



# STAINLESS STEEL LEAN DUPLEX SECTIONS

ANGLE SECTIONS

BEAM SECTIONS

CHANNEL SECTIONS

T SECTIONS

HOLLOW SECTIONS

LASER WELDED  
(in lengths up to 14 meters)

---

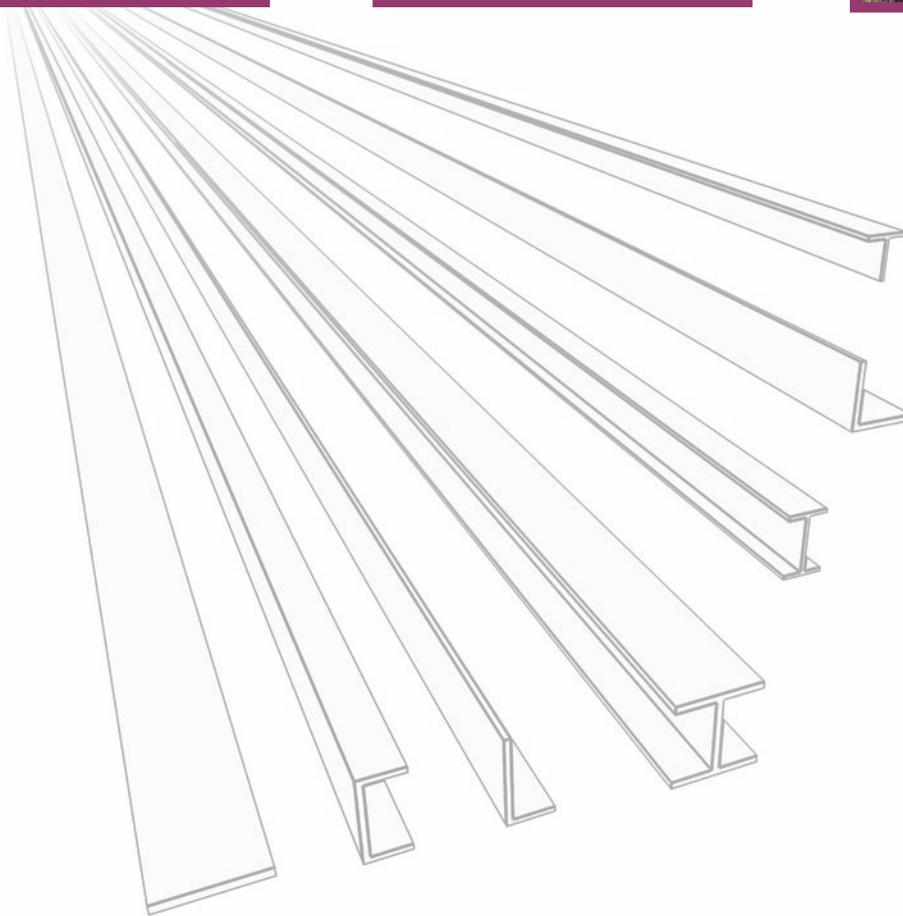
Millstock Stainless Limited  
Fusion House, The Crescent  
Willenhall, West Midlands, WV13 2QR

- Telephone: 0044 (0) 1902 409 409
- Fax: 0044 (0) 1902 409 411
- Email: [sales@millstockstainless.com](mailto:sales@millstockstainless.com)
- [www.millstockstainless.com](http://www.millstockstainless.com)



# Lean Duplex

High performance laser fused Structural Sections



## Introduction

Stainless steels are used predominantly for their corrosion resistance in moderate to highly aggressive environments. For construction purposes, carbon steel normally is the common choice due to low cost, long experience, applicable design rules and a large variety of strength classes. However, different stainless steel types can also provide a very wide range of mechanical properties and they have the advantage of no need for surface protection. Duplex stainless steels in particular, with twice the mechanical strength of conventional austenitic and ferritic stainless steels, have a potential for use in constructions. Since the introduction of this family of steels about seventy years ago, they have been widely used.

Lean Duplex Stainless Steels (LDSS) are a subset of the duplex family that has seen significant growth and development over the last years. The drivers for this development have been soaring raw material costs along with increasing demand for improved corrosion resistance and strength. Today there are four different LDSS grades available on the market and new ones are being developed.

LDSS have been used or are being considered as substitutes for stainless steel types 1.4301 and 1.4404 in various applications. Some examples of industry end uses are structural supports for the onshore and offshore oil & gas industry, architectural & building, desalination equipment, wastewater treatment facilities, pulp & paper, chemical processing, automotive & transportation, etc. The list keeps growing as more industries become aware of the advantages of LDSS.

## Corrosion aspects

LDSS' resistance to localized corrosion, such as pitting and crevice attack, is similar to type 1.4404 or 1.4571. A numerical relationship between pitting resistance and alloying content has been developed to compare the four LDSS to common austenitic stainless steels (Fig.1). This numerical relationship is known as pitting resistance equivalent number or  $PRE_N$  ( $PRE_N = Cr + 3.3 \times \%Mo + 16 \times \%N$ ).

**Fig.1** Pitting and crevice corrosion resistance

EN	Type equivalent	chemical analysis									$PRE_N$
		C max	Si max	Mn max	P max	S max	Cr	Ni	Mo	N	average
1.4301	304	0,07	1,0	2,0	0,045	0,030	17,0-19,5	8,0-10,5	---	≤ 0,11	18
1.4404	316L	0,03	1,0	2,0	0,045	0,030	16,5-18,5	10,0-13,0	2,0-2,5	≤ 0,11	24
-	2001	0,03	1,0	4,0-6,0	0,040	0,030	19,5-21,5	1,0-3,0	0,1-0,6	0,05-0,17	25
1.4162	2101	0,04	1,0	4,0-6,0	0,040	0,030	21,0-22,0	1,35-1,7	0,1-0,8	0,20-0,25	26
1.4362	2304	0,03	1,0	2,0	0,035	0,015	22,0-24,0	3,5-5,5	0,1-0,6	0,05-0,20	26
-	2003	0,03	1,0	2,0	0,030	0,020	19,5-22,5	3,0-4,0	1,5-2,0	0,14-0,20	30
1.4462	2205	0,03	1,0	2,0	0,035	0,015	21,0-23,0	4,5-6,5	2,5-3,5	0,10-0,22	35

Note: Type 2001 is proprietary of AK Steel (Nitronic® 19D)  
 Type 2101 is proprietary of Outokumpo (LDX 2101®)  
 Type 2003 is proprietary of Allegheny Ludlum (AL 2003™)

LDSS are "leaner" alloys than the standard type 1.4462 duplex stainless steel and cannot equal its corrosion resistance, especially in high chloride environments, but they have a much better resistance than 1.4301 and in most cases perform as well as, or better than 1.4404. As a result, LDSS are suitable for use in a wide range of applications and environments.

### Laser fusion of structural sections in LDSS

Laser fusion of lean duplex does not differ substantially from the process used for austenitic stainless steel grades. While the process parameters vary only slightly, the big difference lies in the microstructure that results from the ultra-rapid cooling of the weld pool.

Duplex grades roughly have a 50% austenitic and 50% ferritic microstructure. The alloying elements are balanced in order to achieve this distribution after a classical solution annealing treatment. There is a certain variance in the distribution and up to a 65:35 ratio in favour of one or the other of the two microstructures is considered normal.

During laser welding the base material melts and then solidifies extremely rapidly. The cooling speed normally is in excess of  $500^{\circ}\text{C/s}$ , which means that the segregations found with classical welding methods are totally avoided when using laser welding. On the other hand, this same rapid cooling rate causes a preference for the ferritic microstructure.



Fig. 2 – Lean Duplex beam

### Corrosion resistance of structural sections in LDSS

In an “as welded” condition the corrosion resistance of the weld and heat affected zone of a LDSS structural section produced by laser fusion still is equivalent or better than stainless steel type 1.4301. By solution annealing or using a laser-hybrid welding system the classical balanced duplex microstructure can be reinstated.

The optional solution annealing or laser-hybrid welding of LDSS should only be considered in cases where high mechanical strength and superior corrosion protection is required.

### Mechanical properties of structural sections in LDSS



Fig. 3 – Crash test

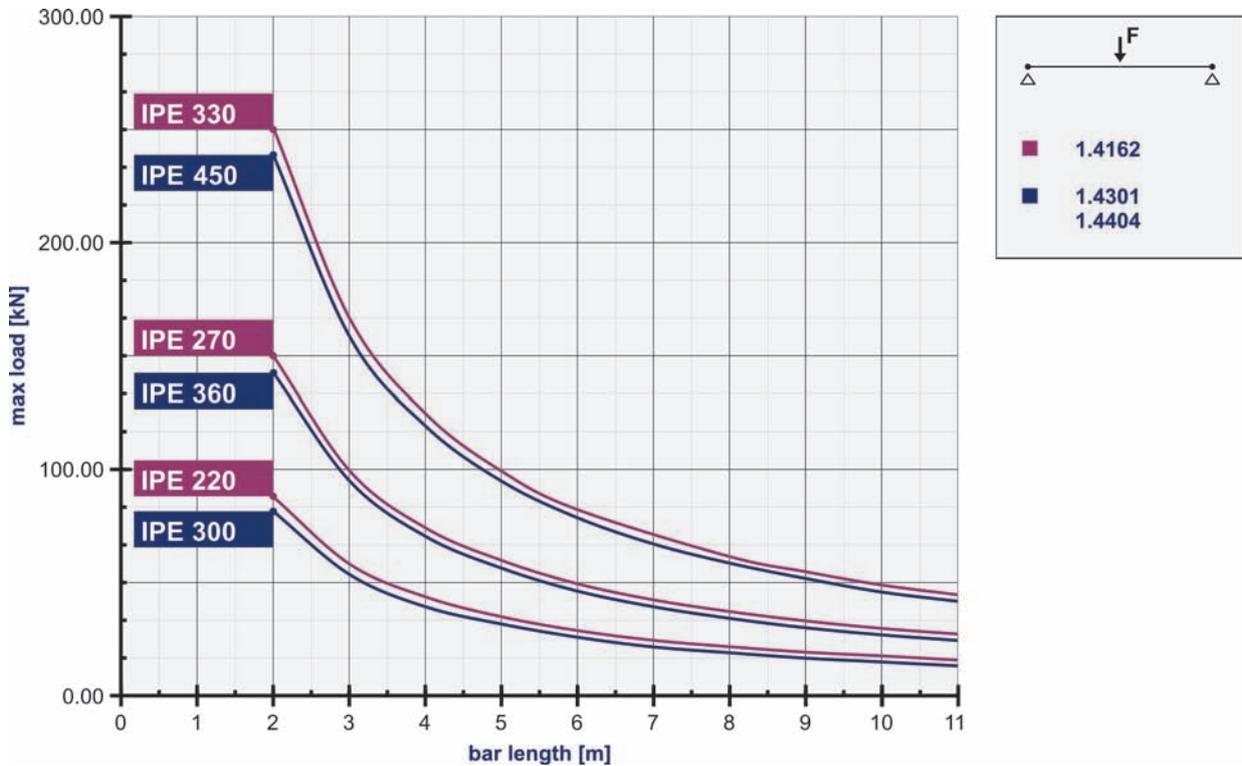
Laser fused structural sections have a monolithic structure with a controlled area of heat input and a small, barely noticeable seam at the juncture of the components. Extensive destructive testing has shown that the fracture points in laser fused sections rarely lie in the weld area itself.

External stresses and loads applied to the sections are transmitted to the neighbouring parent material which then fails according to its own mechanical characteristics (Fig. 3).

The mechanical characteristics of the weld and heat affected zone of structural sections in LDSS are no constraint in industrial applications.

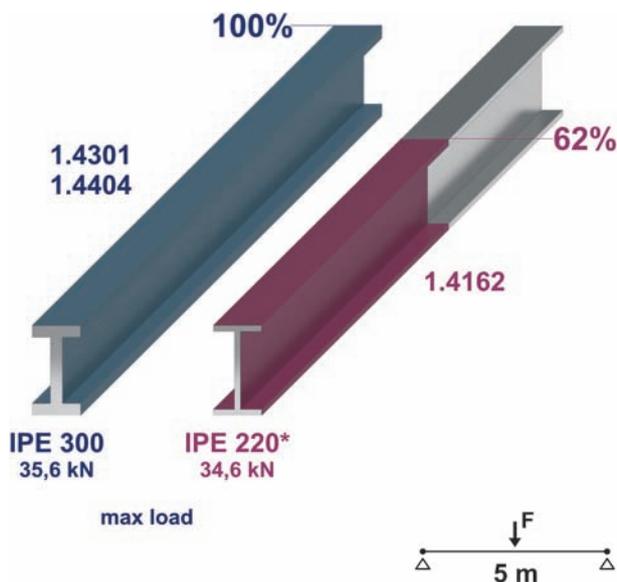
The following chart (Fig. 8) clearly shows the advantages of higher yield properties in structural sections based on single span performance. E.g. a IPE 220 in 1.4162 achieves the same structural performance of an IPE 330 in standard austenitic stainless steel.

**Fig. 8** SINGLE SPAN LOAD - Comparison of beam sizes



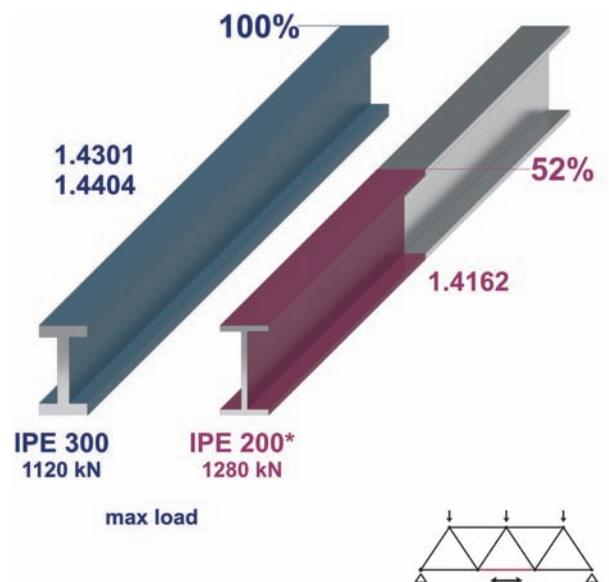
In other terms, under the same span load the material saving potential of 1.4162 is 38% compared to austenitic stainless steel beams on a bar length of 5 m (Fig. 9). When comparing the tension tie of 1.4162 with type 1.4301 or 1.4404 the material saving goes up to 48% by using lighter section with the same structural performance (Fig. 10).

**Fig. 9** SINGLE SPAN LOAD - Material saving



\* same properties as IPE 300 due to better mechanical values

**Fig. 10** TENSION TIE - Material saving



\* same properties as IPE 300 due to better mechanical values