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# Web Crippling Behavior of Cold-Formed Steel Back to Back Lipped Channel Section with Web Holes

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***Abstract:***
*Cold- formed steel sections are used in many industrial building like truss work; these members include web holes for installation purpose. The Existing codes which are used for cold form steel do not consider the effect of such holes in web. In this work, behaviour of theoretical, experimental and finite element analyses were found and are used to investigate the effect of such holes on web crippling under concentrated loading conditions. Similarly the results were found between the three conditions. FE models used for the purpose of parametric study are the effect of different size and position of holes in web. Some of the important factors influencing the web crippling strength are the ratio of the depth of hole to depth of web. In this work investigation about web crippling strength reduction factors were done.*

## 1. Introduction

Cold-formed steel sections are used in building the wall studs and bus body construction. The holes which are provided in web are usually manufactured in industry, it is used for installation purpose. It has been little research on the web crippling of cold-formed steel sections with web holes. Investigate web crippling strength ratio of the depth of the hole to the web depth, and the ratio of the distance from the edge of the bearing plate to the flat depth of web. Asraf Uzzaman et al 19 test on a single lipped channel section investigate the web crippling strength on loading conditions are Interior-two-flange loading condition. ANSYS are used for the numerical investigation.

- Specimen dimensions The specimen details are tabulated in table 1

| Specimen | Web (d) mm | Flange ($b_f$) mm | Lip ($b_l$) mm | Thickness(t) Mm | Fillet mm | Holes mm | Length mm |
|---|---|---|---|---|---|---|---|
| B-BLCS 142 | 142 | 120 | 15.2 | 2 | 4.8 | 0 | 501 |
| B-BLCS 142 | 142 | 121 | 15.5 | 2.2 | 4.8 | 0 | 502 |
| B-BLCS 144 | 144 | 116.2 | 15.4 | 2.2 | 4.8 | 55 | 502 |
| B-BLCS 144 | 144 | 120.8 | 14.4 | 2.2 | 4.8 | 55.6 | 499 |

*Table 1: specimen details*

## 2. Theoretical Analyses

All the works are done with reference to Indian standard code, the sectional properties and other load details according to code are shown in table 2. According to IS801-1974 Theoretically the load carrying capacity of the section are shown in table 3 and table 4.

| Section | Area ($mm^2$) | C.G (mm) | $I_{xx}$ ($mm^4$) | $I_{YY}$ ($mm^4$) | $Z_{XX}$ ($mm^3$) | $Z_{YY}$ ($mm^3$) |
|---|---|---|---|---|---|---|
| B-BLCS 142 | 576.8 | 18.48 | $0.284 X 10^6$ | $0.27 X 10^6$ | $8.03 X 10^3$ | $3.858 X 10^3$ |
| B-BLCS 142 | 637.12 | 18.45 | $0.313 X 10^6$ | $0.307 X 10^6$ | $17.658 X 10^3$ | $4.33 X 10^3$ |
| B-BLCS 144 | 630.52 | 19.129 | $0.322 X 10^6$ | $0.271 X 10^6$ | $17.907 X 10^3$ | $15.09 X 10^3$ |
| B-BLCS 144 | 636.24 | 18.86 | $0.325 X 10^6$ | $0.305 X 10^6$ | $18.08 X 10^3$ | $16.99 X 10^3$ |

*Table 2: Section properties*

| Section | f ($N/mm^2$) | M=f x Zxx (KN.m) | W= M X 6 /L (KN) |
|---|---|---|---|
| B-BLCS 142 | 220 | $1.76 X10^6$ | 42.07 |
| B-BLCS 142 | 220 | $3.88 X10^6$ | 92.49 |
| B-BLCS 144 | 220 | $3.94 X10^6$ | 93.81 |
| B-BLCS 144 | 220 | $3.97 X10^6$ | 95.66 |

*Table 3: load carrying capacity of the section*
*As per IS 801-1974*

| Section | f ($N/mm^2$) | MC=POX Z (kN.m) | W= M X 6 /L (kN) |
|---|---|---|---|
| B-BLCS 142 | 220 | $1.78 X 10^6$ | 21.32 |
| B-BLCS 142 | 220 | $3.96 X 10^6$ | 47.33 |
| B-BLCS 144 | 220 | $4.02 X 10^6$ | 48.05 |
| B-BLCS 144 | 220 | $4.05 X 10^6$ | 97.58 |

*Table 4: Load carrying capacity of Different section*
*Based on BS 5950-1998*

**3. Experimental Investigation**

*3.1. Test Setup*
A test conducted on back to back lipped channel section as shown in fig 1

*Figure 1: concentrated loading condition without web holes*

From the test results graphs are plotted and are shown in fig 2 and fig 3

| Section | B/D ratio | Ultimate Load in (kN) | Max deflection at mid span |
|---|---|---|---|
| B-BLCS 142 | 0.84 | 10.20 | 6.80 |
| B-BLCS 142 | 0.85 | 9.99 | 6.70 |
| B-BLCS 144 | 0.81 | 10.80 | 8.60 |
| B-BLCS 144 | 0.83 | 10.80 | 8.60 |

*Table 5: Flexure test results*

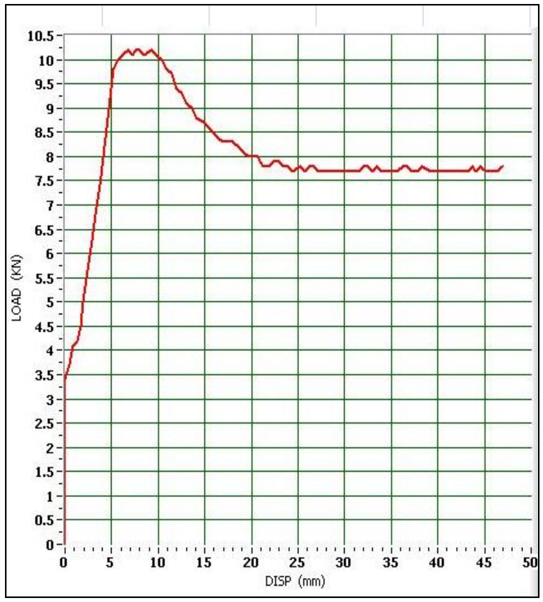


*Figure 2: SPECIMEN 1-B-BLCS 142 without web holes LOAD VS DISPLACEMENT*

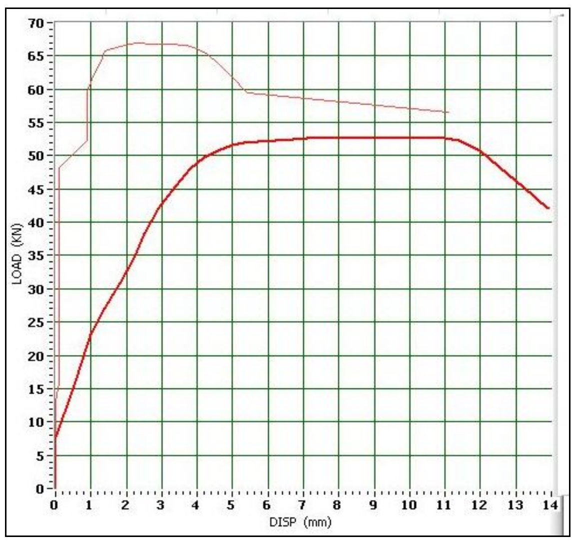


*Figure 3: SPECIMEN III-B-BLCS 144 with web holes LOAD VS DISPLACEMENT*

**4. Mode of Failure**

Local Buckling occurs in the mid span at the compression Flange. Details are shown in table6

*Figure 4: SPECIMEN 1-B-BLCS 142 without web holes*

| | | | | | |
|---|---|---|---|---|---|
| ELEMENT TYPE | SHELL (4 NODES 181) | | | | |
| MATERIAL PROPERTY | Material model | Linear | | Non-Linear | |
| | | Young's Modulus | E=2e5 | Yield Stress | 220 MPa |
| | | Poisson's ratio | 0.3 | Tangent Modulus | 2e4 MPa |
| MODEL | Flange width = 120,121,116.2,120.8 mm<br>Web = 142,142,144,144 mm<br>Lip = 15.2,15.5,15.4,14.4 mm | | | | |
| MESH SIZE | 10 mm | | | | |
| Support Condition | Simply Supported with concentrated load | | | | |

*Table 6: Numerical Investigation Analyses*

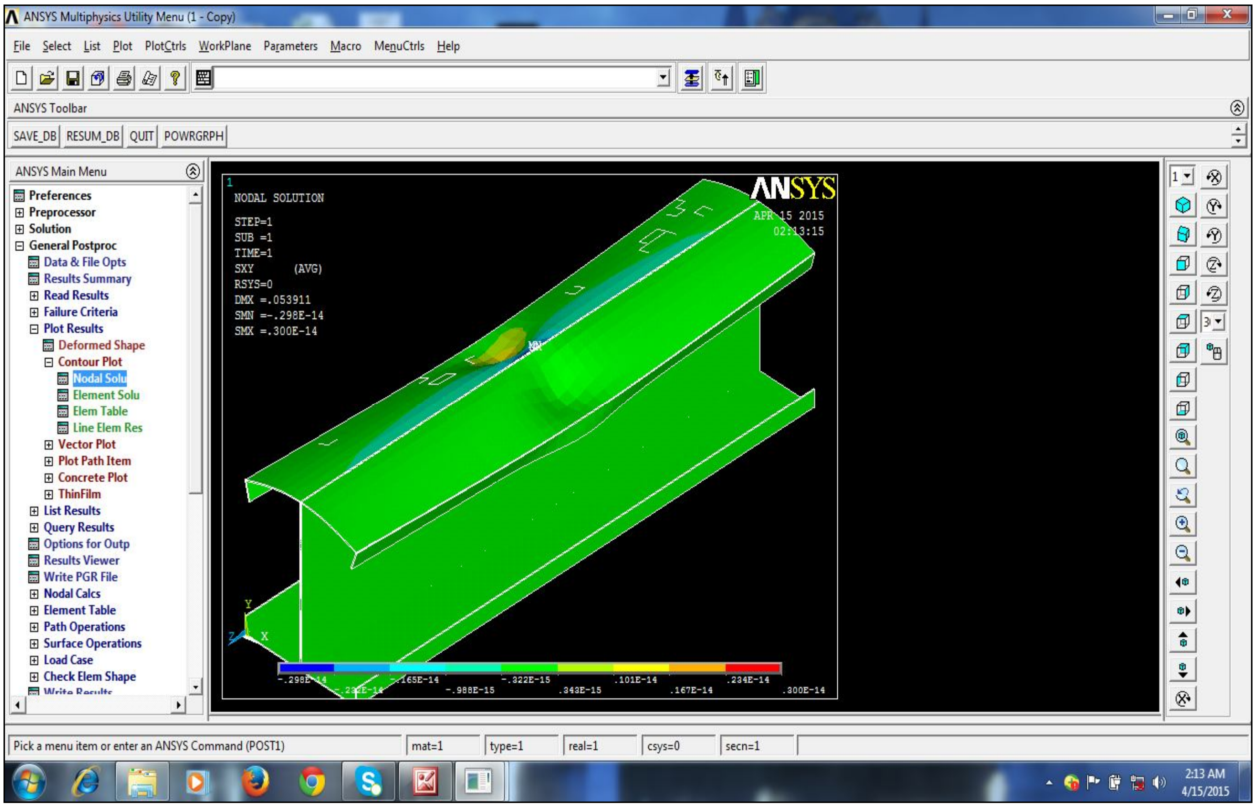


*Figure 5: Local buckling initiate the failure as shown in occurance of the bending zone*

| Section | Load carrying capacity (kN) |
|---|---|
| B-BLCS 142 | 10.21 |
| B-BLCS 142 | 9.79 |
| B-BLCS 144 | 10.81 |
| B-BLCS 144 | 10.79 |

*Table 7: SECTION LOAD DEATILS*

## 5. Comparison of Results

From the numerical analysis (ANSYS) the failure pattern obtained matches with the experimental and it shown table 8

| SECTION | Web slenderness (h/t) | Ratio (a/h) | IS801-1974 | IS5950-1998 | EXPERIMENT | ANSYS |
|---|---|---|---|---|---|---|
| B-BLCS 142 | 70 | 0 | 42.07kN | 21.32kN | 10.20kN | 10.21kN |
| B-BLCS 142 | 63.5 | 0 | 92.49kN | 47.33kN | 9.99kN | 9.79kN |
| B-BLCS 144 | 64.4 | 0.4 | 93.81kN | 48.05kN | 10.80kN | 10.81kN |
| B-BLCS 144 | 64.45 | 0.4 | 95.66kN | 97.58kN | 10.80kN | 10.79kN |

*Table 8: Results of theoretical, Experimental and Numerical Analysis*

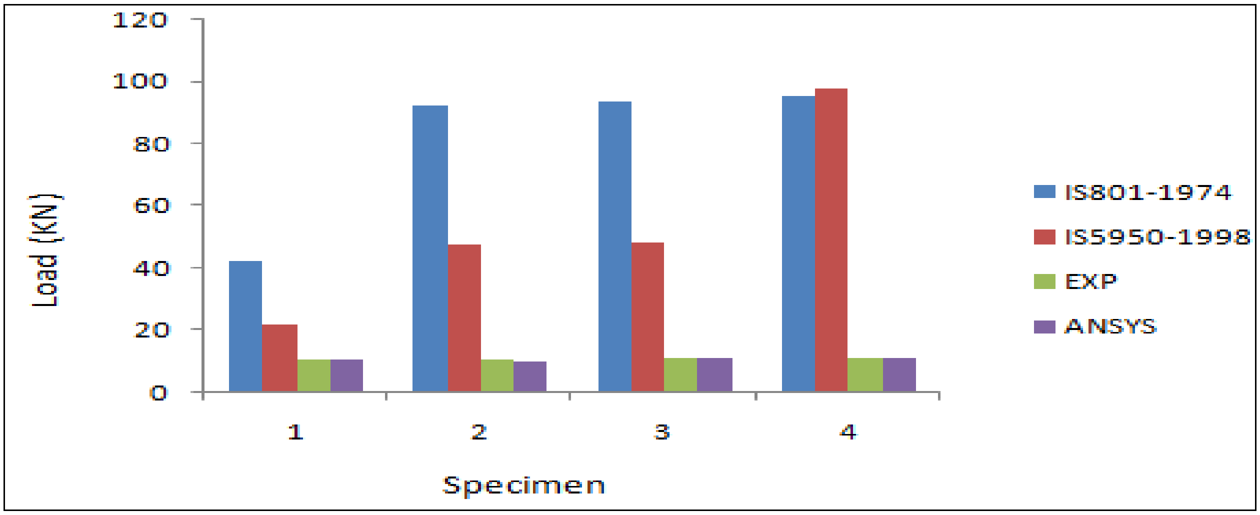


*Figure 6: shows the different category results*

**6. Conclusion**

The theoretical, experimental and the numerical investigation of back to back lipped channel section with and without circular web holes subjected to web crippling strength is investigated. The tests are conducted on concentrated loading condition. The web slenderness and diameter of web holes are varied to investigate web holes of the web crippling strength. The finite element models are shown the web crippling behavior of the back to back lipped channel section both with and without web circular holes. Then the different sizes of the cross-sections and the web holes on the web crippling strength of the back to back lipped channel section is studied. It is shown the ratio of a/h and h/t are the primary parametric relationships, influencing the web crippling behavior of the back to back lipped channel section with the web holes. The strength reduction factors are generally conservative and agree well with the experimental and numerical results, but theoretical values are very high compared to the both. It is concluded that back to back lipped channel section with and without web holes shows good performance when loading is done.

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