ITW Red Head EPCON S7™

Adhesive Anchor

For Cracked, Uncracked & ALL Seismic Zones

Epcon S7 is ITW Red Head's NEW fast cure adhesive solution for all environmental conditions with threaded rod or rebar.

The Epcon S7 adhesive anchor performs among the best in the industry for uncracked and cracked concrete applications; while offering versatile connection configurations.

All information in this Tech Guide is derived from ICC-ES ESR No. 2308

Table 1 - Steel Design for Threaded Rod[1]

CHARACTERISTIC		SYMBOL	UNITS	NOMINAL ROD DIAMETER (inch)						
				3/8	1/2	5/8	3/4	7/8	1	1-1/4
Threaded rod effective cross-sectional area		A_{se}	in^2	0.078	0.142	0.226	0.335	0.462	0.606	0.969
Carbon Steel ASTM A36	Nominal steel strength in tension	N_{sa}	lb	4,500	8,230	13,110	19,400	26,780	35,130	56,210
	Nominal steel strength in shear	V_{sa}	lb	2,250	4,940	7,870	11,640	16,070	21,080	33,730
	Strength reduction factor for tension, steel failure mode	Φ	-	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Strength reduction factor for shear, steel failure mode[1]	Φ	-	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Carbon Steel ASTM A193 Grade B7	Nominal steel strength in tension	N_{sa}	lb	9,690	17,740	28,250	41,810	57,710	75,710	121,140
	Nominal Steel strength in shear	V_{sa}	lb	4,485	10,640	16,950	25,090	34,630	45,430	72,680
	Strength reduction factor for tension, steel failure mode	Φ	-	0.75	0.75	0.75	0.75	0.75	0.75	0.75
	Strength reduction factor for shear, steel failure mode[1]	Φ	-	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Stainless Steel ASTM F593	Nominal steel strength in tension	N_{sa}	lb	5,810	10,640	16,950	25,090	34,630	45,430	72,680
	Nominal steel strength in shear	V_{sa}	lb	2,905	6,390	10,170	15,050	20,780	27,260	43,610
	Strength reduction factor for tension, steel failure mode	Φ	-	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength reduction factor for shear, steel failure mode[1]	Φ	-	0.60	0.60	0.60	0.60	0.60	0.60	0.60
Reduction factor for seismic shear		$\alpha_{V,seis}$	-	0.70	0.70	0.70	0.70	0.70	0.70	0.70

[1]The tabulated values of Φ applieds when the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 of the UBC, or ACI 318 Section 9.2 are used. If the load combinations of Section 1909.2 of the UBC or ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318 D.4.5.

Table 2 - Steel Design for Reinforcing Bars[1]

CHARACTERISTIC		SYMBOL	UNITS	Reinforcing Bar Number						
				#3	#4	#5	#6	#7	#8	#10
Nominal bar diameter		d	in	3/8	1/2	5/8	3/4	7/8	1	1-1/4
Reinforcing bar effective cross-sectional area		A_{se}	in^2	0.11	0.2	0.31	0.44	0.6	0.79	1.27
ASTM A615 GRADE 60	Nominal steel strength in tension	N_{sa}	lb	9,900	18,000	27,900	39,600	54,000	71,100	114,300
	Nominal steel strength in shear	V_{sa}	lb	5,940	10,800	16,740	23,760	32,400	42,660	68,580
	Strength reduction factor for tension, steel failure mode	Φ	-	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength reduction factor for shear, steel failure mode[1]	Φ	-	0.60	0.60	0.60	0.60	0.60	0.60	0.60
	Reduction factor for seismic shear	$\alpha_{V,seis}$	-	0.91	0.91	0.91	0.90	0.90	0.71	0.71

[1]The tabulated value of Φ applies when the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 of the UBC, or ACI 318 Section 9.2 are used. If the load combinations of Section 1909.2 of the UBC or ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318 D.4.5 (b).

Table 3 - Concrete Breakout Design for Threaded Rod & Reinforcing Bar

CHARACTERISTIC	SYMBOL	UNITS	NOMINAL ROD DIAMETER (inch)						
			#3 3/8	#4 1/2	#5 5/8	#6 3/4	#7 7/8	#8 1	#10 1-1/4
Effectiveness factor for uncracked concrete	k_{uncr}	-	24	24	24	24	24	24	24
Effectiveness factor for cracked concrete	k_{cr}	-	17	17	17	17	17	17	17
Minimum concrete thickness	h_{min}	in	h_{ef} + 1-1/4		$h_{ef} + 2d_o$				
Effective embedment depth - minimum	$h_{ef,min}$	in	2-3/8	2-3/4	3-1/8	3-1/2	3-1/2	4	5
Minimum spacing	s_{min}	in	15/16	1-1/2	2-1/2	3	3-1/2	4	5
Minimum edge distance	c_{min}	in	15/16	1-1/2	2-1/2	3	3-1/2	4	5
Critical edge distance	c_{ac}	in	See Critical Edge Distance Below						
Strength reduction factor for tension concrete failure mode[1]	Φ	Cond. B	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Strength reduction factor for shear, concrete failure mode[1]	Φ	Cond. B	0.70	0.70	0.70	0.70	0.70	0.70	0.70

[1]The tabulated values of Φ applieds when the load combinations of Section 1605.2.1 of the IBC, Section 1612.2.1 of the UBC, or ACI 318 Section 9.2 are used and the requirements of ACI 318 D.4.4(c) for Condition B are met. If the load combinations of Section 1909.2 of the UBC or ACI 318 Appendix C are used, the appropriate value of Φ must be determined in accordance with ACI 318 D.4.5 for Condition B.

Critical Edge Distance (c_{ac})

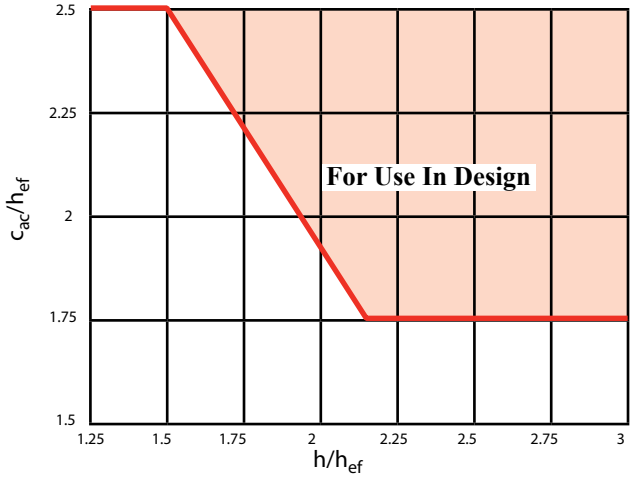

Figure 1: Critical Edge Distance vs. Concrete Thickness

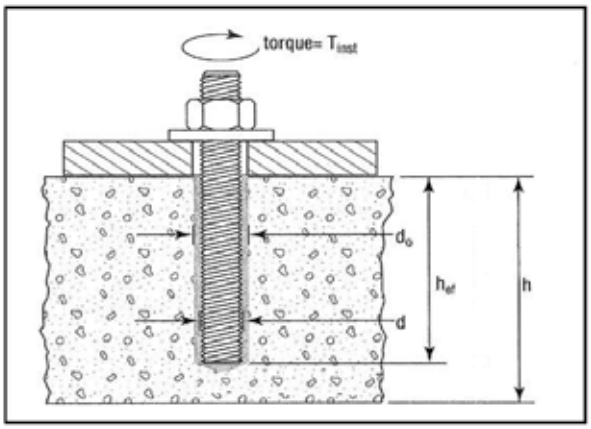

Figure 2: Adhesive Anchor Nomenclature

Critical Edge Distance (c_{ac}): For the calculation of N_{cb}, N_{cbg}, N_a and N_{ag} in accordance with ACI 318 Section D.5.2.7, the critical edge distance (c_{ac}) must be determined as follows:

i. $c_{ac} = 1.75\ h_{ef}$ for $2.2 \le h/h_{ef}$
ii. $c_{ac} = 4.11 h_{ef} - 1.07\ h$ for $1.5 < h/h_{ef} < 2.2$
iii. $c_{ac} = 2.5\ h_{ef}$ for $1.25 \le h/h_{ef} \le 1.5$

For depictions of h_{min} and h_{ef}, see Figure 2 above. Linear interpolation is permitted to determine the ratio of c_{ac}/h_{ef} for values of h_{min}/h_{ef} between 1.5 and 2.2 as shown in the graph above. Allowable combinations of c_{ac}/h_{ef} and h_{min}/h_{ef} must fall in the shaded portion of the Critical Edge vs. Concrete Thickness graph (see Figure 1) above.

Table 4 - Adhesive Anchor Bond Strength For Threaded Rod[1,6]

CHARACTERISTIC		SYMBOL	UNITS	NOMINAL ROD DIAMETER (inch)						
				3/8	1/2	5/8	3/4	7/8	1	1-1/4
Anchor embedment depth - minimum		h_{ef}	in	2-3/8	2-3/4	3-1/8	3-1/2	3-1/2	4	5
Anchor embedment depth - maximum		h_{ef}	in	7-1/2	10	12-1/2	15	17-1/2	20	25
Temperature Range A[2]	Characteristic Bond Strength for Uncracked Concrete	$t_{k,uncr}$	psi	1,735	1,735	1,735	1,735	1,735	1,735	1,333
	Characteristic Bond Strength for Cracked Concrete	$t_{k,cr}$	psi	652	726	726	785	785	785	443
Temperature Range B[3]	Characteristic Bond Strength for Uncracked Concrete	$t_{k,uncr}$	psi	1,611	1,611	1,611	1,611	1,611	1,611	1,238
	Characteristic Bond Strength for Cracked Concrete	$t_{k,cr}$	psi	652	726	726	785	785	785	412
Temperature Range C[4]	Characteristic Bond Strength for Uncracked Concrete	$t_{k,uncr}$	psi	1,544	1,544	1,544	1,544	1,544	1,544	1,186
	Characteristic Bond Strength for Cracked Concrete	$t_{k,cr}$	psi	625	696	696	752	752	752	394

[1]Bond strength values correspond to concrete compressive strengths ranging from 2,500psi to 8,000psi
[2]Temperature range A: Maximum short term temperature of 110ºF and maximum long term temperature of 70°F
[3]Temperature range B: Maximum short term temperature of 130ºF and maximum long term temperature of 110°F
[4]Temperature range C: Maximum short term temperature of 176ºF and maximum long term temperature of 110°F
[5]For load combinations consisting of only short-term loads, such as wind or seismic loads, bond strengths may be increased by 4% for Temperature Range C
[6]Reference Table 6 for Bond Strength Reduction Factors

Table 5 - Adhesive Anchor Bond Strength For Reinforcing Bar[1,7]

CHARACTERISTIC		SYMBOL	UNITS	Reinforcing Bar Number[2]						
				#3	#4	#5	#6	#7	#8	#10
Anchor embedment depth - minimum		h_{ef}	in	2-3/8	2-3/4	3-1/8	3-1/2	3-1/2	4	5
Anchor embedment depth - maximum		h_{ef}	in	7-1/2	10	12-1/2	15	17-1/2	20	25
Temperature Range A[3]	Characteristic Bond Strength for Uncracked Concrete	$t_{k,uncr}$	psi	1,184	1,184	1,184	1,184	1,184	1,184	1,026
	Characteristic Bond Strength for Cracked Concrete	$t_{k,cr}$	psi	506	552	563	608	608	608	601
Temperature Range B[4]	Characteristic Bond Strength for Uncracked Concrete	$t_{k,uncr}$	psi	1,100	1,100	1,100	1,100	1,100	1,100	953
	Characteristic Bond Strength for Cracked Concrete	$t_{k,cr}$	psi	506	552	563	608	608	608	559
Temperature Range C[5,6]	Characteristic Bond Strength for Uncracked Concrete	$t_{k,uncr}$	psi	1,054	1,054	1,054	1,054	1,054	1,054	913
	Characteristic Bond Strength for Cracked Concrete	$t_{k,cr}$	psi	484	528	539	583	583	583	535

[1]Bond strength values correspond to concrete compressive strengths ranging from 2,500psi to 8,000psi
[2]Per ASTM A615 Grade 60
[3]Temperature range A: Maximum short term temperature of 110ºF and maximum long term temperature of 70°F
[4]Temperature range B: Maximum short term temperature of 130ºF and maximum long term temperature of 110°F
[5]Temperature range C: Maximum short term temperature of 176ºF and maximum long term temperature of 110°F
[6]For load combinations consisting of only short-term loads, such as wind or seismic loads, bond strengths may be increased by 4% for Temperature Range C
[7]Reference Table 6 for bond strength reduction factors

Table 6 - Adhesive Reduction Factors for Threaded Rod & Reinforcing Bars[1,2]

CHARACTERISTIC		SYMBOL	NOMINAL ROD DIAMETER (inch)						
			#3 3/8	#4 1/2	#5 5/8	#6 3/4	#7 7/8	#8 1	#10 1-1/4
Continuous Inspection[3]	Strength Reduction Factor - Dry Concrete	$\Phi_{dry,\,ci}$	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Saturated Concrete	$\Phi_{sat,\,ci}$	0.55	0.55	0.55	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Water-Filled Holes	$\Phi_{wf,\,ci}$	0.55	0.55	0.55	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Submerged Concrete	$\Phi_{sub,\,ci}$	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Periodic Inspection[3]	Strength Reduction Factor - Dry Concrete	$\Phi_{dry,\,pi}$	0.65	0.65	0.65	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Saturated Concrete	$\Phi_{sat,\,pi}$	0.45	0.45	0.45	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Water-Filled Holes	$\Phi_{wf,\,pi}$	0.45	0.45	0.45	0.65	0.65	0.65	0.65
	Strength Reduction Factor - Submerged Concrete	$\Phi_{sub,\,pi}$	0.55	0.55	0.55	0.65	0.65	0.65	0.65
Reduction factor for seismic tension		$\alpha_{N,seis}$	0.800						

[1] Φ reduction factors must be applied to calculated adhesive design loads

[2] For structures assigned to IBC or IRC Seismic Design Category C,D, E, or F, or UBC Seismic Zone 2B, 3, or 4, bond strength values must be multiplied by $\alpha_{N,seis}$

[3] Inspections per 2009 IBC Section 1702.1

Illustrative Procedure to Calculate Strength Design Tension Value:

Epcon S7 Adhesive Anchor, threaded rod 1/2 inch diameter, at an embedment of 4-1/2 inches

	PROCEDURE	CALCULATION
Step 1	Calculate steel strength of a single anchor in tension per ACI 318 D 5.1.2, Table 1 of this document	ϕN_{sa} = ϕN_{sa} = 0.75*8,230 **= 6,173 lbs steel strength**
Step 2	Calculate concrete breakout strength of a single anchor in tension per ACI 318 D 5.2.2, Table 3 of this document	N_b = $k_{uncr}\,\lambda\sqrt{f'_c}\,h_{ef}^{1.5}$ = 24*1.0*$\sqrt{2,500}$*4.5$^{1.5}$ = 11,455 lbs ϕN_{cb} = $\phi A_{Nc}/A_{Nco}\,\psi_{ec,N}\,\psi_{c,N}\,\psi_{cp,N}\,N_b$ = 0.65*1.0*1.0*1.0*1.0*11,455 = 0.65*11,455 **= 7,446 lbs concrete breakout strength**
Step 3	Calculate bond strength of a single anchor in tension per Table 4 and Equations D-16a, D-16f from ICC-ES ESR 2308	N_{aa} = $\tau_{k,cr}\,\pi d h_{ef}$ = 1,735*3.14*0.5*4.5 = 12,258 lbs ϕN_{aa} = $\phi A_{Na}/A_{Nao}\,\psi_{ec,Na}\,\psi_{c,Na}\,N_{aa}$ = 0.65*1.0*1.0*1.0*11,092 = 0.65*12,258 **= 7,968 lbs bond strength**
Step 4	Determine controlling resistance strength in tension per ACI 318 D 4.1.1 and D 4.1.2	**= 6,173 lbs controlling resistance (steel)**

Table 7 - Threaded Rod Tension Design Load Estimation Table[1,2]

Threaded Rod Diameter	Effective Embedment Depth (in)	Temperature Range A[3]		Temperature Range C[4]	
		Uncracked Concrete	Cracked Concrete	Uncracked Concrete	Cracked Concrete
3/8	2-3/8	3,155	1,186	2,808	1,137
	3-3/8	4,484	1,685	3,990	1,615
	7-1/2	7,265	3,745	7,265	3,590
1/2	2-3/4	4,499	2,038	4,335	1,954
	4-1/2	7,972	3,336	7,094	3,198
	10	13,303	7,413	13,303	7,106
5/8	3-1/8	5,450	2,896	5,450	2,776
	5-5/8	12,456	5,212	11,084	4,997
	12-1/2	21,188	11,582	21,188	11,104
3/4	3-1/2	6,460	4,208	6,460	4,031
	6-3/4	17,303	8,115	15,962	7,774
	15	31,356	18,034	31,356	17,276
7/8	3-1/2	6,460	4,576	6,460	4,576
	7-7/8	21,804	11,046	21,725	10,581
	17-1/2	43,287	24,546	43,287	23,514
1	4	7,893	5,591	7,893	5,591
	9	26,639	14,427	26,639	13,820
	20	56,788	32,060	56,788	30,712
1-1/4	5	11,031	5,654	11,031	5,029
	11-1/4	37,229	12,721	34,057	11,314
	25	85,064	28,269	75,683	25,143

KEY	CONCRETE[5]	ADHESIVE[6]	STEEL[7]

[1]These load values are for the purposes of estimation only and should not be used in design
[2]Assuming single anchor with no edge or spacing distances, environmental factors that would reduce the load. Design loads include their respective Φ reduction factor from ACI 318-11 Appendix D, Condition B.
[3]Temperature Range A (long term temperature 70°F, short term temperature 110°F)
[4]Temperature Range C (long term temperature 110°F, short term temperature 176°F)
[5]Concrete compressive strength of 4,000 psi
[6]For periodic and continuous inspection with dry concrete
[7]Steel tensile strength of 125,000 psi (ASTM A193 Grade B7)

Table 8 - Reinforcing Bar Tension Design Load Estimation Table[1,2]

Rebar Number	Effective Embedment Depth (in)	Temperature Range A[3]		Temperature Range C[4]	
		Uncracked Concrete	Cracked Concrete	Uncracked Concrete	Cracked Concrete
#3	2-3/8	2,153	920	1,917	880
	3-3/8	3,060	1,308	2,724	1,251
	7-1/2	6,800	2,906	6,053	2,780
#4	2-3/4	3,324	1,550	2,959	1,483
	4-1/2	5,440	2,536	4,843	2,426
	10	12,089	5,636	10,762	5,391
#5	3-1/8	4,722	2,245	4,204	2,150
	5-5/8	8,500	4,042	7,567	3,869
	12-1/2	18,889	8,982	16,815	8,599
#6	3-1/2	6,347	3,259	5,650	3,125
	6-3/4	12,240	6,285	10,896	6,027
	15	27,200	13,968	24,213	13,393
#7	3-1/2	6,460	3,802	6,460	3,646
	7-7/8	16,660	8,555	14,831	8,203
	17-1/2	37,022	19,011	32,957	18,230
#8	4	7,893	4,966	7,893	4,762
	9	21,760	11,174	19,371	10,715
	20	48,355	24,831	43,046	23,810
#10	5	11,031	7,670	11,031	6,828
	11-1/4	29,463	17,258	26,218	15,363
	25	65,473	38,352	58,262	34,140

KEY	CONCRETE[5]	ADHESIVE	STEEL[6]

[1]These load values are for the purposes of estimation only and should not be used in design
[2]Assuming single anchor with no edge or spacing distances, environmental factors that would reduce the load. Design loads include their respective Φ reduction factor from ACI 318-11 Appendix D, Condition B.
[3]Temperature Range A (long term temperature 70°F, short term temperature 110°F)
[4]Temperature Range C (long term temperature 110°F, short term temperature 176°F)
[5]Concrete compressive strength of 4,000 psi
[6]Steel tensile strength of 125,000 psi (ASTM A193 Grade B7)

Table 9 - Reinforcing Bar Development Strengths[1]

Rebar#	Embedment to Develop Yield Strength (in)[2]	Embedment to Develop Tensile Strength (in)[2]	Yield Strength (lbs)[3]	Tensile Strength (lbs)[3]
#3	3-1/2	5	6,600	9,900
#4	4-1/4	6-1/4	12,000	18,000
#5	5-3/4	8-1/2	18,600	27,900
#6	7-1/4	10-3/4	26,400	39,600
#7	7-3/4	11-3/4	36,000	54,000
#8	9-3/4	14-3/4	47,450	71,100
#10	14-1/4	21-1/4	76,200	114,300

[1] Embedments are valid for concrete compressive strengths of 3,000 psi or greater
[2] Calculated embedments are based on comparison of average ultimate adhesive bond values versus yield/tensile strength of rebar
[3]Steel yield strength of 60,000 psi; steel tensile strength of 90,000 psi (ASTM A615)

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