Effect of Cold Formed Steel Column Arranged by Section C-81, C-75, and TH-35 on Compression Load

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Abstract. To reduce the possibility of local buckling of Cold formed steel structural components under compression, especially in column structures, it is necessary to use an arranged by some sections of Cold formed steel. The arranged some sections of Cold formed steel carries a higher load than a single section. This study aims to determine the effect of cold formed steel column that composed of a combination some sections of C-81, C-75, and TH-35 against compression load. There are two variations of the test specimen for column element, which are specimen type 1 in the form of C75 and TH-35, and specimen type 2 in the form of C-81 and C-75. The testing is conducted by applying pressure force on columns with lengths of 400, 600 and 800 mm. The results of specimen type 1 showed that the average actual critical load of column with lengths 400 mm, 600 mm and 800 mm are 51.47 kN, 75 kN, 78.5 kN. Meanwhile for specimen type 2 are 101.37 kN, 66.47 kN, and 85.60 kN. The column arranged by cold formed steel specimen type 2 has better compressive strength than specimen type 1.

1. Introduction

One of the building elements that can be made from cold formed steel is columns. The weakness of cold formed steel structures is about the local buckling. This is caused by a thin cross-section element. This condition causes structural failure before the maximum load capacity is reached. To reduce the possibility of local buckling in the column structure, it is necessary to use an arranged of some sections cold formed steel. The use of cold formed steel is directly proportional to the level of strength. Planning with good strength will produce a good and efficient design.

Cold formed steel section is a type of steel section that has relatively thin thickness dimensions. The ratio of width and thickness of the section elements is very large. Because the dimensions of the section thickness are relatively thin, forming a section can be carried out using a cold forming process. According to [1], when compared with other structural materials such as wood and concrete, cold formed steel material has several advantages which are lighter, stiffer, easily fabricated, faster and easier to install, and more resistant to wet and dry conditions.

One of the biggest difficulties for cold formed steel design is that it prevents bending in compressive elements. This is caused by the ratio of thickness to large width. Some factors that can cause buckling [2], in a compression element are slenderness value. It is the ratio of the length of the compressed rod element (L) to the minimum girth radius. The collapse caused by buckling is influenced by several other factors, such as end condition on the element, load eccentricity, and material imperfections [3]. There are three types of buckling collapse namely local buckling, distortion buckling, and global buckling [4].
Cold Formed Element has a very large difference in value between width and thickness. The asymmetrical cross section shape makes cold formed unstable and causes local buckling. Meanwhile, distortional buckling occurs at half the span length and is determined for the gross cross section of the beam. Global buckling occurs when column elements experience lateral and torsional buckling together. In this condition the cross section of the beam is twisted and the wing is flexed laterally [5].

The column is a slender structural element that is subjected to compressive axial loads at its ends [6]. The ideal column has elastic, straight and perfect properties if given concentric loading. If a column is loaded, the column will bend. Buckling collapse can occur even though the maximum load on the column is smaller than the yield stress of the material. The load that can be supported by the column without causing buckling is called the critical load. The amount of critical load that causes buckling collapse due to eccentric load [7] in the column can be calculated by Equation 1.

\[ P_{cr} = \frac{\pi^2EI}{L^2} \]  

In Equation 1, \( P_{cr} \) is the critical load of column (N), \( E \) is the modulus of elasticity (MPa), \( I \) is the moment of inertia (mm\(^4\)), and \( L \) is the length of the column (mm).

Slenderness value of column is the ratio of column length to minimum cross section radius. The gyration radius is calculated using Equation 2.

\[ r = \sqrt{I/A} \]  

Compression stress is shown in Equation 3.

\[ \sigma = \frac{P_{cr}}{A} = \frac{\pi^2E}{\sigma^2} \]  

In Equation 3, \( \sigma \) is the critical strength of the column (MPa), \( P_{cr} \) is the critical load of the column (N) and \( A \) is the cross-sectional area (mm\(^2\)).

This study aims to determine the critical load section composed of lightseight steel. Two types of cold formed steel section arrangement were examined. Finally the type of arranged by cold formed steel which has the strongest to support compression load was found.

2. Method

2.1. Materials and equipments

This research was conducted by the experimental method in the laboratory. The equipment used includes drilling machines, safety glasses, length measuring gauges, pencils, cutting machine, grindstone, and Universal Testing Machine (UTM). Materials used in the study consisted of mild steel types C 75, C81, TH 35, and screws with lengths of 20 mm and 8 mm.

Research specimens are in the form of cold formed steel Channel C-81, C-75, and TH-35 sections arranged as shown in Figures 1 and 2. The unit is in centi meter. Specimens of type 1 and type 2 are made to determine the effect of the carrying capacity arrangement of column on compression load. Each type of specimen is made in columns with length 40, 60, and 80 cm. The number of test specimens in each type and column length are made 3 piece specimens.
2.2. Procedures of making specimens
Cold formed steel column specimens are made through several stages. The first step is preparing the material. Preparations are made by checking whether the cold formed steel meets the desired specifications, and the amount is also as needed. The second stage is cutting cold formed steel according to size to make the columns arranged. The third stage is the installation of cold formed steel column components. The installation is conducted by combining the components of cold formed steel columns, which comprise of steel sections C-81, C-75, and TH-65 according to the type to be tested. The last step is flating the end of the column by using a grindstone machine.

2.3. Procedures of testing
The test is carried out by giving the axial load eccentrically to the column arranged as in Figure 3. Before the test is carried out, the test specimen is prepared by measuring its dimensions and given an identity to each test object. Testing is performed by UTM (Universal Testing Machine).

![Figure 1. Specimen of type 1.](image1)

![Figure 2. Specimen of type 1.](image2)

![Figure 3. Set up of compression test](image3)
3. Result and Discussions

3.1. Physical properties
Moment of inertia for specimens type 1 is 567,544 mm$^4$, while for specimens type 2 is 618,873 mm$^4$. The column slenderness value ($\lambda$) is shown in Table 1. The value is calculated based on the type of support at both ends of the column. It show that higher dimension of column, the slenderness increases. Higher the slenderness value, occurrence of buckling will raise.

Table 1. Slenderness value

| Length (mm) | Radius of gyration minimum (mm) | Slenderness ($\lambda$) |
|-------------|---------------------------------|------------------------|
|             | Type 1                           | Type 2                 | Type 1 | Type 2 |
| 400         | 30.593                           | 31.392                 | 13.075 | 12.742 |
| 600         | 30.593                           | 31.392                 | 19.612 | 19.113 |
| 800         | 30.593                           | 31.392                 | 26.150 | 25.484 |

3.2. Critical Load ($P_{cr}$)
Actual Critical Load ($P_{cr}$) is the result of compressive testing of cold formed steel columns arranged from some sections in the laboratory. $P_{cr}$ is a load that can be applied on the column before occurrence of buckling collapse. Actual $P_{cr}$ are presented in Tables 2 and 3.

Table 2. Critical load at specimen type 1

| Number of specimen | Length (mm) | $P_{cr}$ (kN) | Average of $P_{cr}$ (kN) |
|--------------------|-------------|---------------|--------------------------|
| 1                  | 400         | 62.00         |                          |
| 2                  | 400         | 41.70         | 51.47                    |
| 3                  | 400         | 50.70         |                          |
| 1                  | 600         | 86.40         |                          |
| 2                  | 600         | 68.00         | 75.00                    |
| 3                  | 600         | 70.60         |                          |
| 1                  | 800         | 91.40         |                          |
| 2                  | 800         | 87.30         | 78.50                    |
| 3                  | 800         | 56.80         |                          |

Table 3. Critical load at specimen type 2

| Number of specimen | Length (mm) | $P_{cr}$ (kN) | Average of $P_{cr}$ (kN) |
|--------------------|-------------|---------------|--------------------------|
| 1                  | 400         | 95.50         |                          |
| 2                  | 400         | 87.40         | 101.37                   |
| 3                  | 400         | 121.20        |                          |
| 1                  | 600         | 82.70         |                          |
| 2                  | 600         | 71.80         | 66.47                    |
| 3                  | 600         | 44.90         |                          |
| 1                  | 800         | 82.40         |                          |
| 2                  | 800         | 79.60         | 85.60                    |
| 3                  | 800         | 94.80         |                          |
Table 2 shows the load that is capable of being supported by columns composed of cold formed steel type 1. The average Pcr in columns with a length of 400 mm is 51.47 kN. Meanwhile, for column sizes with lengths of 600 and 800 mm, the average Pcr are 75 kN and 78.5 kN consecutively. Type 1 specimens show that the greater the value of slenderness, the Pcr goes up. It means that the arrangement of cold formed steel section type is not good and can not work in a single unit.

Table 3 shows the load that is able to be supported by column composed of cold formed steel type 2. The average Pcr in column specimens with lengths of 400, 600 and 800 mm is 101.37, 66.47, and 85.60 kN respectively. Cold formed steel type 2 specimens show a solid and sturdy arrangement. Columns with shorter heights have higher carrying capacity when compared to columns that have greater heights. This is also shown by the greater slenderness value, the lower the critical load that can be supported by the column. In addition, the carrying capacity of type 2 specimens has a higher load carrying capacity when compared to specimen 1.

4. Conclusions

Based on the results of the discussion above, several things can be concluded as follows.

a. The use of sections arranged in a cold formed steel column type 2 specimen has a higher carrying capacity when compared to type 1 specimens.
b. The greater the value of the slenderness of the column, the lower the carrying capacity of the column to the eccentric axial load.
c. The compression test of column showed that the actual critical load of specimen type 1 were 51.47 kN, 75 kN and 78.5 kN for column lengths of 400 mm, 600 mm and 800 mm respectively.
d. Specimen type 2 with column heights of 400, 600 and 800 mm has an average critical load of 101.37 kN, 66.47 kN, and 85.60 kN respectively.

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6. References

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