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Parametric Study on Lean Duplex Stainless Steel Channel Column

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ABSTRACT: In actual practice carbon steel is used as a construction material. Generally stainless steel is used as a corrosion resistance and architectural requirements instead of inherent structural properties of the steel. The reason is due to high cost of stainless steel. Lean duplex stainless steel (LDSS) sections are being used popularly in shops, factories, automobile engineering and industries on account of their high strength to weight ratio, simplicity in construction, flexibility in fabrication and high structural efficiency. A lot of research work has been carried out to study the structural behavior of doubly symmetric LDSS column sections considering different parameters. However, structural behavior of singly symmetric LDSS column sections considering axial loading has not received much attention. In this work the effect of slenderness ratio, cross section aspect ratio and corner radius to material thickness on the load carrying capacity is observed. Finite element analysis of the section is also done using ABAQUS software for determining the effect of slenderness ratio, cross section aspect ratio and corner radius to material thickness on the L.C.C and buckling behavior of the channel column sections.

KEYWORDS: Axial loading, Cross section aspect ratio, Corner radius to material thickness ratio, Finite element analysis, LDSS, Slenderness ratio

I. INTRODUCTION

Duplex stainless steels are a family of grades combining good corrosion resistance with high strength and ease of fabrication. Their physical properties are between those of the austenitic and ferrite stainless steels but tend to be closer to those of the ferrites and to carbon steel. The chloride pitting and crevice corrosion resistance of the duplex stainless steels are a function of chromium, molybdenum, tungsten, and nitrogen content. They may be similar to those of type 316 or range above that of sea water stainless steels such as the 6% Mo austenitic steels. All duplex stainless steels have chloride stress corrosion cracking resistance significantly greater than that of the 3000 series austenitic stainless steels. They all provide significantly greater strength than the austenitic grades while exhibiting good ductility and toughness.

Duplex stainless steels, meaning those with a mixed microstructure of about equal proportions of austenite and ferrite, have existed for nearly 80 years. The early grades were alloys of chromium, nickel, and molybdenum. The first wrought duplex stainless steels were produced in Sweden in 1930 and were used in the sulfite paper industry. These grades were developed to reduce the intergranular corrosion problems in the early, high carbon austenitic stainless steels. Duplex stainless steel sections are commonly used where chances of corrosion is more. The basic idea of duplex is to produce a chemical composition that leads to an approximately equal mixture of ferrite and austenite

II. RELATED WORK

1.M. Ashrat et al. (2006), they developed a new design approach for the stainless steel. Generally strength of a stainless steel is determined similar as carbon steel. The strength is determined from elastic or plastic distribution of stresses or yielding of effective section. New design approach is developed that replaces these discrete behavioral classes with continuous measure of the deformation capacity of the cross section. The strength is determined by using the capacity in conjunction with a material model that accurately reflects the rounded nature of stainless steel stress-strain curve. For validation of this method they used ABAQUS software and experimental results. After study they conclude that the new design approach gives better result than the European Code.**2. Lecce et al. (2006)**, they present both experimental and numerical investigation of square and rectangular hollow section subjected to both major and minor axes bending were tested. Also the strength predicted by finite element model and experimentally it is checked with the existing codes. Also during the study they give the modification to the design specification.**3. Jurgen Becque et al. (2009)**, they studied the local and overall buckling under axial compression. Tensile and compressive properties are studied at the corner of cold worked corners. 29 stub columns are tested for axial compression in which 18 are tested



at a nominal eccentricity of towards the web. The stress strain behavior of stainless steel is also studied in this paper. The stress strain behavior of lean duplex stainless steel is different than the carbon steel. During study they observe that the stress strain behavior is non-linear with low proportionality of stress and due to that they lose stiffness at relatively low stress levels.

III. METHODOLOGY

A lot of study is carried out on doubly symmetrical Lean duplex stainless steel sections. Also most of studies have indicated that that the failure of a section is local and distortional buckling. However very little work has been done study the effects of parameters on the ultimate load capacity of a singly symmetric channel section. Few researches have studied the different Codal provision to analyses and design LDSSCC sections. Also they recommended the changes required in the codes. Generally while selecting a compression member only slenderness ratio is considered but in this study the effects of other parameters like cross section aspect ratio, corner radius to material thickness ratio, eccentricity are considered. In first chapter some introduction and general information about Lean Duplex Stainless Steel (LDSS) is given along with the motivation and objectives of the dissertation work.includes literature review including review of previous studies carried out by the some of the researchers. deals with the design methods given by the Euro code along with the methodology adopted to achieve the objectives the dissertation.covers all the modeling of the channel column in ABAQUS.experimental work carried out during the dissertation work to validation of the results of parametric study done by Finite element analysis in ABAQUS.Results of all the parametric study and the experimental work are summarized in this Comparative study and discussion is done further more.All the dissertation work carried out up to this phase of work is concluded in this chapter and further work is also explained.

IV. EXPERIMENTAL RESULTS

1result as per ABAQUS

.Table 1: Ultimate compressive load for channel column by varying slenderness ratio as per ABAQUS

Sr. No	Section size	Slenderness ratio	Ultimate compressive load (kN)
1	75 X 40 X 2 L250	20.235	113.57
2	75 X 40 X 2 L300	24.282	111.69
3	75 X 40 X 2 L350	28.329	108.53
4	75 X 40 X 2 L400	32.376	107.67
5	75 X 40 X 2 L450	36.423	106.29
6	75 X 40 X 2 L500	40.47	105.72
7	75 X 40 X 2 L550	44.517	105.03
8	75 X 40 X 2 L600	48.564	104.62
9	75 X 40 X 2 L650	52.611	104.22
11	75 X 40 X 2 L700	56.658	103.91
12	75 X 40 X 2 L750	60.705	103.64
13	75 X 40 X 2 L800	64.752	103.4
14	75 X 40 X 2 L850	68.799	103.2



For cross section aspect ratio

Table 2: Ultimate compressive load for channel column by varying cross section aspect ratio as per ABAQUS

Sr. No	Section size	Cross section aspect ratio	Ultimate compressive load
1	85 X 35 X 2L500	2.42	105.72
2	75X 40 X 2L500	1.87	104.62
3	65 x 45 x 2L500	1.44	103.91

For corner radius to material thickness ratio

Table 3: Ultimate compressive load for channel column by varying corner radius to material thickness ratio as per ABAQUS

Sr. No	Section size	Corner radius to material thickness aspect ratio	Ultimate compressive load (kN)
1	75 X 35X 2 L500 R3.17	1.58	105.1
2	75X 35 X 2 L500 R3.57	1.78	103
3	75X 35 X 2 L500 R3.96	1.98	99.8
4	75 X 35 X 2 L500 R4.36	2.18	98.5

For finding position of load having max LCC

Table 4: Ultimate compressive load for channel column by varying eccentricity as per ABAQUS

Sr. No	Section size	eccentricity	Ultimate compressive load (kN)
1	75 X 35X 2 L500 e-10	-10	73.53
2	75X 35 X 2 L500 e0	0	117.16
3	75X 35 X 2 L500 e10	10	118.5
4	75 X 35 X 2 L500 e20	20	90.98
5	75 X 35 X 2 L500 e30	30	71.19

Test to determine the effect of slenderness ratio on the maximum load carrying capacity of the column channel section

Table 5: Ultimate compressive load for channel column by varying Slenderness ratio

Sr. No	Section size	Slenderness ratio	Ultimate load (kN)		
			EC3	ABAQUS	Experimental
1	75 X 40 X 2 L500	40.47	109.37	105.72	114.2
2	75 X 40 X 2 L600	48.56	102.78	104.62	112.8
3	75 X 40 X 2 L700	56.66	93.56	103.91	101.30



Test to study the effect of cross section aspect ratio on load carrying capacity on the LDSSCC section

Table 6: Ultimate compressive load for channel column by varying C/S aspect ratio

Sr. No	Section size	C/S aspect ratio	Ultimate load (kN)		
			EC3	Abaqus	Experimental
1	85 X 35 X 2 L500	2.42	109.37	105.72	99.10
2	75X 40 X 2 L500	1.87	102.78	104.62	96.50
3	65 x 45 x 2 L500	1.44	93.56	103.91	91.40

Test to study the effect of corner radius to material thickness ratio on the load carrying capacity of the LDSSCC section.

Table 7: Ultimate compressive load for channel column by varying corner radius to material thickness ratio

Sr. No	Section size	Corner radius to material thickness ratio	Ultimate compressive load (kN)	
			Abaqus	Experimental
1	75 X 35X 2 L500 R3.17	1.58	105.1	99.60
2	75X 35 X 2 L500 R3.57	1.78	103	98.90
3	75X 35 X 2 L500 R3.96	1.98	99.8	96.5
4	75 X 35 X 2 L500 R4.36	2.18	98.5	95.44

Test to determine proper location of load for maximum load carrying capacity of the LDSSCC section.

Table 8. Ultimate compressive load for channel column by varying eccentricity

Sr. No	Section size	Eccentricity	Ultimate compressive load (kN)	
			ABAQUS	Experimental
1	75 X 35X 2 L500 e-10	-10	73.53	86.45
2	75X 35 X 2 L500 e0	0	117.16	85.90
3	75X 35 X 2 L500 e10	10	118.5	99.10
4	75 X 35 X 2 L500 e20	20	90.98	81.90
5	75 X 35 X 2 L500 e30	30	71.19	49.56

V. CONCLUSION

Load carrying capacity increases with decrease in cross section aspect ratio. Average 23% increase in cross section aspect ratio results average 4% decrease in ultimate load carrying capacity of a section. Load carrying capacity of column decreases with increase in corner radius to material thickness ratio. Average 10% increase in corner radius to material thickness ratio results average 1.5% decrease in load carrying capacity. Lean duplex stainless steel channel column sections are subjected to local, distortional failure due to their smaller thickness. Under small load local and distortional buckling is observed in the web and then the buckling is observed in the flange also. The results obtained by finite element based software (ABAQUS) and experimental are compared with Euro Code get 9% difference in the value of ultimate compressive strength of a channel column sections.



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