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EFFECT OF RESAM FIBER ADDITION (DICRANOPTERIS LINEARIS) ON THE CHARACTERISTICS OF CONCRETE

* Nopen Bariski[1], Vike Itteridi[1], and Edowinsyah[1]

[1] Pagar Alam Institute of Technology, Indonesia
*edopga18@gmail.com

Abstract

Concrete has the advantage of having a high compressive strength, can be formed according to desire, is easy to maintain, and can be used for both light and heavy construction. However, concrete also has the disadvantage that its small tensile strength makes it brittle, which can lead to sudden failure. To make concrete stronger against tensile forces caused by weather, climate, and temperature, which usually happen in concrete with a large surface area, more material can be added to the mix at the time of mixing or during the mixing process. One of the concrete additives to increase the tensile strength of concrete is fiber. The fiber in concrete prevents cracks, making it more ductile than ordinary concrete and increasing its tensile strength. Concrete that is given fiber additives is called fiber concrete.

This article shows the results of a study that looked at how adding Resam (Dicranopteris linearis) fiber to concrete changed its properties. Resam is a type of grass from the Gleicheniaceae family that grows widely in Indonesia, whose stems can be utilized as raw material for resam woven crafts. In 2022, the research was done in the lab of the Pagar Alam Institute of Technology in Kota Pagar Alam, Sumatra Selatan Province. The laboratory tests carried out in this study were (a) organic content testing (SNI 03-2816-1992), (b) mud content testing (SNI 03-6821-2002), (c) acceptable aggregate inspection, (d) slump testing (SNI 03-2458-1991), (e) concrete specific gravity testing, and (f) concrete compressive and flexural strength testing.

From the study results, adding resam fiber (Dicranopteris linearis) with a percentage of 0.5% by weight of cement affects the compressive strength and flexural strength of concrete. Based on the test results, 3 cm and 5 cm of soaked fibers were used. The compressive strength of 28-day-old concrete decreased by 0.36% from regular concrete in 3 cm of wet concrete, while the flexural strength increased by 0.02% from regular concrete in 5 cm. Compared to traditional concrete, the compressive strength dropped by 0.6%, and the flexural strength went up by 0.4%. The decrease in compressive strength is due to the addition of more absorbent fibers into the concrete, which will cause voids or cavities in the concrete, reduce the specific gravity of concrete, disrupt the bond between cement and other concrete aggregates, and increase the flexural strength due to the role of absorbent fibers to resist cracking due to high pressure. It occurs in concrete to increase the flexural strength of concrete.

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1. Introduction

Concrete is an engineering material closely resembling rock qualities and is made up of tightly linked particles. It is primarily a mix of aggregates, usually sand, gravel, and crushed rock (Kabir et al, 2019). They are linked together by a hydraulic binder, such as Portland cement, and activated by water to produce a thick, semi-homogeneous mass (Elsen et al., 2011). Concrete is the most commonly utilized building material. It has structural flexibility since it can be shaped into various shapes (Gag, 2014). As concrete becomes the primary building material, it must be high-quality and easy to use (Bura & Narkhede, 2020). This is in line with the growing need for high-quality, cost-effective concrete construction (Guida, 2017; Bura & Narkhede, 2020).

Concrete has the advantage of having a high compressive strength, can be formed according to desire, is easy to maintain, and can be used for both light and heavy construction (Ghinaya & Masek, 2022). On the other hand, concrete has a low tensile strength, which makes it weak and brittle. This can cause it to fall apart quickly. To make concrete stronger against tensile forces caused by weather, climate, and temperature, which usually happen in concrete with a large surface area, more material can be added to the mix at the time of mixing or during the mixing process. One of the concrete additives to increase the tensile strength of concrete is fiber (AL-Kharabsheh et al, 2022).

Fiber concrete is a composite material that consists of regular concrete and other materials like fibers. The function of fibers is to prevent cracks. So the concrete is thicker than regular concrete. (Hasanr et al., 2013).

One fiber that can be used as an additive is resam fiber (Marbawi & Gunawan, 2015). Resam (Dicranopteris linearis, syn. Gleichenia linearis) is a large fern species that commonly grows on roadside cliffs in the mountains. This plant is easily recognized because of its two-lined, pinnate leaves and dichotomously branched stems (Russel et al, 2003). Resam contains horn substances and is termite and humidity resistant. Inside the resam stem, some fibers are strong and durable, so they are appropriate as natural fiber for composites. (Rosa, 2016).

Based on this, it is necessary to conduct research on the use of resam fiber as a concrete mix additive, primarily to determine its effect on concrete characteristics, especially in reducing compressive strength and increasing the tensile strength of concrete; thus, cracks in concrete can be minimized and it more ductile than ordinary concrete.

2. Materials and Methods

2.1. Theoretical Frame Work

One of the advantages of concrete is that it has high compressive strength and is easy to form, making it a widely used construction material in building structures. Concrete that is weak to tensile can be increased in strength by adding fiber as an additional admixture to concrete; therefore, in the development of fibrous concrete, research is often carried out on using natural fibers for concrete, which is considered more economical and environmentally friendly. One of the fibers that can be used as an economical and environmentally friendly addition to concrete mixes is resam fiber.

a. The compressive strength of concrete

The compressive strength of concrete is the most important property of concrete quality compared to other properties. The compressive strength of concrete is determined by the ratio of cement, coarse and fine aggregates, and water. The compressive strength of concrete is the load per unit area that causes a test piece of concrete to break when a press machine applies a certain amount of force (SNI 03-1974-1990).

b. The tensile strength of concrete

Tensile strength is a measure of the strength of concrete caused by a force that tends to separate a portion of the concrete under tension (Sarfarazi, 2016). A material's tensile strength is also important for making sure it doesn't crack because of changes in humidity or temperature. The tensile strength of concrete is about one-eighth of the compressive strength when it is young and about one-twentieth after that (Shemirani, 2018).

The tensile strength of concrete is usually 8%–15% of the compressive strength of concrete. Although the tensile strength of concrete does not play a major role in the analysis and design of concrete structures, knowledge of the behaviour of concrete under stress is valuable in order to estimate the deflection at which cracks will occur.

The tensile strength can be divided into direct tensile and split cylinders. Tensile strength is a measure of the strength of concrete caused by a force that tends to separate parts of the concrete due to pulling (Resan et al, 2020).

(i). Direct Tensile

The direct tensile strength test is carried out by making a test piece in the form of a dog bone specimen (Van der Merwe, 2022). The tensile strength value obtained is calculated from the maximum tensile load (N) divided by the smallest cross-sectional area (mm^2). Direct tensile strength testing was done according to the AST M C-307-03 to compare the tensile strength of a test specimen to the plan.

(ii). Split Cylender

The tensile strength of the split is the indirect tensile strength value of the cylindrical concrete test specimen obtained from the loading of the test specimen, which is placed flat and parallel to the surface of the pressing test table (SNI-03-2491-2002).

The relationship between compressive and tensile strengths can be figured out and shown by formulas that depend heavily on how tensile tests are done in the lab.

2.2. Research Location

The research is carried out in the laboratory of the Institut Teknologi Pagar Alam, Kota Pagar Alam, Sumatera Selatan Province, in 2022.

2.3. Data

In this study, the data used for processing were obtained from laboratory test results with the following materials and equipments;

2.3.1. Materials

In this research, the materials used are:

a. Cement

Cement is a glue that holds coarse and fine aggregates together. When mixed with water, cement makes a dense mass that fills the spaces between aggregates. (Rajiman et al., 2020)

b. Aggregate

Aggregate is granular material such as sand, gravel and crushed stone, which is used together with a binding medium to form concrete. Aggregate is a very important supporting factor for fluency production. Good aggregate design is hoped that production progress can run smoothly. Aggregates in their natural properties are divided into two, namely natural aggregates and artificial aggregates. Aggregate implementation is classified into 3 groups:

- Stone for a grain size of more than 40 mm.
- Gravel for grain size between 5 to 40 mm.
- Sand for granular sizes of 0.15 to 5 mm.

c. Water

Water is used to make concrete mixtures, which causes a chemical reaction to happen between the cement and the other materials. The function of water is to liquefy concrete so that it is easily formed and can fill cavities evenly. Based on PUBI 1982, the requirements for good water to be able to react when making concrete are as follows:

- Water must be clean.
- Water does not contain levels of mud, oil, and other floating objects that can be seen by the eye.
- Water does not contain salt which can dissolve and damage concrete more than 5 gr.

d. Addictive Concrete Mixture

Resam is a grass in the Gleicheniaceae family that grows abundantly in Indonesia. Resam stems can be used as raw material for woven resam handicrafts. As soon as the stems are taken from where they grow, they are peeled and then woven into handicrafts. In addition, the peeled stems can be used as rope, and the advantage is that they are not easily broken and have a fairly strong tensile strength (Marbawi & Gunawan, 2015).

Resam is a pteridophyte (fern) that usually grows on cliffs by mountain roads. Resam is also a type of forest fern that lives around rubber plantations. Resam stem fiber can be utilized as a raw material for woven crafts that have termite-resistant properties, are resistant to moist air, and have good enough tensile strength (Rosa, 2016).

2.3.2. Equipments

Figure 1. Resam Tree

The equipment used in this study is available at the Pagar Alam Institute of Technology laboratory. The tools used in this study are as follows:

- Scales, it is used to weigh the weight of the material when testing the material.
- A 100 ml measuring cup, is used to test the silt content of coarse aggregate and fine aggregate.
- One set of sieves, it used for fine aggregate gradation testing.
- Length measuring tool (meter), is used to measure the value of the slump.
- A concrete mixer, is used to mix all the ingredients or materials.
- Slump test to determine the value of a settlement in concrete.
- The bucket is used as a tool for weighing materials and mixing ingredients.
- The cement scoop is used to move the material to the cylindrical mold.
- The brush is a tool to clean the cylinder.
- Gram scales are used to weigh fermented fiber.

- Cylindrical concrete mold with a diameter of 15 cm and a height of 30 cm is used to make a sample of the test object.
- Concrete beam molds with a width of 15 cm, a height of 15 cm, and a length of 60 cm are used to make a sample of the test object.
- UTM (Universal Testing Machine) compressive strength machine is used for testing the compressive strength of specimen samples.
- A water bath is used to soak the test object during the curing

2.4. Analysis Method

In this research, the effect of the addition of stem fiber on the characteristics of concrete is examined using an experimental method. The goal of this method is to find out what effect stem fiber has on how concrete works. Experiments include material physical tests, slump tests, and compressive and flexural strengths in concrete. In this study, 0.5% recycled stem fiber was added by weight to the concrete mix instead of regular concrete cement. All samples are tested at the ages of 3, 7, 14, 21, and 28 days to analyze the concrete's compressive strength and flexural strength.

2.4.1. Mix Design

In this study, the concrete mix design uses the method issued by the Ministry of Public Works and Public Housing of the Republic of Indonesia and included in SNI DT-91-2007 concerning the procedure for making a concrete mix design based on a standard concrete mix design.

Table 1. Composition of F_c' 16.9 Mpa Fiber Concrete Mixture in Cylindrical Mold

No	Code	Cement (Kg)	Aggregate		Water	Fiber Length (gram)	Fiber Length
			Fine Aggregate (Kg)	Coarse Aggregate (Kg)	(Liter)	0,50%	cm
1	BN	2,112	3,873	4,392	1,29	0	0
2	BS1	2,112	3,873	4,392	1,29	10,56	3
3	BS2	2,112	3,873	4,392	1,29	10,56	5

BN is normal concrete, BS1 is fiber concrete with 3 cm of length fiber, and BS2 is fiber concrete with 5 cm of length fiber.

3. Result and Discussion

3.1. Organic Content Test

An organic content test is carried out for fine aggregate (sand). This test is meant to find out how much organic matter is in the sand, which can slow down how fast cement binds. The organic content test is presented in Figure 2.

Figure 2. The result of the Organic Content Test

Based on Figure 2, it can be seen that after 24 hours, the liquid becomes yellowish, so it can be seen that Lematang river sand has a low organic content. The sand is safe to use in the concrete mixture. The function of NaOH is to neutralize organic substances in the sand because organic content is acidic, and NaOH is basic.

3.2. Sludge Content Test

Based on SNI 03-6821-2002, this test is carried out for fine aggregate in order to determine whether the silt content fulfil the minimum standard requirements of fine aggregate and the percentage of silt content contained in fine aggregate. It has to examine that fine aggregate can be used for the mixture to make fiber concrete. The result of test in presented in Figure 3.

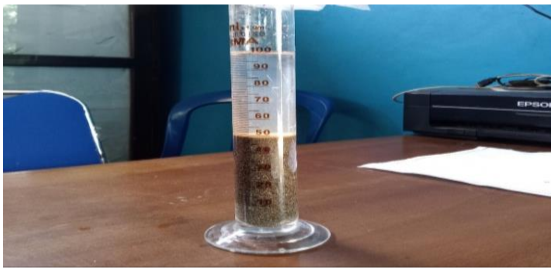

Figure 3. Sludge Content Test

The volume of Sand : 48 ml

Volume of Precipitate : 1 ml

Sludge Content : $\frac{1}{48} \times 100\% = 2.1\%$

It has to be examined so that the mixture can use fine aggregate to make fiber concrete. Based on SNI 03-6821-2002, this test is carried out for fine aggregate to determine whether the silt content meets the minimum standard requirements for fine aggregate and the percentage of silt content contained in fine aggregate. The results of the test are presented in Figure 3.

3.3. Fine Aggregate Gradation

The purpose of examining fine aggregate is to determine variations in grain diameter and fineness modulus. The tool used is a sieve with a determined size. These sieves are arranged based on the number of sieve holes. Then 500 grams of the test object are inserted. Examination of fine aggregate gradation is presented in Table 2.

Table 2. Fine Aggregate Examination

Sieve Hole		Holding Weight		Cumulative Weight	Cumulative Weight
US Sieve	Mm	Gram	%	% Restrained	% Restrained
4	4,76	5	1	1	99
10	2	5	1	2	98
20	0,84	30	6	8	92
40	0,42	150	30	38	62
60	0,25	160	32	70	30
100	0,15	115	23	93	7
200	0,07	30	6	99	1
PAN		5	1	100	0
Amount		500	100	311	

Fine modulus = $\frac{311}{10}$ = 3.11

The results of the test show that the fine modulus of fine aggregate is 3.11. It can be concluded that the fine modulus fulfils the requirements, which is between 1.5 – 3.8.

3.4. Slump Test

The purpose of the slump test is to determine the level of settlement of normal concrete and fiber concrete; besides that, the slump test is carried out to determine the ease of working, which is tested in the laboratory of the Pagar Alam Institute of Technology. The results are shown in Table 3 and Figure 4.

BN BS1 BS2

Figure 4. Slump Test

Table 3. The Value of Slump Test

No	Samples code	Value of *slump test* (cm)	Standard of *slump test*
1	BN	14	qualify
2	BS1	11	qualify
3	BS2	10	qualify

Based on the results of the slump test in this study, it shows the value of the slump test for normal concrete is 14 cm, for 3 cm long fiber concrete, it is 11 cm, and for 5 cm long fiber concrete, it is 10 cm. It can be concluded that the results fulfill the requirements.

3.5. Concrete Specific Gravity Test

The test of concrete is carried out on concrete aged 3, 7, 14, 21, and 28 days. The object uses code BN for normal concrete, BS1 for 3 cm of long fiber concrete, and BS2 for 5 cm of long fiber concrete. The test results are presented in Table 4 and Figure 5.

Table 4. Specific Gravity of Concrete

Code	Specific Gravity (Gram/Cm³)				
	test age				
	3	7	14	21	28
BN	2,24	2,25	2,26	2,27	2,29
BS1	2,21	2,23	2,25	2,26	2,27
BS2	2,19	2,2	2,23	2,25	2,26

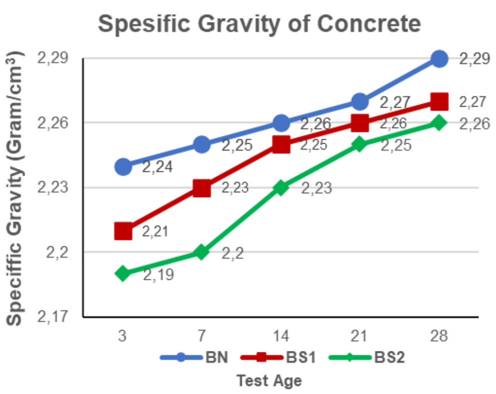

Figure 5. Graph of Specific Gravity of Concrete

Table 4 and Figure 5 say that the addition of fiber to the concrete reduces the specific gravity of the concrete itself. It happens because fiber is a lightweight material and easily absorbs water. The addition of fiber to the concrete creates voids that cause some reduction in the density of the concrete. The result of this study indicates that the longer the curing period, the greater the specific gravity value.

3.6. The Compressive and Flexural Strength of Concrete

The results of concrete's compressive strength are presented in Table 5 and Figure 6.

Table 5. Concrete Compressive Strength

CODE	Concrete Compressive Strength (MPa)				
	3	7	14	21	28
BN	6,45	10,71	12,52	15,59	19,52
BS1	6,2	8,5	12,12	14,8	17,67
BS2	4,39	5,51	8,73	11,65	16,12

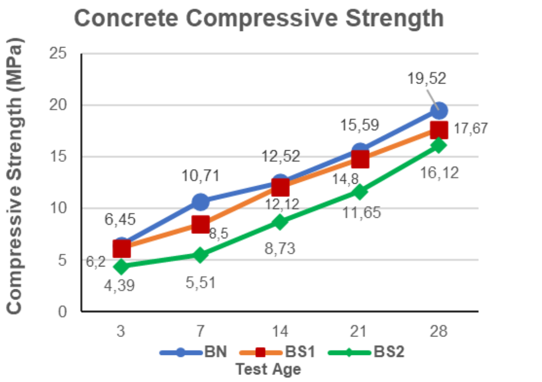

Figure 6. Graph of Concrete Compressive Strength

According to Table 5 and Figure 6, adding soaked fiber increases compressive strength. The highest compressive strength of fiber concrete is 17.67 MPa with 3 cm of fiber length.

3.7. Concrete Flexural Strength

The results of concrete flexural strength are presented in Table 6 and Figure 7.

Table 6. Concrete Flexural Strength

Code	Concrete Flexural Strength (MPa)				
	3	7	14	21	28
BN	1,72	2,19	2,84	3,14	3,67
BS1	1,84	2,55	3,14	3,56	4,09
BS2	2,19	2,96	3,5	3,97	4,8

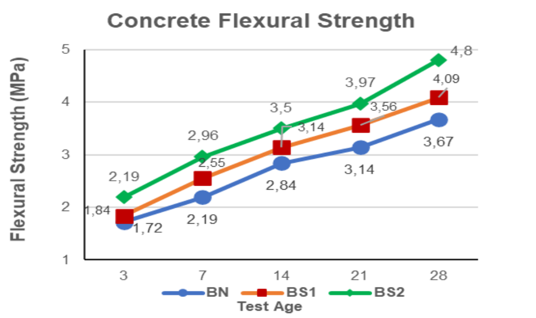

Figure 5. Graph of Concrete Flexural Strength

According to the findings, adding fiber significantly boosts the flexural strength of concrete. The highest flexural strength is 4.80 MPa with 5 cm of fiber length.

3.8. The Effect of Resam Fiber To The Compressive Strength and Flexural Strength of Concrete

The addition of fiber to concrete at a percentage of 0.5 percent by weight of cement has an impact on the compressive strength and flexural strength of the material. The experiment uses resam fiber with a length of between 3 and 5 cm. In concrete, aged 28 days, 3 cm of resam fiber length results in a 0.36 percent decrease in normal concrete compressive strength and a 0.02% increase in normal concrete flexural strength. Meanwhile, at the same age, the 5 cm fiber length of concrete decreases by 0.66% of its normal compressive strength and increases by 0.04% of its normal flexural strength. By adding more absorbent fiber to the concrete, which makes holes or voids, the compressive strength goes down. So, the density of concrete decreases. The bond between the cement and other aggregates is disrupted.

The flexural strength goes up because the absorbent material from the fibers helps stop cracks from happening because of the pressure in the concrete. All of the above statements are also explained by research previously carried out (Trimutiningrum, 2018), with the research title, "The effect of adding bamboo fiber to the tensile and compressive strengths of concrete.".

4. Conclusion

Based on the research results, adding resam fiber (Dicranopteris linearis) with a percentage of 0.5% by weight of cement affects the compressive strength and flexural strength of concrete. When the concrete is 28 days old, and the fiber length is 3 cm, the average compressive strength goes down by 0.36 percent, while the normal flexural strength goes up by 0.02%. For the exact age of concrete, adding 5 cm of length causes the compressive strength to go down by 0.66 percent and the flexural strength to go up by 0.04%. The decrease in compressive strength happens because the absorbent substance in the fiber creates voids in the concrete. It also influences the reduction of concrete density and the disruption of the bond between cement and other aggregates. The absorbent substance in fiber also affects flexural strength. The fiber keeps the concrete from cracking when there is too much pressure. This makes the concrete more flexible and robust.

5. Acknowledgment

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6. Author's Note

All data, information, interpretations, and statements in the discussion and conclusions presented in this study, except for those stated as sources, are the results of our observations, research, management, and thoughts.

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