INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ACCOUNTING, FINANCE AND MANAGEMENT SCIENCES

www.hrmars.com
ISSN: 2225-8329

Engineering Properties of Green Lightweight Foamed Concrete Strengthen with *'Saccharum Officinarum'* Fiber

Md Azree Othuman Mydin

To Link this Article: http://dx.doi.org/10.6007/IJARAFMS/v12-i1/12173 DOI:10.6007/IJARAFMS /v12-i1/12173

Received: *18* November 2021*, **Revised:** 21* December 2021*, **Accepted:** 0*6 January 2022

Published Online: 26 January 2022

In-Text Citation: (Mydin, 2022)

To Cite this Article: Mydin, M. A. O. (2022). Engineering Properties of Green Lightweight Foamed Concrete Strengthen with 'Saccharum Officinarum' Fiber. *International Journal of Acdemic Research in Accounting, Finance and Managment Science*, *12*(1), 174–183.

Vol. 12, No. 1, 2022, Pg. 174 - 183

http://hrmars.com/index.php/pages/detail/IJARAFMS | **JOURNAL HOMEPAGE**

INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ACCOUNTING, FINANCE AND MANAGEMENT SCIENCES
www.hrmars.com
ISSN: 2225-8329

Engineering Properties of Green Lightweight Foamed Concrete Strengthen with *'Saccharum Officinarum'* Fiber

Md Azree Othuman Mydin
School of Housing, Building and Planning, Universiti Sains Malaysia, 11800, Penang, MALAYSIA
Email: azree@usm.my

Abstract
This study focuses on extricating the impending utilization of '*saccharum officinarum*' fiber into lightweight foamed concrete for engineering properties enhancement. This study wishes to establish the engineering performance of lightweight foamed concrete with the inclusion of '*saccharum officinarum*' fibre of 1000 kg/m^3 density. Different weight fractions of '*saccharum officinarum*' fibre of 0.1%, 0.2%,0.3% and 0.4% were used. There were four parameters that were assessed such as water absorption, porosity, drying shrinkage, ultrasonic pulse velocity. Protein-based foaming agent Noraite PA-1 was used to produce the targeted density of lightweight foamed concrete. In turn, to attain comparable results, the water-cement ratio was fixed to 0.40 while the cement-sand ratio was constant at 1:1.5. The results had revealed that the addition of 0.3% of '*saccharum officinarum*' gave the best results for all the engineering performance parameters considered in this research. At 0.3% weight fraction of '*saccharum officinarum*', the fibers and the cementitious matrix accomplished full compaction, which led to outstanding mix uniformity. Further, than the optimum level of '*saccharum officinarum*' fibre addition, accumulation, and the non-uniform distribution of fibers was detected, which preceded to a reduction in entire engineering properties evaluated.
Keywords: Foamed Concrete, '*Saccharum Officinarum*', Natural Fibre, Engineering Properties, Water Absorption, Porosity

Introduction

Lightweight foamed concrete is one of the types of lightweight concrete which can be defined as a cementitious material that comprises a minimum of 20% by volume of mechanically entrained foam in mortar in which air-pores are entrapped in the matrix by means of a suitable foaming agent. Lightweight concrete can be defined as a type of concrete that includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as nailbility and lessening the dead weight. It is lighter than conventional concrete. Lightweight foamed concrete is produced by the mixing of ordinary Portland cement (OPC), sand, water, and preformed stable foam. The foam is engendered with the aid of a foam-making machine, by means of foaming solution with a 1:33 ratio to water. The air content is generally between 40 to 80 percent of the total volume. Lightweight foamed concrete is diverse compared to aerated concrete, where the foam is chemically formed by means of reaction of aluminum powder with calcium hydro oxide and other alkalizes unconfined by cement hydration and, air-entrained concrete, which a much lower volume of entrained air is used in concrete for engineering purpose (Raj et al., 2019). The air-pores are initiated by agitating air with a foaming agent diluted in water; the foam then carefully is mixed with the mortar to form or produce lightweight foamed concrete. Due to the air-pores inside the matrix, concrete with properties of low self-weight, high workability, excellent insulating values, but lower strength compared to normal concrete is produced. Moreover, the use of lightweight foamed concrete can contribute many advantages such as rapid and relatively simple construction, economical in terms of transportation and reduction in main power, reduce structural weight with a minimum number of frames and piles, better nail-ability, and saving properties than heavier and stronger conventional concrete (Munir et al., 2015).

There are two approaches used to formulate lightweight foamed concrete. The first method is by injecting the gas into the mortar slurry during its plastic condition by means of a chemical reaction and the second method is by introducing the air, either by mixing-in stable foam or by whipping-in air, using an air-entraining agent. The first technique is typically utilized in prefab concrete factories where the precast units are consequently autoclaved to produce concrete with a rational high strength and low shrinkage (Ramli et al., 2013). On the other hand, the second technique is usually used for in-situ concrete which is appropriate for insulation of roof screeds components and pipe lagging. The minimum strength of the compression of crushing strength of the normal brick is ranging between 4.2-16.4 N/mm^2. The application of lightweight foamed concrete in civil engineering works is very broad as it can be used in almost every part of a building from the superstructure right down to the substructure, including wall panels and roofing (Elrahman et al., 2019). Hence this research aims to distinguish the effect of 'saccharum officinarum' fiber on the engineering properties of lightweight foamed concrete.

Material Constituents

Cement

The cement used for the study is an Ordinary Portland Cement (OPC) from Phoenix Ordinary Portland Cement as been shown in Figure 1. Phoenix is the brand name of specifically blended bagged Portland-composite cement. It is manufactured by Portland Cement Clinker and other carefully selected secondary constituents (pozzolanic materials, fly ash, and other constituents permitted under BS EN 197-1:2000). Under an effective system of testing controlling and monitoring by Lafarge Malayan Cement, Malaysia's leader in clinker and cement manufacturer.

Fine Aggregate

The fine aggregate used was natural sand obtained from a local distributor. Sieve analysis has been carried out to identify the suitability of the sand to be used according to British Standard BS 882: 1992. The result of the sieve analysis shows in Table 1 and the grading curve of sieve analysis shows in Figure 1.

Table 1. Result of Sieve Analysis

Sieve Size Range (mm)	Mass Retained (g)	Cumulative Retained (g)	Cumulative % mass Retained	Cumulative % mass passing through
10.00-5.00	0	0	0	100
5.00-2.00	3.8	3.8	0.8	99.2
2.00-1.18	38.3	42.1	8.4	91.6
1.18-0.600	135.0	177.1	35.4	64.6
0.600-0.300	160.6	337.7	67.5	32.5
0.300-0.150	114.3	452.0	90.4	9.6

From Figure 1, it was found that the sand provided by the local distributor can be considered as very fine sand. This is due to the fine modulus of the sand being equal to 2.02 instead of ranging between 2.2 to 2.6 as required for fine sand. Furthermore, the sand fell in zone 4. However, the sand was accepted to be used in this research because more than 20% of the total quantity of the sand has a size less than 0.5mm as per requirement.

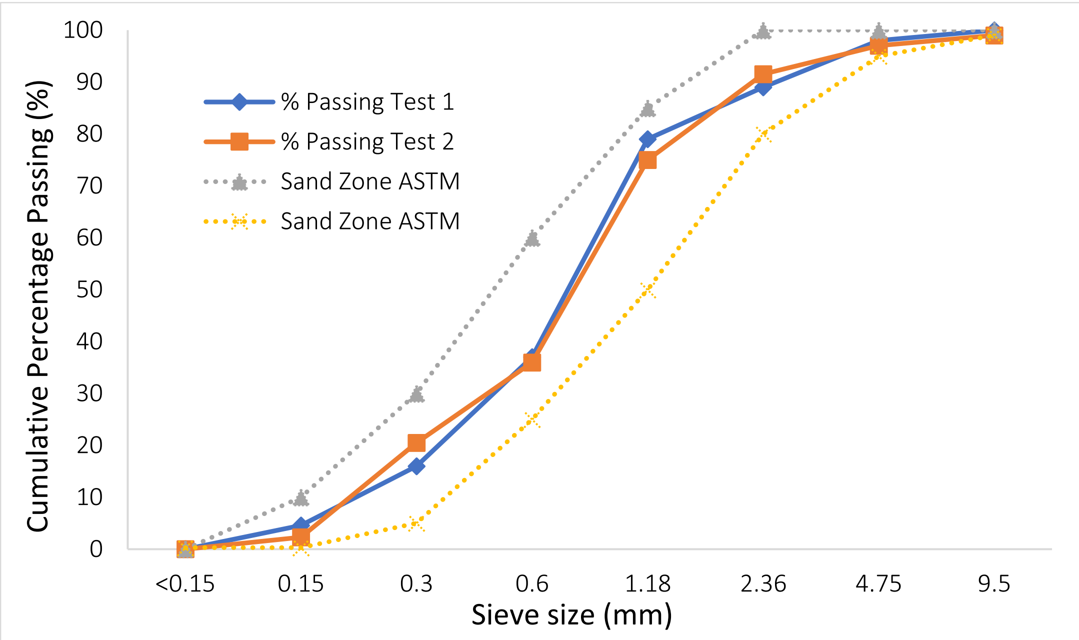

Figure 1. Sieve Analysis Grading Result

'Saccharum officinarum' fiber

'Saccharum officinarum' had high cellulose percentage which may assist significantly when in composite action with lightweight foamed concrete cementitious matrix. Natural plant fibers like *'saccharum officinarum'* with high cellulose content, typically, present a low deformation capacity with excellent young's modulus and this is confirmed by the experimental evidence attained in the study. Additionally, it was testified that commonly the tensile strength and young's modulus of plant fiber improve with improving cellulose content of the *'saccharum officinarum'. Weight fractions of 'Saccharum officinarum' utilized in this study were 0.0%, 0.1%, 0.2%, 0.3% and 0.4%.* Figure 2 shows the raw *'Saccharum officinarum'* fiber used in this study

Figure 2. *'Saccharum officinarum'* used in this study

Water

The clean water is used for mixing and curing shall be clean and free from any debris and other organic materials. This is because if the water used is not clean, it can affect the performance of concrete. Otherwise, cleaned water is needed to mix with the protein to create a good foam agent that is free from debris. Basically, the water-cement ratio that has been used for this research is 0.45 because most of the previous studies used this ratio to achieve reasonable workability of foamed concrete.

Surfactants

The type of foaming agent used for this research was a protein-based type (PA-1). The reason for using a protein-based foaming agent is that it is more stable compared to other types. The protein is made of organic protein that is not the acidic type that can be contacted on the skin. Generally, protein-based surfactants may produce a tiny bubble size, which can contribute to a more stable and stronger closed bubble structure. Portable foaming generator (Portafoam) is the name of the foam generator machine used for this research.

Experimental Setup

The tests were carried out investigating the engineering properties of lightweight foamed concrete with the addition of '*saccharum officinarum*' which includes water absorption, porosity, drying shrinkage, and ultrasonic pulse velocity.

Water absorption capacity

Water absorption test was accomplished in line with BS 1881: Part 122 on 75mm diameter x 100mm height size cylinder. The cylinder specimens were separated a day prior to the curing process, and the specimens were cleaned and weighed to establish the dry weight. Following this, the specimens were placed in an oven at 105 °C for 72 hours to make sure that the specimens were fully dry prior to the water absorption test.

Porosity

The porosity of specimens was established via Vacuum Saturation Apparatus. The dried specimens were placed under a vacuum in a desiccator for three days. During that time, the desiccator was filled with de-aired and distilled water. The specimens were placed in a ventilated oven set to 105 °C for three days to identify oven-dry mass. After that, the specimens were removed from the oven and cooled at room temperature. The objective of measuring the specimens' weight is to determine their oven-dray mas and, at the same time to prepare them for vacuum saturation. Meanwhile, the vacuum line connector connects with a pressure gage, and the vacuum will pump and continued for three days.

Drying Shrinkage

The drying shrinkage test was accomplished in line with AASTM C878. A 75mm with length 250mm prism was used with an estimated overall length of 290mm, including the rod and cap nuts. For each test, a minimum of 3 specimens was taken to obtain the average result. The initial length measurement was taken with a length comparator equipped with a 250m invar bar which is capable of adjusting the measurement up to 0.001mm. The comparator's length was adjusted against a reference invar for each specimen.

Ultrasonic Pulse Velocity (UPV)

The test was performed by assessing the transmission velocity of a transmitted longitudinal ultrasonic pulse across the cross-sectional area. Mortar prisms were measured at the dimensions of 100mm x 100mm x 500mm. An electro-acoustical transducer was used to examine the transmission of the ultrasonic pulse It is held in contact with an electrical signal by a second transducer after the pulse traversing a known path length in the specimen. Electromagnet transducer was then showed the transmitted time and velocity. The standard procedures were conducted according to the standard prescribed in BS EN 12504-4. A mortar prism with the dimensions of 100mm x 100mm x500mm was constructed for all mix designs and examined at day 7, day 28, day 60, and day 180 during the curing stage. Readings were taken and the average velocity of the UPV result was taken.

Results and Discussion

Porosity

Figure 3 shows the percentage of porosity of lightweight foamed concrete with various weight fractions of *'saccharum officinarum'* fiber. The trend of porosity is decreasing along with the increase of *'saccharum officinarum'* fiber in the lightweight foamed concrete. The results show that the lowest percentage of porosity is 51.1% which contained 0.4% weight fraction of *'saccharum officinarum'* in lightweight foamed concrete; meanwhile, the highest percentage of porosity is 57.5% with the inclusion of 0.1% of *'saccharum officinarum'*. Figure 2 also revealed that 0.3% and 0.2% of *'saccharum officinarum'* in lightweight foamed concrete result in 54.2% and 56.2% of porosity, respectively. The decrease in porosity value with the supplement of *'saccharum officinarum'* described in this study ranges between 0.8%-5.9%, which is very little and insignificant. Variation and geomorphology variation of the *'saccharum officinarum'* fiber activates the reduction in porosity of lightweight foamed concrete (Fu et al., 2020). The higher volume fraction of *'saccharum officinarum'* fiber in lightweight foamed concrete aid to connect the matrix thus decreasing the porosity of lightweight foamed concrete (Jalal et al., 2017).

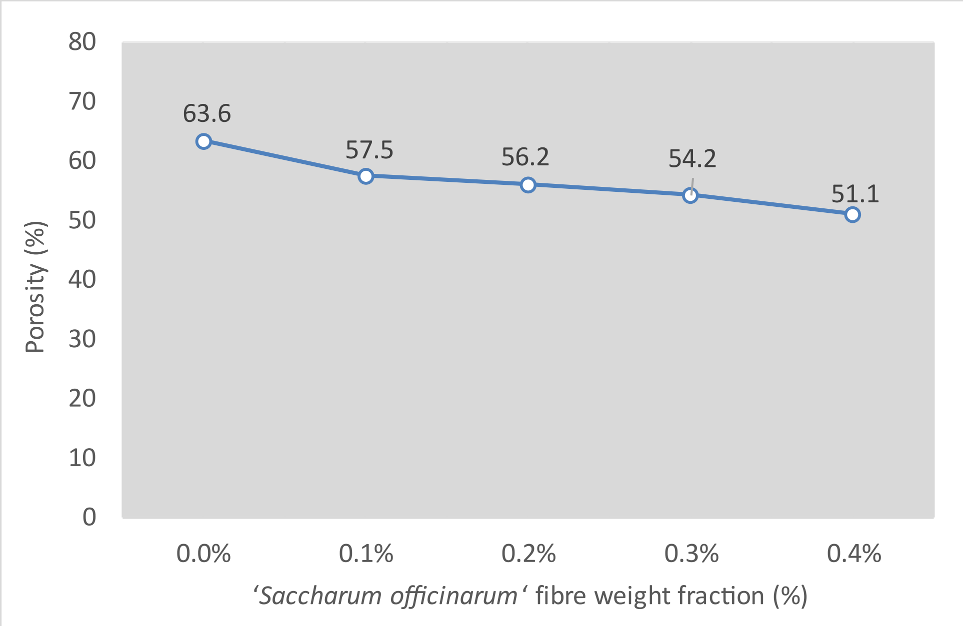

Figure 3: Porosity of lightweight foamed concrete of different weight fraction of *'saccharum officinarum'*

Water Absorption

Figure 4 reveals the water absorption capacity results with the inclusion of a different weight fraction of '*saccharum officinarum*' in lightweight foamed concrete. It can be seen from Figure 4 that the water absorption decreased as the weight fraction of *'saccharum officinarum'* in lightweight foamed concrete increased. The decreasing trend is due to the inclusion of *'saccharum officinarum'* in lightweight foamed concrete, in which 0.4% weight fraction *'saccharum officinarum'* inclusion led to the lowest water absorption, which is 13.9%, compared to the inclusion of 0.1% *'saccharum officinarum'* by mix resulting in 16.4% water absorption value. Meanwhile, the second lowest of water absorption is 15.0% which contained 0.3% of *'saccharum officinarum'* in foamed concrete, followed by 0.2% of *'saccharum officinarum'*, which resulted in a 15.8% water absorption value. This result indicates that lightweight foamed concrete has high water absorption because the low density of lightweight foamed concrete contains more foam, creating many air voids (Jhatial et al., 2017).

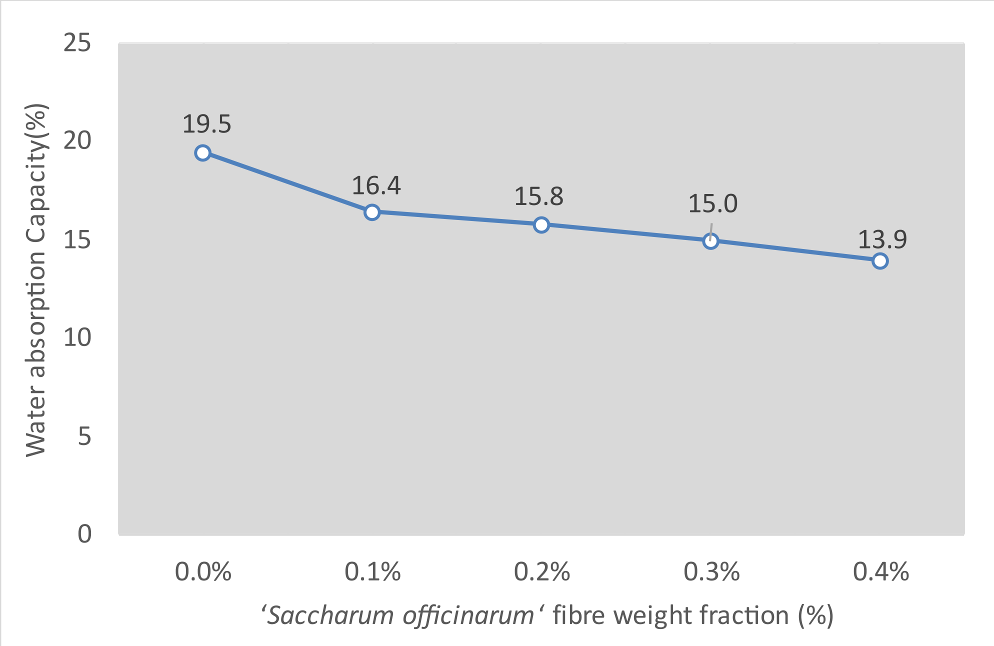

Figure 4: Water absorption capacity of lightweight foamed concrete of different weight fraction of *'saccharum officinarum'*

Drying Shrinkage

According to Figure 5, all the specimens are drastically increased day-1 until day-28 and started constant reading on day-28 until day-60. The control specimens show the highest reading compared to the specimens with *'saccharum officinarum'* in lightweight foamed concrete with a density of 1000kg/m^3. Additionally, the lowest value of drying shrinkage contained 0.3% of *'saccharum officinarum'* in lightweight foamed concrete, followed by 0.2%. 0.4% and 0.1%. Lightweight foamed concrete with the addition of *'saccharum officinarum'* has an improvement in shrinkage of the concrete. The factor that affected the shrinkage behavior is caused by the increase of foam content in the concrete. This is because cement paste usage will be reduced when a higher amount of foam is used. Additionally, the reduction of drying shrinkage is also caused by the addition of *'saccharum officinarum'* where there is the absence of aggregates, and *'saccharum officinarum'* also contributes to improving the cement matrix (Memon et al., 2018). At the same time, it also helps to lower the cracks of lightweight foamed concrete. So that it can be concluded that the drying shrinkage can be reduced by the addition of *'saccharum officinarum'* in foamed concrete.

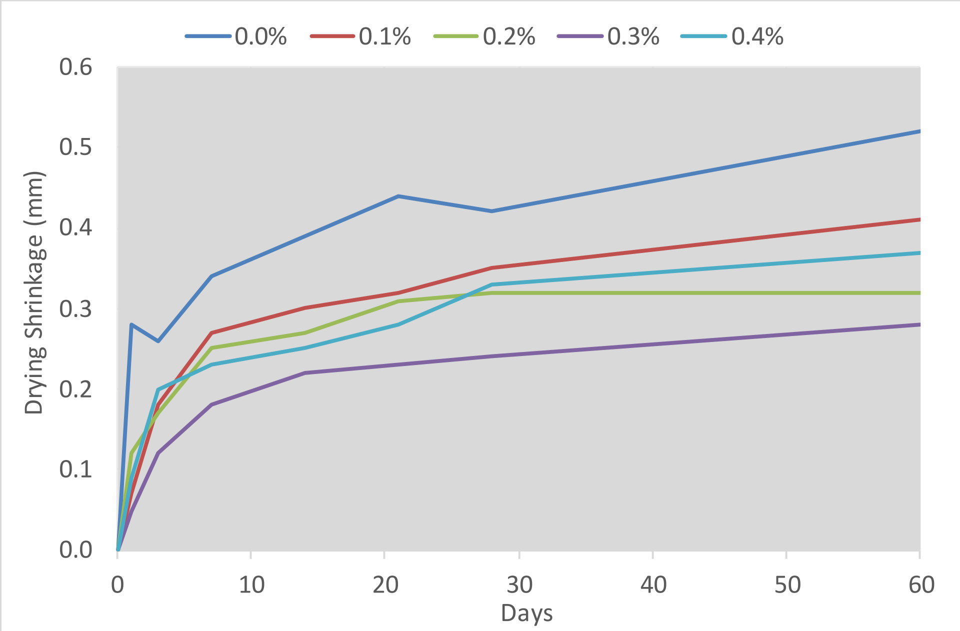

Figure 5: Drying shrinkage of lightweight foamed concrete of different weight fraction of *'saccharum officinarum'*

Ultrasonic Pulse Velocity

Figure 6 shows the results of the ultrasonic pulse velocity test on the specimens of 800kg/m^3 lightweight foamed concrete. The trend of the ultrasonic pulse velocity is increasing with the increase of *'saccharum officinarum'* in the lightweight foamed concrete. It can be observed that the inclusion of 0.4% of *'saccharum officinarum'* in the lightweight foamed concrete resulted in the highest reading of ultrasonic pulse velocity, which is 1842.3 m/s compared to the control mixes, which have the lowest reading of ultrasonic pulse velocity 1564.0 m/s. The result of ultrasonic pulse velocity was obtained for 0.1%, 0.2%, and 0.3% in addition to *'saccharum officinarum'* in lightweight foamed concrete, where it has 1645.7 m/s, 1712.4 m/s, and 1750.3 m/s, correspondingly.

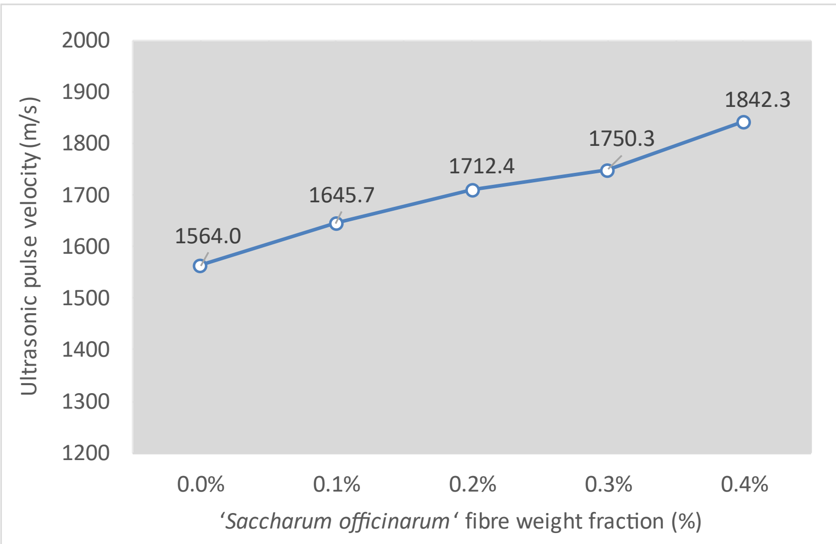

Figure 6: Ultrasonic pulse velocity of foamed concrete of different weight fraction of *'saccharum officinarum'*

Conclusion

In this experimental study, the engineering properties of lightweight foamed concrete with the inclusion of different weight fractions of *'saccharum officinarum'* fiber into lightweight foamed concrete was carried out. A density of 1000kg/m^3 was prepared and tested, with five different weight fractions of *'saccharum officinarum'* added, which were 0.0%, 0.1%, 0.2%, 0.3% and 0.4%. The experimental results discovered that the best results, in terms of the engineering properties (water absorption, porosity, drying shrinkage, and ultrasonic pulse velocity) were achieved with the optimum inclusion of 0.3% weight fraction of *'saccharum officinarum'*. At 0.3% weight fraction of *'saccharum officinarum'*, the fibers and the cementitious matrix attained full compaction, which stemmed in good mix uniformity.

References

Raj, A., Sathyan, D., Mini, K. M. (2019). Physical and functional characteristics of foam concrete: A review. Construction and Building Materials. 221:787-799.

Munir, A., Abdullah, Huzaim, Sofyan, Irfandi, & Safwan. (2015). Utilization of palm oil fuel ash (POFA) in producing lightweight foamed concrete for non-structural building material. Procedia Engineering, 125, 739-746.

Ramli, M., Kwan, W. H., Abas, N. F. (2013). Strength and durability of coconut-fibre-reinforced concrete in aggressive environments. Construction and Building Materials. 38:554-566.

Elrahman, M. A., El Madawy, M. E., Chung, S. Y., Sikora, P., Stephan, D. (2019). Preparation and characterization of ultra-lightweight foamed concrete incorporating lightweight aggregates. Applied Sciences (Switzerland), 9(7): 1-12

Fu, Y., Wang, X., Wang, L., Li, Y. (2020). Foam Concrete: A State-of-the-Art and State-of-the-art Practice Review. Advances in Materials Science and Engineering, 6153602, 1-25

Jalal, M. D., Tanveer, A., Jagdeesh, K., Ahmed, F. (2017). Foam concrete. International Journal of Civil Engineering Research, 8(1): 1-14 Hedjazi S. (2019). Compressive Strength of Lightweight Concrete. In Intech Open:1-18

Jhatial, A. A., Inn, G. W., Mohamad, N., Alengaram, U. J., Mo, K. H., Abdullah, R. (2017). Influence of polypropylene fibres on the tensile strength and thermal properties of various densities of foamed concrete. IOP Conference Series: Materials Science and Engineering 271 (1), 012058

Memon, I. A., Jhatial, A. A., Sohu, S., Lakhiar, M. T., Hussai,n Z. (2018). Influence of Fibre Length on the Behaviour of Polypropylene Fibre Reinforced Cement Concrete. Civil Engineering Journal, 4(9): 2124-2131.