Review of Technical Assessment Report No: 25539-200-C0R-0000-00001

Structural Evaluation of Shield Building

Davis-Beese Nuclear Plant

Review By: David Darwin

In addition to reviewing the subject document, I had the opportunity to have two telephone conversations with Javeed Munshi and to study drawing C-110 of the Shield Building along with sketches showing the location of the crack within the architectural flute shoulder. This review includes comments on individual sections of the technical assessment report followed by overall observations.

On page 2 in the second full paragraph, the statement is made that "[t]here is no evidence of noticeable corrosion on the reinforcement. It is therefore, possible that cracks may have existed within the thickness of the structure ... for some period of time." While the cracks may have been in place "for some period of time," it is not clear how a lack of noticeable corrosion supports this point. One could argue that a lack of noticeable corrosion indicates a recent crack. Considering the widespread extent of the cracking in the flute regions on the structure, however, I agree with the conclusion that the cracks do not represent a recent occurrence but have likely been in place for an extended period of time.

On page 3 in the third paragraph under "Description of Laminar Crack," it is noted that the "cracks do not exist when approaching these reinforcing hooks." Based on the sketch provided by Dr. Munshi, I gather that the cracks are totally enclosed within the thickened region of the flutes.

In the next paragraph, it is observed that the cracks have widths ranging from 0.003 to 0.007 inches.

On page 4 in the first paragraph under "Structural Integrity Evaluation," it is observed that "[c]racking occurs in virtually all concrete structures and because of concrete's inherently low tensile strength can never be totally eliminated." While this is essentially true, it is not true for the type of cracking observed in this structure.

On page 4 in subparagraph 1 following the third paragraph under "Structural Integrity Evaluation," it is stated that "[t]he laminar cracks are mostly located on the outside face of the outermost layer of reinforcing steel ..." It would be helpful to state where else laminar cracks are located. The last sentence in the subparagraph states [t]here is no loss in bond, confinement or cover for the outside reinforcement of the shell that would adversely impact the design basis, as established below." I will address this point in my summary comments.

On page 4 in subparagraph 2, it states that "[t]he sub-surface laminar cracks rarely propagate to the surface..." It may be helpful to state where they do propagate to the surface. Also in subparagraph 2, I expect that the wording of the first sentence should have been modified by dropping "they do."

D/46

On page 5 in subparagraph 4, the observation is made that "[n]o surface rust stains exist on the outside surface of the Shield Building, again indicating the cracks are tight and stable (i.e. not active). The steel reinforcing was observed to have generally light corrosion or no corrosion at all with no areas of reinforcing exhibiting loss of material." I agree that this indicates a fairly stable situation with little access of air or moisture to the crack region.

On page 5, subparagraph 5 addresses the reinforcement in the region of the flute. As shown in drawing C-110, the hooked bars at the corner of the flutes are lapped with the outer steel in the flute. The lap length, 3 ft-4 in., is not enough to fully develop the No. 8 bars but adequate to provide confinement to the corner of the flutes. The 180° hook at one end and the 90° hook at the other fully anchors this tie steel as it crosses the circumferential steel in the Shield Building cylindrical wall, thus providing some local confinement to the outer shell reinforcement.

On page 5 in subparagraph 6, it is pointed out that the "concrete strength was on average greater than 6,000 psi." The statement is further made that "[s]ince concrete strength has an indirect impact on bond strength, this adds extra margin to the available bond strength." I would disagree to some extent in that, once a crack has formed in the plane of the reinforcement, the effect of compressive strength is minimal since it only governs the cracking capacity and not the ability of the concrete to withstand crack growth.

Also on page 5 in subparagraph 6, the statement is made that "[s]hould the crack in any way reduce the load transfer mechanism, its effect on bar-to-bar continuity within the structure will not be impacted since the rebar stresses are sufficiently low." If the design of the wall is based on lower bar forces than can be provided, then the low stresses have some import. However, if the strength of the wall requires the full strength of the reinforcement, the stresses in the bars under working stresses are not the stresses of interest.

On page 6, subparagraph 7 points out that the height of the deformations is several times that of the crack width. This is not pertinent to the discussion because splitting crack widths just prior to bond failure can be on the order of 0.01 inch for No. 11 bars.

On page 8 under "Recommended Mode Changes or Operating Restrictions," the statement is made that "[b]ased on the information provided, there is NO mode change or operating restrictions required for this condition."

Summary

Overall, I think that the presence of the laminar cracks has the potential to reduce the bond strength of the bars because the cracks are in the same plane as the reinforcing steel. With that said, the local reduction in bond strength is of little concern unless bars are spliced within the crack region. The principal purpose of reinforcing bars is to provide tensile strength and that tensile strength can be provided as long as the bars are anchored to the concrete. If the lap slices are located outside the crack region then, at most, there will be a small discontinuity in strain between the steel and the concrete, but the steel will still serve its intended purpose. Thus, if the splices in the circumferential steel are located outside of the crack region, I agree with and

support the conclusion that "no mode change or operating restrictions" are required for this condition.

Based on my discussions with Dr. Munshi, it is not clear if any circumferential-bar splices are located within the crack regions. I, therefore, recommend that this point be investigated further. In addition, I recommend that the location of the vertical bar splices be investigated to determine the number and location of these splices within the crack regions. The capacity of the vertical-bar splices in the crack regions should be investigated based on appropriate assumptions tied to the location of the bars within these regions (such as low or no cover) and the degree of confinement provided by the circumferential bars crossing these splices.