No	Tanggal	Keterangan
1	27 Agustus 2020	Penulis korespondensi mengirimkan **naskah publikasi** ke redaksi.
2	20 April 2020	Redaksi memberikan hasil review, penulis diminta memperbaiki.
		Penulis mengirimkan naskah yang sudah direvisi (Revisi ke-1).
3	14 Mei 2020	Redaksi memberikan hasil review yaitu **Diterima dengan Revisi**.
	15 Mei 2020	Penulis mengirimkan naskah yang sudah direvisi (Revisi ke-2).
	17 Mei 2020	Redaksi menerima naskah revisi ke-2.
		Naskah memasuki proses editing.
4		Naskah **terbit** pada **Volume 10 Nomor 1 Tahun 2019**.

Re: Volume enam nomor dua

Wahyu Dwianto <wahyudwianto@yahoo.com>
to me

Apr 22, 2020, 12:33 PM

Translate to English

Yth. Pak Yosafat,

Berikut ini english-checking & hasil pemeriksaan Reviewer naskahnya dengan dan tanpa track changes.

Salam,
Wahyu

On Monday, November 5, 2018, 08:46:17 PM GMT+7, wahyu dwianto <wahyudwianto@yahoo.com> wrote:

Yth. Pak M. Rusli & Pak Yosafat,

Berikut ini english-checking & hasil pemeriksaan Reviewer naskahnya dengan dan tanpa track changes. Mohon konfirmasinya apakah setuju dengan english-checking tersebut & memperbaiki/menambahkan saran2 Reviewer.

Kami tunggu segera, terimakasih.

Salam,
Wahyu

Wahyu Dwianto <wahyudwianto@yahoo.com>
to me

May 14, 2020, 7:46 PM

Translate to English

Yth. Pak Yosafat,

Kami mulai menangani WRJ Vol. 10 No. 1 dimana naskah Bapak rencananya akan dipublikasikan di edisi ini. Apabila setuju dengan koreksian & telah merevisi naskah tersebut sesuai dengan pemeriksaan Reviewer, dimohon untuk segera mengirimkannya via e-mail ini. Terimakasih sebelumnya.

Salam,
Wahyu

...

---

yosafat ap <yosafat.ap@gmail.com>
to Wahyu

May 15, 2020, 6:18 PM

Kepada Bapak Wahyu Dwianto yth.
di tempat

Dengan hormat,
Saya sampaikan Revisi Naskah saya. Terima kasih atas perhatian dan kesempatan yang diberikan kepada saya pada WRJ Journal.

Hormat saya,
Yosafat Aji Pranata

...

One attachment • Scanned by Gmail

3. Yosafat Aji Pra...

wahyu dwianto <wahyudwianto@yahoo.com>
to me

May 17, 2020, 4:13 AM

Translate to English

Yth. Pak Yosafat,

Terimakasih banyak atas revisi naskahnya.

Salam,
Wahyu

Sent from my iPhone

> On 15 May 2020, at 18.18, yosafat ap <yosafat.ap@gmail.com> wrote:
>
> •••
>
> <3. Yosafat Aji Pranata - Revision_May15-2020.doc>

Reply Forward

Behavior of Beam-Column Timber Joint Connection (Partial Tests) Using Nail and Modified-Washer Reinforcements

> **Commented [nobody1]:** Recommended title:
>
> Beam-Column Timber Joint Connection Behavior Due to Nail and Modified-Washer Reinforcement Tests

Yosafat Aji Pranata, Anang Kristianto and Olga Catherina Pattipawaej

Abstract

Timber connection capacity, in case of beam-column joint connection provides ~~, give a~~ significant impact on the ~~behavior of~~ wooden building structures. ~~Capacity in question in this case is the s~~Strength and stiffness ~~of the connection~~of timber connections using reinforcement technique of wooden building structures have not been studied intensively. ~~One strategy to retrofitting timber connections which aims to increase the capacity of both the strength and stiffness of the connection, which is using the reinforcement technique.~~ This paper ~~In this research~~ studie~~d~~s the use of nails and modified-washer to improve ~~performance~~ wood connection's performance. The ~~Studies using~~ experimental tests were conducted in the laboratory~~,~~ by comparing the partial connection between ~~the~~ test specimen timber without reinforcement (standard type) and the reinforcement ~~type~~ (~~named~~ PRP type). The ~~scope of research in this paper is the~~ testing was conducted based on ~~method used is a~~ partial connection beam-column joint test using Universal Testing Machine's with a modified holder. ~~Type of w~~Wood studied includes ~~used in this study is M~~meranti ~~wood~~ (*Shorea* spp.) and ~~M~~mersawa ~~wood~~ (*Anisoptera* spp.). PRP type connection was ~~s~~ using ~~e~~ nails and modified-washer strengthening, and ~~while S~~standard type connection was using a classic washer. Parameters studied were ~~the~~ strength and stiffness of the connection, reviewed both: ~~of the~~ proportional limit load and ultimate limit load conditions. ~~The r~~Results show~~ed~~ that in general the connection type of PRP produce higher strength capacities ~~ranging from (~~8.58 ~~to~~ 8.94%) than ~~compared to the~~ standard connection of ~~type for M~~meranti wood species. ~~, while for~~ Mersawa timber species difference range~~d~~s from 30.77 to 34.59%. The stiffness capacity of ~~the M~~meranti and mersawa, PRP type is higher ~~ranged from 0.45 to 2.48%~~ than ~~compared to the~~ standard type. The stiffness capacity of meranti ranges from 0.45 to 2.48% and mersawa was ~~, while for the Mersawa PRP type is higher ranged from~~ 21.27 to 56.66%. ~~compared to the standard type.~~ This result indicates ~~that~~ the use of nails and modified-washer provides ~~make a~~ positive contribution in ~~to~~ improving ~~the performance of~~ the beam-column joint connections performance.

> **Formatted:** Font: Italic

Keywords: Partial test, ~~B~~beam-~~C~~column ~~J~~joint, ~~T~~timber, ~~N~~nail and ~~M~~modified-~~W~~washer, ~~B~~behavior~~.~~

Introduction

Connection ~~P~~performance of ~~connection on a~~ wooden house building structure plays an important role with regard to the overall performance of the building structure. Ductile connection systems are expected to contribute in ~~positively to~~ the behavior of the strength and stiffness of the building structure positively.

Figure 1 and Figure 2 show~~s~~ the beam-column joint connection in a traditional house of Minahasa, North Sulawesi, Indonesia. The observed connection ~~in question~~ is ~~o~~in the exterior ~~of the~~ residence (Figure 1) and in the interior ~~of the~~ residence (Figure 2). The wood joints were connected ~~Connecting t~~using ~~cols used are~~ nails.

Figure 1. Beam-column joint connection of Minahasa ~~T~~traditional ~~H~~house: Exterior joint~~.~~

Figure 2. Beam-column joint connection of Minahasa ~~T~~traditional ~~H~~house: Interior joint~~.~~

In order ~~T~~to review ~~the performance of~~ the connection system performance, it is necessary to limit the burden of disproportionate amount of information that could~~an~~ be retained by ~~the~~ connection. It ~~This~~ is helpful in ~~the~~ designing the ~~of~~ timber connection to ~~is for the~~ calculate~~ion of~~ lateral resistance (Z) in accordance to ~~with~~ Indonesian National Standard (SNI 7973: 2013) (Badan Standardisasi Nasional~~,~~ 2013).

Information on the load-slip curve relationship of timber connection~~s~~, moment-curvature curve timber connections~~,~~ and ~~s well as the~~ idealization model approachs~~,~~ are also an important empirical data in relation to the numerical modeling of the wood building structure. The accuracy of numerical modeling relies heavily on modeling parameters or ~~/~~ idealization of the connection structure elements. T~~, besides of course t~~he mechanical properties of the material ~~property~~ parameters and of the cross section dimensions size of structural elements.

This study ~~Research in this paper~~ is a continuation of previous research development reported by ~~(~~Pranata *et al.*~~,~~ (2014) who mentioned that there is related research capacity of the axial tensile connections of standard type ~~connection~~ and ~~the connection~~ of ~~with~~ the nail and modified-washer reinforcements, as well as ~~related~~ research capacity of the beam-column joint connection (Pranata *et al.*~~,~~ 2015). The study ~~-~~of standard type connection and ~~the connection with the~~ strengthened connections ~~ing~~ using the reference of ASTM test methods (ASTM~~,~~ 2000).

The ~~Concept~~ testing specimen concept ~~s~~ used in this study differs from previous studies particularly in ~~(Pranata et al., 2015) that in this study using~~ a model specimen partial connection (Pranata *et al.*, 2015).

In this ~~research~~ study, ~~ied~~ the ~~use of~~ nails and modified-washer was used to improve performance of ~~the~~ timber connections. ~~Studies using e~~Experimental tests i the lab were conducted ~~in the laboratory,~~ by comparing ~~the~~ partial connection between ~~the~~ test specimens timber without reinforcement (standard type) and the reinforced specimens ~~ment~~ (~~named~~ PRP type).

~~The scope of research is the testing method used is a p~~Partial beam-column joint connection test was conducted to test ~~using Universal Testing Machine's with a modified holder. Type of timber used is M~~meranti ~~wood~~ (*Shorea* spp.) and ~~M~~mersawa ~~wood~~ (*Anisoptera* spp.) wood using Universal Testing Machine (UTM). PRP types were counducted ~~—~~ using~~e~~ nails and modified-washer strengthener~~ing~~. Parameters studied were the strength and stiffness ~~of the~~ connection and ~~, reviewed the~~ proportional limit of loading as well as ~~and~~ ultimate limit loading conditions. The testing method used is the monotonic loading pattern.

Methods

The ~~method used in this~~ study ~~i~~was divided into 4 ~~(~~four~~)~~ main stages. The first stage wa~~i~~s the study of literature. The second stage is to study secondary data and preparation of test specimens. The third stage is the experimental testing in the laboratory. The fourth stage is processing the data to get the results of the discussion and conclusions.

Basic Theory

Due to the limited length of timber that is in-trade, then for a long timber construction timber is needed for the connection of two wooden trunks or more mutually connected to one another so that a single piece of wood long. Understanding the relationship is two sticks of wood or more interconnected with each other at a certain point that it becomes a part of the construction. Please note the terms of wooden ties, among others: as simple as possible but sturdy, attractive avoid deep wood, placement of connection, will withstand the forces acting on it. Mechanical connection can be used, among others tools connecting bolts or nails.

Kobel (~~Kobel,~~ 2011) studied the effect of strengthening, especially for connections that resist lateral loads (hereinafter referred pull axial connection) for a long-span truss. There are four types of reinforcement are studied, namely the retrofitting of type A2 + B2, strengthening 02 + A2, inclined reinforcement and Dywidag strengthening. Retrofitting is done by adding a dowel in the direction intersecting with the mechanical connection.

Noguchi *et al.* (~~Noguchi et al.,~~ 2006) also studied the timber connection (beam-column connections), as well as developing new connection models to bolster the performance of the strength of the beam-column connections.

The thickness of the ring having an impact as well as the influence of pretension effect of the bolts. Pretension effect thus will not increase the capacity of joint significantly, however, a positive effect is to improving connection's ductility. Another effect is by the initials pretension then bolt becomes more difficult to bend or fail flexibly, so that it is suitable to be applied to high quality of wood with high bearing strength. Pretension with a note that the amount does not exceed the compressive strength perpendicular to

Formatted: Justified, Indent: Left: 0 cm, Hanging: 1.27 cm

Formatted: English (United States)

Commented [nobody2]: It represents the stage of research. The method must straight to the point of method/testing to achieve the research objectives

Commented [nobody3]: It should not be here. Basic theory is part of introduction and it must support the research question arguments

the wood fibers (Awaludin *et al.*~~,~~ 2008; Awaludin *et* ~~,~~*al*.~~,~~ 2008b).

Results and Discussion

Figure 3 shows a schematic model of ~~the~~ partial connection test object ~~for to be tested in the~~ laboratory test. ~~Furthermore,~~ Figure 4 shows the partial connection ~~for the~~ standard type of ~~the~~ timber connection. ~~While~~ Figure 5 shows the partial connection for the connection with the reinforcement (named PRP type).

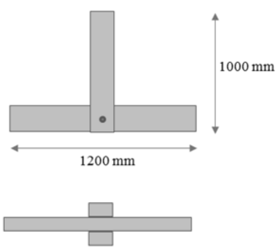

Figure 3. Schematic model of the specimen~~.~~

Figure 4. ~~-~~Example for the standard type of the timber connection~~.~~

Figure 5. ~~-~~Example for the PRP type of the timber connection~~.~~

Specimens that used in this research are tested using a Universal Testing Machine (UTM). UTM used to apply a monotonic loads from zero load to the specimen failure. For this purpose it would require additional equipment in the form of a holder for placement of the test object. Setups of the test specimen are shown in Figure 6.

Figure 6. UTM and setup of the specimen~~.~~

Testing is done by applying a load, from zero loading to the test specimen failure and could not withstand the load again. Figure 7 shows the process of testing the specimen.

Figure 7. Testing process of the Meranti timber connection.

While Figure 8.a and Figure 8.b shows an example of the failure of the test specimen during an ultimate load is reached.

(a). Meranti timber connection.

Formatted: Font: Italic

Formatted: English (United States)

Formatted: English (United States)

Formatted: English (United States)

Formatted: Justified

Formatted: English (United States)

Formatted: Justified, Indent: Left: 0 cm, Hanging: 1.27 cm

Formatted: English (United States)

Commented [nobody4]: It is method

Formatted: English (United States)

(b). Mersawa timber connection.

Figure 8. Failure mode of the specimens.

More test results shown in Figure 9, Figure 10, Figure 11, and Table 1 for the Meranti wood connections. While Figure 12, Figure 13, Figure 14, and Table 2 shows the results of the Mersawa wood connections.

Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, and Figure 14 generally shows test results of the load vs. deformation curve for both ~~M~~meranti and m~~M~~ersawa specimens, which indicates that the overall capacity of the standard type lower than the PRP type.

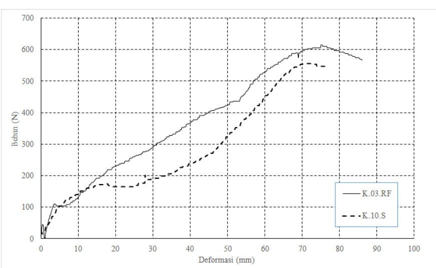

Figure 9. Meranti wood connections test results: Comparison of Load-Deformation Relations curve for the standard type and the PRP type connections.

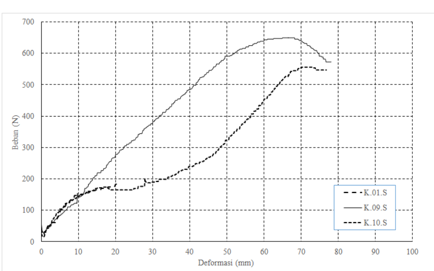

Figure 10. Meranti wood connections test results: The load-deformation curve relationships for Standard-type connection.

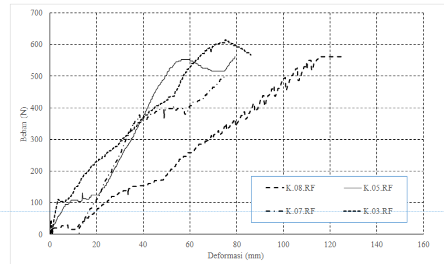

Figure 11. Meranti wood connections test results: The load-deformation curve relationships for PRP-type connection.

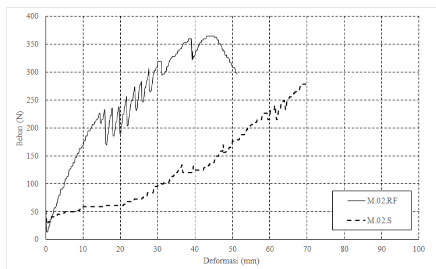

Figure 12. Mersawa wood connections test results: Comparison of Load-Deformation Relations curve for the standard type and the PRP type connections, Specimen M.02.

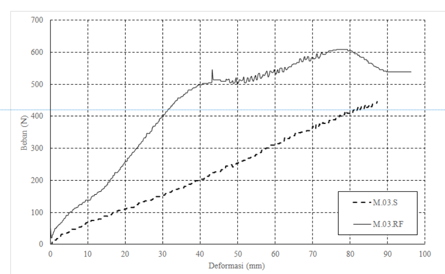

Figure 13. Mersawa wood connections test results: Comparison of Load-Deformation Relations curve for the standard type and the PRP type connections, Specimen M.03.

Formatted: Justified, Indent: Left: 1.27 cm, First line: 0.08 cm
Formatted: English (United States)
Formatted: English (United States)
Formatted: Justified
Formatted: Justified, Indent: First line: 1.27 cm
Formatted: English (United States)
Commented [nobody5]: Present general finding and then detail of finding but avoid repeatition of graph or table.
Formatted: Justified
Formatted: Justified, Indent: Left: 1.27 cm, First line: 0.08 cm
Formatted: English (United States)
Formatted: Justified, Indent: Left: 0 cm, Hanging: 1.27 cm
Formatted: English (United States)
Formatted: Justified
Formatted: Justified, Indent: First line: 1.27 cm
Formatted: English (United States)
Formatted: Justified

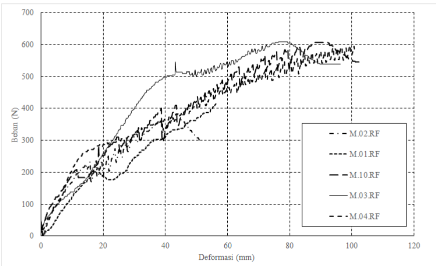

Figure 14. Mersawa wood connections test results: The load-deformation curve relationships for PRP-type connection

Table 2 and Tab 3 shows the results of the idealization of the load vs. deformation curve, i.e with reviewing the conditions of the proportional limit and ultimate limit. Method that used to determine both the proportional (P_y) and ultimate (P_u) limit loads using literature review of Munoz *et al*. research (Munoz *et al*., 2010).

Table 2. Summary of experimental results: meranti specimens

Specimen	P_y (N)	D_y (mm)	P_u (N)	D_u (mm)
K.01.S	590.64	50.00	649.48	67.40
K.10.S	526.49	66.40	555.86	72.60
K.03.RF	571.68	66.10	605.57	74.40
K.05.RF	511.61	50.20	547.83	55.90
K.07.RF	413.51	47.40	494.85	73.50
K.08.RF	491.24	100.10	561.41	123.20

Note: S = standard type, RF = PRP type.

Table 3. Summary of experimental results: mersawa specimens

Specimen	P_y (N)	D_y (mm)	P_u (N)	D_u (mm)
M.02.S	178.78	51.10	278.35	68.90
M.03.S	350.76	67.50	441.28	86.70
M.01.RF	330.40	41.90	409.60	55.90
M.02.RF	224.04	15.50	364.35	43.10
M.03.RF	468.44	35.90	604.22	79.40
M.04.RF	404.47	20.00	587.50	97.90
M.10.RF	389.23	25.00	588.38	85.80

Note: S = standard type, RF = PRP type.

Conclusions

The results showed that in general the connection type of PRP produce higher strength capacities ranging from 8.58 to 8.94% compared to the standard connection type for Meranti wood species, while for Mersawa timber species difference ranged from 30.77 to 34.59%.

The stiffness capacity of the Meranti PRP type is higher ranged from 0.45 to 2.48% compared to the standard type, while for the Mersawa PRP type is higher ranged from 21.27 to 56.66% compared to the standard type.

This result indicates that the use of nails and modified-washer make a positive contribution to improving the performance of the beam-column joint connections.

Mersawa wood is more brittle than meranti wood, it has an impact on the results. PRP-type of mersawa timber connection produces a higher strength than the standard type. While the PRP-type of meranti timber connection produces a similar strength to the standard type

Acknowledgements

The authors gratefully acknowledge the financial support of "Hibah Bersaing" DIKTI, DIPA 023.04.1.673453/2015, date 14 November 2014 revision 01 date 3 March 2015. The authors also gratefully acknowledged laboratory support of Mr. Jumali of Department of Civil Engineering, Maranatha Christian University.

References

American Society for Testing and Materials. 2000. Standard Test Methods for Bolted Connections in Wood and Wood Base Products, Designation D 5652-95(2000), ASTM, West Conshohocken, PA.

Awaludin, A., Hirai, T., Hayashikawa, T., Sasaki, Y., Oikawa, A. 2008a. Effects of pretension in bolts on hysteretic responses of moment-carrying timber joints. Journal of Wood Science 54: 114-120, The Japan Wood Research Society.

Awaludin, A., Hirai, T., Hayashikawa, T., Sasaki, Y. 2008b. Load-carrying capacity of steel-to-timber joints with a pretensioned bolt", Journal of Wood Science 54: 362-368, The Japan Wood Research Society.

Badan Standardisasi Nasional. 2013. Spesifikasi Desain untuk Kontruksi Kayu SNI 7973:2013. Badan Standardisasi Nasional (in Indonesian).

Kobel, P. 2011. "Modelling of Strenghthened Connections for Large Span Truss Structures. Department of Structural Engineering, Lund Institute of Technology, Box 118, S-221 00 LUND, Sweden.

Munoz, W., Mohammad, M., Salenikovich, A., Quenneville, P. 2010. Determination of Yield Point and Ductility of Timber Assemblies: In Search for a Harmonized Approach. Engineered Wood Products Association.

Commented [nobody9]: This results have not been discussed in 'Result and Discussion'

Commented [nobody10]: Please see previous comment

Formatted: Justified

Formatted: Justified, Indent: Left: 1.36 cm

Commented [nobody6]: Please add more discussion on Figure 9 – 14. Is the pattern is normal? And support your argument by referencing

Formatted: English (United States)

Commented [nobody11]: Please see comment 9

Formatted: English (United States)

Commented [nobody7]: ??

Formatted: Justified, Indent: Left: 0 cm, Hanging: 1.27 cm

Formatted: Justified, Indent: Left: 0 cm, Hanging: 1.43 cm

Commented [nobody8]: Add more discussion on findings

Formatted: English (United States)

Noguchi, M., Takino, S., Komatsu, K. (2006). "Development of wooden portal frame structures with improved columns.", Journal of Wood Science , Volume 52: pp 51-57, The Japan Wood Research Society.

Pranata, Y.A., Kristianto, A., Pattipawaej, O. (2014). "Pengembangan Sambungan Kayu Batang Tarik dengan Ring-Modifikasi dan Perkuatan-Paku.", Seminar Rumah Tradisional 2014 – Transformasi Nilai-nilai Tradisional dalam Arsitektur Masa Kini, Puskim, Balitbang, Kementerian Pekerjaan Umum, Lombok, 19-20 November 2014 (in Indonesian).

Pranata, Y.A., Kristianto, A., Pattipawaej, O. (2015). "Pengembangan Sambungan Hubungan Join Balok-Kolom Kayu dengan Ring-Modifikasi dan Perkuatan-Paku".., Jurnal Teknik Sipil: , Volume 22 No.(1): page?, April 2015, ISSN 0853-2982, Accredited by DIKTI No. 56/DIKTI/Kep/2012 (in Indonesian).

Yosafat Aji Pranata, Anang Kristianto, and Olga Pattipawaej
Department of Civil Engineering, Engineering Faculty,
Maranatha Christian University,
Jl. Suria Sumantri 65, Bandung 40164, West Java,
Indonesia
Tel : +62-816623703
E-mail : yosafat.ap@gmail.com

Behavior of Beam-Column Timber Joint Connection (Partial Tests) Using Nail and Modified-Washer Reinforcements

Commented [nobody1]: Recommended title:

Beam-Column Timber Joint Connection Behavior Due to Nail and Modified-Washer Reinforcement Tests

Yosafat Aji Pranata, Anang Kristianto and Olga Catherina Pattipawaej

Abstract

Timber connection capacity, in case of beam-column joint connection provides significant impact on the wooden building structures. Strength and stiffness of timber connections using reinforcement technique of wooden building structures have not been studied intensively. This paper studies the use of nails and modified-washer to improve wood connection's performance. The experimental tests were conducted in the laboratory by comparing the partial connection between test specimen timber without reinforcement (standard type) and the reinforcement (PRP type). The testing was conducted based on partial connection beam-column joint test using Universal Testing Machine's with a modified holder. Wood studied includes meranti (*Shorea* spp.) and mersawa (*Anisoptera* spp.). PRP type connection was using nails and modified-washer strengthening, and standard type connection was using a classic washer. Parameters studied were strength and stiffness of the connection, reviewed both: proportional limit load and ultimate limit load conditions. Results show that in general the connection type of PRP produce higher strength capacities (8.58 - 8.94%) than standard connection of meranti wood species. Mersawa timber species difference ranges from 30.77 to 34.59%. The stiffness capacity of meranti and mersawa, PRP type is higher than standard type. The stiffness capacity of meranti ranges from 0.45 to 2.48% and mersawa was 21.27 to 56.66%. This result indicates the use of nails and modified-washer provides positive contribution in improving the beam-column joint connections performance.

Keywords: Partial test, beam-column joint, timber, nail and modified-washer, behavior

Introduction

Connection performance of wooden house building structure plays an important role with regard to the overall performance of the building structure. Ductile connection systems are expected to contribute in the behavior of the strength and stiffness of the building structure positively. Figure 1 and Figure 2 show the beam-column joint connection in a traditional house of Minahasa, North Sulawesi, Indonesia. The observed connection is in the exterior residence (Figure 1) and in the interior residence (Figure 2). The wood joints were connected using nails.

Figure 1. Beam-column joint connection of Minahasa traditional house: Exterior joint

Figure 2. Beam-column joint connection of Minahasa traditional house: Interior joint

In order to review the connection system performance, it is necessary to limit the burden of disproportionate amount of information that could be retained by connection. It is helpful in designing the timber connection to calculate lateral resistance (Z) in accordance to Indonesian National Standard (SNI 7973: 2013) (Badan Standardisasi Nasional 2013).

Information on the load-slip curve relationship of timber connection, moment-curvature curve timber connection and ideal model approachs are also an important empirical data in relation to the numerical modeling of the wood building structure. The accuracy of numerical modeling relies heavily on modeling parameters or idealization of the connection structure elements. The mechanical properties of the material parameters and of the cross section dimensions size of structural elements.

This study is a continuation of previous research development reported by Pranata *et al.* (2014) who mentioned that there is related research capacity of the axial tensile connections of standard type and of the nail and modified-washer reinforcements, as well as research capacity of the beam-column joint connection (Pranata *et al.* 2015). The study of standard type connection and strengthened connections using the reference of ASTM test methods (ASTM 2000).

The testing specimen concept used in this study differs from previous studies particularly in a model specimen partial connection (Pranata *et al*., 2015). In this study, the nails and modified-washer was used to improve performance of timber connections. Experimental tests i the lab were conducted by comparing partial connection between test specimens timber without reinforcement (standard type) and the reinforced specimens (PRP type). Partial beam-column joint connection test was conducted to test meranti (*Shorea* spp.) and mersawa (*Anisoptera* spp.) wood using Universal Testing Machine (UTM). PRP types were counducted using nails and modified-washer strengthener. Parameters studied were the strength and stiffness connection and proportional limit of loading as well as ultimate limit loading conditions. The testing method used is the monotonic loading pattern.

Methods

The study was divided into four main stages. The first stage was the study of literature. The second stage is to study secondary data and preparation of test specimens. The third stage is the experimental testing in the laboratory. The fourth stage is processing the data to get the results of the discussion and conclusions.

Basic Theory

Due to the limited length of timber that is in-trade, then for a long timber construction timber is needed for the connection of two wooden trunks or more mutually connected to one another so that a single piece of wood long. Understanding the relationship is two sticks of wood or more interconnected with each other at a certain point that it becomes a part of the construction. Please note the terms of wooden ties, among others: as simple as possible but sturdy, attractive avoid deep wood, placement of connection, will withstand the forces acting on it. Mechanical connection can be used, among others tools connecting bolts or nails.

Kobel (2011) studied the effect of strengthening, especially for connections that resist lateral loads (hereinafter referred pull axial connection) for a long-span truss. There are four types of reinforcement are studied, namely the retrofitting of type A2 + B2, strengthening 02 + A2, inclined reinforcement and Dywidag strengthening. Retrofitting is done by adding a dowel in the direction intersecting with the mechanical connection.

Noguchi *et al.* (2006) also studied the timber connection (beam-column connections), as well as developing new connection models to bolster the performance of the strength of the beam-column connections.

The thickness of the ring having an impact as well as the influence of pretension effect of the bolts. Pretension effect thus will not increase the capacity of joint significantly, however, a positive effect is to improving connection's ductility. Another effect is by the initials pretension then bolt becomes more difficult to bend or fail flexibly, so that it is suitable to be applied to high quality of wood with high bearing strength. Pretension with a note that the amount does not exceed the compressive strength perpendicular to the wood fibers (Awaludin *et al.* 2008; Awaludin *et al.* 2008b).

Result and Discussion

Figure 3 shows a schematic model of partial connection test object for laboratory test. Figure 4 shows the partial connection standard type of timber connection. Figure 5 shows the partial connection for the connection with the reinforcement (named PRP type).

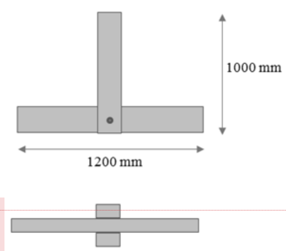

Figure 3. Schematic model of the specimen

Figure 4. Example for the standard type of the timber connection

Commented [nobody2]: It represents the stage of research. The method must straight to the point of method/testing to achieve the research objectives

Commented [nobody3]: It should not be here. Basic theory is part of introduction and it must support the research question arguments

Figure 5. Example for the PRP type of the timber connection

Specimens that used in this research are tested using a Universal Testing Machine (UTM). UTM used to apply a monotonic loads from zero load to the specimen failure. For this purpose it would require additional equipment in the form of a holder for placement of the test object. Setups of the test specimen are shown in Figure 6.

Figure 6. UTM and setup of the specimen

Testing is done by applying a load, from zero loading to the test specimen failure and could not withstand the load again. Figure 7 shows the process of testing the specimen.

Figure 7. Testing process of the Meranti timber connection

While Figure 8.a and Figure 8.b shows an example of the failure of the test specimen during an ultimate load is reached.

(a). Meranti timber connection.

Commented [nobody4]: It is method

(b). Mersawa timber connection

Figure 8. Failure mode of the specimens

More test results shown in Figure 9, Figure 10, Figure 11, and Table 1 for the Meranti wood connections. While Figure 12, Figure 13, Figure 14, and Table 2 shows the results of the Mersawa wood connections.

Commented [nobody5]: Present general finding and then detail of finding but avoid repeatition of graph or table.

Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, and Figure 14 generally shows test results of the load vs. deformation curve for both meranti and mersawa specimens, which indicates that the overall capacity of the standard type lower than the PRP type.

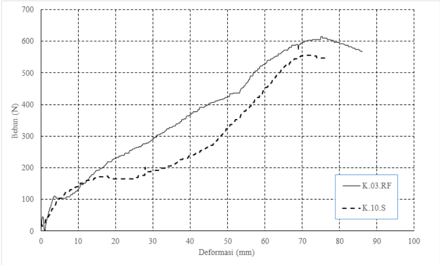

Figure 9. Meranti wood connections test results: Comparison of Load-Deformation Relations curve for the standard type and the PRP type connections

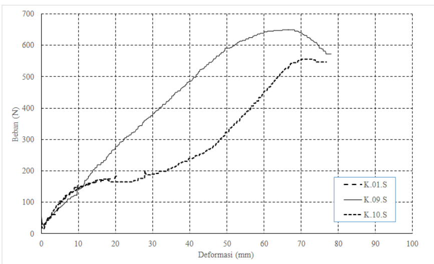

Figure 10. Meranti wood connections test results: The load-deformation curve relationships for Standard-type connection

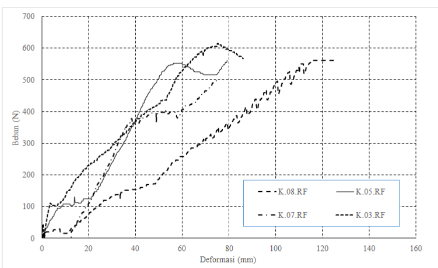

Figure 11. Meranti wood connections test results: The load-deformation curve relationships for PRP-type connection

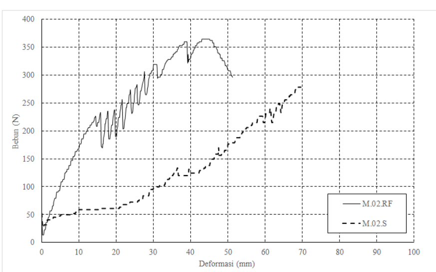

Figure 12. Mersawa wood connections test results: Comparison of Load-Deformation Relations curve for the standard type and the PRP type connections, Specimen M.02

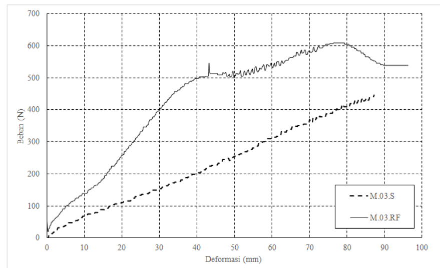

Figure 13. Mersawa wood connections test results: Comparison of Load-Deformation Relations curve for the standard type and the PRP type connections, Specimen M.03

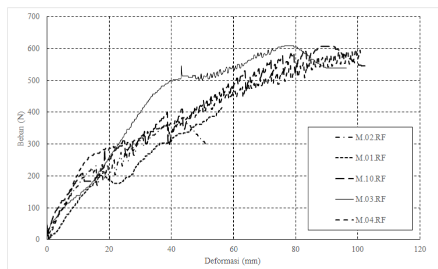

Figure 14. Mersawa wood connections test results: The load-deformation curve relationships for PRP-type connection

Table 2 and Tab 3 shows the results of the idealization of the load vs. deformation curve, i.e with reviewing the conditions of the proportional limit and ultimate limit. Method that used to determine both the proportional (P_y) and ultimate (P_u) limit loads using literature review of Munoz *et al*. research (Munoz *et al*., 2010).

Table 2. Summary of experimental results: meranti specimens

Specimen	P_y (N)	D_y (mm)	P_u (N)	D_u (mm)
K.01.S	590.64	50.00	649.48	67.40
K.10.S	526.49	66.40	555.86	72.60
K.03.RF	571.68	66.10	605.57	74.40
K.05.RF	511.61	50.20	547.83	55.90
K.07.RF	413.51	47.40	494.85	73.50
K.08.RF	491.24	100.10	561.41	123.20

Note: S = standard type, RF = PRP type.

Commented [nobody6]: Please add more discussion on Figure 9 – 14. Is the pattern is normal? And support your argument by referencing

Commented [nobody7]: ??

Table 3. Summary of experimental results: mersawa specimens

Specimen	P_y (N)	D_y (mm)	P_u (N)	D_u (mm)
M.02.S	178.78	51.10	278.35	68.90
M.03.S	350.76	67.50	441.28	86.70
M.01.RF	330.40	41.90	409.60	55.90
M.02.RF	224.04	15.50	364.35	43.10
M.03.RF	468.44	35.90	604.22	79.40
M.04.RF	404.47	20.00	587.50	97.90
M.10.RF	389.23	25.00	588.38	85.80

Note: S = standard type, RF = PRP type.

Conclusion

The esults showed that in general the connection type of PRP produce higher strength capacities ranging from 8.58 to 8.94% compared to the standard connection type for Meranti wood species, while for Mersawa timber species difference ranged from 30.77 to 34.59%.

The stiffness capacity of the Meranti PRP type is higher ranged from 0.45 to 2.48% compared to the standard type, while for the Mersawa PRP type is higher ranged from 21.27 to 56.66% compared to the standard type.

This result indicates that the use of nails and modified-washer make a positive contribution to improving the performance of the beam-column joint connections.

Mersawa wood is more brittle than meranti wood, it has an impact on the results. PRP-type of mersawa timber connection produces a higher strength than the standard type. While the PRP-type of meranti timber connection produces a similar strength to the standard type

Acknowledgement

The authors gratefully acknowledge the financial support of “Hibah Bersaing” DIKTI, DIPA 023.04.1.673453/2015, date 14 November 2014 revision 01 date 3 March 2015. The authors also gratefully acknowledged for laboratory support of Mr. Jumali of Department of Civil Engineering, Maranatha Christian University.

References

American Society for Testing and Materials. 2000. Standard Test Methods for Bolted Connections in Wood and Wood Base Products, Designation D 5652-95(2000), ASTM, West Conshohocken, PA.

Awaludin, A., Hirai, T., Hayashikawa, T., Sasaki, Y., Oikawa, A. 2008a. Effects of pretension in bolts on hysteretic responses of moment-carrying timber joints. Journal of Wood Science 54: 114-120, The Japan Wood Research Society.

Awaludin, A., Hirai, T., Hayashikawa, T., Sasaki, Y. 2008b. Load-carrying capacity of steel-to-timber joints with a pretensioned bolt, Journal of Wood Science 54: 362-368, The Japan Wood Research Society.

Badan Standardisasi Nasional. 2013. Spesifikasi Desain untuk Kontruksi Kayu SNI 7973:2013. Badan Standardisasi Nasional (in Indonesian).

Kobel, P. 2011. Modelling of Strenghthened Connections for Large Span Truss Structures. Department of Structural Engineering, Lund Institute of Technology, Box 118, S-221 00 LUND, Sweden.

Munoz, W., Mohammad, M., Salenikovich, A., Quenneville, P. 2010. Determination of Yield Point and Ductility of Timber Assemblies: In Search for a Harmonized Approach. Engineered Wood Products Association.

Noguchi, M., Takino, S., Komatsu, K. 2006. Development of wooden portal frame structures with improved columns. Journal of Wood Science 52: 51-57, The Japan Wood Research Society.

Pranata, Y.A., Kristianto, A., Pattipawaej, O. 2014. Pengembangan Sambungan Kayu Batang Tarik dengan Ring-Modifikasi dan Perkuatan-Paku. Seminar Rumah Tradisional 2014 – Transformasi Nilai-nilai Tradisional dalam Arsitektur Masa Kini, Puskim, Balitbang, Kementerian Pekerjaan Umum, Lombok, 19-20 November 2014 (in Indonesian).

Pranata, Y.A., Kristianto, A., Pattipawaej, O. 2015. Pengembangan Sambungan Hubungan Join Balok-Kolom Kayu dengan Ring-Modifikasi dan Perkuatan-Paku. Jurnal Teknik Sipil: 22 (1): page?, ISSN 0853-2982, Accredited by DIKTI No. 56/DIKTI/Kep/2012 (in Indonesian).

Yosafat Aji Pranata, Anang Kristianto, and Olga Pattipawaej
Department of Civil Engineering, Engineering Faculty,
Maranatha Christian University,
Jl. Suria Sumantri 65, Bandung 40164, West Java, Indonesia
Tel : +62-816623703
E-mail : yosafat.ap@gmail.com

Commented [nobody8]: Add more discussion on findings

Commented [nobody9]: This results have not been discussed in ‘Result and Discussion’

Commented [nobody10]: Please see previous comment

Commented [nobody11]: Please see comment 9

Beam-Column Timber Joint Connection Behavior Due to Nail and Modified-Washer Reinforcement Tests

Commented [nobody1]: Recommended title:

Beam-Column Timber Joint Connection Behavior Due to Nail and Modified-Washer Reinforcement Tests

Yosafat Aji Pranata, Anang Kristianto and Olga Catherina Pattipawaej

Abstract

Timber connection capacity, in case of beam-column joint connection provides significant impact on the wooden building structures. Strength and stiffness of timber connections using reinforcement technique of wooden building structures have not been studied intensively. This paper studies the use of nails and modified-washer to improve wood connection's performance. The experimental tests were conducted in the laboratory by comparing the partial connection between test specimen timber without reinforcement (standard type) and the reinforcement (PRP type). The testing was conducted based on partial connection beam-column joint test using Universal Testing Machine's with a modified holder. Wood studied includes Meranti (*Shorea* spp.) and Mersawa (*Anisoptera* spp.). PRP type connection was using nails and modified-washer strengthening, and standard type connection was using a classic washer. Parameters studied were strength and stiffness of the connection, reviewed both: proportional limit load and ultimate limit load conditions. Result obtained from this research indicates that the use of nails and modified-washer make a positive contribution to improving the performance of the beam-column timber joint connections, in terms of strength capacity (both of proportional limit and ultimate limit loads) and stiffness capacity (displacement ductility ratio). Meranti beam-column timber joint is more brittle than Mersawa beam column timber joint, it has an impact on the results. PRP-type of Mersawa timber connection produces a higher ductility than the standard type, while the PRP-type of Meranti timber connection produces a similar ductility to the standard type.

Keywords: Partial test, beam-column joint, timber, nail and modified-washer, behavior

Introduction

Connection performance of wooden house building structure plays an important role with regard to the overall performance of the building structure. Ductile connection systems are expected to contribute in the behavior of the strength and stiffness of the building structure positively. Figure 1 and Figure 2 show the beam-column joint connection in a traditional house of Minahasa, North Sulawesi, Indonesia. The observed connection is in the exterior residence (Figure 1) and in the interior residence (Figure 2). The wood joints were connected using nails.

Figure 1. Beam-column joint connection of Minahasa traditional house: Exterior joint

In order to review the connection system performance, it is necessary to limit the burden of disproportionate amount of information that could be retained by connection. It is helpful in designing the timber connection to calculate lateral resistance (Z) in accordance to Indonesian National Standard (SNI 7973: 2013) (Badan Standardisasi Nasional 2013).

Figure 2. Beam-column joint connection of Minahasa traditional house: Interior joint

Information on the load-slip curve relationship of timber connection, moment-curvature curve timber connection and ideal model approachs are also an important empirical data in relation to the numerical modeling of the wood building structure. The accuracy of numerical modeling relies heavily on modeling parameters or idealization of the connection structure elements. The mechanical properties of the material parameters and of the cross section dimensions size of structural elements.

This study is a continuation of previous research development reported by Pranata *et al.* (2014) who mentioned that there is related research capacity of the axial tensile connections of standard type and of the nail and modified-washer reinforcements, as well as research capacity of the beam-column joint connection (Pranata *et al.* 2015). The study of standard type connection and strengthened connections using the reference of ASTM test methods (ASTM 2000).

The testing specimen concept used in this study differs from previous studies particularly in a model specimen partial connection (Pranata *et al.*, 2015). In this study, the nails and modified-washer was used to improve performance of timber connections. Experimental tests i the lab were conducted by comparing partial connection between test specimens timber without reinforcement (standard type) and the reinforced specimens (PRP type). Partial beam-column joint connection test was conducted to test Meranti (*Shorea* spp.) and Mersawa (*Anisoptera* spp.) wood using Universal Testing Machine (UTM). PRP types were counducted using nails and modified-washer strengthener. Parameters studied were the strength and stiffness connection and proportional limit of loading as well as ultimate limit loading conditions. The testing method used is the monotonic loading pattern.

Due to the limited length of timber that is in-trade, then for a long timber construction timber is needed for the connection of two wooden trunks or more mutually connected to one another so that a single piece of wood long. Understanding the relationship is two sticks of wood or more interconnected with each other at a certain point that it becomes a part of the construction. Please note the terms of wooden ties, among others: as simple as possible but sturdy, attractive avoid deep wood, placement of connection, will withstand the forces acting on it. Mechanical connection can be used, among others tools connecting bolts or nails.

Basic Theory

Kobel (2011) studied the effect of strengthening, especially for connections that resist lateral loads (hereinafter referred pull axial connection) for a long-span truss. There are four types of reinforcement are studied, namely the retrofitting of type A2 + B2, strengthening 02 + A2, inclined reinforcement and Dywidag strengthening. Retrofitting is done by adding a dowel in the direction intersecting with the mechanical connection.

Noguchi *et al.* (2006) also studied the timber connection (beam-column connections), as well as developing new connection models to bolster the performance of the strength of the beam-column connections.

The thickness of the ring having an impact as well as the influence of pretension effect of the bolts. Pretension effect thus will not increase the capacity of joint significantly, however, a positive effect is to improving connection's ductility. Another effect is by the initials pretension then bolt becomes more difficult to bend or fail flexibly, so that it is suitable to be applied to high quality of wood with high bearing strength. Pretension with a note that the amount does not exceed the compressive strength perpendicular to the wood fibers (Awaludin *et al.* 2008; Awaludin *et al.* 2008b).

One indicator to know stiffness is displacement ductility ratio, which is calculated by the Equation 1,

$$\mu = D_u / D_y \qquad (1)$$

where μ is displacement ductility ratio, D_u is deformation due to ultimate limit load, and D_y is deformation due to proportional limit load.

Methods

The study was divided into four main stages. The first stage was the study of literature. The second stage is to study secondary data and preparation of test specimens. The third stage is the experimental testing in the laboratory. The fourth stage is processing the data to get the results of the discussion and conclusions.

The research method uses empirical methods, namely experimental testing in the laboratory. The total number of test specimens are 6 (six) specimens, which are 2 (two) specimens for Meranti timbers and 4 (four) specimens for Mersawa timbers.

Figure 3 shows a schematic model of partial connection test object for laboratory test. Figure 4 shows the partial connection standard type of timber connection. Figure 5 shows the partial connection for the connection with the reinforcement (named PRP type).

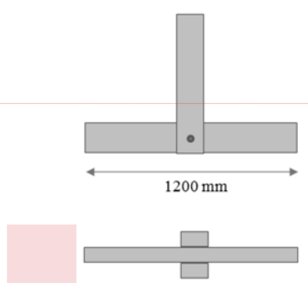

Figure 3. Schematic model of the specimen

Specimens that used in this research are tested using a Universal Testing Machine (UTM). UTM used to apply a monotonic loads from zero load to the specimen failure. For this purpose it would require additional equipment in the form of a holder for placement of the test object. Setups of the test specimen are shown in Figure 6.

Commented [nobody3]: It represents the stage of research. The method must straight to the point of method/testing to achieve the research objectives

Commented [nobody2]: It should not be here. Basic theory is part of introduction and it must support the research question arguments

Figure 4. Example for the standard type of the Beam-Column Timber Joint onnection

Figure 5. Example for the PRP type of the Beam-Column Timber Joint Connection

Figure 6. UTM and setup of the specimen

Result and Discussion

Testing is done by applying a load, from zero loading to the test specimen failure and could not withstand the load again. Figure 7 shows the process of testing the specimen.

While Figure 8.a and Figure 8.b shows an example of the failure of the test specimen during an ultimate load is reached.

Figure 7. Testing process of the Meranti Timber Beam-Column Joint Connection

(a). Meranti timber specimen.

(b). Mersawa timber specimen

Figure 8. Failure mode of the specimens

Test results for the Beam-Column Timber Joint Connections (six specimens) shown in Figure 9 (Meranti Timber specimens), and Figure 10 and Figure 11 (Mersawa Timber specimens). The test results are a curve of the load vs deformation, which represents the behavior and capacity of the beam-column joint.

Commented [nobody4]: It is method

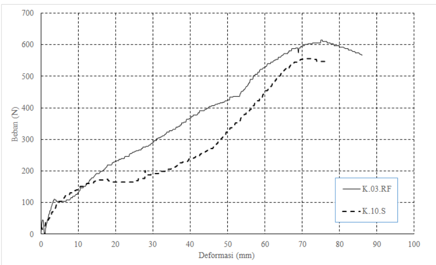

Figure 9. Meranti wood connections test results: Comparison of Load-Deformation Relations curve for the standard type and the PRP type connections

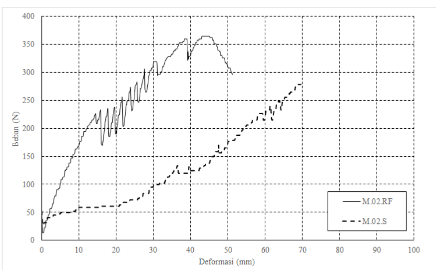

Figure 10. Mersawa wood connections test results: Comparison of Load-Deformation Relations curve for the standard type and the PRP type connections, Specimen M.02

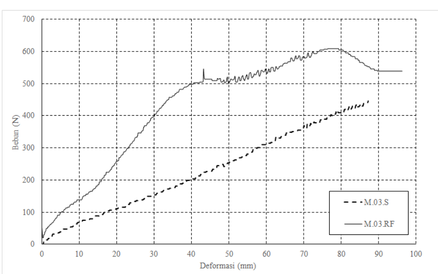

Figure 11. Mersawa wood connections test results: Comparison of Load-Deformation Relations curve for the standard type and the PRP type connections, Specimen M.03

Figure 9, Figure 10, and Figure 11 generally shows test results of the load vs. deformation curve for both Meranti (Figure 9) and Mersawa specimens (Figure 10 and Figure 11), which indicates that the overall capacity of the standard type lower than the PRP type.

Table 1 shows results of the timber joints made with Meranti wood, which are the idealization of the load vs. deformation curve, while Table 2 shows results of the timber joints made with Mersawa wood, i.e with reviewing the conditions of the proportional limit and ultimate limit. Method that used to determine both the proportional (P_y) and ultimate (P_u) limit loads using Yasumura and Kawai (Y&K) Method, namely a method for determining proportional limit loads and ultimate limit loads, specifically for wood material (Munoz *et al*., 2010).

Proportional limit load is a condition when there is a change from elastic to plastic behavior, while ultimate limit load is a peak load or peak capacity of the joints. Displacement ductility ratio is calculated using Equation 1.

Table 1. Summary of experimental results: Meranti specimens

Specimen	P_y	D_y	P_u	D_u	μ
	(N)	(mm)	(N)	(mm)	(mm/mm)
S (Standard)	526.49	66.40	555.86	72.60	1.09
RF (PRP)	571.68	66.10	605.57	74.40	1.13
%-difference	8.58%		8.94%		2.94%

Note: S = standard type, RF = PRP type.

Table 2. Summary of experimental results: Mersawa specimens

Specimen	P_y	D_y	P_u	D_u	μ
	(N)	(mm)	(N)	(mm)	(mm/mm)
S (Standard)					
M.02.S	178.78	51.10	278.35	68.90	1.35
M.03.S	350.76	67.50	441.28	86.70	1.28
Average	264.77		359.82		1.32
RF (PRP)					
M.02.RF	224.04	15.50	364.35	43.10	2.78
M.03.RF	468.44	35.90	604.22	79.40	2.21
Average	346.24		484.29		2.50
%-difference	30.77		34.59		89.62

Note: S = standard type, RF = PRP type.

The test results show that the beam-colum joint connection with the strengthening of the PRP type is more ductile than the Standard (S) type connection, both for Meranti and Mersawa wood connections.

In general the beam-column Mersawa timber joint connection type of PRP produce higher strength capacities ranging from 30.77% to 34.59% compared to the standard beam-column joint connection (in terms of Proportional Limit

Commented [nobody6]: Add more discussion on findings

Commented [nobody5]: Please add more discussion on Figure 9 – 14. Is the pattern is normal? And support your argument by referencing and Ultimate Limit Loads), while the beam-column Meranti timber joint connection of type PRP also produce higher than standard type ranging from 8.58% to 8.94%.

The stiffness capacity, in term of Displacement Ductility Ratio of the Mersawa PRP type is 89.62% higher than standard type, while the Meranti PRP type is 2.94% higher than standard type.

Commented [nobody7]: Please see previous comment

Conclusion

This result indicates that the use of nails and modified-washer make a positive contribution to improving the performance of the beam-column joint connections, in terms of strength capacity (both of proportional limit and ultimate limit loads) and stiffness capacity (displacement ductility ratio). Meranti beam-column timber joint is more brittle than Mersawa beam column timber joint, it has an impact on the results. PRP-type of Mersawa timber connection produces a higher ductility than the standard type. While the PRP-type of Meranti timber connection produces a similar ductility to the standard type.

Commented [nobody8]: Please see comment 9

Acknowledgement

The authors gratefully acknowledge the financial support of “Hibah Bersaing” DIKTI, DIPA 023.04.1.673453/2015, date 14 November 2014 revision 01 date 3 March 2015. The authors also gratefully acknowledged for laboratory support of Mr. Jumali of Department of Civil Engineering, Maranatha Christian University.

References

American Society for Testing and Materials. 2000. Standard Test Methods for Bolted Connections in Wood and Wood Base Products, Designation D 5652-95(2000), ASTM, West Conshohocken, PA.

Awaludin, A., Hirai, T., Hayashikawa, T., Sasaki, Y., Oikawa, A. 2008a. Effects of pretension in bolts on hysteretic responses of moment-carrying timber joints. Journal of Wood Science 54: 114-120, The Japan Wood Research Society.

Awaludin, A., Hirai, T., Hayashikawa, T., Sasaki, Y. 2008b. Load-carrying capacity of steel-to-timber joints with a pretensioned bolt, Journal of Wood Science 54: 362-368, The Japan Wood Research Society.

Badan Standardisasi Nasional. 2013. Spesifikasi Desain untuk Kontruksi Kayu SNI 7973:2013. Badan Standardisasi Nasional (in Indonesian).

Kobel, P. 2011. Modelling of Strenghthened Connections for Large Span Truss Structures. Department of Structural Engineering, Lund Institute of Technology, Box 118, S-221 00 LUND, Sweden.

Munoz, W., Mohammad, M., Salenikovich, A., Quenneville, P. 2010. Determination of Yield Point and Ductility of Timber Assemblies: In Search for a Harmonized Approach. Engineered Wood Products Association.

Noguchi, M., Takino, S., Komatsu, K. 2006. Development of wooden portal frame structures with improved columns. Journal of Wood Science 52: 51-57, The Japan Wood Research Society.

Pranata, Y.A., Kristianto, A., Pattipawaej, O. 2014. Pengembangan Sambungan Kayu Batang Tarik dengan Ring-Modifikasi dan Perkuatan-Paku. Seminar Rumah Tradisional 2014 – Transformasi Nilai-nilai Tradisional dalam Arsitektur Masa Kini, Puskim, Balitbang, Kementerian Pekerjaan Umum, Lombok, 19-20 November 2014 (in Indonesian).

Pranata, Y.A., Kristianto, A., Pattipawaej, O. 2015. Pengembangan Sambungan Hubungan Join Balok-Kolom Kayu dengan Ring-Modifikasi dan Perkuatan-Paku. Jurnal Teknik Sipil: 22 (1): page?, ISSN 0853-2982, Accredited by DIKTI No. 56/DIKTI/Kep/2012 (in Indonesian).

Yosafat Aji Pranata, Anang Kristianto, and Olga Pattipawaej
Department of Civil Engineering, Faculty of Engineering, Universitas Kristen Maranatha,
Jl. Suria Sumantri 65, Bandung 40164, West Java, Indonesia
Tel : +62-816623703
E-mail : yosafat.ap@gmail.com or yosafat.ap@eng.maranatha.edu