GLENN L. KOESTER
VICE PRESIDENT-OPERATIONS

June 6, 1979

Mr Olan D Parr, Chief
Light Water Reactors Branch No 3
Division of Project Management
Nuclear Regulatory Commission
Washington, D C   20555

Dear Mr Parr:

During a telecon on May 29, 1979 between the applicant,
their consultants, NRC staff members and Bechtel Power
Corporation, several questions were raised by the staff
to clarify the information that was presented at the
public meeting held in Burlington, Kansas on May 15.

Attached for your information are the answers to all
of those questions raised.

Sincerely,

Glenn L Koester

GLK/ash

Attach

cc-Mr Karl V Seyfrit, Director
   Office of Inspection and Enforcement
   U S Nuclear Regulatory Commission
   Region IV
   611 Ryan Plaza Drive, Suite 1000
   Arlington, Texas   76011

cc-w/attach

2230 352

7906110 /59 A

Additional Information for Wolf Creek Base Mat

1. Selection of the eleven remnants to be petrographically/chemically
    tested during the second phase of 90 days remnant testing was based
    on the following considerations:

    a. The remnants which had already been tested in phase one.

    b. Remants were selected which had indicated strengths less than
        5,000 psi (8 of the 11 were below 5,000 psi).

    c. Remnants were selected from sets which had 90-day average strengths
        less than the 28-day average strengths (9 of the 11 were from
        sets with strength reversal).

    d. All available remnants were not tested so that material would
        be available for testing by other organizations or for differ-
        ent tests which might be proposed. (Subsequent to the second
        phase testing, three pairs of remnants were turned over to the
        NRC.)

2. Windsor probe testing, considered separately, does not provide data
    which absolutely establishes concrete compressive strength. Many
    factors including proximity of rebars, concrete preload, aggregate
    size and hardness, etc. may affect the test results. However, when
    Windsor probe testing is supplemented with other tests, a high de-
    gree of assurance of concrete quality is obtainable. This much is
    for certain regarding the Windsor probe testing of the Wolf Creek
    Reactor Building base mat; it gave positive indication that concrete
    around the periphery is uniform, no "soft" spots or areas of
    significantly different strength are present; it gave positive
    indication that the strength of the concrete around the periphery
    is high, probably above 5,500 psi.

3. The attached table provides the base mat seismic loads obtained from
    a seismic analysis based on a fixed base approach. This analysis,
    which considers a lumped mass model utilizing modal response and
    response spectrum techniques, was performed in accordance with
    BC-TOP-4A. Fixed base analyses were performed to provide upper
    bound results. Based on the shear moduli shown in Appendix F of
    the base mat reanalysis report all subsurface material greater
    than 35.5 feet below grade has a shear wave velocity greater than
    3,500 fps, and may therefore be considered rock. The effect of this
    rock on the soil-structure-interaction is negligible, as implied
    by Section 3.7.2 of the SRP. Accounting for the tendon gallery,
    reactor cavity and lean concrete fill that occupies the annular
    space between the two, less than 10 ft. of soil (which has a soil

2230 353

-1-

modulus of 15,000 ksf at a 10^{-4}% strain level) separates the base mat and rock. The fundamental frequency of this soil column is above 33 hz. The foundation medium for the base mat can therefore be considered as rigid, resulting in a building response which simulates that obtained on a fixed base. This approach is further justified by the fact that studies (12, 13) have shown that the fixed base analysis provides an upper bound response for the soil-structure-interaction system.

Since the horizontal response in the two orthogonal directions are nearly identical, the higher east-west direction results are shown.

Loads at Top of Base Mat (Elevation 2000'-0")

	.12g (SSE)		.06g (OBE)	
	Horizontal (Orthogonal Directions)	Vertical	Horizontal (Orthogonal Directions)	Vertical
Shear (kips x 10^3)	14.11	---	9.46	---
Moment (kip-ft x 10^6)	1.78	---	1.21	---
Vertical Force (kips x 10^3)	---	10.27	---	6.05
Base Mat Acceleration (g's)				
	0.12	0.12	0.06	0.06

These results may be compared with the 0.2g SSE/0.12g OBE seismic loads used in the base mat reanalysis and reported in Appendix H of the reanalysis report. In general, the SSE results are approximately 60% of the corresponding values presented in Appendix H. Similarly the OBE results are approximately 50% of those values presented in Appendix H.

2230 354

4. The load carrying capacity of the base mat has not been appreciably
    reduced by using the 4460 psi as the design concrete strength
    instead of using the 5000 psi as specified.

    In performing the Wolf Creek reactor building base mat reanalysis,
    the stress levels in the reinforcing and the concrete were determined
    due to combined flexural and axial loads at each design section in
    the mat in accordance with BC-TOP-5A. The method used quantified
    the stress levels in the mat for comparison with allowables (as
    opposed to using load interaction tables). By inspection of these
    stress levels, it is evident that concrete compressive stresses
    did not control design. Concrete compressive strength also influ-
    ences the load carrying capacity of the section by virtue of the
    bond between reinforcing steel and concrete. Since no lap splicing
    of reinforcing steel is used in the base mat, only end anchorage of
    bars is influenced. As defined in BC-TOP-5A, the anchorage criteria
    is a function of the square root of $f'c$, as well as other parameters
    (such as section loads, section properties, and anchorage methods).
    Therefore, since the reduction in $f'c$ is 10.8%, an upper bound limit
    for the reduction in load carrying capacity to resist combined
    flexural and axial loads of the base mat is 3.3%.

    The load carrying capacity of the base mat for shear loads at any
    given section is dependent upon the cross-sectional concrete dimensions
    and properties as well as the reinforcing ties provided and the
    particular load combination to which the mat is subjected. The
    shear stress that can be resisted by the concrete is a function of
    the square root of $f'c$ (and it may be equal to 0 under certain
    conditions). Therefore, since the reduction in $f'c$ is 10.8%, an
    upper bound limit for the reduction in shear load carrying capacity
    of the base mat is 3.3%.

5. The site specific soil properties for each site were used in the original
    soil structure interaction analysis (FLUSH analysis) to develop the
    seismic loads. The upper bound results of the site specific seismic
    analyses were used as the SNUPPS envelope. The use of Wolf Creek site
    soil properties resulted in seismic loads which were within the SNUPPS
    design envelope. Presented below is a quantitative comparison, in
    terms of percent reduction of the loads at the Wolf Creek site versus
    the SNUPPS design envelope loads (utilizing the same ground motion).

| | SSE | | | OBE | | |
	N-S	E-W	Vert	N-S	E-W	Vert
Moment at top of mat	14%	10%	---	25%	23%	---
Shear at top of mat	9%	4%	---	26%	17%	---
Vertical force at top of mat	---	---	18%	---	---	0%
Base mat acceleration	15%	7%	5%	10%	6%	4%

2230 555

6. Uplift of the base mat due to load combinations identified in Appendix D of the reanalysis report is considered. The nonaxisymmetric finite element model utilizes a "bed" of linear vertical and horizontal springs at each nodal point below the base mat. The stiffness values used for these springs are representative of the foundation media soil characteristics. The initial analytical run is made utilizing the applied load on the structure with all springs intact for a completely elastic solution. The initial run is then reviewed to determine which vertical springs are in tension. All vertical springs in tension are then released (by assigning an insignificantly small stiffness) and the analysis rerun. This review and adjustment is performed manually for each cycle and the analysis is iterated until equilibrium is reached with no soil springs in tension. The results of this converged run are utilized in the determination of resultant section loads on the base mat.

7. Consideration of the heavy equipment anchored to the base mat (not shown in the BSAP nonaxisymmetric model) was not limited solely to the inclusion of dead loads. The heavy equipment was incorporated in the seismic analysis model together with the other internals (e.g., primary shield wall, secondary shield wall). The results of the seismic analysis indicate that seismic loads due to all internal structures and equipment contribute approximately 5% to the total building load. This load was incorporated in the static application of the seismic loads and conservatively applied at the shell to provide maximum uplift patterns. Incorporation of the internals in the BSAP model was conservatively omitted since no appreciable stiffness is added to the base mat by their inclusion. In addition, equipment anchorage in the base mat was checked in detail (see Section 4.2.1 of the reanalysis report) for reaction loads, LOCA loads, and seismic loads to insure that the base mat could adequately sustain the resulting forces and moments locally.

8. The stress definitions provided in BC-TOP-5A are in terms of section stresses, not principal stresses, and the associated acceptance criteria are consistent with these definitions.

The maximum stress levels provided in the report are due to combined membrane plus bending effects and the corresponding acceptance criteria of paragraphs CC-3410 and CC-3420 of BC-TOP-5A are utilized. BC-TOP-5A, Appendix C, paragraph CC-3136 provides the following definitions:

2230 _56

"CC-3136.1   Membrane Stress[a]

'embrane stress is the component of normal stress, hoop or meridi-
onal, which is uniformly distributed and equal to the average of
stress across the thickness of the section under consideration.

CC-3136.2   Bending Stress

Bending stress is the variable component of normal stress. The
variation may or may not be linear across the thickness.

---

[a] As applied in this appendix not to be substituted for principal
stress or stress intensity."

The "sections under consideration" for the reanalysis are oriented
in radial and hoop directions.

Principal stresses and their orientations are not utilized directly
in the analysis of a cracked reinforced concrete section. No
allowable stress limits are specified with respect to principal
stresses. The same criteria and definitions are also specified
in ASME Section III, Division 2, Section CC-3000 for Concrete
Containments.

The normal stresses utilized in the computation of section forces
and moments are those that are resolved in radial and hoop directions.
The resultant reinforcing steel and concrete stresses are determined
by cracking the reinforced concrete section due to the applied loads.
Since principal stresses are not used as the design basis, the
shear stresses associated with the normal stress orientation are
utilized in determining shear loads for which the section is designed.

9.   Maximum stresses resulting from the inclusion of thermal loads
     in both service and factored load combinations are provided in the
     attached tables (Appendices N & P). Corresponding allowable stress
     levels have been increased in accordance with the criteria provided
     in Bechtel Topical Report BC-TOP-5A. All stresses are within the
     allowable limits.

10. The following computer programs used in the reanalysis effort which
     are not referenced in the SNUPPS PSAR submitted for the Wolf Creek
     Construction Permit (CP) or referenced topical reports are:

     a. FLUSH
     b. BSAP
     c. Miscellaneous project developed programs

Revisions of the PSAR, prepared subsequent to the CP, reference
the FLUSH program. Verification of the FLUSH program is through the
"public domain" acceptance alternative, i.e., it is a recognized
program in the public domain and has had a sufficient history of
use to justify its applicability and validity without further
demonstration (Ref: SRP 3.8.1.4).

2230 357

The computer program verification information requested for
items b and c will be forwarded under separate cover directly
from Bechtel Power Corporation. It is requested that this
material be handled as proprietary to Bechtel Power Corporation.

References to Response #3

12) Hadjian, A. H., "Soil-Structure-Interaction - an Engineering
     Evaluation", Nuclear Engineering and Design, 1976

13) Parmelee, R. A., Perelman, D. S., Lee, S. L., and Keer, L. M.,
     "Seismic Response of Structure - Foundation Systems", Journal
     of the Engineering Mechanics Division, ASCE, Vol. 94, No. EM6,
     December, 1968.

2230 358

SUMMARY OF MAXIMUM PRIMARY + SECONDARY (THERMAL)
STRESSES AND SHEAR TIE REQUIREMENTS DUE TO SERVICE LOADS

Radial Zone	From Radius	To Radius	Reinforcing Steel Stress (Tension) (Allowable Stress = 40.0 ksi) Maximum Stress (ksi)				Concrete Stress (Compression) (Allowable Stress = 2.68 ksi) Maximum Stress (ksi)		Shear Tie Requirements (See Note Below)
			Radial Bottom	Radial Top	Hoop Bottom	Hoop Top	Radial	Hoop	Required / Provided
B1	16'-6" *	25'-0"	3.8 d	3.2 c	7.8 c	7.8 c	0.95 a	0.55 d	0.23 d
B2	25'-0"	35'-0"	5.8 a	7.3 d	6.8 c	6.2 c	1.01 a	0.67 a	0.37 d
B3	35'-0"	45'-0"	30.6 a	13.5 d	14.2 a	7.1 c	1.59 a	0.99 a	0.37 d
B4	45'-0"	55'-0"	31.3 a	13.2 d	18.4 a	4.7 c	1.49 a	1.12 a	0.37 a
B5	55'-0"	65'-0"	24.0 a	8.0 d	20.6 a	3.8 d	0.99 a	1.10 a	0.92 a
B6	65'-0"	77'-0" **	11.0 d	18.1 a	16.1 a	0.0 --	0.92 d	0.89 a	0.99 a

* Edge of Reactor Cavity
** Outside Edge of Base Mat

Note on Shear Tie Requirements

The values listed are the ratios of the maximum shear tie area required to the shear tie area provided. Ratios less than or equal to 1.00 indicate that shear stresses are within allowable stress limits for the reduced concrete strength.

APPENDIX P

SUMMARY OF MAXIMUM PRIMARY + SECONDARY (THERMAL)
STRESSES AND SHEAR TIE REQUIREMENTS DUE TO FACTORED LOADS

Radial Zone	From Radius	To Radius	Reinforcing Steel Stress (Tension) (Allowable Stress = 60.0 ksi) ***				Concrete Stress (Compression) (Allowable Stress = 3.79 ksi)		Shear Tie Requirements (See Note Below)
			Maximum Stress (ksi)				Maximum Stress (ksi)		Required / Provided
			Radial		Hoop		Radial	Hoop	
			Bottom	Top	Bottom	Top			
B1	16'-6" *	25'-0"	41.7 g	0.0 --	39.2 g	2.7 g	3.00 g	1.50 g	0.23 g
B2	25'-0"	35'-0"	56.8 g	12.6 g	47.2 g	2.3 e	3.51 g	1.94 g	0.68 g
B3	35'-0"	45'-0"	59.2 g	21.5 h	51.1 g	0.9 e	3.37 g	2.18 g	0.72 g
B4	45'-0"	55'-0"	51.6 g	23.2 h	56.4 g	1.3 e	2.59 g	2.13 g	0.87 g
B5	55'-0"	65'-0"	30.5 g	26.5 g	55.4 g	2.8 e	1.30 g	1.81 g	0.68 g
B6	65'-0"	77'-0" **	10.7 e	33.9 f	49.9 g	4.3 h	0.93 e	1.26 g	0.66 g

* Edge of Reactor Cavity   *** Per BC-TOP-5A, strain may exceed yield
** Outside Edge of Base Mat

Note on Shear Tie Requirements

The values listed are the ratios of the maximum shear tie area required to the shear tie area provided.
Ratios less than or equal to 1.00 indicate that shear stresses are within allowable stress limits for
the reduced concrete strength.

P-8