

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

PALO VERDE NUCLEAR GENERATING STATION, UNITS 1, 2 AND 3

ENGINEERING BRANCH

DIVISION OF PWR LICENSING-B

DOCKET NOS. 50-528, 529 AND 530

PALO VERDE MASONRY WALL EVALUATION

We have reviewed the report on Palo Verde masonry walls submitted by the licensee, dated September 19, 1986 (Reference 1). The report was constituted by three enclosures. Enclosure 1 was written by Bechtel Western Power Corporation, entitled "Supplemental Report on the Evaluation of Masonry Walls for the Arizona Nuclear Power Project, Palo Verde Nuclear Generating Station, Units 1, 2 and 3." Enclosure 2 was written by Atkinson - Noland and Associates, entitled "Factors Influencing Deflections In Grouted Hollow Unit Concrete Masonry Walls." Enclosure 3 was a report on the test results of 30 full size concrete and masonry walls subjected to short-term loadings simulating wind or seismic pressure published by American Concrete Institute, Southern California Chapter and the Structural Engineers Association of Southern California, entitled "Test Report on Slender Walls."

Enclosure 1 continued to use a 3-stage moment of inertia method developed by Bechtel for estimating the effective moment of inertia of masonry walls, as it did in the June 19, 1986 report. This 3-stage moment of inertia method has been evaluated by the staff and its consultant, and both conclude that the 3-stage moment method is neither conservative nor realistic. The evaluation was documented in the previous SER (Reference 2).

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The staff has stated that the ACI 318 Code equation for estimating the effective moment of inertia of walls should be used. However, Bechtel disagreed with the staff's position by stating that "For PVNGS, the 3-stage moment of inertia methodology was utilized to more accurately predict the response of the masonry wall, because the ACI equation is intended for determining deflections for reinforced concrete elements under long-term (dead load) loadings. Since the masonry walls are unstressed prior to a seismic event, the ACI equation does not predict actual masonry wall response due to seismic inertia forces." This statement is incorrect regarding the applicability of ACI 318 Code equation, and is not consistent with the conclusions in the supporting documents, Enclosures 2 and 3 to the submittal.

Section 9.5.2.3 of the current edition of ACI 318 Code (Reference 3) clearly states that the equation for estimating the effective moment of inertia is to be used for immediate deflection calculations subjected to short-term (instantaneous) loadings. Enclosure 3 states that "The goal of the Task Committee was to test slender concrete and masonry walls to determine their behavior when subjected to eccentric axial and lateral forces that simulated gravity loads, along with wind or seismic pressure." This statement is clear that all deflection measurements of these walls were subjected to short-term simulated wind or seismic loadings, not to the long-term loadings which cause concrete to creep. Enclosure 2 has plotted in Figures 2.16 and 2.17 the lateral loads versus mid-height deflections of test walls from measurements



and calculations by the ACI 318 Code equation. Based on the good comparison of deflections between the test measurements and calculations, Atkinson - Noland and Associates has concluded that the ACI 318 Code equation provides reasonably accurate predictions for seismic applications. Therefore, Enclosures 2 and 3 have provided additional verification on the applicability of the ACI 318 Code Equation, which has been endorsed by the NRC, for estimating the effective moment of inertia of masonry walls for seismic applications.

Bechtel performed an analysis using a modulus of rupture higher than the value specified by the 1985 Uniform Building Code (Reference 4), and concluded that the walls at elevation 74 feet would remain uncracked even under SSE events. Bechtel believed that the use of a higher value of modulus of rupture was justified, based on a review of available published literature. However, Enclosure 2 has concluded that "It is apparent, however, based upon the experience of this study and the experience of Atkinson - Noland and Associates in many previous masonry studies, that it would be very difficult to base precise conclusions regarding the values of the modulus of rupture and the modulus of elasticity for a specific wall or walls upon data in the literature." The staff agrees with this statement, and does not believe that Bechtel has properly justified its use of a higher value of modulus of rupture.

Regarding the required length of lapped splices in masonry walls, Section 2409(e)6 of the 1985 Uniform Building Code specifies that "The amount of lapped splices



shall be sufficient to transfer the allowable stress of the reinforcement as in Section 2409(e)3a. In no case shall the length of the lapped splice be less than 30 bar diameters for compression and 40 bar diameters for tension." The vertical reinforcing steel in the walls at elevation 74 feet is No. 6 bar, which has a nominal diameter of 3/4 inch. A 40 bar diameters of No. 6 bars require a lap length of 30 inches. The steel stress needs to be transferred at the splice, based on the ACI Code method, was reported as 31,700 psi (Reference 5). Based on Section 2409(e)3a, the required lapped length for the stress transfer was calculated by the staff as 48 inches. By comparing these numbers to the actual available lapped length of 16 inches in the walls, it has provided a good indication that the solution to the problem should be a physical repair instead of rigorous analysis.

The review results performed by A. Hamid of Drexel University on the September 19, 1986 submittal are presented in Appendix A. Appendix A was prepared independently by Dr. Hamid and its conclusion is in agreement with the staff's evaluation.

Based on the review of the information submitted by the licensee and the reasons as stated and discussed above, the staff has concluded that strengthening the walls at evaluation 74 feet is required.



References

1. "Masonry Wall Evaluation Confirmatory Data," from J. G. Haynes, Arizona Nuclear Power Project, to G. W. Knighton, NRC, dated September 19, 1986.
2. "Safety Evaluation Report for Palo Verde Masonry Walls," from E. A. Licitra, NRC, to E. E. Van Burnt, Jr., Arizona Nuclear Power Plant Project, dated October 6, 1986.
3. "Building Code Requirements for Reinforced Concrete (ACI 318-83)," American Concrete Institute.
4. "Uniform Building Code," International Conference of Building Officials, 1985 Edition.
5. "Evaluation of Masonry Walls," from E. E. Van Brunt, Jr., Arizona Nuclear Power Project, to G. W. Knighton, NRC, dated April 16, 1986.

