

Blast Design of Cold-Formed Steel Connections

Technical Note

Strength Tables for Special Seismic and Blast
Design of Cold-Formed Steel Connections

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STRENGTH TABLES FOR SPECIAL SEISMIC AND BLAST DESIGN OF COLD FORMED STEEL CONNECTIONS

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Introduction

Various specifications and design standards allow the use of nominal strength of material when calculating resistance values of components for special blast or seismic design. Beyond the use of nominal strength, some design codes allow the use of an increased nominal strength or an increased expected strength. A Static Increase Factor (SIF) and a Dynamic Increase Factor (DIF) can be applied to nominal and expected strength, respectively, to attain greater material strength of components for special design purposes. The Steel Network has developed LRFD design strength, nominal strength and ultimate strength tables for each connector manufactured which can be used in special seismic and blast design and are compatible with the Static and Dynamic Strength Increase factors. This technical note provides background on the development of TSN connectors' strength and how to use it for seismic and blast design per various codes and standards in the US.

Seismic Design

Special seismic design requirements are mandated in AISI S213 section C1.1 "Seismic Requirements", which are applicable to the design of cold formed steel shear walls or systems using diagonal strap bracing that resists wind, seismic, or other in-plane lateral loads. Section C1.1 directs the designer to the "Special Seismic Requirements" section, Section C5, if the design is in the United States or Mexico and the Response Modification coefficient, R , is greater than 3.

Section C5 "Special Seismic Requirements" is referenced and contains the provisions allowing nominal strength of materials to be used in the design of members and/or connections. Section C5.1 "Shear Walls" and Section C5.2 "Diagonal Strap Bracing" presents the provisions for design of connections, chord studs and anchorage, and foundations when using a shear wall or diagonal strap bracing lateral force resistance systems. Section C5.2.2.2 presents provisions that allow the nominal strength to be used for design of connections in the load path of diagonal strap bracing. This section states:

*"All members in the load path and uplift and shear anchorage thereto from the diagonal strap bracing member to the foundation shall have the **nominal strength** to resist the expected yield strength $A_g R_y F_y$, of the diagonal strap bracing member(s), except the **nominal strength** need not exceed the following, as applicable:*

- (a) In the United States and Mexico: Amplified seismic load.*
- (b) In Canada: Maximum anticipated seismic loads calculated with $R_d R_o = 1.0$."*

The load to design for is the expected strength of the diagonal strap bracing, but not to exceed the amplified seismic load.

Blast Design

UFC 4-010-01 Section B-3 outlines the design of window and skylight systems under extreme pressure loading such as a blast. Provisions are given for a static or dynamic method of design for window and skylight opening framing and connections. Section B-3.1.2 “Supporting Structural Elements” allows the use of nominal strength when performing **static** design of structural elements which support windows and skylights. These elements include jamb, header, and sill members along with connections between them. The code states:

*“For window and skylight systems, surrounding wall and roof elements and their connections to the rest of the structure may be designed using their **nominal strengths**. For systems using laminated glass, the design load will be eight times the glazing resistance determined using ASTM E 1300 in conjunction with ASTM F 2248 based on the applicable explosive weight at the actual standoff distance at which the window is sited. This design load will be distributed to the structural element only from the tributary area of the window.”*

The UFC design code provides an alternative design method utilizing the **dynamic** material properties of the window glazing, framing members, connections, and supporting structural elements. Section B-3.1.4 “Alternate Method of Analysis” states:

“As an alternative to the design approach described above, any or all of the glazing, framing members, connections, and supporting structural elements may be designed using dynamic analysis to prove the window system will provide performance equivalent to or better than the hazard rating associated with the applicable level of protection as indicated in Table 2-1. The design loading for a dynamic analysis will be the appropriate pressure and impulse from the applicable explosive weight at the actual standoff distance at which the window is sited, but not greater than the conventional construction standoff distance. The design loading will be applied over the area tributary to the element being analyzed.”

The dynamic method of analysis and design of framing members incorporates strength increase factors that enhance the nominal and expected strength of materials. A Static Increase Factor (SIF) or Average Strength Factor (ASF) can be applied to the nominal strength of a material, while a Dynamic Increase Factor (DIF) can be applied to the expected strength of a material.

Documents such as the UFC 3-340-02, the ASCE Publication “Design of Blast-Resistant Buildings in Petrochemical Facilities”, and the ASCE committee approved document “Mandatory Blast Protection of Buildings Provisions” describe Static and Dynamic Increase Factors and the uses of each. Since the nominal strength is typically taken as the lower bound minimum yield strength of the material, the Static Increase Factor (SIF) or Average Strength Factor (ASF) are applied to the nominal strength to account for higher yield strength of installed components than minimum specified yield

strength values. The resultant value is the “expected strength”. Beyond the use of this expected strength level, ASCE and the UFC code states that the Dynamic Increase Factor (DIF) is to be applied to the expected strength to account for strain rate effects from a rapid blast loading to achieve greater dynamic strengths. Table 1 shows suggested increase factors to be used for cold-formed steel design as recommended by two different ASCE publications and the DoD UFC 3-340-02.

Table 1 - Static and Dynamic Increase Factors for Cold-Formed Steel

	Static Increase Factor (SIF) or Average Strength Factor (ASF)	Dynamic Increase Factor (DIF)	
		Bending/Shear	Tension/Compression
ASCE Blast Protection of Buildings Standard (under review)	1.1	1.1	1.1
ASCE Design of Blast-Resistant Buildings in Petrochemical Facilities (2010)	1.21	1.1	1.1
UFC 3-340-02 (2008)	1.21	1.1	1.1

In reference to the AISI S100-07 specifications and the development of the nominal strength tables, it should be noted that LRFD design strength is typically determined as the nominal strength multiplied by the appropriate resistance factor (ϕ). Chapter F of the AISI specification permits the calculation of LRFD design strength based upon the ultimate strength of a specimen tested according to the provisions given within. This ultimate strength value is then multiplied by a lesser resistance factor than the main specification. **Figure 1** is a diagram depicting the various levels of strength and the relationship between LRFD design strength, nominal strength, expected strength, ultimate strength, and dynamic strength.

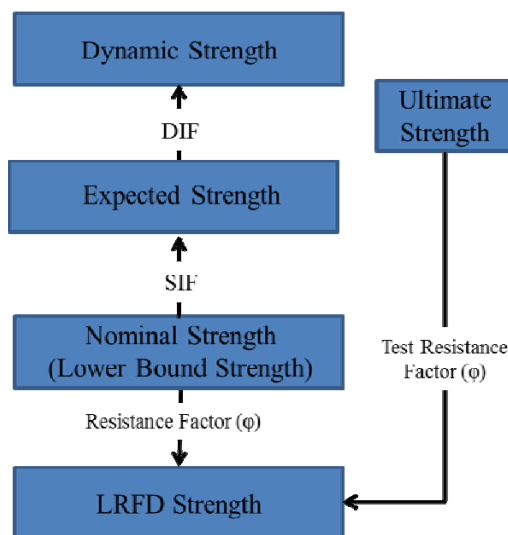


Figure 1 - Strength Relationship Diagram

Strength Tables

The Steel Network has developed the following tables to present the LRFD design strength, nominal strength, and ultimate strength for all clip connectors manufactured. The ultimate and LRFD values for each clip are calculated according to the test method specified in AISI S100-07, Chapter F. The nominal strength is calculated as the LRFD strength divided by an average resistance factor of 0.9.

VertiClip® Series

Clip/Load Direction	LRFD Design Strength (lbs)	Nominal Strength (lbs)	Ultimate Strength (lbs)
SL362			
F1 Direction	397	441	721
F2 Direction	1696	1885	2680
SL400			
F1 Direction	318	353	600
F2 Direction	1817	2019	3074
SL600			
F1 Direction	588	653	1068
F2 Direction	2691	2990	4251
SL800			
F1 Direction	579	643	1052
F2 Direction	2994	3327	4730
SL1000			
F1 Direction	664	738	1206
F2 Direction	2521	2801	4266
SL1200			
F1 Direction	611	679	1110
F2 Direction	2863	3182	4845
SLD150			
F2 Direction	82	91	139
SLD250			
F2 Direction	254	282	430
SLD362/400			
F2 Direction	575	639	973
SLD600			
F2 Direction	648	720	1302
SLD800			
F2 Direction	1091	1212	1844
SLB362			
F1 Direction	364	405	661
F2 Direction	2563	2848	4381
SLB600			
F1 Direction	364	405	661
F2 Direction	2563	2848	4381
SLB800			
F1 Direction	357	397	604
F2 Direction	2563	2848	4381

Clip/Load Direction	LRFD Design Strength (lbs)	Nominal Strength (lbs)	Ultimate Strength (lbs)
SLB1000			
F2 Direction	2266	2517	4112
SLB1200			
F2 Direction	2266	2517	4112
SLBxxx-10, -12			
F2 Direction	2266	2517	4112
SLS			
F2 Direction	3315	3489	5237
SLT9.5			
F1 Direction	546	575	991
F2 Direction	822	865	1492
SLT(L)			
F1 Direction	784	825	1422
F2 Direction	1116	1175	2026
Splice			
F2 Direction	2282	2402	3861
F3 Direction	3888	4092	6578

Notes:

Strength values provided are those of the clip only. Attachment to stud framing and to structure must be evaluated independently.

Nominal Strength is calculated as LRFD Strength divided by an average resistance factor of 0.9.

Ultimate Strength is the average maximum load obtained from tests.

When dynamic analysis is used for blast design, the Nominal Strength may be allowed to be increased by a Static Increase Factor (SIF) and a Dynamic Increase Factor (DIF).

DriftClip[®] and DriftTrak[®] Series

Clip/Load Direction	LRFD Design Strength (lbs)	Nominal Strength (lbs)	Ultimate Strength (lbs)
DSLB	Fastener Pattern 1		
F2 Direction	1467	1630	2317
DSLB	Fastener Pattern 2		
F2 Direction	916	1018	1663
DSLS600-12	Fastener Pattern 1		
F2 Direction	2980	3311	4707
DSLS600-12	Fastener Pattern 2		
F2 Direction	2788	3098	4405
DSLS600-15	Fastener Pattern 1		
F2 Direction	3045	3383	4811
DSLS600-15¹	Fastener Pattern 2		
F2 Direction	3045	3383	5008
DSL362	Fastener Pattern 1		
F2 Direction	186	207	317
DSL362	Fastener Pattern 2		
F2 Direction	85	94	141
DSL600	Fastener Pattern 1		
F2 Direction	286	317	481
DSL600	Fastener Pattern 2		
F2 Direction	399	443	869

Clip/Load Direction	LRFD Design Strength (lbs)	Nominal Strength (lbs)	Ultimate Strength (lbs)
DSL800	Fastener Pattern 1		
F2 Direction	318	354	578
DSL800	Fastener Pattern 2		
F2 Direction	293	326	858
DSL362	Fastener Pattern 1		
F2 Direction	796	884	1320
DSL362	Fastener Pattern 2		
F2 Direction	397	441	720
DSL600	Fastener Pattern 1		
F2 Direction	1242	1380	2254
DSL600	Fastener Pattern 2		
F2 Direction	1840	2044	3051
DSL800	Fastener Pattern 1		
F2 Direction	1666	1851	3023
DSL800¹	Fastener Pattern 2		
F2 Direction	1666	1851	4122
DTSL	8" Fastener Spacing - Pattern 1		
F2 Direction	1001	1112	1807
DTSL	8" Fastener Spacing - Pattern 2		
F2 Direction	770	856	1303
DTSL	16" Fastener Spacing - Pattern 1		
F2 Direction	1338	1487	2264
DTSL	16" Fastener Spacing - Pattern 2		
F2 Direction	774	860	1309
DTSLB	8" Fastener Spacing - Pattern 1 and 2		
F2 Direction	1292	1435	2186
DTSLB	16" Fastener Spacing - Pattern 1 and 2		
F2 Direction	1206	1340	2040

Notes:

¹LRFD strength limited by fastener pattern 1.

Strength values provided are those of the clip only. Attachment to stud framing and to structure must be evaluated independently.

Nominal Strength is calculated as the LRFD Strength divided by an average resistance factor of 0.9.

Ultimate Strength is maximum load obtained from tests.

When dynamic analysis is used for blast design, the Nominal Strength may be allowed to be increased by a Static Increase Factor (SIF) and a Dynamic Increase Factor (DIF).

StiffClip[®] Series

Clip/Load Direction	LRFD Design Strength	Nominal Strength	Ultimate Strength
	(lbs or in-lbs)	(lbs or in-lbs)	(lbs or in-lbs)
AL362			
F1 Direction	1177	1308	2137
F2 Direction	2493	2770	4219
F3 Direction	4522	5025	7652

Clip/Load Direction	LRFD Design Strength	Nominal Strength	Ultimate Strength
	(lbs or in-lbs)	(lbs or in-lbs)	(lbs or in-lbs)
AL600			
F1 Direction	1388	1542	2348
F2 Direction	3493	3882	5911
F3 Direction	4830	5366	8172
AL800			
F1 Direction	2827	3141	4784
F2 Direction	4022	4469	6806
F3 Direction	9798	10887	16579
LB362			
F1 Direction	1481	1646	2506
F2 Direction	3297	3664	5579
F3 Direction	4256	4729	7202
LB600			
F1 Direction	1481	1646	2506
F2 Direction	3297	3664	5579
F3 Direction	3080	3423	5212
LB800			
F1 Direction	1993	2214	3617
F2 Direction	3297	3664	5579
F3 Direction	6188	6875	10470
LB800-4" Offset			
F1 Direction	1993	2214	3617
F2 Direction	3297	3664	5579
F3 Direction	2496	2773	4223
LB1000			
F1 Direction	1465	1627	2658
F2 Direction	2270	2522	4120
F3 Direction	2872	3191	4859
LB1000-4" Offset			
F2 Direction	2270	2522	4120
F3 Direction	2506	2784	4240
LB1200			
F1 Direction	1465	1627	2658
F2 Direction	2270	2522	4120
F3 Direction	3041	3379	5146
HE(L)-43 mil			
F2 Direction	2005	2227	3392
F3 Direction	4901	5446	8293
HE(H)-68 mil			
F2 Direction	3478	3864	5885
F3 Direction	8880	9867	15026
CL362/400-68			
F1 Direction	2267	2519	4122
F2 Direction	3071	3412	4851
F3 Direction	1842	2047	3349
M1 Direction (in-lbs)	2888	3209	5251

Clip/Load Direction	LRFD Design Strength	Nominal Strength	Ultimate Strength
	(lbs or in-lbs)	(lbs or in-lbs)	(lbs or in-lbs)
CL362/400-118			
F1 Direction	3880	4311	6129
F2 Direction	7090	7878	11201
F3 Direction	3611	4012	6565
M1 Direction (in-lbs)	6299	6999	11453
CL362/400-118H			
F1 Direction	4160	4622	6572
F2 Direction	7973	8858	12595
F3 Direction	9150	10167	14455
M1 Direction (in-lbs)	10750	11944	19545
CL600-68			
F1 Direction	2275	2528	3594
F2 Direction	4020	4467	6351
F3 Direction	1932	2147	3513
M1 Direction (in-lbs)	4978	5531	9050
CL600-118			
F1 Direction	4131	4590	7147
F2 Direction	6578	7308	10391
F3 Direction	3561	3956	6474
M1 Direction (in-lbs)	9126	10140	16592
CL600-118H			
F1 Direction	6659	7399	10520
F2 Direction	10337	11485	16330
F3 Direction	9620	10689	15197
M1 Direction (in-lbs)	9958	11065	18106
CL800-68			
F1 Direction	2298	2553	3630
F2 Direction	4263	4736	6734
F3 Direction	1724	1916	3135
M1 Direction (in-lbs)	4578	5086	8323
CL800-118			
F1 Direction	5375	5972	8491
F2 Direction	10265	11406	16217
F3 Direction	4270	4744	8291
M1 Direction (in-lbs)	13170	14634	23946
CL800-118H			
F1 Direction	7713	8570	12185
F2 Direction	13251	14723	20933
F3 Direction	11925	13250	18839
M1 Direction (in-lbs)	17834	19815	32425
TD			
F3 Direction	17149	19055	20863

Notes:

Strength values provided are those of the clip only. Attachment to stud framing and to structure must be evaluated independently.

Nominal Strength is calculated as LRFD Strength divided by an average resistance factor of 0.9.

Ultimate Strength is the average maximum load obtained from tests.

When dynamic analysis is used for blast design, the Nominal Strength may be allowed to be increased by a Static Increase Factor (SIF) and a Dynamic Increase Factor (DIF).

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