Slip Critical Bolts: New Available Strength Values

There are significant differences between current methods for designing with slip critical bolts compared with previous approaches.

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THE AVAILABLE SLIP STRENGTH IN SECTION J3.8 IS A CHANGE IN THE 2005 AISC SPECIFICATION THAT DESERVES DISCUSSION. As engineers begin to work with the specification they will notice that the available slip resistance for slip critical (SC) bolts matches neither the 1989 values for ASD nor the 1999 values for LRFD. Four factors combined to generate the strength in the 2005 specification, and a new distinction can be confusing due to the nuances of the terminology used.

The nominal slip resistance of high strength bolts changed in the 2005 specification. Factors involved in the change include:

- The distinction of slip resistance at a strength limit state in addition to the previous serviceability limit state;
- The potential effect of hole type on pretensioning and slip resistance;
- Combination of the Class A and Class C slip coefficients (μ); and
- Reconciling slip resistance using nominal loads and factored loads.

Slip Resistance as a Strength Limit State vs. a Serviceability Limit State

The change that may lead to the most confusion is a provision for slip as a strength limit as opposed to slip as a serviceability limit. The concept of design at a serviceability limit state verses a strength limit state is not the same as design using nominal (ASD) verses factored (LRFD) loads. Prior to the 2005 specification, slip resistance of slip critical connections was established with a reliability against slip that provided a level of confidence that slip would not occur at nominal loads. In the 2005 specification a 0.85 resistance factor applied to the nominal slip resistance results in a reliability against slip that is higher than in previous specifications and is approximately equal to that of the limit states of the connected main members.

The lower reliability was permitted in previous editions of the specification due to the concept that connection slip might result in a serviceability problem but it would not lead to a strength problem such as fracture of the connecting material or bolts. A corollary to the slip as service concept is that the bolts will slip before the connection reaches a strength limit; therefore, all slip critical connections were required to be checked for bearing limit states. The 2005 specification recognizes that there may be connections for which slip could lead to a strength-related failure. An example of such a connection would be a splice in a flat roof truss. In this case, a slip of the splice could result in an increase in ponding effects, raising loads above the strength limits of the connecting material or the bolts. Deliberations on the subject of this provision focused on relatively unusual connections such as the truss example cited above. Typical brace, beam or column connections were not thought to demand an increase in reliability above that which has been used historically. The distinction between connections that deserved a higher reliability and ones that did not could not be succinctly defined, but connections that could slip only 1⁄16 in., such as those using standard holes or transverse slots, were not subject to strength limits. The specification gives a default choice:

> *Connections with standard holes or slots transverse to the direction of the load shall be designed as a serviceability limit state. Connections with oversized holes or slots parallel to the direction of the load shall be designed to prevent slip at the required strength level.*

Table 1. The Formulae and Select Variables

Formula/ Specification	D_u*	μ A	μ B	μ C	φ or 1/Ω*** STD	φ or 1/Ω*** OVS SSt=	φ or 1/Ω*** SSt +	φ or 1/Ω*** LSt =	φ or 1/Ω*** LSt +	hsc** STD	hsc** OVS SLt	hsc** LSt	hsc (φ or 1/Ω) STD	hsc (φ or 1/Ω) OVS SLt=	hsc (φ or 1/Ω) SSt +	hsc (φ or 1/Ω) LSt =	hsc (φ or 1/Ω) LSt +
F_vA_{nom} 1989 ASD	1.13	0.33	0.5	0.4	N/A (0.72)			N/A (0.61)	N/A (0.72)	1.0	0.85	0.70	0.72	0.61		0.43	0.50
$\phi(1.13)(\mu)T_b$ 1999 LRFD				0.35	1.00 (1.00)	0.85 (1.00)		0.60 (0.85)	0.70 (1.00)				1.00	0.85		0.60	0.70
$(D_u)(\mu)(hsc)T_b/\Omega$ 2005 ASD		0.35		N/A	0.67	0.57	0.67	0.57	0.67				0.67	0.48	0.57	0.40	0.74
$\phi(D_u)(\mu)(hsc)T_b$ 2005 LRFD					1.00	0.85	1.00	0.85	1.00				1.00	0.72	0.85	0.60	0.70

OVS Oversize **SSt** Short slot **LSt** long slot **+** transverse **=** parallel

* D_u was not denoted in the 1989 ASD or 1999 LRFD, but D_u = 1.13 was implicit in the values in the AISC specifications.

** hsc was not denoted in the 1989 ASD or 1999 LRFD, but the values shown were implicit in the AISC specifications.

*** Numbers in parentheses represent equivalent φ or 1/Ω factors.

Table 2. Other Variables

Tensile Strength (ksi)		
F_u	A325 (F1852)	120*
	A490	150
	*F_u for A325 > 1″ = 105 ksi	
Areas (in.^{2})		
	A_{nom}	$A_{tensile}$
¾ in.	0.442	0.334
⅞ in.	0.601	0.462
1 in.	0.785	0.606
1⅛ in.	0.994	0.763
Pretension (kips) EXCERPT OF TABLE J3.1		
	A325 (F1852)	A490
¾ in.	28	35
⅞ in.	39	49
1 in.	51	64
1⅛ in.	56	80

That means use ϕ = 1.00 (Ω = 1.5) with standard holes and slots transverse to the load (slip will be 1⁄16 in. at most) and use ϕ = 0.85 (Ω = 1.76) with oversize holes or slots parallel to the load (where slip can exceed 1⁄16 in.).

Specification section J3.8 specifically allows the engineer to override the default available slip resistance. For that reason, the *Manual* lists strengths for slip critical bolts in standard holes using the strength limit state. This is contrary to the specified default requirement but may on rare occasions be determined by the engineer to be necessary.

There are also many cases in which it would be reasonable to decide that the increase in reliability is not required. This would be true where slip would result in distress to finishes, misalignment of pieces, or other service issues, but not fracture of the piece or collapse of the structure. Brick shelf angles should not demand strength level reliability. Brace connections probably do not need strength level reliability when the length of the slot relative to the length of the brace is short enough to prevent a significant geometric distortion in the frame. The use of an oversized hole could permit the braced column to slip about 3⁄16 in. If the column was 12 ft. long, that variance would be less than 1:750, which is well within the range of normal building tolerances. This would be true for most braces.

Viewed from a historical perspective, all slip-critical connections using oversized holes prior to the 2005 specification were designed under the concept that slip was a serviceability issue. To the authors' knowledge there has never been a problem stemming from this practice

The *Manual* lists strengths for slip critical bolts in standard holes using the strength limit state (ϕ= 0.85), which is more conservative than the default requirement. However, the *Manual* does not include bolt values that are less conservative than the recommended default values. For example, values are not provided to resist slip at the service level (ϕ =1.0) when oversized holes are provided, though in some cases this may be an acceptable choice. Available strength for bolts in oversized holes and slots parallel to the load using the serviceability limit are shown in the bottom lines of Table 3.

Holes Types and Consequences of Slip

In 1989 both the AISC and RCSC specifications gave allowable stresses for each bolt and hole type with no explanation. The *Guide to Design Criteria for Bolted and Riveted Joints* (2001) indicates that the variation in allowable stress in previous specification related to hole type included variations in the probability of slip due to the effect of hole type on pretension and included some consideration of the potential impact of slip on performance of the connection.

It is clear that the direction of long slots should not effect pretension and therefore not reduce slip resistance, but slip parallel to the long slot could be detrimental to the performance of the structure so it has historically had a lower allowable stress.

The 1999 LRFD specification combined the variations in the slip resistance and the potential for detriment to the performance of the connection into the resistance factors. The RCSC specification published in the same 3rd Edition *Manual* also used the resistance factors to capture both the reduction in slip and impact of slip. The RCSC specification also gave the engineer a method to design using nominal (unfactored or service) loads.

A common misconception is that the use of factored loads provided a connection with more slip resistance that one designed using nominal loads. In fact, if the L/D ratio is as assumed in the normal relationship between ASD and LRFD, the connections designed using factored loads will give the same number of bolts as those designed using nominal loads. Appendix B of the RCSC specification gave an ASD-based design method using a hole factor in lieu of a resistance factor but the result was almost the same; all slip-critical connections were designed to resist slip at the same level. In the RCSC specification the hole factor (H) combined some effects of

Table 3. Examples: Class A Single Shear

			¾ in. A325 F_u = 120; A_{nom} = 0.442; $A_{tensile}$ = 0.334; T_b= 0.7$F_u A_t$ = 28						1⅛ in. A490 F_u =150; A_{nom} = 0.994; $A_{tensile}$ = 0.763; T_b= 0.7$F_u A_t$ = 80					
		μ	Std	OVS	SSt+	SSt=	LSt+	LSt=	Std	OVS	SSt+	SSt=	LSt+	LSt=
1989	ASD	0.33	7.51	6.63	6.63	6.63	5.30	4.42	20.87	17.89	17.89	17.89	14.91	12.92
1999	LRFD	0.33	10.44	8.88	8.88	8.88	7.31	6.26	29.83	25.36	25.36	25.36	20.88	17.90
	RCSC Factor	0.33	10.44	8.88	8.88	8.88	7.31	6.26	29.83	25.36	25.36	25.36	20.88	17.90
	RCSC Nominal	0.33	7.39	6.28	6.28	6.28	5.17	4.44	21.12	17.95	17.95	17.95	14.78	12.67
	RCSC ASD	0.33	7.39	6.28	6.28	6.28	5.17	4.44	21.12	17.95	6.28	17.95	14.78	12.67
2005	LRFD	0.35	**11.07**	8.00	**9.41**	8.00	**7.75**	**6.59**	**31.64**	22.86	**26.89**	22.86	**22.15**	**18.83**
	ASD	0.35	7.38	5.35	6.28	5.35	5.17	4.40	**21.09**	15.28	**17.93**	15.28	14.77	12.58
	LRFD Service			9.41		9.41		7.75		26.89		26.89		22.15
	ASD Service			6.28		6.28		5.17		17.93		17.93		14.77

Bold greater than 1989 ASD — Red less than 1989 ASD

Bold greater than 1999 LRFD — Red less than 1999 LRFD reliability, the effect of slip on the structure and some reduction in pretensioning and slip resistance due to deformation of the compressed material particularly at long slots. When the provision for the strength limit state was made using a lower resistance factor, that part of the hole factor was modified to reflect only the change in nominal slip strength due to hole type. The resistance factor is used to adjust for the impact of slip on the connection.

Slip Coefficients

In 1989, the slip coefficient for galvanized surfaces was 0.40. By 2005 it was 0.35. The implication that the slip coefficients are precise enough to merit a difference between 0.33 for Class A, clean mill scale and 0.35 for, Class C, galvanized surfaces was not warranted. In the 2005 specification clean mill scale and galvanized surfaces are both designed using $\mu = 0.35$.

Slip Resistance Using Nominal and Factored Loads

Historic formulations for design at nominal loads (ASD) and design at factored loads (LRFD) were based on different theories. When the LRFD and ASD specifications were combined it became apparent that the relationship between these formulations did not correspond to the fundamental relationship between ASD and LRFD design: that the results should be the same when the L/D ratio is three. There was not valid reason for the differences in theoretical nominal strengths used in historic practice, so the formulation in the 2005 specification was selected as the most transparent and the design factors were adjusted to provide the appropriate relationship that is used for the remainder of the specification.

The result is that the available strength for bolts in slip critical connections differs from those in RCSC and previous AISC specifications, some higher and others lower. Table 3 serves as a comparison of strengths. One needs to use caution with these charts as the concept of design as a serviceability limit state is easily confused with designing using service loads. RCSC gives a method using service loads and another using factored loads which are both still based on reliability as a serviceability limit state. This is not the same as designing as a strength limit state in either ASD or LRFD.

Tables 1 and 2 compare parameters that have changed in the evolution of SC bolt strength provisions, give parameters necessary to calculate bolts strength, compare selected bolts strengths in the various specifications. Charts similar to tables in the *Manual* but that show default and non default values for SC bolts are available online at **www.modernsteel.com** with the web version of this article.

If you still have questions, please call the Solution Center at 866.ASK.AISC. MSC

References

Guide to Design Criteria for Bolted and Riveted Joints, Kulak, Fisher Struik, AISC Chicago, 2001.

Specification for Structural Steel Buildings, AISC, Chicago, 2005.

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A325

Alternate Table 7-3

Slip Critical Connections

Available Shear Strength, kips, when

Slip is a Serviceability Limit-State

(Class A Faying Surface, μ = 0.35)

ASTM A325/F1852 Bolts

Hole Type	Loading	Nominal Bolt Diameter d, in.							
		⅝		¾		⅞		1	
		Minimum ASTM A325/F1852 Bolt Pretension, kips							
		19		28		39		51	
		r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
STD	Default for STD								
	S	5.01	7.51	7.38	11.1	10.3	15.4	13.4	20.2
	D	10.0	15.0	14.8	22.1	20.6	30.8	26.9	40.3
OVS & SSL	Default for SSL+. See Table 7-4 for the OSZ and SSL= default								
	S	4.26	6.39	6.28	9.41	8.74	13.1	11.4	17.1
	D	8.52	12.8	12.6	18.8	17.5	26.2	22.9	34.3
LSL	Default for LSL+. See Table 7-4 for the LSL= default								
	S	3.51	5.26	5.17	7.75	7.20	10.8	9.41	14.1
	D	7.01	10.5	10.3	15.5	14.4	21.6	18.8	28.2

Hole Type	Loading	Nominal Bolt Diameter d, in.							
		1 ⅛		1 ¼		1 ⅜		1 ½	
		Minimum ASTM A325/F1852 Bolt Pretension, kips							
		56		71		85		103	
		r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
STD	S	14.8	22.1	18.7	28.1	22.4	33.6	27.2	40.7
	D	29.5	44.3	37.4	56.2	44.8	67.2	54.3	81.5
OVS & SSL	Default for SSL+. See Table 7-4 for the OSZ and SSL= default								
	S	12.6	18.8	15.9	23.9	19.0	28.6	23.1	34.6
	D	25.1	37.7	31.8	47.7	38.1	57.1	46.2	69.3
LSL	Default for LSL+. See Table 7-4 for the LSL= default								
	S	10.3	15.5	13.1	19.7	15.7	23.5	19.0	28.5
	D	20.7	31.0	26.2	39.3	31.4	47.1	38.0	57.0

STD = Standard Hole OVS = Oversize Hole SSL = Short Slot LSL = Long Slot

'+' = slot length transverse to the load: '=' = slot length parallel to the load

S= Single Shear: D = Double Shear

ASD	LRFD	
Ω_v= 1.50	Φ_v= 1.00	Notes: For available slip resistance when slip is a strength limit state, see Table 7-4 For Class B faying surfaces (μ = 0.50) multiply the tabulated available strength by 0.50/0.35 = 1.43 The required strength is determined using LRFD load combinations for LRFD design and ASD Load combinations for ASD design.

Alternate Table 7-3

Slip Critical Connections

Available Shear Strength, kips, when

Slip is a Serviceability Limit-State

(Class A Faying Surface, μ = 0.35)

A490

ASTM A490 Bolts

Hole Type	Loading	Nominal Bolt Diameter d, in.							
		5/8		3/4		7/8		1	
		Minimum ASTM A490 Bolt Pretension, kips							
		24		35		49		64	
		r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
STD		Default for STD							
	S	6.33	9.49	9.23	13.8	12.9	19.4	16.9	25.3
	D	12.7	19.0	18.5	27.7	25.8	38.8	33.7	50.6
OVS & SSL		Default for SSL+. See Table 7-4 for the OSZ and SSL= default							
	S	5.38	8.07	7.84	11.8	11.0	16.5	14.3	21.5
	D	10.8	16.1	15.7	23.5	22.0	32.9	28.7	43.0
LSL		Default for LSL+. See Table 7-4 for the LSL= default							
	S	4.43	6.64	6.46	9.69	9.04	13.6	11.8	17.7
	D	8.86	13.3	12.9	19.4	18.1	27.1	23.6	35.4

Hole Type	Loading	Nominal Bolt Diameter d, in.							
		1 1/8		1 1/4		1 3/8		1 1/2	
		Minimum ASTM A490 Bolt Pretension, kips							
		80		102		121		148	
		r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
STD	S	21.1	31.6	26.9	40.3	31.9	47.9	39.0	58.5
	D	42.2	63.3	53.8	80.7	63.8	95.7	78.0	117.1
OVS & SSL		Default for SSL+. See Table 7-4 for the OSZ and SSL= default							
	S	17.9	26.9	22.9	34.3	27.1	40.7	33.2	49.8
	D	35.9	53.8	45.7	68.6	54.2	81.4	66.3	99.5
LSL		Default for LSL+. See Table 7-4 for the LSL= default							
	S	14.8	22.1	18.8	28.2	22.3	33.5	27.3	41.0
	D	29.5	44.3	37.7	56.5	44.7	67.0	54.6	81.9

STD = Standard Hole OVS = Oversize Hole SSL = Short Slot LSL = Long Slot
'+' = slot length transverse to the load: '=' = slot length parallel to the load
S= Single Shear: D = Double Shear

ASD	LRFD	Notes
Ω_v= 1.50	Φ_v= 1.00	For available slip resistance when slip is a strength limit state, see Table 7-4 For Class B faying surfaces (μ = 0.50) multiply the tabulated available strength by 0.50/0.35 = 1.43 The required strength is determined using LRFD load combinations for LRFD design and ASD Load combinations for ASD design.

A325

Alternate Table 7-4

Slip Critical Connections

Available Shear Strength, kips, when

Slip is a Strength Limit-State

(Class A Faying Surface, μ = 0.35)

ASTM A325/F1852 Bolts

Hole Type	Loading	Nominal Bolt Diameter d, in.							
		5/8		3/4		7/8		1	
		Minimum ASTM A325/F1852 Bolt Pretension, kips							
		19		28		39		51	
		r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
STD	See Table 7-3 for the STD default								
	S	4.27	6.39	6.29	9.41	8.76	13.1	11.5	17.1
	D	8.54	12.8	12.6	18.8	17.5	26.2	22.9	34.3
OVS & SSL	Default for OSZ and SSL=. See Table 7-3 for the SSL+ default								
	S	3.63	5.43	5.35	8.00	7.45	11.1	9.74	14.6
	D	7.26	10.9	10.7	16.0	14.9	22.3	19.5	29.1
LSL	Default for LSL=. See Table 7-3 for the LSL+ default								
	S	2.99	4.47	4.40	6.59	6.13	9.18	8.02	12.0
	D	5.98	8.94	8.81	13.2	12.3	18.4	16.0	24.0

Hole Type	Loading	Nominal Bolt Diameter d, in.							
		1 1/8		1 1/4		1 3/8		1 1/2	
		Minimum ASTM A325/F1852 Bolt Pretension, kips							
		56		71		85		103	
		r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
STD	S	12.6	18.8	16.0	23.9	19.1	28.6	23.1	34.6
	D	25.2	37.7	31.9	47.7	38.2	57.1	46.3	69.3
OSZ & SSL	Default for OSZ and SSL=. See Table 7-3 for the SSL+ default								
	S	10.7	16.0	13.6	20.3	16.2	24.3	19.7	29.4
	D	21.4	32.0	27.1	40.6	32.5	48.6	39.3	58.9
LSL	Default for LSL=. See Table 7-3 for the LSL+ default								
	S	8.81	13.2	11.2	16.7	13.4	20.0	16.2	24.2
	D	17.6	26.4	22.3	33.4	26.7	40.0	32.4	48.5

STD = Standard Hole OVS = Oversize Hole SSL = Short Slot LSL = Long Slot
'+' = slot length transverse to the load: '=' = slot length parallel to the load
S= Single Shear: D = Double Shear

ASD	LRFD	Notes
Ω_v= 1.76	Φ_v= 0.85	For available slip resistance when slip is a serviceability limit state, see Table 7-3 For Class B faying surfaces (μ = 0.50) multiply the tabulated available strength by 0.50/0.35 = 1.43 The required strength is determined using LRFD load combinations for LRFD design and ASD Load combinations for ASD design.

Alternate Table 7-4

Slip Critical Connections

Available Shear Strength, kips, when

Slip is a Strength Limit-State

(Class A Faying Surface, μ = 0.35)

A490

ASTM A490 Bolts

Hole Type	Loading	Nominal Bolt Diameter d, in.							
		5/8		3/4		7/8		1	
		Minimum ASTM A490 Bolt Pretension, kips							
		24		35		49		64	
		r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
STD	See Table 7-3 for the STD default								
	S	5.39	8.07	7.87	11.8	11.0	16.5	14.4	21.5
	D	10.8	16.1	15.7	23.5	22.0	32.9	28.8	43.0
OVS & SSL	Default for OSZ and SSL=. See Table 7-3 for the SSL+ default								
	S	4.58	6.86	6.69	10.0	9.36	14.0	12.2	18.3
	D	9.17	13.7	13.4	20.0	18.7	28.0	24.4	36.6
LSL	Default for LSL=. See Table 7-3 for the LSL+ default								
	S	3.78	5.65	5.51	8.24	7.71	11.5	10.1	12.0
	D	7.55	11.3	11.0	16.5	15.4	23.1	20.1	30.1

Hole Type	Loading	Nominal Bolt Diameter d, in.							
		1 1/8		1 1/4		1 3/8		1 1/2	
		Minimum ASTM A490 Bolt Pretension, kips							
		80		102		121		148	
		r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$	r_n/Ω_v	$\Phi_v r_n$
		ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD
STD	S	18.0	26.9	22.9	34.3	27.2	40.7	33.3	49.8
	D	36.0	53.8	45.8	68.6	54.4	81.4	66.5	99.5
OVS & SSL	Default for OSZ and SSL=. See Table 7-3 for the SSL+ default								
	S	15.3	22.9	19.5	29.1	23.1	34.6	28.3	42.3
	D	30.6	45.7	39.0	58.3	46.2	69.2	56.5	84.6
LSL	Default for LSL=. See Table 7-3 for the LSL+ default								
	S	12.6	18.8	16.0	24.0	19.0	28.5	23.3	34.8
	D	25.2	37.7	32.1	48.0	38.1	56.9	46.6	69.7

STD = Standard Hole OVS = Oversize Hole SSL = Short Slot LSL = Long Slot
'+' = slot length transverse to the load: '=' = slot length parallel to the load
S= Single Shear: D = Double Shear

ASD	LRFD	Notes:
Ω_v= 1.76	Φ_v= 0.85	For available slip resistance when slip is a serviceability limit state, see Table 7-3 For Class B faying surfaces (μ = 0.50) multiply the tabulated available strength by 0.50/0.35 = 1.43 The required strength is determined using LRFD load combinations for LRFD design and ASD Load combinations for ASD design.