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Numerical Analysis in Development of a Cross-Sectional Model of the "C" Profile Cold-Formed Steel SNI-1729:2015

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***Abstract*—Lightweight structural steel profiles are often called cold-formed steel profiles-steels are formed by means of cold rolling of thin steel sheet so that the mass of steel profiles are extremely light. Because it has a thin plate thickness and mass of very light steel profile lateral stiffness is relatively low and is determined by the shape of the cross-section profile. This paper will discuss the development of a cross-sectional model of profile "C" size of 70 mm in the cold-forming steel SNI 1729:2015 is done numerically with the help of software. The analysis was carried out on the cross-sectional shape of the SNI 1729:2015 standard and the results of the development of the cross-sectional shape. The analysis was conducted by reviewing the deflection that occurs in the lateral direction on rod dimensions and the same type of loading. Results of the analysis show that in the cross-sectional shape of the development results there is a decrease in the lateral deflection, this shows that there is an increase in the lateral stiffness of the lightweight steel structure profile after the development of the cross-sectional model.**

***Keywords*—cold-formed steel, sectional area, stiffness, SNI-1729:2015**

I. Introduction

The lightweight structural steel is a steel profile that is currently widely used as a constituent frame residential building roof structure. A Steel profile is formed from a thin steel plate with a cold-forming process so that the weight of the profile is light relatively. The raw materials are low carbon steel plate ASTM A792, JIS G3302, G550, and SGC 570. To improve the corrosion resistance, the surface is coated with zinc, aluminum, and magnesium alloys with a thickness of 100 gr/m^2. The tensile strength of lightweight structural steel is the same as the raw material of 550 MPa [1].

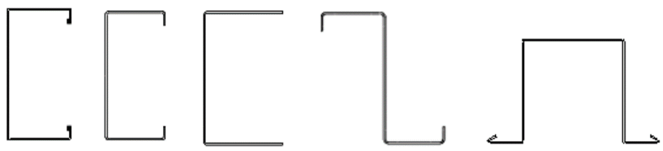

Fig. 1. The typical cross-sectional shape of a lightweight steel structure profile is standardized by SNI 1729:2015 [1].

The typical cross-sectional shape of a lightweight steel structure profile in Indonesia is standardized by SNI 1729:2015 whose shape can be seen in Figure 1. The thickness of the steel plates a lightweight structure between 0.4 - 1.0 mm. A weight per meters of lightweight structural steel profile can be defined by the equation.

$$B = [(t \times L \times \gamma) + (w \times L)] \times 10^{-6} \qquad (1)$$

B is a weight of profile per meter (kg/m), L is the width of raw material (mm), t is the nominal thickness of raw material (mm), w is the weight of the coating (gr/m^2), and γ is the density of the steel raw materials.

The use of lightweight steel structural profiles has developed not only for the use of roof truss structures but has developed for other uses in static building structures [2-6]. To improve the strength lightweight structural steel profiles developed a model of the profile cross-sectional area and material that has resistance to plastic deformation [7].

Lightweight structural steel profiles are made by the cold-forming process of thin-steel sheets coated with aluminum, zinc, and magnesium as surface protection against corrosion. The formation process is done by gradually rolling process. The process is relatively simple so that the process can be done in small-medium enterprises.

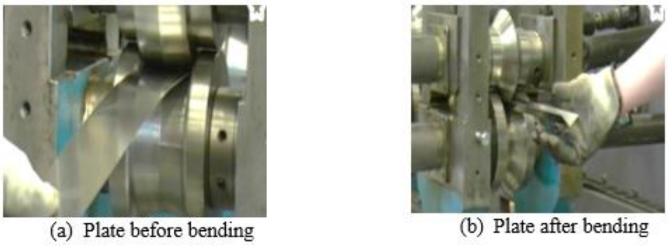

Fig. 2. The manufacturing process of lightweight structural steel profiles [8].

The making process of lightweight steel structural profiles in Indonesia is currently mostly made by small-medium enterprises. However, the control of raw material quality in this small-medium enterprise is still low, that the use of raw materials is still below the smallest standardized thickness, as a result, the resulting profile is relatively less rigid and below the predetermined standard.

Fig. 3. The manufacturing process of lightweight structural steel profiles in Indonesia [9].

The improved rigidity of the lightweight steel profile can be done by modifying web forms and addition folds at the end of lips flanges [8-16]. The strength of a structure is determined by the stiffness and flexibility of the beams. Beam stiffness is the force required to produce displacement, whereas flexibility is the displacement produced by an applied force. The lateral displacement on a beam is determined by the value of the beam's moment of inertia about the neutral axis and modulus elasticity of materials. The deflection of the beam as shown in Figure 4 is defined:

$$\delta = -\frac{Fl^3}{48EI} \qquad (2)$$

l is the length of the beam, E is the modulus elasticity, and I is the beam's moment of inertia about the neutral axis. The modulus of elasticity is a mechanical property of a material, whereas inertia is a property of its tendency to resist physical changes that occur. So, by increasing values of a moment of inertia, the rod will become stiffer.

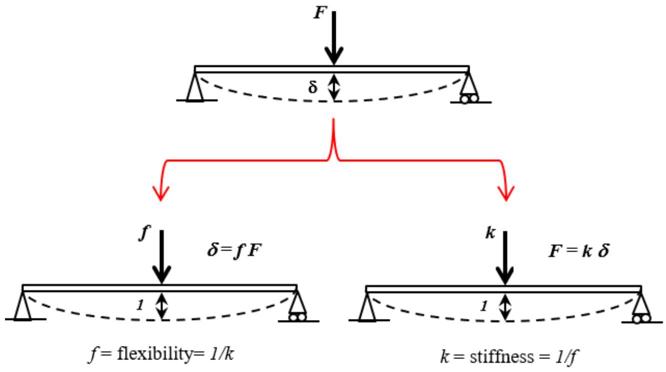

Fig. 4. Relationship between force, stiffness, and flexibility.

This paper will explain an improvement of the stiffness of the C70 profile beam-type C70 lightweight steel structure SNI 1729:2015. Improving the stiffness is done by modifying the web form and addition fold at the end on the lips of flanges. The only modification made on the size of the indentation web profile stiffened and addition several folds on the lip end flange without increasing the thickness of the plates. The analysis was performed numerically with the aids of software. See figure 5 below.

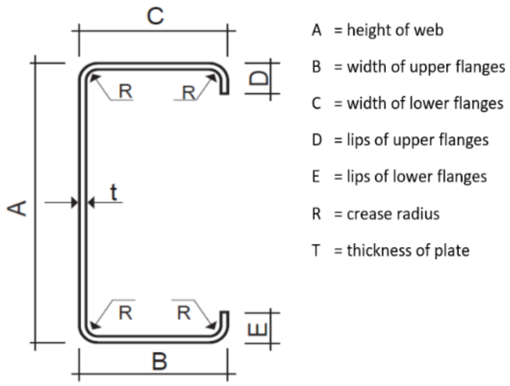

Fig. 5. The geometry and cross-sectional dimensions "C' Profile of the SNI-1729:2015 [1].

II. Methods

It has been explained above that the stiffness of a rod to bending loads is determined by the value of the beam's moment of inertia about the neutral axis. The value of the beam's moment of inertia is determined by the shape of the cross-section of the profile, the greater the inertia value, the smaller the deflection of the beam to the bending load. In this paper, the cross-sectional shape of the profile chosen in the analysis is the shape of the "C" profile, the geometry of the profile defined as shown in Figure 5. The geometry and cross-sectional dimensions of the SNI-1729: 2015 for the C70 profile are shown in Figure 6 and Figure 7.

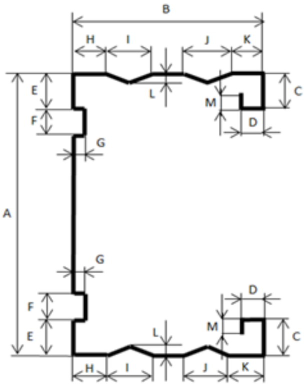

Fig. 6. Development model of cross-section geometry and dimension of C70 Profile.

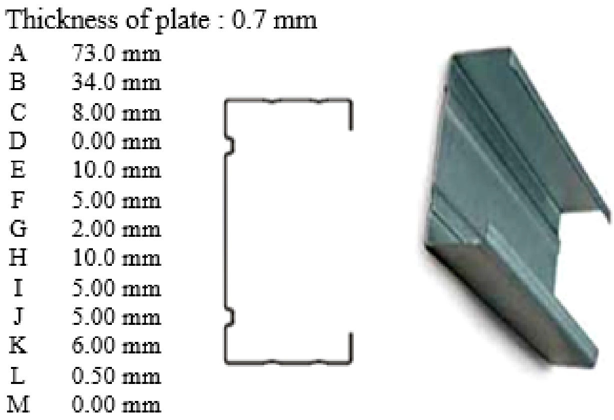

Fig. 7. Cross-section geometry and dimension of C70 profile SNI-1729:2015 [1].

Analyses were performed numerically, the beam modeled with a cantilever beam model with a length of 1.0 m, given a load at the end of 1.0 kg. The shape of the cross-section of the rod is the shape of the C70 profile of lightweight SNI-1729:2015 with a plate thickness of 0.7 mm. The maximum deflection for the cantilever loading model is defined:

$$\delta = -\frac{Fl^3}{3EI} \quad (3)$$

The analysis was initiated at the cross-section of the profile "C" without modification on the web and folds at the end lips of the flange. Furthermore, the analysis was carried out on the cross-section that had been given fold on the lips at the end of the flange. This is done to see changes resulting from changes in cross-section.

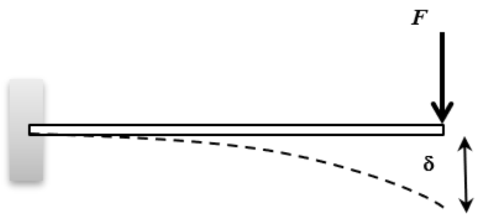

Fig. 8. Cantilever beam model.

The analysis results are used as the basis for making changes to the "C" profile cross-section model with the geometry and dimensions according to SNI-1729:2015. Analysis of using SolidWorks software using sheet metal models. The material used is AISI-4130 annealed which has a tensile strength of 560 N/mm^2, and a modulus of elasticity of 205000 N/mm^2. The analysis amounted only evaluates lateral deflection that occurs in the vertical direction (y-axis) under the given loading direction.

III. Results and Discussion

The results of the analysis on the "C" profile SNI-1729: 2015 obtained the vertical deflection (y-axis) of 8.12 mm. The analysis results, geometry, and cross-sectional dimensions of "C" profile SNI-1729: 2015 can be seen in Figure 9.

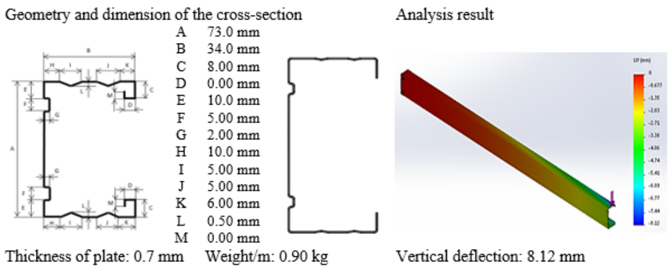

Fig. 9. Cross-section geometry and dimension of C70 profile SNI-1729:2015 [1]

While results of the analysis on the "C" profile SNI-1729:2015 after cross-sectional shape modification obtained the vertical deflection (y-axis) of 6.55 mm. The analysis results, geometry, and cross-sectional dimensions of "C" profile SNI-1729:2015 after modification can be seen in Figure 10.

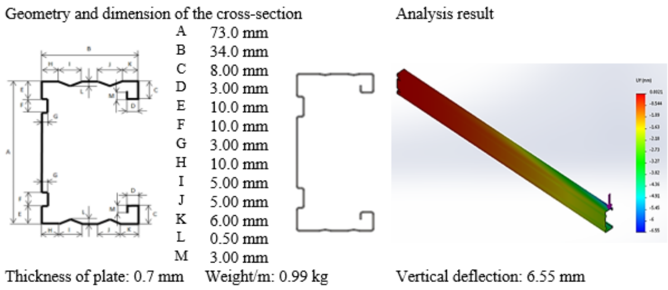

Fig. 10. Cross-section geometry and dimension of C70 profile SNI-1729:2015 after modification.

The results of the analysis show that changes in the shape of the cross-section will affect the deflection, this is due to an increase in the inertia value of the section. This has been proven by equations (2) and (3), and the results of research by several previous researchers [8,10-12,16]. Another important thing that must be considered in addition to the optimal shape of the cross-section is the manufacturing process of the cross-sectional shape to producing a shape of the cross-section with a high inertia value and a relatively simple manufacturing process.

IV. CONCLUSION

The analysis concluded that the increase in the lateral stiffness of the "C" profile of light structural steel SNI 1729: 2015 can be done by reducing the lateral deflection value. Deflection can be reduced by increasing the value of the inertia by modifying the shape of the cross-section. Numerical modification of the cross-section can be done easily, but it will be very different if the section has to be made, so that in the modification of the section it is necessary to consider the manufacturing aspect.

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