 mm aggregate sort in different dosages from 0 to 100%. Among that three waste materials, PTA is the most suitable as a substitute for cement. The mix with PET showed higher values of the mechanical strengths compared to the value of the mixes with polystyrene granules and wood (Ciocan *et al.*, 2018).

A partial replacement of cement with alccofine and fine fly ash is the other researchers state that the addition of alccofine increases the self-compatibility characteristics like filling ability, passing ability, and resistance to segregation. This research showed that excellent fresh and hardened properties are made with some replacement of cement with alccofine and fine fly ash. Alccofine has a unique chemistry and ultra-fine particle size. Alccofine1203 is known to produce high-strength concrete (Reddy *et al.*, 2016).

Also, there is an experiment that using ceramic waste as the partial replacement of cement via 0, 10, 20, 30, and 50%. In this experiment, concrete on 30% replacement of cement with ceramic powder becomes more economical without compromising concrete strength than the standard concrete (Raval *et al.*, 2013).

The other experiment is using foundry sand. The fine aggregate has been replaced by used foundry sand accordingly in the range of 0%, 10%, 30% & 50% by weight for M-20 grade concrete. This study concluded the replacement of fine aggregate with this used foundry sand material provides maximum compressive strength at 50% replacement. (Bhimani, Pitroda, & Bhavsar, 2013).

There is also the experiment with using candlenut skin as a substitute for coarse aggregate in making environmentally friendly concrete. Jangin *et al.*, (2016) this research was conducted by other researchers. The main objective of their research was to determine the effect of using hazelnut skin waste as coarse aggregate in the design of the concrete mixture on the resulting compressive strength. However, **Figure 1** shows that the characteristic compressive strength of concrete using candlenut shells is much weaker than that of using coarse aggregate.

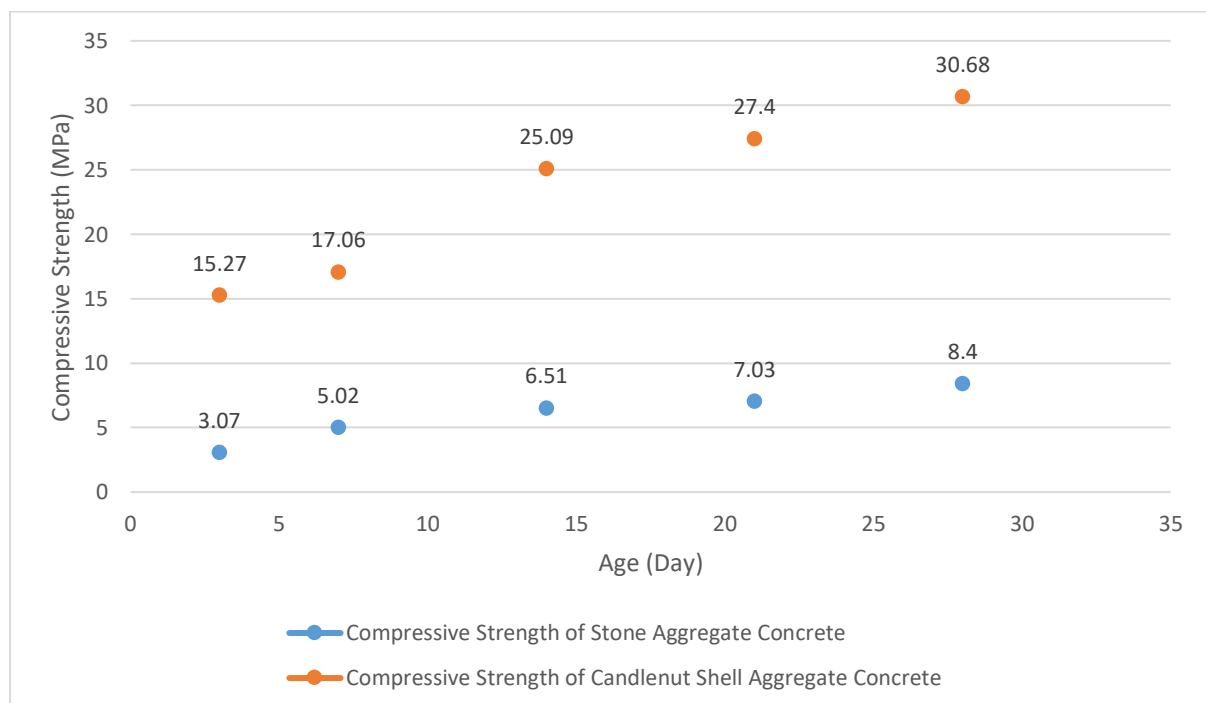


Figure 1. Compressive strength ratio of concrete characteristics.

Although concrete mixes are proportioned based on achieving the desired compressive strength at the specified age, tensile strengths often play a vital role in concrete making. In concrete, cracks can propagate very easily in tension, and the cracking of concrete due to its tensile stress being exceeded may cause serviceability and durability problems (Bhanja & Sengupta, 2005).

Figure 2 explains that in their research, the tensile strength produced using candlenut as an aggregate has a very low number.

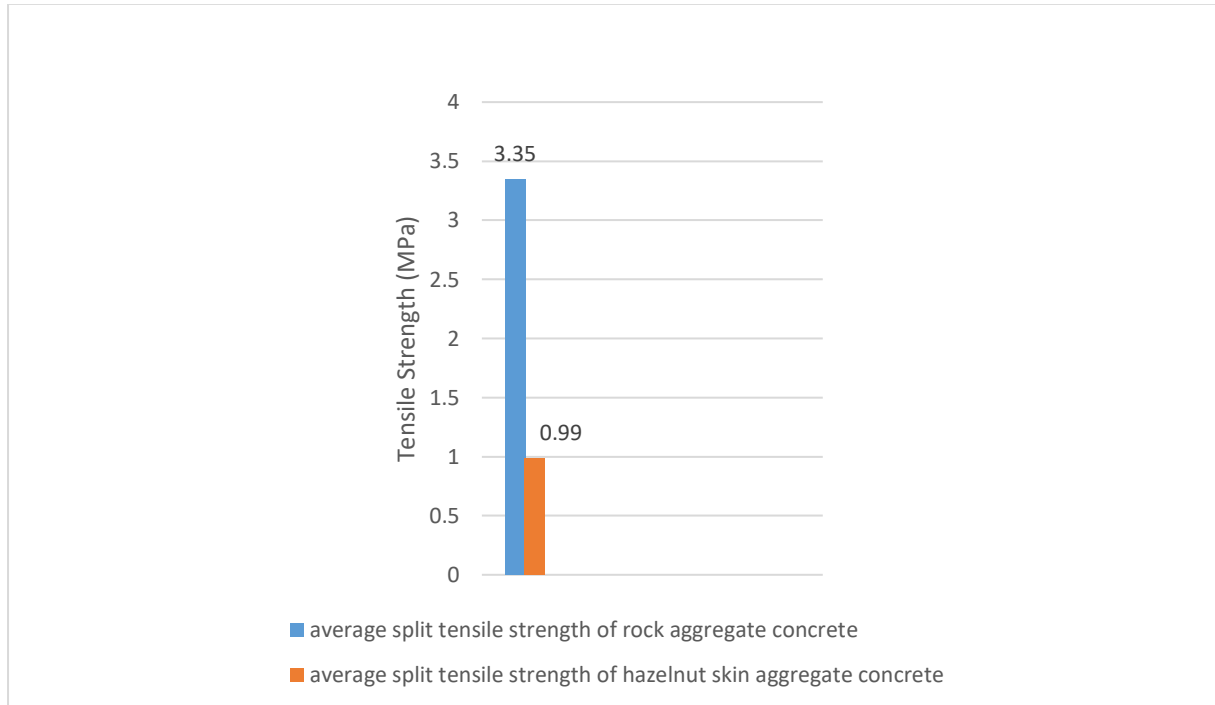


Figure 2. Average split tensile strength of concrete

As shown in Table 1, there are still several studies using several materials that support green concrete innovation that is not appropriate to be applied in the field. However, most of the studies have succeeded in testing the research by getting the desired results, namely concrete that is strong enough and feasible.

Table 1. The appropriateness of using environmentally friendly materials in the manufacture of green concrete

No	Material Used	Appropriateness
1.	Candlenut skin	Not appropriateness
2.	Lime and Sea Sand	Good
3.	Clay and Artificial Aggregates	Not appropriateness
4.	High volume fly ash	Good
5.	Rice husk ash waste	Good
6.	Steel slag	Not appropriateness
7.	Millet husk ash	Not appropriateness
8.	Plastic bottle (pet)	Good
9.	Alccofine	Good
10.	Ceramic waste	Good
11.	Foundry sands	Good

4. DISCUSSION

The construction of a safe and earthquake-resistant shelter is the most important thing in a project. After all, security is the most important, after that it's about price, aesthetics, and so on. [Ahmad et al. \(2009\)](#) the properties of concrete are generally influenced by the quality of materials, workmanship, and treatment. cement characteristics that affect the quality of concrete and its hardening. Gradation fine affects the workmanship; moderate coarse gradation affects the strength of concrete. Air quality and quantity affecting hardening and strength.

When the age of maturity of the concrete is reached, the concrete is expected to be able to support load so that the main property that must be possessed by concrete is its strength. Very strong concrete is influenced by the amount of water and cement used or depending on the water-cement ratio and degree of cohesiveness. The factors that affect the strength of concrete are the ratio weight of water and cement, type and gradation of aggregate, quality cement, and treatment (curing) ([Ahmad et al., 2009](#)).

Tjokrodimuljo states that the properties of concrete are generally better if the compressive strength is higher, thus to review the quality of concrete is usually generally only reviewed with compressive strength. The compressive strength of concrete is influenced by many factors, namely the proportion of constituent materials, design methods, maintenance of concrete, as well as conditions at the time of casting ([Amelia et al., 2021](#)). [Amelia et al. \(2021\)](#) explained that the most important factors that influence the strength of concrete are: (i) Cement quality, (ii) The proportion of cement to the mixture is the Water Cement Factor, (iii) Aggregate strength is the abrasion value of coarse aggregate and aggregate surface area, and (iv) Interaction or adhesion between cement paste and aggregate in the form of aggregate-cement ratio.

5. CONCLUSION

Environmentally friendly concrete is an innovation that is very beneficial for sustainable development. Environmentally friendly concrete itself is still undergoing several trials and research. In connection with the results of research that has been carried out by several experts and non-experts, there are environmentally friendly concrete strength requirements that have been able to meet the concrete requirements according to the standard. But not all types of environmentally friendly concrete. For example, in a test using candlenut shells, it was concluded by the examiner that the use of candlenut shells as a substitute for aggregate does not meet the requirements for the use of concrete as a building construction material. But, using lime and sea sands, high volume fly ash, rice husk ash waste, plastic bottle, alccofine, ceramic waste, a foundry sands the requirements of good concrete can be achieved. Using one of them as the replacement of the cement or as a concrete mix can bring advantages in the use of environmentally friendly materials in the manufacture of concrete which reduces global warming.

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7. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

8. REFERENCES

- Ahmad, I. A., Taufieq, N. A. S., and Aras, A. H. (2009). Analisis pengaruh temperatur terhadap kuat tekan beton. *Jurnal Teknik Sipil ITB*, 16(2), 63-70.
- Amelia, R., Suhendra, S., and Amalia, K. R. (2021). Hubungan Faktor-Faktor yang Mempengaruhi Kuat Tekan Beton. *Jurnal Talenta Sipil*, 4(2), 225-235.
- Bhanja, S., and Sengupta, B. (2005). Influence of silica fume on the tensile strength of concrete. *Cement and Concrete Research*, 35(4), 743-747.
- Ciocan, V., Burlacu, A., Bărbuță, M., Verdeș, M., Șerbănoiu, A. A., and Ștefan, I. (2018). Eco-friendly concrete from wastes. *Environmental Engineering & Management Journal (EEMJ)*, 16(12), 2969-2976.
- Jangin, A. I., Samsurizal, E., and Supriyadi, A. (2016). Studi eksperimental beton ramah lingkungan menggunakan kulit kemiri sebagai agregat kasar. *Jurnal Mahasiswa Teknik Sipil Universitas Tanjungpura*, 2(2), 1-12.
- Kandi, Y. S., Ramang, R., and Cornelis, R. (2012). Substitusi Agregat Halus Beton Menggunakan Kapur Alam dan Menggunakan Pasir Laut pada Campuran Beton. *Jurnal Teknik Sipil*, 1(4), 74-86.
- Raval, A. D., Patel, D. I. N., and Pitroda, P. J. (2013). Ceramic waste: Effective replacement of cement for establishing sustainable concrete. *International Journal of Engineering Trends and Technology (IJETT)*, 4(6), 2324-2329.
- Reddy, M. V. S., Ashalatha, K., and Surendra, K. (2006). Studies on eco-friendly concrete by partial replacement of cement with Alccofine and fine Fly Ash. *micron*, 10, d90.
- Suhendro, B. (2014). Toward green concrete for better sustainable environment. *Procedia Engineering*, 95, 305-320.
- Susilorini, R. M. R., Hardjasaputra, H., Tudjono, S., Hapsari, G., Wahyu, S. R., Hadikusumo, G., and Sucipto, J. (2014). The advantage of natural polymer modified mortar with seaweed: green construction material innovation for sustainable concrete. *Procedia Engineering*, 95, 419-425.
- Tangadagi, R. B., Manjunatha, M., Bharath, A., and Preethi, S. (2020). Utilization of steel slag as an eco-friendly material in concrete for construction. *Journal of Green Engineering*, 10(5), 2408-2419.
- Widyawati, R. (2011). Studi Kuat Tekan Beton Beragregat Ramah Lingkungan. *Jurnal Rekayasa Teknik Sipil Universitas Lampung*, 15(3), 140975.

Yu, J., Mishra, D. K., Wu, C., and Leung, C. K. (2018). Very high-volume fly ash green concrete for applications in India. *Waste Management & Research*, 36(6), 520-526.