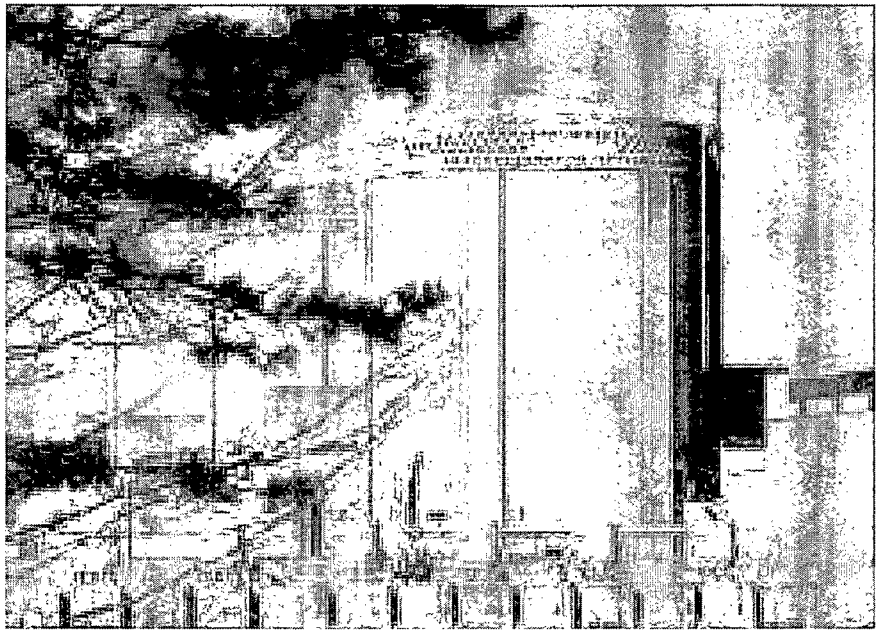


Duke Power®

Proposed Use of a Fiber-Reinforced Polymer System at the Oconee Nuclear Station

Presentation to:
The United States Nuclear Regulatory Commission (NRC)
Rockville, MD
May 14, 2007

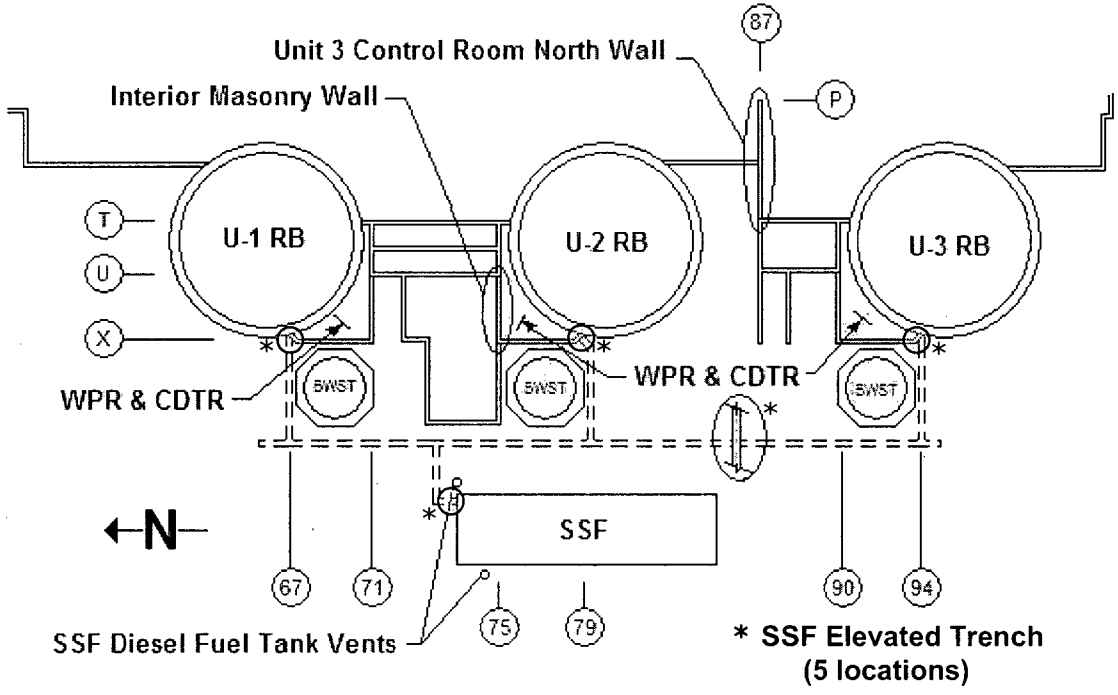
Duke Participants

- Larry Nicholson, Manager, Safety Assurance
- Rich Freudenberger, Tornado-HELB Design Basis Group
- Stephen Newman, Regulatory Compliance
- Jim Sumpter, Regulatory Compliance
- Clifford Davis, Major Projects Group
- Lawrence Llibre, Major Projects Group
- Tommy Mills, Major Projects Group

Agenda

- Introductions
- Purpose of Meeting
  - Identify information needed to license the use of FRP to strengthen masonry walls at ONS
- Brief Description of the Natural Phenomenon Barrier System
- Timeline
- Example Exercise using Design Method
- Discussion of Additional NRC Comments to Duke's RAI Response
- Closing Remarks

Brief Description of the Natural Phenomenon Barrier System



Construction Pictures

Brief Description of the Natural Phenomenon Barrier System

- **Application**: Bond-critical application for flexural strengthening of non-load bearing, infill masonry walls to resist higher design loads.

  Note: Application is similar to traditional technique of employing externally bonded steel plates.

- **Loading Condition**: Uniform pressure on masonry wall resulting from tornado-induced differential pressure and possibly tornado wind causing tensile stresses in FRP system.

  Note: FRP system will not be relied upon as a compressive reinforcement.

Brief Description of the Natural Phenomenon Barrier System

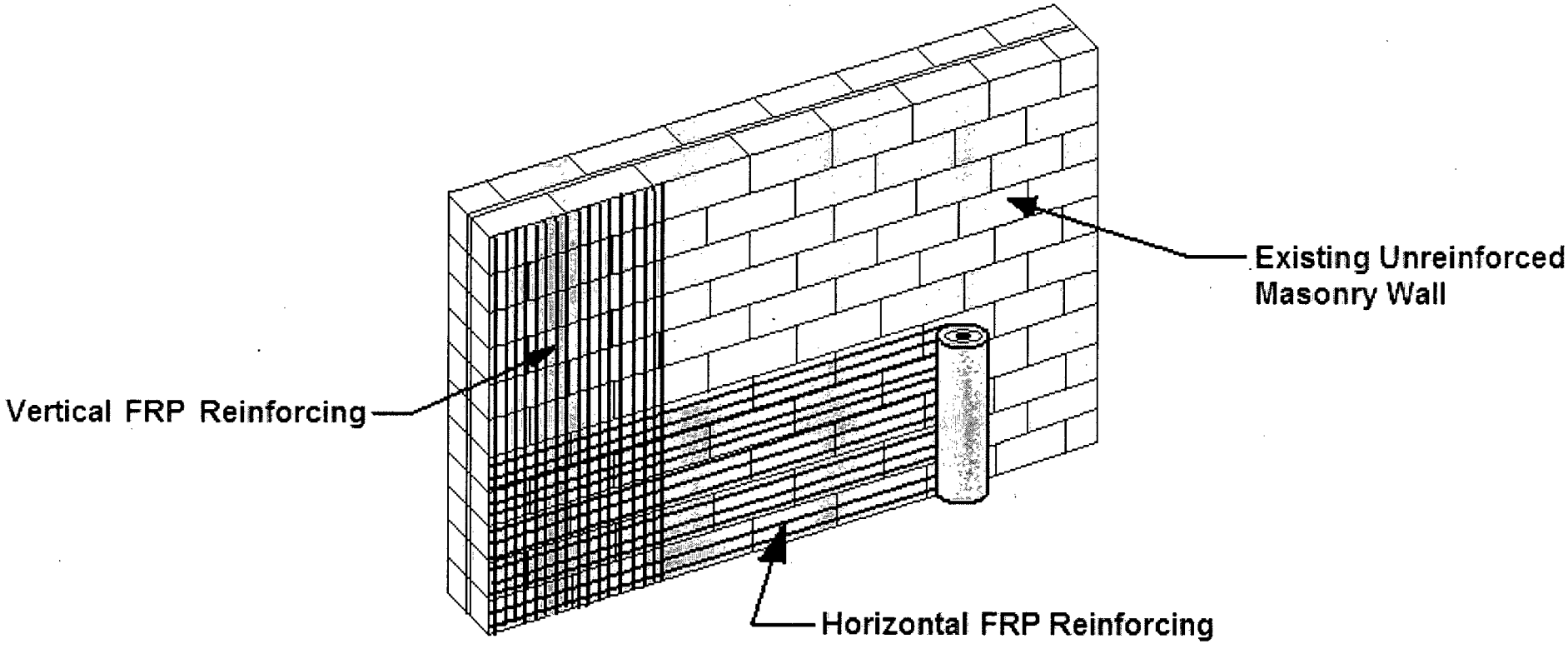
- **Example Location**: Exterior surfaces of selected Units 1, 2, and 3 West Penetration and Cask Decontamination Tank Room walls.

  Note: FRP system will be shielded from sunlight (i.e., UV) by siding.

- **Environment**: Ambient temperature and humidity conditions associated with local climate and Auxiliary Building equipment rooms.

  Note: FRP system will not be located in a high radiation environment or exposed to high temperature gas and/or liquid.

Typical FRP Application



Timeline

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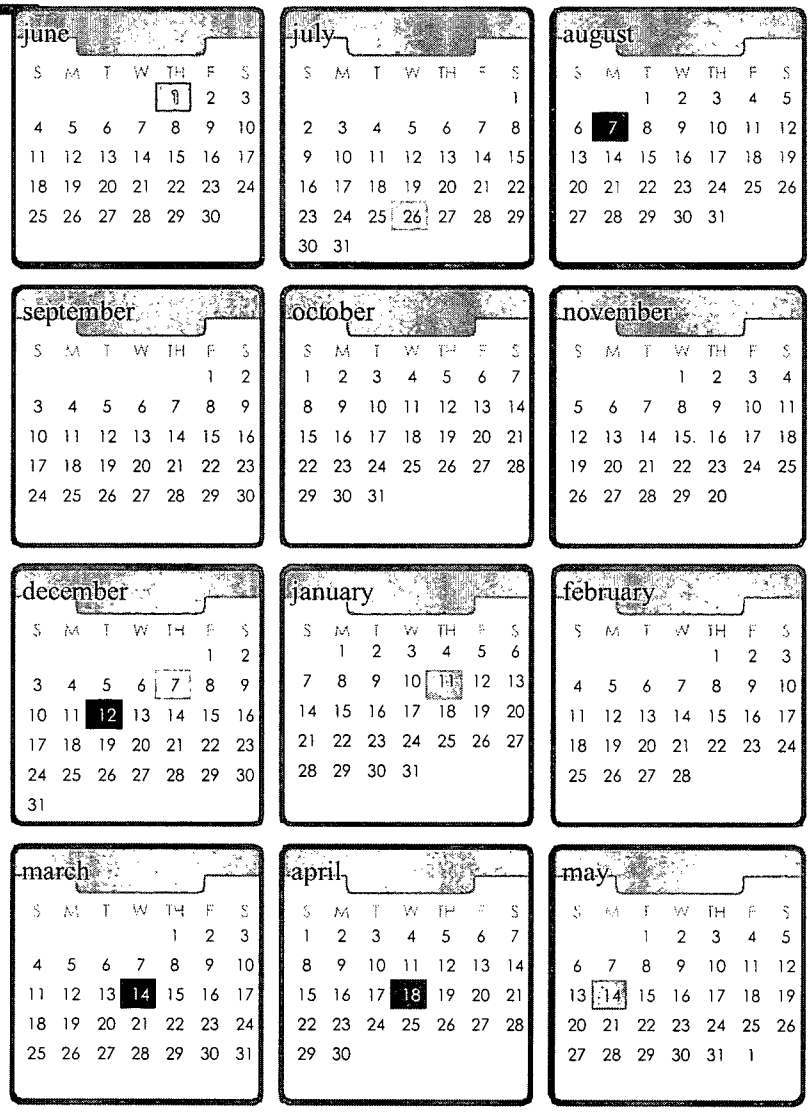
2006-2007

PROJECT PHASE	DATE
Duke/NRR Pre-LAR Meeting (Rockville, MD)	3/23/06
NRR Meeting Summary Letter	4/05/06
FRP LAR Submitted	6/01/06
NRR RAIs received (1st set - via email)	7/26/06
Duke RAI responses sent via email	8/7/06
Duke/NRR conference Call	9/14/06
NRR RAIs received (2nd set - via email)	12/7/06
Duke/NRR Public Meeting (Rockville, MD)	12/12/06
NRR Issues meeting agreement letter	1/11/07
Duke RAI responses formally submitted	3/14/07
NRR comments to Duke RAI responses received - via email	4/18/07



Example Exercise Using Design Method

Discussion of Additional NRC Comments to Duke's RAI Responses

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Ref.: Issues Table

Closing Remarks

- Questions
- Action Items

Item #	NRC Issue	Duke Comments	Resolution of Item[1]
FRP 1	Enclosure 3 to the letter listed 53 walls that currently planned to be strengthened using FRP. The walls include single-wythe 8" hollow-core concrete block and double-wythe 4" solid concrete brick. The aspect ratios (height/width) of walls vary from 0.6 to 2.9. The edge conditions of walls are mortat-joint edges at top, bottom, and both sides, and mortat-joint edges at top, bottom, and one side. We made very clear to the licensee in our previous meetings that the licensee needs to present their specific methods (equations) for using FRP to strengthening the particular type of masonary walls and submit test data that can substantiate the methods (equations) that they propose to use. However, the licensee failed again to response to this request.	• This appears to be an introductory, summary statement of the content of Enclosure 3 to Duke's response to the RAI. • Duke presented the proposed analytical methods and detailed equations in Enclosures 4 and 5 to its response to the RAI. Sample calculations using these equations are presented in Enclosures 6 and 7 to its response to the RAI. Test data to substantiate the analytical methods is presented in Enclosures 8 and 9. The test data is evaluated using the analytical methods and detailed equations of Enclosures 4 and 5 to demonstrate their validity and conservative results.	• Simple beam and plate theory will be used to calculate masonry wall stresses. • FRP will be substituted for steel reinforcing when necessary. • The various configurations from the list of 53 walls will be bounded (meets code allowables) by one of the two design methodologies proposed in the RAI response. These methodologies are supported by test data. • If a wall does not meet one of these two methodologies, the wall(s) will be physically modified to meet the criteria. • Test coupons and pull tests will verify FRP strength and adhesion.
FRP 2	Instead, the licensee responded that it would use ACI 440.2R-02 or FRP system manufacturer's method, as documented on page 9 of Enclosure 5.	• This statement appears to indicate a misunderstanding of the information presented in Enclosure 5 to Duke's response to the RAI. On page 9 of Enclosure 5, Duke stated that it would use the working stress design method (our current LB) for reinforced masonry to design the FRP flexural reinforcement. To supplement these equations, Duke also stated that it would use the environmental and strength reduction factors and most restrictive strain limitations (i.e., allowable stress) for the FRP from ACI	• The more conservative reduction factors from either the FRP system manufacturer or ACI 440.2 will be used.

[1] Duke will provide hardcopies of the RAI response (with all enclosures) to all present at the May 14th meeting.

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Item #	NRC Issue	Duke Comments	Resolution of Item[1]
		440.2 or the FRP system manufacturer. • Based on the types of masonry construction tabulated in Enclosure 3 to Duke's response to the RAI, only two fundamental wall types exist: simply-supported one-way span and simply-supported plate (4 sides). Additional test data would be representative of these two types of masonry construction.	
FRP 3	The licensee agreed with the staff in our previous meetings that ACI 440.2R-02 had not been reviewed and adopted by the ACI code, and the staff did not accept it as an accepted method. However, the staff stated that it would accept the licensee's methods if they can be substantiated by, or were derived from, test data. During our last meeting, the licensee referred the method and substantiation as a box and stated that only walls falling within the box could use the method.	Duke presented test data to substantiate the proposed analytical methods in Enclosures 8 and 9 to its response to the RAI. The parameters, extent, and format of any additional test data require clarification.	
FRP 4	During our last meeting, the licensee did not know how many types of walls they had and therefore did not know how many boxes they would have. Now, they know the types of walls they plan to strengthen using FRP, but provided no single box. For an example, based on available test data, a box can be established for walls of single-wythe 8" hollow-core concrete block with mortat-joint edges at top, bottom, and both sides for aspect ratios between x and y and another box can be established for walls of double-wythe 4" solid concrete brick with mortat-joint edges at top, bottom, and one side for aspect ratios between x and y. The licensee needs to establish as many boxes as required to	See Response to FRP #2.	

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Item #	NRC Issue	Duke Comments	Resolution of Item[1]
	cover the 53 walls.		
FRP 5	I have also reviewed the FRP system manufacturer's (FYFE CO.) design manual, and it has no reference to Oconee's walls.	Duke does not understand the intent of this statement.	
FRP 6	It is the licensee's responsibility to provide the methods (equations) for using FRP and present test data to substantiate the adequacy of the methods for Oconee walls.	See response to FRP 2.	
FRP 7 (Conf. call note)	The NRC stated that there is an engineering mechanics problem with the way Duke is attempting to equate the test data with the given methodology.	• If this statement refers to the applicability of plate theory in the computation of masonry wall internal forces/moments for the simply-supported plate (4 sides) assumption, Duke cites the position of ACI 530, Masonry Standards Joint Committee, on the matter as reflected in the Commentary on ACI 530-05, Section 1.1.3: • "For allowable stress design, linear elastic materials following Hooke's Law are assumed, that is, deformations (strains) are linearly proportional to the loads (stresses). All materials are assumed to be homogeneous and isotropic, and sections that are plane before bending remain plane after bending. These assumptions are adequate within the low range of working stresses under consideration."	

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