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ICC-ES Evaluation Report

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ESR-4564

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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
Section: 05 05 27—Metal Connectors

REPORT HOLDER:

ONGUARD GROUP LTD

EVALUATION SUBJECT:

ONGUARD OG PRO SEISMIC ANCHORS

1.0 EVALUATION SCOPE

Compliance with the following code:

2018 and 2015 *International Building Code*® (IBC)

Property evaluated:

Structural

2.0 USES

The Onguard OG PRO Seismic Anchors (referred hereafter as OG PRO Anchors), shown in Figure 1, are anchoring devices used in Onguard Seismic Systems to connect metal liquid containment vessels (tanks) to reinforced concrete foundations as shown in Figure 2. A series of OG Pro Anchors are welded to the side of the tank around its base, and the OG Pro Anchor bottoms are installed to the supporting concrete foundation. The OG PRO Anchors are used to resist uplift and shear forces that are induced by wind and earthquake (Seismic Design Categories A through F) loads.

3.0 DESCRIPTION

3.1 General:

The OG PRO Anchor is a ductile seismic anchor device that is fillet welded to the tank or the tank's skirt on the side as shown in Figure 2. OG PRO Anchors are available in five models: OG PRO 33, OG PRO 51, OG PRO 81, OG PRO 117, and OG PRO 172. The bottom of the OG PRO Anchor is installed to the threaded end of a threaded stud that is embedded in concrete. The OG PRO Anchor consists of a casing, a cap, a pin (yield pin), a sleeve, a coupler, and a threaded stud. Components of the OG PRO Anchor are shown in Figure 3. The yield pin is encased in the plastic sleeve and a casing to restrict the pin's buckling under compression. The casing consists of two parts: casing tube and casing block, that are fillet welded to each other with a 316L stainless steel flux-cored MIG (Metal Inert Gas) wire. The weld minimum tensile strength is 69.9 ksi (482 MPa). Diameter and threads of the stud are similar to the bottom threaded part of the pin. Dimensions of different OG PRO Anchor models are included in Table 1.

3.2 Materials:

The pin is made from AS/NZS 3679.1 Grade 300 carbon steel with a minimum tensile yield stress of 46.4 ksi (320 MPa) and a minimum ultimate tensile strength of 76.9 ksi (550 MPa). The internal sleeve is made from Polystick Ultra-High-Molecular-Weight Polyethylene (UHMWPE) Natural 1000 Grade by Polymer Industries. The casing and the cap are made from 304 stainless steel with a minimum tensile yield stress of 30.4 ksi (210 MPa) and a minimum tensile strength of 74.7 ksi (515 MPa).

The coupler is made from AISI 1018 or AISI 1215 carbon steel with minimum yield stress of 53.7 ksi (370 MPa) and minimum tensile strength of 63.8 ksi (440 MPa). The stud is a fully threaded rod that is made from G8.8 high tensile strength galvanized steel [with minimum tensile strength of 76.9 ksi (550 MPa)] or stronger. The required thread specifications of the stud for each of the OG PRO Anchors are included in Table 1.

4.0 DESIGN AND INSTALLATION

4.1 Design:

Resistance of the Onguard Seismic Systems to earthquakes relies primarily on the ductility of OG PRO Anchors in the axial (vertical) direction. The pin and the surrounding sleeve and casing (buckling restrained pin) is the Designated Energy-Dissipating Mechanism (DEDM) in the vertical direction. The pin can deform inelastically under tension and deform back to its original length under compression, while the sleeve and casing restrain buckling of the pin. Compressive deformation of the pin beyond its original length is restrained, since the tank is bearing on the supporting foundation or steel stand. Axial deformation in the pin is a result of the overturning moment on the tank that is caused by earthquakes. Ductility of the OG PRO Anchor mitigates the cyclic overturning moment on the tank during an earthquake. The maximum allowable strain in the pin is 2.89 percent.

The OG PRO Anchor performance in the horizontal direction (shear) remains elastic and is considered a Non-Designated Energy-Dissipating Mechanism (Non-DEDM).

The central yield pin within the anchors is designed and manufactured for a predetermined tension load as specified in Table 2. The diameter of the middle part of the pin must be determined by a registered design professional based on the actual yield stress of the pin from static tension testing according to ASTM A370 and the actual yielding load in Table 2. Determination of the actual yield stress is part of the quality control program of the manufacturer. The required number of anchors and model shall be determined by the registered design professional based on tank size, wind and seismic loads, site specific seismic information, and in accordance with the requirements ASCE 7 and the applicable code. Axial and shear capacities of the OG PRO Seismic Anchors are provided in Table 3, separately.

Determining the number of required OG PRO Anchors based on the axial capacities in Table 3 must not be based upon the overstrength seismic load, E_{mh}, as specified in ASCE 7 Section 11.3, because axial inelastic deformation is allowed in the pin during earthquakes. Nevertheless, overstrength seismic loads must be considered for other loading directions on the OG PRO Anchors.

The tank system design including the tank, the supporting member (concrete foundation), the connection between the OG PRO Anchors and the tank, the connection between the OG PRO Anchors and the supporting concrete member, and spacings and edge distances of the OG PRO Anchors are outside the scope of this evaluation report and shall be designed in accordance with ASCE 7 (Section 15.7) and the applicable codes by a registered design professional. The expected inelastic tensile strength of the OG PRO Anchors, $T_{u,adj}$, and the expected inelastic compressive strength of the OG PRO Anchors (after elongation of the anchor's pin), $C_{u,adj}$, are:

$$T_u = \phi.P_y$$

$$T_{u,adj} = T_u.R_y.\omega$$

$$C_{u,adj} = T_{u,adj}.\beta$$

where, R_y, ω, and β values are included in Table 2.

- T_u is the LRFD tension capacity of the OG PRO Anchor (Table 3).
- ϕ is the strength resistance factor = 0.90.
- P_y is the predetermined tension yield load of the Pin (Table 2).
- R_y is the ratio of the expected yield stress to the specified yield stress of the pin, which is equal to 1, since the pin is designed based on the predetermined yield load, P_y.
- ω is the strain hardening adjustment factor, which is the ratio of the expected tensile stress in the pin at the maximum allowable strain (2.89%) to the expected tensile yield stress of the pin.
- β is the ratio of the expected compressive strength to the expected tensile strength of the pin.
- $T_{u,adj}$ and $C_{u,adj}$ are referenced as strength of anchor in ASCE 7 Section 15.7.3.a.

4.2 Installation:

A series of OG PRO Anchors are welded to the side of the tank and epoxied into the concrete foundation. OG PRO Anchors must be installed in accordance with the manufacturer's installation instructions: "Technical Manual for Installation (TM3)", and this report. Welding of anchors to the tank must be in accordance with the Technical Manual for Welding (TM4), AWS D1.6 and this report, where the most restrictive governs. Installation of threaded studs in concrete foundation along with Anchors spacing and edge distances must comply with the Technical Manual for Tank Specifications, ACI 318, and this report, where the most restrictive governs.

All parts must be clean and free from loose rust, oils, dust, and other foreign materials. All foreign matter and water must be removed. The system must be prepared and installed in accordance with the applicable code, the approved construction documents and the recommendations noted in the Technical Manuals (TM3 and TM4). Anchors shall be equally spaced around the perimeter of the tank, or as shown in the design drawings.

Anchorage design of the epoxied threaded studs, for which the OG PRO Anchors are installed to, shall be determined by a registered design professional and installed in accordance with the concrete anchoring system supplier specifications.

An anti-seize lubricating compound must be applied to all threads when reassembling anchors that may have been disassembled. The pin's threads must be fully engaged with the coupler. The minimum engagement length of the threaded stud in the coupler (L_e) must be as specified in Table 1.

4.3 Special Inspection:

Special inspection at the jobsite is required in accordance with Sections 1704 and 1705 of the IBC, Chapter N of AISC 360, Chapter J of AISC 341, and Clause 7 of AWS D1.8.

Following a seismic event, all installed anchors shall be inspected according to the manufacturer's guidelines outlined in the Technical Manual for Post-Earthquake Monitoring (TM6) and replaced as necessary.

5.0 CONDITIONS OF USE

The OG PRO Anchors described in this report comply with, or are suitable alternatives to what is specified in the code indicated in Section 1.0 of this report, subject to the following conditions:

5.1 The OG PRO Anchors must be identified and installed in accordance with the applicable code, the manufacturer's instructions and this report. In case of conflict, the most restrictive governs.

5.2 Special inspection must be provided in accordance with Section 4.3 of this report.

5.3 The use of OG PRO Anchors in fire-resistance-rated construction, is outside the scope of this evaluation report.

5.4 The compressive strength of the concrete foundation, f_c', that is used for calculation purposes must not exceed 8,000 psi (55.2 MPa).

5.5 OG PRO Anchors in this report were evaluated in temperatures ranging from 50°F to 66°F (10°C to 18.9°C). Evaluation in other temperatures and other conditions that may affect the properties and performance of the OG PRO Anchors components is outside the scope of this evaluation report.

5.6 The evaluation report includes tension and shear capacities of the OG PRO Anchors, separately. Evaluation of other capacities and combined loading conditions are outside the scope of this evaluation report and must be determined by a registered design professional.

5.7 Loads applied to the OG PRO Anchors shall be determined by a registered design professional and comply with applicable loads from the IBC Chapter 16.

5.8 The design of the tank and the supporting member (concrete foundation) are outside the scope of this evaluation report and shall be in accordance with ASCE 7 (including Section 15.7) and the applicable codes.

5.9 The strength design values listed in Table 3 are for the OG PRO Anchor. The connection between the anchor and tank and between the anchor and supporting member shall not govern the design and shall be in accordance with ASCE 7 Section 15.7 and the applicable codes.

5.10 The epoxy used for the anchorage between the threaded stud and the concrete foundation must be approved by the code official or have a current ICC-ES evaluation report.

5.11 All calculations and design details must be prepared by a registered design professional and submitted to the code official for approval prior to field installation.

5.12 OG PRO Anchors are manufactured in Bromley in New Zealand under an approved quality control program with inspections performed by ICC-ES.

6.0 EVIDENCE SUBMITTED

6.1 Manufacturer's descriptive literature and installation instructions.

6.2 Report of static tension tests conducted in accordance with ASTM A370

6.3 Report of cyclic tension tests in accordance with FEMA 461 with modifications.

6.4 Engineering calculations in accordance with AISC 360, AISC 341, AWS D1.6, and ASCE 7.

6.5 Quality documentation in accordance with ICC-ES Acceptance Criteria for Quality Documentation (AC10), dated January 2019.

7.0 IDENTIFICATION

7.1 The OG PRO anchors are identified in the field by dimensional characteristics, head stamp, material specifications and packaging. The OG PRO anchor has the Onguard logo and model number etched into the top cap. The packaging label bears the manufacturer's name and contact information, anchor name, anchor size, quantity, and the ICC-ES evaluation report number (ESR-4564).

7.2 Each batch of identical OG PRO Anchors for each site must be accompanied with a document containing the actual yield stress and the actual diameter of the middle part of the pin.

7.3 The report holder's contact information is the following:

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TABLE 1—DIMENSIONS OF OG PRO ANCHORS[1]

ANCHOR MODEL	DIMENSIONS IN INCHES								
	Casing's Height	Casing's Outer Diameter	Coupler's Outer Diameter	Coupler's Height	Cap's Threads (thread's length)	Stud's Threads (L_e, in.)[2]	Pin's Length (Middle Part Length)	Pin's Nominal. Diameter[3]	Pin's Threads (thread's length)
OG PRO 33	4.862	1.575	1.181	3.268	M32x2.0 (0.472)	M20x2.5 (1.417)	5.453 (2.756)	0.492	M20x2.5 (1.465)
OG PRO 51	5.453	2.165	1.378	3.819	M39x2.0 (0.591)	M24x3.0 (1.693)	6.299 (3.150)	0.610	M24x3.0 (1.706)
OG PRO 81	6.319	2.165	1.772	4.449	M45x2.0 (0.787)	M30x3.5 (1.969)	7.205 (3.543)	0.768	M30x3.5 (1.913)
OG PRO 117	7.028	2.736	1.772	4.685	M52x3.0 (0.984)	M30x3.5 (2.047)	7.953 (3.937)	0.925	M30x2.0 (2.244)
OG PRO 172	7.421	2.933	2.165	5.276	M62x3.0 (1.181)	M30x3.5 (2.362)	8.543 (3.937)	1.122	M36x2.0 (2.547)

For **SI**: 1 inch = 25.4 mm.
[1]Cap thickness, T, of all anchors is 0.375 inches.
[2]L_e is the minimum engagement length of the threaded stud in the coupler.
[3]Pin's diameter at mid-height varies and must be determined based on the actual yielding stress so that the predetermined yielding tension load of the pin is as predetermined in Table 2.

TABLE 2—PIN'S MECHANICAL PROPERTIES

ANCHOR MODEL	PREDETERMINED TENSION YIELD LOAD, lb (KN) = P_y	ω	R_y	β
OG PRO 33	7,500 (33)	1.21	1	1
OG PRO 51	11,500 (51)			
OG PRO 81	18,200 (81)			
OG PRO 117	26,300 (117)			
OG PRO 172	38,700 (172)			

For **SI**: 1 inch = 25.4 mm, 1 pound = 4.448 N

TABLE 3—LRFD CAPACITY OF OG PRO ANCHORS, LB (KN)[1,2,3]

ANCHOR MODEL	T_u = TENSION CAPACITY, lb (kN)	V_u = SHEAR CAPACITY, lb (kN)
OG PRO 33	6,800 (30)	12,100 (54)
OG PRO 51	10,400 (46)	17,000 (76)
OG PRO 81	16,400 (73)	18,900 (84)
OG PRO 117	23,700 (105)	29,500 (131)
OG PRO 172	34,800 (155)	33,500 (149)

For **SI**: 1 inch = 25.4 mm, 1 pound = 4.448 N

[1]The reported LRFD design capacities are for wind loads and Seismic Design Categories of A through F.
[2]The overstrength seismic load, E_{mh}, specified in ASCE 7 shall not be considered with the reported tension capacities of the OG PRO Anchors, while it shall be considered for the reported shear capacities.
[3]For allowable design capacities (ASD) the T_u and V_u values in Table 3 must be divided by 1.5.

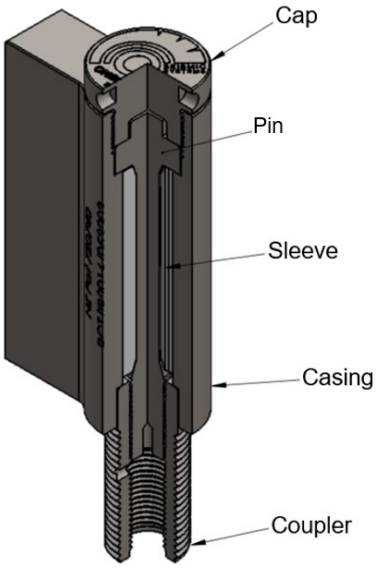
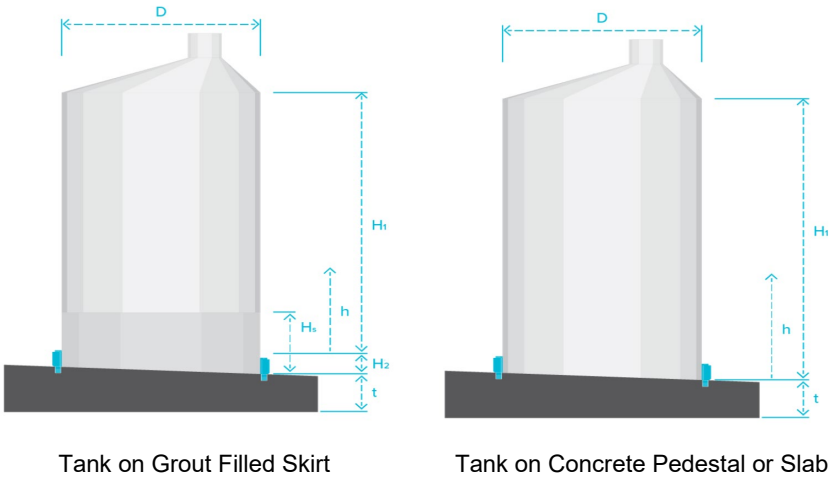


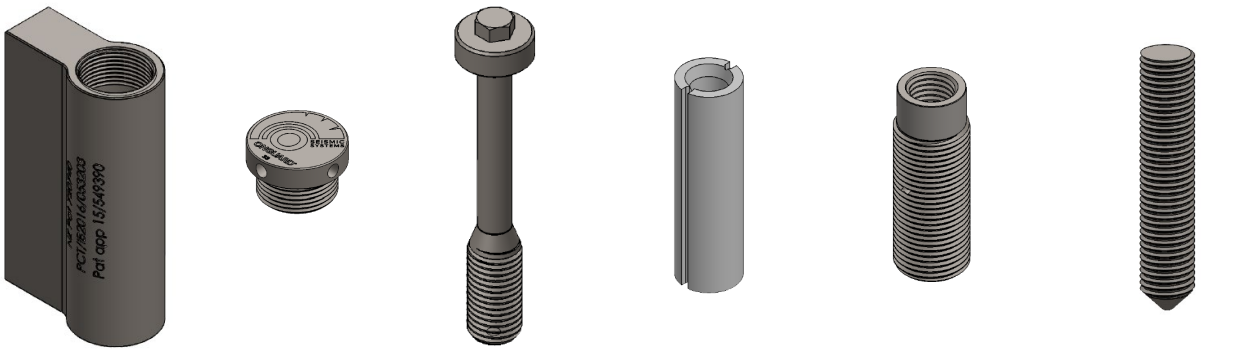
FIGURE 1—OG PRO ANCHOR



Tank on Grout Filled Skirt

Tank on Concrete Pedestal or Slab

FIGURE 2–INSTALLATION OF OG PRO ANCHORS TO CONCRETE FOUNDATION



Casing **Cap** **Pin** **Sleeve** **Coupler** **Threaded Stud**

FIGURE 3—OG PRO ANCHOR COMPONENTS