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RECORD OF REVISIONS

Rev	Date	Description	POC	OIC
0	6/28/99	Initial issue in Facility Eng Manual.	Doug Volkman, *PM-2*	Dennis McLain, *FWO-FE*
1	2/09/04	Incorporated IBC & ASCE 7 in place of UBC 97; incorporated DOE-STD-1020-2002 versus 1994 and concepts from DOE O 420.1A; FEM became ESM, an OST.	Mike Salmon, *FWO-DECS*	Gurinder Grewal, *FWO-DO*
2	5/17/06	Major revision: Reduced commentary in favor of IBC 2003 amendments only; clarification of PC-0 applicability; OST became ISD.	Mike Salmon, *D-5*	Mitch Harris, *ENG-DO*
3	10/27/06	Administrative changes only. Organization and contract reference updates from LANS transition; 420.1A became 420.1B. IMP and ISD number changes based on new Conduct of Engineering IMP 341. Master Spec number/title updates.	Mike Salmon, *D-5*	Kirk Christensen, *CENG*
4	6/19/07	Incorporated new seismic hazard analysis results into the seismic design parameters (1.7.1); supersedes Salmon interim guidance of 1/22/07 (D5:07-021). Added App A on concrete anchor design.	Mike Salmon, *D-5*	Kirk Christensen, *CENG*
5	6/16/08	Incorporated IBC 2006 & ASCE 7-05 in place of IBC 2003 & ASCE 7-02; minor App A changes.	Mike Salmon, *D-5*	Kirk Christensen, *CENG*
6	6/20/11	Update for IBC 2009. New Commentary on design and inspection. Admin changes including document number.	Mike Salmon, *D-5*	Larry Goen, *CENG*
7	10/30/12	Added TA-50/55 ground motion values at 1613.5, mass concrete at 1904, erection planning at 2205.1, drawing requirements in App A. Updated references.	Mike Salmon, *AET-2*	Larry Goen, *ES-DO*
8	11/03/14	Consolidated anchorage App. A, added adhesive anchors and limited use of anchorage to masonry; also, eliminated former brittle PI anchor procedure in deference to similar provision in IBC 2009/ ACI 318-08. Other minor changes in section proper.	Mike Salmon, *AET-2*	Mel Burnett, *ES-DO*
9	3/27/15	Major revision. Incorporated IBC-2015, DOE-STD-1020-2012 versus 2002, and anchorage material from Sect I App A. Eliminated historical 10-psf future-floor-DL and, for roofs, 30-psf min roof LL (Lr) and prohibition on LL reduction. Eliminated Commentary companion to this document.	Mike Salmon, *AET-2*	Larry Goen, *ES-DO*
10	12/20/16	Programmatic anchorage flowchart superseded by Ch 16. Other changes to App A, mostly A.13 anchorage drawing requirements. Added App B on small offsite-built structures.	Mike Salmon, *AET-2*	Larry Goen, *ES-DO*

Contact the Structural Standards POC
for upkeep, interpretation, and variance issues

Ch. 5, Section II	**Structural POC/Committee**

This Chapter is online at http://engstandards.lanl.gov

II COMMERCIAL DESIGN & ANALYSIS REQUIREMENTS

A. This Section provides the minimum requirements for the structural design and analysis of commercial (i.e., non-nuclear[1]) structures, systems, components (SSCs), to include non-building structures, at LANL, as well as programmatic equipment. These are designed using commercial codes [the International Building Code (IBC) and International Existing Building Code (IEBC)].

1. Regarding the requirements for design, analysis, evaluation, etc. of existing SSCs, refer to Section I of this chapter (*e.g., paragraphs 1.3.C and 1.4.A*).

B. Nuclear, biological, chemical, or toxicological SSCs that are designated NDC-1 or NDC-2 must also follow this Section (as modified by Section III).

1. *Guidance: For facilities with significant chemical or toxicological hazards, the design should consider the guidance and criteria in DOE-STD-1020-2012, Section 2.3.9, or equivalent.*

C. *Guidance: The structural design process generally consists of the following:*

- *Establish structural arrangement/geometry*
- *Establish loads and load combinations*[2]
- *Establish a complete load path for vertical and horizontal loads*
- *Evaluate the structural response to the loads*
- *Specification of structural capacity and drift limits (acceptance criteria)*
- *Application of special design considerations, such as ductile detailing requirements*
- *Specification of inspections (e.g., special inspections) and tests*

D. The design, tests, inspections, observations, quality, and construction of non-nuclear SSCs shall comply with the provisions of Section I of this chapter; of ESM Chapter 16, IBC Program (which invokes a specific edition of the IBC, and makes amendments to it); and the provisions contained herein (i.e., Section II), which include additional amendments to the IBC (i.e., Chapters 16 – 23). The IBC edition currently invoked is the 2015.

E. *Guidance: Note that Chapter 6 – Mechanical, Chapter 7 – Electrical, and others of this ESM also contain design requirements for many nonstructural components, and non-building structures.*

[1] Per DOE-STD-1020-2012, and as indicated in Section III, non-nuclear pertains to facilities other than Hazard Category 1, 2, and 3 nuclear facilities.

[2] Unless noted/footnoted otherwise, “Design-Load Basis for LANL Structures, Systems, and Components,” LANL Report No. LA-14165 [6] provides the basis for the non-seismic loads and analysis procedures.

1.0 IBC CHAPTER 16 STRUCTURAL DESIGN

1.1 SECTION 1607 LIVE LOADS

A. **1607.9 Impact loads**

1. Add **1607.9.5 Experimental explosion loads.**[3]

   a. Reactions from experimental explosion containment structures, due to explosions, shall be considered live loads.

   b. External loads from experimental explosions shall be calculated in accordance with DOD TM 5-1300 and shall be considered live loads.

1.2 SECTION 1608 SNOW LOADS

A. **1608.2 Ground snow loads.** Substitute the following text:

The ground snow load shall be taken as 16 psf.[4]

1.3 SECTION 1609 WIND LOADS

A. **1609.1.1 Determination of Wind Loads.** Revise the second sentence to read as follows:

The ultimate design wind speed, V_{ult}, and the exposure category shall be as indicated in Section 1609.[5]

B. **1609.3 Ultimate design wind speed.** Substitute the following text:

The ultimate design wind speed, V_{ult}, for the determination of the wind loads for the design of buildings and structures shall be as follows[6]:

- 105 mph for Risk Category I,
- 115 mph for Risk Category II, and
- 120 mph for Risk Category III and IV.

C. **1609.4 Exposure category.** Substitute the following text:

The exposure category shall be taken as Exposure C for each wind direction considered.

1.4 SECTION 1613 EARTHQUAKE LOADS

A. **1613.3 Seismic ground motion values**

1. **1613.3.1 Mapped acceleration parameters.** Substitute the following text:

   S_s and S_1[7]

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[3] LANL conducts experiments involving explosions; however, the IBC does not address the loads that result from such (i.e., either in the form of reaction forces on a building as a result of an explosion that occurs inside of an internal containment structure, or loads on a building as a result of an exterior explosion).

[4] This load comes from LA-14165. It is used instead of the load from ASCE 7 (Fig. 7-1) because it exceeds the value of the load contour nearest to LANL. Also, since LANL is located in a Case Study area, no ASCE-7 contour actually applies.

[5] For photovoltaic (PV) wind design, references include this article and SEAOC report PV2-2012.

[6] The wind speeds come from the maps in IBC (i.e., Figs. 1609.3(1) – 1609.3(3)) instead of from LA-14165 for two (2) reasons: (1) The 90-mph, 3-second-gust speed in LA-14165 was equivalent to the mapped speed* in the 'old' ASCE 7, and (2) The basis of the wind speed in 'new'/current ASCE 7 is quite different, as is how the wind speed is used to determine wind loads. The exposure category (in the next sub-para., 1.3.C) still comes from LA-14165 since that hasn't changed in ASCE 7 since publication of LA-14165.

*There never was, nor is there, a mapped-speed value applicable to LANL since it's in a Special Wind Region.

	Labwide	TA-50/55 may use these if desired
At short periods, S_S	1.03 g	0.75 g
At 1-second period, S_1	0.64 g	0.52 g

2. **1613.3.2 Site class definitions.** Substitute the following text:

   The site class shall be taken as Site Class D[8].

3. **1613.3.4 Design spectral response acceleration parameters.**[9] Substitute the following text:

Five-percent damped design spectral response acceleration

	Labwide	TA-50/55 may use these if desired[10]
At short periods, S_{DS}	0.75 g	0.60 g
At 1-second period, S_{D1}	0.64 g	0.52 g

4. Replace in Sections 11.3 and 11.4.5 of ASCE 7, the definition for T_o from $T_o = 0.2\ S_{D1}/S_{DS}$ to $T_o = 0.1$ sec.

5. For the design approach to certain commercially fabricated buildings used in multi-state jurisdictions, also refer to Appendix B of this document.

6. **1613.3.5 Determination of seismic design category.** Substitute the following text:

   The seismic design category shall be taken as Seismic Design Category D.

B. **1613.5 Amendments to ASCE 7**

1. Add **1613.5.2 Siting**. Modify ASCE 7 **11.8.1, Site Limitation for Seismic Design Categories E and F**, to read as follows:

   Site Limitation

   Structures shall not be located within 50 feet of known active faults. Hazardous waste treatment, storage and disposal facilities must not be located within 200 feet of a fault that has had displacement within the last 11,000 years per 40 CFR 264.

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[7] These values are required in certain code equations (e.g., IBC, ASCE 7, NFPA 13, etc.). Values were back-calculated starting from the 5% damped design spectral response acceleration values (ref. para. 1.4.1.C), and using IBC Tables 1613.3(1) and 1613.3(2). Checking those back-calculations:

Labwide: $S_{DS} = 2/3S_{MS} = 2/3F_aS_s = 2/3(1.09)(1.03) = 0.749 \approx 0.75$✓ $S_{D1} = 2/3F_vS_1 = 2/3(1.5)(0.64) = 0.64$✓

TA-50/55: $S_{DS} = 2/3S_{MS} = 2/3F_aS_s = 2/3(1.2)(0.75) = 0.60$✓ $S_{D1} = 2/3F_vS_1 = 2/3(1.5)(0.52) = 0.52$✓

[8] From ESM Ch. 5, Section II, Rev. 1, para. 1.1.10.D, and LA-14165, para. 2.1.5.2.

[9] The values given for the 3 parameters (i.e., S_{DS}, S_{D1}, and T_o) come from the 2007 UPSHA (ref. Misc. Ref. [7] in Ch. 5 Sect. I), and LANL Memo D5:07-021.

[10] Memorandum, "Design Basis Ground Motion for Use in the Design of PC1 and PC2 Facilities at Los Alamos National Laboratory (SAFER-012-001)", Michael Salmon, January 18, 2012 (EMRef-66). Incorporates VAR-2012-053, same topic. For evaluation of existing SSCs at TA-50/55, other response spectrum may be more appropriate (e.g., Site Spec Alt Function of Memo's calc Fig. 6 (pg. 9) per L. Goen.

2. Add **1613.5.3 Anchorage of architectural, mechanical, and electrical components.**

Refer to this document's Appendix A, Anchorage to Concrete and Masonry.

1.5 ADD SECTION 1616 ACCIDENTAL BLAST LOADS[11]

A. Permanent explosive facilities shall comply with DOD UFC 3-340-02 and, as applicable, UFC 3-340-01. Protective construction design features are provided in DOD UFC 3-340-02 and UFC 3-340-01. When evaluating for accidental blast load, A_B, the loading A_B shall replace E (earthquake) loads in the load combination equations. All potential blast effects shall be considered including blast overpressure, gas pressure, fragments, and ground shock.

B. The design of all new facilities containing explosives, or those that can be affected by detonation (inadvertent or planned) of explosives, shall comply with DOE-STD-1212, Explosives Safety (*e.g., Chapters IV and X*).

1. This requirement also applies to significant (e.g., IEBC Alteration Level 3) modifications of facilities containing explosives, or those that can be affected by detonation (inadvertent or planned) of explosives.

1.6 ADD SECTION 1617 MINIMUM ANTITERRORISM STRUCTURAL DESIGN MEASURES[12]

Structural design measures on progressive-collapse avoidance and window protection presented in DOD UFC 4-010-01 shall be considered for those buildings where there is a credible terrorist threat. LANL Physical Security (PS) Division shall specify (to the LANL Project Manager) whether these minimum antiterrorism measures are to be implemented; see also ESM Chapter 9, Facility Protection and Security.

1.7 ADD SECTION 1618 VOLCANIC ASHFALL LOADS

Consideration shall be given for potential ashfall loads on roofs and impact on designated seismic systems (DSS). See Section III (*paragraph H.6*) for guidance, details, etc.[13]

2.0 IBC CHAPTER 17 SPECIAL INSPECTIONS AND TESTS

Refer to LANL ESM Chapter 16, IBC Program for LANL amendments to this and other IBC chapters.

[11] LANL has buildings that contain explosives: however, the IBC does not address the loads that result from such, nor does it address how such buildings are to be designed. The addition of the material in 1.5.A and 1.5.B addresses both loads and design (and more). Treating A_B like E (i.e., with regard to load combination equations and use of a load factor = 1.0) is consistent with documents that address the design of structures to resist blast loads. The standard for the design of non-explosive facilities (subjected to accidental or malicious explosions) is ASCE-59.

[12] LANL has buildings where there is a credible terrorist threat; however, the IBC does not address how such buildings should be designed. The addition of the material in 1.6 addresses this shortcoming.

[13] Ashfall load as a function of RC or NDC was not available in 2015. LANL is undertaking a NPH program that may define additional NPH loads. Check with the Structural POC to determine if volcanic ashfall loads need to be considered for new designs or major modifications to existing facilities

3.0 IBC CHAPTER 18 SOILS AND FOUNDATIONS

3.1 SECTION 1803 GEOTECHNICAL INVESTIGATIONS

A. **1803.5 Investigated Conditions.**

1. **1803.5.12 Seismic Design Categories D through F.** Modify the first item (i.e., "1.") to read as follows:

The determination of dynamic seismic lateral earth pressures…A conservative alternative for obtaining such pressures is use of the Elastic Solution in ASCE 4 (para. 3.5.3.2)[14].

3.2 SECTION 1808 FOUNDATIONS

A. **1808.1 General.** Add the following text:

Permanent buildings and similar structures shall have a permanent foundation (e.g., full perimeter support, rodent-excluding, no trailer skirting, etc.). Permanent is defined in ESM Chapter 16, Section IBC-GEN[15].

1. Exception: For transportables[16], a permanent foundation may be achieved by placing gravity bearing pads on 24 inches of non-frost susceptible ground or fill (95% compacted granular material with less than 6% material passing the 200 sieve)*, and providing insulated skirting around the perimeter of the buildings[17]. *See also LANL Standard Details ST-Z1052-1 and -2 regarding foundation support for temporary trailers.*

* If fill is used, it must replace the existing material to depth of at least 24 inches.

3.3 SECTION 1809 SHALLOW FOUNDATIONS

A. **1809.5 Frost protection.** Edit the first sub-bullet (i.e., "1") to read as follows:

Extending to 36".[18]

B. **1809.13 Footing seismic ties.** Substitute the following text:

Interconnect all spread-footing-type foundations using tie beams. The tie beam shall be capable of resisting, in tension or compression, a minimum horizontal force equal to 10% of the larger column vertical load. The tie beams shall also be capable of resisting bending due to prescribed differential settlements of the interconnected footings, as stipulated by the project geotechnical engineer.[19]

[14] Historical LANL alternative for determining these pressures (ref. ESM Ch. 5 Sect. II Rev. 1, para. 1.1.8.C). Applicable for use in the absence of geotech investigation. Per ASCE 4, this alternative is not applicable "When there is …significant structure-structure interaction…"

[15] LANL experience is that permanent foundations reduce O&M costs by minimizing settling that causes roof and structure cracks, excluding rodents and other pests, and improving energy efficiency by virtue of their superior insulation.

[16] A transportable is an easily moved prefabricated building (e.g., a trailer or manufactured office) generally intended for less than a 20 year life. See ESM Ch 1 Sect. Z10 on design goals and Ch 16 IBC-GEN on temporary.

[17] Cost-effective given limited service life and meets ASCE 32 (Sect 4.2); the 24-inch depth is in keeping with LA-14165 re frost (page 3-53). Wind anchors provide motion control.

[18] LA-14165 para. 3.3.1

[19] LANL-specific requirement for conservatism. The conservatism (compared with IBC provision) includes use of the provision in Site Class D (vs. only E or F), and requiring tie beam to resist 10% of column load (vs. 10% x S_{DS} x column load).

4.0 IBC CHAPTER 19 CONCRETE

4.1 SECTION 1901 GENERAL

A. **1901.3, Anchoring to concrete** Revise first part of sentence to read as follows:

Anchoring to concrete shall be in accordance with LANL ESM Chapter 5, Section II, Appendix A, Anchorage to Concrete and Masonry[20]; ACI 318; and the amendments to ACI 318 in Section 1905; and applies to…anchors.

4.2 SECTION 1904 DURABILITY REQUIREMENTS[21]

Add **1904.3 Mass Concrete**:

A. Mass concrete is defined as "any volume of structural concrete in which a combination of dimensions of the member being cast, the boundary conditions, the characteristics of the concrete mixture, and the ambient conditions can lead to undesirable thermal stresses, cracking, deleterious chemical reactions, or reduction in the long-term strength as a result of elevated concrete temperature due to heat from hydration. *In general, a placement of structural concrete with a minimum dimension* $\geq$ *4 ft should be considered mass concrete. Similar considerations should be given to other concrete placement that do not meet this minimum dimension but contain Type III cement, accelerating admixtures, or cementitious materials in excess of 660 lb/yd*^{3} *of concrete. Consideration should also be given to placements that trap heat.*

B. <u>The Construction Documents shall designate those portions of the structure, or concrete placement that are to be treated as mass concrete.</u> The Project Specification (e.g., Section 03 3001, Reinforced Concrete) shall adopt the ACI 301, Section 8 requirements. The structural Engineer of Record (SEOR) shall review the Project-Specification-version of 03 3001 against the checklists presented in ACI 301 (i.e.., Mandatory, Optional Requirements, and Submittals) to ensure that this Section adequately addresses mass concrete.

1. In lieu of mass concrete designation and specification requirements, the SEOR can opt to demonstrate (analytically, using ACI 207.2R) that these requirements are not required/applicable.

5.0 IBC CHAPTER 20 ALUMINUM

No change.

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[20] Criteria provided in Appendix A for anchorage to concrete have been adapted through ACI 318 and ASCE 7 and were developed to avoid differences in anchorage provisions presented in ACI 318, ASCE 7, and other material standards.

[21] Highlights need for such measures when required by ACI 301, since neither the IBC nor ACI 318 explicitly address mass concrete. ACI 318 Introduction states (on pp. 4), 'The Code [ACI 318] provides a means of establishing minimum standards …the contract documents should contain all of the necessary requirements to ensure compliance with the Code…ACI publications, such as "Specification for Structural Concrete (ACI 301)" are written specifically for use as contract documents for construction.' ACI 301 is used in this manner in the LANL Master Spec Section 03 3001 and contains provisions pertaining to mass concrete, and since some of these provisions are beyond the capability of the constructor, the SEOR must ensure compliance with ACI 301. Added under durability since that is the primary concern with mass concrete (i.e., cracks resulting from temperature differential between the exposed surface and the interior can be detrimental to serviceability, service life, or appearance). See ACI 201.2R, para. 3.6; ACI 207.1R, para. 1.1; and ACI 207.2R, para. 1.2.

6.0 IBC CHAPTER 21 MASONRY

6.1 SECTION 2107 ALLOWABLE STRESS DESIGN

A. **2107.1 General.** Add the following sentence to the end:

Anchoring to masonry shall be in accordance with ESM Chapter 5, Section II, Appendix A, Anchorage to Concrete and Masonry; and TMS 402/ACI 530/ASCE 5.

6.2 SECTION 2108 STRENGTH DESIGN OF MASONRY

A. **2108.1 General.** Add the following sentence to the end:

Anchoring to masonry shall be in accordance with Appendix A (Anchorage to Concrete and Masonry) of this document and TMS 402/ACI 530/ASCE 5.

7.0 IBC CHAPTER 22 STEEL

7.1 SECTION 2205 STRUCTURAL STEEL

A. **2205.1 General.** Add the following text:

Designs shall allow for, if not ensure, compliance with OSHA provisions 29 CFR 1926, Subpart R (Steel Erection), Section 755(a), General Requirements for Erection Stability. Columns shall be securely anchored with a minimum of four (4) anchor rods or anchor bolts to address construction safety. Furthermore, each column base plate assembly, including the column-to-base plate weld and the column foundation, shall be designed to resist a minimum eccentric gravity load of 300 pounds located 18 inches from the extreme outer face of the column in each direction at the top of the column shaft to address construction safety. *See also LANL Master Specification Section 05 1000, Structural Metal Framing, for additional discussion.*[22]

8.0 IBC CHAPTER 23 WOOD

No change.

[22] As is indicated in the User Note associated with AISC 360, Section J9, Anchor Rods and Embedments, OSHA mandates special erection requirements for anchor rods. Lessons Learned, 2011 TA-16-200 stairs incident (ORPS-2011-1963). Subpart R definitions: *Column* means a load-carrying vertical member that is part of the primary skeletal framing system. Columns do not include posts. *Post* means a structural member with a longitudinal axis that is essentially vertical, that: (1) weighs 300 pounds or less and is axially loaded (a load presses down on the top end), or (2) is not axially loaded, but is laterally restrained by the above member. Posts typically support stair landings, wall framing, mezzanines and other substructures.

Appendix A–Anchorage to Concrete and Masonry

A.1 DESCRIPTION

A. This appendix establishes the technical design requirements for designing concrete anchors for non-nuclear SSCs at LANL. There are different design criteria for anchorage of nuclear SSCs. An anchor type /product acceptable for a nuclear SSC may be used for a non-nuclear SSC.

B. Not Included: Design of anchorage for nuclear SSCs except nuclear facility SSCs that are designated NDC-1 or NDC-2 must also follow this appendix (as indicated by, and per modifications in, Section III).

C. Cast-in-place (CIP) anchors: This appendix covers the design of the following CIP anchors: Headed bolts, threaded and nutted bolts, headed studs, and hooked bolts. Cast-in anchors are ASTM A36, A193 Gr. B7, A354 Gr. BD, A449, A572, A588, A687, or F1554 material. ASTM F1554 Gr. 55 is the preferred material specification in AISC 360. Welding and mechanical properties of headed studs shall comply with AWS D1.1 (per AISC 360) and ESM Chapter 13–Welding, Joining, and NDE.

D. Post-installed (PI) anchors: This appendix covers the design of the following types of PI concrete anchors: expansion, adhesive, undercut, screw, and power-actuated. PI anchorage to grout-filled concrete masonry ("grouted-masonry anchors" hereafter) is also covered, as is grouted rebar. Purchase, installation, and testing requirements for PI anchors are given in the LANL Master Specification Sections listed below

E. Definitions: Definitions of anchors per ACI 355.2 and ACI 355.4 apply.

A.2 APPLICABLE CODES

IBC International Building Code by International Code Council (ICC), edition per ESM Ch. 16

A.3 APPLICABLE INDUSTRY STANDARDS AND REPORTS[23]

ACI 355.2	Qualification of Post-Installed Mechanical Anchors in Concrete and Commentary
ACI 355.4	Qualification of Post-Installed Adhesive Anchors in Concrete and Commentary
ACI 318	Building Code Requirements for Structural Concrete and Commentary
ICC-ES ACs	ICC Evaluation Service Acceptance Criteria (http://www.icc-es.org/)
ICC ES Reports	ICC Evaluation Services Reports (http://www.icc-es.org/)

A.4 LANL DOCUMENTS

Master Specification

Section 03 6000	Grout
Section 05 0520	Post-installed Concrete and Grouted-Masonry Anchors – Normal Confidence
Section 05 0521	Post-installed Concrete Anchors – High Confidence

Engineering Standards Manual

Chapter 13	Welding, Joining, and NDE
Chapter 16	IBC Program, Section IBC-GEN

LANL Standard Details for anchorage

[23] As a minimum, use standard edition referenced by required IBC edition; more recent also acceptable.

Note: At time of writing, these details complied with pre-IBC-2015 expectations. The user is responsible for any/all edits required to comply with current requirements.

- Motor Control Center Anchorage, ST-D5020-3
- Low Voltage Dry Type Three Phase Transformer Anchorage Requirements, ST-G4010-40 Sheet 2
- Wall Mounted Enclosures, ST-F1033-1
- Trailers, ST-Z1052-1 & -2

A.5 PREREQUISITES FOR DETERMINING ANCHOR DESIGN LOADS

A. As indicated in IBC/ASCE 7, the magnitude of natural-phenomena-hazard (NPH) loading that a structure (and a non-building structure, and structural /nonstructural anchorage) must be designed to resist depends on its Risk Category (RC). If the RC of a building/ structure has not already been assigned (in accordance with IBC 1604.5), then this must be accomplished by the Project design team. *This team will likely consist of at least some of the following: LANL Project Management, a safety analyst, the SEOR, and the Cognizant System Engineer (responsible for the design of mechanical and electrical equipment).*

B. *Unlike the design of the anchorage of structures (ref. A.5.A), the design of the anchorage of many (nonstructural) systems and components is NOT directly tied to RC.* The only type of NPH that many systems and components must be braced and/or anchored to resist is seismic; and in order to determine the seismic-design load (i.e., F_p), ASCE 7 (in its Chapter 13) requires the use of a Component Importance Factor, I_p. *The value of I_p can be 1.0 or 1.5, depending on the importance of the system/ component. ASCE 7 lists the conditions that require the use of $I_p = 1.5$, and only one of them is related to RC. Thus, additional time and effort will be required by the team (refer to A.5.A) in order to provide the necessary input for the design of system/component anchorage.*

C. *The value of I_p for a given system or component (ref. A.5.B) may not be sufficient to determine F_p, (and, subsequently, design the anchorage). The reason being Consequential Damage (ref. ASCE 7, paragraph 13.2.3) / System Interaction (ref. DOE G 420.1-1A).* Consideration of consequential damage requires the team (ref. A.5.A) to assess the potential for functional and physical interactions between essential/safety systems and components and nonessential/non-safety systems and components. If the potential exists for such interactions, the team must then determine whether or not they are both credible and significant. In short, the failure of essential or nonessential systems and components shall not cause the failure of essential ones, and ensuring such can affect anchorage design. *For example, if there is a suspended '$I_p = 1.0$' piping system directly above an '$I_p = 1.5$' motor control center (MCC), increasing the I_p used to design the anchorage of the piping system (to 1.5) might be necessary. And similar would apply to an '$I_p = 1.0$' piping system located above an NDC-3 / safety-class MCC, etc.*[24] If the affected essential SSC is SDC-3 then Section III on System Interaction (*para 1.7.2*) must be met.

D. Engineering drawings shall indicate the designated RC, I_p, and I_e[25] values used to design the anchorage of SSCs.

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[24] For more information and examples, see ASCE (2013) Commentary for Chapters 11-22 (seismic), para. C13.2.3 and DOE-STD-1020-2012, para. 5.5.3.9.
[25] Per ASCE 7 Chapter 15, I_e is the Importance Factor used to determine seismic-design loading for non-building structures, and its value is tied to RC.

A.6 ENVIRONMENTAL CONDITIONS

A. Anchors for indoor use in non-aggressive chemical environments may be carbon steel with zinc electroplating. Anchors for use outdoors or in aggressive environments shall be galvanized or made of stainless steel.

A.7 SEISMICALLY EXEMPT ANCHORS[26]

A. Anchors for nonstructural components that are exempt per ASCE 7 paragraph 13.1.4 need not be designed for seismic forces.

1. The exemptions from ASCE 7 paragraph 13.1.4 shall be taken to be as follows[27]:
   a. Furniture (except for "Cabinets" in ASCE 7 Table 13.5-1)[28]
   b. Temporary[29] or movable components /equipment[30].
   c. Mechanical and electrical components where all of the following apply:
      1) I_p = 1.0;
      2) The component is positively attached to the structure;
      3) Flexible connections are provided between the component and associated ductwork, piping, and conduit; and either
         a) The component weighs 400 lb or less and has a center of mass located 4 ft. or less above the adjacent floor level; or
         b) The component weighs 20 lb or less, or in the case of a distributed system, 5 lb/ft.

B. Seismically exempt anchors must comply with the provisions of this Appendix other than those related to the design for seismic forces, and the prohibition herein against the use of anchors in masonry (*A.11.B.3*) doesn't apply to seismically-exempt anchors in masonry.

A.8 POWER-ACTUATED FASTENERS

A. Power-actuated fasteners may be used for anchorage of nonstructural components provided that such use is in accordance with ASCE 7, paragraph 13.4.5. "Approved" in paragraph 13.4.5 shall be taken to mean allowed by the IBC and applicable ICC ES report (ESR). Finally, design shall comply with all requirements of the respective ESR (e.g., minimum spacing, edge distance, embedment; maximum loads; etc.).

A.9 GROUTED REINFORCING STEEL

A. Reinforcing steel (rebar) may be post-installed into hardened concrete by using an epoxy, acrylic, or cementitious grout. The design of epoxy and acrylic grouted rebar shall be in accordance with the applicable ESR. In cases where the ESR does not stipulate an embedment depth sufficient to develop the full design strength of the rebar, and the

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[26] The term "non-structural anchors" was used in this document prior to the Rev. 9 (Mar 2015) edition.
[27] The primary reason for 'LANL-izing' the ASCE 7 exemptions is LANL being located in IBC SDC D.
[28] At LANL, no 'cabinet-like' furniture is exempt (e.g., relatively tall, narrow, and heavy components /equipment, like some safes, etc.).
[29] That is, the LANL definition of temporary: per ESM Ch. 16, IBC-GEN (3 years or less per Rev. 10 Article 9.0).
[30] Movable components /equipment that are not "temporary", are not moved often, are in/near occupied areas, and that are 'Cabinet-like' will likely require at least 'non-permanent anchorage (e.g., detachable cable restraint, etc.).' Contact the ESM Ch. 5 POC for guidance.

application is such that rebar 'development' is required / assumed, an embedment depth equal to the development length of the rebar being post-installed shall be used.

B. Embedment depth of grouted rebar or threaded rod shall be determined per manufacturer design guides/ guidance, subject to the ESM Structural POC approval.

A.10 REQUIREMENTS FOR TRANSFER OF SHEAR LOAD TO FOUNDATIONS

For structures where the eave height exceeds twenty feet, provide shear lugs on base plates of columns in the SLRS. Design the lugs in accordance with the recommendations of the most current version of the AISC Steel Design Guide 1 - Base Plates and Anchor Rod Design. Do not rely on anchor bolts to transmit shear load in elements of the SLRS to foundation elements.

A.11 GENERAL DESIGN REQUIREMENTS

A. *CIP anchors (ref. A.1.C herein) should be used in lieu of PI anchors whenever possible.*

B. Use of PI anchors shall comply with the following:

1. PI anchor design shall provide for limited anchor relocation (at least ± 1 inch) to facilitate anchor installation. Due consideration shall be given to the location tolerances of the anchors to avoid interferences with reinforcement.[31]

2. Welding of PI anchors, to include welding base plates to them, is not permitted without the permission of the anchor manufacturer. And such permission must be submitted to the SEOR (for review and approval) prior to commencement of welding.

3. Except as indicated below (in A.12.B), PI anchors shall not be used in masonry walls. [32] Through-bolting may be an acceptable alternative.

4. PI anchors shall not be located in the bottom of precast and pre/post-tensioned T-beam stems. PI anchors in the sides of the T-beam stems shall be designed, and the design must be approved by the SEOR.

5. Adhesive anchors shall not be used in in environments with temperature extremes in excess of that allowed by the applicable ESR. Manufacturer's data and ESRs typically require a reduction in strength at elevated temperatures, and stipulate limitations on use in aggressive exposure conditions including fire. *At elevated temperatures where strength reduction is significant for epoxy and adhesive anchors, consider the use of cementitious grout.*

A.12 DESIGN REQUIREMENTS

A. Anchor types/ products must comply with the IBC as amended below.

[31] Spec sections 05 0520 and 05 0521 require existing concrete to be GPR-scanned (to preclude anchors from damaging rebar), the results of which might require anchor relocation. And, even when avoidance of rebar (based on existing drawings) is attempted during anchor design, GPR-scan results still might require relocation.

[32] The reason for the LANL prohibition (i.e., subject to the exception noted) is two-fold: 1) Concern for the structural integrity of the wall (following introduction of the anchor and the new load). 2) Unpredictability associated with the behavior / response of the anchorage system.

B. Additional requirements for architectural, mechanical, and electrical components, and their supports and attachments. (ref. 1613.5.3 added to IBC in Section II, paragraph1.4.2.B).

1. Revise ASCE 7, Section 13.4.2 as follows:

13.4.2 Anchors in Concrete or Masonry

13.4.2.1 Anchors in Concrete. Replace the one and only sentence with the following:
Anchors in concrete used for component anchorage shall be designed in accordance with ESM Chapter 5, Section II.

13.4.2.2 Anchors in Masonry. Replace the first sentence with the following:
Anchors in masonry shall be designed in accordance with LANL ESM, Chapter 5, Section II.

13.4.2.3 Post-Installed Anchors in Concrete and Masonry. Replace the second sentence with the following:
PI anchors in masonry used for component anchorage shall be prequalified for seismic applications in accordance with ICC-ES AC01, AC58, or AC106[33].

C. **Sections 2107.1 and 2108.1 General.** Add the following text at the end of 2107.1 and 2108.1:

PI anchors can be used in masonry provided they comply with Paragraph A.11.B above.[34]

A.13 DRAWING REQUIREMENTS

A. The SEOR shall specify each anchor to be installed. This specification shall include type, size, location requirements, effective embedment depth, minimum edge distance (in accordance with ACI 318 paragraph 17.7), and installation requirements in ACI 318 paragraph 17.8.

B. In addition to the above, for PI anchors, the SEOR shall indicate the manufacturer's name, product name, anchor diameter, minimum spacing, and the ESR number. Also, in instances in which the product has options for the type and grade of the steel, the steel type and grade to be installed must be specified. Finally, for adhesive anchors, the following shall also be indicated:

1. Anchors that are horizontal or upwardly inclined that support sustained tension.
2. Service environment of anchors (i.e., "Indoor" or "Outdoor" per ACI 318 17.4.5.2).
3. In-service temperature range of anchors (i.e., minimum and maximum temperatures in °F).

C. The SEOR shall specify, for each location in which a PI anchor is to be installed, parameters associated with the strength used for design, including anchor category and

[33] The three acceptance criteria listed come from the ASCE 7-10 Commentary para. C13.4.2
[34] The industry standard (ref. ASCE 7-10, Ch. 13) has evolved to where use of PI anchors in grouted masonry is permitted (for nonstructural components only, and subject to limitations placed on the anchor products), and IBC takes no exception to this. Furthermore, the 2015-IBC-referenced-standard edition of TMS 402/ACI 530/ASCE 5 allows the use of PI anchors embedded in grout if their capacities are determined by testing. Refer to Sections 8.1.3, and 9.1.6. The testing requirements refer to ASTM E488, which is standard to ICC ACs; thus, it's likely to be part of the three (3) ACs referenced in A.11.B herein.

'base-material-specific' information listed below[35]. In the event that none of these parameters/properties change from one anchorage location to another, they need only be indicated once.

1. Concrete Installations: Concrete type (i.e., normal- versus light-weight); compressive strength, f'c; and thickness.
2. Grouted-Masonry Installations: Masonry compressive strength (f'm) and thickness; concrete masonry unit (CMU) type (i.e., grade; type; and weight); mortar type (i.e., M, S, or N); and grout compressive strength, f'g.

NOTE: There are differences in CMU and mortar types permitted by the ESRs for masonry anchors acceptable for use (per A.12.B).

D. The SEOR shall indicate which, if any, anchors to be installed are Seismically Exempt Anchors (per A.7 herein).

E. The SEOR shall indicate corrosion protection for exposed anchors intended for attachment with future Work.

A.14 Recommended Methodology for Seismic Design of Anchorage to Concrete or Masonry for Nonstructural Components

A. Determine demand on component.

2015 IBC (1613) → ASCE 7-10 (Chapter 13, 13.2.3 and 13.3)

B. Compute demand(s) on anchorage, to include any prying effects and allowance for (potential) ± 1 inch anchor relocation.

1. For concrete, ACI 318-14 (Chapter 17, 17.2) will affect the demand(s) that must be designed for in many instances.
2. For grouted masonry, Allowable Stress Design (ASD) is a permissible alternative to Strength Design (SD; also known as Load and Resistance Factor Design, or LRFD).[36]

C. Compute anchor capacities, to include allowance for (potential) ± 1 inch anchor relocation.

1. For concrete, compute anchor capacities for various failure modes per ACI 318-14 (Chapter 17, 17.2 – 17.3).
2. For grouted masonry, use TMS 402-13/ACI 530-13/ASCE 5-13 (Chapter 8, 8.1.3.3 for ASD; or Chapter 9, 9.1.6.3 for SD) for CIP anchors; and, for PI anchors, use ICC-ES reports based on ICC-ES AC01, AC58, or AC106.

D. Determine controlling capacity.

1. For concrete, compute the controlling anchor capacity per ACI 318-14 (Chapter 17, 17.3.1.1).

[35] Since the design and performance of PI anchors are dependent upon the indicated properties (i.e., in addition to those listed in A.13.A), they are included in the Special Inspections section of each ESR, as well as the inspection table in each of the PI-anchor specification sections. Given this, the fact these properties can't be found in an ESR, and the possibility that the installer and the inspector don't know them (particularly for projects on / in existing structures), they must appear on the construction drawings.

[36] If ASD is selected, the seismic demand, Fp (ref. ASCE 7, 13.3) can be reduced by 30% (i.e., multiplying by 0.7). This reduction is required by ASCE 7, 13.1.7 for some ASD designs.

2. For grouted masonry, use TMS 402-13/ACI 530-13/ASCE 5-13 (Chapter 8, 8.1.3.3 for ASD; or Chapter 9, 9.1.6.3 for SD) for CIP anchors; and, for PI anchors, use ICC-ES reports based on ICC-ES AC01, AC58, or AC106.

E. Check capacity $\geq$ demand, to include, if applicable, interaction.

1. For concrete interaction, use either the provisions of 17.6 or equation in R17.6.
2. For grouted-masonry interaction, use TMS 402-13/ACI 530-13/ASCE 5-13 (Chapter 8, 8.1.3.3.3 for ASD; or Chapter 9, 9.1.6.3.3 for SD) for CIP anchors; and, for PI anchors, use ICC-ES reports based on ICC-ES AC01, AC58, or AC106.

A.15 ANCHORAGE OF NON-FACILITY COMPONENTS (E.G., PROGRAMMATIC, UTILITIES, INFRASTRUCTURE, ENVIRONMENTAL REMEDIATION)

Refer to ESM Chapter 16, Section IBC-GEN tables on scope (*e.g., IBC-GEN-1 and -2*) regarding need for such anchorage.

Appendix B–Design Approach to Commercially Fabricated Buildings used in Multi-State Jurisdictions[37]

1. Approval is currently limited to the following (others with Chapter POC written permission): ARMAG, MSSI, and US Chemical.

2. For ASCE 7 Risk Category I, II and III (Table 1.5-1) structures and designated-as-ML-4 structures that are not included as credited SSCs in nuclear or radiological safety documentation, commercially fabricated building-like structures that are not one of the type categories described in ASCE 7 Chapter 12 may be designed/treated as follows:

    a. Such buildings may be treated as those structures that are designed and detailed in accordance with ASCE 7 Section 15.5 for non-building structures similar to buildings, as stipulated in Section 11.1.3. However, if a nationally marketed structure type does not fit into the categories listed in Chapter 12 or in Section 15.5, then ASCE 7 Section 15.6 covering non-building structures not similar to buildings shall be used as the default structure type under the listing of "All other self-supporting structures, tanks, or vessels not covered above or by reference standards that are not similar to buildings."

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[37] A commercial building that is marketed nationally is termed "commercial building structure." Typically, these structures are factory built, transported to the site on trailers, and anchored to engineered foundations. At LANL, the intended purpose for these structures is to serve as storage facilities, control facilities for experimental work, weather proofing structures for materials, equipment or piping systems, security portals for entry access, etc. These structures are sometimes occupied, but not continuously; the occupancy is limited for the special purpose of the facility. These structures have building geometries and framing systems that may be different from the broader class of occupied structures addressed in ASCE 7, Chapter 12.

ASCE 7-10, 11.1.3, states:

"Structures and their nonstructural components shall be designed and constructed in accordance with the requirement of the following sections based on the type of structure or component:

a. Buildings: Chapter 12
b. Nonbuilding Structures: Chapter 15
c. Nonstructural Components: Chapter 13
d. Seismically Isolated Structures: Chapter 17
e. Structures with Damping Systems: Chapter 18

Buildings whose purpose is to enclose equipment or machinery and whose occupants are engaged in maintenance or monitoring of that equipment, machinery or their associated processes shall be permitted to be classified as nonbuilding structures designed and detailed in accordance with Section 15.5 of this standard…"

The limited nature of the occupancy associated with these structures reduces the life-safety risk associated with their performance in hazards such as wind and earthquakes, and therefore appropriately applies to these classes of structures as implied in the text of Section 11.1.3. This approach to Section 11.1.3, to cover both Section 15.5 and the default structure reference of Section 15.6, is necessary to cover structures in which hybrid structural systems, such as when structural steel and cold formed members are used concurrently, or other non-listed structural types that are commonly fabricated and marketed nationally.

These structures are comparatively small with respect to normal building structures and have inherent strength that is not always accounted for in normal engineering calculations. Also, given that they are transported to the site on trailers, they are essentially load-tested while in transport through road vibration and wind resistance. This provides added assurance of acceptable performance.

This approach is in keeping with ASCE 7-10, Section 11.1.4 Alternate Materials and Methods of Construction, which states "alternate materials and methods of construction to those prescribed in the seismic requirements of this standard shall not be used unless approved by the authority having jurisdiction. Substantiating evidence [as described in this clarification] shall be submitted demonstrating that the proposed alternate will be at least equal in strength, durability, and seismic resistance for the purpose intended." Approval relies on the fact that commercial building structures are engineered and that all such structures have design documents that have been appropriately stamped by a registered professional engineer.

This appendix incorporates and supersedes Clarification CIR-16-004.