7P95

Masters, Anthony

From: Lake, Louis
Sent: Thursday, November 12, 2009 7:27 AM
To: Khanna, Meena; Boyce, Tom (NRR); Sykes, Marvin; Franke, Mark; Farzam, Farhad; Thomas, George; Jessup, William; Kuntz, Robert; Tsao, John; Reyes, Rogerio; Lake, Louis; Carrion, Robert; Masters, Anthony; nausdj@ornl.gov; Orf, Tracy; Paige, Jason; Saba, Farideh
Subject: FW: CR-3 Reactor Building Design Model
Attachments: CR3_Model_Overview_NRC.ppt

Categories: Perform Review

See attached presentation for today's conference call scheduled for 10:00am.

Lou Lake

From: Herrin, Dennis W. [mailto:Dennis.Herrin@pgnmail.com]
Sent: Wednesday, November 11, 2009 8:23 PM
To: Paige, Jason; Lake, Louis
Cc: Saba, Farideh; Reyes, Roger; Williams, Charles R.; Dyksterhouse, Don; Fagan, Paul; Radford, Sammy; Zimmerman, Tony; McCabe, Brian; Miller, Garry; Powell, Sid; Knott, Ronald
Subject: RE: CR-3 Reactor Building Design Model

Mr. Paige,

As promised, please find attached the information developed by MPR Associates, Inc., to support the conference call on the CR-3 Reactor Building design model.

Dennis W. Herrin
Lead Engineer - Licensing & Regulatory Programs
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From: Herrin, Dennis W.
Sent: Wednesday, November 11, 2009 3:08 PM
To: Jason Paige (Jason.Paige@nrc.gov); Louis Lake (Louis.Lake@nrc.gov)
Cc: Farideh Saba (farideh.saba@nrc.gov); Reyes, Roger; Williams, Charles R.; Dyksterhouse, Don; Fagan, Paul; Radford, Sammy; Zimmerman, Tony; McCabe, Brian; Miller, Garry; Powell, Sid; Herrin, Dennis W.
Subject: CR-3 Reactor Building Design Model

Mr. Paige,

Mr. Louis Lake (NRC Special Inspection Team Lead) has requested that a conference call be scheduled for 10:00, on November 12, 2009, between the NRC (Special Inspection Team and NRR), the CR-3 Reactor Building Concrete Delamination Root Cause Team and MPR Associates, Inc. The purpose of this conference call is to discuss the CR-3 Reactor Building design model. The following conference call information will be used:

AT&T Toll-Free number: (877) 848-7030
Access Code: (b)(4) 44

Information in this record was deleted in accordance with the Freedom of Information Act. Exemptions 6
FOIA/PA 2010-0116

Q-30

Information being developed by MPR Associates, Inc., to support the conference call will be provided as soon as it is available.

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Crystal River 3 Containment FEA Model Progress Report

November 11, 2009

1

- Analysis Model Status
  - Required capabilities defined for model
  - Analysis approach defined
  - Load cases identified
  - Geometry model complete
  - Initial model checks completed
  - Analyses underway

2

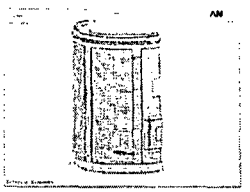
CR3 FEA Model

- 180 degree Symmetric model
  - Symmetry plane @ 150 degrees midway Between Buttress 3 & 4 / 1 & 6
  - ½ Opening, ½ Damage & ½ Hatch Modeled Explicitly
- Concrete Model
  - Brick elements for all components
  - Dome and Base modeled independently
  - Simplified ring beam and buttress geometry
  - Constraint equations used to join dome and ring girder for meshing efficiency
  - Constraint equation used to model sloped surfaces of the hatch
- Liner Model
  - Shell mesh with variable thickness
  - Shared nodes with containment inner surface
- Tendon Modeling
  - Hoop tendons modeled explicitly for release and re-tensioning
  - Vertical Tendons modeled explicitly for release and re-tensioning
  - Dome tendons modeled independently with forces ported to global model

3

CR3 FEA Model

- Gravity Analysis solved for Model check
  - Symmetry boundary and full base fixity
  - Displacement Plots
  - Stress Plots
- Tendon Loads solved for Model check
  - Symmetry boundary and full base fixity (will add soil springs)
  - Displacement Plots
  - Stress Plots
  - Tendon Force Plots
- Preliminary Data
  - Removed Hole
  - Removed Tendons



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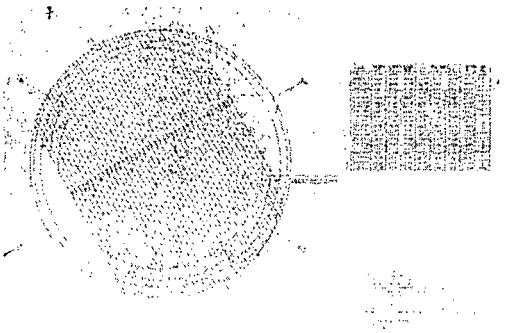
- Concrete Geometry Based on Gilbert Associates drawings - 1970

5

- Tendon Geometry Based on Prescon drawings - 1971



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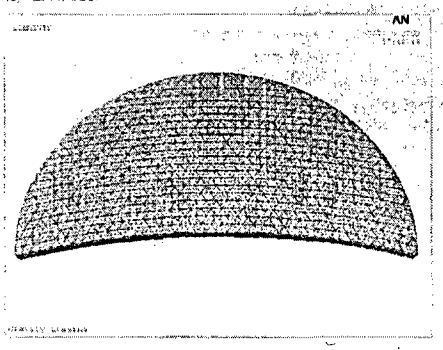
- Dome FEA Model



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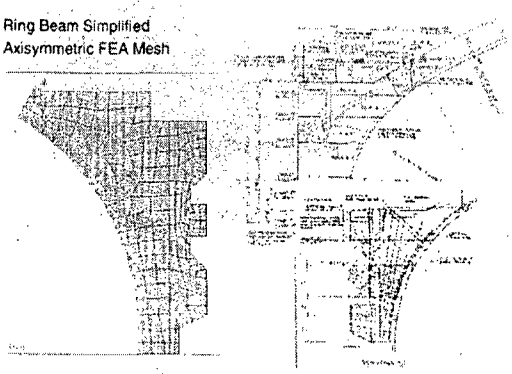
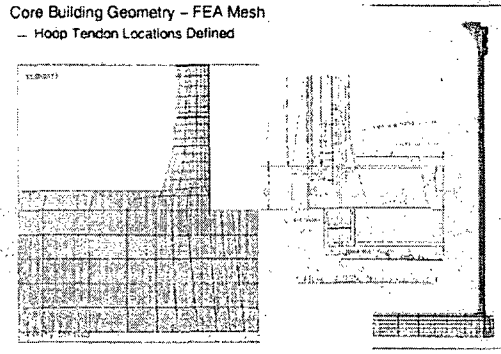
- Ring Beam Simplified Axisymmetric FEA Mesh



8

- Core Building Geometry – FEA Mesh
  - Hoop Tendon Locations Defined



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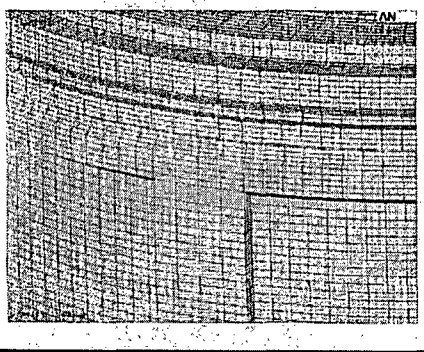
- Core Building Geometry –Buttresses



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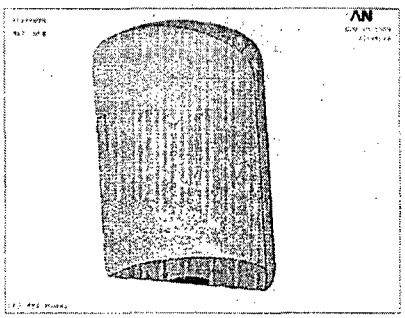
- Liner



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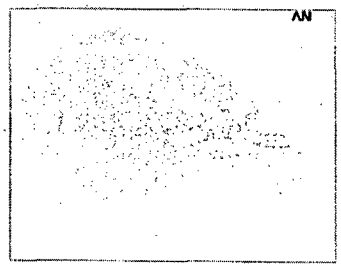
- Dome Tendon Loss assumptions:
  - Friction coefficient: t_fric=0.16
  - Wobble Value: t_wobb=0.0003
  - End Force: 1635 kips (1215lb - 40 years)



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Tendon Loading

- The tendons are preloaded to a prescribed load magnitude.
- The application of the tendon loads is achieved in the analysis using initial strain input
- An empirical formula has been developed to account for the loss of load as the distance from the anchor point increases:
  - Where: $P = P_0 e^{-(ma + ks)}$
    - P_0 = preload magnitude
    - m = friction coefficient
    - a = inflection angle
    - k = wobble coefficient
    - s = distance from anchor point
  - Tendon preloads used in analysis:
    - $P_{0\text{-dome}}$ = 1635 Kips (1,215,000 lb. 40 years)
    - $P_{0\text{-horizontal}}$ = 1635 Kips (1,252,000 lb. 40 years)
    - $P_{0\text{-vertical}}$ = 1635 Kips (1,149,000 lb. 40 years)

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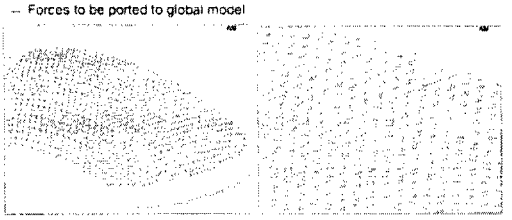
Dome Tendon Analysis

- Geometry profile matches all tendons that intersect the ½ model
  - 3 layers of tendons defined: 100, 200 and 300 series
- FEA Model & Boundary Conditions
  - All nodes fixed in all directions
  - Initial strain defined to represent Tendon Loading and Loss
  - Forces to be ported to global model



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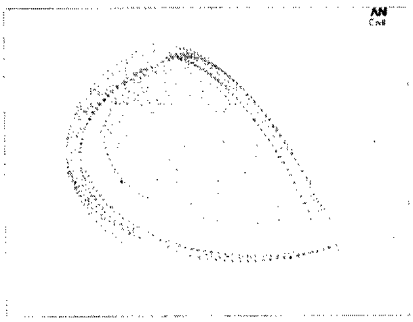
- Dome Force Vectors



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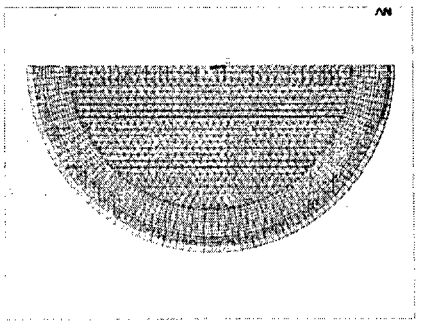
- Dome Force Vectors



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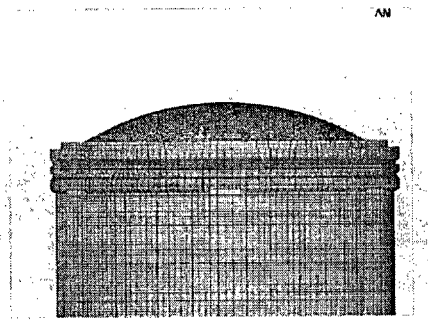
- Dome Force Vectors



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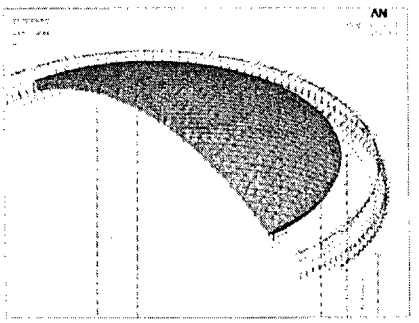
- Dome FEA



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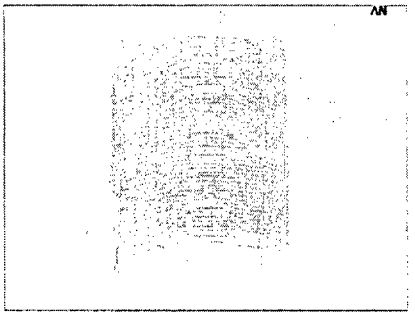
- FEA Model – Vertical and Hoop Tendons



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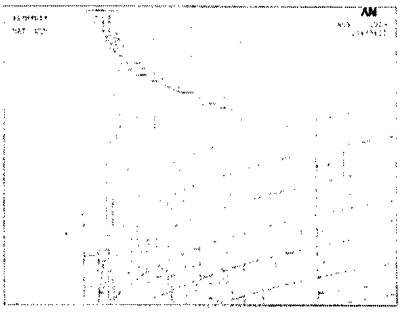
- FEA Model – Vertical and Hoop Tendons Supports



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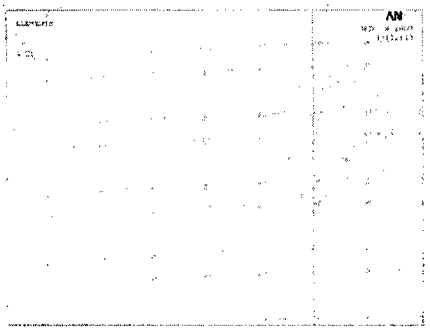
- FEA Model –Hoop Tendons Couples and Supports



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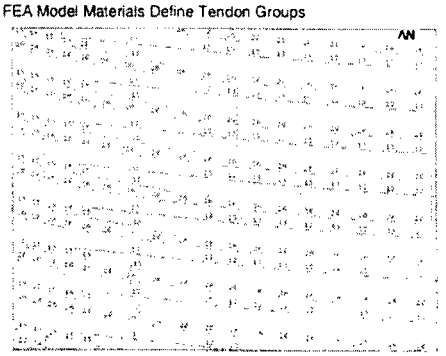
- FEA Model Materials Define Tendon Groups



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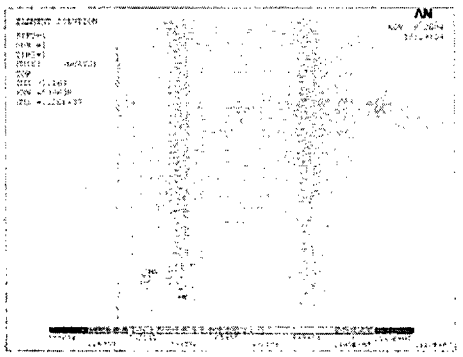
Hoop Tendon Forces



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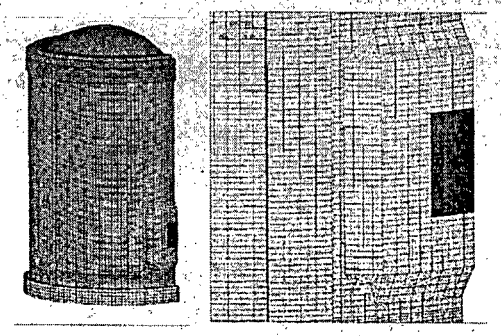
- Equipment Hatch Model



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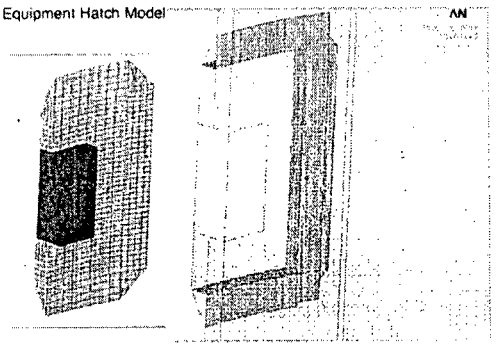
- Equipment Hatch Model



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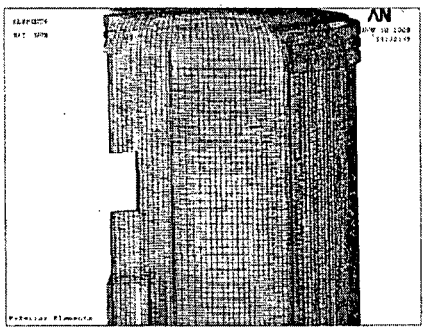
SGR Opening Model

- SGR Opening and Tendons removed



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Planned Analysis

- Existing Design Cases for Comparison
  - Gravity (.95 G)
  - Internal Dead Load (200 psf)
  - Tendons (1635 kips / tendon)
    - Include losses
  - Internal Pressure (55.0 psi)
  - Wind Pressure (0.568 psi)
  - Seismic
  - Accident Thermal
- Planned Analysis Steps
  - Dead Load + Tendons
  - Remove Hoop + Vertical Tendons in SGR Opening
  - Remove SGR Opening
  - Delamination
  - Remove Additional Hoop & Vertical Tendons
  - Replace the SGR Plug
  - Grout / Epoxy Repair
  - Retension Tendons
  - SAVE Path Dependent Model for Starting point to Run 5 Controlling Design cases

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Design Basis Controlling Load Steps

- Restart the Re-tensioned Model and solve the following Controlling Load Steps
  - 1.5 Internal Pressure + Accident Thermal
  - 1.25 Wind + 1.25 Pressure + Accident Thermal
  - 1.25 Earthquake + 1.25 Pressure + Accident Thermal
  - 2.0 Wind + Pressure + Accident Thermal
  - SSE Earthquake + Pressure + Accident Thermal
- Restart with Accident Thermal with plastic material properties for liner such that load capability limited to 36 ksi stress.
- Run Comparison to original building elastic design results to show repair has restored building to original condition

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