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Effect of Fiber Percentage of Mensiang Plant (*Actinoscirpus grossus* L.f.) on the Physical Properties of Cement Board

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Abstract: Grasses and sedges (Cyperaceae) are among the lignocellulosic materials that can be used as raw materials. *Actinoscirpus grossus* L.f., commonly known as mensiang, is one of the many sedge species found in Indonesia. With appropriate technology and processing, mensiang can serve as a raw material for composite boards such as cement board. This study aimed to determine the physical properties of cement boards made from mensiang fibers (*A. grossus* L.f.) at different cement and fiber percentages. The experiment was arranged in a completely randomized design with five cement-fiber ratios: 95:5, 90:10, 85:15, 80:20, and 75:25 (%). The mean values of the physical properties of the cement boards were as follows: moisture content ranged from 9.6733% to 12.6567%, density ranged from 0.9267 to 1.7800 g/cm3, water absorption ranged from 21.2100% to 63.1367%, and thickness swelling ranged from 1.3300% to 8.6367%. Moisture content, density, and thickness swelling met the JIS A 5417-1992 standard at fiber percentages of 10–25%, whereas this standard does not specify a requirement for the water absorption of cement boards. The best moisture content and thickness swelling were obtained at a fiber percentage of 15%, whereas the best density and water absorption were obtained at a fiber percentage of 5%.

Keywords: *Actinoscirpus grossus* L.f., cement board, physical properties.

1. INTRODUCTION

The demand for wood-based materials continues to increase, while the supply of wood from forests is increasingly constrained. Alongside the shortage of raw wood, it is becoming increasingly difficult to obtain building boards made from solid wood, which has prompted the wood panel industry to look for alternative raw materials (Lee et al., 2022; Neitzel et al., 2022). This situation creates a need for new materials that can replace wood. Building construction requires boards made from safe, environmentally friendly, and recyclable materials. Wood is a material that meets these requirements.

One way to address the decline in wood supply is to use alternative materials, such as lignocellulosic materials that are available in sufficient quantities (Ferraz et al., 2020; Lee et al., 2022; Neitzel et al., 2022). Grasses and sedges (Cyperaceae) are among these lignocellulosic materials. Cyperaceae are grass-like plants found mainly in wet habitats, and the fibers of some species, such as *Scirpus grossus*, have been explored for particleboard, acoustic, and other fiber-based applications (Khaidar et al., 2020; Kongkaew et al., 2019; Suhaeri et al., 2024).

Actinoscirpus grossus L.f., commonly known as mensiang, is one of the many sedge species found in Indonesia. It is often found in wet habitats such as swamps, ponds, ditches, and rice fields, and it is regarded as a principal weed of rice fields in several Southeast Asian countries (Ganapathi et al., 2017). Fibers of mensiang, which is also known under the synonym *Scirpus grossus*, have been examined for particleboard (Kongkaew et al., 2019), sound-absorbing materials (Suhaeri et al., 2024), and tensile properties after alkali treatment (Khaidar et al., 2020). With appropriate technology and processing, mensiang can be used as a raw material for composite boards.

Several types of composite boards can be made from sawdust and lignocellulosic plants, one of which is cement board, a wood-based panel product with considerable potential for development. Cement board is a panel made from a mixture of wood particles or other lignocellulosic materials, cement, and additives. Plant-based natural fibers have been widely studied as reinforcement in cement composites (Kochova et al., 2020; Onuaguluchi & Banthia, 2016). Compared with other biocomposite products, cement board offers several advantages, including good resistance to decay, fungi, insects, moisture, and fire, as well as good thermal and acoustic insulation (Wang et al., 2016; Yel et al., 2020). In addition, because the binder is inorganic cement, it does not depend on the synthetic adhesives used in conventional particleboard (Rossi et al., 2025). Despite these advantages, cement board also has drawbacks, including its relatively high density and weight (Hasan et al., 2021) and limited use in construction. A further challenge is the compatibility between lignocellulosic fibers and cement, because extractives, sugars, and other inhibitory compounds in the fibers can disturb cement setting (Hasan et al., 2021, 2022; Marques et al., 2016). Owing to its advantages, cement board is an alternative to plywood and gypsum board. This study aimed to determine the physical properties of cement boards made from mensiang fibers (*Actinoscirpus grossus* L.f.) at different fiber and cement percentages.

2. METHOD

The study was conducted from March to May 2023. The cement boards were manufactured and their physical properties were tested at the laboratory of the Faculty of Forestry, Universitas Muhammadiyah Sumatera Barat.

The equipment used in this study comprised a balance, a mixing container, a cold press, a sample cutter, an oven, spoons, scissors, a hammer, a wire brush, gloves, a measuring cylinder, a 30 × 30 cm mold, zinc plates, aluminum foil, a camera, and stationery. The materials used were mensiang fibers, cement, distilled water, and a catalyst (alum), which was used as a curing accelerator for the cement (Hasan et al., 2021; Tichi et al., 2019).

Cement Board Manufacturing Process

Cement boards were manufactured from mensiang (*Actinoscirpus grossus* L.f.) fibers, with cement as the binder, through the following steps:

1. Fiber preparation
   The raw material was mensiang (*Actinoscirpus grossus* L.f.). The plants were flattened with a hammer, and the outer skin was then separated from the fibers by scraping with a wire brush; the fibers were subsequently sun-dried. The dried fibers were then cut into 1-cm lengths to prepare the fiber samples.

2. Mixing of materials

Before mixing, the raw materials were weighed to obtain the desired fiber-to-cement composition. After weighing according to the ratios used, a solution of water and catalyst was mixed into the fibers, and the cement was then sprinkled in gradually. The mixture was stirred until homogeneous. The material formulation used to produce the cement boards is shown in the following table:

Table 1. Material formulation

Sample	Cement (g)	Fiber (g)	Water (mL)	Catalyst (g)
A	855	45	427.5	25.65
B	810	90	405	24.3
C	765	135	382.5	22.95
D	720	180	360	21.6
E	675	225	337.5	20.25

a. Cement board sheet formation

The mixture of mensiang (*Actinoscirpus grossus* L.f.) fibers and cement was placed in a 30 × 30 × 1 cm mold and cold-pressed for 24 hours. The boards were then removed from the press and stored at room temperature for 14 days for conditioning.

b. Cutting of cement board sheets

After conditioning, the air-dried cement boards were cut into four sections, with the shape and dimensions of the test-specimen cutting pattern following JIS A 5417-1992.

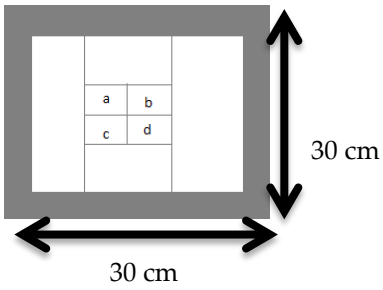


Figure 1. Cutting pattern of the test specimens: (a) moisture content specimen (5 × 5 × 1 cm); (b) density specimen (5 × 5 × 1 cm); (c) thickness swelling specimen (5 × 5 × 1 cm); (d) water absorption specimen (5 × 5 × 1 cm).

c. Testing standard

The standard used for testing the physical and mechanical properties in this study was JIS A 5417-1992 (Japanese Industrial Standards Committee, 1992), as shown in Table 2.

Table 2. Testing requirements of JIS A 5417-1992

No	Physical and mechanical property parameters	Standard
1	Density (g/cm^3)	≥0.8
2	Moisture content (%)	≤16
3	Thickness swelling (%)	≤8.3
4	MOE (kg/cm^2)	≥ 24,000
5	MOR (kg/cm^2)	≥63

Physical Property Testing of Cement Board

Several physical property tests were conducted in this study, namely:

1. Moisture content

   Air-dried specimens measuring 5 × 5 × 1 cm were weighed to obtain the initial weight, then oven-dried at approximately 103 °C for 24 hours, and subsequently cooled in a desiccator for approximately 10–15 minutes until a constant weight was reached. The moisture content of the cement board was calculated using the following formula:

$$\text{Moisture content (\%)} = \frac{Wi\text{-}Wod}{Wod} \times 100$$

   Where: Wi = initial weight
   Wod = oven-dry weight

2. Density

   The density test was conducted to assess the relationship between the weight and the volume of the cement board, based on its length, width, and thickness. The specimens measured 5 × 5 × 1 cm. Density was calculated using the following formula:

$$\rho = \frac{W}{V}$$

   Where: ϱ = density (g/cm^3)
   W= air-dry weight (g)
   V = volume (cm^3)

3. Water absorption

   Water absorption was tested by immersing specimens measuring 5 × 5 × 1 cm in water for 24 hours. The JIS A 5417-1992 standard (Japanese Industrial Standards Committee, 1992) does not specify a requirement for the water absorption of cement-bonded particleboard, which implies that the water absorption value has little influence on the overall quality standard of the board. Water absorption was calculated using the following formula:

$$\text{Water absorption (\%)} = \frac{W2\text{-}W1}{W1} \times 100$$

   Where: W1 = weight before immersion
   W2 = weight after immersion

4. Thickness swelling

   This test was conducted to assess the increase in the thickness of the cement board caused by immersion in water, using specimens measuring 5 × 5 × 1 cm. The specimens were immersed in water for 24 hours to determine the swelling of the cement board. Thickness swelling after immersion was calculated using the following formula:

$$\text{Thickness swelling (\%)} = \frac{T2\text{-}T1}{T1} \times 100$$

   Where: T1 = initial thickness
   T2 = thickness after immersion

3. RESULT AND DISCUSSION

Physical Properties of Cement Boards Made from Mensiang (*Actinoscirpus grossus* L.f.)

1. Moisture content

The mean moisture content of the cement boards was 10.7100% in treatment A, 10.6967% in treatment B, 9.6733% in treatment C, 12.1900% in treatment D, and 12.6567% in treatment E. All mean values met the JIS A 5417-1992 requirement of a maximum of 16%. The moisture content results for the cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers are presented in Table 3.

Table 3. Moisture content of cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers

Treatment	Replicate	Moisture content (%)	Mean moisture content (%)
A	A1	7.78	10.7100**a**
	A2	10.49	
	A3	13.86	
B	B1	8.41	10.6967**a**
	B2	10.54	
	B3	13.14	
C	C1	3.77	9.6733**a**
	C2	11.59	
	C3	13.66	
D	D1	9.42	12.1900**a**
	D2	13.58	
	D3	13.57	
E	E1	10.27	12.6567**a**
	E2	13.18	
	E3	14.52	

Note: A = 5% fiber, 95% cement; B = 10% fiber, 90% cement; C = 15% fiber, 85% cement; D = 20% fiber, 80% cement; E = 25% fiber, 75% cement. Means followed by the same lowercase letter are not significantly different according to *Duncan's New Multiple Range Test* (DNMRT) at the 5% level.

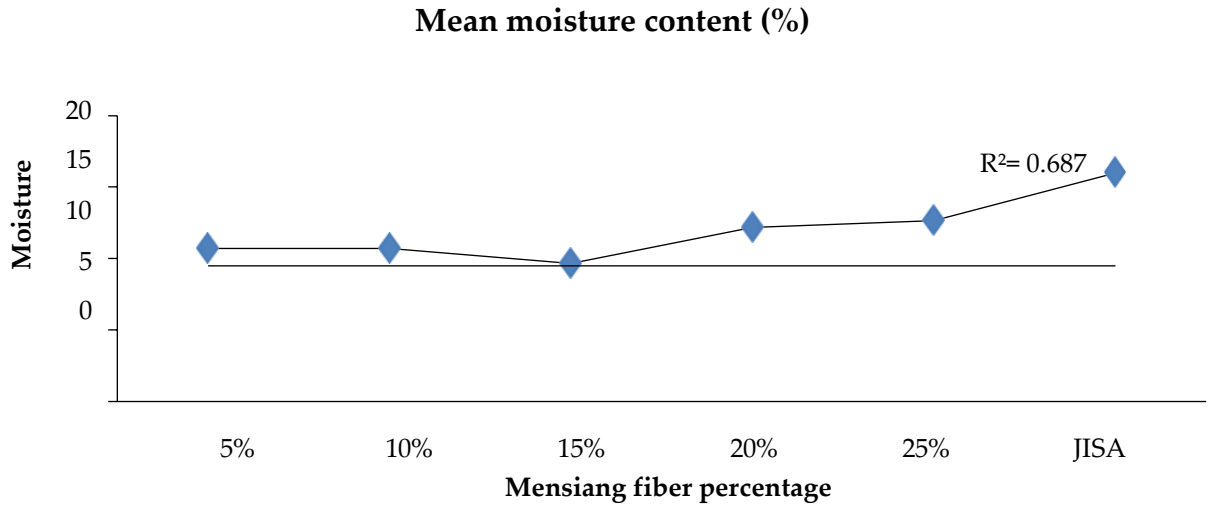


Figure 2. Graph of the mean moisture content of cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers

To determine the effect of the mensiang (*Actinoscirpus grossus* L.f.) fiber percentage on the moisture content of the cement boards, analysis of variance (ANOVA) was performed on the data in Table 3. The ANOVA showed no significant effect; therefore, no follow-up test with Duncan's New Multiple Range Test (DNMRT) at the 5% level was required.

In this study, moisture content varied widely among samples. This variation was attributed to differences in the fiber-to-binder ratio among the samples, to insufficiently homogeneous mixing of the cement with the mensiang (*Actinoscirpus grossus* L.f.) fibers, and to uneven leveling of the mixture in the mold; manual mixing and compression have likewise been linked to deviations in board density and non-homogeneous distribution of the components in fiber–cement boards (Hasan et al., 2021). In this study, the samples with the best quality in terms of moisture content were obtained at a fiber percentage of 15%. All mean values (9.67–12.66%) were higher than the 6.1–7.7% reported by Hasan et al. (2021) for cement-bonded lignocellulosic fiber panels, although they still met the JIS A 5417-1992 limit of 16%. The difference may be related to fiber type and to the compatibility between the fibers and cement, which influences the physical properties of fiber–cement boards (Marques et al., 2016).

2. Density

   Density is a physical property that expresses the weight of the cement board per unit volume. The mean density was 1.7800 g/cm^3 in treatment A, 1.6100 g/cm^3 in treatment B, 1.4333 g/cm^3 in treatment C, 1.1167 g/cm^3 in treatment D, and 0.9267 g/cm^3 in treatment E. All mean values met the JIS A 5417-1992 requirement of a density of ≥ 0.8 g/cm^3. The density results for the cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers are presented in Table 4.

Table 4. Density of cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers

Treatment	Replicate	Density (g/cm^3)	Mean density (g/cm^3)
A	A1	1.75	1.7800**c**
	A2	2.03	
	A3	1.56	
B	B1	1.44	1.6100**bc**
	B2	1.83	
	B3	1.56	
C	C1	1.07	1.4333**bc**
	C2	1.53	
	C3	1.70	
D	D1	0.83	1.1167**ab**
	D2	1.24	
	D3	1.28	
E	E1	0.58	0.9267**a**
	E2	1.11	
	E3	1.09	

Note: A = 5% fiber, 95% cement; B = 10% fiber, 90% cement; C = 15% fiber, 85% cement; D = 20% fiber, 80% cement; E = 25% fiber, 75% cement. Means followed by the same lowercase letter are not significantly different according to *Duncan's New Multiple Range Test* (DNMRT) at the 5% level.

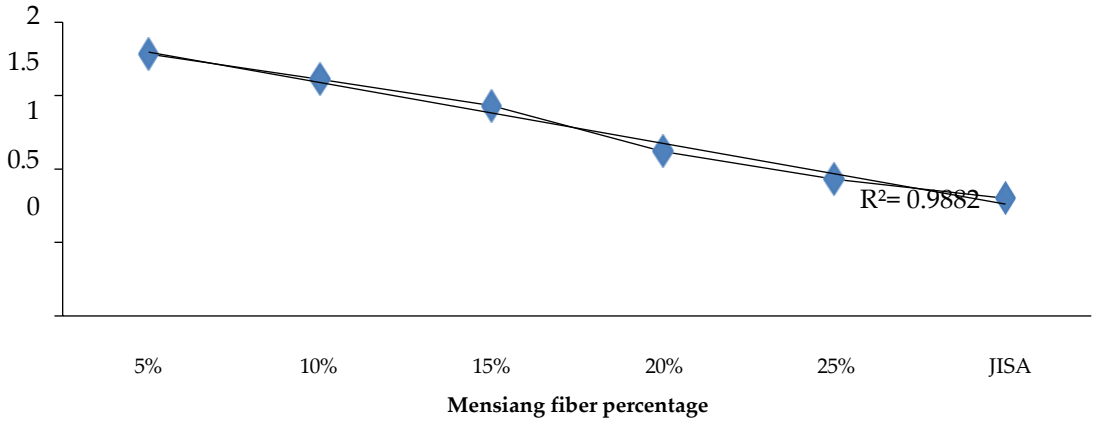


Figure 3. Graph of the mean density of cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers

To determine the effect of the mensiang (*Actinoscirpus grossus* L.f.) fiber percentage on the density of the cement boards, analysis of variance was performed (Appendix 6). The ANOVA showed a significant effect; therefore, a follow-up test with Duncan's New Multiple Range Test (DNMRT) at the 5% level was conducted.

These results show that the more cement is used, the higher the density of the board. In this study, the samples with the best quality in terms of density were obtained at a fiber percentage of 5%. Density is an important parameter of fiber–cement composites, and a higher density reflects stronger bonding between the fibers and the cement in the matrix (Hasan et al., 2021). A higher density was also associated with lower water absorption in lightweight cement boards made with sugar palm fiber (*ijuk*) (Wardani et al., 2018).

3. Water absorption

   The mean water absorption of the cement boards was 21.2100% in treatment A, 30.6800% in treatment B, 35.7967% in treatment C, 48.6933% in treatment D, and 63.1367% in treatment E. JIS A 5417-1992 does not specify a requirement for the water absorption of cement boards (Japanese Industrial Standards Committee, 1992). The water absorption results for the cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers are presented in Table 5.

To determine the effect of the mensiang (*Actinoscirpus grossus* L.f.) fiber percentage on the water absorption of the cement boards, analysis of variance was performed. The ANOVA showed no significant effect; therefore, no follow-up test with Duncan's New Multiple Range Test (DNMRT) at the 5% level was required. The graph of water absorption by fiber composition is shown in Figure 4.

Table 5. Water absorption of cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers

Treatment	Replicate	Water absorption (%)	Mean water absorption (%)
A	A1	25.68	21.2100**a**
	A2	15.10	
	A3	22.85	
B	B1	46.92	30.6800**ab**
	B2	22.14	
	B3	22.98	
C	C1	62.12	35.7967**ab**
	C2	25.94	
	C3	19.33	
D	D1	83.07	48.6933**ab**
	D2	33.19	
	D3	29.82	
E	E1	86.77	63.1367**b**
	E2	38.86	
	E3	63.78	

Note: A = 5% fiber, 95% cement; B = 10% fiber, 90% cement; C = 15% fiber, 85% cement; D = 20% fiber, 80% cement; E = 25% fiber, 75% cement. Means followed by the same lowercase letter are not significantly different according to *Duncan's New Multiple Range Test* (DNMRT) at the 5% level.

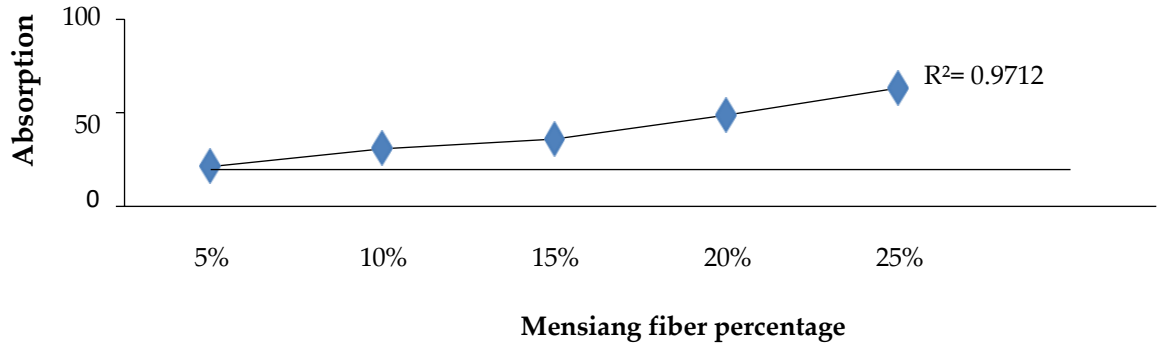


Figure 4. Graph of the mean water absorption of cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers

Water absorption increased with each increase in the percentage of mensiang (*Actinoscirpus grossus* L.f.) fibers. This may be because mensiang is a cellulose-rich lignocellulosic fiber: cellulose and hemicellulose contain hydroxyl groups that form hydrogen bonds with water, and water can also diffuse into the fiber–cement interface (Hasan et al., 2021), so that a higher fiber percentage results in higher water absorption and, consequently, a lower-quality cement board. In this study, the samples with the best quality in terms of water absorption were obtained at a fiber percentage of 5%. The formation of air voids during molding and pressing may also have contributed. The response of water absorption to fiber content depends on the fiber type; for example, replacing eucalypt wood with coconut husk fibers reduced water absorption and thickness swelling in wood–cement boards (Souza et

al., 2021). Fiber treatments and compatible additives have been proposed to improve fiber–cement compatibility (Hasan et al., 2022; Quiroga et al., 2016).

4. Thickness swelling

   The mean thickness swelling of the cement boards was 8.6367% in treatment A, 3.8767% in treatment B, 1.3300% in treatment C, 4.5367% in treatment D, and 2.7267% in treatment E. The mean thickness swelling in treatments B to E met the JIS A 5417-1992 requirement of a maximum of 8.3%, whereas treatment A did not; however, the overall mean across all treatments (4.2213%) met the requirement. The thickness swelling results for the cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers are presented in Table 6.

Table 6. Thickness swelling of cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers

Treatment	Replicate	Thickness swelling (%)	Mean thickness swelling (%)
A	A1	7.04	8.6367b
	A2	9.78	
	A3	9.09	
B	B1	3.2	3.8767a
	B2	7.41	
	B3	1.02	
C	C1	2.13	1.3300a
	C2	0.85	
	C3	1.01	
D	D1	3.84	4.5367ab
	D2	1.57	
	D3	8.20	
E	E1	3.87	2.7267a
	E2	0.66	
	E3	3.65	

Note: A = 5% fiber, 95% cement; B = 10% fiber, 90% cement; C = 15% fiber, 85% cement; D = 20% fiber, 80% cement; E = 25% fiber, 75% cement. Means followed by the same lowercase letter are not significantly different according to *Duncan's New Multiple Range Test* (DNMRT) at the 5% level.

To determine the effect of the mensiang (*Actinoscirpus grossus* L.f.) fiber percentage on the thickness swelling of the cement boards, analysis of variance was performed. The ANOVA showed a significant effect; therefore, a follow-up test with Duncan's New Multiple Range Test (DNMRT) at the 5% level was conducted. The graph of the mean thickness swelling of the cement boards is shown in Figure 5.

The thickness swelling values were not uniform, probably because the fibers used still retained some of their outer skin, which made it difficult for water to penetrate the samples,

and because the specimens may not have been cut straight along the cutting pattern, which would have added to their dimensions. In this study, the samples with the best quality in terms of thickness swelling were obtained at a fiber percentage of 5%. Hasan et al. (2021) noted that thickness swelling is a physical property related to the dimensional stability of cement board.

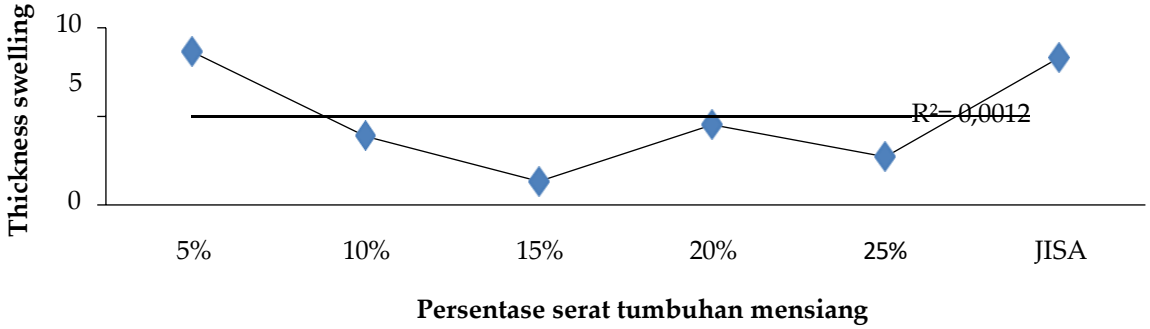


Figure 5. Graph of the mean thickness swelling of cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers

4. CONCLUSIONS

Cement boards made from mensiang (*Actinoscirpus grossus* L.f.) fibers had mean moisture content of 9.6733–12.6567%, density of 0.9267–1.7800 g/cm^3, water absorption of 21.2100–63.1367%, and thickness swelling of 1.3300–8.6367%. Moisture content, density, and thickness swelling met JIS A 5417-1992 at fiber percentages of 10–25%, whereas the standard sets no requirement for water absorption. The best moisture content and thickness swelling were obtained at 15% fiber, and the best density and water absorption at 5% fiber. The cement-to-fiber ratio significantly affected density and thickness swelling (followed by DNMRT), but not moisture content or water absorption.

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