

# Choosing Stainless Steel Rebar



by:

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**Compared to carbon steel, stainless steel rebar is marginally heavier, stronger, has far superior corrosion resistance, is more ductile and can be nonmagnetic—good qualities to consider.**

Use of high-strength, corrosion-resistant stainless steel rebar for concrete reinforcement in bridges, highways, buildings and other construction projects has been on the rise—especially when the life cycle costs of this material upgrade are appropriately weighed against carbon steel. The trend to stainless has been particularly evident in coastal areas of the USA, and in Canada and Europe.

Increasingly, the higher up-front costs of solid, spiral ribbed stainless steel rebar can be justified when compared with the initial costs, lifetime maintenance costs, replacement costs and operating costs incurred when using carbon steel rebar, with and without cladding or coating.

In practice, stainless steel rebar has been used in many concrete structures to provide high strength and long-term resistance to the corrosive attack of chlorides from road salt and harsh marine environments which penetrate the concrete in which the rebar is buried. Carbon steel will corrode leading to concrete spalling.

The most dramatic example of the longevity difference between carbon and stainless rebar can be found in Yucatan, Mexico, where a marine pier constructed in 1937 with stainless rebar is still in use while the pier constructed in 1960 with carbon steel is in ruins.

Applications for corrosion-resistant stainless rebar include a host of marine structures such as bridge decks, sidewalks, ramps, parapets, pilings, barriers, retaining walls, anchoring systems, parking garages, sea walls, columns, piers, jetties and moorings. Stainless rebar can be considered also for the infrastructure of chemical and other process plants where corrosion resistance is important.

Stainless steel rebar, offering a good combination of high strength, toughness, ductility and fatigue resistance,



**Threaded stainless steel rebar.**

along with corrosion resistance, has been used for construction of bridges and other structures in seismic areas. Of paramount concern here is the need for high strength and ductility to preserve the structural integrity of any bridge subject

to a seismic disturbance, and the safety of motorists using it.

There are also an increasing number of rebar applications, requiring controlled magnetic permeability, where carbon steel cannot be considered an option. Nonmagnetic stainless steel rebar has been used successfully in electric motor foundations and in buildings that house MRI and similar equipment.

In addition, the same nonmagnetic stainless alloys have been used in constructing "deperming" piers, where the proper function of instrumentation is restored in docked ships before they return to sea.

### Appropriate Stainless Alloys

Although *ASTM A 276* lists a good number of stainless alloys that are suitable for use in concrete reinforcement, any one of four major stainless steels can be considered for most applications. These are 2205 stainless (S31803), stainless type 316LN (S31653), 18Cr-3Ni-12Mn stainless (S24000) and stainless type 304LN (S30453).

For rebar applications, the process should start with the designed mechanical property requirements. *ASTM A955*, covering deformed and plain stainless steel bars for concrete reinforcement, lists these requirements. This standard allows stainless steel rebar to be produced at three strength levels.

However, Carpenter can achieve a yield strength of 75 ksi (518 MPa) or higher for all four alloys to be considered, and a tensile strength of 100 ksi minimum (690 MPa). These values represent the highest of the three strength levels listed by *ASTM A955*. The highest strength level can be reached in all standard bar diameters from No. 3 to No. 14 or 0.375" to 1.75" (10 to 45 mm) diameter—metric sizes are available as well. Strength levels, in fact, can be tailored to bar size by modifying the hot rolling production parameters.

All four stainless steels offer exceptional ductility, which allows the rebar to be easily formed and fabricated. Their elongation properties are in the range of 20% to 30%, which is greater than the 7% to 12% minimum elongation in *ASTM A955* for the same alloys at the 75 ksi (518 MPa) yield strength level. Elongation is

a key property of fabricators who perform numerous bending operations. In addition, all four alloys have good toughness and fatigue resistance.

This unique combination of mechanical properties makes all four stainless steels candidates for construction projects in seismic areas. Their high strength levels allow designers to use less material and conserve weight. Their good ductility permits structures to flex without breaking during any seismic disturbance.

Selection of the best candidate stainless steel for a rebar application may depend on the amount of corrosion resistance required, particularly in view of the similarities in the alloys' key mechanical properties. Of the four rebar grades discussed, 2205 stainless offers the best overall corrosion resistance.

Three of the four alloys discussed may be considered for those rebar applications where controlled magnetic permeability is most important—type 316LN alloy, 18Cr-3Ni-12Mn stainless and type 304LN.

### Applications

Over 200 tons of stainless steel rebar was recently supplied to **The Fort Miller Co.**, Schyulerville, NY, USA. Carpenter 2205 duplex alloy rebar was used to produce precast concrete modules for a new **NYSDOT (New York Department of Transportation)**-designed highway bridge (the **NYC DOT** was equally involved). The bridge will be on the Belt Parkway, over the Ocean Parkway, in Brooklyn, NY, USA. Fort Miller precast the modules in a climate-controlled facility and then completely assembled the structure on its property. After inspection, the bridge will be disassembled, moved to the site and reassembled quickly and efficiently. The modular approach and the use of stainless steel rebar helped meet the two main objectives specified by NYSDOT:

- Erect the bridge in a busy urban area with minimum disruption to traffic and the surrounding neighborhoods;
- Erect a bridge that will last a lifetime with minimal maintenance.

This is the first major use of stainless rebar in a precast application in the USA. Other conventional on-site USA bridge projects utilizing stainless rebar include the Haynes Inlet Slough Bridge in Oregon (400 tons of stainless rebar expected to provide maintenance-free service for 120 years), Driscoll Bridge in New Jersey (using 1300 tons stainless rebar) and the Woodrow Wilson Bridge which spans Maryland and Virginia (about 1000 tons). These projects should provide the catalyst for DOT engineers to specify stainless rebar.

Typically the use of stainless vs. black carbon rebar adds only incremental cost for greater benefits. The bridge in Brooklyn only had an increase in the cost of the bridge of about 1% by using stainless rebar, a small



**Stainless steel rebar on the Haynes Inlet Slough Bridge deck.**



**Vertical arrangement of bent stainless rebar; Haynes Inlet Slough Bridge.**

price to pay for the long-life benefit you get. With stainless rebar, the high cost of corrosion inhibitors can be eliminated.

Asia is a fairly new market for stainless rebar as well. Three big projects in Asia are coming up: West Corridor which will connect Hong Kong to mainland China and use 1300 tons of stainless rebar, Stonecutters Bridge using 3000 tons of stainless rebar and probably that much in carbon rebar and a bridge to Disney World being built on Lantau Island in Hong Kong. Total Asian demand in the next two to three years is about 7000 tons. Canada, Europe and the Middle East fabricators have been using stainless rebar for a while.

### Conclusion

Everyone knows there is a need to upgrade the use of black carbon rebar when you expect corrosion problems. Different coatings and claddings have been tried, but they have not met expectation, so now bridge designers are using solid stainless rebar because they know it will work. We're helping bridge designers and DOTs understand the value of using solid stainless bar, and we have brought expanded sizes and lengths to the market.

For more information on stainless steel rebar, contact the author or **Circle 205**.

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**Company Profile...Carpenter Technology Corporation** is a leading manufacturer and distributor of specialty alloys including stainless steel and titanium, and various engineered products made from metallic and ceramic materials.