Experimental Study of Axially Tension Cold Formed Steel Channel Members

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Abstract: Experimental testing is commonly used as one of the steps to determine the cause of the collapse of a building structure. The collapse of structures can be due to low quality materials. Although material samples have passed laboratory tests and the existing technical specifications have been met but there may be undetected defects and known material after failure. In this paper will be presented Experimental Testing of Axially Tension Cold Formed Steel Channel Members to determine the cause of the collapse of a building roof truss in Pekanbaru. Test of tensile strength material cold formed channel sections was performed to obtain the main characteristics of Cold Formed steel material, namely ultimate tensile strength loads that can be held by members and the yield stress possessed by channel sections used in construction. Analysis of axially tension cold formed steel channel section presents in this paper was conducted through experimental study based on specifications Annual Book of ASTM Standards: Metal Test methods and Analitical Procedures, Section 3 (1991). The result of capacity loads experimental test was compared with design based on SNI 03-7971-2013 standard of Indonesia for the design of cold formed steel structural members. The results of the yield stress of the material will be seen against the minimum allowable allowable stress range. After the test, the percentage of ultimate axial tension capacity theory has a result that is 16.46% larger than the ultimate axial tension capacity experimental. When compared with the load that must be borne 5.673 kN/m it can be concluded that 2 specimens do not meet. Yield stress of member has fulfilled requirement that was bigger than 550 MPa. Based on the curve obtained ultimate axial tension capacity theory, results greater than experimental. The greatest voltage value (fu) is achieved 5.71. 5068 MPa has fulfilled the minimum melting point value of 550 MPa required for standard mild steel materials in accordance with the code SNI 03-7971-2013 about Cold formed steel.

Keywords: cold formed channel sections, axially tension members, SNI 03-7971-2013.

1. Introduction

Failure of roof truss structure of the building can lead to large losses for building owners as well as threaten the security and safety of building users. Based on surveyed, in 2016 there is a failure in the roof truss structure X building in Pekanbaru which resulted in nearly the entire framework of the roof of the building collapsed. Based on visual observation the failure at the connection and bend at a couple of bars. The collapse of structures can be caused by low quality materials. Although the material samples have passed laboratory tests and the existing technical specifications have been met but there may be undetected defects and known material after failure. Changes in cross-sectional shape will affect the strength of the structural elements and their bending behavior. In addition, in the field found the case of the roof structure more quickly collapsed than the results of the analysis performed, because the calculation analysis is done using the specifications of the actual lightweight steel while in practice used zinkalume which has much lower strength than mild steel (Amalia, 2012).

From the above description it was necessary to analyze the factors causing the failure of the structure include how the strength of lightweight steel plate material used in the roof framework of Building X Pekanbaru?
2. Cold Formed Steel Design Method

The Cold formed steel design method used is SNI 03-7971-2013 which is a modified adoption of AS / NZS 4600: 2005 because the majority of cold rolled steel industry uses this standard. Several modifications are made to this SNI to suit the conditions in Indonesia. Design for axial tension to a member subject a design axial tension force (N) according to SNI 03-7971-2013 shall satisfy based on eq 1:

\[ N \leq \phi N_t \]  

\[ \text{where} \]

\[ \phi = \text{capacity reduction factor for members in tension (0.9)} \]

\[ N_t = \text{nominal section capacity of the member in tension.} \]

based on SNI 7971 2013, the nominal section capacity of a member in tension shall be taken as the lesser of:

\[ N_t = A_g f_y \]  

\[ N_t = 0.85 k_t A_n f_u \]  

\[ \text{where:} \]

\[ A_g = \text{gross area of the cross section} \]

\[ f_y = \text{yield strength used in design} \]

\[ k_t = \text{correction factor for distribution of forces} \]

\[ A_n = \text{net area of the cross-section, obtained by deducting from the gross area of the cross section, the sectional area of all penetrations and holes, including fasteners holes} \]

\[ f_u = \text{tensile strength used in design} \]

3. Material Properties and Test Specimens

The material tensile test is performed to obtain Ultimate Axial Tension Capacity Experimental-kN as well as the main characteristics of lightweight steel material. Specimens and tests refer to the Annual Book of ASTM Standards: Metal Test Methods and Analytical Procedures, Section 3 (1991). Tensile test specimens were taken from the Channel profile portions of C 150.75.80 and 150.75.75. Which has a nominal thickness of 0.75 mm. The shape and dimensions of the material tensile test specimens are given in Figure 1.

Tensile testing is performed by providing static loads that gradually increase at a rate of 1 mm per minute until a breaking condition occurs in the specimen. The number of specimens tested were 4 pieces from 2 different light steel rods: Stem-1, Stem-2 is light steel 150.75.80 and 3 and 4 test pieces are mild steel 150.75.75.

Experimental procedure to carry out Tension test and determine modulus of elasticity is as given below: a) A piece of standard size was cut from the C section using Shear off machine b) Gauge length 50.2 mm was marked on the specimen and is fixed on the testing machine. c) Initially the thickness of member is 0.75 and 0.8 mm. d) Tensile test is carried out by using loads e) Tensile load was applied gradually on the specimen and observations were recorded f) Photograph shows the specimen (before and after test). g) A graph is plotted on the basis of recorded value.
4. **Analytical Investigation**

After the analysis was done, the inner force of the axial tensile force is obtained in the maximum structure of the lightweight steel frame structure in the form of a tensile force. From the above roof frame load analysis, the maximum tensile load to be retained is 5,673 kN/m. The experimental tension capacity loads (figure 3) was obtained based on specificationsAnnualBook of ASTM Standards: Metal Test methods and Analytical Procedures, Section 3 (1991).
Tabel 1. Ultimate Axial Tension Capacity Theoretical and Experimental

| Specimens | $F_y$ (Mpa) | Ultimate Axial Tension Capacity Experimental-kN | Ultimate Axial Tension Capacity-Theoritical -kN |
|-----------|-------------|-----------------------------------------------|-----------------------------------------------|
| 1         | 571.51      | 5,578                                         | 6.001                                         |
| 2         | 559.22      | 5,458                                         | 5.872                                         |
| 3         | 632.88      | 4,633                                         | 6.645                                         |
| 4         | 509.62      | 4,850                                         | 2.201                                         |

Figure 4. Ultimate Axial Tension Capacity Theoretical and Experimental

After the test, from the table we had observed the following result. The percentage of ultimate axial tension capacity theory has a result that is 16.46% larger than the ultimate axial tension capacity experimental. When compared with the load that must be borne 5.673 kN/m it can be concluded that 2 specimens do not meet. Yield stress of member has fulfilled requirement that is bigger than 550 Mpa. Based on the curve obtained ultimate axial tension capacity theory results greater than ultimate axial tension capacity experimental of figure 4.

4.1 Curve Stress and strain cold formed steel
The various material failures that occur in all test specimens show the same result that the breaking condition occurs suddenly without preceded by a significant increase in the length of the specimen visible. The approximate average length increase measured from the post-tensile specimen length is $\Delta = 12.8$ mm. At the disconnected nor a reduction in cross-sectional area (necking) such as those encountered in the tensile test ductile material. The material stress-strain curve obtained from the tensile test of all specimens shows the same curve pattern. As shown in Fig. 5, at the beginning the stress and strain loading increases almost linearly to a value of 568.3 MPa; This stress can be taken as the value of the yield stress of the material ($f_y$). Furthermore, the strain value increases at a relatively equal value of stress until the specimen breaks out. The greatest tension value ($f_u$) is achieved under the same conditions as its yield stress. For this specimen with a yield stress value $f_y = 571.5068$ MPa has fulfilled the minimum yield stress value of 550 MPa required for the standard cold formed steel material in accordance with the SNI 03-7971-2013. In this rule it is also established that the ultimate voltage value ($f_u$) is equal to the voltage value yield stress ($f_y$) if the minimum steel quality of 550 MPa is met. Material elasticity ($E$); The results obtained close to the standard elasticity modulus value set in the regulation. Recapitulation of tensile test results can be seen in Table 2.
Table 2. Characteristic of axially tension test material

| specimen | $f_y$ (MPa) | $f_u$ (MPa) | $E_l$ (%) |
|----------|------------|------------|----------|
| 1        | 571.5      | 571.5      | 5.6      |
| 2        | 559.2      | 559.2      | 8.0      |
| 3        | 474.7      | 474.7      | 7.6      |
| 4        | 496.9      | 496.9      | 12.8     |

(source: Testing laboratory of Materials Technology University of Riau)

Figure 5. Characteristic of axially tension test material

5. Conclusions

Axially tension tests on cold-formed channel sections were conducted. A total of 4 lipped channel specimens were tested. This paper has outlined current approaches to the design of lipped channel sections using SNI 03-7971-2013 as well as the test results. The experimental test results are the percentage of ultimate axial tension capacity theory has a result that is 16.46% larger than the ultimate axial tension capacity experimental. Yield stress of member has fulfilled requirement that is bigger than 550 Mpa. Based on the curve obtained Ultimate Axial Tension Capacity Theory results greater than Ultimate Axial Tension Capacity experimental.

6. References

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