
| RESEARCH ARTICLE

Utilization of Pineapple Leaf Fiber as An Added Material for Environmentally Friendly Earthquake-Resistant Concrete Repair at LPG Lombok-Indonesia Terminal

Cucuk Basuki¹ | Yudha Anugerah Putra² ✉ | Lutfii Bahroni³ | Ary Ardianto⁴ | Julian C Pratama⁵

^{1,2,3}*Institut Teknologi Sepuluh Nopember, Indonesia*

⁴*Institut Teknologi Adhi Tama Surabaya, Indonesia*

⁵*Universita Jendral Achmad Yani, Indonesia*

Corresponding Author: Yudha Anugerah Putra, **E-mail:** yudha.putra@pertamina.com

| ABSTRACT

Concrete is a building material that is often used because it is strong against presses but weak to bending forces. A solution is needed to fix the weakness. To overcome this, this study was conducted to increase the strength of the compressive force and bending force on environmentally friendly earthquake-resistant concrete, as well as reduce the pollution of concrete materials in the Lombok LPG Terminal. This research uses a descriptive qualitative approach starting from literature studies, repair preparation, implementation of improvements, strong press, and strong flexure tests, analysis and discussion, and conclusions. The results showed that the compressive and flexible strength of concrete that was given additional pineapple leaf fiber material with a composition of 15% had a strength greater than normal concrete. In conclusion, the utilization of pineapple leaf fiber in the manufacture of environmentally friendly earthquake-resistant concrete is able to increase the compressive strength and strong bending of concrete.

| KEYWORDS

Earthquake Resistant Concrete, Pineapple Leaf Fiber, Compressive Strength and Bending Strength

| ARTICLE DOI: [10.32996/jhsss.2022.4.2.14](https://doi.org/10.32996/jhsss.2022.4.2.14)

1. Introduction

Based on the instructions of the president director by Fax. No. 139/C00000/2020-S4 dated April 06, 2020, concerning efforts to secure the company's operational and financial conditions in 2020. The instructions mentioned that all directorates/functions/subsidiaries make OPEX savings of at least 30% while still prioritizing HSE so that operational activities can run effectively and efficiently. The results of the analysis showed that the most common problems found were service costs, including; repair, maintenance, replacement, and calibration. The pareto data shows that building construction repair work is the most carried out within 1 (one) year, so it is necessary to make improvements, especially in materials used to be more economically valuable, environmentally friendly, and strongly fibrous.

Repair of building construction, not separated from the building materials used. Concrete is a building material produced by a mixture of cement, fine aggregates, and water and can be added with other additive materials (Almachzuuni, 2020). In terms of building work, concrete dominates the use in building structures because concrete material is a material that is easy to obtain in all places. In addition, the concrete material is cheaper, able to carry a large load, and practical in its work (Humaidi et al., 2019). Concrete, as the main material in building structures, has undergone rapid progress and development. This can be reviewed in terms of the quality of the concrete produced (Fauzaan, 2022).

The problem that often occurs is that many materials are cracked and broken easily because concrete materials have a much greater compressive strength compared to flexible strength based on mechanical characteristics (Agustina, 2021). This is the driver that a concrete material needs to be developed with composite materials, such as reinforced concrete so that the tensile area on

the building structure is held and shouldered by reinforcement steel (Aritonang, 2020). Composite concrete that gets tensile voltage exceeding the tensile strength of concrete can create cracks and corrosion in reinforcement steel, which in the long run can result in the failure of building structures (Yudoprasetyo, 2021). Reviewing this, it is necessary to improve the quality and properties of concrete through the replacement or addition of aggregate and cement staple materials.

Along with the times, the construction industry continues to increase and strive for the preservation and saving of natural resources (Ervianto, 2018). Thus, it is necessary to make intensive efforts in the utilization of waste, such as pineapple leaf waste that can be added to the concrete making mixture to create an environmentally friendly earthquake-resistant concrete material. The provision of the waste material of pineapple leaf fiber is intended in order to speed up the hardening process, slow down the binding time, increase the level of dilution of the complainukan, reduce cracks during hardening, increase da'ethylity, reduce hydration heat, increase the level of durability, and increase the steadiness of concrete material (Anuar, 2020).

Fiber or fiber is one of the materials that can be added to the concrete mixture (marzuki, 2020). Fiber on concrete aims to prevent cracks in concrete so that concrete becomes more daktail (Iqbal, 2021). As for the types of fiber that can be used, namely natural fiber and artificial fiber (Hanafi, 2018). In this case, the fiber used is a type of natural fiber, namely pineapple leaf fiber.

Pineapple is a fruit plant in the form of a shrub with the scientific name *Ananas comosus* (Amsia, 2020). The plant is easily cultivated in Indonesia because of the tropical climate that is very suitable for pineapple plants. This is evidenced by the area of pineapple plants that occupy the first position over other types of commercial fruits in Indonesia (Astoko, 2020). Pineapple leaves are shaped like a tapered sword with a blackish-green color, and there are sharp thorns on the edges of the leaves (Hidayat Nisa, 2018). The fiber of pineapple leaves is a type of fiber derived from pineapple leaves that have a high fiber content (Wiranto, 2021). Pineapple leaf fiber is a composite of natural fibers, with a flexible strength reaching 42.33 kg / mm² (Supriyatna Solihin, 2018). Pineapple leaves have as well as classified as fine fibers, where the finer the fiber, the wider it can bear the shear load and allow the smaller the defect in the matrix (Oktaviani Puryati, 2020).

The utilization of waste used as additional material in the concrete manufacturing mixture has produced positive results. This is reviewed from previous research that said that the use of waste shell dara as an added material against the strength of normal concrete presses showed results were able to provide an increase of 7 MPa in the mixture of added materials of 5% and 3 MPa in the mixture of added materials 7.5% (Andika Safarizki, 2019). This is in line with Purwanto (2022), which shows the result that there is a strong increase in pressure on K225 concrete in the addition of banana ash by 2%. The novelty in this study is the added material used in the concrete-making mixture, namely pineapple leaf fiber, to create earthquake-resistant concrete that is environmentally friendly.

Based on the above exposure, the author felt interested in conducting research with the title of utilizing pineapple leaf fiber as an added material for the improvement of environmentally friendly earthquake-resistant concrete at the Lombok-Indonesia LPG terminal. Reviewing that pineapple leaf fiber is easy to obtain, economically valuable, benefits pineapple farmers, and avoids environmental pollution caused by excessively rotting pineapple leaves. In addition, pineapple leaves are considered to have strong fiber; pineapple leaves used are pineapple leaves that have been dried. This research aims to increase the strength of compressive force and bending force on environmentally friendly earthquake-resistant concrete, as well as reduce the pollution of concrete materials in Lombok LPG Terminal.

2. Literature Review

2.1 concrete

Concrete is a material from a mixture of cement, water, and aggregates, both rough and fine (Mustika et al., 2016). Cement and water are put together and can form a cement paste that serves as a binder. Fine aggregates and coarse aggregates are used for fillers (Rasoni Yurisman, 2014), where fine aggregates act as coarse aggregate cavity fillers. The material is selected and mixed with a certain comparison in order to produce the desired concrete, with characteristics including; weather resistance, strong press and flexible, quality, and has an economical cost (Mulawarman et al., 2019). Even the mixing of materials will be homogeneous so that they bind and fill each other between all materials at the time of casting and printing concrete (Ayu, 2020).

2.1.1 concrete compressive strength

Concrete is known for its prominent press strength, so it has become something targeted in the manufacture of concrete. The ratio of cement to water, grading, surface texture, cement to aggregate ratio, shape, the strength of aggregate particles, as well as the maximum size of aggregates can affect the strength of concrete (Zulhendri, 2018). A strong concrete press check needs to be done to find out the compressive strength of the concrete at the age of 28 days and whether it is as planned. In the concrete press strong test machine, the object is placed and given a load until the object collapses, that is, when the maximum load is working.

2.1.2 Strong Bending Concrete

The tensile strength of concrete bending is a concrete block's ability to bear the bending tensile tension caused by the bending moment placed on two beds (Rumajar et al., 2019). The unit to express the tensile strength of concrete bending is the Mega Pascal unit (MPa).

2.2 Pineapple Leaf Fiber

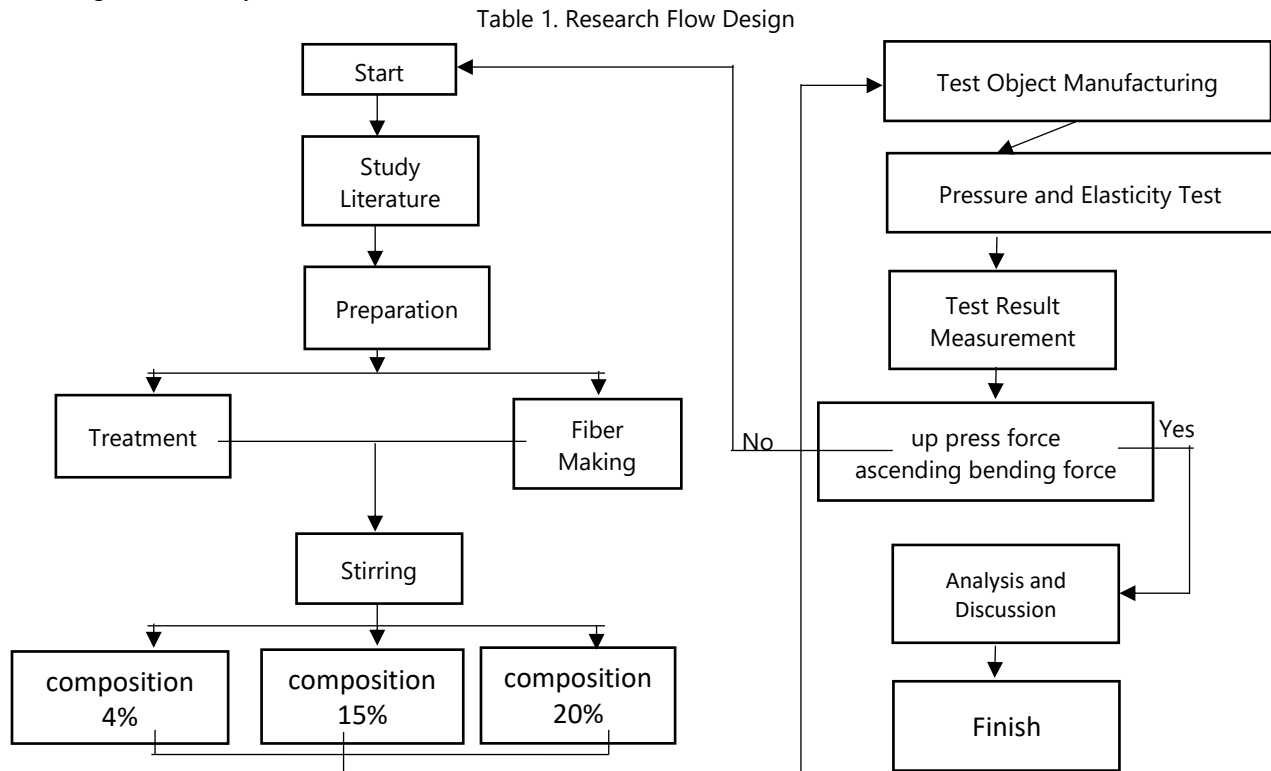
Pineapple leaf fiber is one type of fiber from the leaves of the pineapple plant. The pineapple plant is scientifically named *Ananas Cosmosus*, which generally belongs to the annual plant type. This plant originated in Brasilia and was then brought to Indonesia by Spanish and Portuguese sailors around 1599 (Ramadan et al., 2019). In Indonesia, the plant is widely cultivated, especially on the islands of Java and Sumatra, as one of the natural resources that are quite potential (Shofi et al., 2018). Pineapple plants will be dismantled after two or three harvests to replace new plants. Pineapple leaf waste is quite a lot, and sustainable can be used as an added material for making concrete to provide added value to the compressive strength and bending of concrete.

The shape of pineapple leaves is similar to a tapered sword at the end of which is blackish-green, and on the edges of the leaves, there are sharp thorns. The length of pineapple leaves ranges from 55 to 75 cm, with a width of 3.1 to 5.3 cm and a leaf thickness between 0.18 to 0.27 cm. The planting distance and intensity of the sunlight can affect the growth of leaf length and the nature of the fiber produced. The intensity of sunlight is not too much and will produce fibers that are strong, smooth, and silk-like (Paradise, 2021). There are more than 50 varieties of pineapple plants in the world; some varieties of pineapple plants that have been cultivated in Indonesia include Cayenne, Spanish / Spanish, Abacaxi, and Queen (Murdiyanto, 2017).

3. Methodology

3.1 Research Flow Design

The flow design in this study is as follows:



3.2 Repair Plan

Plans and efforts made in order to reduce the cost of building construction repairs at lpg terminal Lombok in this study include; the collection of literature studies used to collect data as a basis for work; preparing the materials to be used; conducting material trials in the laboratory of Mataram University to get the best material results that can be used as a mixing material on concrete; manufacture and blending of cement, water, sand, gravel, and pineapple leaf fibers; conduct a trial until successful; and evaluation and manufacture of finished products that can be used in the construction of Bresting Dolpin buildings in LPG Lombok Terminal.

3.3 Preparation and Manufacture of Test Samples

Pineapple leaves are crushed and taken fiber, and then dried to dry; the length of pineapple leaf fiber in each sample mold is the same, which is 30 cm x15 cm. The fibrous concrete board is made with mold measuring 30 cm x 15 cm for testing water absorption, density, compressive strength, and bending strength. The materials used in the manufacture of fibrous concrete can be seen in Figure 1 as follows:

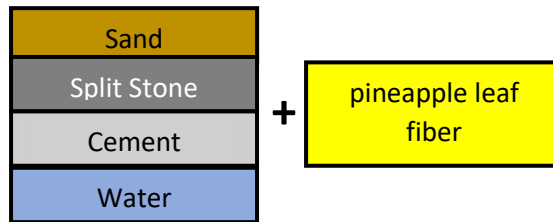


Figure 1. Fibrous Concrete Mix Material

Comparison between cement, sand, and split on masing-each sample is 1:2:3. The percentage of pineapple leaf fiber used is 4%, 15%, and 20%. The printed sample is idled for 28 days at room temperature before being used for standardized testing. The study was conducted three times for each type.

3.4 Testing of Mechanical Properties of Earthquake-Resistant Concrete with Pineapple Leaf Fiber Added Material

3.4.1 Compressive Strength

The compressive force is the magnitude of the burden of broad unity that causes the test object to disintegrate (Mardian et al., 2022). The pressure strength value is calculated using equations as follows:

$$f_c = \frac{P}{A}$$

The equation above indicates that f_c is the compressive force (kg / cm²), P is the maximum load (kg), and A is the surface area (cm²).

3.4.2 Bending Strength

Bending strength is a concrete ability to withstand bending forces in a perpendicular direction in the cross-section of test samples (Kahani Susilo, 2019). The bending strength value is calculated using equations as follows:

$$F_r = \frac{3pL}{2BH^2}$$

The equation above shows that f_r is the flexure force (kg / cm²), P is the maximum load (kg), L is the focal distance (cm), B is the width of the test sample (cm), and H is the thickness of the test sample (cm).

4. Results and Discussion

4.1 Compressive Strength Test Results

This compressive strength test uses a cylinder measuring 15 x 30 cm. After testing the compressive strength of concrete, aged 28 days. The results of the concrete compressive strength for each variation are seen in the table below:

Table 2. Concrete Press Strength Test Results with Pineapple Leaf Fiber Added Material

Test Name	Before Repair	experiment 1	experiment 2	experiment 3
Type Material	Concrete	Pineapple Leaf Fiber + Concrete	Pineapple Leaf Fiber + Concrete	Pineapple Leaf Fiber + Concrete
Test Method	Press Strength Test	Press Strength Test	Press Strength Test	Press Strength Test
Specimen Size (mm)	300 x 150	300 x 150	300 x 150	300 x 150
Pineapple Leaf Fiber Composition	0%	4%	15%	20%
Compressive Strength	24,39 MPa	29,11 MPa	37,89 MPa	36,47 MPa

Based on table 2. Above, it can be obtained the following graph:

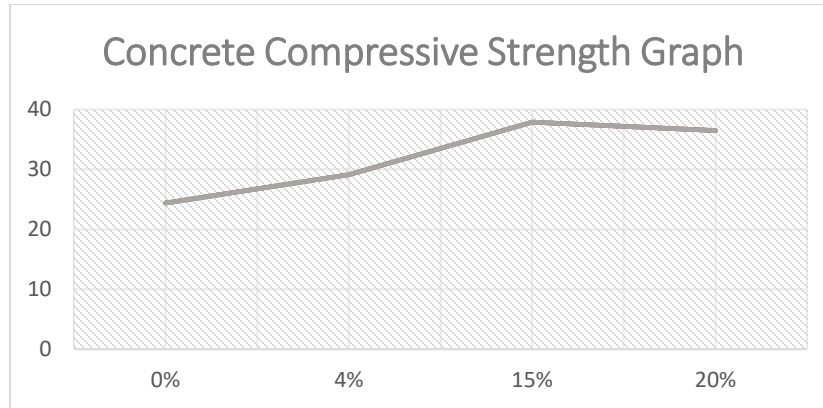


Figure 2. Concrete Press Strength Graph with Addition of Pineapple Leaf Fiber

Based on the results of testing the influence of the percentage of pineapple leaf fiber on the pressure strength value of earthquake-resistant concrete, it is known that the greatest pressure strength value among the concrete given the additional material of pineapple leaf fiber is earthquake-resistant concrete which is given a percentage of pineapple leaf fiber of 15%. Thus, it is known that the results of environmentally friendly earthquake-resistant concrete press strength with pineapple leaf fiber added material increased by 13.50 MPa from normal concrete, which, if indicated, the increase reached 36%. This is in line with the results of yanti et al. (2019) research that pineapple leaf fiber is able to provide an increase in the value of compressive strength and bending strength of concrete.

4.2 Bending Strength

Flexure strength testing on earthquake-resistant concrete samples with pineapple leaf fiber additives can be seen in the table below:

Table 2. Concrete Bending Strength Test Results with Pineapple Leaf Fiber Added Material

Test Name	Before Repair	experiment 1	experiment 2	experiment 3
Type Material	Concrete	Pineapple Leaf Fiber + Concrete	Pineapple Leaf Fiber + Concrete	Pineapple Leaf Fiber + Concrete
Test Method	Flexure Strength Test	Flexure Strength Test	Flexure Strength Test	Flexure Strength Test
Specimen Size (mm)	300 x 150	300 x 150	300 x 150	300 x 150
Pineapple Leaf Fiber Composition	0%	4%	15%	20%
Bending Strength	13,33 MPa	13,68 MPa	16,41 MPa	15,04 MPa

Based on table 2. Above, then can be obtained a graph, as follows:

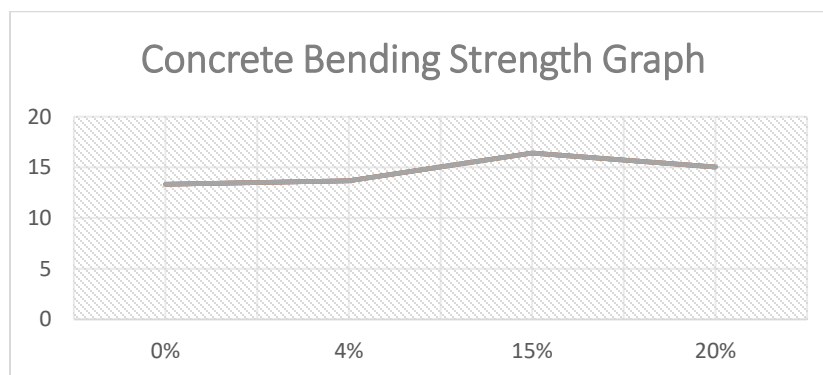


Figure 2. Concrete Bending Strength Graph with The Addition of Pineapple Leaf Fiber

Based on the results of testing the influence of the percentage of pineapple leaf fiber on the value of the pressure strength of earthquake-resistant concrete, it is known that the greatest bending strength value among concrete given the additional material of pineapple leaf fiber is earthquake-resistant concrete given a percentage of pineapple leaf fiber of 15%. Thus, it is known that the results of environmentally friendly earthquake-resistant concrete bending strength with pineapple leaf fiber added material

increased by 3.08 MPa from normal concrete, which, if indicated, the increase reached 23%. This is in line with the results of Setiawan's research (2021) that there is an interaction between concrete bending and the addition of pineapple leaf fibers, where there is an increase in the value of compressive strength, bending strength, and tensile strength.

5. Conclusion

After literature studies, manufacture of test objects, testing of compressive strength and bending strength, and calculations carried out in the Laboratory of Mataram University; it can be concluded, among others: pineapple leaf fibers added in the manufacture of environmentally friendly earthquake-resistant concrete affect the mechanical properties of the resulting concrete. The most optimal pineapple leaf fibrous concrete is at a percentage or fiber composition of 15% with a pressure strength value of 37.89 MPa and a bending strength value of 16.41 MPa. Pineapple leaf fiber that is used as an added material in the manufacture of gamba-resistant concrete is intended to reduce the pollution of concrete materials.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

- [1] Agustina, A. (2021). Calculation of Concrete Volume in The Canteen Building Column (Construction Project of Pt. Pelabuhan Indonesia II Long Branch). *Journal of Engineering Sciences*, 1(3).
- [2] Almachzuuni, K. A. (2020). Effect of Adding Corn Janggal Ash Variation With Bamboo Fiber Against Concrete Tensile Strength Test. The Islamic University of Malang.
- [3] Amsia, M. H. S. (2020). Pineapple Fruit (Ananas Comosus L.) As a Factor in Reducing The Risk of Chronic Inflammation In Infectious Diseases. *Medical Profession Journal Of Lampung*, 10(2), 365–369.
- [4] Andika, R., Safarizki, H. A. (2019). Utilization of Dara Shell Waste (Anadara Granosa) As An Added Material And Complement To Normal Concrete Press Strength. *Modulus: World Communication Media Civil Sciences*, 1(1), 1–6.
- [5] Anuar, M. (2020). Effect of Addition of Andilau Bark Fiber (Commersonia Bartramia) With Alkali Treatment Against Compressive Strength, Pull, And Bending Concrete. Bangka Belitung University.
- [6] Aritonang, R. V. (2020). Effect of Variation in Spiral Sengkang Reinforcement Distance on The Bending Strength of Reinforced Concrete Blocks. Medan Area University.
- [7] Astoko, E. P. (2020). Pineapple Agribusiness Development Concept (Ananas Comosus L. Merr.) In Kediri Regency, East Java Province. *Habitat*, 30(3), 111–122.
- [8] Ayu, I. S. R. I. (2020). Effect of Concrete Press Strength With The Addition of Stone Ash As A Fine Aggregate. Quality University
- [9] Ervianto, W. I. (2018). Study of the Competitiveness of Construction Service Providers in the Perspective of Sustainable Construction in Indonesia. *Scientific Journal of Civil Engineering*, 22(1), 7–15.
- [10] Fauzaan, F. (2022). Effect of The Addition of Vegetable Waste Extract In Part Of Cement Weight Against Slump Value 60-180 And Concrete Press Strength Value In Self Healing Concrete Process. *The Islamic University of Riau*.
- [11] Firdaus, M. Y. (2021). Characterization Test of Natural Fiber Contained Composite Material Volume Fraction 10% Injection Molding Method. *National Institute of Technology*
- [12] Hanafi, M.M. (2018). Addition of Bamboo Skin Fiber Alkali Treatment To The Mechanical Properties of Concrete With Age Variation. The State University of Malang.
- [13] Hidayat, R. A., Nisa, A. A. (2018). Extraction of Pineapple Leaf Fiber as a Material For Textile Fiber. *Ten November Institute of Technology*.
- [14] Humaidi, M., Yanuar, K., Rafik, A. (2019). Local Aggregate Effect on Index Value And Cost On Concrete Work Unit Analysis F'c 20 Mpa. *Journal of Civil Gradation*, 2(2), 22–29.
- [15] Iqbal, M. (2021). Study of The Addition of Toothpick Fiber From Bamboo To Concrete Press Strength. *Civil Engineering*.
- [16] Kahani, M. A., Susilo, D. (2019). Effect of Addition of High-Density Polyethylene Plastic Waste Fiber (Hdpe) With Percentage 0.5%, 0, 7%, And 0.9% On Reinforced Concrete Against Bending Strength Effect Of Adding High-Density Polyethylene (Hdpe Plastic Waste) With Percentage Of 0.5%, 0.7%, And 0.9% In Reinforced Concrete Against Flexural Strength. University Technology Yogyakarta.
- [17] Mardian, F., Indra, F., Rini, M. (2022). Effect of Various Distances External Confinement Against Concrete Press Strength By Using Steel Strapping. Hatta University.
- [18] Marzuki, R. (2020). Study Analyzes the Use of Fiber Fiber as a Material to Add Concrete Mixture Fc 300. Curve S: *Journal of Scientific and Civil Engineering Applications*, 7(1), 46–60.
- [19] Mulawarman, B. P., Rahman, T., Abdi, F. N. (2019). Study of The Effect of Adding Plastocrete Rt6 Plus To Concrete Quality On Foundries That Experience Delays By Maintaining Slump Value. *Proceedings of the National Seminar on Technology, Innovation and Applications in the Tropical Environment*, 2(1), 9–17
- [20] Murdiyanto, D. (2017). The Potential of Natural Fiber of Indonesian Plants as a Fiber Reinforced Composite Dentistry Material. *Journal of Dental Materials*, 6(1), 14–22
- [21] Mustika, W., Salain, I.M. A. K., Sudarsana, I. K. (2016). Use of Nickel Slag as an Aggregate In Concrete Mixtures. *Spektran Journal*, 4(2)
- [22] Oktaviani, S., Puryati, D. (2020). Effect of Pineapple Leaf Fiber Addition On Physical And Mechanical Properties of Gypsum Cement Board. *Journal of Physics Unand*, 9(1), 31–37.
- [23] Purwanto, H. (2022). Utilization of Banana Frond Geda Jejawi Village as an Alternative Added Material for Concrete Press Strength. *Cycle: Journal of Civil Engineering*, 8(1), 58–69.

- [24] Ramadan, B. R., Rangkuti, M. E., Safitri, S. I., Apriani, V., Raharjo, A. S., Titisgati, E. A., Afifah, D. N. (2019). The Effect of The Use of Sugar And Urea Source Types on Nata De Pina Fermentation Results. *Journal Of Nutrition College*, 8(1), 49–52
- [25] Rasoni, Y., Yurisman, Y. (2014). High-Quality Concrete Manufacturing Research With Cement Pcc Uses Sikafume And Viscocrete-10 As Added Materials. Abstract Of Undergraduate Research, Faculty Of Civil And Planning Engineering, Hatta University, 1(2)
- [26] Rumajar, R. J., Sumajouw, M. D. J., Pandaleke, R. E. (2019). Geopolymer Concrete Bending Tensile Strength With Room Temperature. *Static Civil Journal*, 7(1)
- [27] Setiawan, T. (2021). Fiber Concrete Experiment Study Using Pineapple Leaf Waste Fiber With Concrete Quality 30 Mpa. Bengkalis State Polytechnic.
- [28] Shofi, M., Fatikasari, S., Adzim, R. A., Fitriasari, I., Yoga, A. T. R. I. (2018). Initiation of Root Formation on the Crown of pineapple plants (*Ananas Comosus* (L.) Merr.) After Being Treated with Iba Hormones. Synthesis Proceedings (National Seminar on Science, Technology, and Analysis)
- [29] Supriyatna, A., Solihin, Y. (2018). Development of Pineapple Fiber-Filled Epoxy Composites for Car Interior Applications. *Teknobiz: Scientific Journal of the Master of Mechanical Engineering Study Program*, 8(2), 88–93.
- [30] Wiranto, A. (2021). Polymer Composite Strength Analysis With Pineapple Leaf Fiber Booster. *Journal of Materials Engineering, Manufacturing, and Energy*, 4(1), 47–55.
- [31] Yanti, G., Zainuri, Z., Megasari, S. W. (2019). Study of Waste Utilization of Pineapple Leaf Fiber On Compressive Strength And Bending Strength of Concrete. *Cycle: Journal of Civil Engineering*, 5(2), 79–86.
- [32] Yudoprasetyo, K. (2021). Pull Out Test Behavior On Corroded Reinforcement On Concrete Using Meso Scale Modeling. Ten November Institute of Technology.
- [33] Zuhendri, Z. (2018). Comparison Study on the Use of Various Brands of Cement Against the Connection of Compressive Strength And Flexible Strength of Rigid Pavement Concrete. *Islamic University of Riau*