CP&L
Carolina Power & Light Company

SERIAL: LAP-83-414

SEP 20 1983

Director of Nuclear Reactor Regulation
Attention: Mr. D. B. Vassallo, Chief
Operating Reactors Branch No. 2
Division of Licensing
United States Nuclear Regulatory Commission
Washington, DC 20555

BRUNSWICK STEAM ELECTRIC PLANT, UNIT NOS. 1 AND 2
DOCKET NOS. 50-325 AND 50-324
LICENSE NOS. DPR-71 AND DPR-62
SPENT FUEL POOL EXPANSION

Dear Mr. Vassallo:

In a series of meetings and telephone calls during June and July of this year, Mr. Owen Rothberg of the Structural Review Branch expressed concern over the way in which United Engineers and Constructors, Inc., (UE&C) combined certain values in their calculations of the edge shear of the spent fuel pool floor slab and support. In particular, Mr. Rothberg questioned the use of SRSS for combining certain loads rather than using ABS methods.

As requested by Mr. Rothberg, UE&C has recalculated these loads by removing the redundancy of including fuel weight in the calculation of seismic loads due to rack motion (referred to in the attachments as the first phenomenon) and summing by ABS method the loads produced by seismic motion of the rack without fuel with impact loads of the fuel bundles (second phenomenon). As described in the attachments, by not "double-counting" the fuel bundle mass, the subsequent summation of loads shows at least a 13% margin of safety.

Mr. Rothberg also requested clarification of our May 5, 1983 letter which referred to the Response Spectra Method in Regulatory Guide 1.92. Stress analyses were performed for both OBE and DBE conditions, based upon the shears and moments developed in the finite-element dynamic analysis of the seismic response. The Response Spectra Method was used to calculate these shears and moments. The maximum amount of sliding and the stability of the modules against overturning were determined by use of two independent time histories for each horizontal direction. Combination of the modal response was done by taking the square root of the sum of the squares of the maximum representative values of the three spatial components of earthquake motion. This same method was used to combine the effect of the three components of earthquake motion. The basis for using this method is contained in the NRC Regulatory Guide 1.92, page 1.92-4, paragraphs 2.1 and 2.2.a.

A001
1/1

Should you have any further questions regarding this issue, please contact our staff.

Yours very truly,

S. R. Zimmerman
Manager - Licensing

JSD/ccc (7824JSD)

cc: Mr. D. O. Myers (NRC-BSEP)
Mr. J. P. O'Reilly (NRC-RII)
Mr. S. D. MacKay (NRC)

FORM 3500

MEMORANDUM

united engineers & constructors inc.

JOB NO. 7453.121

DEPT. Structural Technical Support

TO: L. R. Scott

FROM: R. H. Toland/S. A. Yeh

OFFICE: Philadelphia
Memo #1822

DATE: August 12, 1983

COPIES: J. Katz, S. Ahuja, S.A. Yeh, H.F. Hsu, DCC (3 Copies), SAG File, SAG Day File

SUBJECT: Carolina Power & Light Company
Brunswick Steam Electric Plant
Units 1 and 2
Spent Fuel Storage Expansion

Reference: MM #1802, from S.A. Yeh to J. Katz, dated 7/26/83, same subject.

Review and partial reworking of the analysis of the fuel pool floor slab and support has shown the margin of safety with respect to shear to be at least 13% to 16% (greater than the previously indicated 2%). Seismic and impact loads were combined by the absolute summation (ABS) method. Conservatism in the generation of the loads was reduced.

Discussion

In their review of the supporting analyses for spent fuel storage expansion, the NRC expressed concern for the indicated low margin in edge shear of the fuel pool floor slab and support (localized area). The particular load combination involves two dynamic loads, seismic and the impact effects of the fuel bundle within its cell due to seismic motion. The analyses combined these two loads by the SRSS method. While UE&C holds that this method is appropriate, the NRC required that the margin be determined when the load cases are combined by the ABS method. In order to demonstrate a positive margin while combining by the ABS method, it is required that conservatisms in either the load definitions, or the analysis, or both, be reduced. Reference 1 recommended an approach wherein the load definitions be refined. In this approach, an effective 'double-counting' of fuel bundle mass is removed.

It is our opinion that the margin is actually greater than the 13% to 16% since the analytically predicted uplift of the supporting truss will be of much lessor extent (or will not occur). It is this uplift which causes the local high shear. This rework of the analysis has only factored down the load without accounting for the added benefit of reduced uplift.

ATTACHMENT No C TO UC 34189

The revised calculations will be forwarded separately.

If you have any questions, please contact us.

R. H. Toland, Manager
Structural Analysis Group

S. A. Yeh
Structural Analysis Group

RHT/SAY:lrs

ATTACHMENT No 2 TO UC 34127

Form 5605

united engineers & constructors inc.

CALCULATION REVISION CONTROL SHEET

CALC. SET NO.	
PRELIM.	9527-E-
FINAL	RB-FP-08-F
VOID	

PROJECT TITLE CP&L BSEP UNITS 1 & 2 DISCIPLINE ZSIZ

REVISION NO. 1

SYSTEM Spent Fuel Handling

SUBJECT Spent Fuel Storage Expansion

DESIGN CLASSIFICATION Seismic Catagory I

REASON FOR REVISION To show higher margin of safety than it appears for the edge shear of the fuel pool concrete floor (2% margin in the study)

REVISION STARTED BY S. A. Yeh DATE July 28 '83

REVISION AUTHORIZED BY L. R. Scott DATE July 28 '83

PREVIOUS CONTROL SHEETS NOTED FOR NEW REVISION BY N/A

PROBLEM STATEMENT

NRC has objected to the SRSS combination for the seismic and impact loading (ABS method is recommended), and is concerned about the 2% margin of safety for the edge shear on the fuel pool concrete floor based on SRSS load combination.

A more detailed study by trimming the unnecessary conservatism for the load generation and using the ABS method for load combination to show a more accurate safety margin.

DESIGN BASIS

1. Letter from L.R. Scott to R.L. Sanders of CP&L (UC-34189, File No. A-5.150) dated July 27, 1983.
2. Calculation set No. 9527-1-RB-FP-01-F.
3. Calculation set No. 9527-E-RB-FP-08-F.

ATTACHMENT No 3 to UC 34189

TOTAL NUMBER OF SET COMPUTATION SHEETS 10 + 1 (ADD REVISION CONTROL SHEET AND pg 40a thru 40j)

FINISHED BY S. A. Yeh 7/28/83 CHECKED BY H F Hsu 8/3/83

	CHECKER	DESIGN SUPER	COGNIZANT ENG'R	DESIGN REVIEW
BY	H F Hsu	[illegible]	R A [illegible]	
DATE	8-3-83	8.15.83	8-12-83	

REVISION ___ STARTED DATE ___ BY ___

Form 5604

united engineers & constructors inc

CALCULATION CONTROL SHEET

PROJECT TITLE CP&L BSEP UNITS 1 & 2 DISCIPLINE 2512

CALC. SET NO.	
~~PRELIM.~~	9527-E
FINAL	RB-FP-08-F
VOID	

SYSTEM Spent Fuel Handling

SUBJECT Spent Fuel Storage Expansion

DESIGN CLASSIFICATION Seismic Category I

STARTED BY S. A. Yeh DATE 8-18-80

AUTHORIZED BY P. F. Duerr DATE 8-18-80

PROBLEM STATEMENT

By reducing the wt. of spent fuel shipping cask from 110 ton to 75 ton, check whether the fuel pool structure has enough capacity to accomodate the fuel rack arrangement of alternate proposals A1 and A2. (Alternate A1 has been voided)

DESIGN BASIS

(1) G.E. letter dated July 23, 1980, and Aug 12, 1980. Subject Estimated max. seismic loads on Brunswick pool floor.
(2) U.S. NRC Standard Review Plan
(3) CPL BSEP 1&2 FSAR, Vol. 1 Section 2.6 Seismic Response Spectra. April '72
(4) CPL BSEP Design Report No. 4, Addendum B Nov. 8. '72
(5) ACI 318-77
(6) Files 1-RB-FC-06, 1-RB-FC-05.
(7) CP&L BSEP original calculation book #21, Job 9527-01 "Slabs walls betw'n F.P. girders"
(8) Comments on G.E. letter July 23, 1980 and rack layout proposal #C dated Aug 6, 1980. By T.R. Browning

TOTAL NUMBER OF SET COMPUTATION SHEETS 110

FINISHED BY S A YEH CHECKED BY R. Galunic

	CHECKER	DESIGN SUPER	COGNIZANT ENG'R	DESIGN REVIEW
BY	R G	ARC	JCF	
DATE	10-10-81	6-24-82	6-25-82	

REVISION 1 STARTED DATE July 29 '83 BY S A YEH

Form 5603

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CALCULATION SUMMARY & REFERENCE SHEET

CALC. SET NO.	
~~PRELIM.~~	9527-E-
FINAL	RB-FP-08-F
VOID	
SHEET 40a OF 109	
J.O. 7253.121	

PROJECT TITLE CPEL BSED Units 1&2 DISCIPLINE 25/2

SYSTEM Spent Fuel Handling

SUBJECT Spent Fuel Storage Expansion

DESIGN CLASSIFICATION Seismic Catagory I

REV	COMP. BY	CHK'D BY
0	DATE	DATE
1	[signature] DATE 8-1-83	HFH DATE 8-3-83

SUMMARY/CONCLUSIONS

By trimming the unnecessay conservatism and using ABS method for combining seismic and impact force at the base of the rack as required by NRC, an additional 13 to 16% of safety margin on the force to be transferred to the grid-truss system was obtained.

With the geometry-nonlinear nature of the grid-truss system to transfer these forces to the concrete floor, a min. of 13 to 16% additional factor of safety to the edge shear can therefore be obtained.

REFERENCES: (SPECIFICATIONS, DRAWINGS, CODES, CALCULATION SETS, TEXTS, REPORTS, COMPUTER DATA PSAR ETC.)

1 Cal. Set. No. 9527-1-RB-FP-01-F.

2 Pg 20 thru Pg 40 of original File No. 9527-E-RB-FP-08-F.

FORM 5007 REV. 7/79

(DISCIPLINE)

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CALC. SET NO.		REV	COMP BY	CHK'D BY
~~PREL~~	9527-E-RB-FP-08-F	0	Kay	LFH
FINAL			DATE 7-30-83	DATE 8-3-83
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NAME OF COMPANY CP&L BSEP UNIT/S 1&2

SUBJECT Spent Fuel Storage Expansion

a. 2% margin of ultimate capacity based on the factored load for the edge shear at the critical location of the fuel pool floor has shown in the analysis of "Spent Fuel Storage Expansion" (Pg 105 of file NO. 9527-E-RB-FP-08-F*).

This fact has alarmed NRC, when reviewing the liscensing application for the modification to the fuel pool storage arrangement. Therefore, a more detailed look into the load generation by trim out the unnecessary conservatism is undertaking here to justify to NRC that a higher margin exist, and it is not as alarming as it appears.

* reference 3

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SUBJECT Spent Fuel Storage Expansion

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The response of the fuel rack structure due to the postulated seismic event at the plant site can be best described in term of energy.

Two phenomena both based on the assumptions that no other forms of energy disscipation (such as wave, Thermal, etc) except kinetic and strain energy are described in the following.

(1) The fuel assemblies are riding along with the rack structure during the seismic event (no relative velocity and displacement between the fuel assemblies and the rack structure). The total seismic energy imparted on the rack system have been transformed into kinetic energy of the mass of the rack system (including water, rack structure, and fuel assemblies) and then absorbed by the rack structure in the form of strain energy.

(2) Due to different phasing characteristics of the rack structure and the fuel assemblies in the water environment relative displacement and velocity between the two objects will occur, and when

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the relative displacement between the two objects is equal to or greater than the gap between them, impact is then occured. Under impact situation, the total seismic energy will distributed in the form of kinetic energy between the rack structure (including water) and the fuel assemblies.

In the form of mathematic expressions, the two phenomena can be described in the following equations

For 1st phenomenon,

$$E_T = E_K = E_S .$$

Where: E_T = Total seismic energy imparted on the system.

E_K = Total kinetic energy on the rack system transformed from E_T.

E_S = The strain energy absorbed by the rack structure due to E_K.

For 2nd phenomenon,

$$E_T = E_{KR} + E_{KF} = E_{SR} + E_{SF} = E_S$$

Where: E_{KR} = The kinetic energy imparted on the rack structure (including water).

E_{KF} = The kinetic energy imparted on the fuel assemblies.

E_{SR} = The strain energy absorbed by the rack structure due to E_{KR}

E_{SF} = The strain energy absorbed by the rack structure due to E_{KF}.

Since the worst case occured at OBE situation; and overturning moment of the fuel rack which force the redistrution of vertical loading on the concrete slab causing higher shear stress in certain location, therefore, only OBE overturning of fuel rack system will be looked at.

Analysis based on the 1st phenomenon has been done in the previous analysis (pg 20 thru 40 of file no. 9527-E-RB-FP-08-F) for the 18 and 36 cell rack under OBE condition and the overturning moments at the base of the rack are:

1081 K-" for 18 cell (half) rack on the weak axis.

1795 K-" for 36 cell (full) rack.

For the second phenomenon, it is assumed that the fuel rack system is vibrating with the pattern of 1st phenomenon, and suddenly the fuel assembly masses are separated from the rack structure mass (including water mass). This will divide the total imparted seismic energy into two groups of kinetic energy of each mass group (rack structure and fuel assembly).

The weight composition of the rack system (refer to pg 6 & 15 of file no. 9527-1-RR-FP-01) are as follows.

Type of Rack \ Weight	Total (kips)	Rack structure *		Fuel Assembly	
		Weight (kips)	%	Weight (kips)	%
18 cell rack (half rack)	23.8	10.6	45	13.2	55
36 cell rack (full rack	47.2	20.9	44	26.3	56

* including water weight.

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A moving object, when suddenly breaking into pieces, the energy distribution of each piece is directly propotional to its mass, if no other form of energy dissipation is considered, therefore, the kinetic energy for rack structure and fuel assemblies can be calculated. The overturning moment at the base of the rack due to the kinetic energy imparted on the rack structure can be directly scaled from the analysis of 1st phenomenon based on the mass ratio of the rack structure to the total system, since the stiffness of the system did not change, and they are:

1081×0.45 = 486.5 K-" for 18 cell (half) rack on the weak axis

1795×0.44 = 789.8 K-" for 36 cell (full) rack.

To account for the kinetic energy of fuel assemblies, the same approach (equating the kinetic energy to strain energy) and assumptions (a. the fuel assemblies and rack structure are impacting at the peak velocity as calculated from the analysis of 1st phenomenon, and b. a standard deviation of ±1σ is used to calculate the forces at base of the rack to account for

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random nature of the positioning of the fuel assembly in the fuel rack which will spread the time of impact for each fuel assembly to the rack) are used, and direct relationships of mass ratio are applied. The overturning moments due to kinetic energy of fuel assemblies are:

pg. 28 of ref. 1

Overturning Moment = 558.8 K-" (18 cell rack)

pg 30 of Ref 1

Overturning Moment = 1017.2 K-" (36 cell rack)

Total overturning Moment for 2nd phenomenon by ABS combination are:

(1) For 18 cell rack:

O.M. = 486.5 + 558.8 = 1045.3 K-"

(2) For 36 cell rack

O.M. = 789.8 + 1017.2 = 1807.0 K-"

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The values of overturning moment used for creating the 2% margin on edge shear are:

1216.9 K-" for 18 cell (pg. 28 of Ref. 1)

2063.2 K-" for 36 cell (pg 40 of ref. 1)

Therefore, the additional factor of safety by trim out the unnecessary conservatism and using ABS combination method for 2nd phenomenon are

Type of Rack	Overturning Moment Used for design (K-")	1st Phenomenon		2nd Phenomenon	
		O.M. (K-")	Factor of safety	O.M. (K-")	Factor of safety
18 Cell Rack	1216.9	1081	1.13	1045.3	1.16
36 Cell Rack	2063.2	1795	1.15	1807.0	1.14