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CONCRETE SLABS STRUCTURE BEHAVIOR WITH VARIATIONS BAMBOO DISTANCE USING FOR IRRIGATION WATERGATE

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ABSTRACT

Concrete building construction in the future is not only sturdy, durable but also inexpensive and environmentally friendly. One of the cheap and environmentally friendly innovations is making irrigation floodgates from reinforced concrete slabs with bamboo reinforcement. In this study, irrigation flood gates were made with a size of 400 m x 500 mm x 30 mm, bamboo reinforcement measuring 10 mm x 10 mm which was varied using reinforcement distances of 4.5 cm, 5 cm, 6 cm and 8 cm. Each variation was made 3 samples so that the total tested was 12 samples. The slabs is then flexibly tested with line loads and the test results with 4 variations are then compared to the variation of the distance and the percentage of the remaining strength of the concrete slabs against the hydrostatic load of water. From the results of tests in the laboratory obtained a maximum load of the four types of slabs is 1058 kg and a minimum of 256 kg. The maximum deflection is 27 mm while the minimum is 8.6 mm. Flexural strength tends to decrease when the reinforcement area ratio increases up to 0.36 and at the ratio of bamboo reinforcement area around 0.37, the flexural strength of the slabs reaches the lowest limit up to 230 kg. The debris produced by the four panel variations is a type of bending collapse. All flood gates with varying distances are able to withstand the hydrostatic load of water with a safety factor between 3.49 - 14.42.

Keywords: Slabs Reinforcement, Bamboo, Flexural Strength, Deflection.

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1. INTRODUCTION

Along with the times and science and technology, new ideas grow in building construction technology that aims to make buildings lightweight, sturdy, economical and easy in the manufacturing process. However, the aspect of sustainability is one of the important topics discussed in making the construction of world buildings in the future. Sustainability is defined as development that meets the needs of the present without disrupting the ability of future generations to meet their own needs [1]. The slabs is the main structure of the building where all high-rise buildings must use a slabs. Reinforced concrete floor slabss are generally cast in place, together with supporting beams and supporting columns.

There is also a slabs that is used as a wall and even water retaining wall innovations or at the same time for floodgates that can be operated open and close. Thus a strong relationship will become a unity. In making slabss, of course, consider the tensile and compressive strength. Concrete which has a high strength on the press cannot hold the pull well, so the weakness of the concrete will be overcome by installing reinforcement as a drag on the concrete slabs, holding the moment of tensile and flexural. Bamboo strength increases with age and reaches maximum strength at 3-4 years and then begins to decrease strength [2]. Bamboo is also an environmentally friendly plant because it absorbs a lot of nitrogen and carbon dioxide in the air [3]. The compressive strength characteristics of bamboo is less than its tensile strength [4], while the tensile test performance with bamboo is almost the same as that of ordinary steel rods [5].

In some previous studies Bamboo Semantan has been chosen because it is the type of bamboo that is most widely used commercially and is currently being studied in terms of its functional, physical, and mechanical properties for its contribution to the expansion of the bamboo industry [6]. Bamboo reinforcement used is petung bamboo which is arranged to resemble a series of steel bars, so that its function will work in accordance with the function of steel reinforcement.

To find out the effect of variations in the distance of bamboo reinforcement on bending on a two-way slabs, then a comparison of the value of the flexural strength of bamboo reinforced slabss of 4 variations, each consisting of 3 samples so that there are a total of 12 variations. There are several recommendations for choosing bamboo to be used [10]:

a) Only bamboo which shows a brown color must be used to ensure that the plant is ripe and ripe for at least three years old.

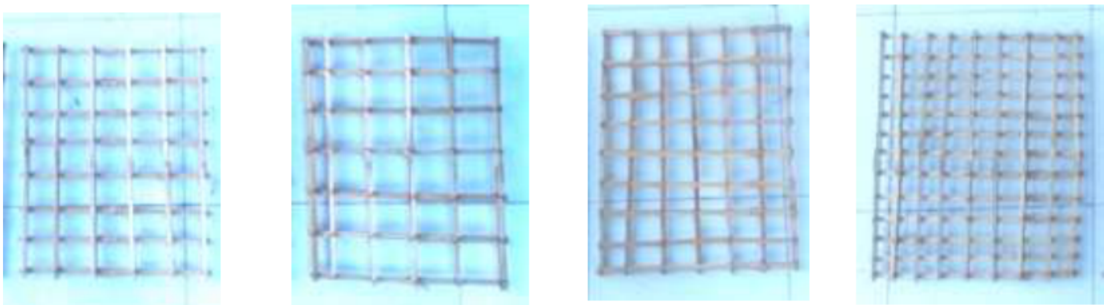
b) Bamboo is not cut down in wet conditions because the stems are weaker due to increased fiber moisture content.

c) Bamboo species with the highest number of vertices are chosen because they will increase bonds

In dry conditions, the strength of bamboo characteristics is at least comparable to high-quality hardwoods between 30 MPa (Oak) and 50 MPa (American White Oak) [8]. Bamboo is usually hollow, anisotropic, a natural material with a high variability in physical and mechanical properties across parts and along the stem. The density of bamboo varies through a cross section (from inside to outside of the stem wall) with typical values ranging from 500 to 800 kg/m^3. In a longitudinal mode of failure that is dominated by tension, bamboo usually exhibits fragile behavior. The variability in longitudinal mechanical properties of bamboo similar to those of wood, has a coefficient of variance between 10 and 30% [9-11].

2. METHODS

In this study, 12 specimens were made which were 500 mm long, 400 mm wide and 30 mm thick. From these 12 samples 4 variations (A, B, C and D) were made with the same vertical and horizontal reinforcement distances.



a. Sample A b. Sample B c. Sample C d. Sample D

Figure 1 Distance of bamboo reinforcement on samples A, B, C and D

Sample A reinforcement distance 45 mm, sample B reinforcement distance 50 mm, sample C reinforcement distance 60 mm and sample D reinforcement distance 80 mm. Concrete slabss made in this study use a 1: 4 ratio mixture (cement: sand), where the composition of coarse aggregates does not exist. Coarse aggregate is not used in order to make concrete lighter. In this test additives were not added, because the additives of lightweight additives did not show a contribution to the compressive strength but increased flexural and shrinkage tests [13]. Before making a concrete slabs, a compressive test is first performed by making 3 test samples namely S_1, S_2 and S_3 using a cylindrical mold with a diameter of 80 mm and a height of 160 mm.

3. RESULT AND DISCUSSION

3.1. Hydrostatic Load Sluice

The calculation of hydrostatic pressure at the sluice is calculated in full water conditions as high as a channel so as to get the maximum hydrostatic pressure value, with the following calculation:

- Theoretical width = 40 cm
- High floodgate (H) = 60 cm
- γ water = 10 kN/m^3
- Thickness of the floodgates (d) = 3 cm

The size of the floodgates and the force diagram acting on the floodgates are presented in Figure 2.

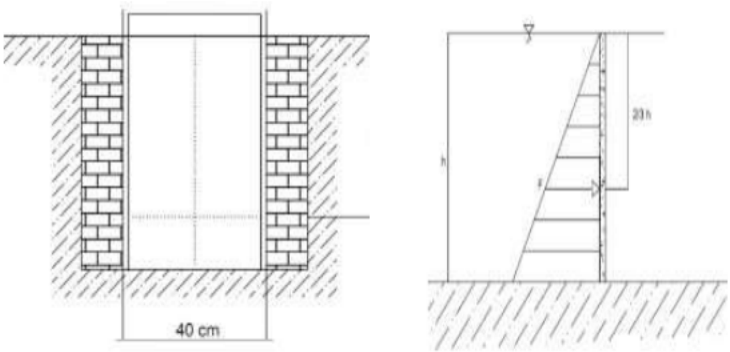


Figure 2 Distribution of forces acting on flood gates

In determining the hydrostatic pressure acting on the panel are:

F = 1 / 2.γ.h^2.b

F = 1 / 2.10. 0.62.0.35

= 0.72 kN

Safety factor

1.4 F = 1.4. .72

= 1,008 kN

≈ 100.8 kg

In determining the capture point the hydrostatic pressure is calculated as follows:

hp = ⅔ h

= ⅔. 0.6

= 0.4 m from the surface of the water

From the above calculation, the hydrostatic pressure of the concrete panel is 100.8 kg and occurs at a depth of 0.4 m from the surface of the water.

3.2. Concrete Compressive Strength Test

To test the compressive strength value of concrete, 3 samples were made namely S_1, S_2 and S_3 with a 1: 4 mixture composition (cement: sand). After testing the concrete compressive strength, the results obtained as presented in table 1.

Table 1 Compressive Strength Test Results Concrete samples S_1, S_2 and S_3

No	Sampel	Mass (Kgf)	Surface area (mm^2)	Compressive force (N)	Compressive strength/ Fc (Mpa)	Stress Crush (kN/cm^2)
1	S1	9.597	18.133	230,000	12.7	1.50
2	S2	9.984	18.133	230,000	16.5	1.95
3	S3	9.864	18.133	230,000	16.0	1.89
					Average	**1.78**

As for the compressive strength value of concrete in samples S_2 and S_3 the value is almost the same (1.95 kN/m^2 and 1.89 kN/m^2), then after averaging the compressive strength of sample S_1 the average collapse strength obtained when the concrete is destroyed is 1.78 kN/cm^2. Based on the results of the compressive strength test samples S_1, S_2 and S_3, although not using coarse aggregate it turns out that the concrete has a compressive strength sufficient for the purpose of making floodgates from concrete. The reason for not using coarse aggregate is because the activity of making small floodgates is the task of the water user farmer. The average in making construction needs a quick and practical, especially what is abundant in the study area is sand, if the gross aggregate is not uniform in gradation and the amount is small.

3.3. Bamboo Reinforcement

Reinforcement used is bamboo petung, with dimensions of 10 x 10 mm^2. Reinforcement is made with a length that adjusts the dimensions on the slabs. For vertical reinforcement the length is 46 cm and for horizontal reinforcement the length is 36 cm. After the bamboo is completely dry and smooth, then the bamboo is coated with paint and sand. Because bamboo will later be combined with concrete, where there is water in the concrete itself, bamboo coated with paint can at least break down bamboo to absorb water in the concrete. After the bamboo is coated with paint, it is covered with sand. Bamboo which has been coated in paint and sand in order to be able to harden the contact area of bamboo with concrete when bamboo has been installed as reinforcement, so that bamboo and concrete can be perfectly integrated.

Figure 3. The process of drying reinforcement and preparation for casting

Pull-out testing used cylindrical concrete samples with dimensions of 15 cm in diameter and 30 cm in height. Cylindrical concrete is given bamboo reinforcement. Then the sample is tensile tested to determine the sticking strength of the bamboo, and the result is 1.5 kN. Bamboo reinforcement is not the same as steel reinforcement, in steel reinforced concrete. The concrete collapse occurs because the steel reinforcement has reached its melting point. However, in reinforced concrete bamboo, collapse in the concrete occurs because of the loss of attachment between concrete and bamboo.

3.4. Testing of Flexural Strength of Two-Way Concrete Slabss

Before testing, the 12 samples to be tested are given the following codes:

A: 45 mm reinforcement distance (A1, A2, A3)

B: 50 mm reinforcement distance (B1, B2, B3)

C: 60 mm reinforcement distance (C1, C2, C3)

D: 80 mm reinforcement distance (D1, D2, D3)

After coding, all sluice slabss are weighed first. In general, the closer the distance between reinforcement, the less weight the concrete slabs. The results of calculating the weight of a concrete slabs from various variations of reinforcement distances are presented in table 2.

In sample C and sample D the average weight of the concrete slab is almost the same. This is possible because the reinforcement area ratio is almost the same. As for sample A having the lightest weight with a difference of almost 1 kg or 10% of sample D with an average weight of around 11.26 kg, the sample is an alternative construction that can be chosen for making sluice gates from concrete slabs, but needs to be considered also how the strength when receiving hydrostatic pressure of water and how to graph the effect of loading with deflection that occurs. In flexural strength testing is done by two methods, the first reading uses the load control method where the reading is based on the load received by the slabs.

Table 2 Calculation of concrete slab weight from various reinforcement distance variations

No	Variation	Sampel	Slab Weight (Kg)	Average (Kg)
1	A	A1	0.00	7.80
2		A2	11.35	
3		A3	12.05	
4	B	B1	11.03	11.74
5		B2	12.15	
6		B3	12.05	
7	C	C1	11.60	11.75
8		C2	11.80	
9		C3	11.85	
10	D	D1	12.10	11.95
11		D2	12.25	
12		D3	11.50	

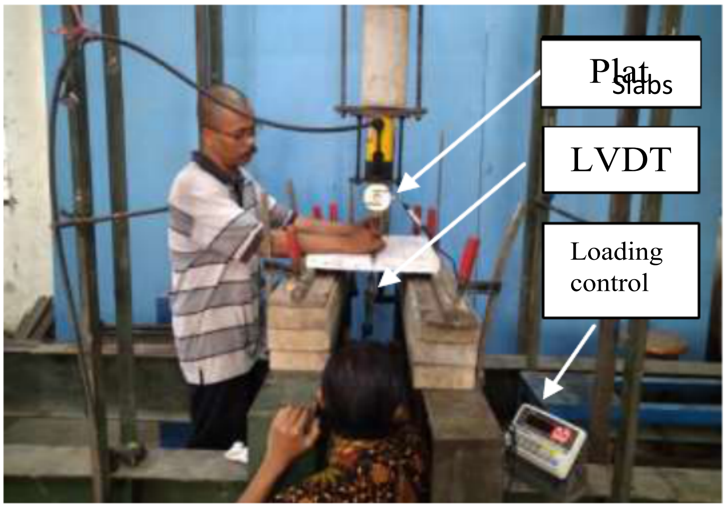


Figure 4 Loading of Concrete Slabss

The second method uses the displacement control method, where the method is read based on deflection that occurs after the maximum load is reached. For load control, use a constant load addition at intervals every 50 kg. While displacement control after reaching the maximum load and the load has decreased until it reaches the collapsed slabs. LVDT is placed in the middle of the span for reading deflection that occurs on the slabs. Because it uses a free pedestal, it is necessary to pay attention to the condition of the slabs when placed on the pedestal. The results of the flexural strength test are presented in table 3. Based on table 3 the maximum Variation D Slabs that can be carried is 738 kg, while the maximum variation of B that can be shouldered is 560 kg.

However, if you look closely at each variation of treatment shows different results so it is difficult to conclude how the influence of the reinforcement distance on the flexural strength of concrete slabs. For example on slabs B, the flexural strength value of B1 is almost the same as B2 while the B3 value deviates quite far. Likewise for Slabs D, the D1 value is very different from the D1 value with a 3x increase.

Table 3. Results of slabs flexural strength testing at a variety of bamboo reinforcement distances

No	Variation	Sampel	Slab Load (kN)	Average (kN)
1	A	A1	3.67	5.94
2		A2	5.98	
3		A3	8.17	
4	B	B1	2.51	5.50
5		B2	4.54	
6		B3	9.44	
7	C	C1	5.26	6.21
8		C2	6.12	
9		C3	7.25	
10	D	D1	3.66	7.25
11		D2	7.70	
12		D3	10.38	

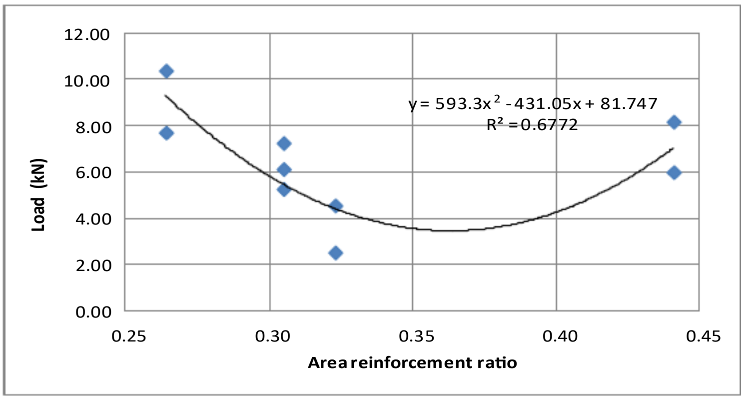


Figure 5 Relationship of reinforcement area ratio to flexural strength of concrete slabs.

Then based on the results of this test will try to connect several values so that patterns can be made closer relations between distances with flexural strength. In order to get a more precise conclusion, each distance calculated is the ratio of the bamboo reinforcement area to the flexural strength value regardless of the extreme values such as the A3, B3 and D1 values, a significant relationship is obtained between the ratio of the bamboo reinforcement area to the slabs flexural strength as presented in figure 5. Based on the Fig 5. It can be seen that the flexural strength tends to decrease when the reinforcement area ratio increases up to 0.36 and at the bamboo reinforcement area ratio around 0.37, the slabs flexural strength reaches the lowest limit up to 230 kg, while the next increases the area ratio bamboo reinforcement then the strength of the senture value goes up too. This behavior follows a polynomial graph with the equation $y = 593.3x^2 - 431.05x + 81.747$ with a correlation coefficient close to 0.70.

Based on the test results compared with theoretical calculations, the load that is capable of carrying a slabs for flood gates is 100 kg. So that in general all variations are able to withstand the hydrostatic load of water as presented in table 4.

Table 4. Controls the ability to withstand the hydrostatic load of water

No	Variation	Sampel	Slabs Load (kN)	Hydrostatic pressure of water (kN)	Safety factor
1	A	A1	3.67	0.72	5.10
2		A2	5.98	0.72	8.31
3		A3	8.17	0.72	11.35
4	B	B1	2.51	0.72	3.49
5		B2	4.54	0.72	6.31
6		B3	9.44	0.72	13.11
7	C	C1	5.26	0.72	7.30
8		C2	6.12	0.72	8.50
9		C3	7.25	0.72	10.07
10	D	D1	3.66	0.72	5.08
11		D2	7.70	0.72	10.70
12		D3	10.38	0.72	14.42

Based on table 3, all sluice gates with various reinforcement distances are able to withstand the hydrostatic load of water with the lowest safety rate at B1 sluice at 39.38% while the highest at D3 sluice is 9.53%. It is known that by using 4 variations of concrete slabss can withstand the hydrostatic load of water. So for the purposes of sluice use a distance of 4 cm can be used and lighter than other slabss. The weight loss is 10%, while for the slabs strength is 13%.

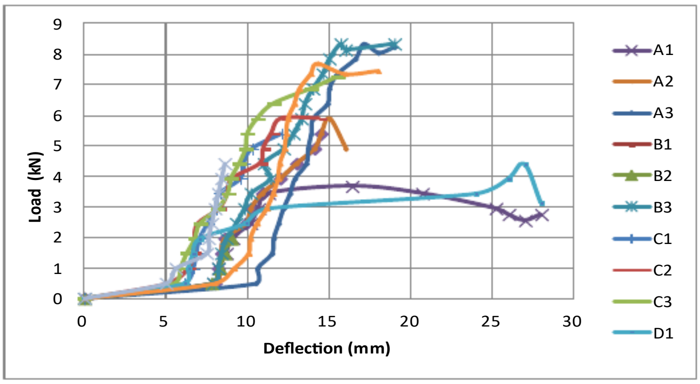


Figure 5 Combined Relationship Graph Slabs Load and Deflection

From the test results 12 variations of the concrete slabs look almost have the same pattern. At a load of 0-300 kg the graph is still linear, above 300-1000 kg some are linear because there are no cracks. When the load reaches 1050 kg, then the first crack occurs until the load is added, the other cracks also increase. At this stage, increasing the value of the load will also increase the deflection value equally. When the initial cracking phase has been skipped, with the addition of a load it will still be followed by the addition of deflection values in a balanced manner.

When it reaches the maximum load, drastically the load that is able to work on the slabs goes down. Then the cracks that occur on the slabs also continues to grow. Seen at a load reaching 629.4 kg, a crack occurred. After that, at 1129.4 kg, cracks 5.6 and 7 also occurred, but new cracks emerged.

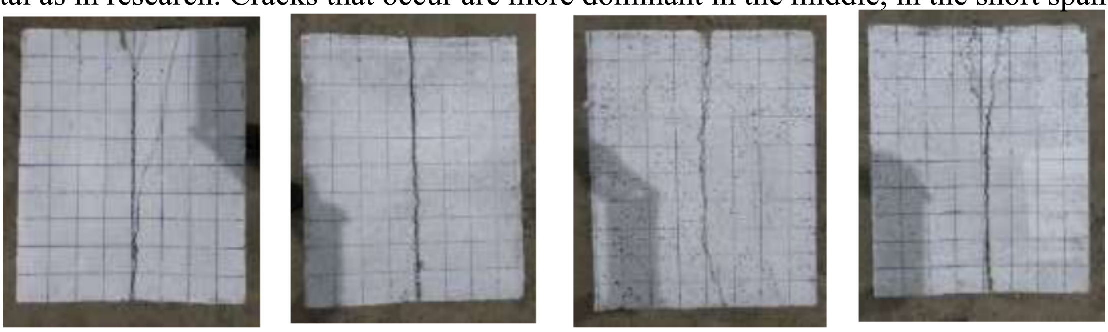
Table 5. Comparison of Deflection

No	Variation	Sampel	Slabs Load (kN)	Deflection (mm)
1	A	A1	3.67	27.0
2		A2	5.98	15.0
3		A3	8.17	17.1
4	B	B1	2.51	9.0
5		B2	4.54	11.8
6		B3	9.44	16.0
7	C	C1	5.26	12.1
8		C2	6.12	14.4
9		C3	7.25	15.5
10	D	D1	3.66	25.5
11		D2	7.70	14.3
12		D3	10.38	8.6

Based on laboratory test results, the maximum deflection is 27 mm while the minimum is 8.6 mm. Concrete Slabs Collapse Pattern. The initial crack occurs under the slabs, which is the tensile part of the slabs. Then the cracks propagate to the top of the slabs little by little. Before the crack occurs, the slabs still acts as an elastic slabs.

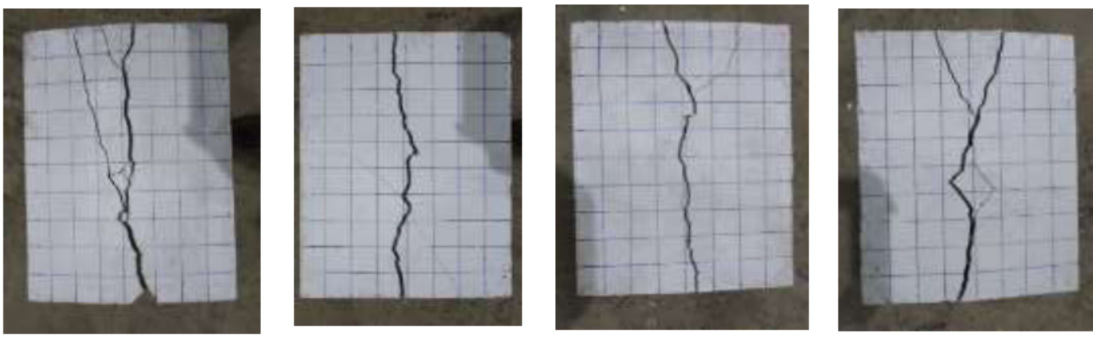
Figure 6 The testing process and cracks that occur during testing

As a result of the external load acting on it, the slabs will sag and the corner will be lifted if it is not monolithically casted with its pedestal, this also applies to slabss with a free pedestal as in research. Cracks that occur are more dominant in the middle, in the short span.



A1 B1` C1 D1

Figure 7 The collapse pattern of the floodgates in the press section



A1 B1 C1 D1

Figure 8 Failure Pattern of Flood Gate in the Pull Section.

The age of a bamboo reinforced sluice plate can depend on several factors, including the hydrostatic load of water, the quality of concrete, the type of bamboo reinforcement used. If the maximum hydrostatic load of water has been calculated, then the quality of the concrete has been determined, then the characteristics of the bamboo reinforcement determine the age of the bamboo reinforced water gate plate. The age of a concrete plate will be short if cracks occur in a concrete plate. Cracks occur due to shrinkage of concrete caused by shrinkage of bamboo reinforcement and absorption of concrete water when casting by bamboo reinforcement.

To overcome the shrinkage of bamboo reinforcement, the bamboo must be dried in the sun until it is completely dry (about 3 days) and does not shrink again. As for avoiding the absorption of concrete water during casting, the bamboo reinforcement is coated with waterproof paint so that there is no more absorption of concrete water by bamboo reinforcement. As the results of our tests on bamboo bars that have been dried but not waterproofed, within 1 month cracks occur in the direction of the bamboo reinforcement as presented in Figure 9.

a. Bamboo drying

b. Bamboo painting

c. Cracks in concrete

Figure 9. Treatment of bamboo reinforcement and its effects if there is no treatment

If bamboo as a reinforcement on the sluice plate has been dried and painted to be waterproof, there will be no more cracks, so that the sluice plate age will be the same as the age of concrete buildings immersed in water for around 20 years. So that the lateral resistance of reinforced concrete structures will increase, the surface of both sides of the sluice plate can be plastered using mortar [14].

4. CONCLUSIONS

Based on all the results of the research and analysis conducted, the following conclusions are obtained: From the results of research in the laboratory obtained a maximum load of the four types of slabss, where the maximum load of 1058 kg and a minimum of 256 kg. The maximum deflection is 27 mm while the minimum is 8.6 mm. The collapse produced by the four panel variations is a type of bending collapse. The results showed that the flexural strength tends to decrease when the reinforcement area ratio increases up to 0.36 and at the bamboo reinforcement area ratio around 0.37, the slabs flexural strength reaches the lowest limit up to 230 kg, while the next increases the area ratio bamboo reinforcement then the strength of the senture value goes up too. All flood gates with varying distances are able to withstand the hydrostatic load of water with a safety factor between 3.49 - 14.42.

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