Table 1—Reinforcing Bars 1911 to Present; ASTM Specifications; Minimum Yield and Tensile Strengths in psi

ASTM Spec	Years		Steel Type	Grade 33 (Structural)		Grade 40 (Intermediate)		Grade 50 (Hard)		Grade 60		Grade 75	
	Start	End		Min. Yield	Min. Tensile	Min. Yield	Min. Tensile	Min. Yield	Min. Tensile	Min. Yield	Min. Tensile	Min. Yield	Min. Tensile
A15	1911	1966	Billet	33,000	55,000	40,000	70,000	50,000	80,000				
A408	1957	1966	Billet	33,000	55,000	40,000	70,000	50,000	80,000				
A432	1959	1966	Billet							60,000	90,000		
A431	1959	1966	Billet									75,000	100,000
A615	1968	1972	Billet			40,000	70,000			60,000	90,000	75,000	100,000
A615	1974	1986	Billet			40,000	70,000			60,000	90,000		
A615	1987	Present	Billet			40,000	70,000			60,000	90,000	75,000	100,000
A16	1913	1966	Rail					50,000	80,000				
A61	1963	1966	Rail							60,000	90,000		
A616	1968	1999	Rail					50,000	80,000	60,000	90,000		
A160	1936	1964	Axle	33,000	55,000	40,000	70,000	50,000	80,000				
A160	1965	1966	Axle	33,000	55,000	40,000	70,000	50,000	80,000	60,000	90,000		
A617	1968	1999	Axle			40,000	70,000			60,000	90,000		
A996	2000	Present	Rail, Axle			40,000	70,000	50,000	80,000	60,000	90,000		
A706	1974	Present	Low-Alloy							60,000	80,000		
A955M	1996	Present	Stainless			40,000	70,000			60,000	90,000	75,000	100,000

BOND AND ANCHORAGE

After establishing the yield strength of the reinforcing bars, the next important property required for evaluation of old structures concerns bond and anchorage. Steel mills in the USA completed conversion of their production to "high-bond" deformations about 1947, which continue virtually unchanged to the present day. In 1947, ASTM issued a specification, designated as A305, which prescribed requirements for deformations on reinforcing bars. The A305 specification existed from 1947 to 1968. In 1968, the requirements for deformations were merged into the specifications for reinforcing bars—A615 (billet-steel), A616 (rail-steel), and A617 (axle-steel).

For older structures, it is prudent to consider all varieties of reinforcing bars—plain round, old-style deformed, twisted square, and so on—conservatively and simply as 50 percent as effective in bond and anchorage as current bars. In other words, the tension development lengths, ℓ_d, for the old bars would be twice (double) the ℓ_d required for modern reinforcing bars. Since most strength design reviews for flexure will be based on a yield strength, f_y = 33,000 psi instead of today's 60,000 psi, the tension development lengths for the old bars can be determined by adding 10 percent to any current table of tension development lengths, ℓ_d, for modern reinforcing bars. The main deficiencies encountered in old structures will be in tension lap splice lengths provided for bars larger than #6, and typical details with top bars larger than #6 cut off at 0.25 times clear span.

Standard end hooks, 90° or usually 180°, on old-style bars in earlier codes were considered to develop half the allowable tension stress. Under today's strength design method, this value would approximate $\phi f_y/2$ = (0.90)(33,000 psi)/2 ≈ 15,000 psi.

DETAILS OF REINFORCING BARS

Flexural Members. For structures built during the period 1900 to 1940, design standards and accompanying typical details of reinforcing bars evolved gradually, beginning with a bewildering variety of patented systems. Where design drawings or project specifications are not available, and no clue remains to the system used, caution is particularly prudent. Many of the older patented systems would be considered much less effective today—some were theoretically sound and went out of style because of high costs, but others were based upon theory not acceptable today. In two-way slabs, do ***not*** assume that there was only two-way reinforcement. Especially, if the topmost layer is disappointingly light, it may be part of a *four-way* system, with four layers instead of two. Look for diagonal bands of bars.

Where original design drawings are not available, typical details for reinforcing bars as shown in ACI Detailing Manuals (Reference 4) were commonly used since 1947. These typical details can be assumed and used for initial calculations if original service loads are known. In any case, these calculations should be confirmed or modified as soon as data on bar sizes, bar spacings, and effective depths of structural members can be checked in the field.

Particularly for flexural members, load tests are especially convincing when used to check calculated capacity based upon material tests and reconstituted