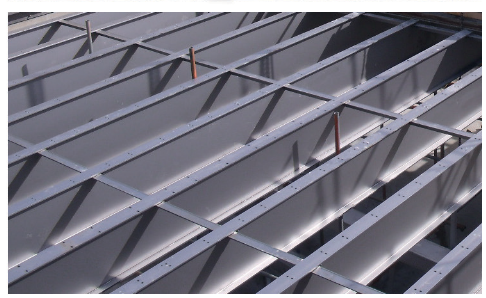
Steel Knowledge

27 Steel Design Guide

Structural Stainless Steel



Steel Design Guide

27

Structural Stainless Steel

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The American Institute of Steel Construction carries out technical and market-building activities for the steel construction sector.

Philippe Richard (ICDA)

The International Chromium Development Association seeks to promote and increase end-use applications of chromium, an essential alloy in all stainless steels.

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The Nickel Institute works to develop new markets and support growth in existing markets for nickel, one of the main alloying elements of stainless steel.

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Chapter 1 Introduction

1.1 WHAT IS STAINLESS STEEL?

Stainless steel is the name given to a family of corrosion and heat resistant steels containing a minimum of 10.5% chromium. Just as there are various structural and engineering carbon steels meeting different strength, weldability and toughness requirements, there is also a wide range of stainless steels with varying levels of corrosion resistance and strength. This array of stainless steel properties is the result of controlled alloying element additions, each affecting specific attributes of strength and ability to resist different corrosive environments. To achieve the optimal economic benefit, it is important to select a stainless steel which is adequate for the application without being unnecessarily highly alloyed and costly.

With a combination of the chromium content above 10.5%, a clean surface and exposure to air or any other oxidizing environment, a transparent and tightly adherent layer of chromium-rich oxide forms spontaneously on the surface of stainless steel. If scratching or cutting damages the film, it reforms immediately in the presence of oxygen. Although the film is very thin, about 0.2×10^{-6} in. (5×10^{-6} mm), it is both stable and nonporous and, as long as the type of stainless steel is corrosion resistant enough for the service environment, it will not react further with the atmosphere. For this reason, it is called a passive film. The stability of this passive layer depends on the composition of the stainless steel, its surface treatment, and the corrosiveness of its environment. Its stability increases as the chromium content increases and is further enhanced by alloying additions of molybdenum and nitrogen.

Stainless steels can be classified into the following five basic groups, with each group providing unique properties and a range of different corrosion resistance levels.

Austenitic stainless steels

The most widely used types of austenitic stainless steel are based on 17 to 18% chromium and 8 to 11% nickel additions. In comparison to structural carbon steels, which have a body-centered cubic atomic (crystal) structure, austenitic stainless steels have a different, face-centered cubic atomic structure. As a result, austenitic stainless steels, in addition to their corrosion resistance, have high ductility, are easily cold-formed, and are readily weldable. Relative to structural carbon steels, they also have significantly better toughness over a wide range of temperatures. They can be strengthened by cold working, but not by heat treatment. Their corrosion performance can be further enhanced by higher levels of chromium and additions of molybdenum and nitrogen.

Ferritic stainless steels

The chromium content of the most popular ferritic stainless steels is between 10.5% and 18%. Ferritic stainless steels contain either no or very small nickel additions and their body-centered atomic structure is the same as that of structural carbon steels. They are generally less ductile, less formable and less weldable than austenitic stainless steels. They can be strengthened by cold working, but to a more limited degree than the austenitic stainless steels. Like the austenitics, they cannot be strengthened by heat treatment and can be used in a broad range of corrosive environments. They have good resistance to stress corrosion cracking and their corrosion performance can be further enhanced by additions of molybdenum.

Duplex stainless steels

Duplex stainless steels have a mixed microstructure of austenite and ferrite, and so are sometimes called austenitic-ferritic steels. They typically contain 20 to 26% chromium, 1 to 8% nickel, 0.05 to 5% molybdenum, and 0.05 to 0.3% nitrogen. They provide higher strength levels than austenitic steels and are suitable for a broad range of corrosive environments. Although duplex stainless steels have good ductility, their higher strength results in more restricted formability compared to the austenitics. They can also be strengthened by cold working, but not by heat treatment. They have good weldability and good resistance to stress corrosion cracking.

Martensitic stainless steels

Martensitic stainless steels have a similar body-centered cubic structure as ferritic stainless steel and structural carbon steels, but due to their higher carbon content, they can be strengthened by heat treatment. Martensitic stainless steels are generally used in a hardened and tempered condition, which gives them high strength and provides moderate corrosion resistance. They are used for applications that take advantage of their wear and abrasion resistance and hardness, like cutlery, surgical instruments, industrial knives, wear plates and turbine blades. They are less ductile and more notch sensitive than the ferritic, austenitic and duplex stainless steels. Although most martensitic stainless steels can be welded, this may require preheat and postweld heat treatment, which can limit their use in welded components.