Experimental Study of Joint Tool Variations in Cold Rolled Steel Structure Connection Systems C75 – 0,65 mm

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ABSTRACT

C75 cold rolled steel is a commonly used material in building construction due to its lighter weight in comparison to conventional steel. A key element in designing C75 light steel structures is the connection system, as it needs to be robustly designed to maintain the building's structural integrity and guarantee user safety. Therefore, this study aims to identify a suitable formulation for C75 mild steel connection types, with a particular focus on the impact of the steel's thickness on connection strength and reliability. The methodology employed involved developing various connection models, such as those using only screws, a combination of screws and bolts, and connections using rivet nails. Testing revealed that the modified connection model that combined screws and bolts produced higher strength values than those relying solely on screws or rivets. This trend was observed across different thickness levels of mild steel tested, specifically 0.65 mm, 0.75 mm, and 1.00 mm. The highest load capacity was achieved with a connection setup involving four screws and one bolt on mild steel with a 1.00 mm thickness, which sustained a load of 100.00 N and exhibited a deflection of 2.58 mm. Compared to riveted connections, this setup offered a strength improvement of 42.50%, while it showed a 20.00% increase over screw-only connections. These results suggest that rivet-based connections tend to be more brittle, while the combination of screws and bolts results in a more ductile and resilient joint, making it an ideal recommendation for light steel construction. Moreover, thicker mild steel sections showed better resistance to buckling under load, whereas thinner steel sections were more prone to buckling. This study concludes that selecting the appropriate connection type and material thickness are essential factors in improving both the strength and overall safety of steel structures used in construction projects.

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1. INTRODUCTION

Current construction developments have had many impacts on construction industry technology, one of which is the existence of new materials used in construction. One of the materials currently widely used in construction is cold-rolled steel C75, which is called mild steel on the market. C75 cold rolled steel has advantages in terms of strength, corrosion resistance, efficiency in using materials, is relatively easy to work with, namely just using cutting gutters and a drilling machine, and has a more economical price. Therefore, C75 cold rolled steel is increasingly popular for use in building construction, both for commercial, industrial and residential buildings.

One of the key aspects in the design and construction of C75 cold-rolled steel buildings is the joints, which must be safely designed to maintain the structural integrity of the building and ensure the safety of occupants and users. In C75 cold-rolled steel construction, screws are used for connections. Until now, there has been no specific standard for using connectors in C75 cold-rolled steel; the connectors used rely only on three screws for each joint without considering the thickness of the connected C75 cold-rolled steel or the diameter of the screws used.

On the other hand, theoretically the number of connecting devices is determined by the magnitude of the force acting on the elements being connected, and the magnitude of the force on the element determines the thickness or dimensions of the element. So the problem arises, is it appropriate for every C75 cold rolled steel connection to always use three screws and what is the effect if the screw connection is combined with bolts and whether the use of rivets in the connection tool will produce a stronger connection. So the researcher feels it is necessary to make research that can be used as a reference for a connection in C75 cold rolled steel construction, this is the novelty of this research.

2. METHODS

In each research there are several stages which are made in diagram form, with the aim that the research can be carried out systematically.

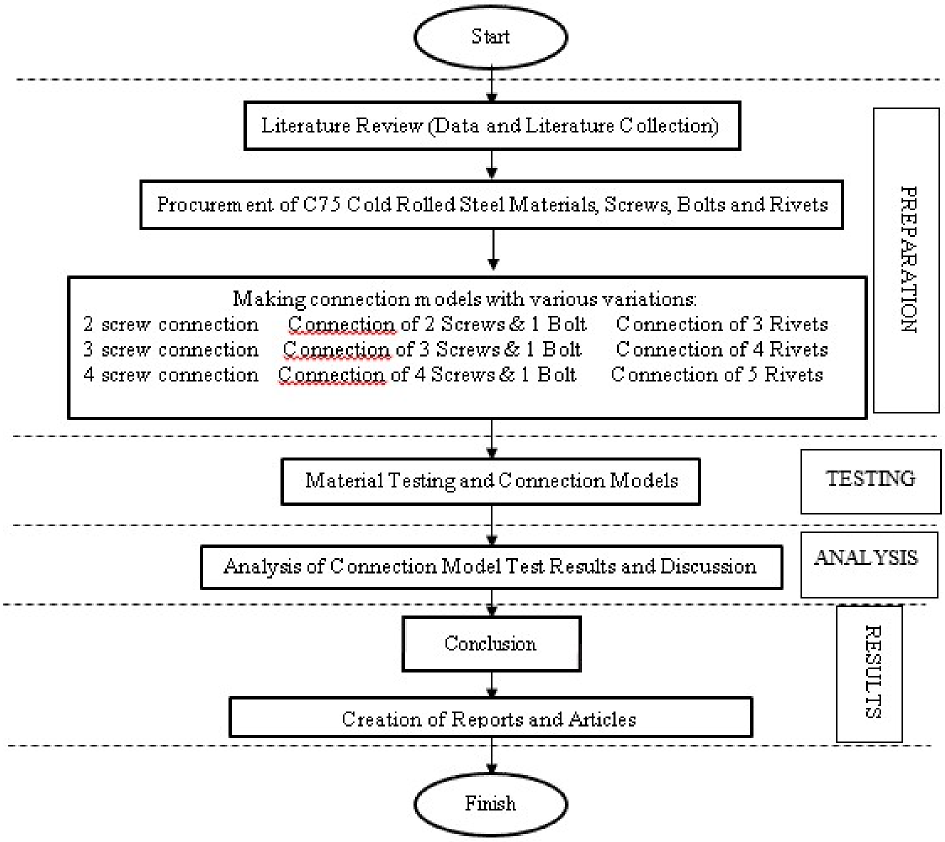

Figure 1. Research Flowchart

2.1 Observed/Measured Variables

The variable observed is the ability of the connection to withstand shear where the force applied is in the form of a tensile or compressive force at each end of the connected element, then the damage that occurs due to the application of this force occurs at the connection or element, from here the service of the connection type can be observed. at each thickness of the C75 cold rolled steel being joined.

2.1.1 Research Design Model Used

The following is a test of C75 cold rolled steel material in research to obtain the tensile strength of light steel profiles for each profile thickness.

Table 1. Material Test Cold rolled steel C75

Test Type	Profile Type	Number of Test objects	Total
Tensile Test of C75 cold rolled steel	C75-0,65	3	9

C75 – 0,65

Figure 2. Material Test Cold rolled steel C75

Here is a sample connection design model from the study, aimed at finding the most suitable joint configuration for each thickness of the C75 cold-rolled steel profile.

Table 2. Joint Model Plan C75 cold rolled steel

Test Type	Profile Type	Connection Configuration	Jumlah
Joint shear test	C 75 - 0,65	2 screw	3
		3 screw	3
		4 screw	3
		2 screw 1 bolt	3
		3 screw 1 bolt	3
		4 screw 1 bolt	3
		3 rivet nails	3
		4 rivet nails	3
		5 rivet nails	3

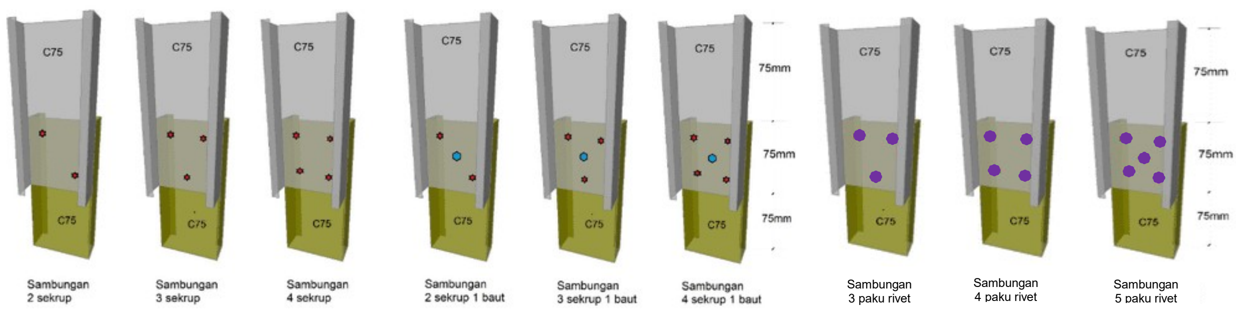

Figure 3. Variations in Connection Models

3. RESULTS AND DISCUSSION

Tensile testing of mild steel involves a series of standard procedures designed to evaluate the mechanical properties and strength of materials to withstand tensile forces. Tensile testing on mild steel materials is carried out using a simple test portal tool where the tensile test object is systemd in such a way as to be able to obtain tensile results on the test object. The following is the tensile testing system carried out in this research.

Figure 4. Tensile Strength Testing Set-Up

From the results of tensile strength tests that have been carried out on tensile test objects, it is obtained.

Table 3. Table of Recapitulation of Tensile Strength Test Results

No	Load (Kg)	Deformation Average (mm)	Stressing (kg/mm^2)	Stressing (MPa)
Mild Steel Thickness 0,65				
1	50	0,685	7,69	76,92
2	100	0,485	15,38	153,85
3	150	0,53	23,08	230,77
4	200	0,715	30,77	307,69
5	250	0,92	38,46	384,62
6	300	1,14	46,15	461,54
7	350	1,43	53,85	538,46
8	400	1,72	61,54	615,38
9	450	2,065	69,23	692,31
10	500	2,805	76,92	769,23
11	536	3,925	82,46	824,62

The table above is outlined in graphical form as in the graphic below:

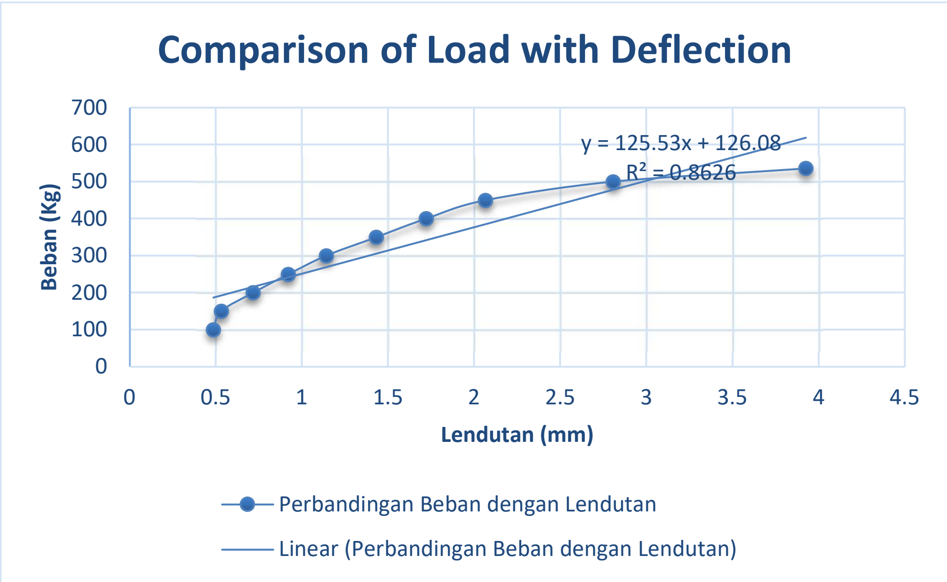

Figure 5. Graph of Recapitulation of Tensile Strength Test Results

From the results of tensile testing of mild steel material, it was found that the maximum tensile resistance possessed by mild steel with a thickness of 0.65 mm, 0.75 mm. And 1.00 mm respectively 824.62 MPa, 933.33 MPa, and 975.00 MPa. It can be concluded that the thicker a mild steel material of the same type will get a higher tensile resistance value where the increase in tensile resistance between thicknesses of 0.65 mm, 0.75 mm and 1.00 mm is around ± 4.27% up to 11.65%. So in other words, what can be recommended for the use of light steel for construction is to compare thicknesses of 0.65 mm, 0.75 mm and 1.00 mm, namely with a thickness of 1.00 mm, because it has a high tensile strength, namely around 975 MPa. Based on research by Duppa, 2018, thin mild steel has a tensile strength of between 500 – 550 MPa, exceeding conventional steel at around 300 MPa. For the roof frame, the light steel quality standard used is G550, meaning it has a tensile strength value of at least 550 MPa. So this is in accordance with the test results in this study.

Testing of shear connections in mild steel is usually carried out using a shear tensile testing method called a "shear test" or "lap shear test." This method makes it possible to measure the strength of shear connections and identify the behavior of the connection when subjected to shear loads. In this research, the method used is a static test using a compression testing portal tool but a shear test system is prioritized. So the results of the compression test have a shear effect or impact on the connection. The following is documentation for setting up the tool for joint shear testing.

Figure 6. Setting-Up Shear Test of Light Steel Joints

The test results show that the method of using the type of connection has a significant influence on the strength and deformation of light steel connections. Light steel connections with various dimensions, namely 0,65 mm, 0,75 mm and 1,00 mm and the use of connecting tools such as screws, combinations of screws with bolts and rivet nails show different maximum strengths. Apart from that, the maximum deformation that occurs also varies between each sample, the following are the results of testing the light steel connection..

Table 4. Table of Recapitulation of Shear Joint Test Results

Profile Type	Connection Configuration	Maximum Load Average (N)	Average Maximum Deformation (mm)
C 75 - 0,65	2 screw	24,17	1,75
	3 screw	47,50	3,35
	4 screw	25,00	2,56
	2 screw 1 bolt	45,00	2,92
	3 screw 1 bolt	25,00	0,55
	4 screw 1 bolt	42,50	2,33
	3 rivet nails	25,00	1,17
	4 rivet nails	35,00	1,53
	5 rivet nails	25,00	0,54

The table above is outlined in graphical form as in the graphic below:

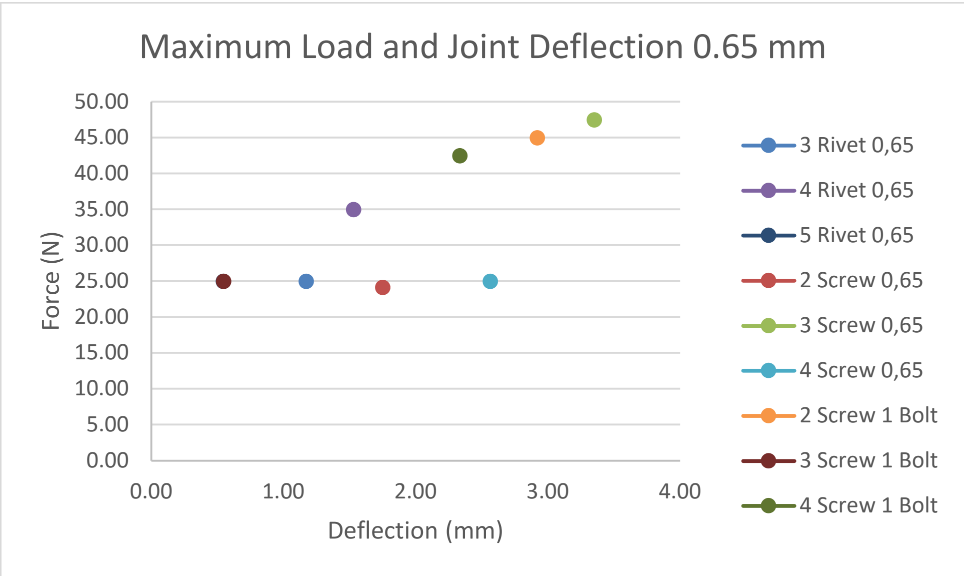

Figure 7. Graph of Recapitulation of Shear Rivet Joint Test Results

The test results revealed that light steel connections using a modified combination of screws and bolts yielded higher values compared to connections using only rivets or screws. This outcome was consistent across all tested light steel thicknesses—0.65 mm, 0.75 mm, and 1.00 mm. The highest result was achieved with a connection using 4 screws and 1 bolt on a light steel thickness of 1.00 mm, reaching up to 100.00 N with a deflection of 2.58 mm.

4. CONCLUSION

In general, the test results indicate that using light steel connections with a screw model produces higher strength values than connections using only rivets or modified rivet screws with a steel thickness of 0.65 mm. This pattern was consistent across all tested light steel thicknesses of 0.65 mm.

The highest result was achieved with a configuration of 3 screws, reaching up to 47.5 N with a deflection of 3.35 mm. This suggests that rivet connections are more brittle compared to screw connections, while screw and bolt connections are more ductile.

The key factor affecting durability is the thickness of the light steel itself, which influences the type of failure in the material. Light steel with greater thickness tends to prevent buckling in the material, unlike thinner light steel, where buckling is more likely to occur.

This research can be continued by identifying the layout and effective distance between connecting devices.

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