ENCLOSURE

SEQUOYAH NUCLEAR PLANT UNITS 1 AND 2
DEFICIENT FOUNDATION PREPARATION FOR CONCRETE CELLS
FOR THE ERCW PUMPING STATION ACCESS ROADWAY
NCR 37

REVISED FINAL REPORT

Description of Condition

TVA drawing 31W307-5 shows the general arrangement of the ERCW pumping station, access roadway, and dike. TVA drawing 31W211-2 identifies the concrete cells A to F in the access roadway. TVA drawing 31W211-1, section B1-B1 shows the typical cross-section of the concrete cells. The concrete cells are designed as founded on rock.

The cells were constructed by TVA's contractor, Gulf Foundation, Incorporated. Cells E and F were constructed first. Sheet piling for cells E and F was driven to refusal, overburden material was excavated from within the cells, and tremie concrete was placed in the cells. Cores taken through the concrete into the base rock in cells E and F revealed several feet of soft compressible material between sound rock and concrete. The cores also revealed a number of lenses or planes of weakness. The weak zones did not occur at the same elevations, and the average core loss was less than 10 percent of the total concrete core. These zones were evaluated and the concrete in the cells was found to be functionally adequate for design needs. The foundation condition, however, was totally inadequate and removal of cells E and F was required.

As a result of this, construction and inspection records and procedures both for foundation preparation and concrete placement were reviewed. The investigation revealed that the foundation mapping and construction procedures used for the original construction of cells E and F were not adequate to ensure the cells were founded properly on rock and that a good concrete-rock interface had been established. The investigation also revealed that the weak zones in the concrete were the result of the pumping method used in the original placement of cells E and F which was not in accordance with the original specifications nor in accordance with ACI 304, "Recommended Placement of Tremie Concrete."

Safety Implication

If this deficiency had remained uncorrected, significant settlement of cells E and F of the pumping station access roadway may have occurred. Such settlement may have resulted in severing the ERCW piping embedded in the roadway cells and, hence, failure of both ERCW system trains. Loss of both ERCW system trains would jeopardize the ability of both reactors to reach a safe shutdown condition.

Corrective Action

Concrete cells E and F were removed. The foundation inspection procedures and tremie concrete placement procedures were revised to ensure proper foundation cleanup and to bring the tremie concrete placement procedure in accordance with ACI 304, "Recommended Placement of Tremie Concrete." The primary concern for these structures is the seismic stability of the cells. The access cells as shown on drawings 31N211-1, -2, -7, and -8, attached, are structurally tied together with a system of steel wide flanges and dowels to act as a unit during a seismic event. Another concern was to minimize differential settlement which could damage the ERCW pipes and electrical conduits supported by the cells. These pipes and conduits are wrapped with compressible material to tolerate some differential settlement. Permanent markers were incorporated on these structures to monitor the settlement after completion to verify the expectation of little or no settlement. Concrete was selected for fill material because of its weight effect on stability and to ensure against differential settlement. Settlement is also affected by the foundation material; therefore, foundation preparation required a reasonably clean rock base uncontaminated by layers of mud or compressible material.

An elaborate foundation inspection program was used to ensure proper foundation cleanup and to further verify the adequacy of the foundation. Inspection was performed by Suboceanic Consultants, Incorporated. Their work was verified by TVA divers, TVA engineering personnel, and TVA geologists who were also qualified divers. Overburden and weathered rock was excavated in the general area of the cells and spot checks were made by divers to verify the adequacy of the foundation. The cell piling was set and final cleaning, mapping, and inspection performed. A wire grid separated in 5-foot squares was placed underwater on the foundation of each cell after final cleanup. Each segment of the grid was then mapped for foundation elevation, rock type, weathering, and cleanup. Samples were taken at many node points for confirmation at the surface. This procedure verified acceptable bearing rock had been reached and the cleanup was adequate for placement of concrete. The revised procedures for foundation inspection and tremie concrete placement were then used for the construction of the ERCW pumping station cells and access roadway cells. The in situ overburden around the exterior of the sheet piling which had been removed during excavation was replaced by rockfill to conform to the original design contours.

After placement of the ERCW pumping station cells, cores were again taken to evaluate the condition of the structures. Minor core loss at the contact zone between concrete and base rock was experienced in only two of eight cores indicating a fully adequate foundation. Some local pockets of aggregate were encountered throughout the concrete section. These pockets were attributed to washout whenever the discharge end of 1 of the 16 tremie pipes was inadvertently pulled out of the concrete. There appeared to be no alignment of these pockets; however, pockets in

five out of eight cores appeared to occur between 5 feet and 10 feet of base rock where the first sections of tremie pipe were removed. In the construction process, pipe sections were removed as the concrete rose in elevation. A conservative estimate was made of the percentage of cross section occupied by rock pockets, and the structure was reanalyzed with a reduced stiffness in those zones where rock pockets were identified. Under these conditions, the structure still fulfilled all design requirements.

The same construction procedures were used in the construction of cells A through F. Cores were again taken after concrete placement. No mud or soft material was encountered between concrete and base rock in any of the cells. The only evidence of placement problems in any of the cells occurred in cell D where the cores indicated a gravel pocket resulting from a probable loss of tremie and washout of concrete in the lower end of the sloping base. This condition was evaluated and it was determined not to affect the stability of the access cells because of the confined nature of the gravel pocket and the low stress levels which would exist in the gravel. The gravel pocket is also a localized condition and does not influence settlement. In addition all cells are stable against sliding using only frictional resistance.

The geologic structure of the base rock and the step slope of the inner bedded layers of limestone and shale provide a natural key between concrete and base rock (see attached drawings 31W307-5, section B5 and 31W211-1 and -7) which virtually excludes sliding as a possibility without shearing a large cross-sectional area of concrete or rock irrespective of the absence of bond between rock and concrete. Nevertheless for conservatism resistance to sliding was calculated on the basis of friction alone and the structures were found to be stable.

The Sequoyah FSAR is being revised to incorporate the description of the ERCW pumping station, access roadway and access dike.