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Numerical Analysis of Cold Formed Steel Compression Members Based on Buckling Profile Under Eccentric Loading

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Abstract: This paper notably investigated the strength (ultimate load) of the member by taking the buckling profile that commemorates the application of the load. This study mainly contravenes with the previous studies that are majorly dependent on the empirical formulas that fails to provide similar results that outrage in experimental results. Considering the pinned ends that compensate a perfect parabolic curve, which helps in assessing the load details, carried out potential studies. The principle which envisages the investigation is that load acting on the pre-stressing can be decided based on the profile of the tendon. The numerical study further proceeded by the simulation technique and determined the distortional buckling characterstics of the compression member. The use of harmonic sine(or)cosine waves make significant escalated factor for the application of mathematical model in engineering sciences but the results are dejected when compared to parametric analysis.

Index Terms: Distortional buckling, Harmonic wave, Parabolic profile, Pinned ends, Ultimate load.

I. INTRODUCTION

The beam column with slenderness ratio(l/r) greater than 22 is called slender column. High strength slender beam column is explicitly used in industrial parks installation due to owing to strength and stiffness properties. The numerical investigation of cold formed steel by using finite element analysis subjected to major axis bending agreed strength with combined shear and moment capacities of the specimen[1].The non linear inelastic analysis is used to determine the equilibrium state under eccentric loading .The post buckling characterstics can be entertained by redistributing the in-plane stresses within the buckled column. The modified direct strength method which is developed by the (AS/NZS) Australian and Newzeland code is seems to be more conservative for finding the ultimate load compared to American codes [2].

The top most attention and care should be taken to residual stresses which is developed during manufacturing of cold formed steel they can show a lot of influence on the post buckling strength of the member [3]. Highest load that is acting on the member is given by secant formula incase of negative eccentricities between shear centre and close to centroid and incase of positive eccentricity the torsional-flexural load plays a anchor role [4].The ultimate load of the column can be found by axial load-strain analysis procedure. Distortional mode developed in a member is included in NBR(Brazilian association 2001), using finite strip method the inelastic analysis is carried out to determine the elastic buckling stresses for various half wave lengths [5]. Beam-column theory is the conservativeprocedure to carry out the investigation oninitial imperfections, second order effects, local buckling due to residual stresses, variation of yield strength at corners [6]. The buckling type depends on the edge and intermediate stiffeners provided in the member which also takes consideration of non-linear analysis, geometric non-linearity [7]. In inelastic local and distortional buckling the strain capacity was decoded through finite element model extension to existing four point bending test that separates local and distortional buckling [8]. Post buckling strength of the stiffened compression plate elements makes them capable of resisting the stresses above buckling stresses and strains above that of yielding strains [9]. A finite element model of member subjected to bi- axial bending and torsion is engaged to study the large deflection and rotation analysis [10].The entire numerical analysis is based on the mathematical principles that expedite the application of mathematical principle in engineering sciences. First step in the numerical analysis is the application of the trail load that produce maximum bending moment and curvature from parameter study. The second step is to inculcate the parabola that is expected to come out of the given loading condition. Third step is to develop algebraic equation that needs to satisfy the given loading conditions.Since this is beam-column member to find the distortional buckling characteristics.A cold formed steel member mainly fails by the local buckling due to local imperfection and by distortional buckling at the cross section level. Numerical analysis is engaged for the outcome of the results related to the buckling profile of the member for different support conditions. The present investigation includes use of pinned supports for the generation of curve as shown in Fig. 1.

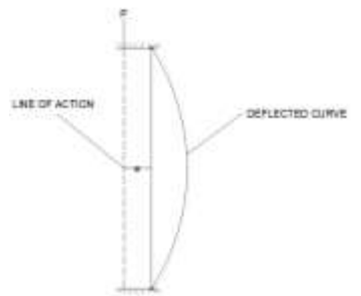

Fig. 1: Deflected Curve for Columns Having Pinned Ends

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A. Parametric Analysis

In recent investigation we are not conducting experimental set up so in this case parametric study need to be conductedso consider one column size on which the numerical analysis is to be conducted. Consider a section that is T1.2F80W150X where T,W,F represents the thickness of section ,web and flange dimensions. This is the member that is ultimately taken and numerical analysis is performed.

II. EMPERICAL RELATIONS FOR DETERMINING ULTIMATE LOAD

Generally for calculatingthe ultimate load in the buckling of plate element we consider the elastic critical stress that is given by the formula.

$$F_{CR} = 3\pi^2 KE/12(1-v^2)\times(t/b)^2 \quad (1)$$

K = coefficient which depends on the dimensions
E = elastic modulus of the material
v = poison ratio of the material
t = thickness of the plate
b =breadth of the plate

A. Post Buckling Behavior of Section

Let us consider a cold -formed steel channel section is subjected to the uniform bending by the application of the loads at the ends as shown in fig.(a). In this stage the local buckling is characterized by the undulations along the length of the member. The portion that is near to the supports got less effected and the middle portion got more effected due to the buckling effect. The stress developed across the section is considered to be non-uniform. From the observation it is the fact that applied moment is largely resisted by the edges not by the middle portion of the member..

B. Effective Width Concept

The best way to define the local buckling concept is to effective method. In this case most of the stresses are taken the edges only so stress at corners is multiplied by the effective width will give the sectional behavior. Magnitude guiding factor of the applied stress is the basic guiding factor for determining the effective width of the member. Effective width based on the compressive stress of the element is given by

When $f_c > 0.123p_{cr}$

$$b_e/b = 1+14((f_c/p_{cr})^{0.5}-0.15)^4)^{0.2} \quad (2)$$

Similarly when $f_c < 0.123p_{cr}$
$b_e = b$; b_e = effective width

C. Lipped Channels Buckling Coefficient

In case of lipped channels based on the buckling coefficient we can find the magnitude of buckling that is going to act on a member.
For lipped channels,

$$B_1 = 7-1.8h/0.15+h-1.43h^3 \quad (3)$$

Where h is equal to the ratios of the widths of flanges
$B_1 =$ buckling coefficient for one direction width

$$B_2 = B_1 h^2(t_1/t_2)^2 \quad (4)$$

t_1= thickness in longer direction
t_2= thickness in shorter direction

Incase of plain channel the values of buckling coefficient is given by
The buckling coefficient

$$B_1 = 2/(1+15h^3)^{0.5}+(2+4.8h)/(1+15h^3) \quad (5)$$

$$B_2 = B_1$$

The cold formed steel column under combination of axial load and uni-axial bending is affected by various factors such as slenderness ratio, cross-sectional dimensions, second order effects, geometric imperfections. The present analysis is based on the column member having the pin-ended supportsand load is acting eccentrically in uni-axial direction. Considera general term in a column such as 'l' is the length of the column, load is acting at an eccentricity (e), the mi-height deflection is taken as 'y_m'. The second order effects between lateral deflection and axial load which affects the magnitude of bending moment in non- linear analysis is taken into consideration.

The shape that is deflected due to the application of the load is assumed with a proper function of displacement such as y=f(x,y) the number of variables in a function depends on the uni-axial bending ,bi-axial bending. In this investigation we are considering only uni-axial bending so number of variables will be equal to one. In this investigation we are implementing the equations of cosine displacement functions.For a material the initial imperfections that effect the post buckling characters of the cold formed members are taken into effect in the analysis

Therefore, $y_m = y_0 \cos(\pi z/l)$ (6)

y_m = mid-height deflection
y_0 = amount of imperfections

The curvature of the beam column can be defined by following equation.

$$\text{Curvature } (c_c) = D^2(y) = (\pi/l)^2 \cos(\pi z/l)\, y_m \quad (7)$$

Curvature at mid-height is given by

$$c_c = (\pi/l)^2 y_m \quad (8)$$

The external bending moment acting due to applied load is a function of appliedload, imperfections, eccentricity, mid height deflection. During the manufacturing of any kind of material residual stresses are developed in molding. The insertion of harmonic curve in a grid is diagrammatically represented in Fig. 2.

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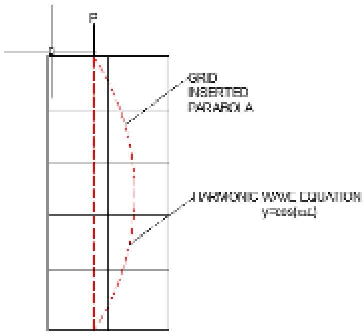

Fig. 2: Harmonic cosine wave

III. ROOT FINDING ALGORITHM

A number 'a' is called root of an equation f(x) =0 if f(a) = 0here 'a' is called the root of the equation. The following methods are adopted for the following investigation. Direct method and bisection methods are generally useful for finding roots. Direct method is suitable for algebraic equation but not useful for non- algebraic equation so bisection method is the method that is going to adopt in this investigation.

A. Bisection Method

To find the roots of the non-algebraic function accurately this is most accurate root finding algorithm. It is a iterative method which gives the roots of the desired parabola in between successive intervals with more degree of precision.suppose f(x) = 0 is anon-algebraic equation then it has only one root lies between the two real numbers x_o and x_1. This number is chosen such that $f(x_0)$ and $f(x_1)$ have opposite signs. Bisect the interval (x_0,x_1) into two halves and find

$$x_2 = (x_0 + x_1)/2$$

$f(x_2) \neq 0$ and $f(x_1),f(x_2)$ have same sign the root lies between [x_0 x_2] otherwise root lies between [x_2 x_1] repeating the procedure of bisection method until we obtain successive sub intervals which are smaller. The process is terminated when interval is smaller than design accuracy.Consider an equation and the process of finding roots can be known.

$$f(x) = e^x \sin x - 1 \tag{9}$$

Find the values of 'x' by keeping the values 0,1,2,3,4... in this case find the values of intervals whichgive the opposite signs. In the above said equation the values show opposites signs at f(2) and f(3). In this case after calculation we get the repeated roots at $x_4 = 2.9625$ and $x_5 = 2.9626$ by this we can show that root lies between $[x_4 x_5]$.

B. Newton-Raphson Method

It is a powerful and elegant method to find the roots of the equation. It is used to improve the results obtained by using the bisection method. Let x_0 be an approximate root of f(x)take $x_1 = x_0 + h$ be the correct root of f(x) by using Taylor series we can expand the equation(10) and pictorially represents as fig.(c).

$$f(x_0 + h) = f(x_0) + h f^1(x_0)$$

$$\text{Substitute } h = -f(x_0)/f^1(x_0) \tag{10}$$

IV. CURVE FITTING

The data or observations that are obtained from the above bisection and Newton-Raphson method may be plotted graphically and smooth curve is drawn joining the data points such a graph is called an approximate curve. The

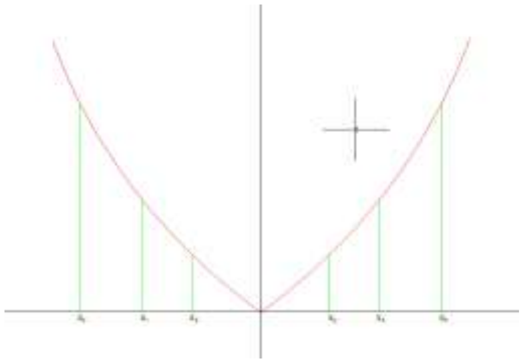

Fig. 3: Root finding algorithm for a curve

process of finding a curve that is best fit for the given data is called curve fitting. The best suitable method for curve fitting is methods of least squares.consider x_i, $y_i$for 1<i< m be the data and $e_i = y_i - f(x_i)$ be the error in observation i. which may be positive or negative in order to obtain the best fit we have to minimize the sum of the squares of the errors is denoted by E.

$$E = \sum (y_i - f(x_i))^2 \tag{11}$$

This equation gives the residual error that is going to incur in a curve while performing the exercise. Consider the second degree polynomial parabolic equation ($y = a+bx+cx^2$). By least squares method in order to minimize the we have to solve equations

$$\frac{\partial E}{\partial a} = \frac{\partial E}{\partial b} = \frac{\partial E}{\partial c} = 0 \tag{12}$$

After solving these differential equations the solutions that is obtained is given as

$$\sum y_i = na + b\sum x + c\sum x^2 \tag{13}$$

$$\sum x_i y_i = a\sum x + b\sum x^2 + c\sum x^3$$

$$\sum x^2 y_i = a\sum x^2 + b\sum x^3 + c\sum x^4$$

These are called normal equations by solving this equations we get the best fit for the given data points. In this investigation considering the values that is obtained for Newton-Raphsonmethod and bisection method is given by Table I.

Table I: Curve Fitting Coordinates

Y	0	1	2	3	4	5	6	7
X	10	21	35	54	40	28	12	0

Consider this table takes 'y' coordinates along the length of the column and the x coordinate as the perpendicular ordinate from y-axis. These tabular values can be solved by solving the normal equations. The normal equations will enumerate the constants that is obtained in the assigned parabolic equation.

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In this analysis the assumed parabolic equation will be in the form which consists of two constants 'a' and'b'.

$$y = ab^x$$

The following curve represents the parabolic curve in which 'a' and 'b' are constants.The following table represents the complete calculation procedure for complete calculation of the constants in the curve. Table II is Summation table to find constants.

Table II: Summation table to find constants

X	Y	Y =logy	xY	X^2
0	10	1	0	0
1	21	1.32221	3.08812	1
2	35	1.54406	5.1969	4
3	54	1.7323	7.8548	9
4	40	1.9637	11.5052	16
5	28	2.3010	15.6123	25
6	0	2.60205	19.4971	36

After summation of all the terms in the equations we get the required terms as follows

$\sum Y = 15.2506; \sum xY = 64.0762; \sum x = 28; \sum x^2 = 140$

Substitute this constants in the required normal equations solve the constants 'a' and 'b'.

$$15.2506 = 8a+28b \tag{14}$$

$$64.0764 = 28a+140b$$

On solving this above normal equations we get the constants such as

$$a = 10.3445$$

$$b = 1.79762$$

The final equation can be represented as follows

$$y = (10.3445)(1.7976)^x \tag{15}$$

This is the desired parabolic equation that is developed by the required ultimate load. The desired parabola suitable in a grid is represented in Fig. 4.

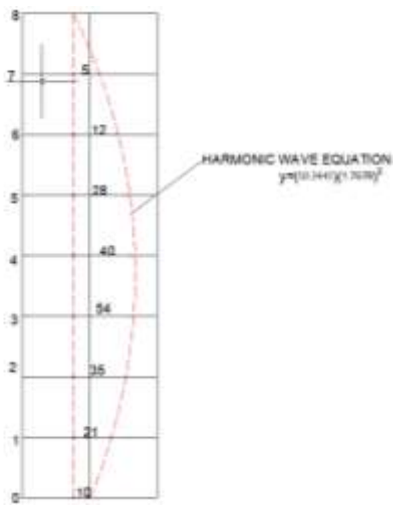

Fig. 4: Curve fitting in a grid

A. Lagrange Interpolation

To check whether the obtained curve is suited to the obtained tabular values then it is easily checked by the Lagrange's interpolation form. From the above obtained values the curve that can be obtained by Lagrange's interpolation is

$$y = 1.5x^3+2.86x^2+36 \tag{16}$$

the desired solution which closely related to the approximate solution that is obtained by curve fitting and other methods that can be used for verification is Gaussian forward and backward interpolation, Stirlingformula, Bessel's formula

V. COMPUTATIONAL PROCEDURE

The axial load-deflection analysis of beam-column members due to eccentric loading and inelastic analysis which tends to second order imperfections, and initial geometric imperfections. The mid-height deflection of beam-column is incrementally increased incase of the load-deflection analysis. For increase in each axial load by certain amount check the values of mid-height deflection. In the numerical analysis the ultimate axial load p_u of the column that undergoes on axial compression is first determined by using load-deflection analysis. Initially the applied load to be taken zero from zero onwards it incrementally increases from 0 to $0.9p_u$. The load is incrementally increased to a step size of $p_u/10$. For every axial load increment corresponding curvature at mid height is determined. For each curvature increment the internal moment is calculated from moment curvature relationship. The curvature of the column at the ends is adjusted iteratively to produce external moment m_e. A set of axial loads and moments is obtained from which axial load and moment interaction curves are drawn.

A. Input Data

1. Discretize the column into number of small elements.
2. Compute the axial load (p_u) from the axial load and deflection curve.
3. Initially the applied load $p_u = 0$
4. Initially the mid height curvature of the column $ø_m = dø_m$
5. Calculate mid- deflection (u_m)
6. Compute the internal moment (m_i) from the moment-curvature relationship.
7. Adjust the curvature at the column ends
8. Calculate the moments at the ends using the moment - curvature relationship.
9. Increase the curvature at mid-height of beam column $ø_m = ø_m + dø_m$.
10. Increase the load by $p_u = p_u + dp_u$.
11. Plot the axial load and moment diagrams

VI. COMPARISION WITH EXPERIMENTAL RESULTS

The precision of numerical model is examined by considering the parametric study. The predicted values that are obtained from parametric analysis and numerical

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analysis is slightly varied and the content of precisionbetween numerical value and parametric value is 37 percent. However post-yield strength of the column is correctly predicted by numerical analysis. The effects of local buckling it was the fact that local buckling was not considered in the non-linear analysis, flexural strength, ultimate axial strength of the column is overestimated. It can be observed that ultimate strength of the thin gauge column is reduced. However the effect of local buckling can be largely reduced by increasing slenderness of the column. The decrease in ultimate load capacity from zero column length is found to be 8.7%. For a column whose slenderness ratio greater than 150 the local buckling effects can be 0.9% so in the design of these columns we can neglect the effect of local buckling.

VII. MOMENT CURVATURE RELATIONSHIP

For the column the maximum moment can be obtained from the moment-curvature relationship. Moment-curvature relation can be obtained by continuously increasing the curvature and getting corresponding moments. The computed stress resultants for given curvature increments must be equal to the appliedaxial load and moment. since this is beam-column member to find the distortional buckling characteristics we assume the fundamental concept of the bending stress that is external moment due to the applied load should be made equal to the internal moment developed by the member in case of inelastic analysis. The corresponding buckling profile due to applied load resembles a perfectparabolic shape which in turn allows to perform the numerical activity that is required. The obtained profile is treated as the simple harmonic sine or cosine function which further precedes the process of finding the distortional characteristics of the half sine wave. At the mid height deflection the equilibrium condition that we deal with must satisfy.The obtained parabolic profile can be numerical analyzed by part harmonic functions, displacement functions, Newtonmethod, false position method and the ultimate of all these methods is to find the parameters associated with the parabolic generation. Table III denotes the Moment-curvature readings and Fig. 5 indicates Moment-curvature relationship.

Table III: Moment-curvature readings

Moment(kNm)	500	1500	2500	3000	4000
Curvature(mm)	0.02	0.042	0.06	0.087	0.07

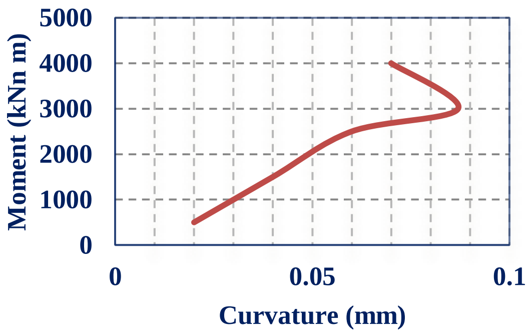

Fig. 5: Moment-Curvature relationship

VIII. EFFECTS OF COLUMN SLENDERNESS RATIO

The axial load was applied at an eccentricity (e/D) 0.1 for bending about the major principal axis of column cross-section. It is seen that with increasing in slenderness ratio significantly reduces flexural stiffness and ultimate axial strength of column. Increasing the slenderness ratio from 22 to 40, from 70 to 100 the ultimate axial strength of the column is reduced by 11.2%,32.8%and 54.0% respectively.

IX. CHECKING OF THE ABOVE RESULTS WITH FOURIER HARMONIC FUNCTIONS

Fourier harmonic transformations are commonly used to cross check the data available from the above prescribed methods. Earlier in this investigation we have taken a cosine function for expressing the buckling of the column that function is applied within the prescribed integrand limit that is from 0 to π. so that integrating of all the elements we get the required empirical relation for the harmonic function. In this investigation calculus part plays a major indicator role for finding the various aspects.

A. Methodology

Let us consider a function $f(z) = \cos(\pi z/l)$ be the simple harmonic function the equation is then perform Fourier transformation between the prescribed limits. Then conversion of the above equation into Fourier transform is

$$f(u) = \int_0^{\pi} \cos\left(\frac{\pi z}{l}\right) sinzdz \qquad (17)$$

$$f(u) = \int_0^{\pi} \cos\left(\frac{\pi z}{l}\right) coszdz$$

In the above equations f(u) represents the Fourier sine and cosine transforms that can be performed on the above harmonic equation. By performing all of these operations in between the limits the desired empirical relation as a function of sine and cosine can be obtained. The obtained value in Fourier transforms is quiet deviated from the results that are obtained from the curve fitting procedure. In other words we can say that f(u) is the amplitude function of the designated harmonic sine or cosine wave. Simplification of the above said equation is quite complex because it represents two variable functions of different order. Example for amplitude function is given in

$$f(u) = 1/l *(\pi/l^{1.158}+\pi^{0.8588}/l^{8.33})\int_0^{1.718} f(z)dz \qquad (18)$$

The above equation shows a complex integral transform which makes the calculations more complex and hence from MATLAB we can get the solution that is deviated from the above curve fitting solutions.

X. CONCLUSION

From the observations of the investigation it is the fact that while performing the numerical analysis of the any structural member with experience the application of the principles gives pleasant analytical experience. But in actual practice it is complex procedure to perform the mathematical calculations which are tedious in nature due to the application of the integrand principles in it. It is difficult to revoke the experimental values from the numerical analysis and there is large deviation in the values of numerical analysis because of calculation constrains and human made errors. Even one function is replaced by other it will greatly influence the magnitude of the error to a greater extent. In future there is a scope for performing the multi-nodal analysis by dividing the column into small number of elements with multiple nodes. The elements may be divided into triangles and rectangular elements. The triangular elements consists of two nodes and rectangular element consists of four nodes in general in practice triangular elements is taken into consideration for simplification purpose. From entire investigation it is found that ultimate load of the above preceding analysis shows that variation of ultimate load that is found from parametric study and numerical analysis is 30%-40%.

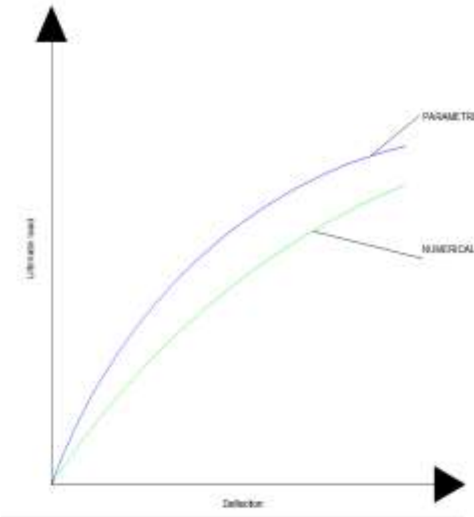

Fig. 6: Variation between parametric numerical values

REFERENCES

1. N. T. Nugyen., T. C. Fung, B.Young." Strength and behavior of cold-formed steel Z-sections subjected to major axis bending". *Journal of structural engineering*, Vol.132, Issue 10,2006,pp. 1632-1640.
2. Y. Huang, B.Young."Design of cold-formed lean duplex stainless steel members in combined compression and bending", *Journal of Structural Engineering*, Vol.141, Issue 5,2014, pp.04014138.
3. T. Pekoz, C. C. Weng. "Compression tests of cold-formed steel columns", *Journal of StructuralEngineering*, Vol.116, Issue 5, pp..1990,1230-1246.
4. L. L. Chan, S. Kitteppornchai. "Inelastic post-buckling behavior of tubularstruts." *J. Struct. Engrg.*,ASCE, Vol.114, Issue 5,1988,pp. 1091-1105.
5. D. B. Choudrai, G. M.Neto, J. M. Gonçalves, R. M.Malite.."Distortional buckling of cold-formed steel members", *Journal of Structural Engineering*, Vol.132, Issue 4,2006,pp. 636-639.
6. C. C. Weng, C. P. Lin."Study on maximum strength of cold-formed steel columns". *Journal of Structural Engineering*, Vol.118, Issue 1, 1992, pp. 128-146.
7. B. W. Schafer, S. Adany. "Buckling analysis of cold-formed steel members using CUFSM: Conventional and constrained finite stripmethods." Proc. 18th Int. Specialty Conf. on Cold-Formed Steel Struct.,Univ. of Missouri, Vol.200, Issue 7, 2006,pp. 39–54.
8. L. Wang, B. Young."Behavior of cold-formed steel built-up sections with intermediate stiffeners under bending. I: tests and numerical validation", *Journal of StructuralEngineering*, Vol.142, Issue 3,2015, pp.0401-5150.
9. Y. Shifferaw, B. W. Schafer. "Inelastic bending capacity of cold-formed steel members",*Journal of StructuralEngineering*, Vol. 138, Issue 4,2012, pp.468-48.
10. M.Yerner, T. Pekoz." Partial moment redistribution in cold-formed steel". *Journal of Structural Engineering*, Vol.111, Issue 6,1985,pp. 1187-1203.

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