The Light company Houston Lighting & Power P.O. Box 1700 Houston, Texas 77001 (713) 228-9211

December 31, 1982
ST-HL-AE-919
File No: G9.15

Mr. Thomas M. Novak
Assistant Director of Licensing
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Novak:

South Texas Project
Units 1 & 2
Docket Nos. STN 50-498, STN 50-499
Responses to NRC Review Questions

By letter dated February 4, 1982, your office transmitted review questions to Houston Lighting & Power Company (HL&P) from the Geosciences, Accident Evaluation, Generic Issues, Power Systems, Chemical Engineering and Structural Engineering Branches. In order to expedite the staff review for the South Texas Project (STP) on certain of the issues, we are providing the attached advance copies of HL&P's responses to Questions 220.06, 220.08, 220.09, 230.01, 230.04, 231.02 and 231.03 which concern Structural Engineering and Geosciences. These responses will be incorporated into the FSAR in a future amendment.

In addition, supplementary information as requested at the December 7, 1982 Soil-Structure Interaction presentation is provided in the response and Attachment 2 to Question 220.08 and is summarized in Attachment 3 to Question 220.08. Attachments 2 and 3 are provided for information only and will not be incorporated in the FSAR.

B001

8303250084 821231
PDR ADOCK 05000498
A PDR

If you should have any questions concerning this matter, please contact Mr. Michael E. Powell at (713) 877-3281.

Very truly yours,

J. H. Goldberg

J. H. Goldberg
Vice President
Nuclear Engineering and Construction

MEP/syt

Attachment

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Revision Date 12-20-82

ATTACHMENT

SOUTH TEXAS PROJECT
UNITS 1 & 2

RESPONSES TO NRC QUESTIONS
220.06, 220.08, 220.09,
230.01, 230.04, 231.02 and 231.03

220.06 Confirm that the frequency intervals used for floor spectra generation are small enough that their reduction does not result in more than 10 percent change in the computed spectral values.

Response to Question 220.06

Response spectra calculations parallel to the original B&R calculations, incorporating the prescribed frequency intervals per Regulatory Guide 1.122 and other minor modifications, were performed in order to resolve the frequency-interval concern and to evaluate the original seismic dynamic analyses. The results indicate that the only significant difference associated with the frequency interval pertains to the sparseness of the intervals used for the spectral response calculation detected at frequencies below 2.5cps and only for the Reactor Containment Building. For the higher frequency range, the frequency intervals used are adequate and the original response spectra is conservative; refer to Figure 1 through 4. For a comparison of the frequency intervals per R.G. 1.122 with those used in the original calculation refer to Table I. From the tabulation the sparseness of the original frequency intervals is evident.

The FSAR does not define the frequency intervals used for the calculation of floor response spectra. In Section 3.7.1.2 the frequency range/no. of points data tabulated pertains to the calculation of spectra performed to confirm the artificial spectra. The tabulated data does not apply to floor response spectra calculations. In Section 3.7.2.5 only the frequency range for floor response spectra calculations was stated as 0.1 cps to 33 cps, which subsequently has been corrected to 0.5 to 33 cps and will be reflected in a future amendment to the FSAR.

The distinctly higher peaks of the B&R solution compared to the Bechtel solution are attributed to (1) the method used by B&R to combine response spectra along parallel directions due to orthogonal input, and (2) slight variations in the structural model configurations. However, for response spectra comparisons, the fact that there are no frequency shifts and similar high-frequency range and zero-period accelerations are preserved is a more meaningful basis for comparison than on the basis of similitude of peak values.

The sparseness of the frequency intervals of the original calculations diminished the resolution of the spectral calculation and contributed to the under-representation of spectral response in the low frequency range identified in Response 220.08 pertaining to the EHS method for SSI. The spectral response calculated using the R.G. 1.122 frequency intervals exceeds slightly the original spectra and extends the range of resolution into the low frequency range. The resultant spectra however, is consistently enveloped by the EHS spectra addressed in the cited response; refer to Figure 1. Therefore the frequency-interval implications on the spectral response are analogous and bounded by the EHS implications and are similarly dispositioned.

Figure 1

RCB CONTAINMENT STRUCTURE, N-S, AVG. SOIL, OBE, EL. 108 FT.

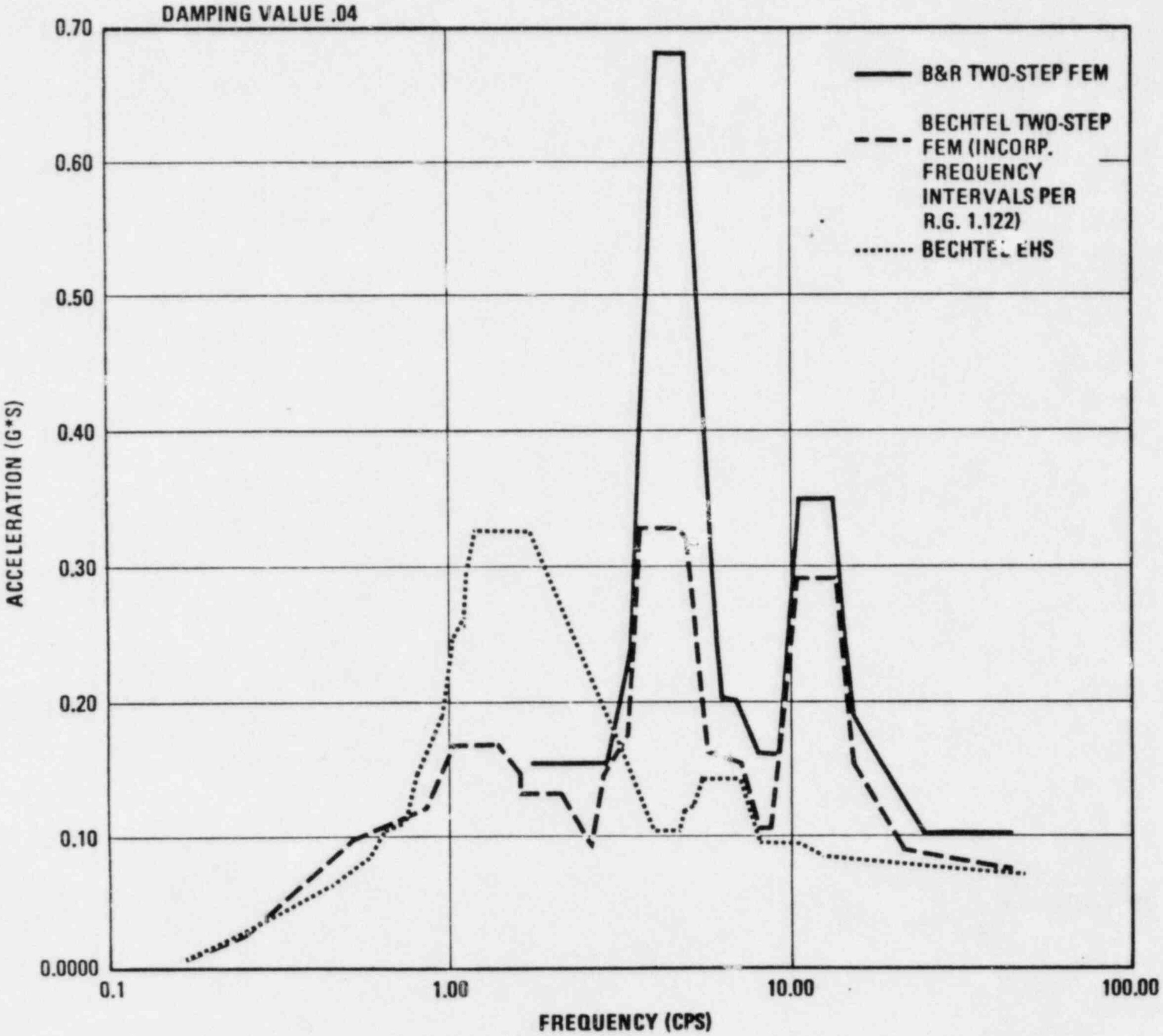


Figure 2

STP – MEAB, E-W DESIGN SPECTRA, OBE, EL. 86 FT.

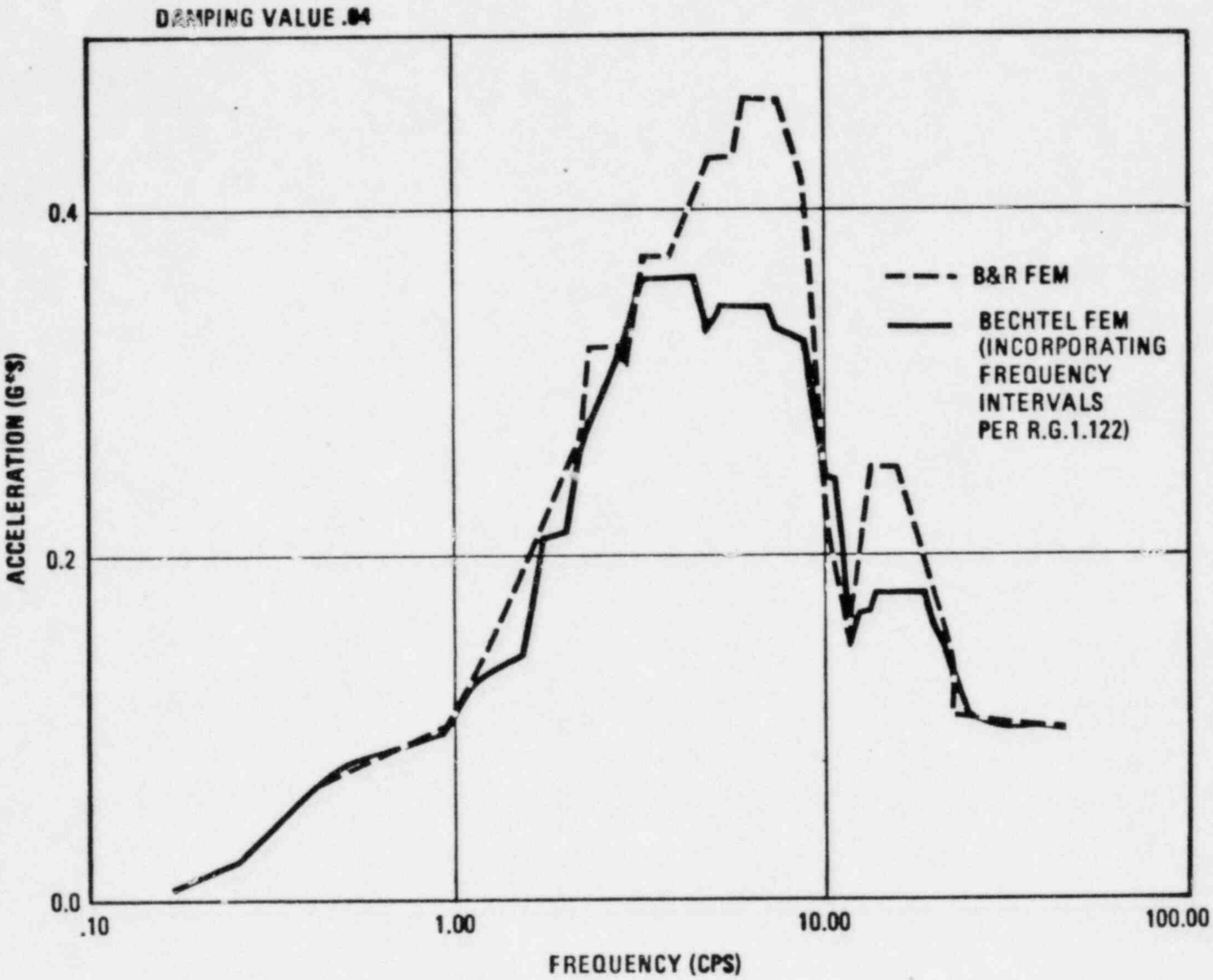


Figure 3

STP – FHB, N-S DESIGN SPECTRA, OBE, EL. 68 FT.

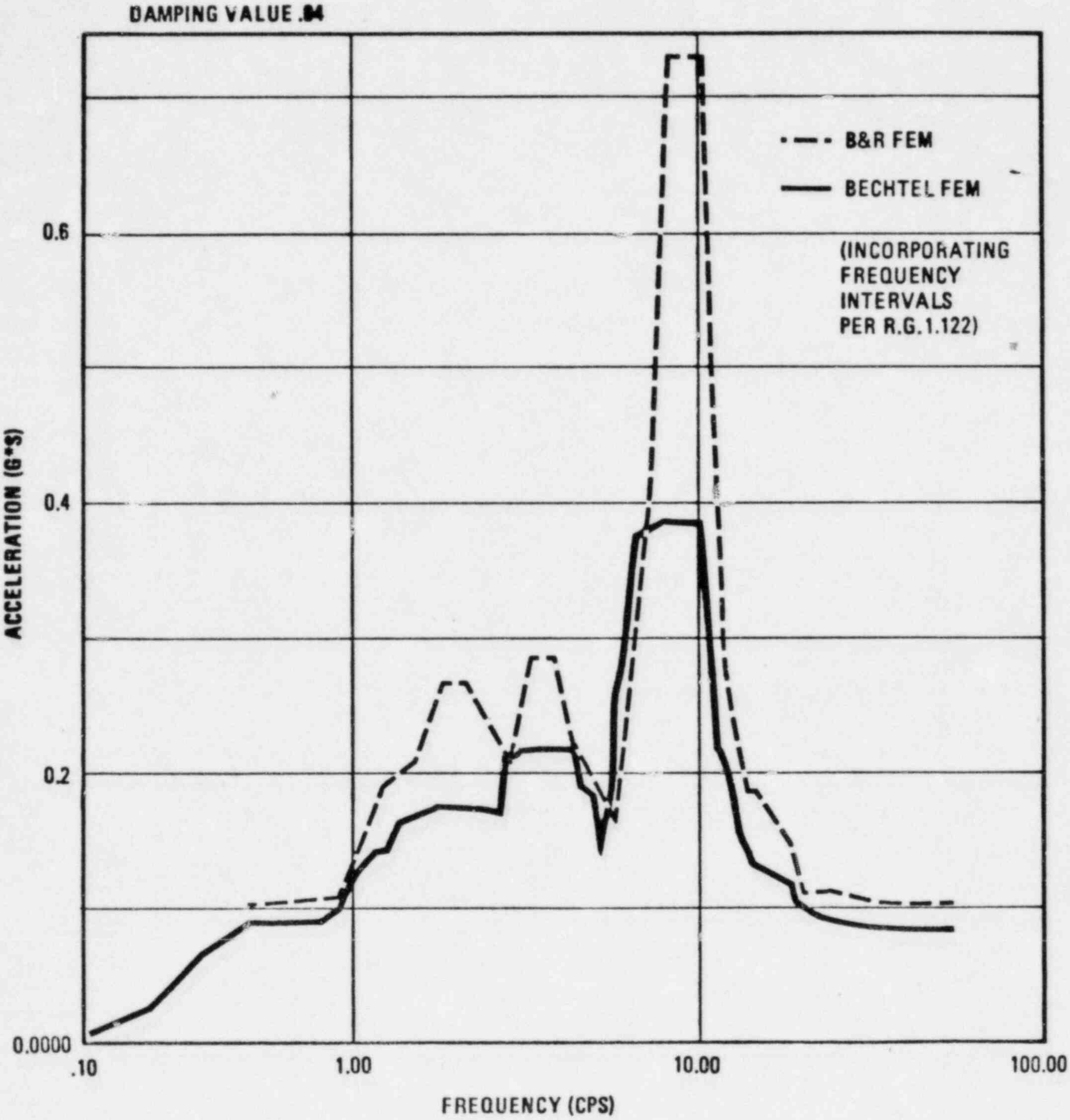


Figure 4

STP – DGB, N-S DESIGN SPECTRA, OBE, EL. 82 FT.

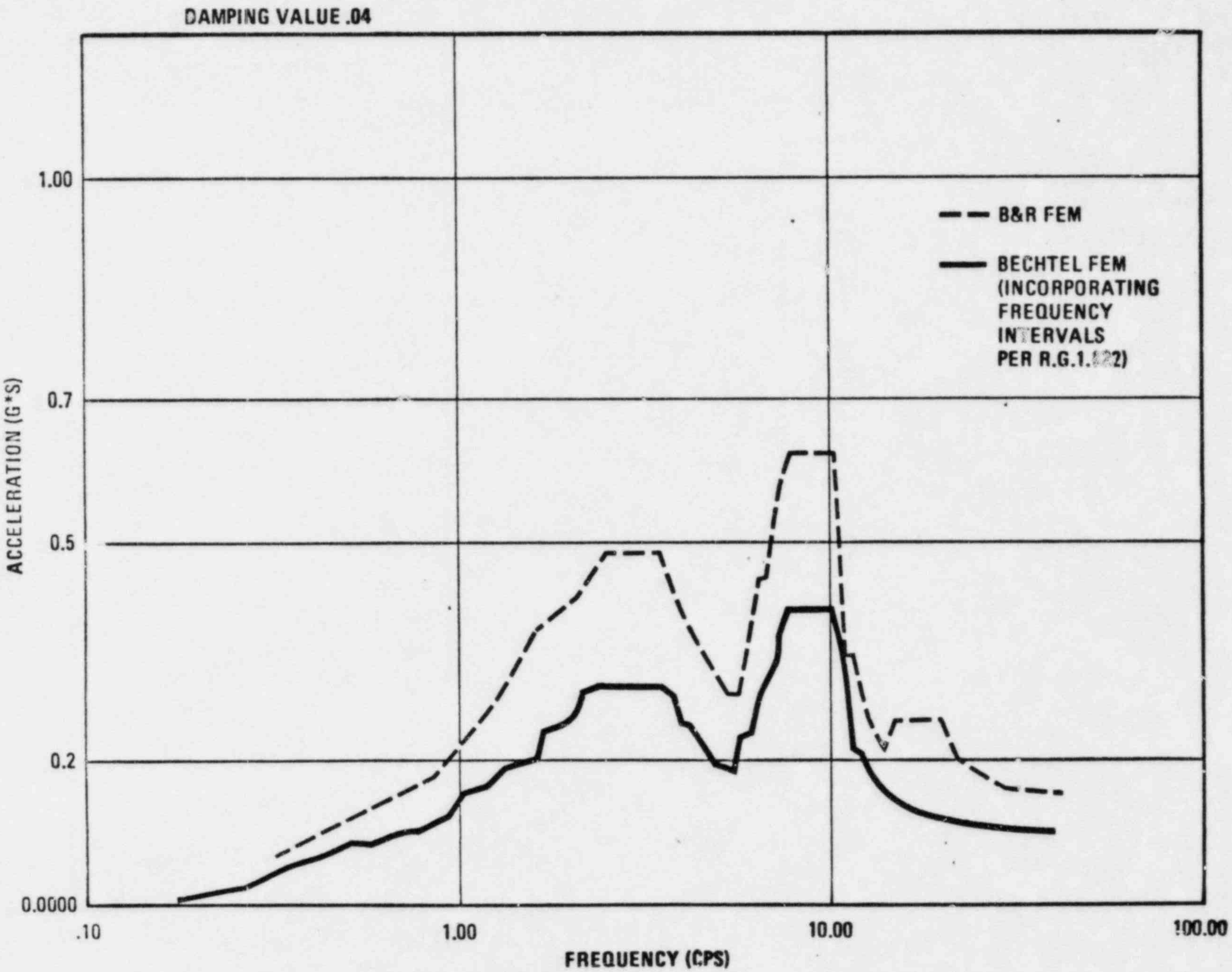


TABLE I
FREQUENCY INTERVALS USED TO CALCULATE
FLOOR RESPONSE SPECTRA

NRC RG 1.122 (used by Bechtel)	B&R	NRC RG 1.122 (used by Bechtel)	B&R	NRC RG 1.122 (used by Bechtel)	B&R
.2		3.8		16.0	
.3		4.0	4.0	17.0	17.0
.4		4.2		18.0	
.5	.5	4.4			19.0
.6			4.5	20.0	
.7		4.6			21.0
.8		4.8		22.0	
.9		5.0	5.0		23.0
1.0	1.0	5.25		25.0	25.0
1.1		5.5	5.5		27.0
1.2		5.75		28.0	
1.3		6.0	6.0		29.0
1.4		6.25		31.0	31.0
1.5	1.5	6.5	6.5		33.0
1.6		6.75		34.0	
1.7		7.0	7.0		35.0
1.8		7.25		TOTAL 75	TOTAL 36
1.9		7.5	7.5		
2.0	2.0	7.75			
2.1		8.0	8.0		
2.2		8.5	8.5		
2.3		9.0	9.0		
2.4		9.5	9.5		
2.5	2.5	10.0	10.0		
2.6		10.5	10.5		
2.7		11.0	11.0		
2.8		11.5	11.5		
2.9		12.0	12.0		
3.0	3.0	12.5			
3.15		13.0	13.0		
3.30		13.5			
3.45		14.0			
	3.5	14.5			
3.60		15.0	15.0		

220.08 In the meeting of August 7, 1981 on SSI of South Texas Project, after having explained the technical basis for the SEB SSI related position and discussed with the applicant on South Texas SSI issues, the SEB staff suggested that among various options available to the applicant for the resolution of the SSI issue, the use of the following approach to meet the intent of the SEB SSI position would be acceptable:

Use Elastic Half Space Method of Analysis without reducing the input motion due to embedment of structure in soil. Apply the R.G. 1.60 motion properly anchored at the OBE/SSE "g" values in the free field at the foundation level, and compare the resulting response spectra with those of Finite Element Method. The applicant should demonstrate that at least the intent of the following position is fully met:

> Methods for implementing the soil structure interaction analysis should include both the half space and finite element approaches. Category I structures, systems and components should be designed to responses obtained by any one of the following methods:
>
> (a) Envelop the results of both EHS and FEM;
>
> (b) Results of one method with conservative design considerations of effects from use of the other method; and
>
> (c) Combination of (a) and (b) with provisions of adequate conservatism in design.
>
> The above mentioned comparison of floor response spectra needs to be done only for key structures at key levels, e.g., 6 key levels of reactor containment building, 4 key levels of auxiliary building, etc.

The SEB staff mentioned that if the actual design floor response spectra are compared with those obtained by enveloping the spectra resulting from the FEM and EHS methods of analysis, there may not be any appreciable change in the design of structural elements, because HL&P and Brown & Root have mentioned that enough conservatism is already built in the design by using Finite Element Method. However, there may be cases where the components and equipment may not meet the seismic criteria based upon the enveloped response spectra. HL&P may need to look into these cases and study the specific impact of NRC's current position on the cases in order to qualify them for the seismic criteria.

If the floor response spectra obtained by enveloping are higher than those used for actual design, HL&P still has a choice to justify that the additional stresses resulting from the enveloped spectra are acceptable and overall design adequacy is maintained by considering the actual as-built strength of the structure. For concrete structures, the as-built yield strength will be the average of compressive strength established by tests. For both reinforcing and structural steel, the as-built yield strength will be the average of the actual tested yield strength, but in no case shall it be greater than 70 percent of the ultimate strength. The scope and the extent of test program and resulting test data shall be submitted for review and approval by the staff.

Other approaches for demonstrating the seismic design adequacy of Category I structures and systems which meet the intent of this position are also acceptable if reviewed and accepted by the staff. For example, if enough seismic data for the South Texas site and other sites having similar regional and local seismicity characteristics are available, then the site specific spectra approach may be a viable option to be considered.

Response to NRC Question 220.08

A study of the STP design-basis seismic response spectra was performed to compare the soil-structure-interaction (SSI) analyses by the two-step finite element method (FEM) with the elastic-half-space (EHS) method. The results of this study were summarized in Reference (1).

Specific responses addressing the concerns and suggestions stated in NRC Question 220.08 are presented herein. This response also updates the response to previous NRC Question 130.12.

> The free-field input motion used by Bechtel in the EHS SSI analyses was applied at the base of all structures without resorting to any reduction due to the embedment of structures in soil, which is consistent with the NRC's position.
>
> The FEM spectra envelopes the EHS spectra for the frequency range that is relevant for the design and/or qualification of structural elements, and essentially all equipment and components. The most significant difference is restricted to the low frequency range (f $<$ 4 cps, generally), corresponding to soil-structure interaction frequencies where the EHS spectral response for horizontal directions in some buildings is distinctly higher than the FEM spectra. This difference prevails and is significant only in the RCB. In the FHB and the DGB the difference is evident to an insignificant extent, and in the MEAB it is essentially non-existent (see figures 1, 2, 3 and 4). Therefore the difference is well bounded and suitable for systematic asessment by natural-frequency segregation of the limited number of items susceptible to the higher seismic response developed exclusively in the low frequency range.
>
> A program for the systematic segregation and evaluation of affected equipment and components is defined in Attachment (1). The program will be implemented as a specific task to verify the adequacy of all the prior and future seismic designs and/or qualifications based on the original STP floor response spectra augmented by the EHS solution in the low frequency range. The results of the initial implementation of the program on a selected sampling of susceptible items is included in Table 1. The results confirm the anticipated trend that very few items have natural frequencies within the low range of concern, and that the limited number of items in that range have sufficient design margin to accomodate the moderately higher seismic load predicated by the EHS-augmented spectra.
>
> The comparison of FEM and EHS response spectra has been performed for the RCB, MEAB, FHB and DGB for the OBE event. All levels and locations within buildings corresponding to the original spectra will be compared for OBE and SSE events in order to permit complete implementation of the program described above.

The EHS spectra does not result in higher zero-period accelerations nor in higher peak amplifications than those obtained from the FEM spectra. Therefore the seismic designs of all the superstructures and most of the structural subsystems, which invariably have frequencies higher than 4 cps or are already designed for near peak seismic response, are not affected by the EHS-augmented spectra. Accordingly there is no need to rely on a justification of structures by means of existing design margins nor by means of the actual as-built material strengths as suggested in Question 220.08.

Supplementary information pursuant to the presentation of Reference (1) material to the NRC is also submitted herein as follows:

The original FEM response spectra calculated by B&R included parametric studies involving the average, upper and lower bound soil properties. The response spectra issued as the seismic design basis represent the envelope of the three soil-property solutions and include a ± 10% frequency-based broadening to further account for uncertainties in structural materials and modelling techniques. It is noted that the enveloping of soil properties was specifically performed only for the OBE along the finite element model cross-sections 1 and 2 as defined in Figure 10. For the OBE along cross-section 3 and for the SSE analysis the soil property parametric study was not performed. Instead, a higher broadening of ± 15% was applied to the spectra calculated on the basis of average soil properties.

The EHS response spectra calculated by B&R and by Bechtel for comparative purposes are based on average soil properties and include a ± 15% frequency-based broadening in lieu of a soil property parametric study. It was considered that the full scope parametric study, while warranted for the design-basis spectra, was not necessary for the comparative-study spectra and accordingly it was not incorporated in the EHS solutions.

As stated previously, in the EHS solution performed by Bechtel the free-field surface ground motion was applied directly as input without any reduction to account for the embedment depth of the RCB and FHB structures. This direct application is conservative and avoids the controversial reduction of surface input motion. Accordingly, the Bechtel EHS response spectra solutions are consistently higher than the B&R solutions which are based on reduced input motions; refer to Figures 5, 6, 7, 8 and 9 for typical comparisons. Aside from input motion, the Bechtel and B&R EHS solutions are nearly identical in method. Both solutions are based on the same structural model which has been reviewed by Bechtel, and utilize the same soil impedances (springs and dampers) developed by Woodward-Clyde Consultants (WCC) as described in Reference (2). The equivalent springs and dampers used are a frequency-independent mechanical analog of the foundation impedances based on elastic-half-space theory.

In conclusion, the original seismic response spectra calculated by two-step FEM SSI are re-affirmed to be adequate seismic design bases for the STP, subject to verification of the related seismic design and/or qualification of the limited number of items affected by the discrepant spectral response confined to the low frequency range.

References: (1) Soil-Structure Interaction Outline-A presentation by HL&P and Bechtel delivered to the NRC on December 7, 1982.

(2) "Computations of Spring and Damping Coefficients for Category I Structures, South Texas Project, Units 1 and 2", by Woodward-Clyde Consultants, April 1980.

TABLE 1

Equipment or System	Fundamental Frequencies (cps)/ Method of Seismic Qualifi.	Remarks	(see sheet 3 for code number definition)
Diesel Generator and Diesel Generator Control Panels	17.0; 17.5; 22.0/Test	1	
Hydrogen Monitoring System; Remote Control Panel	29.2; 34.4/Test & Analysis	2	
Electrical Panels MCC	8.75; 10/Test	2	
Containment Electrical Penetration	11.0; 16/Test & Analysis	1	
Load Center Enclosed Switchgear Assembly	10.0; 11.3; 13.4; 15.5; 15.7/Test & Analysis	2	
1000 & 2000 KVA Transformers Load Center	2.0; 2.5; 3.5/Test	2	
Low Head Safety Injection Pump	Higher than 33/ Test & Analysis	1	
2" & 3" dia. RTD Lines Loop 2 & 3	8.903; 12.903; 13.510; 14.167; 15.464/Analysis	1	
2" dia. Seal Water Injection Loop 2	12.120; 12.457; 15.266 15.477; 15.741/Analysis	1	
12" & 14" dia. RHR/SI Suction Line	11.886; 14.549; 18.931 19.597; 21.390/Analysis	1	
2" & 4" dia. Normal Letdown	15.200; 16.206; 17.155; 17.37; 17.599/Analysis	1	
16" dia. RCS Pressurizer Surge Line	9.514; 13.876;16.464 21.063; 26.393/Analysis	1	
8"; 10" & 12" dia. RHR/SI Cold Leg Injection Lines	7.153; 11.857; 12.323 12.902; 13.599/Analysis	1	
6" & 8" dia. SI Cold Leg Injection Line and CS Pump Discharge Line	4.203; 5.064; 5.431 6.562; 8.844/Analysis	1	

TABLE 1 (cont'd)

Equipment or System	Fundamental Frequencies (cps)/ Method of Seismic Qualifi.	Remarks
HVAC Ducts a)MEAB b)FHB	21.0/Analysis	1
Duct Supports a)MEAB b)FHB, DGB & RCB	4.89; 9.28/Analysis	3
Cable Tray Support	4.8; 5.3; 3.3; 4.1/Analysis	3
Cable Trays	15 (Vert); 13.2 (Trans)/Test	3
Existing Cable Tray System in Switchgear Rooms	5.4/Analysis	2
RCB Polar Crane Runway Girder and Bracket	1.64; 2.21; 5.61; 6.84/Analysis	4
RCB Orbital Service Bridge	1.55 (Radial); 2.8 (Tang.); 6.0 (Tang.)/Analysis	5
FHB 150 Ton Crane	0.28; 2.95; 6.48; 9.81; for out-of-plane motion of supporting wall: about 6 cps/Analysis	4

Remarks applicable to Table 1

1) Frequency above 4 cps, out of range - No effect

2) FEM spectra envelopes the EHS spectra for MEAB, where equipment is located - No effect

3) Generic design is based on seismic acceleration levels in the range of peak amplification, which is not increased by EHS spectra - No effect.

4) Enough margin in existing design - No effect

5) Enough margin was found in the existing support embedment - No effect- Some structural members in the bridge truss appear to be marginal and hence may need to be reinforced. A confirmatory analysis appears to be warranted.

Figure 1

STP — RCB INTERNAL STRUCTURE, E-W SPECTRA, OBE, EL. 68 FT.

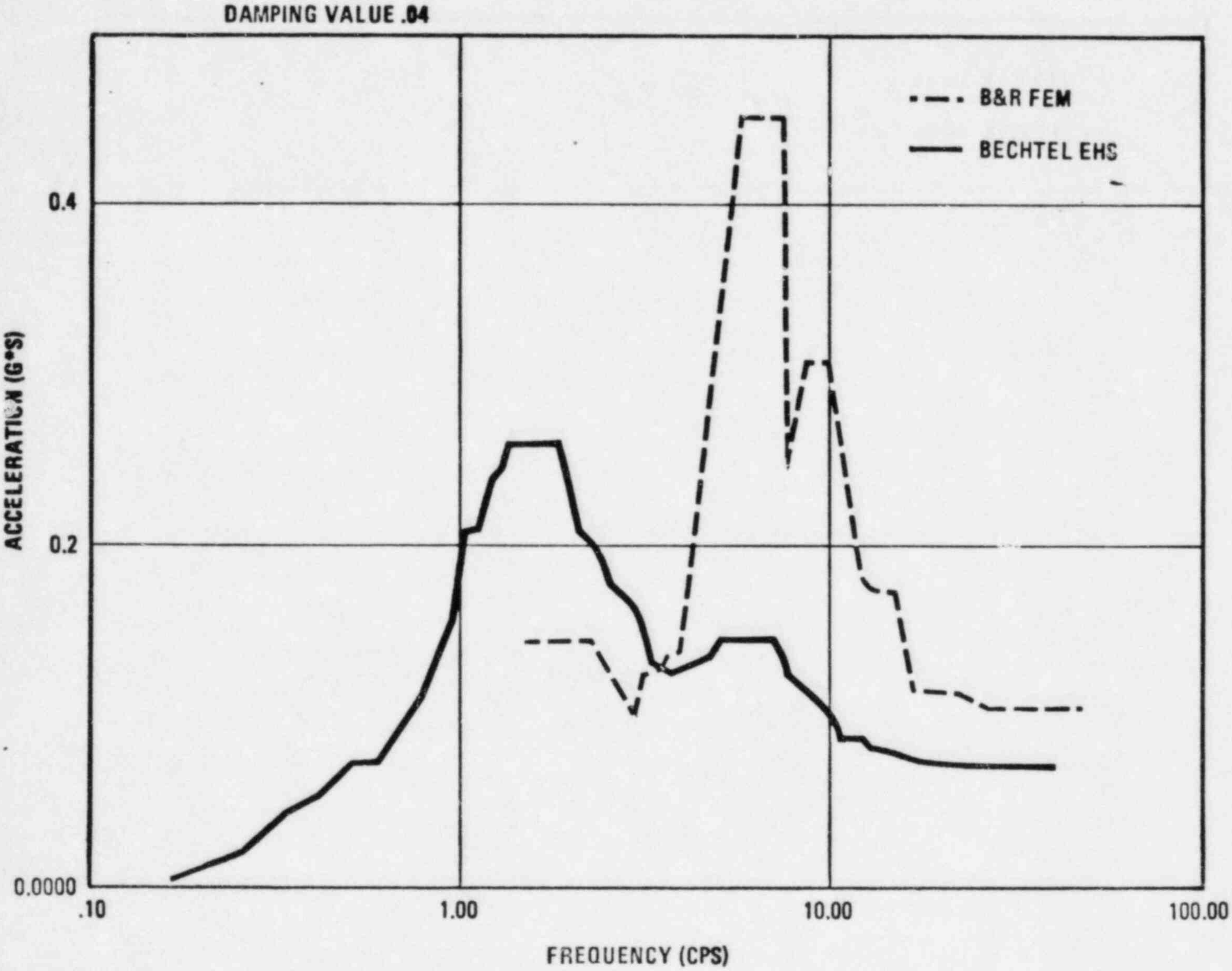


Figure 2

STP – FHB, N-S SPECTRA, OBE, EL. 30 FT.

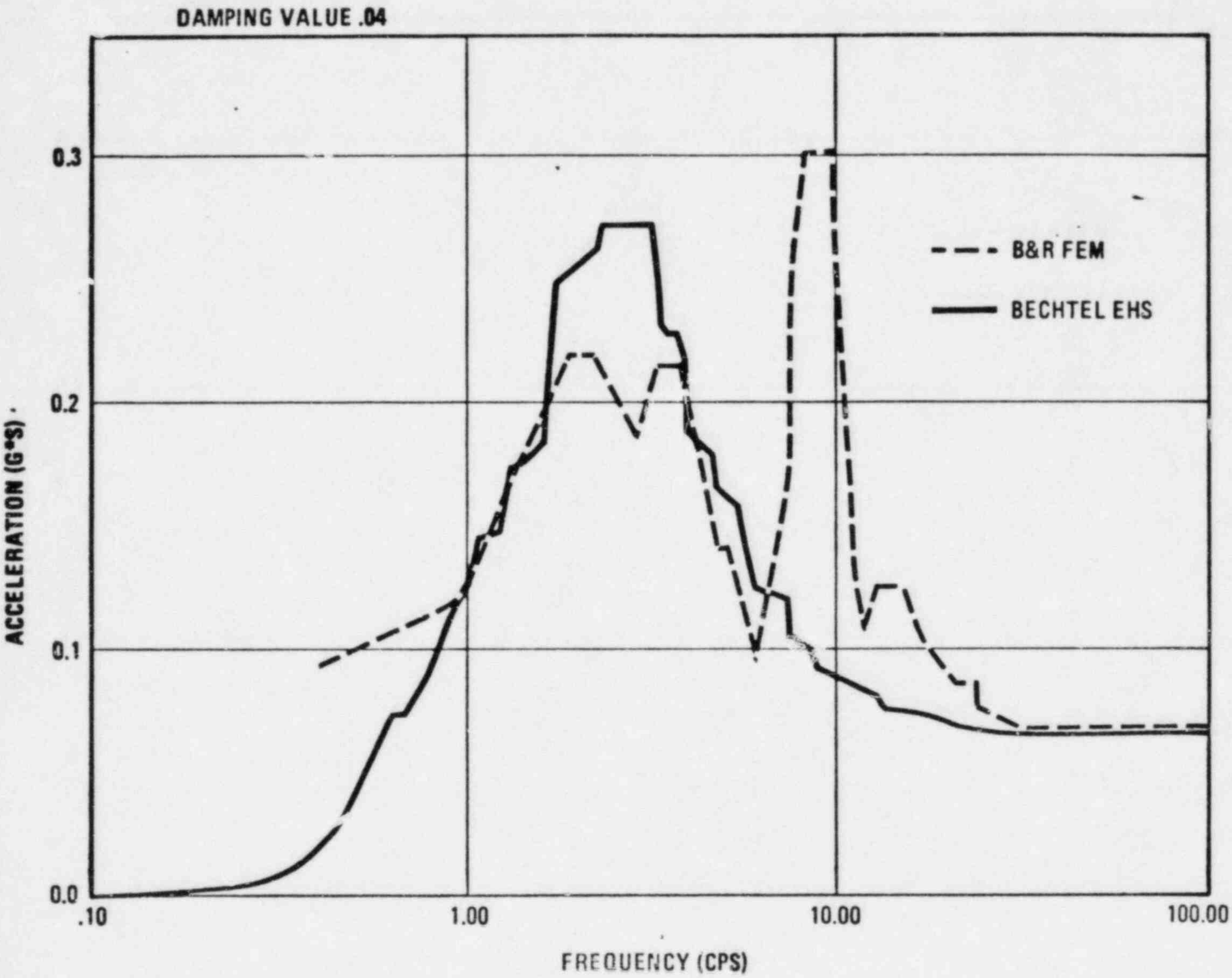


Figure 3

STP – DIESEL GENERATOR BUILDING, N-S SPECTRA, OBE, EL. 100 FT.

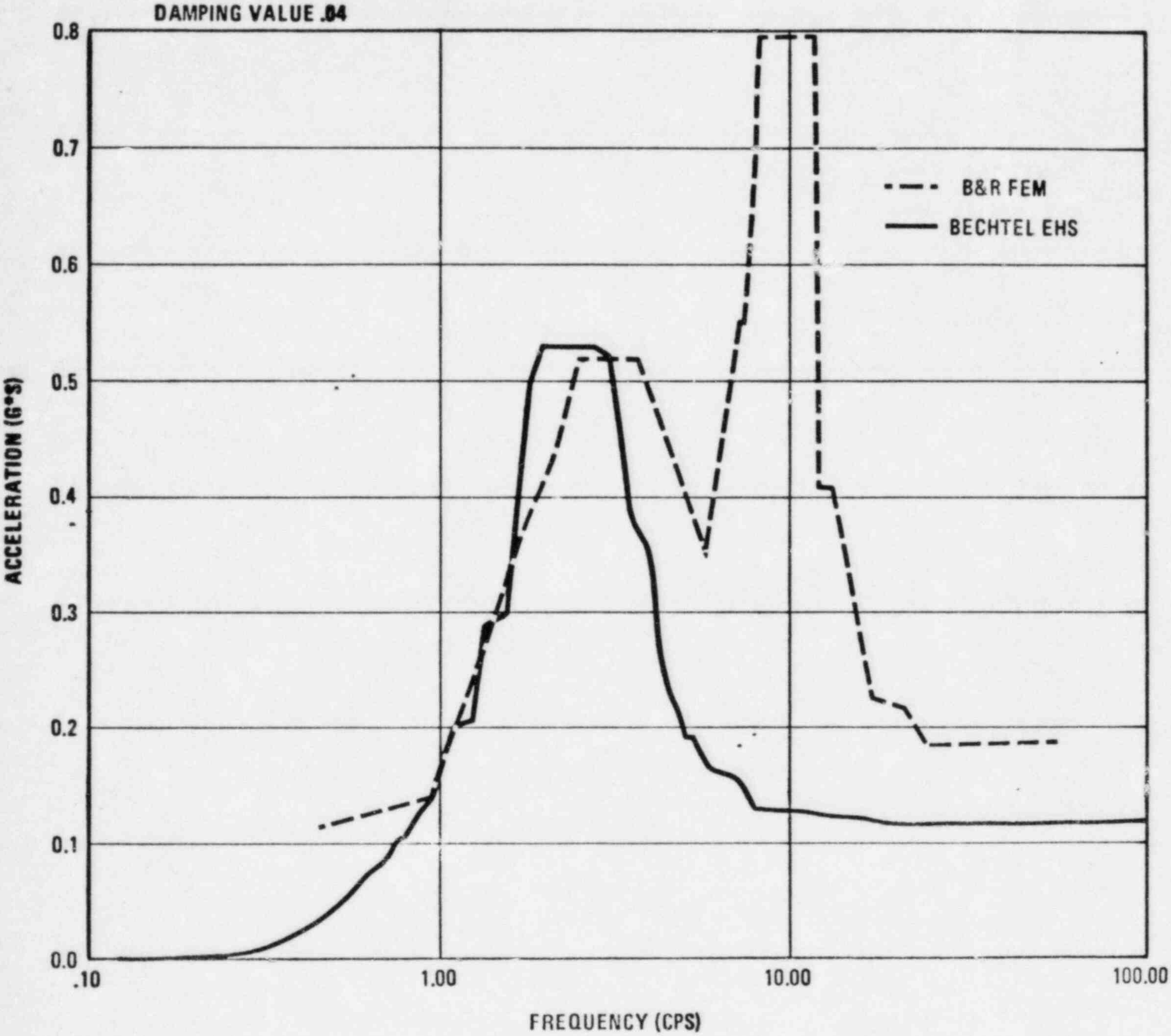


Figure 4

STP – MEAB, E-W SPECTRA, OBE, EL. 85 FT.

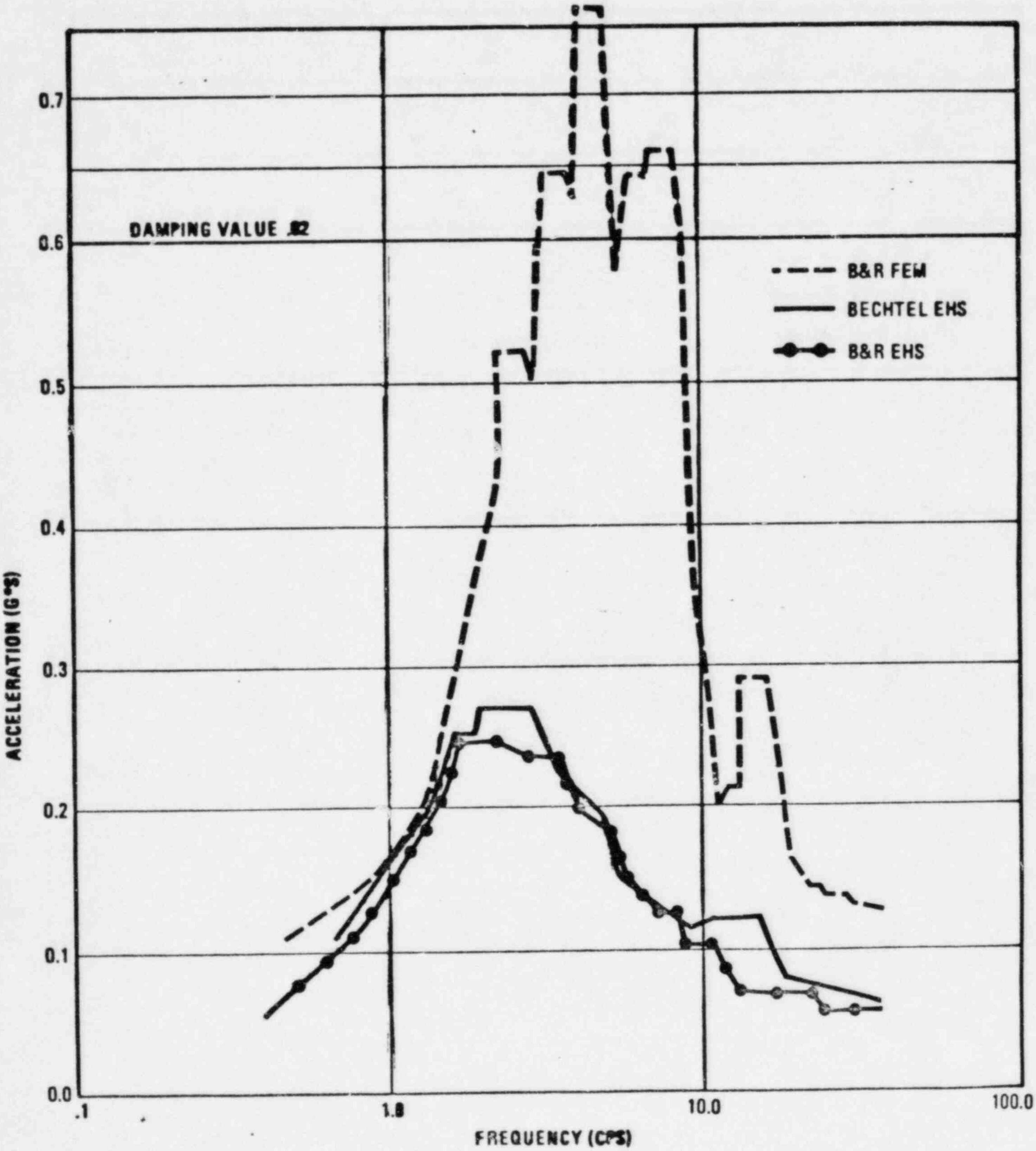


Figure 5

STP – RCB CONTAINMENT STRUCTURE, N-S SPECTRA, OBE, EL. 68 FT.

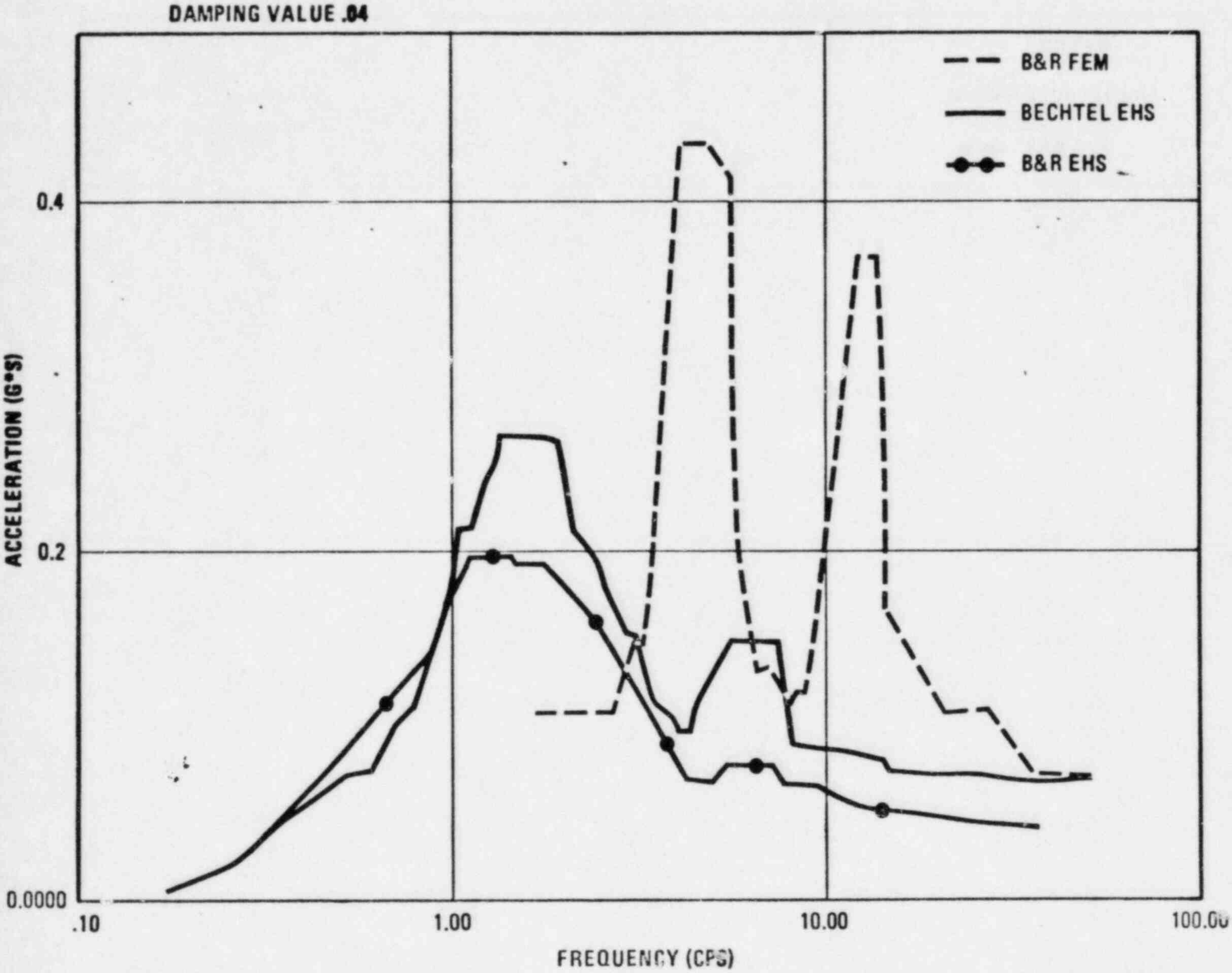


Figure 6

STP – RCB INTERNAL STRUCTURE, N-S SPECTRA, OBE, EL. 68 FT.

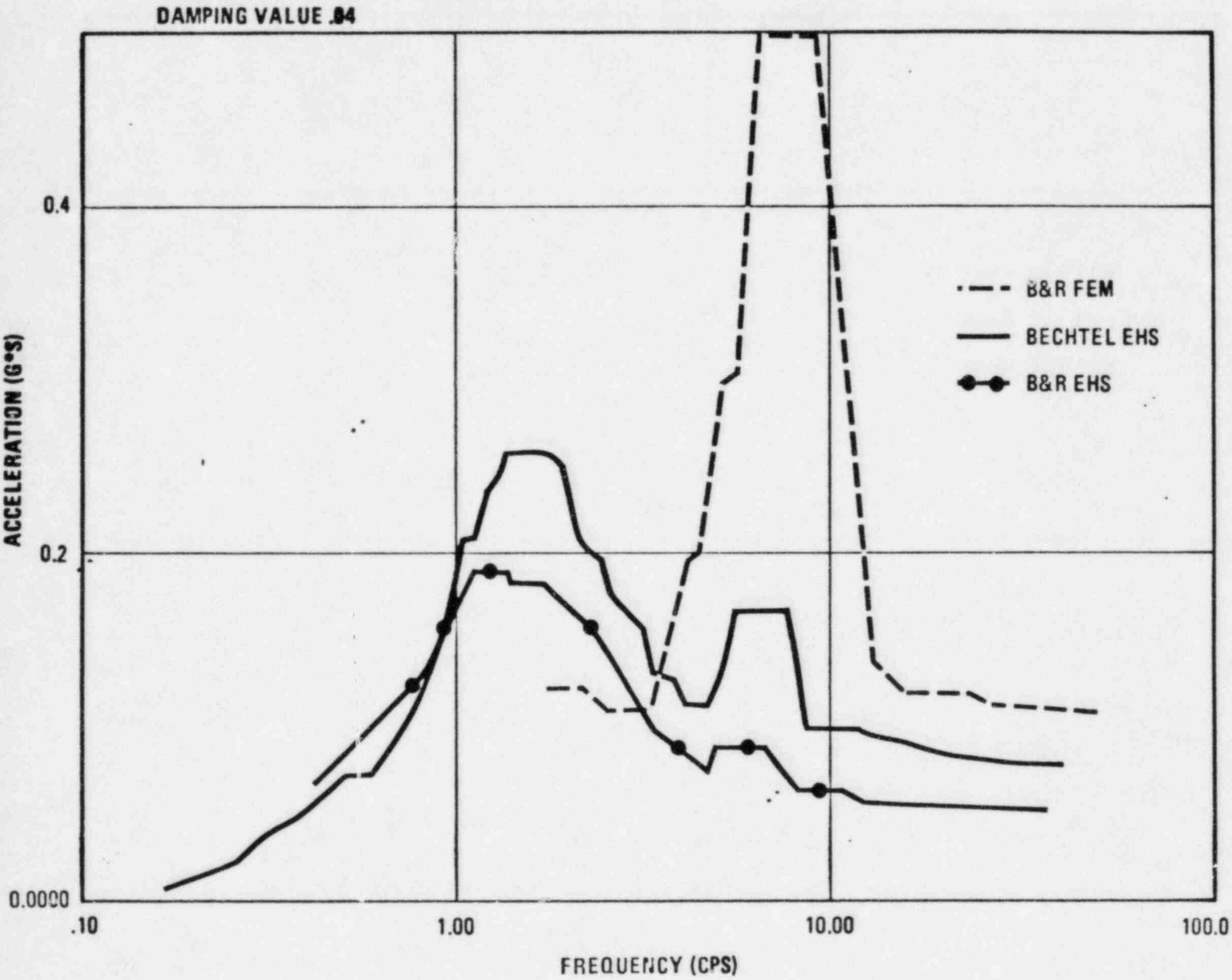


Figure 7

STP – DGB, N-S SPECTRA, OBE, EL. 55 FT.

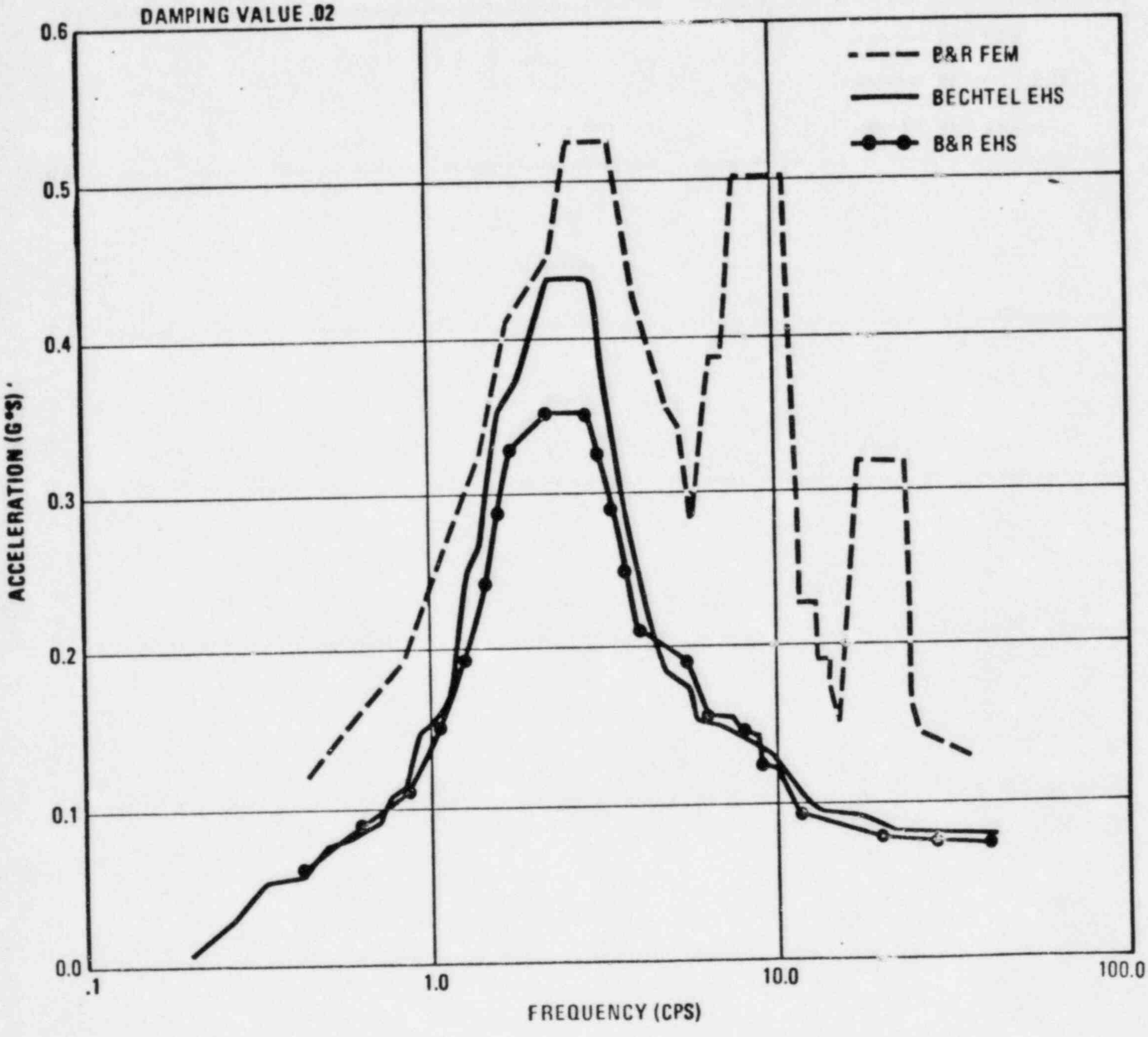


Figure 8

STP – FUEL HANDLING BLDG., N-S SPECTRA, OBE, EL. 30 FT.

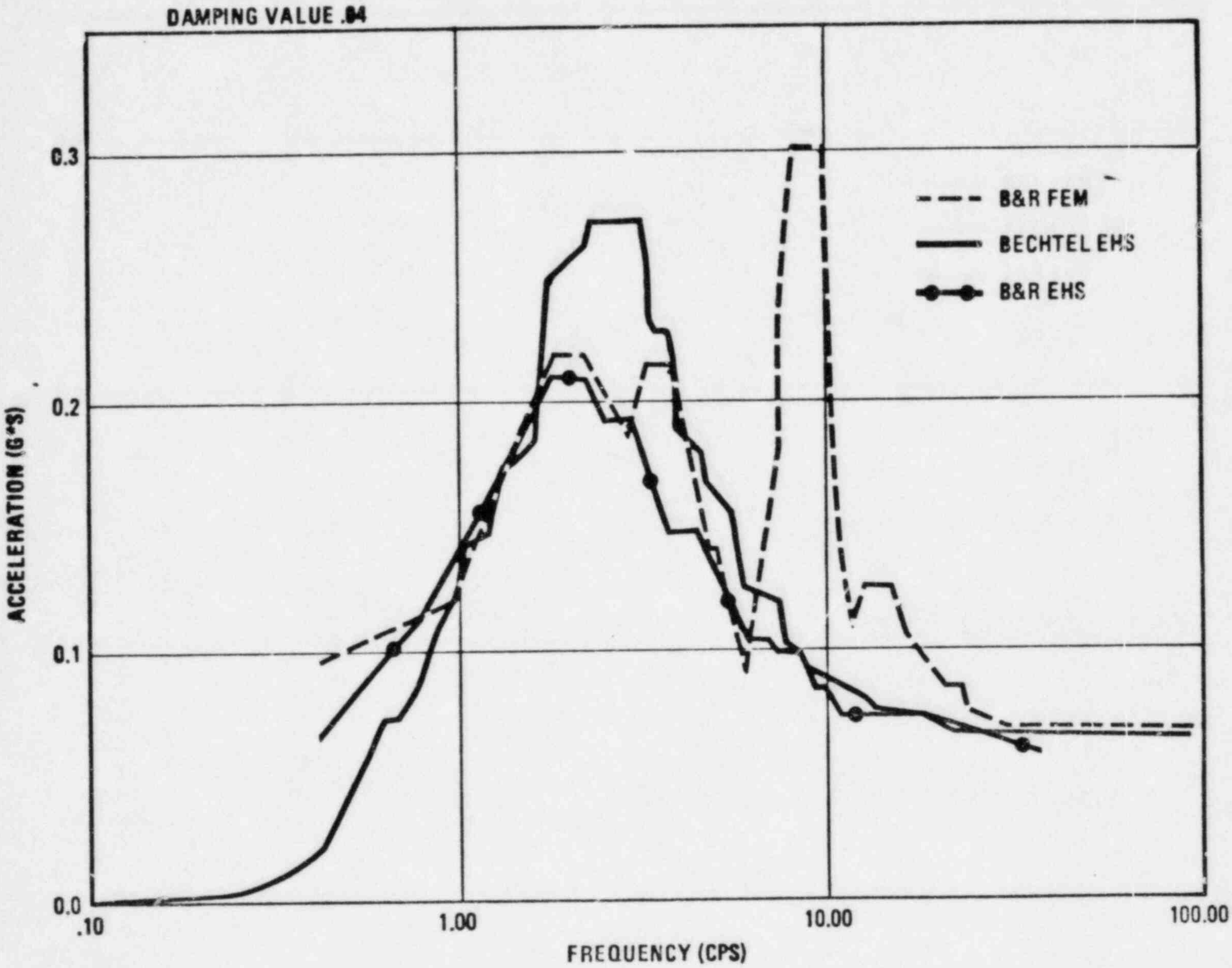
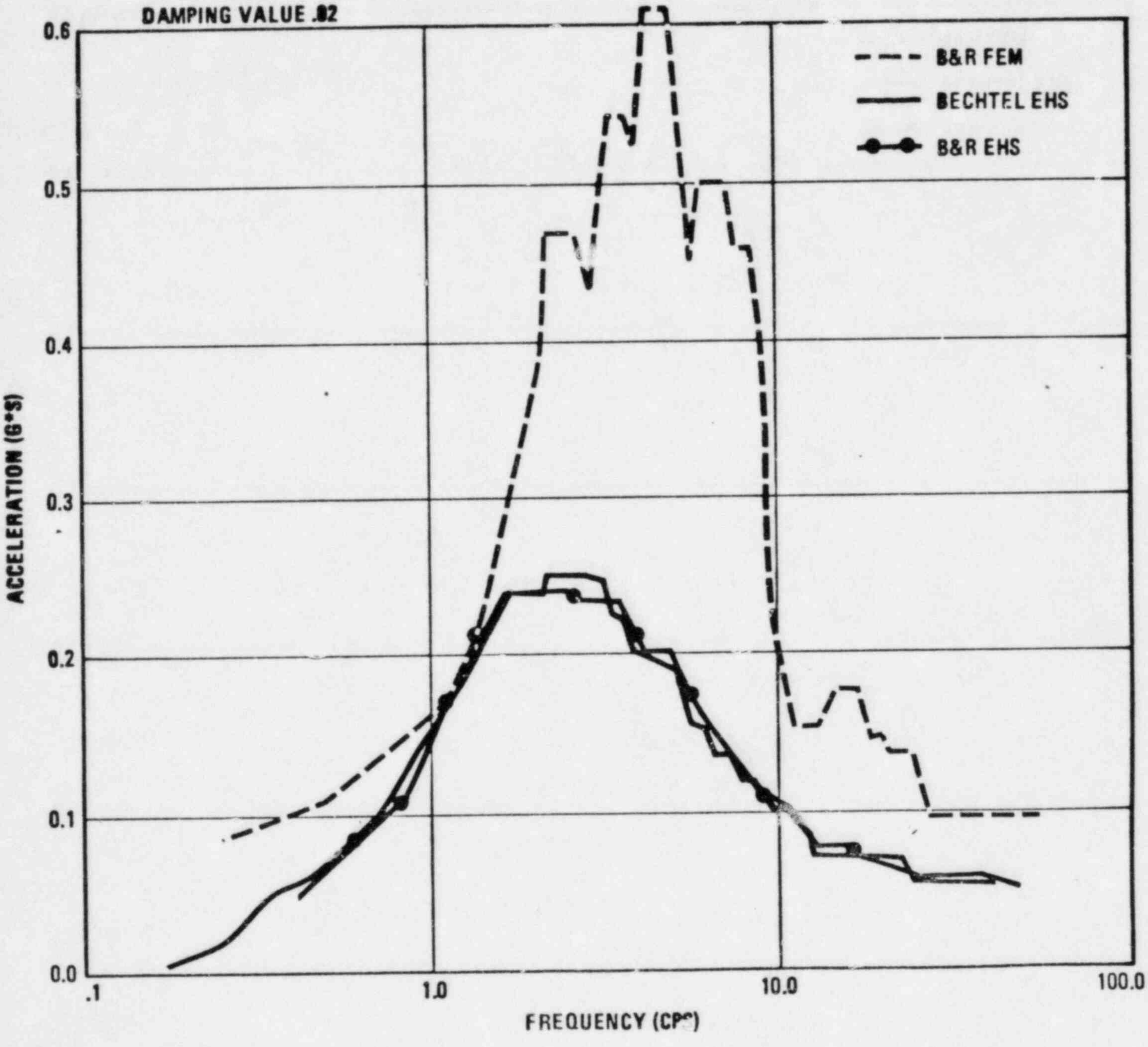
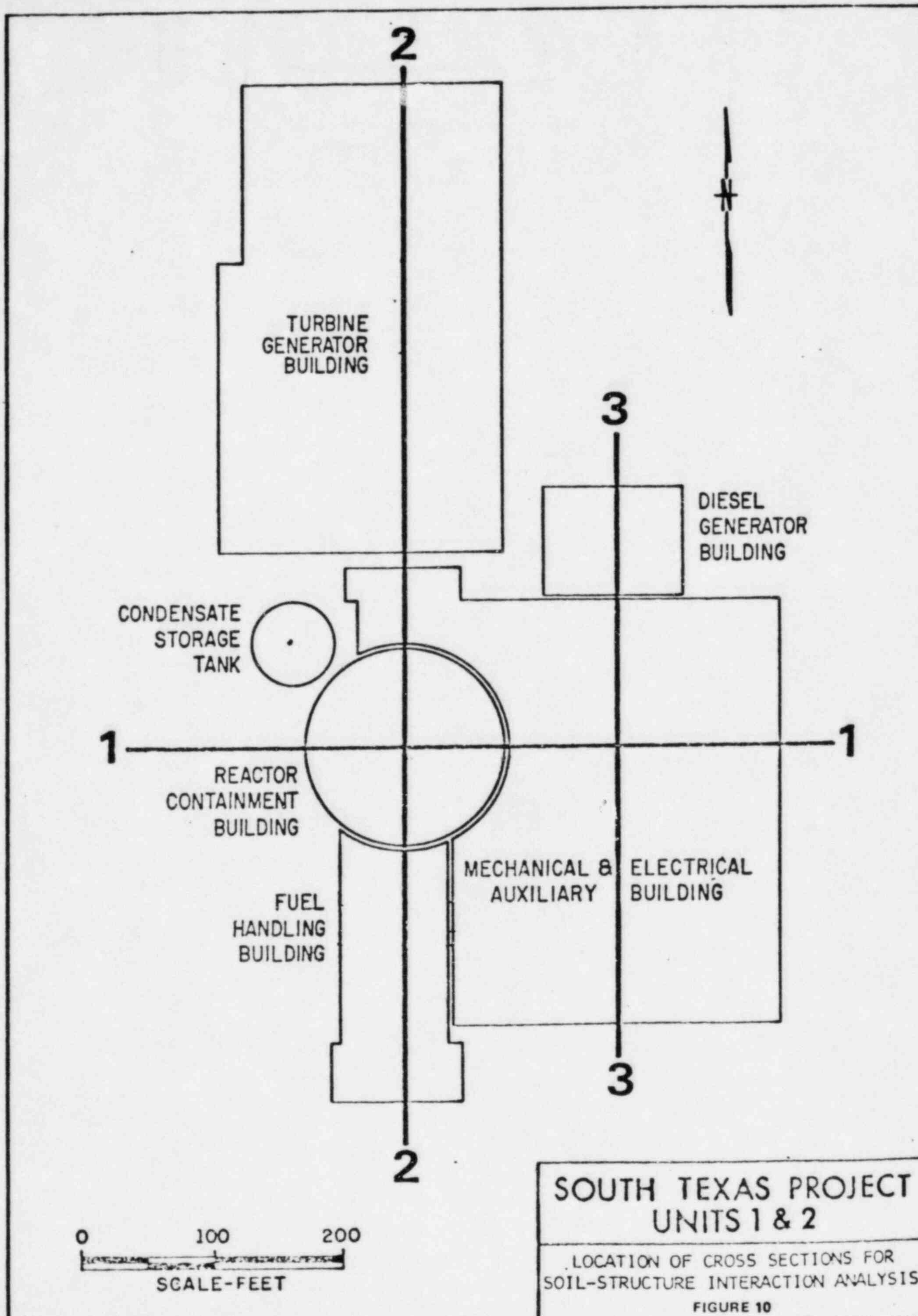


Figure 9

STP – MECHANICAL ELECTR. AUX. BLDG., E-W SPECTRA, OBE, EL. 51 FT.





SOUTH TEXAS PROJECT
UNITS 1 & 2

LOCATION OF CROSS SECTIONS FOR SOIL-STRUCTURE INTERACTION ANALYSIS

FIGURE 10

Procedure for the Verification of Seismic Qualification and/or Design of Equipment and Components with Respect to the Floor Response Spectra Augmented by Elastic-half-space (EHS) Soil-structure Interaction (SSI) Analysis

References: (A) Floor Seismic Acceleration Response Spectra
Design Basis for STP
Bechtel Drawings No's. 4N16-9-S-39000 thru -39146, & -39150

(B) Floor Seismic Acceleration Response Spectra
augmented by EHS SSI Analysis for STP
C/S Calculation No.CC-9150, Sketches No.Sk C-5 thru Sk C-160

1.0 The seismic qualification and/or design (SQ/D) of all Seismic Category I equipment and components shall be reviewed and verified, if required, in accordance with the steps defined in this procedure.

2.0 Establish the latest and governing SQ/D document for the equipment/component (E/C). Verify that the SQ/D document is based on the appropriate response spectra selected from Reference (A) in accordance with the installed location(s) of the E/C within the respective building(s).

Any SQ/D which is found to be based on response spectra other than that of Reference (A) shall be referred to Civil/Structural Discipline (C/S) for specific consideration and disposition.

3.0 If the installed location of the E/C is in the Mechanical Electrical Auxiliary Building (MEAB), the E/C is not affected by the EHS-augmented spectra; proceed to section 8.0. For E/C in other buildings proceed to section 4.0.

4.0 Scrutinize the natural frequencies reported for the E/C. Establish the nature and direction of the modal response corresponding to the low frequency range (less than 10 cps) if such information is available from the SQ/D. Ascertain that the low frequencies as reported are representative and valid for the E/C system, and are not related to irrelevant subsystems within the E/C.

If the lowest natural frequency is 10 cps or higher, the E/C is not affected by the EHS-augmented spectra; proceed to section 8.0. E/C's with natural frequencies lower than 10 cps are potentially affected; proceed to section 5.0.

5.0 Select the response spectra from Reference (B) that corresponds to the installed location of the E/C. Start a data sheet (Form A) for the E/C, fill in data for columns (A) thru (C). If the SQ/D of the E/C is by analysis proceed to section 6.0, if by test proceed to section 7.0.

6.0 Establish frequency bands of $0.9f_n$ to $1.1f_n$ for each natural frequency lower than 10 cps. Read the spectral acceleration corresponding to the established frequency band(s) from the selected Reference (B) spectra. If at corresponding frequencies, any spectral acceleration derived from Reference (B) spectra is higher than the acceleration by Reference (A) spectra proceed to section 6.1, if otherwise, the E/C is not affected by EHS-augmented spectra, and proceed to section 8.0.

6.1 By review of the analysis establish the maximum lateral acceleration value for which the equipment was qualified and/or designed, denote the value as S_{amax} and enter in column (D) of Form A.

Establish the augmented spectral acceleration level from the Reference (B) spectra by performing the square root of the sum of the squares (SRSS) of the highest spectral accelerations corresponding to each frequency band established in section 6.0, denote S_{aESH}.

If $S_{aEHS} < S_{amax}$ the E/C is considered adequate insofar as the effect of EHS-augmented spectra is concerned, proceed to section 8.0. If $S_{aEHS} > S_{amax}$, evaluate the analysis and design to establish whether the availabe seismic design margin is adequate to accommodate the higher seismic load indicated by S_{aEHS}. If the existing SQ/D analysis for the E/C does not permit the foregoing scrutiny, or if the results indicate inadequate margin or are inconclusive, refer the case to C/S for specific evaluation and disposition.

7.0 Establish the method of test used. If the test response spectra (TRS) method was used proceed to section 7.1. If other method, such as harmonic input (sine-beat) was used, proceed to section 7.2.

7.1 Establish the TRS used. Compare the TRS to the corresponding spectra from Reference (B). If the TRS envelopes the Reference (B) spectra the E/C is considered adequate, proceed to section 8.0. If the Reference (B) spectra exceeds the TRS, proceed to calculate the augmented spectral acceleration level, S_{aEHS}, as defined in section 6.1. From the TRS and the report establish the qualification acceleration level for the E/C, denote it as S_{aT}. Compare the S_{aEHS} to S_{aT}, if $S_{aEHS} <$ S_{aT} the E/C is considered adequate, proceed to Section 8.0. If $S_{aEHS} >$ S_{aT} refer the case to C/S for specific consideration and disposition.

7.2 Establish the qualification level for the E/C based on the harmonic input of the test, denote it as S_{aT} and compare to S_{aEHS} as described in Section 7.1.

8.0 All of the Seismic Category I E/C shall be documented with data sheet, Form A, completed as follows:

Column (E), disposition, shall be completed in all cases and the following code for predefined dispositions may be used:

CODE	Definition of Disposition
(1)	The installed location of E/C is in the MEAB, which is not affected by EHS-augmented spectra.
(2)	The E/C natural frequencies are over 10 cps, above which there is absolutely no effect due to EHS-augmented spectra.
(3)	The spectral response specifically determined from the EHS-augmented spectra and the E/C frequencies in the low frequency range, does not exceed the design basis spectral response.
(4)	The spectral response specifically determined from the EHS-augmented spectra and the E/C frequencies in the low frequency range, exceeds the design basis response but there is adequate margin in the existing design.
(5)	The E/C was qualified by test utilizing a TRS that envelopes the EHS-augmented spectra.
(6)	The E/C was qualified by test utilizing a TRS that does not envelope the EHS-augmented spectra. However, the spectral response analytically determined from the EHS-augmented spectra and the E/C frequencies in the low frequency range, is substantially below the qualification acceleration level of the TRS and the E/C is adequate.
(7)	The E/C was qualified by test utilizing harmonic input motion. The spectral response analytically determined from the EHS-augmented spectra and the E/C frequencies in the low frequency range, is substantially below the qualification acceleration level of the test and the E/C is adequate..

Other, non-predefined dispositions must be specifically stated. The cases referred to C/S for specific evaluation and disposition, as well as any cases dispositioned for re-analysis or re-testing must be specifically defined.

Equipment (A) or System	Method of (B) Seismic Qualification	Fundamental (C) Frequencies	Qualification (D) Acceleration Level	(for notes (A) thru (D) see Sheet 2) Remarks/Disposition (E)

NOTES

(A) Descriptive name of equipment or system. Include weight, size, capacity, etc., as applicable, and B&R or Bechtel Spec. No. and P. O. No.

(B) Indicate if method is by Analysis or by test.

If by Analysis, define method such as: Modal Response Spectra or Equivalent Static.

If by Test indicate: Test Response Spectra, or Required Input Motion (RIM).

(C) Indicate source: Analysis or test. Give numerical values, include the lower 4 or 5 frequencies, and indicate if they correspond to lateral or vertical modes.

(D) Attach all the Floor Response Spectra used for the qualification, and define the governing cases if the information is available from qualification package.

Define acceleration value for RIM or Static methods. Attach the test response spectra, when used.

Enclosure (3)

Supplementary Information on the Usage of Response Spectra Calculated by Single-Step FEM

The Bechtel review of SSI analyses also addressed (1) the over-conservatism of the spectral response in the high frequency range as derived from the two-step FEM solution, and (2) the surmised sensitivity of the two-step FEM response spectra calculation to the structural configuration. These two concerns were addressed by incorporating single-step FEM solutions in conjunction with the EHS solutions in order to achieve an appropriate datum for the comparison of response spectra solutions by two-step FEM. Typical results are shown in Figures 1 and 2. In these figures the solid and dashed curves are the B&R solutions for "old" and "new" configurations of the structures. Both of these solutions by two-step FEM are characteristically over-conservative with respect to the dotted and dot/dashed curves representing the datum by EHS and single-step FEM solutions, and also exhibit frequency shifts and amplitude variations attributed to changes in the structural configuration. The shifts and variations in spectral response, however, are analytically originated by an artificial sensitivity related to the decoupled fixed-base models used in the second step analyses. Therefore the artificial nature of the changes in spectral response, plus the over-conservatism of the two-step FEM solution render the changes as inconsequential, and the EHS/single-step FEM datum spectra is considered to be a more realistic and governing evaluation of the seismic response spectra.

It is emphasized that the single-step FEM solutions used in the Bechtel study were developmental calculations performed by WCC, and were incorporated in the study only to augment the EHS solution and demonstrate the conservatism of the two-step FEM solutions in the high frequency range. For the single-step FEM solutions, the finite element modelling of the soil, as well as the three planar directions and the input motion considered are identical to those used in the two-step FEM solutions; refer to Figures 3, 4, 5 and 6. The fundamental difference between the two FEM's is that the two-step solution relies on decoupled lumped parameter structural models excited by base interaction motion derived from the first step-analyses, whereas the single-step solution consists of single transient analyses through planar finite element models of the coupled structure and soil. In both analyses identical accelerograms are used to define the input motion at the base of the idealized soil model. The artificial accelerograms were developed as described in the FSAR Section 3.7.1.2, and are in full compliance with R. G. 1.60 pertaining to (1) the comparison of the calculated free-field spectra at grade with the STP design response spectrum, and (2) the comparison of calculated response spectra at foundation level with 60% of the design spectrum.

Figure 1

STP – DGB FLOOR DESIGN SPECTRA AT EL. 55 FT.
N-S OBE (2%)

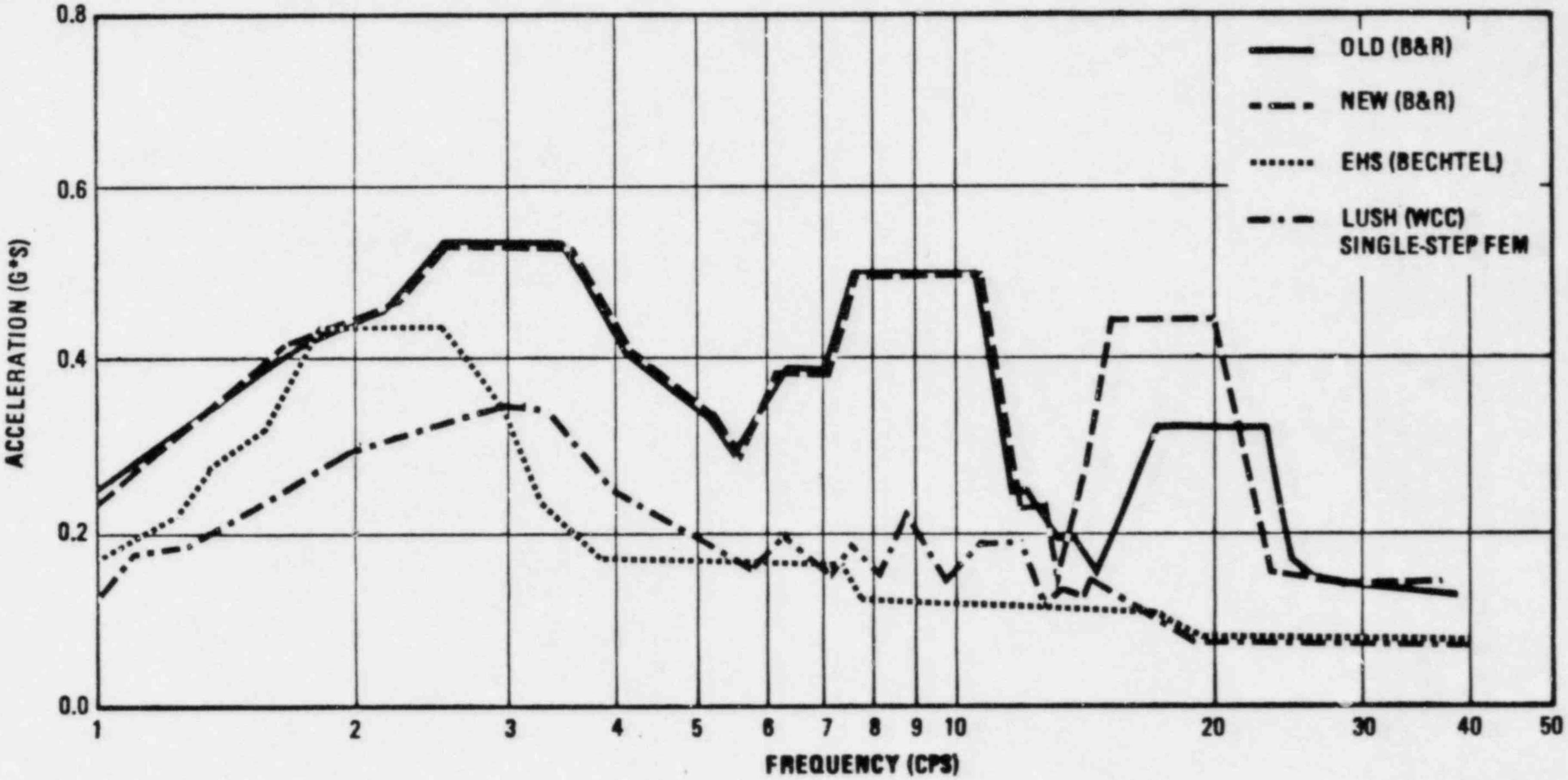
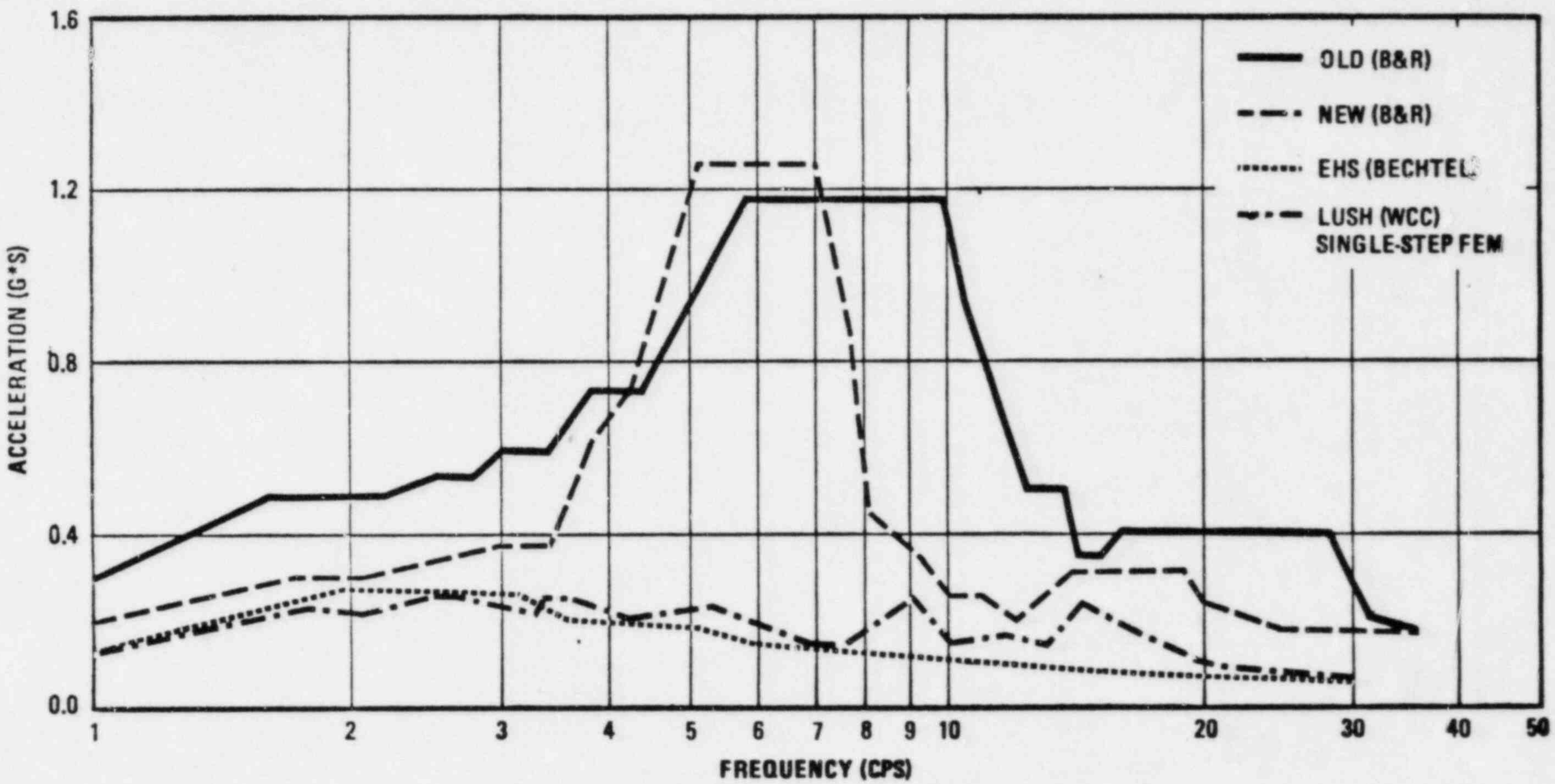
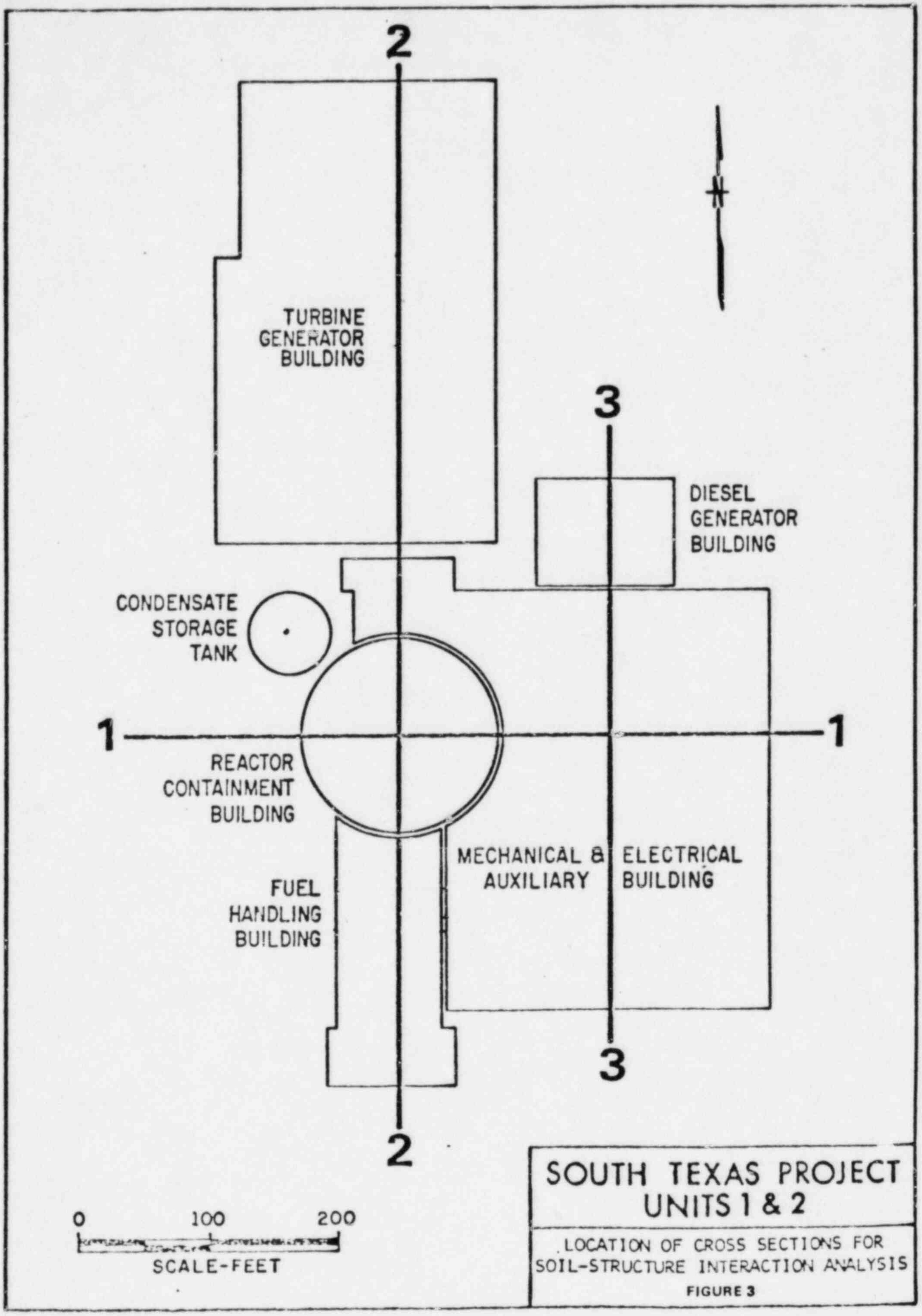


Figure 2

STP – MEAB FLOOR DESIGN SPECTRA AT EL. 86 FT.
N-S OBE (2%)

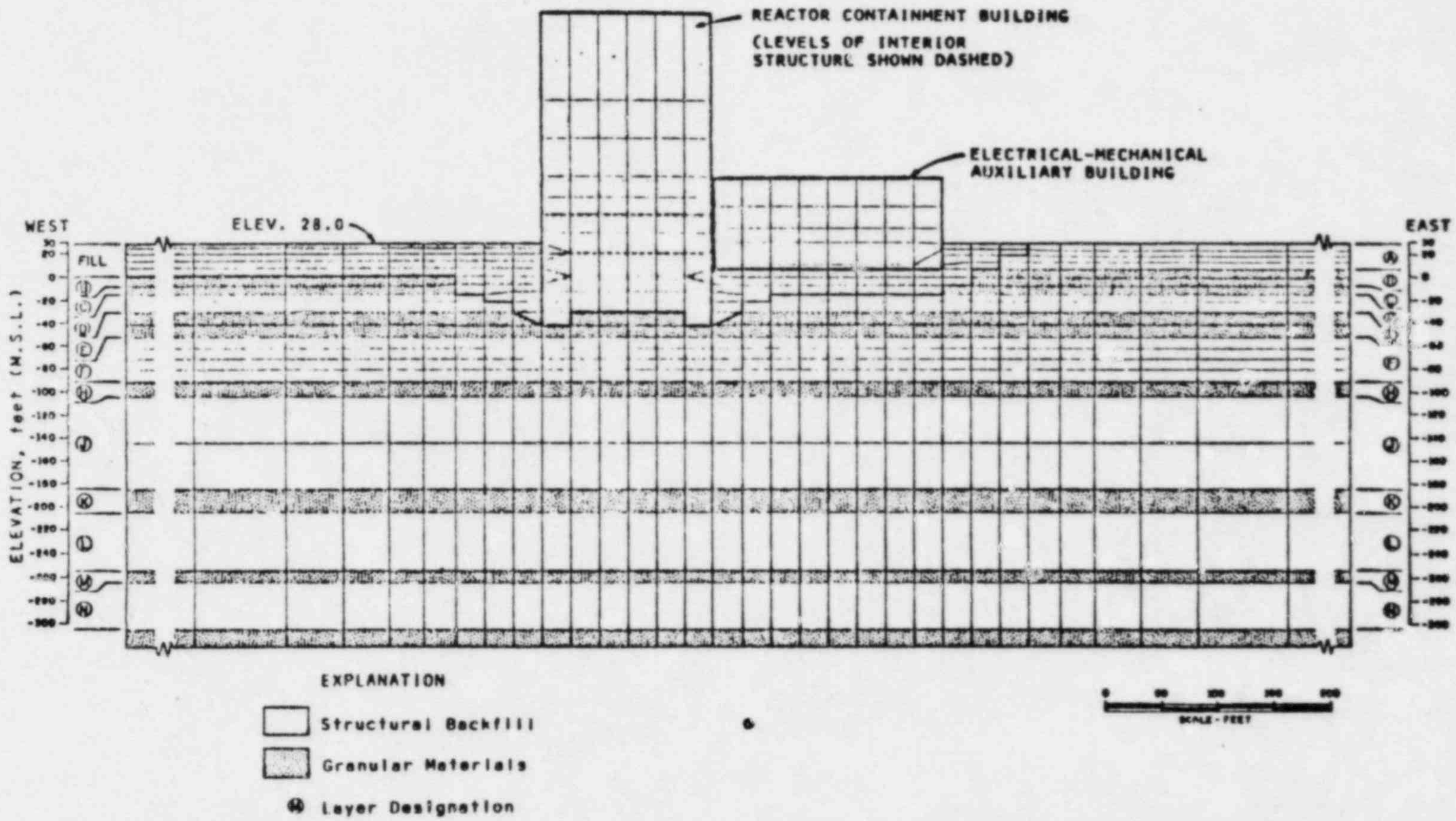




SOUTH TEXAS PROJECT UNITS 1 & 2

LOCATION OF CROSS SECTIONS FOR SOIL-STRUCTURE INTERACTION ANALYSIS

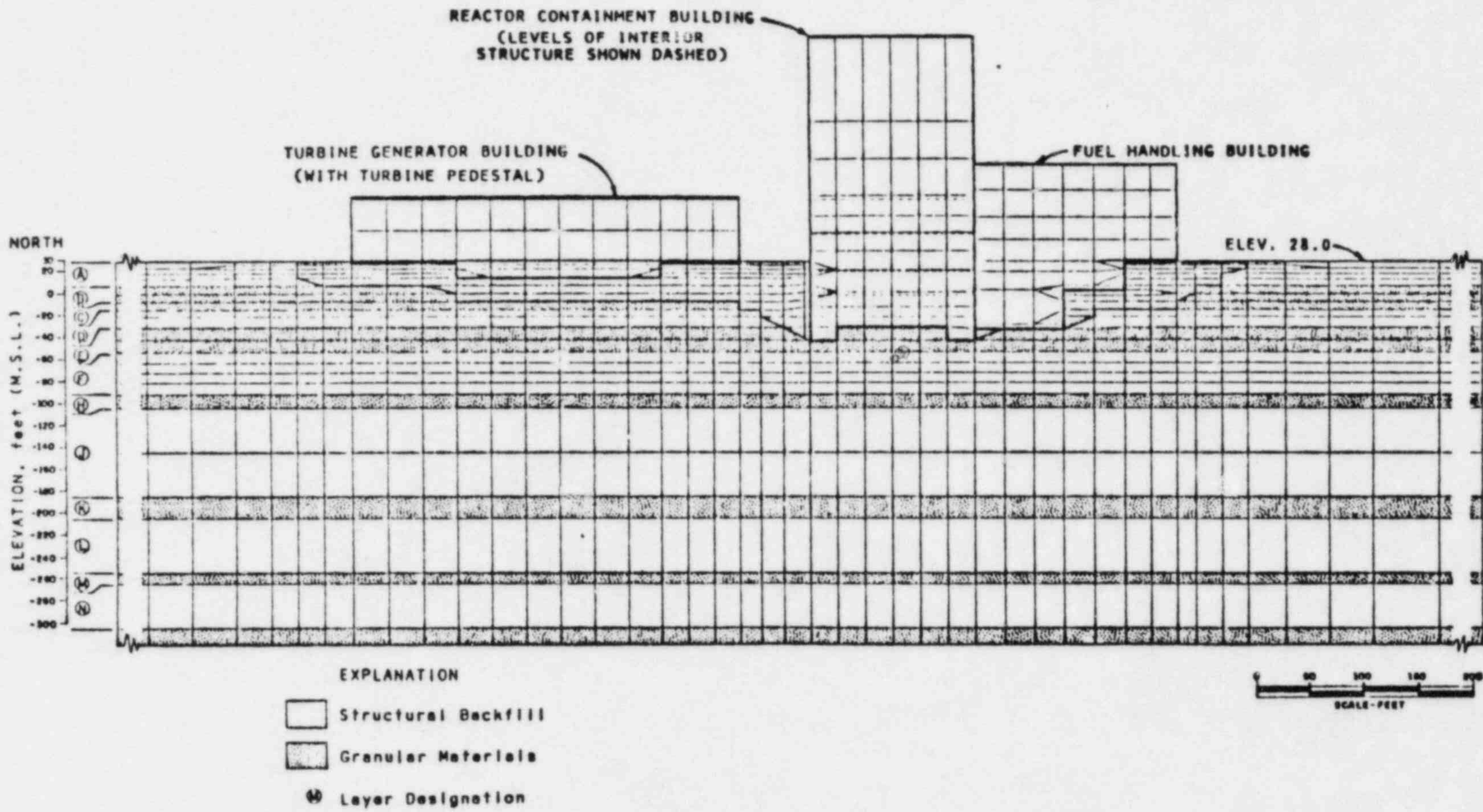
FIGURE 3



SOUTH TEXAS PROJECT
UNITS 1 & 2

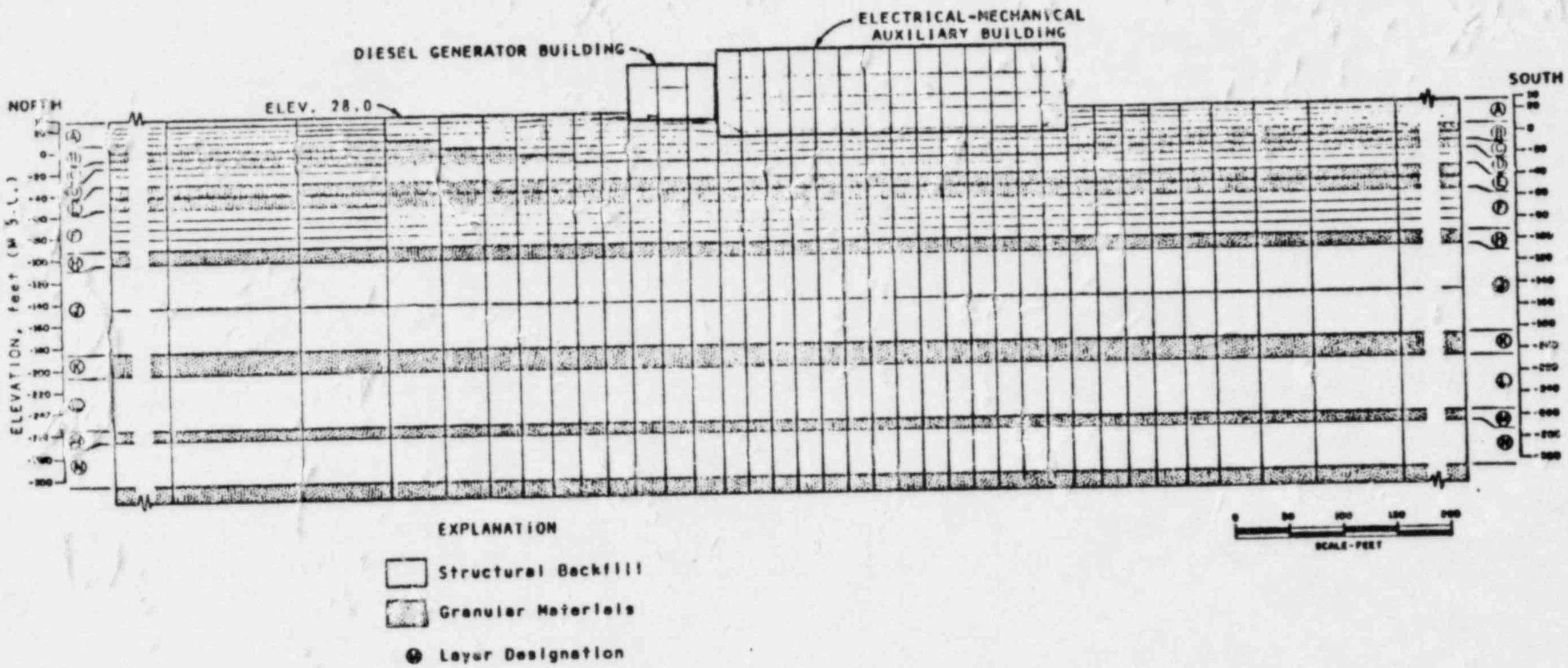
FINITE ELEMENT MESH
CROSS SECTION 1

FIGURE 4



SOUTH TEXAS PROJECT
UNITS 1 & 2

FINITE ELEMENT MESH
CROSS SECTION 2
FIGURE 5



SOUTH TEXAS PROJECT
UNITS 1 & 2

FINITE ELEMENT MESH
CROSS SECTION 3
FIGURE 6

Supplementary Information for the NRC
Evaluation of SSI Analyses and Calculation of
Seismic Response Spectra for STP

1. Clarification of the broadening of the calculated response spectra, and the incorporation of the average, upper and lower bound soil properties into the calculation.

2. Definition of the specific procedure to be implemented for the verification of the seismic qualification/design of equipment and components affected by the EHS response spectra. The procedure should address the selection criteria used to determine the items affected and the acceptance criteria used to disposition their adequacy. An unconditional and arbitrary frequency cut-off will not be used to segregate the items not affected by the EHS spectra.

3. Documentation of the EHS SSI analysis performed by Bechtel.

4. Comparison of response spectra solutions by EHS SSI analyses as performed by B&R and Bechtel.

5. Clarification on the methodology and input used for the single-step FEM calculation of response spectra. It is emphasized that this calculation was introduced only to appropriately augment the EHS solution and demonstrate the over-conservatism of the two-step FEM spectral response in the high structural frequency range.

6. Clarification on the frequency tables presented in the FSAR as to their applicability to the floor response spectra calculations.

7. Clarification to confirm that the SSI analyses performed for STP are in conformance with R. G. 1.60.

8. Clarification on the difference in peak spectral response evidenced between the two-step FEM solutions performed by B&R and by Bechtel.

Question 220.09

State what kind of maximum relative displacement you expect due to earthquake and other applicable loads among supports of Category I structures, systems and components, and what considerations have been given in this respect. Confirm that the staff position stipulated in SRP Section 3.7.3 is fully complied with.

Response

Maximum relative displacements due to earthquake and settlement among principal power block structures are as follows:

	Max. Relative Displacement (in.)		
Interface	OBE	SSE	Long Term Diff. Settlement
RCB/MEAB	0.14	0.23	0.2 - 1.0
RCB/FHB	0.22	0.44	0.2 - 0.4
DGB/MEAB	0.03	0.06	0.0 - 0.5

RCB: Reactor Containment Building
FHB: Fuel Handling Building
MEAB: Mechanical-Electrical Auxiliary Building
DGB: Diesel Generator Building

As stated in the FSAR Sections 3.7.3.8 and 3.7.3.9, the effect of maximum relative displacements is included in the analysis of systems which interconnect structures.

For Piping systems, the analysis is in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section III. The procedure used is in compliance with SRP Section 3.7.3.

Question 230.01

Provide a map showing the locations of all proposed and existing geothermal wells within 15 miles of the site. Examine if fluid injection or withdrawal may cause small magnitude earthquakes (Yerkes and Castle, 1976, Engineering Geology, v. 10, pp. 151-167). If the occurrence of these events is deemed reasonable, discuss ground motion resulting from such small earthquake(s) within 5 miles of the site and examine the effect upon estimate of earthquake hazard at the site and exceedence of the SSE response spectra.

Response

Should any geothermal wells exist or be proposed within a 15-mile radius of the site, their locations and specifics will be provided to the staff with the updated oil and gas production data which is to be supplied as described in the response to NRC Question 231.2. However, the site is located on the northern edge of a geopressured, geothermal fairway in the Frio Formation in Matagorda County (Gustavson and Kreitler, 1976) which is unsuitable for geothermal development. As reported by Bebout, et al. (1978) this is due to "...limited lateral extent of reservoirs and lack of sufficient thickness of permeable sandstones." Therefore, future geothermal exploration within the STP site vicinity is not anticipated.

Although the occurrence at the site of such earthquakes is not deemed reasonable, historically the earthquakes associated with fluid injection or withdrawal have been shallow and of small magnitude. Ground motions associated with such small magnitude earthquakes, even within five miles of the site, would not have an effect on the design basis for the STP.

The low intensity seismic effects which accompany fluid extraction studied by Yerkes and Castle (1976) are attributed to differential compaction at depth, but they note that the relative effects of fluid extraction followed by injection are not easily separated. The nature and occurrence of the seismicity and faulting associated with this differential compaction is chiefly a function of

> "... (1) the pre-exploitation strain regime, and (2) the magnitude of contractional horizontal strain centered over the compacting materials relative to that of the surrounding annulus of extensional horizontal strain ..."

Response 230.01 (cont'd)

Based on data presented in FSAR Section 2.5.2.4 it has been concluded that the Cenozoic and upper Mesozoic sequence underlying the site vicinity is incapable of storing significant amounts of strain energy. The magnitude of contractional horizontal strain is directly related to the extent of fluid withdrawal. Since the potential fluid withdrawal in the vicinity of the site is small, based on data presented in FSAR Section 2.5.1.1.6.6.7.2, it is concluded that the magnitude of contractional horizontal strain is also small. Therefore, since the chief functions of seismicity associated with fluid withdrawal or injection are small, it is expected that the seismicity will be of small magnitude. An earthquake of this small magnitude would not have an effect on the design basis for the STP.

A paragraph that summarizes the potential for geothermal development in the STP site vicinity will be included in FSAR Section 2.5.1.1.6.6.7.2. FSAR Section 2.5.2.3 will be amended to include a discussion of the potential for ground motion due to fluid injection.

REFERENCES:

Bebout, D.G., R. G. Loucks, and A. R. Gregory, Frio Sandstone Reservoirs In The Deep Subsurface Along The Texas Gulf Coast - Their Potential For Production of Geopressured Geothermal Energy, Bureau of Economic Geology, Report Investigation No. 91, University of Texas, Austin, 1978.

Gustavson, Thomas C., and Charles W. Kreitler, Geothermal Resources Of The Texas Gulf Coast - Environmental Concerns Arising From The Production And Disposal Of Geothermal Waters, Bureau Of Economic Geology, Geologic Circular 76-7, University Of Texas, Austin, 1976.

Yerkes, Robert F., and Robert O. Castle, " Seismicity And Faulting Attributable To Fluid Extraction," Engineering Geology, Vol. 10 (1976), pp. 151-167.

Question 230.04

In the FSAR, you have indicated that growth faults are not a source of earthquakes. Provide a discussion, including supporting basis which you have used to support your statement. Discuss this in light of the article by Mauk, Sorrel's and Kimball, 1981. (Fifth Geopressured Geothermal Energy Conference, Baton Rouge, La).

Response

Growth "faults" are not associated with seismic activity capable of generating earthquakes which could cause damaging ground motion at STP. As will be noted in FSAR Section 2.5.2.4:

> The microseismic ground motion which may result from nontectonic sources such as growth "faults" is considered insignificant in relation to the ground shaking that may result from tectonic sources in basement rocks... The upper Mesozoic and Cenozoic sequence in which growth "faults" are known to occur are incapable of storing significant amounts of strain energy.

Based on an evaluation Texas Gulf Coastal Plain geology, growth "faults" flatten at depth and do not extend into basement rock, which is evidence that they are not caused by tectonic forces nor are they an extention upward of basement faults. It is therefore concluded that growth "faults" are the result of gravitational forces acting on the poorly consolidated sediments overlying downwarping basement rock (FSAR Section 2.5.1.1.6.6.6). Mauk, et. al. report microearthquake activity associated with growth "faults" in Brazoria County, Texas and Parcperdue, Vermillion Parish, Louisiana. This activity may be either high-stress-drop microearthquakes associated with the top of a geopressured zone* or low-stress-drop microearthquakes associated with gravity slide phenomenon. In either case this activity is:

> "... very low and the size (magnitude) of the events is very small. No events have been recorded with magnitudes larger than 1.5 (Mauk, et al, P. 106)."

Therefore, it is concluded that ground motion that might be generated by growth "faults" will not result in shaking which will affect plant design at the STP site.

*A geopressured zone exists where fluid pressure in the aquifer exceeds normal hydrostatic pressure of 0.465 pounds per square inch per foot of depth.

Response 230.04 (cont'd)

FSAR Section 2.5.1.1.6.6.6 will be revised to reflect this conclusion. The observation that nontectonic, microseismic activity may be associated with growth "faults" will be clarified in FSAR Section 2.5.2.4.

Question 231.02

Correspondence received from Houston Lighting & Power Company in May, 1981 indicated an increase in hydrocarbon exploration in the South Texas Plant vicinity. Since revisions to the FSAR relating to oil and gas production and subsurface exploration have not been submitted to the NRC since May, 1979, please update the FSAR accordingly. As a portion of your response, include (1) a discussion of the well production horizons and (2) the subsurface structural interpretation of the upper-most mapped horizon underlying the site area such as that developed by commercial firms (Cambe Geological Service, the Geomap Company, etc.). Provide the staff with a copy of the above commercial firm's product.

Response

Since May, 1979, there has been an increase in oil and gas subsurface exploration activity in the vicinity of the STP Site. A study of oil and gas production and subsurface exploration currently underway will be the basis of a subsequent amendment to the FSAR. This study includes an evaluation of onsite potential and a status update of offsite oil and gas production.

Houston Lighting & Power has retained a consultant, Miller and Lents, to assess the potential for hydrocarbon development within the STP site boundaries. The consultant's preliminary conclusion is that the potential for such development is negligible. The final result of the Miller and Lents assessment will be provided in a future amendment to the FSAR. Planning and scoping is in progress on a program to update the status of offsite oil and gas production in the vicinity of STP. The effort includes the acquisition of structural data such as that cited as available from commercial firms as well as estimates of hydrocarbon production in the site vicinity.

FSAR Section 2.5.1.1.6.6.7.2 will be revised in a subsequent amendment with an update of oil and gas production and subsurface exploration since May 1979, based on the above study. The requested interpretive data will be supplied to the staff at that time.

The referenced FSAR amendment is expected to be submitted to the NRC in mid 1983.

Question 231.03

Please update the FSAR (text and figures) to reflect Post-Amendment 5 (May 4, 1979) observations in all subsidence-related matters such as shallow and deep aquifer level variations, horizontal and vertical benchmark changes, and an overall discussion of actual vs. calculated site subsidence. Discuss the effect, if any, of the subsidence on the integrity of the plant.

Response

Based on an evaluation of the data obtained from the subsidence monitoring program, it is concluded that regional subsidence is not significant to the integrity of the plant.

Subsidence-related data, including shallow and deep aquifer level variations and horizontal and vertical deep benchmark changes through January 1981, have been incorporated in the FSAR by Amendment 26. Subsidence data for the period January 1981 through December 1982 will be provided to the FSAR during 1983.

As will be reported in a revision to FSAR Section 2.5.C.5.6, the monitored data through January 1981 indicate that:

"The vertical movements of the near-surface subsidence movements have ranged between 1.0 and 2.0 inches. The average long term trend is about 0.3 in. of regional subsidence per year, which is less than the 0.6 to 0.8 in. predicted during the PSAR studies (i.e, 2.5 to 3.0 ft. between 1973 and 2020...)."

Also recent information from the monitoring program affirms the original conclusion that:

"...the regional subsidence and the decline in regional piezometric pressure within the deep aquifer have been less than anticipated for the monitored period. The regional behavior supports the conclusion expressed in the PSAR that there are no discontinuities in the geological stratigraphy in the site area..."

The potential effect of regional subsidence on the integrity of the plant site was evaluated during the analyses of subsidence models and has been considered in terms of the monitored data. FSAR Section 2.5.4.1.1.2 concludes:

"...subsidence would be broad and regional in nature; therefore, it would tend to be very uniform at the site and thus would have no influence on subsurface stability."

Response 231.03 (cont'd)

There is no evidence from the post-1979 data which would alter this conclusion. Regional subsidence is, therefore, not significant from the standpoint of plant integrity.

FSAR Section 2.5.1.2.9.6 will be revised to include these conclusions regarding the significance of regional subsidence to the plant site.