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WEB CRIPPLING OF STAINLESS STEEL COLD-FORMED BEAMS

S. A. Korvink[1] and G. J. van den Berg[2]

ABSTRACT

The results of an investigation on the web crippling strength of cold-formed stainless steel channel sections are presented in this paper. The steels under consideration are AISI Type 430 stainless steel and a modified AISI Type 409, designated Type 3CR12 corrosion resisting steel.

The lipped channel sections were manufactured by a press braking process. Beams were tested in pairs, lips facing, in an interior-one-flange loading configuration.

Experimental results were compared with the theoretical predictions given in the 1991 edition of the Specification for the Design of Cold-Formed Stainless Steel Structural Members[1]. It was concluded in this study that the experimental results compare reasonably well with the theoretical predictions. For longer bearing lengths the theoretical strengths appear to be conservative.

INTRODUCTION

The usefulness of cold-formed structural members lies basically in its high strength-to-weight ratio compared with structural materials such as concrete and timber.

Beams with large plate width-to-thickness ratios are used more generally in the structural steel industry. When designing for flexure it is more economical to minimise the material in the web. Because of this trend in the reduction of web material the designer has to focus more thoroughly on checks for web buckling, web crippling, buckling due to shear, vertical buckling of the compression flange into the web as well as buckling due to the linear flexural stress distribution[9].

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Because of the high strength-to-weight ratio, cold-formed steel sections are ideally suited where lightweight construction is of primary importance. This implies the use of thinner sections. The thinness of sections leads to local instability and therefore web crippling as a general problem.

Local instability can occur where members have high width-to-thickness and high height-to-thickness ratios so that, in designing such members, care should be taken where stresses are excessive. Such excessive stresses are often induced by point loads, either applied or as reactions.

The use of stiffeners in these cold-formed steel members is more often than not impractical[3]. Where such loads are applied to channel sections and other sections with large web depths, web buckling, web crippling and often a combination of web buckling and web crippling can occur.

OBJECTIVE OF THE INVESTIGATION

The 1991 ASCE Specification for the Design of Cold-Formed Stainless Steel Structural Members[1] makes provision for the design of flexural members against web crippling based on the 1989 AISI Specification for the Design of Cold-Formed Steel Structural Members with Commentary[4]. The 1989 AISI[4] design specification may not be directly applicable to stainless steel structural members. The 1991 ASCE Specification for the Design of Cold-Formed Stainless Steel Structural Members[1], however, uses the equations for the evaluation of web crippling loads from the 1989 AISI[4] design specification. The validity of Section 3.3.4 "Web Crippling" of the 1991 ASCE Specification needed to be researched.

It is clear that[5], no matter which design specification one refers to for the calculation of web crippling loads, the calculations tend to be loaded with constants that need to be precalculated resulting in a tedious design procedure. To assist designers it is therefore necessary to develop equations that provide a reasonably fast and efficient web crippling check for a small but important part in the design of cold-formed structural flexural members.

The literature on cold formed stainless steel design[1] is very clear on the lack of experimental data available for the evaluation of web crippling of stainless steel structural members. It was decided, for this particular investigation, to research AISI Type 430 stainless steel and a modified Type 409 steel designated Type 3CR12 corrosion resisting steel in order to gain more knowledge on the behaviour of such steels under web crippling loading conditions.

The experimental work reported on in this paper forms part of an on-going research project on the web crippling of stainless steel cold-formed structural members.

THEORETICAL BACKGROUND

The theoretical analysis of web crippling under concentrated loading conditions is very complex. This can clearly be seen in the literature available on web crippling. Most research and therefore predictions as well as recommendations have been based on experimental results resulting in empirical solutions[6, 7, 8, 9]. These solutions have been generated over a number of years, initially with the investigations of plates that buckle under in-plane loading conditions.

Further development lead to the research of web crippling as well as the combined effects of web crippling and bending of flexural members.

The analysis of cold-formed steel structural sections require different attention compared to hot rolled structural steel sections. Because of the high width-to-thickness ratios of cold-formed structural steel sections, local instability at relatively low loads (for example loads that are transferred from purlins to girders and rafters) is not uncommon. Where loads are not transferred evenly into webs, web crippling failure, either bearing failure or buckling failure, can occur. Web crippling is caused by high localised stress concentrations, which in turn are caused by concentrated loads or reactions applied on a short length of beam. This condition can reduce the load carrying capacity of flexural members[9] as the bearing capacity of a beam on a support is governed by the web crippling resistance of such a beam[6]. The use of stiffeners is not always possible due to section geometry such as shape and thickness.

In 1986 Santaputra, Parks and Yu[9] investigated web crippling of high strength steel beams. Tests were carried out to determine the web crippling strength of webs of cold-formed steel beams fabricated from high strength sheet steels commonly used in the automotive industry. The high strength steels used in this investigation had yield strengths of 414 MPa to 1138 MPa (60 ksi to 165 ksi). The sections under consideration were hat sections as well as I-beams.

The investigation covered the following loading conditions (refer to Figure 1):

* Interior one flange loading (IOF);
* End one flange loading (EOF);
* Interior two flange loading (ITF);
* End two flange loading (ETF).

Santaputra et al[9] observed the following failure mechanisms:

- bearing failure or overstressing which occurs just under the bearing plates with small lateral deformations of the webs of the hat sections. I-sections show no lateral movement of the webs before ultimate loads are reached. The bearing plate penetrates the web as the load increases to ultimate and remains there;

- buckling failure: the load increases steadily until the ultimate load is reached. At the ultimate load the web becomes unstable and buckles, the load dropping suddenly thereafter.

ANSI/ASCE-8-90[1] DESIGN SPECIFICATION PROVISIONS

The 1991 Specification for the Design of Cold-Formed Stainless Steel Structural Members[1] published by the American Society of Civil Engineers (ASCE) covers web crippling of flexural members based on the 1989 Specification for the Design of Cold-Formed Steel Structural Members[4] published by the American Iron and Steel Institute (AISI). The design specifications in the AISI Specification are for the design of cold-formed carbon steel sections.

The conditions for application as well as the equations given in the 1991 ASCE Specification[1] pertaining to this particular investigation are the following:

For members consisting of single webs, of which opposite loads are spaced at a distance greater than 1,5 times the depth of the flat portion of the web measured in the plane of the web, h, and of which the interior reactions are the concentrated loads, the nominal strength, P_n, for a concentrated load or reaction for one solid web connecting top and bottom flanges is given by equation (1):

$$P_n = t^2 C_1 C_2 C_\theta \left(3{,}71 - 0{,}005\left(\frac{h}{t}\right)\right)\left(1 + 0{,}007\left(\frac{N}{t}\right)\right) \qquad (1)$$

For $F_y \leq 631$ Mpa

$$C_1 = (1{,}22 - 0{,}22k\,)\,k \qquad (2)$$

For $F_y > 631$ MPa

$$C_1 = 1{,}69 \tag{3}$$

$$C_2 = \left(1{,}06 - 0{,}06\frac{R}{t}\right) \le 1{,}0 \tag{4}$$

$$C_\theta = 0{,}7 + 0{,}3\left(\frac{\theta}{90}\right)^2 \tag{5}$$

$$45° \le \theta \le 90° \tag{6}$$

where

C_1	function of the yield strength of the material
C_2	dimensionless function of (R,t)
C_θ	dimensionless function of (θ)
F_y	yield strength of material
h	depth of the flat portion of the web measured in the plane of the web
k	$F_y/228$
N	bearing length
P_n	theoretical web crippling load
R	inside bend radius
t	web thickness
θ	angle between plane of web and plane of bearing surface

The following limitations are applicable to equations (1) to (6):

$h/t \le 200$

$N/t \le 210$

$N/h \le 3{,}5$

$R/t \le 6$

where (refer to Figure 2)

h	depth of the flat portion of the web measured in the plane of the web
N	bearing length
R	inside bend radius
t	web thickness

In the above-mentioned equations the value of F_y adopted by both the 1974[10] and 1991[1] specifications is that of longitudinal compression. The 1974 Specification[10] states that: "...Since no research work has been done in the Cornell project to study the problem of web crippling of beams made of high yield strength steels, a conservative approach has been taken by using the longitudinal compressive yield strength of the stainless steel which is the lowest value of the four yield strengths..".

The 1991 Specification[1] suggests the use of the longitudinal compression value without any particular reason. It is therefore assumed that the reason is as quoted above.

EXPERIMENTAL PROGRAM

Mechanical Properties

Uniaxial tensile and compression tests were carried out to determine the mechanical properties of the steels. Two specimens were taken from each plate from which the beams were fabricated, in both the longitudinal and transverse rolling directions. Therefore the specimens and results are designated longitudinal tension, LT, longitudinal compression, LC, transverse compression, TC, and transverse tension, TT. All specimens were tested using an INSTRON 1195 Universal Testing Machine[5].

Results

The initial modulus, E_0, the proportional limit F_p, defined as the 0,01 % offset strength, the yield strength, F_y, defined as the 0,2 % offset strength, were calculated for each specimen and the statistical data is given in Table 1. Refer to Figure 3 and Figure 4 for tensile and compression test results of Type 3CR12 corrosion resisting steel and Type 430 stainless steel respectively.

WEB CRIPPLING TESTS

Preparation of Test Specimens

Channel sections were fabricated using stainless steel Type 430 and Type 3CR12 corrosion resisting sheet steel. The channels were fabricated by the press brake method. The material thickness was kept constant at 1,6 mm and the web heights varied from 100 mm to 325 mm at increments of approximately 25 mm. Five specimen sets were prepared for each steel type, and each set was tested on a constant bearing length. The bearing lengths varied from 20 mm to 100 mm, at increments of 20 mm. Flange widths and lip widths were kept constant at 50 mm and 20 mm respectively. The ratios of the web heights and bearing lengths to the web thickness (h/t and N/t) are given in Table 2 and Table 3.

The beams were tested in pairs as shown in Figure 5, open ends facing.

The beam lengths were chosen such that the distance between the load application and the reaction areas were greater than 1,5h.

For some of the tests, small flat plates were bolted to the top flanges at quarter lengths to prevent lateral instability. Plates were also bolted to the bottom flanges at half distances between bearing plates and loading plates to prevent the bottom flanges from buckling outwards.

Bearing plates were bolted to the beam flanges and were simply supported on rollers.

Experimental Procedure

The beams were tested using an Avery-Denison loading apparatus. The loading rate was kept constant at 5 kN/min and the failure load was recorded digitally by the Avery-Denison.

Both beam webs buckled at the load application points before failure. At failure a large and sudden deformation occurred in the beams with larger web depths. This last deformation was also permanent.

A statistical average of 1,275 mm was calculated from 100 measurements and used as the inside bending radius throughout the calculations that followed.

Web Crippling Test Results

Experimental crippling loads, P_e, for Type 430 stainless steel and Type 3CR12 corrosion resisting steel are tabulated in Tables 2 and 3 respectively.

The failure mechanisms were bearing failures, equivalent to those described by Santaputra et al[9] mentioned earlier on in this report.

THEORETICAL COMPARISONS

ANSI/ASCE-8-90

In the calculation of web crippling loads according to the 1991 Specification for the Design of Cold-Formed Stainless Steel Structural Members, ANSI/ASCE-8-90[1] the following parameters and equations have been used:

- Longitudinal compression yield strength, F_y (LC) as given in Table 1.
- Average web thicknesses, average web heights as well as an average inside bend radius.
- Bearing length-to-web thickness ratios as given in Tables 2 and 3.
- Equations (1) to (6).

The web crippling loads, P_{nL}, obtained by applying the equations of ANSI/ASCE-8-90[1] as well as the ratio of the experimental web crippling loads, P_e, to the theoretical web crippling loads, P_{nL}, obtained by applying the equations of ANSI/ASCE-8-90[1] are given in Tables 2 and 3.

Figure 6 and Figure 7 present the theoretical web crippling loads for the different bearing lengths, P_{nL}, as solid lines and the experimental web crippling loads, P_e, as symbols.

* ANSI/ASCE-8-90

The calculation of web crippling loads according to ANSI/ASCE-8-90[1] has been repeated using the transverse compression yield strength, F_y, (TC). All other parameters were kept constant as before.

The theoretical web crippling loads, P_{nT}, obtained by applying the equations of ANSI/ASCE-8-90[1] as well as the ratio of the experimental web crippling loads, P_e, to the theoretical web crippling loads, P_{nT}, are given in Tables 2 and 3. Figure 8 and Figure 9 present the theoretical web crippling loads, P_{nT}, as solid lines and the experimental web crippling loads, P_e, as symbols.

DISCUSSION OF RESULTS

The channel sections failed because of flange bearing failure, with a clear imprint of the bearing plate in the flange.

The channel sections with larger web heights buckled in the top section of the web, creating buckle lines from the bearing plate in two opposite directions towards the beam ends. The extent of these lines were proportional to the web heights of the beams.

There is a gradual transition between bearing failure and buckling failure as a clear transition between these two mechanisms could not be observed.

The ratio of the experimental web crippling loads, P_e, to the theoretical web crippling loads, P_{nL}, obtained by applying the equations of ANSI/ASCE-8-90[1] are conservative except the values obtained for Type 3CR12 corrosion resisting steel where the longitudinal yield strength F_y (LC) was substituted by the transverse compression yield strength, F_y, (TC).

The web crippling loads tend to be more conservative with an increase in web slenderness ratio as well as an increase in bearing length. Refer to Tables 2 and 3.

CONCLUSIONS

The literature reveals different approaches in the theoretical analysis of the web crippling of flexural members. The literature also reveals the difficulty associated with the theoretical analysis of the web crippling of flexural members. Most of the studies rely on experimental evidence for the verification of a certain idea or approach.

The direct improvement brought about by a substitute yield strength indicates that the web crippling resistance of a stainless steel channel section is in some way dependent upon the transverse compression yield strength of the material. The general increase in accuracy of prediction failure loads with an increase in web slenderness indicates that, in the equations of ANSI/ASCE-8-90[1] more emphasis should be placed on the web slenderness section of the equation.

The web crippling modes observed in the experimental part of this study are in accordance with those observed by Santaputra[9] and include the following:

* bearing failure or overstressing which occurs in the sections with smaller web slenderness ratios. The bearing plates are imprinted in the flanges of the beams and small lateral deformations can be observed in the section of the beam webs adjacent to the position of the bearing plates,

* buckling failure where the bearing plates do not become imprinted in the flanges of the

beams. The web of a beam subjected to the crippling load buckles and this instability leads to the resulting failure of the beam web.

The transition between the two failure mechanisms cannot be distinguished clearly enough to draw a definite conclusion.

APPENDIX : REFERENCES

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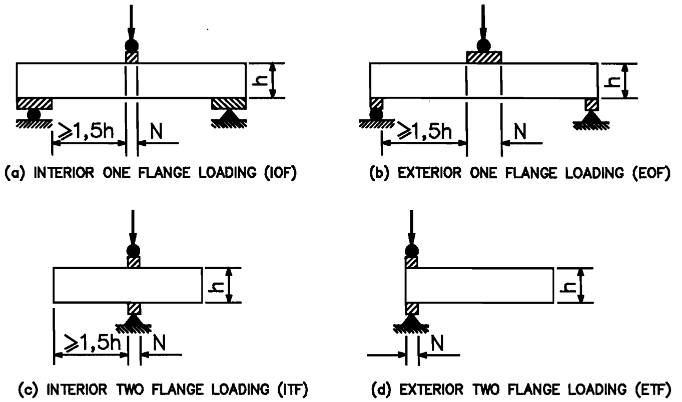
APPENDIX : NOTATION

C_1	function of the yield strength of the material
C_2	dimensionless function of (R,t)
C_θ	dimensionless function of (θ)
F_y	yield strength of material
h	depth of the flat portion of the web measured in the plane of the web
k	$F_y/228$
N	bearing length
P_n	theoretical web crippling load
P_{nL}	theoretical web crippling load using ANSI/ASCE-8-90[1] with the longitudinal compression yield strength, F_y, (LC)
P_{nT}	theoretical web crippling load using ANSI/ASCE-8-90[1] with the transverse compression yield strength, F_y, (TC)
R	inside bend radius
t	web thickness
θ	angle between plane of web and plane of bearing surface



(a) INTERIOR ONE FLANGE LOADING (IOF)

(b) EXTERIOR ONE FLANGE LOADING (EOF)

(c) INTERIOR TWO FLANGE LOADING (ITF)

(d) EXTERIOR TWO FLANGE LOADING (ETF)

Figure 1. Web crippling loading arrangements

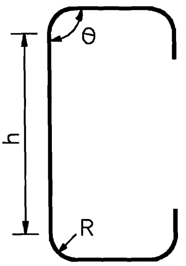


Figure 2. Definitions for h, R and θ

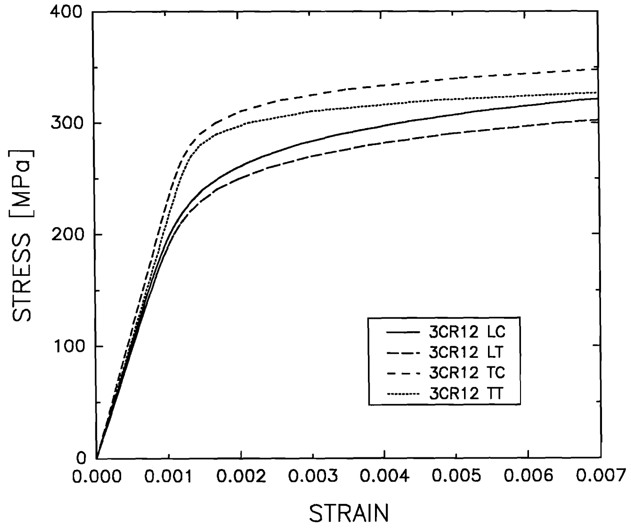


Figure 3. Stress-strain curves for Type 3CR12 corrosion resisting steel

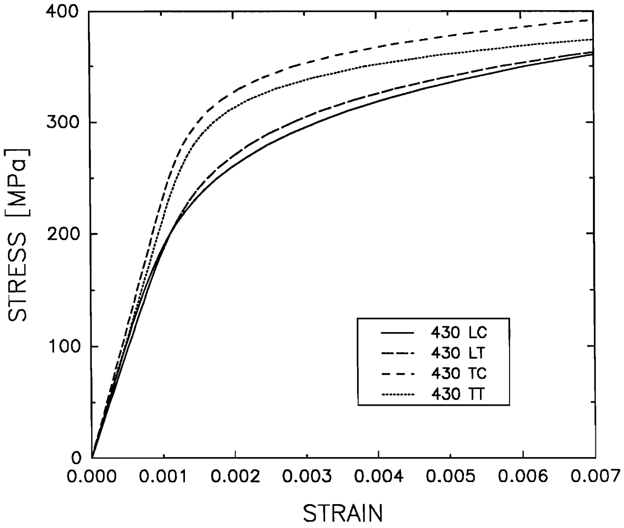


Figure 4. Stress-strain curves for Type 430 stainless steel

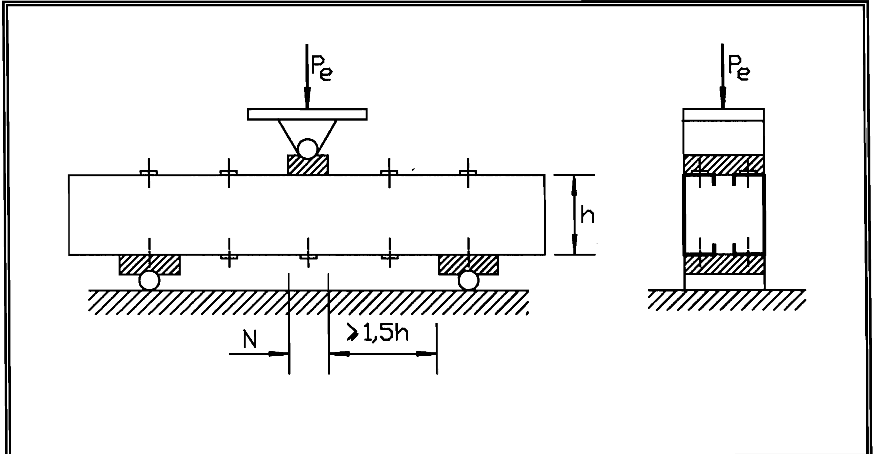


Figure 5. Assembly of test specimen

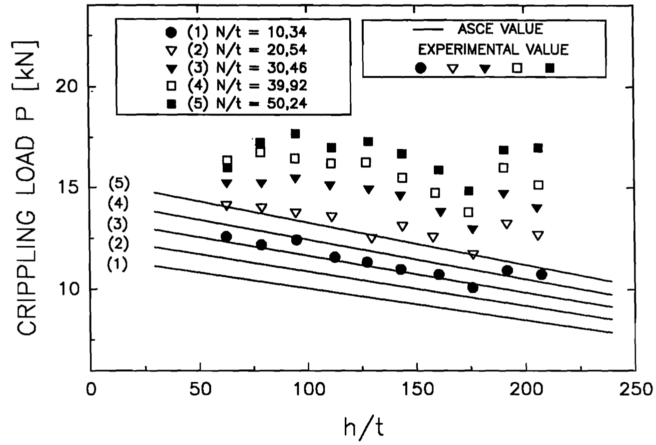


Figure 6. Experimental and theoretical web crippling loads for corrosion resisting steel Type 3CR12. ANSI/ASCE-8-90[1].

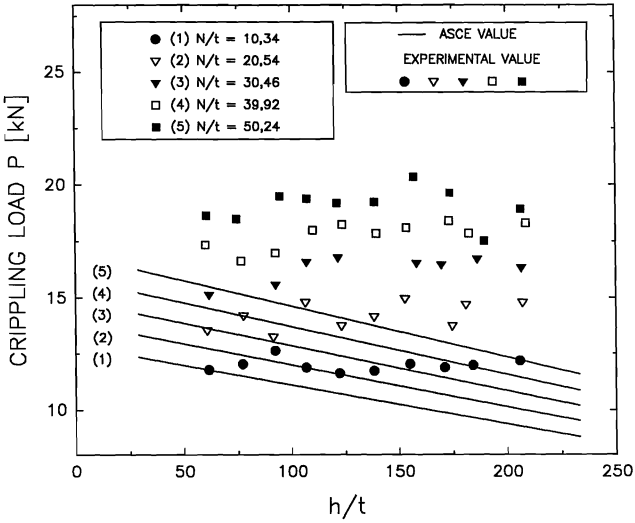


Figure 7. Experimental and theoretical web crippling loads for stainless steel Type 430. ANSI/ASCE-8-90[1].

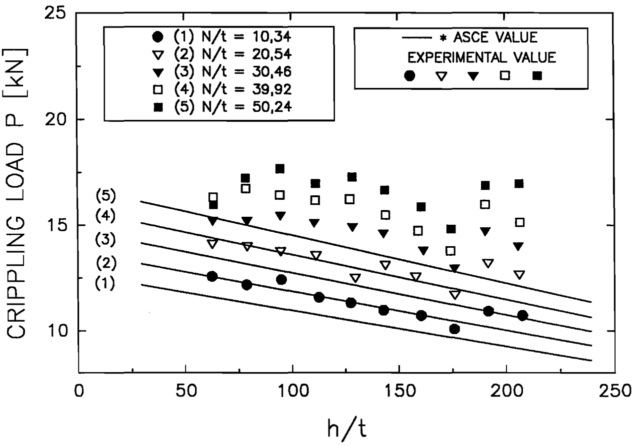


Figure 8. Experimental and theoretical web crippling loads for corrosion resisting steel Type 3CR12. * ANSI/ASCE-8-90[1].

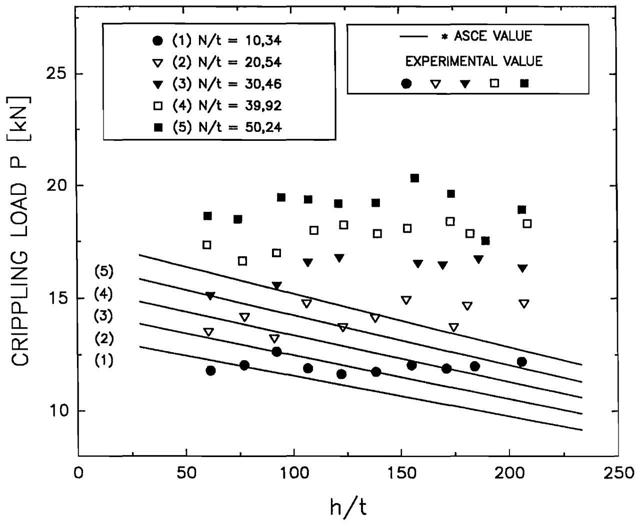


Figure 9. Experimental and theoretical web crippling loads for stainless steel Type 430. * ANSI/ASCE-8-90[1].

TABLE 1. MECHANICAL PROPERTIES of STAINLESS STEELS USED.

Number of Specimens 430 3CR12	21 14			21 13			12 17			10 17		
MECHANICAL PROPERTY	LONGITUDINAL TENSION			TRANSVERSE TENSION			LONGITUDINAL COMPRESSION			TRANSVERSE COMPRESSION		
	MEAN	STD DEV	COV %	MEAN	STD DEV	COV %	MEAN	STD DEV	COV %	MEAN	STD DEV	COV %
Initial Modulus E_0 [GPa] 430 3CR12	192,35 195,24	9,19 7,04	4,78 3,60	213,65 212,29	5,78 3,99	2,70 1,88	210,08 204,14	13,77 8,74	6,55 4,28	233,70 229,48	8,06 6,46	3,45 2,82
Yield Strength F_y [MPa] 430 3CR12	319,48 275,36	6,75 5,48	2,11 1,99	347,33 313,42	5,44 7,00	1,57 2,23	307,13 289,82	10,37 11,42	3,38 3,94	361,71 329,17	4,05 13,46	1,12 4,09
Proportional Limit F_p [MPa] 430 3CR12	212,36 207,29	7,88 19,52	3,71 9,42	274,31 275,63	9,51 10,14	3,47 3,68	186,87 212,22	11,27 13,80	6,03 6,50	281,92 279,25	16,16 23,25	5,73 8,33
Ultimate Strength F_u [MPa] 430 3CR12	495,54 443,22	14,43 12,69	2,91 2,86	524,14 459,99	5,99 10,73	1,14 2,33	-	-	-	-	-	-
Elongation 430 3CR12	29,13 31,10	1,43 2,26	4,93 7,27	29,50 30,59	1,31 2,48	4,45 8,11	-	-	-	-	-	-

TABLE 2. WEB CRIPPLING LOAD RATIOS P_e/P_n FOR TYPE 3CR12 CORROSION RESISTING STEEL

N/t	h (mm)	P_e (kN)	ANSI/ASCE-80-90[1]		*ANSI/ASCE-80-90[1]	
			P_{nL} (kN)	P_e/P_{nL}	P_{nT} (kN)	P_e/P_{nT}
10,34	102,1	12,60	10,902	1,156	11,921	1,057
	126,0	12,20	10,384	1,175	11,354	1,075
	150,2	12,45	10,005	1,244	10,939	1,138
	176,2	11,60	9,611	1,207	10,509	1,104
	201,6	11,35	9,620	1,180	10,519	1,079
	225,5	11,00	9,379	1,173	10,255	1,073
	251,1	10,75	8,992	1,196	9,832	1,093
	274,9	10,10	8,753	1,154	9,570	1,055
	301,3	10,95	8,614	1,271	9,418	1,163
	325,7	10,75	8,367	1,285	9,148	1,175
20,54	101,8	14,15	11,646	1,215	12,734	1,111
	126,4	14,05	11,232	1,251	12,281	1,144
	150,8	13,80	10,966	1,258	11,990	1,151
	176,4	13,60	10,686	1,273	11,684	1,164
	202,2	12,55	10,129	1,239	11,075	1,133
	225,4	13,15	10,014	1,313	10,949	1,201
	250,4	12,60	10,013	1,258	10,948	1,151
	275,4	11,75	9,471	1,241	10,355	1,135
	301,1	13,25	9,324	1,421	10,194	1,300
	325,6	12,70	9,186	1,382	10,044	1,264
30,46	102,2	15,25	12,485	1,221	13,651	1,117
	126,4	15,25	12,051	1,265	13,176	1,157
	150,7	15,50	11,766	1,317	12,865	1,205
	176,4	15,15	11,610	1,305	12,694	1,193
	201,7	14,95	11,024	1,356	12,053	1,240
	225,5	14,65	10,888	1,345	11,905	1,231
	251,1	13,85	10,308	1,344	11,270	1,229
	275,2	13,00	10,167	1,279	11,117	1,169
	301,2	14,75	10,140	1,455	11,087	1,330
	324,8	14,05	9,861	1,425	10,782	1,303
39,92	102,1	16,35	13,164	1,242	14,393	1,136
	126,5	16,75	13,014	1,287	14,229	1,177
	150,5	16,45	12,558	1,310	13,731	1,198
	176,3	16,20	12,236	1,324	13,378	1,211
	201,3	16,25	11,922	1,363	13,036	1,247
	225,7	15,50	11,470	1,351	12,541	1,236
	250,6	14,75	11,306	1,305	12,362	1,193
	274,1	13,80	11,012	1,253	12,040	1,146
	301,4	16,00	10,815	1,479	11,825	1,353
	326,1	15,15	10,504	1,442	11,485	1,319
50,24	102,1	16,00	14,096	1,135	15,412	1,038
	126,2	17,25	13,918	1,239	15,218	1,134
	150,8	17,70	13,443	1,317	14,698	1,204
	176,4	17,00	13,100	1,298	14,323	1,187
	201,7	17,30	12,619	1,371	13,798	1,254
	225,3	16,70	12,304	1,357	13,453	1,241
	251,4	15,90	11,956	1,330	13,073	1,216
	274,5	14,85	11,786	1,260	12,886	1,152
	301,4	16,90	11,564	1,461	12,643	1,337
	325,9	17,00	11,234	1,513	12,283	1,384
		MEAN C.O.V.		1,297 6,794		1,186 6,794

Refer to text for symbols and *

TABLE 3. WEB CRIPPLING LOAD RATIOS P_e/P_n FOR TYPE 430 STAINLESS STEEL

N/t	h (mm)	P_e (kN)	ANSI/ASCE-80-90[1]		*ANSI/ASCE-80-90[1]	
			P_{nL} (kN)	P_e/P_{nL}	P_{nT} (kN)	P_e/P_{nT}
10,34	102,3	11,80	11,914	0,990	12,391	0,952
	127,4	12,05	11,639	1,035	12,105	0,995
	151,8	12,65	11,372	1,112	11,828	1,070
	174,7	11,9	11,122	1,070	11,567	1,029
	201,1	11,65	11,013	1,058	11,454	1,017
	225,4	11,75	10,567	1,112	10,990	1,069
	248,1	12,05	9,970	1,209	10,369	1,162
	275,7	11,90	9,844	1,209	10,238	1,162
	301,2	12,00	9,911	1,211	10,307	1,164
	325,8	12,20	8,967	1,361	9,326	1,308
20,54	102,0	13,55	13,064	1,037	13,587	0,997
	126,2	14,20	12,198	1,164	12,687	1,119
	151,3	13,25	12,477	1,062	12,977	1,021
	175,7	14,80	12,188	1,214	12,676	1,168
	201,1	13,75	11,697	1,176	12,165	1,130
	225,4	14,15	11,410	1,240	11,867	1,192
	250,5	14,95	11,298	1,323	11,751	1,272
	274,9	13,75	10,110	1,360	10,515	1,308
	300,7	14,70	11,066	1,328	11,510	1,277
	325,2	14,80	9,532	1,553	9,914	1,493
30,46	101,6	15,15	13,582	1,115	14,126	1,072
	151,0	15,60	12,962	1,204	13,481	1,157
	175,4	16,60	12,852	1,292	13,367	1,242
	200,4	16,80	12,731	1,320	13,241	1,269
	251,3	16,55	11,325	1,461	11,778	1,405
	275,7	16,50	11,583	1,425	12,046	1,370
	300,1	16,75	11,088	1,511	11,532	1,453
	326,9	16,35	10,386	1,574	10,802	1,514
39,92	101,1	17,35	14,907	1,164	15,504	1,119
	126,8	16,65	14,349	1,160	14,924	1,116
	152,1	17,00	14,008	1,214	14,569	1,167
	176,0	18,00	13,078	1,376	13,601	1,323
	200,6	18,25	13,152	1,388	13,678	1,334
	249,7	18,10	12,692	1,426	13,201	1,371
	225,7	17,85	12,815	1,393	13,329	1,339
	275,1	18,40	11,765	1,564	12,236	1,504
	300,8	17,85	12,397	1,440	12,893	1,384
	325,1	18,30	10,728	1,706	11,157	1,640
50,24	101,6	18,65	15,816	1,179	16,449	1,134
	126,1	18,50	15,859	1,167	16,494	1,122
	150,8	19,50	14,144	1,379	14,711	1,326
	175,7	19,40	14,556	1,333	15,139	1,281
	199,6	19,20	14,406	1,333	14,983	1,281
	226,0	19,25	13,836	1,391	14,390	1,338
	251,3	20,35	13,098	1,554	13,623	1,494
	275,5	19,65	12,570	1,563	13,073	1,503
	300,3	17,55	12,219	1,436	12,708	1,381
	326,5	18,95	11,847	1,600	12,321	1,538
		MEAN		1,275		1,226
		C.O.V.		19,752		19,752

Refer to text for symbols and *.

SUMMARY

The results of an investigation on the web crippling strength of cold-formed stainless steel channel sections are presented in this paper. The steels under consideration are AISI Type 430 stainless steel and a modified AISI Type 409, designated Type 3CR12 corrosion resisting steel.

The lipped channel sections were manufactured by a press braking process. Beams were tested in pairs, lips facing, in an interior-one-flange loading configuration.

Experimental results were compared with predictions given in the American Society of Civil Engineers Specification for the Design of Cold-Formed Stainless Steel Structural Members, ANSI/AISI-8-90, 1991. It was concluded in this study that the experimental results compare reasonably well with the theoretical predictions. For longer bearing lengths the theoretical strengths appear to be conservative.

The literature reveals different approaches in the theoretical analysis of the web crippling of flexural members. The literature also reveals the difficulty associated with the theoretical analysis of the web crippling of flexural members. Most of the studies rely on experimental evidence for the verification of a certain idea or approach.

The direct improvement brought about by a substitute yield strength indicates that the web crippling resistance of a stainless steel channel section is in some way dependent upon the transverse compression yield strength of the material. The general increase in accuracy of prediction failure loads with an increase in web slenderness indicates that, in the equations of the American Society of Civil Engineers Specification for the Design of Cold-Formed Stainless Steel Structural Members, ANSI/AISI-8-90, 1991, more emphasis should be placed on the web slenderness section of the equation.

The web crippling modes observed in the experimental part of this study are:

- bearing failure or overstressing which occurs in the sections with smaller web slenderness ratios. The bearing plates are imprinted in the flanges of the beams and small lateral deformations can be observed in the section of the beam webs adjacent to the position of the bearing plates,
- buckling failure where the bearing plates do not become imprinted in the flanges of the beams. The web of a beam subjected to the crippling load buckles and this instability leads to the resulting failure of the beam web.

The transition between the two failure mechanisms cannot be distinguished clearly enough to draw a definite conclusion.