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CITY OF SUNNYVALE

WATER POLLUTION CONTROL PLANT

DESIGN STANDARDS

STRUCTURAL AND SEISMIC

June 2014

in association with

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CITY OF SUNNYVALE

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

1.0 PURPOSE AND CONTENT

This document describes the structural and seismic engineering design standards for work on the City of Sunnyvale's Water Pollution Control Plant (WPCP) projects located at 1444 Borregas Ave., Sunnyvale, CA. Included in the criteria are required design loads for buildings, tanks, miscellaneous structures, and components. Also included are analysis and design methodologies for various materials of construction including concrete (cast-in-place and precast), steel, masonry, aluminum, fiberglass, and stainless steel.

In case of this document's overlap and conflict with governing codes and standards, the stricter interpretation or directive shall be followed.

2.0 STANDARD DEFINITIONS AND ABBREVIATIONS

Allowable Strength Design (ASD), or Working Strength Design (WSD)	A method of structural design that applies actual loads to structural elements, and limits the stress on elements to a code-prescribed fraction of the yield or ultimate strength of the material(s).
ACI	American Concrete Institute
ANSI	American National Standard Institute
ASCE	American Society of Civil Engineers
ASD	Allowable Strength Design
BSSA	Bulletin of Seismological Society of America
Building Code	California Building Code (CBC) with City of Sunnyvale Amendments
CBC	California Building Code
CIP	Cast-in-Place (refers to concrete construction)
CMAA	Crane Manufacturers Association of America
CMU	Concrete Masonry Unit (concrete block)
Exposure Level	Concrete exposure to sulfates, deicing chemicals, and other corrosive environments as defined in ACI 350, Chapter 4.
FRP	Fiber-reinforced plastic

Geotechnical Report	The geotechnical report prepared under the WPCP Master Plan entitled “Geotechnical Study Master Plan and Facilities Upgrade Project – Water Pollution Control Plant, Sunnyvale, California” prepared by Fugro Consultants, Inc.
IAPMO	International Association of Plumbing and Mechanical Officials
ICC-ESR	International Code Council Evaluation Service Reports
IPC	International Plumbing Code
LRFD	Load and Resistance Factor Design
MCJ	Masonry Control Joint
PCI	Precast Concrete Institute
PCA	Portland Cement Association
Strength Method (or Ultimate Strength Method or LRFD)	A method of structural design that applies factored design loads to structural elements, and strength reduction factors to the yield or ultimate strength of the material.
TMS	The Masonry Society
WSD	Working Strength Design

3.0 CODES AND STANDARDS

Structural designs fall under the jurisdiction of the California Building Code (CBC) with City of Sunnyvale Amendments (hereafter called Building Code). All codes, standards, and specifications referenced in the Building Code are applicable. Designers shall follow latest edition of codes and standards as adopted by the City of Sunnyvale Building Division, including but not limited to the following:

A. Aluminum Association (AA):
   1. ADM-1: Aluminum Design Manual, 2010 Edition.

B. American Society of Civil Engineers (ASCE):
   1. 207.1 – Guide to Mass Concrete
   2. 7 – Minimum Design Loads for Buildings and Other Structures.
   3. 31 – Seismic Evaluation of Existing Structures
   4. 41 – Seismic Rehabilitation of Existing Buildings

C. American Concrete Institute (ACI):
   1. 318 - Building Code Requirements for Structural Concrete and Commentary.

2. 350 - Code Requirements for Environmental Engineering Concrete Structures and Commentary.
3. 350.3 - Seismic Design of Liquid-Containing Concrete Structures and Commentary.
4. 350.4 - Design Considerations for Environmental Engineering Concrete Structures.
5. 351.3 - Foundations for Dynamic Equipment by American Concrete Institute.
6. 530 - Building Code Requirements for Masonry Structures.
7. Manual of Concrete Practice.

D. American Institute of Steel Construction (AISC):
1. 303 - Code of Standard Practice for Steel Buildings and Bridges.
2. 341 – Seismic Provisions for Structural Steel Buildings.
3. 360 - Specification for Structural Steel Buildings.
4. Design Guide 27 – Structural Stainless Steel.

E. Crane Manufacturers Association of America (CMAA):
1. Specification No. 70: Multiple Girder Cranes: Specification for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes
2. Specification No. 74: Single Girder Cranes: Specification for Top Running and Under Running Single Girder Electric Cranes Utilizing Under Running Trolley Hoists.

F. Portland Cement Association (PCA):
1. Circular Concrete Tanks Without Prestressing.
2. Rectangular Concrete Tanks.

G. United States Bureau of Reclamation (USBR):
1. Moments and Reactions for Rectangular Plates, Engineering Monograph No. 27.

H. U.S. Atomic Energy Commission (USAEC):
1. Nuclear Reactor and Earthquake, Report No. TID-7024, Chapter 6, Dynamic Pressure of Fluid Containers.

I. American Water Works Association (AWWA):
1. D100 – Welded Carbon Steel Tanks for Water Storage.
2. D103 – Factory-Coated Bolted Carbon Steel Tanks for Water Storage.
3. D110 – Wire and Strand-Wound, Circular, Prestressed Concrete Water Tanks.
4. D115 – Tendon-Prestressed Concrete Water Tanks

J. Steel Joist Institute (SJI):
1. Standard Specifications, Load Tables, and Weight Tables for Steel Joists and Joist Girders.

K. Steel Deck Institute (SDI):
1. Steel Deck Institute Design Manual, No. 26.
2. Diaphragm Design Manual.

L. Bulletin of the Seismological Society of America (BSSA):
1. Earthquake Response Considerations of Broad Liquid Storage Tanks, appendix A, F. J. Cambra, Earthquake Engineering Research Center UCB/EERC 82/25, November 1982.

M. Miscellaneous:

1. Design of Welded Structures, O.W. Blodgett, Section 4.7, “Open-Web Expanded Beams and Girders.”
2. Torsional Analysis of Rolled Steel Sections, Steel Design File, Bethlehem Steel Corporation.
3. Simplified Design for Torsional Loading of Rolled Steel Members, Philip H. Lin.
4. Designing with Steel Joists, Joist Girders, and Steel Deck, J.M. Fisher, M.A. West, and J.P. Van de Pas.

3.1 Concrete Structures

All concrete design shall be based on ACI 318, except environmental structures shall follow ACI 350.

4.0 GUIDELINES AND PROCEDURES

4.1 General

All structural engineering shall be done in accordance with this document and applicable codes, specifications, and standards, as well as to reflect the judgment and experience of the responsible Professional Engineer. Designers shall use the guidelines contained herein unless there is an overriding reason not to use them for particular components of the Project. In that event, documentation shall be provided in the calculations or by separate memorandum, and accepted by the City’s Engineer.

Design engineers shall consult the “Geotechnical Report” as defined above, to gather geotechnical data and obtain a summary of information on the other existing geotechnical data gathered at the plant over the years. If additional geotechnical data is required for the design of the project, additional geotechnical investigations shall be conducted to obtain the information needed. See Table 3 for additional geotechnical parameters.

Contract documents shall include a statement of Special Inspections and Field Observations in accordance with CBC requirements. The aforementioned statement shall include, but not be limited to the following:

- Soil and Earthwork
- Concrete and Reinforcing Steel
- Structural Steel
- Masonry Construction
- Wood Construction
- Seismic resistance

Design Engineer shall contact City's building division at project inception to coordinate expectations at each milestone, and establish a review process. A stamped and signed set of drawings and calculations shall be provided to the City of Sunnyvale building division for review by a civil or structural engineer registered in the state of California.

4.1.1 Calculations

Structural design shall be performed in accordance with recent engineering literature on the subject. Provide drawings and signed calculations performed by civil or structural engineer registered in the state of California:

1. Provide design calculations that clearly disclose assumptions, design loads, and material strength values.

2. Furnish references acceptable to the City Engineer for review, substantiating appropriateness of design assumptions, criteria, and stress values.

Computer software shall be appropriate industry-standard programs. Samples of specific industry-standard software that may be used on projects include:

1. Computers and Structures Inc. (CSI), Berkeley CA: SAP2000 Finite Element Structural Analysis and Design Program

2. Bentley Systems Incorporated: STAAD Structural Analysis and Design Program

3. Structure Point Concrete Software Solutions: SPCOLUMN, SPSLAB, SPBEAM, SPWALL, SPMATS, AND SPFRAME

4. RISA Technologies: RISA 2D, and RISA 3D

5. ENERCALC, INC.: ENERCALC structural engineering software for steel, wood, concrete, masonry, foundations and frames

6. CSC: TEDDS Structural Calculations Software

All calculations shall be checked according to quality control procedures of the design firm.

All software shall be up-to-date conforming to the current Building Code requirements.

4.1.2 Structural Design Checklist

A structural design checklist shall be included with structural calculations. The checklist presented in appendix-A of this document is intended to serve as a guideline for future designers, and as an example of a structural design checklist. Designers shall select the applicable items in the list that pertain to each project, and may add their own items as applicable to their specific project.

4.1.3 Design Method (unless otherwise noted)

- For concrete design: Strength Method, including ACI 350 provisions for durability. Concrete for environmental structures shall be designed taking "Exposure Level" and environmental durability factor into account.

- For steel design: Allowable Strength Design or Load and Resistance Factor Design Methods.

- For masonry design: Allowable Stress Design or Load and Resistance Factor Design Methods.

- All other designs: Allowable Stress Design

4.2 Loads

4.2.1 General

- Loads used for design shall be obtained from Section 3.0 Codes and Standards.

- Loads to be considered include lateral and vertical loads.
  - Lateral loads are imposed by wind, seismic, soil and liquid pressures, and surcharge loads adjacent to walls.
  - Lateral Loads shall include dynamic soil and hydrodynamic fluid pressures resulting from earthquakes, including lateral loads generated by the vertical component of seismic loads.
  - Vertical loads include dead loads, live loads, seismic vertical loads, suction and uplift loads imposed by wind, and uplift loads imposed by groundwater.

- Equipment, piping, and pipe thrust loads shall be determined per ASCE 7-10 Chapter 13 and incorporated into the structure's design, except as outlined in Section 13.1.4.6 of said reference as modified per 2013 CBC Section 1616.10.15.

- The following is a partial list of loads that shall be used for structural analysis of roofs and framing:
  - Roof live loads
  - Roof dead loads
  - Roof wind (uplift) loads
  - Floor and platform live loads
  - Floor and platform dead loads
  - Ceiling/collateral loads
  - Interior wall loads
  - Exterior wall loads, including horizontal loads

- Erection and construction loads
- Future loads, if known
- Hoist loads and lay down loads
- Equipment loads
- Piping and electrical loads
- Phantom gravity loads (if used)
- Seismic loads
- Any other appropriate loads

4.2.2 Dead and Live Loads

- For dead load, include all permanent or semi-permanent loads. This includes items such as equipment, piping, banks of conduit, electrical trays, floors, supporting members, walls, partitions, chemicals in bins or on storage floors, liquid contents of piping, containers and equipment and the member itself.

- Include weight of soil on soil-covered roofs, where applicable. Soil load should use ASCE 7 load factors for “H” due to variability of soil properties.

- Storage area loads for bagged chemicals shall be based on the assumption that material is stacked to 2/3 of clear ceiling height over entire area.

- Live loads include all loads not defined as dead loads. Examples of live loads include people, tools and equipment that may be placed on floors temporarily. A summary of applicable live loads is included in Section 4.2.13.

- Live loads need not be applied to floor areas permanently covered by equipment, unless the live load is higher than the equipment load.

- Reduction of live loads may be considered only as specified in the Building Code.

- Design uniform live loads shall be indicated on drawings, as required by the Building Code.

4.2.3 Liquid-Containing Structures

- Structural design shall be performed for “maximum” liquid levels indicated by process requirements. Load factors and durability coefficients from ACI 350 shall be applied to these loads. Conservatively, it shall be assumed that there is no soil outside of the structure when it is loaded internally with liquid (leakage test), and conversely, no liquid inside the structure when it is externally loaded with soil pressures. Structures shall be designed for any combination of empty and full compartments that shall produce worst-case loading.

- Seismic loadings on Liquid-containing structures shall be calculated using the recommendations of ACI 350.3. Design shall include, but not be limited to the effects of, impulsive, convective, inertia, and vertical component of seismic loads. Combination of Seismic lateral loads, impulsive, convective, vertical, and soil loads, shall be governed by the Square Root of Sum of Squares (SRSS) method.

- Liquid-containing structures such as digesters, etc. shall be designed for internal forces caused by change in temperature as appropriate.

- Maximum stress in reinforcing shall not exceed the limits for applicable exposure level as defined in ACI 350.

- The worst-case or overtopping condition shall be checked unless there is an absolutely fail-safe overflow below the overtopping level, and the worst case loading level shall be indicated in the calculations.

- The following densities shall be used for structural design calculations:
  - Water: 62.4 pcf
  - Raw sewage: 63 pcf
  - Digested sludge: 70 pcf
  - Thickened or dewatered sludge: 85 pcf
  - Fixed Growth Reactor (FGR) media: 40 pcf, or as specified by media manufacturer.

4.2.4 Uplift Stability

- Structures shall be designed to resist flotation (buoyant) forces considering dead loads only to resist uplift, with a minimum factor of safety of 1.10.

- Resisting loads shall not consider the weights of pumps, piping or other appurtenances, nor any of the liquid contents of the structure.

- Resisting loads may consider the buoyant weight of any soil above the extended footing, using a 20 degree angle from vertical plane located at footing perimeter. The resisting force shall be confirmed by the geotechnical engineer.

- In the event that construction becomes uneconomical, the use of soil/rock anchors or pressure-relief valves shall be considered.

- The minimum groundwater elevation to be used in uplift calculations is at grade. The design groundwater elevation shall be confirmed by the geotechnical engineer.

4.2.5 Structural Stability

Lateral stability shall be checked for all appropriate structures and shall include:

- Wind loads
- Seismic loads
- Thrust loads
- Column stability loads (if used)

In combining the effects of Seismic lateral loads, such as impulsive, convective, and soil loads, Square Root of Sum of Squares (SRSS) shall be used.

See Sections 4.2.8, 4.2.9 and 4.2.13 for wind and seismic parameters. Column stability loads shall be used where normal structural framing provides minimum lateral support for the column. Otherwise provide bracing to resist lateral loads, the magnitude of which shall be one percent of the vertical load on the column.

4.2.6 Impact and Vibration

The following allowances shall be made to account for impact:

Table 1 Impact Load Allowances
Structural and Seismic Design Standards
City of Sunnyvale

Item	Allowance
Elevators	100% of the lifted load
Cab operated traveling cranes and hoists	25% of the lifted load
Pendant operated traveling cranes and hoists	10% of the lifted load
Rotating equipment	20% of the total machine weight
Reciprocating equipment	50% of the total machine weight
Railroads and forklifts	25% of the wheel loads

All machinery shall be mounted on concrete foundations or concrete supports. Vibration isolators or dampeners shall be installed wherever practical and when used vibration shall not be disregarded. The ratio of supporting structure's natural frequency to the machinery's frequency ratio shall be kept out of the 0.5 to 1.5 range to minimize resonant vibrations. Vibration design shall be accordance with ACI 351.3R. Consideration shall be given to the deflection and of beams supporting rotating and reciprocating machines. To help dampen vibration, equipment shall be supported on a concrete foundation having a weight at least 3 times the total weight of the equipment or 15 times the rotating weight, whichever is greater. Where vibrating equipment is supported using spread footings or concrete base on grade, the soil bearing design pressure shall not be larger than one half of the allowable bearing pressure in accordance with ACI 350.4R.

For heavy equipment on ground-supported slabs, consideration shall be given to separate isolated equipment foundations. In this case, expansion joint material shall be provided between the machine foundation and the remainder of the slab.

4.2.7 Horizontal Crane Loads

The lateral force on crane or hoist runways shall be 20 percent of the sum of the weights of the lifted load and the crane trolley or hoist, exclusive of other parts. The force shall be assumed to be applied at the top of the rails, acting in either longitudinal, or transverse direction to rails, and distributed with due regard to lateral stiffness of the supporting structure.

The longitudinal force on crane runway beams shall be 10 percent of the maximum wheel load of the crane. The longitudinal force acts horizontally at the traction surface of the runway beam.

The above loads shall not be less than the loads specified in the appropriate Crane Manufacturer's Association of America Standards, CMAA No. 70 and No.74.

4.2.8 Wind Loads

All structures and components shall be designed to wind loads in accordance with the requirements of the Building Code.

- Basic Wind Speed: 115 mph
- Risk Category III
- Exposure C

For the purposes of design, the wind pressure shall be applied to the gross area of the vertical projected area of the building, structure and components.

4.2.9 Seismic Loads

Seismic design forces and methodologies shall be developed for structures and components in accordance with the requirements of the Building Code and ASCE 7. The referenced code requirements utilize a design base shear (V) that is based on the Risk-Targeted Maximum Considered Earthquake (MCE_R) as indicated in CBC Figures 1613.3.1(1) and 1613.3.1(2). The required site specific design criteria shall be provided in the project geotechnical report.

- Importance factors are based on structure's occupancy category. All structures shall be considered Risk Category III.
  - The seismic importance factor for main structural systems shall be 1.25.
  - The seismic importance factor for elements of structures, nonstructural elements, and equipment supported by structures shall be 1.0 except as outlined per ASCE 7-10, Section 13.1.3.

- Buried and earth retaining structures shall be designed for earth dynamic loading due to seismic loading in accordance with parameters provided in the project geotechnical report.

4.2.9.1 Hydrodynamic Loads

Unless noted otherwise below, the seismic loadings on water containing structures shall be calculated using the recommendations of ACI 350.3. Combination of Seismic lateral loads, such as impulsive, convective, vertical seismic, and soil loads, shall be calculated by the Square Root of Sum of Squares (SRSS) method.

a. For Welded Carbon Steel Tanks for Water Storage, see AWWA - D100
b. For Factory-Coated Bolted Carbon Steel Tanks for Water Storage, see AWWA - D103
c. For Wire and Strand-Wound, Circular, Prestressed Concrete Water Tanks, see AWWA - D110
d. For Tendon-Prestressed Concrete Water Tanks, see AWWA - D115

During a seismic event, submerged objects shall resist lateral hydrodynamic forces generated by water accelerating against them. Such forces shall be calculated in accordance with recommendations of "Earthquake Response Considerations of Broad Liquid Storage Tanks, appendix A, by F. J. Cambra, Earthquake Engineering Research Center UCB/EERC 82/25 November 1982".

4.2.10 Rain Loads

Each building shall be designed for a primary roof drainage system and/or a secondary drainage system in accordance with Chapter 11 of the IPC. Where the building is configured such that water will not collect on the roof, there is no requirement for a secondary drainage system and there would be no rain load required in the design of the roof.

Section 1107 of the IPC specifically requires a secondary roof drainage system where the building construction extends above the roof at the perimeter. This applies to parapet walls, stepped buildings or any other construction that would allow rainwater to pond on the roof. The implementation of secondary system indicates possible blockage of the primary drainage system. Where the potential exists for the accumulation of rainwater on a roof, whether it is intentional (i.e. in controlled drainage system) or otherwise, the roof must be designed for this rain load.

Rain load design values shall be developed in accordance with the requirements of the Building Code and ASCE 7. It is derived from the weight of accumulated rainwater on roof that is based on the 100-year hourly rainfall rate indicated in the Building Code or determined from approved local weather data:

http://sunnyvale.ca.gov/Departments/CommunityDevelopment/CommunityDevelopmentDivisions/Building.aspx

Structural engineer shall work with plumbing engineer in determining the following key parameters for rain load:

- d_s – Depth of water on the undeflected roof up to the inlet of the secondary drainage system when the primary drainage system is blocked (in).
- d_h – Additional depth of water on the undeflected roof above the inlet of the secondary drainage system at its design flow (in).

Provide adequate roof framing stiffness, or camber roof framing in order to mitigate effects of increasingly larger deflections due to the buildup of rainwater, i.e. ponding instability. Conduct ponding instability check for roof bays susceptible to this progressive deflection assuming the primary roof drains are blocked. Roof slope of at least ¼ inch per foot towards points of free drainage need not be considered a susceptible bay.

4.2.11 Loads on Vendor-Designed Items

Certain structural components are commonly specified to be designed by the vendor (e.g., prestressed concrete tanks, steel tanks, FRP tanks, precast prestressed concrete hollow-core planks and double tee sections, aluminum domes, specialty FRP components, open-web metal joists, etc.). For vendor-designed items, all loads shall be indicated on drawings or in related specification sections. Load information shall include uniform dead and live loads, point loads from piping, hoists, strip loads from walls, transient loads such as wind or seismic, future loads, etc.

4.2.12 Future Loads

Consideration shall be given to loads from future expansions and equipment to the extent directed by the Owner or Design Engineer.

4.2.13 Typical Structural Design Loads

Typical design loads are presented in the Table 2. All design live loads (distributed or concentrated) shall be validated, based on the specific requirements of projects.

Table 2 Design Loads
Structural and Seismic Design Standards
City of Sunnyvale

Load Case		Load	Units
Wind	Basic Wind Speed	115	mph
	Exposure	D	-
	Risk Category	III	
Snow	Basic Ground Snow Load	0	psf
	Drift	0	psf
Seismic	Risk Category	III	
	S_s	1.5 g	ft / sec^2
	S_1	0.6g	ft / sec^2
	Site Class	D	
	Site Coefficient F_a	1.00	-
	Site Coefficient F_v	1.5	-
	Importance Factor	1.25	-
Live (1) Loads	Process Equipment Areas	300/2000	psf/lb
	Electrical Equip. Rooms	250/2000	psf/lb
	Storage, Shop, Maintenance	200/3000	psf/lb
	Chemical Feed Rooms	150/1000	psf/lb
	Corridors, Walkways, Stairways	100/1000	psf/lb
	Offices, Labs, Lunchrooms	100/1000	psf/lb
	Roofs	20/300	psf/lb

Notes:

(1) Distributed and concentrated loads do not happen simultaneously.

4.2.14 Load Combinations

Structural systems, members and connections shall be designed to most stringent load case using the load combinations specified in the Building Code. Refer to ASCE 7 and ACI 350 for additional load combinations for steel and concrete liquid-containing structures.

4.3 Foundations

4.3.1 General

Sub-surface conditions vary throughout the project site, and different types of foundation systems might be required in different areas. Design engineers shall study existing geotechnical reports, and perform additional geotechnical investigations as required, to establish an appropriate foundation type and related design parameters. The criteria listed in Table 3 shall be used for design purposes, unless higher allowable and/or soil pressures are recommended by the geotechnical report.

Table 3 Geotechnical Parameters
Structural and Seismic Design Standards
City of Sunnyvale

	Parameters
Allowable Bearing Pressure	
Mat Foundation	1000 psf (dead and live load) (1)
Spread Footings	1000 psf (dead and live load) (1)
Active Pressure	
Above ground water level	35 psf
Below ground water level	80 psf
At Rest Pressure	
Above ground water level	50 psf
Below ground water level	85 psf
Soil Dynamic Pressure	25(H) psf (3)
Allowable Passive Pressure	300 pcf (2) (4)
Friction Factor	0.45 (2)

Notes:

(1) Allowable bearing pressures are based on the maximum service level values permitted. Minimum footing width shall be 24 inch, and bottom of foundation shall be minimum 18 inch below adjacent grade.

(2) Value shall be used at ultimate level forces.

(3) H is height of structure in feet.

(4) Top 12” of soil will not contribute to passive pressure.

4.3.2 Foundation Types

Depending on sub-surface conditions of different areas, the following foundation types can be used:

- Shallow foundations: such as strip footings, spread footings, mat foundation, etc.
- Deep foundations utilizing a combination of pile caps with, prestressed precast concrete pile, steel piles, or cast-in-place drilled piers.

4.3.3 Lateral Load Resistance

All structures shall be able to resist lateral forces as follows:

- Shallow foundation: Lateral Loads shall be resisted by means of friction, passive pressure, or a combination of both, as recommended by the geotechnical report, or Table 3.
- Deep Foundation: Friction shall not be used as a method of transferring lateral forces to the sub-grade. All Lateral Forces are to be resisted by piles or piers, passive pressure against pile cap, or a combination of both, as recommended by the geotechnical report.

4.3.4 Foundation Stability

- Provide a stability safety factor for both sliding and overturning in accordance with ACI 350.4R, Section 3.1, and as specified herein.
- For structures founded on yielding soils, the resultant of all forces shall fall within the middle one third of the base. All foundation subgrade, with the exception of hard shale and solid rock, is considered to be yielding soils.
- For structures founded on rock, hard shale, piling or piers, the structure shall be designed for a factor of safety against overturning of not less than 2.0.
- Buoyancy and uplift forces shall be included in calculating the position of the resultant force and the factor of safety against overturning.

4.4 Deflections

- Cast-in-place concrete framing members meeting the minimum depth criteria listed per Section 9.5 of ACI 318-11 or ACI 350-06 as applicable shall generally not need to be checked for deflection. Cast-in-place framing members shall not exceed the maximum deflections listed in Table 4 and Table 5 of this document.
- Spot-checks for deflection shall be performed where the design engineer deems necessary.

- Deflections shall be calculated for concrete members not meeting these depth criteria. Prestressed concrete members shall meet the limitations of Paragraph 9.5.4, of ACI 350/318 references.

- All grating shall be designed for 100 psf minimum, and deflection shall be limited to L/240.

Table 4 Cast-in-Place Concrete Framing Load Deflections
Structural and Seismic Design Standards
City of Sunnyvale

Member	Allowable Live Load Deflection(1)(3)
Roof beam	L/240(2)
Roof beam supporting ceiling below	L/360(2)
Floor beam	L/360
Floor beam supporting ceiling below	L/480
Floor beam supporting masonry wall	L/480

Note:
(1) See ACI 318 or ACI 350 Section 9.5 as applicable, for limitations affecting deflection calculations.
(2) Beam may be cambered for 75% of dead load deflection. Ponding shall be investigated.
(3) The span L is in inches.

Table 5 Structural Steel Framing Load Deflections
Structural and Seismic Design Standards
City of Sunnyvale

Member	Allowable Deflection(2)
Roof beam	L/240(1)(5)
Roof beam supporting ceiling below	L/360(1)(3)
Floor beam	L/360(3)
Floor beam supporting ceiling below	L/480(3)
Floor beam supporting masonry wall	1/8 inch for L < 60 inches(5)
	L/480 for L > 60 inches(5)
Bridge Structures (such as for circular clarifiers)	L/480(3)
Crane support beam and monorails	L/800 (not including impact) (5)
Monorails for underslung hoists	L/450(5)
Girt (horizontal)	L/360(4)
Girt (vertical)	L/240(5)
Girt supporting window (vertical)	1/8 inch for L< 100 inches(5)
	L/480 for L > 100 inches(5)

Table 5	Structural Steel Framing Load Deflections Structural and Seismic Design Standards City of Sunnyvale
Member	**Allowable Deflection[(2)]**
Pre-engineered Building sway due to lateral load	H/300[(4)]

Notes:

(1) Beams may be cambered for 75% of dead load deflection. Ponding shall be investigated.
(2) The span length L is in inches.
(3) The deflection limitation indicated applies to service level live loads.
(4) The deflection limitation indicated applies to service level wind, or seismic loads.
(5) The deflection limitation indicated applies to total service level loads.

4.5 Materials of Construction

4.5.1 Materials

- Chemical tanks shall be made of FRP.
- Below-grade structures in contact with soil shall be made of reinforced concrete as follows:
  - a) Manholes shall be precast concrete.
  - b) Vaults shall be made of cast-in-place, or precast concrete.
  - c) Tanks shall be made of cast-in-place concrete, precast concrete, or prestressed concrete tanks per AWWA-D110, or AWWA-D115.
  - d) All other below-grade structures shall be made of cast-in-place concrete.
- Above-grade tanks shall be made of cast-in-place concrete with mild steel reinforcing, precast concrete, prestressed concrete tanks per AWWA-D110, welded steel tanks per AWWA-D100, bolted steel tanks per AWWA-D103, or tendon-prestressed concrete water tanks per AWWA-D115.
- Above ground building construction shall be as follows:
  - a) CMU construction – Building walls shall be solid grouted CMU. Roofs shall be supported on steel beam/or truss joists with metal deck as diaphragm. Elevated floors shall be constructed from either reinforced concrete beam/slabs, or steel beam/truss joists with concrete topping over metal deck as diaphragm.
  - b) Cast-in-place concrete – Walls, floors and roofs shall be cast-in-place concrete. Alternatively, roofs over non-liquid retaining structures may be constructed with metal deck diaphragm over steel beam/or truss joists.

c) Structural steel – The lateral and gravity load resisting elements shall be made of structural steel in accordance with AISC 341 and 360. Roofs shall be supported on steel beam/or truss joists with metal deck as diaphragm, and elevated floors shall be constructed from steel beam/or truss joists with concrete topping over metal deck as diaphragm.

- Engineer shall consider economics and speed of construction, as well as any Owner-dictated material requirements when deciding upon materials to be used in non-corrosive environments.

- Where above- or below-grade structures are subject to wet or corrosive atmosphere, floors, walls, and roofs shall be made of cast-in-place concrete.

- Materials for other structures or components in corrosive areas are described in section 4.5.2.

Table 6 Structural Material Specifications
Structural and Seismic Design Standards
City of Sunnyvale

Item	Minimum Value	Unit
Cast-in-place Concrete Design Compressive Strength f'_c	4,000[(1)]	psi
Precast prestressed concrete Design Compressive Strength f'_c	5,000	psi
Reinforcing Steel Yield Strength f_y	60,000	psi
Structural Steel Yield Strength F_y	50,000/36,000[(2)]	psi
Structural Aluminum alloy	6061-T6	NA
Concrete Masonry Design Compressive Strength f'_m	1,500	psi
Stainless Steel Yield Strength f_y	30,000	psi
Post-tensioning Strand Yield Strength f_y	250,000	psi
Prestressing Bar Ultimate Strength f_u	150,000	psi

Notes:
(1) Except for environmental structures as outlined in Table 4.2.2, ACI 350-06.
(2) All wide flange sections shall have a minimum yield stress of 50,000 psi. All plates, channels, angles, and tees shall a minimum yield stress of 36,000 psi.
(3) For additional information see section 4.7.2.1.

4.5.2 Corrosion

- For corrosive conditions, consideration shall be given to the usage of inherently corrosion-resistant materials or conventional materials with high performance and low maintenance corrosion-resistant coatings.
  - The Owner shall be consulted to determine which material to specify.
  - Structural engineer shall participate in the decision to the extent of providing relative cost comparisons for Owner's consideration.
- Concrete for tanks containing sulfites shall be specified to contain approximately 15 percent fly ash in the mix. Engineer shall also consider specifying extra cover over the reinforcing steel on the faces exposed to this more corrosive atmosphere.
- In corrosive areas, type "316" stainless steel, or FRP shall be selected.
- All expansion or adhesive post-installed anchors into concrete or masonry shall be stainless steel.

4.6 Concrete

Concrete mix design shall include coarse aggregate complying with ASTM C33, No 57 or No 67, corresponding to 1" or ¾" aggregate size, respectively. All surfaces of concrete structures exposed to severe corrosive environments shall be lined with a protective layer of T-Lock or approved equal.

Provide provisions for future addition/expansion to the treatment plant. Such provisions include but shall not be limited to:

- Provide and protect in place waterstops for future addition to liquid-containing concrete structures.
- Extend foundations as appropriate, and provide footings to receive future columns.
- Knock-out panels in cast-in-place concrete walls/slabs shall be clearly marked by means of reveals. Provide additional reinforcing around the knock-out panel to anticipate the future condition when panel is removed.

4.6.1 Standard Details

Design Engineers shall provide Standard Detail Sheets for Projects. Such sheets shall include but not be limited to details on typical extra reinforcement requirements such as at wall and foundation corners, around openings, etc.

Typical extra reinforcement in the standard details need not be repeated on the detailed structural drawings, and shall be considered when design calculations are performed.

4.6.2 Minimum Dimensions

All members shall be sized using the minimum values specified per ACI 318 or ACI 350 as applicable. Concrete cover and clear spacing between bars for reinforcement shall be as given in Chapter 7.7 of referenced codes.

Slabs:

- Except for joist top slabs and slabs supporting members that could be damaged by deflection such as partitions, minimum thickness of slabs shall be in accordance with Table 9.5(a) or Table 9.5(c) of ACI 318 or ACI 350 or as modified by the Building Code.
- Deflections shall be calculated for members supporting construction that could be damaged by deflection of the slabs, and the thickness increased as required.

Beams:

- Beams shall have a minimum width of 12 inches.
- Minimum depth shall be in accordance with ACI 318 Table 9.5(a) or as modified by the Building Code.
- Deflection of beams shall be further limited by increasing the depth for those cases where the deflection exceeds the allowable.
- Design engineers shall consider locating construction joints at the tops of walls to provide block-outs for beams in such away, that the entire beams can be cast as a separate pour, extending across the wall thickness.

Walls:

- Liquid-containing structures shall have a wall thickness of at least 12 inches.
- All other walls shall be at least 8 inches thick.
- Bearing walls shall have a minimum thickness of $^{1}/_{25}$ of the supported height or length (whichever is shorter) but not less than 8 inch.
- The designer shall consider whether the structure shall be backfilled before the top of the wall is supported or braced, and design wall accordingly.
- Walls shall be designed for unsupported loads on either wall side without the benefit of a resisting load on the opposite side.

Footings:

- Unless otherwise recommended in the geotechnical report, the bottom of all spread and strip footings shall be at least 12 inches below the adjacent grade.

4.6.3 Concrete joints

- Concrete joint requirements in liquid-containing structures shall be in accordance with recommendations of ACI 350.4R. Joints are as follows:

1. Construction joints – require the following:
    a. Continue 100% of reinforcing through the joint.
    b. Roughen the joint.
    c. Waterstop in liquid-containing structures.
2. Control Joints – (Slab-On-Grades) require the following:
    a. Continue 100% of reinforcing through the joint.
    b. Saw cut the joint, or use continuous fiberboard strip at non-liquid-containing structures.
    c. Waterstop in liquid-containing structures.
3. Expansion Joints – require the following:
    a. No reinforcing extends through the joint, except smooth dowels.
    b. Pre-molded joint filler.
    c. Waterstop with center bulb in liquid-containing structures or walls below the groundwater table.
    d. Joint sealant.
4. Contraction Joints - require the following:
    a. No reinforcing extends through the full contraction joints. For partial contraction joints allows 50% of rebar shall be continuous through joint.
    b. Roughen joint.
    c. Waterstop with Center bulb in liquid-containing structures or walls below the groundwater table.
    d. Joint sealant.
    e. Smooth dowels only at full contraction joints.

- All required joints shall be indicated on the drawings. Contractor shall provide and submit a plan indicating proposed sequence of concrete placement, based on requirements of concrete specifications.

- For non-liquid-containing structures, the horizontal spacing of construction joints shall not exceed 60 feet. For liquid-containing structures, the maximum length between "movement joints" shall be determined from ACI 350-06 Table 7.12.2.1, based on the provided minimum shrinkage and temperature reinforcement ratio. Expansion joints, contraction joints, and partial construction joints qualify as "movement joints".
- Any concrete member may have a joint; however, it is desirable to minimize their quantity. Construction joints in beams shall be optimally located at points of minimal flexural load. Expansion joints shall be used on very large structures or only when absolutely necessary to avoid thermal movement induced stresses.
- Use of stay-in-place forms at bulkheads of slabs and walls of water containing structures is prohibited.

4.6.4 Waterstops

Construction, expansion, and control joints shall have waterstops at the following locations:

- All walls and bottom slabs of dry pits or rooms below finished grade and in contact with fluid or backfill material.
- All walls and slabs in contact with liquid.
- All other locations shown on the drawings or specified.

Appropriate types of waterstops are as follows:

- PVC type
- Stainless Steel type
- TPV/TPER type
- Adhesive(Hydrophilic, Non-Bentonite) type
- Injection type
- Retrofit type

The specifications for waterstops shall be performance based. Waterstops in joints at the base of the walls (or similar applications) shall be so specified to assure they remain in their intended position during the construction cycle.

Hydrophilic, retrofit or injection type waterstops shall be used when modifying existing structures.

All new construction shall use PVC, Stainless Steel, or TPV/TPER waterstops.

Waterstop details shall be shown on the Standard Detail Sheets. The designer shall consider the embedded length of waterstops to avoid interference with the reinforcement.

All PVC/TPV/TPER waterstop “L” or “T” intersections shall be shop fabricated. Field welding shall be limited to straight extension of waterstops, where weld is perpendicular to concrete joint.

Contractor shall submit waterstop layout drawings to include waterstop sizes, types, fittings, etc.

4.6.5 Splices, Connections and Development of Reinforcement

Development lengths and splice lengths shall be in accordance with the Building Code and shall be shown on the Standard Detail Sheets. Welded splices shall not be used, unless specifically allowed by the Contract Documents. Mechanical connectors shall be as indicated in the Specifications. Mechanical connectors and lap splices shall be staggered except for couplers used at the face of a construction joint, and shall comply with the requirements of the specifications. Minimum cover shall be provided to the face of mechanical connectors in liquid-containing or below grade structures.

4.6.6 Arrangement of Reinforcement

Concrete is difficult to place when reinforcement is congested. Beam and column joints, wall corners, and extra reinforcement at openings are places that shall be considered when selecting member sizes and reinforcement size and spacing.

Reinforcement shall be arranged according to the following:

4.6.6.1 *Slabs and Footings*

The center-to-center spacing of flexural and shrinkage and temperature reinforcement shall be at least 6 inches for No. 6 and larger, and at least 4 inches for No. 5 and smaller, and not more than 12 inches for structures designed as environmental structures. For other structures, spacing shall be not more than 18 inches. Bars smaller than No. 4, shall not be used, except in pavements, roof slabs, beam ties, or column ties. Reinforcement in one-way or square two-way footings shall be spaced uniformly across the entire width or area of the footing. Reinforcement in rectangular two-way footings shall be spaced uniformly across the long direction and distributed across the short direction as outlined in Paragraph 15.4 of ACI 318 or ACI 350 as applicable.

4.6.6.2 *Deep Foundations*

Per the geotechnical report, no structures were anticipated to require piles or drilled piers at the WPCP site. Any future structures which are built offsite at the oxidation pond site may require deep foundations, and design engineers are required to provide additional geotechnical investigations.

For all deep foundations such as drilled piers, precast piles, etc., a minimum of four longitudinal bars with a minimum longitudinal reinforcement ratio of 0.005 shall be provided through the minimum reinforced length as defined by the Building Code. Transverse reinforcement shall consist of closed ties or spirals no smaller than No. 3 bars for piles with a least dimension up to 20 inch, and No. 4 bars for larger piles. The remaining reinforced region outside the minimum reinforced length shall have transverse reinforcement spacing complying with the Building Code requirements.

4.6.6.2.1 Cast-In-Place Concrete Drilled Piers

For Site Classes C through F, transverse confinement reinforcement shall be provided in piers in accordance with Sections 21.6.4 ACI 318-11, and ACI 336.1 within certain regions specified in the Building Code. Casing shall be used at high groundwater levels.

4.6.6.2.2 Precast Concrete Piles

Longitudinal steel shall be arranged in a symmetrical pattern around the pile cross section.

4.6.6.2.2.1 Precast Non-Prestressed Piles

For structures assigned to Seismic Design Category D, the minimum longitudinal reinforcement ratio shall be 0.01 throughout the entire length. Spacing of transverse reinforcement shall not exceed the smaller of eight times the diameter of the smallest longitudinal bar or 6 inch within a distance of three times the least pile dimension from the bottom of the pile cap. Spacing of transverse reinforcement shall not exceed 6 inch throughout the remainder of the pile.

4.6.6.2.2.2 Precast Prestressed Piles

For structures assigned to Seismic Design Category D, the following requirements shall be met:

a) The ductile region to place lateral transverse reinforcement shall be the full length if less than 35 ft. or the greater of 35 ft. and the distance from the underside of the pile cap to the point of zero curvature plus three times the least pile dimension.

b) In the ductile region, the center-to-center spacing of the spirals or hoop reinforcement shall not exceed one-fifth of the least pile dimension, six times the diameter of the longitudinal strand or 8 inch, whichever is smallest.

c) Circular spiral reinforcement shall be spliced by lapping one full turn and bending the end of each spiral to a 90-degree hook, or by use of a mechanical or welded splice complying with Section 12.14.3 of ACI 318-11.

d) The volumetric ratio of spiral transverse reinforcement in the ductile region shall comply with the Building Code requirements. The required amount of spiral reinforcement is permitted to be obtained by providing an inner and outer spiral.

e) Where transverse reinforcement consists of rectangular hoops and cross ties, the total cross-sectional area of lateral transverse reinforcement in the ductile region shall conform to the Building Code requirements. Rectangular hoop ends shall terminate at a corner with seismic hooks. Outside of the length of the pile requiring transverse confinement reinforcing, the spiral or hoop reinforcing with a volumetric ratio not less than one-half of that required for transverse confinement reinforcing shall be provided.

4.6.6.3 *Beams*

The clear vertical distance between parallel flexural reinforcement in the same plane shall be at least 1-inch. Horizontal clear spacing shall not be less than two times the maximum aggregate size. Bars smaller than No. 5, shall not be used for flexural reinforcement. Bars larger than No. 5 shall not be used for beam ties. Where nominal ties are required, they shall be a single size and spaced equally across the length of the beam. When greater than nominal reinforcement is required, beam ties shall be of a single size with a maximum of two different spacing distances across the length of the beam.

Where beams intersect at columns, designer shall decide which beam shall have depressed top bars. Steel area shall be calculated based on the reduced “d” dimension. Drawings shall show which beams have depressed top steel. Comply with any specific seismic detailing requirements dictated by the Building Code.

4.6.6.4 *Walls*

All walls 8 inches thick shall have one layer of reinforcement in both vertical and horizontal directions. Walls greater than 8 inches thick shall have reinforcement in each face in both vertical and horizontal directions. The spacing of vertical or horizontal reinforcement shall be at least 6 inches but not more than 12 inches. Bars smaller than No. 4 shall not be used, except in non-load-bearing walls, and as temperature and shrinkage steel.

Lower parts of concrete walls are more susceptible to vertical cracking caused by shrinkage of cast-in-place concrete. For the lower 4’-0” of walls provide increased horizontal temperature and shrinkage reinforcement.

All surfaces of concrete structures exposed to severe corrosive environments in contact with concrete, shall be lined with a protective layer of T-Lock or approved equal.

Selection of the Concrete wall-form ties shall be based on the following requirements:

- Provide ties with built-in waterstops in all walls that will be in contact with process liquid during plant operation (i.e. She-Bolt System by Dayton).
- Through-wall ties that are designed to be entirely removed are not allowed in walls that will be in contact with process liquid during plant operation.
- Wire ties shall not be used.

- Embedded portion of ties shall be not less than 1-1/2 inch from face of concrete after ends have been removed.

4.6.6.5 *Circular Walls*

Cast-in-Place concrete tanks, without Prestressing steel:

- For best crack control, horizontal reinforcement in direct tension in circular walls shall be kept as small as possible, with tighter spacing. Bars shall be at least No. 5 bars with a minimum spacing of 4 inches and a maximum spacing of 12 inches. Splice locations shall be staggered per Standard Detail Sheets. The allowable concrete tensile stress and crack control requirements of “Circular Concrete Tanks”, apply only to non-seismic load combinations.

- Wall bending moments shall be calculated. Provide reinforcement capable of resisting all vertical and horizontal bending moments.

- Wall base connections may be constructed as hinged or fixed. For all fixed-base conditions, wall bending moments shall be calculated based on the actual rotational flexibility of the wall footing, and the flexibility of the supporting subgrade.

- Forms can be made of wood or metal; with the exception that aluminum forms are not allowed.

AWWA-D110 and AWWA-D115 tanks:

- For wire-wound, strand-wound, circular, prestressed concrete, and tendon-prestressed concrete water Tanks, provide vertical and circumferential prestressing steel generating compressive forces capable of resisting vertical (uplift) and circumferential tension in concrete walls, respectively. In addition provide minimum mild steel in vertical and horizontal directions to resist temperature and shrinkage forces.

- Wall bases connection may be constructed in accordance with any of the following:

  1. Reinforced non-sliding base: Tank wall is cast against concrete base with vertical dowels connecting the two elements.

  2. Anchored Flexible Base: Tank wall rests on a neoprene pad providing horizontal (radial) flexibility, and vertical seismic cables connect wall and footing to transfer in-plane seismic forces to the foundation.

- Forms can be made of wood or metal; with the exception that aluminum forms are not allowed.

4.6.6.6 *Compression Members*

The clear distance between longitudinal reinforcement in compression members including splices shall be in accordance with section 7.6 of ACI 318-11 or ACI 350-06 as applicable. Interaction of column bars and beam bars shall be considered in order to avoid congestion.

Provide concrete protection for reinforcement in accordance with section 7.7 of ACI 318-11 or ACI 350-06.

Tie spacing shall be as outlined in section 7.10 of ACI 318-11 or ACI 350-06 as applicable.

4.6.7 Shrinkage and Temperature Reinforcement

Control of shrinkage and temperature cracking is essential, particularly in liquid-containing structures. The required percentages of this reinforcement shall be sized based on the requirements of Section 7.12 of ACI 318 or ACI 350 as applicable.

Concrete sections 24 inches or thicker shall have minimum shrinkage and temperature reinforcement based on a 24-inch thickness. Minimum size of shrinkage and temperature reinforcement shall be No. 4, except in pavements, which may be No. 3 or equivalent welded wire fabric.

Shrinkage and temperature reinforcement shall be divided equally between the two surfaces of the concrete section. Vertical faces of deep beams shall have distributed longitudinal reinforcement to prevent longitudinal shrinkage cracking.

Lower parts of concrete walls are more susceptible to vertical cracking caused by shrinkage of cast-in-place concrete. For the lower 4’-0” of walls provide increased horizontal temperature and shrinkage reinforcement.

4.6.8 Analysis and Design

4.6.8.1 *Design Methods*

Reinforced members shall be proportioned using the methods and factors that follow:

- Slab panels with a ratio of length-to-width of 1.5 or greater shall be analyzed as one-way slabs.
- Two-way and flat slabs may be analyzed by the direct-design method outline in Chapter 13 of ACI 318 or ACI 350 as applicable, providing the limitations of Section 13.6 are met. Two-way and flat slabs that do not meet these limitations shall be analyzed by the equivalent frame method or finite element computer analysis.
- Beams shall be analyzed as rectangular beams unless depth limitations require the use of T-beams. Minimum shear reinforcement shall be provided per Building Code.

- Wall panels supported on three or four sides may be analyzed using the moment coefficients tabulated in "Moments and Reactions for Rectangular Plates", U.S. Bureau of Reclamation Engineering Monograph No. 27, or PCA Publication "Rectangular Concrete Tanks". Supporting walls and slabs shall be designed to adequately resist the shears and moments calculated by this method.

- The design engineer shall ensure by means of notes on Drawings that members (such as walls that are to support backfill) shall not be loaded until all supporting members are constructed and reached their full design strength. The designer must consider the above condition in the structural design of the walls, if support cannot be assured, or if constructability concerns dictate that the walls shall be backfilled before support or bracing can be constructed.

- Walls fixed at the bottom transfer moment to the footing, so the footing shall be designed to accommodate this moment.

- Circular walls in direct tension shall be analyzed using the coefficients tabulated in PCA publication "Circular Concrete Tanks without Prestressing". Reinforcement shall be sized to develop the full factored/modified tensile load, as well as vertical and horizontal bending moments. To prevent leakage and control crack width, the tensile stress of concrete shall be calculated based on the unfactored ring tension, and compared with the allowable tensile stress of 10%f'c as defined in above publication.

- The horizontal length of wall considered as effective for each concentrated load shall not exceed either the width of the loaded area plus four times the wall thickness or the center-to-center distance between the concentrated loads.

4.6.8.2 *Frame Analysis Factors*

When loading conditions meet the limitations listed in Chapter 8 of ACI 318 or ACI 350 as applicable, the moment and shear factors given in said documents shall be used for analysis of continuous one-way slabs and beams.

For simple structures, $w_u l^2/10$ may be used for both positive and negative moment of members with fixed ends.

4.6.8.3 *Load Factors*

Load factors for all structures except liquid-containing structures shall be per Building Code.

Load factors for all liquid-containing structures shall be as tabulated in Section 9.2 of ACI 350.

4.6.8.4 *Durability Factors for Liquid-containing Structures*

When a liquid-containing-structure is designed in accordance with the strength design method, it shall be proportioned for the required strength U as defined in ACI 350-06, chapter 9. For liquid-containing structures, the required strength U shall be multiplied by the durability factors S_d in accordance with ACI 350-06 Section 9.2.6. S_d factor need not be applied to load combinations that include earthquake loads:

$U_{provided} > S_d \, U_{required}$

Concrete reinforcement shall be calculated using $U_{provided}$ for flexure, direct tension, and diagonal tension (shear). In calculating reinforcement for the compressive region of flexure, compressive axial loads, and for all loads carried by concrete, the required strength shall be 1.0U.

Durability factor S_d shall not be used for designs using service loads and permissible service load stresses.

4.6.8.5 *Strength Reduction Factors*

Strength reduction factors shall be per Building Code.

4.6.8.6 *Reinforcement Ratios*

For singly reinforced flexural members with f'_c = 4,000 psi, and f_y = 60,000 psi, the minimum and maximum reinforcement ratios are:

ρ_{min} = 0.0033

ρ_{max} = 0.021

The above minimum reinforcement ratio need not be applied, if at every section the area of tensile reinforcement provided is at least one-third greater than that required by analysis for required strength U, not including the environmental durability factor S_d.

In no case shall flexural reinforcement be less than that provided for shrinkage and temperature reinforcement.

4.6.8.7 *Mass Concrete*

Mass concrete is defined as concrete greater than (3') thick and shall be designed in accordance with recommendations of ACI 207.

4.6.8.8 *Post Installed Anchors*

Design of concrete post-installed anchors shall be in accordance with the following:

- ICC-ES Acceptance Criteria AC308 for Adhesive Anchors and Concrete.
- ACI 355.2 Qualifications of Post-Installed Mechanical Anchors in Concrete.
- ACI 318-11 Appendix D for post-installed expansion, undercut, and adhesive anchors.

4.7 Steel

4.7.1 General

All structural steel shall be galvanized. Provide a protective coat of paint for all steel in contact with dissimilar material.

4.7.1.1 *Codes and References*

Structural design shall conform to the requirements of the California Building Code; the Specification for Structural Steel Buildings AISC 360; the AISC Manual of Steel Construction; and the Seismic Provisions for Structural Steel Buildings AISC 341.

4.7.1.2 *Method of Design*

Analysis and design of structural steel systems shall be based on the Allowable Strength Design (ASD) Method or the Load and Resistance Factor Design (LRFD) Method.

4.7.2 Structural Steel

For protection of steel against environmental conditions, see section 4.7.1.

4.7.2.1 *Materials*

- Rolled Shapes, Wide Flanges: ASTM A992
- Rolled Shapes, Plates and Bars: ASTM A36
- Structural Steel Pipe: ASTM A501, or ASTM A53, Type E or S, Grade B
- Structural Tubing: ASTM A500, Grade B (Fy = 46 ksi)
- High-Strength Bolted Connections: ASTM A325
- Anchor Bolts: ASTM F1554, SST Anchor Bolts ASTM A193
- Welding electrodes: E70XX
    1. AWS D1.1 Structural Welding Code – Structural Steel
    2. AWS D1.2 Structural Welding Code – Aluminum
    3. AWS D1.3 Structural Welding Code – Steel Sheets
    4. AWS D1.4 Structural Welding Code – Reinforcing Steel
- Stainless Steel Bolts and Nuts: ASTM A193 and A194, AISI Type 316, B8MN, B8M2, or B8M3
- Aluminum Bolts and Nuts: Not allowed

4.7.2.2 *Design*

Composite Design:

- Using the concrete floor slab as a composite compression flange to stiffen and strengthen a steel beam is often a cost-effective method of minimizing the depth of framing.
- For long spans (over 30 feet) with pedestrian traffic, check vibration of the composite system.
- The number of welded shear studs should be centered about the point of maximum moment, or zero shear.
- Provide camber up for steel beams in unshored composite floor construction. Camber shall not exceed 75% of expected dead load (under wet weight of concrete). Also, anticipate and include the weight of leveling concrete. For additional deflection requirements see Table 5.
- Composite concrete slabs shall be constructed as follows:

  1. Formed slab with shear studs welded to steel framing below to develop composite action.
  2. Use wide-rib galvanized steel composite floor deck with shear studs welded to steel framing below.

Beam Web Openings:

- Locate beam web openings at points of minimum shear and center within the depth of the beam.
- Reinforce openings with a doubler plate at the web, or gusset plates above and below the opening.
- See Reference, Design of Welded Structures, O.W. Blodgett, Section 4.7, “Open-Web Expanded Beams and Girders.”

Torsion:

For spandrel beams with short spans and stiff rotational restraint at the supports, check the torsional stresses. In addition investigate the support strength and stiffness to ensure it is capable of providing the assumed torsional restraint. Use the following references.

– Torsional Analysis of Rolled Steel Sections, Steel Design File, Bethlehem Steel Corporation.

– Simplified Design for Torsional Loading of Rolled Steel Members, Philip H. Lin.

4.7.2.3 *Connections*

4.7.2.3.1 <u>Bolted Connections</u>

Use ASTM A325 high-strength bolted connections for all structural steel framing as follows:

- Use type 1 bolts for high temperatures.
- Use hot-dipped-galvanized A325 bolts (per ASTM A153) for atmospheric corrosive environment.
- Use hot-dipped-galvanized A325 bolts (per ASTM A153) for applications with non-corrosive environment.

Use bearing-type connections unless the connection will be subjected to vibration or stress-reversal or will be carrying shear in a moment-resistant connection with welded flanges. In that case, use slip-critical connections with direct tension indicators (load indicator washers) and hardened washers to ensure adequate bolt tension in the field.

For bolted beam connections, use the AISC Manual of Steel Construction. Check all beam reactions with the AISC connection table and the standard detail to ensure that connections have adequate capacity to carry the design loads.

Avoid mixing bolt diameters or connection types on the same project or facility.

In bolted moment-resistant or direct tension connections, calculate the additional bolt tension due to prying action, in accordance with the *AISC Manual of Steel Construction*.

For minor bolted connections of miscellaneous fabricated metalwork or wood framing, ASTM A307 bolts may be used. All A307 bolts shall be hot-dipped galvanized per ASTM A153. All bolts exposed to liquid, or corrosive gases shall be type 316 stainless steel.

4.7.2.3.2 <u>Welded Connections</u>

For A36, A992, A500, and A501 steel, use E70XX electrodes. Keep weld sizes to a minimum for economy, unnecessary heat distortion, and fabrication time. Use a minimum 3/16-inch fillet weld for structural connections. Specify end returns for all welds.

Orient structural welds parallel to the load whenever possible. Use knife-plate connections where required at tube shapes. All tube ends shall be closed with a welded cap plate. Avoid welding across beam flanges to minimize built-in stresses. Use continuous seal welds in exterior or corrosive environments. Avoid built-up members with intermittent welds in humid or corrosive environments.

Refer to the CBC for weld inspection and ANSI/AWS D1.1 for weld inspection, quality control, and repair of defective welds. Specify a percentage of weld inspection for critical structural members, such as shop or field splices in truss main tension members or for moment-resistant beam-column connections. Generally, all butt or groove welds should be complete-penetration welds.

4.7.3 <u>Open-Web Steel Joists</u>

4.7.3.1 *Design References*

- Standard Specifications, Load Tables, and Weight Tables for Steel Joists and Joist Girders, Steel Joist Institute.
- Designing with Steel Joists, Joist Girders, and Steel Deck, J.M. Fisher, M.A. West, and J.P. Van de Pas.

4.7.3.2 *Design Guidelines*

Avoid using open-web steel joists in areas of high humidity and corrosive environment. Because of the joint configurations of the truss members, it is difficult to ensure that all steel surfaces shall be adequately protected by the specified coating system.

Show design load criteria on the framing plan, or include in the specifications. Such criteria shall include, but not be limited to uniform dead loads, uniform live loads, all concentrated loads on the top and bottom chords due to equipment supports, monorails, possible future loads, vertical seismic loads, wind uplift, additional truss-chord axial loads generated by wall out-of-plane wind/seismic loads, etc.

Show the rows of bridging on the framing plan, the type of bridging (horizontal or diagonal), and the detail reference for attachment of the bridging to the end walls. Dimension the centerline of bearing on the wall section.

Where open-web steel joists are to be used for with long span floor framing (more than 40 feet), check for floor bounce. Floor bounce is especially critical in open areas with no wall partitions. Top chord of open-web steel joist receiving welded metal deck connections, shall be at least ¼" thick.

4.7.4 <u>Steel Deck</u>

4.7.4.1 *Design References*

Use the following references to determine deck type, gauge, coating, allowable spans for uniform loading, and allowable diaphragm shear values for various fastening systems:

- Steel Deck Institute Design Manual, No. 26, Steel Deck Institute.
- Diaphragm Design Manual, Steel Deck Institute.
- Manufacturer's catalogues, with accompanying test reports, such as the ICC-ESR or IAPMO evaluation reports on section properties, allowable diaphragm shear values for roof deck / composite floor deck, and allowable superimposed loads on composite deck.

4.7.4.2 *Design Guidelines*

For roof deck, use an 18-gauge minimum thickness with galvanized coating. For composite floor deck, use 18-gauge minimum, galvanized. If welded shear studs are to be used for composition action, use wide-rib profile.

The following information should be shown on the plans:

- Metal deck profile type
- Depth
- Section properties
- Minimum gauge
- Coating.

Show the required diaphragm shear demand loads on the framing plan, along with the design dead and live vertical loads. Where diaphragm demand loads are large and require extra welding, consider showing zones for different diaphragm shear capacities on the roof plan for economy. All shoring required shall be indicated on the drawings.

All metal attachments at supports perpendicular to flutes, parallel to flutes, and at side laps shall be clearly shown on drawings or specifications.

Show openings in the steel deck and reference details for steel framing required around the openings. Show details for deck attachment to bearing and shear walls, such as deck welding and anchor bolts with a continuous steel ledger angle. Where the ledger angle also functions as a chord member to stiffen the diaphragm, butt weld all splices.

4.8 Masonry

4.8.1 <u>Standard Details</u>

In addition to the typical vertical and horizontal wall reinforcing, the standard drawings are required to show the minimum reinforcement as follows:

- Around wall openings.
- Two vertical bars at wall ends, each side of control joints, wall intersections, and openings.
- Continuous horizontal reinforcing at wall intersections
- Continuous horizontal bond beam reinforcing at floor, and roof levels.

The above reinforcing shall be considered when design calculations are performed, and are not required to be repeated on the drawings detailing the Construction.

All members shall be constructed of 8 inch or 12 inch nominal concrete masonry units (CMU). Walls shall be solidly grouted, with running bond layout. Masonry Buildings shall be constructed using Medium or Regular weight CMU units, and regular weight grout.

4.8.2 Control Joints

The exact location of all Masonry Control Joints (MCJ) shall be determined by the design professionals to control cracking. All required MCJ shall be indicated on the drawings. Control Joints shall be constructed in accordance with the following requirements:

- Provide two vertical bars on each side of MCJ.
- Sash units shall be used with preformed gasket to seal the joint.
- All typical bond beam reinforcing shall stop at MCJ (ending in a standard hook), except the bond beams at floors and roofs shall be continuous through the all MCJ.
- MCJ shall not be constructed by “saw cut” method.

4.8.3 Splices, Connections and Development of Reinforcement

Development lengths and splice lengths shall be in accordance with ACI 530 and the Building Code and shall be shown on the Standard Detail Sheets. Horizontal shear wall reinforcing shall end with a standard hook around vertical bars at wall ends, or control joints.

4.8.4 Arrangement of Reinforcement

Masonry reinforcing is based on Seismic Design Category “D”. Walls shall be designed and detailed as special reinforced masonry shear walls as required by ACI 530. They shall have reinforcing such that the sum of the vertical and horizontal reinforcement is minimum 0.002 times the gross cross-sectional of the wall and neither horizontal nor vertical reinforcement area shall be less than 0.0007 times the gross cross-sectional area of the wall.

4.8.5 Post- Installed Anchors

Design of masonry post-installed anchors shall be in accordance with the following standards:

- ICC-ES Acceptance Criteria AC58 for adhesive anchors in masonry
- ICC-ES Acceptance Criteria AC01 for expansion anchors in masonry
- ICC-ES Acceptance Criteria AC106 for screw anchors in masonry

4.8.6 Analysis and Design

All CMU buildings shall be designed and detailed as Special Reinforced Masonry Shear Wall Structures, as defined per ASCE 7. Shear walls shall be designed to resist 1.5 times the minimum design shear forces (in-plane and diagonal tension stresses).

Columns shall be designed to have a minimum of four longitudinal reinforcing bars and reinforcing area of at least $0.0025A_n$, and not more than $0.04A_n$ and lateral ties at 8 inches maximum spacing. Columns shall be detailed per Section 1.14 of ACI 530-11.

4.9 Aluminum

- Aluminum materials shall conform to the requirements of Chapter 20 of the Building Code and parts 1-A and 1-B of the Aluminum Association's Design Manual "Specifications and Guidelines for Aluminum Structures".
- Aluminum design shall be done in accordance with Chapter 20 of the Building Code and the Aluminum Association's Design Manual.
- Perform deflection checks for all aluminum members to account for aluminum's relatively low elastic modulus.
- Aluminum shall not be used in a submerged condition.
- For all Bolted connections, use Stainless Steel bolts.
- Specific requirements for the structural components used in this project are as follows:
  - Alloy 6061-T6 for structural shapes, plates, and grating
  - Alloy 6063-T6 for extruded aluminum pipe and railing

4.10 Fiberglass

- Fiberglass structural design shall generally be specified to be performed by the vendor.
- Where necessary to arrive at accurate preliminary sizes, engineering data from manufacturers shall be used in preliminary calculations.
- Fiberglass grating (when used) shall be sized by the designer.
- Provide integral UV inhibitor in all FRP grating and shapes.
- Provide Stainless Steel bolts for all connections.

4.11 Stainless Steel

- Structural Stainless steel design shall follow the requirements of AISC Design Guide 27 Structural Stainless Steel and the "Specification for the Design of Cold-Formed Stainless Steel Structural Members".
- Use type 316 stainless steel for all applications.

4.12 Anchorage of Nonstructural Components

Anchorage of nonstructural components shall be in accordance with ASCE 7-10, section 13.4. Components are as follows:

1. Architectural components.
2. Electrical and Mechanical Components
   a. Mechanical and Electrical Components
   b. Vibration Isolated Components and Systems
   c. Distribution Systems (Piping)
      i. Pipes with diameters 8” or less. Provide performance criteria in specifications, such as maximum pipe support spacing for gravity loads, maximum spacing for seismic bracing, etc. Contractor to provide drawings indicating pipe support types, capacities, anchorage detail, and locations.
      ii. Pipes with diameters larger than 8”. Provide performance criteria in specifications, such as maximum pipe support spacing for gravity loads, maximum spacing for seismic bracing, etc. Contractor to provide drawings indicating pipe support types, anchorage details, locations, and structural calculations stamped by a registered civil/structural engineer licensed in state of California.
      iii. Atypical pipe supports. All atypical pipe supports, and special conditions shall be designed by the Engineer of record, and shown on construction documents.

APPENDIX A – STRUCTURAL DESIGN CHECKLIST

APPENDIX – A

STRUCTURAL DESIGN CHECKLIST

TABLE OF CONTENTS

The below reflects typical milestone submittals for the City of Sunnyvale Water Pollution Control Plant (WPCP) Projects, and shall be adjusted if the project requires submittals at different milestones.

SUBMITTAL MILESTONES:

- ER – Engineering Report
- PDR – Preliminary Design Report
- 60% – 60% Design Submittal
- 95% – 95% Design Submittal
- 100% – 100% Design Submittal

The checklist presented in this document is intended to serves as a guideline for future designers and as an example of a structural design checklist. Designers shall select the applicable items in the list that pertain to each project, and may add their own items as applicable to specific project.

STRUCTURAL DESIGN CHECKLIST

1.0 General	ER	PDR	60%	95%	Comments
1.1 Have cut sheets been received from the Mechanical Engineer for pumps, and air handling equipment?		X	X		
1.2 Have cut sheets been received from the Electrical Engineer for emergency generators, transformers and switchgear?		X	X		
1.3 Have cut sheets been received from the Project Architect for, skylights, high density storage systems, folding partitions, Dock levelers/lifts, material handling systems, lab equipment?		X	X		
1.4 In California, all equipment over 400 lbs mounted on a floor or 20 lbs. Mounted on a wall?				X	
1.5 Review building design criteria including loading, vibration, specialty equipment, deflection and lateral forces.	X				
1.6 Identify Potential problems with adjacent Structures.	X				
1.7 Verify availability of Geotechnical Report.		X			
1.8 Verify availability of Existing Building Drawings	X				
1.9 Are all building code issues resolved? If no, explain	X				
2.0 Calculations	**ER**	**PDR**	**60%**	**95%**	**Comments**
• Verify that design is consistent with assumptions? Provide an overview of procedures and methodology.				X	
• Review member as it appears on design drawings. Look at geometry and loading for appropriate plan dimensions, orientation and loads consistent with design loads.				X	
• Spot check calculations other than computer calculation when sizes appear incorrect.				X	
• Check final design shown in calculation against information on drawings.				X	
2.1 Gravity Loading					
• Review and compare initial dead load assumptions with the weights of the members chosen for final design.				X	
• Are Dead Loads overly conservative, i.e., very heavy such that wind uplift and lateral overturning are not safe, use .				X	
• Verify dead load slope correction factors.				X	
• Verify 100 psf live load at all exits, corridors, common areas, unreducible				X	

• Review mechanical equipment loads including suspended equipment, roof-top units, tanks, etc.				X	
• Verify partition allowance has been accounted for.				X	
• Has live load reduction been properly utilized?				X	
• Verify unbalanced loading combinations.				X	
• Has deflection, ponding, and vibration perceptibility been addressed?				X	
• Any hydrostatic uplift? (Such as tunnels, basements, tanks, etc.)				X	
2.2 Load Combinations					
• Are all code required load combinations included?				X	
• Verify that deflection calculations are based on service loads.				X	
• Verify that calculations clearly show which method is used and that it is consistent throughout project (Stress/ASD vs. LRFD/Ultimate).				X	
2.3 Wind Loading					
• Exposure and importance factor.				X	
2.4 Wind speed					
• 1.5 factor of safety for overturning (2/3 dead load resisting moment).				X	
• Net uplift: Is assumed Dead Load appropriate for resisting wind uplift and overturning?				X	
• Review load path for uplift forces (H clips at wood trusses, brace bottom/compression flange of beams). (Review load path.)				X	
2.5 Is wind drift within acceptable limits?				X	
2.6 Quartering wind, corner columns.					
• Has code required torsion and diagonal wind direction been considered?				X	
• Verify that elements and components wind load is correct.				X	
2.7 Seismic Loading					
• Irregular structure, plan or vertical.				X	
• Simplified static procedure limitations.				X	
• Dynamic analysis trigger.				X	
2.8 Base Shear.					
• Redundancy, overstrength factors (Verify proper application for chords, drags, & collectors).				X	
2.9 Seismic Weight					
• 25% of storage live load in seismic				X	

mass.					
• 10 psf partition seismic weight to floors.				X	
• Mapped Spectral Acceleration					
• Operating weight of equipment in seismic weight.				X	
• Ballpark check: Period T approximately = 0.1 x Number of stories.				X	
• Vertical distribution of force formula.				X	
• 5% accidental torsion included.				X	
• Column strength (Omega) load combinations for irregular structures.				X	
• Is calculated drift within allowable code limits.				X	
• Has deformation compatibility been considered?				X	
• Has adequate building separation been provided?				X	
• Have out of plane seismic forces on parts of structure been considered?				X	
• If tank with toxic substances, Ip=1.5.				X	
• Corner columns, orthogonal effects, SRSS combinations.				X	
2.10 Global Load Path					
• Load Path: Continuous and in proportion to relative rigidities of elements.				X	
• Gravity: From roof to foundation, connections.				X	
• Seismic: From each mass and/or level to foundation, connections.				X	
2.11 Wind: From walls and roof to foundation, connections.					
• Review lateral load path including load transfer from base plate to soil.				X	
• Review global overturning and sliding resistance calculations.				X	
2.12 Computer Analysis					
• Units consistent, ft, in, kips, degrees vs radians.				X	
• Member orientation correct? Week vs strong axis bending.				X	
• Check plot of model for configuration, load and reaction direction, case by case.				X	
• Global Restraints: Are global restraints appropriate? Review horizontal reactions for appropriateness.				X	
• Beams cambered for 75 percent or less of calculated dead load				X	

deflection.					
• Typical beam connection table checked for project loads.				X	
• Typical beam vibration characteristics checked.				X	
• Special loading conditions incorporated into design.				X	
2.13 Other drag loads.					
• Are mid span moments, forces, deflections reported and critical? Or reports at nodes only?				X	
• Connection design based on load path vs reported member end force: e.g., for a concentric braced frame with an in-plane offset, the connection of beam to column may need to be designed for the reported end force plus the horizontal component of the brace.				X	
• Thermal expansion and contraction stresses (building greater than 200' in plan).				X	
• Are horizontal members in braced frames designed for the proper axial force?				X	
2.14 Foundations					
• Allowable bearing pressures, net? Working stress?				X	
• 1.33 stress increase OK.				X	
• Piling: group action reduction factors when closely spaced.				X	
• Are tie beams required and are they properly designed				X	
• Lateral earth pressures: Active equivalent fluid pressure or higher "at rest" pressure if top is constrained (i.e., basement wall).				X	
• Hydrostatic pressures or adequately drained condition.				X	
2.15 Retaining Walls					
• Factor of Safety and minimum loads.				X	
• Surcharge loading, parking, construction equipment.				X	
• Allowable bearing pressures, net?				X	
• Check overturning stability, sliding, bearing pressure, concrete bending/shear in wall and footing, assure adequate development length in footing rebar.				X	
2.16 Concrete					
• Verify that load factors and phi factors are consistent with code used.				X	

• Flexure ballpark check:				X	
• As req'd (in^2) = Mu (ft-k) / [4*d (in)].				X	
• Check for proper bar size and spacing.				X	
• Spread footings: check against CRSI tables.				X	
• Stirrups for torsion (Spandrel beams, offset beams, etc).				X	
• Lightweight concrete: Reduction factor, lambda, for shear.				X	
• Splices: factors affecting splice length: fc, Fy, spacing, cover, col/beam/wall/ductile, top bar, lightweight conc, epoxy coated, excess reinforcing, class A or B.				X	
• Check beam and slab deflection and long term creep per ACI.				X	
• Check for proper bar size and spacing				X	
• 135 degree stirrups and ties @ 4" oc, ductile detailing.				X	
• Anchor Bolts, Headed Studs and Expansion Anchors Review connection with close spacings or edge distances.				X	
2.17 (CMU) Concrete Block Masonry					
• Check bond length of flexural reinforcement.				X	
• Minimum anchorage of walls to roof.				X	
• Deflection for lintel or veneer support L/600.				X	
• CMU Seismic				X	
• Working Stress Design.				X	
• 1.5 factor for seismic loads in shearwalls, working stress.				X	
• CMU Columns.				X	
• CMU Lintels.				X	
• CMU Walls (Bearing / Shear)				X	
2.18 Steel					
• Verify material grade used, i.e., Gr 50 for shapes, but also for plates and small angles?				X	
• Steel Beams				X	
o Brace compression flange: bottom flange for continuous beams, net wind uplift, design brace for 2% of flange force.				X	
o Beam stiffeners required atop steel columns for stability.				X	
o Torsion accounted for?				X	
• Steel Columns				X	

o K > 1.0 if moment frame, i.e., column not braced with shearwall or X braced frame.				X	
o Moment due to eccentricity of beam end connection used.				X	
o Transverse loads from cladding connections included in calculations.				X	
o Eccentricity of loads considered at perimeter and other non concentrically loaded columns.				X	
2.19 Steel Connections					
• Prying Action.				X	
• Eccentricities on bolt groups.				X	
• Eccentricities on welds.				X	
• Gusset plates: width thickness, Whitmore section.				X	
• Net section.				X	
• Bolt bearing on thin plates.				X	
• Bolt capacities, SC or bearing				X	
• Collector and chord forces.				X	
2.20 Steel Seismic Allowable Stress Design					
• Reduce earthquake forces by E/1.4.				X	
• Member strength allowables 1.7 * allowable: do not also include 1.33 stress increase, increase loads by Omega.				X	
• Column strength, splices, slenderness.				X	
• Ordinary Moment Frame requirements OMF.				X	
• Special Moment Frame requirements SMRF.				X	
• Connections, seismic provisions, follow Code.				X	
2.21 Ordinary Concentric Braced Frames (OCBF).					
• Slenderness ratio maximums.				X	
• Built-up members, stitch plates, local l/r.				X	
• Width thickness minimums.				X	
• Chevron bracing requirements, 1.5 factor apply to diagonal brace member only and not to beams, columns or brace connection.				X	
• No K bracing, no non-concentric bracing.				X	
• Non-building Structures: R from Non-building table, need only comply with connection requirements for braced frames				X	

2.22 Steel Seismic Bracing Connections					
• Brace connections: Seismic*Omega, or 1.7 allowable.				X	
• Net area.				X	
2.23 Wood					
• Allowable stress adjustment factors for: duration, size, repetitive member, flat use, wet use, etc.				X	
o Wind: 1.6 duration factor in lieu of 1.33; members only, not connections.				X	
o SPF studs, low allowable shear and E				X	
o Dead load slope correction factors				X	
• Wood Connections				X	
o Bolts: Min edge distance, end dist, spacing.				X	
o Nails: Adequate penetration, reductions for wet use.				X	
o Increases for metal side plates.				X	
o No cross grain tension or ending stresses.				X	
o No heel cuts or bottom notches near bearing.				X	
o Adequate bearing area for engineered products, LVL, PSL.				X	
• Wood Seismic				X	
o Ties, Collectors, Chords.				X	
o Anchorage to heavy walls, 200 plf min.				X	
o Diaphragms: Flexible, Deflection.				X	
o Force equation.				X	
o Continuous cross ties.				X	
o Large diaphragm openings detailed.				X	
3.0 Drawings	**ER**	**PDR**	**60%**	**95%**	**Comments**
3.1 General Notes					
• Abbreviation list, symbols and marks defined.		X			
• Shore and protect existing.	X	X			
3.2 Design Basis: Code Used (i.e., CBC)					
• Dead load assumptions.		X			
• Live load used.		X			
• Snow load, exposure, rain on snow surcharge.		X			
• Wind speed, exposure, enclosed/ partially open, importance factor.		X			
• Seismic accelerations, design category, site class, base shear,		X			

analysis procedure, response coefficients.					
3.3 Soils report referenced					
• Basis of foundation design noted, allowable bearing pressure, equivalent fluid pressure etc.		X			
• Are encroachments into vertical chases coordinated on arch background?		X			
• Have major openings been located on structural drawings?		X			
• Are perforated drains behind basement and retaining walls shown in section and coordinated with mechanical?		X			
3.4 Concrete Notes					
• fc, regular weight, verify all uses and coordinate with specifications.		X	X		
• Rebar: Grade 40/60, A706 where welded.		X	X		
• Splice lengths called out.		X	X		
3.5 Steel Notes					
• Grade of Steel (A36, Gr50) Shapes, Plates, Tubes, Pipes.		X	X		
• 65 ksi steel, if used, is clearly specified.		X	X		
• High strength bolts (A325, A490), Anchor bolts (A307).			X	X	
• Expansion anchor (i.e., Hilti…), Epoxy, Headed studs.			X	X	
• Powder Actuated Fasteners (i.e., Hilti…) size, penetration.			X	X	
3.6 Wood Notes					
• Plywood (roof, floor, shearwall) thickness, span rating, exposure, finish, T&G, Blocked/unblocked, nailing pattern.			X	X	
• Equivalent OSB OK?			X	X	
• Glue to floor plywood to joist (adhesive AFG-01).			X	X	
• Framing material and grade (DF#2, SP#2, SPF#2) for joists, rafters, studs, beams, columns, sills.			X	X	
• Plates in contact with concrete are Preservative Treated.			X	X	
• Framing hardware (Simpson, Kant-Sag) note to fill all holes with nails or bolts.			X	X	
• Anchor bolts, through bolts, lag screws (A307).			X	X	
3.7 CMU Notes					
• Block grade N, lightweight or normal			X	X	

weight if exposed to weather, moisture controlled, compressive strength.					
• Rebar grade, lap splice.			X	X	
• Horizontal bed joint reinforcement, size, type, spacing.			X	X	
• Mortar type M if below grade, otherwise type S.			X	X	
• Grout 3/8” max aggregate size, fg, 8 to 10” slump.			X	X	
3.8 Foundation Plans					
• Datum elevation defined, coordinated with civil, architect.			X	X	
• Pipe penetrations through foundations coordinated.				X	
• Compaction and quality of fill defined.			X	X	
• Detail anchor bolt placement for steel columns. Detail rebar dowels for concrete columns and walls.			X	X	
• Show sump pit locations. Coordinate with mechanical/plumbing engineer and architect.		X	X		
• Show vapor retarder and capillary water barriers as required.			X	X	
• Coordinate slab depressions with architect and civil engineer.		X	X		
• Show floor drains and slopes.				X	
• Dimension pits (including depth).				X	
• Foundation type verify with soils report. Also, foundation design criteria preparatory earthwork.				X	
• Foundation elevations – Top of footing, pile, pier length for bidding, etc.				X	
• Exterior grades, interior elevations, depth of footing at exterior for frost.		X	X		
• Pilasters – top of pilaster, reinforcing size; - coordinate with column and footing.		X	X		
• Foundation/perimeter drains defined and coordinated with soils report.			X	X	
• Stoops defined – detail if frost is present.		X	X		
• Mechanical/electrical pads and curbs detailed.			X	X	
• Requirements at existing footings – shoring, underpinning, etc.			X	X	
• Coordinate with demolition plans – what is still remaining, fill compaction, etc.			X	X	
• Embeds in grade beams/foundation walls located, protected if in contact with soil.			X	X	

• Have existing footings requiring underpinning been clearly identified on the foundation plan?	X	X	X		
• Is the permanent under-floor dewatering system shown on the mechanical piping plan and detailed on the structural drawings?			X	X	
• Are existing utilities that are to remain in service shown on the foundation plan?			X	X	
3.9 Chiller, Boiler, and Emergency Generator Foundations:					
• Are foundations sizes and location coordinated with HVAC or Electrical drawings?				X	
• Are foundation details provided?				X	
3.10 Power Company Transformer Pads within 5' of Building:					
• Are power company pad sizes shown on electrical drawings?			X	X	
• Are power company pads located on electrical drawings?			X	X	
• Are pads shown on structural drawings for coordination?			X	X	
3.11 Loading Docks					
• Are dock walls located with respect to column grids?			X		
• Is there a section cut through each loading dock?			X		
• Are dock bumpers detailed on architectural drawings?			X		
• Is there an edge angle shown in each loading dock section?			X		
3.12 Spread Footings					
• Verify all column footings are scheduled.			X	X	
• Verify all column footings length, width, thickness and reinforcing are scheduled.			X	X	
• Verify continuous wall footing sizes and reinforcing are detailed.			X	X	
• Verify top of footing elevation for each footing is clearly shown.			X	X	
• Bottom below frost depth, or below soils report recommendation.			X		
• Sleeve holes for utilities, max size allowed, add bars.				X	
• Step continuous footing where elevation changes.			X	X	
3.13 Mat Foundations					
• Verify top of mat elevation is clearly shown.			X	X	
• Verify depth, length, width, and			X	X	

location of depressions in mat clearly shown.					
• Verify mat thickness clearly shown.			X	X	
• Verify mat reinforcement shown on plan or scheduled.			X	X	
• Verify construction joint details are provided.			X	X	
• Verify reinforcing placing sequence shown on plans where applicable.			X	X	
3.14 Drilled Piers (Caissons)					
• Verify drilled pier detail shows top and bottom of pier, reinforcing steel, bells and caps.			X	X	
• Is there a typical caisson section?			X	X	
• Verify tension drilled piers clearly indicated on schedule or plans.				X	
• Verify all necessary tension drilled pier details shown.				X	
• Plan showing location with individual piers numbered.				X	
• Tip elevation, top elevation.				X	
• Reinforcing called out.			X	X	
• Spiral lap splice length.				X	
• If the doweled rebars protruding from top of pier have hooks, are they compatible with casing removal?			X		
• Hooked bars compatible with grade beam rebar?			X	X	
3.15 Auger Cast Piling					
• Verify pile cap plans, show length, width, thickness and reinforcing for each pile cap.			X	X	
• Verify top of pile cap elevation for each pile cap clearly shown.			X	X	
• Verify pile detail showing reinf. Embed in pile cap bottom.				X	
• Verify pile diameters clearly indicated.			X	X	
• Verify total bid length clearly shown or bottom and cut-off el. For pile groups noted.				X	
• Verify required pile capacity clearly indicated.			X	X	
• Verify reinforcing shown for piles.			X	X	
• Verify tension piles clearly indicated and detailed.			X	X	
• Verify soil stratum that pile bears on is noted on pile detail if pile is bearing. If pile is friction note friction material.				X	
3.16 Driven Piles (Steel H or pipe, precast, prestressed)					

• Verify pile cap plans showing length, width thickness and reinforcing for each pile cap.			X	X	
• Is there a typical pile cap elevation?				X	
• Is there a typical pile cap section?				X	
• Is tip elevation indicated for each pile?			X	X	
• Is pile size and material strengths clearly indicated?			X	X	
• Is pile capacity clearly indicated?			X	X	
• Verify batter (usually 1 to 3 max.; 1 to 4 more common) is clearly indicated for each battered pile.				X	
3.17 Concrete Driven Piles					
• Precast performance specification.				X	
• Dowels to grade beams				X	
3.18 Mud Slab					
• Verify top of mud slab elevation shown.			X	X	
• Verify thickness of mud slab shown.			X	X	
3.19 Slab-on-Grade					
• Supported on Piles or Grade Beams:					
o Void forms if expansive clays.			X	X	
o Verify slab thickness clearly shown.			X	X	
o Verify reinforcing scheduled or shown on plan.			X	X	
o Verify typical slab section shown showing thickness reinforcing, and reinforcing location and placing sequence.			X	X	
o Verify each grade beam scheduled with depth, width and reinforcing.			X	X	
o Verify a pile to slab section.			X	X	
• Supported on Soil					
o Verify slab thickness clearly shown.			X	X	
o Verify reinforcing clearly shown.			X	X	
o Are construction and control joints located?				X	
o Are isolation joints shown where required?				X	
o Are construction and control joints detailed?				X	
o Are isolation joints detailed?				X	
o Are thickened slab locations for masonry wall clearly indicated?			X	X	
o Are turned down slab locations clearly indicated?			X	X	
o Are joint sealants specified?				X	

(Generally applies to industrial floors and paving.)					
o Expansion joint material at walls or existing construction (floating slab), or dowels for tied together construction.			X	X	
o Expansion joint material around steel columns.				X	
3.20 Stairs-on-Grade					
• Are treads and risers shown on architectural drawings?				X	
• Are abrasive nosings detailed on architectural drawings and/or specified where required?				X	
• Is there a section cut through the stairs on grade showing reinforcing?				X	
3.21 Cast-in-Place Concrete Walls					
• Basement Walls					
o Are all walls located with respect to column grids?			X		
o Is there a section cut at each basement wall condition?			X	X	
o Is thickness clearly shown for each basement wall condition?			X	X	
o Is reinforcing shown for each basement wall condition?			X	X	
o Is there a note stating that walls cannot be backfilled until bracing slabs are in place?				X	
o Are construction, control and expansion joints shown on foundation plan where necessary?				X	
o Are construction, control and expansion joints detailed?				X	
o Are brick ledges or other changes in wall thickness clearly located and have tops of ledge elevations been indicated?				X	
o Are ledges detailed where support of slab-on-grade, at fill side, is required?				X	
o Call out finishes. Coordinate exposed concrete wall finishes required with architect.				X	
• Cantilevered Retaining Walls					
o Are all walls located?			X	X	
o Is there a section cut at each retaining wall condition?			X	X	
o Is thickness clearly shown for each retaining wall condition?				X	
o Is retaining wall batter clearly shown?				X	

o Is reinforcing shown in sections and/or schedules?			X	X	
o Are construction control and expansion joints indicated?				X	
o Are construction control and expansion joints detailed?				X	
o Are brick ledges or other changes in wall thickness clearly located and have tops of ledge elevations been indicated?				X	
o Allow movement at top to occur.				X	
o Drainage behind wall, drain rock with geotextile fabric.				X	
o Detail length of lap splice between vertical bars in wall and footing dowels.				X	
• Concrete Walls					
o Add bars at openings and re-entrant corners.			X	X	
o Corner bars at wall intersections and corners.				X	
o Add bars around handrail post sleeves.				X	
o Dampproofing, bituminous coating (basements)			X	X	
• Tilt-up					
o Wall h/t				X	
o Chord bar connection.				X	
o Continuous cross ties.				X	
• Precast					
o Performance specification, design responsibility, seal by fabricator.				X	
o Allowable camber, deflection, weight.				X	
o Detail shear transfer and load path.				X	
o Wall panels and Cladding.				X	
3.22 Columns/Steel					
• Wide Flange, Pipe, Tube or Built up:					
o Are all columns either scheduled or their sizes shown on plans?				X	
o Is each different type of column detailed?				X	
o Is there a future column extension detail?				X	
o Coordinate fireproofing (U.L. design numbers) with architect.				X	
o Column splices shown 4’ above floor level.				X	
3.23 Steel baseplates					
• Plan dimensions, thickness.					
o Anchor bolts; length, embedment,			X	X	

projection, threads, min edge distance, minimum of 4 bolts for erection safety (OSHA requirement).					
o L bolts or nut tack welded.				X	
o Oversized holes OK, shear key req'd, for large shear force transfer.				X	
o Weld to column (avoid fillet welds in tension for high seismic loads in critical locations).				X	
o Grout: "non-shrink", thickness, relief holes for large baseplates.				X	
o Bracing work points defined.				X	
• Concrete					
o Is every column scheduled?			X	X	
o Is concrete unit weight and strength clearly indicated in the General Notes and column schedule?				X	
o Are mechanical splices detailed?				X	
o Is there a typical column construction detail?				X	
o Is there a detail for column transition from round to square, or vice versa if necessary?				X	
o Are splice lengths indicated?				X	
o Are dowel embedment lengths indicated?				X	
o Is there a future column extension detail?				X	
o Is the orientation of rectangular columns defined?				X	
3.24 Supported Floors and Roofs					
• Concrete Curbs					
o Are all curbs shown on plans?				X	
o Is there a section through each curb showing reinforcing?				X	
o Are curbs coordinated with architectural and mechanical drawings with regard to location, width and depth?				X	
• Topping Slabs					
o Is thickness and reinforcing called out for topping slabs?				X	
o Is concrete unit weight and strength called out in the General Notes and/or specifications?				X	
o Is a depression in the structural slab required for the topping slab?			X	X	
o Is required slope to floor drains indicated?			X	X	

o Has differential shrinkage and curling been addressed?				X	
• Self-Leveling Concrete:					
o Are locations where self-leveling concrete is required clearly shown?				X	
o Are maximum and minimum thicknesses called out?				X	
• Equipment Pads					
o Are pad sizes shown on HVAC/plumbing/electrical drawings?			X	X	
o Are pad detailed or specified by discipline requiring them?			X	X	
o Are pads located on HVAC/plumbing/electrical drawings?			X	X	
o Are pads shown on structural drawings for coordination?				X	
• Trench Drains					
o Are trenches tied to column grids in two directions?			X	X	
o Is width shown for each trench?			X	X	
o Are trench inverts given?				X	
o Is there a section cut through each trench?			X	X	
o Are structural drawings coordinated with plumbing and/or architectural drawings?				X	
o Plan notes on each plan.			X	X	
o Is the depth and location of each depression in the slab shown and coordinated with architectural/process drawings?			X	X	
o All slab reinforcing called out.			X	X	
o Show where slopes to drain, recesses.			X	X	
o Finish: Hard Trowel/Broom, F number. Coordinate with specifications.				X	
o Is the required fire resistance provided?			X	X	
o Elevations: Top of steel, top of concrete, finished floor, joist bearing, top of plywood, and top of column.			X	X	
o HVAC duct openings shown, located and framed.			X	X	
o Vertical Bracing locations shown, type.			X	X	
o Moment connections locations shown.			X	X	
• Dimension floor openings, shear wall			X	X	

lengths (and thicknesses), etc.					
• Schedule final post tensioning forces.				X	
• Roof drainage accounted for, built up insulation or sloping top of steel, slopes, work points.			X	X	
• Weight of roof top equipment shown on drawing.				X	
3.25 Steel Framing/Steel Framing Plans					
o Top of steel defined.				X	
o Edge of deck condition, edge angles defined.				X	
o Cladding connection detail.				X	
o Framing for roof screen columns and braces.				X	
o Vertical bracing locations shown, type.				X	
o Moment connections located.				X	
o Is the top of steel for roofs clearly shown and coordinated with slopes required by architectural drawings?				X	
• Steel Beams					
o All beam sizes are labeled.			X	X	
o Camber, composite stud size, length and spacing.				X	
o Spandrel beams braced for interior cladding support.				X	
• Steel Details, Connections					
o Work points defined.			X	X	
o Weld sizes, lengths, symbols, electrodes, procedures, inspections.				X	
o Complete penetration vs. partial penetration welds clearly and efficiently specified.				X	
o Bolt sizes, quantity, type (A325N, A325SC, A307), scheduled per beam depth or location.				X	
o Hole types: STD, OVS, short or long slots and orientation of slot.				X	
o Snug tight, fully pretensioned or slip critical; inspection.				X	
o Special detail for W6 and C6 connections w/ 2 bolts.			X	X	
o Web stiffeners req'd for steel beams continuous over tops of columns for stability.			X	X	
o Web stiffeners req'd for handrail posts at steel beams?				X	
o Have HDR standard connection details and capacities been used.			X	X	
• Steel Embed Plates					

o Adequate thickness if field welded (prevent concrete popping).			X	X	
o Adequate room or weep holes to allow concrete to flow under horizontal plates.				X	
o Nelson studs in specifications.				X	
o Stud or anchor bolt locations compatible with rebar.				X	
• Open Web Steel Joists					
o Joist bearing elevation.			X	X	
o Depth of bearing ends of joists coordinated with manufacturer requirements?				X	
o Performance specification, design responsibility, seal by fabricator.				X	
o Bridging design by fabricator, connection to building by designer, detail connection.				X	
o Define loads for design, including dead load to be used, equipment, roof screens, live load reduction.			X	X	
o Define collector loading.		X	X		
o Specify deflection criteria, vibration.				X	
o Paint (primer/none)				X	
o Hat or tube steel between joist bearings for shear transfer (between metal deck and collector beam), weld size and spacing.			X		
o Bolted connections required at top of column locations (OSHA requirement).				X	
o Joist girder bottom chord stabilization plate, label “do not weld.”				X	
o Is joist bridging clearly indicated either on plans or in specifications?				X	
o Are joist girders properly indicated?				X	
• Metal Deck					
o Depth, Gauge, Acceptable, Manufacturer or Section properties.				X	
o Galvanized or painted, vented, WWF.				X	
o Welding: Size, type and spacing; ends, edges, sidelaps.				X	
o Direction of span shown.			X	X	
o Minimum gage thickness of end dam material.			X	X	

o Reinforcement at openings, Support at column openings.			X	X	
o Detail connections in load path from diaphragm to vertical shear resisting elements.				X	
o Maximum deck spans checked for shoring.				X	
o Deck designations consistent between plans, schedule and specifications.			X	X	
o Are deck cantilever conditions detailed and supporting calculations (including cladding loads) provided?				X	
o Is a construction joint detail in concrete fill over deck included?				X	
o Typical opening details provided? Larger openings framed in plan? Diagonal trim rebar shown at larger openings?				X	
• Is concrete fill unit weight and strength called out in the General Notes?				X	
• Is reinforcing in slab indicated?				X	
• Is each floor or roof opening shown and coordinated with architectural/process/mechanical			X	X	
3.26 Cast-in-Place Concrete					
• Concrete Pan Joists, Beam and Slab			X	X	
o Are pan widths and depths shown on plan?			X	X	
o Is every joist and beam marked and scheduled?				X	
o Are distribution ribs indicated on framing plans?				X	
o Is there a distribution rib detail?				X	
o Is slab reinforcing either scheduled or shown on plans and/or sections?				X	
o Is concrete unit weight and strength called out in the General Notes and/or sections?				X	
o Is there a construction joint detail for slabs, beams, and joists?				X	
o Are post-tensioning cable ordinates and forces for each joist and/or beam scheduled?				X	
• Flat Plate or Flat Slab					
o Is slab thickness shown?			X	X	
o Are all reinforcing bars either scheduled or shown on framing plans?			X	X	
o Is reinforcing steel placing				X	

sequence shown? Are drop panels dimensioned with regards to plan size and depth?					
o Is concrete unit weight and strength called out in the General Notes and/or specifications?				X	
o Are reinforcing placement diagrams shown for column and middle strips, added column bars and corners?				X	
o Is each beam marked and scheduled?				X	
o Are final post-tensioning cable ordinates and forces scheduled?				X	
• Concrete Beams					
o Stirrup and tie spacing and size, type of hook 90/135 Verify proper bar development at beam ends.				X	
o Intersecting bars are compatible and layered.				X	
o Avoid hooking both ends of a continuous bar, accurate length problems.				X	
o Chamfer corners.				X	
• Concrete Detailing / General					
o Adequate hook embedment.				X	
o Adequate development length.				X	
o Rebar spacing large enough to allow flow of concrete between bars, at splice locations also.				X	
o Add bars at openings, reentrant corners.				X	
o Corner bars at wall and beam intersections.				X	
o Section cuts are consistent for layering of bars (walls, slabs, beams).				X	
o Construction joints are detailed.				X	
3.27 Structural Precast Concrete					
• Are all precast concrete members shown in plan?			X	X	
• Are loading diagrams provided for every member?				X	
• Is topping concrete unit weight and strength called out in General Notes?				X	
• Is topping reinforcing called out?				X	
• Are coring limitations specified?				X	
3.28 Wood Framing					
• Wood Framing Plans.				X	
o Top of plate or joist bearing elevation.				X	

o Differentiate bearing walls from non-bearing walls.				X	
o Continuous cross ties for roof.				X	
o Shearwall locations shown.				X	
o Shearwall nailing, sill nailing/bolting, anchor bolts.				X	
o Hold downs dimensioned adequately for concrete workers to locate.				X	
o Hold Down size, bolts, embedment, post size.				X	
o Dimensions are to face of stud UNO.				X	
o Typ door and window headers called out.				X	
o Large diaphragm openings detailed.				X	
• Wood Details					
o Shrinkage considered.				X	
o Minimum bolt edge and end distance (4d and 7d).				X	
o No cross grain tension or bending stresses.				X	
o No nails in withdrawal.				X	
o Detail connection load path from diaphragm to vertical shear resisting elements.				X	
o Blocking at 4' oc at walls parallel to joists				X	
o Continuous 2x6 studs at tall walls.				X	
o Note to "edge nail" shearwall plywood to hold down post.				X	
o Minimum distance of wood above earth, exterior and crawl space.				X	
• Manufactured Wood Products.					
o Floor stiffness, vibration, perceptibility.				X	
o Allowable Fb, E, Wet-use.				X	
o Hanger type, size and nail quantity, web stiffeners.				X	
o Glulam beam camber.				X	
o Adequate nailer thickness for top mounted hangers.				X	
• Prefabricated Wood Trusses.					
o Performance specification, design responsibility, seal by fabricator.				X	
o Bridging and connection responsibility.				X	
o Define loads for design, including dead load to be used,				X	

equipment, snow (Pg vs Pf), snow drift, rain on snow surcharge, live load reduction.					
o Dead load should be realistic for net wind uplift condition.				X	
o Specify deflection criteria, inter-panel deflection.	X			X	
o Roof slope, ceiling profile.	X				
o Define bearing type, dimensions, and cantilever/overhang dimensions.	X				
o Define "no bearing" partition walls.	X				
o H clips at net wind uplift conditions.	X				
o Show plywood sheathing below valley trusses and below "California Framing."	X				
• Is plywood sheathing grade, span rating and thickness indicated?	X			X	
3.29 Lateral Load Resisting Elements				X	
3.30 Moment Resisting Steel Frames:				X	
• Is every beam to column connection requiring Type I construction clearly indicated?					
• Is every Type I connection completely detailed on structural drawings?					
3.31 Braced Steel Frames:				X	
• Are elevations of each braced frame drawn showing every member size?				X	
• Is every connection detailed on structural drawings?					
• Are member forces and transfer forces shown on braced frame elevations?				X	
• Are braced frames locations shown on foundation and framing plans?			X	X	
• Verify architectural and HVAC drawings coordinated with structural drawings with regard to braced frames (enclosure thicknesses, opening locations and sizes, details when adjacent to shafts, etc.).				X	
• Describe lateral load path from baseplate to soil.				X	
• Are drag connections completely detailed?				X	
• Do shear lugs clear grade beam reinforcement?				X	
• Oversized holes in baseplate acceptable?				X	
• High strength anchor bolts checked				X	

availability?					
3.32 Concrete Shear Walls					
• Verify all walls are dimensioned to column grids in two directions.			X	X	
• Verify the thickness, length, and height of every wall shown.			X	X	
• Verify elevations of each wall is drawn showing reinforcing steel, HVAC openings, door and window openings, sleeves, etc.			X	X	
• Verify concrete unit weight and strength called out in the General Notes and/or specifications.				X	
• Verify rebar splices and development lengths scheduled or noted.				X	
• Verify mechanical couplers required and detailed.				X	
• Is all reinforcing steel scheduled or shown on enlarged plans?				X	
• Verify reinforcing steel specification matches code requirements for ductility.				X	
3.33 Partially Restrained Steel Frames					
• Verify every beam to column connection requiring Type 3 construction clearly indicated.				X	
• Verify every Type 3 connection completely detailed on structural drawings.				X	
3.34 Knee Braces:					
• Verify every location where knee braces are required is clearly indicated.				X	
• Verify knee brace sizes and connections fully detailed showing plate thicknesses, welds, bolts, etc.				X	
3.35 Steel Bracing					
• Spacing of double angle spacers, stitch plates.				X	
• Verify locations do not conflict with windows, louvers, etc.				X	
3.36 Masonry					
3.37 CMU Reinforcing:					
• Vertical bar size and spacing, foundation dowels to match, show lap splice length and hook.			X	X	
• Horizontal bond beams, locations and max spacing, size.			X	X	
• Additional rebar: corners, wall intersections, door and window openings, below beam bearings.			X	X	
• Define which cells to grout (cells w/			X	X	

rebar only, or all cells).					
3.38 CMU Plans					
• Dimension to only one face of wall (nominal dimension problems).			X	X	
• Wall joint spacing, type.				X	
3.39 CMU Detail					
• Joint types, cut rebar and joint reinforcement at joints except at floor and roof bond beams.				X	
• Lateral bracing at top of non-bearing walls, with vertical slots.				X	
3.40 CMU Lintels					
• Bottom of lintel elevation, minimum depth, reinforcing				X	
• Bearing condition, extend beyond opening.				X	
• Verify all lintels scheduled and or detailed. Verify type-steel, precast, bond beam and bearing length and detail.				X	
• Verify reinforcing for every masonry wall clearly indicated.				X	
• Verify bracing or connection details for all masonry walls which properly anchor walls to building frame and are they coordinated with architecture when exposed?				X	
• Are brick expansion and control joints clearly shown on architectural elevations?				X	
• Is the maximum spacing for CMU control joints clearly specified?				X	
• Coordinate specification for reinforced masonry.				X	
• Design and schedule lintels.				X	
• Steel Bar Grating				X	
• Galvanized/painted, thickness, size, attachment to framing.				X	
• Span direction, support at large holes.				X	
• Cold Formed Steel				X	
• Gauge, size, section properties, grade.				X	
• Weld lengths, screw size and quantity.				X	
• Bridging (walls and roof/floors).				X	
• Strap bracing locations, details.				X	
• Expansion Anchors				X	
• Diameter, Embedment, Min edge distance, spacing				X	
• Epoxy Anchors				X	

• Diameter, Embedment, Min edge distance, spacing.				X	
• Use only if non-rated construction and less than 130 degrees F.				X	
• Miscellaneous				X	
• Steel Stairs				X	
• Performance specification, design responsibility, seal by fabricator.				X	
• Slotted holes at connection to floor slab.				X	
3.41 Metal Buildings					
• Wind columns are (or are not) allowed.			X	X	
• Rebar in slab (hair pins) for outward horz forces at column bases.				X	
• Performance specification, design responsibility, seal by fabricator				X	
4.0 Specifications	**ER**	**PDR**	**60%**	**95%**	**Comments**
• Has the perimeter and under slab drainage specification been coordinated with the geotechnical report?				X	
• Check that add/deduct bid items explicitly state what is intended.				X	
• Check specifications for phasing of construction.				X	
• Compare architectural finish schedule to concrete specification.				X	
• Verify that the items specified “as indicated” or “where indicated” in the specifications are in fact indicated on contract drawings.				X	
• Verify that all specification sections are in the index and that cross referenced specifications sections exist.				X	
• Try not to indicate thickness of materials or quantities of materials in specifications				X	
• Tailor the specifications to the project.				X	
• Avoid duplications between specification sections				X	
5.0 Coordination/Structural	**ER**	**PDR**	**60%**	**95%**	**Comments**
• Column Grid, Column Locations, Column Orientation.		X	X		
• Floor-to-Floor Heights, Floor Elevations.		X	X		
• Bracing System Locations.		X	X		
• Major Floor Openings.				X	
• Fire Resistance Requirements.		X		X	

• Occupancy and Floor Loadings.		X	X	X	
• Major Mechanical Equipment Locations.		X	X		
• Building Expansion Joint Locations.				X	
• Verify depressed or raised slabs are indicated and match architectural. (Include depressions required for floor finishes such as terrazzo or quarry tile.		X	X		
• Verify slab or roof thickness meet required fire resistance rating.		X	X		
• Verify location of all skylights. Review support details.			X	X	
• Review bracing concepts for architectural building cladding.				X	
• Verify that acceptable connection points and any limitations for exterior stud, precast, and curtain wall systems that are to be designed by others are defined.				X	
• Review location of cladding load application to structural frame. Size and detail all miscellaneous metal members such as hangers, bracing, etc., along with necessary welds and bolts shown on architectural drawings.				X	
• Review floor elevation nomenclature to be used.		X			
o Actual civil elevation.		X			
o 100' – 0" = civil elevation 1542.0'		X			
• Determine roofing system and weights.			X		
• Verify building code information on drawings.		X	X		
• Verify construction/depression requirements of bathroom floors.		X	X		
o Architectural Items with Structural Implications				X	
o At sloping roofs, do horizontal or large members protrude through ceiling or roof				X	
o Parapets secure for wind load and window washing equipment support.				X	
o Brick veneer ties and cavity space size.				X	
o Cladding and Windows attachment and support.				X	
o Performance specifications and design responsibility for stairs, exterior stud wall, curtain wall, precast, etc.				X	

	ER	PDR	60%	95%	Comments
o Roof elevations provide sufficient slope for the entire roof (¼"/ft. min.).				X	
o Partitions and ceiling bracing adequately detailed by architect.				X	
o Verify structural adequacy and code compliance of railing designs handrails, guardrails, and post connections.				X	
o Anchorage/attachment of medical equipment.				X	
o Check lintels-special conditions not covered in typical lintel schedule.				X	
• Vented roof deck provided at locations with lightweight roof fill covered by a waterproof membrane.				X	
• Verify correct opening sizes and locations in walls.				X	
• Verify locations requiring waterstops.				X	
• Verify correct edge of slab dimensions at building perimeter and openings.				X	
• Coordinate structural deflections with all architectural elements.				X	
• Coordinate special tolerance required for concrete elements.				X	
• Coordinate special tolerance requirements for structural steel.				X	
• Coordinate locations requiring architecturally exposed steel (check specs.).				X	
• Coordinate floor flatness requirements.				X	
• Coordinate all areas requiring sloped slabs.				X	
• Verify stair opening sizes and headroom with architectural drawings.				X	
6.0 Coordination /Civil	**ER**	**PDR**	**60%**	**95%**	**Comments**
• Verify correct location and grades for retaining walls outside of building. Verify that retaining walls are designed and detailed.				X	
• Check grades around building, coordinating ledge elevations.				X	
• Coordinate location of foundation with property lines.				X	
7.0 Coordination/Plumbing	**ER**	**PDR**	**60%**	**95%**	**Comments**
• Check for interference between footings and underground utilities.				X	

	ER	PDR	60%	95%	Comments
• Verify requirements for sumps at lowest level.				X	
• Verify top of footing elevations with roof drain leaders and other piping.				X	
• Coordinate requirements for horizontal sleeves through beams and concrete walls.				X	
• Coordinate the location of all pipe trenches and trench drains.				X	
• Locate all wet columns.				X	
• Review plumbing drawings for locations of sleeves through each floor that have structural implications (such as at grouped sleeves at drop panels).				X	
8.0 Coordination/HVAC	**ER**	**PDR**	**60%**	**95%**	**Comments**
• Verify the clear height in mechanical equipment rooms.		X	X		
• Verify duct shafts are open or in-filled.		X	X		
• Verify size, location and weight of all major mechanical equipment.		X	X		
• Coordinate hanging loads in mechanical equipment rooms.		X	X		
• Coordinate requirements for curbs and pads in mechanical rooms.			X	X	
• Coordinate the requirements of isolation slabs in the mechanical rooms.			X	X	
• Coordinate the size and location of all roof openings.			X	X	
• Coordinate vibration requirements with mechanical equipment.			X	X	
• Coordinate location and size of duct openings through shearwalls or bracing.			X	X	
• Coordinate size and location of underfloor air ducts with footings.			X	X	
• Verify size and location of all vertical duct shafts through floors.		X	X	X	
• Coordinate areaway and/or louver requirements.		X	X	X	
9.0 Coordination/Electrical	**ER**	**PDR**	**60%**	**95%**	**Comments**
9.1 Verify the size, location and weight of emergency generator.		X	X		
9.2 Coordinate the location and weight of transformers.		X	X		
9.3 Verify requirements for conduit runs in slabs.			X	X	
9.4 Coordinate requirements for in-floor electrification.			X	X	
9.5 Coordinate the size and location of bus			X	X	

duct with footings.					
9.6 Verify the adequacy of light pole foundations (see Electrical Drawings).			X	X	
9.7 Verify location of trench headers in floor slabs			X	X	
10.0 Constructability	**ER**	**PDR**	**60%**	**95%**	**Comments**
10.1 Can it be built without skyhooks?				X	
10.2 Sequence of construction.				X	
10.3 Rebar congestion.				X	
10.4 Bolt tightening access.				X	
10.5 Locations of construction joints				X	