01 Aug 1995

CCFSS Technical Bulletin August 1995

Wei-Wen Yu Center for Cold-Formed Steel Structures

CCFSS Technical Bulletin

Vol. 4, No. 2 August 1995

TORSIONAL WARPING CONSTANTS OF COLD-FORMED STEEL SECTIONS

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INTRODUCTION

Torsional warping constants for most common cold-formed steel sections can be found in Part III of the American Iron and Steel Institute (AISI) Design Manual[1]. It is stated under properties of sections that centerline dimensions are to be used in the calculations of the torsional warping constants, C_w, and that square corners are assumed between elements. However, in most cases the expressions for C_w are given in terms of other parameters such as moment of inertia and cross sectional area, which are calculated including the rounded corner elements. Hence, the resulting C_w values are not totally consistent with the stated objective. Also, in the case of Z-sections, the C_w expression given is only for perpendicular edge stiffeners, which are rarely found in practice because such sections are not readily stackable. Usually, Z-sections have inclined edge stiffeners.

Contained in this technical paper are consistent torsional warping constant expressions, C_w, for the following section geometries:

1) equal-leg angle sections with edge stiffeners
2) C-sections with perpendicular edge stiffeners
3) hat sections
4) Z-sections with inclined edge stiffeners within the range of $0^0 \leq \theta \leq 90^0$

The resulting C_w expressions are all in terms of the original centerline section dimensions without rounded corner elements, i.e., square corners are assumed.

The derivations of the expressions were based on first principles as presented in Appendix B of the book by W.W. Yu[2], and the resulting expressions were checked by using MAPLE, a computer algebra system (CAS) that can integrate and perform symbolic calculations. As well, Mr. Richard Kaehler, P. Eng. with Computerized Structural Design, Inc. of Milwaukee, Wisconsin used "CARS" (a computer software package) to substantiate the correctedness of the resulting expressions.

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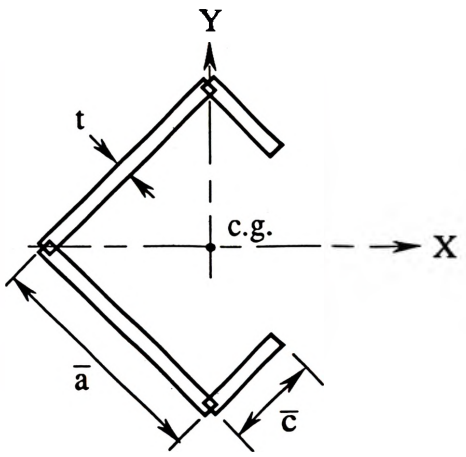
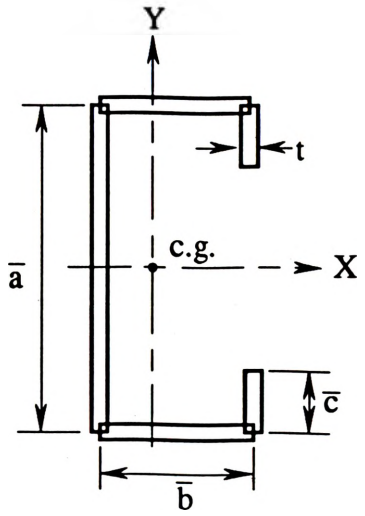
[1] American Iron and Steel Institute, *Cold-Formed Steel Design Manual*, Supplementary Information - Part III, Washington, DC, 1986.

[2] Yu, W.W., *Cold-Formed Steel Design*, Second Edition, John Wiley & Sons, Inc., New York, 1991



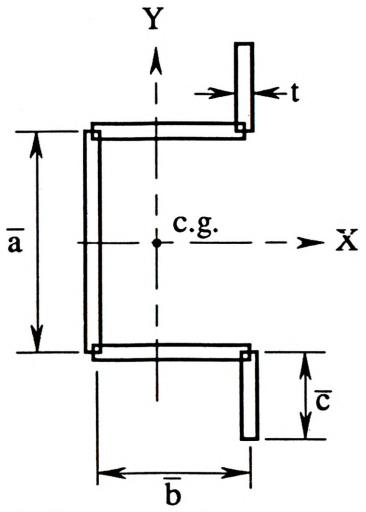
$$Cw = \frac{(\bar{a})^4 \cdot (\bar{c})^3 \cdot t}{6} \cdot \frac{(4 \cdot \bar{a} + 3 \cdot \bar{c})}{\left[2 \cdot (\bar{a})^3 - (\bar{a} - \bar{c})^3\right]}$$

Equal-Leg Angle Section with Edge Stiffeners



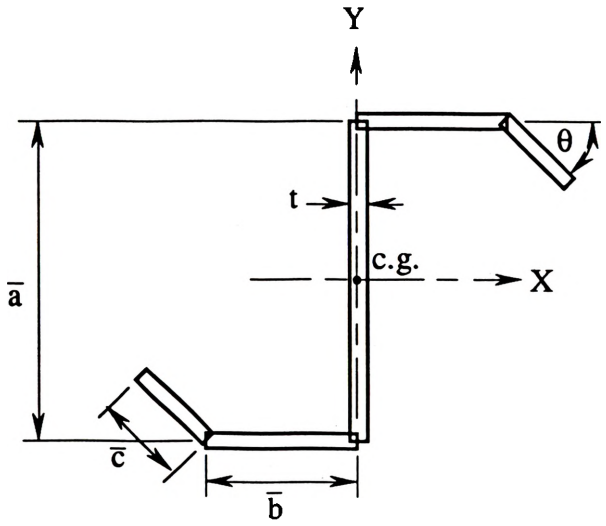
$$Cw = \frac{(\bar{a})^2 \cdot (\bar{b})^2 \cdot t}{12} \cdot \frac{\left[\begin{array}{l} 48 \cdot (\bar{c})^4 + 112 \cdot \bar{b} \cdot (\bar{c})^3 + 8 \cdot \bar{a} \cdot (\bar{c})^3 + 48 \cdot \bar{a} \cdot \bar{b} \cdot (\bar{c})^2 + 12 \cdot (\bar{a})^2 \cdot (\bar{c})^2 + 12 \cdot (\bar{a})^2 \cdot \bar{b} \cdot \bar{c} \ldots \\ +6 \cdot (\bar{a})^3 \cdot \bar{c} + 2 \cdot (\bar{a})^3 \cdot \bar{b} + 3 \cdot (\bar{a})^2 \cdot (\bar{b})^2 \end{array}\right]}{\left[6 \cdot (\bar{a})^2 \cdot \bar{b} + (\bar{a} + 2 \cdot \bar{c})^3 - 24 \cdot (\bar{a}) \cdot (\bar{c})^2\right]}$$

C-Section with Perpendicular Edge Stiffeners



$$Cw = \frac{(\bar{a})^2 \cdot (\bar{b})^2 \cdot t}{12} \cdot \frac{\left[\begin{array}{l} 48\cdot(\bar{c})^4 + 112\cdot\bar{b}\cdot(\bar{c})^3 + 8\cdot\bar{a}\cdot(\bar{c})^3 - 48\cdot\bar{a}\cdot\bar{b}\cdot(\bar{c})^2 - 12\cdot(\bar{a})^2\cdot(\bar{c})^2 + 12\cdot(\bar{a})^2\cdot\bar{b}\cdot\bar{c}\ldots \\ +6\cdot(\bar{a})^3\cdot\bar{c} + 2\cdot(\bar{a})^3\cdot\bar{b} + 3\cdot(\bar{a})^2\cdot(\bar{b})^2 \end{array}\right]}{\left[6\cdot(\bar{a})^2\cdot\bar{b} + (\bar{a}+2\cdot\bar{c})^3\right]}$$

Hat Section



$0^o \le \theta \le 90^o$

$$Cw = \frac{t}{12} \cdot \frac{\left[\begin{array}{l} (\bar{b})^2\cdot\left[4\cdot(\bar{c})^4 + 16\cdot\bar{b}\cdot(\bar{c})^3 + 6\cdot(\bar{a})^3\cdot\bar{c} + 4\cdot(\bar{a})^2\cdot\bar{b}\cdot\bar{c} + (\bar{a})^2\cdot(\bar{b})^2 + 2\cdot(\bar{a})^3\cdot\bar{b} + 8\cdot\bar{a}\cdot(\bar{c})^3\right]\ldots \\ +6\cdot\bar{a}\cdot\bar{b}\cdot(\bar{c})^2\cdot(\bar{a}+\bar{b})\cdot\left[2\cdot\bar{b}\cdot\sin\theta + \bar{a}\cdot\cos\theta\right] + 4\cdot\bar{a}\cdot\bar{b}\cdot(\bar{c})^3\cdot(2\cdot\bar{a}+4\cdot\bar{b}+\bar{c})\cdot\sin\theta\cdot\cos\theta\ldots \\ +(\bar{c})^3\cdot\left[2\cdot(\bar{a})^3 + 4\cdot(\bar{a})^2\cdot\bar{b} - 8\cdot\bar{a}\cdot(\bar{b})^2 + (\bar{a})^2\cdot\bar{c} - 16\cdot(\bar{b})^3 - 4\cdot(\bar{b})^2\cdot\bar{c}\right]\cdot\cos^2\theta \end{array}\right]}{\left[\bar{a}+2\cdot(\bar{b}+\bar{c})\right]}$$

Z-Section with Inclined Edge Stiffeners

CURRENT RESEARCH ON COLD-FORMED STEEL STRUCTURES

The Center for Cold-Formed Steel Structures has maintained a database for research on cold-formed steel structures. This information was based primarily on the committee report prepared by the ASCE Subcommittee on Current Research and Future Needs of the Committee on Cold-Formed Members. If you are currently conducting any research related to cold-formed steel structural members, connections, and assemblies or have just completed any recent projects, please provide the information listed for Survey of Current Research to the Center for our use. In addition to update our database, the Center also plans to prepare and publish a new Research Directory and Research Abstracts.

These new publications will include the research projects in the following areas:

Influence of cold work on material properties, buckling behavior and post-buckling strength of structural elements/sections/systems, shear diaphragms, bracing and stiffening of thin-walled members and structural systems, dynamic analysis of cold-formed steel structures, welded and bolted connections, special plated and shell type structures, design criteria, computer aided design, construction methods, application and energy conservation related to production and use of cold-formed steel structures, and other related subjects.

SURVEY OF CURRENT RESEARCH

1. Project title: _____

2. Investigators (Name, title, address, telephone number, Fax number, E-mail): _____

3. Sponsor (Name, address, amount of funding): _____

4. Abstract of the project (Use separate sheet as necessary): _____

5. Publications: _____

Date: _____ Signature: _____

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