ASTONJADRO

pISSN 2302-4240
eISSN 2655-2086

Volume 13, Issue 2, June 2024, pp.397-406
DOI: http://dx.doi.org/10.32832/astonjadro.v13i12 http://ejournal.uika-bogor.ac.id/index.php/ASTONJADRO

Effect of Fine Modulus of Coarse Aggregate on the Mechanical Properties of Concrete Submerged in Seawater

Sulkarnain Sulkarnain[1], Erniati Erniati[2], Sri Gusty[1], Ritnawaty Ritnawaty[2], Ashraf Ashraf[2], Miftakhul Huda[2], Herwina Rahayu Putri[2]

[1]Program Studi Magister Rekayasa Infrastruktur dan Lingkungan, University of Fajar, Makassar, INDONESIA
[2]Program Studi Teknik Sipil, University of Fajar, Makassar, INDONESIA

E-mail: sulkarnain97@gmail.com

| Submitted: August 08, 2023 | Revised: August 15, 2023 | Accepted: April 04, 2024 |

| Published: May 20, 2024 |

ABSTRACT

The durability of concrete can be determined by mixing coarse aggregate, fine aggregate, cement, and water, with or without additives. The properties of concrete can be influenced by several things, such as the mixture ratio, mixing method, transportation method, molding method, and compaction method. To analyze the values of compressive strength, flexural strength and split tensile strength of concrete submerged in seawater with variations in fineness modulus. The research used 3 variations in fineness modulus of coarse aggregate, 6.0, 6.52, and 7.1 with fresh water and sea water treatments. The compressive strength results were 35.67Mpa, 31.63Mpa, 29.30Mpa respectively, while the compressive strength of concrete soaked in sea water was 36.94Mpa, 36.52Mpa and 30.15Mpa. The splitting tensile strength results were 2.71Mpa, 2.65Mpa, and 1.91MPa respectively, while the splitting tensile strength of concrete submerged in seawater with the same variations were 3.29MPa, 2.76MPa and 2.12MPa respectively. The flexural strength results were 4.22Mpa, 4.21Mpa, and 4.14MPa respectively, while the flexural strength of concrete submerged in seawater with the same variations was 4.27MPa, 4.22MPa and 4.18MPa respectively. The influence of the fine grain modulus on the resulting compressive strength, split tensile strength and flexural strength is very significant, the higher the coarse aggregate fineness modulus, the smaller the resulting value.

Keywords: compressive strength; split tensile strength; flexural strength; concrete; coarse aggregate.

INTRODUCTION

Concrete is a building material that is widely used for implementing construction projects, especially in marine areas, this cannot be separated from its advantages, namely the ease of finding materials and the ease of the manufacturing process. Concrete is a mixture of hydraulic cement as well as other Portland cement, water, gravel and sand with or without additives, thus forming a solid mass (BSN, 2002). Concrete will harden over time and produce compressive strength (f`c) within 28 days. Concrete has quite good compressive strength, therefore concrete is often used and used as a structural choice, especially for road structures, buildings and bridges. Mix ratio, mixing method, transportation method, molding method, compaction method, etc. influence the properties of concrete (Pujianto et al., 2019). The volume of concrete usually occupies 70% to 80% of coarse aggregate so it has an important influence on the properties of concrete (Ginting, 2014).

Concrete is resistant to corrosion, easy to shape and easy to work with, which is very beneficial for development in coastal areas, especially on a large scale. One of the development concepts that many investors are starting to look at to develop in Indonesia is a waterflow city, which is a maritime country. In several countries, for example Singapore, Japan, England, America, they succeeded in implementing this concept long before, thus triggering the Indonesian government to support the project to implement this concept. Maximizing coastal areas is a very good solution to improve the economy and the distribution of sea water development is very aggressive, so this building requires sea water resistant building materials. Concrete is a good choice of building material for use in coastal areas compared to corrosive steel.

Sea water has a high salt content, so it can reduce the strength and durability of concrete. In general, sea water contains sea salts of ± 3.5% of its weight, while the salt content in fresh water is less than 1%. Concrete structures that are located on the edge of the sea and are exposed to salt in sea water can be damaged after some time of exposure. Salt can gradually enter the structure and cause the iron inside to corrode, causing the concrete to be unable to withstand the load. The smaller the iron construction, for example bridges, docks, ports, the faster it will corrode. Damage can occur in concrete due to the reaction between aggressive sea water that enters the concrete and the compounds in the concrete which causes the concrete to lose some of its mass, lose its strength and stiffness and speed up the weathering process. Damage to concrete will result in losses, especially concrete used in marine infrastructure such as ports and docks. This damage will of course have an impact on reducing the strength of the structure and shortening the service life of the building. If left untreated and the damage gets worse, the building cannot be used again (Khirunnisa, Rifqi and Amin, 2019).

Lightweight concrete is a type of concrete that has a lower density compared to conventional concrete, usually due to the use of lightweight aggregates such as pumice, vermiculite, or styrofoam. The use of lightweight concrete is generally to reduce structural loads and increase thermal efficiency. Lightweight concrete offers many advantages in terms of load reduction and thermal efficiency, but usually has lower compressive and tensile strengths than conventional concrete. With the right material selection and good quality control, lightweight concrete can be used effectively in a variety of construction applications, both structural and non-structural (Artawan IP et.al, 2023); (Verdian R, Muin RB, 2023); (Paikun P et.al, 2023).

Compressive strength is one of the important parameters in determining the quality and ability of a concrete material to withstand loads. For simple construction projects, such as creating small concrete blocks or floor slabs, it is important to know the compressive strength that can be achieved with the materials and methods available. In simple construction, following the steps above can help determine and ensure the concrete used has adequate compressive strength. Proper testing and good care are key to achieving desired results. For larger or more complex projects, it is recommended to follow stricter standards and procedures and work closely with civil engineering professionals (Sitompul ST, Pariatmono P, 2022); (Romadhon ES et.al, 2022); (Widodo S et.al, 2022).

RESEARCH METHODS

Materials

In the research several materials were used. Types of Portland Composite Cement (PCC), fresh water, sea water, local crushed stone (maximum size 20 mm), local sand (maximum size 4.75) and super plasticizer while the equipment used is a scale with a capacity of 50 kg for weighing the aggregate, cement, water. Oven with temperature 300 oC and electric power 2200 W to dry material. Sieve with sieve numbers 1 ½, ¾, 3/8, 4, 8, 16, 30, 50, 100, 200, PAN. The test object mold is a cylinder measuring 100 mm x 200 mm and a concrete block measuring 100 mm x 100 mm x 400 mm. Compression Testing Machine. Universal Testing Machine.

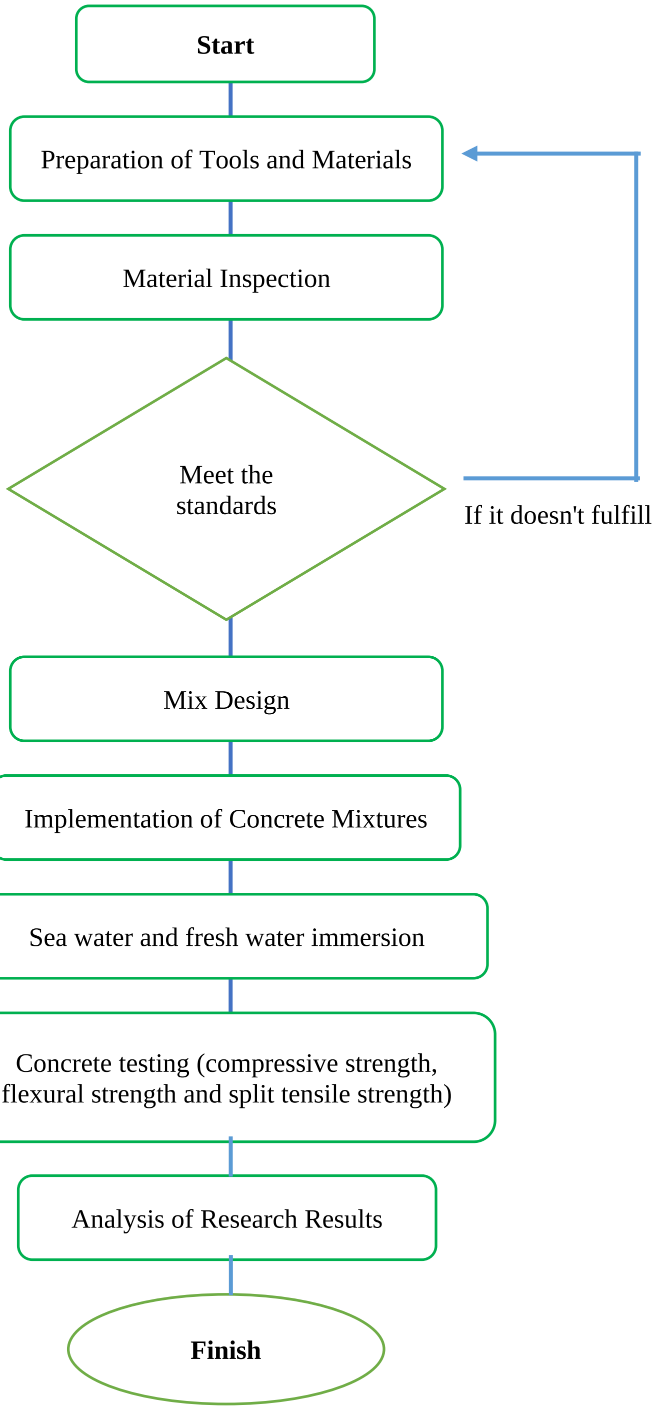

Figure 1. Flow chart

Methods

This research was carried out using scientific methods, so this research must be carried out in a systematic and more organized manner in order to obtain reliable research results. The independent variables used in this research are coarse aggregate fineness modulus and sea water immersion, while the dependent variables are concrete compressive strength, split tensile strength and flexural strength. The mixture variations for coarse aggregate consist of Fine Grain Modulus 6.0; 6.5 ; 7.1

with additional curing of sea water and fresh water for 28 days. By using varying fineness modulus measurements in the concrete mixture, it is hoped that the compressive strength, splitting tensile strength and flexural strength will be used as reference data in determining the effect of fineness modulus on compressive strength, splitting tensile strength and flexural strength.

Testing for compressive strength in this study was divided into two, namely compressive strength in fresh water immersion and compressive strength in sea water immersion. A cylindrical test object measuring 10 cm x 20 cm is mounted on the UTM testing equipment in a vertical position. The load is applied until the sample breaks or the sample can no longer withstand the load received, if the black needle has gone down then the load on the test object has reached its maximum.

Figure 2. Compressive Strength Test

Testing for split tensile strength in this research consisted of 2 types of treatment, first with sea water and also fresh water as a comparison. This is intended as a control test object. The test object is a cylinder with dimensions of 10 cm x 20 cm installed on the UTM tool with the test object horizontal. Loading is carried out until the test object cracks or the test object can no longer withstand the given load, this is indicated by the pointer on the UTM tool, if the colored needle has gone down then the load on the test object has reached its maximum.

Figure 3. Split Tensile Strength Test

Flexural strength testing in this research consisted of 2 types of treatment, first with sea water and also fresh water as a comparison. This is intended as a control test object. The test object is a beam with dimensions of 10 cm x 10 cm x 40 cm installed on the UTM tool with the test object positioned horizontally. Loading is carried out until the test object cracks or the test object can no longer withstand the given load, this is indicated by the pointer on the UTM tool, if the colored needle has gone down then the load on the test object has reached its maximum.

Figure 4. Flexural Strength Test

Data Analysis

Data analysis researchers tested the characteristics of the materials that make up high quality concrete, namely fine aggregate and coarse aggregate. In this test the requirements are adjusted to the aggregate characteristic specifications according to SNI. From this test, it can be seen that the concrete constituent materials meet the standards.

RESULTS AND DISCUSSION

Compressive Strength Testing

The compressive strength test submerged in sea water can be seen in Figure 4.3, concrete with MHB 6.0 has an average compressive strength value of 36.94 then decreases to MHB 6.5 with an average compressive strength value of 36.52 MPa and decreases. at MHB 7.1 with an average compressive strength value of 30.15 MPa. The effect of fine grain modulus on the compressive strength of concrete which forms a 2nd order polynomial equation, $Y = -8.8879x^2 + 110.26x - 304.65$ and $R^2 = 1$.

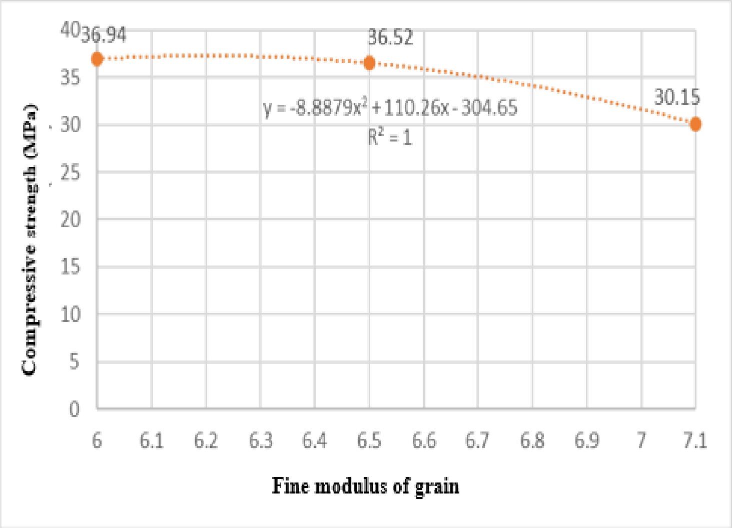

Figure 5. Relationship between fine grain modulus and compressive strength of concrete submerged in sea water

Meanwhile, when testing the compressive strength of concrete by immersion in fresh water, it can be seen that there is a decrease in the compressive strength value. Concrete with MHB 6.0 has an average compressive strength value of 35.7 MPa, then decreases to MHB 6.5 with an average compressive strength value of 31.63 MPa and decreases again to MHB 7.1 with an average compressive strength value. -average 29.3 MPa. Besides that, Figure 4.4 shows the effect of the fine grain modulus on the compressive strength of concrete which forms a 2nd order polynomial equation, Y = $-3.7959x^2 + 55.517x - 232.12$ and $R^2 = 1$.

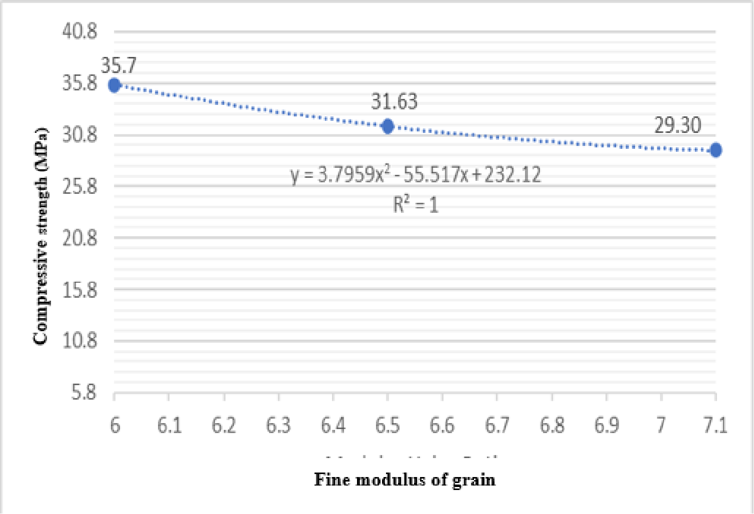

Figure 6. Relationship between Fine Grain Modulus and Concrete Compressive Strength Submerged in Fresh Water

Split Tensile Strength Testing

Split tensile strength testing, fresh water soaked concrete with a fineness modulus of 6.0; 6.52 and 7.1 have split tensile strength values that continue to decrease, starting with 2.71 MPa then decreasing to 2.65 MPa and ending at 1.91 MPa. The results of the graphic analysis of polynomial equations show that y = -1.055x2 + 13.093x - 37.868 or $R^2 = 1$.

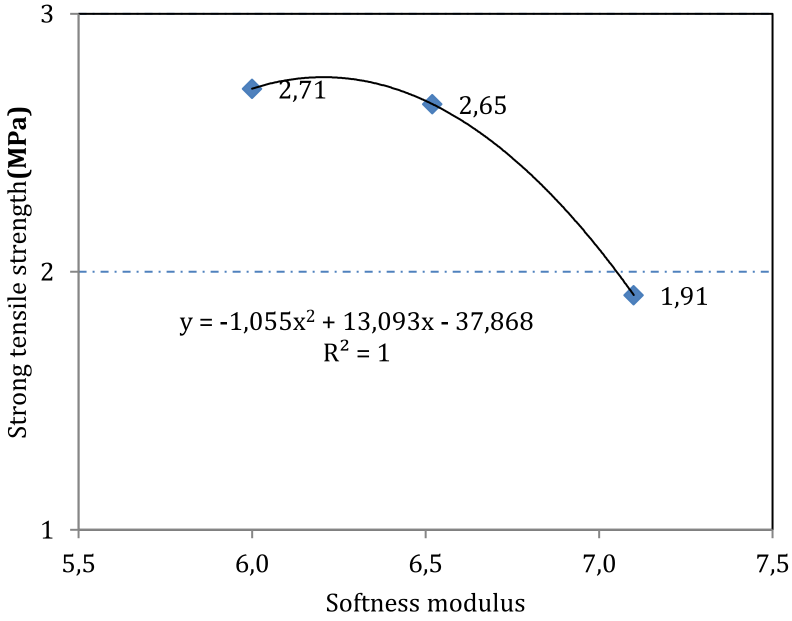

Figure 7. Relationship between tensile strength of concrete and fresh water immersion

The split tensile strength test results show that seawater soaked concrete with a fineness modulus of 6.0, 6.52 and 7.1 has a split tensile strength value that continues to decrease, starting with 2.71 MPa then decreasing to 2.65 MPa and ending at 1.91 MPa. The results of the graphic analysis of polynomial equations show that y = -1.055x2 + 13.093x - 37.868 or R² = 1.

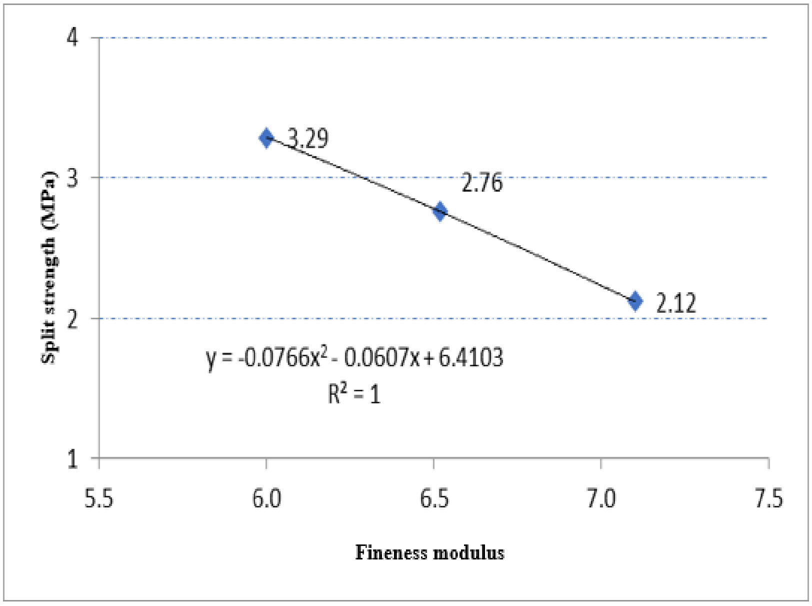

Figure 8. Relationship between tensile strength of concrete and sea water immersion

Flexural Strength Testing

Flexural strength testing, freshwater-soaked concrete with a fineness modulus of 6.0, 6.52, and 7.1 has a flexural strength value that continues to decrease, starting with 4.22 MPa then dropping to 4.21 MPa and ending at 4, 14 MPa. The results of the graphic analysis of polynomial equations show that y = -0.0922x2 + 1.1356x + 0.7271 or R²=1.

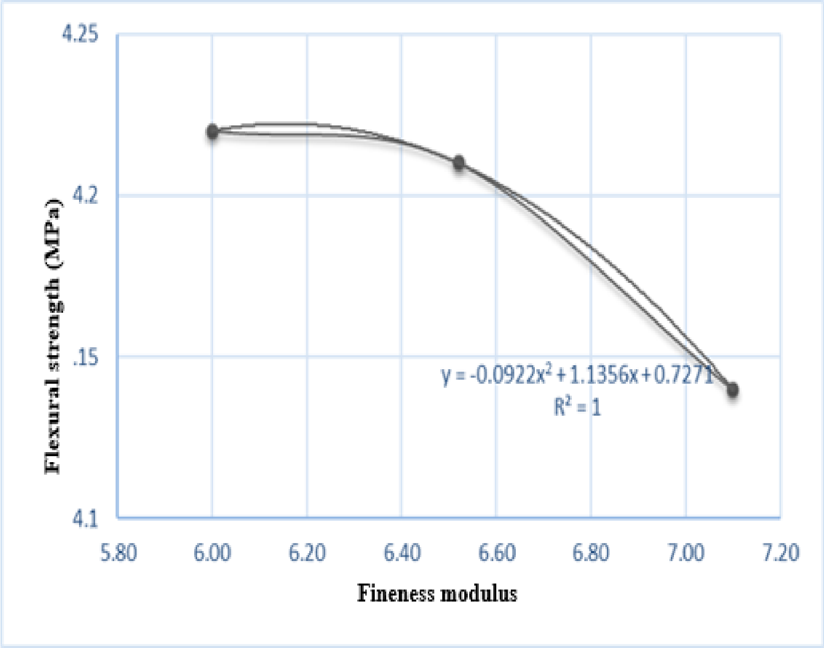

Figure 8. Relationship between tensile strength of concrete and sea water immersion

Flexural Strength Testing

Flexural strength testing, freshwater soaked concrete with a fineness modulus of 6.0, 6.52, and 7.1 has a flexural strength value that continues to decrease, starting with 4.22 MPa then dropping to 4.21 MPa and ending at 4, 14 MPa. The results of the graphic analysis of polynomial equations show that $y = -0.0922x2 + 1.1356x + 0.7271$ or $R^2=1$.

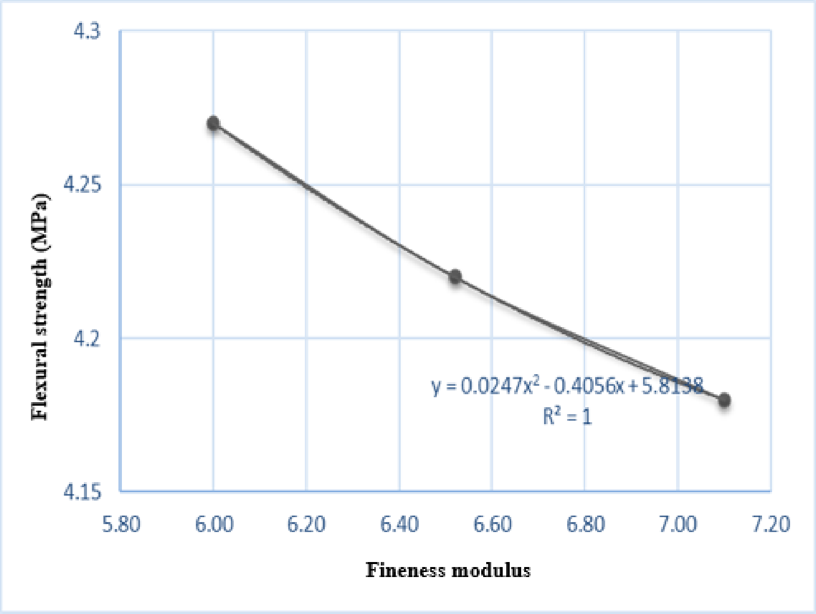

Figure 9. Relationship between the flexural strength of concrete and sea water immersion

CONCLUSION

Compressive strength value with variations in fineness modulus 6.0; 6.52; and 7.1, there was a decrease of 36.94 MPa, 36.52 MPa and 30.15 MPa respectively in seawater immersion. Meanwhile, samples soaked in fresh water had a lower compressive strength than sea water with values of 35.67 MPa, 31.63 MPa and 29.30 MPa. So there is a decrease in strength with immersion in fresh water compared to sea water. Split tensile strength value with variations in fineness modulus 6.0; 6.52; and 7.1, there was a decrease of 3.29 MPa, 2.76 MPa and 2.12 MPa respectively when submerged in sea water. Meanwhile, samples soaked in fresh water had a lower split tensile strength than sea water with values of 2.71 MPa, 2.65 MPa and 1.91 MPa. So there is a decrease in strength with immersion in fresh water compared to sea water. Flexural strength value with variations in fineness modulus 6.0; 6.52; and 7.1, there was a decrease respectively of 4.27 MPa, 4.22 MPa and 4.18 MPa in seawater immersion. Meanwhile, samples soaked in fresh water had lower flexural strength than sea water with values of 4.22 MPa, 4.21 MPa and 4.14 MPa. So there is a decrease in strength with immersion in fresh water compared to sea water. The greater the fineness modulus value of the coarse aggregate, the smaller the compressive strength, splitting tensile strength and flexural strength values obtained.

ACKNOWLEDGEMENT

The authors would like to thank the University of Fajar Makassar and the author is also grateful to those who have helped in carrying out this service.

REFERENCES

Ahmad, S.B. (2018) ‘Investigasi Pengaruh Air Laut Sebagai Air Pencampuran Dan Perawatan Terhadap Sifat Beton’, Intek: Jurnal Penelitian, 5(1), P. 48. Doi:10.31963/Intek.V5i1.200.

Arinata, A.S., Hidayat, M.T. And Wibowo, A. (2012) ‘Pengaruh Campuran Kadar Bottom Ash Dan

Lama Perendaman Air Laut Terhadap Kuat Tekan Pada Silinder Beton', 59, Pp. 1–11.

Asmara, F.J., Suhendra, S. And Dwiretnani, A. (2021) 'Analisis Perbandingan Kuat Tekan Dan Kuat Tarik Beton Yang Menggunakan Pasir Sungai Batang Asai Dan Pasir Sungai Batanghari', Jurnal Talenta Sipil, 4(1), P. 1. Doi:10.33087/Talentasipil.V4i1.42.

Besouw, G.V., Manoppo, M.R.E. And Palenewen, S.C.N. (2019) 'Pengaruh Modulus Kehalusan Agregat Terhadap Penentuan Kadar Aspal Pada Campuran Jenis Ac-Wc', Jurnal Sipil Statik, 7(4), Pp. 481–490.

Hunggurami, E., Utomo, S. And Wadu, A. (2014) 'Pengaruh Masa Perawatan (Curing) Menggunakan Air Laut Terhadap Kuat Tekan Dan Absorpsi Beton', Jurnal Teknik Sipil, 3(2), Pp. 103–110.

Khirunnisa, S., Rifqi, M.G. And Amin, M.S. (2019) 'Kajian Kuat Tekan Beton Di Lingkungan Laut Tropis Banyuwangi', Potensi : Jurnal Sipil Politeknik, 21(2), Pp. 47–53. Doi:10.35313/Potensi.V21i2.1583.

Mindrasari, P., Sambowo, K.A. And Basuki, A. (2014) 'Pengaruh Curing Air Laut Pada Beton Mutu Tinggi Dengan Bahan Tambah Abu Sekam Padi Ditinjau Terhadap Kuat Tarik Belah Dan Modulus Of Rupture _ Mindrasari _ Matriks Teknik Sipil', (September), Pp. 391–399.

Mulyadi, A., Suanto, P. And Meiza, R. (2020) 'Analisis Kuat Tarik Belah Beton Pada Standar Kuat Tekan K200 Dengan Menggunakan Limbah Pecahan Tempurung Kelapa Sebagai Pengganti Agregat Kasar', Jurnal Teknik Sipil, 10(2), Pp. 69–76. Doi:10.36546/Tekniksipil.V10i2.465.

Pandaleke, R.E. And Windah, R.S. (2017) 'Perbandingan Uji Tarik Langsung Dan Uji Tarik Belah Beton', Jurnal Sipil Statik, 5(10), Pp. 649–662.

Pujianto, A. Et Al. (2021) 'Kuat Tekan Dan Tarik Belah Beton Serat Menggunakan Aggregat Ringan', Semesta Teknika, 24(1), Pp. 1–9. Doi:10.18196/St.V24i1.12084.

Saputra, R.D. And Hepiyanto, R. (2017) 'Pengaruh Air Pdam, Laut, Comberan Pada Proses Curing Terhadap Kuat Tekan Beton Fc 14,53 Mpa', Jurnal Civila, 2(2), P. 6. Doi:10.30736/Cvl.V2i2.78.

Wibowo, W., Sunarmasto, S. And Rashad, H. (2019) 'Kajian Kuat Tarik Langsung Dan Kuat Lekat Pada Beton Mutu Tinggi Memadat Mandiri Dengan Variasi Kadar Metakaolin', Matriks Teknik Sipil, 7(4), Pp. 458–465. Doi:10.20961/Mateksi.V7i4.38486.

Wiranti, A.D. (2019) 'Beton Slag Terhadap Variasi Perawatan (Studi Eksperimental)'.

Erniati, M.W. Tjaronge, R. Djamaluddin and Victor Sampebulu. (2013) Consistency and Compressive Strength of Mortar using Seawater as mixing water. National Conference of Civil Engineering (KONTEKS 7). Vol. 1-M-33. (Indonesia).

Erniati, Tjaronge. M.W., R. Djamaluddin and Victor Sampebulu, (2014). Microstructure Characteristics of Self Compacting Concrete using Sea Water, International Journal of Applied Engineering Research (IJAER), Vol 9 No. 22 (2014) pp 18087-18095.

Artawan, I. P., Chaerul, M., & Gusty, S. (2023). Characterization of Oil and Diesel Waste Modifiers in Lasbutag Asphalt Cold Mix (Aggregated Buton Asphalt Layer). ASTONJADRO, 12(3), 823–829. https://doi.org/10.32832/astonjadro.v12i3.13868

Verdian, R., & Muin, R. B. (2023). The effect of variation in the length of water hyacinth fiber twisted on split tensile strength high performance fiber concrete. ASTONJADRO, 12(2), 546–557. httpBaggio, E. Y., Bagio, T. H., & Tistogondo, J. (2023). Mix design programming for normal concrete using cubic equation. ASTONJADRO, 12(1), 77–85. https://doi.org/10.32832/astonjadro.v12i1.7143s://doi.org/10.32832/astonjadro.v12i2.9346

Paikun, P., Amdani, S. A., Susanto, D. A., & Saepurrahman, D. (2023). Analysis of the compressive strength of concrete from brick wall waste as a concrete mixture. ASTONJADRO, 12(1), 150–162. https://doi.org/10.32832/astonjadro.v12i1.8145

Sitompul, S. T., & Pariatmono, P. (2022). Reliability of simple space truss structure.

ASTONJADRO, 11(3), 600–607. https://doi.org/10.32832/astonjadro.v11i3.7399

Romadhon, E. S., Antonius, A., & Sumirin, S. (2022). Design of Low Alkali activator Geopolymer Concrete Mixtures. ASTONJADRO, 11(3), 627–638. https://doi.org/10.32832/astonjadro.v11i3.7484

Widodo, S., Safarizki, H. A., & Marwahyudi, M. (2022). Durability of concrete based on the remaining life of the building Case study: reinforced concrete in klaten district. ASTONJADRO, 11(3), 713–720. https://doi.org/10.32832/astonjadro.v11i3.7848