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BEHAVIOUR OF BAMBOO REINFORCEMENT IN FLEXURAL STRENGTH OF SEA WATER CONCRETE SLAB

Alamsyah, HeryWaluyo, Muhammad Zulkarnain, Faisal Ananda, Zev Aljauhari

Politeknik Negeri Bengkalis

ABSTRACT

World Resources Institute data shows that there will be a fresh water crisis in 2040 including Indonesia. Responding to the above, many studies have been carried out using seawater, one of which is on concrete. Several studies have shown that seawater does not reduce the quality of concrete, but provides a corrosion effect on reinforcement.

In this study, sea water concrete slabs have been made using bamboo as a reinforcement that will not corrode due to seawater. For concrete mix design refers to SNI SNI 03-2834-2000 and for slab flexural strength refers to 03-2847-2002. Slab specimens with sea water concrete that have been made consist of Slab concrete of steel reinforcement (SCS), Slab concrete of bamboo reinforcement V type notch (SCBV) and Slab concrete of bamboo reinforcement U type notch (SCBU).

The result of the compressive strength of sea water concrete can reach the compressive strength of the plan. Tensile strength of bamboo reaches 223.5MPaand approaching the tensile strength of steel reinforcement. The maximum load of SCBV and SCBU were decrease than theoretical analysis of0.14% and 21.51% respectively. Otherwise, the maximum load of SCS greater than theoretical analysis with a difference of 14.67%. The flexural strength of the concrete slab was not affected by sea water as in compressive strength of cylinder.

Keywords: Bamboo reinforcement slab, Flexural strength, Seawater concrete

I. INTRODUCTION

Seawater is water with salt content and more available in coastal areas. On the other hand, the availability of fresh water in coastal areas is limited for drinking and other uses. Infrastructure enhancements, particularly those made of concrete, cannot be removed with water requirements for the cement hydration process, so that the use of sea water in concrete certainly provides a positive value in saving the availability of fresh water and optimizing the use of sea water.

A lot of studies about seawater on concrete, but concrete with a mixture of seawater that some researchers claim has increased the quality of concrete and had the disadvantage of causing corrosion of reinforcement. So it is necessary to think of the use of sea water concrete and reduce negative impacts such as corrosion. Corrosion occurs in materials containing Fe compounds, one of that is reinforcing steel. Because corrosion occurs in Fe, where one of the anodic reactions that cause corrosion in the form of 4Fe(OH)3, it is necessary to combine other materials in concrete mixed with sea water that does not contain compounds that cause corrosion.

Bamboo which has a high tensile strength needs to be utilized in the structure, particularly in the many available areas of the tree. This research has tried to use bamboo on concrete plate with a mixture of seawater, where high tensile strength of bamboo thatexpected to contribute well to the specimens. But the nature of bamboo which generally occursthe debondingin concrete has beensolved by making a notch on the bamboo.

Finally, the results of this study were expected to have a positive impact on seawater utilization in improving the quality of concrete and bamboo reinforcement as reinforcement that will not occurs ofcorrosion. With the benefits of sea water on concrete structures will reduce the cause of reduced availability of fresh water for other needs.

II. LITERATURE REVIEW

A. MATERIAL

In general the material that has been used to make concrete slab:

1. Portland cement (Holcim)
2. Seawater (Bengkalis Strait)
3. Fine Aggregate (Tg. BalaiKarimun)
4. Coarse Aggregate (Tg. BalaiKarimun)
5. Bamboo (Petung)

The seawater that has been used has quality such as Table 1:

Table 1. Quality of Bengkalis Strait Seawater

Sample	Ph (%)	Salinity (%)	BOD5 (mg/L)
Sample 1	8	5.2	85.15
Sample 1	7.6	7.2	64.2
Sample 1	7.6	6.4	45.24

Source: SLHD 2017, BadanLingkunganHidup

Olutoge et al (2014) conducted a study on the effect of sea water on compressive strength of concrete. The total test specimens of 140 cubes were w/c 0.6 and tested at 7, 14, 21, 28 and 90 days. In general the results showed an increase in concrete compressive strength.

The use of seawater which allows corrosion of materials containing **Fe**, the use of bamboo is able to avoid corrosion.

Research on the strength of the outer and inner bamboo has been carried out by Morisco (1999). The sampling can be seen in Figure 1.

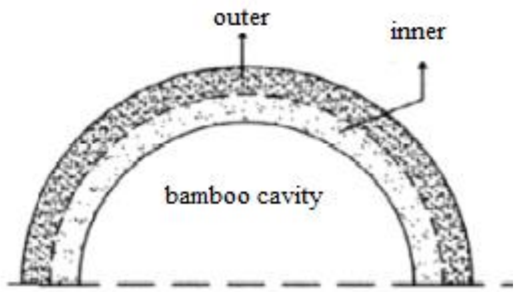

Figure 1. Collection of bamboo specimens (source: Morisco, 1999)

Amit Singh et al., 2016, tested the beam with bamboo reinforcement. The test specimens was made with a size of 150x150x700 mm and 150x200x700. The results showed that the beam with bamboo reinforcement had flexural strengthgreater than the Plain cement concrete of 53.23%.

Several studies have shown that there are often bonding problems between bamboo and concrete, particularly when the bamboo was coated with other materials.

Consequently, the bamboo reinforcement in this study was made U and V type notches to avoid bonding problems.

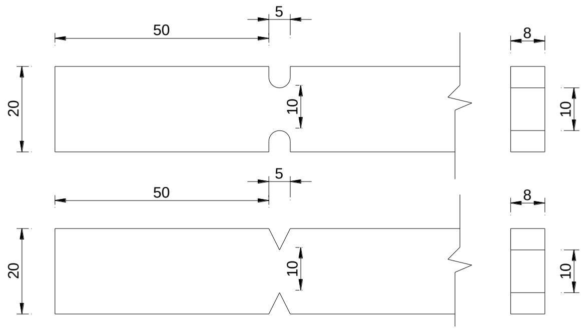

Figure 2. Type notches of Bamboo

The specimens of slab that have been made in this study are:

1. Slab concrete of steel reinforcement (SCS)
2. Slab concrete of bamboo reinforcementV type notch (SCBV)
3. Slab concrete of bamboo reinforcement U type notch (SCBU)

B. FLEXURAL STRENGTH

Flexural strength is the ability of a beam or concrete slab placed on two support to resist the force in the direction perpendicular to the axis of the specimen, given to it, until the test object is broken, expressed in Mega Pascal (MPa) force per unit area (SNI 4431:2011).

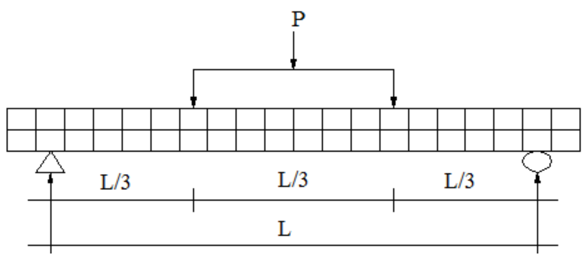

Figure 3. Set-up of testing

Based on the placement support as in Figure 3, moments and force are obtained such as Eq. 1 and Eq. 2.

$$M = \frac{P}{2}\left(\frac{L}{2}\right) = \frac{PL}{6} \qquad \text{Eq. 1}$$

$$P = \frac{6.M}{L} \qquad \text{Eq. 2}$$

Where, M = Moment (kNm); P = Load (kN); L = length between support (m)

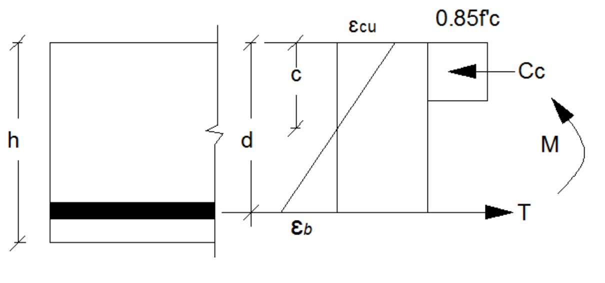

Figure 4. Strain and stress of slab concrete

The strong theoretical analysis of bamboo bending with bamboo reinforcement uses the following equation:

$$Cc = 0.85 f'c.a.b \qquad \text{Eq. 3}$$

$$T = Asb.ftb \qquad \text{Eq. 4}$$

$$M = Cc(d - \frac{a}{2}) \qquad \text{Eq. 5}$$

III. RESULT AND DISCUSSION

A. TEST RESULT OF MATERIAL

Testing of the constituent material of the slab concrete has been carried out on fine aggregate, coarse aggregate, steel and bamboo. The results can be seen on Table 1, Table 2, Table 3 and Table 4.

Table 2. Test of Fine Aggregate

No	Test	Result
1	Zone	II
2	Water content	1.01%
3	Bulk specific gravity on SSD Basic	2.588
4	Water absorption	1.59%
5	Fineness Modulus	2.78

Table 3. Test of Coarse Aggregate

No	Test	Result
1	Grading	Max. 40 mm
2	Water content	0.3%
3	Bulk specific gravity on SSD Basic	2.75
4	Water absorption	0.45%
5	Fineness Modulus	7.19
6	Abrasion test	27.62%

Table 4. Tensile test of Steel Ø10 mm

Sample	Max. Load	Yield Load	f_u	f_y
	(N)	(N)	(MPa)	(Mpa)
Steel 1	29554.09	20666.04	376.3	263.1
Steel2	28531.64	20920.37	363.3	266.4
			Average	**264.7**

Table 5. Tensile test of Bamboo

Bamboo Specimens	Max. Load	*Cross Area*	f_{tb}
	(N)	(mm)	(Mpa)
Bamboo1	39057.45	160	244,109
Bamboo2	31357.06	160	195,982
Bamboo3	35955.22	160	224,720
Bamboo4	36703.93	160	229,400
		Average	**223.5**

f_{tb}= bamboo tensile strength

B. JOB MIX FORMULA *f'c* 20 MPa

Based on existing data properties in Tables 1 and 2, referring to SNI 03-2834-2000, the composition can be seen on Table 6.

Table 6. Mix design composition, f'c 20 Mpa

Seawater (kg/m³)	Cement (kg/m³)	Fine Aggregate (kg/m³)	Coarse Aggregate (kg/m³)
185	385	653	1212

C. COMPRESSIVE STRENGTH

Compressive strength testing was carried out at 28 days. The compressive strength obtained was the result of the load per cylinder area.

Table 7. Compressive test of cylinder

Cylinder Sample	Compressive strength, *f'c* (MPa)	Average (MPa)
Sample 1	20.296	21.41
Sample 2	22.528	

The results of compressive strength have proved that the compressive strength of concrete can be achieved even though the mixture uses sea water.

D. RESULT TEST OF FLEXURAL STRENGTH

The shape of the slab and number of bars can be seen in Figure 5.

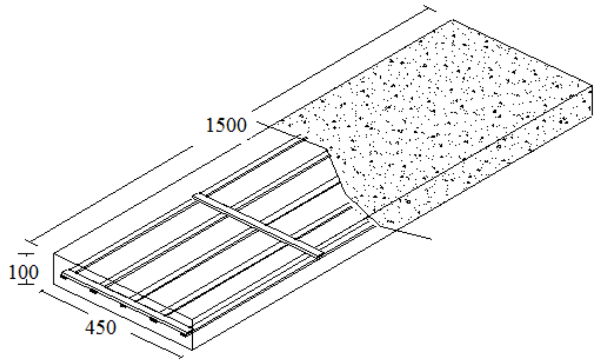

Figure 5. slab specimen

From the results previously obtained can be summarized:

Numbers of bar/bamboo = 5
Reinforcement area 10mm = 78.54 mm²
Compressive strength, *f'c* = 21.41 MPa
Yield strength of steel, f_y = 264.7 MPa
Bamboo Tensile strength, f_{tb} = 223.5 MPa

1. Theory analysisslab concrete of bamboo reinforcement

The bamboo reinforced concrete slab capability in resistance loads theoretically can be described as follows:

Depth effective, *d* = 75 mm
Length between support, *L* = 1300 mm
Bamboo area, A_{sb} = n x 10 x 8
= 5 x 80
= 400 mm²

$$\rho = \frac{A_{sb}}{b.d} = \frac{400}{450x75} = 0.0118$$

$$\rho_{\min} = \frac{1.4}{223.5} = 0.0062$$

T = A_{sb}xf_{tb}
= 400 x 223.5 = 89400 N

T = Cc = 0.85xf'c x a x b

$$a = \frac{T}{0,85xf'cxb} = 10.917\ mm$$

$$a_b = 0.85 \text{ x } \frac{600x75}{600+223.5} = 46.44mm$$

a_{max} = 0.75 x a_b = 34.83 mm

$\rho > \rho$ min and a $< a_{max}$

The theoretical nominal moment of the slab refer to Eq. 5:

$$M = Cc(d - \frac{a}{2}) = 89400x(75 - \frac{10.917}{2})$$

= 6217025.7Nmm = 6.217kNm

Refer to Eq. 2, maximum load :

$$P = \frac{6.217}{1.3} = 28.69kN$$

2. Experimental result slab concrete of bamboo reinforcement

Figure 6. slab testing two point load

From experimental tests such as Figure 6, results have been obtained such as Table 8 and Table 9.

Table 7. Flexural strength Slab type V

No	Type of slab	Theory load (kN)	Experimental load (kN)
1	SCBV-1	28.69	29.57
2	SCBV-2		25.49
3	SCBV-3		30.90
		Average	28.65

Table 8 has shown that the results of the slabflexural test with bamboo reinforcement V type notch can reach an average load of 28.65 kN. The maximum load difference in theory and actual was 0.14%.

Table 9. Flexural strength Slab type U

No	Type of slab	Theory load (kN)	Experimental load (kN)
1	SCBU-1	28.69	26.00
2	SCBU-2		26.50
3	SCBU-3		18.34
		Average	23.61

In contrast to Table 7, the results shown in Table 8 have shown that the results of slabflexural test with U type bamboo reinforcement only reach an average load of 23.61 kN. So, the difference between the maximum theoretical load and the actual difference was 21.51%.

Based on Figure 2, it can be assumed that the U notch with a distance of 50 mm is more likely to have a broken shear block between the notches and this causes the slab to not get the load as a theoretical analysis.

In addition, another cause that causes slab to collapse quickly was that bamboo was not uniform with bamboo in other samples. Gusti et al (2014) also explained that the node part of the bamboo results in a lower tensile of parallel grain strength than the other parts. It can also be a cause of damage to slab with bamboo reinforcement faster.

3. Comparison of the results of slab bamboo and slab steel reinforcement

As with bamboo reinforcement slab, steel reinforcement slab have been analyzed with equations and loaded a theoretical P of 28.69kN.For laboratory testing results can be seen in Table 10.

Table 10. Flexural strength Slab by steel

No	Type of slab	Theory load (kN)	Experimental load (kN)
1	SCS-1	35.34	40.78
2	SCS-2		40.00
3	SCS-3		40.80
		Average	40.52

Table 10 has shown the results of theoretical analysis and experimental tests for slab with steel reinforcement. The average load of experimental testing in the laboratory was 40.52 and the difference with the theory was 14.67%.

Similar the results of the concrete compressive strength of seawater that showed good results, the results of the bending strength of this slab also showed that the seawater concrete on the slab did not reduce the ability of the slab to accept the load.

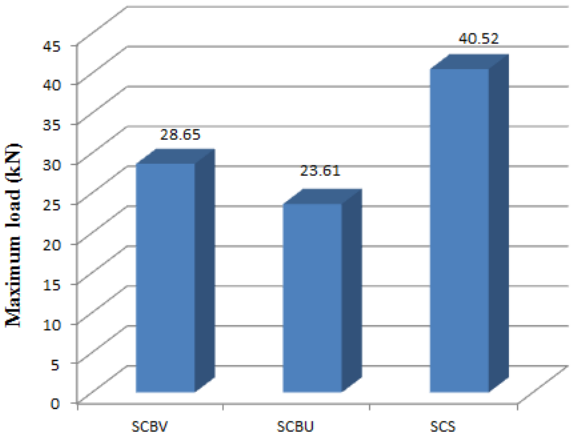

Figure 7. Experimental result of slab

The difference in tensile strength of steel and the tensile strength of bamboo causes the ability of the slab to resistance the load differently. Figure 7 has shown that the load on the steel reinforcement slab was greater than the bamboo reinforcement slab because the tensile strength of the steel was greater than the tensile strength of the bamboo as shown in Tables 3 and 4.

IV. CONCLUSION AND RECOMMENDATIONS

A. CONCLUSION

1. The compressive strength of sea water concrete can reach the compressive strength of the plan.
2. The tensile strength of bamboo reaches 223.5MPa.
3. The maximum load of slab with bamboo type V notch reaches 28.65 kN and smaller 0.14% thanthe theoretical load.
4. The maximum load of slab with bamboo type u notch reaches 23.61 kN and smaller 21.51% than the theoretical load.
5. The maximum load of slab with steel reinforcement reaches 40.51 kN and greater 14.67% than the theoretical load.

B. RECOMMENDATIONS

Further research designed the theoretical load of bamboo reinforcement slab and steel reinforcement slab made the same by considering the difference in tensile strength of the steel and bamboo.

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