Jurnal MKTS
Jurnal Ilmu dan Terapan Bidang Teknik Sipil
ISSN 0854-1809

SURAT PERNYATAAN

Dengan hormat,

Kami memerlukan konfirmasi Saudara dengan menandatangani dan mengembalikan pernyataan di bawah ini.

Penulis menjamin bahwa artikel adalah karya asli penulis dan belum pernah dipublikasikan sebelumnya. Penulis juga menjamin bahwa artikel tersebut tidak mengandung pernyataan yang memfitnah atau melanggar hukum dan tidak melanggar hak orang lain. Jika artikel dipersiapkan bersama, penulis setuju untuk memberi tahu rekan penulis ketentuan perjanjian dan untuk menandatangani atas nama mereka.

Editor,

Saya menyatakan bahwa naskah dengan

Judul	:	Performance of the Pivot Hooks to Enhance the Flexural Capacity of Bamboo Reinforced Concrete Beams
Nama Penulis Pertama	:	Alfinna Mahya Ummati
Nama/Alamat Instansi	:	Institut Teknologi Sumatera/National Central University
Nama Penulis Kedua	:	Michael
Nama/Alamat Instansi	:	Institut Teknologi Sumatera
Nama Penulis Ketiga	:	I Putu Ellsa Sarassantika
Nama/Alamat Instansi	:	National Central University/Universitas Warmadewa
Nama Penulis Keempat	:	Gibral Tariq Fanna
Nama/Alamat Instansi	:	Institut Teknologi Sumatera
Nama Penulis Kelima	:	Syahidus Syuhada
Nama/Alamat Instansi	:	Institut Teknologi Sumatera
Nama Penulis Keenam	:	Bayzoni
Nama/Alamat Instansi	:	Universitas Lampung
Nama Penulis Ketujuh	:	Ade Prayoga Nasution
Nama/Alamat Instansi	:	Institut Teknologi Sumatera

Lampung Selatan, 12/8/2022

Alfinna Mahya Ummat

Performance of the Pivot Hooks to Enhance the Flexural Capacity of Bamboo Reinforced Concrete Beams

by 芬娜 艾

Submission date: 12-Aug-2022 06:21PM (UTC+0800)
Submission ID: 1794930126
File name: MKTS-Pivot_Hooks_Final.docx (1.42M)
Word count: 3919
Character count: 21256

MEDIA KOMUNIKASI TEKNIK SIPIL
Website : mkts.sipil.undip.ac.id
E-ISSN : 2549 - 6778
doi: mkts.v22i2.12871

Performance of the Pivot Hooks to Enhance the Flexural Capacity of Bamboo Reinforced Concrete Beams

*Alfinna Mahya Ummati[1,2], Michael[1], I Putu Ellsa Sarassantika[2,4], Gibral Tariq Fanna[1], Syahidus Syuhada[1], Bayzoni[3], Ade Prayoga Nasution[1]
[1]Department of Civil Engineering, Institut Teknologi Sumatera, Lampung Selatan, Indonesia
[1]Department of Civil Engineering, National Central University, Taoyuan, Taiwan
[1]Department of Civil Engineering, Universitas Lampung, Bandar Lampung, Indonesia
[1]Department of Civil Engineering, Universitas Warmadewa, Denpasar, Indonesia

*)Corresponding Author: Alfinna.mahya@si.itera.ac.id

Received: ……. Revised: …….. Accepted: ……..

Abstract

Some researcher missed the role of hooks in their bamboo reinforcement. Consequently, the bamboo reinforcement and concrete used to have slip and failure to composited, this make the concrete and bamboo working independently to sustain the given loading and the bond failure become the main issue than the beam failure. This research studied about the role of the pivot hooks that capable to enhance the loading capacity higher than the beams without the pivot hooks. Experimental test performed in order to identify the effect of the pivot hooks presence which added to the flexural reinforcement which made by bamboo materials to avoid the bond slip failure that mostly occur in the bamboo reinforced concrete beams. The experimental test which verified by the numerical analysis by FEA NX commercial software proof that the pivot hooks are able to increase the loading capacity of a concrete beam 33% - 40% higher than the bamboo reinforcement without the pivot hooks. Architectural façade and budget efficiency caused the bamboo become unavoidable material in construction, by adding the structure modification such as the pivot hooks for the bamboo reinforcement, the failure can be reduced, then the entanglement of bamboo in construction become more functional.

Keywords: *Pivot Hooks, Bamboo, Reinforced Concrete, Beam, Static Loading*

Abstrak

Peran dari kait pada ujung-ujung tulangan bambu sebagai tulangan utama seringkali diabaikan. Mempertimbangkan material bambu dan beton yang dikombinasikan bersama menjadi struktur komposit sangat rentan terhadap selip akibat susut yang dialami bambu dan beton seiring bertambahnya usia material. Penelitian ini mempelajari peran dari *pivot hooks*, merupakan kait berbentuk pasak yang terpasang di setiap tulangan lentur bermaterial bambu, dalam penelitian ini membuktikan bahwa penambahan *pivot hooks* dapat meningkatkan kapasitas beban yang dapat diterima oleh balok jika dibandingkan dengan tulangan bambu tanpa adanya *pivot hooks*. Pada dasarnya *pivot hooks* ditambahkan sebagai tindakan preventif terhadap selip tulangan dengan beton yang menyebabkan kedua material tidak dapat bekerja bersama secara komposit. Penelitian secara eksperimen yang hasilnya divalidasi berdasarkan Analisa numerik dengan *software* komersial FEA NX. Sejalan dengan hipotesis yang ada, baik berdasarkan studi eksperimen ataupun *solid modelling* dalam FEA NX membuktikan bahwa peran *pivot hooks* dalam tulangan bambu dapat meningkatkan kapasitas beban yang dapat diterima sebesar 33% - 40% dari tulangan tanpa *pivot hooks*. Saat ini dalam sisi arsitektural dan efisiensi biaya, bamboo menjadi material alternative pengganti tulangan baja yang keberadaannya-pun juga melimpah untuk pembangunan berkelanjutan, *pivot hooks* merupakan upaya peningkatan kekuatan struktur pada bambu untuk meningkatkan fungsi bambu dalam konstruksi bangunan.

Kata kunci: *Pivot Hooks, Bambu, Beton Bertulang, Balok, Beban Statik*

1. Introduction

As a developing country, Indonesia has a big responsibility to maintain its economy stability and support Indonesian need through its massive infrastructure development. The development mostly still utilizes conventional concrete and its reinforcement, though there have several innovations applied on the construction, nevertheless steel reinforcement is commonly utilized on. According to The Indonesian Iron and Steel Industry Association (IISIA), the need of rebar in Indonesia is increasing annually, which is counted more than 3 million ton every year since 2018. This phenomenon indicates that every year the production of rebar is getting massive as well as its emission, namely carbon dioxide, sulphate oxide, nitrogen oxide, and other particulate. As the impact of cement and rebar production to the environment is extremely increasing, an alternative to the specific materials needs to be discussed (Dixit & Puri, 2019) (Riofrio, Cornejo, & Baykara, 2022), such as the utilization of ground glass and coal bottom ashes (Kasaniya, Thomas, & Moffatt, 2021), fly ashes (Pangestuti, Handayani, Purnomo, Silitonga, & Fathoni, 2018), and bamboo leaf (Odeyemi, et al., 2022).

Specifically discussing about bamboo, as a species of flora that massively grow in Indonesia (Putra, Sinarta, & Bagiarta, 2020), this kind of plant is often be used in traditionally architectural component of custom houses in every part of Indonesia. Some people in specific regions use bamboo as structural components of the houses, such as its beam and columns. The trend using bamboo can be considered that bamboo can be easily shaped (Fahim, Haris, Khan, & Zaman, 2022) and affordable (Putra, Sedana, & Santika, 2007). In the perspective of the material strength, bamboo culms have a quite good mechanical properties, such as tensile strength up to 210 MPa and the elastic modulus up to 17500 MPa depends on its species. This fact shows that bamboo can be considered to replace steel as concrete reinforcement (Fahim, Haris, Khan, & Zaman, 2022) (Javadian, Smith, Saeidi, & Hebel, 2019) (Qaiser, Hameed, Alyousef, Aslam, & Alabduljabbar, 2020).

Bamboo reinforced concrete performance depends on the species of bamboo used, because of its natural characteristics that every species has its own morphology. The studies, that conducted to beam structures, show a trend that bamboo reinforced concrete is able to improve the flexural strength of structures (Qaiser, Hameed, Alyousef, Aslam, & Alabduljabbar, 2020) (Sutharsan, Ramprasanna, Gnanappa, & Chithambar, 2019) (Awoyera, Karthik, Mao, & Gobinath, 2019) (Dey & Chetia, 2018) (Rahman, Rashid, Hossain, Hasan, & Hasan, 2011). The strength is in line to the number of days of curing and the dimension of the rebars (Dey & Chetia, 2018). The use of bamboo as rebar contributes the minimum deformation and crack propagation, but low elastic modulus (Awoyera, Karthik, Mao, & Gobinath, 2019). The strength of bamboo reinforced concrete can be improved by adjusting the shape of the bamboo rebar, such as the present of bark and node contribute the higher tensile strength up to 50% (Muhtar, Analisis Eksperimental Pengaruh Jarak Klem Selang Pada Perilaku Lentur Balok Beton Bertulang Bambu, 2021). Another study also shows the presence of notches and clamps can increase the bond-stress and flexural capacity, as well as reducing slip between the bamboo and concrete (Al-Fasih, Hamzah, Ahmad, Ibrahim, & Ariffin, 2021) (Budi & Rahmadi, 2019) (Muhtar, Dewi, & Munawir, Enhancing bamboo reinforcement using a hose-clamp to increase bond- stress and slip resistance, 2019). However, the utilization of bamboo as rebar is still under study, thus some scholars still oppose this trend because bamboo reinforced concrete still has low strength compared to steel reinforced (Nuraeni, Widyarti, & Sapei, 2018) (Archila, Kaminski, Trujillo, Escamilla, & Harries, 2018) (Mali & Datta, 2020), while some innovation brings to an improvement to the bamboo reinforced concrete (Karthik, Rao, & Awoyera, 2017) (Wei, Chen, Jiang, Zhou, & Zhao, 2021). Hence, this paper will discuss bamboo reinforced concrete with pivot hooks at the end of the bamboo rebar.

2. Materials and Methodology

The experimental test conducted to identify effect on applying pivots as the representative of hooks on both ends of embedded bamboo reinforcement as the flexural reinforcements in improving the flexural capacity of the bamboo reinforced concrete beam. Material preparation carried out to investigate the quality of materials which consist of: Aggregates gradation, cement, concrete mix proportions, reinforcement preparation.

2.1. Concrete

Composition of normal concrete consist of fine aggregate, coarse aggregate, and cement. Fine aggregate used in the mixing process is ordinary sand with fineness modulus is 2.9, accepted value of the standard fineness modulus regarding SNI 7656-2012 which proposed the value in range of 1.5-3.8. Water content evaluate in 1500 gram of fine aggregate sample which used in this research and was found that the water content of fine aggregate is 5.933% after reducing the weight to

1411 gram with 4.9% of the mud content. The specific gravity of fine aggregate is 2.53 in SSD condition with water absorptions 0.5%. The density of fine aggregate used in this research is 486.9 kg/m^3.

The coarse aggregate is the crushed gravel with the fineness modulus 4.1 and the maximum size is 25 mm. The water content is 4.117% which evaluates from 3000 gram of the coarse aggregate sample that reduced to 2876.5 gram, with the mud content 1.7%. The specific gravity in SSD condition is 2.473 with the capability of absorption is 2.58%. The coarse aggregate that used in this experiment has the density 1753.2 kg/m^3. Physical identification to evaluate the cement properties resulted that the cement that used for the specimens is the ordinary Portland cement has the setting time 120 minutes with 26 mm of penetration. The density of cement that used in the experiment is 3.048 gram/cm^3.

The material preparation as mentioned before was done in order to design the mix proportion regarding with the Job Mix Formula (JMF) based on SNI 7656-2021 with the targeted compressive strength and slump of concrete is 30 MPa and 100 mm, respectively. The parameter used for JMF calculation is regarding the entity listed on Table 1, regarding this JMF parameters, for 1 m^3 of concrete require: 357.41 kg of cement, 204.54 kg of water, 821.5 kg of fine aggregate, and 996.55 kg of coarse aggregate.

Table 1 Parameters used on the Job Mixed Formula

No.	Parameters	Quantity	Unit
1	Targeted compressive strength	30	MPa
2	Targeted slump	100	mm
3	Maximum aggregates size	25	mm
4	Free water	193	kg/m^3
5	Water cement ratio	0.54	
6	Cement	357.41	kg/m^3
7	Fineness modulus of fine aggregate	2.9	
8	Weight of coarse aggregate (Dry)	1506	kg/m^3
9	Coarse aggregate volume (Dry)	0.66	m^3
10	Coarse aggregate weight	993.9703	kg
11	Fresh concrete weight	2380	kg/m^3
12	Weight of fine aggregate	835.62	kg/m^3

Compressive test was done for the concrete at the age of 28 days within the cylinder model using Compression Testing Machine. 3 concrete cylinder sample taken during the mixing process of the beam specimens. The mix proportion designed for f'c 30 MPa and the compressive strength of cylinder identified the actual f'c is 25.57 MPa, with the average concrete density is 2228 kg/m^3.

Figure 1 Cylinder testing

Table 2 Cylinder testing result

No	Weight (kg)	f'c (MPa)
1	12.04	27.74
2	11.36	22.65
3	12.02	26.33
Mean	11.81	25.57

2.2. Reinforcement

Bamboo used as the longitudinal reinforcement to evaluate the capacity of bamboo to combine with the concrete as the flexural reinforcement since bamboo is the anisotropic material with the strength is varied depend on the fiber direction, bamboo indicated has the strong capacity in the axial fiber direction. There are 5 specimens to evaluate the bamboo capacity within Universal Tensile Machine (UTM) with the applied speed load was 10 MPa/second. Local bamboo materials which tested in dry condition with the size of 5 x 10 x 300 mm clamped in their both ends. Regarding with the tensile test that was done from 5 specimens, the local bamboo which tested and used as the longitudinal reinforcement has the average yield strength 192.734 MPa, this value is under the range of 100 – 260.68 MPa from the yield strength which proposed by the previous studies. Steel reinforcement used as the confinement with the dimension of Ø8-100 mm to avoid the shear failure.

Figure 2 Tensile testing

Table 3 Tensile testing result

No	Specimen ID	fy (MPa)
1	B1	259.177
2	B2	200.656
3	B3	183.549
4	B4	153.018
5	B5	167.271
Mean		192.734

3. Experimental Test and Discussion

3.1. Numerical Analysis

Numerical analysis performed in order to validate the experimental test, the beam modelled as 3D solid finite element within Midas FEA NX commercial software. Concrete modelled as a solid element, bamboo and confinement modelled as truss element which embedded inside the concrete. Material properties of the specimens listed on

Table ***4*** based on the actual material laboratory testing, the geometry modelling of the reinforcement assembling showed on **Error! Reference source not found.**, three-point bending loading protocol applied to the beam as in Figure 4. Material and section properties in the numerical modelling analyzed by Von Misses failure criteria to define the nonlinearity.

A displacement loading applied with the design loading of 60 mm, load and displacement curve plotted in order to evaluate the beams behavior under the static loading. Control beam is the beam with the ordinary flexural reinforcement which made from bamboo materials. However, Pivot hooks beam is the model which added a pivot hook in both end of the flexural reinforcement which made from the same material. The pivots have the similar role as the hooks in rebar.

Table 4 Material properties

No	Mate-rial	Size (mm)	E (MPa)	Poisson's Ratio	f'c (MPa)	fy (Mpa)
1	Concrete	150 x 250 x 1700	23766	0.2	25.57	-
2	Bamboo	5 x 10	14279	0.16	-	192.73
4	Confinement	Ø8 - 100	210000	0.3	-	556

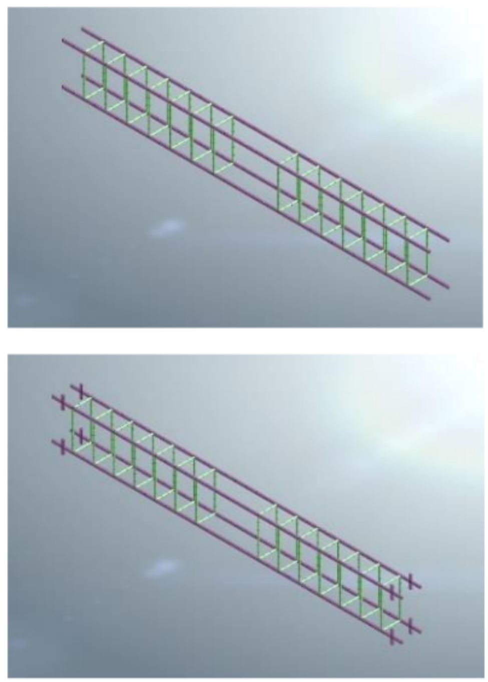

Figure 3 Reinforcement assembling of: (Top) Control beam, (Bottom) Pivot hooks beam

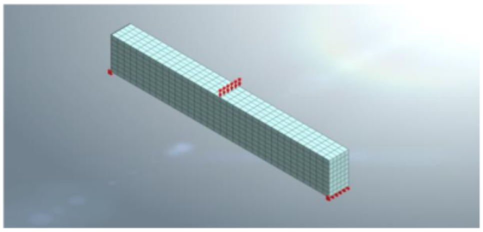

Figure 4 Loading protocol and boundary conditions of the numerical analysis

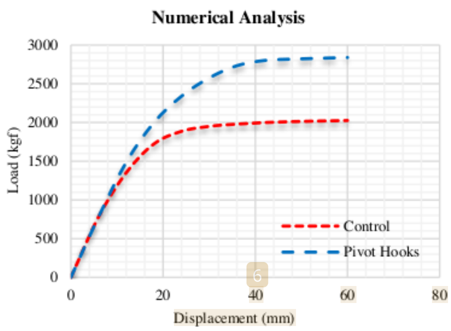

Figure 5 Load and displacement curve comparison

By adding these pivots on the bamboo bar, the failure due to the bond slip between the bamboo and concrete can be reduced since this is the most important problem with high possibility will happen on the practical issue. Regarding the comparison load and displacement relation between the control beam and the pivot hooks beam with the given load control of 60 mm, the red line with small dashed line shows the load-displacement relation of the control beam which failure under 2026.004 kgf, meanwhile the blue line with large dashed line shows the load-displacement relation of the pivot hooks beam which failure under 2839.147 kgf. Based on the numerical analysis, the bamboo RC beam with the pivot hooks could bear 40% higher than the load which can be sustained by the control beams as the estimation of what will happen on the experimental test.

The evaluation of stress (Sxx) under the given loading is closed related to the location of cracks, the numerical modelling resulted that the stress of control beams described as in Figure 6 with the maximum stress is 27.903 MPa in tension, 41.769 MPa in compression. Meanwhile, for the pivot hooks beam, the stress described as in Figure 7 with the maximum stress is 27.914 MPa in tension, 42.156 in compression.

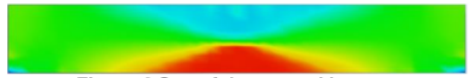

Figure 6 Sxx of the control beam

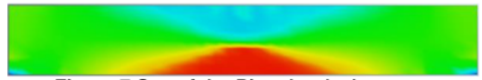

Figure 7 Sxx of the Pivot hooks beam

Cracks will develop on the location which the internal stress is larger than the allowable tensile stress, for both cases, the initial crack predicted to occur on the middle bottom span due to the tensile stress and continue to improve on the middle top due to the compression.

3.2. Experimental Test

There are two variants of beam with and without the pivot hook applied on the flexural reinforcements, with the aim to identify the effect of pivot hooks to enhance the flexural capacity of beam with the dimension of 15 x 25 x 170 cm. The clear area from outer beam surface to the reinforcement is 3 cm, the beams designed to have four longitudinal reinforcements which made from 5 x 10 mm square section bamboo. The confinement made from the steel bar Ø8 - 100 mm, a number of 14 confinements located on the shear zone. Experimental design of the specimens showed on Figure 8.

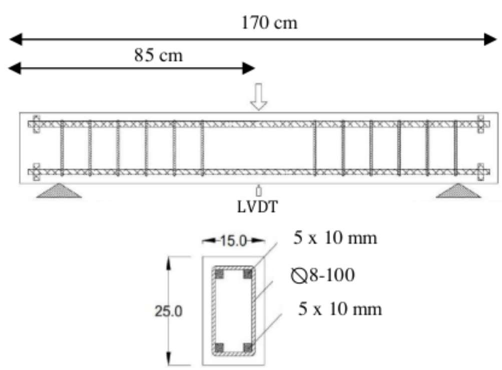

Figure 8 Details of pivot hooks beam

There are four specimens consist of: 2 beams with ordinary flexural reinforcement which made from bamboo materials in further named control beams as in **Error! Reference source not found.** (left), 2 beams other with the pivot hooks in both end of the flexural reinforcement which made from the same materials as in Figure 8 and **Error! Reference source not found.** (right). The beams loaded by the concentrated force in the middle span as the position of load cell, the displacement measured by LVDT which placed on the middle bottom of the beams. Table 5 and

Table ***6*** shows the load capacity and displacement of all specimens which tested on the laboratory testing.

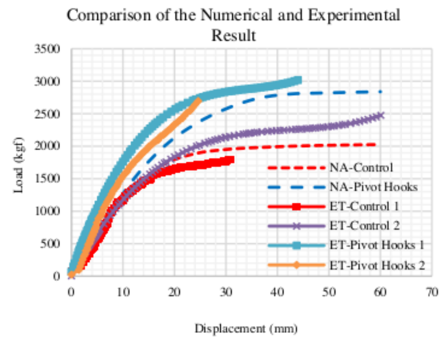

Figure 9 Load and Displacement Curve Comparison of The Numerical Analysis and Experimental Test

Table 5 Load capacity based on the experimental test

Specimen	Maximum Load (kgf)	Average (kgf)	Difference
Control 1	1777.92	2105.510	33%
Control 2	2433.1		
Pivot Hooks 1	2980.97	2806.225	
Pivot Hooks 2	2631.48		

Table 6 Displacement of all beams by the experimental test

Specimen	Maximum Disp (mm)	Average (mm)	Difference
Control 1	31.63	45.850	25%
Control 2	60.07		
Pivot Hooks 1	43.98	34.590	
Pivot Hooks 2	25.2		

Regarded the experimental test that was done for two beams in each category, the role of pivot hooks may increase the load capacity up to 33% and the displacement can reduce 25% from the normal beams without the pivot hooks.

Figure 9 is the load and displacement relation of the control beams and pivot hooks beams by the experimental test (ET) and comparing with the dashed line of the numerical analysis (NA). Both result between numerical analysis and experimental test showed that the pivot hooks affect the beams to have more flexural capacity compared with the beams without the pivot hooks.

The cracks developed by the given loading as shown in Figure 10 for the control beams, Figure 11 for the pivot hooks beams, the crack depth and width show in the picture with the unit of mm.

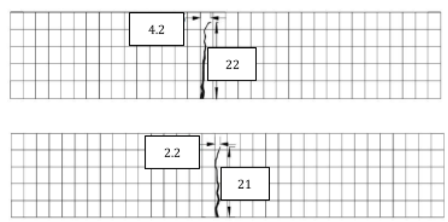

Figure 10 Crack pattern for the: (Top) Control beam 1, (Bottom) Control beam 2

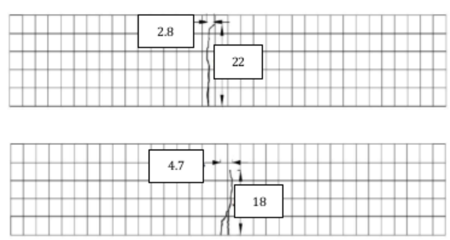

Figure 11 Crack pattern for the:(Top) Pivot hooks beam 1, (Bottom) Pivot hooks beam 2

The crack which appear as the consequences of the given loading described that the failure dominantly on flexure, started from the tension part on the middle span then growth to the compression zone as predicted by the numerical analysis.

4. Conclusion

The experimental test which validated by the numerical analysis was conducted in order to identify the effect of pivot hooks presence on the bamboo reinforcement to enhance the flexural capacity of bamboo RC beams. Bamboo has been widely entangled as the material construction since their anisotropic characteristic which give more advantage in their strong fiber direction to combine with the concrete to substitute the tension strength. Previous studies which have been verified by the experimental test that was done in this research identified that the tension capacity of the bamboo is half of the steel, the yield strength of bamboo is 192.734 MPa. The pivot hooks which added in the both ends of the reinforcement help the bar to enhance the bonding capability of the bamboo rebar and concrete, it was proofed by the experimental test that the capacity of loading which could sustained by the beams with the pivot hooks is 33% higher than the beam without the pivot, this result was in line with the numerical analysis which predict that the pivot hooks was able to improve the loading capacity up to 40% in perfect modelling. This result is satisfied to enhance the capacity of the concrete beams which reinforced by the bamboo material which definitely has the lower capacity than the steel RC beam. The role of bamboo in construction is unavoidable considering the architectural and financial efficiency especially for the people in the countryside. Thus, the presence of the pivot hooks will be the solution to reduce the bonding slip failure between the concrete and reinforcement in order to enhanced the capacity of the bamboo reinforced concrete beams.

5. Acknowledgement

A research collaboration between Institut Teknologi Sumatera, National Central University, Universitas Lampung, and Universitas Warmadewa. This research is supported by Institut Teknologi Sumatera, especially: LPPM (Department of Research and Public Service) to provide the research grant with the number of B/763ag/IT9.C1/PT.01.03/2022 in year 2022 for conducting the experimental test.

6. References

Al-Fasih, M. Y., Hamzah, S., Ahmad, Y., Ibrahim, I. S., & Ariffin, M. M. (2021, July 05). Tensile properties of bamboo strips and flexural behaviour of the bamboo reinforced concrete beams. *European Journal of Environmental and Civil Engineering*.

Archila, H., Kaminski, S., Trujillo, D., Escamilla, E. Z., & Harries, K. A. (2018). Bamboo reinforced concrete: a critical review. *Materials and Structures, 51*.

Awoyera, P. O., Karthik, S., Mao, P. M., & Gobinath, R. (2019). Experimental and numerical analysis of large-scale bamboo-reinforced concrete beams containing crushed sand. *Innovative Infrastructure Solutions, 4*.

Budi, A. S., & Rahmadi, A. P. (2019). Flexural behavior of petung bamboo strip notched reinforced concrete beams. *IOP Conf. Series: Journal of Physics*.

Dey, A., & Chetia, N. (2018). Experimental study of Bamboo Reinforced Concrete beams having various frictional properties. *International Conference on Processing of Materials, Minerals and Energy*, *5*. Ongole.

Dixit, A., & Puri, V. (2019, September). Bamboo Bonding in Concrete: A Critical Review. *International Journal of Innovative Technology and Exploring Engineering (IJITEE), 8*(11S).

Fahim, M., Haris, M., Khan, W., & Zaman, S. (2022). Bamboo as a Construction Material: Prospects and Challenges. *Advances in Science and Technology Research Journal, 16*(3), 165-175.

Javadian, A., Smith, I. F., Saeidi, N., & Hebel, D. E. (2019). Mechanical Properties of Bamboo Through Measurement of Culm Physical Properties for Composite Fabrication of Structural Concrete Reinforcement. *Frontiers in Materials, 6*(15).

Karthik, S., Rao, P. R., & Awoyera, P. O. (2017). Strength properties of bamboo and steel reinforced concrete containing manufactured sand and mineral admixtures. *Journal of King Saud University - Engineering Sciences*.

Kasaniya, M., Thomas, M. D., & Moffatt, E. G. (2021). Pozzolanic reactivity of natural pozzolans, ground glasses and coal bottom ashes and implication of their incorporation on the chloride permeability of concrete. . *Cement and Concrete Research, 139*.

Mali, P. R., & Datta, D. (2020, March). Experimental Evaluation of Bamboo Reinforced Concrete Beams. *Journal of Building Engineering, 28*.

Muhtar. (2021). Analisis Eksperimental Pengaruh Jarak Klem Selang Pada Perilaku Lentur Balok Beton Bertulang Bambu. *Jurnal Penelitian Ipteks, 6*(2).

Muhtar, Dewi, S. M., & Munawir, A. (2019). Enhancing bamboo reinforcement using a hose-clamp to increase bond- stress and slip resistance. *Journal of Building Engineering, 26*.

Nuraeni, R., Widyarti, M., & Sapei, A. (2018, April 01). Felxural Capacity Assessment of Bamboo Petung Reinforce Concrete Beams. *Jurnal Teknik Sipil dan Lingkungan, 03*(01).

Odeyemi, S. O., Atoyebi, O. D., Kegbeyale, O. S., Anifowose, M. A., Odeyemi, O. T., Adeniyi, G., & Orisadare, O. A. (2022). Mechanical properties and microstructure of High-Performance Concrete with bamboo leaf ash as additive. *Cleaner Engineering and Technology, 6*.

Pangestuti, E. K., Handayani, S., Purnomo, M., Silitonga, D. C., & Fathoni, M. H. (2018). The Use of Fly Ash as Additive Material to High Strength Concrete. *Jurnal Teknik Sipil & Perencanaan, 20*(2).

Putra, D., Sedana, I. W., & Santika, K. B. (2007, Januari). Kapasitas Lentur Plat Beton Bertulangan Bambu. *Jurnal Ilmiah Teknik Sipil, 11*(1).

Putra, I. R., Sinarta, I. N., & Bagiarta, I. Y. (2020, March). Analisa Kekuatan Struktur Bambu Pada Pembangunan Entry Building Green School Ubud. *U KaRsT : Journal of Civil Engineering Research at the University of Kadiri, 4*(1).

Qaiser, S., Hameed, A., Alyousef, R., Aslam, F., & Alabduljabbar, H. (2020). Flexural strength improvement in bamboo reinforced concrete beams subjected to pure bending. *Journal of Building Engineering, 31*.

Rahman, M. M., Rashid, M. H., Hossain, M. A., Hasan, M. T., & Hasan, M. K. (2011). Performance Evaluation of Bamboo Reinforced Concrete Beam. *International Journal of Engineering & Technology IJET-IJENS, 11*(04).

Riofrio, A., Cornejo, M., & Baykara, H. (2022). Environmental performance of bamboo fibers and sugarcane bagasse reinforced metakaolin-based geopolymers. *Case Studies in Construction Materials, 17*.

Sutharsan, R., Ramprasanna, S. R., Gnanappa, S. B., & Chithambar, A. (2019). Experimental Study on Bamboo as a Reinforcing Material in Concrete. *2nd International Conference on Emerging Research in Civil, Aeronautical and Mechanical Engineering*.

Wei, Y., Chen, S., Jiang, J., Zhou, M., & Zhao, K. (2021). Experimental investigation of bamboo-concrete composite beams with threaded reinforcement connections. *Journal of Sandwich Structures and Materials, 0*(0), 1-26.

Performance of the Pivot Hooks to Enhance the Flexural Capacity of Bamboo Reinforced Concrete Beams

ORIGINALITY REPORT

5%	5%	3%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Universitas Riau Student Paper	2%
2	repository.unmuhjember.ac.id Internet Source	1%
3	jurnal.unmuhjember.ac.id Internet Source	<1%
4	jurnal.ugm.ac.id Internet Source	<1%
5	scholarcommons.sc.edu Internet Source	<1%
6	www.dot.ca.gov Internet Source	<1%
7	www.nat-hazards-earth-syst-sci.net Internet Source	<1%
8	Emmanuel Owoichoechi Momoh, Adelaja Israel Osofero, Oleksandr Menshykov. "Behaviour of clamp-enhanced palm tendons	<1%

reinforced concrete", Construction and Building Materials, 2022
Publication

9	N.S Kathiravan, R Manojkumar, P Jayakumar, J Kumaraguru, V Jayanthi. "State of art of review on bamboo reinforced concrete", Materials Today: Proceedings, 2020 Publication	<1 %
10	os.zhdk.cloud.switch.ch Internet Source	<1 %
11	techscience.com Internet Source	<1 %
12	uwe-repository.worktribe.com Internet Source	<1 %
13	Muhtar, Sri Murni Dewi, Wisnumurti, As'ad Munawir. "Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance", Journal of Building Engineering, 2019 Publication	<1 %

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		