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ESR-2254

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DIVISION: 03 00 00—CONCRETE

SECTION: 03 16 00—CONCRETE ANCHORS

DIVISION: 05 00 00—METALS

SECTION: 05 05 19—POST-INSTALLED CONCRETE ANCHORS

REPORT HOLDER:

**CYW, INC., /CHUN YU WORKS (U.S.A.) INC.,
dba WESTERN STATES FASTENING SYSTEMS**

**1037 WALNUT AVENUE
POMONA, CALIFORNIA 91766**

EVALUATION SUBJECT:

POWER BULL WEDGE ANCHORS IN UNCRACKED CONCRETE



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Section: 03 16 00—Concrete Anchoring

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REPORT HOLDER:

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EVALUATION SUBJECT:

**POWER BULL WEDGE ANCHORS IN UNCRACKED
 CONCRETE**

1.0 EVALUATION SCOPE
Compliance with the following codes:

- 2012, 2009 and 2006 *International Building Code*® (IBC)
- 2012, 2009 and 2006 *International Residential Code*® (IRC)

Property evaluated:

Structural

2.0 USES

Power Bull Wedge Anchors are used to resist static, wind, and earthquake (Seismic Design Categories A and B only) tension and shear loads in uncracked normal-weight concrete and uncracked lightweight concrete having a specified compressive strength, f_c , of 2,500 psi to 8,500 psi (17.2 MPa to 58.6 MPa).

The Power Bull wedge anchors comply with Section 1909 of the 2012 IBC, and Section 1912 of the 2009 and 2006 IBC. The anchors are alternatives to cast-in-place anchors described in Section 1908 of the 2012 IBC and Section 1911 of the 2009 and 2006 IBC. The anchors may

also be used under the IRC where an engineered design is submitted in accordance with Section R301.1.3.

3.0 DESCRIPTION
3.1 Power Bull Anchors:

The Power Bull wedge anchors are torque-controlled expansion anchors. The anchors consist of a stud, nut, washer and expander collar as illustrated in Figure 1. The stud is manufactured from Grade G 10080 cold-finished carbon steel, partially threaded with one end terminating in a flared mandrel. The expander collar is formed around the anchor stud and has three equally spaced extrusions around the periphery to engage the sides of the drilled hole during anchor installation. All components, including nuts and washers, are zinc-coated in accordance with ASTM B633 classification SC1, Type III. Installation information and dimensions are set forth in Section 4.3 and Tables 1 and 2 of this report.

3.2 Concrete:

Normal-weight and lightweight concrete must comply with Sections 1903 and 1905 of the IBC, as applicable.

4.0 DESIGN AND INSTALLATION
4.1 Strength Design:

4.1.1 General: Design strength of anchors complying with the 2012 IBC, as well as Section R301.1.3 of the 2012 IRC, must be determined in accordance with ACI 318-11 Appendix D and this report.

Design strength of anchors complying with the 2009 IBC, as well as Section R301.1.3 of the 2009 IRC, must be determined in accordance with ACI 318-08 Appendix D and this report.

Design strength of anchors complying with the 2006 IBC and Section R301.1.3 of the 2006 IRC must be determined in accordance with ACI 318-05 Appendix D and this report.

The strength design of anchors must comply with ACI 318 D.4.1, except as required in ACI 318 D.3.3. Strength reduction factors, ϕ , as given in ACI 318-11 D.4.3 (ACI 318-08 and -05 D.4.4), must be used for load combinations calculated in accordance with Section 1605.2 of the IBC and ACI 318, Section 9.2. Strength reduction factors, ϕ , described in ACI 318-11 D.4.4 (ACI 318-08 and -05 D.4.5) must be used for load combinations calculated in accordance with ACI 318, Appendix C. The value of f_c , used in calculations must be limited to a maximum of 8,000 psi (55.2 MPa), in accordance with ACI 318-11 D.3.7.

4.1.2 Requirements for Static Steel Strength in Tension, N_{sa} : The nominal steel strength of a single anchor in tension, N_{sa} , calculated in accordance with ACI 318 D.5.1.2 must be calculated based on the information given in Table 1 and must be used for design. The strength reduction factor, ϕ , corresponding to a ductile steel element must be used for all anchors.

4.1.3 Requirements for Static Concrete Breakout Strength in Tension, N_{cb} or N_{cbg} : The nominal concrete breakout strength of a single anchor or a group of anchors in tension, N_{cb} and N_{cbg} , respectively, must be calculated in accordance with ACI 318 D.5.2, with modifications as described in this section. The basic concrete breakout strength in tension, N_b , must be calculated in accordance with ACI 318 D.5.2.2 using the values of h_{ef} and k_{uncr} as given in Table 1 of this report. The nominal concrete breakout strength in tension in regions of concrete where analysis indicates no cracking at service loads must be calculated in accordance with ACI 318 D.5.2.6 with $\psi_{c,N} = 1.0$. The value of f'_c used in the calculations must be limited to 8,000 psi (55.2 MPa), in accordance with ACI 318 D.3.7.

4.1.4 Requirements for Pullout Strength in Tension, N_{pn} : The nominal pullout strength of a single anchor in tension in accordance with ACI 318 D.5.3.1 and D.5.3.2 in uncracked concrete, $N_{p,uncr}$, is given in Table 1. In lieu of ACI 318 D.5.3.6, $\psi_{c,P} = 1.0$ for all design cases. In accordance with ACI 318 D.5.3, the nominal pullout strength in uncracked concrete may be calculated in accordance with the following equation:

$$N_{p,f'_c} = N_{p,uncr} \sqrt{\frac{f'_c}{2,500}} \quad (\text{lb, psi}) \quad (\text{Eq-1})$$

$$N_{p,f'_c} = N_{p,uncr} \sqrt{\frac{f'_c}{17.2}} \quad (\text{N, MPa})$$

Where values for $N_{p,uncr}$ are not provided, the pullout strength in tension need not be evaluated.

4.1.5 Requirements for Static Steel Strength in shear, V_{sa} : The nominal steel strength in shear, V_{sa} , of a single anchor must be calculated from ACI 318-11, Eq. D-29 (ACI 318-08 and -05, Eq. D-20) in accordance with ACI 318 D.6.1.2. The strength reduction factor, ϕ , corresponding to a ductile steel element must be used for all anchors.

4.1.6 Requirements for Static Concrete Breakout Strength in Shear, V_{cb} or V_{cbg} : The nominal concrete breakout strength of a single anchor or group of anchors in shear, V_{cb} or V_{cbg} , respectively, must be calculated in accordance with ACI 318 D.6.2 with modifications as described in this section. The value of l_e calculated in accordance with ACI 318 D.6.2.2 must be taken as no greater than h_{ef} , or $8d_a$ (d_o), whichever is less.

4.1.7 Requirements for Static Concrete Pryout Strength of Anchor in Shear, V_{cp} or V_{cpg} : The nominal concrete pryout strength of a single anchor or group of anchors, V_{cp} or V_{cpg} , respectively, must be calculated in accordance with ACI 318 D.6.3, based on the value of K_{cp} provided in Table 1 and the value of N_{cb} or N_{cbg} as calculated in Section 4.1.3 of this report.

4.1.8 Requirements for Interaction of Tensile and Shear Forces: For loadings that include combined tensile and shear forces, the design must be determined in accordance with ACI 318 D.7.

4.1.9 Requirements for Critical Edge Distance: In applications where the installed edge distance $c < c_{ac}$ and supplemental reinforcement to control splitting of the

concrete is not present, the concrete breakout strength for the anchors loaded in tension for uncracked concrete, calculated in accordance with ACI 318 D.5.2, must be further multiplied by the factor $\psi_{CP,N}$ as given by the following equation:

$$\psi_{cp,N} = \frac{c}{c_{ac}}$$

where the factor $\psi_{CP,N}$ need not be taken as less than $1.5h_{ef}/c_{ac}$.

For all other cases, $\psi_{CP,N} = 1.0$. Values for the critical edge distance c_{ac} must be taken from Table 1. In all cases, c must not be less than c_{min} described in Table 1 of this report.

4.1.10 Requirements for Minimum Member Thickness, Minimum Anchor Spacing and Minimum Edge Distance: In lieu of using ACI 318 D.8.1 and D.8.3, values of s_{min} and c_{min} as given in Table 1 of this report must be used. In lieu of using ACI 318 D.8.5, minimum member thicknesses h_{min} as given in Table 1 of this report must be used.

4.1.11 Lightweight Concrete: For the use of anchors in lightweight concrete, the modification factor λ_a equal to 0.8λ is applied to all values of $\sqrt{f'_c}$ affecting N_n and V_n .

For ACI 318-11 (2012 IBC) and ACI 318-08 (2009 IBC), λ shall be determined in accordance with the corresponding version of ACI 318.

For ACI 318-05 (2006 IBC), λ shall be taken as 0.75 for all lightweight concrete and 0.85 for sand-lightweight concrete. Linear interpolation shall be permitted if partial sand replacement is used. In addition, the pullout strengths $N_{p,uncr}$ shall be multiplied by the modification factor, λ_a , as applicable.

4.2 Allowable Stress Design (ASD):

4.2.1 General: Design values for use with allowable stress design load combinations, calculated in accordance with Section 1605.3 of the IBC, must be established in accordance with the following equations:

$$T_{allowable,ASD} = \frac{\phi N_n}{\alpha}$$

$$V_{allowable,ASD} = \frac{\phi V_n}{\alpha}$$

where:

$T_{allowable,ASD}$ = Allowable tension load (lbf or kN)

$V_{allowable,ASD}$ = Allowable shear load (lbf or kN)

ϕN_n = Lowest design strength of an anchor or anchor group in tension as determined in accordance with ACI 318 D.4.1, and 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, as applicable (lbf or N).

ϕV_n = Lowest design strength of an anchor or anchor group in shear as determined in accordance with ACI 318 D.4.1, and 2009 IBC Section 1908.1.9 or 2006 IBC Section 1908.1.16, as applicable (lbf or N).

α = Conversion factor calculated as a weighted average of the load factors for the controlling load combination. In addition, α must include all applicable factors to account for nonductile failure modes and required over-strength.

The requirements for member thickness, edge distance and spacing, described in this report, must apply.

4.2.2 Interaction of Tensile and Shear Forces: The interaction must be calculated and consistent with ACI 318 D.7 as follows:

For shear loads $V_{applied} \leq 0.2V_{allowable,ASD}$, the full allowable load in tension must be permitted.

For tension loads $T_{applied} \leq 0.2T_{allowable,ASD}$, the full allowable load in shear must be permitted.

For all other cases the following equation applies:

$$\frac{T_{applied}}{T_{allowable,ASD}} + \frac{V_{applied}}{V_{allowable,ASD}} \leq 1.2$$

4.3 Installation:

Embedment, spacing, edge distance, and concrete requirements must comply with Table 1 and Figure 2. Anchor locations must comply with this report and the plans and specifications approved by the code official. The Power Bull Wedge Anchor must be installed in accordance with the manufacturer's published instructions and this report. In case of conflict, this report governs. To install the wedge anchor, a hole must be drilled into the concrete using a carbide-tipped masonry drill bit complying with ANSI B212.15-1994. The nominal drill bit diameter must be equal to the nominal diameter of the anchor. The hole must be drilled deeper than the required anchor embedment. Before the anchor is driven into the hole using a hammer, dust and other deleterious materials must be removed using a blow-out bulb. The expansion collar must then be set by tightening the nut to the predetermined installation torque values, T_{inst} in Table 1 using a calibrated torque wrench.

4.4 Special Inspection:

Periodic special inspection is required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, Section 1704.15 and Table 1704.4 of the 2009 IBC, or Section 1704.13 of the 2006 IBC, as applicable. The special inspector must make periodic inspections during anchor installation to verify anchor type, anchor dimensions, concrete type, concrete compressive strength, drill bit type, hole dimensions, hole cleaning procedure, concrete member thickness, anchor embedment, anchor spacing, edge distances, tightening torque and adherence to the manufacturer's printed installation instructions. The special inspector must be present as often as required in accordance with the "statement of special inspection."

5.0 CONDITIONS OF USE

The Power Bull Wedge Anchors described in this report comply with, or are suitable alternatives to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

- 5.1 The anchors are installed in accordance with the manufacturer's published instructions and this report. In case of a conflict, this report governs.
- 5.2 The anchors are installed in uncracked normal-weight concrete and lightweight concrete having a specified compressive strength $f_c = 2,500$ psi to 8,500 psi (17.2 MPa to 58.6 MPa).
- 5.3 Anchor sizes, dimensions, minimum embedment depths, and other installation parameters are as set forth in this report.
- 5.4 The values of f_c used for calculation purposes must not exceed 8,000 psi (55.1 MPa).

5.5 Strength design values must be established in accordance with Section 4.1 of this report.

5.6 Allowable stress design values must be established in accordance with Section 4.2.

5.7 Anchor spacing(s) and edge distance(s) as well as minimum member thickness must comply with Table 1.

5.8 Prior to installation, calculations and details demonstrating compliance with this report must be submitted to the code official. The calculations and details must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

5.9 Since an ICC-ES acceptance criteria for evaluating data to determine the performance of anchors subjected to fatigue or shock loading is unavailable at this time, the use of these anchors under such conditions is beyond the scope of this report.

5.10 The use of the Power Bull Wedge Anchor is limited to installation in uncracked normal-weight concrete. Anchors may not be installed in regions of a concrete member where cracking has occurred or where analysis indicates cracking may occur at service load levels, subject to the conditions of this report.

5.11 The anchors may be used to resist short-term loading due to wind or seismic forces limited to structures assigned to Seismic Design Categories A and B under the IBC, subject to the conditions of this report.

5.12 Where not otherwise prohibited in the code, Power Bull Wedge Anchors are permitted for use with fire-resistance-rated construction provided that at least one of the following conditions is fulfilled:

- The anchors are used to resist wind forces 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 recognized standards.
- Anchors are used to support nonstructural elements.

5.13 Use of the anchors is limited to dry, interior locations.

5.14 Special inspection is provided as set forth in Section 4.4. The Power Bull Wedge Anchors are produced in Ningbo, China, under a quality control program with inspections by ICC-ES.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Mechanical Anchors in Concrete Elements (AC193), dated October 2015; and quality control documentation.

7.0 IDENTIFICATION

Anchors are packaged in containers labeled with the company name and, address and product name as set forth in Table A of this report, the product size, and the evaluation report number (ESR-2254).

TABLE A—CROSS REFERENCE OF PRODUCT NAMES TO COMPANY NAMES

COMPANY NAME	PRODUCT NAME
CYW, Inc./Chun Yu Works (U.S.A.) Inc, dba Western States Fastening Systems	Power Bull Wedge Anchors
Midwest Fastener Corp. Torquemaster	Blue Wedge Anchor

TABLE 1—DATA FOR POWER BULL WEDGE ANCHORS FOR USE IN UNCRACKED CONCRETE^{1,2}

CHARACTERISTIC	SYMBOL	UNITS	NOMINAL ANCHOR DIAMETER			
			³ / ₈ inch	¹ / ₂ inch	⁵ / ₈ inch	³ / ₄ inch
Installation Information						
Anchor diameter	$d_a (d_o)^3$	in.	³ / ₈	¹ / ₂	⁵ / ₈	³ / ₄
Minimum diameter of hole clearance in fixture	d_h	in.	¹ / ₂	⁵ / ₈	³ / ₄	⁷ / ₈
Nominal drill bit diameter	d_{bit}	in.	³ / ₈	¹ / ₂	⁵ / ₈	³ / ₄
Minimum nominal embedment depth	h_{nom}	in.	$2 \frac{5}{16}$	$2 \frac{7}{8}$	3	$3 \frac{15}{16}$
Minimum effective embedment depth	h_{ef}	in.	2	$2 \frac{1}{2}$	$2 \frac{1}{2}$	$3 \frac{1}{2}$
Minimum hole depth	h_o	in.	$2 \frac{1}{2}$	$3 \frac{1}{8}$	$3 \frac{1}{2}$	$4 \frac{1}{8}$
Installation torque	T_{inst}	ft-lb	30	80	130	130
Minimum edge distance	c_{min}	in.	3	$3 \frac{3}{4}$	$5 \frac{1}{4}$	$5 \frac{1}{4}$
Minimum spacing	s_{min}	in.	3	$3 \frac{3}{4}$	$5 \frac{1}{4}$	$5 \frac{1}{4}$
Minimum concrete thickness ⁴	h_{min}	in.	4	5	6	7
Critical edge distance	c_{ac}	in.	4	5	6	7
ANCHOR DATA						
Category number	1, 2 or 3	–	2	3	1	2
Yield strength of anchor steel	f_{ya}	lb/in ²	44,500	44,500	75,000	44,500
Ultimate strength of anchor steel	f_{uta}	lb/in ²	60,200	60,200	85,000	60,200
Effective tensile stress area	$A_{se,N}$	in ²	0.0597	0.112	0.192	0.285
Steel strength in tension	N_{sa}	lb	3,595	6,740	16,320	17,155
Steel strength in shear	V_{sa}	lb	2,800	5,125	8,370	12,065
Effectiveness factor for concrete breakout	k_{unscr}	–	24	24	24	24
Pull-out resistance	$N_{p,unscr}$	lb	3,021	4,232	N/A ⁵	N/A ⁵
Coefficient for pryout strength	k_{cp}	-	1.0	2.0	2.0	2.0
Axial stiffness in service load range	β	lb/in	97,589	539,500	741,700	1,413,876
Strength reduction factor, ϕ , for tension, steel failure modes ⁶	0.75					
Strength reduction factor, ϕ , for shear, steel failure modes ⁶	0.65					
Strength reduction factor, ϕ , for tension, concrete failure modes, Condition B ⁷	0.55	0.45	0.65	0.55		
Strength reduction factor, ϕ , for shear, concrete failure modes, Condition B ⁷	0.70					

For SI: 1 in = 25.4 mm, 1 in² = 6.451×10⁻⁴ m, 1 ft-lb = 1.356 N.m, 1 lb/in² = 6.895 Pa.

¹The information presented in this table must be used in conjunction with the design criteria of ACI 318 Appendix D.

²Installation must comply with the manufacturer's published installation instructions

³The notation in parentheses is for the 2006 IBC.

⁴Concrete thickness must be the greater of 2 h_{ef} or the tabulated value.

⁵See Section 4.1.4 of this report. N/A (not applicable) denotes that this value does not govern for design.

⁶Anchors are considered to be manufactured using ductile steel in accordance with ACI 318 D.1. Strength reduction factors are for use with the load combinations of ACI 318 Section 9.2 or IBC Section 1605.2.

⁷Condition B applies where supplementary reinforcement in conformance with ACI 318-11 D.4.3 is not provided, or where pull-out or pry-out strength governs. For cases where supplementary reinforcement can be verified, the strength reduction factors associated with Condition A may be used. Strength reduction factors are for use with the load combinations of ACI 318 Section 9.2 or IBC Section 1605.2.

TABLE 2—POWER BULL WEDGE ANCHOR LENGTH CODE IDENTIFICATION SYSTEM

Length ID marking on threaded stud head		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
Overall anchor length, l_{anch} (inches)	From	1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/2	10	11
	Up to but not including	2	2 1/2	3	3 1/2	4	4 1/2	5	5 1/2	6	6 1/2	7	7 1/2	8	8 1/2	9	9 1/2	10	11	12

For SI: 1 inch = 25.4 mm.

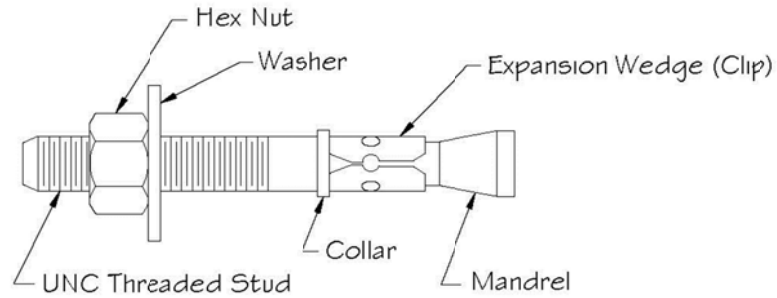


FIGURE 1—POWER BULL WEDGE ANCHOR

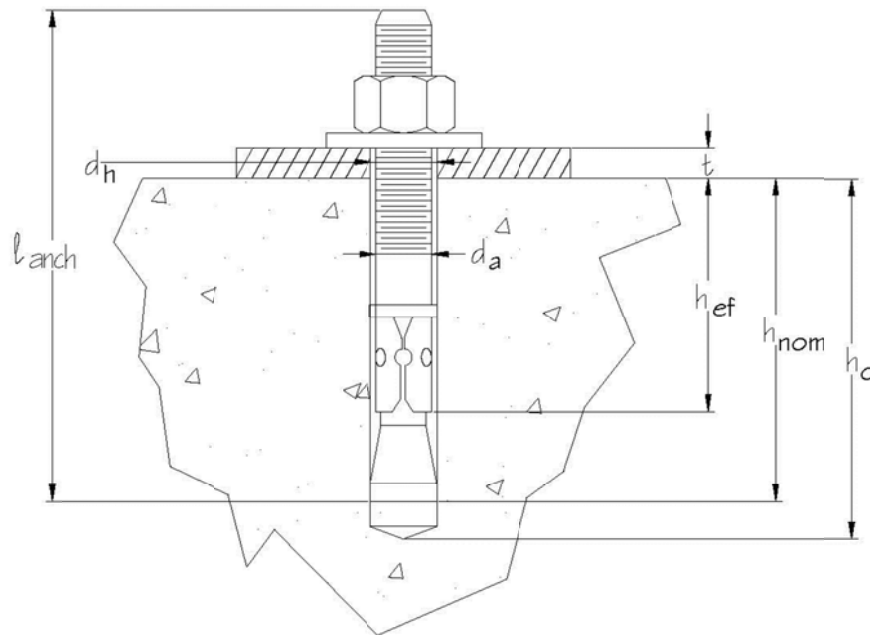


FIGURE 2—POWER BULL WEDGE ANCHOR INSTALLATION