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Analysis Of Comparative Strength Model Connection Bolts And Weld To The Plate Materials ST. 42

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ABSTRACT
The research objective to be achieved is determine the ratio of tensile strength connections of weld combination (longitudinal and transversal) with a tensile strength of connection models with 2 bolts, 3 bolts and 4 bolts. The method used is to form specimens of weld connections (longitudinal and transverse) and the model of connections (2, 3 and 4) bolts, and testing of tensile strength using a tensile test machine to produce maximum load value, the maximum tension and strain. The purpose of the test is to compare the tensile strength of the bolts connection of the various models are supplied with a value of tensile strength connection of weld variations and strong current given (100, 120, 140, and 160) Ampere.
Result of tensile test showed for the highest tensile strength of each connection was connection of 2 diagonal bolts models σ_{max} = 126, 759 MPa, connections of 3 B bolts triangle models , σ_{max} = 135,278 Mpa, connection of 4 bolts diagonal models, max = 163.529 MPa. The greatest tensile strength of each weld connections with transverse, longitudinal and combination direction (trans + long) with strong variations in flow was a strong connection with the use of 100 A σ_{max_Komb} = 290,175 MPa, strong currents of 120 Aσ_{max_Komb} = 275,098 Mpa, strong current of 140 Aσ_{max_Komb} = 295,885 MPaand strong currents of 160 A=σ_{max_Komb} = 303,605 MPa.
The strength of the connection combination of weld direction (transverse + longitudinal) with the use of strong currents of 160 A was the greatest of tensile strength values compared with the tensile strength of the connection with 4 bolts of parallelogram Amodel with percentage (%), comparisons were significant enough that 64.993: 35.007.

Keywords - Connection of bolt and weld, strong current, Comparison of tensile strength

I. INTRODUCTION

1.1.Background

Connection model of two or more materials is one of the deciding factors in the use of a construction, whether in ship building construction, bridges, roof trusses or other construction uses metal plate material in the process of connection. In the construction, a lot of damage that occurred in the connection, whether in the full connection process or welding process as well as the use of bolts and nuts as a binder in the use of connection construction. Improved of the tensile strength of connection is either done various forms of the model towards welding with longitudinal or transversal direction and by combining between the weld longitudinal and transverse directions, as well as the use of the welding current at variance so as to find an optimal tensile strength Improved of the bolts tensile strength connection can be obtained by varying connection models 2, 3, and 4 bolts, so that both the types and connection models can be compared to each strength. Results of research and testing will be known the value of tensile strength or ultimate tensile stress, strain value and the reduction value of sections as well as extension through testing of the tensile test.
The main problems for all welding process in a construction are distortion and residual stress. It is a phenomenon that occurs in the metal material and if the constructor ignores the problem, it can lead to material results of the welding process a failure when operated. The use scope of combination of weld connections (longitudinal and transverse) and bolts connection models in the construction field is very broad, which includes shipping industry, building, bridge structures, steel structures, pressure vessels, rail vehicles and so on.

The previous results of research on tensile testing of steel weld connections ST 42 is464,50 MPa, with strength increase of 0.15% ***(Imam Pujo M. etal)*** and the testing results of the use of bolts in the connection system with specially grooved ring is provide pretensioning with the vertical direction at connection plate, pretensioning is a key component of the work mechanism at the new connection system is that the greater of pretensioning force can be provided, will increase strength before the slip,

despite strong ultimate in a particular condition particular, does not provide a significant improvement, (Wiryanto Dewobroto), as well as the results of tensile testing at 110 A of welding current strength is the strength of weld connections of 507, 33 N/mm^{2}with increase of tensile strength of 0.65%, ***(Fenoria Putri)***.

One method to determine the ratio of the strength connection by varying each bolts of the connection models and combining forms of welding direction (longitudinal and transverse) using the appropriate weld current model to obtain the best models. To determine the best of tensile strength connection model, it is necessary to conduct a research to find out the comparison the strength of weld connection (longitudinal, transverse and combinations) and connection models (2, 3 and 4) each bolt. Testing result by using a tensile test machine can be obtained percentage of the increasing of the strength of the connection models to the welding process as compared to the strength of the connections model with variations of bolts number. By knowing the maximum tensile strength of each model of plate material connection, it can be selected the connection models in use of construction field.

1.2. Problem Statement

The statements of problem in the research on comparative analysis of the strength of the bolts and weld connection to the plate material ST 42 as follows:

1) How much is the influence of connection models (2, 3 and 4) bolts to the tensile strength of the material plate ST 42?
2) How much is the influence of the weld current variation (100, 120, 140 and 160) Ampere to the tensile strength of weld connections with direction of (transverse, longitudinal and combinations) of the plate material ST 42?
3) How much is the comparison of the tensile strength value of connection models (2, 3, and 4) bolts with weld connection models with direction of (Longitudinal, transversal and combinations) with variation of weld current (100, 120, 140 and 160) Ampere?

1.3. Objectives of Research

Objectives to be achieved in research on comparative analysis of the strength of the bolts and weld connection to the plate material ST.42 as follows:

1) to analyze the influence of connection models (2, 3 and 4) bolts to the tensile strength of the material plate ST 42?
2) To analyze the influence of the weld current variation (100, 120, 140 and 160) Ampere to the tensile strength of the weld connection with direction (transverse, longitudinal and combinations) of the plate material ST 42?
3) To analyze the comparison of the tensile strength value of connection models (2, 3, and 4) screws of weld connection models with direction (Longitudinal, transversal and combinations) with variation of weld current (100, 120, 140 and 160) Ampere?

1.4. Benefits of research

Results of the study are expected on comparative analysis of the strength of the bolts and weld connection to the plate material ST 42 as follows:

1) As a basis for the use and utilization of bolt and weld connection models for the industry engaged in shipping industry, building and bridge construction or industrial field relating to the use of the connection.
2) Determine the best connection model for bolt or weld as well as increase understanding of the development of the use of connection models that fit in a connection construction.
3) Guidelines for the technical implementation of learning for implementing the use of construction models and right current.

It can extend the use of models in some shipping construction, building, bridge structures or other construction related to the use of the bolt and nut connection.

II. BASIS THEORY

2.1. BOLT

In construction of bolt connection, usually to get a good connection strength required forms or bolt position adapted to load it receives. If a given load is greater than the strength of the bolt connection can be subjected to various forms of failure or deformation. The deformation can be broken off because of the pull, torsion, and shear bolts. In a previous study on the position of the bolt optimal receive shear force is the position of the bolt 2 the shear stress of 695 MPa and the position of the bolt 4 with shear stress 697 MPa, while bolt with suboptimal position receive shear force is the position 6 with the smallest of shear stress of 421 MPa, (Nofriyadi Handra, 2011). While the study results from Sanda and Suryanto, (2007) that the failure factors of bolt connection can occur not only on the amount of pressure that is given in the vessel processes, but also can be caused by any technical errors, which are broken due to static load, a failure in the operation due to fatigue materials, can also be caused by excessive tightening, so that the bolt experiencing to necked out.

2.2. THE STRENGTH ASPECTS OF WELDING CONNECTION

The quality of welds is influenced by thermal energy which means influenced by three parameters: welding current, welding voltage and welding speed.

The relationship between the three parameters that produce energy welding is often called heat input.

The strength of welding connection

The calculation of the welding strength can be obtained through:

1) Strength of transverse welding connection consists of:

Single

fillet: $F = \frac{t\ x\ L}{\sqrt{2}} x\ \overline{\sigma}_t = 0{,}707\ x\ t\ x\ L\ x\ \overline{\sigma}_t$ (1)

Double

fillet; $F = 2\frac{t\ x\ L}{\sqrt{2}} x\ \overline{\sigma}_t = 1{,}414\ x\ t\ x\ L\ x\ \overline{\sigma}_t$ …… (2)

Strength of parallel welding connections (longitudinal) consists of:

1) The maximum sheer force of single parallel fillet: $F_s = \frac{t\ x\ L}{\sqrt{2}} x\ \overline{\tau} = 0{,}707\ x\ t\ x\ L\ x\ \overline{\tau}$ (3)

2) The maximum sheer force of double parallel fillet:

$F_s = 2\frac{t\ x\ L}{\sqrt{2}} x\ \overline{\tau} = 1{,}414\ x\ t\ x\ L\ x\ \overline{\tau}$ ……(4)

Where: F_s= maximum of shear force (N) and τ= Shear welding *(N/mm$^{2)}$*

Comparison between stress and strain is called the modulus of elasticity. The greater the attractive force among the metal atoms, the higher the modulus of elasticity. At the time of testing rod receiving sheer force of F, with cross-sectional area A_0, then the length of the rod will increase of ΔL by causing voltage magnitude.

$\sigma = \frac{F}{A_o}$ ……..(5)

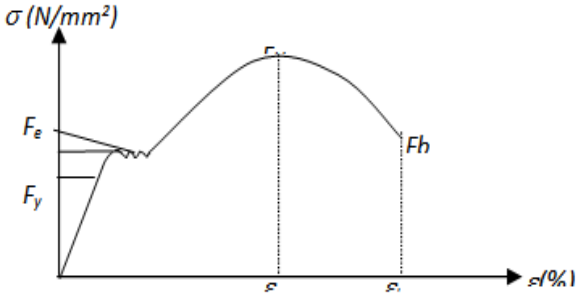
With; F = Load (N) and A_0 = initial cross-sectional area (mm2)

Comparison between the length (ΔL = Li - Lo) and initial length (lo) is called strain.

$\varepsilon = \frac{L_{i-L_o}}{L_o}$ ……..…. (6)

With, ε = Strain (%), L_i = the length (mm) and L_0 = initial length (mm)

In the tensile specimen test loaded gradually, which grew little by little? Loading due to this, it changes the length of the magnitude of the load by tensile machine, causing the relationship diagram (σ - ε) On this diagram can be seen the dots of proportional limit identify voltage limit is proportional to the strain.



picture 1. Relationship between voltage and strain

Up to a peak point called the proportional limit, when a voltage proportional to the strain, then the graph will show a straight line. When it comes to the elastic limit, the voltage is no longer proportional to strain. If the load is removed, the length of the rod will be returned to its original state. For the record that could be considered the elastic limit and the limit of proportionality is no different. If the load acting on the test rod passed up beyond the elastic limit will happen suddenly extension permanently from a test rod, is called Yield point (limit melted), where the strain increases even if there is no increase in voltage (only occurs in soft steel), At this point the work load is equal to Fy, resulting in a voltage.

III. RESEARCH METHODS

Analysis to compare the strength of the model of the bolt connection with welding material ST.42 plate, using a testing machine tensile test. The purpose of testing the maximum tensile strength values both for models bolt connection or weld connection direction (longitudinal, transverse and combination) with variation of strong current (100, 120, 140, and 160) Ampere. The equation used is Tensile Strength; $\sigma = F/A$, Where for the strength of the bolt connection, $\sigma_g = \frac{4F}{n.\pi.d^2}$, and the connection combination of the weld direction $F_s = 2\frac{t\ x\ L}{\sqrt{2}} x\ \overline{\tau} = 1{,}414\ x\ t\ x\ L\ x\ \overline{\tau}$.

From the test results of tensile strength, analyzed how much influence the strength of the bolt connection models and weld connections combination with providing a variation of strong current (100, 120, 140, and 160) Ampere to the plate material ST. 42.

IV. RESULT AND DISCUSSI

4.1. Bolts Connection

Results of testing the tensile strengtl various models of connection (2, 3 and obtain maximum tensile strength values, is max = 163.519MPa, compared toσconnectio

of parallelogram A, other connection models. Data tensile strength bolt connection models in Table 1.

Table. 1. Value of Tensile Strength of Bolt Connection Model

Types of connection	**Model**	**Load (kN)**	**Displecement (mm)**	**Stress (**MPa**)**	**Strain %**
2 Bolts	Horisontal	45.450	9.031	84.167	2.374
	Vertikal	45.500	10.194	84.259	2.888
	Diagonal	45.700	8.935	84.630	2.214
3 Bolts	Triangle A	73.050	9.609	135.278	8.230
	Triangel B	63.900	9.216	118.333	5.230
	Diagonal	68.450	10.322	126.759	7.394
4 Bolts	Persegi	85.950	7.948	159.167	7.588
	Ketupat	83.800	11.237	155.185	9.112
	parallelogram A	88.300	11.445	163.519	11.148
	parallelogram B	86.950	12.785	161.019	10.732

Based on Table 1, the value of the maximum tensile strength of each additional number of bolts, the maximum tensile strength of 2 bolts of diagonally models with valueσ_{max}**=** ***84.630 MPa***, 3 of triangle bolts models **max = 135.278 MPa**, and 4 of parallel organ bolts models parallelogram A**,** σ_{max} **= 163.519 MPa.** Based on Table 1 obtained a graph of the variation model of the bolt connection to the maximum tensile strength shown in the graph below.

4.2. Welding connection

Testing results of the maximum tensile strength of weld connection with transverse, longitudinal and combination (Trans + Long) by providing a variation of current strength (100, 120, 140, and 160) Ampere can be seen in table 2 below.

Table 2 Value of maximum tensile strength of weld connection model with variations of strong current of material ST 42.

Current Strength	**MODEL**	**ΔLi (mm)**	**Stress (**MPa**)**	**Strain (%)**
100 A	**TRANS**	13.113	255.643	26.227
	LONG	14.038	252.435	28.076
	KOMB	16.502	290.175	33.005
120 A	**TRANS**	14.465	273.943	28.931
	LONG	10.722	247.522	21.444
	KOMB	24.578	275.098	49.156
140 A	**TRANS**	12.295	245.499	24.654
	LONG	15.980	264.051	31.960
	KOMB	17.931	295.885	35.863
160 A	**TRANS**	13.501	266.078	27.002
	LONG	17.071	262.762	34.142
	KOMB	18.387	303.605	36.773

Based on the maximum tensile strength values in Table 2, showed that the addition of currents strength from 100 A to 160 A (step 20) welded connection either direction of transverse, longitudinal or combination (trans + long), an increase in tensile strength of the welded connections. The highest of tensile strength values of each given by the current strength is the kind of combination direction (trans + long), which strength currents of 100 A, $\sigma_{\max\_Komb}$ = **290.175 MPa**, strength current 120A, $\sigma_{\max\_Komb}$ = **275.098 MPa**, strength currents of 140 A, $\sigma_{\max\_Komb}$ **= 303.605 MPa** and strength currents of 160 A $\sigma_{\max\_Komb}$ **= 303,605 MPa.**

Based on the results obtained by tensile testing of each the maximum tensile strength (σ_{max}) as in Table 2, then in this case the relationship between the variation of weld current strength to the strength of the weld connection with transverse, longitudinal and combinations direction shown in the graph below.

Testing results of tensile connections of welding direction with combination (transverse + longitudinal) indicated the best of weld connection when compared with the treatment of combination transversal or longitudinal direction, as well as the use of current strength in the welding process showed that the greater current strength that applied**,** the tensile strength also increased, namely the strong current of 160 amperes was the best current strength

in the use of welding process of steel plate connections ST. 42.

V. CONCLUSION

Research result with comparative analysis of the model strength of bolts and weld connection to plate material has concluded:

1. The greater number of bolts and variations of the connection model given in the plate connection process has increased tensile strength values of each connection type. The connection type of 4 bolts with parallelogram model is the best model of connections.
2. The greater number of current strength given (100, 120, 140, and 160) Ampere in the connection with direction of transverse, longitudinal and combination direction (trans + long) has increased value of the tensile strength of the connection with the model combination direction (trans + long) is the best type of connection.
3. The tensile strength of the weld connection with combination direction (transverse + longitudinal) with a current strength of 160 Amperes σ_{max_Kom}**= 303.605 MPa** compared with the tensile strength of connection of 4 bolts with parallelogram A model, σ_{max_Kom} **=63.519 MPa**

REFERENCES

[1] Adriansyah. October 2007. ***Effect of Heat Treatment Temperature In Process To Improve Wear Resistance Steel Karbor Low On Pena Spring Leaf***. Scientific Journal Poly Engineering. Volum 3. Number. 1

[2] Ali Shariati. Dkk. 9 June 2012**.** ***Varios types of shear connectors in composite structures: A review.*** International Journal of Physical Sciances Vol. 7(22).

[3] Ahmed Drai. Dkk. June 2012. ***Analysis of plastic deformation behavior of HDPE during high pressure torsion process.*** ELSEVIER. Engineering Structures.

[4] Augustine Purna Irawan August 2009. ***Hand Out Machine Element*** . Department of Engineering, Faculty of Engineering, University Tarumanagara

[5] B. Ramesh Kumar. Dkk. 2012. ***Thick SS316 materials TIG welding development activities towards fusion reactor vacuum vessel applications.*** IOP Science. Journal of Physich.

[6] *John Wiley & Sons, Inc 1965. "****The Theoritical Engineering Statistic and Aplication"****.* Hald.Jakarta.

[7] Johanes Leonard. Dkk. ***Analysis of Tensile and Flexural Strength of Epoxy Composites Reinforced With Fibers Bark Khombouw.***

[8] Kuncoro Diharjo. March 2006. ***Study of Effects of Mechanical Tensile StrengthAgainst Hole Making Composite Hybrid Fiber Fiber Glass and plastic sacks.*** TEKNOIN Journal, Volum . 11, Number.1.

[9] Mehdi Ghassemich. Dkk. February 2012. ***Evaluation of Stiffened End-Plate Moment Connection Through Optimized Artificial Neural Network.*** Scientific Research. Journal of Engineering And Aplications

[10] Mahmood Md Tahir. Dkk. 2008. ***Experimental Tests on Extended End-Plate Connections with Variable Parameters.*** SEEL STRUCTURES.

[11] N. Saliba. Dkk. September 2012. ***Coss – section stability of lean duplex stainless steel welded I-sections.*** ELSEVIER. Journal of constructional steel Research.

[12] R. Chacon. Dkk. June 2012. ***Transversally stiffened plate girdes subjected to patch loading Part 2. Additional numerical study and design proposal.*** ELSEVIER. Journal of constructional steel Research.

[13] Surdia Tata. 1985.***Knowledge of Materials Engineering.***Jakarta: PT. Pradnya Paramita.

[14] Suhemi and syamsuri. July 2007. ***Effects of Changes in Flow Las TIG Against Impact Strength In Different Materials*.**SAINTEK. VOLUM 11. Number 1.

[15] Sami Rizkalla. Dkk. 2008. ***Development of a carbon fiber reinforced polymer system for strengthening steel structures.*** ELSEVIER. COMPOSITES. Part A: Applied Science and manufacturing.

[16] T. N. Chakherlou*, M. J. Razavi* and A. B. Aghdam, 2012. ***On the Variation of Clamping Force in Bolted Double Lap Joints Subjected to Longitudinal Loading: A Numerical and Experimental Investigation***. Strain. An International Journal for Experimental Mechanics.

[17] ***Wiryosunarto, Harsono . 1994. Metal Welding Technology.*** Jakarta: PT. Pradnya Paramita.

[18] DewabrotoWiryanto. 2008. "***Effect of Shape and Size Washer (Ring) to Conduct High Quality Bolt connection with Pretensioning in Cold - Rolled Steel",*** Dissertation Parahyangan Chatolic Univercity.

[19] Z. Al-Sarraf. Dkk. 2012. ***A numerical and experimental study of ultrasonic metal welding.*** IOP Science. Materials Science and Engineering.