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HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*

KARYA ILMIAH: JURNAL ILMIAH

Judul Karya Ilmiah (Paper)	: **Numerical Validation data of Tensile Stress Zone and Crack Zones in Bamboo Reinforced Concrete Beams Using the Fortran PowesStation 4.0 Program**		
Jumlah Penulis	: 1 Orang (1. Muhtar, 2. ...., 3. .... 4. ....)		
Status Pengusul	: Penulis pertama / ~~penulis ke....~~ / penulis korespondensi**		
Identitians Jurnal/Prosiding	: a. Nama Jurnal/ Prosiding	: Journal Data in Brief	
	b. ISSN/ISBN	: 2352-3409	
	c. Tahun Terbit, (tempat pelaksanaan jika prosiding)	: 2020	
	d. Penerbit/Organiser	: Elsevier B.V	
	e. Alamat repository PT/ Web	: http://repository.unmuhjember.ac.id/4026/	
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(Beri √ pada kategori yang tepat)	[ ] Jurnal Internasional		
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(Prof. Dr. Ir. Sri Murni Dewi, MS.)
NPK/NIP. 195112111981032001
Unit kerja: Teknik Sipil UB Malang
Jafung : Guru Besar
Bidang Ilmu : Teknik Sipil

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HASIL PENILAIAN SEJAWAT SEBIDANG ATAU *PEER REVIEW*

KARYA ILMIAH: JURNAL ILMIAH

Judul Karya Ilmiah (Paper)	: **Numerical Validation data of Tensile Stress Zone and Crack Zones in Bamboo Reinforced Concrete Beams Using the Fortran PowesStation 4.0 Program**
Jumlah Penulis	: 1 Orang (1. Muhtar, 2. ………….., 3. …………….. 4. ………………)
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All Authors: Muhtar - Muhtar, M.T.
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All Authors: Muhtar - Muhtar, M.T.

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Answers to comment of Managing Editor and Reviewer

A. The merging of the two articles

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1. There are two topics and two calculation methods very different
2. Abstract as part of the initial promotion that must be easy to understand, concise, and lead to one topic.
3. Merging two titles into one title results in a title that is longer than the existing title.

B. Specification table/related research article:

Deletion of unrelated articles has been carried out and there is only one related article as shown in the "abstract" last line and "Specification table / related research article".

C. Value of the data:

Background deletion and refinement of data value points have been carried out, especially at the last point, this can be seen in the "Value of Data" item.

Detailed Response to Reviewers

A. The merging of the two articles

After I considered, the merging of the two articles was not carried out for the following reasons:

1. There are two topics and two calculation methods very different
2. Abstract as part of the initial promotion that must be easy to understand, concise, and lead to one topic.
3. Merging two titles into one title results in a title that is longer than the existing title.

B. Specification table/related research article:

Deletion of unrelated articles has been carried out and there is only one related article as shown in the "abstract" last line and "Specification table / related research article".

C. Value of the data:

Background deletion and refinement of data value points have been carried out, especially at the last point, this can be seen in the "Value of Data" item.

Article Title

Numerical validation data of tensile stress zones and crack zones in bamboo reinforced concrete beams using the Fortran PowerStation 4.0 program

Authors

Muhtar

Affiliations

Department of Civil Engineering, Faculty of Engineering, University of Muhammadiyah Jember, Jember, 68121, Indonesia

Corresponding author(s)

Muhtar (muhtar@unmuhjember.ac.id)

Abstract

Numerical verification is carried out in order to control the compatibility of the BRC beam crack pattern with the stress contour at the ultimate load. The numerical method used is the finite element method (FEM). Ultimate load data and beam crack pattern data are taken from BRC beam testing in the laboratory. The beam tensile stress data was obtained from FEM analysis using the Fortran PowerStation 4.0 program by inputting ultimate load data from the beam test. Material data entered is the elasticity modulus (E) and Poisson ratio (v). Bamboo reinforcement and concrete are considered to have the same displacement with a different elasticity modulus (E), so they experience different stresses. The triangle element is employed to model the plane-stress with two directions of displacement at each nodal point, so that each element has six degrees of freedom. The BRC beam tensile stress data from the Fortran PowerStation 4.0 program is processed into a tensile stress data table and becomes the Surfer program data for mapping stress contour images. Crack pattern data from laboratory beam testing is processed into crack zone pattern photo data. The stress contour data from the Surfer program is processed into image data of the tensile stress zone. The Fortran PowerStation 4.0 programming language data in this article can be used for further research with the discretization of triangular elements in other cases. This article consists of a data table, a picture of a crack pattern zone, a drawing of tensile stress zones, and photo documentation. The data is related to "Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance" [1].

Keywords

numerical validation, finite element method, tensile stress zone, crack zone, bamboo reinforced concrete

Specifications Table

Subject	Engineering.
Specific subject area	Civil and structural engineering.
Type of data	Table, image, program.
How data were acquired	The crack pattern data was obtained from the beam flexural test (Fig. 15). The stress contour data was obtained from FEM analysis, using the Fortran PowerStation 4.0 and Surfer programs. Crack pattern data from the beam flexural test is processed and analyzed into crack zone image data. Stress data from FEM analysis is processed into stress table data and becomes the input data for the Surfer program. Data from the Surfer program is processed into stress zone image data. Then, all data is processed, compared, and analyzed into table data, cracks pattern zone image data, tensile stress zone image data, and photo data.
Data format	Raw and analyzed.
Parameters for data collection	Crack pattern data and maximum tensile stress data are two highly related data, in which cracks will occur at the maximum tensile stress position. The initial cracks until the collapsed beams are obtained through observation with a crack detector under a gradually increasing load. Crack pattern zone data from the laboratory beam test needs to be validated by other methods to determine compatibility with stresses that occur. Stress data and stress zone images data are obtained through FEM analysis using the Fortran PowerStation 4.0 and the Surfer programs. The Fortran PowerStation 4.0 programming language can be used for further research.
Description of data collection	The crack pattern data was collected through beam testing in the laboratory. Initial crack and subsequent crack data up to the beam collapsing are obtained through observation in stages, according to the beam loading stage. The crack detector is used to observe cracks. Each crack is numbered and drawn as the crack line. Then the crack data is processed and documentation taken, with results termed the crack zone image data. Tensile stress zone data was obtained from two sources, FEM analysis using the Fortran PowerStation 4.0 and the Surfer programs. FEM analysis with the Fortran PowerStation 4.0 program was obtained for direction stresses of X, Y, and Z. The X directional stress is tensile stress that causes cracks. The X direction stress data is then transferred to the Surfer program to generate the stress zone contour image data. The crack pattern data and the stress zone contour image data are compared and analyzed into table data, image data, program data, and photo data, all of which are termed intact data. This intact data was obtained from two specimens, namely a BRC beam and an SRC beam, to obtain crack patterns and tensile stresses with different reinforcement materials. The behaviors

	of the crack pattern and the stress zone from the two beams can be used as basis for further research.
Data source location	University of Muhammadiyah Jember, Jember, 68121, Indonesia, and University of Brawijaya, Malang 65145, Indonesia
Data accessibility	Data with the article, raw data can be found in Table 1, Table 2, Table 3, http://bit.ly/351FPqU, http://bit.ly/2MBqas9, http://bit.ly/2F17w8F, http://bit.ly/2rDPeaI, http://bit.ly/2Q4Ihc1, http://bit.ly/2MTh22j, http://bit.ly/2ZvZWMU, http://bit.ly/2u2K2xR, http://bit.ly/2ZybLCd, and http://bit.ly/2Q7j2Wp
Related research article	Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance. https://doi.org/10.1016/j.jobe.2019.100896 [1]

Value of the Data

- This data contains a program that can be used as a reference in analyzing and calculating stresses of the BRC beam and SRC beam by triangular element discretizing.
- This data is useful for researchers in developing bamboo reinforced concrete structures, especially for simple construction in areas of abundant bamboo.
- Data can be used for further insight and development, especially stress analysis, capacity, and behavior of bamboo reinforced concrete beams with strengthening reinforcement.
- The added value of this data is in the programming language; Fortran PowerStation 4.0 can now be used generally in further research to analyze the displacement and stress of two-dimensional plane-stress elements.

Data

The discretization image data of the BRC beam and SRC beam with triangular elements is shown in Fig. 1 and Fig. 2. The reduction data of the stiffness of the BRC beam and the SRC beam after the initial crack occurs up until the beam collapses is shown in Table 1 and Table 2. The input data for the Fortran PowerStation 4.0 program for the BRC beam is shown in the following link: http://bit.ly/351FPqU, and the input data for the SRC beam is shown in the link: http://bit.ly/2MBqas9. The programming language data for the Fortran PowerStation 4.0 program with the discretization of triangular elements is shown in the link: http://bit.ly/2F17w8F.

The data of the load-displacement relationship of the BRC beam and SRC beam from experiments and FEM analyses is shown in Table 3, while the image data of the load-displacement relationship diagrams from experiments and FEM analyses is shown in Fig. 3. The displacement contours data in the X-direction and Y-direction of the Surfer program for the BRC beam is shown in Fig. 8 and Fig. 9,

and the displacement contour data in the X-direction and Y-direction from the Surfer program for the SRC beam is shown in Fig. 12 and Fig. 13.

The table data of stress on the X-direction, Y-direction, and XY-direction from FEM analysis for the BRC beam is shown in the following link: http://bit.ly/2rDPeaI, and the stress contour image data from the Surfer program is shown in Fig. 4, Fig. 6, and Fig. 7. The table data of stress on the X-direction, Y-direction, and XY-direction from FEM analysis for the SRC beam is shown in the following link: http://bit.ly/2Q4Ihc1, while the stress contour image data from the Surfer program is shown in Fig. 5, Fig. 10, and Fig. 11. Photographs of crack pattern data and tensile stress contour data for the analysis of the compatibility of the zone are shown in Fig. 4 and Fig. 5.

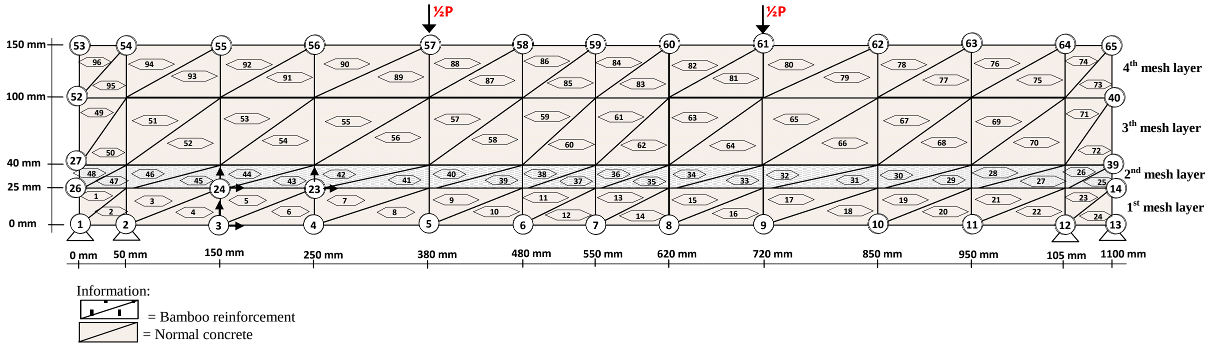

Fig. 1. The discretization of the BRC beam using the triangle element [1]

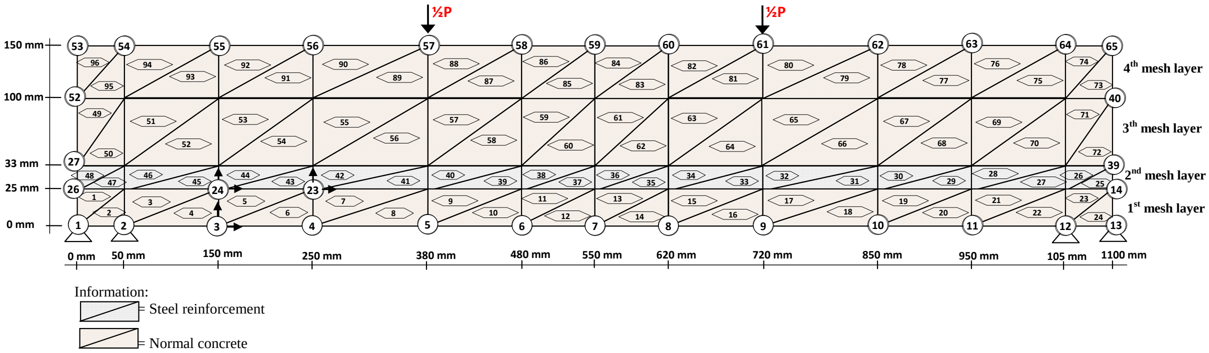

Fig. 2. The discretization of the SRC beam using the triangle element

Table 1
The reduction data of the stiffness of the BRC beam after initial cracking occurs up until the ultimate load [2]

Layer number	Modulus of elasticity (E) of the BRC beam									
	Elastic condition	Plastic conditions with gradual loads								
	0 - 8.5 kN	9 kN	11 kN	15 kN	17 kN	21 kN	23 kN	25 kN	27 kN	29 kN	33 kN
4th mesh layer	268512,89	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	120830,80	112775,41	85924,12
3th mesh layer	268512,89	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	120830,80	107405,16	93979,51	75183,61
2nd mesh layer	247451,73	138845,32	115704,43	115704,43	115704,43	104133,99	104133,99	104133,99	69422,66	69422,66	55538,13
1st mesh layer	268512,89	134256,45	118145,67	83239,00	67128,22	51017,45	51017,45	37591,80	32221,55	26851,29	13291,39

Table 2
The reduction data of the stiffness of the SRC beam after initial cracking occurs up until the ultimate load [2]

Layer number	Modulus of elasticity (E) of the SRC beam										
	Elastic condition	Plastic conditions with gradual loads									
	0 - 9 kN	10 kN	11 kN	12 kN	13 kN	15 kN	17 kN	19 kN	21 kN	23 kN	24 kN
4th mesh layer	268512,89	268512,89	201384,67	201384,67	201384,67	201384,67	201384,67	187959,02	187959,02	134256,45	114117,98
3th mesh layer	268512,89	268512,89	201384,67	201384,67	187959,02	187959,02	187959,02	174533,38	174533,38	134256,45	114117,98
2nd mesh layer	407825,73	432093,18	324069,88	324069,88	302465,22	302465,22	280860,56	280860,56	259255,91	216046,59	183639,60
1st mesh layer	268512,89	268512,89	201384,67	201384,67	187959,02	187959,02	174533,38	161107,73	147682,09	134256,45	120830,80

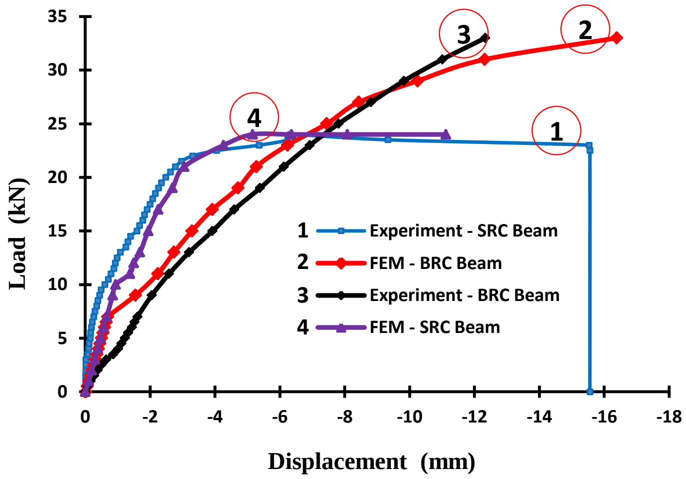

Fig. 3. The load-displacement relationship of the BRC and SRC beams with experiment and FEM

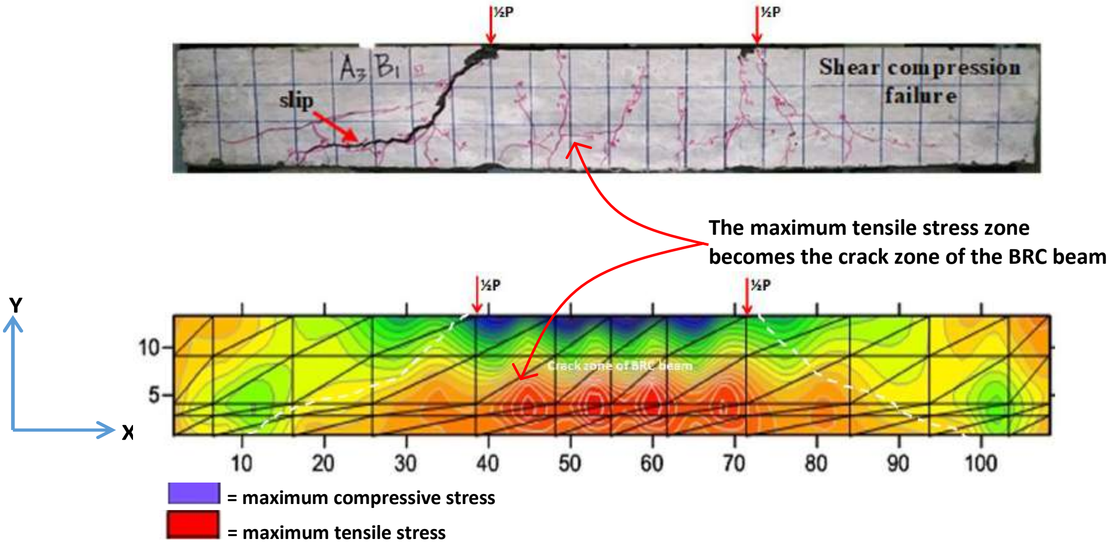

Fig. 4. The data validation of crack pattern with tensile stress contours of the BRC beam

Table 3
The data of load and displacement of BRC beams and SRC beams

The data of load and displacement of BRC beams and SRC beams							
Experiment–BRC Beam		Experiment–SRC Beam		FEM–BRC Beam		FEM–SRC Beam	
Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)
0,00	0,00	0,00	0,00	0,00	-0,00	0,00	0,00
0,50	-0,07	1,00	-0,01	0,50	-0,07	1,00	-0,11
1,00	-0,17	2,00	-0,02	1,00	-0,12	2,00	-0,20
1,50	-0,28	4,00	-0,10	1,50	-0,16	3,00	-0,29
2,00	-0,38	5,00	-0,15	2,00	-0,21	4,00	-0,39
2,50	-0,51	6,00	-0,19	2,50	-0,26	5,00	-0,48
3,00	-0,65	7,00	-0,26	3,00	-0,31	6,00	-0,57
3,50	-0,86	8,00	-0,35	3,50	-0,36	7,00	-0,66
4,00	-1,02	9,00	-0,44	4,00	-0,41	9,00	-0,85
4,50	-1,12	10,00	-0,60	4,50	-0,45	10,00	-0,94
5,00	-1,22	11,00	-0,79	5,00	-0,50	11,00	-1,37
5,50	-1,33	12,00	-0,93	5,50	-0,55	12,00	-1,49
6,00	-1,44	13,00	-1,08	6,00	-0,60	13,00	-1,69
6,50	-1,52	14,00	-1,31	6,50	-0,65	15,00	-1,94
7,00	-1,61	15,00	-1,59	7,00	-0,70	17,00	-2,25
9,00	-2,05	16,00	-1,77	9,00	-1,55	19,00	-2,69
11,00	-2,59	17,00	-1,91	11,00	-2,24	21,00	-3,05
13,00	-3,20	18,00	-2,08	13,00	-2,74	23,00	-4,26
15,00	-3,93	19,00	-2,26	15,00	-3,29	24,00	-5,16
17,00	-4,59	20,00	-2,48	17,00	-3,92	24,00	-6,35
19,00	-5,39	21,00	-2,78	19,00	-4,71	24,00	-8,09
21,00	-6,13	22,00	-3,31	21,00	-5,28	24,00	-11,12
23,00	-6,93	23,00	-5,36	23,00	-6,24		
25,00	-7,81	24,00	-6,33	25,00	-7,45		
27,00	-8,81	23,50	-9,33	27,00	-8,43		
29,00	-9,83	23,00	-15,54	29,00	-10,25		
31,00	-11,01	22,50	-15,56	31,00	-12,32		
33,00	-12,34	0,00	-15,56	33,00	-16,39		

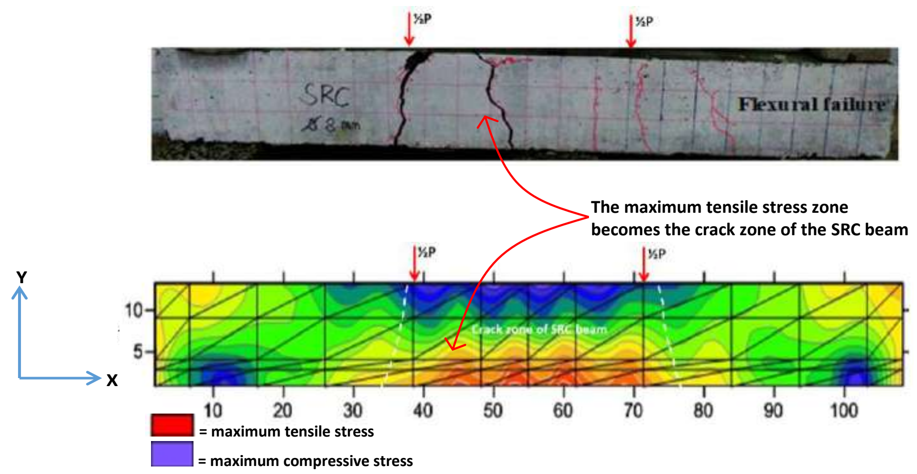

Fig. 5. The data validation of crack pattern with tensile stress contours of the SRC beam

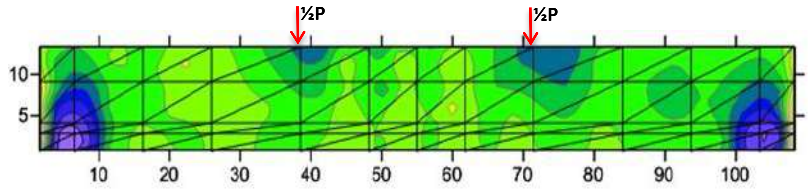

Fig. 6. The stress of Y-direction of BRC beam

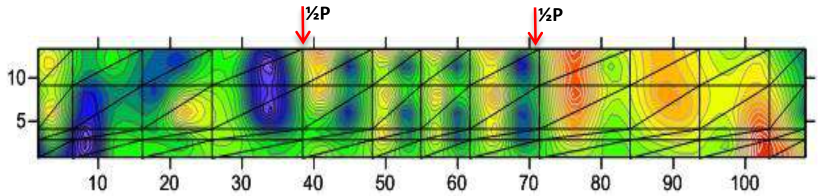

Fig. 7. The stress of XY-direction of BRC beam

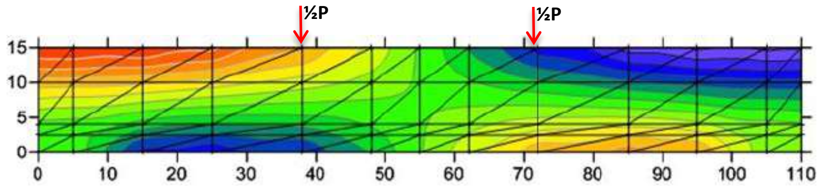

Fig. 8. The displacement of X-direction of BRC beam

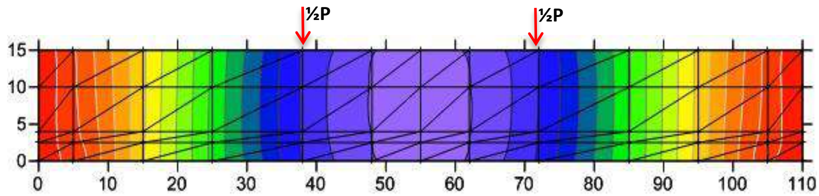

Fig. 9. The displacement of Y-direction of BRC beam

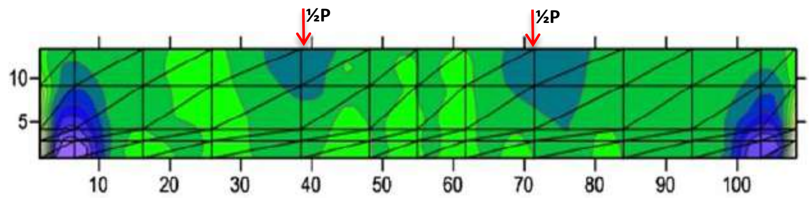

Fig. 10. The stress of Y-direction of SRC beam

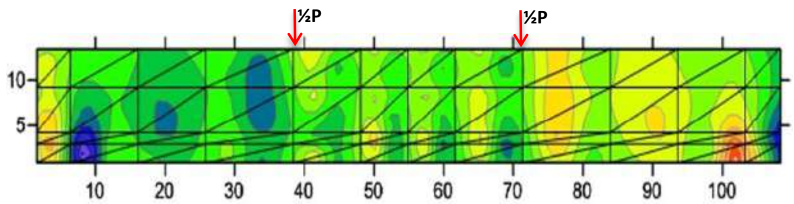

Fig. 11. The stress of XY-direction of SRC beam

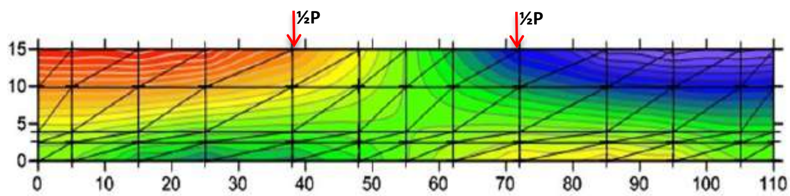

Fig. 12. The displacement of X-direction of SRC beam

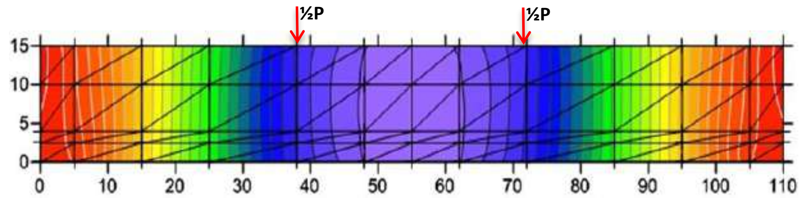

Fig. 13. The displacement of Y-direction of SRC beam

Experimental Design, Materials, and Methods

Data validation between laboratory data and numerical analysis is carried out through a series of activities, namely beam flexural testing in the laboratory, numerical analysis with finite element method (FEM), program simulation with Fortran PowerStation 4.0, and simulation with the Surfer program. Activities in the laboratory are flexural tests of the BRC beam and the SRC beam to obtain data on crack patterns, collapse patterns, and ultimate loads. The test settings for the BRC beam and the SRC beam are shown in Fig. 15. The geometry and details of the reinforcement of BRC beams and SRC beams are shown in Fig. 14.

The constitutive relationship analysis of the finite element method employs plane-stress theory. The triangle element is used to model the plane-stress element with two main displacement directions at each nodal point, so that the element has six degrees of freedom. The discretization of the beam plane using the triangular element is shown in Fig. 1 and Fig. 2. Modulus of elasticity (*E*) for each layer is calculated according to material conditions. Layers consisting of concrete and bamboo reinforcement are calculated using Eq. (1) [1], and for layers consisting of concrete and steel using Eq. (2) [3]. The solution to the plane-stress problem in the BRC beam and SRC beam is based on the stress-strain relationship as shown in Eq. (3) [1]. The main stresses on the BRC beam and SRC beam are calculated using Eq. (4) [1].

$$E_e = E_b.V_b + E_c.V_c \quad (1)$$

$$E_e = E_s.V_s + E_c.V_c \quad (2)$$

$$\begin{Bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{Bmatrix} = \frac{E}{(1+\nu^2)} \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix} \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix} \quad (3)$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}{}^2} = \sigma_{max} \quad (4)$$

The steps for compiling the Fortran PowerStation 4.0 program data to get the beam tensile stress contour data are summarized as follows:

Step 1: Discretization of the plane of the BRC beam and the SRC beam with the discretization of the triangular element, as shown in Fig. 1 and Fig. 2.

Step 2: Numbering of the triangular elements and the nodal points, as shown in Fig. 1 and Fig. 2.

Step 3: Collection and calculation of the geometry data and the beam material data, such as modulus of elasticity of materials (*E*), Poisson ratio (*v*), etc.

Step 4: Writing the programming language for the Fortran PowerStation 4.0 program for the triangular element, as shown in the following link: http://bit.ly/2F17w8F.

Step 5: Opening the Fortran PowerStation 4.0 program. As an example, the front view in the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2MTh22j.

Step 6: Writing programming language data (Step 4) in the Fortran PowerStation 4.0 program. As an example, a display of programming language is shown in the following link: http://bit.ly/2ZvZWMU.

Step 7: The Input DATA.DAT of the BRC beam and SRC beam in the Fortran PowerStation 4.0 program. The input data is shown in the following links: http://bit.ly/351FPqU and http://bit.ly/2MBqas9. An example of the input data display is shown in the following link: http://bit.ly/2u2K2xR.

Step 8: Running and processing the program analysis until there are no warnings and errors. If there are warnings and errors, check and correct the program data and input data.

Step 9: Downloading stress data X-direction, Y-direction, and XY-direction. Stress data is shown in the following link: http://bit.ly/2rDPeaI for the BRC beam stress, and http://bit.ly/2Q4Ihc1 for the SRC beam stress. For example, the display of stress data from the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2ZybLCd.

Step 10: Downloading displacement data X-direction and Y-direction. The displacement data for the BRC beam and SRC beam is shown in Table 3. An example of the displacement data display from the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2Q7j2Wp.

Step 11: Inputting stress data and displacement data on the Surfer program, running the program, and obtaining stress contour images data and displacement. Image data of stress contours and displacement are shown in Figs. 4-13.

Step 12: Validation of drawing data for tensile stress contours (X-direction stress) with beam crack patterns from laboratory tests.

Step 13: Obtaining crack zone image data and tensile stress zone contour data. Image data of crack zones and contour zones of tensile stress are shown in Fig. 4 and Fig. 5.

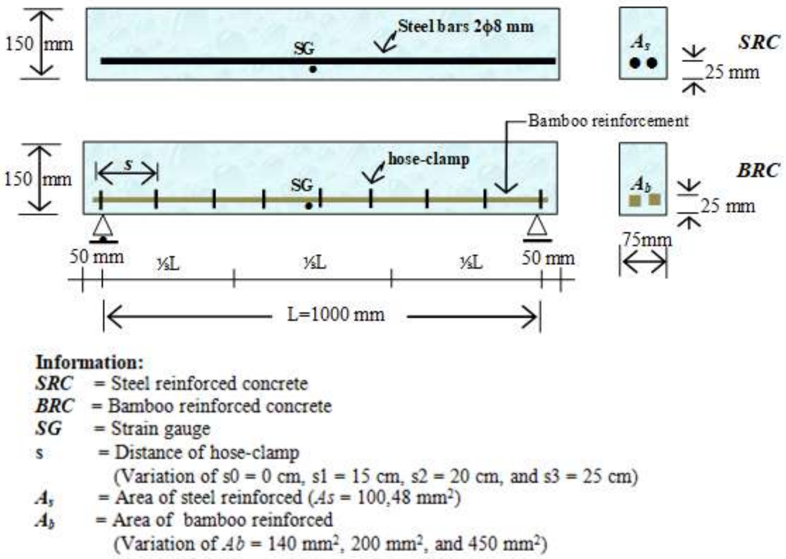

Fig. 14. Detail and geometry of the bamboo reinforced concrete beam [1,4]

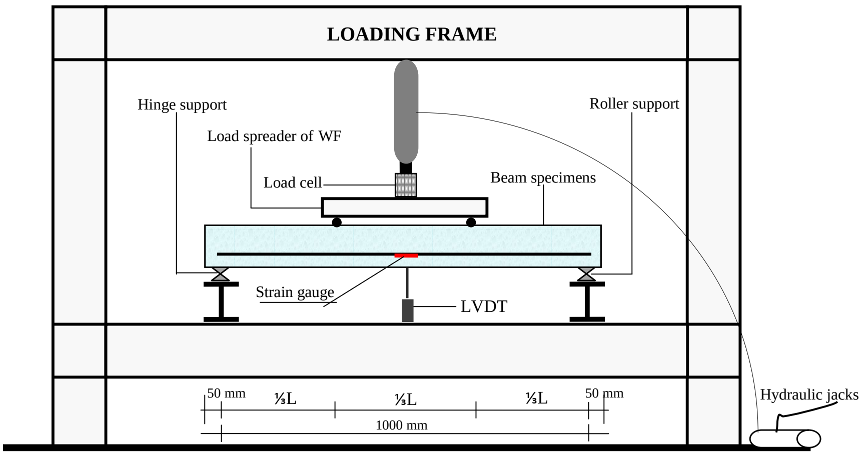

Fig. 15. Flexural test settings for the four-point flexural test method [1,4,5,6]

List of symbols

E	Modulus of elasticity
E_e	The equivalent elasticity modulus of BRC beam or SRC beam
E_b	Modulus of elasticity of bamboo reinforcement
E_c	Modulus of elasticity of concrete
E_s	Modulus of elasticity of steel reinforcement
V_b	The relative volume of bamboo reinforcement in the calculated layer
V_c	The relative volume of concrete in the calculated layer
V_s	The relative volume of steel reinforcement in the calculated layer
σ_x	Stress of X-direction
σ_y	Stress of Y-direction
$\sigma_{1,2}$	Main stress
τ_{xy}	Shear stress of XY-direction
v	Poisson's ratio
ε_x	Strain of X-direction
ε_y	Strain of Y-direction
Υ_{xy}	Shear strain of XY-direction

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Conflict of Interest

The authors declare that they know of no competition for financial interests or personal relationships that could appear to have influenced the work reported in this paper.

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[1] Muhtar, S.M. Dewi, Wisnumurti, A. Munawir, Enhancing bamboo reinforcement using a hose-clamp to increase bond- stress and slip resistance, Journal of Building Engineering. 26 (2019) 100896. https://doi.org/10.1016/j.jobe.2019.100896.

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Article Title

The numerical validation data to determine the compatibility of the tensile stress zone with the crack zone in bamboo reinforced concrete beam using the Fortran PowerStation 4.0 program

Authors

Muhtar

Affiliations

Department of Civil Engineering, Faculty of Engineering, University of Muhammadiyah Jember, Jember, 68121, Indonesia

Corresponding author(s)

Muhtar (muhtar@unmuhjember.ac.id)

Abstract

Numerical verification is done to control the compatibility of the BRC beam crack pattern with the stress contour at the ultimate load. The numerical method used is the finite element method (FEM). Ultimate load data and beam crack pattern data are taken from the BRC beam testing in the laboratory. The beam tensile stress data were obtained from FEM analysis using the Fortran PowerStation 4.0 program by inputting ultimate load data from the beam test. Material data entered is elasticity modulus (*E*) and Poisson ratio (*v*). Bamboo reinforcement and concrete are considered to have the same displacement with the different elasticity modulus (*E*), so they experience different stresses. The triangle element is used to model the plane-stress element with two directions of displacement at each nodal point so that each element has six degrees of freedom. The BRC beam tensile stress data from the Fortran PowerStation 4.0 program is processed into a tensile stress data table and becomes the Surfer program data for mapping stress contour images. Crack pattern data from beam testing in the laboratory is processed into crack zone pattern photo data. The stress contour data from the Surfer program is processed into image data of the tensile stress zone. The Fortran PowerStation 4.0 programming language data in this article can be used for further research with the discretization of triangular elements in other cases. This article consists of a data table, a picture of a crack pattern zone, a drawing of tensile stress zones, and photo documentation. The data is related to "Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance" [1] and “Experimental data from strengthening bamboo reinforcement using adhesives and hose-clamps” [2].

Keywords

numerical validation, finite element method, tensile stress zone, crack zone, bamboo reinforced concrete

Specifications Table

Subject	Engineering
Specific subject area	Civil and Structural Engineering
Type of data	Table, image, program
How data were acquired	The crack pattern data were obtained from the beam flexural test (Fig. 15). The stress contour data obtained from FEM analysis using the Fortran PowerStation 4.0 program and Surfer program. Crack pattern data from the beam flexural test is processed and analyzed into crack zone image data. Stress data from FEM analysis is processed into stress table data and becomes input data of the Surfer program. Data from the Surfer program is processed into stress zone image data. Then, all data is processed, compared, and analyzed into table data, cracks pattern zone image data, tensile stress zone image data, and photo data.
Data format	Raw and analyzed
Parameters for data collection	Crack pattern data and maximum tensile stress data are two very related data. Where cracks will occur at the maximum tensile stress position. The initial cracks until the collapsed beams are obtained through observation with a crack detector with a gradual load. Crack pattern zone data from the beam test in the laboratory needs to be validated by other methods to determine suitability with the stresses that occur. Stresses data and stress zone images data are obtained through FEM analysis using the Fortran PowerStation 4.0 program and the Surfer program. The Fortran PowerStation 4.0 programming language can be used for further research.
Description of data collection	The crack pattern data was collected through-beam testing in the laboratory. Initial crack and subsequent crack data until the beam collapses are obtained through observation in stages according to the beam loading stage. The crack detector is used to observe cracks that occur. Each crack is numbered and draws as the crack line. Then the crack data is processed and the documentation is taken, and it is then called the crack zone image data. Tensile stress zone data were obtained from two analyzes namely through FEM analysis using the Fortran PowerStation 4.0 program and the Surfer program. FEM analysis with the Fortran PowerStation 4.0 program was obtained direction stresses of X, Y, and Z. The X directional stress is tensile stress that causes cracks. Then the X direction stress data is transferred to the Surfer program and obtained the stress zone contour image data. Then the crack pattern data and the stress zone contour image data are compared and analyzed into table data, image data, program data, and photo data which are then called intact data. This intact data was obtained from two specimens namely BRC beam and SRC beam to obtain crack patterns and tensile stresses with different reinforcement material. The behavior of the crack pattern

	and the stress zone from the two beams can be used as a basis for further research.
Data source location	University of Muhammadiyah Jember, Jember, 68121, Indonesia, and University of Brawijaya, Malang 65145, Indonesia
Data accessibility	Data with the article, raw data can be found in Table 1, Table 2, Table 3, http://bit.ly/351FPqU, http://bit.ly/2MBqas9, http://bit.ly/2F17w8F, http://bit.ly/2rDPeaI, http://bit.ly/2Q4Ihc1, http://bit.ly/2MTh22j, http://bit.ly/2ZvZWMU, http://bit.ly/2u2K2xR, http://bit.ly/2ZybLCd, and http://bit.ly/2Q7j2Wp
Related research article	Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance. https://doi.org/10.1016/j.jobe.2019.100896 [1] Experimental data from strengthening bamboo reinforcement using adhesives and hose-clamps. https://doi.org/10.1016/j.dib.2019.104827 [2]

Value of the Data

The data can be used as a reference to develop bamboo reinforced concrete, especially for simple house construction. Fortran PowerStation 4.0 program data can be used to analyze the stresses of plane-stress elements in further research.

- This data contains a program that can be used as a reference in analyzing and calculating of stresses of the BRC beam and SRC beam by triangular element discretizing.
- This data is useful for researchers to develop bamboo reinforced concrete structures, especially for simple construction in areas of many bamboos.
- Data can be used for further insight and development, especially stress analysis, capacity, and behavior of bamboo reinforced concrete beams with strengthening reinforcement.
- The added value of this data is the programming language Fortran PowerStation 4.0 can be used generally in further research to analyze the displacement and stress of two-dimensional plane-stress elements.

Data

The discretization image data of the BRC beam and SRC beam with triangular elements are shown in Fig. 1 and Fig. 2. The reduction data of the stiffness of the BRC beam and the SRC beam after the initial crack occurs until the beam collapses is shown in Table 1 and Table 2. The input data for the Fortran PowerStation 4.0 program for the BRC beam is shown in the following link: http://bit.ly/351FPqU, whereas the input data for the SRC beam is shown in the link: http://bit.ly/2MBqas9. The programming language data for the Fortran PowerStation 4.0 program with the discretization of triangular elements are shown in the following link: http://bit.ly/2F17w8F.

The data of the load-displacement relationship of the BRC beam and SRC beam from experiments and FEM analyses are shown in Table 3. While the image data of the load-displacement relationship diagrams from experiments and FEM analyses are shown in Fig. 3. The displacement contours data in the X-direction and Y-direction of the Surfer program for the BRC beam are shown in Fig. 8 and Fig. 9. While the displacement contour data in the X-direction and Y-direction from the Surfer program for the SRC beam are shown in Fig. 12 and Fig. 13.

The table data of stress on the X-direction, Y-direction, and XY-direction from FEM analysis for the BRC beam are shown in the following link: http://bit.ly/2rDPeaI and the stress contour image data from the Surfer program is shown in Fig. 4, Fig. 6, and Fig. 7. Whereas the table data of stress on the X-direction, Y-direction, and XY-direction from FEM analysis for the SRC beam are shown in the following link: http://bit.ly/2Q4Ihc1, while the stress contour image data from the Surfer program is shown in Fig. 5, Fig. 10, and Fig. 11. Photograph of crack pattern data and tensile stress contour data for the analysis of the compatibility of the zone are shown in Fig. 4 and Fig. 5.

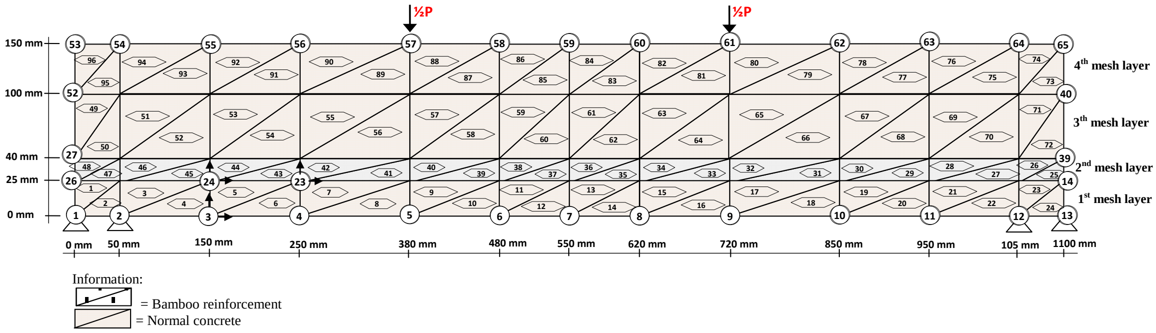

Fig. 1. The discretization of the BRC beam using the triangle element [1]

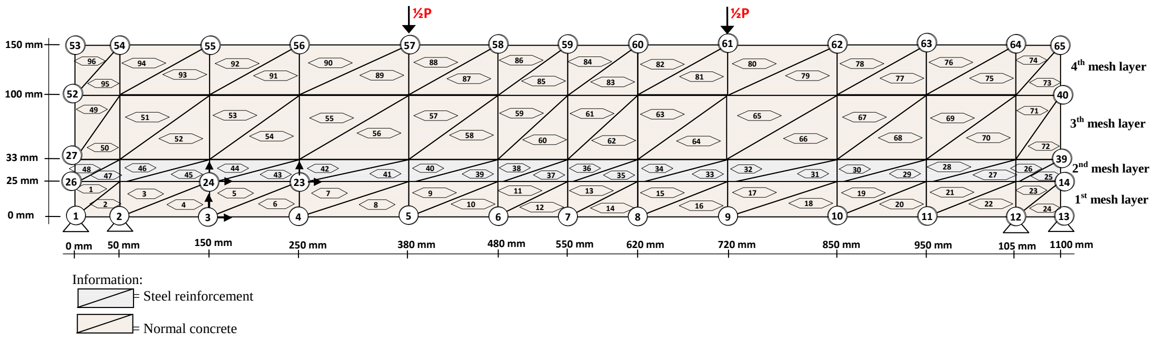

Fig. 2. The discretization of the SRC beam using the triangle element

Table 1
The reduction data of the stiffness of the BRC beam after initial cracking occurs until the ultimate load [3]

Layer number	Modulus of elasticity (E) of the BRC beam									
	Elastic condition	Plastic conditions with gradual loads								
	0 - 8.5 kN	9 kN	11 kN	15 kN	17 kN	21 kN	23 kN	25 kN	27 kN	29 kN	33 kN
4th mesh layer	268512,89	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	120830,80	112775,41	85924,12
3th mesh layer	268512,89	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	120830,80	107405,16	93979,51	75183,61
2nd mesh layer	247451,73	138845,32	115704,43	115704,43	115704,43	104133,99	104133,99	104133,99	69422,66	69422,66	55538,13
1st mesh layer	268512,89	134256,45	118145,67	83239,00	67128,22	51017,45	51017,45	37591,80	32221,55	26851,29	13291,39

Table 2
The reduction data of the stiffness of the SRC beam after initial cracking occurs until the ultimate load [3]

Layer number	Modulus of elasticity (*E*) of the SRC beam										
	Elastic condition	Plastic conditions with gradual loads									
	0 - 9 kN	10 kN	11 kN	12 kN	13 kN	15 kN	17 kN	19 kN	21 kN	23 kN	24 kN
4th mesh layer	268512,89	268512,89	201384,67	201384,67	201384,67	201384,67	201384,67	187959,02	187959,02	134256,45	114117,98
3th mesh layer	268512,89	268512,89	201384,67	201384,67	187959,02	187959,02	187959,02	174533,38	174533,38	134256,45	114117,98
2nd mesh layer	407825,73	432093,18	324069,88	324069,88	302465,22	302465,22	280860,56	280860,56	259255,91	216046,59	183639,60
1st mesh layer	268512,89	268512,89	201384,67	201384,67	187959,02	187959,02	174533,38	161107,73	147682,09	134256,45	120830,80

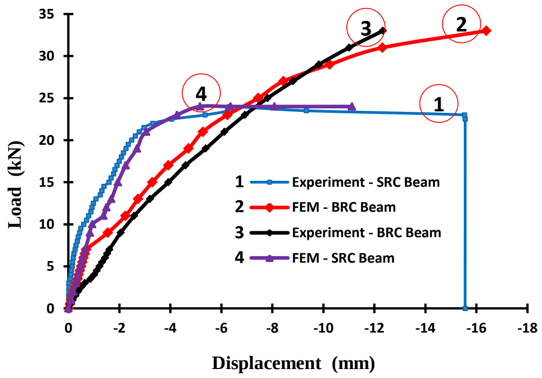

Fig. 3. The load- displacement relationship of BRC beam and SRC beam with Experiment and FEM

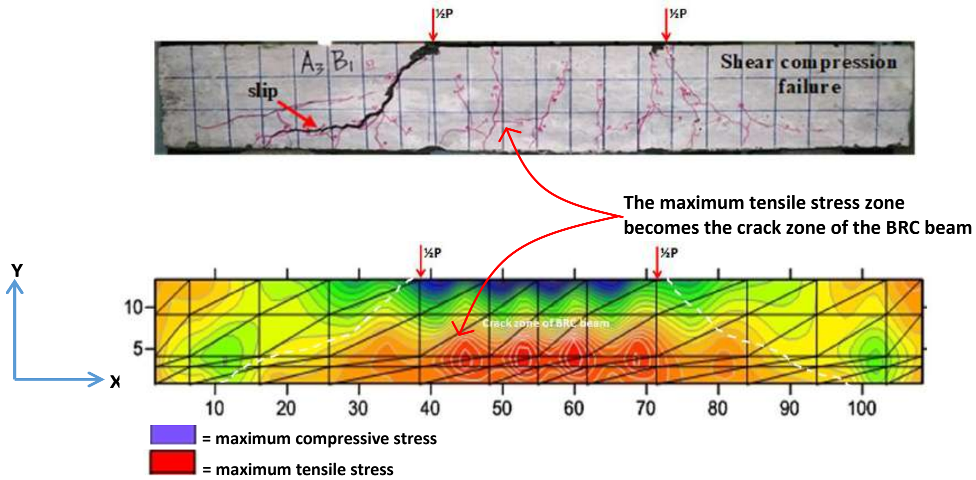

Fig. 4. The data validation of crack pattern with tensile stress contours of the BRC beam

Table 3
The data of load and displacement of BRC beams and SRC beams

The data of load and displacement of BRC beams and SRC beams							
Experiment – BRC Beam		Experiment – SRC Beam		FEM – BRC Beam		FEM – SRC Beam	
Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)
0,00	0,00	0,00	0,00	0,00	-0,00	0,00	0,00
0,50	-0,07	1,00	-0,01	0,50	-0,07	1,00	-0,11
1,00	-0,17	2,00	-0,02	1,00	-0,12	2,00	-0,20
1,50	-0,28	4,00	-0,10	1,50	-0,16	3,00	-0,29
2,00	-0,38	5,00	-0,15	2,00	-0,21	4,00	-0,39
2,50	-0,51	6,00	-0,19	2,50	-0,26	5,00	-0,48
3,00	-0,65	7,00	-0,26	3,00	-0,31	6,00	-0,57
3,50	-0,86	8,00	-0,35	3,50	-0,36	7,00	-0,66
4,00	-1,02	9,00	-0,44	4,00	-0,41	9,00	-0,85
4,50	-1,12	10,00	-0,60	4,50	-0,45	10,00	-0,94
5,00	-1,22	11,00	-0,79	5,00	-0,50	11,00	-1,37
5,50	-1,33	12,00	-0,93	5,50	-0,55	12,00	-1,49
6,00	-1,44	13,00	-1,08	6,00	-0,60	13,00	-1,69
6,50	-1,52	14,00	-1,31	6,50	-0,65	15,00	-1,94
7,00	-1,61	15,00	-1,59	7,00	-0,70	17,00	-2,25
9,00	-2,05	16,00	-1,77	9,00	-1,55	19,00	-2,69
11,00	-2,59	17,00	-1,91	11,00	-2,24	21,00	-3,05
13,00	-3,20	18,00	-2,08	13,00	-2,74	23,00	-4,26
15,00	-3,93	19,00	-2,26	15,00	-3,29	24,00	-5,16
17,00	-4,59	20,00	-2,48	17,00	-3,92	24,00	-6,35
19,00	-5,39	21,00	-2,78	19,00	-4,71	24,00	-8,09
21,00	-6,13	22,00	-3,31	21,00	-5,28	24,00	-11,12
23,00	-6,93	23,00	-5,36	23,00	-6,24		
25,00	-7,81	24,00	-6,33	25,00	-7,45		
27,00	-8,81	23,50	-9,33	27,00	-8,43		
29,00	-9,83	23,00	-15,54	29,00	-10,25		
31,00	-11,01	22,50	-15,56	31,00	-12,32		
33,00	-12,34	0,00	-15,56	33,00	-16,39		

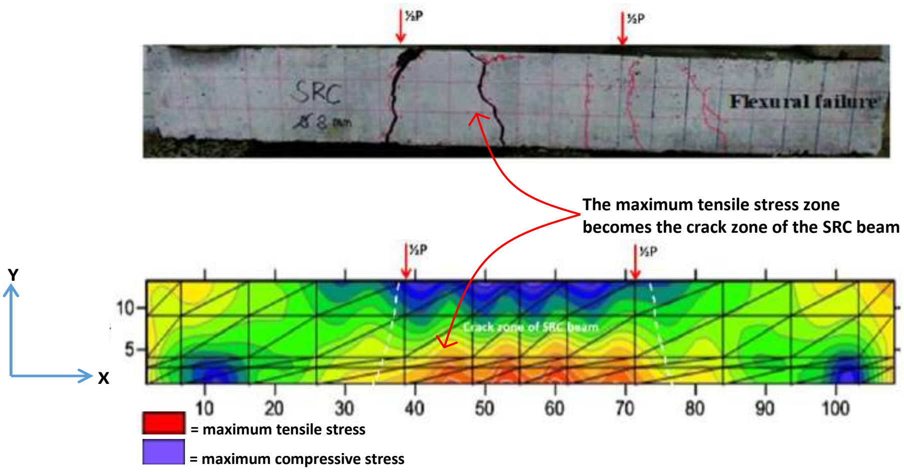

Fig. 5. The data validation of crack pattern with tensile stress contours of the SRC beam

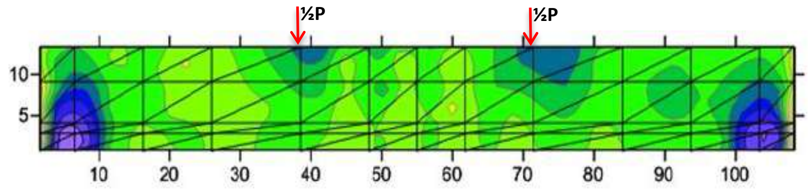

Fig. 6. The stress of Y-direction of BRC beam

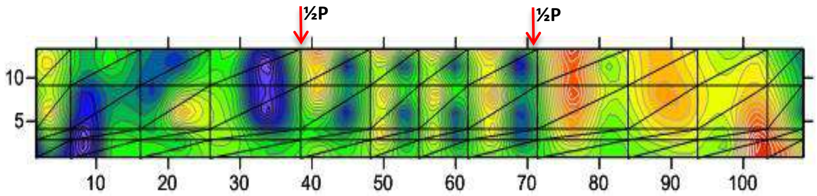

Fig. 7. The stress of XY-direction of BRC beam

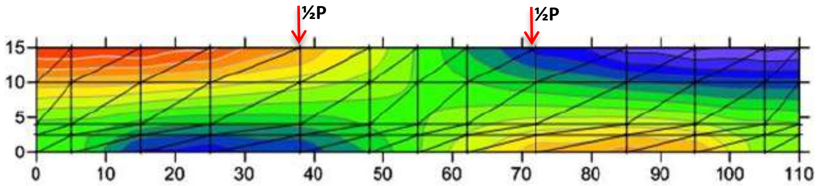

Fig. 8. The displacement of X-direction of BRC beam

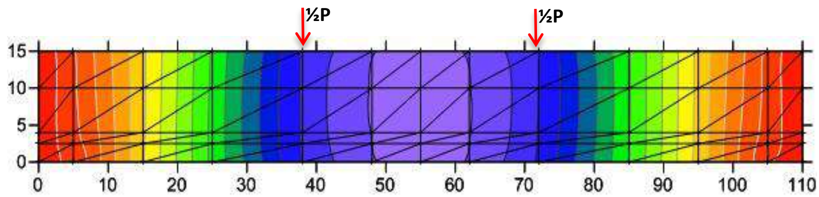

Fig. 9. The displacement of Y-direction of BRC beam

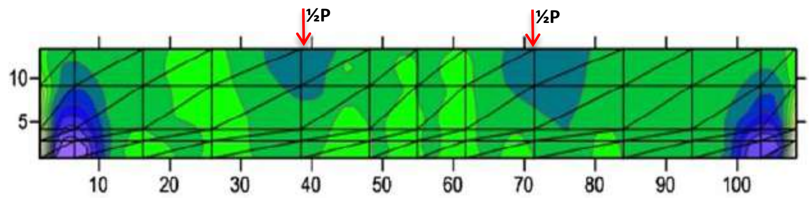

Fig. 10. The stress of Y-direction of SRC beam

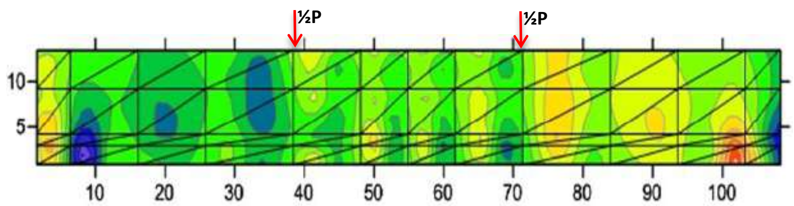

Fig. 11. The stress of XY-direction of SRC beam

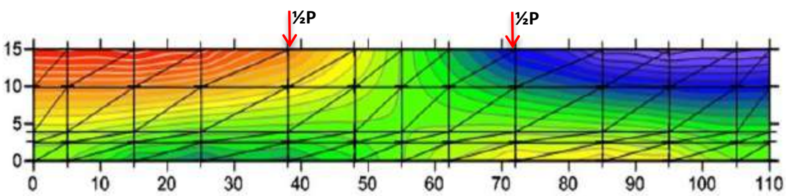

Fig. 12. The displacement of X-direction of SRC beam

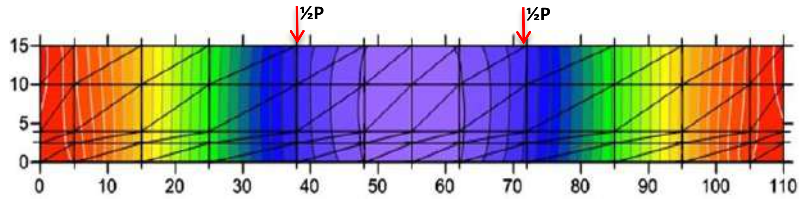

Fig. 13. The displacement of Y-direction of SRC beam

Experimental Design, Materials, and Methods

Data validation between laboratory data and numerical analysis is carried out through a series of activities namely beam flexural testing in the laboratory, numerical analysis with finite element method (FEM), program simulation with Fortran PowerStation 4.0, and simulation with the Surfer program. Activities in the laboratory are flexural tests of the BRC beam and the SRC beam to obtain data on crack patterns, collapse patterns, and ultimate loads. The test settings for the BRC beam and the SRC beam are shown in Fig. 15. The geometry and details of the reinforcement of BRC beams and SRC beams are shown in Fig. 14.

The constitutive relationship analysis of the finite element method that is using plane-stress theory. The triangle element is used to model the plane-stress element with two main displacement directions at each nodal point so that the element has six degrees of freedom. The discretization of the beam plane using the triangular element shown in Fig. 1 and Fig. 2. Modulus of elasticity (*E*), for each layer, is calculated according to material conditions. Layers consisting of concrete and bamboo reinforcement are calculated using Eq. (1) [1], and for layers consisting of concrete and steel using Eq. (2) [4]. The solution to the plane-stress problem in the BRC beam and SRC beam is based on the stress-strain relationship as shown in Eq. (3) [1]. As for the main stresses on the BRC beam and SRC beam calculated using Eq. (4) [1].

$$E_e = E_b.V_b + E_c.V_c \tag{1}$$

$$E_e = E_s.V_s + E_c.V_c \tag{2}$$

$$\begin{Bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{Bmatrix} = \frac{E}{(1+\nu^2)} \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix} \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix} \tag{3}$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}{}^2} = \sigma_{\max} \tag{4}$$

The steps for compiling the Fortran PowerStation 4.0 program data to get the beam tensile stress contour data are summarized as follows:

Step 1: Discretization of the plane of the BRC beam and the SRC beam with the discretization of the triangular element as shown in Fig. 1 and Fig. 2.

Step 2: The triangular element numbering and the nodal point numbering as shown in Fig. 1 and Fig. 2.

Step 3: Collection and calculation of the geometry data and the beam material data such as modulus of elasticity of materials (*E*), Poisson ratio (*v*), etc.

Step 4: The writing of the programming language of the Fortran PowerStation 4.0 program for the triangular element as shown in the following link: http://bit.ly/2F17w8F.

Step 5: Open the Fortran PowerStation 4.0 program. As an example, the front view in the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2MTh22j.

Step 6: The writing programming language data (Step 4) in the Fortran PowerStation 4.0 program. As an example, the display of programming language is shown in the following link: http://bit.ly/2ZvZWMU.

Step 7: The Input DATA.DAT of the BRC beam and SRC beam in the Fortran PowerStation 4.0 program. The input data is shown in the following link: http://bit.ly/351FPqU, and http://bit.ly/2MBqas9. The example the display of input data is shown in the following link: http://bit.ly/2u2K2xR.

Step 8: Run and process the program analysis until there are no warnings and errors. If there are warnings and errors, check and correct the program data and input data.

Step 9: The download of stress data X-direction, Y-direction, and XY-direction. Stress data is shown in the following link: http://bit.ly/2rDPeaI for the BRC beam stress and http://bit.ly/2Q4Ihc1 for the SRC beam stress. For example, the display of stress data from the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2ZybLCd.

Step 10: The download of displacement data X-direction and Y-direction. The displacement data for the BRC beam and SRC beam is shown in Table 3. An example of the displacement data display from the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2Q7j2Wp.

Step 11: Stress data input and displacement data on the Surfer program, run the program, and the obtained of stress contour images data and displacement. Image data of stress contours and displacement are shown in Figs. 4-13.

Step 12: Validation of drawing data for tensile stress contours (X-direction stress) with beam crack patterns from laboratory tests.

Step 13: Obtained of crack zone image data and tensile stress zone contour data. Image data of crack zones and contour zones of tensile stress are shown in Fig. 4 and Fig. 5.

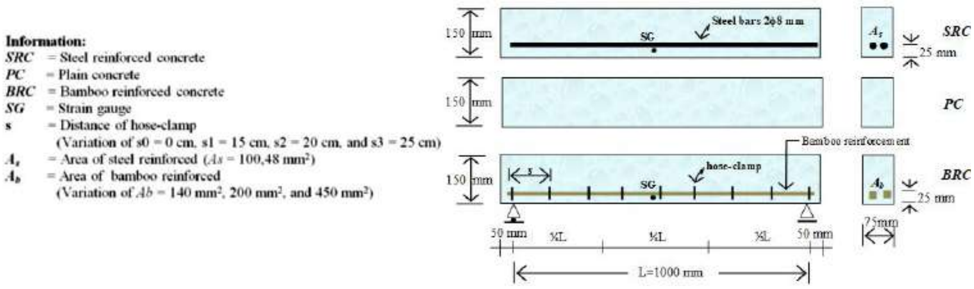

Fig. 14. Detail and geometry of the bamboo reinforced concrete beam [1,2]

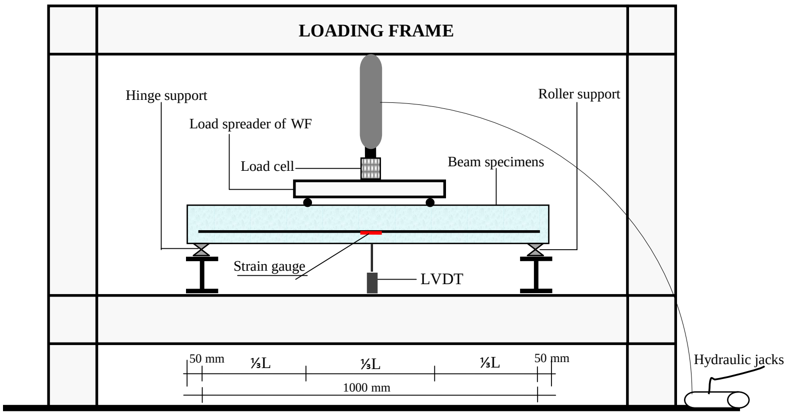

Fig. 15. Flexural test settings for the four-point flexural test method [1,2,5,6]

List of symbols

E	Modulus of elasticity
E_e	The equivalent elasticity modulus of BRC beam or SRC beam
E_b	Modulus of elasticity of bamboo reinforcement
E_c	Modulus of elasticity of concrete
E_s	Modulus of elasticity of steel reinforcement
V_b	The relative volume of bamboo reinforcement in the calculated layer
V_c	The relative volume of concrete in the calculated layer
V_s	The relative volume of steel reinforcement in the calculated layer
σ_x	Stress of X-direction
σ_y	Stress of Y-direction
$\sigma_{1,2}$	Main stress
τ_{xy}	Shear stress of XY-direction
v	Poisson's ratio
ε_x	Strain of X-direction
ε_y	Strain of Y-direction
Υ_{xy}	Shear strain of XY-direction

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Conflict of Interest

The authors declare that they have no known competing for financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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[1] Muhtar, S.M. Dewi, Wisnumurti, A. Munawir, Enhancing bamboo reinforcement using a hose-

clamp to increase bond- stress and slip resistance, Journal of Building Engineering. 26 (2019) 100896. https://doi.org/10.1016/j.jobe.2019.100896.
[2] Muhtar, Experimental data from strengthening bamboo reinforcement using adhesives and hose-clamps, Data in Brief. 27 (2019) 104827. https://doi.org/10.1016/j.dib.2019.104827.
[3] ACI Committee 318, Building Code Requirements for Structural Concrete (ACI 318M-14), 2014.
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[6] Muhtar, S.M. Dewi, Wisnumurti, A. Munawir, The Stiffness and Cracked Pattern of Bamboo Reinforced Concrete Beams Using a Hose Clamp, International Journal of Civil Engineering and Technology (IJCIET). 9 (2018) 273–284. http://www.iaeme.com/MasterAdmin/uploadfolder/IJCIET_09_08_028/IJCIET_09_08_028.pdf.

*REVISED Manuscript(Text with changes MARKED)

Article Title

Numerical validation data of tensile stress zones and crack zones in bamboo reinforced concrete beams using the Fortran PowerStation 4.0 program

Abstract

Numerical verification is ~~done~~ carried out in order to control the compatibility of the BRC beam crack pattern with the stress contour at the ultimate load. The numerical method used is the finite element method (FEM). Ultimate load data and beam crack pattern data are taken from ~~the~~ BRC beam testing in the laboratory. The beam tensile stress data ~~were~~ was obtained from FEM analysis using the Fortran PowerStation 4.0 program by inputting ultimate load data from the beam test. Material data entered is the elasticity modulus (*E*) and Poisson ratio (*v*). Bamboo reinforcement and concrete are considered to have the same displacement with ~~the~~ a different elasticity modulus (*E*), so they experience different stresses. The triangle element is ~~used~~ employed to model the plane-stress ~~element~~ with two directions of displacement at each nodal point, so that each element has six degrees of freedom. The BRC beam tensile stress data from the Fortran PowerStation 4.0 program is processed into a tensile stress data table and becomes the Surfer program data for mapping stress contour images. Crack pattern data from laboratory beam testing ~~in the laboratory~~ is processed into crack zone pattern photo data. The stress contour data from the Surfer program is processed into image data of the tensile stress zone. The Fortran PowerStation 4.0 programming language data in this article can be used for further research with the discretization of triangular elements in other cases. This article consists of a data table, a picture of a crack pattern zone, a drawing of tensile stress zones, and photo documentation. The data is related to "Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance" [1].

Comment [PJ1]: 'Data' is, strictly speaking, a plural noun (from the singular 'datum'). However, in modern usage, 'data' has become much more commonly used as a singular noun. You have it both ways in this document, but I've conformed it to singular.

Keywords

numerical validation, finite element method, tensile stress zone, crack zone, bamboo reinforced concrete

Specifications Table

Subject	Engineering.
Specific subject area	Civil and s~~S~~tructural e~~E~~ngineering.
Type of data	Table, image, program.
How data were acquired	The crack pattern data ~~were~~ was obtained from the beam flexural test (Fig. 15). The stress contour data was obtained from FEM analysis, using the Fortran PowerStation 4.0 ~~program~~ and Surfer programs. Crack pattern data from the beam flexural test is processed and analyzed into crack zone image data. Stress data from FEM analysis is

	processed into stress table data and becomes the input data ~~of~~ for the Surfer program. Data from the Surfer program is processed into stress zone image data. Then, all data is processed, compared, and analyzed into table data, cracks pattern zone image data, tensile stress zone image data, and photo data.
Data format	Raw and analyzed.
Parameters for data collection	Crack pattern data and maximum tensile stress data are two ~~very~~ highly related data, in which~~. Where~~ cracks will occur at the maximum tensile stress position. The initial cracks until the collapsed beams are obtained through observation with a crack detector ~~with~~ under a gradually increasing load. Crack pattern zone data from the laboratory beam test ~~in the laboratory~~ needs to be validated by other methods to determine ~~suitability~~ compatibility with ~~the~~ stresses that occur. Stress~~es~~ data and stress zone images data are obtained through FEM analysis using the Fortran PowerStation 4.0 ~~program~~ and the Surfer programs. The Fortran PowerStation 4.0 programming language can be used for further research.
Description of data collection	The crack pattern data was collected through ~~-~~beam testing in the laboratory. Initial crack and subsequent crack data ~~until~~ up to the beam collapsinges are obtained through observation in stages, according to the beam loading stage. The crack detector is used to observe cracks~~ that occur~~. Each crack is numbered and drawn~~s~~ as the crack line. Then the crack data is processed and ~~the~~ documentation ~~is~~ taken, ~~and it is then called~~with results termed the crack zone image data. Tensile stress zone data ~~were~~ was obtained from two ~~analyzes namely through~~sources, FEM analysis using the Fortran PowerStation 4.0 ~~program~~ and the Surfer programs. FEM analysis with the Fortran PowerStation 4.0 program was obtained for direction stresses of X, Y, and Z. The X directional stress is tensile stress that causes cracks. ~~Then~~ T~~t~~he X direction stress data is then transferred to the Surfer program ~~and~~ to generate ~~obtained~~ the stress zone contour image data. ~~Then~~ T~~t~~he crack pattern data and the stress zone contour image data are compared and analyzed into table data, image data, program data, and photo data, all of which are ~~then called~~termed intact data. This intact data was obtained from two specimens, namely a BRC beam and an SRC beam, to obtain crack patterns and tensile stresses with different reinforcement materials. The behaviors of the crack pattern and the stress zone from the two beams can be used as ~~a~~ basis for further research.
Data source location	University of Muhammadiyah Jember, Jember, 68121, Indonesia, and University of Brawijaya, Malang 65145, Indonesia
Data accessibility	Data with the article, raw data can be found in Table 1, Table 2, Table 3, http://bit.ly/351FPqU, http://bit.ly/2MBqas9, http://bit.ly/2F17w8F, http://bit.ly/2rDPeaI, http://bit.ly/2Q4Ihc1, http://bit.ly/2MTh22j, http://bit.ly/2ZvZWMU, http://bit.ly/2u2K2xR, http://bit.ly/2ZybLCd, and http://bit.ly/2Q7j2Wp

Related research article	Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance. https://doi.org/10.1016/j.jobe.2019.100896 [1]

Value of the Data

- This data contains a program that can be used as a reference in analyzing and calculating ~~of~~ stresses of the BRC beam and SRC beam by triangular element discretizing.
- This data is useful for researchers ~~to~~ in developing bamboo reinforced concrete structures, especially for simple construction in areas of ~~many~~ abundant bamboo~~s~~.
- Data can be used for further insight and development, especially stress analysis, capacity, and behavior of bamboo reinforced concrete beams with strengthening reinforcement.
- The added value of this data is in the programming language; Fortran PowerStation 4.0 can now be used generally in further research to analyze the displacement and stress of two-dimensional plane-stress elements~~ in further research~~.

Data

The discretization image data of the BRC beam and SRC beam with triangular elements ~~are~~ is shown in Fig. 1 and Fig. 2. The reduction data of the stiffness of the BRC beam and the SRC beam after the initial crack occurs up until the beam collapses is shown in Table 1 and Table 2. The input data for the Fortran PowerStation 4.0 program for the BRC beam is shown in the following link: http://bit.ly/351FPqU, ~~whereas~~ and the input data for the SRC beam is shown in the link: http://bit.ly/2MBqas9. The programming language data for the Fortran PowerStation 4.0 program with the discretization of triangular elements ~~are~~ is shown in the ~~following~~ link: http://bit.ly/2F17w8F.

The data of the load-displacement relationship of the BRC beam and SRC beam from experiments and FEM analyses ~~are~~ is shown in Table 3, w~~. W~~hile the image data of the load-displacement relationship diagrams from experiments and FEM analyses ~~are~~ is shown in Fig. 3. The displacement contours data in the X-direction and Y-direction of the Surfer program for the BRC beam ~~are~~ is shown in Fig. 8 and Fig. 9,~~.~~ ~~While~~ and the displacement contour data in the X-direction and Y-direction from the Surfer program for the SRC beam ~~are~~ is shown in Fig. 12 and Fig. 13.

The table data of stress on the X-direction, Y-direction, and XY-direction from FEM analysis for the BRC beam ~~are~~ is shown in the following link: http://bit.ly/2rDPeaI, and the stress contour image data from the Surfer program is shown in Fig. 4, Fig. 6, and Fig. 7. ~~Whereas~~ T~~t~~he table data of stress on the X-direction, Y-direction, and XY-direction from FEM analysis for the SRC beam ~~are~~ is shown in the following link: http://bit.ly/2Q4Ihc1, while the stress contour image data from the Surfer program is shown in Fig. 5, Fig. 10, and Fig. 11. Photographs of crack pattern data and tensile stress contour data for the analysis of the compatibility of the zone are shown in Fig. 4 and Fig. 5.

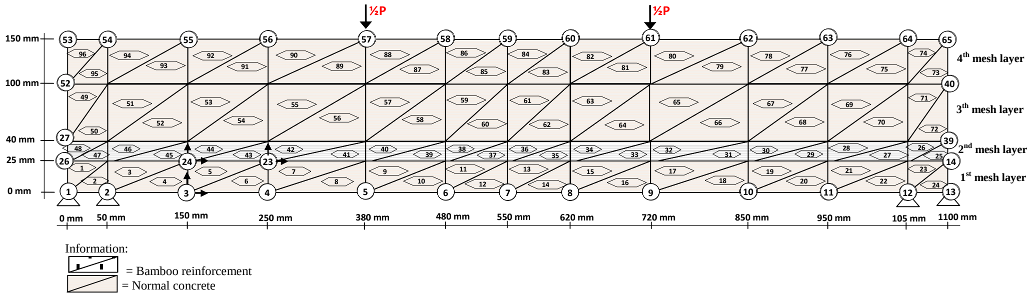

Fig. 1. The discretization of the BRC beam using the triangle element [1]

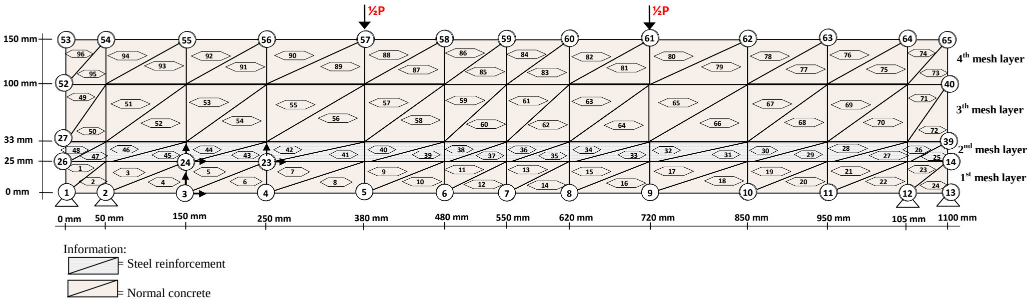

Fig. 2. The discretization of the SRC beam using the triangle element

Table 1

The reduction data of the stiffness of the BRC beam after initial cracking occurs up until the ultimate load [3]

Layer number	Modulus of elasticity (*E*) of the BRC beam									
	Elastic condition	Plastic conditions with gradual loads								
	0 - 8.5 kN	9 kN	11 kN	15 kN	17 kN	21 kN	23 kN	25 kN	27 kN	29 kN	33 kN
4th mesh layer	268512,89	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	120830,80	112775,41	85924,12
3th mesh layer	268512,89	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	120830,80	107405,16	93979,51	75183,61
2nd mesh layer	247451,73	138845,32	115704,43	115704,43	115704,43	104133,99	104133,99	104133,99	69422,66	69422,66	55538,13
1st mesh layer	268512,89	134256,45	118145,67	83239,00	67128,22	51017,45	51017,45	37591,80	32221,55	26851,29	13291,39

Table 2

The reduction data of the stiffness of the SRC beam after initial cracking occurs up until the ultimate load [3]

Layer number	Modulus of elasticity (*E*) of the SRC beam										
	Elastic condition	Plastic conditions with gradual loads									
	0 - 9 kN	10 kN	11 kN	12 kN	13 kN	15 kN	17 kN	19 kN	21 kN	23 kN	24 kN
4th mesh layer	268512,89	268512,89	201384,67	201384,67	201384,67	201384,67	201384,67	187959,02	187959,02	134256,45	114117,98

3th mesh layer	268512,89	268512,89	201384,67	201384,67	187959,02	187959,02	187959,02	174533,38	174533,38	134256,45	114117,98
2nd mesh layer	407825,73	432093,18	324069,88	324069,88	302465,22	302465,22	280860,56	280860,56	259255,91	216046,59	183639,60
1st mesh layer	268512,89	268512,89	201384,67	201384,67	187959,02	187959,02	174533,38	161107,73	147682,09	134256,45	120830,80

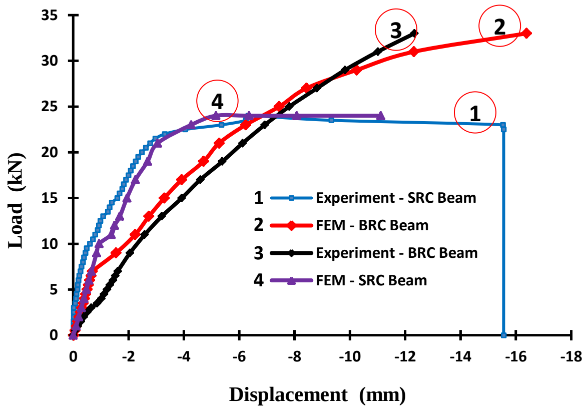

Fig. 3. The load-displacement relationship of the BRC beam and SRC beams with eExperiment and FEM

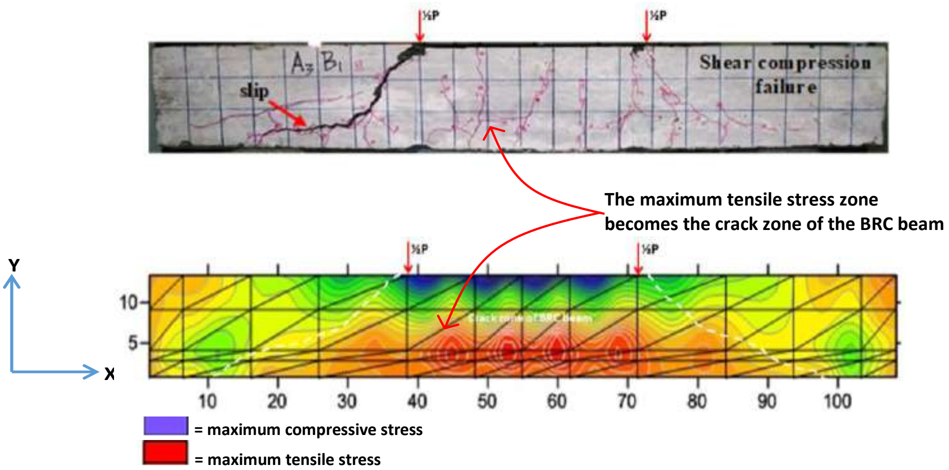

Fig. 4. The data validation of crack pattern with tensile stress contours of the BRC beam

Table 3
The data of load and displacement of BRC beams and SRC beams

The data of load and displacement of BRC beams and SRC beams							
Experiment–BRC Beam		Experiment–SRC Beam		FEM–BRC Beam		FEM–SRC Beam	
Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)
0,00	0,00	0,00	0,00	0,00	-0,00	0,00	0,00

0,50	-0,07	1,00	-0,01	0,50	-0,07	1,00	-0,11
1,00	-0,17	2,00	-0,02	1,00	-0,12	2,00	-0,20
1,50	-0,28	4,00	-0,10	1,50	-0,16	3,00	-0,29
2,00	-0,38	5,00	-0,15	2,00	-0,21	4,00	-0,39
2,50	-0,51	6,00	-0,19	2,50	-0,26	5,00	-0,48
3,00	-0,65	7,00	-0,26	3,00	-0,31	6,00	-0,57
3,50	-0,86	8,00	-0,35	3,50	-0,36	7,00	-0,66
4,00	-1,02	9,00	-0,44	4,00	-0,41	9,00	-0,85
4,50	-1,12	10,00	-0,60	4,50	-0,45	10,00	-0,94
5,00	-1,22	11,00	-0,79	5,00	-0,50	11,00	-1,37
5,50	-1,33	12,00	-0,93	5,50	-0,55	12,00	-1,49
6,00	-1,44	13,00	-1,08	6,00	-0,60	13,00	-1,69
6,50	-1,52	14,00	-1,31	6,50	-0,65	15,00	-1,94
7,00	-1,61	15,00	-1,59	7,00	-0,70	17,00	-2,25
9,00	-2,05	16,00	-1,77	9,00	-1,55	19,00	-2,69
11,00	-2,59	17,00	-1,91	11,00	-2,24	21,00	-3,05
13,00	-3,20	18,00	-2,08	13,00	-2,74	23,00	-4,26
15,00	-3,93	19,00	-2,26	15,00	-3,29	24,00	-5,16
17,00	-4,59	20,00	-2,48	17,00	-3,92	24,00	-6,35
19,00	-5,39	21,00	-2,78	19,00	-4,71	24,00	-8,09
21,00	-6,13	22,00	-3,31	21,00	-5,28	24,00	-11,12
23,00	-6,93	23,00	-5,36	23,00	-6,24		
25,00	-7,81	24,00	-6,33	25,00	-7,45		
27,00	-8,81	23,50	-9,33	27,00	-8,43		
29,00	-9,83	23,00	-15,54	29,00	-10,25		
31,00	-11,01	22,50	-15,56	31,00	-12,32		
33,00	-12,34	0,00	-15,56	33,00	-16,39		

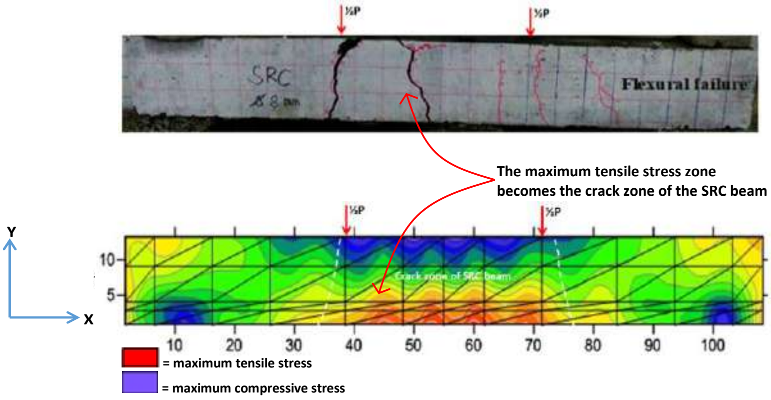

Fig. 5. The data validation of crack pattern with tensile stress contours of the SRC beam

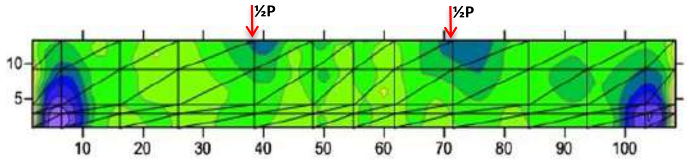

Fig. 6. The stress of Y-direction of BRC beam

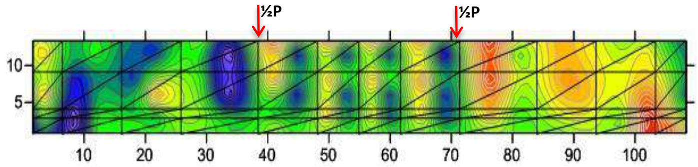

Fig. 7. The stress of XY-direction of BRC beam

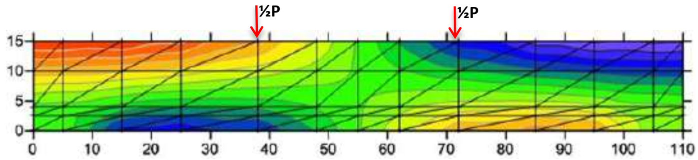

Fig. 8. The displacement of X-direction of BRC beam

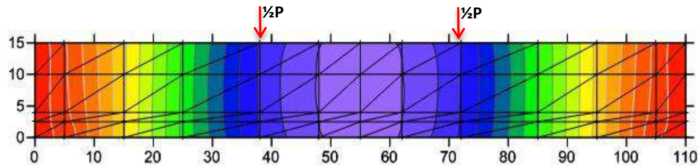

Fig. 9. The displacement of Y-direction of BRC beam

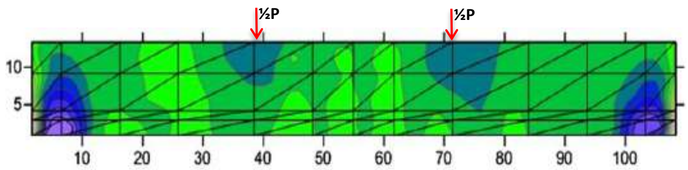

Fig. 10. The stress of Y-direction of SRC beam

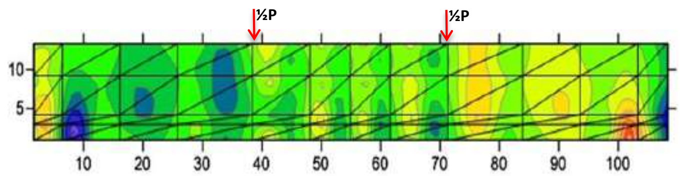

Fig. 11. The stress of XY-direction of SRC beam

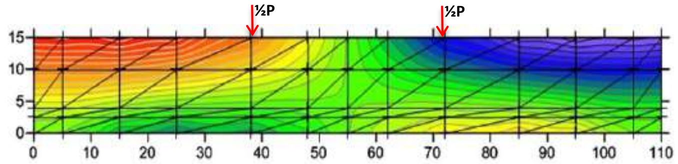

Fig. 12. The displacement of X-direction of SRC beam

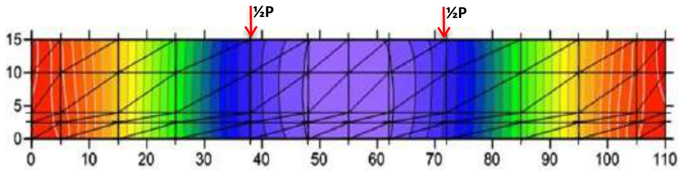

Fig. 13. The displacement of Y-direction of SRC beam

Experimental Design, Materials, and Methods

Data validation between laboratory data and numerical analysis is carried out through a series of activities, namely beam flexural testing in the laboratory, numerical analysis with finite element method (FEM), program simulation with Fortran PowerStation 4.0, and simulation with the Surfer program. Activities in the laboratory are flexural tests of the BRC beam and the SRC beam to obtain data on crack patterns, collapse patterns, and ultimate loads. The test settings for the BRC beam and the SRC beam are shown in Fig. 15. The geometry and details of the reinforcement of BRC beams and SRC beams are shown in Fig. 14.

The constitutive relationship analysis of the finite element method ~~that is using~~employs plane-stress theory. The triangle element is used to model the plane-stress element with two main displacement directions at each nodal point, so that the element has six degrees of freedom. The discretization of the beam plane using the triangular element is shown in Fig. 1 and Fig. 2. Modulus of elasticity (*E*)~~,~~ for each layer~~,~~ is calculated according to material conditions. Layers consisting of concrete and bamboo reinforcement are calculated using Eq. (1) [1], and for layers consisting of concrete and steel using Eq. (2) [4]. The solution to the plane-stress problem in the BRC beam and SRC beam is based on the stress-strain relationship as shown in Eq. (3) [1]. ~~As for t~~The main stresses on the BRC beam and SRC beam are calculated using Eq. (4) [1].

$$E_e = E_b.V_b + E_c.V_c \tag{1}$$

$$E_e = E_s.V_s + E_c.V_c \tag{2}$$

$$\begin{Bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{Bmatrix} = \frac{E}{(1+\nu^2)} \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix} \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix} \tag{3}$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}{}^2} = \sigma_{\max} \tag{4}$$

The steps for compiling the Fortran PowerStation 4.0 program data to get the beam tensile stress contour data are summarized as follows:

Step 1: Discretization of the plane of the BRC beam and the SRC beam with the discretization of the triangular element, as shown in Fig. 1 and Fig. 2.

Step 2: Numbering of t~~T~~he triangular elements ~~numbering~~ and the nodal points, ~~numbering~~ as shown in Fig. 1 and Fig. 2.

Step 3: Collection and calculation of the geometry data and the beam material data, such as modulus of elasticity of materials (*E*), Poisson ratio (*v*), etc.

Step 4: ~~The~~ W~~w~~riting ~~of~~ the programming language ~~of~~ for the Fortran PowerStation 4.0 program for the triangular element, as shown in the following link: http://bit.ly/2F17w8F.

Step 5: Opening the Fortran PowerStation 4.0 program. As an example, the front view in the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2MTh22j.

Step 6: ~~The~~ W~~w~~riting programming language data (Step 4) in the Fortran PowerStation 4.0 program. As an example, ~~the~~ a display of programming language is shown in the following link: http://bit.ly/2ZvZWMU.

Step 7: The ~~-~~Input DATA.DAT of the BRC beam and SRC beam in the Fortran PowerStation 4.0 program. The input data is shown in the following links: http://bit.ly/351FPqU~~,~~ and http://bit.ly/2MBqas9. ~~The~~ An example of the ~~display of~~ input data display is shown in the following link: http://bit.ly/2u2K2xR.

Step 8: Running and processing the program analysis until there are no warnings and errors. If there are warnings and errors, check and correct the program data and input data.

Step 9: ~~The~~ D~~d~~ownloading ~~of~~ stress data X-direction, Y-direction, and XY-direction. Stress data is shown in the following link: http://bit.ly/2rDPeaI for the BRC beam stress, and http://bit.ly/2Q4Ihc1 for the SRC beam stress. For example, the display of stress data from the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2ZybLCd.

Step 10: ~~The~~ D~~d~~ownloading ~~of~~ displacement data X-direction and Y-direction. The displacement data for the BRC beam and SRC beam is shown in Table 3. An example of the displacement data display from the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2Q7j2Wp.

Step 11: Inputting s~~S~~tress data ~~input~~ and displacement data on the Surfer program, running the program, and ~~the~~ obtaining~~ed of~~ stress contour images data and displacement. Image data of stress contours and displacement are shown in Figs. 4-13.

Step 12: Validation of drawing data for tensile stress contours (X-direction stress) with beam crack patterns from laboratory tests.

Step 13: Obtaining~~ed of~~ crack zone image data and tensile stress zone contour data. Image data of crack zones and contour zones of tensile stress are shown in Fig. 4 and Fig. 5.

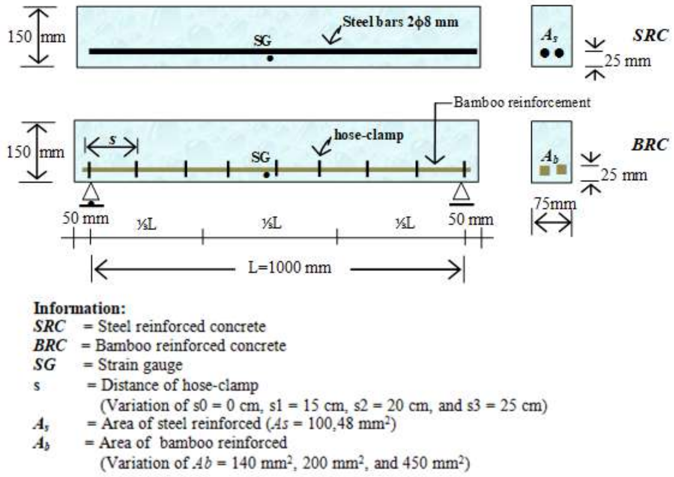

Fig. 14. Detail and geometry of the bamboo reinforced concrete beam [1,2]

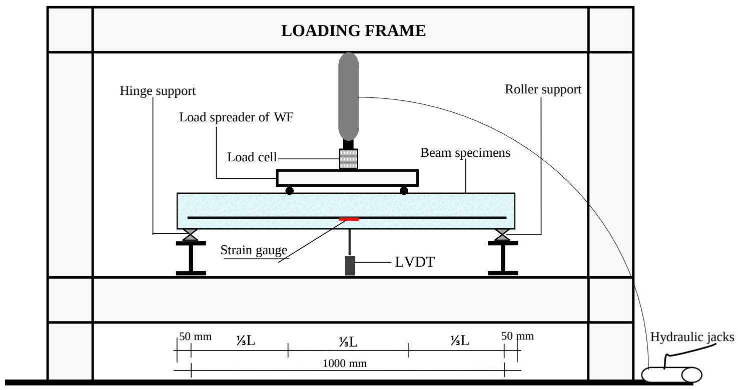

Fig. 15. Flexural test settings for the four-point flexural test method [1,2,5,6]

List of symbols

E	Modulus of elasticity
E_e	The equivalent elasticity modulus of BRC beam or SRC beam
E_b	Modulus of elasticity of bamboo reinforcement
E_c	Modulus of elasticity of concrete
E_s	Modulus of elasticity of steel reinforcement
V_b	The relative volume of bamboo reinforcement in the calculated layer
V_c	The relative volume of concrete in the calculated layer
V_s	The relative volume of steel reinforcement in the calculated layer
σ_x	Stress of X-direction
σ_y	Stress of Y-direction
$\sigma_{1,2}$	Main stress

τ_{xy}	Shear stress of XY-direction
ν	Poisson's ratio
ε_x	Strain of X-direction
ε_y	Strain of Y-direction
γ_{xy}	Shear strain of XY-direction

Acknowledgments

The research described in this paper and publication costs ~~is~~ are fully financially supported by the Research Support Program (PBR-UMJ) of the University of Muhammadiyah Jember, Indonesia.

Conflict of Interest

The authors declare that they ~~have~~ know of no ~~known competing~~ competition for financial interests or personal relationships that could ~~have~~ appear~~ed~~ to have influenced the work reported in this paper.

Elsevier Editorial System(tm) for Data in Brief

Manuscript Draft

Manuscript Number: DIB-D-20-00045R2

Title: Numerical validation data of tensile stress zones and crack zones in bamboo reinforced concrete beams using the Fortran PowerStation 4.0 program

Article Type: Data Article

Keywords: numerical validation; finite element method; tensile stress zone; crack zone; bamboo reinforced concrete.

Corresponding Author: Dr. Muhtar - Muhtar, M.T.

Corresponding Author's Institution: University of Muhammadiyah Jember

First Author: Muhtar - Muhtar, M.T.

Order of Authors: Muhtar - Muhtar, M.T.

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Research Data Related to this Submission

There are no linked research data sets for this submission. The following reason is given:
I have submitted my raw data as a supplementary data file along with my manuscript

Muhtar

Jl. Karimata 49
Jember, East Java, 68121 Indonesia
(062)812-4920-3171
muhtar@unmuhjember.ac.id

February 17, 2020

Managing Editor-Co-EiC
Data in Brief

Dear **Hao-Ran Wang** and **Ganhui Lan**,

I hereby submit the revised article in accordance with the email notification from "Managing Editor-Co-EiC" on February 13, 2020, with the Subject "Your Data in Brief Submission: DIB-D-20-00045R1". The data of my article is:

Title	:	Numerical validation data of tensile stress zones and crack zones in bamboo reinforced concrete beams using the Fortran PowerStation 4.0 program.
Manuscript No.	:	DIB-D-20-00045R1
Related research article	:	Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance. https://doi.org/10.1016/j.jobe.2019.100896
Corresponding Author	:	Muhtar, Department of Civil Engineering, Faculty of Engineering, University of Muhammadiyah Jember, Jember, 68121, Indonesia. E-mail: muhtar@unmuhjember.ac.id

The answers to the comments of the Reviewers and Managing Editor are listed below this letter.

I hope my submission can go through the review process and published as specified in the Author Information Pack for Journal of Data in Brief.

Sincerely,

Muhtar

Answers to comment of Managing Editor and Reviewer

1. **Abstract:**

although understandable it is a bit confusing and hard to follow from the first read, it could have been made more connected and organised. I suggest to re-write.

The abstract has rewritten:

Numerical verification is carried out in order to control the compatibility of the BRC beam crack pattern with the stress contour at the ultimate load. The numerical method used is the finite element method (FEM) using the Fortran PowerStation 4.0 program. Material data entered is the elasticity modulus (*E*) and Poisson's ratio (*v*). Ultimate load input data is taken from BRC beam testing in the laboratory. Bamboo reinforcement and concrete are considered to have the same displacement with a different elasticity modulus (*E*), so they experience different stresses. The triangle element is employed to model the plane-stress with two directions of displacement at each nodal point, so that each element has six degrees of freedom. The BRC beam tensile stress data from the Fortran PowerStation 4.0 program is processed into a tensile stress data table and becomes the Surfer program input data for mapping tensile stress zone images. Crack pattern data from laboratory beam testing is processed into crack zone pattern photo data and then compared to the tensile stress zone images. From the image data of the tensile stress zones and the crack zones of the BRC beam have compatibility. The Fortran PowerStation 4.0 programming language data in this article can be used for further research with the discretization of triangular elements in other cases. This article consists of a data table, a picture of a crack pattern zone, a drawing of tensile stress zones, and photo documentation. The data is related to "Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance" [1]

2. **Modelling concept:**

The numerical analysis is 2D and the experiments are 3D. Could the author comment on the justification of his approach highlighting the advantages and disadvantages more clearly to the reader.

"Numerical analysis was carried out with 2D and the experiments with 3D as shown in Fig. 15. Data from 2D numerical analysis obtained data of X-direction stress, Y-direction stress, XY-direction stress, X-direction deflection, and Y-direction deflection. While the data from the experiments only obtained data on crack patterns, loads, strain, and deflection. So that the validation of both focuses on X-direction stress or tensile stress that causes cracking and Y-direction deflection. The validation of the tensile stress zone and crack patterns zone is shown in Fig. 4 and Fig. 5 and the validation of deflection are shown in Table 3, Fig. 9, and Fig. 13. The validation of Y-direction stress, XY-direction stress, and X-direction deflection are not done because experimental data are not obtained".

This explanation has been written at the paper in the item "Experimental Design, Materials, and Methods" in the first paragraph.

3. **Some important data are not shown:**
including the E and v values of the bamboo.

“The material data of bamboo, steel, and concrete consists of Modulus of elasticity (E) and Poisson's ratio (ν). The modulus of elasticity of bamboo (Eb) is 17,235.74 MPa with Poisson's ratio (νb) of 0.25. The modulus of elasticity of concrete (Ec) is 26,299.01 MPa with Poisson's ratio (νc) of 0.20. The modulus of elasticity of steel (Es) is 207,735.92 MPa with Poisson's ratio (νs) of 0.3”.

This explanation has been written at the paper in the item "**Experimental Design, Materials, and Methods**" in the third paragraph.

4. **Figures 5-15:**
These figures do not provide a bar showing the numerical value range corresponding to the colours. Without this bar it is not clear from the figure the actual value representing the colour.

The image revision has been carried out in the paper

5. **Figure 14:**
Add a boundary line to the figure as the text in the figure might be confused with the actual text of the paper.

The image revision has been carried out in the paper

6. **Managing editor:**
The first sentence of the value of the data should also be a bullet point.

“This data is useful for researchers in developing bamboo reinforced concrete structures, especially for simple construction in areas of abundant bamboo”.

The first sentence has been written at the paper in the item "**Value of the Data**"

*Detailed Response to Reviewers

Answers to comment of Managing Editor and Reviewer

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Article Title

Numerical validation data of tensile stress zones and crack zones in bamboo reinforced concrete beams using the Fortran PowerStation 4.0 program

Authors

Muhtar

Affiliations

Department of Civil Engineering, Faculty of Engineering, University of Muhammadiyah Jember, Jember, 68121, Indonesia

Corresponding author(s)

Muhtar (muhtar@unmuhjember.ac.id)

Abstract

Numerical verification is carried out in order to control the compatibility of the BRC beam crack pattern with the stress contour at the ultimate load. The numerical method used is the finite element method (FEM) using the Fortran PowerStation 4.0 program. Material data entered is the elasticity modulus (*E*) and Poisson's ratio (*v*). Ultimate load input data is taken from BRC beam testing in the laboratory. Bamboo reinforcement and concrete are considered to have the same displacement with a different elasticity modulus (*E*), so they experience different stresses. The triangle element is employed to model the plane-stress with two directions of displacement at each nodal point, so that each element has six degrees of freedom. The BRC beam tensile stress data from the Fortran PowerStation 4.0 program is processed into a tensile stress data table and becomes the Surfer program input data for mapping tensile stress zone images. Crack pattern data from laboratory beam testing is processed into crack zone pattern photo data and then compared to the tensile stress zone images. From the image data of the tensile stress zones and the crack zones of the BRC beam have compatibility. The Fortran PowerStation 4.0 programming language data in this article can be used for further research with the discretization of triangular elements in other cases. This article consists of a data table, a picture of a crack pattern zone, a drawing of tensile stress zones, and photo documentation. The data is related to "Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance" [1].

Keywords

numerical validation, finite element method, tensile stress zone, crack zone, bamboo reinforced concrete

Specifications Table

Subject	Engineering.
Specific subject area	Civil and structural engineering.
Type of data	Table, image, program.
How data were acquired	The crack pattern data was obtained from the beam flexural test (Fig. 15). The stress contour data was obtained from FEM analysis, using the Fortran PowerStation 4.0 and Surfer programs. Crack pattern data from the beam flexural test is processed and analyzed into crack zone image data. Stress data from FEM analysis is processed into stress table data and becomes the input data for the Surfer program. Data from the Surfer program is processed into stress zone image data. Then, all data is processed, compared, and analyzed into table data, cracks pattern zone image data, tensile stress zone image data, and photo data.
Data format	Raw and analyzed.
Parameters for data collection	Crack pattern data and maximum tensile stress data are two highly related data, in which cracks will occur at the maximum tensile stress position. The initial cracks until the collapsed beams are obtained through observation with a crack detector under a gradually increasing load. Crack pattern zone data from the laboratory beam test needs to be validated by other methods to determine compatibility with stresses that occur. Stress data and stress zone images data are obtained through FEM analysis using the Fortran PowerStation 4.0 and the Surfer programs. The Fortran PowerStation 4.0 programming language can be used for further research.
Description of data collection	The crack pattern data was collected through beam testing in the laboratory. Initial crack and subsequent crack data up to the beam collapsing are obtained through observation in stages, according to the beam loading stage. The crack detector is used to observe cracks. Each crack is numbered and drawn as the crack line. Then the crack data is processed and documentation taken, with results termed the crack zone image data. Tensile stress zone data was obtained from two sources, FEM analysis using the Fortran PowerStation 4.0 and the Surfer programs. FEM analysis with the Fortran PowerStation 4.0 program was obtained for direction stresses of X, Y, and Z. The X directional stress is tensile stress that causes cracks. The X direction stress data is then transferred to the Surfer program to generate the stress zone contour image data. The crack pattern data and the stress zone contour image data are compared and analyzed into table data, image data, program data, and photo data, all of which are termed intact data. This intact data was obtained from two specimens, namely a BRC beam and an SRC beam, to obtain crack patterns and tensile stresses with different reinforcement materials. The behaviors

	of the crack pattern and the stress zone from the two beams can be used as basis for further research.
Data source location	University of Muhammadiyah Jember, Jember, 68121, Indonesia, and University of Brawijaya, Malang 65145, Indonesia
Data accessibility	Data with the article, raw data can be found in Table 1, Table 2, Table 3, http://bit.ly/351FPqU, http://bit.ly/2MBqas9, http://bit.ly/2F17w8F, http://bit.ly/2rDPeaI, http://bit.ly/2Q4Ihc1, http://bit.ly/2MTh22j, http://bit.ly/2ZvZWMU, http://bit.ly/2u2K2xR, http://bit.ly/2ZybLCd, and http://bit.ly/2Q7j2Wp
Related research article	Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance. https://doi.org/10.1016/j.jobe.2019.100896 [1]

Value of the Data

- This data is useful for researchers in developing bamboo reinforced concrete structures, especially for simple construction in areas of abundant bamboo.
- Data can be used for further insight and development, especially stress analysis, capacity, and behavior of bamboo reinforced concrete beams with strengthening reinforcement.
- This data contains a program that can be used as a reference in analyzing and calculating stresses of the BRC beam and SRC beam by triangular element discretizing.
- The added value of this data is in the programming language; Fortran PowerStation 4.0 can now be used generally in further research to analyze the displacement and stress of two-dimensional plane-stress elements.

Data

The discretization image data of the BRC beam and SRC beam with triangular elements is shown in Fig. 1 and Fig. 2. The reduction data of the stiffness of the BRC beam and the SRC beam after the initial crack occurs up until the beam collapses is shown in Table 1 and Table 2. The input data for the Fortran PowerStation 4.0 program for the BRC beam is shown in the following link: http://bit.ly/351FPqU, and the input data for the SRC beam is shown in the link: http://bit.ly/2MBqas9. The programming language data for the Fortran PowerStation 4.0 program with the discretization of triangular elements is shown in the link: http://bit.ly/2F17w8F.

The data of the load-displacement relationship of the BRC beam and SRC beam from experiments and FEM analyses is shown in Table 3, while the image data of the load-displacement relationship diagrams from experiments and FEM analyses is shown in Fig. 3. The displacement contours data in the X-direction and Y-direction of the Surfer program for the BRC beam is shown in Fig. 8 and Fig. 9,

and the displacement contour data in the X-direction and Y-direction from the Surfer program for the SRC beam is shown in Fig. 12 and Fig. 13.

The table data of stress on the X-direction, Y-direction, and XY-direction from FEM analysis for the BRC beam is shown in the following link: http://bit.ly/2rDPeaI, and the stress contour image data from the Surfer program is shown in Fig. 4, Fig. 6, and Fig. 7. The table data of stress on the X-direction, Y-direction, and XY-direction from FEM analysis for the SRC beam is shown in the following link: http://bit.ly/2Q4Ihc1, while the stress contour image data from the Surfer program is shown in Fig. 5, Fig. 10, and Fig. 11. Photographs of crack pattern data and tensile stress contour data for the analysis of the compatibility of the zone are shown in Fig. 4 and Fig. 5.

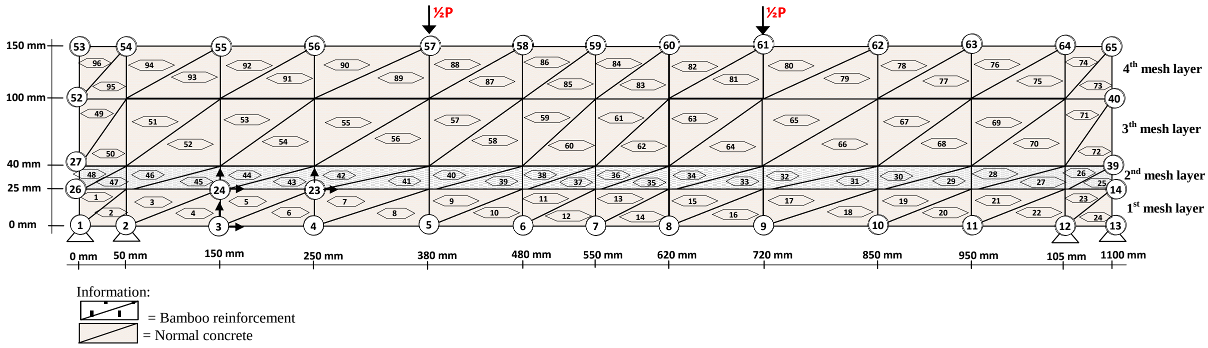

Fig. 1. The discretization of the BRC beam using the triangle element [1]

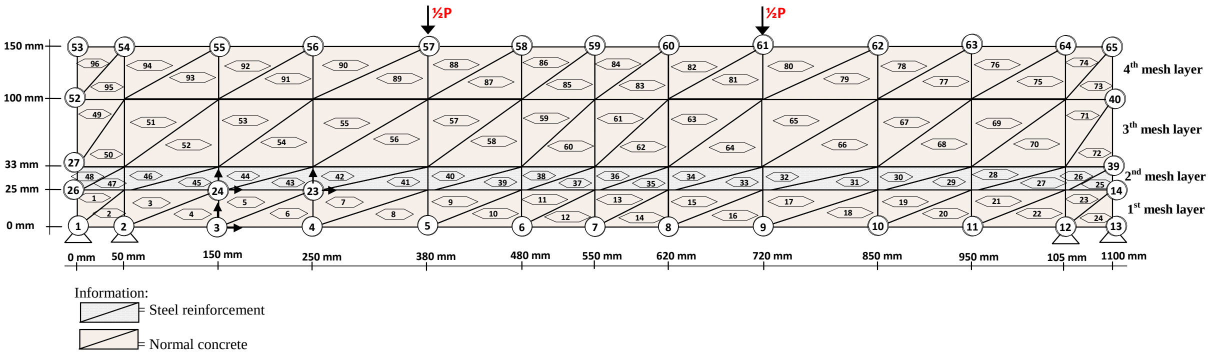

Fig. 2. The discretization of the SRC beam using the triangle element

Table 1

The reduction data of the stiffness of the BRC beam after initial cracking occurs up until the ultimate load [2]

Layer number	Modulus of elasticity (E) of the BRC beam										
	Elastic condition	Plastic conditions with gradual loads									
	0 - 8.5 kN	9 kN	11 kN	15 kN	17 kN	21 kN	23 kN	25 kN	27 kN	29 kN	33 kN
4th mesh layer	268512,89	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	120830,80	112775,41	85924,12
3th mesh layer	268512,89	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	120830,80	107405,16	93979,51	75183,61
2nd mesh layer	247451,73	138845,32	115704,43	115704,43	115704,43	104133,99	104133,99	104133,99	69422,66	69422,66	55538,13
1st mesh layer	268512,89	134256,45	118145,67	83239,00	67128,22	51017,45	51017,45	37591,80	32221,55	26851,29	13291,39

Table 2
The reduction data of the stiffness of the SRC beam after initial cracking occurs up until the ultimate load [2]

Layer number	Modulus of elasticity (*E*) of the SRC beam										
	Elastic condition	Plastic conditions with gradual loads									
	0 - 9 kN	10 kN	11 kN	12 kN	13 kN	15 kN	17 kN	19 kN	21 kN	23 kN	24 kN
4th mesh layer	268512,89	268512,89	201384,67	201384,67	201384,67	201384,67	201384,67	187959,02	187959,02	134256,45	114117,98
3th mesh layer	268512,89	268512,89	201384,67	201384,67	187959,02	187959,02	187959,02	174533,38	174533,38	134256,45	114117,98
2nd mesh layer	407825,73	432093,18	324069,88	324069,88	302465,22	302465,22	280860,56	280860,56	259255,91	216046,59	183639,60
1st mesh layer	268512,89	268512,89	201384,67	201384,67	187959,02	187959,02	174533,38	161107,73	147682,09	134256,45	120830,80

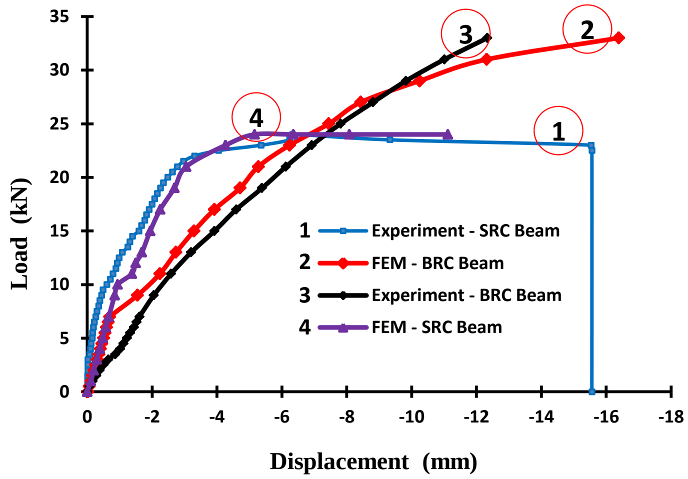

Fig. 3. The load-displacement relationship of the BRC and SRC beams with experiment and FEM

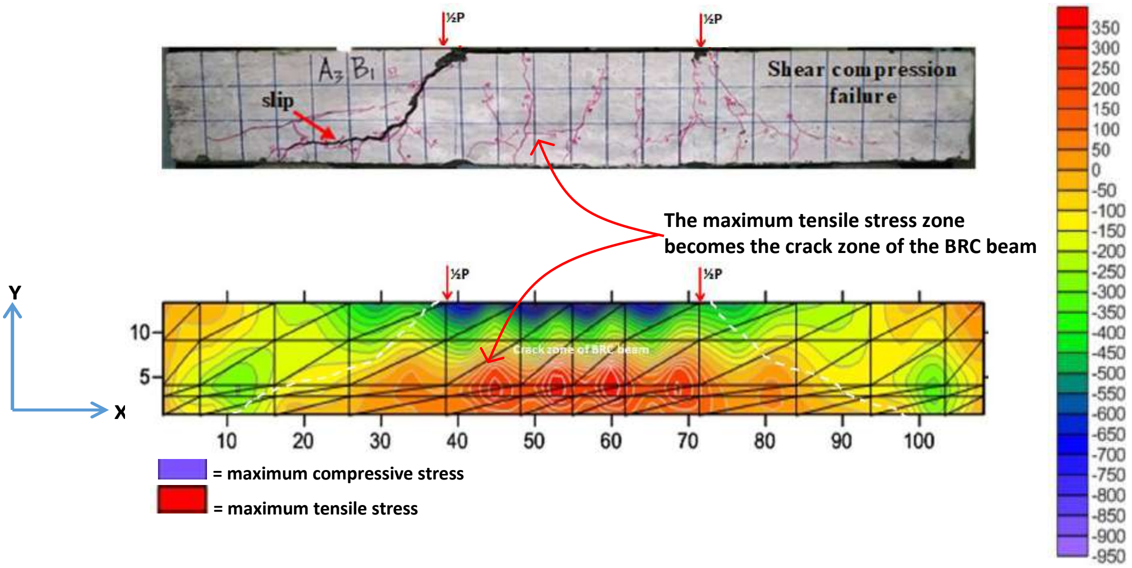

Fig. 4. The data validation of crack pattern with tensile stress contours of the BRC beam

Table 3
The data of load and displacement of BRC beams and SRC beams

The data of load and displacement of BRC beams and SRC beams							
Experiment–BRC Beam		Experiment–SRC Beam		FEM–BRC Beam		FEM–SRC Beam	
Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)
0,00	0,00	0,00	0,00	0,00	-0,00	0,00	0,00
0,50	-0,07	1,00	-0,01	0,50	-0,07	1,00	-0,11
1,00	-0,17	2,00	-0,02	1,00	-0,12	2,00	-0,20
1,50	-0,28	4,00	-0,10	1,50	-0,16	3,00	-0,29
2,00	-0,38	5,00	-0,15	2,00	-0,21	4,00	-0,39
2,50	-0,51	6,00	-0,19	2,50	-0,26	5,00	-0,48
3,00	-0,65	7,00	-0,26	3,00	-0,31	6,00	-0,57
3,50	-0,86	8,00	-0,35	3,50	-0,36	7,00	-0,66
4,00	-1,02	9,00	-0,44	4,00	-0,41	9,00	-0,85
4,50	-1,12	10,00	-0,60	4,50	-0,45	10,00	-0,94
5,00	-1,22	11,00	-0,79	5,00	-0,50	11,00	-1,37
5,50	-1,33	12,00	-0,93	5,50	-0,55	12,00	-1,49
6,00	-1,44	13,00	-1,08	6,00	-0,60	13,00	-1,69
6,50	-1,52	14,00	-1,31	6,50	-0,65	15,00	-1,94
7,00	-1,61	15,00	-1,59	7,00	-0,70	17,00	-2,25
9,00	-2,05	16,00	-1,77	9,00	-1,55	19,00	-2,69
11,00	-2,59	17,00	-1,91	11,00	-2,24	21,00	-3,05
13,00	-3,20	18,00	-2,08	13,00	-2,74	23,00	-4,26
15,00	-3,93	19,00	-2,26	15,00	-3,29	24,00	-5,16
17,00	-4,59	20,00	-2,48	17,00	-3,92	24,00	-6,35
19,00	-5,39	21,00	-2,78	19,00	-4,71	24,00	-8,09
21,00	-6,13	22,00	-3,31	21,00	-5,28	24,00	-11,12
23,00	-6,93	23,00	-5,36	23,00	-6,24		
25,00	-7,81	24,00	-6,33	25,00	-7,45		
27,00	-8,81	23,50	-9,33	27,00	-8,43		
29,00	-9,83	23,00	-15,54	29,00	-10,25		
31,00	-11,01	22,50	-15,56	31,00	-12,32		
33,00	-12,34	0,00	-15,56	33,00	-16,39		

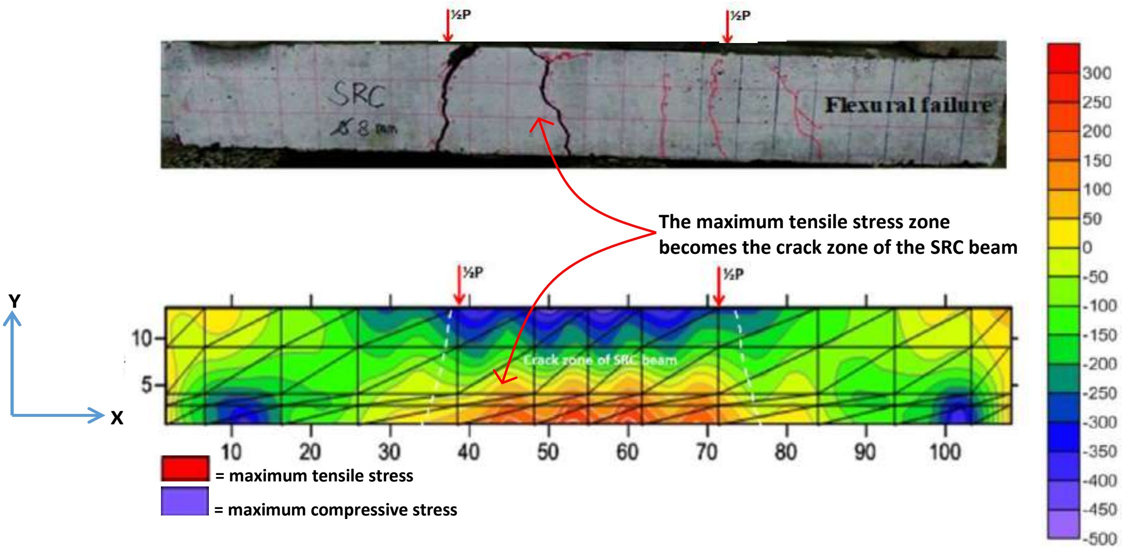

Fig. 5. The data validation of crack pattern with tensile stress contours of the SRC beam

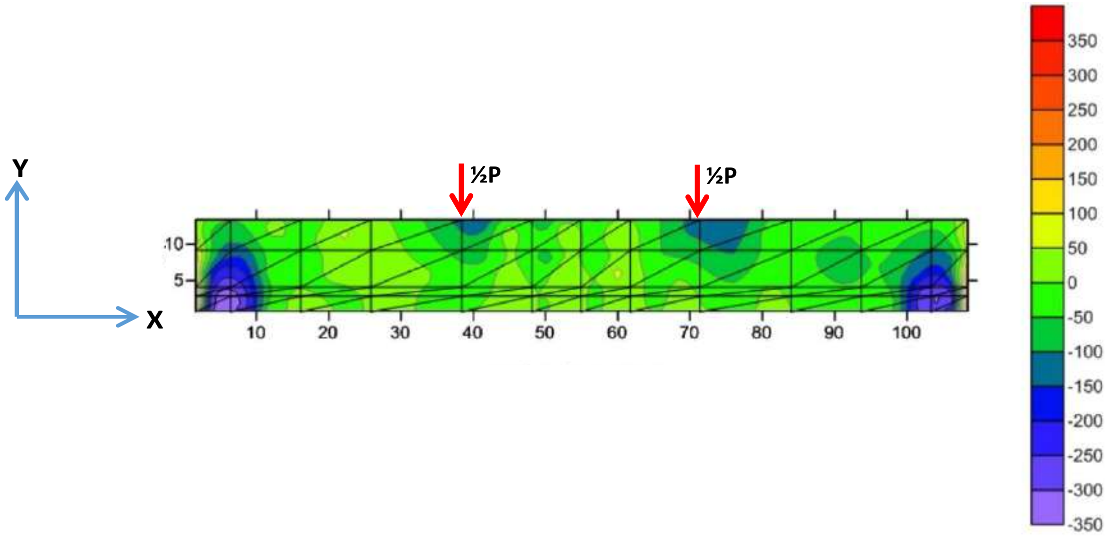

Fig. 6. The stress of Y-direction of BRC beam

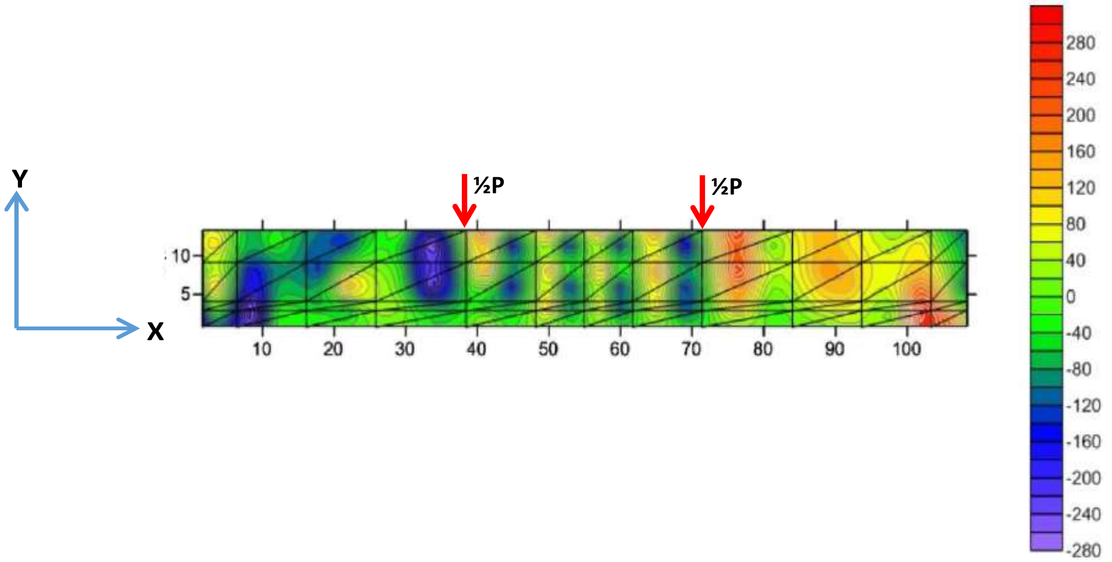

Fig. 7. The stress of XY-direction of BRC beam

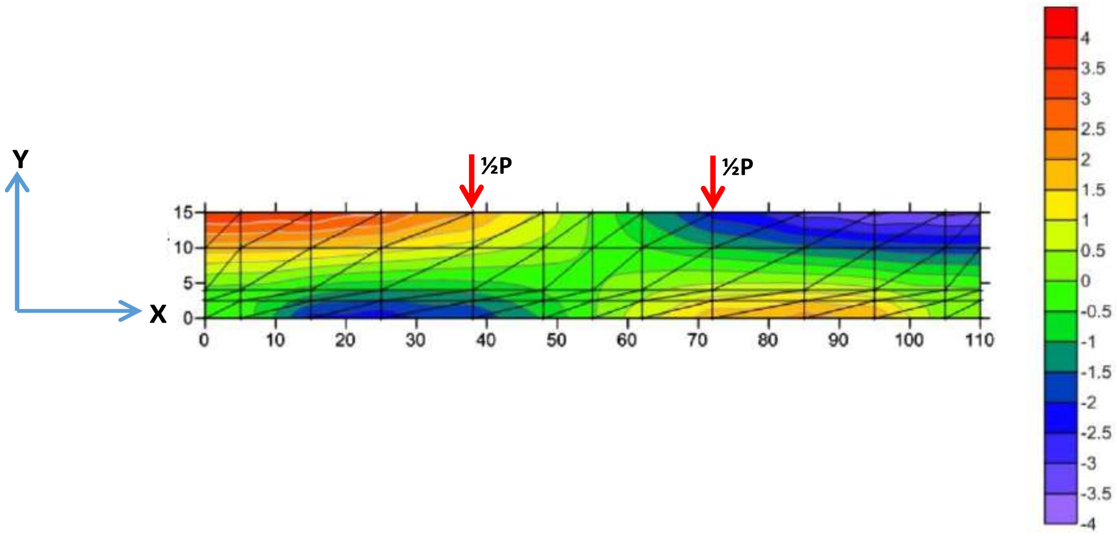

Fig. 8. The displacement of X-direction of BRC beam

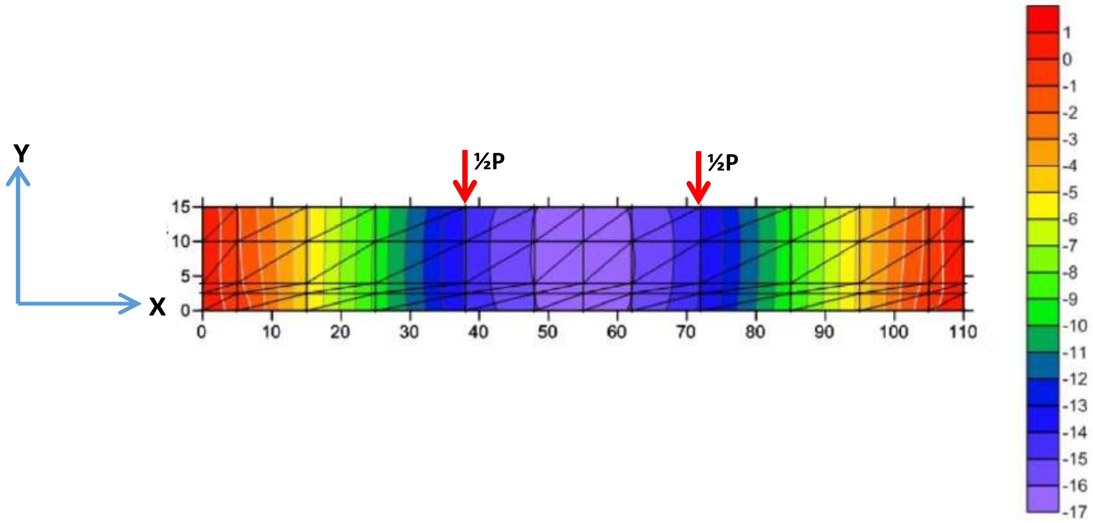

Fig. 9. The displacement of Y-direction of BRC beam

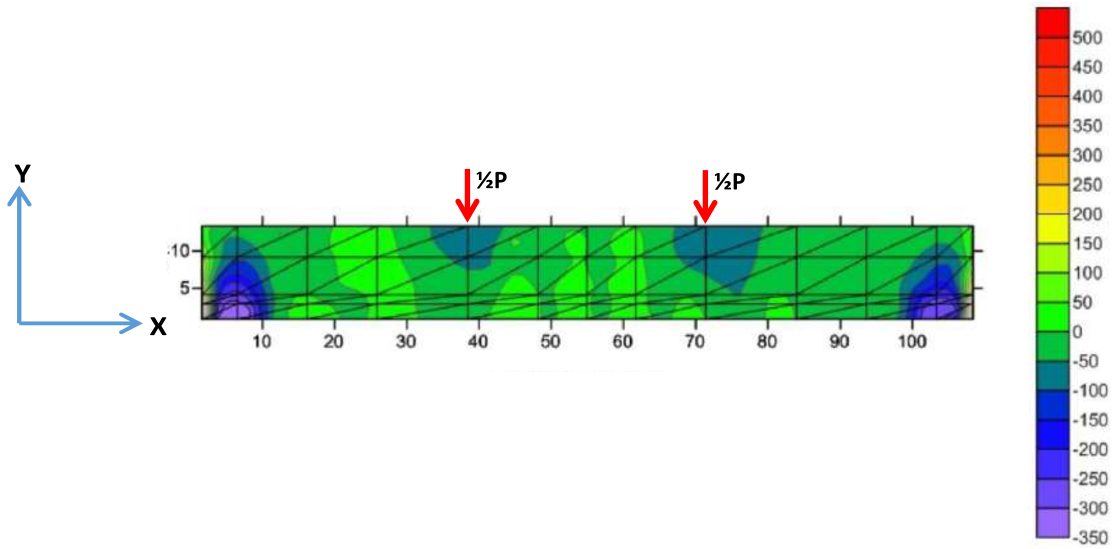

Fig. 10. The stress of Y-direction of SRC beam

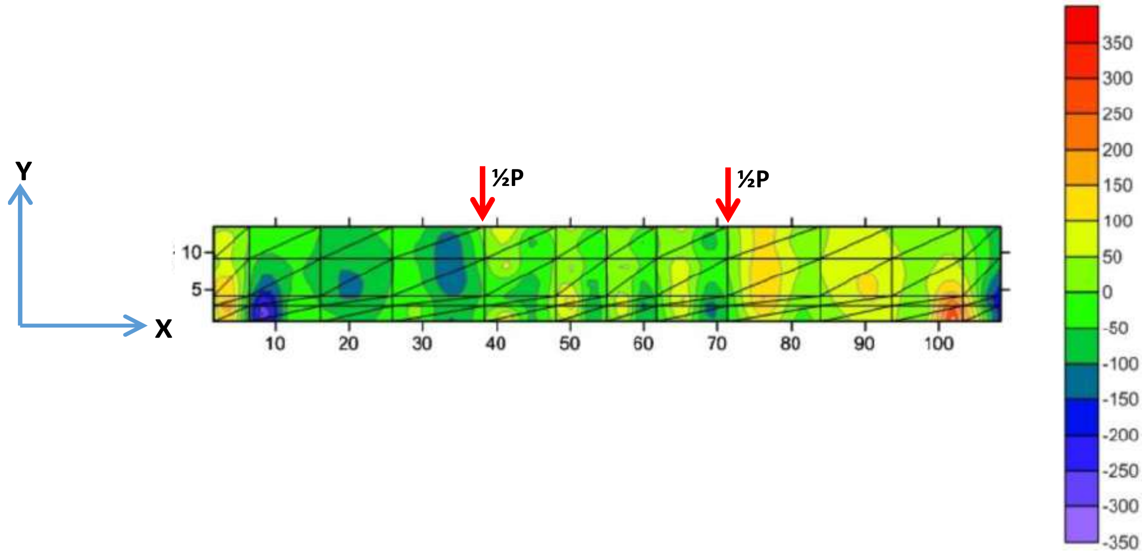

Fig. 11. The stress of XY-direction of SRC beam

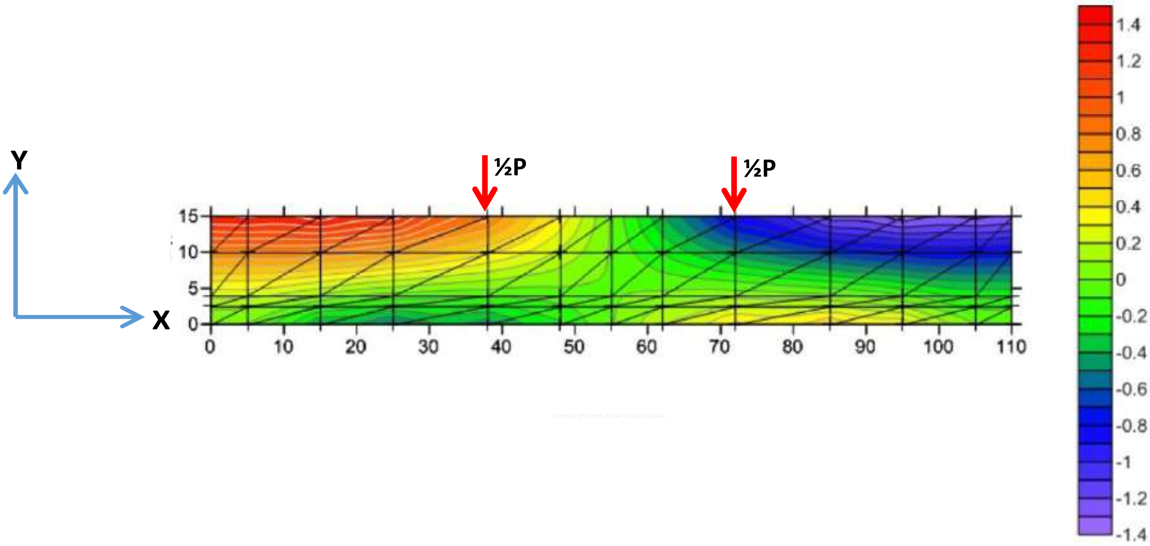

Fig. 12. The displacement of X-direction of SRC beam

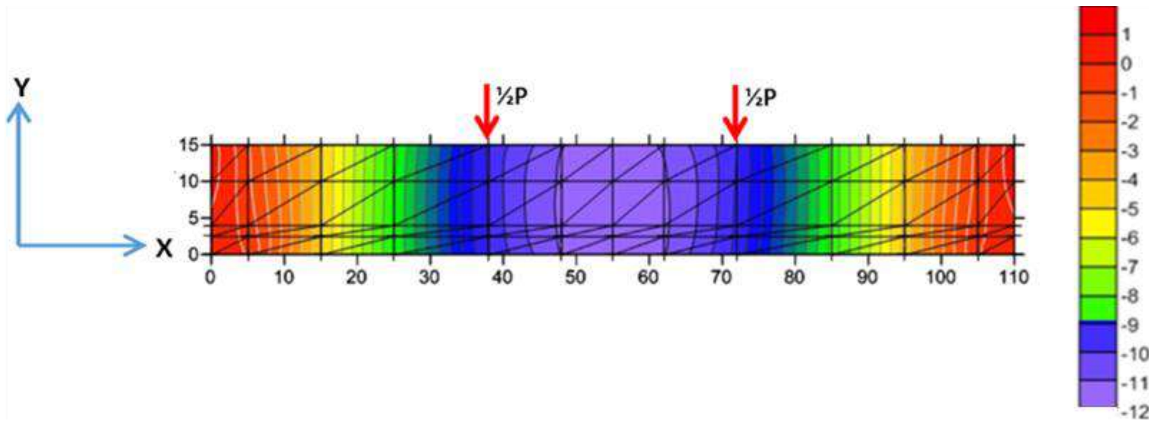

Fig. 13. The displacement of Y-direction of SRC beam

Experimental Design, Materials, and Methods

Numerical analysis was carried out with 2D and the experiments with 3D as shown in Fig. 15. Data from 2D numerical analysis obtained data of X-direction stress, Y-direction stress, XY-direction stress, X-direction deflection, and Y-direction deflection. While the data from the experiments only obtained data on crack patterns, loads, strain, and deflection. So that the validation of both focuses on X-direction stress or tensile stress that causes cracking and Y-direction deflection. The validation of the tensile stress zone and crack patterns zone is shown in Fig. 4 and Fig. 5 and the validation of deflection are shown in Table 3, Fig. 9, and Fig. 13. The validation of Y-direction stress, XY-direction stress, and X-direction deflection are not done because experimental data are not obtained.

Data validation between laboratory data and numerical analysis is carried out through a series of activities, namely beam flexural testing in the laboratory, numerical analysis with finite element method (FEM), program simulation with Fortran PowerStation 4.0, and simulation with the Surfer program. Activities in the laboratory are flexural tests of the BRC beam and the SRC beam to obtain data on crack patterns, collapse patterns, and ultimate loads. The test settings for the BRC beam and the SRC beam are shown in Fig. 15. The geometry and details of the reinforcement of BRC beams and SRC beams are shown in Fig. 14.

The material data of bamboo, steel, and concrete consists of Modulus of elasticity (E) and Poisson's ratio (v). The modulus of elasticity of bamboo (E_b) is 17,235.74 MPa with Poisson's ratio (v_b) of 0.25. The modulus of elasticity of concrete (E_c) is 26,299.01 MPa with Poisson's ratio (v_c) of 0.20. The modulus of elasticity of steel (E_s) is 207,735.92 MPa with Poisson's ratio (v_s) of 0.3.

The constitutive relationship analysis of the finite element method employs plane-stress theory. The triangle element is used to model the plane-stress element with two main displacement directions at each nodal point, so that the element has six degrees of freedom. The discretization of the beam plane using the triangular element is shown in Fig. 1 and Fig. 2. Modulus of elasticity (E) for each layer is calculated according to material conditions. Layers consisting of concrete and bamboo reinforcement are calculated using Eq. (1) [1], and for layers consisting of concrete and steel using Eq. (2) [3]. The solution to the plane-stress problem in the BRC beam and SRC beam is based on the stress-strain relationship as shown in Eq. (3) [1]. The main stresses on the BRC beam and SRC beam are calculated using Eq. (4) [1].

$$E_e = E_b.V_b + E_c.V_c \tag{1}$$

$$E_e = E_s.V_s + E_c.V_c \tag{2}$$

$$\begin{Bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{Bmatrix} = \frac{E}{(1+\nu^2)} \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix} \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix} \tag{3}$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}{}^2} = \sigma_{max} \tag{4}$$

The steps for compiling the Fortran PowerStation 4.0 program data to get the beam tensile stress contour data are summarized as follows:

Step 1: Discretization of the plane of the BRC beam and the SRC beam with the discretization of the triangular element, as shown in Fig. 1 and Fig. 2.

Step 2: Numbering of the triangular elements and the nodal points, as shown in Fig. 1 and Fig. 2.

Step 3: Collection and calculation of the geometry data and the beam material data, such as modulus of elasticity of materials (*E*), Poisson ratio (*v*), etc.

Step 4: Writing the programming language for the Fortran PowerStation 4.0 program for the triangular element, as shown in the following link: http://bit.ly/2F17w8F.

Step 5: Opening the Fortran PowerStation 4.0 program. As an example, the front view in the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2MTh22j.

Step 6: Writing programming language data (Step 4) in the Fortran PowerStation 4.0 program. As an example, a display of programming language is shown in the following link: http://bit.ly/2ZvZWMU.

Step 7: The Input DATA.DAT of the BRC beam and SRC beam in the Fortran PowerStation 4.0 program. The input data is shown in the following links: http://bit.ly/351FPqU and http://bit.ly/2MBqas9. An example of the input data display is shown in the following link: http://bit.ly/2u2K2xR.

Step 8: Running and processing the program analysis until there are no warnings and errors. If there are warnings and errors, check and correct the program data and input data.

Step 9: Downloading stress data X-direction, Y-direction, and XY-direction. Stress data is shown in the following link: http://bit.ly/2rDPeaI for the BRC beam stress, and http://bit.ly/2Q4Ihc1 for the SRC beam stress. For example, the display of stress data from the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2ZybLCd.

Step 10: Downloading displacement data X-direction and Y-direction. The displacement data for the BRC beam and SRC beam is shown in Table 3. An example of the displacement data display from the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2Q7j2Wp.

Step 11: Inputting stress data and displacement data on the Surfer program, running the program, and obtaining stress contour images data and displacement. Image data of stress contours and displacement are shown in Figs. 4-13.

Step 12: Validation of drawing data for tensile stress contours (X-direction stress) with beam crack patterns from laboratory tests.

Step 13: Obtaining crack zone image data and tensile stress zone contour data. Image data of crack zones and contour zones of tensile stress are shown in Fig. 4 and Fig. 5.

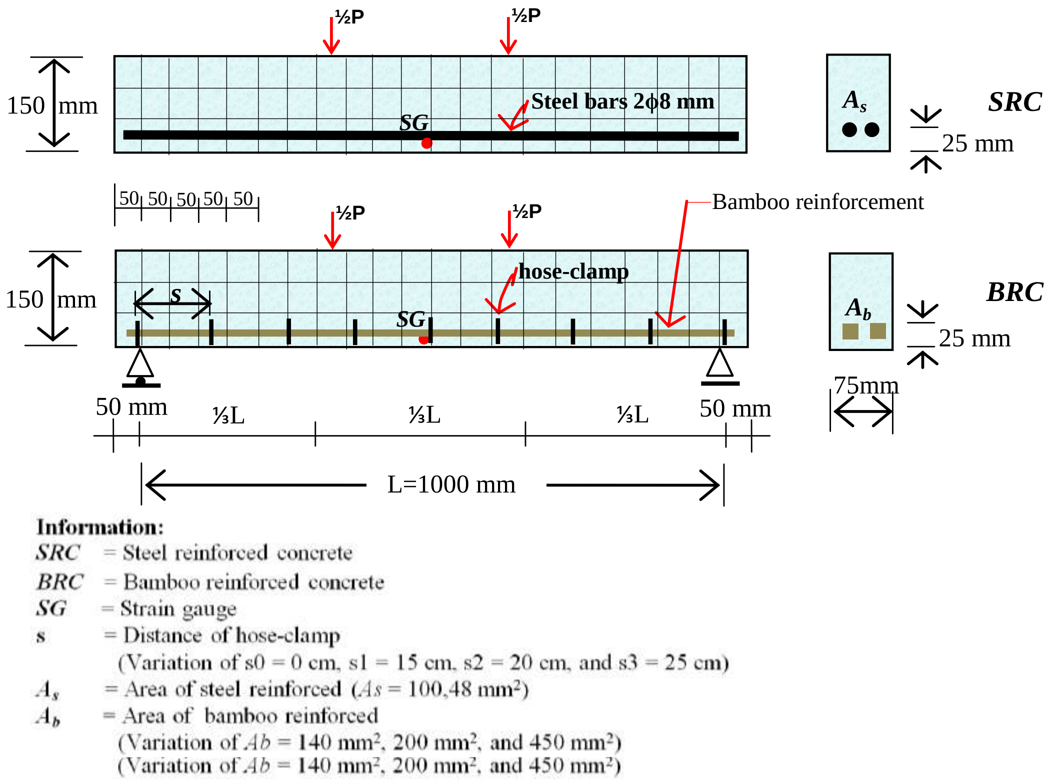

Fig. 14. Detail and geometry of the bamboo reinforced concrete beam [1,4]

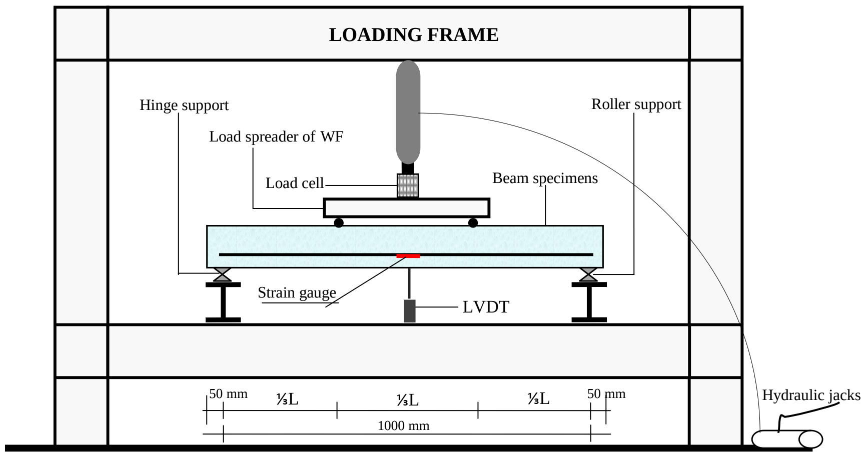

Fig. 15. Flexural test settings for the four-point flexural test method [1,4,5,6]

List of symbols

E	Modulus of elasticity
E_e	The equivalent elasticity modulus of BRC beam or SRC beam
E_b	Modulus of elasticity of bamboo reinforcement
E_c	Modulus of elasticity of concrete
E_s	Modulus of elasticity of steel reinforcement
V_b	The relative volume of bamboo reinforcement in the calculated layer
V_c	The relative volume of concrete in the calculated layer
V_s	The relative volume of steel reinforcement in the calculated layer

σ_x	Stress of X-direction
σ_y	Stress of Y-direction
$\sigma_{1,2}$	Main stress
τ_{xy}	Shear stress of XY-direction
v	Poisson's ratio
ε_x	Strain of X-direction
ε_y	Strain of Y-direction
Υ_{xy}	Shear strain of XY-direction

Acknowledgments

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Conflict of Interest

The authors declare that they know of no competition for financial interests or personal relationships that could appear to have influenced the work reported in this paper.

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[1] Muhtar, S.M. Dewi, Wisnumurti, A. Munawir, Enhancing bamboo reinforcement using a hose-clamp to increase bond- stress and slip resistance, Journal of Building Engineering. 26 (2019) 100896. https://doi.org/10.1016/j.jobe.2019.100896.

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Article Title

Numerical validation data of tensile stress zones and crack zones in bamboo reinforced concrete beams using the Fortran PowerStation 4.0 program

Authors

Muhtar

Affiliations

Department of Civil Engineering, Faculty of Engineering, University of Muhammadiyah Jember, Jember, 68121, Indonesia

Corresponding author(s)

Muhtar (muhtar@unmuhjember.ac.id)

Abstract

Numerical verification is carried out in order to control the compatibility of the BRC beam crack pattern with the stress contour at the ultimate load. The numerical method used is the finite element method (FEM) using the Fortran PowerStation 4.0 program. Material data entered is the elasticity modulus (*E*) and Poisson's ratio (*v*). Ultimate load input data is taken from BRC beam testing in the laboratory. Bamboo reinforcement and concrete are considered to have the same displacement with a different elasticity modulus (*E*), so they experience different stresses. The triangle element is employed to model the plane-stress with two directions of displacement at each nodal point, so that each element has six degrees of freedom. The BRC beam tensile stress data from the Fortran PowerStation 4.0 program is processed into a tensile stress data table and becomes the Surfer program input data for mapping tensile stress zone images. Crack pattern data from laboratory beam testing is processed into crack zone pattern photo data and then compared to the tensile stress zone images. From the image data of the tensile stress zones and the crack zones of the BRC beam have compatibility. The Fortran PowerStation 4.0 programming language data in this article can be used for further research with the discretization of triangular elements in other cases. This article consists of a data table, a picture of a crack pattern zone, a drawing of tensile stress zones, and photo documentation. The data is related to "Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance" [1].

Keywords

numerical validation, finite element method, tensile stress zone, crack zone, bamboo reinforced concrete

Specifications Table

Subject	Engineering.
Specific subject area	Civil and structural engineering.
Type of data	Table, image, program.
How data were acquired	The crack pattern data was obtained from the beam flexural test (Fig. 15). The stress contour data was obtained from FEM analysis, using the Fortran PowerStation 4.0 and Surfer programs. Crack pattern data from the beam flexural test is processed and analyzed into crack zone image data. Stress data from FEM analysis is processed into stress table data and becomes the input data for the Surfer program. Data from the Surfer program is processed into stress zone image data. Then, all data is processed, compared, and analyzed into table data, cracks pattern zone image data, tensile stress zone image data, and photo data.
Data format	Raw and analyzed.
Parameters for data collection	Crack pattern data and maximum tensile stress data are two highly related data, in which cracks will occur at the maximum tensile stress position. The initial cracks until the collapsed beams are obtained through observation with a crack detector under a gradually increasing load. Crack pattern zone data from the laboratory beam test needs to be validated by other methods to determine compatibility with stresses that occur. Stress data and stress zone images data are obtained through FEM analysis using the Fortran PowerStation 4.0 and the Surfer programs. The Fortran PowerStation 4.0 programming language can be used for further research.
Description of data collection	The crack pattern data was collected through beam testing in the laboratory. Initial crack and subsequent crack data up to the beam collapsing are obtained through observation in stages, according to the beam loading stage. The crack detector is used to observe cracks. Each crack is numbered and drawn as the crack line. Then the crack data is processed and documentation taken, with results termed the crack zone image data. Tensile stress zone data was obtained from two sources, FEM analysis using the Fortran PowerStation 4.0 and the Surfer programs. FEM analysis with the Fortran PowerStation 4.0 program was obtained for direction stresses of X, Y, and Z. The X directional stress is tensile stress that causes cracks. The X direction stress data is then transferred to the Surfer program to generate the stress zone contour image data. The crack pattern data and the stress zone contour image data are compared and analyzed into table data, image data, program data, and photo data, all of which are termed intact data. This intact data was obtained from two specimens, namely a BRC beam and an SRC beam, to obtain crack patterns and tensile stresses with different reinforcement materials. The behaviors

	of the crack pattern and the stress zone from the two beams can be used as basis for further research.
Data source location	University of Muhammadiyah Jember, Jember, 68121, Indonesia, and University of Brawijaya, Malang 65145, Indonesia
Data accessibility	Data with the article, raw data can be found in Table 1, Table 2, Table 3, http://bit.ly/351FPqU, http://bit.ly/2MBqas9, http://bit.ly/2F17w8F, http://bit.ly/2rDPeaI, http://bit.ly/2Q4Ihc1, http://bit.ly/2MTh22j, http://bit.ly/2ZvZWMU, http://bit.ly/2u2K2xR, http://bit.ly/2ZybLCd, and http://bit.ly/2Q7j2Wp
Related research article	Enhancing bamboo reinforcement using a hose-clamp to increase bond-stress and slip resistance. https://doi.org/10.1016/j.jobe.2019.100896 [1]

Value of the Data

- This data is useful for researchers in developing bamboo reinforced concrete structures, especially for simple construction in areas of abundant bamboo.
- Data can be used for further insight and development, especially stress analysis, capacity, and behavior of bamboo reinforced concrete beams with strengthening reinforcement.
- This data contains a program that can be used as a reference in analyzing and calculating stresses of the BRC beam and SRC beam by triangular element discretizing.
- The added value of this data is in the programming language; Fortran PowerStation 4.0 can now be used generally in further research to analyze the displacement and stress of two-dimensional plane-stress elements.

Data

The discretization image data of the BRC beam and SRC beam with triangular elements is shown in Fig. 1 and Fig. 2. The reduction data of the stiffness of the BRC beam and the SRC beam after the initial crack occurs up until the beam collapses is shown in Table 1 and Table 2. The input data for the Fortran PowerStation 4.0 program for the BRC beam is shown in the following link: http://bit.ly/351FPqU, and the input data for the SRC beam is shown in the link: http://bit.ly/2MBqas9. The programming language data for the Fortran PowerStation 4.0 program with the discretization of triangular elements is shown in the link: http://bit.ly/2F17w8F.

The data of the load-displacement relationship of the BRC beam and SRC beam from experiments and FEM analyses is shown in Table 3, while the image data of the load-displacement relationship diagrams from experiments and FEM analyses is shown in Fig. 3. The displacement contours data in the X-direction and Y-direction of the Surfer program for the BRC beam is shown in Fig. 8 and Fig. 9,

and the displacement contour data in the X-direction and Y-direction from the Surfer program for the SRC beam is shown in Fig. 12 and Fig. 13.

The table data of stress on the X-direction, Y-direction, and XY-direction from FEM analysis for the BRC beam is shown in the following link: http://bit.ly/2rDPeal, and the stress contour image data from the Surfer program is shown in Fig. 4, Fig. 6, and Fig. 7. The table data of stress on the X-direction, Y-direction, and XY-direction from FEM analysis for the SRC beam is shown in the following link: http://bit.ly/2Q4Ihc1, while the stress contour image data from the Surfer program is shown in Fig. 5, Fig. 10, and Fig. 11. Photographs of crack pattern data and tensile stress contour data for the analysis of the compatibility of the zone are shown in Fig. 4 and Fig. 5.

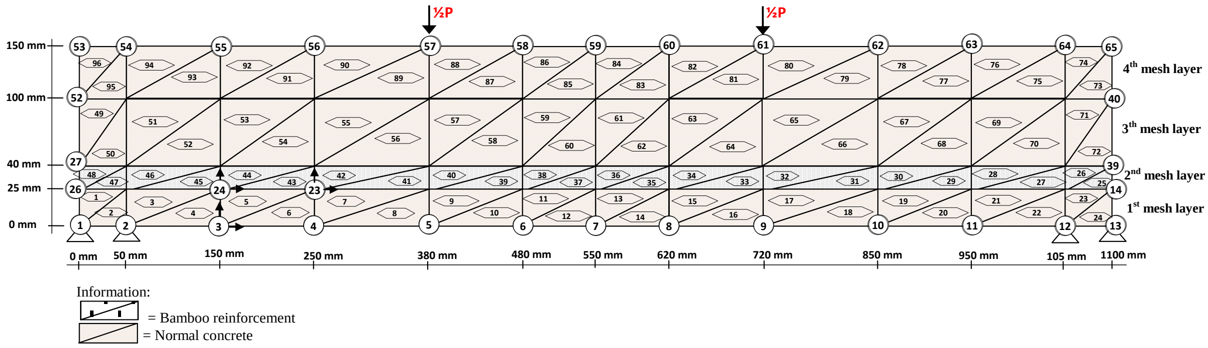


Fig. 1. The discretization of the BRC beam using the triangle element [1]

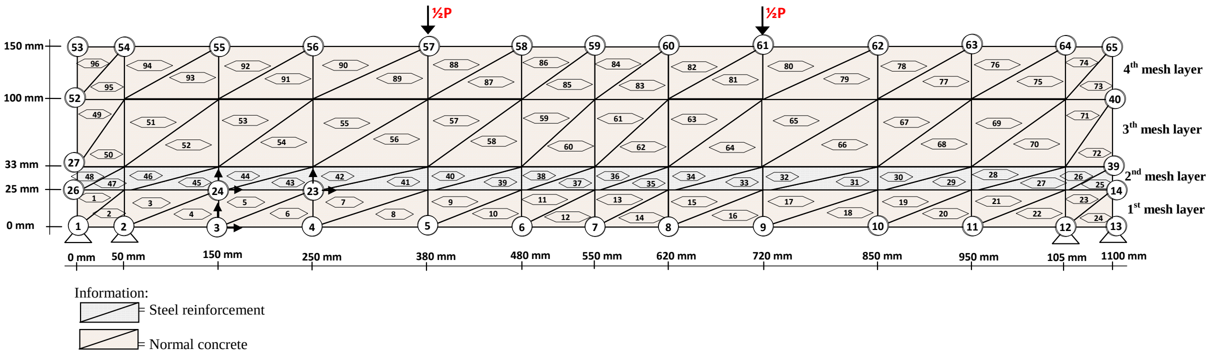


Fig. 2. The discretization of the SRC beam using the triangle element

Table 1

The reduction data of the stiffness of the BRC beam after initial cracking occurs up until the ultimate load [2]

Layer number	Modulus of elasticity (E) of the BRC beam									
	Elastic condition	Plastic conditions with gradual loads								
	0 - 8.5 kN	9 kN	11 kN	15 kN	17 kN	21 kN	23 kN	25 kN	27 kN	29 kN	33 kN
4th mesh layer	268512,89	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	120830,80	112775,41	85924,12
3th mesh layer	268512,89	161107,73	161107,73	161107,73	161107,73	161107,73	161107,73	120830,80	107405,16	93979,51	75183,61
2nd mesh layer	247451,73	138845,32	115704,43	115704,43	115704,43	104133,99	104133,99	104133,99	69422,66	69422,66	55538,13
1st mesh layer	268512,89	134256,45	118145,67	83239,00	67128,22	51017,45	51017,45	37591,80	32221,55	26851,29	13291,39

Table 2
The reduction data of the stiffness of the SRC beam after initial cracking occurs up until the ultimate load [2]

Layer number	Modulus of elasticity (*E*) of the SRC beam										
	Elastic condition	Plastic conditions with gradual loads									
	0 - 9 kN	10 kN	11 kN	12 kN	13 kN	15 kN	17 kN	19 kN	21 kN	23 kN	24 kN
4th mesh layer	268512,89	268512,89	201384,67	201384,67	201384,67	201384,67	201384,67	187959,02	187959,02	134256,45	114117,98
3th mesh layer	268512,89	268512,89	201384,67	201384,67	187959,02	187959,02	187959,02	174533,38	174533,38	134256,45	114117,98
2nd mesh layer	407825,73	432093,18	324069,88	324069,88	302465,22	302465,22	280860,56	280860,56	259255,91	216046,59	183639,60
1st mesh layer	268512,89	268512,89	201384,67	201384,67	187959,02	187959,02	174533,38	161107,73	147682,09	134256,45	120830,80

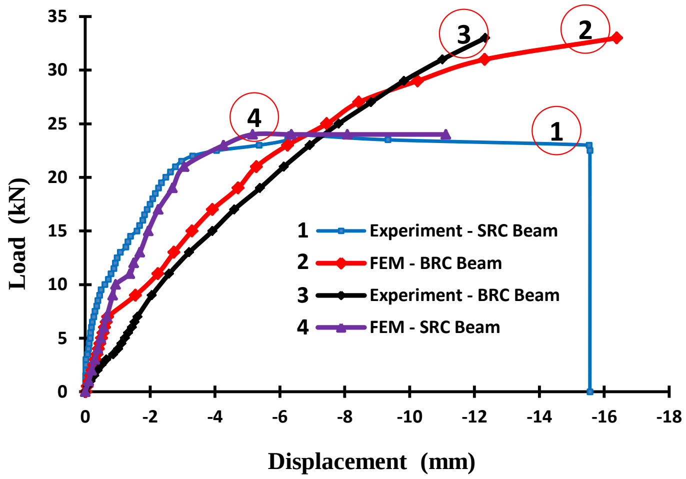


Fig. 3. The load-displacement relationship of the BRC and SRC beams with experiment and FEM

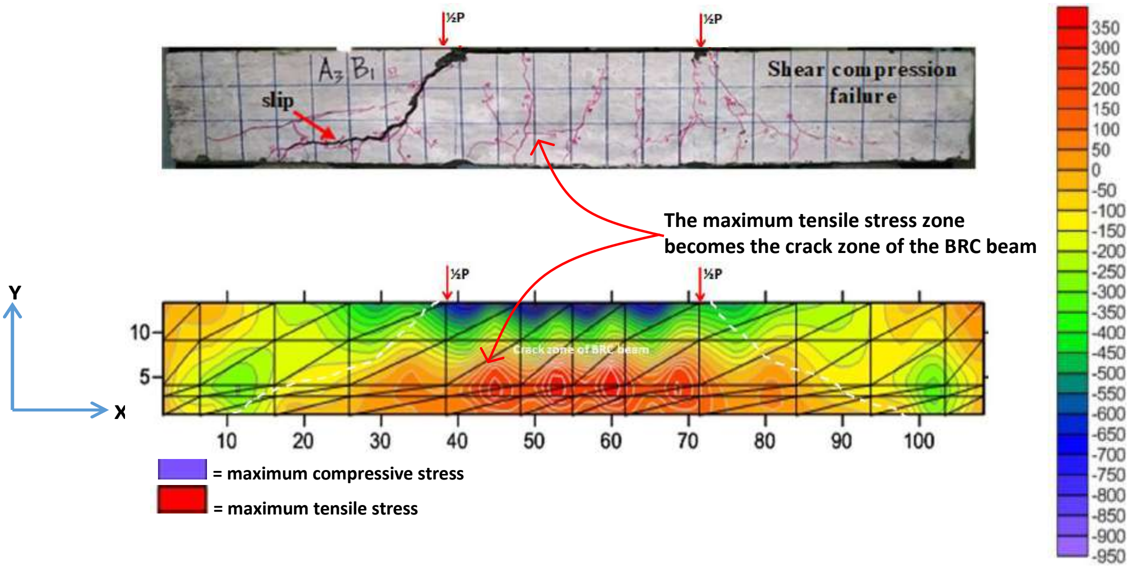


Fig. 4. The data validation of crack pattern with tensile stress contours of the BRC beam

Table 3
The data of load and displacement of BRC beams and SRC beams

The data of load and displacement of BRC beams and SRC beams							
Experiment–BRC Beam		Experiment–SRC Beam		FEM–BRC Beam		FEM–SRC Beam	
Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)	Load (kN)	Displacement (mm)
0,00	0,00	0,00	0,00	0,00	-0,00	0,00	0,00
0,50	-0,07	1,00	-0,01	0,50	-0,07	1,00	-0,11
1,00	-0,17	2,00	-0,02	1,00	-0,12	2,00	-0,20
1,50	-0,28	4,00	-0,10	1,50	-0,16	3,00	-0,29
2,00	-0,38	5,00	-0,15	2,00	-0,21	4,00	-0,39
2,50	-0,51	6,00	-0,19	2,50	-0,26	5,00	-0,48
3,00	-0,65	7,00	-0,26	3,00	-0,31	6,00	-0,57
3,50	-0,86	8,00	-0,35	3,50	-0,36	7,00	-0,66
4,00	-1,02	9,00	-0,44	4,00	-0,41	9,00	-0,85
4,50	-1,12	10,00	-0,60	4,50	-0,45	10,00	-0,94
5,00	-1,22	11,00	-0,79	5,00	-0,50	11,00	-1,37
5,50	-1,33	12,00	-0,93	5,50	-0,55	12,00	-1,49
6,00	-1,44	13,00	-1,08	6,00	-0,60	13,00	-1,69
6,50	-1,52	14,00	-1,31	6,50	-0,65	15,00	-1,94
7,00	-1,61	15,00	-1,59	7,00	-0,70	17,00	-2,25
9,00	-2,05	16,00	-1,77	9,00	-1,55	19,00	-2,69
11,00	-2,59	17,00	-1,91	11,00	-2,24	21,00	-3,05
13,00	-3,20	18,00	-2,08	13,00	-2,74	23,00	-4,26
15,00	-3,93	19,00	-2,26	15,00	-3,29	24,00	-5,16
17,00	-4,59	20,00	-2,48	17,00	-3,92	24,00	-6,35
19,00	-5,39	21,00	-2,78	19,00	-4,71	24,00	-8,09
21,00	-6,13	22,00	-3,31	21,00	-5,28	24,00	-11,12
23,00	-6,93	23,00	-5,36	23,00	-6,24		
25,00	-7,81	24,00	-6,33	25,00	-7,45		
27,00	-8,81	23,50	-9,33	27,00	-8,43		
29,00	-9,83	23,00	-15,54	29,00	-10,25		
31,00	-11,01	22,50	-15,56	31,00	-12,32		
33,00	-12,34	0,00	-15,56	33,00	-16,39		

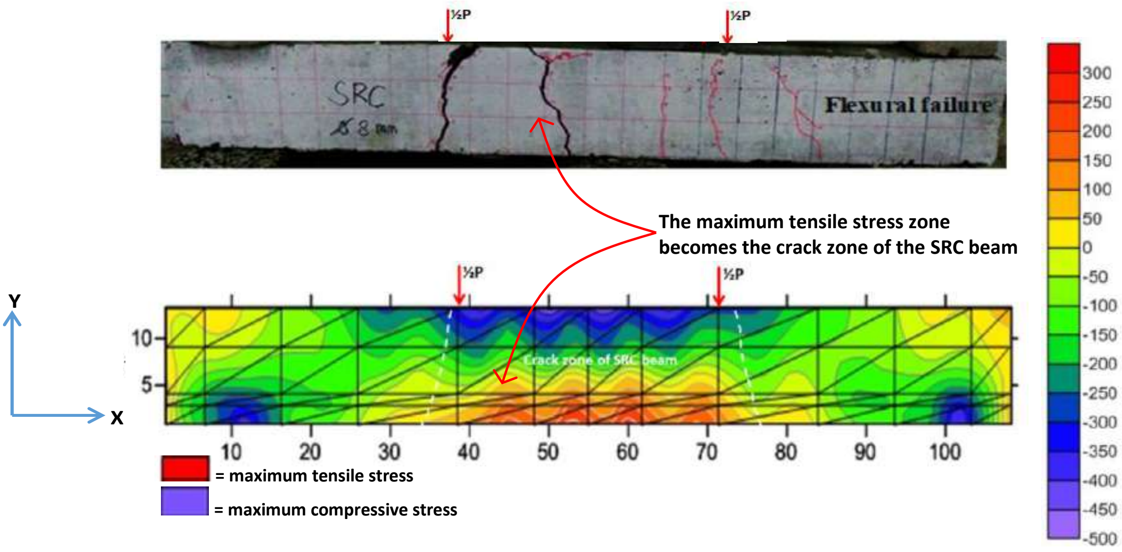


Fig. 5. The data validation of crack pattern with tensile stress contours of the SRC beam

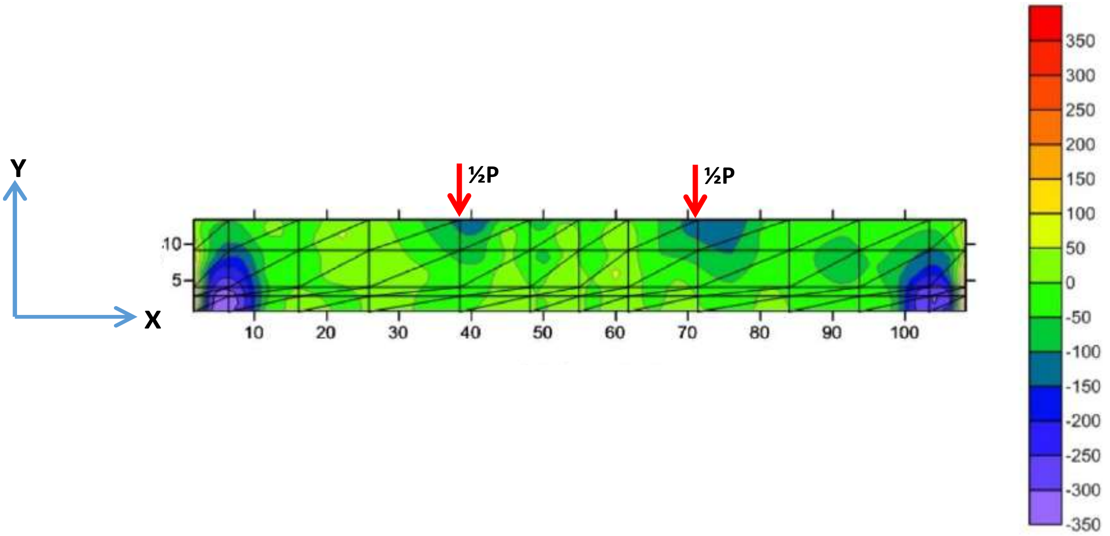


Fig. 6. The stress of Y-direction of BRC beam

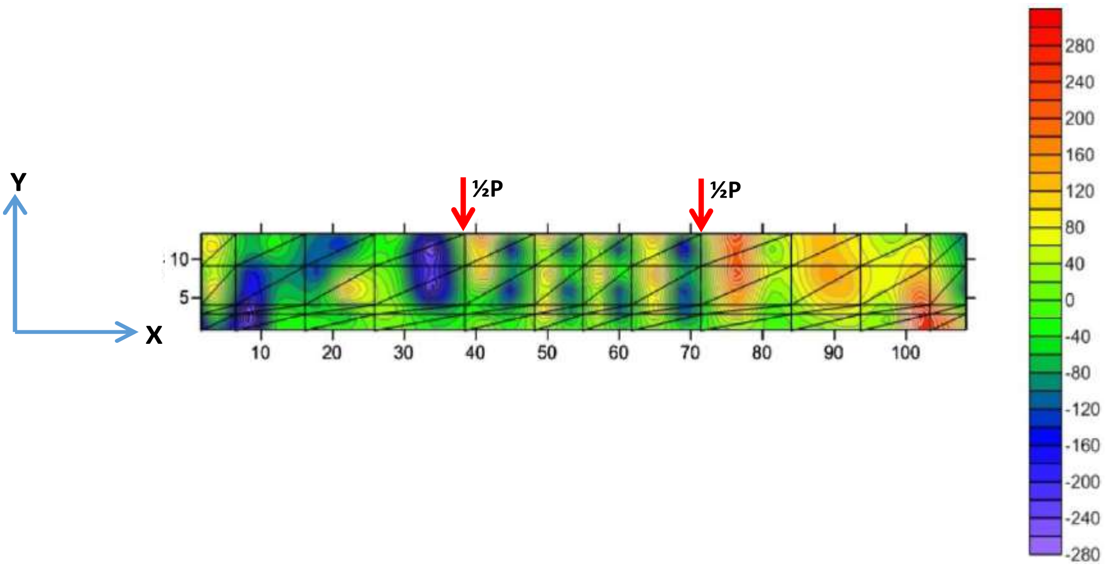


Fig. 7. The stress of XY-direction of BRC beam

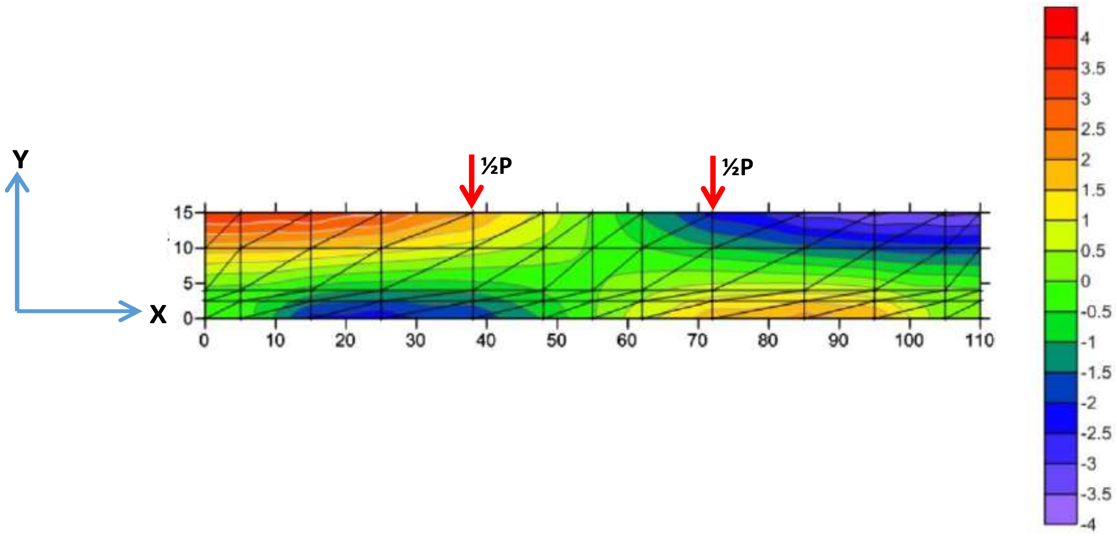


Fig. 8. The displacement of X-direction of BRC beam

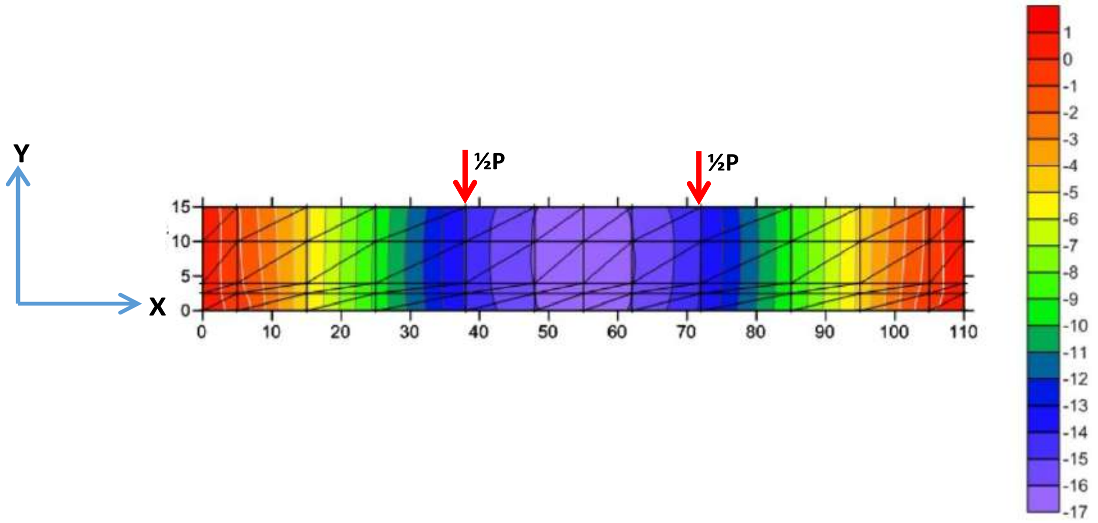


Fig. 9. The displacement of Y-direction of BRC beam

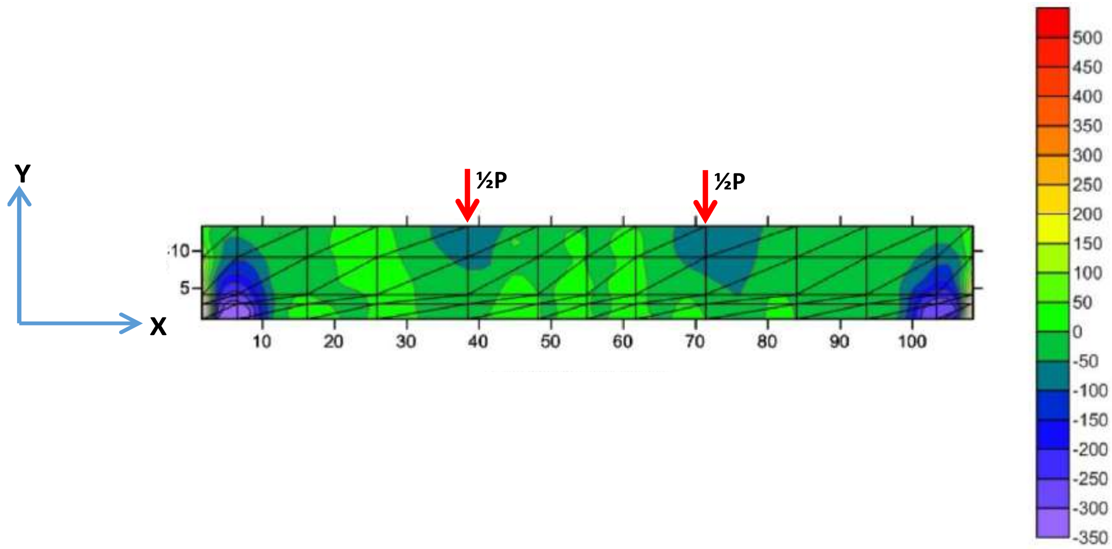


Fig. 10. The stress of Y-direction of SRC beam

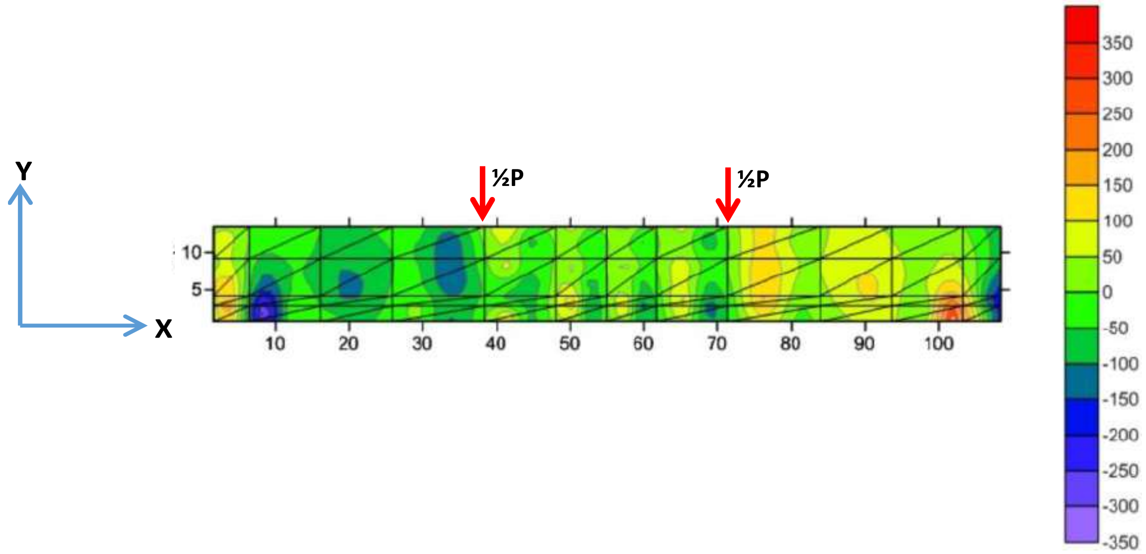


Fig. 11. The stress of XY-direction of SRC beam

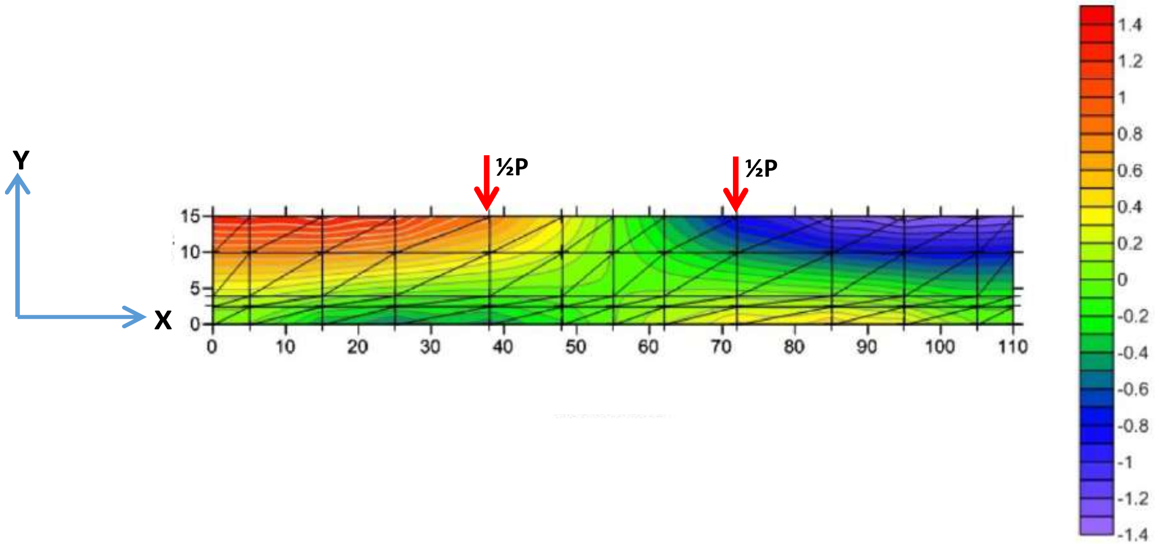


Fig. 12. The displacement of X-direction of SRC beam

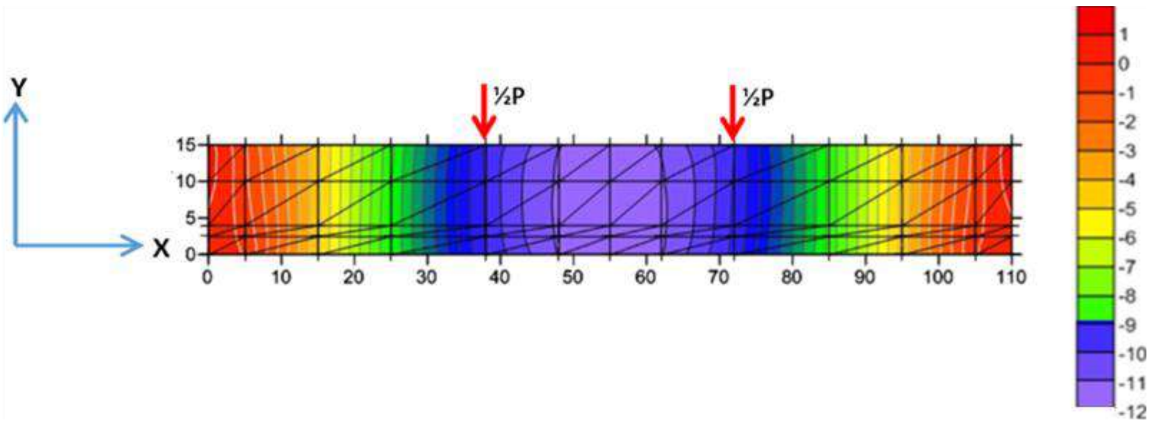


Fig. 13. The displacement of Y-direction of SRC beam

Experimental Design, Materials, and Methods

Numerical analysis was carried out with 2D and the experiments with 3D as shown in Fig. 15. Data from 2D numerical analysis obtained data of X-direction stress, Y-direction stress, XY-direction stress, X-direction deflection, and Y-direction deflection. While the data from the experiments only obtained data on crack patterns, loads, strain, and deflection. So that the validation of both focuses on X-direction stress or tensile stress that causes cracking and Y-direction deflection. The validation of the tensile stress zone and crack patterns zone is shown in Fig. 4 and Fig. 5 and the validation of deflection are shown in Table 3, Fig. 9, and Fig. 13. The validation of Y-direction stress, XY-direction stress, and X-direction deflection are not done because experimental data are not obtained.

Data validation between laboratory data and numerical analysis is carried out through a series of activities, namely beam flexural testing in the laboratory, numerical analysis with finite element method (FEM), program simulation with Fortran PowerStation 4.0, and simulation with the Surfer program. Activities in the laboratory are flexural tests of the BRC beam and the SRC beam to obtain data on crack patterns, collapse patterns, and ultimate loads. The test settings for the BRC beam and the SRC beam are shown in Fig. 15. The geometry and details of the reinforcement of BRC beams and SRC beams are shown in Fig. 14.

The material data of bamboo, steel, and concrete consists of Modulus of elasticity (E) and Poisson's ratio (v). The modulus of elasticity of bamboo (E_b) is 17,235.74 MPa with Poisson's ratio (v_b) of 0.25. The modulus of elasticity of concrete (E_c) is 26,299.01 MPa with Poisson's ratio (v_c) of 0.20. The modulus of elasticity of steel (E_s) is 207,735.92 MPa with Poisson's ratio (v_s) of 0.3.

The constitutive relationship analysis of the finite element method employs plane-stress theory. The triangle element is used to model the plane-stress element with two main displacement directions at each nodal point, so that the element has six degrees of freedom. The discretization of the beam plane using the triangular element is shown in Fig. 1 and Fig. 2. Modulus of elasticity (E) for each layer is calculated according to material conditions. Layers consisting of concrete and bamboo reinforcement are calculated using Eq. (1) [1], and for layers consisting of concrete and steel using Eq. (2) [3]. The solution to the plane-stress problem in the BRC beam and SRC beam is based on the stress-strain relationship as shown in Eq. (3) [1]. The main stresses on the BRC beam and SRC beam are calculated using Eq. (4) [1].

$$E_e = E_b.V_b + E_c.V_c \tag{1}$$

$$E_e = E_s.V_s + E_c.V_c \tag{2}$$

$$\begin{Bmatrix} \sigma_x \\ \sigma_y \\ \tau_{xy} \end{Bmatrix} = \frac{E}{(1+\nu^2)} \begin{bmatrix} 1 & \nu & 0 \\ \nu & 1 & 0 \\ 0 & 0 & \frac{1-\nu}{2} \end{bmatrix} \begin{Bmatrix} \varepsilon_x \\ \varepsilon_y \\ \gamma_{xy} \end{Bmatrix} \tag{3}$$

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}{}^2} = \sigma_{\max} \tag{4}$$

The steps for compiling the Fortran PowerStation 4.0 program data to get the beam tensile stress contour data are summarized as follows:

Step 1: Discretization of the plane of the BRC beam and the SRC beam with the discretization of the triangular element, as shown in Fig. 1 and Fig. 2.

Step 2: Numbering of the triangular elements and the nodal points, as shown in Fig. 1 and Fig. 2.

Step 3: Collection and calculation of the geometry data and the beam material data, such as modulus of elasticity of materials (*E*), Poisson ratio (*v*), etc.

Step 4: Writing the programming language for the Fortran PowerStation 4.0 program for the triangular element, as shown in the following link: http://bit.ly/2F17w8F.

Step 5: Opening the Fortran PowerStation 4.0 program. As an example, the front view in the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2MTh22j.

Step 6: Writing programming language data (Step 4) in the Fortran PowerStation 4.0 program. As an example, a display of programming language is shown in the following link: http://bit.ly/2ZvZWMU.

Step 7: The Input DATA.DAT of the BRC beam and SRC beam in the Fortran PowerStation 4.0 program. The input data is shown in the following links: http://bit.ly/351FPqU and http://bit.ly/2MBqas9. An example of the input data display is shown in the following link: http://bit.ly/2u2K2xR.

Step 8: Running and processing the program analysis until there are no warnings and errors. If there are warnings and errors, check and correct the program data and input data.

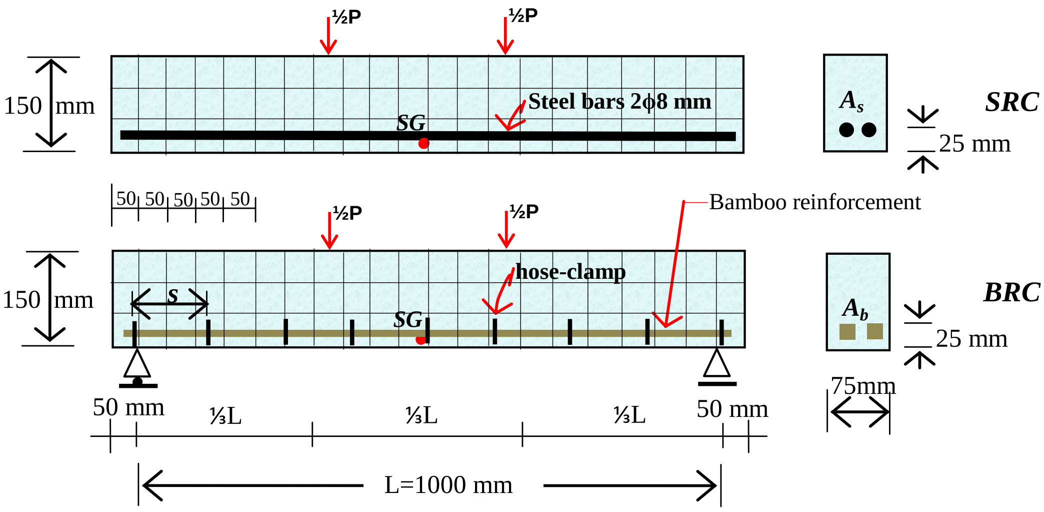
Step 9: Downloading stress data X-direction, Y-direction, and XY-direction. Stress data is shown in the following link: http://bit.ly/2rDPeaI for the BRC beam stress, and http://bit.ly/2Q4Ihc1 for the SRC beam stress. For example, the display of stress data from the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2ZybLCd.

Step 10: Downloading displacement data X-direction and Y-direction. The displacement data for the BRC beam and SRC beam is shown in Table 3. An example of the displacement data display from the Fortran PowerStation 4.0 program is shown in the following link: http://bit.ly/2Q7j2Wp.

Step 11: Inputting stress data and displacement data on the Surfer program, running the program, and obtaining stress contour images data and displacement. Image data of stress contours and displacement are shown in Figs. 4-13.

Step 12: Validation of drawing data for tensile stress contours (X-direction stress) with beam crack patterns from laboratory tests.

Step 13: Obtaining crack zone image data and tensile stress zone contour data. Image data of crack zones and contour zones of tensile stress are shown in Fig. 4 and Fig. 5.



Information:

SRC = Steel reinforced concrete
BRC = Bamboo reinforced concrete
SG = Strain gauge
s = Distance of hose-clamp
(Variation of s0 = 0 cm, s1 = 15 cm, s2 = 20 cm, and s3 = 25 cm)
A_s = Area of steel reinforced (As = 100,48 mm²)
A_b = Area of bamboo reinforced
(Variation of Ab = 140 mm², 200 mm², and 450 mm²)
(Variation of Ab = 140 mm², 200 mm², and 450 mm²)

Fig. 14. Detail and geometry of the bamboo reinforced concrete beam [1,4]

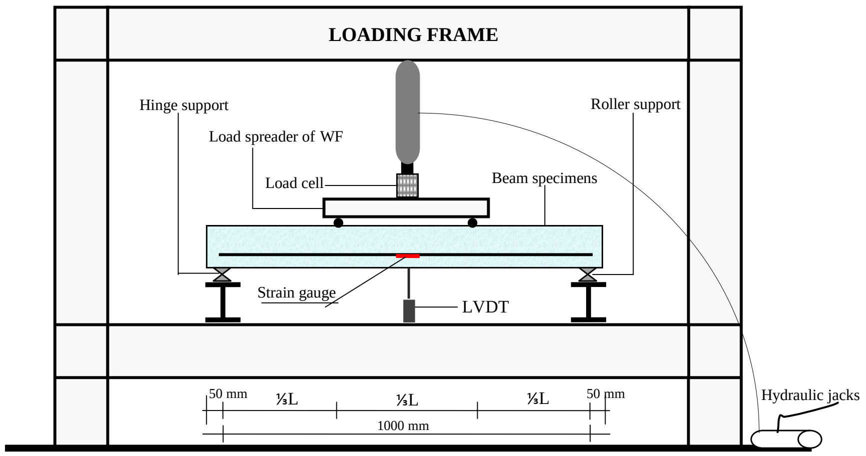


Fig. 15. Flexural test settings for the four-point flexural test method [1,4,5,6]

List of symbols

E	Modulus of elasticity
E_e	The equivalent elasticity modulus of BRC beam or SRC beam
E_b	Modulus of elasticity of bamboo reinforcement
E_c	Modulus of elasticity of concrete
E_s	Modulus of elasticity of steel reinforcement
V_b	The relative volume of bamboo reinforcement in the calculated layer
V_c	The relative volume of concrete in the calculated layer
V_s	The relative volume of steel reinforcement in the calculated layer

σ_x	Stress of X-direction
σ_y	Stress of Y-direction
$\sigma_{1,2}$	Main stress
τ_{xy}	Shear stress of XY-direction
v	Poisson's ratio
ε_x	Strain of X-direction
ε_y	Strain of Y-direction
Υ_{xy}	Shear strain of XY-direction

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Conflict of Interest

The authors declare that they know of no competition for financial interests or personal relationships that could appear to have influenced the work reported in this paper.

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