

DEC 20 1983

MEMORANDUM FOR: Thomas E. Novak, Assistant Director
for Licensing
Division of Licensing

FROM: James P. Knight, Assistant Director
for Components and Structures Engineering
Division of Engineering

SUBJECT: SAFETY EVALUATION REPORT SUPPLEMENT
WPPSS NUCLEAR PROJECT NO. 2 - RESOLUTION
OF CONSTRUCTION DISCREPANCIES IN CONCRETE
STRUCTURES

Plant Name: WPPSS Nuclear Project No. 2

Docket Number: 50-397

Licensing Stage: OL Review

Responsible Branch and Project Manager: LB #2, R. Auluck

The enclosed supplement to the Safety Evaluation Report (SSER) is provided in response to a RV request for assistance to evaluate the adequacy of applicant's disposition of the construction discrepancies in some of the WNP-2 concrete structures. The deficiencies were identified by an I&E Construction Appraisal Team (CAT) during its recent inspection of the plant. This evaluation is performed by K. C. Leu of Section A of the Structural and Geotechnical Engineering Branch based on information provided by the CAT/I&E and the applicant.

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Enclosure: Safety Evaluation Report Supplement

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ENCLOSURE

WASHINGTON PUBLIC POWER SUPPLY SYSTEM
NUCLEAR PROJECT NO. 2
DOCKET NO. 50-397

SAFETY EVALUATION REPORT SUPPLEMENT
RESOLUTION OF CONSTRUCTION DISCREPANCIES IN
CONCRETE STRUCTURES
STRUCTURAL AND GEOTECHNICAL ENGINEERING BRANCH

References:

1. "Construction Appraisal Inspection 50-397/83-29" from Richard C. DeYoung to Washington Public Power Supply System, dated July 26, 1983.
2. "Response to Inspection Report 83-28, Notice of Violation Section "E" - Evaluation of Concrete and Reinforcing Steel" from C. S. Carlisle to J. B. Martin dated September 16, 1983.
3. Task Interface Agreement Requesting Technical Assistance on CAT Findings dated October 19, 1983.
4. Meeting Between the Applicant and Its Consultants and NRC Staff in Bethesda, MD dated October 14, 1983.
5. Memo from C. S. Carlisle to J. B. Martin - Response to Requests Made at Ref. 4 dated October 31, 1983.
6. Conference Call Between the Applicant and SGEB Staff Clarifying Responses from Ref. 5 dated November 8, 1983.
7. Memo from G. C. Sorensen to A. Schwencer Re-submitting Responses to SGEB Staff dated November 15, 1983.

1. BACKGROUND

The above listed Reference 1 report issued by the CAT of the Office of Inspection and Enforcement (I&E) identified several construction program weaknesses. One of these weaknesses pertains to civil and structural construction aspects. The deficiencies related to the civil and structural area identified by the CAT include: concrete reinforcement steel placement, rebar splicing and spacing, concrete mix and its qualities, inspection records and disposition of nonconformance report (NCR), etc. The CAT findings were based on information generated from ten out of twelve actually examined structural locations in the reactor building.

In a Task Interface Agreement identified in Ref. 3, Region V requested NRR assistance to perform an evaluation of the validity of the applicant's conclusions and the adequacy of the applicant's dispositions of the above CAT identified deficiencies.

The Structural and Geotechnical Engineering Branch (SGEB) has provided the requested assistance and has performed the evaluation. The SGEB evaluation findings are discussed below.

2. KEY AREAS OF REVIEW AND DISCUSSIONS

The applicant has selected a total of 17 members with 23 excavated locations for the purpose of evaluating the extent of the deficiencies identified by the CAT. The 23 locations include the 12 locations previously examined by the CAT. Twelve excavation samples were identified by CAT as having design specification deviations (See Table V-2 of Ref. 1). The deviations include items such as rebar spacing, rebar alignment, missing rebar, concrete honeycombing and aggregate mix change, etc. Each of the above deviations is reviewed and discussed as follows:

(1) Rebar Spacing Problem

According to the CAT report, eight beams (Beams Nos. 2B11, 2B25, 2B5, 2B3, 3B18, 3B10, 4B30 and 6B9) and two reactor building mat locations have rebar spacing and alignment problems which range from spacing problems between rebars, spacing problems between layers of rebars and the problems of rebar misalignments (bars in different layers not lined-up directly above one another). All of which deviated from ACI 318-71 code requirements.

A. Discrepancy in In-Layer Rebar Spacing and Rebar Alignment Between Layers

In addressing the above described problems, the applicant responded (Refs. 2, 4, 5 and 7) that:

- a. ACI 318-71, Section 3.3.2 permits lesser spacing if, in the judgment of the engineer, workability and method of consolidation are such that the concrete can be placed without honeycomb or void,
- b. The WNP-2 investigation has found good bond between the concrete and reinforcing steel in all the sample excavations except for beams 2B11 and 2B25, which were further excavated to sound concrete part of the beams and appropriately repaired,
- c. All the eight beams are shown to have sustained construction loads, which, in turn, were determined to be more severe than their corresponding operating loads, and
- d. The 1960 ASCE paper No. 3047 titled "Concrete Beams and Columns with Ductile Reinforcement" provided test results indicating that no significant difference in behavior or ultimate strength

was found between bundled reinforcement case and the case of using spaced reinforcement.

We have reviewed the above applicant's responses and other pertinent information. We note that in heavy-engineering construction such as the WNP-2 construction, heavy reinforcements are often required due to load requirements, thus, in many instances, causing rebars to be placed closer than the code limits. Under such conditions, however, the code allows some deviations in rebar spacing provided that the engineer/constructor takes measures to assure that sound concrete consolidation is achieved.

Based on the facts that it has been confirmed by the applicant via field tests that the concrete consolidation was of good quality, that the beams possess large safety margins over their design loads and whenever needed, appropriate repair of the excavated beams were done, and furthermore, some related tests on bundled rebar applications showed no significantly detrimental effects upon beam strength, we conclude that the applicant's response to and disposition of the issue are acceptable and the issue is considered as resolved.

B. Discrepancy in Between-Layers Rebar Spacing

The CAT report raised an issue on discrepancy pertaining to "Between-Layers Rebar Spacing." Beams 2B11, 2B25 and 2B5 were reported to have rebar spacing deviations between layers of rebars.

We have reviewed the applicant's response to the issue (Ref. 2) and held a discussion with the applicant on December 16, 1983 to obtain additional information regarding rebar spacings applicable to the above identified beams. Based on the findings of our review and the additional information provided by the applicant, and considering the fact that beams designed in accordance with the requirements of ACI 318-71 Code generally possess considerable safety margins, we conclude that the intent of the code requirement governing the "between layers rebar spacing" is met by beams 2B11, 2B25 and 2B5 and the issue is considered resolved.

(2). Concrete Honeycombing Problem

Table V-2 of the Ref. 1 indicated deficient conditions related to concrete honeycomb (voids) for the following beams:

Beam 2B11: honeycomb visible and concentrated predominately between bars even where concrete below bar appeared sound

Beam 2B25: same as beam 2B11

Beam 2B3: honeycomb at the region of dowel lap splices was initially identified via NCR-1851. This area was re-repaired due to deficiencies related to the initial repair prior to the CAT inspection.

In Reference 7, the applicant pointed out that out of 23 excavated locations in 17 members, three bars (2B11, 2B25 and 2B3) had been

identified as having severe congestion and honeycombing and voids during construction. It also indicated that the honeycombing associated with the three beams had been repaired in accordance with approved construction procedures. In addition, the beams had been re-analyzed taking into account the deficient conditions and were found to be structurally adequate to sustain their design loads and meeting pertinent code allowables. This finding is acceptable to the staff for resolving the issue.

(3) Missing Rebar Problem

The CAT reported the missing of rebars at the following locations:

Beam 2B5: Two of seven #11 bars missing from bottom rebar layer

Beam 2B11: One of eight dowels appeared to be missing in first layer; stirrups have inadequate cover; also a discrepancy on the size and spacing of stirrups.

Beam 3B18: One of eight dowels not located.

In his effort to justify the design acceptability of the beams with the above noted deficiencies, the applicant provided the following justifications:

- A. With respect to Beam 2B5, its original design called for two rows of seven #11 bars. However, the as-built showed five bars in bottom most layer, five in the middle and four in the top layer providing the required amount of rebars.
- B. With respect to Beam 2B11, the dowel which appeared to be missing during CAT inspection has been found after further excavation; as to the question of not providing adequate concrete cover to the stirrups, the applicant committed to provide adequate concrete cover over the stirrups during patching work. As to the question on the size and spacing of stirrups, a checked and approved original calculation sheet, not previously viewed by the CAT, shows that both the size and spacing of stirrups for Beam 2B11 agree with those shown on the design drawing.
- C. With respect to the missing dowel of Beam 3B18, a re-evaluation of the beam with the missing dowel was carried out and the beam was shown to have adequate capacity for its design loads.

Based on review of the above information, we conclude that the justifications provided by the applicant in resolving the issues are reasonable and acceptable.

(4) The Issue of Horizontal Lapping Vs. Vertical Lapping

The CAT report also identified as a discrepancy, the reinforcement lapped horizontally contrary to the required vertical lappings applicable to beams 2B11, 2B25 and 3B18.

The applicant responded that the orientation of lap splices was not defined on the shop drawing, therefore, lap splices can be placed in either plane and the item should not be treated as a discrepancy.

Since there is no clear cut code requirement governing the orientation of lap splices, we conclude that the particular lap splice orientation adopted is not a deficiency and should be acceptable.

(5) Concrete Mix Change

The CAT report raised a concern pertaining to the fact that 1-1/2" aggregate concrete was substituted for 3/4" aggregate concrete for beam 4B30 and beam 6B9 without a "Request for Information (RFI)." In an effort to justify the concrete mix change, the applicant stated that:

- A. the mix substitute from 4SA-P (3/4"aggregate) to 4MA-P (1-1/2" aggregate) was approved by the Burns and Roe field engineer prior to concrete placement,
- B. both classes of concrete have the same required minimum 28-day strength of $f_c' = 4000$ psi, and
- C. the concrete bond and consolidation in these two beams was determined as excellent, therefore, the mix change adopted should not affect the structural integrity or capacity and should be acceptable to the staff.

We consider the applicant's justification adequate and acceptable.

(6) Documentation Review and Disposition of NCR and RFI

In the CAT report, deviations of the documentation of the as-built structural elements from the design/construction specifications were noted. It also identified deficiencies in dispositions of NCR pertaining to beams 2B11, 2B3 and 2B25.

In addressing the above deficiencies, the applicant provided the procedures adopted for evaluation of the 23 locations in 17 members (Ref. 2) which included the following items:

- A. The design drawings on each member were checked against the design calculations.
- B. The shop drawings were checked against the design drawings.

- C. The excavated areas shown on the as-built drawings were checked against the shop drawings.
- D. The structural capacity was checked against the structural design loads. Beams 2B5 and 2B11 were checked in detail.
- E. The pour records were reviewed for RFIs and NCRs. The applicant also stated that some of the NCRs and RFIs were found deficient in that the deviations in the as-built members such as rebar spacing, concrete voids, mix change and patching, etc., were not properly identified. However, the results of the re-analysis and re-evaluation indicated that all the as-built structural members are found to be structurally adequate for their specified loads and corrective actions have been taken on Beams 2B3, 2B11 and 2B25, where the patching of concrete voids was implemented in accordance with approved construction procedures. Therefore, the above noted deficiencies should be accepted as resolved.

We have reviewed the applicant's justifications and conclude that the above deficiencies with the stated corrective actions implemented are resolved.

3. Selection of Samples

In the course of our review, the staff raised a concern about how representative and conservative are the selected excavation samples in determining the overall concrete construction adequacy at WNP-2. The applicant responded to the staff concern with the following:

- (1) Beams selected at EL. 471 in the reactor building include four beams (2B3, 2B5, 2B11 and 2B25) out of 35 beams that have two or more layers of reinforcement at the bottom. These are the locations with heavy rebars and dowels that lack of concrete consolidation, if any, would be most likely to occur. To diversify sampling pattern, four other beams at different locations, and samples at west and east external walls, pilaster/column, north wall of separation pool, fuel pool wall, foundation mat and slab were taken to make a total of 17 members with 23 locations samples.
- (2) An evaluation summary table was made of the 17 members in terms of design margin. The table showed that the design margins range from 1.0 to 5.6 for moments (positive and negative) and 1.1 to 2.2 for shear with 1.0 being the design margin complying with ACI 318-71 code requirements and licensing commitments.
- (3) The sample selection was not based on a random nor a statistical approach. Rather, it was based on a conservative one. The 17 members selected are believed to be the ones most likely to exhibit

misplaced bars and honeycombing because of heavy rebar requirement. Thus the samples are purposefully selected to be on the conservative side and, therefore, should be acceptable to the staff.

We have evaluated the applicant's justification and rationale for sampling and conclude that the sampling approach used is acceptable.

4. Conclusion

The discrepancies outlined in the CAT report (Ref. 1), the responses provided by the applicant (Ref. 2.5.7) including the discussions held between the staff and the applicant (Refs. 4 and 6) pertaining to the concrete construction problems at WNP-2, have been reviewed. Based on the discussions provided above in this SSER, we conclude that the as-built Category I structures at WNP-2 have met the intent of WNP-2 FSAR commitments and the applicable SRP provisions, thus, the issues raised by CAT/I&E are considered resolved.

Docket No.: 50-397

DEC 20 1983

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THRU: A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing

FROM: R. Auluck, Project Manager
Licensing Branch No. 2
Division of Licensing

SUBJECT: DAILY HIGHLIGHT - WASHINGTON PUBLIC POWER SUPPLY
SYSTEM NUCLEAR PROJECT NO. 2

On December 20, 1983, an operating license was issued to Washington Public Power Supply System for Nuclear Project No. 2, at reactor core power levels not in excess of 3323 megawatts thermal (100% power). Pending Commission's approval, operation is restricted to power levels not to exceed 5% of full power.

R. Auluck, Project Manager
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