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ANALYTICAL STUDY ON COLD FORMED STEEL FLEXURAL MEMBERS USING FINITE STRIP METHOD

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Abstract* — To the date, Cold Formed Steel structural members have been increasingly used to improve the strength and performance in practice provided buckling is properly dealt. These cold formed steel members can be produced in a wide variety of section profiles, e.g. Channel(C) sections, Z – sections, angle sections (L), tubular sections and hollow flange section. The escalating demand of economic and efficient materials has favoured adapting the Cold Formed Steel as it has the effect of increasing the yield strength of steel as it works well in to the strain hardening range. In spite of being expedient it suffers a serious disadvantage that it is susceptible to buckling due to its slenderness, mainly under compression. But hollow flange section has high buckling capacity due to its unique shape. The distortional buckling is eliminated by the torsionally rigid hollow flanges and its local buckling capacity is improved due to the absence of free edges and reduced width of the web. The study is focused on optimizing the structural dimensions of cold formed hollow steel channel sections using finite element software ABAQUS 6.16. The most efficient channel section with respect to loads and stresses identified. The sections having breadth smaller than the depth with respect to the adjacent member withstands layer loads and intron subjected to out of plane moments between each other.

***Keywords*— Cold formed steel, ABAQUS 6.16, Finite Strip Method, Channel Section.**

I. INTRODUCTION

Cold-formed steel members are normally utilized in building construction either as a main structural part like beams, columns, frames, etc., or as a secondary structural part like roof purlins. It will be economical than hot-rolled members because of their high strength/weight magnitude relation, light-weight weight and their straightforward strategies of fabrication and construction. The strength and behavior of cold formed steel members are ruled by the fabric and sectional properties. It will be improved by numerous ways in which the flexural strength of the cold-formed steel section in bending is mostly improved by introducing numerous innovative sections like hollow projection section. This work aims to develop optimized cold formed steel hollow channel sections among the chosen to withstand higher load with lower deflection by executing experimental and analytical investigations. In this work it is intended to focus on maintaining constant weight justifying optimization, by varying the sectional dimensions using finite element software ABAQUS 6.16. The aspect ratio of flanges were varied as 0.5, 1, 1.6, 2, 2.5 by maintaining constant weight. The length of all the specimens was kept constant as 2000mm. Finally the analytical results for the sections is compared to find out the optimal section exhibiting better load carrying capacity and flexural behavior.

II. NUMERICAL INVESTIGATION ON FLEXURAL MEMBERS

2.1 ABAQUS

Abaqus can be used to study more than just structural (stress/displacement) problems. It can simulate problems in such diverse areas as heat transfer, mass diffusion, thermal management of electrical components (coupled thermal-electrical analyses), acoustics, soil mechanics (coupled pore fluid-stress analyses), and piezoelectric analysis. Abaqus offers a wide range of capabilities for simulation of linear and nonlinear applications. Problems with multiple components are modeled by associating the geometry defining each component with the appropriate material models and specifying component interactions. In a nonlinear analysis Abaqus automatically chooses appropriate load increments and convergence tolerances and continually adjusts them during the analysis to ensure that an accurate solution is obtained efficiently.

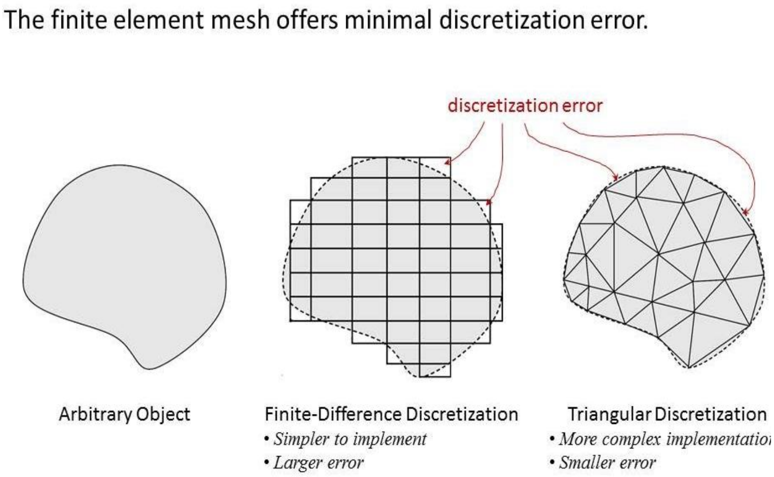

Fig.1 Finite Element Discretization

2.2 DEVELOPING OF HOLLOW CHANNEL SECTION

The finite element ABAQUS is a software suite for finite element analysis and Computer-aided Engineering. Using this model, the load-deflection behavior and the failure pattern of the Cold Formed Steel Hollow Channel beams is obtained. Every complete finite-element analysis consists of 3 separate stages:

- Selection of element type
- Assigning material properties
- Modeling and meshing the geometry

2.3 SECTION GEOMETRY

A typical Hollow channel specimen configuration, with a length of 2000 mm and cross-section dimensions as shown in the figure 3.3, was used for the analysis. The parameters under investigation included:

a) Five different specimens selected based on the priori- aspect ratio (B/D) of 1.0, 1.25, 1.5, 1.75, 2.0 and five different specimens with varying aspect ratio (D/B) of 1.25, 1.5, 1.75, and 2.0.

b) All the specimens having constant thickness of 2mm

c) All the specimens having constant profile length of 385mm.

d) All the specimens having nominal yield strength of 250 MPa.

This is to ensure the weight of the specimens remain constant to vindicate the comparison and optimization. The detailed configurations of the Hollow channel sections are tabulated as shown Table

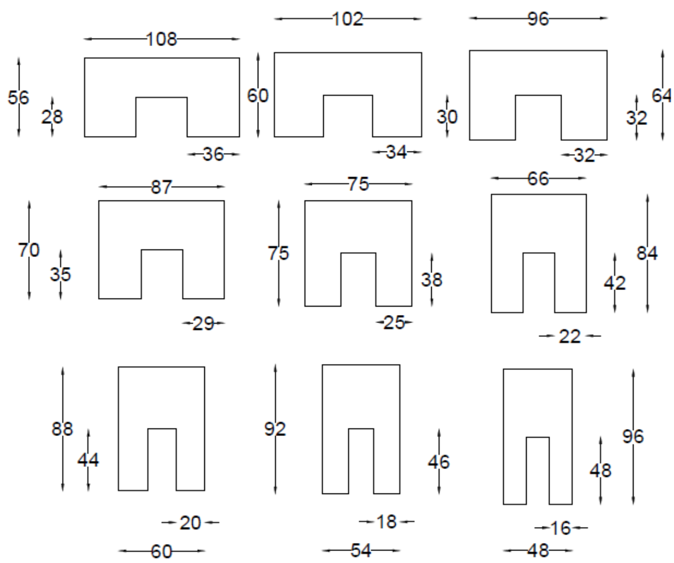

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Fig.2 Geometry of the proposed Hollow Channel sections

Table 1 Configurations of the Specimen

S. No	Breadth, B(mm)	Depth, D(mm)	Aspect Ratio (B/D)	Rib Breadth, B(mm)	Rib Depth, D(mm)
1	75	75	1	25	37.5
2	66	84	1/1.25	22	42
3	60	88	1/1.5	20	44
4	54	92	1/1.75	18	46
5	48	96	1/2	16	48
6	87	70	1.25	29	35
7	96	64	1.5	32	32
8	102	60	1.75	34	30
9	108	56	2	36	28

These beam specimens were analysed. As mentioned earlier the buckling occurs in the compression zone and this work intend to make the specimens equally strong in compression and tension which validate the selection of the following geometry for the specimens. The dimensions of the ribs are chosen in such a way that the breadth of the rib is one third of the total breadth of the specimen and the depth of the rib is half the total depth of the specimen, for all specimens as shown in the figure below.Modelling is done in ABAQUS 6.16 with 3D- Deformable Shell Element.

2.4 MATERIAL PROPERTIES

In most materials, at crystalline scale, plasticity in metals is usually a consequence of dislocations. Elastic deformation, however, is an approximation and its quality depends on the time frame considered and loading speed. If, as indicated in the graph opposite, the deformation includes elastic deformation, it is also often referred to as Elasto-plastic deformation or elastic-plastic deformation. The young's modulus is given for thickness of 2mm is obtained from the stress-strain curve from Coupon test results. The Poisson ratio is given as 0.3.The yield stress and plastic strain values are calculated from engineering stress -strain and are given to the flexural member.

2.5 MODELING AND MESHING

The modelling of hollow flange beam was started by creating three dimensional, deformable SHELL part in ABAQUS. The shell element (S4R) was used in all the finite element models. Finite element models simulating the simply supported boundary conditions and two-point loading were developed. The size of the mesh taken as 1cm and surface-to-surface interactions was created between the stiffener and beam section & tie constrains are given at both ends of the section.Quadrilateral meshing is done to the model by fixing the global seed as 10. This cell shape is a basic 4 sided one. It is most common in structured grids. Quadrilateral elements are usually excluded from being or becoming concave.

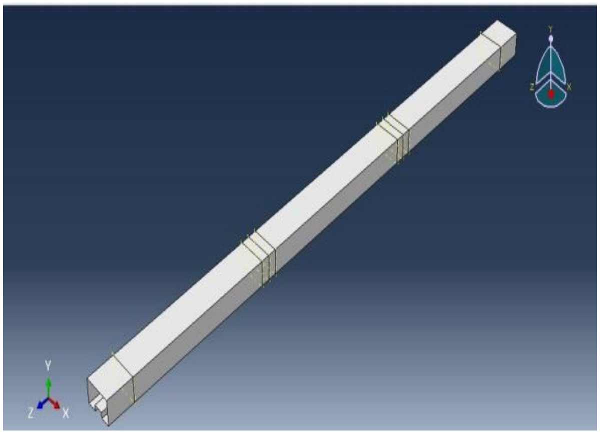

Fig.3 Modelling of Hollow Channel section

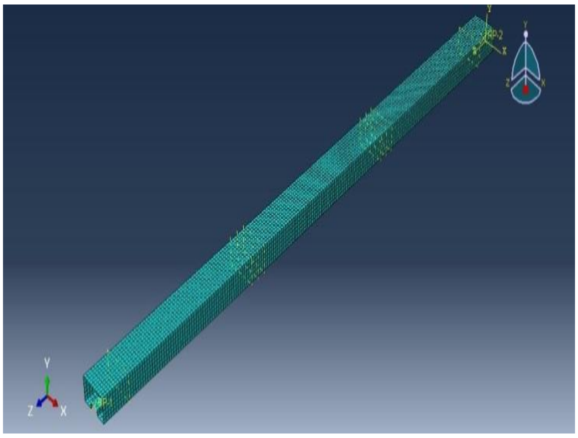

Fig.4 Meshing of Hollow Channel section

2.6 ANALYSIS

Boundary conditions in Abaqus/CAE take effect through different steps where we may be applying different load cases to a model. BC-1 is given by restraining rotation and displacement (U3 and UR3) and BC-2 is given by restraining displacement (UR3). This means that when the model solves Step given in Boundary condition, it uses BC-1 andBC-2.If there are any parameters like displacements to control, they can be changed from the manager as well Non - linear analysis is carried out by enabling the nlgeom option in the Step and Static Riks method is created. The deformation may be composed of either rigid body translations and rotations, or significant strains, or a combination of both.

III RESULTS AND GRAPHS

3.1 VON MISES STRESS CONTOUR

The Von Mises yield criterion also known as the maximum distortion energy criterion suggests that yielding of a ductile material begins when the second deviatoric stress invariant reaches a critical value. It is part of plasticity theory that applies best to ductile materials, such as some metals. Prior to yield, material response can be assumed to be of a nonlinear elastic, viscoelastic or linear elastic behavior.The contour plot of Von – Mises stress for aspect ratios 1 .0, 1.25, 1.5, 1.75, 1/1.25, 1/1.5, 1/1.75, 2.0 thickness 2mm is obtained by numerical investigation using ABAQUS 6.16. The stress contours are maximum at the top and mid span regions, near the stiffeners. The top portion of the section ch75 behaves as the stiffened element which resists local buckling and fails by lateral torsional buckling as shown in the figure 5. The maximum value of stress obtained is 398.6 kN/m^2. The failure occur at the midspan of the specimen

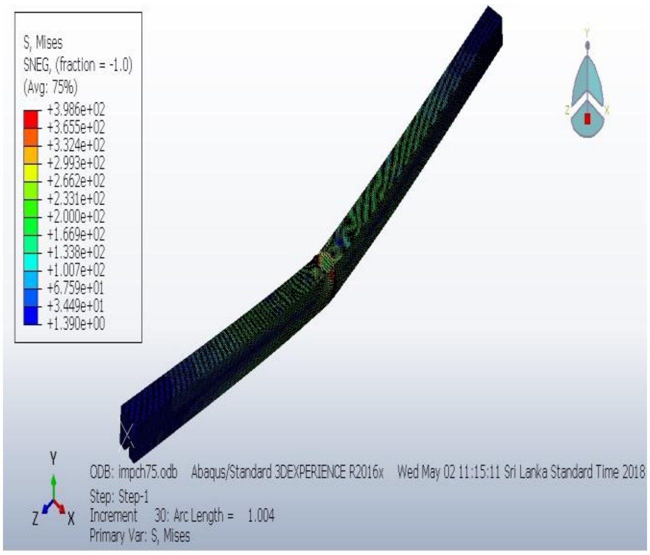

Fig.5 Von Mises Stress Contour for Ch75

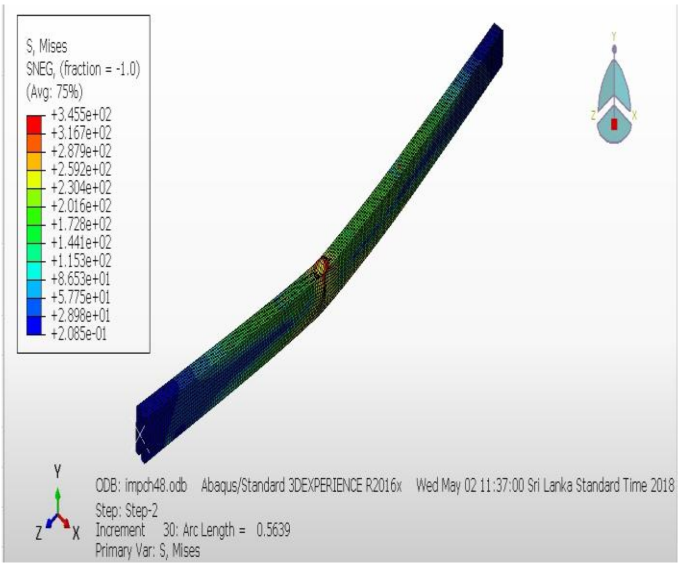

Fig.6 Von Mises Stress Contour for Ch48

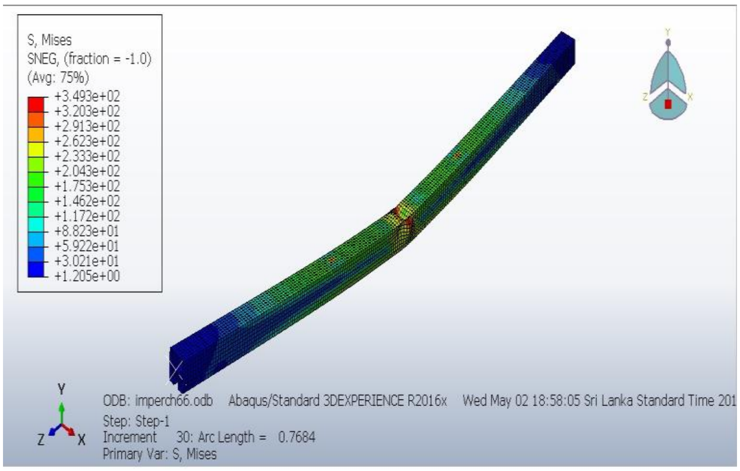

Fig.7 Von Mises Stress Contour for Ch48

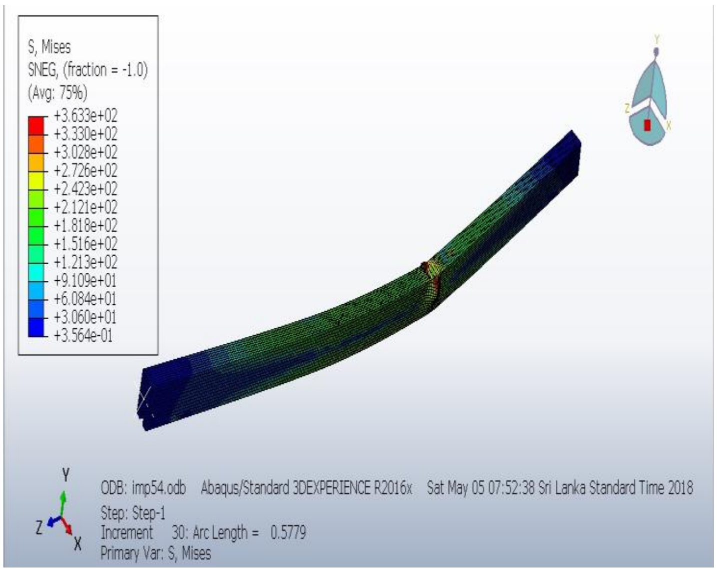

Fig.8 Von Mises Stress Contour for Ch54

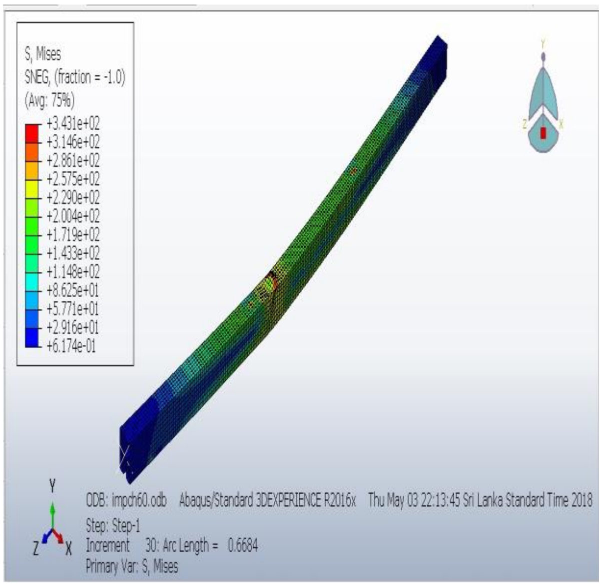

Fig.9 Von Mises Stress Contour for Ch60

The sections with greater depth (ch48, ch54, ch60 & ch66) withstand local buckling to some extend and the failure pattern progresses along the depth of the section. The section fails at the locations in the close proximity of the stiffeners. As the depth of the specimen decreases, the failure location glides from the vicinity of the stiffener to the midpoint of the specimen. As in the case of ch75, it can be featured that the failure point is at the mid span

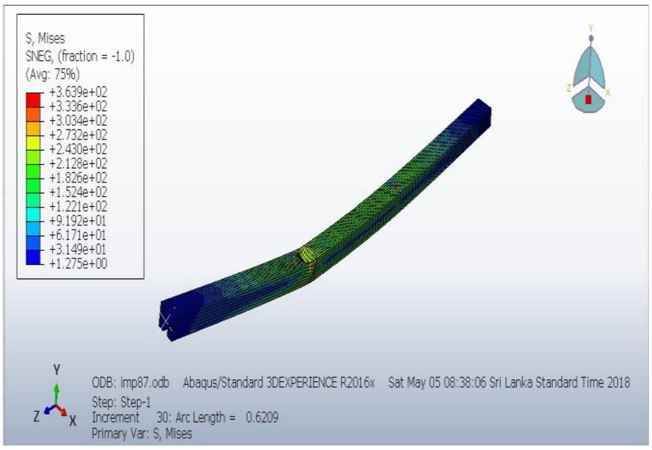

Fig.10 Von Mises Stress Contour for Ch87

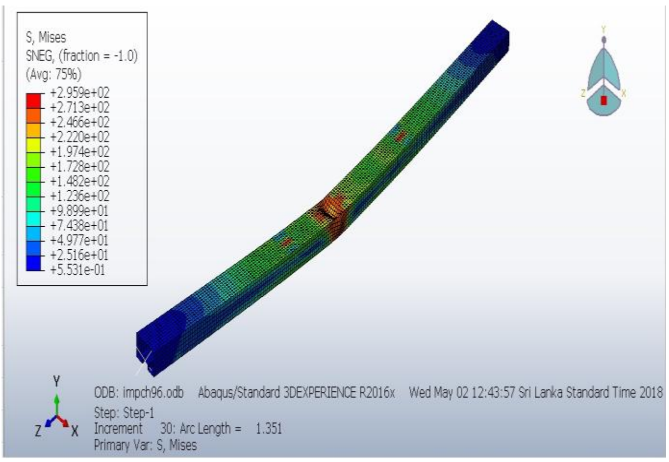

Fig.11 Von Mises Stress Contour for Ch96

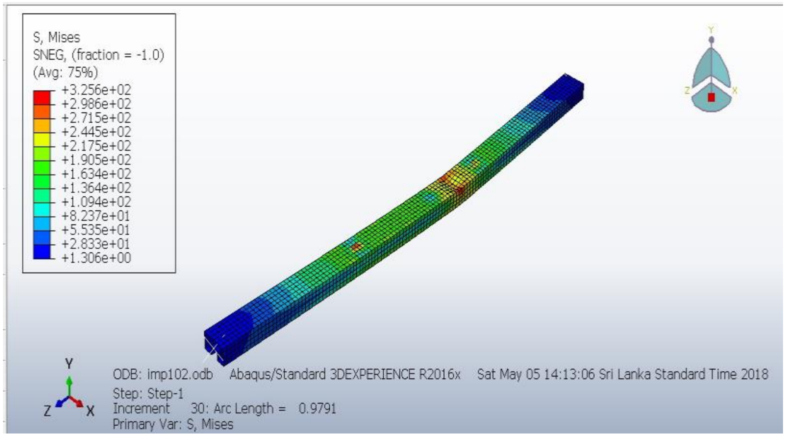

Fig.12 Von Mises Stress Contour for Ch102

The sections with greater breadth (ch87, ch96, ch102& ch108) don't withstand local buckling as the greater breadth makes it susceptible to buckling.to some extend and the failure pattern progresses along the breadth of the section as laid out by the figure above. This behavior is due to the fact that the top portion of theses specimens doesn't behave as stiffened member. The section fails at the quarter span part between the stiffeners and also in locations the vicinage of the stiffeners

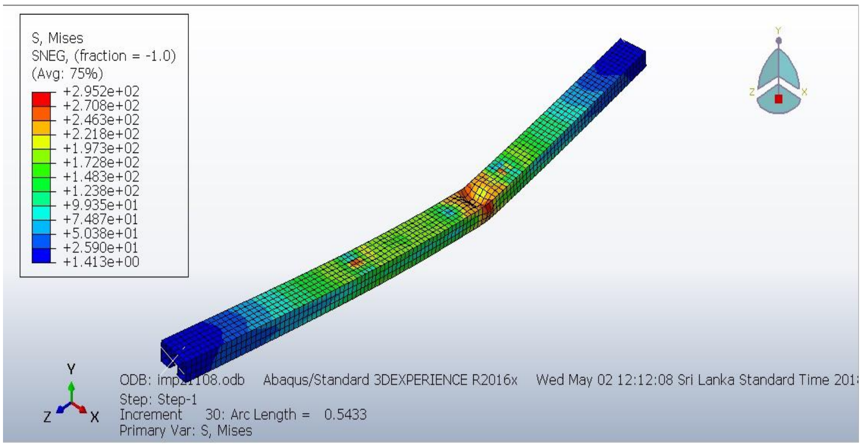

Fig.13 Von Mises Stress Contour for Ch108

3.2 LOAD VS DEFLECTION

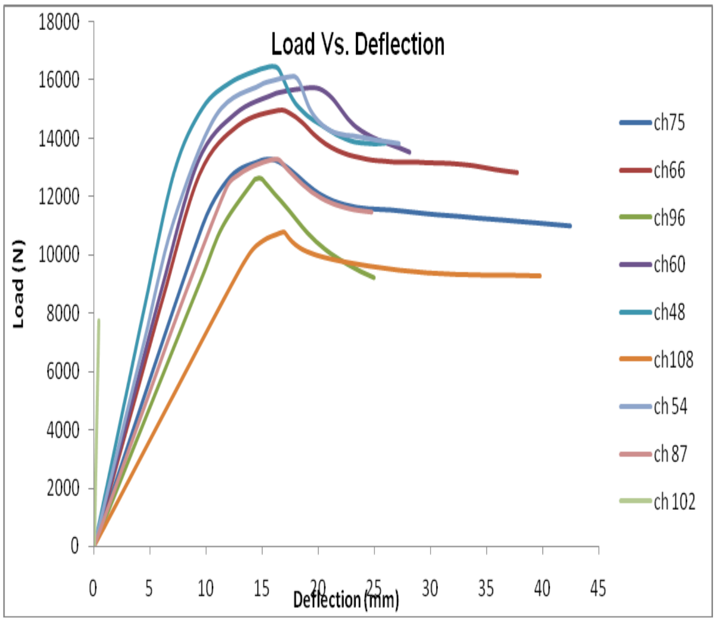

Chart 1 Load vs. Deflection curve from Numerical Investigation

From chart 1, it can be ascertained that the sections with greater breadth (ch48, ch54, ch60 & ch66) has comparatively lower load carrying capacity and the sections with greater depth (ch48, ch54, ch60 & ch66) has higher load carrying capacity. The section ch75 whose breadth and depth are equal lies in between the magnitudes of these two types of sections. The post load vs deflection curve of the sections is suggestive of the fact that sections with lower load has better post buckling behavior and vice versa. The section ch75 has the best post buckling behavior and proves to be optimum with lower deflections for higher loads. The drop in the curves of sections vindicates the lateral torsional buckling, which affects its performance after buckling. Thus, the behaviour of Cold Formed Steel Hollow Channel Section is studied using experimental and analytical investigations.

IV CONCLUSIONS

The numerical study is executed for the specimens with aspect ratios (B/D) 1.0, 1.25, 1.5, 1.75, 2.0, 1/1.25, 1/1.5, 1/1.75, ½ is obtained from the numerical investigation ABAQUS 6.16. The section ch75 has the highest load carrying capacity and the maximum value of stress is 398.6 kN/m^2. The section ch75 withstands larger load with least value of deflection.The sections with breadth smaller than the depth withstands larger load due to the stiffening action by the adjacent members of the section and there is drop in these specimens due to out of plane movement of the specimen. The sections with breadth greater the depth of the specimen has better post buckling behaviour as the greater breadth prevents it from moving out of plane but it makes it prone to local buckling. The above observation infers that the section with equal breadth and depth proves to be optimum.

REFERENCES

[1] M. Mao and Hughes (1996), “Lateral distortional buckling of mono symmetric I-beams under distributed vertical load, “Thin walled structures, Vol. 26, No. 2, pp 133-145.

[2] P.Avery, M.Mahendran, (1997),” Finite-element analysis of hollow flange beams with web stiffeners”, J.Struct.Eng.123 (9)(1997)1123–1129.

[3] E.Magnucka-Blandzi(2011),“Effective shaping of cold-formed thin-walled channel beams with double-box flanges in pure bending“, Thin-Walled Structures 49 (2011) 121–128.

[4] TharmarajahAnapayan, MahenMahendran (2012), “ Improved design rules for hollow flange sections subject to lateral distortional buckling”, Thin-Walled Structures 50 (2012) 128–140

[5] Mohammadreza M Gargari, ArghavanLouhdhalam and Tootkaboni (2013), “Optimal Cross Sections for Cold Formed Steel Members under Compression”, Thin-Walled Structures 67 , 262–275

[6] PoologanathanKeerthan, David Hughes, MahenMahendran (2014), “Experimental studies of hollow flange channel beams subject to combined bending and shear actions”, Thin-Walled Structures 77 (2014) 129–140.

[7] Hong-Xia Wan and Mahen Mahendran (2015), “Behaviour and strength of hollow flange channel sections under torsion and bending “, Thin-Walled Structures 94 (2015) 612–623.

[8] Edward Steau, MahenMahendran, PoologanathanKeerthan (2015), “Web crippling tests of Rivet Fastened Rectangular Hollow Flange Channel Beams under Two Flange Load Cases”, Thin-Walled Structures 95 (2015) 262–275.

[9] P. B. Patil, P.D. Kumbhar (2015), “Parametric Study of Light gauge steel Lipped Channel Column section”, Elsevier Ltd Composites: Part B 58 (2014) 122-133.

[10] Jun Ye N, ImanHajirasouliha, JurgenBecque and KyprosPilakoutas (2016),”Development of more efficient cold-formed steel channel sections in bending”,

[11] Ropalin Siahaan, Poologanathan Keerthan and Mahen Mahendran (2018), “Section moment capacity design rules for rivet fastened rectangular hollow flange channel beams”, Thin-Walled Structures 127 (2018) 781–797.

[12] IS:801-1975 Code of Practice for Use of Cold Formed Light Gauge Steel Structural members in general building construction.

[13] IS:811-1987 Specification for Cold-Formed Light Gauge Structural Steel Sections

[14] IS:800-2007 Code of Practice for General Construction In Steel

[15] SP:6 (5) – 1980 Handbook for Structural Engineers-Part-5- Cold Formed, Light-Gauge Steel Structures