## 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.

			μ			ф (	or 1/Ω*	**			hsc**			hsc	: (¢ or 1	/Ω)							
Formula/ Specification	D <sub>u</sub> *	А	В	С	STD	OVS SSt=	SSt +	LSt =	LSt +	STD	OVS SLt	LSt	STD	OVS SLt=	SSt + .61 .85	LSt =	LSt +						
F <sub>v</sub> A <sub>nom</sub> 1989 ASD		0.22	0.5	0.4		N/A (0.72)		N/A (0.61)	N/A (0.72)				0.72	0.	61	0.43	0.50						
φ(1.13)(μ) <i>T<sub>b</sub></i> 1999 LRFD	1.13	1.13	0.33	0.5	0.35	1.00 (1.00)	0.8 (1.0	85 20)	0.60 (0.85)	0.70 (1.00)	1.0	0.05	0.70	1.00	0.8	85	0.60	0.70					
( <i>D<sub>u</sub></i> )(μ)(hsc) <i>T<sub>b</sub>/Ω</i> 2005 ASD			1.15	1.15	1.15	1.15	1.13	1.13	1.13	0.25		N1/A	0.67	0.57	0.67	0.57	0.67	1.0	0.00	0.70	0.67	0.48	0.57
φ( <i>D<sub>u</sub></i> )(μ)(hsc) <i>T<sub>b</sub></i> 2005 LRFD		0.35		N/A	1.00	0.85	1.00	0.85	1.00				1.00	0.72	0.85	0.60	0.70						
			C		ersize	SSt	Short s	lot	I St lon	a slot	-	trans	Verse	= na	rallel								

#### Table 1. The Formulae and Select Variables

\*  $D_{\mu}$  was not denoted in the 1989 ASD or 1999 LRFD, but  $D_{\mu}$  = 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  $\phi$  or  $1/\Omega$  factors.

#### Table 2. Other Variables

Tensile S <sup>.</sup>	trength (ksi)	
Fu	A325 (F1852)	120*
	A490	150
	$*F_{u}$ for A325 > 1"	= 105 ksi
Areas (in	<sup>2</sup> )	
	Anom	A <sub>tensile</sub>
¾ in.	0.442	0.334
<sup>7</sup> ∕8 in.	0.601	0.462
1 in.	0.785	0.606
1½ in.	0.994	0.763
Pretensic	on (kips) excerpt of TA	ABLE J3.1
	A325 (F1852)	A490
¾ in.	28	35
7∕8 in.	39	49
1 in.	51	64
1 <sup>1</sup> / <sub>8</sub> in.	56	80

That means use  $\phi = 1.00$  ( $\Omega = 1.5$ ) with standard holes and slots transverse to the load (slip will be  $\frac{1}{16}$  in. at most) and use  $\phi = 0.85$  ( $\Omega = 1.76$ ) with oversize holes or slots parallel to the load (where slip can exceed  $\frac{1}{16}$  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 <sup>3</sup>/<sub>16</sub> 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 ( $\phi$ = 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 ( $\phi$  =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 ASDbased 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.	<b>Examples:</b>	<b>Class A</b>	Single	Shear
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			$^{3}$ in. A325 $F_u = 120; A_{nom} = 0.442; A_{tensile} = 0.334;$ $T_b = 0.7F_uA_t = 28$							1½ in. A490 $F_u = 150; A_{nom} = 0.994; A_{tensile} = 0.763;$ $T_b = 0.7F_uA_t = 80$					
		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	
	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	
1999	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	
	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	
2005	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	
2005	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 gre	ater than	1989 ASE	)			Red less	than 198	9 ASD				
			Bold gre	ater than	1999 LRF	D			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 fac-

tored 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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			Alter	mate T	able 7-	3			
		Slin	Criti		onno	oction	16		
A325		Silp					13		
		Availai	ble She	ear Stre	ength, I	kips, wi	hen		
		<u>SI</u>	ip is a Si	erviceab	ility Limi	t-State			
		(Clas	s A Fa	ying Su	irface,	<u>μ = 0.3</u>	5)		
	1	1	ASTM	A325/F	1852 Bo	olts			
				Nomin	al Bolt I	Diamete	r d, in.		
		5/	8	3/	4	7	8		1
Hole	Loading	Mi	nimum	ASTM A	325/F18	352 Bolt	Pretens	sion, ki	ps
Type	_	1	9	28		3	9	5	1
		$r_n/\Omega_v$	Φ <sub>v</sub> r <sub>n</sub>	$r_n/\Omega_v$	Φ <sub>v</sub> r <sub>n</sub>	$r_n/\Omega_v$	Φ <sub>v</sub> r <sub>n</sub>	$r_n/\Omega_v$	Φ <sub>v</sub> r <sub>n</sub>
		ASD	LRFD	ASD	LKFD ault for ST		LRFD	ASD	LRFD
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
		Default	for SSL+.	See Table	e 7-4 for th	ne OSZ an	d SSL= de	fault	
SSL	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
		D	efault for L	SL+. See	Table 7-4	for the LSI	L= default		
LSL	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
			1/	Nomin			<b>r</b> a, in.		1/
		1 1/8 1 1/4 1 %						1	/2
Hala		ding Minimum		ASTM A	A325/F18	852 Bolt	: Pretens		ps
Hole Type	Loading			_	4	•	-		
Hole Type	Loading	5	6 0	7	1 • • •	8	5 •	10 10	<b>)3</b>
Hole Type	Loading	Γ <sub>n</sub> / Ω <sub>v</sub>	6 ⊕ <sub>v</sub> r <sub>n</sub> LRFD	7 r <sub>n</sub> / Ω <sub>v</sub>	1 Φ <sub>v</sub> r <sub>n</sub>	8 r <sub>n</sub> / Ω <sub>v</sub>	5 Φ <sub>v</sub> r <sub>n</sub>	<b>1(</b> r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b>	)3 Φ <sub>v</sub> r <sub>n</sub>
Hole Туре	Loading	<b>Γ</b> <b>Γ</b> <b>Λ</b> <b>Λ</b> <b>Λ</b> <b>Λ</b> <b>Λ</b> <b>Λ</b> <b>Λ</b> <b>Λ</b>	6 Φ <sub>v</sub> r <sub>n</sub> LRFD 22.1	7 r <sub>n</sub> / Ω <sub>v</sub> ASD 18.7	1 Φ <sub>v</sub> r <sub>n</sub> LRFD 28.1	8 r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 22.4	5 Φ <sub>v</sub> r <sub>n</sub> LRFD 33.6	<b>1</b> ( r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 27.2	<b>03</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 40.7
Hole Type STD	Loading S D	Γη/ Ων           ASD           14.8           29.5	6 Φ <sub>ν</sub> r <sub>n</sub> LRFD 22.1 44.3	7 r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 18.7 37.4	1 Φ <sub>ν</sub> r <sub>n</sub> LRFD 28.1 56.2	8 r <sub>n</sub> / Ω <sub>v</sub> ASD 22.4 44.8	5 Φ <sub>v</sub> r <sub>n</sub> LRFD 33.6 67.2	<b>1(</b> r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 27.2 54.3	<b>Δ</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 40.7 81.5
Hole Type STD OVS &	Loading S D	<b>5</b> r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 14.8 29.5 Default	6 Φ <sub>v</sub> r <sub>n</sub> LRFD 22.1 44.3 t for SSL+.	7 r <sub>n</sub> / Ω <sub>v</sub> ASD 18.7 37.4 . See Table	1 Φ <sub>v</sub> r <sub>n</sub> <b>LRFD</b> 28.1 56.2 e 7-4 for th	8 r <sub>n</sub> / Ω <sub>v</sub> ASD 22.4 44.8 ne OSZ an	5 Φ <sub>v</sub> r <sub>n</sub> LRFD 33.6 67.2 d SSL= de	<b>10</b> r <sub>n</sub> / Ω <sub>ν</sub> <b>ASD</b> 27.2 54.3 fault	<b>Φ</b> <sub>ν</sub> <b>r</b> <sub>n</sub> <b>LRFD</b> 40.7 81.5
Hole Type STD OVS & SSL	Loading S D	5 r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 14.8 29.5 Default 12.6	6 Φ <sub>ν</sub> Γ <sub>n</sub> 22.1 44.3 t for SSL+.	7 r <sub>n</sub> / Ω <sub>v</sub> ASD 18.7 37.4 . See Table	1 Φ <sub>v</sub> r <sub>n</sub> 28.1 56.2 e 7-4 for th 23.9	8 r <sub>n</sub> / Ω <sub>v</sub> 22.4 44.8 ne OSZ an 19.0	5 Φ <sub>v</sub> r <sub>n</sub> <b>LRFD</b> 33.6 67.2 d SSL= de	1011, Ki r <sub>n</sub> / Ω <sub>v</sub> ASD 27.2 54.3 ifault	<b>Δ</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 40.7 81.5
Hole Type STD OVS & SSL	Loading S D S D	5 r <sub>n</sub> / Ω <sub>v</sub> ASD 14.8 29.5 Default 12.6 25.1	6 Φ <sub>ν</sub> r <sub>n</sub> 22.1 44.3 : for SSL+. 18.8 37.7	7 r <sub>n</sub> / Ω <sub>v</sub> ASD 18.7 37.4 . See Table 15.9 31.8	<b>1</b> Φ <sub>v</sub> r <sub>n</sub> <b>LRFD</b> 28.1 56.2 e 7-4 for th 23.9 47.7	8 r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 22.4 44.8 ne OSZ an 19.0 38.1	<b>5</b> Φ <sub>v</sub> r <sub>n</sub> <b>LRFD</b> 33.6 67.2 d SSL= de 28.6 57.1	r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 27.2 54.3 fault 23.1 46.2	<b>Φ</b> <sub>v</sub> r <sub>n</sub> <b>LRFD</b> 40.7 81.5 34.6 69.3
Hole Type STD OVS & SSL	Loading S D S D	<b>5</b> <b>r</b> <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 14.8 29.5 Default 12.6 25.1 D	6 Φ <sub>ν</sub> r <sub>n</sub> 22.1 44.3 t for SSL+. 18.8 37.7 efault for L	7 r <sub>n</sub> / Ω <sub>v</sub> ASD 18.7 37.4 . See Table 15.9 31.8 .SL+. See	<b>1</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 28.1 56.2 e 7-4 for th 23.9 47.7 Table 7-4	8 r <sub>n</sub> / Ω <sub>v</sub> 22.4 44.8 ne OSZ an 19.0 38.1 for the LSI	5 Φ <sub>v</sub> r <sub>n</sub> LRFD 33.6 67.2 d SSL= de 28.6 57.1 L= default	r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 27.2 54.3 fault 23.1 46.2	<b>Φ</b> , <b>r</b> <sub>n</sub> <b>LRFD</b> 40.7 81.5 34.6 69.3
Hole Type STD OVS & SSL LSL	Loading S D S D	5 r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 14.8 29.5 Default 12.6 25.1 Dr 10.3	6 Φ <sub>ν</sub> r <sub>n</sub> LRFD 22.1 44.3 for SSL+. 18.8 37.7 efault for L 15.5	7 r <sub>n</sub> / Ω <sub>v</sub> ASD 18.7 37.4 . See Table 15.9 31.8 .SL+. See 13.1	<b>1</b> Φ,r <sub>n</sub> <b>LRFD</b> 28.1 56.2 e 7-4 for th 23.9 47.7 Table 7-4	8 r <sub>n</sub> / Ω <sub>v</sub> 22.4 44.8 ne OSZ an 19.0 38.1 for the LSI 15.7	<b>5</b> Φ <sub>v</sub> r <sub>n</sub> <b>LRFD</b> 33.6 67.2 d SSL= de 28.6 57.1 L= default 23.5	III           Γ <sub>n</sub> / Ω <sub>v</sub> ASD           27.2           54.3           afault           23.1           46.2           19.0           20.0	<b>Δ</b> Φ,r <sub>n</sub> <b>LRFD</b> 40.7 81.5 34.6 69.3 28.5 28.5
Hole Type STD OVS & SSL LSL	Loading S D S D S D D	5 r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 14.8 29.5 Default 12.6 25.1 Do 10.3 20.7	6 Φ <sub>ν</sub> r <sub>n</sub> LRFD 22.1 44.3 : for SSL+. 18.8 37.7 efault for L 15.5 31.0 S = Overs	7 r <sub>n</sub> / Ω <sub>v</sub> ASD 18.7 37.4 . See Table 15.9 31.8 .SL+. See 13.1 26.2 ize Hole	<b>1</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 28.1 56.2 e 7-4 for th 23.9 47.7 Table 7-4 19.7 39.3	8 $r_n/ Ω_v$ ASD 22.4 44.8 ne OSZ an 19.0 38.1 for the LSI 15.7 31.4 = Short	<b>5</b> Φ <sub>v</sub> r <sub>n</sub> <b>LRFD</b> 33.6 67.2 d SSL= de 28.6 57.1 L= default 23.5 47.1	1011, Ki 10 r <sub>n</sub> / Ω <sub>v</sub> ASD 27.2 54.3 afault 23.1 46.2 19.0 38.0 = Long S	Φ <sub>v</sub> r <sub>n</sub> LRFD           40.7           81.5           34.6           69.3           28.5           57.0
Hole Type STD OVS & SSL LSL STD = Sta '+' = slot le	Loading S D S D S D Indard Hole ngth transve	Γη/ Ων           ASD           14.8           29.5           Default           12.6           25.1           Dut           10.3           20.7           OV	6	7 r <sub>n</sub> / Ω <sub>v</sub> ASD 18.7 37.4 . See Table 15.9 31.8 .SL+. See 13.1 26.2 ize Hole = slot leng	<b>1</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 28.1 56.2 e 7-4 for th 23.9 47.7 Table 7-4 19.7 39.3 SSI th parallel	8 r <sub>n</sub> / Ω <sub>v</sub> ASD 22.4 44.8 the OSZ an 19.0 38.1 for the LSI 15.7 31.4 L = Short to the load	5 Φ <sub>v</sub> r <sub>n</sub> LRFD 33.6 67.2 d SSL= det 28.6 57.1 L= default 23.5 47.1 Slot LSI	$\frac{100}{r_n/\Omega_v}$ ASD 27.2 54.3 ifault 23.1 46.2 19.0 38.0 - = Long S	<b>D3</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 40.7 81.5 34.6 69.3 28.5 57.0 Slot
Hole Type STD OVS & SSL LSL STD = Sta '+' = slot le S= Single S	Loading S D S D ndard Hole ngth transve Shear: D =	Image: marked state         S           r <sub>n</sub> / Ω <sub>v</sub> ASD           14.8         29.5           Default         12.6           25.1         Dr           10.3         20.7           OV         ov           rse to the I         = Double S	6	7 r <sub>n</sub> / Ω <sub>v</sub> ASD 18.7 37.4 . See Table 15.9 31.8 .SL+. See 13.1 26.2 ize Hole = slot leng	<b>1</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 28.1 56.2 e 7-4 for th 23.9 47.7 Table 7-4 19.7 39.3 SS th parallel	8 $r_n/ Ω_v$ <b>ASD</b> 22.4 44.8 ne OSZ an 19.0 38.1 for the LSI 15.7 31.4 L = Short to the loac	<b>5</b> Φ <sub>v</sub> r <sub>n</sub> <b>LRFD</b> 33.6 67.2 d SSL= de 28.6 57.1 L= default 23.5 47.1 Slot LSL	$\frac{100}{r_n/\Omega_v}$ ASD 27.2 54.3 ifault 23.1 46.2 19.0 38.0 - = Long S	<b>D3</b> Φ <sub>v</sub> r <sub>n</sub> <b>LRFD</b> 40.7 81.5 34.6 69.3 28.5 57.0 Slot
Hole Type STD OVS & SSL LSL STD = Sta '+' = slot le S= Single S ASD	Loading S D S D S D S hdard Hole Shear: D = LRFD	Γη/ Ων           ASD           14.8           29.5           Default           12.6           25.1           Do           10.3           20.7           OV           rse to the I           Double S           Notes: F	6 $\Phi_v r_n$ LRFD 22.1 44.3 for SSL+. 18.8 37.7 efault for L 15.5 31.0 S = Overs oad: '=': hear For availab For availab	$7$ $r_n/ \Omega_v$ <b>ASD</b> $18.7$ $37.4$ . See Table $15.9$ $31.8$ .SL+. See $13.1$ $26.2$ ize Hole = slot leng ole slip resi	<b>1</b>	8 $r_n/ Ω_v$ ASD 22.4 44.8 ne OSZ and 19.0 38.1 for the LSI 15.7 31.4 L = Short to the load in the load in the load in the load in the load in the load	5 Φ <sub>v</sub> r <sub>n</sub> LRFD 33.6 67.2 d SSL= de 28.6 57.1 L= default 23.5 47.1 Slot LSL	$r_n/\Omega_v$ <b>ASD</b> 27.2 54.3 afault 23.1 46.2 19.0 38.0 - = Long S limit state,	Φ,rn           LRFD           40.7           81.5           34.6           69.3           28.5           57.0           Slot
Hole Type STD OVS & SSL LSL STD = Sta '+' = slot le S= Single S ASD	Loading S D S D ndard Hole ngth transve Shear: D = LRFD	Γη/ Ων           ASD           14.8           29.5           Default           12.6           25.1           Dofault           10.3           20.7           OV           rse to the I           = Double S           Notes: F           I           F	6 $\Phi_v r_n$ 22.1 44.3 for SSL+. 18.8 37.7 efault for L 15.5 31.0 S = Overs oad: '=' fault fault for L 5	$7$ $r_n/ \Omega_v$ <b>ASD</b> 18.7 37.4 . See Table 15.9 31.8 .SL+. See 13.1 26.2 ize Hole = slot leng ble slip resi B faying su	1 $\Phi_{v,r_n}$ 28.1 56.2 e 7-4 for th 23.9 47.7 Table 7-4 19.7 39.3 SSI th parallel stance wh urfaces ( $\mu$ :	8 $r_n/ Ω_v$ ASD 22.4 44.8 ne OSZ an 19.0 38.1 for the LSI 15.7 31.4 L = Short to the load en slip is a = 0.50) mu	5 Φ <sub>v</sub> r <sub>n</sub> LRFD 33.6 67.2 d SSL= de 28.6 57.1 L= default 23.5 47.1 Slot LSL I a strength	$\frac{100}{r_n/\Omega_v}$ $\frac{ASD}{27.2}$ $\frac{27.2}{54.3}$ $\frac{100}{38.0}$ $\frac{19.0}{38.0}$ $\frac{19.0}{38.0}$ $\frac{19.0}{38.0}$ $\frac{19.0}{38.0}$ $\frac{19.0}{38.0}$ $\frac{19.0}{38.0}$ $\frac{100}{38.0}$ $\frac{100}{38$	Φ <sub>v</sub> r <sub>n</sub> LRFD           40.7           81.5           34.6           69.3           28.5           57.0           Slot           see           vailable
Hole Type STD OVS & SSL LSL STD = Sta '+' = slot le S= Single S ASD $\Omega_v$ = 1.50	Loading S D S D S D Indard Hole ngth transve Shear: D = LRFD $\Phi_v$ = 1.00	Image: marked state           r <sub>n</sub> / Ω <sub>v</sub> ASD           14.8           29.5           Default           12.6           25.1           Default           10.3           20.7           OV           rse to the I           Double S           Notes:           F           S	6 $\Phi_v r_n$ 22.1 44.3 c for SSL+. 18.8 37.7 efault for L 15.5 31.0 S = Overs oad: '=' = hear For availab Table 7-4 For Class B strength by	7           r <sub>n</sub> / Ω <sub>v</sub> ASD           18.7           37.4           See Table           15.9           31.8           .SL+. See           13.1           26.2           ize Hole           = slot leng           ole slip resi           3 faying sL           (0.50/0.35)	<b>1</b> $\Phi_{v}r_n$ <b>LRFD</b> 28.1 56.2 e 7-4 for th 23.9 47.7 Table 7-4 19.7 39.3 SSI th parallel stance wh urfaces ( $\mu$ = 1.43	8 $r_n/ Ω_v$ ASD           22.4           44.8           ne OSZ an           19.0           38.1           for the LSI           15.7           31.4           L = Short           to the load           en slip is a           = 0.50) mu	5 Φ <sub>v</sub> r <sub>n</sub> LRFD 33.6 67.2 d SSL= def 28.6 57.1 L= default 23.5 47.1 Slot LSI a strength I ltiply the ta	$r_n / \Omega_v$ <b>ASD</b> 27.2 54.3 ifault 23.1 46.2 19.0 38.0 - = Long S limit state, abulated a	Φ <sub>v</sub> r <sub>n</sub> Φ <sub>v</sub> r <sub>n</sub> LRFD           40.7           81.5           34.6           69.3           28.5           57.0           Slot           see           vailable

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Default for STD         STD       S       6.33       9.49       9.23       13.8       12.9       19.4       16.9       25.3         OVS & SSL       D       12.7       19.0       18.5       27.7       25.8       38.8       33.7       50.6         OVS & SSL       D       Default for SSL+. See Table 7-4 for the OSZ and SSL= default       0       14.3       21.5         OVS & SSL       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       S       4.43       6.64       6.46       9.69       9.04       13.6       11.8       17.7         SD       4.43       6.64       6.46       9.69       9.04       13.6       11.8       17.7         LSL       S       4.43       6.64       6.46       9.69       9.04       13.6       11.8       17.7         LSL       S       4.43       6.64       6.46       9.69       9.04       13.6       11.8       17.7         LSL       S       4.43       6.64<			ASD	LRFD	ASD	LRFD	ASD	LRFD	ASD	LRFD						
SID         S         6.33         9.49         9.23         13.8         12.9         19.4         16.9         25.3           D         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         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         Minimum ASTM A490         Bolt Drameter d, in.         1 $\frac{1}{2}$ 1 $\frac{1}{2}$ 1 $\frac{1}{2}$ Hole Type         S         8.07 $r_n/\Omega_v$ $\Phi_v r_n$ $r_n/\Omega_v$ $\Phi_v r_n$ $r_n/\Omega_v$ $\Phi_v r_n$ Hole Type         Loading         S	OTD				Def	ault for ST	D									
$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	510	S	6.33	9.49	9.23	13.8	12.9	19.4	16.9	25.3						
$\begin{tabular}{ c c c c c c c } \hline $ Default for SSL+. See Table 7-4 for the OSZ and SSL= default $$ SSL$ is a set of the SSL$ is a s$		D	12.7	19.0	18.5	27.7	25.8	38.8	33.7	50.6						
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Type         Solution         Solution <t< td=""><td rowspan="2">Hole Type</td><td>Looding</td><td>-</td><td>Minim</td><td>um AST</td><td>M A490</td><td>Bolt Pr</td><td>etensior</td><td>, kips</td><td>/2</td></t<>	Hole Type	Looding	-	Minim	um AST	M A490	Bolt Pr	etensior	, kips	/2						
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$		Loading	8	0	10	)2	12	21	<u>1, 14</u>	18						
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			$r_n/\Omega_v$	Φ <sub>v</sub> r <sub>n</sub>	$r_n/\Omega_v$	$\Phi_v r_n$	r <sub>n</sub> / Ω <sub>v</sub>	Φ <sub>v</sub> r <sub>n</sub>	r <sub>n</sub> /Ω <sub>v</sub>	Φ <sub>v</sub> r <sub>n</sub>						
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			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						
Default for SSL+. See Table 7-4 for the OSZ and SSL= default			42.2	62.2	<b>520</b>	007	62.0	05 7	ASD         LRFI           39.0         58.4           78.0         117.							
SSL S 17.9 26.9 22.9 34.3 27.1 40.7 33.2 49.8		D	42.2 Default	63.3 for SSL+.	53.8 See Table	80.7 e 7-4 for th	63.8 ne OSZ an	95.7 d SSL= de	78.0 fault	117.1						
D 35.9 53.8 45.7 68.6 54.2 81.4 66.3 99.5	OVS & SSL	D	42.2 Default	63.3 t for SSL+. 26.9	53.8 See Table	80.7 e 7-4 for th 34 3	63.8 ne OSZ an 27 1	95.7 d SSL= de 40.7	78.0 fault 33.2	49.8						
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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	OVS & SSL LSL	D S D S	42.2 Default 17.9 35.9 D	63.3 for SSL+. 26.9 53.8 efault for L 22.1	53.8 See Tabl 22.9 45.7 SL+. See 18.8	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3	95.7 d SSL= de 40.7 81.4 _= default 33.5	78.0 fault 33.2 66.3 27.3	49.8 99.5 41.0						
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	OVS & SSL LSL	D S D S D	42.2 Default 17.9 35.9 D 14.8 29.5	63.3 : for SSL+. 26.9 53.8 efault for L 22.1 44.3	53.8 See Table 22.9 45.7 .SL+. See 18.8 37.7	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0	78.0 fault 33.2 66.3 27.3 54.6	49.8 99.5 41.0 81.9						
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	OVS & SSL LSL STD = Sta	D S D S D Indard Hole ngth transve	42.2 Default 17.9 35.9 D 14.8 29.5 OV rse to the I	63.3 : for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs oad: '=':	53.8 See Tabl 22.9 45.7 SL+. See 18.8 37.7 ize Hole = slot leng	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS th parallel	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 L = Short to the load	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSL	78.0 fault 33.2 66.3 27.3 54.6 . = Long S	49.8 99.5 41.0 81.9 Slot						
S         14.8         22.1         18.8         28.2         22.3         33.5         27.3         41.0           S         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         LSL = Long Slot           '+' = slot length transverse to the load:         '=' = slot length parallel to the load         '=' = slot length parallel to the load <td< td=""><td>OVS &amp; SSL LSL STD = Sta '+' = slot le S= Single S</td><td>D S D S D Indard Hole ngth transve Shear: D =</td><td>42.2 Default 17.9 35.9 D 14.8 29.5 OV rse to the I = Double S</td><td>63.3 : for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs oad: '=': hear</td><td>53.8 See Tabl 22.9 45.7 .SL+. See 18.8 37.7 ize Hole = slot leng</td><td>80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS th parallel</td><td>63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 L = Short to the load</td><td>95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSL</td><td>78.0 fault 33.2 66.3 27.3 54.6 . = Long S</td><td>49.8 99.5 41.0 81.9 Slot</td></td<>	OVS & SSL LSL STD = Sta '+' = slot le S= Single S	D S D S D Indard Hole ngth transve Shear: D =	42.2 Default 17.9 35.9 D 14.8 29.5 OV rse to the I = Double S	63.3 : for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs oad: '=': hear	53.8 See Tabl 22.9 45.7 .SL+. See 18.8 37.7 ize Hole = slot leng	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS th parallel	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 L = Short to the load	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSL	78.0 fault 33.2 66.3 27.3 54.6 . = Long S	49.8 99.5 41.0 81.9 Slot						
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           S         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         LSL = Long Slot           '+' = slot length transverse to the load:         '=' = slot length parallel to the load         SSL = Short Slot         LSL = Long Slot           S = Single Shear:         D = Double Shear         Single stance when slip is a strength limit state, see	OVS & SSL LSL STD = Sta '+' = slot le S= Single S ASD	D S D Ndard Hole ngth transve Shear: D = LRFD	42.2 Default 17.9 35.9 D 14.8 29.5 OV rse to the I = Double S Notes: F	63.3 for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs oad: '=': hear For availab	53.8 See Tabl 22.9 45.7 SL+. See 18.8 37.7 ize Hole = slot leng	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS th parallel	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 L = Short to the load en slip is a	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSL	78.0 fault 33.2 66.3 27.3 54.6 . = Long S imit state,	49.8 99.5 41.0 81.9 Slot						
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$\begin{tabular}{ c c c c c c } \hline $Default for LSL+. See Table 7-4 for the LSL= default $$ISL+. See Table 7-4 for the LSL- default $$ISL+. See Table 7-4 for the LSL- default $$ISL+. See Table 7-4 for Class B faying surfaces $$($\mu = 0.50$) multiply the tabulated available $$ISL+. See Table 7-4 for Class B faying surfaces $$($\mu = 0.50$) multiply the tabulated available $$ISL+. See Table 7-4 for Class B faying surfaces $$($\mu = 0.50$) multiply the tabulated available $$ISL+. See Table 7-4 for Class B faying surfaces $$($\mu = 0.50$) multiply the tabulated available $$ISL+. See Table 7-4 for Class B faying surfaces $$($\mu = 0.50$) multiply the tabulated available $$ISL+. See Table 7-4 for Class B faying surfaces $$($\mu = 0.50$) multiply the tabulated available $$ISL+. See Table 7-4 for Class B faying surfaces $$($\mu = 0.50$) multiply the tabulated available $$ISL+. See Table 7-4 for Class B faying surfaces $$($\mu = 0.50$) multiply the tabulated available $$ISL+. See Table 7-4 for Class B faying surfaces $$($\mu = 0.50$) multiply the tabulated available $$ISL+. See Table 7-4 for Class B faying surfaces $$($\mu = 0.50$) multiply the tabulated available $$ISL+. See Table 7-4 for Class B faying $$ISL+. $	OVS & SSL LSL STD = Sta '+' = slot le S= Single S ASD $\Omega_v$ = 1.50	D S D ndard Hole ngth transve Shear: D = LRFD $\Phi_v$ = 1.00	42.2 Default 17.9 35.9 D 14.8 29.5 OV rse to the I = Double S Notes: F	63.3 for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs oad: '=': hear For availab Table 7-4 For Class E strength by	53.8 See Tabl 22.9 45.7 SL+. See 18.8 37.7 ize Hole = slot leng ole slip resi 3 faying su 0.50/0.35	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS th parallel istance wh infaces (µ is = 1.43	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 L = Short to the load en slip is a = 0.50) mu	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSL a strength I Itiply the ta	78.0 fault 33.2 66.3 27.3 54.6 . = Long S imit state, abulated a	49.8 99.5 41.0 81.9 Slot see vailable						
	OVS & SSL	D S D	42.2 Default 17.9 35.9	63.3 for SSL+. 26.9 53.8	53.8 See Table 22.9 45.7	80.7 e 7-4 for th 34.3 68.6	63.8 ne OSZ an 27.1 54.2	95.7 d SSL= de 40.7 81.4	78.0 fault 33.2 66.3	49.8 99.5						
Default for $ S  + See Table 7.4$ for the $ S  = default$	OVS & SSL	D S D	42.2 Default 17.9 35.9	63.3 t for SSL+. 26.9 53.8	53.8 See Tabl 22.9 45.7	80.7 e 7-4 for th 34.3 68.6 Table 7-4	63.8 ne OSZ an 27.1 54.2	95.7 d SSL= de 40.7 81.4	78.0 fault 33.2 66.3	49.8 99.5						
Default for LSL+. See Table 7-4 for the LSL= default	OVS & SSL	D S D	42.2 Default 17.9 35.9 D	63.3 t for SSL+. 26.9 53.8 efault for L	53.8 See Tabl 22.9 45.7 .SL+. See	80.7 e 7-4 for th 34.3 68.6 Table 7-4	63.8 ne OSZ an 27.1 54.2 for the LSI	95.7 d SSL= de 40.7 81.4 _= default	78.0 fault 33.2 66.3	49.8 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	OVS & SSL LSL	D S D S	42.2 Default 17.9 35.9 D 14.8	63.3 for SSL+. 26.9 53.8 efault for L 22.1	53.8 See Tabl 22.9 45.7 SL+. See 18.8	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3	95.7 d SSL= de 40.7 81.4 _= default 33.5	78.0 fault 33.2 66.3 27.3	49.8 99.5 41.0						
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	OVS & SSL LSL	D S D S D ndard Hole	42.2 Default 17.9 35.9 Dr 14.8 29.5 OV	63.3 : for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs	53.8 See Tabl 22.9 45.7 SL+. See 18.8 37.7 ize Hole	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 = Short	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSI	78.0 fault 33.2 66.3 27.3 54.6 = Long S	49.8 99.5 41.0 81.9						
S         14.8         22.1         18.8         28.2         22.3         33.5         27.3         41.0           STD = Standard Hole         OVS = Oversize Hole         SSL = Short Slot         LSL = Long Slot         44.7         67.0         54.6         81.9	OVS & SSL LSL '+' = slot le	D S D S D undard Hole ngth transve	42.2 Default 17.9 35.9 D 14.8 29.5 OV rse to the I	63.3 for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs oad: '='	53.8 See Tabl 22.9 45.7 .SL+. See 18.8 37.7 ize Hole = slot leng	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS th parallel	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 L = Short to the load	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSL	78.0 fault 33.2 66.3 27.3 54.6 . = Long S	49.8 99.5 41.0 81.9 Slot						
S         14.8         22.1         18.8         28.2         22.3         33.5         27.3         41.0           STD = Standard Hole         OVS = Oversize Hole         SSL = Short Slot         LSL = Long Slot         SLSL = Long Slot           '+' = slot length transverse to the load:         '=' = slot length parallel to the load         '=' = slot length parallel to the load         SSL = Short Slot         LSL = Long Slot	OVS & SSL LSL STD = Sta '+' = slot le S= Single S	D S D Ndard Hole ngth transve Shear: D =	42.2 Default 17.9 35.9 D 14.8 29.5 OV rse to the I = Double S	63.3 for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs oad: '=': hear	53.8 See Tabl 22.9 45.7 SL+. See 18.8 37.7 ize Hole = slot leng	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS th parallel	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 L = Short to the loac	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSL	78.0 fault 33.2 66.3 27.3 54.6 . = Long S	49.8 99.5 41.0 81.9 Slot						
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         SSL = Long Slot           S= Single Shear:         D = Double Shear         Single stance when slip is a strength limit state, see           ASD         LRFD         Notes:         For available slip resistance when slip is a strength limit state, see	OVS & SSL LSL STD = Sta '+' = slot le S= Single S ASD	D S D Ndard Hole ngth transve Shear: D = LRFD	42.2 Default 17.9 35.9 D 14.8 29.5 OV rse to the I = Double S Notes: F	63.3 for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs oad: '=': hear For availab	53.8 See Tabl 22.9 45.7 SL+. See 18.8 37.7 ize Hole = slot leng	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS th parallel istance wh	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 L = Short to the loac en slip is a	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSL	78.0 fault 33.2 66.3 27.3 54.6 . = Long S imit state,	49.8 99.5 41.0 81.9 Slot						
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$\begin{tabular}{ c c c c c c } \hline $Default for LSL+. See Table 7-4 for the LSL= default $$ISL+. See Table 7-4 for the LSL See Table 7-4 for th$	OVS & SSL LSL STD = Sta '+' = slot le S= Single S ASD $\Omega_v$ = 1.50	D S D ndard Hole ngth transve Shear: D = LRFD $\Phi_v$ = 1.00	42.2 Default 17.9 35.9 D 14.8 29.5 OV rse to the I = Double S Notes: F	63.3 for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs oad: '=': hear For availab Table 7-4 For Class E strength by	53.8 See Tabl 22.9 45.7 SL+. See 18.8 37.7 ize Hole = slot leng ole slip resi 3 faying su 0.50/0.35	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS th parallel istance wh infaces (µ is = 1.43	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 L = Short to the load en slip is a = 0.50) mu	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSL a strength I Itiply the ta	78.0 fault 33.2 66.3 27.3 54.6 . = Long S imit state, abulated a	49.8 99.5 41.0 81.9 Slot see vailable						
$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	OVS & SSL LSL STD = State of the set of the	D S D ndard Hole ngth transve Shear: D = LRFD $\phi_v$ = 1.00	42.2 Default 17.9 35.9 D 14.8 29.5 OV rse to the I = Double S Notes: F	63.3 for SSL+. 26.9 53.8 efault for L 22.1 44.3 S = Overs oad: '=' : hear For availab Fable 7-4 For Class E strength by The require	53.8 See Tabl 22.9 45.7 SL+. See 18.8 37.7 ize Hole = slot leng le slip resi 0.50/0.35 ed strengt	80.7 e 7-4 for th 34.3 68.6 Table 7-4 28.2 56.5 SS th parallel istance wh infaces ( $\mu$ = 1.43 n is determ	63.8 ne OSZ an 27.1 54.2 for the LSI 22.3 44.7 L = Short to the load en slip is a = 0.50) mu	95.7 d SSL= de 40.7 81.4 _= default 33.5 67.0 Slot LSL a strength I ltiply the ta	78.0 fault 33.2 66.3 27.3 54.6 . = Long S imit state, abulated a d combina	49.8 99.5 41.0 81.9 Slot see vailable ations for						

			Alter	mate T	able 7-	4				
		Slin	Criti	cal C	onne	oction	IC			
A325							13			
		Availai		ear Stre	ength, P	kips, wi	nen			
			Slip is a	Strengt	<u>n Limit-S</u>					
		(Clas	s A Fa	ying St	irface,	$\mu = 0.3$	5)			
	1	I	ASTM	A325/F	1852 Bo	olts				
				Nomin	al Bolt I	Diamete	r d, in.			
		5⁄	8	3	4	7/	8	1		
Hole	Loading	Minimum /		ASTM A	325/F18	352 Bolt	Pretens	sion, ki	ps	
Type		1	9	2	8	3	9	5	1	
		$r_n/\Omega_v$	Φ <sub>v</sub> r <sub>n</sub>	$r_n/\Omega_v$		$r_n/\Omega_v$	Φ <sub>v</sub> r <sub>n</sub>	$r_n/\Omega_v$	Φ <sub>v</sub> r <sub>n</sub>	
		ASD	LKFD	ASD	LKFD	ASD	LKFD	ASD	LKFD	
етр	See Table 7-3 for the STD default									
STD	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 &		Default	for OSZ a	and SSL=.	See Table	e 7-3 for th	e SSL+ de	fault		
SSL	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	
		D	efault for L	SL=. See	Table 7-3	for the LSI	_+ default			
LSL	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	
				Nomin	al Bolt I	Diamete	r d, in.			
					4 /					
		1	1/8	1	1/4	1	<b>%</b>	1	1/2	
Hole Type	Loading	1 Mi	⅓ inimum	1 ASTM A	<sup>1</sup> ⁄4 \325/F18	1 852 Bolt	% Pretens	1 sion, ki	1/2 ps	
Hole Type	Loading	1 Mi	<sup>1</sup> / <sub>8</sub> inimum 6	1 ASTM A 7	1/4 A325/F18 1	1 852 Bolt 8	% Pretens 5	1 sion, ki 1(	<sup>1</sup> ⁄₂ os )3	
Hole Type	Loading	1 Μi 5 r <sub>n</sub> / Ω <sub>ν</sub>	1/8 inimum 6 ΦνΓη	1 ASTM Α Γ <sub>n</sub> / Ω <sub>ν</sub>	1/4 A325/F18 1 Φ <sub>ν</sub> r <sub>n</sub>	1 852 Bolt 8 r <sub>n</sub> / Ω <sub>v</sub>	%       Pretens       5       Φ <sub>ν</sub> r <sub>n</sub>	1 sion, ki 1( r <sub>n</sub> / Ω <sub>v</sub>	<sup>1</sup> / <sub>2</sub> os <b>)3</b> Φ <sub>v</sub> r <sub>n</sub>	
Hole Type	Loading	1 Μi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6	1/8 inimum 6 Φ <sub>ν</sub> r <sub>n</sub> LRFD 18.8	1 ASTM A 7 r <sub>n</sub> / Ω <sub>v</sub> ASD 16.0	1/4 A325/F18 1 Φ <sub>ν</sub> r <sub>n</sub> LRFD 23.9	1 852 Bolt 8 r <sub>n</sub> / Ω <sub>v</sub> ASD 19.1	<b>78</b> <b>Pretens</b> 5 Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 28.6	<b>1</b> sion, ki r <sub>n</sub> / Ω <sub>v</sub> <b>ASD</b> 23.1	1/2 DS 03 Φ <sub>ν</sub> r <sub>n</sub> LRFD 34.6	
Hole Type STD	Loading S D	1 Μi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2	1/8 inimum 6 Φνrn LRFD 18.8 37.7	1 ASTM A 7 r <sub>n</sub> / Ω <sub>v</sub> ASD 16.0 31.9	1/4 A325/F18 1 Φ <sub>ν</sub> r <sub>n</sub> LRFD 23.9 47.7	1 852 Bolt 8 r <sub>n</sub> / Ω <sub>v</sub> ASD 19.1 38.2	<b>78</b> <b>Pretens</b> <b>5</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 28.6 57.1	<b>1</b> sion, ki 10 r <sub>n</sub> / Ω <sub>ν</sub> <b>ASD</b> 23.1 46.3	<b>½</b> 0S <b>3</b> <b>Δ</b> <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 34.6 69.3	
Hole Type STD	Loading S D	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default	<b>1/8</b> inimum 6 Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 18.8 37.7 t for OSZ a	1 ASTM A r <sub>n</sub> / Ω <sub>v</sub> ASD 16.0 31.9 and SSL=.	1/4 A325/F13 1 Φ <sub>ν</sub> Γ <sub>n</sub> 23.9 47.7 See Table	1 852 Bolt 8 r <sub>n</sub> / Ω <sub>v</sub> ASD 19.1 38.2 2 7-3 for th	<b>7</b> 8 <b>Pretens</b> <b>5</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 28.6 57.1 e SSL+ de	1 sion, ki 10 r <sub>n</sub> / Ω <sub>v</sub> ASD 23.1 46.3 ifault	1/2 0S 03 Φ <sub>ν</sub> Γ <sub>n</sub> LRFD 34.6 69.3	
Hole Type STD OSZ & SSL	Loading S D	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default	<b>1/8</b> inimum 6 Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 18.8 37.7 t for OSZ a 16.0		1/4 A325/F13 1 Φ <sub>ν</sub> Γ <sub>n</sub> 23.9 47.7 See Table	1 852 Bolt r <sub>n</sub> / Ω <sub>v</sub> ASD 19.1 38.2 2 7-3 for th	<b>7</b> 8 <b>Pretens</b> <b>5</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 28.6 57.1 e SSL+ de 24.3	1 sion, ki 1( r <sub>n</sub> / Ω <sub>v</sub> ASD 23.1 46.3 fault	1/2 DS 03 Φ <sub>ν</sub> r <sub>n</sub> LRFD 34.6 69.3 29.4	
Hole Type STD OSZ & SSL	Loading S D S D	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default 10.7 21.4	Φ <sub>ν</sub> r <sub>n</sub> Δ <sub>ν</sub> r <sub>n</sub> LRFD           18.8           37.7           a for OSZ a           16.0           32.0		1/4 A325/F18 Φ <sub>ν</sub> Γ <sub>n</sub> LRFD 23.9 47.7 See Table 20.3 40.6	1 852 Bolt r <sub>n</sub> / Ω <sub>ν</sub> ASD 19.1 38.2 e 7-3 for th 16.2 32.5	%8 Pretens: 5 Φ <sub>ν</sub> r <sub>n</sub> LRFD 28.6 57.1 e SSL+ de 24.3 48.6	1 sion, ki r <sub>n</sub> / Ω <sub>v</sub> ASD 23.1 46.3 fault 19.7 39.3	1/2 DS 03 Φ <sub>ν</sub> r <sub>n</sub> LRFD 34.6 69.3 29.4 58.9	
Hole Type STD OSZ & SSL	Loading S D S D	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default 10.7 21.4	ψ           6           Φ <sub>ν</sub> r <sub>n</sub> LRFD           18.8           37.7           : for OSZ a           16.0           32.0           efault for L	1 ASTM A 7 r <sub>n</sub> / Ω <sub>v</sub> ASD 16.0 31.9 and SSL=. 13.6 27.1 .SL=. See	1/4 A325/F18 1 Φ <sub>ν</sub> Γ <sub>n</sub> LRFD 23.9 47.7 See Table 20.3 40.6 Table 7-3	1 852 Bolt Γ <sub>n</sub> / Ω <sub>ν</sub> ASD 19.1 38.2 e 7-3 for th 16.2 32.5 for the LS	%8 Pretens 5 Φ <sub>ν</sub> r <sub>n</sub> 28.6 57.1 e SSL+ de 24.3 48.6 -+ default	1 sion, ki r <sub>n</sub> / Ω <sub>v</sub> ASD 23.1 46.3 ifault 19.7 39.3	1/2 DS 03 Φ <sub>ν</sub> r <sub>n</sub> LRFD 34.6 69.3 29.4 58.9	
Hole Type STD OSZ & SSL LSL	Loading S D S D	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default 10.7 21.4 Du 8.81	1/8 inimum 6 Φ <sub>ν</sub> r <sub>n</sub> 18.8 37.7 if or OSZ a 16.0 32.0 efault for L 13.2	1 ASTM A 7 $r_n/ Ω_v$ ASD 16.0 31.9 and SSL=. 13.6 27.1 .SL=. See 11.2	1/4 A325/F18 1 Φ <sub>ν</sub> Γ <sub>n</sub> 23.9 47.7 See Table 20.3 40.6 Table 7-3	1 852 Bolt 8 $r_n/ Ω_v$ ASD 19.1 38.2 7-3 for th 16.2 32.5 for the LSI for the LSI	<b>7</b> 8 <b>Pretens</b> <b>5</b> Φ <sub>ν</sub> r <sub>n</sub> <b>LRFD</b> 28.6 57.1 e SSL+ de 24.3 48.6 _+ default 20.0	1 sion, ki r <sub>n</sub> / Ω <sub>v</sub> ASD 23.1 46.3 ifault 19.7 39.3	1/2 DS 03 Φ <sub>ν</sub> Γ <sub>n</sub> LRFD 34.6 69.3 29.4 58.9 24.2	
Hole Type STD OSZ & SSL LSL	Loading S D S D S D	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default 10.7 21.4 Default 8.81 17.6	1/8 inimum 6 Φ <sub>v</sub> r <sub>n</sub> 18.8 37.7 t for OSZ a 16.0 32.0 efault for L 13.2 26.4	1 ASTM A 7 r <sub>n</sub> / Ω <sub>v</sub> ASD 16.0 31.9 and SSL=. 13.6 27.1 .SL=. See 11.2 22.3	1/4           A325/F18           1           Φ <sub>ν</sub> r <sub>n</sub> LRFD           23.9           47.7           See Table           20.3           40.6           Table 7-3           16.7           33.4	1           852 Bolt           8           r <sub>n</sub> / Ω <sub>v</sub> ASD           19.1           38.2           7-3 for th           16.2           32.5           for the LSI           13.4           26.7	<ul> <li>%8</li> <li>Pretens</li> <li>5</li> <li>Φ<sub>ν</sub>r<sub>n</sub></li> <li>28.6</li> <li>57.1</li> <li>e SSL+ de</li> <li>24.3</li> <li>48.6</li> <li>_+ default</li> <li>20.0</li> <li>40.0</li> </ul>	1 sion, kij r <sub>n</sub> / Ω <sub>v</sub> 23.1 46.3 fault 19.7 39.3	<ul> <li>½</li> <li>DS</li> <li>D3</li> <li>Φ<sub>v</sub>r<sub>n</sub></li> <li>LRFD</li> <li>34.6</li> <li>69.3</li> <li>29.4</li> <li>58.9</li> <li>24.2</li> <li>48.5</li> </ul>	
Hole Type STD OSZ & SSL LSL	Loading S D S D S D nndard Hole	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default 10.7 21.4 Default 10.7 21.4 Default	½8           Φ,νrn           Φ,νrn           18.8           37.7           for OSZ a           16.0           32.0           efault for L           13.2           26.4           S = Overs	1 ASTM A r <sub>n</sub> / Ω <sub>v</sub> ASD 16.0 31.9 and SSL=. 13.6 27.1 .SL=. See 11.2 22.3 ize Hole	1/4           A325/F18           Φ <sub>ν</sub> Γ <sub>n</sub> LRFD           23.9           47.7           See Table           20.3           40.6           Table 7-3           16.7           33.4           SS	$\begin{array}{c} 1 \\ 852 \text{ Bolt} \\ 8 \\ \hline r_n / \Omega_v \\ \textbf{ASD} \\ 19.1 \\ 38.2 \\ e 7-3 \text{ for the} \\ 16.2 \\ 32.5 \\ for the LSI \\ 16.4 \\ 26.7 \\ L = Short \\ e Sho$	%8 Pretens 5 Φ <sub>ν</sub> r <sub>n</sub> LRFD 28.6 57.1 e SSL+ de 24.3 48.6 -+ default 20.0 40.0 Slot LSL	1 sion, kij r <sub>n</sub> / Ω <sub>v</sub> ASD 23.1 46.3 fault 19.7 39.3 16.2 32.4 - = Long S	1/2 DS D3 Φ <sub>ν</sub> r <sub>n</sub> LRFD 34.6 69.3 29.4 58.9 24.2 48.5 Slot	
Hole Type STD OSZ & SSL LSL STD = Sta '+' = slot le S= Single S	Loading S D S D Indard Hole ngth transve	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default 10.7 21.4 Dr 8.81 17.6 OV rse to the I	½8           6           Φ <sub>ν</sub> r <sub>n</sub> LRFD           18.8           37.7           for OSZ a           16.0           32.0           efault for L           13.2           26.4           S = Overs           oad: '=';           bear		$\frac{1}{4}$	1           852 Bolt           8 $r_n/ Ω_v$ ASD           19.1           38.2 $e$ 7-3 for the           16.2           32.5           for the LSI           13.4           26.7           L         = Short           to the load	%8 Pretens: 5 Φ <sub>ν</sub> r <sub>n</sub> LRFD 28.6 57.1 e SSL+ de 24.3 48.6 -+ default 20.0 40.0 Slot LSL	$ \begin{array}{r} 1 \\ sion, ki \\ \hline r_n / \Omega_v \\ ASD \\ 23.1 \\ 46.3 \\ efault \\ 19.7 \\ 39.3 \\ 16.2 \\ 32.4 \\ - = Long S \end{array} $	½           DS           J3           Φ <sub>v</sub> r <sub>n</sub> LRFD           34.6           69.3           29.4           58.9           24.2           48.5           Slot	
Hole Type STD OSZ & SSL LSL STD = Sta '+' = slot le S= Single S ASD	Loading S D S D S D Indard Hole ngth transve Shear: D = LRFD	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default 10.7 21.4 Default 10.7 21.4 Default 17.6 OV rse to the I = Double S Notes: F	$\frac{1}{8}$ inimum 6 $\Phi_v r_n$ 18.8 37.7 if or OSZ a 16.0 32.0 efault for L 13.2 26.4 S = Overs oad: '=' i hear For availab	1 ASTM A 7 $r_n/ Ω_v$ ASD 16.0 31.9 and SSL=. 13.6 27.1 .SL=. See 11.2 22.3 ize Hole = slot leng ole slip resi	$\frac{1}{4}$	1           852 Bolt           8 $r_n/ Ω_v$ ASD           19.1           38.2 $\epsilon$ 7-3 for th           16.2           32.5           for the LSI           13.4           26.7           L = Short           to the load           en slip is $\epsilon$	%8 Pretens: 5 Φ <sub>ν</sub> r <sub>n</sub> LRFD 28.6 57.1 e SSL+ de 24.3 48.6+ default 20.0 40.0 Slot LSL a serviceab	1           sion, kij           10           r <sub>n</sub> / Ω <sub>v</sub> ASD           23.1           46.3           ifault           19.7           39.3           16.2           32.4	1/2 DS 03 Φ <sub>ν</sub> r <sub>n</sub> LRFD 34.6 69.3 29.4 58.9 24.2 48.5 Slot tate,	
Hole Type STD OSZ & SSL LSL STD = Sta '+' = slot le S= Single S ASD	Loading S D S D S D ndard Hole ngth transve Shear: D = LRFD	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default 10.7 21.4 Default 10.7 21.4 Dufault 0v rse to the I Double S Notes: F s	$\frac{1}{8}$ <b>6</b> $\Phi_{v}r_n$ <b>18.8</b> 37.7 <b>16 or OSZ a</b> 16.0 32.0 efault for L 13.2 26.4 S = Overs oad: '='' hear For availab see Table	1           ASTM A           7 $r_n/ Ω_v$ ASD           16.0           31.9           and SSL=.           13.6           27.1           .SL=. See           11.2           22.3           ize Hole           = slot leng           ole slip resi           7-3	$\frac{1}{4}$	$\begin{array}{c} 1 \\ 852 \text{ Bolt} \\ \hline 852 \text{ Bolt} \\ \hline 8 \\ \hline r_n / \Omega_v \\ \hline 4 \\ 8 \\ \hline 7 \\ 38.2 \\ \hline 7 \\ 38.2 \\ \hline 7 \\ 38.2 \\ \hline 7 \\ 57 \\ 57 \\ 57 \\ 57 \\ 57 \\ 57 \\ 5$	%8           Pretens           Φ <sub>ν</sub> r <sub>n</sub> LRFD           28.6           57.1           e SSL+ de           24.3           48.6           _+ default           20.0           40.0           Slot           LSL	1 sion, kij r <sub>n</sub> / Ω <sub>v</sub> 23.1 46.3 fault 19.7 39.3 fault 19.7 39.3	1/2 DS D3 Φ <sub>ν</sub> Γ <sub>n</sub> LRFD 34.6 69.3 29.4 58.9 24.2 48.5 Slot tate,	
Hole Type STD OSZ & SSL LSL STD = Sta '+' = slot le S= Single S ASD	Loading S D S D S D S D S D S D S D S D S D S	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default 10.7 21.4 Dr 8.81 17.6 OV rse to the I Double S Notes: F s F	$\frac{1}{8}$ $\frac{1}{8}$ $\frac{1}{8}$ $\frac{1}{8}$ $\frac{1}{8}$ $\frac{1}{8}$ $\frac{1}{8}$ $\frac{1}{8}$ $\frac{3}{7}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{2}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{6}$ $\frac{1}{3}$ $\frac{1}{6}$	1 ASTM $A$ $r_n/ Ω_v$ ASD 16.0 31.9 and SSL=. 13.6 27.1 .SL=. See 11.2 22.3 ize Hole = slot leng le slip resi 7-3 3 faying sL	$\frac{1}{4}$	1         852 Bolt         8 $r_n/ Ω_v$ ASD         19.1         38.2 $2$ 7-3 for the         16.2         32.5         for the LSI         13.4         26.7         L = Short         to the load         en slip is a         = 0.50) mu	%8           Pretens           Φ <sub>ν</sub> r <sub>n</sub> LRFD           28.6           57.1           e SSL+ de           24.3           48.6           _+ default           20.0           40.0           Slot           LSL	1         sion, kij         10         rn/ Ωv         23.1         46.3         afault         19.7         39.3         16.2         32.4         - = Long S         pility limit s         abulated a	1/2 DS D3 Φ <sub>ν</sub> r <sub>n</sub> LRFD 34.6 69.3 29.4 58.9 24.2 48.5 Slot tate, vailable	
Hole Type STD OSZ & SSL LSL STD = Sta '+' = slot le S= Single S ASD $\Omega_v$ = 1.76	Loading S D S D S D S hotard Hole ngth transve Shear: D = LRFD $\Phi_v$ = 0.85	1 Mi 5 r <sub>n</sub> / Ω <sub>v</sub> ASD 12.6 25.2 Default 10.7 21.4 Default 10.7 21.4 Default 10.7 21.4 Default Notes: F S F S F S S S S	$\frac{1}{8}$ inimum 6 $\Phi_{vr_n}$ 18.8 37.7 if of OSZ a 16.0 32.0 efault for L 13.2 26.4 S = Overs oad: '=' hear For availab see Table F for Class B strength by the require	1 ASTM $A$ $r_n/ Ω_v$ ASD 16.0 31.9 and SSL=. 13.6 27.1 .SL=. See 11.2 22.3 ize Hole = slot leng ole slip resi 7-3 3 faying sL 0.50/0.35 ed strendt	$\frac{1}{4}$ <b>A325/F1</b> <b>1</b> $\Phi_{v\Gamma_n}$ <b>LRFD</b> 23.9 47.7 See Table 20.3 40.6 Table 7-3 16.7 33.4 SS th parallel stance wh urfaces ( $\mu$ = 1.43 is determ	1           852 Bolt           8 $r_n/ Ω_v$ ASD           19.1           38.2 $e$ 7-3 for the           16.2           32.5           for the LSI           13.4           26.7           L           L           en slip is a           = 0.50) mu           ined using	♥8           Pretens           5           Φ√rn           LRFD           28.6           57.1           e SSL+ de           24.3           48.6           _+ default           20.0           40.0           Slot           LSL           a serviceat           Itiply the ta           LRFD loa	1           sion, kij           10           rn/ Ωv           ASD           23.1           46.3           afault           19.7           39.3           16.2           32.4           - = Long S           bility limit s           abulated a           ad combina	½           DS           J3           Φ <sub>ν</sub> r <sub>n</sub> LRFD           34.6           69.3           29.4           58.9           24.2           48.5           Slot           tate,           vailable           ations for	

			Alte	rnate T	able 7-	4						
		Slip	Criti	cal C	onne	ection	าร	A 40	<b>^</b>			
			blo Sh	oor Str	onath I			A45				
		Avalla		Strongt	b Limit C	NIPS, WI						
		(0)	Slip is a	Strengt	<u>n Limit-S</u>							
		(Clas	<u>s A Fa</u>	ying Si	inace,	$\mu = 0.3$	5)					
	1		AS	TM A49	0 Bolts							
				Nomin	al Bolt	Diamete	r d, in.	1				
		5/	8	3	4	7	8		1			
Hole	Loading		Minim	um AST	M A490	Bolt Pre	etensior	<u>n, kips</u>				
Type	_	2	4	3	5	4	9	6	4			
		r <sub>n</sub> / Ω <sub>v</sub>	Φ <sub>v</sub> r <sub>n</sub>	r <sub>n</sub> /Ω <sub>v</sub>	Φ <sub>v</sub> r <sub>n</sub>	r <sub>n</sub> /Ω <sub>v</sub>	Φ <sub>v</sub> r <sub>n</sub>	r <sub>n</sub> / Ω <sub>v</sub>	Φ <sub>v</sub> r <sub>n</sub>			
		ASD	LRFD	ASD		ASD	LRFD	ASD	LRFD			
STD			Se	e Table 7-	3 for the S	TD defaul	t					
	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	ASU LRF 14.4 21 28.8 43 Jefault 12.2 18 24.4 36 It	43.0			
OVS &		Defaul	t for OSZ a	and SSL=.	See Table	e 7-3 for th	e SSL+ de	efault				
SSL	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	SL+ default 14.0 12.2 18.3 28.0 24.4 36.6 default				
LSI		D	efault for L	SL=. See	Table 7-3	for the LS	L+ default					
	S	3.78	5.65	5.51	8.24	7.71	11.5	10.1	12.0			
		7.00	11.3	Nomin	al Bolt	Diamoto	rd in	20.1	30.1			
		1	1/_	1	1/,	1	3/	1	1/_			
Hole		- 1	/8 Minim		/4 M A/00	Bolt Dr	/8 stoncior	l l	/2			
Type	Loading	0			1VI A430		210113101	I, KIPS	19			
		r_/ O.	<b>υ</b> Φ.r.	r_/ O.	<b>02</b> Φ.r.	r_/ O.	<b>Δ</b> .r.	r_/ O	<b>+Ο</b>			
		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 &		Defaul	t for OSZ a	and SSL=.	See Table	e 7-3 for th	e SSL+ de	efault				
SSL	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			
		D	efault for L	SL=. See	Table 7-3	for the LS	L+ default					
LSL	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			
SID = Sta	indard Hole	OV rse to the l	S = Overs	ize Hole = slot leng	th narallel	to the load	SIOT LSI	_ = Long t	Slot			
S= Single	Shear: D =	Double S	hear	olotiong	an paraner		•					
ASD	LRFD	Notes: F	or availab	ole slip res	istance wh	en slip is a	a serviceat	oility limit s	tate,			
		S	see Table	7-3 Flaving ci	urfaces (m	- 0 50) m	ultiply the t	abulated a	vailable			
Ω <sub>v</sub> = 1.76	Φ <sub>v</sub> = 0.85		strength by	/ 0.50/0.35	5 = 1.43	– 0.50) mu	nupiy the t	abulateu a	valiable			
		-	The require	ed strengt	n is determ	nined using	LRFD loa	d combina	ations for			
1			RFD desi	on and AS	D Load co	mbination	s for ASD	desian				