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Durability of Bamboo Reinforced Concrete Columns on The Effect of High Temperature

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ABSTRACT
Reinforced concrete plays a crucial role in structural systems by providing strength and stability to buildings. Recent advancements in construction technology have introduced bamboo as an alternative reinforcement material to steel, due to its relatively high tensile strength (up to 253 MPa). However, bamboo's high cellulose content increases its vulnerability to fire. During building fires, structural elements may be exposed to temperatures between 800–1000°C for up to one hour. This study aims to investigate the effect of elevated temperatures on the axial load capacity and strain behavior of bamboo-reinforced concrete columns. Two reinforcement types were tested: (1) intact round bamboo with spiral steel stirrups, and (2) slatted bamboo with rectangular steel stirrups. All specimens were made using 25 MPa concrete with dimensions of 15×15×60 cm, and were exposed to 800°C for one hour before testing. Results showed that the round bamboo column with spiral stirrups sustained a maximum axial load of 247.6 kN (4.67% lower than analytical predictions and 59.83% lower than pre-fire values). The slatted bamboo column with rectangular stirrups held 233.2 kN (4.18% lower analytically and 61.78% lower than pre-fire values). Axial and lateral strain values varied slightly between specimens. This research highlights the structural viability of bamboo reinforcement under high-temperature exposure.

Keywords: *High Temperature Effect; Concrete Column; Bamboo Reinforced Concrete.*

1. Introduction

Reinforced concrete is one of the important structural elements for a building because it is a point in supporting the strength of the building. Reinforced concrete has characteristics and problems that must always be observed and explored further. The reinforcement commonly used in reinforced concrete is steel reinforcement material. According to SNI 2052:2017 there are 2 types of reinforcement in Indonesia, namely using reinforcement with a smooth surface and reinforcement with a finned/threaded surface. The function of reinforcement in concrete is to provide a much higher tensile strength compared to concrete to cover the weakness of concrete against tensile strength [6].

According to data from the Meteorology, Climatology and Geophysics Agency (BMKG), Indonesia is an area prone to earthquakes because it is crossed by three main tectonic plates, namely the Indian-Australian, Eurasian, and Pacific plates. Therefore, in planning earthquake-resistant building structures, the self-weight of a structure must be taken into account, because the earthquake force that works will be directly proportional to the mass of the building. Columns are very important elements in calculating earthquake-resistant building structures [9].

Bamboo is a material whose utilization has attracted the attention of scientists because of its environmentally friendly characteristics and lighter mass compared to conventional materials such as steel. Bamboo can be used as an alternative to steel reinforcement in concrete structures because it can provide many benefits, for example in terms of strength, bamboo has a tensile strength of 253 MPa, almost as strong as steel [18]. However, bamboo has a strength to weight ratio of about 4 to 8 times greater than conventional reinforcement. To achieve structural strength and full maturity, bamboo stems require 3 to 4 years of age [6]. In Indonesia, there are several types of bamboo, including apus bamboo/bamboo rope, petung bamboo, ori bamboo, and wulung bamboo. One type

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of bamboo that has the characteristics of a straight stem and a diameter that is not too large, high tensile strength although not the type with the highest tensile strength, and is the type of bamboo that is most durable against powder attacks is apus bamboo/bamboo rope [19].

Although bamboo can be used as an alternative material for steel reinforcement, it cannot be absolute like steel. One of the weaknesses of bamboo as reinforcement is its lower tensile strength compared to steel reinforcement [8]. In addition, bamboo is a material that contains quite high cellulose with a content of around 42.4 - 53.6%, making bamboo a material that is easily flammable [4]. Meanwhile, steel is a material that can withstand high temperatures without melting up to a temperature of 1500 ° C [10]. Although the steel reinforcement is in the concrete material, if the reinforced concrete is exposed to high temperatures, the steel reinforcement in the concrete will experience energy dissipation [1]. If a building catches fire, generally the fire temperature of a building can reaches a temperature of 800 to 1000 ° C with an average duration of 1 hour [5].

There are 2 types of reinforcement models and arrangements that can be used in reinforced concrete structural elements [6]. The first model is that the main reinforcement is replaced with a completely intact bamboo reinforcement with spiral stirrups, while the second model is to replace the main reinforcement with a smaller type of bamboo or bamboo that is split with square or rectangular stirrups. The function of the spiral reinforcement arrangement in reinforced concrete structural elements, especially in column elements, is to provide the column with the ability to absorb large enough deformation before collapsing so as to prevent the destruction of the entire building structure before the redistribution of moments and stresses is realized [14]. Meanwhile, the rectangular or square reinforcement arrangement model has the function of maintaining building stability by distributing the load more effectively so as to prevent the building from collapsing or sinking.

Based on the description above, important research is needed to conduct research by conducting experiments and reviewing the effect of high temperatures on bamboo reinforcement in reinforced concrete on the axial capacity and strain of columns with two different reinforcement arrangement models. This research is expected to determine the durability value of bamboo reinforced concrete columns against the effects of high temperatures or after a fire.

2. Material and Method

This study is planned to use an experimental method by creating variations in reinforcement in bamboo reinforced concrete. The first variation uses the main reinforcement of whole round bamboo with spiral-shaped steel stirrups, while the second variation uses the main reinforcement of bamboo that has been cut with rectangular steel stirrups. As a quality control and performance of the bamboo reinforced concrete column, it is a conventional reinforced concrete column with P8 steel main reinforcement and P6 steel stirrups. The quality of the concrete used in this study is 25 MPa. In the experimental study, the existing conditions were manipulated according to the researcher's needs. Then the researcher observed the effects produced by the manipulation logically [16]. The test specimens will be tested under normal conditions and burned at the age of 28 days. The size of the test specimens to be used in this study is a reinforced concrete column with a size of 15x15x60 cm and will be burned for 1 hour at a maintained temperature between 800-810 °C.

2.1. Concrete Mix Design

The fine aggregate used is black sand from Lumajang. The following test results include sieve analysis, specific gravity and absorption, and water content are listed in Table 1.

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Table 1. Fine Aggregate Inspection

Test Type	Unit	Test Result	Standart	Reference	Description
Fineness Modulus	-	2,63	1,5 – 3,8	ASTM C136-01	In accordance
SSD Specific Gravity	gr/cm^3	2,66	2,5 – 2,8	SNI 1970-2008	In accordance
Absorption	%	0,54	1% - 10%	SNI 1970-2008	In accordance
Water content	%	1,92	1% - 5%	SNI 03-1971-2011	In accordance

For the examination, the coarse aggregate used is aggregate from Pasuruan with a size of 10 mm. The following test results, including sieve analysis, specific gravity, absorption, and water content, are listed in Table 2.

Table 2. Coarse Aggregate Inspection

Test Type	Unit	Test Result	Standart	Reference	Description
Fineness Modulus	-	4,38	5,0 – 8,0	ASTM C136-01	In accordance
SSD Specific Gravity	gr/cm^3	2,59	2,5 – 2,8	SNI 1970-2008	In accordance
Absorption	%	1,19	1% - 5%	SNI 1970-2008	In accordance
Water content	%	1,09	1% - 5%	SNI 03-1971-2011	In accordance

To determine the mix design of concrete according to SNI 03-2834-2000. The mix design results for the column mix composition can be seen in Table 3.

Table 3. Mix Design Composition

f'c	Materials	Needed/m^3 (kg)	Needed/Collumns (kg)
25	Cement	426,7	5,8
	Water	213,3	2,9
	Fine Agregate	770,9	10,4
	Coarse Agregate	942,2	12,7

Table 3 presents the mix design composition for concrete with a target compressive strength of 25 MPa. The table provides the required amount of materials both in kilograms per cubic meter of concrete and per individual test column. The materials used include cement, water, fine aggregate (sand), and coarse aggregate (gravel). For every 1 m³ of concrete, the mix requires 426.7 kg of cement, 213.3 kg of water, 770.9 kg of fine aggregate, and 942.2 kg of coarse aggregate. Meanwhile, the material requirement for one test column includes 5.8 kg of cement, 2.9 kg of water, 10.4 kg of fine aggregate, and 12.7 kg of coarse aggregate. This composition reflects a water-cement ratio of approximately 0.5, which is suitable for medium-strength concrete. The data serves as an essential reference for mixing and casting concrete test columns, as well as for calculating material efficiency during the experimental process.

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2.2. Reinforcement Plan

The concrete column reinforcement plan in this study is divided into three types of reinforcement, namely conventional steel reinforcement, round bamboo reinforcement, and bamboo blade reinforcement. At this stage, test objects will be made with a total of 6 concrete column test objects and 10 cylindrical concrete test objects.

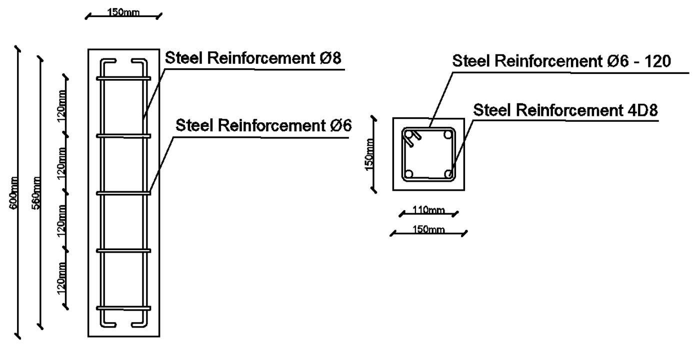

Figure 1. Conventional Column Reinforcement Plan

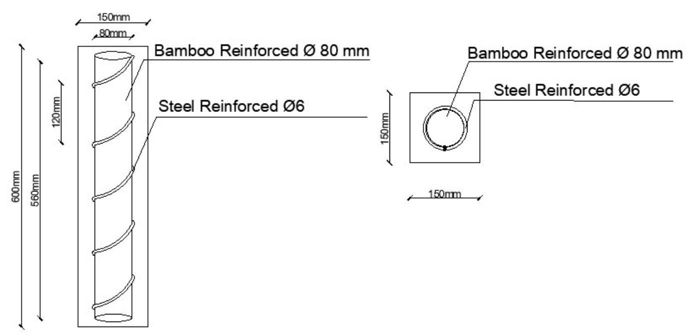

Figure 2. Round Bamboo Column Reinforcement Plan

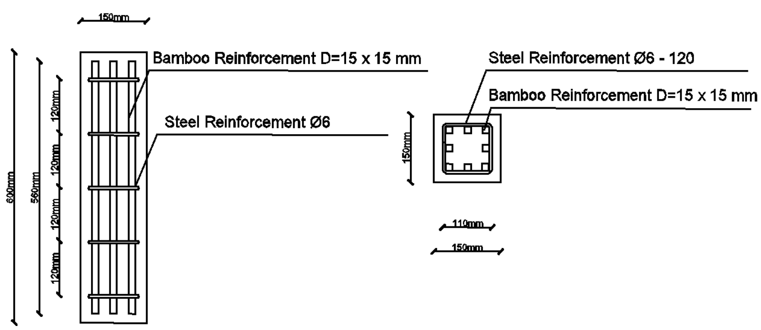

Figure 3. Square Bamboo Column Reinforcement Plan

2.3. Column Axial Load Test Equipment Settings

For setting the column axial load test tool, refer to ASTM C39 regarding "Standard Test Method for Compressive Strength of Cylindrical Concrete" (ASTM C39 International, 2023). This is done to assess the load capacity and behavior of the column when receiving axial loads until the column collapses. The process involves preparing tools such as UTM (Universal Testing Machine), LVDT (Linear Variable Differential Transformer) to measure deformation values (front and back), data loggers, recording loads and deformations, and observing crack patterns. The following is the setting for testing the axial load of the column in Figure 4.

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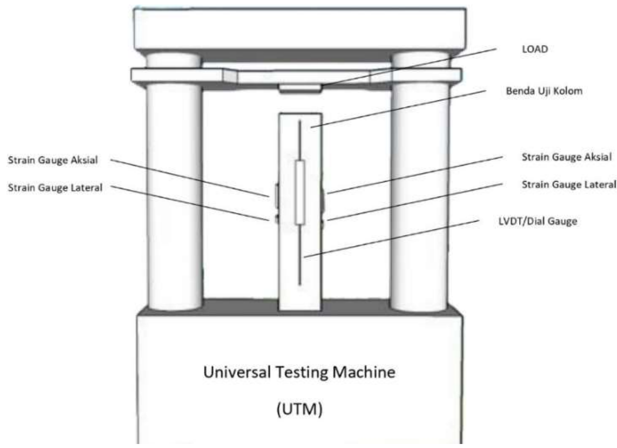

Figure 4. Column Axial Load Test Equipment *Settings*

The following is a flowchart of the research implementation sequence in figure 5.

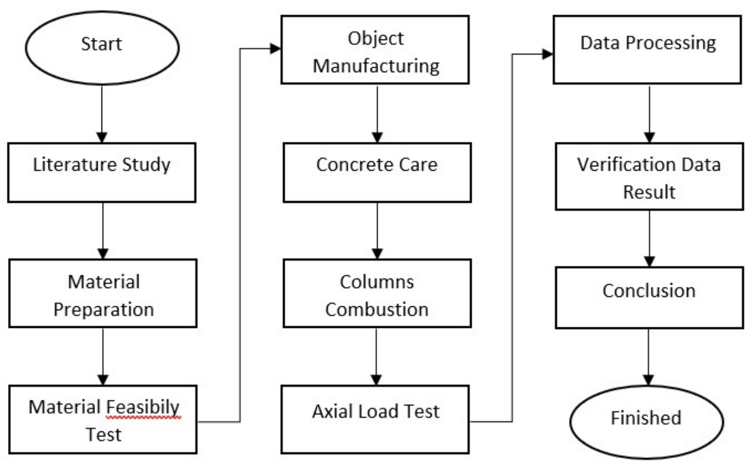

Figure 5. Research Flow Diagram

3. Result and Discussion

3.1. Material Properties Testing

Steel Reinforcement Inspection

This test refers to SNI 2052 – 2017. This test uses 3 (three) steel reinforcement samples with a sample length of 25 cm. Tensile testing uses a UTM (Universal Testing Machine) with a capacity of 1000 kN, an accuracy of 0.1 kN at the Structural Laboratory of Malang State University.

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Table 4. Tensile Test of Steel Reinforcement Material

Sample	Load		A	L_0	Stress		Strain		Dia	Steel Type
	yield	peak			yield	peak	yield	peak		
	(kN)	(kN)	(mm^2)	(mm)	(MPa)	(MPa)	(MPa)	(MPa)	(mm)	
8A	16803	25081	42,22	251	398,03	594,12	0,0029	0,0589	7,53	Bj TP 280
8B	16753	25182	42,22	250	376,05	565,26	0,0028	0,0654	7,53	
8C	16803	25282	42,22	250	377,17	587,5	0,0026	0,0628	7,53	
8D	16301	25081	42,22	250	386,14	592,93	0,0028	0,0619	7,53	
8E	16652	25182	42,22	250	386,05	565,25	0,0027	0,0557	7,53	
Average	**16662**	**25161**	42,22	**250**	**384,69**	**583,01**	**0,0028**	**0,0609**	**7,53**	

From the tensile test results of ø8 steel in Table 4, the average yield stress (fy) was 384.69 MPa, and the average maximum tensile stress (fu) was 577.01 MPa.

Bamboo Reinforcement Inspection

The bamboo samples used were the Apus gigantochloa apus bamboo type, as many as 5 (five) samples with a length of 25 cm and a diameter of ± 2.5 mm. This test refers to ISO 22157-2019, "Bamboo-Determination of physical and mechanical properties - Part 2: Laboratory manual." The following are the results of the bamboo examination listed in Table 5.

Table 5. Tensile Test of Bamboo Reinforcement Material

Sample	D (mm)	A (mm^2)	L_0 (mm)	fyb (Mpa)	σ_u (MPa)	ε_{yb}	ε_u	MOE (MPa)	Types of Bamboo
B1	2.4	4.52	250	132.26	251	0.00983	0.0187	17886	*Gigantochloa Apus*
B2	2.3	4.15		122.39	217	0.00755	0.0187	16850	
B3	2.1	3.46		124.47	238	0.00853	0.0221	17617	
B4	2.2	3.80		128.18	269	0.00519	0.0171	18058	
B5	2.3	4.15		129.74	272	0.00788	0.0182	18342	
Average	**2.3**	**4.02**		**127.41**	**249.4**	**0.00779**	**0.0190**	**17750.6**	

From the results of the bamboo tensile test data in Table 5, it can be seen that the average value of the tensile stress of apus bamboo (fyb) was obtained at 127.41 MPa. While the average maximum tensile stress (fub) was 249.4 MPa.

Examination of Concrete Compressive Strength and Elastic Modulus

The compressive strength and modulus of elasticity tests were carried out simultaneously until the maximum load carried by the concrete was reached. The following are the results of the compressive strength and modulus of elasticity tests of concrete listed in Table 6.

From the results of the concrete compressive strength test in Table 6, it can be seen that the average compressive strength of conventional concrete is 29.36 MPa, and the average compressive strength of post-fired concrete is 17.29 MPa. From these results, it can be concluded that the compressive strength of the concrete meets the planned compressive strength, where the planned compressive strength for normal quality is 25 MPa. While for post-fired concrete, the compressive strength decreases by 12.07 MPa or by 41.11% from the normal concrete compressive strength.

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Table 6. Concrete Compressive Strength and Elastic Modulus Test

Sample	P_{max} (kN)	ε_{max} (MPa)	ε_{max}	MOE (MPa)
Normal Concrete				
N1	544,00	30,39	0,00133	22851,97
N2	525,50	29,75	0,00120	24742,04
N3	510,00	28,87	0,00117	24696,85
N4	538,50	30,49	0,00131	23199,74
N5	502,50	30,39	0,00137	22238,87
Average		**29,36**		**23545,89**
Concrete Effect of High Temperature				
S1	323,00	18,05	0,00142	12923,91
S2	302,00	16,87	0,00138	12405,11
S3	315,00	17,83	0,00141	12447,74
S4	283,80	16,67	0,00135	11931,64
S5	305,50	17,07	0,00138	12548,87
Average		**17,29**		**12451,45**

The test results above show that the average normal concrete modulus of elasticity is 22952.74 MPa, and the average concrete modulus of elasticity affected by high temperature / post-fired is 12451.45 MPa. Based on these data, the value of the concrete modulus of elasticity due to the influence of high temperature / post-fired decreases by 10501.29 or decreases by 45.75% from the normal concrete modulus of elasticity.

3.2. Testing of Normal Reinforced Concrete Columns

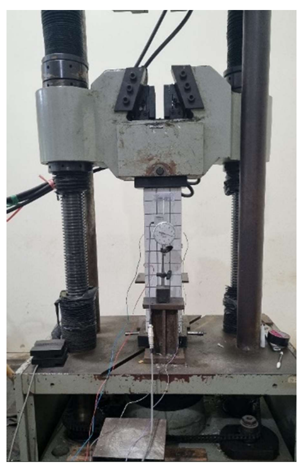

Figure 6. Column Axial Testing

Based on the calculation results of the axial load capacity of normal columns and high-temperature-influenced columns. Where the analytical calculation results are guided by ACI 440-2R-2017. The following table shows the increase in analytical and experimental load capacity of normal columns presented in Table 7.

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Table 7. Normal Concrete Column Axial Capacity

Type of Concrete	Type of Reinforce	Pu (kN)		Difference Between Analytical and Experimental Results	
		Analitycal	Experiment	(kN)	(%)
Normal	Steel	590,75	626,70	35,95	4,80
	Round Bamboo	598,28	616,50	18,22	3,04
	Square Bamboo	569,21	610,20	40,98	7,20

Round Bamboo Reinforcement Column

From the test data, it can be seen that the maximum axial load occurs at a value of 616.5 KN with a left-side axial strain value of -0.02376 μ, a right-side axial strain value of -0.03212 μ, a left-side lateral strain value of -0.01342 μ, and a right-side lateral strain value of -0.01746 μ, and a stress value of 26.86 MPa.

From these results, it is known that the experimental test result value is 3.04% greater than the analytical calculation value. The maximum stress and strain that occurs in the column is 26.86 Mpa while the left side axial strain is -0.02376 μ, the rightside axial strain value is -0.03212 μ, the left side lateral strain value is 0.01342 μ, and the rightside lateral strain value is 0.01746 μ. The difference in maximum load values can occur because it is influenced by field conditions such as the casting process, compaction, and the concrete curing process carried out [9]. Other studies also state that the axial load value of bamboo reinforced concrete columns with circular or spiral steel stirrups has a value of 537 kN. The lateral stress and strain that occur at the maximum load are 27 MPa and 0.020 μ [2].

The test results of conventional concrete columns with steel reinforcement carried out in this study have a maximum axial load value in the experiment of 626.7 kN while in analytical calculations it occurs at a value of 590.756 kN. From these results it is known that the experimental test result value is 4.08% greater than the analytical calculation value. While the maximum stress and strain that occurs in the column is 27.13 Mpa while the left side axial strain is -0.01996 μ, the rightside axial strain value is -0.02360 μ, the left side lateral strain value is 0.02064 μ, and the rightside lateral strain value is 0.02280 μ. The insignificant difference in the axial load, strain and stress values in round bamboo reinforced concrete columns and conventional steel reinforced concrete columns can occur because the bamboo Axle is 5.46 times larger than the steel Axle. This is in accordance with the fact that the Axes used in bamboo must be ≥ 4 and ≤ 8 of the Axes used in steel [6].

Square Bamboo Reinforcement Column

From the test data, it can be seen that the maximum axial load occurs at a value of 610.2 KN with a left-side axial strain value of -0.02334 μ, a right-side axial strain value of -0.02662 μ, a left-side lateral strain value of -0.01196 μ, and a right-side lateral strain value of -0.01388 μ, and a stress value of 26.41 MPa.

From these results, it is known that the experimental test result value is 3.20% greater than the analytical calculation value. The maximum stress and strain that occurs in the column is 26.41 Mpa while the left side axial strain is -0.02334 μ, the rightside axial strain value is -0.02662 μ, the left side lateral strain value is 0.01196 μ, and the rightside lateral strain value is 0.01388 μ. The difference in maximum load values can occur because it is influenced by field conditions such as the casting process, compaction, and the concrete curing process carried out [9]. Other studies also state that the axial load value of bamboo reinforced concrete columns with simple steel stirrups or rectangular shapes with column dimensions of 0.15 x 0.15 m and f,c concrete 25 MPa has a value of 521 kN. The lateral stress and strain that occur at the maximum load are 24 MPa and 0.017 μ [2].

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3.3. Testing of Reinforced Concrete Columns Effect of High Temperature

Figure 7. Column Axial After Testing

Based on the calculation results of the axial load capacity of normal columns and high temperature influenced columns. Where the analytical calculation results are guided by ACI 440-2R-2017. The following table shows the increase in analytical and experimental load capacity of normal columns presented in Table 8.

Table 8. Effect of High Temperature on Concrete Column Axial Capacity

Type of Concrete	Type of Reinforcement	Pu (kN)		Difference Between Analytical and Experimental Results	
		Analitycal	Experiment	(kN)	(%)
Effect of High Temperature	Steel	355,89	329,70	-56,20	-7,94
	Round Bamboo	259,73	247,60	-12,13	-4,67
	Square Bamboo	243,37	233,20	-10,17	-4,18

Round Bamboo Reinforcement Column

From the test data, it can be seen that the maximum axial load occurs at a value of 247.6 KN with a left-side axial strain value of -0.02766 μ, a right-side axial strain value of -0.02280 μ, a left-side lateral strain value of -0.00695 μ, and a right-side lateral strain value of -0.00880 μ, and a stress value of 10.86 MPa.

From these results, it is known that the experimental test result value is 4.67% smaller than the analytical calculation value. The maximum stress and strain that occurs in the column is 10.86 Mpa while the left side axial strain is -0.02766 μ, the rightside axial strain value is -0.02284 μ, the left side lateral strain value is 0.00695 μ, and the rightside lateral strain value is 0.00880 μ.

In the results of the values of conventional steel reinforced concrete columns due to the influence of high temperatures carried out in this study. The maximum axial load value in the experiment is 329.7 kN while in the analytical calculation it occurs at a value of 385.902 kN. From these results it is known that the experimental test results are 14.5% smaller than the analytical calculation value. Meanwhile, the maximum stress and strain that occurs in the column is 14.36 Mpa while the left side axial strain is -0.05300 μ, the rightside axial strain value is -0.04426 μ, the left side lateral strain value is 0.01190 μ, and the rightside lateral strain value is 0.01016 μ.

The difference between the axial load value in the experimental test and the analytical calculation of the round bamboo reinforced concrete column can occur because the bamboo reinforcement in the concrete has been destroyed or has become charcoal due to the influence of high temperatures up to 800 ° C received by the concrete column, so that the column is no longer able to

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withstand the pressure according to the planned load. This can happen because bamboo is a material that contains quite high cellulose with a content of around 42.4 - 53.6%, making bamboo a flammable material [3]. In fact, if a building burns, the temperature received by the building's structural elements can reach 800 - 1000 ° C. Unlike conventional steel-reinforced concrete columns in this study, the axial load values in experimental tests and analytical calculations are not too different because steel is a material that can withstand high temperatures without melting up to 1500 ° C [10]. However, even though the steel reinforcement is in the concrete material, if the reinforced concrete is exposed to high temperatures, the steel reinforcement in the concrete will experience energy dissipation which results in a difference between experimental tests and analytical calculations on conventional steel-reinforced columns.

The findings in this study as presented above, it can be seen that the steel-reinforced concrete column obtained an experimental value that was 14.5% smaller than the analytical calculation results, or equal to 85.5% of its analytical calculation. So that the correlation coefficient value for calculating the axial load capacity of the steel-reinforced concrete column due to the influence of high temperatures or after burning is 0.855. This is in accordance with the fact that steel is a material that can withstand high temperatures without melting up to a temperature of 1500°C [10]. However, even though the steel reinforcement is in the concrete material, if the reinforced concrete is exposed to high temperatures, the steel reinforcement in the concrete will experience energy dissipation.

Square Bamboo Reinforcement Column

From the test data, it can be seen that the maximum axial load occurs at a value of 233.2 KN with a left-side axial strain value of -0.01626 μ, a right-side axial strain value of -0.02370 μ, a left-side lateral strain value of -0.00756 μ, and a right-side lateral strain value of -0.01054 μ, and a stress value of 10.16 MPa.

From these results, it is known that the experimental test result value is 4.18% smaller than the analytical calculation value. The maximum stress and strain that occurs in the column is 10.16 Mpa while the left side axial strain is -0.01626 μ, the rightside axial strain value is -0.02370 μ, the left side lateral strain value is 0.00756 μ, and the rightside lateral strain value is 0.01054 μ.

In the results of the values of conventional steel reinforced concrete columns due to the influence of high temperatures carried out in this study. The maximum axial load value in the experiment was 329.7 kN while in the analytical calculation it occurred at a value of 385.902 kN. Meanwhile, the maximum stress and strain that occurs in the column is 14.36 Mpa while the left side axial strain is -0.05300 μ, the rightside axial strain value is -0.04426 μ, the left side lateral strain value is 0.01190 μ, and the rightside lateral strain value is 0.01016 μ.

The difference between the axial load values in the experimental test and the analytical calculations of the bamboo blade reinforced concrete column can occur because the bamboo reinforcement in the concrete has been destroyed or has become charcoal and only the stirrup reinforcement remains due to the influence of high temperatures up to 800 ° C received by the concrete column, so that the column is no longer able to withstand the pressure according to the planned load. This can happen because bamboo is a material that contains quite high cellulose with a content of around 42.4 - 53.6%, making bamboo a flammable material. In fact, if a building is on fire, the temperature received by the building's structural elements can reach 800 - 1000 ° C [4]. Unlike conventional steel-reinforced concrete columns in this study, the axial load value in experimental testing and analytical calculations is not too different because steel is a material that can withstand high temperatures without melting up to 1500 ° C [10]. However, even though the steel reinforcement is in the concrete material, if the reinforced concrete is exposed to high temperatures, the steel reinforcement in the concrete will experience energy dissipation which results in a difference between experimental testing and analytical calculations in conventional steel-reinforced columns.

The findings in this study as presented above, it can be seen that the axial load capacity value of bamboo-reinforced concrete columns with rectangular stirrups has an experimental value that is 4.18% smaller than the analytical calculation, or equal to 95.8% times the analytical calculation. So

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it can be obtained that the value of the correlation coefficient for calculating the axial load capacity for round bamboo-reinforced concrete columns is 0.958.

4. Conclusion

The maximum axial load value that occurs in round bamboo reinforced concrete columns with circular or spiral steel stirrups is 616.5 kN, this value is 3.04% higher than the analytical calculation and 1.62% lower than the maximum load on conventional steel reinforced concrete columns. The maximum stress that occurs in the column is 26.86 Mpa while the axial strain is -0.02794 μ, and the lateral strain value is 0.01544 μ. Meanwhile, the maximum axial load value that occurs in bamboo reinforced concrete columns with rectangular steel stirrups is 610.2 kN, this value is 3.20% higher than the analytical calculation and 2.63% lower than the maximum load on conventional steel reinforced concrete columns. The maximum stress that occurs in the column is 26.41 Mpa while the axial strain is -0.02498 μ, and the lateral strain value is 0.01292 μ.

The maximum axial load value that occurs in the concrete column due to the influence of high temperature reinforced with round bamboo with circular or spiral steel stirrup reinforcement is 247.6 kN, this value is 4.67% lower than the analytical calculation and 24.90% lower than the maximum load on the concrete column due to the influence of high temperature reinforced with steel. The maximum stress that occurs in the column is 10.86 Mpa while the axial strain is -0.02525 μ, and the lateral strain value is 0.00788 μ. Meanwhile, the maximum axial load value that occurs in the concrete column due to the influence of high temperature reinforced bamboo blades with rectangular steel stirrups is 233.2 kN, this value is 4.18% lower than the analytical calculation and 29.26% lower than the maximum load on the concrete column due to the influence of high temperature reinforced steel. The maximum stress that occurs in the column is 10.16 Mpa while the axial strain is -0.01998 μ, and the lateral strain value is 0.00905 μ.

All bamboo reinforcement models have an increase in the deformation value that occurs in the concrete column that has been affected by high temperatures. The deformation of the round bamboo reinforced concrete column increased by 180.38% from before being affected by high temperatures. While the deformation in the bamboo reinforced concrete column increased by 141.37% from before being affected by high temperatures. This is because when the concrete is exposed to high temperatures, the concrete will experience degradation, and the presence of bamboo reinforcement reduces the cross-sectional area of the column, thereby reducing its elastic modulus. Due to the axial load acting on the reinforced concrete column and the deformation of the column, cracks will occur. In all types of column reinforcement, all crack patterns are included in the diagonal crack type or shear crack type, because the column is a short column type.

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