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HILTI® KB1 EXPANSION ANCHORS FOR USE IN CRACKED AND UNCRACKED CONCRETE

CSI Division:

03 00 00—CONCRETE
05 00 00—METALS

CSI Sections:

03 15 19—Cast-In Concrete Anchors
05 05 19—Post-installed Concrete Anchors

1.0 RECOGNITION

HILTI KB1 Expansion Anchors recognized in this report have been evaluated for use as torque-controlled, mechanical expansion anchors. The structural performance properties of the HILTI KB1 Expansion Anchors comply with the intent of the provisions of the following codes and regulations as alternative solutions:

- National Building Code of Canada 2015 (NBC 2015)
- CSA A23.3-14, Design of Concrete Structures

2.0 LIMITATIONS

Use of the HILTI KB1 Expansion Anchors recognized in this report is subject to the following limitations:

2.1 KB1 Expansion Anchors are limited to the sizes, embedment depths, spacings, and other installation requirements as provided in NBC 2015, CSA A23.3-14, and this report.

2.2 The KB1 Expansion Anchor installation shall be in conformance with the manufacturer's published installation instructions and this report. Where there is a conflict between the requirements of this report and the instructions, the more restrictive shall prevail.

2.3 KB1 Expansion Anchors shall be limited to use in cracked and uncracked normal-density concrete and structural low-density concrete with a specified compressive strength, f'_c from 20 MPa to 58 MPa.

2.4 The maximum value of f'_c used in the calculation equations given in this report shall be 55 MPa.

2.5 Minimum spacings and edge distances for anchors and minimum thicknesses of members shall comply with Tables 3, 4, and 5, and Figure 5.

2.6 In accordance with CSA A23.3-14 Clause D.1.4, the use of KB1 Expansion Anchors to resist high cycle fatigue, impact, or shock loads is beyond the scope of this report.

2.7 KB1 Expansion Anchors may be installed in a region of the concrete member where cracking has occurred or where analysis indicates cracking may occur ($f_t > f_r$) at service load levels, subject to the provisions of this report.

2.8 KB1 Expansion Anchors may be used to resist short-term wind or earthquake loads, subject to the provisions of this report. Wind or earthquake loads shall be determined according to NBC 2015 Subsections 4.1.7 or 4.1.8.

2.9 Subject to specific requirements in NBC 2015 and the acceptance of the authority having jurisdiction, KB1 Expansion Anchors may be used with fire-resistance-rated assemblies or structural members where one or more of the following limitations are satisfied:

- Anchors are used to resist wind or earthquake loads only.
- Anchors that support a fire-resistance-rated envelope or a fire-resistance-rated membrane are protected by approved fire-resistance-rated materials, or have been evaluated for resistance to fire exposure in accordance with standards referenced in the NBC.
- Anchors are used to support nonstructural elements.

2.10 Uses of anchors where conditions are corrosive to steel are beyond the scope of this report.

2.11 Anchors are manufactured by Hilti AG under an approved quality-control program with inspections by IAPMO-UES.

3.0 PRODUCT USE

3.1 General: The KB1 Expansion Anchors are used to resist static, wind, and earthquake tension, and shear loads in cracked and uncracked normal-density concrete and structural low-density concrete that has a specified compressive strength, f'_c, between 20 MPa and 58 MPa. Cracked concrete shall be assumed except for anchors located in a region of the concrete member where analysis indicates no cracking (uncracked) at service load levels or restrained shrinkage. Cracked concrete also shall be assumed for anchors in structures designed to resist earthquake loads.

Installation instructions and information are set forth in Section 3.3, Tables 1 through 3, and Figures 2 and 3a of this report.

3.2 Ultimate Limit States Design: Design strengths for compliance with the 2015 NBC shall be determined in accordance with CSA A23.3-14 Annex D and this report.

Design provisions in Tables 4 and 5 of this report are intended for use with the 2015 NBC (CSA A23.3-14). The limit states design of anchors shall comply with CSA A23.3-14 Clause D.5.1, except as modified in CSA A23.3-14 Clause D.4.3, for seismic considerations.

Material resistance factors of ϕ_c = 0.65 and ϕ_s = 0.85 in accordance with CSA A23.3-14 Clauses 8.4.2 and 8.4.3, and resistance modification factors, *R*, as given in CSA A23.3-14 Clause D.5.3, are noted in Tables 4 and 5 of this report. The factored steel resistances, N_{sar} or V_{sar}, in Tables 4 and 5 of this report have been multiplied by f_s and *R*. The factored pullout resistances, $N_{cpr,uncr}$, $N_{cpr,cr}$, or $N_{cpr,eq}$ in Table 4 of this report have been multiplied by ϕ_c and *R*. These factors and factored resistances shall be used with the load combinations in Division B, Part 4, Subsection 4.1.3 of the 2015 NBC, or Annex C of CSA A23.3-14.

Requirements for Factored Pullout Resistance in Tension: The factored pullout resistances of an anchor in tension in cracked and uncracked concrete, $N_{cpr,cr}$ and $N_{cpr,uncr}$, respectively, are provided in Table 4 . and comply with CSA A23.3-14 Clause D.6.3.2. For all design cases, $\Psi_{c,P}$ = 1.0.

The factored pullout resistance in tension in cracked concrete may be adjusted for compressive strength in accordance with Eq-1:

$$N_{cpr,cr,f_c'} = N_{cpr,cr}\left(\frac{f_c'}{17.2}\right)^{n_{cr}} \text{ (N, MPa)} \qquad \text{(Eq-1)}$$

In regions where analysis indicates no cracking in accordance with CSA A23.3-14 Clause D.6.3.6, the factored pullout resistance in tension may be adjusted for compressive strength in accordance with Eq-2:

$$N_{cpr,uncr,f_c'} = N_{cpr,uncr}\left(\frac{f_c'}{17.2}\right)^{n_{uncr}} \text{ (N, MPa)} \qquad \text{(Eq-2)}$$

The values of n_{cr} and n_{uncr} are provided in Table 4.

Where values for $N_{cpr,cr}$ or $N_{cpr,uncr}$ are listed as "NA" in Table 4, the pullout resistance in tension does not need to be considered in the anchor design.

Requirements for Critical Edge Distance: For installations where $c < c_{ac}$ without supplementary reinforcement to control splitting, the concrete breakout resistance in tension of an anchor or anchor group for uncracked concrete shall be calculated in accordance with CSA A23.3-14 Clause D.6.2.

In lieu of CSA A23.3-14 Clause D.9.7, values of c_{ac} shall be taken from Table 4.

3.3 Installation: The KB1 Expansion Anchor installation shall be in conformance with the manufacturer's published installation instructions and this report. Where there is a conflict between the requirements of this report and the instructions, the more restrictive shall prevail. Details and setting information are provided in Figures 2 and 3A and Table 1 of this report. Anchor locations shall be determined as set forth in this report and detailed on plans and specifications accepted by the authority having jurisdiction. The holes shall be drilled into the concrete as illustrated in Figure 3B with 1) carbide-tipped masonry drill bits complying with ANSI B212.15-1994 and optional Hilti dust removal system or 2) the Hilti SafeSet System™, using Hilti TE-YD or TE-CD Hollow Carbide Drill Bits complying with ANSI B212.15-1994 and a Hilti vacuum system. The Hollow Drill Bits are limited to $^1/_2$ inch (12.7 mm), $^5/_8$ inch (15.9 mm), and $^3/_4$ inch (19.05 mm) diameters only. The minimum drilled hole depth, h_0, is given in Table 1. If dust and debris are removed from the drilled hole with the Hilti TE-YD or TE-CD Hollow Drill Bits, the DRS attachment system, or compressed air or a manual pump, h_{nom} is achieved at the specified value of h_0 noted in Table 1. The anchor shall be hammered into the predrilled hole until h_{nom} is achieved. The nut shall be tightened against the washer until the torque values specified in Table 1 are achieved.

4.0 PRODUCT DESCRIPTION

4.1 Product Information: KB1 Expansion Anchors are torque-controlled expansion anchors that are comprised of an anchor body (bolt), expansion element (clip), hex nut, and washer. A typical anchor is shown in Figure 1 of this report.

The anchor bolt has a tapered mandrel formed on the installed end of the anchor and a threaded upper end. The taper of the mandrel increases in diameter toward the installed end of the anchor. The expansion clip wraps around the tapered mandrel. Before installation, this expansion clip is free to rotate about the mandrel. The anchor is installed in a predrilled hole. When the anchor is set by applying torque to the hex nut, the mandrel is drawn into the expansion clip, which engages the drilled hole and transfers the load to the base material.

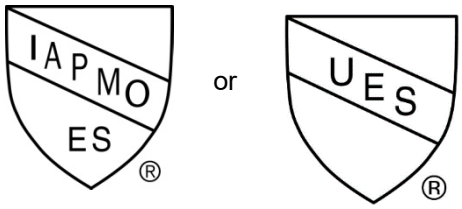
The anchors are available in $^3/_8$ inch (9.5 mm), $^1/_2$ inch (12.7 mm), $^5/_8$ inch (15.9 mm), and $^3/_4$ inch (19.1 mm) diameters of various lengths. The product names and sizes are presented in Table 1 of this report.

The KB1 anchor body is manufactured from carbon steel with a 5µm (0.0002 inch) minimum Fe/Zn plating per ASTM F1941. The expansion clip is manufactured from carbon steel. The nuts conform to the requirements of ASTM A563, Grade A, Hex. The washers conform to the requirements of ASTM F844.

5.0 IDENTIFICATION

Hilti KB1 Expansion Anchors are identified by dimensional characteristics and packaging. The packaging label lists the name and address of Hilti Inc., the manufacturing location, the anchor size and type; and the IAPMO UES evaluation

report number (UEL-5029), One of the following IAPMO UES Marks of Conformity may also be used. The threaded end of each KB1 Expansion Anchor is stamped with a length identification code letter.



IAPMO UES UEL-5029

6.0 SUBSTANTIATING DATA

Testing and analytical data for cracked and uncracked concrete in accordance with ACI 355.2-07, Qualification of Post-Installed Anchors in Concrete, including testing for seismic tension and seismic shear. Test reports are from laboratories accredited to ISO/IEC 17025.

7.0 STATEMENT OF COMPLIANCE

This evaluation report describes the results of research completed by IAPMO Uniform Evaluation Service on HILTI KB1 Expansion Anchors to assess conformance to NBC Clause 1.2.1.1.(1)(b), Division A, as alternative solutions that achieve at least the minimum level of performance required by Division B in the areas defined by the objectives and functional statements attributed to the following applicable acceptable solutions:

Article 4.1.1.3, Design Requirements (Structural Loads and Procedures)

Article 4.3.3.1, Design Basis for Plain, Reinforced and Pre-stressed Concrete

This report serves as documentation of an alternative solution in accordance with NBC Division C Subsection 2.3.1. Products are manufactured as noted in Section 2.14 of this report under a quality control program with periodic inspections under the supervision of IAPMO UES.

For additional information about this evaluation report please visit www.uniform-es.org or email us at info@uniform-es.org

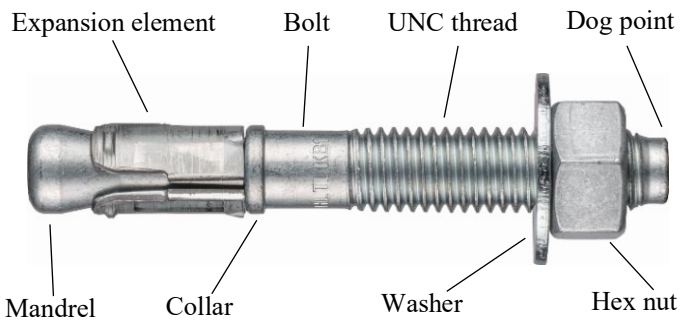


FIGURE 1 - HILTI CARBON STEEL KB1

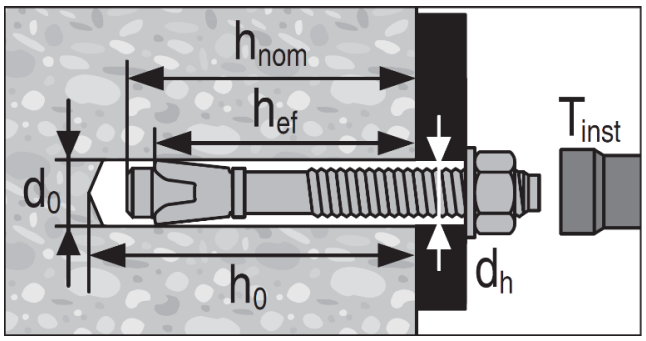
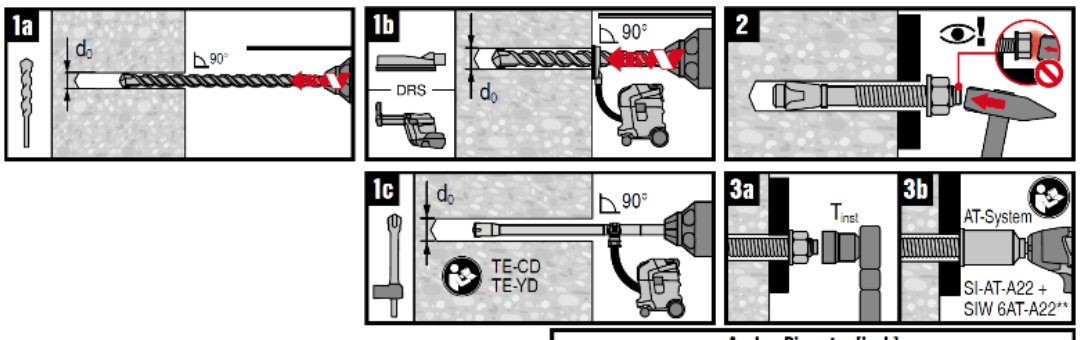


FIGURE 2 – KB1 INSTALLED



		Anchor Diameter [inch]			
Symbol	**Setting Information**	⅜	½	⅝	¾
HDB	Hollow Drill Bit	–	✔	✔	✔
DRS	Dust Removal Systems	✔	✔	✔	✔
AT-System	Adaptive Torque System	✔	✔	✔	–

FIGURE 3A – INSTALLATION INSTRUCTIONS

Hilti SafeSet™ System with Hollow Drill Bit	Hilti SafeSet™ System with the Adaptive Torque Tool	Hilti Dust Removal Systems
 Hilti TE-CD or TE-YD Hollow Carbide Drill Bit, with  Hilti Vacuum (per section 4.3)	 Hilti SIW-6AT-A22 Impact Wrench, with  Hilti SI-AT-A22 Adaptive Torque Module	 Hilti Rotary Hammer Drill with DRS (Dust Removal System) Module, or  Hilti TE DRS-D Dust Removal System with Hilti Vacuum

FIGURE 3B – HILTI SYSTEM COMPONENTS

TABLE 1 – SETTING INFORMATION

Design Information	Symbol	Units	Nominal anchor diameter (in.)							
			3/8		1/2		5/8		3/4	
Nominal drill bit diameter	d_0	in. (mm)	0.375 (9.5)		0.500 (12.7)		0.625 (15.9)		0.750 (19.1)	
Effective min. embedment	h_{ef}	mm	38	51	51	83	70	102	83	121
Nominal embedment	h_{nom}	mm	48	60	60	92	83	114	102	140
Min. hole depth	h_o	mm	54	70	70	108	95	121	108	146
Fixture hole diameter	d_h	mm	11.1		14.3		17.5		20.6	
Installation torque	T_{inst}	Nm	27		54		81		149	

TABLE 2 – LENGTH IDENTIFICATION SYSTEM

Stamp on Anchor		a	b	c	d	e	f	g	h	I	j	k	l	m	n	o	p	q	r	s	t	u	v	w
Length of anchor ℓ_{anch}(mm)	From	38	51	64	76	89	102	114	127	140	152	165	178	191	203	216	229	241	254	279	305	330	356	381
	Up to but not including	51	64	76	89	102	114	127	140	152	165	178	191	203	216	229	241	254	279	305	330	356	381	406

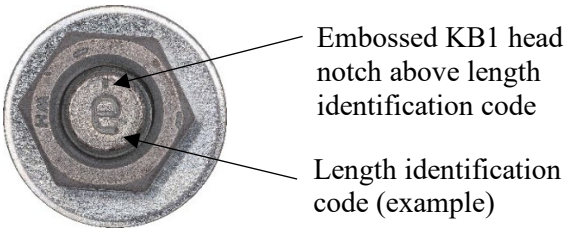


FIGURE 4 – BOLT HEAD WITH LENGTH IDENTIFICATION CODE

TABLE 3 – MINIMUM EDGE DISTANCE, SPACING, AND CONCRETE THICKNESS FOR KB1

Setting Information	Symbol	Units	Nominal anchor diameter (in)							
			3/8		1/2		5/8		3/4	
Effective minimum embedment	h_{ef}	mm	38	51	51	83	70	102	83	121
Minimum concrete thickness	h_{min}	mm	83	102	102	152	127	152	140	203
Minimum edge distance	c_{min}	mm	203	64	102	70	140	108	241	114
	for $s \geq$	mm	203	178	216	178	203	108	127	178
Minimum anchor spacing	s_{min}	mm	203	89	127	102	140	108	127	102
	for $c \geq$	mm	203	152	178	102	203	108	241	165

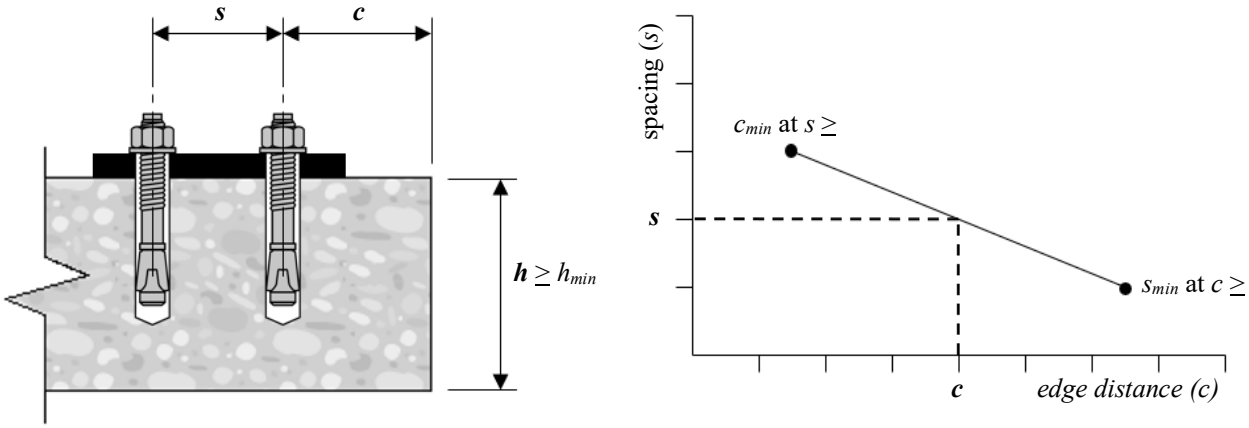


FIGURE 5 – INTERPOLATION OF MINIMUM EDGE DISTANCE AND ANCHOR SPACING

TABLE 4 – HILTI KB1 DESIGN INFORMATION, TENSION

Design Parameter	Symbol	Units	Nominal anchor diameter (in)							
			3/8		1/2		5/8		3/4	
Effective min. embedment[1]	h_{ef}	mm	38	51	51	83	70	102	83	121
Tension, Steel Failure Modes										
Steel embedment material resistance factor for reinforcement	ϕ_s	-	0.85		0.85		0.85		0.85	
Resistance modification factor for tension, steel failure modes[2]	R	-	0.80		0.80		0.80		0.80	
Min. specified yield strength	f_y	N/mm^2	656		584		576		560	
Min. specified ult. strength	f_{uta}	N/mm^2	820		730		720		700	
Effective-cross sectional steel area in tension	$A_{se,N}$	mm^2	34		66		106		154	
Nominal steel strength in tension	N_{sar}	kN	28.2		48.3		76.4		108.1	
Tension, Concrete Failure Modes										
Anchor category[3]	-	-	1		1		1		1	
Concrete material resistance factor	ϕ_c	-	0.65		0.65		0.65		0.65	
Resistance modification factor for tension, concrete failure modes, Condition B[4]	R	-	1.0		1.0		1.0		1.0	
Effectiveness factor for uncracked concrete	k_{uncr}	-	10.0		10.0		10.0		10.0	
Effectiveness factor for cracked concrete[5]	k_{cr}	-	7.1		7.1		7.1		8.8	
Modification factor for anchor resistance, tension, uncracked concrete[6]	$\psi_{c,N}$	-	1.0		1.0		1.0		1.0	
Critical edge distance	c_{ac}	mm	203	127	152	254	279	229	305	279
Pullout strength uncracked concrete[7]	$N_{cpr,uncr}$	kN	NA	14.2	NA	NA	21.5	40.2	NA	NA
Pullout strength cracked concrete[7]	$N_{cpr,cr}$	kN	NA	NA	NA	NA	NA	NA	22.2	39.6
Pullout strength seismic[7]	$N_{cpr,eq}$	kN	NA	NA	NA	22.0	NA	NA	22.2	35.6
Normalization factor, uncracked concrete	n_{uncr}	-	0.16	0.16	0.23	0.23	0.50	0.50	0.50	0.50
Normalization factor, cracked concrete, seismic	n_{cr}	-	0.16	0.16	0.23	0.23	0.5	0.50	0.50	0.50
Tension, Axial Stiffness										
Axial stiffness in service load range[8]	β_{uncr}	kN/mm	26.7		22.4		23.2		23.3	
	β_{cr}	kN/mm	21.7		11.6		12.3		12.0	

[1] Figure 2 of this report illustrates anchor embedment.
[2] The KB1 is a ductile steel element as defined by CSA A23.3-14 Clause D.2, except for the 3/4" x 12" KB1, which is considered a brittle steel element with a strength reduction factor for steel in tension, R = 0.70.
[3] The use of the anchor category is explained in CSA A23.3-14 Clause D.5.3.
[4] For use with the load combinations of Division B, Part 4, Section 4.1.3 of the 2015 NBC or CSA A23.3-14 Annex C. Condition B applies where supplementary reinforcement in conformance with CSA A23.3-14 Clause D.5.3(c) is not provided, or where pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the strength reduction factors associated with Condition A may be used.
[5] These parameters apply to CSA A23.3-14 Clause D.6.2.2.
[6] For all design cases $\psi_{c,N}$=1.0. The appropriate effectiveness factor for cracked concrete (k_{cr}) or uncracked concrete (k_{uncr}) shall be used.
[7] For all design cases $\psi_{c,P}$=1.0. NA (not applicable) denotes that this value does not control for design.
[8] Mean values are shown, and actual stiffness may vary considerably depending on concrete strength, loading, and geometry of application.

TABLE 5 – HILTI KB1 DESIGN INFORMATION, SHEAR

Design Parameter	Symbol	Units	Nominal anchor diameter (in)							
			3/8		1/2		5/8		3/4	
Anchor O.D.	d_a	mm	9.5		12.7		15.9		19.1	
Effective min. embedment [1]	h_{ef}	mm	38	51	51	83	70	102	83	121
Shear, Steel Failure Modes										
Steel embedment material resistance factor for reinforcement	ϕ_s	-	0.85		0.85		0.85		0.85	
Resistance modification factor for shear, steel failure modes[2]	R	-	0.75		0.75		0.75		0.75	
Nominal steel strength in shear	V_{sar}	kN	11.3		23.2		39.6		47.9	
Nominal steel strength in shear, seismic	$V_{sar,eq}$	kN	11.3		23.2		39.6		40.7	
Shear, Concrete Failure Modes										
Concrete. material resistance factor	ϕ_c	-	0.65		0.65		0.65		0.65	
Resistance modification factor for shear, concrete failure modes, Condition B[3]	R	-	1.0		1.0		1.0		1.0	
Load bearing length of anchor in shear	ℓ_e	mm	38	51	51	83	70	102	83	121
Effectiveness factor for pryout	k_{cp}	-	1.0	1.0	1.0	2.0	2.0	2.0	2.0	2.0

[1] Figure 2 of this report illustrates anchor embedment.
[2] The KB1 is a ductile steel element as defined by CSA A23.3-14 Clause D.2, except for the 3/4" x 12" KB1, which is considered a brittle steel element with a strength reduction factor for steel in shear, $R = 0.65$.
[3] For use with the load combinations of Division B, Part 4, Section 4.1.3 of the 2015 NBC or CSA A23.3-14 Annex C. Condition B applies where supplementary reinforcement in conformance with CSA A23.3-14 Clause D.5.3(c) is not provided, or where pullout or pryout strength governs. For cases where the presence of supplementary reinforcement can be verified, the strength reduction factors associated with Condition A may be used.