

Rusty Steel

By Alexander “Sash” Williams



Fig. 1: Reinforcing bar with minor surface rusting

If you’ve seen reinforcing steel, you’ve likely also seen rusty reinforcing steel. Is this OK? Yes, but there are limits.

Section 7.4.2 of ACI 318-11 states:

“Except for prestressing steel, steel reinforcement with rust, mill scale, or a combination of both shall be considered satisfactory, provided the minimum dimensions (including height of deformations) and weight of a hand-wire-brushed test specimen comply with the applicable ASTM specifications referenced in 3.5 (Steel Reinforcement provisions in Chapter 3 – Materials of ACI 318-11).”

The reinforcing steel found on the majority of conventional projects is likely to fall under ASTM A615 or A706. Within the body of these ASTM standards, under the heading of “Finish,” the standards expand the list of acceptance criteria provided by ACI 318-11 for the weight, dimensions, cross-sectional area, and tensile properties of the reinforcing bar in question. Each standard includes a table that lists the required nominal weights and dimensions for reinforcing steel from No. 3 up to No. 18 (10M up to 57M). It’s worth noting that these nominal dimensions are equivalent to those of a plain (undeformed) round bar.

How do these ASTM documents and tables help a contractor determine when a rusty reinforcing bar is acceptable to use or when an engineer has sufficient grounds to reject the reinforcing bar? The following may be a reasonable first pass: for surface rust that can be wiped off, it is almost certainly OK; if it can be brushed or scraped off

and it does not leave any discernible pitting, it is likely OK; if there is scale and shows pitting of the surface when wire brushed, it likely does not meet the ASTM standards (refer to Fig. 1 to 3). If it is a questionable call, the final determination would likely have to be made by a qualified lab; however, there are alternatives. Provided the rust does not adversely affect the bond or tensile properties of the reinforcing bar, it would be reasonable to assume that a No. 5 (16M) bar with minor pitting would meet the ASTM designated criteria of a No. 4 (13M) bar, and so on. If the reinforcing bar is already installed, the engineer could consider allowing the contractor to add supplemental reinforcing bar to compensate for cross section reduced by rusting.

It is valuable to point out that rust can actually increase the bond between reinforcing steel and concrete. Deformed reinforcing steel is manufactured with deformations in the form of patterned ridges to increase the surface roughness, leading to an increase in the bond as compared to a plain bar. Surface rusting increases the roughness of the reinforcing bar and, in doing so, rust can increase the bond. This should not in itself be considered a valid argument for using rusty reinforcing steel. The design equations using bond between reinforcing steel and concrete, such as the calculation of reinforcing bar development length, do not include a variable for rusting. Any additional bonding that could be attributed to the rust would be supplemental to what was already determined to be necessary.

Shotcrete Corner

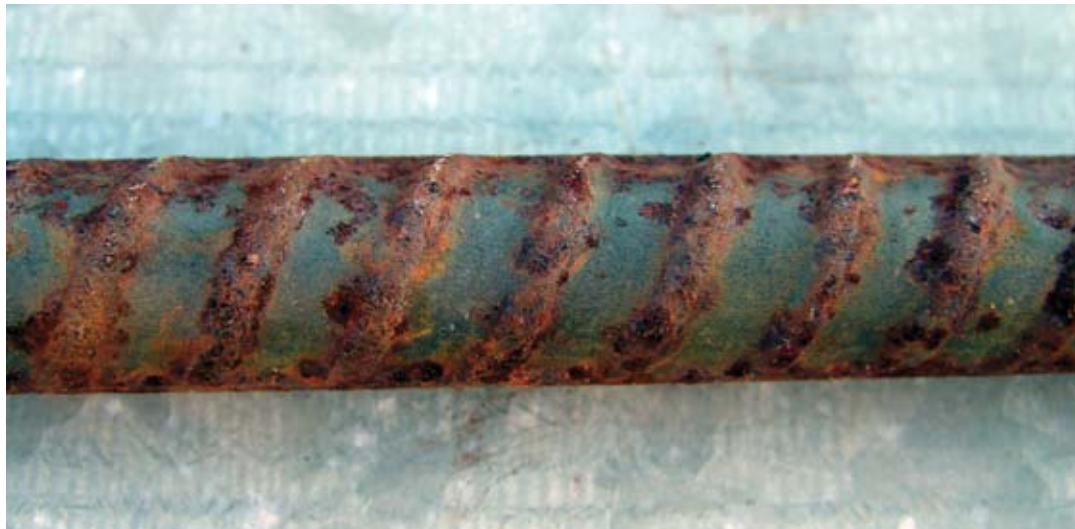


Fig. 2: Reinforcing bar with surface rusting and the beginning of rust scale



Fig. 3: Reinforcing bar with surface rust and scale

According to ACI and ASTM standards, the presence of rust alone is not sufficient grounds for rejection. For situations where the rust has progressed beyond surface rust, there may be some judgment needed in the field by both the contractor and engineer. Ultimately, the best scenario is a project where proper material handling and storage leads to reinforcing bar with nothing more than the occasional areas of surface rust.

References

ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-11) and Commentary," American Concrete Institute, Farmington Hills, MI, 2011, 503 pp.

ASTM A615/A615M-12, "Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement," ASTM International, West Conshohocken, PA, 2012, 6 pp.

ASTM A706/A706M-09b, "Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement," ASTM International, West Conshohocken, PA, 2009, 6 pp.



Alexander "Sash" Williams is a licensed professional engineer; an ASA, American Concrete Institute (ACI), and ASCE member; and President of Williams Associates Engineering, Inc., in northern California. Williams specializes in temporary and permanent earth retention design, including wine caves in California.