16.4 MATERIAL PROPERTIES FOR EXISTING STRUCTURES

16.4.1 GENERAL

This BDM provides material properties for existing structures.

16.4.2 ACTUAL MATERIAL PROPERTIES

Actual material properties acquired through testing may be used in place of specified minimum and expected material properties when determining existing bridge element capacities. The Project Engineer should contact METS to obtain physical material test results of existing steel components and reinforcement. Guidelines for material sampling and determining the material's mechanical properties are provided in the AASHTO MBE (AASHTO, 2018), Articles 5.3 and 6A.6.2, respectively.

16.4.3 SPECIFIED MINIMUM MATERIAL PROPERTIES

In the absence of physical test results, specified minimum material properties of existing concrete, structural steel, and reinforcement found from as-built plans or "Report of Completion – Bridges" may be used.

When material information for structural steel or reinforcement is unavailable on as-built plans or "Report of Completion – Bridges", specified minimum yield and tensile strengths listed in Tables 16.4.3-1 and 16.4.3-2 may be used. Table 16.4.3-1 is based on the AASHTO MBE (AASHTO, 2018). Table 16.4.3-2 is based on the past and current AASHTO bridge design specifications from the 1st Edition of Standard Specifications (AASHO, 1927) to the 8th Edition of the AASHTO LRFD Bridge Design Specifications (AASHTO, 2017).

Table 16.4.3-1 Material Properties for Steel Reinforcement

Steel Reinforcement	Allowable stress f_s (ksi)	F_{yr} (ksi)	F_{ur} (ksi)
Unknown steel prior to 1954	18	33	55
Structural Grade	20	36	58
Billet, Intermediate Grade and Unknown after 1954 (Grade 40)	20	40	60
Rail or Hard Grade (Grade 50)	24	50	65
Grade 60	24	60	90

Table 16.4.3-2 Material Properties for Historical Structural Steel

ASTM Designation	Plate Thickness t (in.)	Shape Groups	F_y (ksi)	F_u (ksi)	Date Built-Steel (AASHTO Design Specifications)
-	N/A	N/A	26	52	Prior to 1905
-	N/A	N/A	30	55	1905 to 1936
-	N/A	N/A	33	55	1936-1963
-	N/A	N/A	36	58	After 1963
A7	N/A	N/A	30	55	1927 (1st Edition)
A7	N/A	N/A	33	60	1935 -1961 (2nd – 8th Edition)
A8	N/A	N/A	55	90	1935 -1961 (2nd – 8th Edition)
A94	$t \leq 1.125''$	N/A	50	75	1935 -1961 (2nd – 8th Edition)
	$1.125'' < t \leq 2''$	N/A	47	72	
	$2'' < t \leq 4''$	N/A	45	60	
A36	$t \leq 8''$	All	36	58	1965 -1983 (9th – 13th Edition)
A441	$4'' < t \leq 8''$	N/A	40	60	1965 – 1973 (9th – 11th Edition)
A242, A440, A441	$t \leq 3/4''$	I, 1, 2	50	70	1961 – 1973 (8th – 11th Edition)
	$3/4'' < t \leq 1.5''$	II, 3	46	67	
	$1.5'' < t \leq 4''$	III, 4,5	42	63	
A588	$t \leq 4''$	1-4	50	70	1973 (11th Edition)
	$4'' < t \leq 5''$	5	46	67	
	$5'' < t \leq 8''$	N/A	42	63	
A558	$t \leq 4''$	All	50	70	1977 -1983 (12th -13th Edition)

Table 16.4.3-2 (continued) Material Properties for Historical Structural Steel

ASTM Designation	Plate Thickness t (in.)	Shape Groups	F_y (ksi)	F_u (ksi)	Date Built-Steel (AASHTO Design Specifications)
A514/A517	$t \leq 2.5''$	N/A	100	110	1977 -1983 (12th -13th Edition)
	$2.5'' < t \leq 4''$	N/A	90	100	
A852	$t \leq 4''$	N/A	70	90	1983 (13th Edition)
A709 Grade 36	$t \leq 4''$	All	36	58	1989 – 2017 (14th–LRFD 8th Edition)
A709 Grade 50	$t \leq 4''$	All	50	65	1989 – 2017 (14th–LRFD 8th Edition)
A709 Grade 50W	$t \leq 4''$	All	50	70	1989 – 2017 (14th–LRFD 8th Edition)
A709 Grade 70W	$t \leq 4''$	N/A	70	90	1989 -1992 (14th -15th Edition)
A709 Grade 100/100W	$t \leq 2.5''$	N/A	100	110	1989 – 2007 (14th–LRFD 4th Edition)
	$2.5'' < t \leq 4''$	N/A	90	100	
A709 Grade 50S	N/A	All	50	65	2004- 2017 (LRFD 3rd - 8th Edition)
A709 Grade HPS 50W	$t \leq 4''$	N/A	50	70	2004-2017 (LRFD 3rd - 8th Edition)
A709 Grade HPS 70W	$t \leq 4''$	N/A	70	85	2004-2017 (LRFD 3rd - 8th Edition)
A709 Grade HPS 100W	$t \leq 2.5''$	N/A	100	110	2010 – 2017 (LRFD 5th - 8th Edition)
	$2.5'' < t \leq 4''$	N/A	90	100	

where:

F_u = specified minimum tensile strength of steel (ksi)

F_{ur} = specified minimum tensile strength of steel reinforcement (ksi)

F_y = specified minimum yield strength of steel (ksi)

F_{yr} = specified minimum yield strength of steel reinforcement (ksi)

f_s = allowable stress for steel reinforcement (ksi)

When material information for concrete is not available on the as-built plans or "Report of Completion – Bridges" and the concrete is in satisfactory condition, concrete compressive strength used in design, f'_c, may be taken as 2.5 ksi for structures built prior to 1960, and 3.0 ksi for structures built after 1959 (AASHTO, 2018).

16.4.4 EXPECTED MATERIAL PROPERTIES

In the absence of physical test results, the expected material properties provided in this section should be used.

16.4.4.1 Structural Steel

The expected yield strength, F_{ye}, and the expected tensile strength, F_{ue}, of existing steel components should be taken as follows (Caltrans, 2016):

$$F_{ye} = R_y F_y \quad (16.4.4\text{-}1)$$

$$F_{ue} = R_t F_u \quad (16.4.4\text{-}2)$$

where:

R_y = ratio of the expected yield strength to the specified minimum yield strength

R_t = ratio of the expected tensile strength to the specified minimum tensile strength

The values of R_y and R_t are given in Table 16.4.4-1.

Table 16.4.4-1 R_y and R_t Values for Structural Steel

Steel Grade	R_y	R_t
Plate and all other products		
ASTM A709 Grade 36, A36	1.3	1.2
ASTM A709 Grade 50	1.1	1.2
Hot-rolled structural shapes and bars		
ASTM A709 Grade 36, A36	1.5	1.2
ASTM A709 Grade 50, A992	1.1	1.1
Hollow structural sections (HSS)		
ASTM A500 Grade B	1.4	1.3
ASTM A501 Grade B	1.4	1.3
ASTM A1085	1.25	1.15
Pipe		
ASTM A53	1.6	1.2

16.4.4.2 Steel Reinforcement

The expected yield strength, F_{yer}, and the expected tensile strength, $F_{uer,}$ of existing steel reinforcement should be taken as follows:

Table 16.4.4-2 F_{yer} and F_{uer} for Steel Reinforcement

Steel Reinforcement Grade	F_{yr} (ksi)	F_{yer} (ksi)	F_{ur} (ksi)	F_{uer} (ksi)
A706 Grade 60	60	68	80	95
A706 Grade 80	80	85	98	112
A615 Grade 60	60	68	90	95
A615 Grade 40 or older Grade 40	40	48	60	68

16.4.4.3 Structural Concrete

The expected compressive strength, f'_{ce}, of existing structural concrete in good condition should be taken as 5000 psi.

16.4.5 REFERENCES

1. AASHTO. (2018). *The Manual for Bridge Evaluation*, 3rd Edition, American Association of State Highway and Transportation Officials, Washington, DC.
2. AASHTO. (2017). *AASHTO LRFD Bridge Design Specifications*, 8th Edition, American Association of State Highway and Transportation Officials, Washington, DC.
3. AASHO. (1927). *Standard Specifications for Highway Bridges and Incidental Structures*, American Association of State Highway Officials, Washington, DC.
4. Caltrans. (2016). *Caltrans Seismic Design Specifications for Steel Bridges*, 2nd Edition, California Department of Transportation, Sacramento, CA.