STUDY ON BEHAVIOUR OF AUSTENITIC STAINLESS STEEL CHANNEL SECTIONS

Tittu K Philip[1], C. Justin Raj[2] , P.Vetri Selvi[3]

[1] II Year, M.E(Structural), RVS Technical Campus, Coimbatore, Tamil Nadu
[2] Assistant Professor, Department of Civil Engineering, RVS Technical Campus, Coimbatore, Tamil Nadu
[3] Assistant Professor, Department of Civil Engineering, RVS Technical Campus, Coimbatore, Tamil Nadu

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Abstract - Austenitic stainless steel is relatively new material in the constructional industry. It found wide applications in the field of roofing, transmission towers and structural works apart from its economic perspective. The relevance of this study is that by better understanding of the behavior of the material it is possible for the better utilization of the material. At present only international codes are available for the design of stainless steel members. Most of the literatures reviewed for the study are that of various stainless steel sections under compression or bending, comparison of design codes etc. Several papers which gave information regarding stress strain behavior of the material, initial imperfection used in modelling were also reviewed for creation of the analytical model.

***Key Words*:** Austenitic stainless steel, Design codes, Bending, Compression

1.INTRODUCTION

Stainless steel is an iron-based alloy with a minimum of 11% chromium, a composition that prevents the iron from rusting while also offering thermal resistance. Carbon, Nitrogen, Aluminum, Silicon, Sulphur, Titanium, Nickel, Copper, Selenium, Niobium, and Molybdenum are some of the elements found in stainless steels. From a metallurgical standpoint, stainless steel is known as Inox steel. Because of the presence of chromium in the alloy, which creates a passive coating that protects the material beneath from corrosion attack and can self-heal in the presence of oxygen, stainless steel is resistant to ferric oxide formation.

1.1 Austenitic Stainless Steel

Austenitic stainless steel accounts for over 70% of total stainless steel production, making it the largest stainless steel family. The primary crystalline structure of these stainless steels is austenite (face-centered cubic). The austenite stabilising elements nickel, manganese, and nitrogen are added in sufficient amounts to achieve this austenite crystalline structure. Due to their crystalline structure, austenitic steels cannot be hardened by heat treatment and are fundamentally non-magnetic. From a metallurgical standpoint, austenitic stainless steels have numerous advantages. They can be made soft enough to be easily formed, with yield strengths of 200 MPa, using the same processes as carbon steel, but they can also be made extraordinarily strong by cold work, with yield strengths of over 2000 MPa. Even at absolute zero, their austenitic structure is ductile and tough. They also don't lose their tensile strength when exposed to extreme temperatures.

1.2 Applications of Stainless Steel in construction industry

Stainless steel has a wide range of applications in modern construction due to its corrosion resistance, strength, and flexibility. It is employed in the outside cladding of big, high-impact structures and may also be found in the interiors as handrails, counter tops, backsplashes, wall support goods, structural works, and fasteners, as well as in drainage and water systems.

2. LITERATURE REVIEW

Austenitic stainless steel sections are very new to the industry, hence there aren't many research articles on their behaviour when subjected to web crippling. The majority of the literatures investigated for this study are on various stainless steel sections under compression or bending, design code comparisons, and so on. For the building of the analytical model, several articles were studied that provided information on stress strain behaviour of the material, as well as initial imperfection used in modelling. This chapter gave a general evaluation of journals related to Austenitic stainless steel, coupled bending and compression, and web crippling, and they are listed in the references section at the end of the report.

Arrayago et al., 2015 investigates on the stress-strain behavior of stainless steel alloys. The nonlinear stress-strain response of stainless steel alloys and its modelling are discussed in this study. Around 600 experimental stress-strain curves were collected and examined, comprising austenitic, duplex, and ferritic grades. Values and predictive equations for the primary material parameters of the Rasmussen model were re-established based on the received set of data. For all stainless steel families, a corrected prediction equation and updated numeric values for the strain hardening parameter have been proposed. For all stainless steel classes, a revised equation for predicting the second strain hardening parameter is also proposed. It is suggested that the ideas be implemented into future revisions of EN 1993-1-4.

Asraf et al., 2017 conducted study on the effect of unstiffened and stiffened web holes on the web crippling strength of cold-formed steel sections. In this investigation, only one flange loading condition was used. Both numerical and experimental investigations are included in the research. A total of 36 experimental specimens and 54 finite element specimens were used in the investigation. The findings reveal that, given the proper edge stiffener length, the web crippling strength of a cold formed steel channel section with holes can be as high as that of a cold formed steel channel section without holes.

Baddoo, 2004 introduce a comparative study on design standards of structural stainless steel. This paper compares design standards for structural stainless steel. The European (Eurocode 3 ENV 1993-1-4), American (SEI/ASCE 8-02) and Australian/New Zealand (AS/NZS 4673) standards are reviewed in some detail. The design parameters for cross sections and members is explained and compared. The major difference is that SEI/ASCE and AS/NZS Specifications use the tangent modulus method for calculating the buckling strength of members, which generally requires iteration to find a solution. By comparison, the Eurocode buckling curves are based on the initial modulus of elasticity and avoid the need for iteration; they were derived by calibration against experimental data. The buckling curves in the SEI/ASCE Specification are generally more conservative than the European curves.

Bock et al., 2015 presents a statistical evaluation of a new resistance function for web crippling design of cold-formed stainless steel cross sections in accordance with EN 1990 (2002). This paper proposes a resistance function. The statistical analysis revealed that the suggested resistance function needs to be tweaked to meet the EN 1993-1-4 safety level (2006). The provisions for web crippling design in EN 1993-1-3 (2006) and SEI/ASCE 8-02 (2002) American standards for application to stainless steel are statistically examined here as well. When compared to test and numerical data, the recalibrated resistance function's predictions are more appropriate and consistent than the existing design provisions

Garnder et al., 2019 conducted study on the design of stainless steel structural stability A review of recent developments in research and design practice surrounding the structural use of stainless steel is carried out in this paper, with a focus on structural stability. This answer is also examined and evaluated using current and new design methodologies. In summary, the study claims that in scenarios regulated by strength, such as in plane bending of stocky beams, significant strain hardening of stainless steel leads to capacity gains, whereas in circumstances governed by stability, the early onset of stiffness degradation leads to capacity reductions.

Janarthanan in 2019 and 2020 A numerical evaluation of the combined effects of bending and web crippling in cold formed steel sections is presented. The combined web crippling-bending interaction behaviour of un-lipped channel sections used as bearers in floor systems with fastened supports is investigated in this study. Finite element models that are web crippling have been designed and validated. The effects of bending and web crippling on channels were investigated, and new finite element models for bending were constructed and validated using available experimental data. Under pure and mixed web crippling and bending motions, a detailed parametric investigation was done to determine the capacities of 12 un-lipped channel sections constructed of G250 and G450 steels. The accuracy of forecasting the mid-span load capacity of channel sections subject to combined web crippling and bending actions was then improved using a new design equation with a suitable capacity reduction factor.

Korvink et al., 1994 studied on the web crippling of the cold formed stainless steel beams. The steels under consideration are AISI Type 430 stainless steel and a modified AISI Type 409, designated Type 3CR12 corrosion resisting steel. 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. 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.

Natario et al., 2014 The use of quasi-static analysis with explicit integration to analyse the web crippling behaviour of cold formed steel beams is investigated. The research focuses on the characterization of the quasi-static analysis approach, with a focus on the management of dynamic effects and the shell finite element model of a lipped channel beam under external two-flange stress. This study described a number of typical finite element analysis parameters, including mesh type and size, steel model, hardening effects due to cold forming, residual stresses, starting flaws, and support conditions. According to the findings, imperfections have just a minor impact on the web's crippling strength

Soliman et al., 2012 The resistance of cold-formed steel sections to bending and web crippling was examined. Numerical investigations on web crippling and the interaction between bending and web crippling are carried out in this study, which takes into account the material's and geometry's nonlinearities. The research is carried out on channel sections that have been web crippled under IOF loading conditions. The web crippling strength of the analysed channel sections is predicted using finite element models that have been validated against experimental tests. The relationship between bending and web crippling in C-sections is studied using Finite Element Analysis. The effects of various parameters on the resistance of the sections are investigated using Finite Element findings. It was found that, for channels with a practical web slenderness range the strengths predicted by design codes are generally inadequate. Therefore, modifications were proposed to improve the strength obtained by codes.

Sundararaja et al, 2019 presents a research work that used numerical modelling to analyse the web crippling behaviour of lipped channel beams under one flange load scenarios, and then created revised design equations for prospective inclusion in cold formed steel design standards. The numerical models were compared to experimental data, and a parametric investigation was carried out by changing the inside bend radius, bearing length, and yield strength. This work proposed both unified web crippling equations and direct strength technique based equations, with the proposed equations having increased accuracy.

Yousefi et al., 2020 conducted an experimental and numerical investigation on the web bearing performance of cold-formed steel channels manufactured with austenitic stainless steels when subjected to intense transverse stresses. The research involves a 16-sample experimental programme and 88-sample numerical analysis. Web thickness and internal fillet radius were the characteristics that were taken into account. There were also comparative studies on the efficiency of existing design codes. The equations given by existing stainless steel standards have been found to be unreliable for austenitic stainless steel, resulting in uneconomical designs. The study suggested new equations and verified their validity.

Zhou et al., 2006 experimentally studied on the web crippling strength of the cold formed stainless steel hollow sections. Tests were conducted on square and rectangular hollow sections of austenitic stainless steel type 304. Tensile and compression coupon tests were performed to obtain the longitudinal tension and transverse compression material properties. The web crippling tests were conducted under two loading conditions for end-two-flange and interior-two-flange specified in the current American Specification and Australian/New Zealand Standard for cold- formed stainless steel structures. In addition, the test strengths are also compared with the design strengths obtained using the unified web crippling equation as specified in the North American Specification for cold-formed carbon steel structural members. A unified web crippling equation for cold-formed stainless steel sections with single web is proposed in this paper.

3. CONCLUSIONS

Austenitic stainless steel is relatively new material with wide applications. Better understanding of the material leads to better utilization of the material. From the Literature survey we will have an idea about the properties of Austenitic stainless steel, variation of its crippling strength with respect to other parameters. It also helps to conduct a comparative study on the web crippling capacities obtained from design codes and numerical study

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