DCD Seismic and Soil Site Interfaces

Richard Orr

Thursday August 10

Site Interface for Seismic

- **The Combined License applicant must demonstrate that the proposed site meets the following requirements:**
  1. The free field peak ground acceleration at the finished grade level is less than or equal to a 0.30g SSE.
  2. The site design response spectra at the finished grade level in the free-field are less than or equal to those given in Figures 3.7.1-1 and 3.7.1-2 (*these spectra are shown in Figures 2.1-1 and 2.1-2 of this report*).
  3. In lieu of (1) and (2) above, for a site where the nuclear island is founded on competent rock with shear wave velocity greater than 3500 feet per second and there are thin layers of soft material overlying the rock, the site specific peak ground acceleration and spectra may be developed at the top of the competent rock and shown at the foundation level to be less than or equal to those given in Figures 3.7.1-1 and 3.7.1-2.
  4. Foundation material layers are approximately horizontal (dip less than 20 degrees) and the shear wave velocity of the soil is greater than or equal to 1000 feet per second.

From Seismic Report, section 5.0

Interface for Soils

Average Allowable Static Bearing Capacity	Greater than or equal to 8,600 lb/ft^2 over the footprint of the nuclear island at its excavation depth
Maximum Allowable Dynamic Bearing Capacity for Normal Plus SSE	Greater than or equal to TBD lb/ft^2 at the edge of the nuclear island at its excavation depth
Lateral Variability	Soils supporting the nuclear island should not have extreme variations in subgrade stiffness
Shear Wave Velocity	Greater than or equal to 1,000 ft/sec based on low-strain best-estimate soil properties over the footprint of the nuclear island at its excavation depth

Lateral Variability

Soils supporting the nuclear island should not have extreme variations in subgrade stiffness

Case 1: For a layer with a low strain shear wave velocity greater than or equal to 2500 feet per second, the layer should have approximately uniform thickness, should have a dip not greater than 20 degrees, and should have less than 20 percent variation in the shear wave velocity from the average velocity in any layer.

Case 2: For a layer with a low strain shear wave velocity less than 2500 feet per second, the layer should have approximately uniform thickness, should have a dip not greater than 20 degrees, and should have less than 10 percent variation in the shear wave velocity in any layer.

Containment Vessel Technical Report

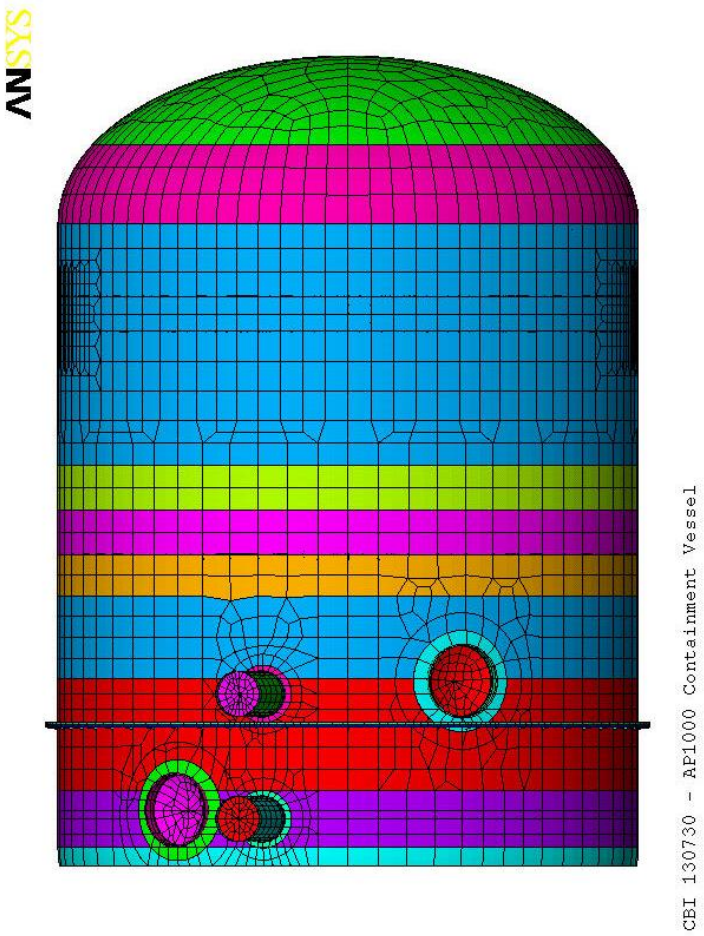
Richard Orr

Containment Vessel Design Adjacent to Large Penetrations

AP1000

1.0 INTRODUCTION
2.0 TECHNICAL BACKGROUND
2.1 3D model of containment vessel
2.2 Dynamic analyses of 3D model
2.3 Static analyses of 3D model
2.4 Stress and buckling evaluation adjacent to large penetrations
    2.4.1 External pressure and thermal loads
    2.4.3 Stress and buckling evaluation
2.5 Application of AP1000 at soil sites
2.6 ASME Code Design Specification and Design Report
3. REGULATORY IMPACT
4. REFERENCES
5. DCD MARK UP

Containment Vessel Design Adjacent to Large Penetrations



- 3D time history analysis to obtain local response at large penetrations
- 3D equivalent static analyses on model with increased refinement around penetrations for stress and buckling evaluation
- Containment vessel reconciliation for envelope of hard rock and soil sites

New Fuel/Spent Fuel Racks

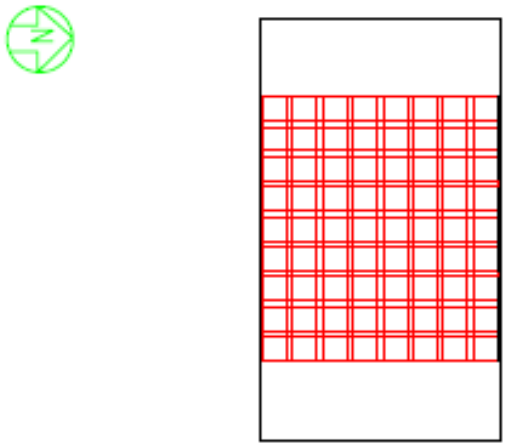
for AP1000

August 10, 2006

Richard Orr

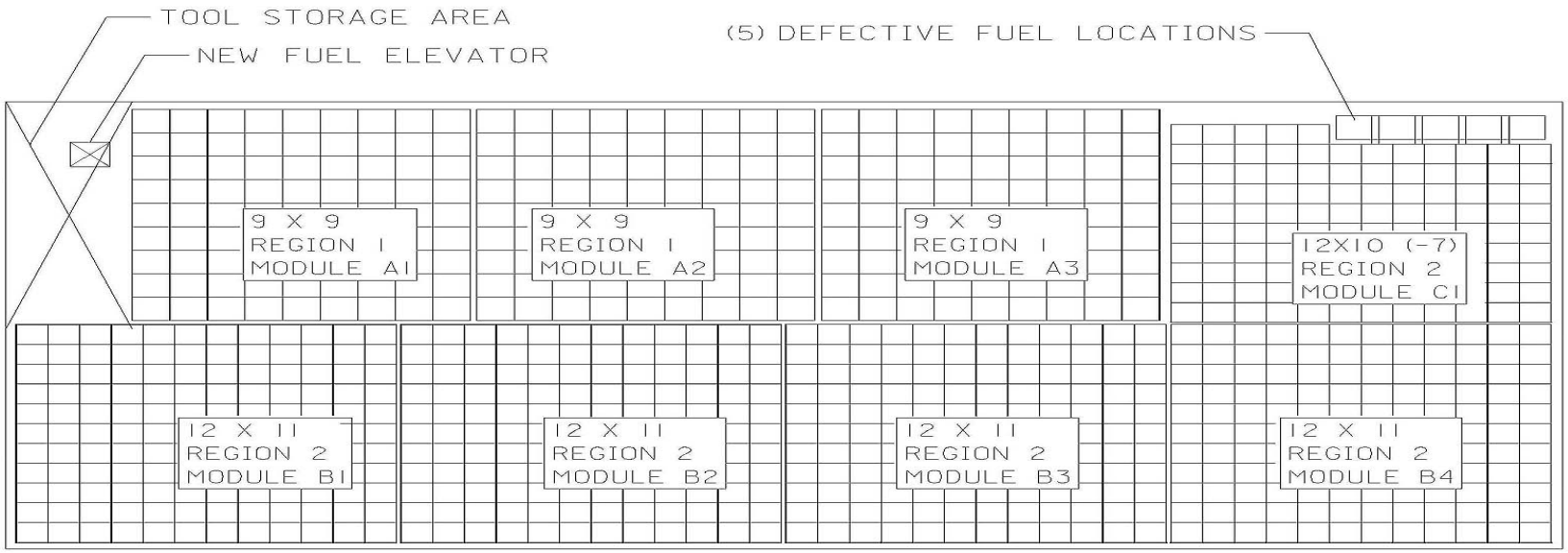
New Fuel Storage Rack/Vault Layout 72 Storage Locations

Plan View



Elevation View

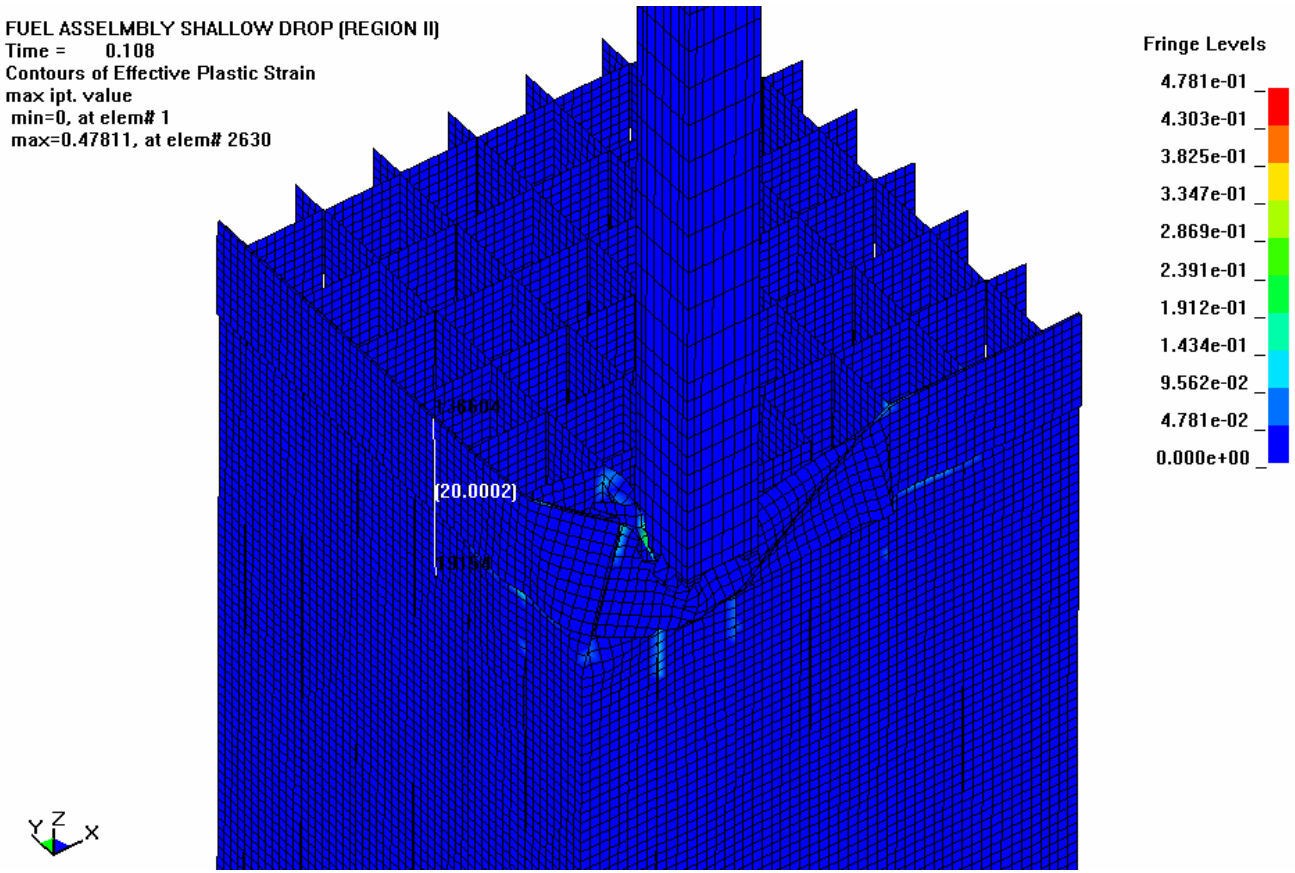
Spent Fuel Pool Layout-889 Storage Locations



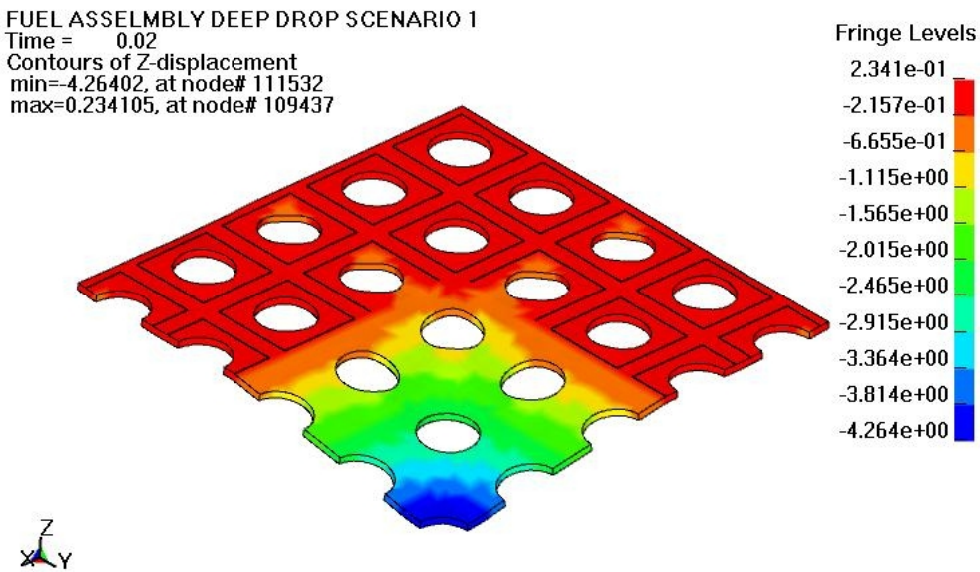
Structural Analysis

- Considered adequacy of racks under postulated loading conditions including seismic and mishandling accidents
- Acceleration time histories enveloping AP1000 Floor Response Spectra
- Documented in COLA Technical Reports submitted to NRC:
  - APP-GW-GLR-033 Spent Fuel Storage Racks Structural/Seismic Analysis
  - APP-GW-GLR-026 New Fuel Storage Rack Structural/Seismic Analysis

LS-DYNA Simulation of Dropped Fuel Assemble



LS-DYNA Simulation of Dropped Fuel Assemble onto rack baseplate



Conclusions:

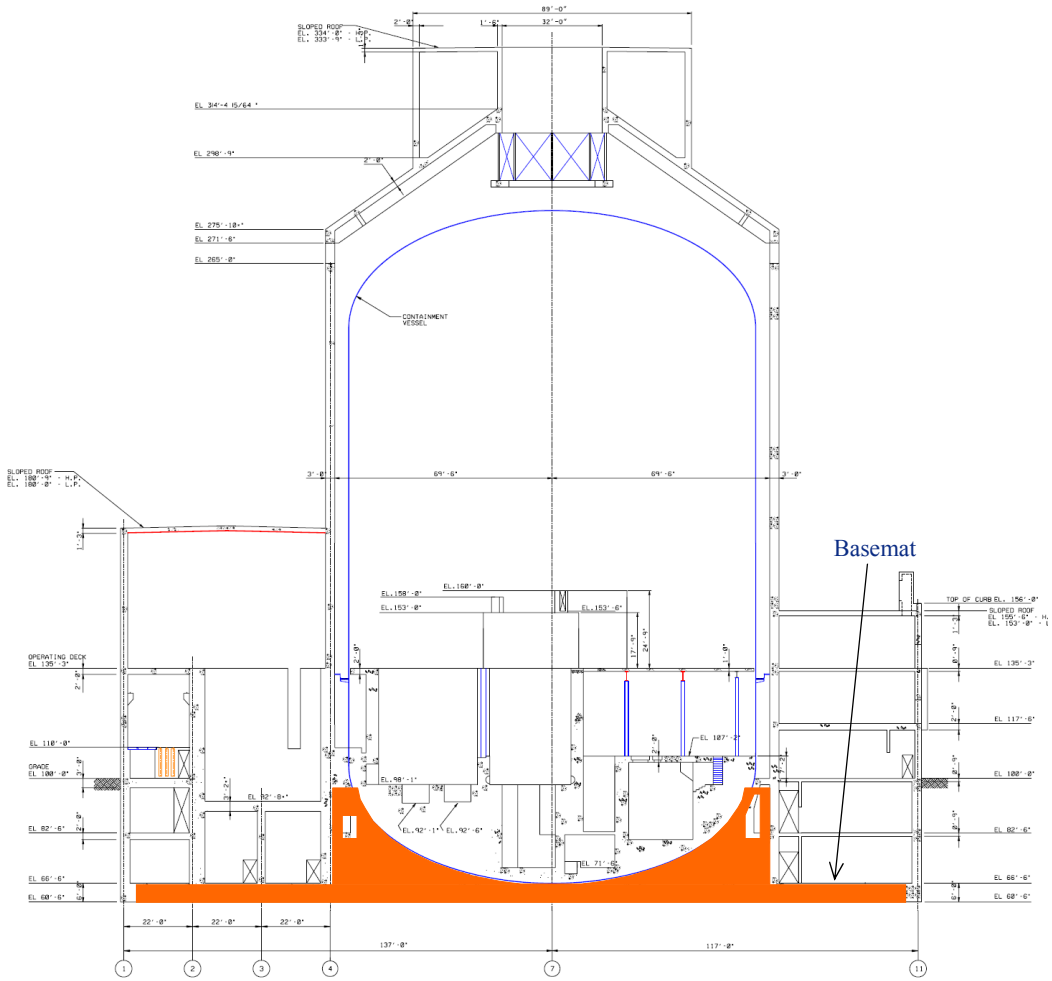
- All rack cell wall and pedestal stress factors are below the allowable stress factor limit of 1.0.
- The impacts between stored fuel assemblies and the cell walls are within the limit for dynamic loading set by the Lawrence Livermore Laboratory.
- All weld stresses are below the allowable limits.
- A stuck fuel assembly does not cause a bounding stress condition.
- Fuel assembly drops were analyzed for each rack type.
- Design of the AP1000 New and Spent Fuel Storage Racks meets the requirements for structural integrity for the postulated Level A and Level D conditions defined.

AP1000 Standard Combined License Technical Report

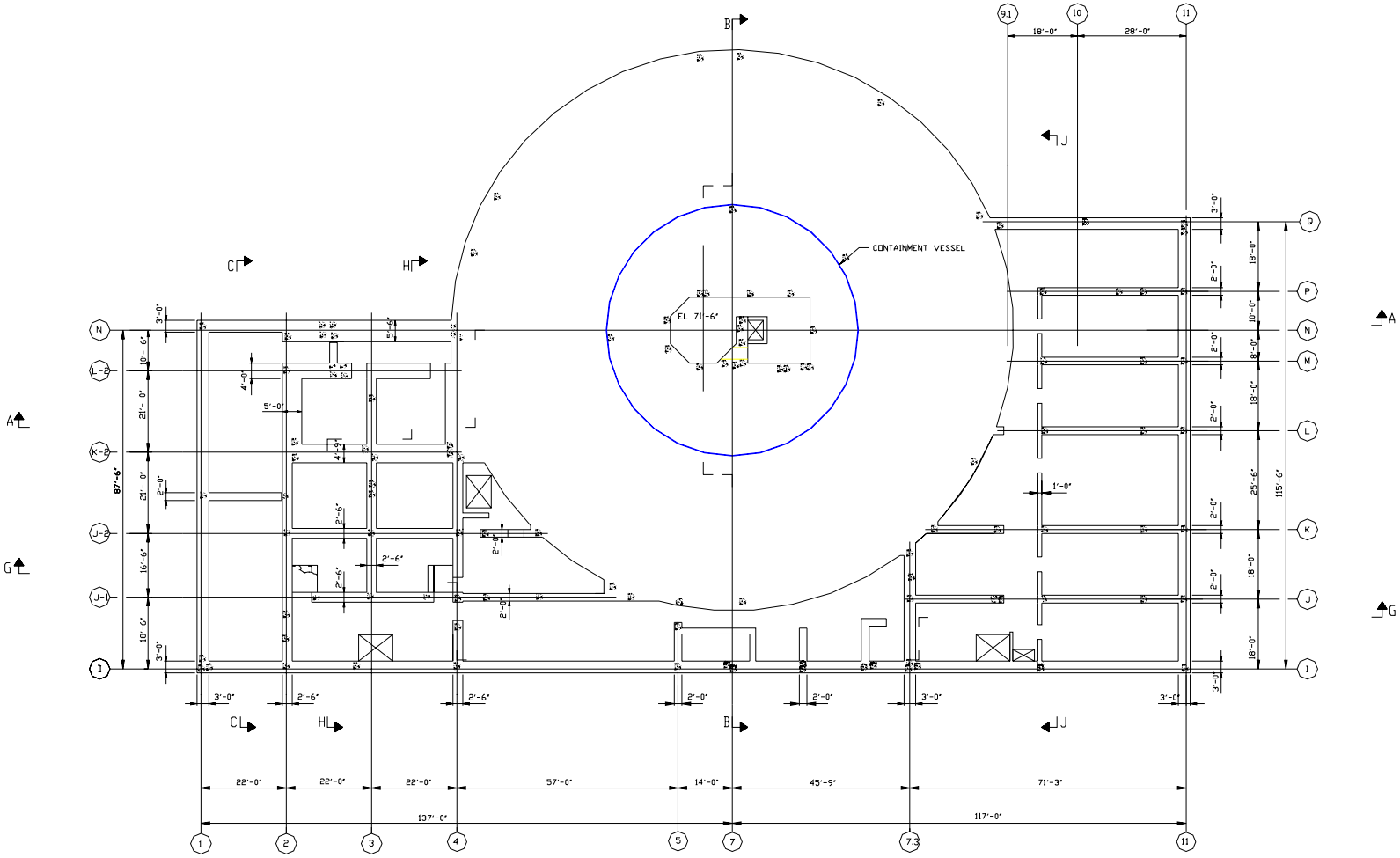
Nuclear Island Basemat and Foundation

Richard Orr

Nuclear Island Cross Section



Nuclear Island Basemat Elevation 66’ 6”



Basemat and Foundation Design Report

1.0 INTRODUCTION
2.0 TECHNICAL BACKGROUND
- 2.1 Description of Nuclear Island Basemat and Embedded Portion
- 2.2 AP600 certified design for hard rock and soil sites
- 2.3 AP1000 certified design for hard rock sites
- 2.4 Analyses of AP1000 foundation response on hard rock and soil sites
- 2.5 Analyses of settlement during construction
- 2.6 Nuclear island basemat design
- 2.7 Basemat design studies
- 2.8 Summary of basemat design
- 2.9 Nuclear island stability

3.0 REGULATORY IMPACT
4.0 REFERENCES
5.0 DCD MARK UP

Basemat and Foundation Design Report

AP1000

2.2 AP600 certified design for hard rock and soil sites
- 2.2.1 AP600 basemat analyses and design
- 2.2.2 AP600 analyses of settlement during construction
- 2.2.3 AP600 design for lateral earth pressure
- 2.2.4 AP600 nuclear island stability

2.3 AP1000 certified design for hard rock sites
- 2.3.1 AP1000 basemat analyses and design
- 2.3.2 AP1000 analyses of settlement during construction
- 2.3.3 AP1000 design for lateral earth pressure
- 2.3.4 AP1000 nuclear island stability

Basemat and Foundation Design Report

2.4 Analyses of AP1000 foundation response on hard rock and soil sites

- 2.4.1 SASSI analyses
  - 2.4.1.1 2D SASSI
  - 2.4.1.2 3D SASSI
- 2.4.2 2D ANSYS non-linear dynamic analyses
- 2.4.3 Site interface for soil

2.5 Analyses of settlement during construction

Basemat and Foundation Design Report

AP1000

2.6 Nuclear island basemat design
- 2.6.1 3D ANSYS Equivalent Static Non-Linear Analysis
  - 2.6.1.1 Subgrade modulus
  - 2.6.1.2 Equivalent static accelerations
  - 2.6.1.3 Normal load bearing reactions
  - 2.6.1.4 Normal plus seismic reactions
- 2.6.2 Basemat reinforcement design

2.7 Basemat design studies
- 2.7.1 Soil modeling
  - 2.7.1.1 Effect of Lower Stiffness Soil Springs
  - 2.7.1.2 Comparison of soil finite element ANSYS models versus subgrade springs
- 2.7.2 VECTOR analyses

2.8 Summary of basemat design

Draft DCD Revisions Seismic/Structures

Richard Orr

Thursday August 10

Sections to be Modified in DCD

Section 2.5: Geology, Seismology & Geotechnical

- Site Interfaces (including Table 2-1)

Section 3.7: Seismic Design

- Changes to Section 3.7.2
- Remove lump mass stick models
- Remove lump mass stick model results
- Refer to Appendix 3G
- provides discussion of dynamic models & results

Sections to be Modified in DCD

Appendix 3G: Extension of Nuclear Island Seismic Analysis to Soil Sites

- Input from topical report APP-GW-S2R-010
- Dynamic Models
- Soil Cases & SSI Analyses
- Interface Seismic Response
- Results (Accelerations, displacements)
- Seismic uplift and bearing

Sections to be Modified in DCD

Section 3.8: Design of Category I Structures

- Subsection 3.8.2 Steel Containment
- Subsection 3.8.3 Concrete and Steel Internal Structures
- Subsection 3.8.5 Foundations

Appendix 3H Auxiliary and Shield Building

Critical Sections

Update of Codes for design of non-seismic structures

Codes for Design of Non-Seismic Buildings

UBC	Uniform Building Code
IBC	International Building Code
ASCE 7	Minimum Design Loads for Buildings and Other Structures
ACI 318	Building Code Requirements for Structural Concrete
AISC 335	Specification for Structural Steel Buildings, Allowable Stress Design and Plastic Design
AISC 360	Specification for Structural Steel Buildings
AISC 341	Seismic Provisions for Structural Steel Buildings

Proposed Alternative Code Editions for Design of Non-Seismic Buildings

Code	AP600 DCD	AP1000 DCD	Proposed
UBC	1991	1997	
IBC			2006
ASCE 7	1993	1998	2005
ACI 318	1995 (1)	1999 (1)	2005
AISC 335	1989 ASD (1)	1989 ASD (1)	
AISC 360			2005 ASD or LRFD
AISC 341		2000	2005

Note (1): The Code edition is not specified in the DCD; the dates shown are those listed in the Civil/Structural Design Criteria

Application of Updated Codes to AP1000 Non-Seismic Buildings

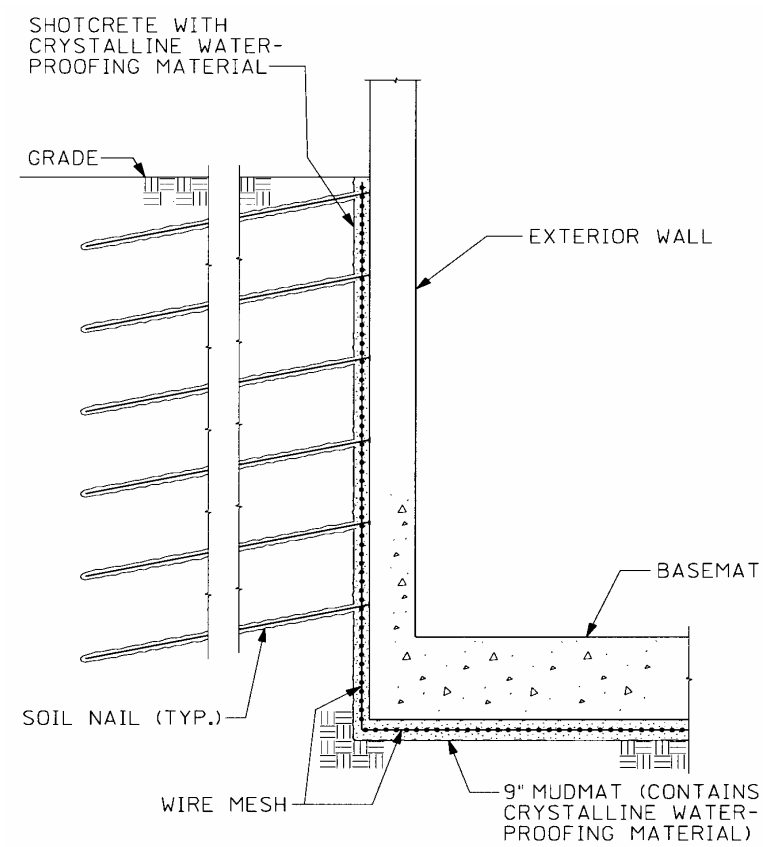
- **Non-seismic structures include turbine building, radwaste building and diesel generator building.**
- **IBC has replaced UBC and references latest editions of ASCE, ACI and AISC codes.**
- **ASCE, AISC and ACI codes incorporate lessons learned from earthquakes such as North ridge**
- **Westinghouse may request option to design buildings to more recent codes.**
- **Westinghouse will apply these alternative codes for buildings which have to be redesigned.**
- **Existing codes will be retained for buildings where design is substantially complete.**

•Turbine building upgraded to prevent collapse onto nuclear island.

Turbine Building

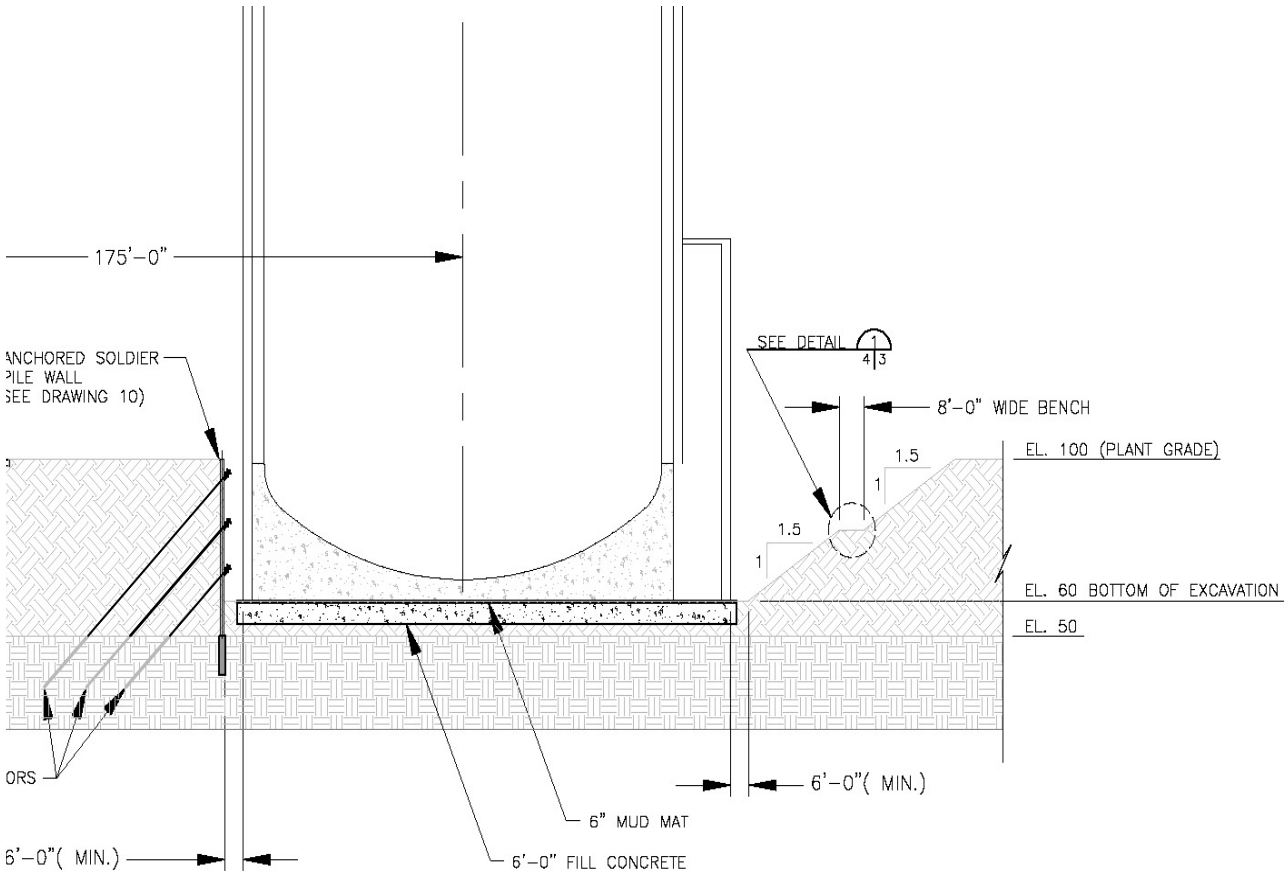
- **AP1000 DCD**
  - Design per UBC for Zone 3, Importance Factor of 1.0
  - Eccentric Bracing
- **Westinghouse to define equivalent seismic input per IBC.**
- **Lateral load resisting system need not be limited to eccentric bracing but could be designed with concentric bracing satisfying IBC and ASCE 07.**

Excavation method and waterproofing



DCD Figure 3.4.1

Excavation method and waterproofing



Alternate excavation methods