

Reinforcing Bars Specifications and Current Situations in Myanmar

Engr. San Kyu

Civil Engineering Consultant

Central Executive Committee Member (Fed.MES)

PE (Construction), ACPE

M.ASCE, Hon.F.AFEO, AER, FM.Fed.MES

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- **Rebar** is primarily composed of iron (Fe) with key alloying elements added to enhance strength and ductility, typically including Carbon (C < 0.30% - 0.35%), Manganese (Mn < 1.60%), Silicon (Si), and small amounts of Phosphorus (P) and Sulfur (S).
- **Standard Carbon Steel** (ASTM A615) is most common, while ASTM A706 (low alloy) improves weldability.
- **Carbon Steel** (ASTM A615): Typically contains 0.30% - 0.35% max Carbon for grades 40 and 60, with Manganese up to 1.50%.
- **Low-alloy Steel** (ASTM A706): Designed for better welding and ductility, containing lower Carbon ($\leq 0.30\%$) and higher, controlled Manganese ($\sim 1.50\%$).
- **Stainless Steel** (ASTM A955): Contains Chromium (10.5-12%), Nickel (3-5%), and Molybdenum (1-2.5%) for corrosion resistance.
- **Trace Elements**: Small amounts of Silicon (0.15%-0.3%), Copper (0.1%-0.4%), and limited Phosphorus ($< 0.060\%$) and Sulfur ($< 0.060\%$) are included to enhance durability.

ACI-318-19 **Steel Reinforcement**

- Reinforcement shall be deformed reinforcement, except that plain reinforcement shall be permitted for spirals or prestressing steel.
- Specifications of deformed reinforcement are
 - (a) Carbon steel - ASTM A615
 - (b) Low-alloy steel - ASTM A706
 - (c) Rail-Steel and Axle Steel - ASTM A996
 - (d) Stainless steel - ASTM A955
 - (e) High-strength low-carbon chromium steel - ASTM A1035
- **The values of f_y and f_{yt} used in design calculation shall not exceed 80,000 psi, except for prestressing steel and for transverse reinforcement (spiral reinforcement in special moment frames and special structural walls.)**

CODES & STANDARDS TO FOLLOW

AMERICAN CODES & STANDARDS

- ACI-318-19
- ASTM-A615
- ASTM-A706

BRITISH STANDARDS

- BS-4449 – Steel for Reinforcement of Concrete

ASTM A615

Carbon-Steel Reinforcement

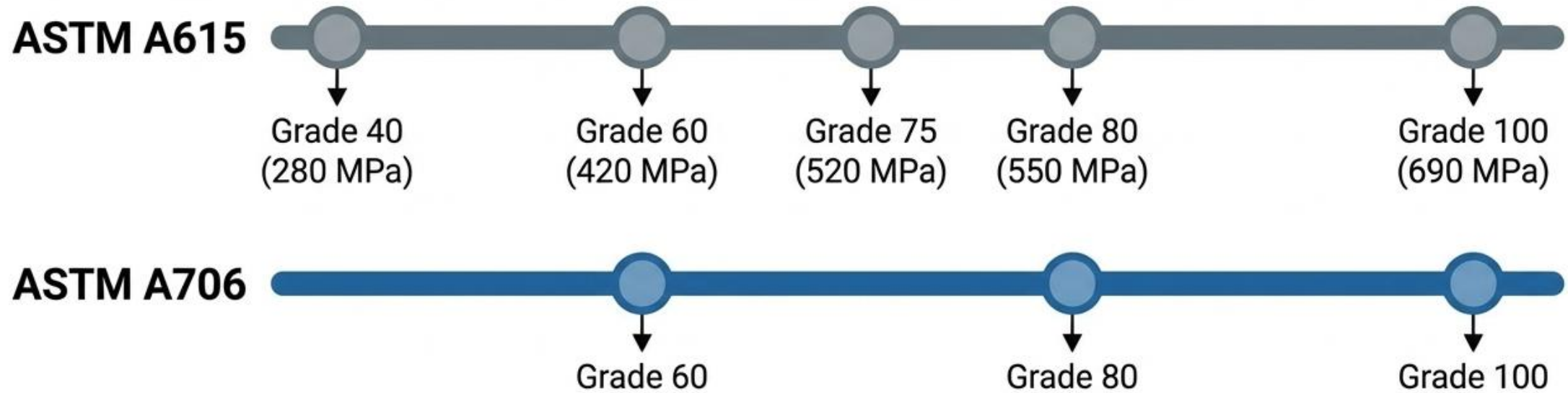
- The general-purpose workhorse of the construction industry.
- Manufactured from carbon steel billets.

ASTM A706

Low-Alloy Steel Reinforcement

- The upgraded standard.
- Engineered with restricted chemical composition to provide controlled tensile properties and enhanced weldability.

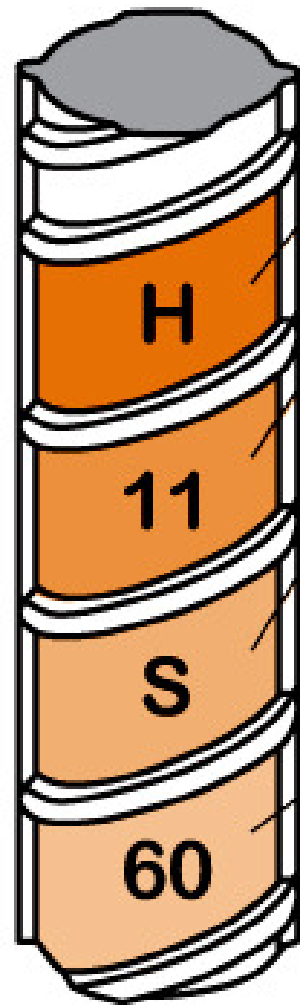
The Grade Spectrum



Code Insight

Grade 100 is a recent addition to ASTM A706, introduced to accommodate higher strength demands in ACI 318-19.

Decoding The Bar Anatomy



Point of Origin

Letter(s) or symbol(s) of producing mill

Size Designation

3, 4, 5, 6, 7, 8, 9, 10, 11, 14, 18
[10, 13, 16, 19, 22, 25, 29, 32, 36, 42, 57]

Type of Steel

S = Carbon-Steel (A615/A615M)
W = Low-Alloy Steel (A706/A706M)
SS = Stainless-Steel (A955/A955M)
R = Rail-Steel (A996/A996M)
I = Rail-Steel (A996/A996M)
A = Axle-Steel (A996/A996M)
CS = Low-Carbon Chromium (A1035/A1035M)

Minimum Yield Designation (Grade Mark or Grade Line)

Inch-Pound Markings		Metric Markings	
60	Grade 60*	4	Grade 420*
75	Grade 75**	5	Grade 520**
80	Grade 80***	6	Grade 550***
100	Grade 100****	6	Grade 690****
120	Grade 120****	8	Grade 830****
None	Grade 40 or 50	None	Grade 280 or 350

*Or 1 Grade Line / **Or 2 Grade Lines / ***Or 3 Grade Lines / ****Or 4 Grade Lines

For stainless-steel (ASTM A955/A955M) reinforcing bars:

"•" for Grade 60 [420], "••" for Grade 75 [520]

Verifying the Steel Type



Denotes ASTM A615 (Carbon-Steel)



Denotes ASTM A706 (Weldable / Low-Alloy Steel)

Note: 'W' signifies the restricted carbon equivalent intended to enhance weldability per AWS D1.4.

PRODUCTS NORMALLY USED IN MYANMAR

GRADE DESIGNATION (HRB400, HRB500, HRB500E, etc.)

- THE **HRB** system (**H**ot-**R**olled **B**ar) (Ribbed)
- **Numbers (400, 500)** indicate the minimum yield strength in MPa.
- The “**E**” denotes “**E**arthquake” resistance. These bars have strict metallurgical requirements for seismic ductility, ensuring they bend and stretch under extreme stress rather than snapping abruptly.

Grade	Minimum Yield Strength (MPa)	Minimum Tensile Strength (MPa)	Elongation at Break	Seismic Suitability
HRB400	400	540	≥ 16%	Standard
HRB400E	400	540	≥ 16%	High (Enhanced ductility)
HRB500	500	630	≥ 15%	Standard
HRB500E	500	630	≥ 15%	High (Enhanced ductility)

Sample of Hot Rolled Bars



HRB 400, 20 mm Rebar



HRB 500E, 25 mm Rebar

Deformed Bar Designation Numbers, Nominal Weights [Masses], Nominal Dimensions, and Deformation Requirements ASTM – A 615/ A 615M

Bar Designation No.	Nominal Weight, lb/ft [Nominal Mass, kg/m]	Nominal Dimensions			Deformation Requirements, in. [mm]		
		Diameter, in. [mm]	Cross-Sectional Area, in. ² [mm ²]	Perimeter, in. [mm]	Maximum Average Spacing	Minimum Average Height	Maximum Gap (Chord of 12.5 % of Nominal Perimeter)
3 [10]	0.376 [0.560]	0.375 [9.5]	0.11 [71]	1.178 [29.9]	0.262 [6.7]	0.015 [0.38]	0.143 [3.6]
4 [13]	0.668 [0.994]	0.500 [12.7]	0.20 [129]	1.571 [39.9]	0.350 [8.9]	0.020 [0.51]	0.191 [4.9]
5 [16]	1.043 [1.552]	0.625 [15.9]	0.31 [199]	1.963 [49.9]	0.437 [11.1]	0.028 [0.71]	0.239 [6.1]
6 [19]	1.502 [2.235]	0.750 [19.1]	0.44 [284]	2.356 [59.8]	0.525 [13.3]	0.038 [0.97]	0.286 [7.3]
7 [22]	2.044 [3.042]	0.875 [22.2]	0.60 [387]	2.749 [69.8]	0.612 [15.5]	0.044 [1.12]	0.334 [8.5]
8 [25]	2.670 [3.973]	1.000 [25.4]	0.79 [510]	3.142 [79.8]	0.700 [17.8]	0.050 [1.27]	0.383 [9.7]
9 [29]	3.400 [5.060]	1.128 [28.7]	1.00 [645]	3.544 [90.0]	0.790 [20.1]	0.056 [1.42]	0.431 [10.9]
10 [32]	4.303 [6.404]	1.270 [32.3]	1.27 [819]	3.990 [101.3]	0.889 [22.6]	0.064 [1.63]	0.487 [12.4]
11 [36]	5.313 [7.907]	1.410 [35.8]	1.56 [1006]	4.430 [112.5]	0.987 [25.1]	0.071 [1.80]	0.540 [13.7]
14 [43]	7.65 [11.38]	1.693 [43.0]	2.25 [1452]	5.32 [135.1]	1.185 [30.1]	0.085 [2.16]	0.648 [16.5]
18 [57]	13.60 [20.24]	2.257 [57.3]	4.00 [2581]	7.09 [180.1]	1.58 [40.1]	0.102 [2.59]	0.864 [21.9]

- ❑ Bar numbers are based on the number of eighths of an inch included in the nominal diameter of the bars [bar numbers approximate the number of millimeters of the nominal diameter of the bar].
- ❑ The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight [mass] per foot [meter] as the deformed bar.


A706/A706M – 22a
TABLE 1 Deformed Bar Designation Numbers, Nominal Weights [Masses], Nominal Dimensions, and Deformation Requirements

Bar Designation No.	Nominal Weight, lb/ft [Nominal Mass, kg/m]	Nominal Dimensions ^A			Deformation Requirements, in. [mm]		
		Diameter, in. [mm]	Cross-Sectional Area in. ² [mm ²]	Perimeter, in. [mm]	Maximum Average Spacing	Minimum Average Height	Maximum Gap (Chord of 12.5 % of Nominal Perimeter)
3 [10]	0.376 [0.560]	0.375 [9.5]	0.11 [71]	1.178 [29.9]	0.262 [6.7]	0.015 [0.38]	0.143 [3.6]
4 [13]	0.668 [0.994]	0.500 [12.7]	0.20 [129]	1.571 [39.9]	0.350 [8.9]	0.020 [0.51]	0.191 [4.9]
5 [16]	1.043 [1.552]	0.625 [15.9]	0.31 [199]	1.963 [49.9]	0.437 [11.1]	0.028 [0.71]	0.239 [6.1]
6 [19]	1.502 [2.235]	0.750 [19.1]	0.44 [284]	2.356 [59.8]	0.525 [13.3]	0.038 [0.97]	0.286 [7.3]
7 [22]	2.044 [3.042]	0.875 [22.2]	0.60 [387]	2.749 [69.8]	0.612 [15.5]	0.044 [1.12]	0.334 [8.5]
8 [25]	2.670 [3.973]	1.000 [25.4]	0.79 [510]	3.142 [79.8]	0.700 [17.8]	0.050 [1.27]	0.383 [9.7]
9 [29]	3.400 [5.060]	1.128 [28.7]	1.00 [645]	3.544 [90.0]	0.790 [20.1]	0.056 [1.42]	0.431 [10.9]
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14 [43]	7.65 [11.38]	1.693 [43.0]	2.25 [1452]	5.32 [135.1]	1.185 [30.1]	0.085 [2.16]	0.648 [16.5]
18 [57]	13.60 [20.24]	2.257 [57.3]	4.00 [2581]	7.09 [180.1]	1.58 [40.1]	0.102 [2.59]	0.864 [21.9]

^A The nominal dimensions of a deformed bar are equivalent to those of a plain round bar having the same weight [mass] per foot [metre] as the deformed bar.

ASTM – A 615/ A 615M

Material and Manufacture

- The bars shall be rolled from properly identified heats of mold cast or strand cast steel using the open-hearth, basic-oxygen, or electric-furnace process.

Chemical Composition

- An analysis of each heat of steel shall be made by the manufacturer from test samples taken preferably during the pouring of the heats.
- The percentages of carbon, manganese, phosphorus and sulfur, shall be determined.
- The phosphorus content thus determined shall not exceed 0.06 %.
- An analysis may be made by the purchaser from finished bars.
- The phosphorus content thus determined shall not exceed by more than 25 % of that during casting period.

Permissible Variation in Weight [Mass]

- The permissible variation shall not exceed 6 % under nominal weight [mass].

Tests for Reinforcing Steel Bars

- Chemical analysis including carbon, manganese, phosphorus, and sulfur.
- Tensile properties.
- Bend test.

11. Permissible Variation in Weight [Mass]

11.1 Deformed reinforcing bars shall be evaluated on the basis of nominal weight [mass]. The weight [mass] determined using the measured weight [mass] of the test specimen and rounding in accordance with Practice **E29**, shall be at least 94 % of the applicable weight [mass] per unit length prescribed in **Table 1**. In no case shall overweight [excess mass] of any deformed bar be cause for rejection.

BS-4449-2005

Table 7 — Nominal cross-sectional area and mass per metre

Nominal diameter mm	Cross sectional area mm ²	Mass per metre kg
6 ^a	28.3	0.222
7 ^a	38.5	0.302
8	50.3	0.395
9 ^a	63.6	0.499
10	78.5	0.617
12	113	0.888
16	201	1.58
20	314	2.47
25	491	3.85
32	804	6.31
40	1257	9.86
50	1963	15.4

^a Preferred diameters for the manufacture of welded fabric to BS 4483 only.

- The permissible deviation from nominal mass per meter shall be not more than $\pm 4.5\%$ on nominal diameters greater than 8 mm, and $\pm 6.0\%$ on nominal diameters less than or equal to 8 mm.

ASTM – A 615/ A 615M

TABLE 2 Tensile Requirements

	Grade 40 [300] ^A	Grade 60 [420]	Grade 75 [520] ^B
Tensile strength, min, psi [MPa]	70 000 [500]	90 000 [620]	100 000 [690]
Yield strength, min, psi [MPa]	40 000 [300]	60 000 [420]	75 000 [520]
Elongation in 8 in. [203.2 mm], min, %:			
Bar Designation No.			
3 [10]	11	9	..
4, 5 [13, 16]	12	9	...
6 [19]	12	9	7
7, 8 [22, 25]	...	8	7
9, 10, 11 [29, 32, 36]	...	7	6
14, 18 [43, 57]	...	7	6

^A Grade 40 [300] bars are furnished only in sizes 3 through 6 [10 through 19].

^B Grade 75 [520] bars are furnished only in sizes 6 through 18 [19 through 57].

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TABLE 2 Tensile Requirements

	Grade 60 [420]	Grade 80 [550]	Grade 100 [690]
Tensile strength, min, psi [MPa]	80 000 [550]	100 000 [690]	117 000 [805]
Yield strength, min, psi [MPa]	60 000 [420]	80 000 [550]	100 000 [690]
Yield strength, max, psi [MPa]	78 000 [540]	98 000 [675]	118 000 [815]
Ratio of actual tensile strength to actual yield strength, min	1.25	1.25	1.17
Elongation in 8 in. [200 mm], min, %			
Bar Designation Nos.			
3, 4, 5, 6 [10, 13, 16, 19]	14	12	10
7, 8, 9, 10, 11 [22, 25, 29, 32, 36]	12	12	10
14, 18 [43, 57]	10	10	10

Remark: This table is mandatory in the main body for standard projects to verify the rebar meets the required strength

TABLE S1.1 Additional Tensile Requirements

Uniform Elongation (E _l) min, % in 4 in. [100 mm]	Grade 60 [420]	Grade 80 [550]	Grade 100 [690]
Bar Designation Nos.			
10 [32] and smaller	9	7	6
11 [36] and larger	6	6	6

Remark: This table is a supplementary(optional) located in the annex

Bend Test

- The ASTM A615 bend test evaluates the ductility and surface integrity of steel reinforcing bars by bending them around a mandrel (typically 180° for sizes #3-#11, and 90° for #14 and #18) at specific temperatures (10° C to 30° C) to check for cracks or fractures on the outside radius.
- Key Bend Test Requirements (ASTM A615):
- Purpose: Ensures the rebar can be bent during construction without losing strength, confirming it meets ductility standards.
- Procedure: A specimen is bent over a pin (mandrel) of a specified diameter, which varies based on the bar size and grade (Grade 40, 60, 75, or 80).
- Bend Angles: Generally, a 180-degree bend is required, but 90-degree bends are permitted for larger bar sizes (#14 and #18).
- Pass/Fail Criteria: After bending, the bar must show no signs of cracks or fissures when inspected by a person with normal vision.

ASTM – A 615/ A 615M

TABLE 3 Bend Test Requirements

Bar Designation No.	Pin Diameter for Bend Tests ^A				
	Grade 40 [280]	Grade 60 [420]	Grade 75 [520]	Grade 80 [550]	Grade 100 [690]
3, 4, 5 [10, 13, 16]	$3\frac{1}{2}d^B$	$3\frac{1}{2}d$	$5d$	$5d$	$5d$
6 [19]	$5d$	$5d$	$5d$	$5d$	$5d$
7, 8 [22, 25]	...	$5d$	$5d$	$5d$	$5d$
9, 10, 11 [29, 32, 36]	...	$7d$	$7d$	$7d$	$7d$
14, 18 [43, 57] (90°)	...	$9d$	$9d$	$9d$	$9d$
20 [64] (90°)	...	$10d$	$10d$	$10d$...

^A Test bends 180° unless noted otherwise.

^B d = nominal diameter of specimen.

Bending Requirements

The bend-test specimen shall withstand being bent around a pin without cracking on the outside radius of the bent portion. The requirements for degree of bending and sizes of pins are prescribed in Table 3. When material is furnished in coils, the test sample shall be straightened prior to placing it in the bend tester.

ASTM – A 706

TABLE 3 Bend Test Requirements

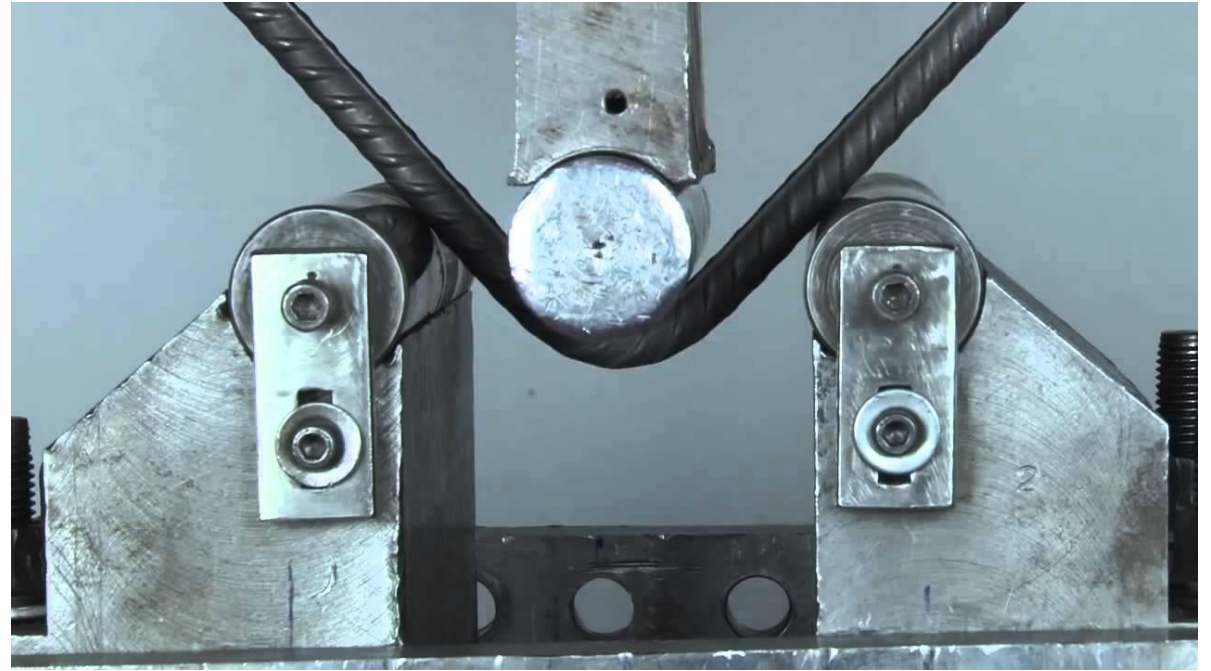
Bar Designation No.	Pin Diameter for 180° Bend Tests		
	Grade 60 [420]	Grade 80 [550]	Grade 100 [690]
3, 4, 5 [10, 13, 16]	$3d^A$	$3\frac{1}{2} d^A$	$3\frac{1}{2} d$
6, 7, 8 [19, 22, 25]	$4d$	$5d$	$5d$
9, 10, 11 [29, 32, 36]	$6d$	$7d$	$7d$
14, 18 [43, 57]	$8d$	$9d$	$9d$

^A d = nominal diameter of specimen.

Bend Test of Steel



Bend Test on Site



Bend Test in Lab

Cracks on Rebars After Bend Test



3. ASTM A615 Rebar Chemical Composition

The **ASTM A615 rebar chemical composition** requirements for Grades 40, 60, and 75 are **generally the same** under ASTM A615. Differences between grades are mainly reflected in **mechanical properties** rather than chemical limits.

Element	Maximum Content (%)
Carbon (C)	0.30–0.50 (varies slightly with bar size)
Manganese (Mn)	0.60–1.50
Phosphorus (P)	≤ 0.050
Sulfur (S)	≤ 0.060

Influence of elements on ASTM A615 rebar properties:

- **Carbon (C):** Increases strength but lowers weldability.
- **Manganese (Mn):** Improves toughness and durability.
- **Phosphorus (P) & Sulfur (S):** Must be minimized to avoid brittleness and cracking.

*The **ASTM A615 Grade 60 chemical composition** follows this standard range, ensuring consistent tensile strength and reliable performance across construction applications.

Chemical Composition

ASTM – A 706

6.2 The chemical composition as shown by heat analysis shall be limited by the following:

Element	max, %
Carbon	0.30
Manganese	1.50
Phosphorus	0.035
Sulfur	0.045
Silicon	0.50

CARBON EQUIVALENT (CE) FORMULA

$$\text{C.E.} = \% \text{ C} + \frac{\% \text{ Mn}}{6} + \frac{\% \text{ Cu}}{40} + \frac{\% \text{ Ni}}{20} + \frac{\% \text{ Cr}}{10} - \frac{\% \text{ Mo}}{50} - \frac{\% \text{ V}}{10} \quad (1)$$

☐ To guarantee weldability, the heat analysis must not exceed a maximum CE of 0.55%.

20.2.2.5 Deformed nonprestressed longitudinal reinforcement resisting earthquake-induced moment, axial force, or both, in special moment frames, special structural walls, and all components of special structural walls including coupling beams and wall piers shall be in accordance with (a) or (b):

(a) **ASTM A706**, Grade 60

(b) **ASTM A615** Grade 40 reinforcement if (i) and (ii) are satisfied and ASTM A615 Grade 60 reinforcement if (i) through (iii) are satisfied.

(i) Actual yield strength based on mill tests does not exceed f_y by more than 18,000 psi

(ii) Ratio of the actual tensile strength to the actual yield strength is at least 1.25

(iii) Minimum elongation in 8 in. shall be at least 14 percent for bar sizes No. 3 through No. 6, at least 12 percent for bar sizes No. 7 through No. 11, and at least 10 percent for bar sizes No. 14 and No. 18.

**Thank you So Much For Your Kind Attention.
Discussions and Questions are Welcome.**