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Implementation Support Document
ISD 341-2.0

Engineering Standards Manual Introduction

Los Alamos National Laboratory

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Issued By: W. Scott Gibbs, ADE

Contact: Conduct of Engineering Office (CENG), 665-2780

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1.0 Introduction

1.1 Summary

This institutional Engineering Standards Manual (ESM) establishes the technical and administrative requirements of the LANL Engineering Standards established by Implementing Procedure IMP 341, *Conduct of Engineering* (CoE).

Except as noted, the Engineering Standards are mandatory documents and apply to all LANL and subcontracted personnel performing design, fabrication, construction, and maintenance services for programmatic and facility work at LANL.

The Engineering Standards implement applicable DOE Orders and other Contract requirements.

The scope of the Engineering Standards includes the *Engineering Standards Manual* (ISD 341-2) as well as three mandatory companion documents. Also included with the Standards is a set of non-mandatory Design Guides.

The topical breadth and application of the Standards are summarized in Table 1 below and shown in much greater detail by the "LANL Engineering Standards Scope and Applicability Matrix."

Table 1 LANL Engineering Standards Breadth and Application – Summary

ENGINEERING STANDARD DOCUMENT	FACILITY	PROGRAMMATIC*
Eng Standards Manual Chapter		
Introduction (this document)	X	X
General	X	X
Fire Protection	X	
Civil	X	
Architectural	X	
Structural	X	X
Mechanical	X	X
Electrical	X	X
Instrumentation and Control	X	X
Security	X	X
Hazardous Process	X	X
Radiation Protection	X	X
Nuclear	X	X
Welding and Joining	X	X
Sustainable Design	X	
Commissioning (when issued)	X	
IBC Building Safety Program	X	alterations meet App B
LANL Master Specifications Manual	X	X
LANL Standard Drawings and Details	X	X
LANL Drafting Standards Manual	X	when added
Design Guides (guidance)	X	X

* Also applicable when such systems are perfoming the same functions as facility systems (e.g., cooling towers, electrical supply, etc.); see subsection on Programmatic Applicability below.

Standards Discipline Points of Contact (POCs) are the delegated Authorities Having Jurisdiction (AHJ) for judgments on the Standards per IMP 342, *Design Authority*. Interpretations and variances are addressed in ESM Chapter 1, Section Z10, *General Requirements for All Disciplines.*

Organization of Standards

ESM chapters are organized by the UniFormat system of the Construction Specifications Institute (CSI).

Master Specifications are arranged by the CSI MasterFormat 2004 system.

Standard Drawings and Details are numbered by the National CAD Standard and UniFormat systems.

Programmatic Applicability: In addition to the matrices of applicability discussed above, the ESM shall be applied to programmatic equipment as follows:

A. Headings in ESM chapter sections followed by "Programmatic and Facility" or a bold capital "P" or "P&F" help to indicate that subsection shall be complied with by all of LANL, including programs.

B. Furthermore, programmatic structures, systems, and components (SSCs) performing the same function as facility equipment shall be considered "facility" from the standpoint of being required to follow the entire LANL Engineering Standards (i.e., follow everything in the ESM, Master Specifications Manual, and Drafting Manual. Examples include buildings, transportables, HVAC equipment, electrical equipment, etc.).

1.2 Purpose

The purpose of the LANL Engineering Standards is to define the technical requirements for design, fabrication, construction, repair and replacement for programmatic and facility work at LANL including maintenance and modification of existing equipment and facilities, and new facilities and equipment.

This manual is established and authorized by IMP 341, *Conduct of Engineering*, and is governed by Institutional Policy IP 340, *Engineering*. Taken together, they document and define how the engineering-related elements in the paragraph above are performed by or for LANL.

The LANL Engineering Standards, in conjunction with ISD 341-1, *Engineering Processes Manual*, and ISD 341-3, *Engineering Training and Qualifications Manual,* provide a framework for the CoE Program for meeting customer needs in a safe, secure, compliant, and quality manner.

LANL Contract Appendix G contains provisions considered necessary to safety. Compliance with App. G and proper maintenance and quality assurance will result in installations with minimal hazards, but not necessarily efficient, convenient or adequate for changing mission requirements. Therefore, the LANL Engineering Standards include requirements in addition to the requirements of App. G based on:

- unique site expectations relative to existing national codes and standards,
- justifiable unique site application or configuration; or
- site-specific lessons learned.

The ESM also establishes a formal system to control the initiation, preparation, revision, and approval of engineering requirements relative to the national codes, standards and directives listed in LANL Contract App. G and unique site-specific engineering criteria.

The establishment of the Engineering Standards thus provides a method for LANL's compliance to App. G and a consistent level of quality in the design, construction, and maintenance of LANL systems, structures, and components.

1.3 Scope

The LANL Engineering Standards are institutional documents, and as such, apply to all LANL and subcontracted personnel, including those performing design, fabrication, construction, repair, and replacement. LANL Engineering Standards apply to all activities performed by and for LANL throughout the design, operation and maintenance, and other project lifecycle phases.

1.4 Requirements

The LANL Engineering Standards are written to implement contractual requirements relating to the CoE Program.

1.5 References

The LANL Engineering Standards are written using numerous references, including national codes and standards and DOE Orders, Guides, Standards, and Handbooks that contain mandates and best practices.

The ESM captures such references and others such as lessons learned, generally as footnotes.

1.6 Definitions and Acronyms

Terms used in the LANL Engineering Standards are defined in ESM Chapter 1 Section Z10. When possible, definitions are derived from higher-tier requirement and reference documents with the references listed parenthetically after the definition. In addition, acronyms are defined at their first use in each section.

1.7 Change Control

Development, review, approval, issuance, and revision of the ESM and companion documents are governed by ESM Chapter 1 Section 100. The ESM including its revisions are issued under the approval signature of the Associate Director Engineering and Engineering Sciences (ADE), the Issuing Authority for the manual. However, the CENG Office Director is authorized by ADE to issue revisions as needed.

The CENG Office has full administrative control for this manual and its associated companion documents.

1.8 Implementation

Personnel shall not deviate from the LANL Engineering Standards in developing the technical project requirements (including programming documents, functional and operational requirements, and performance criteria), in design, in practice (execution), or in written direction to any subcontractor unless such variance is formally granted as described in ESM Chapter 1 Section Z10.

Project managers shall ensure that subcontracts for design or construction require compliance with applicable portions of the Standards (e.g., non-hazardous facilities would not follow those requirements).

1.9 Record of Revisions

Rev. 0: Initial issue October 25, 2006 based on material in former IMP 342, *Engineering Standards*, and ESM Chapter 1 Section Z10. Design Guides added to scope.

1.10 Assistance

The LANL Engineering Standards, including this Introduction to the ESM, are online at http://engstandards.lanl.gov. Please contact the Discipline POCs or Standards Manager/General POC for upkeep, interpretation, and variance issues. Training on the LANL Engineering Standards is available and highly recommended for users of the Standards. There is an introductory course as well as several discipline-specific courses; see http://engstandards.lanl.gov/trn_courses.htm.

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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	2/9/04	Incorporated IBC & ASCE 7 in place of UBC 97; incorporated DOE-STD-1020-2002 versus 1994; incorporated concepts from DOE O 420.1A. FEM became ESM, an OST. General revision and improvements.	Mike Salmon, *FWO-DECS*	Gurinder Grewal, *FWO-DO*
2	5/17/06	General revision and improvements; 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; deleted NM Bldg Code based on 9/18/06 variance. Clarified table. IMP and ISD number changes based on new Conduct of Engineering IMP 341. Master Spec number/title updates. Other administrative changes.	Mike Salmon, *D-5*	Kirk Christensen, *CENG*
4	6/19/07	Added risk evaluation for projects underway due to increased seismic design basis from 2007 PSHA update (Applicability sections 1.3.B and C).	Mike Salmon, *D-5*	Kirk Christensen, *CENG*

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

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

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

I GENERAL CRITERIA FOR ALL LANL STRUCTURES

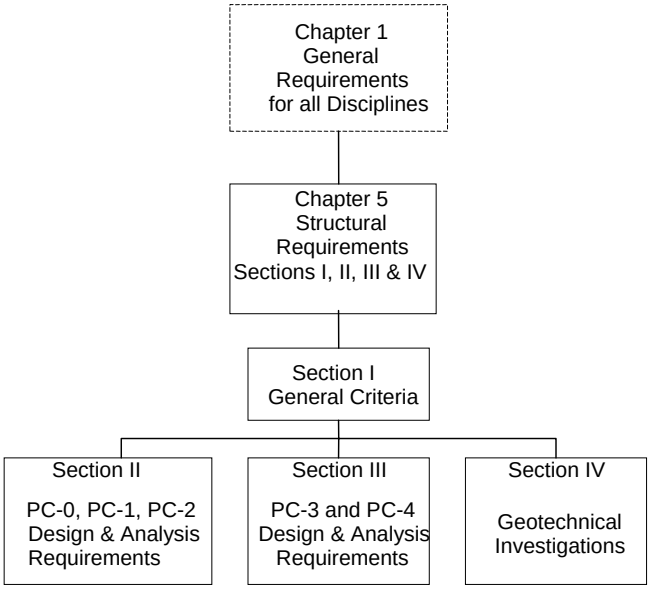
1.0 USE OF THIS CHAPTER

1.1 Purpose

A. This Chapter of the Los Alamos National Laboratory (LANL) Engineering Standards Manual (ESM) presents structural design criteria that are unique to LANL. The criteria presented herein are in addition to nationally accepted design criteria for structures. In general, the International Building Code (version and amendments per ESM Ch 16, IBC Program) shall be the code of record for the design of structures, systems, and components (SSC) at LANL. In addition, these criteria implement the Natural Phenomena Hazards (NPHs) mitigation requirements in Department of Energy (DOE) Order 420.1B, *Facility Safety*, that are applicable to all DOE nuclear and non-nuclear facilities.

B. This Chapter presents the requirements of the DOE Orders and implementing standards specific to LANL so that design engineers not familiar with DOE requirements may utilize this as a source document without referring to the parent Orders, Standards, and Guidance documents. This Chapter provides overall requirements and guidance for developing structural designs. The design organization is responsible for providing the complete design package including drawings, specifications, a design basis document, and other documentation as described in this Chapter. Goals for design basis documentation include:

- Achieve uniformity in documentation for LANL structure designs.
- Provide assurance that LANL-specific loads are addressed.



C. *Guidance: This Chapter also implements the DOE and LANL policy of a graded approach applied to structural design. Per LANL requirements (AP-341-502[1]), facility work is subjected to a level of management control commensurate with the importance of the work to safety, environmental compliance, safeguards and security, programmatic importance, magnitude of hazard, and financial impact.*

At LANL, the graded approach is implemented in Management Levels (ML). The greatest level of management control and rigor is exercised for ML-1 with the least level for ML-4. From a structural design standpoint with respect to safety, ML-1 SSC are normally those designated as safety class for Hazard Category (HC) 2 and 3 nuclear facilities or serve to provide protection to the public for non-nuclear facilities. ML-2 SSC are those designated as safety significant for HC 2 and 3 nuclear facilities or provide worker protection or significant protection against the uncontrolled release of hazardous materials from non-nuclear facilities. ML-3 SSC are important to safety but their failure would have only minimal off-site impact. ML-4 SSC failure could neither cause nor allow any significant health effects to workers or the public.

DOE requirements and guidance for implementation of a graded approach are implemented in design for NPH through the designation of Performance Categories (PCs) as defined in DOE O 420.1B, DOE G 420.1-2, DOE-STD-1021, and DOE-STD-1020 are discussed in the following section. This Chapter utilizes the NPH PCs for assigning the appropriate structural design requirements. LANL ML designations and requirements must also be included for structure design projects.

1.2 DOE Natural Phenomena Hazard Mitigation Requirements

A. *Guidance: NPH mitigation objectives defined in Chapter IV of DOE O 420.1B are to ensure that DOE facilities are designed, constructed, and operated so that the general public, workers, and the environment are protected from the impact of NPHs. The provisions in the Order apply to DOE sites and facilities and cover all NPHs such as seismic, wind, flood, and lightning. Where no specific requirements are specified, model building codes or national consensus industry standards shall be used.*

B. SSC shall be designed, constructed, and operated to withstand the effects of NPH as necessary to ensure the confinement of hazardous material, the operation of essential facilities, the protection of government property, and the protection of life safety for occupants of DOE buildings.[2] The design process shall consider potential damage and failure of SSC due to both direct and indirect natural phenomena effects, including common cause effects and interactions from failures of other SSC.

C. SSC for new DOE facilities, and additions or major modifications to existing systems, structures, and components shall be designed, constructed, and operated to meet the requirements in the previous paragraph. Any addition and modifications to existing DOE facilities shall not degrade the performance of existing systems, structures, and components to the extent that the objectives in this Section cannot be achieved under the effects of natural phenomena.

D. *Guidance: DOE G 420.1-2 notes that a key element of DOE NPH mitigation requirements is the use of a graded approach. DOE facilities are diverse enough to warrant a graded approach (e.g., some are office buildings while others contain substantial inventories of*

[1] LANL, AP-341-502, Management Level Determination
[2] NPH mitigation design requirements are presented in Ch IV of DOE 420.1B.

hazardous material). Such an approach recognizes the diversity of objectives for NPH protection, the diversity of facilities, and the diversity of measures that are appropriate to ensure suitable NPH protection. When properly developed and implemented, a graded approach optimizes the allocation of effort and resources.

E. The graded approach is implemented by assigning SSC to PCs depending on facility characteristics and defining several sets of NPH design/evaluation provisions with increasing conservatism (i.e., producing a decrease in probability of damage or failure to perform the intended safety function). Five PCs are defined in DOE G 420.1-2 ranging from PC-0 through PC-4. PC-0, PC-1, and PC-2 NPH requirements are similar to those of the IBC, and PC-3 and PC-4 NPH requirements approach those for commercial nuclear power plants.

F. *Guidance: Specific design criteria for DOE facilities for each PC are provided in DOE-STD-1020. These criteria are adopted for design of LANL facilities in this Chapter.*

1.3 Applicability

A. The requirements of this Chapter shall be applied to the design of new facility and programmatic SSC. In addition to new structural designs, this Chapter applies to renovation, replacement, modification, maintenance, or rehabilitation projects. Applicability of the provisions of this Chapter is illustrated in Table I - 1.

Table I - 1 Applicability of LANL ESM Chapter 5 to Structural Design

Circumstance	Is ESM Chapter 5 Applicable?
New structures, including replacement of existing facilities, and new SSCs that are PC-0 (e.g., sheds, sidewalks)	Yes
New non-structural systems & components in new and existing structures, including programmatic equipment	Yes, for anchorage and support design[3]
New anchorage or support for existing systems and components	Yes, for anchorage or bracing only
Renovations, modifications, repairs, alterations, or rehabilitation to existing structural systems and sub-systems	Yes[4]
Existing facility safety basis change	Yes, existing and new SSC shall be evaluated against these criteria
Existing structures (evaluation only)	No (follow DOE-STD-1020, FEMA-356, and ASCE 31)

B. **Projects which have not yet established their code of record** in accordance with ESM Chapter 1, Section Z10 on Code of Record (Subsection 4.0) shall revise their design criteria to reflect the June 2007 revision of this chapter.

[3] This chapter primarily covers the design of supports and anchorage of nonstructural systems and components. This includes complete requirements for the seismic design of those supports and anchorage. In addition, the chapter does provide some information and requirements for the seismic design of the systems and components.
[4] Work done on existing PC-0, PC-1, and PC-2 SSCs shall be in accordance with the International Existing Building Code as amended by LANL; see also LANL ESM Chapter 16, IBC Program (IBC-GEN App B, LEBC). PC-3 and PC-4 design shall follow Structural Chapter Section III.

C. For projects **with a code of record established** per Section Z10, application of the June 2007 criteria depends upon the category of the facility or system as follows:

Non-Nuclear and Low Hazard Facility

- Projects which not yet received approval to start construction (e.g., CD-3) shall perform an evaluation to assess the increased risk associated with the change in seismic response spectra. The Structural Standards POC should be consulted with regard to the evaluation methodology to be employed. The project shall work with their DOE Federal Project Director before starting the risk evaluation to reach agreement on the schedule for performing that evaluation, and after completing the risk evaluation to determine the course of action required to address the results.
- In the special case of design-build projects which have received combined CD-2/3 approval but have not yet finalized design of structural elements which are part of the lateral-force-resisting system (i.e., issued PE-stamped final drawings), the project shall perform an evaluation to assess the increased risk associated with the change in seismic response spectra. The Structural Standards POC should be consulted with regard to the evaluation methodology to be employed. The project shall work with their DOE Federal Project Director before starting the risk evaluation to reach agreement on the schedule for performing that evaluation, and after completing the risk evaluation to determine the course of action required to address the results.
- For projects which have received CD-3 approval and have issued the final, stamped design for structural elements which are part of the lateral-force-resisting system, no change in criteria or evaluation is required. Construction may proceed in accordance with the final design. The impact of the June, 2007, seismic response spectra will be evaluated in conjunction with a separate project which assesses the impact of the updated hazard on existing facilities.

Moderate and High Hazard Facility

- Projects which have not yet received approval to start operations (e.g., CD-4) shall work with their DOE Federal Project Director before starting any risk evaluation to reach agreement to determine whether to follow the requirements above (for non-nuclear) or below (for nuclear) and, after completing the evaluation, consult with DOE to determine the course of action required to address the results. The Structural Standards POC should be consulted with regard to the evaluation methodology to be employed.

Nuclear Facility

- Projects which have not yet received approval to start operations (e.g., CD-4) shall perform an evaluation to assess the increased risk associated with the change in seismic response spectra. The Structural Standards POC should be consulted with regard to the evaluation methodology to be employed. The project shall work with their DOE Federal Project Director before starting the risk evaluation to reach agreement on the schedule for performing that evaluation, and after completing the risk evaluation to determine the course of action required to address the results.

For modification projects without a DOE Federal Project Director, consult the LANL Design Authority Representative.

D. The criteria in this Chapter are intended to be used in the design of structures and structural supports for equipment and distribution systems by licensed structural design engineers. The SSC shall be assigned to NPH performance categories by LANL prior to performing the structural design. Note that over the course of the structural design, some SSC may be reclassified in higher performance categories due to system interaction effects as discussed in Section 2.5 of DOE-STD-1021. SSC reclassified into higher performance categories will need to be checked against the corresponding higher NPH loads. The appropriate PC is a function of the safety or mission importance of the SSC. Criteria are presented in this chapter for:

- PC-0, PC-1, PC-2, PC-3, and PC-4 SSC
- Structural support and anchorage of PC-0, PC-1, PC-2, PC-3, and PC-4 SSC

E. This Chapter is not intended for the design of non-structural systems and components. Refer to other chapters of the ESM for criteria that govern the design of electrical and mechanical components. The design requirements for the systems and components such as distribution systems or equipment (other than the support and anchorage) are presented in Chapter 2 (Fire Protection), Chapter 6 (Mechanical), and Chapter 7 (Electrical) as appropriate. This Chapter does address the structural and seismic analysis aspects of fire protection, architectural, mechanical, and electrical equipment, and distribution systems.

F. This chapter presents structural design criteria to be used in the design of structures and component supports against the effects of gravity loads, normal operating loads, natural phenomena hazard loads, and blast loads. The chapter presents minimum antiterrorism requirements as specified by the Department of the Defense (DOD) UFC 4-010-01. Minimum antiterrorism requirements should be considered for all facilities to the extent it is not cost prohibitive, but particular attention should be paid to antiterrorism requirements for those highly visible facilities and HC 2 or 3 nuclear facilities. The provisions in this chapter for blast are focused on structural design for blast loads. Blast loading criteria will be provided by LANL. These blast loads may either be intentional, as is the case for an experimental facility, or they may be accidental. LANL conducts experiments involving explosions and, for some of these experiments, a containment structure is provided to limit explosion effects on the surrounding area. The design of such containment structures is not within the scope of this chapter.

1.4 Exclusions

A. The provisions of this ESM apply to all LANL nuclear and non-nuclear facilities that are regulated by DOE. The following are exclusions[5] to the provisions of the ESM:

1. Requirements in this Order that overlap or duplicate requirements of the Nuclear Regulatory Commission (NRC) related to radiation protection, nuclear safety, (including quality assurance), and safeguards and security of material, do not apply to the design, construction, operations, and decommissioning of DOE facilities. This exclusion does not apply to requirements for which the NRC defers to DOE or does not exercise regulatory authority;
2. Pursuant to Executive Order (E.O.) 12344, Naval Nuclear Propulsion Program, the Director, Naval Nuclear Propulsion Program, will implement and oversee requirements of this Order for programs under the Directors cognizance as set forth

[5] From DOE O 420.1B.

in the Defense Procurement Reform Act of 1984 [Public Law (P.L.) 98-525] and the Military Lands Withdrawal Act of 1999 (P.L. 106-65);

3. Requirements of this Order that overlap or duplicate requirements of the Department of Transportation (DOT) do not apply. This exclusion does not apply to requirements for which DOT defers to DOE or does not exercise regulatory authority;

4. Activities under the Nuclear Explosives and Weapons Safety Program for prevention of accidental or unauthorized nuclear detonation are excluded from a requirement of this Order only if the requirement would compromise the effectiveness or safety of those activities.[6]

1.5 Chapter Contents and Conventions

A. This Chapter consists of four sections. Sections I, II, and III provide the structural design and analysis criteria for SSC at LANL. Section I provides general guidance, criteria, and background on structural design, quality assurance, and design documentation. Sections II and III provide more prescriptive criteria to be used in the actual structural design. Due to similarity of PC-0, PC-1, and PC-2 NPH requirements, the design of PC-0, PC-1 and PC-2 structures and the design of the structural support and anchorage of PC-0, PC-1 and PC-2 systems and components are addressed together in Section II. Similarly, due to similarity of PC-3 and PC-4 NPH requirements, the design of PC-3 and PC-4 structures and the design of the structural support and anchorage of PC-3 and PC-4 systems and components are also addressed together in Section III. Section IV provides geotechnical requirements.

B. All text in regular type indicates mandatory requirements unless prefaced with wording identifying it as guidance or a recommendation. Where appropriate, guidance is provided to aid the cost-effective implementation of site-specific requirements and the requirements in the applicable codes. *Italicized* text identifies recommended guidance (not mandatory), based on good business practice and through lessons-learned at LANL. Footnotes throughout the chapter add commentary or additional background information on the basis of particular provisions.

1.6 Project Records for Structural Design

A. **Project Requirements for Structural Designs:**

1. This Chapter (structural) of the ESM along with applicable building codes, DOE Orders and Standards, and applicable material standards and design manuals provide the basic project requirements for structural design projects. In addition, there are generally project specific design requirements provided by LANL. Project specific requirements may be in the following form:

   - Design bid package including the Request for Proposal (RFP)
   - Project functional requirements.
   - Facility safety analysis reports.
   - Project design criteria

2. All of these project requirements shall be referenced, where applicable, in the project submittals to LANL.

[6] 49 CFR 173.3 “Shippers-General Requirements for Shipments and Packagings, U. S. Government Material.”

B. **Project Submittals:**

1. Project records for structural design shall be prepared considering the concept of a graded approach where the level of detail and rigor is consistent with the importance to safety, mission importance, and project cost. The greatest level of detail and rigor is required in the design and documentation for SSC that are in ML-1 or ML-2 projects or are in systems designated as PC-3 or PC-4. Lesser level of detail is acceptable for SSC in ML-3 or ML-4 projects or in systems designated as PC-0, PC-1 or PC-2. Extensive documentation is generally required for the structural design of new buildings.
2. If such buildings are classified as PC-3 or PC-4, the structural design will be performed under close scrutiny by LANL and DOE reviewers such that the level of documentation is especially important and extensive documentation will generally be required. However, many LANL structural design projects may be simple efforts involving modifications to portions of buildings or installation of new equipment or systems in existing buildings. For these types of projects, it may be possible to document the structural design by drawings with notes along with structural calculations. For all structural design projects, large or small, all of the information described in this section must be documented in some manner.
3. The project records for structural design to be submitted to LANL shall consist of the following:
   - Design Basis Document (DBD)
   - Structural Calculations
   - Test and Inspection Requirements
   - Project Quality Assurance (QA) Plan
   - Construction Drawings
   - LANL Master Specifications
4. At a minimum, the DBD, construction drawings, and construction specifications shall be submitted to LANL for review. The review is conducted by the LANL Engineering Standards Chapter 5 Point of Contact (POC), or his/her designee, as the structural authority having jurisdiction for review and approval.
5. Construction documents shall comply with the applicable sections of the New Mexico Engineering and Surveying Practice Act (Chapter 61, Article 23-21, Paragraph B, NMSA 1978).[7]

   http://www.state.nm.us/pepsboard/act.html

   The New Mexico professional engineer in charge and directly responsible for the structural engineering work shall seal and sign the DBD, structural calculations, construction drawings, construction specifications, and test and inspection requirements. Also see LANL ESM Chapter 1, Section Z10 on Design Output Submittals.

C. **Design Basis Document (DBD):**

1. The DBD provides a summary of the specific facility structural design basis and shall include the PC of the SSC being designed, design codes of record (dates and editions), methods (computer codes, analytical methods), load definition, load

[7] This section of the act is currently scheduled to be repealed effective July 1, 2006.

combinations, load path, member capacity equations, and corresponding applicable acceptance criteria. The DBD shall describe the design of building structures, non-structural components, equipment, and distribution systems. A sample format for a DBD is presented in Figure I - 1.

2. The DBD may be used to eliminate load combinations as described in Sections II and III from consideration by showing that they are either not applicable or bounded by other load combination equations. Once the design basis document is established, **it does not** have to be revisited during the project duration for changes or updates in the ESM or the referenced standards unless otherwise noted in the LANS/DOE Contract. Also see LANL ESM Chapter 1 Section Z10 on Code of Record.

- Facility Background and Mission*
- Facility Hazard Categorization and Basis per IMP 111 and ISD 111-1.0[8]*
- Management Level for the Project per LIR 230-01-02 and LIG 230-01-02*
- Assignment of SSC as Safety Class, Safety Significant, or Important to Safety and Assignment of SSC to NPH Performance Categories*
- Facility Siting Considerations (standoff distance from known faults, flood levels, etc.)*
- Natural Phenomena Hazard Definition
  - Earthquake (DBE ground response spectra)
  - Wind (peak gust speed)
  - Wind Driven Missiles (definition)
  - Snow
  - Flood and local precipitation (if applicable or basis for not considering)
- Antiterrorism Measures*
- Experimental Explosion Design Considerations
- Accidental Explosion Design Considerations
- LANL ESM Revision and Edition
- Design Codes and Standards of Record (Edition and Rev. Date)
- Rationale for Selection of Structural Systems
- Analysis Methodology (Determination of Structural Demand)
- Member Capacity Equations Not Included in Design Codes or Not Commonly Used
- Load Combinations (May Refer to Chapter 5 of the ESM)
- Load Path
- Means of Accounting for Inelastic Behavior During the DBE in the Seismic Analysis and in Design Detailing

* This information is typically found in other documents such as the Facility Design Description (FDD) or System Design Descriptions (SDD) and only a brief summary from these documents need be included in the DBD.

Figure I - 1 Design Basis Document Sample Format

3. In addition to describing the design basis for gravity loads, normal operating loads, and NPH loads, the DBD shall describe the design basis for blast loads and any antiterrorism measures implemented. Blast loads can result from either planned experiments or accidents involving explosives or flammable materials. The design

[8] IMP 111.0, "Facility Hazard Categorization," March 2007.
ISD 111-1.0, "Facility Hazard Categorization Procedure," March 2007.

blast loads, methods of analysis, and levels of acceptable blast damage shall be addressed in the DBD. Antiterrorism measures, if present, shall follow the minimum standards from the DOD UFC 4-010-01 and shall also be addressed in the DBD.

4. A PC must be assigned to an SSC to establish the appropriate NPH (earthquake, wind, and flood) design and analysis requirements as put forth in DOE-STD-1020. This standard provides design criteria for four performance categories, PC-1 through PC-4. The assignment of NPH performance categorization is accomplished using the guidance established in DOE-STD-1021. The basis for assignment of performance categories to SSC shall be either summarized or presented in detail in the DBD. The assignment of performance categories may be summarized when a safety analysis report exists that contains the detailed information. The assignment of performance categories shall be presented in detail when a separate document, such as a safety analysis report, does not present the basis for assignment of performance categories. NPH performance categories will be provided to the structural designer by LANL.
5. A separate DBD is required for major structural design projects. Where the ESM is employed for the design of small buildings, equipment slabs, or structural components, etc., the contents of the DBD, as described above, may be included as front matter in the structural calculations.[9]

D. **Structural Calculations:**

1. Structural Calculations shall be performed, numbered, and approved in a consistent format as described in the Project QA Plan (see Section I 1.6.F and Figure I - 2) and shall include, at a minimum, sections for Purpose and Objective, Methodology and Acceptance Criteria, Assumptions, Design Input, References, Calculations, and Summary and Conclusions. Calculations may be performed by hand or by computer analysis. Computer analyses shall conform to the requirements given below. *One acceptable procedure for performing calculations for LANL is AP-ENG-605 (becoming AP-341-605).*[10] Structural Calculations shall be signed by a Preparer, a Checker (that attests to numerical accuracy), and an Approver (attests to reasonableness of the theory and assumptions and to the validity of the conclusions reached). The checker and approver may be the same individual but not the preparer. All structural design calculations shall be performed following a LANL approved QA program. The requirements of the QA program may be tiered for the various NPH performance categories by the graded approach philosophy.
2. *Calculations performed by computer analysis.* When computer analysis is performed, input and output shall be numbered in a consistent format as described in the Project QA Plan. The documentation for the computer analysis shall be included in the overall calculation, as described above. *Computer Input and Output files may be included in Attachments/Appendixes to the Calculation.* Preparer, Checker and Reviewer requirements are as described above. The documentation for computer analysis shall, at a minimum, include a brief description of the structural model, the loading, a figure showing the model configuration [with control nodes shown along with the most limiting structural components (members)], and how the results of the analysis are applied. The analysis input file

[9] The majority of LANL structural design projects are small and will not require a formal DBD.
[10] "Engineering Calculations," LANL ADE-ES Division, AP-ENG-605-R3, 2006.

and condensed output files directly used to support the analysis results shall be included. Additional output files may either be included or stored in an electronic format. Documentation shall be sufficient to insure that a third party may take the input file and reproduce the analysis results. Also, documentation shall be sufficient to the extent that the reviewer can determine that the model is valid and that the results were properly interpreted.

E. **Test and Inspection Requirements:**

1. Special inspection, test, and structural observation requirements shall be provided on the drawings, or in a stand-alone document, for new construction or modifications to existing SSC. Minimum requirements for special inspection, testing, and structural observation are given in ESM Chapter 16, IBC Program. The special inspection, test, and structural observation requirements should be conducted within the framework of a graded approach with an increasing level of rigor employed from PC-0 to PC-4 SSC. The goal of these requirements is to ensure that construction is implemented in the manner intended by the structural design engineer.

F. **Project Quality Assurance Program (QAP)**

The following sections describe the QAP and Peer Review requirements for the structural aspects of a project. The QA and peer review should be conducted within the framework of a graded approach with increasing level of rigor employed from PC-0 to PC-4 facilities. These requirements shall be documented in a Project QAP. A sample format covering the required structural design elements of a project for the Project QAP is presented in Figure I - 2.

1. **QA Requirements:**

a. The LANL basic QAP requirements are described in LANL IP 330.0[11] which invokes NQA-1 and 10 CFR Part 830 (Subpart A, Quality Assurance Requirements) for nuclear facility applications and DOE Order 414.1C (CRD/Att. 2 Section 3.f.6 deals with design QA) for non-nuclear-related facilities. A QAP that, at a minimum achieves the DOE/LANL QA requirements for specifications, drawings, procedures, and instructions shall be used. The basic elements of the structural analysis and design QAP shall address the following:

- Design Organization: Analysis team, division of responsibility, team interface control, and organizational procedures and standards.
- Design Procedures
- Design Basis Document
- Methods for Design Verification
- Design reviews and independent peer review
- Design output documents (i.e., drawings, specifications, and calculations)
- Design document control

b. The QAP shall at a minimum include provisions for verifying and checking the adequacy of the analysis and design either by directly checking the original analysis and verifying the underlying assumptions, or by use of alternate or simplified calculation methods or the performance of a suitable testing program or by the performance of design reviews.

[11] IP 330.0, LANL Quality Assurance Program, March, 2007.

QA PLAN

- QA Requirements for Project (May refer to a manual, rev. and date)
- Project and QA Team Qualifications
- QA Training Requirements
- Design Basis Document Requirements
- Design Procedures
- Calculation Requirements (may refer to a LANL master specification)
- Computer Analysis Requirements (may refer to a LANL master specification)
- Inspection, Observation, and Testing Requirements
- Drawing/Specification Requirements (including New Mexico PE Stamp requirements)
- Document Control and Records Management
- Design Review and Independent Peer Review
- Application of Graded Approach for QA Process
- Work Processes

PEER REVIEW PLAN

- Peer Reviewer Qualifications
- Scope of Peer Review Process (When, What, and Where)
- Format of Final Report from Peer Reviewer
- Application of Graded Approach for Peer Review Process

Figure I - 2 Structural Design Project QA Plan and Peer Review Samples Format

2. **Peer Review Plan**

a. Qualified LANL staff will review PC-0 and PC-1 SSC. Qualified LANL staff or external expert consultants, hired by the Laboratory, will be engaged to peer review the design and analysis of PC-2, PC-3, and PC-4 SSC. In all cases, the project peer reviewer shall not be engaged in design activities for the project. Peer review is in addition to the design review performed in the QA portion of the project and provides an independent evaluation of the design. Peer review shall be performed by either internal and/or external personnel with recognized technical credentials concerning the unique features of the design and analysis. The peer review effort may be performed in series or in parallel with the design or analysis process. *However, for most projects, it is recommended that peer review should be performed in parallel.*[12] The Peer Review Plan will include the requirements for Structural Calculations, Computer Analyses, and Test and Inspection Requirements as discussed above.

b. A graded approach shall be used so the scope of the review, including the number of reviewers engaged, is consistent with the complexity of the design, the number of disciplines involved, and the uncertainty in the data.

[12] For large projects, it is recommended that the peer review effort should at least include a review of the DBD, sample calculations performed early in the project, specialized or unique calculations and the final documentation at the end of the project. This enables the peer review effort to have a positive effect on the project throughout and minimizes re-work and surprises at the end of the project.

c. Peer Review of the analysis of the structural system used to verify the proposed design should consider the following elements:

- Applied loads
- Adequacy of model
- Assumptions upon which the model is based
- Use of the results from the analysis
- Appropriateness of the solution technique or analysis software
- Adequacy of horizontal and vertical load paths
- Proper inclusion of the geotechnical investigation into the analysis

G. **Construction Drawings:**

1. Construction drawings for new design and modifications to existing design shall be prepared in accordance with the LANL Drafting Manual. Applicable codes and manuals and design criteria shall be provided on the general structural notes sheet of the drawing set. Codes and manuals and project design requirements, including their edition or date, used for the structural design shall be listed. Also, vertical (e.g., dead load, live load, etc.), horizontal (e.g., wind loads), and seismic loads used in the design shall be listed.

H. **Master Specifications** (Programmatic and Facility)**:**

1. Construction specifications for new design and modifications to existing design shall be prepared to provide project specific construction requirements associated with the structural design of the building and the construction/installation of supports and anchorage for systems and components. The specifications shall include all applicable requirements in the templates provided in the LANL Master Specifications Manual.[13]

2. The LANL Standards Program maintains standard specifications for those that provide and construct PC-0, PC-1, and PC-2 building structures as well as certain nonstructural components at the LANL site. These specifications should be edited to suit the particular project; however, when editing, author shall add job-specific requirements and delete only those portions that do not apply to the Project (e.g., a component that does not apply). To seek a variance from applicable requirements, contact the Engineering Standards Structural POC.

   Available Master Specifications include:

   Section 03 3001 – Reinforced Concrete
   Section 03 1512 – Post-installed Concrete Anchors for ML-1 and ML-2 – Purchase
   Section 03 1534 – Post-installed Concrete Anchors for ML-3 and ML-4 – Purchase
   Section 03 1550 – Post-installed Concrete Anchors – Installation and Testing
   Section 03 3053 – Miscellaneous Cast-in-place Concrete
   Section 04 2000 – Unit Masonry
   Section 05 1000 – Structural Metal Framing
   Section 05 1305 – Stainless Steel
   Section 05 2100 – Steel Joist Framing
   Section 05 3113 – Steel Floor Decking
   Section 05 3123 – Steel Roof Decking
   Section 05 4000 – Cold-Formed Metal Framing

[13] For small structural design projects, specifications may be in the form of notes on the drawings.

Section 05 5200 – Metal Railings
Section 05 5350 – Metal Gratings and Floor Plates
Section 13 3425 – Pressure Relief Wall Panels
Section 13 4800 – Sound, Vibration, and Seismic Control
Section 13 3419 – Metal Building Systems
Section 22 0548 – Vibration and Seismic Controls for Plumbing Piping and Equipment
Section 26 0529 – Hangars and Supports for Electrical Systems
Section 41 2213.13 – Bridge Cranes

NOTE: The specifications were developed for ML-4, PC-0, and PC-1 projects. For ML-1/ML-2/ML-3, PC-2, PC-3, and PC-4, additional requirements and QA reviews are normally required. Refer to ASCE/SEI-43 Section 9.0, Seismic Quality Provisions, for guidance.

1.7 Codes and Standards

A. The Standards and Manuals discussed in Section 1.7 are not intended to cover all requirements necessary to provide a complete operating facility. The engineer/designer should review the project specific requirements to identify additional requirements. Project specific requirements are provided by LANL.

B. Refer to ESM Chapter 1 Section Z10 if there is a conflict between codes, standards, and LANL requirements.

C. Refer to Chapter 1 Section Z10 for variances and exemptions from the LANL Standards.

D. Questions concerning the contents in these standards and manuals should also be addressed to the LANL Engineering Standards Chapter 5 POC.

E. **Codes of Record and Additional References**

1. The user of the ESM shall comply with the code edition referenced herein (Section I.1.7) or the latest edition at the time of design contract RFP (or design initiation in the case when LANL staff is performing the design or evaluation). That same code edition will normally be used throughout the project's design and construction. The DBD shall identify the exceptional cases where the code edition is updated while project design and construction phases are ongoing shall take precedence over code editions in effect at project start. The edition of the codes and standards used in the design shall be referenced in the DBD as noted in Section 1.2.B. The codes, standards, laws, orders, and additional references (publications and papers) presented in Section I.1.7 are used in the evaluation of SSCs as described in this Chapter.
2. If there is a conflict between the referenced codes, standards, and LANL structural design requirements in this manual, contact the LANL Engineering Standards Chapter 5 POC for assistance in resolving the conflict.
3. If there is a conflict between the referenced books, papers and report, and LANL structural design requirements in this manual, the LANL ESM requirements shall govern.[14]

[14] The papers, books and reports referenced are normally used in this Chapter for narrow technical issues. The

F. **LANS/DOE Contract (Programmatic and Facility)**:

- A number of contractually-required Order and standards are contained in the LANS/DOE Contract Appendix G.
- Comply with the edition and addenda(um) in effect on the effective date noted in the LANS contract unless otherwise noted[15], and the latest edition of the CFRs.

  http://www.doeal.gov/laso/NewContract.aspx or internally http://int.lanl.gov/orgs/pcm/

G. **Conduct of Engineering, IMP 341**

LANL organizations are required to follow the primary manual and the three companion manuals:

- **Primary Manual: ISD 341-2, LANL Engineering Standards Manual.** The LANL Engineering Standards Manual is arranged by discipline specific chapters and provides site-specific engineering requirements, guidance, and design criteria for LANL facilities.
- **Companion Manual: LANL Master Specifications**: The LANL Master Specifications Manual provides templates for the preparation of project specific construction specifications at LANL. These documents are referenced throughout the ESM. The specifications shall be edited to reflect the scope of the project. Variances taken by the engineer/designer for a portion of an applicable Master Specification template shall be approved by the LANL Engineering Standards Chapter 5 POC.
- **Companion Manual: LANL Standard Drawings and Details**: The LANL Standard Drawings and Details provides standard drawings and details for preparation of the construction drawings.
- **Companion Manual: LANL Drafting Standards Manual**: The LANL Drafting Manual provides drafting requirements for use when creating or revising construction drawings for LANL construction projects and preparing as-built drawings.
- The four manuals are available at http://engstandards.lanl.gov/New_Home.html

2.0 ACRONYMS AND NOTATIONS

The following is a list of acronyms, notation, symbols, and shortened titles used in this Chapter. Load related symbols and factors are defined in Section II.1A and III.1A.

AA – Aluminum Association

AASHTO – American Association of State Highway and Transportation Officials

ACI – American Concrete Institute

ADM – Aluminum Design Manual

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provisions of this Chapter are included to be consistent with the governing consensus code or standard not individual papers, books or reports.

[15] On May 17, 2006 the WSS stated "IBC International Building Code, latest edition, as amended by the LANL Engineering Standards Manual." At the same time, because ESM Ch 1 Z10 amended this to the 2003 edition, thus 2003 was required.

AISC – American Institute of Steel Construction

AISI – American Iron and Steel Institute

ANSI – American National Standards Institute

API – American Petroleum Institute

ASCE – American Society of Civil Engineers

ASME - American Society of Mechanical Engineers

ASTM – American Society of Testing Materials

ASD – Allowable Stress Design

ATC – Applied Technology Council

ASME – American Society of Mechanical Engineers

AWS – American Welding Society

BLEVE – Boiling Liquid Expanding Vapor Explosion

BNL – Brookhaven National Laboratory

CCPS – Center for Chemical Process Safety

CE – Carbon Equivalent

CFR – Code of Federal Regulations

DBD – Design Basis Document

DBE – Design Basis Earthquake

DOD – Department of Defense

DOD-TM - Department of Defense Technical Manual

DOE – Department of Energy

DOE G – Department of Energy Guideline

DOE M – Department of Energy Manual

DOE-STD – Department of Energy Standard

DOT – Department of Transportation

EBF – Eccentric Braced Frame

ESM – Engineering Standards Manual

F_μ – Inelastic Energy Absorption Factor

FDD – Facility Design Description

FEMA – Federal Emergency Management Agency

FIMS – Facility Information Management System

FS – Factor of Safety

HC – Hazard Category

HVAC – Heating Ventilation and Air Conditioning

I – Importance Factor

IBC – International Building Code

ICC – International Code Council

ICC ES – International Code Council Evaluation Service

IEBC – International Existing Building Code

IEEE – Institute of Electrical and Electronics Engineers

IMP – Implementation procedure

IMRF – Intermediate Moment Resisting Frame

ISD – Implementation Support Documents

LANL – Los Alamos National Laboratory

LANS – Los Alamos National Security, LLC

LLNL – Lawrence Livermore National Laboratory

LRFD – Load & Resistance Factor Design

ML – Management Level

MMRWF – Masonry Moment Resisting Wall Frame

$N_{allowable}$ – Allowable strength in tension

N_n – Nominal strength in tension

NASPEC – North American Specification

NEMA – National Electrical Manufacturers Association

NFPA – National Fire Protection Association

NNSA – National Nuclear Security Administration

NPH – Natural Phenomena Hazard

NRC/NUREG – Nuclear Regulatory Commission

OMRF – Ordinary Moment Resisting Frame

PC – Performance Category

PGA – Peak Ground Acceleration

PI – Post-installed

POC – Point of Contact

QA – Quality Assurance

QAP – Quality Assurance Program

R, R_p – Response Modification Coefficient

RFP – Request for Proposal

RRS – Required Response Spectrum

SAM – Seismic Anchor Motion

SD – Strength Design

SDD – System Design Description

S_{D1} – Response Spectral Acceleration at 1 Second Period

S_{DS} – Peak Response Spectral Acceleration (0.2 Second Period)

SF – Scale Factor

SMACNA – Sheet Metal and Air Conditioning Contractors' National Association

SMRF – Special Moment Resisting Frame

SRSS – Square Root Sum of the Squares

SSI – Soil Structure Interaction

SSC – Structures, Systems, and Components

TEMA – Tubular Exchanger Manufacturers Association

TRS – Test Response Spectra

TNT – Trinitrotoluene

UFC – Unified Facilities Criteria

UHRS – Uniform Hazard Response Spectrum

$V_{allowable}$ – Allowable strength in shear

V_n – Nominal strength in shear

ZPA – Zero Period Acceleration

θ – Stability Coefficient Used to Measure the Significance of P-Delta Effects

Ω_0 – System Overstrength Factor

ϕ – Capacity Reduction Factor

λ – Reduction Factor for Concrete Cracking

ρ – Redundancy Coefficient for the Structure

3.0 DEFINITIONS

Anchor – A steel element either cast into concrete or masonry or post installed into a hardened concrete or masonry member. Including headed bolts, hooked bolts (J- or L- bolt), headed studs, expansion anchors, or undercut anchors. Anchors in the context of the ESM also include steel to steel connection elements and welds. Anchors are used to transmit applied loads.

Anchorage – A device or a collection of devices that provide structural support or restraint for systems and components to prevent falling, sliding, overturning, and excessive displacement.

Attachment – The structural assembly, external to the surface of the concrete that transmits loads to or receives loads from the anchor.

Bearing wall system – A structural system without a complete vertical load-carrying space frame. Bearing walls provide support for some of the gravity loads. Resistance to lateral load is provided by shear walls or braced frames, which also provide resistance to gravity loads.

Cast-in Place Anchor – A headed bolt, headed stud, or hooked bolt installed before placing concrete.

Collector Elements – A diaphragm or shear wall element parallel to the applied load that collects and transfers shear forces to the vertical-force-resisting elements or distributes forces within a diaphragm or shear wall.

Critical Damping – Level of damping at which no oscillations of dynamic response occur.

Distribution System – A system whose function is to distribute material (fluid, signals, power).

Dual system – A structural system with the following features: An essentially complete space frame that provides support for gravity loads, resistance to lateral load is provided by shear walls or braced frames or moment-resisting frames (SMRF, IMRF, MMRWF or steel OMRF) with the moment-resisting designed to independently resist at least 25 percent of the design base shear, and the two systems designed to resist the total design base shear in proportion to their relative rigidities considering the interaction of the dual system at all levels.

Edge Distance – The distance from the edge of the concrete surface to the center of the nearest anchor. Also, the distance from the edge of a steel plate to the center of the nearest anchor bolt.

Effective Stiffness Factor – Modifier (e.g., 0.5, 0.8) that is applied to the uncracked section properties of a reinforced concrete member to account for the softening effect that cracking has.

Embedment Depth – The overall depth through which the anchor transfers force to or from the concrete by direct bearing or friction or both. The embedment depth is measured from the bearing contact surface of the bolt end to the top of concrete.

Exceedance Frequency – The annual probability of exceeding a given ground motion. For example, at LANL, the mean exceedance frequency associated with a peak ground acceleration of 0.34g is 4×10^{-4} (i.e., 1/2500) or an average return period of 2,500 years.

Existing Facility – A facility that has received authorization to operate on or before the effective date of this ESM Chapter, or if authorization is not required, a facility that has begun normal operation on or before the effective date of this ESM Chapter.

Expansion Anchor – A post-installed anchor, inserted into hardened concrete that transfers loads to or from the concrete by direct bearing or friction or both. Expansion anchors may be torque-controlled, where the expansion is achieved by a torque acting on the screw or bolt; or displacement-controlled, where the expansion is achieved by impact forces acting on a sleeve or plug and the expansion is controlled by the length of travel of the sleeve or plug.

Facility – One or more building(s) or structure(s), including systems and components, dedicated to a common function (includes operating, non-operating, and facilities slated for decontamination and decommissioning).

Fragility – A conditional cumulative probability density function related to failure or other dysfunction limit. The function is often related to a key parameter, such as PGA (or sometimes spectral acceleration or displacement) associated with failure level.

Inelastic Energy Absorption Factor (F_μ) – A factor used to reduce linearly estimated demand to account for limited inelastic behavior in PC-3 and PC-4 SSCs. The Inelastic Energy Absorption Factor is a function of the target limit state and the structural system configuration.

Graded Approach – A process by which the level of analysis, documentation, and actions necessary to comply with requirements are commensurate with: the relative importance to safety, safeguards, and security; the magnitude of any hazard involved; the life cycle stage of a facility; the programmatic mission of a facility; the particular characteristics of a facility; and any other relevant factor.

Hazard – A source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to personnel or damage to an operation or to the environment (without regard for the likelihood or credibility of accident scenarios or consequence mitigation).

Headed Stud – A steel anchor conforming to the dimensional specifications in AWS D1.1 consisting of a steel rod with a larger diameter head on its end for providing mechanical anchorage in concrete. Applications are for attaching steel base plates or embedded steel plates to concrete or to effectively tie the concrete to the steel beams and to resist shear loadings between the concrete slab and steel beam in composite construction. The head of the anchor typically has a diameter equal to twice that of the rod.

High Confidence of Low Probability of Failure (HCLPF) – Usually a 90% confidence of a less than 10% probability of failure which results in about a 1% to 2% probability of failure

Hooked Bolt – A cast-in anchor anchored mainly by mechanical interlock from the 90-degree bend (L-bolt) or 180-degree bend (J-bolt) at its lower end.

Headed Stud – A steel anchor conforming to the requirements of AWS D1.1 and affixed to a plate or similar steel attachment by the stud arc welding process before casting.

Item – Structural component, structure, system or component (see individual definitions).

Limit State – The limiting acceptable condition of the SSC. The limit state may be defined in terms of a maximum acceptable displacement, strain, ductility, or stress.

Load Path – The path of resistance consisting of structural or non-structural members that an imposed load will follow from the point of origin (inertial forces at location or structure mass) to the point of final resistance (supporting soil).

Mean Annual Hazard – The expected (or average) exceedance frequency associated with a given hazard. Future seismic loads are highly variable. For a given site, there is typically, a “mean annual seismic hazard” curve that expresses the average (or expected) value of a ground motion parameter, such as peak ground acceleration, as a function of the probability of exceedance of that variable.

Moment Resisting Frame System – A structural system with an essentially complete space frame providing support for gravity loads. Moment-resisting frames provide resistance to lateral load primarily by flexural action of members.

Natural Phenomena Hazard (NPH) – An act of nature (e.g., earthquake, wind, tornado, flood, precipitation, volcanic eruption, or lightning strike) that poses a threat or danger to workers, the public, or to the environment by potential damage to structures, systems, and components.

New Facility – A DOE facility that does not qualify as an existing facility.

P-Delta (P-Δ) Effect – Additional moment induced in axial load carrying members caused by structural deformation of the joints. The P-Delta moment is the product of the axial force and the relative displacement between the end points of the member.

Peak Ground Acceleration (PGA) – The maximum absolute value of the ground acceleration time history.

Peak Spectral Acceleration – The maximum acceleration response that a prescribed forcing function can produce in a single degree of freedom oscillator (independent of the natural frequency of the oscillator).

Peer Review – A formal review process in which an external party (independent from the project) will review the methodology, results, and process by which a design is developed.

Pinched Hysteretic Behavior –A characteristic of the load-deformation loop of a structural component subjected to cyclic loading that is marked by both strength and stiffness degradation in successive loading and unloading cycles beyond yield. See example below.

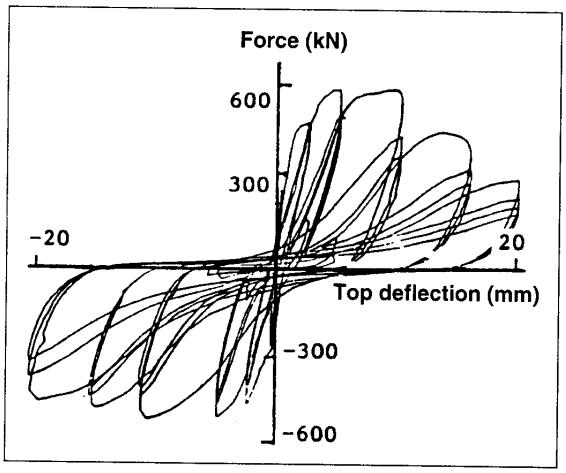

Figure C6-21 Lateral Shear Force versus Top Displacement of Shear Wall Specimen 1

Plan Structural Irregularity – Structural irregularity at a given floor level in the building due to unsymmetric mass or stiffness.

Plastic Hinge Length – Region of plastic deformation, may be approximated by a length equal to one beam depth.

Post-installed anchor – An anchor installed in hardened concrete. Expansion anchors and undercut anchors are examples or post-installed anchors.

Response Modification Coefficient (R) – A factor used to reduce demand to account for limited inelastic behavior and other factors (e.g., overstrength, redundancy) in PC-1 and PC-2 SSCs. The Response Modification Coefficient is a function of the structural system configuration.

Required Response Spectra (RRS) – The representation of the response spectra that are required to qualify a structure, system or component. The required response spectra will often include factors of conservatism required to meet probabilistic performance goals.

Safety Class – A category for facilities or structures, systems, and components identified by a safety analysis whose importance to safety is to prevent or mitigate potential adverse consequences to the general public or the environment.

Safety Significant – A category for facilities or structures, systems, and components identified by a safety analysis whose importance to safety is to prevent or mitigate potential adverse consequences to the facility workers or occupants.

Seismic Capacity – The capacity of a structure, system or component to withstand the loadings imposed on them from an earthquake. The capacity is a combination of the structures strength and

ductility.

Seismic Demand – The demand imposed on the structure, system, or component being evaluated at the earthquake level under consideration. The seismic demand may be a force or a displacement.

Seismic Hazard Curves (HC) – Description of the ground motion parameter of interest as a function of annual frequency of exceedance. Peak ground acceleration and spectral accelerations at 0.2 sec and 1 second natural period plotted as a function of annual frequency of exceedance are common. The seismic hazard curves are determined from a probabilistic hazard assessment following the guidance in DOE-STD-1022 and DOE-STD-1023.

Significant – Greater than a 5% increase in the response item of interest.

Special Moment Resisting Frame (SMRF) – Also known as special moment frame, is a moment-resisting frame specially detailed to provide ductile behavior and comply with the requirement given in AISC Seismic Provisions, and the IBC

Spectral Acceleration – The maximum acceleration response of a single-degree or freedom oscillator of a know frequency, f and viscous damping, β, subjected to a prescribed forcing function.

Structural Element – Portion of a structure such as a beam column, brace, anchor or support (pipe or cable tray, etc.).

Structural Lead Engineer – Engineer appointed to lead the structural design activities for a project.

Structures, Systems, and Components (SSC) – A structure is an element or a collection of elements to provide support or enclosure (such as a building, free-standing tank, basins, dikes, or stacks). A system is a collection of components assembled to perform a function (such as piping, cable trays, conduits, or HVAC. A component is an item of equipment (such as a pump, valve, or relay, or an element of a larger array such as a length of pipe, elbow, or reducer).

Test Response Spectra (TRS) – Response spectra specified for the seismic qualification test of an equipment item. The TRS is specified to envelope the RRS.

Trinitrotoluene (TNT) – toxic flammable, explosive yellow crystals used as an explosive intermediate. Lbs of TNT is used as a general measure of detonation intensity for all types of explosive sources.

Undercut Anchor – A post-installed anchor that develops its tensile strength from the mechanical interlock provided by undercutting of the concrete at the embedded end of the anchor. The undercutting is achieved with a special drill before installing the anchor or alternatively by the anchor itself during its installation.

Vertical Structural Irregularity – Significant differences in stiffness or mass from one story of a structure to another.

Zero Period Acceleration (ZPA) – Same as PGA. The maximum absolute value of the ground or in-structure acceleration time history record.

4.0 REFERENCES

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AISC (American Institute of Steel Construction)

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ATC (Applied Technology Council)

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